SUBMITTED TO PHYSICS LETTERS

CERN/TC/PHYSICS 65-16
3.8.1965

MASS, WIDTH AND BRANCHING FRACTION OF Y^* (1385)

R. Armenteros, M. Ferro-Luzzi, D.W.G. Leith, R. Levi-Setti(*), A. Minten, R.D. Tripp.**

C.E.R.N., Geneva.

H. Filthuth, V. Hepp, E. Kluge, H. Schneider.

Institut für Hochenergiephysik, Heidelberg.University.

R. Barloutaud, P. Granet, J. Meyer, J.-P. Porte, J.-C. Scheuer.

C.E.N., Saclay.

In a systematic study of K^-p reactions at 14 different momenta in the range from 950 to 1200 MeV/c, strong production of $Y^*(1385)$ has been observed in the channels

$$K^- + p \longrightarrow \Lambda + \pi^+ + \pi^- \qquad (1)$$

$$K^- + p \longrightarrow \Sigma^0 + \pi^+ + \pi^- \qquad (2)$$

By isolating a sample of $\sim$ 2,000 final states of the type $Y^*(1385) + \pi$ from the above reactions, a new measurement of the $Y^*(1385)$ parameters has emerged. In contrast with the currently reported value of 0.06 ± 0.03 [1], the $\Sigma\pi$ branching fraction $\Gamma_{\Sigma\pi}/\Gamma$ of $Y^*(1385)$ is found to be 0.14 ± 0.03. The value of the mass difference $(M^- - M^+)$ is measured as (2.0 ± 1.5) MeV and the full width at half maximum Γ, as (35 ± 3) MeV.

The experiment has been performed with the 81 cm Saclay hydrogen bubble chamber exposed to a low energy K^- beam at the CERN protonsynchrotron [2]. About 150,000 pictures, corresponding to $\sim$ 2 events per μb, were scanned and rescanned for, among others, the topology of two-prongs-plus-V^0. The combined scanning efficiency was $\sim$ 98 %. From the usual kinematical fitting, 3,005 events were attributed to reaction (1) and 432 to reaction (2). Fig.1 shows the distribution of the missing-mass squared obtained when the reactions are treated as $K^- + p \longrightarrow \pi^+ + \pi^-$ + missing-mass, i.e. when the

---

(*) John Simon Guggenheim Memorial Fellow, on leave of absence from the University of Chicago.

(**) National Science Foundation Senior Postdoctoral Fellow, on leave of absence from the University of California, Berkeley.

PS/4989/dmh

measurements on the Λ-decay secondaries are ignored. The shaded area corresponds to the 432 events of reaction (2). The histogram illustrates clearly that, under our experimental conditions, the separation is subject to very little ambiguity. Further confidence in the results of the fitting procedure is obtained from the angular distribution of the $\Sigma^0 \longrightarrow \Lambda + \gamma$ decay, which is found to be in agreement with the expected isotropy.

The spectra of invariant-masses of $\Lambda\pi^+$ and $\Lambda\pi^-$ from reaction (1) are shown in Fig.2 as gaussian ideograms. Production of $Y^*(1385)$ is very abundant. It should be remarked that, for K^- momenta larger than 950 MeV/c, interference between Y^{*+} and Y^{*-} should not be important because the bands for $\Lambda\pi^+$ and $\Lambda\pi^-$ in the mass range from 1350 to 1420 MeV intersect well outside the allowed region of the Dalitz plot. Therefore it appears justified to fit the observed distributions of Fig.2 under the assumption that reaction (1) proceeds through 3 independent channels: $Y^{*+}\pi^-$, $Y^{*-}\pi^+$ and $\Lambda\pi^+\pi^-$. The mass spectrum for the non-resonant $\Lambda\pi^+\pi^-$ events is taken to be represented by a phase-space distribution; a Breit-Wigner formula with constant width was introduced to describe the mass distribution of the Y^* which was assumed to decay isotropically in its rest system. A maximum likelihood method [3] was used to obtain the relevant parameters, which are given in Table I. The solid curves in Fig.2 show the distributions calculated with the above parameters.

