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 $K^-p \rightarrow \Lambda^0 \pi^0 \pi^0$ AND $K^-p \rightarrow \Sigma^0 \pi^0 \pi^0$ FORMATION

IN THE 1570-1750 MeV c.m. REGION *

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We report the results of an experiment designed to study the $K^-p \rightarrow \Lambda^0 \pi^0 \pi^0$ and $K^-p \rightarrow \Sigma^0 \pi^0 \pi^0$ formation channels in a heavy liquid bubble chamber. These channels are impossible to observe directly by the hydrogen bubble chamber technique. We present reaction cross sections for the two channels. A comparison is made with cross sections of other relevant experiments. We calculate the fraction $\gamma^*(1385)\pi^0$ and $\Lambda(1405)\pi^0$ on their respective Dalitz Plots.

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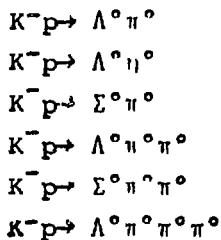
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I - INTRODUCTION

Although several experiments have given results for $\Lambda\pi\pi$ and $\Sigma\pi\pi$ final states, the pure isospin states $\Lambda^0\pi^0\pi^0$ ($I=0$) and $\Sigma^0\pi^0\pi^0$ ($I=1$) can only be observed directly using a heavy liquid bubble chamber, where all of the gammas can be detected.

In order to study the reactions of the form $K^-p \rightarrow \Lambda^0 +$ neutrals 600,000 photos were used of the exposure taken in the CERN heavy liquid 1.1 meter chamber filled with a freon-propane mixture having a density ~ 0.93 g/cm³ and a radiation length of about 22 cm. This mixture gives $\sim 10\%$ interactions on free protons and approximately 70% mean gamma detection efficiency. The three incident K^- beam momenta (780, 870, and 950 MeV/c) were chosen to cover the complete center of mass energy range between 1570 and 1750 MeV. The pictures were scanned for 0 prong $V^0n\gamma$ topologies ($2 \leq n \leq 7$). We have discussed the experimental procedures in a previous paper.⁽¹⁾ The following reactions were analyzed:



The results concerning the $\Lambda^0\pi^0$ and $\Sigma^0\pi^0$ reactions have been submitted to this conference in a separate paper.⁽²⁾ In this article we are primarily concerned with the analysis of the $\Lambda^0\pi^0\pi^0$ and $\Sigma^0\pi^0\pi^0$ channels.

II - CROSS SECTIONS

1.) WEIGHTS AND CUTS

In order to get a clean sample of events, some cuts have been made to eliminate regions of low detection efficiency and to reduce the fit ambiguities. The cuts were chosen to allow a direct calculation of the corresponding losses and are summarized in our previous paper.⁽¹⁾ Nevertheless, the lambdas with a very low momentum are almost undetectable (a cut of $P_{\Lambda^0} < 190$ MeV was made). The correction for this effect has been made by a Monte Carlo method, using an extrapolation of our experimental distributions.

2.) BACKGROUNDS AND LOSSES

There exist in our experiment three sorts of background: The background due to events on nuclei, the presence of spurious gammas and the choice of the wrong fit when there is an ambiguity. The measurement of the nuclear background ($8. \pm 3.8$) has been reported in reference 1.

To obtain all other backgrounds a Monte Carlo program was developed to simulate as closely as possible the experimental conditions. Kinematic errors in the Monte Carlo study were taken from real protons, pions, and electrons which have similar momenta. When necessary, spurious gammas were added. They were taken from extraneous gammas of real events which have an unambiguous fit with either maximum or maximum-minus-one number of constraints. These Monte Carlo events were passed through our kinematics program to give a D.S.T. similar to the real D.S.T. From these events we determined the fitting efficiency for the correctly chosen configuration and studied the following backgrounds:

- 1) Contamination from lower channel adding a spurious gamma. (e.g. $\Sigma^0\pi^0+\gamma_{sp}$ background in $\Lambda^0n^0\pi^0$)
- 2) Contribution from the wrong combination of correct gammas that give a distinct fit, i.e. the kinematic variables describing the event differ by more than a standard deviation in their mean errors from those of the correct fit.
- 3) Contribution from a combination of gammas using a spurious gamma giving a fit distinct from the correct fit.
- 4,5) Contamination from upper channel with or without spurious gamma.

