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# REVIEWS OF MODERN PHYSICS

VOLUME 45, NUMBER 2, PART II

APRIL 1973

## Review of Particle Properties Particle Data Group

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This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group (Phys. Letters 39B, No. 1 (1972)). Data are evaluated, listed, averaged, and summarized in tables. A data booklet is also available.

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### I. INTRODUCTION, CREDITS, CONSULTANTS

This review is an updating through January 1973 of our previous review (Particle Data Group, 1972). In this version of the text we concentrate on topics that are either new or essential. For complementary information on our standard procedures the reader is referred

\* The Berkeley Particle Data Center is jointly supported by the U.S. Atomic Energy Commission, the Office of the Standard Reference Data of the National Bureau of Standards, and the National Science Foundation.

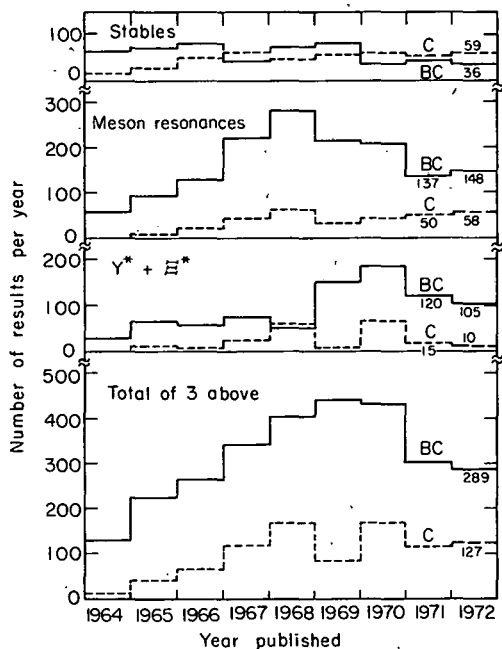


FIG. 1. Statistics on the rate of production of data on particle properties. From the top to the bottom, the number of results per year are presented for stable particles, meson resonances,  $Y^* + Z^*$ 's, and the total of the three above. The full lines correspond to bubble-chamber techniques (BC) and interrupted lines correspond to counters, spark chambers and spectrometers (C). Note that the figure omits  $N^*$  and  $Z^*$ , the field where counters have overwhelmed bubble chambers, because we punch mainly results from partial wave analyses instead of primary data.

to our January 1970 article (Particle Data Group, 1970).

Again we wish to emphasize that we compile the experimental results of others. It is inappropriate to give us the credit for their countless hours of effort. We urge that references be given directly to the original data, and we provide complete references in the Data Card Listings for that purpose. Only then is it appropriate to state "average value obtained from Rev. Mod. Phys. 45, No. 2, S1 (1973)." If the list of experiments is so long that this is impractical, we suggest the form: Jones *et al.* 70, Smith *et al.* 69, ... average value and complete references in *Review of* ...

The responsibilities of the authors of this compilation can roughly be broken down as follows:

(1) *Stable particles*: A. Barbaro-Galtieri, N. Barash-Schmidt, and T. G. Trippe.

(2) *Meson resonances*: V. Chaloupka, M. Roos, A. H. Rosenfeld, and P. Söding.

(3) *Baryon resonances*: A. Barbaro-Galtieri, C. Bricman, R. L. Kelly, and T. A. Lasinski.

*General*: All Berkeley authors.

*Consultants*: The three teams just mentioned must come to a consensus on how to treat the data and must write a number of mini-reviews. It is impractical to

spread this responsibility over more than a few people in each team and still expect to meet publication deadlines. Hence we limit our number of authors (to eleven in this edition), but thereby leave gaps in our coverage, both intellectual and geographical. To help us overcome this deficiency, we have solicited the help of consultants:

- Stanley J. Brodsky (Stanford Linear Accelerator Center)
- Chih-Yung Chien (Johns Hopkins University)
- Anatoli Kuznetsov (JINR, Dubna), starting 1973
- R. Gordon Moorhouse (University of Glasgow)
- Horst Oberlack (Lawrence Berkeley Laboratory)
- Oliver E. Overseth (University of Michigan)
- LeRoy R. Price (University of California at Irvine)
- Mark Sakitt (Brookhaven National Laboratory).

The usefulness of this compilation depends in large part on the interaction between the users and authors and consultants. We appreciate comments, criticisms, and suggestions for improvements of all stages of data retrieval, processing, and presentation.

## II. COLLECTION AND TREATMENT OF DATA

### A. Annual Growth of Data

Figure 1 shows the rate at which we have been recording results, as a function of year published. Through 1969 we subdivided our annual count into two parts:

(1) Highest quality data. These are the results that we accept for averaging and fitting.

(2) Lesser quality data; results which, for one of the reasons mentioned in Section B, below, we encoded but did not accept for averaging.

We have found that this subdivision stays at a fairly constant 60:40 ratio, and is not otherwise very informative, so we now merely count the total.

We see that the number of results per year from bubble chambers, though still dominant, is now dropping; that from counters is roughly constant.

It is of interest to compare the declining rate at which bubble chambers produce results on particle properties with the fact that the number of bubble chamber events measured each year is roughly constant. Apparently experiments have become larger and more specialized, and we now find ourselves encoding more density matrix elements for our compilations of cross sections, and fewer masses and widths of bumps.

It is of interest to compare the decreasing total rate at which we encode data on particle properties with the fact that the rate of publication of experimental papers is about constant. Some differences are that many new experiments are above the resonance

region, there are many photon and electron experiments, and many studies of inclusive reactions. Again, compilers are flooded with new data, but the great majority go into collections of cross sections.

### B. Selection of Data

All particles are considered to fall into one of the three groups:

- (1) Stable particles, immune to decay via the strong interaction
- (2) Meson resonances
- (3) Baryon resonances

These groups are maintained within the two main parts of the compilation:

- (1) Tables of Particle Properties
- (2) Data Card Listings.

The Data Card Listings contain the original information (data, references, etc.), weighted averages, comments and "mini-reviews." Immediately preceding the Data Card Listings is an Illustrative Key thereto. We attempt to give complete Data Card Listings up to our closing date (February 1, 1973) for all journals listed in the Illustrative Key. We also include preprints and unpublished conference reports which have come to our attention, but make no attempt at completeness.

Roughly 40% of our encoded results have not been accepted for averaging. They are set off in parentheses; our reasoning is then often given in a footnote below the data. If the reason is not given, it is one of the following:

- The quantity was presented with no error stated.
- The result comes from a preprint or conference report. It is our experience that such results (and particularly the errors) often change before final publication. Accordingly we keep these new results in parentheses until we have corresponded with the authors.
- It involves some assumptions that we do not wish to incorporate.
- It is of poor quality, e.g., bad signal-to-noise ratio.
- Two or more experiments give contradictory results, so that it is senseless to average the data.

When the data for a particle have received special treatment or when they present special problems, this is noted in a mini-review in the Data Card Listings.

The Tables of Particle Properties represent the output of weighted averages and some critical judgment. The extent to which "blind" averaging has been tempered with judgment is explained in footnotes to the Tables. In general, however, the footnotes are less complete than is the collection of notes and mini-

reviews in the Data Card Listings. The reader is therefore encouraged to familiarize himself with the Data Card Listings and, ultimately, with the original experiments.

### III. CRITERIA FOR RESONANCES

An experimentalist who finds some evidence for a peak in a mass spectrum will of course want to know what has been seen in that region in the past; hence, we strive to have the Data Card Listings serve as an archive for any substantial claim or evidence for a new state.

For the Tables of Particle Properties, on the other hand, we wish to be more conservative, and to include only those peaks or resonances which we feel have a  $\geq 90\%$  chance of survival. One's betting odds for survival are of course completely subjective; they are influenced mainly by the amount of information available (such as partial-wave analyses) and somewhat by the degree of controversy over interpretation and how long it will be before more information is available. An arrow ( $\rightarrow$ ) at the left of the Tables of Particle Properties indicates that a questionable candidate has been omitted from the Table, but that it can be found in the corresponding part of the Data Card Listings.

More details on our acceptance criteria are as follows.

#### 1. Partial Wave Analyses

(a) In those cases where energy-independent partial-wave analyses are available (mostly for  $N^*$ 's), approximate Breit-Wigner behavior of the amplitude appears to us to be the most satisfactory test for a resonance. We can check that the Argand plot follows roughly a left-hand circle, and that the "speed" of the amplitude also shows a maximum near the resonance energy; further, there should be data well above the resonance, showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude could accredit a resonance even if its elasticity is too small to make a noticeable peak in the cross section.

Of course, even if Argand plots are available, it may still be a matter of opinion as to what behavior constitutes a resonance. Such an example is the  $K^+p$  peak (near  $K\Delta$  threshold) called  $Z_1(1900)$ , which is discussed in a mini-review in the Baryon Data Card Listings.  $K^+p$   $P_{13}$  Argand plots are displayed there, and most suggest a resonance; however, there is disagreement between the various analyses as to the speed of the amplitude, i.e., as to whether it has a Breit-Wigner type of behavior. In addition the errors on the amplitudes are still large, and we prefer to wait a bit longer before we put  $Z_1$  in the Baryon Table.

(b) Often where there are insufficient data to perform energy-independent analyses, one resorts to energy-dependent partial-wave analyses (mostly for

$Y^*s$ ). In this case Breit-Wigner behavior is an input. We therefore require that resonance solutions be found by several different analyses, preferably in different channels ( $\bar{K}N \rightarrow \bar{K}N$ ,  $\pi\Sigma$ , etc.), before putting the claim in the table.

(c) Partial-wave analyses of three-body final states ( $\pi N \rightarrow \pi\pi N$ ) are becoming available. While these analyses are based on the isobar model ( $\pi N \rightarrow \rho N$ ,  $\pi\Delta$ , etc.) and are subject to theoretical objections of varying importance (triangle graphs, double counting, unitarity), they provide increasingly reliable information on inelastic decay modes of otherwise established resonances.

## 2. "Bumps"

This category includes most mesons,  $Z^*$  peaks, and the higher-mass ( $\geq 2300$  MeV)  $N^*$ ,  $Y^*$  peaks. Unless the peak is experimentally shaky, we put it in the table. Thus we accept peaks of high statistical significance or states that are observed via several different production processes.

## 3. "Diffractive Mesons"

(a) This category includes statistically significant peaks like  $A_1$ ,  $A_3$ , or  $Q$ , which are not far above the  $\rho\pi$ ,  $f\pi$ , or  $K^*\pi$  thresholds. Although the threshold behavior in these channels may be described by the "Deck effect" or by its modern version "double Regge-pole exchange", the question of resonance interpretation has for some time been open. Several years ago we put these peaks into the Meson Table, but warned the reader not to conclude that we claim they are necessarily genuine resonances. However, if such effects can be convincingly associated with poles of the  $S$ -matrix on some unphysical sheet, we shall call them resonances (see, e.g., Chew, 1968).

(b) Recently Ascoli and collaborators (Ascoli, 1972) have attempted partial-wave analyses of the  $\pi\pi\pi$  system in reactions like  $\pi N \rightarrow (\pi\pi\pi)N$ . There are several important aspects to such analyses:

(i) for a given  $t$ , the  $\pi\pi\pi$  vertex is assumed to be independent of the  $NN$  vertex;

(ii) the  $\pi\pi\pi$  reaction is assumed to proceed through quasi-two-body states ( $\rho\pi$ ,  $\epsilon\pi$ , etc.) in the spirit of the isobar model;

(iii) in order to keep the number of parameters manageable, certain plausible assumptions are made on the vanishing of some of the spin density matrix elements of the  $(\pi\pi\pi)$  system.

In view of the novelty and difficulty of this analysis, we are reluctant to place these partial-wave analyses in the same category as 1(c) above. However, through such an analysis, the already significant  $A_2$  peak has been confirmed to be a Breit-Wigner type resonance through an observed phase change of  $90^\circ$  relative to other slowly varying partial waves. In contrast, peaks

like  $A_1$  and  $A_3$  show an enhancement in a now "pure"  $J^P$  mass plot but reveal *no* relative  $90^\circ$  phase change. While this observation suggests that the  $A_1$  and  $A_3$  are not resonances, a mechanism has been suggested by Wright (1972) that reproduces the  $A_1$  "partial wave" and still associates the  $A_1$  with a pole on an unphysical sheet. In the sense of Chew 68, the  $A_1$  may still be called a resonance.

We now ask "How likely is it that peaks of class 2 and 3(a) above (not checked by partial-wave analysis) will eventually be confirmed as resonances?" We know of no experimentally convincing peak that has been shown to have *nothing* to do with a resonance. But be warned that broad peaks may be misleading: they may contain several resonances, or they may include a resonance narrower than the peak, plus some other complications; for example:

• Before 1966 we might have tabulated the  $\pi p$  bumps at 1520 and 1688 MeV as single resonances, whereas partial-wave analysis shows that each contains several resonances.

• Before the  $N'(1470, P_{11})$  was confirmed in partial-wave analyses, it was seen as a missing mass or  $p\pi\pi$  peak produced peripherally in high-energy  $pp$  collisions, and (like  $A_1$ ,  $Q$ , and  $A_3$ ) was partly explained by the Deck effect and later by double-Regge-pole exchange.

In summary, we enter into the Tables of Particle Properties experimentally convincing peaks unless there is contradictory information; and we expect that most of these peaks will eventually be confirmed as one or more resonances.

## IV. PARAMETERS AND CONVENTIONS

### A. Quantum Numbers

The symbols  $I^G(J^P)C$  represent:

$I$  = isospin

$G$  =  $G$ -parity

$J$  = spin

$P$  = space parity

$C$  = charge conjugation parity.

### Mesons

The charge conjugation operator  $C$  turns particle into antiparticle and has eigenvalues  $\pm 1$  only for neutral states; so it is useful to define an extension  $G$  which has eigenvalues for charged states too. It is usually<sup>1</sup> defined by

$$G = C \exp(i\pi I_y). \quad (1)$$

<sup>1</sup> Most texts define it as in Eq. (1); see, e.g., Gasiorowicz (1966); however, sometimes the rotation is taken about  $I_z$ . The difference between the two conventions is mentioned in a footnote in Källen (1964).

A neutral nonstrange state is an eigenstate of  $\exp(i\pi I_y)$  with eigenvalue  $(-1)^I$ . Then we can write the eigenvalue equation for the whole multiplet as

$$G = C_n(-1)^I, \quad (2)$$

where  $C_n$  ( $n$  for neutral) is the eigenvalue  $C$  would have if applied to the neutral member of the multiplet. Thus, for a  $\pi^0$ ,  $C$  has the eigenvalue  $+1$ , and since  $I=1$ ,  $G=-1$ . For the charged pion there are no eigenvalues corresponding to  $C$  and to the isospin rotation, but Eqs. (1) and (2) still give  $G=-1$ .

Consider a meson as a bound state of fermion-antifermion, e.g.,  $\bar{q}q$ , with orbital angular momentum  $l$ , and with the two fermion spins coupling to give a spin  $S$ . Then one can show that the charge-conjugation eigenvalue [defined in Eq. (2)] is

$$C_n = (-1)^{l+S}. \quad (3)$$

Equations (2) and (3) combine to give

$$G = (-1)^{l+S+I}. \quad (4)$$

The parity is

$$P = -(-1)^l. \quad (5a)$$

Equations (3) and (5) combine to give

$$C_n P = -(-1)^S \quad (5b)$$

so all singlet ( $^1S_0$ ,  $^1P_1$ , ...) have  $C_n P = -1$ , and all triplets ( $^3S_1$ , ...) have  $C_n P = +1$ . For proofs of the above, see our 1969 text (Particle Data Group, 1969) and Appendix by C. Zemach.

If, instead of  $\bar{q}q$ , we consider the meson as a state of boson-antiboson (e.g.,  $A_2 \rightarrow \bar{K}K$ ), it turns out that some signs cancel, and Eqs. (3) and (4) [not (5)!] apply *unchanged*. Of course the mesons are usually spinless and  $S$  is zero, but the equations are more general. Equations (3) and (4) can be considered as selection rules forbidding many decays.

We now use Eqs. (3) and (4) to introduce the concept of "Abnormal-C" mesons, i.e. mesons that cannot be composed of  $\bar{q}q$ .

The unitary triplets of quarks is of course defined to have isospin and hypercharge properties such that  $\bar{q}q$  can combine (according to the  $SU(3)$  relations  $\{3\} \otimes \{3\} = \{8\} \oplus \{1\}$ ) so as to form only unitary octets and singlets. The non-observation of "exotic" mesons (i.e. mesons in more complicated supermultiplets) is of course one of the bases of the quark model. But it is slightly less obvious that even some *octets* are forbidden by the model, for example those with  $(J^P)C_n = (1^-)^-$ ,  $(2^+)^-$ , .... Such states are also not observed, and this is an additional piece of evidence for the quark model.

In what follows, do not confuse "Abnormal-C" with Normal or Abnormal  $J^P$ , both of which are allowed by the quark model. The series,  $J^P = 0^+$ ,  $1^-$ ,  $2^+$ , ... is called Normal because  $P = (-1)^J$  as for normal

spherical harmonics, and  $J^P = 0^-$ ,  $1^+$ , ... is called Abnormal.

The top part of Table I shows all the low angular momentum states that can be formed from  $\bar{q}q$ . Note that half of the  $J^P$  states can be formed by both a triplet and a singlet  $\bar{q}q$  state, e.g.  $^3P_1$ ,  $^1P_1$  or  $^3D_2$ ,  $^1D_2$ . Equation (3) shows that  $^3P_1$  and  $^1P_1$  have opposite  $C_n$ , so the  $\bar{q}q$  model allows both. But the states  $^3P_0$  and  $^3P_2$  have no  $^1P$  counterparts. According to Eq. (5.1) they have  $C_n P = +1$ , and with the  $\bar{q}q$  model there is no way to form a state with a  $J^P$  of  $^3P_{0,2}$  (i.e.  $J^P = \text{Normal}$ ) and with  $C_n P = -1$ . As mentioned, such octets have not shown up. With the help of Table I one can also see that the special state  $^1S_0$ ,  $C_n P = +1$ , cannot be formed, so has Abnormal  $C$ .

### Baryons and Mesons

Well-established quantum numbers are underlined (except for stable particles, where most of the quantum numbers are established). We have used flimsy evidence to guess many of the remaining ones, and we have indicated with "?" the ones for which there is almost no evidence.

As is customary, we define antiparticles as the result of operating with  $CPT$  on particles, so both share the same spins, masses, and mean lives. Whenever there is a particularly interesting test of  $CPT$  invariance we include it in the Stable Particles Table.

### B. Particle Names

If a *meson* has a well-accepted colloquial name, we use it. If not, we name it by a single symbol which specifies its baryon number  $B$  ( $=0$  for mesons), its isospin  $I$ , its hypercharge  $Y$ , and, for a nonstrange meson, its  $G$  parity. For convenience, we also list the strangeness  $S$ , which is related to  $Y$  and  $B$  by

$$S = Y - B.$$

The name conventions for mesons are given in the first part of Table II.

To crowd even more information onto the symbol, we sometimes add a subscript giving  $J^P$ . If  $J^P$  is not known, but must be "Normal" ( $0^+$ ,  $1^-$ ,  $2^+$ , ...), e.g., because  $K\pi$  decays are seen, we use the subscript  $N$ . Thus  $K_N(1420)$ . If such modes are *not* seen (and are not otherwise forbidden), we *guess* that it is because  $J$  is "Abnormal", and we write, for example,  $K_A(1240)$ .

For *baryons* ( $B=1$ ) no attempt has been made to attach a subscript about  $J$  and  $P$ . The name conventions for baryons are given in the second part of table 2. For stable baryons of each  $I$  and  $Y$  we use the symbol standing alone; for resonances, the mass is in parentheses [i.e.,  $N(1688)$ ,  $\Lambda(1405)$ ,  $\Sigma(1765)$ , etc.]. The  $J^P$  assignments are reported in the Baryon Table as  $\frac{1}{2}^+$ ,  $\frac{3}{2}^-$ ,  $\frac{5}{2}^+$ , etc., and also by the symbols  $P_{11}$ ,  $D_{13}$ ,  $F_{15}$ ,

Table I.  $I^G(J^P)$  of mesons from  $\bar{q}q$  model. For the distinction between abnormal  $J^P$  and abnormal C, see text below Eq. (5). K mesons share the same values of  $J^P$  as the I = 0 and 1 states shown, but are not eigenstates of G. The middle column, which gathers together  $(J^P)_{\text{Normal or Abnormal}}$  CP, is a redundant intermediate step intended to make the table easier to read.

| Parity   | $\bar{q}q$ State | $(J^P)_{\text{CP}}$ | $I^G(J^P)C_n$                                      | Examples and comments                                                        |
|----------|------------------|---------------------|----------------------------------------------------|------------------------------------------------------------------------------|
|          | CP -             | CP +                |                                                    |                                                                              |
| Parity - | $1S_0$           | $(0^-)_{A^-}$       | $\begin{cases} 0^+(0^-)+ \\ 1^-(0^-)+ \end{cases}$ | $\eta, \eta'$<br>$\pi$                                                       |
|          | $3S_1$           | $(1^-)_{N^+}$       | $\begin{cases} 0^-(1^-)- \\ 1^+(1^-)- \end{cases}$ | $\omega, \phi$<br>$\rho$                                                     |
| Parity + | $1P_1$           | $(1^+)_{A^-}$       | $\begin{cases} 0^-(1^+)- \\ 1^+(1^+)- \end{cases}$ | B                                                                            |
|          | $3P_0$           | $(0^+)_{N^+}$       | $\begin{cases} 0^+(0^+)+ \\ 1^-(0^+)+ \end{cases}$ | $\epsilon, S^*$<br>$\pi_N(1016)$                                             |
|          | $3P_1$           | $(1^+)_{A^+}$       | $\begin{cases} 0^+(1^+)+ \\ 1^-(1^+)+ \end{cases}$ | A1                                                                           |
|          | $3P_2$           | $(2^+)_{N^+}$       | $\begin{cases} 0^+(2^+)+ \\ 1^-(2^+)+ \end{cases}$ | f, f'<br>A2                                                                  |
| Parity - | $1D_2$           | $(2^-)_{A^-}$       | $\begin{cases} 0^+(2^-)+ \\ 1^-(2^-)+ \end{cases}$ | Regge recurrence<br>of $1S_0, 0^-$                                           |
|          | $3D_1$           | $(1^-)_{N^+}$       | same as $3S_1$                                     |                                                                              |
|          | $3D_2$           | $(2^-)_{A^+}$       | $\begin{cases} 0^-(2^-)- \\ 1^+(2^-)- \end{cases}$ | Regge recurrence of<br>top abnormal-C state<br>below: $(J^P)_{C_n} = (0^-)-$ |
|          | $3D_3$           | $(3^-)_{N^+}$       | $J > 2$                                            |                                                                              |
| Parity + | $1F_3$           | $(3^+)_{A^-}$       | $J > 2$                                            |                                                                              |
|          | $3F_2$           | $(2^+)_{N^+}$       | same as $3P_2$                                     |                                                                              |
|          | $3F_3$           | $(3^+)_{A^+}$       | $J > 2$                                            |                                                                              |
|          | $3F_4$           | $(4^+)_{N^+}$       | etc.                                               |                                                                              |

#### ABNORMAL C STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL

|                                                     |               |                                                    |                                                                         |
|-----------------------------------------------------|---------------|----------------------------------------------------|-------------------------------------------------------------------------|
| Abnormal C<br>states<br>Have no $\bar{q}q$<br>model | $(0^-)_{A^+}$ | $\begin{cases} 0^-(0^-)- \\ 1^+(0^-)- \end{cases}$ | All except<br>$J^P = 0^-$<br>are<br>$J^P = \text{normal},$<br>$CP = -1$ |
|                                                     | $(1^-)_{N^-}$ | $\begin{cases} 0^+(1^-)+ \\ 1^-(1^-)+ \end{cases}$ |                                                                         |
|                                                     | $(0^+)_{N^-}$ | $\begin{cases} 0^-(0^+)- \\ 1^+(0^+)- \end{cases}$ |                                                                         |
|                                                     | $(2^+)_{N^-}$ | $\begin{cases} 0^-(2^+)- \\ 1^+(2^+)- \end{cases}$ |                                                                         |
|                                                     | $(3^-)_{N^-}$ | $\begin{cases} 0^+(3^-)+ \\ 1^-(3^-)+ \end{cases}$ |                                                                         |
|                                                     |               |                                                    |                                                                         |

TABLE II. Particle name conventions.

| Name                 | $I$           | $Y$ | $S$ | $G$ |
|----------------------|---------------|-----|-----|-----|
| Mesons               |               |     |     |     |
| $\eta$               | 0             | 0   | 0   | +   |
| $\omega$ or $\phi^a$ | 0             | 0   | 0   | -   |
| $\rho$               | 1             | 0   | 0   | +   |
| $\pi$                | 1             | 0   | 0   | -   |
| $K^+, K^0$           | $\frac{1}{2}$ | +1  | +1  |     |
| $K^-, \bar{K}^0$     | $\frac{1}{2}$ | -1  | -1  |     |
| Baryons              |               |     |     |     |
| $N$                  | $\frac{1}{2}$ | +1  | 0   |     |
| $\Delta$             | $\frac{3}{2}$ | +1  | 0   |     |
| $Z_0, Z_1$           | 0, 1          | +2  | +1  |     |
| $\Lambda$            | 0             | 0   | -1  |     |
| $\Sigma$             | 1             | 0   | -1  |     |
| $\Xi$                | $\frac{1}{2}$ | -1  | -2  |     |
| $\Omega$             | 0             | -2  | -3  |     |

<sup>a</sup> Starting in 1973, we use the symbol  $\omega$  for those  $I^G=0^-$  mesons that decay mainly into  $3\pi$  [ $\omega(784)$ ,  $\omega(1675)$ ]; we reserve the symbol  $\phi$  for  $\phi(1019)$  and possible future higher-mass  $I^G=0^-$  mesons that decay mainly into  $K\bar{K}$ .

which refer to the  $\pi p$  or  $K p$  partial-wave amplitude in which the resonant state occurs (the first subscript refers to the isospin state;  $2 \times I$  for  $N$  and  $\Delta$  and just  $I$  for  $Z$ ,  $\Lambda$ , and  $\Sigma$ ).

When two *baryons* have identical quantum numbers we warn the reader by adding a *prime* to the symbol for the heavier one, e.g.,  $p$ ,  $N'(1470, \frac{1}{2}^+)$ . In the case of baryon resonances described by Argand diagrams which exhibit more than one resonance, we use one prime for the first, two for the second, ...; thus the series of which the proton is the stable member becomes:  $p$ ,  $N'(1470, \frac{1}{2}^+)$ ,  $N''(1780, \frac{1}{2}^+)$ .

If there is only one resonance on an Argand plot, and thus no need for distinctions, we use no primes.

For some pairs of *mesons* with supposedly identical quantum numbers, we also use primes; e.g.,  $\eta$ ,  $\eta'$ ;  $f$ ,  $f'$ .

### C. Masses and Widths

An unstable particle of mass  $M$ , decaying with a mean life  $\tau$ , has a wave function

$$\psi(t) \propto \exp \{-i\omega t - t/2\tau\} = \exp \{-(i/\hbar)(M - i\frac{1}{2}\Gamma)t\},$$

where  $\Gamma = \hbar/\tau$ . Its Fourier transform is

$$\psi(m) \propto 1/(M - m - \frac{1}{2}i\Gamma)$$

which we call a nonrelativistic Breit-Wigner resonance.

For the metastable particles in the Stable Particle Table, we tabulate  $\tau$ , but for resonances which decay by the strong interaction, we tabulate  $\Gamma$ , which is the full width at half-maximum of  $|\psi(m)|^2$ .

In practice, values of  $M$  and  $\Gamma$  are extracted from data via *models*, and we cannot average these values if the models are dissimilar. In the next few paragraphs we discuss this point in slightly more detail, using the example of an  $s$ -channel resonance.

An *elastic* nonrelativistic Breit-Wigner  $T$ -matrix element is usually written

$$T_{11} = \frac{1}{2}\Gamma/(M - m - \frac{1}{2}i\Gamma). \quad (6)$$

Here  $\Gamma(m)$  is the width for decay into the channel 1, with angular momentum  $l$ . It contains barrier-penetration factors which can vary rapidly with energy; near threshold,  $\Gamma(m)$  should start up as  $q^{2l+1}$ , and then level off. Various  $m$  dependences are used, mostly variants of the general form

$$\Gamma(m) \propto [q^2/\{1 + (qR)^2\}]^l q. \quad (7)$$

For a choice of forms, see Jackson (1964), Pišut and Roos (1968), and Barbaro-Galtieri (1968). Of course the detailed shape of the amplitude and also the value of  $\Gamma$  will depend slightly on the form chosen.

The width is also related to the behavior of  $T$  at resonance. It is easy to show (Herndon *et al.*, 1970) that, ignoring terms in  $d\Gamma/dm$ ,

$$\text{"Speed"}(\text{res}) = |dT/dm|_{m=M} = x_e/(\frac{1}{2}\Gamma(M)), \quad (8)$$

where the elasticity,  $x_e = \Gamma_e/\Gamma$ , is introduced next. More detailed properties of "Speed" are discussed in the baryon mini-review at the front of the Baryon Data Card Listings of our April 1971 edition (Particle Data Group, 1971).

For an *inelastic* resonance feeding into channel  $\beta$ ,

$$T_{1\beta} = \frac{1}{2}(\Gamma_1\Gamma_\beta)^{1/2}/(M - m - \frac{1}{2}i\Gamma) = (x_1x_\beta)^{1/2} \times [\frac{1}{2}\Gamma/(M - m - \frac{1}{2}i\Gamma)], \quad (9)$$

where

$$\Gamma = \sum_1^N \Gamma_\beta, \quad x_\beta = \Gamma_\beta/\Gamma, \quad (10)$$

and  $x_1$  (called the elasticity) is often written  $x_e$ . (Note that in the Data Card Listings we use the symbol  $P_\beta$  rather than  $x_\beta$ .)

The channel cross section  $\sigma_{1\beta}$  for the reaction  $1 \rightarrow \beta$  is

$$\sigma_{1\beta} = 4\pi\lambda^2(J + \frac{1}{2}) |T_{1\beta}|^2, \quad (11)$$

where  $J = l \pm \frac{1}{2}$ .

Resonances seen in production are even more complicated. Here  $\Gamma_1^{1/2}$  disappears from  $T$ , and must be replaced with some model-dependent parametrization of the production process.

In conclusion, we have seen that because of the energy dependence of  $\Gamma$  even the amplitude  $T$  for a resonance does not have a full-width at half-maximum equal to  $\Gamma$  (but it does peak at or near  $M$ ). Then kinematic factors enter into the cross section for

## SU(3) RELATIVE SIGN OF RESONANT AMPLITUDES

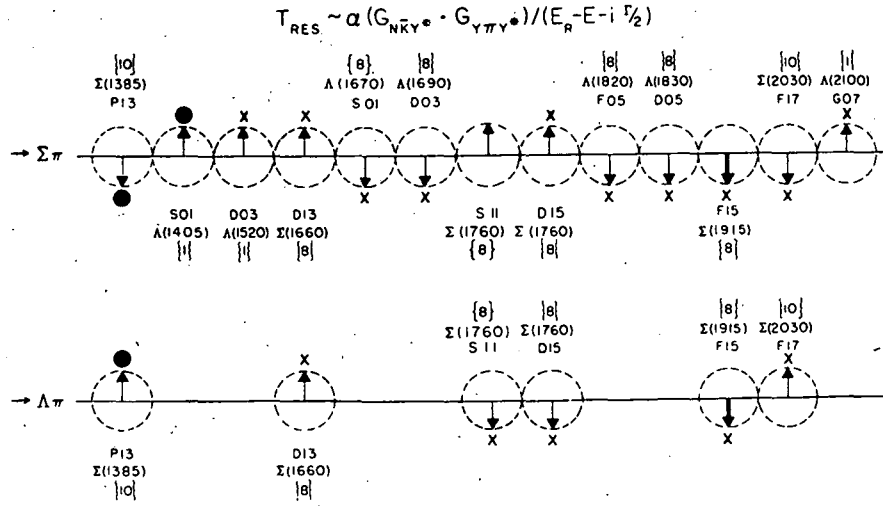


FIG. 2. Plot adapted from Levi Setti (1969) showing the sign convention adopted here for the  $\Sigma\pi$  and  $\Lambda\pi$  amplitudes. Once the signs of one  $I=0$  and one  $I=1$  amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by  $SU(3)$ ;  $\times$  marks indicate the observed phases;  $\bullet$  indicates phase chosen according to sign convention described in text. The  $\Sigma(1915)$  predictions have been changed from Levi Setti's original figure.

formation [Eq. (11)] or production, and displace the observed peak away from  $M$ . For quantitative examples, see Barbaro-Galtieri (1968).

Most of the useful information on the  $N$ ,  $\Delta$ ,  $\Lambda$ , and  $\Sigma$  baryon resonances with  $M < 2000$  MeV has come from partial-wave analysis. Masses and widths of most of these states are dependent on the model, as well as on the data used by the different groups that performed these analyses; therefore, the masses in the Baryon Table are not averages, but plausible guesses, and the errors are "external errors" based on the consistency among different analyses. For the procedures adopted, different from resonance to resonance, see the appropriate mini-review in the Data Card Listings. Resonances with mass  $M > 2000$  MeV have been detected primarily in total-cross-section experiments.

We can use Eq. (11) to relate the height of the peak at resonance  $\sigma_{\text{res}}$  to the elasticity  $x_e$ . At resonance the channel cross section is

$$\sigma_{\text{res}}(1 \rightarrow \beta) = 4\pi\lambda^2(J + \frac{1}{2})x_e x_\beta \quad (12)$$

and the total cross section is

$$\sigma_{\text{res}}(\text{total}) = 4\pi\lambda^2(J + \frac{1}{2})x_e. \quad (13)$$

If  $J$  is known, we can solve for  $x_e$ . If  $J$  is not known, the product  $(J + \frac{1}{2})x_e$  is given in the Baryon Table.

Starting this year we give information in the Baryon Table relating to the photon couplings of  $N$  and  $\Delta$  resonances. One of the mini-reviews on  $N$ 's and  $\Delta$ 's in the Baryon Data Card Listings contains a discussion of these couplings.

#### D. $SU(3)$ Sign Conventions for $\Lambda$ and $\Sigma$ Resonances

Consider the partial width  $\Gamma_\beta$  of a resonance decaying into the channel  $\beta$ . We can always define a coupling

constant such that

$$\Gamma_\beta \propto G_\beta^2.$$

In this case the inelastic [Eq. (9)] amplitude for such a resonance will go as

$$T_{1\beta} \propto G_1 G_\beta / (M - m - \frac{1}{2}i\Gamma),$$

where  $G_1$  is the coupling constant for the elastic channel. In the context of exact  $SU(3)$  symmetry the relative signs of the product  $G_1 G_\beta$  for different resonances are often useful as a consistency check on  $SU(3)$  assignments of  $\Lambda$  and  $\Sigma$  resonances. See Appendix II for further details.

In the Data Card Listings for  $\Lambda$  and  $\Sigma$  resonances, we tabulate measured values for  $(x_1 x_\beta)^{1/2} \propto G_1 G_\beta$ . Whenever there is an explicit sign, it will be according to the convention advocated by Levi Setti (1969) and used in the table of  $SU(3)$  Isoscalar Factors presented in this review. This convention is shown in Fig. 2 from Levi Setti (1969).

#### E. Muon-Decay Parameters

The  $\mu$ -decay parameters describe the momentum spectrum ( $\rho$  and  $\eta$ ), the asymmetry ( $\xi$  and  $\delta$ ), and the helicity ( $h$ ) of the electron in the process  $\mu^\pm \rightarrow e^\pm + \nu + \bar{\nu}$ . Assuming a local and lepton-conserving interaction, the matrix element may be written as

$$\sum_i \langle \bar{e} | \Gamma_i | \mu \rangle \langle \bar{\nu} | \Gamma_i (C_i + C_i' \gamma_5) | \nu \rangle, \quad (14)$$

where the summation is taken over  $i = S, V, T, A, P$ . Using the definitions and sign conventions of Kinoshita and Sirlin (1957), we have for the momentum param-

eters:

$$\rho = [3g_A^2 + 3g_V^2 + 6g_T^2]/D, \quad (15)$$

$$\eta = [g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2]/D, \quad (16)$$

for the asymmetry parameters:

$$\xi = [+6g_S g_P \cos \phi_{SP} - 8g_A g_V \cos \phi_{AV} + 14g_T^2 \cos \phi_{TT}]/D, \quad (17)$$

$$\delta = [-6g_A g_V \cos \phi_{AV} + 6g_T^2 \cos \phi_{TT}]/D\xi, \quad (18)$$

and for the parameter describing the helicity of the electron:

$$h = \pm [2g_S g_P \cos \phi_{SP} - 8g_A g_V \cos \phi_{AV} - 6g_T^2 \cos \phi_{TT}]/D. \quad (19)$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 + 6g_T^2 + 4g_A^2, \quad (20)$$

$$g_i^2 = |C_i|^2 + |C_i'|^2, \quad (21)$$

and

$$\cos \phi_{ij} = \text{Re} (C_i^* C_j' + C_i' C_j^*). \quad (22)$$

The quantities  $g_i$  are defined to be real non-negative numbers, and the  $\phi_{ij}$  are phase angles between the  $i$ -type and  $j$ -type interactions. Under the assumption of two-component neutrinos,  $C_i' = -C_i$  and  $C_j' = -C_j$ , the  $S$ ,  $P$ , and  $T$  terms vanish, and  $\phi_{AV}$  is the phase angle between  $C_A$  and  $C_V$  in the complex plane.

By using the above equations and the experimental determinations of  $\rho$ ,  $\eta$ ,  $\xi$ ,  $\delta$ , and  $h$ , limits can be placed on  $g_S/g_V$ ,  $g_A/g_V$ ,  $g_T/g_V$ ,  $g_P/g_V$ , and  $\phi_{AV}$ . The results, given in the Data Card Listings assume neither two-component neutrinos nor time-reversal invariance. If, however, two-component neutrinos are assumed, then  $\sin \phi_{AV}$  is the amplitude of time-reversal violation. Note that most experiments study only the upper end of the spectrum where  $\rho$  and  $\eta$  are highly correlated, so they can only report  $\rho$  for  $\eta \equiv 0$  and  $\eta$  for  $\rho \equiv \frac{3}{4}$ . The values for  $\rho$  and  $\eta$  we use here were obtained by combining measurements of both upper and lower ends of the spectrum and turn out to be nearly uncorrelated.

Note also that the radiative corrections are unambiguous only when  $g_S = g_T = g_P = 0$ . The same limits on  $g_A/g_V$  and  $\phi_{AV}$  are obtained, however, as when  $g_S$ ,  $g_T$ , and  $g_P$  are left free.

Current values for the asymmetry parameters as well as  $|g_A/g_V|$  and  $\phi_{AV}$  are given in the Addendum to the Stable Particle Table. In addition, upper limits on  $|g_S/g_V|$ ,  $|g_T/g_V|$  and  $|g_P/g_V|$  are given in the  $\mu$  section of the Stable Particle Data Card Listings.

## F. K-Decay Parameters

### F.1. Dalitz Plot for $K \rightarrow 3\pi$ Decays

The small deviation from uniformity of the Dalitz plot for the  $3\pi$  decay of the  $K$  meson is usually de-

scribed by a "slope parameter" (Dalitz, 1956). For the  $\tau$  and  $\tau'$  decays of the charged  $K$ 's, and the  $\tau^0$  decay mode of the  $K_L^0$ , we parametrize the Dalitz plot distribution by the expression

$$|M|^2 \propto 1 + g[(s_3 - s_0)/m_{\pi^+}^2] + h[(s_3 - s_0)/m_{\pi^+}^2]^2 + j[(s_2 - s_1)/m_{\pi^+}^2] + \dots, \quad (23)$$

where  $m_{\pi^+}^2$  has been introduced so as to make the coefficients  $g$ ,  $h$ , and  $j$  dimensionless, and

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i \quad i = 1, 2, 3 \quad (24)$$

$$s_0 = \frac{1}{3} \sum_i s_i = \frac{1}{3} (m_K^2 + m_1^2 + m_2^2 + m_3^2). \quad (25)$$

Here the  $P_i$  are 4-vectors,  $m_i$  and  $T_i$  are mass and kinetic energy of the  $i$ th pion, and the index 3 is used for the odd pion.

The coefficient  $g$  is a measure of the slope in the variable  $s_3$  (or  $T_3$ ) of the Dalitz plot, while  $h$  measures the quadratic dependence on  $s_3$ . The coefficient  $j$  is related to the asymmetry of the plot and must be zero if  $CP$  invariance holds. Note also that if  $CP$  is good,  $g$  must be the same for  $\tau^+$  and  $\tau^-$ , and similarly for  $h$ .

At present there is no compelling experimental evidence for either the  $h$  or the  $j$  term (for upper limits on the  $j$  term, see section F.3(b) below). Thus we stop the above expansion at the first term and list only  $g$ . Since different experiments use different forms for  $|M|^2$ , in order to compare the experiments we have converted to  $g$  whatever coefficients have been measured. See the mini-review in the  $K^\pm$  section of the Stable Particle Data Card Listings for details on this point. The results are given in the Addendum to the Stable Particle Table and in the  $K^\pm$  and  $K_L^0$  sections of the Stable Particle Data Card Listings.

Relations among  $\tau^\pm$ ,  $\tau'^\pm$ , and  $\tau^0$  are predicted by the  $\Delta I = \frac{1}{2}$  rule. See Appendix I for these relations and a discussion of this rule.

### F.2. Form Factors in $K_{13}$ Leptonic Decays

Assuming that only the vector current contributes to these decays, we write the matrix element as

$$M \propto f_+(q^2) [(P_K + P_\pi)_\mu \bar{u} \gamma_\mu (1 + \gamma_5) u_\nu] + f_-(q^2) [m_l \bar{u}_l (1 + \gamma_5) u_\nu], \quad (26)$$

where  $P_K$  and  $P_\pi$  are the four momenta of  $K$  and  $\pi$  mesons;  $m_l$  is the lepton mass;  $f_+$  and  $f_-$  are dimensionless form factors which can depend only on  $q^2 = (P_K - P_\pi)^2$ , the square of the momentum transfer to the leptons. The parameters we list are  $\lambda_\pm$ , the energy dependence of the  $f_\pm(q^2)$  form factor, assuming the form

$$f_\pm(q^2) = f_\pm(0) [1 + \lambda_\pm (q/m_\pi)^2]; \quad (27)$$

and  $\xi$ , the ratio of the two form factors,

$$\xi = f_-/f_+. \quad (28)$$

The quantity  $\xi$  can be determined in different ways:

(1) By measuring the  $K_{\mu 3}/K_{e 3}$  branching ratio and comparing it with the theoretical ratio as given in terms of  $\xi(0) = f_-(0)/f_+(0)$ .

$$\Gamma(K_{\mu 3}^\pm)/\Gamma(K_{e 3}^\pm) = 0.6457 + 0.1264 \operatorname{Re} \xi + 0.0192 |\xi|^2 + 1.4115\lambda_+ + 0.4754\lambda_- \operatorname{Re} \xi + 0.0080\lambda_+ \operatorname{Re} \xi,$$

$$\Gamma(K_{\mu 3}^0)/\Gamma(K_{e 3}^0) = 0.6452 + 0.1246 \operatorname{Re} \xi + 0.0186 |\xi|^2 + 1.3162\lambda_+ + 0.4370\lambda_- \operatorname{Re} \xi + 0.0064\lambda_+ \operatorname{Re} \xi. \quad (29)$$

See Cabibbo (1966) and Fearing *et al.* (1970) (for the charge-dependent formulas). Note that the first constant has been changed to 0.6457; the earlier value was a misprint,<sup>2</sup> which we copied from Cabibbo (1966).

(2) By studying the Dalitz plot of the  $K_{\mu 3}$  decay. The  $K_{e 3}$  Dalitz plot distribution is only dependent upon the  $\lambda_+$  parameter, whereas the  $K_{\mu 3}$  distribution is dependent upon  $\lambda_-$ ,  $\lambda_+$ ,  $\xi$ . Often experimenters have measured only the momentum spectrum of either the  $\pi$  or the lepton and compared it with the predicted spectrum. See the note on form factors in the  $K^\pm$  Data Card Listings for a discussion of this method. For a formula relating the Dalitz plot variables to  $\xi$  see, for example, Brene *et al.* (1961).

(3) By measuring the muon polarization in  $K_{\mu 3}$  decay. In the rest frame of the  $K$  the  $\mu$  is expected to be polarized in the direction  $\mathbf{A}$  with  $\mathbf{P} = \mathbf{A}/|\mathbf{A}|$ , where  $\mathbf{A}$  is given (Cabibbo and Maksymowicz, 1964) by

$$\mathbf{A} = \alpha_1(\xi) \mathbf{p}_\mu - \alpha_2(\xi) \{ (\mathbf{p}_\mu/m_\mu) [m_K - E_\pi + (\mathbf{p}_\pi \cdot \mathbf{p}_\mu/|\mathbf{p}_\mu|^2) (E_\mu - m_\mu)] + \mathbf{p}_\pi \} + m_K \operatorname{Im} \xi(q^2) (\mathbf{p}_\pi \times \mathbf{p}_\mu). \quad (30)$$

If time-reversal invariance holds,  $\xi$  is real, and thus there is no polarization perpendicular to the  $K$ -decay plane.

If we remove the assumption of a pure vector current, then the matrix element for the decay, in addition to the terms in Eq. (26), would contain

$$+ 2m_K f_S \bar{u}_l (1 + \gamma_5) u_\nu + (2f_T/m_K) (P_K)_\lambda (P_\pi)_\mu \times \bar{u}_l \sigma_{\lambda\mu} (1 + \gamma_5) u_\nu,$$

where  $f_S$  is the scalar form factor and  $f_T$  is the tensor form factor. In the case of the  $K_{e 3}$  decays where the  $f_-$  term can be neglected, experiments have yielded limits on  $|f_S/f_+|$  and  $|f_T/f_+|$ .

The experimental results for  $\xi$ ,  $\lambda_\pm$ , and the upper limits on  $|f_S/f_+|$  and  $|f_T/f_+|$  are given in the  $K^\pm$  and  $K_L^0$  sections of the Stable Particle Data Card

<sup>2</sup> We thank Drs. H. W. Fearing and J. Smith for calling this mistake to our attention.

Listings. See the note on form factors in the  $K^\pm$  Data Card Listings for discussions of these results.

### F.3. CP Violation in $K^0$ Decays

We list parameters for four different reactions in which  $CP$  can be tested [For details see Okun and Rubbia (1967), Steinberger (1969), and Wolfenstein (1969)].

(a)  $K_S \rightarrow \pi^+ \pi^- \pi^0$ . The quantity measured here is the ratio of amplitudes

$$A_S(K_S \rightarrow \pi^+ \pi^- \pi^0)/A_L(K_L \rightarrow \pi^+ \pi^- \pi^0) \equiv x + iy. \quad (31)$$

If  $CPT$  invariance holds and there is no  $I=3$  state present, then  $x$  can be neglected and  $CP$  violation would be observed as a nonzero  $y$ . We give the result for (31) in the  $K_L^0$  section of the Stable Particle Table and under Branching Ratio  $R4$  in the  $K_S^0$  section of the Stable Particle Data Card Listings. Our procedure is to assume that  $x=0$ , and to list  $(A_S/A_L)^2$  in the form of a branching ratio.

(b) *Charge asymmetry in  $K_L \rightarrow 3\pi$  decays.* As mentioned above, the presence of a term in  $(s_2 - s_1)$  in expression (23) describing the Dalitz plot distribution for  $\tau^\pm$ ,  $\tau^0$  decays of  $K$  mesons would be an indication of  $CP$  violation. Rather than listing values of the  $(s_2 - s_1)$  coefficient  $j$  in Eq. (23), we choose to list  $\sigma_\pm$  from the equivalent expression

$$|M|^2 \propto 1 + \sigma_\pm (2/\sqrt{3}) (T_+ - T_-)/T_{\pm \max} + (CP \text{ nonviolating terms}), \quad (32)$$

where  $T_\pm$  are the kinetic energies of the charged pions. We have momentarily abandoned the form involving the Mandelstam variables  $s_i$  in favor of (32) because the latter has been consistently used by experimenters searching for  $CP$  violation. We list  $\sigma_\pm$  among the  $CP$ -violating parameters at the back of the  $K_L^0$  section of the Stable Particle Data Card Listings. Note that only upper limits have been reported for this quantity.

(c) *Asymmetry in the  $K_L \rightarrow \pi^\mp l^\pm \nu$  decays.* The quantity measured and compiled here is

$$\delta = \frac{\Gamma(K_L \rightarrow \pi^- l^+ \nu) - \Gamma(K_L \rightarrow \pi^+ l^- \nu)}{\Gamma(K_L \rightarrow \pi^- l^+ \nu) + \Gamma(K_L \rightarrow \pi^+ l^- \nu)}. \quad (33)$$

This asymmetry violates  $CP$  invariance. If  $CPT$  is good, for a pure  $K_L^0$  beam,  $\delta$  can be written as

$$\delta = 2[(1 - |x|^2)/(1 + |x|^2)] \operatorname{Re} \epsilon, \quad (34)$$

where  $x$  is the  $\Delta S = \Delta Q$ -violating parameter defined in Section F.4, and  $\epsilon$  is the parameter of the expansion

$$|K_L\rangle = [(1 + \epsilon)|K\rangle - (1 - \epsilon)|\bar{K}\rangle]/[2(1 + |\epsilon|^2)]^{1/2}, \quad (35a)$$

$$|K_S\rangle = [(1 + \epsilon)|K\rangle + (1 - \epsilon)|\bar{K}\rangle]/[2(1 + |\epsilon|^2)]^{1/2}. \quad (35b)$$

We give  $\delta$  in the Addendum to the Stable Particle Table. In addition, in the  $K_L^0$   $CP$ -violation section of the Stable Particle Data Card Listings, we list  $\delta$  separately for  $K_L^0 \rightarrow \pi\mu\nu$  and  $K_L^0 \rightarrow \pi e\nu$ .

(d)  $K_L \rightarrow 2\pi$  decay. The relevant parameters are

$$\eta_{+-} = A(K_L \rightarrow \pi^+\pi^-)/A(K_S \rightarrow \pi^+\pi^-) = |\eta_{+-}| \exp(i\phi_{+-}), \quad (36)$$

$$\eta_{00} = A(K_L \rightarrow \pi^0\pi^0)/A(K_S \rightarrow \pi^0\pi^0) = |\eta_{00}| \exp(i\phi_{00}), \quad (37)$$

$\epsilon$ , defined in Eqs. (35) above, and

$$\epsilon' = \frac{1}{2}i\sqrt{2}[\exp i(\delta_2 - \delta_0)] \text{Im}(A_2/A_0). \quad (38)$$

Here  $A_i$  and  $\delta_i$  are the amplitude and phase of  $\pi\pi$  scattering at the  $K$  mass, defined by

$$\langle I=0 | T | K \rangle = \exp(i\delta_0) A_0, \quad (39a)$$

$$\langle I=2 | T | K \rangle = \exp(i\delta_2) A_2. \quad (39b)$$

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon', \quad (40a)$$

$$\eta_{00} = \epsilon - 2\epsilon'. \quad (40b)$$

At present many models have been proposed to explain the experimental results on  $CP$  violation, but more data are needed before the cause of  $CP$  violation can be ascertained.

We give  $\eta_{+-}$ ,  $\eta_{00}$ ,  $\phi_{+-}$ , and  $\phi_{00}$  in the Addendum to the Stable Particle Table. The phases are measured directly, whereas the magnitudes  $\eta_{+-}$  and  $\eta_{00}$  are derived parameters. We use, as far as we can, the directly measured quantities as input and calculate  $\eta_{+-}$  and  $\eta_{00}$  from the values given by our constrained fits. Therefore, if one looks at the Data Card Listings, most of the  $|\eta|$  measurements appear in the form of branching ratios, with appropriate comments. We then give the values of  $\eta_{+-}$  and  $|\eta_{00}|^2$  in a separate list at the end of the  $CP$ -violating parameters section of the  $K_L^0$  section of the Stable Particle Data Card Listings.

#### F.4. $\Delta S = \Delta Q$ Rule in $K^0$ Decays

The relative amount of  $\Delta S \neq \Delta Q$  component present is measured by the parameter  $x$ , defined as

$$x = A(K^0 \rightarrow \pi^- l^+ \nu)/A(K^0 \rightarrow \pi^- l^+ \nu). \quad (41)$$

We list  $\text{Re}\{x\}$  and  $\text{Im}\{x\}$  for both  $K_{e3}$  and  $K_{\mu 3}$  at the end of the Stable Particle Data Card Listings and give values in the Addendum to the Stable Particle Table.

#### G. $\eta$ -Decay Parameters

As a test of possible  $C$  violation in electromagnetic interactions, a number of experiments have looked for

possible charge asymmetries in the decays  $\eta \rightarrow \pi^+\pi^-\pi^0$  and  $\eta \rightarrow \pi^+\pi^-\gamma$ . For both modes we use the convention

$$\text{Asymmetry} = f(+)-f(-),$$

where  $f(\pm)$  means the fraction of the events with the  $\pi^{(\pm)}$  energy greater than the  $\pi^{(\mp)}$  energy in the  $\eta$  rest frame. We list the asymmetry parameters in the  $\eta$  section of the Stable Particle Data Card Listings and give average values in the Addendum to the Stable Particle Table.

#### H. Baryon-Decay Parameters

##### H.1. $A/V$ Ratio for Baryon Leptonic Decays

Consider the decay

$$B_i \rightarrow B_f + l + \nu.$$

Assuming  $V$ ,  $A$  theory, neglecting "induced" scalar, "induced" pseudoscalar, and axial weak-magnetism terms, and neglecting the  $q^2$  dependence of the form factors, the baryon part of the matrix element for these decays may be written (Goldberger and Treiman, 1958) as

$$\langle B_f | \gamma_\lambda (g_V - g_A \gamma_5) + (g_W/m_{B_i}) \sigma^{\lambda\nu} q_\nu | B_i \rangle, \quad (42)$$

where  $B_i$  and  $B_f$  represent initial and final baryons,  $g_A$  and  $g_V$  the axial and vector coupling constants,  $g_W$  the weak magnetism coupling constant, and  $q_\nu$  the sum of the lepton momenta. Here the Pauli representation is used for the  $\gamma$  matrices. The definition of  $g_A/g_V$  is

$$g_A/g_V = |g_A/g_V| \exp(i\delta), \quad (43)$$

where  $\delta$  is  $0 + \pi$  if time-reversal invariance holds (see Jackson *et al.*, 1957).

In neutron beta decay the measurements are consistent with time reversal, so  $g_A/g_V$  is nearly real and has been considered to be such in all the baryon leptonic decays. Notice that by using the above definition of the matrix element with the Pauli representations, the value of  $g_A/g_V$  in neutron beta decay is negative.

Due to statistical limitation the weak magnetism form factor  $g_W$  is usually assumed from CVC and  $SU(3)$ , so only  $g_A$  and  $g_V$  are determined experimentally. This determination is accomplished in a variety of ways:

(a) The lepton-neutrino angular correlation provides a measure of the absolute value of  $g_A/g_V$  (for relevant formulas see, e.g., Albright, 1959).

(b) The up-down asymmetry of the lepton from polarized baryon decays provides a measure of  $g_A/g_V$  with its sign (for relevant formulas, see, e.g., Albright, 1959).

(c) The lepton spectrum, given enough statistics, provides a measure of  $g_A/g_V$  with its sign (for relevant formulas see, e.g., Bender, 1968).

(d) The polarization of the decay baryon, from polarized or unpolarized initial baryon, also provides  $g_A/g_V$  with its sign (for formulas, see, e.g., Willis and Thompson, 1968).

We compile the ratio  $g_A/g_V$  with its sign, for those decays for which it has been measured. For the neutron beta decay we compile also the phase  $\delta$ .

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory (Cabibbo, 1964). The latest fit to this theory can be found in Ebenhöh (1971).

## H.2. Asymmetry Parameters in Nonleptonic Hyperon Decays.

The transition matrix for the hyperon decay may be written as

$$M = s + p(\sigma \cdot q), \quad (44)$$

where  $s$  and  $p$  are the parity-changing and the parity conserving amplitudes, respectively,  $\sigma$  is the Pauli spin operator, and  $q$  is a unit vector along the direction of the decay baryon in the hyperon rest frame.

The asymmetry parameters are defined by the relations

$$\alpha = 2 \operatorname{Re}(s^*p)/(|s|^2 + |p|^2), \quad (45a)$$

$$\beta = 2 \operatorname{Im}(s^*p)/(|s|^2 + |p|^2), \quad (45b)$$

$$\gamma = (|s|^2 - |p|^2)/(|s|^2 + |p|^2). \quad (45c)$$

With the transition matrix (44), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha \mathbf{P}_Y \cdot \mathbf{q}, \quad (46)$$

where  $\mathbf{P}_Y = \langle Y | \sigma | Y \rangle$  is the hyperon polarization.

In the notation of Lee and Yang (1957) the polarization  $\mathbf{P}_B$  of the decay baryon is<sup>3</sup>

$$\mathbf{P}_B = \frac{(\alpha + \mathbf{P}_Y \cdot \mathbf{q})\mathbf{q} + \beta(\mathbf{P}_Y \times \mathbf{q}) + \gamma\mathbf{q} \times (\mathbf{P}_Y \times \mathbf{q})}{1 + \alpha \mathbf{P}_Y \cdot \mathbf{q}}, \quad (47)$$

where  $\mathbf{P}_B$  is defined in that rest system of the baryon obtained by a Lorentz transformation along  $\mathbf{q}$  from the hyperon rest system in which  $\mathbf{q}$  and  $\mathbf{P}_Y$  are defined. Note that  $\alpha$  is the helicity of the decay baryon for unpolarized hyperons.

The three parameters  $\alpha$ ,  $\beta$ , and  $\gamma$  satisfy the relation

$$\alpha^2 + \beta^2 + \gamma^2 = 1. \quad (48)$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters  $\alpha$

and the angle  $\phi$  defined by

$$\beta = (1 - \alpha^2)^{1/2} \sin \phi, \quad (49a)$$

$$\gamma = (1 - \alpha^2)^{1/2} \cos \phi, \quad (49b)$$

which has a more nearly Gaussian distribution than  $\beta$  or  $\gamma$ . Evidently

$$-\frac{1}{2}\pi \leq \phi \leq \frac{1}{2}\pi \quad \text{for } \gamma > 0, \quad (50a)$$

$$+\frac{1}{2}\pi \leq \phi \leq \frac{3}{2}\pi \quad \text{for } \gamma < 0. \quad (50b)$$

In discussing time-reversal invariance, the quantity of interest is  $\Delta$ , defined by

$$\alpha = 2 |s| |p| \cos \Delta / (|s|^2 + |p|^2), \quad (51a)$$

$$\beta = -2 |s| |p| \sin \Delta / (|s|^2 + |p|^2); \quad (51b)$$

that is  $\Delta$  is the phase angle of  $s$  relative to  $p$ . Evidently

$$-\frac{1}{2}\pi \leq \Delta \leq \frac{1}{2}\pi \quad \text{for } \alpha > 0, \quad (52a)$$

$$+\frac{1}{2}\pi \leq \Delta \leq \frac{3}{2}\pi \quad \text{for } \alpha < 0. \quad (52b)$$

Under the assumption of time-reversal invariance, the angle  $\Delta$  must satisfy the relation

$$\Delta = \delta_s - \delta_p, \quad (53)$$

modulo  $\pi$ , where  $\delta_s$  and  $\delta_p$  are the pion-baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For  $\Lambda$  decay, assuming the validity of the  $|\Delta I| = \frac{1}{2}$  rule,

$$\Delta = \delta_s - \delta_p = (6.8 \pm 2.0) \text{ deg.}^4$$

In the Stable Particle Data Card Listings we give  $\alpha$  and  $\phi$  for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions. In the Stable Particle Table we give  $\alpha$ ,  $\phi$ , and  $\Delta$  with errors; and for convenience we also give the central value of  $\gamma$ , without an error.

## V. STATISTICAL PROCEDURES

This section is a much abbreviated version of Section IX in the text of our January 1970 edition (Particle Data Group, 1970) to which the reader is referred for details. See also the mini-review on  $K^*$  masses and mass differences in the  $K^*(892)$  section of the Meson Data Card Listings.

### A. Confidence Levels and Errors

Quoted errors represent one standard deviation ( $\sigma$ ). Upper and lower limits represent 68.3% confidence

<sup>3</sup> Note that Lee and Yang (1957) contains a misprint. The minus sign in the definition of  $\beta$  should be replaced by a 2. In addition, our unit vector  $q$  is the direction of the baryon, whereas their unit vector  $p$  is the direction of the pion.

<sup>4</sup> This value for  $\delta_s - \delta_p$  is derived from the phase-shift analyses by Roper *et al.* (1965). The error is our estimation of the uncertainty.

bounds ( $1\sigma$ ), unless otherwise stated. The errors in the Tables of Particle Properties and the errors of the averages in the Data Card Listings often include a scale factor  $S$ ; see section V.B. below.

Quantities that have changed more than  $1\sigma$  since our April 1972 edition (Particle Data Group, 1972) are italicized in the Tables of Particle Properties. For a discussion see Section V.B in the text of the 1970 edition (Particle Data Group, 1970).

### B. Unconstrained Averaging Scale Factors

In the absence of constraints, we calculate a weighted average

$$\bar{x} \pm \delta\bar{x} = \sum w_i x_i / \sum w_i \pm (\sum w_i)^{-1/2};$$

$$w_i = 1/(\delta x_i)^2, \quad (54)$$

where the sums run over  $N$  experiments. We also calculate  $\chi^2$  and compare it with its expectation value of  $N-1$ . If  $\chi^2 > N-1$ , we increase the error  $\delta\bar{x}$  in Eq. (54) by a factor

$$S = [\chi^2/(N-1)]^{1/2}. \quad (55)$$

It is easy to design statistical tests for determining whether one experiment (or a group of experiments) is consistent with the other experiments. However, statistics does not tell us who is wrong in case of contradictions. When  $S \gg 1$ , one can conclude either that:

- (1) some (or all) experiments are wrong, or
- (2) some (or all) experiments have underestimated their errors, or
- (3) the experiments do not measure the same quantity (systematic errors).

We do our best to resolve these cases. If we cannot, we *assume* that *all* experimentalists underestimated their errors by the same scale factor. If we scale up all input errors by this factor,  $\chi^2$  returns to  $N-1$ , and of course the output error scales up by the same factor.

If all the experiments have errors of about the same size, the above procedure is straightforward. If, however, there are both precise and imprecise (large errors) measurements of a particular quantity, one must be very careful not to permit the imprecise ones to "dilute" the scale factor. See our January 1970 edition (Particle Data Group, 1970) for the prescription we use to handle this effect.

We often plot an ideogram to guide the reader in deciding which data he might reject before making his own selected average.

For further discussion of ideograms and scale factors, we refer the reader to Section IX of our January 1970 edition (Particle Data Group, 1970).

### C. Constrained Fits

The information on partial-decay fractions  $P_i$ <sup>5</sup> and partial widths  $\Gamma_i = P_i \Gamma_{\text{total}}$  is frequently given by branching ratios  $R_j$ , say,  $R_1 = P_1/(P_1+P_2)$ ,  $R_2 = P_2/P_3$ ,  $R_3 = P_1/P_2$ ,  $R_4 = P_3/(P_1+P_2+P_3)$ , etc.<sup>6</sup>

The number of experimental inputs  $R_j$  is often greater than the number of decay modes. In these cases we fit all available information on the  $P_i$ ,  $\Gamma_i$ , and  $R_j$  subject to the constraint  $\sum P_i = 1$ . When, in addition, the input  $R_j$  are contradictory so that scale factors may have to be introduced, one has to resort to iterative procedures.

The Data Card Listings give the values of the fitted  $R_i$ ,  $P_i$ , and  $\Gamma_i$ , together with the error matrices of the  $P_i$  and of the  $\Gamma_i$ . For details about this procedure, the reader is referred to the text of the January 1970 edition (Particle Data Group, 1970), Sec. IV.B.

## VI. PARTICLE DATA GROUP PUBLICATIONS

To obtain a reprint of this report, or any of the items listed below, write either Scientific Information Service, CERN, or Technical Information Division, Lawrence Berkeley Laboratory, whichever is closer.

### A. Pocket-Sized Particle Data Booklet

In addition to the present complete, full-size version of the Review of Particle Properties available from CERN and LBL, a pocket-size data booklet is available. It contains the first part of this report, up to the Data Card Listings. The complete set of pocket-size items available comprises the data booklet, a 16-month diary, a mini-atlas contributed by Digital Equipment Corporation, and a plastic cover. Any of these items that you have requested in the past will automatically be sent to you, but please note that our mailing lists are self-cancelling; unless you return the request card that is sent once a year, your name will be removed from our mailing list. If you wish to order any items in bulk we must charge 25 cents (US) for each of the pocket-sized items.

### B. Other Compilations

We compile data not only on particle properties, but also on other aspects of strong interactions ( $\pi N$ ,  $KN$ ,  $pN$ ,  $\dots$  cross sections; partial-wave amplitudes, etc.) Until 1971, our reports were called UCRL 20 000; they are now numbered LBL 50,  $\dots$ , 99. In the front of each of these reports is a list of all relevant compilations. A complementary series of compilations is

<sup>5</sup> We use the symbol  $P_i$  for partial-decay fractions throughout the Data Card Listings for stable particles, mesons, and baryons, although for baryons  $x_i$  is the commonly accepted symbol. See Eq. (10).

<sup>6</sup> We are also able to fit *products* of rates from formation experiments as given in Eq. (12).

produced by the CERN HERA Group. Both series are available from both LBL and CERN.

### C. Magnetic Tapes

The Particle Data Group at LBL also has available for distribution magnetic tapes containing cross section data compilations produced by E. Flaminio *et al.* ( $\pi N$ ,  $KN$ ,  $\bar{K}N$ ,  $NN$ ,  $\bar{N}N$ ); G. Giacomelli *et al.* ( $\pi N$ ); C. Lovelace *et al.* ( $\pi N$ ; some  $KN$ ,  $\bar{K}N$ ); L. D. Roper *et al.* ( $\bar{K}N$ ); P. Spillantini and V. Valente, or H. Oberlack ( $\gamma N$ ); and F. Wagner *et al.* ( $KN$ ,  $\bar{K}N$ ; some  $\pi N$ ). The original versions of these tapes are available immediately, while updated and corrected versions will be available in the near future. In addition, tapes containing partial-wave amplitudes for  $\pi N$ ,  $KN$ , and  $\gamma N$  exist and may also be requested. If you are interested in more details on the contents of any of these tapes, please write us.

### D. Next Edition

We currently produce a new Review of Particle Properties every April. It is published alternately by Physics Letters and by Reviews of Modern Physics.

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# TABLES OF PARTICLE PROPERTIES

April 1973

N. Barash-Schmidt, A. Barbaro-Galtieri, C. Bricman, V. Chaloupka  
 R. L. Kelly, T. A. Lasinski, A. Rittenberg, M. Roos, A. H. Rosenfeld,  
 P. Söding, and T. G. Trippe

(Closing date for data: Feb. 1, 1973)

## Stable Particle Table

For additional parameters, see Addendum to this table.

 Quantities in *italics* have changed by more than one (old) standard deviation since April 1972.

| Particle       | IG(J <sup>P</sup> )C <sub>n</sub>                               | Mass                                             | Mean life                                        | Partial decay mode                                          |                       |                                                  |
|----------------|-----------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|-----------------------|--------------------------------------------------|
|                |                                                                 | (MeV)<br>Mass <sup>2</sup><br>(GeV) <sup>2</sup> | (sec)<br>cτ<br>(cm)                              | Mode                                                        | Fraction <sup>a</sup> | p or<br>p <sub>max</sub> <sup>b</sup><br>(MeV/c) |
| γ              | 0, 1(1 <sup>-</sup> ) <sup>-</sup>                              | 0(< 2)10 <sup>-21</sup>                          | stable                                           | stable                                                      |                       |                                                  |
| ν              | ν <sub>e</sub> J = ½                                            | 0(< 60 eV)                                       | stable                                           | stable                                                      |                       |                                                  |
|                | ν <sub>μ</sub>                                                  | 0(< 1.2)                                         |                                                  |                                                             |                       |                                                  |
| e              | J = ½                                                           | 0.5110041<br>±.00000016                          | stable<br>(> 2×10 <sup>21</sup> y)               | stable                                                      |                       |                                                  |
| μ              | J = ½                                                           | 105.6595<br>±.0003                               | 2.1994×10 <sup>-6</sup><br>±.0006 S=1.1*         | eν̄                                                         | 100                   | 53                                               |
|                | m <sup>2</sup> = 0.0112                                         |                                                  | cτ=6.593×10 <sup>4</sup>                         | eγγ                                                         | ( < 1.6 )             | 10 <sup>-5</sup> 53                              |
|                | m <sub>μ</sub> -m <sub>π</sub> <sup>±</sup> = -33.909           |                                                  |                                                  | 3e                                                          | ( < 6 )               | 10 <sup>-9</sup> 53                              |
|                | ±.006                                                           |                                                  |                                                  | eγ                                                          | ( < 2.2 )             | 10 <sup>-8</sup> 53                              |
| π <sup>±</sup> | 1 <sup>-</sup> (0 <sup>-</sup> )                                | 139.5688<br>±.0064                               | 2.6024×10 <sup>-8</sup><br>±.0024                | μν                                                          | 100 %                 | 30                                               |
|                | m <sup>2</sup> = 0.0195                                         |                                                  | cτ=780.2<br>(τ <sup>+</sup> -τ <sup>-</sup> )/τ= | eν                                                          | ( 1.24±0.03)          | 10 <sup>-4</sup> 70                              |
|                |                                                                 |                                                  | (0.05±0.07)%<br>(test of CPT)                    | μνγ                                                         | c( 1.24±0.25)         | 10 <sup>-4</sup> 30                              |
|                |                                                                 |                                                  |                                                  | π <sup>0</sup> eν                                           | ( 1.02±0.07)          | 10 <sup>-8</sup> 5                               |
|                |                                                                 |                                                  |                                                  | eνγ                                                         | c( 3.0 ±0.5 )         | 10 <sup>-8</sup> 70                              |
|                |                                                                 |                                                  | eνe <sup>+</sup> e <sup>-</sup>                  | ( < 3.4 )                                                   | 10 <sup>-8</sup> 70   |                                                  |
| π <sup>0</sup> | 1 <sup>-</sup> (0 <sup>-</sup> ) <sup>+</sup>                   | 134.9645<br>±.0074                               | 0.84×10 <sup>-16</sup><br>±.10 S=2.1*            | γγ                                                          | ( 98.8±0.05)%         | 67                                               |
|                | m <sup>2</sup> = 0.0182                                         |                                                  | cτ=2.5×10 <sup>-6</sup>                          | γγe <sup>+</sup> e <sup>-</sup>                             | ( 1.17±0.05)%         | 67                                               |
|                | m <sub>π<sup>±</sup></sub> -m <sub>π<sup>0</sup></sub> = 4.6043 |                                                  |                                                  | γγγ                                                         | ( < 5 )               | 10 <sup>-6</sup> 67                              |
|                | ±.0037                                                          |                                                  |                                                  | e <sup>+</sup> e <sup>-</sup> e <sup>+</sup> e <sup>-</sup> | d( 3.47 )             | 10 <sup>-5</sup> 67                              |
|                |                                                                 |                                                  |                                                  |                                                             |                       |                                                  |

## Stable Particle Table (cont'd)

| Particle                 | $I(G^P)C_n$                                                                                       | Mass                                                                                                                                      | Mean life                                                                                                                                             | Partial decay mode      |                          |                                                  |
|--------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------------|--------------------------------------------------|
|                          |                                                                                                   | (MeV)<br>Mass <sup>2</sup><br>(GeV) <sup>2</sup>                                                                                          | (sec)<br>$c\tau$<br>(cm)                                                                                                                              | Mode                    | Fraction <sup>a</sup>    | p or<br>p <sub>max</sub> <sup>b</sup><br>(MeV/c) |
| $K^\pm$                  | $\frac{1}{2}(0^-)$<br><br>$m^2=0.244$<br><br>$m_{K^\pm}-m_{K^0}=-3.99$<br>$\pm 0.13$<br>$S=1.1^*$ | 493.715<br>$\pm 0.037$                                                                                                                    | $1.2371 \times 10^{-8}$<br>$\pm .0026$ $S=1.9^*$<br>$c\tau=370.8$<br>$(\tau^+-\tau^-)/\bar{\tau}=$<br>$(.11 \pm .09)\%$<br>(test of CPT)<br>$S=1.2^*$ | $\mu\nu$                | ( 63.52 $\pm$ 0.19)%     | 236                                              |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^0$              | ( 21.06 $\pm$ 0.18)%     | $S=1.1^*$ 205                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^+\pi^-$         | ( 5.59 $\pm$ 0.03)%      | $S=1.1^*$ 125                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^0\pi^0$         | ( 1.73 $\pm$ 0.05)%      | $S=1.4^*$ 133                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\mu\pi^0\nu$           | ( 3.24 $\pm$ 0.10)%      | $S=1.9^*$ 215                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e\pi^0\nu$             | ( 4.85 $\pm$ 0.06)%      | $S=1.1^*$ 228                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e\pi^0\pi^0\nu$        | ( 1.8 $\pm$ 0.6 )        | $10^{-5}$ 207                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^\mp e^\pm\nu$   | ( 3.7 $\pm$ 0.2 )        | $10^{-5}$ 203                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^\mp e^\mp\nu$   | ( < 5 )                  | $10^{-7}$ 203                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^\mp\mu^\pm\nu$  | ( 0.9 $\pm$ 0.4 )        | $10^{-5}$ 151                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^\pm\mu^\mp\nu$  | ( < 3 )                  | $10^{-6}$ 151                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e\nu$                  | ( 1.38 $\pm$ 0.20 )      | $10^{-5}$ 247                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e\nu\gamma$            | ( < 7 )                  | $10^{-5}$ 247                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^0\gamma$        | h, c ( 2.66 $\pm$ 0.18 ) | $10^{-4}$ 205                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\pi^+\pi^-\gamma$   | c ( 10 $\pm$ 4 )         | $10^{-5}$ 125                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi e\nu\gamma$        | c ( 3.7 $\pm$ 1.4 )      | $10^{-4}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi e^+e^-$            | ( < 0.4 )                | $10^{-6}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^\mp e^\pm e^\pm$   | ( < 1.5 )                | $10^{-5}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\mu^+\mu^-$         | ( < 2.4 )                | $10^{-6}$ 172                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\gamma\gamma$       | c ( < 3.5 )              | $10^{-5}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\gamma\gamma\gamma$ | c ( < 3 )                | $10^{-4}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\nu\nu$             | ( < 1.4 )                | $10^{-6}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\gamma$             | ( < 4 )                  | $10^{-8}$ 227                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^\pm e^\pm\mu^\pm$  | ( < 3 )                  | $10^{-8}$ 214                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^\pm e^\pm\mu^\mp$  | ( < 1.4 )                | $10^{-8}$ 214                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\mu\nu\nu$             | ( < 7 )                  | $10^{-6}$ 236                                    |
| $K_S^0$                  | $\frac{1}{2}(0^-)$                                                                                | 497.71<br>$\pm 0.13$<br>$S=1.1^*$<br>$m^2=0.248$                                                                                          | 50% $K_{\text{Short}}$ , 50% $K_{\text{Long}}$<br><br>$0.882 \times 10^{-10}$<br>$\pm .008$ $S=2.5^*$<br>$c\tau=2.65$                                 | $\pi^+\pi^-$            | ( 68.81 $\pm$ 0.29)%     | 206                                              |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^0\pi^0$            | ( 31.19 $\pm$ 0.29)%     | $S=1.1^*$ 209                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\mu^+\mu^-$            | ( < 0.7 )                | $10^{-5}$ 225                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e^+e^-$                | ( < 35 )                 | $10^{-5}$ 249                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^+\pi^-\gamma$      | c ( 2.3 $\pm$ 0.8 )      | $10^{-3}$ 206                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\gamma\gamma$          | ( < 0.7 )                | $10^{-3}$ 249                                    |
| $K_L^0$                  | $\frac{1}{2}(0^-)$                                                                                | $5.181 \times 10^{-8}$<br>$\pm 0.041$<br>$c\tau=1553$<br><br>$m_{K_L}-m_{K_S}=0.5402 \times 10^{-10}$ h sec <sup>-1</sup><br>$\pm 0.0035$ | $5.181 \times 10^{-8}$<br>$\pm 0.041$<br>$c\tau=1553$                                                                                                 | $\pi^0\pi^0\pi^0$       | ( 21.5 $\pm$ 0.8 )%      | $S=1.4^*$ 139                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^+\pi^-\pi^0$       | ( 12.6 $\pm$ 0.3 )%      | 133                                              |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi\mu\nu$             | ( 26.9 $\pm$ 0.6 )%      | $S=1.1^*$ 216                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi e\nu$              | ( 38.8 $\pm$ 0.6 )%      | $S=1.1^*$ 229                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi e\nu\gamma$        | c ( 1.3 $\pm$ 0.8 )%     | 229                                              |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^+\pi^-$            | ( 0.157 $\pm$ 0.005)%    | 206                                              |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^0\pi^0$            | ( 0.094 $\pm$ 0.019)%    | $S=1.5^*$ 209                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^+\pi^-\gamma$      | c ( < 0.4 )              | $10^{-3}$ 206                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\pi^0\gamma\gamma$     | ( < 2.4 )                | $10^{-4}$ 231                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\gamma\gamma$          | ( 4.9 $\pm$ 0.4 )        | $10^{-4}$ 249                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e\mu$                  | i ( < 1.6 )              | $10^{-9}$ 238                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\mu^+\mu^-$            | ( < 1.9 )                | $10^{-9}$ 225                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $e^+e^-$                | ( < 1.6 )                | $10^{-9}$ 249                                    |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       | $\eta$                  | $0^+(0^-)^+$             | 548.8<br>$\pm 0.6^*$<br>$S=1.4$<br>$m^2=0.301$   |
| $\pi^0\gamma\gamma$      | e ( 3.1 $\pm$ 1.1 )%                                                                              | $S=1.2^*$ 258                                                                                                                             |                                                                                                                                                       |                         |                          |                                                  |
| $3\pi^0$                 | ( 30.0 $\pm$ 1.1 )%                                                                               | $S=1.1^*$ 180                                                                                                                             |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^+\pi^-\pi^0$        | ( 23.9 $\pm$ 0.6 )%                                                                               | $S=1.1^*$ 175                                                                                                                             |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^+\pi^-\gamma$       | ( 5.0 $\pm$ 0.1 )%                                                                                | 236                                                                                                                                       |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^0 e^+ e^-$          | ( < 0.04 )%                                                                                       | 258                                                                                                                                       |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^+\pi^- e^+ e^-$     | ( 0.1 $\pm$ 0.1 )%                                                                                | 236                                                                                                                                       |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^+\pi^-\pi^0\gamma$  | ( < 0.2 )%                                                                                        | 175                                                                                                                                       |                                                                                                                                                       |                         |                          |                                                  |
| $\pi^+\pi^-\gamma\gamma$ | ( < 0.2 )%                                                                                        | 236                                                                                                                                       |                                                                                                                                                       |                         |                          |                                                  |
| $\mu^+\mu^-$             | ( 2.2 $\pm$ 0.8 )                                                                                 | $10^{-5}$ 253                                                                                                                             |                                                                                                                                                       |                         |                          |                                                  |
| $\mu^+\mu^-\pi^0$        | ( < 5 )                                                                                           | $10^{-4}$ 211                                                                                                                             |                                                                                                                                                       |                         |                          |                                                  |
| $p$                      | $\frac{1}{2}(\frac{1}{2}^+)$                                                                      | 938.2592<br>$\pm 0.0052$<br>$m^2=0.8803$                                                                                                  | stable<br>( $> 2 \times 10^{28}y$ )                                                                                                                   |                         |                          |                                                  |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       |                         |                          |                                                  |
| $n$                      | $\frac{1}{2}(\frac{1}{2}^+)$                                                                      | 939.5527<br>$\pm 0.0052$<br>$m^2=0.8828$<br>$m_p-m_n=-1.29344$<br>$\pm 0.00007$                                                           | $(0.918 \pm 0.014)10^3$<br>$c\tau=2.75 \times 10^{13}$                                                                                                | $pe^- \nu$              | 100 %                    | 1                                                |
|                          |                                                                                                   |                                                                                                                                           |                                                                                                                                                       |                         |                          |                                                  |

# Stable Particle Table (cont'd)

| Particle   | $I(GJP)C_n$                    | Mass                                             | Mean life                                      | Partial decay mode |                                |                                                  |
|------------|--------------------------------|--------------------------------------------------|------------------------------------------------|--------------------|--------------------------------|--------------------------------------------------|
|            |                                | (MeV)<br>Mass <sup>2</sup><br>(GeV) <sup>2</sup> | (sec)<br>$c\tau$<br>(cm)                       | Mode               | Fraction <sup>a</sup>          | p or<br>p <sub>max</sub> <sup>b</sup><br>(MeV/c) |
| $\Lambda$  | $0(\frac{1}{2}^+)$             | 1115.59                                          | $2.521 \times 10^{-10}$                        | $p\pi^-$           | ( 64.2 $\pm$ 0.5 )%            | 100                                              |
|            |                                | $\pm 0.05$                                       | $\pm .021$ S=1.2*                              | $n\pi^0$           | ( 35.8 $\pm$ 0.5 )%            | 104                                              |
|            |                                | S=1.1*                                           | $c\tau = 7.56$                                 | $pe\nu$            | ( 8.13 $\pm$ 0.29 ) $10^{-4}$  | 163                                              |
|            |                                | $m^2 = 1.245$                                    |                                                | $p\mu\nu$          | ( 1.57 $\pm$ 0.35 ) $10^{-4}$  | 131                                              |
|            |                                |                                                  |                                                | $p\pi^-\gamma$     | c( 0.85 $\pm$ 0.14 ) $10^{-3}$ | 100                                              |
|            |                                |                                                  |                                                |                    |                                |                                                  |
| $\Sigma^+$ | $1(\frac{1}{2}^+)$             | 1189.41                                          | $0.800 \times 10^{-10}$                        | $p\pi^0$           | ( 51.6 $\pm$ 0.7 )%            | 189                                              |
|            |                                | $\pm 0.07$                                       | $\pm .006$                                     | $n\pi^+$           | ( 48.4 $\pm$ 0.7 )%            | 185                                              |
|            |                                | S= 1.6*                                          | $c\tau = 2.40$                                 | $p\gamma$          | c( 1.24 $\pm$ 0.18 ) $10^{-3}$ | S=1.4* 225                                       |
|            |                                | $m^2 = 1.415$                                    |                                                | $n\pi^+\gamma$     | c( 1.31 $\pm$ 0.24 ) $10^{-4}$ | 185                                              |
|            |                                | $m_{\Sigma^+} - m_{\Sigma^-} = -7.94$            |                                                | $\Lambda e^+\nu$   | ( 2.02 $\pm$ 0.47 ) $10^{-5}$  | 72                                               |
|            |                                | $\pm .09$                                        | $\Gamma(\Sigma^+ \rightarrow l^+ n\nu) < .035$ | $(n\mu^+\nu)$      | ( < 2.4 ) $10^{-5}$            | 202                                              |
|            |                                | S= 1.2                                           | $\Gamma(\Sigma^- \rightarrow l^- n\nu)$        | $(ne^+\nu)$        | ( < 1.0 ) $10^{-5}$            | 224                                              |
|            |                                |                                                  |                                                | $pe^+e^-$          | ( < 7 ) $10^{-6}$              | 225                                              |
|            |                                |                                                  |                                                |                    |                                |                                                  |
|            |                                |                                                  |                                                |                    |                                |                                                  |
| $\Sigma^0$ | $1(\frac{1}{2}^+)$             | 1192.48                                          | $< 1.0 \times 10^{-14}$                        | $\Lambda \gamma$   | 100 %                          | 74                                               |
|            |                                | $\pm 0.10$                                       | $c\tau < 3 \times 10^{-4}$                     | $\Lambda e^+e^-$   | d( 5.45 ) $10^{-3}$            | 74                                               |
| $\Sigma^-$ | $1(\frac{1}{2}^+)$             | 1197.34                                          | $1.484 \times 10^{-10}$                        | $n\pi^-$           | 100 %                          | 193                                              |
|            |                                | $\pm 0.07$                                       | $\pm .019$ S=1.6*                              | $ne^-\nu$          | ( 1.10 $\pm$ 0.05 ) $10^{-3}$  | 230                                              |
|            |                                | S= 1.2*                                          | $c\tau = 4.45$                                 | $n\mu^-\nu$        | ( 0.45 $\pm$ 0.04 ) $10^{-3}$  | 210                                              |
|            |                                | $m^2 = 1.434$                                    |                                                | $\Lambda e^-\nu$   | ( 0.60 $\pm$ 0.06 ) $10^{-4}$  | 79                                               |
|            |                                | $m_{\Sigma^0} - m_{\Sigma^-} = -4.86$            |                                                | $n\pi^-\gamma$     | c( 1.0 $\pm$ 0.2 ) $10^{-4}$   | 193                                              |
|            |                                | $\pm .06$                                        |                                                |                    |                                |                                                  |
| $\Xi^0$    | $\frac{1}{2}(\frac{1}{2}^+)^f$ | 1314.9                                           | $2.98 \times 10^{-10}$                         | $\Lambda\pi^0$     | 100 %                          | 135                                              |
|            |                                | $\pm 0.6$                                        | $\pm .12$                                      | $p\pi^-$           | ( < 0.9 ) $10^{-3}$            | 299                                              |
|            |                                | $m^2 = 1.729$                                    | $c\tau = 8.93$                                 | $pe^-\nu$          | ( < 1.3 ) $10^{-3}$            | 323                                              |
|            |                                | $m_{\Xi^0} - m_{\Xi^-} = -6.4$                   |                                                | $\Sigma^+e^-\nu$   | ( < 1.5 ) $10^{-3}$            | 119                                              |
|            |                                | $\pm .6$                                         |                                                | $\Sigma^-e^+\nu$   | ( < 1.5 ) $10^{-3}$            | 112                                              |
|            |                                |                                                  |                                                | $\Sigma^+\mu^-\nu$ | ( < 1.5 ) $10^{-3}$            | 64                                               |
|            |                                |                                                  |                                                | $\Sigma^-\mu^+\nu$ | ( < 1.5 ) $10^{-3}$            | 49                                               |
|            |                                |                                                  |                                                | $p\mu^-\nu$        | ( < 1.3 ) $10^{-3}$            | 309                                              |
|            |                                |                                                  |                                                |                    |                                |                                                  |
|            |                                |                                                  |                                                |                    |                                |                                                  |
| $\Xi^-$    | $\frac{1}{2}(\frac{1}{2}^+)^f$ | 1321.29                                          | $1.672 \times 10^{-10}$                        | $\Lambda\pi^-$     | 100 %                          | 139                                              |
|            |                                | $\pm 0.14$                                       | $\pm .032$ S=1.1*                              | $\Lambda e^-\nu$   | g( 0.70 $\pm$ 0.21 ) $10^{-3}$ | 190                                              |
|            |                                | $m^2 = 1.746$                                    | $c\tau = 5.01$                                 | $\Sigma^0e^-\nu$   | ( < 0.5 ) $10^{-3}$            | 123                                              |
|            |                                |                                                  |                                                | $\Lambda\mu^-\nu$  | ( < 1.3 ) $10^{-3}$            | 163                                              |
|            |                                |                                                  |                                                | $\Sigma^0\mu^-\nu$ | ( < 0.5 )%                     | 70                                               |
|            |                                |                                                  |                                                | $n\pi^-$           | ( < 1.1 ) $10^{-3}$            | 303                                              |
|            |                                |                                                  |                                                | $ne^-\nu$          | ( < 1.0 )%                     | 327                                              |
| $\Omega^-$ | $0(\frac{3}{2}^+)^f$           | 1672.5 $\pm$ 5                                   | $1.3^{+0.4}_{-0.3} \times 10^{-10}$            | $\Xi^0\pi^-$       | Total of<br>28 events<br>seen  | 294                                              |
|            |                                | $m^2 = 2.797$                                    | $c\tau = 3.9$                                  | $\Xi^-\pi^0$       |                                | 290                                              |
|            |                                |                                                  |                                                | $\Lambda K^-$      |                                | 211                                              |

\* S = Scale factor =  $\sqrt{\chi^2/(N-1)}$ , where  $N \approx$  number of experiments. S should be  $\approx 1$ . If  $S > 1$ , we have enlarged the error of the mean,  $\delta x$ , i. e.,  $\delta x \rightarrow S\delta x$ . This convention is still inadequate, since if  $S \gg 1$ , the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than  $S\delta x$ . See text and ideogram in Stable Particle Data Card Listings.

a. Quoted upper limits correspond to a 90% confidence level.

b. In decays with more than two bodies,  $P_{max}$  is the maximum momentum that any particle can have.

c. See Stable Particle Data Card Listings for energy limits used in this measurement.

d. Theoretical value; see also Stable Particle Data Card Listings.

e. See note in Stable Particle Data Card Listings.

f. P for  $\Xi$  and  $J^P$  for  $\Omega^-$  not yet measured. Values reported are SU(3) predictions.

g. Assumes rate for  $\Xi^- \rightarrow \Sigma^0 e^-\nu$  small compared with  $\Xi^- \rightarrow \Lambda e^-\nu$ .

h. The direct emission branching ratio is  $(1.56 \pm .35) \times 10^{-5}$ .

i. A contradictory unpublished result of  $\sim 9 \times 10^{-9}$  (with 6 events seen) has been reported by Carithers et al. See note in Stable Particle Data Card Listings.

# ADDENDUM TO Stable Particle Table

| Magnetic moment                        |                                                                                                     |                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                 |
|----------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| e                                      | 1.001 159 6577 $\frac{e\hbar}{2m_e c}$<br>$\pm 0.000\ 000\ 0035$                                    | $\mu$ Decay parameters <sup>a</sup>                                                                                                                                                                              |                                                                                                                                                                                                                                                                                 |
| $\mu$                                  | 1.001 166 16 $\frac{e\hbar}{2m_\mu c}$<br>$\pm 0.000\ 000\ 31$                                      | $\rho = 0.752 \pm 0.003$ $\eta = -0.12 \pm 0.21$<br>$\xi = 0.972 \pm 0.013$ $\delta = 0.755 \pm 0.009$ $h = 1.00 \pm 0.13$<br>$ g_A/g_V  = 0.86^{+0.33}_{-0.11}$ $\phi = 180^\circ \pm 15^\circ$                 |                                                                                                                                                                                                                                                                                 |
| $K^\pm$                                | Mode                                                                                                | Partial rate (sec <sup>-1</sup> )                                                                                                                                                                                | $\Delta I = \frac{1}{2}$ rule for $K^\pm \rightarrow 3\pi$                                                                                                                                                                                                                      |
|                                        | $\mu\nu$<br>$\pi\pi^0$<br>$\pi\pi^+\pi^-$<br>$\pi\pi^0\pi^0$<br>$\mu\pi^0\nu$<br>$e\pi^0\nu$        | $(51.35 \pm 0.19)10^6$ $S=1.2^*$<br>$(17.02 \pm 0.15)10^6$ $S=1.1^*$<br>$(4.52 \pm 0.02)10^6$ $S=1.1^*$<br>$(1.40 \pm 0.04)10^6$ $S=1.4^*$<br>$(2.62 \pm 0.08)10^6$ $S=1.9^*$<br>$(3.92 \pm 0.05)10^6$ $S=1.1^*$ | $\pi^+\pi^+\pi^-$ $c_g = -0.214 \pm 0.005$ $S=1.7^*$<br>$\pi^-\pi^+\pi^-$ $c_g = -0.214 \pm 0.007$ $S=2.7^*$<br>$\pi^+\pi^0\pi^0$ $c_g = 0.523 \pm 0.023$ $S=1.4^*$<br>See also Stable Particle Data Card Listings and Appendix I                                               |
| $K_S^0$                                | $\pi^+\pi^-$<br>$\pi^0\pi^0$                                                                        | $(0.780 \pm 0.008)10^{10}$ $S=1.9^*$<br>$(0.353 \pm 0.005)10^{10}$ $S=1.4^*$                                                                                                                                     | CP violation parameters<br>$ \eta_+  = (1.98 \pm 0.04)10^{-3}$ , $\phi_+ = (42 \pm 3)^\circ$ $S=1.1^*$<br>$ \eta_{00}  = (2.09 \pm 0.10)10^{-3}$ , $\phi_{00} = (43 \pm 19)^\circ$ $S=1.2^*$<br>$d\delta = (-0.33 \pm 0.04)10^{-2}$ $S=1.5^*$<br>$f_y^2 < 0.27$                 |
|                                        |                                                                                                     |                                                                                                                                                                                                                  | $\Delta I = \frac{1}{2}$ rule for $K_L^0 \rightarrow 3\pi$<br>$\pi^+\pi^-\pi^0$ $c_g = 0.60 \pm 0.02$ $S=2.7^*$<br>See Data Cards & App. I                                                                                                                                      |
| $K_L^0$                                | $\pi^0\pi^0\pi^0$<br>$\pi^+\pi^-\pi^0$<br>$\pi\mu\nu$<br>$\pi e\nu$<br>$\pi^+\pi^-$<br>$\pi^0\pi^0$ | $(4.15 \pm 0.16)10^6$ $S=1.3^*$<br>$(2.43 \pm 0.05)10^6$ $S=1.1^*$<br>$(5.19 \pm 0.12)10^6$ $S=1.1^*$<br>$(7.48 \pm 0.13)10^6$ $S=1.1^*$<br>$(3.02 \pm 0.10)10^4$ $S=1.5^*$<br>$(1.82 \pm 0.38)10^4$ $S=1.5^*$   | $\Delta S = -\Delta Q$<br>$\text{Re } x = -0.003 \pm 0.027$ $S=1.6^*$<br>$\text{Im } x = -0.005 \pm 0.038$ $S=1.2^*$<br>Form Factors for leptonic decays<br>$\lambda_\mu^e = 0.025 \pm 0.005$ $S=1.3^*$<br>See Stable Particle Data Card Listings for $\lambda_\mu^e$ and $\xi$ |
|                                        | Mode                                                                                                | Asymmetry parameter                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                 |
| $\eta$                                 | $\pi^+\pi^-\pi^0$<br>$\pi^+\pi^-\gamma$                                                             | $e(0.24 \pm 0.40)\%$ $S=2.0^*$<br>$(0.61 \pm 0.54)\%$                                                                                                                                                            |                                                                                                                                                                                                                                                                                 |
| Magnetic moment<br>( $e\hbar/2m_p c$ ) |                                                                                                     | Decay parameters <sup>b</sup>                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                 |
|                                        |                                                                                                     | Measured                                                                                                                                                                                                         | Derived                                                                                                                                                                                                                                                                         |
|                                        |                                                                                                     | $\alpha$                                                                                                                                                                                                         | $\phi(\text{degree})$                                                                                                                                                                                                                                                           |
| p                                      | 2.792782<br>$\pm 0.000017$                                                                          |                                                                                                                                                                                                                  | $\gamma$ $\Delta(\text{degree})$                                                                                                                                                                                                                                                |
| n                                      | -1.913148<br>$\pm 0.000066$                                                                         | $p e^- \nu$                                                                                                                                                                                                      | $-1.248 \pm 0.010$<br>$\delta = (181.1 \pm 1.3)^\circ$                                                                                                                                                                                                                          |
| $\Lambda$                              | -0.67<br>$\pm 0.06$                                                                                 | $p\pi^-$ $0.647 \pm 0.013$ $(-6.5 \pm 3.5)^\circ$<br>$n\pi^0$ $0.651 \pm 0.045$<br>$p e \nu$                                                                                                                     | $0.76$ $(7.6^{+4.0}_{-4.1})^\circ$<br>$-0.66 \pm 0.06$ $S=1.2^*$                                                                                                                                                                                                                |
| $\Sigma^+$                             | 2.59<br>$\pm 0.46$                                                                                  | $p\pi^0$ $-0.984 \pm 0.017$ $(22 \pm 90)^\circ$<br>$n\pi^+$ $+0.066 \pm 0.016$ $(167 \pm 20)^\circ$<br>$p\gamma$ $-1.03^{+0.52}_{-0.42}$ $S=1.1^*$                                                               | $0.17$ $(184 \pm 15)^\circ$<br>$-0.97$ $(-73^{+136}_{-10})^\circ$                                                                                                                                                                                                               |
|                                        |                                                                                                     | $n\pi^-$ $-0.069 \pm 0.008$ $(10 \pm 15)^\circ$<br>$n e^- \nu$<br>$\Lambda e^- \nu$                                                                                                                              | $0.98$ $(249^{+12}_{-115})^\circ$<br>See Data Cds.<br>$0.37 \pm 0.20$                                                                                                                                                                                                           |
| $\Xi^0$                                | -                                                                                                   | $\Lambda\pi^0$ $-0.39 \pm 0.09$ $(25 \pm 21)^\circ$<br>$S=1.2^*$                                                                                                                                                 | $0.84$ $(225^{+16}_{-35})^\circ$                                                                                                                                                                                                                                                |
| $\Xi^-$                                | -1.93<br>$\pm 0.75$                                                                                 | $\Lambda\pi^-$ $-0.40 \pm 0.03$ $(-4 \pm 8)^\circ$<br>$S=1.1^*$                                                                                                                                                  | $0.91$ $(170^{+18}_{-17})^\circ$                                                                                                                                                                                                                                                |

## ADDENDUM TO

## Stable Particle Table (cont'd)

\*S = scale factor. Quoted error includes scale factor; see footnote to main Stable Particle Table for definition.

a.  $|g_A/g_V|$  defined by

$$g_V^2 = |C_V|^2 + |C'_V|^2,$$

$$g_A^2 = |C_A|^2 + |C'_A|^2,$$

$$\Sigma \langle \bar{e} | \Gamma_i | \mu \rangle \langle \bar{\nu} | \Gamma_i (C_i + C'_i \gamma_5) | \nu \rangle;$$

$$\phi \text{ defined by } \cos \phi = -R_e(C_A^* C'_V + C'_A C_V^*) / g_A g_V \text{ [for more details, see text Section IV E]}$$

b. The definition of these quantities is as follows [for more details on sign convention, see text Section IV H]:

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2 + |p|^2};$$

$$\beta = \frac{-2|s||p|\sin\Delta}{|s|^2 + |p|^2}.$$

$$\beta = \sqrt{1-\alpha^2} \sin\phi;$$

$$\gamma = \sqrt{1-\alpha^2} \cos\phi.$$

$$g_A/g_V \text{ defined by } \langle B_f | \gamma_\lambda (g_V - g_A \gamma_5) | B_i \rangle;$$

$$\delta \text{ defined by } g_A/g_V = |g_A/g_V| e^{i\delta}.$$

c. The definition of the slope parameter of the Dalitz plot is as follows:

$$|M|^2 = 1 + g \left( \frac{s_3 - s_0}{m_{\pi^+}^2} \right).$$

d. The definition for the charge asymmetry is as follows:

$$\delta = \frac{\Gamma(K_L^0 \rightarrow \ell^+) - \Gamma(K_L^0 \rightarrow \ell^-)}{\Gamma(K_L^0 \rightarrow \ell^+) + \Gamma(K_L^0 \rightarrow \ell^-)}$$

e. See note in Stable Particle Data Card Listings.

f. The quantity  $y^2$  is defined as follows:

$$y^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^+ \pi^- \pi^0)}{\Gamma(K_L^0 \rightarrow \pi^+ \pi^- \pi^0)}$$

where CPT is assumed valid.

## Meson Table

April 1973

In addition to the entries in the Meson Table, the Meson Data Card Listings contain all substantial claims for meson resonances. See Contents of Meson Data Card Listings<sup>(1)</sup>.

*Quantities in italics have changed by more than one (old) standard deviation since April 1972.*

|                                                                                                        |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                | Partial decay mode                                                                                            |                                                  |                                        |
|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------------|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------|
| Name                                                                                                   | $G \begin{smallmatrix} I \\ 0 \\ - \end{smallmatrix} \begin{smallmatrix} 0 \\ \omega/\phi \\ + \end{smallmatrix} \begin{smallmatrix} 1 \\ \pi \\ \rho \end{smallmatrix}$ | $I^G(J^P)C_n$                               | Mass<br>M<br>(MeV)           | Full<br>Width<br>$\Gamma$<br>(MeV) | $M^2$<br>$\pm \Gamma M^{(a)}$<br>(GeV) <sup>2</sup>                                                                                            | Mode                                                                                                          | Fraction (%)<br>[Upper limits are 1 $\sigma$ (%) | p or<br>Pmax<br>(MeV/c) <sup>(b)</sup> |
|                                                                                                        |                                                                                                                                                                          | estab.                                      |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |
| $\pi^\pm(140)$<br>$\pi^0(135)$                                                                         | <u><math>1^-(0^-)+</math></u>                                                                                                                                            | 139.57<br>134.96                            | 0.0<br>7.8 eV<br>$\pm 9$ eV  | 0.019483<br>0.018217               |                                                                                                                                                | See Stable Particle Table                                                                                     |                                                  |                                        |
| $\eta(549)$                                                                                            | <u><math>0^+(0^-)+</math></u>                                                                                                                                            | 548.8<br>$\pm 0.6$                          | 2.63 keV<br>$\pm 58$ keV     | 0.301<br>$\pm 0.000$               | All neutral<br>$\pi^+\pi^-\pi^0 + \pi^+\pi^-\gamma$                                                                                            | 71<br>29                                                                                                      | See Stable Particle Table                        |                                        |
| $\epsilon$                                                                                             | <u><math>0^+(0^+)+</math></u>                                                                                                                                            | $\lesssim 700^{(c)}$                        | $\gtrsim 600^{(c)}$          |                                    | $\pi\pi$                                                                                                                                       |                                                                                                               |                                                  |                                        |
| Existence of pole not established. See note on $\pi\pi$ S wave <sup>¶</sup> .                          |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |
| $\rho(770)$                                                                                            | <u><math>1^+(1^-)-</math></u>                                                                                                                                            | 770 <sub>S</sub><br>$\pm 5$                 | 146 <sub>S</sub><br>$\pm 10$ | 0.593<br>$\pm 0.112$               | $\pi\pi$<br>$e^+e^-$<br>$\mu^+\mu^-$<br>For upper limits, see footnote (e)                                                                     | $\approx 100$<br>0.0043 $\pm 0.0005$ (d)<br>0.0067 $\pm 0.0012$ (d)                                           |                                                  | 359<br>385<br>370                      |
| $\omega(784)$                                                                                          | <u><math>0^-(1^-)-</math></u>                                                                                                                                            | 783.8 <sup>(f)</sup><br>$\pm 0.3$<br>S=1.3* | 9.8<br>$\pm 5$<br>S=1.1*     | 0.614<br>$\pm 0.008$               | $\pi^+\pi^-\pi^0$<br>$\pi^+\pi^-$<br>$\pi^0\gamma$<br>$e^+e^-$<br>For upper limits, see footnote (g)                                           | 89.6 $\pm 0.6$<br>1.3 $\pm 0.3$<br>9.1 $\pm 0.5$<br>0.0076 $\pm 0.0017$                                       | S=1.1*<br>S=1.5*<br>S=1.9*                       | 328<br>366<br>380<br>392               |
| $\ddot{\pi}$<br>$\eta'(958)$<br>or $X^0$                                                               | <u><math>0^+(0^-)+</math></u>                                                                                                                                            | 958.1<br>$\pm 0.4$<br>S=1.4*                | < 2                          | 0.918<br>< 0.002                   | $\eta\pi\pi$<br>$\pi^+\pi^-\gamma$ (mainly $\rho^0\gamma$ )<br>$\gamma\gamma$<br>For upper limits, see footnote (h)                            | 71.8 $\pm 3.9$<br>26.2 $\pm 3.5$<br>1.9 $\pm 0.3$                                                             | S=2.0*<br>S=2.2*                                 | 234<br>458<br>479                      |
| $\delta(970)$                                                                                          | <u><math>1^-(0^+)+</math></u><br>formerly called $\pi_N(975)$                                                                                                            | $\sim 970$                                  | 50 <sub>S</sub><br>$\pm 30$  | 0.941<br>$\pm 0.049$               | $\eta\pi$                                                                                                                                      |                                                                                                               |                                                  | 311                                    |
| Possibly a virtual bound state of the $I = 1$ $K\bar{K}$ system <sup>¶</sup> .                         |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |
| $S^*$                                                                                                  | <u><math>0^+(0^+)+</math></u>                                                                                                                                            | $\sim 997^{(c)}$                            | 50-150 <sup>(c)</sup>        | 0.993                              | $\pi\pi$<br>$K\bar{K}$                                                                                                                         |                                                                                                               |                                                  | 479<br>near threshold                  |
| See notes on $\pi\pi$ and $K\bar{K}$ S wave <sup>¶</sup> .                                             |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |
| $\phi(1019)$                                                                                           | <u><math>0^-(1^-)-</math></u>                                                                                                                                            | 1019.6<br>$\pm 0.3$<br>S=1.9                | 4.2<br>$\pm 2$               | 1.040<br>$\pm 0.004$               | $K^+K^-$<br>$K_LK_S$<br>$\pi^+\pi^-\pi^0$ (incl. $\rho\pi$ )<br>$\eta\gamma$<br>$e^+e^-$<br>$\mu^+\mu^-$<br>For upper limits, see footnote (i) | 46.8 $\pm 2.7$<br>35.0 $\pm 2.8$<br>15.2 $\pm 3.6$<br>3.0 $\pm 1.1$<br>0.032 $\pm 0.003$<br>0.025 $\pm 0.003$ | S=1.6<br>S=1.6*<br>S=1.8*<br>S=1.6*<br>S=1.9*    | 127<br>110<br>462<br>362<br>510<br>499 |
| $A_1(1100)$                                                                                            | <u><math>1^-(1^+)+</math></u>                                                                                                                                            | $\sim 1100$                                 | 200-400                      | 1.21                               | $\rho\pi$                                                                                                                                      | $\sim 100$                                                                                                    |                                                  | 253                                    |
| Broad enhancement in the $J^P=1^+$ $\rho\pi$ partial wave; not a Breit-Wigner resonance <sup>¶</sup> . |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |
| $B(1235)$                                                                                              | <u><math>1^+(1^+)-</math></u>                                                                                                                                            | 1237 <sub>S</sub><br>$\pm 10$               | 120 <sub>S</sub><br>$\pm 20$ | 1.53<br>$\pm 0.12$                 | $\omega\pi$                                                                                                                                    | only mode seen                                                                                                |                                                  | 351                                    |
| For upper limits, see footnote (j)                                                                     |                                                                                                                                                                          |                                             |                              |                                    |                                                                                                                                                |                                                                                                               |                                                  |                                        |

[illegible]

## Meson Table (cont'd)

| Name                                              |                                             |                    |                                    | Partial decay mode                                                           |                               |                                                   |                                                    |
|---------------------------------------------------|---------------------------------------------|--------------------|------------------------------------|------------------------------------------------------------------------------|-------------------------------|---------------------------------------------------|----------------------------------------------------|
| $\frac{G}{I} \frac{J}{P} \frac{C}{n}$             | $I^G(J^P)C_n$                               | Mass<br>M<br>(MeV) | Full<br>Width<br>$\Gamma$<br>(MeV) | $M^2$<br>$\pm \Gamma M^{(a)}$<br>(GeV) <sup>2</sup>                          | Mode                          | Fraction (%)<br>[Upper limits are 1 $\sigma$ (%)] | p or<br>p <sub>max</sub> <sup>(b)</sup><br>(MeV/c) |
| $\frac{0}{-} \frac{0}{\omega/\phi} \frac{1}{\pi}$ | $\frac{1}{-} \frac{0}{\eta} \frac{1}{\rho}$ | estab.             |                                    |                                                                              |                               |                                                   |                                                    |
| $\kappa$ $\frac{1}{-} \frac{2}{0}(0^+)$           |                                             |                    |                                    | $\delta_0^1$ is near 90°, with slow variation, in mass region 1200-1400 MeV. |                               |                                                   |                                                    |
| See note on $K\pi$ S wave <sup>¶</sup> .          |                                             |                    |                                    |                                                                              |                               |                                                   |                                                    |
| Q                                                 | $K_A(1240) \frac{1}{-} \frac{2}{0}(1^+)$    | 1242               | 127                                | 1.54                                                                         | $K\pi\pi$                     | only mode seen                                    |                                                    |
|                                                   | or C                                        | $\pm 10$           | $\pm 25$                           | $\pm 1.16$                                                                   | $\dagger[K^*\pi]$             | large]                                            |                                                    |
|                                                   | $K_A(1280) \frac{1}{-} \frac{2}{0}(1^+)$    | 1280 to            |                                    |                                                                              | $\dagger[K\rho]$              | seen]                                             |                                                    |
|                                                   | to 1400                                     | 1400               |                                    |                                                                              | $\dagger[K(\pi\pi)_{\ell=0}]$ | possibly seen]                                    |                                                    |
| See note (m).                                     |                                             |                    |                                    |                                                                              |                               |                                                   |                                                    |
| $K_N(1420)$                                       | $\frac{1}{-} \frac{2}{0}(2^+)$              | 1421 <sub>s</sub>  | 100 <sub>s</sub>                   | 2.02                                                                         | $K\pi$                        | 55.0 $\pm$ 3.3                                    | S=1.2 <sup>*</sup> 616                             |
|                                                   |                                             | $\pm 5$            | $\pm 10$                           | $\pm 1.14$                                                                   | $K^*\pi$                      | 29.5 $\pm$ 2.7                                    | 415                                                |
|                                                   |                                             |                    |                                    |                                                                              | $K\rho$                       | 9.2 $\pm$ 2.9                                     | S=1.2 <sup>*</sup> 319                             |
|                                                   |                                             |                    |                                    |                                                                              | $K\omega$                     | 4.4 $\pm$ 1.7                                     | 304                                                |
|                                                   |                                             |                    |                                    |                                                                              | $K\eta$                       | 2.0 $\pm$ 1.8                                     | 482                                                |
| See note (n).                                     |                                             |                    |                                    |                                                                              |                               |                                                   |                                                    |
| L(1770)                                           | $\frac{1}{-} \frac{2}{0}(A)$                | 1765 <sub>s</sub>  | 140 <sub>s</sub>                   | 3.11                                                                         | $K\pi\pi$                     | dominant                                          | 788                                                |
|                                                   |                                             | $\pm 10$           | $\pm 50$                           | $\pm 2.25$                                                                   | $K\pi\pi\pi$                  | seen                                              | 757                                                |
| $J^P=2^-$ favoured, $1^+$ and $3^+$ not excluded. |                                             |                    |                                    | $\dagger[K_N(1420)\pi$ and other subreactions <sup>¶</sup> ]                 |                               |                                                   |                                                    |
| See note (1) for possible heavier states.         |                                             |                    |                                    |                                                                              |                               |                                                   |                                                    |

## (1) Contents of Meson Data Card Listings

| Non-strange (Y = 0)      |               |               |                  |               |                                 | Strange ( Y  = 1)      |                                |                                |
|--------------------------|---------------|---------------|------------------|---------------|---------------------------------|------------------------|--------------------------------|--------------------------------|
| entry                    | $I^G(J^P)C_n$ |               | entry            | $I^G(J^P)C_n$ | entry                           | $I^G(J^P)C_n$          | entry                          | $I(J^P)$                       |
| $\pi$ (140)              | $1^-(0^-)^+$  | $\rightarrow$ | $\eta_N$ (1080)  | $0^+(N)^+$    | R-region {                      | $A_3$ (1640)           | $1^-(2^-)^+$                   | K (494) $1/2(0^-)$             |
| $\eta$ (549)             | $0^+(0^-)^+$  |               | $A_1$ (1100)     | $1^-(1^+)^+$  |                                 | $\omega$ (1675)        | $0^-(N)^-$                     | $K^*$ (892) $1/2(1^-)$         |
| $\epsilon$ (600)         | $0^+(0^+)^+$  | $\rightarrow$ | M (1150)         |               |                                 | g (1680)               | $1^+(3^-)^-$                   | $\kappa$ $1/2(0^+)$            |
| $\rho$ (770)             | $1^+(1^-)^-$  | $\rightarrow$ | $A_{1,s}$ (1170) | $1^-$         |                                 | $\rightarrow$ X (1690) |                                | $\rightarrow K_A$ (1175) $3/2$ |
| $\omega$ (784)           | $0^-(1^-)^-$  |               | B (1235)         | $1^+(1^+)^-$  |                                 | $\rightarrow$ X (1795) | $1^+$                          | $\rightarrow K_A$ (1265) $3/2$ |
| $\rightarrow M$ (940)    |               |               | F (1270)         | $0^+(2^+)^+$  | $\rightarrow \eta/\rho$ (1830)  |                        | Q $1/2(1^+)$                   |                                |
| $\rightarrow M$ (953)    | $+$           |               | D (1285)         | $0^+(A)^+$    | $\rightarrow \omega/\pi$ (1830) |                        | $K_N$ (1420) $1/2(2^+)$        |                                |
| $\eta'$ (958)            | $0^+(0^-)^+$  |               | $A_2$ (1310)     | $1^-(2^+)^+$  | $\rightarrow$ S (1930)          |                        | $\rightarrow K_N$ (1660) $1/2$ |                                |
| $\delta$ (970)           | $1^-(0^+)^+$  |               | E (1420)         | $0^+(A)^+$    | $\rightarrow \rho$ (2100)       | $1^+$                  | $\rightarrow K_N$ (1760) $1/2$ |                                |
| $\rightarrow H$ (990)    | $0^-(A)^-$    | $\rightarrow$ | X (1430)         | 0             | $\rightarrow$ T (2200)          | 1                      | L (1770) $1/2(A)$              |                                |
| $S^*$ (1000)             | $0^+(0^+)^+$  | $\rightarrow$ | X (1440)         | 1             | $\rightarrow \rho$ (2275)       | $1^+$                  | $\rightarrow K_N$ (1850)       |                                |
| $\phi$ (1019)            | $0^-(1^-)^-$  |               | $f'$ (1514)      | $0^+(2^+)^+$  | $\rightarrow$ U (2360)          | 1                      | $\rightarrow K^*$ (2200)       |                                |
| $\rightarrow M$ (1033)   |               |               | $F_1$ (1540)     | 1 (A)         | $\rightarrow N\bar{N}$ (2375)   | 0                      | $\rightarrow K^*$ (2800)       |                                |
| $\rightarrow B_1$ (1040) | $1^+$         |               | $\rho'$ (1600)   | $1^+(1^-)^-$  | $\rightarrow$ X (2500-3600)     |                        |                                |                                |

# Meson Table (cont'd)

- + indicates an entry in Meson Data Card Listings not entered in the Meson Table. We do not regard these as established resonances.
- ¶ See Meson Data Card Listings.
- \* Quoted error includes scale factor  $S = \sqrt{\chi^2/(N-1)}$ . See footnote to Stable Particle Table.
- + Square brackets indicate a subreaction of the previous (unbracketed) decay mode(s).
- § This is only an educated guess; the error given is larger than the error of the average of the published values. (See Meson Data Card Listings for the latter.)
- (a)  $\Gamma_M$  is approximately the half-width of the resonance when plotted against  $M^2$ .
- (b) For decay modes into  $\geq 3$  particles,  $p_{\max}$  is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated by using the averaged central mass values, without taking into account the widths of the resonances.
- (c) From pole position  $(M - i\Gamma/2)$ . For both  $\epsilon$  and  $S^*$  the pole is on Riemann Sheet 2.
- (d) The  $e^+e^-$  branching ratio is from  $e^+e^- \rightarrow \pi^+\pi^-$  experiments only. The  $\omega\rho$  interference is then due to  $\omega\rho$  mixing only, and is expected to be small. See note in Meson Data Card Listings. The  $\mu^+\mu^-$  branching ratio is compiled from 3 experiments; each possibly with substantial  $\omega\rho$  interference. The error reflects this uncertainty; see notes in Meson Data Card Listings. If eq universality holds,  $\Gamma(\rho^0 \rightarrow \mu^+\mu^-) = \Gamma(\rho^0 \rightarrow e^+e^-) \times \text{phase space correction}$ .
- (e) Empirical limits on fractions for other decay modes of  $\rho(765)$  are  $\pi^+\gamma < 0.5\%$ ,  $\pi^+\eta < 0.8\%$ ,  $\pi^+\pi^+\pi^-\pi^- < 0.15\%$ ,  $\pi^+\pi^+\pi^-\pi^0 < 0.2\%$ .
- (f) Note that experiments with final state  $K_S K_S \omega$  ( $\bar{p}p$  at rest) give  $M_\omega = 780.6 \pm 0.5^\circ$ .
- (g) Empirical limits on fractions for other decay modes of  $\omega(784)$  are  $\pi^+\pi^-\gamma < 5\%$ ,  $\pi^0\pi^0\gamma < 1\%$ ,  $\eta + \text{neutral}(s) < 1.5\%$ ,  $\mu^+\mu^- < 0.02\%$ ,  $\pi^0\mu^+\mu^- < 0.2\%$ ,  $\eta\gamma < 0.5\%$ .
- (h) Empirical limits on fractions for other decay modes of  $\eta'(958)$ :  $\pi^+\pi^- < 2\%$ ,  $\pi^+\pi^-\pi^0 < 5\%$ ,  $\pi^+\pi^+\pi^-\pi^- < 1\%$ ,  $\pi^+\pi^+\pi^-\pi^0 < 1\%$ ,  $6\pi < 1\%$ ,  $\pi^+\pi^-e^+e^- < 0.6\%$ ,  $\pi^0e^+e^- < 1.3\%$ ,  $\eta e^+e^- < 1.1\%$ ,  $\pi^0\rho^0 < 4\%$ ,  $\pi^0\omega < 8\%$ .
- (i) Empirical limits on fractions for other decay modes of  $\phi(1019)$  are  $\pi^+\pi^- < 0.03\%$ ,  $\pi^+\pi^-\gamma < 4\%$ ,  $\omega\gamma < 5\%$ ,  $\rho\gamma < 2\%$ ,  $\pi^0\gamma < 0.35\%$ ,  $2\pi^+2\pi^-\pi^0 < 9\%$ .
- (j) Empirical limits on fractions for other decay modes of  $B(1235)$ :  $\pi\pi < 15\%$ ,  $K\bar{K} < 2\%$ ,  $4\pi < 50\%$ ,  $\phi\pi < 1.5\%$ ,  $\eta\pi < 25\%$ ,  $(K\bar{K})^+\pi^0 < 8\%$ ,  $K_S K_S \pi^\pm < 2\%$ ,  $K_S K_L \pi^\pm < 6\%$ .
- (k) Empirical limits on fractions for other decay modes of  $f'(1514)$  are  $\pi^+\pi^- < 20\%$ ,  $\eta\eta < 50\%$ ,  $\eta\pi\pi < 30\%$ ,  $K\bar{K}\pi + K^*\bar{K} < 35\%$ ,  $2\pi^+2\pi^- < 32\%$ .
- (l) We assume as a working hypothesis that peaks with  $I^G = 1^+$  observed around 1.7 GeV all come from  $g(1680)$ . For indications to the contrary see Meson Data Card Listings.
- (m) See Q-region note in Meson Data Card Listings. Some investigators see a broad enhancement in mass' ( $K\pi\pi$ ) from 1250-1400 MeV (the Q region), and others see structure. The  $K\eta$ ,  $K\omega$ , and  $K\pi$  are less than a few percent.
- (n) The tabulated mass of 1421 MeV comes only from charged  $K_N(1420) \rightarrow K\pi$  measurements; the average of the neutral  $K_N(1420)$  mass is 1423 MeV.  $K\pi\pi$  mode can be contaminated with diffractively produced  $Q^\pm$ .
- (o) Empirical limits on fractions for other decay modes of  $f(1270)$  are  $\eta\pi\pi < 15\%$ ;  $K^0K^-\pi^+ + \text{c.c.} < 6\%$ .
- (p) The tiny partial width for  $\rho^+ \rightarrow \pi^+\pi^0$  ( $\Gamma < 2$  MeV) is based on an OPE model.<sup>¶</sup> Empirical limits are  $\pi\pi < 20\%$ ,  $K\bar{K} < 8\%$ .

Established Nonets, and octet-singlet mixing angles from Appendix IIB, Eq. (2'). Of the two isosinglets, the "mainly octet" one is written first, followed by a semi-colon.

| $(J^P)C_n$ | Nonet members             | $\theta_{\text{lin.}}$ | $\theta_{\text{quadr.}}$ |
|------------|---------------------------|------------------------|--------------------------|
| $(0^-)^+$  | $\pi, K, \eta; \eta'$     | $24 \pm 1^\circ$       | $10 \pm 1^\circ$         |
| $(1^-)^-$  | $\rho, K^*, \phi; \omega$ | $36 \pm 1^\circ$       | $39 \pm 1^\circ$         |
| $(2^+)^+$  | $A_2, K_N(1420), f'; f$   | $29 \pm 2^\circ$       | $31 \pm 2^\circ$         |

# Baryon Table

April 1973

Baryon States for which information can be found in the Data Card Listings. The name, the mass, the quantum numbers, and the status are shown. Those states with four or three stars can be found in the following Table, the others have been omitted because the evidence for the existence of the effect and/or for its interpretation as a resonance is open to considerable question.

|                  |                         |                          |                         |                         |
|------------------|-------------------------|--------------------------|-------------------------|-------------------------|
| N(940) P11 ****  | $\Delta(1236)$ P33 **** | $\Lambda(1115)$ P01 **** | $\Sigma(1190)$ P11 **** | $\Xi(1320)$ P11 ****    |
| N(1470) P11 **** | $\Delta(1650)$ S31 **** | $\Lambda(1330)$ Dead     | $\Sigma(1385)$ P13 **** | $\Xi(1530)$ P13 ****    |
| N(1520) D13 **** | $\Delta(1670)$ D33 ***  | $\Lambda(1405)$ S01 **** | $\Sigma(1440)$ PE Dead  | $\Xi(1630)$ **          |
| N(1535) S11 **** | $\Delta(1690)$ P33 *    | $\Lambda(1520)$ D03 **** | $\Sigma(1480)$ PE *     | $\Xi(1820)$ ***         |
| N(1670) D15 **** | $\Delta(1890)$ F35 ***  | $\Lambda(1670)$ S01 **** | $\Sigma(1620)$ S11 **   | $\Xi(1940)$ ***         |
| N(1688) F15 **** | $\Delta(1910)$ P31 ***  | $\Lambda(1690)$ D03 **** | $\Sigma(1620)$ P11 **   | $\Xi(2030)$ **          |
| N(1700) S11 **** | $\Delta(1950)$ F37 **** | $\Lambda(1750)$ P01 **   | $\Sigma(1620)$ PE **    | $\Xi(2250)$ *           |
| N(1700) D13 **   | $\Delta(1960)$ D35 *    | $\Lambda(1845)$ F05 **** | $\Sigma(1670)$ D13 **** | $\Xi(2500)$ **          |
| N(1780) P11 ***  | $\Delta(2160)$ P33 *    | $\Lambda(1830)$ D05 ***  | $\Sigma(1670)$ PE **    |                         |
| N(1860) P13 ***  | $\Delta(2420)$ H311 *** | $\Lambda(1860)$ P03 **   | $\Sigma(1690)$ PE **    |                         |
| N(1990) F17 **   | $\Delta(2850)$ ***      | $\Lambda(1870)$ S01 **   | $\Sigma(1750)$ S11 **** |                         |
| N(2040) D13 **   | $\Delta(3230)$ ***      | $\Lambda(2010)$ D03 **   | $\Sigma(1765)$ D15 **** | $\Omega(1670)$ P03 **** |
| N(2100) S11 *    |                         | $\Lambda(2020)$ F07 **   | $\Sigma(1840)$ P13 *    |                         |
| N(2100) D15 *    |                         | $\Lambda(2400)$ G07 **** | $\Sigma(1880)$ P11 **   |                         |
| N(2175) F15 *    |                         | $\Lambda(2410)$ *        | $\Sigma(1915)$ F15 **** |                         |
| N(2190) G17 ***  | Z0(1780) P01 *          | $\Lambda(2350)$ ****     | $\Sigma(1940)$ D13 ***  |                         |
| N(2220) H19 ***  | Z0(1865) *              | $\Lambda(2585)$ ***      | $\Sigma(2000)$ S11 *    |                         |
| N(2650) ***      | Z1(1900) P13 *          |                          | $\Sigma(2030)$ F17 **** |                         |
| N(3030) ***      | Z1(2150) *              |                          | $\Sigma(2070)$ F15 *    |                         |
| N(3245) *        | Z1(2500) *              |                          | $\Sigma(2080)$ P13 **   |                         |
| N(3690) *        |                         |                          | $\Sigma(2100)$ G17 **   |                         |
| N(3755) *        |                         |                          | $\Sigma(2250)$ ****     |                         |
|                  |                         |                          | $\Sigma(2455)$ ***      |                         |
|                  |                         |                          | $\Sigma(2620)$ ***      |                         |
|                  |                         |                          | $\Sigma(3000)$ **       |                         |

\*\*\*\* Good, clear, and unmistakable. \*\*\* Good, but in need of clarification or not absolutely certain.  
 \*\* Needs confirmation. \* Weak.

[ See notes on N's and  $\Delta$ 's, on possible Z's, and on Y's at the beginning of those sections in the Baryon Data Card Listings; also see notes on individual resonances in the Baryon Data Card Listings.]

| Particle <sup>a</sup> | I (J <sup>P</sup> )<br>I <sup>1/2</sup> estab. | $\pi$ or K Beam                                     |                                 | Full<br>Width<br>$\Gamma^b$<br>(MeV) | M <sup>2</sup><br>$\pm \Gamma M^c$<br>(GeV <sup>2</sup> ) | Partial decay mode                                                                                                                  |                                                                                                        |                                                  |
|-----------------------|------------------------------------------------|-----------------------------------------------------|---------------------------------|--------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------|
|                       |                                                | T(GeV)<br>p(GeV/c)<br>$\sigma = 4\pi\lambda^2$ (mb) | Mass<br>M <sup>b</sup><br>(MeV) |                                      |                                                           | Mode                                                                                                                                | Fraction<br>%                                                                                          | p or<br>p <sub>max</sub> <sup>d</sup><br>(MeV/c) |
| p                     | $1/2(1/2^+)$                                   |                                                     | 938.3                           |                                      | 0.880                                                     | See Stable Particle Table                                                                                                           |                                                                                                        |                                                  |
| n                     |                                                |                                                     | 939.6                           |                                      | 0.883                                                     |                                                                                                                                     |                                                                                                        |                                                  |
| N'(1470)              | $1/2(1/2^+)$ P'11                              | T=0.53 $\pi$ p<br>p=0.66<br>$\sigma$ =27.8          | ~1470                           | 165 to<br>300                        | 2.16<br>$\pm 0.41$                                        | N $\pi$<br>N $\pi\pi$<br>[N $\epsilon$<br>$\Delta\pi$<br>N $\rho$<br>p $\gamma$ <sup>g</sup><br>n $\gamma$ <sup>g</sup>             | 60<br>40<br>5-30] <sup>e</sup><br>20-30] <sup>e</sup><br>~7] <sup>e</sup><br>0.05<br>0.0               | 420<br>368<br>173<br>435<br>435                  |
| N'(1520)              | $1/2(3/2^-)$ D'13                              | T=0.61<br>p=0.74<br>$\sigma$ =23.5                  | 1510 to<br>1540                 | 105 to<br>150                        | 2.31<br>$\pm 0.18$                                        | N $\pi$<br>N $\pi\pi$<br>[N $\epsilon$<br>N $\rho$<br>$\Delta\pi$<br>N $\eta$<br>p $\gamma$ <sup>g</sup><br>n $\gamma$ <sup>g</sup> | 50<br>~50<br>0-2] <sup>e</sup><br>7-25] <sup>e</sup><br>15-40] <sup>e</sup><br>0.2-1.4<br>0.55<br>0.30 | 456<br>410<br>224<br>471<br>471                  |
| N'(1535)              | $1/2(1/2^-)$ S'11                              | T=0.64<br>p=0.76<br>$\sigma$ =22.5                  | 1500 to<br>1600                 | 50 to<br>160                         | 2.36<br>$\pm 0.18$                                        | N $\pi$<br>N $\eta$<br>N $\pi\pi$<br>[N $\rho$<br>p $\gamma$ <sup>g</sup><br>n $\gamma$ <sup>g</sup>                                | 35<br>55<br>~10<br>1-2] <sup>e</sup><br>0.2-0.4<br>0.12                                                | 467<br>182<br>422<br>481<br>481                  |

## Baryon Table (cont'd)

| Particle <sup>a</sup>                                                           | $J^P$<br>estab.         | $\pi$ or K Beam                                           | Mass<br>$M^b$<br>(MeV) | Full<br>Width<br>$\Gamma^b$<br>(MeV) | $M^2$<br>$\pm \Gamma M^c$<br>(GeV <sup>2</sup> ) | Partial decay mode                                                                                              |                                                                                                                                |                                                      |
|---------------------------------------------------------------------------------|-------------------------|-----------------------------------------------------------|------------------------|--------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
|                                                                                 |                         | $T$ (GeV)<br>$p$ (GeV/c)<br>$\sigma = 4\pi\lambda^2$ (mb) |                        |                                      |                                                  | Mode                                                                                                            | Fraction<br>%                                                                                                                  | $p$ or<br>$p_{\max}^d$<br>(MeV/c)                    |
| $N^*(1670)^i$                                                                   | $1/2(5/2^-)$ $D_{15}^*$ | $T=0.87$<br>$p=1.00$<br>$\sigma=15.6$                     | 1670 to<br>1685        | 115 to<br>175                        | 2.79<br>$\pm 0.24$                               | $N\pi$<br>$N\pi\pi$<br>$[\Delta\pi$<br>$\Delta K$<br>$N\eta$<br>$p\gamma g$<br>$n\gamma g$                      | 40<br>60<br>50-60 <sup>e</sup><br><1<br><1 <sup>j</sup><br>0.01<br>0.02                                                        | 560<br>525<br>357<br>200<br>368<br>572<br>572        |
| $N^*(1688)^i$                                                                   | $1/2(5/2^+)$ $F_{15}^*$ | $T=0.90$<br>$p=1.03$<br>$\sigma=14.9$                     | 1680 to<br>1690        | 105 to<br>180                        | 2.85<br>$\pm 0.21$                               | $N\pi$<br>$N\pi\pi$<br>$[N\pi$<br>$N\rho$<br>$\Delta\pi$<br>$\Delta K$<br>$N\eta$<br>$p\gamma g$<br>$n\gamma g$ | 60<br>40<br>12 <sup>e</sup><br>15 <sup>e</sup><br>13-40 <sup>e</sup><br><0.1 <sup>j</sup><br><0.3 <sup>j</sup><br>0.20<br>0.01 | 572<br>538<br>340<br>372<br>231<br>388<br>583<br>583 |
| $N^*(1700)^i$                                                                   | $1/2(1/2^-)$ $S_{11}^*$ | $T=0.92$<br>$p=1.05$<br>$\sigma=14.3$                     | 1665 to<br>1765        | 100 to<br>300                        | 2.89<br>$\pm 0.42$                               | $N\pi$<br>$N\pi\pi$<br>$[N\pi$<br>$N\rho$<br>$\Delta K$<br>$N\eta$<br>$p\gamma g$<br>$n\gamma g$                | 60<br>25-30 <sup>e</sup><br>10-20 <sup>e</sup><br>5<br>~3 <sup>j</sup><br>0.05-0.1<br>0.05                                     | 580<br>547<br>355<br>250<br>340<br>591<br>591        |
| $N^*(1780)^i$                                                                   | $1/2(1/2^+)$ $P_{11}^*$ | $T=1.07$<br>$p=1.20$<br>$\sigma=12.2$                     | 1650 to<br>1860        | 50 to<br>350                         | 3.17<br>$\pm 0.51$                               | $N\pi$<br>$N\pi\pi$<br>$[N\pi$<br>$\Delta\pi$<br>$\Delta K$<br>$N\eta$<br>$p\gamma g$<br>$n\gamma g$            | ~20<br>30-40 <sup>e, h</sup><br>25-35 <sup>e, h</sup><br><7 <sup>j</sup><br>10-20 <sup>j</sup><br>0.01<br>0.01                 | 633<br>603<br>440<br>445<br>353<br>476<br>643<br>643 |
| $N(1860)$                                                                       | $1/2(3/2^+)$ $P_{13}$   | $T=1.22$<br>$p=1.36$<br>$\sigma=10.4$                     | 1770 to<br>1860        | 180 to<br>330                        | 3.46<br>$\pm 0.57$                               | $N\pi$<br>$N\pi\pi$<br>$[N\rho$<br>$\Delta K$<br>$N\eta$                                                        | 25<br>55-65 <sup>e, h</sup><br>~5<br>~4 <sup>j</sup>                                                                           | 685<br>657<br>366<br>437<br>545                      |
| $N(2190)$                                                                       | $1/2(7/2^-)$ $G_{17}$   | $T=1.94$<br>$p=2.07$<br>$\sigma=6.21$                     | 2000 to<br>2260        | 270 to<br>325                        | 4.80<br>$\pm 0.67$                               | $N\pi$<br>$N\pi\pi$                                                                                             | 25                                                                                                                             | 888<br>868                                           |
| $N(2220)$                                                                       | $1/2(9/2^+)$ $H_{19}$   | $T=2.00$<br>$p=2.14$<br>$\sigma=5.97$                     | 2200 to<br>2245        | 260 to<br>330                        | 4.93<br>$\pm 0.65$                               | $N\pi$<br>$N\pi\pi$                                                                                             | 15                                                                                                                             | 905<br>887                                           |
| $N(2650)$                                                                       | $1/2( ?^- )$            | $T=3.12$<br>$p=3.26$<br>$\sigma=3.67$                     | ~2650                  | ~360                                 | 7.02<br>$\pm 0.95$                               | $N\pi$<br>$N\pi\pi$                                                                                             | $(J+1/2)x$<br>=0.45 <sup>f</sup>                                                                                               | 1154<br>1140                                         |
| $N(3030)$                                                                       | $1/2( ? )$              | $T=4.27$<br>$p=4.41$<br>$\sigma=2.62$                     | ~3030                  | ~400                                 | 9.18<br>$\pm 1.21$                               | $N\pi$<br>$N\pi\pi$                                                                                             | $(J+1/2)x$<br>=0.05 <sup>f</sup>                                                                                               | 1366<br>1354                                         |
| $\Delta^*(1236)^m$                                                              | $3/2(3/2^+)$ $P_{33}^*$ | $T=0.195(++)$<br>$p=0.304$<br>$\sigma=91.8$               | 1230 to<br>1236        | 110 to<br>122                        | 1.53<br>$\pm 0.14$                               | $N\pi^+\pi^-$<br>$N\pi^+\pi^0$<br>$N\pi^0\pi^0$                                                                 | 99.4<br>0<br>~0.6                                                                                                              | 231<br>90<br>262                                     |
| Pole position <sup>m</sup> : $M-i\Gamma/2 = (1211.6 \pm 0.7) - i(49.5 \pm 1.8)$ |                         |                                                           |                        |                                      |                                                  |                                                                                                                 |                                                                                                                                |                                                      |
| $\Delta(1650)$                                                                  | $3/2(1/2^-)$ $S_{31}$   | $T=0.83$<br>$p=0.96$<br>$\sigma=16.4$                     | 1615 to<br>1695        | 130 to<br>200                        | 2.72<br>$\pm 0.28$                               | $N\pi$<br>$N\pi\pi$<br>$[N\rho$<br>$\Delta\pi$<br>$N\gamma g$                                                   | 28<br>72<br>8-16 <sup>e</sup><br>26-32 <sup>e</sup><br>0.30                                                                    | 547<br>511<br>558<br>340<br>558                      |

## Baryon Table (cont'd)

| Particle <sup>a</sup>                                                                                                             | I (J <sup>P</sup> )<br>— estab. | $\pi$ or K Beam                                     | Mass                            | Full                           | M <sup>2</sup>                          | Partial decay mode                                                                                    |                                                                      |                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------------------------------|---------------------------------|--------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------|
|                                                                                                                                   |                                 | T(GeV)<br>p(GeV/c)<br>$\sigma = 4\pi\lambda^2$ (mb) | M <sup>b</sup><br>(MeV)         | Width<br>$\Gamma^b$<br>(MeV)   | $\pm \Gamma M^c$<br>(GeV <sup>2</sup> ) | Mode                                                                                                  | Fraction<br>%                                                        | p or<br>P <sub>max</sub> <sup>d</sup><br>(MeV/c) |
| $\Delta(1670)$                                                                                                                    | $3/2(3/2^-) D_{33}$             | T=0.87<br>p=1.00<br>$\sigma=15.6$                   | 1650 to<br>1720                 | 175 to<br>300                  | 2.79<br>$\pm 0.40$                      | N $\pi$<br>N $\pi\pi$<br>[ $\Delta\pi$<br>N $\gamma\pi$ ]                                             | 15<br>22-30] <sup>e</sup><br>0.05                                    | 560<br>525<br>357<br>572                         |
| $\Delta(1890)$                                                                                                                    | $3/2(5/2^+) F_{35}$             | T=1.28<br>p=1.42<br>$\sigma=9.88$                   | 1840 to<br>1920                 | 200 to<br>350                  | 3.57<br>$\pm 0.49$                      | N $\pi$<br>N $\pi\pi$<br>[N $\rho$<br>N $\gamma\pi$ ]                                                 | 17<br>55-70] <sup>e</sup><br>0.03                                    | 704<br>677<br>403<br>712                         |
| $\Delta(1910)$                                                                                                                    | $3/2(1/2^+) P_{31}$             | T=1.33<br>p=1.46<br>$\sigma=9.54$                   | 1780 to<br>1935                 | 200 to<br>340                  | 3.65<br>$\pm 0.52$                      | N $\pi$<br>N $\pi\pi$<br>[N $\rho$<br>$\Delta\pi$<br>N $\gamma\pi$ ]                                  | 25<br>3-16] <sup>e</sup><br>4-16] <sup>e</sup><br>0.03               | 716<br>691<br>429<br>543<br>725                  |
| $\Delta(1950)$                                                                                                                    | $3/2(7/2^+) F_{37}$             | T=1.41<br>p=1.54<br>$\sigma=8.90$                   | 1930 to<br>1980                 | 170 to<br>270                  | 3.80<br>$\pm 0.44$                      | N $\pi$<br>N $\pi\pi$<br>[N $\rho$<br>$\Delta\pi$<br>N $\gamma\pi$<br>$\Sigma K$<br>$\Sigma(1385)K$ ] | 45<br>8-12] <sup>e</sup><br>14-19] <sup>e</sup><br>0.15<br>~2<br>1.4 | 741<br>716<br>471<br>571<br>749<br>460<br>232    |
| $\Delta(2420)$                                                                                                                    | $3/2(11/2^+) \text{---}$        | T=2.50<br>p=2.64<br>$\sigma=4.68$                   | 2320 to<br>2450                 | 270 to<br>350                  | 5.86<br>$\pm 0.75$                      | N $\pi$<br>N $\pi\pi$                                                                                 | 11<br>>20                                                            | 1023<br>1006                                     |
| $\Delta(2850)$                                                                                                                    | $3/2( ?^+ )$                    | T=3.71<br>p=3.85<br>$\sigma=3.05$                   | ~2850                           | ~400                           | 8.12<br>$\pm 1.14$                      | N $\pi$<br>N $\pi\pi$                                                                                 | (J+1/2) <sub>x</sub><br>=0.25 <sup>f</sup>                           | 1266<br>1254                                     |
| $\Delta(3230)$                                                                                                                    | $3/2( ? )$                      | T=4.94<br>p=5.08<br>$\sigma=2.25$                   | ~3230                           | ~440                           | 10.4<br>$\pm 1.4$                       | N $\pi$<br>N $\pi\pi$                                                                                 | (J+1/2) <sub>x</sub><br>=0.05 <sup>f</sup>                           | 1475<br>1464                                     |
| Z* Evidence for states with hypercharge 2 is controversial. See the Baryon Data Card Listings for discussion and display of data. |                                 |                                                     |                                 |                                |                                         |                                                                                                       |                                                                      |                                                  |
| $\Lambda$                                                                                                                         | $0(1/2^+)$                      |                                                     | 1115.6                          |                                | 1.24                                    | See Stable Particle Table                                                                             |                                                                      |                                                  |
| $\Lambda'(1405)$                                                                                                                  | $0(1/2^-) S'_{01}$              | p<0 K <sup>-</sup> p                                | 1405 <sub>-5</sub> <sup>n</sup> | 40 <sub>-10</sub> <sup>n</sup> | 1.97<br>$\pm 0.06$                      | $\Sigma\pi$                                                                                           | 100                                                                  | 142                                              |
| $\Lambda'(1520)$                                                                                                                  | $0(3/2^-) D'_{03}$              | p=0.389<br>$\sigma=84.5$                            | 1518 <sub>-2</sub> <sup>n</sup> | 16 <sub>-2</sub> <sup>n</sup>  | 2.30<br>$\pm 0.02$                      | N $\bar{K}$<br>$\Sigma\pi$<br>$\Lambda\pi\pi$<br>$\Sigma\pi\pi$                                       | 45 $\pm 1$<br>41 $\pm 1$<br>10 $\pm 5$<br>1.0 $\pm 1$                | 234<br>258<br>250<br>140                         |
| $\Lambda''(1670)$                                                                                                                 | $0(1/2^-) S''_{01}$             | p=0.74<br>$\sigma=28.5$                             | ~1670                           | 15 to<br>38                    | 2.79<br>$\pm 0.04$                      | N $\bar{K}$<br>$\Lambda\eta$<br>$\Sigma\pi$                                                           | 15-35<br>15-25<br>30-50                                              | 410<br>64<br>393                                 |
| $\Lambda''(1690)$                                                                                                                 | $0(3/2^-) D''_{03}$             | p=0.78<br>$\sigma=26.1$                             | ~1690                           | 27 to<br>85                    | 2.86<br>0.09                            | N $\bar{K}$<br>$\Sigma\pi$<br>$\Lambda\pi\pi$<br>$\Sigma\pi\pi$                                       | 20-30<br>40-70<br><25<br><25                                         | 429<br>409<br>415<br>352                         |
| $\Lambda'(1815)$                                                                                                                  | $0(5/2^+) F'_{05}$              | p=1.05<br>$\sigma=16.7$                             | 1820<br>$\pm 5$ <sup>n</sup>    | 64 to<br>104                   | 3.30<br>$\pm 0.15$                      | N $\bar{K}$<br>$\Sigma\pi$<br>$\Sigma(1385)\pi$                                                       | 61<br>11<br>15-20                                                    | 542<br>508<br>362                                |
| $\Lambda'(1830)$                                                                                                                  | $0(5/2^-) D'_{05}$              | p=1.09<br>$\sigma=15.8$                             | 1810<br>to 1840                 | 60 to<br>150                   | 3.33<br>$\pm 0.19$                      | N $\bar{K}$<br>$\Sigma\pi$<br>$\Lambda\pi\pi$                                                         | ~10<br>20-60                                                         | 554<br>519<br>536                                |
| $\Lambda(2100)$                                                                                                                   | $0(7/2^-) G_{07}$               | p=1.68<br>$\sigma=8.68$                             | ~2100                           | 60 to<br>140                   | 4.41<br>$\pm 0.22$                      | N $\bar{K}$<br>$\Sigma\pi$<br>$\Lambda\eta$<br>$\Xi K$<br>$\Lambda\omega$                             | 25<br>~5<br><3<br>~2<br>~1                                           | 748<br>699<br>617<br>483<br>443                  |

## Baryon Table (cont'd)

| Particle <sup>a</sup>                                                                                                                                                                      | J <sup>P</sup><br>— estab.             | $\pi$ or K Beam                                     | Mass                                       | Full                                    | M <sup>2</sup>                          | Partial decay mode                                                                                       |                                |                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------|--------------------------------------------|-----------------------------------------|-----------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------|--------------------------------------------------|
|                                                                                                                                                                                            |                                        | T(GeV)<br>p(GeV/c)<br>$\sigma = 4\pi\lambda^2$ (mb) | M <sup>b</sup><br>(MeV)                    | Width<br>$\Gamma^b$<br>(MeV)            | $\pm \Gamma M^c$<br>(GeV <sup>2</sup> ) | Mode                                                                                                     | Fraction<br>%                  | p or<br>p <sub>max</sub> <sup>d</sup><br>(MeV/c) |
| $\Lambda$ (2350)                                                                                                                                                                           | 0( ? )                                 | p=2.29<br>$\sigma=5.85$                             | ~2350                                      | 140 to<br>324                           | 5.52<br>$\pm 0.55$                      | $N\bar{K}$                                                                                               | (J+1/2)x<br>$=0.7^f$           | 913                                              |
| $\Lambda$ (2585)                                                                                                                                                                           | 0( ? )                                 | p=2.91<br>$\sigma=4.37$                             | ~2585                                      | ~300                                    | 6.66<br>$\pm 0.77$                      | $N\bar{K}$                                                                                               | (J+1/2)x<br>$=1.0^f$           | 1058                                             |
| $\Sigma$                                                                                                                                                                                   | 1(1/2 <sup>+</sup> )                   |                                                     | (+)1189.4<br>(0)1192.5<br>(-)1197.3        |                                         | 1.41<br>1.42<br>1.43                    | See Stable Particle Table                                                                                |                                |                                                  |
| $\Sigma'(1385)$                                                                                                                                                                            | 1(3/2 <sup>+</sup> ) P <sub>13</sub>   | p < 0 K <sup>-</sup> p                              | (+)1383±1<br>S=1.3*<br>(-)1386±2<br>S=2.2* | (+)34±2<br>S=2.0*<br>(-)36±6<br>S=3.5*! | 1.92<br>$\pm 0.05$                      | $\Lambda\pi$<br>$\Sigma\pi$                                                                              | .89±2<br>11±2                  | 208<br>117                                       |
| $\Sigma'(1670)^k$                                                                                                                                                                          | 1(3/2 <sup>-</sup> ) D <sub>13</sub>   | p=0.74<br>$\sigma=28.5$                             | ~1670                                      | 35-65                                   | 2.79<br>$\pm 0.08$                      | $N\bar{K}$<br>$\Sigma\pi$<br>$\Lambda\pi$<br>$\Sigma\pi\pi$<br>$[\Lambda(1405)\pi]^e$<br>$\Lambda\pi\pi$ | ~8<br>~40<br>~12<br>5-15       | 410<br>387<br>447<br>326<br>207<br>397           |
| Parameters here are obtained from partial wave analyses for a D <sub>13</sub> resonance. Production experiments suggest two such states; see footnote k and the Baryon Data Card Listings. |                                        |                                                     |                                            |                                         |                                         |                                                                                                          |                                |                                                  |
| $\Sigma'(1750)$                                                                                                                                                                            | 1(1/2 <sup>-</sup> ) S <sub>11</sub>   | p=0.91<br>$\sigma=20.7$                             | 1700<br>to 1790                            | 50 to<br>100                            | 3.05<br>$\pm 0.13$                      | $N\bar{K}$<br>$\Lambda\pi$<br>$\Sigma\eta$                                                               | seen<br>seen<br>seen           | 483<br>507<br>54                                 |
| $\Sigma$ (1765)                                                                                                                                                                            | 1(5/2 <sup>-</sup> ) D <sub>15</sub>   | p=0.94<br>$\sigma=19.6$                             | 1765 <sub>n</sub><br>$\pm 5$               | ~120                                    | 3.12<br>$\pm 0.21$                      | $N\bar{K}$<br>$\Lambda\pi$<br>$\Lambda(1520)\pi$<br>$\Sigma(1385)\pi$<br>$\Sigma\pi$                     | ~41<br>~13<br>~15<br>~10<br>~1 | 496<br>518<br>187<br>315<br>461                  |
| $\Sigma$ (1915) <sup>i</sup>                                                                                                                                                               | 1(5/2 <sup>+</sup> ) F <sub>15</sub>   | p=1.25<br>$\sigma=13.0$                             | 1900-1930                                  | 50-100                                  | 3.67<br>$\pm 0.14$                      | $N\bar{K}$<br>$\Lambda\pi$<br>$\Sigma\pi$                                                                | ~14<br>~6<br>~6                | 612<br>619<br>568                                |
| Formation and production experiments do not agree on $\Sigma\pi/\Lambda\pi$ ratio.                                                                                                         |                                        |                                                     |                                            |                                         |                                         |                                                                                                          |                                |                                                  |
| $\Sigma''(1940)$                                                                                                                                                                           | 1(3/2 <sup>-</sup> ) D <sub>13</sub>   | p=1.32<br>$\sigma=12.0$                             | ~1940                                      | ~220                                    | 3.77<br>$\pm 0.43$                      | $N\bar{K}$<br>$\Lambda\pi$<br>$\Sigma\pi$                                                                | seen<br>seen                   | 678<br>680<br>589                                |
| $\Sigma$ (2030)                                                                                                                                                                            | 1(7/2 <sup>+</sup> ) F <sub>17</sub>   | p=1.52<br>$\sigma=9.93$                             | ~2030                                      | 100 to<br>170                           | 4.12<br>$\pm 0.27$                      | $N\bar{K}$<br>$\Lambda\pi$<br>$\Sigma\pi$<br>$\Xi K$                                                     | ~20<br>~20<br>~4<br>< 2        | 700<br>700<br>652<br>412                         |
| $\Sigma$ (2250)                                                                                                                                                                            | 1( ? )                                 | p=2.04<br>$\sigma=6.76$                             | ~2250                                      | 100 to<br>230                           | 5.06<br>$\pm 0.37$                      | $N\bar{K}$<br>$\Lambda\pi$                                                                               | (J+1/2)x<br>$=0.3^f$           | 849<br>842<br>799                                |
| $\Sigma$ (2455)                                                                                                                                                                            | 1( ? )                                 | p=2.57<br>$\sigma=5.09$                             | ~2455                                      | ~120                                    | 6.03<br>$\pm 0.29$                      | $N\bar{K}$                                                                                               | (J+1/2)x<br>$=0.2^f$           | 979                                              |
| $\Sigma$ (2620)                                                                                                                                                                            | 1( ? )                                 | p=2.95<br>$\sigma=4.30$                             | ~2620                                      | ~175                                    | 6.86<br>$\pm 0.46$                      | $N\bar{K}$                                                                                               | (J+1/2)x<br>$=0.3^f$           | 1064                                             |
| $\Xi^f$                                                                                                                                                                                    | 1/2(1/2 <sup>+</sup> ) -               |                                                     | (0)1314.9<br>(-)1321.3                     |                                         | 1.73<br>1.75                            | See Stable Particle Table                                                                                |                                |                                                  |
| $\Xi$ (1530) <sup>l</sup>                                                                                                                                                                  | 1/2(3/2 <sup>+</sup> ) P <sub>13</sub> |                                                     | (0) 1531.6±0.4<br>S=1.3*<br>(-) 1535.0±0.6 | (0) 9.1±0.5<br>(-) 12.9±4.1             | 2.34<br>$\pm 0.01$                      | $\Xi\pi$                                                                                                 | 100                            | 144                                              |
| $\Xi$ (1820) <sup>l</sup>                                                                                                                                                                  | 1/2( ? )                               |                                                     | 1795 to<br>1870                            | 12 to<br>99                             | 3.31<br>$\pm 0.10$                      | $\Lambda\bar{K}$<br>$\Xi\pi$<br>$\Xi(1530)\pi$<br>$\Sigma K$                                             |                                | 396<br>413<br>234<br>306                         |
| All four decay modes have been seen. Branching ratios not quoted because there may be more than one state here.                                                                            |                                        |                                                     |                                            |                                         |                                         |                                                                                                          |                                |                                                  |
| $\Xi$ (1940) <sup>l</sup>                                                                                                                                                                  | 1/2( ? )                               |                                                     | 1894 to<br>1961                            | 42 to<br>140                            | 3.72<br>$\pm 0.18$                      | $\Xi\pi$<br>$\Xi(1530)\pi$                                                                               |                                | 499<br>336                                       |
| Seen in both final states; not clear if one, or more, states present.                                                                                                                      |                                        |                                                     |                                            |                                         |                                         |                                                                                                          |                                |                                                  |
| $\Omega^-$                                                                                                                                                                                 | 0(3/2 <sup>+</sup> )                   |                                                     | 1672.5                                     |                                         | 2.80                                    | See Stable Particle Table                                                                                |                                |                                                  |

## Baryon Table (cont'd)

- \* Quoted error includes an S(scale) factor. See footnote to Stable Particle Table.
- An arrow at the left of the Table indicates a candidate that has been omitted because the evidence for the existence of the effect and (or) for its interpretation as a resonance is open to considerable question. For convenience all Baryon States for which information exists in the Baryon Data Card Listings are listed at the beginning of the Baryon Table. In that list, states with only a one or two star (\*) rating have been omitted from the Baryon Table; for additional information on such states, see the Baryon Data Card Listings.
- a. For the baryon states, the name [such as  $N'(1470)$ ] contains the mass, which may be different for each new analysis. The convention for using primes in the names is as follows: when there is more than one resonance on a given Argand diagram, the first has been designated with a prime, the second with a double prime, etc. The name (col. 1) is the same as can be found in large print in the Baryon Data Card Listings.
- b. For  $M$  and  $\Gamma$  of most baryons we report here an interval instead of an average. Averages are appropriate if each result is based on independent measurements, but inappropriate here where the spread in parameters arises because different models or procedures have been applied to a common set of data. Where only one value is given it is either because only one experiment reports that state or because the various experiments agree. An error is quoted only when the various experiments averaged have taken into account the systematic errors.
- c. For this column  $M$  is the rounded average which also appears in the name column.  $\Gamma$  is taken as the center of the interval given in the column labeled " $\Gamma$ ".
- d. For decay modes into  $\geq 3$  particles  $p_{\max}$  is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated using the averaged central mass values, without taking into account the widths of the resonances. For isobars,  $p$  is computed using the nominal isobar masses. If the isobar plus stable mass is less than the resonance mass, no value for  $p$  is given.
- e. Square brackets indicate a sub-reaction of the previous unbracketed decay mode. Our estimate is from data in the Baryon Data Card Listings (where available) and from the isobar model Argand plots of HERNDON 72. See the Mini-Review preceding the  $N^*$  Data Card Listings.
- f. This state has been seen only in total cross sections.  $J$  is not known;  $x$  is  $\Gamma_{el}/\Gamma$ .
- g. The tabulated radiative fractions involve a sum over two helicities ( $1/2, 3/2$ ). In the case of  $I=1/2$  resonances, there are two distinct isospin couplings, whence  $\gamma_p$  and  $\gamma_n$ . For further information and conventions, see the Mini-Review preceding the Baryon Data Card Listings.
- h. These values are particularly crude. Any naive estimate from the Argand plots of HERNDON 72 (see the Mini-Review preceding the  $N^*$  Data Card Listings) yields branching fractions the sum of which is greater than one. The values given have been scaled downward to be consistent with the branching fractions from other (non-isobar) channels.
- i. Only information coming from partial-wave analyses has been used here. For the production experiments results see the Baryon Data Card Listings.
- j. Value obtained in an energy-dependent partial-wave analysis which uses a  $t$ -channel-poles-plus-resonance parametrization. The values of the couplings obtained for the resonances may be affected by double counting.
- k. In this energy region the situation is still confused. In addition to the  $D_{13}(1670)$ , formation experiments have found evidence for fairly narrow ( $\Gamma \sim 50$  MeV)  $S_{11}$  and/or  $P_{11}$  states near 1620 MeV. It is not clear how many such states really exist. No one has reported a strong coupling of any of these states to  $\bar{K}N$ , but there is much disagreement about branching ratios  $\pi\Lambda$  and  $\pi\Sigma$ .
- l. Only  $\Xi(1530)$  is firmly established; information on the other states comes from experiments that have poor statistics due to the fact that the cross sections for  $S=-2$  states are very low. For  $\Xi$  states, because of the meager statistics, we lower our standards and tabulate resonant effects if they have at least a four-standard-deviation statistical significance and if they are seen by more than one group. So  $\Xi(2030)$ , with main decay mode  $\Sigma\bar{K}$ , reported as a 3.5-standard-deviation effect, is not tabulated. See the Baryon Data Card Listings for the other states.
- m. See note on  $\Delta(1236)$  in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position appears to be much less dependent upon the parametrization used.
- n. This is only an educated guess; the error given is larger than the error of the average of the published values (see the Baryon Data Card Listings for the latter).

## PHYSICAL AND NUMERICAL CONSTANTS\*

## PHYSICAL CONSTANTS

|                                          |   |                                                                                                                               |
|------------------------------------------|---|-------------------------------------------------------------------------------------------------------------------------------|
| N                                        | = | 6.022169(40)×10 <sup>23</sup> mole <sup>-1</sup> (based on A <sub>C12</sub> = 12)                                             |
| c                                        | = | 2.9979250(10)×10 <sup>10</sup> cm sec <sup>-1</sup>                                                                           |
| e                                        | = | 4.803250(21)×10 <sup>-10</sup> esu = 1.6021917(70)×10 <sup>-19</sup> coulomb                                                  |
| 1 MeV                                    | = | 1.6021917(70)×10 <sup>-6</sup> erg                                                                                            |
| ħ                                        | = | 6.582183(22)×10 <sup>-22</sup> MeV sec = 1.0545919(80)×10 <sup>-27</sup> erg sec                                              |
| ħc                                       | = | 1.9732891(66)×10 <sup>-11</sup> MeV cm = 197.32891(66) MeV fermi                                                              |
|                                          | = | 0.6240088(21) GeV mb <sup>1/2</sup>                                                                                           |
| α                                        | = | e <sup>2</sup> /ħc = 1/137.03602(21)                                                                                          |
| k <sub>Boltzmann</sub>                   | = | 1.380622(59)×10 <sup>-16</sup> erg K <sup>-1</sup>                                                                            |
|                                          | = | 8.61708(37)×10 <sup>-11</sup> MeV K <sup>-1</sup> = 1 eV/11604.85(49)K                                                        |
| m <sub>e</sub>                           | = | 0.5110041(16) MeV = 9.109558(54)×10 <sup>-31</sup> kg                                                                         |
| m <sub>p</sub>                           | = | 938.2592(52) MeV = 1836.109(11) m <sub>e</sub> = 6.72211(63) m <sub>π±</sub>                                                  |
|                                          | = | 1.00727661(8) m <sub>1</sub> (where m <sub>1</sub> = 1 amu = $\frac{1}{12}$ m <sub>C12</sub> = 931.4812(52) MeV)              |
| m <sub>d</sub>                           | = | 1875.587(10) MeV                                                                                                              |
| r <sub>e</sub>                           | = | e <sup>2</sup> /m <sub>e</sub> c <sup>2</sup> = 2.817939(13) fermi (1 fermi = 10 <sup>-13</sup> cm)                           |
| λ <sub>e</sub>                           | = | ħ/m <sub>e</sub> c = r <sub>e</sub> α <sup>-1</sup> = 3.861592(12)×10 <sup>-11</sup> cm                                       |
| a <sub>∞ Bohr</sub>                      | = | ħ <sup>2</sup> /m <sub>e</sub> e <sup>2</sup> = r <sub>e</sub> α <sup>-2</sup> = 0.52917715(81) Å (1 Å = 10 <sup>-8</sup> cm) |
| σ <sub>Thomson</sub>                     | = | $\frac{8}{3}\pi r_e^2$ = 0.6652453(61)×10 <sup>-24</sup> cm <sup>2</sup> = 0.6652453(61) barns                                |
| μ <sub>Bohr</sub>                        | = | eħ/2m <sub>e</sub> c = 0.5788381(18)×10 <sup>-14</sup> MeV gauss <sup>-1</sup>                                                |
| μ <sub>nucleon</sub>                     | = | eħ/2m <sub>p</sub> c = 3.152526(21)×10 <sup>-18</sup> MeV gauss <sup>-1</sup>                                                 |
| $\frac{1}{2}\omega_e^{\text{cyclotron}}$ | = | e/2m <sub>e</sub> c = 8.794014(27)×10 <sup>6</sup> rad sec <sup>-1</sup> gauss <sup>-1</sup>                                  |
| $\frac{1}{2}\omega_p^{\text{cyclotron}}$ | = | e/2m <sub>p</sub> c = 4.789484(27)×10 <sup>3</sup> rad sec <sup>-1</sup> gauss <sup>-1</sup>                                  |

Hydrogen-like atom (nonrelativistic, μ = reduced mass):

$$\frac{v}{c}_{\text{rms}} = \frac{ze^2}{n\hbar c}; E_n = \frac{\mu}{2} v^2 = \frac{\mu z^2 e^4}{2(n\hbar)^2}; a_n = \frac{n^2 \hbar^2}{\mu z e^2}$$

$$R_\infty = m_e e^4 / 2\hbar^2 = m_e c^2 \alpha^2 / 2 = 13.605826(45) \text{ eV (Rydberg)}$$

pc = 0.3 Hp (MeV, kilogauss, cm); 0.3 (which is 10<sup>-11</sup> c) enters because there are ≈ 300 "volts"/esu volt.

|                            |   |                                                                               |
|----------------------------|---|-------------------------------------------------------------------------------|
| 1 year (sidereal)          | = | 365.256 days = 3.1558×10 <sup>7</sup> sec (≈ π×10 <sup>7</sup> sec)           |
| density of dry air         | = | 1.205 mg cm <sup>-3</sup> (at 20°C, 760 mm)                                   |
| acceleration by gravity    | = | 980.62 cm sec <sup>-2</sup> (sea level, 45°)                                  |
| gravitational constant     | = | 6.6732(31)×10 <sup>-8</sup> cm <sup>3</sup> g <sup>-1</sup> sec <sup>-2</sup> |
| 1 calorie (thermochemical) | = | 4.184 joules                                                                  |
| 1 atmosphere               | = | 1033.2275 g cm <sup>-2</sup>                                                  |
| 1 eV per particle          | = | 11604.85(49)°K (from E = kT)                                                  |

## NUMERICAL CONSTANTS

|                     |   |           |                     |   |                |     |   |           |
|---------------------|---|-----------|---------------------|---|----------------|-----|---|-----------|
| π                   | = | 3.1415927 | 1 rad               | = | 57.2957795 deg | √π  | = | 1.7724539 |
| e                   | = | 2.7182818 | 1/e                 | = | 0.3678794      | √2  | = | 1.4142136 |
| ln 2                | = | 0.6931472 | ln 10               | = | 2.3025851      | √3  | = | 1.7320508 |
| log <sub>10</sub> 2 | = | 0.3010300 | log <sub>10</sub> e | = | 0.4342945      | √10 | = | 3.1622777 |

\* Compiled by Stanley J. Brodsky, based mainly on the adjustment of the fundamental physical constants by B. N. Taylor, W. H. Parker, and D. N. Langenberg, *Rev. Mod. Phys.* **41**, 375 (1969). The figures in parentheses correspond to the 1 standard deviation uncertainty in the last digits of the main number.

## CLEBSCH-GORDAN COEFFICIENTS AND SPHERICAL HARMONICS

Note: A  $\sqrt{\quad}$  is to be understood over every coefficient; e.g., for  $-8/15$  read  $-\sqrt{8/15}$ .

Notation:

|       |       |              |
|-------|-------|--------------|
| $J$   | $J$   | ...          |
| $M$   | $M$   | ...          |
| $m_1$ | $m_2$ |              |
| $m_1$ | $m_2$ | Coefficients |

$$1/2 \times 1/2$$

|           |     |      |
|-----------|-----|------|
| 1         | 0   | 0    |
| +1/2 +1/2 | 1   | 0    |
| +1/2 -1/2 | 1/2 | 1/2  |
| -1/2 +1/2 | 1/2 | -1/2 |
| -1/2 -1/2 | 1   |      |

$$Y_1^0 = \sqrt{\frac{3}{4\pi}} \cos \theta$$

$$Y_1^1 = -\sqrt{\frac{3}{8\pi}} \sin \theta e^{i\phi}$$

$$Y_2^0 = \sqrt{\frac{5}{4\pi}} \left( \frac{3}{2} \cos^2 \theta - \frac{1}{2} \right)$$

$$Y_2^1 = -\sqrt{\frac{15}{8\pi}} \sin \theta \cos \theta e^{i\phi}$$

$$Y_2^2 = \frac{1}{4} \sqrt{\frac{15}{2\pi}} \sin^2 \theta e^{2i\phi}$$

$$2 \times 1/2$$

|         |          |           |
|---------|----------|-----------|
| 5/2     | 3/2      |           |
| +5/2    | 1        | 3/2 + 3/2 |
| +2      | 1/2      | 1         |
| +2 -1/2 | 1/5      | 4/5       |
| +1 +1/2 | 4/5 -1/5 | 1/2 +1/2  |

$$3/2 \times 1/2$$

|           |          |     |
|-----------|----------|-----|
| 2         | 1        |     |
| +2        | 1        | 1   |
| +3/2 +1/2 | 1        | 1   |
| +3/2 -1/2 | 1/4      | 3/4 |
| +1/2 +1/2 | 3/4 -1/4 | 0   |

$$1 \times 1/2$$

|         |          |           |
|---------|----------|-----------|
| 3/2     | 1/2      |           |
| +3/2    | 1        | 1/2 +1/2  |
| +1 +1/2 | 1        | 1/2 +1/2  |
| +1 -1/2 | 1/3      | 2/3       |
| 0 +1/2  | 2/3 -1/3 | -1/2 -1/2 |

$$2 \times 1$$

|       |          |     |
|-------|----------|-----|
| 3     | 2        |     |
| +3    | 1        | 2   |
| +2 +1 | 1        | 2   |
| +2 0  | 1/3      | 2/3 |
| +1 +1 | 2/3 -1/3 | 1   |

$$3/2 \times 1$$

|         |          |           |
|---------|----------|-----------|
| 5/2     | 3/2      |           |
| +5/2    | 1        | 3/2 + 3/2 |
| +3/2 +1 | 1        | 3/2 + 3/2 |
| +3/2 0  | 2/5      | 3/5       |
| +1/2 +1 | 3/5 -2/5 | 1/2 +1/2  |

$$1 \times 1$$

|       |          |     |
|-------|----------|-----|
| 2     | 1        |     |
| +2    | 1        | 1   |
| +1 +1 | 1        | 1   |
| +1 0  | 1/2      | 1/2 |
| 0 +1  | 1/2 -1/2 | 0   |

|       |           |           |
|-------|-----------|-----------|
| 3     | 2         | 1         |
| +3    | 2         | 1         |
| +2 0  | 1/3       | 2/3       |
| +1 +1 | 2/3 -1/3  | 1         |
| +2 -1 | 1/15      | 1/3       |
| +1 0  | 8/15      | 1/6 -3/10 |
| 0 +1  | 6/15 -1/2 | 3/10      |

|       |          |      |
|-------|----------|------|
| 3     | 2        | 1    |
| +3    | 2        | 1    |
| +2 0  | 1/3      | 2/3  |
| +1 +1 | 2/3 -1/3 | 1    |
| +1 -1 | 1/5      | 1/2  |
| 0 0   | 3/5      | 0    |
| -1 +1 | 1/5 -1/2 | 3/10 |

|         |            |            |
|---------|------------|------------|
| 5/2     | 3/2        | 1/2        |
| +5/2    | 3/2        | 1/2        |
| +3/2 -1 | 1/10       | 2/5        |
| +1/2 0  | 3/5        | 1/15 -1/3  |
| -1/2 +1 | 3/10 -8/15 | 1/6        |
| +1/2 -1 | 3/10       | 8/15       |
| -1/2 0  | 3/5        | -1/15 -1/3 |
| -3/2 +1 | 1/10 -2/5  | 1/2        |

$$Y_\ell^{-m} = (-1)^m Y_\ell^m$$

|    |    |          |     |   |
|----|----|----------|-----|---|
| 0  | -1 | 1/2      | 1/2 | 2 |
| -1 | 0  | 1/2 -1/2 | -2  |   |
| -1 | -1 | 1        |     |   |

|       |          |     |     |      |
|-------|----------|-----|-----|------|
| 0     | -1       | 1/6 | 1/2 | 1/10 |
| -1    | 0        | 2/3 | 0   | -1/3 |
| -1 +1 | 1/6 -1/2 | 1/3 | -1  | -1   |

$$\langle j_1 j_2 m_1 m_2 | j_1 j_2 J M \rangle = (-1)^{J-j_1-j_2} \langle j_2 j_1 m_2 m_1 | j_2 j_1 J M \rangle$$

## SU(3) CONVENTIONS

for Isoscalar Factor Table on next page

Since January 1970 we have used the convention that the first particle shall be a baryon, the second a meson (R. Levi Setti, Proceedings of Lund Conference, 1969, p. 339 and Table II). Note, for comparison, that the de Swart table of 8×8 is merely labeled with symbols like ( $I_1 = 1/2$ ,  $Y_1 = 1$ ,  $I_2 = 1$ ,  $Y_2 = 0$ ), which can be read either as ( $N\pi$ ) or ( $K\Sigma$ ). Since there are no decuplet mesons, however, his 8×10 table is unambiguous; it must be read with the meson first.

The de Swart convention violates the other convention that the  $N, N\pi$  coupling shall be  $D + F$  (as opposed to  $-D + F$ ). To get  $D + F$  one must use the first line of the "N" table, which reads. . .  $3\sqrt{5}/10 |8_D\rangle + 1/2 |8_F\rangle$  as opposed to. . .  $-3\sqrt{5}/10 |8_D\rangle + 1/2 |8_F\rangle$ . The first line must then be labeled  $N\pi$  rather than  $K\Sigma$ , i.e., with the baryon first.

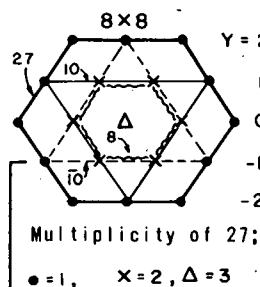
Levi Setti further advocates the convention of writing the baryon first for SU(2) as well as SU(3). For example, the sign of the amplitudes as plotted on his and our Argand plots comes from using our SU(2) Clebsch-Gordan coefficients (Condon Shortley notation) and writing the baryon first. To make it easier to abide by this universal convention we have changed de Swart's 8×10 (SU(3) table to 10×8, with the help of his Eq. (14.3):

$$\langle \mu_1 \mu_2 | \mu \rangle = \xi_1 (-1)^{I_1+I_2-I} \langle \mu_2 \mu_1 | \mu \rangle$$

## SU(3) ISOSCALAR FACTORS

Adapted from J. J. de Swart, Rev. Mod. Phys. **35**, 916 (1963)  
(See note on previous page concerning conventions)

$$[8] \otimes [8] = [27] \oplus [10] \oplus [10^*] \oplus [8]_1 \oplus [8]_2 \oplus [1].$$



\* Five single-coefficient tables are omitted. The one involving a  $\{10^*\}$  has a negative coefficient, i.e.  $(NK|10^*) = -1$ . The others, involving  $\{27\}$  and  $\{10\}$ , are all  $+1$ .

| $\xi_1 \rightarrow$ | $27$           | $8_D$           | $8_F$  | $10^*$ |
|---------------------|----------------|-----------------|--------|--------|
| $N\pi$              | $\sqrt{5}/10$  | $3\sqrt{5}/10$  | $1/2$  | $-1/2$ |
| $\Sigma K$          | $-\sqrt{5}/10$ | $-3\sqrt{5}/10$ | $1/2$  | $-1/2$ |
| $N\eta$             | $3\sqrt{5}/10$ | $-\sqrt{5}/10$  | $1/2$  | $1/2$  |
| $\Delta K$          | $3\sqrt{5}/10$ | $-\sqrt{5}/10$  | $-1/2$ | $-1/2$ |

| $\xi_1 \rightarrow$ | $27$         | $10$          |
|---------------------|--------------|---------------|
| $N\pi$              | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma K$          | $\sqrt{2}/2$ | $\sqrt{2}/2$  |

| $\xi_1 \rightarrow$ | $27$            | $8_D$           | $1$           | $8_F$        |
|---------------------|-----------------|-----------------|---------------|--------------|
| $NK$                | $\sqrt{15}/10$  | $-\sqrt{10}/10$ | $1/2$         | $\sqrt{2}/2$ |
| $\Sigma K$          | $-\sqrt{15}/10$ | $-\sqrt{10}/10$ | $-1/2$        | $\sqrt{2}/2$ |
| $\Sigma\pi$         | $\sqrt{10}/20$  | $-\sqrt{15}/5$  | $\sqrt{6}/4$  | $0$          |
| $\Delta\eta$        | $3\sqrt{30}/20$ | $-\sqrt{5}/5$   | $-\sqrt{2}/4$ | $0$          |

| $\xi_1 \rightarrow$ | $27$           | $8_D$           | $8_F$         | $10$          | $10^*$        |
|---------------------|----------------|-----------------|---------------|---------------|---------------|
| $NK$                | $\sqrt{5}/5$   | $-\sqrt{30}/10$ | $-\sqrt{6}/6$ | $-\sqrt{6}/6$ | $\sqrt{6}/6$  |
| $\Sigma K$          | $\sqrt{5}/5$   | $-\sqrt{30}/10$ | $-\sqrt{6}/6$ | $\sqrt{6}/6$  | $-\sqrt{6}/6$ |
| $\Sigma\pi$         | $0$            | $0$             | $\sqrt{6}/3$  | $\sqrt{6}/6$  | $-\sqrt{6}/6$ |
| $\Sigma\eta$        | $\sqrt{30}/10$ | $\sqrt{5}/5$    | $0$           | $1/2$         | $1/2$         |
| $\Delta\pi$         | $\sqrt{30}/10$ | $\sqrt{5}/5$    | $0$           | $-1/2$        | $-1/2$        |

| $\xi_1 \rightarrow$ | $27$           | $8_D$           | $8_F$  | $10$   |
|---------------------|----------------|-----------------|--------|--------|
| $\Sigma\pi$         | $-\sqrt{5}/10$ | $-3\sqrt{5}/10$ | $1/2$  | $1/2$  |
| $\Sigma K$          | $\sqrt{5}/10$  | $3\sqrt{5}/10$  | $1/2$  | $1/2$  |
| $\Sigma\eta$        | $3\sqrt{5}/10$ | $-\sqrt{5}/10$  | $-1/2$ | $1/2$  |
| $\Delta K$          | $3\sqrt{5}/10$ | $-\sqrt{5}/10$  | $1/2$  | $-1/2$ |

| $\xi_1 \rightarrow$ | $27$         | $10^*$        |
|---------------------|--------------|---------------|
| $\Sigma\pi$         | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma K$          | $\sqrt{2}/2$ | $\sqrt{2}/2$  |

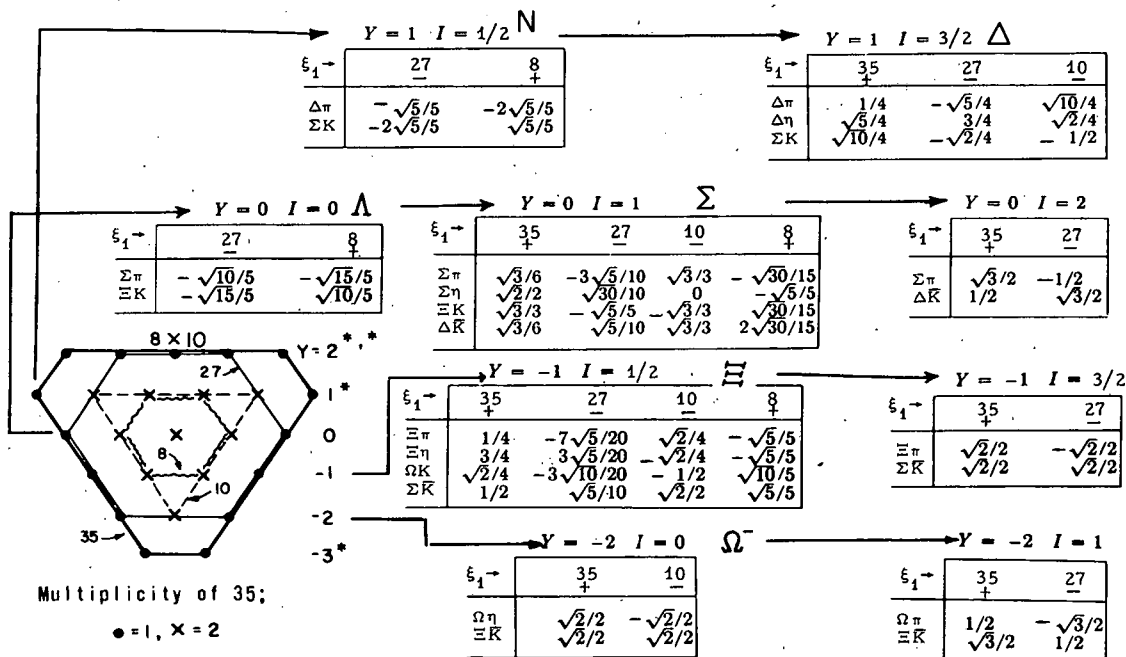
The phase factor  $\xi_1 = \pm 1$ , from de Swart's Table I, enters in his symmetry formula (14. 3):

$$(\mu_1\mu_2|\mu) = \xi_1(-1)^{I_1+I_2-I}(\mu_2\mu_1|\mu).$$

This factor is irrelevant if you are doing your own self-consistent calculations; it enters when you try to check someone else who chose  $\mu_2 \otimes \mu_1$  instead of  $\mu_1 \otimes \mu_2$ .

$$[10] \otimes [8] = [35] \oplus [27] \oplus [10] \oplus [8].$$

\* Four single coefficient tables are omitted; only the  $\{27\}$  is  $-1$ ; the three with  $\{35\}$  are  $+1$ .



| $\xi_1 \rightarrow$ | $27$           | $8$            |
|---------------------|----------------|----------------|
| $\Delta\pi$         | $-\sqrt{5}/5$  | $-2\sqrt{5}/5$ |
| $\Sigma K$          | $-2\sqrt{5}/5$ | $\sqrt{5}/5$   |

| $\xi_1 \rightarrow$ | $35$          | $27$          | $10$          |
|---------------------|---------------|---------------|---------------|
| $\Delta\pi$         | $1/4$         | $-\sqrt{5}/4$ | $\sqrt{10}/4$ |
| $\Delta\eta$        | $\sqrt{5}/4$  | $3/4$         | $\sqrt{2}/4$  |
| $\Sigma K$          | $\sqrt{10}/4$ | $-\sqrt{2}/4$ | $-1/2$        |

| $\xi_1 \rightarrow$ | $27$           | $8$            |
|---------------------|----------------|----------------|
| $\Sigma\pi$         | $-\sqrt{10}/5$ | $-\sqrt{15}/5$ |
| $\Sigma K$          | $-\sqrt{15}/5$ | $\sqrt{10}/5$  |

| $\xi_1 \rightarrow$ | $35$         | $27$            | $10$          | $8$             |
|---------------------|--------------|-----------------|---------------|-----------------|
| $\Sigma\pi$         | $\sqrt{3}/6$ | $-3\sqrt{5}/10$ | $\sqrt{3}/3$  | $-\sqrt{30}/15$ |
| $\Sigma\eta$        | $\sqrt{2}/2$ | $\sqrt{30}/10$  | $0$           | $-\sqrt{5}/5$   |
| $\Sigma K$          | $\sqrt{3}/3$ | $-\sqrt{5}/5$   | $-\sqrt{3}/3$ | $\sqrt{30}/15$  |
| $\Delta K$          | $\sqrt{3}/6$ | $\sqrt{5}/10$   | $\sqrt{3}/3$  | $2\sqrt{30}/15$ |

| $\xi_1 \rightarrow$ | $35$         | $27$         |
|---------------------|--------------|--------------|
| $\Sigma\pi$         | $\sqrt{3}/2$ | $-1/2$       |
| $\Delta K$          | $1/2$        | $\sqrt{3}/2$ |

| $\xi_1 \rightarrow$ | $35$         | $27$             | $10$          | $8$           |
|---------------------|--------------|------------------|---------------|---------------|
| $\Sigma\pi$         | $1/4$        | $-7\sqrt{5}/20$  | $\sqrt{2}/4$  | $-\sqrt{5}/5$ |
| $\Sigma\eta$        | $3/4$        | $3\sqrt{5}/20$   | $-\sqrt{2}/4$ | $-\sqrt{5}/5$ |
| $\Sigma K$          | $\sqrt{2}/4$ | $-3\sqrt{10}/20$ | $-1/2$        | $\sqrt{10}/5$ |
| $\Delta K$          | $1/2$        | $\sqrt{5}/10$    | $\sqrt{2}/2$  | $\sqrt{5}/5$  |

| $\xi_1 \rightarrow$ | $35$         | $27$          |
|---------------------|--------------|---------------|
| $\Sigma\pi$         | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma K$          | $\sqrt{2}/2$ | $\sqrt{2}/2$  |

| $\xi_1 \rightarrow$ | $35$         | $10$          |
|---------------------|--------------|---------------|
| $\Omega\eta$        | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma K$          | $\sqrt{2}/2$ | $\sqrt{2}/2$  |

| $\xi_1 \rightarrow$ | $35$         | $27$          |
|---------------------|--------------|---------------|
| $\Omega\pi$         | $1/2$        | $-\sqrt{3}/2$ |
| $\Sigma K$          | $\sqrt{3}/2$ | $1/2$         |

## C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

$$E_{cm} dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

| PBEAM<br>(MEV/C) | ---C.M. ENERGY---<br>(MEV) |      |      |      | ---MOMENTUM IN C.M.---<br>(MEV/C) |     |     |     | PBEAM<br>(MEV/C) | ---C.M. ENERGY---<br>(MEV) |                         |      |      | ---MOMENTUM IN C.M.---<br>(MEV/C) |     |     |     | PBEAM<br>(GEV/C) | ---C.M. ENERGY---<br>(GEV) |                         |      |      | ---MOMENTUM IN C.M.---<br>(GEV/C) |      |      |    |  |
|------------------|----------------------------|------|------|------|-----------------------------------|-----|-----|-----|------------------|----------------------------|-------------------------|------|------|-----------------------------------|-----|-----|-----|------------------|----------------------------|-------------------------|------|------|-----------------------------------|------|------|----|--|
|                  | YP<br>ep                   | TP   | Kp   | pp   | YP<br>ep                          | TP  | Kp  | pp  |                  | YP<br>ep                   | TP                      | Kp   | pp   | YP<br>ep                          | TP  | Kp  | pp  |                  | YP<br>ep                   | TP                      | Kp   | pp   | YP<br>ep                          | TP   | Kp   | pp |  |
| 0                | 939                        | 1078 | 1432 | 1877 |                                   | 0   | 0   | 0   | 0                | 1500                       | 1922                    | 1930 | 2022 | 2254                              | 732 | 729 | 696 | 624              | 3.0                        | 2.56                    | 2.61 | 2.77 | 1.10                              | 1.08 | 1.02 |    |  |
| 20               | 958                        | 1079 | 1432 | 1877 |                                   | 20  | 17  | 13  | 10               | 1520                       | 1932                    | 1940 | 2031 | 2261                              | 738 | 735 | 702 | 631              | 3.2                        | 2.63                    | 2.68 | 2.83 | 1.14                              | 1.12 | 1.05 |    |  |
| 40               | 977                        | 1083 | 1433 | 1877 |                                   | 38  | 35  | 26  | 20               | 1540                       | 1942                    | 1950 | 2039 | 2268                              | 744 | 741 | 709 | 637              | 3.4                        | 2.70                    | 2.75 | 2.89 | 1.18                              | 1.16 | 1.10 |    |  |
| 60               | 996                        | 1089 | 1434 | 1877 |                                   | 56  | 52  | 39  | 30               | 1560                       | 1951                    | 1959 | 2048 | 2275                              | 750 | 747 | 715 | 643              | 3.6                        | 2.77                    | 2.82 | 2.96 | 1.22                              | 1.20 | 1.14 |    |  |
| 80               | 1015                       | 1096 | 1436 | 1878 |                                   | 74  | 68  | 52  | 40               | 1580                       | 1961                    | 1969 | 2057 | 2282                              | 756 | 753 | 721 | 650              | 3.8                        | 2.83                    | 2.88 | 3.02 | 1.26                              | 1.24 | 1.18 |    |  |
|                  | T(P1) = PBEAM - 59 MEV     |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 133 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 137 GEV |      |      |                                   |      |      |    |  |
| 100              | 1033                       | 1105 | 1439 | 1879 |                                   | 91  | 85  | 65  | 50               | 1600                       | 1970                    | 1978 | 2065 | 2289                              | 762 | 759 | 727 | 656              | 4.0                        | 2.90                    | 2.95 | 3.08 | 1.29                              | 1.27 | 1.22 |    |  |
| 120              | 1051                       | 1116 | 1441 | 1880 |                                   | 107 | 101 | 78  | 60               | 1620                       | 1980                    | 1988 | 2074 | 2296                              | 768 | 765 | 733 | 662              | 4.2                        | 2.96                    | 3.01 | 3.14 | 1.33                              | 1.31 | 1.26 |    |  |
| 140              | 1069                       | 1127 | 1445 | 1882 |                                   | 123 | 117 | 91  | 70               | 1640                       | 1989                    | 1997 | 2083 | 2304                              | 773 | 770 | 739 | 668              | 4.4                        | 3.03                    | 3.07 | 3.19 | 1.36                              | 1.34 | 1.29 |    |  |
| 160              | 1087                       | 1139 | 1449 | 1883 |                                   | 138 | 132 | 104 | 80               | 1660                       | 1999                    | 2006 | 2091 | 2311                              | 779 | 776 | 745 | 674              | 4.6                        | 3.09                    | 3.13 | 3.25 | 1.40                              | 1.38 | 1.33 |    |  |
| 180              | 1104                       | 1152 | 1453 | 1885 |                                   | 153 | 147 | 116 | 90               | 1680                       | 2008                    | 2016 | 2100 | 2318                              | 785 | 782 | 751 | 680              | 4.8                        | 3.15                    | 3.19 | 3.31 | 1.43                              | 1.41 | 1.36 |    |  |
|                  | T(P1) = PBEAM - 92 MEV     |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 134 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 138 GEV |      |      |                                   |      |      |    |  |
| 200              | 1121                       | 1165 | 1457 | 1887 |                                   | 167 | 161 | 129 | 99               | 1700                       | 2018                    | 2025 | 2109 | 2325                              | 791 | 788 | 756 | 686              | 5.0                        | 3.21                    | 3.25 | 3.36 | 1.46                              | 1.44 | 1.40 |    |  |
| 220              | 1137                       | 1178 | 1462 | 1889 |                                   | 182 | 175 | 141 | 109              | 1720                       | 2027                    | 2034 | 2117 | 2332                              | 796 | 793 | 762 | 692              | 5.2                        | 3.27                    | 3.31 | 3.42 | 1.49                              | 1.48 | 1.43 |    |  |
| 240              | 1154                       | 1192 | 1468 | 1892 |                                   | 195 | 189 | 153 | 119              | 1740                       | 2036                    | 2043 | 2126 | 2339                              | 802 | 799 | 768 | 698              | 5.4                        | 3.32                    | 3.36 | 3.47 | 1.53                              | 1.51 | 1.46 |    |  |
| 260              | 1170                       | 1206 | 1474 | 1894 |                                   | 209 | 202 | 166 | 129              | 1760                       | 2045                    | 2053 | 2134 | 2346                              | 807 | 805 | 774 | 704              | 5.6                        | 3.38                    | 3.42 | 3.52 | 1.56                              | 1.54 | 1.49 |    |  |
| 280              | 1186                       | 1219 | 1480 | 1897 |                                   | 222 | 215 | 178 | 138              | 1780                       | 2054                    | 2062 | 2143 | 2353                              | 813 | 810 | 779 | 710              | 5.8                        | 3.43                    | 3.47 | 3.58 | 1.59                              | 1.57 | 1.52 |    |  |
|                  | T(P1) = PBEAM - 107 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 134 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 138 GEV |      |      |                                   |      |      |    |  |
| 300              | 1201                       | 1233 | 1486 | 1900 |                                   | 234 | 228 | 189 | 148              | 1800                       | 2064                    | 2071 | 2151 | 2360                              | 818 | 816 | 785 | 716              | 6.0                        | 3.49                    | 3.52 | 3.63 | 1.61                              | 1.60 | 1.55 |    |  |
| 320              | 1217                       | 1247 | 1493 | 1903 |                                   | 247 | 241 | 201 | 158              | 1820                       | 2073                    | 2080 | 2159 | 2367                              | 824 | 821 | 791 | 721              | 6.2                        | 3.54                    | 3.58 | 3.68 | 1.64                              | 1.63 | 1.58 |    |  |
| 340              | 1232                       | 1261 | 1500 | 1906 |                                   | 259 | 253 | 213 | 167              | 1840                       | 2082                    | 2089 | 2168 | 2374                              | 829 | 827 | 796 | 727              | 6.4                        | 3.59                    | 3.63 | 3.73 | 1.67                              | 1.65 | 1.61 |    |  |
| 360              | 1247                       | 1274 | 1507 | 1910 |                                   | 271 | 265 | 224 | 177              | 1860                       | 2091                    | 2098 | 2176 | 2381                              | 835 | 832 | 802 | 733              | 6.6                        | 3.65                    | 3.68 | 3.78 | 1.70                              | 1.68 | 1.64 |    |  |
| 380              | 1262                       | 1288 | 1514 | 1913 |                                   | 282 | 277 | 235 | 186              | 1880                       | 2100                    | 2107 | 2184 | 2388                              | 840 | 837 | 808 | 739              | 6.8                        | 3.70                    | 3.73 | 3.83 | 1.73                              | 1.71 | 1.67 |    |  |
|                  | T(P1) = PBEAM - 115 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 134 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 138 GEV |      |      |                                   |      |      |    |  |
| 400              | 1277                       | 1302 | 1522 | 1917 |                                   | 294 | 288 | 247 | 196              | 1900                       | 2108                    | 2115 | 2193 | 2395                              | 845 | 843 | 813 | 744              | 7.0                        | 3.75                    | 3.78 | 3.87 | 1.75                              | 1.74 | 1.70 |    |  |
| 420              | 1292                       | 1315 | 1530 | 1921 |                                   | 305 | 300 | 258 | 205              | 1920                       | 2117                    | 2124 | 2201 | 2402                              | 851 | 848 | 818 | 750              | 7.2                        | 3.80                    | 3.83 | 3.92 | 1.78                              | 1.76 | 1.72 |    |  |
| 440              | 1306                       | 1329 | 1538 | 1925 |                                   | 316 | 311 | 268 | 214              | 1940                       | 2126                    | 2133 | 2209 | 2409                              | 856 | 853 | 824 | 756              | 7.4                        | 3.85                    | 3.88 | 3.97 | 1.81                              | 1.79 | 1.75 |    |  |
| 460              | 1320                       | 1342 | 1546 | 1929 |                                   | 327 | 322 | 279 | 223              | 1960                       | 2135                    | 2142 | 2217 | 2416                              | 861 | 859 | 829 | 761              | 7.6                        | 3.89                    | 3.93 | 4.02 | 1.83                              | 1.82 | 1.78 |    |  |
| 480              | 1335                       | 1356 | 1554 | 1933 |                                   | 337 | 332 | 290 | 233              | 1980                       | 2144                    | 2150 | 2226 | 2423                              | 867 | 864 | 835 | 767              | 7.8                        | 3.94                    | 3.97 | 4.06 | 1.86                              | 1.84 | 1.80 |    |  |
|                  | T(P1) = PBEAM - 120 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 135 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 138 GEV |      |      |                                   |      |      |    |  |
| 500              | 1349                       | 1369 | 1563 | 1938 |                                   | 348 | 343 | 300 | 242              | 2000                       | 2153                    | 2159 | 2234 | 2430                              | 872 | 869 | 840 | 772              | 8.0                        | 3.99                    | 4.02 | 4.11 | 1.88                              | 1.87 | 1.83 |    |  |
| 520              | 1362                       | 1382 | 1572 | 1943 |                                   | 358 | 353 | 310 | 251              | 2020                       | 2161                    | 2168 | 2242 | 2437                              | 877 | 874 | 845 | 778              | 8.2                        | 4.04                    | 4.07 | 4.15 | 1.91                              | 1.89 | 1.85 |    |  |
| 540              | 1376                       | 1395 | 1580 | 1947 |                                   | 368 | 363 | 321 | 260              | 2040                       | 2170                    | 2176 | 2250 | 2444                              | 882 | 879 | 851 | 783              | 8.4                        | 4.08                    | 4.11 | 4.20 | 1.93                              | 1.92 | 1.88 |    |  |
| 560              | 1390                       | 1408 | 1589 | 1952 |                                   | 378 | 373 | 331 | 269              | 2060                       | 2179                    | 2185 | 2258 | 2451                              | 887 | 885 | 856 | 789              | 8.6                        | 4.13                    | 4.16 | 4.24 | 1.95                              | 1.94 | 1.90 |    |  |
| 580              | 1403                       | 1421 | 1598 | 1957 |                                   | 388 | 383 | 341 | 278              | 2080                       | 2187                    | 2194 | 2266 | 2458                              | 892 | 890 | 861 | 794              | 8.8                        | 4.17                    | 4.20 | 4.29 | 1.98                              | 1.96 | 1.93 |    |  |
|                  | T(P1) = PBEAM - 123 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 135 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 138 GEV |      |      |                                   |      |      |    |  |
| 600              | 1416                       | 1434 | 1607 | 1962 |                                   | 397 | 393 | 350 | 287              | 2100                       | 2196                    | 2202 | 2274 | 2465                              | 897 | 895 | 866 | 799              | 9.0                        | 4.22                    | 4.25 | 4.33 | 2.00                              | 1.99 | 1.95 |    |  |
| 620              | 1430                       | 1446 | 1616 | 1967 |                                   | 407 | 402 | 360 | 296              | 2120                       | 2204                    | 2211 | 2282 | 2472                              | 902 | 900 | 872 | 805              | 9.2                        | 4.26                    | 4.29 | 4.37 | 2.03                              | 2.01 | 1.97 |    |  |
| 640              | 1443                       | 1459 | 1625 | 1973 |                                   | 416 | 412 | 370 | 304              | 2140                       | 2213                    | 2219 | 2290 | 2479                              | 907 | 905 | 877 | 810              | 9.4                        | 4.31                    | 4.33 | 4.41 | 2.05                              | 2.03 | 2.00 |    |  |
| 660              | 1456                       | 1472 | 1634 | 1978 |                                   | 425 | 421 | 379 | 313              | 2160                       | 2221                    | 2227 | 2298 | 2486                              | 912 | 910 | 882 | 815              | 9.6                        | 4.35                    | 4.38 | 4.46 | 2.07                              | 2.06 | 2.02 |    |  |
| 680              | 1468                       | 1484 | 1644 | 1984 |                                   | 434 | 430 | 388 | 322              | 2180                       | 2230                    | 2236 | 2306 | 2493                              | 917 | 915 | 887 | 821              | 9.8                        | 4.39                    | 4.42 | 4.50 | 2.09                              | 2.08 | 2.04 |    |  |
|                  | T(P1) = PBEAM - 125 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 135 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 139 GEV |      |      |                                   |      |      |    |  |
| 700              | 1481                       | 1496 | 1653 | 1989 |                                   | 443 | 439 | 397 | 330              | 2200                       | 2238                    | 2244 | 2314 | 2500                              | 922 | 920 | 892 | 826              | 10.0                       | 4.43                    | 4.46 | 4.54 | 2.12                              | 2.10 | 2.07 |    |  |
| 720              | 1494                       | 1509 | 1662 | 1995 |                                   | 452 | 448 | 406 | 339              | 2220                       | 2246                    | 2253 | 2322 | 2507                              | 927 | 925 | 897 | 831              | 10.2                       | 4.47                    | 4.50 | 4.58 | 2.14                              | 2.12 | 2.09 |    |  |
| 740              | 1506                       | 1521 | 1671 | 2001 |                                   | 461 | 457 | 415 | 347              | 2240                       | 2255                    | 2261 | 2330 | 2514                              | 932 | 930 | 902 | 836              | 10.4                       | 4.51                    | 4.54 | 4.62 | 2.16                              | 2.14 | 2.11 |    |  |
| 760              | 1519                       | 1533 | 1681 | 2007 |                                   | 470 | 465 | 424 | 355              | 2260                       | 2263                    | 2269 | 2338 | 2520                              | 937 | 934 | 907 | 841              | 10.6                       | 4.55                    | 4.58 | 4.66 | 2.18                              | 2.16 | 2.13 |    |  |
| 780              | 1531                       | 1545 | 1690 | 2013 |                                   | 478 | 474 | 433 | 364              | 2280                       | 2271                    | 2277 | 2346 | 2527                              | 942 | 939 | 912 | 846              | 10.8                       | 4.59                    | 4.62 | 4.70 | 2.20                              | 2.18 | 2.15 |    |  |
|                  | T(P1) = PBEAM - 127 MEV    |      |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 135 MEV |      |      |                                   |     |     |     |                  |                            | T(P1) = PBEAM - 139 GEV |      |      |                                   |      |      |    |  |
| 800              | 1543                       | 1557 | 1705 | 2019 |                                   | 486 | 482 | 442 | 372              | 2300                       | 2280                    | 2286 | 2353 | 2534                              | 947 | 944 | 917 | 852              | 11.0                       | 4.63                    | 4.66 | 4.74 | 2.22                              | 2.20 | 2.17 |    |  |
| 820              | 1555                       | 1569 | 1709 | 2025 |                                   | 495 | 490 | 450 | 380              | 2320                       | 2288                    | 2294 | 2361 | 2541                              | 951 | 949 | 922 | 857              | 11.2                       | 4.67                    | 4.70 | 4.78 | 2.24                              | 2.22 | 2.19 |    |  |
| 840              | 1567                       | 1580 | 1718 | 2031 |                                   | 503 | 499 |     |                  |                            |                         |      |      |                                   |     |     |     |                  |                            |                         |      |      |                                   |      |      |    |  |

# SPECIAL RELATIVITY, PHASE SPACE, AND CROSS SECTIONS

**Notation.** 4-vector in c.m.  $p = (w, \vec{p})$ ; in lab  $P = (W, \vec{P})$ ,  $T = W - m$ .  
Solid-angle element  $d\omega = 2\pi d\cos\theta$ ;  $d\Omega = 2\pi d\cos\Theta$ .  
 $p^2 = w^2 - \vec{p}^2 = m^2$  is an invariant. Cross section  $\sigma$  is invariant.

## Lorentz Transformation

$$\begin{pmatrix} w \\ p_x \\ p_y \\ p_z \end{pmatrix} = \begin{pmatrix} \gamma & -\gamma\beta & 0 & 0 \\ 0 & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} W \\ P_x \\ P_y \\ P_z \end{pmatrix} \quad \text{If } \theta \text{ and } \Theta \text{ are measured with respect to the transformation axis x,}$$

$$\frac{p_x}{p_x} = \tan\theta = \frac{|\vec{P}| \sin\Theta}{-\gamma W + \gamma |\vec{P}| \cos\Theta} \quad (1)$$

If particle 1 is beam, 2 is target, then  $(W_2, \vec{P}_2) = (m_2, \vec{0})$  and  
 $\vec{v} = (W_1 + m_2)/\sqrt{s}$ ,  $\vec{p} = \vec{P}_1/\sqrt{s}$ ,  $|\vec{P}_1| = |\vec{P}_2| = \gamma m_2 = |\vec{P}_1| m_2/\sqrt{s}$ . (2)  
For  $m_1 = m_2$ ,  $\vec{v}^2 = 1 + T_1/2m_1$ .

**General Lorentz Transformation** [characterized by  $\vec{\beta}$ , with  $\gamma = (1 - \beta^2)^{-1/2}$  and  $\vec{n} = \vec{\beta}/\beta$ ]  
 $w = \gamma W - \vec{n} \cdot \vec{P}$ ;  $\vec{p} = \vec{P} - \frac{\vec{n} W + \vec{P} \cdot \vec{n}}{\gamma + 1}$ .

**A Useful Transformation:** Consider two 4-vectors  $Q = (E, \vec{Q})$  and  $q = (e, \vec{q})$ . In the rest frame of  $Q$  [ $Q' = (M, \vec{0})$ ],  $q$  becomes  $(q, \vec{q}')$

$e' = Q \cdot q/M$  and  $\vec{q}' = \vec{q} - f\vec{Q}$ ,  
where  $Q^2 = M^2$  and  $f = (e + e')/(E + M)$ . These equations follow from example (b), p. 34 of Hagedorn. They are particularly useful when  $Q$  is a sum of four-vectors that correspond to a resonant state.

**Invariants.** Notation:  $1 + 2 \rightarrow 1' + 2'$ .

$$s = (p_1 + p_2)^2 = m_1^2 + m_2^2 + 2(w_1 w_2 - \vec{p}_1 \cdot \vec{p}_2); \quad (3)$$

$$t = (p_1' - p_1)^2 = m_1^2 + m_1'^2 - 2(w_1 w_1' - \vec{p}_1 \cdot \vec{p}_1'), \quad (i = 1, 2), \quad (4)$$

$$u = (p_1' - p_2)^2 = (p_1' - p_1)^2 \quad [\text{use (6), below}]. \quad (5)$$

$$\text{General relation: } s + t + u = m_1^2 + m_1'^2 + m_2^2 + m_2'^2. \quad (6)$$

In lab system  $P_2 = (m_2, \vec{0})$ , and writing  $W = m + T$ ,

$$s = m_1^2 + m_2^2 + 2W_1 m_2 = (m_1 + m_2)^2 + 2T_1 m_2, \quad (3, \text{lab})$$

$$t = m_2^2 + m_1'^2 - 2W_1' m_2 = (m_2 - m_1')^2 - 2T_1' m_2. \quad (4, \text{lab})$$

$$\text{In c.m. system } dt = +2|\vec{P}_1| |\vec{P}_1'| d\cos\theta. \quad (4, \text{cm})$$

For elastic scattering ( $m_1 = m_1'$ ,  $m_2 = m_2'$ ), (4) and (5) in c.m. become

$$t = -2\vec{p}^2 (1 - \cos\theta) = -4\vec{p}^2 \sin^2\theta/2, \quad (4, \text{el})$$

$$u = (m_1^2 - m_2^2)^2/s - 2\vec{p}^2 (1 + \cos\theta) = (m_1^2 - m_2^2)^2/s - 4\vec{p}^2 \cos^2\theta/2. \quad (5, \text{el})$$

For elastic scattering, using (4, lab), (4, el), and (2),

$$T_2' = \frac{2\vec{P}_1^2 m_2}{s} \sin^2\left(\frac{\theta}{2}\right) \text{ (useful for calculating } \delta\text{-ray energies)}. \quad (7)$$

**Two-Body States.** Energies and momenta in c.m.

$$w_1 = \frac{s + m_1^2 - m_2^2}{2\sqrt{s}}, \quad \vec{p}_1^2 = \vec{p}_2^2 = \frac{1}{4s} [s - (m_1 + m_2)^2] [s - (m_1 - m_2)^2]. \quad (8)$$

**3- and 4-Body States.** Let  $m_{ij}^2 = (p_i + p_j)^2$ , etc.; then

$$\sum_{i < j} m_{ij}^2 = \sum m_1^2 + m_{123}^2 = \text{const. } (i, j = 1, 2, 3) \text{ [follows from (6)]} \quad (9)$$

$$= 2\sum m_1^2 + m_{1234}^2 = \text{const.} \quad (i, j, k = 1, 2, 3, 4.) \quad (10)$$

$$\sum_{i < j < k} m_{ijk}^2 = \sum m_1^2 + 2m_{1234}^2 = \text{const.}$$

## $R_n$ , Invariant Volume in n-Body Momentum Space

A useful invariant is  $\int d^4p \delta(p^2 - m^2) = \int \frac{d^3\vec{p}}{2w} = \int \frac{p^2 d\vec{p}}{2w} = \frac{1}{2} \int |\vec{p}| d\omega d\omega$ .  
 $R_2 = \pi |\vec{P}_1|/\sqrt{s}$ ,  $R_3 = \pi^2 \int dw_1 dw_2 = (\pi^2/4s) \int dm_{12}^2 dm_{23}^2$ .

## Recurrence Relation for Factoring $R_n$ (see e.g., Hagedorn, p. 93\*)

Write  $N \rightarrow 1, 2, \dots, k, k+1, \dots, n$  ( $R_n$ ),  
as  $N \rightarrow K, k+1, \dots, n$  ( $R_{n-k+1}$ )  $\left\{ \begin{array}{l} \text{then} \\ 1, 2, \dots, k \end{array} \right\}$  ( $R_k$ )  $\left\{ \begin{array}{l} \text{then} \\ R_n = \int d(m_K^2) R_{n-k+1} R_k \end{array} \right.$   
or as  $N \rightarrow K, L$   $\left\{ \begin{array}{l} L, k+1, \dots, n \end{array} \right\}$  ( $R_L$ )  $\left\{ \begin{array}{l} \text{then} \\ R_n = \int d(m_K^2) d(m_L^2) R_{n-k} R_L \frac{\pi p(KL)}{\sqrt{s}} \end{array} \right.$

## Cross Sections and Decay Rates†

For a system of  $n$  particles with overall four-momentum  $p$  and final momenta  $q_1, \dots, q_n$  [ $q_i = (e_i, \vec{q}_i)$ ], define Lorentz Invariant Phase Space

$$d\text{LIPS}(s; q_1, \dots, q_n) = (2\pi)^4 \delta^4(p - \sum q_i) \frac{1}{(2\pi)^{3n}} \prod_{i=1}^n \frac{d^3\vec{q}_i}{2e_i}. \quad (11)$$

Note that  $R_n = (2\pi)^{3n-4} \int d\text{LIPS}$ .

For  $1 + 2 \rightarrow n$  particles or  $1 \rightarrow n$  particles, in general  $|i\rangle \rightarrow |f\rangle$ ,

$$\sigma_{if} = \frac{1}{4F} \int |T_{if}|^2 d\text{LIPS}(s; q_1, \dots, q_n), \quad (12)$$

or

$$\Gamma_{if} = \frac{1}{2m_1} \int |T_{if}|^2 d\text{LIPS}(m_1^2; q_1, \dots, q_n), \quad (13)$$

where  $T_{if}$  is an invariant matrix element.  $F$  is Møller's invariant flux factor,  $F^2 = (p_1 \cdot p_2)^2 - p_1^2 p_2^2$ . In every system where  $\vec{p}_1$  and  $\vec{p}_2$  are collinear,  $F = w_1 w_2 |\vec{v}_1 - \vec{v}_2|$  ( $\vec{v} = \vec{p}/w$ ). If 1 is beam, 2, target ( $p_2 = 0$ ), then  $F = |\vec{P}_1| m_2 = |\vec{P}_1| \sqrt{s}$ .

For elastic scattering in c.m.,  $\frac{d\text{LIPS}}{d\Omega} = \frac{1}{(4\pi)^2} \frac{|\vec{P}_1|}{\sqrt{s}}$ , and (12) yields

$$\frac{d\sigma}{d\Omega} = \frac{|T|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|T|^2}{64\pi |\vec{P}_1|^2 s}. \quad (14)$$

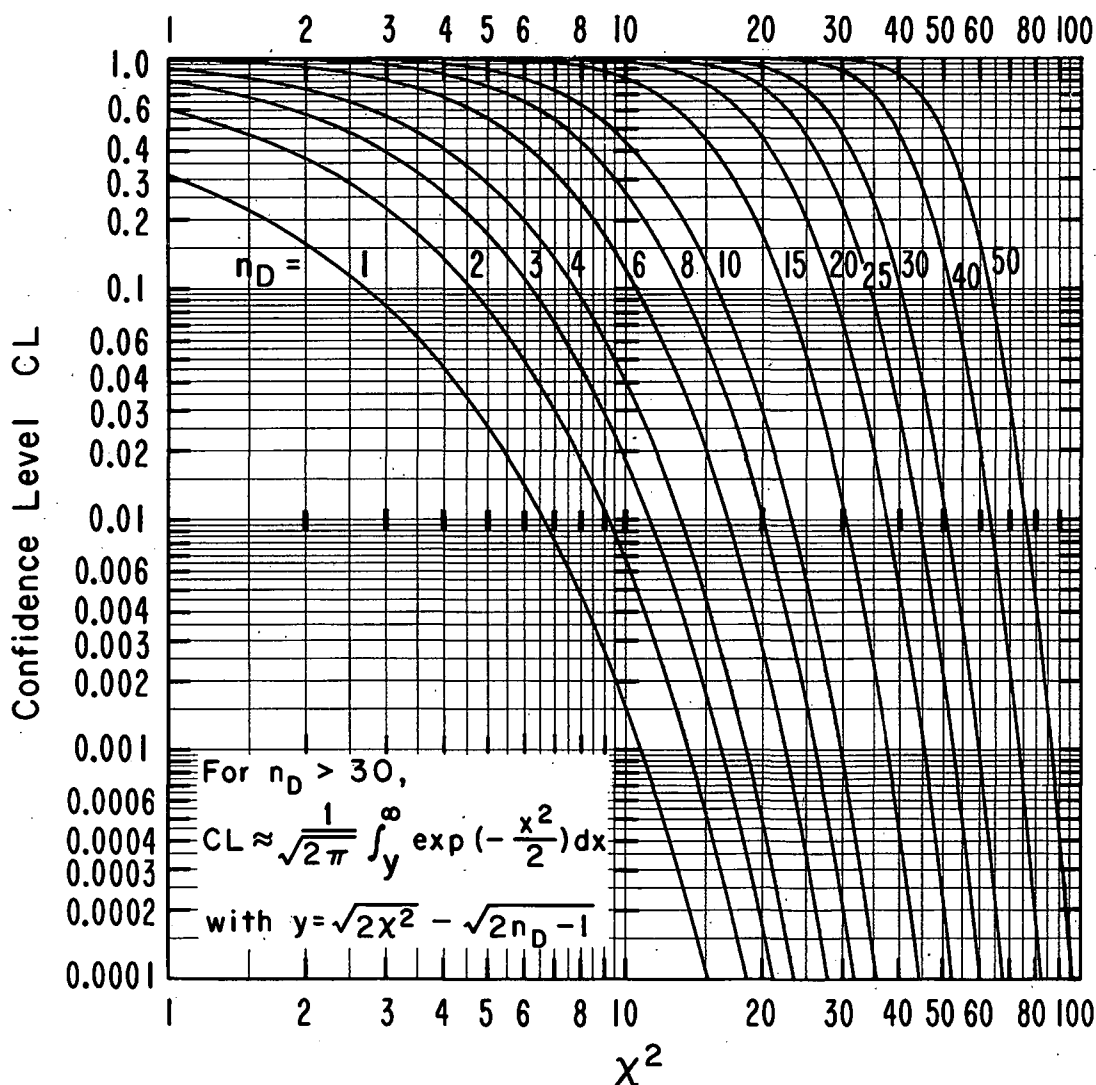
The normalization is such that the optical theorem reads

$$\text{Im } T|_{t=0} = 2|\vec{P}_1| \sqrt{s} \sigma_{\text{tot}}. \quad (15)$$

The choice of Eq. (11) implies a particular normalization of any spinors that may occur in  $T$ .† The advantage of this normalization is that it greatly simplifies the structure of  $T$  by putting factors such as  $\frac{1}{(2\pi)^3} \frac{1}{2E}$  into the phase space where they really belong. In addition, the labels,  $i, f$ ; refer to specific spin (helicity) states, so that the usual "average and sum" rule is implicit.

†R. Hagedorn, Relativistic Kinematics, W. A. Benjamin, New York, 1964.

†See, for example, Chaps. 1 and 2 of H. Pilkuhn, The Interactions of Hadrons, John Wiley & Sons, New York, 1967.

CONFIDENCE LEVEL VS.  $\chi^2$  FOR  $n_D$  DEGREES OF FREEDOM

For any  $n_D$ ,  $\langle \chi^2 \rangle = n_D$ ,  $\delta(\chi^2) = \sqrt{2n_D}$ . For large  $n_D$ ,  $\chi^2$  becomes normally distributed about  $n_D$ . Thus in the notation of the box in the figure,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \text{ has unit s. d.}$$

A better approximation, due to Fisher,\* is that  $\chi$ , not  $\chi^2$ , is normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \text{ has unit s. d.}$$

One sees then that  $y_1$  underestimates small C.L.'s. Thus for  $n = 50$  and  $\chi^2 = 80$ ,  $y_1 = 3.0$  and C.L. = 0.13% vs.  $y_2 = 2.7$ , C.L. = 0.35%.

\* R. A. Fisher, *Statistical Methods for Research Workers*, Oliver and Boyd, Edinburgh.

The Poisson distribution for  $x$ , when expected value is  $\bar{x}$ :

$$P(x, \bar{x}) = \bar{x}^x e^{-\bar{x}} / x!$$

Approximation for  $n!$ :

$$\sqrt{2\pi n} (n/e)^n < n! < \sqrt{2\pi n} (n/e)^n [1 + 1/(12n - 1)]$$

## GAUSSIANLIKE DISTRIBUTIONS

The distribution

$$P_{2n+1}(x) = \frac{1}{2^n n! \sigma^{2n+2}} x^{2n+1} \exp \left[ -\frac{x^2}{2\sigma^2} \right]$$

is normalized so that  $\int_0^\infty P_{2n+1}(x) dx = 1$ ; the normalization is valid for  $n > -1$  and not necessarily integral ( $(\frac{1}{2})! = \sqrt{\pi}/2$ ). For  $n = -1/2$  it reduces to the Gaussian distribution. Through a change of variables it yields the  $\chi^2$  distribution for  $n_D$  degrees of freedom:

$$P_{n_D}(\chi^2) = \frac{1}{2^{n_D/2} (\frac{n_D}{2} - 1)!} (\chi^2)^{n_D/2 - 1} \exp \left[ -\chi^2/2 \right].$$

Relation between standard deviation  $\sigma$  and mean deviation  $\alpha$ :

$$2\sigma^2 = \pi\alpha^2; \sigma = 1.4826 \text{ probable error.}$$

Odds against exceeding one standard deviation = 2.15:1; two, 21:1; three, 370:1; four, 16,000:1; five, 1,700,000:1.

## ATOMIC AND NUCLEAR PROPERTIES OF MATERIALS

| Material                                                 | Z  | A      | Nominal <sup>a</sup> Cross<br>Section $\sigma$<br>barns | Nominal Collision<br>Length $L_{\text{Coll.}}$ <sup>b</sup><br>g cm <sup>-2</sup> | Absorption<br>Length <sup>m, n</sup><br>$\lambda$ , cm | $dE/dx^c$<br>MeV<br>g/cm <sup>2</sup> | min.<br>MeV<br>cm   | Radiation Length                         |                      | Density<br>$\rho$<br>g cm <sup>-3</sup> |
|----------------------------------------------------------|----|--------|---------------------------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------|---------------------------------------|---------------------|------------------------------------------|----------------------|-----------------------------------------|
|                                                          |    |        |                                                         |                                                                                   |                                                        |                                       |                     | $L_{\text{rad}}^d$<br>g cm <sup>-2</sup> | cm                   |                                         |
| H <sub>2</sub>                                           | 1  | 1.01   | 0.063                                                   | 26.5                                                                              | 374 <sup>e</sup>                                       | 4.13                                  | 0.292 <sup>e</sup>  | 62.8                                     | 887 <sup>e</sup>     | 0.0708 <sup>e</sup>                     |
| D <sub>2</sub>                                           | 1  | 2.01   | 0.100                                                   | 33.4                                                                              | 202 <sup>e</sup>                                       | 2.07                                  | 0.342 <sup>e</sup>  | 126                                      | 764 <sup>e</sup>     | 0.165 <sup>e</sup>                      |
| He                                                       | 2  | 4.00   | 0.16                                                    | 42.0                                                                              | 336 <sup>e</sup>                                       | 1.94                                  | 0.243 <sup>e</sup>  | 93.1                                     | 745 <sup>e</sup>     | 0.125 <sup>e</sup>                      |
| Li                                                       | 3  | 6.94   | 0.23                                                    | 50.4                                                                              | 94.4                                                   | 1.69                                  | 0.902               | 83.3                                     | 156                  | 0.534                                   |
| Be                                                       | 4  | 9.01   | 0.28                                                    | 55.0                                                                              | 29.8                                                   | 1.60                                  | 2.96                | 66.0                                     | 35.7                 | 1.848                                   |
| C                                                        | 6  | 12.01  | 0.33                                                    | 60.4                                                                              | f                                                      | 1.78                                  | f                   | 43.3                                     | f                    | $\approx 1.55^f$                        |
| N <sub>2</sub>                                           | 7  | 14.01  | 0.36                                                    | 63.6                                                                              | 78.7 <sup>e</sup>                                      | 1.81                                  | 1.46 <sup>e</sup>   | 38.6                                     | 47.8 <sup>e</sup>    | 0.808 <sup>e</sup>                      |
| Ne                                                       | 10 | 20.18  | 0.465                                                   | 72.1                                                                              | 60.1 <sup>e</sup>                                      | 1.73                                  | 2.08 <sup>e</sup>   | 29.1 <sup>i</sup>                        | 24.3 <sup>e, i</sup> | 1.200 <sup>e, k</sup>                   |
| Al                                                       | 13 | 26.98  | 0.57                                                    | 79.2                                                                              | 29.3                                                   | 1.62                                  | 4.37                | 24.3                                     | 9.00                 | 2.70                                    |
| Fe                                                       | 26 | 55.85  | 0.92                                                    | 101.2                                                                             | 12.9                                                   | 1.48                                  | 11.6                | 13.9                                     | 1.77                 | 7.87                                    |
| Cu                                                       | 29 | 63.54  | 1.00                                                    | 105.4                                                                             | 11.8                                                   | 1.44                                  | 12.9                | 13.0                                     | 1.45                 | 8.96                                    |
| Sn                                                       | 50 | 118.69 | 1.55                                                    | 129.7                                                                             | 17.7                                                   | 1.28                                  | 9.4                 | 8.9                                      | 1.22                 | 7.31                                    |
| W                                                        | 74 | 183.85 | 2.02                                                    | 150.8                                                                             | 7.81                                                   | 1.17                                  | 22.6                | 6.8                                      | 0.35                 | 19.3                                    |
| Pb                                                       | 82 | 207.19 | 2.20                                                    | 156.2                                                                             | 13.8                                                   | 1.13                                  | 12.8                | 6.4                                      | 0.56                 | 11.35                                   |
| U                                                        | 92 | 238.03 | 2.42                                                    | 163.6                                                                             | $\approx 8.63$                                         | 1.09                                  | $\approx 20.7$      | 6.1                                      | $\approx 0.32$       | $\approx 18.95$                         |
| Air                                                      |    |        |                                                         | 64.6                                                                              | 53610 <sup>g</sup>                                     | 1.81                                  | 0.0022 <sup>g</sup> | 37.2                                     | 30870 <sup>g</sup>   | 0.001205 <sup>g</sup>                   |
| Freon (CF <sub>3</sub> Br)                               |    |        |                                                         | 87.1                                                                              | $\approx 58$                                           | 1.52                                  | $\approx 2.3$       | 16.7                                     | $\approx 11$         | $\approx 1.5$                           |
| H <sub>2</sub> (bubble chamber, 27° K)                   |    |        |                                                         | 26.5                                                                              | 442 <sup>h</sup>                                       | 4.13                                  | 0.248 <sup>h</sup>  | 62.8                                     | 1050 <sup>h</sup>    | $\approx 0.060^h$                       |
| H-Ne mixture (bubble chamber) <sup>j</sup>               |    |        |                                                         | 67.3                                                                              | 96.1                                                   | 1.83                                  | 1.28                | 29.2 <sup>i</sup>                        | 42.6 <sup>i</sup>    | 0.70                                    |
| H <sub>2</sub> O                                         |    |        |                                                         | 57.2                                                                              | 57.2                                                   | 2.03                                  | 2.03                | 36.4                                     | 36.4                 | 1.00                                    |
| Ilford Emulsion                                          |    |        |                                                         | 103.0                                                                             | 27.0                                                   | 1.44                                  | 5.49                | 11.2                                     | 2.94                 | 3.815                                   |
| LiF                                                      |    |        |                                                         | 63.8                                                                              | 24.2                                                   | 1.69                                  | 4.46                | 39.8                                     | 15.1                 | 2.64                                    |
| Mylar (C <sub>5</sub> H <sub>4</sub> O <sub>2</sub> )    |    |        |                                                         | 59.1                                                                              | 42.8                                                   | 1.91                                  | 2.64                | 40.4                                     | 29.3                 | 1.38                                    |
| NaI                                                      |    |        |                                                         | 119.0                                                                             | 32.4                                                   | 1.32                                  | 4.84                | 9.5                                      | 2.59                 | 3.67                                    |
| Polyethylene (CH <sub>2</sub> )                          |    |        |                                                         | 51.0                                                                              | $\approx 55$                                           | 2.09                                  | $\approx 1.92$      | 45.3                                     | $\approx 49$         | $\approx 0.92$                          |
| Polystyrene (CH) <sup>k</sup> [ $\approx$ Scintillator ] |    |        |                                                         | 54.9                                                                              | $\approx 52$                                           | 2.03                                  | $\approx 2.13$      | 44.3                                     | $\approx 42$         | $\approx 1.05$                          |
| Propane (C <sub>3</sub> H <sub>8</sub> , bubble chamber) |    |        |                                                         | 48.9                                                                              | 119                                                    | 2.28                                  | 0.94                | 45.9                                     | 112                  | 0.41                                    |

- a.  $\sigma = \sigma_{\text{nominal}} = \pi (h/m_e c)^2 \times A^{2/3} = 62.8 \text{ mb} \times A^{2/3}$  } NOTE: These quantities are calculated assuming a "nuclear  
b.  $L_{\text{coll}} = A/(N\sigma_{\text{natural}}) = 26.5 \text{ g cm}^{-2} \times A^{1/3}$  } radius" =  $(h/m_e c) A^{1/3} = (1.4f) A^{1/3}$ . But attenuation of 25 GeV/c  
c. From W. H. Barkas and M. J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles,  
NASA SP-3013 (1964). } protons<sup>m</sup> and 20 GeV/c neutrons<sup>n</sup> is only 3/4 nominal.  
d. Mainly from O. I. Dovzhenko and A. A. Pomanskii, Soviet Physics JETP **18**, 187 (1964).  
e. For liquid phase at 1 atm. and boiling temperature.  
f. Density variable.  
g. At 20° C.  
h. May vary by about ±3% depending on operating conditions.  
i. From F. R. Huson, Ionization Loss, Range, Straggling and Multiple Scattering, BNL 11386 (1967).  
j. 53.7 atomic percent Ne.  
k. Density of gas at STP =  $0.900 \times 10^{-3} \text{ g cm}^{-3}$ , i.e.,  $0.75 \times 10^{-3}$  times the density (1.200) of the boiling liquid.  
l. Typical scintillator; e.g., PILOT B has an atomic ratio H/C = 1.1.  
m. G. Cocconi, Proc. 1960 Rochester Conf., p. 804, Fig. 6, find for attenuation,  $r$  (nuclear) =  $1.23 A^{1/3}$ .  
n. J. Engler et al., Nucl. Instr. and Meth. **106**, 189 (1973) report  $\lambda(\text{Fe}) = (17.1 \pm 0.3) \text{ cm}$ ,  $\lambda(\text{Scintillator}) = (68.5 \pm 1.5) \text{ cm}$ .

## MULTIPLE COULOMB SCATTERING\*

The rms projected angle  $\theta$  due to multiple Coulomb scattering (only) of a particle of charge  $z$  (in units of electron charge), momentum  $p$  (in MeV/c), and velocity  $v$  (in units of  $c$ ) is

$$\theta_{\text{proj}} = z \frac{15}{\beta v} \sqrt{\frac{L}{L_{\text{rad}}}} (1 + \epsilon) \text{ radians;}$$

where  $L$  = length in scatterer.

For  $L \geq 1/10 L_{\text{rad}}$ ,  $\epsilon$  is generally  $< 1/10$ . The distribution of  $\theta$  is not truly Gaussian.<sup>†</sup>

The rms projected displacement  $y$  on traversing an absorber of thickness  $L$  is

$$y_{\text{rms}} = L \theta_{\text{proj}} \sqrt{3}.$$

\*Mainly from G. Z. Molière, Naturforsch. **3** (a), 78 (1948).

†See, for example, the experimental work of A. D. Hansen, L. H. Lanzl, E. M. Lyman, and M. B. Scott, Phys. Rev. **84**, 634 (1951).

## RADIOACTIVITY AND RADIATION PROTECTION

Unit of activity = Curie:

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ disintegrations/sec}$$

Unit of exposure dose for  $x$  and  $\gamma$  radiation = Roentgen:

$$1 \text{ R} = 1 \text{ esu/cm}^2 = 87.8 \text{ erg/g} (5.49 \times 10^7 \text{ MeV/g}) \text{ of air}$$

Unit of absorbed dose = rad:

$$1 \text{ rad} = 100 \text{ erg/g} (6.25 \times 10^7 \text{ MeV/g}) \text{ in any material}$$

Unit of dose equivalent (for protection) = rem:

rems (Roentgen equivalents for man) = rads  $\times$  QF, where QF (quality factor) depends upon the type of radiation and other factors. For  $\gamma$  rays and HE protons, QF  $\approx 1$ ; for thermal neutrons, QF  $\approx 3$ ; for fast neutrons, QF ranges up to 10; and for  $\alpha$  particles and heavy ions, QF ranges up to 20. Maximum permissible occupational dose for the whole body:

$$5 \text{ rem/year (or } \approx 100 \text{ millirem/week)}$$

Fluxes (per cm<sup>2</sup>) to liberate 1R in carbon:

$$3 \times 10^7 \text{ minimum ionizing singly charged particles}$$

$$0.9 \times 10^9 \text{ protons of 1 MeV energy}$$

(These fluxes are correct to within a factor of 2 for all materials.)

Natural background: 120 to 130 millirem/year

cosmic radiation (charged particles + neutrons) ~ 25

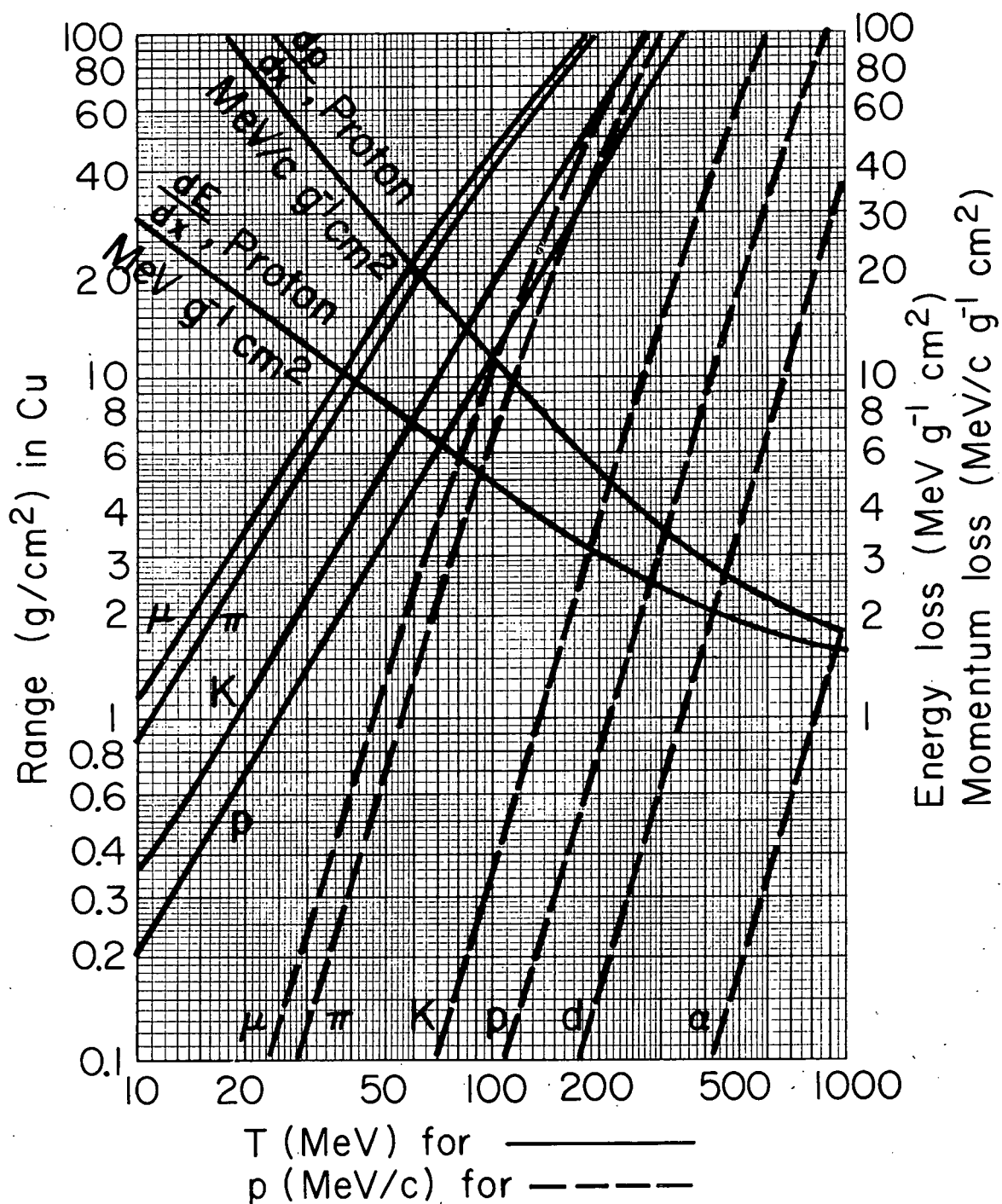
cosmic radiation ( $\gamma$  rays) ~ 25

radiation from rocks and air ( $\gamma$  rays) ~ 73

Cosmic ray background in counters: ~ 1/min/cm<sup>2</sup>/ster

mrem/yr

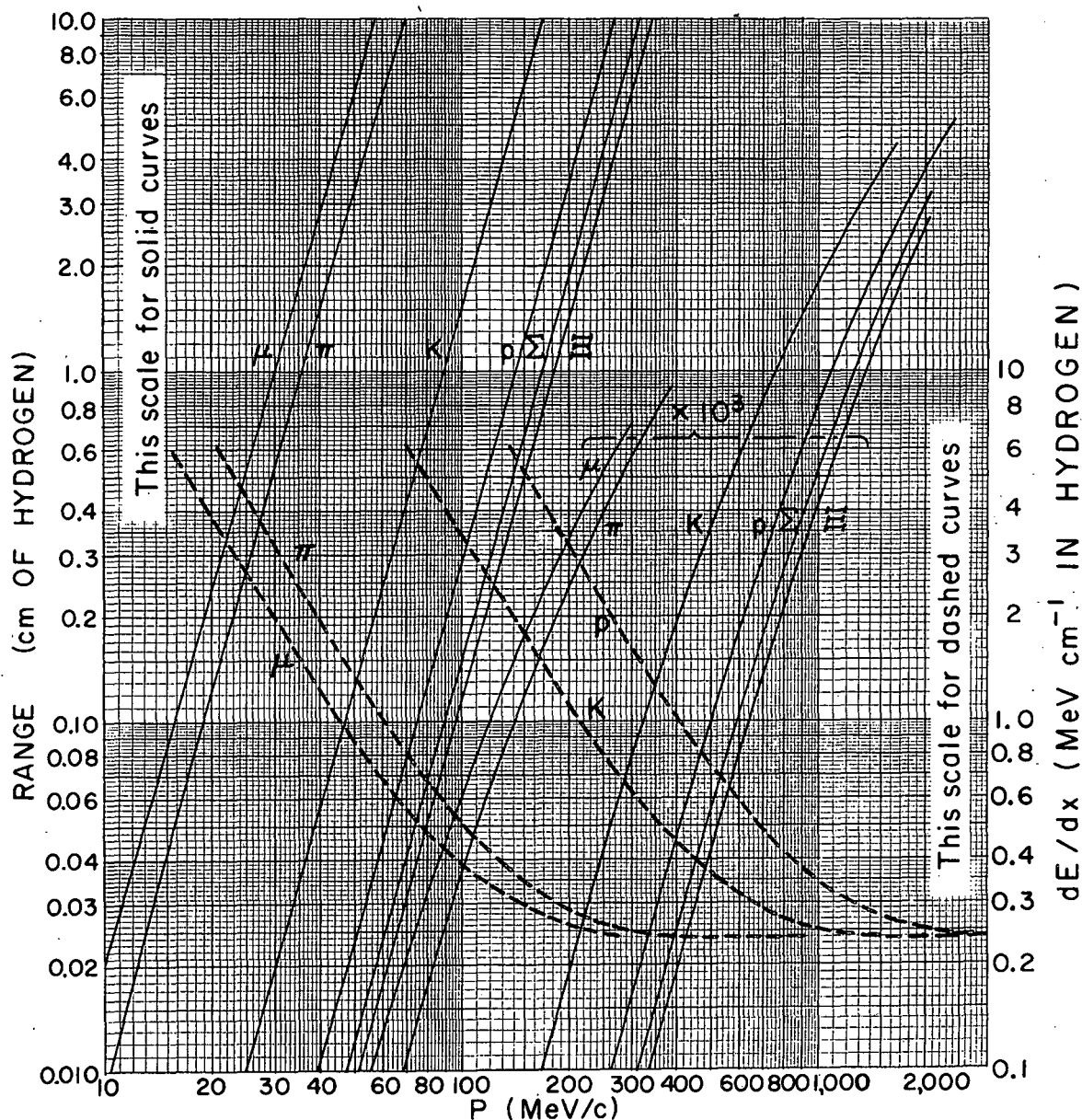
## RANGE AND ENERGY LOSS IN COPPER



Range and energy/momentum loss in copper, based on a calculation assuming a nominal mean excitation potential of 310 eV. (Calculation by W. A. Aron, UCRL-1325, 1951). The abscissa is to be read as kinetic energy  $T$  for the solid curves and momentum  $p$  for the dashed curves.

See scaling law at bottom of next page.

## RANGE AND ENERGY LOSS IN LIQUID HYDROGEN

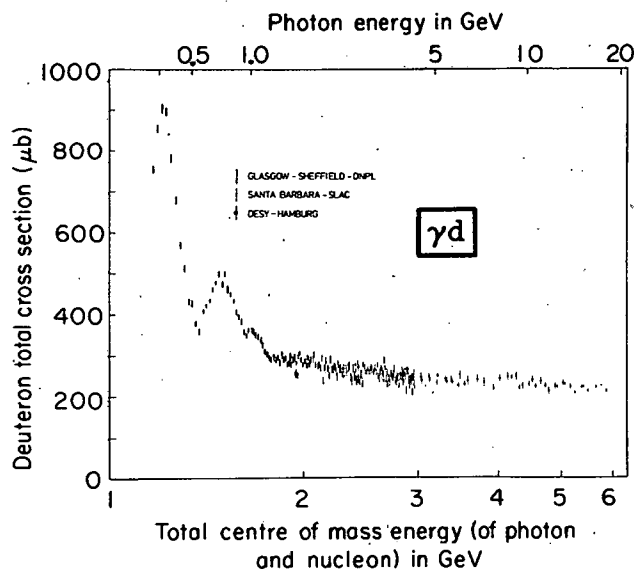
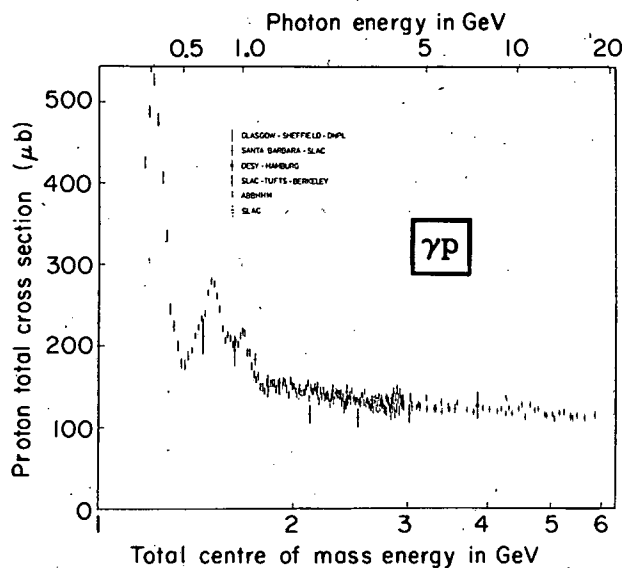


Range and energy loss in liquid hydrogen bubble chamber, determined by a  $\mu^+$  range of  $1.103 \pm 0.003$  cm from the  $\pi^+ \rightarrow \mu^+ \nu$  decay. Liquid hydrogen conditions:  $T = 27.6 \pm 0.1^\circ K$ ;  $P = 48 \pm 5$  psia;  $\rho = (5.86 \pm 0.06) 10^{-2} g/cm^3$ . (Data by Clark and Diehl, UCRL-3789, 1957.) Bubble chamber physicists: note that the number of bubbles per cm is proportional to  $1/\beta^2$ , not to  $dE/dx$ .

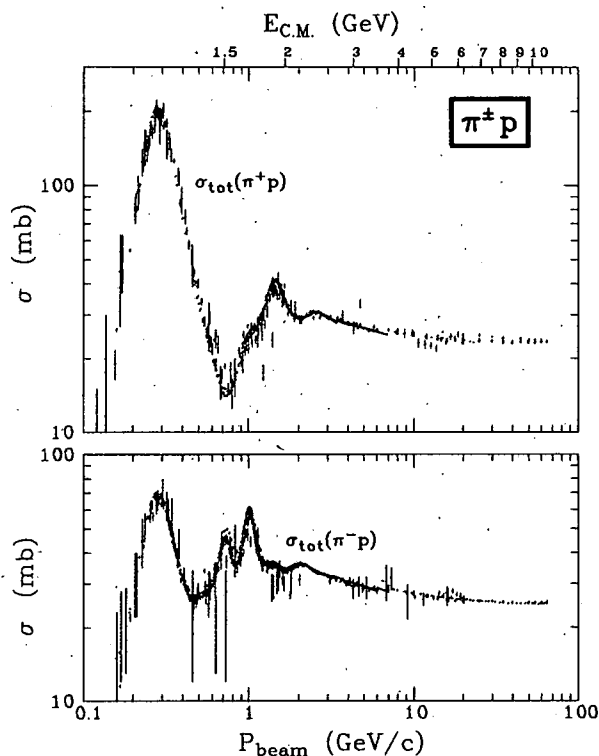
Scaling law for particles of other mass or charge: for a given medium, the range  $R_b$  of any beam particle with mass  $M_b$ , charge  $z_b$ , and momentum  $p_b$  is given in terms of the range  $R_a$  of any other particle with mass  $M_a$ , charge  $z_a$ , and momentum  $p_a = p_b M_a / M_b$  (i. e., having the same velocity) by the expression

$$R_b(M_b, z_b, p_b) = \left[ \frac{M_b/M_a}{z_b^2/z_a^2} \right] R_a(M_a, z_a, p_a = p_b M_a / M_b).$$

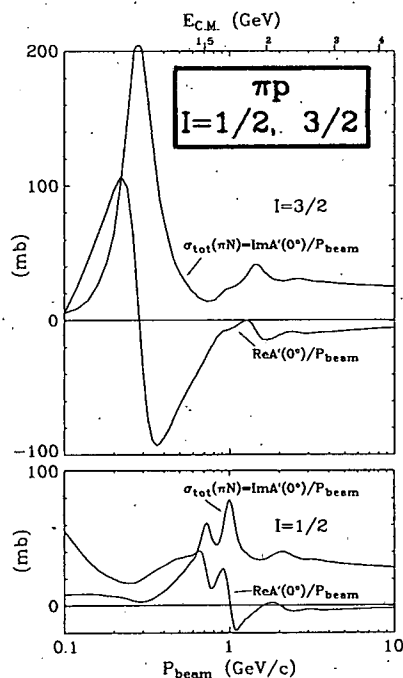
## CROSS SECTION PLOTS



$\sigma_{\text{tot}}(\gamma p)$  and  $\sigma_{\text{tot}}(\gamma d)$  as compiled by G. M. Lewis, Glasgow.