The gaussian ideograms for the invariant-masses of $\Sigma^0\pi^+$ and $\Sigma^0\pi^-$ from reaction (2) are given in Fig.3 and show definite structure in the mass region of $Y^*(1385)$. In addition to this resonance, here one may expect that some $Y^*(1660)$ is also produced. In order to account for the contribution due to $Y^*(1660)$ under the peaks at 1385 MeV, the fitting procedure employed previously for the $\Lambda\pi^+\pi^-$ events was modified to accommodate also a percentage of $Y^*(1660)$. The proportion of the latter resonance found in the sample is (15 ± 5) %. The $Y^*(1385)$ percentage was found to be (39 ± 6) %, assuming masses and widths in the $\Sigma\pi$ decay mode identical to those in the $\Lambda\pi$ mode. The ratio of Y^{*-} to Y^{*+} obtained from the $\Sigma\pi$ decay mode is (2.0 ± 0.6), in agreement with the value obtained from the $\Lambda\pi$ decay mode (see Table I). The above results are shown on Fig.3, where the amount of non-resonant $\Sigma^0\pi^+\pi^-$ is given by the dotted curve, of $Y^*(1385)$ by the dashed curve and of $Y^*(1660)$ by the dashed-dotted curve. The solid line is the sum of these three contributions.

In order to verify that the presence of $Y^*(1660)$ has been adequately accounted for, the analysis was repeated for K^- momenta below $Y^*(1660)$ threshold. The results of this partial analysis yield identical conclusions as for the branching fraction discussed below.

From the above results one can calculate the $\Sigma\pi$ branching fraction of $Y^*(1385)$. Strict charge independence would demand that the decay rate of $Y^{*\pm}$ into $\Sigma^0\pi^\pm$ be equal to that into $\Sigma^\pm\pi^0$ [4]. Denoting by R the decay rates and correcting for the mass differences of the decay products using the p-wave barrier($\sim p^3$)of the $Y^*(1385)$ decay, one calculates

$$\Gamma_{\Sigma\pi}/\Gamma = \frac{2.22.R(\Sigma^0\pi^+)}{2.22.R(\Sigma^0\pi^+) + R(\Lambda\pi^+)} = 0.142 \pm 0.03 \text{ for } Y^{*+}$$

and

$$\Gamma_{\Sigma\pi}/\Gamma = \frac{1.95.R(\Sigma^0\pi^-)}{1.95.R(\Sigma^0\pi^-) + R(\Lambda\pi^-)} = 0.136 \pm 0.03 \text{ for } Y^{*-}$$

The average value of the branching fraction, 0.14 ± 0.03, is larger than that obtained in previous measurements, which reported 0.04 ± 0.04 [5] and 0.08 ± 0.04 [6]. The disagreement between the present result and that of Ref.5 can perhaps be attributed to the presence of interference effects in the latter data which were taken in an energy region where the Y^{*+} and Y^{*-} bands are subject to a considerable kinematical overlap. We notice that the prediction of unitary symmetry for this branching fraction is 0.13 [7].

From Table I, the mass difference between Y^{*-} and Y^{*+} is seen to be $(M^- - M^+) = (2.0 \pm 1.5)$ MeV. This value may be compared to previous measurements of (4.4 ± 2.2) MeV [6] and (17 ± 7) MeV [8]. Theoretical models based on SU(3) and SU(6) invariance predict values of this mass difference ranging from ~ 4.7 to ~ 7.4 MeV [9,10].

Finally, an average of the widths for Y^{*+} and Y^{*-} gives $\Gamma = (35 \pm 3)$ MeV, which is considerably narrower than the presently accepted value of (51 ± 2) MeV [1] and in better agreement with the simple predictions of SU(3).

We wish to thank the staff of the CERN protonsynchrotron, the crew of the Saclay 81 cm hydrogen bubble chamber and our scanning and measuring staff for their valuable cooperation.

