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THE OUTLOOK FOR BARYON SPECTROSCOPY†

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I. Introduction

It is hazardous to foretell the future of any field of science since the unexpected discoveries are invariably those of greatest interest. However, a limited objective would be to assess where we are now in the study of the conventional (non-charmed) baryon resonances and to project the present trends into the immediate future. Extrapolation requires a knowledge of the rate of progress in the field, and for this we may glance back to the previous conferences on the same subject at Duke (1970) and Purdue (1973). The impression conveyed by the results of these conferences was that the field of baryon resonances was in the doldrums. The reason is not hard to find. The discoveries of resonances in rapid succession during the 60's culminated in the successful classification of these states according to an approximate SU(3) symmetry. This in turn was followed by more recent efforts to combine the SU(3) multiplets into SU(6) multiplets with decay rates calculated in terms of a broken $SU(6)_W$ symmetry. Yet the experimental situation remained far from satisfactory, particularly among the Y^* and Ξ^* resonances. Many of the states filling out the higher multiplets are arrived at by combing the PDG Tables for any likely candidate at an appropriate mass with little regard for its reliability, to say nothing of its quantum numbers. Since among hadronic resonances the nucleon and S = -1 hyperon resonances are uniquely blessed with the possibility of being studied in a systematic and quantitative way by means of formation experiments, at least here remained the possibility of substantial improvement in the experimental situation with presently available techniques. Yet the effort in this direction suddenly and inexplicably waned. Without the driving force of new results the discussions at previous meetings centered largely on modest improvements in data and inconclusive reanalyses of existing data in different ways. Perhaps the outstanding exception to this was the major new effort dedicated to the isobar model analysis of $\pi N \to \pi\pi N$ and the interpretation of the resulting branching fractions of nucleon resonances into $\pi\Delta$ and ρN in terms of $SU(6)_W$.

At this conference I was relieved to find that the situation has changed. A number of new generation experiments with greatly improved statistics have emerged and in their various ways are enhancing our experimental knowledge of baryon resonances. Here I would like to recall some of these experiments, point out the directions which experiments are taking in the immediate future, and mention some problems and deficiencies which can be resolved with contemporary techniques.

II. Recent Progress

A. S = 0 Resonances

Two major experiments have recently been completed at Nimrod with splendid statistical precision and detailed momentum coverage. Brown et al.[(1)] have reported at this conference their work on the experimentally difficult reaction $\pi^- p \to \pi^\circ n$ where they have measured both the angular distribution and polarization at 22 momenta from 0.6 to 2.3 GeV/c with unprecedented statistical accuracy. Another important experiment by Bardsley et al.[(2)] has measured the differential cross sections for both $\pi^+ p$ and $\pi^- p$ at 51 momenta from 0.4 to 2.15 GeV/c, with a coverage and accuracy much improved over that previously available. It is encouraging to see that there are still high energy physicists willing to devote an appreciable fraction of their scientific life making the definitive measurements on one of the most fundamental of interactions.

A new level of statistical precision has also been reached in the study of the associated production $\pi^- p \to \Lambda K^\circ$. Baton et al.[(3)] have presented results from a 2 meter bubble chamber experiment on the angular distribution and polarization from threshold to 1.4 GeV/c with many more events than were previously available. Combined with a new

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spark chamber experiment by Abbot et al.[4] covering the same region and including older data, a partial wave analysis has been performed leading to a better understanding of the couplings of nucleon resonances to this strange-particle channel.

B. S = -1 Resonances

A new generation of $\overline{K}N$ bubble chamber experiments, done mainly in Europe and mostly with the 2 meter CERN chamber, have been making substantial improvements in the data available for Y^* partial wave analysis. Rutherford Lab-Imperial College (RL-IC) have recently reported[5] analysis of a 0.96-1.36 GeV/c high statistics K^-p experiment, and at this conference have also presented[6] results on three-body reactions, while CERN-Heidelberg-Munich last year presented[7] analysis of $K^-p \to \overline{K}N$ with comparable precisions from 1.4 to 1.8 GeV/c. College de France-Saclay[8] have covered the range from 1.934-2.516 GeV/c with somewhat lower statistics. Results from large deuterium exposures with much improved statistics were reported by CERN-Heidelberg-Munich[9] from 0.68 to 0.84 GeV/c and Birmingham[10] from 1 to 2 GeV/c. These will be invaluable in untangling the individual isospin contributions. In this regard the new monoenergetic K_Lp exposures from 0.3 to 0.8 GeV/c, also presented at this conference,[11,12] will be vital, since they have certain virtues (as well as defects) relative to K^-n for the exploration of I - 1 reactions.

New generation electronic experiments are now making important contributions to Y^* studies, once the nearly exclusive domain of bubble chambers. CERN-Caen[13] have here reported their work on K^-n elastic scattering from 1.2 to 2.2 GeV/c, yielding both higher statistics and events better representative of the free neutron interaction than those obtainable from bubble chambers. Two electronic experiments have been recently completed in the U.S. at the unique low energy separated beam facility at BNL, where K^-p fluxes of up to 10^5/pulse are available below 1.1 GeV/c. One experiment[14] has measured the K^-p charge-exchange cross section with better than 1% statistical precision at 48 closely spaced momenta from 0.51 to 1.07 GeV/c, thus improving bubble chamber accuracy by a factor of about 10. The other experiment[15] has extended the very important measurements of K^-p polarization down to 650 MeV/c, thereby filling in a serious deficiency for partial wave analyses, since previous polarization measurements ended at 862 MeV/c.

Partial wave analyses have just begun to digest this new wave of data. RL-IC[5] have reported a three-channel ($\overline{K}N$, $\Sigma\pi$, $\Lambda\pi$) analysis over a wide momentum range incorporating their new results. This analysis is certainly the most comprehensive and perhaps the most reliable to date. We have presented a preliminary analysis[14] using our charge-exchange data along with other available information on the elastic and charge-exchange channels. More ambitious efforts are also in progress: one, an energy-dependent multi-channel analysis using the K-matrix,[16] and the other an energy-independent $\overline{K}N$ analysis.[17] The data are now of sufficient quality over some energy regions that such programs should be more successful than they have been in the past.

C. S = -2 Resonances

In recent years there has been a great experimental effort on Ξ^*. Bubble chamber experiments directed toward searches for missing cascade resonances and attempts to better the knowledge of their branching fractions so vital to classification schemes, have more than doubled the world path length. Much improved branching fractions for $\Xi(1820)$[18] and convincing evidence for $\Xi(2030)$ and $\Xi(2130)$ and $\Xi(2350)$ have emerged.[19] The latter has been identified by the novel decay mode $\Xi(2350) \to \Omega^-\overset{+}{K}{}^o$.

As a by-product of the largest of these efforts, the ACNO 4.2 GeV/c K^-p exposure, the Ω^- lifetime has been remeasured[20] to be $0.75 \pm 0.15 \times 10^{-10}$ sec, nearly a factor of 2 shorter than the previous world-average.

D. S = +1 Resonances

No new experiments have been reported at this conference, although a steady accumulation of data, both in K^+p and K^+n, has been taking place over the past several years. Unfortunately, the P13 Z_1^* remains tantalizingly small in most partial wave solutions, too contorted to convince the skeptic of its reality, yet capable of passing as a highly inelastic resonance if it had been found in N^* and Y^* analyses.[21] A more promising candidate, the P01 Z_0^*, is less accessible experimentally and requires further work which is now in progress. (See discussion in the next section.)