Should an ambiguity of fit choice exist (more than one fit having a probability greater than 20% of the highest) the fit using the fewest number of gammas was taken. If both fits have the same number of gammas, that with the maximum probability was used. We found that this procedure minimized the sum of backgrounds present without creating evident biases. These backgrounds are given in table 1:

TABLE I

<u>$\Lambda^0 \pi^0 \pi^0$ Background</u>			<u>$\Sigma^0 \pi^0 \pi^0$ Background</u>		
1	$\Lambda^0 \pi^0 \pi^0 + \gamma_{sp}$	$0.0 \pm 1.0\%$	$\Sigma^0 \pi^0 \pi^0 + \gamma_{sp}$	$3.3 \pm 3.3\%$	
2	$\Lambda \pi \pi$ wrong combination of correct gammas	$2.3 \pm 0.9\%$	$\Sigma \pi \pi$ wrong combination of correct gammas	$11.7 \pm 4.4\%$	
3	$\Lambda \pi \pi$ wrong combination with γ_{sp}	$4.7 \pm 1.7\%$	$\Sigma \pi \pi$ wrong combination with γ_{sp}	$10.6 \pm 6.8\%$	
4	Feed down from $\Sigma \pi \pi$	$6.9 \pm 1.5\%$	Feed down from $\Lambda \pi \pi \pi$	$1.1 \pm 1.7\%$	
5	Feed down from $\Sigma \pi \pi + \gamma_{sp}$	$2.4 \pm 1.1\%$	Feed down from $\Lambda \pi \pi \pi + \gamma_{sp}$	~ 0	
6	Nuclear background	$5.0 \pm 3.0\%$	Nuclear Background	$8.0 \pm 3.0\%$	
	Total	$24.3 \pm 3.3\%$	Total	$33.6 \pm 10.1\%$	
	Fitting efficiency	$84.0 \pm 3.0\%$	Fitting efficiency	$58.0 \pm 8.0\%$	

3) NORMALIZATION

The normalization of the data was made in a direct way with a special scan for obtaining the π^- and μ^- contaminations by counting the δ -rays, the K^- beam attenuation length for each energy region and the average number number of beam tracks per picture.

The flux function (fig. 1) was computed by convoluting the beam momentum spread and the exponential attenuation of the beam.

4) RESULTS

The results are given in table II dividing the energy region into five bins of about equal statistics.

TABLE II
CROSS SECTIONS IN mb FOR THE REACTIONS
 $K^-p \rightarrow \Lambda^0 \pi^0 \pi^0$ AND $K^-p \rightarrow \Sigma^0 \pi^0 \pi^0$

c.m. Energy in MeV	1570-1630	1630-1660	1660-1690	1690-1720	1720-1750
$K^-p \rightarrow \Lambda^0 \pi^0 \pi^0$	0.48 ± 0.13	0.78 ± 0.13	0.78 ± 0.11	1.01 ± 0.14	1.00 ± 0.20
$K^-p \rightarrow \Sigma^0 \pi^0 \pi^0$	0.21 ± 0.13	0.15 ± 0.09	0.40 ± 0.16	0.44 ± 0.16	0.70 ± 0.34

The $K^-N \rightarrow \Lambda^0 \pi^0 \pi^0$ $I=0$ total cross section has been computed from the world data for the reactions $K^-p \rightarrow \Lambda^0 \pi^- \pi^0$ (3,4,5). Using the Clebsh-Gordan relation $\sigma(K^-p \rightarrow \Lambda^0 \pi^0 \pi^0) = \frac{1}{6} \sigma(K^-N \rightarrow \Lambda \pi \pi, I=0)$ we have made a comparison with this data. Figure 2 shows that the agreement is fairly good.

In addition the C.H.S collaboration gives a result in hydrogen for $K^-p \rightarrow \Lambda^0 + \text{neutrals}$, the neutrals having two or more neutral pions. We have compared this result with the sum of cross sections in the $\Lambda^0 \pi^0 \pi^0$ and $\Sigma^0 \pi^0 \pi^0$ channels. We give the results in Fig 3.

