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Authors
Alston, Margaret H.
Alvarez, Luis W.
Eberhard, Philippe
et al.

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THE Σ/Λ BRANCHING RATIO OF Y_1^* †

Margaret H. Alston, Luis W. Alvarez, Philippe Eberhard,§ Myron L. Good,** William Graziano, Harold K. Ticho,†† and Stanley G. Wojcicki

Lawrence Radiation Laboratory and Department of Physics
University of California, Berkeley, California

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Recently a $T = 1$ resonance in the $\Lambda\pi$ system called Y_1^* has been observed with a mass of 1385 Mev.[1-6] Two types of resonances have been predicted that might relate this observation to other elementary-particle interactions: (1) P 3/2 resonances in the $\Lambda\pi$ and $\Sigma\pi$ systems predicted by global symmetry[7,8] corresponding to the (3/2, 3/2) resonance of the πN system, (2) a spin-1/2 Y-π resonance resulting from a bound state in the $\bar{K}N$ system.[9,10] The position and width of the observed Y_1^* resonance agree with both theories but since the spin and parity have not yet been determined, it is impossible at present to distinguish between the two theoretical interpretations.

Global symmetry[11] predicts a theoretical branching ratio $(Y_1^{*+} \rightarrow \Sigma^0 + \pi^+)/(Y_1^{*+} \rightarrow \Lambda + \pi^+) = 1/4$ for the $T = 1$ resonance. The phase-space factor $(P_\Sigma/P_\Lambda)^3 = (126/207)^3 = 0.225$ reduces the expected branching ratio for this process to $R = (1/4) \times 0.225 \sim 5\%$. Furthermore, as a consequence of charge independence the rates $Y_1^{*\pm} \rightarrow \Sigma^\pm + \pi^0$, $Y_1^{*\pm} \rightarrow \Sigma^0 + \pi^\pm$, and $Y_1^{*0} \rightarrow \Sigma^\pm + \pi^\mp$ are equal. In addition to the $T = 1$ resonance, a $T = 2$ Σ-π resonance with a total energy of 1540 Mev and a half width, $\Gamma/2$, of 60 Mev is predicted by global symmetry.[8]

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§Presently at Laboratoire de Physique Atomique, College de France, Paris, France.

**Presently at University of Wisconsin, Madison, Wisconsin.

††Presently at the University of California at Los Angeles, Los Angeles, California

The $\overline{K}$-N bound-state model suggests values of R considerably larger than 5%. However, when non-zero effective ranges are taken into account[12] R can become quite small, especially if the ($\Sigma\Lambda$) parity should be odd.

To investigate these possibilities, we have continued our study of K^- - p interactions at 1.15 Bev/c in the Lawrence Radiation Laboratory 15-in. hydrogen bubble chamber by studying events in which a Σ is observed. The total cross sections for these interactions are shown in Table I; only statistical errors are indicated. The separation of $\Sigma^{\pm} + \pi^{\mp} + \pi^0$ and $\Sigma^{\pm} + \pi^{\mp} + 2\,\pi^0$ events was difficult because many of the latter events can also be fitted to the first hypothesis. The numbers given in Table I and in the Dalitz and mass plots below were corrected to account for this ambiguity. The correction factor was estimated by using our $\Sigma^{\pm} + \pi^{\mp} + \pi^+ + \pi^-$ events.

Dalitz plots for the three-body reactions are shown in Fig. 1. The Y_1^* resonance of mass 1385 Mev should appear as a bunching of events about both horizontal and vertical lines corresponding to $T_\pi = 282$ Mev. To obtain an upper limit for the branching ratio R, we combined the events into different charge states of the $\Sigma\pi$ system. All charged Σ were observed; however, in the Σ^0 cases only two-thirds of the events were observable because of the neutral decays of the Λ^0. Furthermore, we had estimated that about one-third of the $\Sigma^0\,\pi^+ + \pi^-$ events also fitted a $\Lambda\pi^+\pi^-$ interpretation and had been included in already published data.[1] Consequently each $\Sigma^0\,\pi^+\pi^-$ event was given a weight of 2.25. The resultant mass spectra are shown in Fig. 2. In the cases of $(\Sigma\pi)^+$ and $(\Sigma\pi)^-$ there appears to be no excess of events in the region of M = 1385 Mev. Using the number of $(\Lambda\pi^+)$ and $(\Lambda\pi^-)$ events with 1355 Mev $< M_{\Lambda\pi} <$ 1415 Mev from reference 1, and assuming that all $\Sigma\pi$ events in the same regions of Fig. 2 are Y_1^*, we obtain $R_{max} \leqslant 8\%$.