III. Prospects for the Immediate Future

A. S = 0 Resonances

Apart from redoing the first-generation π^-p polarization experiments at lower energies to bring them up to the quality of the more recent π^+p polarization data, it appears to me that the experimental effort to investigate the elastic pion-nucleon system through the resonance region has now produced data which is as complete and precise as any partial wave analyst can reasonably expect. In most instances the statistical errors are no longer the dominant uncertainty, and one must seriously face up to the problem of data selection and of assessing the effect of systematic errors on the partial wave analysis. Here the data amalgamation techniques of LBL-CMU[22] are becoming of great importance. I hope that they will soon be extended to Y^* and Z^* analyses as data for these reactions improve. Although there will continue to be demands for measurements of rotation parameters to add further constraints to πN analyses, these appeals will surely have to be supported with concrete evidence of outstanding problems before experiments of such difficulty are undertaken. As the theoretical effort to understand the behavior of higher partial waves progresses,[23] it would, of course, be desirable to extend the present set of experiments upward in energy.

We witnessed great progress several years ago in the study of the reaction $\pi p \to \pi\pi N$, from which very important measurements of the strengths and relative signs of coupling constants emerged.[24] These have been a valuable source of data, unobtainable from elastic analysis, with which to confront and constrain symmetry schemes.[25] My impression now is that the experimental possibilities have been pushed to the limit of what can be convincingly extracted from the difficult study of these quasi-two-body processes without further refinements in the method of analysis. More work on associated production might, however, be fruitfully pursued, as could a vigorous analysis of $\bar{K}N$ and KN three-body reactions along the same lines as the πN work.

B. <u>S = -1 Resonances</u>

Here there are some obvious deficiencies in data available for partial wave analyses to which I would like to draw your attention. With a comparatively modest effort the situation could be considerably improved.

Let me first discuss the need for bubble chamber experiments. During the past 15 years there have been many K^-p bubble chamber exposures in the resonance region. Those suitable for use in systematic formation studies amount to a total of about 130 events/μb distributed from 0 to 2.5 GeV/c among at least 20 experiments. Not a large quantity, considering the magnitude of contemporary Ξ^* experiments, but sufficient to do carefuly partial wave analyses of the major two-body channels, since if it had been uniformly distributed it would on the average amount to about 1500 events per mb per 25 MeV/c. But alas the coverage has been extremely haphazard, often with little thought devoted at the time of picture-taking to their eventual use in formation experiments, which after all is the only way to really understand what is going on in the $\bar{K}N$ system. Huge exposures have been taken at certain momenta for reasons known only to the promoters of the experiments. Others have covered too limited a range, with the result that they are used with reluctance in partial wave analyses for fear of introducing energy-dependent artifacts in regions where they join other experiments with different biases. As a result, only during the past several years have we achieved anything approaching a uniform and reliable level of 1000 events per mb per 25 MeV/c. But there is still an unfortunate gap in the coverage. Figure 1 exhibits the distribution of K^- path length in hydrogen chambers, where for each experiment I have shown the <u>average</u> level of the experiment, although within some of them the coverage is highly erratic. Also in many of these experiments only certain reactions have been analyzed. What I find appalling is that there still remains a major deficiency in path length between 430 and 860 MeV/c. The systematic and comprehensive CHS (CERN-Heidelberg-Saclay) experiment lacks statistical precision to reveal resonances of low elasticity, and yet the many $\bar{K}N$ partial wave analyses covering this region rely almost exclusively upon it. Disagreements between these various analyses as to the masses and widths of resonants as well as the actual existence of a number of resonances stem from this paucity of data. If the indicated CHM exposure above 680 MeV/c (the companion to their deuterium exposure reported here) is analyzed or if the Tennessee-Massachusetts experiment is completed, then this will help substantially although the region below 680 MeV/c will remain with poor coverage. Unfortunately this is just where high intensity K^- beams for electronic experiments begin to fail, so that help from this quarter, except for certain simple experiments, should not be expected for some time. Thus it seems to me imperative that before the 2 meter chamber is retired, a real effort should be made to bring this region up to the level of at least 1000 events per mb per 25 MeV/c. Incidentally, this amounts to only about 1/2 million pictures, i.e. 10% of the current 8.2 GeV/c K^-p run.

No doubt the reason for the neglect of this K^-p region is the apparent absence of any significant structure to enliven interest for further investigation. However, in recent years there have been new indications for structure in the I = 1 total cross section,[27] and a reanalysis of the CHS data for $K^-p \to \Lambda\pi^o$ in that region suggests a resonance $\Sigma(1580)$.[28] This has, however, been disputed by a $K_Lp \to \Lambda\pi^-$ experiment.[29] There are two further hints from CHS[30] that all is not inert here. Figure 2 shows a 3 std. dev. bump in the $K^-p \to \Sigma^{\pm}\pi^{\mp}\pi^o$ cross section at 534 MeV/c (1578 MeV), while figure 3 indicates a broader enhancement just above threshold for the reaction $K^-p \to \bar{K}^o n\pi^o$. Neither of these three-body reactions reveal enhancements in other corresponding charge channels accessible to measurement with K^-p. Since previous results suggest structure in I = 1, a careful analysis of deuterium film in this region could be fruitful.

Several electronic experiments designed to substantially improve on bubble chamber statistics for certain selected reactions should be yielding data in the near future. Bristol-Southampton-Rutherford Laborabory,[2] who have reported their precise $\pi^{\pm}p$ angular distribution work at this meeting, are now set up to extend their experiment to the investigation of K^-p elastic scattering. The goal is to measure the angular distribution at closely spaced momentum intervals from 1.2 to 2.5 GeV/c with about 50,000 events/momentum, i.e. at least five times the bubble chamber statistics at each momentum.

At BNL, the LBL-Mt. Holyoke group[31] have just completed data-taking on the $K^-p \to \bar{K}^o n$ angular distribution at 22 momenta from 515 to 960 MeV/c. Over most of the range the number of events obtained exceeds that from existing bubble chamber experiments by a factor of 10. Next year we shall return to do another counter experiment designed specifically to measure K^-p backward scattering with high precision at closely spaced momenta from 500 to 1100 MeV/c.[32] With the same apparatus it will also be possible to measure K^+p backward scattering as well as $K^-p \to \Sigma^{\mp}\pi^{\pm}$ for $\pi^{\pm}$ at 0°. The object here is to make a precision study of the energy dependence of specific processes, being thereby complementary to bubble chamber experiments which investigate the entire angular distribution, but with limited precision. Of course, the more ambitious goal of extending the above-mentioned Nimrod experiments on K^-p angular distributions to lower momenta with the higher fluxes available at BNL would also be highly desirable.

The beam intensity at the BNL low energy separated beam (LESB) is such that electronic experiments are quite competitive with bubble chamber experiments for many reactions down to about 600 MeV/c, where the flux falls below 5000 K^-/ pulse. In order to provide higher fluxes of K^- and $\bar{p}$ at low momenta, a new beam (LESB II) has been designed[33] and should be operational by the end of 1977. Somewhat shorter in length and with about 5 times the solid angle as LESB I, the new beam is expected to yield up to 10^6 K^-/pulse at its highest momentum of 800 MeV/c! For aficionados of beams, figure 4 shows the layout and table I compares the parameters of the two beams. With such flux, K^- momenta above 400 MeV/c should be accessible to electronic experiments requiring high intensity. Perhaps the single most important experiment here would be to extend K^-p polarization measurements below 650 MeV/c. With no prominent resonances to sample all components of the background amplitudes by means of interference, partial wave analyses in this momentum region have always been very shaky. Polarization measurements are exactly what is needed to constrain these analyses.