III - DALITZ PLOT ANALYSIS

The $\Lambda^0 \pi^0 \pi^0$ data give a strong indication of the presence of $Y^*(1385) \pi^0$. To determine the fraction of $\Lambda^0 \pi^0 \pi^0$ events which are $Y^* \pi^0$ we have fitted the following function on the Dalitz Plot:

$$F = a(|f_1|^2 + |f_2|^2) + b \operatorname{Re} f_1^* f_2 + c$$

$$f_1 = \frac{\sqrt{\Gamma/2}}{(m_1 - m_{Y^*}) + i\Gamma/2}$$

where we have used $m_{Y^*} = 1385$ MeV and $\Gamma = 36$ MeV

f_i is the Breit-Wigner amplitude for the $Y^*(1385)^+$ and a, b, c are the parameters to be fitted. We performed a maximum likelihood fit using Monte-Carlo methods to take into account our detection efficiency. In table II we give the $Y^* \pi^0$ fraction including both the events in the Y^* bands and in the Y^* interference region. Figure 4 gives our experimental $\Lambda^0 \pi^0$ mass distribution. The super-imposed curve corresponds to the fitted function F times the detection efficiency function. Also we indicate the three - body phase space found. Using our previous calculation of background we find $59.7 \pm 10.8\%$ $Y^*(1385)\pi^0$, $16.0 \pm 10.8\%$ non-resonant $\Lambda^0 \pi^0 \pi^0$ and $24.3 \pm 3.3\%$ background.

TABLE III
FRACTION $Y^* \pi^0$ IN THE $\Lambda^0 \pi^0 \pi^0$ EVENTS BEFORE
SUBTRACTION OF BACKGROUND

Energy Region (MeV)	Fraction	Number of Events
1570 - 1630	$5.6 \pm 39.0\%$	15
1630 - 1660	$94.5 \pm 25.2\%$	46
1660 - 1690	$81.1 \pm 17.4\%$	61
1690 - 1720	$40.0 \pm 18.4\%$	72
1720 - 1750	$59.8 \pm 22.4\%$	34
1570 - 1750	$59.7 \pm 10.0\%$	228

A similar analysis was performed on the $\Sigma^0 \pi^0 \pi^0$ data looking for the presence of $\Lambda^0(1405) \pi^0$; we found $66 \pm 19\%$ $\Lambda^0(1405)\pi^0$ and $34 \pm 17\%$ non resonant $\Sigma^0 \pi^0 \pi^0$, which is the size of the background present (fig.5). So we can conclude that the process $K^- p \rightarrow \Sigma^0 \pi^0 \pi^0$ is compatible with a pure $\Lambda(1405)$ production.

IV - CONCLUSION

From a heavy liquid bubble chamber we were able to give a direct measurement of the $K^- p \rightarrow \Lambda^0 \pi^0 \pi^0$ and $\Sigma^0 \pi^0 \pi^0$ cross sections, which are in reasonable agreement with previous experiments. However using our cross sections alone we do not see evidence of the $\Lambda(1690)$. The Dalitz plot study indicates the presence of $80. \pm 14.8\%$ $Y^*(1385)$ production in the $K^- p \rightarrow \Lambda^0 \pi^0 \pi^0$ reaction and is compatible with pure $\Lambda(1405)$ production in the $\Sigma^0 \pi^0 \pi^0$ channel.

REFERENCES

- 1 - Channel Cross Sections for $K^-p \rightarrow \Lambda^0 + \text{Neutrals}$ between
0.525 and 0.820 Gcv/c
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- 2 - Analysis of the Interaction $K^-p \rightarrow \Sigma^0\pi^0$ in the 1575 - 1750
Mev/c Region
Submitted to the Conference at Aix-en-Provence
- 3 - R. Armenteros et al, Nuclear Physics B8 223 (1968)
- 4 - R. Armenteros et al, Nuclear Physics B21 15 (1970)
- 5 - J. H. Bartley et al, Physical Review Letters 21 1111 (1968)