This treatment yields an unrealistic upper limit, since there is no evidence of any peaking above background. The results are consistent with R = 0. The $\Sigma^{\pm} + \pi^{+} + 2\pi^{0}$ events possibly misidentified as $\Sigma^{\pm} + \pi^{\mp} + \pi^{0}$ (or vice versa) do not fall into the mass band used in this analysis, since they yield apparently high masses of the $\Sigma^{\pm}\pi^{0}$ system.

We conclude that the Σ/Λ branching ratio R for the strong decay of the T = 1 Y_1^* is at most a few percent and is consistent with zero. This result agrees with the value of R obtained by Berge.[3] As indicated above this value of R does not rule out either the global symmetry or the $\bar{K}N$ bound-state model of the Y_1^* resonance. No evidence for the resonance with T = 2 predicted by global symmetry at M = 1540 Mev is observed; however, this wide resonance would be hard to separate from background.

The authors wish to thank the many members of the Bevatron and 15-in. bubble chamber crews and the scanners who made this experiment possible. One of us, Philippe Eberhard, wishes to thank the Philippe Foundation, Inc. and the Commisariat à L'Energie Atomique for a fellowship.

Table I. Cross sections for the Σ producing interactions at 1.15 Bev/c

Reaction	No. of events (uncorrected)	Cross sections (mb)
$K^- + p \rightarrow \Sigma^- + \pi^+$	87	1.40 ± 0.16
$\rightarrow \Sigma^+ + \pi^-$	84	1.34 ± 0.18
$\rightarrow \Sigma^+ + \pi^- + \pi^0$	57	0.97 ± 0.16
$\rightarrow \Sigma^- + \pi^+ + \pi^0$	54	0.83 ± 0.20
$\rightarrow \Sigma^0 + \pi^+ + \pi^-$	27	0.97 ± 0.20
$\rightarrow \Sigma^+ + \pi^- + \pi^0 + \pi^0$	13	0.18 ± 0.06
$\rightarrow \Sigma^- + \pi^+ + \pi^0 + \pi^0$	9	0.12 ± 0.05
$\rightarrow \Sigma^+ + \pi^+ + \pi^- + \pi^-$	19	0.19 ± 0.06
$\rightarrow \Sigma^- + \pi^- + \pi^+ + \pi^+$	13	0.12 ± 0.05

FOOTNOTES

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FIGURE LEGENDS

Fig. 1. Dalitz plots for the reactions:

(a) $K^- + p \rightarrow \Sigma^+ + \pi^- + \pi^0$ (57 events)

(b) $K^- + p \rightarrow \Sigma^- + \pi^+ + \pi^0$ (54 events)

(c) $K^- + p \rightarrow \Sigma^0 + \pi^+ + \pi^-$ (27 events).

Fig. 2. Mass plots of the charged and neutral Σ-π systems, including curves representing phase-space distributions.

(a) Mass of $(\Sigma\pi)^-$, from the reactions: $K^- + p \rightarrow \Sigma^0 + \pi^- + \pi^+$
$\rightarrow \Sigma^- + \pi^0 + \pi^+$

(b) Mass of $(\Sigma\pi)^+$, from the reactions: $K^- + p \rightarrow \Sigma^0 + \pi^+ + \pi^-$
$\rightarrow \Sigma^+ + \pi^0 + \pi^-$

(c) Mass of $(\Sigma\pi)^0$, from the reactions: $K^- + p \rightarrow \Sigma^+ + \pi^- + \pi^0$
$\rightarrow \Sigma^- + \pi^+ + \pi^0$.