At this point I would like to bring to your attention some problems looming up for low energy K^-p partial wave analyses. The K^-p and K^-d total cross sections were measured with great statistical precision at BNL several years ago, and their final results have just become available.[27] Figure 5 shows the K^-p cross sections measured in this and other experiments. From K^-p and K^-d measurements it is possible to extract the I = 0 and I = 1 total cross sections after making appropriate corrections for deuterium effects [which are by no means trivial near large narrow resonances like $\Lambda(1520)$]. These cross sections have been reported in preliminary form and we have used them in our partial wave analysis, as has the RL-IC analysis. However, if one wishes to anchor the partial wave amplitudes at 400 MeV/c with the high statistics data of the K-65 bubble chamber experiment,[34] a problem ensues. Figures 6 and 7 show the individual I = 0 and I = 1 total cross sections obtained from the BNL experiment as well as those extracted through partial wave analysis of the K-65 data alone. The I = 0 cross sections agree reasonably well, but the I = 1 cross sections, where they overlap, differ by about 8 mb. Although the K^-p bubble chamber data do not have corresponding K^-d data for an isospin decomposition, a partial wave analysis of all channels in the presence of the dominant $\Lambda(1520)$ resonance permits such a decomposition with considerable confidence. The shaded area shows the uncertainty derived from comparing two of our analyses of data below 450 MeV/c: one uses a scattering length approximation for all non-resonant amplitudes, while the other parametrizes the large S wave amplitudes with the effective range matrix. They differ at most by 1 mb. What happens when a PWA extending to higher momenta such as ours or RL-IC uses both sets of data is that the I = 1 cross sections make a smooth transition from the values suggested by K-65 at 400 MeV/c to the BNL data near 600 MeV/c. But is that right? Is there further structure as suggested by the BNL data and are we seriously distorting the amplitudes by this procedure? It appears to me to be worthwhile to redo these total cross sections when the new BNL beam of higher intensity becomes available, particularly in the controversial low momentum region. It should also be noted that the BNL data and previous total cross section work by Bowen et al.(35) show systematic disagreements, as can be seen in figures 5-7. The latter's I = 0 and 1 cross sections are in even worse disagreement with the bubble chamber results.

Six heretofore unobserved structures have been reported by the BNL experimenters(27) in the isospin-decomposed cross sections shown in figures 6 and 7. Nearly all of them fall into the 420 - 860 MeV/c gap left in high statistics bubble chamber coverage. In the isospin 1 channel they claim, in addition to their bump at 546 MeV/c [Σ(1580)], evidence for smaller enhancements at 602 and 657 MeV/c as well as a new bump at 833 MeV/c. In isospin 0 they find new structure at 685 and 875 MeV/c. All are exceedingly narrow — the quoted widths range from 10 to 28 MeV — and highly inelastic. As we have seen, there is some confirmation for the existence of structure at 534 and 600 MeV/c from three-body reactions observed in the bubble chamber, as well as evidence for $\Sigma(1580) \rightarrow \Lambda\pi^\circ$.

None of these new structures are evident in the K^-p or K^-d cross sections alone. In order to bring them out one must perform the delicate operation of unfolding from the deuterium data the energy spread due to internal momentum. The dangers inherent in this procedure were well expressed by G. Lynch in the 1970 Hyperon Resonances Conference,(36) who found that narrow structures could easily be generated due to the nonuniqueness of the unfolding process. Since a substantial portion of the less prominent bumps in the BNL isospin-decomposed cross sections come from dips at the corresponding momentum in the other isospin state, I for one will be convinced only when better evidence emerges from a detailed partial wave analysis of the elastic channel or from analyses of other channels to which they must be more strongly coupled.

A problem closely related to the I = 1 total cross section discrepancy mentioned above concerns the 0° differential cross section for $K^-p \rightarrow \bar{K}^\circ n$. The data points obtained from extrapolation of the bubble chamber angular distributions are shown in figure 8. On the other hand, these differential cross sections can also be predicted from a knowledge of the individual I = 0 and I = 1 total cross sections for the imaginary part and a dispersion relation calculation for the real part of the amplitudes. Thus,

$$\mathrm{Im} f = \frac{k}{4\pi}\left[\frac{\sigma_1 - \sigma_0}{2}\right]$$

and $$\frac{d\sigma}{d\Omega} = |\mathrm{Re} f|^2 + |\mathrm{Im} f|^2 .$$

The solid line in figure 8 is the differential cross section prediction obtained, using the CERN-Caen dispersion relation calculation(37) of the real part of the K^-p and K^-n forward scattering amplitudes. The shaded area displays the error band coming roughly equally from the uncertainty in the I = 0,1 total cross sections and from other uncertainties associated with the dispersion relation calculation.(38) In some regions, particularly at low momentum, the agreement is poor. A substantial part of the uncertainty comes from disagreement on the I = 1 total cross section noted previously, for in the prediction of the 0° cross section the total cross sections enter twice: once in the imaginary part and then again when evaluating the dispersion integral for the real part. It would clearly be healthier to use the data shown in figure 8 to constrain the dispersion relations, thereby diminishing reliance on the uncertain total cross sections. These dispersion relations are used in several places in partial wave analyses of the $\bar{K}N$ channel and are therefore important for the study of Y^*'s. First they are needed in a somewhat circular way to make small corrections to the measured K^-p and K^-d total cross sections. Later they are of more direct use in the partial wave analysis itself as a valuable constraint on the real part of the forward scattering amplitude.

C. S = -2 Resonances

Lacking formation experiments with which to do partial wave analyses, Ξ^* spectroscopy has always been the weak point (or the way out) for classification schemes of baryon resonances. Only in rare situations of unusually clean signals exemplified by $\Xi^*(1530)$ can one hope to convincingly establish the spin-parity of a bump found in production experiments. For resonances at higher energies it is also an act of faith to quote branching fractions of structures seen in this way; as we have learned from studies of N^* and Y^*, what at first appears to be a simple resonance when seen as an enhancement in the total cross section, has frequently, upon detailed partial wave analysis, been found to be in fact composed of a number of overlapping resonances.

But any information, however limited, is welcome and great effort has been expended in this direction. As Hemingway[19] has summarized in this conference, we will soon have accumulated about 300 events/μb of analyzed bubble chamber film in this search. A new, even larger, experiment with 5 million pictures of 8.2 GeV/c K^-p in the 2 meter CERN chamber is well under way. This should extend Ξ^* spectroscopy to higher energies and perhaps even reveal Ω^* states predicted by the quark model.