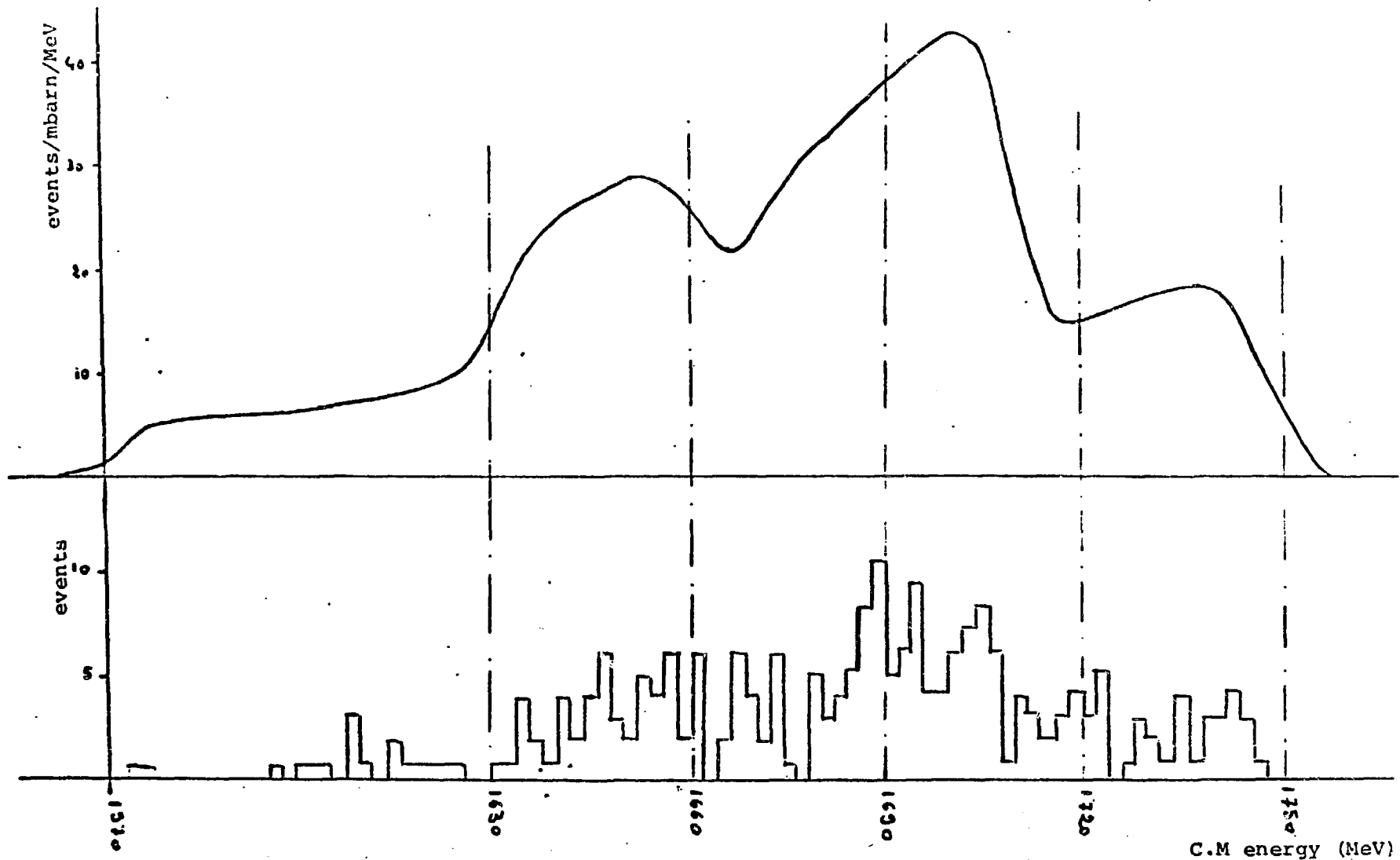


FIG 1 : a) Flux function for the normalization of cross-sections
b) Distribution of the real events (before any weighting)