FIG. 1

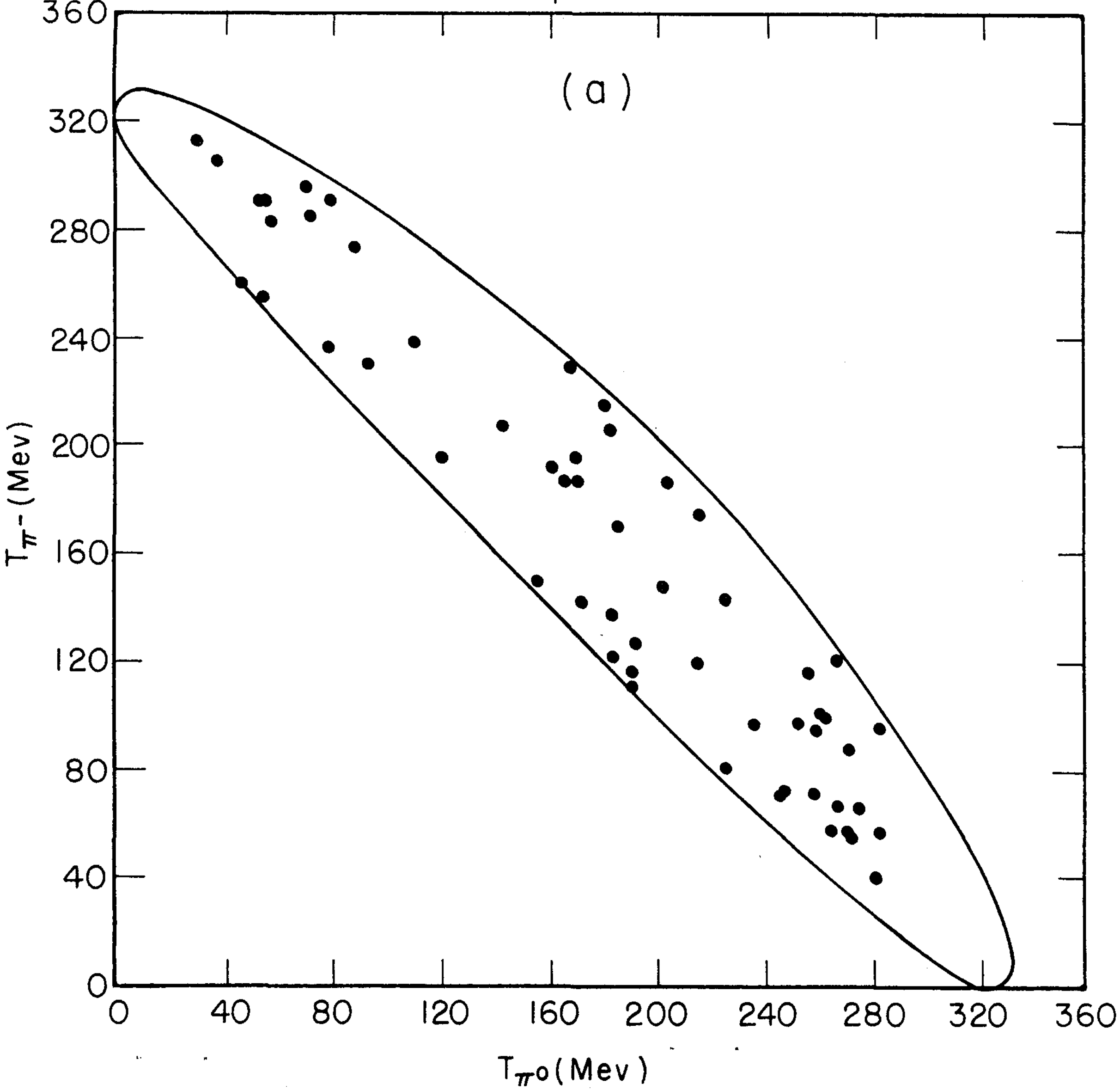
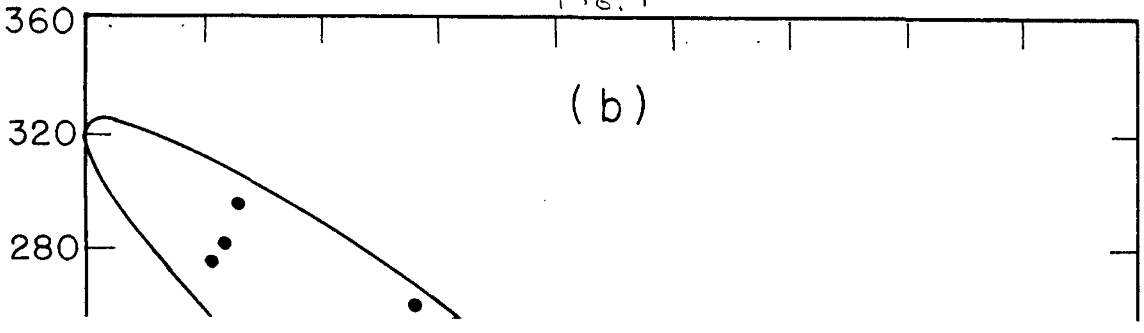