Several hopes remain for obtaining substantially larger numbers of Ξ^* events. One is to use the recently completed rapid cycling bubble chamber at RHEL. Surrounded by cylindrical spark chambers, the bubble chamber picture-taking is to be triggered by external counters requiring a high multiplicity final state. It is anticipated that a cross-section sensitivity of about 1000 events/μb will be achieved with K^- of 2.8 GeV/c.[39] The objective of the experiment is to explore the Ξ^* spectrum up to a mass of 2 GeV with much higher statistics than has heretofore been possible. At BNL two Ξ^* experiments have recently been approved, using as a detector the Multi-Particle Spectrometer (MPS). Each anticipates a cross-section sensitivity in excess of 1000 events/μb. One of them employs a stopping K^+ detector as a signal for Ξ production,[40] while the other uses as a trigger a high-multiplicity final state.[41] Finally, there remains the possibility that the Ξ^- beams at FNAL and the CERN SPS will be a copious source of Ξ^* produced by means of inelastic collisions such as $\Xi^-p \to \Xi^*N$. Similar reactions were hoped for using Σ^- hyperon beams at lower energy accelerators, but this was not to be and even the ubiquitous $\Sigma(1385)$ has yet to make an appearance.[42]

D. S = +1 Resonances

Two new experiments designed to measure K^+n polarization are currently running. One at RHEL uses a polarized deuterium target,[43] while the other at BNL uses an unpolarized target and analyses the neutron polarization by means of a subsequent np scattering.[44] The goal of these two experiments is the same: to subject to closer scrutiny the more promising of the Z^* candidates, the P01 amplitude, which according to the BGRT "resonant" solutions C and D[45] rises nearly to the maximum of the unitary circle before becoming highly inelastic. Polarization measurements at several momenta are crucial to constrain the analysis. If indeed the amplitude is found to be resonant, then it will decidedly affect our thinking in baryon spectroscopy since it will be the first clear case of an exotic resonance.

The RHEL experiment also hopes to measure polarization in the reaction $K^+n \to K^\circ p$, thereby differentiating more clearly between the C and D solutions. An extension of the BNL experiment is also being considered; they may attempt to measure in the same way the polarization parameter in K^-n elastic scattering as a further constraint on Y^* analyses.

IV. Conclusions

There has been an impressive amount of new data presented at this conference. The full impact of these data on partial wave analyses has not yet been felt. We will shortly, I expect, learn what their implications are concerning the existence of many unsettled baryon resonances.

Too much of what we think we know about the relation between baryons and symmetry theory is still based on wishful thinking. Perhaps this is a legitimate attitude in view of the apparent successes which brought us to the present situation. Still, some of us conservatives find it uneasy to see everyone now heading towards a new spectroscopy, lured by the appearance of charm while reasonable doubts remain concerning the old spectroscopy. Too many easily accessible experiments are still possible. While these are being pursued during the next several years we can anticipate continued improvement in the experimental situation. In my opinion the new results, assuming that there are no experimental surprises nor new theoretical developments, will suffice to bring to a satisfactory state the major issues still open in conventional baryon spectroscopy. This cannot help but lead to further insights concerning the structure of baryons.

Charmed baryons are adding a new dimension to our thinking in this field. But rapid progress in the experimental knowledge of these objects does not appear at this time to be very likely.[46] Thus, if I may attempt a forecast, I think that the next conference on baryon spectroscopy will have prominently in its program most of the same subjects that have occupied us at this meeting.

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TABLE I. Comparison of the two BNL beams.

	800 MeV/c	
	LESB I	LESB II
$\Delta\Omega \frac{\Delta p}{p}$	10.6 mr%	77.2 mr%
$\frac{\Delta p}{p}$	±0.02	±0.03
$\Delta\Omega$	2.65 msr	12.9 msr
$\Delta\theta_V$	±11 mr	±15 mr
$\Delta\theta_H$	±60 mr	±215 mr
Length	600" 1524 cm	540" 1372 cm
Decay factor	0.079	0.102 @ 800 MeV/c
$K/10^{12}$ p	8×10^4	7×10^5 @ 800 MeV/c

FIGURE CAPTIONS

Fig. 1. Path lengths of K^-p bubble chamber experiments below 2.5 GeV/c. Numbers refer to the approximate date of the exposure. Horizontal lines show the momentum interval and average level of the exposure over that interval. Dashed lines indicate that the data from the experiment has not yet been analyzed or is otherwise unavailable. A listing of the experiments appears in reference 26.

Fig. 2. Cross section for the reactions $K^-p \rightarrow \Sigma^{\pm}\pi^{\mp}\pi^{\circ}$ as a function of momentum.

Fig. 3. Cross section for the reaction $K^-p \rightarrow \bar{K}^{\circ}n\pi^{\circ}$ as a function of momentum. The curve shown is a smooth fit through the data.

Fig. 4. Layout of the proposed high-intensity low-energy separated beam (LESB II) at Brookhaven National Laboratory.

Fig. 5. The K^-p total cross section as a function of momentum.

Fig. 6. The $\bar{K}N$ I = 0 total cross section as a function of momentum.

Fig. 7. The $\bar{K}N$ I = 1 total cross section as a function of momentum.

Fig. 8. The differential cross section at 0° for K^-p charge exchange as a function of momentum. The curve is a dispersion relation prediction of the 0° cross section (Refs. 37 and 38).