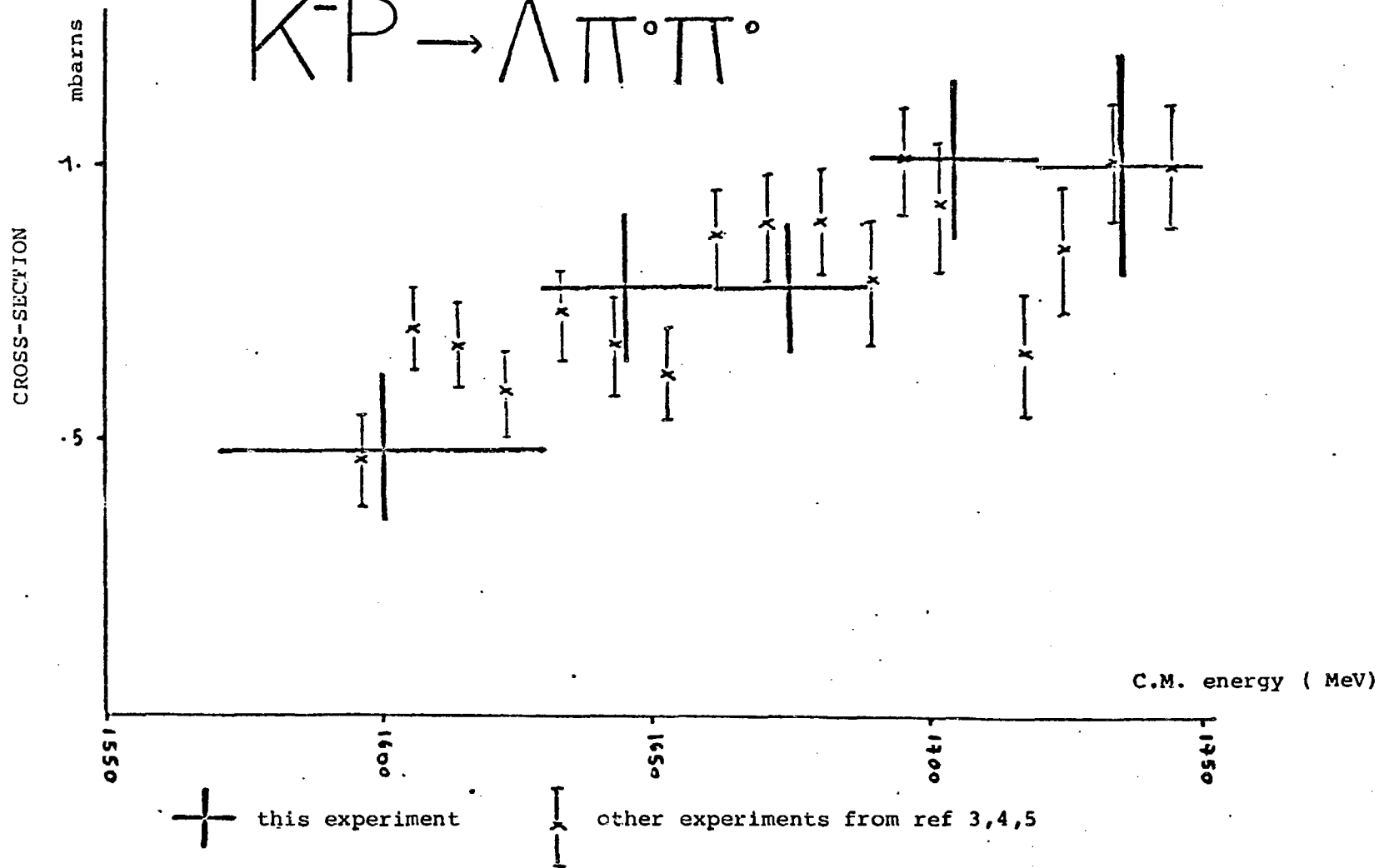
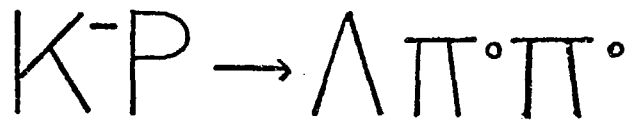