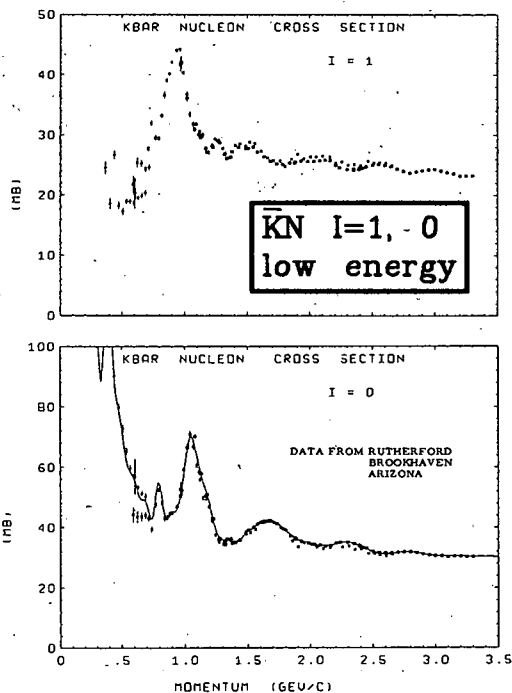
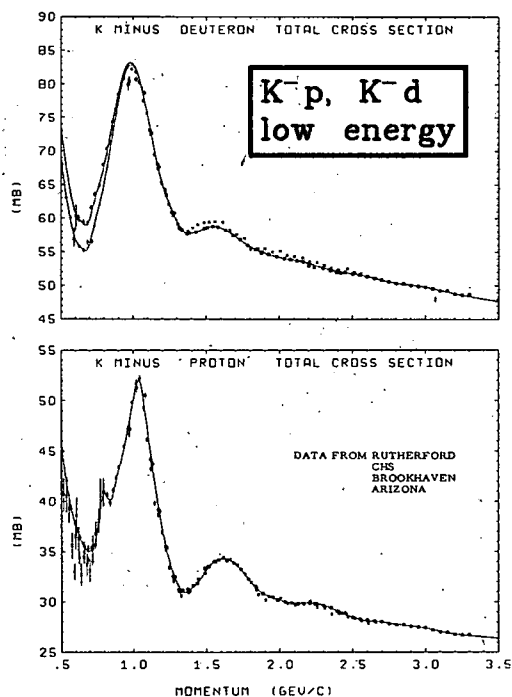


$\pi N$  total cross section data from the compilation of C. Lovelace, et al. (see Sec. VI C of the text).

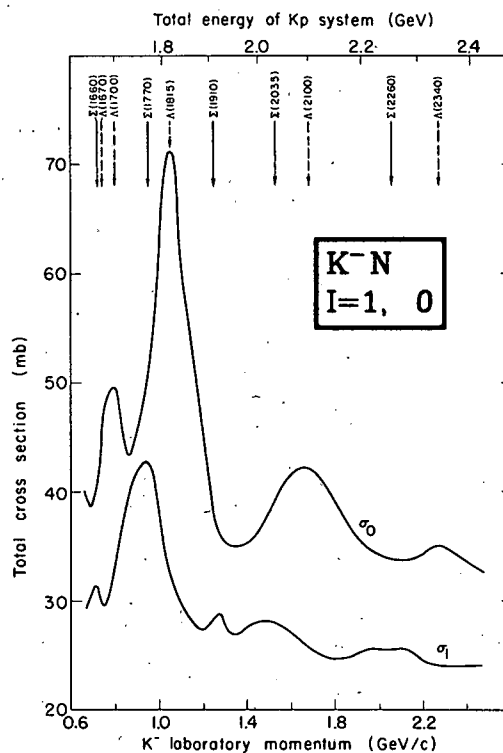
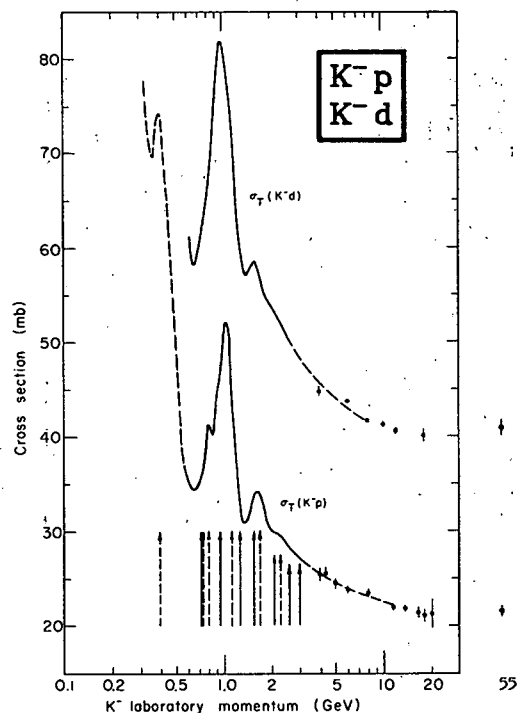


A smooth interpolation of the  $\pi N$  total cross sections for  $I=3/2$  and  $I=1/2$ , and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by G. Hühler and H. P. Jakob (private communication). The normalization of the curves for each value of  $I$  is such that the sum of their squares divided by 49.6 gives  $d\sigma/dt$  at  $0^\circ$  in  $\text{mb}/(\text{GeV}/c)^2$ .

## CROSS SECTION PLOTS

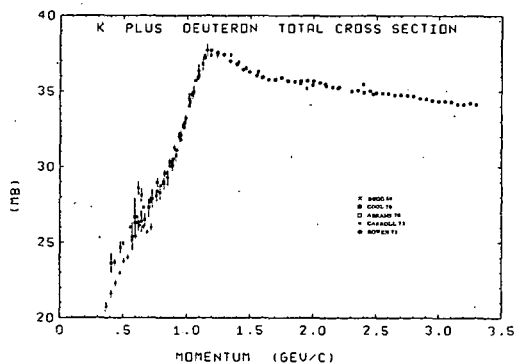
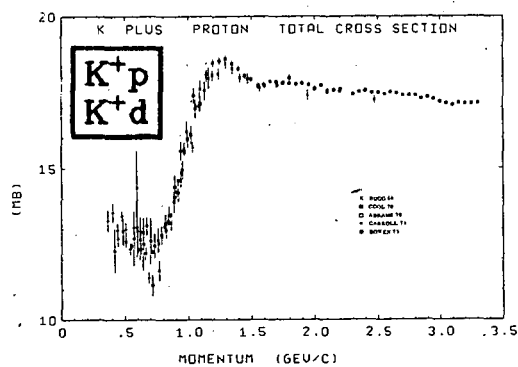


Compiled and unfolded by G. R. Lynch,  
 Proc. 1970 Duke Baryon Conference.

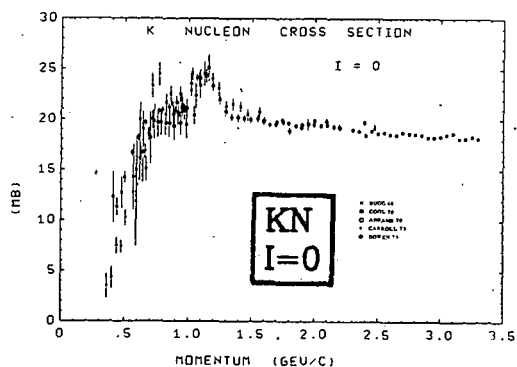


From A. Barbaro-Galtieri in *Advances in Particle Physics*,  
 Vol. 2, edited by R. L. Cool and R. E. Marshak (Wiley &  
 Sons, 1968). The points at 55 GeV/c are taken from IHEP-  
 CERN Collab., Phys. Letters **30B**, 500 (1969).

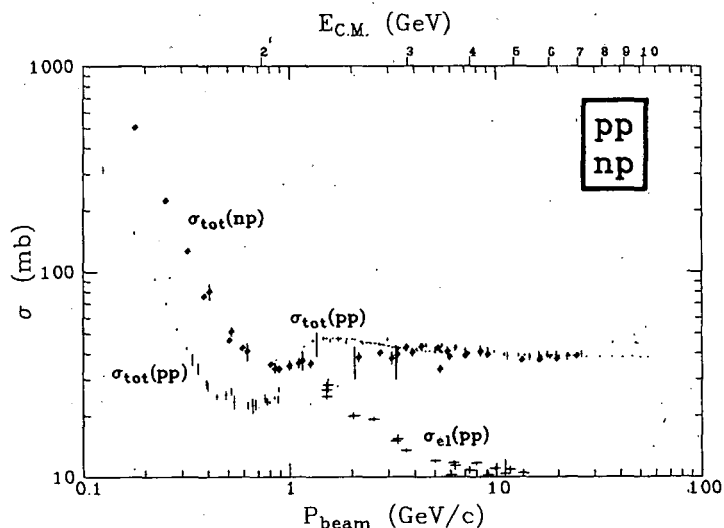
## CROSS SECTION PLOTS



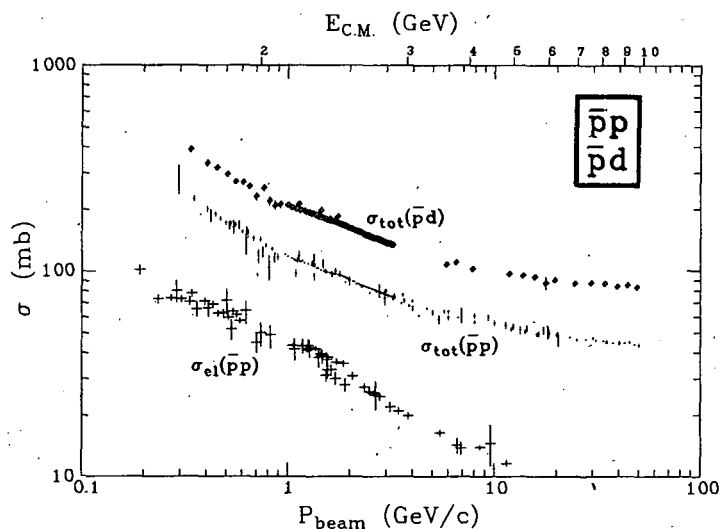
Compilation of recent  $K^+p$  and  $K^+d$  total cross-section measurements. References can be found in the Baryon Data Card Listings.



Total cross-section for isospin zero KN system. Unfolding of the BUGG 68 and BOWEN 70 and 73 data was done by G. R. Lynch (as in Proc. of 1970 Duke Conference). Tables of  $\sigma_0$  were provided by the BNL authors. Lynch and BNL use the same method of unfolding; the BOWEN 73 unfolded distribution is obtained by a different method (see plot in Z<sup>+</sup> mini-review in the Baryon Data Card Listings).



pp and np cross sections from Particle Data Group, "NN and ND Interactions -- A Compilation". UCRL-20 000 NN (August 1970); some points at higher energies added since original compilation.



$\bar{p}p$  and  $\bar{p}d$  cross sections from Particle Data Group, "A Compilation of  $\bar{N}N$  and  $\bar{N}D$  Reactions", LBL-58 (1972).

## DATA CARD LISTINGS

## Illustrative Key

Name of particle as it appears in table. **XX(1200)**

Arrow indicates this particle omitted from table. **74 XX MESON (1200, JP<sub>G</sub>= -) I=1**

Quantity tabulated below. **74 XX(1200) MASS (MEV)**

Code for quantity tabulated (M=mass, W=width, etc.)

Symbols used to key together data card and related comments.

Number of events above background.

Measured values (parentheses indicate value not used in average).

\* Error in measured value (- field blank if error symmetric; parentheses on error only indicate data not used in average due to problems with error estimation).

Average value (and error) of quantity measured.

Vertical bar indicates average; width of horizontal bar on top is error (scaled) in average.

Value and error for each experiment.

Particle name, and quantum numbers (if known).

Particle code (for internal use only).

General comments on particle.

Abbreviated reference for this result; full reference given below.

Measurement technique (see abbreviations on next page.)

Charge(s) of particle detected.

Reaction producing particle, or comments.

Date this result punched (asterisk indicates result added or changed since previous edition).

Scale factor > 1 indicates inconsistent data.

Ideogram to display inconsistent data; curve is sum of Gaussians, one for each experiment (area of Gaussian = 1/error; width of Gaussian =  $\pm$  error).

Contribution of experiment to  $\chi^2$  (if no entry present, experiment not used in calculating  $\chi^2$  or scale factor because of large error).

74 XX(1200) MASS (MEV)

| EXPT           | MASS (MEV) | ERR (MEV) | CHISQ     |
|----------------|------------|-----------|-----------|
| MERRILL 66 HBC | 1216.      | 11.       | 0/3.2 K-P |
| LYNCH 67 HBC   | 1192.      | 16.       | 2.7 PI-P  |
| PIERCE 68 ASPK | 1198.      | 10.       | 2.1 K-P   |
| FENNER 69 HBC  | 1208.1     | 8.        | 4.2 PI+P  |
| SMITH 70 MMS   | 1210.      | 8.        | 3.5 PI-P  |

LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION

80 SUPERSEDES EARLIER RESULT

AVG 1206.9 5.1 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

74 XX(1200) WIDTH (MEV)

| EXPT           | WIDTH (MEV) | ERR (MEV) | CHISQ     |
|----------------|-------------|-----------|-----------|
| MERRILL 66 HBC | 35.         | 5.        | 0/3.2 K-P |
| PIERCE 68 ASPK | 50.         | 10.       | 2.1 K-P   |
| FENNER 69 HBC  | 70.         | 40.       | 4.2 PI+P  |
| SMITH 70 MMS   | (60.)       | OR LESS   | 3.5 PI-P  |

OR LESS

AVG 38.4 6.0 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

WEIGHTED AVERAGE = 38.4  $\pm$  6.0  
ERROR SCALED BY 1.3

74 XX(1200) PARTIAL DECAY MODES

| MODE                    | DECAY MASSES  |
|-------------------------|---------------|
| P1 XX(1200) INTO 3PI    | 139+ 139+ 139 |
| P2 XX(1200) INTO K KBAR | 493+ 493      |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
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| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
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| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
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| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
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| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 XX(1200) INTO KKBAR/TOTAL                            | .35             | .05   | (P2)                                          |
| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

74 XX(1200) BRANCHING RATIOS

| MODE                                                    | BRANCHING RATIO | ERR   | CHISQ                                         |
|---------------------------------------------------------|-----------------|-------|-----------------------------------------------|
| R1 XX(1200) INTO 3PI/TOTAL                              | .66             | .02   | (P1)                                          |
| R1 L                                                    | (.68)           | (.03) | 2.7 PI-P                                      |
| R1 L LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION |                 |       |                                               |
| R1 FIT                                                  | 0.675           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
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| R2 FIT                                                  | 0.325           | 0.012 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
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| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           | 0.043 | 3.5 PI-P                                      |
| R3 FIT                                                  | 0.480           | 0.026 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)  |

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| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
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| R3 XX(1200) INTO KKBAR/3PI                              | .50             | .03   | (P2)/(P1)                                     |
| R3 P3                                                   | .41             | .04   | 4.2 PI+P                                      |
| R3 AVG                                                  | 0.468           |       |                                               |

## Illustrative Key (cont'd)

## Abbreviations

## Journals

|       |                                               |
|-------|-----------------------------------------------|
| APAH  | Acta Phys. Acad. Hungarica                    |
| ADVP  | Advances in Physics                           |
| ANP   | Annals of Physics                             |
| ARNS  | Annual Reviews of Nuclear Science             |
| BAPS  | Bulletin of the American Physical Society     |
| JETP  | English Translation of Soviet Physics JETP    |
| JETPL | Letters to Soviet Physics JETP                |
| LNC   | Letters to Nuovo Cimento                      |
| NC    | Nuovo Cimento                                 |
| NP    | Nuclear Physics                               |
| PL    | Physics Letters                               |
| PN    | Particles and Nuclei                          |
| PPSL  | Proceedings of the Physical Society of London |
| PR    | Physical Review                               |
| PRL   | Physical Review Letters                       |
| PRSL  | Proceedings of the Royal Society of London    |
| RMP   | Reviews of Modern Physics                     |
| SJNP  | Soviet Journal of Nuclear Physics             |
| ZJPY  | Zeitschrift für Physik                        |

## Institutions

|         |                                        |
|---------|----------------------------------------|
| AACH    | TECHNISCHE UNIV. AACHEN                |
| AERE    | ATOMIC ENERGY RES. ESTAB.              |
| AMST    | UNIV. OF AMSTERDAM                     |
| ANKA    | MIDDLE EAST TECHNICAL UNIV.            |
| ARGONNE | ARGONNE NAT. LAB.                      |
| ARIZ    | UNIV. OF ARIZONA                       |
| ATEN    | NUCLEAR RES. CENTRE DEMOKRITOS         |
| BARI    | UNIV. DELI STAD. DI BARI               |
| BELG    | INST. INTERUNIV. DES SCI. NUC.         |
| BORG    | FYSIK INSTITUT                         |
| BERL    | INST. HOCHENERGIEPHYS. DAM             |
| BERN    | UNIV. BERN                             |
| BOLGNA  | UNIV. DI BOLOGNA                       |
| BING    | STATE UNIV. OF NEW YORK AT BINGHAMTON  |
| BIRM    | BIRMINGHAM UNIV.                       |
| BNL     | BROOKHAVEN NATIONAL LAB.               |
| BOHR    | NIELS BOHR INSTITUTE                   |
| BOHN    | UNIV. BOHN                             |
| BOST    | BOSTON UNIV.                           |
| BRAN    | BRANDEIS UNIV.                         |
| BRIS    | H. H. WILLS PHYS. LAB., U. OF BRISTOL  |
| BROU    | BROUWER UNIV.                          |
| BRUX    | UNIV. LIBRE DE BRUXELLES               |
| BUCH    | BUCHAREST STATE UNIV.                  |
| BUDA    | CENTRAL RESEARCH INSTITUTE OF PHYSICS  |
| BUFF    | STATE UNIV. OF NEW YORK AT BUFFALO     |
| CAEN    | LAB. DE PHYS. CORPUSCULAIRE            |
| CARL    | CARLTON UNIV.                          |
| CARN    | CARNEGIE-MELLON UNIV.                  |
| CASE    | CASE WESTERN RESERVE UNIV.             |
| CAVE    | CAVENDISH LAB., CAMBRIDGE UNIV.        |
| CEFE    | COLLEGE DE FRANCE                      |
| CEA     | CANDIDE ELECTRON ACCEL.                |
| CERN    | EUROPEAN ORG. FOR NUC. RES.            |
| CHIC    | UNIV. OF CHICAGO                       |
| CINC    | UNIV. OF CINCINNATI                    |
| CIT     | CALIF. INSTITUTE OF TECHNOLOGY         |
| CNRC    | CANADIAN NATIONAL RESEARCH COUNCIL     |
| COLO    | UNIV. OF COLORADO                      |
| COLU    | COLUMBIA UNIV.                         |
| CORN    | CORNELL UNIV.                          |
| CUNY    | INST. FOR NUCLEAR RESEARCH             |
| CUP1    | LABORATOIRE JOLIO-CURIE                |
| DARE    | DARESBURY NUC. PHYS. LAB.              |
| DART    | DARTMOUTH COLLEGE                      |
| DESY    | DEUTISCHE ELEKTROEN-SYNCH.             |
| DUKE    | DUKE UNIV.                             |
| DURH    | UNIV. OF DURHAM                        |
| DURM    | DURHAM COLLEGE                         |
| EDIN    | UNIV. OF EDINBURGH                     |
| EPR     | ENRICO FERMI INST. FOR NUC. STUDIES    |
| EPOL    | ECOLE POLYTECHNIQUE                    |
| ETHZ    | SWISS FEDERAL INST. OF TECHNOLOGY      |
| FIPZ    | UNIV. DI FIRENZE                       |
| FISK    | FISK UNIV.                             |
| FLOR    | UNIV. OF FLORIDA                       |
| FRAS    | LAB. NAZIONALE DEL SINCROTRONE         |
| FSU     | FLORIDA STATE UNIV.                    |
| GENO    | UNIV. DI GENOVA                        |
| GEVA    | UNIV. DE GENEVE                        |
| GLAS    | UNIV. OF GLASGOW                       |
| GRAZ    | UNIV. GRAZ                             |
| HAIF    | TECHNION - ISRAEL INST. OF TECHNOLOGY  |
| HAMB    | HAMBURG UNIV.                          |
| HARV    | HARVARD UNIV.                          |
| HAWA    | UNIV. OF HAWAII                        |
| HEID    | UNIV. HEIDELBERG                       |
| HELS    | HELSINKI UNIV.                         |
| ILL     | ILLINOIS INST. OF TECH.                |
| ILL     | UNIV. OF ILLINOIS                      |
| ILLC    | UNIV. OF ILLINOIS AT CHICAGO           |
| INDO    | UNIV. OF INDIANA                       |
| IOWA    | UNIV. OF IOWA                          |
| IPNL    | INST. DE PHYS. NUCLEAIRE               |
| IPNP    | INSTITUT DE PHYSIQUE NUCLEAIRE         |
| IRAD    | INSTITUTE DU RADIUM                    |
| IOWA    | IOWA STATE UNIV.                       |
| JEP     | INST. FOR TEOR. AND EXP. PHYS.         |
| IUPU    | INDIANA U. - PURDUE U. AT INDIANAPOLIS |
| JAGL    | JAGIELLONIAN UNIV.                     |
| JHU     | JOHNS HOPKINS UNIV.                    |
| JINR    | JOINT INST. FOR NUCL. RESEARCH         |
| KANS    | UNIV. OF KANSAS                        |
| KARLS   | TECHNISCHE UNIV. KARLSRUHE             |
| KNTY    | UNIV. OF KENTUCKY                      |
| LANC    | LANCASTER UNIV.                        |
| LASL    | U. C. LOS ALAMOS SCIENTIFIC LAB.       |
| LAUS    | UNIV. DE LAUSANNE                      |
| LBL     | U. C. LAWRENCE BERKELEY LAB.           |
| LEBD    | LEBEDEV PHYSICS INST.                  |
| LENI    | LENIN UNIV.                            |
| LEID    | INST. LORENTZ                          |
| LINZ    | LINZ INSTITUT FÜR PHYSIK, KEPLER MOCH. |
| LIVP    | LIVERPOOL UNIV.                        |
| LOIC    | LITERARY COL. OF SCI. AND TECH.        |
| LOOM    | QUEEN MARY COLLEGE                     |
| LOUC    | UNIVERSITY COLLEGE                     |
| LOWC    | WESTFIELD COLLEGE                      |
| LPNP    | LAB. DE PHYS. NUCL. ET HAUTES ENERGIES |
| LRL     | U. C. LAWRENCE BERKELEY LAB.           |

## Measurement techniques

|      |                                          |
|------|------------------------------------------|
| ASPK | Automatic spark chambers                 |
| CC   | Cloud chamber                            |
| CNTR | Counters, electronics                    |
| DBC  | Deuterium bubble chamber                 |
| DPWA | Energy-dependent partial wave analysis   |
| EMUL | Emulsions                                |
| HBC  | Hydrogen bubble chamber                  |
| HEBC | Helium bubble chamber                    |
| HLBC | Heavy liquid bubble chamber              |
| IPWA | Energy-independent partial wave analysis |
| MMS  | Missing mass spectrometer                |
| MPWA | Model-dependent partial wave analysis    |
| OSPK | Optical spark chambers                   |
| RVUE | Review of previous experimental data     |
| STRC | Streamer chamber                         |

## Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

|       |                                        |
|-------|----------------------------------------|
| LSU   | LOUISIANA STATE UNIV.                  |
| LUND  | UNIV. I LUND                           |
| MADR  | JUNTA DE ENERGIA NUCLEAR               |
| MANH  | MANHATTAN COLLEGE                      |
| MANZ  | UNIV. OF MANCHESTER                    |
| MASA  | UNIV. OF MASSACHUSETTS                 |
| MASB  | UNIV. OF MASSACHUSETTS                 |
| MCGI  | MC GILL UNIV.                          |
| MCHS  | UNIV. MANCHESTER                       |
| MICH  | UNIV. OF MICHIGAN                      |
| MINN  | UNIV. OF MINNESOTA                     |
| NAGO  | NAGOYA UNIV.                           |
| NAL   | NATIONAL ACCELERATOR LAB.              |
| NAPL  | UNIV. DI NAPOLI                        |
| NORD  | UNIV. OF NOTRE DAME                    |
| NEAS  | NORTHEASTERN UNIV.                     |
| NEVI  | NEVIS LAB.                             |
| NIJM  | R. K. UNIV. NIJMEGEN                   |
| NORD  | NORDISK INS. FOR TEOR. ATOMFYS.        |
| NOVO  | INST. OF NUCL. PHYS.                   |
| NRL   | NAVAL RESEARCH LABORATORY              |
| NORTH | NORTHWESTERN UNIV.                     |
| NYU   | NEW YORK UNIV.                         |
| OHIO  | OHIO UNIV.                             |
| OREG  | UNIV. OF OREGON                        |
| ORNL  | ORNL NATIONAL LAB.                     |
| ORSA  | UNIV. DE PARIS, FAC. DES SCI.          |
| OSLO  | OSLO UNIV.                             |
| OSU   | OHIO STATE UNIV.                       |
| OXF   | OXFORD UNIV.                           |
| PADO  | UNIV. OF PADOVA                        |
| PATR  | UNIV. OF PATRAS                        |
| PENN  | UNIV. OF PENNSYLVANIA                  |
| PISA  | UNIV. DI PISA                          |
| PITT  | UNIV. OF PITTSBURGH                    |
| PRAG  | PRINCETON-PRAG. PROTON ACCEL.          |
| PRIN  | INSTITUTE OF PHYSICS, CSAY             |
| PRIN  | PRINCETON UNIV.                        |
| PURD  | PURDUE UNIV.                           |
| RECH  | RECH. INST. OF SCI.                    |
| RHEL  | RUTHERFORD HIGH ENERGY LAB.            |
| RISO  | RESEARCH ESTAB. RISO                   |
| ROSD  | UNIV. OF ROCHESTER                     |
| ROMA  | UNIV. DEGLI STUDI DI ROMA              |
| RUTG  | RUTGERS UNIV.                          |
| SACL  | CHTR. D'ETUDES NUC. SACLAY             |
| SEAT  | SEATTLE PACIFIC COLLEGE                |
| SERP  | INST. OF HIGH EN. PHYS.                |
| SETO  | SETON HALL UNIV.                       |
| SHMO  | UNIV. OF SOUTHAMPTON                   |
| SLAC  | STANFORD LINEAR ACCEL. CENTER          |
| SOFI  | BULGARIAN ACAD. OF SCI.                |
| STAN  | STANFORD UNIV.                         |
| STEV  | STEVENS INST. OF TECH.                 |
| STLO  | ST. LOUIS UNIV.                        |
| STON  | STOCKHOLM UNIV.                        |
| STON  | STATE UNIV. OF NEW YORK AT STONY BROOK |
| STRB  | CENTRE DES RES. NUCLEAIRES             |
| SUSS  | SUSSEX UNIV.                           |
| SYRA  | SYRACUSE UNIV.                         |
| TELA  | UNIV. OF TEL-AVIV                      |
| TENN  | UNIV. OF TENNESSEE                     |
| TINT  | UNIV. OF TORONTO                       |
| TOHO  | TOKYO UNIV.                            |
| TOKY  | UNIV. OF TOKYO                         |
| TORI  | UNIV. DI TORINO                        |
| TRST  | UNIV. OF TRIESTE                       |
| TUFT  | TUFTS UNIV.                            |
| UCB   | UNIV. OF CALIF. AT BERKELEY            |
| UCD   | UNIV. OF CALIF. AT DAVIS               |
| UCI   | UNIV. OF CALIF. AT IRVINE              |
| UCLA  | UNIV. OF CALIF. AT LOS ANGELES         |
| UCND  | UNION CARBIDE NUCLEAR DIVISION         |
| UCR   | UNIV. OF CALIF. AT RIVERSIDE           |
| UCSB  | UNIV. OF CALIF. AT SANTA BARBARA       |
| UCSC  | UNIV. OF CALIF. AT SANTA CRUZ          |
| UCSD  | UNIV. OF CALIF. AT SAN DIEGO           |
| UNIV  | UNIV. OF UTAH                          |
| UPNJ  | UNIV. OF UTAH                          |
| UTAH  | UNIV. OF UTAH                          |
| VAND  | VANDERBILT UNIV.                       |
| VIRG  | INST. FOR HIGH EN. PHYS., A. A. S.     |
| VIRG  | UNIV. OF VIRGINIA                      |
| VPI   | VIRGINIA POLYTECHNIC INST.             |
| WASH  | UNIV. OF WASHINGTON                    |
| WASH  | SEATTLE, WASH., USA                    |
| WIEN  | UNIV. WIEN                             |
| WILL  | COLLEGE OF WILLIAM AND MARY            |
| WISC  | UNIV. OF WISCONSIN                     |
| WOOD  | WOODSTOCK COLLEGE                      |
| WUSL  | WASHINGTON UNIV.                       |
| WYOM  | UNIV. OF WYOMING                       |
| YALE  | YALE UNIV.                             |
| ZEEN  | ZEEMAN LAB., UNIV. OF AMSTERDAM        |

|                                |
|--------------------------------|
| BATON ROUGE, LA., USA          |
| LUND, SWEDEN                   |
| MADRID, SPAIN                  |
| NEW YORK, N. Y., USA           |
| AMHERST, MASS., USA            |
| BOSTON, MASS., USA             |
| MONTREAL, CANADA               |
| MANCHESTER, ENGLAND            |
| ANN ARBOR, MICH., USA          |
| MILANO, ITALY                  |
| MINNEAPOLIS, MINN., USA        |
| OXFORD, OHIO, USA              |
| CAMBRIDGE, MASS., USA          |
| MODENA, ITALY                  |
| MUNICH, GERMANY                |
| MESSINA, ITALY                 |
| EAST LANSING, MICH., USA       |
| NAGOYA, JAPAN                  |
| BATAVIA, ILL., USA             |
| NAPOLI, ITALY                  |
| NOTRE DAME, IND., USA          |
| BOSTON, MASS., USA             |
| IRVINGTON-ON-HUDSON, N.Y., USA |
| NIJMEGEN, NETHERLANDS          |
| COPENHAGEN, DENMARK            |
| NOVOSEBIRSK, USSR              |
| WASHINGTON, D.C., USA          |
| EVANSTON, ILL., USA            |
| NEW YORK, N. Y., USA           |
| ATHENS, OHIO, USA              |
| EUGENE, ORE., USA              |
| OKRIDGE, TENN., USA            |
| ORSA, FRANCE                   |
| OSLO, NORWAY                   |
| COLUMBUS, OHIO, USA            |
| OXFORD, ENGLAND                |
| PADOVA, ITALY                  |
| PATRAS, GREECE                 |
| PHILADELPHIA, PA., USA         |
| PISA, ITALY                    |
| PITTSBURGH, PA., USA           |
| PRINCETON, N. J., USA          |
| PRAGUE, CZECHOSLOVAKIA         |
| PRINCETON, N. J., USA          |
| LAFAYETTE, IND., USA           |
| RECHIOVOT, ISRAEL              |
| CHILTON, DOD., BERKS., ENGLAND |
| ROSKILDE, DENMARK              |
| ROCHESTER, N. Y., USA          |
| ROME, ITALY                    |
| NEW BRUNSWICK, N. J., USA      |
| GIF-SUR-YVETTE, FRANCE         |
| SEATTLE, WASH., USA            |
| SERPUKOV, USSR                 |
| SOUTH ORANGE, N. J., USA       |
| SOUTHAMPTON, ENGLAND           |
| STANFORD, CALIF., USA          |
| SOFIA, BULGARIA                |
| STANFORD, CALIF., USA          |
| BROOKLYN, N. Y., USA           |
| ST. LOUIS, MO., USA            |
| STOCKHOLM, SWEDEN              |
| STONY BROOK, L.I., USA         |
| STRAUBOURG, FRANCE             |
| SUSSEX, ENGLAND                |
| SYRACUSE, N. Y., USA           |
| TEL-AVIV, ISRAEL               |
| KNOXVILLE, TENN., USA          |
| TORONTO, CANADA                |
| SENDAI, JAPAN                  |
| TOKYO, JAPAN                   |
| TORINO, ITALY                  |
| TRIESTE, ITALY                 |
| ROCHESTER, N. Y., USA          |
| BERKELEY, CALIF., USA          |
| DAVIS, CALIF., USA             |
| LOS ANGELES, CALIF., USA       |
| OAK RIDGE, TENN., USA          |
| RIVERSIDE, CALIF., USA         |
| SANTA BARBARA, CALIF., USA     |
| SANTA CRUZ, CALIF., USA        |
| LA JOLLA, CALIF., USA          |
| GEORGETOWN, MD., USA           |
| EAST ORANGE, N. J., USA        |
| SALT LAKE CITY, UTAH, USA      |
| NASHVILLE, TENN., USA          |
| VIENNA, AUSTRIA                |
| CHARLOTTESVILLE, VA., USA      |
| BLACKSBURG, VA., USA           |
| WARSAW, POLAND, USA            |
| SEATTLE, WASH., USA            |
| WIEN, AUSTRIA                  |
| PELLERNSBURG, VA., USA         |
| WISCONSIN, WISC., USA          |
| WOODSTOCK, MD., USA            |
| ST. LOUIS, MO., USA            |
| LARABIE, WYOMING, USA          |
| NEW HAVEN, CONN., USA          |
| AMSTERDAM, NETHERLANDS         |

## Stable Particles

 $\gamma, \nu_e, \nu_\mu, e, \mu$ 

3 ELECTRON MEAN LIFE (UNITS 10\*\*21 YR)

|   |             |     |         |      |
|---|-------------|-----|---------|------|
| T | 2.0 OR MORE | MOE | 65 CNTR | 6/66 |
|---|-------------|-----|---------|------|

| 3 ELECTRON MAGNETIC MOMENT(E/2ME) |                |             |           |    |      |            |
|-----------------------------------|----------------|-------------|-----------|----|------|------------|
| MM                                | (1.0011609)    | ←(24)=10**7 | SCHUPP    | 61 | CNTR | -          |
|                                   | (1.001159622)  | ←(27)=10**9 | WILKINSON | 63 |      | 8/66       |
|                                   | (1.001168)     | ←(22)=10**6 | RICH      | 66 | CNTR | + POSITRON |
| MM R                              | (1.001159577)  | ←(30)=10**9 | 9         | 68 |      | 8/66       |
| MM                                | (1.0011596389) | ←(31)=10**9 | 10TAYLOR  | 69 | RUE  | 2/71       |
|                                   | (1.001159644)  | ←(7)=10**9  | MESEV     | 70 | CNTR | 6/70       |
| MM                                | (1.0011596577  | ←(35)=10**9 | LOWESLEY  | 71 | CNTR | 2/72       |
| MM                                | (1.0011603)    | ←(12)=10**7 | GILLELAND | 72 | CNTR | + 2/72     |

| REFERENCES FOR ELECTRON |    |             |                                            |
|-------------------------|----|-------------|--------------------------------------------|
| SCHUPP                  | 61 | PR 121 1    | A A SCHUPP, R W PIDDO, H R CRANE (MICH)    |
| WILKINSO                | 63 | PR 130 852  | D T WILKINSO, H R CRANE (MICH)             |
| COHEN                   | 65 | RMP 37 137  | COHEN, DUMOND IN A.VIATION SCI.CENTR-6(11) |
| MOE                     | PR | 140 R 292   | M O E, F REINES (CASE INST TECHNOLOGY)     |
| RICH                    | 66 | PRL 17 271  | A RICH, H R CRANE (MICH)                   |
| RICH                    | 68 | PRL 20 967  | A RICH (MICH)                              |
| TAYLOR                  | 69 | RMP 41 375  | *PARKER, LANGENBERG (PRIN+UCI+PENN)        |
| WESLEY                  | 70 | PRL 24 1320 | J C WESLEY, A RICH (MICH)                  |
| WESLEY                  | 71 | PR 44 1341  | J C WESLEY, A RICH (MICH)                  |
| GILLELAN                | 72 | PR 45 38    | J GILLELAN, A RICH (MICH)                  |

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4 MUON (106,J=1/2)

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      4 MUON MASS (MEV)
M      (105.659) (0.002) FEINBERG 63 RVUE
M      (105.659) (0.0014) TAYLOR 69 RVUE USING NEW E/H 7/70
M      C 105.6597 0.0005 CRANE 71 CNTR 1/73
M      D 105.6594 0.0004 CROME 72 CNTR 2/72
M      C CRANE 71 GIVES MU/ME=206.76878(85). WE USE ME=.5110041(16)MEV. 1/73
M      D CROME 72 GIVES MU/ME=206.7682(5) AND USES ME=.5110041(16)MEV. 1/73
M      C
M      AVE 105.65952 0.00031 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M      FIT 105.6595 0.0003 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) 1/73

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|   |     |                                  |         |                 |                                   |            |       |  |
|---|-----|----------------------------------|---------|-----------------|-----------------------------------|------------|-------|--|
|   |     | 4 MUON MEAN LIFE (UNITS 10***-6) |         |                 |                                   |            |       |  |
| T |     | 2.198                            | 0.001   | 0.001 FARLEY    | 62 CNTR                           |            |       |  |
| T |     | 2.203                            | 0.004   | LUNDY           | 62 CNTR                           | CONLEV=.98 | 11/67 |  |
| T |     | 2.202                            | 0.003   | CORHAUSE        | 63 CNTR +                         |            |       |  |
| T |     | 2.197                            | 0.005   | MEYER           | 63 CNTR -                         |            |       |  |
| T |     | 2.198                            | 0.002   | MEYER           | 63 CNTR -                         |            | 7/66  |  |
| T |     | 2.20026                          | 0.00081 | WILLIAMS        | 72 CNTR +                         |            | 2/72  |  |
| T |     |                                  |         |                 |                                   |            |       |  |
| T | AVG | 2.19936                          | 0.00061 | 0.00061 AVERAGE | (ERROR INCL. SCALE FACTOR OF 1.1) |            |       |  |

| 4 MU+/MU- MEAN LIFE RATIO |       |       |       |         |                   |      |
|---------------------------|-------|-------|-------|---------|-------------------|------|
| DT                        | 1.000 | 0.001 | MEYER | 63 CNTR | MEAN LIFE MU+/MU- | 7/66 |
|                           |       |       |       |         |                   |      |

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      .4 MUON ANOMALOUS MAGN. MOMENT (10**4*E/(2*MU MASS))

MM      (1162.0)  (5.0)      CHARPAK      62 CNTR +
MM B    (1165.75) (0.71)    BAILEY      68 CNTR + STOR. RINGS      5/69
MM      (1166.25) (0.24)    BAILEY      68 CNTR + STOR. RINGS      5/69
MM B    ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+ - VALUE BELOW 5/69
MM      1166.16  0.31      BAILEY      68 CNTR + STOR. RINGS      5/69

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| 4 MUON TO PROTON MAGNETIC MOMENT RATIO |                                                                    |                                     |      |  |  |
|----------------------------------------|--------------------------------------------------------------------|-------------------------------------|------|--|--|
| MNR                                    | THIS RATIO IS USED TO OBTAIN PRECISE VALUES OF THE MUON MASS.      | 3/72                                |      |  |  |
| MNR                                    | SEE CROWE 72.                                                      | 3/72                                |      |  |  |
| MNR                                    | 3.1865 .0022                                                       | COFFIN 58 CNTR + SPIN RESONANCE     | 2/72 |  |  |
| MNR                                    | 3.1880 .0011                                                       | LUNDY 58 CNTR + PRECESSION STROB    | 2/72 |  |  |
| MNR                                    | 3.176 .013                                                         | LUNDY 58 CNTR + PRECESSION STROB    | 2/72 |  |  |
| MNR                                    | 3.1834 .0002                                                       | GARWIN 60 CNTR + PRECESSION PHASE   | 2/72 |  |  |
| MNR                                    | 3.18336 .00007                                                     | BINGHAM 63 CNTR + PRECESSION STROB  | 2/72 |  |  |
| MNR                                    | 3.1808 .0004                                                       | BINGHAM 63 CNTR + PRECESSION PHASE  | 2/72 |  |  |
| MNR                                    | 3.1838 .0004                                                       | ERLICH 63 CNTR + PRECESSION PHASE   | 2/72 |  |  |
| MNR D                                  | (3.183511(.000016)                                                 | ERLICH 69 CNTR HFS SPLITTING        | 2/72 |  |  |
| MNR C                                  | (3.183141(.000034)                                                 | THOMPSON 69 CNTR HFS SPLITTING      | 2/72 |  |  |
| MNR                                    | 3.183330 .000044                                                   | HUTCHINS 70 CNTR + PRECESSION PHASE | 2/72 |  |  |
| MNR H                                  | (3.183471(.000009)                                                 | HAGUE 70 CNTR + PRECESSION PHASE    | 2/72 |  |  |
| MNR                                    | *3.183336 .000013                                                  | CRAME 71 CNTR HFS SPLITTING         | 1/73 |  |  |
| MNR D                                  | (3.183449 .000015                                                  | DEVOE 71 CNTR HFS SPLITTING         | 1/73 |  |  |
| MNR F                                  | (3.183261(.000013)                                                 | FAVART 71 CNTR HFS SPLITTING        | 2/72 |  |  |
| MNR H                                  | 3.1833667 .0000082                                                 | CROWE 72 CNTR + PRECESSION PHASE    | 2/72 |  |  |
| MNR C                                  | CRAME 71 SUPERSEDES THOMPSON 69. THIS IS NOT A DIRECT MEASUREMENT. | 1/73                                |      |  |  |
| MNR                                    | CRAME 71 SUPERSEDES HAGUE 70.                                      | 1/73                                |      |  |  |
| MNR                                    | FAVART 71 ASSUMES A ZERO VALUE FOR THE PROTON POLARIZABILITY.      | 1/73                                |      |  |  |
| MNR D                                  | DEVOE 71 SUPERCEDES ERLICH 69. * THIS IS NOT A DIRECT MEASUREMENT. | 1/73                                |      |  |  |
| MNR D                                  | WE GIVE A NEW VALUE WHICH CONTAINS A THEORETICAL CORRECTION OF     | 1/73                                |      |  |  |
| MNR D                                  | -7.8+-2.3 PPM, AS DISCUSSED IN FOOTNOTE 35A OF CROWE 72.           | 1/73                                |      |  |  |
| MNR AVG                                | 3.1833447 .0000061 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |                                     |      |  |  |

## Stable Particles

 $\mu$ ,  $\pi^\pm$ 

## 4 MUON PARTIAL DECAY MODES

|    |                              | DECAY MASSES |
|----|------------------------------|--------------|
| P1 | MUON INTO E (E-NEU) (MU-NEU) | .5+ 0+ 0     |
| P2 | MUON INTO E 2GAMMA           | .5+ .0+ 0    |
| P3 | MUON INTO 3ELECTRONS         | .5+ .5+ .5   |
| P4 | MUON INTO E GAMMA            | .5+ 0        |

## 4 MUON BRANCHING RATIOS

|      |                                                                                                                                                                         |           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| R1   | MUON INTO E+2GAMMA (IN UNITS OF $10^{-8}$ -5)                                                                                                                           | (P2)/(P1) |
| R1   | (1.6) OR LESS CL=.90 FRANKEL                                                                                                                                            | 63 OSPK   |
| R2   | MUON INTO 3E (IN UNITS OF $10^{-8}$ -7)                                                                                                                                 | (P3)/(P1) |
| R2 F | 5.0 OR LESS CL=.90 PARKER                                                                                                                                               | 62 CNTR   |
| R2 F | 1.3 OR LESS CL=.90 ALIKHANOV                                                                                                                                            | 62 OSPK   |
| R2 F | 1.5 OR LESS CL=.90 FRANKEL2                                                                                                                                             | 63 CNTR   |
| R2 F | 1.2 OR LESS CL=.90 BABAEV                                                                                                                                               | 63 OSPK   |
| R2 K | 0.062 OR LESS CL=.90 KORENCH2                                                                                                                                           | 71 OSPK   |
| R2 K | KORENCHENKOZ 71 ASSUMES A CONSTANT MATRIX ELEMENT.                                                                                                                      | 2/72      |
| R2 F | FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED B ASSUMING A CONSTANT MATRIX ELEMENT. | 2/72      |
| R3   | MUON INTO E+GAMMA (IN UNITS OF $10^{-8}$ -8)                                                                                                                            | (P4)/(P1) |
| R3   | 4.3 OR LESS CL=.90 FRANKEL1                                                                                                                                             | 63 OSPK   |
| R3   | 2.2 OR LESS CL=.90 PARKER                                                                                                                                               | 64 OSPK   |
| R3   | 2.9 OR LESS CL=.90 KORENCH1                                                                                                                                             | 71 OSPK + |

## 4 MUON DECAY PARAMETERS

## RELATED TEXT SECTION IV E

|            |                                                                     |                                              |       |
|------------|---------------------------------------------------------------------|----------------------------------------------|-------|
| RHO        | RHO PARAMETER                                                       | (V-A THEORY PREDICTS RHO=0.75)               |       |
| RHO C      | (0.741) (0.027)                                                     | DUZIAK 59 CNTR + 20-53 MEV E+                | 10/69 |
| RHO P9213  | 0.745 0.025                                                         | PLANO 60 HBC + WHOLE SPECTRUM                | 10/69 |
| RHO P      | TWO PARAMETER FIT TO RHO AND ETA.                                   |                                              |       |
| RHO C 2276 | (0.751) (0.034)                                                     | BLOCK 62 HBC - WHOLE SPECTRUM                | 10/69 |
| RHO D      | (0.641) (0.04)                                                      | BARLOW 64 CNTR - WHOLE SPECTRUM              | 10/69 |
| RHO D      | (0.661) (0.016)                                                     | BARLOW 64 CNTR + WHOLE SPECTRUM              | 10/69 |
| RHO D      | (0.867) (0.035)                                                     | PONTECORV 64 CC -                            | 10/69 |
| RHO D      | RESULTS IN DOUBT.                                                   |                                              |       |
| RHO C 800K | (0.7503) (0.0026)                                                   | PEOPLES 66 ASPK + 20-53 MEV E+               | 10/69 |
| RHO C 280K | (0.760) (0.009)                                                     | SHERWOOD 67 ASPK + 25-53 MEV E+              | 10/69 |
| RHO C 170K | (0.762) (0.008)                                                     | FRYBERGER 68 ASPK + 25-53 MEV E+             | 10/69 |
| RHO C      | ETA CONSTRAINED = 0. THESE VALUES INCORPORATED INTO A TWO PARAMETER |                                              |       |
| RHO C      | FIT TO RHO AND ETA BY DERENZO 69.                                   |                                              |       |
| RHO        | 0.7518 0.0026                                                       | DERENZO 69 RVUE                              | 10/69 |
| RHO        | 0.7517 0.0026                                                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| ETA        | ETA PARAMETER                                                       | (V-A THEORY PREDICTS ETA=0)                  |       |
| ETA P 9213 | (-2.0) (0.9)                                                        | PLANO 60 HBC + WHOLE SPECTRUM                | 10/69 |
| ETA P      | TWO PARAMETER FIT TO RHO AND ETA- PLANO 60 DISCOUNTS VALUE FOR ETA  |                                              |       |
| ETA C 800K | (0.05) (0.5)                                                        | PEOPLES 66 ASPK + 20-53 MEV E+               | 10/69 |
| ETA C 280K | (-0.7) (0.6)                                                        | SHERWOOD 67 ASPK + 25-53 MEV E+              | 10/69 |
| ETA C 170K | (-0.7) (0.5)                                                        | FRYBERGER 68 ASPK + 25-53 MEV E+             | 10/69 |
| ETA C      | RHO CONSTRAINED = 0.75.                                             |                                              |       |
| ETA        | 6346 -0.12 0.21                                                     | DERENZO 69 HBC + 1.6-6.8 MEV E+              | 10/69 |
| XSI        | XSI PARAMETER                                                       | (V-A THEORY PREDICTS XSI=1)                  |       |
| XSI 9K     | 0.97 0.05                                                           | BARLOW 64 CNTR BRONCHFORM TARGET             | 10/69 |
| XSI 8354   | 0.93 0.06                                                           | PLANO 60 HBC + 8.6 KGAUSS                    | 10/69 |
| XSI A      | (0.903) (0.027)                                                     | ALTI-ZADE 61 EMUL + 27 KGAUSS                | 10/69 |
| XSI A      | DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL.               |                                              |       |
| XSI G 66K  | (0.975) (0.030)                                                     | GUREVICH 67 EMUL 140 KGAUSS                  | 10/69 |
| XSI        | (0.975) (0.014)                                                     | GUREVICH 67 EMUL                             | 10/69 |
| XSI G      | GUREVICH 67 SUPERSEDES GUREVICH 64                                  |                                              |       |
| XSI        | 0.972 0.013                                                         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| DEL        | DELTA PARAMETER                                                     | (V-A THEORY PREDICTS DELTA=0.75)             |       |
| DEL 8354   | 0.78 0.05                                                           | PLANO 60 HBC + WHOLE SPECTRUM                | 10/69 |
| DEL        | 0.782 0.031                                                         | KRUGER 61                                    | 10/69 |
| DEL 490K   | 0.752 0.009                                                         | FRYBERGER 68 ASPK + 25-53 MEV E+             | 10/69 |
| DEL        | VOSSLER 69 HAS MEASURED THE ASYMMETRY BELOW 10 MEV                  |                                              | 11/69 |
| DEL        | 0.7551 0.0085                                                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| HEL        | HELICITY OF DECAY ELECTRON.                                         |                                              |       |
| HEL        | (V-A THEORY PREDICTS HELICITY=+1 FOR E+, RESPECTIVELY)              |                                              |       |
| HEL        | WE HAVE FLIPPED THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE         |                                              |       |
| HEL D      | (0.28) (0.16)                                                       | DICK 63 CNTR + ANNIHILATION                  | 10/69 |
| HEL D      | IN DOUBT- POSITRONS POSSIBLY DEPOLARIZED IN BE MODERATOR.           |                                              |       |
| HEL        | 1.05 0.30                                                           | BUHLER 63 CNTR + ANNIHILATION                | 10/69 |
| HEL        | 0.94 0.38                                                           | BLOOM 64 CNTR + BREMS TRANSMISS              | 10/69 |
| HEL        | 1.04 0.18                                                           | DUCLLOS 64 CNTR + BHABHA SCATT               | 10/69 |
| HEL 29K    | 0.89 0.28                                                           | SCHWARTZ 67 OSPK - MOLLER SCATT              | 10/69 |
| HEL        | 1.00 0.13                                                           | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| GS         | SCALAR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)             |                                              |       |
| GS         | (0.33) OR LESS                                                      | DERENZO 69 RVUE                              | 10/69 |
| GAV        | AXIAL VECTOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)       |                                              |       |
| GAV        | 0.86 0.33 0.11                                                      | DERENZO 69 RVUE                              | 10/69 |
| FAV        | PHASE BETWEEN VECTOR AND AXIAL VECTOR COUPLINGS (DEGREES)           |                                              |       |
| FAV        | 180. 15.                                                            | DERENZO 69 RVUE                              | 10/69 |
| GT         | TENSOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)             |                                              |       |
| GT         | (0.28) OR LESS                                                      | DERENZO 69 RVUE                              | 10/69 |
| GP         | PSEUDOSCALAR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)       |                                              |       |
| GP         | (0.33) OR LESS                                                      | DERENZO 69 RVUE                              | 10/69 |

## Data Card Listings

For notation, see key at front of Listings.

## REFERENCES FOR MUON

|           |                      |                                                   |
|-----------|----------------------|---------------------------------------------------|
| COFFIN    | 58 PR 109 973        | +GARWIN, PENMAN, LEDERMAN, SACHS (COLUMBIA)       |
| LUNDY     | 58 PRL 1 38          | +SENS, SWANSON, TELEGOI, YOYANOVITCH (CHI CAGO)   |
| BARDON    | 59 PRL 2 56          | M BARDON, D BERLEY, L LEDERMAN (COLUMBIA)         |
| DUZIAK    | 59 PR 114 336        | M DUZIAK, R SAGANE, J VEDDER (LRL)                |
| GARWIN    | 60 PR 118 271        | GARWIN, HUTCHINSON, PENMAN, SHAPIRO (COLUMBIA)    |
| PLANO     | 60 PR 119 1400       | R J PLANO (COLUMBIA)                              |
| ALTI-ZADE | 61 JETP 13 313       | ALTI-ZADE, GUREVICH, NI KOLSKI (USSR)             |
| KRUGER    | 61 UCRL-9322 (UNPUB) | H KRUGER (LRL)                                    |
| ALIKHANOV | 62 CERN CONF 423     | A I ALIKHANOV, A BABAEV + (ITEP MOSCOW)           |
| BLOCK     | 62 NC 23 1114        | BLOCK, FIORINI, KIKUCHI + (DUKE, BOLOGNA, MILANO) |
| CHARPAK   | 62 PL 1 16           | G CHARPAK, F J M FARLEY, R L GARWIN + (CERN)      |
| FARLEY    | 62 CERN CONF 415     | FARLEY, MASSAN, MULLER, ZICHICH (CERN)            |
| LUNDY     | 62 PR 125 1686       | S FRANKEL, M FRATI, J HALPERN + (PENN)            |
| PARKER    | 62 NC 23 485         | S PARKER, S PENMAN (EFI)                          |
| BABAEV    | 63 JETP 16 1397      | BABAEV, BALATS, KAFATANOV, LANDSBERG + (ITEP)     |
| BINGHAM   | 63 NC 27 1352        | G. MCD. BINGHAM (LRL)                             |
| BUHLER    | 63 PL 7 368          | +CARIBBO, F IDECARO, MASSAM, MULLER+ (CERN)       |
| DICK      | 63 PL 7 150          | DICK, FEUVRAIS, SPIGHEL (CERN)                    |
| ECKHAUSE  | 63 PR 132 422        | M ECKHAUSE, T A FILIPPAS + (CARNegie)             |
| FEINBERG  | 63 ARNS 13 431       | GERALD FEINBERG, L M LEDERMAN (COLUMBIA)          |
| FRANKEL1  | 63 NC 27 894         | S FRANKEL, M FRATI, J HALPERN + (PENN)            |
| FRANKEL2  | 63 PR 130 350        | S FRANKEL, M FRATI, J HALPERN + (PENN)            |
| HUTCHINS  | 63 PR 131 1351       | HUTCHINSON, MENES, PATLACH, SHAPIRO (COLUMBIA)    |
| MEYER     | 63 PR 132 2693       | S L MEYER, ANDERSON, BLESER, LEDERMAN+ (COLU)     |
| BARLOW    | 64 PPS 84 239        | +BOOTH, CARROL, COURT, DAVIES, EDWARDS+ (LIVP)    |
| BLOOM     | 64 PL 1 5            | +DICK, FEUVRAIS, HENRY, MACI, SPIGHEL (CERN)      |
| DUCLLOS   | 64 PL 9 62           | +HEINTZE, DE RUJULA, SOERGER (CERN)               |
| GUREVICH  | 64 PL 11 185         | GUREVICH, MAKARIYNA+ (KURCHATOV, MOSCOW)          |
| PONTECORV | 64 DUBNA CONF        | PONTECORVO, SULYAEV (MOSCOW)                      |
| PARKER    | 64 PR 133B 768       | S PARKER, H L ANDERSON, C REY (EFI)               |
| PEOPLES   | 66 NEVIS-147 (UNPUB) | J PEOPLES (COLUMBIA)                              |
| GUREVICH  | 67 IAE 1297          | GUREVICH, MAKARIYNA, MISHAKOVA+ (KURCHATOV)       |
| SCHWARTZ  | 67 PR 162 1306       | D M SCHWARTZ (EFI)                                |
| SHERWOOD  | 67 PR 156 1475       | B A SHERWOOD (CERN)                               |
| BAILEY    | 68 PL 288 287        | +BARTL, VON BOCHMANN, BROWN, FARLEY+ (CERN)       |
| FRYBERGER | 68 PR 166 1379       | +BARTL, VON BOCHMANN, BROWN, FARLEY+ (CERN)       |
| DERENZO   | 69 PR 181 1854       | S DERENZO (EFI)                                   |
| SHRILICH  | 69 PRL 23 513        | +HOFER, MAGNOD, STOWELL, SWANSON+ (CHI CAGO)      |
| TAYLOR    | 69 RMP 41 375        | +PARKER, LANGENBERG (PRIN+UCI+PENN)               |
| THOMPSON  | 69 PRL 22 163        | +AMATO, CRANE, HUGHES, MOBLEY+ (YALE)             |
| HAGUE     | 70 PRL 25 628        | +ROTHBERG, SCHENCK, WILLIAMS+ (WASH+LRL)          |
| HUTCHINS  | 70 PRL 24 1254       | HUTCHINSON, LARSON, SCHOEN, SOBER+ (PPA)          |
| CRANE     | 71 PRL 27 474        | +CASPERSON, CRANE, EGAN, HUGHES+ (YALE)           |
| DEVDE     | 71 PRL 25 1779 (ERR) | +MCINTYRE, MAGNOD, STOWELL, SWANSON+ (CHI CAGO)   |
| ALSO      | 71 PRL 26 213        | DEVDE, MCINTYRE, MAGNOD, STOWELL+ (CHI CAGO)      |
| FARVART   | 71 PRL 27 1336       | +MCINTYRE, STOWELL, TELEGOI, DEVDE+ (CHI CAGO)    |
| KORENCH1  | 71 SJNP 13 190       | KORENCHENKO, KOSTIN, MICEL MACHER+ (JINR)         |
| KORENCH2  | 71 SJNP 13 728       | KORENCHENKO, KOSTIN, MICEL MACHER+ (JINR)         |
| CROWE     | 72 PR 05 2145        | +HAGUE, ROTHBERG, SCHENCK+ (LRL+MASH)             |
| WILLIAMS  | 72 PR 06 737         | R W WILLIAMS, D L WILLIAMS (WASHINGTON)           |
| FISHER    | 59 PRL 3 349         | FISHER, LEONTIC, LUNDBY, MEUNIER, STROOT (CERN)   |
| ASTBURY   | 60 ROCH CONF 60 542  | ASTBURY, MATTERSLEY, HUSSAIN + (LIVERPOOL)        |
| DEVONS    | 60 PRL 5 330         | DEVONS, CIOAL, LEDERMAN, SHAPIRO (COLUMBIA)       |
| LATHROP   | 60 NC 17 109         | J LATHROP, R A LUNDY, V L TELEGOI + (EFI)         |
| LATHROP   | 60 NC 17 114         | J LATHROP, R A LUNDY, S PENMAN + (EFI)            |
| REITER    | 60 PRL 5 22          | REITER, ROMANOWSKI, SUTTON + (CARNegie)           |
| TELEGOI   | 60 ROCH CONF 60 713  | V L TELEGOI (CERN)                                |
| CHARPAK   | 61 PRL 6 128         | CHARPAK, FARLEY, GARWIN, MULLER, SENS + (CERN)    |
| HUTCHINS  | 61 PRL 7 129         | D P HUTCHINSON, J MENES + (COLUMBIA)              |
| SHAPIRO   | 62 PR 125 1022       | G SHAPIRO, L M LEDERMAN (COLUMBIA)                |
| FAIRLEY   | 66 NC 45A 281        | FAIRLEY, BAILEY, BROWN, GIESCH + (CERN)           |
| VOSSLER   | 69 NC 63A 423        | C VOSSLER (EFI)                                   |

## PAPERS NOT REFERRED TO IN DATA CARDS

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## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $\pi^\pm$ ,  $\pi^0$ 8 CHARGED PION MEAN LIFE (UNITS  $10^{-9}$ )

|   |         |                                                                    |       |           |                                           |      |
|---|---------|--------------------------------------------------------------------|-------|-----------|-------------------------------------------|------|
| T | 25.6    | 0.5                                                                | 0.5   | CROWE     | 57 RVUE                                   |      |
| T | 25.6    | 0.8                                                                | 0.8   | ANDERSON  | 60 CNTR                                   |      |
| T | 25.4    | 0.32                                                               | 0.32  | ASHKIN    | 60 CNTR +                                 |      |
| T | 26.02   | 0.04                                                               |       | ECKHAUSE  | 65 CNTR +                                 | 9/66 |
| T | 25.6    | 0.3                                                                |       | BARON     | 66 CNTR                                   | 6/66 |
| T | 25.9    | 0.3                                                                |       | DUNAITSEV | 66 CNTR                                   | 6/66 |
| T | (26.40) | (0.08)                                                             |       | KINSEY    | 66 CNTR +                                 | 6/66 |
| T | N       | SYSTEMATIC ERRORS IN CALIBR. IN THIS EXP. DISCUSSED BY NORDBERG 67 |       |           |                                           | 8/67 |
| T | N       | 26.67                                                              | 0.24  | LOBKOWICZ | 66 CNTR                                   | 9/66 |
| T | N       | 26.04                                                              | 0.05  | NORDBERG  | 67 CNTR +                                 | 8/67 |
| T | N       | 26.02                                                              | 0.04  | AYRES     | 71 CNTR +                                 | 3/71 |
| T | AVG     | 26.024                                                             | 0.024 | 0.024     | AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0) |      |

## 8 ((P1+) - (P1-))/AVG., MEAN LIFE DIFFERENCE (PERCENT)

|    |     |                                                        |       |           |                                              |                 |
|----|-----|--------------------------------------------------------|-------|-----------|----------------------------------------------|-----------------|
| DT | N   | THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.   |       |           |                                              |                 |
| DT | L   | 0.23                                                   | 0.40  | LOBKOWICZ | 66 CNTR                                      | SEE NOTE L 9/66 |
| DT | L   | ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS |       |           |                                              | 9/66            |
| DT | L   | 0.4                                                    | 0.7   | BARON     | 66 CNTR                                      | 7/66            |
| DT | L   | -0.14                                                  | 0.29  | LOBKOWICZ | 66 CNTR                                      | 9/66            |
| DT | L   | 0.055                                                  | 0.071 | AYRES     | 71 CNTR                                      | 3/71            |
| DT | AVG | 0.053                                                  | 0.068 | 0.068     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                 |

## 8 CHARGED PION PARTIAL DECAY MODES

|    |       |                             |      |     |              |    |
|----|-------|-----------------------------|------|-----|--------------|----|
| P1 | CHAR. | PION INTO MU (MU-NEU)       | 105+ | 0   | DECAY MASSES |    |
| P2 | CHAR. | PION INTO E (E-NEU)         | .5+  | 0   |              |    |
| P3 | CHAR. | PION INTO MU (MU-NEU) GAMMA | 105+ | 0+  | 0            |    |
| P4 | CHAR. | PION INTO P10 E (E-NEU)     | 134+ | .5+ | 0            |    |
| P5 | CHAR. | PION INTO E NEU GAMMA       | .5+  | 0+  | 0            |    |
| P6 | CHAR. | PION INTO E NEU E+ E-       | .5+  | 0+  | .5+          | .5 |

## 8 CHARGED PION BRANCHING RATIOS

|    |       |                                                               |           |                                              |                         |      |
|----|-------|---------------------------------------------------------------|-----------|----------------------------------------------|-------------------------|------|
| R1 | CHAR. | PION INTO MU NEU GAMMA (UNITS 10 <sup>-4</sup> )              | (P3)/(P1) |                                              |                         |      |
| R1 | 26    | 1.24                                                          | 0.25      | CASTAGNOL 58 EMUL                            | E(MU).LT.3.38 MV        |      |
| R2 | CHAR. | PION INTO E NEU (UNITS 10 <sup>-4</sup> )                     | (P2)/(P1) |                                              |                         |      |
| R2 |       | 1.21                                                          | 0.07      | ANDERSON                                     | 60 CNTR                 |      |
| R2 |       | 1.247                                                         | 0.028     | DI CAPUA                                     | 64 CNTR                 |      |
| R2 | AVG   | 1.242                                                         | 0.026     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                         |      |
| R3 | CHAR. | PION INTO P10 E NEU (UNITS 10 <sup>-4</sup> )                 | (P4)/(P1) |                                              |                         |      |
| R3 | D     | 52                                                            | (1.15)    | (.22)                                        | DEPOMIER 63 CNTR +      |      |
| R3 | D     | 36                                                            | 0.97      | 0.20                                         | BARTLETT 64 OSPK +      |      |
| R3 | D     | 38                                                            | 1.07      | 0.21                                         | BACASTON 65 OSPK +      |      |
| R3 | D     | 1.10                                                          | 0.26      |                                              | BERTRAM 65 OSPK +       |      |
| R3 | D     | 43                                                            | 1.1       | 0.2                                          | DUNAITSEV 65 CNTR +     |      |
| R3 | D     | 332                                                           | 1.00      | 0.08                                         | 0.10 DEPOMIER 68 CNTR + |      |
| R3 | AVG   | 1.023                                                         | 0.069     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                         |      |
| R4 | D     | DEPOMIER 68 STATES THAT THE RESULT OF DEPOMIER 63 IS AT LEAST |           |                                              |                         | 2/72 |
| R4 | D     | 10 PERCENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE P10 |           |                                              |                         | 2/72 |
| R4 | D     | DETECTION EFFICIENCY. THIS MAY BE TRUE OF ALL THE PREVIOUS    |           |                                              |                         | 2/72 |
| R4 | D     | MEASUREMENTS ACCORDING TO DEPOMIER 68 AND V.SORGEEL, PRIVATE  |           |                                              |                         | 2/72 |
| R4 | D     | COMMUNICATION, 1972.                                          |           |                                              |                         |      |
| R4 | CHAR. | PION INTO E NEU GAMMA (UNITS 10 <sup>-4</sup> )               | (P5)/(P1) |                                              |                         |      |
| R4 | 143   | 3.0                                                           | 0.5       | DEPOMIER 63 CNTR                             | GAM KE 50-90 MEV        |      |
| R5 | CHAR. | PION INTO E NEU E+ E- (UNITS 10 <sup>-4</sup> )               | (P6)/(P1) |                                              |                         |      |
| R5 | 3.4   | OR LESS                                                       | CL=.90    | KORENCHEN 71 OSPK +                          | 10/71                   |      |

## REFERENCES FOR CHARGED PION

|                         |                     |                                            |                      |
|-------------------------|---------------------|--------------------------------------------|----------------------|
| CROWE                   | 54 PR 96 470        | K M CROWE, R H PHILLIPS                    | (LRL)                |
| BARKAS                  | 56 PR 101 778       | M H BARKAS, W BIRNBAUM, F M SMITH          | (LRL)                |
| CROWE                   | 57 NC 5 541         | K M CROWE                                  | (STANFORD HEPL)      |
| CASTAGNO                | 58 PR 112 1779      | C CASTAGNOL, M MUCHNIK                     | (ROMA)               |
| ANDERSON                | 60 PR 119 2050      | H L ANDERSON, T FUJII, R H MILLER +        | (EFI)                |
| ASHKIN                  | 60 NC 16 490        | ASHKIN, FAZZINI, FIDECARD, LIPMAN +        | (CERN)               |
| DEPOMIER                | 63 PL 5 61          | DEPOMIER, HEINTZE, RUBBIA, SOERGEL         | (CERN)               |
| DEPOMIER                | 63 PL 7 285         | P DEPOMIER, HEINTZE, RUBBIA, SOERGEL       | (CERN)               |
| BARTLETT                | 64 PR 1368 1452     | BARTLETT, DEVONS, MEYER, ROSEN             | (COLUMBIA)           |
| DI CAPUA                | 64 PR 1338 1333     | DI CAPUA, GARLAND, PONDROM, STRELZOFF      | (COLU)               |
| BACASTON                | 65 PR 139 8407      | +GHESQUIERE, WIEGAND, LARSEN               | (LRL+SLAC)           |
| BERTRAM                 | 65 PR 139 B 617     | BERTRAM, MEYER, CARRIGAN +                 | (MICH+CARNEGIE)      |
| DUNAITSEV               | 65 JETP 20 58       | DUNAITSEV, PETRUKHIN, PROKOSHIN +          | (DUBNA)              |
| ECKHAUSE                | 65 PL 19 348        | ECKHAUSE, HARRIS, SMULER +                 | (WILLIAM AND MARY)   |
| BARON                   | 66 PRL 16 775       | BARON, DORE, DORFAN, KRIEGER +             | (COLUMBIA)           |
| DUNAITSEV               | 66 PL 23 283        | +KUTYIN, PROKOSHIN, RASUVAEV, SIMONOV      | (DUBNA)              |
| KINSEY                  | 66 PR 144 1132      | KINSEY, LOBKOWICZ, NORDBERG                | (ROCHESTER UNIV)     |
| LOBKOWICZ               | 66 PRL 17 548       | LOBKOWICZ, MELISSINOS, NAGASHIMA +         | (ROCH+BNL)           |
| HYMAN                   | 67 PL 258 376       | +LOKEN, PEWITT, DERRICK +                  | (LANL+CERN+MNS)      |
| NORDBERG                | 67 PL 248 594       | NORDBERG, LOBKOWICZ, BURMAN                | (ROCHESTER UNIV)     |
| SHAFFER                 | 67 PR 163 1453      | ROBERT E. SHAFFER                          | (LRL)                |
| ALSO 65 PRL 14 923      |                     | SHAFFER, CROWE, JENKINS                    | (LRL)                |
| DEPOMIER                | 68 NP 84 189        | DEPOMIER, DUCLOS, HEINTZE, KLEINKNECHT +   | (CERN)               |
| PETRUKHIN               | 68 JINR-P1-3862     | PETRUKHIN, RYKALIN, KHAZINS, CISEK         | (DUBNA)              |
| AYRES                   | 71 PR 30 1051       | +CORMACK, GREENBERG, KENNEY +              | (LRL, UCSB)          |
| ALSO 67 PR 157 1288     |                     | AYRES, CALDWELL, GREENBERG, KENNEY, KURZ + | (LRL, UCSB)          |
| ALSO 68 PRL 21 261      |                     | AYRES, CORMACK, GREENBERG, KENNEY +        | (LRL, UCSB)          |
| ALSO 69 UCRL-13939      |                     | DEPOMIER, HEINTZE, RUBBIA, SOERGEL         | (LJNR)               |
| ALSO 69 PRL 23 1267     |                     | GREENBERG, AYRES, CORMACK, KENNEY +        | (LRL, UCSB)          |
| BOOTH                   | 70 PL 328 723       | +JOHNSON, WILLIAMS, WORMALD                | (LIVP)               |
| BACKENST                | 71 PL 368 403       | BACKENSTOSS, DANIEL, KOCH +                | (CERN, KARL, HEID)   |
| ALSO 70 THESIS          |                     | C. VON DER MALSBERG                        | (THEIDELBERG)        |
| KORENCHEN               | 71 JINR 13 189      | KORENCHENKO, KOSTIN, MICELMACHER +         | (LJNR)               |
| BACKENST                | 73 SUBMITTED TO P L | BACKENSTOSS, DANIEL, KOCH +                | (CERN, KARL, MUNICH) |
| ALSO 73 SUBMITTED TO NP |                     | L. TAUSCHER                                |                      |
| SHAFFER                 | 72 PRIVATE COMM.    | R. SHAFFER, 1972                           |                      |

## PAPERS NOT REFERRED TO IN DATA CARDS

|          |                |                         |             |
|----------|----------------|-------------------------|-------------|
| MERRISON | 62 ADVP 11 1   | A W MERRISON            | (LIVERPOOL) |
| SHAPIRO  | 62 PR 125 1022 | G SHAPIRO, L M LEDERMAN | (COLUMBIA)  |
| CZIRR    | 63 PR 130 341  | JOHN B CZIRR            | (LRL)       |

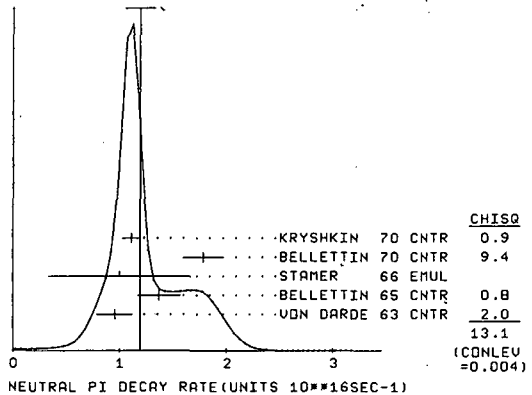
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## 9 NEUTRAL PION (135, JPC=0--) I=1

|   |        |        |           |           |                                              |
|---|--------|--------|-----------|-----------|----------------------------------------------|
| 0 | (5.37) | (1.0)  | PANOFSKY  | 51 CNTR - |                                              |
| 0 | 4.50   | 0.31   | CHINOWSKY | 54 CNTR - |                                              |
| 0 | 4.62   | 0.05   | HADDOCK   | 59 CNTR - |                                              |
| 0 | 4.60   | 0.04   | HILLMAN   | 59 CNTR   |                                              |
| 0 | 4.55   | 0.07   | CASSELLS  | 59 CNTR   |                                              |
| 0 | 4.69   | 0.07   | SAMIOS    | 60 HBC    | 2/72                                         |
| 0 | 4.6056 | 0.0055 | CZIRR     | 63 CNTR   |                                              |
| 0 | 4.59   | 0.03   | PETRUKHIN | 63 CNTR - |                                              |
| 0 | 4.6034 | 0.0052 | VASILEVSK | 66 CNTR - | 9/66                                         |
| 0 | AVG    | 4.6043 | 0.0037    | 0.0037    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

9 NEUTRAL PION MEAN LIFE (UNITS  $10^{-16}$ )

|   |     |                                                                   |       |       |       |           |                                           |                        |
|---|-----|-------------------------------------------------------------------|-------|-------|-------|-----------|-------------------------------------------|------------------------|
| T | N   | 76                                                                | (1.9) | (0.5) | (0.5) | GLASSER   | 61 EMUL                                   |                        |
| T | N   | 45                                                                | (2.3) | (1.1) | (1.0) | TIEGT     | 62 EMUL                                   |                        |
| T | N   | 88                                                                | (2.8) | (0.9) | (0.9) | KOLLER    | 63 EMUL                                   | SEE STAMER 66          |
| T | N   | 75                                                                | 1.05  | 0.18  | 0.18  | VON DARDE | 63 CNTR                                   |                        |
| T | N   | 75                                                                | (1.7) | (0.5) |       | SHME      | 64 EMUL                                   |                        |
| T | N   | 67                                                                | 0.730 | 0.105 |       | BELLETIN  | 65 CNTR                                   | 6/66                   |
| T | N   | 232                                                               | (1.6) | (0.6) | (0.5) | EVANS     | 65 EMUL                                   | 6/66                   |
| T | K   | 232                                                               | 1.0   | 0.5   |       | STAMER    | 66 EMUL                                   | 8/67                   |
| T | N   | 0.56                                                              | 0.06  |       |       | BELLETIN  | 70 CNTR                                   | PRIM.EFF. ON NUC 7/70  |
| T | N   | 0.9                                                               | 0.068 |       |       | KRYSHKIN  | 70 CNTR                                   | PRIMAKOFF EFFECT 12/70 |
| T | N   | OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC |       |       |       |           |                                           | 0                      |
| T | N   | SHIFT TO LARGER MEAN LIFE VALUES.                                 |       |       |       |           |                                           |                        |
| T | K   | INCLUDES EVENTS OF KOLLER 63.                                     |       |       |       |           |                                           | 8/67                   |
| T | AVG | 0.839                                                             | 0.103 | 0.092 | 0.092 | 0.092     | AVERAGE (ERROR INCL. SCALE FACTOR OF 2.1) |                        |
|   |     |                                                                   |       |       |       |           | (SEE IDEOGRAM BELOW)                      |                        |

WEIGHTED AVERAGE =  $1.19 \pm 0.14$   
ERROR SCALED BY 2.1

## 9 NEUTRAL PION PARTIAL DECAY MODES

|    |                      |                |  |
|----|----------------------|----------------|--|
| P1 | P10 INTO 2 GAMMA     | DECAY MASSES   |  |
| P2 | P10 INTO E+ E- GAMMA | 0+ 0           |  |
| P3 | P10 INTO 4 ELECTRONS | .5+ .5+ 0      |  |
| P4 | P10 INTO 3 GAMMA     | .5+ .5+ .5+ .5 |  |
|    |                      | 0+ 0+ 0        |  |

## 9 NEUTRAL PION BRANCHING RATIOS

|    |                                              |                                         |                     |                                              |        |                       |
|----|----------------------------------------------|-----------------------------------------|---------------------|----------------------------------------------|--------|-----------------------|
| R1 | P10 INTO (GAMMA E+ E-)/(2GAMMA) (PERCENT)    | (P2)/(P1)                               |                     |                                              |        |                       |
| R1 | (1.196) THEORET. CALC. JOSEPH                | 60                                      | QUANTUM ELECT. 9/66 |                                              |        |                       |
| R1 | 27                                           | 1.17                                    | 0.15                | BUDAGOV                                      | 60 HBC |                       |
| R1 | 3071                                         | 1.166                                   | 0.047               | SAMIOS                                       | 61 HBC | P1-P TO P10 N         |
| R1 | S                                            | SAMIOS VALUE USES PANOFSKY RATIO = 1.62 |                     |                                              |        |                       |
| R1 | AVG                                          | 1.166                                   | 0.045               | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                       |
| R2 | P10 INTO (3 GAMMA)/(2 GAMMA) (UNITS 10**=-6) | (P4)/(P1)                               |                     |                                              |        |                       |
| R2 | 0                                            | 5.0                                     | OR LESS             | CL=.90                                       | DUCLOS | 65 CNTR 6/66          |
| R2 | 0                                            | 5.0                                     | OR LESS             | CL=.90                                       | KUTIN  | 65 CNTR 3/68          |
| R3 | P10 INTO (E+E+E-)/(2 GAMMA) (UNITS 10**=-5)  | (P3)/(P1)                               |                     |                                              |        |                       |
| R3 | (3.47) THEORETICAL CAL. KROLL                | 55                                      | QUANTUM ELECT. 9/66 |                                              |        |                       |
| R3 | 146                                          | 3.18                                    | 0.30                | SAMIOS                                       | 62 HBC | SEE NOTE N BELOW 6/66 |
| R3 | N                                            | ABOVE VALUE USES PANOFSKY RATIO = 1.62  |                     |                                              |        |                       |

## Stable Particles

 $\pi^0, K^\pm$ 

## Data Card Listings

For notation, see key at front of Listings.

## REFERENCES FOR NEUTRAL PION

PANOFSKY 51 PR 81 565  
CHENOWSK 54 PR 93 586  
KROLL 55 PR 98 1355  
CASSELS 59 PPS 74 92  
HADDUCK 59 PRL 3 478  
HILLMAN 59 NC 14 887

BUDAGOV, VIKTOR, DZHELEPOV, ERMOLOV + (JINR)  
JOSEPH 60 NC 16 997  
SAMIOS 60 NC 18 154  
GLASSER 61 PR 123 1014  
SAMIOS 61 PR 121 275  
SAMIOS 62 PR 126 1844  
TJETGE 62 PR 127 1324

JOHN B CZIRR (LRL)  
E L KOLLER, S TAYLOR, T HUETTER (STEVENS)  
V I PETRUKHIN, YU D PROKOSHIN (JINR)  
VON DARDEL, DEKKERS, MERMOD, VAN PUTTEN + (CERN)

H SHWE, F M SMITH, W H BARKAS (LRL)  
BELLETTINI, BEMPORAD, BRACCINI + (PISA + FIRENZE)  
DUCLOS, FREYTAG, HEINTZE + (CERN + HEIDELBERG)  
D A EVANS (OXFORD)  
KUTIN, PETRUKHIN, PROKOSHIN (JINR)

STAMER, TAYLOR, KOLLER, HUETTER + (STEVENS)  
VASILEVSKY, VISHNYAKOV, DUNAITSKY + (DUBNA)  
BELLETTINI, BEMPORAD, LUBELSMY + (PISA + BONN)  
KRYSHKIN 70 JETP 30 1037

 $K^\pm$ 

## 10 CHARGED K (494, JP=0-) 1=1/2

10 CHARGED K MASS (MEV)

| M | 493.9                                                                                     | 0.2   | COHEN                                         | 57 RVUE +               |
|---|-------------------------------------------------------------------------------------------|-------|-----------------------------------------------|-------------------------|
| M | 493.7 <th>0.3</th> <td>BARKAS</td> <td>63 EMUL -</td>                                     | 0.3   | BARKAS                                        | 63 EMUL -               |
| M | 493.78 <th>0.17</th> <td>GREINER</td> <td>65 EMUL + VIA TAU DECAY</td>                    | 0.17  | GREINER                                       | 65 EMUL + VIA TAU DECAY |
| M | 493.87 <th>0.19</th> <td>KUNSELMAN</td> <td>71 CNTR - KAONIC ATOMS</td>                   | 0.19  | KUNSELMAN                                     | 71 CNTR - KAONIC ATOMS  |
| M | 493.691 <th>0.040</th> <td>BACKENSTO</td> <td>73 CNTR - KAONIC ATOMS</td>                 | 0.040 | BACKENSTO                                     | 73 CNTR - KAONIC ATOMS  |
| M | 493.709 <th>0.037</th> <td colspan="2">AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)</td>  | 0.037 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                         |
| M | 493.715 <th>0.037</th> <td colspan="2">FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)</td> | 0.037 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |                         |

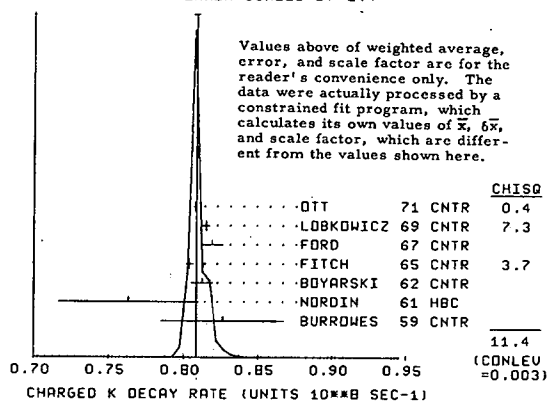
## 10 (K+) - (K-) MASS DIFFERENCE (MEV)

DM F 1.5M -0.032 0.090 FORD 72 ASPK +- 4/72  
DM F FORD 72 USES (MIP1+)-(MIP1-) = +28-70 KEV. 1/73

10 CHARGED K MEAN LIFE (UNITS 10<sup>-8</sup>)

| T | CHAR. K MEAN LIFE                                           | (0.25)    | IOFF                                          | 56 EMUL   |
|---|-------------------------------------------------------------|-----------|-----------------------------------------------|-----------|
| T | 0 (0.951) (0.36)                                            | (0.3)     | EISENBERG                                     | 58 EMUL   |
| T | 0 52 (1.601) (0.3)                                          | 0.06      | BURROWS                                       | 59 CNTR   |
| T | 0 33 (1.381) (0.24)                                         | (0.24)    | FREDEN                                        | 60 EMUL   |
| T | 0 (1.251) (0.22)                                            | (0.17)    | BARKAS                                        | 61 EMUL   |
| T | 0 51 (1.271) (0.36)                                         | (0.23)    | BIDMIRK                                       | 61 EMUL   |
| T | 293 1.31 0.08                                               | 0.08      | NORDIN                                        | 61 HBC -  |
| T | (1.24) (0.071)                                              | 0.011     | BOYARSKI                                      | 62 CNTR + |
| T | 1.231 0.011                                                 | 0.011     | BOYARSKI                                      | 62 CNTR + |
| T | 1.2443 0.0038                                               | FITCH     | 65 CNTR + K AT REST                           |           |
| T | 1.221 0.011                                                 | FORD      | 67 CNTR +                                     |           |
| T | 1.2272 0.0036                                               | LOBKOWICZ | 69 CNTR + K IN FLIGHT                         |           |
| T | 1.2380 0.0016                                               | OTT       | 71 CNTR + STOPPING K                          |           |
| T | 0 OLD EXPERIMENTS WITH LARGE ERRORS EXCLUDED FROM AVERAGING |           |                                               |           |
| T | AVG 1.2370 0.0032                                           | 0.0032    | AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)     |           |
| T | FIT 1.2371 0.0026                                           | 0.0026    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9) |           |

WEIGHTED AVERAGE = 0.8084 ± 0.0021  
ERROR SCALED BY 2.4



## 10 (K+) - (K-)/AVG., MEAN LIFE DIFFERENCE (PERCENT)

OT N THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

| OT | 0.47  | 0.30  | FORD                                         | 67 CNTR | 8/67  |
|----|-------|-------|----------------------------------------------|---------|-------|
| OT | 0.090 | 0.078 | LOBKOWICZ                                    | 69 CNTR | 12/70 |
| OT | 0.114 | 0.093 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |         |       |

## 10 CHARGED K PARTIAL DECAY MODES

| P1  | CHAR. K INTO MU NEU              | K MU2        | 105+ 0           |
|-----|----------------------------------|--------------|------------------|
| P2  | CHAR. K INTO PI P10              | K PI2        | 139+ 134         |
| P3  | CHAR. K INTO PI P1+ P1-          | TAU          | 139+ 139+ 139    |
| P4  | CHAR. K INTO MU P10 NEU          | TAU PRIME    | 139+ 134+ 134    |
| P5  | CHAR. K INTO E P10 NEU           | K MU3        | 105+ 134+ 0      |
| P6  | CHAR. K INTO PI P1- E- NEU       | K E3         | 5+ 134+ 0        |
| P7  | K+ INTO P1+ P1- E- NEU           | K E+ 4       | 139+ 139+ .5+ 0  |
| P8  | K+ INTO P1+ P1+ E- NEU           | K E- 4       | 139+ 139+ .5+ 0  |
| P9  | K+ INTO P1+ P1- MU- NEU          | K+MU+ 4      | 139+ 139+ 105+ 0 |
| P10 | K+ INTO P1+ P1+ MU- NEU          | K+MU- 4      | 139+ 139+ 105+ 0 |
| P11 | CHAR. K INTO E NEU               | K E2         | 5+ 0             |
| P12 | CHAR. K INTO MU NEU GAMMA        | K MU RAD     | 105+ 0+ 0        |
| P13 | CHAR. K INTO PI P10 GAMMA        | K PI RAD     | 139+ 134+ 0      |
| P14 | CHAR. K INTO PI P1+ P1- GAMMA    | TAU RAD      | 139+ 139+ 139+ 0 |
| P15 | CHAR. K INTO PI E+ E-            | PI E E       | 139+ .5+ .5      |
| P16 | CHAR. K INTO PI MU+ MU-          | PI MU MU     | 139+ 105+ 105    |
| P17 | CHAR. K INTO PI GAMMA GAMMA      | PI GAM GAM   | 139+ 0+ 0        |
| P18 | CHAR. K INTO PI E NEUTRINO GAMMA | PI E NEU GAM | 139+ .5+ 0+ 0    |
| P19 | K- INTO P1+ E- E-                | PI E- E-     | 139+ .5+ .5      |
| P20 | CHAR. K INTO PI NEU NEU          | PI NEU NEU   | 139+ 0+ 0        |
| P21 | CHAR. K INTO E NEU GAMMA         | K E2 RAD     | 5+ 0+ 0          |
| P22 | CHAR. K INTO PI GAMMA            | K PI GAM     | 139+ 0           |
| P23 | CHAR. K INTO PI 3GAMMA           | PI 3GAM      | 139+ 0+ 0+ 0     |
| P24 | CHAR. K INTO P10 P10 E NEU       | K E4 2P10    | 134+ 134+ .5+ 0  |
| P25 | K+ INTO P1+ E+ MU+               | PI E+ MU+    | 139+ .5+ 105     |
| P26 | K+ INTO P1+ E+ MU-               | PI E+ MU-    | 139+ .5+ 105     |
| P27 | CHAR. K INTO MU NEU NEU NEUBAR   | MU 3NEU      | 105+ 0+ 0+ 0     |

## CHARGED K CONSTRAINED FIT

OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING RATIOS USES 52 DATA POINTS TO DETERMINE SIX QUANTITIES. OVERALL FIT HAS  $\chi^2/DOF = 82.2$ . MAIN CONTRIBUTION (16.3) COMES FROM R19 OF HAIDT (WE SEE NO REASON TO REJECT THIS EXPERIMENT AT THIS TIME)

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm 6P_i$ , where  $6P_i = \sqrt{(\delta P_i \delta P_i) / (\delta P_i \delta P_i)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_i)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

| P1 | P2            | P3            | P4            | P5            | P6            |
|----|---------------|---------------|---------------|---------------|---------------|
| P1 | .6352+-0.0019 |               |               |               |               |
| P2 | -.7953        | .2106+-0.0018 |               |               |               |
| P3 | -.1750        | -.0694        | .0559+-0.0003 |               |               |
| P4 | -.1814        | -.0728        | .1456         | .0173+-0.0005 |               |
| P5 | -.2968        | -.1830        | .0439         | -.0155        | .0324+-0.0010 |
| P6 | -.2852        | -.1793        | .1199         | -.0085        | .4265         |

## FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e.,  $G_i = \Gamma_i = \Gamma_{\text{total}} P_i$ , in appropriate units. In analogy to the matrix above, the diagonal elements are  $G_i \pm 6G_i$ , where  $6G_i = \sqrt{(\delta G_i \delta G_i)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta G_i \delta G_j) / (\delta G_i \delta G_i)$ . Note that, because of the error in  $\Gamma_{\text{total}}$ , the errors and correlations here are not directly derivable from those above.

| G1 | G2            | G3            | G4            | G5            | G6            |
|----|---------------|---------------|---------------|---------------|---------------|
| G1 | .5135+-0.0019 |               |               |               |               |
| G2 | -.4575        | .1702+-0.0015 |               |               |               |
| G3 | -.1104        | -.0435        | .0452+-0.0002 |               |               |
| G4 | -.1284        | -.0607        | .1396         | .0140+-0.0004 |               |
| G5 | -.2040        | -.1598        | .0464         | -.0142        | .0262+-0.0008 |
| G6 | -.1399        | -.1299        | .1207         | -.0059        | .4297         |

## 10 CHARGED K DECAY RATES

| W1 | CHAR. K INTO MU NEU (UNITS 10 <sup>-8</sup> SEC <sup>-1</sup> )              | (G1)    | 8/67                                          |                    |
|----|------------------------------------------------------------------------------|---------|-----------------------------------------------|--------------------|
| W1 | 51.2                                                                         | 0.8     | FORD                                          |                    |
| W1 | 51.35                                                                        | 0.19    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                    |
| W2 | CHAR. K INTO PI P1+ P1- (UNITS 10 <sup>-8</sup> SEC <sup>-1</sup> )          | (G3)    | 8/67                                          |                    |
| W2 | F (4.496) (0.0301)                                                           | FORD    | 67 CNTR +- SEE NOTE F                         |                    |
| W2 | F 3.2M (4.529) (0.032)                                                       | FORD    | 70 ASPK SEE NOTE F                            |                    |
| W2 | 4.511                                                                        | 0.024   | FORD                                          | 70 ASPK SEE NOTE F |
| W2 | F THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70                     |         |                                               |                    |
| W2 | FIT 4.520                                                                    | 0.023   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                    |
| W3 | CHAR. K INTO (TAU) - (TAU PRIME) (UNITS 10 <sup>-8</sup> SEC <sup>-1</sup> ) | (G3-G4) |                                               |                    |
| W3 | USED FOR DELTA I = 1/2 TEST.                                                 |         |                                               |                    |
| W3 | 3.117                                                                        | 0.043   | FROM FIT                                      |                    |

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

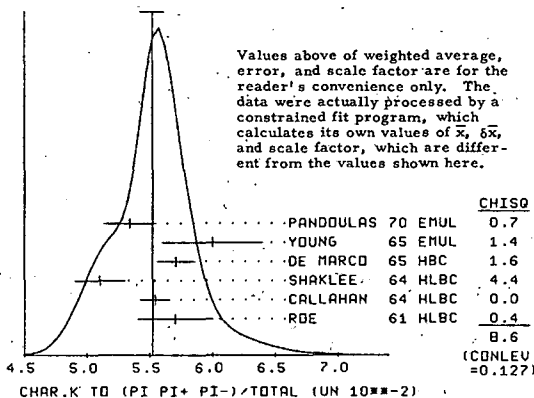
K<sup>±</sup>

W4 CHAR. K INTO (MU P10 NEU) + (E P10 NEU) (UNITS 10\*\*6 SEC-1)  
 W4 USED FOR DELTA I = 1/2 TEST.  
 W4  
 W4 FIT 6.542 0.083 FROM FIT

| 10 ((K+) - (K-))/AVG., DECAY RATE DIFFERENCE (PERCENT)         |                                                        |                                              |                  |       |
|----------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------|------------------|-------|
| D1                                                             | DIFFERENCE IN K MU2 RATES                              | ((G1+)-(G1-))/G1                             | (PERCENT)        |       |
| D1                                                             | -0.54 0.41                                             | FORD 67 CNTR                                 |                  | 8/67  |
| DIFFERENCE IN TAU RATES ((G3+)-(G3-))/G3 (PERCENT)             |                                                        |                                              |                  |       |
| D2                                                             | -0.50 0.90                                             | FLETCHER 67 OSPK                             |                  | 8/67  |
| D2 F                                                           | (-0.04) (0.21)                                         | FORD 67 CNTR                                 | SEE NOTE F       | 8/67  |
| D2 F 3.2M                                                      | (0.10) (0.14)                                          | FORD 70 ASPK                                 | SEE NOTE F       | 11/70 |
| D2                                                             | 0.08 0.12                                              | FORD 70 ASPK                                 | SEE NOTE F       | 11/70 |
| D2 F                                                           | THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70 |                                              |                  |       |
| D2                                                             | 0.07 0.12                                              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                  |       |
| DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE (PERCENT)  |                                                        |                                              |                  |       |
| D3                                                             | 1802 -1.1 1.8                                          | MERZO 69 OSPK                                |                  | 5/70  |
| DIFFERENCE IN K P12 RATES ((G2+)-(G2-))/AVERAGE (PERCENT)      |                                                        |                                              |                  |       |
| D4                                                             | 0.8 1.2                                                | MERZO 69 OSPK                                |                  | 5/70  |
| DIFFERENCE IN K P1 RAD RATES ((G13+)-(G13-))/AVERAGE (PERCENT) |                                                        |                                              |                  |       |
| D5                                                             | 24 0.0 24.0                                            | EDWARDS 72 OSPK                              | P1+ KE 58-90 MEV | 8/72* |

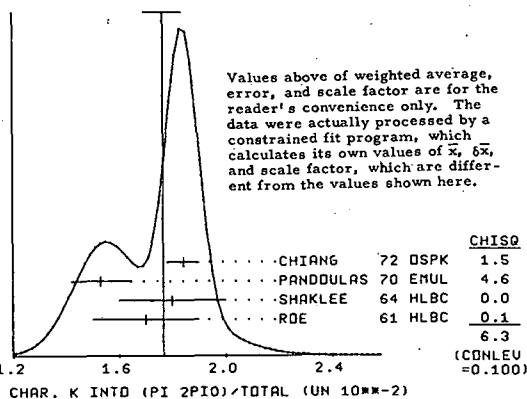
| 10 CHARGED K BRANCHING RATIOS |                                                                   |                                               |  |            |
|-------------------------------|-------------------------------------------------------------------|-----------------------------------------------|--|------------|
| OLD DATA EXCLUDED             |                                                                   |                                               |  |            |
| R1                            | CHAR. K INTO (MU P10)/TOTAL (UNITS 10**--2) (P1)                  |                                               |  |            |
| R1 O                          | (58.5) (3.0)                                                      | BIRGE 56 EMUL +                               |  |            |
| R1 O                          | (56.9) (2.6)                                                      | ALEXANDER 57 EMUL +                           |  |            |
| R1 O                          | OLD EXPERIMENTS NOT INCLUDED IN AVERAGING                         |                                               |  |            |
| R1                            | 62K 63.24 0.44                                                    | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 1/71 9/72* |
| R1 FIT                        | 63.52 0.19                                                        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |  |            |
| R2                            | CHAR. K INTO (PI P10)/TOTAL (UNITS 10**--2) (P2)                  |                                               |  |            |
| R2 O                          | (27.7) (2.7)                                                      | BIRGE 56 EMUL +                               |  |            |
| R2 O                          | (23.2) (2.2)                                                      | ALEXANDER 57 EMUL +                           |  |            |
| R2 O                          | EARLIER EXPERIMENTS NOT AVERAGED                                  |                                               |  |            |
| R2                            | (21.0) (0.6)                                                      | CALLAHAN 65 HLBC SEE R17                      |  |            |
| R2                            | (21.6) (0.6)                                                      | TRILLING 65 RVUE                              |  | 6/66       |
| R2                            | 16K 21.18 0.28                                                    | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 9/72*      |
| R2 FIT                        | 21.06 0.18                                                        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |  |            |
| R3                            | CHAR. K INTO (PI P1+ PI-)/TOTAL (UNITS 10**--2) (P3)              |                                               |  |            |
| R3 O                          | (5.6) (0.4)                                                       | BIRGE 56 EMUL +                               |  |            |
| R3 O                          | (6.8) (0.4)                                                       | ALEXANDER 57 EMUL +                           |  |            |
| R3 O                          | (5.2) (0.3)                                                       | TAYLOR 59 EMUL +                              |  |            |
| R3 O                          | EARLIER EXPERIMENTS NOT AVERAGED                                  |                                               |  |            |
| R3                            | 5.7 0.3                                                           | ROE 61 HLBC +                                 |  | 9/66       |
| R3                            | 2332 5.54 0.12                                                    | CALLAHAN 64 HLBC +                            |  |            |
| R3                            | 540 5.1 0.2                                                       | SHAKLEE 64 HLBC +                             |  | 9/66       |
| R3                            | 5.71 0.15                                                         | DE MARCO 65 HBC                               |  | 6/66       |
| R3                            | 44 6.0 0.4                                                        | YOUNG 65 EMUL +                               |  | 6/66       |
| R3 P                          | 693 5.34 0.21                                                     | PANDOLAS 70 EMUL +                            |  | 10/70      |
| R3 C                          | 2330 (5.54) (0.20)                                                | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 9/72*      |
| R3 C                          | THIS VALUE IS NOT INDEPENDENT OF CHIANG 72 R1, R2, R4, R5, AND R6 |                                               |  |            |
| R3 P                          | INCLUDES EVENTS OF TAYLOR 59.                                     |                                               |  |            |
| R3                            |                                                                   |                                               |  |            |
| R3 AVG                        | 5.521 0.098                                                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)  |  |            |
| R3 FIT                        | 5.591 0.030                                                       | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |  |            |
|                               | [SEE IDEOGRAM BELOW]                                              |                                               |  |            |

WEIGHTED AVERAGE = 5.521 ± 0.098  
 ERROR SCALED BY 1.3



| CHAR. K INTO (PI P10)/TOTAL (UNITS 10**--2) (P4) |                                  |                                               |  |       |
|--------------------------------------------------|----------------------------------|-----------------------------------------------|--|-------|
| R4 O                                             | (2.1) (0.5)                      | BIRGE 56 EMUL +                               |  |       |
| R4 O                                             | (2.2) (0.4)                      | ALEXANDER 57 EMUL +                           |  |       |
| R4 O                                             | (1.5) (0.2)                      | TAYLOR 59 EMUL +                              |  |       |
| R4 O                                             | EARLIER EXPERIMENTS NOT AVERAGED |                                               |  |       |
| R4                                               | 1.7 0.2                          | ROE 61 HLBC +                                 |  | 11/67 |
| R4                                               | 108 1.8 0.2                      | SHAKLEE 64 HLBC +                             |  | 11/67 |
| R4 P                                             | 198 1.53 0.11                    | PANDOLAS 70 EMUL +                            |  | 10/70 |
| R4 P                                             | 1307 1.84 0.06                   | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 9/72* |
| R4 P                                             | INCLUDES EVENTS OF TAYLOR 59.    |                                               |  |       |
| R4                                               |                                  |                                               |  |       |
| R4 AVG                                           | 1.767 0.049                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)  |  |       |
| R4 FIT                                           | 1.735 0.049                      | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4) |  |       |
|                                                  | [SEE IDEOGRAM BELOW]             |                                               |  |       |

WEIGHTED AVERAGE = 1.767 ± 0.071  
 ERROR SCALED BY 1.4



|         |                                                                                                                              |                                               |  |       |
|---------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|--|-------|
| R5      | CHAR. K INTO (MU P10 NEU)/TOTAL (UNITS 10**--2) (P5)                                                                         |                                               |  |       |
| R5 O    | (2.8) (1.0)                                                                                                                  | BIRGE 56 EMUL +                               |  |       |
| R5 O    | (5.9) (1.3)                                                                                                                  | ALEXANDER 57 EMUL +                           |  |       |
| R5 O    | (2.8) (0.4)                                                                                                                  | TAYLOR 59 EMUL +                              |  |       |
| R5 O    | EARLIER EXPERIMENTS NOT AVERAGED                                                                                             |                                               |  |       |
| R5      | 2345 3.33 0.16                                                                                                               | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 9/72* |
| R5 FIT  | 3.24 0.10                                                                                                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9) |  |       |
| R6      | CHAR. K INTO (E P10 NEU)/TOTAL (UNITS 10**--2) (P6)                                                                          |                                               |  |       |
| R6 O    | (3.2) (1.3)                                                                                                                  | BIRGE 56 EMUL +                               |  |       |
| R6 O    | (5.1) (1.3)                                                                                                                  | ALEXANDER 57 EMUL +                           |  |       |
| R6 O    | EARLIER EXPERIMENTS NOT AVERAGED                                                                                             |                                               |  |       |
| R6      | 5.0 0.5                                                                                                                      | ROE 61 HLBC +                                 |  | 11/67 |
| R6      | 429 4.7 0.3                                                                                                                  | SHAKLEE 64 HLBC +                             |  | 11/67 |
| R6      | 3516 4.86 0.10                                                                                                               | CHIANG 72 OSPK + 1.84 GEV/C K+                |  | 9/72* |
| R6      |                                                                                                                              |                                               |  |       |
| R6 AVG  | 4.849 0.093                                                                                                                  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |  |       |
| R6 FIT  | 4.851 0.055                                                                                                                  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |  |       |
| R7      | CHAR. K INTO (P12 + MU3)/TOTAL (UNITS 10**--2) (P2+P5)                                                                       |                                               |  | 11/67 |
| R7      | WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC                                                              |                                               |  |       |
| R7      | BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE                                                                             |                                               |  |       |
| R7      | 23.4 1.1                                                                                                                     | ROE 61 HLBC +                                 |  | 11/67 |
| R7      | 886 25.4 0.9                                                                                                                 | SHAKLEE 64 HLBC +                             |  | 11/67 |
| R7      |                                                                                                                              |                                               |  |       |
| R7 AVG  | 24.60 0.98                                                                                                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)  |  |       |
| R7 FIT  | 24.30 0.19                                                                                                                   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |  |       |
| R8      | K+ INTO (PI+ PI+ E- NEU)/TOTAL (UNITS 10**--7) (P8)                                                                          |                                               |  |       |
| R8      | 20.0                                                                                                                         | BIRGE 65 FBC +                                |  | 8/66  |
| R8      | 0 6.9 OR LESS CL=95                                                                                                          | ELY 69 HLBC +                                 |  | 10/69 |
| R8      | 0 9.0 OR LESS CL=95                                                                                                          | SCHNEIBER 71 HLBC +                           |  | 9/71  |
| R9      | K+ INTO (PI+ PI- MU+ NEU)/TOTAL (UNITS 10**--5) (P9)                                                                         |                                               |  |       |
| R9      | 1 0.77 0.54 0.50                                                                                                             | CLINE 65 FBC +                                |  | 8/66  |
| R10     | K+ INTO (PI+ PI+ MU- NEU)/TOTAL (UNITS 10**--6) (P10)                                                                        |                                               |  |       |
| R10     | 0 3.0 OR LESS CL=95                                                                                                          | BIRGE 65 FBC +                                |  | 8/66  |
| R11     | CHAR. K INTO (E NEU)/TOTAL (UNITS 10**--5) (P11)                                                                             |                                               |  |       |
| R11     | 160.0 OR LESS CL=95                                                                                                          | BORREANI 64 HBC +                             |  | 11/67 |
| R11     | 4 2.1 1.8 1.3                                                                                                                | BOWEN 67 OSPK +                               |  | 8/67  |
| R11     | BOWEN RESULT SHOULD BE CORRECTED TO 1.9(1.7-1.2) BECAUSE OF K+ TO E- NEU GAMMA DECAYS BEFORE COMPARING WITH BOTTERILL 67 R28 |                                               |  |       |
| R12     | CHAR. K INTO (PI GAMMA GAMMA)/TOTAL (UNITS 10**--4) (P12)                                                                    |                                               |  |       |
| R12     | ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM                                                              |                                               |  |       |
| R12     | 1.1 OR LESS CL=95                                                                                                            | CHEN 68 OSPK + T(PI) 60-90 MEV                |  | 2/72  |
| R12     | 0.5 OR LESS CL=90                                                                                                            | ALEXIS 71 OSPK + T(PI) 117 MEV                |  | 6/71  |
| R12     | 0 0.35 OR LESS CL=90                                                                                                         | LJUNG 72 HLBC + 6-102, 114-127 MEV            |  | 2/72  |
| R13     | CHAR. K INTO (PI P10 GAMMA)/TOTAL (UNITS 10**--4) (P13)                                                                      |                                               |  |       |
| R13     | 18 2.2 0.7                                                                                                                   | CLINE 64 FBC + PI+ KE 55-80 MEV               |  | 8/66  |
| R13     | 0 1.9 OR LESS CL=90                                                                                                          | CHERNERSON 69 OSPK + PI+ KE 55-80 MEV         |  | 10/69 |
| R13     | A2100 2.71 0.19                                                                                                              | ABRAMS 72 ASPK + PI+ KE 55-90 MEV             |  | 1/73* |
| R13     | 24 2.4 0.8                                                                                                                   | EDWARDS 72 OSPK + PI+ KE 58-90 MEV            |  | 8/72* |
| R13     | A ABRAMS 72 OBSERVES DIRECT EMISSION BR. RATIO OF (1.56+0.35)*10**--5                                                        |                                               |  |       |
| R13     | A +-0.5*10**--5 ADDNL. SYST. ERROR AND INNER BREMSSTRAHLUNG BR. RATIO                                                        |                                               |  |       |
| R13     | A OF (2.35+-0.18)*10**--4. WE QUOTE THE SUM OF THESE BR. RATIOS.                                                             |                                               |  |       |
| R13     |                                                                                                                              |                                               |  | 1/73* |
| R13 AVG | 2.66 0.18                                                                                                                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |  |       |
| R14     | CHAR. K INTO (PI P1+ PI- GAMMA)/TOTAL (UNITS 10**--4) (P14)                                                                  |                                               |  |       |
| R14     | 1.0 0.4                                                                                                                      | STAMER 65 EMUL + EGAM GT LINEV                |  | 8/66  |
| R15     | CHAR. K INTO (PI E+ E-)/TOTAL (UNITS 10**--6) (P15)                                                                          |                                               |  |       |
| R15     | 1 2.45 OR LESS CL=90                                                                                                         | CAMERINI 64 FBC +                             |  | 8/66  |
| R15     | 4.4 OR LESS CL=90                                                                                                            | BISI 67 OBC +                                 |  | 11/67 |
| R15     | 0.4 OR LESS                                                                                                                  | CLINE 67 FBC +                                |  | 11/67 |
| R15     | 32.0 OR LESS CL=90                                                                                                           | BETTER 72 OSPK +                              |  | 9/72* |
| R16     | CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**--6) (P16)                                                                        |                                               |  |       |
| R16     | 3.0 OR LESS CL=90                                                                                                            | CAMERINI 65 FBC +                             |  | 8/66  |
| R16     | 2.4 OR LESS CL=90                                                                                                            | BISI 67 OBC +                                 |  | 11/67 |
| R17     | CHAR. K INTO (E P10 NEU)/(MU2+P12) (UNITS 10**--2) (P6)/(P1+P2)                                                              |                                               |  |       |
| R17     | 134 3.24 0.34                                                                                                                | YOUNG 65 EMUL +                               |  | 8/66  |
| R17     | 1045 3.96 0.15                                                                                                               | CALLAHAN 66 FBC +                             |  | 9/66  |
| R17     |                                                                                                                              |                                               |  |       |
| R17 AVG | 3.84 0.27                                                                                                                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)  |  |       |
| R17 FIT | 3.767 0.040                                                                                                                  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |  |       |

## Stable Particles

 $K^\pm$ 

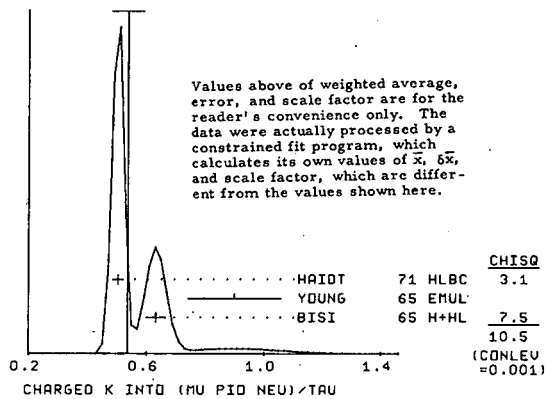
## Data Card Listings

For notation, see key at front of Listings.

| R18 | CHAR. | K INTO (PI 2P10)/TAU | (P4)/(P3) |                                               |           |
|-----|-------|----------------------|-----------|-----------------------------------------------|-----------|
| R18 | 2027  | 0.303                | 0.009     | BISI                                          | 65 H+HL + |
| R18 | 17    | 0.393                | 0.099     | YOUNG                                         | 65 EMUL + |
| R18 | AVG   | 0.3037               | 0.0090    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |           |
| R18 | FIT   | 0.3103               | 0.0087    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4) |           |

| R19 | CHAR.      | K INTO (MU P10 NEU)/TAU       | (P5)/(P3) |                                               |           |
|-----|------------|-------------------------------|-----------|-----------------------------------------------|-----------|
| R19 | 2175       | 0.632                         | 0.035     | BISI                                          | 65 H+HL + |
| R19 | 38         | 0.90                          | 0.16      | YOUNG                                         | 65 EMUL + |
| R19 | H 1505     | (0.510)                       | (0.017)   | EICHEN                                        | 68 HLBC + |
| R19 | H1505      | 0.503                         | 0.019     | HAIDT                                         | 71 HLBC + |
| R19 | H HAIDT 71 | IS A REANALYSIS OF EICHEN 68. |           |                                               |           |
| R19 | AVG        | 0.536                         | 0.054     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.2)  |           |
| R19 | FIT        | 0.580                         | 0.018     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9) |           |

WEIGHTED AVERAGE =  $0.536 \pm 0.054$   
 ERROR SCALED BY 3.2



| R20 | CHAR.      | K INTO (E P10 NEU)/TAU        | (P6)/(P3) |                                               |           |
|-----|------------|-------------------------------|-----------|-----------------------------------------------|-----------|
| R20 | 230        | 0.90                          | 0.06      | BORREANI                                      | 64 HBC +  |
| R20 | 37         | 0.90                          | 0.16      | YOUNG                                         | 65 EMUL + |
| R20 | 854        | 0.94                          | 0.09      | BELLOTI 2                                     | 67 HLBC + |
| R20 | H 4385     | (0.846)                       | (0.021)   | EICHEN                                        | 68 HLBC + |
| R20 | H4385      | 0.850                         | 0.019     | HAIDT                                         | 71 HLBC + |
| R20 | H HAIDT 71 | IS A REANALYSIS OF EICHEN 68. |           |                                               |           |
| R20 | AVG        | 0.858                         | 0.018     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |           |
| R20 | FIT        | 0.868                         | 0.010     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |           |

|     |                                                                |                                               |       |  |
|-----|----------------------------------------------------------------|-----------------------------------------------|-------|--|
| R22 | K+ INTO (PI+ MU+ NEU)/TAU (UNITS 10**--4)                      | (P9)/(P3)                                     |       |  |
| R22 | 1 (2.51 APPROX GREINER                                         | 64 EMUL                                       |       |  |
| R22 | 7 2.57 1.55 BISI                                               | 67 DBC +                                      | 8/66  |  |
| R23 | CHAR. K INTO (E PI NEU)/(MU2+PI2) (UNITS 10**--2) (P6)/(P1+P2) |                                               | 11/67 |  |
| R23 | 1679 5.89 0.21 CESTER                                          | 66 OSPK +                                     | 8/67  |  |
| R23 | 5110 6.16 0.22 ESCHMUTZ                                        | 68 OSPK +                                     | 3/68  |  |
| R23 | AVG 6.02 0.15                                                  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |  |
| R23 | FIT 5.736 0.064                                                | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |  |

|     |                                |        |        |                                               |                                      |       |
|-----|--------------------------------|--------|--------|-----------------------------------------------|--------------------------------------|-------|
| R24 | CHAR. K INTO (PI P10)/(MU NEU) |        |        |                                               | (P2)/(P1)                            |       |
| R24 |                                | 0.3253 | 0.0065 | AUERBACH                                      | 67 O5PK +                            | 8/67  |
| R24 | 1600                           | 0.3205 | 0.018  | ZELLER                                        | 69 ASPK +                            | 10/69 |
| R24 |                                |        |        |                                               |                                      |       |
| R24 | AVG                            | 0.3230 | 0.0065 | AVERAGE                                       | (ERROR INCLUDES SCALE FACTOR OF 1.1) |       |
| R24 | FIT                            | 0.3316 | 0.0037 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |                                      |       |

|     |                                                                  |                             |           |                         |
|-----|------------------------------------------------------------------|-----------------------------|-----------|-------------------------|
| R25 | CHAR.                                                            | K INTO (E P10 NEU)/(MU NEU) | (P6)/(P1) |                         |
| R25 | 472                                                              | 0.0797                      | 0.0054    | AUERBACH 67 OSPK + 8/67 |
| R25 | THE VALUE -.0785---.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF |                             |           |                         |
| R25 | AUERBACH 67 R25 AND CESTER 66 R25.                               |                             |           |                         |
| R25 | 960                                                              | -.0775                      | 0.003     | OSLER1 68 ASPK + 5/68   |
| R25 | 561                                                              | 0.069                       | 0.006     | GARLAND 68 ASPK + 4/68  |
| R25 | 350                                                              | 0.069                       | 0.006     | ZELLER 69 ASPK + 10/69  |
| R25 | . . . . .                                                        |                             |           |                         |

| R24 | CHAR. | K INTO (PI P10)/(MU NEU) | (P2)/(P1) |                                               |           |
|-----|-------|--------------------------|-----------|-----------------------------------------------|-----------|
| R24 | 1600  | 0.3253                   | 0.0065    | AUERBACH                                      | 67 OSPK + |
| R24 |       | 0.305                    | 0.018     | ZELLER                                        | 69 ASPK + |
| R24 | AVG   | 0.3230                   | 0.0065    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)  |           |
| R24 | FIT   | 0.3316                   | 0.0027    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |           |

| R25 | CHAR.                                                                                              | K INTO (E P10 NEU)/(MU NEU) | (P6)/(P1) |                                               |           |
|-----|----------------------------------------------------------------------------------------------------|-----------------------------|-----------|-----------------------------------------------|-----------|
| R25 | 472                                                                                                | 0.0797                      | 0.0054    | AUERBACH                                      | 67 OSPK + |
| R25 | THE VALUE .0785--0.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF AUERBACH 67 R25 AND CESTER 66 R23. |                             |           |                                               |           |
| R25 | 960                                                                                                | 0.0775                      | 0.0033    | BOTTERILL                                     | 68 ASPK + |
| R25 | 561                                                                                                | 0.069                       | 0.006     | GARLAND                                       | 68 OSPK + |
| R25 | 350                                                                                                | 0.069                       | 0.006     | ZELLER                                        | 69 ASPK + |
| R25 | AVG                                                                                                | 0.0753                      | 0.0025    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)  |           |
| R25 | FIT                                                                                                | 0.07638                     | 0.00085   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |           |

| R26 | CHAR. | K INTO (MU P10 NEU)/(MU NEU) | (P5)/(P1) |                                               |           |
|-----|-------|------------------------------|-----------|-----------------------------------------------|-----------|
| R26 | 310   | 0.0602                       | 0.0046    | AUERBACH                                      | 67 OSPK + |
| R26 | 424   | 0.055                        | 0.004     | GARLAND                                       | 68 OSPK + |
| R26 | 240   | 0.054                        | 0.009     | ZELLER                                        | 69 ASPK + |
| R26 | AVG   | 0.0569                       | 0.0029    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |           |
| R26 | FIT   | 0.0510                       | 0.0016    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9) |           |

| R27 | CHAR. | K INTO (MU NEU)/TAU                                               | (P1)/(P3) |          |           |
|-----|-------|-------------------------------------------------------------------|-----------|----------|-----------|
| R27 | R 427 | (10.38)                                                           | (0.82)    | YOUNG    | 65 EMUL + |
| R27 | R     | DELETED FROM OVERALL FIT BECAUSE YOUNG 65 CONSTRAINS HIS RESULTS. |           |          |           |
| R27 | R     | TO ADD UP TO 1. ONLY YOUNG MEASURED MU2 DIRECTLY.                 |           |          |           |
| R27 | FIT   | 11.361                                                            | 0.075     | FROM FIT |           |

| R28 | CHAR. | K INTO (E NEU)/(MU NEU) (UNITS 10**--5) | (P11)/(P1) |                                              |           |
|-----|-------|-----------------------------------------|------------|----------------------------------------------|-----------|
| R28 | 10    | 1.9                                     | 0.7        | BOTTERILL                                    | 67 ASPK + |
| R28 | 8     | 1.8                                     | 0.8        | MACEK                                        | 69 ASPK + |
| R28 | 113   | 2.42                                    | 0.42       | CLARK                                        | 72 OSPK + |
| R28 | AVG   | 2.16                                    | 0.31       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |           |

| R29 | CHAR.  | K INTO (MU P10 NEU)/(E P10 NEU) | (P5)/(P6) |           |                         |
|-----|--------|---------------------------------|-----------|-----------|-------------------------|
| R29 | C1509  | 0.703                           | 0.056     | CALLAHAN  | 66 HLBC                 |
| R29 | 5601   | 0.667                           | 0.017     | BOTTERILL | 68 ASPK +               |
| R29 | A 1398 | (0.604)                         | (0.022)   | EICHEN    | 68 HLBC                 |
| R29 | AH     | (0.596)                         | (0.025)   | HAIDT     | 71 HLBC +               |
| R29 | D3480  | 0.698                           | 0.025     | CHIANG    | 72 OSPK + 1.84 GEV/C K+ |

|     |     |                                                                   |                                               |
|-----|-----|-------------------------------------------------------------------|-----------------------------------------------|
| R29 | D   | THIS VALUE IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.   | 9/72*                                         |
| R29 | H   | HAIDT 71 IS A REANALYSIS OF EICHEN 68.                            |                                               |
| R29 | A   | ONLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).         | 11/68                                         |
| R29 | C   | FROM THIS EXPERIMENT WE USE ONLY THE MU3/E3 RATIO AND DO NOT      |                                               |
| R29 | C   | INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY SHOW |                                               |
| R29 | C   | LARGE DISAGREEMENTS WITH THE REST OF THE DATA.                    |                                               |
| R29 |     | *****                                                             |                                               |
| R29 | AVG | 0.678 0.014                                                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R29 | FIT | 0.668 0.024                                                       | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.2) |

|          |                                                                     |                                 |       |  |  |
|----------|---------------------------------------------------------------------|---------------------------------|-------|--|--|
| R30      | CHAR. K INTO (PI E NEU GAMMA)/(PI E NEU)                            | (P18)/(P6)                      |       |  |  |
| R30 R    | (0.012) (0.008)                                                     | BELLOTI 67 HLBC + EGAM GT 30MEV | 11/67 |  |  |
| R30 R 13 | 0.0076 0.0028                                                       | ROMANO 71 HLBC EGAM GT 10MEV    | 10/71 |  |  |
| R30 R    | WE USE LOWEST E(GAMMA) CUT-SEE ROMANO 71 FOR DEPENDENCE ON THIS CUT |                                 | 2/72  |  |  |

| R31 | K- INTO (PI+ E- E-)/TOTAL (UNITS 10**--5) | (P19) |        |      |
|-----|-------------------------------------------|-------|--------|------|
| R31 | TEST OF LEPTON NUMBER CONSERVATION.       |       |        |      |
| R31 | (1.5) OR LESS                             | CHANG | 68 HBC | 3/68 |

|     |                                                      |                                                        |         |          |                            |                           |      |
|-----|------------------------------------------------------|--------------------------------------------------------|---------|----------|----------------------------|---------------------------|------|
| R32 | CHAR. K INTO (PI NEU NEU)/TOTAL (UNITS 10**-6) (P20) |                                                        |         |          |                            |                           |      |
| R32 | (100.0)                                              | OR LESS                                                | CL=90   | CAMERINI | 69 HLBC + TEST NEUTR.CURR. | 5/70                      |      |
| R32 | K                                                    | 1.4                                                    | OR LESS | CL=90    | KLEMS                      | 71 OSPK + (P1) GT 117 MEV | 8/71 |
| R32 | K                                                    | ASSUMES PI+ SPECTRUM SAME AS PI0 SPECTRUM IN KE3 DECAY |         |          |                            |                           |      |

| R33 | CHAR. | K INTO (E NEU GAMMA)/TOTAL (UNITS 10**--5)              | (P21) |                            |       |
|-----|-------|---------------------------------------------------------|-------|----------------------------|-------|
| R33 | M     | (7.1) OR LESS                                           | MACEK | 70 OSPK + (P1E) 234 TO 247 | 12/70 |
| R33 | M     | ABOVE IS MEASUREMENT OF STRUCTURE-DEPENDENT DECAY ONLY. |       |                            |       |

|     |                                                      |      |
|-----|------------------------------------------------------|------|
| R34 | CHAR. K INTO (PI GAMMA)/TOTAL (UNITS 10**-6) . (P22) |      |
| R34 | 4.0 OR LESS CL=90 KLEMS 71 OSPK +                    | 8/71 |
| R35 | CHAR. K INTO (TAU)/(TAU PRIME) (P3/P4)               |      |

| R35 | CHAR. | K INTO (TAU)/(TAU PRIME)   | (P3/P4) |          |  |
|-----|-------|----------------------------|---------|----------|--|
| R35 |       | USED FOR DELTA I=1/2 TEST. |         |          |  |
| R35 | FIT   | 3.223                      | 0.090   | FROM FIT |  |

|     |                                                |                           |      |  |
|-----|------------------------------------------------|---------------------------|------|--|
| R36 | CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**--4) | (P23)                     |      |  |
| R36 | 3.0 OR LESS CL=90 KLEMS                        | 71 OSPK + T(PI) GT 117MEV | 8/71 |  |
| R36 | CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**--4) | (P23)                     |      |  |

|     |                                                            |           |       |
|-----|------------------------------------------------------------|-----------|-------|
| R37 | K+ INTO (PI+ PI+ E- NEU)/(PI+ PI- E- NEU)                  | (P8)/(P7) | 2/72  |
| R37 | 0 0.013 OR LESS CL=95 BOURQUIN 71 ASPK                     |           | 12/71 |
| R38 | CHAR. K INTO (PIO PIO E NEU)/KE3 (UNITS 10**=4) (P24)/(P6) |           | 12/71 |

|     |                                                  |      |         |       |        |           |       |
|-----|--------------------------------------------------|------|---------|-------|--------|-----------|-------|
| R38 | 0                                                | 37.0 | OR LESS | CL=90 | ROMANO | 71 HLBC + | 12/71 |
| R38 | 2                                                | 3.8  | 5.1     | 1.3   | CLINE  | 72 HLBC + | 2/72  |
| R39 | K+ INTO (PI- E+ MU+)/TOTAL (UNITS 10**--8) (P25) |      |         |       |        |           |       |

|     |                                                  |         |       |       |                  |  |
|-----|--------------------------------------------------|---------|-------|-------|------------------|--|
| R39 | K- INTO (PI+ E- MU-)/TOTAL IS ALSO INCLUDED HERE |         |       |       |                  |  |
| R39 | 2.8                                              | OR LESS | CL=90 | BEIER | 72 OSPK +- 9/72* |  |
| R40 | K+ INTO (PI+ E+ MU-)/TOTAL (UNITS 10**-8) (P26)  |         |       |       |                  |  |

|     |                                                    |         |       |       |                  |  |
|-----|----------------------------------------------------|---------|-------|-------|------------------|--|
| R40 | K- INTO (PI- E- MU+)/TOTAL IS ALSO INCLUDED HERE   |         |       |       |                  |  |
| R40 | 1.4                                                | OR LESS | CL=90 | BEIER | 72 OSPK +- 9/72* |  |
| R41 | CHAR. K INTO (MU 3NEU)/TOTAL (UNITS 10**--6) (P27) |         |       |       |                  |  |

|       |     |         |       |       |           |        |
|-------|-----|---------|-------|-------|-----------|--------|
| R41   | 7.0 | OR LESS | CL=90 | CABLE | 72 CNTR + | 10/72* |
| ----- |     |         |       |       |           |        |

Note on Slope Parameter for  $K \rightarrow 3\pi$  Decays

As was discussed in Section IV F. 1 of the text, for the  $3\pi$  decays of the K mesons we list the slope parameter "g" which is defined, as in that section, by

$$|M|^2 \propto 1 + g \frac{(s_3 - s_0)}{m_\pi^2} + h \left( \frac{s_3 - s_0}{m_\pi^2} \right)^2 + j \frac{(s_2 - s_1)}{m_\pi^2} \quad (1)$$

where

$$s_i = (p_K - p_i)^2 = (m_K - m_i)^2 - 2 m_K T_i \quad (2)$$

$$s_0 = \frac{1}{3} \sum s_i = \frac{1}{3} (m_K^2 + m_1^2 + m_2^2 + m_3^2) \quad (3)$$

$p_K, p_i$  are the four-vectors for the K and the  $i^{\text{th}}$  pion, and the index 3 refers to the odd pion. (4)

We refer to the three possible charged decays as  $\tau, \tau', \tau''$

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For notation, see key at front of Listings.

## Stable Particles

 $K^\pm$ 

$$\begin{aligned}\tau^\pm & K^\pm \rightarrow \pi^+ \pi^- \pi^\pm \\ \tau^{1\pm} & K^\pm \rightarrow \pi^0 \pi^0 \pi^\pm \\ \tau^0 & K^0 \rightarrow \pi^+ \pi^- \pi^0\end{aligned}$$

where the odd pion is the third one.

There is no strong evidence so far that a second order term in  $(s_3 - s_0)$  is needed in Eq. (1), nor that the term in  $(s_2 - s_1)$  is present. A value of  $j \neq 0$  indicates CP violation as would a value of  $g$  for  $\tau^+$  different from that for  $\tau^-$ . The CP violation tests in  $\tau$  decays are listed as  $\frac{(g^+ - g^-)}{(g^+ + g^-)}$  for charged K and as  $\sigma^\pm$  for neutral K (see Sec. IV F. 3b in the text).

As for the coefficient  $h$ , most of the experimenters have fitted their data with a second order term, which turned out to be consistent with zero. We use the value of  $g$  obtained when the second order term was dropped from the fit. HEUSSE 70 have studied the  $K_L^0 \rightarrow \pi^0 \pi^0 \pi^0$  decay where only a second order term could explain deviation from uniformity of the Dalitz plot. They also get results consistent with a zero coefficient. ALBROW 70 have studied  $K_L^0 \rightarrow \pi^+ \pi^- \pi^0$  and found that the fit to the Dalitz plot improves if second and third order terms are added (CL goes from 24% to 48%), but the fit with no higher orders is a perfectly acceptable one (CL = 24%). FORD 72 have studied  $K^\pm \rightarrow \pi^\pm \pi^\mp \pi^\pm$  and find that the  $\chi^2/DF$  goes from 1.38 to 1.20 when the second order and the CP violation terms are added. However, the authors state that since their Coulomb correction is larger than the experimental errors and is not well known, it is difficult to interpret these results.

In the literature other definitions of slope parameters have appeared. We have converted to the definition of  $g$  in Eq. (1) whatever experimental quantity has been reported. We give the conversion to the definition (1) for two of the most widely used parameterizations and tabulate the conversion factors for the reader's convenience.

(a) For analysis of charged K's the expression often used is:

$$|M|^2 = 1 + a_y Y$$

with

$$Y = \frac{3T_3 - Q}{Q}, \quad Q = m_K - \sum m_i$$

The relevant formulae are:

$$Y = -\frac{3}{2} \frac{s_3 - s_0}{m_K Q} + \Delta, \quad \text{with } \Delta = \frac{m_{12} - m_3}{Q} \left(2 - \frac{m_3 + m_{12}}{m_K}\right)$$

and

$$g = \frac{-c_y a}{1 + a_y \Delta}, \quad \text{with } c_y = \frac{3}{2} \frac{m_{\pi^+}^2}{m_K Q}$$

(b) For the analysis of  $K^0$  decay the expression often used is:

$$|M|^2 = 1 + 2a_t \frac{m_K}{m_{\pi^+}^2} (2T_3 - T_{3\max})$$

with

$$T_{3\max} = \frac{m_K^2 + m_3^2 - 4m_{12}^2}{2m_K} - m_3$$

The relevant transformations are

$$T_3 = -\frac{s_3 - s_0}{2m_K} + \frac{Q}{3} (1 + \Delta)$$

and

$$g = \frac{-2a_t}{1 + a_t c_t}, \quad \text{with } c_t = \frac{2m_K}{m_{\pi^+}^2} \left[ \frac{2}{3} Q(1 + \Delta) - T_{3\max} \right]$$

For the reader's convenience we give a table of numerical values for  $Q$ ,  $T_{3\max}$ ,  $\Delta$ ,  $c_y$  and  $c_t$ , obtained using the masses from our August 1970 edition. The  $g$  values quoted in these Data Card Listings would not be changed if the current mass values were used.

|               | $Q$   | $T_{3\max}$ | $\Delta$ | $c_y$  | $c_t$   |
|---------------|-------|-------------|----------|--------|---------|
| $\tau^\pm$    | 74.96 | 48.15       | 0        | 0.7894 | 0.0924  |
| $\tau^{1\pm}$ | 84.24 | 53.27       | -0.0789  | 0.7025 | -0.0778 |
| $\tau^0$      | 83.54 | 53.92       | 0.0798   | 0.7028 | 0.3176  |

Some  $K^0$  authors use the above form of matrix element:

$$|M|^2 = 1 + 2a_u \frac{m_K}{m_{\pi^+}^2} (2T_3 - T_{3\max}),$$

but define

$$T_{3\max} = \frac{2}{3} Q.$$

The relevant transformation is then

## Stable Particles

 $K^\pm$ 

$$g = \frac{-2a_u}{1 + \frac{a_u c_u}{m_\pi^+}}, \text{ with } c_u = \frac{2m_K}{m_\pi^+} \Delta = 0.2272.$$

Older  $K^0$  analyses were done using

$$|M|^2 = 1 + a_v \frac{T_3}{m_K}$$

The relevant transformation is then

$$g = \frac{-c_v a_v}{1 + \frac{d_v a_v}{m_K}}$$

with

$$c_v = \frac{m_\pi^+}{2m_K} = 0.0393$$

$$\text{and } d_v = \frac{Q}{3m_K} (1 + \Delta) = 0.0604.$$

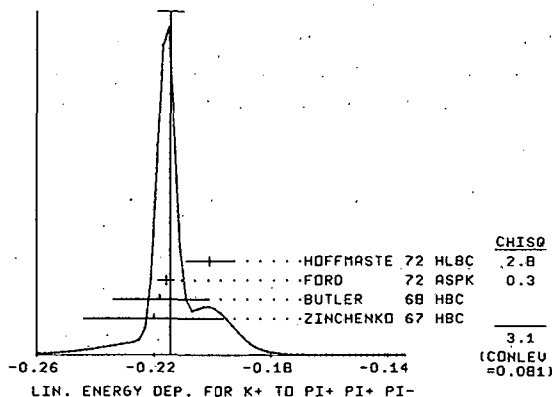
## 10 CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

RELATED TEXT SECTION IV F.1, APPENDIX I, AND MINI-REVIEW ABOVE

MATRIX ELEMENT SQUARED =  $1 + G (S3-S0)/(M\pi^{**2})$ 

GT- LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  $K^+ \rightarrow \pi^+ \pi^+ \pi^-$   
 GT- THESE EXPTS FIT  $M^{**2} = 1 + AY + Y^2$ . WE LIST G IN THE MAIN LISTING AND  
 GT- GIVE AY AT RIGHT.  $G = 1.5 \cdot AY \cdot (M\pi^{**2}) / (M_K^2)$ . SEE NOTE ABOVE.  
 GT+ 5428 -0.22 0.024 ZINCHENKO 67 HBC + AY=0.28+-0.03 10/69  
 GT+ 9994 -0.218 0.016 BUTLER 68 HBC + AY=0.277+-0.020 10/69  
 GT+ G17898 (-0.196) (0.012) GRAUMAN 70 HLBC + AY=0.228+-0.030 8/70  
 GT+ 750K -0.2158 0.0028 FORD 72 ASPK + AY=0.273+-0.0035 4/72\*  
 GT+ 39819 -0.201 0.008 HOFFMASTER 72 HLBC + INCLUDES GRAUMAN 1/71\*  
 GT+ Q THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH  $Y^{**2}$  COEF=-0.030+-0.010. 4/72\*  
 GT+ Q A LINEAR FIT IS QUOTED ONLY FOR THEIR COMBINED  $K^+$  AND  $K^-$  SAMPLE. 4/72\*  
 GT+ Q IT GIVES AY=0.2737+-0.0032. THE QUADRATIC FIT TO THE COMBINED 4/72\*  
 GT+ Q SAMPLE GIVES AY=0.2752+-0.0033 AND  $Y^{**2}$  COEFF=0.025+-0.010. 4/72\*  
 GT+ Q (CHISO/DFI)=1.38 FOR LINEAR FIT AND 1.20 FOR QUADRATIC FIT. 1/73\*  
 GT+ G EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72 1/71  
 GT+ Z ALSO INCLUDES OBC EVENTS.  
 GT+ AVG -0.2144 0.0045 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) (SEE IDEOGRAM BELOW)

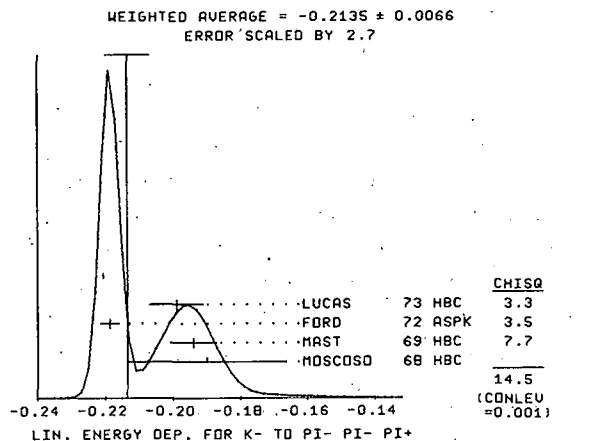
WEIGHTED AVERAGE =  $-0.2144 \pm 0.0045$   
 ERROR SCALED BY 1.7



GT- LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  $K^- \rightarrow \pi^- \pi^- \pi^+$   
 GT- FOR DEFINITION OF AY SEE NOTE UNDER S106T+.  
 GT- F 1347 (-0.220) (0.035) FERRO-LUZ 61 HBC - AY=0.28+-0.045 10/69  
 GT- M 5778 -0.190 0.023 MDCOSO 68 HBC - AY=0.242+-0.029 10/69  
 GT- S 50919 -0.194 0.007 MAST 69 HBC - AY=0.247+-0.009 10/69  
 GT- Q 750K -0.2187 0.0028 FORD 72 ASPK - AY=0.2770+-0.0035 4/72\*  
 GT- 84K -0.199 0.008 LUCAS 73 HBC - AY=0.252+-0.011 10/72\*  
 GT- Q THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH  $Y^{**2}$  COEF=-0.020+-0.010. 4/72\*  
 GT- Q SEE ALSO THE NOTE Q IN THE GT+ SECTION ABOVE. 4/72\*  
 GT- F NO RADIATIVE CORRECTIONS INCLUDED.  
 GT- M ALSO INCLUDES OBC EVENTS.  
 GT- AVG -0.2135 0.0066 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7) (SEE IDEOGRAM BELOW)

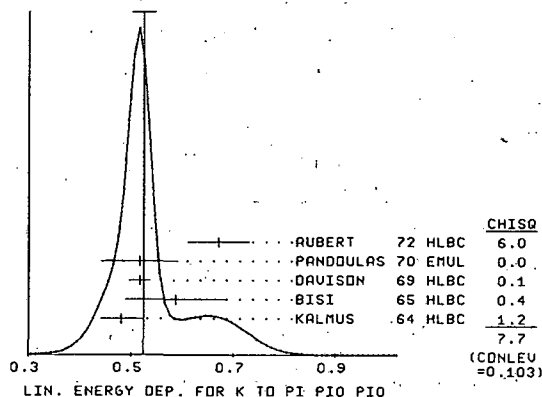
## Data Card Listings.

For notation, see key at front of Listings.



DG ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT  
 DG A NON-ZERO VALUE FOR THIS QUANTITY INDICATES CP VIOLATION  
 DG 3.2M -0.70 0.53 FORD 70 ASPK 11/70  
 GTP LINEAR ENERGY DEPENDENCE (G) FOR TAU PRIME DECAY  $CH^+ K \rightarrow \pi^+ \pi^0 \pi^0$   
 GTP 1792 0.48 0.04 KALMUS 64 HLBC + 10/69  
 GTP 1874 0.586 0.098 BISI 65 HLBC + ALSO HBC 10/69  
 GTP 4048 0.516 0.020 DAVISON 69 HLBC + ALSO EMUL 10/69  
 GTP 198 0.516 0.074 PANDOLAS 70 EMUL + 10/70  
 GTP A1365 0.67 0.06 AUBERT 72 HLBC 1/73\*  
 GTP A WE GIVE LINEAR TERM OF HIGHER ORDER FIT. EQ.1 OF APP.11, AUBERT 72. 1/73\*  
 GTP AVG 0.523 0.023 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE =  $0.523 \pm 0.023$   
 ERROR SCALED BY 1.4

Note on  $K^+$  and  $K^0$  Form Factors

The definitions of the parameters  $\lambda_+$ ,  $\lambda_-$ , and  $\xi$  can be found in Section IV F.2 of the text. Many approximations are usually made to extract these or related parameters from the experimental data.

1) Scalar and tensor currents: there is no evidence for scalar or tensor currents, so pure vector current is usually assumed.

2)  $\text{Im } \xi$  so far is consistent with 0, and this is usually assumed in most of the experiments.

3) Radiative corrections are not serious; they change  $\lambda_+$  by about 0.005 (GINSBERG 67 and 70).

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $K^{\pm}$ 

4) Older  $K_{\mu 3}$  experiments have determined  $\xi$  assuming  $\lambda_+ = \lambda_0 = 0$ .

5) Momentum transfer dependence of  $\xi$ : many  $K_{\mu 3}$  experiments have determined  $\xi$  assuming a linear  $q^2$  dependence for  $f_+$ , as in Eq. (27) of the main text. Some of these assume  $\lambda_- = 0$  since there is no strong evidence for a non-zero  $\lambda_-$ . Others allow  $\lambda_- \neq 0$  or equivalently  $\Lambda \neq 0$  where

$$\xi(q^2) = \xi(0) + \Lambda \frac{q^2}{m_\pi^2}$$

Instead of  $\lambda_-$  or  $\Lambda$ , HAIDT 71 ( $K^+$ ) gives  $\xi(q^2)$  where  $q^2$  is chosen to minimize the correlation with  $\xi(0)$ .

6) Most  $K_{e3}$  experiments have assumed a linear  $q^2$  dependence for  $f_+$ .

Since it is now clear that  $\lambda_+ \neq 0$ , assumption-4 values of  $\xi$  are parenthesized. Assumption-5 values of  $\xi$  and  $\lambda_+$  are encoded and any corresponding non-zero values of  $\lambda_-$  or  $\Lambda$  are given in footnotes. No attempt is made to average these  $\xi$  or  $\lambda_+$  values because they are highly correlated.<sup>1,2</sup> As in the past, we keep the values of  $\xi$  as obtained in the  $\mu$  polarization measurements ( $\xi_B$ ) separated from the values obtained from branching ratios and spectra ( $\xi_A$ ).

Assumption-6 values of  $\lambda_+$  (for  $K_{e3}$ ) are encoded and averaged. There is some indication from CHIEN 71 ( $K_L^0$ ) that a quadratic  $q^2$  term may be required in  $f_+$  for  $K_{e3}$ . Chounet, Gaillard, and Gaillard<sup>2</sup> further suggest that the large values of  $\lambda_+$  in  $K_{\mu 3}^0$  (compared with  $K_{e3}^0$ ) could be explained by the presence of a second order term.

See references 1 and 2 for excellent reviews of  $K_{l3}$  form factors and for a thorough treatment of the problems of correlations, higher order terms, and alternative parametrizations.

## References

1. M. K. Gaillard and L. M. Chounet,  $K_{l3}$  Form Factors, CERN 70-14 (May 1970), and Phys. Letters **32B**, 505 (1970).
2. L. M. Chounet, J. M. Gaillard, and M. K. Gaillard, Physics Reports **4C**, 199 (1972).

## 10 CHARGED K FORM FACTORS

8/67

RELATED TEXT SECTION IV F.2 AND MINI-REVIEW ABOVE

F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT  
FS AND FT REFER TO THE SCALAR AND TENSOR TERM

XIA F-/F+ (DETERMINED FROM SPECTRA AND  $K_{\mu 3}/K_{e3}$ )  
XIA SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS  
XIA INDEPENDENT OF THE MOMENTUM TRANSFER ( $q^2$ ), I.E., THEY SET  $\lambda_+ = \lambda_- = 0$ .  
XIA OTHERS HAVE ASSUMED A VALUE FOR  $\lambda_+$  AND USED  $\lambda_- = 0$ . ONLY RECENTLY  
XIA BOTH  $\lambda_+$  AND  $\lambda_-$  AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLUDED IN THE FITS. SEE HAIDT 71. (OR CHIEN 70 FOR  $K_L^0$ ).

XIA L 76 (+1.8) (1.6) BRDMN 62 XEBC + MU+ P10 SPECTRA 8/67  
XIA L 87 (+0.7) (0.5) GIACOMELLI 64 EMUL + MU+ SPECTRUM 8/67  
XIA L (-0.1) (0.7) JENSEN 64 XEBC + MU+ P10 SPECTRUM 8/67  
XIA L (-0.17) (0.75) (0.99) SHAKLEE 64 XEBC + MU+ P10 SPECTRUM 8/67  
XIA L (+0.6) (0.5) BISI 1 65 HBC + MU+ P10 SPECTRUM 8/67  
XIA BTMN +0.2 AND +1.4 CUTTS 65 OSK + MU+ SPECTRUM 8/67  
XIA L 1509 (+0.4) (0.4) CALLAHAN 66 FRBC + MU+ P10 SPECTRUM 8/67  
XIA 2648 0.0 1.1 0.9 CALLAHAN 66 FRBC + MU+ SPECTRUM 8/67  
XIA 444 +0.72 0.9 CALLAHAN 66 FRBC + P10 SPEC, FIX MU 8/67  
XIA L (+0.75) (0.50) AERBACH 67 OSK + MU+ P10 SPECTRUM 8/67  
XIA E 1398 (-0.60) (0.20) EICHEN 68 HLBC + MU+ P10 SPECTRUM 8/67  
XIA B 5601 (-0.08) (0.15) BOTTERILL 68 ASPK + MU+ P10 SPECTRUM 8/67  
XIA L 78 (-0.5) (0.9) EISLER 68 HLBC + P10 SPEC, L=-0 6/68  
XIA L 976 (+1.0) (0.6) GARLAND 68 OSK + MU+ P10 SPECTRUM 8/67  
XIA 0.91 0.82 ZELLER 69 ASPK + MU+ P10 SPECTRUM 8/67  
XIA B -0.35 0.22 BOTTERILL 70 OSK + MU+ P10 SPECTRUM 8/67  
XIA H3240 -0.80 0.50 HAIDT 71 HLBC + D.P. L=-0.05, T=7 2/72  
XIA 3240 -0.50 1.5 HAIDT 71 HLBC + D.P. L=-0.05, T=0 2/71  
XIA 1505 -0.72 0.21 HAIDT 71 HLBC + MU+ P10 SPECTRUM 8/67  
XIA 4025 -0.24 0.28 ANKENBRAN 72 ASPK + P10 L=-0.02, T=0 6/72  
XIA 3480 -0.09 0.28 CHIANG 72 OSK + D.P. L=-0.02, T=0 9/72  
XIA L+ AND L- ASSUMED TO BE ZERO.  
XIA E EICHEN 68 REPLACED BY HAIDT 71.  
XIA E T=4 ASSUMES L=-0.029+0.008 - INSENSITIVE TO L-.  
XIA B T=0 BOTTERILL 70 IS REEVALUATION OF BOTTERILL 68 WITH DIFF. L+. 10/69  
XIA H HAIDT 71 T=6.8 VALUE CORRECTED USING FIGURE 188. 2/72  
XIA H VALUES AT T=0 AND AT T=6.8 ARE UNCORRELATED. 2/72  
XIA K T=3.9 HAIDT 71 K3/K3E VALUE ASSUMES L=-0.029 - INDEPENDENT OF L-. 1/73  
XIA AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

XIB XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN  $K_{\mu 3}$ )  
XIB THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L-  
XIB NECESSARY, T SHOULD BE SPECIFIED.  
XIB 2100 2.4 1.8 BORREANI 65 HLBC + POLARIZATION 8/67  
XIB 397 -1.4 1.8 CALLAHAN 66 FRBC + TOTAL POLA- 8/67  
XIB 2950 -0.7 0.9 3.3 CALLAHAN 66 FRBC + LONG. POLA- 8/67  
XIB 3133 -0.95 0.3 CUTTS 68 OSK + TOTAL POL. T=3 6/68  
XIB H6000 0.6 1.1 HAIDT 71 HLBC + TOTAL POL. T=0 2/72  
XIB H6000 -1.0 0.3 HAIDT 71 HLBC + TOTAL POL. T=4.9 2/72  
XIB H HAIDT 71 VALUES AT T=0 AND T=4.9 ARE UNCORRELATED.  
XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

IXI IMAGINARY PART OF XI (TEST OF T REVERSAL)  
IXI 0.1 0.4 0.3 BETTELS 68 HLBC POLARIZATION 10/69  
FS FS/F+ RATIO OF SCALAR TO F+ COUPLINGS FOR  $K_{e3}$  DECAY (ABS. VALUE)----  
FS .30 OR LESS CL=-90 BELLOTT 67 HLBC + 10/69  
FS .23 OR LESS CL=-90 KALNUS 67 HLBC + 10/69  
FS 2707 0.14 0.03 0.04 BOTTERILL 68 ASPK 8/66  
FS 4017 0.13 OR LESS CL=-90 STEINER 71 HLBC + L+, FS, FT, PHI FIT 2/72  
CHIANG 72 OSK + 9/72

FT FT/F+ RATIO OF TENSOR TO F+ COUPLINGS FOR  $K_{e3}$  DECAY (ABS. VALUE)----  
FT .58 OR LESS CL=-90 BELLOTT 67 HLBC 10/69  
FT 1.1 OR LESS CL=-90 KALNUS 67 HLBC + 10/69  
FT 0.58 OR LESS CL=-90 BOTTERILL 68 ASPK 8/66  
FT 2707 0.24 0.16 0.14 STEINER 71 HLBC + L+, FS, FT, PHI FIT 2/72  
FT 4017 0.75 OR LESS CL=-90 CHIANG 72 OSK + 9/72

L+E LAMBDA+ ((LINEAR ENERGY DEPENDENCE OF F+ IN  $K_{e3}$  DECAY) ----  
L+E FOR RAD. CORR. TO DALITZ PLOT, SEE GINSBERG 67.  
L+E 217 +0.036 0.045 BRDMN 62 XEBC + P10 SPEC, NO R.C. 8/67  
L+E 407 -0.010 0.029 JENSEN 64 XEBC + P10 SPEC, NO R.C. 8/67  
L+E 230 -0.04 0.05 BORREANI 65 HBC + E+ SPEC, NO R.C. 8/67  
L+E 854 0.045 0.017 0.018 BELLOTT 67 FBC + DLTZ PLT, R.C. 11/67  
L+E 1393 0.016 0.016 IMAY 67 OSK + DLTZ PLT, NO R.C. 8/66  
L+E 515 +0.028 0.013 KALNUS 67 FBC + E+ SPEC, NO R.C. 8/67  
L+E 960 (0.8) (0.4) BOTTERILL 68 ASPK + E SPEC USES R.C. 6/68  
L+E 90 -0.02 0.08 0.12 EISLER 68 HLBC + P10 SPEC, NO R.C. 6/68  
L+E 1458 0.045 0.015 BOTTERILL 70 OSK + P10 SPECTRUM RC 10/69  
L+E 2707 0.027 0.01 STEINER 71 HLBC DLTZ PLT, USES R.C. 8/66  
L+E 4017 0.029 0.011 CHIANG 72 OSK + DLTZ PLOT, NO RC 9/72  
L+E AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

L+M LAMBDA+ ((LINEAR ENERGY DEPENDENCE OF F+ IN  $K_{\mu 3}$  DECAY) ----  
L+M FOR RAD. CORR. TO DALITZ PLOT OF  $K_{\mu 3}$  SEE GINSBERG 70  
L+M 3240 0.055 0.025 HAIDT 71 HLBC  $K_{\mu 3}$  DAL. PLOT 2/71  
L+M 4025 0.024 0.022 ANKENBRAN 72 ASPK + P10 SPEC, XI=-.62 6/72  
L+M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

## REFERENCES FOR CHARGED K

BIRGE 56 NC 4 834 BIRGE, PERKINS, PETERSON, STORK, WHITEHA (LRL)  
ILOFF 56 PR 102 927 ILOFF, GOLDHABER, LANNUTTI, GILBERT + (LRL)  
ALEXANDER 57 NC 6 478 ALEXANDER, JOHNSTON, OCEALLAIGH (DUBLIN INST)  
COHEN 57 FUND-CONS. PHYS. + CROWE, DUMOND (ATOMIC INTER.-LRL-CT)  
EISENBERG 58 NC 8 563 EISENBERG, KOCH, LOHRMANN, NIKOLIC + (BERN)  
BURROWS 59 PRL 2 117 BURROWS, CALDWELL, FRISCH, HILL + (MIT)  
TAYLOR 59 PR 114 359 S TAYLOR, HARRIS, OREAR, LEE, BAUMEL (COLUMBIA)  
FREDEN 60 PR 118 564 S C FREDEN, F C GILBERT, R S WHITE (LRL)  
BARKAS 61 PR 124 1209 BARKAS, DYER, MASON, MORRIS, NICKOLS, SMIT (LRL)  
BHOWMIK 61 NC 20 857 B BHOWMIK, P C JAIN, P C MATHUR (DELHI UNIV)  
FERRO-LU 61 NC 22 1087 FERRO-LUZZI, MILLER, MURRAY, ROSENFELD (LRL)  
NORDIN 61 PR 123 2166 PAUL NORDIN JR (LRL)  
ROE 61 PRL 7 346 ROE, SINCLAIR, BROWN, GLASER + (MICH-LRL)  
BOYARSKI 62 PR 128 2398 BOYARSKI, LOH, NIEBELA, RITSON (MIT)  
BROWN 62 PRL 8 450 BROWN, KADYK, TRILLING, ROE+ (LRL, MICH)  
BARKAS 63 PRL 11 26 W H BARKAS, J N DYER, H H HECKMAN (LRL)  
BORREANI 64 PL 12 123 G BORREANI, G RINAUDO, A VERBROUCK (TURIN)  
CALLAHAN 64 PR 136 B 1463 A CALLAHAN, R MARCH, R STARK (WISCONSIN)  
CAMERINI 64 PRL 13 318 CAMERINI, CLINE, FRY, POWELL (WISCONSIN-LRL)  
CLINE 64 PRL 13 101 D CLINE, W F FRY (WISCONSIN)  
GIACOMELLI 64 NC 34 1134 GIACOMELLI, MONTI, QUARENTA+ (BOLOGNA, MUNICH)  
GREINER 64 PR 139 B 1068 D GREINER, W OSBORNE, W BARKAS (LRL)  
JENSEN 64 PR 136 B1431 JENSEN, SHAKLEE, ROE, SINCLAIR (MICH)  
KERNAN, PU, POWELL, OODW (LRL, WISC)  
SHAKLEE 64 PR 136 B 1423 SHAKLEE, JENSEN, ROE, SINCLAIR (MICH)

BIRGE 65 PR 139 B 1600 BIRGE, ELY, GIDAL, CAMERINI, CLINE + (LRL-WISC)  
BISI 65 NC 35 768 BISI, BORREANI, CESTER, FERRARO + (TORINO)  
BISI 1 65 PR 139 B 1068 BISI, MARZARI-CHIESA, RINAUDO (TORINO)  
BORREANI 65 PR 140 B1686 BORREANI, GIDAL, RINAUDO, CAFORIO+ (BARI, TORI)

## Stable Particles

 $K^{\pm}$ ,  $K^0$ ,  $K_S^0$ 

|                                                             |                                                      |
|-------------------------------------------------------------|------------------------------------------------------|
| CALLAHAN 65 PRL 15 129                                      | A CALLAHAN, D CLINE (WISCONSIN)                      |
| CAMERINI 65 NC 37 1795                                      | *CLINE, GIDAL, KALMUS, KERNAN (WISC+LRL)             |
| CLINE 65 PL 7-15 293                                        | A CLINE, W F FRY (WISCONSIN)                         |
| DE MARCO 65 PR 140 8 1430                                   | DE MARCO, GROSSO, RINAUDO (TORINO-CERN)              |
| FITCH 65 PR 140 8 1088                                      | FITCH, QUARLES, WILKINS (PRINCETON+MT HOLYOKE)       |
| GREINER 65 ARNS 15 67                                       | QUOTED BY BARKAS (LRL)                               |
| STAMER 65 PR 139 8 440                                      | STAMER, HUBERT, KOLLER, TAYLOR, GRAUMAN (STEVE)      |
| TRILLING 65 UCLR 16473                                      | GEORGE H TRILLING (LRL)                              |
| UPDATED FROM 1965 ARGONNE                                   | CONF., PAGE 5.                                       |
| YOUNG 65 UCLR 16362                                         | POH-SHIEN YOUNG (THESIS; BERKELEY) (LRL)             |
| ALSO 67 PR 156 1464                                         | P-S YOUNG, W. Z. OSBORNE, W. H. BARKAS (LRL)         |
| CALLAHAN 66 PR 150 1153                                     | CALLAHAN, CAMERINI + WISC, LRL, RIVERSIDE, BARI      |
| CALLAHAN 66 NC 44A 90                                       | A C CALLAHAN (WISCONSIN)                             |
| CESTER 66 PL 21 343                                         | CESTER, ESCHSTRUTH, ONEILL (PRINCETON-PENN)          |
| ALSO 67 AUERBACH, FOOTNOTE 1.                               |                                                      |
| AUERBACH 67 PR 155 1505                                     | *DOBBS, MANN, MCFARLANE, WHITE + (PENN, PRIN)        |
| BELLOTTI 67 HEIDELBERG CONF                                 | BELLOTTI, PULLIA (MILAN)                             |
| BELLOTTI 67 NC 52A 1287                                     | BELLOTTI, FIORINI, PULLIA (MILAN)                    |
| ALSO 66 PL 20 690                                           | BELLOTTI, FIORINI, PULLIA + (MILAN)                  |
| BISI 67 PL 258 572                                          | BISI, CESTER, CHIESA, VIGONE (TORINO)                |
| BOTTERILL 67 PRL 119 982                                    | BOTTERILL, BROWN, CORBETT, CULLIGAN + (OXFORD)       |
| ALSO 68 BOTTERILL                                           |                                                      |
| BOWEN 67 PR 154 1314                                        | BOWEN, MANN, MCFARLANE, HUGHES + (PENN-PRINCETON)    |
| CLINE 67 HEIDELBERG CONF                                    | CLINE, HAGGERTY, SINGLETON, FRY + (WISCONSIN)        |
| FLETCHER 67 PRL 19 98                                       | FLETCHER, BEIER, EDWARDS + (ILLINOIS)                |
| FORD 67 PRL 18 1214                                         | *LEMONICK, NAUENBERG, PIRQUE (PRINCETON)             |
| IMLAY 67 PR 160 1203                                        | IMLAY, ESCHSTRUTH, FRANKLIN + (PRINCETON)            |
| KALMUS 67 PR 159 1187                                       | KALMUS, KERNAN (LRL)                                 |
| ZINCENKO 67 RUTGERS (THESIS)                                | ZINCENKO (RUTGERS)                                   |
| BETTLES 68 NC 56A 1106                                      | AACHEN-BARI-BERGEN-CERN-EP-NIJMEGEN-ORSAY +          |
| BOTTERILL 68 PR 171 1402                                    | BOTTERILL, BROWN, CORBETT, CULLIGAN + (OXFORD)       |
| BOTTERILL 68 PR 174 1661                                    | BOTTERILL, BROWN, CLEGG, CORBETT + (OXFORD)          |
| BOTTERILL 68 PR 21 766                                      | BOTTERILL, BROWN, CLEGG, CORBETT + (OXFORD)          |
| BUTLER 68 UCLR-18420                                        | *BLAND, GOLDBERGER, GOLDBERGER, HIRATA + (LRL)       |
| CHANG 68 PRL 20 510                                         | CHANG, YODH, EHRLICH, PLAND + (MARYLAND, RUTGERS)    |
| CHEN 68 PRL 20 73                                           | CHEN, CUTTS, KIJEWSKI, STIENING + (LRL, MIT)         |
| CUTTS 68 PRL 20 955                                         | CUTTS, STIENING, WIEGAND, DEUTSCH (LRL, MIT)         |
| ALSO 65 PR 138 8969                                         | CUTTS, ELIOFF, STIENING (LRL)                        |
| ALSO 69 PR 184 1380                                         | *STIENING, WIEGAND, DEUTSCH (LRL, MIT)               |
| EICHEN 68 PL 278 586                                        | AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA            |
| EISLER 68 PR 165 1090                                       | EISLER, FUNG, HARA, KLEGG, MEYER, PLAND (RUTGERS)    |
| ESCHSTRUTH 68 PR 165 1487                                   | ESCHSTRUTH, FRANKLIN, HUGHES + (PRINCETON, PENN)     |
| GARLAND 68 PR 167 1225                                      | *TSIPIS, DE VON, ROSEN + (COLUMBIA, RUTG, WISC)      |
| MOSCOSO 68 THESIS                                           | M L MOSCOSO (UNIV PARIS ORSAY)                       |
| CAMERINI 69 PRL 23 326                                      | *LJUNG, SHEAFF, CLINE (WISCONSIN)                    |
| DAVIDSON 69 PR 180 1333                                     | *BACASTON, BARKAS, EVANS, FUNG, PORTER + (UCR)       |
| ELY 69 PR 180 1319                                          | ELY, GIDAL, HAGOPIAN, KALMUS + (LOUC+MISC+LRL)       |
| EMMERSON 69 PRL 23 393                                      | EMMERSON, QUIRK (OXFORD)                             |
| HERZO 69 PR 186 1403                                        | *BANNER, BEIER, BERTRAM, EDWARDS + (ILL)             |
| LOBKOWICZ 69 PR 185 1676                                    | *MELISSINOS, NAGASHIMA, TEWKSBURY + (ROCH, BNL)      |
| ALSO 66 PRL 17 548                                          | LOBKOWICZ, MELISSINOS, NAGASHIMA + (ROCH+BNL)        |
| MAKCEK 69 PRL 22 32                                         | MAKCEK, MANN, MCFARLANE, ROBERTS + (PENN, TEMPLE)    |
| MAST 69 PR 183 1200                                         | *GERSHWIN, ALSTON-GARAJOST, BANGERTER + (LRL)        |
| ZELLER 69 PR 182 1420                                       | ZELLER, HADDOCK, HELLAND, PAHL + (UCLA, LRL)         |
| BOTTERILL 70 PL 318 325                                     | *BROWN, CLEGG, CORBETT, CULLIGAN + (OXF)             |
| FORD 70 PRL 25 1370                                         | *PIROUE, REMHEL, SMITH, SOUDER (PRIN)                |
| GRAUMAN 69 PRL 25 1277                                      | *KOLLER, TAYLOR, PANDOLA + (STEVE, SETO, LEHI)       |
| ALSO 69 PR 23 1277                                          | *KOLLER, TAYLOR, PANDOLA + (STEVE, SETO, LEHI)       |
| MAKCEK 70 PR D1 1249                                        | *MANN, MCFARLANE, ROBERTS (PENN)                     |
| PANDOLA 70 PR D2 1205                                       | *TAYLOR, KOLLER, GRAUMAN + (STEVE, SETO)             |
| BOURQUIN 71 PL 368 615                                      | *BOYMOND, EXTERMANN, MARASCO + (GEVA, SACL)          |
| HAIDT 71 PR D3 10                                           | AACHEN+BARI+CERN+EP+NIJMEGEN+ORSAY+PADOVA +          |
| ALSO 69 PL 298 691                                          | *AACH, BARI, CERN, EPOL, NIJMEGEN, ORSAY, PADO, TORI |
| KLEMS 71 PR D4 66                                           | *HILDEBRAND, STEINING (CHIC, LRL)                    |
| ALSO 70 PRL 24 1086                                         | KLEMS, HILDEBRAND, STEINING (LRL, CHIC)              |
| ALSO 70 PRL 25 473                                          | KLEMS, HILDEBRAND, STEINING (LRL, CHIC)              |
| KUNSELMA 71 PL 348 485                                      | R. KUNSELMA (WYOMING)                                |
| OTT 71 PR D3 52                                             | OTT, PRITCHARD (LOOM)                                |
| ROMANO 71 PL 368 525                                        | *RENTON, AUBERT, BURBAN-LUTZ (BARI, CERN, ORSAY)     |
| SCHWEIN 71 PL 368 246                                       | AACHEN+BELGIUM+CERN+NIJMEGEN+PADOVA+COLLAB           |
| STEINER 71 PL 368 521                                       | AACHEN+BARI+CERN+EPOL+ORSAY+NIJMEGEN+PADO+TORIN      |
| ABRAMS 72 PRL 29 1118                                       | *CARROLL, KYCIA, LI, MENES, MICHAEL + (BNL)          |
| ANKENBRA 72 PRL 28 1472                                     | ANKENBRA, LARSEN + (BNL+LASL+NAL+YALE)               |
| AUBERT 72 NC 124 509                                        | *HEUSSE, PASCAUD, VIAL, LE + (ORSAY+BRUX+EPOL)       |
| BEIER 72 PRL 29 678                                         | *BUCHHOLZ, MANN, PARKER (PENNSYLVANIA)               |
| CABLE 72 PL 408 699                                         | *HILDEBRAND, PANG, STEINING (EFI, LBL)               |
| CHIANG 72 PR D6 1254                                        | *ROSEN, SHAPIRO, HANDLER, OLSEN + (ROCH+WISC)        |
| CLARK 72 PRL 29 1274                                        | *CORR, EL IOFF, KERTH, MCREYNOLDS, NEWTON + (LBL)    |
| CLINE 72 PRL 28 1287                                        | D CLINE, D LJUNG (WISCONSIN)                         |
| EDWARDS 72 PR D5 2720                                       | *BEIER, BERTRAM, HERZO, KOESTER + (ILL)              |
| FORD 72 PL 388 335                                          | *PIROUE, REMHEL, SMITH, SOUDER (PRINCETON)           |
| HOFFMAST 72 NP 836 1                                        | HOFFMAST, KOLLER, TAYLOR + (STEVE+SETO+LEHI)         |
| LJUNG 72 PRL 28 523                                         | D LJUNG (WISCONSIN)                                  |
| BACKENST 73 TO BE PUB. IN PL B                              | BACKENSTOSS, BAMBERGER + (CERN, KARL, HEID, STON)    |
| LUCAS 73 PR TO BE PUBL.                                     | P M LUCAS, H D TAFT, W J WILLIS (YALE)               |
| QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS |                                                      |
| BLOCK 62 CERN CONF 371                                      | BLOCK, LENDINARA, MONARI (NWES+BOLOGNA)              |
| PAPERS NOT REFERRED TO IN DATA CARDS                        |                                                      |
| BRENE 61 NP 22 553                                          | BRENE, EGARDT, QVIST (NORR)                          |
| BIRGE 63 PRL 11 35                                          | BIRGE, ELY, GIDAL, CAMERINI + (LRL+WISC+BARI)        |
| ADAIR 64 PL 12 67                                           | ADAIR, LEIPUNER (YALE, BNL)                          |
| CABIBBO 64 PL 9 352                                         | CABIBBO, MAKSYMOWICZ (CERN)                          |
| ALSO 64 PL 12 67                                            | CABIBBO, MAKSYMOWICZ (CERN)                          |
| ALSO 65 PL 14 72                                            | CABIBBO, MAKSYMOWICZ (CERN)                          |
| CABIBBO 66 BERKELEY CONF 33                                 | CABIBBO (CERN)                                       |
| GINSBERG 67 PR 162 1570                                     | EDWARD S GINSBERG (U. MASS BOSTON)                   |
| WILLIS 67 HEIDELBERG 273                                    | M J WILLIS - RAPPORTEUR TALK (YALE)                  |
| CROHN 68 VIENNA CONF 241                                    | RAPPORTEUR TALK (PRINCETON)                          |
| HAIDT 2 69 PL 298 696                                       | *AACH, BARI, CERN, EPOL, NIJMEGEN, ORSAY, PADO, TORI |
| FEARING 70 PR D3 542                                        | *FISCHBACK, SMITH (STON+BOHR)                        |
| GINSBERG 70 PR D1 229                                       | E S GINSBERG (IIT HAIFA)                             |

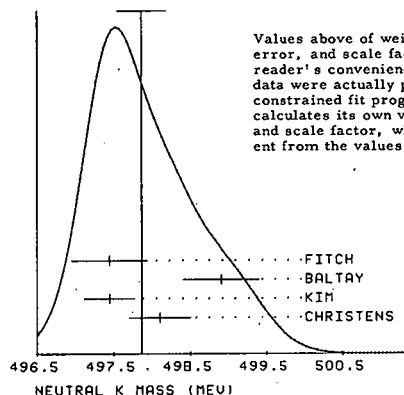
## Data Card Listings

For notation, see key at front of Listings.

 $K^0$ 

11 NEUTRAL K (498, JP=0-) 1=1/2

| 11 NEUTRAL K MASS (MEV)           |      |        |      |                                               |                |       |  |  |  |
|-----------------------------------|------|--------|------|-----------------------------------------------|----------------|-------|--|--|--|
| M                                 |      | 498.1  | 0.4  | CHRISTENS 64 DSPK                             |                |       |  |  |  |
| M                                 | 2223 | 497.44 | 0.33 | KIM 65 HBC                                    | KO FROM PBAR P | 6/66  |  |  |  |
| M                                 | 4500 | 498.9  | 0.5  | BALTAY 66 HBC                                 | KO FROM PBAR P | 6/66  |  |  |  |
| M                                 |      | 497.44 | 0.50 | FITCH 67 DSPK                                 |                | 11/67 |  |  |  |
|                                   |      |        | 0.32 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)  |                |       |  |  |  |
| M                                 | AVG  | 497.87 | 0.13 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                |       |  |  |  |
| M                                 | FIT  | 497.71 |      |                                               |                |       |  |  |  |
| WEIGHTED AVERAGE = 497.87 ± 0.32. |      |        |      |                                               |                |       |  |  |  |
| ERROR SCALED BY 1.5               |      |        |      |                                               |                |       |  |  |  |



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of  $\bar{x}$ ,  $\bar{\sigma}$ , and scale factor, which are different from the values shown here.

CHISO  
0.7  
4.3  
1.7  
0.3  
7.0  
(CONLEV  
= 0.072)

| 11 (K0) - (K+-) MASS DIFFERENCE (MEV) |     |      |                  |                                               |              |             |      |  |  |
|---------------------------------------|-----|------|------------------|-----------------------------------------------|--------------|-------------|------|--|--|
| D                                     | 3.9 | 0.6  | ROSENFELD 59 HBC | -                                             |              |             |      |  |  |
| D                                     | 5.4 | 1.1  | GRAUFORD 59 HBC  | +                                             |              |             |      |  |  |
| D                                     | 9   | 0.25 | BURNSTEIN 65 HBC | +                                             |              |             |      |  |  |
| D                                     | 7   | 0.35 | KIM 65 HBC       | -                                             | K- P TO KO N | 6/68        |      |  |  |
| D                                     | 417 | 3.95 | 0.21             | HILL 68 DBC                                   | -            | K+ D TO KOP | 3/68 |  |  |
| D                                     | AVG | 3.92 | 0.14             | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |              |             |      |  |  |
| D                                     | FIT | 3.99 | 0.13             | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |              |             |      |  |  |

## REFERENCES FOR NEUTRAL K

|                           |                                                 |
|---------------------------|-------------------------------------------------|
| CRAWFORD 59 PRL 2 112     | CRAWFORD, CRESTI, GOOD, STEVENSON, TICHON (LRL) |
| ROSENFELD 59 PRL 2 110    | A H ROSENFELD, F SOLMITZ, R D TRIPP (LRL)       |
| CHRISTEN 64 PRL 13 138    | CHRISTENSON, CROHN, FITCH, TURLAY (PRINCETON)   |
| BURNSTEIN 65 PR 138 8 895 | R A BURNSTEIN, H A RUBIN (MARYLAND)             |
| KIM 65 PR 140 8 1334      | J K KIM, L KIRSCH, D MILLER (COLUMBIA)          |
| BALTAY 66 PR 142 932      | BALTAY, SANDWEISS, STONEHILL + (YALE+BNL)       |
| FITCH 67 PR 164 1711      | FITCH, ROTH, RUSS, VERNON (PRINCETON)           |
| HILL 68 PR 168 1534       | HILL, ROBINSON, SAKITT, CANTER (BNL, CARNEGIE)  |

 $K_S^0$ 

12 SHORT-LIVED NEUTRAL K (498, JP=0-) 1=1/2

Note on the  $K_S^0$  Mean Life

In a bubble chamber experiment SKJEGGE-STAD 72 obtain a value for the  $K_S^0$  mean life,  $\tau_S = (0.8958 \pm 0.0045) \times 10^{-10}$  sec, which is significantly higher than the combined results of previous experiments  $[(0.862 \pm 0.006) \times 10^{-10}$  sec from our 1972 edition]. In addition, the CERN-Heidelberg Collaboration (in a vacuum regeneration experiment) reported a preliminary value  $(0.899 \pm 0.005) \times 10^{-10}$  sec (Batavia 1972) in agreement with SKEGGESTAD. However, it should be pointed out that the CERN-Heidelberg number is highly correlated with  $|\eta_{+-}|$  for which they find a value of  $(2.35 \pm 0.07) \times 10^{-3}$ .

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $K_S^0$ 

We have not entered the CERN-Heidelberg results in our listings because they have not been published yet.

The corrections for systematic biases in SKJEGGESTAD 72 and in HILL 68 (updated) amount to +1% and 0.7% respectively. Similar corrections, if applied to the older bubble chamber results, would probably increase their average by only about one standard deviation and would not account for the discrepancy. We therefore retain all results in the average,  $\tau_S = (0.882 \pm 0.008) \times 10^{-10}$  sec, where we have increased the error by a scale factor of 2.5 because of the disagreement.

Because of the uncertain future of  $\tau_S$ , we have not attempted to adjust the  $K_L^0$ - $K_S^0$  mass difference,  $\phi_{+-}$  or  $\phi_{00}$  values. The fitted  $K_S^0$  rates,  $|\eta_{+-}|$ , and  $|\eta_{00}|$  are automatically adjusted to our new  $\tau_S$  value by our fitting procedure.

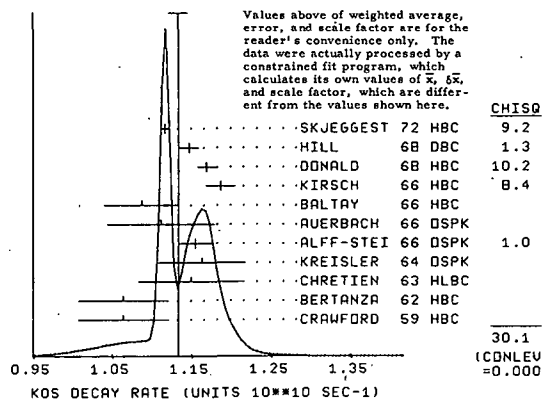
To show how  $\Delta m(K_L^0 - K_S^0)$  and  $\phi_{+-}$  are affected by our new  $\tau_S$ , we use the correlation given by ARONSON 70 ( $K_L^0$ ) between  $\Delta m(K_L^0 - K_S^0)$  and  $\tau_S$ , which indicates that a change in  $\tau_S$  from 0.862 to 0.882 increases their value of  $\Delta m$  by about  $.006 \times 10^{10} \text{ sec}^{-1}$ . A change in  $\Delta m$  of this amount would lead to an increase in  $\phi_{+-}$  of about 3.5%, using the  $\Delta m$  dependence of JENSEN 70, which is the most precise measurement of  $\phi_{+-}$ . (See the  $F_{+-}$  section in the  $K_L^0$  Data Card Listings.)

|                      |                                                                         | 12 KOS MEAN LIFE (UNITS $10^{*-10}$ SEC)               |         |        |                                                      |
|----------------------|-------------------------------------------------------------------------|--------------------------------------------------------|---------|--------|------------------------------------------------------|
| T                    | KOS MEAN LIFE                                                           |                                                        |         |        |                                                      |
| T 0                  | 90                                                                      | (1.07)                                                 | (0.13)  | (0.13) | BOLDT 58 CC                                          |
| T 1                  | 512                                                                     | 0.94                                                   | 0.05    | 0.05   | CRAWFORD 59 HBC                                      |
| T 2                  | 63                                                                      | (1.09)                                                 | (0.18)  | (0.15) | BOWEN 60 CC                                          |
| T 3                  | 0                                                                       | OLD EXPTS WITH LOW STATISTICS NOT INCLUDED IN AVERAGE. |         |        | 6/68                                                 |
| T 4                  | 378                                                                     | 0.94                                                   | 0.05    | 0.05   | BERTANZA 62 HBC                                      |
| T 5                  | 503                                                                     | 0.87                                                   | 0.05    |        | CHRETIEN 63 HLBC                                     |
| T 6                  | 545                                                                     | 0.86                                                   | 0.04    |        | KREISLER 64 OSPK                                     |
| T 7                  |                                                                         | 0.866                                                  | 0.016   |        | ALFF-STEI 66 OSPK                                    |
| T 8                  | 572                                                                     | 0.90                                                   | 0.06    | 0.05   | AUERBACH 66 OSPK                                     |
| T 9                  | 4500                                                                    | 0.92                                                   | 0.04    |        | BALTAY 66 HBC                                        |
| T 10                 |                                                                         | (0.904)                                                | (0.024) |        | BOTT-BODE 66 OSPK                                    |
| T 11                 | 5000                                                                    | 0.843                                                  | 0.013   |        | KIRSCH 66 HBC                                        |
| T 12                 | 19994                                                                   | 0.856                                                  | 0.08    |        | DONALD 68 HBC                                        |
| T 13                 | H 20000                                                                 | 0.872                                                  | 0.009   |        | HILL 68 HBC                                          |
| T 14                 | H 50K                                                                   | 0.8958                                                 | 0.0045  |        | SKJEGGESTAD 72 HBC                                   |
| T 15                 | H HILL 68 HAS BEEN CHANGED BY THE AUTHORS FROM THE PUBLISHED VALUE      |                                                        |         |        | 11/72*                                               |
| T 16                 | H (0.865+0.009) BECAUSE OF A CORRECTION IN THE SHIFT DUE TO $\eta_{+-}$ |                                                        |         |        | 11/72*                                               |
| T 17                 | H SKJEGGESTAD 72 AND HILL 68 GIVE DETAILED DISCUSSIONS OF SYSTEMATICS   |                                                        |         |        |                                                      |
| T 18                 | H ENCOUNTERED IN THIS TYPE OF EXPERIMENT                                |                                                        |         |        |                                                      |
| T 19                 | H KOS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.         |                                                        |         |        | 6/68                                                 |
| T 20                 | AVG                                                                     | 0.8824                                                 | 0.0092  | 0.0091 | AVERAGE (ERROR INCL. SCALE FACTOR OF 2.7)            |
| T 21                 | FIT                                                                     | 0.8824                                                 |         |        | 0.0092 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.5) |
| (SEE IDEOGRAM BELOW) |                                                                         |                                                        |         |        |                                                      |

## 12 KOS PARTIAL DECAY MODES

|    | DECAY MODES                         | DECAY MASSES |
|----|-------------------------------------|--------------|
| P1 | KOS INTO $\pi^+ \pi^-$              | 139+ 139     |
| P2 | KOS INTO $\pi^0 \pi^0$              | 134+ 134     |
| P3 | KOS INTO $\mu^+ \mu^-$              | 105+ 105     |
| P4 | KOS INTO $e^+ e^-$                  | 5+ 5         |
| P5 | KOS INTO $\pi^+ \pi^- \gamma$ GAMMA | 139+ 139+ 0  |
| P6 | KOS INTO GAMMA GAMMA                | 0+ 0         |

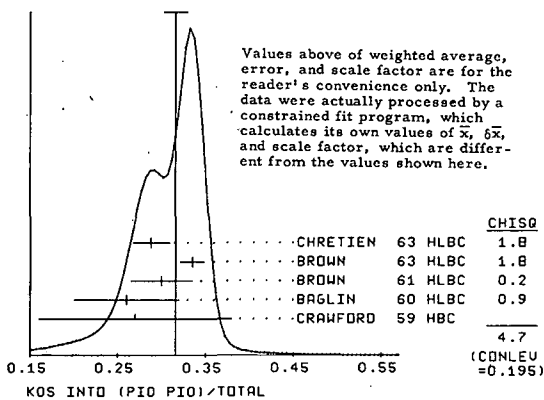
WEIGHTED AVERAGE =  $1.133 \pm 0.012$   
ERROR SCALED BY 2.7



## 12 KOS BRANCHING RATIOS

|                      |                                                             | 12 KOS BRANCHING RATIOS |        |  |                                               |
|----------------------|-------------------------------------------------------------|-------------------------|--------|--|-----------------------------------------------|
| R1                   | KOS INTO ( $\pi^+ \pi^-$ )/TOTAL                            |                         |        |  | (P1)                                          |
| R1                   | 0.68                                                        | 0.04                    |        |  | CRAWFORD 59 HBC                               |
| R1                   | 0.70                                                        | 0.08                    |        |  | COLUMBIA 60 HBC                               |
| R1 U                 | (0.740)                                                     | (0.024)                 |        |  | ANDERSON 62 HBC                               |
| R1 U                 | 0.684                                                       | 0.011                   |        |  | DOYLE 69 HBC                                  |
| R1 U                 | ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE |                         |        |  | P1-P TO LAN-KO 2/71                           |
| R1                   | AVG                                                         | 0.684                   | 0.011  |  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R1                   | FIT                                                         | 0.6881                  | 0.0029 |  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
|                      |                                                             |                         |        |  |                                               |
| R2                   | KOS INTO ( $\pi^0 \pi^0$ )/TOTAL                            |                         |        |  | (P2)                                          |
| R2                   | 0.27                                                        | 0.11                    |        |  | CRAWFORD 59 HBC                               |
| R2                   | 0.26                                                        | 0.06                    |        |  | BAGLIN 60 HLBC                                |
| R2                   | 0.30                                                        | 0.035                   |        |  | BROWN 61 HLBC                                 |
| R2                   | 1066                                                        | 0.335                   | 0.014  |  | BROWN 63 HLBC                                 |
| R2                   | 198                                                         | 0.288                   | 0.021  |  | CHRETIEN 63 HLBC                              |
| R2                   | AVG                                                         | 0.316                   | 0.014  |  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)  |
| R2                   | FIT                                                         | 0.3119                  | 0.0029 |  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
| (SEE IDEOGRAM BELOW) |                                                             |                         |        |  |                                               |

WEIGHTED AVERAGE =  $0.316 \pm 0.014$   
ERROR SCALED BY 1.3

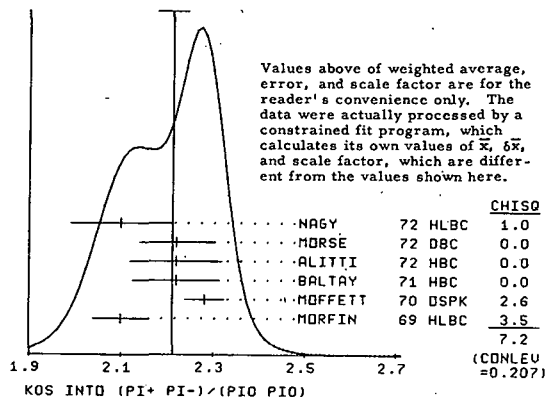


|                      |                                                                               | 12 KOS BRANCHING RATIOS |         |  |                                               |
|----------------------|-------------------------------------------------------------------------------|-------------------------|---------|--|-----------------------------------------------|
| R3                   | KOS INTO ( $\pi^+ \pi^-$ )/TOTAL                                              |                         |         |  | (P1)/(P2)                                     |
| R3 G                 | 3016                                                                          | (2.285)                 | (0.055) |  | COBBI 69 OSPK K+N TO KOP 5/69                 |
| R3                   | 3700                                                                          | 2.10                    | 0.06    |  | MOFFETT 70 OSPK K+N TO KOP 10/69              |
| R3 G                 | 7944                                                                          | 2.282                   | 0.043   |  | MOFFETT 70 OSPK K+N TO KOP 2/72               |
| R3 B                 | 6150                                                                          | 2.22                    | 0.095   |  | BALTAY 71 HBC K-P TO K0 + NEUTRALS 12/71      |
| R3 A                 | 3068                                                                          | 2.22                    | 0.10    |  | ALITTI 72 HBC K+P TO $\pi^+ \pi^-$ K0 6/72*   |
| R3                   | 6380                                                                          | 2.22                    | 0.08    |  | MOSE 72 HBC K+N TO KOP 2/72                   |
| R3                   | 701                                                                           | 2.10                    | 0.11    |  | NAGY 72 HLBC K+N TO KOP 1/73*                 |
| R3 A                 | THE DIRECTLY MEASURED QUANTITY IS KOS TO $\pi^+ \pi^-$ / ALL KOS = .345+-.005 |                         |         |  | 6/72*                                         |
| R3 B                 | THE DIRECTLY MEASURED QUANTITY IS KOS TO $\pi^+ \pi^-$ / ALL KOS = .345+-.005 |                         |         |  | 12/71                                         |
| R3 G                 | MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES COBBI 69.                         |                         |         |  | 2/72                                          |
| R3                   | AVG                                                                           | 2.212                   | 0.034   |  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)  |
| R3                   | FIT                                                                           | 2.207                   | 0.029   |  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
| (SEE IDEOGRAM BELOW) |                                                                               |                         |         |  |                                               |

## Stable Particles

 $K_S^0$ ,  $K_L^0$ 

WEIGHTED AVERAGE =  $2.212 \pm 0.034$   
 ERROR SCALED BY 1.2



|      |                                                                   |       |                  |
|------|-------------------------------------------------------------------|-------|------------------|
| R4   | (KOS INTO PI+ PI- PIO, CP VIOLATING)/(KOL INTO PI+ PI- PIO)       |       |                  |
| R4   | TEST OF CP VIOLATION - SEE TEXT SECTION IV F.3A FOR DEFINITIONS   |       |                  |
| R4   | CPT ASSUMED VALID - (I.E. RE(A)=0) - ONLY (I.M.A)*2 QUOTED HERE   |       |                  |
| R4   | 18 (3.0) OR LESS CL=90 ANDERSON 65 HBC                            | 10/69 |                  |
| R4   | 0.45 OR LESS CL=90 WEBER 70 HBC                                   | 8/66  |                  |
| R4   | 53 (1.7) OR LESS CL=90 WEBER 70 HBC                               | 8/70  |                  |
| R4 C | 71 0.8 OR LESS CL=90 WEBER 70 HBC                                 | 8/70  |                  |
| R4   | 99 1.2 OR LESS CL=90 CHD 71 DBC                                   | 4/71  |                  |
| R4 M | 50 (1.2) OR LESS CL=95 MEISNER 71 HBC                             | 2/71  | CL=.9 NOT AVAIL. |
| R4   | 180 0.66 OR LESS CL=90 JAMES 72 HBC                               | 1/73  |                  |
| R4   | 99 1.2 OR LESS CL=90 JONES 72 DSPK                                | 10/72 |                  |
| R4   | 384 0.27 OR LESS CL=90 METCALF 72 ASPK                            | 11/72 |                  |
| R4 M | THESE AUTHORS FIND RE(A)= 2.75+-0.65, ABOVE VALUE AT RE(A)=0      | 2/71  |                  |
| R4 C | THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBER 70           |       |                  |
| R5   | KOS INTO (MU+ MU-)/CHARGED (UNITS 10**5) (P3)/(P1)                |       |                  |
| R5   | 10.0 OR LESS CL=90 BOTT-BODE 67 OSK                               | 8/67  |                  |
| R5   | 20.0 OR LESS CL=90 BOHM 69 OSK                                    | 2/71  |                  |
| R5   | 1.07 OR LESS CL=90 HYAMS 69 OSK                                   | 10/69 |                  |
| R5 S | 32.4 OR LESS CL=90 STUTZKE 69 OSK                                 | 5/69  |                  |
| R5 S | VALUE CALCULATED BY US, USING 2.3 INSTEAD OF U EVENT, 90 PERC. CL |       |                  |
| R6   | KOS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN. 10**3) (P5)/(P1)          |       |                  |
| R6   | 27 NO RATIO GIVEN BELLOTTI 66 HBC PG GT 50 MEV/C                  | 10/69 |                  |
| R6   | 10 3.3 1.2 WEBER 70 HBC PG GT 50 MEV/C                            | 10/69 |                  |
| R7   | KOS INTO (E+ E-)/CHARGED (UNITS 10**5) (P4)/(P1)                  |       |                  |
| R7   | 50.0 OR LESS CL=90 BOHM 69 OSK                                    | 2/71  |                  |
| R8   | KOS INTO 2 GAMMA/TOTAL (UNITS 10**3) (P6)                         |       |                  |
| R8 R | 0 21.0 OR LESS CL=90 BANNER 69 OSK                                | 12/71 |                  |
| R8 R | 0 2.2 OR LESS CL=90 REPELLIN 71 OSK                               | 12/71 |                  |
| R8 R | 0 0.71 OR LESS CL=90 BANNER 72 OSK                                | 8/72  |                  |
| R8 R | 0 2.0 OR LESS CL=90 MORSE 72 DBC                                  | 2/72  |                  |
| R8 R | THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN K-S-KL TO 2 GAMMAS   | 12/71 |                  |
| R9   | (KOS INTO PI+ PI- PIO, CP CONSERVING)/(KOL INTO PI+ PI- PIO)      |       |                  |
| R9   | 384 0.42 OR LESS CL=90 METCALF 72 ASPK                            | 11/72 |                  |

## REFERENCES FOR KOS

|                                                     |                                                   |
|-----------------------------------------------------|---------------------------------------------------|
| BOLDT 58 PRL 1 150                                  | E BOLDT, D O CALDWELL, Y PAL (MIT)                |
| CRAWFORD 59 PRL 2 266                               | CRAWFORD, CRESTI, DOUGLASS, GOOD, TICHO + (LRL)   |
| BAGLIN 60 NC 18 1043                                | BAGLIN, BLOCH, BRISSON, HENNESSY + (EPOL)         |
| BOMEN 60 PR 119 2030                                | BOMEN, HARDY, REYNOLDS, SUN, MOORE + (PRIN+BNL)   |
| COLUMBIA 60 ROCH CONF 727                           | M SCHWARTZ + (COLUMBIA)                           |
| BROWN 61 NC 19 1155                                 | BROWN, BRYANT, BURNSTEIN, GLASER, KADYK + (MICH)  |
| ANDERSON 62 CERN CONF 836                           | J A ANDERSON, F S CRAWFORD + (LRL)                |
| BERTANZA 62 PREPRINT D105                           | BERTANZA, CONNOLLY, CULWICK, EISLER + (BNL)       |
| UNPUBLISHED, BUT RECERTIFIED BY AUTHORS, AUGUST 66. |                                                   |
| CHRETIEN 63 PR 131 2208                             | CHRETIEN + (BRANDEIS+BROWN+HARVARD+ MIT)          |
| BROWN 63 PR 130 769                                 | BROWN, KADYK, TRILLING, ROE + (LRL+MICH)          |
| KREISLER 64 PR 136 8 1074                           | M KREISLER, OR VERTSETH, J CRONIN (PRINCETON)     |
| ANDERSON 65 PRL 14 475                              | +CRAWFORD, GOLDEN, STERN, BINFORD + (LRL+MISC)    |
| ALFF-STE 66 PL 21 595                               | ALFF-STEINBERGER, HEUER, KLEINKNECHT + (CERN)     |
| AUERBACH 66 PR 149 1052                             | AUERBACH, DOBBS, LANDE, MANN, SCULLI + (PENN)     |
| ALSO 65 AUERBACH                                    |                                                   |
| BALTAY 66 PR 142 932                                | BALTAY, SANDWEISS, STONEHILL + (YALE+BNL)         |
| BEHR 66 PL 22 540                                   | BEHR, BRISSON, PETIAU + (EPOL, MILA, PADO, ORSAY) |
| BELLOTTI 66 NC 45A 737                              | +PULLIA, BALDO-COLIN + (MILAN+PADUA)              |
| BOTT-BOD 66 PL 23 277                               | BOTT-BODENHAUSEN-DE BOUARD + (CERN)               |
| KIRSCH 66 PR 147 939                                | L KIRSCH, P SCHMIDT (COLUMBIA)                    |
| BOTT-BOD 67 PL 248 194                              | BOTT-BODENHAUSEN, DE BOUARD, CASSEL + (CERN)      |
| DONALD 68 PL 278 58                                 | DONALD, EDWARDS, MISAR + (LIVP, CERN, IPNP, COEF) |
| HILL 68 PR 171 1418                                 | HILL, ROBINSON, SAKITT + (BNL, CARNEGIE)          |
| BANNER 69 PR 188 2033                               | +CRONIN, LIU, PILCHER (PRINCETON)                 |
| BOHM 69 THESIS                                      | A. BOHM (AACH)                                    |
| DOYLE 69 UCRL 18139-THESIS                          | J.C. DOYLE (LRL)                                  |

## Data Card Listings

For notation, see key at front of Listings.

GOBBI 69 PRL 22 682  
 HYAMS 69 PL 298 521  
 MORFIN 69 PRL 23 660  
 STUTZKE 69 PR 177 2009

MOFFETT 70 BAPS 15 512  
 WEBER 70 PR 01 1967  
 ALSO 69 UCRL 19226 THESIS  
 BALTAY 71 PRL 27 1678  
 ALSO 71 NEVIS-187 THESIS  
 CHD 71 PR 03 1557  
 MEISNER 71 PR 03 59  
 REPELLIN 71 PL 368 603

ALITTI 72 PL 398 568  
 BANNER 72 PRL 29 237  
 JAMES 72 NP 849 1  
 ALSO 71 PL 358 265  
 JONES 72 NC 9A 151  
 METCALF 72 PL 408 703  
 MORSE 72 PRL 28 388  
 NAGY 72 NP 847 94  
 ALSO 69 PL 308 498  
 SKJEGGES 72 NP 848 343

PAPERS NOT REFERRED TO IN DATA CARDS  
 BIRGE 60 ROCH CONF 601  
 MULLER 60 PRL 4 418  
 FITCH 61 NC 22 1160  
 GOOD 61 PR 124 1223  
 CRAWFORD 62 CERN CONF 827  
 AUERBACH 65 PRL 14 192  
 TRILLING 65 UCRL 16473  
 UPDATED FROM 1965 ARGONNE CONF., PAGE 115.

\*\*\*\*\*  
 K<sup>0</sup>  
 13 LONG-LIVED NEUTRAL K (498, JP=0-) I=1/2

13 (KOL) - (KOS) MASS DIFFERENCE  
 WE GIVE (KOL-KOS MASS DIFFERENCE / HBARI) IN UNITS OF 10\*\*10 SEC-1

|       |                                                                      |        |                   |                                             |                     |
|-------|----------------------------------------------------------------------|--------|-------------------|---------------------------------------------|---------------------|
| D T   | (2.20)                                                               | (0.35) | FITCH             | 61 CNTR                                     |                     |
| D T   | 0.84                                                                 | 0.29   | 0.22 GOOD         | 61 HLBC                                     |                     |
| D T   | 1.02                                                                 | 0.23   | 61 CAMERINI       | 62 HLBC                                     | SEE NOTE C BELOW    |
| D C   | VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)                  |        |                   |                                             | 8/67                |
| D     | 0.55                                                                 | 0.24   | AUBERT            | 65 HLBC                                     | 6/66                |
| D     | 0.26                                                                 | 0.36   | 0.26 BALDO-CEO    | 65 HLBC                                     | ASSUMES CP CONS.    |
| D T A | 0.64                                                                 | 0.12   | CHRISTENS 65 OSK  |                                             | 6/66                |
| D A   | CHRISTENSEN 65 HAS BEEN CORRECTED FOR INTERFERENCE BY FITCH 65 FNDOT |        |                   |                                             | 1/71                |
| D T   | 0 (0.70) OR LESS                                                     |        | FITCH             | 65 OSK                                      | CF. MEISNER 66      |
| D V   | 130 (0.89) (0.15)                                                    |        | VISHNEVSKY 65 OSK | CU AND AL REGEN                             | 8/67                |
| D V   | VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS                 |        |                   |                                             | 3/68                |
| D     | 0.514                                                                | 0.039  | ALFF-STE 1        | 66 OSK                                      | 6/66                |
| D     | 84 0.42                                                              | 0.24   | 0.36 BALDO-CEO    | 66 HLBC                                     | KO+N INTO HYPER.    |
| D B   | (0.531) (0.027)                                                      |        | BOTT-BODE         | 66 OSK                                      | C REGEN             |
| D T   | 77 0.58                                                              | 0.17   | CAMERINI          | 66 HBC                                      | DBC KO+N INTO HYPER |
| D N   | 72 (+0.64) (0.18)                                                    |        | CANTER            | 66 DBC                                      | KO SCATTER IN D2    |
| D N   | ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS. THESE EVENTS ARE          |        |                   |                                             | 10/71               |
| D N   | USED IN HILL 71                                                      |        |                   |                                             |                     |
| D     | 95 0.62                                                              | 0.10   | 0.16 CHANG        | 66 HBC                                      | KO+P INTO HYPER.    |
| D     | 0.81                                                                 | 0.17   | FUJII             | 66 OSK                                      | IRON REGENERATOR    |
| D     | 59 0.74                                                              | 0.34   | MEISNER 1         | 66 HBC                                      | SEE NOTE M1         |
| D M1  | + SIGN FAVORED                                                       |        | MEISNER 2         | 66 HBC                                      | 9/66                |
| D     | 0.38                                                                 | 0.16   | JOVANOVIC         | 66 OSK                                      | C+URANUM REGEN.     |
| D T   | 136 +0.64                                                            | 0.19   | CANTER            | 67 DBC                                      | KO+D INTO HYPER.    |
| D     | 0.65                                                                 | 0.11   | MISCHKE           | 67 OSK                                      | 11/67               |
| D     | 590 0.59                                                             | 0.13   | BALATZ            | 68 OSK                                      | AL REGENERATOR      |
| D     | 0.520                                                                | 0.08   | CARNEGIE          | 68 HBC                                      | 3/68                |
| D T   | +0.487                                                               | 0.046  | MEISNER           | 68 OSK                                      | GAP METHOD          |
| D B   | 0.547                                                                | 0.024  | BOTT-BOD          | 69 OSK                                      | ST-STEEL REGEN      |
| D B   | BOTT-BOD 69 IS A REEVALUATION OF BOTT-BOD 66                         |        |                   |                                             | 1/71                |
| D F   | 0.555                                                                | 0.020  | FAISSNER          | 69 ASPK                                     | REGEN IN CU         |
| D F   | ESTIMATED ADDITIONAL SYSTEMATIC UNCERTAINTY LESS THAN TWO PERCENT    |        |                   |                                             | 10/69               |
| D     | 0.542                                                                | 0.006  | CULLEN            | 70 CNTR                                     | 1/71                |
| D     | 0.481                                                                | 0.052  | 0.075 BALATS      | 71 OSK                                      | GAP METHOD          |
| D     | 0.534                                                                | 0.007  | CARNEGIE          | 71 ASK                                      | GAP METHOD          |
| D TH  | 119 (+0.67) (0.14)                                                   |        | HILL              | 71 DBC                                      | 10/71               |
| D H   | THE PRIMARY RESULT OF THIS EXPERIMENT IS THAT DM IS POSITIVE.        |        |                   |                                             | 10/71               |
| D H   | THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12  |        |                   |                                             | 10/71               |
| D T   | A KOS MEAN LIFE OF 0.862 10**10 SEC WAS USED IN CONVERTING THE       |        |                   |                                             | 1/71                |
| D T   | MASS DIFFERENCE FROM UNITS OF INVERSE KOS MEAN LIVES TO ABSOLUTE     |        |                   |                                             | 1/71                |
| D T   | UNITS. VALUES NOT BEARING THIS FOOTNOTE EITHER WERE GIVEN IN         |        |                   |                                             | 1/71                |
| D T   | ABSOLUTE UNITS OR WERE CONVERTED USING THE AUTHORS' VALUE OF THE     |        |                   |                                             | 1/71                |
| D T   | KOS MEAN LIFE.                                                       |        |                   |                                             | 1/71                |
| D     | AVG                                                                  | 0.5402 | 0.0035            | AVERAGE ERROR INCLUDES SCALE FACTOR OF 1.01 |                     |

13 KOL MEAN LIFE (UNITS 10\*\*8 SECI)

|   |                               |       |       |                                                |         |
|---|-------------------------------|-------|-------|------------------------------------------------|---------|
| T | KOL MEAN LIFE                 |       |       |                                                |         |
| T | 34 8.1                        | 3.2   | 2.4   | BARDON                                         | 58 CNTR |
| T | ASSUMED DS=DD AND DELTA I=1/2 |       |       | CRAWFORD                                       | 59 HBC  |
| T | 15 5.1                        | 2.4   | 1.3   | DARROW                                         | 62 FBC  |
| T | 5.3                           | 0.5   |       | FUJII                                          | 64 OSK  |
| T | 1700 6.1                      | 1.5   | 1.2   | ASTBURY3                                       | 65 CNTR |
| T | 5.15                          | 0.14  |       | DEVLIN                                         | 67 CNTR |
| T | (5.01) (0.51)                 |       |       | LOVYS                                          | 67 HLBC |
| T | 4M 5.154                      | 0.046 |       | VOSSBURGH                                      | 72 CNTR |
| T | L SUM OF PARTIAL DECAY RATES. |       |       |                                                | 2/71    |
| T | AVG                           | 5.158 | 0.042 | AVERAGE ERROR INCL. SCALE FACTOR OF 1.01       |         |
| T | FIT                           | 5.181 | 0.041 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.01) |         |

# Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

### 13 KOL PARTIAL DECAY MODES

|     |                         |             | DECAY MASSES  |
|-----|-------------------------|-------------|---------------|
| P1  | KOL INTO 3P10           | TAU 0 PRIME | 134+ 134+ 134 |
| P2  | KOL INTO PI+ PI- P10    | TAU 0       | 139+ 139+ 134 |
| P3  | KOL INTO PI MU NEUTRINO | KL MU3      | 139+ 105+ 0   |
| P4  | KOL INTO PI E NEUTRINO  | KL E3       | 139+ .5+ 0    |
| P5  | KOL INTO PI+ PI-        | KL PI+ PI-  | 139+ 139      |
| P6  | KOL INTO MU+ MU-        | KL 2MU      | 105+ 105      |
| P7  | KOL INTO E+ E-          | KL 2E       | .5+ .5        |
| P8  | KOL INTO E MU           | KL EMU      | .5+ 105       |
| P9  | KOL INTO TWO GAMMAS     | KL 2GAMMA   | 0+ 0          |
| P10 | KOL INTO PI+ PI- GAMMA  | KL PI+G     | 139+ 139+ 0   |
| P11 | KOL INTO P10 P10        | KL 2P10     | 134+ 134      |
| P12 | KOL INTO PI E NEU GAMMA | KL E3GAM    | 139+ .5+ 0+ 0 |
| P13 | KOL INTO P10 TWO GAMMAS | KL P12GAMMA | 134+ 0+ 0     |

NEUTRAL K CONSTRAINED FIT  
OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING  
RATIOS USES 62 DATA POINTS TO DETERMINE SIX  
QUANTITIES. OVERALL FIT HAS CHISQ=56.5.

### FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

| P 1               | P 2           | P 3           | P 4           | P 5           | P 11          |
|-------------------|---------------|---------------|---------------|---------------|---------------|
| P 1 .2151+-0.0079 |               |               |               |               |               |
| P 2 -.2654        | .1257+-0.0027 |               |               |               |               |
| P 3 -.4833        | -.0695        | .2691+-0.0059 |               |               |               |
| P 4 -.5850        | -.0638        | -.3326        | .3876+-0.0065 |               |               |
| P 5 -.2849        | .0431         | .1412         | .1702         | .0016+-0.0001 |               |
| P 11 .1531        | -.0508        | -.0862        | -.1044        | -.0511        | .0009+-0.0002 |

### FITTED PARTIAL DECAY MODE RATES

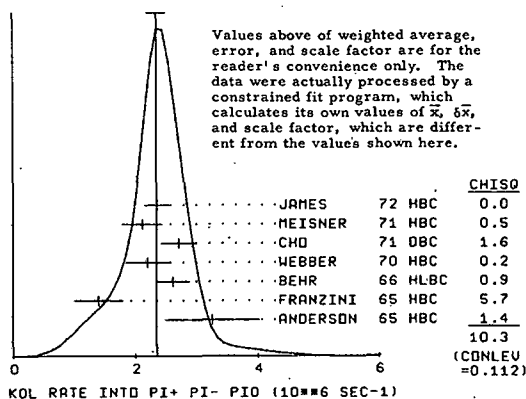
The matrix below is the branching fraction matrix above, transformed into rate space; i.e.,  $G_i = \Gamma_i = \Gamma_{\text{total}} P_i$ , in appropriate units. In analogy to the matrix above, the diagonal elements are  $G_i \pm \delta G_i$ , where  $\delta G_i = \sqrt{(\delta G_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta G_i \delta G_j) / (\delta G_i \delta G_j)$ . Note that, because of the error in  $\Gamma_{\text{total}}$ , the errors and correlations here are not directly derivable from those above.

| G 1               | G 2           | G 3           | G 4           | G 5           | G 11          |
|-------------------|---------------|---------------|---------------|---------------|---------------|
| G 1 .0415+-0.0016 |               |               |               |               |               |
| G 2 -.1448        | .0243+-0.0005 |               |               |               |               |
| G 3 -.3444        | .0341         | .0519+-0.0012 |               |               |               |
| G 4 -.4047        | .0572         | -.1801        | .0748+-0.0013 |               |               |
| G 5 -.2032        | .1036         | .1950         | .2298         | .0003+-0.0000 |               |
| G 11 .1617        | -.0300        | -.0638        | -.0751        | -.0379        | .0002+-0.0000 |

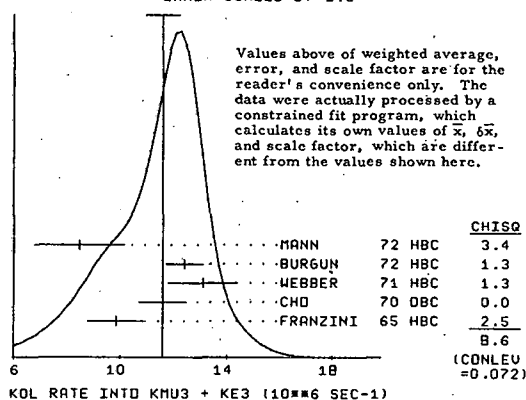
### 13 KOL DECAY RATES

| W1 | KOL INTO P10 P10 P10 (UNITS 10**6 SEC-1)                            | (G1)       |       |                                               |
|----|---------------------------------------------------------------------|------------|-------|-----------------------------------------------|
| W1 | 54                                                                  | 5.22       | 1.03  | 0.84 BEHR                                     |
| W1 |                                                                     |            |       | 66 HLBC ASSUMES CP                            |
| W1 | FIT                                                                 | 4.15       | 0.16  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| W2 | KOL INTO PI+ PI- P0 (UNITS 10**6 SEC-1)                             | (G2)       |       |                                               |
| W2 | 18                                                                  | 3.26       | 0.77  | ANDERSON 65 HBC                               |
| W2 | 14                                                                  | 1.4        | 0.4   | FRANZINI 65 HBC                               |
| W2 | 136                                                                 | 2.62       | 0.28  | 0.27 BEHR 66 HLBC ASSUMES CP                  |
| W2 | 53                                                                  | 2.20       | 0.35  | WEBBER 70 HBC ASSUMES CP                      |
| W2 | 99                                                                  | 2.71       | 0.28  | CHO 71 OBC ASSUMES CP                         |
| W2 | 50                                                                  | 2.12       | 0.33  | MEISNER 71 HBC ASSUMES CP                     |
| W2 | 180                                                                 | 2.35       | 0.20  | JAMES 72 HBC ASSUMES CP                       |
| W2 | IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AN |            |       |                                               |
| W2 | THE BRANCHING RATIO R2. FOR THIS REASON THE DISCREPANCY BETWEEN THE |            |       |                                               |
| W2 | W2 MEASUREMENTS DOES NOT AFFECT THE SCALE FACTOR OF THE OVERALL FIT |            |       |                                               |
| W2 | AVG                                                                 | 2.36       | 0.15  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)  |
| W2 | FIT                                                                 | 2.425      | 0.054 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
|    | (SEE IDEOGRAM BELOW)                                                |            |       |                                               |
| W3 | KOL INTO PI E NEUTRINO (UNITS 10**6 SEC-1)                          | (G4)       |       |                                               |
| W3 | 7.52                                                                | 0.85       | 0.72  | AUBERT 65 HLBC DS=DQ,CP ASSUMED               |
| W3 | 620                                                                 | 7.81       | 0.56  | CHAN 71 HBC                                   |
| W3 | AVG                                                                 | 7.71       | 0.46  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| W3 | FIT                                                                 | 7.48       | 0.13  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
| W4 | KOL INTO CHARGED (3-BODY) (UNITS 10**6 SEC-1)                       | (G2+G3+G4) |       |                                               |
| W4 | 98                                                                  | 15.1       | 1.9   | AUERBACH 66 OSPK                              |
| W4 | FIT                                                                 | 15.10      | 0.18  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
| W5 | KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1)                    | (G3+G4)    |       |                                               |
| W5 | D 109                                                               | 9.85       | 1.15  | 1.05 FRANZINI 65 HBC                          |
| W5 | C 335                                                               | (10.3)     | (0.8) | HILL 67 OBC K+N TO KO P                       |
| W5 | D 393                                                               | 11.6       | 0.9   | CHO 70 OBC K+N TO KO P                        |
| W5 | D 252                                                               | 13.1       | 1.3   | WEBBER 71 HBC K- P TO KOBAR N                 |
| W5 | D 410                                                               | 12.4       | 0.7   | BURGUN 72 HBC K+P TO KOPPI+                   |
| W5 | D 126                                                               | 8.47       | 1.69  | MANN 72 HBC K- P TO KOBAR N                   |
| W5 | C CHO TO INCLUDES EVENTS OF HILL 67                                 |            |       |                                               |
| W5 | D ASSUMES DS=DQ RULE                                                |            |       |                                               |
| W5 | AVG                                                                 | 11.60      | 0.65  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)  |
| W5 | FIT                                                                 | 12.68      | 0.16  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |
|    | (SEE IDEOGRAM BELOW)                                                |            |       |                                               |

WEIGHTED AVERAGE =  $2.36 \pm 0.15$   
ERROR SCALED BY 1.3



WEIGHTED AVERAGE =  $11.60 \pm 0.65$   
ERROR SCALED BY 1.5



| W6 | KOL INTO PI MU NEUTRINO UNITS 10**6 SEC-1 | (G3) |      |                                               |
|----|-------------------------------------------|------|------|-----------------------------------------------|
| W6 | 19                                        | 4.54 | 1.24 | 1.08 LOWYS 67 HLBC                            |
| W6 | FIT                                       | 5.19 | 0.12 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |

### 13 KOL BRANCHING RATIOS

| R1 | KOL INTO (P10 P10 P10)/CHARGED                        | (P1)/(P2+P3+P4) |         |                                               |
|----|-------------------------------------------------------|-----------------|---------|-----------------------------------------------|
| R1 | 24                                                    | 0.24            | 0.08    | ANIKINA 64 CC                                 |
| R1 | 549                                                   | 0.251           | 0.014   | BUDAGOV 68 HLBC                               |
| R1 | 444                                                   | 0.277           | 0.021   | BUDAGOV 68 HLBC                               |
| R1 | 29                                                    | 0.31            | 0.07    | 0.06 KULYUKINA 68 CC                          |
| R1 | AVG                                                   | 0.260           | 0.011   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R1 | FIT                                                   | 0.275           | 0.013   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |
| R2 | KOL INTO (PI+ PI- P10)/CHARGED                        | (P2)/(P2+P3+P4) |         |                                               |
| R2 | 59                                                    | 0.185           | 0.038   | ASTIER 61 CC                                  |
| R2 | 79                                                    | 0.151           | 0.020   | ADAIR 64 HBC                                  |
| R2 | 75                                                    | 0.157           | 0.03    | 0.04 LUERS 64 HBC                             |
| R2 | 66                                                    | 0.15            | 0.03    | 0.04 ASTBURY1 65 CC                           |
| R2 | 326                                                   | 0.159           | 0.015   | ASTBURY2 65 CC                                |
| R2 | 566                                                   | 0.178           | 0.017   | GUIDONI 65 HBC                                |
| R2 | 1729                                                  | (0.144)         | (0.004) | HOPKINS 65 HBC                                |
| R2 | 126                                                   | 0.162           | 0.015   | HAWKINS 66 HBC                                |
| R2 | 161                                                   | 0.161           | 0.015   | HOPKINS 67 HBC                                |
| R2 | 1402                                                  | 0.167           | 0.016   | KULYUKINA 68 CC                               |
| R2 | 558                                                   | 0.159           | 0.010   | EVANS 73 HLBC                                 |
| R2 | AVG                                                   | 0.1615          | 0.0038  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R2 | FIT                                                   | 0.1606          | 0.0034  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| R3 | KOL INTO (PI MU NEUTRINO)/CHARGED                     | (P3)/(P2+P3+P4) |         |                                               |
| R3 | C 251                                                 | (0.356)         | (0.07)  | LUERS 64 HBC                                  |
| R3 | C 172                                                 | (0.39)          | (0.08)  | (0.101) ASTBURY1 65 CC                        |
| R3 | C 330                                                 | (0.335)         | (0.05)  | KULYUKINA 68 CC                               |
| R3 | C THIS MODE NOT MEASURED INDEPENDENTLY FROM R2 AND R4 |                 |         |                                               |
| R3 | FIT                                                   | 0.3440          | 0.0066  | FROM FIT                                      |
| R4 | KOL INTO (PI E NEUTRINO)/CHARGED                      | (P4)/(P2+P3+P4) |         |                                               |
| R4 | 153                                                   | 0.487           | 0.05    | LUERS 64 HBC                                  |
| R4 | 202                                                   | 0.46            | 0.08    | 0.10 ASTBURY1 65 CC                           |
| R4 | 500                                                   | 0.498           | 0.052   | KULYUKINA 68 CC                               |
| R4 | AVG                                                   | 0.488           | 0.033   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R4 | FIT                                                   | 0.4954          | 0.0067  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |

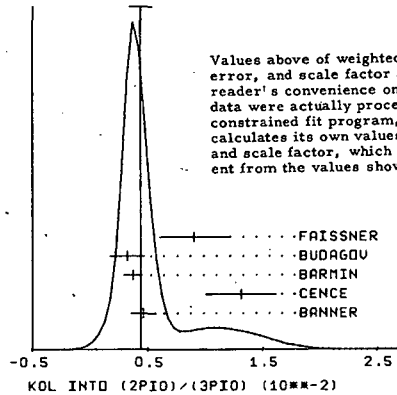
## Stable Particles

 $K_L^0$ 

## Data Card Listings

For notation, see key at front of Listings.

|     |                                                                     |                 |
|-----|---------------------------------------------------------------------|-----------------|
| R5  | KOL INTO (PI E NEU)/(PI E NEU)+(PI MU NEU)                          | (P4)/(P3+P4)    |
| R5  | 320 0.415 0.120 ASTIER 61 CC                                        |                 |
| R5  | FIT 0.5902 0.0077 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)     |                 |
| R6  | KOL INTO (PI+ PI- P10)/TOTAL                                        | (P2)            |
| R6  | FIT 0.1257 0.0027 FROM FIT                                          |                 |
| R7  | KOL INTO (LEPTON PI NEUTRINO)/TOTAL                                 | (P3+P4)         |
| R7  | FIT 0.4568 0.0072 FROM FIT                                          |                 |
| R8  | KOL INTO (2 GAMMA)/TOTAL (UN. 10 <sup>-4</sup> )                    | (P9)            |
| R8  | C 11.31 (10.6) CRIEGEE 66 OSPK 8/66                                 |                 |
| R8  | 32 6.7 2.2 TODDROFF 67 OSPK 11/68                                   |                 |
| R8  | 33 (7.4) (1.6) CRONIN 1 67 OSPK 11/67                               |                 |
| R8  | 90 5.5 1.1 KUNZ 68 OSPK NORM. TO 3P1(C+N) 2/71                      |                 |
| R8  | 23 4.5 1.0 ENSTROM 71 OSPK KOL 1.5-9 GEV/C 2/72                     |                 |
| R8  | 5.0 (1.0) REPELLIN 71 OSPK 11/71                                    |                 |
| R8  | 4.54 0.84 BANNER 72 OSPK 8/72*                                      |                 |
| R8  | THIS VALUE USES (E00/E+)*2=1.05+0.14. IN GENERAL, S13R =            |                 |
| R8  | (4.32-0.55)*(10 <sup>-4</sup> )*(E00/E+)*2.                         |                 |
| R8  | ASSUMES REGEN AMPL IN COPPER AT 2GEV IS 22 MB. TO EVALUATE          |                 |
| R8  | FOR A GIVEN REGEN AMPL AND ERROR, MULTIPLY BY (REGEN AMPL/22MB)**2  |                 |
| R8  | C CRIEGEE 66 REPLACED BY TODDROFF 67 11/68                          |                 |
| R8  | K CRONINI 67 REPLACED BY KUNZ 68. 2/71                              |                 |
| R8  | AVG 4.89 0.54 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)          |                 |
| R9  | KOL INTO (PI+ PI-)/CHARGED (UNIT 10 <sup>-3</sup> )                 | (P5)/(P2+P3+P4) |
| R9  | 45 2.0 0.4 CHRISTENS 64 OSPK ETA += 1.94                            |                 |
| R9  | 54 2.08 0.35 GALBRAITH 65 OSPK ETA += 2.02                          |                 |
| R9  | 1.93 0.26 BASILE 66 OSPK ETA += 1.86                                |                 |
| R9  | 1.993 0.080 BOTT-BODE 66 OSPK ETA += 1.935                          | 9/66            |
| R9  | AVG 1.992 0.073 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)        |                 |
| R9  | FIT 2.001 0.063 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)       |                 |
| R10 | KOL INTO (PI MU NEU)/(PI E NEU)                                     | (P3)/(P4)       |
| R10 | 0.81 0.19 ADAIR 64 HBC 6/66                                         |                 |
| R10 | 0.82 0.10 DEBOUARD 67 OSPK 11/67                                    |                 |
| R10 | 273 0.7 0.2 HAWKINS 67 HBC 8/67                                     |                 |
| R10 | 0.81 0.08 HOPKINS 67 HBC 8/67                                       |                 |
| R10 | 770 0.71 0.05 BUDAGOV 68 HLBC 10/68                                 |                 |
| R10 | 0.67 0.13 KULYUKINA 68 CC 2/71                                      |                 |
| R10 | (0.71) (0.04) BEILLIERE 69 HLBC 10/69                               |                 |
| R10 | 1309 (0.648) (0.030) EVANS 69 HLBC REPL. BY EVANS 73 1/73*          |                 |
| R10 | 3548 0.68 0.08 BASILE 70 OSPK 10/70                                 |                 |
| R10 | 1309 0.662 0.030 EVANS 73 HLBC 1/73*                                |                 |
| R10 | B BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68 |                 |
| R10 | AVG 0.695 0.022 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)        |                 |
| R10 | FIT 0.694 0.022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)       |                 |
| R11 | KOL INTO (MU+MU-)/CHARGED (UNITS 10 <sup>-6</sup> )                 | (P6)/(P2+P3+P4) |
| R11 | 100.0 OR LESS ANIKINA 65 CC 6/66                                    |                 |
| R11 | 250.0 OR LESS CL=90 ALFF-STEE 66 OSPK 9/66                          |                 |
| R11 | 2.0 OR LESS CL=90 BOTT-BODE 67 OSPK 8/67                            |                 |
| R11 | 35.0 OR LESS CL=90 FITCH 67 OSPK 3/68                               |                 |
| R12 | KOL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10 <sup>-3</sup> )            | (P10)           |
| R12 | 15.0 OR LESS ANIKINA 65 CC 6/66                                     |                 |
| R12 | 0 5.0 OR LESS ANIKINA 66 HLBC GAM KE 40-130 MV 8/67                 |                 |
| R12 | 1 3.0 OR LESS NEFKENS 66 OSPK GAM KE 120 MEV 7/66                   |                 |
| R12 | 0.4 OR LESS CL=90 THATCHER 68 OSPK GAM KE 20-170 MV 2/71            |                 |
| R13 | KOL INTO (E+ E-)/CHARGED (UNITS 10 <sup>-6</sup> )                  | (P7)/(P2+P3+P4) |
| R13 | 100.0 OR LESS ANIKINA 65 CC 6/66                                    |                 |
| R13 | 200.0 OR LESS CL=90 ALFF-STEE 66 OSPK 6/66                          |                 |
| R13 | 23.0 OR LESS CL=90 BOTT-BODE 67 OSPK 8/67                           |                 |
| R14 | KOL INTO (E MU)/CHARGED (UNITS 10 <sup>-4</sup> )                   | (P8)/(P2+P3+P4) |
| R14 | 1.0 OR LESS CL=90 CARPENTER 66 OSPK 6/66                            |                 |
| R14 | 0.1 OR LESS CL=90 BOTT-BODE 67 OSPK 8/67                            |                 |
| R14 | 0.08 OR LESS CL=90 FITCH 67 OSPK 3/68                               |                 |
| R15 | KOL INTO (E+ PI- NEU)/(E- PI+ NEU)                                  |                 |
| R15 | 97 (1.01) (0.18) NEAGU 61 CC 8/66                                   |                 |
| R15 | (1.01) (0.16) LUERS 64 HBC 9/66                                     |                 |
| R15 | 894 (0.99) (0.023) KULYUKINA 66 CC 8/67                             |                 |
| R15 | 1539 (1.06) (0.05) VERMEY 66 OSPK 8/67                              |                 |
| R15 | LOW PRECISION EXPTS NOT AVERAGED. FOR MORE PRECISE VALUE,           |                 |
| R15 | SEE S13A2 (BENNETT 70, MARK 70)                                     |                 |
| R16 | KOL INTO (MU+ PI- NEU)/(MU- PI+ NEU)                                |                 |
| R16 | 1M 1.0081 0.0027 DORFAN 67 OSPK 11/67                               |                 |
| R16 | SEE ALSO S13A2 AND S13AL IN THE CP VIOLATION SECTION 2/71           |                 |
| R17 | KOL INTO (P10 P10)/TOTAL (UNITS 10 <sup>-3</sup> )                  | (P11)           |
| R17 | C 7 (1.21) (1.51) CRIEGEE 66 OSPK 7/66                              |                 |
| R17 | C CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 P10 DECAY MODE             |                 |
| R17 | G 189 (2.51) (0.81) GAILLARD 69 OSPK E00=3.6+0.6 5/69               |                 |
| R17 | G LATEST RESULT OF THIS EXPERIMENT GIVEN BY FAISSNER 70 R19 1/71    |                 |
| R17 | FIT 0.94 0.19 FROM FIT                                              |                 |
| R18 | KOL INTO (3P10)/(PI+PI- P10)                                        | (P11)/(P2)      |
| R18 | 188 2.0 0.6 ALEKSANYA 64 FBC 9/66                                   |                 |
| R18 | 1010 1.80 0.13 BUDAGOV 68 HLBC 10/68                                |                 |
| R18 | AVG 1.711 0.081 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)        |                 |
| R18 | FIT 1.711 0.081 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)       |                 |
| R19 | KOL INTO (2P10)/(3P10) (UNITS 10 <sup>-2</sup> )                    | (P11)/(P1)      |
| R19 | C 109 (1.36) (0.31) CRONIN 1 67 OSPK ETA00=4.9+0.5 8/67             |                 |
| R19 | C CRONIN 2 67 OSPK ETA00=3.92+0.3 11/67                             |                 |
| R19 | C CRONIN IS FURTHER ANALYSIS OF CRONINI, NOW BOTH WITHDRAWN 11/68   |                 |
| R19 | NO EVENTS SEEN BARTLETT 68 OSPK SEE E00 BELOW 11/68                 |                 |
| R19 | 57 0.46 0.11 BANNER 69 OSPK ETA00=2.2+0.3 2/72                      |                 |
| R19 | 133 1.31 0.31 CENCE 69 OSPK ETA00=3.7+0.5 10/69                     |                 |
| R19 | 29 0.37 0.08 BARNIN 70 HLBC ETA00=2.02+0.23 12/70                   |                 |
| R19 | 30 0.32 0.15 BUDAGOV 70 HLBC ETA00=1.9+0.5 10/70                    |                 |
| R19 | F 172 0.90 0.30 FAISSNER 70 OSPK ETA00=3.2+0.5 12/70                |                 |
| R19 | F FAISSNER 70 CONTAINS SAME 2P10 EVENTS AS GAILLARD 69 R17          |                 |
| R19 | AVG 0.439 0.098 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)        |                 |
| R19 | FIT 0.44 0.29 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 5.1)         |                 |
| R19 | (SEE IDEOGRAM BELOW)                                                |                 |

WEIGHTED AVERAGE = 0.439 ± 0.098  
ERROR SCALED BY 1.7

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of  $\bar{x}$ ,  $\bar{\sigma}$ , and scale factor, which are different from the values shown here.

CHISO  
2.4  
0.6  
0.7  
7.9  
0.0  
11.7  
(CONLEV  
=0.020)

|     |                                                                  |              |
|-----|------------------------------------------------------------------|--------------|
| R20 | KOL INTO (PI+ PI-1)/(KE3 + KMU3) (UNITS 10 <sup>-3</sup> )       | (P5)/(P3+P4) |
| R20 | 309 2.51 0.23 DEBOUARD 67 OSPK 6/68                              |              |
| R20 | 525 2.35 0.19 FITCH 67 OSPK ETA+=1.91+-0.06 6/68                 |              |
| R20 | AVG 2.41 0.15 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)       |              |
| R20 | FIT 2.384 0.076 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)    |              |
| R21 | KOL INTO (2GAMMA)/(3 P10) (UNITS 10 <sup>-3</sup> )              | (P9)/(P1)    |
| R21 | 16 2.5 0.7 ARNOLD 68 HLBC VACUUM DECAY 11/68                     |              |
| R21 | BANNER 69 IS NEW EXPT. NOT TO BE CONF WITH R8 OF CRONINI 67 2/72 |              |
| R21 | 115 2.24 0.28 BANNER 69 OSPK 11/68                               |              |
| R21 | 28 2.13 0.43 BARNIN 71 HLBC 8/71                                 |              |
| R21 | AVG 2.24 0.22 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)       |              |

Note on the  $K_L^0 \rightarrow \mu^+ \mu^-$  Controversy

The  $K_L^0 \rightarrow \mu^+ \mu^-$  branching ratios (R22) given by CLARK 71 and CARITHERS 73 are incompatible. We therefore make no attempt to combine their results.

CARITHERS 73 is a preliminary result based on their reported observation of 6 events. They are continuing data-taking and analysis.

CLARK 71 observe no events but would expect around 12 based on the CARITHERS 73 rate. CLARK 71 are rechecking their analysis but have found nothing, which could account for the loss of these events (A. Clark, private communication).

The discrepancy is interesting on theoretical grounds because the CLARK 71 result is below the "unitarity" lower limit for this decay.

|     |                                                                                     |            |
|-----|-------------------------------------------------------------------------------------|------------|
| R22 | KOL INTO (MU+MU-1)/(PI+PI-1) (UNITS 10 <sup>-5</sup> )                              | (P6)/(P5)  |
| R22 | 0 14.0 OR LESS CL=90 FOETH 69 ASPK 5/70                                             |            |
| R22 | 0 1.8 OR LESS CL=90 DARRULAT 70 ASPK 11/70                                          |            |
| R22 | 0 0.12 OR LESS CL=90 CLARK 71 ASPK 6/71                                             |            |
| R22 | 6 (10.6) CARITHERS 73 ASPK PRELIMINARY 1/73*                                        |            |
| R22 | C CARITHERS 72 GIVES K3L TO MU+MU-ALL=9*10 <sup>-9</sup> . WE CONVERT TO R22. 1/73* |            |
| R23 | KOL INTO (E+ E- 1)/(PI+PI-1) (UNITS 10 <sup>-5</sup> )                              | (P7)/(P5)  |
| R23 | 0 10.0 OR LESS CL=90 FOETH 69 ASPK 5/70                                             |            |
| R23 | 0.10 OR LESS CL=90 CLARK 71 ASPK 6/71                                               |            |
| R24 | KOL INTO (E MU)/(PI+PI-1) (UNITS 10 <sup>-5</sup> )                                 | (P8)/(P5)  |
| R24 | 0.10 OR LESS CL=90 CLARK 71 ASPK 6/71                                               |            |
| R25 | KOL INTO (PI E NEU GAM)/(KL E3) (UNITS 10 <sup>-2</sup> )                           | (P12)/(P3) |
| R25 | 10 3.3 2.0 PEACH 71 HLBC GAM KE GT 15 MEV 6/71                                      |            |
| R26 | KOL INTO (P10 TWO GAMMAS)/(3P10) (UNITS 10 <sup>-3</sup> )                          | (P13)/(P1) |
| R26 | 0 1.1 OR LESS CL=90 BANNER 69 OSPK 2/72                                             |            |

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

K<sub>L</sub>

## 13 KOL ENERGY DEPENDENCE OF DALITZ PLOT

RELATED TEXT SECTION IV F.1, APPENDIX 1, AND MINI-REVIEW ON SLOPE PARAMETERS IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE

MATRIX ELEMENT SQUARED =  $1 + G (S3-S0)/(MP1+2)$ 

| GTO       | LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS | KLONG INTO PI+ PI- PI0 |                                         |
|-----------|---------------------------------------------|------------------------|-----------------------------------------|
| GTO 79    | 0.55                                        | 0.23                   | ADAIR 64 HBC AV=7.6 ± 1.7 3/71          |
| GTO 77    | 0.51                                        | 0.20                   | LUERS 64 HBC AV=7.3 ± 1.6 3/71          |
| GTO 66    | 0.32                                        | 0.13                   | ASTBURY1 65 CC AV=5.5 ± 1.5 3/71        |
| GTO 310   | 0.51                                        | 0.09                   | ASTBURY2 65 CC AV=(7.3 ± 1.6 -1.8) 3/71 |
| GTO 280   | 0.64                                        | 0.17                   | ANIKINA 66 CC AV=(18.2 ± 9 -1.3) 3/71   |
| GTO 126   | 0.70                                        | 0.12                   | HANKINS 66 HBC AV=8.6 ± 0.7 3/71        |
| GTO 1350  | 0.669                                       | 0.044                  | HOPKINS 67 HBC AT=-0.294 ± .018 10/69   |
| GTO 1198  | 0.428                                       | 0.055                  | NEFKENS 67 OSKP AV=-0.204 ± .025 3/71   |
| GTO 2446  | 0.400                                       | 0.045                  | BASILE2 68 OSKP AT=-0.188 ± .020 3/71   |
| GTO 29000 | 0.651                                       | 0.012                  | ALBROW 70 ASKP AV=-0.862 ± .015 1/73    |
| GTO 6     | 36K                                         | 0.555                  | BUCHANAN 70 ASKP AU=-0.261 ± .007 3/71  |
| GTO 4400  | 0.656                                       | 0.058                  | SMITH 70 OSKP AT=-0.297 ± .024 3/71     |
| GTO 180   | 0.50                                        | 0.11                   | JAMES 72 HBC 1/73*                      |
| GTO 1486  | 0.608                                       | 0.043                  | KRENZ 72 HLBC AT=-0.277 ± .018 11/72*   |
| GTO 384   | 0.688                                       | 0.074                  | METCALF 72 ASKP AT=-0.31 ± .03 11/72*   |

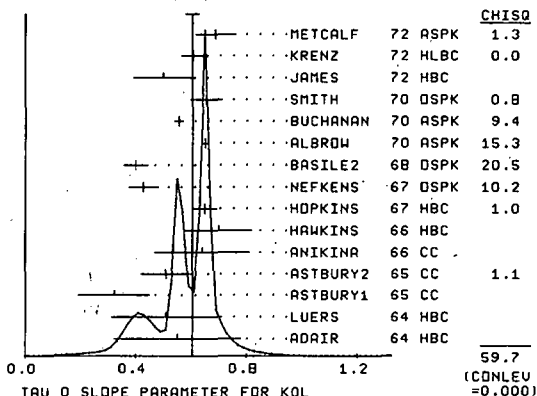
GTO B BUCHANAN 70 GIVES A=0.257 ± .005 FOR A QUADRATIC FIT WITH

GTO B STATISTICAL ERRORS ONLY. THE A VALUE USED HERE IS FOR A LINEAR

GTO B FIT AND INCLUDES SYSTEMATIC ERRORS. QUADRATIC FIT DOES NOT

GTO B IMPROVE CHI SQUARED PROBABILITY.

GTO AVG 0.604 ± 0.023 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)

WEIGHTED AVERAGE =  $0.604 \pm 0.023$   
ERROR SCALED BY 2.7

## 13 KOL FORM FACTORS

RELATED TEXT SECTION IV F.2 AND MINI-REVIEW ON FORM FACTORS IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE

| XIA        | XIA = F-/F+ (DETERMINED FROM SPECTRA AND KM3/KE3)                   |      |
|------------|---------------------------------------------------------------------|------|
| XIA        | SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS |      |
| XIA        | INDEPENDENT OF THE MOMENTUM TRANSFER (T) I.E., THEY SET L=0.        |      |
| XIA        | OTHERS HAVE ASSUMED A VALUE FOR L+ AND USED L=0. ONLY RECENTLY      |      |
| XIA        | BOTH L+ AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLU-    |      |
| XIA        | DED IN THE FITS. SEE CHIEN 70, DALY 72, ALBROW 72.                  |      |
| XIA L 389  | (+1.1) (0.9) (1.3) ADAIR 64 HBC KM3/KE3 8/67                        |      |
| XIA L 1371 | (+1.2) (0.8) (1.3) CARPENTER 66 OSKP MU, PI SPECTRA 8/67            |      |
| XIA K      | (0.2) (0.8) (1.2) KULYUKINA 68 CC MU, PI SPECTRA 2/71               |      |
| XIA 770    | +0.3 +0.4 BUDAGOV 68 HLBC KM3/KE3, LM=0.023 11/68                   |      |
| XIA E 1309 | (-0.22) (0.30) EVANS 69 HLBC KM3/KE3, LM=0.02 10/69                 |      |
| XIA 3140   | -3.9 0.4 BASILE 70 OSKP DAL.PLT.LM=0.02 10/70                       |      |
| XIA 3548   | -0.50 0.5 BASILE 70 OSKP KM3/KE3, LM=0.02 10/70                     |      |
| XIA C 16K  | (-0.68) (0.12) (0.20) CHIEN 70 ASKP DAL.PLT.LM=0.08 2/71            |      |
| XIA A9086  | -1.5 0.7 ALBROW 72 ASKP DAL.PLT.LM=0.085 8/72*                      |      |
| XIA C 16K  | 0.50 0.61 DALY 72 ASKP DAL.PLT.LM=0.11 1/73*                        |      |
| XIA E1309  | -0.08 0.25 EVANS 73 HLBC KM3/KE3, LM=0.02 1/73*                     |      |
| XIA L      | LM+ AND LM- ASSUMED TO BE ZERO.                                     |      |
| XIA K      | LM+ AND LM- NOT GIVEN.                                              |      |
| XIA C      | CHIEN 70 VALUE AT L=0. L- AND XI(0) ARE HIGHLY CORRELATED.          | 2/71 |
| XIA C      | DALY 72 IS A REANALYSIS OF CHIEN 70. LAMBDA=0.37 ± 0.15 1/73*       |      |
| XIA A      | ALBROW 72 GETS LM=0.030 ± 0.060. LAMBDA=0.15 ± 0.17 ± 0.11 1/73*    |      |
| XIA E      | EVANS 73 REPLACES EVANS 69. LM=0 1/73*                              |      |

XIA AVERAGE MEANINGLESS (SCALE FACTOR = 4.0)

| XIB      | XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN K3)             |      |
|----------|-----------------------------------------------------------------|------|
| XIB      | THE MU POLARIZATION IS A MEASURE OF XI(1). NO ASSUMPTIONS ON L= |      |
| XIB      | NECESSARY, T SHOULD BE SPECIFIED.                               |      |
| XIB      | FOR RAD. CORR. TO MUON POLARIZATION IN KM3, SEE GINSBERG 71.    | 2/72 |
| XIB 2608 | -1.2 0.3 AUERBACH 66 OSKP POLARIZATION 8/67                     |      |
| XIB 638  | -1.6 0.5 ABRAMS 68 OSKP POLARIZATION 5/69                       |      |
| XIB      | -1.81 0.50 0.26 LONGO 69 CNTR POL. T=2.65 11/69                 |      |

XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

| IXI | IMAGINARY PART OF XI (TEST OF T REVERSAL)                |  |
|-----|----------------------------------------------------------|--|
| IXI | -0.2 0.6 ABRAMS 68 OSKP MU POLARIZATION 10/69            |  |
| IXI | -0.02 0.08 LONGO 69 CNTR POL. T=2.65 11/69               |  |
| IXI | 0.023 0.079 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |  |

FS FS/F+ RATIO OF SCALAR TO F+ COUPLINGS FOR KES DECAY (ABS. VALUE)----

FS 0.15 OR LESS CL=68 KULYUKINA 67 CC 10/69

FT FT/F+ RATIO OF TENSOR TO F+ COUPLINGS FOR KES DECAY (ABS. VALUE)----

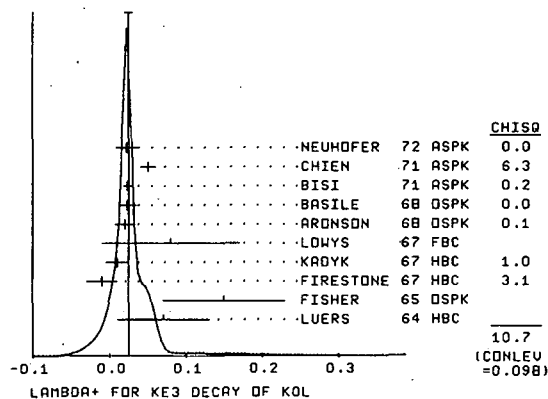
FT 1.0 OR LESS CL=68 KULYUKINA 67 CC 10/69

L+E LAMBDA+ (LINEAR ENERGY DEPENDENCE OF F+ IN KO E3 DECAY) -----

L+E FOR RAD. CORR. TO DALITZ PLOT OF KES, SEE GINSBERG 67.

| L+E | 153  | +0.07  | .06   | LUERS     | 64 HBC  | DLTZ PLOT, NO R.C.  | 8/67             |
|-----|------|--------|-------|-----------|---------|---------------------|------------------|
| L+E | 577  | +0.15  | .08   | FISHER    | 65 OSKP | DLTZ PLOT, NO R.C.  | 8/67             |
| L+E | 762  | -0.01  | .02   | FIRESTONE | 67 HBC  | DLTZ PLOT, NO R.C.  | 8/67             |
| L+E | 531  | +0.01  | .015  | KADYK     | 67 HBC  | E, PI SPEC, NO R.C. | 8/67             |
| L+E | 240  | +0.08  | .10   | .08       | LOMYS   | 67 FBC              | PI SPEC, RAD COR |
| L+E | 1000 | 0.02   | 0.013 | ARONSON   | 68 OSKP | PI SPECTRUM         | 5/69             |
| L+E | 4800 | +0.023 | 0.012 | BASILE    | 68 OSKP | DLTZ PLOT, NO R.C.  | 3/68             |
| L+E | 42K  | 0.023  | 0.005 | BISI      | 71 ASKP | DLTZ PLOT, R.C.     | 12/71            |
| L+E | 16K  | 0.05   | 0.01  | CHIEN     | 71 ASKP | DLTZ PLOT, NO R.C.  | 6/71             |
| L+E | 1910 | 0.022  | 0.014 | NEUHOFFER | 72 ASKP | PI SPEC, RAD COR    | 1/73*            |

L+E AVG 0.0249 ± 0.0049 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

WEIGHTED AVERAGE =  $0.0249 \pm 0.0049$   
ERROR SCALED BY 1.3

L+M LAMBDA+ (LINEAR ENERGY DEPENDENCE OF F+ IN KM3 DECAY)

L+M FOR RAD. CORR. TO DALITZ PLOT OF KM3, SEE GINSBERG 70

| L+M | 16K   | (0.07)                                                              | (0.02) | CHIEN  | 70 ASKP | XIA=-.68 ± .12 ± .20 | 3/71  |
|-----|-------|---------------------------------------------------------------------|--------|--------|---------|----------------------|-------|
| L+M | A9086 | 0.085                                                               | 0.015  | ALBROW | 72 ASKP | XIA=-1.5 ± 0.7       | 8/72* |
| L+M | C 16K | 0.11                                                                | 0.04   | DALY   | 72 ASKP | XIA=-.50 ± .01       | 1/73* |
| L+M | C     | CHIEN 70 VALUE AND ERROR HAVE BEEN CHANGED FROM 0.08 ± 0.01 TO      |        |        |         |                      | 3/71  |
| L+M | C     | INCLUDE SYSTEMATIC EFFECTS. DALY 72 IS A REANALYSIS OF CHIEN 70.    |        |        |         |                      | 3/71  |
| L+M | C     | SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SEC. XIA ABOVE. |        |        |         |                      | 1/73* |
| L+M | AVG   |                                                                     |        |        |         |                      | 1/73* |

L+M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

## 13 CP VIOLATION PARAMETERS IN KOL DECAYS

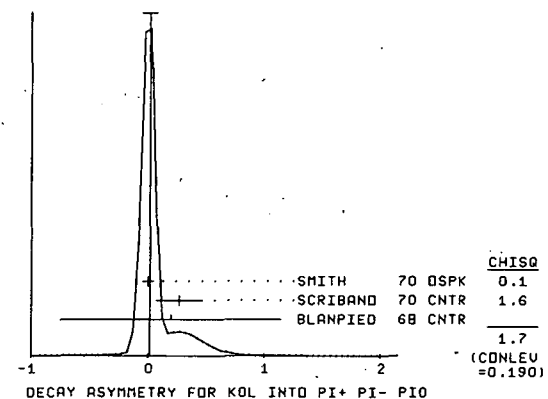
RELATED TEXT SECTION IV F.3 AND MINI-REVIEW BELOW

TEXT SECTION IV F.3 B

SEE SCRIBAND 70 FOR DEFINITION (THIS SIGMA+). A=1 FOR MAX ASYMMETRY

(M)\*2 =  $1 + \text{SIG} - (2/\sqrt{3}) * ((T+)-(T-))/T_{\text{MAX}}$  AS SCRIBAND 70

| A | DECAY ASYMMETRY PARAMETER FOR PI+ PI- PI0 (UNITS 10**2)        |       |
|---|----------------------------------------------------------------|-------|
| A | 3M 0.2 0.95 BLANPIED 68 CNTR                                   | 4/70  |
| A | 3M 0.27 0.2 SCRIBAND 70 CNTR                                   | 12/70 |
| A | 4400 0.000 0.050 SMITH 70 OSKP                                 | 10/70 |
| A | AVG 0.016 ± 0.063 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |       |
| A | (SEE IDEOGRAM BELOW)                                           |       |

WEIGHTED AVERAGE =  $0.016 \pm 0.063$   
ERROR SCALED BY 1.3

DECAY ASYMMETRY FOR KOL INTO PI+ PI- PI0

where

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $K_L^0$ 

$l(p)$  is the thickness of regenerator measured in units of the mean decay length of  $K_S$ .

$N$  is the number of nuclei per cubic centimeter,

$\Lambda$  is the  $K_S$  mean decay length, and

$f_0(p)$ ,  $\bar{f}_0(p)$  are the forward scattering amplitude of  $K^0$  and  $\bar{K}^0$ .

From (1) above it is clear that the value of  $\phi_{+-}$  is correlated with the value of  $\Delta m$  and  $\phi_R$ . Usually  $\Delta m$  is a parameter of the fit and  $\phi_R$  is determined by some other means (optical model calculations, time dependence of the charge asymmetry in  $K_{e3}$  decay, etc.).