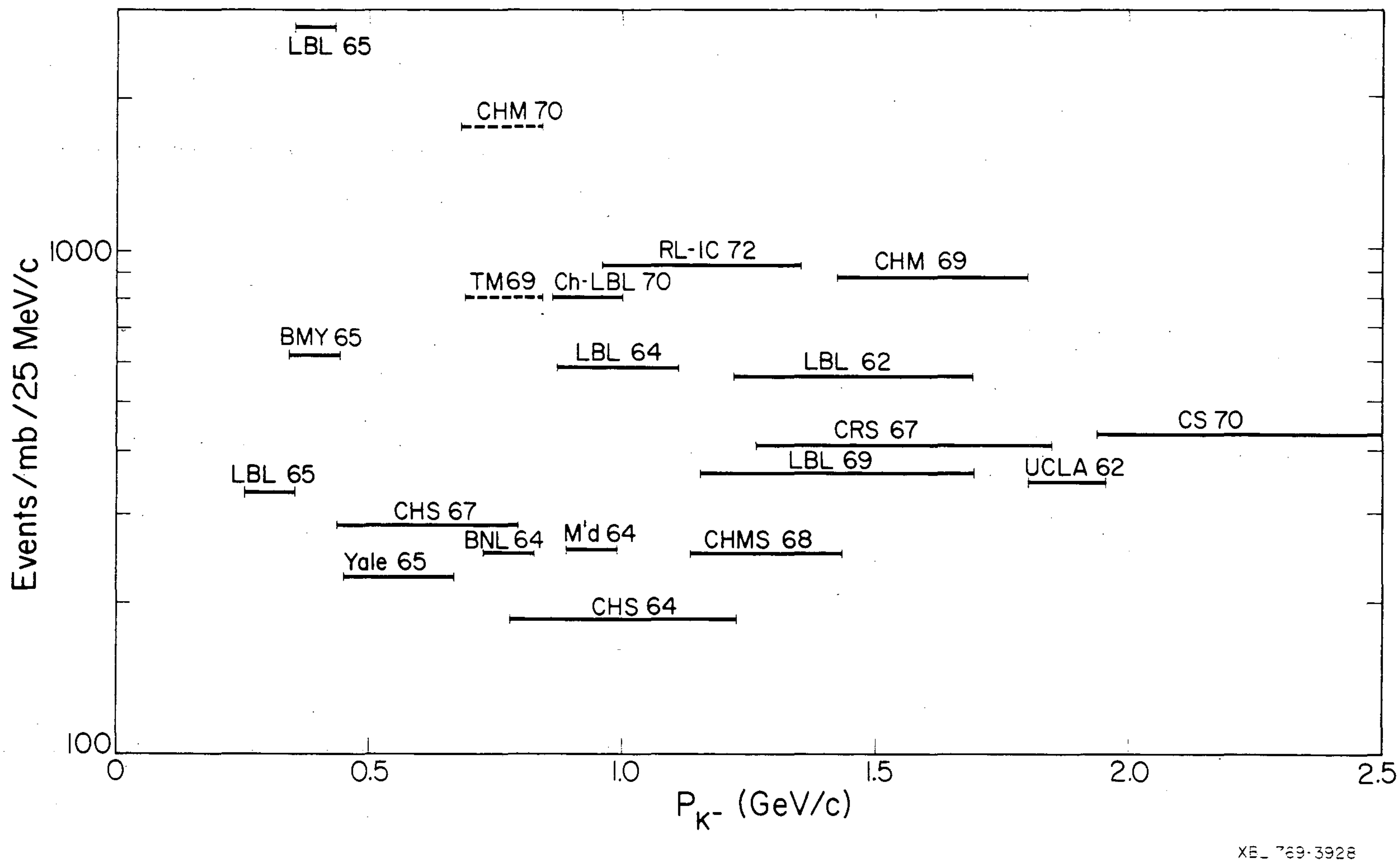

LBL 65
CHM 70
RL-IC 72
CHM 69
TM69
Ch-LBL 70
BMY 65
LBL 64
LBL 62
CS 70
CRS 67
LBL 69
LBL 65
UCLA 62
CHS 67
BNL 64
M'd 64
CHMS 68
Yale 65
CHS 64
1000
100
Events /mb /25 MeV/c
0
0.5
1.0
1.5
2.0
2.5
P_{K^-} (GeV/c)
XBL 729-3928

Fig. 1

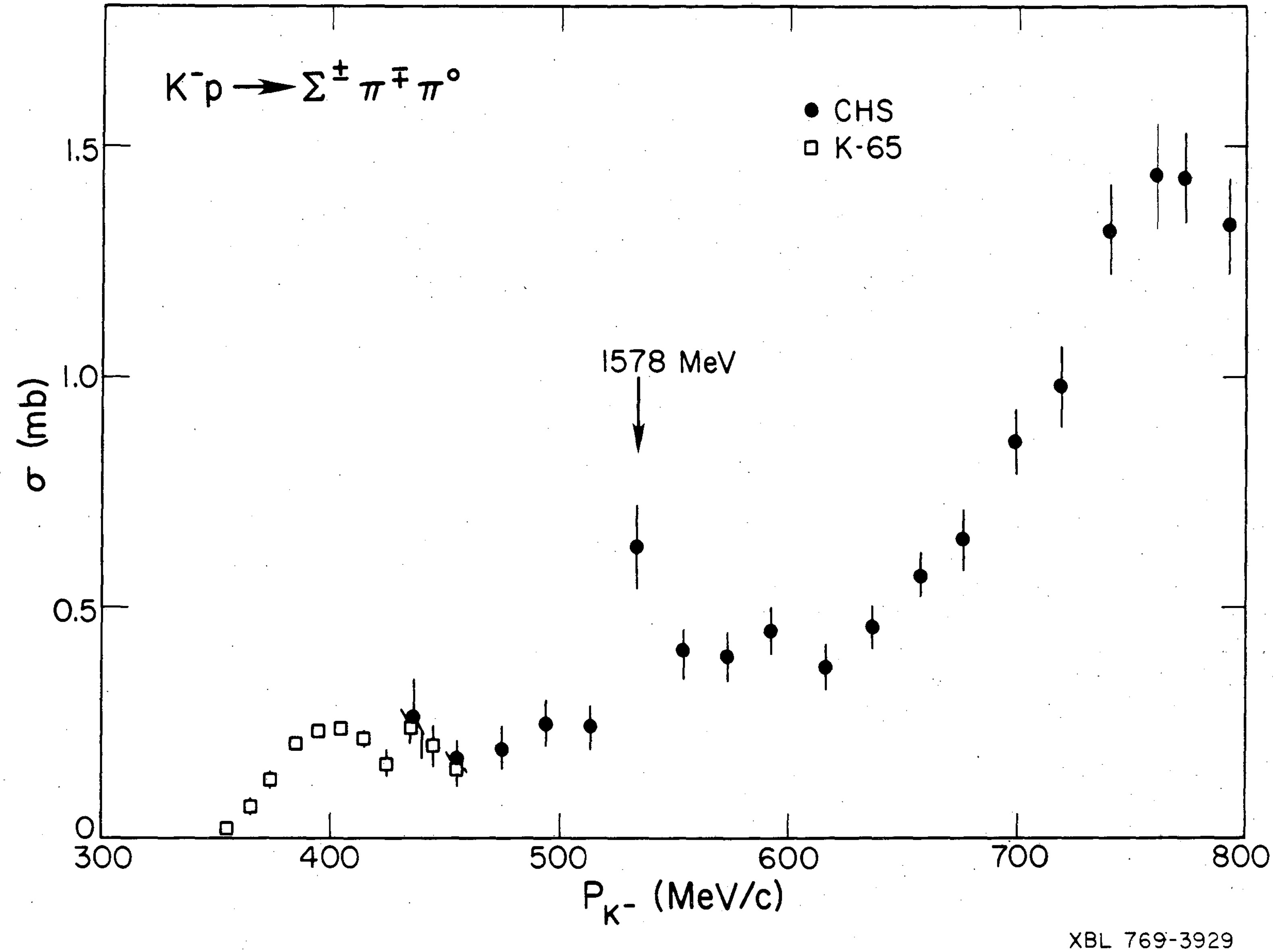
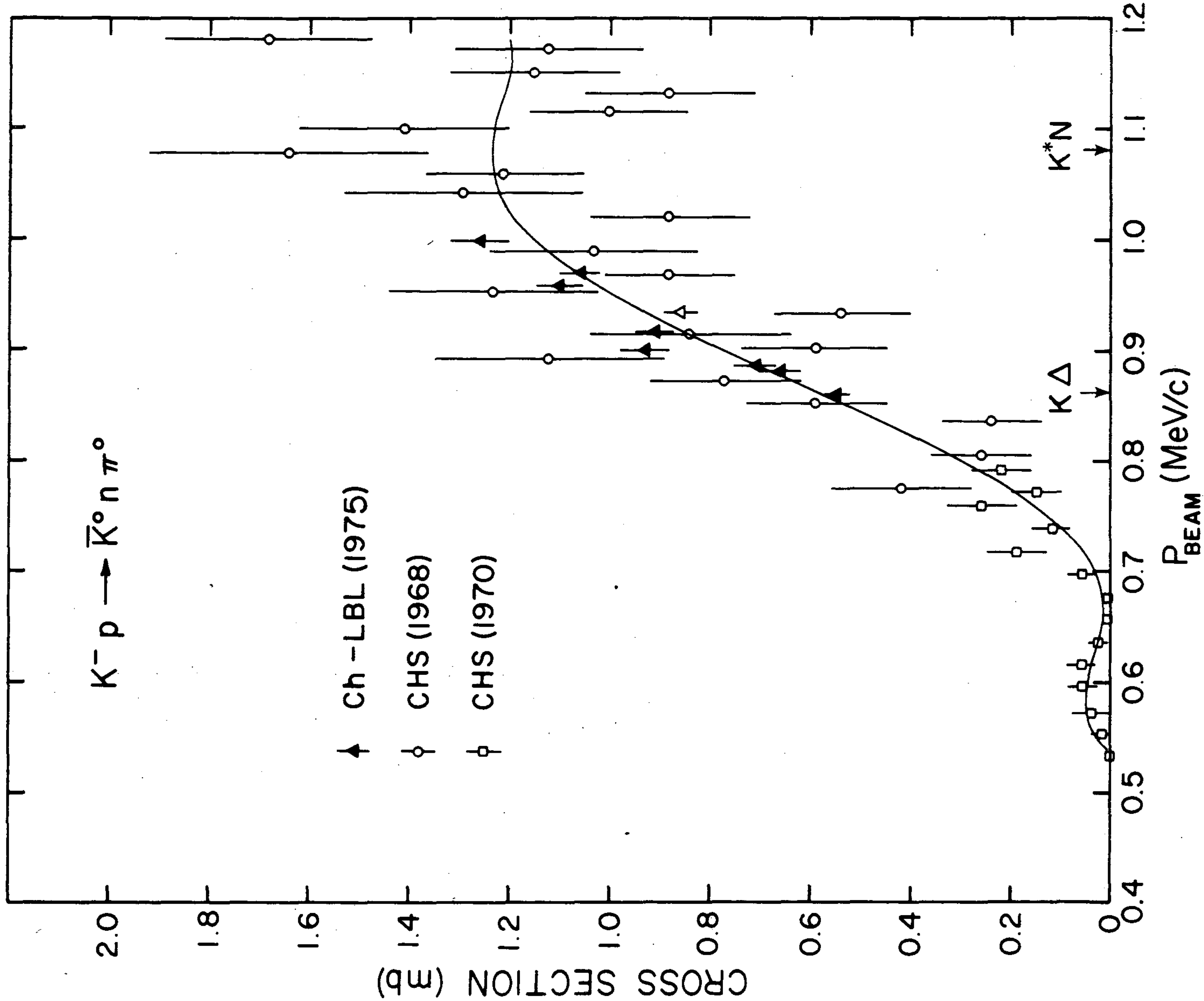