FIG 2 : $K^- p \rightarrow \Lambda^0 \pi^0 \pi^0$ total cross section

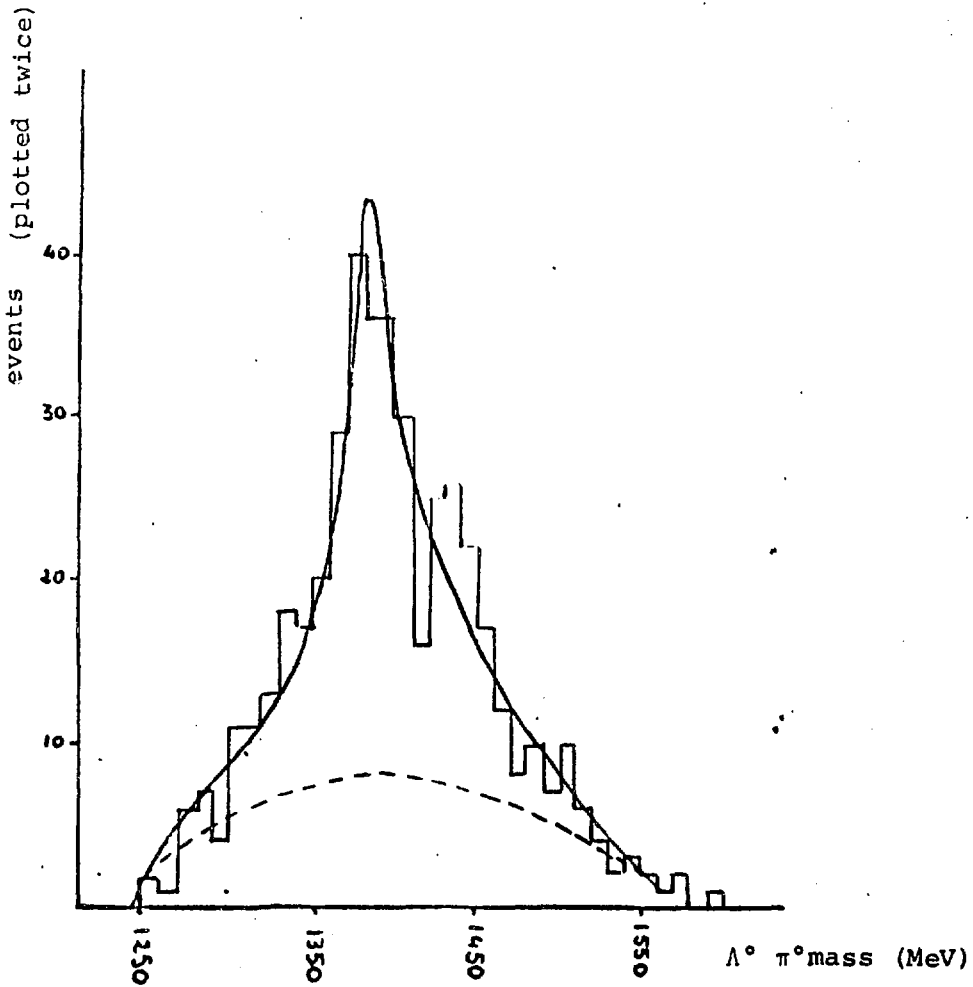
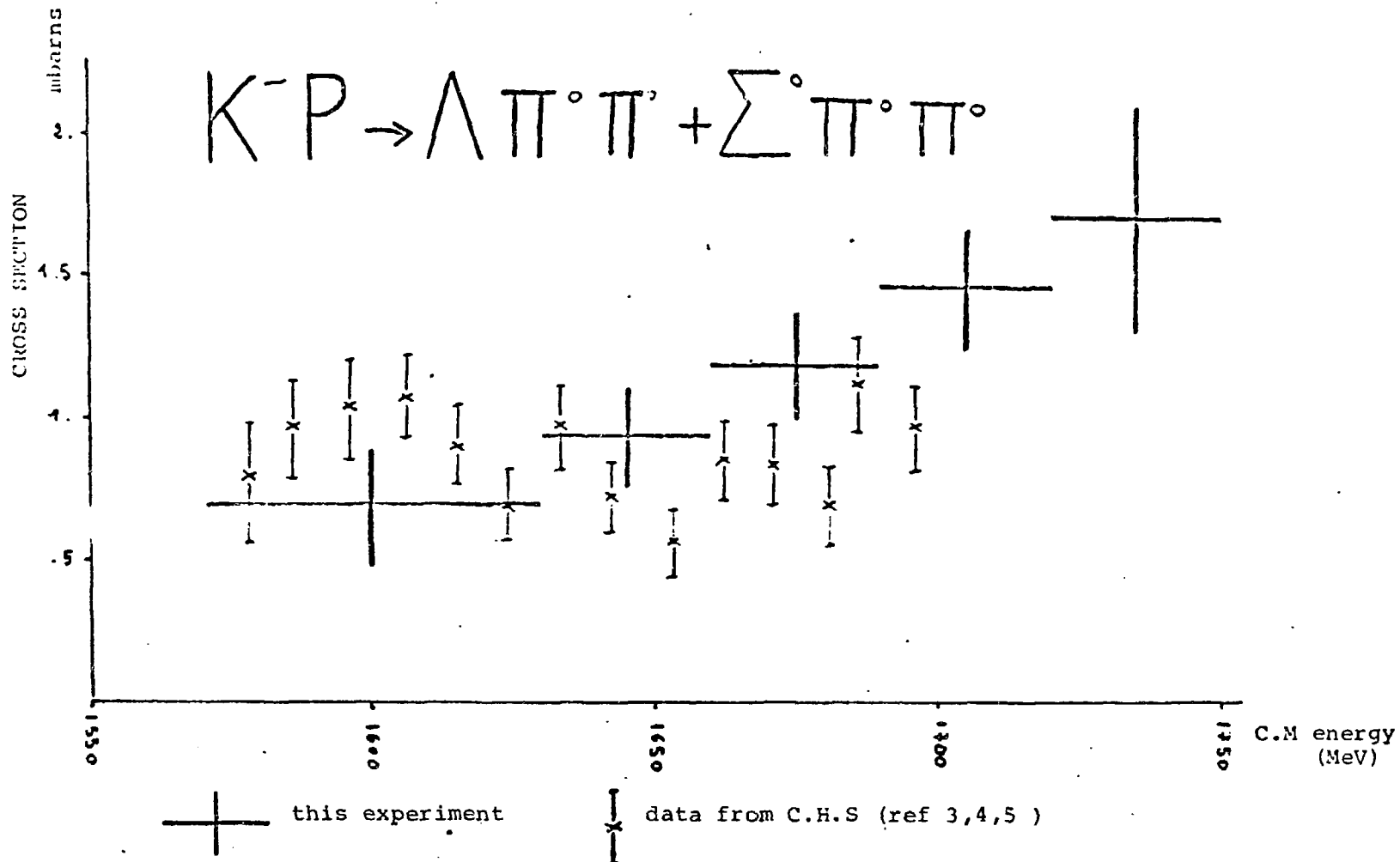
$M_{\Lambda\pi}$ $1570 < W_{cm} < 1750$ 