We list  $\phi_{+-}$  and give in comment cards both the value of  $\phi_R$  used by the authors and the  $\Delta m$  dependence of

$\phi_{+-}$ .

| PHASE OF $\eta_{+-}$ (DEGREES)                                                                            |       |
|-----------------------------------------------------------------------------------------------------------|-------|
| F-- DM IS (KOL-KOS MASS DIFFERENCE / HBAR) IN UNITS OF $10^{10} \text{ SEC}^{-1}$                         | 2/71  |
| F-- SEE SECTION D OF KOL LISTINGS FOR LATEST VALUE                                                        |       |
| F-- WE HAVE ADDED THE MASS DEPENDENCE AND PROPAGATED THE ERROR IN DM                                      | 2/71  |
| F-- USING $\Delta m = 0.5398 \pm 0.0033$ FOR BENNETT 69, BOHM 69, FAISSNER 69,                            | 2/71  |
| F-- JENSEN 70, AND BALATS 71. THE APRIL 1972 DM ( $0.5402 \pm 0.0035$ ) WOULD                             | 3/72  |
| F-- NOT MAKE A SIGNIFICANT CHANGE IN THE PHASE.                                                           | 3/72  |
| F-- FITCH 65 OSPK BE REGEN                                                                                | 11/67 |
| F-- 30.0 45.0 FIRESTONE 66 HBC                                                                            | 11/67 |
| F-- 70.0 21.0 BOTT-BODE 67 OSPK C REGEN                                                                   | 11/67 |
| F-- 25.0 35.0 MISCHKE 67 OSPK CU REGEN                                                                    | 7/68  |
| F-- N (51.0) (11.0) BENNETT 68 CNTR CU REG. USES                                                          | 8/68  |
| F-- C 34.5 10.0 BENNETT 69 CNTR CU REGEN                                                                  | 2/71  |
| F-- B 47.6 12.1 BOHM 69 OSPK VACUUM REGEN                                                                 | 2/71  |
| F-- F 46.2 7.4 FAISSNER 69 ASPK CU REGEN                                                                  | 2/71  |
| F-- J 43.4 4.4 JENSEN 70 ASPK VACUUM REGEN                                                                | 2/71  |
| F-- D 38.0 12.0 BALATS 71 OSPK CU REGEN                                                                   | 9/71  |
| F-- P 36.2 6.1 CARNEGIE 72 ASPK                                                                           | 1/73* |
| F-- AVG 41.8 2.8 AVERAGE ERROR INCLUDES SCALE FACTOR OF 1.01                                              |       |
| COMMENTS                                                                                                  |       |
| F-- N BENNETT 69 IS A REEVALUATION OF BENNETT 68.                                                         | 11/69 |
| F-- C BENNETT 69 USES MEASUREMENT OF $(F+-)(\text{PHI})$ OF ALFF-STEE 66                                  | 2/71  |
| F-- C BENNETT 69 $F+- = 34.9 \pm 10.0$ , NOT INCLUDING ERROR IN DM                                        | 2/71  |
| F-- C DM DEPENDENCE OF BENNETT 69 IS $69 \pm (DM - 0.545) \text{ DEG.}$ $FR = 49.9 \pm 5.4 \text{ DEG.}$  | 2/71  |
| F-- B BOHM 69 $F+- = 41 \pm 12$ , NOT INCLUDING ERROR IN DM.                                              | 2/71  |
| F-- B DM DEPENDENCE OF BOHM 69 IS $47.9 \pm (DM - 0.526) \text{ DEG.}$                                    | 2/71  |
| F-- F FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE.                                   | 11/69 |
| F-- F FAISSNER 69 $F+- = 49.3 \pm 7.4$ , NOT INCLUDING ERROR IN DM.                                       | 2/71  |
| F-- F DM DEPENDENCE OF FAISSNER 69 IS $205 \pm (DM - 0.555) \text{ DEG.}$ $FR = 42.7 \pm 50 \text{ DEG.}$ | 2/71  |
| F-- J JENSEN 70 $F+- = 42.4 \pm 4.0$ , NOT INCLUDING ERROR IN DM.                                         | 2/71  |
| F-- J DM DEPENDENCE OF JENSEN 70 IS $57.6 \pm (DM - 0.538) \text{ DEG.}$                                  | 2/71  |
| F-- D BALATS 71 $F+- = 39 \pm 12$ , NOT INCLUDING ERROR IN DM. $FR = 43 \pm 4 \text{ DEG.}$               | 9/71  |
| F-- D DM DEPENDENCE OF BALATS 71 IS $198 \pm (DM - 0.544) \text{ DEG.}$                                   | 9/71  |
| F-- P CARNEGIE 72 INSENSITIVE TO DM. $FR = 56.2 \pm 5.2 \text{ DEG.}$                                     | 1/73* |
| PHASE OF $\eta_{00}$ (DEGREES)                                                                            |       |
| FOO FIRST QUADRANT PREFERRED                                                                              |       |
| FOO C 51. 30. GOBBI 69 OSPK                                                                               | 11/69 |
| FOO W 56 38.0 25.0 CHOLLET 70 OSPK CU REG. 4 GAMMAS                                                       | 10/70 |
| FOO W 56 38.0 25.0 WOLFF 71 OSPK CU REG. 4 GAMMAS                                                         | 12/71 |
| FOO AVG 53.2 6.1 AVERAGE ERROR INCLUDES SCALE FACTOR OF 1.01                                              |       |
| FOO C CHOLLET 70 USES REGENERATOR PHASE $FR = 46.5 \pm 4.4 \text{ DEG.}$                                  | 1/73* |
| FOO W WOLFF 71 USES REGENERATOR PHASE $FR = 48.2 \pm 3.5 \text{ DEG.}$                                    | 1/73* |

## Superweak Model Predictions

for  $\phi_{+-}$  and  $\phi_{\eta_{00}}$ 

The superweak model of Wolfenstein, Phys.

Letters 13, 562 (1964) predicts that

$$\phi_{+-} = \phi_{00} = \tan^{-1} \left( \frac{2\Delta m \tau_S}{\hbar} \right)$$

and

$$\text{Re } \epsilon = |\eta_{+-}| \left[ 1 + \left( \frac{2\Delta m \tau_S}{\hbar} \right)^2 \right]^{-1/2}$$

The  $K_L^0 - K_S^0$  mass difference, the  $K_S$  lifetime, and  $|\eta_{+-}|$  given in the Stable Particle Table result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.63 \pm 0.32)^\circ$$

and

$$\text{Re } \epsilon = (1.433 \pm 0.027) \times 10^{-3}$$

These can be compared with the experimental values

$$\phi_{+-} = (41.8 \pm 2.8)^\circ$$

$$\phi_{00} = (43 \pm 19)^\circ$$

$$\text{Re } \epsilon = (1.62 \pm 0.20) \times 10^{-3}$$

where  $\epsilon$  has been computed from  $\delta$ , the charge asymmetry parameter for leptonic  $K_L^0$  decays, and  $(\text{Re } x, \text{Im } x)$ , the  $\Delta S = -\Delta Q$  amplitude, using Eq. (34) of the text.

As noted in the mini-review preceding the  $K_S^0$  mean life, the measured values of  $\Delta m$  and  $\phi_{+-}$  used above have not been adjusted for our new value of  $\tau_S$ . Had we used the adjusted value for  $\Delta m$ , the predictions would be

$$\phi_{+-} = \phi_{00} = (43.95 \pm .32)^\circ$$

and

$$\text{Re } \epsilon = (1.426 \pm 0.027) \times 10^{-3}$$

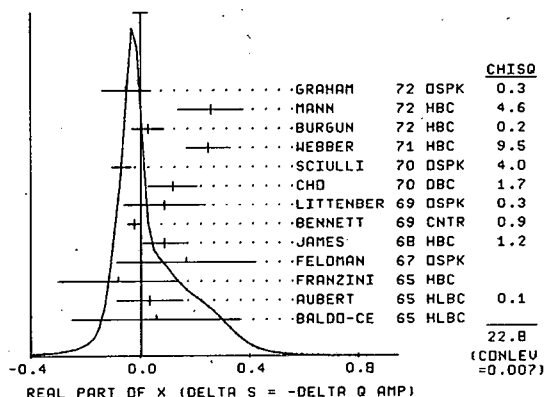
The measured value of  $\phi_{+-}$  would be adjusted to

$$\phi_{+-} \approx (45.2 \pm 2.8)^\circ$$

$$13 \quad X = (\Delta S = -\Delta Q \text{ AMPLITUDE}) / (\Delta S = +\Delta Q \text{ AMPLITUDE})$$

## RELATED TEXT SECTION IV F.4

|           |                                                                   |        |                                                                   |           |         |                  |       |  |  |
|-----------|-------------------------------------------------------------------|--------|-------------------------------------------------------------------|-----------|---------|------------------|-------|--|--|
| REX       | REAL PART OF X                                                    |        |                                                                   |           |         |                  |       |  |  |
| REX C 152 | 0.06                                                              | 0.18   | 0.44                                                              | BALDO-CE  | 65 HLBC | K+ CHARGE EXCHNG | 11/67 |  |  |
| REX 196   | 0.035                                                             | 0.11   | 0.13                                                              | AUBERT    | 65 HLBC | K+ CHARGE EXCHNG | 11/67 |  |  |
| REX F 109 | -0.08                                                             | 0.16   | 0.28                                                              | FRANZINI  | 65 HBC  | PBAR P           | 11/67 |  |  |
| REX 116   | 0.17                                                              | 0.16   | 0.35                                                              | FELDMAN   | 67 OSPK | P1-P TO KO LMBDA | 11/67 |  |  |
| REX N 335 | (0.17)                                                            | (0.10) |                                                                   | HILL      | 67 DBC  | K+O YIELDS KOPP  | 11/67 |  |  |
| REX B     | (0.03)                                                            | (0.03) |                                                                   | BENNETT   | 68 CNTR |                  | 7/68  |  |  |
| REX 121   | 0.09                                                              | 0.07   | 0.09                                                              | JAMES     | 68 HBC  | PBAR P           | 5/69  |  |  |
| REX B     | -0.020                                                            | 0.025  |                                                                   | BENNETT   | 69 CNTR | CHAR ASYM+ CU RE | 10/69 |  |  |
| REX 686   | 0.09                                                              | 0.14   | 0.16                                                              | LITTENBER | 69 OSPK | K+O TO KOP       | 4/69  |  |  |
| REX N 215 | 0.12                                                              | 0.09   |                                                                   | CHO       | 70 DBC  | K+O TO KOPP      | 10/70 |  |  |
| REX 1079  | -0.069                                                            | 0.036  |                                                                   | SCIULLI   | 70 OSPK | P1-P             | 11/70 |  |  |
| REX 252   | 0.25                                                              | 0.07   | 0.09                                                              | WEBBER    | 71 HBC  | K-P TO KBAR N    | 10/69 |  |  |
| REX 410   | 0.03                                                              | 0.06   | 0.06                                                              | BURGUM    | 72 HBC  | K+P TO KOPPI+    | 1/73* |  |  |
| REX 126   | 0.26                                                              | 0.10   | 0.14                                                              | MANH      | 72 HBC  | K-P TO KOBAR N   | 9/72* |  |  |
| REX G 342 | (-0.13)                                                           | (0.11) |                                                                   | MAITSCH   | 72 OSPK | KE3 FROM KO LMB  | 2/72  |  |  |
| REX G 100 | (0.04)                                                            | (0.10) | (0.13)                                                            | GRAHAM    | 72 OSPK | KMU3 FROM KO LMB | 2/72  |  |  |
| REX G 442 | -0.05                                                             | 0.09   |                                                                   | GRAHAM    | 72 OSPK | P1-P TO KO LMBDA | 2/72  |  |  |
| REX G     | SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH     |        |                                                                   |           |         |                  | 2/72  |  |  |
| REX B     | MAITSCH 72.                                                       |        |                                                                   |           |         |                  |       |  |  |
| REX C     | BENNETT 69 IS A REANALYSIS OF BENNETT 68                          |        |                                                                   |           |         |                  |       |  |  |
| REX B     | BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.     |        |                                                                   |           |         |                  | 11/67 |  |  |
| REX F     | FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.     |        |                                                                   |           |         |                  | 11/67 |  |  |
| REX N     | CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67. |        |                                                                   |           |         |                  |       |  |  |
| REX       | MAITSCH 72.                                                       |        |                                                                   |           |         |                  |       |  |  |
| REX AVG   | 0.003                                                             | 0.027  | AVERAGE ERROR INCLUDES SCALE FACTOR OF 1.61 (SEE IDEOGRAM BELOW). |           |         |                  |       |  |  |

WEIGHTED AVERAGE =  $0.003 \pm 0.027$   
ERROR SCALED BY 1.6

## Stable Particles

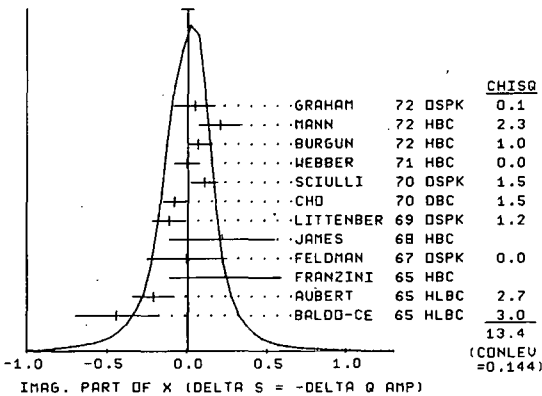
 $K_L^0$ 

## Data Card Listings

For notation, see key at front of Listings.

IMX IMAGINARY PART OF X (ASSUMES MIKLI-MKSI) POSITIVE -- SEE S130)  
 IMX C 152 -0.44 0.32 0.19 BALDO-CE 65 HLCB K+ CHARGE EXCHNG 3/68  
 IMX 196 -0.21 0.11 0.15 AUBERT 65 HLCB K+ CHARGE EXCHNG 3/68  
 IMX F 109 +0.24 0.40 0.30 FRANZINI 65 HLCB PBAR P 3/68  
 IMX 116 0.0 0.25 FELDMAN 67 DSPK P1-P TO KO LMBDA 11/67  
 IMX N 335 (-0.20) (0.10) HILL 67 DBC K+D YIELDS KOPP 11/67  
 IMX 121 +0.22 0.37 0.29 JAMES 68 HBC PBAR P 5/69  
 IMX 686 -0.11 0.10 0.11 LITTENBER 69 DSPK K+N TO KOP 4/69  
 IMX N 215 -0.08 0.07 0.07 CHO 70 DBC K+D TO KOPP 10/70  
 IMX 1079 0.108 0.092 0.074 SCIULLI 70 DSPK P1-P 11/70  
 IMX 252 0.0 0.08 WEBBER 71 HBC K-P TO KBAR N 10/69  
 IMX 410 0.07 0.06 0.07 BURGUN 72 HBC K-P TO KOPP1+ 1/73+  
 IMX 126 0.21 0.15 0.12 MANN 72 HBC K-P TO KOBAR N 9/72+  
 IMX G 342 (-0.04) (0.16) MANTSCH 72 DSPK KE3 FROM KO LMB 2/72  
 IMX G 100 (0.12) (0.17) (0.16) GRAHAM 72 DSPK KNU3 FROM KO LMB 2/72  
 IMX G 442 0.05 0.13 GRAHAM 72 DSPK P1-P TO KO LMBDA 2/72  
 IMX G SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH 2/72  
 IMX G MANTSCH 72 2/72  
 IMX C BALDO-CE 65 GIVES X AND THETA. CONVERTED BY US TO REX AND IMX. 11/67  
 IMX F FRANZINI 65 GIVES X AND THETA. FOR REX AND IMX SEE SCHMIDT 67. 11/67  
 IMX N FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV.COM.). 3/68  
 IMX N CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.  
 IMX AVG 0.005 0.038 AVERAGE ERROR INCLUDES SCALE FACTOR OF 1.2) (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.005 ± 0.038  
 ERROR SCALED BY 1.2

REFERENCES FOR  $K_L^0$ 

BARDON 58 ANP 5 156  
 CRAWFORD 59 PRL 2 361  
 ASTIER 61 AIX CONF 1 227  
 FITCH 61 NC 22 1160  
 GOOD 61 PR 124 1223  
 NEAGU 61 PRL 6 552  
 CAMERINI 62 PR 128 362  
 DARMON 62 PL 3 57  
 ADAIR 64 PL 12 67  
 ALEKSANY 64 DUBNA 2 102  
 ALEKSANYAN 64 JETP 19 1019  
 ANIKINA 64 JETP 19 42  
 CHRISTEN 64 PRL 13 138  
 FUJII 64 DUBNA 2 146  
 LUERS 64 PR 133 B 1276  
 ANIKINA 65 JINR P 2488  
 ANDERSON 65 PRL 14 475  
 ASTBURY 65 PL 16 80  
 ASTBURY 65 HELV. PH. AC. 39 523  
 ASTBURY 65 PL 18 178  
 AUBERT 65 PL 17 59  
 BALDO-CE 65 NC 38 684  
 CHRISTEN 65 PR 140 B 74  
 FISHER 65 ANL 7130 83  
 FITCH 65 PRL 15 73  
 FRANZINI 65 PR 140 B 127  
 GALBRAITH 65 PRL 14 383  
 GUIDONI 65 ARGONNE CONF 49  
 HOPKINS 65 ARGONNE CONF 67  
 VISHNEVS 65 PL 18 339  
 ALFF-STE 66 PL 21 595  
 ANIKINA 66 SJNP 2 339  
 AUERBACH 66 PRL 17 980  
 AUERBACH 66 PR 149 1052  
 BALDO-CE 66 NC 45A 733  
 BASILE 66 BALATON CONF  
 BEHR 66 PL 22 540  
 BELLOTTI 66 NC 45A 737  
 BOTT-BOD 66 PL 23 277  
 CAMERINI 66 PR 150 1148  
 CANTER 66 PRL 17 942  
 CARPENTE 66 PR 142 871  
 CHANG 66 PL 23 702  
 M BARDON, K LANDE, L LEDERMAN (COLUMBIA+BNL)  
 CRAWFORD, CRESTI, DOUGLASS, GOOD + (LRL)  
 ASTIER, BLASKOVIC, RIVET, STAUD + (EPOL)  
 V FITCH, P PIROU, R PERKINS (PRINCETON)  
 GOOD, MATSEN, MULLER, PICCIONI, POWELL + (LRL)  
 NEAGU, OKONOV, PETROV, ROSANOVA, RUSAKOV (JINR)  
 CAMERINI, FRY, GAIOSOS, BIRGE, ELY + (WISC+LRL)  
 J DARMON, A ROUSSET, J SIX (EPOL)  
 R K ADAIR, L B LEIPUNER (YALE+BNL)  
 ALEKSANYAN, ALIKHANYAN, VARTAZARYAN (EREVAN)  
 ALEKSANYAN + (LEBEDEV+ENG PHYS+YERVAN)  
 ANIKINA, ZHURAVLEVA + (GEORG ACAD SCI+ DUBNA)  
 CHRISTENSON, CRONIN, FITCH, TURLAY (PRINCETON)  
 FUJII, JOVANOVIH, TURKOT + (BNL+MARYLAND, MIT)  
 LUERS, MITTAR, WILLIS, YAMAMOTO (BNL)  
 ANIKINA, VARDENGA, ZHURAVLEVA, KOTLYA + (DUBNA)  
 ANDERSON, CRAWFORD, GOLDEN, STERN + (LRL+WISC)  
 ASTBURY, FINOCCHIARO, BEUSCH + (CERN+ZURICH)  
 M PERIN  
 ASTBURY, MICHELINI, BEUSCH + (CERN+ZURICH)  
 ASTBURY, MICHELINI, BEUSCH + (CERN+ZURICH)  
 AUBERT, BEHR, CANAVAN, CHOUNET + (EPOL+ORSAY)  
 BALDO-CEOLIN, CALIMANI, CIAMPOLILLO + (PADUA)  
 CHRISTENSON, CRONIN, FITCH, TURLAY (PRINCETON)  
 FISHER, ABASHIAN, ABRAMS, CARPENTER + (ILL)  
 FITCH, ROTH, RUSS, VERNON (PRINCETON)  
 FRANZINI, KIRSCH, PLANO + (COLUMBIA+RUTGERS)  
 GALBRAITH, MANNING, JONES + (AERE+BRIS+RHEL)  
 BARNES, FOELSCH, FERBEL, FIRESTO + (BNL+YALE)  
 H W K HOPKINS, BACON, EISLER (VAND+RUTGERS)  
 VISHNEVS, GALANINA, SEMENOV + (ITEP)  
 ALFF-STEINBERGER, HEUER, RUBBIA + (CERN)  
 ANIKINA, VARDENGA, ZHURAVLEVA + (JINR)  
 AUERBACH, MANN, MCFARLANE, SCIULLI (PENN)  
 AUERBACH, DOBBS, LANDE, MANN, SCIULLI + (PENN)  
 \*LANDE, MANN, SCIULLI, UTO, WHITE, YOUNG (PENN)  
 BALDO-CEOLIN, CALIMANI, CIAMPOLILLO + (PADUA)  
 BASILE, CRONIN, THEVENET + (SACLAY)  
 \*BRISSEN, BALDO-CEOLIN, AUBERT + (IPAD, EPOL)  
 BELLOTTI, PULLI, BALDO-CEOLIN (MILAN, PADUA)  
 BOTT-BODENHAUSEN, DE BOUARD, CASSEL + (CERN)  
 CAMERINI, CLINE, ENGLISH, FISCHBEIN+WISCONSIN  
 \*CHO, ENGLER, FISK, HILL + (CARNegie+BNL)  
 CARPENTER, ABASHIAN, ABRAMS, FISHER (ILLINOIS)  
 CHANG, BASSAND, KIKUCHI, ODDO + (SYRACUSE, BNL)

CRIGEE 66 PRL 17 150  
 FIRESTON 66 PR 16 556  
 FIRESTON 66 PRL 17 116  
 FUJII 66 PRL 13 253  
 FUJII 66 IS THE CORRECTED  
 HAWKINS 66 PL 21 238  
 ALSO 67 PR 156 1444  
 JOVANOVI 66 PRL 17 1075  
 KULYUKIN 66 BERKELEY 28  
 MEISNER 66 PRL 16 278  
 MEISNER 66 PRL 17 492  
 NEFKENS 66 PL 19 706  
 VERHEY 66 PRL 17 669  
 BENNETT 67 PRL 19 993  
 BOTT-BOD 67 PL 248 194  
 BOTT-BOD 67 PL 248 438  
 ALSO 66 PL 20 212  
 ALSO 66 PL 23 277  
 CANTER 67 THESIS  
 CRONIN 1 67 PRL 18 25  
 CRONIN 2 67 PRINC. CONF(11/67)  
 DEBOUARD 67 NC 52A 662  
 ALSO 65 PL 15 58  
 DEVLIN 67 PRL 18 54  
 ALSO 68 PR 169 1045  
 DORFAN 67 PRL 19 987  
 FELDMAN 67 PR 155 1611  
 FIRESTON 67 PRL 11 1650  
 FITCH 67 PR 164 1711  
 HAWKINS 67 PR 156 1444  
 HILL 67 PRL 19 668  
 HOPKINS 67 PRL 19 185  
 KADYK 67 PRL 19 597  
 KADYK, CHAN, DRIJARD, OREN, SHELTON (LRL)  
 KULYUKIN 67 PREPRINT  
 LOWYS 67 PL 248 75  
 MISCHKE 67 PRL 18 138  
 NEFKENS 67 PR 157 1233  
 TODOROFF 67 THESIS  
 ABRAMS 68 PR 176 1603  
 ARNOLD 68 PR 280 58  
 ARNOLDSON 68 PL 20 287  
 ALSO 69 PR 175 1708  
 BALATZ 68 PL 268 320  
 BARTLETT 68 PRL 21 558  
 BASILE 68 PL 268 542  
 BASILE 68 PL 280 58  
 BENNETT 68 PL 278 244  
 BENNETT 68 PL 278 248  
 FIRESTON 68 PR 21 1650  
 BUDAGOV 68 NC 57A 182  
 ALSO 68 PL 288 215  
 CARNegie 68 PRINC TR44 THESIS  
 ARNOLD 68 NP 88 345  
 JAMES 68 PRL 21 257  
 KULYUKIN 68 JETP 26 20  
 KUNZ 68 THESIS (PU 46)  
 MELCHOP 68 PR 172 1613  
 THATCHER 68 PR 174 1674  
 BANNER 69 PR 188 2033  
 ALSO 68 PRL 21 1103  
 ALSO 68 PRL 21 1107  
 BEILLIER 69 PR 308 202  
 BENNETT 69 PL 298 317  
 BOHM 69 NP 89 605  
 ALSO 68 PL 278 321  
 BOTT-BOD 69 CERN 69-7 329  
 CENCE 69 PRL 22 1210  
 EVANS 69 PRL 23 427  
 FAISSNER 69 PL 308 204  
 FOETH 69 PR 308 282  
 GAILLARD 69 NC 59A 453  
 ALSO 67 PRL 18 20  
 GOBBI 69 PRL 22 685  
 LITTENBER 69 PRL 22 654  
 LONGO 69 PR 181 1808  
 PACIOTTI 69 THESIS, UCRL 19446  
 SAAL 69 THESIS  
 ALBROW 70 PL 338 516  
 ARNOLDSON 70 PRL 25 1057  
 BARMIN 70 PL 338 377  
 BASILE 70 PR 02 78  
 BUCHANAN 70 PL 338 623  
 ALSO PRIVATE COMMUNICATION  
 BUDAGOV 70 PR 02 815  
 ALSO 68 PL 288 215  
 CHIEN 70 PL 338 627  
 ALSO PRIVATE COMMUNICATION  
 CHO 70 PR 01 3031  
 ALSO 67 PRL 19 668  
 COLLET 70 PL 318 658  
 CULLEN 70 PL 328 528  
 DARRIULAT 70 PL 338 249  
 FAISSNER 70 NC 70A 57  
 JENSEN 70 THESIS  
 ALSO 67 PRL 23 615  
 MARX 70 PR 328 19  
 ALSO 70 THESIS, NEVIS 179  
 SCIULLI 70 PRL 25 1214  
 SCRIBANO 70 PL 328 224  
 SMITH 70 PL 328 133  
 WEBBER 70 PR 01 1967  
 ALSO 69 UCRL 19226 THESIS  
 BALATS 71 SJNP 13 53  
 BARMIN 71 PL 358 604  
 BISI 71 PL 368 533  
 CARNegie 71 PR 04 1  
 CHAN 71 LBL-350 THESIS  
 \*FOX, FRAUENFELDER, HANSON, MOSCAT + (ILLINOIS)  
 FIRESTONE, KIM, LACH, SANDWEISS + (YALE, BNL)  
 FIRESTONE, KIM, LACH, SANDWEISS + (YALE, BNL)  
 FUJII, JOVANOVIH, TURKOT, ZORN (BNL+MARYLAND)  
 VALUE GIVEN BY JOVANOVIH + 66 (YALE)  
 J J HAWKINS (YALE)  
 C J B HAWKINS (YALE)  
 JOVANOVIH, FUJII, TURKOT, ZORN + (BNL+UMD+MIT)  
 KULYUKINA, MESTVIRISHVILI, NEAGU, PETR + (JINR)  
 G W MEISNER, B B CRAWFORD, F CRAWFORD (LRL)  
 G MEISNER, B CRAWFORD, F CRAWFORD (LRL)  
 NEFKENS, ABASHIAN, ABRAMS, CARPENTER + (ILL)  
 VERHEY, NEFKENS, ABASHIAN + (ILL)  
 BENNETT, NYGREN, SAAL, STEINBERGER + (COLUMBIA)  
 BOTT-BODENHAUSEN, DEBOUARD, CASSEL + (CERN)  
 BOTT-BODENHAUSEN, DEBOUARD, DEKKERS + (CERN)  
 BOTT-BODENHAUSEN, DEBOUARD, CASSEL + (CERN)  
 BOTT-BODENHAUSEN, DEBOUARD, CASSEL + (CERN)  
 J M CANTER (CARNegie)  
 \*KUNZ, RISK, WHEELER (PRINCETON)  
 \*KUNZ, RISK, WHEELER (PRINCETON)  
 DEBOUARD, DEKKERS, JORDAN, HERMOD + (CERN)  
 DE BOUARD, DEKKERS, SCHARFF + (CERN+ORSA+MPI)  
 DEVLIN, SLOMON, SHEPARD, BEALL + (PRIN+UMD)  
 SAYER, BEALL, DEVLIN, SHEPARD + (UMD+PPA+PRIN)  
 DORFAN, ENSTROM, RAYMOND, SCHWARTZ + (SLAC+LRL)  
 FELDMAN, FRANKEL, HIGGARD, SLOAN (YALE, BNL)  
 FIRESTONE, KIM, LACH, SANDWEISS + (YALE, BNL)  
 FITCH, ROTH, RUSS, VERNON (PRINCETON)  
 C J B HAWKINS (YALE)  
 HILL, LUERS, ROBINSON, CANTER + (BNL, CARNegie)  
 HOPKINS, BACON, EISLER (BNL)  
 KADYK, CHAN, DRIJARD, OREN, SHELTON (LRL)  
 KULYUKINA, MESTVIRISHVILI, NEAGU + (JINR)  
 LOWYS, AUBERT, CHOUNET, PASCAUD + (EPOL, ORSA)  
 MISCHKE, ABASHIAN, ABRAMS + (ILLINOIS)  
 \*ABASHIAN, ABRAMS, CARPENTER, FISHER + (ILLINOIS)  
 JOHN A TODOROFF (ILLINOIS)  
 \*ABASHIAN, MISCHKE, NEFKENS, SMITH + (ILLINOIS)  
 ARNOLD, BUDAGOV, CUNDY, AUBERT + (CERN+ORSAY)  
 S H ARNOLDSON, K W CHEN (PRINCETON)  
 S H ARNOLDSON, K W CHEN (PRINCETON)  
 BALATZ, BEREZIN, VISHNEVSKY, GALANINA + (ITEP)  
 BARTLETT, CARNegie, FITCH + (PRINCETON)  
 BASILE, CRONIN, THEVENET, TURLAY + (SACLAY)  
 \*CRONIN, THEVENET, TURLAY, ZYLBERAJCH + (SACLAY)  
 BENNETT, NYGREN, STEINBERGER + (COLUMBIA+ERN)  
 BENNETT, NYGREN, STEINBERGER + (COLUMBIA+ERN)  
 FIRESTON 69 PR 157 1233  
 BUDAGOV, BURMEISTER, CUNDY + (CERN, ORSA, ITP)  
 \*CUNDY, MYATT, NEZIRICK + (CERN, ORSA, EPOL)  
 R K CARNegie (PRINCETON)  
 F JAMES, H BRIAND (TPNP, CERN)  
 HELLAND, LONGO, YOUNG (UCLA, MICH)  
 KULYUKINA, MESTVIRISHVILI, NEAGU + (JINR)  
 P F KUNZ (PRINCETON)  
 MELCHOP, KURTY BOWLES, BURNETT (LA JOLLA)  
 THATCHER, ABASHIAN, ABRAMS, CARPENTER + (ILL)  
 \*CRONIN, LIU, PILCHER (PRINCETON)  
 BANNER, CRONIN, LIU, PILCHER (PRINCETON)  
 BANNER, CRONIN, LIU, PILCHER (PRINCETON)  
 BEILLIER, BOUTANG, LI MON (EPOL)  
 \*NYGREN, SAAL, STEINBERGER + (CERN, BNL)  
 \*DARRIULAT, GROSSO, KAPTANOV + (CERN)  
 BOHM, DARRIULAT, GROSSO, KAPTANOV (CERN)  
 BOTT-BODENHAUSEN, DE BOUARD, CASSEL + (CERN)  
 CENCE, JONES, PETERSON, STENGER + (HAWAII, LRL)  
 EVANS, GOLDEN, MUIR, PEACH + (EDINBURGH, CERN)  
 \*FOETH, STAUDE, TITTEL + (AACH, CERN, TORI)  
 \*HOLDER, RADENMACHER + (AACH, CERN, TORI)  
 \*GALBRAITH, HUSSRI, JANE + (CERN, RHEL, AACHEN)  
 \*KRIEKEN, GALBRAITH, HUSSRI + (CERN+RHEL+AACH)  
 \*GREEN, MAKEL, HOFFETT, ROSEN, GOSZ + (ROCH+RUTG)  
 LITTENBER, FIELD, PICCIONI, MEHLHOP + (UCSD)  
 M J LONGO, K K YOUNG, J A HELLAND (MICH, UCLA)  
 H A PACIOTTI (LRL)  
 J S SAAL (COLUMBIA)  
 \*ASTON, BARBER, BIRD, ELLISON + (MCHS+DARE)  
 \*EHRICH, HOFER, JENSEN + (EFI, ILL, SLAC)  
 \*BARYLON, BORISOV, BYSHEVA + (ITEP, JINR)  
 \*CRONIN, THEVENET, TURLAY, ZYLBERAJCH + (SACLAY)  
 \*DRICKEY, RUONICK, SHEPARD + (SLAC, JHU, UCLA)  
 B B COX, FEB. 71  
 \*CUNDY, MYATT, NEZIRICK + (CERN, ORSA, EPOL)  
 \*CUNDY, MYATT, NEZIRICK + (CERN, ORSA, EPOL)  
 C Y CHEN, COX, ETTLINGER + (JHU+SLAC+UCLA)  
 B COX FEB. 71  
 \*ORRALL, CANTER, ENGLER, FISK + (CARN, BNL, CASE)  
 HILL, LUERS, ROBINSON, SAKITT + (BNL, CERN)  
 \*GAILLARD, JANE, RATCLIFFE, REPELLIN + (CERN)  
 \*DARRIULAT, DEUTSCH, FOETH + (AACH, CERN, TORI)  
 \*FERRERO, GROSSO, HOLDER + (AACH, CERN, TORI)  
 \*REITHLER, THOME, GAILLARD + (AACH, CERN, RHEL)  
 J A JENSEN (EFI)  
 \*JENSEN, ARNOLDSON, EHRICH, FRYBERGER + (EFI, ILL)  
 \*NYGREN, PEOPLES, STEINBERGER + (CERN, RHEL, CERN)  
 JAY MARX (COLUMBIA)  
 \*GALLIVAN, BINNIE, GOMEZ, MALLARY, PECK + (CIT)  
 \*MANNELLI, PIERAZZINI, MARX + (PISA, COLU, MARV)  
 \*WANG, WHATLEY, ZORN, HORNOSTE + (UCSD)  
 \*SOLMITZ, CRAWFORD, ALSTON-GARNJOST (LRL)  
 R B WEBBER (LRL)  
 \*BEREZIN, VISHNEVSKY, GALANINA + (ITEP)  
 \*BARYLOV, VESELOVSKY, DAVIDENKO + (ITEP)  
 \*DARRIULAT, FERREIRO, RUBBI + (AACH, CERN, TORI)  
 \*CESTER, FITCH, STROVINK, SULAK (PRIN)  
 J HONG-SING CHAN (UCSD)

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $K_L^0$   $\eta$ CHIEN 71 PL 358 261 +COX, ETLINGER, RESVANIS\* (JHU, SLAC, UCLA)  
ALSO 72 DALLYCHO 71 PR 03 1557 +DRALLE, CANTER, ENGLER, FISK\* (CERN, BNL, CASE)  
CLARK 71 PRL 26 1667 +ELOFF, FIELD, FRISCH, JOHNSON, KERTH\* (LRL)ALSO 70 UCRL 19709-THESIS ROLLAND, JOHNSON (LRL)  
ALSO 71 UCRL 20264-THESIS HENRY, FRISCH (LRL)ENSTROM 71 PR 04 2629 +AKAVIA, COOMBS, DORFAN\* (SLAC, STAN)  
ALSO 70 THESIS (SLAC 1251) J E ENSTROM (STANFORD)HILL 71 PR 04 7 +SAKITT, SKJEGGESTAD, CANTER\* (BNL, CERN, CASE)  
MEISNER 71 PR 03 59 +MANN, HERTZBACH, KOFLER + (MASA+BNL+YALE)  
PEACH 71 PL 358 351 +EVANS, MUIR, BUDAGOV, HOPKINS\* (EDIN, CERN)REPELLIN 71 PL 368 603 +WOLFF, CHOLLET, GAILLARD, JANE\* (ORSA, CERN)  
WEBER 71 PR 03 64 +SOLMITZ, CRAWFORD, ALSTON-GARNJOST (LRL)ALSO 68 PRL 21 498 WEBER, SOLMITZ, CRAWFORD, ALSTON-GARNJOST (LRL)  
ALSO 69 UCRL 19266-THESIS B R WEBER (LRL)

WOLFF 71 PL 368 517 +CHOLLET, REPELLIN, GAILLARD\* (ORSA, CERN)

ALBROW 72 NP 844 1 +ASTON, BARBER, BIRD, ELLISON\* (MCHS+DARE)  
ASHFORD 72 PL 388 47 +BROWN, MASEK, MAUNG, MILLER, RUDERMAN\* (UCSD)BANNER1 72 PRL 28 1597 +CRONIN, HOFFMAN, KNAPP, SHOCHE (PRINCETON)  
BANNER2 72 PRL 29 237 +CRONIN, HOFFMAN, KNAPP, SHOCHE (PRINCETON)BURGUN 72 PR 03 184 +BURGUN, MULLER, PAULI\* (SACL+CEM+OSLO)  
ALSO 71 LNC 2 1169 BURGUN, LESOUQUY, MULLER + (SACL+CEM+OSLO)CARNEGIE 72 PR 06 2335 +CESTER, FITCH, STROVINK, SULAK (PRINCETON)  
DALLY 72 PL 418 647 +INNOCENTI, SEPTI, CHIEN, COX\* (SLAC+JHU+UCLA)

ALSO 70 CHIEN

GRAHAM 72 NC 9A 166 +ABASHIAN, JONES, MANTSCH, ORR\* (ILL+NEAS)  
HOLDER 72 PL 408 141 +RADERMACHER, STAUDE\* (AACH+CERN+TORI)JAMES 72 NP 849 1 +MONTANET, PAUL, SAETRE\* (CERN+SACL+OSLO)  
ALSO 71 PL 358 265 JAMES, MONTANET, PAUL, PAULI\* (CERN+SACL+OSLO)KRENZ 72 LNC 4 213 +HOPKINS, EVANS, MUIR, PEACH (AACH+CERN+EDIN)  
MANN 72 PR 06 137 +KOFLER, MEISNER, HERTZBACH\* (MASA+BNL+YALE)MANTSCH 72 NC 9A 160 +ABASHIAN, GRAHAM, JONES, ORR\* (ILL+NEAS)  
MCCARTHY 72 PL 428 291 +BREMER, BUDNITZ, ENTIS, GRAVEN, MILLER\* (LBL)ALSO 71 THESIS 181 - 550 R L MCCARTHY (LBL)  
METCALF 72 PL 408 703 +NEUHOFFER, NIEBERGALL\* (CERN+IPN+WIEN)NEUHOFFER 72 PL 418 642 +NIEBERGALL, REGLER, STIER\* (CERN+ORSA+VIEN)  
PICCIONI 72 PRL 29 1412 +COOMBS, DONALDSON, DORFAN, FRYBERGER\* (SLAC)VOISBURGH 72 PR 06 1834 +DEVILIN, ESTERLING, GOZ + (RUTG, MASA)  
ALSO 71 PRL 26 866 VOISBURGH, DEVILIN, ESTERLING, GOZ + (RUTG, MASA)

WEBB 72 THESIS ROBERT CARROLL WEBB (PRINCETON)

CARITHER 73 BAPS 18 26 CARITHERS, MODIS, NYGREN, PUN\* (COLU+CERN+NYU)  
EVANS 73 PR 07 36 +MUIR, PEACH, BUDAGOV\* (EDINBURGH+CERN)

ALSO 69 PRL 23 427 EVANS, GOLDEN, MUIR, PEACH\* (EDINBURGH+CERN)

ALEXANDER 62 PRL 9 69 G ALEXANDER, S ALMEIDA, F CRAWFORD (LRL)

JOVANOVI 63 BNL CONF 42, JOVANOVI, FISCHER, BURRIS + (BNL+MARYLAND)

STERN 64 PRL 12 459 STERN, BINFORD, LIND, ANDERSON + (WISC+LRL)

BEHR 65 ARGONNE CONF 59 BEHR, BRISSON, BELLOTTI\* (EPOL, MILA, PADO)

MESTVIRI 65 JINR P 2449 MESTVIRI, SHVILIT, NYAGU, PETROV, RUSAKOV\* (JINR)

TRILLING 65 UCRL 16473 GEORGE H TRILLING (LRL)

UPDATED FROM 1965 ARGONNE CONF., PAGE 115.  
GINSBERG 67 PR 162 1570 EDWARD S GINSBERG (U. MASS BOSTON)

RUBBIA 67 PL 248 531 C. RUBBIA, J. STEINBERGER (CERN+COLU)

ALSO 1 66 PL 20 207 ALFF-STEINBERGER, HEUER, KLEINKNECHT\* (CERN)

ALSO 2 66 PL 21 595 ALFF-STEINBERGER, HEUER, KLEINKNECHT\* (CERN)

ALSO 3 66 PL 23 167 C. RUBBIA, J. STEINBERGER (CERN+COLU)

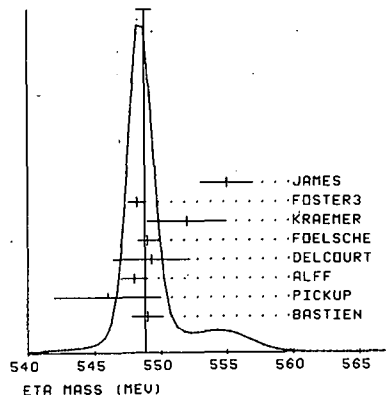
SCHMIDT 67 NEVIS 1601(THESIS13) P. SCHMIDT (COLUMBIA)

CRONIN 68 VIENNA CONF P.281 CRONIN, RAPORTEURS TALK (PRINCETON)

GINSBERG 70 PR 01 229 E S GINSBERG (IIT HAIIFA)

HEUSSE 70 LNC 3 449 +AUBERT, PASCAUD, VIALLE (ORSAY)

GINSBERG 71 PR 04 2893 E S GINSBERG (MIT)

WEIGHTED AVERAGE = 548.82 ± 0.56  
ERROR SCALED BY 1.4

CHISO

|                  |         |      |
|------------------|---------|------|
| JAMES            | 66 HBC  | 9.6  |
| FOSTER3          | 65 HBC  | 0.9  |
| KRAEMER          | 64 DBC  | 1.1  |
| FOELSCH          | 64 HBC  | 0.1  |
| DELICOURT        | 63 CNTR | 0.0  |
| ALFF             | 62 HBC  | 0.7  |
| PICKUP           | 62 HBC  | 0.0  |
| BASTIEN          | 62 HBC  | 0.0  |
| (CONLEU = 0.054) |         | 12.4 |

14. ETA PARTIAL DECAY MODES

|     | DECAY MASSES                              |
|-----|-------------------------------------------|
| P1  | ETA INTO 2GAMMA                           |
| P2  | ETA INTO 3P10                             |
| P3  | ETA INTO P1+ P1- P10                      |
| P4  | ETA INTO P1+ P1- GAMMA                    |
| P5  | ETA INTO E+ E- P10 (VIOLATES C IN E.M.I.) |
| P6  | ETA INTO E+ E- P1+ P1-                    |
| P7  | ETA INTO P10 2GAMMA                       |
| P8  | ETA INTO E+ E- GAMMA                      |
| P9  | ETA INTO 2P10 GAMMA (VIOLATES C)          |
| P10 | ETA INTO P1+ P1- P10 GAMMA                |
| P11 | ETA INTO P1+ P1- 2GAMMA                   |
| P12 | ETA INTO MU+ MU- GAMMA                    |
| P13 | ETA INTO MU+ MU- GAMMA                    |
| P14 | ETA INTO MU+ MU- P10                      |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

| P 1                                           | P 2 | P 3 | P 4 | P 7 |
|-----------------------------------------------|-----|-----|-----|-----|
| P 1 .3800+-0.0098                             |     |     |     |     |
| P 2 -.2762 .3000+-0.0107                      |     |     |     |     |
| P 3 -.3387 -.2116 .2390+-0.0055               |     |     |     |     |
| P 4 -.3091 -.1946 .8620 .0497+-0.0013         |     |     |     |     |
| P 7 -.4203 -.5972 -.0815 -.0725 .0313+-0.0111 |     |     |     |     |

14. ETA DECAY RATES

| W1 | ETA INTO 2GAMMA (UNITS KEV) | (G1)                                    |
|----|-----------------------------|-----------------------------------------|
| W1 | (0.93) (0.2)                | BEMPORAD 67 CNTR PRIMAOKFF EFFECT 11/67 |

The above value for  $\Gamma_{\eta}$  assumes that  $\Gamma_{\eta}/\Gamma_{\text{total}} = 31.4\%$ . However, the results of that experiment may be stated more generally than is given in the paper, as

$$\Gamma_{\eta} \times \frac{\Gamma_{\eta}}{\Gamma_{\text{total}}} = 0.380 \pm 0.083 \text{ keV}$$

(private communication from C. Bemporad). Thus our new value of

$$\Gamma_{\eta}/\Gamma_{\text{total}} = 38.0 \pm 1.0\%$$

would give

$$\Gamma_{\eta} = 1.00 \pm 0.22 \text{ keV}$$

and

$$\Gamma_{\text{total}} = 2.63 \pm 0.58 \text{ keV.}$$

See G. Benfatto, "Coherent Nuclear Photoproduction of the  $\eta$ -meson," *Nuovo Cimento* **69A**, 109 (1970) for a critique of this technique.

 $\eta$ 

14. ETA (549, JPC=0-+) I=0

FOR C. BALTAY'S REVIEW OF THE  $\eta$ -MESON, SEE PROC. UNIV. OF PENN. CONF. ON MESON SPECTROSCOPY (W.A. BENJAMIN, N.Y., 1968)

14. ETA MASS (MEV)

|   |     |        |      |                                              |         |
|---|-----|--------|------|----------------------------------------------|---------|
| M | 53  | 549.0  | 1.2  | BASTIEN                                      | 62 HBC  |
| M | 35  | 546.0  | 4.0  | PICKUP                                       | 62 HBC  |
| M | 91  | 549.0  | 1.0  | ALFF                                         | 62 HBC  |
| M |     | 549.3  | 2.9  | DELICOURT                                    | 63 CNTR |
| M | 148 | 549.0  | 0.7  | FOELSCH                                      | 64 HBC  |
| M | 325 | 552.0  | 3.0  | KRAEMER                                      | 64 DBC  |
| M |     | 548.2  | 0.65 | FOSTER3                                      | 65 HBC  |
| M | 250 | 555.0  | 2.0  | JAMES                                        | 66 HBC  |
| M | AVG | 548.82 | 0.56 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) |         |
|   |     |        |      | (SEE IDEOGRAM BELOW)                         |         |

7/66  
6/66

14. ETA WIDTH (MEV)

|   |     |        |               |         |         |
|---|-----|--------|---------------|---------|---------|
| W | 91  | (10.0) | OR LESS       | ALFF    | 62 HBC  |
| W | 140 | (10.0) | OR LESS       | FOELSCH | 64 HBC  |
| W | 31  | (12.0) | OR LESS       | JAMES   | 66 HBC  |
| W |     | (4.0)  | OR LESS       | BALTAY  | 66 DBC  |
| W |     | (1.9)  | OR LESS CL=95 | JONES   | 66 CNTR |

6/66  
7/66  
7/67

ALSO SEE ETA DECAY RATES (BELOW).

## Stable Particles

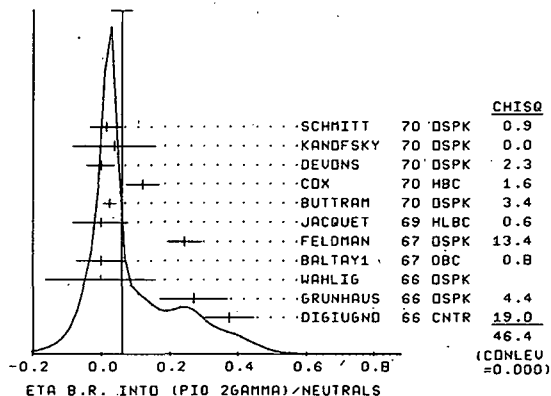
 $\eta$ 14  $\eta$  BRANCHING RATIOS

| ETA INTO NEUTRALS/CHARGED                                         |                  | (P1+P2+P7)/(P3+P4)                            |       |
|-------------------------------------------------------------------|------------------|-----------------------------------------------|-------|
| R1 N                                                              | 10 (2.5) (1.0)   | PICKUP 62 HBC                                 |       |
| R1 N                                                              | 53 (3.20) (1.26) | BASTIEN 62 HBC                                |       |
| R1 N                                                              | (2.7) (0.8)      | SHAFFER 62 HBC                                |       |
| R1 N                                                              | 2.6              | BUSCHBECK 63 HBC                              | 7/66  |
| R1 N                                                              | 280 (4.5) (1.0)  | JAMES 66 HBC                                  | 6/66  |
| THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES    |                  |                                               |       |
| AS THEY WERE UNABLE TO SEPARATE CLEARLY PARTIAL MODES (3) AND (4) |                  |                                               |       |
| FROM EACH OTHER. THE REPORTED VALUES THUS PROBABLY CONTAIN        |                  |                                               |       |
| SOME (UNKNOWN) FRACTION OF MODE (4).                              |                  |                                               |       |
| R1                                                                | 2.64 0.23        | BALTAY2 67 DBC                                | 11/67 |
| R1 AVG                                                            | 2.64 0.23        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |
| R1 FIT                                                            | 2.463 0.080      | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |       |
| ETA INTO 2GAMMA/CHARGED                                           |                  | (P1)/(P3+P4)                                  |       |
| R2                                                                | 0.99 0.48        | CRAWFORD 63 HBC                               |       |
| R2 FIT                                                            | 1.316 0.053      | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |       |

Note on  $\eta \rightarrow \pi^0 \gamma\gamma$ 

The discrepancies between various measurements of branching ratios involving  $\eta \rightarrow \pi^0 \gamma\gamma$  are displayed in the ideogram below, in which all relevant experiments have been converted to a common ratio,  $\pi^0 \gamma\gamma$ /neutrals. Our branching ratio fit does not include DIGIUGNO 66, FELDMAN 67 or the upper limit measurements. See page 43 of "Review of Particle Properties", Physics Letters **39B**, No. 1 (1972) for more discussion.

WEIGHTED AVERAGE =  $0.061 \pm 0.031$   
ERROR SCALED BY 2.3



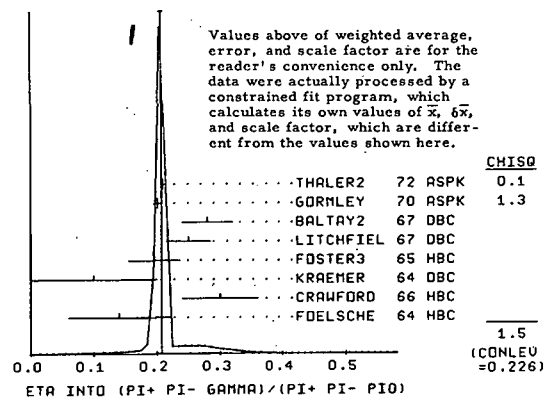
| ETA INTO (PIO 2GAMMA)/NEUTRALS                                                                                                                  |                       | (P7)/(P1+P2+P7)                               |       |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------|-------|
| R3 S                                                                                                                                            | (0.375) (0.072)       | DIGIUGNO 66 CNTR                              | 6/66  |
| THE ERRORS OF DIGIUGNO 66 HAVE BEEN INCREASED BY A FACTOR OF TWO, TO TAKE INTO ACCOUNT POSSIBLE SYSTEMATIC ERRORS, AS SUGGESTED BY THE AUTHORS. |                       |                                               |       |
| R3                                                                                                                                              | .27 .10               | GRUNHAUS 66 DSPK                              | 8/67  |
| R3 R                                                                                                                                            | (.028) (.044)         | BUNIAIOV 67 DSPK                              | 11/67 |
| R3 S                                                                                                                                            | (.244) (.051)         | FELDMAN 67 DSPK                               | 9/67  |
| SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.                                                                                                  |                       |                                               |       |
| R3                                                                                                                                              | .026 .019             | BUTTRAM 70 DSPK                               | 12/70 |
| R3                                                                                                                                              | .122 .052             | COX 70 HBC                                    | 6/70  |
| R3                                                                                                                                              | (.071) OR LESS CL=.90 | DEVONS 70 DSPK                                | 12/70 |
| R3 R                                                                                                                                            | .016 .047             | SCHMITT 70 DSPK                               | 12/70 |
| R3 R                                                                                                                                            | .042 .023             | STRUGALSK 71 HLBC                             | 5/71  |
| R3 E                                                                                                                                            | (0.11) (0.03)         | SCHMITT 70 IS A REANALYSIS                    | 2/71  |
| THIS MEASUREMENT HAS BEEN EXCLUDED BECAUSE THE ERROR APPEARS TO BE SERIOUSLY UNDERESTIMATED.                                                    |                       |                                               |       |
| R3                                                                                                                                              |                       |                                               | 2/71  |
| R3 AVG                                                                                                                                          | 0.042 0.023           | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)  |       |
| R3 FIT                                                                                                                                          | 0.044 0.016           | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |       |

## Data Card Listings

For notation, see key at front of Listings.

| ETA INTO (P1+ P1- GAMMA)/(P1+ P1- PIO)                                                                                        |                  | (P41)/(P3)                                    |       |
|-------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------|-------|
| R4                                                                                                                            | 0.14 0.08        | FOELSCH 64 HBC                                |       |
| R4 M                                                                                                                          | 24 (0.73) (0.25) | PAULI 64 DBC                                  |       |
| THIS EXPERIMENT HAS NOT BEEN INCLUDED IN THE AVERAGES SINCE IT IS NOT CLEAR THAT THEIR CLASS B EVENTS ARE ACTUALLY FROM ETAS. |                  |                                               |       |
| R4                                                                                                                            | 0.30 0.06        | CRAWFORD 66 HBC                               | 6/66  |
| R4                                                                                                                            | .10 .10          | KRAEMER 64 DBC                                | 7/66  |
| R4                                                                                                                            | .196 .041        | FOSTER3 65 HBC                                | 7/66  |
| R4                                                                                                                            | .25 .035         | LITCHFIEL 67 DBC                              | 8/67  |
| R4                                                                                                                            | 0.28 0.04        | BALTAY2 67 DBC                                | 11/67 |
| R4                                                                                                                            | .201 .006        | GORMLEY 70 ASPK                               | 6/70  |
| R4                                                                                                                            | 18K .0209 0.003  | THALER2 72 ASPK                               | 1/73  |
| R4 AVG                                                                                                                        | 0.2080 0.0032    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)  |       |
| R4 FIT                                                                                                                        | 0.2080 0.0027    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| (SEE IDEOGRAM BELOW)                                                                                                          |                  |                                               |       |

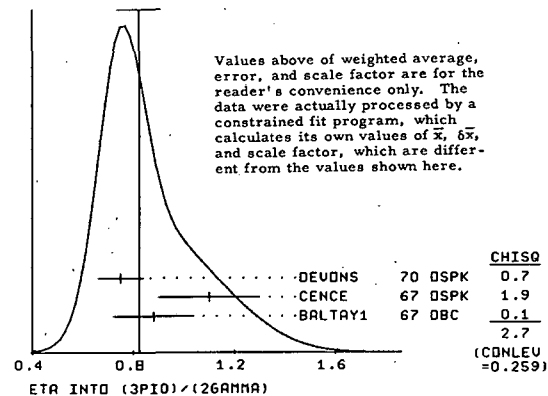
WEIGHTED AVERAGE =  $0.2080 \pm 0.0032$   
ERROR SCALED BY 1.2



| ETA INTO (3PIO) + 2/3(PIO 2GAMMA) / (P1+P1-PIO) |             | (P2+2/3P7)/P3                                 |      |
|-------------------------------------------------|-------------|-----------------------------------------------|------|
| R5                                              | 0.83 0.32   | CRAWFORD 63 HBC                               | 7/66 |
| R5                                              | 2.0 1.0     | FOELSCH 64 HBC                                | 7/66 |
| R5                                              | 0.90 0.24   | FOSTER1 65 HBC                                | 7/66 |
| R5 AVG                                          | 0.91 0.19   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |      |
| R5 FIT                                          | 1.342 0.055 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |      |

| ETA INTO 3PIO/2GAMMA |               | (P2)/(P1)                                     |       |
|----------------------|---------------|-----------------------------------------------|-------|
| R6                   | (.90) OR MORE | CHRETIEN 62 PBC                               | 11/67 |
| R6                   | 0.88 0.16     | BALTAY1 67 DBC                                | 6/70  |
| R6                   | 1.1 0.2       | CENCE 67 DSPK                                 | 12/70 |
| R6                   | 0.75 0.09     | DEVONS 70 DSPK                                |       |
| R6 AVG               | 0.824 0.085   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)  |       |
| R6 FIT               | 0.790 0.039   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |       |
| (SEE IDEOGRAM BELOW) |               |                                               |       |

WEIGHTED AVERAGE =  $0.824 \pm 0.085$   
ERROR SCALED BY 1.2



| ETA INTO 2GAMMA/(P1+ P1- P0) |              | (P11)/(P3)                                    |      |
|------------------------------|--------------|-----------------------------------------------|------|
| R7                           | 1.61 0.39    | FOSTER1 65 HBC                                | 7/69 |
| R7                           | 401 1.72 .25 | BAGLIN 69 HLBC                                |      |
| R7 AVG                       | 1.69 0.21    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |      |
| R7 FIT                       | 1.590 0.064  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |      |

## Data Card Listings

## Stable Particles

For notation, see key at front of Listings.

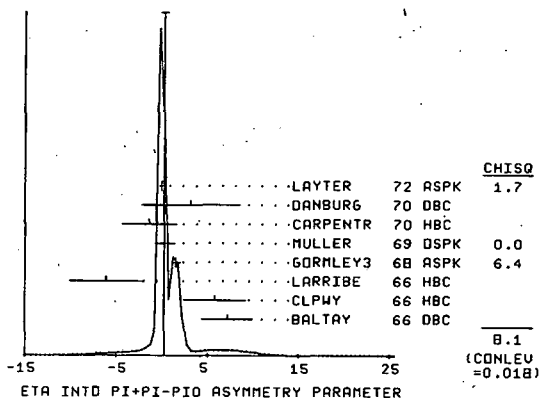
 $\eta$ 

|       |                                                                     |                                                                 |         |                                               |                         |                  |       |
|-------|---------------------------------------------------------------------|-----------------------------------------------------------------|---------|-----------------------------------------------|-------------------------|------------------|-------|
| R8    | ETA INTO NEUTRAL/(PI+ PI- PI0)                                      |                                                                 |         |                                               |                         | (P1+P2+P7)/(P3)  |       |
| R8    | 50                                                                  | 3.6                                                             | 0.8     | KRAEMER                                       | 64 DBC                  |                  |       |
| R8    |                                                                     | 3.8                                                             | 1.1     | PAULI                                         | 64 DBC                  |                  | 7/66  |
| R8    |                                                                     | 2.89                                                            | 0.56    | ALFF-STEE                                     | 66 HBC                  |                  | 9/66  |
| R8    | 244                                                                 | 3.6                                                             | 0.6     | FLATTE                                        | 67 HBC                  |                  | 1/68  |
| R8    | 29                                                                  | 3.4                                                             | 1.1     | AGUILAR-B                                     | 72 HBC                  |                  | 11/72 |
| R8 B  | 70                                                                  | 2.83                                                            | 0.80    | BLOODWORTH                                    | 72 HBC                  |                  | 11/72 |
| R8 B  | ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM. |                                                                 |         |                                               |                         |                  |       |
| R8    |                                                                     |                                                                 |         |                                               |                         |                  | 1/73* |
| R8    | AVG                                                                 | 3.28                                                            | 0.31    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                         |                  |       |
| R8    | FIT                                                                 | 2.976                                                           | 0.097   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                         |                  |       |
| R9    | ETA INTO (E+E-PI0)/(PI+PI-PI0)                                      |                                                                 |         | (UNITS 10**=-2)                               |                         | (P5)/(P3)        |       |
| R9    |                                                                     | 1.1                                                             | OR LESS | PRICE                                         | 65 HBC                  |                  |       |
| R9    |                                                                     | 0                                                               | OR LESS | FOSTER2                                       | 65 HBC                  |                  |       |
| R9    |                                                                     | .42                                                             | OR LESS | BAGLINI                                       | 67 HLBC                 |                  | 8/67  |
| R9    |                                                                     | .16                                                             | OR LESS | BILLING                                       | 67 HLBC                 |                  | 11/67 |
| R10   | ETA INTO (E+E-PI+PI-)/TOTAL (UNITS 10**=-2)                         |                                                                 |         |                                               |                         | (P6)             |       |
| R10   |                                                                     | (0.71)                                                          | OR LESS | RITTENBERG                                    | 65 HBC                  |                  | 6/66  |
| R11   | ETA INTO (E+E-PI+PI-)/(PI+PI-GAMMA)                                 |                                                                 |         |                                               |                         | (P6)/(P4)        |       |
| R11   | 1                                                                   | 0.026                                                           | 0.026   | GROSSMAN                                      | 66 HBC                  |                  | 6/66  |
| R12   | ETA INTO 2 GAMMA/NEUTRALS                                           |                                                                 |         |                                               |                         | (P1)/(P1+P2+P7)  |       |
| R12 S | (0.416)                                                             | (0.044)                                                         |         | DIGIUGNO                                      | 66 CNTR                 |                  | 6/66  |
| R12   |                                                                     | .44                                                             | .07     | GRUNHAUS                                      | 66 DSPK                 |                  | 8/67  |
| R12 S | (.579)                                                              | (.052)                                                          |         | FELDMAN                                       | 67 DSPK                 |                  | 8/67  |
| R12 S | SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.                      |                                                                 |         |                                               |                         |                  |       |
| R12 T | (.39)                                                               | (0.06)                                                          |         | JONES                                         | 66 CNTR                 |                  | 8/67  |
| R12 T | THIS RESULT FROM COMBINING CROSS SECTIONS FROM TWO DIFFERENT EXPTS. |                                                                 |         |                                               |                         |                  |       |
| R12   |                                                                     | .59                                                             | .033    | BUNIATOV                                      | 67 DSPK                 |                  | 11/67 |
| R12   |                                                                     | .535                                                            | .018    | BUTTRAM                                       | 70 DSPK                 |                  | 12/70 |
| R12   |                                                                     | .486                                                            | .036    | COX                                           | 70 HBC                  |                  | 6/70  |
| R12   |                                                                     | .057                                                            | .009    | STRUGALSK                                     | 71 HLBC                 |                  | 5/71  |
| R12   | AVG                                                                 | 0.535                                                           | 0.018   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)  |                         |                  |       |
| R12   | FIT                                                                 | 0.534                                                           | 0.013   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                         |                  |       |
| R13   | ETA INTO 3PI0/NEUTRALS                                              |                                                                 |         |                                               |                         | (P2)/(P1+P2+P7)  |       |
| R13 S | (0.209)                                                             | (0.054)                                                         |         | DIGIUGNO                                      | 66 CNTR                 |                  | 6/66  |
| R13 R | (.29)                                                               | (.10)                                                           |         | GRUNHAUS                                      | 66 DSPK                 |                  | 8/67  |
| R13 S | (.177)                                                              | (.035)                                                          |         | FELDMAN                                       | 67 DSPK                 |                  | 8/67  |
| R13 S | SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.                      |                                                                 |         |                                               |                         |                  |       |
| R13   | .41                                                                 | .033                                                            |         | BUNIATOV                                      | 67 DSPK                 |                  | 11/67 |
| R13 R | REDUNDANT INFORMATION FROM THIS EXPERIMENT.                         |                                                                 |         |                                               |                         |                  |       |
| R13 R | (.439)                                                              | (.024)                                                          |         | BUTTRAM                                       | 70 DSPK                 |                  | 12/70 |
| R13   |                                                                     | .392                                                            | .042    | COX                                           | 70 HBC                  |                  | 6/70  |
| R13   |                                                                     | .032                                                            | .009    | STRUGALSK                                     | 71 HLBC                 |                  | 5/71  |
| R13   | AVG                                                                 | 0.397                                                           | 0.025   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                         |                  |       |
| R13   | FIT                                                                 | 0.422                                                           | 0.015   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                         |                  |       |
| R14   | ETA INTO PI0 (2 GAMMA)/2GAMMA                                       |                                                                 |         |                                               |                         | (P7)/(P1)        |       |
| R14   |                                                                     | (.51)                                                           | OR LESS | CL=.90                                        | MAHLIG                  | 66 SPRK          | 7/66  |
| R14   |                                                                     | 0.0                                                             | 0.14    |                                               | BALTAY1                 | 67 DBC           | 11/67 |
| R14 P | (0.05)                                                              | (0.04)                                                          |         |                                               | BONAMY                  | 67 SPRK          | 11/67 |
| R14   | PRELIMINARY RESULT                                                  |                                                                 |         |                                               |                         |                  |       |
| R14   | FIT                                                                 | 0.082                                                           | 0.030   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                         |                  |       |
| R15   | ETA INTO (E+E-PI0)/TOTAL (UNITS 10**=-2)                            |                                                                 |         |                                               |                         | (P5)             |       |
| R15   |                                                                     | (0.71)                                                          | OR LESS | RITTENBERG                                    | 65 HBC                  |                  | 6/66  |
| R15   |                                                                     | (0.084)                                                         | OR LESS | CL=.90                                        | BAZIN                   | 68 DBC           | 6/68  |
| R16   | ETA INTO 2GAMMA/(3PI0 + PI0 2GAMMA)                                 |                                                                 |         |                                               |                         | (P1)/(P2+P7)     |       |
| R16   |                                                                     | 0.80                                                            | .25     | BACCI                                         | 63 CNTR                 |                  | 7/66  |
| R16   | FIT                                                                 | 1.147                                                           | 0.060   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                         |                  |       |
| R17   | ETA INTO (PI+PI-PI0 GAMMA)/(PI+PI-PI0)                              |                                                                 |         |                                               |                         | (P10)/(P3)       |       |
| R17   |                                                                     | (.07)                                                           | OR LESS | FLATTE                                        | 67 HBC                  |                  | 8/67  |
| R17   |                                                                     | (.009)                                                          | OR LESS | PRICE                                         | 67 HBC                  |                  | 8/67  |
| R17   |                                                                     | (.016)                                                          | OR LESS | CL=.95                                        | BALTAY2                 | 67 DBC           | 11/67 |
| R17   |                                                                     | (.017)                                                          | OR LESS | CL=.90                                        | ARNOLD                  | 68 HLBC          | 9/68  |
| R17   |                                                                     | 0.035                                                           | OR LESS | CL=.90                                        | THALER2                 | 72 ASPK          | 1/73* |
| R18   | ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PI0)                                |                                                                 |         |                                               |                         | (P11)/(P3)       |       |
| R18   |                                                                     | (.009)                                                          | OR LESS | CL=.95                                        | 67 HBC                  |                  | 8/67  |
| R18   |                                                                     | (.016)                                                          | OR LESS | CL=.95                                        | BALTAY2                 | 67 DBC           | 11/67 |
| R19   | ETA INTO 3PI0/(PI+ PI- PI0)                                         |                                                                 |         |                                               |                         | (P2)/(P3)        |       |
| R19   |                                                                     | 1.3                                                             | .4      | BAGLIN2                                       | 67 HLBC                 |                  | 8/67  |
| R19   |                                                                     | 1.47                                                            | 0.20    | 0.17                                          | BULLOCK                 | 68 HLBC          | 9/68  |
| R19   | 199                                                                 | 1.50                                                            | .15     | .29                                           | BAGLIN                  | 69 HLBC          | 7/69  |
| R19   | AVG                                                                 | 1.46                                                            | 0.13    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                         |                  |       |
| R19   | FIT                                                                 | 1.255                                                           | 0.058   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                         |                  |       |
| R20   | ETA INTO 2GAMMA/((3PI0)+2(PI0 2GAMMA))                              |                                                                 |         |                                               |                         | (P1)/(P2+2(3PT)) |       |
| R20   |                                                                     | 1.10                                                            | 0.5     | MULLER                                        | 63 DBC                  |                  | 7/66  |
| R20   | FIT                                                                 | 1.184                                                           | 0.058   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                         |                  |       |
| R21   | ETA INTO NEUTRALS/TOTAL                                             |                                                                 |         |                                               |                         | (P1+P2+P7)       |       |
| R21   |                                                                     | .79                                                             | .08     | BUNIATOV                                      | 67 DSPK                 |                  | 11/67 |
| R21   | 16K                                                                 | .705                                                            | .008    | BASILE                                        | 71 CNTR MM SPECTROMETER |                  | 8/71  |
| R21   | AVG                                                                 | .705                                                            | .0080   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                         |                  |       |
| R21   | FIT                                                                 | 0.713                                                           | 0.0067  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                         |                  |       |
| R22   | ETA INTO (PI0 2GAMMA)/TOTAL                                         |                                                                 |         |                                               |                         | (P7)             |       |
| R22   |                                                                     | .12                                                             | OR LESS | CL=.95                                        | JACQUET                 | 69 HLBC          | 6/70  |
| R22   | FIT                                                                 | 0.031                                                           | 0.011   | FROM FIT                                      |                         |                  |       |
| R23   | ETA INTO MU+MU-/TOTAL (UNITS 10**=-5)                               |                                                                 |         |                                               |                         | (P12)            |       |
| R23   | 0                                                                   | 2.                                                              | OR LESS | CL=.95                                        | WEHMANN                 | 68 DSPK          | 4/68  |
| R24   | ETA INTO MU+MU-PI0/TOTAL (UNITS 10**=-4)                            |                                                                 |         |                                               |                         | (P14)            |       |
| R24   | 5.                                                                  | OR LESS                                                         |         | WEHMANN                                       | 68 DSPK                 |                  | 4/68  |
| R25   | ETA INTO MU+MU-/2GAMMA (UNITS 10**=-5)                              |                                                                 |         |                                               |                         | (P12)/(P1)       |       |
| R25   | 5.9                                                                 | 2.2                                                             |         | HYAMS                                         | 69 DSPK                 |                  | 7/69  |
| R26   | ETA INTO (PI0 2GAMMA)/(3PI0 + PI0 2GAMMA)                           |                                                                 |         |                                               |                         | (P7)/(P2+P7)     |       |
| R26   | N                                                                   | 0.1                                                             | 0.3     | KANOFSKY                                      | 70 DSPK                 |                  | 2/71  |
| R26   | N                                                                   | WE HAVE CHANGED THE ERROR ON THIS EXPERIMENT FROM +0.3, -0.1    |         |                                               |                         |                  |       |
| R26   | N                                                                   | TO THE ABOVE +0.3, -0.3 SINCE IT IS CLEAR FROM FIGURE 7 IN THE  |         |                                               |                         |                  |       |
| R26   | N                                                                   | ARTICLE THAT A CENTRAL VALUE OF 0.0 IS ABOUT AS PROBABLE AS THE |         |                                               |                         |                  |       |
| R26   | N                                                                   | QUOTED VALUE OF 0.1.                                            |         |                                               |                         |                  |       |
| R26   | FIT                                                                 | 0.094                                                           | 0.032   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) |                         |                  |       |

## 14 ETA C-NONCONSERVING DECAY PARAMETER

## RELATED TEXT SECTION IV G AND MINI-REVIEW BELOW

| A |        | DECAY ASYMMETRY PARAMETER FOR PI+ PI- PI0      |       | (UNITS 10**=-2)                              |                           |       |
|---|--------|------------------------------------------------|-------|----------------------------------------------|---------------------------|-------|
| A | 1351   | 7.2                                            | 2.8   | BALTAY                                       | 66 DBC                    | 8/66  |
| A | 1300   | 5.8                                            | 3.4   | CLPHY                                        | 66 HBC                    | 8/66  |
| A | 10665  | (0.3)                                          | (1.0) | CNOPS                                        | 66 DSPK REPL BY MULLER 69 | 8/67  |
| A | 705    | -6.1                                           | 4.0   | LARKIBE                                      | 66 HBC                    | 8/67  |
| A | 36800  | 1.5                                            | .5    | GORMLEY3                                     | 68 ASPK                   | 6/68  |
| A | 10709  | .3                                             | 1.1   | MULLER                                       | 69 DSPK                   | 9/69  |
| A | 1138   | -1.4                                           | 3.    | CARPENTR                                     | 70 HBC                    | 6/70  |
| A | 349    | 3.2                                            | 5.4   | DANBURG                                      | 70 DBC                    | 2/71  |
| A | L 220K | -0.05                                          | 0.22  | LAYER                                        | 72 ASPK                   | 8/72* |
| A | L      | ALSO REPORTS SEXTANT AND QUADRANT ASYMMETRIES. |       |                                              |                           |       |
| A | AVG    | 0.24                                           | 0.40  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0) |                           |       |
|   |        |                                                |       | (SEE IDEOGRAM BELOW)                         |                           |       |

WEIGHTED AVERAGE = 0.24 ± 0.40  
ERROR SCALED BY 2.0

H. Yutä and S. Okubo [Phys. Rev. Letters **21**, 781 (1968)] have pointed out that an asymmetry in the decay  $\eta \rightarrow \pi^+ \pi^- \pi^0$  of about 2% need not imply a breakdown of C invariance, since an asymmetry of this amount could be caused by an interference between the  $\eta$  and the  $3\pi$  background. Gormley et al. [Phys. Rev. Letters **22**, 198 (1969)], however, believe that this effect can account for only  $\leq 0.23\%$  in their experiment (above). Also see: A. Frenkel and G. Vesztegombi, "C-Violation in  $\eta$ -Decay," Nucl. Phys. **B15**, 429 (1970) and K. Taggart, "Asymmetry and Background in  $\eta \rightarrow 3\pi$ ," Phys. Rev. D **2**, 1960 (1970).

| B |                                                                        | DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA |      | (UNITS 10**=-2)                              |         |       |
|---|------------------------------------------------------------------------|---------------------------------------------|------|----------------------------------------------|---------|-------|
| B | 33                                                                     | -2.                                         | 17.  | CRAWFORD                                     | 66 HBC  | 11/66 |
| B |                                                                        | .4.                                         | 8.   | LITCHFIELD                                   | 67 DBC  | 8/67  |
| B | N 1620                                                                 | 1.5                                         | 2.5  | MULLER                                       | 69 DSPK | 9/69  |
| B | N ABOVE EXPERIMENT IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM |                                             |      |                                              |         |       |
| B | 7257                                                                   | 1.22                                        | 1.36 | GORMLEY                                      | 70 ASPK | 6/70  |
| B | 36K                                                                    | 0.5                                         | 0.6  | THALER1                                      | 72 ASPK | 8/72* |
| B | AVG                                                                    | 0.61                                        | 0.54 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |         |       |

## REFERENCES FOR ETA

|           |    |            |     |     |                                                |                                                |
|-----------|----|------------|-----|-----|------------------------------------------------|------------------------------------------------|
| PEVSNER   | 61 | PRL        | 7   | 421 | PEVSNER, KRAEMER, NUSSBAUM, RICHARDSON + (JHU) |                                                |
| ALFF      | 62 | PRL        | 9   | 322 | ALFF, BERLEY, COLLEY, BRUGGER + (COLU+RUTGERS) |                                                |
| BASTIEN   | 62 | PRL        | 8   | 114 | BASTIEN, BERGE, DAHL, FERRO-LUZZI + (LRL)      |                                                |
| CHRETIEN  | 62 | PRL        | 9   | 127 | CHRETIEN + (BRAN+BRONN+HARVARD+MIT+PAOIVA)     |                                                |
| PICKUP    | 62 | PRL        | 8   | 329 | E PICKUP, ROBINSON, SALANT (CNRC+BNL)          |                                                |
| SHAFFER   | 62 | CERN CONF  | 307 |     | J SHAFFER, FERRO-LUZZI, MURRAY + (UCB+LRL)     |                                                |
| BACCI     | 63 | PRL        | 11  | 37  | BACCI, PENSO, SALVINI + (ROMA+FRAS)            |                                                |
| BUSCHBECK | 63 | SIENA CONF | 1   | 166 | BUSCHBECK-CZAPP, COOPER + (VIENNA, CERN, AMST) |                                                |
| CRAWFORD  | 63 | PRL        | 10  | 546 | F S CRAWFORD, LLOYD-FOWLER (LRL+DUKE)          |                                                |
| ALSO      | 66 | PRL        | 16  | 907 | F S CRAWFORD, LLOYD-FOWLER (LRL+DUKE)          |                                                |
| DELICOURT | 63 | PL         | 7   | 215 | DELICOURT, LEFRANCOIS, PEREZ Y JORBA+ (ORSAY)  |                                                |
| MULLER    | 63 | SIENA CONF | 99  |     | MULLER, PAULI + (SACL+ROMA)                    |                                                |
| FOELSCHKE | 64 | PR         | 134 | 8   | 1138                                           | H M FOELSCHKE, H L KRAYBILL (YALE)             |
| KRAEMER   | 64 | PR         | 136 | 8   | 496                                            | KRAEMER, MADANSKY, FIELDS + (JHU+WES+MODO)     |
| PAULI     | 64 | PL         | 13  | 351 | E PAULI, A MULLER (SACLAY)                     |                                                |
| FOSTER1   | 65 | PR         | 138 | B   | 652                                            | FOSTER, PETERS, MEER, LOEFFLER + (WISC+PURDUE) |
| FOSTER2   | 65 | ATHENS     |     |     |                                                | FOSTER, GOOD, MEER (WISCONSIN)                 |

## Stable Particles

 $\eta$ , p, n

FOSTER3 65 THESIS  
PRICE 65 PRL 15 123  
RITTENBE 65 PRL 15 556

ALFF-STE 66 PR 145 1072  
BALTAY 66 PRL 16 1224  
CRAWFORD 66 PRL 16 333  
DIGIUGNO 66 PRL 16 767  
GROSSMAN 66 PR 146 993  
GRUNHAUS 66 THESIS  
JAMES 66 PR 142 896  
JONES 66 PL 23 597  
WAHLIG 66 PRL 17 221

M.C.FOSTER  
L.R.PRICE,F.S.CRAWFORD  
RITTENBERG,KALBFLEISCH

(WISCONSIN)  
(LRL)  
(LRL+BNL)

BAGLIN1 67 PL 248 637  
BAGLIN2 67 BAPS 12 567  
BALTAY1 67 PRL 19 1495  
BALTAY2 67 PRL 19 1498  
BENPORAD 67 PL 258 380  
ALSO PRIVATE COMMUNICATION  
BILLING 67 PL 258 435  
BONAMY 67 HEIDELBERG CONF.  
BUNIATOV 67 PL 258 560  
CENCE 67 PRL 19 1393  
FELDMAN 67 PRL 18 868  
FLATTE 67 PRL 18 976  
FLATTE2 67 PR 163 1441  
LITCHFIELD 67 PL 248 486  
PRICE 67 PRL 18 1207

BAGLIN, BEZAGUET, DEGRANGE, + (EPOL+UCB)  
BAGLIN, BEZAGUET, DEGRANGE, + (EPOL+UCB)  
BALTAY, FRANZINI, KIM, NEWMAN+ (COLU+STON)  
BALTAY, FRANZINI, KIM, NEWMAN+ (COLU+STON)  
BENPORAD, BRACCI, FIDA, LUBELSMY+ (PISA, BONN)  
BILLING, BULLOCK, ESTEN, GOVAN, + (LOUC, OXF)  
BONAMY, SONDEREGGER (SACLAY)  
BUNIATOV, ZAVATTINI, DEINET, + (CERN+KARL)  
CENCE, PETERSON, STENGER, CHIU+ (HAWAII+LRL)  
FELDMAN, FRATI, GLEESON, HALPERN, + (PENNY)  
S.M. FLATTE (LRL)  
S.M. FLATTE AND C.G. WOLFF (LRL)  
LITCHFIELD, RANGAN, SEGAR, SMITH+ (RHEL+SACLAY)  
L.R. PRICE, F.S. CRAWFORD (LRL)

ARNOLD 68 PL 278 466  
BAZIN 68 GOSMAN, ZACHER, + (EPOL, MADR, STRB)  
BULLOCK 68 PL 278 402  
WEHMANN 68 PRL 20 748

\*PATY, BAGLIN, BINGHAM+ (STRB+MADR+EPOL+UCB)  
BAZIN, GOSMAN, ZACHER, + (EPOL, MADR, STRB)  
\*ESTEN, FLEMING, GOVAN, HENDERSON, OWEN+ (LOUC)  
WEHMANN, ENGELS, + (HARV+CASE+SLAC+CORN+MGI)

BAGLIN 69 PL 298 445  
BAZIN 69 PL 298 445  
HYAMS 69 PL 298 128  
JACQUET 69 NC 58 743

BAGLIN, BEZAGUET, + (EPOL, UCB, MADR, STRB)  
\*BAZIN, BEZAGUET, DEGRANGE, MUSSET + (EPOL, MADR, STRB)  
HYAMS, KOCH, POTTER, VON LINDERN, + (CERN, MPIM)  
JACQUET, NGUYEN-KHAC, HAUTUFT+ (EPOL, BERG)

BUTTRAM 70 PRL 25 1358  
COX 70 PRL 24 534  
DEVONS 70 PR D1 936  
GORMLEY 70 PR D2 501  
ALSO 70 NEVIS 1811 THESIS  
KANDFSKY 70 NC 68 413  
SCHMITT 70 PL 328 638

\*KREISLER, MISCHKE (PRIN)  
COX, FORTNEY, GOLSON (DUKE)  
\*GRUNHAUS, KOZLOWSKI, NEMETHY + (COLU, SYR)  
GORMLEY, HYMAN, LEE, NASH, PEOPLES+ (COLU+BNL)  
MICHAEL GORMLEY (COLU)  
A. KANDFSKY (LEHI)  
\*BUNIATOV, ZAVATTINI, DEINET+ (CERN, KARL)

BASILE 71 NC 34 796  
STRUGALS 71 NP 827 429  
AGUILAR 72 PR D6 29  
BLOODWORTH 72 NP 839 525

\*BOLLINI, DALPIAZ, FRABETTI+ (CERN, BGN, STRB)  
\*CHUVILO, GEMESY, IVANDOVSKAYA+ (JINR)  
AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
BLOODWORTH, JACKSON, PRENTICE, YOON (TORONTO)

## QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN 62 PRL 8 114  
CARMONY 62 PRL 8 117  
ROSENFEL 62 PRL 8 293

BASTIEN, BERGE, DAHL, FERRO-LUZZI, MILLER+ (LRL)  
CARMONY, A. ROSENFELD, VAN DE WALLE (LRL)  
A. ROSENFELD, D. CARMONY, VAN DE WALLE (LRL)

## REFERENCES ON ETA ASYMMETRY PARAMETERS

BALTAY 66 PRL 16 1224  
CNOPS 66 PL 22 546  
CRAWFORD 66 PRL 16 333  
CLPHY 66 PR 149 1044  
LARRIBE 66 PL 23 600

BALTAY, FRANZINI, KIM, KIRSCH+ (COLU+STON)  
CNOPS, FINOCCHIARO, LASSALLE, (CERN, ETHZ, SACL)  
F.S. CRAWFORD, L.R. PRICE (LRL)  
COLUMBIA, LRL, PURDUE, WISCONSIN, YALE  
LARRIBE, LEVEQUE, MULLER, PAULI, + (SACL+RHEL)

BOWEN 67 PL 248 206  
LITCHFIELD 67 PL 248 486  
GORMLEY2 68 PRL 21 402  
MULLER 69 THESIS  
CARPENTER 70 PR D1 1303  
DANBURG 70 PR D2 2564  
LAYTER 72 PRL 29 316  
THALER1 72 PRL 29 313  
THALER2 72 NEVIS 194(THESIS) JON J THALER

BOWEN, CNOPS, FINOCCHIARO, + (CERN+ETHZ+SACL)  
LITCHFIELD, RANGAN, SEGAR, SMITH+ (RHEL+SACLAY)  
GORMLEY, HYMAN, LEE, NASH, PEOPLES+ (COLU+BNL)  
BRAND MULLER (STRB)  
CARPENTER, BINKLEY, CHAPMAN, COX, DAGAN+ (DUKE)  
\*ABOLINS, DAHL, DAVIES, HOCH, KIRZ, + (LRL)  
\*APPEL, KOTLEWSKI, LEE, STEIN, THALER (COLU)  
\*APPEL, KOTLEWSKI, LAYTER, LEE, STEIN (COLU)  
JON J THALER (COLU)

p

## 16 PROTON (938, J=1/2) I=1/2

## 16 PROTON MASS (MEV)

M (938.256) (0.005) COHEN 65 RVUE 7/66  
938.2592 .0052 TAYLOR 69 RVUE 7/70 USING NEW E/H

16 PROTON MEAN LIFE (UNITS 10<sup>-26</sup> YR)

T (1.000001) OR MORE GOLDHABE 54 TH 232 FISS. MODE INDEPEN  
T (0.002) OR MORE FLEROV 57 TH 232 FISS. MODE INDEPEN  
T B (1.5) OR MORE BACKENSTOSS 60 CNTR  
T B (160.0) OR MORE KROPP 65 CNTR  
T (200.0) OR MORE GURR 67 CNTR DEP. ON DECAY MODE  
T B KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROT

## 16 PROTON MAGNET. MOMENT (E/2MP)

NM (2.792763 (0.000030) COHEN 65 RVUE 7/70  
2.792782 .000017 TAYLOR 69 RVUE USING NEW E/H

## 16 ANTIPROTON MAGNETIC MOMENT (E/2MP)

NM1 -2.83 0.10 FOX 72 11/72

16 PROTON ELECTRIC DIPOLE MOMENT (UNITS 10<sup>-23</sup> E CM)  
NONZERO VALUE IMPLIES VIOLATION OF T AND P IN EM INTERACTION

EDM 16 700. 900. HARRISON 69 MBR 10/69

## Data Card Listings.

For notation, see key at front of Listings.

## REFERENCES FOR PROTON

GOLDHABE 54 PR 96 1157 FN02E GOLDHABER, F. REINES+ (LOS ALAMOS, BNL)  
FLEROV 57 SOV PHYS DOK 3 79 FLEROV, KLOCHKOV, SKOBKIN, TERENTEV (USSR)  
BACKENST 60 NC 16 749 BACKENSTOSS, FRAUENFELDER, HYAMS + (CERN)  
COHEN 65 RMP 37 537 \*DUMOND (N.AMER. AVIATION SCIENCE CENT., CIT)  
KROPP 65 PR 137 B 740 M R KROPP, F. REINES (CASE INST TECHNOLOGY)  
GURR 67 PR 158 1321 GURR, KROPP, REINES, NEVER (CASE, JOHANNESBURG)  
HARRISON 69 PRL 22 1263 HARRISON, SANDARS, WRIGHT (CLARENDON OXFORD)  
TAYLOR 69 RMP 41 375 \*PARKER, LANGENBERG (PRIN+UCI+PENN)  
FOX 72 PRL 29 193 FOX, BARNES, EISENSTEIN+ (CARN+VPI+WILL+WMYON)

n

## 17 NEUTRON (939, J=1/2) I=1/2

## 17 NEUTRON MASS (MEV)

M T 939.5527 .0052 TAYLOR 69 RVUE USING NEW E/H 7/70  
M T TAYLOR DETERMINATION OF NEUTRON MASS NOT INDEPENDENT OF 7/70  
M T NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW. 7/70

## 17 (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D M 1.29344 0.00007 MATTAUCH 65 RVUE 3/71  
D M WE HAVE CONVERTED MATTAUCH NEUTRON-PROTON MASS DIFFERENCE TO 3/71  
D M AND A HYDROGEN BINDING ENERGY OF 13.6 EV. 3/71

## 17 NEUTRON MAGNETIC MOMENT (MAGNETONS, 938.2 MEV)

NM -1.913148 0.000066 COHEN 56 RVUE 7/66

17 NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10<sup>-23</sup> E CM)  
TEST OF C VIOLATION IN THE EM INTERACTION

EDM (5.) OR LESS BAIRD 69 MBR 10/69

17 NEUTRON MEAN LIFE (UNITS 10<sup>-3</sup> SEC)

THE MEASUREMENT OF THE NEUTRON MEAN LIFE BY SOSNOVSKII 59 HAS BEEN DISCARDED SINCE 1. IT DISAGREES WITH THE BETTER AND MORE RECENT RESULT OF CHRISTENSEN 67. 2. THE VALUE OF GA/GV OBTAINED FROM THE NEW VALUE OF THE MEAN LIFE AGREES WELL WITH THE GA/GV VALUE OBTAINED FROM THE FREE NEUTRON DATA.

T (1.012) (0.021) SOSNOVSKI 59 PILE SEE NOTE E 7/68  
T (0.935) (0.014) CHRISTENS 67 PILE REPL BY CHRISTENS72 3/68  
T 0.918 0.014 CHRISTENS 72 PILE 6/72  
E ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION  
E IN GOLD HAS BEEN REDUCED.

## 17 NEUTRON BETA DECAY COUPLING CONSTANTS

## RELATED TEXT SECTION IV H.1

AV GA/GV (SEE TEXT FOR SIGN CONVENTION)  
AV C (-1.250) (0.044) CONFORTO 67 RVUE SEE NOTE C BELOW  
AV EP (-1.23) (0.01) CHRISTENS 67 CNTR N DECAY FT VALUE 11/68  
AV P (-1.22) (0.08) GRIGOREV 68 CNTR E-NEU ANG CORREL 10/71  
AV P (-1.26) (0.02) CHRISTENS 70 CNTR PE-NEUT SPIN CORREL 10/71  
AV EP (-1.27) (0.025) EROZOLIM 71 CNTR PE-NEUT SPIN CORREL 10/71  
AV EP (-1.250) (0.011) CHRISTENS 72 CNTR N DEC. FT VALUE 1/73  
AV P (-1.263) (0.016) KROPP 73 RVUE N DECAY ALONE 1/73  
AV P -1.248 0.010 KROPP 73 RVUE N DEC. FT VALUE 1/73  
AV C CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967. REPL. BY KROPP 73. 1/73  
AV E THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY 10/71  
AV P KROPP 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972. 1/73

F PHASE ANGLE OF GA RELATIVE TO GV (DEGREES)  
F C (176.1) (6.4) CONFORTO 67 RVUE POLAR. NEUTRON 11/68  
F P (181.3) (1.3) EROZOLIM 70 CNTR N DECAY 10/69  
F C CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967. REPL. BY KROPP 73. 1/73  
F P KROPP 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972. 1/73

## REFERENCES FOR NEUTRON

COHEN 56 PR 104 283 V W COHEN, CORNGOLD, RAMSEY (BNL+HARVARD)  
SOSNOVSKI 59 JETP 9 717 SOSNOVSKII, SPIVAK, PROKOFEV + (IAE MOSCOW)  
MATTAUCH 65 NP 67 1 \*THIELE, HAPSTRA (MAX PLANCK INST. CHEM.)  
CHRISTEN 67 PL 268 11 CHRISTENSEN, NIELSEN, BAHNSEN, BROWN+ (RISO)  
CONFORTO 67 APAM 22 15 G. CONFORTO (CERN)  
GRIGOREV 68 SJNP 6 239 \*GRISHIN, VLADIMIRSKII, NIKOLAEVSKII + (ITEP)

BAIRD 69 PR 179 1285 \*MILLER, DRESS, RAMSEY (ORNL+HARV)  
TAYLOR 69 RMP 41 375 \*PARKER, LANGENBERG (PRIN+UCI+PENN)  
CHRISTEN 70 PR C1 1693 CHRISTENSEN, KROHN, RINGO (ANL)  
EROLZIM 70 SJNP 11 583 EROZOLIMSKI, BONDARENKO, + (KURC MOSCOW)  
ALSO PL 278 557 EROZOLIMSKI, BONDARENKO + (KURC MOSCOW)  
EROLZIM 71 JETPL 13 252 EROZOLIMSKI, BONDARENKO + (KURC MOSCOW)  
CHRISTEN 72 PR D5 1628 CHRISTENSEN, NIELSEN, BAHNSEN, BROWN+ (RISO)  
KROPP 73 SUBM. TO NP A A KROPP, H PAUL (LINZ)  
ALSO 70 NP A154 160 H PAUL (WIEN)

## PAPERS NOT REFERRED TO IN DATA CARDS

JACKSON 57 PR 106 517 JACKSON, TREIMAN, WYLD (PRINCETON)  
COHEN 65 RMP 37 537 \*DUMOND (N.AMER. AVIATION SCIENCE CENT., CIT)  
BHALLA 66 PL 19 691 C P BHALLA (ALABAMA)

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

A

A

18 LAMBDA (1115,JP=1/2+) I=0

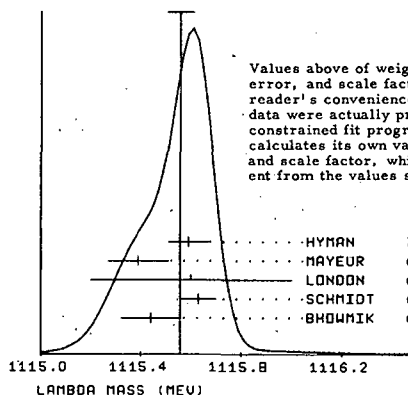
18 LAMBDA MASS (MEV)

M N SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM  
 M N DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,  
 M N WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER  
 M N THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.  
 M N SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD  
 M N IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES  
 M N DEPENDING ON PROTON AND PION RANGES.

M L 1115.44 0.12 BHOWMIK 63 RVUE + SEE NOTE L BELOW  
 M L ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV  
 M L INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.  
 M S 635(1115.86) (0.09) BALTAY 65 HBC ERROR IS STATIS. 6/66  
 M 488 1115.63 0.07 SCHMIDT 65 HBC SEE NOTE N 6/68  
 M S 1147(1115.74) (0.04) CHIEN 66 HBC 6.9 PBAR P 9/67  
 M S 972(1115.69) (0.05) CHIEN 66 HBC 6.9 PBAR PANTIL 9/67  
 M 1115.6 0.4 LONDON 66 HBC 6/66  
 M (1116.0) (0.2) BADIER 67 HBC 2.4 PBAR P,LLBAR 8/67  
 M 195 1115.39 0.12 MAYEUR 67 EMUL 11/67  
 M B 1524(1115.52) (0.03) BOHM 70 EMUL 3/72  
 M 935 1115.59 0.08 HYMAN 72 HBC 11/71  
 M B AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY. AUTHORS  
 M B DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRIBUTE  
 M B TO ERROR IN RANGE-ENERGY RELATIONS, IN REGION BETA=0.6-0.7.  
 M B THIS EFFECT, IF CONFIRMED, WOULD AFFECT VERY LITTLE THE VALUES OF  
 M B BHOWMIK 63 AND MAYEUR 67.  
 M S ERROR PURELY STATISTICAL. 3/72

M AVG 1115.558 0.052 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)  
 M FIT 1115.592 0.046 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) 1/73\*

WEIGHTED AVERAGE = 1115.558 ± 0.052  
 ERROR SCALED BY 1.2



Values above of weighted average,  
 error, and scale factor are for the  
 reader's convenience only. The  
 data were actually processed by a  
 constrained fit program, which  
 calculates its own values of  $\bar{x}$ ,  $\delta\bar{x}$ ,  
 and scale factor, which are differ-  
 ent from the values shown here.

CHI-SQ

.....HYMAN 72 HBC 0.2  
 .....MAYEUR 67 EMUL 2.0  
 .....LONDON 66 HBC  
 .....SCHMIDT 65 HBC 1.1  
 .....BHOWMIK 63 RVUE 1.0  
 (CONLEV = 0.246)

DM 0.05 18 LAMBDA - ANTILAMBDA MASS DIFFERENCE (MEV)  
 DM 0.29 0.06 CHIEN 66 HBC 6.9 PBAR P 9/67  
 DM 0.15 0.07 BADIER 67 HBC 2.4 PBAR P 8/67  
 DM AVG 0.083 0.083 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

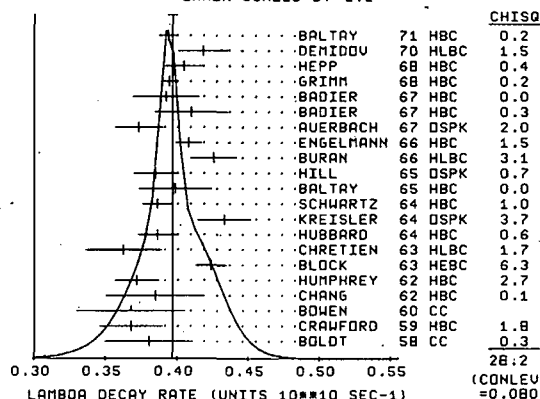
18 LAMBDA MEAN LIFE (UNITS 10<sup>-10</sup>)

T 188 2.63 0.21 0.21 BOLDT 58 CC  
 T 825 2.72 0.14 0.16 CRAWFORD 59 HBC  
 T 140 2.72 0.29 0.27 BOHEN 60 CC  
 T 186 2.60 0.28 0.20 CHANG 62 HBC  
 T 799 2.69 0.11 0.11 HUMPHREY 62 HBC  
 T 2239 2.36 0.06 0.06 BLOCK 63 HBC  
 T 706 2.76 0.20 0.06 CHRETIEN 63 HBC  
 T 794 2.59 0.09 HUBBARD 64 HBC  
 T 2260 2.31 0.10 KREISLER 64 OSPK  
 T 1378 2.59 0.07 SCHWARTZ 64 HBC  
 T 635 2.51 0.16 BALTAY 65 HBC 6/66  
 T 2534 2.6 0.1 HILL 65 OSPK 6/66  
 T 916 2.35 0.09 BURAN 66 HBC  
 T S 1147 (2.50) (0.14) CHIEN 66 HBC 6.9 PBAR P 9/67  
 T S 972 (2.70) (0.20) CHIEN 66 HBC 6.9 PBAR P,ANTI 9/67  
 T 2213 2.452 0.056 0.054 ENGELMANN 66 HBC 9/66  
 T 585 2.68 0.15 0.11 AUERBACH 67 OSPK 8/67  
 T 2.44 0.15 BADIER 67 HBC 2.4 PBAR P 6/68  
 T 2.55 0.15 BADIER 67 HBC 2.4 PBAR P,ANTIL 6/68  
 T 8342 2.535 0.035 GRIMM 68 HBC 6/68  
 T 2600 2.47 0.08 HEPP 68 HBC 8/68  
 T 1059 2.39 0.10 DEMITOV 70 HLBC PI-P, 3.86 GEV/C 12/70  
 T 4572 2.54 0.04 BALDIT 71 HBC K-P AT REST 6/71  
 T S ERROR PURELY STATISTICAL.  
 T AVG 2.521 0.021 0.021 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.2)  
 (SEE IDEOGRAM BELOW)

18 ((LAMBDA) - (ANTI-LAMBDA))/AVG., MEAN LIFE DIFFERENCE

DT 0.044 0.085 BADIER 67 HBC 2.4 PBAR P 8/67

WEIGHTED AVERAGE = 0.3967 ± 0.0033  
 ERROR SCALED BY 1.2



CHI-SQ

.....BALTAY 71 HBC 0.2  
 .....DEMIDOV 70 HLBC 1.5  
 .....HEPP 68 HBC 0.4  
 .....GRIMM 68 HBC 0.2  
 .....BADIER 67 HBC 0.0  
 .....BADIER 67 HBC 0.3  
 .....AUERBACH 67 OSPK 2.0  
 .....ENGELMANN 66 HBC 1.5  
 .....BURAN 66 HLBC 3.1  
 .....HILL 65 OSPK 0.7  
 .....BALTAY 65 HBC 0.0  
 .....SCHWARTZ 64 HBC 1.0  
 .....KREISLER 64 OSPK 3.7  
 .....HUBBARD 64 HBC 0.6  
 .....CHRETIEN 63 HLBC 1.7  
 .....BLOCK 63 HBC 6.3  
 .....HUMPHREY 62 HBC 2.7  
 .....CHANG 62 HBC 0.1  
 .....BOHEN 60 CC  
 .....CRAWFORD 59 HBC 1.8  
 .....BOLDT 58 CC 0.3  
 28.2  
 (CONLEV = 0.080)

18 LAMBDA MAGNETIC MOMENT (MAGNETONS, 938.26 MEV)

MM -1.5 0.5 COOL 62 OSPK  
 MM 0.0 0.6 KERNAN 63 CC  
 MM 8553 -1.39 0.72 ANDERSON 64 HBC  
 MM 151 -0.5 0.28 CHARRIERE 65 EMUL  
 MM 49 -0.67 0.31 SAROKY 71 EMUL PRELIM. RESULT 2/72  
 MM -1300 -0.66 0.07 DAHLJENSE 71 EMUL MAG FIELD=200KG 6/71  
 MM 3868 -0.73 0.18 HILL 71 OSPK 10/71  
 MM AVG -0.672 0.061 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

18 LAMBDA ELECTRIC DIPOLE MOMENT (UNITS 10<sup>-14</sup> E CM)

NONZERO VALUE IMPLIES VIOLATION OF T AND P  
 EDM 5.0 OR LESS CL=95 GIBSON 66 EMUL 2/72  
 EDM B 1.0 OR LESS CL=95 BARONI 71 EMUL 2/72  
 EDM B BARONI MEASURES (-5.9+-2.9)\*10<sup>-15</sup> E CM 2/72

18 LAMBDA PARTIAL DECAY MODES

DECAY MASSES  
 P1 LAMBDA INTO PROTON PI- 938+ 139  
 P2 LAMBDA INTO NEUTRON P0 939+ 134  
 P3 LAMBDA INTO PROTON MU- NEUTRINO 938+ 105+ 0  
 P4 LAMBDA INTO PROTON E- NEUTRINO 938+ 5+ 0  
 P5 LAMBDA INTO PROTON PI- GAMMA 938+ 139+ 0

18 LAMBDA BRANCHING RATIOS

R1 LAMBDA INTO (P PI-)/(P PI-)+(N P0) (P1)/(P1+P2)  
 R1 0.627 0.031 CRAWFORD 59 HBC  
 R1 0.65 0.05 COLUMBIA 60 HBC  
 R1 U (0.685) (0.017) ANDERSON 62 HBC  
 R1 903 0.643 0.016 HUMPHREY 62 HBC  
 R1 U 4736 0.635 0.007 DOYLE 69 HBC PI-P TO LAM. KO 2/71  
 R1 4572 0.646 0.008 BALTAY 71 HBC K-P AT REST 6/71  
 R1 U ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE. 2/71  
 R1 AVG 0.6399 0.0049 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R1 FIT 0.6419 0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R2 LAMBDA INTO (N P0)/(P PI-)+(N P0) (P2)/(P1+P2)  
 R2 0.23 0.09 EISLER 57 HLBC  
 R2 0.43 0.14 CRAWFORD 59 HBC  
 R2 0.28 0.08 BAGLIN 60 HLBC  
 R2 0.35 0.05 BROWN 63 HBC  
 R2 75 0.291 0.034 CHRETIEN 63 HLBC  
 R2 AVG 0.304 0.025 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R2 FIT 0.3581 0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R3 LAMBDA INTO (P E- NEU)/TOTAL (UNITS 10<sup>-4</sup>) (P4)/(P1+P2)  
 R3 O 15 (2.0) (0.5) HUMPHREY 62 RVUE  
 R3 O 8 (2.9) (1.5) AUBERT 62 FBC  
 R3 N 150 (0.82) (0.12) ELY 63 FBC K- AT REST  
 R3 N 102 (0.78) (0.12) (0.13) BAGLIN 64 FBC K- AT 1.45 GEV/C  
 R3 O 20 (1.55) (0.34) LIND 64 HBC  
 R3 N 143 (0.80) (0.08) MALONEY 69 HBC  
 R3 N 86 (0.78) (0.09) CANTER 71 HBC K-P AT REST 4/71  
 R3 N 218 (0.88) (0.10) LINDQUIST 71 OSPK PI- P TO KO LAM 2/72  
 R3 N THESE VALUES HAVE BEEN CHANGED BY US INTO RATIOS TO PROTON PI-, 3/72  
 R3 N BECAUSE THAT IS THE DIRECTLY MEASURED QUANTITY. SEE R5 BELOW 3/72  
 R3 O LOW STATISTICS EXPERIMENTS. NOT AVERAGED. 7/70  
 R4 LAMBDA INTO (P MU- NEU)/TOTAL (UNITS 10<sup>-4</sup>) (P3)/(P1+P2)  
 R4 1 (0.2) OR MORE GOOD 62 HBC  
 R4 1 (1.0) OR LESS ALSTON 63 HBC  
 R4 2 (1.0) OR LESS KERNAN 64 FBC  
 R4 BETWEEN 1.3 AND 6.0 LIND 64 HBC  
 R4 3 1.3 0.7 LIND 64 RVUE 7/66  
 R4 2 1.5 1.2 RONNE 64 FBC  
 R4 9 2.4 0.8 CANTER 71 HBC STOPPED K-P 7/71  
 R4 14 1.4 0.5 BAGGETT 72 HBC STOP K- 8/72  
 R4 AVG 1.57 0.35 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

## Stable Particles

 $\Lambda$ ,  $\Sigma^+$ 

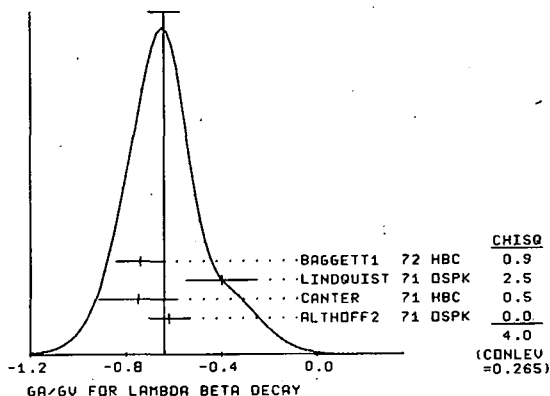
|    |                                                                       |                                              |
|----|-----------------------------------------------------------------------|----------------------------------------------|
| R5 | LAMBDA INTO (P E- NEU)/(P P1-) (UNITS 10 <sup>-3</sup> ) (P4)/(P1)    |                                              |
| R5 | 150 1.23 0.20                                                         | ELY 63 FBC 2/72                              |
| R5 | 120 1.17 0.18                                                         | BAGLIN 64 FBC 2/72                           |
| R5 | 143 1.20 0.12                                                         | MALONEY 69 HBC 2/72                          |
| R5 | 1078 1.31 0.06                                                        | ALTHOFF2 71 OSPK 2/72                        |
| R5 | C 86 1.17 0.13                                                        | CANTER 71 HBC K-P AT REST 3/72               |
| R5 | C 218 1.32 0.15                                                       | LINDQUIST 71 OSPK P1-P TO K0 LAM 3/72        |
| R5 | C CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P P1-)/TOT=2/3  | 3/72                                         |
| R5 | AVG 1.267 0.044                                                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| R6 | LAMBDA INTO (P P1- GAMMA)/(P P1-) (UNITS 10 <sup>-3</sup> ) (P5)/(P1) | 1/73                                         |
| R6 | 72 1.32 0.22                                                          | BAGGETT3 72 HBC P1- MOM LT 95 MEV/C 1/73     |

## 18 LAMBDA DECAY PARAMETERS

## RELATED TEXT SECTION IV H AND APPENDIX III

|    |                                                                   |                                                 |
|----|-------------------------------------------------------------------|-------------------------------------------------|
| A- | ALPHA LAMBDA- (LAMBDA INTO P1- PROTON)                            |                                                 |
| A- | 1156 0.62 0.07                                                    | CROBIN 63 CNTR LAMBDA FROM P1-P 8/67            |
| A- | (0.663) (0.022)                                                   | BERGE 66 RVUE INCLUDES ABOVE 9/66               |
| A- | 10130 0.645 0.017                                                 | OVERSETH 67 OSPK LAMBDA FROM P1-P 8/67          |
| A- | M 2529 (0.747) (0.086)                                            | MERRILL 68 HBC REPL BY DAUBER 68 6/68           |
| A- | 3520 0.67 0.06                                                    | DAUBER 69 HBC FROM XI DECAY 6/68                |
| A- | 10325 0.649 0.023                                                 | CLELAND 72 OSPK LAMBDA FROM P1-P 5/72           |
| A- | AVG 0.647 0.013                                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |
| AO | ALPHA- /ALPHA- FOR LAMBDA (L INTO P10 N/L INTO P1- P)             |                                                 |
| AO | 1.10 0.27                                                         | CORK 60 CNT 5/70                                |
| AO | 4760 1.000 0.068                                                  | OLSEN 70 OSPK P1-N TO K+ LAMBDA 5/70            |
| AO | AVG 1.006 0.066                                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |
| AO | DONE BY COMPARING PROTON DISTR. WITH N DISTR. FROM LAMBDA DECAY.  |                                                 |
| F- | PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)                |                                                 |
| F- | 1156 13.0 17.0                                                    | CROBIN 63 OSPK LAMBDA FROM P1-P 11/67           |
| F- | 10130 -8.0 6.0                                                    | OVERSETH 67 OSPK LAMBDA FROM P1-P 11/67         |
| F- | 7377 (-9.2) (5.2)                                                 | CLELAND 67 OSPK REPL BY CLELAND 72 5/72         |
| F- | 10325 -7.0 4.5                                                    | CLELAND 72 OSPK LAMBDA FROM P1-P 5/72           |
| F- | AVG -6.5 3.5                                                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |
| AV | GA/GV FOR LAMBDA BETA DECAY (SEE TEXT SEC. IV H.1 FOR SIGN CONV.) |                                                 |
| AV | C 22 (-1.03)                                                      | LIND 64 HBC 6/68                                |
| AV | C 102 (0.6) OR MORE                                               | BAGLIN 65 HLBC NO SIGN GIVEN 1/71               |
| AV | C BETH 0. AND -1.1                                                | BARLOW 65 OSPK 6/68                             |
| AV | C 102 (0.7) OR MORE CL=95                                         | ELY 65 HLBC ABS. VALUE 1/71                     |
| AV | M 148 -0.72 0.14                                                  | CONFORTO 65 RVUE 11/67                          |
| AV | M 1078 -0.62 0.08                                                 | 0.09 ALTHOFF2 71 OSPK POLARIZED LAMBDAS 2/72    |
| AV | M 141 -0.75 0.15                                                  | 0.18 CANTER 71 HBC 4/71                         |
| AV | L 173 (-0.32) (0.13)                                              | (0.17) LINDQUIST 71 OSPK UP-DOWN ASYMMETRY 9/71 |
| AV | ML 173 (-0.68) (0.27)                                             | (0.54) LINDQUIST 71 OSPK E-NEU CORRELATION 9/71 |
| AV | L 173 -0.40 0.13                                                  | 0.17 LINDQUIST 71 OSPK E-NEU AND UP-DOWN 9/71   |
| AV | M 352 -0.74 0.09                                                  | 0.12 BAGGETT1 72 HBC STOP-K- 2/72               |
| AV | C EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE                       | 6/68                                            |
| AV | M EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V                    |                                                 |
| AV | A USES E AND PROTON UP-DOWN ASYM. AND E-NEU CORRELATIONS          | 2/72                                            |
| AV | L LINDQUIST 71 GETS THREE VALUES. WE AVERAGE THE ONE THAT USES    | 10/71                                           |
| AV | L ALL DATA.                                                       | 10/71                                           |
| AV | AVG -0.665 0.063                                                  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)    |
| AV | (SEE IDEOGRAM BELOW)                                              |                                                 |

WEIGHTED AVERAGE = -0.639 ± 0.065  
ERROR SCALED BY 1.1



## REFERENCES FOR LAMBDA

|                 |        |                                              |
|-----------------|--------|----------------------------------------------|
| EISLER 57 NC    | 5 1700 | EISLER, PLAND, SAMIOS, SCHWARTZ + (COLU+BNL) |
| BOLDT 58 PRL    | 1 146  | E BOLDT, O CALDWELL, Y PAL (MIT)             |
| CRAWFORD 59 PRL | 2 268  | CRAWFORD, CRESTI, DOUGLASS, GOOD + (LRL)     |

## Data Card Listings

For notation, see key at front of Listings.

|                                      |                   |                                                 |
|--------------------------------------|-------------------|-------------------------------------------------|
| BAGLIN 60 NC                         | 18 1043           | BAGLIN, BLOCH, BRISSON, HENNESSY + (EPOL)       |
| BOWEN 60 PR                          | 119 2030          | BOWEN, HADY, REYNOLDS, SUN + (PRINCETON)        |
| CORK 60 PR                           | 120 1000          | CORK, KERTH, MENZEL, CRONIN + (LRL+PRIN+BNL)    |
| COLUMBIA 60 ROCH                     | CONF 726          | M SCHWARTZ + (COLUMBIA)                         |
| HUMPHREY 61 PRL                      | 6 478             | HUMPHREY, KIRZ, ROSENFELD, RHEE + (LRL+SYRA)    |
| ANDERSON 62 CERN                     | CONF 832          | ANDERSON, CRAWFORD, GOLDEN, LLOYD + (LRL)       |
| AUBERT 62 NC                         | 25 479            | AUBERT, BRISSON, HENNESSY, SIX + (EPOL)         |
| CHANG 62 THESIS                      | DUKE              | CHUEN CHUEN CHANG (DUKE)                        |
| COOL 62 PR                           | 127 2223          | COOL, HILL, MARSHALL + (BNL+MIT+NYU+ANL)        |
| GOOD 62 PRL                          | 9 518             | M L GOOD, V G LIND (WISCONSIN)                  |
| HUMPHREY 62 PR                       | 127 1305          | M E HUMPHREY, R R ROSS (LRL)                    |
| ALSTON 63 UCRL                       | 10926             | ALSTON, KIRZ, NEUFELD, SOLMITZ, WOHLMUT (LRL)   |
| BHOWMIK 63 NC                        | 28 1494           | B BHOWMIK, D P GOYAL (DELHI)                    |
| BLOCK 63 PR                          | 130 766           | BLOCK, GESSAROLI, RATTI + (INMS+BGNA+SYRA+ORNL) |
| BROWN 63 PR                          | 130 769           | BROWN, KADYK, TRILLING, ROE + (LRL+MICH)        |
| CHRETIEN 63 PR                       | 131 2208          | CHRETIEN, CROUCH + (BRAN+BROWN+HARVARD+MIT)     |
| CRONIN 63 PR                         | 129 1795          | J M CRONIN, O E OVERSETH (PRINCETON)            |
| ELY 63 PR                            | 131 868           | ELY, GIDAL, KALMUS, OSWALD, POWELL + (LRL)      |
| KERNAN 63 PR                         | 129 870           | KERNAN, NOVEY, WARSHAW, WATTENBERG (ANL+ILL)    |
| ANDERSON 64 PRL                      | 13 167            | J A ANDERSON, F S CRAWFORD (LRL)                |
| BAGLIN 64 NC                         | 35 977            | BAGLIN, BINGHAM + (EPOL+CERN+LOUC+RHEL+BERG)    |
| HUBBARD 64 PR                        | 135 B 183         | HUBBARD, BERGE, KALBFLEISCH, SHAFER + (LRL)     |
| KERNAN 64 PR                         | 133 B 1271        | KERNAN, POWELL, SANDLER (LRL+LOUC)              |
| KREISLER 64 PR                       | 135 B 1074        | M W KREISLER, WEINSTEIN, J CRONIN (PRIN)        |
| LIND 64 PL                           | 11 357            | LIND, BINFORD, GOOD, STERN (WISCONSIN)          |
| RONNE 64 PL                          | 11 357            | RONNE + (CERN+EPOL+LOUC+UNIV. BERGEN)           |
| SCHWARTZ 64 UCRL                     | 11360 THESIS      | JOSEPH ADAM SCHWARTZ (LRL)                      |
| BAGLIN 65 NC                         | 35 977            | BAGLIN + (EPOL, CERN, LOUC, RHEL, BERGEN)       |
| BALTAY 65 PR                         | 140 B 1027        | BALTAY, SANDWEISS, CULWICK, KOPP + (YALE+BNL)   |
| BARLOW 65 PL                         | 18 64             | J BARLOW, BLAIR, CONFORTO + (CERN+RHEL+PENNY)   |
| CHARRIERE 65 PL                      | 15 66             | CHARRIERE, GIBSON + (EPOL+BRIS+CERN+PRIN)       |
| CONFORTO 65                          | CONF 205          | CHARRIERE, GIBSON + (EPOL, BRIS, CERN, PRIN)    |
| CONFORTO 65                          | CONF 205          | CONFORTO (CERN)                                 |
| ELY 65 PR                            | 137 81302         | ELY, GIDAL, KALMUS, POWELL + (LRL, LOUC)        |
| HILL 65 PRL                          | 15 85             | HILL, LI, JENKINS, KYCIA, RUDERMAN (MIT, BNL)   |
| SCHMIDT 65 PR                        | 140 B 1328        | P SCHMIDT (COLUMBIA)                            |
| BERGE 66 BERKELEY                    | 46                | BERGE, CABIBBO (RVUE) LRL, CERN                 |
| BURAN 66 PL                          | 20 318            | BURAN, EIVINDSON, SKJEGGESTAD, TOFT + (OSLO)    |
| CHEN 66 PR                           | 152 1171          | +LACH, SANDWEISS, TAFT, YEH, OREN + (YALE+BNL)  |
| ENGELMANN 66 NC                      | 45A 1038          | ENGELMANN, FILTHUTH, ALEXANDER + (HEID, REHO)   |
| GIBSON 66 NC                         | 45A 882           | M GIBSON, K GREEN (BRIS)                        |
| LONDON 66 PR                         | 143 1034          | LONDON, RAU, GOLDBERG, LICHTMAN + (BNL, SYRA)   |
| AUERBACH 67 NC                       | 47A 19            | AUERBACH, BOWEN, DOBBS, LANDE, MANN + (PENN)    |
| BADIER 67 PL                         | 258 152           | +BONNET, BRIANDET, SADOULET (EPOL)              |
| CLELAND 67 PL                        | 268 45            | CLELAND, BIELEIN, CONFORTO + (CERN+GEVA+LUND)   |
| HAYEUR 67 U                          | 118B, BRUX, BUL32 | C-HAYEUR, E, TOMPA, J, WICKENS (BELG, LOUC)     |
| OVERSETH 67 PRL                      | 19 391            | O E OVERSETH, R F ROTH (MICH+PRIN)              |
| GRIMM 68 NC                          | 54A 187           | H-J, GRIMM (HEIDELBERG)                         |
| HEPP 68 ZPHY                         | 214 71            | V. HEPP, H. SCHLEICH (HEIDELBERG)               |
| MERRILL 68 PR                        | 167 1202          | MERRILL, SHAFER (LRL)                           |
| DAUBER 69 PR                         | 179 1262          | +BERGE, HUBBARD, MERRILL, MILLER (LRL)          |
| DOYLE 69 UCRL                        | 18139-THESIS      | J. C. DOYLE (UNIV MARYLAND)                     |
| MALONEY 69 PRL                       | 23 425            | MALONEY, SECHI-ZORN (MIT, BNL)                  |
| BOHM 70 NC                           | 70A 384           | +KRECKER + (BERL+BRUX+DUUC+LOUC+LOUC+WARS)      |
| DEHIOV 70 SJNP                       | 10 681            | +KIRILOV, UGRYUMOV, PONOSOV, PROTASOV + (ITEP)  |
| OLSEN 70 PRL                         | 24 843            | +PONDROM, HANDLER, LIMON, SMITH + (WISC, MICH)  |
| ALTHOFF1 71 PL                       | 378 531           | +BROWN, FREYTAG, HEARD, HEINTZE + (CERN, HEID)  |
| ALTHOFF2 71 PL                       | 378 535           | +BROWN, FREYTAG, HEARD, HEINTZE + (CERN, HEID)  |
| BALTAY 71 PR                         | DA 670            | +BRIDGEWATER, COOPER, HABI BI + (COLU+BING)     |
| GARKOV 71 JETPL                      | 14 60             | +GUREVICH, MAKARINA, MARTEMYANOV + (ITEP)       |
| BARONI 71 LNC                        | 2 1256            | G BARONI, S PETRERA, G ROMANO (ROMA)            |
| CANTER 71 PRL                        | 26 868            | +COLE, LEE-FRANZINI, LOVELESS + (STON+COLU)     |
| CANTER1 71 PRL                       | 27 59             | +COLE, LEE-FRANZINI, LOVELESS + (STON+COLU)     |
| DAHLIENS 71 NC                       | 3A 1              | DAHL-JENSEN + (CERN+ANKA+LAUS+MPI+ROMA)         |
| HILL 71 PR                           | DA 1979           | +LI, JENKINS, KYCIA, RUDERMAN (MIT, BNL)        |
| ALSO 65 PRL                          | 15 85             | HILL, LI, JENKINS, KYCIA, RUDERMAN (MIT, BNL)   |
| LINDQUIST 71 PRL                     | 27 612            | LINDQUIST, ST, SUMNE + (EFI, MUSL, OSU, ANL)    |
| BAGGETT1 72 ZPHY                     | 249 279           | +BAGGETT, EISELE, FILTHUTH, FREHSE + (HEID)     |
| BAGGETT2 72 ZPHY                     | 252 362           | +BAGGETT, EISELE, FILTHUTH, FREHSE + (HEID)     |
| BAGGETT3 72 PL                       | 428 379           | +BAGGETT, EISELE, FILTHUTH, FREHSE, HEPP (HEID) |
| CLELAND 72 NP                        | 840 221           | +CONFORTO, EATON, GERBER + (CERN+GEVA+LUND)     |
| HYMAN 72 PR                          | DS 1063           | +BUNNELL, DERRICK, FIELDS, KATZ + (ANL+CERN)    |
| PAPERS NOT REFERRED TO IN DATA CARDS |                   |                                                 |
| ARMENTER 62 CERN                     | CONF 236          | ARMENTEROS + (CERN+EPOL+LOIC+BIRM+CEN-SACLAY)   |
| BALTAY 62 CERN                       | CONF 233          | BALTAY, FOWLER, SANDWEISS, CULWICK + (YALE+BNL) |
| BERGE 63 THESIS                      | (BERKELEY)        | J PETER BERGE (LRL)                             |

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19 SIGMA+ (1189, JP=1/2+) I=1

19 SIGMA+ MASS (MEV)

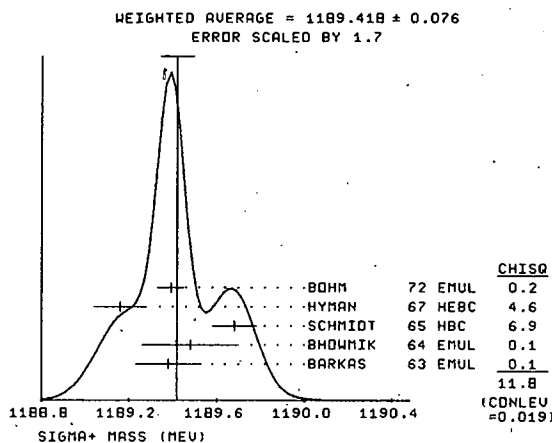
## M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

|   |                                                                   |       |                                               |
|---|-------------------------------------------------------------------|-------|-----------------------------------------------|
| M | 144 1189.38                                                       | 0.15  | BARKAS 63 EMUL + SEE NOTE 5 BELOW             |
| M | 58 1189.40                                                        | 0.22  | BHOWMIK 64 EMUL + SEE NOTE 5 BELOW            |
| S | ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30 KEV TO ACCOUNT FOR 46 KEV |       |                                               |
| M | 4205 1189.68                                                      | 0.10  | SCHMIDT 65 HBC SEE NOTE N 6/68                |
| M | 1189.16                                                           | 0.12  | HYMAN 67 HBC 6/68                             |
| M | 607 1189.39                                                       | 0.06  | BOHM 72 EMUL 1/73                             |
| M | AVG 1189.418                                                      | 0.076 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)  |
| M | FIT 1189.406                                                      | 0.068 | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |
|   |                                                                   |       | (SEE IDEOGRAM BELOW)                          |

## Data Card Listings

*For notation, see key at front of Listings.*

## Stable Particles

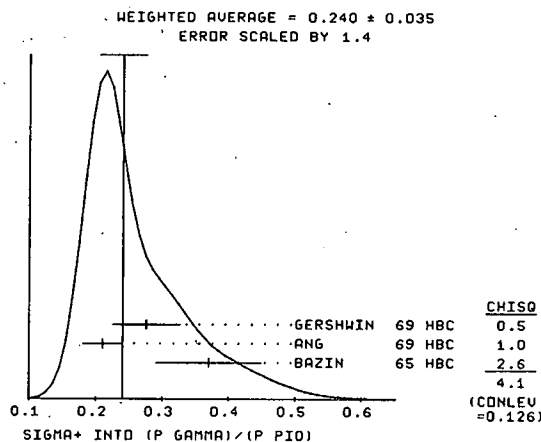
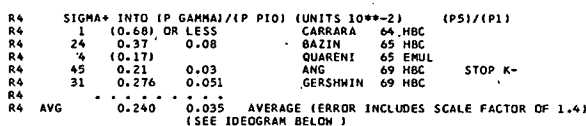
 $\Sigma^+$ 

| 19 SIGMA+ MEAN LIFE (UNITS 10**10) |                                                                      |        |        |        |                                           |    |      |                   |       |
|------------------------------------|----------------------------------------------------------------------|--------|--------|--------|-------------------------------------------|----|------|-------------------|-------|
| T                                  |                                                                      |        |        |        | GLASER                                    | 58 | RVUE |                   |       |
| T                                  | 127                                                                  | 0.98   | 0.16   | 0.12   | PUSCHEL                                   | 60 | EMUL |                   |       |
| T                                  | 0.82                                                                 | 0.34   | 0.20   | 0.20   | EVANS                                     | 60 | EMUL |                   |       |
| T                                  | 117                                                                  | 0.85   | 0.14   | 0.11   | FREDEN                                    | 60 | EMUL |                   |       |
| T                                  | 54                                                                   | 0.80   | 0.10   | 0.067  | KAPLON                                    | 60 | EMUL |                   |       |
| T                                  | 23                                                                   | 0.76   | 0.22   | 0.14   | CHIESA                                    | 61 | EMUL |                   |       |
| T                                  | 0.75                                                                 | 0.13   | 0.09   | 0.09   | BERTHELOT                                 | 61 | HLBC |                   |       |
| T                                  | 140                                                                  | 0.82   | 0.10   | 0.08   | BARKAS                                    | 61 | EMUL |                   |       |
| T                                  | 192                                                                  | 0.749  | 0.056  | 0.052  | GRARD                                     | 62 | HBC  |                   |       |
| T                                  | 456                                                                  | 0.765  | 0.04   | 0.04   | HUMPHREY                                  | 62 | HBC  |                   |       |
| T                                  | 0.84                                                                 | 0.20   | 0.12   | 0.08   | BHOWMIK                                   | 62 | EMUL |                   |       |
| T                                  | 181                                                                  | 0.84   | 0.09   |        | BALTAY                                    | 65 | HBC  |                   | 6/66  |
| T                                  | 900                                                                  | 0.76   | 0.03   |        | CARAYAN                                   | 65 | HBC  |                   | 6/66  |
| T                                  | 1300                                                                 | 0.83   | 0.032  |        | CHANG                                     | 66 | HBC  |                   | 6/66  |
| T                                  | S 125                                                                | (0.61) | (0.15) |        | CHISH                                     | 66 | HBC  | + 6.9 PBAR P      | 9/67  |
| T                                  | S 117                                                                | (1.10) | (0.24) |        | CHIEN                                     | 66 | HBC  | + 6.9 PBAR P,ANTI | 9/67  |
| T                                  | 381                                                                  | 0.80   | 0.07   |        | COOK                                      | 66 | OSPK |                   | 7/66  |
| T                                  | 10664                                                                | 0.803  | 0.008  |        | KARLOUTAU                                 | 69 | HBC  | K-P 4-1.2 GEV/C   | 11/69 |
| T                                  | 0.795                                                                | 0.04   | 0.04   |        | LEGLE                                     | 70 | RELE | K-P 4-1.2 GEV/C   | 2/70  |
| T                                  | 526                                                                  | 0.83   | 0.04   |        | BARKER                                    | 71 | DBC  | K-N TO SIG 2P1-   | 10/71 |
| T                                  | C CHANG ERROR 0.018 RAISED BY US. SE 1970 EDITION, RMP 42, 123(1970) |        |        |        |                                           |    |      |                   |       |
| T                                  | S ERROR PURELY STATISTICAL                                           |        |        |        |                                           |    |      |                   |       |
| T                                  | Y                                                                    |        |        |        |                                           |    |      |                   |       |
| T                                  | AVG                                                                  | 0.8004 | 0.0058 | 0.0057 | AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0) |    |      |                   |       |

| 19 SIGMA* MAGNETIC MOMENT (MAGNETONS, 938.26 MEV) |       |      |      |                                              |    |      |                  |       |  |
|---------------------------------------------------|-------|------|------|----------------------------------------------|----|------|------------------|-------|--|
| MM                                                | 381   | 1.5  | 1.1  | COOK                                         | 66 | OSP  |                  | 7/66  |  |
| MM                                                | 52    | 3.5  | 1.5  | KOTELCHUC                                    | 67 | EMUL | K-P AT 1.15BEV/C | 8/67  |  |
| MM                                                | 51    | 3.0  |      | SULLIVAN                                     | 68 | EMUL | PHOTOGRAPHIC     | 8/67  |  |
| MM                                                | 69    | 3.5  | 1.2  | COMBE                                        | 68 | EMUL |                  | 10/68 |  |
| MM                                                | 29333 | 2.1  | 1.0  | MAST                                         | 68 | HBC  | K-P AT .4 GEV/C  | 6/68  |  |
| MM                                                | 955   | 2.67 | 0.97 | ALLEY                                        | 71 | OSP  | 1.28 GEV/C P1+P  | 10/70 |  |
| MM                                                |       |      |      |                                              |    |      |                  |       |  |
| MM                                                | AVG   | 2.59 | 0.46 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |    |      |                  |       |  |

| 19. SIGMA+ PARTIAL DECAY MODES |        |                           |      | DECAY MASSES |   |
|--------------------------------|--------|---------------------------|------|--------------|---|
| P1                             | SIGMA+ | INTO PROTON P10           | 938  | + 134        |   |
| P2                             | SIGMA+ | INTO NEUTRON P1+          | 939  | + 139        |   |
| P3                             | SIGMA+ | INTO NEUTRON P1+ GAMMA    | 939  | + 139        | 0 |
| P4                             | SIGMA+ | INTO LAMBDA 0             | 1115 | + 5          | 0 |
| P5                             | SIGMA+ | INTO PROTON GAMMA         | 938  | + 0          |   |
| P6                             | SIGMA+ | INTO NEUTRON MU+ NEUTRINO | 938  | + 105        | 0 |
| P7                             | SIGMA+ | INTO SIGMA+ NEUTRINO      | 938  | + 5          | 0 |
| P8                             | SIGMA+ | INTO PROTON E+ E-         | 938  | + 5          | 2 |

| 19 SIGMA+ BRANCHING RATIOS |                                                  |                                                 |        |                         |              |                      |         |           |       |       |
|----------------------------|--------------------------------------------------|-------------------------------------------------|--------|-------------------------|--------------|----------------------|---------|-----------|-------|-------|
| R1                         | SIGMA+ INTO (NEUTRON P1+)/(NUCLEON P1)           |                                                 |        |                         | (P2)/(P1+P2) |                      |         |           |       |       |
| R1                         | 308                                              | 0.490                                           | 0.024  | HUMPHREY                |              | 62 HBC               |         |           |       |       |
| R1                         | 534                                              | 0.46                                            | 0.02   | CHANG                   |              | 66 HBC               |         |           |       |       |
| R1                         | 1331                                             | 0.488                                           | 0.10   | BART OUTAU              |              | 69 HBC               | K-P     | 4.-1.2    | GEV/C | 11/69 |
| R1                         | 537                                              | 0.484                                           | 0.015  | TOVEE                   |              | 71 EMUL              | 12/71   |           |       |       |
| R1                         |                                                  |                                                 |        |                         |              |                      |         |           |       |       |
| R1                         | AVG                                              | 0.4835                                          | 0.0073 | AVERAGE (ERROR INCLUDES |              | SCALE FACTOR OF 1.0) |         |           |       |       |
|                            |                                                  |                                                 |        |                         |              |                      |         |           |       |       |
| R2                         | SIGMA+ INTO (NEUT P1 GAM)/(P1+NU) (UNITS 10**+3) |                                                 |        |                         | (P3)/(P2)    |                      |         |           |       |       |
| R2                         |                                                  | (1.8)                                           | ABOUT  | BAZING                  |              | 65 HBC               | P1+ L   | 116 MEV/C | 8/67  |       |
| R2                         | 29                                               | 0.27                                            | 0.05   | ANG                     |              | 69 HBC               | P1+ L   | 110 MEV/C | 11/68 |       |
|                            |                                                  |                                                 |        |                         |              |                      |         |           |       |       |
| R3                         | SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNITS 10**+5) |                                                 |        |                         | (P4)         |                      |         |           |       |       |
| R3                         | W                                                | 4                                               | (3.3)  | (1.7)                   |              | WILLIS               | 64 HBC  | STOP K-   |       |       |
| R3                         | W                                                | EVENTS FROM THIS EXPERIMENT, INCLUDED IN EISELE |        |                         |              | 69                   | 11/69   |           |       |       |
| R3                         | 6                                                | 2.0                                             | 0.8    | BARASH                  |              | 67 HBC               | STOP K- |           |       |       |
| R3                         | 5                                                | 1.6                                             | 0.7    | BALTAI                  |              | 69 HBC               | STOP K- |           |       |       |
| R3                         | 10                                               | 2.9                                             | 1.0    | EISELE                  |              | 69 HBC               | STOP K- |           |       |       |
| R3                         |                                                  |                                                 |        |                         |              |                      |         |           |       |       |
| R3                         | AVG                                              | 2.02                                            | 0.47   | AVERAGE (ERROR INCLUDES |              | SCALE FACTOR OF 1.0) |         |           |       |       |



|       |                                                                   |                                        |                             |                    |                 |       |
|-------|-------------------------------------------------------------------|----------------------------------------|-----------------------------|--------------------|-----------------|-------|
| R5    | SIGMA+ INTO IN E+ NEU/(IN P+)                                     | (UNITS 10**5-5)                        | (P71/P22)                   |                    |                 |       |
| R5 E  | 0                                                                 | 16220 EFFECTIVE DENOM.                 | COURANT                     | 64 HBC SEE NOTE E  | 11/67           |       |
| R5 E  | 0                                                                 | 2720 EFFECTIVE DENOM.                  | MURPHY                      | 64 HBC SEE NOTE E  | 11/67           |       |
| R5 E  | 1                                                                 | 9690 EFFECTIVE DENOM.                  | NAUENBERG                   | 64 HBC SEE NOTE E  | 6/68            |       |
| R5    | 0                                                                 | (32406) EFFECTIVE DENOM.               | BIERMAN                     | 68 HBC             | 6/68            |       |
| R5 UA | 0                                                                 | (10400) EFFECTIVE DENOM.               | EISELEZ                     | 69 HBC + STOP K-   | 6/68            |       |
| R5 U  | 1                                                                 | 30000 EFFECTIVE DENOM.                 | NORTON                      | 69 HBC             | 11/69           |       |
| R5 U  | 0                                                                 | 110200 EFFECTIVE DENOM.                | EBENHOH                     | 70 HBC STOP K-     | 12/70           |       |
| R5 E  |                                                                   | EFFECTIVE DENOM. CALCULATED BY US      |                             |                    |                 |       |
| R5 A  |                                                                   | EFFECTIVE DENOM. TAKEN FROM EISELEZ 67 |                             |                    | 11/67           |       |
| R5    |                                                                   | EISELEZ 69 REPLACED BY EBENHOH 70      |                             |                    |                 |       |
| R5    | 4.0                                                               | 2.0 OR LESS CL=90                      | OUR AVERAGE USING ALL ABOVE |                    | 12/70           |       |
| R5    |                                                                   | NUMBER OF EVENTS INCREASED TO 4.0      | FOR 90PC CONFIDENCE LEVEL   |                    | 2/71            |       |
| R6    | SIGMA+ INTO IN MU+ NEU/(PI+N)                                     | (UNITS 10**5-5)                        | (P61/P22)                   |                    |                 |       |
| R6    | 1                                                                 | (120) ANALYSED EVENTS                  | GALTIERI                    | 62 EMUL            | NO RATIO QUOTED | 11/67 |
| R6 E  | 0                                                                 | 10150 EFFECTIVE DENOM.                 | COURANT                     | 64 HBC SEE NOTE E  | 11/67           |       |
| R6 E  | 0                                                                 | 1710 EFFECTIVE DENOM.                  | NAUENBERG                   | 64 HBC SEE NOTE E  | 11/67           |       |
| R6    | 2                                                                 | 62000 EFFECTIVE DENOM.                 | EISELEZ                     | 69 HBC             | 11/67           |       |
| R6 E  | 0                                                                 | 33800 EFFECTIVE DENOM.                 | BAGGETT                     | 69 HBC             | 11/68           |       |
| R6    |                                                                   | EFFECTIVE DENOM.                       | TAKEN FROM EISELEZ 67       |                    | 11/67           |       |
| R6    | 5.3                                                               | 2.0 OR LESS CL=90                      | OUR AVERAGE USING ALL ABOVE |                    | 11/69           |       |
| R6    |                                                                   | NUMBER OF EVENTS INCREASED TO 5.3      | FOR 90PC CONFIDENCE LEVEL   |                    | 2/71            |       |
| R7    |                                                                   | SEE NOTES ACCOMPANYING R5              |                             |                    |                 |       |
| R7    | (SIGMA+ INTO LEPTONS)/(SIGMA- INTO LEPTONS)                       |                                        |                             |                    |                 |       |
| R7    | 0                                                                 | 0.034 OR LESS                          | BAGGETT                     | 67 HBC             | 6/68            |       |
| R7    | 1                                                                 | 0.08 OR LESS                           | NORTON                      | 69 HBC             | 10/69           |       |
| R7    | 6.7                                                               | 0.035 OR LESS CL=90                    | OUR AVERAGE USING R5 AND R6 |                    | 2/71            |       |
| R7    |                                                                   | NUMBER OF EVENTS INCREASED TO 6.7      | FOR 90PC CONFIDENCE LEVEL   |                    | 2/71            |       |
| R8    | SIGMA+ INTO (PROTON E+ E-)/TOTAL                                  | (UNITS 10**6-6)                        | (P8)                        |                    |                 |       |
| R8    | 7.0                                                               | OR LESS                                | ANG                         | 69 HBC STOP K-     | 10/69           |       |
| R8 A  | ANG 69 FOUND 3 E+ E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF |                                        |                             |                    |                 |       |
| R8 A  | PROTON GAMMA DECAY - LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT      |                                        |                             |                    |                 |       |
| R9    | (SIGMA+ INTO N MU+ NEU)/(SIGMA- INTO N MU- NEU)                   |                                        |                             |                    |                 |       |
| R9    | 2                                                                 | 0.06 0.045 0.03                        | EISELEZ                     | 69 HBC +--         | STOP K-         | 10/69 |
| R9    | 5.3                                                               | 0.095 OR LESS CL=90                    | OUR AVERAGE USING R6        |                    | 2/71            |       |
| R9    |                                                                   | NUMBER OF EVENTS INCREASED TO 5.3      | FOR 90PC CONFIDENCE LEVEL   |                    | 2/71            |       |
| R10   | (SIGMA+ INTO N+ NEU)/(SIGMA- INTO N- NEU)                         |                                        |                             |                    |                 |       |
| R10 E | 0                                                                 | (0.03) OR LESS CL=90                   | EBENHOH                     | 70 HBC +-- STOP K- | 10/69           |       |
| R10   | 0                                                                 | 0.019 OR LESS CL=90                    | EBENHOH                     | 70 HBC STOP K-     | 12/70           |       |
| R10   | 0                                                                 | 0.12 OR LESS CL=95                     | COLE                        | 71 HBC STOP K-     | 10/71           |       |
| R10 E |                                                                   | EISELEZ REPLACED BY EBENHOH 70         |                             |                    |                 |       |
| R10   | 4.0                                                               | 0.014 OR LESS CL=90                    | OUR AVERAGE USING R5        |                    | 2/71            |       |
| R10   |                                                                   | NUMBER OF EVENTS INCREASED TO 4.0      | FOR 90PC CONFIDENCE LEVEL   |                    | 2/71            |       |

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      19 SIGMA+ DECAY PARAMETERS

      RELATED TEXT SECTION IV H AND APPENDIX III

      ALPHA+ALPHA0 FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PI0 P)
A+0      +0.04      0.11      CORK      60 CNTR      SIG+ FROM PI+P
A+0      (+.20)      (0.49)      TRIPP      62 HBC + REPLAC BY BANGER
A+0 0 3500      (-.014)      (0.052)      BANGERTER      66 HBC + SIG+ FROM K-P      9/66
A+0 0 2600      (-.047)      (.07)      BERLEY      66 HBC + SIG+ FROM K-P      9/66
A+0 0      OLD RESULTS HAVE BEEN REPLACED . SEE BELOW -

A+      ALPHA SIGMA+ (SIG+ TO PI+ N)
A+      35000      0.069      0.017      BANGERTER      69 HBC      K-P AT 400 MEV/C      11/69
A+      4101      0.037      0.049      BERLEY      70 HBC      12/70
A+      * * *
A+      .066      .016      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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## Stable Particles

 $\Sigma^+$ ,  $\Sigma^-$ 

## Data Card Listings

For notation, see key at front of Listings.

AO ALPHA SIGMA<sup>+</sup> (SIG<sup>+</sup> INTO P10 PROTON) 62 CNTR  
 AO -0.80 0.16 BEALL 62 HBC REPLAC. BY BANGE  
 AO (-0.901) (0.25) TRIPP 62 HBC K-P TO SIG<sup>+</sup> P1- 7/66  
 AO 5200 (-0.986) (0.072) BANGERTER 66 HBC NEUTRON RESCATT. 10/69  
 AO 32000 -0.999 0.022 BANGERTER 69 HBC  
 AO H 1335 -0.98 0.05 0.02 HARRIS 70 OSPK P1+P TO SIG<sup>+</sup> K+ 5/70  
 AO H 16K -0.940 0.045 BELLAMY 72 ASPK P1+P TO SIG<sup>+</sup> K+ 11/72\*  
 AO H DECAY PROTONS SCATTERED OFF CARBON  
 AO AVG -0.984 0.017 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 F+ PHI+ ANGLE (SIG<sup>+</sup> INTO N P1) SIN(PHI1)/COS(PHI1)=BETA/GAMMA (DEGREE)  
 F+ 0 370 (180.) (30.) BERLEY 66 HBC + NEUTRON RESCATT. 9/66  
 F+ 560 143. 29. BANGERTER 69 HBC  
 F+ C1054 184. 24. BERLEY 70 HBC K-P AT 400 MEV/C 11/69  
 F+ C CHANGED FROM 176 TO 184 TO AGREE WITH SIGN CONVENTION.  
 F+ AVG 167.3 20.1 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

AG ALPHA SIGMA<sup>+</sup> (SIG<sup>+</sup> INTO PROTON GAMMA)  
 AG 61 -1.03 0.52 0.42 GERSHWIN 69 HBC K-P TO SIG PI 11/69  
 FO H PHIO ANGLE (SIG<sup>+</sup> INTO P10 PROTON) SIN(PHI1)/COS(PHI1)=BETA/GAMMA (DEG)  
 FO H 22. 70.0 HARRIS 70 OSPK P1+P TO SIG<sup>+</sup> K+ 5/70  
 FO H DECAY PROTONS SCATTERED OFF CARBON.

REFERENCES FOR SIGMA<sup>+</sup>

CORK 60 PR 120 1000 CORK, KERTH, WENZEL, CRONIN, COOL (LRL+PRIN+BNL)  
 EVANS 60 NC 15 873 BRIST+BRUSS+IAS-U. COL-DUBLIN+LON+MILAN+PAD  
 FREDEN 60 NC 16 611 S FREDEN, H KORNBUM, R WHITE (LRL)  
 KAPLOW 60 ANP 9 139 N KAPLOW, A MELLISINDS, YAMAGUCHI (RUCOL)  
 PUSCHEL 60 NP 20 254 M PUSCHEL (MAX PLANCK INST)  
 BARKAS 61 PR 124 1209 BARKAS, DYER, MASON, NICHOLS, SMITH (LRL)  
 BERTHELO 61 NC 21 693 BERTHELO, DAUDIN, GOUSSU + (SACLAY+ORSAY)  
 CHIESA 61 NC 19 1171 CHIESA, QUASSTATTI, RINAUDO (INFN-TURIN)  
 BEALL 62 PRL 8 75 BEALL, CORK, KEEFE, MURPHY, WENZEL (LRL)  
 GRARD 62 PR 127 607 F GRARD, G A SMITH (LRL)  
 GALTIERI 62 PRL 9 26 GALTIERI, BARKAS, HECKMAN, PATRICK, SMITH (LRL)  
 HUMPHREY 62 PR 127 1305 W E HUMPHREY, R ROSS (LRL)  
 TRIPP 62 PRL 9 66 R D TRIPP, M B WATSON, M FERRO-LUZZI (LRL)  
 BARKAS 63 PRL 11 26 H H BARKAS, J N DYER, H H HECKMANN (LRL)  
 ALSO 61 UCRL 9450 JOHN DYER (THEISIS, BERKELEY) (LRL)  
 BHOWMIK 64 NP 53 22 B BHOWMIK, P JAIN, P MATHUR, LAKSHMI (DELHI)  
 CARRARA 64 PL 12 72 CARRARA, CRESTI, GRIGOLETTO, PERUZZO (PADOVA)  
 COURANT 64 PR 136 8 1791 COURANT, FILTHUTH\* (CERN+HEID+UMD+BNL+BNL)  
 MURPHY 64 PR 134 8 188 C THORNTON, MURPHY (WISCONSIN)  
 NAUENBERG 64 PRL 12 679 NAUENBERG, KARATECK\* (COLU+RUTG+PRIN)  
 WILLIS 64 PRL 13 291 WILLIS, COURANT, ENGELMANN\* (BNL, CERN, HEID, UMD)  
 BALTAY 65 PR 140 8 1027 BALTAY, SANDWEISS, CULWICK, KOPP + (YALE+BNL)  
 BAZIN 65 PR 140 8 1358 BAZIN, BLUMENFELD, NAUENBERG + (PRIN+COLU)  
 BAZIN 65 PR 140 8 1358 BAZIN, PLANO, SCHMIDT\* (PRIN, RUTG, COLU)  
 CARAYAN 65 PR 138 8 433 CARAYANNOPOULOS, TAUFEST, WILLMANN (PURDUE)  
 QUARENI 65 NC 40 928 QUARENI, CARTACCI + (BGNA, FIRZ, GENO, PARMA)  
 SCHMIDT 65 PR 140 8 1328 P SCHMIDT (COLUMBIA)  
 BANGERTER 66 PRL 17 495 BANGERTER, GALTIERI, BERGE, MURRAY\* (LRL)  
 BERLEY 66 PRL 17 1071 +HERZBACH, KOFLER, YAMAMOTO + (BNL+MASA+YALE)  
 CHANG 66 PR 151 1081 CHUNG YUN CHANG (COLUMBIA)  
 ALSO 65 NEVIS 145 THESIS CHUNG YUN CHANG (COLUMBIA)  
 CHEN 66 PRL 152 1171 +LACH, SANDWEISS, TAFT, YEH, OREN + (YALE+BNL)  
 COOK 66 PRL 17 223 V COOK, EWART, HASKER, ORR, PLATNER (WASHINGTON)  
 BAGGETT 67 PRL 19 1458 BAGGETT, DAY, GLASSER, KEHOE, KNOP\* (MARYLAND)  
 ALSO 68 VIENNA ABS. 374 BAGGETT, KEHOE (MARYLAND)  
 ALSO 68 PRIVATE COMM. N. BAGGETT (MARYLAND)  
 BARASH 67 PRL 19 181 BARASH, DAY, GLASSER, KEHOE, KNOP + (MARYLAND)  
 EISELE 67 ZPHYS 205 409 +ENGELMANN, FILTHUTH, FOLISH, HEPP\* (HEID)  
 NYHAN 67 PL 25 8 376 +LOKEN, PENNITT, MCKENZIE\* + (ANL+CERN+MEX)  
 KOTELCHUK 67 PRL 18 1164 KOTELCHUK, GOZA, SULLIVAN, ROSS (VANDERBILT)  
 SULLIVAN 67 PRL 18 1163 SULLIVAN, MCINTURFF, KOTELCHUK (VANDERBILT)  
 ALSO 64 PRL 13 246 A D MCINTURFF, C E ROOS (VANDERBILT)  
 BIERMAN 68 PRL 20 1459 BIERMAN, KOLVOSU, NAUENBERG + (PRINCETON)  
 COMBE 68 NC 574 54 CERN-BRISTOL-LAUSANNE-MUNICH-ROME-COLLABOR  
 MAST 68 PRL 20 1312 MAST, GERSHWIN, ALSTON-GARNJOST + (LRL)  
 ANG 69 ZPHYS 228 151 +EBENHOH, EISELE, ENGELMANN, FILTHUTH\* (HEID)  
 BAGGETT 69 NDP-TR-973 H V BAGGETT (THEISIS) (UMD)  
 BALTAY 69 PRL 22 615 BALTAY, FRANZINI, NEWMAN, NORTON\* (COLU+STON)  
 BANGERTER 69 UCRL-19244 ROGER ODELL BANGERTER (THEISIS) (LRL)  
 BANGERTER 69 PR 187 1821 BANGERTER, GARNJOST, GALTIERI, GERSHWIN\* (LRL)  
 BARLOUTAU 69 NP 814 153 BARLOUTAU, BELLEFON, GRANET\* (SACL+CERN+HEID)  
 EISELE 69 ZPHYS 221 171 +ENGELMANN, FILTHUTH, FOHLISCH, HEPP\* (HEID)  
 EISELE 69 ZPHYS 221 401 +ENGELMANN, FILTHUTH, FOHLISCH, HEPP\* (HEID)  
 GERSHWIN 69 PR 188 2077 +ALSTON-GARNJOST, BANGERTER + (LRL)  
 ALSO 69 UCRL 19246 THESIS LAWRENCE K GERSHWIN (COLUMBIA)  
 NORTON 69 NEVIS 175 (THEISIS) HERBERT NORTON (COLUMBIA)  
 BERLEY 70 PR 01 2015 +YAMIN, HERTZBACH, KOFLER + (BNL, MASA, YALE)  
 EBENHOH 70 KIEV CONF +EISELE, ENGELMANN, FILTHUTH, FOHLISCH\* (HEID)  
 ALSO 70 ZPHY 228 151 ANG, EISELE, ENGELMANN, FILTHUTH + (HEID)  
 EISELE 70 ZPHY 238 372 +FILTHUTH, HEPP, PRESSER, ZECH (HEIDELBERG)  
 HARRIS 70 PRL 24 165 +OVERSETH, PONDROM, DETTMANN (MICH, WISC)  
 ALLEY 71 PR 03 75 +BENBROOK, COOK, GLASS, GREEN, HAGUE + (WASH)  
 BAKKER 71 LNC 1 37 +, SABRE COLLAB. (ZEEM+SACL+BGNA+REMO+EPOL)  
 COLE 71 PR 04 631 +LEE-FRANZINI, LOVELESS, BALTAY\* (STON, COLU)  
 TOVEE 71 NP 135 493 LOUC, BELGRADE, BERL, BRUX, DUBLIN, WARS COLLAB  
 BELLAMY 72 PL 398 299 +ANDERSON, CRAWFORD, OSMON\* (LOWC+RHEL+SUSS)  
 BOHM 72 NP 848 1 BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAM

PAPERS NOT REFERRED TO IN DATA CARDS

GLASER 58 CERN CONF 270 GLASER, GOOD, MORRISON (MICH+LRL)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

TRIPP 62 PRL 8 175 R TRIPP, M WATSON, M FERRO-LUZZI (LRL) P  
 ALFF 63 SIENA CONF 1 205 ALFF, NAUENBERG, KIRSCH, + (COLU+RUTG+BNL)  
 ALSO 63 PR 137 8 1105 ALFF, GELFAND, BRUGGER, BERLEY\* (COLU+RUTG+BNL)  
 COURANT 63 SIENA CONF 1 73 COURANT, FILTHUTH, BURNSTEIN, DAY\* (CERN+UMD)

 $\Sigma^-$ 

20 SIGMA- (1198, JP=1/2+) I=1

20 SIGMA- MASS (MEV)

M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M 3000 1197.47 0.11 SCHMIDT 65 HBC SEE NOTE N 6/68  
 M FIT 1197.34 0.07 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) 1/73\*

20 (SIGMA-) - (SIGMA+) MASS DIFFERENCE (MEV)

D 87 8.25 0.40 BARKAS 63 EMUL -  
 D 2500 8.25 0.25 DOSCH 65 HBC  
 D 86 7.91 0.23 BOHM 72 EMUL 1/73\*  
 D AVG 8.09 0.16 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 D FIT 7.94 0.09 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2) 1/73\*

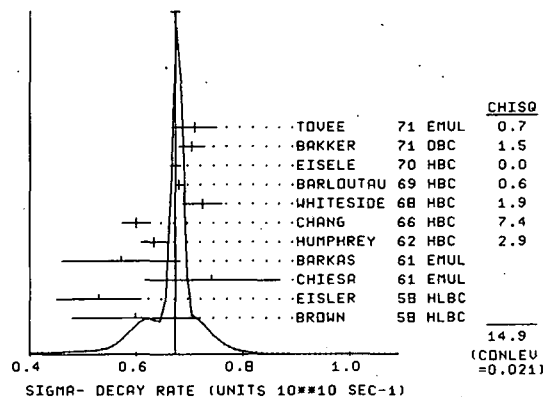
20 (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

DL N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL 85 81.70 0.19 BURNSTEIN 64 HBC SEE NOTE N 9/66  
 DL 2279 81.64 0.09 SCHMIDT 65 HBC 6/68  
 DL 86 81.64 0.09 HEPP 68 HBC 8/68  
 DL AVG 81.666 0.077 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 DL FIT 81.749 0.067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) 1/73\*

20 SIGMA- MEAN LIFE (UNITS 10\*\*=-10)

T 1.67 0.40 0.28 BROWN 58 HLBC  
 T 1.89 0.33 0.25 EISLER 58 HLBC  
 T 45 1.35 0.32 0.17 CHIESA 61 EMUL  
 T 41 1.75 0.39 0.30 BARKAS 61 EMUL  
 T 1208 1.58 0.06 HUMPHREY 62 HBC  
 T C 3267 1.666 0.075 CHANG 66 HBC STOP. K- 1/66  
 T S 61 (2.08) (0.22) CHEN 66 HBC + 6.9 PBAR P 9/67  
 T S 64 (1.46) (0.31) CHEN 66 HBC + 6.9 PBAR P, ANTI 9/67  
 T 506 1.38 0.07 WHITESIDE 68 HBC STOP. K- 6/68  
 T 10253 1.472 0.016 BARLOUTAU 69 HBC K-P -4-1.2 GEV/C 11/69  
 T 1M 1.485 0.022 EISELE 70 HBC K-P AT REST 2/71  
 T 1383 1.42 0.05 BAKER 71 HBC -K-N TO SIG- 2P1 10/71  
 T 1.41 0.09 TOVEE 71 EMUL 12/71  
 T C CHANGE ERROR 0.018 RAISED BY US. SEE 1970 EDITION, RMP 42, 123 (1970) 1/73\*  
 T S ERROR PURELY STATISTICAL.  
 T AVG 1.484 0.019 0.018 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)  
 (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.6738 ± 0.0085  
ERROR SCALED BY 1.6

20 SIGMA- PARTIAL DECAY MODES

P1 SIGMA- INTO NEUTRON P1- DECAY MASSES 939+ 139  
 P2 SIGMA- INTO NEUTRON P1- GAMMA 939+ 139+ 0  
 P3 SIGMA- INTO NEUTRON MU- NEUTRINO 939+ 105+ 0  
 P4 SIGMA- INTO NEUTRON E- NEUTRINO 939+ 15+ 0  
 P5 SIGMA- INTO LAMBDA E- NEUTRINO 1115+ 15+ 0

20 SIGMA- BRANCHING RATIOS

R1 SIGMA- INTO (N MU- NEU) (IN PI-) (UNITS 10\*\*=-3) (P3)/(P1)  
 R1 22 0.66 0.15 COURANT 64 HBC FROM STOP. K- 6/66  
 R1 11 0.56 0.20 BAZIN 65 HBC STOP. K- 10/69  
 R1 56 0.43 0.09 BAGGETT 69 HBC STOP. K- 10/69  
 R1 72 0.43 0.06 ANG 1 69 HBC STOP. K- 10/71  
 R1 13 0.38 0.11 COLE 71 HBC  
 R1 AVG 0.447 0.043 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

 $\Sigma^-$ ,  $\Sigma^0$ 

| R2 | SIGMA- | INTO (N E- NEU)/(N P1-) | (UNITS 10 <sup>-3</sup> ) | (P4)/(P1) |                                              |        |
|----|--------|-------------------------|---------------------------|-----------|----------------------------------------------|--------|
| R2 | 9      | 1.0                     | 0.4                       | 0.3       | MURPHY                                       | 64 HBC |
| R2 | 16     | 1.37                    | 0.34                      |           | NAUENBERG                                    | 64 HBC |
| R2 | 16     | 1.15                    | 0.4                       |           | MILLER                                       | 64 FBC |
| R2 | 31     | 1.4                     | 0.3                       |           | COURANT                                      | 64 HBC |
| R2 | 180    | 1.11                    | 0.09                      |           | BIERMAN                                      | 68 HBC |
| R2 | 2      | (1.11)                  | (0.15)                    |           | SECHIZOR                                     | 68 HBC |
| R2 | A 331  | (1.02)                  | (0.08)                    |           | ANG 1                                        | 69 HBC |
| R2 | 601    | 1.09                    | 0.06                      |           | EDENHOM                                      | 70 HBC |
| R2 | 57     | 0.97                    | 0.15                      |           | COLE                                         | 71 HBC |
| R2 | A      | ANG1                    | REPLACED BY EDENHOM 70.   |           |                                              |        |
| R2 | AVG    | 1.096                   | 0.046                     |           | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |

| R3 | SIGMA- | INTO (LAMBDA E- NEU)/(N P1-) | (UNITS 10 <sup>-3</sup> ) | (P5)/(P1) |                                              |        |
|----|--------|------------------------------|---------------------------|-----------|----------------------------------------------|--------|
| R3 | 11     | 0.75                         | 0.28                      |           | COURANT                                      | 64 HBC |
| R3 | 35     | 0.64                         | 0.12                      |           | BARASH                                       | 67 HBC |
| R3 | 31     | 0.69                         | 0.12                      |           | EISELEI                                      | 69 HBC |
| R3 | 31     | 0.52                         | 0.09                      |           | BALTAY                                       | 69 HBC |
| R3 | AVG    | 0.604                        | 0.060                     |           | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |

| R4 | SIGMA-         | INTO (N P1- GAMMA)/(N P1-) | (UNITS 10 <sup>-3</sup> ) | (P2)/(P1)        |        |            |
|----|----------------|----------------------------|---------------------------|------------------|--------|------------|
| R4 | (1.1)APPROXIM. | BAZIN                      | 65 HBC                    | P1- LT 166 MEV/C | 8/67   |            |
| R4 | 23             | 0.10                       | 0.02                      | ANG 2            | 69 HBC | P1- LT 110 |
| R4 | AVG            |                            |                           |                  | 10/69  |            |

## 20 SIGMA- DECAY PARAMETERS

## RELATED TEXT SECTION IV H AND APPENDIX III

| A- | ALPHA   | SIGMA-       |                       |           |                    |                                              |
|----|---------|--------------|-----------------------|-----------|--------------------|----------------------------------------------|
| A- | (-0.16) | (0.21)       | TRIPP                 | 62 HBC    | REPL. BY BANGERTER |                                              |
| A- | 0.6500  | (-0.010)     | (0.043)               | BANGERTER | 66 HBC             | K-P TO SIG- P1+                              |
| A- | 0.6068  | (-0.104)     | (0.04)                | BERLEY    | 67 HBC             | K-P TO SIG- P1+                              |
| A- | 51000   | (-0.07)      | (0.012)               | BANGERTER | 69 HBC             |                                              |
| A- | B 5978  | (-0.134)     | (0.034)               | BERLEY    | 70 HBC             | K-P AT 400 MEV/C                             |
| A- | 60000   | -0.067       | 0.011                 | BOGERT    | 70 HBC             | K-P AT 400 MEV/C                             |
| A- | 0       | OLD RESULTS. | HAVE BEEN REPLACED.   |           |                    |                                              |
| A- | B       | BERLEY 70    | REPLACED BY BOGERT 70 |           |                    |                                              |
| A- | AVG     | -0.0688      | 0.0081                |           |                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

| F- | PHI   | ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) | (DEGREES)                     |           |        |                                              |
|----|-------|--------------------------------------|-------------------------------|-----------|--------|----------------------------------------------|
| F- | 0     | 1006                                 | (+22.1)                       | (30.)     | BERLEY | 67 HBC                                       |
| F- | 1385  | 14.                                  | 19.                           | BANGERTER | 69 HBC | K-P TO SIG- P1+                              |
| F- | C1092 | + 5.                                 | 23.                           | BERLEY    | 70 HBC | NEUTRON RESECT.                              |
| F- | C     | CHANGED FROM -5 TO +5                | TO AGREE WITH SIGN CONVENTION |           |        |                                              |
| F- | AVG   | 10.3                                 | 14.6                          |           |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

| AV | GV/GA                | FOR SIGMA TO LAMBDA BETA DECAY (TEXT SEC IV H.1 FOR SIGN CONV) |                                                      |        |          |        |
|----|----------------------|----------------------------------------------------------------|------------------------------------------------------|--------|----------|--------|
| AV | PREDICTED TO BE ZERO | BY CONSERVED VECTOR CURRENT THEORY                             |                                                      |        |          |        |
| AV | FB                   | 45                                                             | (0.31)                                               | (0.30) | BARASH   | 67 HBC |
| AV | FS                   | 51                                                             | (0.71)                                               | (0.4)  | BALTAY   | 69 HBC |
| AV | FS                   | 81                                                             | (+0.22)                                              | (0.28) | EISELEI  | 69 HBC |
| AV | F                    | 186                                                            | 0.37                                                 | 0.20   | FRANZINI | 72 HBC |
| AV | B                    | BARASH 67                                                      | MEASURED ABSOLUTE VALUE.                             |        |          |        |
| AV | S                    | SIGN CHANGED TO AGREE WITH OUR CONVENTION.                     |                                                      |        |          |        |
| AV | F                    | FRANZINI 72                                                    | INCLUDES EVENTS OF BARASH 67, EISELEI 69, BALTAY 69. |        |          |        |

| AV1 | GA/GV                                          | FOR SIGMA TO NEUTRON BETA DECAY (TEXT SEC IV H.1 FOR SIGN CONV) |                                                        |        |            |                |
|-----|------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------|--------|------------|----------------|
| AV1 | 57                                             | (0.051)                                                         | (0.23)                                                 | (0.32) | GERSHWIN   | 68 HBC         |
| AV1 | C                                              | 49                                                              | 0.23                                                   | 0.16   | COLLERAINE | 69 HBC         |
| AV1 | C                                              | 33                                                              | 0.37                                                   | 0.26   | 0.19       | EISELEI 69 HBC |
| AV1 | 61                                             | +0.19                                                           | 0.20                                                   | 0.17   | GERSHWIN   | 69 HBC         |
| AV1 | 63                                             | -0.33                                                           | 0.30                                                   | 0.85   | BOGERT     | 70 HBC         |
| AV1 | S                                              | 5                                                               | 0.20                                                   | 0.28   | EDENHOM    | 70 HBC         |
| AV1 | C                                              | 36                                                              | 0.29                                                   | 0.28   | BALTAY     | 72 HBC         |
| AV1 | C                                              | 43                                                              | -0.4                                                   | 0.52   | 1.5        | ELLIS 72 ASPK  |
| AV1 | E                                              | (+0.10)                                                         | (0.11)                                                 |        | ELLIS      | 72 RVUE        |
| AV1 | E                                              | (-0.27)                                                         | (0.13)                                                 | (0.17) | ELLIS      | 72 RVUE        |
| AV1 | C                                              | COLLERAINE, EISELEI, BALTAY                                     | MEASURE ABSOLUTE VALUE OF GA/GV.                       |        |            |                |
| AV1 | GERSHWIN 69, BOGERT 70, EDENHOM 70,            | AND ELLIS 72                                                    | MEASURE THE SIGN.                                      |        |            |                |
| AV1 | BUT NEITHER HAS A DEFINITE SIGN DETERMINATION. | SINCE THE SIGN IS                                               |                                                        |        |            |                |
| AV1 | UNDETERMINED THE AVERAGE OF THE SIX VALUES IS  | MEANINGLESS.                                                    |                                                        |        |            |                |
| AV1 | E                                              | ELLIS 72                                                        | HAS COMBINED THE MAXIMUM LIKELIHOODS OF COLLERAINE 69, |        |            |                |
| AV1 | E                                              | EISELEI 69, GERSHWIN 69, ELLIS 72,                              | AND GETS TWO POSSIBLE VALUES.                          |        |            |                |
| AV1 | S                                              | SIGN CHANGED TO AGREE WITH OUR CONVE.                           | INCLUDES BIERMAN 68 EVENTS.                            |        |            |                |
| AV1 | AVG                                            |                                                                 |                                                        |        |            |                |
| AV1 | AVG                                            |                                                                 |                                                        |        |            |                |

\*\*\*\*\*

## REFERENCES FOR SIGMA-

|           |    |                 |                                                   |  |
|-----------|----|-----------------|---------------------------------------------------|--|
| BROWN     | 58 | CERN CONF 270   | BROWN, GLASER, GRAVES, PERL, CRONIN + (MICH)      |  |
| EISLER    | 58 | NC SERIO 10 150 | EISLER, BASSI, CONVERSI + (COLU, BNL, BGNA, PISA) |  |
| BARKAS    | 61 | PR 124 1209     | BARKAS, DYER, MASON, NICKOLS, SMITH (LRL)         |  |
| CHIESA    | 61 | NC 19 1171      | A M CHIESA, B QUASSIATI, G RINAUDO (TURIN)        |  |
| HUMPHREY  | 62 | PR 127 1305     | M E HUMPHREY, R ROSS (LRL)                        |  |
| TRIPP     | 62 | PRL 9 66        | R D TRIPP, M WATSON, M FERRO-LUZZI (LRL)          |  |
| BARKAS    | 63 | PRL 11 26       | M H BARKAS, J N DYER, H H HECKMAN (LRL)           |  |
| BURNSTEI  | 64 | PRL 13 66       | BURNSTEIN, DAY, KEHDE, SECHI ZORN, SNOW (UMD)     |  |
| COURANT   | 64 | PR 136 8 1791   | COURANT, FILTHUTH + (CERN+HEID+UMD+NRL+BNL)       |  |
| MILLER    | 64 | PL 11 262       | MILLER, STANNARD, BEZAQUET + (LOUC, EPOL+BERG)    |  |
| MURPHY    | 64 | PR 134 8 188    | C THORNTON MURPHY (WISCONSIN)                     |  |
| NAUENBERG | 64 | PRL 12 679      | NAUENBERG, SCHMIDT, MARATECK + (COLU+RUTG+PRIN)   |  |
| BAZIN     | 65 | PR 140 8 1358   | BAZIN, PLAND, SCHMIDT + (PRIN+RUTG+COLU)          |  |
| DOSCH     | 65 | PL 14 239       | DOSCH, ENGELMANN, FILTHUTH, HEPP, KLUGE + (HEID)  |  |
| ALSO      | 66 | PR 151 1081     | CHUNG YUN CHANG (COLUMBIA)                        |  |
| SCHMIDT   | 65 | PR 140 8 1328   | P SCHMIDT (COLUMBIA)                              |  |
| BANGERTER | 66 | PRL 17 495      | BANGERTER, GALTIERI, BERGE, MURRAY + (LRL)        |  |
| CHANG     | 66 | PR 151 1081     | CHUNG YUN CHANG (COLUMBIA)                        |  |
| CHIEN     | 66 | PR 152 1171     | *LACH, SANDWEISS, TAFT, YEH, OREN + (YALE+BNL)    |  |

|            |    |                  |                                                  |  |
|------------|----|------------------|--------------------------------------------------|--|
| BARASH     | 67 | PRL 19 181       | BARASH, DAY, GLASSER, KEHDE, KNOP + (MARYLAND)   |  |
| BERLEY     | 67 | PRL 19 979       | BERLEY, HERTZBACH, KOFLER + (BNL, MASA, YALE)    |  |
| BIERMAN    | 68 | PRL 20 1459      | BIERMAN, KOUNDSU, NAUENBERG + (PRINCETON)        |  |
| GERSHWIN   | 68 | PRL 20 1270      | GERSHWIN, ALSTON-GARNJOST, BANGERTER + (LRL)     |  |
| HEPP       | 68 | ZPHY 214 71      | V. HEPP, H. SCHLEICH (HEIDELBERG)                |  |
| SECHIZOR   | 68 | TO BE PUBL.      | DAY, GLASSER, KNOP + VIENNA 375 (MARYLAND)       |  |
| WHITESID   | 68 | NC 54A 537       | H. WHITESIDE, J. GOLLUS (OBERLIN)                |  |
| ANG 1      | 69 | ZPHY 223 103     | ANG, EISELE, ENGELMANN, FILTHUTH + (HEID)        |  |
| ANG 2      | 69 | ZPHY 228 151     | *EDENHOM, EISELE, ENGELMANN, FILTHUTH + (HEID)   |  |
| BAGGETT    | 69 | PRL 23 249       | BAGGETT, KEHDE, SNOW (UNIV MARYLAND)             |  |
| BALTAY     | 69 | PRL 22 615       | BALTAY, FRANZINI, NEWMAN, NORTON + (COLU, STON)  |  |
| BANGERTER  | 69 | UCRL-19244       | ROGER ODELL BANGERTER (THEIS)                    |  |
| BANGERTER  | 69 | PR 187 1821      | BANGERTER, GARNJOST, GALTIERI, GERSHWIN + (LRL)  |  |
| BARLOUTAU  | 69 | NP 814 153       | BARLOUTAU, BELLEFON, GRANET + (SACL+CERN+HEID)   |  |
| COLLERAINE | 69 | PRL 23 221       | COLLERAINE, DAY, GLASSER, KNOP + (UNIV MARYLAND) |  |
| EISELEI    | 69 | ZPHY 228 1       | *ENGELMANN, FILTHUTH, FOHLISCH, HEPP + (HEID)    |  |
| EISELEI    | 69 | ZPHY 223 487     | EISELE, ENGELMANN, FILTHUTH, FOHLISCH + (HEID)   |  |
| GERSHWIN   | 69 | UCRL-19246       | LAWRENCE KENNETH GERSHWIN (THEIS)                |  |
| BERLEY     | 70 | PR 01 2015       | *YAMIN, HERTZBACH, KOFLER + (BNL, MASA, YALE)    |  |
| BOGERT     | 70 | PR 02 6          | *LUCAS, TAFT, WILLIS, BERLEY + (BNL, MASA, YALE) |  |
| EDENHOM    | 70 | KIEV CONF        | *EISELE, ENGELMANN, FILTHUTH, FOHLISCH + (HEID)  |  |
| EISELE     | 70 | ZPHY 238 372     | *FILTHUTH, HEPP, PRESSER, ZECH (HEIDELBERG)      |  |
| BARKER     | 71 | LNC 1 37         | *SABRE COLLAB. (ZEEM+SACL+BGNA+RHOD+EPOL)        |  |
| COLE       | 71 | PR 04 631        | *LEE-FRANZINI, LOVELESS, BALTAY + (STON, COLU)   |  |
| ALSO       | 69 | NEVIS-175 THESIS | HERBERT NORTON (COLUMBIA)                        |  |
| TOVEE      | 71 | NP 833 493       | LOUC, BELGRADE, BERL, BRUX, DUBLIN, WARS COLLAB  |  |
| BALTAY     | 72 | PR 05 1569       | *FEINMAN, FRANZINI, NEWMAN, YEH + (COLU+STON)    |  |
| BOHM       | 72 | NP 848 1         | BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAM          |  |
| ELLIS      | 72 | NP 839 77        | DXP+AERE+RHEL+LOOM+LYON+WES+ITEP COLLABOR        |  |
| FRANZINI   | 72 | PR 06 2417       | COLUMBIA+HEIDELBERG+MARYLAND+STONY BROOK         |  |

PAPERS NOT REFERRED TO IN DATA CARDS

|       |    |             |                                      |  |
|-------|----|-------------|--------------------------------------|--|
| BROWN | 57 | PR 108 1036 | J BROWN, D GLASER, M PERL (MICH+BNL) |  |
| NIETO | 68 | RMP 40 140  | M NIETO (STON)                       |  |

 $\Sigma^0$ 

21 SIGMA0 (1193, JP=1/2+) I=1

| D1 | N   | SEE NOTE PRECEDING LAMBDA MASS LISTINGS. |       |           |        |                                               |
|----|-----|------------------------------------------|-------|-----------|--------|-----------------------------------------------|
| D1 | 18  | 4.75                                     | 0.1   | BURNSTEIN | 64 HBC |                                               |
| D1 | 37  | 4.87                                     | 0.12  | DOSCH     | 65 HBC |                                               |
| D1 | 12  | 4.99                                     | 0.13  | SCHMIDT   | 65 HBC | SEE NOTE N                                    |
| D1 | AVG | 4.849                                    | 0.069 |           |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| D1 | FIT | 4.863                                    | 0.064 |           |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |

21 (SIGMA0) - (LAMBDA) MASS DIFFERENCE (MEV)

| DL | N   | SEE NOTE PRECEDING LAMBDA MASS LISTINGS. |      |         |        |                                               |
|----|-----|------------------------------------------|------|---------|--------|-----------------------------------------------|
| DL | 208 | 76.63                                    | 0.28 | SCHMIDT | 65 HBC | SEE NOTE N                                    |
| DL | FIT | 76.69                                    | 0.09 |         |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |

21 SIGMA0 MEAN LIFE (UNITS 10<sup>-14</sup>)

|   |       |         |       |         |  |  |
|---|-------|---------|-------|---------|--|--|
| T | (1.0) | OR LESS | DAVIS | 62 EMUL |  |  |
|---|-------|---------|-------|---------|--|--|

21 SIGMA0 PARTIAL DECAY MODES

|    |                          |       | DECAY MASSES |
|----|--------------------------|-------|--------------|
| P1 | SIGMA0 INTO LAMBDA GAMMA | 1115+ | 0            |
| P2 | SIGMA0 INTO LAMBDA E+ E- | 1115+ | .5+ .5       |

21 SIGMA0 BRANCHING RATIOS

| R1 | SIGMA0    | INTO (LAMBDA E+ E-)/TOTAL | (P2)/(P1+P2)   |  |  |      |
|----|-----------|---------------------------|----------------|--|--|------|
| R1 | (0.00545) | THEORET. CAL. FEINBERG 58 | QUANTUM ELECT. |  |  | 9/66 |

## REFERENCES FOR SIGMA0

|          |    |               |                                                  |  |
|----------|----|---------------|--------------------------------------------------|--|
| FEINBERG | 58 | PR 109 1019   | G. FEINBERG (BNL)                                |  |
| DAVIS    | 62 | PR 127 605    | D. DAVIS, R. SETTI, M. RAYMOND, G. TOMASIN (EFI) |  |
| BURNSTEI | 64 | PRL 13 66     | BURNSTEIN, DAY, KEHDE, SECHI ZORN, SNOW (UMD)    |  |
| DOSCH    | 65 | PL 14 239     | DOSCH, ENGELMANN, FILTHUTH, HEPP, KLUGE + (HEID) |  |
| SCHMIDT  | 65 | PR 140 8 1328 | P SCHMIDT (COLUMBIA)                             |  |
| COURANT  | 63 | PRL 10 409    | COURANT, FILTHUTH, FRANZINI + (CERN+UMD+NRL)     |  |
| ALFF     | 65 | PR 137 81105  | ALFF, GELFAND, NAUENBERG + (COLUMBIA+RUTG+BNL)P  |  |

PAPERS NOT REFERRED TO IN DATA CARDS

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

## Stable Particles

 $E^-, E^0$ 

22 XI- (1321, JP=1/2 I=1/2)

22 XI- MASS (MEV)

|   |   |                                                                     |         |            |         |                                               |       |
|---|---|---------------------------------------------------------------------|---------|------------|---------|-----------------------------------------------|-------|
| M | H | 11(1317.0)                                                          | (2.2)   | WANG       | 61 HLBC |                                               |       |
| M | H | 18(1317.9)                                                          | (1.9)   | FOWLER     | 61 HLBC |                                               |       |
| M | H | (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)  |         |            |         |                                               |       |
| M |   | 517 1321.4                                                          | 0.4     | JAUNEAU    | 63 FBC  |                                               |       |
| M |   | 62 1321.1                                                           | 0.65    | SCHNEIDER  | 63 HBC  |                                               |       |
| M |   | 241 1321.1                                                          | 0.3     | BADIERI    | 64 HBC  |                                               |       |
| M |   | ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED    |         |            |         |                                               |       |
| M |   | 149 1321.3                                                          | 0.4     | PJERROU    | 65 HBC  |                                               | 11/67 |
| M |   | 6 1321.67                                                           | 0.52    | CHIEN      | 66 HBC  | - 6.9 PBAR P                                  | 9/67  |
| M |   | 299 1321.4                                                          | 1.1     | LONDON     | 66 HBC  |                                               | 6/66  |
| M | G | 195 1321.87                                                         | 0.51    | GOLDWASSER | 70 HBC  | 5.5 K-P                                       | 8/70  |
| M | G | USES LAMBDA MASS OF 1115.589-M(XI) IS 1322.18 IF M(LAMBDA) IS 1115. |         |            |         |                                               | 4/68  |
| M |   | 268 1321.12                                                         | 0.41    | WILQUET    | 72 HLBC |                                               | 1/73* |
| M |   | AVG                                                                 | 1321.31 |            |         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |
| M |   | FIT                                                                 | 1321.29 | 0.14       |         | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) | 1/73* |

22 ANTI-XI+ MASS (MEV)

|    |   |                               |         |         |        |                                               |        |
|----|---|-------------------------------|---------|---------|--------|-----------------------------------------------|--------|
| M1 |   | 1(1322.0)                     | (1.3)   | BROWN   | 62 HBC | ANTI-XI-                                      | 7/66   |
| M1 |   | 5 1320.69                     | 0.93    | CHIEN   | 66 HBC | + 6.9 PBAR P, ANTI                            | 9/67   |
| M1 | S | 12(1317.7)                    | (0.1)   | SHEN    | 67 HBC | ANTI-XI-                                      | 10/67  |
| M1 |   | 34 1321.2                     | 0.4     | STONE   | 70 HBC |                                               | 10/70  |
| M1 |   | 35 1321.6                     | 0.8     | VOTRUBA | 72 HBC | 10 GEV/C K+ P                                 | 11/72* |
| M1 | S | THE ERROR IS STATISTICAL ONLY |         |         |        |                                               |        |
| M1 |   | AVG                           | 1321.20 | 0.33    |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |        |
| M1 |   | FIT                           | 1321.29 | 0.14    |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) | 1/73*  |

22 (XI-) - (ANTI-XI+) MASS DIFFERENCE (MEV)

|    |  |     |     |       |        |            |      |
|----|--|-----|-----|-------|--------|------------|------|
| DM |  | 1.0 | 1.1 | CHIEN | 66 HBC | 6.9 PBAR P | 9/67 |
|----|--|-----|-----|-------|--------|------------|------|

22 XI- MAGNETIC MOMENT (MAGNETONS, 938.26 MEV)

|    |  |      |       |      |         |         |                                              |       |
|----|--|------|-------|------|---------|---------|----------------------------------------------|-------|
| MM |  | 2724 | -0.1  | 2.1  | BINGHAM | 70 OSPK | - 1.8 GEV/C K-P                              | 2/71  |
| MM |  | 1134 | -2.2  | 0.8  | COOL    | 72 OSPK | - 1.8 GEV/C K-P                              | 1/73* |
| MM |  | AVG  | -1.93 | 0.75 |         |         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |

22 XI- MEAN LIFE (UNITS 10\*\*10)

|   |   |                                                                    |         |         |        |           |         |                                           |       |
|---|---|--------------------------------------------------------------------|---------|---------|--------|-----------|---------|-------------------------------------------|-------|
| T | H | 11                                                                 | (3.5)   | (3.4)   | (1.23) | WANG      | 61 HLBC |                                           |       |
| T | H | 18                                                                 | (1.28)  | (0.41)  | (0.25) | FOWLER    | 61 HLBC |                                           |       |
| T | H | (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD) |         |         |        |           |         |                                           |       |
| T |   | 517                                                                | 1.86    | 0.15    | 0.14   | JAUNEAU   | 63 FBC  |                                           |       |
| T |   | 62                                                                 | 1.55    | 0.31    | 0.31   | SCHNEIDER | 63 HBC  |                                           |       |
| T |   | 356                                                                | (1.77)  | (0.12)  |        | CARMONY   | 64 HBC  | REP BY PJERROU, 65                        |       |
| T |   | 794                                                                | 1.69    | 0.07    |        | HUBBARD   | 64 HBC  |                                           |       |
| T |   | 246                                                                | 1.70    | 0.12    |        | PJERROU   | 65 HBC  |                                           |       |
| T | S | 6                                                                  | (1.37)  | (0.51)  |        | CHIEN     | 66 HBC  | - 6.9 PBAR P                              | 11/67 |
| T |   | 299                                                                | 1.80    | 0.16    |        | LONDON    | 66 HBC  |                                           | 6/66  |
| T |   | 2610                                                               | 1.61    | 0.04    |        | BURGUM    | 68 HBC  | K-P AT 1.3-1.8                            | 2/71  |
| T | S | 2436                                                               | (1.637) | (0.050) |        | COOL      | 72 OSPK | 1.8 GEV/C K-P                             | 6/68  |
| T |   | 680                                                                | 1.73    | 0.08    | 0.07   | MAYEUR    | 72 HLBC | 2.1 GEV/C K-                              | 1/73* |
| T | S | THE ERROR IS STATISTICAL ONLY                                      |         |         |        |           |         |                                           |       |
| T |   | AVG                                                                | 1.672   | 0.032   | 0.031  |           |         | AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1) |       |

22 ANTI-XI+ MEAN LIFE (UNITS 10\*\*10)

|    |   |                               |        |        |        |         |        |                    |        |
|----|---|-------------------------------|--------|--------|--------|---------|--------|--------------------|--------|
| T1 | S | 5                             | (1.51) | (0.55) |        | CHIEN   | 66 HBC | + 6.9 PBAR P, ANTI | 9/67   |
| T1 | S | 12                            | (1.9)  | (0.7)  | (0.5)  | SHEN    | 67 HBC | ANTI-XI-           | 10/67  |
| T1 |   | 34                            | 1.6    | 0.3    |        | STONE   | 70 HBC |                    | 10/70  |
| T1 | S | 35                            | (1.55) | (0.35) | (0.20) | VOTRUBA | 72 HBC | 10 GEV/C K+ P      | 11/72* |
| T1 | S | THE ERROR IS STATISTICAL ONLY |        |        |        |         |        |                    |        |

22 XI- PARTIAL DECAY MODES

|    |                      |          |            |   |  |  |  |
|----|----------------------|----------|------------|---|--|--|--|
| P1 | XI- INTO LAMBDA PI-  | NEUTRINO | 1115+ 139  |   |  |  |  |
| P2 | XI- INTO LAMBDA E-   | NEUTRINO | 1115+ .5+  | 0 |  |  |  |
| P3 | XI- INTO NEUTRON PI- |          | 939+ 139   |   |  |  |  |
| P4 | XI- INTO LAMBDA MU-  | NEUTRINO | 1115+ 105+ | 0 |  |  |  |
| P5 | XI- INTO SIGMA E-    | NEUTRINO | 1192+ .5+  | 0 |  |  |  |
| P6 | XI- INTO SIGMA MU-   | NEUTRINO | 1192+ 105+ | 0 |  |  |  |
| P7 | XI- INTO NEUTRON E-  | NEUTRINO | 939+ .5+   | 0 |  |  |  |

22 XI- BRANCHING RATIOS

|    |                                                     |                         |           |         |  |  |       |
|----|-----------------------------------------------------|-------------------------|-----------|---------|--|--|-------|
| R1 | XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**3) | (P2)/(P1)               |           |         |  |  |       |
| R1 |                                                     |                         |           |         |  |  |       |
| R1 | 1                                                   | (155) EFFECTIVE DENOM.  | CARMONY   | 63 HBC  |  |  | 11/67 |
| R1 | 0                                                   | (260) EFFECTIVE DENOM.  | JAUNEAU   | 63 HBC  |  |  | 11/67 |
| R1 | 0                                                   | (220) EFFECTIVE DENOM.  | BERGE     | 66 HBC  |  |  | 11/67 |
| R1 | 1                                                   | (155) EFFECTIVE DENOM.  | LONDON    | 66 HBC  |  |  | 11/67 |
| R1 | 0                                                   | (717) EFFECTIVE DENOM.  | TRIPPE    | 67 HBC  |  |  | 6/68  |
| R1 | 2                                                   | (1976) EFFECTIVE DENOM. | HUBBARD   | 68 HBC  |  |  |       |
| R1 | 4                                                   | 1.5 0.90 0.55           | HUBBARD   | 68 RVUE |  |  | 6/68  |
| R1 | HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS         |                         |           |         |  |  |       |
| R2 | XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**3)   | (P3)/(P1)               |           |         |  |  |       |
| R2 |                                                     |                         |           |         |  |  |       |
| R2 | 5.0 OR LESS                                         |                         | FERRO-LUZ | 63 HBC  |  |  | 6/68  |
| R2 | 1.1 OR LESS                                         |                         | DAUBER    | 69 HBC  |  |  | 6/68  |
| R3 | XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**3)  | (P4)                    |           |         |  |  |       |
| R3 |                                                     |                         |           |         |  |  |       |
| R3 | 12.0 OR LESS                                        |                         | BERGE     | 66 HBC  |  |  | 6/68  |
| R3 | 1.3 OR LESS                                         |                         | DAUBER    | 69 HBC  |  |  | 6/68  |

## Data Card Listings.

For notation, see key at front of Listings.

|    |                                                                      |           |         |         |            |  |       |
|----|----------------------------------------------------------------------|-----------|---------|---------|------------|--|-------|
| R4 | XI- INTO (SIGMA E- NEUTRINO)/TOTAL (UNITS 10**3)                     | (P5)      |         |         |            |  |       |
| R4 |                                                                      |           |         |         |            |  |       |
| R4 | 3.0 OR LESS                                                          |           | BERGE   | 66 HBC  |            |  | 6/68  |
| R4 | 0.5 OR LESS                                                          |           | DAUBER  | 69 HBC  |            |  | 6/68  |
| R5 | XI- INTO (SIGMA MU- NEUTRINO)/TOTAL                                  | (P6)      |         |         |            |  |       |
| R5 | 0.005 OR LESS                                                        |           | BERGE   | 66 HBC  |            |  | 7/66  |
| R6 | XI- INTO (E- NEUTRINO)/(LAMBDA PI-) (UNITS 10**3)                    | (P7)/(P1) |         |         |            |  |       |
| R6 | 0.01 OR LESS                                                         | CL=90     | BINGHAM | 65 RVUE |            |  | 9/66  |
| R7 | XI- INTO (SIGMA E- NEU + LAMBDA E- NEU)/TOTAL (10**3)                | (P2+P5)   |         |         |            |  |       |
| R7 |                                                                      |           |         |         |            |  |       |
| R7 | 17 0.68 0.22                                                         |           | DUCLUS  | 71 OSPK | SEE NOTE D |  | 10/71 |
| R7 | D THIS EXPERIMENT CANNOT DISTINGUISH SIGMA FROM LAMBDA. THE CABIBBO  |           |         |         |            |  |       |
| R7 | D THEORY PREDICTS SIGMA RATE ABOUT A FACTOR 6 SMALLER THAN THE       |           |         |         |            |  |       |
| R7 | D LAMBDA. TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1. |           |         |         |            |  |       |

22 XI- DECAY PARAMETERS

RELATED TEXT SECTION IV H AND APPENDIX III

|   |                                                              |            |          |                                              |         |                    |                  |       |       |
|---|--------------------------------------------------------------|------------|----------|----------------------------------------------|---------|--------------------|------------------|-------|-------|
| A | ALPHA XI-                                                    |            |          |                                              |         |                    |                  |       |       |
| A | 0                                                            | (-0.44)    | (0.12)   | JAUNEAU                                      | 63 FBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| A | 0                                                            | 62 (-0.73) | (0.23)   | SCHNEIDER                                    | 63 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| A | 240                                                          | -0.5       | 0.38     | BADIERI                                      | 64 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| A | 356                                                          | -0.62      | 0.13     | CARMONY                                      | 64 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| A | 1004                                                         | -0.365     | 0.068    | BERGE                                        | 66 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| A | L                                                            | 364        | -0.47    | 0.13                                         | LONDON  | 66 HBC             | SEE NOTE D BELOW | 6/68  |       |
| A |                                                              | (-0.391)   | (0.032)  | BERGE 2                                      | 66 RVUE | INCLUDES ALL ABOVE | 9/66             |       |       |
| A | M                                                            | 2529       | (-0.375) | (0.051)                                      | MERRILL | 68 HBC             | SEE NOTE A BELOW | 6/68  |       |
| A | 2781                                                         | -0.391     | 0.045    | DAUBER                                       | 69 HBC  | SEE NOTE A BELOW   |                  |       |       |
| A | 2724                                                         | -0.383     | 0.065    | BINGHAM                                      | 70 OSPK |                    |                  |       |       |
| A | 820                                                          | -0.42      | 0.11     | MAYEUR                                       | 72 HLBC | 2.1 GEV/C K-       | 10/70            |       | 1/73* |
| A | A USED ALPHA LAMBDA = 0.647 +- 0.020.                        |            |          |                                              |         |                    |                  |       |       |
| A | D ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI |            |          |                                              |         |                    |                  |       |       |
| A | D POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)      |            |          |                                              |         |                    |                  |       |       |
| A | L LONDON 66 USES ALPHA-LAMBDA = 0.62                         |            |          |                                              |         |                    |                  |       |       |
| A | M DATA OF MERRILL 68 INCLUDED IN DAUBER 68.                  |            |          |                                              |         |                    |                  |       |       |
| A | O OLD DATA NOT INCLUDED IN AVERAGE.                          |            |          |                                              |         |                    |                  |       |       |
| A | *****                                                        |            |          |                                              |         |                    |                  |       |       |
| A | AVG                                                          | -0.403     | 0.029    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |         |                    |                  |       |       |
| F | PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)           |            |          |                                              |         |                    |                  |       |       |
| F | 0                                                            | (-16.0)    | (45.0)   | JAUNEAU                                      | 63 FBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| F | 0                                                            | 62 (45.0)  | (36.0)   | SCHNEIDER                                    | 63 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| F | 356                                                          | 54.0       | 30.0     | CARMONY                                      | 64 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| F | 1004                                                         | 0.         | 12.      | BERGE                                        | 66 HBC  | SEE NOTE D BELOW   | 6/68             |       |       |
| F | L                                                            | 364        | 0.0      | 20.4                                         | LONDON  | 66 HBC             | SEE NOTE D BELOW | 6/68  |       |
| F | M                                                            | 2529       | (9.8)    | (11.6)                                       | MERRILL | 68 HBC             | SEE NOTE A BELOW | 6/68  |       |
| F | F                                                            | 2781       | -14.     | 11.                                          | DAUBER  | 69 HBC             | SEE NOTE A BELOW |       |       |
| F | F                                                            | 2724       | -2.0     | 2.0                                          | BINGHAM | 70 OSPK            |                  | 10/70 |       |
| F | A USED ALPHA LAMBDA = 0.647 +- 0.020.                        |            |          |                                              |         |                    |                  |       |       |
| F | D ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI |            |          |                                              |         |                    |                  |       |       |
| F | D POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)      |            |          |                                              |         |                    |                  |       |       |
| F | L LONDON 66 USES ALPHA-LAMBDA = 0.62                         |            |          |                                              |         |                    |                  |       |       |
| F | M DATA OF MERRILL 68 INCLUDED IN DAUBER 68.                  |            |          |                                              |         |                    |                  |       |       |
| F | O OLD DATA NOT INCLUDED IN AVERAGE.                          |            |          |                                              |         |                    |                  |       |       |
| F | *****                                                        |            |          |                                              |         |                    |                  |       |       |
| F | AVG                                                          | -4.3       | 8.1      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |         |                    |                  |       |       |

REFERENCES FOR XI-

|            |    |                  |                                                    |        |
|------------|----|------------------|----------------------------------------------------|--------|
| FOWLER     | 61 | PR 6 134         | FOWLER, BIRGE, EBERHARD, ELY, GOOD, POWELL+ (LRL)  |        |
| WANG       | 61 | JETP 13 512      | K. WANG, T. WANG, VIRYASOV, TING, SOLOVEV+ (JINR)  |        |
| BROWN      | 62 | PR 18 255        | BROWN, GULWICK, FOWLER, GAILLOUD + (BNL+YALE)      |        |
| CARMONY    | 63 | PR 10 381        | CARMONY, PJERROU                                   | (UCLA) |
| FERRO-LUZ  | 63 | PR 130 156       | FERRO-LUZ, ALSTON, ROSENFELD, WOJCICKI (LRL)       |        |
| JAUNEAU    | 63 | SIEA CONF 4      | JAUNEAU+ (EPOL+CEBN+LOUC+RHEL+BERGEN)              |        |
| ALSO       | 63 | PL 5 261         | JAUNEAU+ (EPOL+CEBN+LOUC+RHEL+BERGEN)              |        |
| SCHNEIDER  | 63 | PL 4 360         | H SCHNEIDER (CERN)                                 |        |
| CARMONY    | 64 | PR 12 482        | CARMONY, PJERROU, SCHLEIN, SLATER, STORK+ (UCLA) J |        |
| BADIERI    | 64 | DUBNA CONF 1 593 | BADIERI, DEMOLIN, BARLOUTAUD+ (LRL, SACL, ZEEN)    |        |
| HUBBARD    | 64 | PR 135 8 183     | HUBBARD, BERGE, KALBFLEISCH, SHAFFER + (LRL)       |        |
| BINGHAM    | 65 | PRSL 285 202     | H BINGHAM (CERN)                                   |        |
| PJERROU    | 65 | PR 14 275        | + SCHLEIN, SLATER, SMITH, STORK, TICHO (UCLA)      |        |
| PJERROU    | 65 | THESIS           | G M PJERROU (UCLA)                                 |        |
| BERGE      | 66 | PR 147 945       | BERGE, EBERHARD, HUBBARD, MERRILL + (LRL)          |        |
| BERGE 2    | 66 | BERKELEY CONF 46 | BERGE, CABIBBO (LRL, CERN+RVUE)                    |        |
| LONDON     | 66 | PR 143 1034      | LONDON, RAU, GOLDBERG, LICHTMAN+ (BNL+SYRACUSE)    |        |
| CHIEN      | 66 | PR 152 1171      | + LACH, SANDWEISS, TAFT, YEH, OREN + (YALE+BNL)    |        |
| SHEN       | 67 | PL 25 8 443      | B.C. SHEN, A. FIRESTONE, G. GOLDBERGER (UCB+LRL)   |        |
| TRIPPE     | 67 | PRIV. COMM.      | T. TRIPPE (UCLA)                                   |        |
| BURGUM     | 68 | NP 88 447        | + MEYER, PAULI, TALLINI, + (SACL+CDEF+RHEL)        |        |
| HUBBARD    | 68 | PR 120 465       | HUBBARD, BERGE, DAUBER (LRL)                       |        |
| MERRILL    | 68 | PR 167 1202      | MERRILL, SHAFFER (LRL)                             |        |
| DAUBER     | 69 | PR 179 1272      | + BERGE, HUBBARD, MERRILL, MILLER (LRL)            |        |
| BINGHAM    | 70 | PR 11 3010       | + GIACOMELLI, JENKINS, KYCIA, LEONTIC, LI+ (BNL)   |        |
| GOLDWASSER | 70 | PR 01 1960       | GOLDWASSER, SCHULTZ (ILL)                          |        |
| STONE      | 70 | PL 328 515       | + BERLINGHIERI, BRONBERG, COHEN, FERBEL + (ROCH)   |        |
| DUCLUS     | 71 | NP 832 493       | + FREYTAG, HEINTZE, HEINZELMAN, JONES+ (CERN)      |        |
| COOL       | 72 | PL 29 1630       | + GIACOMELLI, JENKINS, KYCIA, LEONTIC, LI+ (BNL)   |        |
| MAYEUR     | 72 | NP 847 333       | + VAN BINST, WILQUET+ (BRUX+CEBN+TUFT+LOUC)        |        |
| VOTRUBA    | 72 | NP 845 77        | VOTRUBA, SAFOER, RATLIFF (BIRM+EDIN)               |        |
| WILQUET    | 72 | PL 428 372       | + FLAIGNE, GUY, KNIGHT+ (BRUX+CEBN+TUFT+LOUC)      |        |



23 XIO (1314, JP=1/2 I=1/2)

23 XIO MASS (MEV)

|   |  |           |         |         |         |                                               |       |
|---|--|-----------|---------|---------|---------|-----------------------------------------------|-------|
| M |  | 1 1313.4  | 1.8     | PALMER  | 68 HBC  |                                               | 3/68  |
| M |  | 49 1316.2 | 0.92    | WILQUET | 72 HLBC |                                               | 1/73* |
| M |  | AVG       | 1314.03 | 0.82    |         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |
| M |  | FIT       | 1314.90 | 0.55    |         | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) | 1/73* |

## Data Card Listings

For notation, see key at front of Listings.

## Stable Particles

10

## 23 (X1-) - (X10) MASS DIFFERENCE (MEV)

|   |     |        |       |                                               |        |                |    |       |  |
|---|-----|--------|-------|-----------------------------------------------|--------|----------------|----|-------|--|
| D | 23  | 6.8    | 1.6   | JAUNEAU                                       | 63 FBC |                |    |       |  |
| D | 45  | (6.11) | (1.6) | CARMONY                                       | 64 HBC | REP BY PJERROU | 65 |       |  |
| D | 88  | 6.1    | 0.9   | PJERROU                                       | 65 HBC |                |    | 11/67 |  |
| D | 29  | 6.9    | 2.2   | LONDON                                        | 66 HBC |                |    | 6/66  |  |
| D | AVG | 6.34   | 0.74  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |        |                |    |       |  |
| D | FIT | 6.40   | 0.55  | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                |    | 1/73* |  |

## 23 X10 MEAN LIFE (UNITS 10\*\*10)

|   |     |        |       |       |                                           |         |                |    |       |
|---|-----|--------|-------|-------|-------------------------------------------|---------|----------------|----|-------|
| T | 24  | 3.9    | 1.4   | 0.80  | JAUNEAU                                   | 63 FBC  |                |    |       |
| T | 45  | (3.51) | (1.0) | (0.8) | CARMONY                                   | 64 HBC  | REP BY PJERROU | 65 |       |
| T | 101 | 2.5    | 0.4   | 0.3   | HUBBARD                                   | 64 HBC  |                |    |       |
| T | 80  | 3.0    | 0.5   |       | PJERROU                                   | 65 HBC  |                |    | 11/67 |
| T | 340 | 3.07   | 0.22  | 0.20  | DAUBER                                    | 69 HBC  |                |    | 6/66  |
| T | 469 | 2.85   | 0.20  | 0.18  | BRIDGEWAT                                 | 72 HBC  | 1.75 GEV/C K-P |    | 1/73* |
| T | 157 | 3.04   | 0.26  | 0.23  | MAYEUR                                    | 72 HLBC | 2.1 GEV/C K-   |    | 1/73* |
| T | AVG | 2.98   | 0.12  | 0.11  | AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0) |         |                |    |       |

## 23 X10 PARTIAL DECAY MODES

|    |                              |  |  | DECAY MASSES |   |
|----|------------------------------|--|--|--------------|---|
| P1 | X10 INTO LAMBDA P10          |  |  | 1115* 134    |   |
| P2 | X10 INTO PROTON P1-          |  |  | 938* 139     |   |
| P3 | X10 INTO PROTON E- NEU       |  |  | 938* .5*     | 0 |
| P4 | X10 INTO SIGMA+ E- NEU       |  |  | 1189* .5*    | 0 |
| P5 | X10 INTO SIGMA- E+ NEU       |  |  | 1197* .5*    | 0 |
| P6 | X10 INTO SIGMA+ MU- NEUTRINO |  |  | 1189* 105*   | 0 |
| P7 | X10 INTO SIGMA- MU+ NEUTRINO |  |  | 1197* 105*   | 0 |
| P8 | X10 INTO PROTON MU- NEUTRINO |  |  | 938* 105*    | 0 |

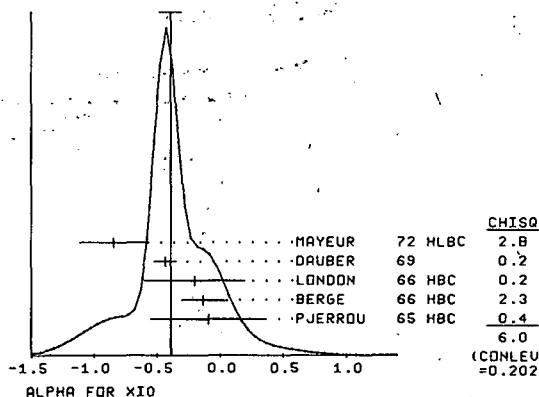
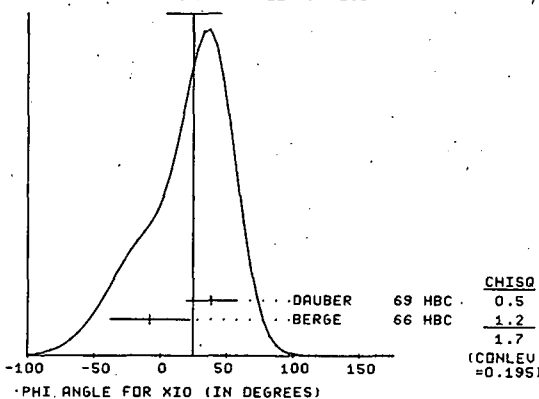
## 23 X10 BRANCHING RATIOS

|    |                                                     |         |         |           |      |
|----|-----------------------------------------------------|---------|---------|-----------|------|
| R1 | X10 INTO (PROTON P1-)/(LAMBDA P10) (UNITS 10**3)    |         |         | (P2)/(P1) |      |
| R1 | 27.0                                                | OR LESS | TICHO   | 63 HBC    | 6/66 |
| R1 | 5.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R1 | 0.9                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R2 | X10 INTO (PROTON E- NEU)/(LAMBDA P10) (UNITS 10**3) |         |         | (P3)/(P1) |      |
| R2 | 27.0                                                | OR LESS | TICHO   | 63 HBC    | 6/66 |
| R2 | 6.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R2 | 1.3                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R3 | X10 INTO (SIGMA+ E- NEU)/(LAMBDA P10) (UNITS 10**3) |         |         | (P4)/(P1) |      |
| R3 | 13.0                                                | OR LESS | TICHO   | 63 HBC    | 6/66 |
| R3 | 7.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R3 | 1.5                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R4 | X10 INTO (SIGMA- E+ NEU)/(LAMBDA P10) (UNITS 10**3) |         |         | (P5)/(P1) |      |
| R4 | 6.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R4 | 1.5                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R5 | X10 INTO (SIGMA+ MU- NEU)/TOTAL (UNITS 10**3)       |         |         | (P6)      |      |
| R5 | 7.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R5 | 1.5                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R6 | X10 INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**3)       |         |         | (P7)      |      |
| R6 | 6.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R6 | 1.5                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |
| R7 | X10 INTO (PROTON MU- NEU)/TOTAL (UNITS 10**3)       |         |         | (P8)      |      |
| R7 | 6.0                                                 | OR LESS | HUBBARD | 66 HBC    | 6/66 |
| R7 | 1.3                                                 | OR LESS | DAUBER  | 69 HBC    | 6/66 |

## 23 X10 DECAY PARAMETER

## RELATED TEXT SECTION IV H AND APPENDIX III

|   |                                                    |                                                            |         |                                              |           |                  |                  |       |
|---|----------------------------------------------------|------------------------------------------------------------|---------|----------------------------------------------|-----------|------------------|------------------|-------|
| A | ALPHA XI 0                                         |                                                            |         |                                              |           |                  |                  |       |
| A | 146                                                | -0.09                                                      | 0.46    | PJERROU                                      | 65 HBC    | SEE NOTE D BELOW | 6/66             |       |
| A | 146                                                | -0.13                                                      | 0.17    | BERGE                                        | 66 HBC    | SEE NOTE D BELOW | 6/66             |       |
| A | L                                                  | 46                                                         | -0.2    | 0.4                                          | LONDON    | 66 HBC           | SEE NOTE D BELOW | 6/66  |
| A | M                                                  | 490                                                        | (-0.33) | (0.11)                                       | MERRILL   | 66 HBC           | SEE NOTE D BELOW | 6/66  |
| A | A                                                  | 739                                                        | -0.43   | 0.09                                         | DAUBER    | 69               | SEE NOTE A BELOW |       |
| A | B                                                  | 507                                                        | (-0.52) | (0.09)                                       | BRIDGEWAT | 72 HBC           | 1.75 GEV/C K-P   | 1/73* |
| A | 130                                                | -0.84                                                      | 0.27    | MAYEUR                                       | 72 HLBC   | 2.1 GEV/C K-     |                  |       |
| A | A                                                  | USED ALPHA LAMBDA = 0.647 +/- 0.020.                       |         |                                              |           |                  |                  |       |
| A | D                                                  | ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI |         |                                              |           |                  |                  |       |
| A | D                                                  | POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)      |         |                                              |           |                  |                  |       |
| A | L                                                  | LONDON 66 USES ALPHA-LAMBDA = 0.62                         |         |                                              |           |                  |                  |       |
| A | M                                                  | MERRILL 66 REPLACED BY DAUBER 69                           |         |                                              |           |                  |                  |       |
| A | B                                                  | ERROR PURELY STATISTICAL                                   |         |                                              |           |                  |                  | 1/73* |
| A | AVG                                                | -0.387                                                     | 0.090   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |           |                  |                  |       |
|   |                                                    |                                                            |         | (SEE IDEOGRAM BELOW)                         |           |                  |                  |       |
| F | PHI ANGLE (SIN(PHI))/COS(PHI)=BETA/GAMMA (DEGREES) |                                                            |         |                                              |           |                  |                  |       |
| F | 146                                                | -8.                                                        | 30.     | BERGE                                        | 66 HBC    | SEE NOTE D BELOW | 6/66             |       |
| F | M                                                  | 490 (107.0)                                                | (46.0)  | MERRILL                                      | 66 HBC    | SEE NOTE D BELOW | 6/66             |       |
| F | A                                                  | 739                                                        | 38.     | 19.                                          | DAUBER    | 69 HBC           | SEE NOTE A BELOW | 6/66  |
| F | B                                                  | 507 (11.2)                                                 | (14.4)  | BRIDGEWAT                                    | 72 HBC    | 1.75 GEV/C K-P   |                  | 1/73* |
| F | A                                                  | USED ALPHA LAMBDA = 0.647 +/- 0.020.                       |         |                                              |           |                  |                  |       |
| F | D                                                  | ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI |         |                                              |           |                  |                  |       |
| F | D                                                  | POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)      |         |                                              |           |                  |                  |       |
| F | M                                                  | MERRILL 66 REPLACED BY DAUBER 69                           |         |                                              |           |                  |                  |       |
| F | B                                                  | ERROR PURELY STATISTICAL                                   |         |                                              |           |                  |                  | 1/73* |
| F | AVG                                                | 24.8                                                       | 20.8    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |           |                  |                  |       |
|   |                                                    |                                                            |         | (SEE IDEOGRAM BELOW)                         |           |                  |                  |       |

WEIGHTED AVERAGE = -0.387 +/- 0.090  
ERROR SCALED BY 1.2WEIGHTED AVERAGE = 24.8 +/- 20.8  
ERROR SCALED BY 1.3

## REFERENCES FOR X10

|           |    |                   |                                                  |
|-----------|----|-------------------|--------------------------------------------------|
| ALVAREZ   | 59 | PRL 2 215         | ALVAREZ, EBERHARD, GODD, GRAZIANO, TICHO* (LRL)  |
| JAUNEAU   | 63 | SIEMA CONF 1 1    | JAUNEAU* (EPOL+CERN+LOUC+RHEL+BERGEN)            |
| ALSO      | 63 | PL 4 49           | JAUNEAU* (EPOL+CERN+LOUC+RHEL+BERGEN)            |
| TICHO     | 63 | BNL CONF 410      | HAROLD K TICHO (UCLA)                            |
| CARMONY   | 64 | PRL 12 482        | CARMONY, PJERROU, SCHLEIN, SLATER, STORK* (UCLA) |
| HUBBARD   | 64 | PR 135 8 183      | HUBBARD, BERGE, KALBFLEISCH, SHAFFER + (LRL)     |
| PJERROU   | 65 | PRL 14 275        | + SCHLEIN, SLATER, SMITH, STORK, TICHO (UCLA)    |
| PJERROU   | 65 | THESIS            | G M PJERROU (UCLA)                               |
| BERGE     | 66 | PR 147 945        | BERGE, EBERHARD, HUBBARD, MERRILL + (LRL)        |
| HUBBARD   | 66 | UCL 11510         | J RICHARD HUBBARD (THESIS, BERKELEY) (LRL)       |
| LONDON    | 66 | PR 143 1034       | LONDON, RAU, GOLDBERG, LICHTMAN* (BNL+SYRACUSE)  |
| MERRILL   | 66 | BERKELEY CONF     | MERRILL, SHAFFER, BERGE (LRL)                    |
| ALSO      | 66 | UCL 16455         | DEANE MERRILL (THESIS, BERKELEY) (LRL)           |
| PALMER    | 68 | PL 268 323        | PALMER, RADOJICIC, RAU, RICHARDSON* (BNL, SYR)   |
| DAUBER    | 69 | PR 179 1262       | *BERGE, HUBBARD, MERRILL, MILLER (LRL)           |
| BRIDGEWAT | 72 | NEVIS 195(THESIS) | ALBERT BRIDGEWAT (COLUMBIA)                      |
| MAYEUR    | 72 | NP 847 333        | *VAN BINST, WILQUET* (BRUX+CERN+TUFT+LOUC)       |
| WILQUET   | 72 | PL 428 372        | *FLIAGINE, GUY, KNIGHT* (BRUX+CERN+TUFT+LOUC)    |

## Stable Particles

 $\Omega^-$  $\Omega^-$ 24 OMEGA- (1675, JP=3/2-) I=0  
QUANTUM NUMBERS ASSIGNED FROM SU3

## 24 OMEGA- MASS (MEV)

| M | 1(1620.0) | (25.0)  | (10.0) | EISENBERG 54 EMUL                            | INTO XI- P10     |       |
|---|-----------|---------|--------|----------------------------------------------|------------------|-------|
| M | 1 1673.0  | 8.0     |        | ABRAMS 64 HBC                                | K-P 4.6+5. GEV/C | 11/69 |
| M | 3 1673.3  | 1.0     |        | PALMER 68 HBC                                | K-P 5.5 GEV/C    | 11/69 |
| M | 3 1671.8  | 0.8     |        | SCHULTZ 68 HBC                               | K-P 6. GEV/C     | 11/69 |
| M | 5 1674.2  | 1.6     |        | SCOTTER 68 HBC                               | K-P 10. GEV/C    | 11/69 |
| M | 6 1671.9  | 1.2     |        | SPETH 69 HBC                                 |                  |       |
| M | AVG       | 1672.49 | 0.52   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                  |       |

## 24 ANTI-OMEGA+ MASS (MEV)

| MB | 1 1673.1 | 1.0 | FIRESTONE 71 HBC | 12 GEV/C K+D | 3/71 |
|----|----------|-----|------------------|--------------|------|
|----|----------|-----|------------------|--------------|------|

## 24 OMEGA- MEAN LIFE (UNITS 10\*\*10 SEC)

| T | A  | 1                                                            | (1.63) | ABRAMS 64 HBC     | 7/66  |
|---|----|--------------------------------------------------------------|--------|-------------------|-------|
| T | A  | 1                                                            | (0.7)  | BARNES 1 64 HBC   | 7/66  |
| T | A  | 1                                                            | (1.4)  | BARNES 2 64 HBC   | 7/66  |
| T | A  | 1                                                            | (1.85) | COLLEY 65 HBC     | 7/66  |
| T | A  | 1                                                            | (1.5)  | RICHARDSON 65 HBC | 7/66  |
| T | A  | 1                                                            | (0.93) | ABCLV COL 68 HBC  | 11/67 |
| T | A  | 1                                                            | (2.6)  | ABCLV COL 68 HBC  | 11/67 |
| T | A  | 1                                                            | (1.6)  | ABCLV COL 68 HBC  | 11/67 |
| T | A  | 1                                                            | (0.21) | ABCLV COL 68 HBC  | 11/67 |
| T | A  | 1                                                            | (1.20) | SCHULTZ 68 HBC    | 11/67 |
| T | A  | 1                                                            | (0.06) | SCHULTZ 68 HBC    | 11/67 |
| T | A  | 1                                                            | (0.63) | SCHULTZ 68 HBC    | 11/67 |
| T | A  | 1                                                            | (0.25) | SCOTTER 68 HBC    | 6/68  |
| T | A  | 1                                                            | (0.30) | SCOTTER 68 HBC    | 6/68  |
| T | A  | 1                                                            | (0.71) | SCOTTER 68 HBC    | 6/68  |
| T | A  | 1                                                            | (0.08) | SCOTTER 68 HBC    | 6/68  |
| T | A  | 1                                                            | (1.04) | SCOTTER 68 HBC    | 6/68  |
| T | A  | 1                                                            | (2.38) | SCOTTER 68 HBC    | 6/68  |
| T | A  | ALLISON INCLUDES ALL ABOVE + 3 MORE BNL EVENTS, UNPUBLISHED. |        |                   | 6/68  |
| T | 21 | 1.31                                                         | 0.37   | ALLISON 68 RVUE   | 6/68  |
| T | 1  | (2.3)                                                        |        | SPETH 69 HBC      | 10/69 |
| T | 1  | (0.31)                                                       |        | SPETH 69 HBC      | 10/69 |

## 24 OMEGA- PARTIAL DECAY MODES

| P1 | OMEGA- INTO LAMBDA K- | DECAY MASSES |
|----|-----------------------|--------------|
| P2 | OMEGA- INTO X10 P1-   | 1115+ 493    |
| P3 | OMEGA- INTO X1- P10   | 1314+ 139    |
|    |                       | 1321+ 134    |

## 24 OMEGA- BRANCHING RATIOS

| R1 | OMEGA- INTO LAMBDA K-     | (P1)           |       |
|----|---------------------------|----------------|-------|
| R1 | 2 EVENTS                  | PALMER 68 HBC  | 11/69 |
| R1 | 3 EVENTS                  | SCHULTZ 68 HBC | 11/69 |
| R1 | 5 EVENTS 1 AMBIG. X10 P1- | SCOTTER 68 HBC | 11/69 |
| R1 | 6 EVENTS                  | SPETH 69 HBC   | 11/69 |
| R2 | OMEGA- INTO X10 P1-       | (P2)           |       |
| R2 | 1 EVENTS                  | ABRAMS 64 HBC  | 11/69 |
| R2 | 4 EVENTS                  | PALMER 68 HBC  | 11/69 |
| R2 | 3 EVENTS                  | SCOTTER 68 HBC | 11/69 |
| R2 | 1 EVENT                   | SPETH 69 HBC   | 11/69 |
| R3 | OMEGA- INTO X1- P10       | (P3)           |       |
| R3 | 1 EVENT                   | PALMER 68 HBC  | 11/69 |
| R3 | 1 EVENT                   | SCOTTER 68 HBC | 11/69 |

## REFERENCES FOR OMEGA-

|                             |                                                   |
|-----------------------------|---------------------------------------------------|
| EISENBERG 54 PR 96 541      | Y EISENBERG (CORNELL)                             |
| ABRAMS 64 PRL 13 670        | + BURNSTEIN, GLASSER + (UMD+NRL)                  |
| BARNES 1 64 PRL 12 204      | V E BARNES, CONNOLLY, CRENNELL, CULWICK+ (BNL)    |
| BARNES 2 64 PL 12 134       | V E BARNES, CONNOLLY, CRENNELL, CULWICK+ (BNL)    |
| COLLEY 65 PL 19 152         | COLLEY, DODD + (BIRMINGHAM+LOIC+MPI+OXF+RHEL)     |
| RICHARDS 65 BAPS 10 115     | RICHARDSON, BARNES, CRENNELL+ (BNL+SYRACUSE)      |
| SAMIOS 65 ARGONNE CONF 189  | N P SAMIOS (IRVUE) BNL                            |
| ABCLV CO 68 NUC PHYS 84 326 | AACHEN+BERLIN+CERN+LONDON IMP. COLL.+VIENNA       |
| ALLISON 68 PRIV. COMM.      | JOHN ALLISON (LANCASTER)                          |
| PALMER 68 PL 268 323        | PALMER, RADOJICIC, RAU, RICHARDSON+ (BNL, SYR)    |
| SCHULTZ 68 PR 168 1509      | SCHULTZ+ (ILL, ARGONNE, NORTHWESTERN, WISC)       |
| SCOTTER 68 PL 268 474       | SCOTTER+ (BIRMINGHAM, GLASGOW, LOIC, MUNICH, OXF) |
| SPETH 69 PL 298 252         | SPETH+ (AACHEN, BERLIN, CERN, LOIC, VIEN)         |
| FIRESTONE 71 PRL 26 410     | *GOLDHABER, LISSAUER, SHELDON, TRILLING (LRL)     |

## . Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $\pi^\pm$ ,  $\pi^0$ ,  $\eta$ ,  $\epsilon$ 

CODE EVENTS QUANTITY ERROR+ ERROR- REFERENCE YR TECN SIGN COMMENTS DATE  
ABOVE PUNCHED  
BACKGROUND

|            |                                                                              |
|------------|------------------------------------------------------------------------------|
| $\pi^\pm$  | 8 CHARGED PION (140, JPC=0-- ) I=1<br>SEE STABLE PARTICLE DATA CARD LISTINGS |
| $\pi^0$    | 9 NEUTRAL PION (135, JPC=0-- ) I=1<br>SEE STABLE PARTICLE DATA CARD LISTINGS |
| $\eta$     | 14 ETA (549, JPC=0-- ) I=0<br>SEE STABLE PARTICLE DATA CARD LISTINGS         |
| $\epsilon$ | 14 PI PI S WAVE, CALLED EPSILON                                              |

S-wave  $\pi\pi$  Interactions in the Region 280-1400 MeV

In this note we first discuss the experimental results on the  $I = 0$   $\pi\pi$  S-wave, and thereafter we comment on the possible interpretation.

At threshold,  $\pi\pi$  interactions in the  $I^G(J^P)C = 0^+(0^+) +$  wave are characterized by a scattering length which still is poorly known (EBEL 71, BASDEVANT 72).

No structure or resonant behavior is indicated near threshold in data from the reaction  $\pi N \rightarrow \pi\pi N$ . In fact, the only structures claimed in this region are due to reactions involving the nuclei d,  $H^3$ , or  $He^3$  (BOOTH 63, HALL 69, BRODY 70, BANAIGS 71), for which the background may be difficult to assess (BRODY 72), and where kinematic reflections from low-mass baryons may contribute (DUBAL 71).

In the region from the  $\pi\pi$  threshold ( $\sim 280$  MeV) up to the region near  $K\bar{K}$  threshold ( $\sim 990$  MeV),  $\pi\pi$  scattering is nearly elastic (BATON 70, CARROLL 72, GRAYER 72, PROTOPOPESCU 72). Up to the  $\rho$  meson mass region,  $\delta_0^0$  is (qualitatively) uniquely determined; it rises monotonically and reaches a value of  $60^\circ$  to  $70^\circ$  near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROLL 72, FRENKIEL 72, GAIDOS 72, GRAYER 72, PROTOPOPESCU 72).

In the mass region of 700 to 900 MeV, all energy-independent analyses find two solutions ("up-down ambiguity"), with the exception of CARROLL 72 who claim to find only the lower ("down") solution. A possibility of resolving the up-down ambiguity arises from the observation by FLATTE 72, GAIDOS 72, and

GRAYER 72 of a very rapid decrease in the S-wave amplitude between 950 and 980 MeV. The size of the observed drop corresponds to a change from nearly the unitarity limit to zero, i.e. to a phase shift change from  $\sim 90^\circ$  to  $\sim 180^\circ$ . This is easily compatible with the "down" solution, which is in the  $70^\circ$  to  $90^\circ$  range between 800 and 900 MeV; in contrast the "up" solution is already near  $150^\circ$  at 900 MeV, and it appears unlikely that it could be smoothly connected with a  $90^\circ$  phase shift at 950 MeV.

In accordance with this, an energy-dependent phase-shift analysis by PROTOPOPESCU 72 using a 2-channel ( $\pi\pi$  and  $K\bar{K}$ ) effective range parametrization, gives a (qualitatively) unique  $I = 0$  S-wave phase-shift solution from 550 to 1150 MeV. After having reached  $180^\circ$  near the  $K\bar{K}$  threshold, inelasticity sets in and the phase continues to rise slowly. A preliminary analysis by GRAYER 72, as well as the analysis by CARROLL 72, suggests that  $\delta_0^0$  may slowly go through  $270^\circ$  somewhere between 1200 and 1400 MeV. (This energy region is however very complicated because the  $4\pi$ ,  $\rho\pi\pi$ , etc. channels are no longer negligible.)

Independent evidence for the correctness of this ("down") solution comes from experiments on  $\pi^0\pi^0$  scattering (APEL 72, SKUJA 72). They observe a wide  $\pi^0\pi^0$  enhancement at  $\sim 800$  MeV which is much better described by the "down" solution than by the "up" solution. Furthermore, indirect information from elastic  $\pi\pi$  scattering in the crossed channel (NIELSEN 70, ELVEKJAER 71 and 72, HAMILTON 71) is compatible with the "down" but not the "up" solution.

It is clear that the behavior of  $\delta_0^0$  is much too complicated to allow a description in terms of one or several Breit-Wigner resonances. We therefore list the positions of the poles of the T matrix, found by searching in the complex energy plane, using the best-fit parameters of the K-matrix or M-matrix. The best fit of PROTOPOPESCU 72 obtains two poles on the second sheet, the  $S^*(990)$  and the  $\epsilon(600)$ . The  $S^*(990)$  is connected with the rapid variation of  $\delta_0^0$  near the  $K\bar{K}$  threshold discussed above, and is also responsible for the large  $K\bar{K}$   $I = 0$  S-wave scattering length. The  $\epsilon(600)$  pole is very far from the real axis and therefore much less certain; it is inferred from the large size and slow variation of the S-wave amplitude between 600 and 900 MeV, but PROTOPOPESCU 72 can fit this

## Mesons

 $\epsilon$ ,  $\rho(770)$ 

behavior also without an  $\epsilon$  pole. Finally, BASDEVANT 72 present a set of  $\pi\pi$  amplitudes consistent with crossing, unitarity, and analyticity, and with the  $\pi\pi$  phase shifts up to 1100 MeV; their amplitude has a very wide ( $\Gamma > 650$  MeV)  $\epsilon$ .

We list the  $S^*$  parameters separately under  $S$ -wave  $I = 0$   $K\bar{K}$  Interactions.

For a recent review see DIEBOLD 72.

## 14 REAL PART OF POLE POSITION (MEV)

|   |         |         |                   |         |               |
|---|---------|---------|-------------------|---------|---------------|
| M | (650.0) | OR LESS | BASDEVANT 72 RVUE | SHEET 2 | 1/73*         |
| M | 660.0   | 100.0   | PROTOPOPE 72 HBC  | SHEET 2 | 7. P1+P 1/73* |

14 NEGATIVE IMAG. PART OF POLE POSITION (MEV)  
CORRESPONDS TO HALF WIDTH, NOT FULL WIDTH.

|   |         |         |                   |                |
|---|---------|---------|-------------------|----------------|
| M | (325.0) | OR MORE | BASDEVANT 72 RVUE | 1/73*          |
| M | 320.0   | 70.0    | PROTOPOPE 72 HBC  | 7. P1+ P 1/73* |

## REFERENCES FOR EPSILON

|                                     |                                                            |
|-------------------------------------|------------------------------------------------------------|
| SAMIOS 62 PRL 9 139                 | +BACHMAN, LEA+ (BNL+CUNY+COLU+KNTY)                        |
| BLOKHINT 63 JETP 17 80              | BLOKHINTSEVA, GREIBINNIK, ZHUKOV + (DUBNA)                 |
| BOOTH 63 PR 132 2314                | + ABASHIN (LRL)                                            |
| KIRZ 63 PR 130 2481                 | + SCHWARTZ + TRIPP (LRL)                                   |
| BARISH 64 PR 135 8 416              | BARISH, KURZ, PEREZ-MENDEZ, SOLOMON (LRL)                  |
| CRAWFORD 64 PRL 13 421              | + GROSSMAN, LLOYD, PRICE, FOWLER (LRL)                     |
| DEL FABR 64 PRL 12 674              | DEL FABRO, DE PRETIS, JONES+ (FRASCATI)                    |
| KALMUS 64 PRL 13 99                 | + KERNAN, PU, POWELL, DOWD (LRL+MISCONSIN)                 |
| BATON 65 NC 36 1149                 | J.P. BATON, J. REGNIER (SACLAY)                            |
| BIRGE 65 PR 139 B 1600              | + ELY+GIDAL+KALMUS+CAMERINI+ (LRL+MISC)                    |
| BROWN 65 CORAL GABLES 219           | BROWN+FAIER (NORTHWESTERN)                                 |
| DURAND 65 PRL 14 329                | L. DURAND AND Y.T. CHIU (YALE)                             |
| JACOBS 66 PRL 16 669                | +SELOVE (LRL)                                              |
| KOPPELMAN 66 PL 22 118              | + ALLEN, GORDEN, MARSHALL + (COLORADO+IOWA)                |
| LOVELACE 66 PL 22 332               | LOVELACE, HEINE, DONNACHIE (CERN)                          |
| ANDERSON 67 PRL 18 89               | +FUKUI+KESSLER+ (CHI+C+ANL+CNRC+MCGILL+LOQM)               |
| CLEGG 67 PR 163 1664                | A.B. CLEGG (LANCASTER)                                     |
| CORBETT 67 PR 156 1451              | +DAMERELL+HIDDELMAN+NEWTON (OXF+RHEL)                      |
| GUTAY 67 PRL 18 142                 | +JOHNSON+LOEFFLER+MC ILWAIN+ (PURDUE+LRL)                  |
| JOHNSON 67 PR 16 239                | +GUTAY, EISNER, KLEIN, PETERS, SAHNI, YEN+PURDUE (CORNELL) |
| MALAMUD 67 PRL 19 1056              | E. MALAMUD + P.E. SCHLEIN (UCLA)                           |
| WALKER 67 RMP 39 695                | W.D. WALKER (MISCONSIN)                                    |
| WALKER 67 PRL 18 630                | +CARROLL, GARFINKEL, OH (CERN)                             |
| BANDER 68 PR 168 1679               | +SHAM, FULCO (UC IRVINE+S. BARBARA)                        |
| BISWAS 68 PR 27 B 513               | CASON, JOHNSON, KENNEY, POIRIER+ (NDAM)                    |
| BAUN 68 PRL 21 1275                 | BAUN, CLINE, SCHERRER (MISCONSIN)                          |
| OUTTA-RO 68 PR 169 1357             | B. OUTTA-ROY, I.R. LAPIDUS (STEVE)                         |
| EISENHAN 68 PRL 20 758              | EISENHAN, HESTER, MISTY, MOSTEK+ (CORNELL)                 |
| FOSTER 68 PR 16 107                 | +GAVILLET+LABROSSE+MONTANET+ (CERN+CDER)                   |
| HYAMS 68 NP 87 1                    | +KOCH, POTTER, .. VON LINDERN, LOREN(CERN+MPI)             |
| JONES 68 PR 166 1405                | +CALDWELL+ZACHAROV+HARTING+BLEULER+ (CERN)                 |
| JOHNSON 68 PR 176 1651              | +POIRIER, BISWAS, GUTAY+ (NDAM+PURD+SLAC)                  |
| LOVELACE 68 PL 28 B 264             | C. LOVELACE (CERN)                                         |
| MARATECK 68 PRL 21 1613             | +HAGOPIAN+ (PENN+LRL+COLO+PURD+TNT+MISC)                   |
| BIZZARRI 69 NP B14 1691(SEE P. 190) | +FOSTER, GAVILLET, GHESQUIERE+ (CERN+CDER)                 |
| DAVISON 69 PR 180 1333              | +BACASTON, BARKAS+ (UCR+UCB)                               |
| DEINET 69 PR 30 B 359               | +MENZ IONE, MULLER, STAUDENMAIER+ (KARL+CERN)              |
| ELY 69 PR 180 1319                  | +GIDAL, HAGOPIAN+ (UCB+OUC+MISC)                           |
| FELDMAN 69 PRL 22 316               | +FRATTI, GLEESON, HALPERN, NUSSBAUM+ (PENN)                |
| GUTAY 69 NP 8 12 31                 | +CARMON, CSOKKA, LOEFFLER, MEIERE (PURDUE)                 |
| HALL 69 NP 8 12 573                 | +MURRAY, RIDI, FORD (BIRMINGHAM)                           |
| HOPKINS 69 NC 59 A 181              | J. HOPKINS, R.G. ROBERTS (CERN)                            |
| MALAMUD 69 ARGONNE CONF. P. 93      | E. MALAMUD, P. SCHLEIN (UCLA)                              |
| MORGAN 69 NP 8 10 261               | D. MORGAN, G. SHAW (RHEL)                                  |
| ROBERTS 69 PL 29 B 368              | R.G. ROBERTS, F. WAGNER (CERN)                             |
| SCHARENZ 69 ARGONNE CONF. 306       | SCHARENGUIVEL (PURD+LRL+CERN+COLO+PENN+TNT)                |
| SCHARENZ 69 PR 186 1387             | G.A. SMITH, R.J. MANNING (MSU+LRL)                         |
| SMITH 69 PRL 23 335                 | +SCHARENGUIVEL, GUTAY, MILLER+ (PURD+PENN)                 |
| SCHARENG 70 NP B 22 16              | +SCHARENGUIVEL, GUTAY, MILLER+ (PURD+PENN)                 |
| OH 70 PR D 1 2494                   | +GARFINKEL, MORSE, WALKER, PRENTICE (WISC+TNT)             |
| SHIBATA 70 PRL 25 1227              | +FRISCH, WAMLIG (MIT)                                      |
| ALSTON-G 71 PL 36 B 152             | ALSTON-GARNJOST, BARBARO-GALTIERI+ (LRL)                   |
| BANAIGS 71 NP 8 28 509              | +BERGER, DUPLD, GOLDOZAM, COTTEREA+ (SACL+CAEN)            |
| BEAUPRE 71 NP 8 28 77               | +DEUTSCHMANN, GRAESSLER+ (AACH+BERL+CERN)                  |
| BENSINGER 71 PL 36 B 134            | BENSINGER, ERWIN, THOMPSON, W.D. WALKER (WISC)             |
| DUBAL 71 NP 8 32 535                | L. DUBAL, D.J. BROWN (CMC+CARL)                            |
| EREL 71 NP 8 33 317                 | +MULLENSIEFEN+ (KARL+CERN+LOUC+RHEL+MIM)                   |
| ELVEKJAE 71 PREPRINT RPP/C22        | F. ELVEKJAE, H. NIELSEN (NORDITA+RHEL)                     |
| GUTAY 71 NP 8 27 486                | +SCHARENGUIVEL, FUCHS, GAIOS, MILLER+ (PURD)               |

|                                                        |                                  |
|--------------------------------------------------------|----------------------------------|
| HAMILTON 71 SPRINGER TRACTS MOD. PHYS., VOL. 57, P. 41 | J. HAMILTON (NORDITA)            |
| KIM 71 PR D 4 265                                      | +BANDER (LUCI)                   |
| LYNG PET 71 PHYS. REPTS. 2 155                         | J. LYNG PETERSEN (REVIEW) (CERN) |
| MORGAN 71 PREPRINT RPP/C30                             | D. MORGAN (RHEL)                 |

|                                   |                                                  |
|-----------------------------------|--------------------------------------------------|
| APEL 72 PL 41 B 542               | +AUSLANDER, MULLER, BERTOLUCCI+ (KARL+PISA)      |
| BAILLON 72 PL 38 B 555            | +CARNegie, KLUGE, LEITH, LYNCH, RATCLIFF+ (SLAC) |
| BASDEVANT 72 PL 41 B 178          | BASDEVANT, FROGGATT, PETERSEN (CERN)             |
| BRODY 72 PRL 28 1217              | H. BRODY (PENN+VLANIA)                           |
| BRODY 72 PRL 28 1215              | +GROVES, MAGLICH, NOREM+ (PENN+RUTG+UPNJ)        |
| CARROLL 72 PRL 28 318             | +DIAMOND, FIREBAUGH, MATTHEWS+ (WISC+TNT)        |
| DIEBOLD 72 BATAV. CONF.           | R. DIEBOLD RAPPOURTEUR TALK (IANL)               |
| ELVEKJAE 72 NP 8 43 445           | F. ELVEKJAE (AARHUS)                             |
| FLATTE 72 PL 38 B 232             | +ALSTON-GARNJOST, BARBARO-GALTIERI+ (LRL)        |
| FRENKIEL 72 NP 8 47 61            | +GHESQUIERE, LILLET, CHUNG+ (CDEF+CERN)          |
| GAIOS 72 NP 8 46 449              | +MILWAIN, THOMPSON, WILLMAN (PURDUE)             |
| GRAYER 72 PHIL. CONF. PROC. 5     | +HYAMS, JONES, SCHLEIN, BLUM, DIETL+ (CERN+MPI)  |
| ODDRICO 72 PREP. ANL/HEP7204      | R. OODRICO (CERN)                                |
| PRASAD 72 PR D 6 3216             | +BREHM (UNIV. OF MASSACHUSETTS)                  |
| PROTOPOPE 72 PHIL. CONF. PROC. 17 | +ALSTON, BARBARO, FLATTE, FRIEDMAN+ (LRL)        |
| PROTOPPE 72 LBL 970 SUBM. PR      | +LASINSKI, LYNCH, RABIN, SOLMITZ (LRL)           |
| RISSEY 72 PREP. OPH T/72/50       | T. RISSEY, M.D. SHUSTER (SACL)                   |
| SKUJA 72 BATAV. CONF. PAPER       | +WAMLIG, RISSEY, PRIPSTEIN, NELSON+ (LRL)        |
| WHITEHEAD 72 NP 8 48 365          | WHITEHEAD, AUDL+ (AER+RHEL+SMH+LOUC)             |
| WILLIAMS 72 PR D 6 3178           | P.K. WILLIAMS (FSU)                              |
| ZYLBERST 72 PL 38 B 457           | ZYLBERST, JEAN, BASILE, BOURQUIN+ (IGEVA+SACL)   |

|                      |                           |
|----------------------|---------------------------|
| FUJII 73 NC 13 A 311 | Y. FUJII, M. KATO (TOKYO) |
|----------------------|---------------------------|

 $\rho(770)$ 

9 RHO (770, JPC = 1-+ ) I=1

## 9 RHO MASS (MEV)

|   |                                                                                                             |       |
|---|-------------------------------------------------------------------------------------------------------------|-------|
| M | WE DO NOT LIST ALL VALUES PUBLISHED. WE AVERAGE ONLY THE MOST SIGNIFICANT DETERMINATIONS OF MASS AND WIDTH. | 2/73* |
| M | SOME OF THE RHO 0 DATA MAY BE INFLUENCED BY RHO-OMEGA INTERFERENCE.                                         | 2/73* |

|   |               |                 |              |       |
|---|---------------|-----------------|--------------|-------|
| M | MIXED CHARGES | ALITI 63 HBC    | -0.16 P1-P   | 2/73* |
| M | 240 (752.0)   | CHADWICK 63 HBC | +0.00 PBAR P | 2/73* |
| M | 290 (755.0)   |                 |              |       |

|   |                                                                     |                  |                                              |       |
|---|---------------------------------------------------------------------|------------------|----------------------------------------------|-------|
| M | CHARGED ONLY                                                        |                  |                                              |       |
| M | (748.0)                                                             | KENNEY 62 HBC    | -1.2 P1-P                                    |       |
| M | 130 (775.0)                                                         | GURIGROSS 63 HBC | -3.3 P1-P                                    |       |
| M | R (760.0) (9.0)                                                     | CARMONY 64 HBC   | +3.5 P1+P, TCUT 4                            |       |
| M | S (760.0) (10.1)                                                    | ARMENISE 65 HBC  | +2.8 P1+P                                    | 6/66  |
| M | R (768.0) (5.0)                                                     | BIEDEN 65 HBC    | -3.5 P1- P                                   | 6/66  |
| M | R (765.0) (5.0)                                                     | ALFF-STEI 66 HBC | +2.3 P1+ P                                   | 6/66  |
| M | R (760.0) (5.0)                                                     | HAGOPIAN 66 HBC  | -3.0 P1- P                                   | 6/66  |
| M | R (765.0) (5.0)                                                     | HAGOPIAN 66 HBC  | -2.14 P1-TCUT12                              | 9/67  |
| M | R 2775 (10.5)                                                       | JAMES 66 HBC     | -2.3 P1-TCUT 20                              | 6/68  |
| M | R (758.0) (10.0)                                                    | JAMES 66 HBC     | +2.1 P1-TCUT2.5                              | 8/66  |
| M | R (749.0) (3.0)                                                     | WEST 66 HBC      | -2.1 P1- P                                   | 10/66 |
| M | B (755.0) (10.0)                                                    | ALLES-BOR 67 HBC | +5.7 PBAR P                                  | 12/66 |
| M | Z 7666 (755.0) (5.0)                                                | BATON 67 HBC     | -2.8 P1- P                                   | 10/66 |
| M | Z 900 (758.0) (5.0)                                                 | EISNER 67 HBC    | -4.2 P1-TCUT10                               | 1/73* |
| M | R (768.0) (5.0)                                                     | MILLER 67 HBC    | -2.7 P1-TCUT20                               | 9/66  |
| M | S (777.0) (7.0)                                                     | ABC COLL. 68 HBC | +8 P1+P TO P3P1                              | 5/68  |
| M | R (773.0) (2.0)                                                     | BATON 68 HBC     | -2.8 P1-TCUT13                               | 7/69  |
| M | 1700 (782.0) (5.0)                                                  | FOSTER 68 HBC    | +PBAR P1+P REST                              | 1/73* |
| M | 965.0 (750.0) (1.9)                                                 | PI SUT 68 RVUE   | -1.7-3.2P1-TCUT10                            | 6/68  |
| M | A 9650 (764.3) (19.2)                                               | PI SUT 68 RVUE   | -1.7-3.2P1-TCUT10                            | 6/68  |
| M | A ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY |                  |                                              |       |
| M | X 1300 777.0 5.0                                                    | REYNOLDS 69 HBC  | -2.26 P1- P                                  | 1/73* |
| M | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.     |                  |                                              |       |
| M | AVG 765.9 2.8                                                       |                  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) |       |

|    |                                                                 |                   |                                              |        |
|----|-----------------------------------------------------------------|-------------------|----------------------------------------------|--------|
| MO | NEUTRAL ONLY                                                    |                   |                                              |        |
| MO | 190 (750.0) (20.0)                                              | SAMIOS 62 HBC     | 0.4, 7 P1-P                                  |        |
| MO | R 300 (760.0) (10.0)                                            | ABOLINS 65 HBC    | 0.3, 5 P1+P                                  |        |
| MO | 160 (775.0) (10.0)                                              | GURIGROSS 63 HBC  | 0.3, 3 P1-P                                  |        |
| MO | R 500 (770.0) (10.0)                                            | GOLDBAER 64 HBC   | 0.3, 7 P1+P                                  |        |
| MO | (750.0)                                                         | CLARK 65 OSPK     | 0.1, 5 P1-P                                  |        |
| MO | R (750.0) (5.0)                                                 | ALFF-STEI 66 HBC  | -2.3 P1+ P                                   | 6/66   |
| MO | R (775.0) (5.0)                                                 | HAGOPIAN 66 HBC   | -3.0 P1- P                                   | 6/66   |
| MO | R (770.0) (5.0)                                                 | HAGOPIAN 66 HBC   | -2.1 P1-TCUT 12                              | 2/67   |
| MO | R 4207 (758.0) (7.5)                                            | JACOBS 66 HBC     | -2.3 P1-TCUT 20                              | 6/68   |
| MO | R (765.0) (8.0)                                                 | JAMES 66 HBC      | -2.1 P1+ P                                   | 6/66   |
| MO | R (760.0) (3.0)                                                 | WEST 66 HBC       | -0.1 P1- P                                   | 10/66  |
| MO | P 4000 (765.0) (5.0)                                            | ASSURY 2 67 CNTR  | 0 GAMMA + P8                                 | 1/73*  |
| MO | R (768.0) (2.0)                                                 | BACON 67 HBC      | -1.7 P1- P                                   | 9/67   |
| MO | B 327 (750.0) (10.0)                                            | DANYSZ 67 HBC     | -3.0 P1+P, P6 P1                             | 7/67   |
| MO | R (761.0) (3.0)                                                 | HUME 67 HBC       | -0.2 P1- P                                   | 7/67   |
| MO | R (770.0) (4.0)                                                 | MILLER 67 HBC     | -2.7 P1-TCUT20                               | 9/66   |
| MO | S (770.0) (13.0)                                                | ABC COLL. 68 HBC  | -8 P1+P TO P3P1                              | 5/68   |
| MO | R (775.0) (2.0)                                                 | ARMENISE 68 HBC   | -5.1 P1+D                                    | 6/68   |
| MO | B (745.0) (5.0)                                                 | DONALD 68 HBC     | -1.2 P1+P, 4 PR.                             | 9/68   |
| MO | 1900 (776.0) (5.0)                                              | FOSTER 68 HBC     | -0.2 P1+P AT REST                            | 1/73*  |
| MO | S 2250 (750.0) (3.0)                                            | HYAMS 68 HBC      | -0.12 P1- P                                  | 9/68   |
| MO | S (765.0) (6.0)                                                 | JONES 68 OSPK     | -12P1-TCUT 2.5                               | 5/68   |
| MO | S (745.0) (13.0)                                                | JONES 68 OSPK     | -18P1-TCUT 2.5                               | 5/68   |
| MO | S (760.0) (5.0)                                                 | KEY 68 HBC        | -0.3 P1- P                                   | 5/68   |
| MO | 13300 766.7 2.8                                                 | PI SUT 68 RVUE    | -1.7-3.2P1-TCUT10                            | 1/73*  |
| MO | E 1751.0 (9.0)                                                  | AUSLANDER 69 OSPK | 0 E+E- COLL. BEAMS                           | 6/68   |
| MO | E SEE ALSO HALLSINSKI 69, WHO FITS AUSLANDER 69 DATA            |                   |                                              |        |
| MO | E 768.0 10.0                                                    | HAISINSKI 69 RVUE | 0 E+E- COLL. BEAMS                           | 12/72* |
| MO | R (768.0) (2.4)                                                 | NALAND 69 RVUE    | -2.4 P1- P                                   | 1/73*  |
| MO | S (755.0) (15.0)                                                | MOTT 69 HBC       | -4.1-5.5 K- P                                | 7/69   |
| MO | X 1700 775.0 5.0                                                | REYNOLDS 69 HBC   | -2.2 P1-TCUT10                               | 1/73*  |
| MO | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS. |                   |                                              |        |
| MO | C 759.0 7.0                                                     | SCHAREN 69 HBC    | -2.4 P1- P                                   | 1/73*  |
| MO | P (765.0) (10.0)                                                | ALVENSEB 70 CNTR  | 0 GAMMA, TCUT.01                             | 1/73*  |
| MO | CT2630 (760.0) 4                                                | BATON 70 HBC      | -2.8 P1- P                                   | 1/71   |
| MO | X 140X 775.0 7.3                                                | BIGGS 70 CNTR     | 0 PHOTOPRODUCTION                            | 1/73*  |
| MO | S (765.0) (6.0)                                                 | GALLOWAY 70 HBC   | -5.97 P1- P                                  | 1/71   |
| MO | C 761.0 5.0                                                     | BAILLON 72 ASKP   | -15. P1- P                                   | 1/73*  |
| MO | 1930 767.0 4.0                                                  | BALLAM 72 HBC     | -0.28 GAMMA P                                | 1/73*  |
| MO | 2430 770.0 4.0                                                  | BALLAM 72 HBC     | -0.47 GAMMA P                                | 1/73*  |
| MO | R 775.0 4.3                                                     | BENAKAS 72 OSPK   | 0 E+E- COLL. BEAMS                           | 2/72   |
| MO | Z 11200 773.5 1.7                                               | JACOBS 72 HBC     | -0.28 P1- P                                  | 1/73*  |
| MO | C 32000 775.0 4.0                                               | PROTOPOPE 72 HBC  | -0.7 P1+P, TCUT.4                            | 1/73*  |
| MO | Z 900 764.0 5.0                                                 | RATCLIFF 72 ASKP  | -15. P1- P                                   | 1/73*  |
| MO | 880 787.0 10.0                                                  | TAKAHASHI 72 HBC  | -0.8 P1- P                                   | 1/73*  |
| MO | AVG 770.3 1.2                                                   |                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |        |
| MO |                                                                 |                   | (SEE IDEOGRAM BELOW)                         |        |

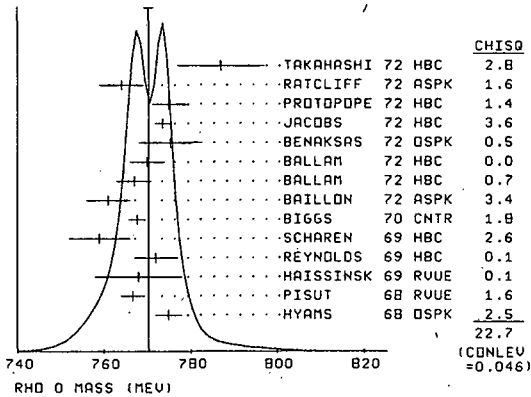
# Data Card Listings

For notation, see key at front of Listings.