K⁻p → Σ± π∓ π°
● CHS
□ K-65
1578 MeV
σ (mb)
1.5
1.0
0.5
0
300
400
500
600
700
800
P_{K⁻} (MeV/c)
XBL 769-3929

Fig. 2



XBL 767 8625

Fig. 3

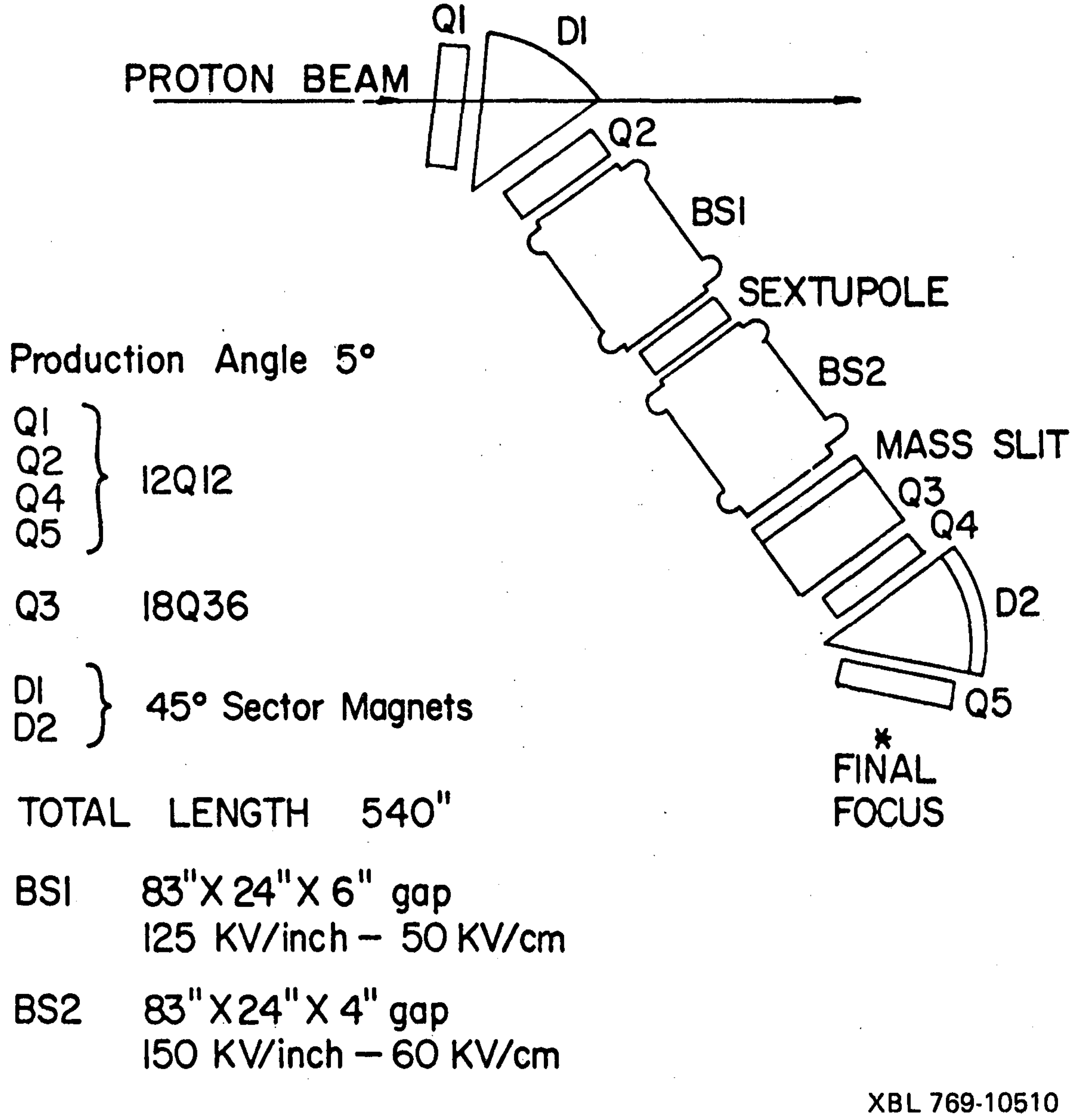
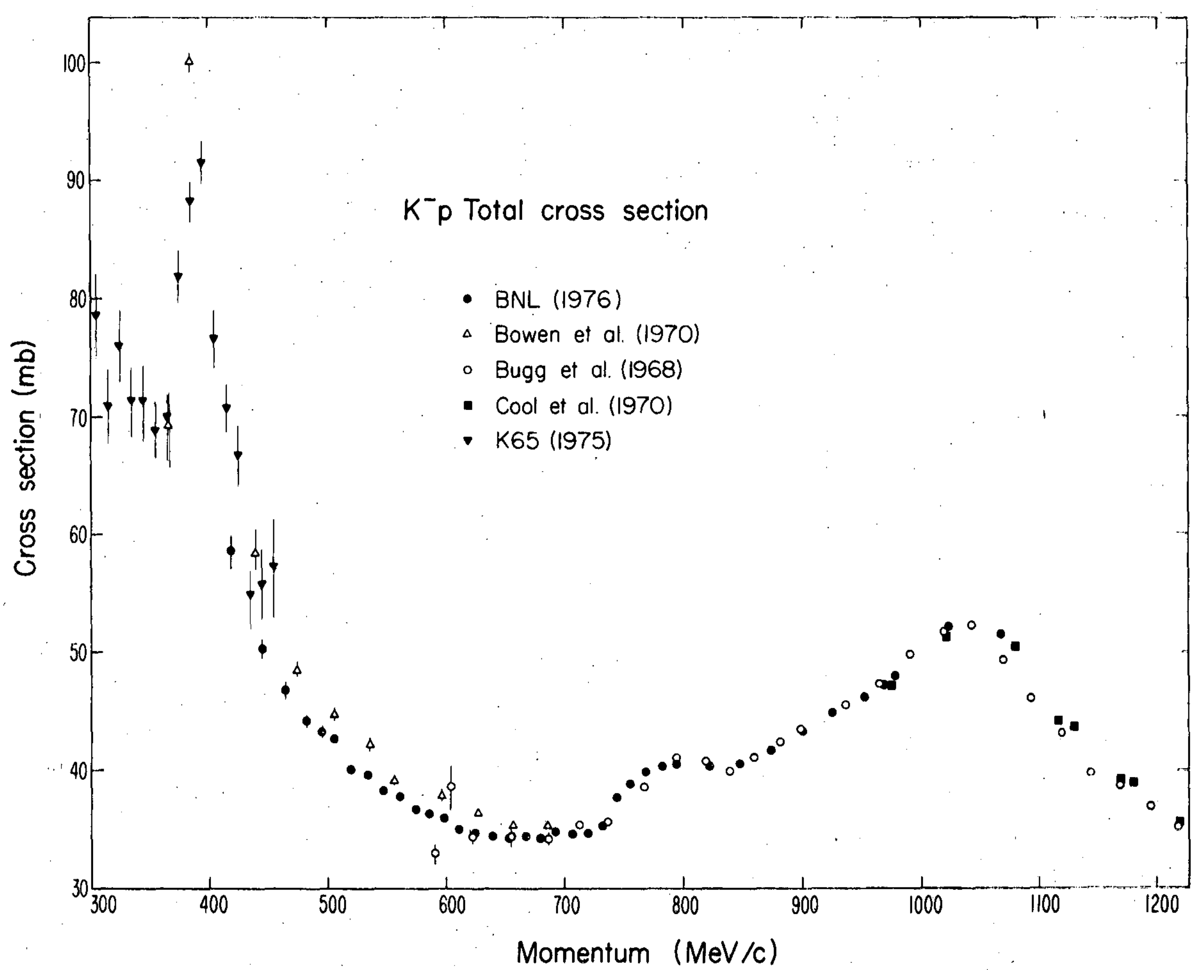