REFERENCES

1. A.H. Rosenfeld, A. Barbaro-Galtieri, W.H. Barkas, P.L. Bastien, J. Kirz and M. Roos, UCRL Report 8030 Rev. (March 1965).
2. J. Duboc, A.G. Minten and S.G. Wojcicki, CERN Report 65-2 (1965).
3. W.E. Humphrey, Lawrence Radiation Laboratory, Alvarez Group Memo P-6 (1962).
4. Based on preliminary results for the reaction $K^- + p \longrightarrow \Sigma^{\pm} + \pi^{\mp} + \pi^o$ in the same film, the branching fraction derived from the comparison between $Y^{*\pm}(1385) \longrightarrow \Sigma^{\pm}\pi^o$ and $Y^{*\pm}(1385) \longrightarrow \Lambda\pi^{\pm}$ gives a value of 0.15 ± 0.03, therefore supporting the above considerations. It should be noticed, however, that the most accurate way of deriving this branching fraction is from the $\Sigma^o\pi^{\pm}$ channel. The $\Sigma^{\pm}\pi^o$ decay mode is obscured by the reflections of $Y^*(1520)$ and $Y^*(1660)$ decaying into $\Sigma^{\pm}\pi^{\mp}$ and may be subject to unknown interference effects.
5. P. Bastien, M. Ferro-Luzzi and A.H. Rosenfeld, Phys. Rev. Letters, 6, 702 (1961).
6. D. Huwe, (Thesis) UCRL Report 11291 (1964)
7. M. Gell-Mann, Report CTSL-20, Pasadena, California.
8. W.A. Cooper, H. Filthuth, A. Fridman, E. Malamud, E.S. Gelsema, J.C. Kluyver and A.G. Tenner, Phys. Letters, 8, 365 (1964).
9. L.A. Radicati, L.E. Picasso, D.P. Zanello, J.J. Sakurai, Phys. Rev. Letters, 14, 160 (1965). (Further references may be found here).
10. A.D. Dolgov, L.B. Okun, I.Ya. Pomeranchuk and V.V. Solovyev, Phys. Letters, 15, 84 (1965).

PS/4989/dmh

FIGURE CAPTIONS

Fig.1. Histogram of the square of the missing mass for 3,437 reactions (1) and (2) when the measurements of the Λ-decay secondaries are ignored and the events are treated as $K^- + p \longrightarrow \pi^+ + \pi^- +$ missing mass. The shaded area indicates the events that were taken as reactions (2).

Fig.2. (a) Gaussian ideogram of the $\Lambda\pi^+$ effective-mass for 3,005 reactions (1). The curve represents the best fit to the data using the parameters given in Table I. Since the reactions are produced by K^- of different momenta, ranging from 950 to 1,200 MeV/c, the distribution for the non-resonant background has been taken as the average of the $\Lambda\pi^+\pi^-$ phase-space weighted over all incident momenta.

(b) Same as above, for the $\Lambda\pi^-$ effective-mass.

Fig.3. (a) Gaussian ideogram of the $\Sigma^0\pi^+$ effective-mass for 432 reactions (2). The best fit to the data is given by the full line, which represents the sum of three contributions: (1) $\Sigma^0\pi^+\pi^-$ phase-space weighted over all incident momenta (dotted curve), (2) $Y^*(1385)$, with the parameters of Table I (dashed curve), and (3) $Y^*(1660)$, with mass 1660 and width 60 MeV (dashed-dotted curve).

(b) Same as above, for the $\Sigma^0\pi^-$ effective-mass.

TABLE I

Mass, width and percentage of $Y^*(1385)$ in reactions (1) and (2). The errors are those given by the diagonal elements of the variance-covariance matrix in the maximum likelihood procedure. The average mass resolution for the $\Lambda\pi$ system is of $\pm$ 8 MeV.