## Mesons

$\rho(770)$

WEIGHTED AVERAGE = 770.3 ± 1.2  
ERROR SCALED BY 1.3



CHISO

|            |         |     |
|------------|---------|-----|
| TAKAHASHI  | 72 HBC  | 2.8 |
| RATCLIFF   | 72 ASPK | 1.6 |
| PROTOPDOPE | 72 HBC  | 1.4 |
| JACOBS     | 72 HBC  | 3.6 |
| BENAKSAS   | 72 OSPK | 0.5 |
| BALLAN     | 72 HBC  | 0.0 |
| BALLAN     | 72 HBC  | 0.7 |
| BALLON     | 72 ASPK | 3.4 |
| BIGGS      | 70 CNTR | 1.8 |
| SCHAREN    | 69 HBC  | 2.6 |
| REYNOLDS   | 69 HBC  | 0.1 |
| HAISSINSKI | 69 RVUE | 0.1 |
| PIST       | 68 RVUE | 1.6 |
| HYAMS      | 68 OSPK | 2.5 |

(CONLEV = 0.046)

22.7

NOTES-

M C FROM POLE EXTRAPOLATION  
M R INCLUDED IN PISUT 68 RVUE  
M S S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES  
M B HIGH COMBINATORIAL BACKGROUND  
M P FROM PHOTOPRODUCTION, MODEL DEPENDENT.  
M Z ERRORS INCREASED BY US. SEE TYPED NOTE ON K\* MASS.

9 (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

|   |     |     |       |         |               |      |
|---|-----|-----|-------|---------|---------------|------|
| D | 2.4 | 2.1 | PISUT | 68 RVUE | PI N TO RHO N | 6/68 |
|---|-----|-----|-------|---------|---------------|------|

9 RHO WIDTH (MEV)

SEE NOTE ON RHO MASS ABOVE

|   |                                                                 |             |           |         |                     |       |
|---|-----------------------------------------------------------------|-------------|-----------|---------|---------------------|-------|
| M | MIXED CHARGES                                                   | 290 (110.0) | CHADWICK  | 63 HBC  | → 0.0 PBAR P        |       |
| M | CHARGED ONLY                                                    | 130 (125.0) | GUIRAGOSS | 63 HBC  | - 3.3 PI-P          |       |
| M | 190 (150.0)                                                     | (10.0)      | SACLAY    | 63 HBC  | + 2.8 PI+P          |       |
| M | 98 (180.0)                                                      |             | BONDAR    | 64 HBC  | - 4.1 PI-P          |       |
| M | 77.0 (20.0)                                                     |             | CARMONY   | 64 HBC  | + 3.5 PI+P, TCUT 4  |       |
| M | 160.1 (10.1)                                                    |             | ARMENISE  | 65 HBC  | + 2.8 PI+P          |       |
| M | 100.0 (10.0)                                                    |             | ALFF-STEI | 66 HBC  | - 2.3 PI+P          | 6/66  |
| M | 127.0 (5.0)                                                     |             | BLIEDEN   | 66 MSP  | - 3.5 PI+P          | 6/66  |
| M | 150.0 (20.0)                                                    |             | HAGOPIAN1 | 66 HBC  | - 3.0 PI+P          | 6/66  |
| M | 135.0 (20.0)                                                    |             | HAGOPIAN2 | 66 HBC  | - 2.14 PI-P, LOW T  | 9/67  |
| M | 2775 (137.1)                                                    | (20.0)      | JACOBS    | 66 HBC  | - 2-3PI-, T CUT 20  | 6/68  |
| M | 147.0 (19.0)                                                    |             | JAMES     | 66 HBC  | + 2.1 PI+, TCUT 2.5 | 8/66  |
| M | 149.0 (13.0)                                                    |             | WEST      | 66 HBC  | - 2.1 PI+P          | 10/66 |
| M | 146.1 (31.1)                                                    |             | ALLES-BOR | 67 HBC  | + 5.7 PBAR P        | 12/66 |
| M | 7666 (110.0)                                                    | (9.0)       | BATON     | 67 HBC  | - 2.8 PI+P          | 10/67 |
| M | 900 146.1                                                       | 13.1        | EISNER    | 67 HBC  | - 4.2 PI-, T CUT10  | 9/67  |
| M | 153.0 (13.0)                                                    |             | MILLER    | 67 HBC  | - 2.7 PI-, T CUT20  | 9/66  |
| M | 149.0 (22.0)                                                    |             | ABR COLL. | 68 HBC  | + 8 PI+P TO P+3PI   | 5/68  |
| M | 150.0 (5.0)                                                     |             | BATON     | 68 HBC  | - 2.8 PI+P          | 7/69  |
| M | 1700 (145.0)                                                    | (10.0)      | FOSTER    | 68 HBC  | + PBAR P AT REST    | 1/73* |
| M | 9650 147.3                                                      | 4.0         | PISUT     | 68 RVUE | - 1.7-3.2PI-, CT10  | 6/68  |
| M | 1300 154.0                                                      | 12.0        | REYNOLDS  | 69 HBC  | - 2.26 PI+P         | 1/73* |
| M | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS. |             |           |         |                     |       |
| M | AVG                                                             | 147.7       | 3.6       |         |                     |       |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

|   |                                                                 |        |                                                   |         |                    |        |
|---|-----------------------------------------------------------------|--------|---------------------------------------------------|---------|--------------------|--------|
| W | NEUTRAL ONLY                                                    |        |                                                   |         |                    |        |
| W | 190 (150.0)                                                     | (20.0) | SAMIOS                                            | 62 HBC  | 0 4.7 PI-P         |        |
| W | 300 (90.0)                                                      | (10.0) | ABOLINS                                           | 63 HBC  | 0 3.5 PI+P         |        |
| W | 160 (175.0)                                                     |        | GUIRAGOSS                                         | 63 HBC  | 0 3.5 PI-P         |        |
| W | 500 (130.0)                                                     |        | GOLDHABER                                         | 64 HBC  | 0 3.7 PI+P         |        |
| W | 100.0 (10.0)                                                    |        | CLARK                                             | 65 OSPK | 0 1.5 PI+P         |        |
| W | 120.0 (10.0)                                                    |        | ALFF-STEI                                         | 66 HBC  | 0 2-3 PI+P         | 6/66   |
| W | 135.0 (20.0)                                                    |        | HAGOPIAN1                                         | 66 HBC  | 0 3.0 PI+P         | 6/66   |
| W | 122.2 (15.0)                                                    |        | HAGOPIAN2                                         | 66 HBC  | 0 2.14 PI-P, LOW T | 9/67   |
| W | 4207 (103.0)                                                    | (15.0) | JACOBS                                            | 66 HBC  | 0 2-3PI-, T CUT 20 | 6/68   |
| W | 102.1 (13.0)                                                    |        | JAMES                                             | 66 HBC  | 0 2.1 PI+P         | 6/66   |
| W | 150.0 (15.0)                                                    |        | WEST                                              | 66 HBC  | 0 2.1 PI+P         | 10/66  |
| W | 4000 (130.0)                                                    | (5.1)  | ASBURY 2                                          | 67 CNTR | 0 GAMMA + PB       | 1/73*  |
| W | 148.0 (8.0)                                                     |        | BACON                                             | 67 HBC  | 0 1.7 PI+P         | 9/67   |
| W | 327 (135.0)                                                     | (25.1) | DARYSZ                                            | 67 HBC  | 0 3.0 PB P, 6 PI   | 1/73*  |
| W | 152.1 (15.1)                                                    |        | HUME                                              | 67 HBC  | 0 2.4 PI+P         | 7/67   |
| W | 150.0 (15.0)                                                    |        | MILLER                                            | 67 HBC  | 0 2.7 PI-, T CUT20 | 9/66   |
| W | 165.0 (10.0)                                                    |        | ABR COLL.                                         | 68 HBC  | 0 8 PI+P TO P+3PI  | 5/68   |
| W | 167.0 (16.0)                                                    |        | ARMENISE                                          | 68 HBC  | 0 5.1 PI+D         | 6/68   |
| W | 150.0 (13.0)                                                    |        | DONALD                                            | 68 HBC  | 0 1.2 PB P, 4 PR.  | 9/68   |
| W | 1900 (132.1)                                                    | (10.1) | FOSTER                                            | 68 HBC  | 0 PBAR P AT REST   | 1/73*  |
| W | 2250 145.0                                                      | 12.0   | HYAMS                                             | 68 OSPK | 0 11.2 PI+P        | 1/73*  |
| W | 129.0 (19.0)                                                    |        | JONES                                             | 68 OSPK | 0 12PI-, T LT 2.5  | 5/68   |
| W | 169.0 (41.0)                                                    |        | JONES                                             | 68 OSPK | 0 18PI-, T LT 2.5  | 5/68   |
| W | 113.0 (16.0)                                                    |        | KEY                                               | 68 HBC  | 0 3.0 PI+P         | 5/68   |
| W | 150.0 (15.0)                                                    |        | LANZEROTT                                         | 68 CNTR | 0 GAMMA P          | 1/73*  |
| W | 14890 (105.0)                                                   | (15.0) | MARATECK                                          | 68 HBC  | 0 1.9-3.0 PI+P     | 9/68   |
| W | 1105.0 (20.0)                                                   |        | AUSLENDER                                         | 69 OSPK | 0 E+E- COLL.BEAMS  | 6/68   |
| W | E                                                               |        | SEE ALSO HISSINSKI 69, WHO FITS AUSLENDER 69 DATA |         |                    |        |
| W | 140.1                                                           | 14.1   | HAISSINSKI                                        | 69 RVUE | 0 E+E- COLL.BEAMS  | 12/72* |
| W | 132.0 (13.0)                                                    |        | MALANUD                                           | 69 RVUE | 0 2-4 PI+P         | 1/73*  |
| W | 130.0 (140.0)                                                   |        | MOTT                                              | 69 HBC  | 0 4.1-5.5 K- P     | 7/69   |
| W | 1700 135.0                                                      | 16.0   | REYNOLDS                                          | 69 HBC  | 0 2.26 PI+P        | 1/73*  |
| W | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS. |        |                                                   |         |                    |        |

|   |                |              |      |            |         |                    |        |
|---|----------------|--------------|------|------------|---------|--------------------|--------|
| W | C              | 119.0        | 20.0 | SCHAREN    | 69 HBC  | 0 2-4 PI- P        | 1/73*  |
| W | P              | 140.0 (15.0) |      | ALVENSLEB  | 70 CNTR | 0 GAMMA A, TCUT.01 | 1/73*  |
| W | C12630         | 131.0 (10.0) |      | BATON      | 70 HBC  | 0 2.8 PI- P        | 1/71   |
| W | 140K           | 146.1        | 2.9  | BIGGS      | 70 CNTR | 0 PHOTOPRODUCTION  | 1/73*  |
| W | S              | 120.0 (7.0)  |      | GALLOWAY   | 70 HBC  | 0 5.97 PI- P       | 1/71   |
| W | C              | 108.0        | 20.0 | BAILLON    | 72 ASPK | 0 15. PI- P        | 1/73*  |
| W | Z              | 2430 155.0   | 12.0 | BALLAN     | 72 HBC  | 0 4.7 GAMMA P      | 1/73*  |
| W | Z              | 1930 145.0   | 13.0 | BALLAN     | 72 HBC  | 0 2.8 GAMMA P      | 1/73*  |
| W |                | 149.6        | 23.2 | BENAKSAS   | 72 OSPK | 0 E+E- COLL.BEAMS  | 12/72* |
| W | 11200 (178.35) | (2.5)        |      | JACOBS     | 72 HBC  | 0 2.8 PI- P        | 1/73*  |
| W | C              | 32000 160.0  | 10.0 | PROTOPDOPE | 72 HBC  | 0 7.1 PI+P, TCUT.4 | 1/73*  |
| W | Z              | 900 157.0    | 21.0 | RATCLIFF   | 72 ASPK | 0 15. PI- P        | 1/73*  |
| W | Z              | 880 144.0    | 19.0 | TAKAHASHI  | 72 HBC  | 0 8.0 PI- P        | 1/73*  |
| W | AVG            | 146.0        | 2.4  |            |         |                    |        |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

NOTES-

M C FROM POLE EXTRAPOLATION  
M R INCLUDED IN PISUT 68 RVUE  
M S S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES  
M B HIGH COMBINATORIAL BACKGROUND  
M P FROM PHOTOPRODUCTION, MODEL DEPENDENT.  
M Z ERRORS INCREASED BY US. SEE TYPED NOTE ON K\* MASS.

9 RHO PARTIAL DECAY MODES

|    |                                   |                    |
|----|-----------------------------------|--------------------|
| P1 | RHO INTO 2PI                      | 139+ 139           |
| P2 | RHO INTO 4PI                      | 139+ 139+ 139+ 139 |
| P3 | RHO INTO PI GAMMA                 | 139+ 0             |
| P4 | RHO INTO E+ E-                    | 5+ 5               |
| P5 | RHO INTO PI ETA (VIOLATES G)      | 139+ 548           |
| P6 | RHO INTO MU+ MU-                  | 105+ 105           |
| P7 | RHO INTO PI+ PI- PI0 (VIOLATES G) | 139+ 139+ 134      |

9 RHO BRANCHING RATIOS

|    |                                           |                                                 |                   |       |
|----|-------------------------------------------|-------------------------------------------------|-------------------|-------|
| R1 | RHO INTO 4PI/2PI                          |                                                 | (P2)/(P1)         |       |
| R1 | RHO+ INTO (PI+ PI+ PI- PI0) / (PI+ PI0)   |                                                 | { }               |       |
| R1 | (0.026) OR LESS                           | DEUTSCHMA 66 MSP                                | - 3.5 PI- P       | 6/66  |
| R1 | (0.011) OR LESS                           | DEUTSCHMA 66 HBC                                | + 8.0 PI+ P       | 6/66  |
| R1 | (0.002) OR LESS                           | FERBEL 66 HBC                                   | + PI+ P ABOVE 2.5 | 10/66 |
| R1 | 0.0035 0.004                              | JAMES 66 HBC                                    | + 2.1 PI+ P       | 11/66 |
| R1 | RHOD INTO (PI+ PI- PI+ PI- ) / (PI+ PI- ) |                                                 |                   |       |
| R1 | (0.008) OR LESS                           | JAMES 66 HBC                                    | 0 2.1 PI+P        | 6/66  |
| R1 | (0.002) OR LESS                           | CHUNG 68 HBC                                    | 0 3.2, 4.2 PI-P   | 7/67  |
| R1 | (0.002) OR LESS                           | HUSON 68 HBC                                    | 0 16.0 PI- P      | 1/71  |
| R1 | (0.0015) OR LESS                          | CL=90 GERMAN CO 69 HBC                          | 0 2.5-5.8 GAMMA P | 10/67 |
| R2 | RHO INTO PI GAMMA/2PI                     |                                                 | (P3)/(P1)         |       |
| R2 | (0.02) OR LESS                            | LANZEROTT 65 CNTR                               | GAMMA P (BRENS)   |       |
| R2 | (0.005) OR LESS                           | CL=97 FIOCARD 66 OSPK                           |                   |       |
| R2 | (0.007) OR LESS                           | HUSON 66 HBC                                    | - 15 PI-PB        |       |
| R2 | (0.002) OR LESS                           | CL=90 GERMAN CO 69 HBC                          |                   |       |
| R2 | M                                         | ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION |                   |       |

Note on  $\rho^0 \rightarrow e^+ e^-$

Extraction of a ratio for  $\rho^0 \rightarrow e^+ e^-$  is complicated by interference with  $\omega^0$  decay. In photoproduction,  $\gamma A \rightarrow e^+ e^- A$ , there is substantial interference between the allowed  $(\rho^0, \omega) \rightarrow e^+ e^-$  decays. The interference in the colliding-beam reaction  $e^+ e^- \rightarrow \pi^+ \pi^-$  is due to G parity violating mixing of the overlapping  $\rho^0$  and  $\omega$  resonances; it alters the results for the rate  $\Gamma(\rho^0 \rightarrow e^+ e^-)$  only by a small amount. Therefore we use at present, for the average, only the values from the  $e^+ e^- \rightarrow \pi^+ \pi^-$  experiments.

|    |                                      |                                                         |                     |        |
|----|--------------------------------------|---------------------------------------------------------|---------------------|--------|
| R3 | RHO INTO(E-)/(PI+)(-) (UNITS 10**+4) | (P4)/(P1)                                               |                     |        |
| R3 | P 94 (0.65) (0.14)                   | ASBURY 1 67 CNTR                                        | PHOTOPRODUCTION     | 9/67   |
| R3 | P                                    | POSSIBLY LARGE RHO-OMEGA INTERFERENCE                   |                     |        |
| R3 | H (0.65) (1.1) (0.5)                 | HERTZBACH 67 OSPK                                       | ASSUME SU(3)+MIXING | 10/66  |
| R3 | H                                    | NOT SEPARATED FROM OMEGA DECAY.                         |                     |        |
| R3 | A 33 (0.53) (0.11)                   | ASTVACATU 68 OSPK                                       | ASSUME SU(3)+MIXING | 6/68   |
| R3 | A                                    | NOT SEPARATED FROM OMEGA DECAY, ERROR STATISTICAL ONLY. |                     |        |
| R3 | E (0.663) (0.085)                    | AUGUST11 69 OSPK                                        | E+E- COLLID.BEAM    | 4/69   |
| R3 | E                                    | ASSUMING RHO WIDTH 111 MEV                              |                     |        |
| R3 | E 0.50 0.10                          | AUSLENDER 69 OSPK                                       | E+E- COLLID.BEAM    | 9/68   |
| R3 | F (0.49) (0.12) (0.15)               | BIGGS 70 CNTR                                           | PHOTOPRODUCTION     | 6/70   |
| R3 | F                                    | ASSUMING RHO WIDTH 140 MEV, ERROR STATISTICAL ONLY.     |                     |        |
| R3 | F 0.41 0.05                          | BENAKSAS 72 OSPK                                        | E+E- COLL.BEAMS     | 12/72* |
| R3 | AVG 0.428 0.045                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)            |                     |        |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

|    |                         |           |                            |       |
|----|-------------------------|-----------|----------------------------|-------|
| R4 | RHO INTO (PI ETA)/(2PI) |           | (P5)/(P1)                  |       |
| R4 | (0.03) OR LESS          | DEUTSCHMA | 66 HBC + 8.0 PI+ P         | 6/66  |
| R4 | (0.008) OR LESS         | FERBEL    | 66 HBC +- PI+- P ABOVE 2.5 | 11/66 |

## Mesons

 $\rho(770)$ ,  $\omega(784)$ 

| R5 | RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10 <sup>-4</sup> )         | (P6)/(P1) |
|----|----------------------------------------------------------------|-----------|
| R5 | SEE NOTE UNDER RHO INTO E+E- ABOVE                             |           |
| R5 | 0.97 0.31 0.33 HYAMS 67 OSPK 11 PI- LI H                       | 6/67      |
| R5 | HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.    |           |
| R5 | 0.82 0.16 0.36 ROTHWELL 69 CNTR PHOTOGRAPHY                    | 4/70      |
| R5 | POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE     |           |
| R5 | THE MINUS ERROR                                                |           |
| R5 | 0.56 0.15 WEHMAN 69 OSPK 12 PI- ON C, FE                       | 7/69      |
| R5 | RESULTS CONTAINS (11 +- 1) PER CENT CORRECTION USING SU(3)     |           |
| R5 | FOR CENTRAL VALUE, THE ERROR ON THE CORRECTION TAKES ACCOUNT   |           |
| R5 | OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES  |           |
| R5 | W WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT. |           |
| R5 | 0.67 0.12 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)         |           |

| R6 | RHO O INTO (PI+ PI- P1)/(PI+ PI-)                          | (P7)/(P1) |
|----|------------------------------------------------------------|-----------|
| R6 | (0.01) OR LESS CL-84 ABRAMS 71 HBC 0 3.7 PI+ P             | 11/71     |
| R6 | MODEL DEPENDENT, ASSUMES I = 1, 2, OR 3 FOR THE 3PI SYSTEM | 11/71     |

## REFERENCES FOR RHO

|                                |                                                      |
|--------------------------------|------------------------------------------------------|
| ANDERSON 61 PRL 6 365          | ANDERSON, BANG, BURKE, CARMONY, SCHMITZ (LRL)        |
| ERWIN 61 P 6 628               | A.R., R. MARCH, M.D., WALKER, E. WEST (WISC)         |
| KENNEY 62 PRL 126 736          | P. KENNEY, M.D. SHEPARD, C.D. GALL (KENTUCKY)        |
| SAMIOS 62 PRL 9 139            | SAMIOS, BACHMAN, LEA* (BNL-CUNY+COLU+KNY)            |
| XUONG 62 PRL 128 1849          | NGUYEN HUU XUONG, GERALD R. LYNCH (LRL)              |
| ABOLINS 63 PRL 11 381          | ABOLINS, LANDER, MEHLHOP, NGUYEN, YAGER (UCSD)       |
| ALITTI 63 NC 29 515            | ALITTI, BATON, ARMINISE* (SACL+ORSA+BARI+BGNA)       |
| CHADWICK 63 PRL 10 62          | CHADWICK, DAVIES, DERRICK, CRESTI* (OXF+PADO)        |
| GUIRAGOS 63 PRL 11 85          | ZAVEN GUIRAGOSIAN (LRL)                              |
| SACLAY 63 SIENA CONF 1 239     | SACLAY+ORSAY+BARI* BOLOGNA- COLLABORATION            |
| BONDAR 64 NC 31 729            | BONDAR* (AACHEN+BIRM+BOON+DESY+LOIC+MPI)             |
| CARMONY 64 DUBNA CONF 1 486    | CARMONY, HOA, LANDER, NG, H. XUONG, YAGER (UCSD)     |
| GOLDHABE 64 PRL 12 336         | GOLDHABER, BROHN, KADYK, SHEN* (LRL+UCB)             |
| ALYEA 65 PL 15 82              | ALYEA, CRITTENDEN, MARTIN, RHODE* (INDIANA)          |
| ARMINISE 65 NC 37 361          | SACLAY+ORSAY+BARI* BOLOGNA- COLLABORATION            |
| BLIEDEN 65 PL 19 444           | CERN MISSING MASS SPECTROMETER GROUP (CERN)          |
| CLARK 65 PL 139 B 1556         | A. CLARK, CHRISTENSEN, CRONIN, TURLAY (PRINCETON)    |
| GUTAY 65 NC 39 381             | GUTAY, LANNUTTI, TULLI (FSU)                         |
| LANZEROT 65 PRL 15 210         | LANZEROTTI, BLUMENFELD, ENH, FAISSLER* (HARV)        |
| ZDANIS 65 PRL 14 721           | ZDANIS, MADANSKY, KRAEMER* (JHU+BNL)                 |
| ACCENS 66 PL 20 557            | ACCENS, ALLES-BORELLI, FRENCH, FRISK* (CERN)         |
| ALFF-STEE 66 PRL 145 1072      | ALFF-STEINBERGER, BERLEY, BRUGGER* (COLU+RUTG)       |
| BALTAY 66 PRL 126 131          | BALTAY, GELMINI, LUTJE, SEVERINS, TYCKO* (COLU+RUTG) |
| BLIEDEN 66 NC 43 71            | CERN MISSING MASS SPECTROMETER GROUP (CERN)          |
| CAMBRIDGE 66 PRL 146 994       | CAMBRIDGE BUBBLE CHAMBER GROUP (MIT+HARV)            |
| CASON 66 PRL 148 1282          | N. M. CASON (WISCONSIN)                              |
| DEUTSCHM 66 PL 20 82           | DEUTSCHMANN, STEINBERG* (AACH+BERLIN+ CERN)          |
| FERDEL 66 PL 21 111            | FERDEL (ROCHESTER)                                   |
| FIDECARO 66 PL 23 163          | G.M. FIDECARO, J. POIRIER, P. SCHIAVON (CERN)        |
| HAGOPIAN 66 PRL 145 1128       | HAGOPIAN, SELOVE, ALITTI, BATON* (PENN+SACLAY)       |
| HAGOPIAN 66 PRL 152 1183       | HAGOPIAN, PAN (PENN+SYLVANIA, LRL-BERKELEY)          |
| HUSON 66 PL 20 91              | HUSON, ALLARD, DRIJARD, HENNESSY* (ORSAY+EPOL)       |
| JACOBS 66 UCRL-16877           | L.D. JACOBS (LRL)                                    |
| JAMES 66 PRL 142 896           | F. E. JAMES, KRAYBILL (YALE-BROOKHAVEN)              |
| WEST 66 PRL 149 1089           | WEST, BOYD, ERWIN, WALKER* (WISCONSIN)               |
| ALLES-BO 67 NC 50 A 776        | ALLES-BORELLI, FRENCH, FRISK* (CERN+BOON)            |
| ASBURY 1 67 PRL 19 869         | +BECKER-BERTRAM+JOOS+JORDAN* (DESY+COLU)             |
| ASBURY 2 67 PRL 19 865         | +BECKER-BERTRAM+JOOS+JORDAN* (DESY+COLU)             |
| BACON 67 PRL 157 1263          | +FICKINGER, HILL, HOPKINS, ROBINSON* (BNL)           |
| BANNER 67 PL 25 B 300          | +FAYOUX, HAMEL, ZSEBERRY, CHEZE* (SACLAY+CAEN)       |
| BARLOW 67 PRL 25 B 419         | +LLESTOL-MONTAUDO, J. REIGNIER (SACLAY)              |
| BATON 67 PL 25 B 419           | J. BATON, G. LAURENS, J. REIGNIER (SACLAY)           |
| ALSO 67 NP 8 3 349             | +JOHNSTON+COOPER+MANNER* (INTO+ANL+WISC)             |
| CLEAR 67 NC 49A 399            | DANYSZ+FRENCH+SIHAK (CERN)                           |
| DANYSZ 67 NC 51 A 801          | +JOHNSON+KLEIN+PETERS+SAHNI+YEN* (PURDUE)            |
| EISNER 67 PRL 16 1489          | +KINSON+MCDONALD+RIDDIFORD* (CERN+BIRM)              |
| FRENCH 67 NC 52A 442           | HERTZBACH, KRAEMER, MADANSKI, ZDANIS* (JHU+BNL)      |
| HERTZBACH 67 PRL 155 1461      | +MARGUIT+OPPENHEIMER+SCHULTZ+WILSON (COLU)           |
| ALSO 65 ZDANIS                 | MILLER, GUTAY, JOHNSON, LOEFFLER* (PURDUE)           |
| HUKE 67 PL 248 252             | +BISWAS, CASON, DERADO, KENNEY* (NDAM+PENN)          |
| HYAMS 67 PL 248 824            |                                                      |
| MILLER 67 PRL 153 1423         |                                                      |
| POIRIER 67 PRL 163 1462        |                                                      |
| ABC COLL 68 NP 84 501          | AACHEN+BERLIN+ CERN COLLABORATION                    |
| ARMINISE 68 NC 56A 999         | +GHIDINI, FORINO* (BARI+BGNA+FRIZ+ORSAY)             |
| ASTVACAT 68 PL 27 B 45         | ASTVACATUROV, AZIMOV, BALDIN* (JINR+MOSCOW)          |
| BATON 68 PRL 176 1574          | J.P. BATON, G. LAURENS (SACLAY)                      |
| BLECHSCH 68 NC 53 A 1045       | BLECHSCHMIDT, DOWD, ELSNER* (DESY+MCHS)              |
| ALSO 67 NC 52 1348             |                                                      |
| CHUNG 68 PRL 165 1491          | S.U. CHUNG, O.I. DAHL, J. KIRZ, D.H. MILLER (LRL)    |
| DONALD 68 NP 8 B 6 174         | +EDWARDS, FRODESEN, BETTINI* (LIVP+OSLO+PADO)        |
| FOSTER 68 NP 8 B 6 107         | +GAVILLET+LABROSSE+MONTANET* (CERN+CDEF)             |
| HUSON 68 PL 288 208            | +LUBATTI, SIX, VEILLET* (ORSAY+MIL+UCLA)             |
| HYAMS 68 NP 7 1                | +KOH, POTTER, WILSON, VON LINDERN* (CERN+MPI)        |
| JONES 68 PRL 166 1405          | +BLEULER, CALDWELL, ELSNER, HARTING* (CERN)          |
| JOHNSON 68 PRL 176 1651        | +POIRIER, BISWAS, GUTAY* (NDAM+PURD+SLAC)            |
| KEY 68 PRL 166 1430            | +PRENTICE+COOPER+MANNER* (INTO+ANL+WISC)             |
| LAMSA 68 PRL 166 1395          | +CASON+BISWAS+DERADO+GROVES* (NOTRE DAME)            |
| LANZEROT 68 PRL 163 1521       | LLESTOL-MONTAUDO, ENH, FAISSLER* (HARV)              |
| KARATECK 68 PRL 21 1613        | +HAGOPIAN* (PENN+LRL+COLU+PURD+INTO+WISC)            |
| PISTUT 68 NP 8 B 325           | J. PISTUT, M. ROOS (CERN)                            |
| AUGUST 11 69 PL 28 B 508       | +BIZOT+BUON+HAISSINSKI+LALANNE* (ORSAY)              |
| AUGUST 12 69 LNC 2 214         | +LEFRANCOIS, LEHMANN, MARIN* (ORSAY)                 |
| AUSLENDER 69 SJNP 9 69         | AUSLENDER, BUDKER, PANTUSOVA, PESTOV* (NOVO)         |
| GERMAN C 69 PRL 188 2060       | GERMAN BUBBLE CHAMBER COLL. (DESY)                   |
| HAISSINS 69 ARGONNE CONF. 373  | J. HAISSINSKI (ORSAY)                                |
| JHALLA 69 PRL 184 1461         | +LEACOCK, RHODE, KOPPELMAN, LIBBY* (ISU+COLU)        |
| MALAMUD 69 ARGONNE CONF. P. 93 | E. MALAMUD, P. SCHLEIN (LRL)                         |
| MILLER 69 PRL 178 2061         | R. MILLER, LICHTMAN, WILLMANN (PURDUE)               |
| MOTT 69 PRL 177 1966           | +AMMAR, DAVIS, KROPAC, SLATE, DAGAN* (MNS+ANL)       |
| REYNOLDS 69 PRL 184 1424       | +ALBRIGHT, BRADLEY, BRUCKER, HARMS* (FSU)            |
| ROOS 69 NP 8 B 10 563          | M. ROOS, J. PISTUT (CERN+BRATISLAVA)                 |
| ROTHWELL 69 PRL 163 1521       | +CHASE, EARLES, GETTNER, GLASS, WEINSTEIN* (NEAS)    |
| SCHAREN 69 ARGONNE CONF. 306   | SCHARENGUIVEL (PURDUE)                               |
| WEHMAN 69 PRL 178 2095         | +ENGELS, WILSON* (HARV+CASE+SLAC+ORNL+MCGI)          |

## Data Card Listings

For notation, see key at front of Listings.

|                               |                                                  |
|-------------------------------|--------------------------------------------------|
| ALVENSLE 70 PRL 24 786        | ALVENSLEBEN, BECKER, BERTRAM, CHEN, COHEN (DESY) |
| BATON 70 PL 33 B 128          | +LAURENS, REIGNIER (SACLAY)                      |
| BIGGS 70 PRL 24 1597          | +BRABEN, CLIFFIT, GABATHULER, KITCHING* (DARE)   |
| BINGHAM 70 PRL 24 1955        | +BISWAS, CASON, GROVES, JOHNSON* (NOTRE DAME)    |
| GALLOWAY 70 PR 0 1 3077       | +FRETTER, MOFFETT, BALLAM* (LRL+SLAC+TUFT)       |
|                               | +MOTT, ALYA, LEE, MARTIN, PRICKETT (IND)         |
| ABRAMS 71 PR 0 4 653          | +BARNHAM, BUTLER, COYNE, GOLDHABER, HALL* (LBL)  |
| BLOODWORTH 71 PREPRINT        | BLOODWORTH, JACKSON, PRENTICE, YOON (TORONTO)    |
| DEERY 71 PR 0 9 635           | +BISWAS, CASON, GROVES, JOHNSON* (NOTRE DAME)    |
| DRIVER 71 DESY 71/56          | +HEINLOTH, HOMME, HOFMANN, JANATA, KARON* (DESY) |
| EISENBER 71 SLAC-PUB-933      | EISENBERG, HABER, BALLAM, CHADWICK* (REHO+STAN)  |
| BAILLON 72 PL 38 B 555        | +CARNegie, KLUGE, LEITH, LYNCH, RATCLIFF* (SLAC) |
| BALLAM 72 PR 0 5 545          | +CHADWICK, BINGHAM, MILBURN* (SLAC+LBL+TUFT)     |
| BASDEVAN 72 PL 41 B 178       | BASDEVANT, FROGGATT, PETERSEN (CERN)             |
| BENAKAS 72 PL 39 B 289        | +COSME, JEAN-MARIE, JULLIAN, LAPLANCHE* (ORSAY)  |
| DRIVER 72 NP 8 38 1           | +HEINLOTH, HOMME, HOFMANN, RATHJE* (DESY+HAMB)   |
| EISENBER 72 PR 0 5 15         | EISENBERG, BALLAM, DAGAN* (REHO+SLAC+TELAV)      |
| GRAYER 72 PHIL. CONF. PROC. 5 | +HYAMS, JONES, SCHLEIN, BLUM, DIETL* (CERN+MPI)  |
| GRAYER 72 NP 8 50 29          | +HYAMS, JONES, WEILHAMMER, BLUM* (CERN+MPI)      |
| JACOBS 72 PR 0 6 1291         | L.D. JACOBS (SACLAY)                             |
| RATCLIFF 72 PL 38 B 345       | +BULOS, CARNegie, KLUGE, LEITH, LYNCH* (SLAC)    |
| PROTOPOP 72 PREPRINT LBL-970  | PROTOPOPESCU, ALSTON, BARBARO, FLATTE* (LBL)     |
| TAKAHASHI 72 PR 0 6 1266      | TAKAHASHI, BARISH* (TORO+PENN+NDAM+ANL)          |

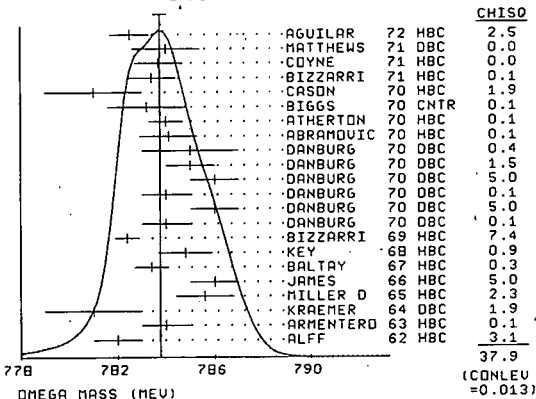
 $\omega(784)$ 

1 OMEGA (784, JP6=1) = 1.0

1 OMEGA MASS (MEV)

HERE WE LIST ONLY EXPERIMENTS IN WHICH THE EFFECTS OF MASS RESOLUTION HAVE BEEN EVALUATED.

| M | FROM FINAL STATE K1 K1 OMEGA            |         |       |                                              |    |      |                       |
|---|-----------------------------------------|---------|-------|----------------------------------------------|----|------|-----------------------|
| M | 64                                      | 779.4   | 1.4   | ARMENTERO                                    | 62 | HBC  | 0.0 PBAR P K1K1       |
| M | 155                                     | 779.5   | 1.5   | BARASH                                       | 67 | HBC  | 0.0 PBAR P K1K1 11/71 |
| M | 510                                     | 781.0   | 0.6   | BIZZARRI                                     | 71 | HBC  | 0.0 P PBAR K1K1 11/71 |
| M | AVG                                     | 780.60  | 0.52  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |    |      |                       |
| M | FROM OTHER FINAL STATES                 |         |       |                                              |    |      |                       |
| M | 400                                     | 782.0   | 1.0   | ALFF                                         | 62 | HBC  | 2.3-2.9 PI+P          |
| M | 34                                      | 784.0   | 1.0   | ARMENTERO                                    | 63 | HBC  | 0.0 PBAR P            |
| M | 220                                     | 781.0   | 2.0   | KRAEMER                                      | 64 | DBC  | 1.2 PI+D              |
| M | 785.6                                   |         |       | MILLER                                       | 65 | HBC  | SEEN WITH K+K-        |
| M | 666                                     | 786.0   | 1.0   | JAMES                                        | 66 | HBC  | 2.1 PI+P 6/66         |
| M | 2198                                    | 783.4   | 0.7   | BALTAY                                       | 67 | HBC  | 0.0 PBAR P 9/66       |
| M |                                         | 784.8   | 1.1   | KEY                                          | 68 | HBC  | 3 PI+P 11/67          |
| M | 2400                                    | 782.4   | 0.5   | BIZZARRI                                     | 69 | HBC  | 0 PBAR P 9/69         |
| M | 250                                     | 784.    | 1.    | DANBURG                                      | 70 | DBC  | 1.2 PI+D 11/71        |
| M | 500                                     | 786.    | 1.    | DANBURG                                      | 70 | DBC  | 1.0 PI+D 11/71        |
| M | 600                                     | 784.    | 1.    | DANBURG                                      | 70 | DBC  | 1.7 PI+D 12/71        |
| M | 500                                     | 786.    | 1.    | DANBURG                                      | 70 | DBC  | 1.9 PI+D 11/71        |
| M | 400                                     | 785.    | 1.    | DANBURG                                      | 70 | DBC  | 2.1 PI+D 11/71        |
| M | 200                                     | 785.    | 2.    | DANBURG                                      | 70 | DBC  | 2.3 PI+D 11/71        |
| M | 750                                     | 784.1   | 1.2   | ARMANDVIC                                    | 70 | HBC  | 3.9 PI+P 6/70         |
| M |                                         | 784.0   | 0.7   | ATHERTON                                     | 70 | HBC  | 3.6 PBAR P, T PI 5/70 |
| M |                                         | 783.2   | 1.6   | BIGGS                                        | 70 | CNTR | PHOTOPRODUCTION 6/70  |
| M | 260                                     | 781.0   | 2.0   | CASON                                        | 70 | HBC  | 8.0 PI+P,4PI 11/71    |
| M | 248                                     | 783.4   | 1.0   | BIZZARRI                                     | 71 | HBC  | 0.0 P PBAR K+K- 11/71 |
| M | C 4270                                  | (784.1) | (0.3) | COYNE                                        | 71 | HBC  | 3.7 PI+P 11/71        |
| M | FROM TOTAL SAMPLE OF COYNE              |         |       |                                              |    |      |                       |
| M | D                                       | 783.7   | 1.0   | COYNE                                        | 71 | HBC  | 3.7 PI+P 11/71        |
| M | FROM BEST-RESOLUTION SAMPLE OF COYNE 71 |         |       |                                              |    |      |                       |
| M | 369                                     | 784.0   | 1.4   | MATTHEWS                                     | 71 | DBC  | 6.95 PI+D 2/71        |
| M | 418                                     | 782.5   | 0.8   | AGUILAR                                      | 72 | HBC  | 3.9,4.4 K- P 12/72    |
| M | AVG                                     | 783.76  | 0.28  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |    |      |                       |
|   |                                         |         |       | (SEE IDEOGRAM BELOW.)                        |    |      |                       |

WEIGHTED AVERAGE = 783.76 ± 0.28  
ERROR SCALED BY 1.3

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $\omega(784)$ 

## 1 OMEGA FULL WIDTH (MEV)

|   |       |                                                   |       |                                              |                                                                   |       |
|---|-------|---------------------------------------------------|-------|----------------------------------------------|-------------------------------------------------------------------|-------|
| W | 34    | 9.0                                               | 3.0   | ARMENTERO 63 HBC                             | 0.0 PBAR P                                                        |       |
| W | 13.6  | 2.0                                               |       | MILLER D 65 HBC                              | SEEN WITH K <sup>+</sup> K <sup>-</sup>                           | 6/66  |
| W | 155   | (12.3)                                            | (2.0) | BARASH 67 HBC                                | SEEN WITH K <sup>+</sup> K <sup>-</sup>                           | 11/71 |
| W | B 171 | (5.8)                                             | (2.8) | BARASH 67 HBC                                | 0.0 PBAR P, K <sup>+</sup> K <sup>-</sup>                         | 11/71 |
| W | B     | UNFOLDED BY COYNE 71                              |       |                                              |                                                                   |       |
| W | 750   | 6.8                                               | 3.0   | ABRAMOVICH 70 HBC                            | 3.9 P <sup>+</sup> P <sup>-</sup>                                 | 6/70  |
| W | 11.2  | 2.7                                               |       | ATHERTON 70 HBC                              | 3.6 PBAR P, 7 P <sup>+</sup>                                      | 5/70  |
| W | 510   | 10.3                                              | 1.4   | BIZZARRI 71 HBC                              | 0.0 P PBAR K <sup>+</sup> K <sup>-</sup>                          | 11/71 |
| W | 248   | 12.8                                              | 3.0   | BIZZARRI 71 HBC                              | 0.0 P PBAR K <sup>+</sup> K <sup>-</sup>                          | 11/71 |
| W | 4270  | 9.5                                               | 1.0   | COYNE 71 HBC                                 | 3.7 P <sup>+</sup> P <sup>-</sup>                                 | 11/71 |
| W | 418   | 13.3                                              | 2.8   | AGUILAR 72 HBC                               | 3.9, 4.6 K <sup>+</sup> P <sup>-</sup>                            | 12/72 |
| W | 9.1   | 0.8                                               |       | BARAKSAS 72 OSPK                             | E <sup>+</sup> E <sup>-</sup> COLL. BEAMS                         | 2/73  |
| W | E 940 | 7.70                                              | 1.65  | BROWN 72 HBC                                 | 2.5 P <sup>+</sup> P <sup>-</sup> , N <sup>+</sup> N <sup>-</sup> | 12/72 |
| W | E     | ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY |       |                                              |                                                                   |       |
| W | AVG   | 9.84                                              | 0.51  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |                                                                   |       |

## 1 OMEGA PARTIAL DECAY MODES

|     |                                                             |                                                    |              |
|-----|-------------------------------------------------------------|----------------------------------------------------|--------------|
| P1  | OMEGA INTO P <sup>+</sup> P <sup>-</sup> P <sup>0</sup>     | 139 <sup>+</sup> 139 <sup>+</sup> 134              | DECAY MASSES |
| P2  | OMEGA INTO P <sup>+</sup> P <sup>-</sup> (VIOLATES G)       | 139 <sup>+</sup> 139 <sup>+</sup>                  |              |
| P3  | OMEGA INTO P <sup>0</sup> GAMMA (ONLY NEUTRAL INPUT TO FIT) | 134 <sup>+</sup> 0                                 |              |
| P4  | OMEGA INTO P <sup>+</sup> P <sup>-</sup> GAMMA              | 134 <sup>+</sup> 134 <sup>+</sup> 0                |              |
| P5  | OMEGA INTO P <sup>0</sup> GAMMA                             | 134 <sup>+</sup> 134 <sup>+</sup> 0                |              |
| P6  | OMEGA INTO ETA GAMMA                                        | 548 <sup>+</sup> 0                                 |              |
| P7  | OMEGA INTO E <sup>+</sup> E <sup>-</sup>                    | .5 <sup>+</sup> .5 <sup>-</sup>                    |              |
| P8  | OMEGA INTO MU <sup>+</sup> MU <sup>-</sup>                  | 105 <sup>+</sup> 105 <sup>-</sup>                  |              |
| P9  | OMEGA INTO ETA P <sup>0</sup> (VIOLATES C)                  | 548 <sup>+</sup> 134                               |              |
| P10 | OMEGA INTO P <sup>+</sup> P <sup>-</sup> GAMMA              | 0 <sup>+</sup> 0 <sup>-</sup> 0                    |              |
| P11 | OMEGA INTO P <sup>0</sup> MU <sup>+</sup> MU <sup>-</sup>   | 134 <sup>+</sup> 105 <sup>+</sup> 105 <sup>-</sup> |              |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

|     |                           |                           |                           |     |  |
|-----|---------------------------|---------------------------|---------------------------|-----|--|
| P 1 | .8961 <sup>+</sup> -.0058 | P 2                       |                           | P 3 |  |
| P 2 | -.3543                    | .0130 <sup>+</sup> -.0027 |                           |     |  |
| P 3 | -.9269                    | -.0226                    | .0909 <sup>+</sup> -.0050 |     |  |

## 1 OMEGA BRANCHING RATIOS

|    |                                                                                                                                    |                                                                |                                           |                                               |                                                                   |
|----|------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------|-----------------------------------------------|-------------------------------------------------------------------|
| R1 | OMEGA INTO NEUTRAL / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> )                                                               | (P3+...)/(P1+...)                                              |                                           |                                               |                                                                   |
| R1 | 0.17                                                                                                                               | 0.04                                                           | ARMENTERO 63 HBC                          | 0.0 PBAR P                                    |                                                                   |
| R1 | 20                                                                                                                                 | 0.11                                                           | 0.02                                      | BUSCHBECK 63 HBC                              | 1.5 K <sup>+</sup> P <sup>-</sup>                                 |
| R1 | 35                                                                                                                                 | 0.08                                                           | 0.03                                      | KRAEMER 64 HBC                                | 1.2 P <sup>+</sup> D                                              |
| R1 | 65                                                                                                                                 | 0.10                                                           | 0.04                                      | ALFF-STEI 66 HBC                              | CORR. BY SCHULTZ(COL)                                             |
| R1 | 850                                                                                                                                | 0.134                                                          | 0.026                                     | DIGIUGNO 66 CNTR                              | 1.4 P <sup>+</sup> P <sup>-</sup>                                 |
| R1 | 348                                                                                                                                | 0.097                                                          | 0.016                                     | FLATTE 66 HBC                                 | 1.8 K <sup>+</sup> P <sup>-</sup>                                 |
| R1 | 19                                                                                                                                 | 0.06                                                           | 0.05                                      | 0.02 JAMES 66 HBC                             | 2.1 P <sup>+</sup> P <sup>-</sup>                                 |
| R1 | 46                                                                                                                                 | 0.10                                                           | 0.03                                      | BARASH 67 HBC                                 | 0.0 PBAR P                                                        |
| R1 | 46                                                                                                                                 | 0.15                                                           | 0.04                                      | AGUILAR 72 HBC                                | 3.9, 4.6 K <sup>+</sup> P <sup>-</sup>                            |
| R1 | AVG                                                                                                                                | 0.1065                                                         | 0.0088                                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                                                                   |
| R1 | FIT                                                                                                                                | 0.1015                                                         | 0.0067                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                                                                   |
| R2 | OMEGA INTO (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> ) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA) | SEE ALSO R15 (P2)/(P1)                                         |                                           |                                               |                                                                   |
| R2 | 0.01109 MORE CL=.95                                                                                                                | ARMENTERO 70 HBC                                               | 3.9 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R2 | 0.035109 OR LESS CL=.95                                                                                                            | BIZZARRI 70 HBC                                                | PBAR N AT REST                            |                                               |                                                                   |
| R2 | 0.019109 OR MORE CL=.95                                                                                                            | CHAPMAN 70 HBC                                                 | 1.6-2.2 P PBAR                            |                                               |                                                                   |
| R2 | 0.002109 OR LESS CL=.90                                                                                                            | FLATTE 70 HBC                                                  | 1.5 K <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R2 | F                                                                                                                                  | FLATTE 70 SEES NO SIGNAL AT 1.7, 2.1, 2.6 GEV/C.               |                                           |                                               |                                                                   |
| R2 | 0.0026109 MORE CL=.84                                                                                                              | HAGOPIAN 70 HBC                                                | 2.3 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R2 | 0.040109 OR LESS CL=.84                                                                                                            | HAGOPIAN 70 HBC                                                | 2.3 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R2 | 0.022                                                                                                                              | 0.009                                                          | 0.01                                      | ROOS 70 RVUE                                  |                                                                   |
| R2 | R                                                                                                                                  | ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70                 |                                           |                                               |                                                                   |
| R2 | 0.028                                                                                                                              | 0.006                                                          | BEHREND 71 ASPK                           | PHOTOPRODUCTION                               |                                                                   |
| R2 | 0.0015109 MORE CL=.95                                                                                                              | HAGOPIAN 71 HBC                                                | 2.3 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R2 | S                                                                                                                                  | 0.021                                                          | 0.028                                     | 0.009 RATCLIFF 72 ASPK                        | 15. P <sup>+</sup> P <sup>-</sup> , N <sup>+</sup> P <sup>+</sup> |
| R2 | S                                                                                                                                  | SIGNIFICANT INTERFERENCE EFFECT OBSERVED. NB OF OMEGA INTO 3P1 |                                           |                                               |                                                                   |
| R2 | S                                                                                                                                  | COMES FROM AN EXTRAPOLATION.                                   |                                           |                                               |                                                                   |
| R2 | AVG                                                                                                                                | 0.0259                                                         | 0.0049                                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                                                                   |
| R2 | FIT                                                                                                                                | 0.0145                                                         | 0.0031                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5) |                                                                   |
| R3 | OMEGA INTO (P <sup>+</sup> P <sup>-</sup> GAMMA) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA)           | (P3)/(P1)                                                      |                                           |                                               |                                                                   |
| R3 | 0.1251 (0.025109 GRTR.                                                                                                             | BARMIN 64 P <sup>+</sup> XBC                                   | 2.8 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R3 | 0.13                                                                                                                               | JACQUET 69 HLBC                                                |                                           |                                               |                                                                   |
| R3 | 0.081                                                                                                                              | 0.020                                                          | BALDIN 71 HLBC                            | 2.9 P <sup>+</sup> P <sup>-</sup>             |                                                                   |
| R3 | 0.109                                                                                                                              | 0.025                                                          | BARAKSAS 72 OSPK                          | E <sup>+</sup> E <sup>-</sup> COLL. BEAMS     |                                                                   |
| R3 | AVG                                                                                                                                | 0.097                                                          | 0.018                                     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                                                                   |
| R3 | FIT                                                                                                                                | 0.1015                                                         | 0.0067                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |                                                                   |
| R4 | OMEGA INTO (P <sup>+</sup> P <sup>-</sup> GAMMA) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA)           | (P4)/(P1)                                                      |                                           |                                               |                                                                   |
| R4 | 0.051 OR LESS                                                                                                                      | FLATTE 66 HBC                                                  | 1.8 K <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R6 | OMEGA INTO (MU <sup>+</sup> MU <sup>-</sup> ) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA)              | (P8)/(P1)                                                      |                                           |                                               |                                                                   |
| R6 | 0.121 OR LESS                                                                                                                      | GALTIERI 65 HBC                                                | 2.7 K <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R6 | 0.171 OR LESS                                                                                                                      | FLATTE 66 HBC                                                  | 1.8 K <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R6 | 0.121 OR LESS                                                                                                                      | WILSON 69 OSPK                                                 | 12 P <sup>+</sup> P <sup>-</sup> ON C, FE |                                               |                                                                   |
| R7 | OMEGA INTO (2P <sup>+</sup> P <sup>-</sup> GAMMA) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA)          | (P5)/(P1)                                                      |                                           |                                               |                                                                   |
| R7 | 0.11 OR LESS                                                                                                                       | BARMIN 64 P <sup>+</sup> XBC                                   | 1.3-2.8 P <sup>+</sup> P <sup>-</sup>     |                                               |                                                                   |
| R7 | 0.451 (0.33)                                                                                                                       | STRUGALSK 69 HLBC                                              | 2.34 P <sup>+</sup> P <sup>-</sup> , N    |                                               |                                                                   |
| R7 | 0.141 OR LESS                                                                                                                      | BALDIN 71 HLBC                                                 | 2.9 P <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R7 | 0.151 OR LESS CL=.90                                                                                                               | BARAKSAS 72 OSPK                                               | E <sup>+</sup> E <sup>-</sup> COLL. BEAMS |                                               |                                                                   |
| R8 | OMEGA INTO (ETA P <sup>+</sup> P <sup>-</sup> + ETA GAMMA) / (P <sup>+</sup> P <sup>-</sup> P <sup>0</sup> + P <sup>0</sup> GAMMA) | (P9+P6)/(P1)                                                   |                                           |                                               |                                                                   |
| R8 | 0.045109 OR LESS CL=.95                                                                                                            | JACQUET 69 HLBC                                                | 1.8 K <sup>+</sup> P <sup>-</sup>         |                                               |                                                                   |
| R8 | 0.045109 OR LESS CL=.95                                                                                                            | JACQUET 69 HLBC                                                |                                           |                                               |                                                                   |

|                               |                                                                |                                                   |                            |
|-------------------------------|----------------------------------------------------------------|---------------------------------------------------|----------------------------|
| R9                            | OMEGA INTO (NEUTRALS) / (CHARGED)                              | (P3+...)/(P1+P2+...)                              |                            |
| R9                            | 0.124 0.021                                                    | FELDMAN 67 OSPK                                   | 1.2 P1-P 3/67              |
| R9                            | FIT 0.1000 0.0067                                              | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)     |                            |
| R10                           | OMEGA INTO (2PIO GAMMA)/(P1+P1-PIO)                            | (P5)/(P1)                                         |                            |
| R10                           | (0.081 OR LESS CL=.95                                          | JACQUET 69 HLBC                                   | 4/70                       |
| R11                           | OMEGA INTO (ETA GAMMA)/(PIO GAMMA)                             | (P6)/(P3)                                         |                            |
| R11                           | (0.581 (0.30)                                                  | STRUGALSK 69 HLBC                                 | 2.34 P1+ N 8/69            |
| R11                           | (0.40) OR LESS                                                 | BALDIN 71 HLBC                                    | 2.9 P1+ P 11/71            |
| R11                           | 0.010 0.045                                                    | APEL 72 OSPK                                      | 4-8 P1+ P,N 3GM 2/73       |
| R11                           | (0.27) OR LESS CL=.90                                          | BARAKSAS 72 OSPK                                  | E+E- COLL. BEAMS 2/73      |
| R12                           | OMEGA INTO (PIO MU+ MU- ) / TOTAL (UNITS 10 <sup>4</sup> +-3)  | (P11)                                             |                            |
| R12                           | (2.1 OR LESS                                                   | WEHMANN 68 OSPK                                   | 12 P1- FE 6/68             |
| R13                           | OMEGA INTO (E+ E-)/TOTAL (UNITS 10 <sup>4</sup> +-4)           | (P7)                                              |                            |
| R13                           | 3 2.1 1.2                                                      | BINNIE 65 OSPK                                    | P1-P NEAR THLD. 6/66       |
| R13 B                         | MASS RESOLUTION OF BINNIE 65 IS ABOUT 15 MEV.                  |                                                   |                            |
| R13 H                         | (1.01 (1.7)                                                    | 0.751 HERTZBACH 67 OSPK                           | ASSUME SU(3)+MIXING. 10/66 |
| R13 H                         | NOT RESOLVED FROM RHO DECAY.                                   |                                                   |                            |
| R13 A                         | 33 (0.651 (0.13)                                               | ASTVACATU 68 OSPK                                 | ASSUME SU(3)+MIXING 6/68   |
| R13 A                         | NOT RESOLVED FROM RHO DECAY. ERROR STATISTICAL ONLY.           |                                                   |                            |
| R13 B                         | 0.40 0.21                                                      | BOLLINI 68 CNTR                                   | 1.7P1+P,NOTE Z 9/68        |
| R13 Z                         | MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV. HIS ERROR IS +-15    |                                                   |                            |
| R13 Z                         | WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD    |                                                   |                            |
| R13 Z                         | CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.   |                                                   |                            |
| R13 E                         | (0.761 (0.14)                                                  | AUGUSTIN 69 OSPK                                  | SEE NOTE E 2/72            |
| R13 E                         | FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV |                                                   | 4/69                       |
| R13                           | 0.83 0.10                                                      | BARAKSAS 72 OSPK                                  | E+E- COLL. BEAMS 2/73      |
| R13                           | AVG 0.76 0.17                                                  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)      |                            |
| R14                           | OMEGA INTO NEUTRALS / TOTAL                                    | (P3+...)                                          |                            |
| R14                           | 0.084 0.015                                                    | BOLLINI 68 CNTR                                   | 2.1 P1- P 6/68             |
| R14                           | 0.09 0.019                                                     | DEINET 69 OSPK                                    | 1.5 P1- P 9/69             |
| R14                           | 0.075 0.025                                                    | BIZZARRI 71 HBC                                   | 0.0 P PBAR 11/71           |
| R14                           | 42 0.073 0.018                                                 | BARILE 72 CNTR                                    | 1.67 P1- P 2/73            |
| R14                           | AVG 0.0788 0.0092                                              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)      |                            |
| R14                           | FIT 0.0909 0.0055                                              | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)     |                            |
| R15                           | OMEGA INTO (P1 P1-)/TOTAL. SEE ALSO R2                         | (P2)                                              |                            |
| R15                           | 0.032 0.028 0.019 AUGUSTIN 69 OSPK                             | E+E- COLL. BEAMS 8/69                             |                            |
| R15                           | 0.0033 OR MORE CL=.95 GOLDBERGER 69 HBC                        | 3.7-4.0 P1+P 11/69                                |                            |
| R15                           | 0.010 OR MORE CL=.95 ALLISON 70 HBC                            | 1.3-1.7 PBAR P 6/70                               |                            |
| R15                           | 0.0080 0.0028 0.00228IGGS 70 CNTR                              | PHOTOPRODUCTION 6/70                              |                            |
| R15                           | 0.0122 0.0030 ALVENSLEB 71 CNTR                                | PHOTOPRODUCTION 11/71                             |                            |
| R15                           | 0.013 0.012 0.009 MOPFET 71 HBC                                | 2.8-4.7 GAMMA P 11/71                             |                            |
| R15                           | 0.036 0.024 0.018 BARAKSAS 72 OSPK                             | E+E- COLL. BEAMS 12/72                            |                            |
| R15                           | AVG 0.0102 0.0019                                              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)      |                            |
| R15                           | FIT 0.0130 0.0027                                              | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)     |                            |
| R16                           | OMEGA INTO (ETA GAMMA) / (ALL NEUTRALS)                        | (P6)/(P3+...)                                     |                            |
| R16                           | (0.24) OR LESS CL=.90 DEINET 69 OSPK                           |                                                   | 9/69                       |
| R16                           | (0.36) OR LESS CL=.90 DAKIN 72 OSPK                            | 1.4 P1- P,N MMO                                   | 12/72                      |
| R17                           | OMEGA INTO (2 PIO GAMMA) / (ALL NEUTRALS)                      | (P5)/(P3+...)                                     |                            |
| R17                           | (0.19) OR LESS CL=.90 DEINET 69 OSPK                           |                                                   | 9/69                       |
| R17 D                         | (0.22) (0.07) DAKIN 72 OSPK                                    | 1.4 P1- P,N MMO                                   | 12/72                      |
| R17 D                         | SEE R18                                                        |                                                   |                            |
| R18                           | OMEGA INTO (PIO GAMMA) / (ALL NEUTRALS)                        | (P3)/(P3+...)                                     |                            |
| R18                           | (0.81) OR MORE CL=.90 DEINET 69 OSPK                           |                                                   | 9/69                       |
| R18 D                         | (0.78) (0.07) DAKIN 72 OSPK                                    | 1.4 P1- P,N MMO                                   | 12/72                      |
| R18 D                         | ERROR STATISTICAL ONLY. AUTHORS OBTAIN GOOD FIT ALSO ASSUMING  |                                                   | 11/71                      |
| R18 D                         | PIO GAMMA AS THE ONLY NEUTRAL DECAY.                           |                                                   | 11/71                      |
| *****                         |                                                                |                                                   |                            |
| REFERENCES FOR OMEGA          |                                                                |                                                   |                            |
| MAGLIC 61 PRL 7 178           |                                                                | B MAGLIC, ALVAREZ, ROSENFELD, STEVENSON (LRL)     |                            |
| PEVNER 61 PRL 7 327           |                                                                | KRAEMER, NUSSBAUM, RICHARD, LJHU+NWES (LRL)       |                            |
| XUONG 61 PRL 7 327            |                                                                | NGUYEN HUU XUONG, GERALD R LYNCH (LRL)            |                            |
| ALFF 62 PRL 9 325             |                                                                | ALFF, BERLEY, COLLEY, GELFAND + (COLU+RUTGERS)    |                            |
| ARMENTERO 62 CERN CONF 90     |                                                                | R ARMENTERO, R BUDE + (CERN+COFF+EPOL)            |                            |
| STEVENSO 62 PR 125 687        |                                                                | STEVENSON, ALVAREZ, MAGLIC, ROSENFELD (LRL)       |                            |
| ARMENTERO 63 SIENA CONF 1 296 |                                                                | ARMENTERO, EDWARDS, JACOBSEN + (CERN+COFF)        |                            |
| BARMIN 63 SIENA CONF 1 207    |                                                                | BARMIN, DOLGOLENO, KRESTNIKOV + (ITEP)            |                            |
| BUSCHBECK 63 SIENA CONF 1 166 |                                                                | BUSCHBECK, CZAPP + (VIENNA+CERN+AMSTERDAM)        |                            |
| GELFAND 63 PRL 11 436         |                                                                | GELFAND, MILLER, NUSSBAUM, RATAU + (COLU+RUTG)    |                            |
| MURRAY 63 PL 7 358            |                                                                | MURRAY, FERROLUZZI, HUME, SHAFER, SOLMITZ + (LRL) |                            |
| BARMIN 64 JETP 18 1289        |                                                                | BARMIN, DOLGOLENO, KRESTNIKOV + (ITEP)            |                            |
| KRAEMER 64 PR 136 B 496       |                                                                | KRAEMER, MADANSKY, MEER + (LJHU+NWES+WOODI)       |                            |
| BINNIE 65 PL 18 348           |                                                                | BINNIE, DUANE, JANE, W JONES + (LOIC+MCHS)        |                            |
| GALTIERI 65 PRL 14 279        |                                                                | A BARBARO GALTIERI, R D TRIPP (LRL)               |                            |
| MILLER D 65 CU-237(NEVIS 131) |                                                                | DAVID C MILLER (THESES) (COLUMBIA)                |                            |
| INCLUDES DATA OF GELFAND      |                                                                |                                                   |                            |
| ALFF-STE 66 PR 145 1072       |                                                                | ALFF-STEINBERGER, BERLEY, BRUGGER + (COLU+RUTG)   |                            |
| ZDANIS 65 PRL 14 721          |                                                                | ZDANIS, MADANSKY, KRAEMER, HERTZBACH + (LJHU+BNL) |                            |
| DIGIUGNO 66 NC 44A 1272       |                                                                | DI GIUGNO, PERUZZI, TROISE + (NAPL+FRAS+TRST)     |                            |
| FLATTE 66 PR 145 1050         |                                                                | HUME, MURRAY, BUTTON-SHAFFER, SOLMITZ + (LRL)     |                            |
| JAMES 66 PR 142 896           |                                                                | F E JAMES, KRAYBILL (YALE+BROOKHAVEN)             |                            |
| BALTAY 67 PRL 18 93           |                                                                | +FRANZINI, SEVERIENS, YEH, ZANELLO (COLUMBIA)     |                            |
| BARASH 67 PR 156 1399         |                                                                | BARASH, KIRSCH, MILLER, TAN (COLUMBIA)            |                            |
| FELDMAN 67 PR 159 1219        |                                                                | +FRATI, GLEESON, HALPERN, NUSSBAUM + (FENH)       |                            |
| HERTZBACH 67 PR 155, 1461     |                                                                | HERTZBACH, KRAEMER, MADANSKY, ZDANIS + (LJHU+BNL) |                            |
| ALSO 65 ZDANIS                |                                                                |                                                   |                            |
| ASTVACATU 68 PL 27 B 451      |                                                                | ASTVACATUROV, AZIMOV, BALDIN + (JINR+MOSCOW)      |                            |
| BOLLINI 68 NC 56 A 531        |                                                                | +BUHLER, DALPIAZ, MASSAH + (CERN+BGN+STRB)        |                            |
| BOLLINI 68 NC 57 A 404        |                                                                | +BUHLER, DALPIAZ, MASSAH + (CERN+BGN+STRB)        |                            |
| KEY 68 PR 166 1430            |                                                                | +PRENTICE+COOPER+MANNER (INTO+ANL+MISC)           |                            |
| PISET 68 PR B 6 325           |                                                                | J. PISET, M. ROOS (CERN)                          |                            |
| WEHMANN 68 PRL 20 748         |                                                                | +ENGELS + (HARVARD+CASE+SAC+CORNELL+MCGILL)       |                            |
| AUGUST 69 PRL 28 B 513        |                                                                | +BARAKSAS, LUON, GRACCO, HAISSINSKI + (ORSAY)     |                            |
| AUGUST 69 PRL 28 B 513        |                                                                | +LEFRANCOIS, BEHMANN, MARIN + (ORSAY)             |                            |
| BIZZARRI 69 NP B 14 169       |                                                                | +FOSTER, GAVILLET, MONTANET + (CERN+COFF)         |                            |
| DANBURG 69 UCRL-19275         |                                                                | JEROME S. DANBURG, THESIS (LRL)                   |                            |
| ALSO DANBURG 70               |                                                                |                                                   |                            |

## Mesons

 $\omega(784)$ ,  $M(940)$ ,  $M(953)$ ,  $\eta'(958)$ 

## Data Card Listings

For notation, see key at front of Listings.

DEINET 69 PL 30 B 426  
 ERWIN 69 NP B 9 364  
 GOLDHABE 69 PRL 23 1351  
 JACQUET 69 NC 63 A 743  
 MILLER 69 PR 178 2061  
 STRUGALS 69 PL 29 B 532  
 WILSON 69 PRIVATE COMM.

ABRAMOV 70 NP B 20 209  
 BIZZARRI 70 PRL 25 1385  
 ALLISON 70 PRL 24 618  
 ATHERTON 70 NP B 18 221  
 BIGGS 70 PRL 24 1201  
 CASON 70 PR D 1 851  
 CHAPMAN 70 NP B 24 445  
 DANBURG 70 PR D 2 2564  
 FLATTE 70 PR D 1 1  
 GOLDHABE 70 PHILA. CONF. P. 59  
 HAGOPIAN 70 PRL 25 1050  
 ROOS 70 DNP/RT P. 173

ABRAMS 71 PR D 4 653  
 ALVENSLE 71 PRL 27 888  
 ANGELOW 71 SJNP 12 427  
 BALDIN 71 SJNP 13 758  
 BARDADIN 71 PR D 4 2711  
 BEHREND 71 PRL 27 61  
 BIZZARRI 71 NP B 27 140  
 BLOODWORTH 71 NP B 35 133  
 CHAPMAN 71 PR D 3 38  
 COYNE 71 NP B 32 333  
 FIELDS 71 PRL 27 1749  
 HAGOPIAN 71 BAPS 16  
 LEFRANCOIS 71 PREPRINT LAL1256  
 MATTHEWS 71 PRL 26 400  
 MOFFETT 71 NP B 29 349

AGUILAR 72 PR D 6 29  
 APEL 72 PL 41 B 234  
 BASILE 72 PHIL. CONF. PROC. 153  
 BENAKSAS 72 PL 38 B 1  
 BENAKSAS172 PL 42 B 507  
 BENAKSAS272 PL 42 B 511  
 BROWN 72 PL 42 B 117  
 DAKIN 72 PR D 6 2321  
 EISENBERG 72 PR D 5 15  
 RATCLIFF 72 PL 38 B 345

+MENZIONE, MULLER, BUNIA TOV+ (KARL+ CERN)  
 +WALKER, GOSMAN, WEINBERG (MISC+PRIN+VAND)  
 +BUTLER, COYNE, HALL, MACNAUGHTON, TRILING (LRL)  
 +NGUYEN-KHAC, HAATUFT, HALSTEINSLI (EPOL+BERG)  
 R. MILLER, LICHTMAN, WILLMANN (PURDUE)  
 +CHUVILO, FENYVES, (HARS+JINR+BUDA)  
 RICHARD WILSON (SEE ALSO PR 178 2095) (HARV)

ABRAMOVICH, BLUMENFELD, BRUYANT, + (CERN)  
 +CIAPETTI, DORE, GASPERO, GUIDONI, + (ROMA+SYRA)  
 +COOPER, FIELDS, RHINES (ANL)  
 +BLAIR, CELMIKER, DOMINGO, FRENCH+ (CERN+IPN)  
 +CLIFFY, GABATHULER, KITCHING, RAND (DARE)  
 +ANDREWS, BISMAS, GROVES, HARRINGTON, + (NDAM)  
 +DAVIDSON, GREEN, LYS, ROE, VANDER VELDE (MICH)  
 +ABOLINS, DAHL, DAVIES, HOCH, KTRZ, MILLER+ (LRL)  
 STANLEY M. FLATTE (LRL)  
 GERSON GOLDHABER, REVIEW (LRL)  
 S. AND V. HAGOPIAN, BOGART, SELOVE (FSU+PENN)  
 PROC. DARESBURY STUDY WEEKEND NO 1. (CERN)

+BARNHAM, BUTLER, COYNE, GOLDHABER, HALL, + (LBL)  
 ALVENSLEBEN, BECKER, BUSZA, CHEN, COHEN, + (DESY)  
 +GRAMENITSKY, KANARISKY, KERATSCHEW, + (JINR)  
 +VERGAKOV, TREBUKHOVSKY, SHISHOV (ITEP)  
 BARDADIN-OTIMONSKY, HOFHOL, MICHEJDA+ (HARS)  
 +LEE, NORDBERG, WEHMAN, + (ROCH+CORN+NAL)  
 +MONTANET, NILSSON, D'ANDLAU, + (CERN+CDEF)  
 BLOODWORTH, JACKSON, PRENTICE, YOUNG (TORONTO)  
 +FORTNEY, FOWLER (DUKE)  
 +BUTLER, FANG-LANDAU, MACNAUGHTON (LRL)  
 +COOPER, RHINES, ALLISON (ANL+OXF)  
 S. HAGOPIAN (FSU+PENN)  
 J. LEFRANCOIS (ORSAY)  
 +PRENTICE, YOUNG, CARROLL, WALKER, + (TNT+MISC)  
 +BINGHAM, FRETTER, BALLAM+ (LRL+UCB+SLAC+TUFT)

AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
 +AUSLANDER, MULLER, BERTOLUCCI, + (KARL+PISA)  
 +BOLLINI, BROGLI, DALPIAZ, FRABETTI, + (CERN)  
 +COSME, JEAN-MARIE, JULLIAN, LAPLANCHE, + (ORSAY)  
 +COSME, JEAN-MARIE, JULLIAN, LAPLANCHE, + (ORSAY)  
 +COSME, JEAN-MARIE, JULLIAN, LAPLANCHE, + (ORSAY)  
 +DOWNING, HOLLOWAY, HULD, BERNSTEIN+ (ILL+ILLC)  
 +HAUSER, KREISLER, MISCHKE (PRINCETON)  
 EISENBERG, BALLAM, DAGAN, + (RHOD+SLAC+TEL)  
 +BULOS, CARNEGIE, KLUGE, LEITH, LYNCH, + (SLAC)

**M(940)**  
 $\rightarrow \pi\pi$

66 M(940)

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.

66 M(940) MASS (MEV)

M N 55 940.5 1.7 CHESHIRE 72 MMS 0 2.4  $\pi^+ \pi^-$  P, N MM 12/72\*  
 M N NOT SEEN BY BINNIE 72 AT THRESHOLD.

66 M(940) WIDTH (MEV)

M N 55 (10.4) OR LESS CL=90 CHESHIRE 72 MMS 0 2.4  $\pi^+ \pi^-$  P, N MM 12/72\*

66 M(940) BRANCHING RATIOS

R1 M(940) INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)  
 R1 0.12 0.86 0.02 CHESHIRE 72 MMS 0 2.4  $\pi^+ \pi^-$  P, N MM 12/72\*

REFERENCES FOR M(940)

CHESHIRE 72 PRL 28 520 +HOFFMAN, GARFINKEL, + (IOWA+ANL+PURD)  
 BINNIE 72 PL 39 B 275 +CAMILLERI, DUANE, GARBUIT, BURTON+ (LOIC+SHMP)

**M(953)**  
 $\rightarrow \gamma\pi^+\pi^-$   
 $\rightarrow \gamma\rho^0$

59 M(953, JPC = +)

WHILE MASS AND WIDTH ARE CONSISTENT WITH THOSE OF THE  $\eta'$  (958), THE  $(\pi^+ \pi^- \gamma)$  DECAY DOES NOT SHOW A RHOD SIGNAL. UNLIKE THE  $\eta'$  (958), THIS IS TAKEN AS EVIDENCE FOR A NEW PARTICLE. WHILE THIS DIFFERENCE IN DALITZ PLOT DISTRIBUTIONS APPEARS SIGNIFICANT, IT STILL NEEDS FURTHER CONFIRMATION TO BE REGARDED AS WELL ESTABLISHED. POSSIBLY SEEN IN MMS. OMITTED FROM TABLE.

59 M MASS (MEV)

M 68 953.0 2.0 AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71  
 M (953.4) (1.5) (3.6) MAGLICH 71 MMS 3.8 P D, ME3 X0 2/72  
 M MISSING MASS SPECTRUM SHOWED THIS PEAK AT 953.4 INSTEAD OF  
 M  $\eta'$  (958). PEAK LISTED UNDER M BECAUSE OF MASS  
 M COINCIDENCE. THE 1.5 MEV ERROR MAY BE UNDERESTIMATED BY  
 M A FACTOR OF 2 (SEE BRODY 72, TABLE III). OBSERVED PEAK COULD  
 M THEN WELL CORRESPOND TO  $\eta'$  (958).

59 M WIDTH (MEV)

M 68 (10.0) OR LESS CL=95 AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71  
 M (15.) OR LESS MAGLICH 71 MMS 3.8 P D, ME3 X0 2/72

59 M PARTIAL DECAY MODES

P1 M INTO  $\pi^+ \pi^- \gamma$  GAMMA DECAY MASSES  
 P2 M INTO RHOD GAMMA 139+ 139+ 0  
 P3 M INTO  $\pi^+ \pi^- \eta$  770+ 0  
 P4 M INTO  $\pi^0 \eta$  139+ 139+ 548  
 P5 M INTO  $\pi^+ \pi^- \pi^0$  139+ 139+ 134

59 M BRANCHING RATIOS

R1 M INTO (RHOD GAMMA)/(ALL  $\pi^+ \pi^-$  GAMMA) (P2)/(P1)  
 R1 58 0.05 0.1 AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71  
 R2 M INTO ( $\pi^+ \pi^-$  GAMMA)/( $\pi^+ \pi^-$  ET NEUTR.) (P1)/(P3N)  
 R2 58 1.2 0.3 AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71  
 R3 M INTO ( $\pi^+ \pi^- \pi^0$ )/TOTAL (P5)  
 R3 58 NOT OBSERVED AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71  
 R4 M INTO ( $\pi^0 \eta$  ET NEUTR.)/TOTAL (P4N)  
 R4 58 NOT OBSERVED AGUILAR 70 HBC 3.9-4.6K-P, P K-M 1/71

REFERENCES FOR M

AGUILAR 70 PRL 25 1635 AGUILAR-BENITEZ, BASSANO, SAMIOS, BARNES+ (BNL)  
 MAGLICH 71 PRL 27 1479 +OOSTENS, BRODY, CVI JANOVICH (RUTG+PENN+UPNJ)  
 ROSNER 71 PRL 26 933 J.L. ROSNER, E.W. COLGLAZIER (MINN+CIT)  
 AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
 BRODY 72 UPR-3E. SUBM. TO PR +GROVES, NOREN, CVI JANOVICH, + (PENN+RUTG+UPNJ)

 **$\eta'(958)$** 2  $\eta'$  PRIME (958, JPC=0-+) I=0

KNOWN ALSO AS X0

Note on the  $J^P$  Assignment of  $\eta' (958)$ 

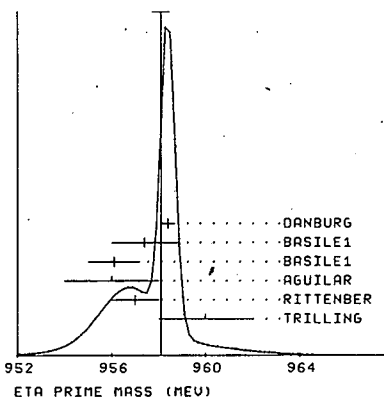
From the Dalitz plot analyses of the  $\eta' \rightarrow \pi^+ \pi^- \eta$  and  $\eta' \rightarrow \pi^+ \pi^- \gamma$  decays, and from the observation of a  $\eta' \rightarrow \gamma\gamma$  decay mode, all assignments except  $J^{PC} = 0^{++}$  and  $2^{++}$  are excluded. The Dalitz plot analyses favor spin 0 but cannot rule out spin 2. However, various attempts to find evidence for a spin different from zero, by searching for anisotropies in  $\eta'$  decay, were unsuccessful. The most complete study was made by DANBURG 72 with about 1000  $\eta'$  decays from the reaction  $K^- p \rightarrow \eta' \Lambda$  at 2.2 GeV/c. This number of events was sufficient to make cuts on momentum transfer and  $\Lambda$  polarization angle. No  $\eta'$  decay anisotropies or correlations were found. This is rather suggestive evidence that the  $\eta'$  spin is indeed zero. Presumably an Adair-type analysis could be used to settle this question unambiguously.

2  $\eta'$  PRIME MASS (MEV)

M 0 ONLY EXPERIMENTS GIVING ERROR LESS THAN 3 MEV KEPT FOR AVERAGING 12/72\*  
 M 85 (957.0) DAUBER 64 HBC 1.95 K-P  
 M K (958.0) (1.0) XALBFLEIS 64 HBC 2.7 K-P 6/66  
 M K KALBFLEIS 64 SUPERSEDED BY RITTENBERG 69  
 M 0 (957.0) (3.0) BADIER 65 HBC 3.0 K-P  
 M 8 960.0 2.0 TRILLING 65 HBC 3.65  $\pi^+ \pi^-$  9/66  
 M 0 7 (955.0) (10.0) CDH 66 DBC 3.3  $\pi^+ \pi^-$  6/66  
 M 0 (959.0) (3.0) LONDON 66 HBC 2.2 K-P 6/66  
 M 0 (960.0) (5.0) MOIT 69 HBC 4.1-5.5 K-P 7/69  
 M 957. RITTENBERG 69 HBC 1.7-2.7 K-P 9/69  
 M 956.0 2.0 AGUILAR 70 HBC 3.9-4.6K-P 1/71  
 M 3415 956.1 1.1 BASILE1 71 CNTR 1.6  $\pi^+ \pi^-$  P, N X0 11/71  
 M 535 957.4 1.4 BASILE1 71 CNTR 1.6  $\pi^+ \pi^-$  P, N X0 11/71  
 M 958.4 0.3 DANBURG 72 HBC 2.2 K- P, L X0 12/72\*  
 M AVG 956.11 0.37 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)  
 (SEE IDEOGRAM BELOW)

## Data Card Listings

For notation, see key at front of Listings.

Mesons  
 $\eta'(958)$ WEIGHTED AVERAGE = 958.11  $\pm$  0.37  
ERROR SCALED BY 1.4

|                  | CHISO |
|------------------|-------|
| DANBURG 72 HBC   | 0.9   |
| BASILE1 71 CNTR  | 0.3   |
| BASILE1 71 CNTR  | 3.3   |
| AGUILAR 70 HBC   |       |
| RITTENBER 69 HBC | 1.2   |
| TRILLING 65 HBC  |       |
| S.B              |       |
| (CONLEV = 0.124) |       |

## 2 ETA PRIME WIDTH (MEV)

|   |      |        |         |                                            |                |        |
|---|------|--------|---------|--------------------------------------------|----------------|--------|
| W | 85   | (4.0)  | OR LESS | DAUBER 64 HBC                              | 1.95 K-P       |        |
| W | K    | (7.0)  | OR LESS | KALBFLEISCH 64 HBC                         | 2.7 K-P        | 6/66   |
| W | K    | (10.0) | OR LESS | KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69 | 3.0 K-P        |        |
| W |      | (15.0) | OR LESS | BADIER 65 HBC                              | 2.2 K-P        | 6/66   |
| W |      | (10.0) | OR LESS | LONDON 66 HBC                              | 1.7-2.7 K-P    |        |
| W |      | (20.0) | OR LESS | RITTENBER 69 HBC                           | 3.9-4.6 K-P    | 1/71   |
| W | 3415 | (8.1)  | OR LESS | AGUILAR 70 HBC                             | 1.6 P1- P1N X0 | 11/71  |
| W |      | (3.8)  | OR LESS | BASILE1 71 CNTR                            | 2.2 K- P1L X0  | 12/72* |
|   |      |        |         | DANBURG 72 HBC                             |                |        |

## 2 ETA PRIME PARTIAL DECAY MODES

|     | ETA PRIME INTO P1+ P1- ETA                            | DECAY MASSES       |
|-----|-------------------------------------------------------|--------------------|
| P1  | P1(N) ETAS DECAY INTO ALL NEUTRALS                    | 139+ 139+ 548      |
| P2  | P1(C) ETAS DECAY CHARGED                              | 134+ 134+ 548      |
| P3  | ETA PRIME INTO P10 P10 ETA                            | 139+ 139+ 0        |
| P4  | P2(N) ETAS DECAY INTO ALL NEUTRALS                    |                    |
| P5  | P2(C) ETAS DECAY CHARGED                              |                    |
| P6  | ETA PRIME INTO P1+ P1- GAMMA                          | 139+ 139+ 0        |
| P7  | (INCLUDING RHO GAMMA)                                 | 0+ 0               |
| P8  | ETA PRIME INTO GAMMA GAMMA                            | 0+ 770             |
| P9  | ETA PRIME INTO P1+ P1- E+ E-                          | 139+ 139+ .5+ .5   |
| P10 | ETA PRIME INTO 2 P1                                   | 139+ 139           |
| P11 | ETA PRIME INTO 3 P1                                   | 139+ 139+ 134      |
| P12 | ETA PRIME INTO 4 P1                                   | 139+ 139+ 139+ 139 |
| P13 | ETA PRIME INTO 5 P1                                   |                    |
| P14 | ETA PRIME INTO 6 P1                                   |                    |
| P15 | ETA PRIME INTO P10 E+ E- (VIOLATES C IN BORN APPROX.) | 134+ .5+ .5        |
| P16 | ETA PRIME INTO P10 E+ E- (VIOLATES C IN BORN APPROX.) | 548+ .5+ .5        |
| P17 | ETA PRIME INTO P10 RHO 0 (VIOLATES C)                 | 134+ 770           |
| P18 | ETA PRIME INTO P10 OMEGA (VIOLATES C)                 | 134+ 783           |
| P19 |                                                       |                    |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i^2 + \delta P_i^2)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

| P 1 | P 2           | P 3            | P 4                 |
|-----|---------------|----------------|---------------------|
| P 1 | .4719+-0.0342 |                |                     |
| P 2 | -.3506        | -.2465+-0.0207 |                     |
| P 3 | -.6026        | -.5278         | -.2622+-0.0350      |
| P 4 | .0217         | -.1663         | .0036 .0194+-0.0029 |

Note on  $\eta'(958)$  Branching Fractions

In our calculation of the branching fractions of the  $\eta'(958)$  we assume the decay modes  $\eta\pi\pi$  (including  $\eta\pi^0\pi^0$ , 71% of the  $\eta'$ s have neutral decays),  $\rho^0\gamma$ , and  $\gamma\gamma$ .

In the fit we do not use the constraint

$$R = \Gamma(\eta' \rightarrow \eta\pi^+\pi^-) / \Gamma(\eta' \rightarrow \eta\pi^0\pi^0) = 2$$

from I-spin conservation. The result of the fit is in agreement with it,  $R = 1.9 \pm 0.2$ .

## 2 ETA PRIME BRANCHING RATIOS

|       |                                                                   |                 |                                                             |
|-------|-------------------------------------------------------------------|-----------------|-------------------------------------------------------------|
| R1    | ETA PRIME INTO (P1+ P1- ETA (NEUTRAL DEC.)) / TOTAL (PIN)         |                 |                                                             |
| R1 K  | 68                                                                | (0.361) (0.051) | KALBFLEISCH 64 HBC 2.7 K-P 10/66                            |
| R1 K  | 281                                                               | 0.314 0.026     | KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69 1.7-2.7 K-P 9/69 |
| R1    | FIT                                                               | 0.336 0.024     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.0)               |
| R2    | ETA PRIME INTO (P1+ P1- NEUTRALS) / TOTAL (PIN+P2C)               |                 |                                                             |
| R2 K  | 33                                                                | 0.35 0.06       | BADIER 65 HBC 3.0 K-P 10/66                                 |
| R2 K  | 39                                                                | 0.4 0.1         | LONDON 66 HBC 2.2 K-P 10/66                                 |
| R2    | AVG                                                               | 0.363 0.051     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)                |
| R2    | FIT                                                               | 0.407 0.023     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)               |
| R3    | ETA PRIME INTO (P1+ P1- ETA (CHRGD.DECAY)) / TOTAL (PIC)          |                 |                                                             |
| R3 K  | 44                                                                | (0.121) (0.021) | KALBFLEISCH 64 HBC 2.7 K-P 10/66                            |
| R3 K  | 281                                                               | (0.361) (0.051) | KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69 1.7-2.7 K-P 9/69 |
| R3    | AVG                                                               | 0.116 0.013     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)                |
| R3    | FIT                                                               | 0.1364 0.0099   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.0)               |
| R4    | ETA PRIME INTO (P1+ P1- NEUTRALS (EXCLUDING TOTAL (PIN+P2C)))     |                 |                                                             |
| R4 K  | 10                                                                | (0.051) (0.041) | KALBFLEISCH 64 HBC 2.7 K-P 10/66                            |
| R4 K  | 42                                                                | 0.045 0.029     | KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69 1.7-2.7 K-P 9/69 |
| R4    | FIT                                                               | 0.0712 0.0060   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)               |
| R5    | ETA PRIME INTO (NEUTRALS) / TOTAL (P2N+P4)                        |                 |                                                             |
| R5 K  | 54                                                                | (0.251) (0.051) | KALBFLEISCH 64 HBC 2.7 K-P 10/66                            |
| R5 K  | 16                                                                | 0.24 0.17       | BADIER 65 HBC 3.0 K-P 10/66                                 |
| R5 K  | 32                                                                | 0.3 0.1         | LONDON 66 HBC 2.2 K-P 10/66                                 |
| R5 K  | 123                                                               | 0.189 0.026     | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R5 K  | 535                                                               | 0.185 0.022     | BASILE1 71 CNTR 1.6 P1- P1N X0 11/71                        |
| R5    | AVG                                                               | 0.195 0.016     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)                |
| R5    | FIT                                                               | 0.195 0.025     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)               |
| R6    | ETA PRIME INTO (P1+ P1- GAMMA (INCLUDING RHO GAMMA)) / TOTAL (P3) |                 |                                                             |
| R6 K  | 42                                                                | (0.221) (0.041) | KALBFLEISCH 64 HBC 2.7 K-P 10/66                            |
| R6 K  | 35                                                                | (0.34) (0.09)   | KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69 1.7-2.7 K-P 9/69 |
| R6 K  | 20                                                                | 0.2 0.1         | BADIER 65 HBC 3.0 K-P 10/66                                 |
| R6 K  | 298                                                               | 0.329 0.033     | LONDON 66 HBC 2.2 K-P 10/66                                 |
| R6    | AVG                                                               | 0.316 0.038     | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R6    | FIT                                                               | 0.262 0.035     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.2)               |
| R7    | ETA PRIME INTO (P1+ P1- GAMMA (INCLUDING RHO GAMMA)) / (P1+ P2)   |                 |                                                             |
| R7 K  | 25                                                                | 0.14            | DAUBER 64 HBC 1.95 K-P 10/66                                |
| R7    | FIT                                                               | 0.365 0.065     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)               |
| R8    | ETA PRIME INTO (P10 E+ E-) / TOTAL (P16)                          |                 |                                                             |
| R8 K  | 10                                                                | (0.13) OR LESS  | RITTENBER 65 HBC 2.7 K-P 10/66                              |
| R9    | ETA PRIME INTO (ETA E+ E-) / TOTAL (P17)                          |                 |                                                             |
| R9 K  | 10                                                                | (0.11) OR LESS  | RITTENBER 65 HBC 2.7 K-P 10/66                              |
| R10   | ETA PRIME INTO (P10 RHO 0) / TOTAL (P18)                          |                 |                                                             |
| R10 K | 10                                                                | (0.04) OR LESS  | RITTENBER 65 HBC 2.7 K-P 10/66                              |
| R11   | ETA PRIME INTO (P10 OMEGA) / TOTAL (P19)                          |                 |                                                             |
| R11 K | 10                                                                | (0.08) OR LESS  | RITTENBER 65 HBC 2.7 K-P 10/66                              |
| R12   | ETA PRIME INTO (P1+ P1- E+ E-) / TOTAL (P10)                      |                 |                                                             |
| R12 K | 10                                                                | (0.006) OR LESS | RITTENBER 65 HBC 2.7 K-P 10/66                              |
| R13   | ETA PRIME INTO (2 P1) / TOTAL (P11)                               |                 |                                                             |
| R13 K | 10                                                                | (0.07) OR LESS  | LONDON 66 HBC COMPILATION 10/66                             |
| R14   | ETA PRIME INTO (3 P1) / TOTAL (P12)                               |                 |                                                             |
| R14 K | 10                                                                | (0.07) OR LESS  | LONDON 66 HBC COMPILATION 10/66                             |
| R15   | ETA PRIME INTO (4 P1) / TOTAL (P13)                               |                 |                                                             |
| R15 K | 10                                                                | (0.01) OR LESS  | LONDON 66 HBC COMPILATION 10/66                             |
| R16   | ETA PRIME INTO (6 P1) / TOTAL (P15)                               |                 |                                                             |
| R16 K | 10                                                                | (0.01) OR LESS  | LONDON 66 HBC COMPILATION 10/66                             |
| R18   | ETA PRIME INTO (RHO GAMMA) / (P1+ P2)                             |                 |                                                             |
| R18 K | 31                                                                | 0.15            | DAVIS 68 HBC 5.5 K-P 9/68                                   |
| R18   | FIT                                                               | 0.365 0.065     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)               |
| R19   | ETA PRIME INTO (2 GAMMA) / TOTAL (P4)                             |                 |                                                             |
| R19 K | 5                                                                 | 0.055 0.036     | BOLLINI 68 CNTR 1.9 P1- P 12/72*                            |
| R19 K | 7                                                                 | 0.126 0.075     | BEISINGER 70 HBC 2.2 P1+ D 12/72*                           |
| R19 K | 41                                                                | (0.017) (0.004) | BASILE2 71 CNTR 1.6 P1- P1N X0 12/72*                       |
| R19 S | 41                                                                | (0.017) (0.004) | BASILE2 71 CNTR 1.6 P1- P1N X0 12/72*                       |
| R19 S | 31                                                                | 0.020 0.008     | HARVEY 71 OSPK 3.65 P1- P1N X0 11/71                        |
| R19 S | 68                                                                | 0.0171 0.0033   | DALPIAZ 72 CNTR 1.6 P1- P1N X0 12/72*                       |
| R19   | AVG                                                               | 0.0181 0.0030   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)                |
| R19   | FIT                                                               | 0.0194 0.0029   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)               |
| R20   | ETA PRIME INTO (P1+ P1-) / TOTAL (P11)                            |                 |                                                             |
| R20 K | 10                                                                | (0.02) OR LESS  | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R21   | ETA PRIME INTO (P1+ P1- P10) / TOTAL (P12)                        |                 |                                                             |
| R21 K | 10                                                                | (0.05) OR LESS  | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R22   | ETA PRIME INTO (P1+ P1+ P1- P1) / TOTAL (P13)                     |                 |                                                             |
| R22 K | 10                                                                | (0.01) OR LESS  | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R23   | ETA PRIME INTO (P1+ P1+ P1- P10) / TOTAL (P14)                    |                 |                                                             |
| R23 K | 10                                                                | (0.01) OR LESS  | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R24   | ETA PRIME INTO (P1+ P1+ P1- NEUTRALS) / TOTAL (P16+...)           |                 |                                                             |
| R24 K | 10                                                                | (0.01) OR LESS  | RITTENBER 69 HBC 1.7-2.7 K-P 9/69                           |
| R25   | ETA PRIME INTO (RHO GAMMA) / (ALL P1+ P1- GAMMA)                  |                 |                                                             |
| R25 K | 94                                                                | 0.20            | AGUILAR 70 HBC 3.9-4.6 K-P 1/71                             |
| R25 K | 11                                                                | (1.1) (0.1)     | DANBURG 72 HBC 2.2 K- P1L X0 12/72*                         |

## Mesons

 $\eta(958)$ ,  $\delta(970)$ 

## Data Card Listings

For notation, see key at front of Listings.

R26 ETA PRIME INTO (PIO PIO ETA INTO 3 PIO)/TOTAL (P2N(3PIO))  
 R26 4 0.11 0.06 BENSINGER TO DBC 2.2 P1+ D 1/71  
 R26 FIT 0.0739 0.0062 FROM FIT (ERROR INCLUDES SCALE-FACTOR OF 1.0)  
 R27 ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETAINETRAL DEC.)  
 R27 (P3)/(P1N)  
 R27 0.54 0.10 AGUILAR 72 HBC 3.9+4.6 K- P 12/72\*  
 R27 (0.81) (0.09) DANBURG 72 HBC 2.2 K- P, L X0 2/73\*  
 R27 FIT 0.78 0.15 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  
 R28 ETA PRIME INTO(2 GAMMA)/(PIO PIO ETAINETRAL DEC.)  
 R28 (P4)/(P2N1)  
 R28 16 0.188 0.056 APEL 72 OSPK 3.8 P1- P, N X0 1/73\*  
 R28 FIT 0.111 0.054 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.8)

## REFERENCES FOR ETA PRIME

DAUBER 64 PRL 13 449 DAUBER, SLATER, SMITH, STORK, TICHQ (UCLA)JP  
 ALSO 64 DUBNA CONF 1 418 DAUBER, SLATER, L T SMITH, STORK, TICHQ (UCLA)  
 GOLDBERG 64 PRL 12 546 +GUNDZIK, LICHTMAN, CONNOLLY, HART, + (SYRA+BNL)  
 GOLDBERG 64 PRL 13 249 +GUNDZIK, LEITNER, CONNOLLY, HART, + (SYRA+BNL)  
 KALBFLEI 64 PRL 13 349 G.R. KALBFLEISCH, O. DAHL, A. RITTENBERG (LRL)JP  
 BADIER 65 PL 17 337 BADIER, DEMOULIN, BARLOUTAUD+ (EPOL+ SACL+ ZEEN)  
 KIENZLE 65 PL 19 438 KIENZLE, MAGLIC, LEVRAT, LEFEBVRES + (CERN)  
 RITTENBERG 65 PL 15 556 RITTENBERG, KALBFLEISCH (LRL+BNL)  
 TRILLING 65 PL 19 427 +BROWN, GOLDBERG, KADYK, SCANIO (LRL)  
 COHN 66 PL 21 347 COHN, MCCULLOCH, BUGG, CONDO (ORNL+TENN+UCND)  
 LONDON 66 PR 143 1034 LONDON, RAU, SAMIOS, GOLDBERG + (BNL+SYRACUSE)JP  
 MARTIN 66 PL 22,352 MARTIN, CRITTENDEN, SCHROEDER (INDIANA U)  
 BARBARO 68 PRL 20 349 BARBARO, GALTIERI, MATISON, RITTENBERG+ (LRL)JP  
 BARLOUTAUD 68 PL 26 8 674 BARLOUTAUD+ (SACLAY+AMST+BGNA+REHO+EPOL)JP  
 BOLLINI 68 NC 58 A 289 +BUHLER, DALPIAZ, MASSAM+ (CERN+BGNA+STRB)  
 DAVIS 68 PL 27 8 532 +AMMAR, MOTT, DAGAN, DERRICK, FIELDS (INVE+ANL)  
 DUFY 69 PL 29 8 605 +GOBBI, POUCHON, CNOPS, + (ETHZ+CERN+ SACL)JP  
 MOTT 69 PR 177 1966 +AMMAR, DAVIS, KROPAC, SLATE, DAGAN+ (INVE+ANL)  
 RITTENBERG 69 UCRL-10863 ALAN RITTENBERG (THESIS) (LRL)JP  
 AGUILAR 70 PRL 25 1635 AGUILAR-BENITEZ, BASSANO, SAMIOS, BARNES+ (BNL)  
 BENSINGER 70 PL 33 8 505 BENSINGER, ERWIN, THOMPSON, W.D. WALKER (WISC)  
 BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA, HOFMOKL, MICHEJDA+ (WARS)  
 BASILE 71 NC 3 A 371 +BOLLINI, DALPIAZ, FRABETTI+ (CERN+BGNA+STRB)  
 BASILE 71 NP 8 33 29 +BOLLINI, DALPIAZ, FRABETTI+ (CERN+BGNA+STRB)  
 HARVEY 71 PRL 27 885 +NARQUIT, PETERSON, RHOADES, + (KINN+MICH)  
 OGIEVETSKY 71 PL 25 8 69 OGIEVETSKY, TYBOR, ZASLAVSKY (DUBNA)  
 AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
 APEL 72 PL 40 8 680 +AUSLANDER, MULLER, BERTOLUCCI, + (KARL+PISA)  
 BINNIE 72 PL 29 8 275 +CAMILLERI, DUANE, GARBUTT, BURTON+ (LOIC+SHMP)  
 BLOODWORTH 72 NP 8 39 525 BLOODWORTH, JACKSON, PRENTICE, YODH (TORONTO)  
 DALPIAZ 72 PL 42 8 377 +FRABETTI, MASSAM, NAVARRIA, ZICHICH (CERN)  
 DANBURG 72 PL PHIL. CONF. PROC. +BORENSTEIN, KALBFLEISCH, CHAPMAN, + (BNL+MICH)  
 JADER 72 PR D 6 3059 +ABOLINS, DAHL, DANBURG, DAVIES, HOCH, + (LBL)

 $\delta(970)$  $\rightarrow \eta\pi, \dots$ 

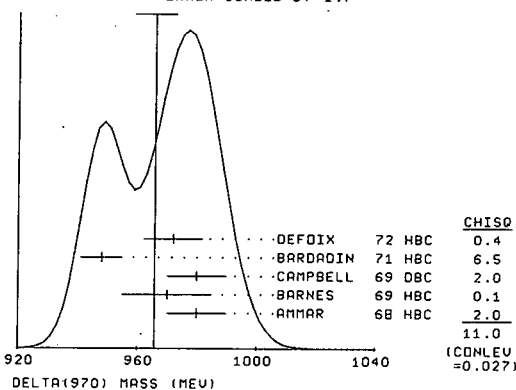
Under this entry, we list three types of  $I = 1$  peaks near  $K\bar{K}$  threshold.

- 1) Missing-mass peaks, some of them controversial.
- 2)  $\eta\pi$  decays, peaking slightly below  $K\bar{K}$  threshold. This defines  $I^G = 1^-$  and  $J^P = \text{Normal}$ .
- 3) Threshold enhancements in the  $(K\bar{K})^\pm$  system with  $I = 1$ . The Q value is low and  $J^P$  therefore probably  $0^+$ .

In listing them together under a common entry we do not imply that they are necessarily all related. However, the  $K\bar{K}$  threshold enhancement may be due to a virtual bound state that could also be responsible for the  $\eta\pi$  peaks (ASTIER 67). More complete studies of the mass dependence of the  $K\bar{K}$  threshold effect, using coupled channel analysis, are needed to clarify this question.

## 36 DELTA(970) MASS (MEV)

M PEAKS SEEN IN MISSING MASS EXPERIMENTS  
 M K 262 (962.0) (5.0) KIENZLE 65 MMS - 3-5 P1- P 9/66  
 M O NOT SEEN BY BANNER 1 67 (1.8 P1- P)  
 M O (966.0) (8.0) OOSTENS 66 MMS + 3.8 PP TO D + MM 9/66  
 M O NOT SEEN BY BANNER 2 67 AND ANDERSON 71  
 M N 975.0 6.0 ABOLINS 70 MMS + 3.8-6.3 PP--D+MM 1/71  
 M N 215 (962.9) (1.7) CHESHIRE 72 MMS 0 2.4 P1- P, N MM 12/72\*  
 M N NOT SEEN BY BINNIE 72 AT THRESHOLD.  
 M ETA P1 FINAL STATE ONLY.  
 M S 30 980.0 10.0 AMMAR 68 HBC + .55K-ETA P1 2/73\*  
 M S SEE ALSO AMMAR 70.  
 M 10 (960.1) APPROX. CHUNG S 68 HBC - 3.2 P1-P 5/70  
 M 80 (975.0) DEFIOX 68 HBC + 1.2 PB P, ETA P1 3/69  
 M 20 970.0 15.0 BARNES 69 HBC - 4-5 K-P, P1-ETA 9/69  
 M 980.0 CAMPBELL 69 DBC - 2.7 P1+ D 1/73\*  
 M 15 (980.0) (10.0) MILLER 69 HBC - 4.5 K-N, ETA P1 7/69  
 M 21 946.0 7.0 BARDADIN 71 HBC + 8 P1+P, P DO P1 2/72  
 M 150 972. 10. DEFIOX 72 HBC + 0.7 PBAR P, P1 1/73\*  
 M AVG 965.8 7.1 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)  
 (SEE IDEOGRAM BELOW)  
 WEIGHTED AVERAGE = 965.8  $\pm$  7.1  
 ERROR SCALE BY 1.7



M K KBAR ONLY, SEE THE TYPED NOTE ABOVE  
 M 143(1003.3) 7.0+SYSTEMATIC ROSENFELD 65 RVUE + 8/66  
 M SCAT. LENGTH 2 TO 6 FERMIS. BALTAY 66 HBC + 3.7 PBAR P 8/66  
 M A 100(1016.) (10.) ASTIER 67 HBC + 0 PBAR P 7/67  
 M SCATT. LENGTH ALSO FITS, SEE BELOW  
 M SCATT. LENGTH +2.5 -1. FERM ASTIER 67 HBC + 0-1.2 PBAR P 7/67  
 M OR CMPLX, RE PART=-2.3 F ..... 7/67  
 M IM PART=-.5F OR LESS ..... 7/67  
 M B (1.8) (0.4) (0.3) DUBOC 72 HBC 1.2 PBAR P, 3PI2K 12/72\*  
 M B ABSOLUTE VALUE OF SCAT. LENGTH 12/72\*

## 36 DELTA(970) WIDTH (MEV)

M PEAKS SEEN IN MISSING MASS EXPERIMENTS  
 M S 262 (5.0) OR LESS KIENZLE 65 MMS - 3-5 P1- P 9/66  
 M S (10.0) OR LESS OOSTENS 66 MMS + 3.8 PP TO D + MM 9/66  
 M 1 60.0 16.0 10.0 ABOLINS 70 MMS + 3.8-6.3 PP--D+MM 1/71  
 M S 215 (5.9) OR LESS CL=90 CHESHIRE 72 MMS 0 2.4 P1- P, N MM 12/72\*  
 M S SEE NOTES ON DELTA MASS ABOVE  
 M ETA P1 FINAL STATE ONLY  
 M 30 80.0 30.0 AMMAR 68 HBC + .55K-ETA P1 2/73\*  
 M 80 (25.0) DEFIOX 68 HBC + 1.2 PB P, ETA P1 3/69  
 M 20 (50.0) OR LESS BARNES 69 HBC - 4-5 K-P, P1-ETA 9/69  
 M 40 15. CAMPBELL 69 DBC - 2.7 P1+ D 1/73\*  
 M R 15 (60.0) (30.0) MILLER 69 HBC - 4.5 K-N, ETA P1 7/69  
 M R 21 (31.0) (28.0) BARDADIN 71 HBC + 8 P1+P, P DO P1 2/72  
 M R 150 (30.) (5.1) DEFIOX 72 HBC + 0.7 PBAR P, P1 1/73\*  
 M R RESOLUTION NOT UNFOLDED  
 M AVG 46.0 16.0 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)  
 M K KBAR ONLY, SEE THE TYPED NOTE ABOVE  
 M 143 (57.0) 13.0+SYSTEMATIC ROSENFELD 65 RVUE + 8/66  
 M A 100 (25.) APPROX. ASTIER 67 HBC + SEE NOTE A ABOVE 7/67

## 36 DELTA(970) PARTIAL DECAY MODES

| P1   | DELTA(970) INTO ETA P1   | DECAY MASSES |
|------|--------------------------|--------------|
| P2   | DELTA(970) INTO 3 P1     | 548+ 134     |
| P3   | DELTA(970) INTO RHO P1   | 770+ 134     |
| P4 S | DELTA(970) INTO K KBAR   | 770+ 134     |
| P4 S | SEE THE TYPED NOTE ABOVE | 770+ 134     |

## 36 DELTA(970) BRANCHING RATIOS

R1 DELTA(970) INTO (RHO P1)/(ETA P1) (P3)/(P2)  
 R1 (0.25) OR LESS CL=.70 AMMAR 70 HBC + 4.1, 5.5K-ETA P1. 5/70  
 R10 CHARGED DELTA OF KIENZLE 65 INTO (1 CHARGED)/(3 OR MORE CHARGED)  
 R10 1.3 0.9 0.7 KIENZLE 65 MMS - 3-5 P1- P 9/66  
 R11 DELTA OF CHESHIRE 72 INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)  
 R11 (0.10) (0.82) (0.08) CHESHIRE 72 MMS 0 2.4 P1- P, N MM 12/72\*

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $\delta(970)$ ,  $H(990)$ ,  $S^*(1000)$ ,  $\phi(1019)$ REFERENCES FOR  $\Delta$ 

TURKOT 63 SIENNA CONF 1 661 + COLLINS, FUJII, KEMPA (BNL-PITTSBURGH)

ARMENTER 65 PL 17 344 + ARMENTEROS, EDWARDS, JACOBSEN + (CERN+CDEF)  
BARASH 65 PR 139 B 1659 + FRANZINI, KIRSCH, MILLER, STEINBERGER + (COLU)  
KIENZLE 65 PL 19 438 + MAGLIC, LEVRAT, LEFEBVRES + (CERN)  
ROSENFELD 65 OXFORD CONF 58 A H ROSENFELD (LRL-RVUE)

ALLEN D 66 PL 22 543 + GP FISHER, G. GOODEN, L. MARSHALL, SEARS (COLO)G++  
BALYAT 66 PR 142 B 932 + LACH, SANDWEISS, TAFT, YEH, STONEHILL + (YALE)  
FOCACCI 66 PRL 17 890 + KIENZLE, LEVRAT, MAGLIC, MARTIN (CERN)  
OOSTENS 66 PL 22 708 + CHAVANDON, COZON, TOCQUEVILLE (SACLAY, CDEF)I=1

ALLISON 67 PL 258 619 + CRUZ + (IOF+MPIH+BIRM+RHEL+GLAS+LOIC)  
ASTIER 67 PL 25 B 294 + MONTANET, BAUBILLIER, DUBOC + (CDEF+CERN+IRAD)  
ASTIER 67 INCLUDES DATA OF BARLOW 67, CONFONTO 67, ARMENTEROS 65.  
BAILLON 67 NC 50A 393 + EDWARDS+D. ANDLAU+ASTIER + (CERN+CDEF+IRAD)  
BANNER 1 67 PL 184 1461 + FAYOUX, HAMEL, ZSEMBERY, CHEZE + (SACLAY+CAEU)  
BANNER 2 67 PL 25 B 569 + CHEZE, HAMEL, MAREL, TEJERO + (CDEF+SACL)  
BARLOW 67 NC 50 A 701 + MONTANET, D. ANDLAU + (CERN+CDEF+IRAD+LIVP)  
CONFONTO 67 NP 83 469 + CONFONTO, MARECHAL + (CERN+CDEF+IPNP+LIVP)

AMMAR 68 PRL 21 1832 + DAVIS, KROPAC, DERRICK, FIELDS + (NWES+ANL)  
CHUNG S 68 PR 165 1491 + O. DAHL, J. KIRZ, D. H. MILLER (LRL)  
DEFOIX 68 PL 28 B 253 + RIVET, STAUD, CONFONTO + (CDEF+IPNP+CERN)  
GALTIERI 68 PRL 20 349 + BARBARO-GALTIERI, MATISON, RITTENBERG + (LRL)  
JUHALL 68 PL 27 B 257 + LEACOCK, RHODE, KOPELMAN, LIBBY + (IOWA+COLO)  
SABRE CO 68 PL 26 B 674 + BARLOTTAUD + (SACL+AMST+BGNA+REHO+EPOL)

BARNES 69 PRL 23 610 + CHUNG, EISNER, BASSANO, GOLDBERG + (BNL+SYRA)  
CAMPBELL 69 PRL 22 1204 J. H. CAMPBELL, L. LICHTMAN, LOEFFLER + (PURDUE)  
CRENNELL 69 PRL 22 1398 + KARSHON, KANAN MU LAI + (BNL+NYU)  
JUHALL 69 PR 184 1461 + LEACOCK, RHODE, KOPELMAN, LIBBY + (IOWA+COLO)  
KRUSE 69 PR 177 195 + KRUSE, LOOS, GOLDMANN + (ILLINOIS)  
MILLER 69 PL 29 B 255 + D. H. MILLER, S. L. KRAMER, D. D. CARMONY + (PURDUE)  
ALSO 69 PR 188 2011 YEN, AMMANN, CARMONY, ELSNER + (PURDUE)  
SCHROEDER 69 PR 188 2081 SCHROEDER, KERNAN, FISHER, LIBBY + (ISU+COLO)

ABOLINS 70 PRL 25 469 + GRAVEN, MCCARTHY, G. SMITH, L. SMITH + (LRL+UCD)  
70 PR D 2 430 + KROPAC, DAVIS, DERRICK + (KANS+NWES+ANL+WLSC)  
COOPER 70 NP 8 23 605 + HANNER, MUSGRAVE, POLLARD, VOYVODIC (ANL)  
YIU 70 THESIS, A 646 TCHIU-PUNG YIU (ORSA)

ANDERSON 71 PRL 26 108 + DIXIT, + (CHIC+ANL+CARL+LASL+CMC+MAGGAY)  
BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA, HOFMOKL, MICHELOA+JAWARS

ATHERTON 72 SUBM. TO PL + FRANK, FRENCH, GHIDINI, MILPERT + (CERN)  
BINNIE 72 PL 39 B 275 + CAMPILLERI, DUANE, GARBUIT, BURTON (LOIC+SWP)  
CHESHIRE 72 PRL 28 520 + HOFFMAN, GARFINKEL + (IOWA+ANL+PURD)  
DEFOIX 72 NP 8 44 125 + NASCIMENTO, BIZZARRI + (CDEF+CERN)  
DUBOC 72 NP 8 46 429 + GOLDBERG, MAKOWSKI, DONALD + (LBNL+LIVP)  
HOLLOWAY 72 PHIL. CONF. PROC. 133+HULD, KOETZ, KRUSE, BERNSTEIN + (ILL+ILLC)

**H(990)**

35 H 990, JPG-A - I=0

THE EVIDENCE OF BENSON 66 HAS DISAPPEARED AFTER RE-ANALYSIS (CHAUDHARY 70). NO STATISTICALLY SIGNIFICANT EVIDENCE FOR THE PRE-1968 H-ENHANCEMENT THEREFORE REMAINS (BARBARO-GALTIERI 69). HOWEVER, GOLDBERGER 69 REPORT A NEW (PI+PI-PI0) ENHANCEMENT AT ABOUT THE SAME MASS, M=1000 MEV, SEEN UNDER CONDITIONS DIFFERENT FROM THOSE OF THE EARLIER OBSERVATIONS. OMITTED FROM TABLE.

## REFERENCES FOR H

BARTSCH 64 PL 11 167 AACHEN-ZEUTHEN-BIRM-BONN-HAMB-MUNCHEN COLL  
GOLDBERGER 65 CORAL GABLES P.76 G. GOLDBERGER (LRL)  
BENSON 66 PRL 17 1234 + MARQUIT, ROE, SINCLAIR, VANDER VELDE (MICH)JIP  
CONN 67 NP 81 57 + MC CULLOCH, BUGG, CONDO (ORNL+UNIV. TENN)  
ROSENFELD 67 RMP 39 1, APPENDIX ROSENFELD, BARBARO-GALTIERI (LRL+CERN+YALE)  
ARMENISE 68 PL 268 336 + GHIDINI, FORINO + (BARI+BGNA+FRIZ+ORSAY)  
BARBARO-GALTIERI 68 PHILAD. CONF. P. 137 A. BARBARO-GALTIERI, P. SODING (LRL)  
FUNG 68 PRL 21 47 + JACKSON+PU+BRONW+GIDAL (U.C. RIVERS+LRL)  
GOLDBERGER 69 LUND CONF. P. 271 G. GOLDBERGER QUOTED BY B. MAGLIC (MINNESOTA)  
CHAUDHARY 70 PR D 2 1110 B. CHAUDHARY + MARQUIT (ILL)  
GORDON 70 CDD 1195 179 THESIS, ILLINOIS (LRL)  
MICHAEL 72 PRL 28 1475 W. MICHAEL, G. GIDAL (LBL)

**S\*(1000)**

3 S\* (1000, JPG-O++) I=0

WE ONLY LIST DETERMINATIONS OF POLE POSITION. FOR EARLY WORK USING BREIT-WIGNER OR SCATTERING LENGTH PARAMETRIZATION IN FITS TO THE (K KBAR) MASS SPECTRUM SEE REFERENCE SECTION AND OUR 1972 EDITION.

S-wave  $K\bar{K}$  Interactions in the Region 990-1200 MeV

Under this entry we list parameters of the  $S^*$  pole in the  $I^G(J^P)C = 0^+(0^+) +$  wave. For discussion, see the entry "S-wave  $\pi\pi$  interactions," near the beginning of these Meson Data Card Listings.

Note that possible evidence of D-wave  $\pi\pi$  interactions in the  $S^*$  region is listed separately under  $\eta_N(1080)$ .

3 REAL PART OF THE  $S^*$  POLE POSITION (MEV)

|   |     |                                                     |     |      |                    |         |     |               |       |
|---|-----|-----------------------------------------------------|-----|------|--------------------|---------|-----|---------------|-------|
| W | H   | 970.                                                | 30. | 130. | HOANG              | 69 OSPK | 4.  | PI-P, KS KS N | 1/73* |
| M | H   | 920.                                                | 80. | 90.  | HOANG              | 69 OSPK | 5.  | PI-P, KS KS N | 1/73* |
| M | H   | CALCULATED FROM SCATTERING LENGTH FIT OF HOANG 69.  |     |      | BEUSCH             | 70 OSPK | 4.6 | PI-P          | 1/73* |
| M | B   | CALCULATED FROM SCATTERING LENGTH FIT OF BEUSCH 70. |     |      | BASEDEVANT 72 RVUE | SHEET 2 |     |               | 1/73* |
| M | B   | (996.0)                                             |     |      | PROTODIPE 72 HBC   | SHEET 2 | 7.  | PI+P          | 1/73* |
| M | B   | 997.                                                | 5.  |      |                    |         |     |               |       |
| M | AVG | 996.6                                               | 5.0 |      |                    |         |     |               |       |

3 NEGATIVE IMAG. PART OF THE  $S^*$  POLE POSITION (MEV) CORRESPONDS TO HALF-WIDTH, NOT FULL WIDTH.

|   |     |                                                  |     |     |                    |         |     |               |       |
|---|-----|--------------------------------------------------|-----|-----|--------------------|---------|-----|---------------|-------|
| W | H   | 40.                                              | 40. | 60. | HOANG              | 69 OSPK | 4.  | PI-P, KS KS N | 1/73* |
| M | H   | 30.                                              | 30. | 70. | HOANG              | 69 OSPK | 5.  | PI-P, KS KS N | 1/73* |
| W | B   | (13.1)                                           |     |     | BEUSCH             | 70 OSPK | 4.6 | PI-P          | 1/73* |
| W | P   | (65.0)                                           |     |     | BASEDEVANT 72 RVUE |         |     |               | 1/73* |
| W | P   | 27.                                              | 8.  |     | PROTODIPE 72 HBC   |         | 7.  | PI+P          | 1/73* |
| W | P   | ANOTHER SOLUTION HAS 52 MEV AND NO EPSILON POLE. |     |     |                    |         |     |               |       |
| W | AVG | 27.4                                             | 7.8 |     |                    |         |     |               |       |

REFERENCES FOR  $S^*$ 

WANG 61 JETP 13 323 WANG TSU-TSENG, VEKSLER, VRANA + (JINR)  
BIGI 62 CERN CONF 247 A BIGI, S. BRANDT, R. CARRARA + (CERN)  
BINGHAM 62 CERN CONF 240 H H BINGHAM, M. BLOCH + (EPOL+CERN)  
ERWIN 62 PRL 9 34 ERWIN, MOYER, MARCH, WALKER, WANDLER (MISC+BNL)  
BALYAT 64 DUBNA CONF 1 409 BALYAT, LACH, CRENNELL, OREN, STUMP + (YALE+BNL)  
BARMIN 64 DUBNA CONF 1 433 BARMIN, DOUGLE, YEROFEEV, KRESTIN + (ITEP)  
CRENNELL 66 PRL 16 1025 CRENNELL, KALBFLEISCH, LAI, SCARR, SCHU + (BNL)  
HESS 66 PRL 17 1109 + DAHL+HARDY+KIRZ+MILLER (LRL)

BARLOW 67 NC 50A 701 + LILLESTO, MONTANET + (CERN+CDEF+IRAD+LIVP)  
BEUSCH 67 PL 25 B 357 + FISCHER, GORDON, ASTUBURY + (ETH+CERN)  
DAHL 67 PR 163 1377 + HARDY+HESS+KIRZ+MILLER (LRL)  
ALITTI 68 PRL 21 1705 + BARNES, CRENNELL, F. LAMINIO, GOLDBERG + (BNL)  
LAI 68 PHILAD. CONF. P. 303 KANAN MU LAI (BNL)  
PHELAN 68 THESIS JAMES J. PHELAN (ANL+ST. LOUIS UNIV)  
ALSO 68 PRL 21 316 HOANG, EARLY, PHELAN, BARLOW + (ANL+CHIC+NDAM)  
AGUILAR 69 PL 29 B 241 M. AGUILAR-BENITEZ, J. BARLOW + (CERN+CDEF)  
ALSO 67 BARLOW T. F. HOANG (ANL)  
HOANG 69 NC 61 A 325 + EARTLY, PHELAN, ROBERTS + (ANL+ILLC)  
HOANG 69 PR 184 1363

BADIER 70 NP 8 22 512 + BONNET, DREVILLON, BAUBILLIER + (EPOL+IPNP)  
BATON 70 PL 33 B 528 + LAURENS, REIGNIER (SACLAY)  
BEUSCH 70 PHILAD. CONF. P. 185 W. BEUSCH (ETH+CERN)  
HYAMS 70 NP 8 22 189 + KOCH, BEUSCH + (CERN+MPIH+ETH+LOIC+HANA)  
OH 70 PR D 1 2494 HYAMS, KOCH, POTTER, V. LINDEN, N. (CERN+MPIH)  
ALSTON-G 71 PL 36 B 152 + GARFINKEL, MORSE, WALKER, PRENTICE (WISC+TNT)  
ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST, BARBARO-GALTIERI + (LBL)

BASEDEVANT 72 PL 41 B 178 BASEDEVANT, FROGGATT, PETERSEN (CERN)  
DAMERI 72 NC 9 A 1 + BORZATTA, GOUSSU + (GENO+MIL+SACL)  
DUBOC 72 NP 8 46 429 + GOLDBERGER, MAKOWSKI, DONALD + (LBNL+LIVP)  
FLATTE 72 PL 38 B 232 + ALSTON-GARNJOST, BARBARO-GALTIERI + (LBL)  
GRAYVER 72 PHIL. CONF. PROC. 5 + HYAMS, JONES, SCHLEIN, BLUM, DIETZ (CERN+MPIH)  
PROTODIPE 72 PREPRINT LBL-970 PROTODIPE, ALSTON, BARBARO, FLATTE + (LBL)  
WILLIAMS 72 PR D 6 3178 P. K. WILLIAMS (FSU)

FUJII 73 NC 13 A 311 Y. FUJII, M. KATO (TOKYO)

 **$\phi(1019)$** 

4 PHI (1019, JPG=1-- ) I=0

## 4 PHI MASS (MEV)

|   |             |         |           |         |                    |               |  |        |
|---|-------------|---------|-----------|---------|--------------------|---------------|--|--------|
| W | 1019.0      | 2.0     | SCHLEIN   | 63 HBC  | 2.0                | K-P           |  |        |
| M | 1018.6      | 0.5     | MILLER D  | 65 HBC  | 0.0                | PBAR P        |  | 8/66   |
| M | 1020.0      | 2.0     | LONDON    | 66 HBC  | 2.2                | K-P           |  | 6/66   |
| M | 1021.5      | 0.8     | ABRAMS    | 67 HBC  | 4.2                | K-P           |  | 11/67  |
| M | 1019.3      | 3.      | BARLOW    | 67 HBC  | 1.2                | PBAR P        |  | 11/66  |
| M | 1021.0      | 4.0     | DAHL      | 67 HBC  | 1-4                | PI-P          |  | 9/66   |
| M | 165 1022.   | 1.5     | MOSEK     | 68 OSPK | 1.8                | GAMMA + C     |  | 6/68   |
| M | 1018.       | 0.5     | HYAMS     | 70 OSPK | 11.                | PI-P          |  | 6/70   |
| M | (1020.1)    | (1.1)   | SABRE     | 70 OBC  | 3.0                | K-N           |  | 1/71   |
| M | 1021.0      | 1.5     | ALVENSLE  | 71 OSPK | GAMMA + C          |               |  | 1/72   |
| M | 1019.9      | 0.6     | DIABIANCA | 71 OBC  | 4.93               | K-N           |  | 1/72   |
| M | 410(1019.9) | (0.3)   | STOTTLEMY | 71 HBC  | 2.9                | K-P, Y K KBAR |  | 11/71  |
| M | 120 1019.6  | 0.3     | AGUILAR   | 72 HBC  | 3.9, 4.6           | K-P           |  | 12/72* |
| M | 100 1019.9  | 0.4     | AGUILAR   | 72 HBC  | 3.9, 4.6           | K-P           |  | 12/72* |
| M | 87 1020.8   | 0.8     | BALAKIN   | 72 OSPK | E+ COLL. BEAMS     |               |  | 12/72* |
| M | 131 1020.4  | 0.5     | COLLEY    | 72 HBC  | 10. K+ P, K+ P PHI |               |  | 12/72* |
| M | AVG         | 1019.59 | 0.31      |         |                    |               |  |        |

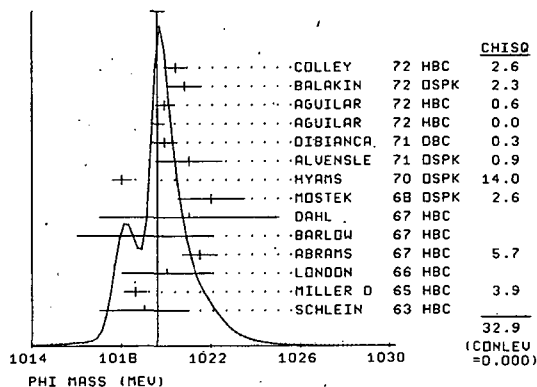
## 4 PHI WIDTH (MEV)

|   |                                |         |           |         |                    |               |  |        |
|---|--------------------------------|---------|-----------|---------|--------------------|---------------|--|--------|
| W | 3.5                            | 1.0     | MILLER D  | 65 HBC  | 0.0                | PBAR P        |  | 8/66   |
| W | 6.0                            | 4.0     | LONDON    | 66 HBC  | 2.2                | K-P           |  | 6/66   |
| W | 1.8                            | 3.0     | ABRAMS    | 67 HBC  | 4.2                | K-P           |  | 11/67  |
| W | (10.1)                         | OR LESS | BARLOW    | 67 HBC  | 1.2                | PBAR P        |  | 11/66  |
| W | 165 (4.5)                      | (3.0)   | MOSEK     | 68 OSPK | 1.8                | GAMMA + C     |  | 6/68   |
| W | 150 4.2                        | 0.9     | AUGUSTIN  | 69 OSPK | E+ COLL. BEAMS     |               |  | 12/72* |
| W | 4.09                           | 0.29    | BIZOT     | 70 OSPK | E+ COLL. BEAMS     |               |  | 12/72* |
| W | 3.3                            | 1.5     | HYAMS     | 70 OSPK | 11.                | PI-P          |  | 6/70   |
| W | 4.67                           | 0.42    | BALAKIN   | 71 OSPK | E+ COLL. BEAM      |               |  | 11/71  |
| W | 5.5                            | 1.1     | DIABIANCA | 71 OBC  | 4.93               | K-N           |  | 1/72   |
| W | (4.7)                          | (0.7)   | LEFRANCOI | 71 OSPK | E+ COLL. BEAMS     |               |  | 2/73*  |
| W | S SUPERSEDED BY JEAN-MARIE 73. |         |           |         |                    |               |  |        |
| W | 110 (4.5)                      | (3.0)   | STOTTLEMY | 71 HBC  | 2.9                | K-P, Y K KBAR |  | 11/71  |
| W | 120 4.6                        | 1.0     | AGUILAR   | 72 HBC  | 3.9, 4.6           | K-P           |  | 12/72* |
| W | 100 4.7                        | 1.3     | AGUILAR   | 72 HBC  | 3.9, 4.6           | K-P           |  | 12/72* |
| W | 131 5.0                        | 1.3     | COLLEY    | 72 HBC  | 10. K+ P, K+ P PHI |               |  | 12/72* |
| W | 3.81                           | 0.34    | JEAN-MARI | 73 OSPK | E+ COLL. BEAMS     |               |  | 2/73*  |
| W | AVG                            | 4.16    | 0.17      |         |                    |               |  |        |

Mesons  
 $\phi(1019)$ 

## Data Card Listings

For notation, see key at front of Listings.

WEIGHTED AVERAGE = 1019.59 ± 0.31  
ERROR SCALED BY 1.9

4 PHI PARTIAL DECAY MODES

|     |                                         | DECAY MASSES  |
|-----|-----------------------------------------|---------------|
| P1  | PHI INTO K+ K-                          | 493± 493      |
| P2  | PHI INTO KL KS                          | 497± 497      |
| P3  | PHI INTO P1+ P1- P10 (INCLUDING RHO P1) | 139± 139± 134 |
| P4  | PHI INTO ETA GAMMA                      | 548± 0        |
| P5  | PHI INTO E+ E-                          | 5± 5          |
| P6  | PHI INTO MU+ MU-                        | 105± 105      |
| P7  | PHI INTO P10 GAMMA                      | 134± 0        |
| P8  | PHI INTO P1+ P1- (VIOLATES G)           | 139± 139      |
| P9  | PHI INTO P1+ P1- GAMMA                  | 139± 139± 0   |
| P10 | PHI INTO OMEGA GAMMA (VIOLATES C)       | 783± 0        |
| P11 | PHI INTO ETA P10 (VIOLATES C)           | 548± 134      |
| P12 | PHI INTO RHO GAMMA (VIOLATES C)         | 770± 0        |
| P13 | PHI INTO ETA NEUTRALS                   |               |
| P14 | PHI INTO S P1                           |               |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

|     | P 1           | P 2           | P 3           | P 4           |
|-----|---------------|---------------|---------------|---------------|
| P 1 | 0.4675±0.0258 |               |               |               |
| P 2 | -0.3925       | 0.3496±0.0272 |               |               |
| P 3 | -0.3805       | -0.6557       | 0.1524±0.0304 |               |
| P 4 | -0.1338       | -0.1588       | -0.1287       | 0.0305±0.0107 |

## 4 PHI BRANCHING RATIOS

|      |                                               |                                               |                   |       |
|------|-----------------------------------------------|-----------------------------------------------|-------------------|-------|
| R1   | PHI INTO (K+ K-)/TOTAL                        | (P1)                                          |                   |       |
| R1 B | 27 (0.26) (0.06)                              | BADIER 65 HBC                                 | 10/66             |       |
| R1 C | 252 0.48 0.04                                 | LINDSEY 66 HBC                                | 2.7 K-P           | 10/66 |
| R1 D | 10 (0.403) (0.044)                            | BIZOT 70 OSPK                                 | E+ E- COLL. BEAMS | 11/71 |
| R1 E | 0.540 0.034                                   | BALAKIN 71 OSPK                               | E+ E- COLL. BEAM  | 11/71 |
| R1 F | 0.486 0.044                                   | CHATELUS 71 OSPK                              | E+ E- COLL. BEAMS | 11/71 |
| R1 G | 0.507 0.022                                   |                                               |                   |       |
| R1 H | 0.468 0.026                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                   |       |
| R1 I |                                               | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |                   |       |
| R2   | PHI INTO (KL KS)/TOTAL                        | (P2)                                          |                   |       |
| R2 B | 25 (0.43) (0.06)                              | BADIER 65 HBC                                 | 10/66             |       |
| R2 C | 167 0.40 0.04                                 | LINDSEY 66 HBC                                | 2.7 K-P           | 10/66 |
| R2 D | 0.257 0.038                                   | BALAKIN 71 OSPK                               | E+ E- COLL. BEAMS | 1/73* |
| R2 E |                                               |                                               |                   |       |
| R2 F | 0.325 0.071                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)  |                   |       |
| R2 G | 0.350 0.027                                   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |                   |       |
| R3   | PHI INTO (P1+ P1- P10 (INCL. RHO P1))/TOTAL   | (P3)                                          |                   |       |
| R3 B | 30 0.12 0.08                                  | LINDSEY 66 HBC                                | 2.7 K-P           | 10/66 |
| R3 C |                                               |                                               |                   |       |
| R3 D | 0.152 0.030                                   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5) |                   |       |
| R5   | PHI INTO (KL KS)/(K BAR)                      | (P2)/(P1+P2)                                  |                   |       |
| R5 B | 10 0.40 0.10                                  | SCHLEIN 63 HBC                                | 2.0 K-P           | 10/66 |
| R5 C | 52 0.46 0.07                                  | BADIER 65 HBC                                 | 3.0 K-P           | 11/67 |
| R5 D | 0.44 0.07                                     | LONDON 66 HBC                                 | 2.2 K-P           | 10/66 |
| R5 E |                                               |                                               |                   |       |
| R5 F | 0.448 0.044                                   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                   |       |
| R5 G | 0.428 0.027                                   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |                   |       |
| R6   | PHI INTO (P1+ P1- P10 (INCL. RHO P1))/(K BAR) | (P3)/(P1+P2)                                  |                   |       |
| R6 B | 30 0.30 0.15                                  | LONDON 66 HBC                                 | 2.2 K-P           | 10/66 |
| R6 C |                                               |                                               |                   |       |
| R6 D | 0.187 0.044                                   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5) |                   |       |
| R7   | PHI INTO (P1+ P1- P10 (INCL. RHO P1))/(KL KS) | (P3)/(P2)                                     |                   |       |
| R7 B | (0.3) OR LESS                                 | BERLEY 65 HBC                                 | 2.9 P1+P          | 10/66 |
| R7 C | 0.69 0.14                                     | BIZOT 71 OSPK                                 | E+ E- COLL. BEAM  | 1/71  |
| R7 D |                                               |                                               |                   |       |
| R7 E | 0.44 0.11                                     | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5) |                   |       |

|       |                                                                |                                               |                    |        |
|-------|----------------------------------------------------------------|-----------------------------------------------|--------------------|--------|
| R8    | PHI INTO (P1+ P1-)/(K BAR) (SEE ALSO R16)                      | (P8)/(P1+P2)                                  |                    |        |
| R8 B  | (0.2) OR LESS                                                  | LONDON 66 HBC                                 | 2.2 K-P            | 10/66  |
| R9    | PHI INTO (E+ E-)/(K BAR) (UNITS 10**4)                         | (P5)/(P1)                                     |                    |        |
| R9 B  | (SEE ALSO R16)                                                 |                                               |                    |        |
| R9 C  | 40 0.61 1.7                                                    | BECKER 68 CNTR                                | GAMMA C            | 9/68   |
| R10   | PHI INTO (MU+ MU-)/TOTAL (UNITS 10**4)                         | (P6)                                          |                    |        |
| R10 B | 3.5 3.5 1.8                                                    | WEHMANN 68 OSPK                               | 12 K- C            | 6/68   |
| R10 C | 2.34 1.01                                                      | MOY 69 CNTR                                   | PHOTOPROD.         | 11/70  |
| R10 D | 2.17 0.60                                                      | EARLES 70 CNTR                                | 6.0 BREMSSTR.      | 11/70  |
| R10 E | 2.69 0.46                                                      | HAYES 71 CNTR                                 | PHOTOPROD.         | 11/71  |
| R10 F |                                                                |                                               |                    |        |
| R10 G | 2.50 0.34                                                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                    |        |
| R11   | PHI INTO (ETA GAMMA)/TOTAL                                     | (P4)                                          |                    |        |
| R11 B | (0.2) OR LESS                                                  | BADIER 65 HBC                                 | 3.0 K-P            | 10/66  |
| R11 C | (0.08) OR LESS                                                 | BENAKSAS 66 HBC                               | 2.7 K-P            | 10/66  |
| R11 D | 10 (0.020) (0.0075)                                            | BENAKSAS 70 OSPK                              | E+ E-              | 2/72   |
| R11 E | SUPERSEDED BY BENAKSAS 72                                      |                                               |                    |        |
| R11 F | 27 0.079 0.019                                                 | BASTIE 72 CNTR                                | 1.8 P1- P          | 12/72* |
| R11 G | 25 0.026 0.007                                                 | BENAKSAS 72 OSPK                              | E+ E- COLL. BEAMS  | 2/73*  |
| R11 H |                                                                |                                               |                    |        |
| R11 I | 0.032 0.015                                                    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)  |                    |        |
| R11 J | 0.030 0.011                                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |                    |        |
| R12   | PHI INTO (P1+ P1- GAMMA)/(K BAR)                               | (P9)/(P1+P2)                                  |                    |        |
| R12 B | (0.05) OR LESS                                                 | LINDSEY 65 HBC                                | 2.7 K-P            | 10/66  |
| R13   | PHI INTO (ETA NEUTRALS)/(K BAR)                                | (P13)/(P1+P2)                                 |                    |        |
| R13 B | (0.15) OR LESS                                                 | LINDSEY 66 HBC                                | 2.7 K-P            | 10/66  |
| R14   | PHI INTO (OMEGA GAMMA) / TOTAL                                 | (P10)                                         |                    |        |
| R14 B | (0.05) OR LESS                                                 | LINDSEY 66 HBC                                | 2.7 K-P            | 10/66  |
| R15   | PHI INTO (RHO GAMMA) / TOTAL                                   | (P12)                                         |                    |        |
| R15 B | (0.02) OR LESS                                                 | LINDSEY 66 HBC                                | 2.7 K-P            | 10/66  |
| R16   | PHI INTO (E+ E-)/TOTAL (UNITS 10**4)                           | (P5)                                          |                    |        |
| R16 B | (SEE ALSO R9)                                                  |                                               |                    |        |
| R16 C | 5 (6.6) (4.4)                                                  | ASTVACATU 68 OSPK                             | 4 P1- P            | 6/68   |
| R16 D | ERROR OF ASTVACATU 68 DOES NOT INCLUDE SIGMA(PHI) UNCERTAINTY. |                                               |                    | 6/68   |
| R16 E | 27 7.2 3.9                                                     | BINNIE 68 OSPK                                | 1.6 P1- P          | 9/68   |
| R16 F | 9 6.1 2.6                                                      | BOLLINI 68 CNTR                               | 1.9 P1- P          | 11/71  |
| R16 G | (3.45) (0.27)                                                  | BIZOT 70 OSPK                                 | E+ E- COLL. BEAMS  | 11/71  |
| R16 H | SUPERSEDED BY CHATELUS 71                                      |                                               |                    |        |
| R16 I | 2.81 0.25                                                      | BALAKIN 71 OSPK                               | E+ E- COLL. BEAM   | 11/71  |
| R16 J | 3.50 0.27                                                      | CHATELUS 71 OSPK                              | E+ E- COLL. BEAMS  | 11/71  |
| R16 K |                                                                |                                               |                    |        |
| R16 L | 3.15 0.34                                                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)  |                    |        |
| R17   | PHI INTO (P10 GAMMA)/(TOTAL)                                   | (P7)                                          |                    |        |
| R17 B | (0.0035) OR LESS                                               | BENPORAD 69 CNTR                              | 5.5 GAMMA N        | 7/69   |
| R17 C | (0.0024) OR LESS CL=0.95                                       | BENAKSAS 70 OSPK                              | E+ E-              | 2/72   |
| R17 D | SUPERSEDED BY BENAKSAS 72                                      |                                               |                    |        |
| R17 E | 7 (0.0025) (0.0012)                                            | BENAKSAS 72 OSPK                              | E+ E- COLL. BEAMS  | 2/73*  |
| R18   | PHI INTO (P1+ P1-)/(TOTAL) (UNITS 10**4)                       | (P8)                                          |                    |        |
| R18 B | (SEE ALSO R8)                                                  |                                               |                    |        |
| R18 C | (500.) OR LESS                                                 | LINDSEY 65 HBC                                | 1.7-2.7 K-P        |        |
| R18 D | (50.) OR LESS CL=0.95                                          | BIZOT 70 OSPK                                 | E+ E- COLL. BEAMS  | 11/71  |
| R18 E | (80.) OR LESS CL=0.95                                          | BALAKIN 71 OSPK                               | E+ E- COLL. BEAM   | 1/71   |
| R18 F | (2.7) OR LESS CL=0.95                                          | ALVENSLE 72 OSPK                              | GAMMA+C            | 1/72   |
| R19   | PHI INTO (KL KS)/(K+ K-)                                       | (P21)/(P1)                                    |                    |        |
| R19 B | 144 0.89 0.10                                                  | AGUILAR 72 HBC                                | 3.9±4.6 K- P       | 12/72* |
| R19 C | 125 1.15 0.15                                                  | COLLEY 72 HBC                                 | 10± K+ P+ K- P PHI | 12/72* |
| R19 D |                                                                |                                               |                    |        |
| R19 E | 0.97 0.12                                                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)  |                    |        |
| R19 F | 0.748 0.082                                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6) |                    |        |
| R20   | PHI INTO (P1+ P1- P10 (INCL. RHO P1))/(K+ K-)                  | (P31)/(P1)                                    |                    |        |
| R20 B | 34 0.28 0.09                                                   | AGUILAR 72 HBC                                | 3.9±4.6 K- P       | 12/72* |
| R20 C |                                                                |                                               |                    |        |
| R20 D | 0.326 0.074                                                    | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4) |                    |        |
| R21   | PHI INTO (2P1+ 2P1- P10)/(K+ K-)                               |                                               |                    |        |
| R21 B | (0.02) OR LESS CL=0.95                                         | AGUILAR 72 HBC                                | 3.9±4.6 K- P       | 12/72* |

## REFERENCES FOR PHI

|                                                |                                                 |
|------------------------------------------------|-------------------------------------------------|
| BERTANZA 62 PRL 9 180                          | BERTANZA, BRISSON, CONNOLLY, HART + (BNL+SYR)   |
| GELFAND 63 PRL 11 438                          | GELFAND, MILLER, NUSBAUM, KIRSCH + (COLU+RUTG)  |
| GELFAND 63 DATA INCLUDED IN MILLER 65 BELOW    |                                                 |
| SCHLEIN 63 PRL 10 368                          | SCHLEIN, SLATER, SMITH, STORK, TICHIO (UCLA)    |
| BADIER 65 PL 17 337                            | BADIER, DEMOLIN, BARLOUTAUD + (SACL+ZEEM)       |
| BERLEY 65 PR 139 B 1097                        | O BERLEY, N GELFAND (BNL+COLUMBIA)              |
| GALTIERI 65 PRL 14 279                         | A BARBARO, GALTIERI, R D TRIPP (LRL)            |
| LINDSEY 65 PRL 15 221                          | JAMES S LINDSEY, GERALD A SMITH (LRL)           |
| LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW   |                                                 |
| LINDSEY 65 UCL 16526                           | JAMES S LINDSEY (THESES)                        |
| MILLER D 65 CU-237(NEVIS 131)                  | DAVID C MILLER (THESES)                         |
| GRAY, L 66 PRL 17 501                          | +HAGERTY, BIZZARRI, CIAPETTI + (SYR+ROMA)JPG    |
| LINDSEY 66 PR 147 913                          | JAMES S LINDSEY, GERALD A SMITH (LRL)           |
| LINDSEY 66 PL 20 93                            | J.S.LINDSEY, G.A.SMITH (LRL)                    |
| LINDSEY 1 66 DATA INCLUDED IN LINDSEY 66 ABOVE |                                                 |
| LONDON 66 PR 143 1034                          | LONDON, RAU, SANTOS, GOLDBERG + (BNL+SYRACUSE)  |
| ABRAMS 67 MD TECH REP 720                      | GERALD ABRAMS, THESIS (MARYLAND)                |
| BARLOW 67 NC 504 701                           | +LILLETOL+MONTANET+ (CERN+CDEF+IRAO+LVP)        |
| CHASE 67 PRL 18 710                            | R.C.CHASE, P.ROTHWELL, R.WEINSTEIN (CEA+NEAS)   |
| DAHL 67 PR 163 1377                            | +HARDY+HESS+KIRZ+MILLER (LRL)                   |
| HERTZBACH 67 PR 155 1461                       | HERTZBACH, KRACMER, MADANSKI, ZDANIS+ (JHU+BNL) |
| KHACHATURIAN 67 PL 248 349                     | KHACHATURIAN+AZIMOV+BALDIN+BELOUSOV+ (OUBN)     |
| ABRAMS 68 PR 175 1697                          | +GLASSER, KEMOE, SECHI-ZORN, WOLSKY (MARYLAND)  |
| ASTVACATU 68 PL 27 B 45                        | ASTVACATU, AZIMOV, BALDIN+ (LJNR+MOSCOW)        |
| ALSO 67 PRL 19 869                             | ASBURY, BECKER, BERTRAM, TING+ (DESY+COLUMBIA)  |
| BECKER 68 PRL 21 1504                          | +BERTRAM, BINKLEY, JORDAN, KNAESEL+ (DESY+MIT)  |
| BINNIE 68 PL 278 106                           | +DUANE+FARUQI+HORSLEY+ (LOIC+RHEL)              |
| BOLLINI 68 NC 5 A 1471                         | +BOLLINI, DALYIAZ, MASSAM+ (CERN+BNL+STR)       |
| MOSTEK 68 PRL 20 1057                          | +EISENHANDLER, MCLELLAN, MISTRY+ (CORNELL)      |
| WEHMANN 68 PRL 20 748                          | +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)     |
| AUGUSTIN 69 PL 28 B 517                        | +BIZOT, BUDN, DELCOURT, MAISSINSKI+ (ORSAY)     |
| BALAKIN 69 IYAF 327 TRANS                      | +BUDKER, KORSHUNOV, KISHNEV, SIDOROV+ (NOVO)    |
| ALSO 69 S100ROV                                |                                                 |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $\phi(1019)$ ,  $M(1033)$ ,  $B_1(1040)$ ,  $\eta_N(1080)$ ,  $A_1(1100)$ 

BEMPORAD 69 PL 29 8 383  
MOY 69 THESIS  
SCOTTER 69 NC 62 4 1057  
SIDOROV 69 LIVERPOOL SYMP.ON

+BRACCINI, CASTALDI, LUBELMEYER, + (PISA+BNON)  
KEN MIN MOY (NORTHEASTERN UNIVERSITY)  
+KERSHNE, PALER, + (BIRMINGHAM+LOIC+MPI+OXX)  
ELECTRONS+PHOTONS, P. 227, SIDOROV (NOVO)

BALAKIN 70 PREPRINT  
BENAKSAS 70 LAL 1240  
BIZOT 70 PL 32 416  
ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP. 69  
BIZOT 70 PRIV. COMM.  
BIZOT 70 LNC 4 1273  
EARLES 70 PRL 25 1312  
HYAMS 70 NP 8 22 189  
SABRE 70 PREPRINT

+BUTLER, PAKHTUSOVA, SIDOROV, SKRINSKY, + (NOVO)  
+COSME, JEAN-MARIE, JULLIAN, LAPLANCHE, + (ORSA)  
+BUON, CHATELUS, JEANJEAN, LALANNE, + (ORSA)  
PEREZ-Y-JORBA (ORSA)  
+DEL COURT, JEANJEAN, LALANNE, + (ORSAY)  
+FAISSLER, GETTNER, LUTZ, MOY, TANG, + (NEAS)  
+KOCI, POTTER, V-LINDERN, LORENZ, LUTJENS (CERN)  
SABRE COLLABOR. (SACL+AMST+BONA+REHO+EPOL)

ALVENSLE 71 PRL 27 441  
BALAKIN 71 PL 34 8 328  
DIBIANCA 71 NP 8 35 13  
CHATELUS 71 LAL 1247 (THESIS)  
HAYES 71 PR 0 4 899  
LEFRANCO 71 PREPRINT LAL1256  
STOTTLEMAN 71 THESIS

ALVENSLEBEN, BECKER, BUSZA, CHEN, + (MIT+DESY)  
+BUDKER, PAKHTUSOVA, SIDOROV, SKRINSKY, + (NOVO)  
+EINSCHLAG, ENDORF, ENGLER, FISK, + (PITT)  
Y. CHATELUS (STRASBOURG)  
+IMLAY, JOSEPH, KEIZER, STEIN (CORN)  
J. LEFRANCOIS (ORSAY)  
A.R. STOTTLEMAN (MARYLAND)

AGUILAR 72 PR 0 6 29  
ALVENSLE 72 PRL 28 66  
BALAKIN 72 PL 40 8 431  
BASILE 72 NP 8 44 605  
BENAKSAS 72 PL 42 8 511  
COLLEY 72 NP 8 50 1

AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
ALVENSLEBEN, BECKER, BIGGS, BINKLEY + (MIT+DESY)  
+BOKIN, PAKHTUSOVA, SIDOROV, + (NOVO+BIIRSK)  
+DALPIAZ, FRABETTI, ZICHICHI + (CERN+BONA+STRB)  
+COSME, JEAN-MARIE, JULLIAN, LAPLANCHE (ORSAY)  
+JOBES, RIDOLFORD, GRIFFITHS, + (BIRMINGHAM+GLAS)

JEAN-MAR 73 PRIV. COMM. B. JEAN-MARIE, G. PARROUR (ORSAY)

**M(1033)**  
→ MM

67 M(1033)  
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

67 M(1033) MASS (MEV)

M 240 1032.6 2.3 GARFINKEL 72 HNS 0 2.4 PI- P, N MM 12/72\*

67 M(1033) WIDTH (MEV)

M 240 16.2 4.8 7.5 GARFINKEL 72 HNS 0 2.4 PI- P, N MM 12/72\*

REFERENCES FOR M(1033)

GARFINKEL 72 PRL 29 1477 GARFINKEL, HOFFMAN, JACOBEL, + (PURD+ANL+IOWA)

**B<sub>1</sub>(1040)**  
→  $\omega\pi$

48 B<sub>1</sub>(1040) IG=1+  
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

48 B<sub>1</sub>(1040) MASS (MEV)

M (1040.) DEFOIX 72 HBC +- 0.7 PBAR P, 7 PY 2/73\*

48 B<sub>1</sub>(1040) WIDTH (MEV)

M (55.) DEFOIX 72 HBC +- 0.7 PBAR P, 7 PY 2/73\*

48 B<sub>1</sub>(1040) PARTIAL DECAY MODES

P1 B<sub>1</sub>(1040) INTO OMEGA PI .DECAY MASSES  
139+ 783

REFERENCES FOR B<sub>1</sub>(1040)

DEFOIX 72 SUBMITTED TO PL +DOBRYNSKI, ESPIGAT, NASCIMENTO, + (CDEF)

**$\eta_N(1080)$**   
→  $\pi\pi\pi$

30 ETA N (1080, JPC=N+1 I=0 J GREATER THAN 1  
SOME EXPERIMENTS SUGGEST J=2.  
OMITTED FROM TABLE

Note on  $\pi^+\pi^-$  Peaks Called  $\eta_N(1080)$ 

The  $\eta_N(1080)$  is seen in  $\pi^+\pi^- \rightarrow \pi^+\pi^-n$  predominant-ly at backward decay angles,  $\cos\theta < -0.75$ . OH 70 state that this "bump" is almost certainly the result of P-D interference."

Note that the selection made in some HBC experiments to reduce the background under the  $\eta_N(1080)$  in the reaction  $\pi^+\pi^- \rightarrow \pi^+\pi^-n$  may lead to a sample of events ambiguous with  $\pi^+\pi^- \rightarrow p\pi^-\pi^0$ . This is so because selection on small momentum transfer to the  $\pi^+\pi^-$  system, together with large  $\pi^+\pi^-$  in-out scattering angle, leads to rather high lab momenta of the  $\pi^+$ , so that ionization cannot be used to discriminate between the two hypotheses (BATON 70, footnote, p. 525; and private communications from G. Laurens).

| 30 ETA N MASS (MEV) |           |        |           |                                              |                  |       |
|---------------------|-----------|--------|-----------|----------------------------------------------|------------------|-------|
| M                   | 1060.0    | 15.0   | MILLER    | 68 HBC                                       | 4.0 PI- P        | 9/68  |
| M                   | 70 1085.0 | 10.0   | WHITEHEAD | 68 ASPK                                      | 3.1-3.6 PI-P     | 10/67 |
| M                   | 1120.0    | 100.0  | OH        | 69 HBC                                       | 7. PI- P, PI+ 0  | 9/69  |
| M                   | 112.0     | 16.0   | CLAYTON   | 70 HBC                                       | 2.5 PBAR P, 4 PI | 1/71  |
| M                   | (1080.0)  |        | DIAZ      | 70 HBC                                       | 0. PBAR P, 4 PI  | 5/70  |
| M                   | 1070.0    | 20.0   | REYNOLDS  | 70 HBC                                       | 2.26-2.36 PI- P  | 1/71  |
| M                   | AVG       | 1083.3 | 9.8       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) |                  |       |

| 30 ETA N WIDTH (MEV) |        |         |           |                                              |                  |       |
|----------------------|--------|---------|-----------|----------------------------------------------|------------------|-------|
| W                    | (70.0) | OR LESS | MILLER    | 68 HBC                                       | 4.0 PI- P        | 9/68  |
| W                    | (25.0) | OR LESS | WHITEHEAD | 68 ASPK                                      | 3.1-3.6 PI-P     | 10/67 |
| W                    | 150.0  | 100.0   | *40.0     | 69 HBC                                       | 7. PI- P, PI+ 0  | 9/69  |
| W                    | (80.0) |         | CLAYTON   | 70 HBC                                       | 2.5 PBAR P, 4 PI | 1/71  |
| W                    | (80.0) |         | DIAZ      | 70 HBC                                       | 0. PBAR P, 4 PI  | 5/70  |
| W                    | 85.0   | 35.0    | REYNOLDS  | 70 HBC                                       | 2.26-2.36 PI- P  | 1/71  |
| W                    | AVG    | 98.0    | 31.3      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                  |       |

REFERENCES FOR ETA N

MILLER 68 PRL 21 1489 +GUTAY, JOHNSON, KENNEY, + (PURDUE+NDAM+SLAC)  
WHITEHEAD 68 NC 53 A 817 C. WHITEHEAD + (AERE+SNMP+LOIC)  
OH 69 PRL 23 331 +WALKER, CARROLL, FIREBAUGH, + (WISC+INTO)  
BATON 70 PL 33' 8 528 +LAURENS, REIGNIER (SACLAY)  
CLAYTON 70 NP 8 22 85 +MASON, MUIRHEAD, RIGOPoulos, + (LIVP+ATEN)  
DIAZ 70 NP 8 16 239 +GAVILLET, LABROSSE, MONTANET, + (CERN+CDEF)  
OH 70 PR D 1 2494 +GARFINKEL, MORSE, WALKER, PRENTICE (WISC+INTO)  
REYNOLDS 70 NP 8 21 77 +ALBRIGHT, BRADLEY, + (OHIO+FSU+MINN+COLO)  
WHITEHEAD 72 NP 8 48 365 WHITEHEAD, AUDL, + (AERE+RHEL+SNMP+LOUC)

**A<sub>1</sub>(1100)** 10 A<sub>1</sub>(1100, JPC=1+-) I=1

The  $A_1 \rightarrow \rho\pi$  bump has been mainly observed in the diffraction-like process  $\pi N \rightarrow (\pi\pi\pi)N$  without quantum number exchange and at small momentum transfer. There are also observations of structure in the  $A_1$  mass region in reactions with production of additional mesons, and in backward production from pions (see Data Card Listings). The indications for  $A_1$  production in charge exchange reactions, or in  $p\bar{p}$  annihilation, do not appear significant.

The dominant effect in the  $A_1$  mass region, for diffractive three-pion production, is a broad  $J^P = 1^+ \rho\pi$  S-wave enhancement starting from  $\rho\pi$  threshold; it has a maximum at ~1150 MeV and a width of the order of 300 to 400 MeV (ASCOLI 71 and 72). Such a behavior is obtained in Reggeized pion exchange models (the so-called Deck effect) [BERGER 71]. In recent partial wave analyses of the three-pion system (ASCOLI 72) one finds very little phase

## Mesons

 $A_1(1100)$ ,  $M(1150)$ 

variation of the  $J^P = 1^+ (\ell = 0)$   $\rho\pi$  amplitude relative to various possible "background" amplitudes. Though not completely model-independent, these results suggest that the  $J^P = 1^+ \rho\pi$  system is not resonant in the  $A_1$  mass region. The observed effect may still be due to a pole on an unphysical sheet, shielded from the physical region by a cut due to coupling to e.g. the  $S^* \pi$  channel (WRIGHT 72). In this case the Breit-Wigner approximation is not a good representation of the effects of the pole. (For further discussion of our criteria for resonances, see our text, Sect. III, 3).

For a recent review of the  $A_1$ , see DIEBOLD 72.

| 10 A1 MASS (MEV)                                              |                                                            |
|---------------------------------------------------------------|------------------------------------------------------------|
| M PRODUCED BY $\pi^+ \pi^-$                                   |                                                            |
| (1080.0)                                                      |                                                            |
| (1089.0) APPROX.                                              | ADERHOLZ 64 HBC + 4.0 $\pi^+ \pi^-$ 6/68                   |
| (1040.0)                                                      | ARMENISE 70 HBC + 0.9 $\pi^+ \pi^-$ A1 P 1/71              |
| M PRODUCED BY $\pi^+ \pi^-$                                   |                                                            |
| (1060.0)                                                      | ASCOLI 68 HBC - 0.5 $\pi^+ \pi^-$ 6/68                     |
| (1089.0) (12.0)                                               | BALLAM 68 HBC - 16.0 $\pi^+ \pi^-$ P 9/68                  |
| (1090.0) APPROX.                                              | CHUNG 68 HBC - 3.2, 4.2 $\pi^+ \pi^-$ 2/67                 |
| (1055.0) (6.0)                                                | JUNKMANN 68 HBC - 16. $\pi^+ \pi^-$ P, $\pi^+ \pi^-$ 9/69  |
| (1119.0) (30.0)                                               | KEY 68 HBC - 3 $\pi^+ \pi^-$ 9/68                          |
| M S SHOULDER ON A2 ONLY                                       |                                                            |
| (1069.0) (7.0)                                                | CASO 70 HBC - 11.2 $\pi^+ \pi^-$ 5/70                      |
| (1120.0)                                                      | CRENNELL 70 HBC - 6. $\pi^+ \pi^-$ P, F $\pi^+ \pi^-$ 5/70 |
| M PRODUCED BY PIONS, BACKWARDS SCATT.                         |                                                            |
| (1115.0) (20.0)                                               | ANDERSON 69 HBC - 16 $\pi^+ \pi^-$ P, BACKW 8/69           |
| (1046.0) (10.0)                                               | BUHL 71 HBC - 2.5 $\pi^+ \pi^-$ P 11/71                    |
| M PRODUCED BY PBARS, SEE TYPED NOTE.                          |                                                            |
| (1054.0) (7.0)                                                | DANYSZ 67 HBC + 3.3, 6 $\pi^+ \pi^-$ P 7/67                |
| (1042.0) (21.0)                                               | FRIDMAN 68 HBC + 5.7 $\pi^+ \pi^-$ P 6/68                  |
| (1076.0) (15.0)                                               | ATHERTON 72 HBC + 5.7 $\pi^+ \pi^-$ P 1/73                 |
| M A JP ANALYSIS GIVES SOME EVIDENCE FOR $\rho^0 \pi^0$ D-WAVE |                                                            |
| M PRODUCED BY $K^+ \pi^-$ , SEE TYPED NOTE.                   |                                                            |
| (1117.0) (30.0)                                               | ALLISON 67 HBC + 6 $K^+ \pi^-$ , $\pi^+ \pi^-$ 1/68        |
| (1060.0) (15.0)                                               | JUHALLA 67 HBC + 6 $K^+ \pi^-$ , $\pi^+ \pi^-$ 1/68        |
| M PRODUCED BY $K^+ \pi^-$ , SEE TYPED NOTE.                   |                                                            |
| (1030.0) (20.0)                                               | ALEXANDER 69 HBC + 9 $K^+ \pi^-$ 9/69                      |
| (1030.0) (20.0)                                               | BERLINGHI 69 HBC + 0 12.7 $K^+ \pi^-$ 9/69                 |
| M K* FOR CONTRADICTORY EVIDENCE SEE RABIN 70 AND TYPED NOTE.  |                                                            |
| M A AVERAGING NOT MEANINGFUL                                  |                                                            |

| 10 A1 WIDTH (MEV)                                              |                                                            |
|----------------------------------------------------------------|------------------------------------------------------------|
| M PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT |                                                            |
| (180.0)                                                        |                                                            |
| (130.0) APPROX.                                                | ADERHOLZ 64 HBC + 4.0 $\pi^+ \pi^-$ 6/68                   |
| (50.0) OR LESS                                                 | ARMENISE 70 HBC + 0.9 $\pi^+ \pi^-$ A1 P 1/71              |
| (300.0) APPROX.                                                | RINAUDO 71 HBC + 5. $\pi^+ \pi^-$ , P, $\pi^+ \pi^-$ 11/71 |
| M F FOR $J^P=1^+$ ( $\rho^0 \pi^0$ ) STATE                     |                                                            |
| M PRODUCED BY $\pi^+ \pi^-$                                    |                                                            |
| (140.0) (31.0)                                                 | BALLAM 68 HBC - 16.0 $\pi^+ \pi^-$ P 9/68                  |
| (125.0) APPROX.                                                | CHUNG 68 HBC - 3.2, 4.2 $\pi^+ \pi^-$ 2/67                 |
| (77.0) (17.0)                                                  | JUNKMANN 68 HBC - 16. $\pi^+ \pi^-$ P, $\pi^+ \pi^-$ 9/69  |
| (76.0) (46.0)                                                  | KEY 68 HBC - 3.0 $\pi^+ \pi^-$ P 11/67                     |
| M K SHOULDER ON A2 ONLY                                        |                                                            |
| (199.0) (15.0)                                                 | CASO 70 HBC - 11.2 $\pi^+ \pi^-$ 5/70                      |
| M PRODUCED BY PIONS, BACKWARDS SCATT.                          |                                                            |
| (98.0) (45.0) (20.0)                                           | ANDERSON 69 HBC - 16 $\pi^+ \pi^-$ P, BACKW 8/69           |
| M PRODUCED BY PBARS, SEE TYPED NOTE.                           |                                                            |
| (133.0) (19.0)                                                 | DANYSZ 67 HBC + 3.3, 6 $\pi^+ \pi^-$ P 7/67                |
| (130.0) APPROX.                                                | FRIDMAN 68 HBC + 5.7 $\pi^+ \pi^-$ P 6/68                  |
| (136.0) (20.0) (15.0)                                          | ATHERTON 72 HBC + 5.7 $\pi^+ \pi^-$ P 1/73                 |
| M A JP ANALYSIS GIVES SOME EVIDENCE FOR $\rho^0 \pi^0$ D-WAVE  |                                                            |
| M PRODUCED BY $K^+ \pi^-$ , SEE TYPED NOTE.                    |                                                            |
| (50.0) (50.0)                                                  | ALLISON 67 HBC + 6 $K^+ \pi^-$ , $\pi^+ \pi^-$ 1/68        |
| (50.0) (25.0)                                                  | ALLISON 67 HBC + 6 $K^+ \pi^-$ , $\pi^+ \pi^-$ 1/68        |
| (120.0) (15.0)                                                 | JUHALLA 67 HBC + 0 4.6-5 $K^+ \pi^-$ , $\pi^+ \pi^-$ 1/68  |
| M PRODUCED BY $K^+ \pi^-$ , SEE TYPED NOTE.                    |                                                            |
| (160.0) (20.0)                                                 | ALEXANDER 69 HBC + 9 $K^+ \pi^-$ 9/69                      |
| (120.0) (30.0)                                                 | BERLINGHI 69 HBC + 12.7 $K^+ \pi^-$ 8/69                   |
| M K* FOR CONTRADICTORY EVIDENCE SEE RABIN 70 AND TYPED NOTE.   |                                                            |
| (130.0) (20.0)                                                 | BERLINGHI 69 HBC + 0 12.7 $K^+ \pi^-$ 9/69                 |
| M A AVERAGING NOT MEANINGFUL                                   |                                                            |

## Data Card Listings

For notation, see key at front of Listings.

| 10 A1 PARTIAL DECAY MODES                     |                                                  |
|-----------------------------------------------|--------------------------------------------------|
| P1 A1 INTO $\rho^0 \pi^0$                     | 770+ 139                                         |
| P2 A1 INTO $K^+ K^-$                          | 493+ 497                                         |
| P3 A1 INTO $\eta \pi^0$                       | 548+ 139                                         |
| P4 A1 INTO $\eta' \pi^0$                      | 958+ 139                                         |
| P5 A1 INTO $3 \pi^0$                          | 139+ 139+ 139                                    |
| 10 A1 BRANCHING RATIOS                        |                                                  |
| R1 A1 INTO ( $K^+ K^-$ ) / ( $\rho^0 \pi^0$ ) | (P2)/(P1)                                        |
| R1 10.002510R LESS                            | DAHL 67 HBC - 4.0 $\pi^+ \pi^-$ P -10/66         |
| REFERENCES FOR A1                             |                                                  |
| BELLINI 63 NC 29 896                          | BELLINI, FIORINI, HERZ, NEGRI, RATTI (MILAN)     |
| ADERHOLZ 64 PL 10 226                         | AACH+BERL+BIRM+BOHN+DESY+HAMBURG+LOIC+MPIN       |
| GOLDHABER 64 PRL 12 336                       | GOLDHABER, BROWN, KADYK, SHEN+ (ILRL+UCB)        |
| LANDER 64 PRL 13 346 A                        | LANDER, ABOLINS, CARMONY, HENDRICKS + (UCSD) JP  |
| ABOLINS 65 ATHENS (OHIO) CONF.                | +CARMONY, LANDER, XUONG, YAGER (LA JOLLA) I=1    |
| ALITTI 65 PL 15 69                            | ALITTI, BATON, DELER, CRUSSARD+ (SACL+BGNA)      |
| ALLARD 66 NC 46A 737                          | +DRIJARD+HENNESSY+ (ORSAY+MILAN+SACL+UCB)        |
| DEUTSCHMANN 66 PL 20 82                       | DEUTSCHMANN, STEINBERG + (AACH+BERLIN+CERN)      |
| HESS 66 UCRL-16032                            | R I HESS (THESES, BERKELEY) (LRL)                |
| ALLISON 67 PL 25B 619                         | +CRUZ+ (OXF+MPIN+BIRM+RHEL+GLAS+LOIC)            |
| DAHL 67 PR 163 1377                           | +HARDY+HESS+KIRZ+MILLER (LRL)                    |
| DANYSZ 67 NC 51 A 801                         | DANYSZ+FRENCH+SIAMAK (CERN)                      |
| JUHALLA 67 PRL 19 1355                        | +LEACOCK+RHODE+KOPPELMAN+ (IOWA+COLO)            |
| SLATTERY 67 NC 50A 377                        | +KRAYBILL+FORMAN+FERBEL (YALE+ROCH) JP           |
| ARMENISE 68 PL 26 B 336                       | +FORINO+CARTACCI+ (BARI+BGNA+FIRZ+ORSAY)         |
| ASCOLI 68 PRL 21 113                          | +CRAWLEY, KRUSE, MORRIS, SCHAFER, + (ILLINOIS)   |
| BALLAM 68 PRL 21 934                          | +BRODY, CHADWICK, FRIES, GUERAGOSIAN+ (SLAC) JP  |
| BOESEBECK 68 NP 8 4 501                       | BOESEBECK, DEUTSCHMANN, + (AACHEN+BERLIN+CERN)   |
| CASO 68 NC 54 A 983                           | +CONTE+CORDS+OJAZZ+ (GENOVA+HAMB+MILA+SACL)      |
| CHUNG 68 PR 165 1491                          | SUO, CHUNG, O, DAHL, J, KIRZ, D, H, MILLER (LRL) |
| CNDPS 68 PRL 21 1609                          | +HOUGH, CONN, BUGG+ (BNL+ORNL+UCND+TENN+PENN)    |
| FRIDMAN 68 PR 167 1268                        | +HAURER, MICHALON, OUDET+ (HEID+STRASBOURG)      |
| JUNKMANN 68 NP 88 471                         | +COCCONI+ (AACH+BERL+BOHN+CERN+WISC)             |
| KEY 68 PR 166 1430                            | +PRENTICE+COOPER+MANNER+ (TNT+ANL+WISC)          |
| ALEXANDER 69 PR 183 1168                      | G. ALEXANDER, A. FIRESTONE, G. GOLDHABER (LRL)   |
| ALLABY 69 PL 29B 198                          | +BINON+DIDDES+DUT ELL+KLOVNING+... (CERN)        |
| ANDERSON 69 PRL 22 1390                       | +COLLINS+ (BNL+CERN)                             |
| BERLINGHI 69 PRL 23 42                        | BERLINGHI, FARRER, + (ROCH)                      |
| DONALD 69 NP 8 11 551                         | +EDWARDS, BURAN, BETTINI, + (LIVP+OSLO+PADO)     |
| FAYOLLE 69 NP 8 13 40                         | +DE MONTAGNAC, MORANO, STRACHMAN+ (PARIS)        |
| JUHALLA 69 PR 184 1461                        | +LEACOCK, RHODE, KOPPELMAN, LIBBY, + (ISU+COLO)  |
| KENYON 69 PRL 23 146                          | +KINSON, SCARR, + (BNL+UCND+ORNL)                |
| ARMENISE 70 LNC 4 199                         | +GHIDINI, FORING, CARTACCI, + (BARI+BGNA+FIRZ)   |
| BRANDENB 70 NP 816 349                        | +BRENNER, LOFFREDO, JOHNSON, KIM+ (HARVARD)      |
| CASO 70 LNC 3 707                             | +CORDS, COSTA+ (GENO+DESY+HAMB+MILA+SACL)        |
| ALSO 68 CASO                                  |                                                  |
| CRENNELL 70 PRL 24 781                        | +KARSHON, LAI, SCARR, SIMS (BNL)                 |
| CHIEN 70 TORONTO PREPRINT                     | +CHAO, JOHNSON, PRENTICE, WALKER (TNT+WISC)      |
| CHIEN 70 JHU 7011                             | C.Y. CHIEN (JOHNS HOPKINS)                       |
| GARELICK 70 PHILAD. CONF. P. 205              | D.A. GARELICK, REVIEW (NORTHEASTERN)             |
| RABIN 70 PRL 24 925                           | +GALTIERI, DERENZO, FLATTE, FRIEDMAN+ (LRL)      |
| SHIH 70 BNL 14059-REV                         | +YOUNG (BNL)                                     |
| ASCOLI 71 PRL 26 929                          | ILLINOIS+GENO+HAMB+MILA+SACL+HARV+TNT+WISC       |
| BEMPORAD 71 NP 8 33 397                       | +BEUSCH, MELISSINOS, + (CERN+ETHZ+LOIC+MILA)     |
| BERGER 71 PHENOMENOLOGY IN                    | PARTICLE PHYSICS, CALTECH 1971                   |
| BUHL 71 PREPRINT                              | +CLINE, TERRA+ (WISCONSIN)                       |
| LAMSA 71 PREPRINT                             | +EZZELL, GAIOS, WILLMANN (PURDUE) JP             |
| RINAUDO 71 NC 5 A 239                         | +BOECKMANN, MAJOR+ (TORI+BOHN+DURH+NIJH+EPOL) JP |
| ANTIPOV 72 PHIL. CONF. PROC.                  | +ASCOLI, BUSNELLO, DAMGAARD, + (SERP+CERN)       |
| ATHERTON 72 SUBM. TO PL                       | +FRANKE, FRENCH, GHIDINI, HILPERT, + (CERN)      |
| BERENYI 72 NP 8 37 621                        | +PRENTICE, STEENBERG, YOON, WALKER (TNT+WISC)    |
| BLOODWORTH 72 NP 8 46 402                     | BLOODWORTH, JACKSON, PRENTICE, YOON (TORONTO)    |
| DIEBOLD 72 BATAV. CONF.                       | R. DIEBOLD RAPPORTEUR TALK (ANL)                 |
| LAMSA 72 NP 8 41 388                          | +EZZELL, GAIOS, WILLMANN (PURDUE)                |
| MORSE 72 NP 8 43 77                           | +OH, WALKER, JOHNSTON, YOON (WISC+TNT)           |

**M(1150)**  
→ MM

68 M(1150)

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

| 68 M(1150) MASS (MEV)  |                                                            |
|------------------------|------------------------------------------------------------|
| M 65 1148.3            | 3.3 JACOBEL 72 HBC 0 2.4 $\pi^+ \pi^-$ P, N MM 12/72*      |
| 68 M(1150) WIDTH (MEV) |                                                            |
| M 65 15.0              | 9.0 11.7 JACOBEL 72 HBC 0 2.4 $\pi^+ \pi^-$ P, N MM 12/72* |
| REFERENCES FOR M(1150) |                                                            |
| JACOBEL 72 PRL 29 671  | +GARFINKEL, HOFFMAN, + (IOWA+PURDUE+ANL)                   |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $A_{1.5}(1170)$ ,  $B(1235)$  $A_{1.5}(1170)$  $\rightarrow 3\pi$ 

44 A 1.5 (1170, JP= -) I=1

THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW STATISTICAL SIGNIFICANCE IN THE 3  $\pi$  SYSTEM BETWEEN THE A1 AND THE A2. OMITTED FROM TABLE.

## REFERENCES FOR A 1.5

BUTTERWORTH 67 HEIDELB. CONF. P. 28 REVIEW TALK ON MESONS AT HEIDELBERG CONF.  
 CASON 67 PRL 18 690 \*LAMS, BISWAS, DERADDO, GROVES, \* (NOTREDAME)  
 ASCOLI 68 PRL 21 113 \*CRAWLEY, KRUSE, MORTARA, SCHAFFER, \* (ILLINOIS)  
 DONALD 68 PL 26 B 327 \*FROEDSEN, BETTINI, \* (LIVERPOOL, OSLO, PADUA)  
 VON KROG 68 PL 278 253 \*MIYASHITA, KOPELMAN, MARSHALL, LIBBY (COLOR)  
 JUNKMANN 68 NP 88 471 \*COCCHI, \* (AACHEN+BERLIN+BOON+CEBN+MARS)  
 ARNEISE 69 LNC 2 501 \*GHIDINI, FORINO, CARTACCI, \* (BARI+BGNA+FIRZ)  
 GALLOWAY 70 PR D 1 3077 \*MOTT, ALYEA, LEE, MARTIN, PRICKETT (IND)  
 MORSE 72 NP B 43 77 \*OH, WALKER, JOHNSTON, YOON (WISC+TNTU)

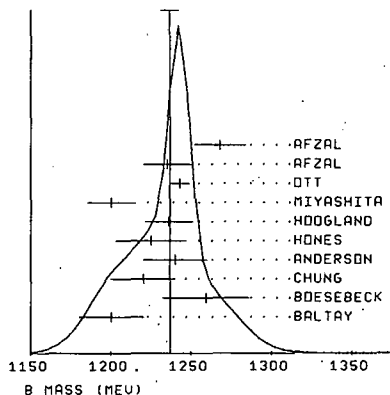
 $B(1235)$ 

11 B (1235, JP=1++) I=1

JP=2+ NOT YET COMPLETELY RULED OUT. FRENKIEL 72 FIT TWO STATES, JP=1+ AND JP=1-, IN THE B-REGION.

## 11 B MASS (MEV)

|   |                                               |           |         |   |                       |        |
|---|-----------------------------------------------|-----------|---------|---|-----------------------|--------|
| M | 60(1220.0)                                    | ABOLINS   | 63 HBC  | + | 3.5 $\pi^+\pi^-$      |        |
| M | (1220.0)                                      | GOLDHABER | 65 HBC  | + | 3.7 $\pi^+\pi^-\pi^0$ | 2/67   |
| M | 376 1200.                                     | BALTAY    | 67 HBC  | + | 0.0 $\pi^+\pi^-\pi^0$ | 1/68   |
| M | 25(1250.)                                     | LEE       | 67 HBC  | + | 3.6 $\pi^+\pi^-$      | 10/67  |
| M | 1259.0                                        | BOESEBECK | 68 HBC  | + | 8.0 $\pi^+\pi^-$      | 9/67   |
| M | 1220.                                         | CHUNG     | 68 HBC  | + | 3.2, 4.2 $\pi^+\pi^-$ | 12/72* |
| M | B 300(1245.)                                  | BIZZARRI  | 69 HBC  | + | 0 $\pi^+\pi^-\pi^0$   |        |
| M | (1245.0)                                      | ANDERSON  | 70 CNTR | 0 | 5-18 $\gamma$         | 11/70  |
| M | 1240.0                                        | CASO      | 70 HBC  | - | 11.2 $\pi^+\pi^-$     | 2/73*  |
| M | C 1265.0                                      | CASON     | 70 HBC  | - | 8.0 $\pi^+\pi^-\pi^0$ | 1/71   |
| M | C SUPERSEDED BY AFZAL 73                      | EROFEEV   | 70 HBC  | - | 3.25 $\pi^+\pi^-$     | 1/70   |
| M | (1272.0)                                      | HONES     | 70 HBC  | + | 18.5 $\pi^+\pi^-$     | 2/71   |
| M | 1200.0                                        | HOOGLAND  | 70 HBC  | - | 3.0 $\pi^+\pi^-$      | 11/71  |
| M | 1225.0                                        | MIYASHITA | 70 HBC  | - | 6.7 $\pi^+\pi^-\pi^0$ | 11/71  |
| M | 1236.0                                        | POLS      | 70 HBC  | + | 5. $\pi^+\pi^-$       | 12/72* |
| M | P 1230.0                                      | FRENKIEL  | 72 HBC  | + | 0. $\pi^+\pi^-\pi^0$  |        |
| M | P HANDRAWN BACKGROUND ERRORS STATISTICAL ONLY |           |         |   |                       |        |
| M | (1228.)                                       |           |         |   |                       |        |
| M | W FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE  |           |         |   |                       |        |
| M | W AT 1256 MEV, WIDTH 129 MEV.                 |           |         |   |                       |        |
| M | O 1163 1243.                                  | OTT       | 72 HBC  | + | 7.1 $\pi^+\pi^-\pi^0$ | 2/73*  |
| M | (1252.)                                       | OTT       | 72 HBC  | + | 7.1 $\pi^+\pi^-\pi^0$ | 2/73*  |
| M | A FROM FIT OF THE MASS SPECTRUM               |           |         |   |                       |        |
| M | A INTERFERENCE WITH THE BACKGROUND.           |           |         |   |                       |        |
| M | 1235.                                         | AFZAL     | 73 HBC  | + | 11.7 $\pi^+\pi^-$     | 2/73*  |
| M | 1268.                                         | AFZAL     | 73 HBC  | - | 11.2 $\pi^+\pi^-$     | 2/73*  |
| M | AVG 1236.8                                    |           |         |   |                       |        |
| M | 5.6                                           |           |         |   |                       |        |
| M | (SEE IDEOGRAM, BELOW)                         |           |         |   |                       |        |

WEIGHTED AVERAGE =  $1236.8 \pm 5.6$   
ERROR SCALED BY 1.3

CHISO  
 3.8  
 0.0  
 1.1  
 6.0  
 0.0  
 0.3  
 0.7  
 0.7  
 0.7  
 3.4  
 16.0  
 (CONLEV  
 =0.067)

## 11 B WIDTH (MEV)

|   |                                               |           |           |         |   |                       |        |
|---|-----------------------------------------------|-----------|-----------|---------|---|-----------------------|--------|
| W | 60 100.0                                      | 20.0      | ABOLINS   | 63 HBC  | + | 3.5 $\pi^+\pi^-$      |        |
| W | (80.0)                                        |           | GOLDHABER | 65 HBC  | + | 3.7 $\pi^+\pi^-\pi^0$ | 2/67   |
| W | 376 100.                                      | 30.       | BALTAY    | 67 HBC  | + | 0.0 $\pi^+\pi^-\pi^0$ | 1/68   |
| W | 25 (100.)                                     | ESTIMATED | LEE       | 67 HBC  | + | 3.6 $\pi^+\pi^-$      | 10/67  |
| W | 203.                                          | 75.       | BOESEBECK | 68 HBC  | + | 8.0 $\pi^+\pi^-$      | 9/67   |
| W | 150.                                          | 20.       | CHUNG     | 68 HBC  | + | 3.2, 4.2 $\pi^+\pi^-$ | 12/72* |
| W | B 300 (182.1)                                 | (12.1)    | BIZZARRI  | 69 HBC  | + | 0 $\pi^+\pi^-\pi^0$   |        |
| W | B SUPERSEDED BY FRENKIEL 72                   |           |           |         |   |                       |        |
| W | (100.0)                                       | APPROX.   | ANDERSON  | 70 CNTR | 0 | 5-18 $\gamma$         | 11/70  |
| W | C 150.0                                       |           | CASO      | 70 HBC  | - | 11.2 $\pi^+\pi^-$     | 2/73*  |
| W | C SUPERSEDED BY AFZAL 73                      |           |           |         |   |                       |        |
| W | (122.0)                                       | (38.0)    | CASON     | 70 HBC  | - | 8.0 $\pi^+\pi^-\pi^0$ | 1/71   |
| W | 100.0                                         | 20-50     | EROFEEV   | 70 HBC  | - | 3.25 $\pi^+\pi^-$     | 1/70   |
| W | 78.0                                          | 14.0      | HONES     | 70 HBC  | + | 18.5 $\pi^+\pi^-$     | 2/71   |
| W | 132.0                                         | 20.0      | HOOGLAND  | 70 HBC  | - | 3.0 $\pi^+\pi^-$      | 11/71  |
| W | 113.0                                         | 44.0      | MIYASHITA | 70 HBC  | - | 6.7 $\pi^+\pi^-\pi^0$ | 11/71  |
| W | P 1120.1                                      | (20.1)    | POLS      | 70 HBC  | + | 5. $\pi^+\pi^-$       | 12/72* |
| W | P HANDRAWN BACKGROUND ERRORS STATISTICAL ONLY |           |           |         |   |                       |        |
| W | (126.)                                        | (10.)     | FRENKIEL  | 72 HBC  | + | 0. $\pi^+\pi^-\pi^0$  |        |
| W | W SEE NOTE UNDER THE MASS ABOVE.              |           |           |         |   |                       |        |
| W | O 1163 134.                                   | 23.       | OTT       | 72 HBC  | + | 7.1 $\pi^+\pi^-\pi^0$ | 2/73*  |
| W | O FROM FIT OF THE MASS SPECTRUM               |           |           |         |   |                       |        |
| W | A 1156.1                                      | (18.1)    | OTT       | 72 HBC  | + | 7.1 $\pi^+\pi^-\pi^0$ | 2/73*  |
| W | A SEE NOTE UNDER THE MASS ABOVE.              |           |           |         |   |                       |        |
| W | 120.                                          | 50.       | AFZAL     | 73 HBC  | + | 11.7 $\pi^+\pi^-$     | 2/73*  |
| W | 130.                                          | 50.       | AFZAL     | 73 HBC  | - | 11.2 $\pi^+\pi^-$     | 2/73*  |
| W | AVG 118.3                                     | 8.1       |           |         |   |                       |        |
| W |                                               |           |           |         |   |                       |        |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

## 11 B PARTIAL DECAY MODES

|    |                                | DECAY MASSES       |
|----|--------------------------------|--------------------|
| P1 | B INTO OMEGA+PI                | 783+ 139           |
| P2 | B INTO 2PI+ 2PI-               | 139+ 139+ 139+ 139 |
| P3 | B INTO K KBAR                  | 493+ 493           |
| P4 | B INTO PI PI                   | 139+ 139           |
| P5 | B INTO PI PHI                  | 134+1019           |
| P6 | B INTO ETA PI (FORBIDDEN BY G) | 548+ 139           |
| P7 | B INTO K KBAR PI               | 493+ 493+ 139      |

## 11 B BRANCHING RATIOS

|    |                                          |          |        |   |                       |        |
|----|------------------------------------------|----------|--------|---|-----------------------|--------|
| R1 | B INTO $(4\pi^+)/( \Omega\pi^+\pi^-)$    | ABOLINS  | 63 HBC | + | 3.5 $\pi^+\pi^-$      |        |
| R2 | B INTO $(K KBAR)/( \Omega\pi^+\pi^-)$    | DAHL     | 67 HBC | + | 1.6-4.2 $\pi^+\pi^-$  | 10/66  |
| R2 | B INTO $(K KBAR)/( \Omega\pi^+\pi^-)$    | BALTAY   | 67 HBC | + | 0.0 $\pi^+\pi^-\pi^0$ | 2/67   |
| R2 | B INTO $(K KBAR)/( \Omega\pi^+\pi^-)$    | BIZZARRI | 69 HBC | + | 0 $\pi^+\pi^-\pi^0$   | 9/69   |
| R3 | B INTO $(\pi^+\pi^0)/( \pi^+\pi^-\pi^0)$ | ADERHOLZ | 64 HBC | + | 4.0 $\pi^+\pi^-$      | 7/66   |
| R3 | B INTO $(\pi^+\pi^0)/( \pi^+\pi^-\pi^0)$ | OTT      | 72 HBC | + | 7.1 $\pi^+\pi^-$      | 12/72* |
| R4 | B INTO $(\pi^+\pi^0)/( \pi^+\pi^-\pi^0)$ | DAHL     | 67 HBC | + | 1.6-4.2 $\pi^+\pi^-$  | 10/66  |
| R4 | B INTO $(\pi^+\pi^0)/( \pi^+\pi^-\pi^0)$ | BIZZARRI | 69 HBC | + | 0 $\pi^+\pi^-\pi^0$   | 9/69   |
| R5 | B INTO $(\pi^+\pi^0)/( \pi^+\pi^-\pi^0)$ | BALTAY   | 67 HBC | + | 0.0 $\pi^+\pi^-\pi^0$ | 2/67   |
| R6 | B INTO $(K KBAR)/( \pi^+\pi^-\pi^0)$     | BALTAY   | 67 HBC | + | 0.0 $\pi^+\pi^-\pi^0$ | 2/67   |
| R6 | B INTO $(K KBAR)/( \pi^+\pi^-\pi^0)$     | BALTAY   | 67 HBC | + | 0.0 $\pi^+\pi^-\pi^0$ | 2/67   |
| R6 | B INTO $(K KBAR)/( \pi^+\pi^-\pi^0)$     | BALTAY   | 67 HBC | + | 0.0 $\pi^+\pi^-\pi^0$ | 2/67   |

## REFERENCES FOR B

|           |                |                                                    |
|-----------|----------------|----------------------------------------------------|
| ABOLINS   | 63 PRL 11 381  | ABOLINS, LANDER, MEHLHOP, XUONG, YAGER (UCSD)      |
| BONDAR    | 63 PL 5 209    | BONDAR, DODD, * (AACHEN+BERLIN+BOON+CEBN+MARS)     |
| ADERHOLZ  | 64 PL 10 240   | AACHEN+BERLIN+BOON+CEBN+MARS                       |
| CARMONY   | 64 PRL 12 254  | CARMONY, LANDER, RINDLE, SCHWAB, YAGER (UCB) JP    |
| GOLDHABER | 65 PRL 15 118  | G GOLDHABER, S GOLDHABER, KADYK, SHEN (LRL)        |
| BALTAY    | 67 PRL 18 93   | *SEVERIENS, YEH+ZANELLO (COLU+BNL)                 |
| DAHL      | 67 PR 163 1377 | *HARDY+HESS+KIRZ+MILLER (LRL)                      |
| LEE       | 67 PR 159 1156 | *MOEBS, ROE, SINCLAIR, VANDERVELDE (MICH)          |
| SLATTERY  | 67 NC 50A 377  | *KRAYBILL+FORMAN+FERBEL (YALE+ROCH)                |
| ASCOLI    | 68 PRL 20 1411 | *CRAWLEY, MORTARA, SHAPIRO (ILL) JP                |
| BOESEBECK | 68 NC 54 A 983 | BOESEBECK, DEUTSCHMANN, * (AACHEN+BERLIN+CEBN)     |
| CASO      | 68 NC 54 A 983 | *CONTE+CORDS+DIAZ, * (GENOVA+HAMB+MILA+SACL)       |
| CHUNG     | 68 PR 165 1491 | S.U. CHUNG, O. DAHL, J. KIRZ, D.H. MILLER (LRL)    |
| BIZZARRI  | 69 NP B 14 169 | *FOSTER, GAVILLET, MONTANET, * (CERN+COEF)         |
| ANDERSON  | 70 PR D 1 27   | *GUSTAVSON, JOHNSON, * (SLAC+MIT+UCSB+NEAS)        |
| CASO      | 70 LNC 3 707   | *CONTE, TOMASINI, CORDS, * (GENOVA+HAMB+MILA+SACL) |
| CASON     | 70 PR D 1 851  | *ANDREWS, BISWAS, GROVES, HARRINGTON, * (NDAM)     |
| EROFEEV   | 70 SJNP 11 450 | *VELITSKY, MLADIMIRSKY, GRIGOREV, * (ITEP)         |
| HONES     | 70 PR 2 827    | *CASON, BISWAS, HELLAND, KENNEY, MCCANN, * (INDAM) |
| HOOGLAND  | 70 PL 33 B 631 | SABRE COLLABOR. * (ZEEN+SACL+BGNA+REHO+EPOL)       |
| MIYASHITA | 70 PR D 1 771  | MIYASHITA, VON KROG, KOPELMAN, LIBBY (COLOR)       |
| POLS      | 70 NP B 25 109 | *BOECKMANN, CIRBA, * (BOON+DURH+EPOL+TORI)         |
| WERBROUCK | 70 LNC 4 1267  | WERBROUCK, RINAUDOU, * (TORI+NIJ+BOON+LBL) JP      |
| DEVONS    | 71 PRL 27 1614 | *KOZLOWSKI, HORWITZ, * (COLU+SYRA)                 |
| FRENKIEL  | 72 NP B 47 61  | *GHESQUIERE, LILLET, CHUNG, * (CDEF+CEBN) JP       |
| OTT       | 72 LBL-1547    | R.L. OTT THESIS (LBL) JP                           |
| SISTERSO  | 72 NP B 48 493 | SISTERSO, HARRISON, HEYDA, JOHNSON, * (HARVARD)    |
| AFZAL     | 73 NCL         | *BASSLER, * (DURH+GENO+DESY+MILA+SACL) JP          |

Mesons  
f(1270)

f(1270)

5 F (1270, JPC=2++) I=0

WE NO LONGER LIST EVERY PUBLISHED VALUE.  
WE AVERAGE ONLY THE MOST SIGNIFICANT  
DETERMINATIONS OF MASS AND WIDTH.1/73\*  
1/73\*

## 5 F MASS (MEV)

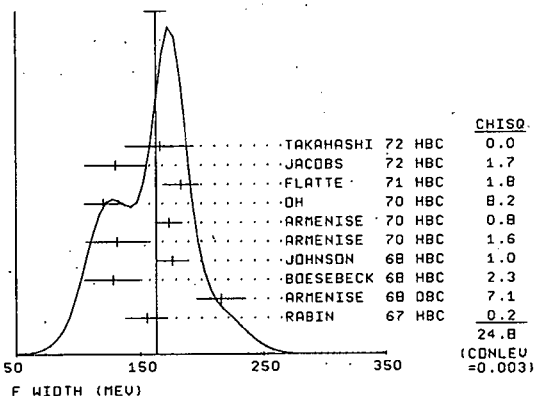
|   |               |        |           |         |                   |        |
|---|---------------|--------|-----------|---------|-------------------|--------|
| M | (1250.0)      | (25.0) | SELOVE    | 62 HBC  | 3.0 PI-P          | 1/73*  |
| M | 1416(1267.0)  | (10.0) | JACOBS    | 66 HBC  | 2-3 PI-P, T CUT20 | 10/67  |
| M | 1276.         | 11.    | RABIN     | 67 HBC  | 8.5 PI+P          | 9/67   |
| M | T 1960 1261.  | 5.     | ARMENISE  | 68 HBC  | 5.1 PI+N, P PI+ - | 1/73*  |
| M | T 360 1270.   | 10.    | ARMENISE  | 68 HBC  | 5.1 PI+N, P PI0   | 1/73*  |
| M | 1265.         | 8.     | BOESEBECK | 68 HBC  | 8 PI+P            | 6/68   |
| M | J 1269.0      | 6.0    | JOHNSON   | 68 HBC  | 3.7-4.2 PI- P     | 7/69   |
| M | J 1275.0      | 13.0   | JOHNSON   | 68 HBC  | 3.7-4.2 PI- P     | 7/69   |
| M | 1273.0        | 7.0    | ARMENISE  | 70 HBC  | 9 PI+ N -- F P    | 1/71   |
| M | 1277.         | 16.    | EISENSTE  | 70 HBC  | 4.2 PI+ N         | 1/71   |
| M | C 1275.0      | 13.0   | ARMENISE  | 70 HBC  | 9 PI+ N -- F P    | 1/71   |
| M | C 1277.       | 16.    | EISENSTE  | 70 HBC  | 4.2 PI+ N         | 1/71   |
| M | C 1275.0      | 13.0   | ARMENISE  | 70 HBC  | 9 PI+ N -- F P    | 1/71   |
| M | C 1277.       | 16.    | EISENSTE  | 70 HBC  | 4.2 PI+ N         | 1/71   |
| M | E 1273.0      | (6.0)  | STUNTENEC | 70 HBC  | 8. PI-P, 5.4 PI+0 | 11/71  |
| M | E 5300 1277.0 | 4.0    | FLATTE    | 71 HBC  | 7.0 PI+ P         | 6/71   |
| M | E 300(1272.1) | 10.0   | KEMP      | 72 HBC  | 11.7 PI+ N        | 12/72* |
| M | 2000 1261.0   | 10.0   | JACOBS    | 72 HBC  | 2.8 PI- P         | 1/73*  |
| M | 600 1258.0    | 10.0   | TAKAHASHI | 72 HBC  | 8. PI- P, N 2PI   | 1/73*  |
| M | 1200 1274.    | 12.    | WHITEHEAD | 72 ASPK | 3.1-3.6 PI- P     | 2/73*  |

EVIDENCE FOR A STRUCTURE CLAIMED  
ERROR INCREASED BY US. SEE TYPED NOTE ON K\* MASS.

AVG 1269.9 2.1 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

## 5 F WIDTH (MEV)

|   |                |        |           |         |                   |        |
|---|----------------|--------|-----------|---------|-------------------|--------|
| M | (100.0)        | (25.0) | SELOVE    | 62 HBC  | 3.0 PI-P          | 10/67  |
| M | 1416 (99.0)    | (10.0) | JACOBS    | 66 HBC  | 2-3 PI-P, T CUT20 | 9/67   |
| M | 1276.          | 11.    | RABIN     | 67 HBC  | 8.5 PI+P          | 9/67   |
| M | T 1960 216.    | 20.    | ARMENISE  | 68 HBC  | 5.1 PI+N, P PI+ - | 1/73*  |
| M | T 360 (188.)   | (40.)  | ARMENISE  | 68 HBC  | 5.1 PI+N, P PI0   | 1/73*  |
| M | 128.           | 23.    | BOESEBECK | 68 HBC  | 8 PI+P            | 6/68   |
| M | J 1269.0       | 13.0   | JOHNSON   | 68 HBC  | 3.7-4.2 PI- P     | 7/69   |
| M | J 1275.0       | 13.0   | JOHNSON   | 68 HBC  | 3.7-4.2 PI- P     | 7/69   |
| M | 131.0          | 25.0   | ARMENISE  | 70 HBC  | 9 PI+ N -- F P    | 1/71   |
| M | 173.0          | 11.0   | ARMENISE  | 70 HBC  | 9 PI+ N -- F P    | 1/71   |
| M | 600 120.0      | 15.0   | OH        | 70 HBC  | 1.26 PI- P, P F   | 1/71   |
| M | E 5300 (119.0) | (18.0) | STUNTENEC | 70 HBC  | 8. PI-P, 5.4 PI+0 | 11/71  |
| M | E 300 (143.)   | 15.0   | FLATTE    | 71 HBC  | 7.0 PI+ P         | 1/71   |
| M | E 2000 130.0   | 25.0   | KEMP      | 72 HBC  | 11.7 PI+ N        | 12/72* |
| M | T 600 166.0    | 28.0   | JACOBS    | 72 HBC  | 2.8 PI- P         | 1/73*  |
| M | T 1200 (121.)  | (24.)  | TAKAHASHI | 72 HBC  | 8. PI- P, N 2PI   | 1/73*  |
| M |                |        | WHITEHEAD | 72 ASPK | 3.1-3.6 PI- P     | 2/73*  |

EVIDENCE FOR A STRUCTURE CLAIMED  
ERROR INCREASED BY US. SEE TYPED NOTE ON K\* MASS.AVG 162.9 8.8 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)  
(SEE IDEOGRAM BELOW)WEIGHTED AVERAGE = 162.9 ± 8.8  
ERROR SCALED BY 1.7

## 5 F PARTIAL DECAY MODES

|    |                  |                    |
|----|------------------|--------------------|
| P1 | F INTO PI PI     | DECAY MASSES       |
| P2 | F INTO 2PI+ 2PI- | 139+ 139           |
| P3 | F INTO K KBAR    | 139+ 139+ 139+ 139 |
| P4 | F INTO K KBAR    | 497+ 497           |
| P5 | F INTO ETA PI PI | 497+ 497+ 139      |
|    |                  | 548+ 139+ 139      |

## Data Card Listings.

For notation, see key at front of Listings.

## 5 F BRANCHING RATIOS

|     |                                                                        |           |
|-----|------------------------------------------------------------------------|-----------|
| R10 | F PARTIAL WAVE (I.E. I=1, JP=2+) AMPLITUDE AT F RESONANCE              |           |
| R10 | WE TABULATE X = 1/2 (1 + ETAI). THIS SHOULD BE PI PI FRACTION          |           |
| R10 | FOR PURE BW WITH NO BACKGROUND.                                        |           |
| R10 | 600 0.8 0.04 OH 70 HBC 01.26 PI- P, P F                                | 1/71      |
| R10 | 250 0.85 0.05 BEAUPRE 71 HBC 08 PI+ P, DELTA+ F                        | 1/71      |
| R10 | AVG 0.820 0.031 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)           |           |
| R1  | F INTO (2PI+ 2PI-) / (PI PI)                                           | (P2)/(P1) |
| R1  | ASCOLI 68 SUGGEST DECAY IS MAINLY RHO-RHO, 1/3 OF WHICH YIELD 2PI+ 2PI |           |
| R1  | 0.08 0.06 BONDAR 63 HBC 4.0 PI- P                                      | 2/73*     |
| R1  | 0.04 0.05 CHUNG 65 HBC 3.2 PI- P                                       | 11/71     |
| R1  | D CORRECTED BY O.DAHL                                                  |           |
| R1  | 50 0.07 0.04 ASCOLI 68 HBC 5 PI- P                                     | 6/68      |
| R1  | 0.022 0.045 0.022 BARADIN 71 HBC 8. PI+ P                              | 2/72      |
| R1  | 0.047 0.013 OH 70 HBC 1.26 PI- P, P F                                  | 2/73*     |
| R1  | AVG 0.047 0.011 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)           |           |
| R2  | F INTO (K KBAR) / (PI PI)                                              | (P3)/(P1) |
| R2  | DETERMINATION DIFFICULT BECAUSE PROXIMITY OF A2 WHICH HAS SAME         |           |
| R2  | NEUTRAL (K KBAR) MODES. SINCE INTERFERENCE MAY BE CONSTRUCTIVE         |           |
| R2  | OR DESTRUCTIVE, EVEN UPPER LIMITS ARE DUBIOUS.                         |           |
| R2  | SOME UPPER LIMITS (X OR LESS) HAVE BEEN PUNCHED AS (0 +-X)             |           |
| R2  | (0.00) (0.09) BARMIN 65 HBC 2.8 PI-                                    | 2/73*     |
| R2  | (0.00) (0.16) WANDLER 65 HBC 3.0 PI- P                                 | 2/73*     |
| R2  | PROBABLY SEEN BARLOW 67 HBC 1.2 PBAR P -- KIKI                         | 11/66     |
| R2  | (0.047) (0.012) + SYST. BEUSCH 67 OSKP 5.7, 12 PI- P                   | 9/67      |
| R2  | 0.05 0.05 DAHL 67 HBC 1.6-4.2 PI- P                                    | 10/66     |
| R2  | D CORRECTED BY O.DAHL                                                  |           |
| R2  | (0.031) (0.012) ADERHOLZ 69 HBC 8 PI+ P, K-K-PI-                       | 8/69      |
| R2  | K-K- PEAK IS AT ABOUT 1240 MEV WHILE 1240 MEV (K KBAR) PEAKS AT 1320.  |           |
| R2  | A ALSO (CROSSSECTION BRANCHING RATIO) FOR A2 IS SMALL.                 |           |
| R2  | (0.06) (0.02) OH 70 HBC 1.26 PI- P, P F                                | 1/73*     |
| R2  | (0.07) OR LESS CL=95 AGUILAR 72 HBC 3.9-4.6 K- P                       | 12/72*    |
| R2  | 0.0 0.04 LIMIT ABOVE RESTATED FOR AVERAGING                            | 12/72*    |
| R2  | L SMALL (TODS SECTION) BRANCHING                                       |           |
| R2  | 0.13 0.05 BISWAS 72 HBC 18.5 PI+ -                                     | 1/73*     |
| R2  | (0.02) OR LESS CL=85 WHITEHEAD 72 ASPK 3.1-3.6 PI- P                   | 12/72*    |
| R2  | AVG 0.051 0.063 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)           |           |
| R3  | F INTO (K0 K- PI+ AND C.C.) / (PI PI)                                  | (P4)/(P1) |
| R3  | (0.07) OR LESS CL=95 AGUILAR 72 HBC 3.9-4.6 K- P                       | 12/72*    |
| R4  | F INTO (ETA PI PI) / (PI PI)                                           | (P5)/(P1) |
| R4  | (0.19) OR LESS CL=95 AGUILAR 72 HBC 3.9-4.6 K- P                       | 12/72*    |

## REFERENCES FOR F

|           |                        |                                                   |
|-----------|------------------------|---------------------------------------------------|
| SELOVE    | 62 PRL 9 272           | SELOVE, HAGGIAN, BRODY, BAKER, LEBOW (PENN)       |
| BONDAR    | 63 PL 5 153            | BONDAR, IACHEN+BARON+BOHN+DESY+LOIC+MIPK          |
| GUIRAGOS  | 63 PRL 11 85           | Z.G.T. GUIRAGOSIAN (LRL)                          |
| HAGGIAN   | 63 PRL 10 533          | V. HAGGIAN, W. SELOVE (PENN)                      |
| VEILLET   | 63 PRL 10 29           | VEILLET, HENNESSY, BINGHAM, BLOCK+EPOL+MILAN      |
| ADERHOLZ  | 64 PL 10 240           | AACHEN-BERLIN-BERLIN-BONN-HAMBURG-LOIC-MPI        |
| BRUYANT   | 64 PL 10 232           | BRUYANT, GOLDBERG, HOLZER, FLEURY+ (ICERN+EPOL)   |
| CL        | 64 PL 12 342           | L. D. JACOBS, THESIS                              |
| SODICKSO  | 64 PRL 12 485          | SODICKSON, MAHLIG, MANNELLI, FRISCH+ (MIT)        |
| BARMIN    | 65 SJNP 1 230          | +DOLGOLENKO, ELENISKY, EROFEEV+ (ITEP MOSCOW)     |
| BARMIN    | 65 SJNP 1 623          | +DOLGOLENKO, EROFEEV, KRESHNKOV+ (ITEP MOSCOW)    |
| CHUNG     | 65 PRL 15 325          | CHUNG, DAHL, HARDY, HESS, JACOBS, KIRZ (LRL)      |
| DERADO    | 65 PRL 14 872          | DERADO, KENNEY, POIRIER, SHEPHARD (NOTRE DAME)    |
| GUIRAGOS  | 65 PRL 11 85           | Z G T GUIRAGOSIAN (LRL)                           |
| WANDLER   | 65 PR 137 B 414        | T P WANDLER, R ERWIN, W WALKER (WISCONSIN)        |
| ACCENSI   | 66 PL 20 557           | ACCENSI, ALLES-BORELLI, FRENCH, FRISK+ (CERN)     |
| JACOBS    | 66 UCLR-16877          | L.D. JACOBS, THESIS                               |
| MAHLIG    | 66 PR 147 941          | +SHIBATA, GORDON, FRISCH, MANNELLI (MIT+PSA)      |
| BARLOW    | 67 NC 50A 701          | +LILLESTOL+MONTANET+ (ICERN+COEF+RAD+LIVP)        |
| BEUSCH    | 67 PL 25 B 357         | +FISCHER, GORDI, ASTBURY+ (ETHZ+ICERN)            |
| DAHL      | 67 PR 163 1377         | +HARDY+HESS+KIRZ+MILLER (LRL)                     |
| EISNER    | 67 PR 164 1699         | +JOHNSON+KLEIN+PETERS+SAHNI+YEN+ (PURDUE)         |
| POIRIER   | 67 PR 163 1462         | +BISWAS, CASON, DERADO, KENNEY+ (NDAM+PENN)       |
| RABIN     | 67 THESIS              | M. RABIN (RUTGERS)                                |
| ARMENISE  | 68 NC 54 A 999         | +FORINO+CARACCI+ (BARI+BGNA+FIRENZE+ORSAY)        |
| ASCOLI    | 68 PRL 21 1712         | G. ASCOLI, H.B. CRAWLEY, D.W. MORTARA+ (ILL)      |
| BOESEBECK | 68 NP 8 4 501          | BOESEBECK, DEUTSCHMANN, + (AACHEN+BERLIN+ICERN)   |
| FOSTER    | 68 NP 8 6 107          | +GAVILLET+LABROSSE+MONTANET (ICERN+COEF)          |
| JOHNSON   | 68 PR 176 1651         | +POIRIER, BISWAS, GUTAY+ (NDAM+PURDUE)            |
| ALSO      | 63BONDAR, LEE 64,      | DERADO 65, EISNER 67                              |
| LAKSA     | 68 PR 166 1395         | +CASON+BISWAS+DERADO+GROVES+ (NOTRE DAME)         |
| ALSO      | 67 POIRIER             |                                                   |
| WHITEHEAD | 68 NC 53A 817          | +MCWEEN, OTT, AITKEN+ (AERE+SHMP+LOUC)            |
| ADERHOLZ  | 69 NP 8 11 259         | +BARTSCH, + (AACH+BERL+CERN+JAGL+WARS)            |
| AGUILAR   | 69 PL 29 B 241         | M. AGUILAR-BENITEZ, J. BARLOW, + (ICERN+COEF)     |
| ARMENISE  | 69 LNC 2 501           | +GHIDINI, FORINO, CARACCI+ (BARI+BGNA+FIRENZE)    |
| CASO      | 69 NC 62 A 755         | +CONTE, BENI, + (GENOVA+DESY+HAMB+MILA+SACL)      |
| DONALD    | 69 NP 8 11 551         | +EDWARDS, BURAN, BETTINI, + (LIVP+OSLO+PADO)      |
| AGUILAR   | 70 PRL 25 58           | AGUILAR-BENITEZ, BARNES, BASSANO, + (BNL+SYR)     |
| ARMENISE  | 70 LNC 4 199           | +GHIDINI, FORINO, CARACCI, + (BARI+BGNA+FIRENZE)  |
| BAOIER    | 70 NP 8 22 512         | +BONNET, DREVLON, BAUBILLIER, + (EPOL+LIVP)       |
| EISENSTE  | 70 CDD 1195 194        | EISENSTEIN, GORDON (ILL)                          |
| OH        | 70 PR D 1 2494         | +GARFINKEL, MORSE, WALKER, PRENTICE (WISC+TNTD)   |
| STUNTENEC | 70 PL 32 B 391         | STUNTENEC, KENNEY, DEERY, BISWAS, CASON+ (NDAM)   |
| BARADIN   | 71 PR D4 2711          | BARADIN-OTWINOWSKA, HOFKOL, + (WARS)              |
| BEAUPRE   | 71 NP 8 28 77          | +DEUTSCHMANN, GRAESSLER, + (AACH+BERL+CERN)       |
| FARBER    | 71 NP 8 29 237         | +DE PINTO, BISWAS, CASON, DEERY, KENNEY, + (NDAM) |
| FLATTE    | 71 PL 34 B 551         | +ALSTON-GARNJOST, BARBARO-GALTIERI, + (LBL)       |
| AGUILAR   | 72 PR D 6 29           | AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)      |
| BISWAS    | 72 PR D 5 1564         | +CASON, HARRINGTON, KENNEY, SHEPHARD (NDAM)       |
| FOGLI     | 72 NC 8 A 670          | FOGLI-MUCIACCA, PICCIARELLI (BARI)                |
| GRAY      | 72 PHIL. CONF. PROC. 5 | +HYAMS, JONES, SCHLEIN, BLUM, DIETL+ (ICERN+MIPK) |
| JACOBS    | 72 PR D 6 1291         | L.D. JACOBS                                       |
| KEMP      | 72 NC 8 A 611          | +MAJOR, CONTRI, + (OURH+GENO+MILA+EPOL+LIVP)      |
| SCARROTT  | 72 LNC 3 271           | SCARROTT, KEMP (DURHAM)                           |
| TAKAHASHI | 72 PR D 6 1266         | TAKAHASHI, BARTSH, + (TOHO+PENN+NDAM+ANL)         |
| WHITEHEAD | 72 NP 8 48 365         | WHITEHEAD, AULD, + (AERE+RHEL+SHMP+LOUC)          |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

D(1285), A<sub>2</sub>(1310)

## D(1285)

8 D (1285, JPC = +) I=0

(JP=0-, 1+, 2- WITH 1+ FAVORED.)

| 8 D MASS (MEV) |              |                                   |           |                                              |
|----------------|--------------|-----------------------------------|-----------|----------------------------------------------|
| M              | (1290.)      | APPROX.                           | BARLOW    | 67 HBC 1.2 PBAR P, 4PFS 5/67                 |
| M              | 1283.0       | 5.0                               | DAHL      | 67 HBC 1.6-4.2 PI- P 10/66                   |
| M              | 1290.        | 7.                                | D. ANDLAU | 68 HBC 1.2 PBAR P, 5-6 PFS 6/68              |
| M              | (1310.0)     |                                   | DEFOIX    | 68 HBC 1.2 PB P, 7 PI 3/69                   |
| M              | 1270.0       | 10.0                              | CAMPBELL  | 69 DBC 2.7 PI+ D 8/69                        |
| M              | 1285.        | 7.                                | LORSTAD   | 69 HBC 0.7 PB P, 4, 5-BODY 9/69              |
| M              | 1303.0       | 8.0                               | BARDADIN  | 71 HBC 8 PI+ P, P+6PI 9/69                   |
| M              | 1283.0       | 6.0                               | BOESEBECK | 71 HBC 16.0 PI P, 5 PI 6/71                  |
| M              | 150 1292.    | 10.                               | DEFOIX    | 72 HBC 0.7 PBAR P, 7 PI 1/73*                |
| M              | 180 1286.    | 3.                                | DUBOC     | 72 HBC 1.2 PBAR P, 2K4PI 12/72*              |
| M              | S 500(1280.) | (13.)                             | THUN      | 72 HBC 13.4 PI- P 12/72*                     |
| M              | S            | SEEN IN THE MISSING MASS SPECTRUM |           | 12/72*                                       |
| M              | AVG          | 1286.1                            | 2.2       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |

| 8 D WIDTH (MEV) |     |                                   |        |                                              |                            |
|-----------------|-----|-----------------------------------|--------|----------------------------------------------|----------------------------|
| W               | R   | (35.0)                            | (10.0) | DAHL                                         | 67 HBC 1.6-4.2 PI- P       |
| W               | U   | 46.                               | 20.    | D. ANDLAU                                    | 68 HBC 1.2 PBAR P, 5-6 PFS |
| W               | U   | UNFOLDED BY DOBRZYNSKI 71         |        |                                              |                            |
| W               | R   | (40.0)                            |        | DEFOIX                                       | 68 HBC 1.2 PB P, 7 PI      |
| W               | R   | 30.0                              | 15.0   | CAMPBELL                                     | 69 DBC 2.7 PI+ D           |
| W               | R   | (60.)                             | (15.)  | LORSTAD                                      | 69 HBC 0.7 PB P, 4, 5-BODY |
| W               | R   | (44.0)                            | (24.0) | BARDADIN                                     | 71 HBC 8 PI+ P, P+6PI      |
| W               | R   | 15.0                              | 10.0   | BOESEBECK                                    | 71 HBC 16.0 PI P, 5 PI     |
| W               | R   | 150 (28.)                         | (5.)   | DEFOIX                                       | 72 HBC 0.7 PBAR P, 7 PI    |
| W               | R   | 180 (46.)                         | (9.)   | DUBOC                                        | 72 HBC 1.2 PBAR P, 2K4PI   |
| W               | S   | 500 (37.)                         | (5.)   | THUN                                         | 72 HBC 13.4 PI- P          |
| W               | S   | SEEN IN THE MISSING MASS SPECTRUM |        |                                              |                            |
| W               | R   | RESOLUTION NOT UNFOLDED           |        |                                              |                            |
| W               | AVG | 20.6                              | 9.6    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |                            |

| 8 D PARTIAL DECAY MODES |                  |    |  |                    |
|-------------------------|------------------|----|--|--------------------|
| P1                      | D INTO K BAR P   | PI |  | DECAY MASSES       |
| P2                      | D INTO PI PI RHO |    |  | 497+ 497+ 134      |
| P3                      | D INTO ETA PI PI |    |  | 134+ 134+ 770      |
| P4                      | D INTO DELTA PI  |    |  | 548+ 134+ 134      |
| P5                      | D INTO 2PI+ 2PI- |    |  | 970+ 134           |
|                         |                  |    |  | 139+ 139+ 139+ 139 |

| 8 D BRANCHING RATIOS |                                                    |                                                  |                                              |                          |
|----------------------|----------------------------------------------------|--------------------------------------------------|----------------------------------------------|--------------------------|
| R1                   | D INTO (PI P1 RHO) / (K KBAR P1)                   |                                                  | (P2)/(P1)                                    |                          |
| R1                   | D                                                  | (2.0) OR LESS                                    | DAHL 67 HBC                                  | CHARGED PI ONLY 10/66    |
| R1                   | D                                                  | (4.0) OR LESS                                    | DONALD 69 HBC                                | 1.2 PBAR P, 5P+ .        |
| R1                   | D                                                  | THIS IS FOR (RHOD P1+ P1-)/(K KBAR P1D)          |                                              |                          |
| R2                   | D INTO (K KBAR P1)/(ETA P1 P1)                     |                                                  | (P1)/(P3)                                    |                          |
| R2                   | K R                                                | 0.166 0.055                                      | DEFOIX 68 HBC                                | 1.2 PBAR P 1/73*         |
| R2                   | R REVISED BY DEFOIX 72                             |                                                  |                                              |                          |
| R2                   | K                                                  | 0.16 0.08                                        | CAMPBELL 69 DBC                              | 2.7 P1+ D 1/73*          |
| R2                   | K                                                  | 0.20 0.08                                        | DEFOIX 72 HBC                                | 0.7 PBAR P, P 7 P1 1/73* |
| R2                   | K                                                  | K KBAR SYSTEM CHARACTERIZED BY THE 1=1 THRESHOLD |                                              |                          |
| R2                   | K                                                  | ENHANCEMENT (SEE UNDER DELTA(970)).              |                                              |                          |
| R2                   | AVG                                                | 0.173 0.039                                      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                          |
| R3                   | D INTO (DELTA P1)/(ETA P1 P1)                      |                                                  | (P4)/(P3)                                    |                          |
| R3                   | POSSIBLY SEEN                                      | AMMAR 70 HBC                                     | 4.1, 5.5K-, ETA 5/70                         |                          |
| R3                   | (0.8) (0.2)                                        | OTWINOWSKI 70 HBC                                | 8 P1+ P, P+6P1 9/69                          |                          |
| R3                   |                                                    | DEFOIX 72 HBC                                    | 0.7 PBAR P, P 7 P1 1/73*                     |                          |
| R4                   | D INTO (2P1+ 2P1- (INCL. RHO P1 P1))/(ETA P1+ P1-) |                                                  | (P5)/(2/3P3)                                 |                          |
| R4                   | 50 (0.55) OR MORE                                  | BOESEBECK 71 HBC                                 | 16. P1+ P, P 5P1 11/71                       |                          |

| REFERENCES FOR D |                  |                                          |                           |  |
|------------------|------------------|------------------------------------------|---------------------------|--|
| D. ANDLAU        | 65 PL 17 347     | +BARLOW, ADAMSON, +                      | (CDEF+CEMN+IRAD+LIVP)     |  |
| MILLER           | 65 PRL 14 1074   | +CHUNG, DAHL, HESS, HARDY, KIRZ, +       | (LRL+UCB)                 |  |
| BARLOW           | 67 NC 50 A 701   | +MONTANET, D. ANDLAU +                   | (CERN+CEMN+IRAD+LIVP)     |  |
| DAHL             | 67 PR 163 1377   | +HARDY+HESS+KIRZ+MILLER                  | (LRL) J P                 |  |
| D. ANDLAU        | 68 NP 8 5 693    | +ASTIER, BARLOW +                        | (CDEF+CEMN+IRAD+LIVP) J P |  |
| DEFOIX           | 68 PL 28 B 353   | +RIVET, SIAUD, CONFORTO +                | (CDEF+IPNP+CEMN)          |  |
| CAMPBELL         | 69 PRL 22 1204   | +LICHTMAN, +                             | (PURD)                    |  |
| DONALD           | 69 NP 8 11 551   | +EDWARDS, BURAN, BETTINI, +              | (LIVP+OSLO+PADO)          |  |
| LORSTAD          | 69 NP 8 14 63    | B. LORSTAD, D. ANDLAU, ASTIER, +         | (CDEF+CEMN) J P           |  |
| OTWINOWSKI       | 69 PL 29 B 529   | S. OTWINOWSKI                            | (WARSAW)                  |  |
| AMMAR            | 70 PR 02 430     | +KROPAC, DAVIS, DERRICK +                | (KANS+NWES+ANL+MISC)      |  |
| BARDADIN         | 71 PR 04 2711    | BARDADIN-OTWINOWSKI, HOFMOKL, MICHEIDA + | (WARS)                    |  |
| DOBRZYNSKI       | 71 PL 34 B 659   | (AACH+BERL+BONN+CEMN+CRAC+HEID+WARS)     |                           |  |
| DOBRZYNSKI       | 71 PRIV. COMMUN. | L. DOBRZYNSKI                            | (CERN+CEMN)               |  |
| GOLDBERG         | 71 LNC 1 627     | +MAKOWSKI, TOUCHARD, DONALD, +           | (IPNP+LIVP) J P           |  |
| BERENYI          | 72 NP 8 37 621   | +PRENTICE, STEENBERG, YOON, WALKER       | (TNTOW+MISC)              |  |
| CHAPMAN          | 72 NP 8 42 1     | +CHURCH, LYS, MURPHY, RING, VANDER VELDE | (MICH)                    |  |
| DEFOIX           | 72 NP 8 44 125   | +MASCINATO, BIZZARRI, +                  | (CDEF+CEMN)               |  |
| DUBOC            | 72 NP 8 46 429   | +GOLDBERG, MAKOWSKI, DONALD, +           | (LPNP+LIVP)               |  |
| THUN             | 72 PRL 28 1733   | +BLIEDEN, FINOCCHIARD, BOWEN, +          | (STON+NEAS)               |  |

A<sub>2</sub>(1310)12 A<sub>2</sub> (1310, JPC=2-) I=1

We list the A<sub>2</sub> as an ordinary Breit-Wigner resonance. This conclusion is based on the failure of experiments with high statistics and good resolution to confirm the reported splitting; moreover the re-analyses of the most significant "split-peak" experiment have reduced the significance of the dip and revealed some experimental difficulties (DAMGAARD 72, e.g., Fig. 8; KIENZLE 72, e.g., Fig. 6).

For a recent review see DIEBOLD 72.

| 12 A <sub>2</sub> MASS (MEV), 3PI MODE |               |                                                                   |            |                                              |
|----------------------------------------|---------------|-------------------------------------------------------------------|------------|----------------------------------------------|
| M                                      | (1320.0)      |                                                                   | ADERHOLZ   | 64 HBC 4.0 PI+P                              |
| M                                      | 1335.0        | 10.0                                                              | GOLDBERGER | 64 HBC + 3.7 PI+ P                           |
| M                                      | 130(1310.0)   |                                                                   | FORINO     | 65 DBC + 0.45 PI+ D 10/66                    |
| M                                      | 1425 1290.0   | (5.0)                                                             | LEFEBVRES  | 65 HBC - 5.6, 6.0 PI-P 1/73*                 |
| M                                      | (1300.0)      |                                                                   | SEIDLITZ   | 65 DBC - 3.2 PI-D 6/66                       |
| M                                      | (1290.0)      | (10.0)                                                            | BARNES     | 66 HBC - 6.0 PI-P 2/73*                      |
| M                                      | 1310.0        | 10.0                                                              | BENSON     | 66 DBC 0.365 PI+D 6/66                       |
| M                                      | 1060 1286.    | (8.)                                                              | LEVAT      | 66 HBC - 6.7 PI- P 1/73*                     |
| M                                      | 4000 1307.    | 16.                                                               | CHIKOVANI  | 67 HBC - 7 PI- P 8/67                        |
| M                                      | 260 1311.0    | 6.0                                                               | ARMENISE   | 68 DBC 0.5-1 PI+D 9/67                       |
| M                                      | 120 1320.     | 18                                                                | BOESEBECK  | 68 HBC 0.8 PI+ P 6/68                        |
| M                                      | (1310.)       | (20.)                                                             | CHUNG      | 68 HBC - 2.7-4.5 PI- P 5/68                  |
| M                                      | (1301.0)      | (8.0)                                                             | VON KROGH  | 68 HBC - 6.7 PI- P 9/68                      |
| M                                      | A (1300.0)    | (4.0)                                                             | JUNKMANN   | 68 HBC - 16. PI- P, 5PI 1/73*                |
| M                                      | A (1299.)     | (14.)                                                             | LAKSA      | 68 HBC - 16. PI- P, 5PI 1/73*                |
| M                                      | A (1299.0)    | (9.0)                                                             | ANDERSON   | 69 HBC - 16 PI- P, BACKW 8/69                |
| M                                      | A 24(1299.0)  | (12.0)                                                            | ARMENISE   | 69 DBC + 5.1 PI+D, 3PI+ 5/70                 |
| M                                      | 1310.0        | 14.0                                                              | EISENBERG  | 69 HBC + 4.3, 5.3 GAMMA P 12/69              |
| M                                      | 1305.         | (3.)                                                              | ASCOLI     | 70 HBC - 5 - 7.5 PI- P 1/71                  |
| M                                      | 941 1305.0    | 4.0                                                               | ALSTON-GA  | 70 HBC + 7.0 PI+P, 3PI P 1/71                |
| M                                      | 280 1313.0    | 7.0                                                               | BOCKMAN    | 70 HBC 0.5. PI+ P 5/70                       |
| M                                      | A 581(1288.0) | (10.0)                                                            | CASO       | 70 HBC - 11.2PI-P, PI RHO 1/73*              |
| M                                      | 1335.0        | 15.0                                                              | DIAZ       | 70 HBC + 0. PBAR P, 4 PI 5/70                |
| M                                      | D (1330.0)    | (15.0)                                                            | GARFINKEL  | 70 DBC - 4.5 K-D, LAMBDA 1/71                |
| M                                      | (1274.0)      | (22.0)                                                            | GORDON     | 70 DBC 0.4-2 PI+ D 1/71                      |
| M                                      | 360 1304.0    | 4.5                                                               | BARNHART   | 71 HBC + 3. PI+ P, (3PI)+ 11/71              |
| M                                      | 10000 1307.   | 5.                                                                | BINNIE     | 71 HBC - PI-P NEAR A2 THR 11/71              |
| M                                      | 5000 1309.    | 5.                                                                | BINNIE     | 71 HBC - PI-P NEAR A2 THR 11/71              |
| M                                      | 28000 1299.0  | 6.0                                                               | BOWEN      | 71 HBC - 5. PI- P 11/71                      |
| M                                      | 24000 1300.   | 6.0                                                               | BOWEN      | 71 HBC + 5. PI+ P 11/71                      |
| M                                      | 17000 1309.0  | 4.0                                                               | BOWEN      | 71 HBC - 7. PI- P 11/71                      |
| M                                      | C (1307.)     | (12.)                                                             | BUHL       | 71 HBC - 2.5 PI- P 11/71                     |
| M                                      | P 1315.       | 4.                                                                | ANTIPOV    | 72 CNTR - 40. PI- P, P, 3PI 12/72*           |
| M                                      | 160 1307.     | 7.                                                                | BLODMORT   | 72 HBC + 5.45 PI+ P, P, 3PI 1/73*            |
| M                                      | 1580 1306.    | 9.                                                                | CHALOUPEK  | 73 HBC + 3.9 PI- P, P, A2 2/73*              |
| M                                      | O             | ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING |            | 12/72*                                       |
| M                                      | D             | MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2-+. COMPARE CRENNELL 69.   |            |                                              |
| M                                      | A             | ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1              |            | 11/71                                        |
| M                                      | C             | 8.8 K-D PRODUCTION                                                |            |                                              |
| M                                      | P             | FROM A FIT TO JPC=2- RHO PI                                       |            |                                              |
| M                                      | AVG           | 1308.8                                                            | 1.6        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |

| 12 A <sub>2</sub> MASS (MEV), K BAR MODE |               |                                                 |           |                                                                   |
|------------------------------------------|---------------|-------------------------------------------------|-----------|-------------------------------------------------------------------|
| MK                                       | 80(1317.0)    | (3.0)                                           | BARLOW    | 67 HBC + 1.2 PBAR P, KK - 2/72                                    |
| MK                                       | 60 1335.0     | 13.0                                            | BARLOW    | 67 HBC + 1.2 PBAR P, KK 9/67                                      |
| MK                                       | N (1344.0)    | (7.)                                            | BEUSCH    | 67 OSPK 0.5-12 PI-P, KIKI 11/71                                   |
| MK                                       | 130 1280.0    | 12.0                                            | CONFORTO  | 67 HBC + 0. PBAR P IN KK. 9/67                                    |
| MK                                       | 1317.2        | 4.0                                             | DAHL      | 67 HBC - 2.7-4.5 PI- P 8/67                                       |
| MK                                       | N (1315.7)    | (10.8)                                          | DAHL      | 67 HBC 0.2-7-4.5 PI- P 11/71                                      |
| MK                                       | N (1311.0)    | (5.0)                                           | CRENNELL  | 68 HBC 0.6-0 PI-P, KIKI 11/71                                     |
| MK                                       | 12(1315.0)    |                                                 | ADERHOLZ  | 69 HBC + 8 PI+ P, K+K 8/69                                        |
| MK                                       | 132 1301.0    | 7.0                                             | ALSTON-GA | 70 HBC + 7.0 PI+P, K+KS P 1/71                                    |
| MK                                       | 190 1313.0    | 7.0                                             | CRENNELL  | 71 HBC - 4.5 PI- P, KSK-P 11/71                                   |
| MK                                       | S 1500 1319.0 | 3.0                                             | GRAVER    | 71 ASPK - 17.2 PI-P, K-KS P 2/72                                  |
| MK                                       | 730 1313.0    | 4.0                                             | FOLEY     | 72 CNTR - 20.3 PI- P, K-KS 12/72*                                 |
| MK                                       | N             | THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON |           |                                                                   |
| MK                                       | S             | SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED       |           |                                                                   |
| MK                                       | AVG           | 1315.0                                          | 3.1       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) (SEE IDEOGRAM BELOW) |

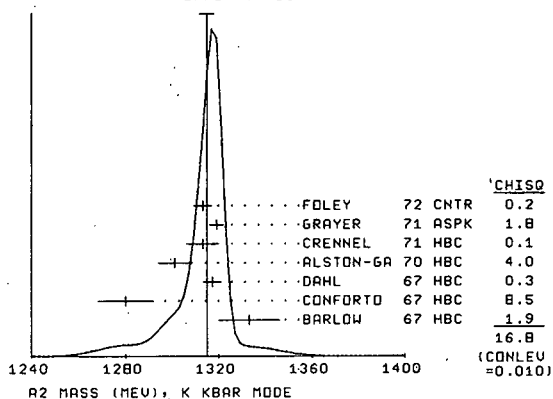
| 12 A <sub>2</sub> MASS (MEV), ETA PI MODE |            |        |           |                                                                   |
|-------------------------------------------|------------|--------|-----------|-------------------------------------------------------------------|
| M                                         | 189 1312.0 | 7.0    | ALSTON-GA | 70 HBC + 7.0 PI+P, PI ETA 1/71                                    |
| M                                         | 1300.0     | 20.0   | CASO      | 70 HBC - 11.2PI-P, PI ETA 5/70                                    |
| M                                         | 32 1300.0  | 8.     | DZIERBA   | 70 HBC - 8. PI- P, PI ETA 1/73*                                   |
| M                                         | 30 1288.   | 7.     | JOHNSTON  | 70 HBC - 7. PI- P, PI-ETA P 1/71                                  |
| M                                         | 120.       | 20.    | ESPIGAT   | 72 HBC + 0. PBAR P, ETA 2PI 11/71                                 |
| M                                         | 906(1326.) | (3.)   | PREPOST   | 72 OSPK - 6. PI- P, PI ETA 1/73*                                  |
| M                                         | AVG        | 1300.8 | 5.3       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) (SEE IDEOGRAM BELOW) |

FOR THE MASSES OF A<sub>2</sub>L AND A<sub>2</sub>N SEE OUR APRIL 72 EDITION.  
SEE ALSO THE TYPED NOTE ABOVE.

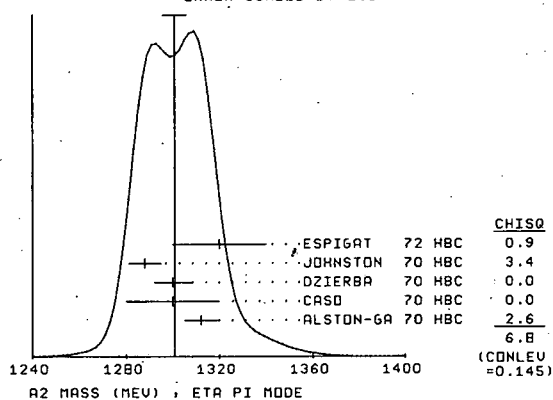
# Mesons

## A<sub>2</sub>(1310)

WEIGHTED AVERAGE = 1315.0 ± 3.1  
ERROR SCALED BY 1.7



WEIGHTED AVERAGE = 1300.8 ± 5.3  
ERROR SCALED BY 1.3



### 12 A2 WIDTH (MEV), 3PI MODE

|   |                |                |           |         |                   |        |
|---|----------------|----------------|-----------|---------|-------------------|--------|
| W | (100.0)        |                | ADERHOLZ  | 64 HBC  | 4.0 P1+P          |        |
| W | 90.0           | 10.0           | GOLDHABER | 64 HBC  | 3.7 P1+P          |        |
| W | 1425           | 99.0 (15.0)    | LEFEBVRES | 65 MMS  | 6.0 P1-P          | 1/73*  |
| W | (140.0)        |                | SEIDLITZ  | 65 DBC  | 3.2 P1-D          | 6/66   |
| W | (70.0)         | (10.0)         | BARNES    | 66 HBC  | 6.0 P1-P          | 2/73*  |
| W | 100.           | 15.            | BENSON    | 66 DBC  | 0.3 65 P1+D       | 1/67   |
| W | 1060           | 98.            | LEVAT     | 66 MMS  | 6.7 P1-P          | 1/73*  |
| W | 4000           | 90.            | CHIKOVANI | 67 MMS  | 7 P1-P            | 8/67   |
| W | 260            | 96.0           | ARMENISE  | 68 DBC  | 0.5 1 P1+D        | 9/67   |
| W | O 120          | (56.) (21.)    | BOESEBECK | 68 HBC  | 0.8 P1+P          | 1/73*  |
| W | O              | (80.) (20.)    | CHUNG     | 68 HBC  | 2.7-4.5 P1-P      | 5/68   |
| W | A              | (40.0) (25.0)  | VON KROGH | 68 HBC  | 6.7 P1-P          | 9/68   |
| W | A              | (52.0) (16.0)  | JUNKMANN  | 68 HBC  | 16. P1-P, 5P1     | 1/73*  |
| W | 90.0           | 10.0           | ANDERSON  | 69 MMS  | 16 P1-P, BACKW    | 8/69   |
| W | AE 241         | (164.0) (20.0) | ARMENISE  | 69 DBC  | 5.1 P1+D, 3P1+P   | 5/70   |
| W | O              | (80.0) (30.0)  | EISENBERG | 69 HBC  | 4.3, 5.3 GAMMA P  | 12/69  |
| W | 941            | 79.0           | ALSTON-GA | 70 HBC  | 7.0 P1+P, 3P1 P   | 1/71   |
| W | O 280          | (70.0) (29.0)  | BOCKMANN  | 70 HBC  | 0.5 P1+P          | 5/70   |
| W | A 581          | (135.0) (26.0) | CASO      | 70 HBC  | 11.2 P1-P, P1 RHO | 1/73*  |
| W | O              | (90.0) (20.0)  | DIAZ      | 70 HBC  | 0. PBAR P, 4 P1   | 5/70   |
| W | D              | (135.0) (35.0) | GARFINKEL | 70 DBC  | 4.5 K-D, LAMBDA   | 1/71   |
| W | (215.0) (22.0) |                | GORDON    | 70 DBC  | 0.4 2 P1+D        | 1/71   |
| W | 360            | 111.4          | GARNHAM   | 71 HBC  | 3.7 P1+P, (3P1)+  | 11/71  |
| W | 10000          | (100.)         | BINNIE    | 71 MMS  | P1-P NEAR A2 THR  | 11/71  |
| W | 5000           | 72.            | BINNIE    | 71 MMS  | P1-P NEAR A2 THR  | 11/71  |
| W | 28000          | 105.0          | BOWEN     | 71 MMS  | 5. P1-P           | 11/71  |
| W | 24000          | 99.0           | BOWEN     | 71 MMS  | 5. P1+P           | 11/71  |
| W | 17000          | 103.0          | BOWEN     | 71 MMS  | 7. P1-P           | 11/71  |
| W | P              | 110.           | ANTIPOV   | 72 CNTR | 40. P1-P, P 3P1   | 12/72* |
| W | O 160          | (72.) (25.)    | BLODMORT  | 72 HBC  | 5.45 P1+P, P 3P1  | 12/72* |
| W | 1580           | 99.            | CHALOUKPA | 73 HBC  | 3.9 P1-P, P A2    | 2/73*  |

W O ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING 12/72\*

W E BACKGROUND SUBTRACTION MODEL-DEPENDENT. 5/70

W A MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2+-. COMPARE CRENNELL 69.

W A ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1

W P FROM A FIT TO JPC=2+ RHO P1

W AVG 99.6 2.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

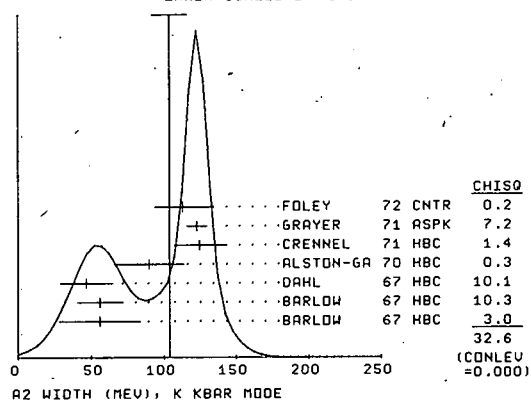
# Data Card Listings

For notation, see key at front of Listings.

### 12 A2 WIDTH (MEV), K KBAR MODE

|    |      |               |       |                                                                   |         |                   |        |
|----|------|---------------|-------|-------------------------------------------------------------------|---------|-------------------|--------|
| WK | 60   | 56.0          | 28.0  | BARLOW                                                            | 67 HBC  | 1.2 PBAR P, KK    | 9/67   |
| WK | 80   | 56.0          | 15.0  | BARLOW                                                            | 67 HBC  | 1.2 PBAR P, KK    | 9/67   |
| WK | N    | (88.) (23.)   | (22.) | BEUSCH                                                            | 67 OSPK | 0.5-12 P1-P, K1K1 | 11/71  |
| WK | 130  | (90.0)        |       | CONFORTO                                                          | 67 HBC  | 0. PBAR P IN KK   | 9/67   |
| WK | 47.  | 18.           |       | DAHL                                                              | 67 HBC  | 2.7-4.5 P1-P      | 8/67   |
| WK | N    | (80.5) (36.5) |       | DAHL                                                              | 67 HBC  | 0.2-7-4.5 P1-P    | 11/71  |
| WK | N    | (21.0) (10.0) | (6.0) | CRENNELL                                                          | 68 HBC  | 0.6-0 P1-P, K1K1  | 11/71  |
| WK | 12   | (34.0)        |       | ADERHOLZ                                                          | 69 HBC  | 8 P1+P, K+K0      | 8/69   |
| WK | 132  | 90.0          | 24.0  | ALSTON-GA                                                         | 70 HBC  | 7.0 P1+P, K+KS P  | 1/71   |
| WK | 190  | 125.0         | 19.0  | CRENNEL                                                           | 71 HBC  | 4.5 P1-P, KSK-P   | 11/71  |
| WK | 1500 | 123.0         | 7.0   | GRAY                                                              | 71 ASPK | 17.2 P1-P, K-KS P | 11/71  |
| WK | 730  | 113.0         | 19.0  | FOLEY                                                             | 72 CNTR | 20.3 P1-P, K-KS   | 12/72* |
| WK | N    |               |       | THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON                   |         |                   |        |
| WK | AVG  | 104.2         | 12.1  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3) (SEE IDEOGRAM BELOW) |         |                   |        |

WEIGHTED AVERAGE = 104.2 ± 12.1  
ERROR SCALED BY 2.3



### 12 A2 WIDTH (MEV), ETA PI MODE

|   |      |                                                   |        |                                              |         |                    |       |
|---|------|---------------------------------------------------|--------|----------------------------------------------|---------|--------------------|-------|
| W | 189  | 103.0                                             | 20.0   | ALSTON-GA                                    | 70 HBC  | 7.0 P1+P, PI ETA   | 1/71  |
| W |      | (120.0)                                           |        | CASO                                         | 70 HBC  | 11.2 P1-P, PI ETA  | 5/70  |
| W | 32   | (41.0) (20.0)                                     | (16.0) | DZIERBA                                      | 70 HBC  | 8. P1-P, PI ETA    | 11/70 |
| W | T 30 | (38.0) (30.0)                                     |        | JOHNSTON                                     | 70 HBC  | 7. P1-P, PI-ETA P  | 1/73* |
| W |      | 120.                                              | 30.    | ESPIGAT                                      | 72 HBC  | 0. PBAR P, ETA 2P1 | 11/71 |
| W | 906  | (116.) (16.)                                      |        | PREPOST                                      | 72 OSPK | 6. P1-P, P PI ETA  | 1/73* |
| W | T    | ERROR INCREASED BY US. SEE TYPED NOTE ON K+ MASS. |        |                                              |         |                    |       |
| W | AVG  | 108.2                                             | 16.6   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |         |                    |       |

FOR THE WIDTHS OF A2L AND A2H SEE OUR APRIL 72 EDITION.  
SEE ALSO THE TYPED NOTE ABOVE.