PROTON BEAM
Q1
D1
Q2
BS1
SEXTUPOLE
BS2
MASS SLIT
Q3
Q4
D2
Q5
FINAL FOCUS
Production Angle 5°
Q1 Q2 Q4 Q5 } 12Q12
Q3 18Q36
D1 D2 } 45° Sector Magnets
TOTAL LENGTH 540"
BS1 83"X 24"X 6" gap
125 KV/inch - 50 KV/cm
BS2 83"X 24"X 4" gap
150 KV/inch - 60 KV/cm
XBL 769-10510

Fig. 4



XBL 769-3963

Fig. 5

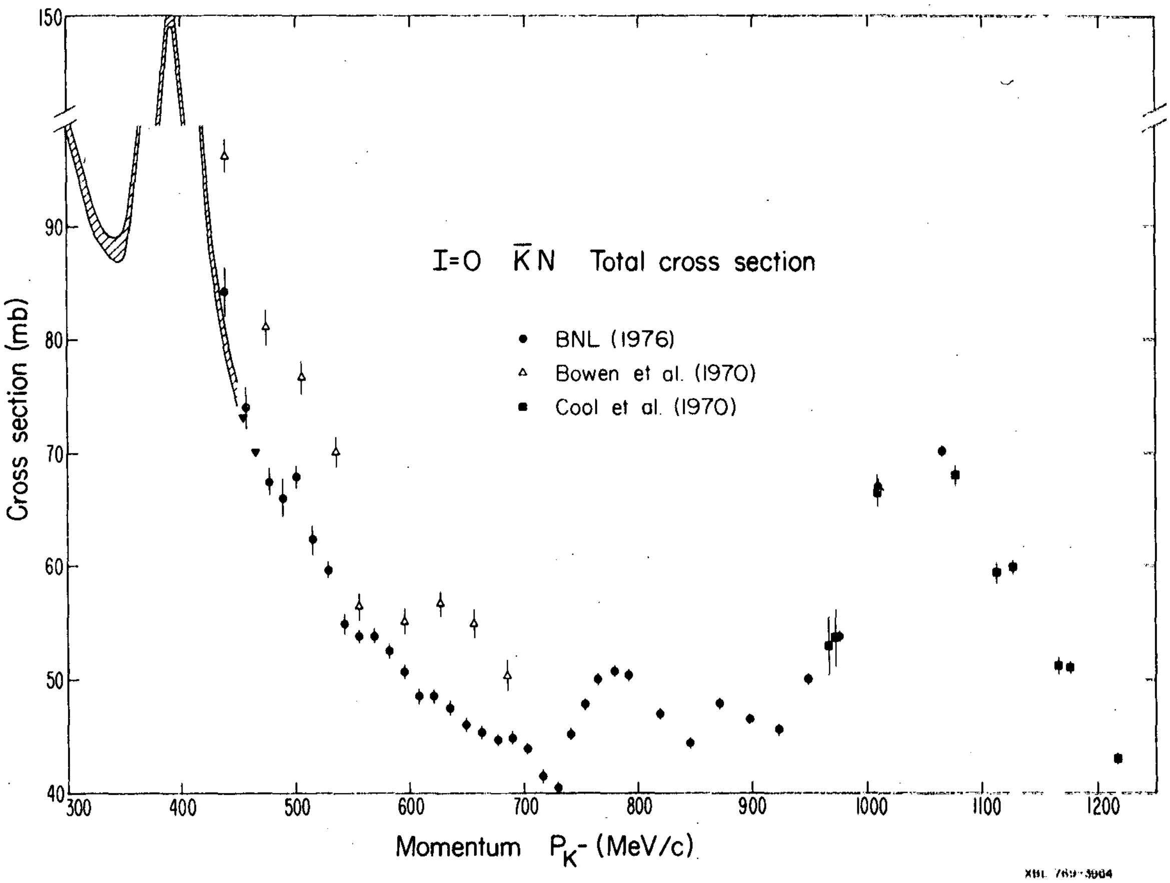
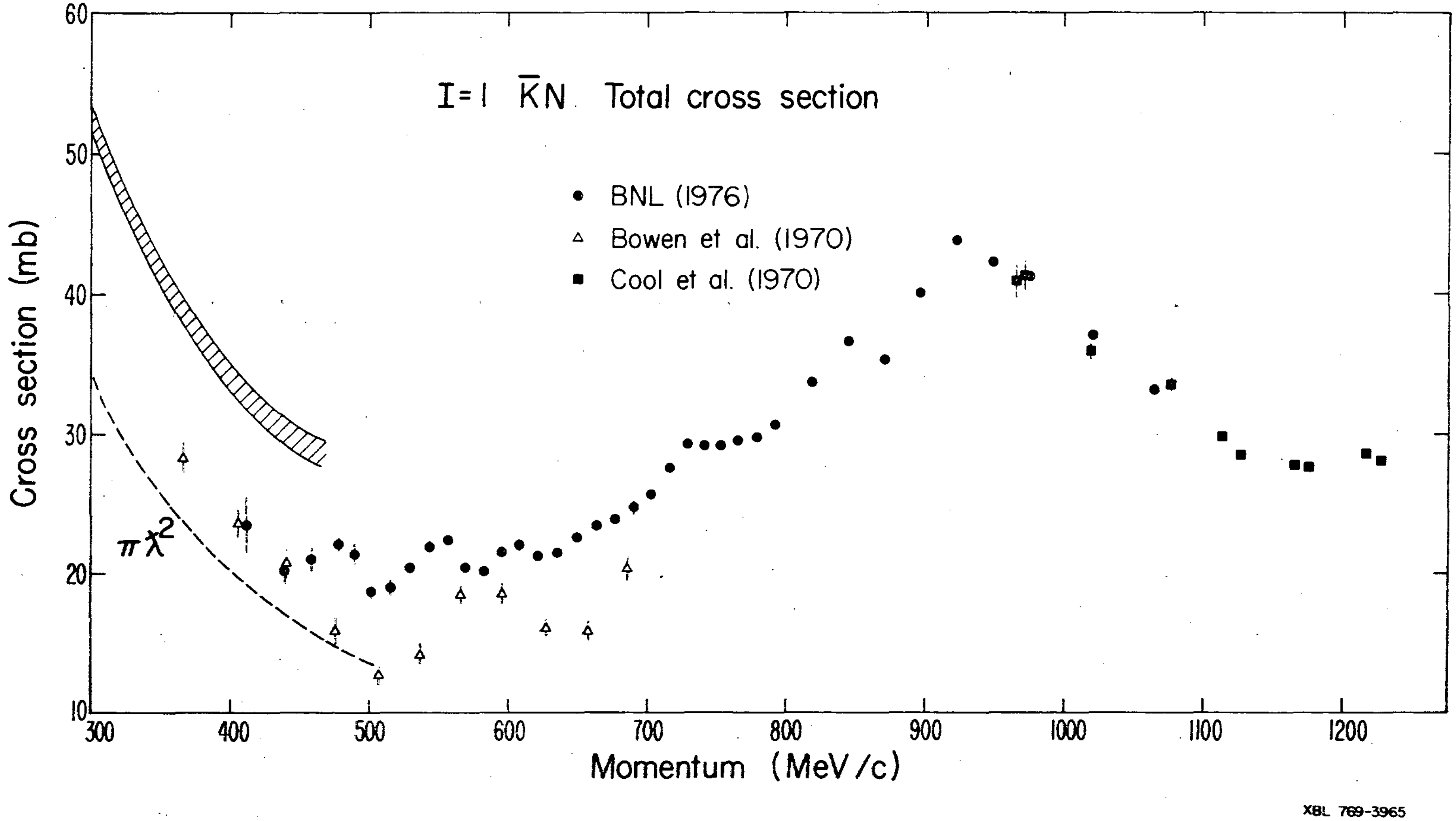
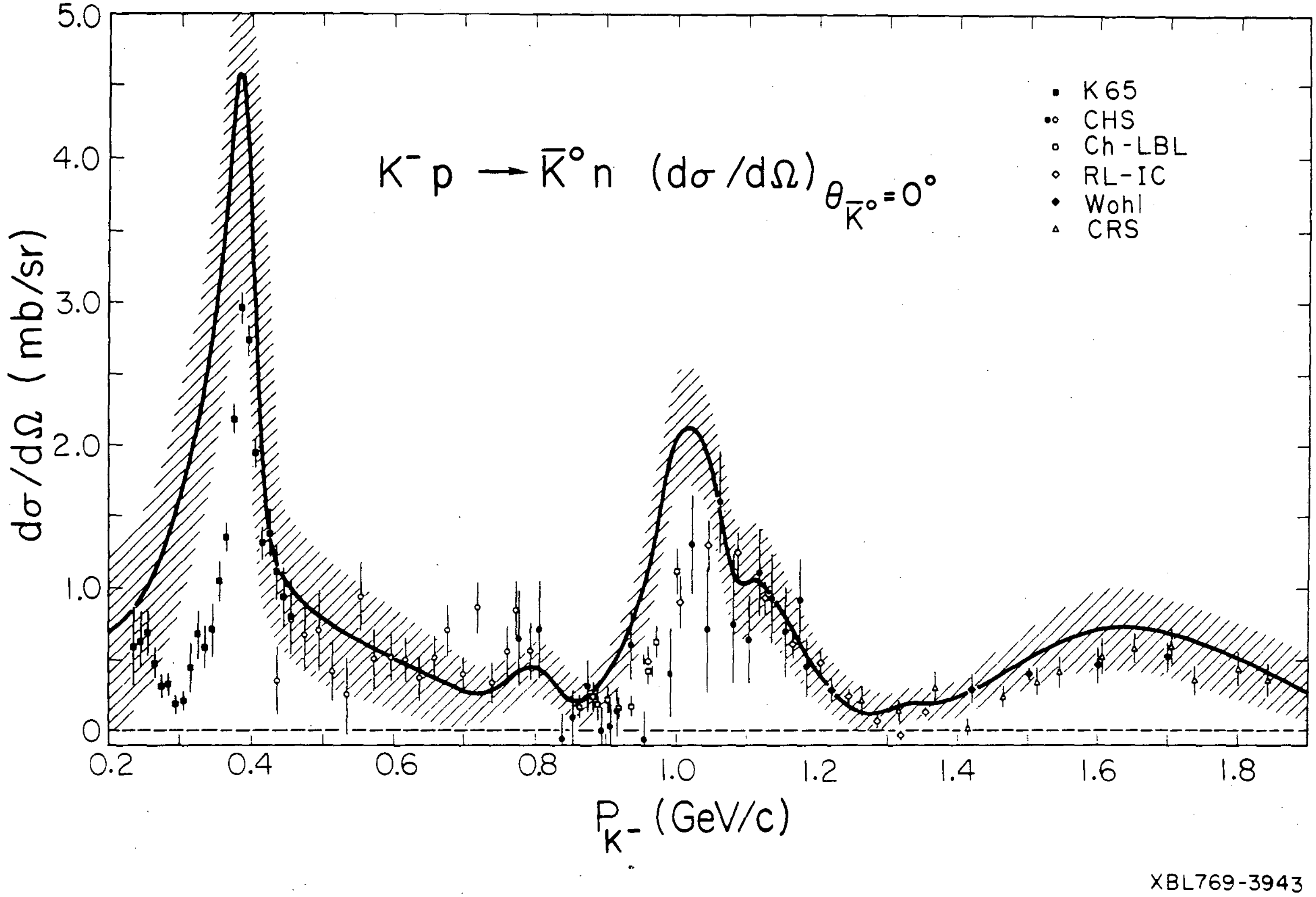

I=0 K̄N Total cross section
BNL (1976)
Bowen et al. (1970)
Cool et al. (1970)
Cross section (mb)
Momentum P_{K^-} (MeV/c)
150
90
80
70
60
50
40
300
400
500
600
700
800
900
1000
1100
1200

Fig. 6



I=1 K̄N Total cross section
BNL (1976)
Bowen et al. (1970)
Cool et al. (1970)
πƛ²
Cross section (mb)
Momentum (MeV/c)
60
50
40
30
20
10
300
400
500
600
700
800
900
1000
1100
1200
XBL 769-3965

Fig. 7



5.0
4.0
3.0
2.0
1.0
0
dσ /dΩ (mb/sr)
K⁻p → K̄°n (dσ /dΩ) θ_K̄° = 0°
K65
CHS
Ch-LBL
RL-IC
Wohl
CRS
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
P_K- (GeV/c)
XBL769-3943

Fig. 8

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