(a)
T_{π^-} (Mev)
T_{π^0} (Mev)
0
40
80
120
160
200
240
280
320
360

FIG. 1


(b)
280
320
360

T_{π^o} (Mev)

FIG. 1

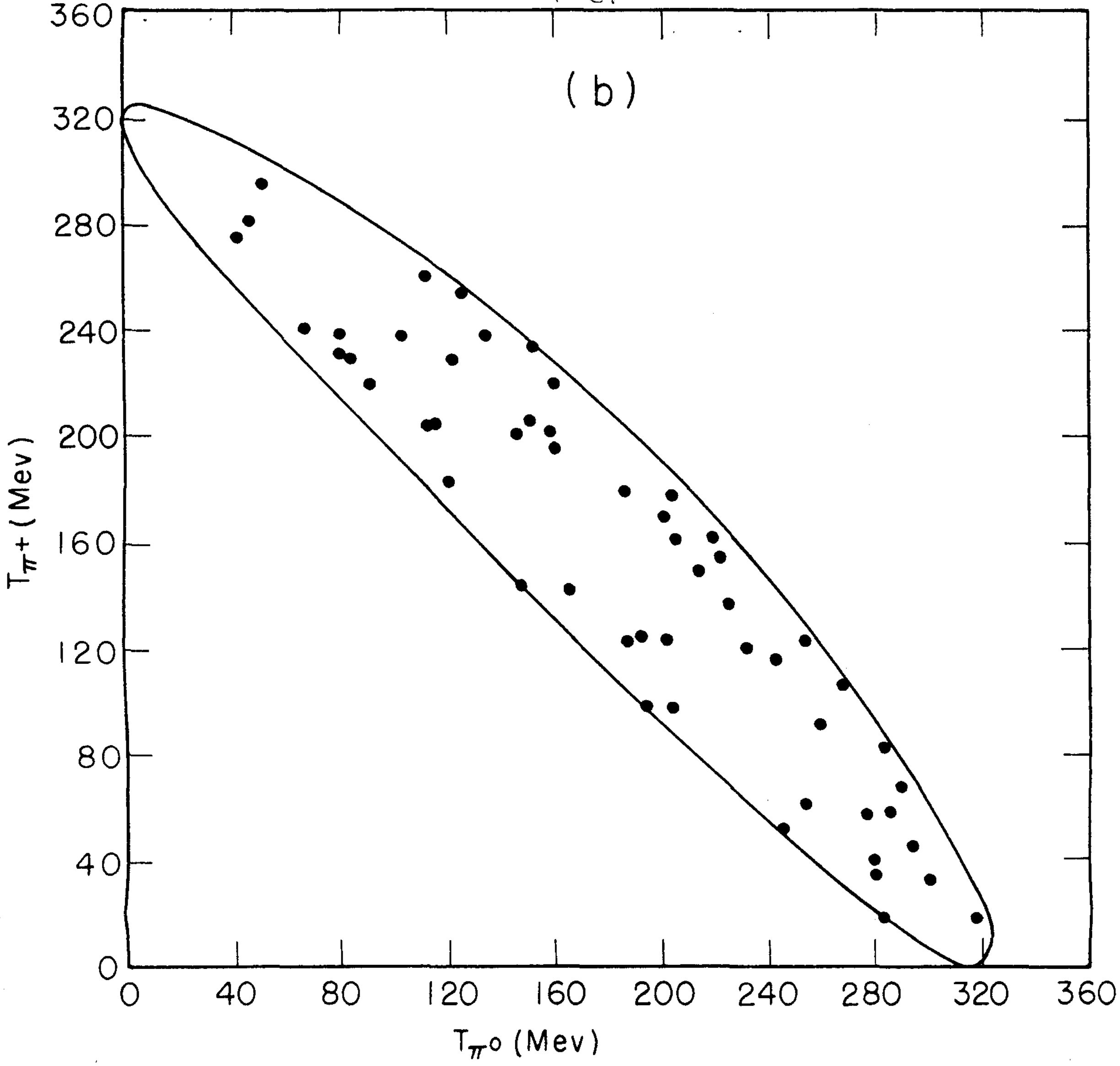
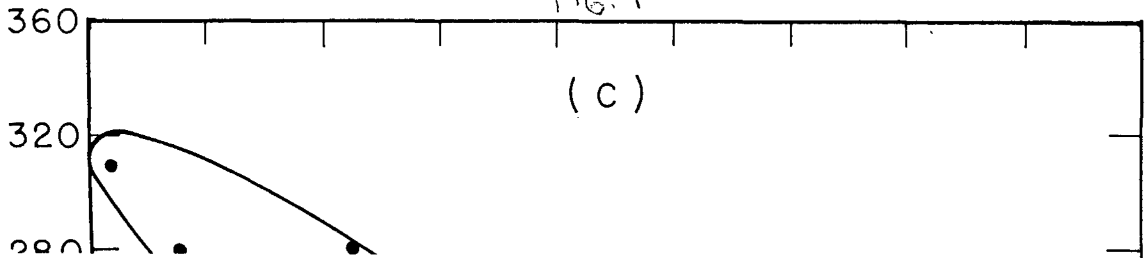