### 12 A2 PARTIAL DECAY MODES

| P1   | A2 INTO RHO P1                   | DECAY MASSES  |
|------|----------------------------------|---------------|
| P2   | A2 INTO K KBAR                   | 770+ 139      |
| P3   | A2 INTO ETA P1                   | 493+ 497      |
| P4   | A2 INTO OMEGA P1                 | 548+ 139      |
| P5 S | A2 INTO P1+ P1- P10 EXCL. RHO P1 | 139+ 139+ 783 |
| P6 S | A2 INTO P1+ P1- P1- EXCL. RHO P1 | 139+ 139+ 139 |
| P7 S | A2 INTO P1 GAMMA                 | 139+ 0        |
| P8 S | A2 INTO ETA PRIME P1             | 958+ 139      |
| P S  | SMALL, NOT USED IN THE FIT       |               |

### FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i^2 + \delta P_j^2)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

| P 1                                    | P 2 | P 3 | P 4 |
|----------------------------------------|-----|-----|-----|
| P 1 .7236+-0.0211                      |     |     |     |
| P 2 .0077 .0475+-0.0058                |     |     |     |
| P 3 -.2538 -.0925 .1526+-0.0132        |     |     |     |
| P 4 -.7960 -.2131 -.3270 .0764+-0.0223 |     |     |     |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $A_2(1310)$ ,  $E(1420)$ 

## 12 A2 BRANCHING RATIOS

| R1  | A2 INTO (K KBAR) / (RHO PI)                                     | (P2)/(P1)                          |        |  |
|-----|-----------------------------------------------------------------|------------------------------------|--------|--|
| R1  | (0.08) OR LESS                                                  | LANDER 64 HBC + 3.5 P1+P           | 10/66  |  |
| R1  | (0.13) (0.03)                                                   | STUSCH 67 OSPK + 5.7, 12 P1+       | 9/67   |  |
| R1  | 11 0.09 0.06 0.09                                               | ASCOLI 68 HBC - 5.7 P1+P           | 6/68   |  |
| R1  | 0.054 0.022                                                     | CHUNG 68 HBC - 3.2 P1-P            | 1/67   |  |
| R1  | (0.03) (0.012)                                                  | DONALD 68 HBC + 1.2 PBAR P.        | 2/72   |  |
| R1  | (0.14) (0.05)                                                   | BOCKMANN 70 HBC + 5.0 P1+P         | 9/69   |  |
| R1  | 0.07 0.05                                                       | BOCKMANN 70 HBC + 5.0 P1+P         | 9/69   |  |
| R1  | N THE NEUTRAL MODE CAN INTERFERE WITH F.                        |                                    |        |  |
| R1  | 0.06 0.03                                                       | ABRAMOVIC 70 HBC - 3.93 P1-P       | 1/71   |  |
| R1  | (0.024) (0.006)                                                 | DIAZ 70 HBC + 0. PBAR P, 4 P1      | 11/71  |  |
| R1  | E SUPERSEDED BY ESPIGAT 71 (SEE UNDER R2 AND R8)                |                                    |        |  |
| R1  | 113 0.097 0.018                                                 | HEF 70 HBC - 7.0 P1-P              | 6/70   |  |
| R1  | 50 0.056 0.014                                                  | ALSTON-GA 71 HBC + 7.0 P1-P        | 2/71   |  |
| R1  | CHALOUKPA 73 HBC - 3.9 P1-P, P A2                               | 2/73*                              |        |  |
| R1  | AVG 0.0678 0.0088 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |                                    |        |  |
| R1  | FIT 0.0656 0.0062 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |                                    |        |  |
| R2  | A2 INTO (ETA PI)/(RHO PI) + K KBAR + ETA PI                     | (P3)/(P1+P2+P3)                    |        |  |
| R2  | 34 0.15 0.04                                                    | BARNHAM 71 HBC + 3.7 P1+P          | 11/71  |  |
| R2  | 0.13 0.04                                                       | ESPIGAT 72 HBC + 0. PBAR P.        | 11/71  |  |
| R2  | AVG 0.140 0.028 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |                                    |        |  |
| R2  | FIT 0.165 0.013 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   |                                    |        |  |
| R3  | A2 INTO (ETA PI) / (RHO PI)                                     | (P3)/(P1)                          |        |  |
| R3  | 0.3 0.2                                                         | ADERHOLZ 64 HBC - 11.0 P1-P        | 8/67   |  |
| R3  | 22 0.23 0.08                                                    | CONTE 67 HBC - 5 P1-P              | 6/68   |  |
| R3  | 0.12 0.08                                                       | ASCOLI 68 HBC - 3.2 P1-P           | 12/66  |  |
| R3  | (0.072) OR LESS                                                 | DONALD 68 HBC + 1.2 PBAR P         | 6/68   |  |
| R3  | 0.16 0.10                                                       | KEY 68 HBC - 3 P1-P                | 11/67  |  |
| R3  | D (0.18) (0.06)                                                 | VETLITSKY 69 HBC - 3.3 P1-P        | 9/68   |  |
| R3  | 0.3 0.13                                                        | ABRAMOVIC 70 HBC - 3.93 P1-P       | 1/71   |  |
| R3  | 15 0.25 0.09                                                    | BOCKMANN 70 HBC + 5.0 P1+P         | 9/69   |  |
| R3  | (0.18) (0.07)                                                   | BOCKMANN 70 HBC + 5.0 P1+P         | 9/69   |  |
| R3  | 39 0.34 0.17                                                    | DIERBA 70 HBC - 6. P1-P            | 11/71  |  |
| R3  | 167 0.246 0.042                                                 | ALSTON-GA 71 HBC + 7.0 P1+P        | 2/71   |  |
| R3  | 149 0.211 0.044                                                 | CHALOUKPA 73 HBC - 3.9 P1-P, P A2  | 2/73*  |  |
| R3  | AVG 0.221 0.023 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |                                    |        |  |
| R3  | FIT 0.221 0.021 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   |                                    |        |  |
| R4  | A2 INTO (ETA PRIME PI) / TOTAL                                  | (P8)                               |        |  |
| R4  | (0.1) OR LESS                                                   | CHUNG 65 HBC - 3.2 P1-P            | 2/72   |  |
| R4  | 0.12 OR LESS CL=97                                              | BARNHAM 71 HBC + 3.7 P1+P          | 2/72   |  |
| R4  | 0.0 0.01                                                        | LIMIT ABOVE RESTATED FOR AVERAGING | 2/72   |  |
| R5  | A2 INTO (ETA PRIME PI)/(RHO PI)                                 | (P8)/(P1)                          |        |  |
| R5  | 14 (0.07) (0.03)                                                | ASCOLI 68 HBC - 5.0 P1-P           | 12/72* |  |
| R5  | S SUPERSEDED BY EISENSTEIN 72                                   |                                    |        |  |
| R5  | 0.06 0.03                                                       | BOCKMANN 70 HBC + 5.0 P1+P         | 9/69   |  |
| R5  | D (0.15) (0.09)                                                 | DIERBA 70 HBC - 8. P1-P            | 11/71  |  |
| R5  | D STRONGLY DEPENDENT ON BACKGROUND SUBTRACTION                  |                                    |        |  |
| R5  | (0.04) OR LESS                                                  | ALSTON-GA 71 HBC + 7.0 P1+P        | 2/71   |  |
| R5  | (0.011) OR LESS CL=90                                           | EISENSTEIN 72 HBC - 5. P1-P, P P61 | 12/72* |  |
| R6  | A2 INTO (PI+ P1- PI0)/(RHO PI)                                  | (P5)/(P1)                          |        |  |
| R6  | (0.17) OR LESS                                                  | BENSON 66 DBC + 0.37 P1+P          | 11/71  |  |
| R7  | A2 INTO (ETA PI)/(K KBAR)                                       | (P3)/(P2)                          |        |  |
| R7  | (3.0) OR LESS                                                   | FOSTER 68 HBC - PBAR P, PBA REST   | 11/71  |  |
| R7  | E SUPERSEDED BY ESPIGAT 72 (SEE UNDER R2 AND R8)                |                                    |        |  |
| R7  | FIT 3.22 0.50 FROM FIT                                          |                                    |        |  |
| R8  | A2 INTO (K KBAR)/(RHO PI) + K KBAR + ETA PI                     | (P2)/(P1+P2+P3)                    |        |  |
| R8  | 17 0.06 0.03                                                    | BARNHAM 71 HBC + 3.7 P1+P, KSK+P   | 11/71  |  |
| R8  | A (0.020) (0.004)                                               | ESPIGAT 72 HBC + 0. PBAR P.        | 2/72   |  |
| R8  | A NOT AVERAGED BECAUSE OF DISCREPANCY BETWEEN MASSES            |                                    |        |  |
| R8  | A FROM A K KBAR AND (RHO PI)                                    |                                    |        |  |
| R8  | 6 0.03 0.02                                                     | DAMERI 72 HBC - 11. P1-P           | 12/72* |  |
| R8  | AVG 0.039 0.017 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |                                    |        |  |
| R8  | FIT 0.0514 0.0062 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |                                    |        |  |
| R9  | A2 INTO (PI+ P1- PI0)/(RHO PI)                                  | (P6)/(P1)                          |        |  |
| R9  | (0.23) OR LESS CL=90                                            | ABRAMOVIC 70 HBC - 3.93 P1-P       | 1/71   |  |
| R11 | A2 INTO (PI GAMMA)/TOTAL                                        | (P7)                               |        |  |
| R11 | (0.005) (0.005)                                                 | 0.003 EISENBERG 71 HBC             | 11/71  |  |
| R11 | PION EXCHANGE MODEL USED IN THIS ESTIMATION                     | PHOTOPRODUCTION                    | 11/71  |  |
| R12 | A2 INTO (OMEGA PI)/(RHO PI)                                     | (P4)/(P1)                          |        |  |
| R12 | D 0.23 0.10                                                     | DEFOIX 72 HBC + 0.7 PBAR P, 7 P1   | 2/73*  |  |
| R12 | D DECAYS TO B1(1040) PI, B1 INTO OMEGA PI                       |                                    |        |  |
| R12 | D ERROR INCREASED TO ACCOUNT FOR POSSIBLE SYST. ERRORS          |                                    |        |  |
| R12 | D OF COMPLICATED ANALYSIS.                                      |                                    |        |  |
| R12 | 279 0.08 0.05                                                   | GARNJUST 72 HBC + 0.7 P1+P         | 2/73*  |  |
| R12 | 0.10 0.05                                                       | CHALOUKPA 73 HBC - 3.9 P1-P, P A2  | 2/73*  |  |
| R12 | AVG 0.106 0.033 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)    |                                    |        |  |
| R12 | FIT 0.106 0.033 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   |                                    |        |  |

## REFERENCES FOR A2

|                               |                                                    |
|-------------------------------|----------------------------------------------------|
| ADERHOLZ 64 PL 10 248         | (AACHEN+BERLIN+BIRO+BONN+HAMBURG+LOIC+MPI)         |
| CHUNG 64 PRL 32 621           | +DAHL, HARDY, HESS, KALBFLEISCH, KIRZ (LRL)        |
| GOLDHABER 64 DUBNA CONF 1 480 | C GOLDHABER, S. GOLDHABER, O. HALLORAN, SHEN (LRL) |
| LANDER 64 PRL 13 346          | +ABOLINS, CARMONY, HENDRICKS, XUONG + (LA JOLLA)   |
| ABOLINS 65 ATHENS(OHIO) CONF. | +CARMONY, LANDER, XUONG, YAGER (LA JOLLA)          |
| ADERHOLZ 65 PR 138 8 897      | (AACHEN+BERLIN+BIRO+BONN+HAMBURG+LOIC+MPI)         |
| ALITTI 65 PL 15 69            | ALITTI, BATON, DELEER, CRUSSARD + (SACLAY+BGNA) JP |
| CHUNG 65 PRL 15 325           | +DAHL, HARDY, HESS, JACOBS, KIRZ, MILLER (LRL)     |
| FORINO 65 PL 19 68            | +GESSAROLI + (BGNA+BARI+FIJZ+ORSAY+ SACL)          |
| LEFEVRE 65 PL 19 434          | CERN MISSING MASS SPECTROMETER GROUP (CERN)        |
| SEIDLITZ 65 PRL 15 217        | L SEIDLITZ, D. I DAHL, D. H MILLER (LRL)           |
| BARNES 66 PRL 16 41           | BARNES, FOWLER, LAI, ORNSTEIN + (BNL+CUY)          |
| BENSON 66 MICH COO-111-2-4    | G.C. BENSON, THESIS (MICH)                         |
| ALSO 66 PRL 16 1177           | G BENSON, LOVELL, MARQUITT, ROE + (MICH)           |
| ERHRLICH 66 PR 152 1194       | R. ERHRLICH, W. SELOVE, H. YUTA (PENN)             |
| FERBEL 66 PL 21 111           | FERBEL (ROCHESTER)                                 |
| LEVART 66 PL 22 714           | CERN MISSING MASS SPECTROMETER GROUP (CERN)        |
| ARMENISE 67 PL 258 53         | ARMENISE, FORINO, + (BARI+BGNA+FIJZ+ORSAY)         |
| BALYAY 67 PL 258 160          | +KIRSH+KUNG+YEH+RABIN (COLU+BNL+RUTGERS)           |
| BARLOW 67 NC 50A 701          | +LILLESSTOL+MONTANET + (CERN+COEF+IRAD+LIVP)       |

|                                    |                                                     |
|------------------------------------|-----------------------------------------------------|
| SARTSCH 67 PL 258 48               | +DEUTSCHMANN+GROTE+COCONI + (AACH+BERL+CERN)        |
| BEUSCH 67 PL 25 8 357              | +FISCHER, GÖBBI, ASTBURY + (ETHZ+CERN)              |
| CASON 67 PRL 18 880                | +LAMA, BISWAS, DEARDO, GROVES, + (INTREDAE)         |
| ALSO 68 LAMA                       |                                                     |
| CHIKOVAN 67 PL 258 44              | CERN MISSING MASS SPECTROMETER GROUP (CERN)         |
| CHUNG 67 PRL 18 100                | +DAHL, HARDY, HESS, KIRZ, MILLER (LRL)              |
| ALSO 66 UCRL-16832                 | RICHARD I HESS-THESIS, BERKELEY (LRL)               |
| COHN 67 NP 81 57                   | +ACULLOCH+BUGG+CONDO (ORNL+UNIV. TENN.)             |
| CONFORTO 67 NP 83 469              | +MARCHEL, MONTANET + (CERN+COEF+IRAD+LIVP)          |
| CONTE 67 NC 51 A 175               | +TOMASINI, CORDS + (GENOVA+HAMB+MILAN+ SACL)        |
| DAHL 67 PR 163 1377                | +HARDY+HESS+KIRZ+MILLER (LRL)                       |
| DANYSZ 67 NC 51 A 801              | DANYSZ+FRENCH+SIMAK (CERN)                          |
| SLATTERY 67 NC 50A 377             | +KRAYBILL+FORMAN+FERBEL (YALE+ROCHI) JP             |
| ARMENISE 68 PL 268 336             | ARMENISE, FORINO, + (BARI+BGNA+FIJZ+ORSAY)          |
| ASCOLI 68 PRL 20 1321              | +CRAWLEY, MORTARA, SHAPIRO, BRIDGES + (ILLINOIS) JP |
| BALLM 68 PRL 21 934                | +BRODY, CHADWICK, FRIES, GUIRAGOSSIAN + (SLAC)      |
| BENZ 68 PL 28 233                  | CERN MISSING MASS SPECTROMETER GROUP (CERN)         |
| BOESEBECK 68 NP 8 4 501            | BOESEBECK, DEUTSCHMANN, + (AACHEN+BERLIN+CERN)      |
| CASO 68 NC 54 A 983                | +CONTE+CORDS+DIAZ + (GENOVA+HAMB+MILAN+ SACL)       |
| CHUNG 68 PR 165 1491               | S.-U. CHUNG, D. DAHL, J. KIRZ, D. H. MILLER (LRL)   |
| CRENNELL 68 PRL 20 1310            | +KARSHON+KAM LAI, SCARR, SKILLICORN (BNL)           |
| DONALD 68 PL 26 8 327              | +FROEDER+BEITINI + (LIVERPOOL+OSLO+PADUA)           |
| FOSTER 68 NP 8 174                 | +GAVILLET, LABROSSE, MONTANET, + (CERN+COEF)        |
| FRIDMAN 68 PR 167 1268             | +MAURER, NICHALON, OUDET+HEID + (STRASBOURG)        |
| JUNKMANN 68 NP 88 471              | +COCCONI, + (AACH+BERL+BONN+CERN+WARS)              |
| KEY 68 PR 166 1430                 | +PRENTICE+COOPER+MANNER + (INTO+ANL+MISC)           |
| LAMA 68 PR 166 1395                | +CASON+BISWAS+DEARDO+GROVES + (INTREDAE)            |
| VOM KROG 68 PL 27 8 253            | +MIYASHITA, KOPELMAN, MARSHALL LIBBY (COLO)         |
| ADERHOLZ 69 NP 8 11 259            | +BARTSCH, + (AACH+BERL+CERN+JAGL+WARS)              |
| AGUILAR 169 PL 29 8 62             | +BARLOW, JACOBS, DELLA NEGRA + (CERN+COEF+LIVP)     |
| AGUILAR 269 PL 29 8 261            | +AGUILAR-BENITEZ, J. BARLOW, + (CERN+COEF)          |
| ANDERSON 69 PRL 22 1390            | +COLLINS, + (BNL+CUY)                               |
| ARMENISE 69 LNC 2 501              | +GHIDINI, FORINO, CARTACCI + (BARI+BGNA+FIJZ)       |
| CHIKOVAN 69 PL 28 8 526            | CERN MISSING MASS SPECTROMETER GROUP (CERN) JP      |
| CRENNELL 69 PRL 22 1327            | +KARSHON, KAM WU LAI, + (BNL+JIP)                   |
| DONALD 69 NP 8 12 325              | +FROEDER+BEITINI + (LIVERPOOL+OSLO+PADUA)           |
| EISENBERG 69 PRL 23 1322           | +EISENBERG, HABER, BALLAM, CHADWICK + (REHO+SLAC)   |
| ALSO 67 BARLOW, 67 CONFORTO        |                                                     |
| VETLITSKY 69 SJNP 9 596            | VETLITSKY, GRIGOREV, GRISHIN, + (ITEP)              |
| ABRAMOVIC 70 NP 8 29 466           | ABRAMOVICH, BLUMENFELD, BRUYANT, + (CERN) JP        |
| ALSTON-GA70 PL 33 607              | +BARBARO, BUHL, DERENZO, EPPERSON, FLATTE (LRL)     |
| ASCOLI 70 PRL 25 962               | +BROCKWAY, CRAWLEY, EISENSTEIN, HANFT, + (ILL) JP   |
| BASILE 70 LNC 4 838                | +DAPLAZ, FRABETTI, MASSAM, + (CERN+BGNA+STRB)       |
| BAUDI 70 PL 318 397                | CERN BOSON SPECTROMETER GROUP (CERN)                |
| BAUDY 70 PHILAD. CONF. P. 311      | CERN BOSON SPECTROMETER GROUP (CERN)                |
| BAUDY 70 PL 31 8 401               | CERN BOSON SPECTROMETER GROUP (CERN)                |
| BOCKMANN 70 NP 8 16 221            | +MAJOR, POLS, + (BONN+DURHAM+JIM+EPOL+TORI)         |
| BUTLER 70 UCRL 19845               | THESIS (LRL)                                        |
| CARDILL 70 PRL 25 1393             | +FIREBAUGH, GARFINKEL, MORSE, OH, + (WISC+INTO)     |
| CASO 70 LNC 3 707                  | +CONTE, TOMASINI, CORDS + (GENOVA+HAMB+MILAN+ SACL) |
| DIAZ 70 NP 8 16 239                | +GAVILLET, LABROSSE, MONTANET + (CERN+COEF) JP      |
| DIERBA 70 PR D 2 2544              | +SHEPARD, BISWAS, CASON, JOHNSON, KENNEY (NDAM)     |
| ALSO 68 LAMA                       |                                                     |
| GARFINKEL 70 PL 33 8 536           | GARFINKEL, AMMANN, CARMONY, YEN (PURDUE+JIC)        |
| GOWEN 70 COO 1195 179              | THESIS, ILLINOIS (MISC)                             |
| JOHNSTON 70 NP 8 24 253            | +KEY, PRENTICE, YOON, GARFINKEL, + (INTO+MISC)      |
| KRUSE 70 PHILAD. CONF. P. 359      | U. KRUSE, PARTIAL WAVE ANALYSIS (ILL) JP            |
| NEUF 70 THESIS+PRIV. COMM.         | CERN BOSON SPECTROMETER GROUP (CERN)                |
| SUTHERLAND 70 PHILAD. CONF. P. 369 | G. SUTHERLAND, INTERFERING RESONANCE (GLASGOW)      |
| AGUILAR 71 PR D 4 2583             | AGUILAR-BENITEZ, EISNER, KINSON (BNL)               |
| ALSTON-GA71 PL 34 8 156            | +BARBARO, BUHL, DERENZO, EPPERSON, FLATTE (LRL)     |
| BARNHAM 71 PRL 26 1494             | +ABRAMS, BUTLER, COYNE, GOLDHABER, HALL, + (LBL)    |
| BENKTOV 71 SJNP 4 765              | +GONKOVSKY, KONDAKOV, KRUTSCHIN, + (ITEP) JP        |
| BINNIE 71 PL 36 8 257              | +CAMILLERI, DUANE, FARUQI, BURTON, + (LOIC+SHMP)    |
| BINNIE 71 PL 36 8 537              | +CAMILLERI, DUANE, FARUQI, BURTON, + (LOIC+SHMP)    |
| BOWEN 71 PRL 26 1663               | +FAIRLES, FAISSLER, BLIEDEN, + (NEAS+STON)          |
| BUEL 71 PREPRINT                   | +CLINE, TERREL (MISCONSIN)                          |
| CLAYTON 71 PHILAD. CONF. P. 185    | +MASON, MUIRHEAD, RIGOPoulos, + (LIVP+ATEH)         |
| CRENNELL 71 PL 35 8 185            | +GORDON, KWAN-WU LAI, SCARR (LRL)                   |
| EISENBERG 71 SLAC-PUB-933          | EISENBERG, HABER, BALLAM, CHADWICK + (REHO+STAN)    |
| FARBER 71 NP 29 237                | +DE PINTO, BISWAS, CASON, DEERY, KENNEY, + (NDAM)   |
| FOLEY 71 PRL 26 413                | +LOVE, OZAKI, PLATNER, LINDENBAUM, + (BNL+CUY)      |
| GRAYER 71 PRL 26 433               | +WANS, JONES, SCHLIE, BLUM, DIETEL+ICERN+MICH       |
| LYNCH 71 LNC 20022 62 AND 71       | AMSTERDAM CONF. G. LYNCH (LBL)                      |
| RNAUDO 71 NC 5 A 239               | +BOECKMANN, MAJOR + (TORI+BONN+DURHAM+JIM+EPOL) JP  |
| ANKENBRAND 72 PRL 29 1688          | ANKENBRANDT, BRABSON, CRITTENDEN, HEINZ, + (INDO)   |
| ANTIPON 72 PHIL. CONF. PROC.       | ASCOLI, BUSNELLO, D'AMARO, + (CERN)                 |
| BERENYI 72 NP 8 37 621             | +PRENTICE, STEENBERG, YOON, WALKER (INTO+MISC)      |
| BLOOMWORTH 72 NP 8 37 203          | BLOOMWORTH, JACKSON, PRENTICE, YOON (INTO)          |
| DAMERI 72 NC 9 A 1                 | +BORZATTA, COUSSU, + (GENOVA+MILA+ SACL)            |
| DAGGAARD 72 UNPUBLISHED MEMO       | +LECHANDINE, MARTIN (BOHR+GEVA)                     |
| DEFOIX 72 SUBMITTED TO PL          | +DOBRYNSKI, ESPIGAT, NASCIMENTO, + (COEF)           |
| DIEBOLD 72 BATAV. CONF.            | R. DIEBOLD, RAPPOREUR TALK (ANL)                    |
| EISENBERG 72 PR D 5 15             | EISENBERG, BALLAM, DAGAN, + (REHO+SLAC+TEL)         |
| EISENSTEIN 72 COO-1195-247         | EISENSTEIN, SCHULTZ, ASCOLI, IOPREDDO, + (ILL)      |
| ESPIGAT 72 NP 8 36 93              | +GHEQUERE, LILLESSTOL, MONTANET (CERN+COEF)         |
| FOLEY 72 PR D 6 747                | +LOVE, OZAKI, PLATNER, LINDENBAUM, + (BNL+CUY)      |
| GARNJUST 72 PRIV. COMMUNIC.        | M. ALSTON-GARNJUST (LBL)                            |
| GETTNER 72 PREPRINT NUB2145        | M. GETTNER (NEAS)                                   |
| KIENZLE 72 UNPUBLISHED MEMO        | M. KIENZLE (CERN)                                   |
| LASSILA 72 PRL 28 1491             | LASSILA, YOUNG (INDO)                               |
| MORSE 72 PR D 6 77                 | +OH, WALKER, JOHNSTON, YOON (WISC+TORI)             |
| PREPOST 72 PHIL. CONF. PROC.       | +CONFORTO, KEY, MOBLEY, + (WISC+CHIC+INTO+NAL)      |
| CHALOUKPA 73 SUBMITTED TO PL       | CHALOUKPA, DOBRZYNSKI, FERRANDO, LOSTY, + (CERN)    |

## E(1420)

6 E (1420, JPG=A) I=0

BAILLON 67 FAVOR JP=0, DAHL 67 FAVOR 1+ BUT DO NOT EXCLUDE 2-, 0-, LORSTAD 69 FIMO 0- OR 1+.

## 6 E MASS (MEV)

|   |        |        |         |                                              |                     |        |
|---|--------|--------|---------|----------------------------------------------|---------------------|--------|
| M | 1425.  | 7.     | BAILLON | 67 HBC                                       | 0. PBAR P           | 11/66  |
| M | 1420.0 | 20.0   | DAHL    | 67 HBC                                       | 1.6+4.2 P1- P       | 10/66  |
| M | 1423.  | 10.    | FRENCH  | 67 HBC                                       | 3-4 PBAR P          | 6/67   |
| M | 310    | 1420.  | LORSTAD | 69 HBC                                       | 0.7 PB P, 4, 5-BODY | 9/69   |
| M | 170    | 1398.  | DEFOIX  | 72 HBC                                       | 0.7 PBAR P, 7 P1    | 1/73*  |
| M | 280    | 1406.  | DUBOZ   | 72 HBC                                       | 1.2 PBAR P, 2K4P1   | 12/72* |
| M | AVG    | 1415.5 | 4.3     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |                     |        |

## Mesons

E(1420), X<sub>0</sub>(1430), X<sub>1</sub>(1440), f'(1514)

## Data Card Listings

For notation, see key at front of Listings.

| 6 E WIDTH (MEV) |      |      |         |                                              |                     |        |
|-----------------|------|------|---------|----------------------------------------------|---------------------|--------|
| W               | 80.  | 10.  | BAILLON | 67 HBC                                       | 0. PBAR P           | 11/66  |
| W               | 60.0 | 20.0 | DAHL    | 67 HBC                                       | 1.6-4.2 PI- P       | 10/66  |
| W               | 45.  | 20.  | FRENCH  | 67 HBC                                       | 3-4 PBAR P          | 6/67   |
| W               | 310  | 60.  | LORSTAD | 69 HBC                                       | 0.7 PB P, 4, 5-BODY | 9/69   |
| W               | 170  | 50.  | DEFOIX  | 72 HBC                                       | 0.7 PBAR P, 7 PI    | 1/73*  |
| W               | 280  | 50.  | DUBOC   | 72 HBC                                       | 1.2 PBAR P, 2K4PI   | 12/72* |
| W               | AVG  | 59.8 | 6.0     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |                     |        |

| 6 E PARTIAL DECAY MODES |                  |               |              |
|-------------------------|------------------|---------------|--------------|
|                         |                  |               | DECAY MASSES |
| P1                      | E INTO K K*(892) | 497+ 891      |              |
| P2                      | E INTO K KBAR PI | 497+ 497+ 139 |              |
| P3                      | E INTO PI PI RHO | 134+ 134+ 770 |              |
| P4                      | E INTO DELTA PI  | 970+ 139      |              |
| P5                      | E INTO ETA PI PI | 548+ 139+ 139 |              |

| 6 E BRANCHING RATIOS |                                          |           |         |        |                  |       |
|----------------------|------------------------------------------|-----------|---------|--------|------------------|-------|
| R1                   | E INTO (KBAR K*(892) + C.C.)/(K KBAR PI) | (P1)/(P2) | BAILLON | 67 HBC | 0.0 PBAR P       | 11/66 |
| R1                   | .50 .10                                  |           |         |        |                  |       |
| R2                   | E INTO (PI PI RHO) / (K KBAR PI)         | (P3)/(P2) | DAHL    | 67 HBC | 0 1.6-4.2 PI- P  | 10/66 |
| R2                   | (2.0) OR LESS                            |           |         |        |                  |       |
| R3                   | E INTO (ETA 2 PI)/(K KBAR PI)            | (P5)/(P2) | FOSTER  | 68 HBC | 0.0 PBAR P       | 9/69  |
| R3                   | (1.5) OR LESS CL=.95                     |           | DEFOIX  | 72 HBC | 0.7 PBAR P       | 1/73* |
| R3                   | 1.5 0.8                                  |           |         |        |                  |       |
| R4                   | E INTO (DELTA PI)/(ETA PI PI)            | (P4)/(P5) | DEFOIX  | 72 HBC | 0.7 PBAR P, 7 PI | 1/73* |
| R4                   | 0.4 0.2                                  |           |         |        |                  |       |

## REFERENCES FOR E

|         |                 |                                                     |    |
|---------|-----------------|-----------------------------------------------------|----|
| BAILLON | 67 NC 50A 393   | *EDWARDS+D. ANDLAU+ASTIER+ (CERN+CDEF+IRAO)         |    |
| BARASH  | 67 PR 156 1399  | *BARASH, KIRSCH, MILLER, TAN (COLUMBIA)             |    |
| DAHL    | 67 PR 163 1377  | *HARDY+HESS+KIRZ+MILLER (LRL+UC)                    | JP |
| ALSO    | 65 PRL 14 1074  | *MILLER, CHUNG, DAHL, HESS, HARDY, KIRZ+ (LRL+UC)   |    |
| FRENCH  | 67 NC 52A 438   | *KINSON+MC DONALD+RIDDIFORD+ (CERN+BIRM)            |    |
| FOSTER  | 68 NP B 8 174   | *GAVILLET, LABROSSE, MONTANET, + (CERN+CDEF)        |    |
| BETTINI | 69 NC 62 A 1038 | *CRESTI, LIMENTANI, BERTAUZA, BIGI+ (PADOV+PISA) IC |    |
| LORSTAD | 69 NP B 14 63   | B. LORSTAD, D. ANDLAU, ASTIER, + (CDEF+CERN)        | JP |
| DEVONS  | 71 PRL 27 1614  | *KOZLOWSKI, HORWITZ, + (CERN+SYRA)                  |    |
| CHAPMAN | 72 NP B 42 1    | *GURCH, LYS, MURPHY, RING, VANDER VELDE (MICH)      |    |
| DEFOIX  | 72 NP B 44 125  | *MASCIMENTO, BIZZARRI, + (CDEF+CERN)                |    |
| DUBOC   | 72 NP B 46 429  | *COLDBERG, MAKOWSKI, DONALD, + (LPLN+LIVP)          |    |

X<sub>0</sub>(1430)→ K<sub>S</sub>K<sub>S</sub>, ρ<sup>0</sup>ρ<sup>0</sup>

29 X (1430, JPG= ) I=0

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE. PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER X(1440) (I=1) AS WELL.

## 29 X(1430) MASS (MEV)

|   |                                                                 |         |         |                                              |      |
|---|-----------------------------------------------------------------|---------|---------|----------------------------------------------|------|
| M | -----RHOD RHOD MODE-----                                        | BETTINI | 66 DBC  | 0 0. PBAR P TO 5PR                           | 9/66 |
| M | (1410.0)                                                        |         |         |                                              |      |
| M | -----KS KS MODE-----                                            | ABRAMS  | 67 HBC  | 4.25 K- P                                    | 5/67 |
| M | POSSIBLY SEEN                                                   | ABRAMS  | 67 HBC  | 4.25 K- P                                    | 5/67 |
| M | THE AUTHORS ASSOCIATE THE PEAK WITH THE F PRIME, BUT BACKGROUND | ABRAMS  | 67 HBC  | 4.25 K- P                                    | 5/67 |
| M | ESTIMATION IS DIFFICULT                                         | ABRAMS  | 67 HBC  | 4.25 K- P                                    | 5/67 |
| M | 1412. 23.                                                       | BARLOW  | 67 HBC  | 1.2 PBAR P                                   | 5/67 |
| M | 1439.0 5.0                                                      | BEUSCH  | 67 OSPK | 5.7, 12 PI-P                                 | 9/67 |
| M | AVG                                                             | 1437.5  | 5.3     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |      |

## 29 X(1430) WIDTH (MEV)

|   |                          |         |         |                                              |      |
|---|--------------------------|---------|---------|----------------------------------------------|------|
| W | -----RHOD RHOD MODE----- | BETTINI | 66 DBC  | 0 0. PBAR P TO 5PR                           | 9/66 |
| W | (190.0)                  |         |         |                                              |      |
| W | -----KS KS MODE-----     | BARLOW  | 67 HBC  | 1.2 PBAR P                                   | 5/67 |
| W | 100. 70.                 | BEUSCH  | 67 OSPK | 5.7, 12 PI-P                                 | 9/67 |
| W | 43.0 17.0                | 18.0    |         |                                              |      |
| W | AVG                      | 46.4    | 17.0    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |      |

## REFERENCES FOR X(1430)

|         |                |                                                 |  |
|---------|----------------|-------------------------------------------------|--|
| BETTINI | 66 NC 42A 695  | *CRESTI, LIMENTANI, LORIA, PERUZZO+ (PADO+PISA) |  |
| ABRAMS  | 67 PRL 18 620  | *KEHOE, GLASSER, SECHI-ZORN, WOLSKY (MARYLAND)  |  |
| BARLOW  | 67 NC 50 A 701 | *MONTANET, D. ANDLAU+ (CERN+CDEF+IRAO+LIVP)     |  |
| BEUSCH  | 67 PL 25 B 357 | *FISCHER, GOBBI, ASTBURY+ (ETHZ+CERN)           |  |
| DONALD  | 69 NP B 11 551 | *EDWARDS, BURAN, BETTINI, + (LIVP+OSLO+PADO)    |  |

X<sub>1</sub>(1440)→ K<sub>S</sub>K<sub>S</sub>

38 X (1440, JPG= ) I=1

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE. PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER X(1430) (I=0) AS WELL.

## 38 X(1440) MASS (MEV)

|   |     |                           |                                              |         |                     |       |
|---|-----|---------------------------|----------------------------------------------|---------|---------------------|-------|
| M | 8   | POSSIBLY SEEN             | ABRAMS                                       | 67 HBC  | 4.25 K P            | 5/67  |
| M | 8   | THE AUTHORS ASSOCIATE THE | PEAK WITH THE F PRIME, BUT BACKGROUND        |         |                     |       |
| M | 8   | ESTIMATION IS DIFFICULT   |                                              |         |                     |       |
| M |     | 1412. 23.                 | BARLOW                                       | 67 HBC  | 1.2 PBAR P          | 5/67  |
| M |     | 1439.0 5.0 6.0            | BEUSCH                                       | 67 OSPK | 5.7, 12 PI-P        | 9/67  |
| M |     | (1425.0)                  | FOLEY                                        | 71 CNTR | - 20.3 PI- P, K- KS | 2/71  |
| M |     | (1405. )                  | DEFOIX                                       | 72 HBC  | 0.7 PBAR P, 7 PI    | 2/73* |
| M | AVG | 1437.5 . . . . . 5.3      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |         |                     |       |

## 38 X(1440) WIDTH (MEV)

|   |                |        |         |                                              |       |
|---|----------------|--------|---------|----------------------------------------------|-------|
| W | 100. 70.       | BARLOW | 67 HBC  | 1.2 PBAR P                                   | 5/67  |
| W | 43.0 17.0      | BEUSCH | 67 OSPK | 5.7, 12 PI-P                                 | 9/67  |
| W | (20.0) OR LESS | FOLEY  | 71 CNTR | 20.3 PI- P, K- KS                            | 2/71  |
| W | (40. )         | DEFOIX | 72 HBC  | 0.7 PBAR P, 7 PI                             | 2/73* |
| W | AVG            | 46.4   | 17.0    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |

## REFERENCES FOR X(1440)

|        |                    |                                                  |  |
|--------|--------------------|--------------------------------------------------|--|
| ABRAMS | 67 PRL 18 620      | *KEHOE, GLASSER, SECHI-ZORN, WOLSKY (MARYLAND)   |  |
| BARLOW | 67 NC 50 A 701     | *MONTANET, D. ANDLAU+ (CERN+CDEF+IRAO+LIVP)      |  |
| BEUSCH | 67 PL 25 B 357     | *FISCHER, GOBBI, ASTBURY+ (ETHZ+CERN)            |  |
| FOLEY  | 71 PRL 26 413      | *LOVE, OZAKI, PLATTNER, LINDENBAUM, + (BNL+GUNY) |  |
| DEFOIX | 72 SUBMITTED TO PL | *DOBRYNIN, ESPIGAT, MASCIMENTO, + (CDEF)         |  |

f'(1514)

13 F PRIME (1514, JPG=2+\*) I=0

## 13 F PRIME MASS (MEV)

|   |            |                                  |          |                                              |            |        |  |
|---|------------|----------------------------------|----------|----------------------------------------------|------------|--------|--|
| M | 14(1480.0) |                                  | CRENNELL | 66 HBC                                       | 6.0        | PI- P  |  |
| M | 8          | 5(1460. ) (10. )                 | ABRAMS   | 67 HBC                                       | 4.25       | K- P   |  |
| M | 8          | BACKGROUND ESTIMATION DIFFICULT. |          |                                              |            |        |  |
| M | 1515.0     | 7.0                              | AMMAR    | 67 HBC                                       | 5.5        | K- P   |  |
| M | S          | 70(1513.0) (7.0)                 | BARNES   | 67 HBC                                       | 4.6, 5.    | K- P   |  |
| M | S          | SUPERSEDED BY AGUILAR 72         |          |                                              |            |        |  |
| M | 100        | 1519. 7.                         | AGUILAR  | 72 HBC                                       | 3.9, 4.6   | K- P   |  |
| M | 46         | 1514. 6.                         | COLLEY   | 72 HBC                                       | 10. K- P   |        |  |
| M | 47         | 1521. 7.                         | VIDEAU   | 72 HBC                                       | 4. K- P, L | FPRIME |  |
| M | AVG        | 1516.1                           | 2.8      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |            |        |  |

## 13 F PRIME WIDTH (MEV)

|   |     |                                                   |        |                                              |        |              |                  |
|---|-----|---------------------------------------------------|--------|----------------------------------------------|--------|--------------|------------------|
| W | 8   | 5 (53.)                                           | 18.1   | ABRAMS                                       | 67 HBC | 4.25 K-P     | 5/67             |
| W | 8   | BACKGROUND ESTIMATION DIFFICULT.                  |        |                                              |        |              | 5/67             |
| W |     | 35.0                                              | 25.0   | AMMAR                                        | 67 HBC | 5.5 K-P      | 9/67             |
| W | 70  | (87.0)                                            | (15.0) | BARNES                                       | 67 HBC | 4.6, 5. K-P  | 12/72*           |
| W | S   | SUPERSED BY AGUILAR T2                            |        |                                              |        |              |                  |
| W | 100 | 69.                                               | 22.    | AGUILAR                                      | 72 HBC | 3.9, 4.6 K-P | 12/72*           |
| W | 46  | 28.                                               | 15.    | COLLEY                                       | 72 HBC | 10. K-P      | 12/72*           |
| W | E   | 47                                                | 40.    | 20.                                          | VIDEAU | 72 HBC       | 4. K-P, L FPRIME |
| W | E   | ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS. |        |                                              |        |              | 12/72*           |
| W | AVG | 39.9                                              | 9.7    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |              |                  |

## 13 F PRIME PARTIAL DECAY MODES

|    |                              |                    |              |  |  |
|----|------------------------------|--------------------|--------------|--|--|
| P1 | F PRIME INTO PI+ PI-         | 139+ 139           | DECAY MASSES |  |  |
| P2 | F PRIME INTO K KBAR          | 497+ 497           |              |  |  |
| P3 | F PRIME INTO K K*(892)       | 493+ 891           |              |  |  |
| P4 | F PRIME INTO ETA ETA         | 548+ 548           |              |  |  |
| P5 | F PRIME INTO PI PI ETA       | 139+ 139+ 548      |              |  |  |
| P6 | F PRIME INTO PI K KBAR       | 139+ 497+ 497      |              |  |  |
| P7 | F PRIME INTO PI+ PI- PI- PI- | 139+ 139+ 139+ 139 |              |  |  |

## 13 F PRIME BRANCHING RATIOS

|    |                                               |              |         |        |               |        |
|----|-----------------------------------------------|--------------|---------|--------|---------------|--------|
| R1 | F PRIME INTO (PI+ PI-)/(K KBAR)               | (P1)/(P2)    | AMMAR   | 67 HBC | 5.5 K- P      | 9/67   |
| R1 | (0.2) OR LESS CL=67                           |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R1 | (0.36) OR LESS CL=95                          |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R3 | F PRIME INTO (ETA ETA)/(K KBAR)               | (P4)/(P2)    | BARNES  | 67 HBC | 4.6, 5.0 K- P | 10/67  |
| R3 | (0.50) OR LESS                                |              | BARNES  | 67 HBC | 4.6, 5.0 K- P | 10/67  |
| R4 | F PRIME INTO (PI PI ETA)/(K KBAR)             | (P5)/(P2)    | AMMAR   | 67 HBC | 4.6, 5.0 K- P | 10/67  |
| R4 | (0.3) OR LESS CL=67                           |              | BARNES  | 67 HBC | 4.6, 5.0 K- P | 10/67  |
| R4 | (0.25) (0.13)                                 |              | BARNES  | 67 HBC | 4.6, 5.0 K- P | 10/67  |
| R4 | A SUPERSEDED BY AGUILAR 72                    |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R4 | (0.41) OR LESS CL=95                          |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R5 | F PRIME INTO (PI K KBAR + K K*(892))/(K KBAR) | (P6+P3)/(P2) | AGUILAR | 67 HBC | 3.9, 4.6 K- P | 10/67  |
| R5 | (0.4) OR LESS CL=67                           |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R5 | (0.35) OR LESS CL=95                          |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R6 | F PRIME INTO (PI+ PI- PI- PI-)/(K KBAR)       | (P7)/(P2)    | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |
| R6 | (0.32) OR LESS CL=95                          |              | AGUILAR | 72 HBC | 3.9, 4.6 K- P | 12/72* |

## REFERENCES FOR F PRIME

|          |                 |                                                   |  |
|----------|-----------------|---------------------------------------------------|--|
| BARNES   | 65 PRL 15 322   | *CULWICK, GUIDONI, KALBFLEISCH, GOZ+ (BNL+SYRA)   |  |
| CRENNELL | 66 PRL 16 1025  | *KALBFLEISCH, LAI, SCARR, SCHUMANN + (BNL+I)      |  |
| ABRAMS   | 67 PRL 18 620   | *KEHOE, GLASSER, SECHI-ZORN, WOLSKY (MARYLAND)    |  |
| AMMAR    | 67 PRL 19 1071  | *DAVIS, HWANG, DAGAN, DERICK + (BNL+ANL) JP       |  |
| BARNES   | 67 PRL 19 964   | *DORRAN, GOLDBERG, LEITNER + (BNL+SYRACUSE) IC JP |  |
| ALITTI   | 68 PRL 21 1705  | *BARNES, CRENNELL, FLAMINIO, GOLDBERG, + (BNL)    |  |
| LORSTAD  | 69 NP B 14 63   | B. LORSTAD, D. ANDLAU, ASTIER, + (CDEF+CERN) JP   |  |
| SCOTTER  | 69 NC 62 A 1057 | *ERSKINE, PALER, + (BIRM+GLAS+LOIC+MPIH+OXF)      |  |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $\rho'(1514)$ ,  $F_1(1540)$ ,  $\rho'(1600)$ ,  $A_3(1640)$ 

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ, CHUNG, EISNER, SAMIOS (BNL)  
COLLEY 72 NP B 50 1 \*JOBS, RIDDIFORD, GRIFFITHS, \* (BIRM+GLAS)  
VIDEAU 72 PL 41 B 213 \*VIDEAU, ROUGE, BARRELET, DEBRION, \* (EPOL+SAEL)

**$F_1(1540)$**   
 **$\rightarrow K\bar{K}\pi$**

47  $F_1(1540, JPC=1-1)$   
JP = 2-, 1+ FAVORED.

47  $F_1$  MASS (MEV)

|   |             |        |          |        |                        |       |
|---|-------------|--------|----------|--------|------------------------|-------|
| W | 101(1490.0) | (20.0) | ADERHOLZ | 69 HBC | + 8 $\pi^+$ P, KKBARPI | 11/69 |
| M | 142(1540.0) | 5.0    | AGUILAR  | 69 HBC | 0.7PBAR, KKBARPI       | 11/69 |
| M | 25(1543.0)  | (3.0)  | DUBOC    | 71 HBC | 0.1-1.2 PBAR P         | 2/72  |

47  $F_1$  WIDTH (MEV)

|   |           |        |          |        |                        |       |
|---|-----------|--------|----------|--------|------------------------|-------|
| W | 10 (85.0) | (39.0) | ADERHOLZ | 69 HBC | + 8 $\pi^+$ P, KKBARPI | 11/69 |
| M | 142 40.0  | 15.0   | AGUILAR  | 69 HBC | 0.7PBAR, KKBARPI       | 11/69 |
| M | 25 (16.0) | (10.0) | DUBOC    | 71 HBC | 0.1-1.2 PBAR P         | 2/72  |

47  $F_1$  PARTIAL DECAY MODES

|    |                         |               |
|----|-------------------------|---------------|
| P1 | $F_1$ INTO K KBAR P1    | DECAY MASSES  |
| P2 | $F_1$ INTO K*(892) KBAR | 134+ 497+ 497 |
|    |                         | 891+ 497      |

REFERENCES FOR  $F_1$ 

ADERHOLZ 69 NP B 11 259 \*BARTSCH, \* (AACH+BERL+CERN+KRAK+WARS)  
AGUILAR 69 PL 29 B 379 \*BARLOW, JACOBS, D ANDLAU, ASTIER, \* (CERN+CDEF)  
AGUILAR 69 NP B 14 195 \*BARLOW, JACOBS, D ANDLAU, ASTIER, \* (CERN+CDEF)  
DUBOC 71 PL 34 B 343 \*GOLDBERG, MAKOWSKI, TOUCHARD, \* (IPNP+LIVP)  
CHAPMAN 72 NP B 42 1 \*CHURCH, LYS, MURPHY, RING, VANDER VELDE (MICH)  
DUBOC 72 NP B 46 429 \*GOLDBERG, MAKOWSKI, DONALD, \* (LPNP+LIVP)

**$\rho'(1600)$**   
 **$\rightarrow 4\pi$**

65 RHO PRIME(1600, JPC=1-+) I=1

The  $\rho'$ , long-sought by looking for its  $2\pi$  decay, has been seen clearly only in the reaction

$$\gamma(\text{real or virtual}) \rightarrow \rho'^0 \rightarrow \rho^0 \epsilon^0 \rightarrow 4\pi.$$

There is some evidence from ALVENSLEBEN 71 and BULOS 71 for a  $2\pi$  bump far out on the  $\rho$  tail, but interpretation is difficult. EISENBERG 72 claim to establish a width of less than 2 MeV for  $\rho' \rightarrow 2\pi$ . This is not easily put in the format of the data cards below, so it is summarized here: Their 5 GeV/c  $\pi^+p$  experiment yields 5600  $\rho\Delta^{++}$  and <37  $\rho'\Delta^{++}$ ; i.e., production ratios are >100:1. With minor corrections, the OPE model then gives a ratio of coupling constants squared for the  $2\pi$  decay of  $\rho'$  and  $\rho$  to be  $g^2(\rho')/g^2(\rho) < 0.02$ , which then yields the surprising  $\Gamma(\rho' \rightarrow 2\pi) < 2$  MeV. If no  $2\pi$  mode is found, MORTARA 72 suggests that the  $\rho'$  is just a  $\rho$  threshold on the tail of the  $\rho$ , but again EISENBERG 72 claim to refute this.

Mass and width values punched below are only indicative, because for such a broad peak they are extremely dependent on the parametrization chosen. For reviews, see DIEBOLD 72 and SILVESTRI 72.

## 65 RHO PRIME MASS (MEV)

|   |            |                  |          |         |                                              |        |
|---|------------|------------------|----------|---------|----------------------------------------------|--------|
| M | 1600.1     | APPROX.          | BARBARII | 72 OSPK | 0 $\pi^+$ $\pi^-$ TO 4 $\pi$                 | 1/73*  |
| M | 400 1430.  | 50.              | BINGHAM  | 72 HBC  | 0 9-3 GAM P, P 4PI                           | 12/72* |
| M | 1586.      | 22.              | DAVIER   | 72 STRC | 0 4.5-18. G P, P4PI                          | 12/72* |
| M | 400(1500.) | M.OF PEAK 400/40 | SHADJA   | 72 HBC  | 0 9-3 GAM P, P 4PI                           | 12/72* |
| M | 1560.7     | 57.5             |          |         |                                              |        |
| M | AVG        |                  |          |         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9) |        |
| S |            |                  |          |         | LATER FITS GIVEN BY BINGHAM 72               |        |

## 65 RHO PRIME WIDTH (MEV)

|   |           |                                |                                |         |                                              |                    |
|---|-----------|--------------------------------|--------------------------------|---------|----------------------------------------------|--------------------|
| W | 400 650.  | 100.                           | BINGHAM                        | 72 HBC  | 0 9-3 GAM P, P 4PI                           | 12/72*             |
| W | 303.      | 64.                            | DAVIER                         | 72 STRC | 0 4.5-18. G P, P4PI                          | 12/72*             |
| W | 400 (600) | FWHM                           | 400/40                         | SHADJA  | 72 HBC                                       | 0 9-3 GAM P, P 4PI |
| W | S         | EXPTL. FULL WIDTH AT HALF MAX. | LATER FITS GIVEN BY BINGHAM 72 |         |                                              |                    |
| W | (1350.)   | APPROX.                        | CERADINI                       | 73 OSPK | 0 $\pi^+$ $\pi^-$ TO 4 $\pi$                 | 1/73*              |
| W | AVG       |                                |                                |         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9) |                    |
|   | 403.8     | 157.5                          |                                |         |                                              |                    |

## 65 RHO PRIME PARTIAL DECAY MODES

|    |                                                  |                    |
|----|--------------------------------------------------|--------------------|
| P1 | RHO PRIME INTO RHO P1 P1                         | DECAY MASSES       |
| P2 | NEUTRAL RHO PRIME INTO ALL CHARGED 4 $\pi$ MODES | 139+ 139+ 139+ 139 |
| P3 | RHO PRIME INTO RHO RHO                           | 770+ 770           |
| P4 | RHO PRIME INTO P1 P1                             | 139+ 139           |
| P5 | RHO PRIME INTO K BAR K                           | 493+ 493           |
| P6 | RHO PRIME INTO P1 OMEGA                          | 139+ 783           |

## 65 RHO PRIME BRANCHING RATIOS

|      |                                                                               |                                                     |
|------|-------------------------------------------------------------------------------|-----------------------------------------------------|
| R1   | RHO PRIME INTO (RHO P1+ P1-)/(4 $\pi$ , ALL CHARGED) (P1)/(P2)                |                                                     |
| R1 S | DOMINANT                                                                      | BARBARII 72 OSPK 0 $\pi^+$ $\pi^-$ TO 4 $\pi$ 1/73* |
| R1 S | (.80)                                                                         | BINGHAM 72 HBC 0 9-3 GAM P, P 4PI 1/73*             |
| R1 S | DOMINANT                                                                      | DAVIER 72 STRC 0 4.5-18. G P, P4PI 1/73*            |
| R1 S | THE P1 $\pi$ SYSTEM IS IN S WAVE                                              |                                                     |
| R2   | RHO PRIME INTO (RHO 0 RHO 0)/(RHO 0 P1+ P1-) (P3)/(P1)                        |                                                     |
| R2   | NONE (FORBIDDEN BY I=1) BINGHAM 72 HBC 0 9-3 GAM P, P 4PI 1/73*               |                                                     |
| R3   | RHO PRIME INTO (P1+ P1-)/(4 $\pi$ , ALL CHARGED) (P4)/(P2)                    |                                                     |
| R3   | (.2) OR LESS 2 SIGMA BINGHAM 72 HBC 0 9-3 GAM P, P 2PI 1/73*                  |                                                     |
| R3 E | (.01) OR LESS 2 SIGMA EISENBERG 72 HBC 0 5 $\pi^+$ $\pi^-$ 2 OR 4 $\pi$ 1/73* |                                                     |
| R3 E | SEE DISCUSSION IN TYPED MINI-REVIEW ABOVE.                                    |                                                     |
| R4   | RHO PRIME INTO (K BAR K)/(4 $\pi$ , ALL CHARGED) (P5)/(P2)                    |                                                     |
| R4   | (.04) OR LESS 2 SIGMA BINGHAM 72 HBC 0 9-3 GAM P 1/73*                        |                                                     |

## REFERENCES FOR RHO PRIME

DAVIER 69 SLAC PUB 666 \*DERAOD, FRIES, LIU, MOZLEY, ODIAN + (SLAC) G  
ALVENSLEB 71 PRL 26 273 ALVENSLEBEN, BECKER, BERTRAM, CHEN, \* (DESY+MIT) G  
BRAUN 71 NP 830 213 \*FRIDMAN, GERBER, GIVERNAUD, \* (STRASBOURG) G  
BULOS 71 PRL 26 149 \*BUSZA, KEOHE, BENISTON, \* (SLAC+UMD+IBM+LBL) G  
BACCI 72 PL 388 551 \*PENSO, SALVINI, STELLA, BALDINI-CECROMA+FRAS JPC  
BARBARII 72 LNC 3 689 \*BARBARINO, CERADINI, \* (FRAS+ROMA+PADO+UMD) IGJP  
BARBARII 72 BAT.CONF.PAP.561 BARBARINO, CERADINI, \* (FRAS+ROMA+PADO+UMD)  
BARTOLI 72 PR D 6 2374 \*FELICETTI, OGREN, \* (FRAS+ROMA+NAPL) IGJP  
BINGHAM 72 PL 41B 635 \*RABIN, ROSENFELD, SHADJA, YOST + (LBL, UCB, SLAC) IGJP  
BRAMON 72 LNC 3 693 \*GRECO (THEORETICAL PAPER) (FRASCATI)  
DAVIER 72 BAT.CONF.PAP.797 \*DERAOD, FRIES, LIU, MOZLEY, ODIAN, PARK, \* (ISLAC)  
DIEBOLD 72 BATAV.CONF. R. DIEBOLD RAPPORTEUR TALK (ANL)  
EISENBERG 72 PR D 5 15 EISENBERG, BALLAM, DAGAN, \* (REHO+SLAC+TELA)  
EISENBERG 72 PREP. WIS 72/41-PH, PLITO BE PUBL. 73), \*KARSHON, \* (REHO)  
MORTARA 72 COD-1195-249 D.W.MORTARA (ILL)  
SILVESTRI 72 BATAV.CONF. V. SILVESTRI RAPPORTEUR TALK (FRASCATI)  
SHADJA 72 PHIL.CONF.PROC349 \*BINGHAM, FRETTER, BALLAM, CHADWICK + (LBL+SLAC)

CERADINI 73 BAT.CONF.PAP.560(PL 1973) \*CONVERSI, D'AN (FRAS+ROMA+PADO+MARY) IGJP

**$A_3(1640)$**

34  $A_3(1640, JPC=2-)$  I = 1

The  $A_3(1640)$  is seen as a bump in the diffraction-like process  $\pi N \rightarrow (\pi\pi\pi)N$ . The dominant effect is a 300-400 MeV wide enhancement in the  $J^P = 2^-$   $\pi\pi$  S-wave system, starting from  $\pi\pi$  threshold. Neither additional (narrower) structure in the  $3\pi$  mass distribution, nor other decay modes, have been clearly established. There appears to be little variation of the  $J^P = 2^-$   $\pi\pi$  phase in the  $A_3$  mass region (ASCOLI 72). The situation thus resembles that of the  $A_1$ .

## Mesons

 $A_3(1640)$ ,  $\omega(1675)$ 

## Data Card Listings

For notation, see key at front of Listings.

34  $A_3$  MASS (MEV)

|   |                                                      |           |                                              |                              |        |
|---|------------------------------------------------------|-----------|----------------------------------------------|------------------------------|--------|
| M | 30(1600.0)                                           | FORINO    | 65 DBC                                       | 04.5 $P_1 + D$               | 10/66  |
| M | 20 1630.0                                            | VELITSKY  | 66 HBC                                       | - 4.7 $P_1 - P$              |        |
| M | 1630.                                                | BALTAY    | 68 HBC                                       | + 7.8 $P_1 + P$              | 6/68   |
| M | 1660.0                                               | BARTSCH   | 68 HBC                                       | + 8. $P_1 + P, 3P_1 P$       | 8/69   |
| M | 1610.                                                | LANSA     | 68 HBC                                       | - 8.0 $P_1 - P, P_1 - F$     | 11/67  |
| M | 297 1673.0                                           | ARMENISE  | 69 DBC                                       | + 5.1 $P_1 + D, 3P_1 +$      | 5/70   |
| M | (1680.)                                              | CASO      | 69 HBC                                       | - 11 $P_1 - P$               | 5/70   |
| M | 1660.0                                               | CASO      | 69 HBC                                       | - 11 $P_1 - P, P_1 - F$      | 5/70   |
| M | 1645.0                                               | CRENNELL  | 70 HBC                                       | - 6. $P_1 + P, P_1 - F$      | 5/70   |
| M | (1633.0)                                             | MIYASHITA | 70 HBC                                       | - 6.7 $P_1 - P, P_1 - F$     | 1/71   |
| M | BACKGROUND SUBTRACTION DIFFICULT.                    |           |                                              |                              |        |
| M | (1672.0)                                             | BEKETOV   | 71 HBC                                       | - 4.45 $P_1 - P$             | 11/71  |
| M | 1600.                                                | PALER     | 71 DBC                                       | + 13. $P_1 + D, D(3P_1) +$   | 11/71  |
| M | 1660.                                                | ASCOLI    | 72 HBC                                       | - 5. -25. $P_1 - P, P_1 A_3$ | 12/72* |
| M | FROM A FIT TO $J^P = 2^- F P_1$                      |           |                                              |                              |        |
| M | 260 1660.                                            | CASO      | 72 HBC                                       | + 11.7 $P_1 + P$             | 11/71  |
| M | (1658.)                                              | HARRISON  | 72 HBC                                       | - 13.20. $P_1 - P$           | 12/72* |
| M | FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.          |           |                                              |                              |        |
| M | EVIDENCE FOR A SUBSTANTIAL DECAY INTO $3P_1$ CLAIMED |           |                                              |                              |        |
| M | AVG 1645.1                                           | 5.5       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |                              |        |

34  $A_3$  WIDTH (MEV)

|   |                                                              |           |                                              |                              |        |
|---|--------------------------------------------------------------|-----------|----------------------------------------------|------------------------------|--------|
| W | 20 (100.)                                                    | VELITSKY  | 66 HBC                                       | - 4.7 $P_1 - P$              | 6/66   |
| W | 70.                                                          | BALTAY    | 68 HBC                                       | + 7.8 $P_1 + P$              | 6/68   |
| W | 115.0                                                        | BARTSCH   | 68 HBC                                       | + 8. $P_1 + P, 3P_1 P$       | 8/69   |
| W | 100.                                                         | LANSA     | 68 HBC                                       | - 8.0 $P_1 - P, P_1 - F$     | 11/67  |
| W | A 297 (240.0)                                                | ARMENISE  | 69 DBC                                       | + 5.1 $P_1 + D, 3P_1 +$      | 5/70   |
| W | A BACKGROUND SUBTRACTION MODEL-DEPENDENT.                    |           |                                              |                              |        |
| W | (130.)                                                       | CASO      | 69 HBC                                       | - 11 $P_1 - P$               | 6/68   |
| W | (150.0)                                                      | CASO      | 69 HBC                                       | - 11.0 $P_1 - P, P_1 - F$    | 6/68   |
| W | A 3 INTO 5 $P_1$                                             | CRENNELL  | 70 HBC                                       | - 6. $P_1 + P, P_1 - F$      | 5/70   |
| W | (137.0)                                                      | MIYASHITA | 70 HBC                                       | - 6.7 $P_1 - P, P_1 - F$     | 1/71   |
| W | M BACKGROUND SUBTRACTION DIFFICULT.                          |           |                                              |                              |        |
| W | (128.0)                                                      | BEKETOV   | 71 HBC                                       | - 4.45 $P_1 - P$             | 11/71  |
| W | 220.                                                         | PALER     | 71 DBC                                       | + 13. $P_1 + D, D(3P_1) +$   | 11/71  |
| W | 270.                                                         | ASCOLI    | 72 HBC                                       | - 5. -25. $P_1 - P, P_1 A_3$ | 12/72* |
| W | FROM A FIT TO $J^P = 2^- F P_1$                              |           |                                              |                              |        |
| W | 200. TO 400.                                                 | CASO      | 72 HBC                                       | + 11.7 $P_1 + P$             | 1/72   |
| W | J FROM PARTIAL-WAVE ANALYSIS, FOR $J^P = 2^- (F P_1)$ -STATE |           |                                              |                              |        |
| W | 260 190.                                                     | CASO      | 72 HBC                                       | + 11.7 $P_1 + P$             | 11/71  |
| W | F (51.) (20.) (16.)                                          | HARRISON  | 72 HBC                                       | - 13.20. $P_1 - P$           | 12/72* |
| W | FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.                  |           |                                              |                              |        |
| W | EVIDENCE FOR A SUBSTANTIAL DECAY INTO $3P_1$ CLAIMED         |           |                                              |                              |        |
| W | AVG 128.6                                                    | 22.2      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |                              |        |

34  $A_3$  PARTIAL DECAY MODES

|    |                         |               |
|----|-------------------------|---------------|
| P1 | A3 INTO 3 $P_1$         | 134+ 134+ 134 |
| P2 | A3 INTO RHO $P_1$       | 134+ 770      |
| P3 | A3 INTO ETA $P_1$       | 134+ 548      |
| P4 | A3 INTO 5 $P_1$         |               |
| P5 | A3 INTO K $K^*(892)$    | 497+ 891      |
| P6 | A3 INTO K $K^*(892)$    | 497+ 497+ 134 |
| P7 | A3 INTO K $K^*(892)$    | 497+ 497      |
| P8 | A3 INTO F $P_1$         | 1270+ 134     |
| P9 | A3 INTO OMEGA $P_1 P_1$ | 783+ 134+ 134 |

34  $A_3$  BRANCHING RATIOS

|     |                                                                    |                                         |
|-----|--------------------------------------------------------------------|-----------------------------------------|
| R2  | A3+ INTO ( $P_1 +$ RHO) / (ALL $P_1 + P_1 - P_1 -$ )               | (P2C) / (P1C)                           |
| R2  | (0.3) OR LESS                                                      | 68 HBC + 8. $P_1 + P, 3P_1 P$           |
| R2  | (0.4) OR LESS                                                      | 68 RVUE + 8. $P_1 + P, 3P_1 P$          |
| R2  | (1.8) OR LESS CL=.95                                               | 68 HBC + 13. $P_1 + D, D(3P_1) +$       |
| R3  | A3+ INTO ( $P_1 +$ F) / (ALL $P_1 + P_1 - P_1 -$ )                 | (P8) / (P1C)                            |
| R3  | (WITH F INTO $P_1 - P_1 -$ )                                       |                                         |
| R3  | INDICATION SEEN                                                    | LUBATTI 66 HBC - 16 $P_1 - P$           |
| R3  | (0.5) FOR $J^P = 2^-$                                              | BARTSCH 68 HBC + 8. $P_1 + P, 3P_1 P$   |
| R3  | (0.5) FOR $J^P = 1^-$                                              | BARTSCH 68 HBC + 8. $P_1 + P, 3P_1 P$   |
| R3  | (0.2) FOR $J^P = 0^-$                                              | BARTSCH 68 HBC + 8. $P_1 + P, 3P_1 P$   |
| R3  | 0.35 0.20                                                          | BALTAY 68 HBC + 7-8.5 $P_1 + P$         |
| R3  | CONSISTENT WITH 1.0                                                | CASO 68 HBC - 11 $P_1 - P$              |
| R3  | (0.76) (0.24) (0.34)                                               | ARMENISE 69 DBC + 5.1 $P_1 + D, 3P_1 +$ |
| R3  | CONSISTENT WITH 1.0                                                | CRENNELL 70 HBC - 6. $P_1 + P, P_1 - F$ |
| R3  | (.85) OR MORE CL=.95                                               | PALER 71 DBC + 13. $P_1 + D, D(3P_1) +$ |
| R5  | A3+ INTO ( $P_1 +$ ETA) / (ALL $P_1 + P_1 - P_1 -$ )               | (P3) / (P1C)                            |
| R5  | (ALL ETA DECAYS)                                                   |                                         |
| R5  | (0.09) OR LESS                                                     | BALTAY 68 HBC + 7-8.5 $P_1 + P$         |
| R5  | (0.10) OR LESS                                                     | CRENNELL 70 HBC - 6. $P_1 + P, P_1 - F$ |
| R6  | A3+ INTO ( $P_1 +$ 2P) / (ALL $P_1 + P_1 - P_1 -$ )                | (P4C) / (P1C)                           |
| R6  | (0.1) OR LESS                                                      | BALTAY 68 HBC + 7.6-5 $P_1 + P$         |
| R6  | (0.10) OR LESS                                                     | CRENNELL 70 HBC - 6. $P_1 + P, P_1 - F$ |
| R8  | A3+ INTO (RHO $P_1$ ) / (F $P_1$ )                                 | (P2) / (P8)                             |
| R8  | 0.03 0.37                                                          | CASO 69 HBC - 11 $P_1 - P$              |
| R9  | A3+ INTO ( $P_1 +$ $P_1 - P_1$ ) / (F $P_1$ )                      | (P1C - P8) / (P8)                       |
| R9  | 0.06 0.47 0.06                                                     | CASO 69 HBC - 11 $P_1 - P$              |
| R9  | POSSIBLY SEEN                                                      | HARRISON 72 HBC - 13.20. $P_1 - P$      |
| R10 | A3+ INTO (UNCORREL. $P_1 + P_1 - P_1$ ) / (ALL $P_1 + P_1 - P_1$ ) |                                         |
| R10 | (.05) OR LESS CL=.95                                               | PALER 71 DBC + 13. $P_1 + D, D(3P_1) +$ |
| R10 | MODEL DEPENDENT FIT                                                |                                         |

REFERENCES FOR  $A_3$ 

|         |                    |                                             |
|---------|--------------------|---------------------------------------------|
| FORINO  | 65 PL 19 68        | +GESSAROLI+ (BGNA+BAR+FI+ORS+SA+CL)         |
| FOCACCI | 66 PRL 17 890      | CERN MISSING MASS SPECTROMETER GROUP (CERN) |
| LEVAT   | 66 PL 22 714       | CERN MISSING MASS SPECTROMETER GROUP (CERN) |
| LUBATTI | 66 THESIS BERKELEY | H.J. LUBATTI (LRL) 11-2-                    |

|          |                        |                                                  |
|----------|------------------------|--------------------------------------------------|
| VELITSKY | 66 PL 21 579           | VELITSKY, GUSZAVIN, KLIGER, ZOLGANOV+ (ITEP)     |
| DANYSZ   | 67 NC 51 A 801         | DANYSZ+FRENCH+SINAK (CERN)                       |
| DUBAL    | 67 NP 83 435           | CERN MISSING MASS SPECTROMETER GROUP (CERN)      |
| ALSO     | 68 THESIS 1456         | L. DUBAL (GENEVE)                                |
| BALTAY   | 68 PRL 20 887          | +KUNG+YEH+FERBEL+ (COLU+ROCH+RUTG+YALE) 1=1      |
| BARTSCH  | 68 NP 8 7 345          | +KEPPEL, KRAUS, + (AACH+BERL+CERN) JP            |
| CASO     | 68 NC 54 A 983         | +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)       |
| FERBEL   | 68 PHILA.CONF. 335     | T. FERBEL (ROCHESTER)                            |
| IOFFREDO | 68 PRL 21 1212         | +BRANDENBURG, BRENNER, EISENSTEIN+ (HARVARD)     |
| LANSA    | 68 PR 166 1395         | +CASO+BISSCHAG+DERADO+GROVES+ (NOTREDAME)        |
| YOST     | 68 UMD T. REPORT 849   | +YODH, EINSCHLAG, DAY, GLASSER (UMD)             |
| ARMENISE | 69 LNC 2 501           | +GHIDINI, FORINO, CARTACCI+ (BARI+BGNA+FI+RZ)    |
| BARNES   | 69 PRL 23 142          | +CHUNG, EISNER, FLAMINIO, + (BNL)                |
| CASO     | 69 LNC 2 437           | +CONTE, TOMASINI, CANTORE+ (GENOVA+MILA+SACL)    |
| ALSO     | 68 CASO                |                                                  |
| BRANDENB | 70 NP 816 369          | +BRENNER, IOFFREDO, JOHNSON, KIM+ (HARVARD)      |
| CRENNELL | 70 PRL 24 781          | +KARSHON, LAI, SCARR, SIMS (BNL)                 |
| CHIEN1   | 70 TORONTO PREPRINT    | +CHAO, JOHNSTON, PRENTICE, WALKER (TNTD+WISC)    |
| CHIEN2   | 70 PHILAD.CONF. P. 275 | C.Y. CHIEN, REVIEW (JOHNS HOPKINS)               |
| MIYASHIT | 70 PR 0 1 771          | MIYASHITA, VON KROGH, KOPPELMAN, LIBBY (COLO)    |
| BEKETOV  | 71 SUNP 4 765          | +SOMBKOWSKY, KONONALOV, KRUTSCHININ, + (ITEP) JP |
| CLAYTON  | 71 PREPRINT            | +MASON, MUIRHEAD, RIGGPOULOS, + (LIVP+ATEN)      |
| PALER    | 71 PRL 26 1675         | +BADEWITZ, BARTON, MILLER, PALFREY, TEBES (PURD) |
| ALEXANDE | 72 NP 8 45 29          | ALEXANDER, BAR-NIR, BEVARY, DAGAN, + (ITEL)      |
| ARMENISE | 72 LNC 4 201           | +FORINO, CARTACCI, + (BARI+BGNA+FI+RZ)           |
| ASCOLI   | 72 PREP. COD-1195233   | ILL-TNTD+GENO+HAMB+MILA+SACL+HARV+COLLAB. JP     |
| ASCOLI   | 72 PHIL. CONF. PROC.   | INTERNAT. COLLABORATION (ILL+)                   |
| CASO     | 72 NP 8 36 349         | +MADDOCK, BASSLER, LOURH+GENO+DESY+MILA+SACL     |
| HARRISON | 72 PRL 28 775          | +HEYDA, JOHNSON, KIM, LAH, MUELLER, + (HARV)     |
| SALZBERG | 72 NP 8 41 397         | +HARRISON, HEYDA, JOHNSON, KIM, LAH, + (HARV)    |

$\omega(1675)$   
→  $p^0 \pi^0$

45 OMEGA(1675, JPC = -) I=0, FORMERLY PHI(1675).  
NAME CHANGED 1973.

THIS  $3P_1$  BUMP OVERLAPS IN MASS WITH THE  $A_3$ , BUT  
IN SOME EXPTS. ONE CAN ESTABLISH THAT THE  
ENHANCEMENT IS (RHO 0  $P_1$ ) INSTEAD OF (F  $P_1$ ),  
SO THE OMEGA(1675) AND  $A_3$  HAVE DIFFERENT ISOSPIN.  
MATTHEWS 71 SUGGEST  $J^P$  = NORMAL, A POSSIBLE  
RECURRING OF OMEGA(784).

## 45 OMEGA(1675) MASS (MEV)

|   |                                                          |        |                                              |        |                        |      |
|---|----------------------------------------------------------|--------|----------------------------------------------|--------|------------------------|------|
| M | 1636.0                                                   | 20.0   | ARMENISE                                     | 68 DBC | 0 5.1 $P_1 + D$        | 9/68 |
| M | 1670.0                                                   | 20.0   | KENYON                                       | 69 DBC | 8 $P_1 + D, 3P_1 2P$   | 8/69 |
| M | (1640.00)                                                |        | ARMENISE                                     | 70 DBC | 9. $P_1 + D$           | 1/71 |
| M | (1616.0)                                                 | (30.0) | GORDON                                       | 70 DBC | 0 4.2 $P_1 + D$        | 1/71 |
| M | 100 1679.0                                               | 17.0   | MATTHEWS                                     | 71 HBC | 06.95 $P_1 D, 2P 3P_1$ | 1/71 |
| M | G NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT |        |                                              |        |                        |      |
| M | AVG 1663.6                                               | 12.9   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |        |                        |      |

## 45 OMEGA(1675) WIDTH (MEV)

|   |                                                          |        |                                              |        |                        |      |
|---|----------------------------------------------------------|--------|----------------------------------------------|--------|------------------------|------|
| W | 112.0                                                    | 60.0   | ARMENISE                                     | 68 DBC | 0 5.1 $P_1 + D$        | 9/68 |
| W | 100.0                                                    | 40.0   | KENYON                                       | 69 DBC | 8 $P_1 + D, 3P_1 2P$   | 8/69 |
| W | G (188.0)                                                | (47.0) | GORDON                                       | 70 DBC | 0 4.2 $P_1 + D$        | 1/71 |
| W | 100 155.0                                                | 20.0   | MATTHEWS                                     | 71 HBC | 06.95 $P_1 D, 2P 3P_1$ | 1/71 |
| W | G NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT |        |                                              |        |                        |      |
| W | AVG 141.4                                                | 17.1   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                        |      |

## 45 OMEGA(1675) PARTIAL DECAY MODES

|    |                            |                    |
|----|----------------------------|--------------------|
| P1 | OMEGA(1675) INTO 3 $P_1$   | 134+ 134+ 134      |
| P2 | OMEGA(1675) INTO 5 $P_1$   | 134+ 134+ 134+ 134 |
| P3 | OMEGA(1675) INTO RHO $P_1$ | 770+ 134           |

## 45 OMEGA(1675) BRANCHING RATIOS

|    |                                                          |                                         |
|----|----------------------------------------------------------|-----------------------------------------|
| R1 | OMEGA(1675) INTO (5 $P_1$ ) / (3 $P_1$ )                 | (P2) / (P1)                             |
| R1 | 0.10 0.10                                                | KENYON 69 DBC 0 8. $P_1 + D$            |
| R2 | OMEGA(1675) INTO (RHO $P_1$ ) / (3 $P_1$ )               | (P3) / (P1)                             |
| R2 | G (100.75) (40.11)                                       | GORDON 70 DBC 0 4.2 $P_1 + D$           |
| R2 | 100 (10.70) OR MORE                                      | MATTHEWS 71 HBC 0 6.95 $P_1 D, 2P 3P_1$ |
| R2 | G NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT |                                         |

## 45 OMEGA(1675) CROSS SECTIONS

|    |                                       |                        |      |
|----|---------------------------------------|------------------------|------|
| CS | FOR A COMPILATION SEE MATTHEWS 71 HBC | 06.95 $P_1 D, 2P 3P_1$ | 1/71 |
|----|---------------------------------------|------------------------|------|

## REFERENCES FOR OMEGA(1675)

|          |                 |                                                 |
|----------|-----------------|-------------------------------------------------|
| ARMENISE | 68 PL 268 336   | +GHIDINI, FORINO+ (BARI+BGNA+FI+RZ+ORSAY)       |
| KENYON   | 69 PRL 23 146   | +KINSON, SCARR, + (BNL+UCND+ORNL)               |
| ARMENISE | 70 LNC 4 199    | +GHIDINI, FORINO, CARTACCI, + (BARI+BGNA+FI+RZ) |
| GORDON   | 70 COO 1195 179 | THESIS, ILLINOIS (ILL)                          |
| MATTHEWS | 71 PR 0 3 2561  | +PRENTICE, YODH, CARROLL, + (TNTD+WISC)         |
| MATTHEWS | 71 LNC 1 361    | +PRENTICE, YODH, CARROLL, + (TNTD+WISC)         |

## Data Card Listings

For notation, see key at front of Listings.

Mesons  
g(1680)

g(1680)

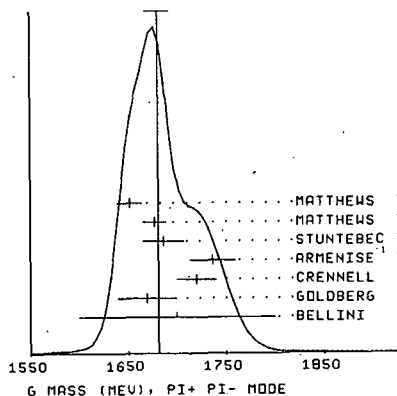
15 G (1680, JPC = 3-+ ) 1-1

This entry contains the  $2\pi$ ,  $4\pi$ ,  $\omega\pi$ ,  $K\bar{K}$  and  $K\bar{K}\pi$  peaks in the region of 1700 MeV. The spin-parity determination and the mass and width in the Meson Table come from the  $2\pi$  decay mode. Analyses of  $2\pi$  using OPE models suggest elasticity considerably less than 1 (BARTSCH 70, MATTHEWS 71). On the other hand, the discrepancies in masses, widths, and branching ratios indicate that there may be more than one  $I^G = 1^+$  meson in this region (see BARNHAM 70, HOLMES 72). For convenience we have collected all the data here under a common entry, without implying that they are necessarily all related. For a review see BARTSCH 70.

## 15 G MASS (MEV)

| PI+ PI- MODE                |        |           |         |                     |       |
|-----------------------------|--------|-----------|---------|---------------------|-------|
| M 1700.0                    | 100.0  | BELLINI   | 65 HLBC | 0 6.1 PI-P          | 6/66  |
| M (1640.0)                  |        | FORINO    | 65 OBC  | 0 4.5 PI+D          | 6/66  |
| M 1670.0                    | 30.0   | GOLDBERG  | 65 HBC  | 0 6 PI+D, 8 PI-P    |       |
| M (1683.)                   | (13.)  | ARMENISE  | 68 OBC  | 0 5.1 PI+D          | 6/68  |
| M 1720.0                    | 20.0   | CRENNELL  | 68 HBC  | 0 6.0 PI-P          | 12/68 |
| M (1655.0)                  | (10.0) | JOHNSTON  | 68 HBC  | 0 7.0 PI-P          | 6/68  |
| M (1750.0)                  |        | CASO      | 69 HBC  | 0 11. PI- P, N2PI   | 8/69  |
| M 1737.0                    | 23.0   | ARMENISE  | 70 OBC  | 0 9 PI+ N           | 1/71  |
| M 1687.                     | 21.    | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M T FROM FIT WITH SINGLE BW |        | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M L (1655.0)                | (4.)   | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M L FROM FIT WITH 2 BW      |        | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M H (1764.)                 | (15.)  | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M H FROM FIT WITH 2 BW      |        | MATTHEWS  | 71 OBC  | 0 7. PI- N          | 2/72  |
| M 1678.                     | 12.    | MATTHEWS  | 71 HBC  | 0 7. PI- P          | 2/72  |
| M 1652.                     | 13.    |           |         |                     |       |
| M AVG                       | 1681.7 |           |         |                     |       |

WEIGHTED AVERAGE = 1681.7 ± 12.0  
ERROR SCALED BY 1.7



| (2PI)+- MODE |        |          |        |                   |       |
|--------------|--------|----------|--------|-------------------|-------|
| M 1640.0     | 25.0   | CRENNELL | 68 HBC | - 6.0 PI- P       | 12/68 |
| M (1600.)    |        | BARISH   | 69 HBC | - 8 PI- P         | 5/70  |
| M 122 1650.0 | 35.0   | BARTSCH  | 70 HBC | + 8 PI+ P, 2 PI   | 5/70  |
| M (1652.0)   | (15.0) | KRAMER   | 70 HBC | + 13.1 PI+ P, 2PI | 11/70 |
| M AVG        | 1643.4 |          |        |                   |       |

| K KBAR + K KBAR PI MODE          |        |          |        |                    |       |
|----------------------------------|--------|----------|--------|--------------------|-------|
| M (1675.)                        |        | ENRICH   | 66 HBC | + 7.9 PI-P, K KBAR | 2/72  |
| M K (1700.)                      |        | FRENCH   | 67 HBC | 0 3.3.6 PBAR P     | 7/67  |
| M K OBSERVED IN NEUTRAL(K* KBAR) |        | FRENCH   | 67 HBC | (KO K+) 3-4 PBAR P | 7/67  |
| M F (1740.)                      |        |          |        |                    |       |
| M F SEE FIG. 9 OF FRENCH 67      |        |          |        |                    |       |
| M 1640.0                         | 20.0   | CRENNELL | 68 HBC | + 6.0 PI-P, KBAR K | 12/68 |
| M 131(1650.0)                    |        | ADERHOLZ | 69 HBC | + 8 PI+ P, K+KO    | 8/69  |
| M 1690.0                         | 16.0   | ADERHOLZ | 69 HBC | + 8 PI+ P, KKBARPI | 8/69  |
| M AVG                            | 1673.2 |          |        |                    |       |

| (4PI)+- MODE              |        |          |        |                     |        |
|---------------------------|--------|----------|--------|---------------------|--------|
| M 1720.                   | 15.    | BALTAY   | 68 HBC | + 7. 8.5 PI+ P      | 6/68   |
| M 1710.                   | 23.    | BISWAS   | 68 HBC | - 8. PI- P          | 2/72   |
| M J (1675.0)              | (10.0) | JOHNSTON | 68 HBC | - 7.0 PI- P         | 6/68   |
| M (1627.)                 | (12.)  | BARNHAM  | 70 HBC | + 10 K+ P, RHO PIPI | 1/73*  |
| M B INCLUDED IN HOLMES 72 |        |          |        |                     |        |
| M 144 1680.0              | 40.0   | BARTSCH  | 70 HBC | + 8 PI+ P, 4 PI     | 4/71   |
| M 90(1640.0)              | (20.0) | BARTSCH  | 70 HBC | + 8 PI+ P, 4 PI     | 4/71   |
| M 102(1689.0)             | (20.0) | BARTSCH  | 70 HBC | + 8 PI+ P, 2 RHO    | 4/71   |
| M 1705.0                  | 21.0   | CASO     | 70 HBC | - 11.2PI-P, RHO 2PI | 5/70   |
| M (1700.)                 |        | BALLAM   | 71 HBC | - 16. PI- P         | 2/72   |
| M 300(1710.0)             |        | ARMENISE | 72 HBC | - 9.1 PI- P, P, 4PI | 12/72* |
| M 1630.                   | 15.    | HOLMES   | 72 HBC | + 10.-12. K+ P      | 1/73*  |
| M AVG                     | 1685.0 |          |        |                     |        |

| (4PI)0 MODE                                           |        |         |        |                     |       |
|-------------------------------------------------------|--------|---------|--------|---------------------|-------|
| M R 80 1717.                                          | 7.     | DANYSZ  | 67 HBC | OSEE NOTE R BELOW   | 5/67  |
| M R SEEN IN 2.5-3 PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- |        | MAURER  | 70 HBC | 05.7 PBAR P, 7 PI   | 2/71  |
| M M (1700.0)                                          |        | MAURER  | 70 HBC | 05.7 PBAR P, 7 PI   | 2/71  |
| M M (1700.0)                                          |        | MAURER  | 70 HBC | 05.7 PBAR P, 7 PI   | 11/71 |
| M M SEEN IN 2 RHO, NOT IN 4 PI OUTSIDE RHO BANDS,     |        |         |        |                     |       |
| M OMEGA PI MODE                                       |        |         |        |                     |       |
| M 1654.                                               | 24.    | BARNHAM | 70 HBC | + 10 K+ P, OMEGA PI | 6/70  |
| M 1630.0                                              | 11.0   | CASO    | 70 HBC | - 11.2PI-P, PI OMEG | 5/70  |
| M AVG                                                 | 1634.2 |         |        |                     |       |

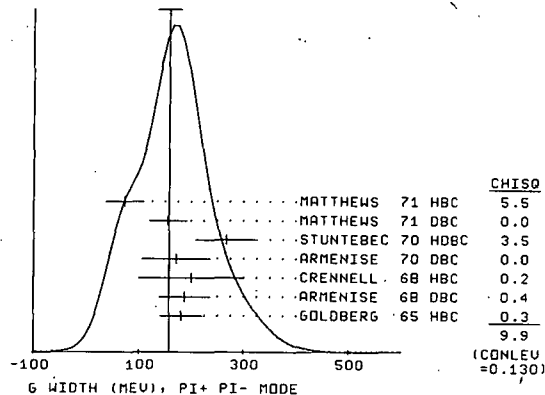
  

| R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW) |        |          |        |                     |        |
|----------------------------------------------------------------------|--------|----------|--------|---------------------|--------|
| M NR1 (1632.)                                                        | (15.)  | FOCACCI  | 66 HMS | - 7-12 PI-P, P, MMS | 12/72* |
| M NR2 (1700.)                                                        | (15.)  | FOCACCI  | 66 HMS | - 7-12 PI-P, P, MMS | 12/72* |
| M NR3 (1748.)                                                        | (15.)  | FOCACCI  | 66 HMS | - 7-12 PI-P, P, MMS | 12/72* |
| M N NOT SEEN BY BOWEN 72                                             |        |          |        |                     |        |
| M R (1700.0)                                                         | (47.0) | ANDERSON | 69 HMS | - 16 PI- P, BACKW   | 8/69   |

## 15 G WIDTH (MEV)

| PI+ PI- MODE                |        |           |         |                     |       |
|-----------------------------|--------|-----------|---------|---------------------|-------|
| M (140.0)                   |        | FORINO    | 65 OBC  | 0 4.5 PI+D          | 6/66  |
| M 180.0                     | 40.0   | GOLDBERG  | 65 HBC  | 0 6 PI+D, 8 PI-P    |       |
| M 188.                      | 49.    | ARMENISE  | 68 OBC  | 0 5.1 PI+D          | 6/68  |
| M 200.0                     | 100.0  | CRENNELL  | 68 HBC  | 0 6.0 PI- P         | 12/68 |
| M (180.0)                   | (20.0) | JOHNSTON  | 68 HBC  | 0 7.0 PI- P         | 6/68  |
| M (200.0)                   |        | CASO      | 69 HBC  | 0 11. PI- P, N2PI   | 8/69  |
| M 171.0                     | 65.0   | ARMENISE  | 70 OBC  | 0 9 PI+ D           | 1/71  |
| M T 267.                    | 72.    | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M T FROM FIT WITH SINGLE BW |        | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M L (120.)                  | (8.)   | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M L FROM FIT WITH 2 BW      |        | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M H (87.)                   | (14.)  | STUNTEBEC | 70 HDBC | 0 8. PI-P, 5.4 PI+D | 2/72  |
| M H FROM FIT WITH 2 BW      |        | MATTHEWS  | 71 OBC  | 0 7. PI- N          | 2/72  |
| M 156.                      | 36.    | MATTHEWS  | 71 HBC  | 0 7. PI- P          | 2/72  |
| M 73.                       | 36.    | MATTHEWS  | 71 HBC  | 0 7. PI- P          | 2/72  |
| M AVG                       | 157.3  |           |         |                     |       |

WEIGHTED AVERAGE = 157.3 ± 22.7  
ERROR SCALED BY 1.3



| (2PI)+- MODE |        |          |        |                   |       |
|--------------|--------|----------|--------|-------------------|-------|
| M 200.0      | 100.0  | CRENNELL | 68 HBC | - 6.0 PI+ P       | 12/68 |
| M (200.)     |        | BARISH   | 69 HBC | - 8 PI+ P         | 5/70  |
| M 122 180.0  | 30.0   | BARTSCH  | 70 HBC | + 8 PI+ P, 2 PI   | 5/70  |
| M (40.0)     | (32.0) | KRAMER   | 70 HBC | + 13.1 PI+ P, 2PI | 11/70 |
| M AVG        | 181.7  |          |        |                   |       |

| K KBAR + K KBAR PI MODE                            |      |          |        |                    |       |
|----------------------------------------------------|------|----------|--------|--------------------|-------|
| M (120.)                                           |      | FRENCH   | 67 HBC | (KO K+) 3-4 PBAR P | 11/69 |
| M F ABOVE VALUE ESTIMATED FROM FIG. 9 OF FRENCH 67 |      |          |        |                    |       |
| M 13 (100.0)                                       | 70.0 | CRENNELL | 68 HBC | + 6.0 PI-P, KBAR K | 12/68 |
| M 112.0                                            | 60.0 | ADERHOLZ | 69 HBC | + 8 PI+ P, K+KO    | 8/69  |
| M 112.0                                            | 60.0 | ADERHOLZ | 69 HBC | + 8 PI+ P, KKBARPI | 8/69  |
| M AVG                                              | 91.7 |          |        |                    |       |

## Mesons

g(1680), X(1690), X<sup>-</sup>(1795)

## Data Card Listings

For notation, see key at front of Listings.

|   |                                                                      |                                                                    |         |                                              |         |              |                     |                   |       |  |       |  |
|---|----------------------------------------------------------------------|--------------------------------------------------------------------|---------|----------------------------------------------|---------|--------------|---------------------|-------------------|-------|--|-------|--|
| W | (4PI)++ MODE                                                         |                                                                    |         |                                              |         |              |                     |                   |       |  |       |  |
| W | 100.                                                                 | 35.                                                                | BALTAY  | 68 HBC                                       | +       | 7. 8.5 PI+ P | 6/68                |                   |       |  |       |  |
| W | 102.                                                                 | 38.                                                                | 40.     | BISWAS                                       | 68 HBC  | -            | 8. PI- P            | 2/72              |       |  |       |  |
| W | J                                                                    | (90.0)                                                             | (20.0)  | JOHNSTON                                     | 68 HBC  | -            | 7.0 PI- P           | 6/68              |       |  |       |  |
| W | NOT SEPARATED FROM 2 PI DECAY                                        |                                                                    |         |                                              |         |              |                     |                   |       |  |       |  |
| W | B                                                                    | (72.)                                                              | (29.)   | 2                                            | BARNHAM | 70 HBC       | +                   | 10 K+ P,RHO PIPI  | 1/73* |  |       |  |
| W | 8                                                                    | INCLUDED IN HOLMES 72)                                             |         |                                              |         |              |                     |                   |       |  |       |  |
| W | 144                                                                  | 135.0                                                              | 30.0    | BARTSCH                                      | 70 HBC  | +            | 8 PI+ P, 4 PI       | 4/71              |       |  |       |  |
| W | 90                                                                   | (180.0)                                                            | (30.0)  | BARTSCH                                      | 70 HBC  | +            | 8 PI+ P, A2 PI      | 4/71              |       |  |       |  |
| W | 102                                                                  | (160.0)                                                            | (30.0)  | BARTSCH                                      | 70 HBC  | +            | 8 PI+ P, 2 RHO      | 5/70              |       |  |       |  |
| W |                                                                      | (160.0)                                                            |         | CASO                                         | 70 HBC  | -            | 11.2PI-P,RHO 2PI    | 5/71              |       |  |       |  |
| W | 300                                                                  | (200.)                                                             |         | ARMENSE                                      | 72 HBC  | -            | 9.1 PI- P, P 4PI    | 12/72*            |       |  |       |  |
| W |                                                                      | 130.                                                               | 30.     | HOLMES                                       | 72 HBC  | +            | 10-12. K+ P         | 1/73*             |       |  |       |  |
| W | AVG                                                                  | 128.4                                                              | 17.0    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |         |              |                     |                   |       |  |       |  |
| W | (4PI)0 MODE                                                          |                                                                    |         |                                              |         |              |                     |                   |       |  |       |  |
| W | R 80                                                                 | (40.)                                                              | (12.)   | DANYSZ                                       | 67 HBC  |              | OSSEE NOTE R BELOW. | 5/67              |       |  |       |  |
| W | R                                                                    | SEEN IN 2.5-3 PBAR P. 2PI+2PI- WITH 0,1,2 PI+PI- PAIRS IN RHO BAND |         |                                              |         |              |                     |                   |       |  |       |  |
| W | OMEGA PI MODE                                                        |                                                                    |         |                                              |         |              |                     |                   |       |  |       |  |
| W |                                                                      | 130.                                                               | 73.     | 43.                                          | BARNHAM | 70 HBC       | +                   | 10 K+ P, OMEGA PI | 6/70  |  |       |  |
| W |                                                                      | (60.0)                                                             |         | CASO                                         | 70 HBC  | -            | 11.2PI-P, PI OMEG   | 5/70              |       |  |       |  |
| W | R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW) |                                                                    |         |                                              |         |              |                     |                   |       |  | 1/73* |  |
| W | NR1                                                                  | (21.)                                                              | OR LESS | FOCACCI                                      | 66 MMS  | -            | 7-12 PI-P, P MMS    | 12/72*            |       |  |       |  |
| W | NR2                                                                  | (30.)                                                              | OR LESS | FOCACCI                                      | 66 MMS  | -            | 7-12 PI-P, P MMS    | 12/72*            |       |  |       |  |
| W | NR3                                                                  | (38.)                                                              | OR LESS | FOCACCI                                      | 66 MMS  | -            | 7-12 PI-P, P MMS    | 12/72*            |       |  |       |  |
| W | H                                                                    | NOT SEEN BY BOWEN 72                                               |         |                                              |         |              |                     |                   |       |  |       |  |
| W | R                                                                    | (195.0)                                                            |         | ANDERSON                                     | 69 MMS  | -            | 16 PI- P, BACKH     | 8/69              |       |  |       |  |

## 15 G PARTIAL DECAY MODES

| DECAY MASSES |                  |  |  |  |  |  |  |  |  |
|--------------|------------------|--|--|--|--|--|--|--|--|
| P1           | G INTO PI PI     |  |  |  |  |  |  |  |  |
| P2           | G INTO 4PI       |  |  |  |  |  |  |  |  |
| P3           | G INTO 2 RHO     |  |  |  |  |  |  |  |  |
| P4           | G INTO PI PI RHO |  |  |  |  |  |  |  |  |
| P5           | G INTO A2 PI     |  |  |  |  |  |  |  |  |
| P6           | G INTO K KBAR    |  |  |  |  |  |  |  |  |
| P7           | G INTO OMEGA PI  |  |  |  |  |  |  |  |  |
| P8           | G INTO K KBAR PI |  |  |  |  |  |  |  |  |
| P9           | G INTO PHI PI    |  |  |  |  |  |  |  |  |

## 15 G BRANCHING RATIOS

| (P1)/(P2) |                                               |        |          |                                              |                   |                  |        |  |  |
|-----------|-----------------------------------------------|--------|----------|----------------------------------------------|-------------------|------------------|--------|--|--|
| R1        | G INTO (2PI1)/TOTAL                           |        |          |                                              |                   |                  |        |  |  |
| R1 P      | (0.4)                                         |        | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R1 P      | (0.22)                                        | (0.04) | MATTHEWS | 71 HBC                                       | 0 7. PI+ N, PI- P | 2/72             |        |  |  |
| R1 P      | OPE MODEL USED IN THIS ESTIMATION             |        |          |                                              |                   |                  |        |  |  |
| R2        | G INTO (PI+ PI0) / (ALL PI+ PI- PI0)          |        |          |                                              |                   |                  |        |  |  |
| R2 D      | (0.08) OR LESS                                |        | BALTAY   | 68 HBC                                       | +                 | 7-8.5 PI+ P      | 6/68   |  |  |
| R2 D      | USING DATA OF DEUTSCHMANN 65 ON PI+ P         |        |          |                                              |                   |                  |        |  |  |
| R2        | 0.8                                           | 0.2    | JOHNSTON | 68 HBC                                       | -                 | 7. PI- P         | 2/72   |  |  |
| R2        | 0.8                                           | 0.15   | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R2        | (0.12) OR LESS                                |        | BALLAM   | 71 HBC                                       | -                 | 16. PI- P        | 2/72   |  |  |
| R2        | (0.2) OR LESS                                 |        | HOLMES   | 72 HBC                                       | +                 | 10-12. K+ P      | 1/73*  |  |  |
| R2        | AVG                                           | 0.80   | 0.12     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                   |                  |        |  |  |
| R3        | G+ INTO (2PI1)/(2RHO)                         |        |          |                                              |                   |                  |        |  |  |
| R3        | (0.48) OR LESS                                |        | BISWAS   | 68 HBC                                       | -                 | 8. PI- P         | 2/72   |  |  |
| R4        | G+ INTO (K KBAR)/(2PI1)                       |        |          |                                              |                   |                  |        |  |  |
| R4        | INDICATION SEEN                               |        | EHRLICH  | 66 HBC                                       | +                 | 7.9 PI- P        | 3/67   |  |  |
| R4        | INDICATION SEEN                               |        | ABRAMS   | 67 HBC                                       | 0 4.25 K- P       | 6/67             |        |  |  |
| R4        | 0.08                                          | 0.08   | CRENNELL | 68 HBC                                       | +                 | 6.0 PI- P        | 12/68  |  |  |
| R4        | 0.08                                          | 0.03   | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 1/71   |  |  |
| R4        | AVG                                           | 0.080  | 0.026    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                   |                  |        |  |  |
| R5        | G+ INTO (K KBAR PI1)/(2PI1)                   |        |          |                                              |                   |                  |        |  |  |
| R5        | 0.10                                          | 0.03   | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R6        | G+ INTO (RHO 2PI1)/(ALL 4PI)                  |        |          |                                              |                   |                  |        |  |  |
| R6        | CONSISTENT WITH 1.                            |        | CASO     | 68 HBC                                       | -                 | 11 PI- P         | 6/68   |  |  |
| R6        | 1.                                            | 0.15   | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R6        | 0.88                                          | 0.15   | BALLAM   | 71 HBC                                       | -                 | 16. PI- P        | 2/72   |  |  |
| R6        | AVG                                           | 0.94   | 0.11     | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                   |                  |        |  |  |
| R7        | G+ INTO (2RHO)/(ALL 4PI)                      |        |          |                                              |                   |                  |        |  |  |
| R7        | SEEN                                          |        | DANYSZ   | 67 HBC                                       | 0 3-4 PBAR P      | 5/68             |        |  |  |
| R7        | (0.63) OR MORE                                |        | BALTAY   | 68 HBC                                       | +                 | 7.8.5 PI+ P      | 6/68   |  |  |
| R7        | SEEN                                          |        | BISWAS   | 68 HBC                                       | -                 | 8. PI- P         | 2/72   |  |  |
| R7        | SEEN                                          |        | JOHNSTON | 68 HBC                                       | -                 | 7 PI- P          | 6/68   |  |  |
| R7        | 0.7                                           | 0.15   | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R7        | (0.92)                                        |        | ARMENSE  | 72 HBC                                       | -                 | 9.1 PI- P, P 4PI | 12/72* |  |  |
| R8        | G+ INTO (2 RHO)/(ALL RHO 2PI)                 |        |          |                                              |                   |                  |        |  |  |
| R8        | 0.48                                          | 0.16   | CASO     | 68 HBC                                       | -                 | 11 PI- P         | 6/68   |  |  |
| R8        | (0.75) OR MORE                                |        | BISWAS   | 68 HBC                                       | -                 | 8. PI- P         | 2/72   |  |  |
| R9        | G+ INTO (PI+ A20)/(ALL 4PI)                   |        |          |                                              |                   |                  |        |  |  |
| R9        | (WITH A20 INTO (PI+ PI- PI0))                 |        |          |                                              |                   |                  |        |  |  |
| R9        | 0.40                                          | 0.20   | BALTAY   | 68 HBC                                       | +                 | 7.8.5 PI+ P      | 6/68   |  |  |
| R9        | NOT SEEN                                      |        | JOHNSTON | 68 HBC                                       | -                 | 7 PI- P          | 6/68   |  |  |
| R9        | (0.6)                                         | (0.15) | BARTSCH  | 70 HBC                                       | +                 | 8. PI+ P         | 2/72   |  |  |
| R10       | G+ INTO (PI OMEGA)/(ALL 4PI)                  |        |          |                                              |                   |                  |        |  |  |
| R10       | (WITH OMEGA INTO (PI+ PI- PI0))               |        |          |                                              |                   |                  |        |  |  |
| R10       | 0.25                                          | 0.10   | BALTAY   | 68 HBC                                       | +                 | 7-8.5 PI+ P      | 5/68   |  |  |
| R10       | 0.25                                          | 0.10   | JOHNSTON | 68 HBC                                       | -                 | 7.0 PI- P        | 6/68   |  |  |
| R10       | 0.12                                          | 0.07   | BALLAM   | 71 HBC                                       | -                 | 16. PI- P        | 2/72   |  |  |
| R10       | AVG                                           | 0.184  | 0.050    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                   |                  |        |  |  |
| R11       | G+ INTO (PI PHI)/(ALL 4PI)                    |        |          |                                              |                   |                  |        |  |  |
| R11       | (0.11) OR LESS                                |        | BALTAY   | 68 HBC                                       | +                 | 7.8.5 PI+ P      | 6/68   |  |  |
| R12       | G+ INTO (PI+ 2PI+ 2PI- PI0)/(ALL PI+ PI- PI0) |        |          |                                              |                   |                  |        |  |  |
| R12       | (0.15) OR LESS                                |        | BALTAY   | 68 HBC                                       | +                 | 7.8.5 PI+ P      | 6/68   |  |  |

| R FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS |         |         |      |         |        |   |                  |      |  |
|-----------------------------------------------------------|---------|---------|------|---------|--------|---|------------------|------|--|
| R13 R1                                                    | (0.37)/ | (0.59)/ | 0.04 | FOCACCI | 66 MMS | - | 7-12 PI-P, P MMS | 2/72 |  |
| R13 R2                                                    | (0.42)/ | (0.56)/ | 0.01 | FOCACCI | 66 MMS | - | 7-12 PI-P, P MMS | 2/72 |  |
| R13 R3                                                    | (0.14)/ | (0.80)/ | 0.05 | FOCACCI | 66 MMS | - | 7-12 PI-P, P MMS | 2/72 |  |

## REFERENCES FOR G

|             |                        |                                                    |
|-------------|------------------------|----------------------------------------------------|
| BELLINI     | 65 NC 40 A 948         | BELLINI, DI CORATO, DUMIO, FIORINI (MILANO)        |
| DEUTSCHMANN | 65 PL 18 351           | M. DEUTSCHMANN ET AL (AACHEN+BERLIN+CEBN)          |
| FORINO      | 65 PL 19 65            | FORINO, GESSAROLI + (BOLOGNA+ORSAY+SACLAY)         |
| GOLDBERG    | 65 PL 17 354           | GOLDBERG + (CERN+EPOL+ORSAY+MILANO+CEBN+SACL)      |
| EHRLICH     | 66 PR 152 1194         | R. EHRLICH, W. SELOVE, H. YUTA (PENNSYLVANIA)      |
| FOCACCI     | 66 PRL 17 890          | CERN MISSING MASS SPECTROMETER GROUP (CERN)        |
| LEVAT       | 66 PL 22 714           | CERN MISSING MASS SPECTROMETER GROUP (CERN)        |
| SEGUNOT     | 66 PL 19 712           | CERN MISSING MASS SPECTROMETER GROUP (CERN)        |
| ABRAMS      | 67 PRL 18 620          | +KEHDE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)        |
| DANYSZ      | 67 PL 248 309          | +FRENCH+KINSON+SIMAK (CERN+LIVERPOOL)              |
| DUBAL       | 67 NP 83 435           | +FOCACCI+KINZLE+LECHANOINE+LEVAT+ (CERN)           |
| ALSO        | 68 THESIS 1456         | L. DUBAL (GENEVE)                                  |
| FRENCH      | 67 NC 52A 442          | +KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)            |
| ARMENSE     | 68 NC 54 A 999         | +FORINO+CARTACCI+(BARI+BGNA+FIENZE+ORSAY+I)        |
| BALTAY      | 68 PRL 20 887          | +KUNG+YEH+FERBEL (COLU+ROCH+RUTG+YALE)I=1          |
| BISWAS      | 68 PRL 21 50           | +CASON, DZIERBA, GROVES, KENNEY + (INDIAN)         |
| BOESEBECK   | 68 NP 8 4 501          | BOESEBECK, DEUTSCHMANN, (AACHEN+BERLIN+CEBN)       |
| CASO        | 68 NC 54 A 983         | +CONE+CORDS+HILZ+ (GENOVA+HAMB+MILA+SACL)          |
| CRENNELL    | 68 PL 28 8 136         | +KARSHON, LAI, SCARR, SKILLICORN (BNL)             |
| JOHNSTON    | 68 PRL 20 1414         | +PRENTICE, STENBERG, YOON (TORONTO+WISC.IIUP)      |
| ADERHOLZ    | 69 NP 8 11 259         | +BARTSCH, (AACH+BERL+CEBN+JAG+WARSI)               |
| ANDERSON    | 69 PRL 22 1390         | +COLLIN, BLIEDEN+ (BNL+CEBN)                       |
| BARISH      | 69 PR 184 1375         | +SELOVE, BISWAS, CASON, + (PENN+NDAM+ROCH)         |
| CASO        | 69 NC 62 A 755         | +CONTE, BENZ, + (GENO+DESY+HAMB+MILA+SACL)         |
| VELITSKY    | 69 SJNP 9 461          | +GUZHAVIN, KLIGER, KOLGANDV, LEBEDEV + (ITEP)      |
| ARMENSE     | 70 LNC 4 199           | +GHIDINI, FORINO, CARTACCI, + (BARI+BGNA+FIENZE)   |
| BARNHAM     | 70 PRL 24 1083         | +COLLEY, JOBS, KENYON, PATHAK, RIDDIFORD (BIRM)    |
| BARTSCH     | 70 NP 8 22 109         | +KRAUS, TSANDOS, GRATE, KOTZAN, (AACH+BERL+CEBN)   |
| CASO        | 70 LNC 3 707           | +CONTE, TOMASINI, CORDS, (GENO+HAMB+MILA+SACL)     |
| KRAEMER     | 70 PRL 25 396          | +BARTON, GUTAY, LICHTMAN, MILLER, + (PURDUE)       |
| MAURER      | 70 THESIS NO. 588      | G. MAURER (STRASBOURG)                             |
| STUNTEBE    | 70 PL 32 8 391         | STUNTEBECK, KENNEY, DEERY, BISWAS, CASON, (INDIAN) |
| BALLAM      | 71 PR D 3 2606         | +CHADWICK, GUIRAGOSSIAN, JOHNSON, + (SLAC)         |
| BRUNN       | 71 NP 8 30 213         | +FRIDMAN, GERBER, GIVERNAUD, KAHN, + (STRB)        |
| GRAY        | 71 PL 35 8 610         | +HYAMS, JONES, SCHLEIN, BLUM, + (CERN+MPII+JP3-)   |
| MATTHEWS    | 71 NP 8 331            | +PRENTICE, YOON, CARROLL, + (ITNT+WISC.IIJP3-)     |
| ARMENSE     | 72 LNC 4 205           | +FORINO, CARTACCI, + (BARI+BGNA+FIENZE)            |
| BOWEN       | 72 PRL 29 890          | +CARLES, FAISSAL, BLIEDEN, + (INEAS+STON)          |
| CLAYTON     | 72 NP 8 47 81          | +KASON, MUIRHEAD, T. REPORT 849, (LIVP+PATR)       |
| GRAY        | 72 PHIL. CONF. PROC. 5 | +HYAMS, JONES, SCHLEIN, BLUM, DIET, + (CERN+MPII)  |
| HOLMES      | 72 PR D 6 3336         | +FERBEL, SLATTERY, WERNER (ROCH)                   |

X(1690)

→ WTTT

64 X(1690)

THIS ENTRY CONTAINS (OMEGA PI PI) PEAKS AROUND 1690 MEV. EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

## 64 X(1690) MASS (MEV)

|   |        |        |        |                                              |                    |       |
|---|--------|--------|--------|----------------------------------------------|--------------------|-------|
| M | 1689.  | 10.    | DANYSZ | 67 HBC                                       | 0 3.3-6 PBAR P     | 1/73* |
| M | 1670.0 | 18.0   | YOST   | 68 HBC                                       | 04.3 K-P, LMBD.SPI | 1/73* |
| M | 1695.0 | 20.0   | BARNES | 69 HBC                                       | 0 4.6 K-P, OMEG2PI | 1/73* |
| M | AVG    | 1686.2 | 8.0    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                    |       |

## 64 X(1690) WIDTH (MEV)

|   |      |      |        |                                              |                    |       |
|---|------|------|--------|----------------------------------------------|--------------------|-------|
| W | 38.  | 18.  | DANYSZ | 67 HBC                                       | 0 3.3-6 PBAR P     | 1/73* |
| W | 50.0 | 15.0 | YOST   | 68 HBC                                       | 04.3 K-P, LMBD.SPI | 1/73* |
| W | 90.  | 20.  | BARNES | 69 HBC                                       | 0 4.6 K-P, OMEG2PI | 1/73* |
| W | AVG  | 56.3 | 14.2   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) |                    |       |

## REFERENCES FOR X(1690)

|        |                      |                                      |
|--------|----------------------|--------------------------------------|
| DANYSZ | 67 NC 51 A 801       | DANYSZ+FRENCH+SIMAK (CERN)           |
| YOST   | 68 UMD T. REPORT 849 | +YODH, EINSCHLAG, DAY, GLASSER (UMD) |
| BARNES | 69 PRL 23 142        | +CHUNG, EISNER, FLAMINIO, + (BNL)    |

X<sup>-</sup>(1795)63 X<sup>-</sup>(1795, J<sub>P</sub>= 1) I=1

SEEN AS A (PBAR N) BOUND STATE IN PBAR D ANNIHILATIONS AT REST. NEEDS FURTHER CONFIRMATION. OMITTED FROM TABLE. BOGDANOVA 72 PREDICT A VECTOR MESON AT THIS ENERGY.

63 X<sup>-</sup>(1795) MASS (MEV)

|   |   |                              |     |      |        |            |      |
|---|---|------------------------------|-----|------|--------|------------|------|
| M | D | 1794.5                       | 1.4 | GRAY | 71 DBC | 0 - PBAR D | 1/72 |
| M | O | DECAYS TO FOUR OR MORE PIONS |     |      |        |            |      |

63 X<sup>-</sup>(1795) WIDTH (MEV)

|   |   |                               |         |         |      |        |            |      |
|---|---|-------------------------------|---------|---------|------|--------|------------|------|
| W | O | (8.)                          | OR LESS | CL= .95 | GRAY | 71 DBC | 0 - PBAR D | 1/72 |
| W | D | DECAYS TO FOUR OR MORE PIONS. |         |         |      |        |            |      |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $X^-(1795)$ ,  $\eta/\rho(1830)$ ,  $\omega/\pi(1830)$ ,  $S(1930)$ ,  
 $\rho(\sim 2100)$ REFERENCES FOR  $X^-(1795)$ GRAY 71 PRL 26 1491  
BOGDANOV 72 PRL 28 1418+HAGERT, KALOGEROPOULOS  
BOGDANOVA, DALKAROV, SHAPIRO(SYRA)  
(ITEP) $\eta/\rho(1830)$   
 $\rightarrow 4\pi, K^+K^-$ 42  $\eta/\rho(1830)$  (JPG= +)THIS ENTRY CONTAINS 4PI AND K KBAR PI PEAKS  
AROUND 1830 MEV, OMITTED FROM TABLE.42  $\eta/\rho(1830)$  MASS (MEV)

|   |     |                |                           |                                              |        |                   |      |
|---|-----|----------------|---------------------------|----------------------------------------------|--------|-------------------|------|
| M | 110 | 1832.          | 6.                        | DANYSZ                                       | 67 HBC | OSEE NOTE R BELOW | 5/67 |
| M | R   | SEEN IN 2.5-3. | PBAR P. 2P1+2P1-          | WITH 0.1, 2 P1+P1- PAIRS                     |        |                   |      |
| M | R   | 1820.          | 12.                       | FRENCH                                       | 67 HBC | OSEE NOTE K BELOW | 7/67 |
| M | K   | SEEN IN 3.-3.6 | PBAR P TO (KS KO P10...). | G PARITY UNKNOWN                             |        |                   |      |
| M | AVG | 1829.6         | 5.4                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                   |      |

42  $\eta/\rho(1830)$  WIDTH (MEV)

|   |     |                |                           |                                              |        |                   |      |
|---|-----|----------------|---------------------------|----------------------------------------------|--------|-------------------|------|
| W | 110 | 42.            | 11.                       | DANYSZ                                       | 67 HBC | OSEE NOTE R BELOW | 5/67 |
| W | R   | SEEN IN 2.5-3. | PBAR P. 2P1+2P1-          | WITH 0.1, 2 P1+P1- PAIRS                     |        |                   |      |
| W | R   | 50.            | 23.                       | FRENCH                                       | 67 HBC | OSEE NOTE K BELOW | 7/67 |
| W | K   | SEEN IN 3.-3.6 | PBAR P TO (KS KO P10...). | G PARITY UNKNOWN                             |        |                   |      |
| W | AVG | 43.5           | 9.9                       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                   |      |

42  $\eta/\rho(1830)$  PARTIAL DECAY MODES

|    |                                  |                    |
|----|----------------------------------|--------------------|
| P1 | $\eta/\rho(1830)$ INTO 4 PI      | 139+ 139+ 139+ 139 |
| P2 | $\eta/\rho(1830)$ INTO RHO PI    | 139+ 139+ 770      |
| P3 | $\eta/\rho(1830)$ INTO RHO RHO   | 770+ 770           |
| P4 | $\eta/\rho(1830)$ INTO K KBAR PI | 134+ 497+ 497      |

REFERENCES FOR  $\eta/\rho(1830)$ 

DANYSZ 67 PL 248 309 +FRENCH+KINSON+SIMAK+ (CERN+LIVERPOOL)  
 FRENCH 67 NC 52A 442 +KINSON+MCDONALD+RIDDI FORD+ (CERN+BIRM)  
 CLAYTON 72 NP 8 47 81 +MASON, MUIRHEAD, RIGOPoulos, (LIVP+PATR)

 $\omega/\pi(1830)$   
 $\rightarrow \omega\pi\pi, K^+K^-$ 43  $\omega/\pi(1830)$  (JPG= -)THIS ENTRY CONTAINS OMEGA PI PI AND K KBAR PI PEAKS  
AROUND 1830 MEV. I=1 IF (OMEGA RHO) MODE EXISTS.  
THE KS KO PI PEAK, IF PRESENT AND EVEN IF NOT PART  
OF  $\eta/\rho(1830)$ , IS ONLY A MINOR MODE.  
OMITTED FROM TABLE.43  $\omega/\pi(1830)$  MASS (MEV)

|   |   |                             |                               |        |        |                 |      |
|---|---|-----------------------------|-------------------------------|--------|--------|-----------------|------|
| M | O | (1848.)                     | (11.)                         | DANYSZ | 67 HBC | O 3, 3.6 PBAR P | 7/67 |
| M | O | OBSERVED IN (OMEGA P1+ P1-) | (AND POSSIBLY (OMEGA RHO(0))) | MODE   |        |                 |      |
| M | K | (1820.)                     | (12.)                         | FRENCH | 67 HBC | O 3, 3.6 PBAR P | 7/67 |
| M | K | OBSERVED IN (KS KO P10...)  | MODE (G-PARITY UNKNOWN)       |        |        |                 |      |

43  $\omega/\pi(1830)$  WIDTH (MEV)

|   |   |                             |                               |        |        |                 |      |
|---|---|-----------------------------|-------------------------------|--------|--------|-----------------|------|
| W | O | (67.)                       | (27.)                         | DANYSZ | 67 HBC | O 3, 3.6 PBAR P | 7/67 |
| W | O | OBSERVED IN (OMEGA P1+ P1-) | (AND POSSIBLY (OMEGA RHO(0))) | MODE   |        |                 |      |
| W | K | (50.)                       | (20.)                         | FRENCH | 67 HBC | O 3-4 PBAR P    | 7/67 |
| W | K | OBSERVED IN (KS KO P10...)  | MODE (G-PARITY UNKNOWN)       |        |        |                 |      |

43  $\omega/\pi(1830)$  PARTIAL DECAY MODES

|    |                                   |                    |
|----|-----------------------------------|--------------------|
| P1 | $\omega/\pi(1830)$ INTO 4 PI      | 139+ 139+ 139+ 139 |
| P2 | $\omega/\pi(1830)$ INTO OMEGA PI  | 139+ 139+ 783.     |
| P3 | $\omega/\pi(1830)$ INTO 2 RHO     | 783+ 770           |
| P4 | $\omega/\pi(1830)$ INTO K KBAR PI | 139+ 497+ 497      |

REFERENCES FOR  $\omega/\pi(1830)$ 

DANYSZ 67 NC 51A 801 DANYSZ+FRENCH+SIMAK (CERN)  
 FRENCH 67 NC 52A 442 +KINSON+MCDONALD+RIDDI FORD+ (CERN+BIRM)  
 CLAYTON 72 NP 8 47 81 +MASON, MUIRHEAD, RIGOPoulos, (LIVP+PATR)

 $S(1930)$   
REGION31  $S(1930)$  (JPG= )THIS ENTRY CONTAINS THE STRUCTURE OBSERVED IN  
PBAR P BACKWARD ELASTIC SCATTERING AND VARIOUS  
PEAKS NEAR 1970 MEV, OMITTED FROM TABLE.  
FOR REVIEW SEE DIEBOLD 72.31  $S$  MASS (MEV)

|   |   |                                                                  |        |           |         |                     |        |
|---|---|------------------------------------------------------------------|--------|-----------|---------|---------------------|--------|
| M | N | (1929.0)                                                         | (14.0) | CHIKOVANI | 66 MMSP | - 12.0 P1-P         | 12/72* |
| M | N | NOT SEEN BY BOWEN 72                                             |        |           |         |                     |        |
| M | A | 1900.                                                            | 40.    | BOESEBECK | 68 HBC  | + 8 P1+ P, P1+ P10  | 6/68   |
| M | A | 1973.0                                                           | 15.0   | CASO      | 70 HBC  | - 11.2P1- P, NOTE C | 5/70   |
| M | A | SEEN IN RHO- P1+ P1- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) |        |           |         |                     | 5/70   |
| M | K | 1975.0                                                           | 12.0   | KRAMER    | 70 HBC  | + 13.1 P1+ P, 2P1   | 11/70  |
| M | K | HAS IG=1+ FROM ABSENCE OF P1+P1+ PEAK. THUS JP=(0DD)-.           |        |           |         |                     | 11/70  |
| M | C | (1940.)                                                          | (8.)   | CLINE     | 70 HBC  | 0 .25-.74 PBAR P    | 2/72   |
| M | C | (1939.)                                                          |        | DANDLAU   | 71 HBC  | 0 .37-.65 PBAR P    | 2/72   |
| M | C | FROM FIT OF A SINGLE BW FORMULA TO THE PBAR P BACKWARD ELASTIC   |        |           |         |                     |        |
| M | C | CROSS SECTION / COS(THETA) IN (-.9, -1.0) /.                     |        |           |         |                     |        |
| M | C | OF AN ADDITIONAL STRUCTURE IN BOTH DATA.                         |        |           |         |                     |        |
| M | C | RESONANT INTERPRETATION QUESTIONED BY LYS 70 AND BIZZARRI 72.    |        |           |         |                     |        |
| M | B | (1968.)                                                          |        | BENVENUTI | 71 HBC  | 0 .1 .8 PBAR P      | 2/72   |
| M | B | SEEN AS A BUMP IN THE PBAR P - KS KL CROSS SECTION WITH JPC=1--- |        |           |         |                     |        |
| M | B | BASED ON ONLY 71 EVENTS OF THIS REACTION.                        |        |           |         |                     |        |
| M | B | NOT SEEN BY CARSON 72 WITH 69 EVENTS.                            |        |           |         |                     | 12/72* |
| M |   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)                         |        |           |         |                     |        |

31  $S$  WIDTH (MEV)

|   |   |                                                                  |               |           |         |                     |        |
|---|---|------------------------------------------------------------------|---------------|-----------|---------|---------------------|--------|
| W | N | (35.0)                                                           | OR LESS       | CHIKOVANI | 66 MMSP | - 12.0 P1-P         | 12/72* |
| W | N | NOT SEEN BY BOWEN 72                                             |               |           |         |                     |        |
| W | A | 216.                                                             | 105.          | BOESEBECK | 68 HBC  | + 8 P1+ P, P1+ P10  | 6/68   |
| W | A | (80.0)                                                           |               | CASO      | 70 HBC  | - 11.2P1- P, NOTE C | 5/70   |
| W | A | SEEN IN RHO- P1+ P1- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) |               |           |         |                     | 5/70   |
| W | K | (52.0)                                                           | OR LESS CL=90 | KRAMER    | 70 HBC  | + 13.1 P1+ P, 2P1   | 11/70  |
| W | K | HAS IG=1+ FROM ABSENCE OF P1+P1+ PEAK. THUS JP=(0DD)-.           |               |           |         |                     | 11/70  |
| W | C | (49.)                                                            | (9.)          | CLINE     | 70 HBC  | 0 .25-.74 PBAR P    | 2/72   |
| W | C | (63.)                                                            |               | DANDLAU   | 71 HBC  | 0 .37-.65 PBAR P    | 2/72   |
| W | B | SEE REMARKS UNDER MASS ABOVE                                     |               | BENVENUTI | 71 HBC  | 0 .1 .8 PBAR P      | 2/72   |
| W | B | (35.)                                                            |               |           |         |                     |        |
| W | B | SEE REMARKS UNDER MASS ABOVE                                     |               |           |         |                     |        |

31  $S$  PARTIAL DECAY MODES

|    |                  |          |
|----|------------------|----------|
| P1 | $S$ INTO P1+ P1- | 139+ 139 |
| P2 | $S$ INTO PBAR P  | 936+ 936 |

REFERENCES FOR  $S$ 

CHIKOVANI 66 PL 22 233 CERN MISSING MASS SPECTROMETER GROUP (CERN)  
 FOCACCI 66 PRL 17 890 CERN MISSING MASS SPECTROMETER GROUP (CERN)  
 BOESEBECK 68 NP 8 4 501 BOESEBECK, DEUTSCHMANN, + (AACHEN+BERLIN+CERN)  
 CLINE 68 PRL 21 1268 +ENGLISH, REEDER, TERRELL, THWITY (WISCONSIN)  
 CASO 70 LNC 3 707 +CORDS, COSTA, + (GENO, DESY, HAMB, MILA, SACL)  
 CLINE 70 PREPRINT D. CLINE, J. ENGLISH, D. D. REEDER (WISC)  
 KRAMER 70 PRL 25 396 +BARTON, GUTAY, LICHTMAN, MILLER, + (PURDUE)  
 LYS 70 PREPRINT J. LYS (MICH)  
 BENVENUTI 71 PRL 27 283 BENVENUTI, CLINE, RUTZ, REEDER, SCHERER (MISC)  
 CLINE 71 REVIEW D. CLINE, TALK AT ANL WORKSHOP JULY 71 (WISC)  
 DANDLAU 71 PREPRINT +ASTIER, PETRI, + (CODEF+PISA)  
 PINSKY 71 PRL 27 1548 STEPHEN S. PINSKY (UTAH+ARGONNE)  
 BIZZARRI 72 PR D 6 160 +GUIDONI, MARZANO, CASTELLI, + (ROMA+TRST)  
 BOWEN 72 PRL 29 890 +EARLES, FAISSLER, BLIEDEN, + (NEAS+STON)  
 BOWEN 72 PREP. NUB 2167 +EARLES, FAISSLER, GARELICK, GETTNER, + (NEAS)  
 CARSON 72 BAT. CONF. PAP. 498 +BUTTON, SHAER, YAMAMOTO, + (MASA+TOKY)  
 DIEBOLD 72 BATAV. CONF. R. DIEBOLD RAPPOREUR TALK (ANL)  
 KIENZLE 72 PHIL. CONF. PROC. 207 W. KIENZLE (CERN)  
 MOHLMUT 72 BAT. CONF. PAP. 275 +YEE, JOHNSON, PETERS, STENGER (HAWAII)

 $\rho(\sim 2100)$   
REGION31  $\rho(2100)$  (JPG= +) I=1NICHOLSON 69 SUGGEST IG=1+, JP=3- FROM ANALYSIS OF  
DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2P1.  
NOT SUPPORTED BY EHRLICH 72.  
OMITTED FROM TABLE.31  $\rho(2100)$  MASS (MEV)

|   |           |      |           |         |                    |       |
|---|-----------|------|-----------|---------|--------------------|-------|
| M | 2086.0    | 38.0 | ANDERSON  | 69 MMS  | - 16 P1- P, BACKW  | 8/69  |
| M | (2120.)   |      | NICHOLSON | 69 CNTR | 0 .7-2.4 P8 P, 2P1 | 9/69  |
| M | 50(2070.) |      | TAKAHASHI | 72 HBC  | 8. P1- P, N 2P1    | 1/73* |

31  $\rho(2100)$  WIDTH (MEV)

|   |   |           |  |           |         |                    |       |
|---|---|-----------|--|-----------|---------|--------------------|-------|
| W | N | (150.0)   |  | ANDERSON  | 69 MMS  | - 16 P1- P, BACKW  | 8/69  |
| W | N | (150.0)   |  | NICHOLSON | 69 CNTR | 0 .7-2.4 P8 P, 2P1 | 9/69  |
| W | N | 50 (160.) |  | TAKAHASHI | 72 HBC  | 8. P1- P, N 2P1    | 1/73* |

REFERENCES FOR  $\rho(2100)$ 

ANDERSON 69 PRL 22 1390 +COLLINS, BLIEDEN+ (BNL+CERN)  
 NICHOLSON 69 PRL 23 603 NICHOLSON, BARISH, DELORME, + (CIT+ROCH+BNL)  
 EHRLICH 72 PRL 28 1147 +ETKIN, GLADIS, HUGHES, KONDO, LU, MORI, + (YALE)  
 TAKAHASHI 72 PR D 6 1266 TAKAHASHI, BARISH, + (TOHO+PENN+NDAM+ANL)

|         |    |                    |                                      |           |
|---------|----|--------------------|--------------------------------------|-----------|
| ASTBURY | 72 | CERN 72 210        | A.ASTBURY REVIEW AT CHEXBRES 22      | (RHEL)    |
| BOWEN   | 72 | PREP-NUB 2 67      | +EARLES,FAITSSLER,GARELICK,GETTNER,+ | (NEAS)    |
| COHEN   | 72 | PHIL.COMF.PROC.    | K.JJ.COHEN                           | (RUTGERS) |
| DIEBOLD | 72 | BATAV.CONF.        | R.DIEBOLD RAPORTEUR TALK             | (ANL)     |
| DONALD  | 72 | BAT.CONF.PAP.265   | INTERNAT.-COLLABORATION              | (LIVP+)   |
| EASTMAN | 72 | NP 8 51 29         | +MING MA,OH,PARKER,SMITH,SPEAKA      | (MSU)     |
| KIEN    | 72 | PHIL.COMF.PROC.207 | +MORSE,GAZLE                         | (CEUS)    |
| MING MA | 72 | NP 8 51 77         | +EASTMAN,DH,PARKER,SMITH,SPEAKA      | (CEUS)    |
| WOLMUT  | 72 | BAT.CONF.PAP.275   | +YEE,JOHNSON,PETERS,STENGER          | (HAWAII)  |

## Data Card Listings

For notation, see key at front of Listings.

 $\bar{N}N_{I=0}(2375)$ 

41 N NBAR (2375, JPC= ) I=0

EVIDENCE FOR RESONANCE PRELIMINARY.  
OMITTED FROM TABLE.

41 N NBAR(2375) MASS

|   |       |                                |        |         |                  |      |
|---|-------|--------------------------------|--------|---------|------------------|------|
| M | 2375. | 10.                            | ABRAMS | 70 CNTR | S CHANNEL NBAR N | 1/71 |
| M | 1     | (2360.)                        | COHEN  | 72 CNTR | S CHANNEL PBAR P | 1/73 |
| M | 1     | ISOSPINS 0 AND 1 NOT SEPARATED |        |         |                  |      |

41 N NBAR(2375) WIDTH

|   |        |                                |        |         |                  |      |
|---|--------|--------------------------------|--------|---------|------------------|------|
| W | (190.) |                                | ABRAMS | 70 CNTR | S CHANNEL NBAR N | 1/71 |
| W | 1      | (163.)                         | COHEN  | 72 CNTR | S CHANNEL PBAR P | 1/73 |
| W | 1      | ISOSPINS 0 AND 1 NOT SEPARATED |        |         |                  |      |

41 N NBAR(2375) SIGMA (MB) FOR FORMATION BN

|    |       |                                |        |         |                  |      |
|----|-------|--------------------------------|--------|---------|------------------|------|
| CS | (2.5) |                                | ABRAMS | 70 CNTR | S CHANNEL NBAR N | 1/71 |
| CS | 1     | (2.0)                          | COHEN  | 72 CNTR | S CHANNEL PBAR P | 1/73 |
| CS | 1     | ISOSPINS 0 AND 1 NOT SEPARATED |        |         |                  |      |

REFERENCES FOR N NBAR (2375)

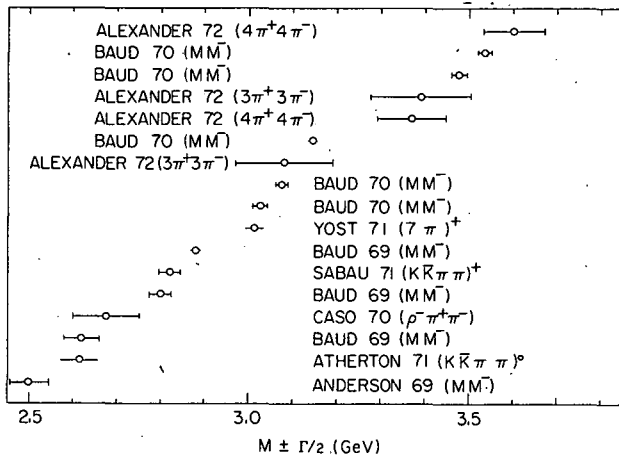
BRICHMAN 69 PL 29 B 451 \*FERRO-LUZZI, BIZARD, (CERN+CAEN+SACL)  
 ABRAMS 70 PR D 1 1917 \*COOL, GIACOMELLI, KYCIA, LEONTIC, LI, (BNL)  
 COHEN 72 PHIL CONF. PROC. K.J. COHEN (RUTGERS)  
 EASTMAN 72 NP B 51 29 \*MING MA, OH, PARKER, SMITH, SPRAFKA (MSU)  
 MING MA 72 NP B 51 29 \*EASTMAN, OH, PARKER, SMITH, SPRAFKA (MSU)

 $X(2500-3600)$ 

46 X(2500-3600)

THIS ENTRY CONTAINS VARIOUS HIGH MASS NON-STRANGE  
PEAKS. OMITTED FROM TABLE.

The high mass region is covered nearly continuously by evidence for peaks of various widths and decay modes (see figure). As a satisfactory grouping into particles is not yet possible, we list all the  $Y = 0$  bumps with  $M > 2400$  MeV together by increasing mass. Note that ANTIPOV 72 ( $\pi^- p \rightarrow pMM^-$  at 25 and 40 GeV/c) see no narrow bumps.



Masses and widths of reported enhancements with  $Y = 0$ ,  $M > 2400$  MeV. (O— indicates that upper limit only was reported for the width.)

Mesons  
 $\bar{N}N_{I=0}(2375)$ ,  $X(2500-3600)$ ,  $K^+$ ,  $K^0$ ,  $K^*(892)$ 

46 X(2500-3600) MASSES AND WIDTHS (MEV)

|   |                                                                  |         |           |        |                     |       |
|---|------------------------------------------------------------------|---------|-----------|--------|---------------------|-------|
| M | 2500.0                                                           | 32.0    | ANDERSON  | 69 MMS | - 16 PI- P, BACKW   | 8/69  |
| W | (87.0)                                                           |         | ANDERSON  | 69 MMS | - 16 PI- P, BACKW   | 8/69  |
| M | 66 2613.                                                         | 7.      | ATHERTON  | 71 HBC | 0 5.7 PBAR P        | 2/73* |
| M | 66 (90.)                                                         | OR LESS | ATHERTON  | 71 HBC | 0 5.7 PBAR P        | 2/73* |
| M | 550 2620.                                                        | 20.     | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| M | 550 85.                                                          | 30.     | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| M | 2676.0                                                           | 27.0    | CASO      | 70 HBC | - 11.2PI- P, NOTE C | 5/70  |
| W | (150.0)                                                          |         | CASO      | 70 HBC | - 11.2PI- P, NOTE C | 5/70  |
| W | SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) |         |           |        |                     | 5/70  |
| M | 640 2800.                                                        | 20.     | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| M | 640 46.                                                          | 10.     | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| M | 15 2820.                                                         | 10.     | SABAU     | 71 HBC | + 8. PI+ P          | 11/71 |
| W | 15 50.                                                           | 10.     | SABAU     | 71 HBC | + 8. PI+ P          | 11/71 |
| W | SEEN IN K KBAR PI PI+ MASS DISTRIBUTION                          |         |           |        |                     | 11/71 |
| M | 230 2880.                                                        | 20.     | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| W | 230 (15.)                                                        | OR LESS | BAUD      | 69 MMS | - 8.-10. PI- P      | 9/69  |
| M | 43 3013.                                                         | 5.      | YOST      | 71 HBC | + 11.PI+ P, P(8P1)+ | 11/71 |
| W | 43 (40.)                                                         | OR LESS | YOST      | 71 HBC | + 11.PI+ P, P(8P1)+ | 5/71  |
| W | 4.3 S.O. EFFECT                                                  |         |           |        | DECAY TO 7 PIONS    | 11/71 |
| M | 3025.0                                                           | 20.0    | BAUD      | 70 MMS | - 10.5-13 PI- P     | 5/70  |
| W | (25.0)                                                           | APPROX. | BAUD      | 70 MMS | - 10.5-13 PI- P     | 5/70  |
| M | 3075.0                                                           | 20.0    | BAUD      | 70 MMS | - 10.5-13 PI- P     | 5/70  |
| W | (25.0)                                                           | APPROX. | BAUD      | 70 MMS | - 10.5-13 PI- P     | 5/70  |
| M | 3080.                                                            | 20.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | 220.                                                             | 70.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | DECAYS TO 3PI+ 3PI-                                              |         |           |        |                     |       |
| M | 3145.0                                                           | 20.0    | BAUD      | 70 MMS | - 10.5-15 PI- P     | 5/70  |
| W | (10.0)                                                           | OR LESS | BAUD      | 70 MMS | - 10.5-15 PI- P     | 5/70  |
| M | 3370.                                                            | 10.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | 150.                                                             | 40.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | DECAYS TO 4PI+ 4PI-                                              |         |           |        |                     |       |
| M | 3390.                                                            | 20.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | 220.                                                             | 100.    | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | DECAYS TO 3PI+ 3PI-                                              |         |           |        |                     |       |
| M | 3475.0                                                           | 20.0    | BAUD      | 70 MMS | - 14-15.5 PI- P     | 5/70  |
| W | (30.0)                                                           | APPROX. | BAUD      | 70 MMS | - 14-15.5 PI- P     | 5/70  |
| M | 3535.0                                                           | 20.0    | BAUD      | 70 MMS | - 14-15.5 PI- P     | 5/70  |
| W | (30.0)                                                           | APPROX. | BAUD      | 70 MMS | - 14-15.5 PI- P     | 5/70  |
| M | 3600.                                                            | 20.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | 190.                                                             | 20.     | ALEXANDER | 72 HBC | 0 6.94 PBAR P       | 1/73* |
| W | DECAYS TO 4PI+ 4PI-                                              |         |           |        |                     |       |

REFERENCES FOR X(2500-3600)

ANDERSON 69 PRL 22 1390 \*COLLINS, (BNL+CERN)  
 BAUD 69 PL 308 129 CERN BOMB SPECTROMETER GROUP (CERN)  
 ALEXANDER 70 PRL 25 63 \*BAR-NIR, DAGAN, GIDAL, GRUNHAUS (TEL-AVIV)  
 BAUD 70 PI 31 B 549 CERN BOMB SPECTROMETER GROUP (CERN)  
 CASO 70 LNC 3 707 \*CONTE, TOMASINI, CORDS (GENO+HAMB+MILA+SACL)  
 ATHERTON 71 CERN PHYS. 71-18 \*CELIKIER, CLAYTON, FRANEK, FRENCH, (CERN)  
 SABAU 71 LNC 1 514 \*URETSKY (BUCH+ANL)  
 YOST 71 PR D 3 642 \*MORRIS, ALBRIGHT, BRUCKER, LANNUTT (FSU)  
 ALEXANDER 72 NP B 45 29 ALEXANDER, BAR-NIR, BEVARY, DAGAN, (TELA)

 $K^+$ 

10 CHARGED K (494, JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

 $K^0$ 

11 NEUTRAL K (498, JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

 $K^*(892)$ 18  $K^*(892, JP=1-)$  I=1/218  $K^*(892)$  MASS (MEV)

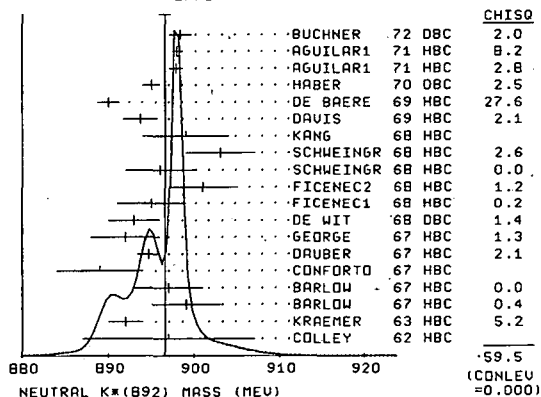
|   |                                                   |     |           |        |                    |       |
|---|---------------------------------------------------|-----|-----------|--------|--------------------|-------|
| M | CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE |     |           |        |                    |       |
| M | 898.0                                             | 5.0 | CHADWICK  | 63 HBC | + 1.5 K+P          |       |
| M | 3870 891.0                                        | 1.0 | MOJICKI   | 64 HBC | - 1.7 K-P          | 6/66  |
| M | 889.5                                             | 2.5 | ADELMAN   | 65 HBC | - 1.5 K-P          |       |
| M | 895.0                                             | 3.0 | GELSEA    | 65 HBC | - 1.5 K-P          |       |
| M | 895.                                              | 67  | BOMB      | 67 HBC | + 2.3 K+P          | 7/67  |
| M | 891.                                              | 2.  | DE BAERE  | 67 HBC | + 3.5 K+P (KO PI+) | 7/67  |
| M | 892.5                                             | 2.5 | DE BAERE  | 67 HBC | + 3.5 K+P (K+ P10) | 7/67  |
| M | 898.                                              | 4.  | SALLSTROM | 67 HBC | + 3. K+ P (KO PI+) | 7/67  |
| M | 883.                                              | 5.  | SALLSTROM | 67 HBC | + 3. K+ P (K+ P10) | 7/67  |
| M | 890.                                              | 67  | BARLOW    | 67 HBC | + 1.2 PBAR P       | 2/72  |
| M | 889.                                              | 3.  | BARLOW    | 67 HBC | + 1.2 PBAR P       | 11/66 |
| M | 896.0                                             | 5.0 | CONFORTO  | 67 HBC | + 0. PBAR P        | 9/67  |
| M | 893.                                              | 4.  | ADERHOLZ  | 68 HBC | - 10 K-P           | 6/68  |
| M | 891.                                              | 4.  | FICENEC1  | 68 HBC | - 1.3 K-P (K-P10)  | 9/67  |
| M | 887.                                              | 3.  | FICENEC1  | 68 HBC | - 1.3 K-P (KOP1-)  | 9/67  |
| M | 890.0                                             | 5.0 | FICENEC2  | 68 HBC | - 2.7 K- P(K-P10)  | 2/69  |
| M | 892.0                                             | 3.0 | FICENEC2  | 68 HBC | - 2.7 K- P(KOP1-)  | 2/69  |
| M | 896.0                                             | 4.0 | SCHWEINGR | 68 HBC | - 4.1 K-P          | 9/67  |
| M | 892.0                                             | 2.0 | SCHWEINGR | 68 HBC | - 5.5 K-P          | 9/67  |
| M | 884.0                                             | 5.0 | KAND      | 68 HBC | - 4.6 K-P          | 7/69  |
| M | 891.0                                             | 2.0 | CRENELL   | 69 HBC | - 3.9 K-N (KOP1-)  | 7/69  |
| M | 892.0                                             | 3.0 | ERWIN     | 69 HBC | + 3.5 K+P          | 9/69  |

## Mesons

 $K^*(892)$ 

|   |                                                                    |                      |       |                                              |          |                   |                     |        |
|---|--------------------------------------------------------------------|----------------------|-------|----------------------------------------------|----------|-------------------|---------------------|--------|
| M | 2886                                                               | (894.1)              | (1.1) | FRIEDMAN                                     | 69 HBC   | - 2.1 K-P (3BDY)  | 2/72                |        |
| M | 728                                                                | (892.1)              | (2.1) | FRIEDMAN                                     | 69 HBC   | - 2.45 K-P (3BDY) | 2/72                |        |
| M | 3229                                                               | (892.1)              | (1.1) | FRIEDMAN                                     | 69 HBC   | - 2.6 K-P (3BDY)  | 2/72                |        |
| M | 1027                                                               | (892.1)              | (1.1) | FRIEDMAN                                     | 69 HBC   | - 2.7 K-P (3BDY)  | 2/72                |        |
| M | 895.                                                               | 2.                   | 2.    | LIND                                         | 69 HBC   | + 9. K-P          | 9/69                |        |
| M | 4404                                                               | 892.2                | 1.5   | AGUILARI                                     | 71 HBC   | - 3.9, 4.6 K-P    | 11/71               |        |
| M | AVG                                                                | 891.71               | 0.50  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |          |                   |                     |        |
| M | NEUTRAL ONLY. BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE |                      |       |                                              |          |                   |                     |        |
| M | 70                                                                 | 897.0                | 10.0  | COLLEY                                       | 62 HBC   | 0 2.0 P1-P        |                     |        |
| M | 200                                                                | 892.0                | 2.0   | KRAEMER                                      | 63 HBC   | 0 2.3 K+P         |                     |        |
| M | 150                                                                | (885.0)              |       | SMITH                                        | 63 HBC   | 0 2.3 P1-P        |                     |        |
| M | 899.                                                               | 4.                   |       | BARLOW                                       | 67 HBC   | 0 1.2 PBAR P      | 11/66               |        |
| M | 897.                                                               | 4.                   |       | BARLOW                                       | 67 HBC   | 0 1.2 PBAR P      | 11/66               |        |
| M | 889.0                                                              | 5.0                  |       | CONFORTO                                     | 67 HBC   | 0 0. PBAR P       | 9/67                |        |
| M | 894.7                                                              | 1.3                  |       | DAUBER                                       | 67 HBC   | 0 2.0 K-P         | 12/66               |        |
| M | 892.0                                                              | 4.0                  |       | GEORGE                                       | 67 HBC   | 0 5.0 K+P         | 11/67               |        |
| M | 893.                                                               | 3.                   |       | DE WIT                                       | 68 HBC   | 0 3. K-P          | 9/69                |        |
| M | F                                                                  | 895.                 | 4.    | FICENEC1                                     | 68 HBC   | 0 1.3 K-P (K-P1+) | 11/69               |        |
| M | F                                                                  | 901.                 | 4.    | FICENEC2                                     | 68 HBC   | 0 2.7 K-P (K-P1+) | 11/69               |        |
| M | SEE TYPED NOTE                                                     |                      |       |                                              |          |                   |                     |        |
| M | F                                                                  | FICENEC ERROR RAISED |       | SCHWEINGR                                    | 68 HBC   | 0 4.1 K-P         | 9/67                |        |
| M | 896.0                                                              | 4.0                  |       | SCHWEINGR                                    | 68 HBC   | 0 5.5 K-P         | 9/67                |        |
| M | 903.0                                                              | 4.0                  |       | KANG                                         | 68 HBC   | 0 4.6 K-P         | 7/69                |        |
| M | 899.0                                                              | 5.0                  |       | DAVIS                                        | 69 HBC   | 0 12. K-P         | 9/69                |        |
| M | 10700                                                              | 893.7                | 2.0   | DE BAERE                                     | 69 HBC   | 0 5.0 K+P         | 9/69                |        |
| M | D                                                                  | 2000                 | 890.0 | 1.25                                         | DE BAERE | 69 HBC            | 0 5.0 K+P           | 9/69   |
| M | ERRORS ENLARGED BY US TO GAMMA/SORT(N). SEE TYPED NOTE.            |                      |       |                                              |          |                   |                     |        |
| M | 4000                                                               | 895.0                | 1.0   | HABER                                        | 70 HBC   | 0 3. K-N          | 5/70                |        |
| M | 2934                                                               | 897.9                | 0.8   | AGUILARI                                     | 71 HBC   | 0 3.9, 4.6 K-P    | 11/71               |        |
| M | 5362                                                               | 898.0                | 0.5   | AGUILARI                                     | 71 HBC   | 0 3.9, 4.6 K-P    | 11/71               |        |
| M | D                                                                  | 1700                 | 898.4 | 1.3                                          | BUCHNER  | 72 HBC            | 0 4.6 K+ N, K+ P1-P | 12/72* |
| M | AVG                                                                | 896.57               | 0.65  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0) |          |                   |                     |        |
| M | (SEE IDEOGRAM BELOW.)                                              |                      |       |                                              |          |                   |                     |        |

WEIGHTED AVERAGE = 896.57 ± 0.65  
ERROR SCALED BY 2.0

Note on  $K^*(892)$  Masses and Mass Difference

1) All mass values listed above come from physical region fits of Breit-Wigner functions. However, a recent  $K\pi$  phase shift analysis (BINGHAM 72) indicates that part of the  $K^*(892)$  peak may be due to a large S wave (see note "S-wave  $K\pi$  interactions"). Because the S-wave phase shift is ambiguous ("up" and "down") in the  $K^*(892)$  region, BINGHAM 72 find two solutions for the P wave:

"up" solution  $m \approx 900$  MeV,  $\Gamma \approx 48$  MeV

"down" solution  $m \approx 895$  MeV,  $\Gamma > 48$  MeV.

2) Impossibly small errors are reported by some experiments. We use simple "realistic" tests for the minimum errors on the determination of mass and width from a sample of N events:

$$\delta_{\min}(m) = \frac{\Gamma}{\sqrt{N}}, \quad \delta_{\min}(\Gamma) = 4 \frac{\Gamma}{\sqrt{N}}$$

## Data Card Listings

For notation, see key at front of Listings.

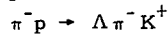
(For detailed discussion see the April 1971 edition of this note.) We have increased some unrealistic errors and scaled up some errors that are inconsistent.

3) There are two more difficulties in measuring a mass difference  $m(K^{*0}) - m(K^{*+})$  of  $\sim 7$  MeV when the half-width  $\Gamma/2$  of the  $K^*$  is 25 MeV:

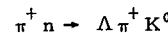
a) The two charges of  $K^*$  have different topologies; this introduces differences in the measuring and fitting of the events, which can also produce mass shifts.

b) Interferences between the resonant amplitude and background can in general shift the peak in the mass spectrum by some fraction of  $\Gamma/2$ .

Some reactions (symmetric under reflection of  $I_z$ ) are immune to this difficulty. Thus compare the mass of  $K^{*0}$  produced in



with the mass of  $K^{*+}$  in the  $I_z$ -reflected reaction



The final-state amplitudes of each will contain not only the  $|K^*\rangle$  with I-spin 1/2, but also an interfering  $I = 3/2$  P-wave, which we can call  $|K^*_{3/2}\rangle$ . But  $I_z$  symmetry forces  $\langle \pi^- p | \Lambda K^{*0} \rangle$  to equal  $\langle \pi^+ n | \Lambda K^{*+} \rangle$ ; and similarly for the two  $K^*_{3/2}$  amplitudes, so that the shifting of the  $K^*$  peak is the same in both reactions. Nobody has published a mass difference exploiting this fact.

| 18 $K^*(0) - K^*(+)$ MASS DIFF. (MEV) |      |     |     |                                              |        |                 |  |       |  |
|---------------------------------------|------|-----|-----|----------------------------------------------|--------|-----------------|--|-------|--|
| D                                     | 330  | 6.3 | 6.0 | BARASH                                       | 67 HBC | 0 PBAR P        |  | 8/67  |  |
| D                                     | 1400 | 6.5 | 5.0 | FICENEC1                                     | 68 HBC | 1.3 K-P         |  | 2/69  |  |
| D                                     | 1600 | 9.5 | 5.0 | FICENEC2                                     | 68 HBC | 2.7 K-P         |  | 2/69  |  |
| D                                     | 7338 | 5.7 | 1.7 | AGUILARI                                     | 71 HBC | -0 3.9, 4.6 K-P |  | 11/71 |  |
| D                                     | AVG  | 6.1 | 1.5 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                 |  |       |  |

| 18 $K^*(892)$ WIDTH (MEV)                           |        |       |       |                                              |        |                    |  |       |  |
|-----------------------------------------------------|--------|-------|-------|----------------------------------------------|--------|--------------------|--|-------|--|
| W CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE |        |       |       |                                              |        |                    |  |       |  |
| W                                                   | 46.0   | 8.0   |       | CHADWICK                                     | 63 HBC | + 1.5 K-P          |  |       |  |
| W                                                   | 3870   | 46.0  | 3.0   | MOJICKI                                      | 64 HBC | - 1.7 K-P          |  |       |  |
| W                                                   | 51.0   | 3.0   |       | ADELMAN                                      | 65 HBC | - 1.5 K-P          |  | 6/66  |  |
| W                                                   | 47.0   | 4.0   |       | FERRER-LUZ                                   | 65 HBC | + 3.0 K-P          |  |       |  |
| W                                                   | 50.0   | 15.0  |       | GELSEMA                                      | 65 HBC | - 1.5 K-P          |  |       |  |
| W                                                   | 50.0   | 5.    |       | BOMSE                                        | 67 HBC | + 2.3 K+P          |  | 7/67  |  |
| W                                                   | 53.    | 8.    |       | DE BAERE                                     | 67 HBC | + 3.5 K+P (K+ P10) |  | 7/67  |  |
| W                                                   | 68.    | 10.   |       | SALLSTROM                                    | 67 HBC | + 3. K+P (K+ P10)  |  | 7/67  |  |
| W                                                   | 47.    | 10.   |       | SALLSTROM                                    | 67 HBC | + 3. K+P (K+ P10)  |  | 7/67  |  |
| W                                                   | 44.    | 7.    |       | BARLOW                                       | 67 HBC | + 1.2 PBAR P       |  | 11/66 |  |
| W                                                   | 43.    | 9.    |       | BARLOW                                       | 67 HBC | + 1.2 PBAR P       |  | 11/66 |  |
| W                                                   | 53.    | 7.    |       | BARLOW                                       | 67 HBC | + 1.2 PBAR P       |  | 11/66 |  |
| W                                                   | 76.    | 7.    |       | ADERHOLZ                                     | 68 HBC | - 10 K-P           |  | 6/68  |  |
| W                                                   | 58.    | 16.   |       | FICENEC1                                     | 68 HBC | - 1.3 K-P (K-P10)  |  | 9/67  |  |
| W                                                   | 44.    | 13.   |       | FICENEC1                                     | 68 HBC | - 1.3 K-P (KOP1-)  |  | 9/67  |  |
| W                                                   | 41.0   | 8.0   |       | SCHWEINGR                                    | 68 HBC | + 4.1 K-P          |  | 9/67  |  |
| W                                                   | 47.0   | 4.0   |       | SCHWEINGR                                    | 68 HBC | - 5.5 K-P          |  | 9/67  |  |
| W                                                   | 57.0   | 13.0  |       | FICENEC2                                     | 68 HBC | - 2.7 K-P (K-P10)  |  | 2/69  |  |
| W                                                   | 48.0   | 9.0   |       | FICENEC2                                     | 68 HBC | - 2.7 K-P (KOP1-)  |  | 2/69  |  |
| W                                                   | 52.0   | 8.0   |       | KANG                                         | 68 HBC | - 4.6 K-P          |  | 7/69  |  |
| W                                                   | (27.0) | (8.0) | (6.0) | ERWIN                                        | 69 HBC | + 3.5 K+P          |  | 9/69  |  |
| W                                                   | (53.1) | (3.1) |       | FRIEDMAN                                     | 69 HBC | - 2.1 K-P (3BDY)   |  | 2/72  |  |
| W                                                   | (49.1) | (6.1) |       | FRIEDMAN                                     | 69 HBC | - 2.45 K-P (3BDY)  |  | 2/72  |  |
| W                                                   | (46.1) | (2.1) |       | FRIEDMAN                                     | 69 HBC | - 2.6 K-P (3BDY)   |  | 2/72  |  |
| W                                                   | (49.1) | (3.1) |       | FRIEDMAN                                     | 69 HBC | - 2.7 K-P (3BDY)   |  | 2/72  |  |
| W                                                   | 50.    | 7.    |       | LIND                                         | 69 HBC | + 9. K+P           |  | 5/70  |  |
| W                                                   | 4404   | 54.3  | 2.6   | AGUILARI                                     | 71 HBC | - 3.9, 4.6 K-P     |  | 11/71 |  |
| W                                                   | AVG    | 50.1  | 1.1   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                    |  |       |  |

## Data Card Listings

For notation, see key at front of Listings.

Mesons  
 $K^*(892)$ ,  $\kappa$ 

|                                              |        |                                                           |      |
|----------------------------------------------|--------|-----------------------------------------------------------|------|
| W NEUTRAL ONLY.                              |        |                                                           |      |
| W                                            | 70     | 60.0                                                      | 10.0 |
| W                                            | 200    | 50.0                                                      | 5.0  |
| W                                            | 53.    | 13.                                                       |      |
| W                                            | 34.    | 8.                                                        |      |
| W                                            | 44.    | 4.                                                        |      |
| W                                            | 58.    | 8.                                                        |      |
| W                                            | 52.    | 12.                                                       |      |
| W                                            | 50.0   | 8.0                                                       |      |
| W                                            | 48.0   | 8.0                                                       |      |
| W                                            | 51.0   | 11.0                                                      |      |
| W                                            | 53.0   | 11.0                                                      |      |
| W                                            | 10700  | 53.2                                                      | 1.6  |
| W                                            | D 2000 | 58.0                                                      | 5.0  |
| W                                            | D      | ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE. |      |
| W                                            | 4000   | 54.0                                                      | 3.0  |
| W                                            | 2934   | 55.8                                                      | 4.2  |
| W                                            | 5362   | 48.5                                                      | 2.2  |
| W                                            | D 1700 | 51.4                                                      | 5.0  |
| W                                            | AVG    | 51.7                                                      | 1.0  |
| AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |        |                                                           |      |

18  $K^*(892)$  PARTIAL DECAY MODES

|    |                                         |               |
|----|-----------------------------------------|---------------|
| P1 | $K^*(892)$ INTO $K$ $\pi$ $\pi$         | DECAY MASSES  |
| P2 | $K^*(892)$ INTO $K$ $\pi$ $\pi$ $\pi$   | 493+ 139      |
| P3 | $K^*(892)$ INTO $K^+$ $\gamma$ $\gamma$ | 493+ 139+ 139 |
|    |                                         | 493+ 0        |

18  $K^*(892)$  BRANCHING RATIOS

|    |                                                      |                                           |
|----|------------------------------------------------------|-------------------------------------------|
| R1 | $K^*(892)$ INTO $(K \pi \pi) / (K \pi \pi)$          | (P2)/(P1)                                 |
| R1 | 0 (0.002) OR LESS                                    | WOJCICKI 2 64 HBC - 1.7 K-P               |
| R2 | $K^*(892)$ INTO $(K^+ \gamma \gamma) / \text{TOTAL}$ | (UNITS 10 <sup>-3</sup> -3) (P3)          |
| R2 | (1.6) OR LESS CL=95                                  | BEMPORAD 72 CNTR + 10.-16. K+ A.COM 1/73* |

REFERENCES FOR  $K^*(892)$ 

|                             |                                                  |
|-----------------------------|--------------------------------------------------|
| ALSTON 61 PRL 6 300         | ALSTON, ALVAREZ, EBERHARD, GOOD, GRAZIANO+ (LRL) |
| ALEXANDER 62 PRL 8 447      | ALEXANDER, KALBFELDSCH, MILLER, G. SMITH (LRL)   |
| COLLEY 62 CERN CONF 315     | D. COLLEY, N. GELFAND + (COLUMBIA+RUTGERS)       |
| CHADWICK 63 PL 6 309        | CHADWICK, CRENNELL, DAVIES, BETTINI+ (OXF+PADO)  |
| GOLDHABER 63 ATHENS CONF 92 | SULAMITH GOLDHABER (LRL)                         |
| KRAEMER 63 ATHENS CONF 130  | R. KRAEMER, L. MADANSKY + (JOHNS HOPKINS)        |
| SMITH 63 PRL 10 138         | SMITH, SCHWARTZ, MILLER, KALBFELDSCH, HUF+ (LRL) |
| WOJCICKI 64 PR 135 8 484    | STANLEY G. WOJCICKI (LRL)                        |
| ADELMAN 65 ATHENS 527       | STUART LEE ADELMAN (CAVENDISH)                   |
| FERRO-LU 65 NC 36 1101      | FERRO-LUZZI, GEORGE, HENRI, JONGE JANS (CERN)    |
| FERRO-LU 65 NC 39 417       | FERRO-LUZZI, GEORGE, GOLDSCHMIDT-CLER+ (CERN)    |
| GELSEMA 65 THESIS           | E. S. GELSEMA (SEE ALSO PL 10 341) (AMSTERDAM)   |
| WANGLER 65 PR 137 8 414     | WANGLER, ERWIN, WALKER (MISCONSIN)               |
| BARASH 67 PR 156 1399       | BARASH, KIRSCH, MILLER, TAN (COLUMBIA)           |
| ALEXANDER 67 NC 50 A 701    | *MONTANET, D'ANDOLAU+ (CERN+CDEF+TRAD+LIVP)      |
| BOMSE 67 PR 158 1298        | *BORENSTEIN+COLE+GILLESPIE+ (JOHN HOPKINS)       |
| CONFORTO 67 NP 83 469       | *HARECHAL, MONTANET+CERN+CDEF+IPN+LIVERPOOL      |
| DAUBER 67 PR 153 1403       | *SCHLEIN, SLATER, TICHQ (UCLA)                   |
| DE BAERE 67 NC 51 A 401     | *GOLDSCHMIDT-CLERMONT, HENRI+ (BRUX+CERN)        |
| FRENCH 67 NC 424 442        | *KINSON+MCDONALD+RIDOLFORD+ (CERN+BRUX)          |
| GEORGE 67 NC 49A 9          | *GOLDSCHMIDT-CLERMONT+HENRI+ (CERN+BRUX)         |
| SALLSTROD 67 NC 49A 348     | SALLSTROD+OTTER+EKSPONG (STOCKHOLM)              |
| ADERHOLZ 68 NP 8 5 567      | *DEUTSCHMANN+ (AACH+BERL+CERN+LOIC+VIENNA)       |
| DE WIT 68 THESIS            | S. DE WIT (AMSTERDAM)                            |
| FICENECI 68 PR 169 1034     | *HULSIZER+SWANSON+TROWER (ILL)                   |
| FICENEC2 68 PR 175 1725     | KANG, GORDON, TROWER (ILLINOIS)                  |
| KANG 68 PR 176 1587         | Y. W. KANG (IOWA)                                |
| SCHWEING 68 PR 166 1317     | SCHWEINGRUBER, DERRICK, FIELDS+ (ANL+NMES)       |
| CRENNELL 69 PRL 22 487      | *KARSHON, LAI, ONEALL, SCARR (BNL)               |
| DAVIS 69 PRL 23 1071        | *DERENZO, FLATTE, ALSTON, LYNCH, SOLMITZ (LRL)   |
| DE BAERE 69 NC 61 A 397     | *GOLDSCHMIDT-CLERMONT, HENRI+ (BELG+CERN)        |
| ERWIN 69 NP 8 9 364         | *WALKER, GOSHAW, WEINBERG (MISC+PRIN+VAND)       |
| FRIEDMAN 69 UCRL-18860      | J. FRIEDMAN, PH. D. THESIS (LRL)                 |
| JUNALA 69 PR 184 1461       | *LEACOCK, RHODE, KOPELMAN, LIBBY+ (ISU+COLD)     |
| LIND 69 NP 14 1             | *ALEXANDER, FIRESTONE, FU, GOLDHABER (LRL) JP    |
| ATHERTON 70 NP 8 16 416     | *FRANEK, FRENCH, FRISK, BEDNAR+ (CERN+PRAG)      |
| DE BAERE 70 CERN PHYS 70 41 | *DEBAISIEUX, DE WOLF, DUFOUR+ (BELG+CERN)        |
| HABER 70 NP 8 17 289        | *SHAPIRA, ALEXANDER+ (REMO+SACL+BGNA+EPOL)       |
| AGUILAR 71 PRL 26 466       | *BARNES, BASSAND, EISNER, KINSON, SAMIOS (BNL)   |
| AGUILAR 71 PR D 4 2583      | *EISNER, KINSON (BNL)                            |
| BARNHAM 71 NP 8 28 171      | *COLLEY, JOHNS, GRIFFITHS, HUGHES, + (BIRM+GLAS) |
| BUCHNER 71 NP 8 29 381      | *DEHN, GEBEL, GOLDSCHMIDT, + (MPIH+CERN+BELG)    |
| CORDS 71 PR D 4 1974        | *ARMSTRONG, ERWIN, REIERE, + (PURDUE+JUP)        |
| MERCER 71 NP 832 381        | *ANTICH, CALLAHAN, CHEN, COX, + (JOHN HOPKINS)   |
| YUTA 71 PRL 26 1502         | *DERRICK, ENGELMANN, MUSGRAVE (ANL+EFFI)         |
| ABRAMOVICH 72 NP 8 39 189   | ABRAMOVICH, CHALOUKIA, CHUNG, HILPERT, + (CERN)  |
| BINGHAM 72 NP 8 41 1        | * (INTERNATIONAL K+ COLLABORATION)               |
| BEMPORAD 72 NP 8 51 1       | *BEUSCH, FREUDENREICH, + (CERN+ETHZ+LOIC)        |
| BRUNET 72 NP 8 37 114       | *DANYSZ, GOLDSACK, + (CDEF+SACL+LOIC+LOWC)       |
| BUCHNER 72 NP 8 45 333      | *DEHN, CHARRIERE, CORNET, + (MPIH+CERN+BRUX)     |
| CHARRIER 72 NP 8 51 317     | *CHARRIER, DUTJARD, DE BAERE, + (CERN+BRUX)      |
| CRENNELL 72 PR D 6 1220     | *GORDON, KWAN-WU LAI, SCARR (BNL)                |
| DEUTSCHMANN 72 NP 8 36 373  | *DEUTSCHMANN, + (ABCLV COLLABORATION)            |
| ENGELMANN 72 PR D 5 2162    | ENGELMANN, MUSGRAVE, FORMAN, + (ANL+EFFI)        |
| ROUGE 72 NP 8 46 29         | *VIDEAU, VOLTE, DE BRION, + (EPOL+SACL)          |
| TIECKE 72 NP 8 39 596       | *GRINS, HEINEN, DE GROOT, + (NIJW+ZEEM)          |

K

19  $K$   $\pi$   $\pi$  S WAVE, CALLED KAPPA(750-1700 MEV)S-wave  $K\pi$  Interactions in the Region 750-1700 MeV

$K\pi$  interactions in the  $I(J^P) = 1/2(0^+)$  wave can be described by the elastic phase shift  $\delta_0^1$  from the  $K\pi$  threshold ( $\sim 630$  MeV) up to at least 1100 MeV (BINGHAM 72). The first inelastic S-wave thresholds are  $K\pi\pi\pi$  and  $K\eta$ , neither of which is known to be important below 1400 MeV. Apart from the inelastic thresholds, the S-wave  $\pi\pi$  and  $K\pi$  interactions are reminiscent of each other. Thus, the remarks in the  $\pi\pi$  section about the meaningfulness of resonance parameters apply.

There are two intrinsic ambiguities in the solutions plotted below:

- Any phase shift can be shifted modulo  $180^\circ$ .
- If one amplitude is dominant [e.g., the P wave near  $K^*(892)$  or the D wave near  $K^*(1420)$ ], then the observed S-P or S-D interference can be explained by two ambiguous S-wave solutions, known as "up" and "down". Readers unfamiliar with the origin of the ambiguity can find a graphical explanation in our 1972 edition.

The combination of these two sorts of ambiguities leads to the multiple paths plotted in the figure. Simplicity favors the most slowly varying ("down") solutions, but where the authors give both, we plot both.

The figure displays the  $\delta_0^1$  solutions of four experimental groups:

- BINGHAM 72 (an international  $K^+$  collaboration), using data on  $K^+p \rightarrow K\pi\Delta^{++}$  up to 12.7 GeV/c, find two solutions for  $\delta_0^1$ , neither of which is a priori preferred:
  - "up", a resonant  $\kappa$  with  $m \sim 890$  MeV,  $\Gamma \leq 30$  MeV (this requires  $\delta_0^1$  to be resonant near 900 MeV with  $\sim 48$  MeV width). Note, however, the evidence of CHUNG 72 against a narrow-width S-wave state in the  $K^*(892)$  region; in addition, the more recent partial-wave analysis of MATISON 72 (see 5, below) seems to rule out the "up" solution.
  - "down", a slowly rising  $\delta_0^1$  reaching  $\sim 70^\circ$  at about 1100 MeV (requiring  $\delta_0^1$  to be resonant at about 895 MeV). Note that the up-down ambiguity is limited to the region 850-920 MeV. Above

## Mesons

 $\kappa$ ,  $K_{A1=3/2}(1175)$ 

920 MeV the "up" solution joins the "down" solution, since all phase shift values are determined only modulo  $180^\circ$ .

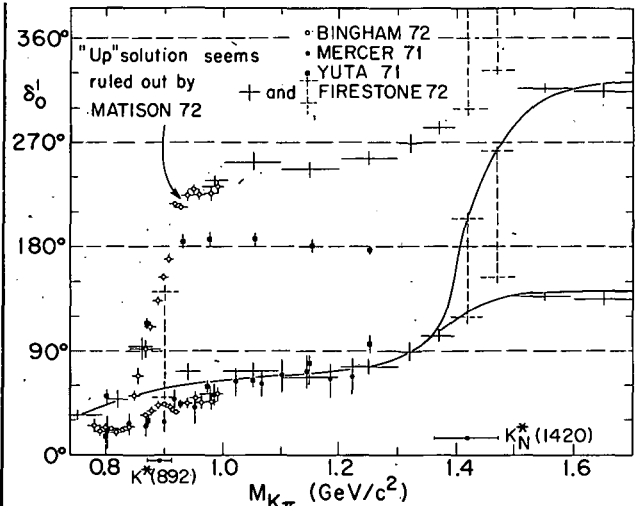
- 2) MERCER 71, using the first half of the data of BINGHAM 72, give phase shifts up to 1230 MeV, ignoring possible inelasticity.
- 3) YUTA 71, using 5.5 GeV/c  $K^+p \rightarrow K\pi N$ , agree with the solutions of BINGHAM 72, their "down" solution agreeing also with MERCER 71, ignoring possible inelasticity up to 1250 MeV.
- 4) FIRESTONE 71 and 72, using 12 GeV/c  $K^+n \rightarrow K^+\pi^-p$ , have continued  $K\pi$  partial wave analysis up to 1700 MeV. They find that  $\delta_0^1$  crosses  $90^\circ$  just below the  $K^*(1420, 2^+)$ , and, indeed, near 1420 MeV, shows the "up-down" ambiguity mentioned above. Their unique solutions are plotted as solid crosses, their ambiguous ones as pairs of dashed crosses joined by dashed vertical lines.
- 5) MATISON 72 has performed a recent analysis of 12 GeV/c  $K^+p \rightarrow K^+\pi^-\Delta^{++}$  (the same reaction as studied by the International  $K^+$  Collaboration, and with comparable statistics, but all at 12 GeV/c). Matison's analysis was similar to that of the Collaboration, except that she added two important constraints to impose internal consistency:

- i) The P wave in the  $K^*$  region was determined by a Breit-Wigner fit to the  $Y_2^0$  moment. (This yielded  $m_{K^*} = 896$  MeV,  $\Gamma_{K^*} = 47$  MeV.)
- ii)  $\sigma_{K\pi}(\text{tot})$  was included in the overall fit. She was then able to resolve the ambiguity in favor of the "down" solution.

Meanwhile several groups have attempted to clarify the situation around 1370 MeV. CORDS 72, FRATI 72, and ROUGE 72 give some support to the resonant S-wave interpretation of FIRESTONE 71. The other groups (AGUILAR 72, BUCHNER 72, CRENNELL 72, ENGELMANN 72) agree that the S wave is important but not necessarily resonant. In analogy with the  $\pi\pi$  case, where a possible  $\epsilon$  pole is located several hundred MeV below the observed  $\pi^0\pi^0$  peak and quite far from the real axis, the 1370 bump could also be caused by a quite distant  $\kappa$  pole.

## Data Card Listings

For notation, see key at front of Listings.



S-wave  $K\pi$  phase shift. The "up-down" ambiguity now seems resolved by MATISON 72, who performs a partial-wave analysis of  $K\pi$  moments extrapolated to the pion pole. In addition, CHUNG 72 imposes positivity on physical region  $K\pi$  moments, and finds a narrow resonance most unlikely.

## REFERENCES FOR KAPPA

|                               |                                                  |
|-------------------------------|--------------------------------------------------|
| TRIPPE 68 PL 28 B 203         | +CHEN, MALAMUD, HELLEMA, SCHLEIN, + (UCLA)       |
| CRENNELL 69 PRL 22 487        | +KARSHON, LAI, O'NEILL, SCARR (BNL)              |
| DODD 69 PR 177 1994           | +JOLDERSMA, PALMER, SAMIOS (BNL)                 |
| GOLDBERG 69 PL 30 B 434       | SABRE COLLABOR. (ISACL+AMST+BGNA+REHO+EPOL)      |
| SCHLEIN 69 ARGONNE CONF. 446  | P. SCHLEIN (UCLA)                                |
| FIRESTONE 71 PRL 26 1460      | A. FIRESTONE, G. GOLDBERGER, D. LISSAUER (LRL)   |
| MERCER 71 NP 832 381          | +GITICH, CALAHAN, CHIEH, CHEN (JOHN HOPKINS)     |
| YUTA 71 PRL 26 1502           | +DERRICK, ENGELMANN, MUSGRAVE (ANL+EFI)          |
| AGUILAR 72 PR D 6 11          | AGUILAR-BENITEZ, CHUNG, EISNER (BNL)             |
| BINGHAM 72 NP 8 41 1          | + (INTERNATIONAL $K^+$ COLLABORATION)            |
| BUCHNER 72 NP 8 45 333        | +DEHN, CHARRIERE, CORNET, + (MPIH+CERN+BRUX)     |
| CHUNG 72 PRL 29 1570          | +EISNER, AGUILAR-BENITEZ (BNL)                   |
| CORDS 72 COO-1428-308         | +CARMONY, LANDER, MEIERE, + (PURD+UCD+IUPUI)     |
| CRENNELL 72 PR D 6 1220       | +GORDON, KHAN-WU LAI, SCARR (BNL)                |
| DIEBOLD 72 BATAV.CONF.        | R. DIEBOLD, RAPPOORTEUR TALK (ANL)               |
| ENGELMANN 72 PR D 5 2162      | ENGELMANN, MUSGRAVE, FORMAN, + (ANL+EFI)         |
| FIRESTONE 72 PR D 5 2188      | +GOLDBERGER, LISSAUER, TRILLING (LBL+PWA)        |
| FRATI 72 PR D 6 2361          | +HALPERN, HARGIS, SNAPE, CARNAHAN, + (PENN+CINC) |
| ROUGE 72 NP 8 46 29           | +VIDEAU, VOLTE, DE BRION, + (EPOL+SACL)          |
| MATISON 72 LBL 1537 (THIS IS) | REVISED VERSION WILL GO TO PHYS. REV. LBL        |

 $K_{A1=3/2}(1175)$ 

24 KA 3/2 (1175, JP = ) I = 3/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE. FOR A DISCUSSION SEE ROSENFELD 68 AND GIACOMELLI TO WHO CONCLUDES THAT IF THIS STATE HAS WIDTH NOT LARGER THAN 100 MEV, THEN ITS PRODUCTION CROSS SECTION IS 1 OR 2 ORDERS OF MAGNITUDE SMALLER THAN THAT OF NON-EXOTIC  $K^*$ 'S.

## REFERENCES FOR KA3/2(1175)

|                                 |                                                      |
|---------------------------------|------------------------------------------------------|
| WANGLER 64 PL 9 71              | T. P. WANGLER, A. R. ERWIN, M. D. WALKER (WISCONSIN) |
| MILLER 65 PL 15 74              | MILLER, KOVACS, MCILWAIN, PALFREY + (PURDUE)         |
| ROSENFELD 68 PHILA.CONF. P. 455 | A. H. ROSENFELD (LRL)                                |
| DODD 69 PR 177 1991             | +JOLDERSMA, PALMER, SAMIOS (BNL)                     |
| CHO 70 PL 32 B 409              | +DERRICK, JOHNSON, MUSGRAVE, + (ANL+NMES+KANS)       |
| GIACOMELLI 70 PL 33 B 373       | G. GIACOMELLI + (BGNA+SACL+ZEEM+REHO+EPOL)           |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $K_{A1}=3/2(1265)$ , Q $K_{A1}=3/2(1265)$ 

25 KA 3/2 (1265, JP = 1) I = 3/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.  
FOR A DISCUSSION SEE ROSENFELD 68.

REFERENCES FOR KA3/2(1265)

FRENCH 67 NC 52A 442 \*KINSON+McDONALD+RIDDIFORD+ (CERN+BIRM)  
ROSENFELD 68 PHILA.CONF.P.455 A.H.ROSENFELD (LRL)  
CHO 70 PL 32 8 409 \*DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NMES+KANS)

 $Q$  REGION,  $K\pi\pi(1240-1400)$ 

28 Q REGION I=1/2

The main effect in the Q region is a broad bump in the  $K\pi\pi$  spectrum between 1200 and 1400 MeV, i.e. not far above  $K^*(892)\pi$  threshold, produced by K beams without charge exchange. In particular, it has been observed in coherent  $K^+d$  interactions (FIRESTONE 72) and in coherent interactions on heavy nuclei (BINGHAM 73). The dominant  $J^P$  assignment throughout the whole region is  $1^+$  and  $I = \frac{1}{2}$ . In addition, evidence for narrower states in the Q region has been reported from non-diffractive reactions ( $\pi^-p$ ,  $\bar{p}p$ ).

The following points are relevant to the rather complex situation in the Q region:

- The broad Q peak does not have a simple Breit-Wigner shape. It can be fitted at all energies by a superposition of two Breit-Wigner amplitudes [FIRESTONE 70, BARNHAM 74, BOWLER 74].
- The Q bump was observed with a similar shape in the backward direction by FIRESTONE 72.
- In addition to the dominant modes  $K^*\pi$  and  $K\rho$ , there is some evidence for a  $K\pi\pi$  mode, with the  $\pi\pi$  system in an S wave. [ALEXANDER 69, BARNHAM 74, DAVIS 72].
- Analyses of the interference between the  $K^*\pi$  and  $K\rho$  modes show the relative magnitude and relative phase of the two amplitudes varying with  $K\pi\pi$  mass. This is suggestive of the presence of two  $J^P = 1^+$  resonances coming possibly from a mixing between the strange members of the  $J^{PC} = 1^{++}$  ("A<sub>1</sub>") and  $1^{+-}$  (B) nonets [GOLDHABER 67, BARNHAM 74, BOWLER 74, GARFINKEL 71, FIRESTONE 72]. The  $K\pi\pi$  mass spectra and the relative magnitudes of the  $K^*\pi$  and  $K\rho$  amplitudes may be understood from the mixing hypothesis; the relative phase variation has not been explained yet [BOWLER 72].

## 28 Q REGION MASS (MEV)

| PRODUCED BY BEAMS OTHER THAN K MESONS |                        |     |      |          |                   |
|---------------------------------------|------------------------|-----|------|----------|-------------------|
| M                                     | 1242.0                 | 9.0 | 10.0 | ASTIER   | 69 HBC            |
| M                                     | A THIS IS THE C MESON. |     |      |          | 0 6 PI - P, LK2P1 |
| M                                     | 45(1300.)              |     |      | CRENNELL | 67 HBC            |
| M                                     | 40(1300.)              |     |      | CRENNELL | 72 HBC            |

| PRODUCED BY K BEAMS             |              |         |  |           |        |
|---------------------------------|--------------|---------|--|-----------|--------|
| M                               | 12(1320.)    | 25.0    |  | ALMEIDA   | 65 HBC |
| M                               | C (1320.0)   | (15.0)  |  | BASSOMPIE | 67 HBC |
| M                               | C 35(1280.0) | (10.0)  |  | BASSOMPIE | 67 HBC |
| M                               | C (1320.0)   | (15.0)  |  | BASSOMPIE | 67 HBC |
| SPLIT THE Q REGION INTO 3 BUMPS |              |         |  |           |        |
| M                               | 1320.0       | APPROX. |  | DE BAERE  | 67 HBC |
| M                               | 1335.0       | 6.0     |  | BARTSCH   | 68 HBC |
| M                               | (1300.)      | APPROX. |  | BARBARO   | 69 HBC |
| M                               | 45 1301.0    | 10.0    |  | BISHOP    | 69 HBC |
| M                               | 21 1300.0    | 10.0    |  | ERWIN     | 69 HBC |
| M                               | 1261.        | 7.0     |  | FRIEDMAN  | 69 HBC |
| M                               | 1300.0       | 10.0    |  | ABRAMS    | 70 HBC |
| M                               | 1260.        | 20.0    |  | FARBBER   | 70 HBC |
| M                               | (1325.0)     |         |  | DENEGRI   | 71 HBC |

AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

## 28 Q LOW (QA) MASS (MEV)

FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS

|    |         |      |           |        |                     |        |
|----|---------|------|-----------|--------|---------------------|--------|
| ML | (1280.) |      | SHEN      | 66 HBC | + 0 4.6 K*P, 5 BODY | 12/72* |
| ML | 1260.0  | 10.0 | ALEXANDER | 69 HBC | + 9.0 K*P           | 12/72* |
| ML | 1240.0  | 5.0  | BARNHAM   | 70 HBC | + 10.0 K*P, K 2P1   | 12/72* |
| ML | 1243.   | 8.   | GARFINKEL | 71 HBC | + 9. K* D           | 12/72* |
| ML | 1228.   | 14.  | ANDERSON  | 72 HBC | + 7.3 K* D          | 12/72* |
| ML | (1260.) |      | DAVIS     | 72 HBC | + 12. K* P          | 12/72* |
| ML | 1234.   | 12.  | FIRESTONE | 72 HBC | + 12. K* D          | 2/73*  |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

## 28 Q HIGH (QB) MASS (MEV)

FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS

|    |    |         |      |           |        |                   |        |
|----|----|---------|------|-----------|--------|-------------------|--------|
| MH | 70 | 1320.0  | 10.0 | SHEN      | 66 HBC | + 4.6 K*P         | 12/72* |
| MH |    | 1380.0  | 20.0 | ALEXANDER | 69 HBC | + 9.0 K*P         | 12/72* |
| MH |    | 1420.0  | 5.0  | BARNHAM   | 70 HBC | + 10.0 K*P, K 2P1 | 12/72* |
| MH |    | 1344.   | 8.   | GARFINKEL | 71 HBC | + 9. K* D         | 12/72* |
| MH |    | 1414.   | 15.  | ANDERSON  | 72 HBC | + 7.3 K* D        | 12/72* |
| MH |    | (1420.) |      | DAVIS     | 72 HBC | + 12. K* P        | 12/72* |
| MH |    | 1368.   | 18.  | FIRESTONE | 72 HBC | + 12. K* D        | 2/73*  |

AVERAGE MEANINGLESS (SCALE FACTOR = 4.9)

## 28 Q REGION WIDTH (MEV)

PRODUCED BY BEAMS OTHER THAN K MESONS

|   |          |     |      |          |        |                  |        |
|---|----------|-----|------|----------|--------|------------------|--------|
| W | 127.0    | 7.0 | 25.0 | ASTIER   | 69 HBC | 0 6 PI - P       | 9/69   |
| W | 45 (60.) |     |      | CRENNELL | 67 HBC | 0 6 PI - P       | 7/67   |
| W | 40 (60.) |     |      | CRENNELL | 72 HBC | 0 4.5PI-P, LK2P1 | 12/72* |

PRODUCED BY K BEAMS

|                                 |                                          |         |         |           |           |                     |           |       |
|---------------------------------|------------------------------------------|---------|---------|-----------|-----------|---------------------|-----------|-------|
| W                               | 12                                       | (60.0)  | (20.0)  | ALMEIDA   | 65 HBC    | + 3-5 K*P           | 12/72*    |       |
| W                               | C                                        | (60.0)  | (20.0)  | BASSOMPIE | 67 HBC    | + 5. K* P           | 11/67     |       |
| W                               | C                                        | 35      | (80.0)  | (20.0)    | BASSOMPIE | 67 HBC              | + 5. K* P | 11/67 |
| W                               | C                                        | (60.0)  | (20.0)  | BASSOMPIE | 67 HBC    | + 5. K* P           | 11/67     |       |
| SPLIT THE Q REGION INTO 3 BUMPS |                                          |         |         |           |           |                     |           |       |
| W                               | (200.)                                   | APPROX. |         | DE BAERE  | 67 HBC    | + 3.5 K* P          | 7/67      |       |
| W                               | 196.0                                    | 16.0    |         | BARTSCH   | 68 HBC    | + 10. K - P, K NP1  | 9/69      |       |
| W                               | B                                        | 250.    | APPROX. | BARBARO   | 69 HBC    | + 12. K* P (K 2P1)  | 9/69      |       |
| NO BACKGROUND SUBTRACTION.      |                                          |         |         |           |           |                     |           |       |
| W                               | 45                                       | 40.0    | 10.0    | BISHOP    | 69 HBC    | + 3.5 K*P (K* P1)   | 9/69      |       |
| W                               | 21                                       | 40.0    | 15.0    | ERWIN     | 69 HBC    | + 0 3.5 K*P (K* P1) | 9/69      |       |
| W                               |                                          | 51.     | 22.     | FRIEDMAN  | 69 HBC    | + 2.6+2.7 K* P      | 9/69      |       |
| W                               |                                          | 80.0    | 20.0    | ABRAMS    | 70 HBC    | + 2.5-3.2 K* P      | 11/70     |       |
| W                               |                                          | 180.    | 28.     | FARBBER   | 70 HBC    | + 12.7 K* P         | 6/70      |       |
| W                               |                                          | (180.0) |         | DENEGRI   | 71 HBC    | + 12-6 K-D, K 2P1 D | 5/71      |       |
| . . . . .                       |                                          |         |         |           |           |                     |           |       |
| W                               | AVERAGE MEANINGLESS (SCALE FACTOR = 4.2) |         |         |           |           |                     |           |       |

AVERAGE MEANINGLESS (SCALE FACTOR = 4.2)

## 28 Q LOW (QA) WIDTH (MEV)

FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS

|    |        |      |     |           |        |                     |        |
|----|--------|------|-----|-----------|--------|---------------------|--------|
| WL | 100.0  | 20.0 |     | SHEN      | 66 HBC | + 0 4.6 K*P, 5 BODY | 12/72* |
| WL | 40.0   | 10.0 |     | ALEXANDER | 69 HBC | + 9.0 K*P           | 12/72* |
| WL | 110.0  | 15.0 |     | BARNHAM   | 70 HBC | + 10.0 K*P, K 2P1   | 12/72* |
| WL | 70.    | 26.  | 18. | GARFINKEL | 71 HBC | + 9. K* D           | 12/72* |
| WL | 111.   | 33.  |     | ANDERSON  | 72 HBC | + 7.3 K* D          | 12/72* |
| WL | (120.) |      |     | DAVIS     | 72 HBC | + 12. K* P          | 12/72* |
| WL | 188.   | 21.  |     | FIRESTONE | 72 HBC | + 12. K* D          | 2/73*  |

AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

## 28 Q HIGH (QB) WIDTH (MEV)

FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS

|    |     |       |         |           |        |                   |        |
|----|-----|-------|---------|-----------|--------|-------------------|--------|
| MH | 70. | 80.0  | 20.0    | SHEN      | 66 HBC | + 4.6 K*P         | 12/72* |
| MH |     | 120.0 | 10.0    | ALEXANDER | 69 HBC | + 9.0 K*P         | 12/72* |
| MH |     | 120.0 | 15.0    | BARNHAM   | 70 HBC | + 10.0 K*P, K 2P1 | 12/72* |
| MH |     | (60.) | OR LESS | GARFINKEL | 71 HBC | + 9. K* D         | 12/72* |
| MH |     | 89.   | 24.     | ANDERSON  | 72 HBC | + 7.3 K* D        | 12/72* |
| MH |     | (80.) |         | DAVIS     | 72 HBC | + 12. K* P        | 12/72* |
| MH |     | 241.  | 30.     | FIRESTONE | 72 HBC | + 12. K* D        | 2/73*  |

AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

## 28 Q REGION PARTIAL DECAY MODES

|    |                          | DECAY MASSES |          |
|----|--------------------------|--------------|----------|
| P1 | Q REGION INTO K*(892) PI | 891+         | 139      |
| P2 | Q REGION INTO K RHO      | 497+         | 170      |
| P3 | Q REGION INTO K PI       | 497+         | 139      |
| P4 | Q REGION INTO K ETA      | 497+         | 548      |
| P5 | Q REGION INTO K OMEGA    | 497+         | 783      |
| P6 | Q REGION INTO K PI PI    | 497+         | 139+ 139 |

# Mesons

## Q. $K_N(1420)$

# Data Card Listings

For notation, see key at front of Listings.

### 28 Q REGION BRANCHING RATIOS

| PRODUCED BY BEAMS OTHER THAN K MESONS |                                                                                                                   |                                   |                                              |                                          |                       |      |  |  |  |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|----------------------------------------------|------------------------------------------|-----------------------|------|--|--|--|
| R1                                    | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / TOTAL (UNITS OF 10 <sup>-2</sup> )                               | (P2)                              |                                              |                                          |                       |      |  |  |  |
| R1                                    | 75.0                                                                                                              | 10.0                              | ARMENTERO 64 HBC                             | 0.0 PBAR P                               | 6/66                  |      |  |  |  |
| R1                                    | DOMINANT                                                                                                          |                                   | CRENNELL 72 HBC                              | 0.45 P <sup>-</sup> P <sup>-</sup> LK2P1 | 12/72*                |      |  |  |  |
| R2                                    | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / TOTAL (UNITS OF 10 <sup>-2</sup> )                               | (P1)                              |                                              |                                          |                       |      |  |  |  |
| R2                                    | 25.0                                                                                                              | 10.0                              | ARMENTERO 64 HBC                             | 0.0 PBAR P                               | 6/66                  |      |  |  |  |
| R3                                    | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> P <sup>0</sup> + P <sup>-</sup> )                |                                   |                                              |                                          |                       |      |  |  |  |
| R3                                    | (0.2) OR LESS                                                                                                     | CL=90                             | CRENNELL 67 HBC                              | 0.6 0 P <sup>-</sup> P                   | 7/67                  |      |  |  |  |
| R4                                    | Q REGION INTO (K <sup>0</sup> P <sup>+</sup> P <sup>-</sup> ) / (K <sup>0</sup> P <sup>0</sup> + P <sup>-</sup> ) |                                   |                                              |                                          |                       |      |  |  |  |
| R4                                    | (0.1) OR LESS                                                                                                     | CL=90                             | CRENNELL 67 HBC                              | 0.6 0 P <sup>-</sup> P                   | 7/67                  |      |  |  |  |
| PRODUCED BY K BEAMS                   |                                                                                                                   |                                   |                                              |                                          |                       |      |  |  |  |
| R10                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> (892) P <sup>+</sup> )                           | (P3)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R10                                   | (0.8) OR LESS                                                                                                     |                                   | SHEN 66 HBC                                  | 4.6 K <sup>+</sup> P, 5 BODY             | 11/67                 |      |  |  |  |
| R10                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> (892) P <sup>+</sup> )                           | (P3)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R10                                   | (0.02) OR LESS                                                                                                    |                                   | SHEN 66 HBC                                  | 4.6 K <sup>+</sup> P                     | 8/66                  |      |  |  |  |
| R11                                   | Q REGION INTO (K <sup>0</sup> P <sup>+</sup> ) / (K <sup>0</sup> (892) P <sup>+</sup> )                           | (P5)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R11                                   | (0.1) OR LESS                                                                                                     |                                   | SHEN 66 HBC                                  | 4.6 K <sup>+</sup> P                     | 10/66                 |      |  |  |  |
| R12                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> (892) P <sup>+</sup> )                           | (P3)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R12                                   | (0.30) OR LESS                                                                                                    |                                   | SHEN 66 HBC                                  | 4.6 K <sup>+</sup> P                     | 10/66                 |      |  |  |  |
| R13                                   | Q REGION INTO (K <sup>+</sup> (892) P <sup>+</sup> ) AND K <sup>0</sup> (OVERLAPPING BANDS)                       | (P1+P2)                           |                                              |                                          |                       |      |  |  |  |
| R13                                   | (1.0) OR LESS                                                                                                     |                                   | BERLINGHI 67 HBC                             | 12.7 K <sup>+</sup> P                    | 7/67                  |      |  |  |  |
| R14                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / TOTAL                                                            | (P3)                              |                                              |                                          |                       |      |  |  |  |
| R14                                   | (0.02) OR LESS                                                                                                    |                                   | BERLINGHI 67 HBC                             | 12.7 K <sup>+</sup> P                    | 11/67                 |      |  |  |  |
| R14                                   | (0.02) OR LESS                                                                                                    | CL=95                             | BARTSCH 68 HBC                               | 10.0 K <sup>+</sup> P                    | 9/68                  |      |  |  |  |
| R15                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / TOTAL                                                            | (P4)                              |                                              |                                          |                       |      |  |  |  |
| R15                                   | (0.02) OR LESS                                                                                                    |                                   | BERLINGHI 67 HBC                             | 12.7 K <sup>+</sup> P                    | 11/67                 |      |  |  |  |
| R16                                   | Q REGION INTO (K <sup>0</sup> P <sup>+</sup> ) / TOTAL                                                            | (P5)                              |                                              |                                          |                       |      |  |  |  |
| R16                                   | (0.02) OR LESS                                                                                                    |                                   | BERLINGHI 67 HBC                             | 12.7 K <sup>+</sup> P                    | 11/67                 |      |  |  |  |
| R16                                   | 12                                                                                                                | 0.01                              | BARTSCH 68 HBC                               | 10.0 K <sup>+</sup> P                    | 9/68                  |      |  |  |  |
| R17                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> (892) P <sup>+</sup> )                           | (P2)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R17                                   | 0.91                                                                                                              | 0.25                              | BERLINGHI 67 HBC                             | 12.7 K <sup>+</sup> P                    | 11/67                 |      |  |  |  |
| R17                                   | 701                                                                                                               | 0.4                               | BARTSCH 68 HBC                               | 10.0 K <sup>+</sup> P                    | 9/68                  |      |  |  |  |
| R17                                   | 0.47                                                                                                              | 0.18                              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9) |                                          |                       |      |  |  |  |
| R18                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / (K <sup>+</sup> (892) P <sup>+</sup> )                           | (P3)/(P1)                         |                                              |                                          |                       |      |  |  |  |
| R18                                   | (0.21) OR LESS                                                                                                    |                                   | DE BAERE 67 HBC                              | 3.5 K <sup>+</sup> P                     | 11/66                 |      |  |  |  |
| R19                                   | Q REGION INTO (K <sup>+</sup> P <sup>-</sup> ) / TOTAL                                                            | (P6)                              |                                              |                                          |                       |      |  |  |  |
| R19                                   | 201                                                                                                               | 0.22                              | 0.08                                         | BARTSCH 68 HBC                           | 10.0 K <sup>+</sup> P | 9/68 |  |  |  |
| R19                                   | 5                                                                                                                 | POSSIBLY SEEN                     | ALEXANDER 69 HBC                             | 9.0 K <sup>+</sup> P                     | 2/73*                 |      |  |  |  |
| R19                                   | 5                                                                                                                 | POSSIBLY SEEN                     | DAVIS 72 HBC                                 | 12.0 K <sup>+</sup> P                    | 1/73*                 |      |  |  |  |
| R19                                   | 5                                                                                                                 | WITH THE (P1 P1) SYSTEM IN S-WAVE |                                              |                                          | 1/73*                 |      |  |  |  |

### REFERENCES FOR Q REGION

#### PRODUCED BY BEAMS OTHER THAN K MESONS

|                               |                                                  |
|-------------------------------|--------------------------------------------------|
| ARMENTERO 64 DUBNA CONF 1 577 | ARMENTEROS, EDWARDS, D-ANDLAU + (CERN+CDEF)      |
| ALSO 64 DUBNA CONF 1 617      | R ARMENTEROS (RAPPORTEUR)                        |
| ALSO 66 PR 145 1095           | BARASH, KIRSCH, MILLER, TAN (COLUMBIA)           |
| CRENNELL 67 PRL 19 44         | +KALBFLEISCH, LAI, SCARR, SCHUMANN (BNL)         |
| ASTIER 69 NP 8 10 65          | +MARECHAL, MONTANET, + (CDEF+CERN+IPNP+LIVP+IJP) |
| BETTINI 69 NC 62 A 1038       | +CRESTI, LIMENTANI, BERTAUZA, BIGI+IPADO+PISAI   |

#### PRODUCED BY K BEAMS

|                                            |                                                 |
|--------------------------------------------|-------------------------------------------------|
| ALMEIDA 65 PL 16 184                       | ALMEIDA, ATHERTON, BYER, DORNAN, FORSON+ (CAVE) |
| SHEN 66 PRL 17 726                         | +BUTTERWORTH, FU, GOLDBABERS, TRILLING (LRL)    |
| ALSO 66 (PRIVATE COMMUNIC)                 | GOLDBABER (LRL)                                 |
| BASSOMPIERRE 67 PL 268 36                  | BASSOMPIERRE, GOLDSCHMIDT+ (CERN+BRUX+BIRM+IJP) |
| BERLINGHI 67 PRL 18 1087                   | +BERLINGHI, FARBET, FERBEL, FORMAN (ROCH)       |
| DE BAERE 67 NC 49A 374                     | +DEBAISIEUX, FAST+FILIPPA+ (CERN+BRUX)          |
| ALSO PRIVATE COMMUNICATION BY B. JONGEJANS |                                                 |
| GOLDBABER 67 PRL 19 976                    | G. GOLDBABER (LBL)                              |
| BARTSCH 68 NP 88 9                         | +COCCONI, + (AACH+BERL+CERN+LOIC+VIEN)          |
| BOMSE 68 PRL 20 1519                       | +BORNSTEIN, CALLAHAN, COLE, COX, + (JOHNHOPK)   |
| DENEGRI 68 PRL 20 1194                     | +CALLAHAN+ETTLINGER+GILLESPIE+ (JOHNHOPK)       |
| ALSO 70 ANTICH                             |                                                 |

|                          |                                                     |
|--------------------------|-----------------------------------------------------|
| ALEXANDER 69 NP 8 13 503 | G. ALEXANDER, FIRESTONE, GOLDBABER, + (LRL)         |
| ANDREWS 69 PRL 22 731    | +LACH, LUDLAM, SANDWEISS, BERGER, + (YALE+LRL)      |
| BARBARO 69 PRL 22 1207   | BARBARO-GALTIERI, DAVIS, FLATTE, + (LRL)            |
| BISHOP 69 NP 8 9 403     | +GOSHAW, ERWIN, WALKER (MISC)                       |
| CHIEN 69 PL 298 433      | +MALAHUD, HELLEKA, RUDNICK, SCHLEIN+ (UCLA)         |
| CHUNG 69 PR 182 1443     | +EISNER+BALL+LUERS (BNL)                            |
| COLLEY 69 NC A 59 519    | +EASTWOOD, + (BIRM+GLAS+LOIC+MPI+OXF+RHUL)          |
| ERWIN 69 NP 8 9 364      | +WALKER, GOSHAW, WEINBERG (MISC+PRIN+VAND)          |
| FRIEDMAN 69 UCL-18860    | J. FRIEDMAN, PH.D. THESIS (LRL)                     |
| WERNER 69 PR 188 2023    | +AMMAR, DAVIS, KROPAC, YARGER, CHO, + (NMES+ANL) 1+ |

|                                 |                                                     |
|---------------------------------|-----------------------------------------------------|
| ABRAMS 70 PR D 1 2433           | +EISENSTEIN, KIM, MARSHALL, O-HALLORAN, + (ILL)     |
| ANTICH 70 NP 8 20 201           | +CARSON, CHIEN, COX, DENEGRI, ETTLINGER, + (JHU) 1+ |
| BOWLER 70 PL 31 B 318           | M. G. BOWLER (OXFORD)                               |
| FARBET 70 PR D 1 78             | +FERBEL, SLATTERY, YUTA (ROCH) 1+                   |
| FIRESTONE 70 PHILAD.CONF.P. 229 | A. FIRESTONE REVIEW (LRL)                           |

|                               |                                                   |
|-------------------------------|---------------------------------------------------|
| BARNHAM 71 NP 825 49          | +COLLEY, GRIFFITHS, ALPER, + (BIRM+GLAS+OXF)      |
| BOWLER 71 BOLOGNA CONF. PROC. | M. G. BOWLER INTRODUCTORY TALK (OXFORD)           |
| DENEGRI 71 NP 8 28 13         | +ANTICH, CALLAHAN, CARSON, CHIEN, COX, + (JHU) 1+ |
| FORMAN 71 PR D 3 2610         | +GELFAND, LEARY, MOSER, SEIDL, WOLFSON (EJF) 1+   |
| GARFINKLE 71 PRL 26 1505      | GARFINKLE, HOLLAND, KARMONY, LANDER+ (PURD+ROCH)  |
| SLATTERY 71 UR-875-332(PREP)  | P. SLATTERY, A REVIEW OF STRANGE MESONS (ROCH)    |

|                          |                                                  |
|--------------------------|--------------------------------------------------|
| ANDERSON 72 PR D 6 1823  | +FRANKLIN, GODDEN, KOPELMAN, LIBBY, TAN (COLO)   |
| BINGHAM 72 NP 8 48 589   | +EISENSTEIN, KARD, HERQUET, + (CERN+BRUX)        |
| BRANDENB 72 NP 8 45 397  | BRANDENBURG, BRODY, JOHNSON, LEITH, LOOS+ (SLAC) |
| BRANDENB 72 PR 28 932    | BRANDENBURG, JOHNSON, LEITH, LOOS, LUSTE+ (SLAC) |
| CRENNELL 72 PR D 6 1220  | +GORDON, KWAN-WU LAI, SCARR (BNL)                |
| DAVIS 72 PR D 5 2688     | +ALSTON, BARBARO, FLATTE, FRIEDMAN, LYNCH+ (LBL) |
| FIRESTONE 72 NP 8 47 348 | A. FIRESTONE (CIT)                               |
| FIRESTONE 72 PR D 5 505  | FIRESTONE, GOLDBABER, LISSAUER, TRILLING (LBL)   |

FRATI 72 PR D 6 2361 +HALPERN, HARGIS, SNAPE, CARNAHAN, + (PENN+CINC)  
 HAATUFT 72 NP 8 48 78 +ARNOLD, HAGENAUER, + (BERG+STRB+EPOL+MADR)  
 BINGHAM 73 NP 8 (TO APPEAR) +FARMELL, + (LBL, DRSAY, BNL, SACLAY, MILNI)  
 \*\*\*\*\*

## $K_N(1420)$

22 KN(1420, JP=2+) I=1/2

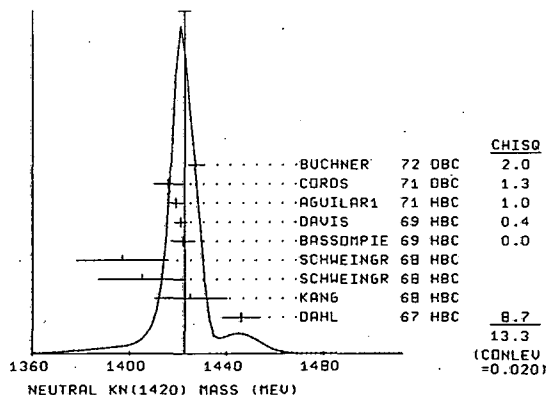
JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.

### 22 KN(1420) MASS (MEV)

M FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE UNDER K\*

|                                       |                                                    |        |     |                                              |        |                       |        |  |  |
|---------------------------------------|----------------------------------------------------|--------|-----|----------------------------------------------|--------|-----------------------|--------|--|--|
| CHARGED ONLY, WITH FINAL STATE K P1   |                                                    |        |     |                                              |        |                       |        |  |  |
| M                                     | 1440.                                              | 24.0   | 40. | DE BAERE                                     | 67 HBC | + 3.5 K+P (K P10)     | 10/66  |  |  |
| M                                     | 1423.                                              | 21.    |     | ADERHOLZ                                     | 68 HBC | - 10 K- P (K P1)      | 6/68   |  |  |
| M                                     | 1401.0                                             | 20.0   |     | SCHWEINGR                                    | 68 HBC | - 4.1 K- P (K P1)     | 2/72   |  |  |
| M                                     | 1427.0                                             | 9.0    |     | SCHWEINGR                                    | 68 HBC | - 5.5 K- P (K P1)     | 9/67   |  |  |
| M                                     | 1425.0                                             | 15.0   |     | BISHOP                                       | 69 HBC | + 3 K+ P              | 9/69   |  |  |
| M                                     | 1416.0                                             | 10.0   |     | CRENNELL                                     | 69 HBC | - 3.9 K-N (KOP1-)     | 7/69   |  |  |
| M                                     | 1414.                                              | 11.    |     | LIND                                         | 69 HBC | + 9. K+ PIKO P1+      | 9/69   |  |  |
| M                                     | 1430.                                              | 10.    |     | ABRAMS                                       | 70 HBC | + 2.5-3.2 K+P,K2P1    | 11/70  |  |  |
| M                                     | 1400 1420.0                                        | 3.1    |     | AGUILARI                                     | 71 HBC | - 3.9, 4.6 K- P       | 11/71  |  |  |
| M                                     | 200 1425.                                          | 6.     |     | BARNHAM                                      | 71 HBC | + K+ P,KO P1+ P       | 1/72   |  |  |
| M                                     | AVG                                                | 1421.3 | 2.3 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                       |        |  |  |
| CHARGED ONLY, WITH OTHER FINAL STATES |                                                    |        |     |                                              |        |                       |        |  |  |
| M                                     | 1400.                                              | 20.0   |     | BADIER                                       | 65 HBC | - 3. K- P (K P1)      | 10/66  |  |  |
| M                                     | 20 1440.0                                          | 20.0   |     | DUBAL                                        | 68 HBC | - 11.5 K- P           | 6/68   |  |  |
| M                                     | 240 1396.                                          | 6.     |     | BASSOMPIERRE                                 | 69 HBC | + 5 K+P (K 2P1)       | 11/69  |  |  |
| M                                     | (1411.)                                            | (7.)   |     | FRIEDMAN                                     | 69 HBC | - 2.7 K- P (K 2P1)    | 2/72   |  |  |
| M                                     | AVG                                                | 1399.7 | 8.2 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5) |        |                       |        |  |  |
| CHARGED AND NEUTRAL                   |                                                    |        |     |                                              |        |                       |        |  |  |
| M                                     | 1406.0                                             | 15.0   |     | FOCARDI                                      | 65 HBC | - 0.3. K- P (K P1)    | 10/66  |  |  |
| M                                     | 1390.0                                             | 30.0   |     | SHEN                                         | 66 HBC | + 0.4 K+ P (K P1)     | 10/66  |  |  |
| M                                     | 1430.0                                             | 10.0   |     | SHEN                                         | 66 HBC | + 0.4 K+ P (K P1)     | 10/66  |  |  |
| M                                     | 1423.0                                             | 7.0    |     | BASSAND                                      | 67 HBC | - 0.4 K- P (K P1)     | 10/67  |  |  |
| M                                     | 1420.0                                             | 10.0   |     | GOLDBABER                                    | 67 HBC | + 9.0 K+ P (K 2P1)    | 10/67  |  |  |
| M                                     | AVG                                                | 1421.2 | 4.7 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |                       |        |  |  |
| NEUTRAL ONLY                          |                                                    |        |     |                                              |        |                       |        |  |  |
| M                                     | 1446.0                                             | 7.9    |     | DAHL                                         | 67 HBC | 0.4 P1- P (K P1)      | 10/66  |  |  |
| M                                     | 1425.0                                             | 15.0   |     | KANG                                         | 68 HBC | 0.4 K- P              | 7/69   |  |  |
| M                                     | 1405.0                                             | 18.0   |     | SCHWEINGR                                    | 68 HBC | 0.4 K- P (K P1)       | 9/67   |  |  |
| M                                     | 1397.0                                             | 19.0   |     | SCHWEINGR                                    | 68 HBC | 0.5 K- P (K P1)       | 9/67   |  |  |
| M                                     | 420 1422.                                          | 5.     |     | BASSOMPIERRE                                 | 69 HBC | 0.5 K+P (K P1)        | 11/69  |  |  |
| M                                     | 8 BASSOMP. ERRORS ENLARGED BY US TO GAMMA/SORTINI. |        |     | SEE K TYPED NOTE.                            |        |                       | 11/69  |  |  |
| M                                     | 2200 1421.1                                        | 2.6    |     | DAVIS                                        | 69 HBC | 0.12. K+ P (K P1+)    | 9/69   |  |  |
| M                                     | 1800 1419.1                                        | 3.7    |     | AGUILARI                                     | 71 HBC | 0.3, 9.4 K- P         | 11/71  |  |  |
| M                                     | 600 1416.                                          | 6.     |     | CORDS                                        | 71 HBC | 0.9. K+ N, K+ P1- P   | 2/72   |  |  |
| M                                     | 1100 1427.                                         | 3.     |     | BUCHNER                                      | 72 HBC | 0.4 K+ K+ N, K+ P1- P | 12/72* |  |  |
| M                                     | AVG                                                | 1422.8 | 2.5 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6) |        |                       |        |  |  |
|                                       |                                                    |        |     | (SEE IDEOGRAM BELOW.)                        |        |                       |        |  |  |

WEIGHTED AVERAGE = 1422.8 ± 2.5  
 ERROR SCALED BY 1.6



### 22 KN(1420) WIDTH (MEV)

|                                       |             |        |      |                                              |        |   |                  |       |  |
|---------------------------------------|-------------|--------|------|----------------------------------------------|--------|---|------------------|-------|--|
| CHARGED ONLY, WITH FINAL STATE K P1   |             |        |      |                                              |        |   |                  |       |  |
| W                                     | 175.        | 57.    |      | ADERHOLZ                                     | 68 HBC | - | 10 K- P (K P1)   | 6/68  |  |
| W                                     | 110.0       | 25.0   |      | BISHOP                                       | 69 HBC | + | 3.5 K+ P         | 9/69  |  |
| W                                     | 96.         | 18.    |      | LIND                                         | 69 HBC | + | 9. K+ P          | 5/70  |  |
| W                                     | 80.0        | 20.0   |      | ABRAMS                                       | 70 HBC | + | 2.5-3.2 K+P,K2P1 | 11/70 |  |
| W                                     | 1400 94.7   | 15.1   | 12.5 | AGUILARI                                     | 71 HBC | - | 3.9, 4.6 K- P    | 11/71 |  |
| W                                     | 200 115.    | 20.    |      | BARNHAM                                      | 71 HBC | + | K+ P,K0 P1+ P    | 1/72  |  |
| W                                     | AVG         | 99.1   | 8.1  | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |   |                  |       |  |
| CHARGED ONLY, WITH OTHER FINAL STATES |             |        |      |                                              |        |   |                  |       |  |
| W                                     | 105.0       | 30.0   |      | BADIER                                       | 65 HBC | - | 3.0 K- P         | 6/66  |  |
| W                                     | B 240 110.0 | 25.    |      | BASSOMPIERRE                                 | 69 HBC | + | 5 K+ P (K 2P1)   | 11/69 |  |
| W                                     | 43.1        | (13.1) |      | FRIEDMAN                                     | 69 HBC | - | 2.7 K- P (K 2P1) | 2/72  |  |
| W                                     | AVG         | 108.0  | 19.2 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |        |   |                  |       |  |

## Data Card Listings

For notation, see key at front of Listings.

## Mesons

 $K_N(1420)$ ,  $K_N(1660)$ 

| CHARGED AND NEUTRAL |       |       |                                                              |
|---------------------|-------|-------|--------------------------------------------------------------|
| W                   | 92.0  | 14.0  | FOCARDI 65 HBC -0 3.0 K- P (K P)                             |
| W                   | 75.0  | 25.0  | SHEN 66 HBC +0 4.6 K+ P 8/66                                 |
| W                   | 65.0  | 20.0  | BASSANO 67 HBC -0 4.6, 5.0 K- P 10/67                        |
| W                   | 80.0  | 20.0  | GOLDBERGER 67 HBC 9.0 K+ P (K P)                             |
| W                   | 107.0 | 20.0  | SCHWEINGER 68 HBC -0 4.1, 5.5 K- P 9/67                      |
| W                   | AVG   | 85.9  | 8.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)             |
| NEUTRAL ONLY        |       |       |                                                              |
| W                   | 61.0  | 24.0  | DAHL 67 HBC 0 3.8-4.2 P- P 9/66                              |
| W                   | 116.0 | 17.0  | KANG 68 HBC 0 4.6 K- P 7/69                                  |
| W                   | 420   | 110   | BASSOMPIE 69 HBC 0 5 K+ P (K P)                              |
| W                   | 8     | 21    | ERRORS ENLARGED BY US TO 4 GAMMA/SORTINI. SEE K+ TYPED NOTE. |
| W                   | 2200  | 101   | DAVIS 69 HBC 0 12 K+ P (K P)                                 |
| W                   | 1800  | 116.6 | AGUILAR 71 HBC 0 3.9, 4.6 K- P 11/71                         |
| W                   | 600   | 144   | COROS 71 HBC 0 9. K+ N, K+ P- P 2/72                         |
| W                   | 1100  | 109   | BUCHNER 72 HBC 0 4.6 K+ N, K+ P- P 12/72                     |
| W                   | AVG   | 108.4 | 6.3 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)             |

22  $K_N(1420)$  PARTIAL DECAY MODES

|                               | DECAY MASSES |
|-------------------------------|--------------|
| P1 $K_N(1420)$ INTO K P       | 493+ 139     |
| P2 $K_N(1420)$ INTO K*(892) P | 891+ 139     |
| P3 $K_N(1420)$ INTO K*(892) P | 891+ 139     |
| P4 $K_N(1420)$ INTO K OMEGA   | 493+ 783     |
| P5 $K_N(1420)$ INTO K ETA     | 493+ 548     |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (P_i P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

|    | P1            | P2            | P3            | P4            | P5            |
|----|---------------|---------------|---------------|---------------|---------------|
| P1 | .5495+-0.0274 |               |               |               |               |
| P2 | -.2293        | .2945+-0.0247 |               |               |               |
| P3 | -.3950        | -.3925        | .0923+-0.0241 |               |               |
| P4 | -.2443        | -.2458        | -.1182        | .0440+-0.0166 |               |
| P5 | -.4097        | -.2442        | -.0787        | -.0502        | .0197+-0.0200 |

22  $K_N(1420)$  BRANCHING RATIOS

| $K_N(1420)$ INTO (K P) / TOTAL       |                                                                                                                                          |         |                                               |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------|-----------------------------------------------|
| R1                                   | (0.37)                                                                                                                                   | (0.19)  | BADIER 65 HBC 3.0 K-P 6/66                    |
| R1 R                                 | (0.39)                                                                                                                                   | (0.11)  | BASSANO 67 HBC -4.6, 5.0 K- P 10/67           |
| R1 R                                 | WE CANNOT USE THIS STATISTICALLY REDUNDANT RATIO. AUTHORS OBTAIN IT MERELY BY SUBTRACTING FROM UNITY THEIR MEASUREMENTS OF OTHER RATIOS. |         |                                               |
| R1 R                                 |                                                                                                                                          |         |                                               |
| R1 FIT                               | 0.550                                                                                                                                    | 0.027   | FROM FIT                                      |
| $K_N(1420)$ INTO (K*(892) P) / TOTAL |                                                                                                                                          |         |                                               |
| R2                                   | (0.47)                                                                                                                                   | (0.10)  | BADIER 65 HBC 3.0 K-P 6/66                    |
| R2 Q                                 | (0.47)                                                                                                                                   | (0.10)  | BASSANO 67 HBC -4.6, 5.0 K- P 10/67           |
| R2 FIT                               | 0.295                                                                                                                                    | 0.025   | FROM FIT                                      |
| $K_N(1420)$ INTO (K RHO) / TOTAL     |                                                                                                                                          |         |                                               |
| R3                                   | (0.14)                                                                                                                                   | (0.05)  | BADIER 65 HBC 3.0 K-P 6/66                    |
| R3 Q                                 | (0.14)                                                                                                                                   | (0.10)  | BASSANO 67 HBC 0 4.6, 5.0 K- P 10/67          |
| R3 FIT                               | 0.092                                                                                                                                    | 0.024   | FROM FIT                                      |
| $K_N(1420)$ INTO (K OMEGA) / TOTAL   |                                                                                                                                          |         |                                               |
| R4                                   | 0.07                                                                                                                                     | 0.04    | BADIER 65 HBC 3.0 K-P 6/66                    |
| R4 FIT                               | 0.044                                                                                                                                    | 0.017   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| $K_N(1420)$ INTO (K ETA) / TOTAL     |                                                                                                                                          |         |                                               |
| R5                                   | 0.02                                                                                                                                     | 0.02    | BADIER 65 HBC 3.0 K-P 6/66                    |
| R5 Q                                 | (0.025) OR LESS                                                                                                                          |         | BASSOMPIE 69 HBC 5.0 K+ P 9/68                |
| R5 FIT                               | 0.020                                                                                                                                    | 0.020   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| $K_N(1420)$ INTO (K*(892) P) / (K P) |                                                                                                                                          |         |                                               |
| R6                                   | 0.33                                                                                                                                     | 0.33    | CHUNG 65 HBC +0 3.9-4.2 P- P 8/66             |
| R6 Q                                 | 0.65                                                                                                                                     | 0.20    | SHEN 66 HBC 0 N+ PRODUCED 10/66               |
| R6 Q                                 | (0.63)                                                                                                                                   | (0.20)  | SHEN 66 HBC 0 N+ PRODUCED 10/66               |
| R6 Q                                 | 0.52                                                                                                                                     | 0.12    | SCHWEINGER 68 HBC 0 4.1-5.5 K- P 10/67        |
| R6 Q                                 | (0.9)                                                                                                                                    | (0.2)   | BASSOMPIE 69 HBC 0 5 K+ P 1/73                |
| R6 Q                                 | 0.93                                                                                                                                     | (0.11)  | BISHOP 69 HBC 3.5 K+ P 9/69                   |
| R6 Q                                 | 0.47                                                                                                                                     | 0.08    | AGUILAR 71 HBC 3.9-4.6 K- P 11/71             |
| R6 Q                                 | 0.78                                                                                                                                     | 0.15    | CHARRIERE 72 HBC 0 5. K+ P, K P 3PI 1/73      |
| R6 Q                                 | 0.537                                                                                                                                    | 0.058   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R6 FIT                               | 0.536                                                                                                                                    | 0.057   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| $K_N(1420)$ INTO (K OMEGA) / (K P)   |                                                                                                                                          |         |                                               |
| R7                                   | (0.08) OR LESS                                                                                                                           |         | SHEN 66 HBC 4.6 K+ P 8/66                     |
| R7                                   | (0.2)                                                                                                                                    | OR LESS | BASSOMPIE 69 HBC 5 K+ P 9/69                  |
| R7                                   | 0.13                                                                                                                                     | 0.07    | BASSOMPIE 69 HBC 0 5 K+ P 9/69                |
| R7                                   | 0.05                                                                                                                                     | 0.04    | AGUILAR 71 HBC 3.9-4.6 K- P 11/71             |
| R7 FIT                               | 0.070                                                                                                                                    | 0.035   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R7 FIT                               | 0.080                                                                                                                                    | 0.031   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| $K_N(1420)$ INTO (K RHO) / (K P)     |                                                                                                                                          |         |                                               |
| R8                                   | (0.09) OR LESS                                                                                                                           |         | CHUNG 65 HBC +0 3.9-4.2 P- P 8/66             |
| R8                                   | 0.26                                                                                                                                     | 0.16    | SCHWEINGER 68 HBC 0 4.1-5.5 K- P 10/67        |
| R8                                   | (0.2)                                                                                                                                    | OR LESS | BASSOMPIE 69 HBC 5 K+ P 9/69                  |
| R8                                   | (0.3) OR LESS                                                                                                                            |         | BASSOMPIE 69 HBC 0 5 K+ P 9/69                |
| R8 Q                                 | 0.15                                                                                                                                     | (0.06)  | BISHOP 69 HBC 3.5 K+ P 9/69                   |
| R8 Q                                 | 0.16                                                                                                                                     | 0.05    | AGUILAR 71 HBC 3.9, 4.6 K- P 11/71            |
| R8 FIT                               | 0.169                                                                                                                                    | 0.048   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R8 FIT                               | 0.168                                                                                                                                    | 0.048   | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |

| $K_N(1420)$ INTO (K RHO) / (K*(892) P)   |                |        |                                   |
|------------------------------------------|----------------|--------|-----------------------------------|
| R9                                       | (0.39) OR LESS |        | BASSOMPIE 67 HBC +5. K+ P 9/67    |
| R9                                       | (0.40) OR LESS | CL-90  | FIELD 67 HBC -3.8 K- P 6/67       |
| R9 FIT                                   | 0.313          | 0.095  | FROM FIT                          |
| $K_N(1420)$ INTO (K OMEGA) / (K*(892) P) |                |        |                                   |
| R10                                      | (0.10)         | (0.04) | FIELD 67 HBC (P3)/(P2) 6/67       |
| R10 FIT                                  | 0.149          | 0.061  | FROM FIT                          |
| $K_N(1420)$ INTO (K ETA) / (K*(892) P)   |                |        |                                   |
| R11                                      | (0.07)         | (0.04) | FIELD 67 HBC (P5)/(P2) 6/67       |
| R11 FIT                                  | 0.067          | 0.069  | FROM FIT                          |
| $K_N(1420)$ INTO (K ETA) / (K P)         |                |        |                                   |
| R12                                      | (0.02) OR LESS |        | BISHOP 69 HBC (P5)/(P1) 9/69      |
| R12                                      | (0.04) OR LESS | CL-95  | AGUILAR 71 HBC 3.9-4.6 K- P 11/71 |
| R12 FIT                                  | 0.036          | 0.037  | FROM FIT                          |

R Q FOLLOWING SUGGESTION BY AGUILAR 70, WE DO NOT MAKE USE OF MEASUREMENTS WHERE THE (K P) BACKGROUND SUBTRACTION IS DIFFICULT DUE TO THE NEARBY Q REGION.

REFERENCES FOR  $K_N(1420)$ 

|                                            |                                                  |
|--------------------------------------------|--------------------------------------------------|
| BADIER 65 PL 19 612                        | BADIER, DEMOULIN, GOLDBERGER, EPOL, SACL, ZEEMAN |
| CHUNG 65 PRL 15 325                        | DAHL, HARDY, HESS, JACOBS, KIRZ, MILLER (LRL)    |
| FOCARDI 65 PL 16 351                       | FOCARDI, MINGUZZI, RANZI, SERRA, BOLOGNA, SACL   |
| SHEN 66 PRL 17 726                         | BUTTERWORTH, FU, GOLDBERGER, TRILLING (LRL)      |
| ALSO 66 (PRIVATE COMMUNICATION) GOLDBERGER |                                                  |
| BASSANO 67 PRL 19 968                      | GOLDBERGER, GOZ, BARNES, LEITNER, BNL, SYRACUSE  |
| BASSOMPIE 67 PL 268 30                     | BASSOMPIERE, GOLDSCHMIDT, CERN, BRUX, BIRM, JP   |
| CRENNELL 67 PRL 19 44                      | KALBFLEISCH, LAI, SCARR, SCHUMANN (BNL)          |
| DAHL 67 PL 163 1377                        | HARDY, HESS, KIRZ, MILLER (LRL)                  |
| DAHL 65 PRL 14 401                         | HARDY, CHUNG, DAHL, HESS, KIRZ, MILLER (LRL)     |
| DE BAERE 67 NC 51 A 401                    | GOLDSCHMIDT, CLERMONT, HENRI, BRUX, CERN         |
| FIELD 67 PL 248 638                        | HENDRICKS, PACCIONI, YAGER (LAJOLLA)             |
| GOLDBERGER 67 PRL 19 972                   | G. GOLDBERGER, FIRESTONE, SHEN (LRL)             |
| ADERHOLZ 68 NP 8 5 567                     | DEUTSCHMANN, AACH, BERL, CERN, LOIC, VIENNA      |
| ALSO 66 PL 22 357                          | BARTSCH, DEUTSCHMANN, MORRISON, ABCL, CIVI       |
| ANTICH 68 PRL 21 1842                      | CALLAHAN, CARSON, COX, DENEGRI, JHU              |
| DUBAL 68 THESIS 1456                       | L. DUBAL (GENEVE)                                |
| KANG 68 PRL 176 1587                       | Y. W. KANG (IOWA)                                |
| SCHWEINGER 68 PRL 166 1317                 | SCHWEINGER, RUBER, DERRICK, FIELDS, ANL, WRES    |
| ALSO 67 THESIS                             | F. L. SCHWEINGER, RUBER (NORTHWESTERN, EVANSTON) |
| BASSOMPIE 69 NP 813 189                    | BASSOMPIERE, GOLDSCHMIDT, CLERN, CERN, BRUX, JP  |
| ALSO 69 DE BAERE                           |                                                  |
| BISHOP 69 NP 8 403                         | GOSHAU, ERWIN, WALKER (WISC)                     |
| CRENNELL 69 PRL 22 487                     | KARSHON, LAI, ONEALL, SCARR (BNL)                |
| DAVIS 69 PRL 23 1071                       | DERENZO, FLATTE, ALSTON, LYNCH, SOLMITZ (LRL)    |
| DE BAERE 69 NC 61 A 397                    | GOLDSCHMIDT, CLERMONT, HENRI, BELG, CERN         |
| ALSO 70 DE BAERE                           |                                                  |
| FRIEDMAN 69 UCRL-18860                     | J. FRIEDMAN, PH. D. THESIS (LRL)                 |
| LIND 69 NP 8 14 1                          | ALEXANDER, FIRESTONE, FU, GOLDBERGER (LRL) JP    |
| ABRAMS 70 PR D 1 2433                      | EISENSTEIN, KIM, MARSHALL, O'MALLORAN, ILL       |
| AGUILAR 70 PR D 25 1362                    | AGUILAR, BENI, BASSANO, EISNER, BNL, GLAS        |
| BIRMINGHAM 70 KIEV CONF                    | ASTIER, RAPORTEURS TALK (BIRM+GLAS+OXF)          |
| DE BAERE 70 CERN PHYS 70 41                | DEBAISIEUX, DE WOLF, DUFOUR, BELG, CERN          |
| AGUILAR 71 PR D 4 2583                     | EISNER, KINSON (BNL)                             |
| BARNHAM 71 NP 8 28 171                     | COLLEY, JONES, GRIFFITHS, HUGHES, BIRM+GLAS      |
| COROS 71 PR D 4 1974                       | CARMONY, ERWIN, MEIERE, PURO+UCD+IUPUI           |
| SLATTERY 71 UR-875-3321 PREP               | P. SLATTERY, A REVIEW OF STRANGE MESONS (ROCH)   |
| BUCHNER 72 NP 8 45 333                     | DEHM, CHARRIERE, CORNET, MPIN+CEBN+BRUX          |
| CHARRIERE 72 NP 8 51 317                   | CHARRIERE, DRIJARD, DE BAERE, CERN, BELG         |
| CRENNELL 72 PR D 6 1220                    | GORDON, KAN, MU LAI, SCARR (BNL)                 |
| DEUTSCHMANN 72 NP 8 36 373                 | DEUTSCHMANN, ABCL, COLLABORATION                 |
| ENGELMANN 72 PR D 5 2162                   | ENGELMANN, MUSGRAVE, FORMAN, ANL+EFI             |
| FRATTI 72 PR D 6 2361                      | HALPERN, HARGIS, SNAPE, CARMAN, PENN+CINC        |
| ROUGE 72 NP 8 46 29                        | VIDEAU, VOLTE, DE BRION, EPOL+SACL               |
| TIECKE 72 NP 8 39 596                      | GRJNS, HEINEN, DE GROOT, NIJK+ZEEM               |

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 $K_N(1660)$ 27  $K_N(1660)$ , JP = 1 1 = 1/2

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE

27  $K_N(1660)$  MASS (MEV)

|   |          |                                                          |
|---|----------|----------------------------------------------------------|
| M | (1660.0) | CARMONY 67 HBC -3.8 K-P, OMEGA K 11/67                   |
| M | 1660.0   | JOBES 67 HBC +5. K+ P 11/67                              |
| M | J        | CLAIMED BY JOBES IN (K P), (K*(892) P), AND (K*(1420) P) |
| M | J        | MODES. K P BUMP INTERFERES MOSTLY WITH DELTA(1236).      |
| M | (1660.)  | CHARRIERE 72 HBC 0 5. K+ P, K P 3PI 1/73                 |

27  $K_N(1660)$  WIDTH (MEV)

|   |       |      |                                          |
|---|-------|------|------------------------------------------|
| W | 60.0  | 20.0 | JOBES 67 HBC +5. K+ P 11/67              |
| W | (60.) |      | CHARRIERE 72 HBC 0 5. K+ P, K P 3PI 1/73 |

27  $K_N(1660)$  PARTIAL DECAY MODES

|                                   | DECAY MASSES  |
|-----------------------------------|---------------|
| P1 $K_N(1660)$ INTO K P           | 493+ 139      |
| P2 $K_N(1660)$ INTO K P P         | 493+ 139+ 139 |
| P3 $K_N(1660)$ INTO K*(892) P     | 891+ 139      |
| P4 $K_N(1660)$ INTO $K_N(1420)$ P | 1421+ 139     |

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## Mesons

 $K_N(1660)$ ,  $K_N(1760)$ ,  $L(1770)$ ,  $K_N(1850)$ ,  $K^*(2200)$ 

## Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR  $K_N(1660)$ 

CARMONY 67 PRL 18 615 D.CARMONY, T. HENDRICKS, L. LANDER (LA JOLLA)  
 JOSES 67 PL 268 49 +BASSOMPIERRE, DE BAERE + (BIRM+CERN+BRUX)  
 CHARRIER 72 NP 8 51 317 CHARRIERE, DRIJARD, DE BAERE, + (CERN+BELG)

 **$K_N(1760)$** 60  $K_N(1760, J_P = )$ 

NEEDS FURTHER CONFIRMATION. OMITTED FROM THE TABLE.  
 FAVORED  $J_P$  IS  $3^-, 1-1/2^-$ .

60  $K_N(1760)$  MASS (MEV)

| M | C | 76(1753.) | (12.-) | CARMONY | 71 DBC | 0 9. K + N | 11/71 |
|---|---|-----------|--------|---------|--------|------------|-------|
|---|---|-----------|--------|---------|--------|------------|-------|

60  $K_N(1760)$  WIDTH (MEV)

| M | C | 76 (60.) | (20.-) | CARMONY | 71 DBC | 0 9. K + N | 11/71 |
|---|---|----------|--------|---------|--------|------------|-------|
|---|---|----------|--------|---------|--------|------------|-------|

W C DISAGREEMENT BETWEEN THE FIT AND DATA ON BOTH SIDES OF THE SIGNAL 11/71

60  $K_N(1760)$  PARTIAL DECAY MODES

| P1 | $K_N(1760)$ INTO K P1         | DECAY MASSES  |
|----|-------------------------------|---------------|
| P2 | $K_N(1760)$ INTO $K(892) P1$  | 493+ 139      |
| P3 | $K_N(1760)$ INTO K RHO        | 891+ 139      |
| P4 | $K_N(1760)$ INTO $K(1420) P1$ | 493+ 770      |
| P5 | $K_N(1760)$ INTO K P1 P1      | 1421+ 139     |
|    |                               | 493+ 139+ 139 |

60  $K_N(1760)$  BRANCHING RATIOS

| R1   | $K_N(1760)$ INTO (K P1)/(K*(892) P1 + K RHO)                                    | (P1)/(P2+P3)              | 11/71 |
|------|---------------------------------------------------------------------------------|---------------------------|-------|
| R1 E | (0.40) (0.10)                                                                   | CARMONY 71 DBC 0 9. K + N |       |
| R2   | $K_N(1760)$ INTO (K*(892) P1)/(K P1 P1) <td>(P2)/(P5)</td> <td></td>            | (P2)/(P5)                 |       |
| R2 E | (0.40) (0.15)                                                                   | CARMONY 71 DBC 0 9. K + N | 11/71 |
| R3   | $K_N(1760)$ INTO (K RHO)/(K P1 P1) <td>(P3)/(P5)</td> <td></td>                 | (P3)/(P5)                 |       |
| R3 E | (0.60) (0.25)                                                                   | CARMONY 71 DBC 0 9. K + N | 11/71 |
| R4   | $K_N(1760)$ INTO (K*(892) P1 + K RHO)/(K P1 P1) <td>(P2+P3)/(P5)</td> <td></td> | (P2+P3)/(P5)              |       |
| R4 E | (1.) (0.12)                                                                     | CARMONY 71 DBC 0 9. K + N | 11/71 |
| R5   | $K_N(1760)$ INTO (K(1420) P1)/(K P1 P1) <td>(P4)/(P5)</td> <td></td>            | (P4)/(P5)                 |       |
| R5 E | (0.06) OR LESS                                                                  | CARMONY 71 DBC 0 9. K + N | 11/71 |
| R5 E | DIFFICULT BACKGROUND SUBTRACTION. ERRORS STATISTICAL ONLY.                      |                           | 11/71 |

REFERENCES FOR  $K_N(1760)$ 

CARMONY 71 PRL 27 1160 +CORDS, CLOPP, ERWIN, MEIERE, + (PURD+UCD+IUPUI)

 **$L(1770)$** 23  $L(1770, J_P = )$  I = 1/2

FOR REVIEWS SEE HUGHES 71, SLATTERY 71.

23  $L$  MASS (MEV)

| M | 20(1780.)                                                       | BERLINGHI 67 HBC + | 12.7 K + P                                   | 7/67                      |
|---|-----------------------------------------------------------------|--------------------|----------------------------------------------|---------------------------|
| M | (1760.0)                                                        | (15.0)             | JOSES 67 HBC +                               | 5. K + P 1/73*            |
| M | (1785.0)                                                        | (12.0)             | BARTSCH 68 HBC +                             | 10.0 K - P 11/71          |
| M | INCLUDED IN BARTSCH 70                                          |                    |                                              | 11/71                     |
| M | 1745.0                                                          | 20.0               | AGUILAR 70 HBC -                             | 4.6 K - P 6/70            |
| M | 1780.0                                                          | 15.0               | BARTSCH 70 HBC -                             | 10.1 K - P 1/71           |
| M | (1760.0)                                                        | (15.0)             | LUOLAM 70 HBC -                              | 12.6 K - P 1/73*          |
| M | 1765.0                                                          | 40.0               | COLLEY 71 HBC +                              | 10. K + P, K 2 P1 1/73*   |
| M | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS. |                    |                                              |                           |
| M | (1740.0)                                                        | 6.                 | DENEGRI 71 DBC -                             | 12.6 K - 0, K 2 P1 D 5/71 |
| M | 1767.                                                           | 20.                | BLIEDEN 72 HBC -                             | 11. -16. K - P 12/72*     |
| M | P 306 1730.                                                     | 20.                | FIRESTONE 72 DBC +                           | 12. K + D 1/73*           |
| M | P PRODUCED IN CONJUNCTION WITH D*                               |                    |                                              |                           |
| M | AVG 1764.6                                                      | 6.7                | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) |                           |

23  $L$  WIDTH (MEV)

| M | 20 (80.)                                                        | BERLINGHI 67 HBC + | 12.7 K + P                                          | 7/67                      |
|---|-----------------------------------------------------------------|--------------------|-----------------------------------------------------|---------------------------|
| M | (60.0)                                                          | (20.0)             | JOSES 67 HBC + <td>5. K + P 1/73*</td>              | 5. K + P 1/73*            |
| M | (127.0)                                                         | (43.0)             | BARTSCH 68 HBC + <td>10.0 K - P 11/71</td>          | 10.0 K - P 11/71          |
| M | INCLUDED IN BARTSCH 70                                          |                    |                                                     | 11/71                     |
| M | 100.0                                                           | 50.0               | AGUILAR 70 HBC - <td>4.6 K - P 6/70</td>            | 4.6 K - P 6/70            |
| M | 138.0                                                           | 40.0               | BARTSCH 70 HBC - <td>10.1 K - P 1/71</td>           | 10.1 K - P 1/71           |
| M | (50.0)                                                          | (40.0) (20.0)      | LUOLAM 70 HBC - <td>12.6 K - P 1/73*</td>           | 12.6 K - P 1/73*          |
| M | X 90.                                                           | 70.                | COLLEY 71 HBC + <td>10. K + P, K 2 P1 1/73*</td>    | 10. K + P, K 2 P1 1/73*   |
| M | X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS. |                    |                                                     |                           |
| M | (130.0)                                                         | 26.                | DENEGRI 71 DBC - <td>12.6 K - 0, K 2 P1 D 5/71</td> | 12.6 K - 0, K 2 P1 D 5/71 |
| M | 100.                                                            | 30.                | BLIEDEN 72 HBC - <td>11. -16. K - P 12/72*</td>     | 11. -16. K - P 12/72*     |
| M | P 306 210.                                                      | 30.                | FIRESTONE 72 DBC + <td>12. K + D 12/72*</td>        | 12. K + D 12/72*          |
| M | P PRODUCED IN CONJUNCTION WITH D*                               |                    |                                                     |                           |
| M | AVG 137.7                                                       | 24.2               | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)        |                           |

23  $L$  PARTIAL DECAY MODES

| P1                                                                              | $L$ INTO K P1 P1                                | DECAY MASSES       |
|---------------------------------------------------------------------------------|-------------------------------------------------|--------------------|
| P2 <td><math>L</math> INTO <math>K(1420) P1</math> <td>497+ 134+ 134</td> </td> | $L$ INTO $K(1420) P1$ <td>497+ 134+ 134</td>    | 497+ 134+ 134      |
| P3 <td><math>L</math> INTO K P1 P1 P1 <td>134+1421</td> </td>                   | $L$ INTO K P1 P1 P1 <td>134+1421</td>           | 134+1421           |
| P4 <td><math>L</math> INTO K*(892) P1 <td>497+ 134+ 134+ 134</td> </td>         | $L$ INTO K*(892) P1 <td>497+ 134+ 134+ 134</td> | 497+ 134+ 134+ 134 |
| P5 <td><math>L</math> INTO K*(892) RHO <td>891+ 134</td> </td>                  | $L$ INTO K*(892) RHO <td>891+ 134</td>          | 891+ 134           |
| P6 <td><math>L</math> INTO K*(892) OMEGA <td>891+ 770</td> </td>                | $L$ INTO K*(892) OMEGA <td>891+ 770</td>        | 891+ 770           |
| P7 <td><math>L</math> INTO K*(892) P1 P1 <td>891+ 783</td> </td>                | $L$ INTO K*(892) P1 P1 <td>891+ 783</td>        | 891+ 783           |
|                                                                                 |                                                 | 891+ 134+ 134      |

23  $L$  BRANCHING RATIOS

| R1 | $L$ INTO $(K(1420) P1) / (K P1 P1)$                          | (P2)/(P1)          | 11/71            |
|----|--------------------------------------------------------------|--------------------|------------------|
| R1 | LARGE                                                        | DENEGRI 68 DBC -   | 12.6 K - D 1/71  |
| R1 | (1.0)                                                        | BARBARO 69 HBC +   | 12.0 K + P 1/71  |
| R1 | 0.2                                                          | AGUILAR 70 HBC -   | 4.6 K - P 1/71   |
| R1 | LESS THAN 1.0                                                | BARTSCH 70 HBC -   | 10.1 K + P 1/71  |
| R1 | LESS THAN 1.0                                                | COLLEY 71 HBC +    | 10. K + P 12/72* |
| R1 | CONSISTENT WITH 1.                                           | FIRESTONE 72 DBC + | 12. K + D 12/72* |
| R1 | P PRODUCED IN CONJUNCTION WITH D*                            |                    |                  |
| R1 | R LESS THAN 1.0 SEEMS TO BE ESTABLISHED.                     |                    |                  |
| R1 | R FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY |                    | 11/71            |
| R1 | R MODES SEE HUGHES 71, SLATTERY 71.                          |                    | 11/71            |

REFERENCES FOR  $L(1770)$ 

BARTSCH 66 PL 22 357 +DEUTSCHMANN, + (AACH+BERL+CERN+LOIC+VIEN)  
 BERLINGHI 67 PRL 18 1087 +BERLINGHI, +FARBER+FERBEL+FORMAN+ (ROCHI)  
 JOSES 67 PL 268 49 +BASSOMPIERRE, DE BAERE + (BIRM+CERN+BRUX)  
 DENEGRI 68 PRL 20 1194 +CALLAHAN+ETTLINGER+GILLESPIE+ (JHU)  
 BARTSCH 68 NP 88 9 +COCCONI, + (AACH+BERL+CERN+LOIC+VIEN)  
 ANDREWS 69 PRL 22 731 +LACH, LUOLAM, SANDWEISS, BERGER, + (YALE+LRL)  
 BARBARO 69 PRL 22 1207 +BARBARO, GALTIERI, DAVIS, FLATTE, + (LRL)  
 COLLEY 69 NC A 59 519 +EASTWOOD, + (BIRM+GLAS+LOIC+MPIN+OXF+RHEL)  
 AGUILAR 70 PRL 25 54 +AGUILAR-BENITEZ, BARNES, BASSAND, CHUNG, + (BNL)  
 BARTSCH 70 PL 33 8 186 +DEUTSCHMANN, + (AACH+BERL+CERN+LOIC+VIEN)  
 CHEN 70 PHILA. CONF. P. 275 I-S-HUGHES, TALK AT BOLONA CONF. (GLASGOW)  
 LUOLAM 70 PR D 2 1234 +SANDWEISS, SLAUGHTER (YALE)  
 COLLEY 71 NP 8 26 71 +JOSES, KENYON, PATHAK, HUGHES, + (BIRM+GLAS)  
 DENEGRI 71 NP 8 28 13 +ANTICH, CALLAHAN, CARSON, CHEN, COX, + (JHU)  
 HUGHES 71 BOLOGNA CONF. PROC. P. 5 +HUGHES, TALK AT BOLONA CONF. (GLASGOW)  
 SLATTERY 71 UR-875-332(PREP) P. SLATTERY, A REVIEW OF STRANGE MESONS (ROCHI)  
 ANDERSON 72 PR D 6 1823 +FRANKLIN, GODDEN, KOPPELMAN, LIBBY, TAN (COLO)  
 BLIEDEN 72 PR D 39 8 668 +INOCENCIO, BODEN, EARLES, + (STON+NEAS)  
 CHARRIER 72 NP 8 51 317 CHARRIERE, DRIJARD, DE BAERE, + (CERN+BELG)  
 FIRESTONE 72 PR D 5 505 FIRESTONE, GOLDBABER, LISSAUER, TRILLING (LBL)

 **$K_N(1850)$** 61  $K_N(1850, J_P = )$ 

STRUCTURE IS SEEN IN THE K P1 SCATTERING ANGULAR DISTRIBUTION  
 AT MASSES NEAR 1850 MEV. THE MOST SIMPLE EXPLANATION INVOLVES  
 A RAPIDLY INCREASING F-WAVE AMPLITUDE, POSSIBLY INDICATING  
 PRESENCE OF A  $J_P = 3^-$  RESONANCE.  
 NEEDS FURTHER CONFIRMATION. OMITTED FROM THE TABLE.