	Mass (MeV)	Width (MeV)	Percentage of $Y^*(1385)$ in: reaction (1)	reaction (2)
Y^{*+}	1382 $\pm$ 1	32 $\pm$ 3	25 $\pm$ 1	13 $\pm$ 3
Y^{*-}	1384 $\pm$ 1	38 $\pm$ 3	46 $\pm$ 1	26 $\pm$ 5

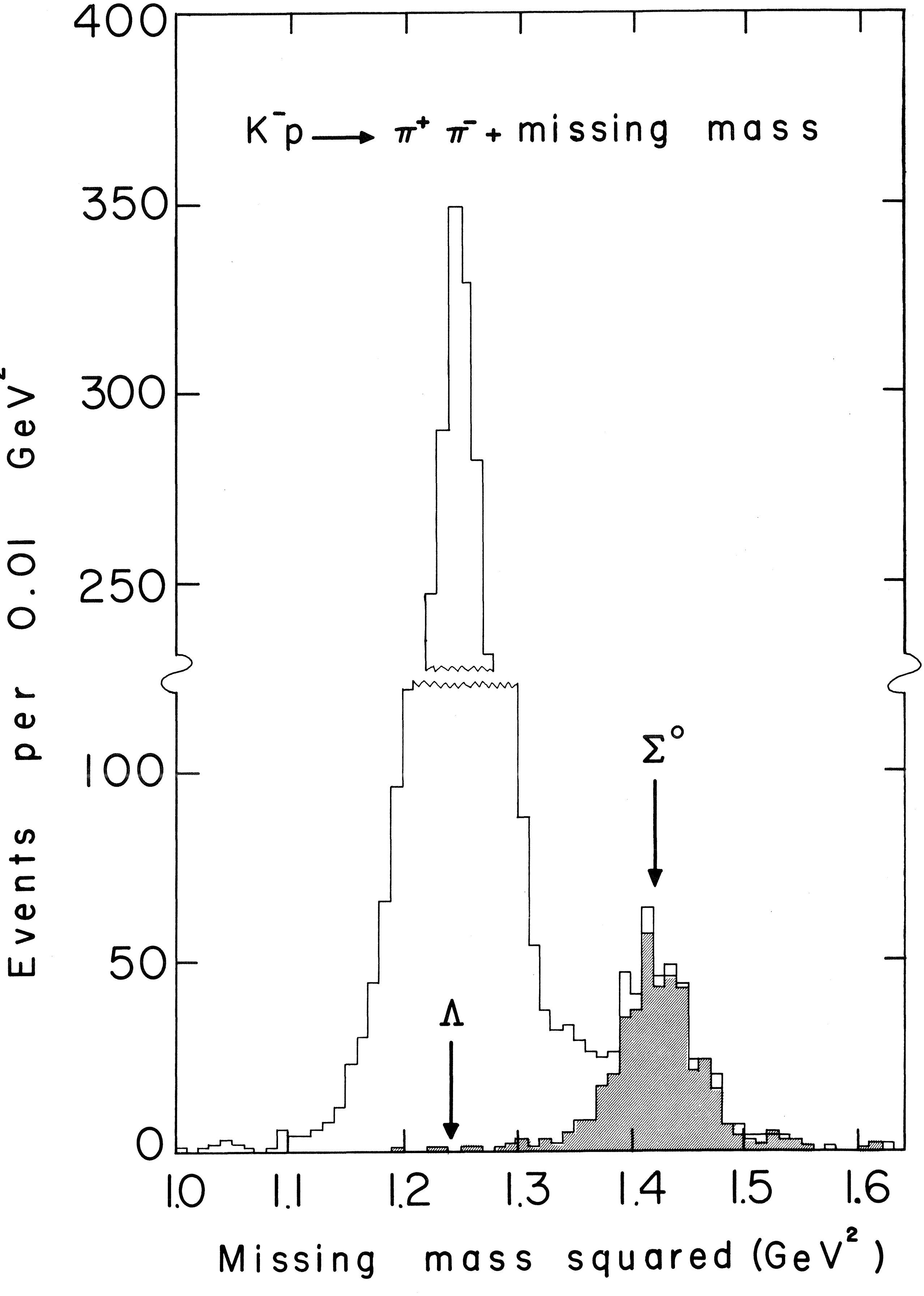
$K^-p \rightarrow \pi^+\pi^- +$ missing mass
Events per 0.01 GeV^2
Missing mass squared (GeV^2)
400
350
300
250
100
50
0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Λ
Σ^0