FIG. 1



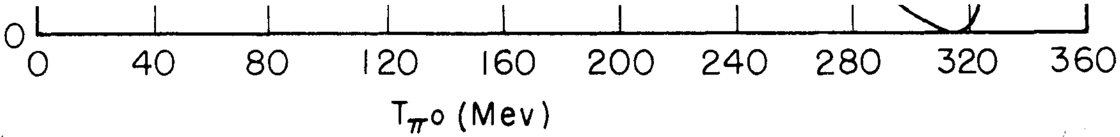
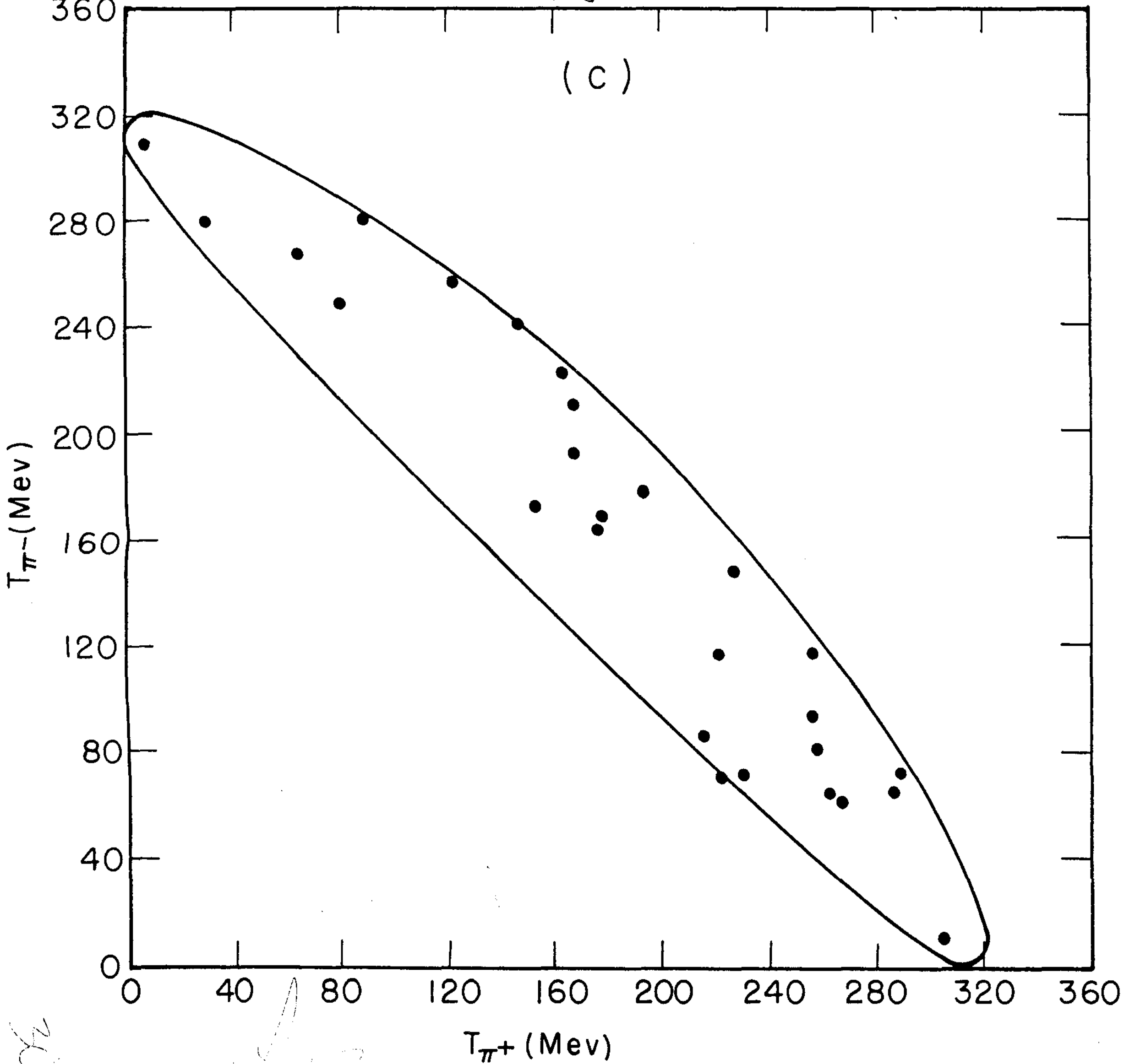
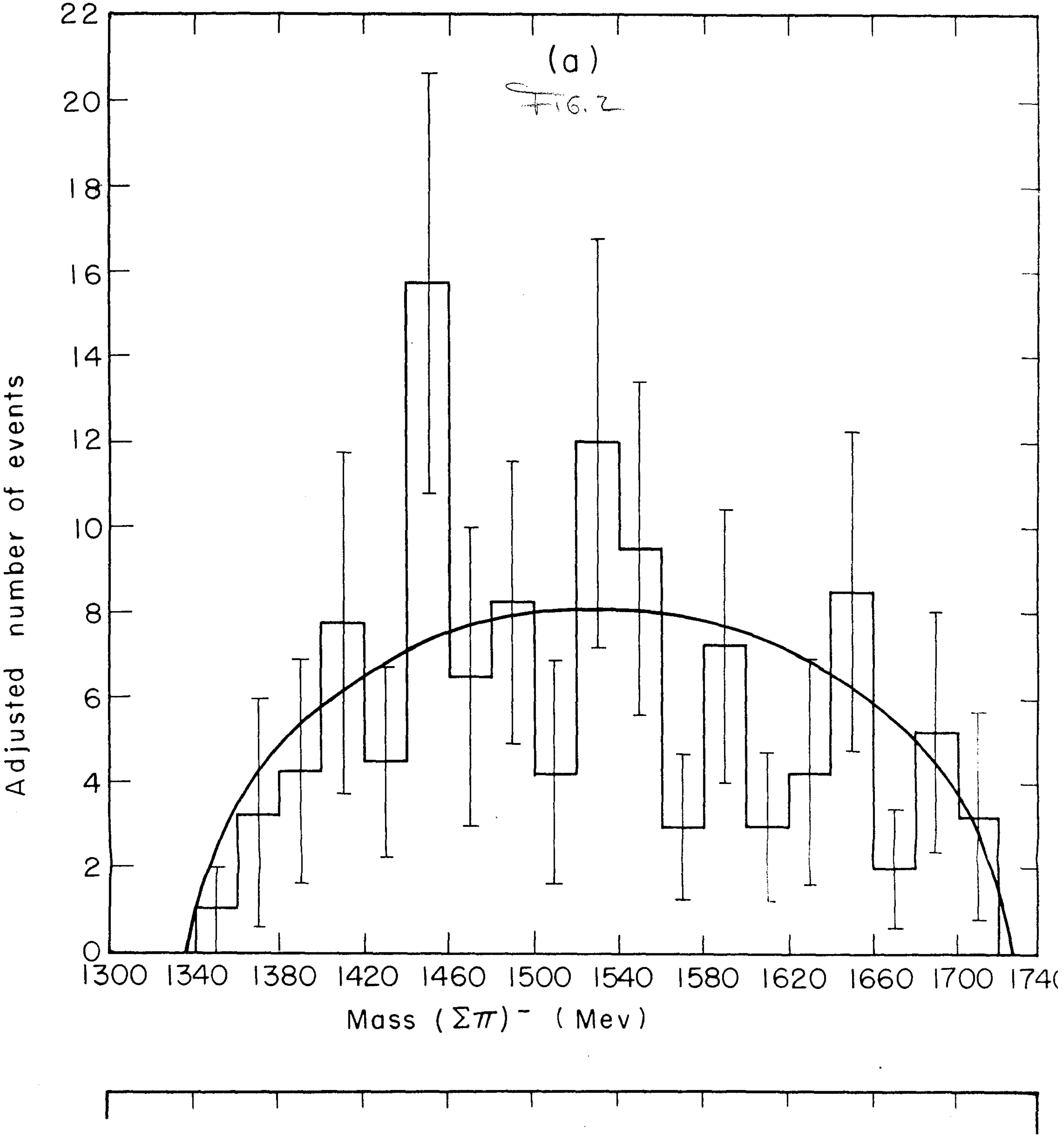