61  $K_N(1850)$  MASS (MEV)

| M | I | (1850.) | APPROX. | FIRESTONE 71 DBC | 0 12. K + N, K + P1 - P1 | 11/71 |
|---|---|---------|---------|------------------|--------------------------|-------|
|---|---|---------|---------|------------------|--------------------------|-------|

61  $K_N(1850)$  WIDTH (MEV)

| M | I | (300.)                                                                                              | APPROX.                                                                             | FIRESTONE 71 DBC                                                   | 0 12. K + N, K + P1 - P1                | 11/71 |
|---|---|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------|-------|
| W | I | (300.) <td>APPROX. <td>FIRESTONE 71 DBC <td>0 12. K + N, K + P1 - P1 <td>11/71</td> </td></td></td> | APPROX. <td>FIRESTONE 71 DBC <td>0 12. K + N, K + P1 - P1 <td>11/71</td> </td></td> | FIRESTONE 71 DBC <td>0 12. K + N, K + P1 - P1 <td>11/71</td> </td> | 0 12. K + N, K + P1 - P1 <td>11/71</td> | 11/71 |
| W | I | APPEARANT INTERFERENCE WITH OTHER AMPLITUDES PRECLUDES                                              |                                                                                     |                                                                    |                                         | 11/71 |
| W | I | PRECISE DETERMINATION.                                                                              |                                                                                     |                                                                    |                                         | 11/71 |

REFERENCES FOR  $K_N(1850)$ 

FIRESTONE 71 PL 36 8 513 FIRESTONE, GOLDBABER, LISSAUER, TRILLING (LBL)

 **$K^*(2200)$** 40  $K^*(2200, J_P = )$ 

ENHANCEMENT SEEN IN (ANTIHYPERON-NUCLEON) MASS  
 NEAR THRESHOLD. INTERPRETATION UNCERTAIN.  
 OMITTED FROM TABLE.

40  $K^*(2200)$  MASS (MEV)

| M | 20 2240.  | 20.                                                             | LISSAUER 70 HBC  | 9. K + P   | 11/71 |
|---|-----------|-----------------------------------------------------------------|------------------|------------|-------|
| M | C (2200.) | APPROX.                                                         | SLATTERY 71 RVUE | 8-13 K + P | 11/71 |
| M | C         | COMPILATION OF (ANTIHYPERON-NUCLEON) MASS IN K + P 8.-13. GEV/C |                  |            | 11/71 |

40  $K^*(2200)$  WIDTH (MEV)

| M | 20 80.   | 20.                                                             | LISSAUER 70 HBC  | 9. K + P   | 11/71 |
|---|----------|-----------------------------------------------------------------|------------------|------------|-------|
| W | C (200.) | APPROX.                                                         | SLATTERY 71 RVUE | 8-13 K + P | 11/71 |
| W | C        | COMPILATION OF (ANTIHYPERON-NUCLEON) MASS IN K + P 8.-13. GEV/C |                  |            | 11/71 |

REFERENCES FOR  $K^*(2200)$ 

ALEXANDER 68 PRL 20 755 ALEXANDER, FIRESTONE, GOLDBABER, SHEN (LRL)  
 LISSAUER 70 NP 8 18 491 ALEXANDER, FIRESTONE, GOLDBABER (LBL)

CARMONY 71 PRL 27 1160 +CORDS, CLOPP, ERWIN, MEIERE, + (PURD+UCD+IND)  
 SLATTERY 71 UR-875-332(PREP) P. SLATTERY, A REVIEW OF STRANGE MESONS (ROCHI)

## Data Card Listings

*For notation, see key at front of Listings.***Mesons****K\*(2800)****K\*(2800)**

62 K\* (2800, JP= )

NEEDS FURTHER CONFIRMATION. OMITTED FROM THE TABLE.

62 K\*(2800) MASS (MEV)

M H 59(2800.) HUGHES 71 HBC + 10.K\*P,P HMS+ 11/71

62 K\*(2800) WIDTH (MEV)

|   |   |                                                                |        |                        |       |
|---|---|----------------------------------------------------------------|--------|------------------------|-------|
| M | H | 59 (40.) OR LESS                                               | HUGHES | 71 HBC + 10.K*P,P HMS+ | 11/71 |
| M | H | ONLY SEEN IN MISSING MASS DISTRIBUTION, NOT IN FITTED EVENTS.  |        |                        | 11/71 |
| M | H | PROBABLY DECAYS INTO (3 CHARGED + 2 OR MORE NEUTRAL) PARTICLES |        |                        | 11/71 |

REFERENCES FOR K\*(2800)

HUGHES 71 PREPRINT +MC+CORNICK, PROCTER, TURNBULL (GLASGOW)

# Baryons

## N's and $\Delta$ 's

### Note on Speed Plots

In the discussion which follows, we use the term "speed plot" to indicate a plot showing the variation with C. M. energy  $m$  of the derivative  $|dT/dm|$  of a partial-wave amplitude  $T$ . (See section IV C of the main text.) In principle such plots are a very sensitive and useful means of searching for a resonance. A rapid increase in speed followed by a rapid decrease is certainly a good indication of the presence of a resonance. In practice these plots must be judiciously used because:

- 1) The values of  $dT/dm$  are sensitive to variations in  $T$ . It is difficult enough to determine  $T(m)$ ; finding its derivative is necessarily more difficult.
- 2) Once the speed plot tells us that a resonance is present, the determination of precise parameters from such a plot requires additional considerations:
  - a) the maximum of the speed is not necessarily at the resonance mass,
  - b) the width cannot simply be obtained by the relation  $|dT/dm|_{m=M} = 2\chi/\Gamma$ .

Consider for example the  $P_{33}$  partial-wave amplitude in  $\pi$ -N scattering. Since its elasticity ( $\chi$ ) is one, we have

$$T(m) = \frac{\Gamma(m)/2}{M - m - i\Gamma(m)/2} \quad (1)$$

If we let  $\Gamma'(m) = d\Gamma/dm$ , then we find that

$$\text{"Speed"} = \left| \frac{dT}{dm} \right| = \frac{2}{\Gamma} \frac{1 + (M - m)\Gamma'/\Gamma}{1 + 4(M - m)^2/\Gamma^2} \quad (2)$$

To estimate where Eq. (2) is maximum, we let  $m = M + \delta$  and find that for small  $\delta$ ,

$$\frac{d}{dm} \left| \frac{dT}{dm} \right| = -\frac{16}{\Gamma^3} \left( \frac{\Gamma\Gamma'}{8} + \delta \right) + \mathcal{O}(\delta^2). \quad (3)$$

Since all reasonable parametrizations of  $\Gamma(m)$  agree that  $\Gamma' \geq 0$ , we may conclude that the "speed" will have its maximum value at an energy about  $\Gamma\Gamma'/8$  less than the resonant value,  $m=M$ .

This effect is illustrated in Fig. 1, which is taken from UCRL-20030  $\pi$ N.<sup>1</sup> For the  $P_{33}$  partial wave, the CERN experimental and CERN Kirsopp solutions indicate the instability of  $|dT/dm|$  in the region of a resonance (the other solutions are "smooth" by the nature of the analysis). In addition, each of the plots, quite consistently, gives  $2/\Gamma \approx 16 \text{ GeV}^{-1}$  at a resonant mass of  $\sim 1236 \text{ MeV}$ . This corresponds to a width at resonance of  $\sim 125 \text{ MeV}$ . The speed, however, peaks

# Data Card Listings

For notation, see key at front of Listings.

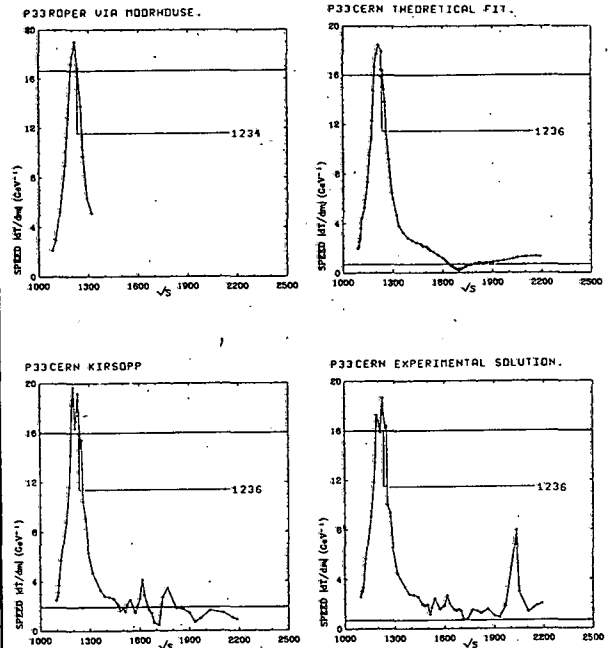


Fig 1. Speed plots as computed from four solutions compiled in Ref. 1. ( $\sqrt{s} = m = \text{c. m. energy in MeV}$ )

some 10 to 15 MeV lower in mass and at a value of  $\sim 18.5 \text{ GeV}^{-1}$ . Hence, were we to estimate the mass and width of the 33-resonance from the maximum speed, we would get  $M \approx 1220 \text{ MeV}$  and  $\Gamma = 108 \text{ MeV}$ . For additional discussion on the mass and width of this resonance, see the mini-review at the beginning of the  $\Delta(1236)$  listings.

### Reference

1. D. Herndon, et al., " $\pi$ N Partial-Wave Amplitudes, a Compilation," UCRL-20030  $\pi$ N, Feb. 1970.

### Note on N's and $\Delta$ 's: Partial-Wave Analyses

There now exist complete partial-wave analyses performed by two groups after the beginning of 1970. The older analysis, AYED 70, is an update of the previous Saclay analyses. These are essentially energy-independent solutions selected on the basis of various energy "smoothness" criteria. A more recent analysis, ALMEHED 72, is a continuation of the "CERN group" program, which uses "smoothness" criteria supplemented by constraints from partial-wave dispersion relations. For a discussion of earlier partial-wave analyses see Refs. 1 and 2.

## Data Card Listings

*For notation, see key at front of Listings.*

## Baryons

N's and  $\Delta$ 's

For the purposes of comparison, we show Argand plots of the solutions in Figs. 1 and 2. The arrow-heads on the lines connecting points at discrete energies are 5 MeV long, and are spaced at 20 MeV intervals. The AYED 70 analysis extends in c.m. energy from 1400 to 2450 MeV; the ALMEHED 72 analysis, from 1100 to 2200 MeV. We have indicated the energies where AYED 70 and ALMEHED 72 claim resonances, and in the case of ALMEHED 72 we have also indicated the grade, A through D, assigned to each of their resonances by this group. In addition, we also show in Figs. 3 and 4 plots of  $\delta$  and  $\eta$  versus c.m. energy ( $\sqrt{s}$ ) for the same two solutions.

The Saclay group has presented preliminary results on a new  $\pi N$  phase-shift analysis in an unpublished report to the 1972 Batavia conference. This analysis includes recent data, and improves some of the methods of the earlier analysis. These improvements include checking the final results for smoothness in energy of invariant amplitudes at fixed  $t$  and the unmeasured charge exchange polarization Legendre coefficients, as well as a qualitative check of the final results for consistency with an unsubtracted forward dispersion relation for the B amplitude. The main differences between the resonance parameters extracted from this new analysis (AYED 72) and those of ALMEHED 72 are summarized below. None of the states listed below were reported by AYED 70 except the  $P_{11}$  with  $M = 1461$ ,  $\Gamma = 164$ , and  $x = 0.56$ .

| Wave     | ALMEHED 72 |          |      | AYED 72      |           |                |
|----------|------------|----------|------|--------------|-----------|----------------|
|          | M          | $\Gamma$ | x    | M            | $\Gamma$  | x              |
| $S_{11}$ | 2100       | 200      | 0.5  | 2195         | 280       | 0.173          |
| $P_{11}$ | 1470       | 220      | 0.65 | 1427<br>1530 | 236<br>65 | 0.524<br>0.120 |
| $D_{13}$ |            |          |      | 1730         | 130       | 0.1            |
| $D_{15}$ | 2100       | 150      | 0.2  | 2055         | 170       | 0.09           |
| $F_{17}$ | 2000       | 200      | 0.15 | 2048         | 183       | 0.058          |
| $G_{19}$ |            |          |      | 2130         | 250       | 0.08           |
| $D_{35}$ | 2200       | 600      | 0.25 | 1870         | 160       | 0.095          |

Of particular interest are the new results on the  $P_{11}$  and  $D_{13}$  partial waves. Previous partial-wave analyses have seen a single fairly elastic ( $x \geq 0.5$ )  $P_{11}$  (1470) resonance in the mass range 1440-1500 MeV, while many production experiments have observed a bump in the invariant mass distribution tending to be some-

what narrower and at somewhat lower mass than that obtained from partial-wave analysis. The Saclay group now claims two states. As for the  $D_{13}$ , the quark model predicts an inelastic resonance in the neighborhood of 1700 MeV, and the existence of such a state is now indicated by isobar model fits to  $\pi N \rightarrow \pi \pi N$  (see the mini-review on this subject) and by AYED 72. The effect now claimed by AYED 72 to be the  $D_{13}$  (1700) is visible in both the ALMEHED 72 and AYED 70 solutions (see Figs. 3 and 4) in the 1700 MeV region.

The remaining new results listed above are five high mass resonances, four of which were seen by ALMEHED 72, but none by the earlier Saclay analysis. In the case of the  $D_{35}$  it may well be that ALMEHED 72 and AYED 72 are reporting completely different effects.

#### Spread in Values of Resonance Parameters

Values of masses, widths, and branching ratios can be obtained only from phase-shift analyses. In production experiments, in fact, it is seldom clear which of the many states at similar masses is being observed. In addition to the two complete phase-shift analyses discussed above, we have other analyses, done by using somewhat incomplete data, by several different groups, but we are quite far from having reliable masses and widths derived therefrom.

There are essentially two problems in obtaining reliable resonance parameters. First there is often disagreement as to just what the values of the phase shifts ( $\eta$ 's and  $\delta$ 's) are. This problem is obviously related to the quality and quantity of the data and to the procedures used to determine or choose the phase shifts. Secondly, even if smooth curves were available for the phase shifts, there would still be some ambiguity in deciding what the resonant parameters are. We might hope that some sort of energy-dependent fit to the smooth phase shifts would yield unique parameters. Unfortunately, however, a sufficiently clever combination of background and/or resonances could fit the phase shifts, satisfy elastic unitarity, and still yield the wrong parameters. (See the Comments on the Mass and Width of  $\Delta(1236)$ , below.)

We list the values of  $M$ ,  $\Gamma$  and  $x$  quoted by the various authors with a comment on the method used to derive such parameters. We now discuss briefly the different methods used. AYED 70 analyze their

# Baryons N's and $\Delta$ 's

## Data Card Listings

For notation, see key at front of Listings.

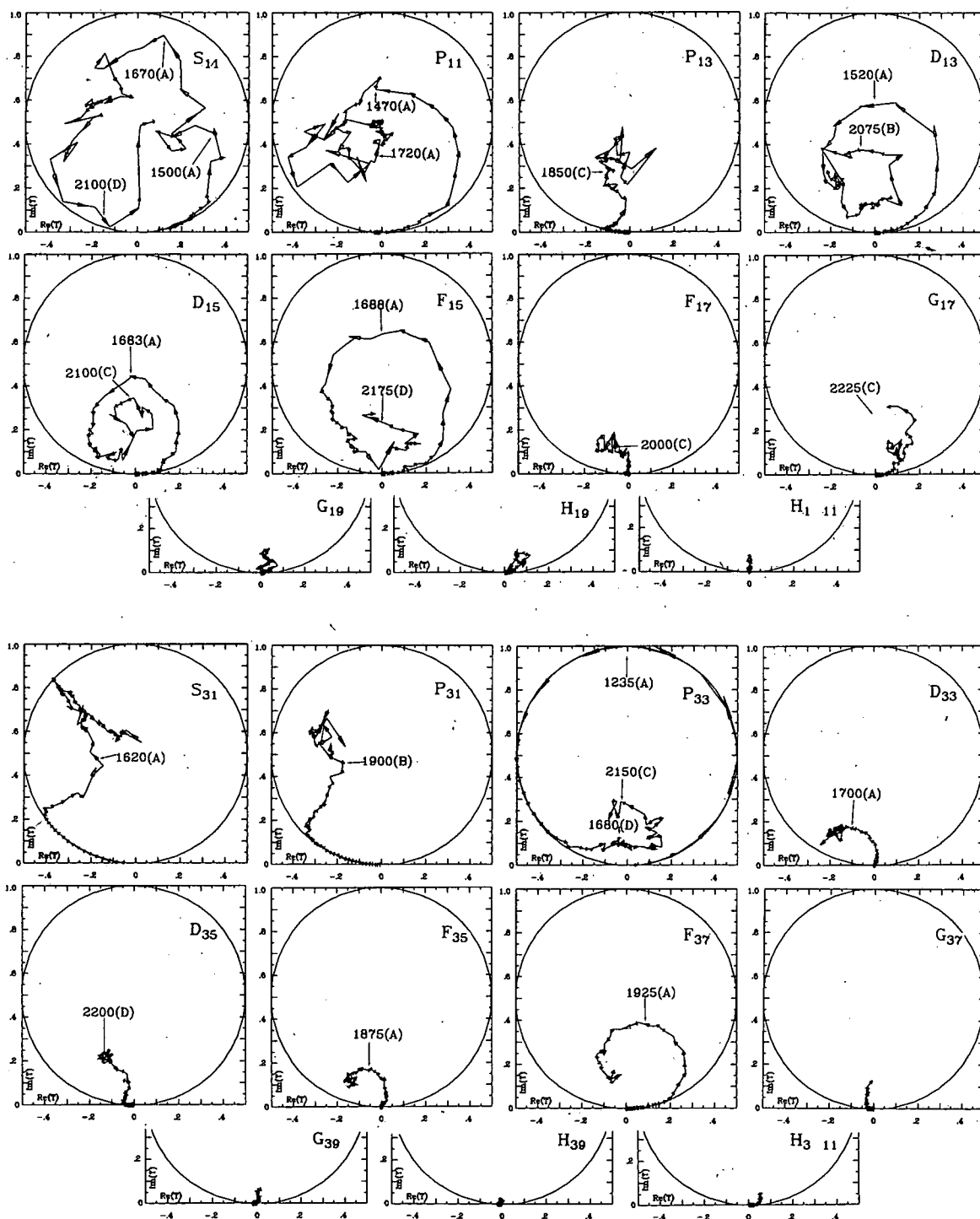


Fig. 1.  $\pi N$  Argand plots from the solution of ALMEHED 72. The bases of the arrowheads are 20 MeV apart; the end point is at  $\sim 2200$  MeV. The numbers are the resonant masses claimed by ALMEHED 72, and the letters indicate their evaluation of the resonance.

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

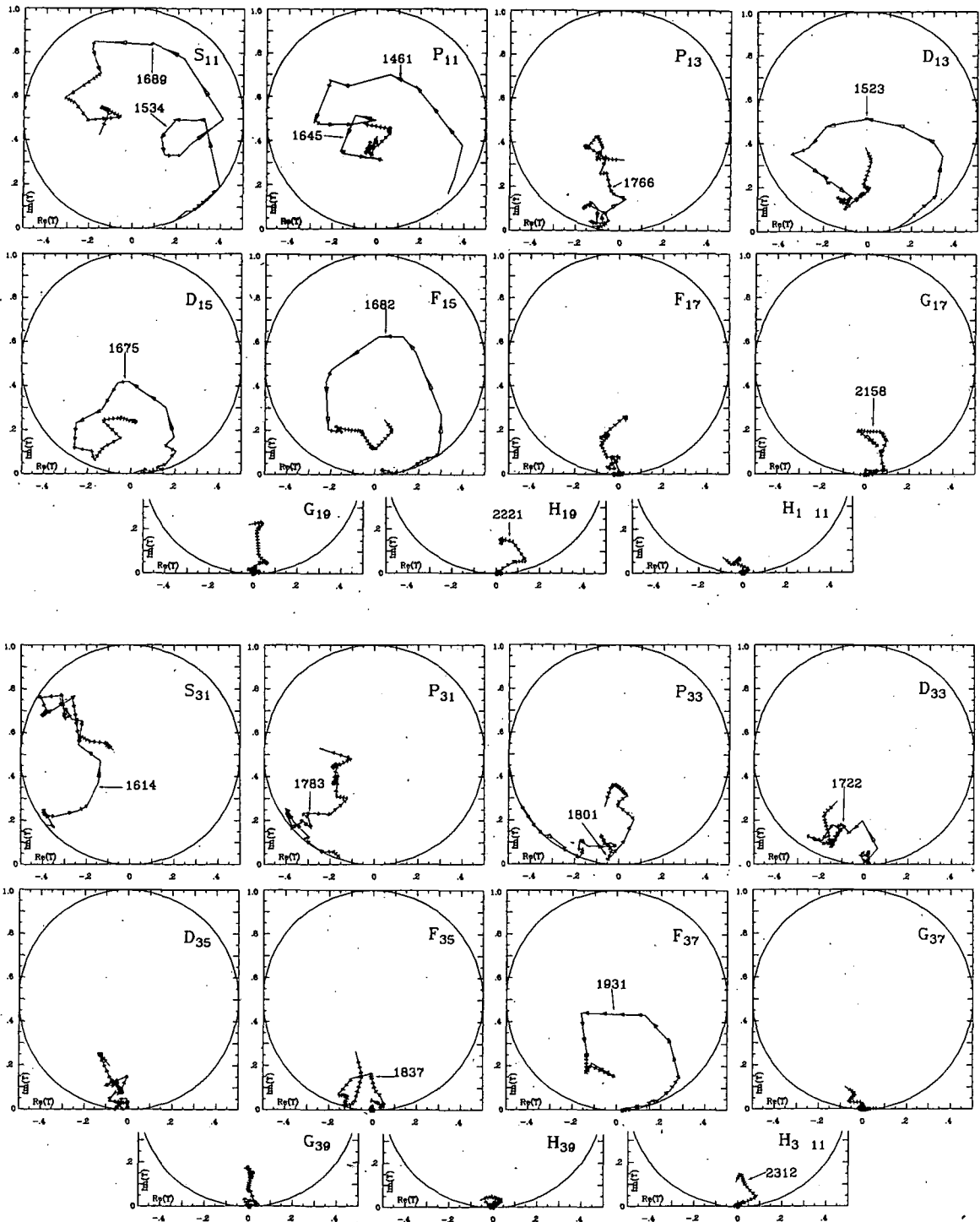
N's and  $\Delta$ 's

Fig. 2.  $\pi N$  Argand plots from the "minimum surface" solution of AYED 70 [Phys. Letters 31B, 598 (1970)]. To conserve space, we arbitrarily do not show the "minimum path" solution; it is not significantly different. The bases of the arrowheads are 20 MeV apart; the last point is at  $\sim 2400$  MeV.

# Baryons

## N's and $\Delta$ 's

## Data Card Listings

For notation, see key at front of Listings.

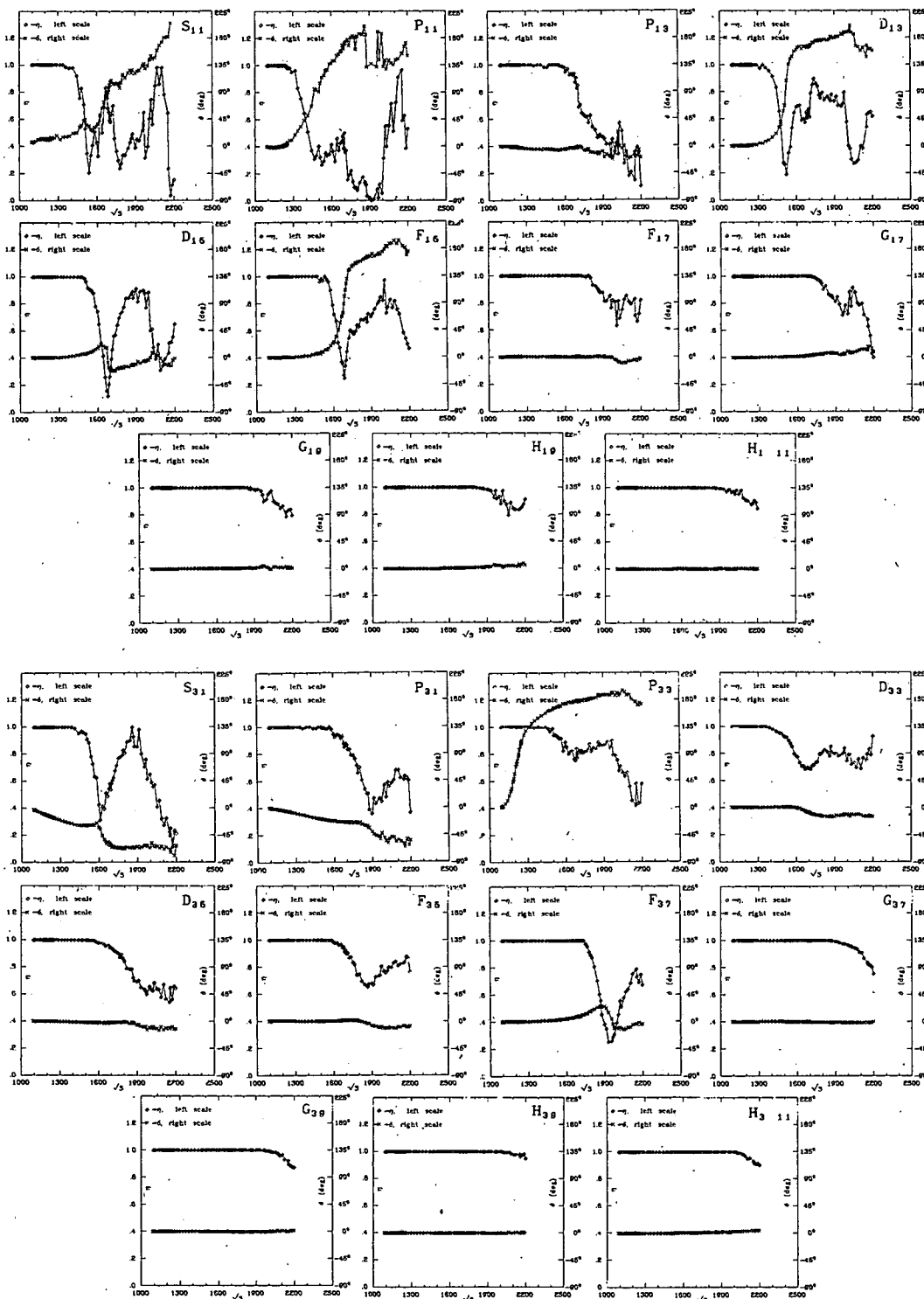


Fig. 3.  $\delta$  and  $\eta$  versus c.m. energy (in MeV) from the  $\pi N$  partial-wave analysis solution of ALMEHED 72.  $\times$  denotes  $\delta$  (right-hand scale),  $\diamond$  denotes  $\eta$  (left-hand scale).

## Data Card Listings

For notation, see key at front of Listings.

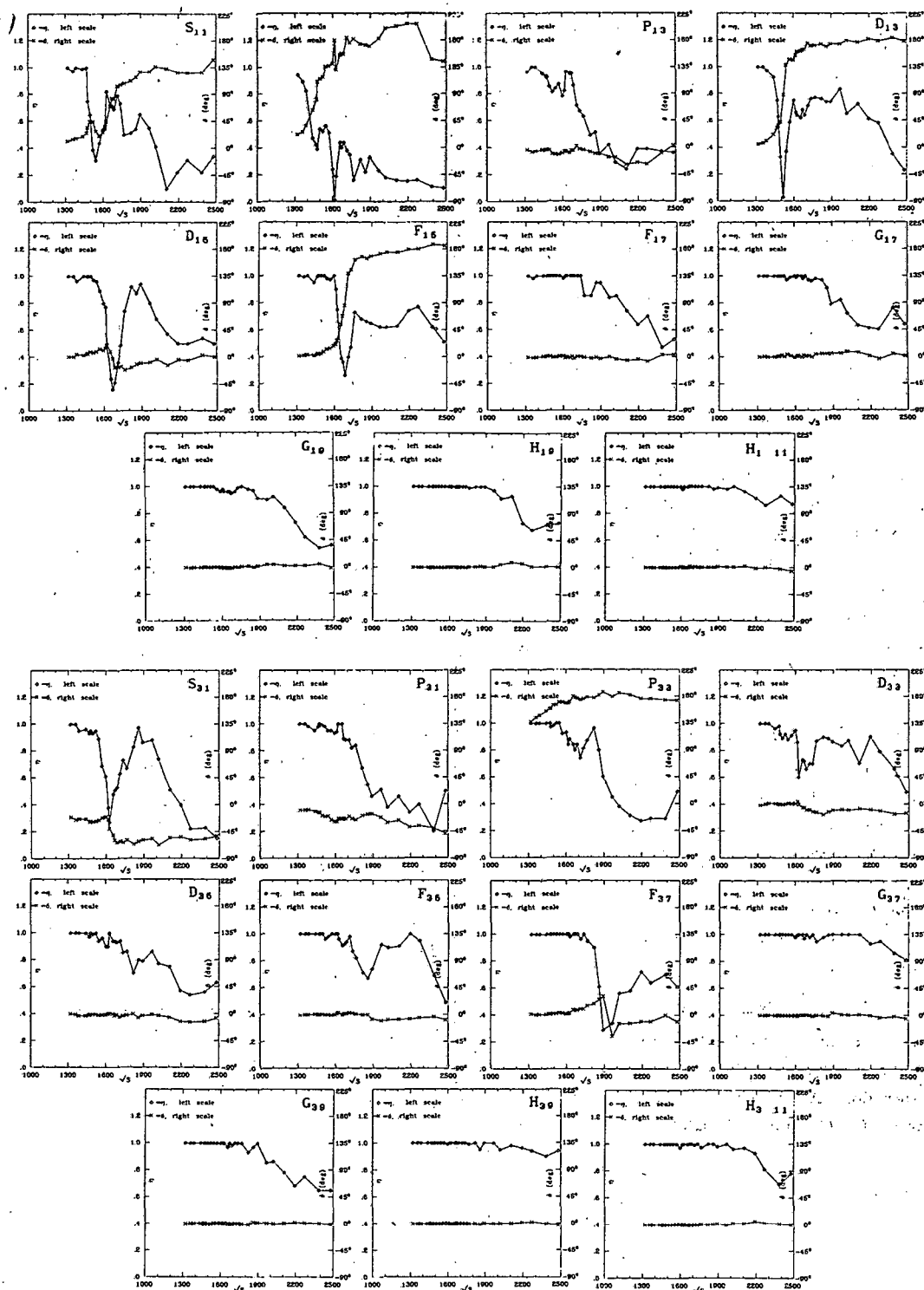
Baryons  
N's and  $\Delta$ 's

Fig. 4.  $\delta$  and  $\eta$  versus c.m. energy (in MeV) from the  $\pi N$  partial-wave analysis "minimum surface" solution of AYED 70 [Phys. Letters 31B, 598(1970)].  $\times$  denotes  $\delta$  (right-hand scale),  $\diamond$  denotes  $\eta$  (left-hand scale).

## Baryons N's and $\Delta$ 's

phase-shift results with an energy-dependent background and Breit-Wigner amplitudes. (This analysis appears only in the unpublished Kiev Conference report of AYED 70, not in their Physics Letter.) BAREYRE 68 uses two methods: 1) cross-section method — the energy where the total cross section is maximum; 2) speed method — the energy where the speed of variation of the amplitude in the Argand plot is maximum. CERN, as well as ALMEHED 72, quotes only one method, usually where the absorption is maximum. The Glasgow group (DAVIES 70) uses Breit-Wigner parametrization; their solutions A and B differ in the starting values of the minimization (CERN I solution was used for solution B). Only the parameters from solution A are included in the listings. For some states no parameters have been quoted by the authors.

At the beginning of the Data Card Listings for N's and  $\Delta$ 's, we present a table giving our evaluation of the N and  $\Delta$  resonances based on information contained in the Listings. In the Table of Particle Properties, we do not quote values and errors for parameters, but only give ranges for masses and widths in order to emphasize that in some cases these parameters are quite poorly determined.

### Availability of Partial-Wave Analyses and Data

All the solutions mentioned in this note, including AYED 70 and ALMEHED 72, are available on tape from the Particle Data Group. This tape is essentially an updated version of the one corresponding to the compilation of Ref. 2. In addition, the extensive input data used by ALMEHED 72 (courtesy of C. Lovelace) are also available on tape from the Particle Data Group.

### References

1. Particle Data Group, Rev. Mod. Phys. **43**, No. 2, Part II, S1 (1971).
2. D. J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld, UCRL-20030  $\pi$ N (Feb. 1970).

## Data Card Listings

*For notation, see key at front of Listings.*

### Note on N's and $\Delta$ 's: Isobar Model Fits

In the figure below we show the inelastic Argand plots of Herndon 72.<sup>1</sup> These plots are the result of a partial-wave analysis, using the isobar model, of  $\pi$ N  $\rightarrow$   $\pi$  $\pi$ N data in the c.m. energy range 1300-2000 MeV. The partial waves are labeled

$$LL'_{2I2J}(R),$$

where L is the incoming ( $\pi$ N) angular momentum, and L' is the outgoing angular momentum between the isobar R [ $\rho$ ,  $\epsilon$  ( $= \pi\pi$  I=0, S wave),  $\Delta$ ] and the remaining hadron ( $\pi$  or N); as usual I and J are the isospin and total spin ( $\vec{J} = \vec{L} + \vec{S} = \vec{L}' + \vec{S}'$ ) respectively. Also indicated on these Argand plots are the locations (in MeV) of known or suspected resonances from  $\pi$ N  $\rightarrow$   $\pi$ N partial-wave analyses.

Clear circular behavior is observed in many of these plots. Perhaps the most interesting among these are the  $DP_{13}(\epsilon)$  and  $DS_{13}(\Delta)$  partial waves. While all the  $D_{13}$  waves show evidence for the well-known N(1520), these two indicate some effect in the 1700-1800 MeV region—perhaps the long sought after  $D_{13}(1700)$ .

In order to estimate the inelastic coupling of the resonances indicated in these plots, we measured (with a ruler!) the diameters of "interpolated" circles. Recall that

$$A = \frac{\sqrt{xx'}}{\epsilon - i}, \quad \epsilon = \frac{2(M-E)}{\Gamma_{\text{tot}}}, \quad x = \frac{\Gamma_{\text{el}}}{\Gamma_{\text{tot}}}, \quad x' = \frac{\Gamma_{\text{inel}}}{\Gamma_{\text{tot}}};$$

thus, at resonance ( $\epsilon = 0$ ) the circle diameter is  $\sqrt{xx'}$ . The amplitudes at resonance thus estimated are given in the following table. The spread in values represents our guess as to the range in resonance circles consistent with the data.

### Reference

1. D. J. Herndon et al., LBL-1065 Rev. (1972), submitted to Phys. Rev.

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

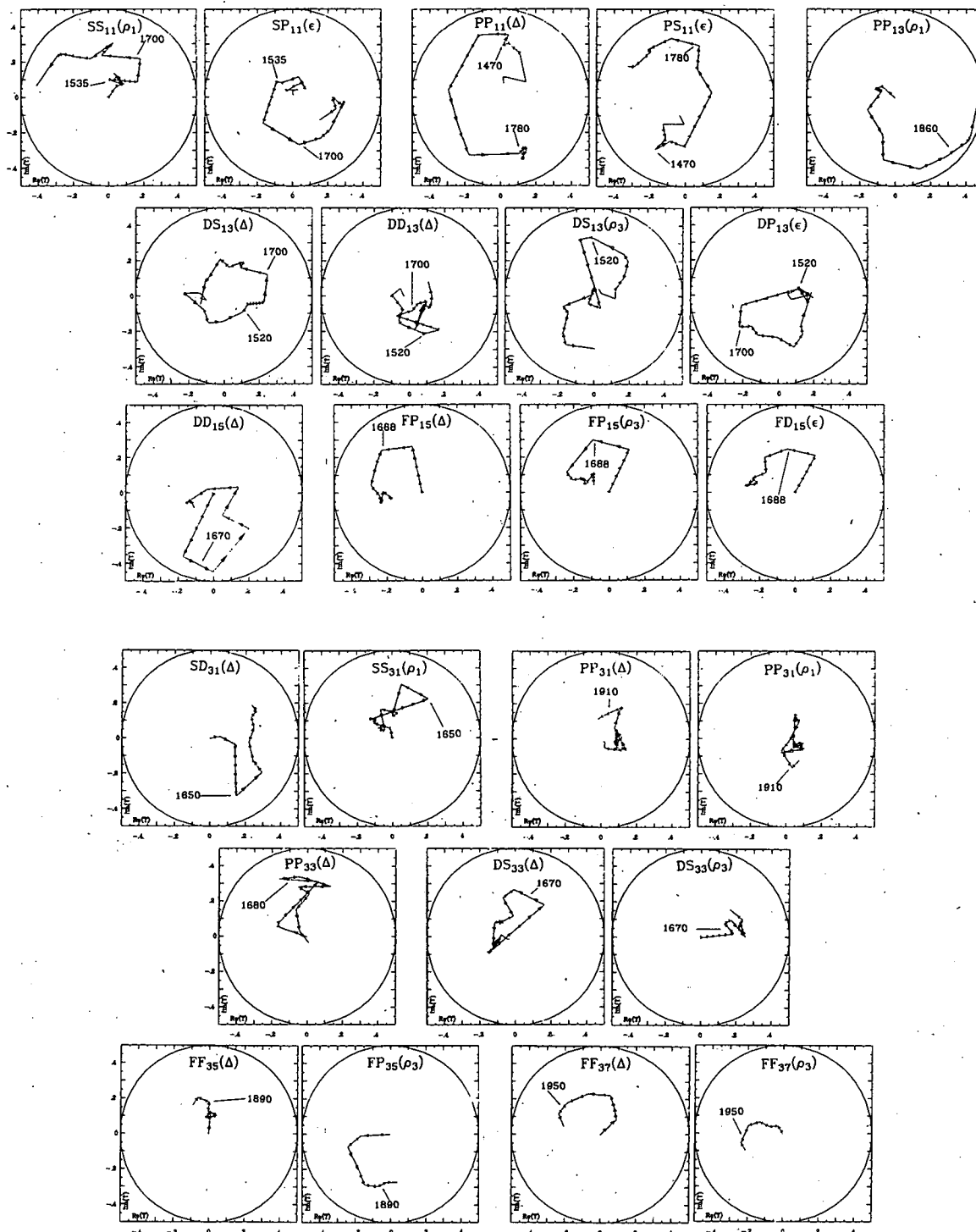
N's and  $\Delta$ 's

Fig. "Isobar" model Argand plots from Herndon 72. The bases of the arrowheads are 20 MeV apart. The solution covers the energy interval 1300-2000 MeV. See the mini-review text for partial-wave notation.

## Baryons

N's and  $\Delta$ 's

## Data Card Listings

For notation, see key at front of Listings.

Amplitude at resonance,  $\sqrt{s} \chi^{\dagger}$ , as estimated from Argand plots of Herndon 72.<sup>1</sup> A dash indicates coupling cannot exist or is essentially zero.

| N's            | $\chi$<br>(PDG) | $\pi N \rightarrow \rho N$ | $\pi N \rightarrow \epsilon N$ | $\pi N \rightarrow \pi \Delta$               | $\Delta$ 's      | $\chi$<br>(PDG) | $\pi N \rightarrow \rho N$ | $\pi N \rightarrow \pi \Delta$ |
|----------------|-----------------|----------------------------|--------------------------------|----------------------------------------------|------------------|-----------------|----------------------------|--------------------------------|
| $S_{11}(1535)$ | .35             | .07-.09                    | small                          | ---                                          | $S_{31}(1650)$   | .28             | .15-.21                    | .27-.30                        |
| $S_{11}(1700)$ | .60             | .20-.30                    | .39-.44                        | ---                                          | $P_{31}(1910)$   | .25             | .08-.20                    | .10-.20                        |
| $P_{11}(1470)$ | .60             | ---                        | .18-.22                        | .35-.42                                      | $P_{33}(1680)^a$ | ~.10            | ---                        | .29-.45                        |
| $P_{11}(1780)$ | .20             | ---                        | .48-.55                        | .43-.50                                      | $D_{33}(1670)$   | .15             | small                      | .18-.21                        |
| $P_{13}(1860)$ | .25             | .43-.51                    | ---                            | ---                                          | $F_{35}(1890)$   | .17             | .31-.35                    | small                          |
| $D_{13}(1520)$ | .50             | .31-.35                    | .05-.10                        | .28-.34 <sup>b</sup><br>.11-.15 <sup>c</sup> | $F_{37}(1950)$   | .45             | .19-.23                    | .25-.29                        |
| $D_{13}(1700)$ | ~.10            | small                      | .29-.35                        | .09-.13 <sup>b</sup><br>small <sup>c</sup>   |                  |                 |                            |                                |
| $D_{15}(1670)$ | .40             | ---                        | ---                            | .45-.49                                      |                  |                 |                            |                                |
| $F_{15}(1688)$ | .60             | .29-.31                    | .27-.28                        | .27-.28                                      |                  |                 |                            |                                |

<sup>a</sup> Not in main Baryon Table.<sup>b</sup>  $DS_{13}$ .<sup>c</sup>  $DD_{13}$ .Note on N's and  $\Delta$ 's: Photon Couplings

In this edition we start to quote results on the couplings of baryon resonances to the  $\gamma N$  system. They can be studied in reactions like

$$\gamma N \rightarrow N^* \rightarrow \pi N, K\Lambda, K\Sigma, \pi\Delta, \dots$$

A partial-wave analysis of these formation processes is the standard technique to determine the coupling strengths,  $g(N^* N \gamma)$ . Up to now almost all results are derived from analyses of pion-photoproduction. In the following we therefore outline the formulation of pion-photoproduction and define the conventions in which results will be quoted.

The process  $\gamma N \rightarrow N^* \rightarrow \pi N$  for a specific intermediate resonance can be symbolically described as

$$\langle \pi N | H_{\pi} | N^* \rangle \langle N^* | H_{\gamma} | \gamma N \rangle. \quad (1)$$

The first term is measured in strong interactions, e. g. by partial-wave analysis of  $\pi N$  elastic scattering. A common feature of almost all analyses of pion-photoproduction is a strong reliance on the knowledge of resonance parameters from  $\pi N$  phase-shift

analyses. Very few attempts are made to determine new  $\pi N$  resonance parameters, partly because of lack of precise enough data, partly because photoproduction is complicated by the fact that the photon has spin states  $\pm 1$  and can react as an isoscalar or isovector. Consequently in general, several couplings for  $N^* \rightarrow \gamma N$  (2 for  $\Delta$ , 4 for N) have to be determined.

Isospin Decomposition

We ignore possible isotensor components and treat the electromagnetic current as having isoscalar and isovector components only, while the final  $\pi N$ -state has isospin 1/2 and 3/2 components. Therefore three independent isospin amplitudes describe the 4 reactions

$$\gamma p \rightarrow \pi^+ n, \pi^0 p$$

$$\gamma n \rightarrow \pi^+ p, \pi^0 n.$$

They can be chosen as the isoscalar transition to final state  $I=1/2$ , isovector transition to final state  $I=1/2$  and isovector transition to final state  $I=3/2$ .

# Data Card Listings

For notation, see key at front of Listings.

## Baryons N's and $\Delta$ 's

We define amplitudes  $A^\Delta$ ,  $A^P$ , and  $A^n$  such that they are naturally related to the excitation of the physical states  $\Delta$ ,  $N^{*+}$  and  $N^{*0}$ . Ignoring spin labels, a transition amplitude  $A(\gamma N \rightarrow \pi N)$  is described by

$$A(\gamma p \rightarrow \pi N) = C_{\pi N}^{3/2} A^\Delta + C_{\pi N}^{1/2} A^P, \quad (2)$$

$$A(\gamma n \rightarrow \pi N) = C_{\pi N}^{3/2} A^\Delta + C_{\pi N}^{1/2} A^n,$$

where  $C_{\pi N}^I$  is the C-G coefficient for the coupling of isospin  $I$  to the specific  $\pi N$  state under consideration.

An alternative set of amplitudes  $A^{V3}$ ,  $A^{V1}$ , and  $A^S$  is used by Walker<sup>1</sup> with the relations

$$\begin{aligned} A^{V3} &= A^\Delta, \\ A^{V1} &= \frac{1}{2} (A^n - A^P), \\ A^S &= \frac{1}{2} (A^n + A^P), \end{aligned} \quad (3)$$

where  $A^{V3}$  refers to isovector transition to final state  $I=3/2$ , and  $A^{V1}$  and  $A^S$  refer to isovector and isoscalar transitions to final state  $I=1/2$  respectively.

### Partial Waves

The S-matrix element for pion-photoproduction ( $\gamma N_1 \rightarrow \pi N_2$ ) is written in the form

$$S_{fi} = i(2\pi)^5 \delta^4(P_f - P_i) W(k\omega E_1 E_2)^{-1/2} A \quad (4)$$

where  $P_f$  and  $P_i$  are the total 4-momenta in the final and initial state,  $k$ ,  $\omega$ ,  $E_1$ , and  $E_2$  denote the c.m. energies of photon, pion, initial and final nucleon, and  $W$  is the total c.m. energy.

For a partial-wave analysis it is convenient to decompose  $A$  into helicity amplitudes<sup>2</sup>. Choosing the x-z plane as the scattering plane, the z-axis along the photon direction, and  $\theta$  as the c.m. scattering angle between photon and pion, we define helicity amplitudes  $A_{\mu\lambda}^j(W, \theta)$  (ignoring isospin labels). Here  $\mu$  and  $\lambda$  denote the total final and initial helicities,  $\mu = \lambda_\pi - \lambda_2$ ,  $\lambda = \lambda_\gamma - \lambda_1$ . Since  $\lambda_\gamma = \pm 1$  and  $\lambda_{1,2} = \pm 1/2$ , we have a set of 8 helicity amplitudes. Because of parity conservation<sup>2</sup> only 4 are independent, which we choose by fixing  $\lambda_\gamma = +1$ . We thus consider  $A_{\pm 1/2, 1/2}$  and  $A_{\pm 1/2, 3/2}$ . They are normalized such that the differential cross section is given by

$$\frac{d\sigma}{d\Omega} = \frac{1}{2} \frac{q}{k} \sum_{\lambda, \mu} |A_{\mu\lambda}|^2.$$

Each of these is expanded in the usual way<sup>2</sup>

$$A_{\mu\lambda}^j(W, \theta) = \sum_j (2j+1) A_{\mu\lambda}^j(W) d_{\lambda\mu}^j(\theta) \quad (5)$$

into partial wave amplitudes  $A_{\mu\lambda}^j(W)$  of total angular momentum  $j$  (but mixed parity) and the Wigner rotation functions.

We define amplitudes of definite parity by

$$\begin{aligned} C_\lambda^{\ell+}(W) &= \frac{1}{\sqrt{2}} [A_{1/2\lambda}^j(W) + A_{-1/2\lambda}^j(W)] \\ C_\lambda^{\ell+1-}(W) &= \frac{1}{\sqrt{2}} [A_{1/2\lambda}^j(W) - A_{-1/2\lambda}^j(W)] \end{aligned} \quad (6)$$

where  $\lambda = 1/2, 3/2$ . The superscripts  $\ell \pm$  refer in the usual notation to states with pion orbital angular momentum  $\ell$  and total angular momentum  $j = \ell \pm 1/2$ .

Unitarity of the S-matrix imposes a phase condition on the C amplitudes known as Watson's theorem. It states that in the elastic region the phase of each  $C_\lambda^{\ell \pm}$  is equal to the scattering phase of the corresponding  $\pi N$ -partial wave.

Since we are interested in intermediate resonances, we approximate the energy dependence of  $C_\lambda^{\ell \pm}(W)$  by a Breit-Wigner form

$$C_\lambda^{\ell \pm}(W) = s \left\{ \frac{\Gamma^\lambda(N^* \rightarrow \gamma N) \Gamma(N^* \rightarrow \pi N)}{k \cdot q} \right\}^{1/2} \frac{W}{W^2 - m_R^2 - iWT} \quad (7)$$

where  $s$  is the sign of the amplitude,  $m_R$  the resonance energy and  $k, q$  the c.m. momenta in the initial, final states. At resonance ( $W = m_R$ )

$$C_\lambda^{\ell \pm}(m_R) = s \left\{ \frac{\Gamma^\lambda_\gamma \Gamma_\pi}{k \cdot q \cdot \Gamma^2} \right\}^{1/2} \quad (8)$$

A dominant feature in pion-photoproduction is the Born approximation which contains the nucleon pole in the s- and u-channel and the pion pole in the t-channel. It reproduces, e.g., the experimentally observed forward peak in charged pion-photoproduction. In partial-wave analyses the sign factor  $s$  is well determined relative to the Born terms.

Introducing helicity amplitudes  $A_{\lambda}^{jP}$  for the decay  $N^*(j^P) \rightarrow (\gamma N)_\lambda$  (where  $j^P$  labels spin and parity of the  $N^*$ ), we can calculate the radiative width  $\Gamma_Y^{\lambda 3}$  at resonance energy  $W = m_R$

$$\Gamma_Y^{\lambda 3} = \frac{k^2}{\pi} \frac{m_N}{m_R} \frac{1}{2j+1} |A_{\lambda}^{jP}(m_R)|^2 \quad (9)$$

# Baryons N's and Δ's

where  $m_N$  is the nucleon mass. Introducing this expression into eq. (8) we find

$$C_{\lambda}^{\ell\pm}(m_R) = \left\{ \frac{1}{(2j+1)\pi} \frac{k}{q} \frac{m_N}{m_R} \frac{\Gamma_{\pi}}{\Gamma^2} \right\}^{1/2} A_{\lambda}^{jP}(m_R). \quad (10)$$

We quote results of partial-wave analyses in terms of the amplitudes  $A_{\lambda}^{jP}$  in units of  $\text{GeV}^{-1/2}$ .

The total radiative width  $\Gamma_{\gamma}$  and the contribution  $\sigma_T^{jP}$  of the partial waves  $C_{\lambda}^{\ell\pm}$  to the total cross section are given by

$$\Gamma_{\gamma} = \sum_{\lambda=-3/2}^{3/2} \Gamma_{\gamma}^{\lambda} = \frac{k^2}{\pi} \frac{m_N}{m_R} \frac{2}{2j+1} \left\{ |A_{1/2}^{jP}|^2 + |A_{3/2}^{jP}|^2 \right\} \quad (11)$$

## Data Card Listings

For notation, see key at front of Listings.

$$\sigma_T^{jP} = (C_{\pi N}^I)^2 2 \frac{m_N}{m_R} \frac{\Gamma_{\pi}}{\Gamma^2} \left\{ |A_{1/2}^{jP}|^2 + |A_{3/2}^{jP}|^2 \right\} \quad (12)$$

### Information in this Edition

The Baryon Table contains the branching fractions  $\Gamma_{\gamma}/\Gamma$  for 13 resonances.

Many partial-wave analyses have been performed over the last years using different methods and different data sets. R. Crawford<sup>4</sup> has averaged the results and tried to estimate the certainty of the parameters. His table is included in this mini-review.

The Data Card Listings contain the results of the analyses by Moorhouse and Oberlack<sup>5</sup> and Metcalf and Walker<sup>6</sup> which use the most recent data set

Photon couplings of baryon resonances as compiled by R. Crawford.<sup>4</sup>

| State      | W<br>(GeV) | $\Gamma$<br>(GeV) | $\kappa$ | $\lambda$  | $A_{\lambda}^P$<br>(GeV) <sup>-1/2</sup>                           | $A_{\lambda}^n$<br>(GeV) <sup>-1/2</sup> | $A_{\lambda}^{V1}$<br>(GeV) <sup>-1/2</sup> | $A_{\lambda}^S$<br>(GeV) <sup>-1/2</sup> | References              |
|------------|------------|-------------------|----------|------------|--------------------------------------------------------------------|------------------------------------------|---------------------------------------------|------------------------------------------|-------------------------|
| $P_{11}^+$ | 1.470      | 0.200             | 0.55     | 1/2        | -.04 <sup>c</sup>                                                  | ~0                                       | +.02                                        | -.02                                     | 1, 5, 9, 10, 11, 12, 13 |
| $D_{13}^+$ | 1.520      | 0.120             | 0.50     | 1/2<br>3/2 | -.03 <sup>b</sup><br>+.17 <sup>a</sup>                             | -.08 <sup>b</sup><br>-.13 <sup>a</sup>   | -.03<br>-.15                                | -.06<br>+.02                             | 1, 5, 9, 10, 11, 12, 13 |
| $S_{11}^+$ | 1.530      | 0.080             | 0.35     | 1/2        | +.07 <sup>b</sup>                                                  | -.07 <sup>b</sup>                        | -.07                                        | 0                                        | 1, 5, 9, 10, 11, 12, 13 |
| $D_{15}^+$ | 1.670      | 0.145             | 0.45     | 1/2<br>3/2 | +.01 <sup>d</sup><br>+.02 <sup>c</sup>                             | +.01 <sup>d</sup><br>-.03 <sup>c</sup>   | 0<br>-.03                                   | +.01<br>-.01                             | 1, 5, 10, 12            |
| $F_{15}^+$ | 1.690      | 0.125             | 0.60     | 1/2<br>3/2 | -.01 <sup>c</sup><br>+.12 <sup>b</sup>                             | +.02 <sup>c</sup><br>~0                  | +.02<br>-.06                                | +.01<br>+.06                             | 1, 5, 10, 12            |
| $S_{11}''$ | 1.700      | 0.200             | 0.65     | 1/2        | +.07 <sup>c</sup>                                                  | -.07 <sup>c</sup>                        | -.07                                        | 0                                        | 5                       |
| $P_{11}''$ | 1.750      | 0.300             | 0.25     | 1/2        | +.03 <sup>d</sup>                                                  | +.03 <sup>c</sup>                        | 0                                           | +.03                                     | 5                       |
|            |            |                   |          |            | $A_{\lambda}^{\Delta} = A_{\lambda}^{V3}$<br>(GeV) <sup>-1/2</sup> | X                                        |                                             |                                          |                         |
| $P_{33}^+$ | 1.236      | 0.120             | 1.00     | 1/2<br>3/2 | -.14 <sup>a</sup><br>-.24 <sup>a</sup>                             |                                          |                                             |                                          | 1, 5, 7, 8, 10          |
| $S_{31}$   | 1.650      | 0.160             | 0.25     | 1/2        | +.09 <sup>c</sup>                                                  |                                          |                                             |                                          | 5                       |
| $D_{33}$   | 1.650      | 0.220             | 0.15     | 1/2<br>3/2 | +.07 <sup>c</sup><br>+.02 <sup>d</sup>                             |                                          |                                             |                                          | 5                       |

<sup>a</sup> The uncertainty of the coupling is less than 20%.

<sup>b</sup> The uncertainty of the coupling is less than 50%.

<sup>c</sup> The sign of the coupling is probably established, but its size may be uncertain by up to 100%.

<sup>d</sup> The sign of the coupling is not clearly established.

## Data Card Listings

For notation, see key at front of Listings.

and cover a large energy region (up to the 4th resonance region).

Moorhouse and Oberlack quote their results in terms of the  $A_{\lambda}^{jP}$  introduced above. Metcalf and Walker follow the conventions of Walker.<sup>1</sup> Their amplitudes  $A_{\ell\pm}$ ,  $B_{\ell\pm}$  are related to the  $A_{\lambda}^{jP}$  by:

$$A_{\ell\pm}(m_R) = \mp \left\{ \frac{1}{(2j+1)\pi} \frac{k m_N}{q m_R} \frac{\Gamma_{\pi}}{\Gamma^2} \right\}^{1/2} C_{\pi N}^I A_{1/2}^{jP}(m_R) \quad (13)$$

$$B_{\ell\pm}(m_R) = \pm \left\{ \frac{1}{(2j+1)\pi} \frac{k m_N}{q m_R} \frac{\Gamma_{\pi}}{\Gamma^2} \right\}^{1/2} \times \left\{ \frac{16}{(2j-1)(2j+3)} \right\}^{1/2} C_{\pi N}^I A_{3/2}^{jP}(m_R) \quad (14)$$

A more comprehensive collection of results and of the relationships between conventions used in different analyses will be included in the next edition.

(H. Oberlack, LBL)

## References

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## Baryons

N's and  $\Delta$ 's, p, n, N(1470)

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CODE EVENTS QUANTITY ERROR+ ERROR- REFERENCE YR TECN SIGN COMMENTS DATE  
ABOVE PUNCHED  
BACKGROUND

\*\*\*\*\*

STATUS OF N\* RESONANCES  
THOSE WITH AN OVERALL STATUS OF \*\*\* OR \*\*\*\* ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

STATUS AS SEEN IN --

| PARTICLE | LIJ | STATUS | OVERALL | TOTAL* | PI | N | ETA | N | K | LAM | K | SIG | PI | DE | GAM | N | OTHER |
|----------|-----|--------|---------|--------|----|---|-----|---|---|-----|---|-----|----|----|-----|---|-------|
| N(940)   | P11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1470) | P11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1520) | D13 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1535) | S11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1670) | D15 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1688) | F15 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1700) | S11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1700) | D13 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1780) | P11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1860) | P13 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(1990) | F17 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2040) | D13 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2100) | S11 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2100) | D15 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2175) | F15 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2190) | G17 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2220) | H19 | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(2650) |     | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(3030) |     | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(3245) |     | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(3690) |     | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |
| N*(3755) |     | ****   |         |        |    |   |     |   |   |     |   |     |    |    |     |   |       |

|          |      |      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|----------|------|------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| DE(1236) | P33  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1650) | S31  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1670) | D33  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1690) | P33  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1890) | F35  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1910) | P31  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1950) | F37  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(1960) | D35  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(2160) | P33  | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(2420) | H311 | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(2850) |      | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| DE(3230) |      | **** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

\*\*\*\* GOOD, CLEAR, AND UNMISTAKABLE.  
\*\*\* GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.  
\*\* NEEDS CONFIRMATION.  
\* WEAK.  
\* ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

p

16 PROTON (938, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

n

17 NEUTRON (939, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

N(1470)

61 N\*1/2(1470, JP=1/2+) I=1/2

P'11

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE ABOVE

THE MASS AND WIDTH ARE BEST DETERMINED FROM PHASE-SHIFT ANALYSES. WE LIST PRODUCTION EXPERIMENTS SEPARATELY--SEE BELOW.  
A PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 CLAIMS THERE ARE TWO P11 STATES IN THE 1500 MEV REGION. THE MOST SERIOUS DISAGREEMENT BETWEEN ALMEHD 72 AND AYED 72 IN FACT OCCURS IN THIS WAVE.  
SEE THE N\* MINI REVIEW.

# Baryons N(1470)

# Data Card Listings For notation, see key at front of Listings.

| 61 N*1/2(1470) MASS (MEV) |          |                                               |         |                  |       |  |  |  |  |
|---------------------------|----------|-----------------------------------------------|---------|------------------|-------|--|--|--|--|
| M                         | (1370.0) | BRANDSEN                                      | 65 RVUE | PHASE-SHIFT ANAL | 9/66  |  |  |  |  |
| M                         | (1380.0) | ROPER                                         | 65 RVUE | PHASE-SHIFT ANAL | 9/66  |  |  |  |  |
| M 1                       | (1470.0) | BARREYRE                                      | 68 RVUE | PHASE-SHIFT ANAL | 11/67 |  |  |  |  |
| M 1                       |          | WHERE CROSS SECTION IS GREATEST - EYEBALL FIT |         |                  |       |  |  |  |  |
| M 3                       | (1466.0) | DONNACHI                                      | 68 RVUE | PHASE-SHIFT ANAL | 6/68  |  |  |  |  |
| M 6                       | (1461.0) | AYED                                          | 70 IPWA |                  | 1/71  |  |  |  |  |
| M 6                       | (1464.0) | FROM ENR. DEP. FIT OF ARGAND DIAGRAM          |         |                  |       |  |  |  |  |
| M 4                       | (1462.0) | DAVIES                                        | 70 RVUE | P-S ANAL SOL A   | 8/69  |  |  |  |  |
| M 7                       | (1470.)  | ALMEHED                                       | 72 IPWA |                  | 2/72  |  |  |  |  |

| 61 N*1/2(1470) WIDTH (MEV)                    |         |          |         |                |       |  |  |  |  |
|-----------------------------------------------|---------|----------|---------|----------------|-------|--|--|--|--|
| W 1                                           | (255.0) | BARREYRE | 68 RVUE |                | 11/67 |  |  |  |  |
| W 3                                           | (211.0) | DONNACHI | 68 RVUE |                | 6/68  |  |  |  |  |
| W 4                                           | (194.0) | AYED     | 70 IPWA |                | 1/71  |  |  |  |  |
| W 4                                           | (391.)  | DAVIES   | 70 RVUE | P-S ANAL SOL A | 8/69  |  |  |  |  |
| W 7                                           | (220.)  | ALMEHED  | 72 IPWA |                | 2/72  |  |  |  |  |
| SEE THE NOTES ACCOMPANYING THE MASSES QUOTED. |         |          |         |                |       |  |  |  |  |

| 61 N*1/2(1470) PARTIAL DECAY MODES |                                      |  |  |               |  |  |  |  |  |
|------------------------------------|--------------------------------------|--|--|---------------|--|--|--|--|--|
| P1                                 | N*1/2(1470) INTO PI N                |  |  | DECAY MASSES  |  |  |  |  |  |
| P2                                 | N*1/2(1470) INTO N EPSILON           |  |  | 139+ 938      |  |  |  |  |  |
| P3                                 | N*1/2(1470) INTO N*3/2(1236) PI      |  |  | 938+ 600      |  |  |  |  |  |
| P4                                 | N*1/2(1470) INTO N PI P1             |  |  | 1236+ 139     |  |  |  |  |  |
| P5                                 | N*1/2(1470) INTO GAMMA N             |  |  | 938+ 139+ 139 |  |  |  |  |  |
| P6                                 | N*1/2(1470) INTO N RHO               |  |  | 0+ 938        |  |  |  |  |  |
| P7                                 | N*1/2(1470) INTO GAM P, HELICITY=1/2 |  |  | 938+ 770      |  |  |  |  |  |
| P8                                 | N*1/2(1470) INTO GAM N, HELICITY=1/2 |  |  | 0+ 939        |  |  |  |  |  |

| 61 N*1/2(1470) BRANCHING RATIOS                                          |                               |          |         |                |       |  |  |  |  |
|--------------------------------------------------------------------------|-------------------------------|----------|---------|----------------|-------|--|--|--|--|
| R1                                                                       | N*1/2(1470) INTO (PI N)/TOTAL |          |         | (P1)           |       |  |  |  |  |
| R1 1                                                                     | (0.66)                        | BARREYRE | 68 RVUE |                | 11/67 |  |  |  |  |
| R1 3                                                                     | (0.58)                        | DONNACHI | 68 RVUE |                | 6/68  |  |  |  |  |
| R1 6                                                                     | (0.564)                       | AYED     | 70 IPWA |                | 1/71  |  |  |  |  |
| R1 4                                                                     | (0.49)                        | DAVIES   | 70 RVUE | P-S ANAL SOL A | 8/69  |  |  |  |  |
| R1 A                                                                     | (0.67) (0.18)                 | SAXON    | 70 HBC  | AT 1400 MEV    | 6/70  |  |  |  |  |
| R1 B                                                                     | (0.58)                        | SAXON    | 70 HBC  |                | 6/70  |  |  |  |  |
| R1 A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. ANALYSIS IS DONE ON THREE |                               |          |         |                |       |  |  |  |  |
| R1 B BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT.            |                               |          |         |                |       |  |  |  |  |
| R1 7                                                                     | (0.65)                        | ALMEHED  | 72 IPWA |                | 2/72  |  |  |  |  |
| SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.                            |                               |          |         |                |       |  |  |  |  |

|                                                                |                                                          |           |         |                    |       |  |  |  |  |
|----------------------------------------------------------------|----------------------------------------------------------|-----------|---------|--------------------|-------|--|--|--|--|
| R2                                                             | N*1/2(1470) INTO (N EPSILON)/TOTAL                       |           |         | (P2)               |       |  |  |  |  |
| R2                                                             | DOMINANT INELASTIC DECAY                                 | THURNAUER | 65 RVUE |                    | 11/67 |  |  |  |  |
| R2                                                             | DOMINANT INELASTIC DECAY                                 | NAMYSLOWS | 66 RVUE |                    | 11/67 |  |  |  |  |
| R2                                                             | DOMINANT INELASTIC DECAY                                 | ROSENFELD | 67 RVUE |                    | 11/67 |  |  |  |  |
| R2                                                             | DOMINANT INELASTIC DECAY                                 | MORGAN    | 68 RVUE | ISOBAR MODEL       | 6/68  |  |  |  |  |
| R2 D                                                           | (0.16)                                                   | DIEM      | 70 IPWA | 3 BODY ANALYSIS    | 1/71  |  |  |  |  |
| R2 O                                                           | ASSUMING R1=0.61                                         |           |         |                    |       |  |  |  |  |
| R2 A                                                           | (0.30) (0.20)                                            | SAXON     | 70 HBC  |                    | 6/70  |  |  |  |  |
| R2 B                                                           | (0.20) (0.12)                                            | SAXON     | 70 HBC  |                    | 6/70  |  |  |  |  |
| R2 A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. SEE NOTE IN R1. |                                                          |           |         |                    |       |  |  |  |  |
| R3                                                             | N*1/2(1470) INTO (N*3/2(1236) PI)/TOTAL                  |           |         | (P3)               |       |  |  |  |  |
| R3 D                                                           | (0.17)                                                   | DIEM      | 70 IPWA | 3 BODY ANALYSIS    | 1/71  |  |  |  |  |
| R3 A                                                           | ASSUMING R1=0.61                                         |           |         |                    |       |  |  |  |  |
| R3 A                                                           | (0.05) (0.20)                                            | SAXON     | 70 HBC  |                    | 6/70  |  |  |  |  |
| R3 B                                                           | (0.22) (0.12)                                            | SAXON     | 70 HBC  |                    | 6/70  |  |  |  |  |
| R3 A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. SEE NOTE IN R1. |                                                          |           |         |                    |       |  |  |  |  |
| R3 R                                                           | (0.20)                                                   | MAKAROV   | 71 IPWA | O PI- P TO PI PI N | 3/72  |  |  |  |  |
| R3 R                                                           | ASSUMES R1=0.6. MAXIMUM CM ENERGY ANALYZED WAS 1435 MEV. |           |         |                    |       |  |  |  |  |
| R4                                                             | N*1/2(1470) INTO (GAMMA N)/(PI N)                        |           |         | (P5)/(P1)          |       |  |  |  |  |
| R4 F                                                           | STRONG INDICATION                                        | ROSSI     | 73 DBC  | O GAM N TO PI-P    | 2/73* |  |  |  |  |
| R4 F                                                           | DISAGREES WITH OTHER DATA                                |           |         |                    | 2/73* |  |  |  |  |
| R5                                                             | N*1/2(1470) INTO (N RHO)/TOTAL                           |           |         | (P6)               |       |  |  |  |  |
| R5 D                                                           | (0.07)                                                   | DIEM      | 70 IPWA | 3 BODY ANALYSIS    | 1/71  |  |  |  |  |
| R5 D                                                           | ASSUMING -R1=0.61                                        |           |         |                    |       |  |  |  |  |
| R6                                                             | N*1/2(1470) INTO (GAMMA N)/TOTAL                         |           |         | (P5)               |       |  |  |  |  |
| R6 E                                                           | (0.006)                                                  | NICKENS   | 71      | THEORETICAL EST.   | 10/71 |  |  |  |  |
| R6 E                                                           | TOTAL WIDTH TAKEN AS 250 MEV.                            |           |         |                    |       |  |  |  |  |

| 61 N*1/2(1470) PHOTON DECAY AMPL(GEV**1/2)                                                       |                                                 |          |         |                 |       |  |  |  |  |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------|----------|---------|-----------------|-------|--|--|--|--|
| FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS. |                                                 |          |         |                 |       |  |  |  |  |
| A1                                                                                               | N*1/2(1470) INTO GAM P, HELICITY=1/2 (GEV**1/2) |          |         | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A1                                                                                               | -0.055 -0.028                                   | OBERLACK | 72 DPWA | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A1                                                                                               | (-0.73)                                         | WALKER   | 73 DPWA |                 |       |  |  |  |  |
| A2                                                                                               | N*1/2(1470) INTO GAM N, HELICITY=1/2 (GEV**1/2) |          |         | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A2                                                                                               | +0.002 -0.025                                   | OBERLACK | 72 DPWA | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A2                                                                                               | (+0.058)                                        | WALKER   | 73 DPWA |                 | 2/73* |  |  |  |  |

## REFERENCES FOR N\*1/2(1470)

|                          |                                                |
|--------------------------|------------------------------------------------|
| BRANDSEN 65 PR 139 81566 | +DONNELL, MOORHOUSE (DURHAM, RHENI)JP          |
| ROPER 65 PR 138 81590    | LD ROPER, RM WRIGHT, BT FELD (LRL-LVNR, MIT)JP |
| THURNAUE 65 PRL 14 985   | P G THURNAUER (ROCH)                           |
| NAMYSLOW 66 PR 157 1328  | NAMYSLOWSKI, RAZMI, ROBERTS (STAN, EDIN, LOIC) |
| ROSENFELD 67 IRVINE CONF | A H ROSENFELD, P SODING (LRL)                  |
| BARREYRE 68 PR 165 1731  | P BARREYRE, C BRICMAN, G VILLET (SACLAY)JP     |
| DONNACHI 68 PL 268 161   | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JP  |
| ALSO 68 VIENNA 139       | DONNACHIE RAPPORTEUR, S TALK (GLAS)            |
| THES 68 THES 15          | R G KIRSOPP (EDIN)                             |
| MORGAN 68 PR 166 1731    | D MORGAN (RHEL)                                |

|                        |                                                 |
|------------------------|-------------------------------------------------|
| AYED 70 KIEV CONF      | R AYED, P BARREYRE, G VILLET (SACL)JP           |
| DAVIES 70 NP B21 359   | A DAVIES (GLAS)                                 |
| DIEM 70 KIEV CONF.     | + SHADJA, CHAVANON, DELER, DOLBEAU+ (SACL)      |
| SAXON 70 PR D2 1790    | SAXON, MULVEY, CHINDOWSKI (OXF, LRL)            |
| MAKAROV 71 SJNP 13 510 | + GASILOVA, NELYUBIN, ++ (IOFFE INST)JP         |
| NICKENS 71 LNC 1 707   | R E NICKENS (FISK)                              |
| ALMEHED 72 NP 840 157  | + LOVELACE (LUND, RUTG)JP                       |
| OBERLACK 72 PL 438 44  | H OBERLACK, R G MOORHOUSE (LBL)                 |
| ROSSI 73 NC 13A 59     | +PIAZZA, SUSINNO, ++ (ROMA, FRAS, NAPL, ROMA)JP |
| ALSO 71 LNC 2 1183     | CARBONARA, FIORE, + (NAPL, FRAS, PAVIA, ROMA)JP |
| WALKER 73 TO BE PUB.   | R L WALKER, W J METCALF (CIT)                   |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                              |                                                 |
|------------------------------|-------------------------------------------------|
| BARREYRE 64 PL 8 137         | +BRICMAN, VALLADAS, VILLET, + (SACLAY, CAEN) JP |
| BARREYRE 65 PL 18 342        | +BRICMAN, STIRLING, VILLET (SACLAY)JP           |
| DALITZ 65 PL 14 159          | R H DALITZ, R G MOORHOUSE (OXF, RHEL)           |
| JOHNSON 67 UCRL-17683 THESIS | C H JOHNSON (LRL)                               |
| DONNACHI 69 NP 108 433       | A DONNACHIE, R KIRSOPP (GLAS+EDIN)              |
| AYED 70 PL 318 598           | +BARREYRE, VILLET (SACLAY)                      |
| BERARD 70 PRL 24 419         | +HADDUCK, NEFKENS, ++, PARSONS+ (UCLA+LRL)      |
| AYED 72 BATAVIA CONF         | R AYED, P BARREYRE, Y LENOIGNE (SACL)           |

THE FOLLOWING ARE THEORETICAL PAPERS CONCERNING THE N\*1/2(1470) --  
 RESNICK 66 PR 150 1292 L RESNICK (NIELS BOHR)  
 SCHWARZ 66 PR 152 1325 J H SCHWARZ (LRL)  
 BALL 67 PR 155 1725 JS BALL, GL SHAW, DY WONG (UCLA, UC, UCSD)  
 GOLDBERG 67 PR 154 1558 H GOLDBERG (CORNELL)

## N(1470) BUMPS

91 N\*1/2(1470, JP= 1 1-1/2 PRODUCTION EXPERIMENTS

IT IS NOT CLEAR THAT THE BUMP SEEN IN PRODUCTION EXPERIMENTS AT LOW INVARIANT MASS CORRESPONDS TO THE P11 RESONANT STATE. DIFFRACTION SCATTERING SEEMS TO BE THE DOMINANT FEATURE IN THIS MASS REGION-- SEE GELLERT 66, WALKER 68 AND CLEGG 68 FOR DISCUSSION OF THIS POINT. WE LIST VALUES OF MASSES AND WIDTHS FROM THESE EXPERIMENTS FOR THE READER'S CONVENIENCE-- THE LIST MAY NOT BE COMPLETE. THE CNTR AND SPRK EXPERIMENTS SEE A BUMP IN THE MISSING MASS PLOT. THE HBC EXPERIMENTS SEE ENHANCEMENTS MAINLY IN THE P1 PI MASS PLOT. PRODUCTION OF THIS STATE IN GAMMA-P OR GAMMA-D IS VERY SMALL, SEE ALBERTI 68.

| 91 N*1/2(1470) MASS (MEV) (PROD. EXP.) |                                                                      |        |               |             |                                    |        |  |  |  |
|----------------------------------------|----------------------------------------------------------------------|--------|---------------|-------------|------------------------------------|--------|--|--|--|
| M                                      | (1400.)                                                              | APPROX | COCCONI       | 64 CNTR +   | PP 3-6-12 GEV/C                    |        |  |  |  |
| M                                      | (1425.)                                                              | APPROX | ADENMAN       | 65 HBC +    | K-P 1.45 GEV/C                     | 7/66   |  |  |  |
| M                                      | (1430.)                                                              | APPROX | ANKERMAN      | 65 CNTR +   | PP 7-1 GEV/C                       | 7/66   |  |  |  |
| M                                      | (1400.)                                                              | APPROX | BELLETTIN     | 65 SPRK +   | PP-D 10-26 GEV/C                   | 7/66   |  |  |  |
| M                                      | (1405.)                                                              | (15.)  | ANDERSON      | 66 SPRK +   | PP 6-30 GEV/C                      | 7/66   |  |  |  |
| M                                      | (1410.)                                                              | (15.)  | BLAIR         | 66 CNTR +   | PP 2.8-7.9 GEV/C                   | 7/66   |  |  |  |
| M                                      | (1400.)                                                              | (30.)  | FOLEY         | 67 CNTR     | PI+- P AND PP                      | 11/67  |  |  |  |
| M                                      | (1450.)                                                              | (17.)  | ALMEIDA       | 68 HBC +    | PP-P2P1, 10GEV/C                   | 10/69  |  |  |  |
| M                                      | (1420.)                                                              | APPROX | BELL          | 68 HBC      | PI+- P, 6 GEV/C                    | 5/68   |  |  |  |
| M                                      | (1400.)                                                              | APPROX | LANKA         | 68 HBC      | PI+- P, 8 GEV/C                    | 6/68   |  |  |  |
| M                                      | S 175(1446.)                                                         | (11.)  | SHAPIRA       | 68 DBC      | INTO PPI, PN 7.0                   | 10/69  |  |  |  |
| M                                      | S (1390.)                                                            | (20.)  | TAN           | 68 HBC      | PP TO PIP, 6.1                     | 10/69  |  |  |  |
| M                                      | 120(1443.)                                                           | (15.)  | RHODE         | 69 HBC      | PP 22 GEV/C                        | 10/69  |  |  |  |
| M                                      | (1410.)                                                              | (13.)  | ANDERSON      | 70 HBC      | PI- P TO PI- HMS                   | 2/71   |  |  |  |
| M                                      | (1430.)                                                              | (20.)  | BALLAM        | 71 HBC +    | PI+- P AT 16GEV                    | 2/72   |  |  |  |
| M                                      | (1460.)                                                              | (10.)  | BEKETOV       | 71 HBC +    | PI- P 4.5GEV/C                     | 3/72   |  |  |  |
| M                                      | (1461.)                                                              | (10.)  | BOISEBEC      | 71 RVUE     | PP, PI+-P, K-P PROD                | 3/72   |  |  |  |
| M                                      | 120(1462.0)                                                          | (16.0) | 71 HBC +      | P TO P N PI | 10/71                              |        |  |  |  |
| M                                      | 1460 TO 1510                                                         |        | MORSE         | 71 HBC      | O PI-P, 7 GEV/C                    | 3/72   |  |  |  |
| M                                      | (1510.0)                                                             | (20.0) | MORSE         | 71 HBC +    | PI+- P, 25 GEV/C                   | 3/72   |  |  |  |
| M                                      | (1425.)                                                              | (25.)  | RUSHBROOKET71 | HBC +       | PP TO P2P1 16GEV                   | 2/72   |  |  |  |
| M                                      | (1411.0)                                                             | (10.0) | EDELSTEIN     | 72 HBC +    | PP 6 TO 30 GEV                     | 1/73*  |  |  |  |
| M                                      | 64(1410.0)                                                           | (33.0) | GAGE          | 72 O        | PD 5.9GEV/C                        | 12/72* |  |  |  |
| M                                      | (1464.0)                                                             | (17.0) | KARSHON       | 72 DBC +    | PD--PD2P1 7 GEV                    | 12/72* |  |  |  |
| M                                      | (1440.)                                                              | (15.)  | RONAT         | 72 HBC      | PI+- P TO 3PI P                    | 2/73*  |  |  |  |
| M                                      | S TAN 68, SHAPIRA 68, AND GAGE 72                                    |        |               |             | ARE ONLY PRODUCTION EXPERIMENTS TO |        |  |  |  |
| M                                      | S SEE PPI DECAY. HOWEVER THE EFFECT OF SHAPIRA 68, WITH MUCH IMPROVE |        |               |             |                                    |        |  |  |  |
| M                                      | S DATA, HAS ALMOST DISAPPEARED (YKUTIEL 72).                         |        |               |             |                                    |        |  |  |  |

| 91 N*1/2(1470) WIDTH (MEV) (PROD. EXP.) |                                 |        |               |          |                     |        |  |  |  |
|-----------------------------------------|---------------------------------|--------|---------------|----------|---------------------|--------|--|--|--|
| W                                       | (100.)                          |        | BELL          | 68 HBC   | PI+- P AND PP       | 6/68   |  |  |  |
| W                                       | S 175 (198.)                    | (40.)  | SHAPIRA       | 68 DBC   |                     | 10/69  |  |  |  |
| W                                       | S (150.)                        | (60.)  | TAN           | 68 HBC + |                     | 10/69  |  |  |  |
| W                                       | 120 (100.)                      | (15.)  | RHODE         | 69 HBC   | PP 22 GEV/C         | 10/69  |  |  |  |
| W                                       | (210.)                          | (15.)  | ANDERSON      | 70 HBC   | PI- P TO PI- HMS    | 2/71   |  |  |  |
| W                                       | (150.)                          | (40.)  | BALLAM        | 71 HBC + | PI+- P AT 16GEV     | 2/72   |  |  |  |
| W                                       | (60.)                           | (20.)  | BEKETOV       | 71 HBC + | PI- P PI- MASS      | 3/72   |  |  |  |
| W                                       | T 120 (54.0)                    | (12.0) | 120/80        | 71 RVUE  | PP, PI+-P, K-P PROD | 3/72   |  |  |  |
| W                                       | T NARROW WIDTH SUGGESTS THIS IS |        | NA            | 71 HBC + | P TO P N PI         | 10/71  |  |  |  |
| W                                       | 80 TO 120                       |        |               |          | THE USUAL N(1470).  |        |  |  |  |
| W                                       | (100.0)                         | (30.0) | MORSE         | 71 HBC   | PI+- P, 7 GEV/C     | 3/72   |  |  |  |
| W                                       | (125.)                          | (25.)  | MORSE         | 71 HBC + | PI+- P, 25 GEV/C    | 3/72   |  |  |  |
| W                                       | (188.0)                         | (38.0) | RUSHBROOKET71 | HBC +    | PP TO P2P1 16GEV    | 2/72   |  |  |  |
| W                                       | (212.0)                         | (62.0) | EDELSTEIN     | 72 HBC + | PP 6 TO 30 GEV      | 1/73*  |  |  |  |
| W                                       | (126.0)                         | (20.0) | GAGE          | 72 DBC   | O PD 5.9GEV/C       | 12/72* |  |  |  |
| W                                       | (100.)                          | (30.)  | KARSHON       | 72 DBC + | PD--PD2P1 7 GEV     | 12/72* |  |  |  |
| W                                       |                                 |        | RONAT         | 72 HBC   | PI+- P TO 3PI P     | 2/73*  |  |  |  |

91 N\*1/2(1470) PARTIAL DECAY MODES (PROD. EXP.)

|    |                                 | DECAY MASSES  |
|----|---------------------------------|---------------|
| P1 | N*1/2(1470) INTO P1 N           | 139+ 938      |
| P2 | N*1/2(1470) INTO N PIP1(J,1=0)  | 938+ 139+ 139 |
| P3 | N*1/2(1470) INTO N*3/2(1236) P1 | 1236+ 139     |
| P4 | N*1/2(1470) INTO N P1 P1        | 938+ 139+ 139 |
| P5 | N*1/2(1470) INTO GAMMA N        | 0+ 938        |
| P6 | N*1/2(1470) INTO N RHO          | 938+ 770      |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

N(1470), N(1520)

## 91 N\*1/2(1470) BRANCHING RATIOS (PROD. EXP.)

| R1 | N*1/2(1470) INTO (PI N)/TOTAL<br>(.66)                    | TAN       | 68 HBC | PP TO PIP, 6.1  | 10/69 |
|----|-----------------------------------------------------------|-----------|--------|-----------------|-------|
| R2 | N*1/2(1470) INTO (N*3/2(1236) P1)/TOTAL<br>PROBABLY SEEN  | JESPERSEN | 68 HBC | PP 22 BEV/C     | 11/68 |
| R2 | PROBABLY SEEN                                             | LAMSA     | 68 HBC | PI-P 8 BEV/C    | 11/68 |
| R3 | N*1/2(1470) INTO IN PIP1(J, I=0)/TOTAL<br>MAIN DECAY MODE | MORSE     | 71 HBC | PI-P 7.25 GEV/C | 3/72  |

## REFERENCES FOR N\*1/2(1470) (PROD. EXP.)

|                          |                                                    |
|--------------------------|----------------------------------------------------|
| COCCONI 64 PL 8 134      | +LILLETHUN, SCANLON, STAHLBRANDT, + (CERN)         |
| ADELMAN 65 PRL 14 1043   | S L ADELMAN (CAMBRIDGE/CERN)                       |
| ANKENBRA 65 NC 35 1052   | ANKENBRANDT, CLYDE, CORK, KEEFE, KERTH + (LRL)     |
| BELLETTI 65 PL 18 167    | BELLETTINI, COCCONI, DIODENS + (CERN)              |
| ANDERSON 66 PRL 16 855   | +BLESER, COLLINS, FUJII, + (BNL, CERN)             |
| BLAIR 66 PRL 17 789      | +TAYLOR, CHAPMAN, + (HARVELL, QUEENMARY, RHEL)     |
| FOLEY 67 PRL 19 397      | +JONES, LINDENBAUM, LOVE, OZAKI + (BNL)            |
| ALMEIDA 68 PR 174 1638   | +RUSHBROOKE, SCHARENGUIVEL + (CAVE, DESY)          |
| BELL 68 PRL 20 164       | +KRENNELL, HUGH, KARSHON, LAI + (BNL, CUNY)        |
| JESPERSE 68 PRL 21 1368  | JESPERSEN, KANG, KERNAN + (IOWA STATE)             |
| LAMSA 68 PR 166 1395     | +CASON, BISWAS, DERADO, GROVES, + (NOTRE DAME)     |
| SHAPIRA 68 PRL 21 1835   | +BENARY, EISENBERG, RONAT, YAFFE + (REHO)          |
| TAN 68 PL 288 195        | TAN, PERL, MARTIN, VIKHINSKY + (SLAC + LRL + UCI)  |
| RHODE 69 PR 187 1844     | RHODE, LEACOCK, KERNAN, JESPERSEN, + (ISU)         |
| ANDERSON 70 PRL 25 699   | +BLESER, BLIEDEN, COLLINS + (BNL, CERN)            |
| BALLAM 71 PR D4 1946     | +CHADWICK, GUIRAGOSSIAN, JOHNSON, + (SLAC) I       |
| BEKETOV 71 SJNP 13 405   | ZOMBOVSKY, KOHOVALOV, KRUCHININ, + (ITEP/IJ)       |
| BOESEBEC 71 NP 833 445   | BOESEBECK, GRAESSLER, KRAUS, + (ABCHLV) I          |
| 71 PRL 26 333            | +COLTON (NSU + BNL) I                              |
| MORSE 71 PR D4 133       | +OH, WALKER, CARROLL, LYNCH + (MISC + TNYD) IJ     |
| RUSHBROOKE 71 PR D4 3273 | RUSHBROOKE, WILLIAMS + BAREFORD + (CAVE, LOIC) IJ  |
| EDELSTEIN 72 PR D5 1073  | EDELSTEIN, CARRIGAN, HIEN, MCMAHON, + (CARN + BNL) |
| GAGE 72 PR D46 21        | W GAGE, E COLTON, W CHINOWSKI (LRL)                |
| KARSHON 72 NP 837 371    | +YEKUTIELI, YAFFE, SHAPIRA, RONAT, + (REHO) I      |
| RONAT 72 NP 838 20       | +EISENBERG, LYONS, SHAPIRA, TOAFF, + (REHO)        |
| YEKUTIEL 72 NP 840 77    | YEKUTIELI, YAFFE, SHAPIRA, RONAT + (REHO)          |
| GELLERT 66 PRL 17 884    | +SMITH, MOJCIK, COLTON, SCHLEIN + (LRL, UCLA)      |
| ALBERI 68 PR 176 1631    | +APPEL, BUDNITZ, CHEN, DUNNING, GOITEIN + (HARV)   |
| CLEGG 68 PREPRINT        | A B CLEGG (LANC)                                   |
| WALKER 68 PRL 20 133     | +THOMPSON, ROBERTSON, OH, LEE, HARTUNG, + (MISC)   |

## PAPERS NOT REFERRED TO IN DATA CARDS

N(1520)

62 N\*1/2(1520, JP=3/2-) I=1/2

D<sub>13</sub>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 62 N\*1/2(1520) MASS (MEV)

|   |          |                                               |          |                  |                  |      |
|---|----------|-----------------------------------------------|----------|------------------|------------------|------|
| M | (1530.0) | BRANDSEN                                      | 65 RVUE  | PHASE-SHIFT ANAL | 9/66             |      |
| M | (1536.0) | ROPER                                         | 65 RVUE  | PHASE-SHIFT ANAL | 9/66             |      |
| M | (1510.0) | BAREYRE                                       | 68 RVUE  | PHASE-SHIFT ANAL | 11/67            |      |
| M | 1        | WHERE CROSS SECTION IS GREATEST - EYEBALL FIT |          |                  |                  |      |
| M | 3        | (1541.0)                                      | DONNACHI | 68 RVUE          | PHASE-SHIFT ANAL | 6/68 |
| M | 6        | (1523.0)                                      | AYED     | 70 IPWA          |                  | 1/71 |
| M | 6        | FROM ENER. DEP. FIT OF ARGAND DIAGRAM         |          |                  |                  |      |
| M | 4        | (1512.0)                                      | DAVIES   | 70 RVUE          | P-S ANAL SOL A   | 8/69 |
| M | 7        | (1520.)                                       | ALMEHD   | 72 IPWA          |                  | 2/72 |

## 62 N\*1/2(1520) WIDTH (MEV)

|   |   |         |                  |                |       |
|---|---|---------|------------------|----------------|-------|
| W | 1 | (125.0) | BAREYRE 68 RVUE  |                | 11/67 |
| W | 3 | (149.0) | DONNACHI 68 RVUE |                | 6/68  |
| W | 6 | (131.0) | AYED 70 IPWA     |                | 1/71  |
| W | 4 | (106.0) | DAVIES 70 RVUE   | P-S ANAL SOL A | 8/69  |
| W | 7 | (120.1) | ALMEHD 72 IPWA   |                | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

## 62 N\*1/2(1520) PARTIAL DECAY MODES

| P1  | N*1/2(1520) INTO PI N                | 139+ 938      | DECAY MASSES |
|-----|--------------------------------------|---------------|--------------|
| P2  | N*1/2(1520) INTO N*3/2(1236) PI      | 1236+ 139     |              |
| P3  | N*1/2(1520) INTO N PI P1             | 938+ 139+ 139 |              |
| P4  | N*1/2(1520)+ INTO NEUTRON PI+        | 939+ 139      |              |
| P5  | N*1/2(1520)+ INTO PROTON PI+ PI-     | 938+ 139+ 139 |              |
| P6  | N*1/2(1520) INTO N ETA               | 939+ 548      |              |
| P7  | N*1/2(1520) INTO N EPSILON           | 938+ 600      |              |
| P8  | N*1/2(1520) INTO N RHO               | 938+ 770      |              |
| P9  | N*1/2(1520) INTO GAM P, HELICITY=1/2 | 0+ 938        |              |
| P10 | N*1/2(1520) INTO GAM P, HELICITY=3/2 | 0+ 938        |              |
| P11 | N*1/2(1520) INTO GAM N, HELICITY=1/2 | 0+ 939        |              |
| P12 | N*1/2(1520) INTO GAM N, HELICITY=3/2 | 0+ 939        |              |

## 62 N\*1/2(1520) BRANCHING RATIOS

| R1 | N*1/2(1520) INTO (PI N)/TOTAL<br>(.66) | TAN     | 68 RVUE          | (P1)           | 11/67 |
|----|----------------------------------------|---------|------------------|----------------|-------|
| R1 | 1                                      | (0.54)  | BAREYRE 68 RVUE  |                | 6/68  |
| R1 | 3                                      | (0.509) | DONNACHI 68 RVUE |                | 1/71  |
| R1 | 6                                      | (0.593) | AYED 70 IPWA     |                | 8/69  |
| R1 | 4                                      | (0.451) | DAVIES 70 RVUE   | P-S ANAL SOL A | 2/72  |
| R1 | 7                                      | (0.581) | ALMEHD 72 IPWA   |                |       |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R1 ALMOST THE ENTIRE INELASTICITY IS IN N PI P1 (ONLY N ETA COULD COMPETE, AND IT DOESN'T). THE N PI P1 SEEMS TO BE MAINLY N\*3/2(1236) PI, IN BOTH S AND D WAVES.

|    |                                                      |                |      |                    |      |
|----|------------------------------------------------------|----------------|------|--------------------|------|
| R2 | N*1/2(1520) INTO (N*3/2(1236) P1)/TOTAL<br>0.20 0.05 | KIRZ 66 HBC    | (P4) | 0 ASSUMING R1=0.72 | 9/66 |
| R2 | DOMINANT INEL DECAY                                  | OLSSON 66 RVUE |      | PI P TO PI P1 N    | 9/66 |
| R2 | (0.40)                                               | DIEH 70 IPWA   |      | 3 BODY ANALYSIS    | 1/71 |
| R2 | ASSUMING R1= 0.5                                     |                |      |                    |      |

|    |                                              |                   |  |              |       |
|----|----------------------------------------------|-------------------|--|--------------|-------|
| R3 | N*1/2(1520) INTO (N*3/2(1236) P1)/(IN PI P1) | (P2)/(P3)         |  |              |       |
| R3 | LARGE                                        | THURNAUER 65 RVUE |  |              | 11/67 |
| R3 | LARGE                                        | NAMYSLOWS 66 RVUE |  |              | 11/67 |
| R3 | LARGE                                        | ROBERTS 67 RVUE   |  |              | 11/67 |
| R3 | LARGE                                        | ROSENFELD 67 RVUE |  |              | 11/67 |
| R3 | LARGE                                        | MORGAN 68 RVUE    |  | ISOBAR MODEL | 6/68  |

|    |                                    |                |  |                 |      |
|----|------------------------------------|----------------|--|-----------------|------|
| R4 | N*1/2(1520) INTO (N EPSILON)/TOTAL | (P7)           |  |                 |      |
| R4 | PROBABLY PRESENT                   | MORGAN 68 RVUE |  | ISOBAR MODEL    | 6/68 |
| R4 | (0.02)                             | DIEH 70 IPWA   |  | 3 BODY ANALYSIS | 1/71 |
| R4 | ASSUMING R1= 0.5                   |                |  |                 |      |

|    |                                                                       |                  |  |                |       |
|----|-----------------------------------------------------------------------|------------------|--|----------------|-------|
| R5 | N*1/2(1520) INTO (N ETA)/TOTAL                                        | (P6)             |  |                |       |
| R5 | (0.006) APPROX                                                        | DAVIES 67 RVUE   |  |                | 11/67 |
| R5 | DAVIES 67 GIVES SEVERAL VALUES DEPENDING ON INPUT DATA. ALL ARE SMALL |                  |  |                |       |
| R5 | (0.014)                                                               | BOTKE 69 MPWA    |  | T POLE+ RESON. | 10/69 |
| R5 | (0.003) (0.001)                                                       | DEANS 69 MPWA    |  | T POLE+ RESON. | 5/70  |
| R5 | (0.002) OR 0.004                                                      | CARRERAS 70 MPWA |  | T POLE+ RESON. | 5/70  |
| R5 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING            |                  |  |                |       |

|    |                                 |              |  |                 |      |
|----|---------------------------------|--------------|--|-----------------|------|
| R6 | N*1/2(1520) INTO (N RHO )/TOTAL | (P8)         |  |                 |      |
| R6 | (0.07)                          | DIEH 70 IPWA |  | 3 BODY ANALYSIS | 1/71 |
| R6 | ASSUMING R1= 0.5                |              |  |                 |      |

## 62 N\*1/2(1520) PHOTON DECAY AMPL(1GEV\*\*=1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                   |                  |  |                 |       |
|----|---------------------------------------------------|------------------|--|-----------------|-------|
| A1 | N*1/2(1520) INTO GAM P, HELICITY=1/2 (1GEV**=1/2) |                  |  |                 |       |
| A1 | -0.26 -015                                        | WALKER 73 DPWA   |  | PI N PHOTO-PROD | 2/73* |
| A1 | (-0.007)                                          |                  |  | PI N PHOTO-PROD | 2/73* |
| A2 | N*1/2(1520) INTO GAM P, HELICITY=3/2 (1GEV**=1/2) |                  |  |                 |       |
| A2 | +0.194 -031                                       | OBERLACK 72 DPWA |  | PI N PHOTO-PROD | 2/73* |
| A2 | (+0.176)                                          | WALKER 73 DPWA   |  | PI N PHOTO-PROD | 2/73* |
| A3 | N*1/2(1520) INTO GAM N, HELICITY=1/2 (1GEV**=1/2) |                  |  |                 |       |
| A3 | -0.085 -014                                       | OBERLACK 72 DPWA |  | PI N PHOTO-PROD | 2/73* |
| A3 | (-0.063)                                          | WALKER 73 DPWA   |  | PI N PHOTO-PROD | 2/73* |
| A4 | N*1/2(1520) INTO GAM N, HELICITY=3/2 (1GEV**=1/2) |                  |  |                 |       |
| A4 | -0.124 -013                                       | OBERLACK 72 DPWA |  | PI N PHOTO-PROD | 2/73* |
| A4 | (-0.116)                                          | WALKER 73 DPWA   |  | PI N PHOTO-PROD | 2/73* |

## REFERENCES FOR N\*1/2(1520)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

|                                                                 |                                                |                     |
|-----------------------------------------------------------------|------------------------------------------------|---------------------|
| BRANDSEN 65 PR 139 81566                                        | +ODONNELL, MOORHOUSE                           | 1 DURHAM, RHELIJJP  |
| ROPER 65 PR 138 8190                                            | LO ROPER, RM WRIGHT, BT FELD                   | (LRL-LVNR, MIT) IJP |
| THURNAUER 65 PRL 14 985                                         | P G THURNAUER                                  | (ROCH)              |
| KIRZ 66 PRIVATE COMM                                            | J KIRZ                                         | (LRL)               |
| NUMBER EXTRACTED FROM DATA DISCUSSED IN KIRZ 63. 2 63.          |                                                |                     |
| NAMYSLOW 66 PR 157 1328                                         | NAMYSLOWSKI, RAZMI, ROBERTS (STAN, EDIN, LOIC) |                     |
| OLSSON 66 PR 145 1309                                           | M G OLSSON, G B YODH                           | (MISC, UMD)         |
| DAVIES 67 NC 52A 1112                                           | A T DAVIES, R G MOORHOUSE (GLASGOW, RHELI)     |                     |
| ROBERTS 67 PREPRINT                                             | R G ROBERTS (DURHAM)                           |                     |
| ROSENFELD 67 IRVINE CONF                                        | A H ROSENFELD, P SODING                        | (LRL)               |
| BAREYRE 68 PR 165 1731                                          | P BAREYRE, C BRICHMAN, G VILLET (SACLAY) IJP   |                     |
| DONNACHI 68 PL 268 161                                          | A DONNACHIE, R G KIRSOPP, C LOVEACE (CERN) IJP |                     |
| ALSO 68 VIENNA 139                                              | DONNACHIE RAPPORTEUR-S TALK                    | (GLAS)              |
| ALSO 68 THESIS                                                  | R G KIRSOPP                                    | (EDIN)              |
| MORGAN 68 PR 166 1731                                           | D MORGAN                                       | (RHELI)             |
| BOTKE 69 PR 180 1417                                            | J C BOTKE                                      | (UCSB)              |
| DEANS 69 PR 185 1797                                            | S DEANS, J WOOTEN                              | (UNIV S FLORIDA)    |
| AYED 70 KIEV CONF                                               | R AYED, P BAREYRE, G VILLET (SACL) IJP         |                     |
| CARRERAS 70 NP 168 35                                           | B CARRERAS, A DONNACHIE (DARE, MCHS)           |                     |
| DAVIES 70 NP 821 359                                            | A DAVIES (GLAS)                                |                     |
| DIEH 70 KIEV CONF.                                              | + SHADJA, CHAVANON, DELER, DOLBEAU + (SACL)    |                     |
| ALMEHD 72 NP 840 157                                            | +LOVELACE                                      | (LUND, RUTG) IJP    |
| OBERLACK 72 PL 438 44                                           | M. OBERLACK, R. G. MOORHOUSE (LBL)             |                     |
| WALKER 73 TO BE PUB.                                            | R. L. WALKER, W. J. METCALF (CIT)              |                     |
| PAPERS NOT REFERRED TO IN DATA CARDS.                           |                                                |                     |
| KIRZ 63 PR 130 2481                                             | J KIRZ, J SCHWARTZ, R D TRIPP (LRL)            |                     |
| BAREYRE 65 PL 18 342                                            | + BRICHMAN, STIRLING, VILLET (SACLAY) IJP      |                     |
| CROUCH 65 DESY CONF II 21                                       | + IBERONCEA, HARVARD, MIT, PADOVA, WEIZMANN    |                     |
| DERADO 65 ATHENS CONF 244                                       | +KENNEY, LAMSA, + (NOTRE DAME, KENTUCKY)       |                     |
| MERLO 66 P ROY SOC 289 489                                      | J P MERLO, G VALLADAO (SACLAY)                 |                     |
| THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE RESONANCE. |                                                |                     |
| JOHNSON 67 UCRL-17682 THESIS                                    | C H JOHNSON (UNIV S FLORIDA)                   |                     |
| DEANS 69 PRL 177 2423                                           | S R DEANS (GLAS+EDIN)                          |                     |
| DONNACHI 69 NP 108 433                                          | A DONNACHIE, R KIRSOPP                         |                     |
| AYED 70 PL 318 598                                              | +BAREYRE-VILLET (SACLAY)                       |                     |

Baryons  
N(1535)

N(1535)

63 N<sup>1/2</sup>(1535), JP=1/2- 1=1/2  
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE  
PRECEDING N<sup>1/2</sup>(1470).S<sub>11</sub>

| 63 N <sup>1/2</sup> (1535) MASS (MEV) |                                                |                                           |         |                  |       |  |  |  |  |
|---------------------------------------|------------------------------------------------|-------------------------------------------|---------|------------------|-------|--|--|--|--|
| M                                     | (1519.0)                                       | HENDRY                                    | 65 RVUE | ETA N + S11 P1 N | 9/66  |  |  |  |  |
| M                                     | (1570.0)                                       | MICHAEL                                   | 66 RVUE | FITS BAREYRE S11 | 7/66  |  |  |  |  |
| M                                     | (1557.0) OR 1565.0                             | UCHIYAMA                                  | 66 RVUE | FITS N ETA DATA  | 9/66  |  |  |  |  |
| M                                     | FITTING GIVES TWO SOLUTIONS. PROBLEMS MATCHING |                                           |         | PI P PHASE SHIFT |       |  |  |  |  |
| M                                     | (1535.0)                                       | BAREYRE                                   | 68 RVUE | PHASE-SHIFT ANAL | 11/67 |  |  |  |  |
| M                                     | 1                                              | WHERE CROSS SECTION IS GREATEST - EYEBALL |         |                  |       |  |  |  |  |
| M                                     | (1591.0)                                       | DONNACHIE                                 | 68 RVUE | PHASE-SHIFT ANAL | 6/68  |  |  |  |  |
| M                                     | (1535.0) (10.0)                                | DELICOURT                                 | 69 CNTR | PHOTOPRODUCT.    | 8/69  |  |  |  |  |
| M                                     | (1534.0)                                       | AYED                                      | 70 IPWA |                  | 1/71  |  |  |  |  |
| M                                     | 6                                              | FROM EMER. DEP. FIT OF ARGAND DIAGRAM     |         |                  |       |  |  |  |  |
| M                                     | (1502.0)                                       | DAVIES                                    | 70 RVUE | P-S ANAL SOL A   | 8/69  |  |  |  |  |
| M                                     | (1500.0)                                       | ALMEHO                                    | 72 IPWA |                  | 2/72  |  |  |  |  |

| 63 N <sup>1/2</sup> (1535) WIDTH (MEV)        |                  |           |         |                  |       |  |  |  |  |
|-----------------------------------------------|------------------|-----------|---------|------------------|-------|--|--|--|--|
| M                                             | (130.0)          | HENDRY    | 65 RVUE |                  | 9/66  |  |  |  |  |
| M                                             | (130.0)          | MICHAEL   | 66 RVUE |                  | 7/66  |  |  |  |  |
| M                                             | (156.0) OR 144.0 | UCHIYAMA  | 66 RVUE | SEE NOTE ON MASS | 9/66  |  |  |  |  |
| M                                             | (155.0)          | BAREYRE   | 68 RVUE |                  | 11/67 |  |  |  |  |
| M                                             | (153.0)          | DONNACHIE | 68 RVUE |                  | 6/68  |  |  |  |  |
| M                                             | (120.0)          | DELICOURT | 69 CNTR | PHOTOPRODUCT.    | 8/69  |  |  |  |  |
| M                                             | (196.0)          | AYED      | 70 IPWA |                  | 1/71  |  |  |  |  |
| M                                             | (136.0)          | DAVIES    | 70 RVUE | P-S ANAL SOL A   | 8/69  |  |  |  |  |
| M                                             | (150.0)          | ALMEHO    | 72 IPWA |                  | 2/72  |  |  |  |  |
| SEE THE NOTES ACCOMPANYING THE MASSES QUOTED. |                  |           |         |                  |       |  |  |  |  |

| 63 N <sup>1/2</sup> (1535) PARTIAL DECAY MODES |                                                         |  |  |              |  |  |  |  |  |
|------------------------------------------------|---------------------------------------------------------|--|--|--------------|--|--|--|--|--|
| P1                                             | N <sup>1/2</sup> (1535) INTO PI N                       |  |  | DECAY MASSES |  |  |  |  |  |
| P2                                             | N <sup>1/2</sup> (1535) INTO N ETA                      |  |  | 139+ 938     |  |  |  |  |  |
| P3                                             | N <sup>1/2</sup> (1535) INTO N PI PI                    |  |  | 939+ 548     |  |  |  |  |  |
| P4                                             | N <sup>1/2</sup> (1535) INTO N EPSILON                  |  |  | 938+ 600     |  |  |  |  |  |
| P5                                             | N <sup>1/2</sup> (1535) INTO N <sup>3/2</sup> (1236) PI |  |  | 1236+ 139    |  |  |  |  |  |
| P6                                             | N <sup>1/2</sup> (1535) INTO N RHO                      |  |  | 938+ 770     |  |  |  |  |  |
| P7                                             | N <sup>1/2</sup> (1535) INTO N GAMMA                    |  |  | 938+ 0       |  |  |  |  |  |
| P8                                             | N <sup>1/2</sup> (1535) INTO GAM P, HELICITY=1/2        |  |  | 0+ 938       |  |  |  |  |  |
| P9                                             | N <sup>1/2</sup> (1535) INTO GAM N, HELICITY=1/2        |  |  | 0+ 939       |  |  |  |  |  |

| 63 N <sup>1/2</sup> (1535) BRANCHING RATIOS |                                           |           |         |                    |       |  |  |  |  |
|---------------------------------------------|-------------------------------------------|-----------|---------|--------------------|-------|--|--|--|--|
| R1                                          | N <sup>1/2</sup> (1535) INTO (PI N)/TOTAL |           |         | (P1)               |       |  |  |  |  |
| R1                                          | (0.69)                                    | HENDRY    | 65 RVUE |                    | 9/66  |  |  |  |  |
| R1                                          | (0.32)                                    | MICHAEL   | 66 RVUE |                    | 9/66  |  |  |  |  |
| R1                                          | (0.71) OR 0.28                            | UCHIYAMA  | 66 RVUE | SEE NOTE ON MASS   | 9/66  |  |  |  |  |
| R1                                          | (0.31) OR 0.43                            | DAVIES    | 67 RVUE | PIP TO N ETA, B, C | 11/67 |  |  |  |  |
| R1                                          | (0.696)                                   | DONNACHIE | 68 RVUE |                    | 6/68  |  |  |  |  |
| R1                                          | (0.33)                                    | DELICOURT | 69 CNTR |                    | 8/69  |  |  |  |  |
| R1                                          | (0.357)                                   | AYED      | 70 IPWA |                    | 1/71  |  |  |  |  |
| R1                                          | (0.36)                                    | DAVIES    | 70 RVUE | P-S ANAL SOL A     | 8/69  |  |  |  |  |
| R1                                          | (0.25)                                    | ALMEHO    | 72 IPWA |                    | 2/72  |  |  |  |  |

|    |                                                                                     |           |         |                    |       |  |  |  |  |
|----|-------------------------------------------------------------------------------------|-----------|---------|--------------------|-------|--|--|--|--|
| R2 | N <sup>1/2</sup> (1535) INTO (N ETA)/TOTAL                                          |           |         | (P2)               |       |  |  |  |  |
| R2 | (0.68)                                                                              | HENDRY    | 65 RVUE |                    | 9/66  |  |  |  |  |
| R2 | (0.68)                                                                              | MICHAEL   | 66 RVUE |                    | 9/66  |  |  |  |  |
| R2 | (0.29) OR 0.71                                                                      | UCHIYAMA  | 66 RVUE | SEE NOTE ON MASS   | 9/66  |  |  |  |  |
| R2 | (0.69) OR 0.45                                                                      | DAVIES    | 67 RVUE | PIP TO N ETA, B, C | 11/67 |  |  |  |  |
| R2 | (0.4)                                                                               | DEANS     | 69 MPWA | T POLE+ RESON.     | 5/70  |  |  |  |  |
| R2 | (0.66)                                                                              | DELICOURT | 69 CNTR |                    | 8/69  |  |  |  |  |
| R2 | (0.69) OR 0.696                                                                     | CARRERAS  | 70 MPWA | T POLE+ RESON.     | 5/70  |  |  |  |  |
| R2 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING                          |           |         |                    |       |  |  |  |  |
| R2 | THE VALUES OF R2 LISTED ABOVE ARE INCOMPATIBLE WITH THE RESULTS OF DIEM ET AL. (70) |           |         |                    |       |  |  |  |  |

|    |                                                                 |       |         |                  |       |  |  |  |  |
|----|-----------------------------------------------------------------|-------|---------|------------------|-------|--|--|--|--|
| R3 | N <sup>1/2</sup> (1535) INTO (N <sup>3/2</sup> (1236) PI)/TOTAL |       |         | (P5)             |       |  |  |  |  |
| R3 | (0.07)                                                          | DIEM  | 70 IPWA | 3 BODY ANALYSIS  | 1/71  |  |  |  |  |
| R3 | ASSUMING R1=0.34                                                |       |         |                  |       |  |  |  |  |
| R4 | N <sup>1/2</sup> (1535) INTO (N EPSILON)/TOTAL                  |       |         | (P4)             |       |  |  |  |  |
| R4 | (0.26)                                                          | DIEM  | 70 IPWA | 3 BODY ANALYSIS  | 1/71  |  |  |  |  |
| R4 | ASSUMING R1=0.34                                                |       |         |                  |       |  |  |  |  |
| R5 | N <sup>1/2</sup> (1535) INTO (N RHO)/TOTAL                      |       |         | (P6)             |       |  |  |  |  |
| R5 | (0.20)                                                          | DIEM  | 70 IPWA | 3 BODY ANALYSIS  | 1/71  |  |  |  |  |
| R5 | ASSUMING R1=0.34                                                |       |         |                  |       |  |  |  |  |
| R6 | N <sup>1/2</sup> (1535) INTO N GAMMA                            |       |         | (P7)             |       |  |  |  |  |
| R6 | 0.004 0.001                                                     | DEANS | 72 MPWA | N ETA PHOTOPROD. | 1/73* |  |  |  |  |

63 N<sup>1/2</sup>(1535) PHOTON DECAY AMPL(GEV<sup>-1/2</sup>)/2  
FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-  
REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                                           |          |         |                 |       |  |  |  |  |
|----|---------------------------------------------------------------------------|----------|---------|-----------------|-------|--|--|--|--|
| A1 | N <sup>1/2</sup> (1535) INTO GAM P, HELICITY=1/2 (GEV <sup>-1/2</sup> )/2 |          |         | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A1 | (0.053) .020                                                              | OBERLACK | 72 DPWA | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A1 | (+0.063)                                                                  | WALKER   | 73 DPWA |                 |       |  |  |  |  |
| A2 | N <sup>1/2</sup> (1535) INTO GAM N, HELICITY=1/2 (GEV <sup>-1/2</sup> )/2 |          |         | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A2 | (-0.048) .021                                                             | OBERLACK | 72 DPWA | PI N PHOTO-PROD | 2/73* |  |  |  |  |
| A2 | (-0.050)                                                                  | WALKER   | 73 DPWA |                 |       |  |  |  |  |

REFERENCES FOR N<sup>1/2</sup>(1535)

HENDRY 65 PL 18 171 A W HENDRY, R G MOORHOUSE (RHEL)  
REVIEWS EARLY PHASE-SHIFT ANALYSIS RESULTS AND PI- P TO ETA N  
EXPERIMENTS. WE TAKE NUMBERS FROM THE SOLUTION USED BY BRANDSEN 65.  
MICHAEL 66 PL 21 93 C MICHAEL (OXF)  
UCHIYAMA 66 PR 149 1220 F UCHIYAMA-CAMPBELL, R K LOGAN (ILL)JJP  
DAVIES 67 NC 52A 1112 A T DAVIES, R G MOORHOUSE (GLASGOW, RHEL)

Data Card Listings  
For notation, see key at front of Listings.

|                                       |                                                |
|---------------------------------------|------------------------------------------------|
| BAREYRE 68 PR 165 1731                | P BAREYRE, C BRIGMAN, G VILLET (SACLAY)JJP     |
| DONNACHIE 68 PL 268 161               | A DONNACHIE, R G KIRSOPP, C LOVELAKE (CERN)JJP |
| ALSO 68 VIENNA 139                    | DONNACHIE RAPPORTEUR-5 TALK (GLAS)             |
| ALSO 68 THESS 1                       | R G KIRSOPP (EDIN)                             |
| DEANS 69 PR 185 1797                  | S DEANS, J WOOTEN (UNIV S FLORIDA)             |
| DELICOURT 69 PL 29B 75                | DELICOURT, LEFRANCOIS, PEREZ-Y-JORBA, (ORSI)   |
| AYED 70 KIEV CONF                     | R AYED, P BAREYRE, G VILLET (SACLAY)JJP        |
| CARRERAS 70 NP 158 35                 | B CARRERAS, A DONNACHIE (DARE, MCHS)           |
| DAVIES 70 NP 821 359                  | A DAVIES (GLAS)                                |
| DIEM 70 KIEV CONF.                    | + SMADJA, CHAVANON, DELER, DOLBEAU (SACL)      |
| ALMEHO 72 NP 840 157                  | + LOVELAKE (LUND, RUTG)JJP                     |
| DEANS 72 NP 3 217                     | + JACOBS, LYONS, HICKS (U S FL TAMPA, CARN)    |
| OBERLACK 72 PL 438 44                 | H OBERLACK, R G MOORHOUSE (LBL)                |
| WALKER 73 TO BE PUB.                  | R L WALKER, W J METCALF (CIT)                  |
| PAPERS NOT REFERRED TO IN DATA CARDS. |                                                |
| BAREYRE 65 PL 18 342                  | + BRIGMAN, STIRLING, VILLET (SACLAY)JJP        |
| BRANDSEN 65 PR 139 B1566              | + O'DONNELL, MOORHOUSE (DURHAM, RHEL)JJP       |
| BASIS OF NUMBERS WE QUOTE             | FROM HENDRY 65.                                |
| JOHNSON 67 UCRL-17683 THESIS          | C H JOHNSON (RL)                               |
| LOVELACE 67 HEIDELBERG C. 79          | C LOVELACE (CERN)JJP                           |
| DONNACHIE 69 NP 10B 433               | A DONNACHIE, R KIRSOPP (GLAS+EDIN)             |
| AYED 70 PL 318 598                    | + BAREYRE+VILLET (SACLAY)                      |

THE FOLLOWING ARTICLES DEAL WITH THE REACTIONS PI- P TO ETA N  
AND GAMMA P TO ETA P NEAR THRESHOLD. THE DATA AND THE THEORETICAL  
ARTICLES ARE USEFUL IN UNDERSTANDING THE BEHAVIOR OF THE S11 AMPLI-  
TUDINE AS DETERMINED IN PI P PHASE-SHIFT ANALYSES. FURTHER REFERENCES  
MAY BE FOUND IN THEM.

| MAINLY EXPERIMENTAL     |                                                       | THEORETICAL             |                                      |
|-------------------------|-------------------------------------------------------|-------------------------|--------------------------------------|
| BULOS 64 PRL 13 486     | (BROWN, BRANDEIS, HARVARD, MIT, PADOVA) I             | BALL 66 PR 149 1191     | J S BALL (UCLA)                      |
| BACCI 66 NC 45A 983     | + PENSO, SALVINI, MENCUCINI, + (ROMA, FRASCATI)JJP    | DORSON 66 PR 146 1022   | P N DORSON (HAWAII)                  |
| JONES 66 PL 23 597      | + DINNIE, DUANE, MORSEY, MASON, + (LOI, G, RHEL)      | MINAMI 66 PR 147 1123   | S MINAMI (OSAKA)                     |
| RICHARDS 66 PRL 16 1221 | + CHIU, EANDI, HELMHOLD, KENNEDY, + (ILL, HAWAII) JJP | DEANS 67 PR 161 1466    | S R DEANS, W G HOLLADAY (VANDERBILT) |
| PREPOST 67 PRL 18 92    | + R PREPOST, D LUNQUIST, D GUINN (STANFORD)           | LOGAN 67 PR 153 1634    | R K LOGAN, F UCHIYAMA-CAMPBELL (ILL) |
| BLOOM 68 PRL 21 1100    | + HEUSCH, PRESCOTT, ROCHESTER (CIT)                   | MENCUCINI 67 NC 48A 579 | C MENCUCINI, A REALE (FRASCATI)      |
| BULOS 69 PR 187 1827    | + LANDU, BORDNER, BASTIEN (BOST+HARV+MIT+PENN)        | MINAMI 67 PR 162 1619   | S MINAMI (OSAKA)                     |
| HEUSCH 70 PRL 25 1381   | + PRESCOTT, ROCHESTER, WINSTEIN (CIT)                 | MOSS 67 PR 163 1785     | T A MOSS (LSU)                       |
| MAINLY THEORETICAL      |                                                       | DEANS 68 PR 165 1886    | S R DEANS, W G HOLLADAY (VANDERBILT) |
| BALL 66 PR 149 1191     | J S BALL (UCLA)                                       | B K PAL 68 PR 167 1350  | B K PAL (NPL NEW DELHI)              |
| DORSON 66 PR 146 1022   | P N DORSON (HAWAII)                                   | BALL 69 PR 177 2257     | + GARG+SHAW (UCLA+UCI)               |
| MINAMI 66 PR 147 1123   | S MINAMI (OSAKA)                                      | LEFIEVRE 70 NC 66A 349  | + LERUSTE (CDFE)                     |
| DEANS 67 PR 161 1466    | S R DEANS, W G HOLLADAY (VANDERBILT)                  |                         |                                      |
| LOGAN 67 PR 153 1634    | R K LOGAN, F UCHIYAMA-CAMPBELL (ILL)                  |                         |                                      |
| MENCUCINI 67 NC 48A 579 | C MENCUCINI, A REALE (FRASCATI)                       |                         |                                      |
| MINAMI 67 PR 162 1619   | S MINAMI (OSAKA)                                      |                         |                                      |
| MOSS 67 PR 163 1785     | T A MOSS (LSU)                                        |                         |                                      |
| DEANS 68 PR 165 1886    | S R DEANS, W G HOLLADAY (VANDERBILT)                  |                         |                                      |
| B K PAL 68 PR 167 1350  | B K PAL (NPL NEW DELHI)                               |                         |                                      |
| BALL 69 PR 177 2257     | + GARG+SHAW (UCLA+UCI)                                |                         |                                      |
| LEFIEVRE 70 NC 66A 349  | + LERUSTE (CDFE)                                      |                         |                                      |

N(1520)  
BUMPS8 N<sup>1/2</sup>(1520, JP= 1=1/2 PRODUCTION EXPERIMENTS

THIS INFORMATION REFERS TO EITHER THE D13 OR THE S11  
STATE SEEN AT THIS MASS  
FOR SPIN-PARTY ANALYSIS OF THIS MASS REGION, SEE JOHNSTAD 72.

| 8 N <sup>1/2</sup> (1520) MASS (MEV) (PROD. EXP.) |        |                               |                  |                                              |                |       |  |  |  |
|---------------------------------------------------|--------|-------------------------------|------------------|----------------------------------------------|----------------|-------|--|--|--|
| M                                                 | 1507.0 | 6.0                           | A-BORELLI 67 HBC | 0 PBAR P 5.7 GEV                             | 10/71          |       |  |  |  |
| M                                                 | 1503.  | 6.                            | ANDERSON 70 MMS  | - P1- P TO PI- MMS                           | 2/71           |       |  |  |  |
| M                                                 | 1500.0 | 10.0                          | AMALDI 71 CNTR   | P P AT 24 GEV                                | 10/71          |       |  |  |  |
| M                                                 | 1512.0 | 2.0                           | ELLIS 71 CNTR    | MMS PP 3.7 GEV/C                             | 10/71          |       |  |  |  |
| M                                                 | 1501.0 | 5.7                           | EDELSTEIN 72 MMS | + PP 6 TO 30 GEV                             | 1/73*          |       |  |  |  |
| M                                                 | AVG    | 1510.8                        | 3.4              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8) |                |       |  |  |  |
| M                                                 | 1      | (1500.)                       | OH               | 72 DBC                                       | 0 P1-N TO PI-P | 2/73* |  |  |  |
| M                                                 | 1      | DETERMINE J=3/2, D13 PROBABLE |                  |                                              |                | 2/73* |  |  |  |

| 8 N <sup>1/2</sup> (1520) WIDTH (MEV) (PROD. EXP.) |       |      |                  |                                              |       |  |  |  |  |
|----------------------------------------------------|-------|------|------------------|----------------------------------------------|-------|--|--|--|--|
| M                                                  | 55.0  | 15.0 | A-BORELLI 67 HBC | 0 PBAR P 5.7 GEV                             | 10/71 |  |  |  |  |
| M                                                  | 120.  | 10.  | ANDERSON 70 MMS  | - P1- P TO PI- MMS                           | 2/71  |  |  |  |  |
| M                                                  | 118.0 | 20.0 | AMALDI 71 CNTR   | P P AT 24 GEV                                | 10/71 |  |  |  |  |
| M                                                  | 88.0  | 2.0  | ELLIS 71 CNTR    | MMS PP 3.7 GEV/C                             | 10/71 |  |  |  |  |
| M                                                  | 140.0 | 43.0 | EDELSTEIN 72 MMS | + PP 6 TO 30 GEV                             | 1/73* |  |  |  |  |
| M                                                  | AVG   | 88.1 | 2.0              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |  |  |  |  |

| 8 N <sup>1/2</sup> (1520) PARTIAL DECAY MODES (PROD. EXP.) |                                                         |  |  |               |  |  |  |  |  |
|------------------------------------------------------------|---------------------------------------------------------|--|--|---------------|--|--|--|--|--|
| P1                                                         | N <sup>1/2</sup> (1520) INTO PI N                       |  |  | DECAY MASSES  |  |  |  |  |  |
| P2                                                         | N <sup>1/2</sup> (1520) INTO N <sup>3/2</sup> (1236) PI |  |  | 1236+ 139     |  |  |  |  |  |
| P3                                                         | N <sup>1/2</sup> (1520) INTO N PI PI                    |  |  | 938+ 139+ 139 |  |  |  |  |  |
| P4                                                         | N <sup>1/2</sup> (1520) INTO NEUTRON PI+                |  |  | 938+ 139      |  |  |  |  |  |
| P5                                                         | N <sup>1/2</sup> (1520) INTO PROTON PI+ PI-             |  |  | 938+ 139+ 139 |  |  |  |  |  |
| P6                                                         | N <sup>1/2</sup> (1520) INTO N ETA                      |  |  | 939+ 548      |  |  |  |  |  |
| P7                                                         | N <sup>1/2</sup> (1520) INTO N PIPI(J,I=0)              |  |  | 939+ 139+ 139 |  |  |  |  |  |
| P8                                                         | N <sup>1/2</sup> (1520) INTO N RHO                      |  |  | 938+ 770      |  |  |  |  |  |

| 8 N <sup>1/2</sup> (1520) BRANCHING RATIOS (PROD. EXP.) |                                                                     |      |                  |                        |                    |      |  |  |  |
|---------------------------------------------------------|---------------------------------------------------------------------|------|------------------|------------------------|--------------------|------|--|--|--|
| R1                                                      | N <sup>1/2</sup> (1520) INTO (N PI)/TOTAL                           |      |                  | (P1)                   |                    |      |  |  |  |
| R1                                                      | N <sup>1/2</sup> (1520) INTO (N PI)/TOTAL                           |      |                  | PRODUCTION EXPERIMENTS |                    |      |  |  |  |
| R1                                                      | 0.78                                                                | 0.24 | BASSOMPIE 67 HBC | + K+ P TO K* N         | 11/68              |      |  |  |  |
| R2                                                      | N <sup>1/2</sup> (1520) INTO (NEUTRON PI+)/(PI+ PI-)                |      |                  | (P4)/(P5)              |                    |      |  |  |  |
| R2                                                      | 0.77                                                                | 0.45 | ALEXANDER 67 HBC | + PP 5.5 BEV/C         | 9/66               |      |  |  |  |
| R3                                                      | N <sup>1/2</sup> (1520) INTO (N PI)/(N PI PI)                       |      |                  | (P1)/(P3)              |                    |      |  |  |  |
| R3                                                      | 1.25                                                                | 0.44 | 0.71             | A-BORELLI 67 HBC       | 0 PBAR P 5.7 BEV/C | 9/66 |  |  |  |
| R4                                                      | N <sup>1/2</sup> (1520) INTO (N <sup>3/2</sup> (1236) PI)/(N PI PI) |      |                  | (P2)/(P3)              |                    |      |  |  |  |
| R4                                                      | 0.00                                                                | 0.09 |                  | A-BORELLI 67 HBC       |                    | 9/66 |  |  |  |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

N(1535), N(1670), N(1688)

R5 N\*1/2(1520) INTO (N P1 P11)/TOTAL (P3)  
 R5 (0.08) OR LESS BASSOMPI 67 HBC + K\*P TO K\* N\* 11/68  
 R6 N\*1/2(1520) INTO (N ETAI)/TOTAL (P6)  
 R6 0.22 0.14 BASSOMPI 67 HBC + K\*P TO K\* N\* 11/68  
 R7 N\*1/2(1520) INTO (P1 N1)/(P1 N\*3/2(1236)) (P11)/(P2)  
 R7 (0.42) OR LESS LEE 67 HBC P1-P 3.6 GEV/C 11/67

## REFERENCES FOR N\*1/2(1520) (PROD. EXP.)

A-BORELL 67 NC 47 232 ALLES-BORELLI, FRENCH, FRISK, MICHEJDA (CERN)  
 ALEXANDE 67 PR 154 1284 ALEXANDER, BENARY, CIAPEK, + (WEIZMANN/CERN)  
 BASSOMPI 67 PL 258 440 BASSOMPIERRE, + (CERN, BRUXELLES)  
 LEE 67 PR 159 1156 +MOBS, ROE, SINCLAIR, VANDER VELDE (NICH)  
 ANDERSON 70 PRL 25 699 +BLESER, BLIEDEN, COLLINS+ (BNL, CERN)  
 AMALDI 71 PL 348 435 +BIANCATELLI, BOSIO, + (I SANITA ROMA/CERN)  
 LEE 71 PRL 27 442 +MAGLICH, NORDEN, SANNES, SILVERMAN (RUTG)  
 EDELSTEI 72 PR 05 1073 EDELSTEIN, CARRIGAN, HIEN, MCMAHON, + (CARN+BNL)  
 JOHNSTAD 72 NP 642 588 +HOLLERUD+...+JACOBSEN, BOHR, HELS, OSLO, STOR, JIP  
 OH 72 PL 428 497 +FUNG, KERMAN, POE, SCHALK, SHEN (UCR/IJIP)

N(1670)

64 N\*1/2(1670, JP=5/2-) I=1/2

D<sub>15</sub>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 64 N\*1/2(1670) MASS (MEV)

| M   | (1650.0) | APPROX                                        | BRANDSEN | 65 RVUE | PHASE-SHIFT ANAL | 7/66  |
|-----|----------|-----------------------------------------------|----------|---------|------------------|-------|
| M 1 | (1680.0) |                                               | BAREYRE  | 68 RVUE | PHASE-SHIFT ANAL | 11/67 |
| M 3 | (1678.0) | WHERE CROSS SECTION IS GREATEST - EYEBALL FIT |          |         |                  |       |
| M 6 | (1674.0) |                                               | DONNACHI | 68 RVUE | PHASE-SHIFT ANAL | 6/68  |
| M 6 | (1675.0) |                                               | DUKE     | 68 CNTR | PI-P EL + POL    | 6/68  |
| M 6 | (1675.0) |                                               | AYED     | 70 IPWA |                  | 1/71  |
| M 6 | (1669.0) | FROM ENER. DEP. FIT OF ARGAND DIAGRAM         |          |         |                  |       |
| M 4 | (1669.0) |                                               | DAVIES   | 70 RVUE | P-S ANAL SOL A   | 8/69  |
| M 7 | (1683.0) |                                               | ALMEHD   | 72 IPWA |                  | 2/72  |

## 64 N\*1/2(1670) WIDTH (MEV)

| M   | (135.0)                                                  | BAREYRE  | 68 RVUE | 11/67 |
|-----|----------------------------------------------------------|----------|---------|-------|
| M 3 | (173.0) <td>DONNACHI</td> <td>68 RVUE</td> <td>6/68</td> | DONNACHI | 68 RVUE | 6/68  |
| M 6 | (143.0) <td>AYED</td> <td>70 IPWA</td> <td>1/71</td>     | AYED     | 70 IPWA | 1/71  |
| M 4 | (115.0) <td>DAVIES</td> <td>70 RVUE</td> <td>8/69</td>   | DAVIES   | 70 RVUE | 8/69  |
| M 7 | (130.0) <td>ALMEHD</td> <td>72 IPWA</td> <td>2/72</td>   | ALMEHD   | 72 IPWA | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

## 64 N\*1/2(1670) PARTIAL DECAY MODES

| P1 | N*1/2(1670) INTO P1 N                | 139+ 938      | DECAY MASSES |
|----|--------------------------------------|---------------|--------------|
| P2 | N*1/2(1670) INTO N ETAI              | 939+ 548      |              |
| P3 | N*1/2(1670) INTO LAMBDA K            | 1115+ 497     |              |
| P4 | N*1/2(1670) INTO N*3/2(1236) P1      | 1236+ 139     |              |
| P5 | N*1/2(1670) INTO N P1 P1             | 938+ 139+ 139 |              |
| P6 | N*1/2(1670) INTO GAM P, HELICITY=1/2 | 0+ 938        |              |
| P7 | N*1/2(1670) INTO GAM P, HELICITY=3/2 | 0+ 938        |              |
| P8 | N*1/2(1670) INTO GAM N, HELICITY=1/2 | 0+ 939        |              |
| P9 | N*1/2(1670) INTO GAM N, HELICITY=3/2 | 0+ 939        |              |

## 64 N\*1/2(1670) BRANCHING RATIOS

| R1   | N*1/2(1670) INTO (P1 N1)/TOTAL (P1) | 11/67 |
|------|-------------------------------------|-------|
| R1 1 | (0.41)                              | 6/68  |
| R1 3 | (0.39)                              | 1/71  |
| R1 6 | (0.392)                             | 8/69  |
| R1 4 | (0.50)                              | 2/72  |
| R1 7 | (0.45)                              |       |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

| R2   | N*1/2(1670) INTO (N ETAI)/TOTAL (P2) | 8/67  |
|------|--------------------------------------|-------|
| R2 1 | (0.02) OR LESS                       | 10/69 |
| R2 8 | (0.018)                              | 5/70  |
| R2 8 | (0.006) (0.004)                      | 5/70  |
| R2 8 | (0.006) OR 0.012                     |       |

PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

| R3   | N*1/2(1670) INTO (LAMBDA K)/TOTAL (P3)                     | 8/67 |
|------|------------------------------------------------------------|------|
| R3 1 | (0.01) OR LESS                                             | 8/69 |
| R3 8 | (0.007) OR LESS                                            | 1/71 |
| R3 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |      |

| R4   | N*1/2(1670) INTO (N*3/2(1236) P1)/TOTAL (P4) | 6/70 |
|------|----------------------------------------------|------|
| R4 E | 12600 0.63 0.1 BRODY 71 HBC P1-P--2P1 N, PWA |      |
| R4 E | ASSUMES ELASTIC BRANCHING RATIO 0.42+0.04    |      |

SEE NOTE PRECEDING THE N\*1/2(1688) INELASTIC DECAY MODE MEASUREMENTS.

## 64 N\*1/2(1670) PHOTON DECAY AMPL(GEV\*\*1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

| A1   | N*1/2(1670) INTO GAM P, HELICITY=1/2 (GEV**1/2) | 2/73* |
|------|-------------------------------------------------|-------|
| A1 1 | +0.011 0.012 OBERLACK 72 DPWA P1 N PHOTO-PROD   | 2/73* |
| A1 1 | (+0.010) WALKER 73 DPWA P1 N PHOTO-PROD         |       |
| A2   | N*1/2(1670) INTO GAM P, HELICITY=3/2 (GEV**1/2) | 2/73* |
| A2 1 | +0.021 0.020 OBERLACK 72 DPWA P1 N PHOTO-PROD   | 2/73* |
| A2 1 | (+0.039) WALKER 73 DPWA P1 N PHOTO-PROD         |       |

| A3   | N*1/2(1670) INTO GAM N, HELICITY=1/2 (GEV**1/2) | 2/73* |
|------|-------------------------------------------------|-------|
| A3 1 | +0.010 0.040 OBERLACK 72 DPWA P1 N PHOTO-PROD   | 2/73* |
| A3 1 | (.001) WALKER 73 DPWA P1 N PHOTO-PROD           |       |
| A4   | N*1/2(1670) INTO GAM N, HELICITY=3/2 (GEV**1/2) | 2/73* |
| A4 1 | -0.035 0.014 OBERLACK 72 DPWA P1 N PHOTO-PROD   | 2/73* |
| A4 1 | (.001) WALKER 73 DPWA P1 N PHOTO-PROD           |       |

## REFERENCES FOR N\*1/2(1670)

BRANDSEN 65 PL 19 420 +ODONNELL, MOORHOUSE (DURHAM, RHEL/IJIP)  
 TRIPP 67 NP 83 10 + LEITH, + (LRL, SLAC, CERN, METD, SACLAY)  
 BAREYRE 68 PR 165 1731 P BAREYRE, C BRICHAN, G VILLET (SACLAY/IJIP)  
 DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN/IJIP)  
 ALSO 68 VIENNA 139 DONNACHIE, RAPPOURTEUR, S TALK (GLAS)  
 DEANS 68 PR 177 2623 S R KIRSOPP (EDIN)  
 DUKE 68 PR 166 1448 +JONES, KEMP, MURPHY, THRESHER, + (RHEL, OXF/IJIP)  
 INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.  
 RUSH 68 PR 173 1776 J E RUSH (UNIV ALABAMA)  
 BOTKE 69 PR 180 1417 J C BOTKE (UCSB)  
 DEANS 69 PR 185 1797 S DEANS, J WOOTEN (UNIV S FLORIDA)  
 AYED 70 KIEV CONF R AYED, P BAREYRE, G VILLET (SACLAY/IJIP)  
 CARRERAS 70 NP 168 35 B CARRERAS, A DONNACHIE (DARE, MCHS)  
 DAVIES 70 NP 821 359 A DAVIES (GLAS)  
 BRODY 71 PL 348 665 +CASHMORE+...+HERNDON+... (SLAC+LRL)  
 WAGNER 71 NP 825 411 F WAGNER, C LOVELACE (CERN)  
 ALMEHD 72 NP 840 157 +LOVELACE (LUND, RUTG/IJIP)  
 OBERLACK 72 PL 438 44 H. OBERLACK, R. G. MOORHOUSE (LBL)  
 WALKER 73 TO BE PUB. R. L. WALKER, W. J. METCALF (CIT)

## PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE 65 PL 18 342 + BRICHAN, STIRLING, VILLET (SACLAY/IJIP)  
 DUKE 65 PRL 15 468 +JONES, KEMP, MURPHY, PRENTICE, + (RHEL, OXF/IJIP)  
 JOHNSON 67 UCL-17683 THESIS C H JOHNSON (LRL)  
 DEANS 69 PRL 177 2623 S R KIRSOPP (UNIV S FLORIDA)  
 DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)  
 AYED 70 PL 318 598 +BAREYRE-VILLET (SACLAY)

N(1688)

65 N\*1/2(1688, JP=5/2+) T=1/2

F<sub>15</sub>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 65 N\*1/2(1688) MASS (MEV)

| M   | (1680.0) | BRANDSEN                                      | 65 RVUE | PHASE-SHIFT ANAL | 7/66  |
|-----|----------|-----------------------------------------------|---------|------------------|-------|
| M 1 | (1690.0) | BAREYRE                                       | 68 RVUE | PHASE-SHIFT ANAL | 11/67 |
| M 1 | (1687.0) |                                               |         |                  |       |
| M 3 | (1687.0) | WHERE CROSS SECTION IS GREATEST - EYEBALL FIT |         |                  |       |
| M 6 | (1682.0) | DONNACHI                                      | 68 RVUE | PHASE-SHIFT ANAL | 6/68  |
| M 6 | (1682.0) | DUKE                                          | 68 CNTR | PI-P EL + POL    | 6/68  |
| M 6 | (1682.0) | AYED                                          | 70 IPWA |                  | 1/71  |
| M 6 | (1682.0) | FROM ENER. DEP. FIT OF ARGAND DIAGRAM         |         |                  |       |
| M 5 | (1685.0) | DAVIES                                        | 70 RVUE | P-S ANAL SOL A   | 8/69  |
| M 7 | (1688.0) | ALMEHD                                        | 72 IPWA |                  | 2/72  |

## 65 N\*1/2(1688) WIDTH (MEV)

| M   | (110.0)                                                  | BAREYRE  | 68 RVUE | 11/67 |
|-----|----------------------------------------------------------|----------|---------|-------|
| M 3 | (177.0) <td>DONNACHI</td> <td>68 RVUE</td> <td>6/68</td> | DONNACHI | 68 RVUE | 6/68  |
| M 6 | (109.0) <td>AYED</td> <td>70 IPWA</td> <td>1/71</td>     | AYED     | 70 IPWA | 1/71  |
| M 4 | (104.0) <td>DAVIES</td> <td>70 RVUE</td> <td>8/69</td>   | DAVIES   | 70 RVUE | 8/69  |
| M 7 | (140.0) <td>ALMEHD</td> <td>72 IPWA</td> <td>2/72</td>   | ALMEHD   | 72 IPWA | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

## 65 N\*1/2(1688) PARTIAL DECAY MODES

| P1  | N*1/2(1688) INTO P1 N                | 139+ 938      | DECAY MASSES |
|-----|--------------------------------------|---------------|--------------|
| P2  | N*1/2(1688) INTO N ETAI              | 939+ 548      |              |
| P3  | N*1/2(1688) INTO LAMBDA K            | 1115+ 497     |              |
| P4  | N*1/2(1688) INTO N*3/2(1236) P1      | 1236+ 139     |              |
| P5  | N*1/2(1688) INTO N P1 P1             | 938+ 139+ 139 |              |
| P6  | N*1/2(1688) INTO GAM P, HELICITY=1/2 | 0+ 938        |              |
| P7  | N*1/2(1688) INTO GAM P, HELICITY=3/2 | 0+ 938        |              |
| P8  | N*1/2(1688) INTO GAM N, HELICITY=1/2 | 0+ 939        |              |
| P9  | N*1/2(1688) INTO GAM N, HELICITY=3/2 | 0+ 939        |              |
| P10 | N*1/2(1688) INTO N EPSILON           | 938+ 600      |              |
| P11 | N*1/2(1688) INTO N RHO               | 938+ 770      |              |

## 65 N\*1/2(1688) BRANCHING RATIOS

| R1   | N*1/2(1688) INTO (P1 N1)/TOTAL (P1) | 11/67 |
|------|-------------------------------------|-------|
| R1 1 | (0.64)                              | 6/68  |
| R1 3 | (0.560)                             | 1/71  |
| R1 6 | (0.593)                             | 8/69  |
| R1 4 | (0.54)                              | 2/72  |
| R1 7 | (0.65)                              |       |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

MORE INFORMATION ON THE INELASTIC DECAY MODES OF THE 1690 NEV BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND BELOW

| R2   | N*1/2(1688) INTO (N ETAI)/TOTAL (P2)                       | 8/67  |
|------|------------------------------------------------------------|-------|
| R2 1 | (0.015) OR LESS                                            | 10/69 |
| R2 8 | (0.004)                                                    | 5/70  |
| R2 8 | (0.003) (0.002)                                            | 5/70  |
| R2 8 | (0.0005) OR .001                                           |       |
| R2 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |       |

# Baryons

## N(1688), N(1700)

# Data Card Listings

## For notation, see key at front of Listings.

|    |                                                                 |          |                                            |      |
|----|-----------------------------------------------------------------|----------|--------------------------------------------|------|
| R3 | N <sup>1</sup> /2(1688) INTO (N ETAI)/(PI N)                    | (P21/P1) |                                            |      |
| R3 | (0.027)OR LESS                                                  | HEUSCH   | 66 RVUE + P10, ETA PHOTO                   | 9/66 |
| R4 | N <sup>1</sup> /2(1688) INTO (LAMBDA K)/TOTAL                   | (P3)     |                                            |      |
| R4 | (0.001)OR LESS                                                  | TRIPP    | 67 RVUE                                    | 8/67 |
| R4 | (0.001)OR LESS                                                  | RUSH     | 68 MPWA T POLE + RESON.                    | 5/70 |
| R4 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING      |          |                                            |      |
| R4 | (0.001)OR LESS CL=.63                                           | WAGNER   | 71 IPWA P1-P TO K LAMB                     | 1/71 |
| R5 | N <sup>1</sup> /2(1688) INTO (N <sup>3</sup> /2(1236) P1)/TOTAL | (P4)     |                                            |      |
| R5 | E 12600 (0.13) (0.04) SOLN.A                                    | BRODY    | 71 HBC P1-P--2P1 N/PWA                     | 6/70 |
| R5 | E 12600 (0.39) (0.10) SOLN.B                                    | BRODY    | 71 HBC P1-P--2P1 N/PWA                     | 6/70 |
| R5 | E                                                               |          | ASSUMES ELASTIC BRANCHING RATIO 0.62+-0.06 |      |

65 N<sup>1</sup>/2(1688) PHOTON DECAY AMPL(GEV--1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                             |          |                         |       |
|----|-------------------------------------------------------------|----------|-------------------------|-------|
| A1 | N <sup>1</sup> /2(1688) INTO GAM P, HELICITY=1/2 (GEV--1/2) |          |                         |       |
| A1 | -.008 .004                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A1 | (+.009)                                                     | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |
| A2 | N <sup>1</sup> /2(1688) INTO GAM P, HELICITY=3/2 (GEV--1/2) |          |                         |       |
| A2 | +.100 .012                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A2 | (+.135)                                                     | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |
| A3 | N <sup>1</sup> /2(1688) INTO GAM N, HELICITY=1/2 (GEV--1/2) |          |                         |       |
| A3 | +.017 .014                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A3 | (.001)                                                      | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |
| A4 | N <sup>1</sup> /2(1688) INTO GAM N, HELICITY=3/2 (GEV--1/2) |          |                         |       |
| A4 | -.005 .018                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A4 | (.001)                                                      | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |

REFERENCES FOR N<sup>1</sup>/2(1688)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

|          |                |                                      |                              |
|----------|----------------|--------------------------------------|------------------------------|
| BRANDSEN | 65 PL 19 420   | +ODONNELL, MOORHOUSE                 | (DURHAM, RHEL)IJP            |
| HEUSCH   | 66 PRL 17 1019 | C A HEUSCH, C Y PRESCOTT, R F DASHEN | (CIT)                        |
| TRIPP    | 67 NP B3 10    | + LEITH, +                           | (LRL,SLAC,CERN,HEID,SLACLAY) |
| BAREYRE  | 68 PR 165 1731 | P BAREYRE, C BRICHAN, G VILLET       | (SACLAY)IJP                  |
| DONNACHI | 68 PL 268 161  | A DONNACHIE, R G KIRSOPP, C LOVELACE | (CERN)IJP                    |
| ALSO     | 68 VIENNA 139  | DONNACHIE RAPPOURTEUR.S TALK         | (GLAS)                       |
| ALSO     | 68 THESIS      | R G KIRSOPP                          | (EDIN)                       |
| DUKE     | 68 PR 166 1448 | +JONES,KEMP,MURPHY,THRESHER, +       | (RHEL,OXF)IJP                |
| RUSH     | 68 PR 173 1776 | J E RUSH                             | (UNIV ALABAMA)               |
| BOTKE    | 69 PR 180 1417 | J C BOTKE                            | (UCSB)                       |
| DEANS    | 69 PR 185 1797 | S DEANS, J WOOTEN                    | (UNIV S FLORIDA)             |
| AYED     | 70 KIEV CONF   | R AYED, P BAREYRE, G VILLET          | (SACLAY)IJP                  |
| CARRERAS | 70 NP 168 35   | B CARRERAS, A DONNACHIE              | (DARE,MCHS)                  |
| DAVIES   | 70 NP 821 359  | A DAVIES                             | (GLAS)                       |
| BRODY    | 71 PL 248 253  | +CASHMORE+..+HERNDON+..              | (SLAC+LRL)                   |
| WAGNER   | 71 NP 825 411  | F WAGNER, C LOVELACE                 | (CERN)                       |
| ALMEHED  | 72 NP 840 157  | +LOVELACE                            | (LUND,RUTG)IJP               |
| OBERLACK | 72 PL 438 44   | H.OBERLACK,R.G.MOORHOUSE             | (LBL)                        |
| WALKER   | 73 TO BE PUB.  | R.L.WALKER,W.J.METCALF               | (CIT)                        |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                          |                      |                                           |                       |
|--------------------------|----------------------|-------------------------------------------|-----------------------|
| CROUCH                   | 65 DESY CONF II 21   | + (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN) |                       |
| DERADO                   | 65 ATHENS CONF 244   | +KENNEY,LAMSA, +                          | (NOTRE DAME,KENTUCKY) |
| DUKE                     | 65 PRL 15 468        | +JONES,KEMP,MURPHY,PRENTICE, +            | (RHEL,OXF)IJP         |
| MERLO                    | 66 P ROY SOC 289 489 | J P MERLO, G VALLADAS                     | (SACLAY)              |
| ROBERTS                  | 67 PREPRINT          | R G ROBERTS                               | (DURHAM)              |
| BANNER                   | 68 PR 166 1347       | +DETOEF,FAYOUX,HAMEL, +                   | (SACLAY,CAEN)         |
| THE ABOVE PAPERS DISCUSS |                      | INELASTIC CHANNELS NEAR THE BUMP.         |                       |
| BAREYRE                  | 65 PL 18 342         | + BRICHAN, STIRLING, VILLET               | (SACLAY)IJP           |
| DEANS                    | 69 PRL 177 2623      | S R DEANS                                 | (UNIV S FLORIDA)      |
| DONNACHI                 | 69 NP 108 433        | A DONNACHIE, R KIRSOPP                    | (GLAS+EDIN)           |
| AYED                     | 70 PL 318 598        | +BAREYRE+VILLET                           | (SACLAY)              |

N(1700)

66 N<sup>1</sup>/2(1700, JP=1/2-) I=1/2S<sup>11</sup>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N<sup>1</sup>/2(1470).

66 N<sup>1</sup>/2(1700) MASS (MEV)

|   |          |                                           |         |                  |       |
|---|----------|-------------------------------------------|---------|------------------|-------|
| M | (1695.0) | BRANDSEN                                  | 65 RVUE | PHASE-SHIFT ANAL | 9/66  |
| M | (1700.0) | MICHAEL                                   | 66 RVUE | FITS BAREYRE S11 | 7/66  |
| M | (1710.0) | BAREYRE                                   | 68 RVUE | PHASE-SHIFT ANAL | 11/67 |
| M | 1        | WHERE CROSS SECTION IS GREATEST - EYEBALL | FIT     |                  |       |
| M | 3        | DONNACHI                                  | 68 RVUE | PHASE-SHIFT ANAL | 8/68  |
| M | (1705.0) | ORITO                                     | 69 RVUE | K LAMBDA PS ANAL | 8/69  |
| M | (1689.0) | WAGNER                                    | 70 IPWA | 1/71             |       |
| M | 6        | FROM ENER. DEP. FIT OF ARGAND             | DIAGRAM |                  |       |
| M | (1766.0) | DAVIES                                    | 70 RVUE | P-S ANAL SOL A   | 8/69  |
| M | (1678.0) | SCHORSCH                                  | 70 DPWA | K LAM PHOTOPRO.  | 10/71 |
| M | (1685.0) | WAGNER                                    | 71 IPWA | P1-P TO K LAMB   | 10/71 |
| M | A        | THERE ARE 3 SIMILAR SOLUTIONS             |         |                  |       |
| M | 7        | ALMEHED                                   | 72 IPWA |                  | 2/72  |

66 N<sup>1</sup>/2(1700) WIDTH (MEV)

|                                               |   |                     |          |         |                       |
|-----------------------------------------------|---|---------------------|----------|---------|-----------------------|
| W                                             |   | (240.0)             | MICHAEL  | 66 RVUE | 7/66                  |
| W                                             | 1 | (260.0)             | BAREYRE  | 68 RVUE | 11/67                 |
| W                                             | 3 | (300.0)             | DONNACHI | 68 RVUE | 8/69                  |
| W                                             |   | (104.0) (15.0)      | ORITO    | 69 RVUE | 8/69                  |
| W                                             | 6 | (166.0)             | AYED     | 70 IPWA | 1/71                  |
| W                                             | 4 | (404.0)             | DAVIES   | 70 RVUE | P-S ANAL SOL A 8/69   |
| W                                             | 4 | SOL B GIVES 121 MEV |          |         | 2/73*                 |
| W                                             |   | (99.0)              | SCHORSCH | 70 DPWA | K LAM PHOTOPRO. 10/71 |
| W                                             | A | (110.0)OR(140.0)    | WAGNER   | 71 IPWA | P1-P TO K LAMB 1/71   |
| W                                             | 7 | (120.)              | ALMEHED  | 72 IPWA | 2/72                  |
| SEE THE NOTES ACCOMPANYING THE PASSES QUOTED. |   |                     |          |         |                       |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

66 N<sup>1</sup>/2(1700) PARTIAL DECAY MODES

|    |                                                  |               |              |
|----|--------------------------------------------------|---------------|--------------|
| P1 | N <sup>1</sup> /2(1700) INTO P1 N                | 139* 938      | DECAY MASSES |
| P2 | N <sup>1</sup> /2(1700) INTO N ETAI              | 939* 548      |              |
| P3 | N <sup>1</sup> /2(1700) INTO LAMBDA K            | 1115* 497     |              |
| P4 | N <sup>1</sup> /2(1700) INTO N GAMMA             | 938* 0        |              |
| P5 | N <sup>1</sup> /2(1700) INTO GAM P, HELICITY=1/2 | 0* 938        |              |
| P6 | N <sup>1</sup> /2(1700) INTO GAM N, HELICITY=1/2 | 0* 939        |              |
| P7 | N <sup>1</sup> /2(1700) INTO N PI PI             | 938* 139* 139 |              |
| P8 | N <sup>1</sup> /2(1700) INTO N EPSILON           | 938* 600      |              |
| P9 | N <sup>1</sup> /2(1700) INTO N RHO               | 938* 770      |              |

66 N<sup>1</sup>/2(1700) BRANCHING RATIOS

|    |                                |         |        |          |         |                     |
|----|--------------------------------|---------|--------|----------|---------|---------------------|
| R1 | N#1/2(1700) INTO (PI N1)/TOTAL |         |        | (P1)     |         |                     |
| R1 | 3                              | (1.0)   | APPROX | MICHAEL  | 66 RVUE | 7/66                |
| R1 | 6                              | (0.79)  |        | DONNACHI | 68 RVUE | 8/69                |
| R1 | 4                              | (0.642) |        | AYED     | 70 IPWA | 1/71                |
| R1 | 4                              | (0.56)  |        | DAVIES   | 70 RVUE | P-S ANAL SOL A 8/69 |
| R1 | 7                              | (0.5)   |        | ALMEHED  | 72 IPWA | 2/72                |

|    |   |                                                                      |          |                         |       |
|----|---|----------------------------------------------------------------------|----------|-------------------------|-------|
| R2 |   | N*1/2(17100) INTO (LAMBDA K)*(PI N)/TOTAL**2                         |          | (P3*P1)                 |       |
| R2 |   | 0.039 0.019                                                          | ORITO    | 69 RVUF                 | 8/69  |
| R2 | A | (0.043)OR 0.054                                                      | WAGNER   | 71 IPWA                 | 1/71  |
| R3 |   | N*1/2(17100) INTO (LAMBDA K)/TOTAL                                   |          | (P3)                    |       |
| R3 | B | (0.028) APPROX.                                                      | RUSH     | 68 MPWA T POLE + RESON. | 8/69  |
| R3 |   | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING           |          |                         |       |
| R4 |   | N*1/2(17100) INTO (N ETAI)/TOTAL                                     |          | (P2)                    |       |
| R4 |   | (0.013)                                                              | BOTKE    | 69 MPWA T POLE + RESON. | 10/69 |
| R4 | B | (0.03) (0.02)                                                        | DEANS    | 69 MPWA T POLE + RESON. | 8/69  |
| R4 | C | (0.19) OR 0.27                                                       | CARRERAS | 70 MPWA T POLE + RESON. | 5/70  |
| R4 | B | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING           |          |                         |       |
| R4 | C | CARRERAS TO USES REGGE POLES + RESONANCES. VALUES SUSPICIOUSLY LARGE |          |                         |       |
| R5 |   | N*1/2(17100) FROM N GAMMA TO LAMBDA K                                |          | SQRT(P3*P4)             |       |
| R5 |   | (0.002)OR LESS                                                       | ORITO2   | 69 CNTR K LAM PHOTOPRO  | 10/71 |
| R5 |   | (0.0072)                                                             | SCHORSCH | 70 DPWA K LAM PHOTOPRO. | 10/71 |
| R5 |   | (0.006)                                                              | DEANS    | 72 MPWA                 | 1/73* |

66 N<sup>1</sup>/2(1700) PHOTON DECAY AMPL(GEV--1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                             |          |                         |       |
|----|-------------------------------------------------------------|----------|-------------------------|-------|
| A1 | N <sup>1</sup> /2(1700) INTO GAM P, HELICITY=1/2 (GEV--1/2) |          |                         |       |
| A1 | +.066 .042                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A1 | (+.011)                                                     | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |
| A2 | N <sup>1</sup> /2(1700) INTO GAM N, HELICITY=1/2 (GEV--1/2) |          |                         |       |
| A2 | 0.072 .066                                                  | OBERLACK | 72 DPWA P1 N PHOTO-PROD | 2/73* |
| A2 | (-.015)                                                     | WALKER   | 73 DPWA P1 N PHOTO-PROD | 2/73* |

REFERENCES FOR N<sup>1</sup>/2(1700)

|          |                |                                      |                     |
|----------|----------------|--------------------------------------|---------------------|
| BRANDSEN | 65 PL 19 420   | +ODONNELL, MOORHOUSE                 | (DURHAM, RHEL)IJP   |
| MICHAEL  | 66 PL 21 93    | C MICHAEL                            | (OXF)               |
| BAREYRE  | 68 PR 165 1731 | P BAREYRE, C BRICHAN, G VILLET       | (SACLAY)IJP         |
| DONNACHI | 68 PL 268 161  | A DONNACHIE, R G KIRSOPP, C LOVELACE | (CERN)IJP           |
| ALSO     | 68 VIENNA 139  | DONNACHIE RAPPOURTEUR.S TALK         | (GLAS)              |
| ALSO     | 68 THESIS      | R G KIRSOPP                          | (EDIN)              |
| RUSH     | 68 PR 173 1776 | J E RUSH                             | (UNIV ALABAMA)      |
| BOTKE    | 69 PR 180 1417 | J C BOTKE                            | (UCSB)              |
| DEANS    | 69 PR 185 1797 | S DEANS, J WOOTEN                    | (UNIV S FLORIDA)    |
| ORITO    | 69 LNC I 936   | S ORITO,S SASAKI                     | (TOKYO-OSAKA)       |
| ORITO2   | 69 INS J 113   | S ORITO (THESIS)                     | (TOKYO)             |
| AYED     | 70 KIEV CONF   | R AYED, P BAREYRE, G VILLET          | (SACLAY)IJP         |
| CARRERAS | 70 NP 168 35   | B CARRERAS, A DONNACHIE              | (DARE,MCHS)         |
| DAVIES   | 70 NP 821 359  | A DAVIES                             | (GLAS)              |
| SCHORSCH | 70 NP 825 179  | +TJETGE,WEINBOECK                    | (MPI)               |
| WAGNER   | 71 NP 825 411  | F WAGNER, C LOVELACE                 | (CERN)              |
| ALMEHED  | 72 NP 840 157  | +LOVELACE                            | (LUND,RUTG)IJP      |
| DEANS    | 72 PN 3 217    | +JACOBS, LYONS, HICKS                | (U S FL TAMPA+GARN) |
| OBERLACK | 72 PL 438 44   | H.OBERLACK,R.G.MOORHOUSE             | (LBL)               |
| WALKER   | 73 TO BE PUB.  | R.L.WALKER,W.J.METCALF               | (CIT)               |

PAPERS NOT REFERRED TO IN DATA CARDS.

|          |                     |                             |                  |
|----------|---------------------|-----------------------------|------------------|
| BAREYRE  | 65 PL 18 342        | + BRICHAN, STIRLING, VILLET | (SACLAY)IJP      |
| JOHNSON  | 67 UCL-17683 THESIS | C H JOHNSON                 | (LRL)            |
| DEANS    | 69 PR 177 2623      | S R DEANS                   | (UNIV S FLORIDA) |
| DONNACHI | 69 NP 108 433       | A DONNACHIE, R KIRSOPP      | (GLAS+EDIN)      |
| AYED     | 70 PL 318 598       | +BAREYRE+VILLET             | (SACLAY)         |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

N(1700)

N(1700)

18 N\*1/2(1700, JP=3/2-) I=1/2

D<sup>13</sup>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1700).

A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 INDICATES THE PRESENCE OF THIS STATE. IN ADDITION AN ISOBAR MODEL ANALYSIS BY HERNDON 72 SHOWS EVIDENCE FOR THIS STATE IN THE SIGMA N AND DELTA P<sub>1</sub> CHANNELS. SEE THE N\* MINI REVIEW.

18 N\*1/2(1700) MASS (MEV)

|     |                                                  |           |    |         |                    |       |
|-----|--------------------------------------------------|-----------|----|---------|--------------------|-------|
| M 3 | (1730.)                                          | DONNACH2  | 68 | RVUE    | PHAS.SHIFT-CERN1   | 10/69 |
| M 3 | (1680.)                                          | KIRSOPP   | 68 | RVUE    | PHASE SHIFT ANAL   | 10/69 |
| M 3 | WHERE MAX. ABSORPTION IS                         | -DONNACH2 | 2  | KIRSOPP | EYEBALL FIT CERN 1 | 10/69 |
| M A | (1780.0)                                         | WAGNER    | 71 | IPWA    | PI-P TO K LAMB     | 1/71  |
| M A | 013 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOL. |           |    |         |                    |       |

18 N\*1/2(1700) WIDTH (MEV)

18 N\*1/2(1700) PARTIAL DECAY MODES

|    |                           |           |              |
|----|---------------------------|-----------|--------------|
| P1 | N*1/2(1700) INTO PI N     | 139+ 938  | DECAY MASSES |
| P2 | N*1/2(1700) INTO LAMBDA K | 1115+ 497 |              |
| P3 | N*1/2(1700) INTO N GAMMA  | 938+ 0    |              |

18 N\*1/2(1700) BRANCHING RATIOS

|    |                                      |             |               |
|----|--------------------------------------|-------------|---------------|
| R1 | N*1/2(1700) FROM N GAMMA TO LAMBDA K | SQRT(P2*P3) |               |
| R1 | (0.008)                              | DEANS       | 72 MPWA 1/73* |

REFERENCES FOR N\*1/2(1700)

|          |    |            |     |                       |                     |        |
|----------|----|------------|-----|-----------------------|---------------------|--------|
| DONNACH2 | 68 | VIENNA     | 139 | DONNACHIE             | RAPPOURTEUR.S TALK  | (GLAS) |
| KIRSOPP  | 68 | THESES     |     | R G KIRSOPP           |                     | (EDIN) |
| WAGNER   | 71 | NP B25 411 |     | F WAGNER, C LOVELAKE  |                     | (CERN) |
| DEANS    | 72 | PN 3 217   |     | +JACOBS, LYONS, HICKS | (U S FL TAMPA-CARN) |        |

PAPERS NOT REFERRED TO IN DATA CARDS.

|         |    |              |  |                               |             |
|---------|----|--------------|--|-------------------------------|-------------|
| AYED    | 72 | BATAVIA CONF |  | R AYED, P BAREYRE, Y LENOIGNE | (SACL)      |
| HERNDON | 72 | BATAVIA CONF |  | +...ROSENFELD...+CASHMORE+... | (LBL, SLAC) |

N(1700)  
BUMPS

20 N\*1/2(1700, JP= ) I=1/2 PRODUCTION EXPERIMENTS

PARTIAL WAVE ANALYSIS REQUIRES AT LEAST FOUR I=1/2 STATES IN THE 1670 TO 1780 REGION (D15, F15, S11, P11) AND AT LEAST ONE I=3/2 STATE (D33). OBVIOUSLY, DIFFERENT EXPERIMENTS ARE SEEING DIFFERENT STATES AND OFTEN I IS NOT CLEAR WHAT ISOSPIN STATE IS BEING OBSERVED. NO EFFORT WAS MADE TO SEPARATE THESE EXPERIMENTS ACCORDING TO JP, SINCE MORE OF THE REPORTED JP IS FIRMLY ESTABLISHED. WE LIST ALL THE INFORMATION HERE, BUT WE HAVE NOT USED IT IN THE BARYON TABLE.

FOR SPIN-PARITY ANALYSIS OF THIS MASS REGION, SEE JOHNSTAD 72 AND LAMSA 72.

20 N\*1/2(1700) MASS (MEV) (PROD. EXP.)

|     |                                                         |        |              |     |                    |                     |        |
|-----|---------------------------------------------------------|--------|--------------|-----|--------------------|---------------------|--------|
| M   | (1695.0)                                                | (9.0)  | A-BORELLI    | 67  | HBC                | + PBAR P 5.7 BEV/C  | 8/67   |
| M   | (1734.0)                                                | (21.0) | ALMEIDA      | 68  | HBC                | + PP 10 BEV/C       | 9/69   |
| M   | (1730.0)                                                | (18.0) | GALLOWAY     | 68  | HBC                | PI-P 6 GEV/C        | 8/69   |
| M 1 | (1712.0)                                                | (6.0)  | BARNES       | 69  | HBC                | K-P TO K-P 2PI      | 7/70   |
| M A | (1667.0)                                                | (5.0)  | BENVENUTI    | 69  | DBC                | 0 PI-D 2.26 GEV     | 5/70   |
| M B | 190(1693.0)                                             | (15.0) | RHODE        | 69  | HBC                | PP 22 GEV/C         | 10/69  |
| M   | (1691.0)                                                | (4.0)  | ANDERSON     | 70  | MMS                | - PI- P TO PI- MMS  | 2/71   |
| M   | 177(1710.0)                                             | (10.0) | CIRBA        | 70  | HBC                | + PI+ P TO P+3PI    | 2/71   |
| M   | 40(1763.0)                                              | (25.0) | COOPER       | 70  | HBC                | + LAMB. K PROD.     | 2/71   |
| M   | 505(1730.0)                                             | (15.0) | CRENNELL     | 70  | HBC                | + PI-P, PI+P 6 GEV  | 1/71   |
| M   | 60(1710.0)                                              | (15.0) | KUZNETSOV    | 70  | HLBC               | - LAMB. K PROD.     | 2/71   |
| M A | (1719.0)                                                | (6.0)  | WILLMANN     | 70  | HBC                | + PI+P 13. GEV      | 5/70   |
| M   | (1694.0)                                                | (8.0)  | AMALOI       | 71  | CNTR               | P P AT 24 GEV       | 10/71  |
| M   | (1730.0)                                                | (20.0) | BALLAM       | 71  | HBC                | + PI+P AT 16GEV     | 2/72   |
| M   | (1700.0)                                                | (10.0) | BEKETOV      | 71  | HBC                | + PI- P 4.45GEV/C   | 3/72   |
| M   | (1711.0)                                                | (10.0) | BOESEBEC     | 71  | RVUE               | PP, PI-P, K-P PROD  | 3/72   |
| M   | (1672.0)                                                | (4.0)  | ELLIS        | 71  | CNTR               | MMS PP 3.7 GEV/C    | 10/71  |
| M   | 80(1650.0)                                              | (10.0) | 80/120 MA    | 71  | HBC                | + P P TO P N PI     | 10/71  |
| M   | (1700.0)                                                | (10.0) | MORSE        | 71  | HBC                | + PI-P 25 GEV/C     | 3/72   |
| M   | 1670. TO 1730.                                          |        | MORSE        | 71  | HBC                | + 0 PI-P 7 GEV/C    | 2/73*  |
| M 1 | (1720.0)                                                | (20.0) | RUSHBROOKET1 | HBC | + PP TO P2PI 16GEV |                     | 3/72   |
| M   | (1690.3)                                                | (4.5)  | EDELSTEIN    | 72  | MMS                | + PP 6 TO 30 GEV    | 1/73*  |
| M   | (1668.0)                                                | (19.0) | KARSHON      | 72  | DBC                | + PD-PD2PI 7 GEV    | 12/72* |
| M C | (1715.0)                                                | (5.0)  | LAMSA        | 72  | HBC                | + PI+P 8TO18 GEV    | 1/73*  |
| M 2 | (1660.0)                                                | (15.0) | OH           | 72  | DBC                | + 0 PI-N TO PI-PI-P | 2/73*  |
| M   | (1720.0)                                                | (15.0) | RONAT        | 72  | HBC                | + PI+P TO SPI P     | 2/73*  |
| M C | ANALYSIS GIVES JP = 5/2+                                |        |              |     |                    |                     |        |
| M 2 | DETERMINE J=5/2, F15 PROBABLE                           |        |              |     |                    |                     |        |
| M B | JP IS PROBABLY 5/2+                                     |        |              |     |                    |                     |        |
| M 1 | J P CONSISTENT WITH S11(1700) OR P11(1760) IN FORMATION |        |              |     |                    |                     |        |
| M A | J CONSISTENT WITH 5/2 OR 7/2                            |        |              |     |                    |                     |        |

20 N\*1/2(1700) WIDTH (MEV) (PROD. EXP.)

|     |             |         |              |     |                    |                     |        |
|-----|-------------|---------|--------------|-----|--------------------|---------------------|--------|
| W   | (170.0)     | (20.0)  | A-BORELLI    | 67  | HBC                |                     | 9/69   |
| W   | (140.0)     | (57.0)  | ALMEIDA      | 68  | HBC                | +                   | 9/69   |
| W   | (155.0)     | (15.0)  | GALLOWAY     | 68  | HBC                |                     | 8/69   |
| W 1 | (70.0)      | (15.0)  | BARNES       | 69  | HBC                | K-P TO K-P 2PI      | 7/70   |
| W A | (105.0)     | (16.0)  | BENVENUTI    | 69  | DBC                | 0                   | 5/70   |
| W B | 190 (235.0) | (50.0)  | RHODE        | 69  | HBC                | PP 22 GEV/C         | 10/69  |
| W   | (130.0)     | (10.0)  | ANDERSON     | 70  | MMS                | - PI- P TO PI- MMS  | 2/71   |
| W   | 177 (66.0)  | (26.0)  | CIRBA        | 70  | HBC                | + PI+ P AT 5 GEV/C  | 2/71   |
| W   | (102.0)     | (40.0)  | COOPER       | 70  | HBC                | + PI+P, 5.5 GEV/C   | 2/71   |
| W   | 505 (130.0) | (30.0)  | CRENNELL     | 70  | HBC                |                     | 1/71   |
| W   | 60 (220.0)  |         | KUZNETSOV    | 70  | HLBC               | - PI-P, 4 GEV/C     | 2/71   |
| W A | (63.0)      | (12.0)  | WILLMANN     | 70  | HBC                | +                   | 5/70   |
| W   | (152.0)     | (15.0)  | AMALOI       | 71  | CNTR               | P P AT 24 GEV       | 10/71  |
| W   | (120.0)     | (50.0)  | BALLAM       | 71  | HBC                | + PI+P AT 16GEV     | 2/72   |
| W   | (57.0)      | (15.0)  | BOESEBEC     | 71  | RVUE               | PP, PI-P, K-P PROD  | 3/72   |
| W   | (102.0)     | (9.0)   | ELLIS        | 71  | CNTR               | MMS PP 3.7 GEV/C    | 10/71  |
| W   | 80 (94.0)   | (20.0)  | 80/120 MA    | 71  | HBC                | + P P TO P N PI     | 10/71  |
| W   | (70.0)      | (20.0)  | MORSE        | 71  | HBC                | + PI-P 25 GEV/C     | 3/72   |
| W   | 70. TO 120. |         | MORSE        | 71  | HBC                | + 0 PI-P 7 GEV/C    | 3/72   |
| W   | (120.0)     | (40.0)  | RUSHBROOKET1 | HBC | + PP TO P2PI 16GEV |                     | 2/72   |
| W   | (133.0)     | (26.0)  | EDELSTEIN    | 72  | MMS                | + PP 6 TO 30 GEV    | 1/73*  |
| W   | (168.0)     | (64.0)  | KARSHON      | 72  | DBC                | + PD-PD2PI 7 GEV    | 12/72* |
| W   | (180.0)     | APPROX. | LAMSA        | 72  | HBC                | + PI P 18.5 GEV/C   | 12/72* |
| W 2 | (128.0)     | (40.0)  | OH           | 72  | DBC                | + 0 PI-N TO PI-PI-P | 2/73*  |
| W   | (60.0)      | (40.0)  | RONAT        | 72  | HBC                | + PI+P TO SPI P     | 2/73*  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

20 N\*1/2(1700) PARTIAL DECAY MODES (PROD. EXP.)

|    |                                    |               |              |
|----|------------------------------------|---------------|--------------|
| P1 | N*1/2(1700) INTO RI N              | 139+ 938      | DECAY MASSES |
| P2 | N*1/2(1700) INTO N PI              | 938+ 139+ 139 |              |
| P3 | N*1/2(1700) INTO N*3/2(1236) PI    | 1236+ 139     |              |
| P4 | N*1/2(1700)+ INTO NEUTRON PI+      | 939+ 139      |              |
| P5 | N*1/2(1700)+ INTO PROTON PI+       | 938+ 139+ 139 |              |
| P6 | N*1/2(1700)+ INTO N*3/2(1236)+ PI- | 1236+ 139     |              |
| P7 | N*1/2(1700) INTO N A               | 939+ 548      |              |
| P8 | N*1/2(1700) INTO LAMBDA K          | 1115+ 497     |              |

20 N\*1/2(1700) BRANCHING RATIOS (PROD. EXP.)

|      |                                              |              |                                              |
|------|----------------------------------------------|--------------|----------------------------------------------|
| R1   | N*1/2(1700) INTO (PI N)/(PI N*3/2(1236))     | (P1)/(P3)    |                                              |
| R1   | (0.77) OR LESS                               | LEE          | 67 HBC                                       |
| R1 A | (9.0) OR MORE                                | BENVENUTI    | 69 DBC                                       |
| R2   | N*1/2(1700) INTO (N ETA)/(N PI + N PI PI)    | (P7)/(P1+P2) |                                              |
| R2   | (0.025) OR LESS                              | KRAEMER      | 64 DBC                                       |
| R2   | (0.042) OR LESS                              | A-BORELLI    | 67 HBC                                       |
| R3   | N*1/2(1700) INTO (LAMBDA K)/(PI PI+PI-)      | (P8)/(P1+P2) |                                              |
| R3   | (0.034) OR LESS                              | ALEXANDER    | 67 HBC                                       |
| R3   | (0.07) OR LESS                               | CIRBA        | 70 HBC                                       |
| R4   | N*1/2(1700) INTO (LAMBDA K)/(N PI + N PI PI) | (P8)/(P1+P2) |                                              |
| R4   | (0.013) OR LESS                              | A-BORELLI    | 67 HBC                                       |
| R4   | SEEN                                         | CHINDOSKY    | 68 HBC                                       |
| R4 1 | LIMITS 0.025 TO 0.11                         | BARNES       | 69 HBC                                       |
| R4   | 0.025                                        | CRENNELL     | 70 HBC                                       |
| R4 A | LESS THAN 0.025                              | WILLMANN     | 70 HBC                                       |
| R4   | 25 SEEN. CONS. WITH J=1/2                    | MORSE        | 71 HBC                                       |
| R5   | N*1/2(1700) INTO (PI)/(N PI PI)              | (P1)/(P2)    |                                              |
| R5   | (1.26) OR LESS                               | A-BORELLI    | 67 HBC                                       |
| R5   | 0.025                                        | CRENNELL     | 70 HBC                                       |
| R6   | N*1/2(1700) INTO (N*3/2(1236) PI)/(N PI PI)  | (P3)/(P2)    |                                              |
| R6   | NO EVIDENCE                                  | A-BORELLI    | 67 HBC                                       |
| R7   | N*1/2(1700) INTO (NEUTRON PI+)/(PI PI+PI-)   | (P4)/(P5)    |                                              |
| R7   | 0.67                                         | ALEXANDER    | 67 HBC                                       |
| R7   | 0.47                                         | A-BORELLI    | 67 HBC                                       |
| R7   | 0.25                                         |              |                                              |
| R7   | 0.53                                         | 0.21         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| R8   | N*1/2(1700) INTO (N*1236)+ PI-)/(PI PI+PI-)  | (P6)/(P5)    |                                              |
| R8   | 0.74                                         | ALEXANDER    | 67 HBC                                       |
| R8   | 1.0                                          | ALMEIDA      | 68 HBC                                       |
| R8   | (0.43)                                       | KAYAS        | 68 HBC                                       |
| R8 1 | LESS THAN 0.15                               | BARNES       | 69 HBC                                       |
| R8   | (0.50) OR LESS                               | CIRBA        | 70 HBC                                       |
| R8   | NO EVIDENCE                                  | CRENNELL     | 70 HBC                                       |
| R8 A | (2.3) OR MORE                                | WILLMANN     | 70 HBC                                       |
| R8   | (1.0) OR MORE                                | BEKETOV      | 71 HBC                                       |
| R8   | 0.75                                         | BOESEBEC     | 71 RVUE                                      |
| R8   | 0.35                                         | RUSHBROOKET1 | HBC                                          |
| R8 C | 0.65                                         | LAMSA        | 72 HBC                                       |
| R8   | 0.66                                         | 0.10         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |
| R9   | N*1/2(1700) INTO (SIG K)/(LAMB K)            | PROD. EXP.   |                                              |
| R9   | LESS THAN .20                                | COOPER       | 70 HBC                                       |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

REFERENCES FOR N\*1/2(1700) (PROD. EXP.)

|           |    |             |                                                 |
|-----------|----|-------------|-------------------------------------------------|
| KRAEMER   | 64 | PR 136 B496 | +MADANSKY, + (J HOPKINS, NWESTERN, WOODSTOCK) I |
| ALEXANDER | 67 | PR 154 1284 | ALEXANDER, BENARY, CZAPEK, + (WEIZMANN(CERN))   |
| A-BORELLI | 67 | NC 47 232   | ALLES-BORELLI, FRENCH, FRISK, MICHEJDA (CERN)   |
| LEE       | 67 | PR 159 1156 | +MOES, ROE, SINCLAIR, VANDER VELDE (MICH)       |
| ALMEIDA   | 68 | PR 174 1638 | +RUSHBROOKE, + (CAVE, DESY(CERN))               |
| CHINDOSKY | 68 | PR 165 1466 | CHINDOSKY, KINSEY, KLEIN, + (LBL, SLAC)         |
| GALLOWAY  | 68 | PL 278 250  | GALLOWAY, ALVEA, CRITTENDEN, PRICKETT, + (IND)  |
| KAYAS     | 68 | NP 85 169   | +GUYADER, SENE, YIOU, ALITTI, + (ORSAY, SACLAY) |

## Baryons

N(1700), N(1780), N(1860)

BARNES 69 PRL 23 1516  
BENVENUT 69 PR 187 1852  
RHODE 69 PR 187 1844

ANDERSON 70 PRL 25,699  
CIRBA 70 NP 823,533  
COOPER 70 NP 823,605  
CRENNELL 71 NP 25 187  
KUZNETSOV 70 SJNP 10,332  
WILLMANN 70 PRL 24 1260

AMALDI 71 PL 348 435  
BALLAM 71 PR 04 1946  
BEKETOV 71 SJNP 13 605  
BOESEBECK 71 NP 833 445  
ELLIS 71 PRL 27 442  
HA 71 PRL 26 933  
MORSE 71 PR 04 133  
RUSHBROOK 71 PR 04 3273

EDELSTEIN 72 PR 05 1073  
JOHNSTAD 72 NP 842 588  
KARSHON 72 NP 837 371  
LAMSA 72 NP 837 364  
OH 72 PL 428 497  
RONAT 72 NP 838 20

+BASSAND+CHUNG+EISNER+FLAMINTO+KINSON (BNL)IJ  
BENVENUT, MARQUIT, OPPENHEIMER (MILN, COLO)  
RHODE, LEACOCK, KERNAN, JESPERSEN, (ISU)

+BLESER, BLIEDEN, COLLINS++ (BNL, CERN)  
+VANDERHAGEN+ (EPOL, DURH, NIJN, TORI, BONN)  
+MANNER, HUSGRAVE, POLLARD, VOYVODIC (ANL)  
+LAI, LOUIE, SCARR, SIMS (BNL)  
+MELNIKOV, RYLTSEVA, CHADRAA, BALINTP (JINR)  
+LAMS, GAIDOS, EZELL (PURD)IJ

+BIANCATELLI, BOSIO, (I SANITA ROMA+ CERN)  
+CHADWICK, GUIRAGOSSIAN, JOHNSON,++ (SLAC) I  
+ZOMBKOVSKII, KONOVALOV, KRUCHININ,++ (ITEP)IJ  
BOESEBECK, GRAESSLER, KRAUS,+++ (ABDCHLV) I  
+MAGLICH, NDREH, SANNES, SILVERMAN (RUTG)  
+COLTON (MSU+LBL) I  
+OH, WALKER, CARROLL, LYNCH + (WISC+TNTOT) I  
RUSHBROOK, WILLIAMS+ BAREFORD++ (CAVE, LOIC) IJ

EDELSTEIN, CARRIGAN, HIEN, MCMAHON, (CARN+BNL)  
+MILLERUD++,+ JACOBSEN (BOUR, HELS, OSLO, STON) IJP  
+YEKUTIELI, YAFFE, SHAPIRA, RONAT,++ (REHO) I  
+WILLMANN++,+GO, BISHAS++ (PURD, NDAM) IJP  
+FUNG, KERNAN, POE, SCHALK, SHEN (UCR) IJP  
+EISENBERG, LYONS, SHAPIRA, TOAFF+ (REHO)

PAPERS NOT REFERRED TO IN DATA CARDS.

MERLO 66 P ROY SOC 289 489 J P MERLO, G VALLADAS (SACLAY)

N(1780)

14 N<sup>1</sup>/2(1780, JP=1/2+) I=1/2P<sub>11</sub>FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N<sup>1</sup>/2(1470).14 N<sup>1</sup>/2(1780) MASS (MEV)

|     |                                       |                  |                  |       |
|-----|---------------------------------------|------------------|------------------|-------|
| M 3 | (1751.0)                              | DONNACHI 68 RVUE | PHASE-SHIFT ANAL | 8/69  |
| M 4 | (1640.0)                              | ORITO 69 RVUE    | K LAMBDA P5 ANAL | 8/69  |
| M 5 | (1700.0)                              | ORITO2 69 CNTR   | K LAM PHOTOPRO   | 10/71 |
| M 6 | (1645.0)                              | AYED 70 IPWA     |                  | 1/71  |
| M 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM |                  |                  |       |
| M 4 | (1770.0)                              | DAVIES 70 RVUE   | P-S ANAL SOL A   | 8/69  |
| M 4 | (1609.0)                              | SCHORSCH 70 DPWA | K LAM PHOTOPRO.  | 10/71 |
| M A | (1685.0)OR(1740.0)                    | WAGNER 71 IPWA   | PI-P TO K LAMB   | 1/71  |
| M A | THERE ARE 3 SIMILAR SOLUTIONS         |                  |                  |       |
| M 7 | (1720.0)                              | ALMEHD 72 IPWA   |                  | 2/72  |

14 N<sup>1</sup>/2(1780) WIDTH (MEV)

|     |                  |                  |                 |       |
|-----|------------------|------------------|-----------------|-------|
| W 3 | (327.0)          | DONNACHI 68 RVUE |                 | 8/69  |
| W 4 | (310.0)          | ORITO 69 RVUE    |                 | 8/69  |
| W 5 | (210.0)          | ORITO2 69 CNTR   | K LAM PHOTOPRO  | 10/71 |
| W 6 | (50.0)           | AYED 70 IPWA     |                 | 1/71  |
| W 4 | (445.0)          | DAVIES 70 RVUE   | SOL A           | 8/69  |
| W 4 | (280.0)          | SCHORSCH 70 DPWA | K LAM PHOTOPRO. | 10/71 |
| W A | (160.0)OR(220.0) | WAGNER 71 IPWA   | PI-P TO K LAMB  | 1/71  |
| W 7 | (160.0)          | ALMEHD 72 IPWA   |                 | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

14 N<sup>1</sup>/2(1780) PARTIAL DECAY MODES

| P1 | N <sup>1</sup> /2(1780) INTO P1 N                | DECAY MASSES  |
|----|--------------------------------------------------|---------------|
| P2 | N <sup>1</sup> /2(1780) INTO LAMBDA K            | 139+ 938      |
| P3 | N <sup>1</sup> /2(1780) INTO N ETA               | 1115+ 497     |
| P4 | N <sup>1</sup> /2(1780) INTO N GAMMA             | 939+ 548      |
| P5 | N <sup>1</sup> /2(1780) INTO GAM P, HELICITY=1/2 | 938+ 0        |
| P6 | N <sup>1</sup> /2(1780) INTO GAM N, HELICITY=1/2 | 0+ 938        |
| P7 | N <sup>1</sup> /2(1780) INTO N PI P1             | 938+ 139+ 139 |
| P8 | N <sup>1</sup> /2(1780) INTO N EPSILON           | 938+ 600      |
| P9 | N <sup>1</sup> /2(1780) INTO N RHO               | 938+ 770      |

14 N<sup>1</sup>/2(1780) BRANCHING RATIOS

|      |                                                            |                  |                       |
|------|------------------------------------------------------------|------------------|-----------------------|
| R1   | N <sup>1</sup> /2(1780) INTO (P1 N)/TOTAL                  | (P1)             |                       |
| R1 3 | (0.32)                                                     | DONNACHI 68 RVUE | 8/69                  |
| R1 6 | (0.149)                                                    | AYED 70 IPWA     | 1/71                  |
| R1 4 | (0.43)                                                     | DAVIES 70 RVUE   | SOL A 8/69            |
| R1 7 | (0.21)                                                     | ALMEHD 72 IPWA   | 2/72                  |
| R2   | N <sup>1</sup> /2(1780) INTO (LAMBDA K)/(PI N)/TOTAL**2    | (P2*P1)          |                       |
| R2 2 | 0.004 0.003                                                | ORITO 69 RVUE    | 8/69                  |
| R2 A | (0.025)OR 0.043                                            | WAGNER 71 IPWA   | PI-P TO K LAMB 1/71   |
| R3   | N <sup>1</sup> /2(1780) INTO (LAMBDA K)/TOTAL              | (P2)             |                       |
| R3 8 | (0.003)TO 0.065                                            | RUSH 68 MPWA     | T POLE + RESON. 8/69  |
| R3 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |                  |                       |
| R4   | N <sup>1</sup> /2(1780) INTO (N ETA)/TOTAL                 | (P3)             |                       |
| R4 8 | (0.09)                                                     | BOTKE 69 MPWA    | T POLE + RESON. 10/69 |
| R4 8 | (0.015)OR 0.035                                            | DEANS 69 MPWA    | T POLE + RESON. 5/70  |
| R4 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING | CARRERAS 70 MPWA | T POLE + RESON. 5/70  |
| R5   | N <sup>1</sup> /2(1780) FROM N GAMMA TO LAMBDA K           | SORT (P2*P4)     |                       |
| R5 5 | (0.0027)                                                   | ORITO2 69 CNTR   | K LAM PHOTOPRO 10/71  |
| R5 5 | (0.0088)                                                   | SCHORSCH 70 DPWA | K LAM PHOTOPRO. 10/71 |
| R5 5 | (0.0104)                                                   | DEANS 72 MPWA    | 1/73*                 |

## Data Card Listings

For notation, see key at front of Listings.

14 N<sup>1</sup>/2(1780) PHOTON DECAY AMPL(GEV\*\*1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                             |                 |                       |
|----|-------------------------------------------------------------|-----------------|-----------------------|
| A1 | N <sup>1</sup> /2(1780) INTO GAM P, HELICITY=1/2 (GEV**1/2) | PI N PHOTO-PROD | 2/73*                 |
| A1 | +0.026 .028                                                 | WALKER 72 DPWA  |                       |
| A1 | (-0.061)                                                    | WALKER 73 DPWA  | PI N PHOTO-PROD 2/73* |
| A2 | N <sup>1</sup> /2(1780) INTO GAM N, HELICITY=1/2 (GEV**1/2) | PI N PHOTO-PROD | 2/73*                 |
| A2 | +0.027 .022                                                 | WALKER 72 DPWA  |                       |
| A2 | (+0.052)                                                    | WALKER 73 DPWA  | PI N PHOTO-PROD 2/73* |

REFERENCES FOR N<sup>1</sup>/2(1780)

|                        |                                               |
|------------------------|-----------------------------------------------|
| DONNACHI 68 PL 268 161 | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJ |
| ALSO 68 VIENNA 139     | DONNACHIE RAPPOREUR.S TALK (GLAS)             |
| ALSO 68 THESES         | R G KIRSOPP (EDIN)                            |
| RUSH 68 PR 173 1776    | J E RUSH (UNIV ALABAMA)                       |
| BOTKE 69 PR 180 1417   | J C BOTKE (UCSB)                              |
| DEANS 69 PR 185 1797   | S DEANS, J WOOTEN (UNIV S FLORIDA)            |
| ORITO 69 LNC 1 936     | S ORITO, S SASAKI (TOKYO-OSAKA)               |
| ORITO2 69 INS J 113    | S ORITO (THESES) (ITOKYO)                     |
| AYED 70 KIEV CONF      | R AYED, P BAREYRE, G VILLET (SACLAY)JP        |
| CARRERAS 70 NP 168 35  | B CARRERAS, A DONNACHIE (DARE,MCHS)           |
| DAVIES 70 NP 821 359   | A DAVIES (GLAS)                               |
| SCHORSCH 70 NP 825 179 | +TIEGTE, WEILNBOECK (MPI)                     |
| WAGNER 71 NP 825 411   | F WAGNER, C LOVELACE (CERN)                   |
| ALMEHD 72 NP 840 157   | +LOVELACE (LLND, RUTG)IJJP                    |
| DEANS 72 PN 3 217      | +JACODS, LYONS, HICKS (U S FL TAMPA+CARN)     |
| OBERLACK 72 PL 438 44  | H OBERLACK, R G MOORHOUSE (LBL)               |
| WALKER 73 TO BE PUB.   | R L WALKER, W J METCALF (CIT)                 |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                        |                                    |
|------------------------|------------------------------------|
| DEANS 69 PR 177 2623   | S R DEANS (UNIV S FLORIDA)         |
| DONNACHI 69 NP 108 433 | A DONNACHIE, R KIRSOPP (GLAS+EDIN) |
| AYED 70 PL 318 598     | +BAREYRE+VILLET (SACLAY)           |

N(1860)

15 N<sup>1</sup>/2(1860, JP=3/2+) I=1/2P<sub>13</sub>FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N<sup>1</sup>/2(1470).15 N<sup>1</sup>/2(1860) MASS (MEV)

|     |                                                       |                  |                  |      |
|-----|-------------------------------------------------------|------------------|------------------|------|
| M 3 | (1860.0)                                              | DONNACHI 68 RVUE | PHASE-SHIFT ANAL | 6/68 |
| M X | (1860.0)                                              | LEA 69 CNTR      | PI-P ELASTIC     | 8/69 |
| M X | SEE ALSO APLIN 71                                     |                  |                  |      |
| M 6 | (1766.0)                                              | AYED 70 IPWA     |                  | 1/71 |
| M 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM                 |                  |                  |      |
| M 4 | (1844.0)                                              | DAVIES 70 RVUE   | P-S ANAL SOL A   | 8/69 |
| M A | (1800.0)                                              | WAGNER 71 IPWA   | PI-P TO K LAMB   | 1/71 |
| M A | P13 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOLUTIONS |                  |                  |      |
| M 7 | (1850.0)                                              | ALMEHD 72 IPWA   |                  | 2/72 |

15 N<sup>1</sup>/2(1860) WIDTH (MEV)

|     |                     |                  |                |       |
|-----|---------------------|------------------|----------------|-------|
| W 3 | (296.00)            | DONNACHI 68 RVUE |                | 8/69  |
| W 6 | (182.0)             | AYED 70 IPWA     |                | 1/71  |
| W 4 | (449.0)             | DAVIES 70 RVUE   | SOL A          | 8/69  |
| W 4 | SOL B GIVES 307 MEV |                  |                | 2/73* |
| W A | (220.0)             | WAGNER 71 IPWA   | PI-P TO K LAMB | 1/71  |
| W 7 | (1300.0)            | ALMEHD 72 IPWA   |                | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

15 N<sup>1</sup>/2(1860) PARTIAL DECAY MODES

| P1 | N <sup>1</sup> /2(1860) INTO P1 N     | DECAY MASSES  |
|----|---------------------------------------|---------------|
| P2 | N <sup>1</sup> /2(1860) INTO LAMBDA K | 139+ 938      |
| P3 | N <sup>1</sup> /2(1860) INTO N ETA    | 1115+ 497     |
| P4 | N <sup>1</sup> /2(1860) INTO N GAMMA  | 939+ 548      |
| P5 | N <sup>1</sup> /2(1860) INTO N PI P1  | 938+ 139+ 139 |
| P6 | N <sup>1</sup> /2(1860) INTO N RHO    | 938+ 0        |
|    |                                       | 938+ 770      |

15 N<sup>1</sup>/2(1860) BRANCHING RATIOS

|      |                                                            |                  |                       |
|------|------------------------------------------------------------|------------------|-----------------------|
| R1   | N <sup>1</sup> /2(1860) INTO (P1 N)/TOTAL                  | (P1)             |                       |
| R1 3 | (0.21)                                                     | DONNACHI 68 RVUE | 8/69                  |
| R1 6 | (0.149)                                                    | AYED 70 IPWA     | 1/71                  |
| R1 4 | (0.40)                                                     | DAVIES 70 RVUE   | SOL A 8/69            |
| R1 7 | (0.25)                                                     | ALMEHD 72 IPWA   | 2/72                  |
| R2   | N <sup>1</sup> /2(1860) INTO (LAMBDA K)/TOTAL              | (P2)             |                       |
| R2 8 | (0.014)TO 0.16                                             | RUSH 68 MPWA     | T POLE + RESON. 8/69  |
| R2 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |                  |                       |
| R3   | N <sup>1</sup> /2(1860) INTO (N ETA)/TOTAL                 | (P3)             |                       |
| R3 8 | (0.0364)                                                   | BOTKE 69 MPWA    | T POLE + RESON. 10/69 |
| R3 8 | (0.003) (0.003)                                            | DEANS 69 MPWA    | T POLE + RESON. 5/70  |
| R3 8 | (0.030)OR 0.094                                            | CARRERAS 70 MPWA | T POLE + RESON. 5/70  |
| R3 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |                  |                       |
| R4   | N <sup>1</sup> /2(1860) INTO (LAMBDA K)/(PI N)/TOTAL**2    | (P2*P1)          |                       |
| R4 A | (0.015)                                                    | WAGNER 71 IPWA   | PI-P TO K LAMB 1/71   |
| R5   | N <sup>1</sup> /2(1860) FROM N GAMMA TO LAMBDA K           | SQRT(P2*P5)      |                       |
| R5   | (0.008)                                                    | DEANS 72 MPWA    | 1/73*                 |

## \*Data Card Listings

For notation, see key at front of Listings.

## Baryons

N(1860), N(1990), N(2040), N(2100)

## REFERENCES FOR N\*1/2(1860)

DONNACHI 68 PL 268 161  
ALSO 68 VIENNA 139  
RUSH 68 PR 173 1776

BOTKE 69 PR 180 1417  
DEANS 69 PR 185 1797  
LEA 69 PL 298 584

AYED 70 KIEV CONF  
CARRERAS 70 NP 168 35  
DAVIES 70 NP 821 359

WAGNER 71 NP 825 411

ALMEHED 72 NP 840 157  
DEANS 72 PN 3 217

A DONNACHIE, R G KIRSOPP, C LOVEFACE (CERN)JIP  
DONNACHIE RAPPORTEUR.S TALK (GLAS)  
R G KIRSOPP (EDIN)  
J E RUSH (UNIV ALABAMA)

J C BOTKE (UCSB)  
S DEANS, J WOOTEN (UNIV S FLORIDA)  
LEA, OADES, WARD, COWAN, + (RHEL, BRISTOL, DARE)

R AYED, P BAREYRE, G VILLET (SACLAY)JIP  
B CARRERAS, A DONNACHIE (DARE, MCHS)  
A DAVIES (GLAS)

F WAGNER, C LOVEFACE (CERN)

+LOVELACE (LUND, RUTG)JIP  
+JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)

PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS 69 PR 177 2623  
DONNACHI 69 NP 108 433

AYED 70 PL 318 598  
APLIN 71 NP 832 253

S R DEANS (UNIV S FLORIDA)  
A DONNACHIE, R KIRSOPP (GLAS+EDIN)

+BAREYRE, VILLET (SACLAY)  
+COWAN, GIBSON, GILMORE++ (RHEL, BRISTOL)

N(2040)

16 N\*1/2(2040, JP=3/2-) I=1/2

D<sup>13</sup>

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 16 N\*1/2(2040) MASS (MEV)

|                                           |                  |                    |       |
|-------------------------------------------|------------------|--------------------|-------|
| M 3 (2057.0)                              | DONNACHI 68 RVUE | PHASE-SHIFT ANAL   | 6/68  |
| M 3 (2030.1)                              | DONNACH2 68 RVUE | PHAS. SHIFT-CERN1  | 10/69 |
| M 3 (2040.1)                              | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL   | 10/69 |
| M 3 WHERE MAX. ABSORPTION IS -DONNACHI, 2 | KIRSOPP 68 RVUE  | EYEBALL FIT CERN 1 | 10/69 |
| M X (2030.0) APPROX                       | LEA 69 CNTR      | PI-P ELASTIC       | 8/69  |
| M X SEE ALSO APLIN 71                     | ALMEHED 72 IPWA  |                    | 2/72  |
| M 7 (2075.1)                              |                  |                    |       |

## 16 N\*1/2(2040) WIDTH (MEV)

|             |                  |                   |       |
|-------------|------------------|-------------------|-------|
| W 3 (293.0) | DONNACHI 68 RVUE |                   | 8/69  |
| W 3 (290.1) | DONNACH2 68 RVUE | PHAS. SHIFT-CERN1 | 10/69 |
| W 3 (240.1) | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL  | 10/69 |
| W 7 (150.1) | ALMEHED 72 IPWA  |                   | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

## 16 N\*1/2(2040) PARTIAL DECAY MODES

|    |                           |               |  |
|----|---------------------------|---------------|--|
| P1 | N*1/2(2040) INTO PI N     | DECAY MASSES  |  |
| P2 | N*1/2(2040) INTO N PI P1  | 139+ 938      |  |
| P3 | N*1/2(2040) INTO N ETA    | 938+ 139+ 139 |  |
| P4 | N*1/2(2040) INTO LAMBOA K | 939+ 548      |  |
| P5 | N*1/2(2040) INTO N GAMMA  | 1115+ 497     |  |
|    |                           | 938+ 0        |  |

## 16 N\*1/2(2040) BRANCHING RATIOS

|      |                                                            |                  |                         |
|------|------------------------------------------------------------|------------------|-------------------------|
| R1   | N*1/2(2040) INTO (PI N)/TOTAL                              | (P1)             |                         |
| R1 3 | (.26)                                                      | DONNACH2 68 RVUE | PHAS. SHIFT-CERN1 10/69 |
| R1 3 | (.15)                                                      | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL 10/69  |
| R1 7 | (0.3)                                                      | ALMEHED 72 IPWA  | 2/72                    |
| R2   | N*1/2(2040) INTO (N ETA)/TOTAL                             | (P3)             |                         |
| R2 8 | (0.1) OR 0.009                                             | CARRERAS 70 MPWA | T POLE + RESON. 5/70    |
| R2 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |                  |                         |
| R3   | N*1/2(2040) FROM N GAMMA TO LAMBOA K                       | DEANS 72 MPWA    | SORT(P4+P5) 1/73*       |
| R3   | (0.007)                                                    |                  |                         |

## REFERENCES FOR N\*1/2(2040)

DONNACHI 68 PL 268 161  
DONNACH2 68 VIENNA 139  
KIRSOPP 68 THESIS

LEA 69 PL 298 584

CARRERAS 70 NP 168 35

ALMEHED 72 NP 840 157  
DEANS 72 PN 3 217

A DONNACHIE, R G KIRSOPP, C LOVEFACE (CERN)JIP  
DONNACHIE RAPPORTEUR.S TALK (GLAS)  
R G KIRSOPP (EDIN)

LEA, OADES, WARD, COWAN, + (RHEL, BRISTOL, DARE)

B CARRERAS, A DONNACHIE (DARE, MCHS)

+LOVELACE (LUND, RUTG)JIP  
+JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)

PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 69 NP 108 433  
AYED 70 PL 318 598  
APLIN 71 NP 832 253

A DONNACHIE, R KIRSOPP (GLAS+EDIN)  
+BAREYRE, VILLET (SACLAY)  
+COWAN, GIBSON, GILMORE++ (RHEL, BRISTOL)

N(2100)

04 N\*1/2(2100, JP=1/2-) I=1/2

S<sup>11</sup>

A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 NOW FINDS EVIDENCE FOR THIS RESONANCE AT ABOUT 2200 MEV. SEE THE N\* MINI REVIEW.

## 04 N\*1/2(2100) MASS (MEV)

|              |                  |      |
|--------------|------------------|------|
| M (2070.1)   | ROYCHOUD 71 DPWA | 3/72 |
| M 7 (2100.1) | ALMEHED 72 IPWA  | 2/72 |

## 04 N\*1/2(2100) WIDTH (MEV)

|             |                 |      |
|-------------|-----------------|------|
| W 7 (200.1) | ALMEHED 72 IPWA | 2/72 |
|-------------|-----------------|------|

## 04 N\*1/2(2100) PARTIAL DECAY MODES

|    |                       |              |  |
|----|-----------------------|--------------|--|
| P1 | N*1/2(2100) INTO PI N | DECAY MASSES |  |
|    |                       | 139+ 938     |  |

N(1990)

17 N\*1/2(1990, JP=7/2-) I=1/2

F<sub>17</sub>

A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 NOW FINDS THIS STATE. SEE THE N\* MINI REVIEW.

## 17 N\*1/2(1990) MASS (MEV)

|                                           |                  |                    |       |
|-------------------------------------------|------------------|--------------------|-------|
| M 3 (1983.0)                              | DONNACHI 68 RVUE | PHASE-SHIFT ANAL   | 10/69 |
| M 3 (1995.1)                              | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL   | 10/69 |
| M 3 WHERE MAX. ABSORPTION IS -DONNACHI, 2 | KIRSOPP 68 RVUE  | EYEBALL FIT CERN 1 | 10/69 |
| M X (2000.0) APPROX                       | LEA 69 CNTR      | PI-P ELASTIC       | 8/69  |
| M X SEE ALSO APLIN 71                     | ALMEHED 72 IPWA  |                    | 2/72  |
| M 7 (2000.1)                              |                  |                    |       |

## 17 N\*1/2(1990) WIDTH (MEV)

|             |                  |                  |       |
|-------------|------------------|------------------|-------|
| W 3 (225.0) | DONNACHI 68 RVUE | PHASE SHIFT ANAL | 8/69  |
| W 3 (250.1) | KIRSOPP 68 RVUE  |                  | 10/69 |
| W 7 (200.1) | ALMEHED 72 IPWA  |                  | 2/72  |

## 17 N\*1/2(1990) PARTIAL DECAY MODES

|    |                           |               |  |
|----|---------------------------|---------------|--|
| P1 | N*1/2(1990) INTO PI N     | DECAY MASSES  |  |
| P2 | N*1/2(1990) INTO N PI P1  | 139+ 938      |  |
| P3 | N*1/2(1990) INTO N ETA    | 938+ 139+ 139 |  |
| P4 | N*1/2(1990) INTO LAMBOA K | 1115+ 497     |  |
| P5 | N*1/2(1990) INTO N GAMMA  | 938+ 0        |  |

## 17 N\*1/2(1990) BRANCHING RATIOS

|      |                                                            |                 |                        |
|------|------------------------------------------------------------|-----------------|------------------------|
| R1   | N*1/2(1990) INTO (PI N)/TOTAL                              | (P1)            |                        |
| R1 3 | (.09)                                                      | KIRSOPP 68 RVUE | PHASE SHIFT ANAL 10/69 |
| R1 7 | (0.15)                                                     | ALMEHED 72 IPWA | 2/72                   |
| R2   | N*1/2(1990) INTO (N ETA)/TOTAL                             | (P3)            |                        |
| R2 8 | (0.02) (0.02)                                              | DEANS 69 MPWA   | T POLE + RESON. 5/70   |
| R2 8 | PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING |                 |                        |
| R3   | N*1/2(1990) FROM N GAMMA TO LAMBOA K                       | DEANS 72 MPWA   | SORT(P4+P5) 1/73*      |
| R3   | (0.003)                                                    |                 |                        |

## REFERENCES FOR N\*1/2(1990)

DONNACHI 68 PL 268 161  
KIRSOPP 68 THESIS

DEANS 69 PR 185 1797  
LEA 69 PL 298 584

ALMEHED 72 NP 840 157  
DEANS 72 PN 3 217

A DONNACHIE, R G KIRSOPP, C LOVEFACE (CERN)JIP  
R G KIRSOPP (EDIN)

S DEANS, J WOOTEN (UNIV S FLORIDA)  
LEA, OADES, WARD, COWAN, + (RHEL, BRISTOL, DARE)

+LOVELACE (LUND, RUTG)JIP  
+JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)

PAPERS NOT REFERRED TO IN DATA CARDS.

S R DEANS (UNIV S FLORIDA)  
+BAREYRE, VILLET (SACLAY)  
+COWAN, GIBSON, GILMORE++ (RHEL, BRISTOL)  
R AYED, P BAREYRE, Y LEMOIGNE (SACL)

## Baryons

N(2100), N(2175), N(2190)

## Data Card Listings

For notation, see key at front of Listings.

04 N\*1/2(2100) BRANCHING RATIOS  
R1 N\*1/2(2100) INTO (PI N)/TOTAL (P1)  
R1 7 (0.5) ALMEHED 72 IPWA 2/72

REFERENCES FOR N\*1/2(2100)  
ROYCHOUD 71 NP 827 125 R K ROYCHOUDHURY, B H BRANSDEN (DURH)JP  
ALMEHED 72 NP 840 157 +LOVELACE (LUND, RUTG)JP  
PAPERS NOT REFERRED TO IN DATA CARDS.

AYED 72 BATAVIA CONF R AYED, P BAREYRE, Y LEMOIGNE (SACL)  
\*\*\*\*\*

N(2100)

05 N\*1/2(2100, JP=5/2-) I=1/2 D<sub>15</sub>  
A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY  
AYED 72 NOW FINDS EVIDENCE FOR THIS RESONANCE AT  
ABOUT 2055 MEV. SEE THE N\* MINI REVIEW.

05 N\*1/2(2100) MASS (MEV)  
M 7 (2100.) ALMEHED 72 IPWA 2/72

05 N\*1/2(2100) WIDTH (MEV)  
M 7 (150.) ALMEHED 72 IPWA 2/72

05 N\*1/2(2100) PARTIAL DECAY MODES  
P1 N\*1/2(2100) INTO PI N DECAY MASSES  
139+ 938

05 N\*1/2(2100) BRANCHING RATIOS  
R1 N\*1/2(2100) INTO (PI N)/TOTAL (P1)  
R1 7 (0.2) ALMEHED 72 IPWA 2/72

REFERENCES FOR N\*1/2(2100)  
ALMEHED 72 NP 840 157 +LOVELACE (LUND, RUTG)JP  
PAPERS NOT REFERRED TO IN DATA CARDS.  
AYED 72 BATAVIA CONF R AYED, P BAREYRE, Y LEMOIGNE (SACL)  
\*\*\*\*\*

N(2175)

06 N\*1/2(2175, JP=5/2+) I=1/2 F<sub>15</sub>  
SEE THE NOTE ON N'S AND DELTAS PRECEDING THE  
BARYON DATA CARD LISTINGS.

06 N\*1/2(2175) MASS (MEV)  
M 7 (2175.) ALMEHED 72 IPWA 2/72

06 N\*1/2(2175) WIDTH (MEV)  
M 7 (150.) ALMEHED 72 IPWA 2/72

06 N\*1/2(2175) PARTIAL DECAY MODES  
P1 N\*1/2(2175) INTO PI N DECAY MASSES  
P2 N\*1/2(2175) INTO LAMBDA K 139+ 938  
P3 N\*1/2(2175) INTO L GAMMA 1115+ 497  
938+ 0

06 N\*1/2(2175) BRANCHING RATIOS  
R1 N\*1/2(2175) INTO (PI N)/TOTAL (P1)  
R1 7 (0.25) ALMEHED 72 IPWA 2/72  
R2 N\*1/2(2175) FROM N GAMMA TO LAMBDA K SORT(P2\*P3)  
R2 (0.002) DEANS 72 MPWA 1/73\*

REFERENCES FOR N\*1/2(2175)  
ALMEHED 72 NP 840 157 +LOVELACE (RUTG)JP  
DEANS 72 PN 3 217 +JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)

N(2190)

71 N\*1/2(2190, JP=7/2-) I=1/2 G<sub>17</sub>  
ROYCHOUDHURY 71 FIND SOME INDICATION OF P11 AND P17 IN  
THIS REGION. BRANSDEN 71 ALSO FIND P11, F15, AND G19 RESO-  
NANT NEAR THIS MASS.

71 N\*1/2(2190) MASS (MEV)  
M (2190.0) DIDDENS 63 CNTR P1+ P TOTAL  
M (2210.0) HOHLER 64 RVUE DATA + DISP REL 7/66  
M (2190.0) APPROX YOKOSAWA 66 CNTR P1- P DISG + POL 7/66  
M 3 (2265.0) DONNACH1 68 RVUE PHASE-SHIFT ANAL 6/68  
M (2000.0) APPROX LEA 69 CNTR P1-P ELASTIC 8/69  
M 2180. ANDERSON 70 HMS P1- P TO PI- HMS 2/71  
M 6 (2158.0) AYED 70 IPWA 1/71  
M 6 FROM ENER. DEP. FIT OF ARGAND DIAGRAM  
M (2260.0) HULL 70 MPWA SMALL ANGLE PI-P 1/71  
M (2160.0) (50.0) AHALDI 71 CNTR P P AT 24 GEV 10/71  
M (2160.) BRANSDEN 71 OPWA 3/72  
M (2200.) ROYCHOUD 71 OPWA 3/72  
M 7 (2225.) ALMEHED 72 IPWA 2/72  
M (2190.) OTT 72 MPWA 0 PI-P BKWD ELSTC 2/73\*

71 N\*1/2(2190) WIDTH (MEV)  
W (200.0) DIDDENS 63 CNTR 7/66  
W (200.0) HOHLER 64 RVUE 7/66  
W 3 (298.0) APPROX YOKOSAWA 66 CNTR 6/68  
W 275. DONNACH1 68 RVUE 2/71  
W 6 (325.0) AYED 70 IPWA 1/71  
W (2200.) HULL 72 IPWA SMALL ANGLE PI-P 1/71  
W 7 (150.) ALMEHED 72 IPWA 2/72  
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

71 N\*1/2(2190) PARTIAL DECAY MODES  
P1 N\*1/2(2190) INTO PI N DECAY MASSES  
P2 N\*1/2(2190) INTO LAMBDA K 139+ 938  
P3 N\*1/2(2190) INTO N PI P1 1115+1765  
P4 N\*1/2(2190) INTO N GAMMA 938+ 139+ 938  
938+ 0

71 N\*1/2(2190) BRANCHING RATIOS  
R1 N\*1/2(2190) INTO (PI N)/TOTAL (P1)  
R1 (0.3) APPROX DIDDENS 63 CNTR 7/66  
R1 (0.3) APPROX HOHLER 64 RVUE 7/66  
R1 3 (0.349) DONNACH1 68 CNTR 6/68  
R1 6 (0.150) AYED 70 IPWA 1/71  
R1 (0.09) HULL 70 MPWA SMALL ANGLE PI-P 1/71  
R1 7 (0.35) ALMEHED 72 IPWA 2/72  
R1 (1.25) OTT 72 MPWA 0 PI-P BKWD ELSTC 2/73\*

REFERENCES FOR N\*1/2(2190)  
DIDDENS 63 PRL 10 262 +JENKINS, KYCIA, RILEY (BNL) I  
HOHLER 64 PL 12 149 G HOHLER, J GIESECKE (KARLSRUHE) I  
YOKOSAWA 66 PRL 16 714 +SUMA, HILL, ESTERLING, BOOTH (ANL, CHIC) JP  
DONNACH1 68 PL 268 161 A DONNACH1, R G KIRSOPP, C LOVELACE (CERN)JP  
ALSO 68 VIENNA 139 DONNACH1E RAPPOREUR-S TALK (GLAS)  
R G KIRSOPP (EDIN)

LEA 69 PL 298 584 LEA, OADES, WARD, COWAN, + (RHEL, BRISTOL, DARE)  
ANDERSON 70 PRL 25, 699 +BLESER, BLIEDEN, COLLINS+ (BNL, CARN)  
AYED 70 KIEV CONF R AYED, P BAREYRE, G VILLET (SACL)JP  
HULL 70 PR 02 1783 J HULL, R LEACOCK (ISU)

AHALDI 71 PL 348 435 +BIANCATELLI, BOSIO, + (I SANITA ROMA-CERN)  
BRANSDEN 71 NP 826 511 +OGDEN (DURH)JP  
ALSO 70 NP 816 461 ROYCHOUDHURY, PERRIN, BRANSDEN (DURH)JP  
ROYCHOUD 71 NP 827 125 R K ROYCHOUDHURY, B H BRANSDEN (DURH)JP

ALMEHED 72 NP 840 157 +LOVELACE (LUND, RUTG)JP  
DEANS 72 PN 3 217 +JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)  
OTT 72 PL 428 133 +TRISCHUK, VAVRA, RICHARDS, + (MCGI, STLO, IOWA)JP  
ALSO 72 MCGILL THESIS J. VAVRA (MCGI) JP

PAPERS NOT REFERRED TO IN DATA CARDS.  
AYED 70 PL 318 598 +BAREYRE, VILLET (SACL)JP

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.  
BARGER 66 PRL 16 913 V BARGER, D CLINE (MISC) P  
CARROLL 66 PRL 16 288 +CORBETT, DAMERELL, MIDDLEMAS, + (RHEL, OXF)J-L  
CARROLL 66 PRL 17 1274 +CORBETT, DAMERELL, MIDDLEMAS, + (RHEL, OXF)J-L  
ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1 (2.)  
KORMANYO 66 PRL 16 709 KORMANYOS, KRISCH, OPALLON, + (MICH, ANL) P  
BUSZA -67 NC 52A 331 +DAVIS, DUFF, MEYHANN, + (LOUC, WESTFIELD)

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

N(2220), N(2650), N(3030), N<sub>7</sub>(3245)

N(2220)

90 N<sup>1</sup>/2(2220, JP=9/2<sup>+</sup>). I=1/2H<sub>19</sub>FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N<sup>1</sup>/2(21470).

| 90 N <sup>1</sup> /2(2220) MASS (MEV) |            |                    |         |         |                   |
|---------------------------------------|------------|--------------------|---------|---------|-------------------|
| M                                     | (2200.)    | APPROX.            | BUSZA   | 67 OSPK | LEG. POLYN. ANAL. |
| M                                     | (2221.0)   |                    | AYED    | 70 IPWA | 2/71              |
| M                                     | FROM ENER. | DEP. FIT OF ARGAND | DIAGRAM |         | 1/71              |
| M                                     | (2245.0)   |                    | HULL    | 70 MPWA | SMALL ANGLE PI-P  |

| 90 N <sup>1</sup> /2(2220) WIDTH (MEV) |         |  |      |         |                  |
|----------------------------------------|---------|--|------|---------|------------------|
| W                                      | (258.0) |  | AYED | 70 IPWA | 1/71             |
| W                                      | (329.0) |  | HULL | 70 MPWA | SMALL ANGLE PI-P |

| 90 N <sup>1</sup> /2(2220) PARTIAL DECAY MODES |                                    |  |  |              |  |
|------------------------------------------------|------------------------------------|--|--|--------------|--|
| P1                                             | N <sup>1</sup> /2(2220) INTO PI N  |  |  | DECAY MASSES |  |
| P2                                             | N <sup>1</sup> /2(2220) INTO N ETA |  |  | 139+ 938     |  |
|                                                |                                    |  |  | 939+ 548     |  |

| 90 N <sup>1</sup> /2(2220) BRANCHING RATIOS |                                           |  |      |         |                  |
|---------------------------------------------|-------------------------------------------|--|------|---------|------------------|
| R1                                          | N <sup>1</sup> /2(2220) INTO (PI N)/TOTAL |  |      | (P1)    |                  |
| R1                                          | (0.140)                                   |  | AYED | 70 IPWA | 1/71             |
| R1                                          | (0.151)                                   |  | HULL | 70 MPWA | SMALL ANGLE PI-P |

REFERENCES FOR N<sup>1</sup>/2(2220)

BUSZA 67 NC 52A 331 +DAVIS, DUFF, HEYMANN, NIMMON + (LOUC+LOWC)  
 AYED 70 KIEV CONF R AYED, P BAREYRE, G VILLET (SACL IJJP)  
 HULL 70 PR D2 1783 J HULL, R LEACOCK (ISU)

PAPERS NOT REFERRED TO IN DATA CARDS

AYED 70 PL 318 598 +BAREYRE, VILLET (SACLAY)

N(2650)  
BUMPS72 N<sup>1</sup>/2(2650, JP= -) I=1/2 PRODUCTION EXPERIMENTS

ROYCHOUDHURY 71 CLAIM F15(2400) AND G19(2400) TO BE POSSIBLE RESONANCES. BRANDSEN 71 FIND THE POSSIBLE RESONANT CANDIDATES S11(2520) AND H19(2590).

| 72 N <sup>1</sup> /2(2650) MASS (MEV) (PROD. EXP.) |          |        |         |         |                 |
|----------------------------------------------------|----------|--------|---------|---------|-----------------|
| M                                                  | (2700.0) |        | ALVAREZ | 64 CNTR | PI PHOTOPROD    |
| M                                                  | (2640.0) |        | HOHLER  | 64 RVUE | DATA + DISP REL |
| M                                                  | (2600.0) | APPROX | MAHLIG  | 64 OSPK | PI-P CH EX      |
| M                                                  | (2633.0) |        | BARGER  | 66 FIT  | TOTAL + CH EX   |
| M                                                  | 2649.0   | 10.0   | CITRON  | 66 CNTR | PI-P TOTAL      |

| 72 N <sup>1</sup> /2(2650) WIDTH (MEV) (PROD. EXP.) |         |      |         |         |               |
|-----------------------------------------------------|---------|------|---------|---------|---------------|
| W                                                   | (100.0) |      | ALVAREZ | 64 CNTR |               |
| W                                                   | (200.0) |      | HOHLER  | 64 RVUE | 7/66          |
| W                                                   | (425.0) |      | BARGER  | 66 FIT  | TOTAL + CH EX |
| W                                                   | 360.0   | 20.0 | CITRON  | 66 CNTR | 11/67         |

| 72 N <sup>1</sup> /2(2650) PARTIAL DECAY MODES (PROD. EXP.) |                                       |  |  |               |  |
|-------------------------------------------------------------|---------------------------------------|--|--|---------------|--|
| P1                                                          | N <sup>1</sup> /2(2650) INTO PI N     |  |  | DECAY MASSES  |  |
| P2                                                          | N <sup>1</sup> /2(2650) INTO LAMBDA K |  |  | 139+ 938      |  |
| P3                                                          | N <sup>1</sup> /2(2650) INTO N PI P1  |  |  | 111+ 497      |  |
|                                                             |                                       |  |  | 938+ 139+ 139 |  |

| 72 N <sup>1</sup> /2(2650) BRANCHING RATIOS (PROD. EXP.) |                                                                         |       |           |         |                   |
|----------------------------------------------------------|-------------------------------------------------------------------------|-------|-----------|---------|-------------------|
| R1                                                       | N <sup>1</sup> /2(2650) INTO (PI N)/TOTAL                               |       |           | (P1)    |                   |
| R1                                                       | ONLY (J+1/2)* (PI N)/TOTAL MEASURED FOR THIS STATE                      |       |           |         |                   |
| R1                                                       | (0.456) (0.018)                                                         |       | CITRON    | 66 CNTR | TOTAL + CH EXC.   |
| R1                                                       | 0.436                                                                   | 0.028 | BARGER    | 67 RVUE | USSES KORMANYOS66 |
| R1                                                       | (0.301)                                                                 |       | DIKMEN    | 67 RVUE | USSES KORMANYOS67 |
| R1                                                       | 8 USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE |       |           |         |                   |
| R1                                                       | 8 FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.                           |       |           |         |                   |
| R1                                                       | D (0.24)                                                                |       | DIKMEN    | 67 RVUE | USSES KORMANYOS66 |
| R1                                                       | D USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES  |       |           |         |                   |
| R1                                                       | (0.061)                                                                 |       | KORMANYOS | 67 CNTR | PI-P AT 180 DEG.  |

REFERENCES FOR N<sup>1</sup>/2(2650) (PROD. EXP.)

ALVAREZ 64 PRL 12 710 +BAR-YAM, KERN, LUCKEY, OSBORNE, + (MIT,CEA)  
 HOHLER 64 PL 12 149 G HOHLER, J GIESECKE (KARLSRUHE) I  
 MAHLIG 64 PRL 13 103 +MANELLI, SODICKSON, FACKLER, WARD, + (MIT)  
 BARGER 66 PR 151 1123 V BARGER, M OLSSON (WISC)  
 CITRON 66 PR 144 1101 +GALBRAITH, KYCIA, LEONTIC, PHILLIPS, + (BNL) I  
 BARGER 67 PR 155 1792 V BARGER, D CLINE (WISC) P  
 DIKMEN 67 PRL 18 798 F N DIKMEN (MICH)  
 KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON, + (MICH,ANL) P

PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE 67 NC 51A 761 J BAACKE, M VYERT (KARLSRUHE,ORSAY)J-L  
 DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CIT)  
 MAHLIG 68 PR 168 1515 M A MAHLIG, I MANELLI (MIT,PISA)  
 FINAL VERSION OF DATA USED IN MAHLIG 64. IN CONJUNCTION WITH  
 CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES  
 COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

BRANDSEN 71 NP B26 511 ,OGDEN (DURHIJJP)  
 ALSO 70 NP B16 461 ROYCHOUDHURY, PERRIN, BRANDSEN (DURHIJJP)  
 ROYCHOUD 71 NP B27 125 R K ROYCHOUDHURY, B H BRANDSEN (DURHIJJP)

N(3030)  
BUMPS73 N<sup>1</sup>/2(3030, JP= ) I=1/2 PRODUCTION EXPERIMENTS

| 73 N <sup>1</sup> /2(3030) MASS (MEV) (PROD. EXP.) |          |  |        |         |                 |
|----------------------------------------------------|----------|--|--------|---------|-----------------|
| M                                                  | (3080.0) |  | HOHLER | 64 RVUE | DATA + DISP REL |
| M                                                  | (3030.0) |  | CITRON | 66 CNTR | PI-P TOTAL      |

| 73 N <sup>1</sup> /2(3030) WIDTH (MEV) (PROD. EXP.) |         |  |        |         |      |
|-----------------------------------------------------|---------|--|--------|---------|------|
| W                                                   | (400.0) |  | CITRON | 66 CNTR | 7/66 |

| 73 N <sup>1</sup> /2(3030) PARTIAL DECAY MODES (PROD. EXP.) |                                      |  |  |               |  |
|-------------------------------------------------------------|--------------------------------------|--|--|---------------|--|
| P1                                                          | N <sup>1</sup> /2(3030) INTO PI N    |  |  | DECAY MASSES  |  |
| P2                                                          | N <sup>1</sup> /2(3030) INTO N PI P1 |  |  | 139+ 938      |  |
|                                                             |                                      |  |  | 139+ 139+ 139 |  |

| 73 N <sup>1</sup> /2(3030) BRANCHING RATIOS (PROD. EXP.) |                                                                         |  |        |         |                   |
|----------------------------------------------------------|-------------------------------------------------------------------------|--|--------|---------|-------------------|
| R1                                                       | N <sup>1</sup> /2(3030) INTO (PI N)/TOTAL                               |  |        | (P1)    |                   |
| R1                                                       | ONLY (J+1/2)* (PI N)/TOTAL MEASURED FOR THIS STATE                      |  |        |         |                   |
| R1                                                       | (0.088) (0.016)                                                         |  | BARGER | 66 RVUE | TOTAL + CH EXC.   |
| R1                                                       | (0.048)                                                                 |  | CITRON | 66 CNTR | TOTAL CROSS-SEC.  |
| R1                                                       | (0.12)                                                                  |  | BARGER | 67 CNTR | USSES KORMANYOS66 |
| R1                                                       | 8 USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE |  |        |         |                   |
| R1                                                       | 8 FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.                           |  |        |         |                   |
| R1                                                       | D (0.016)                                                               |  | DIKMEN | 67 RVUE | USSES KORMANYOS67 |
| R1                                                       | D USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES  |  |        |         |                   |

REFERENCES FOR N<sup>1</sup>/2(3030) (PROD. EXP.)

HOHLER 64 PL 12 149 G HOHLER, J GIESECKE (KARLSRUHE) I  
 BARGER 66 PR 151 1123 V BARGER, M OLSSON (WISC)  
 CITRON 66 PR 144 1101 +GALBRAITH, KYCIA, LEONTIC, PHILLIPS, + (BNL) I  
 BARGER 67 PR 155 1792 V BARGER, D CLINE (WISC) P  
 DIKMEN 67 PRL 18 798 F N DIKMEN (MICH)

PAPERS NOT REFERRED TO IN DATA CARDS

KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON, + (MICH,ANL) P  
 DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CIT)

N<sub>7</sub>(3245)  
BUMPS74 N<sup>1</sup>/2(3245, JP= +) PRODUCTION EXPERIMENTS

EXISTENCE NOT CONCLUSIVELY ESTABLISHED. I-SPIN NOT DETERMINED, BUT THE NARROW WIDTH PRECLUDES IDENTIFICATION WITH THE N<sup>1</sup>/2(3230).

OMITTED FROM TABLE.

| 74 N <sup>1</sup> /2(3245) MASS (MEV) (PROD. EXP.) |        |      |           |         |                 |
|----------------------------------------------------|--------|------|-----------|---------|-----------------|
| M                                                  | 3245.0 | 10.0 | KORMANYOS | 67 CNTR | PI-P 180 DEG EL |

| 74 N <sup>1</sup> /2(3245) WIDTH (MEV) (PROD. EXP.) |        |         |           |         |      |
|-----------------------------------------------------|--------|---------|-----------|---------|------|
| W                                                   | (35.0) | OR LESS | KORMANYOS | 67 CNTR | 6/68 |

| 74 N <sup>1</sup> /2(3245) PARTIAL DECAY MODES (PROD. EXP.) |                                   |  |  |              |  |
|-------------------------------------------------------------|-----------------------------------|--|--|--------------|--|
| P1                                                          | N <sup>1</sup> /2(3245) INTO PI N |  |  | DECAY MASSES |  |
|                                                             |                                   |  |  | 139+ 938     |  |

| 74 N <sup>1</sup> /2(3245) BRANCHING RATIOS (PROD. EXP.) |                                                    |  |           |         |      |
|----------------------------------------------------------|----------------------------------------------------|--|-----------|---------|------|
| R1                                                       | N <sup>1</sup> /2(3245) INTO (PI N)/TOTAL          |  |           | (P1)    |      |
| R1                                                       | J IS NOT KNOWN. FOLLOWING IS (J+1/2)* (PI N)/TOTAL |  |           |         |      |
| R1                                                       | (0.37)                                             |  | KORMANYOS | 67 CNTR | 6/68 |

REFERENCES FOR N<sup>1</sup>/2(3245) (PROD. EXP.)

KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON, + (MICH,ANL) P

## Baryons

N(3690), N<sub>p</sub>(3755), Δ(1236)**N(3690)  
BUMPS**

75 N\*1/2(3690, JP= ) I=1/2 PRODUCTION EXPERIMENTS  
A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLICATED STATE (IN + SEVEN PIS), SO AS EVIDENCE FOR A NEW RESONANCE IT IS NOT CONCLUSIVE. NOT INCLUDED IN TABLE.

75 N\*1/2(3690) MASS (MEV) (PROD. EXP.)  
M 3690.0 10.0 BARTKE 67 HBC + PI+P 8 PRONGS 8/67

75 N\*1/2(3690) WIDTH (MEV) (PROD. EXP.)  
M 50.0 30.0 BARTKE 67 HBC + 8/67

75 N\*1/2(3690) PARTIAL DECAY MODES (PROD. EXP.)  
P1 N\*1/2(3690) INTO N + 7 PIS  
DECAY MASSES  
BARTKE 67 PL 248 118 +CZYZEWski, DANYSZ, (CRACON, ORSAY) I  
REFERENCES FOR N\*1/2(3690) (PROD. EXP.)

**N<sub>p</sub>(3755)  
BUMPS**

76 N\* /2(3755, JP= ) PRODUCTION EXPERIMENTS  
A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM 8.4 BEV/C PI+ P TO PI+ P PBAR EVENTS. AS EVIDENCE FOR A NEW RESONANCE IT IS NOT CONCLUSIVE. OMITTED FROM TABLE.

76 N\* /2(3755) MASS (MEV) (PROD. EXP.)  
M 3755.0 8.0 EHRLICH 68 HBC + PI+ P P PBAR 6/68

76 N\* /2(3755) WIDTH (MEV) (PROD. EXP.)  
M 40.0 20.0 EHRLICH 68 HBC + 6/68

76 N\* /2(3755) PARTIAL DECAY MODES (PROD. EXP.)  
P1 N\* /2(3755) INTO PI+ P P PBAR  
DECAY MASSES  
139+ 938+ 938+ 938  
EHRLICH 68 PRL 20 686 R EHRLICH, R J PLANO, J B WHITTAKER (RUTGERS)  
REFERENCES FOR N\* /2(3755) (PROD. EXP.)

Comments on the Mass and Width of Δ(1236)

In our last edition, we presented an exhaustive discussion of the relative "uniqueness" of the pole position. On the basis of that study we have entered the pole position in both the Table and the Data Card Listings. We remind the reader of our conclusions.

1) Over a reasonable energy interval on the real axis, all parametrizations of the amplitude are equally good provided:

- they fit the data,
- they are unitary and have sensible "cut" features (e.g.,  $\delta_\ell \propto q^{2\ell+1}$ ).

2) For good fits to the same data, the resonance mass and width on the real axis depend upon the parametrization used (background + BW, different BW's, etc.). Indeed, we found that the fitted mass parameter

## Data Card Listings.

For notation, see key at front of Listings.

ranged from 1230 to 1235 MeV, and the width from 109 to 124 MeV. Clearly, it is meaningless for us to average masses and widths corresponding to either different parametrizations or significantly different sets of data.

3) For good fits to the same data, the pole position is essentially independent of the parametrization.

**Δ(1236)**33 N\*3/2(1236, JP=3/2+) I=3/2 **P33**

CARTER 71 REPORT NEW PRECISE CROSS SECTION MEASUREMENTS FOR PI+P, PI-P AND CHARGE EXCHANGE. THEIR ANALYSIS COMBINES TOTAL CROSS SECTION DATA WITH THE PHASE SHIFTS OF DONNACHIE 68 (USED FOR THE BACKGROUND UNDER THE P33) THE CHARGE EXCHANGE DATA WERE NOT USED.  
OLSSON 65 HAS DONE A SIMILAR ANALYSIS ON OLDER DATA, USING ROPEP 65 PHASE SHIFTS WITH A FREE OVERALL NORMALIZATION.  
SEE THE ACCOMPANYING NOTE, 'COMMENTS ON THE MASS AND WIDTH OF DELTA(1236)'.

33 N\*3/2(1236) MASS (MEV)  
M (1234.) ROPER 65 DPWA ++0 PHASE SHIFT AN. 2/72  
M (1235.) ALMEHD 72 IPWA  
M++ 1236.0 0.55 OLSSON 65 RVUE ++ TOTAL-SIGMA DATA 1/71  
M++ 1230.0 0.6 CARTER 71 MPWA ++ PI+P SIG. TOTAL  
M++ AVERAGE MEANINGLESS (SCALE FACTOR = 7.4)  
MO 1236.45 0.65 OLSSON 65 RVUE 0  
MO 1232.9 0.6 CARTER 71 MPWA 0 PI-P SIG. TOTAL 1/71  
MO AVERAGE MEANINGLESS (SCALE FACTOR = 4.0)

33 N\*3/2(1236) WIDTH (MEV)  
M (120.) ROPER 65 DPWA ++0 PHASE SHIFT AN. 2/72  
M (129.) ALMEHD 72 IPWA  
M++ 120.0 2.0 OLSSON 65 RVUE ++  
M++ 112.8 3.0 CARTER 71 MPWA ++ PI+P SIG TOT. 1/71  
M++ AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)  
MO 119.6 2.4 OLSSON 65 RVUE 0  
MO 114.7 3.0 CARTER 71 MPWA 0 PI-P SIG TOT. 1/71  
MO AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

33 N\*3/2(1236) REAL PART OF POLE POSITION(MEV)  
REE P (1211.) BALL 72  
REE P 1211.6 PDG 72  
REE P ERROR EST. FROM FITS WITH SOMEWHAT VARYING ASSUMPTIONS  
FIT DELTA 33 2/73\*  
2/73\*

33 N\*3/2(1236) IMAG PART OF POLE POSITION(MEV)  
IME P 49.5 1.8 PDG 72  
IME P (50.) BALL 72  
FIT DELTA 33 2/73\*  
2/73\*

33 (N\*0) - (N\*++) MASS DIFFERENCE (MEV)  
O R (0.45) (0.85) OLSSON 65 RVUE  
O R (2.9) (0.85) CARTER 71 MPWA PI+- P SIG.TOT. 2/71  
REDUNDANT WITH DATA IN MASS LISTING.

33 N\*3/2(1236) PARTIAL DECAY MODES  
P1 N\*3/2(1236) INTO N PI  
P2 N\*3/2(1236) INTO N GAMMA  
P3 N\*3/2(1236) INTO N PI P1  
P4 N\*3/2(1236) INTO GAM NUCLEON, HELICITY=1/2  
P5 N\*3/2(1236) INTO GAM NUCLEON, HELICITY=3/2  
DECAY MASSES  
938+ 139  
938+ 0  
938+ 139+ 139  
0+ 938  
0+ 938

33 N\*3/2(1236) BRANCHING RATIOS  
R1 N\*3/2(1236) INTO (N GAMMA)/(N PI) (PERCENT) (P2)/(P1)  
R1 0.55 0.02 DALITZ 66 RVUE 7/68  
R1 0.53 0.025 BERENDS 71 IPWA PHOTOPROD. ANAL. 10/71  
R1 AVG 0.542 0.016 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
R2 N\*3/2(1236) INTO (N PI)/TOTAL (P1)  
R2 (0.99) CARTER 71 MPWA 0 PI-P FORM. EXPER 1/71

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Delta(1236)$ ,  $\Delta(1650)$ ,  $\Delta(1670)$ 

33 N\*3/2(1236) PHOTON DECAY AMPL(GEV\*\*=1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                        |  |
|----|--------------------------------------------------------|--|
| A1 | N*3/2(1236) INTO GAM NUCLEON, HELICITY=1/2 (GEV**=1/2) |  |
| A1 | -142 .006 OBERLACK 72 DPWA PI N PHOTO-PROD 2/73*       |  |
| A1 | (-139) WALKER 73 DPWA PI N PHOTO-PROD 2/73*            |  |
| A2 | N*3/2(1236) INTO GAM NUCLEON, HELICITY=3/2 (GEV**=1/2) |  |
| A2 | -259 .016 OBERLACK 72 DPWA PI N PHOTO-PROD 2/73*       |  |
| A2 | (-253) WALKER 73 DPWA PI N PHOTO-PROD 2/73*            |  |

## REFERENCES FOR N\*3/2(1236)

|                                                               |                                              |
|---------------------------------------------------------------|----------------------------------------------|
| OLSSON 65 PRL 14 118                                          | M G OLSSON (MISC)                            |
| ROPER 65 PR 138 8190                                          | L D ROPER, R M WRIGHT, B T FELD (LRL+MIT)JIP |
| DALITZ 66 PR 146 1180                                         | DALITZ, SUTHERLAND (OXFORD)                  |
| CONTAINS REFERENCES TO EARLIER WORK ON DELTA PHOTOPRODUCTION. |                                              |

|                       |                                             |
|-----------------------|---------------------------------------------|
| BERENDS 71 NP 830 575 | *WEAVER (CEA, MIT, TUFT)                    |
| CARTER 71 NP 826 445  | *WILLIAMS, BUGG, BUSSEY, DANCE (CAVE, RHEL) |

|                       |                                         |
|-----------------------|-----------------------------------------|
| ALMEHD 72 NP 840 157  | *LOVELACE (LUND, RUTG)JIP               |
| BALL 72 PRL 28 1143   | *CAMPBELL, LEE, SHAW (UTAH, BOISE, UCI) |
| OBERLACK 72 PL 438 44 | H. OBERLACK, R. G. MOORHOUSE (LBL)      |
| PDG 72 PL 398 103     | R. L. WALKER, W. J. METCALF (CIT)       |
| WALKER 73 TO BE PUB.  |                                         |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                        |                                     |
|------------------------|-------------------------------------|
| DONNACHI 68 PL 268 161 | DONNACHIE, LOVELACE, KIRSOPP (CERN) |
|------------------------|-------------------------------------|

 $\Delta(1236)$   
BUMPS

81 N\*3/2(1236, JP=3/2+) I=3/2 PRODUCTION EXPERIMENTS

## 81 N\*3/2(1236) MASS (MEV) (PROD. EXP.)

|     |          |       |                                              |
|-----|----------|-------|----------------------------------------------|
| M   | 1217.    | 8.    | ANDERSON 70 MMS - PI- P TO PI- MMS 2/71      |
| M   | 1227.0   | 7.0   | ELLIS 71 CNTR MMS PP 3.7 GEV/C 10/71         |
| M   | 1222.7   | 5.3   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| M++ | (1232.0) | (6.0) | FERRO-LUZ 65 HBC ++ K+P TO KO P PI+          |
| M++ | (1236.0) |       | DEANS 66 RVUE ++ PI+P TOTAL 7/66             |
| M++ | (1233.4) | (4.4) | GIDAL 66 DBC ++ D TO MN(IN) PI 7/66          |
| M++ | (1224.0) | (2.0) | HABER 70 DBC K-0 TO 4 BOD(P) 7/70            |
| M++ | 1236.0   | 2.0   | COLTON 72 HBC ++ PP TO PI+PN TGEV 1/73*      |
| M++ | 1226.0   | 2.0   | COLTON 72 HBC ++ TO PI+PI-PP 1/73*           |
| M++ | 1222.0   | 3.0   | COLTON 72 HBC ++ TO PI+PI-PIOPP 1/73*        |
| M++ | 1226.0   | 2.0   | COLTON 72 HBC ++ TO PI+PI-PI-PN 1/73*        |
| M++ | 1228.4   | 2.9   | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7) |
| M-  | (1241.3) | (5.1) | GIDAL 66 DBC - 7/66                          |
| M-  | 1239.0   | 5.0   | COLTON 72 HBC - TO PI+PI-PI-PN 1/73*         |

## 81 (N\*-) - (N\*++) MASS DIFFERENCE (MEV) (PROD. EXP.)

|   |     |     |              |
|---|-----|-----|--------------|
| D | 7.9 | 6.8 | GIDAL 66 DBC |
|---|-----|-----|--------------|

## 81 N\*3/2(1236) WIDTH (MEV) (PROD. EXP.)

|     |         |        |                                              |
|-----|---------|--------|----------------------------------------------|
| M   | 115.    | 5.     | ANDERSON 70 MMS - PI- P TO PI- MMS 2/71      |
| M   | 105.0   | 7.0    | ELLIS 71 CNTR MMS PP 3.7 GEV/C 10/71         |
| M   | 111.6   | 4.7    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |
| M++ | (125.0) | (30.0) | FERRO-LUZ 65 HBC ++                          |
| M++ | (121.0) |        | DEANS 66 RVUE ++ 7/66                        |
| M++ | (124.0) | (14.0) | GIDAL 66 DBC ++ 7/70                         |
| M++ | (120.0) | (8.0)  | HABER 70 DBC K-0 TO 4 BOD(P) 7/70            |
| M++ | 115.0   | 6.0    | COLTON 72 HBC ++ PP TO PI+PN TGEV 1/73*      |
| M++ | 127.0   | 5.0    | COLTON 72 HBC ++ TO PI+PI-PP 1/73*           |
| M++ | 122.0   | 9.0    | COLTON 72 HBC ++ TO PI+PI-PIOPP 1/73*        |
| M++ | 106.0   | 7.0    | COLTON 72 HBC ++ TO PI+PI-PI-PN 1/73*        |
| M++ | 118.8   | 4.7    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5) |
| M-  | (149.0) | (18.0) | GIDAL 66 DBC - 7/66                          |
| M-  | 237.0   | 22.0   | COLTON 72 HBC - TO PI+PI-PI-PN 1/73*         |

## REFERENCES FOR N\*3/2(1236) (PROD. EXP.)

|                        |                                            |
|------------------------|--------------------------------------------|
| FERRO-LU 65 NC 36 1101 | FERRO-LUZZI, GEORGE, + (CERN)              |
| DEANS 66 PREPRINT      | S R DEANS, W G HOLLADAY (VANDERBILT)       |
| GIDAL 66 PR 141 1261   | G GIDAL, A KERNAN, S KIM (LRL)             |
| ANDERSON 70 PRL 25 699 | *BLESER, BLIEDEN, COLLINS++ (BNL, CERN)    |
| HABER 70 NP 178 289    | *SHAPIRA, MERRILL, MONARI++ (SABRE COLL)   |
| ELLIS 71 PRL 27 442    | *MAGLICH, NORDEN, SANNES, SILVERMAN (RUTG) |
| COLTON 72 PR 66 95     | E COLTON, A KIRSCHBAUM (LBL)               |

 $\Delta(1650)$ 

82 N\*3/2(1650, JP=1/2-) I=3/2

 $S_{31}$ 

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 82 N\*3/2(1650) MASS (MEV)

|   |                                  |        |                                               |                  |       |
|---|----------------------------------|--------|-----------------------------------------------|------------------|-------|
| M | (1648.0)                         | (12.0) | DEVLIN 65 CNTR                                | PI- P TOTAL      |       |
| M | (1695.0)                         |        | BAREYRE 68 RVUE                               | PHASE-SHIFT ANAL | 11/67 |
| M | (1635.0)                         |        | WHERE CROSS SECTION IS GREATEST - EYEBALL FIT |                  |       |
| M | (1614.0)                         |        | DONNACHI 68 RVUE                              | PHASE-SHIFT ANAL | 6/68  |
| M | (1614.0)                         |        | AYED 70 IPWA                                  |                  | 1/71  |
| M | ENER. DEP. FIT OF ARGAND DIAGRAM |        | DAVIES 70 RVUE                                | P-S ANAL SOL A   | 8/69  |
| M | (1617.0)                         |        | ALMEHD 72 IPWA                                |                  | 2/72  |
| M | (1620.0)                         |        |                                               |                  |       |

## 82 N\*3/2(1650) WIDTH (MEV)

|                                               |         |  |                  |                |       |
|-----------------------------------------------|---------|--|------------------|----------------|-------|
| M                                             | (250.0) |  | BAREYRE 68 RVUE  |                | 11/67 |
| M                                             | (177.0) |  | DONNACHI 68 RVUE |                | 6/68  |
| M                                             | (142.0) |  | AYED 70 IPWA     |                | 1/71  |
| M                                             | (141.0) |  | DAVIES 70 RVUE   | P-S ANAL SOL A | 8/69  |
| M                                             | (140.0) |  | ALMEHD 72 IPWA   |                | 2/72  |
| SEE THE NOTES ACCOMPANYING THE MASSES QUOTED. |         |  |                  |                |       |

## 82 N\*3/2(1650) PARTIAL DECAY MODES

|    |                                            |               |
|----|--------------------------------------------|---------------|
| P1 | N*3/2(1650) INTO PI N                      | DECAY MASSES  |
| P2 | N*3/2(1650) INTO N PI PI                   | 139+ 938      |
| P3 | N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2 | 938+ 139+ 139 |
| P4 | N*3/2(1650) INTO N*3/2(1236) PI            | 1236+ 139     |
| P5 | N*3/2(1650) INTO N RHO                     | 938+ 770      |

## 82 N\*3/2(1650) BRANCHING RATIOS

|    |                               |         |                  |      |
|----|-------------------------------|---------|------------------|------|
| R1 | N*3/2(1650) INTO (PI N)/TOTAL |         | (P1)             |      |
| R1 | 3                             | (0.284) | DONNACHI 68 RVUE | 6/68 |
| R1 | 6                             | (0.317) | AYED 70 IPWA     | 1/71 |
| R1 | 4                             | (0.28)  | DAVIES 70 RVUE   | 8/69 |
| R1 | 7                             | (0.35)  | ALMEHD 72 IPWA   | 2/72 |

## 82 N\*3/2(1650) PHOTON DECAY AMPL(GEV\*\*=1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                        |  |
|----|--------------------------------------------------------|--|
| A1 | N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2 (GEV**=1/2) |  |
| A1 | +090 .076 OBERLACK 72 DPWA PI N PHOTO-PROD 2/73*       |  |
| A1 | (+112) WALKER 73 DPWA PI N PHOTO-PROD 2/73*            |  |

## REFERENCES FOR N\*3/2(1650)

|                        |                                                |
|------------------------|------------------------------------------------|
| DEVLIN 65 PRL 14 1031  | T J DEVLIN, J SOLOMON, G BERTSCH (PRINCETON) I |
| BAREYRE 68 PR 165 1731 | P BAREYRE, C BRICHMAN, G VILLET (SACLAY)JIP    |
| DONNACHI 68 PL 268 161 | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JIP |
| ALSO 68 VIENNA 139     | DONNACHIE RAPPORTEUR'S TALK (GLAS)             |
| ALSO 68 THESIS         | R G KIRSOPP (EDIN)                             |
| AYED 70 KIEV CONF      | R AYED, P BAREYRE, G VILLET (SACL)JIP          |
| DAVIES 70 NP 821 359   | A DAVIES (GLAS)                                |
| ALMEHD 72 NP 840 157   | *LOVELACE (LUND, RUTG)JIP                      |
| OBERLACK 72 PL 438 44  | H. OBERLACK, R. G. MOORHOUSE (LBL)             |
| WALKER 73 TO BE PUB.   | R. L. WALKER, W. J. METCALF (CIT)              |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                             |                                               |
|-----------------------------|-----------------------------------------------|
| CARRUTHE 60 PRL 4 303       | P CARRUTHERS (CORNELL) I                      |
| DEVLIN 62 PR 125 690        | T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I |
| HELLAND 64 PR 134 B1062     | *DEVLIN, HAGE, LONGO, MOYER, WOOD (LRL) I     |
| BAREYRE 65 PL 18 342        | *BRICHMAN, STIRLING, VILLET (SACLAY)JIP       |
| JOHNSON 67 UCL-17683 THESIS | C H JOHNSON (LRL)                             |
| DONNACHI 69 NP 108 433      | A DONNACHIE, R KIRSOPP (GLAS+EDIN)            |
| AYED 70 PL 318 598          | *BAREYRE, VILLET (SACLAY)                     |
| BOWLER 70 NP 178 331        | *CASHMORE (U. OXFORD)                         |

 $\Delta(1670)$ 

10 N\*3/2(1670, JP=3/2-) I=3/2

 $D_{33}$ 

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

## 10 N\*3/2(1670) MASS (MEV)

|   |                                  |  |                  |                  |      |
|---|----------------------------------|--|------------------|------------------|------|
| M | (1691.0)                         |  | DONNACHI 68 RVUE | PHASE-SHIFT ANAL | 8/69 |
| M | (1722.0)                         |  | AYED 70 IPWA     |                  | 1/71 |
| M | ENER. DEP. FIT OF ARGAND DIAGRAM |  | DAVIES 70 RVUE   | P-S ANAL SOL A   | 8/69 |
| M | (1649.0)                         |  | ALMEHD 72 IPWA   |                  | 2/72 |
| M | (1700.0)                         |  |                  |                  |      |

## Baryons

 $\Delta(1670)$ ,  $\Delta(1690)$ ,  $\Delta(1890)$ 

## Data Card Listings

For notation, see key at front of Listings.

| 10 N*3/2(1670) WIDTH (MEV) |   |         |                  |      |
|----------------------------|---|---------|------------------|------|
| M                          | 3 | (269.0) | DONNACH1 68 RVUE | 8/69 |
| M                          | 4 | (258.0) | AYED 70 IPWA     | 1/71 |
| M                          | 4 | (188.0) | DAVIES 70 RVUE   | 8/69 |
| M                          | 7 | (260.)  | ALMEHD 72 IPWA   | 2/72 |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

| 10 N*3/2(1670) PARTIAL DECAY MODES |             |                                |               |  |
|------------------------------------|-------------|--------------------------------|---------------|--|
| P1                                 | N*3/2(1670) | INTO PI N                      | 139+ 938      |  |
| P2                                 | N*3/2(1670) | INTO N PI P1                   | 938+ 139+ 139 |  |
| P3                                 | N*3/2(1670) | INTO K SIGMA                   | 493+ 1189     |  |
| P4                                 | N*3/2(1670) | INTO GAM NUCLEON, HELICITY=1/2 | 0+ 938        |  |
| P5                                 | N*3/2(1670) | INTO GAM NUCLEON, HELICITY=3/2 | 0+ 938        |  |
| P6                                 | N*3/2(1670) | INTO N*3/2(1236) PI            | 1236+ 139     |  |

| 10 N*3/2(1670) BRANCHING RATIOS |             |                   |                  |      |
|---------------------------------|-------------|-------------------|------------------|------|
| R1                              | N*3/2(1670) | INTO (PI N)/TOTAL | (P1)             |      |
| R1                              | 3           | (0.14)            | DONNACH1 68 RVUE | 8/69 |
| R1                              | 6           | (0.217)           | AYED 70 IPWA     | 1/71 |
| R1                              | 4           | (0.16)            | DAVIES 70 RVUE   | 8/69 |
| R1                              | 7           | (0.16)            | ALMEHD 72 IPWA   | 2/72 |

|    |             |                                              |                   |                      |
|----|-------------|----------------------------------------------|-------------------|----------------------|
| R2 | N*3/2(1670) | INTO (K SIGMA)/TOTAL                         | (P3)              |                      |
| R2 | 1           | (.00002) OR LESS                             | FEUERBACH 70 RVUE | PI P TO K+ SIG+ 7/70 |
| R2 | 1           | ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68 |                   |                      |
| R2 | 1           | MODEL USED MAY DOUBLE COUNT.                 |                   |                      |

| 10 N*3/2(1670) PHOTON DECAY AMPL(GEV**1/2)                                                       |  |  |  |  |
|--------------------------------------------------------------------------------------------------|--|--|--|--|
| FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS. |  |  |  |  |

|    |             |                                           |                  |                       |
|----|-------------|-------------------------------------------|------------------|-----------------------|
| A1 | N*3/2(1670) | INTO GAM NUCLEON, HELICITY=1/2 (GEV**1/2) |                  |                       |
| A1 |             | +0.068 .042                               | OBERLACK 72 DPWA | PI N PHOTO-PROD 2/73* |
| A2 | N*3/2(1670) | INTO GAM NUCLEON, HELICITY=3/2 (GEV**1/2) |                  |                       |
| A2 |             | +0.022 .052                               | OBERLACK 72 DPWA | PI N PHOTO-PROD 2/73* |

## REFERENCES FOR N\*3/2(1670)

DONNACH1 68 PL 268 161  
 ALSO 68 VIENNA 139  
 ALSO 68 THESIS

AYED 70 KIEV CONF  
 DAVIES 70 NP 821 359  
 FEUERBACH 70 NP 168 85

ALMEHD 72 NP 840 157  
 OBERLACK 72 PL 438 44

DONNACH1 69 NP 108 433  
 AYED 70 PL 318 598  
 BOWLER 70 NP 178 331

A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JP  
 DONNACHIE RAPPOURTEUR'S TALK (GLAS)  
 R G KIRSOPP (EDIN)

AYED, P BAREYRE, G VILLET (SACL)JP  
 A DAVIES (GLAS)  
 FEUERBACHER+HOLLADAY (VANDERBILT)

+LOVELACE (LUND, RUTG)JP  
 H. OBERLACK, R. G. MOORHOUSE (LBL)

PAPERS NOT REFERRED TO IN DATA CARDS.