Fig. 1

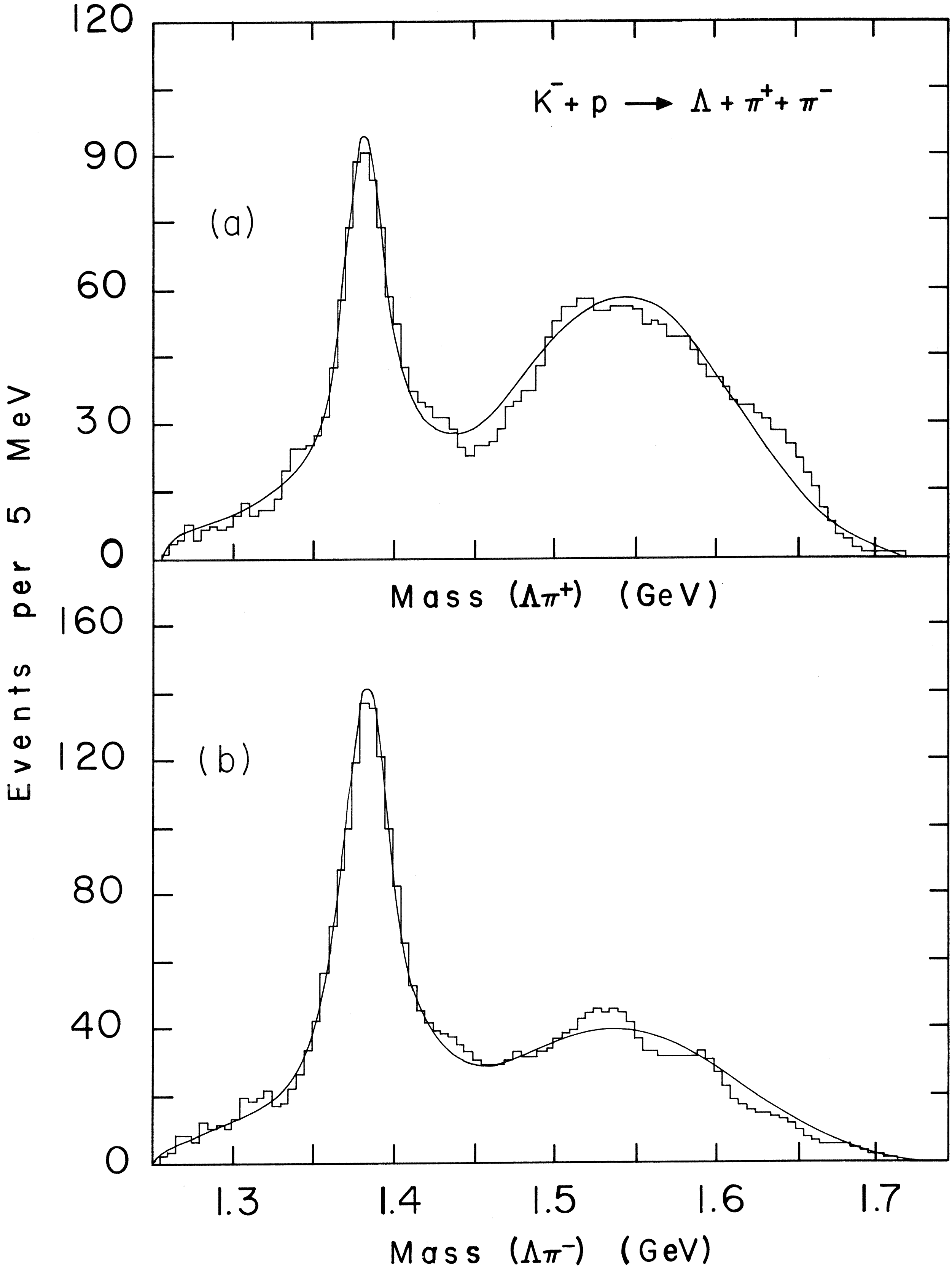
K⁻ + p → Λ + π⁺ + π⁻
(a)
(b)
Events per 5 MeV
Mass (Λπ⁺) (GeV)
Mass (Λπ⁻) (GeV)
120
90
60
30
0
160
120
80
40
0
1.3
1.4
1.5
1.6
1.7