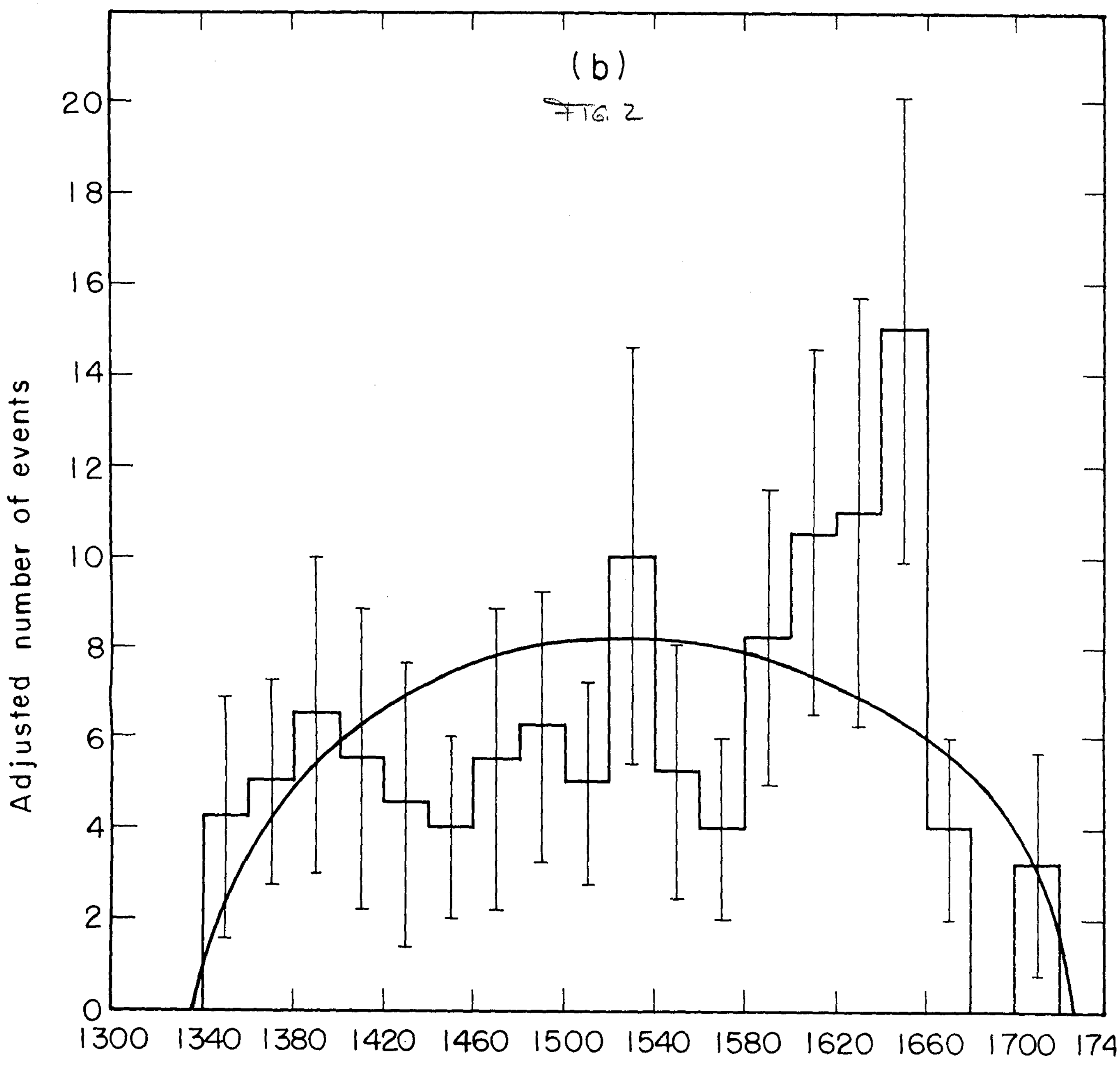