A DONNACHIE, R KIRSOPP (GLAS+EDIN)  
 +BAREYRE, VILLET (SACLAY)  
 +CASHMORE (U. OXFORD)

 $\Delta(1690)$ 

19 N\*3/2(1690, JP=3/2+) I=3/2

 $P_{33}^{++}$ 

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

| 19 N*3/2(1690) MASS (MEV) |   |                                       |                            |                         |
|---------------------------|---|---------------------------------------|----------------------------|-------------------------|
| M                         | 3 | (1690.)                               | DONNACH2 68 RVUE           | PHAS. SHIFT-CERN1 10/69 |
| M                         | 3 | (1690.)                               | KIRSOPP 68 RVUE            | PHASE SHIFT ANAL 10/69  |
| M                         | 3 | WHERE MAX. ABSORPTION IS -DONNACH1, 2 | KIRSOPP EYEBALL FIT CERN 1 | 10/69                   |
| M                         | 6 | (1801.0)                              | AYED 70 IPWA               | 1/71                    |
| M                         | 6 | ENER. DEP. FIT OF ARGAND DIAGRAM      |                            |                         |
| M                         | 7 | (1680.)                               | ALMEHD 72 IPWA             | 2/72                    |

| 19 N*3/2(1690) WIDTH (MEV) |   |         |                  |                         |
|----------------------------|---|---------|------------------|-------------------------|
| M                          | 3 | (281.)  | DONNACH2 68 RVUE | PHAS. SHIFT-CERN1 10/69 |
| M                          | 3 | (240.)  | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL 10/69  |
| M                          | 6 | (598.0) | AYED 70 IPWA     | 1/71                    |
| M                          | 7 | (220.)  | ALMEHD 72 IPWA   | 2/72                    |

| 19 N*3/2(1690) PARTIAL DECAY MODES |             |              |           |  |
|------------------------------------|-------------|--------------|-----------|--|
| P1                                 | N*3/2(1690) | INTO PI N    | 139+ 938  |  |
| P2                                 | N*3/2(1690) | INTO K SIGMA | 493+ 1189 |  |

| 19 N*3/2(1690) BRANCHING RATIOS |             |                   |                  |                         |
|---------------------------------|-------------|-------------------|------------------|-------------------------|
| R1                              | N*3/2(1690) | INTO (PI N)/TOTAL | (P1)             |                         |
| R1                              | 3           | (.10)             | DONNACH2 68 RVUE | PHAS. SHIFT-CERN1 10/69 |
| R1                              | 3           | (.08)             | KIRSOPP 68 RVUE  | PHASE SHIFT ANAL 10/69  |
| R1                              | 6           | (0.135)           | AYED 70 IPWA     | 1/71                    |
| R1                              | 7           | (0.1)             | ALMEHD 72 IPWA   | 2/72                    |

|    |             |                                              |                   |                      |
|----|-------------|----------------------------------------------|-------------------|----------------------|
| R2 | N*3/2(1690) | INTO (K SIGMA)/TOTAL                         | (P2)              |                      |
| R2 | 1           | (.00002) OR LESS                             | FEUERBACH 70 RVUE | PI P TO K+ SIG+ 7/70 |
| R2 | 1           | ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68 |                   |                      |
| R2 | 1           | MODEL USED MAY DOUBLE COUNT.                 |                   |                      |

## REFERENCES FOR N\*3/2(1690)

DONNACH2 68 VIENNA 139  
 KIRSOPP 68 THESIS

AYED 70 KIEV CONF  
 FEUERBACH 70 NP 168 85

ALMEHD 72 NP 840 157

AYED 70 PL 318 598  
 BOWLER 70 NP 178 331

+LOVELACE (LUND, RUTG)JP

PAPERS NOT REFERRED TO IN DATA CARDS.

+BAREYRE, VILLET (SACLAY)  
 +CASHMORE (U. OXFORD)

 $\Delta(1890)$ 

11 N\*3/2(1890, JP=5/2+) I=3/2

 $F_{35}$ 

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

| 11 N*3/2(1890) MASS (MEV) |   |                                       |                  |                        |
|---------------------------|---|---------------------------------------|------------------|------------------------|
| M                         | 3 | (1913.0)                              | DONNACH1 68 RVUE | PHASE-SHIFT ANAL 8/69  |
| M                         | 4 | (1837.0)                              | AYED 70 IPWA     | 1/71                   |
| M                         | 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM |                  |                        |
| M                         | 4 | (1841.0)                              | DAVIES 70 RVUE   | P-S ANAL SOL A 8/69    |
| M                         | 7 | (1875.)                               | ALMEHD 72 IPWA   | 2/72                   |
| M                         |   | (1890.0)                              | MEHTANI 72 DPWA  | PI+P TO D1236 PI 1/73* |

| 11 N*3/2(1890) WIDTH (MEV) |   |         |                  |                        |
|----------------------------|---|---------|------------------|------------------------|
| M                          | 3 | (350.0) | DONNACH1 68 RVUE | 8/69                   |
| M                          | 6 | (198.0) | AYED 70 IPWA     | 1/71                   |
| M                          | 4 | (136.0) | DAVIES 70 RVUE   | 8/69                   |
| M                          | 7 | (250.)  | ALMEHD 72 IPWA   | 2/72                   |
| M                          |   | (300.0) | MEHTANI 72 DPWA  | PI+P TO D1236 PI 1/73* |

SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N\*1/2(1910)

| 11 N*3/2(1890) PARTIAL DECAY MODES |             |                                |               |  |
|------------------------------------|-------------|--------------------------------|---------------|--|
| P1                                 | N*3/2(1890) | INTO PI N                      | 139+ 938      |  |
| P2                                 | N*3/2(1890) | INTO N PI P1                   | 938+ 139+ 139 |  |
| P3                                 | N*3/2(1890) | INTO K SIGMA                   | 493+ 1189     |  |
| P4                                 | N*3/2(1890) | INTO N*3/2(1236) PI            | 1236+ 139     |  |
| P5                                 | N*3/2(1890) | INTO GAM NUCLEON, HELICITY=1/2 | 0+ 938        |  |
| P6                                 | N*3/2(1890) | INTO GAM NUCLEON, HELICITY=3/2 | 0+ 938        |  |
| P7                                 | N*3/2(1890) | INTO N RHO                     | 938+ 770      |  |

| 11 N*3/2(1890) BRANCHING RATIOS |             |                   |                  |      |
|---------------------------------|-------------|-------------------|------------------|------|
| R1                              | N*3/2(1890) | INTO (PI N)/TOTAL | (P1)             |      |
| R1                              | 3           | (0.16)            | DONNACH1 68 RVUE | 8/69 |
| R1                              | 6           | (0.147)           | AYED 70 IPWA     | 1/71 |
| R1                              | 4           | (0.20)            | DAVIES 70 RVUE   | 8/69 |
| R1                              | 7           | (0.18)            | ALMEHD 72 IPWA   | 2/72 |

|    |             |                                              |                   |                      |
|----|-------------|----------------------------------------------|-------------------|----------------------|
| R2 | N*3/2(1890) | INTO (K SIGMA)/TOTAL                         | (P3)              |                      |
| R2 | 1           | (.0001) OR LESS                              | FEUERBACH 70 RVUE | PI P TO K+ SIG+ 7/70 |
| R2 | 1           | ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68 |                   |                      |
| R2 | 1           | MODEL USED MAY DOUBLE COUNT.                 |                   |                      |

|    |             |                                |                 |                      |
|----|-------------|--------------------------------|-----------------|----------------------|
| R3 | N*3/2(1890) | INTO (SIGMA K)*(PI N)/TOTAL**2 | (P3*P1)         |                      |
| R3 |             | (.0016) OR LESS                | KALMUS 70 DPWA  | PI+P TO K+ SIG+ 1/71 |
| R4 | N*3/2(1890) | FROM PI N TO D(1236) PI        | SQRT(P1*P4)     |                      |
| R4 |             | (0.23)                         | MEHTANI 72 DPWA | 1/73*                |

| 11 N*3/2(1890) PHOTON DECAY AMPL(GEV**1/2)                                                       |  |  |  |  |
|--------------------------------------------------------------------------------------------------|--|--|--|--|
| FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS. |  |  |  |  |

|    |             |                                           |                |                       |
|----|-------------|-------------------------------------------|----------------|-----------------------|
| A1 | N*3/2(1890) | INTO GAM NUCLEON, HELICITY=1/2 (GEV**1/2) |                |                       |
| A1 |             | (+.044)                                   | WALKER 73 DPWA | PI N PHOTO-PROD 2/73* |
| A2 | N*3/2(1890) | INTO GAM NUCLEON, HELICITY=3/2 (GEV**1/2) |                |                       |
| A2 |             | (-.027)                                   | WALKER 73 DPWA | PI N PHOTO-PROD 2/73* |

## REFERENCES FOR N\*3/2(1890)

DONNACH1 68 PL 268 161  
 ALSO 68 VIENNA 139  
 ALSO 68 THESIS

AYED 70 KIEV CONF  
 DAVIES 70 NP 821 359  
 FEUERBACH 70 NP 168 85

KALMUS 70 PR D2 1824

ALMEHD 72 NP 840 157  
 MEHTANI 72 PRL 29 1624  
 WALKER 73 TO BE PUB.

+LOVELACE (LUND, RUTG)JP  
 +FUNG, KERNAN, SCHALK, +  
 R.L. WALKER, M.J. METCALF (CIT)

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Delta(1890)$ ,  $\Delta(1910)$ ,  $\Delta(1950)$ 

PAPERS NOT REFERRED TO IN DATA CARDS.

AYED 70 PL 318 598

\*BAREYRE-VILLET.

(SACLAY)

 $\Delta(1910)$ 

12 N\*3/2(1910, JP=1/2+) I=3/2

P31

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

12 N\*3/2(1910) MASS (MEV)

|     |                                       |          |         |                  |      |
|-----|---------------------------------------|----------|---------|------------------|------|
| M 3 | (1934.0)                              | DONNACHI | 68 RVUE | PHASE-SHIFT ANAL | 8/69 |
| M 6 | (1783.0)                              | AYED     | 70 IPWA |                  | 1/71 |
| M 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM | DAVIES   | 70 RVUE | P-S ANAL SOL A   | 8/69 |
| M 4 | (1914.0)                              | ALMEHED  | 72 IPWA |                  | 2/72 |
| M 7 | (1900.0)                              |          |         |                  |      |

12 N\*3/2(1910) WIDTH (MEV)

|     |         |          |         |       |      |
|-----|---------|----------|---------|-------|------|
| M 3 | (339.0) | DONNACHI | 68 RVUE |       | 8/69 |
| M 6 | (308.0) | AYED     | 70 IPWA |       | 1/71 |
| M 4 | (290.0) | DAVIES   | 70 RVUE | SOL A | 8/69 |
| M 7 | (200.0) | ALMEHED  | 72 IPWA |       | 2/72 |

SEE NOTES ACCOMPANYING MASSES QUOTED

12 N\*3/2(1910) PARTIAL DECAY MODES

|    |                                            |               |              |  |  |
|----|--------------------------------------------|---------------|--------------|--|--|
| P1 | N*3/2(1910) INTO P1 N                      | 139+ 938      | DECAY MASSES |  |  |
| P2 | N*3/2(1910) INTO N P1 P1                   | 938+ 139+ 139 |              |  |  |
| P3 | N*3/2(1910) INTO K SIGMA                   | 493+ 1189     |              |  |  |
| P4 | N*3/2(1910) INTO N*3/2(1236) P1            | 1236+ 139     |              |  |  |
| P5 | N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2 | 0+ 928        |              |  |  |
| P6 | N*3/2(1910) INTO N RHO                     | 938+ 770      |              |  |  |

12 N\*3/2(1910) BRANCHING RATIOS

|      |                                              |           |         |                 |      |
|------|----------------------------------------------|-----------|---------|-----------------|------|
| R1   | N*3/2(1910) INTO (P1 N)/TOTAL                | (P1)      |         |                 |      |
| R1 3 | (0.30)                                       | DONNACHI  | 68 RVUE |                 | 8/69 |
| R1 6 | (0.128)                                      | AYED      | 70 IPWA |                 | 1/71 |
| R1 4 | (0.18)                                       | DAVIES    | 70 RVUE | SOL A           | 8/69 |
| R1 7 | (0.33)                                       | ALMEHED   | 72 IPWA |                 | 2/72 |
| R2   | N*3/2(1910) INTO (K SIGMA)/TOTAL             | (P3)      |         |                 |      |
| R2 1 | (0.008) OR LESS                              | FEUERBACH | 70 RVUE | PI P TO K+ SIG+ | 7/70 |
| R2 1 | ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68 |           |         |                 |      |
| R2 1 | MODEL USED MAY DOUBLE COUNT.                 |           |         |                 |      |

12 N\*3/2(1910) PHOTON DECAY AMPL(GEV\*\*1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                       |        |         |                 |       |
|----|-------------------------------------------------------|--------|---------|-----------------|-------|
| A1 | N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2 (GEV**1/2) |        |         |                 |       |
| A1 | (-0.027)                                              | WALKER | 73 DPWA | PI N PHOTO-PROD | 2/73* |

REFERENCES FOR N\*3/2(1910)

|                        |                                                 |  |  |  |  |
|------------------------|-------------------------------------------------|--|--|--|--|
| DONNACHI 68 PL 268 161 | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN) IJP |  |  |  |  |
| ALSO 68 VIENNA 139     | DONNACHIE RAPPOURTEUR'S TALK (GLAS)             |  |  |  |  |
| ALSO 68 THESIS         | R G KIRSOPP (EDIN)                              |  |  |  |  |

|                        |                                          |  |  |  |  |
|------------------------|------------------------------------------|--|--|--|--|
| AYED 70 KIEV CONF      | R AYED, P BAREYRE, G VILLET (SACLAY) IJP |  |  |  |  |
| DAVIES 70 NP 821 359   | A DAVIES (VANDERBILT)                    |  |  |  |  |
| FEUERBACH 70 NP 168 85 | FEUERBACHER+HOLLADAY                     |  |  |  |  |

|                       |                               |  |  |  |  |
|-----------------------|-------------------------------|--|--|--|--|
| ALMEHED 72 NP 840 157 | +LOVELACE (LUND, RUTG) IJP    |  |  |  |  |
| WALKER 73 TO BE PUB.  | R.L.WALKER, W.J.METCALF (CIT) |  |  |  |  |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                                              |                                           |  |  |  |  |
|----------------------------------------------|-------------------------------------------|--|--|--|--|
| CARYANN 65 PR 138 8433                       | CARYANNPOPOULOS, TAUFEST, WILLMANN (PURD) |  |  |  |  |
| A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+ |                                           |  |  |  |  |
| AYED 70 PL 318 598                           | *BAREYRE-VILLET (SACLAY)                  |  |  |  |  |

 $\Delta(1950)$ 

83 N\*3/2(1950, JP=7/2+) I=3/2

F37

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N\*1/2(1470).

83 N\*3/2(1950) MASS (MEV)

|     |                                                |          |          |                  |                        |
|-----|------------------------------------------------|----------|----------|------------------|------------------------|
| M   | (1920.0)                                       | DUKE     | 65 CNTR  | PI-P EL + POL    | 6/68                   |
| M   | (1950.0)                                       | APPROX   | YOKOSAWA | 66 CNTR          | 7/66                   |
| M 1 | (1975.0)                                       |          | BAREYRE  | 68 RVUE          | PHASE-SHIFT ANAL 11/67 |
| M 1 | WHERE CROSS SECTION IS GREATEST - EYE BALL FIT | DONNACHI | 68 RVUE  |                  |                        |
| M 3 | (1946.0)                                       | AYED     | 70 IPWA  | PHASE-SHIFT ANAL | 6/68                   |
| M 6 | (1931.0)                                       |          |          |                  | 1/71                   |
| M 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM          | DAVIES   | 70 RVUE  | P-S ANAL SOL A   | 8/69                   |
| M 4 | (1935.0)                                       | KALMUS   | 70 DPWA  | PI+P TO K+ SIG+  | 1/71                   |
| M   | (1930.0) (20.0)                                | MEHTANI  | 71 MPWA  | PI+P 1.8-2.1 GEV | 3/72                   |
| M   | (1930.0)                                       | ROYCHOUD | 71 DPWA  |                  | 2/72                   |
| M 7 | (1925.0)                                       | ALMEHED  | 72 IPWA  |                  | 2/72                   |
| M   | (1920.0)                                       | MEHTANI  | 72 DPWA  | PI+P TO D1236 PI | 1/73*                  |

83 N\*3/2(1950) WIDTH (MEV)

|     |                       |        |          |         |                   |
|-----|-----------------------|--------|----------|---------|-------------------|
| W   | (170.0)               | DUKE   | 65 CNTR  |         | 7/66              |
| W   | (200.0)               | APPROX | YOKOSAWA | 66 CNTR | 7/66              |
| W 1 | (180.0)               |        | BAREYRE  | 68 RVUE | 11/67             |
| W 3 | (221.0)               |        | DONNACHI | 68 RVUE | 6/68              |
| W 6 | (197.0)               |        | AYED     | 70 IPWA | 1/71              |
| W 4 | (221.0)               |        | DAVIES   | 70 RVUE | 8/69              |
| W   | (300.0) (60.0)        |        | KALMUS   | 70 DPWA | PI+P TO K+ SIG+   |
| W   | (227.0) (12.0) (30.0) |        | MEHTANI  | 71 MPWA | PI+P TO (1236) PI |
| W 7 | (200.0)               |        | ALMEHED  | 72 IPWA | 2/72              |
| W   | (269.0)               |        | MEHTANI  | 72 DPWA | PI+P TO D1236 PI  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

83 N\*3/2(1950) PARTIAL DECAY MODES

|     |                                              |                |              |  |  |
|-----|----------------------------------------------|----------------|--------------|--|--|
| P1  | N*3/2(1950) INTO P1 N                        | 139+ 938       | DECAY MASSES |  |  |
| P2  | N*3/2(1950) INTO SIGMA K                     | 1189+ 493      |              |  |  |
| P3  | N*3/2(1950) INTO N*3/2(1236) P1              | 1236+ 139      |              |  |  |
| P4  | N*3/2(1950) INTO Y*1(1385) K                 | 1384+ 493      |              |  |  |
| P5  | N*3/2(1950) INTO N*3/2(1236) RHO             | 1236+ 770      |              |  |  |
| P6  | N*3/2(1950) INTO NEUTRON PI+ PI+             | 939+ 139+ 139  |              |  |  |
| P7  | N*3/2(1950) INTO N*3/2(1236) P1 PI (NOT RHO) | 1236+ 139+ 139 |              |  |  |
| P8  | N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2   | 0+ 938         |              |  |  |
| P9  | N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2   | 0+ 938         |              |  |  |
| P10 | N*3/2(1950) INTO N RHO                       | 938+ 770       |              |  |  |

83 N\*3/2(1950) BRANCHING RATIOS

|      |                               |        |          |                 |       |
|------|-------------------------------|--------|----------|-----------------|-------|
| R1   | N*3/2(1950) INTO (P1 N)/TOTAL | (P1)   |          |                 |       |
| R1   | (0.41)                        | DUKE   | 65 CNTR  | VERY ENERGY DEP | 7/66  |
| R1   | (0.4)                         | APPROX | YOKOSAWA | 66 CNTR         | 7/66  |
| R1 1 | (0.57)                        |        | BAREYRE  | 68 RVUE         | 11/67 |
| R1 3 | (0.386)                       |        | DONNACHI | 68 RVUE         | 6/68  |
| R1 6 | (0.496)                       |        | AYED     | 70 IPWA         | 1/71  |
| R1 4 | (0.51)                        |        | DAVIES   | 70 RVUE         | 8/69  |
| R1 7 | (0.4)                         |        | ALMEHED  | 72 IPWA         | 2/72  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

|      |                                              |           |         |                 |       |
|------|----------------------------------------------|-----------|---------|-----------------|-------|
| R2   | N*3/2(1950) INTO (SIGMA K)/(PI N)/TOTAL**2   | (P2*P1)   |         |                 |       |
| R2 1 | SEEN                                         | BORREANI  | 68 HBC  | PI+P TO K+ SIG+ | 10/69 |
| R2 1 | (0.004) (0.008)                              | FEUERBACH | 70 RVUE |                 | 7/70  |
| R2 1 | ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68 |           |         |                 |       |
| R2 1 | MODEL USED MAY DOUBLE COUNT.                 |           |         |                 |       |
| R2   | 0.0081 0.0013                                | KALMUS    | 70 DPWA | PI+P TO K+ SIG+ | 1/71  |

|    |                                   |              |      |         |                  |
|----|-----------------------------------|--------------|------|---------|------------------|
| R3 | N*3/2(1950) FROM PI N TO D1236 PI | SORT (P1*P3) |      |         |                  |
| R3 | 0.23                              | 0.04         | FUNG | 68 HBC  | PI+P TO PI+P10 P |
| R3 | 0.24                              | 0.01         | 0.03 | MEHTANI | 71 MPWA          |
| R3 | (0.48)                            |              |      | MEHTANI | 72 DPWA          |
| R3 |                                   |              |      |         | 2/72             |
| R3 |                                   |              |      |         | 1/73*            |

MORE INFORMATION ON INELASTIC DECAY MODES OF BUMPS, SEEN IN PRODUCTION EXPERIMENTS AROUND 1950 MEV, MAY BE FOUND IN THE NEXT ENTRY

83 N\*3/2(1950) PHOTON DECAY AMPL(GEV\*\*1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

|    |                                                       |        |         |                 |       |
|----|-------------------------------------------------------|--------|---------|-----------------|-------|
| A1 | N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2 (GEV**1/2) |        |         |                 |       |
| A1 | (-0.059)                                              | WALKER | 73 DPWA | PI N PHOTO-PROD | 2/73* |
| A2 | N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2 (GEV**1/2) |        |         |                 |       |
| A2 | (-0.089)                                              | WALKER | 73 DPWA | PI N PHOTO-PROD | 2/73* |

REFERENCES FOR N\*3/2(1950)

|                        |                                                   |  |  |  |  |
|------------------------|---------------------------------------------------|--|--|--|--|
| DUKE 65 PRL 15 468     | +JONES, KEMP, MURPHY, PRENTICE, + (RHEL, OXF) IJP |  |  |  |  |
| YOKOSAWA 66 PRL 16 714 | +SUMA, HILL, ESTERLING, BOOTH. (ANL, CHIC) IJP    |  |  |  |  |

|                        |                                                 |  |  |  |  |
|------------------------|-------------------------------------------------|--|--|--|--|
| BAREYRE 68 PR 165 1731 | P BAREYRE, C BRICHMAN, G VILLET (SACLAY) IJP    |  |  |  |  |
| BORREANI 68 UCRL 18350 | BORREANI, KALMUS (LRL)                          |  |  |  |  |
| DONNACHI 68 PL 268 161 | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN) IJP |  |  |  |  |
| ALSO 68 VIENNA 139     | DONNACHIE RAPPOURTEUR'S TALK (GLAS)             |  |  |  |  |
| ALSO 68 THESIS         | R G KIRSOPP (EDIN)                              |  |  |  |  |
| FUNG 68 VIENNA CONF.   | FUNG, KERNAN, KALMUS, BIRGE (RIVERSIDE, LRL)    |  |  |  |  |

|                        |                                          |  |  |  |  |
|------------------------|------------------------------------------|--|--|--|--|
| AYED 70 KIEV CONF      | R AYED, P BAREYRE, G VILLET (SACLAY) IJP |  |  |  |  |
| DAVIES 70 NP 821 359   | A DAVIES (GLAS)                          |  |  |  |  |
| FEUERBACH 70 NP 168 85 | FEUERBACHER+HOLLADAY (VANDERBILT)        |  |  |  |  |
| KALMUS 70 PR 02 1824   | G KALMUS, G BORREANI, J LOUIE (LRL)      |  |  |  |  |

|                            |                                                     |  |  |  |  |
|----------------------------|-----------------------------------------------------|--|--|--|--|
| MEHTANI 71 AMSTERDAM CONF. | +FUNG, KERNAN, WILLIAMSON+ BIRGE, ++ (UCR, LBL) IJP |  |  |  |  |
| ROYCHOUD 71 NP 827 125     | R K ROYCHOUDHURY, B H BRANSDEN (DUR) IJP            |  |  |  |  |

|                        |                                     |  |  |  |  |
|------------------------|-------------------------------------|--|--|--|--|
| ALMEHED 72 NP 840 157  | +LOVELACE (LUND, RUTG) IJP          |  |  |  |  |
| MEHTANI 72 PRL 29 1634 | +FUNG, KERNAN, SCHALK, + (UCR +LBL) |  |  |  |  |
| WALKER 73 TO BE PUB.   | R.L.WALKER, W.J.METCALF (CIT)       |  |  |  |  |

PAPERS NOT REFERRED TO IN DATA CARDS.

|                              |                                               |  |  |  |  |
|------------------------------|-----------------------------------------------|--|--|--|--|
| HOHLER 63 NP 48 470          | G HOHLER, G EBEL (KARLSRUHE) I                |  |  |  |  |
| LAYSON 63 NC 27 724          | W M LAYSON (CERN) IJP                         |  |  |  |  |
| AUVIL 64 NC 33 473           | P AUVIL, C LOVELACE (LOIC) IJP                |  |  |  |  |
| HELLAND 64 PR 134 B1062      | +DEVILIN, HAGGE, LONGO, MOYER, WOOD (LRL) IJP |  |  |  |  |
| HOHLER 64 PL 12 149          | G HOHLER, J GIESECKE (KARLSRUHE) I            |  |  |  |  |
| HOLLADAY 65 PR 139 B1348     | W G HOLLADAY (VANDERBILT)                     |  |  |  |  |
| JOHNSON 67 UCRL-17683 THESIS | C H JOHNSON (LRL)                             |  |  |  |  |
| DONNACHI 69 NP 108 433       | A DONNACHIE, R KIRSOPP (GLAS+EDIN)            |  |  |  |  |
| AYED 70 PL 318 598           | *BAREYRE-VILLET (SACLAY)                      |  |  |  |  |

## Baryons

 $\Delta(1960)$ ,  $\Delta(2160)$ 

## Data Card Listings

For notation, see key at front of Listings.

 $\Delta(1960)$ D<sub>35</sub>13 N<sup>3</sup>/2(1960, JP=5/2-1) I=3/2A NEW PRELIMINARY ANALYSIS BY AYED 72 FINDS EVIDENCE FOR THIS EFFECT AT 1870 MEV. SEE THE N<sup>3</sup> MINI REVIEW.13 N<sup>3</sup>/2(1960) MASS (MEV)

|   |   |                          |             |                     |                  |       |
|---|---|--------------------------|-------------|---------------------|------------------|-------|
| M | 3 | (1954.0)                 | DONNACHI    | 68 RVUE             | PHASE-SHIFT ANAL | 6/68  |
| M | 3 | (1970.1)                 | KIRSOPP     | 68 RVUE             | PHASE SHIFT ANAL | 10/69 |
| M | X | (1950.0)                 | LEA         | 69 CNTR             | PI-P ELASTIC     | 8/69  |
| M | X | SEE ALSO APLIN 70        |             |                     |                  |       |
| M | 3 | WHERE MAX. ABSORPTION IS | DONNACHI, 2 | KIRSOPP EYEBALL FIT | CERN 1           | 10/69 |
| M | 7 | (2200.1)                 | ALMEHD      | 72 IPWA             |                  | 2/72  |
| M |   | (1824.0)                 | MEHTANI     | 72 DPWA             | PI+P TO D1236 PI | 1/73* |

13 N<sup>3</sup>/2(1960) WIDTH (MEV)

|   |   |           |          |         |                  |       |
|---|---|-----------|----------|---------|------------------|-------|
| W | 3 | (1311.00) | DONNACHI | 68 RVUE |                  | 8/69  |
| W | 3 | (1300.0)  | KIRSOPP  | 68 RVUE | PHASE SHIFT ANAL | 10/69 |
| W | 7 | (600.1)   | ALMEHD   | 72 IPWA |                  | 2/72  |
| W |   | (138.0)   | MEHTANI  | 72 DPWA | PI+P TO D1236 PI | 1/73* |

13 N<sup>3</sup>/2(1960) PARTIAL DECAY MODES

|    |                                                         |              |
|----|---------------------------------------------------------|--------------|
| P1 | N <sup>3</sup> /2(1960) INTO PI N                       | DECAY MASSES |
| P2 | N <sup>3</sup> /2(1960) INTO K SIGMA                    | 139+ 938     |
| P4 | N <sup>3</sup> /2(1960) INTO N <sup>3</sup> /2(1236) PI | 493+1189     |
|    |                                                         | 1236+ 139    |

13 N<sup>3</sup>/2(1960) BRANCHING RATIOS

|    |                                                 |                                               |
|----|-------------------------------------------------|-----------------------------------------------|
| R1 | N <sup>3</sup> /2(1960) INTO (PI N)/TOTAL       | (P1)                                          |
| R1 | 3                                               | (.154)                                        |
| R1 | 3                                               | (.12)                                         |
| R1 | 7                                               | (0.25)                                        |
|    |                                                 | DONNACHI 68 RVUE PHASE SHIFT ANAL 10/69       |
|    |                                                 | KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69        |
|    |                                                 | ALMEHD 72 IPWA 2/72                           |
| R2 | N <sup>3</sup> /2(1960) INTO (K SIGMA)/TOTAL    | (P2)                                          |
| R2 | 1                                               | (0.013) (0.01)                                |
| R2 | 1                                               | ASSUME MASS, WIDTH, (X ELAST) OF DONNACHIE 68 |
| R2 | 1                                               | MODEL USED MAY DOUBLE COUNT.                  |
| R3 | N <sup>3</sup> /2(1960) FROM PI N TO D(1236) PI | SORT(P1+P4)                                   |
| R3 |                                                 | (0.19) MEHTANI 72 DPWA 1/73*                  |

REFERENCES FOR N<sup>3</sup>/2(1960)

|                        |                                                  |
|------------------------|--------------------------------------------------|
| DONNACHI 68 PL 268 161 | A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN) IJP  |
| KIRSOPP 68 THESIS      | R G KIRSOPP (EDIN)                               |
| LEA 69 PL 298 584      | LEA, OADES, WARD, COWAN, + (RHEL, BRISTOL, OARE) |
| FEUERBACH 70 NP 168 85 | FEUERBACHER+HOLLADAY (VANDERBILT)                |
| ALMEHD 72 NP 840 157   | +LOVELACE (LUND, RUTG) IJP                       |
| MEHTANI 72 PRL 29 1634 | +FUNG, KERNAN, SCHALK, +. (UCR +LBL)             |
|                        | PAPERS NOT REFERRED TO IN DATA CARDS.            |
| DONNACHI 69 NP 108 433 | A DONNACHIE, R KIRSOPP (GLAS+EDIN)               |
| AYED 70 PL 318 598     | +BAREYRE+VILLET (SACLAY)                         |
| APLIN 71 NP 832 253    | +COWAN, GIBSON, GILMORE++ (RHEL, BRISTOL)        |
| AYED 72 BATAVIA CONF   | R AYED+P BAREYRE, Y LEMOIGNE (SACL)              |

 $\Delta(1950)$   
BUMPS70 N<sup>3</sup>/2(1950, JP= ) I=3/2 PRODUCTION EXPERIMENTS70 N<sup>3</sup>/2(1950) MASS (MEV) (PROD. EXP.)

|   |          |                          |                       |          |                     |       |
|---|----------|--------------------------|-----------------------|----------|---------------------|-------|
| M | (1922.0) | APPROX                   | COOL                  | 56 CNTR  | PI+ P TOTAL         | 7/66  |
| M | (1912.0) | (15.0)                   | BRISSON               | 61 CNTR  | PI+ P TOTAL         | 7/66  |
| M | (1900.0) | (9.0)                    | DEVLIN                | 65 CNTR  | PI+ P TOTAL         |       |
| M | (2080.0) | (12.0)                   | YODN                  | 67 HBC + | 3 BEV/C PI-P        | 8/67  |
| M | N        | THIS BUMP IS NOT SEEN BY | CHUNG 68 AT 3.2 GEV/C |          |                     |       |
| M | (1860.0) |                          | COLTON                | 72 HBC   | ++ PP TO PI+PN TGEV | 1/73* |

70 N<sup>3</sup>/2(1950) WIDTH (MEV) (PROD. EXP.)

|   |         |         |        |          |                     |       |
|---|---------|---------|--------|----------|---------------------|-------|
| W | (256.0) | (139.0) | DEVLIN | 65 CNTR  |                     | 8/67  |
| W | 0.0     | 20.0    | YODN   | 67 HBC + |                     |       |
| W | (180.0) |         | COLTON | 72 HBC   | ++ PP TO PI+PN TGEV | 1/73* |

70 N<sup>3</sup>/2(1950) PARTIAL DECAY MODES (PROD. EXP.)

|    |                                                                      |                |
|----|----------------------------------------------------------------------|----------------|
| P1 | N <sup>3</sup> /2(1950) INTO PI N                                    | DECAY MASSES   |
| P2 | N <sup>3</sup> /2(1950) INTO SIGMA K                                 | 139+ 938       |
| P3 | N <sup>3</sup> /2(1950) INTO N <sup>3</sup> /2(1236) PI              | 1189+ 493      |
| P4 | N <sup>3</sup> /2(1950) INTO *1(1385) K                              | 1236+ 139      |
| P5 | N <sup>3</sup> /2(1950) INTO N <sup>3</sup> /2(1236) RHO             | 1384+ 493      |
| P6 | N <sup>3</sup> /2(1950) INTO NEUTRON PI+ PI+                         | 1236+ 770      |
| P7 | N <sup>3</sup> /2(1950) INTO N <sup>3</sup> /2(1236) PI PI (NOT RHO) | 939+ 139+ 139  |
|    |                                                                      | 1236+ 139+ 139 |

70 N<sup>3</sup>/2(1950) BRANCHING RATIOS (PROD. EXP.)

|    |                                                                      |                                            |
|----|----------------------------------------------------------------------|--------------------------------------------|
| R1 | N <sup>3</sup> /2(1950) INTO (PI N)/TOTAL                            | (P1)                                       |
| R1 | (0.57) (0.12)                                                        | DEVLIN 65 CNTR                             |
| R2 | N <sup>3</sup> /2(1950) INTO (SIGMA K)/(PI N)                        | (P2)/(P1)                                  |
| R2 | 0.059 0.024                                                          | CHINOWSKY 68 HBC ++ PP TO P SIG K 11/68    |
| R3 | N <sup>3</sup> /2(1950) INTO N <sup>3</sup> /2(1236) PI PI (NOT RHO) | (P7)                                       |
| R3 | SEEN                                                                 | CHINOWSKY 68 HBC ++ PP TO (P 3P1) N 11/68  |
| R3 | SEEN                                                                 | BOGGILO 70 HBC PP TO N3P1 (INTRL) 6/70     |
| R4 | N <sup>3</sup> /2(1950) INTO (PI N)/(N <sup>3</sup> /2(1236) PI)     | (P1)/(P3)                                  |
| R4 | (0.55) OR LESS                                                       | LEE 67 HBC PI-P 3.63 BEV/C 11/67           |
| R5 | N <sup>3</sup> /2(1950) INTO ((PI N)+(NEUTRON PI+ PI+))/TOTAL        | *2                                         |
| R5 | 0.05 0.013                                                           | GALLOWAY 68 RVUE ++ PI+P TO N 2PI+ 6/68    |
| R6 | N <sup>3</sup> /2(1950) INTO (*1(1385) K)/(PI N)                     | (P4)/(P1)                                  |
| R6 | 0.035 0.015                                                          | CHINOWSKY 68 HBC ++ PP TO P LAM K PI 11/68 |
| R7 | N <sup>3</sup> /2(1950) INTO (N <sup>3</sup> /2(1236) RHO)/(PI N)    | (P5)/(P1)                                  |
| R7 | (0.45) APPROX                                                        | CHINOWSKY 68 HBC ++ PP TO (P 3P1) N 11/68  |
| R7 | THIS INCLUDES CORRECTION FOR UNSEEN DECAY (ISPIN FACTOR 5/3).        |                                            |
| R8 | N <sup>3</sup> /2(1950) INTO (N <sup>3</sup> /2(1236) RHO)/TOTAL     | (P5)                                       |
| R8 | SEEN                                                                 | YODN 67 HBC +                              |
| R8 | NOT SEEN                                                             | BOGGILO 70 HBC PP TO N3P1 (INTRL) 6/70     |

REFERENCES FOR N<sup>3</sup>/2(1950) (PROD. EXP.)

|                          |                                                  |
|--------------------------|--------------------------------------------------|
| COOL 56 PR 103 1082      | R COOL, O PICCIONI, O CLARK (BNL) I              |
| BRISSON 61 NC 19 210     | +DETDEUF, FALK-VAIRANT, VAN ROSSUM, + (SACLAY) I |
| DEVLIN 65 PRL 14 1031    | T J DEVLIN, J SOLOMON, G BERTSCH (PRINCETON) I   |
| LEE 67 PR 159 1156       | +MOES, ROE, SINCLAIR, VANDER VELDE (MICH)        |
| YODN 67 PL 248 307       | +BERENYI, KEY, PRENTICE, + (TORONTO, WISC)       |
| CHINOWSKY 68 PR 171 1421 | CHINOWSKY, CONDON, KINSEY, KLEIN, + (LRL, SLAC)  |
| CHUNG 68 PR 165 1491     | S U CHUNG, DAHL, KIRZ, MILLER (LRL)              |
| GALLOWAY 68 PL 268 334   | K F GALLOWAY (INDIANA) I                         |
| BOGGILO 70 NP 816 503    | +KOREA-AMO+JACOBSEN+ (BOHR+ HELS+OSLO+STOH)      |
| COLTON 72 PR D6 95       | E COLTON, A KIRSCHBAUM (LBL)                     |

 $\Delta(2160)$ P<sub>33</sub>9 N<sup>3</sup>/2(2160, JP=3/2+) I=3/2  
ROYCHOUDHURY 71 FIND POSSIBLE EVIDENCE FOR P<sub>33</sub>, D<sub>33</sub>, AND D<sub>35</sub> RESONANCES IN THIS MASS REGION. IN A SIMILAR ANALYSIS BRANDSEN 71 FOUND SOME EVIDENCE FOR S<sub>31</sub>, D<sub>33</sub>, AND D<sub>35</sub> RESONANCES IN THIS REGION. VON SCHLIPPE 72 SUGGESTS A G<sub>39</sub>.9 N<sup>3</sup>/2(2160) MASS (MEV)

|   |   |          |          |         |                  |       |
|---|---|----------|----------|---------|------------------|-------|
| M | 3 | (2160.1) | KIRSOPP  | 68 RVUE | PHASE SHIFT ANAL | 10/69 |
| M | 3 | (2120.1) | ROYCHOUD | 71 DPWA |                  | 3/72  |
| M | 7 | (2150.1) | ALMEHD   | 72 IPWA |                  | 2/72  |

9 N<sup>3</sup>/2(2160) WIDTH (MEV)

|   |   |         |         |         |                  |       |
|---|---|---------|---------|---------|------------------|-------|
| W | 3 | (260.1) | KIRSOPP | 68 RVUE | PHASE SHIFT ANAL | 10/69 |
| W | 7 | (200.1) | ALMEHD  | 72 IPWA |                  | 2/72  |

9 N<sup>3</sup>/2(2160) PARTIAL DECAY MODES

|    |                                   |              |
|----|-----------------------------------|--------------|
| P1 | N <sup>3</sup> /2(2160) INTO PI N | DECAY MASSES |
|    |                                   | 139+ 938     |

9 N<sup>3</sup>/2(2160) BRANCHING RATIOS

|    |                                           |                                        |
|----|-------------------------------------------|----------------------------------------|
| R1 | N <sup>3</sup> /2(2160) INTO (PI N)/TOTAL | (P1)                                   |
| R1 | 3                                         | (.25)                                  |
| R1 | 7                                         | (0.3)                                  |
|    |                                           | KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69 |
|    |                                           | ALMEHD 72 IPWA 2/72                    |

REFERENCES FOR N<sup>3</sup>/2(2160)

|                           |                                           |
|---------------------------|-------------------------------------------|
| KIRSOPP 68 THESIS         | R G KIRSOPP (EDIN)                        |
| ROYCHOUD 71 NP 827 125    | R K ROYCHOUDHURY, B H BRANDSEN (DURH) IJP |
| ALMEHD 72 NP 840 157      | +LOVELACE (LUND, RUTG) IJP                |
|                           | PAPERS NOT REFERRED TO IN DATA CARDS.     |
| DONNACHI 69 NP 108 433    | A DONNACHIE, R KIRSOPP (GLAS+EDIN)        |
| BRANDSEN 71 NP 826 511    | +OGDEN (DURH) IJP                         |
| ALSO 70 NP 816 461        | ROYCHOUDHURY, PERRIN, BRANDSEN (DURH) IJP |
| VON SCHLIPPE 72 LNC 4 767 | VON SCHLIPPE (LOWIC) IJP                  |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Delta(2420)$ ,  $\Delta(2850)$ ,  $\Delta(3230)$  $\Delta(2420)$ 84 N<sup>3</sup>/2(2420, JP=11/2+) I=3/2**H<sub>3</sub> 11**BOTH ROYCHOUDHURY 71 AND BRANSDEN 71 SEE A POSSIBLE  
RESONANT F35 IN THIS MASS REGION. IN ADDITION BRANSDEN  
71 FIND A RESONANT P33 AT 2600 MEV.84 N<sup>3</sup>/2(2420) MASS (MEV)

|   |   |                               |          |         |       |
|---|---|-------------------------------|----------|---------|-------|
| M | 6 | (2312.0)                      | AYED     | 70 IPWA | 1/71  |
| M | 6 | FROM ENER. DEP. FIT OF ARGAND | DIAGRAM  |         |       |
| M |   | (2400.)                       | BRANSDEN | 71 DPWA | 3/72  |
| M |   | (2400.)                       | ROYCHOUD | 71 DPWA | 3/72  |
| M |   | (2440.)                       | OTT      | 72 MPWA | 2/73* |

84 N<sup>3</sup>/2(2420) WIDTH (MEV)

|   |   |         |      |         |      |
|---|---|---------|------|---------|------|
| W | 6 | (347.0) | AYED | 70 IPWA | 1/71 |
|---|---|---------|------|---------|------|

84 N<sup>3</sup>/2(2420) PARTIAL DECAY MODES

|    |                                      |              |
|----|--------------------------------------|--------------|
| P1 | N <sup>3</sup> /2(2420) INTO PI N    | DECAY MASSES |
| P2 | N <sup>3</sup> /2(2420) INTO SIGMA K | 139+ 938     |
|    |                                      | 1197+ 493    |

84 N<sup>3</sup>/2(2420) BRANCHING RATIOS

|    |                                           |         |      |         |       |
|----|-------------------------------------------|---------|------|---------|-------|
| R1 | N <sup>3</sup> /2(2420) INTO (PI N)/TOTAL | (PI)    |      |         |       |
| R1 | 6                                         | (0.113) | AYED | 70 IPWA | 1/71  |
| R1 | 7                                         | (94)    | OTT  | 72 MPWA | 2/73* |

REFERENCES FOR N<sup>3</sup>/2(2420)

|          |                       |                                                    |           |
|----------|-----------------------|----------------------------------------------------|-----------|
| AYED     | 70 KIEV CONF          | R AYED, P BAREYRE, G VILLET                        | (SACL)JP  |
| BRANSDEN | 71 NP 826 511         | ODGEN                                              | (DURH)JP  |
| ALSO     | 70 NP 816 461         | ROYCHOUDHURY, PERRIN, BRANSDEN                     | (DURH)JP  |
| ROYCHOUD | 71 NP 827 125         | R K ROYCHOUDHURY, B H BRANSDEN                     | (DURH)JP  |
| OTT      | 72 PL 428 133         | +TRISCHUK, VAVRA, RICHARDS, + (MCGI, STLO, IOWA)JP |           |
|          | ALSO 72 MCGILL THESIS | J. VAVRA                                           | (MCGI) JP |

PAPERS NOT REFERRED TO IN DATA CARDS.

|         |               |                     |                      |
|---------|---------------|---------------------|----------------------|
| BELLAMY | 67 PRL 19 476 | +BUCKLEY, DOBSON, + | (WESTFIELD, LOUC) JP |
| AYED    | 70 PL 318 598 | +BAREYRE-VILLET     | (SACL)JP             |

 $\Delta(2420)$   
BUMPS69 N<sup>3</sup>/2(2420, JP= ) I=3/2 PRODUCTION EXPERIMENTS69 N<sup>3</sup>/2(2420) MASS (MEV) (PROD. EXP.)

|   |          |                                                                         |         |                 |             |
|---|----------|-------------------------------------------------------------------------|---------|-----------------|-------------|
| M | (2360.0) | DIDDENS                                                                 | 63 CNTR | PI+ P TOTAL     |             |
| M | (2520.0) | ALVAREZ                                                                 | 64 CNTR | PI PHOTOPROD    | 7/66        |
| M | (2440.0) | HOHLER                                                                  | 64 RVUE | DATA + DISP REL |             |
| M | (2400.0) | WAHLIG                                                                  | 64 OSRK | 0 PI+ P CH EX   |             |
| M | (2452.0) | BARGER                                                                  | 66 RVUE | TOTAL + CH EX   | 11/67       |
| M | B        | USES REGGE AMP. + RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE |         |                 |             |
| M | B        | FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.                             |         |                 |             |
| M | 2423.0   | 10.0                                                                    | CITRON  | 66 CNTR         | PI+ P TOTAL |

69 N<sup>3</sup>/2(2420) WIDTH (MEV) (PROD. EXP.)

|   |         |         |         |               |       |
|---|---------|---------|---------|---------------|-------|
| W | (200.0) | DIDDENS | 63 CNTR |               | 7/66  |
| W | (245.0) | HOHLER  | 64 RVUE | TOTAL + CH EX | 11/67 |
| W | B       | 66 RVUE |         |               | 7/66  |
| W | (275.0) | BARGER  | 66 CNTR |               |       |
| W | 310.0   | 20.0    | CITRON  | 66 CNTR       |       |

69 N<sup>3</sup>/2(2420) PARTIAL DECAY MODES (PROD. EXP.)

|    |                                                         |               |
|----|---------------------------------------------------------|---------------|
| P1 | N <sup>3</sup> /2(2420) INTO PI N                       | DECAY MASSES  |
| P2 | N <sup>3</sup> /2(2420) INTO SIGMA K                    | 139+ 938      |
| P3 | N <sup>3</sup> /2(2420) INTO N <sup>3</sup> /2(1236) PI | 1197+ 493     |
| P4 | N <sup>3</sup> /2(2420) INTO NEUTRON PI+ PI+            | 1236+ 139     |
|    |                                                         | 939+ 139+ 139 |

69 N<sup>3</sup>/2(2420) BRANCHING RATIOS (PROD. EXP.)

|    |                                           |                                                                      |         |                 |                 |
|----|-------------------------------------------|----------------------------------------------------------------------|---------|-----------------|-----------------|
| R1 | N <sup>3</sup> /2(2420) INTO (PI N)/TOTAL | (PI)                                                                 |         |                 |                 |
| R1 | 6                                         | (0.067)                                                              | DIDDENS | 63 CNTR         | ASSUMING J=11/2 |
| R1 | 6                                         | 0.0036                                                               | CITRON  | 66 CNTR         | ASSUMING J=11/2 |
| R1 | B                                         | (0.12)                                                               | BARGER  | 67 FIT          | ASSUMING J=11/2 |
| R1 | D                                         | (0.163)                                                              | DIKMEN  | 67 FIT          | ASSUMING J=11/2 |
| R1 | D                                         | USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES |         |                 |                 |
| R1 | (0.06)                                    | KORMANYOS                                                            | 67 CNTR | ASSUMING J=11/2 | 11/67           |

|    |                                                                  |         |          |         |      |
|----|------------------------------------------------------------------|---------|----------|---------|------|
| R2 | N <sup>3</sup> /2(2420) INTO (PI N)*(NEUTRON PI+ PI+)/(TOTAL**2) | (PI+P4) |          |         |      |
| R2 | 0.0195                                                           | 0.0048  | GALLOWAY | 68 RVUE | 6/68 |

REFERENCES FOR N<sup>3</sup>/2(2420) (PROD. EXP.)

|         |                |                                         |               |
|---------|----------------|-----------------------------------------|---------------|
| DIDDENS | 63 PRL 10 262  | +JENKINS, KYCIA, RILEY                  | (BNL) I       |
| ALVAREZ | 64 PRL 12 710  | +BAR-YAM, KERN, LUCKEY, OSBORNE, +      | (MIT, CEA)    |
| HOHLER  | 64 PL 12 149   | G HOHLER, J GIESECKE                    | (KARLSRUHE) I |
| WAHLIG  | 64 PRL 13 103  | +MANNELLI, SODICKSON, FACKLER, WARD, +  | (MIT)         |
| BARGER  | 66 PR 151 1123 | V BARGER, M OLSSON                      | (WISC)        |
| CITRON  | 66 PR 144 1101 | +GALBRAITH, KYCIA, LEONTIC, PHILLIPS, + | (BNL) I       |

|           |                |                               |               |
|-----------|----------------|-------------------------------|---------------|
| BARGER    | 67 PR 155 1792 | V BARGER, D CLINE             | (WISC) P      |
| DIKMEN    | 67 PRL 18 798  | F N DIKMEN                    | (MICH)        |
| KORMANYOS | 67 PR 164 1661 | KORMANYOS, KRISCH, OFALLON, + | (MICH, ANL) P |
| GALLOWAY  | 68 PL 268 334  | K F GALLOWAY                  | (INDIANA) I   |

PAPERS NOT REFERRED TO IN DATA CARDS.

|          |                |                                                                 |                       |
|----------|----------------|-----------------------------------------------------------------|-----------------------|
| BAACKE   | 67 NC 51A 761  | J BAACKE, M YVERT                                               | (KARLSRUHE, ORSAY)J-L |
| DOBROWOL | 67 PL 248 203  | DOBROWOLSKI, GUSKOV, LIKHACHEV, +                               | (DUBNA) P             |
| DOLEN    | 68 PR 166 1768 | R DOLEN, D HORN, C SCHMID                                       | (CITI)                |
| WAHLIG   | 68 PR 168 1515 | M A WAHLIG, I MANNELLI                                          | (MIT, PISA)           |
|          |                | FINAL VERSION OF DATA USED IN WAHLIG 64, IN CONJUNCTION WITH    |                       |
|          |                | CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES |                       |
|          |                | COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.              |                       |

 $\Delta(2850)$   
BUMPS85 N<sup>3</sup>/2(2850, JP= ) I=3/2 PRODUCTION EXPERIMENTS85 N<sup>3</sup>/2(2850) MASS (MEV) (PROD. EXP.)

|   |          |        |          |                 |                                |
|---|----------|--------|----------|-----------------|--------------------------------|
| M | (2870.0) | HOHLER | 64 RVUE  | DATA + DISP REL |                                |
| M | (2700.0) | WAHLIG | 64 OSRK  | 0 PI+ P CH EX   |                                |
| M | (2850.0) | APPROX | BARDADIN | 66 HBC          | ++ N <sup>3</sup> TO P + 3 PIS |
| M | 2850.0   | 12.0   | CITRON   | 66 CNTR         | PI+ P TOTAL                    |

85 N<sup>3</sup>/2(2850) WIDTH (MEV) (PROD. EXP.)

|   |         |          |        |         |      |
|---|---------|----------|--------|---------|------|
| W | (150.0) | BARDADIN | 66 HBC | ++      | 7/66 |
| W | 400.0   | 40.0     | CITRON | 66 CNTR | 7/66 |

85 N<sup>3</sup>/2(2850) PARTIAL DECAY MODES (PROD. EXP.)

|    |                                      |                    |
|----|--------------------------------------|--------------------|
| P1 | N <sup>3</sup> /2(2850) INTO PI N    | DECAY MASSES       |
| P2 | N <sup>3</sup> /2(2850) INTO P PI PI | 139+ 938           |
| P3 | N <sup>3</sup> /2(2850) INTO N PI PI | 938+ 139+ 139+ 139 |

85 N<sup>3</sup>/2(2850) BRANCHING RATIOS (PROD. EXP.)

|    |                                                   |                                                                         |         |             |             |
|----|---------------------------------------------------|-------------------------------------------------------------------------|---------|-------------|-------------|
| R1 | N <sup>3</sup> /2(2850) INTO (PI N)/TOTAL         | (PI)                                                                    |         |             |             |
| R1 | ONLY (J=1/2)*(PI N)/TOTAL MEASURED FOR THIS STATE |                                                                         |         |             |             |
| R1 | B                                                 | (0.224)                                                                 | (0.016) | BARGER      | 66 RVUE     |
| R1 | B                                                 | 0.261                                                                   | 0.048   | CITRON      | 66 CNTR     |
| R1 | B                                                 | (0.40)                                                                  |         | BARGER      | 67 RVUE     |
| R1 | B                                                 | USES REGGE AMP. + RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE |         |             |             |
| R1 | B                                                 | FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.                             |         |             |             |
| R1 | C                                                 | (0.49)                                                                  |         | DIKMEN      | 67 RVUE     |
| R1 | C                                                 | USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES    |         |             |             |
| R1 | (0.39)                                            |                                                                         |         | DOBROWOLSKI | 67 CNTR     |
| R1 | (0.10)                                            |                                                                         |         | KORMANYOS   | 67 CNTR     |
| R1 | D                                                 | (0.06) OR LESS CL=95                                                    |         | HALDORSE    | 72 HBC      |
| R1 | D                                                 | UPPER LIMIT ON ELASTICITY, ALSO FIND J=9/2 OR MORE.                     |         |             | PP 19 GEV/C |

REFERENCES FOR N<sup>3</sup>/2(2850) (PROD. EXP.)

|          |                |                                         |               |
|----------|----------------|-----------------------------------------|---------------|
| HOHLER   | 64 PL 12 149   | G HOHLER, J GIESECKE                    | (KARLSRUHE) I |
| WAHLIG   | 64 PRL 13 103  | +MANNELLI, SODICKSON, FACKLER, WARD, +  | (MIT)         |
| BARDADIN | 66 PL 21 357   | BARDADIN-OTIMOWSKA, DAHYSZ, +           | (WARSAW)      |
| BARGER   | 66 PR 151 1123 | V BARGER, M OLSSON                      | (WISC)        |
| CITRON   | 66 PR 144 1101 | +GALBRAITH, KYCIA, LEONTIC, PHILLIPS, + | (BNL) I       |

|           |                |                                   |               |
|-----------|----------------|-----------------------------------|---------------|
| BARGER    | 67 PR 155 1792 | V BARGER, D CLINE                 | (WISC) P      |
| DIKMEN    | 67 PRL 18 798  | F N DIKMEN                        | (MICH)        |
| DOBROWOL  | 67 PL 248 203  | DOBROWOLSKI, GUSKOV, LIKHACHEV, + | (DUBNA) P     |
| KORMANYOS | 67 PR 164 1661 | KORMANYOS, KRISCH, OFALLON, +     | (MICH, ANL) P |
| HALDORSE  | 72 NC 10A 468  | HALDORSE, JACOBSEN                | (OSLO) IJ     |

PAPERS NOT REFERRED TO IN DATA CARDS.

|        |                |                                                                 |                       |
|--------|----------------|-----------------------------------------------------------------|-----------------------|
| BAACKE | 67 NC 51A 761  | J BAACKE, M YVERT                                               | (KARLSRUHE, ORSAY)J-L |
| DOLEN  | 68 PR 166 1768 | R DOLEN, D HORN, C SCHMID                                       | (CITI)                |
| WAHLIG | 68 PR 168 1515 | M A WAHLIG, I MANNELLI                                          | (MIT, PISA)           |
|        |                | FINAL VERSION OF DATA USED IN WAHLIG 64, IN CONJUNCTION WITH    |                       |
|        |                | CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES |                       |
|        |                | COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.              |                       |

 $\Delta(3230)$   
BUMPS86 N<sup>3</sup>/2(3230, JP= ) I=3/2 PRODUCTION EXPERIMENTS86 N<sup>3</sup>/2(3230) MASS (MEV) (PROD. EXP.)

|   |          |        |         |             |      |
|---|----------|--------|---------|-------------|------|
| M | (3230.0) | CITRON | 66 CNTR | PI+ P TOTAL | 7/66 |
|---|----------|--------|---------|-------------|------|

## Baryons

 $\Delta(3230)$ ,  $\text{EX}(1640)$ ,  $Z^*$ 's

## Data Card Listings

For notation, see key at front of Listings.

|                                                 |                                                                      |                                       |
|-------------------------------------------------|----------------------------------------------------------------------|---------------------------------------|
| 86 N*3/2(3230) WIDTH (MEV) (PROD. EXP.)         |                                                                      | 7/66                                  |
| W                                               | (440.0)                                                              | CITRON 66 CNTR                        |
| 86 N*3/2(3230) PARTIAL DECAY MODES (PROD. EXP.) |                                                                      |                                       |
| P1                                              | N*3/2(3230) INTO P1 N                                                | DECAY MASSES                          |
| P2                                              | N*3/2(3230) INTO N P1 P1                                             | 139* 938                              |
|                                                 |                                                                      | 938* 139* 139                         |
| 86 N*3/2(3230) BRANCHING RATIOS                 |                                                                      |                                       |
| R1                                              | N*3/2(3230) INTO (P1 N)/TOTAL                                        | (P1)                                  |
| R1                                              | ONLY (J+1/2) (P1 N)/TOTAL MEASURED FOR THIS STATE                    |                                       |
| R1 B                                            | (0.03) (0.01)                                                        | BARGER 66 RVUE TOTAL + CH EXC. 11/67  |
| R1                                              | (0.06)                                                               | CITRON 66 CNTR TOTAL CROS. SEC. 11/67 |
| R1 B                                            | (0.03) TO 0.1                                                        | BARGER 67 CNTR USES KORMANYOS66 11/67 |
| R2 B                                            | USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE |                                       |
| R2 B                                            | FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.                          |                                       |
| R1 D                                            | (0.25)                                                               | DIKMAN 67 RVUE USES KORMANYOS67 11/67 |
| R1 D                                            | USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES |                                       |
| *****                                           |                                                                      |                                       |
| REFERENCES FOR N*3/2(3230) (PROD. EXP.)         |                                                                      |                                       |
| BARGER 66 PR 151 1123                           | V BARGER, M OLSSON                                                   | (WISC)                                |
| CITRON 66 PR 144 1101                           | +GALBRAITH, KYCIA, LEONTIC, PHILLIPS, + (BNL) 1                      |                                       |
| BARGER 67 PR 155 1792                           | V BARGER, D CLINE                                                    | (WISC) P                              |
| DIKMAN 67 PRL 18 798                            | F N DIKMAN                                                           | (MICH)                                |
| PAPERS NOT REFERRED TO IN DATA CARDS            |                                                                      |                                       |
| KORMANYO 67 PR 164 1661                         | KORMANYOS, KRISCH, OFALLON, + (MICH, ANL) P                          |                                       |
| DOLEN 68 PR 166 1768                            | R DOLEN, D HORN, C SCHMID (CIT)                                      |                                       |
| *****                                           |                                                                      |                                       |

## EXOTIC NUCLEON

THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

**EX(1640)**

92 EX(1640, JP= ) I=5/2

AMMANN 71 AND JOHNSON 71 WITH COMPARABLE (OR BETTER) STATISTICS AND AT MOMENTA NEAR 4.91 ARGUE STRONGLY THAT THE EFFECT SEEN BY PRICE 70 IS A STATISTICAL FLUCTUATION.

IN A MISSING MASS EXPERIMENT, P1+ P TO P1- X+\*, BIRULEV 71 FIND NO EVIDENCE FOR EXOTIC (I=5/2) RESONANCES IN THE MASS INTERVAL 1.2 TO 2.2 GEV.

|                                              |                                                         |                                         |
|----------------------------------------------|---------------------------------------------------------|-----------------------------------------|
| 92 EX(1640) MASS (MEV)                       |                                                         |                                         |
| M A                                          | 29(1627.) (12.)                                         | PRICE 70 OBC — K-D AT 4.91GEV/C 3/71    |
| M A                                          | FOUR S. D. EFFECT                                       |                                         |
| 92 EX(1640) WIDTH (MEV)                      |                                                         |                                         |
| W B                                          | 29 (30.) OR LESS CL=90                                  | PRICE 70 OBC — PI-PI-N BUMP 3/71        |
| W B                                          | CROSS SECTION 13.0+3.9 MICROBARN                        |                                         |
| 92 EX(1640) CROSS SECTION LIMITS (MICROBARN) |                                                         |                                         |
| CS B                                         | (40.) OR LESS                                           | BANNER 70 OSPK +++ PI+P, 1.9 GEV/C 7/70 |
| CS B                                         | I=5/2 LIMIT GIVEN ABOVE IS FOR MASS RANGE 1540-1750 MEV |                                         |
| *****                                        |                                                         |                                         |
| REFERENCES FOR EX(1640)                      |                                                         |                                         |
| BANNER 70 NP 815 205                         | +CHEZE, HAMB, TEIGER, IACONE + (SACLAY)                 |                                         |
| PRICE 70 PL 33B, 533                         | +BERG, SALANT, WATERS, WEBSTER, WEINBERG (VAND)         |                                         |
| PAPERS NOT REFERRED TO IN DATA CARDS         |                                                         |                                         |
| AMMANN 71 PL 34B 533                         | +KORMANY, GARFINKEL, GUTAY, MILLER, YEN (PURD)          |                                         |
| BIRULEV 71 SJNP 12 536                       | +VOVENKO, GUSKOV, DOBROVOLSKII, + (JINR)                |                                         |
| JOHNSON 71 PL 34B 428                        | D JOHNSON (ANL)                                         |                                         |
| *****                                        |                                                         |                                         |

Note on Possible  $Z^*$ 's

Although much work has been done on the strangeness +1 reactions during the past few years, it is not yet clear whether the peaks seen in total KN cross sections near 1 GeV/c are resonances; see Fig. 1. Since positive-

strangeness baryons cannot be made from three quarks, it is very important to find out if these peaks are resonances.

(a)  $I = 0$  System. New  $K^+p$  total cross section data have been reported by the Arizona group in the 0.57 to 1.16 GeV/c region (BOWEN 73) and by the BNL group (CARROLL 73) in the 0.4 to 1.06 GeV/c region. The cross-sections of both groups fail to exhibit the dip at 0.7 GeV/c previously reported. The absence of the dip is also observed in the  $K^+p$  elastic data reported by ADAMS 72. A curve through the  $K^+p$  total cross section data as drawn by CARROLL 73 is shown in Fig. 1. The new  $K^+d$  cross section data around 0.7 GeV/c also show smoother behavior than before, and both effects result in the  $I = 0$  cross section shown in Fig. 1. The data points after unfolding and the smooth curve drawn by CARROLL 73 are shown in Fig. 2a. The double humped structure reported by ABRAMS 69, COOL 70, and DOWELL 70 now looks more like a shoulder and a bump, which is associated with the rapid increase in the inelastic cross section.

Fig. 2a shows large disagreement at low momenta between BOWEN 73 and CARROLL 73 points. However, only part of this disagreement is due to a difference in the measured  $K^+d$  cross sections (for  $P^+ > 0.8$  GeV/c, there is no systematic difference between the two sets of data); the rest can be attributed to differences in the unfolding procedures.

There is, however, no doubt about there being a large broad peak in the isospin 0 elastic cross section. The inelastic cross section increases smoothly until the  $K^*N$  threshold at 1.08 GeV/c is approached where, as shown in Fig. 2b, the  $K^*N$  cross section comes in strongly (HIRATA 70). The total  $KN\pi$  and  $KN\pi\pi$  cross sections are shown in Fig. 1 as eyeball curves drawn through the data (GIACOMELLI 72). Subtracting these from the total cross section one gets  $\sigma_0$  (elastic) also shown in Fig. 1. The resonance (if it

Baryons

Z\*'s

Data Card Listings

For notation, see key at front of Listings.

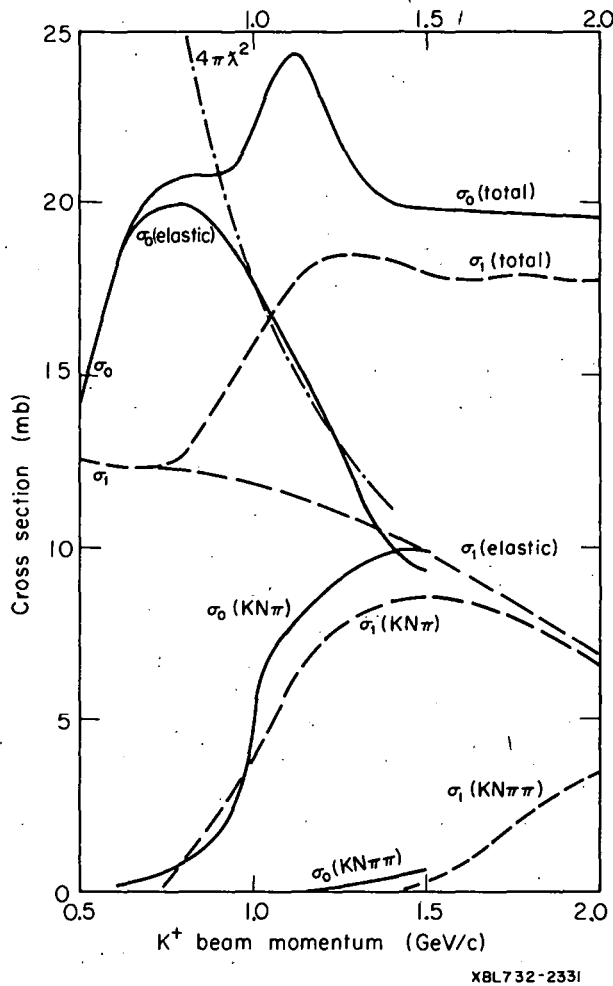


Fig. 1. KN total and partial cross sections. Subscripts indicate isospin. Total cross section curves from CARROLL 73, which uses new data of BOWEN 73 as well as previous data. Elastic I=1 curve is hand-drawn through new and old elastic data. I=0 inelastic curves taken from GIACOMELLI 72. Isospin 1 inelastic curves taken from LOKEN 72.

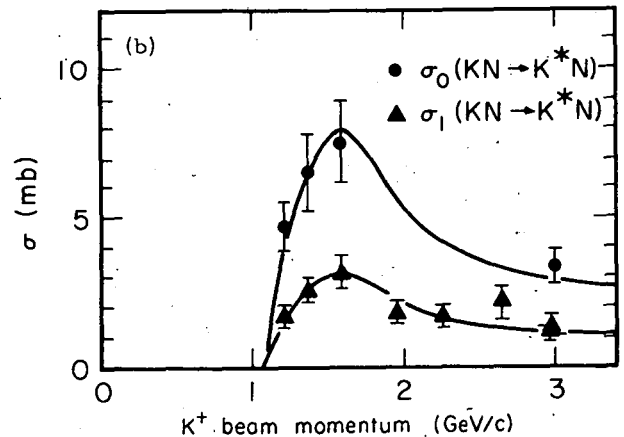
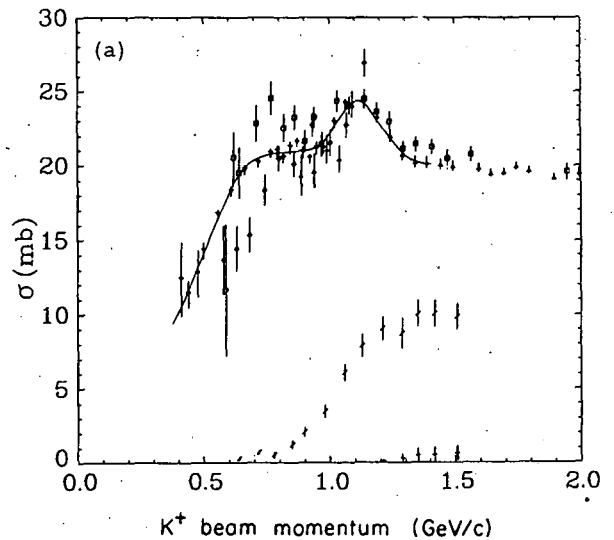


Fig. 2.

(a) Unfolded I=0 cross sections as quoted by the various authors discussed in the Z\* mini-review:

- ◇ BOWEN 73  $\sigma_T$
- BUGG 68  $\sigma_T$  (as unfolded by CARROLL 73)
- ▽ CARROLL 73  $\sigma_T$
- △ COOL 70  $\sigma_T$
- / GIACOMELLI 72  $\sigma(\pi KN)$
- GIACOMELLI 72  $\sigma(\pi\pi KN)$

(b) Energy dependence of the isospin 0 and isospin 1 cross sections for the reaction  $KN \rightarrow K^*N$  (HIRATA 70).

## Baryons

 $Z^*$ 's

exists) would have a mass  $M \sim 1780$  MeV, would be very wide, and would be very elastic because the inelastic cross section is small at the peak. If  $J$  were greater than  $1/2$ , the resonant peak would exceed the observed height of  $\sim 4\pi\lambda^2$ . This fixes the spin as  $1/2$ , and means that there is little cross section left over for other partial waves. Of course it is quite possible that in fact the peak is not caused by a resonance at all.

Differential cross section data on the elastic charge exchange have been reported by HIRATA 71 (5 momenta in the 0.87 to 1.59 GeV/c region) and by GIACOMELLI 72 (13 momenta in the 0.64 to 1.51 GeV/c region). More recently GIACOMELLI 72 reported data on the  $K^+n \rightarrow K^+n$  elastic scattering in the 0.6 to 1.6 GeV/c region, and ARMITAGE 72 has reported very preliminary data of  $K^0p \rightarrow K^+n$ . Attempts to perform partial-wave analyses for the  $I = 0$  system have also been reported recently. HIRATA 71, which does not include the most recent elastic and total cross section data, finds a large  $P_{01}$  partial wave which does not go through  $90^\circ$  as expected for an elastic resonance. WILSON 72 report energy-dependent and energy-independent analyses, which did not include the  $K^+n$  elastic data. S, P, and D waves only were included in the fit and six classes of solutions were found. The addition of the  $K^+n$  data has reduced the solutions to four with two being favored over the others (called C and D).<sup>1</sup> Solution D shows a resonant-like  $P_{01}$  partial wave which crosses the imaginary axis at  $P = 1200$  MeV/c and turns back in toward the center of the Argand plot. The other solution also has a large  $P_{01}$  partial wave, but it does not look resonant. Note, however, that very little polarization data have gone into these analyses; therefore a conclusion on the existence of  $Z_0^*(1780)$  must await more data.

(b)  $I = 1$  System. As discussed above there are new elastic cross section data reported by ADAMS 72 (0.4 to 0.9 GeV/c) and new  $K^+p$  total cross section measurements by BOWEN 73 and CARROLL 73. Elastic cross section results

## Data Card Listings.

*For notation, see key at front of Listings.*

have also been reported by CHARLES 72 (0.9 to 1.9 GeV/c). For the inelastic channels new data have been reported by LOKEN 72. Fig. 1 shows smooth curves drawn through the new total cross section data, the new elastic data, and the inelastic data of LOKEN 72.

Many partial-wave analyses have been performed on the  $K^+p$  data since the  $I = 1$  bump first appeared in 1966. We mention here only the most recent ones and refer the reader to our previous edition for a review of the others.<sup>2</sup> MILLER 72 has reported an analysis which uses a new method, ACE (accelerated convergence expansion), in which high partial waves are included through conformal mapping as suggested by CUTKOSKY 70. The results of ACE are then compared with the two solutions obtained by the same group through conventional partial-wave analysis. CUTKOSKY 72 is a new analysis by the same group with energy smoothing added to a more extensive random search. CHARLES 72 have performed a comparison of their data to existing phase-shift analysis and find that the ALBROW 71  $\alpha, \beta, \gamma$  solutions are the preferred ones, although they cannot choose among them. EHRLICH 72 have reported an analysis of data between 1.3 and 2.3 GeV/c employing the ACE method. Then they use the shortest path method to link the energy-independent solutions and find 25 least path solutions, some resembling previously published solutions, in addition to new ones. Another new analysis has been reported by Martin and Miller (MARTIN 72), who use an energy-dependent parametrization based on partial-wave dispersion relations. As a starting point the ALBROW 71 solution  $\gamma$  is used and they obtain a new solution which is not very different from the starting one.

In conclusion the new analyses, as the old ones, yield more than one solution to choose from, which indicates that the data are not good enough to eliminate some of the possibilities. More data of the conventional type, measurements of the R and A parameters, and the simultaneous analysis of elastic and

## Data Card Listings

For notation, see key at front of Listings.

Baryons

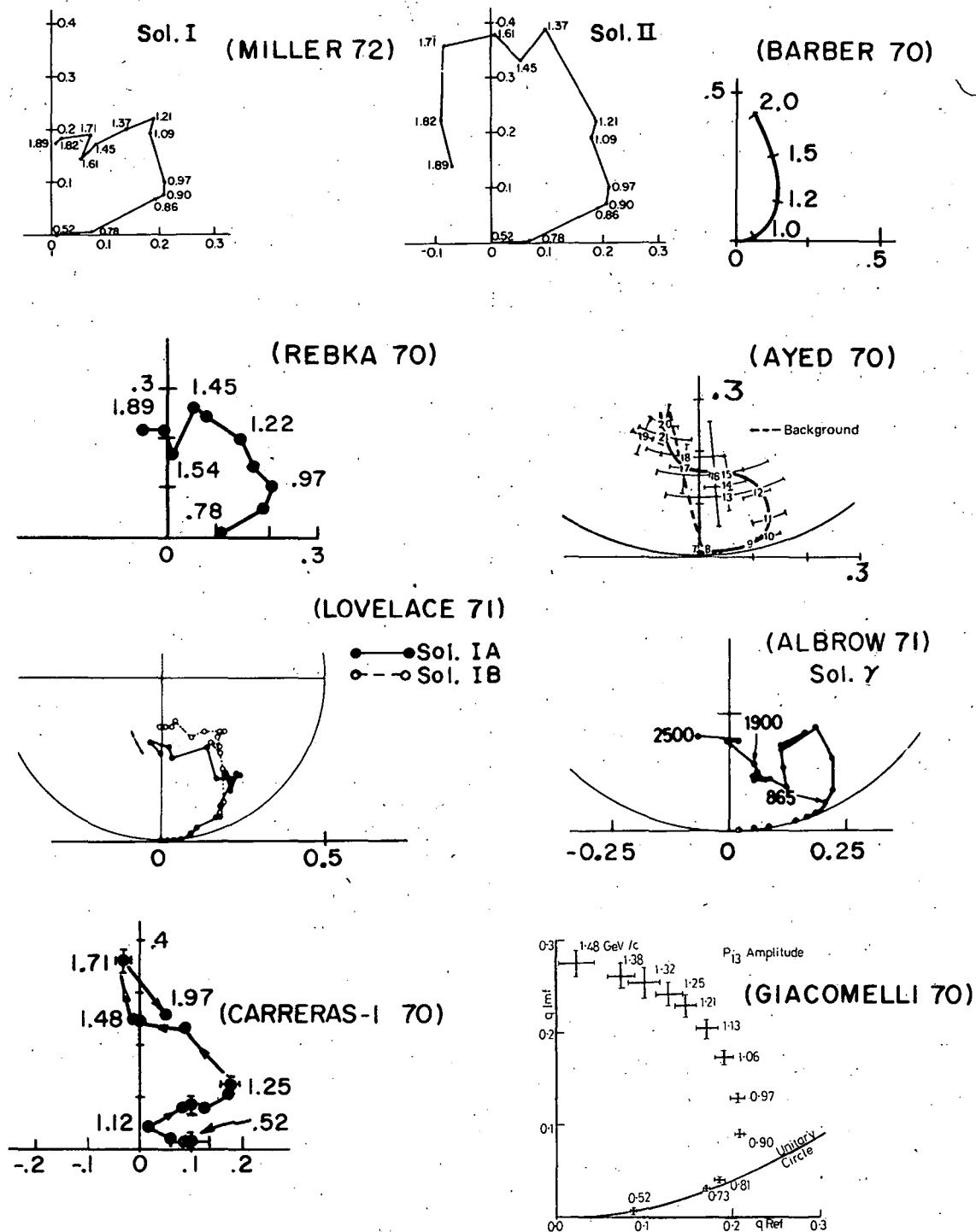
 $Z^*$ 's


Fig. 3. Argand plots for the  $P_{13}$  partial wave as obtained in partial-wave analyses performed by the authors indicated. (CARRERAS-1 70 plotted by us from  $\eta$ ,  $\delta$ .)

## Baryons

 $Z^*$ 's,  $Z_0(1780)$ ,  $Z_0(1865)$ 

inelastic channels (copious inelastic data are desirable at the moment) could improve the understanding of this system.

The  $P_{13}$  amplitude still remains the best candidate for a resonance in the  $K^+p$  system. The preferred  $P_{13}$  Argand plots obtained by some of the groups are shown in Fig. 3. Each analysis in one way or another gets at least one solution with a counterclockwise  $P_{13}$  amplitude. Resonant  $P_{13}$  is preferred by REBKA 70, GIACOMELLI 70, and ALBROW 71; the results of the other analyses are not so clear cut.

**Threshold effects.** An alternative way to describe the  $P_{13}$  amplitude would be in terms of a coupled-channel threshold effect: the KN amplitude becomes rapidly absorptive as it feeds the rapidly increasing  $K\Delta$  channel. The main question still remains: Is it also a resonance? If it is, its elasticity is small ( $\approx 0.2$ ) and it decays mainly into  $K\Delta$ . Partial-wave analyses in this channel do not seem to favor the resonant hypothesis at this time. See BLAND 67, BLAND 70, and GRIFFITHS 72. But a definite conclusion has yet to be made and awaits much more data.

**Production experiments.** One more comment on exotic resonances is that, as pointed out by ERNE 70, the present upper limits for the cross sections for production of broad exotic resonances are not very small; that is, they are of the same order as cross sections for  $Y^*$  or  $N^*$  production.

## References

1. A description of the new WILSON 72 analysis as well as an excellent review of recent work on the  $Z^*$ 's can be found in: J. D. Dowell, "The Search for  $Z^*$ 's", Proceedings of the XVI International Conference on High Energy Physics, Chicago-Batavia (1972).
2. Particle Data Group, Physics Letters **43B**, No. 1 (1972).

## Data Card Listings.

For notation, see key at front of Listings.

 **$Z_0(1780)$** 95  $Z^0(1780)$ , JP=1/2  $I=0$ 

SEE THE MINI-REVIEW PRECEDING THIS LISTING.

THIS EFFECT, IF A RESONANCE, MUST HAVE SPIN=1/2, BECAUSE THE INELASTIC CROSS SECTION IS VERY SMALL AND THE TOTAL CROSS SECTION IS ABOUT  $4\pi P/K^2$ .

HIRATA 71 ARGUE THAT IT IS THE  $P_{01}$  WAVE THAT IS LARGE. HOWEVER, THEY CONCLUDE THAT  $P_{01}$  NEED NOT PASS THROUGH 90 DEGREES TO EXPLAIN THE RELEVANT DATA IN THE 1 GEV/C REGION. WILSON 72 FIND SOME SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE  $P_{01}$  PARTIAL WAVE.

95  $Z^0(1780)$  MASS (MEV)

|   |        |                                                                         |        |           |                   |      |
|---|--------|-------------------------------------------------------------------------|--------|-----------|-------------------|------|
| M | 1780.0 | 10.0                                                                    | COOL   | 70 CNTR + | K*P, D TOTAL      | 1/71 |
| M | D      | SEEN                                                                    | DOWELL | 70 CNTR   | K*P, D TOTAL      | 7/70 |
| M | D      | SEE ALSO DISCUSSION OF LYNCH 70                                         |        |           |                   | 7/70 |
| M | W      | (1800.)                                                                 | WILSON | 72 PMA    | K+N $P_{01}$ WAVE | 3/72 |
| M | W      | ESTIMATE OF PARAMETERS FROM BM + QUADRATIC BACKGROUND FIT TO $P_{01}$ . |        |           |                   | 3/72 |

95  $Z^0(1780)$  WIDTH (MEV)

|   |         |  |        |           |                   |      |
|---|---------|--|--------|-----------|-------------------|------|
| W | (565.0) |  | COOL   | 70 CNTR + | K*P, D TOTAL      | 1/71 |
| W | (300.)  |  | WILSON | 72 PMA    | K+N $P_{01}$ WAVE | 3/72 |

95  $Z^0(1780)$  PARTIAL DECAY MODES

|    |                      |              |
|----|----------------------|--------------|
| P1 | $Z^0(1780)$ INTO K N | DECAY MASSES |
|    |                      | 493+ 939     |

95  $Z^0(1780)$  BRANCHING RATIOS

|    |                              |                                      |
|----|------------------------------|--------------------------------------|
| R1 | $Z^0(1780)$ INTO (K N)/TOTAL | (P1)                                 |
| R1 | W (0.95)                     | COOL 70 CNTR + K*P, D TOTAL 1/71     |
| R1 | W (0.85)                     | WILSON 72 PMA K+N $P_{01}$ WAVE 3/72 |

REFERENCES FOR  $Z^0(1780)$ 

|                                      |                    |                                           |                      |
|--------------------------------------|--------------------|-------------------------------------------|----------------------|
| COOL                                 | 70 DUKE CONF 47    | R L COOL                                  | (BNL)                |
|                                      | ALSO 69 PL 308 564 | ABRAMS, COOL, GIACOMELLI, KYCIA, LI +     | (BNL)                |
|                                      | ALSO 70 PR 01 1887 | COOL, GIACOMELLI, KYCIA, LEONTIC, LI +    | (BNL)                |
| DOWELL                               | 70 DUKE 53         | J. D. DOWELL                              | (BIRM)               |
| WILSON                               | 72 NP 842 445      | +GRIFFITHS, HIRATA +                      | (BGM+GLAS+ROMA+TRST) |
| PAPERS NOT REFERRED TO IN DATA CARDS |                    |                                           |                      |
| LYNCH                                | 70 DUKE 9          | G LYNCH (REVIEWER OF CR. SEC. DATA)       | (LRL)                |
| HIRATA                               | 71 NP 830 157      | +GOLDHABER, HALL, SEEGER, THRILLING, WOHL | (LBL+JJP)            |
| BOWEN                                | 73 PR 07 22        | +JENKINS, KALBACH, PETERSEN +             | (ARIZ+MICH)          |
| CARROLL                              | 73 BNL PREPRINT    | +KYCIA, LI, MICHAEL, MCKEY                | (BNL)                |

|                                                |                  |                              |                      |
|------------------------------------------------|------------------|------------------------------|----------------------|
| EXPERIMENTS MAINLY ABOUT ELASTIC CHANNELS --   |                  |                              |                      |
| ARMITAGE                                       | 72 NAL PAPER 391 | +ASTON, DUERDOTH, ELLISON, + | (MCHS+DARE)          |
| GIACOMEI                                       | 72 NP 842 437    | GIACOMELLI +                 | (BGM+GLAS+ROMA+TRST) |
| GIACOMEI                                       | 72 NP SUBMITTED  | GIACOMELLI +                 | (BGM+GLAS+ROMA+TRST) |
| EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS -- |                  |                              |                      |
| GIACOMEI                                       | 72 NP 837 577    | GIACOMELLI +                 | (BGM+GLAS+ROMA+TRST) |

 **$Z_0(1865)$** 96  $Z^0(1865)$ , JP=  $I=0$ 

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE  $K^*N$  THRESHOLD. SEE HIRATA 68 AND 70. WILSON 72 REPORTS A PARTIAL WAVE ANALYSIS. SEE ALSO  $Z^0(1780)$

96  $Z^0(1865)$  MASS (MEV)

|   |          |        |        |         |                 |      |
|---|----------|--------|--------|---------|-----------------|------|
| M | (1860.0) | (15.0) | CARTER | 67 THEO | DISPERSION REL. | 8/67 |
| M | (1868.0) | (10.0) | COOL   | 70 CNTR | K*P, D TOTAL    | 8/67 |

96  $Z^0(1865)$  WIDTH (MEV)

|   |         |        |        |         |  |      |
|---|---------|--------|--------|---------|--|------|
| W | (200.0) | (50.0) | CARTER | 67 THEO |  | 8/67 |
| W | (160.0) | (30.0) | COOL   | 70 CNTR |  | 8/67 |

96  $Z^0(1865)$  PARTIAL DECAY MODES

|    |                               |                      |
|----|-------------------------------|----------------------|
| P1 | $Z^0(1865)$ INTO K N          | DECAY MASSES         |
| P2 | $Z^0(1865)$ INTO N $K^*(892)$ | 493+ 939<br>938+ 891 |

96  $Z^0(1865)$  BRANCHING RATIOS

|    |                               |                              |
|----|-------------------------------|------------------------------|
| R1 | $Z^0(1865)$ INTO (K N)/TOTAL  | (P1)                         |
| R1 | (0.31) (0.05)                 | CARTER 67 THEO IF J=1/2 8/67 |
| R1 | (0.40) (0.05)                 | COOL 70 CNTR IF J=1/2 8/67   |
| R2 | $Z^0(1865)$ INTO N $K^*(892)$ | (P2)                         |
| R2 | MAIN INELASTIC DECAY          | HIRATA 68 HBC 11/68          |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $Z_0(1865)$ ,  $Z_1(1900)$ ,  $Z_1(2150)$ ,  $Z_1(2500)$ REFERENCES FOR  $Z_0(1865)$ 

CARTER 67 PRL 18 801  
HIRATA 68 PRL 21 1485  
COOL 70 PR D1 1887  
ALSO 66 PRL 17 102  
ALSO 69 PL 308 564

A A CARTER (CAVENDISH)  
HIRATA, MOHL; GOLDBERGER, TRILLING (LRL)  
COOL, GIACOMELLI, KYCIA, LEONTIC, LI + (BNL)  
\*GIACOMELLI, KYCIA, LEONTIC, LI, LUNDQVIST, + (BNL)  
\*ABRAMS, COOL, GIACOMELLI, KYCIA, LI + (BNL)

## PAPERS NOT REFERRED TO IN DATA CARDS

\*GOLDBERGER, SEEGER, TRILLING, MOHL (LRL)  
\*AMADO, SILLER (NEAS, PENN, LASL) JJP  
\*GOLDBERGER, HALL, SEEGER, TRILLING, MOHL (LRL)  
\*GIACOMELLI + (BGNA+GLAS+ROMA+TRST)  
\*GRIFFITHS, HIRATA + (BGNA+GLAS+ROMA+TRST)

 **$Z_1(1900)$** 

97  $Z_1(1900)$ , JP= 1 1=1  
THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K<sup>+</sup> N<sup>+</sup> THRESHOLD. IF A RESONANCE, THE SPIN-PARITY IS ALMOST CERTAINLY 3/2<sup>+</sup>.  
SEE THE MINIREVIEW PRECEDING  $Z_0$

97  $Z_1(1900)$  MASS (MEV)

|     |                                                                                                                                  |         |                         |                      |      |
|-----|----------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------|----------------------|------|
| M 1 | (1932.0)                                                                                                                         | AYED    | 70 IPWA                 | P13, SOL. I          | 6/70 |
| M 1 | (1899.0)                                                                                                                         | AYED    | 70 IPWA                 | P13, SOL. II         | 6/70 |
| M 1 | (2030.0)                                                                                                                         | AYED    | 70 IPWA                 | S11, SOL. III        | 6/70 |
| M 1 | THREE SOLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED TO GIVE PARAMETERS, THEY CONCLUDE RESONANT INTERPRETATION DOUBTFUL. |         |                         |                      |      |
| M 2 | (1840.0)                                                                                                                         | BARNETT | 70 IPWA                 | P13, SOL. III        | 7/70 |
| M 2 | RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS IN THE AMPLITUDES RESULTING FROM THE ANALYSIS                   |         |                         |                      |      |
| M   | 1900.0                                                                                                                           | 10.0    | COOL                    | 70 CNTR ++ K+P TOTAL | 1/71 |
| M   | (1880.1)                                                                                                                         | ALBROW  | 71 IPWA ++ SOL. GAMMA   | 10/71                |      |
| M K | (1890.1)                                                                                                                         | KATO    | 71 IPWA SOL II (FIT BW) | 10/71                |      |
| M K | (2040.1)                                                                                                                         | KATO    | 71 IPWA SOL II (FIT BW) | 10/71                |      |
| M K | KATO 71 ESTIMATE RESONANCE PARAMETERS — UPDATED PHASE SHIFTS                                                                     |         |                         | 3/72                 |      |
| M K | PUBLISHED IN MILLER 72.                                                                                                          |         |                         | 3/72                 |      |

97  $Z_1(1900)$  WIDTH (MEV)

|     |         |         |                         |           |      |
|-----|---------|---------|-------------------------|-----------|------|
| W 1 | (520.0) | AYED    | 70 IPWA                 | K+P       | 6/70 |
| W 1 | (397.0) | AYED    | 70 IPWA                 | K+P       | 6/70 |
| W 1 | (557.0) | AYED    | 70 IPWA                 | K+P       | 6/70 |
| W 2 | (80.0)  | BARNETT | 70 IPWA                 | K+P EIPWA | 7/70 |
| W   | (240.0) | COOL    | 70 CNTR ++ K+P TOTAL    | 1/71      |      |
| W   | (180.1) | ALBROW  | 71 IPWA ++ SOL. GAMMA   | 10/71     |      |
| W K | (280.1) | KATO    | 71 IPWA SOL II (FIT BW) | 10/71     |      |
| W K | (260.1) | KATO    | 71 IPWA SOL II (FIT BW) | 10/71     |      |

SEE THE NOTES ACCOMPANYING MASSES QUOTED.

97  $Z_1(1900)$  PARTIAL DECAY MODES

|    |                                |                       |
|----|--------------------------------|-----------------------|
| P1 | $Z_1(1900)$ INTO K N           | DECAY MASSES          |
| P2 | $Z_1(1900)$ INTO N*3/2(1236) K | 493+ 938<br>1236+ 493 |

97  $Z_1(1900)$  BRANCHING RATIOS

|      |                              |                                           |
|------|------------------------------|-------------------------------------------|
| R1   | $Z_1(1900)$ INTO (K N)/TOTAL | (P1)                                      |
| R1   | (0.10) OR LESS               | CARTER 67 THEO DISPERSION REL. 8/67       |
| R1   | (0.17)                       | AYED 70 IPWA 6/70                         |
| R1   | (0.20)                       | AYED 70 IPWA 6/70                         |
| R1   | (0.17)                       | AYED 70 IPWA 6/70                         |
| R1   | (0.09)                       | BARNETT 70 IPWA K+P EIPWA 7/70            |
| R1   | (0.12) (ASSUMING J=3/2)      | COOL 70 CNTR ++ K+P TOTAL 1/71            |
| R1   | (0.15)                       | ALBROW 71 IPWA ++ SOL. GAMMA 10/71        |
| R1 K | (0.22)                       | A. YOKOSAWA 71 IPWA SOL II (FIT BW) 10/71 |
| R1 K | (0.27)                       | KATO 71 IPWA SOL II (FIT BW) 10/71        |

SEE NOTES ACCOMPANYING THE MASSES QUOTED.

|    |                                |                                        |
|----|--------------------------------|----------------------------------------|
| R2 | $Z_1(1900)$ INTO K N*3/2(1236) | (P2)                                   |
| R2 | MAIN INELASTIC DECAY           | BLAND 67 HBC ++ 8/67                   |
| R2 | NO EVIDENCE, SPEED HAS MINIM.  | GRIFFITHS 72 HBC K+P .9-1.5 GEV/C 3/72 |

REFERENCES FOR  $Z_1(1900)$ 

BLAND 67 PRL 18 1077  
CARTER 67 PRL 18 801  
AYED 70 PL 328 404  
BARNETT 70 DUKE 443  
COOL 70 PR D1 1887  
ALSO 66 PRL 17 102  
ALBROW 71 NP 830 273  
ALSO 70 DUKE 375  
KATO 71 H.E. PHEN., MORIONO  
ALSO 70 DUKE 367  
ALSO 70 PRL 24 615  
GRIFFITH 72 NP 838 365  
MILLER 72 NP 837 401

\*BOWLER, BROWN, G+S GOLDBERGER, SEEGER, + (LRL)  
A A CARTER (CAVENDISH)  
\*BAREYRE, FELTESSE, VILLET (SACLAY) JJP  
\*GOLDMAN, LAASSEN, STEINBERG (MARYLAND) JJP  
\*GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I  
COOL, GIACOMELLI, KYCIA, LEONTIC, LI + (BNL)  
\*ANDERSON, ALMEHED, ..., UDO, WAGNER (CERN) JJP  
ERNE, SENS, WAGNER (CERN) JJP  
\*KOEHLER, ..., YOKOSAWA+BURLESON (ANL, NRES) JJP  
A. YOKOSAWA (ANL) JJP  
KATO, KOEHLER, NOVEY, YOKOSAWA+ (ANL, NRES) JJP  
\*HIRATA, HUGHES + (BGNA+GLAS+ROMA+TRST)  
\*NOVEY, YOKOSAWA, CUTKOSKY + (ANL+CERN+NRES) JJP

PAPERS NOT REFERRED TO IN  $Z_1$  DATA CARDS

TOTAL-CROSS-SECTION EXPERIMENTS —  
BUGG 68 PR 168 1466  
BOWEN 70 PR D2 2599  
BOWEN 73 PR D7 22  
CARROLL 73 BNL PREPRINT  
\*GILMORE, KNIGHT, + (RHEL, BIRM, CAVE) I  
\*CALDWELL, DIXON, JENKINS, KALBACH, + (ARIZ) I  
\*JENKINS, KALBACH, PETERSEN + (ARIZ+MICH)  
\*KYCIA, LI, MICHAEL, MCKEY (BNL)

## A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA —

HITE 67 THESIS G E HITE (ILLINOIS)  
REGGE-POLE ANALYSES —  
CARRERAS 70 NP 819 349 B CARRERAS, A DONNACHIE (DARESBURY, MCHS)

## EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS —

BLAND 68 UCRL-18131 THESIS R W BLAND (LRL)  
BLAND 69 NP 813 595 \*BOWLER, BROWN, KADYK, GOLDBERGER, + (LRL)  
BLAND 70 NP 818 537 \*BOWLER, BROWN, GOLDBERGER, (LRL)  
BLAND 69 AND BLAND 70 REPLACE BLAND 67 AND BLAND 68.  
HIRATA-1 71 NP 833 445 \*GOLDBERGER, HALL, SEEGER, TRILLING, MOHL (LRL)  
GRIFFITH 72 NP 838 365 \*HIRATA, HUGHES, JACOBS+ (BGNA+GLAS+ROMA+TRST) JJP  
LOKEN 72 PR D6 2346 \*BARISH, GOMEZ, DAVIES, SCHLEIN, + (CIT, UCLA)

## THE MAIN ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS —

CARROLL 68 PRL 21 1282 \*FISCHER, LUNDQVIST, PHILLIPS, + (BNL, ROCH)  
ANDERS-1 69 PL 288 611 ANDERSSON, DAUM, ERNE, LAGNAUX, + (CERN)  
ANDERS-2 69 PL 308 56 ANDERSSON, DAUM, ERNE, LAGNAUX, + (CERN)  
ASBURY 69 PRL 23 194 \*DOWELL, KATO, LUNDQUIST, NOVEY, + (ANL, UMD)  
BLAND 69 PL 228 618 R W BLAND, G GOLDBERGER, G H TRILLING (LRL)  
BARBER 70 PL 328 214 \*BROOME, DUFF, HEYMANN, IRIE, + (LOUG+RHEL) JJP  
GIACOMELLI 70 NP 820 301 GIACOMELLI, GRIFFITHS, (BGNA+GLAS+ROMA+TRST) JJP  
HALL 70 DUKE 435 \*BLAND, GOLDBERGER, TRILLING (LRL)  
REBAK 70 PRL 24 160 \*ROTHBERG, ETKINS, GLODIS, + (YALE) JJP  
ADAMS 71 PR D4 2637 \*DAVIES, DOWELL, GRAY, HATTERS + (BIRM+RHEL)  
BARNETT 71 PL 348 655 \*LAASSEN, STEINBERG + (UMD+ANL+NRES+VAL)  
ERLICH 71 PRL 26 925 \*ETKIN, GLODIS, HUGHES, KONDO, LU, MORI, + (YALE)  
WHITMORE 71 PR D3 1092 \*ABRAMS, EISENSTEIN, KIM, OHALLORAN, + (ILL)  
ADAMS 72 NAL PAPER 326 \*COX, DAVIES, DOWELL, GRAY, + (BIRM+RHEL)  
CHARLES 72 PL 408 289 \*COWAN, EDWARDS, GIBSON, + (BRIS, RHEL, SHMP)  
DANYSZ 72 NP 842 29 \*CHARLES, COWAN, EDWARDS + (BRIS+RHEL+SHMP)  
\*PENNEY, STEWART, THOMPSON, + (LOIC, CDEF, LOWC)

## PHASE SHIFT ANALYSES

CARRERA 70 NP 823 525 B CARRERAS, A DONNACHIE (DARE) JJP  
ALSO 70 DUKE 447 \*DONNACHIE, KIRSOPP (DARE+MCHS+ EDIN)  
LEA 71 NP 826 413 \*MARTIN, THOMPSON (RHEL, LOUC) JJP  
LOVELACE 71 NP 828 141 \*WAGNER (CERN) JJP  
ERLICH 72 NAL PAPER 447 \*ETKIN, GLODIS, HUGHES, LU, PATTON + (YALE)  
CUTKOSKY 72 NAL PAPER 210 \*WICKS, KELLY, SHIM, JOHNSON CERN+ILL+ANL  
MARTIN 72 PREPRINT B.R. MARTIN, C.E. MILLER (LOUC)

## EARLIER ANALYSES THAT DO NOT INCLUDE RECENT POLARIZATION DATA —

LEA 68 PR 165 1770 LEA, MARTIN, OADES (RHEL, BNL, CERN)  
MARTIN 68 PRL 21 1286 B R MARTIN (BNL)  
CUTKOSKY 70 PR D1 2547 R E CUTKOSKY, B B DEO (CARNegie-MELLON) I

## LATEST REVIEW TALKS

LEVISETTI 69 LUND CONF 341 R LEVI SETTI (RAPPOREUR) (CHICAGO)  
GOLDBERGER 70 DUKE 407 \*DONNACHIE (REVIEWER)  
DOWELL 72 NAL REVIEW REVIEW TALK IN BARYON SESSION (BIRM)  
LOVELACE 72 NAL REVIEW RAPPOREUR'S TALK (RUTG)

 **$Z_1(2150)$** 

93  $Z_1(2150)$ , JP= 1 1=1  
A SMALL BUMP IN TOTAL CROSS SECTION AT PK=1.8 GEV/C

93  $Z_1(2150)$  MASS (MEV)

|   |       |     |        |                      |       |
|---|-------|-----|--------|----------------------|-------|
| M | 2150. | 20. | ABRAMS | 70 CNTR ++ K+P TOTAL | 10/71 |
|---|-------|-----|--------|----------------------|-------|

93  $Z_1(2150)$  WIDTH (MEV)

|   |        |        |                     |       |
|---|--------|--------|---------------------|-------|
| W | (175.) | ABRAMS | 70 CNTR + K+P TOTAL | 10/71 |
|---|--------|--------|---------------------|-------|

93  $Z_1(2150)$  PARTIAL DECAY MODES

|    |                      |              |
|----|----------------------|--------------|
| P1 | $Z_1(2150)$ INTO K N | DECAY MASSES |
|    |                      | 493+ 938     |

93  $Z_1(2150)$  BRANCHING RATIOS

|    |                                             |                                  |
|----|---------------------------------------------|----------------------------------|
| R1 | $Z_1(2150)$ INTO (K N)/TOTAL                | (P1)                             |
| R1 | J IS NOT KNOWN, THE FOLLOWING IS (J=1/2)*P1 | (LRL)                            |
| R1 | (0.04)                                      | ABRAMS 70 CNTR + K+P TOTAL 10/71 |

REFERENCES FOR  $Z_1(2150)$ 

ABRAMS 70 PR D1 1917 \*COOL, GIACOMELLI, KYCIA, LEONTIC, LI + (BNL)  
ALSO 67 PRL 19 257 ABRAMS, COOL, GIACOMELLI, KYCIA, LEONTIC + (BNL)

 **$Z_1(2500)$** 

94  $Z_1(2500)$ , JP= 1 1=1  
A SMALL BUMP IN TOTAL CROSS SECTION AT PK=2.7 GEV/C

94  $Z_1(2500)$  MASS (MEV)

|   |       |     |        |                      |       |
|---|-------|-----|--------|----------------------|-------|
| M | 2500. | 20. | ABRAMS | 70 CNTR ++ K+P TOTAL | 10/71 |
|---|-------|-----|--------|----------------------|-------|

## Baryons

 $Z_1(2500)$ ,  $\Lambda$ 's and  $\Sigma$ 's

|                                                    |                                             |                                                |                              |       |
|----------------------------------------------------|---------------------------------------------|------------------------------------------------|------------------------------|-------|
| 94 Z <sup>1</sup> (2500) WIDTH (MEV)               |                                             |                                                |                              |       |
| M                                                  | (160.)                                      | ABRAMS                                         | 70 CNTR ++ K+P TOTAL         | 10/71 |
| -----                                              |                                             |                                                |                              |       |
| 94 Z <sup>1</sup> (2500) PARTIAL DECAY MODES       |                                             |                                                |                              |       |
| P1                                                 | Z <sup>1</sup> (2500) INTO K N              | DECAY MASSES                                   |                              |       |
|                                                    |                                             | 493+ 938                                       |                              |       |
| -----                                              |                                             |                                                |                              |       |
| 94 Z <sup>1</sup> (2500) BRANCHING RATIOS          |                                             |                                                |                              |       |
| R1                                                 | Z <sup>1</sup> (2500) INTO (K N)/TOTAL      | (P1)                                           |                              |       |
| R1                                                 | J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)+P1 |                                                |                              |       |
| R1                                                 | (0.03)                                      | ABRAMS                                         | 70 CNTR ++ K+P TOTAL         | 10/71 |
| *****                                              |                                             |                                                |                              |       |
| REFERENCES FOR Z <sup>1</sup> (2500)               |                                             |                                                |                              |       |
| ABRAMS                                             | 70 PR 01 1917                               | +COOL, GIACOMELLI, KYCIA, LEONTIC, LI +        |                              | (BNL) |
| ALSO                                               | 67 PRL 19 257                               | ABRAMS, COOL, GIACOMELLI, KYCIA, LEONTIC +     |                              | (BNL) |
| *****                                              |                                             |                                                |                              |       |
| Z <sub>1</sub> CROSS SECTION LIMITS                |                                             |                                                |                              |       |
| SEE MINIREVIEW PRECEDING Z <sup>0</sup>            |                                             |                                                |                              |       |
| CS                                                 | UNITS MICROBARN                             |                                                |                              |       |
| CS                                                 | LESS THAN 50.                               | BASSOMPIERRE 68 HBC                            | K+P TO Z <sup>0</sup> + P1 + | 10/69 |
| CS                                                 | A LESS THAN +.3                             | -1 ANDERSON 69 ASPK +                          | PI-P TO K-Z <sup>0</sup> +   | 10/69 |
| CS                                                 | A ABOVE LIMIT FOR                           | M=1.2 TO 1.4 GEV -                             | CL= 99 P.C.                  |       |
| CS                                                 | B LESS THAN 1.4                             | +1.9 -5 ANDERSON 69 ASPK +                     | PI-P TO K-Z <sup>0</sup> +   | 10/69 |
| CS                                                 | 8 ABOVE LIMIT FOR                           | M=1.5 TO 2.5 GEV                               |                              |       |
| *****                                              |                                             |                                                |                              |       |
| REFERENCES FOR Z <sup>1</sup> CROSS SECTION LIMITS |                                             |                                                |                              |       |
| BASSOMPIERRE 68 PL 278 468                         |                                             | + (CERN, BRUXELLES)                            |                              |       |
| ANDERSON 69 PL 298 136                             |                                             | +BLESER, BLIEDEN, COLLINS, + (BNL, CARNEGIE)   |                              |       |
| PAPERS NOT REFERRED TO IN DATA CARDS               |                                             |                                                |                              |       |
| TYSON 67 PRL 19 255                                |                                             | +GREENBERG, HUGHES, LU, MINEHART, MORI, (YALE) |                              |       |
| MORI 68 PL 288 152                                 |                                             | +GREENBERG, HUGHES, LU, ROTHBERG, + (YALE)     |                              |       |
| MORI 69 PR 185 1687                                |                                             | +GREENBERG, HUGHES, LU, MINEHART, + (YALE)     |                              |       |
| MORI 69 REPLACES TYSON 67 AND MORI 68.             |                                             |                                                |                              |       |
| *****                                              |                                             |                                                |                              |       |

Note on  $Y^{*1}$ 's

The number of known or suspected  $Y^{*}$  states has increased considerably in the last few years, following closely a similar increase in the number of  $N^{*}$  states. Just as the recently discovered  $N^{*}$ 's are only weakly coupled in the  $\pi N - \pi N$  reaction, so also are the recently discovered  $Y^{*}$ 's only weakly coupled in the  $\bar{K}N - \bar{K}N$ ,  $\bar{K}N - \Lambda\pi$ , and  $\bar{K}N - \Sigma\pi$  reactions. For this reason the newer  $Y^{*}$ 's are more difficult to uncover; they usually appear as small peaks in invariant mass distributions or make no appearance at all. Rather than the 2-body reactions are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. Clearly the results of partial-wave analysis give the  $J^P$  information, whereas a peak seen in an invariant mass distribution or a total cross section often cannot be analyzed for its quantum numbers. We will keep information coming from formation experiments and from production experiments separate, whenever necessary.

Production experiments. These types of experiments are often difficult to analyze. Informa-

## Data Card Listings

For notation, see key at front of Listings.

tion on  $I = 0$  states is possible only when there is no  $I = 1$  state at similar mass. The main controversies at the present time concern resonances in the 1600 to 1700 MeV region. See the mini-reviews on  $\Sigma(1620)$  and on  $\Sigma(1670)$  in these Listings. A good review is given by MILLER 70.<sup>1</sup> Also, the branching ratios of  $\Sigma(1915)$   $F_{15}$  as measured in formation and production experiments do not agree. This is probably due to two facts: 1) the elasticity is small, 2) the nearby  $D_{13}(1940)$  may contribute to production experiments.

Formation experiments. Partial-wave analyses have been performed on  $\bar{K}N$ ,  $\Lambda\pi$ ,  $\Sigma\pi$  and  $\bar{K}K$  channels. Given the present accuracy of the data it is not possible to perform a completely energy-independent analysis, that is, solve for the partial-wave amplitudes at each energy in a model-independent way. Usually many solutions are found and even when it is required that solutions at neighboring energies join smoothly, it is not possible to select a unique overall solution. To overcome this, one specifies the form of the energy dependence of some or all of the partial-wave amplitudes. Analyses in which the energy dependence of all the amplitudes is specified are called energy dependent. When referring to results of this type of analysis, the technique listed is DPWA. Thus an amplitude known to resonate will be given a Breit-Wigner form, whereas an amplitude not a priori known to resonate may be tried alternately with a resonance form and with some simple nonresonant form, the choice between these then being made by comparing the goodness-of-fit for the two fits. Analyses in which the energy dependence of most of the amplitudes is left unspecified are called (not quite correctly) energy independent. These may involve some fixed input resonances in some of the partial waves and/or some method for selecting solutions that join together smoothly as functions of energy. The technique used for these analyses is listed as IPWA.

Three recent analyses have attempted to fit data on three channels ( $\bar{K}N$ ,  $\Sigma\pi$ , and  $\Lambda\pi$ ) at lab momenta below 1226 MeV/c. ARMENTEROS 70 (CH) fit each channel separately. They first fit Legendre series to the available data at each momentum in the range 436-1200 MeV/c, and then obtained smooth curves through the Legendre coefficients by fitting a polynomial in

## Data Card Listings

For notation, see key at front of Listings.

## Baryons Λ's and Σ's

$P_{lab}$  to each coefficient. Finally, the partial wave amplitudes were fit to the smoothed Legendre coefficients (or reconstructed smoothed angular distributions in the case of  $\bar{K}N$ ), and the continuity of the "data" was used to enforce continuity of the amplitudes. With a few exceptions the S and P waves were varied freely, while the higher waves were fixed as sums of Breit-Wigners (BW's) with no background, representing some well known resonances. Single channel inelastic unitarity was imposed during the fitting, and the results were checked against the three-channel unitarity constraint

$$\text{Im } T_{\bar{K}N} \geq |T_{\bar{K}N}|^2 + |T_{\Sigma\pi}|^2 + |T_{\Lambda\pi}|^2 \quad (1)$$

for each isospin. Resonance parameters were estimated visually.

KIM 71 (K) fit data from threshold to 1226 MeV/c using the Ross and Shaw<sup>2</sup> effective-range expansion of the inverse multi-channel K-matrix. The data in each of seven energy intervals bounded by 0, 534, 658, 806, 916, 1022, 1117, and 1226 MeV/c, were fit with a constant effective-range matrix. An extra channel was included for each isospin to approximate the effects of three-particle final states. The parameters for these extra channels were constrained by information on the total three-particle cross sections. Only the  $F_{15}(1915)$  was fixed to a BW form, all other waves included being parametrized by the K-matrix formalism. Resonances were identified on the basis of loops in the Argand diagram correlated with a peak in the speed plot and a pole in the K-matrix. The radius of the loop, the speed criterion, and the residue of the K-matrix were used to determine resonance parameters.

LANGBEIN 72 (LW) performed single energy fits at 40 momenta between 436 and 1226 MeV/c. The partial waves at each energy were parametrized in a form that automatically satisfied Eq. (1), and that could easily be specialized to a BW form by setting one of the parameters to zero. This capability was used to constrain the  $D_{03}(1690)$ ,  $D_{15}(1765)$ ,  $F_{05}(1815)$ , and  $F_{17}(2030)$  to pure BW forms in the range  $|E - M_R| < \Gamma$ . The resonant parameters were fit to known values. Approximately 90 acceptable single-energy fits per energy were generated and were used in shortest path searches over two regions, 1536 to 1700 MeV and 1700 to 1900 MeV. Several candidates for acceptable shortest paths were generated, and a preferred path was

chosen by rejecting those that failed to reproduce known resonance behavior. Resonances in this solution were identified by loops in Argand diagrams correlated with peaks in the  $\geq 3$ -body final state cross section. Resonance parameters were then extracted by fitting BW's with both multiplicative and additive background.

Partial-wave amplitudes from these three analyses are shown in Figs. 1-3. These analyses show, in addition to the well-established states (which we have classified with three or four stars in Table II at the end of this note), other states which we report in Table I. The table includes effects which show as a clear signal in at least one of the analyses (i. e., this is a list of promising "rookies").

Table I. Comparison of recent  $\bar{Y}^*$  claims. Notation is mass (MeV)/width (MeV)/strongest two-body channel; CH = CERN-Heidelberg, K = Kim, LW = Langbein and Wagner.

| Wave     | CH                                          | K                     | LW                   |
|----------|---------------------------------------------|-----------------------|----------------------|
| $S_{01}$ |                                             | 1780/40/ $\bar{K}N$   | 1830/70/ $\bar{K}N$  |
| $P_{01}$ |                                             | 1570/50/?             | 1620/60/?            |
| $P_{01}$ | 1750/70/ $\Sigma\pi$<br>1800/30/ $\bar{K}N$ | 1755/35/ $\bar{K}N$   | 1780/120/ $\bar{K}N$ |
| $P_{03}$ |                                             |                       | 1850/125/ $\bar{K}N$ |
| $S_{11}$ |                                             | 1620/40/ $\Lambda\pi$ | 1630/65/ $\Sigma\pi$ |
| $S_{11}$ | 1730/80/ $\Lambda\pi$                       | 1790/50/ $\bar{K}N$   | 1790/100/ $\bar{K}N$ |
| $P_{11}$ | 1500-1600/50/ $\Sigma\pi$                   | 1670/50/ $\Sigma\pi$  |                      |
| $P_{13}$ |                                             |                       | 1840/120/ $\bar{K}N$ |

Although a certain amount of qualitative agreement is apparent, there are many quantitative discrepancies. Some of these effects have been seen elsewhere, and there is also considerable disagreement with some of these other observations. The branching ratios into  $\bar{K}N$ ,  $\Sigma\pi$ , and  $\Lambda\pi$  are particularly poorly determined (this is also true of some of the better established resonances).

In addition to analyses which treat all of the channels  $\bar{K}N$ ,  $\Sigma\pi$ , and  $\Lambda\pi$ , there have been a number of energy-dependent analyses of a single channel. We will describe three of the most recent of these. CONFORTO 71 fit data on the  $\bar{K}N$  channel between 777 and 1226 MeV/c. The procedure was to parametrize each wave as a term linear in the lab momentum plus (possibly) BW's with adjustable phase. The data were first fit with BW's representing only known resonances. Three more resonances were then added, one at a time,

# Baryons

## $\Lambda$ 's and $\Sigma$ 's

Data Card Listings  
For notation, see key at front of Listings.

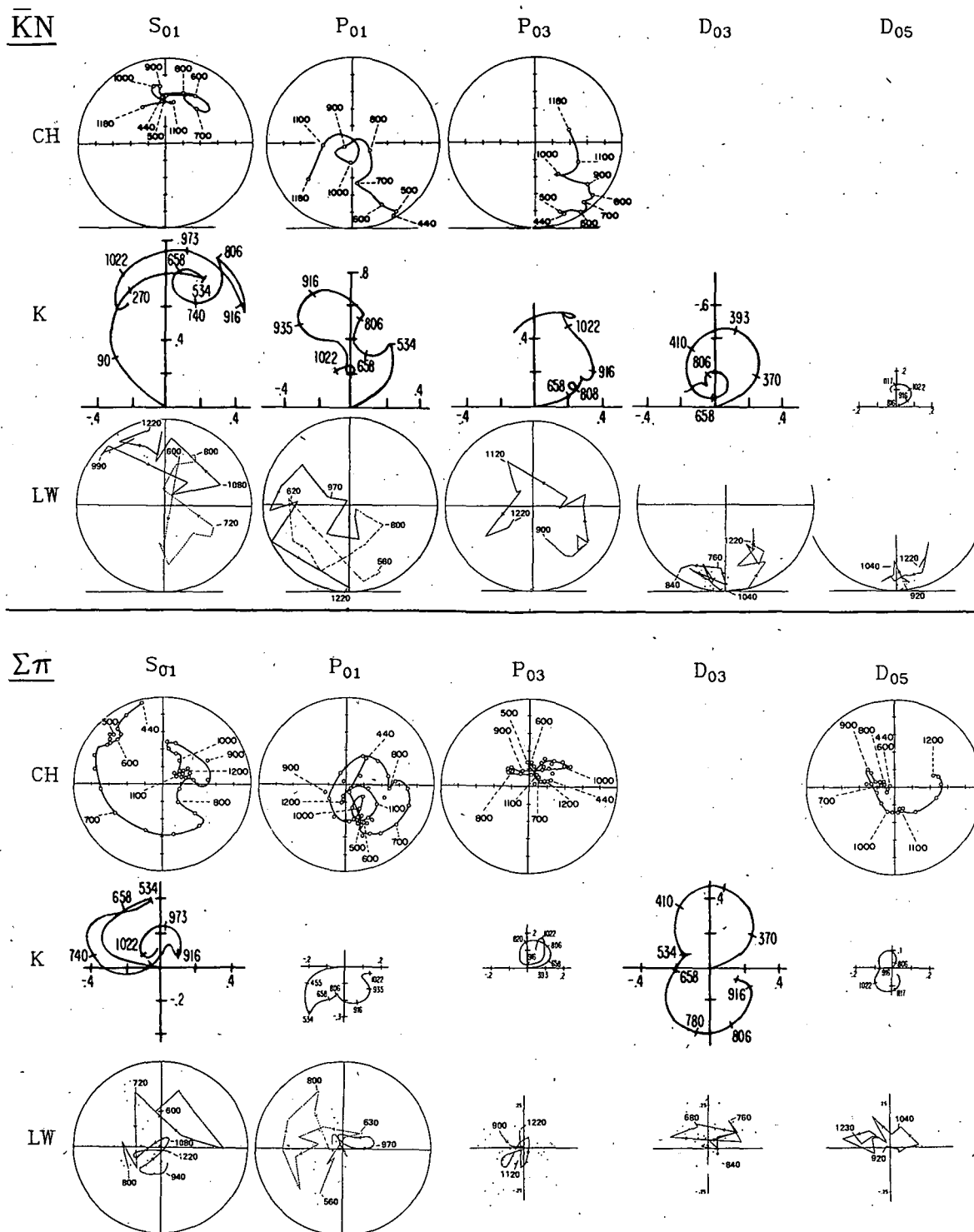


Fig. 1.  $I=0$  partial wave amplitudes for the reactions  $\bar{K}N \rightarrow \bar{K}N$  and  $\bar{K}N \rightarrow \Sigma\pi$  from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The  $\bar{K}$  laboratory momenta are indicated.

# Data Card Listings

For notation, see key at front of Listings.

## Baryons

$\Lambda$ 's and  $\Sigma$ 's

$\bar{K}N$

$S_{11}$

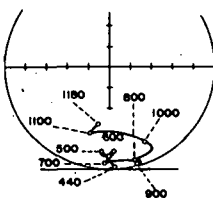
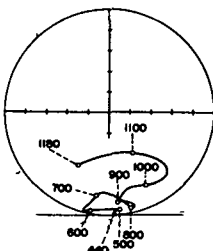
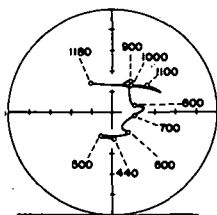
$P_{11}$

$P_{13}$

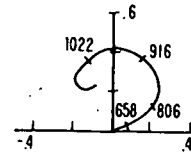
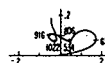
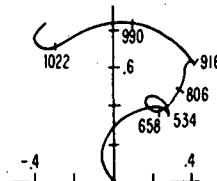
$D_{13}$

$D_{15}$

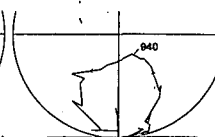
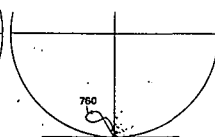
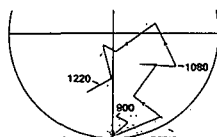
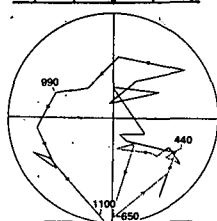
CH



K



LW



$\Sigma\pi$

$S_{11}$

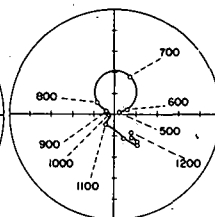
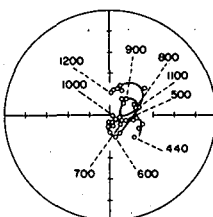
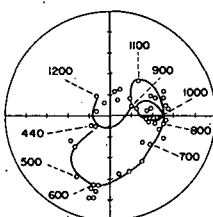
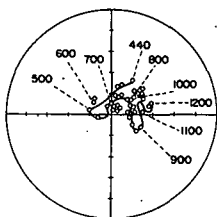
$P_{11}$

$P_{13}$

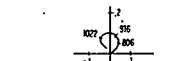
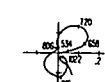
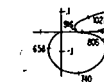
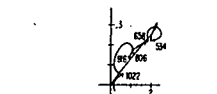
$D_{13}$

$D_{15}$

CH



K



LW

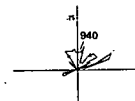
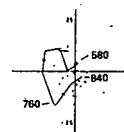
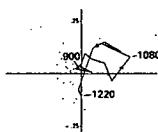
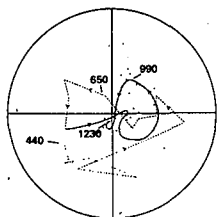


Fig. 2.  $I=1$  partial wave amplitudes for the reactions  $\bar{K}N \rightarrow \bar{K}N$  and  $\bar{K}N \rightarrow \Sigma\pi$  from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The  $\bar{K}$  laboratory momenta are indicated.

# Baryons $\Lambda$ 's and $\Sigma$ 's

## Data Card Listings

For notation, see key at front of Listings.

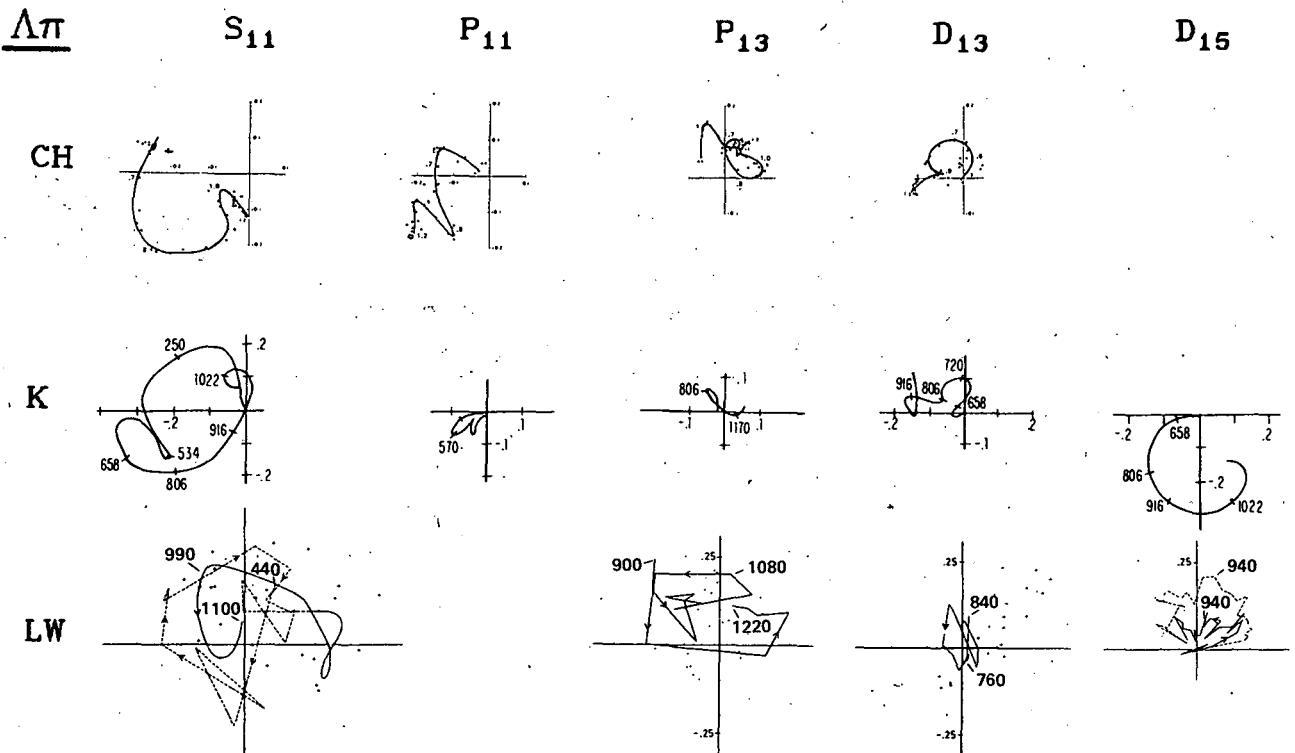


Fig. 3. Partial wave amplitudes for the reaction  $\bar{K}N \rightarrow \Lambda\pi$  from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The  $\bar{K}$  laboratory momenta are indicated.

to the waves where they had the most effect on  $\chi^2$ . Best results were obtained by adding a  $D_{05}(1830)$ ,  $P_{03}(1883)$ , and  $S_{11}(1757)$ . KANE 72 reported an analysis of bubble chamber cross section and polarization data on the  $\Sigma\pi$  channel between 870 and 1694 MeV/c. Legendre coefficients obtained from this data were used to fit an energy-dependent background + BW form for each wave, and the results were checked against the angular distributions from this experiment and against a compilation of Legendre coefficient data. In addition to known resonances, signals for a  $F_{05}(2141)$ ,  $F_{15}(2057)$ , and a  $D_{13}(1985)$  were seen. VAN HORN 72 fit data on the  $\Lambda\pi$  channel Legendre coefficients over the range 1537–2215 MeV, including new bubble chamber data between 1865 and 2106 MeV. An energy dependent parametrization similar to KANE 72 was used for the fitting; the 20 best solutions indicate (in addition to established resonances) the probable resonances

$S_{11}(1697)$ ,  $D_{13}(1949)$ ,  $P_{11}(1668)$ , and four possibilities in other waves. VAN HORN 72 also used the Barrelet<sup>3</sup> method to generate ambiguous solutions that correspond to the same cross sections and polarizations as the best energy-dependent solutions. Seven ambiguous solutions were found that preserved the established resonance behavior of the  $D_{13}(1670)$ ,  $D_{15}(1765)$ ,  $F_{15}(1915)$ , and  $F_{17}(2030)$ , but with varying couplings for these resonances to the  $\Lambda\pi$  channel, and with widely different resonant structures in the lower waves.

**Errors on masses and widths.** Often the quoted errors are only statistical, but the values of masses and widths can change well above these errors when a new parametrization is used. For this reason we report the values of  $M$ ,  $\Gamma$ , and  $x_1$  obtained by different authors even if they analyze the same data. The spread of these masses and widths is certainly a better estimate of the uncertainties than the statistical errors.

## Data Card Listings

For notation, see key at front of Listings.

Recently it has become the custom to quote errors as obtained by inspection of various fits done with different hypotheses [see for example BERTHON 70 and GALTIERI 70 under  $\Sigma(1915)$ ]. These errors are probably more realistic. On the other hand, the value of the parameter itself may be consistent with other determinations and often may even be the best available value. In such circumstances we put only the error in parentheses to remind the reader of the additional uncertainty due to model dependent assumptions. For two states,  $\Lambda(1820)$  and  $\Sigma(1765)$ , there is enough data available to perform an overall fit of the various  $x_i$  of the type discussed in the main text (section VC). In this case we are forced to use the errors, however small they may be, but we warn the reader that the final errors are not to be taken seriously.

In conclusion, we chose not to give errors on masses and total widths determined in partial-wave analyses, but, whenever necessary, we give a range of values. As for the branching ratios, we use the errors when needed to perform an overall fit, but we caution the reader.

**Conclusions.** Table II is an attempt to evaluate the status of the various  $Y^*$ 's. The evaluations are of course partly subjective. A blank indicates that there is no corresponding evidence at all. This may mean either that the relevant couplings are small or that the resonance does not really exist. The Baryon Table includes only the well-established resonances. It seems clear, however, that whereas any particular one of the questionable resonances may disappear with the next analysis, there definitely are many new resonances underlying those we are more familiar with.

## References

1. D. H. Miller, in *Proceedings of the Duke Conference on Hyperon Resonances* (1970), p. 229.
2. M. Ross and G. Shaw, *Ann. Phys. (N. Y.)* **13**, 147 (1961).
3. E. Barrelet, *N. C. 8A*, 331 (1972).
4. A. Barbaro-Galtieri in *Proceedings of the Duke Conference on Hyperon Resonances* (1970), p. 173.

## Baryons

$\Lambda$ 's and  $\Sigma$ 's,  $\Lambda$ ,  $\Lambda(1330)$

TABLE II. STATUS OF  $Y^*$  RESONANCES  
THOSE WITH AN OVERALL STATUS OF \*\*\* OR \*\*\*\* ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

|               |     | STATUS AS SEEN IN -- |                 |        |        |        |                 |
|---------------|-----|----------------------|-----------------|--------|--------|--------|-----------------|
| PARTICLE      | LIT | OVERALL STATUS       | TOTAL* CR. SEC. | KBAR N | LAM PI | SIG PI | OTHER CHANNELS  |
| LAM(1115) P01 |     | ****                 |                 |        |        |        | WEAK TO N PI    |
| LAM(1330)     |     | DEAD                 |                 |        |        |        |                 |
| LAM(1405) S01 |     | ****                 |                 |        |        |        |                 |
| LAM(1520) D03 |     | ****                 | ****            |        | F O    | ****   | LAM2P1, LAM GAM |
| LAM(1670) S01 |     | ****                 | ****            |        | R      | ****   | LAM ET          |
| LAM(1690) D03 |     | ****                 | ****            |        | B      | ****   | LAM2P1, SIG2P1  |
| LAM(1750) P01 |     | **                   | **              |        | I      | **     |                 |
| LAM(1815) F05 |     | ****                 | ****            |        | D      | ****   | SIG(1385) PI    |
| LAM(1830) D05 |     | **                   | **              |        | E      | **     |                 |
| LAM(1860) P03 |     | **                   | **              |        | N      | **     |                 |
| LAM(1870) S01 |     | **                   | **              |        |        | *      |                 |
| LAM(2010) D03 |     | **                   | **              |        | F O    | *      | LAM ONG         |
| LAM(2020) F07 |     | **                   | **              |        | O      | **     |                 |
| LAM(2100) G07 |     | *                    | ****            |        | B      | *      | XI K, LAM ONG   |
| LAM(2110)     |     | *                    | *               |        | I      | *      | LAM ONG         |
| LAM(2350)     |     | ****                 | ****            |        |        |        |                 |
| LAM(2585)     |     | ****                 | ****            |        |        |        |                 |
| SIG(1190) P11 |     | ****                 |                 |        |        |        | WEAK TO N PI    |
| SIG(1385) P13 |     | ****                 |                 |        |        |        |                 |
| SIG(1440) PE  |     | DEAD                 |                 |        |        |        |                 |
| SIG(1480) PE  |     | *                    | *               |        | *      | *      |                 |
| SIG(1620) S11 |     | **                   | **              |        | *      | *      |                 |
| SIG(1620) P11 |     | **                   | **              |        | *      | *      |                 |
| SIG(1620) PE  |     | **                   | **              |        | *      | *      | LAM 2-PI        |
| SIG(1670) D13 |     | ****                 | **              | ****   | ****   | ****   | SEVERAL OTHERS  |
| SIG(1670) PE  |     | **                   | **              | **     | **     | **     | SEVERAL OTHERS  |
| SIG(1690) PE  |     | **                   | *               | *      | *      | *      | LAM 2-PI        |
| SIG(1750) S11 |     | ****                 | ****            | ****   | ****   | ****   | SIG ET          |
| SIG(1765) D15 |     | ****                 | ****            | ****   | ****   | ****   | SEVERAL OTHERS  |
| SIG(1840) P13 |     | *                    | *               | *      | *      | *      |                 |
| SIG(1880) P11 |     | **                   | **              | **     | **     | **     |                 |
| SIG(1915) F15 |     | ****                 | ****            | ****   | ****   | ****   |                 |
| SIG(1940) D13 |     | ****                 | ****            | ****   | ****   | ****   |                 |
| SIG(2000) S11 |     | *                    | *               | *      | *      | *      |                 |
| SIG(2030) F17 |     | ****                 | ****            | ****   | ****   | ****   | XI K            |
| SIG(2070) F15 |     | *                    | *               | *      | *      | *      |                 |
| SIG(2080) P13 |     | **                   | **              | **     | **     | **     |                 |
| SIG(2100) G17 |     | **                   | **              | **     | **     | **     |                 |
| SIG(2250)     |     | ****                 | ****            | *      | *      | *      |                 |
| SIG(2455)     |     | ****                 | ****            | *      | *      | *      |                 |
| SIG(2620)     |     | ****                 | ****            | *      | *      | *      |                 |
| SIG(3000)     |     | **                   | **              | *      | *      | *      |                 |

\*\*\*\* GOOD, CLEAR, AND UNMISTAKABLE.

\*\*\* GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.

\*\* NEEDS CONFIRMATION.

\* WEAK.

\* ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

**$\Lambda$**

18 LAMBDA (1115, JP=1/2+) I=0

SEE TABLE PARTICLE DATA CARD LISTINGS

**$\Lambda(1330)$   
BUMPS**

87  $Y^*(1330, JP=)$  I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE  $Y^*$  LISTINGS.

A PEAK IS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI-PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). IN THE FIRST TWO, THIS WAS TAKEN AS INDIRECT EVIDENCE FOR THE  $Y^*(1670)$  DECAYING TO LAMBDA ET, WITH THE ET DECAYING TO TWO GAMMAS. IN THE THIRD EXPERIMENT THIS INTERPRETATION HAS BEEN RULED OUT. BOZOKI 68 MENTION THE POSSIBILITY OF THERE BEING A  $Y^*(1330)$  WITH A NARROW WIDTH (<25 MEV), BUT DEFER SERIOUS CONSIDERATION OF IT UNTIL THERE IS MORE DATA. SHOULD SUCH A RESONANCE EXIST, IT SHOULD BE SEEN IN PI- P TO KO+ (MISSING MASS). DAHL 67 FOUND NO EVIDENCE FOR IT. A SEARCH FOR A NEW  $Y^*$  NEAR THE LAMBDA OR SIGMA MASS WAS MADE BY TAN 69. NONE WAS FOUND. ANOTHER SEARCH BY MAYEUR 70 REVEALED NO EVIDENCE FOR THIS STATE.

REFERENCES FOR  $Y^*(1330)$  (PROD. EXP.)

Y-CHANG 64 DUBNA CONF I 615 YUNG-CHANG, IN, KLAONITSKAYA, + (DUBNA)  
BUBELEV 67 PL 248 246 +CHADRAA, CHUVELO, + (JINR, BUCHAREST, CERN)  
DAHL 67 PR 163 1377 DAHL, HARDY, HESS, KIRZ, MILLER (LRL)  
BOZOKI 68 PL 288 360 +PENNYVES, GEMESY, + (BUDAPEST, DUBNA)  
TAN 69 PRL 23 101 T H TAN (SLAC)  
MAYEUR 70 PL 338 441 +VAN BINST, WILQUET+++ (BRUX, CERN, TUFT)

## Baryons

 $\Lambda(1405)$ ,  $\Lambda(1520)$  $\Lambda(1405)$   
BUMPS

37 Y\*0(1405, JP=1/2-1 1=0 PRODUCTION EXPERIMENTS

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE K $\bar{K}$ π-N SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K- $\bar{K}$  INTERACTION. WE LIST SUCH EXPERIMENTS SEPARATELY BELOW. WE USE ONLY PRODUCTION EXPERIMENTS FOR AVERAGING OF MASSES AND WIDTHS.

| 37 Y*0(1405) MASS (MEV) (PROD. EXP.) |            |            |        |                    |
|--------------------------------------|------------|------------|--------|--------------------|
| M                                    | (1405.0)   | ALSTON     | 61 HBC | K-P 1.15 BEV/C     |
| M                                    | (1410.0)   | ALEXANDER  | 62 HBC | PI-P 2.1 BEV/C     |
| M                                    | (1405.0)   | ALSTON     | 62 HBC | K-P 1.2-5 BEV/C    |
| M                                    | (1382.0)   | ENGEL      | 65 HBC | PI-P, PI+0 1.68    |
| M                                    | 1400.0     | MUSGRAVE   | 65 HBC | PBAR P 3-4 BEV/C   |
| M                                    | 67 1400.0  | BIRMINGHAM | 66 HBC | K-P 3.5            |
| M                                    | 120 1405.0 | GALTIERI   | 68 HBC | K-D 2.1-2.78 BEV/C |
| M                                    | 1402.4     |            |        | 3.5                |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

| 37 Y*0(1405) WIDTH (MEV) (PROD. EXP.) |          |            |        |      |
|---------------------------------------|----------|------------|--------|------|
| W                                     | (20.0)   | ALSTON     | 61 HBC | 7/66 |
| W                                     | 35.0     | ALEXANDER  | 62 HBC |      |
| W                                     | (50.0)   | ALSTON     | 62 HBC |      |
| W                                     | (89.0)   | ENGEL      | 65 HBC | 7/66 |
| W                                     | 60.0     | MUSGRAVE   | 65 HBC | 7/66 |
| W                                     | 50.0     | BIRMINGHAM | 66 HBC | 9/67 |
| W                                     | 120 35.0 | GALTIERI   | 68 HBC | 6/68 |
| W                                     | 38.1     |            |        | 3.9  |

AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

| 37 Y*0(1405) PARTIAL DECAY MODES (PROD. EXP.) |                         |              |
|-----------------------------------------------|-------------------------|--------------|
| PI                                            | Y*0(1405) INTO SIGMA PI | DECAY MASSES |
|                                               |                         | 1197+ 139    |

## REFERENCES FOR Y\*0(1405) (PROD. EXP.)

|                           |                                                    |
|---------------------------|----------------------------------------------------|
| ALSTON 61 PRL 6 698       | +ALVAREZ, EBERHARD, GOOD, GRAZIANO, + (LRL) I      |
| ALEXANDER 62 PRL 8 447    | ALEXANDER, KALBFLEISCH, MILLER, SMITH (LRL) I      |
| ALSTON 62 CERN CONF 311   | +ALVAREZ, FERRO-LUZZI, ROSENFELD, + (LRL) I        |
| ENGEL 65 PRL 15 224       | +FISK, KRAEMER, MELTZER, WESTGARD, + (CERN, DNL) I |
| MUSGRAVE 65 NC 35 735     | +PETREZAS, + (BIRM, CERN, EPOL, LOIC, SACLAY)      |
| BIRMINGHAM 66 PR 152 1148 | BIRMINGHAM, GLASGOW, LOIC, OXFORD, RUTHERFORD      |
| GALTIERI 68 PRL 21 573    | BARBARO-GALTIERI, CHADWICK + (LRL, SLAC)           |

 $\Lambda(1405)$   
EXTRAP.

24 Y\*0(1405, JP=1/2-1 1=0  
EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y\*0(1405) PRODUCTION EXPERIMENTS -THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

THE QUESTION ON WHETHER Y\*0(1405) IS A K $\bar{K}$ π-N BOUND STATE OR A CDD POLE (DALITZ 70) HAS BEEN INVESTIGATED BY CLINE 71, MARTIN 71, GALTIERI 72, AND DOBSON 72. THE LAST TWO PAPERS CONCLUDE THAT THE DATA CANNOT TELL THE DIFFERENCE.

| 24 Y*0(1405) MASS (MEV) |          |        |                                           |         |
|-------------------------|----------|--------|-------------------------------------------|---------|
| M                       | 1410.7   | (1.0)  | KIM                                       | 65 HBC  |
| M                       | 1409.6   | (1.7)  | SAKITT                                    | 65 HBC  |
| M                       |          |        | DATA OF SAKITT ARE USED IN FIT BY KITTEL. |         |
| M                       | 1407.5   | (11.2) | KITTEL                                    | 66 HBC  |
| M                       | 1403.0   | (3.0)  | KIM                                       | 67 HBC  |
| M                       | 1416.0   | (4.0)  | MARTIN                                    | 69 HBC  |
| M                       | (1421.0) |        | MARTIN                                    | 70 RVUE |

CONST. K MATRIX 6/70

| 24 Y*0(1405) WIDTH (MEV) |        |       |        |         |
|--------------------------|--------|-------|--------|---------|
| W                        | 37.0   | (3.2) | KIM    | 65 HBC  |
| W                        | 28.2   | (4.1) | SAKITT | 65 HBC  |
| W                        | 36.1   | (4.1) | KITTEL | 66 HBC  |
| W                        | 50.0   | (5.0) | KIM    | 67 HBC  |
| W                        | 29.0   | (6.0) | MARTIN | 69 HBC  |
| W                        | (20.0) |       | MARTIN | 70 RVUE |

CONST. K MATRIX 6/70

## REFERENCES FOR Y\*0(1405) (FROM EXTRAPOLATIONS)

|                       |                                    |                |
|-----------------------|------------------------------------|----------------|
| KIM 65 PRL 14 29      | J K KIM                            | (COLUMBIA) IJP |
| SAKITT 65 PR 139 8719 | +DAY, GLASSER, SEEMAN, FRIEDMAN, + | (UMD, LRL) IJP |
| KITTEL 66 PL 21 349   | W KITTEL, G OTTER, I WACEK         | (VIENNA) IJP   |
| KIM 67 PRL 19 1074    | J KIM                              | (YALE) IJP     |
| MARTIN 69 PR 183 1352 | B R MARTIN, M SAKITT               | (LOUC+BNL)     |
| MARTIN 70 NP B16 479  | A D MARTIN, G G ROSS               | (DURHAM) IJP   |

## Data Card Listings

For notation, see key at front of Listings.

## PAPERS NOT REFERRED TO IN DATA CARDS

|                                               |                                 |                  |
|-----------------------------------------------|---------------------------------|------------------|
| ABRAMS 65-PR 139 B454                         | G S ABRAMS, B SECHI-ZORN        | (UMD) IJP        |
| DONALD 66 PL 22 711                           | + EDWARDS, LYS, NISAR, MOORE    | (LIVERPOOL)      |
| KADYK 66 PRL 17 599                           | +OREN, G+S GOLDBERGER, TRILLING | (LRL) IJP        |
| FIT SOLUTIONS GIVING AN I=0 S1 (2 RESONANCE,) |                                 |                  |
| ABRAMS 65, KADYK 66, AND DONALD 66            | SUPPORT THOSE EFFECTIVE-RANGE-  |                  |
| DALITZ 67 PR 153 1617                         | DALITZ, WONG, RAJASEKARAN       | (OXFORD, BOMBAY) |
| DALITZ 70 DUKE-HR 70 03                       | R D DALITZ                      | (OXF)            |
| CLINE 71 PRL 26 1194                          | D CLINE, R LAUMANN, J MAPP      | (WISC)           |
| MARTIN 71 PL 358 62                           | A D MARTIN, B R MARTIN, ROSS    | (DURH+LOUC+RHEL) |
| DOBSON 72 PR D6 3256                          | P N DOBSON, R MCCLANEY          | (HAWA)           |
| GALTIERI 72 LBL 555                           | A BARBARO-GALTIERI              | (LBL)            |

 $\Lambda(1520)$ 

38 Y\*0(1520, JP=3/2-1 1=0

D<sub>03</sub>

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL WITH EACH OTHER, THEREFORE, THEY HAVE NOT BEEN SEPARATE FOR THIS PARTICLE

A POSSIBLE EXCEPTION TO ABOVE IS THE LAM PI PI MODE. BOTH CHAN 72 AND HAST 73 (FORMATION) AGREE THAT IT IS PREDOMINANTLY Y\*(1385) PI. HOWEVER, THEY DISAGREE BY A FACTOR OF 2 AS TO THE CONTRIBUTION OF Y\*0(1520) TO THE OVERALL LAM PI PI CROSS SECTION. BURKHARDT 71 (PRODUCTION), WITH MUCH LESS STATISTICS, FIND A MUCH LOWER BRANCHING RATIO.

| 38 Y*0(1520) MASS (MEV) |            |         |                                                                                                                     |                                              |
|-------------------------|------------|---------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| M                       | 145 1517.2 | 3.0     | GALTIERI                                                                                                            | 63 HBC                                       |
| M                       | 1519.4     | 2.0     | WATSON                                                                                                              | 63 HBC                                       |
| M                       | 29 1520.0  | 4.0     | ALMEIDA                                                                                                             | 64 HBC                                       |
| M                       | (1511.0)   | (15.0)  | MUSGRAVE                                                                                                            | 65 HBC                                       |
| M                       | 30(1510.0) | (2.0)   | BIRMINGHAM                                                                                                          | 66 HBC                                       |
| M                       | 1517.2     | 1.2     | BURKHARDT                                                                                                           | 69 HBC                                       |
| M                       |            |         | QUOTED ERROR INCREASED TO ACCOUNT FOR DISAGREEMENT BETWEEN TWO MEASUREMENTS DONE BY SAME AUTHORS (K-P AND SIGMA PI) |                                              |
| M                       | (1519.1)   |         | KIM                                                                                                                 | 71 DPMA                                      |
| M                       |            |         |                                                                                                                     | K-MATRIX ANAL.                               |
| M                       | AVG        | 1517.65 | 0.95                                                                                                                | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

| 38 Y*0(1520) WIDTH (MEV) |           |         |            |                                              |
|--------------------------|-----------|---------|------------|----------------------------------------------|
| W                        | 16.4      | 2.0     | WATSON     | 63 HBC                                       |
| W                        | (19.0)    | (19.0)  | MUSGRAVE   | 65 HBC                                       |
| W                        | 30 (50.0) | (10.0)  | BIRMINGHAM | 66 HBC                                       |
| W                        | (18.0)    | OR LESS | DAHL       | 67 HBC                                       |
| W                        | 14.7      | 1.8     | BURKHARDT  | 69 HBC                                       |
| W                        | (16.1)    |         | KIM        | 71 DPMA                                      |
| W                        | AVG       | 15.5    | 1.3        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

| 38 Y*0(1520) PARTIAL DECAY MODES |                                |                |
|----------------------------------|--------------------------------|----------------|
| P1                               | Y*0(1520) INTO K $\bar{K}$ π N | DECAY MASSES   |
| P2                               | Y*0(1520) INTO SIGMA PI        | 497+ 939       |
| P3                               | Y*0(1520) INTO LAMBDA PI PI    | 1197+ 139      |
| P4                               | Y*0(1520) INTO LAMBDA GAMMA    | 1115+ 139+ 139 |
| P5                               | Y*0(1520) INTO SIGMA GAMMA     | 1115+ 0        |
| P6                               | Y*0(1520) INTO SIGMA PI PI     | 1102+ 0        |
| P7                               | Y*0(1520) INTO (Y*(1385)+PI)   | 1197+ 139+ 139 |
|                                  |                                | 1384+ 139      |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i)^2}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

|     | P 1           | P 2           | P 3           | P 4           | P 5           | P 6           |
|-----|---------------|---------------|---------------|---------------|---------------|---------------|
| P 1 | .4502+- .0089 |               |               |               |               |               |
| P 2 | -.7405        | .4115+- .0092 |               |               |               |               |
| P 3 | -.2227        | -.3403        | .1004+- .0054 |               |               |               |
| P 4 | -.0689        | -.0647        | -.0324        | .0080+- .0014 |               |               |
| P 5 | -.1739        | -.1633        | -.0819        | -.0095        | .0199+- .0035 |               |
| P 6 | -.0738        | -.0693        | -.0347        | -.0040        | -.0102        | .0100+- .0015 |

| 38 Y*0(1520) BRANCHING RATIOS |                                             |           |                  |                                               |
|-------------------------------|---------------------------------------------|-----------|------------------|-----------------------------------------------|
| R1                            | Y*0(1520) INTO (SIGMA PI)/(K $\bar{K}$ π N) | (P2)/(P1) |                  |                                               |
| R1                            | 1.72                                        | .78       | MUSGRAVE 65 HBC  | 8/67                                          |
| R1                            | 0.96                                        | .20       | DAHL 67 HBC      | 9/66                                          |
| R1                            | 0.73                                        | .11       | DAUBER 67 HBC    | 8/67                                          |
| R1                            | 1.06                                        | .14       | SCHUEER 68 HBC   | 10/69                                         |
| R1                            | 0.82                                        | 0.08      | BURKHARDT 69 HBC | 10/69                                         |
| R1                            |                                             |           |                  | K-P .8-1.2 GEV/C                              |
| R1                            | AVG                                         | 0.85      | 0.064            | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)  |
| R1                            | FIT                                         | 0.914     | 0.036            | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1) |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Lambda(1520)$ ,  $\Lambda(1670)$ 

R2 Y\*0(1520) INTO (LAMBDA PI P1)/(KBAR N) (P3)/(P1) 9/66  
 R2 0.17 0.05 DAHL 67 HBC P1-P 1.6-4 GEV/C 8/67  
 R2 0.21 0.18 DAUBER 67 HBC K-P AT 2.6V/C 10/69  
 R2 0.19 0.04 SCHEUER 68 HBC 0 K-N 3 GEV/C 10/69  
 R2 0.22 0.03 BURKHARDT 69 HBC K-P 1.8-1.2 GEV/C 10/69  
 R2 10.23 KIM 71 DPWA K-MATRIX ANAL. 3/71

R2 AVG 0.202 0.021 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R2 FIT 0.223 0.014 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3 Y\*0(1520) INTO (SIGMA P1)/(LAMBDA PI P1) (P2)/(P3) 7/66  
 R3 4.5 1.0 ARMENTERO 65 HBC 0 K-P TO SIGMA PI 11/68  
 R3 3.3 1.1 BIRMINGHAM 66 HBC K-P 3.5 9/67  
 R3 3.9 1.0 UHLIG 67 HBC K-P .9-1.0 BEV/C 9/66

R3 AVG 3.94 0.59 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R3 FIT 4.10 0.27 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4 Y\*0(1520) INTO (LAMBDA GAMMA)/TOTAL (PERCENT) (P4) 11/68  
 R4 238 0.80 0.14 MAST 68 HBC 0 USING ELAST=45 11/68  
 R4 FIT 0.80 0.14 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5 Y\*0(1520) INTO (SIGMA GAMMA)/TOTAL (PERCENT) (P5) 10/69  
 R5 2.0 .35 MAST 68 HBC SEE NOTE 5  
 R5 RATIOS CALCULATED FROM R4, ASSUMING SU(3). NEEDED TO CONSTRAIN  
 R5 ALL THE Y\*0(1520) BRANCHING RATIOS TO BE UNITY.  
 R5 FIT 1.99 0.35 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6 Y\*0(1520) INTO (KBAR N)/TOTAL (P1) 10/71  
 R6 0.29 0.05 WATSON 63 HBC K-P ALL CHANNELS 10/71  
 R6 0.447 0.018 GALTIERI 69 HBC K-P .28-.45 GEV/C 10/69  
 R6 0.47 0.03 COLLEY 71 HBC K-N 1.5 GEV PROD 10/71  
 R6 10.45 KIM 71 DPWA K-MATRIX ANAL. 3/71

R6 AVG 0.439 0.033 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)  
 R6 FIT 0.4502 0.0089 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R7 Y\*0(1520) INTO (SIGMA P1)/TOTAL (P2) 10/71  
 R7 0.55 0.09 WATSON 63 HBC K-P ALL CHANNELS 10/71  
 R7 0.418 0.017 GALTIERI 69 HBC 0 K-P .28-.45 GEV/C 6/69  
 R7 0.43 0.03 COLLEY 71 HBC K-N 1.5 GEV PROD 10/71  
 R7 10.46 KIM 71 DPWA K-MATRIX ANAL. 3/71

R7 AVG 0.424 0.015 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R7 FIT 0.4115 0.0092 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8 Y\*0(1520) INTO (SIGMA PI P1)/TOTAL (P6) 10/69  
 R8 0.010 0.0015 GALTIERI 69 HBC 0 K-P .28-.45 GEV/C 10/69  
 R8 FIT 0.0100 0.0015 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9 Y\*0(1520) INTO (Y\*1(1385) P1)/(LAMBDA PI P1) (P7)/(P3) 9/69  
 R9 MORE THAN 0.10 CLINE 69 HBC K-O TO 2P1 LAM N 9/69  
 R9 0.39 0.10 BURKHARDT 71 HBC LAM. 3P1 PROD. 3/71  
 R9 11.01 CHAN 72 IPWA K-P TO LAM 2P1 2/73\*  
 R9 0.82 0.10 MAST 73 IPWA K-P TO 2P1 LAM 12/72\*  
 R9 B CENTRAL BIN(1514-1524) GIVES .74+-10 -- OTHER BINS LOWER BY 2-5%  
 R9 C ONLY THE Y\*1(1385)0503 SEEMS TO CONTRIBUTE  
 R9 M BOTH Y\*1(1385)0503 AND SIGMA (PI P1)0P03 CONTRIBUTE  
 R9 AVERAGE MEANINGLESS (SCALE FACTOR = 3.0)

R10 Y\*0(1520) INTO (Y\*1(1385) P1)/TOTAL (P7) 3/71  
 R10 0.041 0.005 CHAN 72 HBC K-P TO LAM 2P1 3/71

R11 Y\*0(1520) INTO (LAMBDA PI P1)/TOTAL (P3) 10/71  
 R11 0.10 0.02 MAST 71 HBC 0 K-N 1.5 GEV PROD 10/71  
 R11 0.11 0.01 COLLEY 71 IPWA 0 K-P TO LAM.PI.PI 1/73\*  
 R11 AVG 0.1080 0.0089 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R11 FIT 0.1004 0.0054 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

\*\*\*\*\*  
 REFERENCES FOR Y\*0(1520)  
 GALTIERI 63 PL 6 296 A BARBARO-GALTIERI, A HUSSAIN, RD TRIPP (LRL)  
 WATSON 63 PR 131 2248 M B WATSON, M FERRO-LUZZI, R D TRIPP (LRL) IJP  
 ALMEIDA 64 PL 9 204 S P ALMEIDA, G R LYNCH (CERN)  
 ARMENTERO 65 PL 19 338 ARMENTEROS, F-LUZZI, + (CERN, HEID, SACLAY)  
 MUSGRAVE 65 NC 35 735 \*PETMEZAS, + (BIRM, CERN, EPOL, LOIC, SACLAY)

BIRMINGHAM 66 PR 152 1148 BIRMINGHAM, GLASGOW, I.C., OXFORD, RUTHERFORD  
 DAHL 67 PR 163 1377 DAHL, HARDY, HESS, KIRZ, MILLER (LRL)  
 DAUBER 67 PL 248 525 \*MILAMUD, SCHLEIN, SLATER, STORK (UCLA)  
 UHLIG 67 PR 155 1448 \*CHARLTON, CONDON, GLASSER, YODH, + (UMD, NRL)  
 MAST 68 PRL 21 1715 MAST, ALSTON, BANGERTER, GALTIERI, + (LRL)  
 SCHEUER 68 NP 88 503 SABRE COLLAB. (SACL+AMST+BGNA+REHOF+EPOL)

BURKHARDT 69 NP 814 106 \*FILTHUTH+KLUGE+... (HEID+EFI+CERN+SACLAY)  
 CLINE 69 LNC 2 407 \*LAUMANN+HAPP (WISC)  
 GALTIERI 69 LUND 352 BARBARO-GALTIERI, BANGERTER, MAST, TRIPP (LRL)  
 ALSO TO DUKE 95 R D TRIPP (LRL)

BURKHARDT 71 NP 827 64 \*FILTHUTH, KLUGE, OBERLACK+... (HEID+CERN+SACLAY)  
 COLLEY 71 NP 831 61 \*COX, EASTWOOD, FRY+... (BIRM+EDIN+GLAS+LOIC)  
 KIM 71 PRL 27 355 J K KIM (HARV) IJP  
 ALSO TO DUKE 161 J. K. KIM (HARV) IJP

CHAN 72 PRL 28 256 \*BUT- SHAFER, HERTZBACH, KOFLER+... (MASA, YALE)  
 MAST 73 PR 07 5 \*ALSTON-CARNOST, BANGERTER, +... (LBL) IJP

PAPERS NOT REFERRED TO IN DATA CARDS  
 BERLEY 70 PR 01 1996 \*YAMIN, KOFLER, MANN, MEISNER+ (BNL, MASA, YALE) IJP

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 $\Lambda(1670)$ 

40 Y\*0(1670, JP=1/2-) 1=0

S<sub>01</sub>

SEE THE MINI-REVUE AT THE START OF THE Y\* LISTINGS.

THIS RESONANCE IS WELL ESTABLISHED.  
(SEE THE NOTE FOR THE Y\*0(1330)).

## 40 Y\*0(1670) MASS (MEV)

M M (1666.0)OR(1675.0) BERLEY 65 HBC 0 K-P TO LAM ETA 7/66  
 M M THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS  
 M SMALL, THE SECOND THAT IT IS LARGE. BECAUSE THE RESONANCE IS NEAR  
 M THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM  
 M DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-  
 M METERS OBTAINED BY FITTING TO THE DATA.  
 M N (1663.0) (3.0) ARMENT-1 68 HBC 0 ELASTIC, CH EXCH 11/68  
 M N (1678.0) (2.0) ARMENT-2 68 HBC 0 K-P TO SIGMA PI 11/68  
 M A 1674.0 (5.0) ARMENT-3 69 HBC 0 MULTICHANNEL 9/69  
 M N 1662.0 (3.0) ARMENT-4 69 HBC 0 ELAST, CH EXC-ED 9/69  
 M N 1680.0 (1.0) ARMENT-4 69 HBC 0 K-P TO SIG PI, ED 9/69  
 M 1674.0 BERLEY 69 HBC 0 K-P TO SIGMA PI 6/70  
 M 1683.0 (5.0) GALTIERI 70 HBC 0 SIG PI, EDPA 7/70  
 M 1670. KIM 71 DPWA K-MATRIX ANAL. 3/71  
 M 1640.0 (40.0) LANGBEIN 72 IPWA MULTICHANNEL 12/72\*  
 M A THE MULTICHANNEL ANALYSIS INCLUDES ELASTIC AND SIGMA PI .  
 M N THE APPARENT DISCREPANCY BETWEEN THESE RESULTS IS PROBABLY NOT  
 M SERIOUS. THE ERRORS GIVEN ARE JUST STATISTICAL. THE SYSTEMATIC  
 M ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION FORCED ON  
 M THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.

## 40 Y\*0(1670) WIDTH (MEV)

W M (22.0)OR(15.0) BERLEY 65 HBC 0 SEE NOTE M ABOVE 7/66  
 W N (26.0) (8.0) ARMENT-1 68 HBC 0 SEE NOTE N ABOVE 11/68  
 W N (26.0) (5.0) ARMENT-2 68 HBC 0 11/68  
 W A 23.0 (3.0) ARMENT-3 69 HBC 0 9/69  
 W N 38.0 (15.0) ARMENT-4 69 HBC 0 ELAST, CH EXC-ED 9/69  
 W N 33.0 (5.0) ARMENT-4 69 HBC 0 K-P TO SIG PI, ED 9/69  
 W 31.0 BERLEY 69 HBC 0 K-P TO SIGMA PI 6/70  
 W 25.0 (5.0) GALTIERI 70 HBC 0 SIG PI, EDPA 7/70  
 W 35. KIM 71 DPWA K-MATRIX ANAL. 3/71  
 W 45.0 (20.0) LANGBEIN 72 IPWA MULTICHANNEL 12/72\*  
 SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

## 40 Y\*0(1670) PARTIAL DECAY MODES

P1 Y\*0(1670) INTO KBAR N DECAY MASSES 497+ 939  
 P2 Y\*0(1670) INTO LAMBDA ETA 1115+ 548  
 P3 Y\*0(1670) INTO SIGMA PI 1189+ 139

## 40 Y\*0(1670) BRANCHING RATIOS

R1 Y\*0(1670) INTO (KBAR N)/TOTAL (P1) 11/68  
 R1 P (0.14) (0.04) ARMENT-1 68 HBC 0 OLD DATA 11/68  
 R1 0.17 ARMENT-3 69 HBC 0 9/69  
 R1 P 0.14 (0.04) ARMENT-4 69 HBC 0 NEW DATA 9/69  
 R1 A (0.39) (0.05) CONFORTO 71 HBC 0 K-P, ELAST, CEX 6/70  
 R1 0.28 KIM 71 DPWA K-MATRIX ANAL. 3/71  
 R1 0.35 (0.06) LANGBEIN 72 IPWA MULTICHANNEL 12/72\*  
 R1 A EFFECT BELOW REGION ANALYZED. VALUE OF .18 DOES NOT  
 R1 A AFFECT FIT OR VALUES OF OTHER PARAMETERS.  
 R1 P THIS IS THE DIAMETER OF THE CIRCLE IN THE ARGAND PLOT. IT IS  
 R1 SUPERIMPOSED ON A LARGE BACKGROUND.

R2 Y\*0(1670) FROM KBAR N TO LAMBDA ETA SORT(P1\*P2) 7/66  
 R2 M (0.20) OR 0.23 BERLEY 65 HBC 0 SEE NOTE M ABOVE 7/66  
 R2 (0.26) ARMENT-3 69 HBC 0 9/69  
 R2 (0.24) KIM 71 DPWA K-MATRIX ANAL. 3/71  
 SEE THE NOTES ACCOMPANYING MASSES QUOTED

R3 Y\*0(1670) FROM KBAR N TO SIGMA PI SORT(P1\*P3) 9/69  
 R3 (-0.25) (0.06) ARMENT-2 68 HBC 0 OLD DATA 9/69  
 R3 -0.27 ARMENT-3 69 HBC 0 9/69  
 R3 -0.30 (0.03) ARMENT-4 69 HBC 0 NEW DATA 9/69  
 R3 -0.27 BERLEY 69 HBC 0 K-P TO SIGMA PI 6/70  
 R3 -0.29 (0.03) GALTIERI 70 HBC 0 SIG PI, EDPA 7/70  
 R3 -0.38 KIM 71 DPWA K-MATRIX ANAL. 3/71

## REFERENCES FOR Y\*0(1670)

BERLEY 65 PRL 15 641 \*CONNOLLY, HART, RAUM, STONEHILL, + (BNL) IJP  
 ARMENT-1 68 NP 88 195 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 ARMENT-2 68 NP 88 223 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP

ARMENT-3 69 LUND PAPER 229 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 VALUES ARE QUOTED IN LEVI SETTI 69.  
 ARMENT-4 69 NP 814 91 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 BERLEY 69 PL 308 430 \*HART, RAUM, WILLIS, YAMAMOTO (LRL) IJP  
 GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL) IJP  
 CONFORTO 71 NP 834 41 \*LEVI SETTI, LASINSKI, OBERLACK+... (EFI+HEID) IJP  
 KIM, 71 PRL 27 356 J K KIM (HARV) IJP  
 ALSO TO DUKE 161 J. K. KIM (HARV) IJP  
 LANGBEIN 72 NP 847 477 \*WAGNER (MPI) IJP

## PAPERS NOT REFERRED TO IN DATA CARDS

BIRMINGHAM 66 PR 152 1148 (BIRMINGHAM, GLASGOW, LOIC, OXFORD, RUTHERFORD)  
 LEVI SETTI 69 LUND 339 R LEVI SETTI (RAPPORTEUR) (CHICAGO)

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## Baryons

 $\Lambda(1690)$ ,  $\Lambda(1750)$ 

## Data Card Listings

For notation, see key at front of Listings.

 **$\Lambda(1690)$** 

55 Y\*0(1690, JP=3/2-) 1=0

**D<sub>03</sub>**

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THIS RESONANCE IS WELL ESTABLISHED.

55 Y\*0(1690) MASS (MEV)

|                                                                      |          |        |          |         |                    |        |
|----------------------------------------------------------------------|----------|--------|----------|---------|--------------------|--------|
| M                                                                    | (1696.0) | (3.0)  | ARMENT-1 | 68 HBC  | O ELASTIC, CH EXCH | 11/68  |
| M                                                                    | (1681.0) | (2.0)  | ARMENT-3 | 68 HBC  | O K-P TO SIGMA PI  | 11/68  |
| M                                                                    | 1681.    | (8.1)  | BARTLEY  | 68 DBC  | O K-P AND K-D DATA | 11/68  |
| M                                                                    | 1695.0   | (4.0)  | BUGG     | 68 CNTR | O K-P, O TOTAL     | 7/68   |
| M                                                                    | (1697.0) | (2.0)  | CONFORTO | 68 HBC  | O ELASTIC, CH EXCH | 11/68  |
| M                                                                    | A        | (2.0)  | ARMENT-4 | 69 HBC  | O ELAS, CH EXC. ED | 9/69   |
| M                                                                    | A        | (2.0)  | ARMENT-4 | 69 HBC  | O K-P TO SIG PI ED | 9/69   |
| M                                                                    | 1688.0   | (2.0)  | BERLEY   | 69 HBC  | O K-P TO SIGMA PI  | 6/70   |
| M                                                                    | 1701.0   | (4.0)  | BERTANZA | 69 HBC  | O ELASTIC, CH EXCH | 9/69   |
| M                                                                    | 1680.0   | (5.0)  | GALTIERI | 70 HBC  | O SIG PI, ED PWA   | 7/70   |
| M                                                                    | 1688.0   | (3.0)  | CONFORTO | 71 HBC  | O K-P, ELAST, CEX  | 6/70   |
| M                                                                    | 1690.    | (20.0) | KIM      | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M                                                                    | 1680.0   | (20.0) | LANGBEIN | 72 IPWA | MULTICHANNEL       | 12/72* |
| THE Y*0(1690) IS AT THE EDGE OF THE ENERGY REGION ANALYZED BY        |          |        |          |         |                    |        |
| CONFORTO. THE SAME DATA AS WELL AS OTHERS EXTENDING TO LOWER         |          |        |          |         |                    |        |
| ENERGIES ARE INCLUDED IN ARMENTEROS 1.                               |          |        |          |         |                    |        |
| ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB. +3-8 GEV/C         |          |        |          |         |                    |        |
| THE APPARENT DISCREPANCY BETWEEN THE SIGMA PI AND OTHER RESULTS IS   |          |        |          |         |                    |        |
| A PROBABLY NOT SERIOUS. THE ERRORS GIVEN ARE JUST STATISTICAL. THE   |          |        |          |         |                    |        |
| A SYSTEMATIC ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION |          |        |          |         |                    |        |
| A OF THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE. |          |        |          |         |                    |        |

55 Y\*0(1690) WIDTH (MEV)

|   |         |         |          |         |                    |        |
|---|---------|---------|----------|---------|--------------------|--------|
| W | (135.0) | (7.0)   | ARMENT-1 | 68 HBC  | O OLD DATA         | 11/68  |
| W | (85.0)  | (7.0)   | ARMENT-3 | 68 HBC  | O OLD DATA         | 11/68  |
| W | 48.     | (15.1)  | BARTLEY  | 68 DBC  | O K-P AND K-D DATA | 11/68  |
| W | 40.0    | (7.0)   | BUGG     | 68 CNTR | O                  | 7/68   |
| W | M       | (127.0) | CONFORTO | 68 HBC  | O SEE NOTE H ABOVE | 11/68  |
| W | A       | (17.0)  | ARMENT-4 | 69 HBC  | O ELAS, CH EXC. ED | 9/69   |
| W | A       | (6.0)   | ARMENT-4 | 69 HBC  | O K-P TO SIG PI ED | 9/69   |
| W | 57.0    | (8.0)   | BERLEY   | 69 HBC  | O K-P TO SIGMA PI  | 6/70   |
| W | 28.0    | (10.0)  | BERTANZA | 69 HBC  | O SIG PI, ED PWA   | 7/70   |
| W | 85.0    | (10.0)  | GALTIERI | 70 HBC  | O K-P, ELAST, CEX  | 6/70   |
| W | 64.0    | (5.0)   | CONFORTO | 71 HBC  | O K-P, ELAST, CEX  | 6/70   |
| W | 55.     | (10.0)  | KIM      | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| W | 40.0    | (10.0)  | LANGBEIN | 72 IPWA | MULTICHANNEL       | 12/72* |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

55 Y\*0(1690) PARTIAL DECAY MODES

| P1 | Y*0(1690) INTO KBAR N       | DECAY MASSES   |
|----|-----------------------------|----------------|
| P2 | Y*0(1690) INTO SIGMA PI     | 497+ 939       |
| P3 | Y*0(1690) INTO LAMBDA PI    | 1189+ 139      |
| P4 | Y*0(1690) INTO SIGMA PI     | 1115+ 139+ 139 |
| P5 | Y*0(1690) INTO Y*1(1385) PI | 1189+ 139+ 139 |
|    |                             | 1384+ 139      |

55 Y\*0(1690) BRANCHING RATIOS

THE SUM OF ALL THE QUOTED BRANCHING RATIOS IS MORE THAN 1.0. THE TWO-BODY RATIOS ARE FROM PARTIAL WAVE ANALYSES, AND THUS PROBABLY ARE MORE RELIABLE THAN THE THREE-BODY RATIOS, WHICH ARE DETERMINED FROM BUMPS IN CROSS SECTIONS. OF THE LATTER, THE SIGMA PI PI BUMP LOOKS MORE SIGNIFICANT (THE ERROR GIVEN FOR THE LAMBDA PI PI RATIO LOOKS UNREASONABLY SMALL). HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA Y\*1(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE REQUIRED.

|    |                                    |                                                                     |          |         |                      |        |
|----|------------------------------------|---------------------------------------------------------------------|----------|---------|----------------------|--------|
| R1 | Y*0(1690) INTO (KBAR N)/TOTAL      |                                                                     |          |         | (P1)                 |        |
| R1 | (0.18)                             | (0.03)                                                              | ARMENT-1 | 68 HBC  | O                    | 11/68  |
| R1 | (0.23)                             | (0.03)                                                              | BUGG     | 68 CNTR | O ASSUMING J=3/2     | 7/68   |
| R1 | M                                  | (0.22)                                                              | CONFORTO | 68 HBC  | O SEE NOTE H ABOVE   | 11/68  |
| R1 | 0.18                               | (0.02)                                                              | ARMENT-4 | 69 HBC  | O NEW DATA           | 9/69   |
| R1 | 0.28                               | (0.04)                                                              | BERTANZA | 69 HBC  | O                    | 9/69   |
| R1 | N                                  | (0.34)                                                              | CONFORTO | 71 HBC  | O K-P, ELAST, CEX    | 6/70   |
| R1 | 0.22                               | (0.05)                                                              | KIM      | 71 DPWA | K-MATRIX ANAL.       | 3/71   |
| R1 | 0.15                               | (0.05)                                                              | LANGBEIN | 72 IPWA | MULTICHANNEL         | 12/72* |
| R1 | N                                  | EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1. |          |         |                      | 3/72   |
|    |                                    | FROM ALL ABOVE WE ESTIMATE X=0.20                                   |          |         |                      |        |
| R2 | Y*0(1690) FROM KBAR N TO SIGMA PI  |                                                                     |          |         | SQRT(P1*P2)          |        |
| R2 | (+0.33)                            | (0.02)                                                              | ARMENT-3 | 68 HBC  | O OLD DATA           | 11/68  |
| R2 | -0.36                              | (0.02)                                                              | ARMENT-4 | 69 HBC  | O NEW DATA           | 9/69   |
| R2 | -0.27                              | (0.02)                                                              | BERLEY   | 69 HBC  | O K-P TO SIGMA PI    | 6/70   |
| R2 | -0.31                              | (0.03)                                                              | GALTIERI | 70 HBC  | O SIG PI, ED PWA     | 7/70   |
| R2 | -0.40                              | (0.07)                                                              | KIM      | 71 DPWA | K-MATRIX ANAL.       | 3/71   |
| R2 | 0.26                               | (0.07)                                                              | LANGBEIN | 72 IPWA | MULTICHANNEL         | 12/72* |
| R3 | Y*0(1690) FROM KBAR N TO LAMBDA PI | PI                                                                  | PI       |         | SQRT(P1*P3)          |        |
| R3 | (0.25)                             | (0.02)                                                              | BARTLEY  | 68 HBC  | O LAM. 2PI CROSS SEC | 11/68  |
| R3 | B                                  | ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71.   |          |         |                      | 3/72   |
| R4 | Y*0(1690) FROM KBAR N TO SIGMA PI  | PI                                                                  | PI       |         | SQRT(P1*P4)          |        |
| R4 | (0.21)                             | (0.03)                                                              | ARMENT-2 | 68 HBC  | O K-N TO SIG PI      | 11/68  |

REFERENCES FOR Y\*0(1690)

DAVIES 67 PRL 18 62 +DOWELL, + (BIRM, CAVE, RHEL) I  
 REPLACED BY BUGG 68.  
 ARMMENT-1 68 NP 88 195  
 ARMMENT-2 68 NP 88 216  
 ARMMENT-3 68 NP 88 223  
 BARTLEY 68 PRL 21 1111 +CHU, DOWD, GREENE, +  
 BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (BIRM, CAVE, RHEL) I  
 CONFORTO 68 NP 88 265 +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL) IJP

ARMMENT-4 69 NP 814 91  
 BERLEY 69 PL 308 430  
 BERTANZA 69 PR 177 2036  
 GALTIERI 70 DUKE 173  
 CONFORTO 71 NP 834 41  
 KIM 71 PRL 27 356  
 ALSO 70 DUKE 161  
 LANGBEIN 72 NP 847 477

ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 + HART, RAHM, WILLIS, YAMAMOTO (BNL) IJP  
 +BIGI, CARRARA, CASALI, + (PISA, BNL, YALE) IJP

A. BARBARO GALTIERI (LRL) IJP  
 +LEVI SETTI, LASINSKI, OBERLACK, + (EP) HEIDEL IJP  
 J. K. KIM (HARV) IJP  
 J. K. KIM (HARV) IJP  
 +WAGNER (MPIM) IJP

PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

 **$\Lambda(1750)$** 

77 Y\*0(1750, JP=1/2+) 1=0

**P<sub>01</sub>**

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THE EVIDENCE FOR THIS STATE IS SOMEWHAT CONFUSED. IT WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF KBAR N DATA BY THE BEHAVIOR OF THE PO1 AMPLITUDE WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE BACKGROUND. WHEN IT WAS REPARAMETRIZED AS A RESONANCE SUPERIMPOSED ON A ONE-STRAIGHT-LINE BACKGROUND, A BROAD RESONANCE RESULTED (ARMENTEROS 68). A REANALYSIS OF ESSENTIALLY THE SAME DATA, BUT THIS TIME WITH THE PO1 AMPLITUDE UNCONSTRAINED, SUGGESTED A MUCH NARROWER RESONANCE AT HIGHER ENERGY (ARMENTEROS 70).

A WIDER AND MORE ELASTIC PO1 RESONANCE AT ABOUT THE SAME MASS IS SUGGESTED BY THE ANALYSIS OF BAILEY 69. THIS USES CONSIDERABLY LESS DATA THAN THE ARMENTEROS ANALYSES. FOR THIS REASON WE DO NOT QUOTE ANY PARAMETERS FOR THE OTHER PARTIAL WAVES OBTAINED IN THIS ANALYSIS.

ARMENTEROS 70, GALTIERI 70, AND KIM 71 PRESENT EVIDENCE FOR A PO1 STATE IN THE SIGMA PI CHANNEL. IN ADDITION THE ANALYSES OF KIM 71 AND LANGBEIN 72 INDICATE A SECOND POSSIBLE PO1 STATE. WE TENTATIVELY LIST THESE EFFECTS TOGETHER.

77 Y\*0(1750) MASS (MEV)

|                                                                      |   |                 |           |         |                    |        |
|----------------------------------------------------------------------|---|-----------------|-----------|---------|--------------------|--------|
| M                                                                    | O | (1745.0)        | ARMENTERO | 68 HBC  | O ELASTIC, CH EXCH | 11/68  |
| M                                                                    |   | (1740.0)        | BAILEY    | 69 DPWA | O ELASTIC, CH EXCH | 10/70  |
| M                                                                    |   | (1800.0)        | ARMENTERO | 70 HBC  | O ELASTIC, CH EX   | 6/70   |
| M                                                                    |   | (1750.0)        | ARMENTERO | 70 HBC  | O SIGMA PI         | 6/70   |
| M                                                                    | N | (1690.0) (10.0) | GALTIERI  | 70 HBC  | O SIG PI, ED PWA   | 7/70   |
| N ERROR STATIST. ONLY-NO ERROR DUE TO PARTICULAR P.W. ANAL. INCLUDED |   |                 |           |         |                    |        |
| M                                                                    |   | (1755.)         | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M                                                                    | 1 | (1570.)         | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M                                                                    | A | 1620.0 (10.0)   | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| M                                                                    | B | 1780.0 (20.0)   | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| A AND B CORRESPOND TO 2 DIFFERENT RESONANCES IN PO1                  |   |                 |           |         |                    |        |
| A POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.                   |   |                 |           |         |                    |        |
| O OLD ANALYSIS, USING OLD DATA.                                      |   |                 |           |         |                    |        |

77 Y\*0(1750) WIDTH (MEV)

|   |         |              |          |                |                  |        |
|---|---------|--------------|----------|----------------|------------------|--------|
| W | (147.0) | ARMENTERO    | 68 HBC   | O              |                  |        |
| W | (300.0) | BAILEY       | 69 DPWA  | O              | ELASTIC, CH EXCH | 10/70  |
| W | (30.0)  | ARMENTERO    | 70 HBC   | O              | ELASTIC, CH EX   | 6/70   |
| W | (70.0)  | ARMENTERO    | 70 HBC   | O              | SIGMA PI         | 6/70   |
| W | N       | (22.0)       | GALTIERI | 70 HBC         | O SIG PI, ED PWA | 7/70   |
| W | (35.1)  | KIM          | 71 DPWA  | K-MATRIX ANAL. |                  | 3/71   |
| W | 1       | (50.1)       | KIM      | 71 DPWA        | K-MATRIX ANAL.   | 3/71   |
| W | A       | 60.0 (10.0)  | LANGBEIN | 72 IPWA        | MULTICHANNEL     | 12/72* |
| W | B       | 120.0 (10.0) | LANGBEIN | 72 IPWA        | MULTICHANNEL     | 12/72* |

SEE NOTES ACCOMPANYING MASSES SUBMITTED

SEE THE NOTES ACCOMPANYING MASSES QUOTED

77 Y\*0(1750) PARTIAL DECAY MODES

|    |                         | DECAY MASSES |
|----|-------------------------|--------------|
| P1 | Y*0(1750) INTO KBAR N   | 497+ 939     |
| P2 | Y*0(1750) INTO SIGMA PI | 1197+ 139    |

77 Y\*0(1750) BRANCHING RATIOS

|      |                                     |         |           |         |                    |        |
|------|-------------------------------------|---------|-----------|---------|--------------------|--------|
| R1   | Y*0(1750) INTO (KBAR N)/TOTAL       |         |           |         | (P1)               |        |
| R1   | (0.4)                               |         | ARMENTERO | 68 DPWA | O ELASTIC, CH EXCH | 11/68  |
| R1   | (0.55)                              |         | BAILEY    | 69 DPWA | O ELASTIC, CH EXCH | 10/70  |
| R1   | (0.15)                              |         | ARMENTERO | 70 DPWA | O ELASTIC, CH EXCH | 10/70  |
| R1   | (0.30)                              |         | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| R1 A | 0.25                                | (0.15)  | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| R1 B | 0.36                                | (0.05)  | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| R2   | Y*0(1750) FROM KBAR N INTO SIGMA PI |         |           |         | SORT(P1*P2)        |        |
| R2   | (+0.20)                             |         | ARMENTERO | 70 DPWA | O K-P TO SIGMA PI  | 6/70   |
| R2 N | (-0.13)                             | (0.03)  | GALTIERI  | 70 DPWA | O K-P TO SIGMA PI  | 7/70   |
| R2   | (10.17)                             |         | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| R2 A | 0.28                                | (0.09)  | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| R2 B | 0.01                                | OR LESS | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

REFERENCES FOR Y\*0(1750)

ARMENTERO 68 NP 88 195  
 BAILEY 69 THESS USCL-50617  
 ARMENTERO 70 DUKE CONF 123  
 GALTIERI 70 DUKE CONF 173  
 KIM 71 PRL 27 356  
 ALSO 70 DUKE 161  
 LANGBEIN 72 NP 847 477

ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 DAVID SAAL BAILEY (LRL, LIVERMORE) IJP  
 ARMENTEROS, BAILLON, + (CERN, HEIDEL) IJP  
 A. BARBARO-GALTIERI (LRL) IJP  
 J. K. KIM (HARV) IJP  
 J. K. KIM (HARV) IJP  
 +WAGNER (MPIM) IJP

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Lambda(1815)$ ,  $\Lambda(1830)$  $\Lambda(1815)$ 

39 Y\*0(1815, JP=5/2+ 1=0

F05

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THIS STATE IS WELL ESTABLISHED. MOST OF THE QUOTED ERRORS ARE STATISTICAL ONLY. THE SYSTEMATIC ERRORS DUE TO THE PARTICULAR PARAMETRIZATION USED IN THE P.W.A. ARE NOT INCLUDED. FOR THIS REASON WE DO NOT CALCULATE WEIGHTED AVERAGES FOR MASS AND WIDTH.

39 Y\*0(1815) MASS (MEV)

|   |   |                |                                  |           |          |                     |        |
|---|---|----------------|----------------------------------|-----------|----------|---------------------|--------|
| M | N | 1813.0         | (2.0)                            | ARMENT-1  | 67 HBC   | 0 K-P TO SIGMA PI   | 8/67   |
| M | N | 1816.0         | (4.0)                            | BELL      | 67 HBC   | 0 K-P TO SIGMA PI   | 11/67  |
| M | N | 1817.0         | (2.0)                            | ARMENT-3  | 68 HBC   | 0 ELASTIC, CH EXCH  | 11/68  |
| M | N | 1819.0         | (4.0)                            | BUGG      | 68 CNTR  | 0 K-P, D TOTAL      | 6/68   |
| M | N | 1825.0         | (11.0)                           | BRICMAN   | 70 CNTR  | 0 TOTAL AND CH EX   | 6/70   |
| M | N | 1819.0         | (11.0)                           | BRICMAN   | 70 DPWA  | SIGTOT, ELAS, CH EX | 1/71   |
| M | N | 1830.0         | (10.0)                           | COOL      | 70 CNTR  | K-P, D TOTAL        | 10/70  |
| M | N | 1820.0         | (10.0)                           | GALTIERI  | 70 DPWA  | 0 K-P TO SIGMA PI   | 7/70   |
| M | N | 1818.0         | (2.0)                            | CONFORTO  | 71 DPWA  | 0 ELASTIC, CH EXCH  | 6/70   |
| M | N | 1810.0         | (15.0)                           | KIM       | 71 DPWA  | K-MATRIX ANAL.      | 3/71   |
| M | N | 1823.0         | (3.0)                            | KANE      | 72 DPWA  | 0 K-P TO PI SIG     | 10/71  |
| M | N | 1818.0         | (3.0)                            | LANGBEIN  | 72 IPWA  | MULTICHANNEL        | 12/72* |
| M | N | ERROR STATIST. | ONLY- NO ERROR DUE TO PARTICULAR | P.W.ANAL. | INCLUDED |                     | 1/71   |

39 Y\*0(1815) WIDTH (MEV)

|   |   |       |        |          |         |                     |        |
|---|---|-------|--------|----------|---------|---------------------|--------|
| W | N | 87.0  | (15.0) | ARMENT-1 | 67 HBC  | 0                   | 8/67   |
| W | N | 64.0  | (12.0) | BELL     | 67 HBC  | 0                   | 11/67  |
| W | N | 71.0  | (4.0)  | ARMENT-3 | 68 HBC  | 0 ELASTIC, CH EXCH  | 11/68  |
| W | N | 75.0  | (7.0)  | BUGG     | 68 CNTR | 0 K-P, D TOTAL      | 6/68   |
| W | N | 80.0  | (6.0)  | BRICMAN  | 70 CNTR | 0 TOTAL AND CH EX   | 6/70   |
| W | N | 79.0  | (3.0)  | BRICMAN  | 70 DPWA | SIGTOT, ELAS, CH EX | 1/71   |
| W | N | 100.0 | (10.0) | COOL     | 70 CNTR | K-P, D TOTAL        | 10/70  |
| W | N | 100.0 | (20.0) | GALTIERI | 70 DPWA | 0 K-P TO SIGMA PI   | 7/70   |
| W | N | 90.0  | (4.0)  | CONFORTO | 71 DPWA | 0 ELASTIC, CH EXCH  | 6/70   |
| W | N | 70.0  | (16.0) | KIM      | 71 DPWA | K-MATRIX ANAL.      | 3/71   |
| W | N | 104.0 | (16.0) | KANE     | 72 DPWA | 0 K-P TO PI SIG     | 10/71  |
| W | N | 70.0  | (15.0) | LANGBEIN | 72 IPWA | MULTICHANNEL        | 12/72* |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

39 Y\*0(1815) PARTIAL DECAY MODES

|    |                             |                |
|----|-----------------------------|----------------|
| P1 | Y*0(1815) INTO K8AR N       | 497+ 939       |
| P2 | Y*0(1815) INTO SIGMA PI     | 1189+ 139      |
| P3 | Y*0(1815) INTO Y*(1385) PI  | 1384+ 139      |
| P4 | Y*0(1815) INTO SIGMA PI P1  | 1192+ 139+ 139 |
| P5 | Y*0(1815) INTO LAMBDA PI P1 | 1115+ 129+ 139 |

## FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: The diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i^2 + \delta P_i^2)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (\delta P_i \delta P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

|               |               |               |               |
|---------------|---------------|---------------|---------------|
| P1            | P2            | P3            | P4            |
| 0.6050+-.0243 |               |               |               |
| -0.5445       | 0.1138+-.0084 |               |               |
| 0.            | 0.            | 0.2000+-.0500 |               |
| -0.3638       | 0.0892        | -0.9224       | 0.0812+-.0542 |

39 Y\*0(1815) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

|    |                                        |             |                                               |
|----|----------------------------------------|-------------|-----------------------------------------------|
| R1 | Y*0(1815) INTO (K8AR N)/TOTAL          | (P1)        |                                               |
| R1 | 0.62                                   | 0.02        | ARMENT-3 68 HBC 0 ELASTIC, CH EXCH 11/68      |
| R1 | (0.72)                                 |             | BUGG 68 CNTR 0 K-P, D TOTAL 6/68              |
| R1 | 0.65                                   | 0.02        | BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70        |
| R1 | 0.58                                   | 0.02        | BRICMAN 70 DPWA SIGTOT, ELAS, CH EX 1/71      |
| R1 | (0.61)                                 |             | COOL 70 CNTR K-P, D TOTAL 10/70               |
| R1 | 0.63                                   | 0.01        | CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70      |
| R1 | (0.52)                                 |             | KIM 71 DPWA K-MATRIX ANAL. 3/71               |
| R1 | 0.47                                   | 0.02        | LANGBEIN 72 IPWA MULTICHANNEL 12/72*          |
| R1 | AVG                                    | 0.605       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.8)  |
| R1 | FIT                                    | 0.605       | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.4) |
| R2 | Y*0(1815) FROM K8AR N INTO SIGMA PI    | SORT(P1*P2) |                                               |
| R2 | 0.27                                   | 0.01        | ARMENT-1 67 DPWA 0 K-P TO SIGMA PI 8/67       |
| R2 | 0.23                                   | 0.05        | BELL 67 DPWA 0 K-P TO SIGMA PI 11/67          |
| R2 | -0.26                                  | 0.03        | GALTIERI 70 DPWA 0 K-P TO SIGMA PI 7/70       |
| R2 | (0.26)                                 |             | KIM 71 DPWA K-MATRIX ANAL. 3/71               |
| R2 | -0.268                                 | 0.027       | KANE 72 DPWA 0 K-P TO PI SIG 10/71            |
| R2 | 0.25                                   | 0.03        | LANGBEIN 72 IPWA MULTICHANNEL 12/72*          |
| R2 | AVG MOD                                | 0.2634      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |
| R2 | FIT                                    | 0.2624      | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |
| R3 | Y*0(1815) FROM K8AR N INTO Y*(1385) PI | SORT(P1*P3) |                                               |
| R3 | 0.31                                   | (0.05)      | ARMENT-2 67 HBC 0 K-P TO LAM P+ P+ 4/67       |
| R3 | 0.348                                  | 0.044       | FROM FIT                                      |
| R4 | Y*0(1815) INTO (Y*(1385) PI)/TOTAL     | (P3)        |                                               |
| R4 | 0.20                                   | 0.05        | BIRGE 65 HBC 0 K-P TO LAM PI P1 7/66          |
| R4 | FIT                                    | 0.200       | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |

R5 Y\*0(1815) INTO (SIGMA PI P1)/TOTAL (P4)  
 R5 P NO CLEAR SIGNAL ARMENT-4 68 HBC 0 K-N TO SIG PI P1 11/68  
 R5 P THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH  
 R5 P WHAT IS EXPECTED FROM SIGMA PI DECAY OF THE Y\*(1385) -- ABOUT 0.02.  
 R5 FIT 0.081 0.054 FROM FIT

REFERENCES FOR Y\*0(1815)

|          |    |                   |     |                                                    |
|----------|----|-------------------|-----|----------------------------------------------------|
| BIRGE    | 65 | ATHENS CONF       | 296 | +ELY, KALMUS, KERNAN, LOUIE, SAHOURIA, + (LRL) IJP |
| ARMENT-1 | 67 | PL 248 198        |     | ARMENTEROS, F LUZZI, + (CERN, HEIDEL, SACLAY) IJP  |
| ARMENT-2 | 67 | ZEIT PHYS 202 486 |     | ARMENTEROS, F LUZZI, + (CERN, HEIDEL, SACLAY) IJP  |
| BELL     | 67 | PL 19 936         |     | R B BELL (LRL) IJP                                 |
| ARMENT-3 | 68 | NP 88 195         |     | ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  |
| ARMENT-4 | 68 | NP 88 216         |     | ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) I    |
| BUGG     | 68 | PR 168 1466       |     | +GILMORE, KNIGHT, + (RHEL+IRM+CAVE) I (LRL) IJP    |
| BRICMAN  | 70 | PL 318 152        |     | +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY)      |
| BRICMAN1 | 70 | PL 338 511        |     | +FERRO-LUZZI, LAGNAUX (CERN)                       |
| COOL     | 70 | PR 01 1887        |     | +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I         |
| GALTIERI | 70 | DUKE CONF 173     |     | A BARBARO-GALTIERI (LRL) IJP                       |
| CONFORTO | 71 | NP 834 41         |     | +LEVI SETTI, LASINSKI, OBERLACK+ (EFI+HEID) IJP    |
| KIM      | 71 | PL 27 356         |     | J K KIM (HARV) IJP                                 |
| ALSO     | 70 | DUKE 161          |     | J. K. KIM (HARV) IJP                               |
| KANE     | 72 | PR 05 1583        |     | D F KANE (LBL) IJP                                 |
| LANGBEIN | 72 | NP 847 477        |     | +WAGNER (MPIN) IJP                                 |

PAPERS NOT REFERRED TO IN DATA CARDS

THE FOLLOWING PAPERS ARE NOW OF ONLY HISTORICAL INTEREST --

|            |    |                   |  |                                                   |
|------------|----|-------------------|--|---------------------------------------------------|
| CHAMBERL   | 62 | PR 125 1696       |  | CHAMBERLAIN, CROWE, KEEFE, KERTH, + (LRL) I       |
| GALTIERI   | 63 | PL 6 296          |  | A BARBARO-GALTIERI, A HUSSAIN, RD TRIPP (LRL) IJP |
| SODICKSON  | 64 | PR 133 8757       |  | SODICKSON, MANNELLI, FRISCH, WAHLIG (MIT(BNL)) J  |
| HOLLEY     | 65 | UCRL-16274 THESIS |  | W R HOLLEY (LRL) J                                |
| BIRMINGHAM | 66 | PR 152 1148       |  | BIRMINGHAM, GLASGOW, I.C., OXFORD, RUTHERFORD     |
| COOL       | 66 | PL 16 1228        |  | +GIACOMELLI, KYCIA, LEONTIC, LUNDBY + (BNL) I     |
| GELFAND    | 66 | PL 17 1224        |  | +HARMSEN, LEVI-SETTI, PREDAZZI+ (EFI+ANL)         |
| ARMENTER   | 67 | NP 83 592         |  | ARMENTEROS, FERRO-LUZZI+ (CERN, HEID, SACLAY) IJP |
| CONFORTO   | 68 | NP 88 265         |  | +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL) IJP       |
| LASINSKI   | 68 | PR 163 1792       |  | LASINSKI, LEVI SETTI, PREDAZZI (CHICAGO) JP       |
| PREVOST    | 71 | AMSTERDAM CONF.   |  | + CHS COLLABORATION (CERN+HEID+SACL)              |

 $\Lambda(1830)$ 

56 Y\*0(1830, JP=5/2- 1=0

D05

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE SIGMA PI CHANNEL. IT APPEARS TO BE WELL ESTABLISHED.

56 Y\*0(1830) MASS (MEV)

|   |   |                                                               |        |           |         |                    |        |
|---|---|---------------------------------------------------------------|--------|-----------|---------|--------------------|--------|
| M | N | 1827.0                                                        | (3.0)  | ARMENTERO | 67 HBC  | 0 K-P TO SIGMA PI  | 8/67   |
| M | N | 1837.0                                                        | (11.0) | BELL      | 67 HBC  | 0 K-P TO SIGMA PI  | 11/67  |
| M | N | 1807.0                                                        | (10.0) | ARMENTERO | 68 HBC  | 0 ELASTIC, CH EXCH | 11/68  |
| M | N | 1840.0                                                        | (15.0) | GALTIERI  | 70 DPWA | 0 K-P TO SIGMA PI  | 7/70   |
| M | N | 1831.0                                                        | (5.0)  | CONFORTO  | 71 DPWA | 0 ELASTIC, CH EXCH | 6/70   |
| M | K | (1720.)                                                       |        | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M | K | (1820.)                                                       |        | KANE      | 72 DPWA | 0 K-P TO PI SIG    | 10/71  |
| M | K | 1810.0                                                        | (10.0) | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| M | K | POSSIBLE EFFECT MAINLY IN SIGMA PI. NOT CLEAR IF UNCORRELATED |        |           |         |                    |        |
| M | K | WITH THE 1830 EFFECT                                          |        |           |         |                    |        |
| M | N | ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL.     |        |           |         | INCLUDED           | 1/71   |

56 Y\*0(1830) WIDTH (MEV)

|   |   |        |        |           |         |                    |        |
|---|---|--------|--------|-----------|---------|--------------------|--------|
| W | N | 75.0   | (9.0)  | ARMENTERO | 67 HBC  | 0 K-P TO SIGMA PI  | 8/67   |
| W | N | 74.0   | (12.0) | BELL      | 67 HBC  | 0 K-P TO SIGMA PI  | 8/67   |
| W | N | 123.0  | (32.0) | ARMENTERO | 68 HBC  | 0 ELASTIC, CH EXCH | 11/68  |
| W | N | 150.0  | (30.0) | GALTIERI  | 70 DPWA | 0 K-P TO SIGMA PI  | 7/70   |
| W | N | 104.0  | (35.0) | CONFORTO  | 71 DPWA | 0 ELASTIC, CH EXCH | 6/70   |
| W | N | 80.0   |        | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| W | K | (20.1) |        | KANE      | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| W | N | 88.0   | (10.0) | KANE      | 72 DPWA | 0 K-P TO PI SIG    | 10/71  |
| W | N | 60.0   | (20.0) | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

56 Y\*0(1830) PARTIAL DECAY MODES

|    |                            |           |
|----|----------------------------|-----------|
| P1 | Y*0(1830) INTO K8AR N      | 497+ 939  |
| P2 | Y*0(1830) INTO SIGMA PI    | 1189+ 139 |
| P3 | Y*0(1830) INTO Y*(1385) PI | 1384+ 139 |

56 Y\*0(1830) BRANCHING RATIOS

|    |                                     |             |                                            |
|----|-------------------------------------|-------------|--------------------------------------------|
| R1 | Y*0(1830) INTO (K8AR N)/TOTAL       | (P1)        |                                            |
| R1 | 0.05                                | (0.01)      | ARMENTERO 68 HBC 0 ELASTIC, CH EXCH 11/68  |
| R1 | 0.03                                | (0.02)      | BRICMAN 70 DPWA 0 SIGTOT, ELAS, CH EX 1/71 |
| R1 | 0.05                                | (0.02)      | CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70   |
| R1 | (0.24)                              |             | KIM 71 DPWA K-MATRIX ANAL. 3/71            |
| R1 | 0.10                                | (0.03)      | LANGBEIN 72 IPWA MULTICHANNEL 12/72*       |
| R2 | Y*0(1830) FROM K8AR N INTO SIGMA PI | SORT(P1*P2) |                                            |
| R2 | 0.15                                | (0.02)      | ARMENTERO 67 DPWA 0 K-P TO SIGMA PI 8/67   |
| R2 | 0.19                                | (0.01)      | BELL 67 DPWA 0 K-P TO SIGMA PI 11/67       |
| R2 | -0.16                               | (0.03)      | GALTIERI 70 DPWA 0 K-P TO SIGMA PI 7/70    |
| R2 | 0.15                                |             | KIM 71 DPWA K-MATRIX ANAL. 3/71            |
| R2 | -0.138                              | (0.018)     | KANE 72 DPWA 0 K-P TO PI SIG 10/71         |
| R2 | 0.27                                | (0.07)      | LANGBEIN 72 IPWA MULTICHANNEL 12/72*       |

## Baryons

 $\Lambda(1830)$ ,  $\Lambda(1860)$ ,  $\Lambda(1870)$ ,  $\Lambda(2010)$ REFERENCES FOR  $\Lambda(1830)$ 

ARMENTER 67 PL 248 198  
 BELL 67 PRL 19 936  
 ARMENTER 68 NP 88 195  
 CONFORTO 68 NP 88 265  
 IS SUPERSEDED BY CONFORTO 71.  
 BRICMAN 70 PL 330 511  
 GALTIERI 70 DUKE CONF 173  
 CONFORTO 71 NP 834 41  
 KIM 71 PRL 27 936  
 ALSO 70 DUKE 161  
 KANE 72 PR D5 1583  
 LANGBEIN 72 NP 847 477

ARMENTEROS, F.-LUZZI, + (CERN, HEIDEL, SACLAY) IJP  
 R. B. BELL (LRL) IJP  
 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL) IJP  
 +FERRO-LUZZI, LAGNAUX (CERN)  
 A BARBARO-GALTIERI (LRL) IJP  
 +LEVI SETTI, LASINSKI, OBERLACK++ (EFI+HEID) IJP  
 J. K. KIM (HARV) IJP  
 J. K. KIM (HARV) IJP  
 D. F. KANE (LBL) IJP  
 +WAGNER (MPIN) IJP

## PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

 $\Lambda(1860)$ 60  $\Lambda(1860)$ , JP=3/2+ I=0P<sub>03</sub>

THE JP=3/2+ ASSIGNMENT IS CONSISTENT WITH ALL AVAILABLE DATA (INCLUDING POLARIZATION) AND RECENT PARTIAL WAVE ANALYSES. THE DOMINANT INELASTIC MODES REMAIN UNKNOWN.

60  $\Lambda(1860)$  MASS (MEV)

| W | A | F07                                                              | 1864.0 | 2.0              | ARMENTERO 68 DPWA    | O ELASTIC, CH EXCH | 11/68 |
|---|---|------------------------------------------------------------------|--------|------------------|----------------------|--------------------|-------|
| M | N | 1870.0                                                           | 5.0    | BUGG 68 CNTR     | O K-P TOTAL          | 7/68               |       |
| M | A | F07 1877.0                                                       | 6.0    | BRICMAN 70 CNTR  | O TOTAL AND CH EX    | 6/70               |       |
| M | N | P03 1870.0                                                       | 6.0    | BRICMAN 70 DPWA  | O SIGTOT, ELAS, CHEX | 1/71               |       |
| M | N | P03 1885.0                                                       | 10.0   | CONFORTO 71 DPWA | O ELASTIC, CH EXCH   | 6/70               |       |
| M | 1 | P03 1710.0                                                       |        | KIM 71 DPWA      | K-MATRIX ANAL.       | 3/71               |       |
| M | A | 1850.0 (20.0)                                                    |        | LANGBEIN 72 IPWA | MULTICHANNEL         | 12/72*             |       |
| M | A | THESE TWO ANALYSES GAVE THE F07 ASSIGNMENT, THEY HAVE TO BE      |        |                  |                      | 1/71               |       |
| M | A | DISCARDED IN VIEW OF CONFORTO 70 AND BRICMAN 70.                 |        |                  |                      |                    |       |
| M | N | DUE TO PARTICULAR PARAMETERIZATION USED, ERROR CAN BE LARGE      |        |                  |                      | 1/71               |       |
| M | 1 | POSSIBLE EFFECT MAINLY IN SIGMA P1. WE TENTATIVELY LIST IT HERE. |        |                  |                      |                    |       |

60  $\Lambda(1860)$  WIDTH (MEV)

| W | A | F07          | 39.0 | 7.0              | ARMENTERO 68 DPWA    | O ELASTIC, CH EXCH | 11/68 |
|---|---|--------------|------|------------------|----------------------|--------------------|-------|
| M | N | 40.0         | 10.0 | BUGG 68 CNTR     | O K-P TOTAL          | 7/68               |       |
| M | A | F07 37.0     | 10.0 | BRICMAN 70 CNTR  | O TOTAL AND CH EX    | 6/70               |       |
| M | N | P03 37.0     | 10.0 | BRICMAN 70 DPWA  | O SIGTOT, ELAS, CHEX | 1/71               |       |
| M | N | P03 80.0     | 20.0 | CONFORTO 71 DPWA | O ELASTIC, CH EXCH   | 6/70               |       |
| M | 1 | P03 20.0     |      | KIM 71 DPWA      | K-MATRIX ANAL.       | 3/71               |       |
| M | A | 125.0 (20.0) |      | LANGBEIN 72 IPWA | MULTICHANNEL         | 12/72*             |       |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

60  $\Lambda(1860)$  PARTIAL DECAY MODES

| P1                                                                  | Y*0(1860) INTO KBAR N   | DECAY MASSES          |
|---------------------------------------------------------------------|-------------------------|-----------------------|
| P2 <td>Y*0(1860) INTO SIGMA P1</td> <td>497+ 939<br/>1189+ 139</td> | Y*0(1860) INTO SIGMA P1 | 497+ 939<br>1189+ 139 |

60  $\Lambda(1860)$  BRANCHING RATIOS

| R1                                   | Y*0(1860) INTO (KBAR N)/TOTAL | (P1)   |
|--------------------------------------|-------------------------------|--------|
| R1 <td>A F07 0.12</td> <td>0.02</td> | A F07 0.12                    | 0.02   |
| R1 <td>(J+1/2)P1=</td> <td>0.40</td> | (J+1/2)P1=                    | 0.40   |
| R1 <td>A F07 0.07</td> <td>0.02</td> | A F07 0.07                    | 0.02   |
| R1 <td>N P03 0.14</td> <td>0.02</td> | N P03 0.14                    | 0.02   |
| R1 <td>N P03 0.25</td> <td>0.03</td> | N P03 0.25                    | 0.03   |
| R1 <td>0.37</td> <td>(0.05)</td>     | 0.37                          | (0.05) |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

| R2                                                                                                   | Y*0(1860) INTO SIGMA P1                                            | (P2)             |
|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------|
| R2 <td>P PROBABLY SEEN</td> <td>GALTIERI 68 DBC</td>                                                 | P PROBABLY SEEN                                                    | GALTIERI 68 DBC  |
| R2 <td>0.03 OR LESS</td> <td>LANGBEIN 72 IPWA</td>                                                   | 0.03 OR LESS                                                       | LANGBEIN 72 IPWA |
| R2 <td>P POSSIBLY THIS BUMP SEEN AT 1840+10 MEV WITH A WIDTH OF 35+10 MEV</td> <td>MULTICHANNEL</td> | P POSSIBLY THIS BUMP SEEN AT 1840+10 MEV WITH A WIDTH OF 35+10 MEV | MULTICHANNEL     |
| R2 <td>IS THE Y*0(1830), WHICH DECAYS STRONGLY TO SIGMA P1. HOWEVER THE</td> <td></td>               | IS THE Y*0(1830), WHICH DECAYS STRONGLY TO SIGMA P1. HOWEVER THE   |                  |
| R2 <td>NARROW WIDTH HERE ARGUES FOR ITS BEING THE Y*0(1860).</td> <td></td>                          | NARROW WIDTH HERE ARGUES FOR ITS BEING THE Y*0(1860).              |                  |

REFERENCES FOR  $\Lambda(1860)$ 

ARMENTERO 68 NP 88 195  
 BUGG 68 PR 168 1466  
 GALTIERI 68 PRL 21 573  
 BRICMAN 70 PL 318 152  
 BRICMAN 70 PL 330 511  
 CONFORTO 71 NP 834 41  
 KIM 71 PRL 27 356  
 ALSO 70 DUKE 161  
 LANGBEIN 72 NP 847 477

ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 +GILMORE, KNIGHT, + (RHEL, BIRM, CAVE) I  
 BARBARO-GALTIERI, MATISON, + (LRL, SLAC)  
 +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY)  
 +FERRO-LUZZI, LAGNAUX (CERN)  
 +LEVI SETTI, LASINSKI, OBERLACK++ (EFI+HEID) IJP  
 J. K. KIM (HARV) IJP  
 J. K. KIM (HARV) IJP  
 +WAGNER (MPIN) IJP

## PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 67 NP 83 592  
 REPLACED BY ARMENTEROS 68  
 CONFORTO 68 NP 88 265  
 SUPERSEDED BY CONFORTO 71.  
 LEVISETTI 69 LUND 339  
 ALBROW 71 NP 829 413

ARMENTEROS, F.-LUZZI, + (CERN, HEIDEL, SACLAY) IJP  
 AND CONFORTO 68  
 +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL) IJP  
 R. LEVI SETTI (RAPPOREUR) (EFI)  
 +ANDERSON, BOSNJAKOVIC, DAUM, ERNZ, + (CERN)

## Data Card Listings

For notation, see key at front of Listings.

 $\Lambda(1870)$ 36  $\Lambda(1870)$ , JP=1/2- I=0S<sub>01</sub>

THE S<sub>01</sub> AMPLITUDE SHOWS A SECOND RESONANCE BEHAVIOR AT ABOUT 1800 MEV IN 3 ANALYSES. THE ELASTICITY OF KIM 71 IS SURPRISINGLY LARGE.

36  $\Lambda(1870)$  MASS (MEV)

| M | (1872.0) | (10.0) | BRICMAN 70 DPWA  | TOT, ELAS, CHEX | 1/71   |
|---|----------|--------|------------------|-----------------|--------|
| M | (1780.0) |        | KIM 71 DPWA      | K-MATRIX ANAL.  | 3/71   |
| M | 1830.0   | (20.0) | LANGBEIN 72 IPWA | MULTICHANNEL    | 12/72* |

36  $\Lambda(1870)$  WIDTH (MEV)

| M | (100.0) | (20.0) | BRICMAN 70 DPWA  | TOT, ELAS, CHEX | 1/71   |
|---|---------|--------|------------------|-----------------|--------|
| M | (40.0)  |        | KIM 71 DPWA      | K-MATRIX ANAL.  | 3/71   |
| M | 70.0    | (15.0) | LANGBEIN 72 IPWA | MULTICHANNEL    | 12/72* |

36  $\Lambda(1870)$  PARTIAL DECAY MODES

| P1                                                                  | Y*0(1870) INTO KBAR N   | DECAY MASSES          |
|---------------------------------------------------------------------|-------------------------|-----------------------|
| P2 <td>Y*0(1870) INTO SIGMA P1</td> <td>497+ 939<br/>1197+ 139</td> | Y*0(1870) INTO SIGMA P1 | 497+ 939<br>1197+ 139 |

36  $\Lambda(1870)$  BRANCHING RATIOS

| R1 | Y*0(1870) INTO (KBAR N)/TOTAL | (P1)   |
|----|-------------------------------|--------|
| R1 | (0.18)                        | (0.02) |
| R1 | (0.80)                        |        |
| R1 | 0.35                          | (0.15) |

BRICMAN 70 DPWA  
KIM 71 DPWA  
LANGBEIN 72 IPWA

TOT, ELAS, CHEX  
K-MATRIX ANAL.  
MULTICHANNEL

1/71  
3/71  
12/72\*

R2 Y\*0(1870) FROM KBAR N TO SIGMA P1  
R2 (0.24) KIM 71 DPWA  
SQRTP1\*P2  
K-MATRIX ANAL. 3/71

REFERENCES FOR  $\Lambda(1870)$   
 C BRICMAN, M FERRO-LUZZI, J P LAGNAUX (CERN) IJP  
 KIM 71 PRL 27 356 (HARV) IJP  
 ALSO 70 DUKE 161 (HARV) IJP  
 LANGBEIN 72 NP 847 477 +WAGNER (MPIN) IJP

 $\Lambda(2010)$ 89  $\Lambda(2010)$ , JP=3/2- I=0D<sub>03</sub>

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY ONLY TWO PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN BARYON TABLE.

89  $\Lambda(2010)$  MASS (MEV)

| M | (2010.0) | (30.0) | GALTIERI 70 DPWA | O K-P TO SIGMA P1 | 7/70  |
|---|----------|--------|------------------|-------------------|-------|
| M | (1971.0) |        | BRANDSTE 72 DPWA | K-P TO LAM. OMEGA | 1/73* |

89  $\Lambda(2010)$  WIDTH (MEV)

| M | (130.0) | (50.0) | GALTIERI 70 DPWA | O K-P TO SIGMA P1 | 7/70  |
|---|---------|--------|------------------|-------------------|-------|
| M | (180.0) |        | BRANDSTE 72 DPWA | K-P TO LAM. OMEGA | 1/73* |

89  $\Lambda(2010)$  PARTIAL DECAY MODES

| P1                                                                  | Y*0(2010) INTO KBAR N       | DECAY MASSES          |
|---------------------------------------------------------------------|-----------------------------|-----------------------|
| P2 <td>Y*0(2010) INTO SIGMA P1</td> <td>497+ 939<br/>1197+ 139</td> | Y*0(2010) INTO SIGMA P1     | 497+ 939<br>1197+ 139 |
| P3 <td>Y*0(2010) INTO LAMBDA OMEGA</td> <td>1115+ 783</td>          | Y*0(2010) INTO LAMBDA OMEGA | 1115+ 783             |

89  $\Lambda(2010)$  BRANCHING RATIOS

| R1 | Y*0(2010) FROM KBAR N TO SIGMA P1 | (P1)   |
|----|-----------------------------------|--------|
| R1 | (-0.20)                           | (0.04) |

GALTIERI 70 DPWA  
BRANDSTE 72 DPWA

SQRTP1\*P2  
O K-P TO SIGMA P1

7/70  
1/73\*

REFERENCES FOR  $\Lambda(2010)$ 

GALTIERI 70 DUKE CONF 173  
BRANDSTE 72 NP 839 13

A BARBARO-GALTIERI (LRL) IJP  
BRANDSTETTER, BUTTERWORTH, + (RHEL+COEF+SACL)

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Lambda(2020)$ ,  $\Lambda(2100)$ ,  $\Lambda(2110)$  $\Lambda(2020)$ 

27 Y\*0(2020, JP=7/2-) I=0

F<sub>07</sub>

EFFECTS IN THIS PARTIAL WAVE HAVE OBSERVED AT SOMEWHAT DIFFERENT ENERGIES IN TWO CHANNELS, HOWEVER, LITCHFIELD 71 NOTE THAT THE NEED FOR THIS STATE IN THEIR ANALYSIS RESTS SOLELY ON A POSSIBLY INCONSISTENT POLARIZATION MEASUREMENT AT 1.784 GEV/C.

| M | (2020.0) | (20.0) | GALTIERI | 70 DPWA | 0 K-P TO SIGMA PI | 7/70  |
|---|----------|--------|----------|---------|-------------------|-------|
| N | (2100.0) | (30.0) | LITCHFIE | 71 DPWA | 0 K-P TO KBAR N   | 10/71 |

| M | (160.0) | (130.0) | GALTIERI | 70 DPWA | 0 K-P TO SIGMA PI | 7/70  |
|---|---------|---------|----------|---------|-------------------|-------|
| N | (120.0) | (30.0)  | LITCHFIE | 71 DPWA | 0 K-P TO KBAR N   | 10/71 |

| P1 | Y*0(2020) INTO KBAR N   | DECAY MASSES |
|----|-------------------------|--------------|
| P2 | Y*0(2020) INTO SIGMA PI | 497+ 939     |
|    |                         | 1197+ 139    |

| R1 | Y*0(2020) INTO (KBAR N)/TOTAL     | (P1)              |
|----|-----------------------------------|-------------------|
| R2 | Y*0(2020) FROM KBAR N TO SIGMA PI | SORT(P1*P2)       |
| R3 | (10.05) (0.02)                    | LITCHFIE 71 DPWA  |
| R4 | (10.15) (0.02)                    | GALTIERI 70 DPWA  |
|    |                                   | 0 K-P TO SIGMA PI |
|    |                                   | 7/70              |

## REFERENCES FOR Y\*0(2020)

GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL)JJP  
LITCHFIE 71 NP 830 125 LITCHFIELD,....LESQUOY,.... (RHEL+CDEF+SACL)JJP

 $\Lambda(2100)$ 

41 Y\*0(2100, JP=7/2-) I=0

G<sub>07</sub>

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE ANALYSES. PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS AND INVARIANT-MASS DISTRIBUTIONS AROUND 2100 MEV ARE GIVEN IN THE NEXT ENTRY. EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD GIVE THE BEST RESULTS, AS THEY ISOLATE THE G<sub>07</sub> WAVE. THIS SUPERIORITY IS, HOWEVER, PROBABLY NOT YET ATTAINED, AND WE RELY ON BOTH ENTRIES FOR PARAMETERS GIVEN IN THE MAIN BARYON TABLE.

| M | (2120.0) | (20.0) | WOHL          | 66 HBC                                                                                                                                                                                                                                               | 0 K-P TO SIGMA PI  | 7/66  |
|---|----------|--------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------|
| N | (2080.0) | (10.0) | BURGUN        | 68 DPWA                                                                                                                                                                                                                                              | 0 K-P TO XI K      | 10/69 |
| M | (2130.0) | (20.0) | BERTHONI      | 70 DPWA                                                                                                                                                                                                                                              | 0 K-P TO SIGMA PI  | 10/70 |
| M | (2110.0) | (20.0) | GALTIERI      | 70 DPWA                                                                                                                                                                                                                                              | 0 K-P TO SIGMA PI  | 7/70  |
| M | (2100.0) | (15.0) | LITCHFIE      | 71 DPWA                                                                                                                                                                                                                                              | 0 K-P TO KBAR N    | 10/71 |
| M | (2110.0) | (30.0) | LITCHFIE      | 71 DPWA                                                                                                                                                                                                                                              | 0 K-P TO SIGMA PI  | 10/71 |
| M | (2113.0) | (0.0)  | BRANDSTE      | 72 DPWA                                                                                                                                                                                                                                              | 0 K-P TO LAM.OMEGA | 1/73* |
| M | (2092.0) | (12.0) | KANE          | 72 DPWA                                                                                                                                                                                                                                              | 0 K-P TO PI SIG    | 10/71 |
| M | (2120.0) | (20.0) | BURGUN 68     | SEE A RESONANCE-LIKE EFFECT IN THIS REGION IN THE REACTION K-P TO XI K. HOWEVER, AS THEY POINT OUT, IT IS NOT CLEAR WHETHER IT IS MAINLY THE G <sub>07</sub> Y*0(2100) OR INSTEAD A SO FAR OTHERWISE UNOBSERVED RESONANCE WITH A SPIN LESS THAN 7/2. |                    |       |
| M | (2110.0) | (30.0) | LITCHFIELD 71 | IS AN UPDATE OF BERTHONI 70                                                                                                                                                                                                                          |                    | 3/72  |

| M | (145.0) | (10.0) | WOHL                                     | 66 HBC  | 0 K-P TO XI K      | 7/66  |
|---|---------|--------|------------------------------------------|---------|--------------------|-------|
| M | (180.0) | (10.0) | BURGUN                                   | 68 DPWA | 0 K-P TO XI K      | 10/69 |
| M | (140.0) | (15.0) | BERTHONI                                 | 70 DPWA | 0 K-P TO SIGMA PI  | 10/70 |
| M | (60.0)  | (25.0) | GALTIERI                                 | 70 DPWA | 0 K-P TO SIGMA PI  | 7/70  |
| M | (170.0) | (30.0) | LITCHFIE                                 | 71 DPWA | 0 K-P TO KBAR N    | 10/71 |
| M | (140.0) | (50.0) | LITCHFIE                                 | 71 DPWA | 0 K-P TO SIG PI    | 10/71 |
| M | (208.0) | (0.0)  | BRANDSTE                                 | 72 DPWA | 0 K-P TO LAM.OMEGA | 1/73* |
| M | (140.0) | (26.0) | KANE                                     | 72 DPWA | 0 K-P TO PI SIG    | 10/71 |
|   |         |        | SEE THE NOTES ACCOMPANYING MASSES QUOTED |         |                    |       |

| P1 | Y*0(2100) INTO KBAR N       | DECAY MASSES |
|----|-----------------------------|--------------|
| P2 | Y*0(2100) INTO SIGMA PI     | 497+ 939     |
| P3 | Y*0(2100) INTO XI K         | 1197+ 139    |
| P4 | Y*0(2100) INTO LAMBDA OMEGA | 1321+ 497    |
|    |                             | 1115+ 783    |

| R1 | Y*0(2100) INTO (KBAR N)/TOTAL | (P1)                    |
|----|-------------------------------|-------------------------|
| R2 | (0.25) (0.33)                 | WOHL 66 HBC             |
| R3 | (0.30) (0.3)                  | DAUM 68 HBC             |
| R4 | (0.30) (0.3)                  | LITCHFIE 71 DPWA        |
|    |                               | 0 K-P TO ELA, POL, SIGT |
|    |                               | 7/70                    |
|    |                               | 0 K-P TO KBAR N         |
|    |                               | 10/71                   |

## REFERENCES FOR Y\*0(2100)

BERTHONI 70 NP 824 417 +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)JJP  
LITCHFIE 71 NP 830 125 LITCHFIELD,....LESQUOY,.... (RHEL+CDEF+SACL)JJP  
BRANDSTE 72 NP 839 13 BRANDSTETTER, BUTTERWORTH, + (RHEL+CDEF+SACL)JJP  
KANE 72 PR 05 1583 D F KANE (LRL)JJP

| R2 | Y*0(2100) FROM KBAR N INTO SIGMA PI | SORT(P1*P2)      |
|----|-------------------------------------|------------------|
| R2 | (+0.16) (0.02)                      | BERTHONI 70 DPWA |
| R2 | (+0.06) (0.03)                      | GALTIERI 70 DPWA |
| R2 | (0.16) (0.05)                       | LITCHFIE 71 DPWA |
| R2 | (+0.096) (0.037)                    | KANE 72 DPWA     |
|    |                                     | 0 K-P TO PI SIG  |
|    |                                     | 10/71            |

| R3 | Y*0(2100) FROM KBAR N TO XI K | SORT(P1*P3)      |
|----|-------------------------------|------------------|
| R3 | (0.05)                        | TRIPP 67 RVUE    |
| R3 | (0.09) (0.01)                 | BURGUN 68 DPWA   |
| R3 | (0.003)                       | MULLER 69 DPWA   |
| R3 | 0.035 0.018                   | LITCHFIE 71 DPWA |
|    |                               | 0 K-P TO XI K    |
|    |                               | 3/72             |
|    |                               | 0 K-P TO PI SIG  |
|    |                               | 10/71            |

| R4 | Y*0(2100) FROM KBAR N INTO LAMBDA OMEGA | SORT(P1*P4)      |
|----|-----------------------------------------|------------------|
| R4 | (0.053)                                 | BRANDSTE 72 DPWA |
|    |                                         | 1/73*            |

SEE THE NOTES ACCOMPANYING MASSES QUOTED

## REFERENCES FOR Y\*0(2100)

WOHL 66 PRL 17 107 C G WOHL, F T. SOLMITZ, M L STEVENSON (LRL)JJP  
TRIPP 67 NP 83 10 + LEITH, + (LRL, SLAC, CERN, HEIDEL, SACLAY)  
BURGUN 68 NP 88 447 + MEYER, PAULI, + (SACLAY, COLFRANCE, RHEL)  
DAUM 68 NP 87 19 + ERNE, LAGNAUX, SENS, STEUER, UDD (CERN)JJP  
CONFIRMS THE SPIN-PARITY ASSIGNMENT.  
MULLER 69 THESIS, UCL 19372 R A MULLER (LRL)  
BERTHONI 70 NP 824 417 +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)JJP  
GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL)JJP  
LITCHFIE 71 NP 830 125 LITCHFIELD,....LESQUOY,.... (RHEL+CDEF+SACL)JJP  
BRANDSTE 72 NP 839 13 BRANDSTETTER, BUTTERWORTH, + (RHEL+CDEF+SACL)JJP  
KANE 72 PR 05 1583 D F KANE (LRL)JJP

 $\Lambda(2110)$ 

35 Y\*0(2110, JP=5/2-) I=0

F<sub>05</sub> or D<sub>05</sub>

BERTHONI 70 FIND EITHER F<sub>05</sub> OR D<sub>05</sub> POSSIBLE IN THE SIG PI CHANNEL, WITH F<sub>05</sub> SLIGHTLY PREFERRED. IN THE KBAR N CHANNEL, LITCHFIELD 71 (SAME GROUP) FIND ONLY D<sub>05</sub>. AS USUAL, THE STATISTICS ARE MUCH BETTER IN THE ELASTIC CHANNEL.

ALTHOUGH KANE 72 FINDS AN F<sub>05</sub> EFFECT, THE UNUSUALLY BROAD WIDTH MAY INVALIDATE A RESONANT INTERPRETATION.

| M | (2110.0)               | (10.0) | BERTHONI                           | 70 DPWA | 0 K-P TO SIG PI    | 1/71  |
|---|------------------------|--------|------------------------------------|---------|--------------------|-------|
| M | (2140.0)               | (40.0) | LITCHFIE                           | 71 DPWA | 0 K-P TO KBAR N    | 10/71 |
| M | F <sub>05</sub> 2034.0 | (6.0)  | BRANDSTE                           | 72 DPWA | 0 K-P TO LAM.OMEGA | 1/73* |
| M | A (2141.0)             | (6.0)  | KANE                               | 72 DPWA | 0 K-P TO PI SIG    | 10/71 |
|   |                        |        | A RESONANCE OUTSIDE RANGE OF DATA. |         |                    |       |

| M | (185.0)   | (30.0) | BERTHONI | 70 DPWA | 0 K-P TO SIG PI    | 1/71  |
|---|-----------|--------|----------|---------|--------------------|-------|
| M | (120.0)   | (40.0) | LITCHFIE | 71 DPWA | 0 K-P TO KBAR N    | 10/71 |
| M | (154.0)   | (0.0)  | BRANDSTE | 72 DPWA | 0 K-P TO LAM.OMEGA | 1/73* |
| M | A (150.0) | (10.0) | KANE     | 72 DPWA | 0 K-P TO PI SIG    | 10/71 |

| P1 | Y*0(2110) INTO KBAR N       | DECAY MASSES |
|----|-----------------------------|--------------|
| P2 | Y*0(2110) INTO SIGMA PI     | 497+ 939     |
| P3 | Y*0(2110) INTO LAMBDA OMEGA | 1197+ 139    |
|    |                             | 1115+ 783    |

| R1 | Y*0(2110) FROM KBAR N TO SIGMA PI       | SORT(P1*P2)      |
|----|-----------------------------------------|------------------|
| R1 | (+0.17) (0.03)                          | BERTHONI 70 DPWA |
| R1 | (+0.156) (0.013)                        | KANE 72 DPWA     |
| R2 | Y*0(2110) INTO (KBAR N)/TOTAL           | (P1)             |
| R2 | (0.14) (0.04)                           | LITCHFIE 71 DPWA |
| R3 | Y*0(2110) FROM KBAR N INTO LAMBDA OMEGA | SORT(P1*P3)      |
| R3 | (0.152)                                 | BRANDSTE 72 DPWA |
|    |                                         | 1/73*            |

## REFERENCES FOR Y\*0(2110)

BERTHONI 70 NP 824 417 +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)JJP  
LITCHFIE 71 NP 830 125 LITCHFIELD,....LESQUOY,.... (RHEL+CDEF+SACL)JJP  
BRANDSTE 72 NP 839 13 BRANDSTETTER, BUTTERWORTH, + (RHEL+CDEF+SACL)JJP  
KANE 72 PR 05 1583 D F KANE (LRL)JJP

 $\Lambda(2100)$   
BUMPS

25 Y\*0(2100, JP= ) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SEE THE NOTE TO THE G<sub>07</sub> Y\*0(2100), WHICH PRECEDES THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y\*0(2100), BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTABLISHED OTHER RESONANCES IN THIS REGION.

## Data Card Listings

 $\Lambda(2110)$ ,  $\Lambda(2350)$ ,  $\Lambda(2585)$ ,  $\Sigma^+$ ,  $\Sigma^-$ ,  $\Sigma^0$ ,  $\Sigma(1385)$  For notation, see key at front of Listings.25  $\Lambda(2100)$  MASS (MEV) (PROD. EXP.)

|   |          |        |         |         |                    |       |
|---|----------|--------|---------|---------|--------------------|-------|
| M | (2097.0) | (6.0)  | BOCK    | 65 HBC  | PBAR P 5.7 BEV/C   | 7/66  |
| M | 2100.0   | (7.0)  | BUGG    | 68 CNTR | K-P, D TOTAL       | 6/68  |
| M | 2121.0   | (5.0)  | BRICMAN | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| M | 2107.0   | (10.0) | COOL    | 70 CNTR | K-P, D TOTAL       | 10/70 |
| M | (2135.0) | (20.0) | LU      | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

25  $\Lambda(2100)$  WIDTH (MEV) (PROD. EXP.)

|   |        |        |        |         |         |                    |       |
|---|--------|--------|--------|---------|---------|--------------------|-------|
| W | (24.0) | (14.0) | (24.0) | BOCK    | 65 HBC  | INTO KBAR N (P1)   | 7/66  |
| W | 140.0  | (15.0) |        | BUGG    | 68 CNTR |                    | 6/68  |
| W | 147.0  | (15.0) |        | BRICMAN | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| W | 185.0  |        |        | COOL    | 70 CNTR | K-P, D TOTAL       | 10/70 |
| W | (40.0) |        |        | LU      | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

25  $\Lambda(2100)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                 |                   |               |
|----|-----------------|-------------------|---------------|
| P1 | $\Lambda(2100)$ | INTO KBAR N       | DECAY MASSES  |
| P2 | $\Lambda(2100)$ | INTO KBAR N P1    | 497+ 939      |
| P3 | $\Lambda(2100)$ | INTO LAMBDA ETA   | 497+ 939+ 139 |
| P4 | $\Lambda(2100)$ | INTO LAMBDA OMEGA | 1115+ 548     |
|    |                 |                   | 1115+ 783     |

25  $\Lambda(2100)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                               |                             |             |
|----|-----------------------------------------------|-----------------------------|-------------|
| R1 | $\Lambda(2100)$                               | INTO (KBAR N)/TOTAL         | (P1)        |
| R1 | THESE VALUES OF ELASTICITIES ASSUME $J=7/2^-$ |                             |             |
| R1 | 0.305                                         | BUGG                        | 68 CNTR     |
| R1 | 0.24 (0.02)                                   | BRICMAN                     | 70 CNTR     |
| R1 | 0.4                                           | COOL                        | 70 CNTR     |
| R2 | $\Lambda(2100)$                               | INTO KBAR N P1              | (P2)        |
| R2 | SEEN                                          | BOCK                        | 65 HBC      |
| R3 | $\Lambda(2100)$                               | FROM KBAR N INTO LAMBDA ETA | SORT(P1=P3) |
| R3 | (0.09) OR LESS                                | FLATTE 2                    | 67 HBC      |
| R4 | $\Lambda(2100)$                               | INTO (LAMBDA OMEGA)/TOTAL   | (P4)        |
| R4 | (0.1) OR LESS                                 | FLATTE 1                    | 67 HBC      |

REFERENCES FOR  $\Lambda(2100)$  (PROD. EXP.)

|          |                        |                                            |                      |
|----------|------------------------|--------------------------------------------|----------------------|
| BOCK     | 65 PL 17 166           | +COOPER, FRENCH, KINSON, +                 | (CERN, SACLAY)       |
| FLATTE 1 | 67 PR 155 1517         | S M FLATTE                                 | (LRL)                |
| FLATTE 2 | 67 PR 163 1441         | S M FLATTE, C G MOHL                       | (LRL)                |
| BUGG     | 68 PR 168 1466         | +GILMORE, KNIGHT, +                        | (RHEL, BIRM, CAVE) I |
| BRICMAN  | 70 PL 318 152          | +FERRO LUZZI, PERREAU, +                   | (CERN, CAEN, SACLAY) |
| COOL     | 70 PR D1 1887          | +GIACOMELLI, KYCIA, LEONTIC, LI, +         | (BNL) I              |
| LU       | 70 PR D2 1846          | +GREENBERG, HUGHES, MINEHART, MORI, +      | (YALE)               |
|          |                        | PAPERS NOT REFERRED TO IN DATA CARDS       |                      |
| COOL     | 66 PRL 16 1228         | +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + | (BNL) I              |
|          | SUPERSEDED BY COOL 70. |                                            |                      |

 **$\Lambda(2350)$   
BUMPS**42  $\Lambda(2350)$ ,  $J_P = \quad$  I=0 PRODUCTION EXPERIMENTSSEE THE MINI-REVIEW AT THE START OF THE  $\Lambda$  LISTINGS.DAUM 68 FAVORS  $J_P=7/2^-$  OR  $9/2^-$ . BRICMAN 70 FAVORS  $9/2^-$ .

LASINSKI 71 SUGGESTS THREE STATES IN THIS REGION USING A POMERON + RESONANCES MODEL.

42  $\Lambda(2350)$  MASS (MEV) (PROD. EXP.)

|   |          |        |         |         |                    |       |
|---|----------|--------|---------|---------|--------------------|-------|
| M | 2340.0   | (7.0)  | BUGG    | 68 CNTR | K-P, D TOTAL       | 6/68  |
| M | 2358.0   | (6.0)  | BRICMAN | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| M | 2344.0   | (15.0) | COOL    | 70 CNTR | K-P, D TOTAL       | 10/70 |
| M | (2360.0) | (20.0) | LU      | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

42  $\Lambda(2350)$  WIDTH (MEV) (PROD. EXP.)

|   |         |        |         |         |                    |       |
|---|---------|--------|---------|---------|--------------------|-------|
| W | 140.0   | (20.0) | BUGG    | 68 CNTR | K-P, D TOTAL       | 6/68  |
| W | 324.0   | (30.0) | BRICMAN | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| W | (190.0) |        | COOL    | 70 CNTR | K-P, D TOTAL       | 10/70 |
| W | (55.0)  |        | LU      | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

42  $\Lambda(2350)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                 |             |              |
|----|-----------------|-------------|--------------|
| P1 | $\Lambda(2350)$ | INTO KBAR N | DECAY MASSES |
|    |                 |             | 497+ 939     |

42  $\Lambda(2350)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                                 |                     |         |
|----|-------------------------------------------------|---------------------|---------|
| R1 | $\Lambda(2350)$                                 | INTO (KBAR N)/TOTAL | (P1)    |
| R1 | J IS NOT KNOWN. THE FOLLOWING IS $(J+1/2)^+ P1$ |                     |         |
| R1 | (0.57)                                          | BUGG                | 68 CNTR |
| R1 | 1.1                                             | BRICMAN             | 70 CNTR |
| R1 | (1.0)                                           | COOL                | 70 CNTR |

REFERENCES FOR  $\Lambda(2350)$  (PROD. EXP.)

|         |                |                                       |                      |
|---------|----------------|---------------------------------------|----------------------|
| BUGG    | 68 PR 168 1466 | +GILMORE, KNIGHT, +                   | (RHEL, BIRM, CAVE) I |
| DAUM    | 68 NP 87 19    | +ERNE, LAGNAUX, SENS, STEUER, UDO     | (CERN) J.P.          |
| BRICMAN | 70 PL 318 152  | +FERRO LUZZI, PERREAU, +              | (CERN, CAEN, SACLAY) |
| COOL    | 70 PR D1 1887  | +GIACOMELLI, KYCIA, LEONTIC, LI, +    | (BNL) I              |
| LU      | 70 PR D2 1846  | +GREENBERG, HUGHES, MINEHART, MORI, + | (YALE)               |

|          |                        |                                            |           |
|----------|------------------------|--------------------------------------------|-----------|
| COOL     | 66 PRL 16 1228         | PAPERS NOT REFERRED TO IN DATA CARDS       |           |
|          | SUPERSEDED BY COOL 70. | +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + | (BNL) I   |
| LASINSKI | 71 NP B29 125          | T A LASINSKI                               | (EFI) IJP |

 **$\Lambda(2585)$   
BUMPS**7  $\Lambda(2585)$ ,  $J_P = \quad$  I=0 PRODUCTION EXPERIMENTSSEE THE MINI-REVIEW AT THE START OF THE  $\Lambda$  LISTINGS.7  $\Lambda(2585)$  MASS (MEV) (PROD. EXP.)

|   |          |        |        |         |                    |       |
|---|----------|--------|--------|---------|--------------------|-------|
| M | 2585.0   | 45.0   | ABRAMS | 70 CNTR | K-P, D TOTAL       | 10/70 |
| M | (2590.0) | (25.0) | LU     | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

7  $\Lambda(2585)$  WIDTH (MEV) (PROD. EXP.)

|   |         |  |        |         |                    |       |
|---|---------|--|--------|---------|--------------------|-------|
| W | (300.0) |  | ABRAMS | 70 CNTR | K-P, D TOTAL       | 10/70 |
| W | (150.0) |  | LU     | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

7  $\Lambda(2585)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                 |             |              |
|----|-----------------|-------------|--------------|
| P1 | $\Lambda(2585)$ | INTO KBAR N | DECAY MASSES |
|    |                 |             | 497+ 939     |

7  $\Lambda(2585)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                                 |                                                         |         |
|----|-------------------------------------------------|---------------------------------------------------------|---------|
| R1 | $\Lambda(2585)$                                 | INTO (KBAR N)/TOTAL                                     | (P1)    |
| R1 | J IS NOT KNOWN. THE FOLLOWING IS $(J+1/2)^+ P1$ |                                                         |         |
| R1 | (1.0)                                           | ABRAMS                                                  | 70 CNTR |
| R1 | (0.12)                                          | BRICMAN                                                 | 70 CNTR |
| R1 | (0.12)                                          | COOL                                                    | 70 CNTR |
| R1 | C                                               | RESONANCE AT END OF REGION ANALYZED -- NO CLEAR SIGNAL. |         |

REFERENCES FOR  $\Lambda(2585)$  (PROD. EXP.)

|         |               |                                       |                      |
|---------|---------------|---------------------------------------|----------------------|
| ABRAMS  | 70 PR 1D 1917 | +COOL, GIACOMELLI, KYCIA, LEONTIC, +  | (BNL) I              |
| BRICMAN | 70 PL 318 152 | +FERRO LUZZI, PERREAU, +              | (CERN, CAEN, SACLAY) |
| LU      | 70 PR D2 1846 | +GREENBERG, HUGHES, MINEHART, MORI, + | (YALE)               |

## PAPERS NOT REFERRED TO IN DATA CARDS

|      |                |                                        |         |
|------|----------------|----------------------------------------|---------|
| COOL | 66 PRL 16 1228 | +GIACOMELLI, KYCIA, LEONTIC, LUNDBY, + | (BNL) I |
|------|----------------|----------------------------------------|---------|

 **$\Sigma^+$** 19 SIGMA+ (1189,  $J_P=1/2^+$ ) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

 **$\Sigma^-$** 20 SIGMA- (1198,  $J_P=1/2^+$ ) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

 **$\Sigma^0$** 21 SIGMA0 (1193,  $J_P=1/2^+$ ) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

 **$\Sigma(1385)$** 43  $\Sigma(1385)$ ,  $J_P=3/2^+$  I=1 **$P_{13}$** 

FOR DISCUSSION OF INCONSISTENCY OF ERRORS AND OUR MODIFICATIONS, SEE NOTE ON K\*(892)

FOR THE TABLES WE USE ONLY THE UNSTARRED DATA, WHICH ATTEMPTS TO OBTAIN THE SEPARATE CHARGE-STATE MASSES AND WIDTHS. SEE HOWEVER THE IDEOGRAMS INSERTED IN LISTING THESE INDICATE SERIOUS SYSTEMATICS, PERHAPS ARISING FROM INTERFERENCE EFFECTS THAT CHANGE WITH PRODUCTION MECHANISM AND BEAM MOMENTUM.