FIG 4 : Fit of the $\Sigma(1385)$ for the $\Lambda^0 \pi^0 \pi^0$ events

the solid curve represents the overall fit
the dotted curve is the contribution of phase space
and background present



$1570 < W^* < 1750 \text{ MeV}$

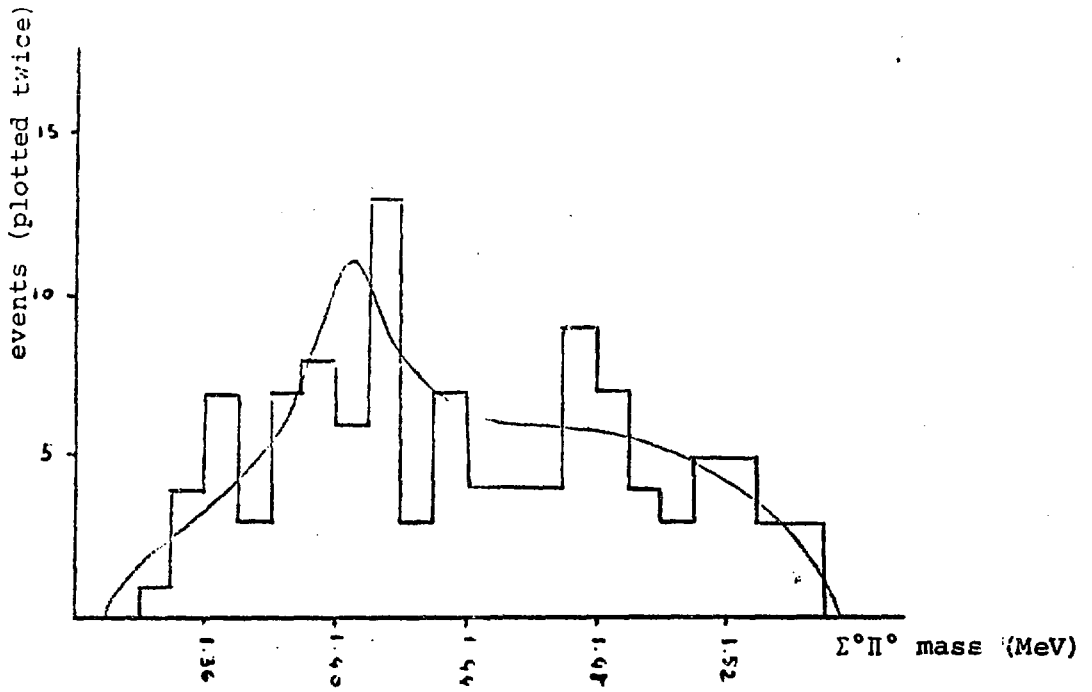


FIG 5 : Fit of the $\Lambda(1405)$ for the $\Sigma^0 \Pi^0 \Pi^0$ events