0
0 40 80 120 160 200 240 280 320 360
T_{π^0} (Mev)

FIG. 1

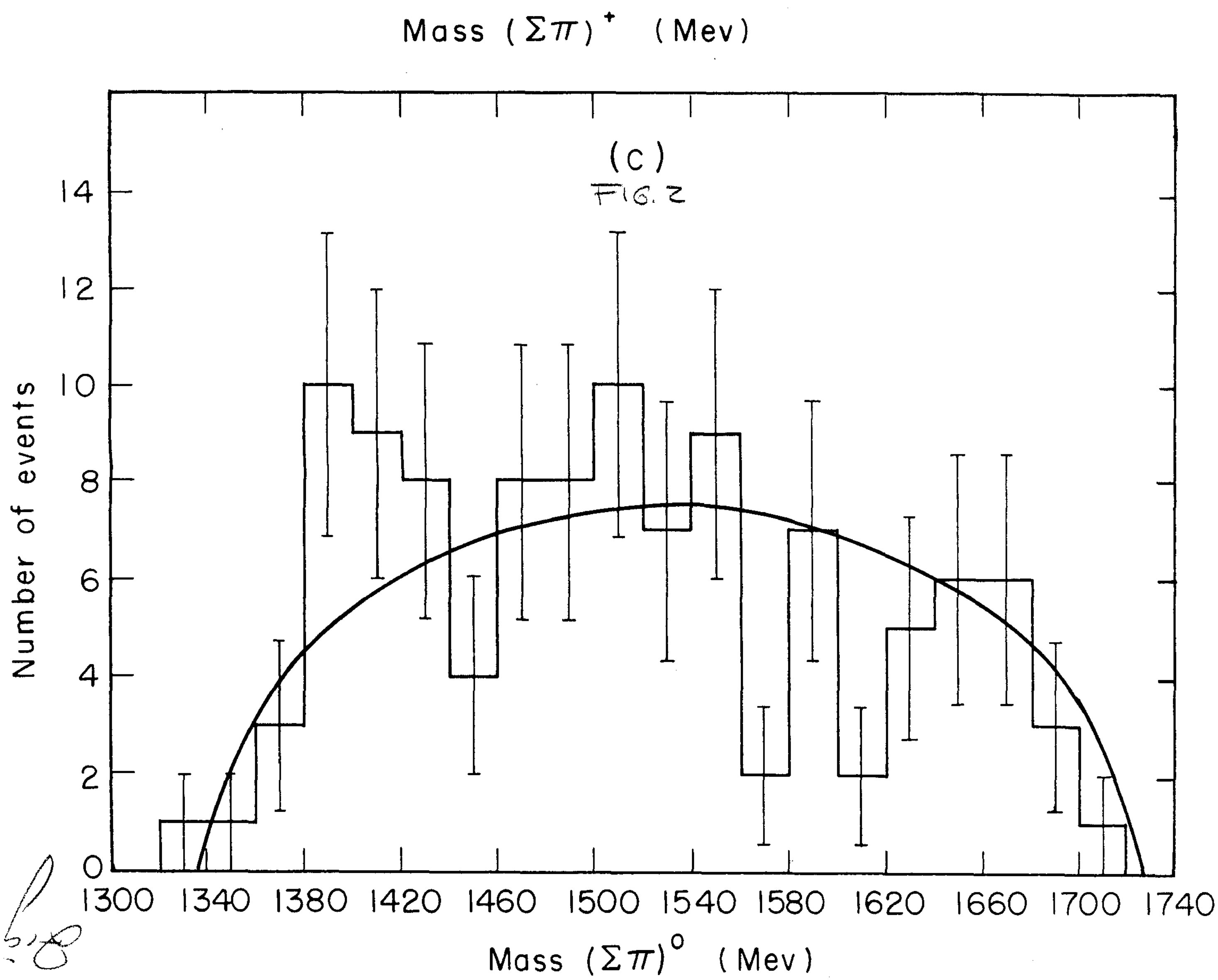

(c)
360 320 280 240 200 160 120 80 40 0
T_{π^-} (Mev)
0 40 80 120 160 200 240 280 320 360
T_{π^+} (Mev)


(a)
Adjusted number of events
0
2
4
6
8
10
12
14
16
18
20
22
1300
1340
1380
1420
1460
1500
1540
1580
1620
1660
1700
1740
Mass $(\Sigma\pi)^-$ (Mev)
FIG. 2

Mass $(\Sigma\pi)$ (Mev)



Mass $(\Sigma\pi)^+$ (Mev)


Mass $(\Sigma\pi)^+$ (Mev)
(c)
FIG. 2
Number of events
0
2
4
6
8
10
12
14
1300 1340 1380 1420 1460 1500 1540 1580 1620 1660 1700 1740
Mass $(\Sigma\pi)^0$ (Mev)