43  $\Sigma(1385)$  MASS (MEV)

|    |             |         |         |                      |      |
|----|-------------|---------|---------|----------------------|------|
| M  | 141(1384.0) | ALSTON  | 60 HBC  | + K-P 1.15 BEV/C     |      |
| M  | (1385.0)    | BERGE   | 61 HBC  | + K-P 4-.85 BEV/C    |      |
| M  | 38(1384.0)  | MARTIN  | 61 HBC  | + K20 P .98 BEV/C    |      |
| M  | (1392.0)    | COLLEY  | 62 HLBC | - O P1- PRP 2. BEV/C |      |
| M  | (1389.0)    | BALTAI  | 65 HBC  | + PBAR P 3.7 BEV/C   | 7/66 |
| M  | (1392.0)    | MUGRAVE | 65 HBC  | + OPBAR P 3-4 BEV/C  | 7/66 |
| MO | 106(1381.0) | CURTIS  | 63 OSKP | O P1-P 1.5 BEV/C     |      |

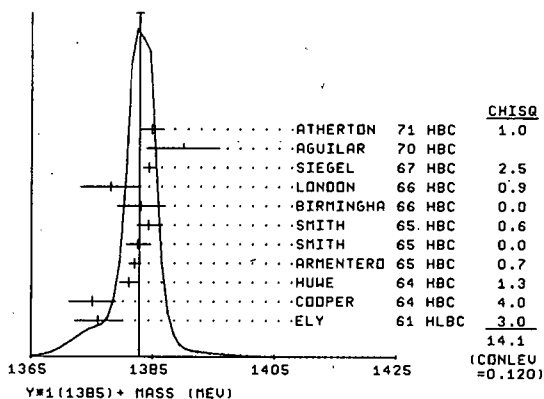
## Data Card Listings

For notation, see key at front of Listings.

Baryons  
 $\Sigma(1385)$ 

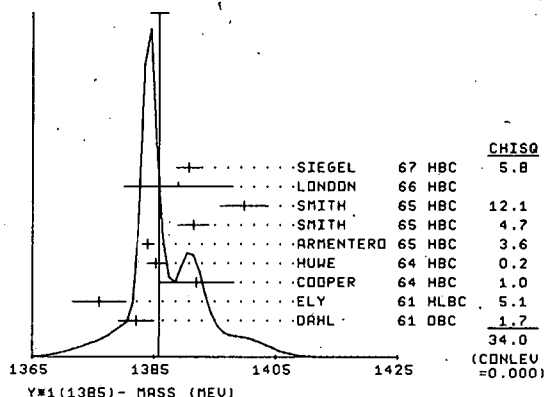
M\* E 154 1376.0 3.9 ELY 61 HLBC + K-P 1.11 BEV/C 8/66  
 M\* E ERROR OF 3.0 ENLARGED TO 3.9 BY US, BECAUSE LT STATIST. ERR. 10/69  
 M\* 170 1375.0 3.9 COOPER 64 HBC + K-P 1.45 BEV/C 10/69  
 M\* 859 1381.0 1.6 HUME 64 HBC + K-P 1.22 BEV/C 8/66  
 M\* 750 1382.0 1.0 ARMENTERO 65 HBC + K-P 1.95 BEV/C 9/66  
 M\* S 250 1382.6 2.1 SMITH 65 HBC + K-P 1.8 BEV/C 9/66  
 M\* S 250 1384.3 1.9 SMITH 65 HBC + K-P 1.8 BEV/C 9/66  
 M\* S ERROR OF 1.4 ENLARGED TO 2.1 BY US, BECAUSE < STATIST. ERR. 10/69  
 M\* S ERROR OF 1.1 ENLARGED TO 1.9 BY US, BECAUSE < STATIST. ERR. 10/69  
 M\* B 40 1383.0 4.0 BIRMINGHA 66 HBC + K-P 3.5 9/67  
 M\* B ERROR OF 2.0 ENLARGED TO 4.0 BY US, BECAUSE < STATIST. ERR. 10/69  
 M\* 1378.0 5.0 LONDON 66 HBC + K-P 2.24 BEV/C 7/66  
 M\* 1260 1384.4 1.0 SIEGEL 67 HBC + K-P AT 2.1 GEV/C 10/69  
 M\* 1390.0 8.0 AGUILAR 70 HBC + K-P 4 GEV/SIG.PI 5/70  
 M\* 1384.8 2.0 ATHERTON 71 HBC LAM PI + C.C. 10/71  
 M\* AVG 1382.81 0.68 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)  
 (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE =  $1382.81 \pm 0.68$   
 ERROR SCALED BY 1.3



M- 93 1382.0 3.0 DAHL 61 OBC - K-O 0.45 BEV/C  
 M- E 224 1376.0 4.4 ELY 61 HLBC -  
 M- ERROR OF 3.0 ENLARGED TO 4.4 BY US, BECAUSE < STATIST. ERR. 10/69  
 M- 200 1392.0 6.2 COOPER 64 HBC -  
 M- 1086 1385.3 1.5 HUME 64 HBC -  
 M- 1380 1384.0 1.0 ARMENTERO 65 HBC -  
 M- S 120 1391.5 2.6 SMITH 65 HBC + K-P 1.8 BEV/C 9/66  
 M- S 58 1399.8 4.0 SMITH 65 HBC + K-P 1.95 BEV/C 9/66  
 M- S ERROR OF 1.8 ENLARGED TO 2.6 BY US, BECAUSE < STATIST. ERR. 10/69  
 M- S ERROR OF 1.4 ENLARGED TO 4.0 BY US, BECAUSE < STATIST. ERR. 10/69  
 M- 1389.0 9.0 LONDON 66 HBC -  
 M- 370 1390.7 2.0 SIEGEL 67 HBC - K-P AT 2.1 GEV/C 10/69  
 M- AVG 1385.9 1.5 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)  
 (SEE IDEOGRAM BELOW)

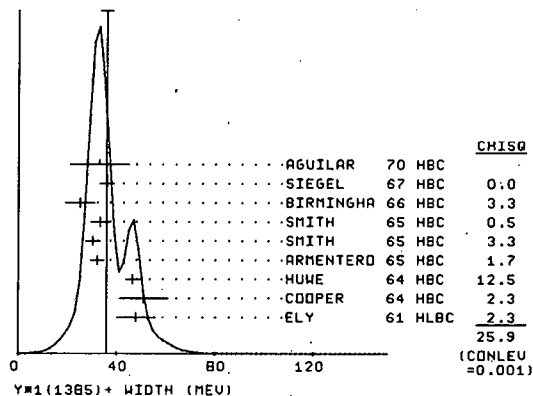
WEIGHTED AVERAGE =  $1385.9 \pm 1.5$   
 ERROR SCALED BY 2.2



43 (Y\*) - (Y\*) MASS DIFFERENCE (MEV)  
 D R (10.0) (4.2) ELY 61 HLBC + K-P 1.11 BEV/C 8/66  
 D R (17.1) (7.1) COOPER 64 HBC 10/69  
 D R (4.3) (2.2) HUME 64 HBC + K-P 1.22 BEV/C 8/66  
 D R (2.0) (1.5) ARMENTERO 65 HBC + K-P 1.95 BEV/C 9/66  
 D R (17.2) (2.1) SMITH 65 HBC + K-P 1.8 BEV/C 9/66  
 D R (17.2) (2.0) SMITH 65 HBC + K-P 1.95 BEV/C 9/66  
 D R (11.0) (9.0) LONDON 66 HBC + K-P 2.24 BEV/C 8/66  
 D R 9.0 6.0 LONDON 66 HBC + LAMBOA 3 PI EVTS 7/66  
 D R (6.3) (2.0) SIEGEL 67 HBC K-P AT 2.1 GEV/C 10/69  
 D R REDUNDANT WITH DATA IN MASS LISTING.

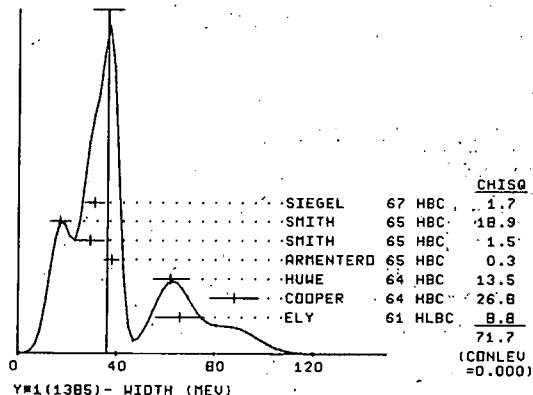
43 Y\*(1385) WIDTH (MEV)  
 W (64.0) ALSTON 60 HBC +-  
 W (40.0) BERGE 61 HBC +-  
 W (20.0) OR LESS MARTIN 61 HBC +0  
 W (180.0) (110.0) COLLEY 62 HLBC -0  
 W (30.0) (9.0) CURTIS 63 OSPK 0  
 W (26.0) (5.0) BALTAY 65 HBC +-  
 W (38.0) (9.0) MUSGRAVE 65 HBC +-0 7/66  
 W\* 48.0 8.0 ELY 61 HLBC +  
 W\* 51.0 10.0 COOPER 64 HBC +  
 W\* 46.5 3.0 HUME 64 HBC +  
 W\* 32.0 3.0 ARMENTERO 65 HBC +  
 W\* 30.3 3.1 SMITH 65 HBC + K-P 1.8 BEV/C 9/66  
 W\* 33.1 3.8 SMITH 65 HBC + K-P 1.95 BEV/C 9/66  
 W\* 40 25.0 6.0 BIRMINGHA 66 HBC + K-P 3.5 9/67  
 W\* 1260 36.0 3.0 SIEGEL 67 HBC K-P AT 2.1 GEV/C 10/69  
 W\* 33.0 12.0 AGUILAR 70 HBC + K-P 4 GEV/SIG.PI 5/70  
 W\* T 40 20.0 ATHERTON 71 HBC LAM PI + C.C. 10/71  
 W\* T FIT B.W. + PHASE SPACE BCKGRD  
 W\* R 40 35.0  
 W\* T FIT B.W. AND NO BCKGRD  
 W\* AVG 34.4 2.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)  
 (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE =  $35.9 \pm 2.6$   
 ERROR SCALED BY 1.9



W- (40.0) DAHL 61 OBC -  
 W- 66.0 10.0 ELY 61 HLBC -  
 W- 88.0 10.0 COOPER 64 HBC -  
 W- 62.0 7.0 HUME 64 HBC -  
 W- 38.0 3.0 ARMENTERO 65 HBC -  
 W- 29.2 5.7 SMITH 65 HBC + K-P 1.80 BEV/C 9/66  
 W- 17.1 4.4 SMITH 65 HBC + K-P 1.95 BEV/C 9/66  
 W- 370 31.0 4.0 SIEGEL 67 HBC K-P AT 2.1 GEV/C 10/69  
 W- AVG 36.3 6.3 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)  
 (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE =  $36.3 \pm 6.3$   
 ERROR SCALED BY 3.5



## Baryons

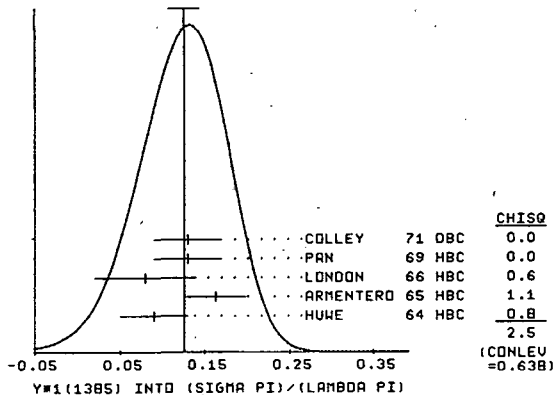
 $\Sigma(1385)$ ,  $\Sigma(1440)$ ,  $\Sigma(1480)$ ,  $\Sigma(1620)$ 43  $\Sigma(1385)$  PARTIAL DECAY MODES

|    |                                  | DECAY MASSES |
|----|----------------------------------|--------------|
| P1 | $\Sigma(1385)$ INTO LAMBDA PI    | 1115+ 139    |
| P2 | $\Sigma(1385)$ INTO SIGMA PI     | 1197+ 139    |
| P3 | $\Sigma(1385)$ INTO LAMBDA GAMMA | 1115+ 0      |

43  $\Sigma(1385)$  BRANCHING RATIOS

| R1 | $\Sigma(1385)$ INTO (SIGMA PI)/(LAMBDA PI) | (P2)/(P1)                                          |
|----|--------------------------------------------|----------------------------------------------------|
| R1 | (0.04) (0.04)                              | BASTIEN 61 HBC $\rightarrow$                       |
| R1 | (0.04) OR LESS                             | ALSTON 62 HBC $\rightarrow$ 0                      |
| R1 | 0.09                                       | HUME 64 HBC $\rightarrow$                          |
| R1 | 0.163                                      | ARMENTERO 45 HBC $\rightarrow$                     |
| R1 | 0.08                                       | LONDON 66 HBC $\rightarrow$                        |
| R1 | 0.13                                       | PAN 69 HBC $\rightarrow$                           |
| R1 | 0.13                                       | COLLEY 71 HBC $\rightarrow$                        |
| R1 | 0.13                                       | PI* P - K Y PI 12/72*                              |
| R1 | 0.13                                       | K-N 1.5 GEV PROD 10/71                             |
| R1 | AVG                                        | 0.126 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |
|    |                                            | (SEE IDEOGRAM BELOW)                               |

WEIGHTED AVERAGE =  $0.126 \pm 0.018$   
 ERROR SCALED BY 1.0



| R2 | $\Sigma(1385)$ INTO LAMBDA GAMMA | (P3)                              |
|----|----------------------------------|-----------------------------------|
| R2 | 1 (0.17)                         | MEISNER 72 HBC 1 EVENT ONLY 1/73* |

REFERENCES FOR  $\Sigma(1385)$ 

|                             |                                                    |
|-----------------------------|----------------------------------------------------|
| ALSTON 60 PRL 5 520         | +ALVAREZ, EBERHARD, GOOD, GRAZIANO, + (LRL) I      |
| BASTIEN 61 PRL 6 702        | +P BASTIEN, FERRO-LUZZI, A H ROSENFELD (LRL)       |
| BERGE 61 PRL 6 557          | +BASTIEN, DAHL, FERRO-LUZZI, KIRZ, + (LRL)         |
| DAHL 61 PRL 6 142           | +HORMITZ, MILLER, MURRAY, WHITE (LRL)              |
| ELY 61 PRL 7 461            | +FUNG, GIDAL, PAN, POWELL, WHITE (LRL) J           |
| MARTIN 61 PRL 6 283         | +LEIPNER, CHINOWSKY, SHIVELY, + (BNL, TALE)        |
| ALSTON 62 CERN CONF 311     | +ALVAREZ, FERRO-LUZZI, ROSENFELD, + (LRL)          |
| COLLEY 62 PR 128 1930       | +GELFAND, NAUENBERG, + (COLUMBIA, RUTGERS) JP      |
| CURTIS 63 PR 132 1771       | +COFFIN, MEYER, TERWILLIGER (MICH) J               |
| COOPER 64 PL 8 365          | +FILTHUTH, FRIDMAN, MALAMUD, + (CERN, AMST) JP     |
| HUME 64 UCRL-11291 THESIS   | D O HUME (LRL)                                     |
| ALSO 49 PR 180 1824         | D O HUME (LRL)                                     |
| ARMENTERO 65 PL 19 75       | ARMENTERO, + (CERN, HEIDEL, SACLAY)                |
| BALTAY 65 PR 140 B1027      | +SANDMEISS, TAFT, CULWICK, KOPP, + (YALE, BNL)     |
| MUSGRAVE 65 NC 35 735       | +PETHEZAS, + (BIRM, CERN, EPOL, LOIC, SACLAY)      |
| SMITH 65 THESIS (UCLA)      | L T SMITH (UCLA)                                   |
| BIRMINGHAM 66 PR 152 1148   | BIRMINGHAM, GLASGOW, I.C., OXFORD, RUTHERFORD      |
| LONDON 66 PR 143 1034       | +RAU, SAKIOS, YAMAMOTO, GOLDBERG, + (BNL, SYRAC) J |
| SIEGEL 67 UCRL 18041 THESIS | D M SIEGEL (LRL)                                   |
| PAN 69 PRL 23 808           | +FORMAN (PENN) I                                   |
| AGUILAR 70 PRL 25 58        | +BARNES, BASSANO, CHUNG, EISNER, + (BNL, SYRAC)    |
| ATHERTON 71 NP 829 477      | +CELNIKIER, CLAYTON, FRENCH, FRISK, + (CERN)       |
| COLLEY 71 NP 831 61         | +COX, EASTWOOD, FRY, + (BIRM, EDIN+GLAS+LOIC)      |
| MEISNER 72 NC 12A 62        | G MEISNER (U NC GREENSBORO+LBL)                    |

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.

|                         |                                        |
|-------------------------|----------------------------------------|
| MALAMUD 64 PL 10 145    | E MALAMUD, P E SCHLEIN (CERN, UCLA) JP |
| SHAFFER 64 PR 134 B1372 | J B SHAFFER, D O HUME (LRL) JP         |

 $\Sigma(1440)$   
BUMPS80  $\Sigma(1440)$ , JP= 1 I=1 PRODUCTION EXPERIMENTSSEE THE MINI-REVUE AT THE START OF THE  $\Sigma$ \* LISTINGS.

CLINE 68 FIND A NARROW PEAK AT 1440 MEV (JUST ABOVE THE  $\bar{K}^0$  N THRESHOLD) IN THE LAMBDA PI INVARIANT MASS FOR  $\bar{K}^0$  D TO LAMBDA PI- P EVENTS. THEY DISCUSS ALTERNATE INTERPRETATIONS -- THAT IT IS A RESONANCE OR A KINEMATIC EFFECT. IN CLINE 68 THE  $\bar{K}^0$  BEAM MOMENTUM IS 0.4 GEV/C. IN A STUDY OF THE SAME REACTION WITH A MOMENTUM OF 1.1 GEV/C, ALEXANDER 69 FIND NO PEAK. IN ADDITION, THEY ARE ABLE TO EXPLAIN THE RESULTS OF BOTH EXPERIMENTS WITHOUT INVOKING A NEW RESONANCE. A REANALYSIS OF THE CLINE 68 DATA MADE BY BUNNELL 70 SHOW AGREEMENT OF THE DATA WITH THE ALEXANDER 69 INTERPRETATION.

## Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR  $\Sigma(1440)$  (PROD. EXP.)

|                         |                                          |
|-------------------------|------------------------------------------|
| CLINE 68 PRL 21 1372    | D CLINE, R LAUMANN, J MAPP (WISCONSIN) I |
| ALEXANDER 69 PRL 22 483 | ALEXANDER, HALL, JEW, + (LRL, RIVERSIDE) |
| BUNNELL 70 LNC 3 224    | +CLINE, LAUMANN, MAPP + (NMES+MISC+ANL)  |

 $\Sigma(1480)$   
BUMPS23  $\Sigma(1480)$ , JP= 1 I=1 PRODUCTION EXPERIMENTSSEE THE MINI-REVUE AT THE START OF THE  $\Sigma$ \* LISTINGS.

PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN THE REACTION  $\pi^+ p \rightarrow \Sigma^+ K^0$  AT 1.7 GEV/C. ALSO THE  $\Sigma$  POLARIZATION OSCILLATES IN THE SAME REGION.

SEE MILLER 70 FOR A DISCUSSION OF THIS STATE. HE SUGGESTS A POSSIBLE ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF  $\Sigma(1620)$  DECAY TO LAMBDA K. HOWEVER, SUCH AN EXPLANATION FOR THE  $\Sigma^+ \rightarrow \Sigma^0 + \pi^+$  CHANNEL SEEMS UNLIKELY (SEE PAN 70) IN TERMS OF KNOWN  $\Sigma(1620)$  DECAY INTO SIGMA K. IN ADDITION SUCH REFLECTIONS WOULD ALSO HAVE TO ACCOUNT FOR THE OSCILLATION OF THE  $\Sigma$  POLARIZATION IN THE 1480 MASS REGION. HANSON 71, WITH FEWER DATA THAN PAN 70, CAN NEITHER CONFIRM NOR DENY THE EXISTENCE OF THIS STATE.

23  $\Sigma(1480)$  MASS (MEV) (PROD. EXP.)

|   |         |                                  |     |          |                   |      |
|---|---------|----------------------------------|-----|----------|-------------------|------|
| M | 1479.   | 10.                              | PAN | 70 HBC + | PI* P TO K PI LAM | 3/71 |
| M | 1465.   | 15.                              | PAN | 70 HBC + | PI* P TO K PI SIG | 3/71 |
| M | AVERAGE | MEANINGLESS (SCALE FACTOR = 1.0) |     |          |                   |      |

23  $\Sigma(1480)$  WIDTH (MEV) (PROD. EXP.)

|   |         |                                  |     |          |                   |      |
|---|---------|----------------------------------|-----|----------|-------------------|------|
| W | 31.     | 15.                              | PAN | 70 HBC + | PI* P TO K PI LAM | 3/71 |
| W | 30.     | 20.                              | PAN | 70 HBC + | PI* P TO K PI SIG | 3/71 |
| W | AVERAGE | MEANINGLESS (SCALE FACTOR = 1.0) |     |          |                   |      |

23  $\Sigma(1480)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                                   | DECAY MASSES |
|----|-----------------------------------|--------------|
| P1 | $\Sigma(1480)$ INTO $\bar{K}^0$ N | 497+ 939     |
| P2 | $\Sigma(1480)$ INTO LAMBDA PI     | 1115+ 139    |
| P3 | $\Sigma(1480)$ INTO SIGMA PI      | 1189+ 139    |

23  $\Sigma(1480)$  BRANCHING RATIOS (PROD. EXP.)

| R1 | $\Sigma(1480)$ INTO (SIGMA PI)/(LAMBDA PI)               | (P3)/(P2)         |
|----|----------------------------------------------------------|-------------------|
| R1 | 0.82                                                     | PAN 70 HBC + 3/71 |
| R2 | $\Sigma(1480)$ INTO (PROTON $\bar{K}^0$ BAR)/(LAMBDA PI) | (P1)/(P2)         |
| R2 | 0.36                                                     | PAN 70 HBC + 3/71 |

REFERENCES FOR  $\Sigma(1480)$  (PROD. EXP.)

|                        |                                      |
|------------------------|--------------------------------------|
| PAN 70 PR D2, 49       | +FORMAN, KO, HAGOPIAN, SELOVE (PENN) |
|                        | PAPERS NOT REFERRED TO IN DATA CARDS |
| YU-LI PA 69 PRL 23 806 | YU-LI PAN, F L FORMAN (PENN) I       |
| YU-LI PA 69 PRL 23 808 | YU-LI PAN, F L FORMAN (PENN) I       |
| MILLER 70 DUKE 229     | D H MILLER (REVIEW TALK) (PURDUE)    |
| HANSON 71 PR D4 1296   | +KALMUS, LOUIE (LRL) I               |

Note on  $\Sigma(1620)$ 

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction  $\bar{K}^0 n \rightarrow \Sigma(1620)^+ \pi^- \pi^+$  with  $\Sigma(1620)^+$  decaying into  $\Lambda \pi^+$ . Since then there have been conflicting reports about this state. A good review of the production experiments has been recently given by MILLER 70. We summarize here the situation.

**Formation Experiments.** Several partial-wave analyses have found evidence for one or two fairly narrow ( $\Gamma \sim 50$  MeV)  $I = 1$ ,  $J = 1/2$  states within  $\sim 50$  MeV of the effect seen in production. It is not clear at present how many such states really exist. No one has reported a strong coupling of any of these states to  $\bar{K}N$ , but there is much disagreement about

## Data Card Listings

For notation, see key at front of Listings.

Baryons  
 $\Sigma(1620)$ 

branching ratios into  $\Lambda\pi$  and  $\Sigma\pi$ . We summarize below the results of several recent partial-wave analyses (see the note on  $Y^*$ 's for a discussion of the methods of analysis).

$S_{11}$ : Both KIM 71 and LANGBEIN 72 report an  $S_{11}$  state near 1620 MeV with  $\Gamma \sim 50$  MeV, but KIM 71 finds  $\Lambda\pi$  to be the dominant two-body decay mode while LANGBEIN 72 finds the  $\Sigma\pi$  mode dominant. ARMENTEROS 70 report no  $S_{11}$  state in any channel in this mass region. VAN HORN 72 finds a 66-MeV-wide  $S_{11}$  state at 1697 MeV in his energy-dependent fits to the  $\Lambda\pi$  channel, and a 50-MeV-wide state at 1655 MeV in five out of seven of his Barrelet ambiguous solutions.

$P_{11}$ : A 50-MeV-wide  $P_{11}$  state in the 1500-1600 MeV mass region of the  $\Sigma\pi$  channel was reported by ARMENTEROS 70 with no corresponding effect in  $\Lambda\pi$  and  $\bar{K}N$ . KIM 71 claims a  $P_{11}$  state at 1670 MeV with  $\Gamma = 50$  MeV, a dominant  $\Sigma\pi$  two-body decay mode, and vanishing coupling to  $\Lambda\pi$ . LANGBEIN 72 reports no  $P_{11}$  resonance. VAN HORN 72 saw a very broad,  $\Gamma = 230$  MeV,  $P_{11}$  resonance at 1668 MeV in his energy-dependent fits to the  $\Lambda\pi$  channel, but a fairly narrow,  $\Gamma = 60$  MeV, resonance at about the same mass in all of his Barrelet ambiguous solutions.

Production experiments. Here the evidence is only in the  $\Lambda\pi$  channel. The BNL-CCNY collaboration, with increased data, CRENNELL 69, still claim the effect in the  $\Lambda\pi$  channel (no evidence seen in  $\bar{K}N$  or  $\bar{K}N\pi$ ). SABRE 70 studied the same reaction at 3.0 GeV/c with comparable statistics and do not see any evidence for it in the  $\Lambda\pi$  channel; on the contrary, they believe it to be a spurious peak resulting from misidentified  $\Sigma^0$  from the production of  $\Sigma(1670)$  decaying into  $\Sigma^0\pi^+$ . CRENNELL 69 give counter arguments to show that this is not the case in their data and the controversy goes on. AMMANN 70 studied the same reaction at 4.5 GeV/c and report a state at 1640 MeV, again decaying only into  $\Lambda\pi$  (no evidence seen in  $\Sigma\pi$  or  $\bar{K}N$  channels). The closeness of this mass to 1670 MeV is suggestive that this effect may be related to what goes on in that region (see discussion below).

In conclusion, for  $\Sigma(1620)$  we have to wait for more data and for a complete understanding of the entire mass region 1600 to 1700 MeV. The hope is

that the determination of quantum numbers for each of these effects for each decay mode may eventually clarify the situation.

 $\Sigma(1620)$  $S'_{11}$ 32  $Y^*(1620, JP=1/2-)$   $I=1$ 

THE  $S_{11}$  STATE AT 1697 MEV REPORTED BY VANHORN72 IS INTERMEDIATE IN MASS BETWEEN THE  $\Sigma(1620)$  AND  $\Sigma(1750)$ . WE TENTATIVELY LIST IT UNDER  $\Sigma(1750)$ .

| 32 $Y^*(1620)$ MASS (MEV)          |             |                                        |          |          |                        |
|------------------------------------|-------------|----------------------------------------|----------|----------|------------------------|
| M                                  | (1620.)     |                                        | KIM      | 71 DPWA  | K-MATRIX ANAL.         |
| M                                  | 1630.0      | (10.0)                                 | LANGBEIN | 72 IPWA  | MULTICHANNEL           |
| 32 $Y^*(1620)$ WIDTH (MEV)         |             |                                        |          |          |                        |
| M                                  | (40.)       |                                        | KIM      | 71 DPWA  | K-MATRIX ANAL.         |
| M                                  | 65.0        | (20.0)                                 | LANGBEIN | 72 IPWA  | MULTICHANNEL           |
| 32 $Y^*(1620)$ PARTIAL DECAY MODES |             |                                        |          |          |                        |
| P1                                 | $Y^*(1620)$ | INTO $\bar{K}B\bar{N}$                 |          |          | DECAY MASSES           |
| P2                                 | $Y^*(1620)$ | INTO $\Sigma\pi$                       |          |          | 497+ 939               |
| P3                                 | $Y^*(1620)$ | INTO $\Lambda\pi$                      |          |          | 1197+ 139              |
|                                    |             |                                        |          |          | 1115+ 134              |
| 32 $Y^*(1620)$ BRANCHING RATIOS    |             |                                        |          |          |                        |
| R1                                 | $Y^*(1620)$ | INTO $\bar{K}B\bar{N}$                 |          | (P1)     |                        |
| R1                                 | (0.05)      |                                        | KIM      | 71 DPWA  | K-MATRIX ANAL.         |
| R1                                 | 0.05        | OR LESS                                | WONG     | 71 DPWA  | K-+P- $\Lambda\pi$ +P1 |
| R1                                 | 0.22        | (0.02)                                 | LANGBEIN | 72 IPWA  | MULTICHANNEL           |
| R1                                 |             | K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) |          | REQUIRES | NO RESONANCE           |
| R2                                 | $Y^*(1620)$ | FROM $\bar{K}B\bar{N}$ TO $\Sigma\pi$  |          |          | DECAY MASSES           |
| R2                                 | (0.08)      |                                        | KIM      | 71 DPWA  | 497+ 939               |
| R2                                 | 0.40        | (0.06)                                 | LANGBEIN | 72 IPWA  | 1197+ 139              |
| R3                                 | $Y^*(1620)$ | FROM $\bar{K}B\bar{N}$ TO $\Lambda\pi$ |          |          | 1115+ 134              |
| R3                                 | (0.15)      |                                        | KIM      | 71 DPWA  | K-MATRIX ANAL.         |

| REFERENCES FOR $Y^*(1620)$ |    |            |           |  |           |
|----------------------------|----|------------|-----------|--|-----------|
| KIM                        | 71 | PRL 27 356 | J K KIM   |  | (HARV)IJP |
| ALSO                       | 70 | DUKE 161   | J. K. KIM |  | (HARV)IJP |
| WONG                       | 71 | NC 2A 353  | N S WONG  |  | (YALE)IJP |
| LANGBEIN                   | 72 | NP 847 477 | +WAGNER   |  | (MPI)IJP  |

PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN 72 LBL-1370 (THESIS) /LBL IJP

 $\Sigma(1620)$  $P'_{11}$ 79  $Y^*(1620, JP=1/2-)$   $I=1$ SEE THE MINI-REVUE AT THE START OF THE  $Y^*$  LISTINGS.

THE PARTIAL-WAVE ANALYSIS OF  $\bar{K}-N$  TO  $\Sigma\pi$  BY ARMENTEROS 70 SUGGESTS SUCH A RESONANCE. KIM 71 FINDS A SIGNAL IN BOTH  $\bar{K}B\bar{N}$  AND  $\Sigma\pi$ .

| 79 $Y^*(1620)$ MASS (MEV)          |                |                                       |               |         |                               |
|------------------------------------|----------------|---------------------------------------|---------------|---------|-------------------------------|
| M                                  | 1500. -- 1600. |                                       | ARMENTEROS 70 | HDSC    | -O $\bar{K}-N$ TO $\Sigma\pi$ |
| M                                  | (1670.)        |                                       | KIM           | 71 DPWA | K-MATRIX ANAL.                |
| M                                  | 1668.          | (.25)                                 | VANHORN       | 72 DPWA | O $\bar{K}-P$ TO $\Lambda\pi$ |
| 79 $Y^*(1620)$ WIDTH (MEV)         |                |                                       |               |         |                               |
| M                                  | (50.0)         |                                       | ARMENTEROS 70 | HDSC    | -O $\bar{K}-N$ TO $\Sigma\pi$ |
| M                                  | (50.)          |                                       | KIM           | 71 DPWA | K-MATRIX ANAL.                |
| M                                  | 230.           | (165.) (60.)                          | VANHORN       | 72 DPWA | O $\bar{K}-P$ TO $\Lambda\pi$ |
| 79 $Y^*(1620)$ PARTIAL DECAY MODES |                |                                       |               |         |                               |
| P1                                 | $Y^*(1620)$    | INTO $\bar{K}B\bar{N}$                |               |         | DECAY MASSES                  |
| P2                                 | $Y^*(1620)$    | INTO $\Sigma\pi$                      |               |         | 497+ 939                      |
| P3                                 | $Y^*(1620)$    | INTO $\Lambda\pi$                     |               |         | 1197+ 139                     |
|                                    |                |                                       |               |         | 1115+ 139                     |
| 79 $Y^*(1620)$ BRANCHING RATIOS    |                |                                       |               |         |                               |
| R1                                 | $Y^*(1620)$    | FROM $\bar{K}B\bar{N}$ TO $\Sigma\pi$ |               |         | DECAY MASSES                  |
| R1                                 | (+0.2)         |                                       | ARMENTEROS 70 | HDSC    | -O $\bar{K}-N$ TO $\Sigma\pi$ |
| R1                                 | (0.24)         |                                       | KIM           | 71 DPWA | K-MATRIX ANAL.                |
| R2                                 | $Y^*(1620)$    | INTO $\bar{K}B\bar{N}$                |               | (P1)    |                               |
| R2                                 | (0.14)         |                                       | KIM           | 71 DPWA | K-MATRIX ANAL.                |

# Baryons

## $\Sigma(1620)$ , $\Sigma(1670)$

# Data Card Listings

For notation, see key at front of Listings.

R3 Y\*(1620) FROM K $\bar{B}$ AR N TO LAMBDA PI SORT(P1\*P3)  
R3 10.0) KIM 71 DPWA K-MATRIX ANAL. 2/73\*  
R3 .12 (.12) (.04) VANHORN 72 DPWA O K- P TO LAM P10 2/73\*

### REFERENCES FOR Y\*(1620)

ARMENTER 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN, HEIDEL) IJP  
KIM 71 PRL 27 356 J. K. KIM (HARV) IJP  
ALSO 70 DUKE 161 J. K. KIM (HARV) IJP  
VANHORN 72 LBL-1370 (THESIS) (LBL) IJP

## $\Sigma(1620)$ BUMPS

78 Y\*(1620, JP=) I=1 PRODUCTION EXPERIMENTS  
SEE THE MINI-REVUE AT THE START OF THE Y\* LISTINGS.

THIS RESONANCE NEEDS CONFIRMATION. THE RESULTS OF CRENNELL 69 AT 3.9 GEV/C ARE NOT CONFIRMED BY THE SABRE COLLABORATION AT 3.0 GEV/C (SABRE 70). HOWEVER IN AN EXPERIMENT AT 4.5 GEV/C, AMMANN 70 SEE A PEAK AT 1642 MEV WHICH ON THE BASIS OF BRANCHING RATIOS THEY DO NOT ASSOCIATE WITH THE Y\*(1670). SEE MILLER 70 FOR A REVIEW OF THESE CONFLICTS.  
THERE WAS AN INDICATION OF A Y\*(1610) IN AN EARLY PHASE-SHIFT ANALYSIS OF K $\bar{P}$  TO LAMBDA PI. HOWEVER MORE DETAILED ANALYSIS OF MORE EXTENSIVE DATA BY THE SAME (CERN, HEIDELBERG, SACLAY) GROUP FAILED TO CONFIRM THIS RESULT. THEY NOW SEE IT IN THE SIGMA PI CHANNEL (SEE PREVIOUS ENTRY). OLD LAMBDA PI ANALYSIS LISTED AS ARMENTEROS 68, NEW ANALYSIS AS ARMENTEROS 70.

### 78 Y\*(1620) MASS (MEV) (PROD. EXP.)

| M | N | (1616.0)                                                       | (8.0)  | CRENNELL 68 DBC  | K-D 3.9 GEV/C                                | 11/68 |
|---|---|----------------------------------------------------------------|--------|------------------|----------------------------------------------|-------|
| M | N | EVENTS OF CRENNELL 68 ARE IN THE LARGER SAMPLE OF CRENNELL 69. |        |                  |                                              |       |
| M | N | 20 1618.0                                                      | 3.0    | BLUMENFEL 69 HBC | + K-O LONG + PROTON                          | 9/69  |
| M | N | 1619.0                                                         | 8.0    | CRENNELL 69 DBC  | + K-N TO LAM 3 PI                            | 9/69  |
| M | N | 1642.0                                                         | 12.0   | AMMANN 70 DBC    | K-P 4.5 GEV/C                                | 6/70  |
| M | N | AVG                                                            | 1619.4 | 3.8              | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) |       |

### 78 Y\*(1620) WIDTH (MEV) (PROD. EXP.)

| M | N | (66.0) | (16.0) | CRENNELL 68 DBC | SEE NOTE N ABOVE                             | 11/68           |
|---|---|--------|--------|-----------------|----------------------------------------------|-----------------|
| M | N | 20     | 72.0   | 22.0            | 15.0                                         | CRENNELL 69 DBC |
| M | N | 55.0   | 24.0   | AMMANN 70 DBC   | K-P 4.5 GEV/C                                | 6/70            |
| M | N | AVG    | 41.3   | 12.2            | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5) |                 |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

### 78 Y\*(1620) PARTIAL DECAY MODES (PROD. EXP.)

| P1 | Y*(1620) INTO K $\bar{B}$ AR N | DECAY MASSES   |
|----|--------------------------------|----------------|
| P2 | Y*(1620) INTO LAMBDA PI        | 497+ 939       |
| P3 | Y*(1620) INTO Y*(1385) PI      | 1115+ 139      |
| P4 | Y*(1620) INTO LAMBDA PI PI     | 1384+ 139      |
| P5 | Y*(1620) INTO SIGMA PI         | 1115+ 139+ 139 |
| P6 | Y*(1620) INTO Y*(0(1405) PI    | 1197+ 139      |
|    |                                | 1405+ 139      |

### 78 Y\*(1620) BRANCHING RATIOS (PROD. EXP.)

| R1 | Y*(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)     | (P4)/(P3)        |
|----|----------------------------------------------|------------------|
| R1 | 14 (2.5) APPROX                              | BLUMENFEL 69 HBC |
| R2 | Y*(1620) INTO (K $\bar{B}$ AR N)/(LAMBDA PI) | (P1)/(P2)        |
| R2 | (0.0) (0.1)                                  | CRENNELL 68 DBC  |
| R2 | 0.4                                          | AMMANN 70 DBC    |
| R3 | Y*(1620) INTO LAMBDA PI                      | (P2)             |
| R3 | LARGE                                        | CRENNELL 68 DBC  |
| R4 | Y*(1620) INTO (Y*(1385) PI)/(LAMBDA PI)      | (P3)/(P2)        |
| R4 | (0.2) (0.1)                                  | CRENNELL 68 DBC  |
| R4 | (0.3) OR LESS CL=95                          | AMMANN 70 DBC    |
| R5 | Y*(1620) INTO (SIGMA PI)/(LAMBDA PI)         | (P5)/(P2)        |
| R5 | (1.1)(95 PC UPPER LIMIT)                     | AMMANN 70 DBC    |
| R6 | Y*(1620) INTO (Y*(0(1405) PI)/(LAMBDA PI)    | (P6)/(P2)        |
| R6 | 0.7                                          | AMMANN 70 DBC    |

### REFERENCES FOR Y\*(1620) (PROD. EXP.)

CRENNELL 68 PRL 21 648 \*DELANEY, FLAMINIO, KARSHON, + (BNL, CUNY) I  
BLUMENFEL 69 PL 298 58 BLUMENFEL, KALBELEISCH (BNL) I  
CRENNELL 69 LUND PAPER 183 \*KARSHON, LI, ONEIL, SCARR, + (BNL, CUNY) I  
RESULTS ARE QUOTED IN LEVI SETTI 69.

AMMANN 70 PRL 24 327 + GARFINKEL, CARMONY, GUTAY, + (PURDUE, IND)

PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP 88 183 ARMENTEROS, BAILLON + (CERN+HEID+SACL)  
LEVISETT 69 LUND CONF R LEVI SETTI (RAPPORTEUR) EFINS  
TRIPP 69 UCRL 19361 R D TRIPP (LBL)  
ARMENTER 70 DUKE 123 ARMENTEROS, BAILLON + (CERN+HEID+SACL)  
MILLER 70 DUKE 229 D H MILLER (REVIEW TALK) (PURDUE)  
SABRE 70 NP 816 201 SABRE COLLAB. (SACL, AMST, BGNA, REMO, EPOL)

## Note on $\Sigma(1670)$

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into  $\bar{K}N$  (7-10%),  $\Lambda\pi$  (10-15%),  $\Sigma\pi$  (30-50%),  $\Sigma\pi\pi$  (5-15%), and some  $\Lambda\pi\pi$  (the experimental situation here is unclear). Its quantum numbers are  $J^P = 3/2^-$ .

Production experiments are more confused.

When determined, the most likely quantum numbers are also  $3/2^-$  [for  $\Sigma\pi$  and  $\Lambda(1405)\pi$ ]. The measured branching ratio  $R = \Sigma\pi/\Sigma\pi\pi$  changes with the momentum transfer to the proton. This was first observed by EBERHARD 69 who suggested the existence of  $2 Y_1^*$  with the same mass and quantum numbers; one object with a large  $\Sigma\pi\pi$  [mainly  $\Lambda(1405)\pi$ ] decay mode produced peripherally, and another one with a large  $\Sigma\pi$  decay mode produced at larger angles. This observation has now been confirmed by AGUILAR-BENITEZ 70.

The other difficulty comes from the different  $\Lambda\pi/\Sigma\pi$  branching ratios reported by the various experiments. Those experiments done with  $K^-$  beams below 2 GeV/c (HUWE 64 and BUTTON-SHAFFER 68) report values for the  $\Lambda\pi/\Sigma\pi$  ratio in agreement with formation experiments; the others report a higher  $\Lambda\pi/\Sigma\pi$  ratio. Therefore, the possibility of a third  $Y_1^*$  state, referred to as  $\Sigma(1690)$  in the Data Card Listings, with a large  $\Lambda\pi/\Sigma\pi$  branching ratio still exists. This large branching ratio is the main justification for this hypothesis and needs confirmation. It relies on the separation between  $K^-p \rightarrow \Lambda\pi^+\pi^-$  and  $K^-p \rightarrow \Sigma^0\pi^+\pi^-$ , which is experimentally difficult at high energy. These problems are reviewed by MILLER 70.

Two resonances of the same spin and parity have been hypothesized by EBERHARD 69 as the origin of much of the complexity observed in the 1600 to 1700 MeV region in production experiments. See also the note on  $\Sigma(1620)$ .

## $\Sigma(1670)$

44 Y\*(1670, JP=3/2-) I=1

D<sub>13</sub>

SEE THE MINI-REVUE AT THE START OF THE Y\* LISTINGS.

SEE NOTE ABOVE

WELL ESTABLISHED RESONANCE. IT HAS BEEN SEEN IN BOTH FORMATION AND PRODUCTION EXPERIMENTS. HOWEVER THE BRANCHING RATIOS OBTAINED BY THESE TWO METHODS SHOW LARGE INCONSISTENCIES.

SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

AS FOR THE QUANTUM NUMBERS, THE ANALYSES OF LAMBDA PI CHANNEL (IN FORMATION EXP.) AS WELL AS THE SIGMA PI CHANNEL AGREE ON JP=3/2-.

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Sigma(1670)$ 

## 44 Y\*(1670) MASS (MEV)

|   |          |        |          |         |                    |        |
|---|----------|--------|----------|---------|--------------------|--------|
| M | 1660.0   |        | BERLEY   | 64 HBC  | 0 K-P TO LAM P10   | 7/66   |
| M | 1661.0   | (5.1)  | ARMENTER | 68 HBC  | 0 K-P ELAS.+CH.EX. | 11/68  |
| M | (1661.0) | (2.0)  | ARMENTE2 | 68 HBC  | 0 K-P TO SIGMA PI  | 11/68  |
| M | 1680.    |        | ARMENTE4 | 69 DBC  | K-N TO SIG- P10    | 12/68  |
| M | 1663.0   | (2.0)  | ARMENT-5 | 69 HBC  | 0 K-P TO SIGMPI ED | 9/69   |
| M | 1672.0   |        | BERLEY   | 69 HBC  | K-P TO SIG P1      | 5/70   |
| M | 1660.    |        | ARMENTER | 70 HBC  | 0 K-P TO LAM.PI EI | 5/70   |
| M | 1681.0   | (3.0)  | BRUCKER  | 70 DBC  | K-N TO SIG 2PI     | 10/71  |
| M | 1662.0   | (5.0)  | GALTIERI | 70 HBC  | 0 SIG PI,EDPWA     | 7/70   |
| M | 1665.    | (10.1) | GALTIERI | 70 HBC  | 0 LAM. PI, EDPWA   | 7/70   |
| M | 1676.    | (2.1)  | BUDGEN   | 71 DPWA | LAM P10,CHS DATA   | 10/71  |
| M | 1670.    |        | KIM      | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M | 1675.0   | (15.0) | LANGBEIN | 72 IPWA | MULTICHANNEL       | 12/72* |
| M | 1659.    | (12.1) | VANHORN  | 72 DPWA | 0 K- P TO LAM P10  | 2/73*  |

## 44 Y\*(1670) WIDTH (MEV)

|   |        |        |          |         |                    |        |
|---|--------|--------|----------|---------|--------------------|--------|
| W | 60.0   |        | BERLEY   | 64 HBC  | 0                  | 7/66   |
| W | 56.0   | (18.1) | ARMENTER | 68 HBC  | 0 K-P ELAS.+CH.EX. | 11/68  |
| W | (44.0) | (4.0)  | ARMENTE2 | 68 HBC  | 0 K-P TO SIGMA PI  | 11/68  |
| W | 47.0   |        | ARMENTE4 | 69 DBC  | K-N TO SIG- P10    | 12/68  |
| W | 49.0   | (4.0)  | ARMENT-5 | 69 HBC  | 0 K-P TO SIGMPI ED | 9/69   |
| W | 34.0   |        | BERLEY   | 69 HBC  | 0                  | 5/70   |
| W | 50.    |        | ARMENTER | 70 HBC  | 0 K-P TO LAMB.PI   | 5/70   |
| W | 30.0   | (10.0) | BRUCKER  | 70 DBC  | 0 K-P TO SIG 2PI   | 10/71  |
| W | 48.0   | (5.0)  | GALTIERI | 70 HBC  | 0 SIG PI,EDPWA     | 7/70   |
| W | 50.    | (10.1) | GALTIERI | 70 HBC  | 0 LAM. PI, EDPWA   | 7/70   |
| W | 59.    | (4.5)  | BUDGEN   | 71 DPWA | LAM P10            | 10/71  |
| W | 40.    |        | KIM      | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| W | 65.0   | (20.0) | LANGBEIN | 72 IPWA | MULTICHANNEL       | 12/72* |
| W | 32.    | (11.1) | VANHORN  | 72 DPWA | 0 K- P TO LAM P10  | 2/73*  |

## 44 Y\*(1670) PARTIAL DECAY MODES

|    |                            | DECAY MASSES   |
|----|----------------------------|----------------|
| P1 | Y*(1670) INTO KBAR N       | 497+ 939       |
| P2 | Y*(1670) INTO LAMBDA PI    | 1115+ 139      |
| P3 | Y*(1670) INTO SIGMA PI     | 1197+ 139      |
| P4 | Y*(1670) INTO LAMBDA PI PI | 1115+ 139+ 139 |
| P5 | Y*(1670) INTO SIGMA PI PI  | 1197+ 139+ 139 |
| P6 | Y*(1670) INTO Y*(1385) PI  | 1384+ 139      |
| P7 | Y*(1670) INTO Y*(1405) PI  | 1405+ 139      |

## 44 Y\*(1670) BRANCHING RATIOS

|      |                                                                     |                  |                            |
|------|---------------------------------------------------------------------|------------------|----------------------------|
| R1   | Y*(1670) INTO (KBAR N)/TOTAL                                        | (P1)             |                            |
| R1   | (0.09) (0.02)                                                       | ARMENTER 68 HBC  | 9/69                       |
| R1   | 0.08 (0.02)                                                         | ARMENT-5 69 HBC  | 0 ELAS. +CH.EX. ED 9/69    |
| R1   | 0.07                                                                | KIM 71 DPWA      | K-MATRIX ANAL. 3/71        |
| R1   | 0.10 (0.03)                                                         | LANGBEIN 72 IPWA | MULTICHANNEL 12/72         |
| R2   | Y*(1670) INTO (LAMBDA PI P1)/TOTAL                                  | (P4)             |                            |
| R2   | (0.11) OR LESS                                                      | ARMENTE3 68 HBC  | K-P (P1=.09) 9/69          |
| R3   | Y*(1670) INTO (SIGMA PI P1)/TOTAL                                   | (P5)             |                            |
| R3 A | (0.14) OR LESS                                                      | ARMENTE3 68 HBC  | K-P AND D-P1=.09 11/68     |
| R3 A | RATIO ONLY FOR (SIG2PI) SYSTEM IN J=1, WHICH CANNOT BE Y*(1385)     |                  | 11/68                      |
| R4   | Y*(1670) INTO (Y*(1405) PI)/TOTAL                                   | (P7)             |                            |
| R4   | (0.06) OR LESS                                                      | ARMENTE3 68 HBC  | K-P AND D-P1=.09 11/68     |
| R5   | Y*(1670) FROM KBAR N TO LAMBDA PI                                   | SORT(P1*P2)      |                            |
| R5   | +0.1                                                                | ARMENTER 70HBC   | K-P TO LAMB PI 5/70        |
| R5   | +0.09 (0.02)                                                        | GALTIERI 70 HBC  | 0 LAM. PI, EDPAW 7/70      |
| R5   | +0.165 (1.01)                                                       | BUDGEN 71 DPWA   | LAM P10 10/71              |
| R5   | 0.08                                                                | KIM 71 DPWA      | K-MATRIX ANAL. 3/71        |
| R5   | 0.13 (0.03)                                                         | LANGBEIN 72 IPWA | MULTICHANNEL 12/72         |
| R5   | +0.09 (1.02)                                                        | VANHORN 72 DPWA  | 0 K- P TO LAM P10 2/73     |
| R6   | Y*(1670) FROM KBAR N TO SIGMA PI                                    | SORT(P1*P3)      |                            |
| R6   | (+0.21) (0.01)                                                      | ARMENTE2 68 HBC  | 0 OLD DATA 11/68           |
| R6   | +0.19                                                               | ARMENTE4 69 DBC  | 9/69                       |
| R6   | +0.20 (0.01)                                                        | ARMENT-5 69 HBC  | 0 NEW DATA 9/69            |
| R6   | +0.18                                                               | BERLEY 69 HBC    | 5/70                       |
| R6   | +0.18 (0.06)                                                        | GALTIERI 70 HBC  | 0 SIG PI,EDPAW 7/70        |
| R6   | 0.15                                                                | KIM 71 DPWA      | K-MATRIX ANAL. 3/71        |
| R6   | 0.23 (0.05)                                                         | LANGBEIN 72 IPWA | MULTICHANNEL 12/72         |
| R7   | Y*(1670) FROM KBAR N TO Y*(1385) PI                                 | SORT(P1*P6)      |                            |
| R7 S | (0.17) (0.02)                                                       | SIMS 68 DBC      | = LAM 2PI CROSS. SEC 10/71 |
| R7 S | SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY |                  | 3/72                       |
| R8   | Y*(1670) INTO (Y*(1405)PI)/(KBAR N)/TOTAL**2                        | (P7*P1)          |                            |
| R8   | (0.03) OR LESS                                                      | BERLEY 69 HBC    | 0 K-P .6-.82 BEV/C 5/70    |
| R8 B | 0.007 (0.02)                                                        | BRUCKER 70 DBC   | = K-N TO SIG 2PI 10/71     |
| R8 B | ASSUMING Y*(1405) PI CROSS SECTION BUMP DUE SOLELY TO 3/2- RESON.   |                  | 10/71                      |
| R9   | Y*(1670) INTO (Y*(1405) PI)/(Y*(1385) PI)                           | (P7)/(P6)        |                            |
| R9   | 0.23 (0.08)                                                         | BRUCKER 70 DBC   | = K-N TO SIG 2PI 10/71     |

## REFERENCES FOR Y\*(1670)

|                             |                                             |                       |
|-----------------------------|---------------------------------------------|-----------------------|
| BERLEY 64 DUBNA CONF I 565  | +CONNOLLY,HART,RAHM,STONEHILL, +            | (BNL)JJP              |
| ARMENTER 68 NP 88 195       | ARMENTEROS,BAILLON +                        | (CERN+HEID+SACLAY)JJP |
| ARMENTE1 68 NP 88 183       | ARMENTEROS,BAILLON +                        | (CERN+HEID+SACLAY)JJP |
| ARMENTE2 68 NP 88 223       | ARMENTEROS,BAILLON +                        | (CERN+HEID+SACLAY)JJP |
| ARMENTE3 68 PL 286 521      | ARMENTEROS,BAILLON +                        | (CERN+HEID+SACLAY)JJP |
| SIMS 68 PRL 21 1413         | SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU,TUFT,BRAN) |                       |
| ARMENTE4 69 NP 810 459      | ARMENTEROS,BAILLON,MINTEN +                 | (CERN+SACLAY)JJP      |
| ARMENT-5 69 NP 814 91       | ARMENTEROS,BAILLON, (CERN,HEIDEL,SACLAY)JJP |                       |
| BERLEY 69 PL 308 430        | BERLEY,HART,RAHM,WILLIS,YAMAMOTO            | (BNL)                 |
| ARMENTER 70 DUKE 123        | ARMENTEROS,BAILLON, +                       | (CERN,HEID)           |
| BRUCKER 70 DUKE 155         | +HARRISON,SIMS,ALBRIGHT,CHANDLER+ (FSU)     |                       |
| GALTIERI 70 DUKE 175        | A. BARBARO GALTIERI                         | (LRL)JJP              |
| BUDGEN 71 LNC 2 85          | D BUDGEN                                    | (DURHAM)JJP           |
| KIM 71 PRL 27 356           | J. K. KIM                                   | (HARV)JJP             |
| ALSO 70 DUKE 161            | +WAGNER                                     | (MPI)JJP              |
| LANGBEIN 72 NP 847 477      |                                             | /LBL JJP              |
| VANHORN 72 LBL-1370(THESIS) |                                             |                       |

## PAPERS NOT REFERRED TO IN DATA CARDS

BASTIEN1 63 PRL 10 188 P L BASTIEN, J P BERGE (LRL) IJ  
 REPLACED BY BASTIEN 2, BUT SIMILAR AND MORE READILY AVAILABLE.  
 BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN (LRL) IJ  
 T-ZADEH 63 PRL 11 470 TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+ (UCLA) JP  
 SEE NOTE FOLLOWING SCHLEIN 66.  
 SCHLEIN 66 UCLA-1016 P.E. SCHLEIN, T.G. TRIPPE (UCLA) JP  
 REANALYSES DATA OF TAHER-ZADEH 63, BASTIEN 63 AND ALL PUBLISHED  
 LAMBDA PI CROSS SECTION DATA IN THE LIGHT OF THE NOW KNOWN  
 Y\*(1765). REVERSES THE MODEL-DEPENDENT CONCLUSION OF TAHER-  
 ZADEH ON THE DEFERRED JP ASSIGNMENT (FROM 3/2+ TO 3/2-). (2-1.)  
 SMART 66 PRL 17 556 W M SMART, A KERNAN, G E KALMUS, R P ELY (LRL)JJP  
 ARMENTER 67 NP 83 592 ARMENTEROS,FERRO-LUZZI+ (CERN,HEID,SACLAY)  
 PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

 $\Sigma(1670)$   
BUMPS

## 51 Y\*(1670, JP= ) I=1 PRODUCTION EXPERIMENTS

SEE NOTE PRECEDING Y\*(1670)  
 PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME  
 QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA  
 PI, THE OTHER INTO Y\*(1405) PI. BRANCHING RATIOS NOT  
 DISENTANGLED YET, WE LIST THEM TOGETHER FOR NOW.

## 51 Y\*(1670) MASS (MEV) (PROD. EXP.)

|   |                                                              |       |           |         |                    |
|---|--------------------------------------------------------------|-------|-----------|---------|--------------------|
| M | (1685.0)                                                     |       | ALEXANDER | 62 HBC  | 0 P1-P 2-2.2 BEV/C |
| M | 1660.0                                                       | 10.0  | ALVAREZ   | 63 HBC  | + K-P 1.51 BEV/C   |
| M | (1665.0)                                                     | (5.0) | BUGG      | 68 CNTR | K-P, D TOTAL C.S.  |
| M | P 70(1661.1)                                                 | (9.1) | PRIMER    | 68 HBC  | + K-P 4.6-5. GEV/C |
| M | P SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA) |       | AGUILAR   | 70 HBC  | SIG-PI K-P 4 GEV   |
| M | 1670.0                                                       | 6.0   | AGUILAR   | 70 HBC  | SIG-2PI K-P 4GEV   |
| M | 1668.0                                                       | 10.0  | AGUILAR   | 70 HBC  | SIG-2PI K-P 4GEV   |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)                     |       |           |         |                    |

## 51 Y\*(1670) MASS (MEV) (PRCD. EXP.)

|   |                                          |        |           |         |                    |
|---|------------------------------------------|--------|-----------|---------|--------------------|
| W | (45.0)                                   |        | ALEXANDER | 62 HBC  | -0                 |
| W | 40.0                                     | 10.0   | ALVAREZ   | 63 HBC  | +                  |
| W | (30.0)                                   | (15.0) | BUGG      | 68 CNTR | + K-P 4.6-5. GEV/C |
| W | P 70 (60.1)                              | (20.1) | PRIMER    | 68 HBC  | + K-P 4.6-5. GEV/C |
| W | 110.0                                    | 12.0   | AGUILAR   | 70 HBC  | SIG-PI K-P 4 GEV   |
| W | 135.0                                    | 40.0   | AGUILAR   | 70 HBC  | SIG-2PI K-P 4GEV   |
| W | AVERAGE MEANINGLESS (SCALE FACTOR = 3.4) |        |           |         |                    |

## 51 Y\*(1670) PARTIAL DECAY MODES (PROD. EXP.)

|    |                            | DECAY MASSES   |
|----|----------------------------|----------------|
| P1 | Y*(1670) INTO KBAR N       | 497+ 939       |
| P2 | Y*(1670) INTO LAMBDA P1    | 1115+ 139      |
| P3 | Y*(1670) INTO SIGMA P1     | 1197+ 139      |
| P4 | Y*(1670) INTO LAMBDA P1 P1 | 1115+ 139+ 139 |
| P5 | Y*(1670) INTO SIGMA P1 P1  | 1197+ 139+ 139 |
| P6 | Y*(1670) INTO Y*(1385) P1  | 1384+ 139      |
| P7 | Y*(1670) INTO Y*(1405) P1  | 1405+ 139      |

## 51 Y\*(1670) BRANCHING RATIOS (PROD. EXP.)

| R1   | Y*(1670) INTO (KBAR N)/(SIGMA PI)                                  | (P1)/(P3)       |
|------|--------------------------------------------------------------------|-----------------|
| R1   | 0 (0.19) OR LESS                                                   | ALVAREZ 63 HBC  |
| R1   | (0.51)- .25 OR MORE                                                | SMITH 63 HBC    |
| R1   | (0.6) OR LESS                                                      | LONDON 66 HBC   |
| R1   | (0.025)                                                            | BUGG 68 CNTR    |
| R1   | 0 (0.24) OR LESS                                                   | PRIMER 68 HBC   |
| R1   | (0.26) OR LESS                                                     | BARNES 69 HBC   |
| R1   | (0.2) OR LESS                                                      | AGUILAR 70 HBC  |
| R2   | Y*(1670) INTO (LAMB.PI)/(SIG PI)                                   | (P2)/(P3)       |
| R2   | 130 (1.20)                                                         | ALVAREZ 63 HBC  |
| R2   | (1.2)                                                              | SMITH 63 HBC    |
| R2   | 0.15                                                               | HUME 64 HBC     |
| R2   | 0.6 OR LESS                                                        | LONDON 66 HBC   |
| R2   | 33 0.11 0.06                                                       | BUTTON-S 68 HBC |
| R2 P | 0 (0.1)                                                            | PRIMER 68 HBC   |
| R2 P | PRIMER 68 ASSUMED THIS DECAY TO BE ALL Y*(1690)- SEE BARNES 69 FOR |                 |
| R2 P | NEW INTERPRETATION OF DATA.(3 TIMES MORE DATA)                     |                 |
| R2   | 0.45 0.15                                                          | BARNES 69 HBC   |
| R2   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)                           |                 |

| R3   | Y*(1670) INTO (LAMB. PI P1)/(SIG PI)       | (P4)/(P3)         |
|------|--------------------------------------------|-------------------|
| R3   | 90 (0.56)                                  | ALVAREZ 63 HBC    |
| R3   | (0.17)                                     | SMITH 63 HBC      |
| R3   | (0.6) OR LESS                              | LONDON 66 HBC     |
| R4   | Y*(1670) INTO (SIGMA PI P1)/(SIG PI)       | (P5)/(P3)         |
| R4   | 180 (0.56)                                 | ALVAREZ 63 HBC    |
| R5   | Y*(1670) INTO (Y*(1405) PI)/(SIG PI)       | (P7)/(P3)         |
| R5   | 50 1.4                                     | LONDON 66 HBC     |
| R5 P | 17 (0.58) (0.20)                           | PRIMER 68 HBC     |
| R6   | Y*(1670) INTO (SIGMA PI)/(SIGMA PI P1)     | (P3)/(P5)         |
| R6   | .4 OR LESS                                 | BIRMINGHAM 66 HBC |
| R6   | 0.30 0.15                                  | LONDON 66 HBC     |
| R6 A | BETWEEN 2.5 AND 0.24                       | EBERHARD 69 HBC   |
| R6 A | DEPENDING ON THE PRODUCTION ANGLE          |                   |
| R7   | Y*(1670) INTO (Y*(1405) PI)/(SIGMA PI P1)  | (P7)/(P5)         |
| R7   | 0.90 0.10 0.16                             | EBERHARD 65 HBC   |
| R8   | Y*(1670) INTO (Y*(1405) PI)/(Y*(1385) PI)  | (P7)/(P6)         |
| R8   | (0.8) OR LESS                              | EBERHARD 65 HBC   |
| R9   | Y*(1670) INTO (LAMBDA PI P1)/(SIGMA PI P1) | (P4)/(P5)         |
| R9   | 0.35 0.2                                   | BIRMINGHAM 66 HBC |

## Baryons

 $\Sigma(1670)$ ,  $\Sigma(1690)$ ,  $\Sigma(1750)$ 

## Data Card Listings

For notation, see key at front of Listings.

R10 Y\*(1670) INTO (LAMBDA PI)/(SIGMA PI) (P2)/(P5) (P2)/(P5)  
 R10 (2) OR LESS BIRMINGHAM 66 HBC + K-P AT 3.5 GEV/C 11/67  
 R11 Y\*(1670) INTO (LAMBDA PI)/(LAMBDA PI + SIG PI) (P2)/(P2+P3)  
 R11 (0.6) OR LESS AGUILAR 70 HBC 5/70

## 51 Y\*(1670) QUANTUM NUMBER DETERMINATION (PROD. EXP.)

Q1 JP=3/2+ LEVEQUE 65 HBC INTO Y\*(1405)+PI 11/68  
 Q3 JP=3/2- EBERHARD 67 HBC + INTO Y\*(1405) PI 11/68  
 Q4 400 JP=3/2- BUTTUN-SH 68 HBC + INTO SIGZERO+PI 11/68

## REFERENCES FOR Y\*(1670) (PROD. EXP.)

ALEXANDE 62 CERN CONF 320 ALEXANDER, JACOBS, KALBFLEISCH, MILLER, + (LRL) I  
 ALVAREZ 63 PRL 10 184 +ALSTON, FERRO-LUZZI, HUME, + (LRL) I  
 SMITH 63 ATHENS CONF 67 G A SMITH (LRL) I  
 HUME 64 PRL 180 1824(1969) J BUTTUN SHAFER (NAS+LRL) JP  
 EBERHARD 65 PRL 14 466 +SHIVELY, ROSS, SIEGAL, FICENEC, + (LRL, ILL) I

BIRMINGHAM 66 PRL 152 1148 BIRMINGHAM, GLASGOW, I. C. Y OXFORD, RUTHERFORD  
 LONDON 66 PRL 143 1034 +RAU, SAMIOS, YAMAMOTO, GOLDBERG, + (BNL, SYR) IJ  
 BUGG 68 PRL 168 1466 +GILMORE, KNIGHT, DAVIES + (BIRM, CAVE, RHELI) I  
 BUTTUN-SH 68 PRL 21 1123 J BUTTUN SHAFER (NAS+LRL) JP  
 PRIMER 68 PRL 20 610 +GOLDBERG, JAEGER, BARNES, DOORAN + (SYR, BNL)  
 BARNES 69 BNL 13023 +CHUNG, EISNER, FLAMINIO + (BNL, SYR)  
 EBERHARD 69 PRL 22 200 +FRIEDMAN, PRIPSTEIN, ROSS (LRL) I  
 AGUILAR 70 PRL 25 58 +BARNES, BASSAND, CHUNG, EISNER, + (BNL, SYR)

## PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE 65 PL 18 69 + (SACLAY, EPOL, GLASGOW, LOIC, OXF, RHEL) JP  
 LEE 66 PRL 17 45 Y Y LEE, D O REEDER, R W HARTUNG (WISC) JP  
 EBERHARD 67 PRL 163 1446 +PRIPSTEIN, SHIVELY, KRUSE, SWANSON (LRL, ILL) JP

 **$\Sigma(1690)$   
BUMPS**

## 58 Y\*(1690, JP= ) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y\* LISTINGS.

SEE NOTE PRECEDING Y\*(1670) LISTINGS, SEEN IN PROD. EXPERIMENTS ONLY, MAIN DECAY MODE IS LAMBDA PI.

## 58 Y\*(1690) MASS (MEV) (PROD. EXP.)

| M | P | N | 30(1715.0) | (12.0) | COLLEY    | 67 HBC                                            | + K-P 6 GEV/C       | 8/67  |
|---|---|---|------------|--------|-----------|---------------------------------------------------|---------------------|-------|
|   |   |   | 60(1694.0) | (24.0) | PRIMER    | 68 HBC <td>+ K-P 4.6-5 GEV/C</td> <td>7/68</td>   | + K-P 4.6-5 GEV/C   | 7/68  |
|   |   |   | 1(1700.0)  | (6.0)  | SIMS      | 68 HBC <td>+ K-N TO LAM PI PI</td> <td>11/68</td> | + K-N TO LAM PI PI  | 11/68 |
|   |   |   | 46(1682.0) | (2.0)  | BLUMENFEL | 69 HBC <td>+ K-O LONG + PROTON</td> <td>9/69</td> | + K-O LONG + PROTON | 9/69  |
|   |   |   | 1(1700.0)  | (20.0) | MOTT      | 69 HBC <td>+ K-P 5.5 GEV/C</td> <td>9/69</td>     | + K-P 5.5 GEV/C     | 9/69  |

SEE Y\*(1670) LISTING-AGUILAR 70 WITH THREE TIMES THE DATA OF  
 P PRIMER 68 SHOW THAT THEY HAVE NO EVIDENCE FOR Y\*(1690)  
 N THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS  
 M AND SHOWS NO UNAMBIGUOUS Y\*(1690) SIGNAL, SUGGESTS JP=5/2+. SUCH A  
 Y\* WOULD LEAD ALL PREVIOUSLY KNOWN Y\* TRAJECTORIES.

## 58 Y\*(1690) WIDTH (MEV) (PROD. EXP.)

| W | N | 30                                                                                              | (100.0)                                                                             | (135.0) | COLLEY                                           | 67 HBC                            | +                | 8/67  |
|---|---|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------|--------------------------------------------------|-----------------------------------|------------------|-------|
|   |   | 60 <td>(105.0) <td>(135.0)</td> <td>PRIMER <td>68 HBC <td>+ <td>7/68</td> </td></td></td></td>  | (105.0) <td>(135.0)</td> <td>PRIMER <td>68 HBC <td>+ <td>7/68</td> </td></td></td>  | (135.0) | PRIMER <td>68 HBC <td>+ <td>7/68</td> </td></td> | 68 HBC <td>+ <td>7/68</td> </td>  | + <td>7/68</td>  | 7/68  |
|   |   | 62                                                                                              | (0.0) <td>(14.0)</td> <td>SIMS</td> <td>68 HBC <td>+ <td>11/68</td> </td></td>      | (14.0)  | SIMS                                             | 68 HBC <td>+ <td>11/68</td> </td> | + <td>11/68</td> | 11/68 |
|   |   | 46 <td>(25.0) <td>(10.0)</td> <td>BLUMENFEL</td> <td>69 HBC <td>+ <td>9/69</td> </td></td></td> | (25.0) <td>(10.0)</td> <td>BLUMENFEL</td> <td>69 HBC <td>+ <td>9/69</td> </td></td> | (10.0)  | BLUMENFEL                                        | 69 HBC <td>+ <td>9/69</td> </td>  | + <td>9/69</td>  | 9/69  |
|   |   | 130                                                                                             | (0.0) <td>(25.0)</td> <td>MOTT</td> <td>69 HBC <td>+ <td>9/69</td> </td></td>       | (25.0)  | MOTT                                             | 69 HBC <td>+ <td>9/69</td> </td>  | + <td>9/69</td>  | 9/69  |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

## 58 Y\*(1690) PARTIAL DECAY MODES (PROD. EXP.)

| P1                                                                        | Y*(1690) INTO KBAR N                                         | DECAY MASSES   |
|---------------------------------------------------------------------------|--------------------------------------------------------------|----------------|
| P2 <td>Y*(1690) INTO LAMBDA PI <td>497+ 939</td> </td>                    | Y*(1690) INTO LAMBDA PI <td>497+ 939</td>                    | 497+ 939       |
| P3 <td>Y*(1690) INTO SIGMA PI <td>1115+ 139</td> </td>                    | Y*(1690) INTO SIGMA PI <td>1115+ 139</td>                    | 1115+ 139      |
| P4 <td>Y*(1690) INTO Y*(1385) PI <td>1197+ 139</td> </td>                 | Y*(1690) INTO Y*(1385) PI <td>1197+ 139</td>                 | 1197+ 139      |
| P5 <td>Y*(1690) INTO LAMBDA PI PI (INCLUDING P4) <td>1384+ 139</td> </td> | Y*(1690) INTO LAMBDA PI PI (INCLUDING P4) <td>1384+ 139</td> | 1384+ 139      |
|                                                                           |                                                              | 1115+ 139+ 139 |

## 58 Y\*(1690) BRANCHING RATIOS (PROD. EXP.)

| R1 | Y*(1690) INTO (KBAR N)/(LAMBDA PI)       | (P1)/(P2)                                    | 8/67  |
|----|------------------------------------------|----------------------------------------------|-------|
| R1 | 18 0.4 0.25                              | COLLEY 67 HBC + 6/30 EVENTS                  | 8/67  |
| R1 | (0.2) OR LESS                            | MOTT 69 HBC +                                | 9/69  |
| R2 | Y*(1690) INTO (SIGMA PI)/(LAMBDA PI)     | (P3)/(P2)                                    | 8/67  |
| R2 | 0.3 0.3                                  | COLLEY 67 HBC + 4/30 EVENTS                  | 8/67  |
| R2 | (0.4) OR LESS CL-90                      | COLLEY 67 HBC +                              | 9/69  |
| R3 | Y*(1690) INTO (Y*(1385) PI)/(LAMBDA PI)  | (P4)/(P2)                                    | 9/69  |
| R3 | (0.5) OR LESS                            | MOTT 69 HBC +                                | 9/69  |
| R4 | Y*(1690) INTO (LAMBDA PI PI)/(LAMBDA PI) | (P5)/(P2)                                    | 8/67  |
| R4 | 0.5 0.25                                 | COLLEY 67 HBC + 15/30 EVENTS                 | 8/67  |
| R4 | 2.0 0.6                                  | BLUMENFEL 69 HBC + 31/15 EVENTS              | 9/69  |
| R4 | 0.72 0.53                                | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3) |       |
| R5 | Y*(1690) INTO (Y*(1385) PI)/(LAMBDA PI)  | (P4)/(P5)                                    | 8/67  |
| R5 | SMALL                                    | COLLEY 67 HBC +                              | 8/67  |
| R5 | LARGE                                    | SIMS 68 HBC + K-N TO L2PI                    | 11/68 |

## REFERENCES FOR Y\*(1690) (PROD. EXP.)

COLLEY 67 PL 248 489 (BIRM, GLAS, LOIC, MUNICH, OXFORD, RHEL) I  
 DERRICK 67 PRL 18 266 +FIELDS, LOKEN, AMMAR, (ARGONNE, NORTHWEST) I  
 REPLACED BY MOTT 69.  
 PRIMER 68 PRL 20 610 +GOLDBERG, JAEGER, BARNES, + (SYRACUSE, BNL) I  
 SIMS 68 PRL 21 1413 +ALBRIGHT, + (PSU, TUFTS, BRANDEIS) I  
 BLUMENFEL 69 PL 298 58 B J BLUMENFEL, G R KALBFLEISCH (BNL) I  
 MOTT 69 PRL 177 1966 +AMMAR, DAVIS, KROPAC, + (NORTHWEST, ARGONNE) I

PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR 70 PRL 25 58 AGUILAR-BENITEZ, BARNES, BASSAND + (BNL+SYR)

 **$\Sigma(1750)$** 

## 57 Y\*(1750, JP=1/2-) I=1

**S<sub>11</sub>**

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S<sub>11</sub> RESONANCE NEAR THIS ENERGY. INTERPRETATION OF THE SIGMA ETA THRESHOLD BUMP ON ITS OWN MERITS IS NOT CONCLUSIVE (CLINE 67) -- MORE DATA ARE NEEDED, BUT BY ANALOGY WITH THE SIMILAR N ETA AND LAMBDA ETA THRESHOLD EFFECTS, WHICH ARE ALMOST CERTAINLY RESONANCES, IT SEEMS VERY LIKELY THAT THIS TOO IS A RESONANCE. SEE THE RAPORTEUR TALKS OF FERRO LUZZI 66 AND MEYER 67 FOR DISCUSSIONS.

IN THE ENERGY-INDEPENDENT PARTIAL WAVE ANALYSIS OF K- N TO LAMBDA PI, THE S<sub>11</sub> AMPLITUDE APPEARS TO RESONATE (ARMENTEROS 69). IN 1968 IT APPEARED TO RESONATE NEAR 1650 MEV (ARMENTEROS 68), AND WAS LISTED HEREIN AS A SEPARATE STATE. NOW IT HAS MOVED CLOSE ENOUGH TO THE OTHER EFFECTS TO BE TENTATIVELY LISTED WITH THEM, BUT THE SIZE OF THE CHANGE IN THE MASS SHOULD BE A HEALTHY WARNING THAT THE PARAMETERS GIVEN FOR RESONANCES IN LOWER PARTIAL WAVES FROM SUCH ANALYSES ARE SUBJECT TO LARGE CHANGE. (ARMENTEROS 70, FROM WHICH THE RESONANCE PARAMETERS ARE QUOTED, IS A SLIGHT UPDATING OF ARMENTEROS 69.)

THERE IS WEAKER EVIDENCE FOR THIS RESONANCE IN AN ENERGY-DEPENDENT PARTIAL-WAVE ANALYSIS OF ELASTIC AND CHARGE-EXCHANGE SCATTERING (CONFORTO 71). KIM 71 IN A MULTICHANNEL ANALYSIS FINDS A SURPRISINGLY LARGE ELASTICITY (.8), AND SMALLER AMPLITUDE IN THE LAMBDA PI CHANNEL. VANHORN 72 FINDS A STATE SOMEWHAT BELOW THE SIGMA ETA THRESHOLD IN AN ANALYSIS OF THE LAMBDA PI CHANNEL. IN VIEW OF THESE DISCREPANCIES WE DO NOT QUOTE ANY VALUES FOR THE BRANCHING RATIOS.

## 57 Y\*(1750) MASS (MEV)

| M                                                                                                             | NEAR SIGMA ETA THRESHOLD | CLINE     | 67 DBC  | - K-N TO SIGMA ETA | 9/66   |
|---------------------------------------------------------------------------------------------------------------|--------------------------|-----------|---------|--------------------|--------|
| M <td>ABOUT 1750.0</td> <td>MEYER</td> <td>67 RVUE</td> <td></td> <td>9/69</td>                               | ABOUT 1750.0             | MEYER     | 67 RVUE |                    | 9/69   |
| M <td>ABOUT 1750.0</td> <td>ARMENTERO</td> <td>70 HBC</td> <td>- K-N TO LAMBDA PI</td> <td>6/70</td>          | ABOUT 1750.0             | ARMENTERO | 70 HBC  | - K-N TO LAMBDA PI | 6/70   |
| M <td>(1757.0) (10.0)</td> <td>CONFORTO</td> <td>71 DPWA</td> <td>0 ELASTIC, CH EXCH</td> <td>6/70</td>       | (1757.0) (10.0)          | CONFORTO  | 71 DPWA | 0 ELASTIC, CH EXCH | 6/70   |
| M <td>(1790.0)</td> <td>KIM</td> <td>71 DPWA</td> <td>K-MATRIX ANAL.</td> <td>3/71</td>                       | (1790.0)                 | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| M <td>(1790.0) (15.0)</td> <td>LANGBEIN</td> <td>72 IPWA</td> <td>MULTICHANNEL</td> <td>12/72*</td>           | (1790.0) (15.0)          | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| M <td>(1697.0) (20.0) (10.0)</td> <td>VANHORN</td> <td>72 DPWA</td> <td>0 K- P TO LAM P10</td> <td>2/73*</td> | (1697.0) (20.0) (10.0)   | VANHORN   | 72 DPWA | 0 K- P TO LAM P10  | 2/73*  |

## 57 Y\*(1750) WIDTH (MEV)

| W | ABOUT 50.0           | MEYER     | 67 RVUE |                    | 9/69   |
|---|----------------------|-----------|---------|--------------------|--------|
| W | ABOUT 80.0           | ARMENTERO | 70 HBC  | - K-N TO LAMBDA PI | 6/70   |
| W | (55.0) (10.0)        | CONFORTO  | 71 DPWA | 0 ELASTIC, CH EXCH | 6/70   |
| W | (50.0)               | KIM       | 71 DPWA | K-MATRIX ANAL.     | 3/71   |
| W | (100.0) (20.0)       | LANGBEIN  | 72 IPWA | MULTICHANNEL       | 12/72* |
| W | (66.0) (14.0) (12.0) | VANHORN   | 72 DPWA | 0 K- P TO LAM P10  | 2/73*  |

## 57 Y\*(1750) PARTIAL DECAY MODES

| P1                                                      | Y*(1750) INTO KBAR N                       | DECAY MASSES |
|---------------------------------------------------------|--------------------------------------------|--------------|
| P2 <td>Y*(1750) INTO SIGMA ETA <td>497+ 939</td> </td>  | Y*(1750) INTO SIGMA ETA <td>497+ 939</td>  | 497+ 939     |
| P3 <td>Y*(1750) INTO LAMBDA PI <td>1197+ 548</td> </td> | Y*(1750) INTO LAMBDA PI <td>1197+ 548</td> | 1197+ 548    |
| P4 <td>Y*(1750) INTO SIGMA PI <td>1115+ 134</td> </td>  | Y*(1750) INTO SIGMA PI <td>1115+ 134</td>  | 1115+ 134    |
|                                                         |                                            | 1197+ 139    |

## 57 Y\*(1750) BRANCHING RATIOS

| R1                                                                                 | Y*(1750) INTO (KBAR N)/TOTAL        | (P1)                                 | 6/70   |
|------------------------------------------------------------------------------------|-------------------------------------|--------------------------------------|--------|
| R1                                                                                 | (0.12) (0.05)                       | CONFORTO 71 DPWA 0 ELASTIC, CH EXCH  | 6/70   |
| R1                                                                                 | (0.8)                               | KIM 71 DPWA K-MATRIX ANAL.           | 3/71   |
| R1                                                                                 | (0.45) (0.05)                       | LANGBEIN 72 IPWA MULTICHANNEL        | 12/72* |
| R2 <th>Y*(1750) FROM KBAR N INTO SIGMA ETA</th> <th>SQRT(P1*P2)</th> <th>9/69</th> | Y*(1750) FROM KBAR N INTO SIGMA ETA | SQRT(P1*P2)                          | 9/69   |
| R2 <td>SEEN</td> <td>CLINE 69 DBC - THRESHOLD BUMP</td> <td>9/69</td>              | SEEN                                | CLINE 69 DBC - THRESHOLD BUMP        | 9/69   |
| R3 <th>Y*(1750) FROM KBAR N INTO LAMBDA PI</th> <th>SQRT(P1*P3)</th> <th>6/70</th> | Y*(1750) FROM KBAR N INTO LAMBDA PI | SQRT(P1*P3)                          | 6/70   |
| R3                                                                                 | (-0.25)                             | ARMENTERO 70 IPWA - K-N TO LAMBDA PI | 6/70   |
| R3                                                                                 | (0.09)                              | KIM 71 DPWA K-MATRIX ANAL.           | 3/71   |
| R3                                                                                 | (0.30) (0.05)                       | LANGBEIN 72 IPWA MULTICHANNEL        | 12/72* |
| R3                                                                                 | (-1.3) (-.04)                       | VANHORN 72 DPWA 0 K- P TO LAM P10    | 2/73*  |
| R4 <th>Y*(1750) FROM KBAR N TO SIGMA PI</th> <th>SQRT(P1*P4)</th> <th>3/71</th>    | Y*(1750) FROM KBAR N TO SIGMA PI    | SQRT(P1*P4)                          | 3/71   |
| R4                                                                                 | (0.16)                              | KIM 71 DPWA K-MATRIX ANAL.           | 3/71   |
| R4                                                                                 | (0.13) (0.02)                       | LANGBEIN 72 IPWA MULTICHANNEL        | 12/72* |

## REFERENCES FOR Y\*(1750)

CLINE 67 PL 258 41 CLINE, OLSSON (WISCONSIN) JP  
 MEYER 67 HEIDELBERG C 117 J MEYER (RAPORTEUR) (SACLAY) JP  
 ARMENTERO 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN, HEIDEL) JP  
 CONFORTO 71 NP 834 41 +LEVI SETTI, LASINSKI, OBERLACK + (EFJ, HEID) JP  
 KIM 71 PRL 27 356 J K KIM (HARV) JP  
 ALSO TO DUKE 161 J. K. KIM (HARV) JP  
 LANGBEIN 72 NP 847 47 +MAGNER (MPI) JP  
 VANHORN 72 LBL-1370 (THIS IS) /LBL JP

*For notation, see key at front of Listings.*

 $\Sigma(1750), \Sigma(1765)$  $\Sigma(1765)$ 

45 Y\*1(1765, JP=5/2-) I=1

**D<sub>15</sub>**

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

45 Y\*1(1765) MASS (MEV)

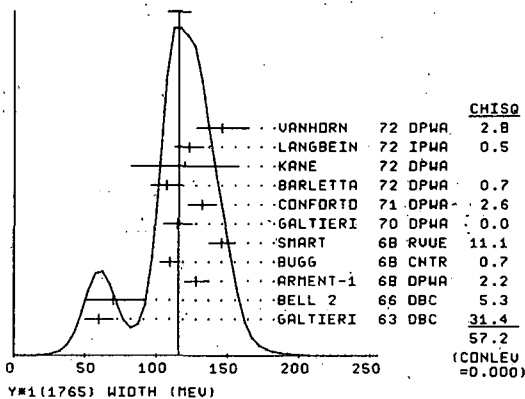
|   |   |                                                                       |      |          |         |                    |       |
|---|---|-----------------------------------------------------------------------|------|----------|---------|--------------------|-------|
| M |   | 1765.0                                                                | 10.0 | GALTIERI | 63 DBC  | 0 K-O 1.51 BEV/C   |       |
| M |   | 1755.0                                                                | 10.0 | ARMENTER | 65 HBC  | 0 K-P TO Y*1520 P1 | 7/66  |
| M |   | 1760.0                                                                | 10.0 | BELL 1   | 66 DBC  | - K-N TO Y*1520 P1 | 7/66  |
| M | N | 1768.0                                                                | 2.0  | ARMENT-1 | 68 DPWA | 0 ELASTIC, CH EXCH | 11/68 |
| M |   | 1768.0                                                                | 4.0  | BUGG     | 68 CNTR | K-P, D TOTAL       | 11/66 |
| M | N | 1755.0                                                                | 7.0  | SMART    | 68 DBC  | 0 K-P TO Y*1520 P1 | 7/66  |
| M |   | 1770.0                                                                | 10.0 | COOL     | 70 DBC  | K-P, D TOTAL       | 11/68 |
| M |   | 1765.0                                                                | 10.0 | GALTIERI | 70 DPWA | 0 K-P TO LAMBDA P1 | 7/70  |
| M | N | 1770.0                                                                | 3.0  | CONFORTO | 71 DPWA | 0 ELASTIC, CH EXCH | 6/70  |
| M |   | (1765.1)                                                              |      | KIM      | 71 DPWA | K-MATRIX ANAL.     | 3/71  |
| M |   | 1769.7                                                                | 3.9  | BARLETTA | 72 DPWA | 0 K-P TO 1.2GEV    | 10/72 |
| M |   | 1765.0                                                                | 5.0  | KANE     | 72 DPWA | 0 K-P TO P1 SIG    | 10/72 |
| M | N | 1770.0                                                                | 5.0  | LAMNGEIN | 72 1PWA | MULTICHANNEL       | 12/72 |
| M |   | 1774.0                                                                | 10.0 | VANHORN  | 72 DPWA | 0 K-P TO LAN P10   | 2/73  |
| M |   | N ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.N. ANAL. INCLUDED |      |          |         |                    | 1/71  |
| M |   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)                              |      |          |         |                    |       |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

45 Y\*1(1765) WIDTH (KEY)

|   |         |       |                                              |         |              |                        |
|---|---------|-------|----------------------------------------------|---------|--------------|------------------------|
| W | 60.0    | 10.0  | GALTIERI                                     | 63 DBC  | 0            |                        |
| W | 70.0    | 20.0  | BELL 2                                       | 66 DBC  | -            | 7/66                   |
| W | 128.0   | 8.0   | ARMENT-1                                     | 68 DPWA | 0            | ELASTIC, CH EXCH 11/68 |
| W | 110.0   | 7.0   | BUGG                                         | 68 CNTR | K-P, D TOTAL | 7/68                   |
| W | 146.0   | 9.0   | SMART                                        | 68 RVUE | -0           | 7/68                   |
| W | (100.0) |       | COOL                                         | 70 CNTR | K-P, D TOTAL | 10/70                  |
| W | 115.0   | 10.0  | GALTIERI                                     | 70 DPWA | 0            | K-P TO LAMBDA PI 7/70  |
| W | 132.0   | 10.0  | CONFORTO                                     | 71      | 0            | ELASTIC, CH EXCH 6/70  |
| W | (100.)  |       | KIM                                          | 71 DPWA | 0            | K-MATRIX ANAL. 3/71    |
| W | 107.0   | 10.9  | BARLETTA                                     | 72 DPWA | 0            | LAM(1520)PI CH. 12/72  |
| W | 120.2   | 38.0  | KANE                                         | 72 DPWA | 0            | K-P TO PI S1G. 10/71   |
| W | 123.0   | 10.0  | LANGBEIN                                     | 72 IPWA |              | MULTICHANNEL 12/72     |
| W | 146.0   | 18.   | VANHORN                                      | 72 DPWA | 0            | K- P TO LAM PIO 2/73*  |
| W | AVG     | 116.0 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5) |         |              |                        |
| W |         |       | [SEF ID068AM,BF(OW.)]                        |         |              |                        |

WEIGHTED AVERAGE = 116.0 ± 7.9  
ERROR SCALED BY 2.5



45 Y\*1(1765) PARTIAL DECAY MODES

|    |                            | DECAY MASSES   |
|----|----------------------------|----------------|
| P1 | Y*(1765) INTO KBAR N       | 497+ 939       |
| P2 | Y*(1765) INTO LAMBDA PI    | 1115+ 134      |
| P3 | Y*(1765) INTO Y*(01520) PI | 1518+ 139      |
| P4 | Y*(1765) INTO Y*(1385) PI  | 1384+ 139      |
| P5 | Y*(1765) INTO SIGMA PI     | 1197+ 139      |
| P6 | Y*(1765) INTO SIGMA ETA    | 1197+ 548      |
| P7 | Y*(1765) INTO SIGMA PI PI  | 1197+ 139+ 139 |

### FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions,  $P_i$ , as follows: the diagonal elements are  $P_i \pm \delta P_i$ , where  $\delta P_i = \sqrt{(\delta P_i^2 \delta P_j^2)}$ , while the off-diagonal elements are the normalized correlation coefficients  $(\delta P_i \delta P_j) / (P_i \cdot P_j)$ . For the definitions of the individual  $P_i$ , see the listings above; only those  $P_i$  appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

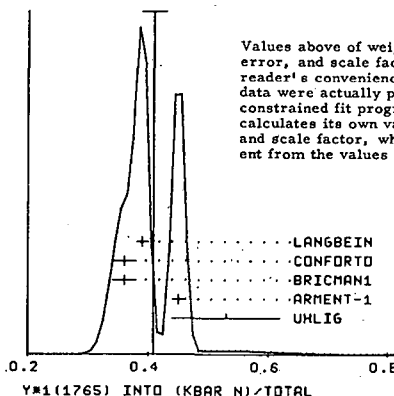
|     | P 1         | P 2         | P 3         | P 4         | P 5         | P 6         |
|-----|-------------|-------------|-------------|-------------|-------------|-------------|
| P 1 | .4113+-0169 |             |             |             |             |             |
| P 2 | .0885       | .1320+-0168 |             |             |             |             |
| P 3 | .0540       | .0048       | .1566+-0328 |             |             |             |
| P 4 | .1118       | .0099       | .0060       | .1028+-0375 |             |             |
| P 5 | -.1181      | -.0104      | -.0064      | -.0132      | .0118+-0040 |             |
| P 6 | -.4158      | -.3284      | -.5764      | -.6970      | -.0210      | .1853+-0585 |

45 Y\*1(1765) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

| R1 | Y*1(1765) INTO (KBAR N)/TOTAL |        |       |  | (P1)        |                |                      |                  |
|----|-------------------------------|--------|-------|--|-------------|----------------|----------------------|------------------|
| R1 |                               | (0.61  |       |  | GALTIERI    | 63 HBC         | 0                    | K-P RVUE         |
| R1 |                               | 0.53   | 0.09  |  | UHLIG       | 67 HBC         | 0                    |                  |
| R1 |                               | 0.45   | 0.01  |  | ARMENT      | 68 DPWA        | 0                    | ELASTIC, CH EXCH |
| R1 |                               | (0.37) |       |  | BUGG        | 68 CNTR        |                      |                  |
| R1 |                               | 0.36   | 0.02  |  | BRICHANI    | 70 DPWA        |                      | SIGTOT,ELAS,CHEX |
| R1 |                               | (0.4)  |       |  | COOL        | 70 CNTR        |                      | K-P, D TOTAL     |
| R1 |                               | 0.36   | 0.02  |  | CONFORTO    | 71 DPWA        | 0                    | ELASTIC CH EXCH  |
| R1 |                               | (0.42) |       |  | KIM         | 71 DPWA        |                      | K-MATRIX ANAL.   |
| R1 |                               | 0.39   | 0.01  |  | LANGBEIN    | 72 IPWA        |                      | MULTICHANNEL     |
| R1 |                               |        |       |  |             |                |                      | 12/72*           |
| R1 |                               |        |       |  |             |                |                      |                  |
| R1 | AVG                           | 0.409  | 0.021 |  | AVERAGE     | ERROR INCLUDES | SCALE FACTOR OF 3.3) |                  |
| R1 | FIT                           | 0.411  | 0.017 |  | FROM FIT    | ERROR INCLUDES | SCALE FACTOR OF 2.7) |                  |
|    |                               |        |       |  | INFOGRAPHIC |                |                      |                  |

WEIGHTED AVERAGE =  $0.409 \pm 0.021$   
ERROR SCALED BY 3.3



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of  $\bar{x}$ ,  $\delta\bar{x}$ , and scale factor, which are different from the values shown here.

[illegible]

## Baryons

 $\Sigma(1765)$ ,  $\Sigma(1840)$ ,  $\Sigma(1880)$ ,  $\Sigma(1915)$ 

## Data Card Listings

For notation, see key at front of Listings.

R6 Y\*1(1765) INTO (LAMBDA PI)/(KBAR N) (P2)/(P1) 9/66  
 R6 0.33 0.05 UHLIG 67 HBC 0 K-P, .9 GEV/C  
 R6 FIT 0.321 0.042 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)  
 R7 Y\*1(1765) INTO (Y\*0(1520)PI)/(KBAR N) (P3)/(P1) 9/66  
 R7 0.28 0.05 UHLIG 67 HBC 0 K-P, .9 GEV/C  
 R7 FIT 0.381 0.080 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)  
 R8 Y\*1(1765) INTO (Y\*1(1385)PI)/(KBAR N) (P4)/(P1) 9/66  
 R8 0.25 0.09 UHLIG 67 HBC 0 K-P, .9 GEV/C  
 R8 FIT 0.250 0.091 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  
 R9 Y\*1(1765) INTO (SIGMA PI PI)/TOTAL (P7) 11/68  
 R9 P (0.12) ARMENT-2 68 HDBC -0 K-N TO SIG PI PI  
 R9 P FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 AND IS ALMOST  
 R9 P ENTIRELY Y\*0(1520). FOR THE OTHER 1/4, THE SIGMA PI HAS I=1. THIS  
 R9 P IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE Y\*1(1765) TO Y\*1(1385)  
 R9 P PI, AS SEEN IN LAMBDA PI PI.

## REFERENCES FOR Y\*1(1765)

GALTIERI 63 PL 6 296 A BARBARO-GALTIERI, A HUSSAIN-AD TRIPP (LRL) IJP  
 ARMENTER 65 PL 19 338 ARMENTEROS, + (CERN, HEIDELBERG, SACLAY) IJP  
 BELL 1 66 PRL 16 203 R B BELL, R W BIRGE, Y-L PAN, R T PU (LRL) IJP  
 BELL 2 66 UCRL-16936 THESIS R B BELL (LRL) IJP  
 ARMENTER 67 PL 248 198 ARMENTEROS, FERRO-LUZZI+ (CERN, HEID, SACLAY) IJP  
 ARMENT-2 67 ZEIT. PHYS. 202 486 ARMENTEROS, FERRO-LUZZI+ (CERN, HEID, SACLAY)  
 UHLIG 67 PR 155 1448 +CHARLTON, CONDON, GLASSER, YODH, + (UMD, NRL)  
 ARMENT-1 68 NP 88 195 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) IJP  
 ARMENT-2 68 NP 88 216 ARMENTEROS, BAILLON, + (CERN, HEIDEL, SACLAY) I  
 BUGG 68 PR 168 1466 +GILMORE, KNIGHT, DAVIES+ (BIRM, CAVE, RHEL) I  
 SIMS 68 PRL 21 1413 SIMS, ALBRIGHT, BARTLEY, MEER+ (FSU, TUFT, BRAN)  
 SMART 68 PR 169 1330 W M SMART (LRL) IJP  
 BRICMANI 70 PL 338 511 +FERRO-LUZZI, LAGNAUX (CERN)  
 COOL 70 LBL 1 1887 +GIACELLI, KYCIA, LEONTE, LI, + (BLU) I  
 GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL) IJP  
 CONFORTO 71 NP 834 41 +LEVI SETTI, LASINSKI, OBERLACK+ (EFI+HEID) IJP  
 KIM 71 PRL 27 356 J K KIM (HARV) IJP  
 ALSO 70 DUKE 161 J. K. KIM (HARV) IJP  
 BARLETTA 72 NP 840 45 W.A. BARLETTA (EFI) IJP  
 KANE 72 PR 15 1583 D F KANE (LBL) IJP  
 LANGBEIN 72 NP 847 477 +WAGNER (MPIM) IJP  
 VANHORN 72 LBL-1370(THESIS) /LBL IJP  
 PAPERS NOT REFERRED TO IN DATA CARDS  
 FENSTER 66 PRL 17 841 +GELFAND, HARMSEN, L-SETTI, + (CHIC, ANL(CERN)) IJP  
 FENSTER 66 IS SUPERSEDED BY BARLETTA 72 (CHICAGO, HEIDEL) IJP  
 CONFORTO 68 NP 88 265 +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL) IJP  
 SUPERSEDED BY CONFORTO 71.  
 HARRISON 70 FSU-HEP 70 3 1 W.C. HARRISON (THESIS) (FSU)  
 PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

 $\Sigma(1840)$ 

01 Y\*1(1840, JP=3/2+) I=1

P'13

SEE THE MINI-REVIEWS PRECEDING THE Y\*0'S.  
 FOR THE TIME BEING, WE LIST THESE TWO CLAIMS  
 TOGETHER.

## 01 Y\*1(1840) MASS (MEV)

| M | 1840.0 | (10.0) | LANGBEIN | 72 IPWA | MULTICHANNEL     | 12/72* |
|---|--------|--------|----------|---------|------------------|--------|
| M | 1925.  | (200.) | VANHORN  | 72 DPWA | 0 K-P TO LAM P10 | 2/73*  |

## 01 Y\*1(1840) WIDTH (MEV)

| W | 120.0 | (10.0) | LANGBEIN | 72 IPWA | MULTICHANNEL | 12/72*                 |
|---|-------|--------|----------|---------|--------------|------------------------|
| W | 65.   | (50.)  | (20.)    | VANHORN | 72 DPWA      | 0 K-P TO LAM P10 2/73* |

## 01 Y\*1(1840) PARTIAL DECAY MODES

| P1                                                      | Y*1(1840) INTO KBAR N    | 497+ 939  |
|---------------------------------------------------------|--------------------------|-----------|
| P2 <th>Y*1(1840) INTO SIGMA PI</th> <th>1197+ 139</th>  | Y*1(1840) INTO SIGMA PI  | 1197+ 139 |
| P3 <th>Y*1(1840) INTO LAMBDA PI</th> <th>1115+ 134</th> | Y*1(1840) INTO LAMBDA PI | 1115+ 134 |

## 01 Y\*1(1840) BRANCHING RATIOS

| R1 | Y*1(1840) INTO (KBAR N)/TOTAL        | (P1)             | 12/72*                 |
|----|--------------------------------------|------------------|------------------------|
| R1 | 0.37 (0.13)                          | LANGBEIN 72 IPWA | MULTICHANNEL           |
| R2 | Y*1(1840) FROM KBAR N INTO SIGMA PI  | SQRT(P1*P2)      | 12/72*                 |
| R2 | 0.15 (0.04)                          | LANGBEIN 72 IPWA | MULTICHANNEL           |
| R3 | Y*1(1840) FROM KBAR N INTO LAMBDA PI | SQRT(P1*P3)      | 12/72*                 |
| R3 | 0.20 (0.04)                          | LANGBEIN 72 IPWA | MULTICHANNEL           |
| R3 | +0.06 (0.04)                         | VANHORN 72 DPWA  | 0 K-P TO LAM P10 2/73* |

## REFERENCES FOR Y\*1(1840)

LANGBEIN 72 NP 847 477 +WAGNER (MPIM) IJP  
 VANHORN 72 LBL-1370(THESIS) /LBL IJP

 $\Sigma(1880)$ 

67 Y\*1(1880, JP=1/2+) I=1

P'11

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL  
 PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE  
 IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN  
 BARYON TABLE.

## 67 Y\*1(1880) MASS (MEV)

| M | 1882.0       | 40.0   | SMART      | 68 DPWA                                      | -0 K-N TO LAM P1    | 7/68  |
|---|--------------|--------|------------|----------------------------------------------|---------------------|-------|
| M | (1850.0)     | 0      | BAILLEY    | 69 DPWA                                      | 0 ELASTIC, CH EXCH  | 10/70 |
| M | ABOUT 1850.0 | 0      | ARMENTERO  | 70 IPWA                                      | -0 ELASTIC, CH EXCH | 6/70  |
| M | 1950.0       | 50.0   | GALTIERI   | 70 DPWA                                      | -0 K-N TO LAM P1    | 7/70  |
| M | 1920.0       | 30.0   | LITCHFIELD | 70 DPWA                                      | -0 K-N TO LAM P1    | 6/70  |
| M | (1772.0)     | 0      | KANE       | 72 DPWA                                      | 0 K-P TO SIGMA PI   | 1/73* |
| M | 1985.        | 50.    | VANHORN    | 72 DPWA                                      | 0 K-P TO LAM P10    | 2/73* |
| M | AVG          | 1925.6 | 19.9       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                     |       |

## 67 Y\*1(1880) WIDTH (MEV)

| W | 222.0      | 150.0 | SMART      | 68 DPWA                                      | -0 K-N TO LAM P1    | 7/68  |
|---|------------|-------|------------|----------------------------------------------|---------------------|-------|
| W | (200.0)    | 0     | BAILLEY    | 69 DPWA                                      | 0 ELASTIC, CH EXCH  | 10/70 |
| W | ABOUT 30.0 | 0     | ARMENTERO  | 70 IPWA                                      | -0 ELASTIC, CH EXCH | 6/70  |
| W | 200.0      | 50.0  | GALTIERI   | 70 DPWA                                      | -0 K-N TO LAM P1    | 7/70  |
| W | 170.0      | 40.0  | LITCHFIELD | 70 DPWA                                      | -0 K-N TO LAM P1    | 6/70  |
| W | (80.0)     | 0     | KANE       | 72 DPWA                                      | 0 K-P TO SIGMA PI   | 1/73* |
| W | 220.       | 140.  | VANHORN    | 72 DPWA                                      | 0 K-P TO LAM P10    | 2/73* |
| W | AVG        | 185.0 | 29.9       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                     |       |

## 67 Y\*1(1880) PARTIAL DECAY MODES

| P1                                                      | Y*1(1880) INTO KBAR N    | 497+ 939  |
|---------------------------------------------------------|--------------------------|-----------|
| P2 <th>Y*1(1880) INTO LAMBDA PI</th> <th>1115+ 134</th> | Y*1(1880) INTO LAMBDA PI | 1115+ 134 |

## 67 Y\*1(1880) BRANCHING RATIOS

| R1 | Y*1(1880) INTO (KBAR N)/TOTAL        | (P1)                | 10/70*                                       |
|----|--------------------------------------|---------------------|----------------------------------------------|
| R1 | (0.22)                               | BAILLEY 69 DPWA     | -0 ELASTIC, CH EXCH                          |
| R1 | (0.20)                               | ARMENTERO 70 IPWA   | -0 ELASTIC, CH EXCH                          |
| R2 | Y*1(1880) FROM KBAR N INTO LAMBDA PI | SQRT(P1*P2)         | 7/68                                         |
| R2 | -0.11 0.03                           | SMART 68 DPWA       | -0 K-N TO LAM P1                             |
| R2 | -0.09 0.04                           | GALTIERI 70 DPWA    | -0 K-N TO LAM P1                             |
| R2 | -0.14 0.03                           | LITCHFIELD 70 DPWA  | -0 K-N TO LAM P1                             |
| R2 | +0.05 .07                            | .02 VANHORN 72 DPWA | 0 K-P TO LAM P10                             |
| R2 | AVG MOD                              | 0.107 0.017         | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |

## REFERENCES FOR Y\*1(1880)

SMART 68 PR 169 1330 W M SMART (LRL) IJP  
 BAILLEY 69 THESIS UCRL-50617 DAVID SAAL BAILLEY (LRL LIVERMORE) IJP  
 ARMENTER 70 DUKE CONF 123 ARMENTEROS, BAILLON, + (CERN, HEIDEL) IJP  
 GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL) IJP  
 LITCHFIELD 70 NP 822 269 P J LITCHFIELD (RUTHERFORD) IJP  
 KANE 72 PR 15 1583 D F KANE (LBL) IJP  
 VANHORN 72 LBL-1370(THESIS) /LBL IJP

 $\Sigma(1915)$ 

46 Y\*1(1915, JP=5/2+) I=1

F'15

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THIS RESONANCE WAS FIRST SEEN IN THE TOTAL-CROSS-SEC-  
 TION MEASUREMENTS OF COOL 66. IN THIS ENTRY, HOWEVER,  
 WE LIST ONLY THE RESULTS FROM PARTIAL-WAVE ANALYSES.  
 SEE THE NEXT ENTRY FOR THE PARAMETERS OF PEAKS SEEN AROUND 1900-1950  
 MEV IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. WE MAKE THIS  
 SEPARATION BECAUSE ONLY THE PARTIAL-WAVE ANALYSES ISOLATE THE F15 WAVE  
 (OR AT LEAST ATTEMPT TO -- THE SIGNAL IS WEAK). THIS MASS REGION IS  
 COMPLICATED AND POORLY UNDERSTOOD AND THE PEAKS MAY CONTAIN MORE THAN  
 JUST THE Y\*1(1915). SEE ALSO THE NOTE TO THE NEXT ENTRY.

## 46 Y\*1(1915) MASS (MEV)

| M | 1902.0                                   | 11.0                                                                 | SMART       | 68 DPWA | -0 K-N TO LAMBDA PI | 7/68   |
|---|------------------------------------------|----------------------------------------------------------------------|-------------|---------|---------------------|--------|
| M | 1910.0                                   | 20.0                                                                 | BERTHON     | 70 DPWA | 0 K-P TO LAMBDA PI  | 7/70   |
| M | 1900.0                                   | 15.0                                                                 | BERTHON     | 70 DPWA | 0 K-P TO SIGMA PI   | 10/70  |
| M | 1936.0                                   | (3.0)                                                                | BRICMANI    | 70 DPWA | SIGTOT, ELAS, CHX   | 1/71   |
| M | 1903.0                                   | 10.0                                                                 | COX         | 70 DPWA | -0 K-N TO LAMBDA PI | 6/70   |
| M | 1905.0                                   | 30.0                                                                 | GALTIERI    | 70 DPWA | 0 K-P TO LAMBDA PI  | 7/70   |
| M | 1895.0                                   | 10.0                                                                 | LITCHFIELD  | 70 DPWA | -0 K-N TO LAMBDA PI | 6/70   |
| M | (1985.0)                                 | (21.0)                                                               | ISLAM       | 71 DPWA | KN-PI-SIG           | 12/72* |
| M | DISCREPANCY                              | DO POSSIBLY TO INSUFFICIENT STATISTICS                               |             |         |                     |        |
| M | 1910.                                    | 15.                                                                  | LITCHFIELD  | 71 DPWA | K-P TO KBAR N       | 10/71  |
| M | 1925.0                                   | 8.0                                                                  | KANE        | 72 DPWA | 0 K-P TO PI SIG     | 10/71  |
| M | 1920.                                    | .15                                                                  | .20 VANHORN | 72 DPWA | 0 K-P TO LAM P10    | 2/73*  |
| M | N                                        | ERROR STATIST. ONLY-- NO ERROR DUE TO PARTICULAR P.W. ANAL. INCLUDED |             |         |                     | 1/71   |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 1.0) |                                                                      |             |         |                     |        |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Sigma(1915)$ ,  $\Sigma(1940)$ 

| 46 Y*(1915) WIDTH (MEV) |   |                                                              |        |            |         |            |                     |       |  |
|-------------------------|---|--------------------------------------------------------------|--------|------------|---------|------------|---------------------|-------|--|
| W                       | A | (50.0)                                                       | (20.0) | ARMENTERI  | 67 DPWA | 0          | ELASTIC, CH EXCH    | 11/67 |  |
| W                       |   | 52.0                                                         | 25.0   | SMART      | 68 DPWA | -0         | K-N TO LAMBDA PI    | 7/68  |  |
| W                       |   | 60.0                                                         | 20.0   | BERTHON    | 70 DPWA | 0          | K-P TO LAMBDA PI    | 7/70  |  |
| W                       |   | 75.0                                                         | 20.0   | BERTHON    | 70 DPWA | 0          | K-P TO SIGMA PI     | 10/70 |  |
| W                       |   | 135.0                                                        | 12.0   | BRICMAN    | 70 DPWA | 0          | SIGTOT, ELAS, CH EX | 1/71  |  |
| W                       |   | 77.0                                                         | 27.0   | COX        | 70 DPWA | -          | K-N TO LAMBDA PI    | 6/70  |  |
| W                       |   | 70.0                                                         | 20.0   | GALTIERI   | 70 DPWA | 0          | K-P TO LAMBDA PI    | 7/70  |  |
| W                       |   | 70.0                                                         | 15.0   | LITCHFIELD | 70 DPWA | -0         | K-N TO LAMBDA PI    | 6/70  |  |
| W                       | B | (159.0)                                                      | (80.0) | ISLAM      | 71 DPWA | KN--PI-SIG | 12/72*              |       |  |
| W                       |   | 70.0                                                         | 15.0   | LITCHFIELD | 71 DPWA | K-P        | TO KBAR N           | 10/71 |  |
| W                       |   | 146.0                                                        | 22.0   | KANE       | 72 DPWA | 0          | K-P TO PI SIG       | 10/71 |  |
| W                       |   | 102.0                                                        | 18.0   | VANHORN    | 72 DPWA | 0          | K-P TO LAM P10      | 2/73* |  |
| W                       | A | LACK OF DATA PREVENTS FROM DETERMINING UNAMB. THIS AMPLITUDE |        |            |         |            |                     |       |  |
| W                       |   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)                     |        |            |         |            |                     |       |  |

| 46 Y*(1915) PARTIAL DECAY MODES |          |                |  |  |  |  |  |       |     |
|---------------------------------|----------|----------------|--|--|--|--|--|-------|-----|
| P1                              | Y*(1915) | INTO KBAR N    |  |  |  |  |  | 497*  | 939 |
| P2                              | Y*(1915) | INTO LAMBDA PI |  |  |  |  |  | 1115* | 139 |
| P3                              | Y*(1915) | INTO SIGMA PI  |  |  |  |  |  | 1197* | 139 |

| 46 Y*(1915) BRANCHING RATIOS |          |                            |             |            |         |            |                     |       |  |
|------------------------------|----------|----------------------------|-------------|------------|---------|------------|---------------------|-------|--|
| R1                           | Y*(1915) | INTO (KBAR N)/TOTAL        | (P1)        |            |         |            |                     |       |  |
| R1                           | A        | (0.12)                     | (.01)       | ARMENTERI  | 67 DPWA | 0          | ELASTIC, CH EXCH    | 11/67 |  |
| R1                           |          | 0.18                       | (0.02)      | BRICMAN    | 70 DPWA | 0          | SIGTOT, ELAS, CH EX | 1/71  |  |
| R1                           |          | 0.11                       | (0.03)      | CONFORTO   | 71 DPWA | 0          | ELASTIC, CH EXCH    | 6/70  |  |
| R1                           |          | 0.15                       | (0.04)      | LITCHFIELD | 71 DPWA | 0          | K-P TO KBAR N       | 10/71 |  |
| R2                           | Y*(1915) | FROM KBAR N INTO LAMBDA PI | SORT(P1*P2) |            |         |            |                     |       |  |
| R2                           |          | -0.08                      | (0.02)      | SMART      | 68 DPWA | -0         | K-N TO LAMBDA PI    | 7/68  |  |
| R2                           |          | -0.1                       | (0.02)      | BERTHON    | 70 DPWA | 0          | K-P TO LAMBDA PI    | 7/70  |  |
| R2                           |          | -0.09                      | (0.02)      | COX        | 70 DPWA | -          | K-N TO LAMBDA PI    | 6/70  |  |
| R2                           |          | -0.11                      | (0.03)      | GALTIERI   | 70 DPWA | 0          | K-P TO LAMBDA PI    | 7/70  |  |
| R2                           |          | -0.07                      | (0.015)     | LITCHFIELD | 70 DPWA | -0         | K-N TO LAMBDA PI    | 6/70  |  |
| R2                           |          | -0.09                      | .02         | VANHORN    | 72 DPWA | 0          | K-P TO LAM P10      | 2/73* |  |
| R3                           | Y*(1915) | FROM KBAR N INTO SIGMA PI  | SORT(P1*P3) |            |         |            |                     |       |  |
| R3                           | A        | (0.00)                     | (0.01)      | ARMENTERI  | 67 DPWA | 0          | K-P TO SIGMA PI     | 11/67 |  |
| R3                           |          | -0.13                      | (0.03)      | BRICMAN    | 70 DPWA | 0          | K-P TO SIGMA PI     | 10/70 |  |
| R3                           |          | -0.06                      | (0.03)      | GALTIERI   | 70 DPWA | 0          | K-P TO SIGMA PI     | 7/70  |  |
| R3                           | B        | (0.06)                     | (0.02)      | ISLAM      | 71 DPWA | KN--PI-SIG | 12/72*              |       |  |
| R3                           |          | -0.137                     | (0.015)     | KANE       | 72 DPWA | 0          | K-P TO PI SIG       | 10/71 |  |

| REFERENCES FOR Y*(1915)              |    |                  |                                                      |                             |  |  |  |          |  |
|--------------------------------------|----|------------------|------------------------------------------------------|-----------------------------|--|--|--|----------|--|
| ARMENTERI                            | 67 | PL 248 198       | ARMENTERIS, FERRO-LUZZI*                             | (CERN, HEID, SACLAY)        |  |  |  | (LRL)JJP |  |
| ARMENTERI                            | 67 | NP 83 592        | ARMENTERIS, FERRO-LUZZI*                             | (CERN, HEID, SACLAY)        |  |  |  | (LRL)JJP |  |
| SMART                                | 68 | PR 169 1330      | W M SMART                                            |                             |  |  |  |          |  |
| BERTHON                              | 70 | NP 820 476       | +RANGAN, VRANA, + (COL FRANCE, RHEL, SACLAY)JJP      |                             |  |  |  |          |  |
| BERTHON                              | 70 | NP 824 417       | +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)JJP       |                             |  |  |  |          |  |
| BRICMAN                              | 70 | PL 338 511       | +FERRO-LUZZI, LAGNAUX                                | (CERN)                      |  |  |  |          |  |
| COX                                  | 70 | NP 819 61        | +ISLAM, COLLEY, +                                    | (BIRM, EDIN, GLAS, LOIC)JJP |  |  |  |          |  |
| GALTIERI                             | 70 | DUKE CONF 173    | A BARBARO-GALTIERI                                   | (LRL)JJP                    |  |  |  |          |  |
| LITCHFIELD                           | 70 | NP 822 269       | P J LITCHFIELD                                       | (RUTHERFORD)JJP             |  |  |  |          |  |
| CONFORTO                             | 71 | NP 834 41        | +LEVI SETTI, LASINSKI, OBERLACK* + (EFI+HEID)JJP     |                             |  |  |  |          |  |
| ISLAM                                | 71 | PJSIR 14 305     | +COX, COLLEY, HEATHCOTE                              | (BIRM) JJP                  |  |  |  |          |  |
| PAKISTAN J. SCI. IND. RES.           |    |                  |                                                      |                             |  |  |  |          |  |
| LITCHFIELD                           | 71 | NP 830 125       | LITCHFIELD, ... + LESQUOY, ... (RHEL+CDEF+SACLAY)JJP |                             |  |  |  |          |  |
| KANE                                 | 72 | PR D5 1583       | D F KANE                                             | (LBL)JJP                    |  |  |  |          |  |
| VANHORN                              | 72 | LBL-1370 (THEIS) |                                                      | (LBL)JJP                    |  |  |  |          |  |
| PAPERS NOT REFERRED TO IN DATA CARDS |    |                  |                                                      |                             |  |  |  |          |  |
| SMART                                | 66 | PRL 17 556       | W M SMART, A KERNAN, G E KALMUS, R P ELY (LRL)JJP    |                             |  |  |  |          |  |
| SUPERSEDED BY SMART 68.              |    |                  |                                                      |                             |  |  |  |          |  |
| CONFORTO                             | 68 | NP 88 265        | +HARMSEN, LASINSKI, + (CHICAGO, HEIDEL)              |                             |  |  |  |          |  |
| SUPERSEDED BY CONFORTO 71.           |    |                  |                                                      |                             |  |  |  |          |  |

 **$\Sigma(1920)$   
BUMPS**

29 Y\*(1920, JP= 1) I=1 PRODUCTION EXPERIMENT'S  
SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.  
SEE THE NOTES TO THE Y\*(1915) AND Y\*(1940), WHICH IMMEDIATELY PRECEDE AND FOLLOW THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS-SECTION PEAKS ARE ALMOST CERTAINLY ASSOCIATED WITH THE F15 Y\*(1915) SEEN IN PARTIAL-WAVE ANALYSES. THE INVARIANT-MASS PEAKS SEEM MORE LIKELY TO BE ASSOCIATED WITH THE NOT-COMpletely-ESTABLISHED D13 Y\*(1940).

| 29 Y*(1920) MASS (MEV) (PROD. EXP.) |                                          |                                                    |         |         |                    |                 |       |  |  |
|-------------------------------------|------------------------------------------|----------------------------------------------------|---------|---------|--------------------|-----------------|-------|--|--|
| M                                   | CROSS-SECTION PEAKS --                   |                                                    |         |         |                    |                 |       |  |  |
| M                                   | 1905.0                                   | 5.0                                                | BUGG    | 68 CNTR | 0                  | K-P, D TOTAL    | 11/66 |  |  |
| M                                   | 1906.0                                   | 6.0                                                | BRICMAN | 70 CNTR | 0                  | TOTAL AND CH EX | 6/70  |  |  |
| M                                   | 1912.0                                   | 10.0                                               | COOL    | 70 CNTR | 0                  | K-P, D TOTAL    | 10/70 |  |  |
| M                                   | INVARIANT-MASS-DISTRIBUTION PEAKS --     |                                                    |         |         |                    |                 |       |  |  |
| M                                   | (1942.0)                                 | (9.0)                                              | BOCK    | 65 HBC  | PBAR P 5.7 BEV/C   |                 | 5/70  |  |  |
| M                                   | 1940.0                                   | 11.0                                               | AGUILAR | 70 HBC  | + 3.9-4.6 GEV/C K- |                 | 2/73* |  |  |
| M                                   | ELASTIC DCS --                           |                                                    |         |         |                    |                 |       |  |  |
| M                                   | 1                                        | 1931.0                                             | DADO    | 72 HBC  | 0                  | K-P ELSTC DCS   | 2/73* |  |  |
| M                                   | 1                                        | G7 INDICATED BY LEGENDRE COEFFS, G9 NOT RULED OUT. |         |         |                    |                 | 2/73* |  |  |
| M                                   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.9) |                                                    |         |         |                    |                 |       |  |  |

| 29 Y*(1920) WIDTH (MEV) (PROD. EXP.) |                                          |        |         |         |        |                    |               |       |  |
|--------------------------------------|------------------------------------------|--------|---------|---------|--------|--------------------|---------------|-------|--|
| W                                    | CROSS-SECTION PEAKS --                   |        |         |         |        |                    |               |       |  |
| W                                    | 60.0                                     | 10.0   | BUGG    | 68 CNTR | 0      | TOTAL AND CH EX    | 11/66         |       |  |
| W                                    | 50.0                                     | 12.0   | BRICMAN | 70 CNTR | 0      | K-P, D TOTAL       | 6/70          |       |  |
| W                                    | (30.0)                                   |        | COOL    | 70 CNTR | 0      | K-P, D TOTAL       | 10/70         |       |  |
| W                                    | INVARIANT-MASS-DISTRIBUTION PEAKS --     |        |         |         |        |                    |               |       |  |
| W                                    | (36.0)                                   | (20.0) | (36.0)  | BOCK    | 65 HBC | + 3.9-4.6 GEV/C K- | 5/70          |       |  |
| W                                    | 90.0                                     | 20.0   | AGUILAR | 70 HBC  | 0      | K-P ELSTC DCS      | 2/73*         |       |  |
| W                                    | ELASTIC DCS --                           |        |         |         |        |                    |               |       |  |
| W                                    | 1                                        | 70.0   | 14.0    | DADO    | 72 HBC | 0                  | K-P ELSTC DCS | 2/73* |  |
| W                                    | AVERAGE MEANINGLESS (SCALE FACTOR = 1.1) |        |         |         |        |                    |               |       |  |

| 29 Y*(1920) PARTIAL DECAY MODES (PROD. EXP.) |          |                |  |  |  |  |  |       |     |
|----------------------------------------------|----------|----------------|--|--|--|--|--|-------|-----|
| P1                                           | Y*(1920) | INTO KBAR N    |  |  |  |  |  | 497*  | 939 |
| P2                                           | Y*(1920) | INTO LAMBDA PI |  |  |  |  |  | 1115* | 139 |
| P3                                           | Y*(1920) | INTO SIGMA PI  |  |  |  |  |  | 1197* | 139 |

| 29 Y*(1920) BRANCHING RATIOS (PROD. EXP.) |          |                               |           |                                              |                |                |                 |       |  |
|-------------------------------------------|----------|-------------------------------|-----------|----------------------------------------------|----------------|----------------|-----------------|-------|--|
| R1                                        | Y*(1920) | INTO (KBAR N)/TOTAL           | (P1)      |                                              |                |                |                 |       |  |
| R1                                        |          | 0.06                          | BUGG      | 68 CNTR                                      | 0              | ASSUMING J=5/2 | 6/68            |       |  |
| R1                                        |          | 0.07                          | 0.02      | BRICMAN                                      | 70 CNTR        | 0              | TOTAL AND CH EX | 6/70  |  |
| R1                                        |          | 0.07                          |           | COOL                                         | 70 CNTR        | 0              | K-P, D TOTAL    | 10/70 |  |
| R1                                        | 1        | THIS ELASTICITY ASSUMES J=7/2 | DADO      | 72 HBC                                       | 0              | K-P ELSTC DCS  | 2/73*           |       |  |
| R1                                        |          | .62                           | .08       |                                              |                |                | 2/73*           |       |  |
| R1                                        | AVG      | 0.10                          | 0.13      | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 6.7) |                |                |                 |       |  |
| R2                                        | Y*(1920) | INTO (KBAR N)/(SIGMA PI)      | (P1)/(P3) |                                              |                |                |                 |       |  |
| R2                                        |          | (.37) OR LESS                 | BARNES    | 69 HBC                                       | + 1 STAN. DEV. |                | 10/69           |       |  |
| R3                                        | Y*(1920) | INTO (LAMBDA PI)/(SIGMA PI)   | (P2)/(P3) |                                              |                |                |                 |       |  |
| R3                                        |          | (.28) OR LESS                 | BARNES    | 69 HBC                                       | + 1 STAN. DEV. |                | 10/69           |       |  |

| REFERENCES FOR Y*(1920) (PROD. EXP.) |    |             |                                                    |                       |  |  |  |  |  |
|--------------------------------------|----|-------------|----------------------------------------------------|-----------------------|--|--|--|--|--|
| BOCK                                 | 65 | PL 17 166   | +COOPER, FRENCH, KINSON, +                         | (CERN, SACLAY) I      |  |  |  |  |  |
| COOL                                 | 66 | PRL 16 1228 | +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + (BNL) I |                       |  |  |  |  |  |
| SUPERSEDED BY COOL 70.               |    |             |                                                    |                       |  |  |  |  |  |
| BUGG                                 | 68 | PR 168 1466 | +GILMORE, KNIGHT, DAVIES +                         | (BIRM, CAVE, RHEL)JJP |  |  |  |  |  |
| BARNES                               | 69 | PRL 22 479  | +FLAMINIO, MONTANET, SANTOS +                      | (BNL+SYRA)            |  |  |  |  |  |
| AGUILAR                              | 70 | PL 25 58    | AGUILAR-BENITEZ, BARNES, +                         | (BNL, SYRA)           |  |  |  |  |  |
| BRICMAN                              | 70 | PL 318 152  | +FERRO LUZZI, PERREAU, +                           | (CERN, CAEN, SACLAY)  |  |  |  |  |  |
| COOL                                 | 70 | PR D1 1887  | +GIACOMELLI, KYCIA, LEONTIC, LI, +                 | (BNL) I               |  |  |  |  |  |
| DADO                                 | 72 | PRL 29 1695 | +BIRMAN, GOLDBERG, WEISS                           | (HAIFI)JJP            |  |  |  |  |  |

PAPERS NOT REFERRED TO IN DATA CARDS  
PRIMER 68 PRL 20 610 +GOLDBERG, JAEGER, BARNES, DORNAN + (SYRA, BNL)  
SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.

 **$\Sigma(1940)$** 

98 Y\*(1940, JP=3/2- 1) I=1

**D13**

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN BARYON TABLE. THIS EFFECT IS PERHAPS ASSOCIATED WITH THE BUMPS SEEN IN PRODUCTION EXPERIMENTS NEAR THIS MASS. SEE THE PRECEDING ENTRY.

| 98 Y*(1940) MASS (MEV) |        |        |            |                                              |                 |                 |       |  |  |
|------------------------|--------|--------|------------|----------------------------------------------|-----------------|-----------------|-------|--|--|
| M                      | 1940.0 | 50.0   | GALTIERI   | 70 DPWA                                      | K- N TO LAM PI  | 7/70            |       |  |  |
| M                      | 1940.0 | 40.0   | GALTIERI   | 70 DPWA                                      | K-P TO SIGMA PI | 7/70            |       |  |  |
| M                      | 1940.0 | 30.0   | LITCHFIELD | 70 DPWA                                      | K- N TO LAM PI  | 7/70            |       |  |  |
| M                      | 1985.0 | (5.0)  | KANE       | 72 DPWA                                      | 0               | K-P TO PI SIG   | 10/71 |  |  |
| M                      | 1949.0 | 40.0   | VANHORN    | 72 DPWA                                      | 0               | K- P TO LAM P10 | 2/73* |  |  |
| M                      | AVG    | 1941.4 | 19.9       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                 |                 |       |  |  |

| 98 Y*(1940) WIDTH (MEV) |       |        |            |                                              |                 |                 |       |  |  |
|-------------------------|-------|--------|------------|----------------------------------------------|-----------------|-----------------|-------|--|--|
| W                       | 200.0 | 50.0   | GALTIERI   | 70 DPWA                                      | K- N TO LAM PI  | 7/70            |       |  |  |
| W                       | 200.0 | 50.0   | GALTIERI   | 70 DPWA                                      | K-P TO SIGMA PI | 7/70            |       |  |  |
| W                       | 280.0 | 40.0   | LITCHFIELD | 70 DPWA                                      | K- N TO LAM PI  | 7/70            |       |  |  |
| W                       | 208.0 | (22.0) | KANE       | 72 DPWA                                      | 0               | K-P TO PI SIG   | 10/71 |  |  |
| W                       | 160.0 | 70.0   | VANHORN    | 72 DPWA                                      | 0               | K- P TO LAM P10 | 2/73* |  |  |
| W                       | AVG   | 220.9  | 26.7       | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) |                 |                 |       |  |  |

| 98 Y*(1940) PARTIAL DECAY MODES |          |                |  |  |  |  |  |       |     |
|---------------------------------|----------|----------------|--|--|--|--|--|-------|-----|
| P1                              | Y*(1940) | INTO KBAR N    |  |  |  |  |  | 497*  | 939 |
| P2                              | Y*(1940) | INTO LAMBDA PI |  |  |  |  |  | 1115* | 139 |
| P3                              | Y*(1940) | INTO SIGMA PI  |  |  |  |  |  | 1197* | 139 |

## Baryons

 $\Sigma(1940)$ ,  $\Sigma(2000)$ ,  $\Sigma(2030)$ 

## Data Card Listings

For notation, see key at front of Listings.

## 98 Y\*(1940) BRANCHING RATIOS

| R1 | Y*(1940) FROM K $\bar{B}$ AR N INTO LAMBDA PI | SQRT(P1*P2)                                  |       |
|----|-----------------------------------------------|----------------------------------------------|-------|
| R1 | -0.12 0.04 GALTIERI 70 DPWA                   | K- N TO LAM PI                               | 7/70  |
| R1 | -0.14 0.03 LITCHFIELD 70 DPWA                 | K- N TO LAM PI                               | 7/70  |
| R1 | -0.05 .03 .02 VANHORN 72 DPWA                 | O K-P TO LAM PI                              | 2/73* |
| R1 | AVG MOD 0.093 0.030                           | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) |       |

| R2 | Y*(1940) FROM K $\bar{B}$ AR N INTO SIGMA PI | SQRT(P1*P3)     |       |
|----|----------------------------------------------|-----------------|-------|
| R2 | -0.12 0.03 GALTIERI 70 DPWA                  | K-P TO SIGMA PI | 7/70  |
| R2 | -0.093 (0.006) KANE 72 DPWA                  | O K-P TO PI SIG | 10/71 |

## REFERENCES FOR Y\*(1940)

|                             |                    |                 |
|-----------------------------|--------------------|-----------------|
| GALTIERI 70 DUKE CONF 173   | A BARBARO-GALTIERI | (LRL)IJP        |
| LITCHFIELD 70 NP 822 269    | P J LITCHFIELD     | (RUTHERFORD)IJP |
| KANE 72 PR 05 1583          | D F KANE           | (LRL)IJP        |
| VANHORN 72 LBL-1370(THESIS) |                    | /LBL IJP        |

 $\Sigma(2000)$ 

02 Y\*(2000, JP=1/2-) I=1

S<sub>11</sub>

| M | 2004. | 40. | VANHORN 72 DPWA | O K-P TO LAM PI | 2/73* |
|---|-------|-----|-----------------|-----------------|-------|
|---|-------|-----|-----------------|-----------------|-------|

| M | 116. | 40. | VANHORN 72 DPWA | O K-P TO LAM PI | 2/73* |
|---|------|-----|-----------------|-----------------|-------|
|---|------|-----|-----------------|-----------------|-------|

## 02 Y\*(2000) PARTIAL DECAY MODES

| P1 | Y*(2000) INTO K $\bar{B}$ AR N | DECAY MASSES          |
|----|--------------------------------|-----------------------|
| P2 | Y*(2000) INTO LAMBDA PI        | 497+ 939<br>1115+ 134 |

## 02 Y\*(2000) BRANCHING RATIOS

| R1 | Y*(2000) FROM K $\bar{B}$ AR N INTO LAMBDA PI | SQRT(P1*P2)     |       |
|----|-----------------------------------------------|-----------------|-------|
| R1 | .07 .02 .01 VANHORN 72 DPWA                   | O K-P TO LAM PI | 2/73* |

## REFERENCES FOR Y\*(2000)

|                             |          |
|-----------------------------|----------|
| VANHORN 72 LBL-1370(THESIS) | /LBL IJP |
|-----------------------------|----------|

 $\Sigma(2030)$ 

47 Y\*(2030, JP=7/2+) I=1

F<sub>17</sub>

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE ANALYSES. PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS AND INVARIANT-MASS DISTRIBUTIONS AROUND 2030 MEV ARE GIVEN IN THE NEXT ENTRY. EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD GIVE THE BEST RESULTS, AS THEY ISOLATE THE F<sub>17</sub> WAVE. THIS SUPERIORITY IS, HOWEVER, PROBABLY NOT YET ATTAINED, AND WE RELY ON BOTH ENTRIES FOR PARAMETERS GIVEN IN THE MAIN BARYON TABLE.

## 47 Y\*(2030) MASS (MEV)

| M | (2030.0) | (20.0) | WOHL 66 HBC        | O K-P TO LAM PI         | 7/66  |
|---|----------|--------|--------------------|-------------------------|-------|
| M | 2032.0   | 6.0    | SMART 68 DPWA      | K- N TO LAMBDA PI       | 6/68  |
| M | 2030.0   | 10.0   | BERTHON 70 DPWA    | O K-P TO LAMBDA PI      | 7/70  |
| M | 2035.0   | 10.0   | BERTHON1 70 DPWA   | O K-P TO SIGMA PI       | 10/70 |
| M | 2027.0   | 6.0    | COX 70 DPWA        | K- N TO LAMBDA PI       | 6/70  |
| M | 2010.0   | 15.0   | GALTIERI 70 DPWA   | O K-P TO LAMBDA PI      | 7/70  |
| M | 2000.0   | 20.0   | GALTIERI 70 DPWA   | O K-P TO SIGMA PI       | 7/70  |
| M | 2022.0   | 4.0    | LITCHFIELD 70 DPWA | K- N TO LAMBDA PI       | 6/70  |
| M | 2025.    | 15.    | LITCHFIELD 71 DPWA | K-P TO K $\bar{B}$ AR N | 10/71 |
| M | 2034.0   | 14.0   | KANE 72 DPWA       | O K-P TO PI SIG         | 10/71 |
| M | 2042.    | 11.    | VANHORN 72 DPWA    | O K-P TO LAM PI         | 2/73* |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

## 47 Y\*(2030) WIDTH (MEV)

| M | (170.0) | (20.0) | WOHL 66 HBC        | O                       | 7/66  |
|---|---------|--------|--------------------|-------------------------|-------|
| M | 160.0   | 16.0   | SMART 68 DPWA      | K- N TO LAMBDA PI       | 6/68  |
| M | 165.0   | 30.0   | BERTHON 70 DPWA    | O K-P TO LAMBDA PI      | 7/70  |
| M | 150.0   | 20.0   | BERTHON1 70 DPWA   | O K-P TO SIGMA PI       | 10/70 |
| M | 158.0   | 16.0   | COX 70 DPWA        | K- N TO LAMBDA PI       | 6/70  |
| M | 115.0   | 15.0   | GALTIERI 70 DPWA   | O K-P TO LAMBDA PI      | 7/70  |
| M | 100.0   | 40.0   | GALTIERI 70 DPWA   | O K-P TO SIGMA PI       | 7/70  |
| M | 170.0   | 15.0   | LITCHFIELD 70 DPWA | K- N TO LAMBDA PI       | 6/70  |
| M | 200.    | 30.    | LITCHFIELD 71 DPWA | K-P TO K $\bar{B}$ AR N | 10/71 |
| M | 118.0   | 12.0   | KANE 72 DPWA       | O K-P TO PI SIG         | 10/71 |
| M | 178.    | 13.    | VANHORN 72 DPWA    | O K-P TO LAM PI         | 2/73* |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

## 47 Y\*(2030) PARTIAL DECAY MODES

| P1 | Y*(2030) INTO K $\bar{B}$ AR N | DECAY MASSES                                    |
|----|--------------------------------|-------------------------------------------------|
| P2 | Y*(2030) INTO LAMBDA PI        | 497+ 939<br>1115+ 134<br>1197+ 139<br>1321+ 497 |
| P4 | Y*(2030) INTO XI K             |                                                 |

## 47 Y\*(2030) BRANCHING RATIOS

| R1 | Y*(2030) INTO (K $\bar{B}$ AR N)/TOTAL                        | (P1)                                         |                               |
|----|---------------------------------------------------------------|----------------------------------------------|-------------------------------|
| R1 | (0.25)                                                        | WOHL 66 HBC                                  | O K-P CH EX 7/66              |
| R1 | (0.11)                                                        | DAUM 68 CNTR                                 | K-P ELA,POL,SIGT 7/70         |
| R1 | 0.17 0.04                                                     | CAMPBELL 71 DBC                              | K- NEUTRON ELAST 1/71         |
| R1 | 0.18 0.02                                                     | LITCHFIELD 71 DPWA                           | K-P TO K $\bar{B}$ AR N 10/71 |
| R1 | DAUM 68 ASSUMES (J+1/2)*P1 VALUE SEEN IN TOTAL CROSS SECTION. |                                              |                               |
| R1 | AVG 0.178 0.018                                               | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |                               |

| R2 | Y*(2030) FROM K $\bar{B}$ AR N INTO LAMBDA PI | SQRT(P1*P2)        |                          |
|----|-----------------------------------------------|--------------------|--------------------------|
| R2 | (0.20)                                        | WOHL 66 HBC        | O K-P TO LAMBDA PI 7/66  |
| R2 | +0.21 0.01                                    | SMART 68 DPWA      | K- N TO LAMBDA PI 6/68   |
| R2 | +0.2 0.02                                     | BERTHON 70 DPWA    | O K-P TO LAMBDA PI 7/70  |
| R2 | +0.19 0.01                                    | COX 70 DPWA        | K- N TO LAMBDA PI 6/70   |
| R2 | +0.16 0.03                                    | GALTIERI 70 DPWA   | O K-P TO LAMBDA PI 7/70  |
| R2 | +0.20 0.008                                   | LITCHFIELD 70 DPWA | O K- N TO LAMBDA PI 6/70 |
| R2 | .20 .01                                       | VANHORN 72 DPWA    | O K-P TO LAM PI 2/73*    |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

| R3 | Y*(2030) FROM K $\bar{B}$ AR N INTO SIGMA PI | SQRT(P1*P3)        |                         |
|----|----------------------------------------------|--------------------|-------------------------|
| R3 | (-0.09) (0.02)                               | BERTHON1 70 DPWA   | O K-P TO SIGMA PI 10/70 |
| R3 | -0.052 0.010                                 | GALTIERI 70 DPWA   | O K-P TO SIGMA PI 7/70  |
| R3 | -0.10 0.03                                   | LITCHFIELD 71 DPWA | O K-P TO SIG PI 3/72    |
| R3 | L LITCHFIELD 71 IS AN UPDATE OF BERTHON1 70  |                    |                         |
| R3 | -0.086 0.014                                 | KANE 72 DPWA       | O K-P TO PI SIG 10/71   |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

| R4 | Y*(2030) FROM K $\bar{B}$ AR N INTO XI K | SQRT(P1*P4)    |                     |
|----|------------------------------------------|----------------|---------------------|
| R4 | (0.05) OR LESS                           | TRIPP 67 RVUE  | O K-P TO XI K 8/67  |
| R4 | (0.05) OR LESS                           | BURGUN 68 DPWA | O K-P TO XI K 10/69 |
| R4 | (0.023) OR LESS                          | MULLER 69 DPWA | O 7/70              |

## REFERENCES FOR Y\*(2030)

|                                        |                                                 |
|----------------------------------------|-------------------------------------------------|
| WOHL 66 PRL 17 107                     | C G WOHL, F T SOLMITZ, M L STEVENSON (LRL)IJP   |
| TRIPP 67 NP 83 10                      | * LEITH, * (LRL,SLAC,CERN,HEIDEL,SACLAY)        |
| BURGUN 68 NP 88 447                    | * MEYER,PAULI,TALLINI * (SACL+CDEF+RHEL)        |
| DAUM 68 NP 87 19                       | * ERNE,LAGNAUX,SENS,STEUER,UDD (CERN)IJP        |
| CONFIRMS THE SPIN-PARITY ASSIGNMENT.   |                                                 |
| SMART 68 PR 169 1336                   | M M SMART (LRL)IJP                              |
| MULLER 69 THESIS,UCRL 19372 R A MULLER | (LRL)                                           |
| BERTHON 70 NP 820 476                  | *RANGAN, VRANA, * (COL FRANCE, RHEL, SACLAY)IJP |
| BERTHON1 70 NP 824 417                 | *VRANA, BUTTERWORTH, * (CDEF, RHEL, SACLAY)IJP  |
| COX 70 NP 819 61                       | *ISLAM, COLLEY, * (BIRM,EDIN,GLAS,LOIC)IJP      |
| GALTIERI 70 DUKE CONF 173              | A BARBARO-GALTIERI (LRL)IJP                     |
| LITCHFIELD 70 NP 822 269               | P J LITCHFIELD (RUTHERFORD)IJP                  |
| CAMPBELL 71 NP 825 75                  | *MORTON, NEGUS, GOYAL, MILLER (GLAS, LOIC)IJP   |
| LITCHFIELD 71 NP 830 125               | LITCHFIELD,....LESQUY,.... (RHEL+CDEF+SACL)IJP  |
| KANE 72 PR 05 1583                     | D F KANE (LRL)IJP                               |
| VANHORN 72 LBL-1370(THESIS)            | /LBL IJP                                        |

 $\Sigma(2030)$   
BUMPS

28 Y\*(2030, JP= ) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SEE THE NOTE TO THE F<sub>17</sub> Y\*(2030), WHICH PRECEDES THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS-SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y\*(2030), BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTABLISHED OTHER RESONANCES IN THIS REGION.

## 28 Y\*(2030) MASS (MEV) (PROD. EXP.)

|   |                                          |        |          |         |                    |       |
|---|------------------------------------------|--------|----------|---------|--------------------|-------|
| M | (2022.0)                                 | (20.0) | BLANPIED | 65 CNTR | O GAMMA P TO K+ Y* |       |
| M | 2020.0                                   | 7.0    | BUGG     | 68 CNTR | K-P, D TOTAL       | 6/68  |
| M | 2049.0                                   | 4.0    | BRICMAN  | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| M | 2025.0                                   | 10.0   | COOL     | 70 CNTR | K-P, D TOTAL       | 10/70 |
| M | (2025.0)                                 | (20.0) | LU       | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |
| M | .....                                    |        |          |         |                    |       |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 2.8) |        |          |         |                    |       |

AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

## 28 Y\*(2030) WIDTH (MEV) (PROD. EXP.)

|   |         |        |          |         |                    |       |
|---|---------|--------|----------|---------|--------------------|-------|
| W | (120.0) | (20.0) | BLANPIED | 65 CNTR | O                  |       |
| W | 130.0   | 10.0   | BUGG     | 68 CNTR |                    | 6/68  |
| W | 126.0   | 11.0   | BRICMAN  | 70 CNTR | O TOTAL AND CH EX  | 6/70  |
| W | 165.0   |        | COOL     | 70 CNTR | K-P, D TOTAL       | 10/70 |
| W | (80.0)  |        | LU       | 70 CNTR | O GAMMA P TO K+ Y* | 1/71  |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

## 28 Y\*(2030) PARTIAL DECAY MODES (PROD. EXP.)

| P1 | Y*(2030) INTO K $\bar{B}$ AR N    | DECAY MASSES              |
|----|-----------------------------------|---------------------------|
| P2 | Y*(2030) INTO K $\bar{B}$ AR N PI | 497+ 939<br>497+ 939+ 139 |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Sigma(2030)$ ,  $\Sigma(2070)$ ,  $\Sigma(2080)$ ,  $\Sigma(2100)$ ,  $\Sigma(2250)$ 

28 Y\*1(2030) BRANCHING RATIOS (PROD. EXP.)

|    |                                              |                  |                    |
|----|----------------------------------------------|------------------|--------------------|
| R1 | Y*1(2030) INTO (KBAR N)/TOTAL                | (P1)             |                    |
| R1 | THESE VALUES OF ELASTICITIES ASSUME J=7/2 -- |                  |                    |
| R1 | 0.131                                        | BUGG 68 CNTR     | 6/70               |
| R1 | 0.27 (0.02)                                  | BRICHMAN 70 CNTR | 0 TOTAL AND CH EX  |
| R1 | 0.12                                         | COOL 70 CNTR     | K-P, D TOTAL 10/70 |

R2 Y\*1(2030) INTO KBAR N PI (P2)

R2 SEEN BOCK HBC

REFERENCES FOR Y\*1(2030) (PROD. EXP.)

BLANPIED 65 PRL 14 741 +GREENBERG, HUGHES, KITCHING, LU, + (YALE/CEA)

COOL 66 PRL 16 1228 +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + (BNL) I

SUPERSEDED BY COOL 70.

BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RHEL, BIRM, CAVE) I

BRICHMAN 70 PL 318 152 +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY)

COOL 70 PR D1 1887 +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I

LU 70 PR D2 1846 +GREENBERG, HUGHES, MINEHART, MORI, + (YALE)

 $\Sigma(2070)$ 

34 Y\*1(2070, JP=5/2+) I=1

F<sub>15</sub>

THIS STATE HAS BEEN SUGGESTED BY ONLY ONE PARTIAL WAVE ANALYSIS ACROSS THIS REGION. IT NEEDS CONFIRMATION THE RESONANCE PROPOSED BY KANE IS TOO BROAD TO BE USED AS EVIDENCE.

34 Y\*1(2070) MASS (MEV)

|   |          |       |          |           |                 |       |
|---|----------|-------|----------|-----------|-----------------|-------|
| M | (2070.)  | (10.) | BERTHONI | 70 DPWA - | K- P TO SIG PI  | 1/71  |
| M | (2057.0) |       | KANE     | 72 DPWA   | K-P TO SIGMA PI | 1/73* |

34 Y\*1(2070) WIDTH (MEV)

|   |         |       |          |           |                 |       |
|---|---------|-------|----------|-----------|-----------------|-------|
| W | (140.)  | (20.) | BERTHONI | 70 DPWA - | K- P TO SIG PI  | 1/71  |
| W | (906.0) |       | KANE     | 72 DPWA   | K-P TO SIGMA PI | 1/73* |

34 Y\*1(2070) PARTIAL DECAY MODES

|    |                         |              |
|----|-------------------------|--------------|
| P1 | Y*1(2070) INTO KBAR N   | DECAY MASSES |
| P2 | Y*1(2070) INTO SIGMA PI | 497+ 939     |
|    |                         | 1197+ 139    |

34 Y\*1(2070) BRANCHING RATIOS

|    |                                |                        |
|----|--------------------------------|------------------------|
| R1 | Y*1(2070) FROM KBAR N TO SIGMA | SORT(P1*P2)            |
| R1 | (+0.12) (0.02)                 | BERTHONI 70 DPWA -     |
| R1 | (+0.104)                       | KANE 72 DPWA           |
|    |                                | K- P TO SIGMA PI 1/73* |

REFERENCES FOR Y\*1(2070)

BERTHONI 70 NP 824 417 +VRANA, BUTTERTWORTH, + (COEF, RHEL, SACLAY) JDP

KANE 72 PR D5 1583 D F KANE (LBL)

 $\Sigma(2080)$ 

88 Y\*1(2080, JP=3/2+) I=1

P<sub>13</sub>

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN BARYON TABLE.

88 Y\*1(2080) MASS (MEV)

|   |          |        |            |           |                  |      |
|---|----------|--------|------------|-----------|------------------|------|
| M | (2082.0) | (4.0)  | COX        | 70 DPWA - | K- N TO LAM PI   | 6/70 |
| M | (2070.0) | (30.0) | LITCHFIELD | 70 DPWA - | 0 K- N TO LAM PI | 6/70 |

88 Y\*1(2080) WIDTH (MEV)

|   |          |        |            |           |                  |      |
|---|----------|--------|------------|-----------|------------------|------|
| W | (87.0)   | (20.0) | COX        | 70 DPWA - | K- N TO LAM PI   | 6/70 |
| W | (1250.0) | (40.0) | LITCHFIELD | 70 DPWA - | 0 K- N TO LAM PI | 6/70 |

88 Y\*1(2080) PARTIAL DECAY MODES

|    |                          |              |
|----|--------------------------|--------------|
| P1 | Y*1(2080) INTO KBAR N    | DECAY MASSES |
| P2 | Y*1(2080) INTO LAMBDA PI | 497+ 939     |
|    |                          | 1115+ 139    |

88 Y\*1(2080) BRANCHING RATIOS

|    |                                    |                       |
|----|------------------------------------|-----------------------|
| R1 | Y*1(2080) FROM KBAR N TO LAMBDA PI | SORT(P1*P2)           |
| R1 | (+0.16) (0.03)                     | COX 70 DPWA -         |
| R1 | (+0.09) (0.03)                     | LITCHFIELD 70 DPWA -  |
|    |                                    | 0 K- N TO LAM PI 6/70 |

## REFERENCES FOR Y\*1(2080)

COX 70 NP 819 61 +ISLAM, COLLEY, + (BIRM, EDIN, GLAS, LOIC) JDP

LITCHFIELD 70 NP 822 269 P J LITCHFIELD (RUTHERFORD) JDP

 $\Sigma(2100)$ 

26 Y\*1(2100, JP=7/2-) I=1

G<sub>17</sub>

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN BARYON TABLE.

26 Y\*1(2100) MASS (MEV)

|   |          |        |          |         |                    |      |
|---|----------|--------|----------|---------|--------------------|------|
| M | (2060.0) | (20.0) | GALTIERI | 70 DPWA | 0 K-P TO LAMBDA PI | 7/70 |
| M | (2120.0) | (30.0) | GALTIERI | 70 DPWA | 0 K-P TO SIGMA PI  | 7/70 |

26 Y\*1(2100) WIDTH (MEV)

|   |         |        |          |         |                    |      |
|---|---------|--------|----------|---------|--------------------|------|
| W | (70.0)  | (30.0) | GALTIERI | 70 DPWA | 0 K-P TO LAMBDA PI | 7/70 |
| W | (135.0) | (30.0) | GALTIERI | 70 DPWA | 0 K-P TO SIGMA PI  | 7/70 |

26 Y\*1(2100) PARTIAL DECAY MODES

|    |                          |              |
|----|--------------------------|--------------|
| P1 | Y*1(2100) INTO KBAR N    | DECAY MASSES |
| P2 | Y*1(2100) INTO LAMBDA PI | 497+ 939     |
| P3 | Y*1(2100) INTO SIGMA PI  | 1115+ 134    |
|    |                          | 1197+ 139    |

26 Y\*1(2100) BRANCHING RATIOS

|    |                                    |                        |
|----|------------------------------------|------------------------|
| R1 | Y*1(2100) FROM KBAR N TO LAMBDA PI | SORT(P1*P2)            |
| R1 | (-0.07) (0.02)                     | GALTIERI 70 DPWA       |
| R2 | Y*1(2100) FROM KBAR N TO SIGMA PI  | SORT(P1*P3)            |
| R2 | (+0.13) (0.02)                     | GALTIERI 70 DPWA       |
|    |                                    | 0 K-P TO SIGMA PI 7/70 |

## REFERENCES FOR Y\*1(2100)

GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL) JDP

 $\Sigma(2250)$   
BUMPS

48 Y\*1(2250, JP= ) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y\* LISTINGS.

THE PHASE-SHIFT-ANALYSIS RESULTS ARE TOO WEAK TO WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-SECTION EXPERIMENTS. IN AN ANALYSIS OF ELASTIC AND POLARIZATION DATA, DAUM 68 COULD NOT EXCLUDE ANY POSSIBILITY FROM JP= 5/2+ TO JP= 11/2+ FOR THIS STATE. BRICHMAN 70 SUGGESTS 712-. VANHORN72 CLAIMS 5/2+.

LASINSKI 71 SUGGESTS TWO RESONANCES IN THIS REGION USING A POMERON + RESONANCES MODEL.

48 Y\*1(2250) MASS (MEV) (PROD. EXP.)

|   |          |        |             |                   |                                          |
|---|----------|--------|-------------|-------------------|------------------------------------------|
| M | (2245.0) |        | BLANPIED    | 65 CNTR           | GAMMA P TO K+ Y*                         |
| M | (2299.0) | (6.0)  | BOCK        | 65 HBC            | PBAR P 5.7 GEV/C                         |
| M | 2250.0   | 7.0    | BUGG        | 68 CNTR           | K-P, D TOTAL 6/68                        |
| M | 2280.    | 14.0   | AGUILAR     | 70 HBC +          | K- 3.9-4.6 GEV/C 5/70                    |
| M | 2237.0   | 11.0   | BRICHMAN    | 70 CNTR           | 0 TOTAL AND CH EX 6/70                   |
| M | 2255.0   | 10.0   | COOL        | 70 CNTR           | K-P, D TOTAL 10/70                       |
| M | (2250.0) | (20.0) | LU          | 70 CNTR           | 0 GAMMA P TO K+ Y* 1/71                  |
| M | V        | 30.    | 20. VANHORN | 72 DPWA           | 0 K-P TO LAM P10 2/73*                   |
| M | V        |        | VANHORN72   | VALUE FROM A DPWA | THAT FINDS JP=5/2+.                      |
| M |          |        |             |                   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.2) |

48 Y\*1(2250) WIDTH (MEV) (PROD. EXP.)

|   |         |        |          |          |                                              |
|---|---------|--------|----------|----------|----------------------------------------------|
| W | (150.0) |        | BLANPIED | 65 CNTR  | GAMMA P TO K+ Y*                             |
| W | (121.0) | (17.0) | (21.0)   | BOCK     | PBAR P 5.7 GEV/C                             |
| W | 230.0   | 20.0   | BUGG     | 68 CNTR  | K-P, D TOTAL 6/68                            |
| W | 100.0   | 20.0   | AGUILAR  | 70 HBC + | K- 3.9-4.6 GEV/C 5/70                        |
| W | 164.0   | 50.0   | BRICHMAN | 70 CNTR  | 0 TOTAL AND CH EX 6/70                       |
| W | (170.0) |        | COOL     | 70 CNTR  | K-P, D TOTAL 10/70                           |
| W | (125.0) |        | LU       | 70 CNTR  | 0 GAMMA P TO K+ Y* 1/71                      |
| W | V       | 192.   | 30.      | VANHORN  | 72 DPWA                                      |
| W | AVG     | 169.5  | 33.4     |          | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7) |
|   |         |        |          |          | SEE THE NOTES ACCOMPANYING THE MASSES QUOTED |

48 Y\*1(2250) PARTIAL DECAY MODES (PROD. EXP.)

|    |                          |               |
|----|--------------------------|---------------|
| P1 | Y*1(2250) INTO KBAR N    | DECAY MASSES  |
| P2 | Y*1(2250) INTO LAMBDA PI | 497+ 939      |
| P3 | Y*1(2250) INTO SIGMA PI  | 1115+ 134     |
| P4 | Y*1(2250) INTO KBAR N PI | 1197+ 139     |
|    |                          | 497+ 939+ 139 |

**Baryons** $\Sigma(2250)$ ,  $\Sigma(2455)$ ,  $\Sigma(2620)$ ,  $\Sigma(3000)$ , EX. HYPE.**Data Card Listings**

For notation, see key at front of Listings.

48  $Y^*(2250)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                                                  |             |                |       |
|----|------------------------------------------------------------------|-------------|----------------|-------|
| R1 | $Y^*(2250)$ INTO (KBAR N)/TOTAL                                  | (P1)        |                |       |
| R1 | J IS NOT KNOWN. THE FOLLOWING IS (J+1/2)*P1.                     |             |                |       |
| R1 | (0.47)                                                           | BUGG        | 68 CNTR        | 6/68  |
| R1 | (0.16)                                                           | BRICMAN     | 70 CNTR        | 6/70  |
| R1 | (0.42)                                                           | COOL        | 70 CNTR        | 10/70 |
| R2 | $Y^*(2250)$ FROM KBAR N TO LAMBDA P1                             | Sort(P1*P2) |                |       |
| R2 | THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP. |             |                |       |
| R2 | (-0.18)                                                          | GALTIERI    | 70 DPWA        | 10/70 |
| R2 | V -0.16                                                          | VANHORN     | 72 DPWA        | 2/73* |
| R2 | .03                                                              |             | K-P TO LAM P10 |       |
|    | SEE THE NOTES ACCOMPANYING THE MASSES QUOTED                     |             |                |       |
| R3 | $Y^*(2250)$ FROM KBAR N TO SIGMA P1                              | Sort(P1*P3) |                |       |
| R3 | THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP. |             |                |       |
| R3 | (+0.07)                                                          | GALTIERI    | 70 DPWA        | 10/70 |
| R4 | $Y^*(2250)$ INTO (KBAR N)/(SIGMA P1)                             | (P1)/(P3)   |                |       |
| R4 | (0.18) OR LESS                                                   | BARNES      | 69 HBC         | 10/69 |
| R5 | $Y^*(2250)$ INTO (LAMBDA P1)/(SIGMA P1)                          | (P2)/(P3)   |                |       |
| R5 | (0.18) OR LESS                                                   | BARNES      | 69 HBC         | 10/69 |

REFERENCES FOR  $Y^*(2250)$  (PROD. EXP.)

|          |                     |                                               |
|----------|---------------------|-----------------------------------------------|
| BLANPIED | 65 PRL 14 741       | +GREENBERG, HUGHES, KITCHING, + (YALE)(CEA))  |
| BOCK     | 65 PL 17 166        | +COOPER, FRENCH, KINSON, + (CERN, SACLAY)     |
| BUGG     | 68 PR 168 1466      | +GILMORE, KNIGHT, + (RHEL, BIRM, CAVE) I      |
| BARNES   | 69 PRL 22 479       | +FLAMINIO, MONTANET, SANTOS + (BNL+SYRA)      |
| AGUILAR  | 70 PRL 25 58        | AGUILAR-BENITEZ, BARNES, + (BNL, SYRA)        |
| BRICMAN  | 70 PL 318 152       | +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY) |
| COOL     | 70 PR D1 1887       | +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I    |
| GALTIERI | 70 DUKE CONF 173    | A BARBARO-GALTIERI (LRL) IJP                  |
| LU       | 70 PR D2 1846       | +GREENBERG, HUGHES, MINEHART, MORI, + (YALE)  |
| VANHORN  | 72 LBL-1370(THESIS) | /LBL IJP                                      |

## PAPERS NOT REFERRED TO IN DATA CARDS

|          |                                                             |                                                    |
|----------|-------------------------------------------------------------|----------------------------------------------------|
| COOL     | 66 PRL 16 1228                                              | +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + (BNL) I |
|          | SUPERSEDED BY COOL 70.                                      |                                                    |
| DAUBER   | 60 PL 23 154                                                | +SCHLEIN, SLATER, STORK, TICHON (UCLA)(LRL) J      |
|          | SUGGESTS J=9/2 RESONANT BEHAVIOR IN SIGMA- P1+, BUT APPEARS |                                                    |
|          | INCONSISTENT WITH PARAMETERS OF COOL 66.                    |                                                    |
| DAUM     | 68 NP B7 19                                                 | +ERNE, LAGNAUX, SENS, STEUER, UDO (CERN)JP         |
| LASINSKI | 71 NP B29 125                                               | T A LASINSKI (EFI) IJP                             |

 **$\Sigma(2455)$   
BUMPS**53  $Y^*(2455)$ , JP=    I=1    PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE  $Y^*$  LISTINGS.  
THERE IS ALSO SOME SLIGHT EVIDENCE FOR  $Y^*$  STATES IN  
THIS MASS REGION FROM THE REACTION  $\gamma + p \rightarrow K^+ + \text{MISSING MASS}$  --  
SEE GREENBERG 68.

53  $Y^*(2455)$  MASS (MEV) (PROD. EXP.)

|   |        |        |        |                                              |              |       |
|---|--------|--------|--------|----------------------------------------------|--------------|-------|
| M | 2455.0 | 7.0    | BUGG   | 68 CNTR                                      | K-P, D TOTAL | 6/68  |
| M | 2455.0 | 10.0   | ABRAMS | 70 CNTR                                      | K-P, D TOTAL | 10/70 |
| M | AVG    | 2455.0 | 5.7    | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |              |       |

53  $Y^*(2455)$  WIDTH (MEV) (PROD. EXP.)

|   |       |      |        |         |              |       |
|---|-------|------|--------|---------|--------------|-------|
| W | 100.0 | 20.0 | BUGG   | 68 CNTR |              | 6/68  |
| W | 140.0 |      | ABRAMS | 70 CNTR | K-P, D TOTAL | 10/70 |

53  $Y^*(2455)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                         |              |
|----|-------------------------|--------------|
| P1 | $Y^*(2455)$ INTO KBAR N | DECAY MASSES |
|    |                         | 497+ 939     |

53  $Y^*(2455)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                              |                                                           |         |       |
|----|----------------------------------------------|-----------------------------------------------------------|---------|-------|
| R1 | $Y^*(2455)$ INTO (KBAR N)/TOTAL              | (P1)                                                      |         |       |
| R1 | J IS NOT KNOWN. THE FOLLOWING IS (J+1/2)*P1. |                                                           |         |       |
| R1 | (0.3)                                        | BUGG                                                      | 68 CNTR | 6/68  |
| R1 | (0.39)                                       | ABRAMS                                                    | 70 CNTR | 10/70 |
| R1 | C (0.05) (0.05)                              | BRICMAN                                                   | 70 CNTR | 6/70  |
| R1 | C                                            | FIT OF TOTAL CROSS SECTION GIVEN BY BRICMAN 70 IS POOR IN |         |       |
| R1 | C                                            | THIS REGION.                                              |         |       |

REFERENCES FOR  $Y^*(2455)$  (PROD. EXP.)

|           |                |                                                |
|-----------|----------------|------------------------------------------------|
| BUGG      | 68 PR 168 1466 | +GILMORE, KNIGHT, + (RHEL, BIRM, CAVE) I       |
| ABRAMS    | 70 PR 10 1917  | +COOL, GIACOMELLI, KYCIA, LEONTIC, + (BNL) I   |
| BRICMAN   | 70 PL 318 152  | +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY)  |
| ABRAMS    | 67 PRL 19 678  | PAPERS NOT REFERRED TO IN DATA CARDS.          |
| GREENBERG | 68 PRL 20 221  | +COOL, GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) |
|           |                | GREENBERG, HUGHES, LU, MINEHART, + (YALE)      |

 **$\Sigma(2620)$   
BUMPS**54  $Y^*(2620)$ , JP=    I=1    PRODUCTION EXPERIMENTSSEE THE MINI-REVIEW AT THE START OF THE  $Y^*$  LISTINGS.54  $Y^*(2620)$  MASS (MEV) (PROD. EXP.)

|   |        |      |        |         |              |       |
|---|--------|------|--------|---------|--------------|-------|
| M | 2620.0 | 15.0 | ABRAMS | 70 CNTR | K-P, D TOTAL | 10/70 |
|---|--------|------|--------|---------|--------------|-------|

54  $Y^*(2620)$  WIDTH (MEV) (PROD. EXP.)

|   |         |  |        |         |              |       |
|---|---------|--|--------|---------|--------------|-------|
| W | (175.0) |  | ABRAMS | 70 CNTR | K-P, D TOTAL | 10/70 |
|---|---------|--|--------|---------|--------------|-------|

54  $Y^*(2620)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                         |              |
|----|-------------------------|--------------|
| P1 | $Y^*(2620)$ INTO KBAR N | DECAY MASSES |
|    |                         | 497+ 939     |

54  $Y^*(2620)$  BRANCHING RATIOS (PROD. EXP.)

|    |                                              |         |         |                   |
|----|----------------------------------------------|---------|---------|-------------------|
| R1 | $Y^*(2620)$ INTO (KBAR N)/TOTAL              | (P1)    |         |                   |
| R1 | J IS NOT KNOWN. THE FOLLOWING IS (J+1/2)*P1. |         |         |                   |
| R1 | (0.32)                                       | ABRAMS  | 70 CNTR | K-P, D TOTAL      |
| R1 | 0.36                                         | BRICMAN | 70 CNTR | 0 TOTAL AND CH EX |

REFERENCES FOR  $Y^*(2620)$  (PROD. EXP.)

|         |               |                                                |
|---------|---------------|------------------------------------------------|
| ABRAMS  | 67 PRL 19 678 | +COOL, GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) |
| ABRAMS  | 70 PR 10 1917 | +COOL, GIACOMELLI, KYCIA, LEONTIC, + (BNL) I   |
| BRICMAN | 70 PL 318 152 | +FERRO LUZZI, PERREAU, + (CERN, CAEN, SACLAY)  |

 **$\Sigma(3000)$   
BUMPS**59  $Y^*(3000)$ , JP=    I=1    PRODUCTION EXPERIMENTSSEE THE MINI-REVIEW AT THE START OF THE  $Y^*$  LISTINGS.

ENHANCEMENT IN LAMBDA P1 AND KBAR N INVARIANT MASS  
SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING  
AGAINST  $K^0$ . EVIDENCE NOT CONCLUSIVE. OMITTED FROM  
TABLE.

59  $Y^*(3000)$  MASS (MEV) (PROD. EXP.)

|   |          |  |         |        |                   |      |
|---|----------|--|---------|--------|-------------------|------|
| M | (3000.0) |  | EHRLICH | 66 HBC | 0 P1-P 7.91 BEV/C | 9/66 |
|---|----------|--|---------|--------|-------------------|------|

59  $Y^*(3000)$  PARTIAL DECAY MODES (PROD. EXP.)

|    |                            |              |
|----|----------------------------|--------------|
| P1 | $Y^*(3000)$ INTO KBAR N    | DECAY MASSES |
| P2 | $Y^*(3000)$ INTO LAMBDA P1 | 1115+ 139    |

REFERENCES FOR  $Y^*(3000)$  (PROD. EXP.)

|         |                |                                           |
|---------|----------------|-------------------------------------------|
| EHRLICH | 66 PR 152 1194 | R EHRLICH, V SELOVE, H YUTA (PENN)(BNL) I |
|---------|----------------|-------------------------------------------|

**EXOTIC HYPERON CROSS SECTION LIMITS**

THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

|    |                                                                           |          |        |                       |
|----|---------------------------------------------------------------------------|----------|--------|-----------------------|
| CS | UNITS MICROBARN                                                           |          |        |                       |
| CS | G (20.) OR LESS                                                           | GALTIERI | 68 DBC | K-N TO SG-PI-P10 7/70 |
| CS | G ABOVE LIMIT FOR MASS < 2.15 GEV AND GAMMA < 50 MEV- (2.1 GEV/C K-) 7/70 |          |        |                       |
| CS | A (40.) OR LESS                                                           | GALTIERI | 68 DBC | K-N TO SG-PI-P10 7/70 |
| CS | A ABOVE LIMIT FOR MASS < 2.3 GEV AND GAMMA < 120 MEV- (2.7 GEV/C K-) 7/70 |          |        |                       |

## REFERENCES FOR EXOTIC HYPERONS

|          |               |                                            |
|----------|---------------|--------------------------------------------|
| GALTIERI | 68 PRL 21 573 | A. BARBARO-GALTIERI, CHADWICK + (LRL+SLAC) |
|----------|---------------|--------------------------------------------|

## Data Card Listings

For notation, see key at front of Listings.

 $\Xi$  Resonances

The  $\Xi$  resonance situation has long been and will probably long remain unsettled. This is because 1) they can only be produced as part of a final state,  $K^+p \rightarrow \Xi^* + \text{others}$ , and 2) they are so produced with very small cross sections ( $<50 \mu\text{b}$ ). Thus the numbers of events available are small, and the analysis is more complicated than if direct formation were possible. Only the  $\Xi(1530)$  is really well established. There are at least two  $\Xi$  states in the 1800-2000 MeV region and there are indications of several more above 2000 MeV, but the situation is very unclear. We are forced to group together rather disparate observations and await new results. Figures in the listings point out disagreements among various experiments. The table following this note gives our evaluation of the status of the  $\Xi$  resonances, based on the meager data available at this time.

STATUS OF  $\Xi^*$  RESONANCES  
THOSE WITH AN OVERALL STATUS OF \*\*\* OR \*\*\*\* ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

STATUS AS SEEN IN --

| PARTICLE        | LIJ | OVERALL STATUS | $\Xi$ P1 | LAM K | SIG K | $\Xi^*$ P1 | OTHER CHANNELS |
|-----------------|-----|----------------|----------|-------|-------|------------|----------------|
| $\Xi(1320)$ P11 |     | ****           |          |       |       |            | WEAK TO LAM P1 |
| $\Xi(1530)$ P13 |     | ****           | ****     |       |       |            |                |
| $\Xi(1630)$     |     | **             | **       |       |       |            |                |
| $\Xi(1820)$     |     | ***            | ***      | ***   | **    | ***        |                |
| $\Xi(1940)$     |     | ***            | ***      |       |       |            |                |
| $\Xi(2030)$     |     | **             |          | **    | **    |            | 3-BODY DECAYS  |
| $\Xi(2250)$     |     | *              |          |       |       |            | 3-BODY DECAYS  |
| $\Xi(2500)$     |     | **             |          | **    | **    |            | 3-BODY DECAYS  |

\*\*\*\* GOOD, CLEAR, AND UNMISTAKABLE.

\*\*\* GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.

\*\* NEEDS CONFIRMATION.

\* WEAK.

 $\Xi^-$ 22  $\Xi^- (1321, JP=1/2^-) I=1/2$ 

SEE STABLE PARTICLE DATA CARD LISTINGS

 $\Xi^0$ 23  $\Xi^0 (1314, JP=1/2^-) I=1/2$ 

SEE STABLE PARTICLE DATA CARD LISTINGS

 $\Xi(1530)$ 49  $\Xi^* 1/2(1530, JP=3/2^+) I=1/2$ 

P13

THIS IS THE ONLY REALLY WELL-ESTABLISHED  $\Xi^*$ . THE QUANTUM NUMBERS  $3/2^+$  ARE FAVORED BY THE DATA.

WE DO NOT USE DETERMINATIONS OF THE MASS AND THE WIDTH OF THIS STATE UNLESS THEY ARE ACCOMPANIED BY SOME DISCUSSION OF SYSTEMATICS AND RESOLUTION.

49  $\Xi^* 1/2(1530)$  MASS (MEV)

|   |             |         |           |        |                                               |       |
|---|-------------|---------|-----------|--------|-----------------------------------------------|-------|
| M | 55(1529.0)  | (5.0)   | PJERROU   | 62 HBC | -0 K-P 1.8 GEV/C                              |       |
| M | (1532.0)    | (2.0)   | BADIER    | 64 HBC | -0 K-P 3 GEV/C                                |       |
| M | 38 1535.7   | 3.2     | LONDON    | 66 HBC | -0 K-P 2.24 GEV/C                             | 7/66  |
| M | 334 1534.7  | 1.1     | BALTAY    | 72 HBC | -0 K-P 1.75 GEV                               | 1/73* |
| M | 185 1536.2  | 1.6     | KIRSCH    | 72 HBC | -0 K-P 2.87GEV/C                              | 2/72  |
| M | AVG         | 1535.22 |           |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |
| M | FIT         | 1535.05 |           |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
| M | 76 1528.7   | 1.1     | LONDON    | 66 HBC | 0 K-P 2.24 GEV/C                              | 7/66  |
| M | 59 1531.4   | 0.8     | BADIER    | 72 HBC | 0 K-P AT 3.95GEV/C                            | 10/71 |
| M | 1262 1532.0 | 0.4     | BALTAY    | 72 HBC | 0 K-P 1.75 GEV                                | 1/73* |
| M | 324 1531.3  | 0.6     | BORNSTEIN | 72 HBC | 0 K-P 2.2GEV/C                                | 2/72  |
| M | 286 1532.3  | 0.7     | KIRSCH    | 72 HBC | 0 K-P 2.87GEV/C                               | 2/72  |
| M | AVG         | 1531.63 |           |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)  |       |
| M | FIT         | 1531.64 |           |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) |       |

49 ( $\Xi^* -$ ) - ( $\Xi^0$ ) MASS DIFFERENCE (MEV)

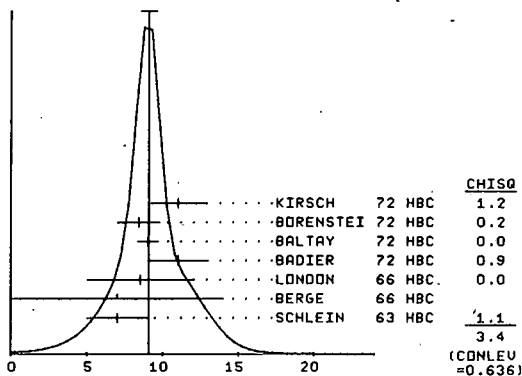
|   |       |       |         |        |                                               |       |
|---|-------|-------|---------|--------|-----------------------------------------------|-------|
| D | 5.7   | 3.0   | PJERROU | 65 HBC | -0 1.8-1.95 GEV/C                             | 7/66  |
| D | (7.0) | (4.0) | LONDON  | 66 HBC | -0 2.24 GEV/C                                 | 7/66  |
| D | 2.0   | 3.2   | MERRILL | 66 HBC | -0 1.7-2.7 GEV/C                              | 7/66  |
| D | 2.7   | 1.0   | BALTAY  | 72 HBC | -0 K-P 1.75 GEV                               | 1/73* |
| D | 3.9   | 1.8   | KIRSCH  | 72 HBC | -0 K-P 2.8 GEV/C                              | 2/72  |
| D | AVG   | 3.12  |         |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)  |       |
| D | FIT   | 3.41  |         |        | FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |

49  $\Xi^* 1/2(1530)$  WIDTH (MEV)

|    |      |      |           |        |                                              |       |
|----|------|------|-----------|--------|----------------------------------------------|-------|
| WO | 7.0  | 2.0  | SCHLEIN   | 63 HBC | 0 1.8-1.95 GEV/C                             | 7/66  |
| WO | 7.0  | 7.0  | BERGE     | 66 HBC | 0 1.5-1.7 GEV/C                              | 7/66  |
| WO | 8.5  | 3.5  | LONDON    | 66 HBC | 0 2.24 GEV/C                                 | 7/66  |
| WO | 11.0 | 2.0  | BADIER    | 72 HBC | 0 K-P AT 3.95GEV/C                           | 10/71 |
| WO | 9.0  | 0.7  | BALTAY    | 72 HBC | 0 K-P 1.75 GEV                               | 1/73* |
| WO | 8.4  | 1.4  | BORNSTEIN | 72 HBC | 0 $\Xi^- \pi^+$ MODE                         | 2/72  |
| WO | 11.0 | 1.8  | KIRSCH    | 72 HBC | 0 $\Xi^- \pi^+$                              | 2/72  |
| WO | AVG  | 9.07 |           |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) |       |
|    |      | 0.54 |           |        | (SEE IDEOGRAM BELOW)                         |       |

WEIGHTED AVERAGE =  $9.07 \pm 0.54$ 

ERROR SCALED BY 1.0



XI\*1/2(1530)0 WIDTH (MEV)

|    |      |      |        |        |                                              |       |
|----|------|------|--------|--------|----------------------------------------------|-------|
| W- | 7.8  | 3.5  | BALTAY | 72 HBC | -0 K-P 1.75 GEV                              | 1/73* |
| W- | 16.2 | 4.6  | KIRSCH | 72 HBC | -0 $\Xi^- \pi^0, \Xi^0 \pi^-$                | 2/72  |
| W- | AVG  | 12.9 |        |        | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) |       |

49  $\Xi^* 1/2(1530)$  PARTIAL DECAY MODES

|    |                                                           |              |
|----|-----------------------------------------------------------|--------------|
| P1 | $\Xi^* 1/2(1530)$ INTO $\Xi$ P1                           | DECAY MASSES |
|    |                                                           | 1321+ 139    |
|    | OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION. |              |

REFERENCES FOR  $\Xi^* 1/2(1530)$ 

|           |                      |                                                     |
|-----------|----------------------|-----------------------------------------------------|
| PJERROU   | 62 PRL 9 114         | +PROMISE, SCHLEIN, SLATER, STORK, TICHIO (UCLA) I   |
| SCHLEIN   | 63 PRL 11 167        | +CARMONY, PJERROU, SLATER, STORK, TICHIO (UCLA) IJP |
| BADIER    | 64 DUBNA I 593       | +DEMOULIN, GOLDBERG, + (EPOL, SACLAY, AMST) I       |
| PJERROU   | 65 PRL 14 275        | +SCHLEIN, SLATER, SMITH, STORK, TICHIO (UCLA) I     |
| BERGE     | 66 PR 147 945        | +EBERHARD, HUBBARD, MERRILL, B-SHAFFER, + (LRL) I   |
| LONDON    | 66 PR 143 1034       | +RAU, SAMIOS, YAMAMOTO, GOLDBERG, + (BNL, SYR) IJ   |
| MERRILL   | 66 UCRL-16455 THESIS | D W MERRILL (LRL) JP                                |
| BADIER    | 72 NP 837 429        | +BARRELET, CHARLTON, VIDEAU (EPOL)                  |
| BALTAY    | 72 PL 428 129        | +BRIDGEWATER, COOPER, GERSHWIN, + (COLU+BNL)        |
| BORNSTEIN | 72 PR D5 1559        | +BORNSTEIN, DANBURG, KALBFLEISCH, + (BNL, MICH) I   |
| KIRSCH    | 72 NP 840 349        | +SCHMIDT+CHANG, HEMINGWAY (BRAN, UMD, SYR, TUFT) I  |

## PAPERS NOT REFERRED TO IN DATA CARDS

|         |               |                                                 |
|---------|---------------|-------------------------------------------------|
| SHAFFER | 66 PR 142 883 | BUTTON-SHAFFER, LINDSEY, MURRAY, SMITH (LRL) JP |
|         |               | A SPIN-PARITY DETERMINATION.                    |

*For notation, see key at front of Listings.*

## E(1630)

THIS EFFECT NEEDS CONFIRMATION.  
THIS IS A 3- OR 4-STANDARD-DEVIATION BUMP SEEN IN ONE  
CHANNEL IN ONE EXPERIMENT. BARTSCH 69 SEE A SMALL, BROAD  
ENHANCEMENT NEAR 1650 MEV - IT IS NOT CLEAR THAT IT IS  
THE SAME PHENOMENON AS BMST 70, WHO FIND CS=3.6+-1.6  
MICROBARN AT 2.87 GEV/C INCIDENT K- MOMENTUM.

BORENSTEIN 72 SEE NO EFFECT IN THIS REGION. THEY FIND  
CR < 2 MUB AT 2.18.  
ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT SEEN  
BY BMST 70. ROSS 72 FIND CS = 2+-1 MICROBARN AT 3.3 GEV/C

|   |     |        |      |                                              |        |                  |      |
|---|-----|--------|------|----------------------------------------------|--------|------------------|------|
| M | 40  | 1635.  | 10.  | BMST                                         | 70 HBC | 0 INTO XI- PI+   | 7/70 |
| M | 29  | 1606.  | 6.   | ROSS                                         | 72 HBC | 0 K-P AT 3.1-3.7 | 3/72 |
| M |     |        |      |                                              |        |                  |      |
| M | AVG | 1613.7 | 12.8 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5) |        |                  |      |

|   |     |      |      |                                              |        |                   |      |
|---|-----|------|------|----------------------------------------------|--------|-------------------|------|
| W | 40  | 57.  | 18.  | BMST                                         | 70 HBC | 0 K-P AT 2.87     |      |
| W |     | 21.  | 7.   | ROSS                                         | 72 HBC | 0 XI-PI+ K*Q(890) | 3/72 |
| W |     | .    | .    |                                              |        |                   |      |
| W | AVG | 25.7 | 12.2 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9) |        |                   |      |

|    |                         | DECAY MASSES |
|----|-------------------------|--------------|
| P1 | XI*1/2(1630) INTO XI P1 | 1321+ 139    |

SEEN IN K- P TO XI- PI+ KO.

REFERENCES FOR XI\*1/2(1630)

BMST 70 DUKE 317  
BORENSTE 72 PR 05 1559  
ROSS 72 PL 38B 177

BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLABOR.  
BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I  
.BURAN,LLOYD,MULVEY,RADQJICIC (QXF) I

+ (BRANDETS, MARYLAND, SYRACUSE, TIENTS)

APSELL 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)  
SUPERSEDED BY BMST 70.  
BARTSCH 69 PL 288 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)  
KALBFLEI 70 DUKE CONF 331 G R KALBFLEISCH (BNL) I  
SUMMARIZES EVIDENCE FOR ISOSPIN 1 (2.)

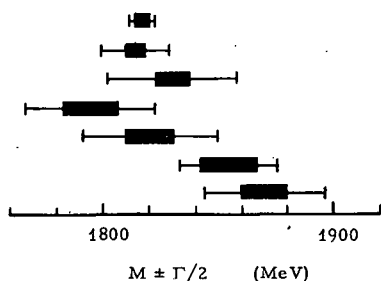
 $\Xi(1820)$ 

AS THE ACCOMPANYING IDEOGRAMS ILLUSTRATE, THE SITUATION IS CONFUSED. UNTIL SOME FUTURE CLARIFICATION, WE LIST UNDER XI(1820) EVERYTHING REPORTED IN THE MASS RANGE 1750-1875 MEV. WHEN BRANCHING RATIOS ARE REPORTED, WE ONLY THE MOST QUALITATIVE CONCLUSIONS ARE JUSTIFIED.

 $\Xi(1820)$ 

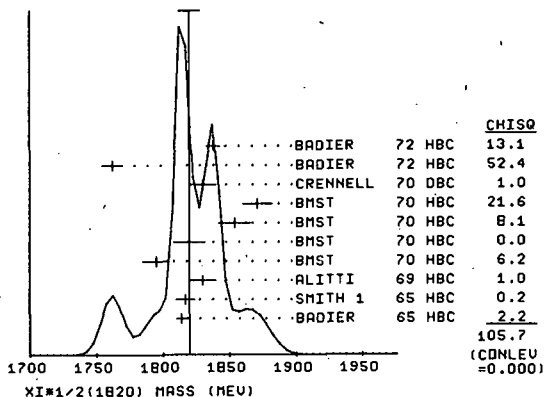
Masses and widths of reported enhancements in the  $\Xi(1820)$  region (solid rectangles indicate error on mass).

## Decay mode

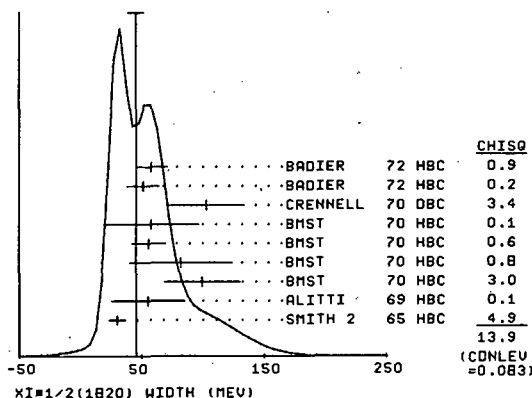
$$\begin{array}{l} \Lambda \bar{K}^0 \\ \Lambda \bar{K}^0 \\ \Xi^* \pi, \Lambda \bar{K}^0 \\ \Xi^- \pi^+ \\ \Xi(1530) \pi \\ \Sigma^- \bar{K}^0 \\ \Lambda \bar{K}^c \end{array}$$


BADIER 65  
SMITH-2 65  
ALITTI 69  
BMST 70  
BMST 70  
BMST 70  
BMST 70

| M | (1770.0)                                 | HALSTEIN     | 63 FBC      | -0 K-FR 3.5 GEV/C          |  |
|---|------------------------------------------|--------------|-------------|----------------------------|--|
| M | 30 1814.0                                | 4.0          | BADIER      | 65 K LAMBA KBAR            |  |
| M | 29 1817.0                                | 7.0          | SMITH I     | 65 HBC -0 LAMBA KBAR       |  |
| M | 40 1830.0                                | 10.0         | ALITTI      | -0 LAMB, SIG KBAR          |  |
| M | 65 1795.                                 | BMST         | 70 HBC      | 0 XI-PI+ (2.9 K-P)         |  |
| M | 55 1820.                                 | 12.          | BMST        | 70 HBC XII(1530) PI        |  |
| M | 35 1854.                                 | 12.          | BMST        | 70 HBC -0 SIGMA- KOBAR     |  |
| M | 65 1871.                                 | 11.          | BMST        | 70 HBC 0 LAMBA KOBAR       |  |
| M | 25 1830.0                                | 10.0         | CNRELL      | -0 3.6, 3. GEV/C           |  |
| B | 28 1862.0                                | 5.0          | BADIER      | XI PI, XI2PI,K Y           |  |
| K | 38 1838.0                                | 5.0          | BADIER      | 72 HBC XI PI, XI2PI,K Y    |  |
| B | BADIER 71 ADDS                           | ALL CHANNELS | AND DIVIDES | PEAK IN LOWER AND HIGHER M |  |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 3.4) |              |             |                            |  |
| M | (SEE (DEFGRAN, BELOW)                    |              |             |                            |  |



|     |                                          |         |                                              |        |     |                 |                |                |
|-----|------------------------------------------|---------|----------------------------------------------|--------|-----|-----------------|----------------|----------------|
| W   | (80.0)                                   | OR LESS | BADIER                                       | 63     | FBC | -0              | K-FR 3.5 GEV/C |                |
| W   | (12.0)                                   | (4.0)   | HALSTEIN                                     | 65     | HBC | 0               | LAMBDA KBAR    |                |
| W   | 30.0                                     | 7.0     | SMITH 2                                      | 65     | HBC | -0              |                |                |
| W   | 55.0                                     | 40.0    | ALTTI                                        | 69     | HBC | -               | LAM, SIG KBAR  | 9/69           |
| W   | 65                                       | 99.0    | BMST                                         | 70     | HBC | XI+1(-12-9 K-P) |                |                |
| W   | 55                                       | 82.     | 42.                                          | BMST   | 70  | HBC             | XI(1530) P1    | 7/70           |
| W   | 35                                       | 56.     | 14.                                          | BMST   | 70  | HBC             | SIGMA- KOBAR   | 7/70           |
| W   | 65                                       | 58.     | 39.                                          | 70     | HBC | 0               | LAMBDA KOBAR   | 7/70           |
| W   | 109.                                     | 38.     | 24.0                                         | CNRELL | 70  | HBC             | -0             | 3.61 3+9 GEV/C |
| W B | 51.0                                     | 13.0    | 8ADIER                                       | 72     | HBC | LOW MASS        |                | 10/71          |
| W B | 58.0                                     | 13.0    | BADIER                                       | 72     | HBC | HIGHER MASS     |                | 10/71          |
| W   |                                          |         | SEE THE NOTES ACCOMPANYING THE MASSES QUOTED |        |     |                 |                |                |
| W   | AVERAGE MEANINGLESS (SCALE FACTOR = 1.3) |         |                                              |        |     |                 |                |                |
| W   | (SEE DFDGRAM REF 0-1)                    |         |                                              |        |     |                 |                |                |



|    |                                           | DECAY MASSES   |
|----|-------------------------------------------|----------------|
| P1 | XI*1/2(1820) INTO LAMBDA KBAR             | 1115+ 497      |
| P2 | XI*1/2(1820) INTO XI PI                   | 1321+ 139      |
| P3 | XI*1/2(1820) INTO SIGMA KBAR              | 1197+ 497      |
| P4 | XI*1/2(1820) INTO XI*1/2(1530) PI         | 1533+ 139      |
| P5 | XI*1/2(1820) INTO XI PI PI (EXCLUDING P4) | 1321+ 139+ 139 |

## Data Card Listings

For notation, see key at front of Listings.

## Baryons

 $\Xi(1820)$ ,  $\Xi(1940)$ ,  $\Xi(2030)$ 50  $\Xi^{*1/2}(1820)$  BRANCHING RATIOS

|    |                                                                          |               |      |
|----|--------------------------------------------------------------------------|---------------|------|
| R1 | $\Xi^{*1/2}(1820)$ INTO ( $\Lambda$ BARDA KBAR)/TOTAL                    | (P1)          |      |
| R1 | 0.3 0.15 ALITTI 69 HBC -                                                 |               | 9/69 |
| R2 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi$ P1)/TOTAL                                | (P2)          |      |
| R2 | 0.1 0.1 ALITTI 69 HBC -                                                  |               | 9/69 |
| R3 | $\Xi^{*1/2}(1820)$ INTO ( $\Sigma$ BARDA KBAR)/TOTAL                     | (P3)          |      |
| R3 | (0.02) OR LESS TRIPP 67 RVUE -                                           |               | 8/67 |
| R3 | 0.3 0.15 ALITTI 69 HBC -                                                 |               | 9/69 |
| R4 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi^{*1/2}(1530)$ P1)/TOTAL                   | (P4)          |      |
| R4 | 0.3 0.15 ALITTI 69 HBC -                                                 |               | 9/69 |
| R4 | (0.25) OR LESS DAUBER 69 HBC -                                           | K-P 2.7 BEV/C | 9/69 |
| R5 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi$ P1)/( $\Lambda$ BARDA KBAR)              | (P2)/(P1)     |      |
| R5 | 0.20 0.20 BADIER 65 HBC -                                                |               | 7/66 |
| R6 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi^{*1/2}(1530)$ P1)/( $\Lambda$ BARDA KBAR) | (P4)/(P1)     |      |
| R6 | 0.26 0.13 SMITH 1 65 HBC -                                               |               |      |
| R7 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi$ P1 P1)/( $\Lambda$ BARDA KBAR)           | (P5)/(P1)     |      |
| R7 | (0.1) OR MORE SMITH 1 65 HBC -                                           |               |      |
| R8 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi$ P1)/( $\Xi^{*1/2}(1530)$ P1)             | (P2)/(P4)     |      |
| R8 | 1.5 0.6 0.4 APSELL 70 HBC 0                                              |               | 6/70 |
| R9 | $\Xi^{*1/2}(1820)$ INTO ( $\Xi$ P1 P1)/( $\Xi^{*1/2}(1530)$ P1)          | (P5)/(P4)     |      |
| R9 | 0.3 0.5 APSELL 70 HBC 0                                                  |               | 6/70 |

REFERENCES FOR  $\Xi^{*1/2}(1820)$ 

HALSTEIN 63 SIENA CONF 173  
 BADIER 65 PL 16 171  
 SMITH 1 65 PRL 14 25  
 SMITH 2 65 ATHENS CONF 251  
 TRIPP 67 NP 83 10  
 USES DATA OF SMITH 1.

ALITTI 69 PRL 22 79  
 DAUBER 69 PR 179 1262  
 APSELL 70 PRL 24 777  
 BMST 70 DUKE 317  
 CRENNELL 70 PR 10 847  
 BADIER 72 NP 837 429

+BARNES, FLAMINIO, METZGER, + (BNL, SYRACUSE) I  
 +BERGE, HUBBARD, MERRILL, MULLER (LRL)  
 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I  
 +LINDSEY, BUTTON-SHAFFER, MURRAY (LRL) JP  
 G A SMITH, J S LINDSEY (LRL)  
 +LEITH, + (LRL, SLAC, CERN, HEIDEL, SACLAY)

PAPERS NOT REFERRED TO IN DATA CARDS

MERRILL 68 PR 167 1202  
 WEAK EVIDENCE CONCERNING JP.  
 APSELL 69 PRL 23 984  
 SUPERSEDED BY BMST 70.

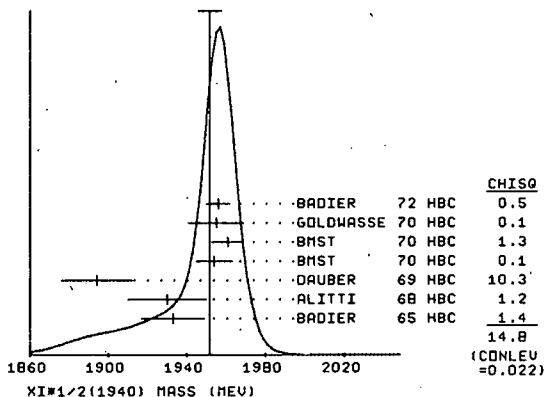
**E(1940)**52  $\Xi^{*1/2}(1940)$ , JP= 1 I=1/2

WE LIST UNDER  $\Xi(1940)$  EVERYTHING REPORTED IN THE MASS RANGE 1875-2000 MEV. THE SITUATION IS PERHAPS NOT QUITE SO UNCLEAR AS IS THE CASE FOR THE  $\Xi(1820)$ .

52  $\Xi^{*1/2}(1940)$  MASS (MEV)

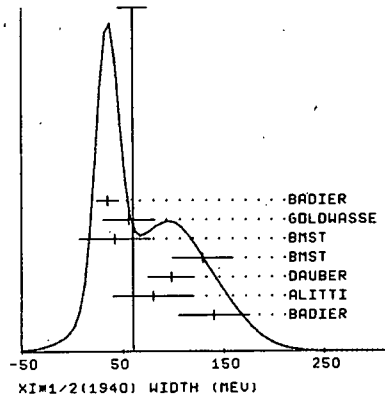
|   |           |      |                  |                             |  |       |
|---|-----------|------|------------------|-----------------------------|--|-------|
| M | 35 1933.0 | 16.0 | BADIER 65 HBC    | 0 $\Xi$ - P1+               |  |       |
| M | 27 1930.0 | 20.0 | ALITTI 68 HBC    | 0 $\Xi$ - P1+               |  | 11/68 |
| M | 66 1894.0 | 18.0 | DAUBER 69 HBC    | - $\Xi$ P1                  |  | 11/68 |
| M | 110 1954  | 9.   | BMST 70 HBC      | 0 $\Xi$ -P1+ (2.9 K-P)      |  | 7/70  |
| M | 40 1961   | 8.   | BMST 70 HBC      | $\Xi(1530)$ P1              |  | 7/70  |
| M | 21 1955.0 | 14.0 | GOLDWASSE 70 HBC | - $\Xi$ P1                  |  | 10/70 |
| M | 29 1956.0 | 6.0  | BADIER 72 HBC    | $\Xi$ P1, $\Xi(12P1)$ , K Y |  | 10/71 |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)  
 (SEE IDEOGRAM BELOW)

52  $\Xi^{*1/2}(1940)$  WIDTH (MEV)

|   |          |      |                  |                             |  |       |
|---|----------|------|------------------|-----------------------------|--|-------|
| W | 35 140.0 | 35.0 | BADIER 65 HBC    | 0 $\Xi$ - P1+               |  |       |
| W | 27 80.0  | 40.0 | ALITTI 68 HBC    | 0 $\Xi$ - P1+               |  | 11/68 |
| W | 66 98.0  | 23.0 | DAUBER 69 HBC    | - $\Xi$ P1                  |  | 11/68 |
| W | 110 129. | 30.  | BMST 70 HBC      | 0 $\Xi$ -P1+ (2.9 K-P)      |  | 7/70  |
| W | 40 42.   | 35.  | BMST 70 HBC      | $\Xi(1530)$ P1              |  | 7/70  |
| W | 21 56.0  | 26.0 | GOLDWASSE 70 HBC | - $\Xi$ P1                  |  | 10/70 |
| W | 29 35.0  | 11.0 | BADIER 72 HBC    | $\Xi$ P1, $\Xi(12P1)$ , K Y |  | 10/71 |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)  
 (SEE IDEOGRAM, BELOW)

52  $\Xi^{*1/2}(1940)$  PARTIAL DECAY MODES

|    |                                                    |              |                |
|----|----------------------------------------------------|--------------|----------------|
| P1 | $\Xi^{*1/2}(1940)$ INTO $\Xi$ P1                   | DECAY MASSES | 1321+ 139      |
| P2 | $\Xi^{*1/2}(1940)$ INTO $\Xi^{*1/2}(1530)$ P1      |              | 1533+ 139      |
| P3 | $\Xi^{*1/2}(1940)$ INTO $\Xi$ P1 P1 (EXCLUDING P2) |              | 1321+ 139+ 139 |

52  $\Xi^{*1/2}(1940)$  BRANCHING RATIOS

THE  $\Xi(1940)$  IS SEEN MAINLY IN  $\Xi$  P1 AND SOME IN  $\Xi(1530)$  P1. IT HAS BEEN LOOKED FOR IN OTHER CHANNELS BUT NOT SEEN.

|    |                                                                 |           |      |
|----|-----------------------------------------------------------------|-----------|------|
| R1 | $\Xi^{*1/2}(1940)$ INTO ( $\Xi$ P1)/( $\Xi^{*1/2}(1530)$ P1)    | (P1)/(P2) |      |
| R1 | 2.8 0.7 0.6 APSELL 70 HBC 0                                     |           | 6/70 |
| R2 | $\Xi^{*1/2}(1940)$ INTO ( $\Xi$ P1 P1)/( $\Xi^{*1/2}(1530)$ P1) | (P3)/(P2) |      |
| R2 | 0.0 0.3 APSELL 70 HBC 0                                         |           | 6/70 |

REFERENCES FOR  $\Xi^{*1/2}(1940)$ 

BADIER 65 PL 16 171  
 ALITTI 68 PRL 21 1119  
 DAUBER 69 PR 179 1262  
 APSELL 70 PRL 24 777  
 BMST 70 DUKE 317  
 GOLDWASS 70 PR 10 1960  
 BADIER 72 NP 837,429

+DEMOULIN, GOLDBERG, + (EPOL, SACLAY, AMST) I  
 +FLAMINIO, METZGER, RADJICIC, + (BNL, SYRACUSE) I  
 +BERGE, HUBBARD, MERRILL, MULLER (LRL)  
 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I  
 +BRANDEIS, MARYLAND, SYRACUSE, TUFTS COLLABOR.  
 E L GOLDWASSER, P F SCHULTZ (ILLINOIS)  
 +BARRELET, CHARLTON, VIDEAU (EPOL)

## PAPERS NOT REFERRED TO IN DATA CARDS

APSELL 69 PRL 23 884  
 SUPERSEDED BY BMST 70.

**E(2030)**68  $\Xi^{*1/2}(2030)$ , JP= 1 I=1/268  $\Xi^{*1/2}(2030)$  MASS (MEV)

|   |           |      |                |                   |  |      |
|---|-----------|------|----------------|-------------------|--|------|
| M | 42 2030.0 | 10.0 | ALITTI 69 HBC  | - K-P 3.9-5 BEV/C |  | 9/69 |
| M | 40 2058.0 | 17.0 | BARTSCH 69 HBC | - K-P 10GEV/C     |  | 9/69 |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

68  $\Xi^{*1/2}(2030)$  WIDTH (MEV)

|   |      |      |      |                |   |      |
|---|------|------|------|----------------|---|------|
| W | 45.0 | 40.0 | 20.0 | ALITTI 69 HBC  | - | 9/69 |
| W | 57.0 | 30.0 |      | BARTSCH 69 HBC |   | 9/69 |

AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

**Baryons** **$\Xi(2030)$ ,  $\Xi(2250)$ ,  $\Xi(2500)$ ,  $\Omega^-$** **Data Card Listings***For notation, see key at front of Listings.***68  $\Xi^0(2030)$  PARTIAL DECAY MODES**

|    |                                           | DECAY MASSES   |
|----|-------------------------------------------|----------------|
| P1 | $\Xi^0(2030) \rightarrow \Xi^0 \pi^0$     | 1321+ 139      |
| P2 | $\Xi^0(2030) \rightarrow \Lambda^0 \pi^0$ | 1115+ 497      |
| P3 | $\Xi^0(2030) \rightarrow \Sigma^0 \pi^0$  | 1197+ 497      |
| P4 | $\Xi^0(2030) \rightarrow \Xi^0 \pi^0$     | 1533+ 139      |
| P5 | $\Xi^0(2030) \rightarrow \Lambda^0 \pi^0$ | 1115+ 497+ 139 |

**68  $\Xi^0(2030)$  BRANCHING RATIOS**

|    |                                                              |                    |      |
|----|--------------------------------------------------------------|--------------------|------|
| R1 | $\Xi^0(2030) \rightarrow \Xi^0 \pi^0$ (MODES P1 TO P4)       | (P1)/(P1+P2+P3+P4) |      |
| R1 | (0.30) OR LESS                                               | ALITTI 69 HBC      | 9/69 |
| R2 | $\Xi^0(2030) \rightarrow \Lambda^0 \pi^0$ (MODES P1 TO P4)   | (P2)/(P1+P2+P3+P4) |      |
| R2 | 0.25 0.15                                                    | ALITTI 69 HBC      | 9/69 |
| R3 | $\Xi^0(2030) \rightarrow \Sigma^0 \pi^0$ (MODES P1 TO P4)    | (P3)/(P1+P2+P3+P4) |      |
| R3 | 0.75 0.20                                                    | ALITTI 69 HBC      | 9/69 |
| R4 | $\Xi^0(2030) \rightarrow \Xi^0 \pi^0$ (MODES P1 THRU P4)     | (P4)/(P1+P2+P3+P4) |      |
| R4 | (0.15) OR LESS                                               | ALITTI 69 HBC      | 9/69 |
| R5 | $\Xi^0(2030) \rightarrow \Lambda^0 \pi^0$ (OR SIGMA) KBAR P1 | (P5)               |      |
| R5 | SEEN                                                         | BARTSCH 69 HBC     | 9/69 |

**REFERENCES FOR  $\Xi^0(2030)$** 

ALITTI 69 PRL 22 79 +BARNES, FLAMINIO, METZGER, + (BNL, SYRACUSE) I  
 BARTSCH 69 PL 288 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)

 **$\Xi(2250)$** **22  $\Xi^0(2250)$ , JP= 1**

THE EVIDENCE FOR THIS STATE IS WEAK. BARTSCH 69 SEE A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN  $\Lambda^0 \pi^0$  KBAR- $\pi^0$ ,  $\Sigma^0 \pi^0$ , AND  $\Xi^0 \pi^0$  MASS SPECTRA. GOLDWASSER TO SEE A NARROWER BUMP IN  $\Xi^0 \pi^0$  AT A HIGHER MASS. PERHAPS THEY ARE THE SAME STATE, PERHAPS THEY ARE NOT.

**22  $\Xi^0(2250)$  MASS (MEV)**

|   |                                          |      |                   |               |       |
|---|------------------------------------------|------|-------------------|---------------|-------|
| M | 35 2244.0                                | 52.0 | BARTSCH 69 HBC    | K-P 10 GEV/C  | 9/69  |
| M | 18 2295.0                                | 15.0 | GOLDWASSER 70 HBC | K-P 5.5 GEV/C | 10/70 |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 1.0) |      |                   |               |       |

**22  $\Xi^0(2250)$  WIDTH (MEV)**

|   |           |      |                   |               |       |
|---|-----------|------|-------------------|---------------|-------|
| W | 130.0     | 80.0 | BARTSCH 69 HBC    |               | 9/69  |
| W | LESS THAN | 30.0 | GOLDWASSER 70 HBC | K-P 5.5 GEV/C | 10/70 |

**22  $\Xi^0(2250)$  PARTIAL DECAY MODES**

|    |                                           | DECAY MASSES   |
|----|-------------------------------------------|----------------|
| P1 | $\Xi^0(2250) \rightarrow \Xi^0 \pi^0$     | 1321+ 139+ 139 |
| P2 | $\Xi^0(2250) \rightarrow \Lambda^0 \pi^0$ | 1115+ 497+ 139 |
| P3 | $\Xi^0(2250) \rightarrow \Sigma^0 \pi^0$  | 1197+ 497+ 139 |

**REFERENCES FOR  $\Xi^0(2250)$** 

BARTSCH 69 PL 288 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)  
 GOLDWASSER 70 PR 10 1960 E L GOLDWASSER, P F SCHULTZ (ILLINOIS)

 **$\Xi(2500)$** **99  $\Xi^0(2500)$ , JP= 1 I=1/2**

IT IS QUITE POSSIBLE THAT THE REASON THE EXPERIMENTS DISAGREE ABOUT THE MASS AND WIDTH IS THAT THEY ARE SEEING DIFFERENT  $\Xi^0$ 'S. FOR NOW, HOWEVER, WE GROUP THEM TOGETHER.

IT IS QUITE POSSIBLE THAT THE REASON THE EXPERIMENTS DISAGREE ABOUT THE MASS AND WIDTH IS THAT THEY ARE SEEING DIFFERENT  $\Xi^0$ 'S. FOR NOW, HOWEVER, WE GROUP THEM TOGETHER.

**99  $\Xi^0(2500)$  MASS (MEV)**

|   |                                          |      |                |                 |      |
|---|------------------------------------------|------|----------------|-----------------|------|
| M | 30 2430.0                                | 20.0 | ALITTI 69 HBC  | K-P 4.6-5 GEV/C | 9/69 |
| M | 45 2500.0                                | 10.0 | BARTSCH 69 HBC | K-P 10 GEV/C    | 9/69 |
| M | AVERAGE MEANINGLESS (SCALE FACTOR = 3.1) |      |                |                 |      |

**99  $\Xi^0(2500)$  WIDTH (MEV)**

|   |                                          |      |                |  |      |
|---|------------------------------------------|------|----------------|--|------|
| W | 150.0                                    | 60.0 | ALITTI 69 HBC  |  | 9/69 |
| W | 59.0                                     | 27.0 | BARTSCH 69 HBC |  | 9/69 |
| W | AVERAGE MEANINGLESS (SCALE FACTOR = 1.6) |      |                |  |      |

**99  $\Xi^0(2500)$  PARTIAL DECAY MODES**

|    |                                                              | DECAY MASSES   |
|----|--------------------------------------------------------------|----------------|
| P1 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$                        | 1321+ 139      |
| P2 | $\Xi^0(2500) \rightarrow \Lambda^0 \pi^0$                    | 1115+ 497      |
| P3 | $\Xi^0(2500) \rightarrow \Sigma^0 \pi^0$                     | 1197+ 497      |
| P4 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$                        | 1533+ 139      |
| P5 | $\Xi^0(2500) \rightarrow \Lambda^0 \pi^0$ (OR SIGMA) KBAR P1 | 1115+ 497+ 139 |
| P6 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$                        | 1321+ 139+ 139 |

**99  $\Xi^0(2500)$  BRANCHING RATIOS**

|    |                                                                    |                    |      |
|----|--------------------------------------------------------------------|--------------------|------|
| R1 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$ (MODES P1 THRU P4)           | (P1)/(P1+P2+P3+P4) |      |
| R1 | (0.5) OR LESS                                                      | ALITTI 69 HBC      | 9/69 |
| R2 | $\Xi^0(2500) \rightarrow \Lambda^0 \pi^0$ (MODES P1 THRU P4)       | (P2)/(P1+P2+P3+P4) |      |
| R2 | 0.5 0.2                                                            | ALITTI 69 HBC      | 9/69 |
| R3 | $\Xi^0(2500) \rightarrow \Sigma^0 \pi^0$ (MODES P1 THRU P4)        | (P3)/(P1+P2+P3+P4) |      |
| R3 | 0.5 0.2                                                            | ALITTI 69 HBC      | 9/69 |
| R4 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$ (MODES P1 THRU P4)           | (P4)/(P1+P2+P3+P4) |      |
| R4 | (0.2) OR LESS                                                      | ALITTI 69 HBC      | 9/69 |
| R5 | $\Xi^0(2500) \rightarrow \Lambda^0 \pi^0$ (OR SIGMA) KBAR P1/TOTAL | (P5)               |      |
| R5 | SEEN                                                               | BARTSCH 69 HBC     | 9/69 |
| R6 | $\Xi^0(2500) \rightarrow \Xi^0 \pi^0$ (OR SIGMA) KBAR P1/TOTAL     | (P6)               |      |
| R6 | SEEN                                                               | BARTSCH 69 HBC     | 9/69 |

**REFERENCES FOR  $\Xi^0(2500)$** 

ALITTI 69 PRL 22 79 +BARNES, FLAMINIO, METZGER, + (BNL, SYRACUSE) I  
 BARTSCH 69 PL 288 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)

 **$\Omega^-$** **24  $\Omega^-(1675)$ , JP=3/2+ I=0**

SEE STABLE PARTICLE DATA CARD LISTINGS

## Appendix I

TEST OF  $\Delta I=1/2$  RULE FOR K DECAYS

The quantities of interest for making tests of theoretical predictions regarding the  $\Delta I=1/2$  rule for K decay are usually partial decay rates for single channels or special sums of channels. It is not possible to compute the errors on sums, differences, and ratios of partial decay rates from the information given in the Table of Stable Particles because of the presence of off-diagonal terms in the error matrix. For this reason we give some of these quantities in Table I. Throughout this Appendix, italics are used to indicate that a quantity has changed by more than one (old) standard deviation since our previous edition, and S gives the scale factor included in the quoted error because of inconsistencies in the data (see footnote at end of Stable Particle Table for definition of S).

Table I. (000) or (+-0) refer to the sign of the pions into which the  $K_L$  decays.

|                                                                                                                    |         |
|--------------------------------------------------------------------------------------------------------------------|---------|
| $\Gamma_{K_{\ell 3}^+} = \Gamma_{K_{e3}^+} + \Gamma_{K_{\mu 3}^+} = (6.542 \pm .083) \times 10^6 \text{ sec}^{-1}$ |         |
| $\Gamma_{K_{\mu 3}^+} / \Gamma_{K_{e3}^+} = 0.668 \pm .024$                                                        | $S=2.2$ |
| $\Gamma_{K_{\tau}^+} / \Gamma_{K_{\tau'}^+} = 3.223 \pm .090$                                                      |         |
| $\Gamma_{K_{\ell 3}^0} = \Gamma_{K_{e3}^0} + \Gamma_{K_{\mu 3}^0} = (12.68 \pm .16) \times 10^6 \text{ sec}^{-1}$  | $S=1.1$ |
| $\Gamma_{K_{\mu 3}^0} / \Gamma_{K_{e3}^0} = 0.694 \pm .022$                                                        |         |
| $\Gamma_{K^0(000)} / \Gamma_{K^0(+0)} = 1.711 \pm .081$                                                            | $S=1.3$ |

1. Leptonic decay rates

The  $\Gamma_{K_{\ell 3}}$  rates are useful in testing the

leptonic  $\Delta I = 1/2$  rule in the way suggested by Trilling.<sup>1</sup> The predictions are

$$\Gamma_{K_{\ell 3}^0} / 2\Gamma_{K_{\ell 3}^+} = 1.012, \text{ a phase-space factor,}^2 \text{ and}$$

$$\Gamma_{K_{\mu 3}^0} / \Gamma_{K_{e3}^0} = \Gamma_{K_{\mu 3}^+} / \Gamma_{K_{e3}^+}$$

From Table I,

$$\Gamma_{K_{\ell 3}^0} / 2\Gamma_{K_{\ell 3}^+} = 0.969 \pm .017$$

$$\text{and } \frac{\Gamma_{K_{\mu 3}^0}}{\Gamma_{K_{e3}^0}} \left[ \frac{\Gamma_{K_{\mu 3}^+}}{\Gamma_{K_{e3}^+}} \right]^{-1} = 1.039 \pm .050.$$

These results seem to show a less than  $2\sigma$  disagreement with the predictions, but the errors should be regarded with caution in view of the internal disagreements in the data. (Note the ideograms in the data listing for the charged K meson.)

2. Three-pion decays

We follow here the tests done by Mast et al.,<sup>3</sup> based on the general analysis of K decays suggested by Zemach.<sup>4</sup> Both decay rates ( $\Gamma$ ) and slopes ( $g$ , the energy dependence of the Dalitz plot distributions) are used. The  $\Delta I = 1/2$  rule predicts that the following test quantities are all equal to zero:

$$\text{Test 1} = \frac{2}{3} \frac{\Gamma_{K^0(000)}}{\phi_1} \left[ \frac{\Gamma_{K^0(+0)}}{\phi_2} \right]^{-1} - 1,$$

$$\text{Test 2} = \frac{1}{4} \frac{\Gamma_{K_{\tau}^+}}{\phi_3} \left[ \frac{\Gamma_{K_{\tau'}^+}}{\phi_4} \right]^{-1} - 1,$$

$$\text{Test 3} = \frac{1}{2} \frac{\Gamma_{K_{\tau}^+}}{\phi_3} \left[ \frac{\Gamma_{K^0(+0)}}{\phi_2} \right]^{-1} - 1,$$

$$\text{Test 4} = \frac{1}{2} g_{K_{\tau'}^+} + g_{K_{\tau}^+},$$

$$\text{Test 5} = g_{K^0(+0)} + g_{K_{\tau}^+} - \frac{1}{2} g_{K_{\tau'}^+}.$$

The  $\phi_i$  are phase-space factors which have been calculated as described in Mast et al.<sup>3</sup> by use of a relativistic formulation and the masses and slopes from this compilation. The factors labeled UDP are the relative areas of the Dalitz plots, assuming a uniform distribution. The NUUDP include the observed slopes (see below). The CNUUDP have been calculated by including the final-state Coulomb interaction. The values are:

|                 | Method |       |        |
|-----------------|--------|-------|--------|
|                 | UDP    | NUUDP | CNUUDP |
| $\phi_1(000) =$ | 1.489  | 1.489 | 1.444  |
| $\phi_2(+0) =$  | 1.221  | 1.294 | 1.279  |
| $\phi_3(++-) =$ | 1.000  | 1.000 | 1.000  |
| $\phi_4(+00) =$ | 1.247  | 1.183 | 1.147  |

For convenience, we repeat the slope parameters tabulated in the Stable Particle Table. They are as follows:

$$\begin{aligned}
g_{K_{\tau}^+} &= -0.214 \pm 0.005 & S=1.7 \\
g_{K_{\tau}^-} &= -0.214 \pm 0.007 & S=2.7 \\
\bar{g}_{K_{\tau}^{\pm}} &= -0.214 \pm 0.004 \\
g_{K_{\tau}^+} &= 0.523 \pm 0.023 & S=1.4 \\
g_{K^0(+0)} &= 0.604 \pm 0.023 & S=2.7
\end{aligned}$$

A difference in the  $\tau^+$  and  $\tau^-$  slopes would be an indication of CP violation in this decay. Since no difference is observed at this time, we average the two and use this value in Test 4.

We use the CNUDP factors and the rates and slopes reported here to compute the five test quantities which the  $\Delta I=1/2$  rule predicts to be zero. The results are:

$$\begin{aligned}
\text{Test 1} &= 0.010 \pm 0.048 \\
\text{Test 2} &= -0.076 \pm 0.026 \\
\text{Test 3} &= 0.190 \pm 0.025 \\
\text{Test 4} &= 0.048 \pm 0.012 \\
\text{Test 5} &= 0.128 \pm 0.026
\end{aligned}$$

The three-pion final state can be in isospin states  $I = 1, 2, 3$ . Tests 1 and 2 test the existence of isospin  $I = 3$  in the final state. Since the rate tests (Tests 1, 2, and 3) could differ from zero by as much as 0.1 owing to the mass differences and the occurrence of big slopes<sup>5</sup>, no evidence for  $I=3$  is found. Test 4 is related to the  $I=2$  amplitude in the final state and indicates the presence of  $I=2$ . Tests 3 and 5 give information on the  $\Delta I = 3/2$  part of the  $I=1$  amplitude relative to the  $\Delta I = 1/2$  part. Both tests indicate the presence of  $\Delta I = 3/2$ .

#### References

1. G. Trilling, K-Meson Decays, UCRL-16473, (updated from Argonne Conference Proceedings, 1965, p. 115).
2. N. Brene (CERN), private communication. In our Jan. 1968 edition we had erroneously used 1.04.
3. T. S. Mast, L. K. Gershwin, M. Alston-Garnjost, R. O. Bangerter, A. Barbaro-Galtieri, J. J. Murray, F. T. Solmitz, and R. D. Tripp, Phys. Rev. **183**, 1200 (1969).
4. C. Zemach, Phys. Rev. **133**, B1201 (1964).
5. C. Bouchiat and M. Veltman, Topical Conference on Weak Interactions, CERN 69-7 (1969), p. 225.

#### Appendix II

##### A. SU(3) CLASSIFICATION OF BARYON RESONANCES

There are a few multiplets that have been studied and we report here the results.

Exact SU(3) symmetry predicts that all the members of a multiplet should have the same mass and the same couplings for decays into other multiplets. It has been found, however, that the members of the octet of Stable Baryons lie within 20% of their mean mass; therefore a symmetry breaking interaction has been introduced by GELL-MANN 62 and OKUBO 62 independently. In addition, for the isospin-0 vector mesons ( $\omega$  and  $\phi$ ) an additional symmetry-breaking interaction had to be introduced (SAKURAI 62) to take care of octet-singlet mixing. The relevant formulae for masses and decay rates are given below.

##### Mass Formulae

Broken SU(3) gives:

$$\text{Decuplet} \quad \Delta - \Sigma = \Xi - \Xi^* = \Xi^* - \Omega \quad \text{GMO} \quad (1)$$

$$\text{Octet} \quad 2(N + \Xi) = 3\Lambda + \Sigma \quad \text{GMO} \quad (2)$$

$$\begin{aligned}
\text{Octet-Singlet mixing} \quad \left\{ \begin{aligned} \sin^2 \theta &= \frac{\Lambda - M_8}{\Lambda - \Lambda'} & \text{Mixing angle} \\ M_8 &= \frac{2(N + \Xi) - \Sigma}{3} & \text{GMO} \end{aligned} \right. \quad (3) \quad (4)
\end{aligned}$$

Here GMO stands for the Gell-Mann-Okubo formula; the particle symbol indicates its mass. The formulae would be the same if squared masses were used. For the nonet case,  $\Lambda$  is the "mostly-octet" particle,  $\Lambda'$  is the "mostly-singlet" particle.

##### Decay Rates

In terms of a relativistically invariant matrix element  $T$ , the decay rate for two-body decay of a resonance of mass  $M_R$  is

$$\Gamma \propto \frac{|T|^2 R_2}{M_R} \quad (5)$$

where  $R_2 = k/M_R$  is the two-body phase space factor. Since the numerator is an invariant, and since  $\Gamma$  must transform as  $1/E$ , we introduce the denominator  $1/M_R$  (see FEYNMAN 62).

For meson decays (see below) the rates are calculated according to Eq. (5); for baryon resonance decays into  $1/2^+$  baryons and  $0^-$  mesons, one next takes into account the fact that spin sums in  $|T|^2$  introduce another factor  $M_R$ , cancelling the  $1/M_R$ . We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} M_N, \quad \text{for baryons} \quad (5')$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2, \quad \text{for mesons} \quad (5'')$$

The powers of the nucleon mass  $M_N$  or  $M_N^2$  have been introduced so that we can treat  $|T|$  as dimensionless.

$|T|^2$  contains centrifugal barrier factors, which we call  $B_\ell$ . We then have

$$\left. \begin{array}{l} \text{Decuplet} \\ \text{Singlet} \end{array} \right\} \Gamma = (c_g)^2 B_\ell(k) \frac{M_N}{M_R} k \quad (6)$$

$$\text{Octet} \quad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \quad (7)$$

$$\left. \begin{array}{l} \text{Octet-Singlet} \\ \text{mixing} \end{array} \right\} \begin{cases} G_8 = \Lambda \cos\theta - \Lambda' \sin\theta \\ G_1 = \Lambda \sin\theta + \Lambda' \cos\theta \end{cases} \quad (8)$$

$$\text{with} \quad \begin{cases} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 \end{cases} \quad (9)$$

Here  $c_i$  are the SU(3) coefficients with the sign convention adopted in this article [see note preceding the table of SU(3) isoscalar factors and Fig. 2 in the text].  $M_N$  is the nucleon mass,  $M_R$  is the resonance mass for which  $\Gamma$  is calculated,  $k$  is the center-of-mass momentum for the channel being considered,  $g_i$  are the relevant couplings. For the case of singlet-octet mixing, formula (8) has to be used in conjunction with (6) and (7).  $G_8$  and  $G_1$  represent the couplings for the multiplet, and  $\Lambda$  and  $\Lambda'$  represent the couplings for the physical states.

The relation between  $g_D$ ,  $g_F$ , and the parameter  $\alpha$  is

$$\alpha = \left[ 1 + \frac{\sqrt{5}}{3} \frac{g_F}{g_D} \right]^{-1} \quad (10)$$

Exact SU(3) predicts that the couplings  $g_i$  for all the members of a multiplet are the same; however, since the symmetry is broken for the masses, it is probably broken for the widths. In the case of the  $3/2^+$  decuplet, for broken SU(3) a sum rule has been derived by BECCHI 64 and by GUPTA 64 independently. It relates the  $g_i$  for the members of the decuplet by the relation

$$2(\Delta + \Xi) = 3\Sigma^*(\Lambda\pi) + \Sigma^*(\Sigma\pi), \quad (11)$$

where  $\Sigma^*(\Lambda\pi)$  is the coupling for the  $\Sigma(1385) \rightarrow \Lambda\pi$  decay and  $\Sigma^*(\Sigma\pi)$  is the coupling for the decay  $\Sigma(1385) \rightarrow \Sigma\pi$ .

As mentioned in the text (Sec. IV D) the determination of the relative signs of resonant amplitudes can be useful in making an SU(3) assignment of resonances. In fact the resonant amplitude  $T \propto \sqrt{x_e x_i} \propto G_e G_i$  where the subscript  $e$  refers to the elastic channel and the  $G_e$ ,  $G_i$  are the couplings of Eqs. (6) through (9). Assuming that all  $g_i$  are positive, the sign of the  $G_i$  are dependent upon the sign of the Clebsch-Gordon coefficients  $c_i$ . Once a sign convention is adopted (we use the LEVI-SETTI 69 convention, see Fig. 2 in the text) and the sign for a  $\Sigma$  state ( $I = 1$ ) and a  $\Lambda$  state ( $I = 0$ ) of known SU(3) assignment have been chosen for reference, the signs of all the other amplitudes can be useful in determining multiplet assignments. For exact SU(3) all the decays of members of a decuplet have the same sign. For octets the relative sign depends upon the value of  $g_D/g_F$  and the mixing angle, as seen from Eqs. (7) through (9).

#### Fits to the Data

Fits of baryon decay rates within SU(3) can be found, among others, in TRIPP 68 and 69, LEVI SETTI 69, SAMIOS 70 and PLANE 70. The most recent fits were made by BARBARO-GALTIERI 72.

In fitting the data a choice for  $B_\ell$  has to be made. PLANE 70 tried two forms for  $B_\ell$ :

(a) The form  $B_\ell = (kr)^{2\ell} D_\ell(kr)$ ,  $r$  being the radius of interaction and  $D_\ell$  the polynomials in  $kr$  given by BLATT-WEISSKOPF 52.

Usually  $r$  is taken to be 1 fermi (TRIPP 68).

(b) The form  $B_\ell = k^{2\ell}$ .

However, for their final results they used form (b). A discussion of the differences among these two forms can be found in BARBARO-GALTIERI 71. It turns out that not only the values of the couplings,  $g_i$  depend upon the form used for  $B_\ell$ , but also the value obtained for the mixing angle. For the  $3/2^-$  singlet,  $\Lambda(1520)$ , and isospin-0 member of the octet,  $\Lambda(1690)$ , the mixing angles obtained in the two cases are

$$\theta_a = (-16.1^{+1.4}_{-1.3})^\circ, \quad \theta_b = (-27.5^{+3.6}_{-3.4})^\circ,$$

in disagreement by a few standard deviations. It turns out that if a radius of interaction of  $r = 0.15$  fermi is used for form (a), the two values of  $\theta$  agree. This value of  $r$  does not fit resonance shapes when used in the Breit-Wigner resonant form.

Table I is a summary of the fits made by BARBARO-GALTIERI 72 using the barrier factor form (b) and exact SU(3). A few comments follow.

### $\frac{1}{2}^-$ - Nonet (Baryon - Eta Resonances)

For this nonet Eq. (7) was multiplied by the factor

$$\left[ \frac{M_R - M_B}{\bar{M}_R - \bar{M}_B} \right]^2,$$

where  $M_B$  is the decay baryon and  $\bar{M}_R - \bar{M}_B = 564$  MeV is the difference of the mean  $1/2^-$  and  $1/2^+$  baryon octet masses. This kinematic factor comes from PCAC arguments (i.e., the assumption that axial vector current remains an octet in presence of symmetry breaking) and it was advocated by Graham et al. (GRAHAM 67). For the  $1/2^-$  nonet it has been used in this form first by Gell-Mann et al. (GELL-MANN 68).

### $\frac{3}{2}^+$ Decuplet

The agreement among the coupling constants obtained for the four rates in this decuplet is very bad. The fit made using form (b) for  $B_{\frac{1}{2}}$  has  $\chi^2=50$  for 3 Degrees of Freedom; the one made with form (a) for  $B_{\frac{1}{2}}$  has  $\chi^2=24/3\text{DF}$ . The broken SU(3) relation (11), however, is very well satisfied.

### B. SU(3) CLASSIFICATION OF MESON RESONANCES

All of the discussion above applies, except that for Bosons the GMO formula is usually applied to the square of the masses, as opposed to the first power for fermions. Thus for example, Eq. (2) becomes

$$4\hat{K} = 3\hat{\eta} + \hat{\pi}. \quad (2')$$

The symbol  $\hat{K}$  was introduced by Glashow and Socolow<sup>†</sup> for the square of the K mass, etc.

Because of the difference between Eqs. (5') and (5''), there is also an extra factor of  $(M_N/M_R)$  in Eqs. (6) and (7). The three established nonets ( $0^-$ ,  $1^-$ ,  $2^+$ ) and their mixing angles are listed at the bottom of the Meson table.

### Footnotes and References

<sup>†</sup>The formula has been calculated from analogy with the formula for mixing of meson states, first put in this form by S. L. Glashow and R. H. Socolow, Phys. Rev. Letters **15**, 329 (1966). For the baryon formula see A. Barbaro-Galtieri, Phenomenology of Resonances and Particle Supermultiplets. UCRL-17054 (1966).

<sup>‡</sup>This is an updated version of the fits by Flaminio et al., BNL report 14572.

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Table I. SU(3) baryon multiplets with two or more known members. Values of  $\theta$  and  $\alpha$  [defined by Eqs. (8) and (10)] are the results of fits made by BARBARO-GALTIERI 72 to all the measured two-body decay rates of each multiplet.

| $J^P$            | Octet members <sup>a</sup> |                 |                |               | Singlet         | $\theta(\text{deg})^b$ | $\alpha$               |
|------------------|----------------------------|-----------------|----------------|---------------|-----------------|------------------------|------------------------|
| $1/2^-$          | N(1535)                    | $\Lambda(1670)$ | $\Sigma(1750)$ | $[\Xi(1825)]$ | $\Lambda(1405)$ | $8 \pm 3$              | $1.2 \pm .1$           |
| $3/2^-$          | N(1520)                    | $\Lambda(1690)$ | $\Sigma(1670)$ | $[\Xi(1815)]$ | $\Lambda(1520)$ | $-23 \pm 4$            | $.34 \pm .09$          |
| $5/2^-$          | N(1670)                    | $\Lambda(1830)$ | $\Sigma(1765)$ |               |                 |                        | $1.13 \pm .05$         |
| $5/2^+$          | N(1688)                    | $\Lambda(1815)$ | $\Sigma(1915)$ |               |                 |                        | $.62 \pm .04$          |
| Decuplet members |                            |                 |                |               | $\Xi_{10}$      |                        |                        |
| $3/2^+$          | $\Delta(1236)$             | $\Sigma(1385)$  | $\Xi(1530)$    | $\Omega^-$    |                 | $1.78 - 2.29$          | $\chi^2=50/3\text{DF}$ |
| $7/2^+$          | $\Delta(1950)$             | $\Sigma(2030)$  |                |               |                 |                        |                        |

<sup>a</sup>Masses in parentheses are the nominal masses used in the Baryon Table. The  $\Xi$  members have masses as calculated by using formulae (1) and (2) with the mixing angle  $\theta$  derived from the decay widths.

<sup>b</sup>See text for a discussion of the  $3/2^-$  mixing angle.

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### Appendix III

#### TEST OF $\Delta I=1/2$ RULE FOR HYPERON DECAYS

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##### 1. Nonleptonic Decay Amplitudes

In this edition we are adopting a new convention for the amplitudes A and B. Some theorists have suggested that dimensionless amplitudes are more useful to them than the ones appearing in the literature. Berge (1966) used a convention, which we adopted last year, with A and B in units of  $\text{sec}^{-1/2}$ . Samios (1965) used a convention which gave A and B in units of  $(\text{MeV} \cdot \text{sec})^{-1/2}$ . Following is the convention suggested by Jackson (1973), which gives dimensionless A and B, which we will adopt in this edition.

The effective Lagrangian density for nonleptonic hyperon decays ( $B_1 \rightarrow B_2 + \pi$ ) can be written

$$\mathcal{L}_{\text{eff}} = G \mu_c^2 [\bar{\psi}_2 (A + B \gamma_5) \psi_1] \phi_\pi,$$

where  $G = 10^{-5} m_p^{-2}$  is a coupling constant characteristic of first-order weak decays,  $\mu_c$  is the charged pion mass, and A and B are dimensionless complex numbers giving the relative amplitudes of the parity-violating and parity-conserving decays, respectively. The matrix  $\gamma_5$  is to be taken in the Pauli form,  $\gamma_5 = \begin{pmatrix} 0 & -I \\ -I & 0 \end{pmatrix}$ . The invariant amplitude for the decay is

$$\mathcal{M} = G \mu_c^2 [\bar{u}(p)(A + B \gamma_5) u(P)],$$

where P is the 4-momentum of the decaying hyperon of mass M, and p is the 4-momentum of the baryon decay product of mass m. With the normalization convention,  $\bar{u}_1 u_1 = 2m_1$ , the Pauli form of the matrix element in the rest frame of the decaying hyperon is

$$\mathcal{M} = G \mu_c^2 \langle \chi_2 | \sqrt{2M(E+m)} A + \sqrt{2M(E-m)} B \vec{\sigma} \cdot \hat{q} | \chi_1 \rangle,$$

where E is the total energy of the final baryon and  $\hat{q}$  is a unit vector in the direction of motion of the final baryon. Comparison with Section IV H shows that the amplitudes s and p defined there are proportional to A and B:

$$\frac{p}{s} = \left( \frac{E-m}{E+m} \right) \frac{B}{A} = \sqrt{\frac{(M-m)^2 - \mu^2}{(M+m)^2 - \mu^2}} \frac{B}{A}.$$

Here  $\mu$  is the mass of the pion entering the decay. The parameters  $\alpha, \beta, \gamma$  can therefore be expressed in terms of A and B, rather than s and p, if desired.

The decay rate for  $B_1 \rightarrow B_2 + \pi$  is

$$\Gamma = \frac{G_{\mu c}^2}{8\pi} q \left\{ \left[ \frac{(M+m)^2 - \mu^2}{M^2} \right] |A|^2 + \left[ \frac{(M-m)^2 - \mu^2}{M^2} \right] |B|^2 \right\},$$

where  $q$  is the c.m.s. momentum of the decay products. For reference, the dimensionless constant in this expression has the value  $(G_{\mu c}^2/8\pi) = 1.9488 \times 10^{-15}$ .

To convert numbers for  $A$  and  $B$  of Table I, Appendix III, April 1972 edition to the new dimensionless numbers, multiply old values by  $0.98124 \times 10^{-5} \text{ sec}^{1/2}$ . This is the value of

$$\frac{\sqrt{\hbar} 10^5}{G_{\mu c}^2 \sqrt{\mu c}} = \sqrt{\frac{65.822}{0.13958}} \left( \frac{0.93826}{0.13958} \right)^2 \times 10^{-13} \times 10^5 \times 10^5 \text{ sec}^{1/2}.$$

$$A_{\text{new}} = 0.98124 A_{\text{old}} \times 10^{-5} \text{ sec}^{1/2}$$

$$B_{\text{new}} = 0.98124 B_{\text{old}} \times 10^{-5} \text{ sec}^{1/2}.$$

Table I summarizes the amplitudes  $A$  and  $B$  for the nonleptonic decays of the  $\Lambda$ ,  $\Sigma$ , and  $\Xi$  hyperons. These amplitudes have been calculated by using the experimental data for mean lives, branching ratios, and the decay asymmetry  $\alpha$  given in the Stable Particle Table of this review. Time-reversal invariance is assumed and final-state interactions are neglected, so  $A$  and  $B$  are taken to be relatively real and  $\beta = 0$ . The subscript on the hyperon refers to the sign of the decaying pion. The statistical correlation coefficient

$$C_{AB} = \frac{\langle \Delta A \Delta B \rangle}{\sqrt{\langle \Delta A^2 \rangle \langle \Delta B^2 \rangle}}$$

is also given. The absolute signs of  $A$  and  $B$  have been assigned, using the following convention. Taking  $A(\Lambda_-^0)$  as positive, the other S-wave decay amplitudes are chosen to give an approximate fit to the triangular relationships

$$\sqrt{2}A(\Sigma_0^+) + A(\Sigma_+^+) = A(\Sigma_-^-) \text{ and } \sqrt{3}A(\Sigma_0^+) + A(\Lambda_-^0) = 2A(\Xi_-^-).$$

The signs of the  $B$  amplitudes relative to those of the corresponding  $A$  amplitudes are determined by the sign of the appropriate  $\alpha$  decay parameter.

Table I

| M             | $\rightarrow m + \mu$         | A               | B                 | $C_{AB}$ |
|---------------|-------------------------------|-----------------|-------------------|----------|
| $\Lambda_-^0$ | $\rightarrow p + \pi^-$       | $1.50 \pm 0.01$ | $10.28 \pm 0.25$  | $-0.264$ |
| $\Sigma_+^+$  | $\rightarrow n + \pi^+$       | $0.06 \pm 0.02$ | $19.04 \pm 0.16$  | $0.003$  |
| $\Sigma_0^+$  | $\rightarrow p + \pi^0$       | $1.46 \pm 0.06$ | $-12.22 \pm 0.70$ | $0.945$  |
| $\Sigma_-^-$  | $\rightarrow n + \pi^-$       | $1.93 \pm 0.01$ | $-0.65 \pm 0.08$  | $-0.030$ |
| $\Xi_0^0$     | $\rightarrow \Lambda + \pi^0$ | $1.54 \pm 0.03$ | $-5.12 \pm 1.24$  | $0.362$  |
| $\Xi_-^0$     | $\rightarrow \Lambda + \pi^-$ | $2.03 \pm 0.02$ | $-6.86 \pm 0.52$  | $0.207$  |

## 2. Tests of the $\Delta I = 1/2$ Rule

### (a) $\Lambda$ Decay

For  $\Lambda$  decay the  $\Delta I = 1/2$  rule predicts that  $\Gamma_0/\Gamma_- = 0.50$  and  $\alpha_0 = \alpha_-$ . In order to determine the magnitude of possible  $\Delta I = 3/2$  amplitudes present we write the linear expressions [Overseth and Pakvasa (1969)] for the  $\Delta I = 3/2$  S- and P-wave amplitudes in terms of  $\Delta\alpha$ , where  $\Delta\alpha$  is the measured value of  $\alpha_0/\alpha_-$  minus the predicted value, and in terms of  $\Delta\Gamma$  similarly defined. Evaluating these we find

$$\Delta\alpha = -1.54(S_3/S_1) + 1.61(P_3/P_1),$$

$$\Delta\Gamma = 1.84(S_3/S_1) + 0.26(P_3/P_1).$$

Here the  $\Delta I = 3/2$  amplitudes are expressed relative to the  $\Delta I = 1/2$  amplitudes. The numerical values of the coefficients depend on the ratio  $P/S$ . The uncertainties in the coefficients are small compared to the uncertainties in  $\Delta\alpha$  and  $\Delta\Gamma$ . Final-state  $\pi$ -N interactions have been included in these relations but have a very small effect. From the Stable Particle Table,

$$\Delta\alpha = 0.006 \pm 0.066, \quad \Delta\Gamma = 0.058 \pm 0.012,$$

and hence

$$(S_3/S_1) = 0.027 \pm 0.008$$

and

$$(P_3/P_1) = 0.030 \pm 0.037.$$

The possible 3%  $\Delta I = 3/2$  S-wave amplitude is due to the disagreement of decay rates with prediction. At this level the results are sensitive to electromagnetic corrections. However, in  $\Lambda$  decay the phase space correction and the other radiative corrections appear to be about equal in magnitude and have opposite signs [Belavin and Narodetsky (1968); and Intemann (1973)], and hence cancel each other in the correction to the decay rates.

### (b) $\Xi$ Decay

The analysis for  $\Xi$  decay is very similar to that for  $\Lambda$  decay. If the  $\Delta I = 1/2$  rule is valid,  $\Gamma_0(\Xi^0)/\Gamma_-(\Xi^-) = 0.50$  and  $\alpha_0 = \alpha_-$ . For this case the expressions linear in  $\Delta I = 3/2$  S- and P-wave amplitudes are [Overseth and Pakvasa (1969)]

$$\Delta\alpha = 1.37(S_3/S_1) - 1.37(P_3/P_1),$$

$$\Delta\Gamma = -1.44(S_3/S_1) - 0.06(P_3/P_1).$$

From the Stable Particle Table,

$$\Delta\alpha = -0.040 \pm 0.234, \quad \Delta\Gamma = 0.061 \pm 0.025,$$

and we find

$$(S_3/S_1) = -0.042 \pm 0.018$$

and

$$(P_3/P_1) = -0.013 \pm 0.164.$$

### (c) $\Sigma$ Decay

The traditional test of the  $\Delta I = 1/2$  rule in  $\Sigma$  decay is that the amplitudes satisfy the relationship  $\sqrt{2} \Sigma_0^+ + \Sigma_+^+ - \Sigma_- = 0$ . Graphically this is equivalent to closing the  $\Sigma$  triangle when the amplitudes are plotted on A, B axes. Including  $\Delta I \geq 3/2$  amplitudes in  $\Sigma$  decay analysis, the " $\Sigma$  triangle" relationship becomes

$$\sqrt{2} A_0 + A_+ - A_- = -3 \sqrt{\frac{2}{5}} A_3 + \frac{2}{\sqrt{15}} A_5,$$

where  $A_3$ ,  $A_5$  are  $\Delta I = 3/2$ ,  $5/2$  amplitudes, respectively. There is a similar equation for the B amplitudes. From Table I,

$$\begin{aligned} \sqrt{2} A_0 + A_+ - A_- &= 0.19 \pm 0.11 \\ \text{and } \sqrt{2} B_0 + B_+ - B_- &= 2.41 \pm 1.23. \end{aligned}$$

If we neglect the  $\Delta I = 5/2$  amplitudes and assume all amplitudes to be real we can solve for possible  $\Delta I = 3/2$  amplitudes. The result is

$$\frac{A_3}{A_-} = -0.052 \pm 0.029$$

and

$$\frac{B_3}{B_+} = -0.067 \pm 0.033.$$

Thus for hyperon decay, present experimental data limit  $\Delta I = 3/2$  amplitudes to less than about 5%.

### 3. The Lee-Sugawara Relation

From Table I the Lee-Sugawara [Lee (1964) and Sugawara (1964)] relation  $\sqrt{3} \Sigma_0^+ + \Lambda_- - 2 \Xi_- = 0$  is satisfied to  $-0.03 \pm 0.15$  for the A amplitudes, and to  $2.83 \pm 2.50$  for the B amplitudes.

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$$\frac{\Gamma_0}{\Gamma_-} \approx \frac{1}{2} \left\{ 1 + 3\sqrt{2} \times \left( \frac{[S_{11}S_{33}\cos(\delta_1 - \delta_3) + P_{11}P_{33}\cos(\delta_{11} - \delta_{31})]}{S_{11}^2 + P_{11}^2} \right) \right\}$$
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Careful attention should be given to symbols and nomenclature. Many authors will want to use the paper in a piecemeal manner so that notations and terminologies should be redefined in captions and table headings sufficiently often to make this convenient. A glossary is also often useful. Data should be expressed in units clearly defined, rather than (or in addition to) the shorthand conventions common to some specialists. For symbols and abbreviations, use those recommended in the AIP Style Manual (copy available on request).

With regard to footnotes and references, the Editors recommend the "British form" in which author and year are cited parenthetically in the text and references are listed alphabetically at the end. Footnote comments may then appear with asterisk, dagger, etc., on each page. This style facilitates reordering the text and addition of references, as well as ready identification of the work cited.

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