Fig. 2

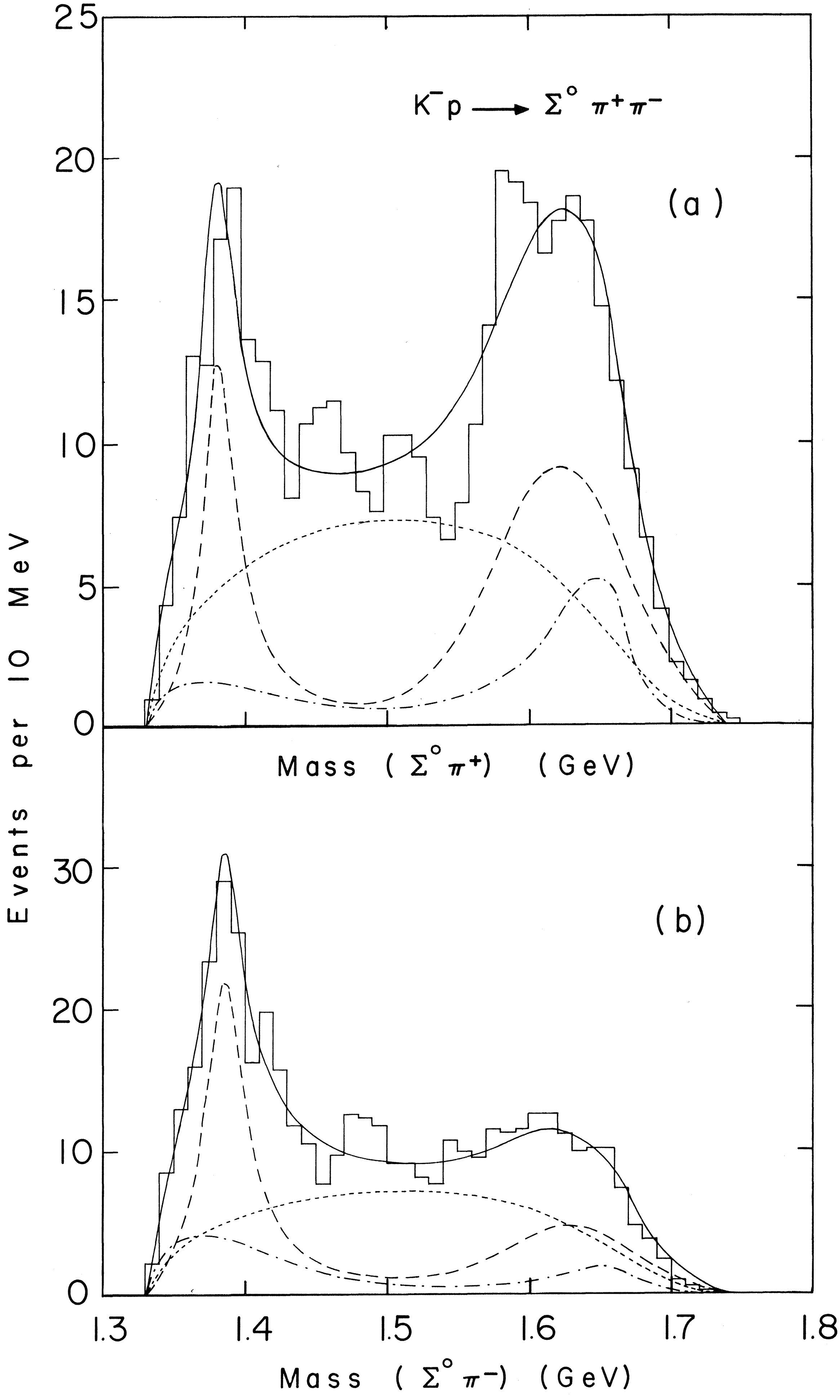

Fig. 3

SIS/R/11276