N^{*++}_{33} ISOBAR PRODUCTION IN $\pi^{\pm}$ p-REACTIONS

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(Presented by M. NEVEU)

In this paper we report two results obtained in an extensive study of two and four prong events produced by incident π^+ and π^- of 1.6 and 2.75 GeV/c in the Saclay 80 cm H_2 bubble chambers exposed at Saclay and at CERN PS.

Attention has been focused on N^{*++}_{33} isobar production in two different reactions.

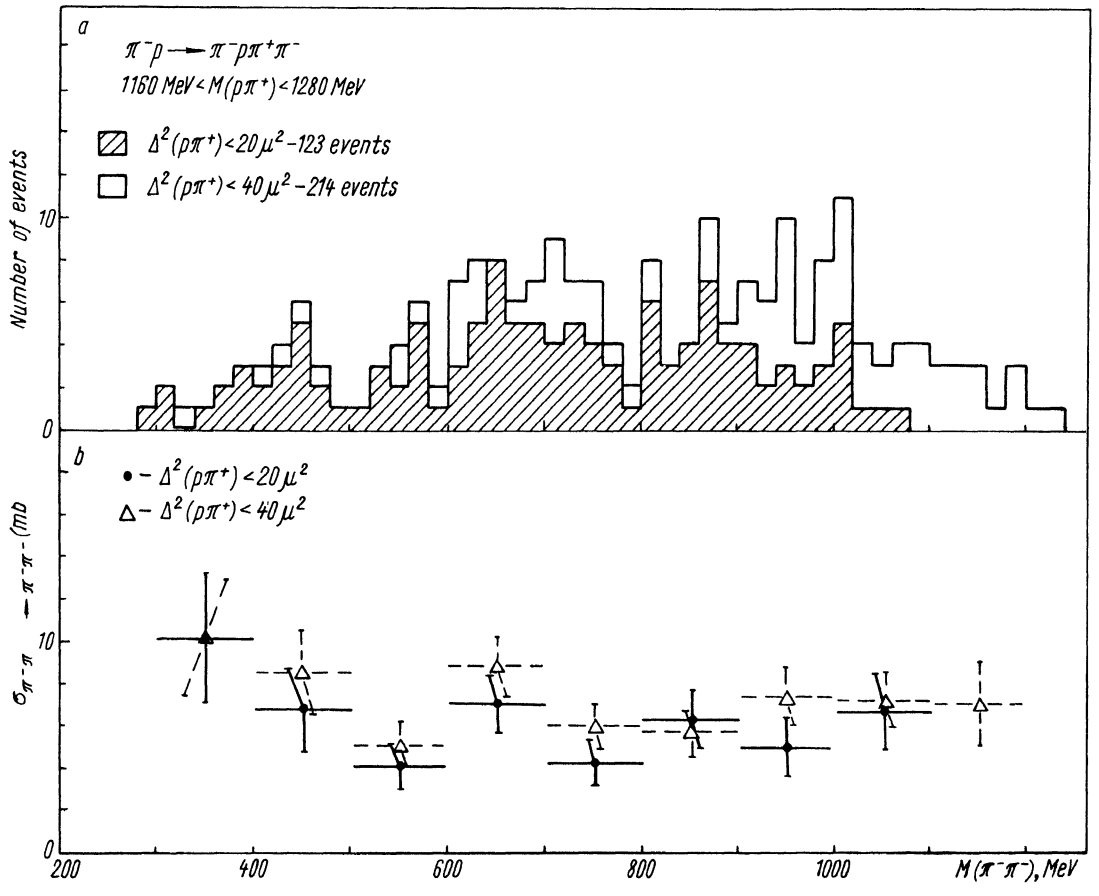

Fig. 1.

FOUR BODY REACTION $\pi^- p \to p\pi^+\pi^-\pi^-$

3.500 four prong events have been measured in the 2.75 GeV/c experiment. 1324 events correspond to the four body reaction mentioned above leading to a cross section of (1.81 ± ± 0.05) mb.

Two channels appear to be important

1) $\pi^- p \to N_{33}^{*++}\pi^-\pi^-$, $\sigma = 0{,}61 mb$;

2) $\pi^- p \to p\pi^-\varrho^0$, $\sigma = 0.36 mb$.

As far as the first channel is concerned, a one pion exchange mehanism seems to be responsible for isobar production.

The arguments for this are:

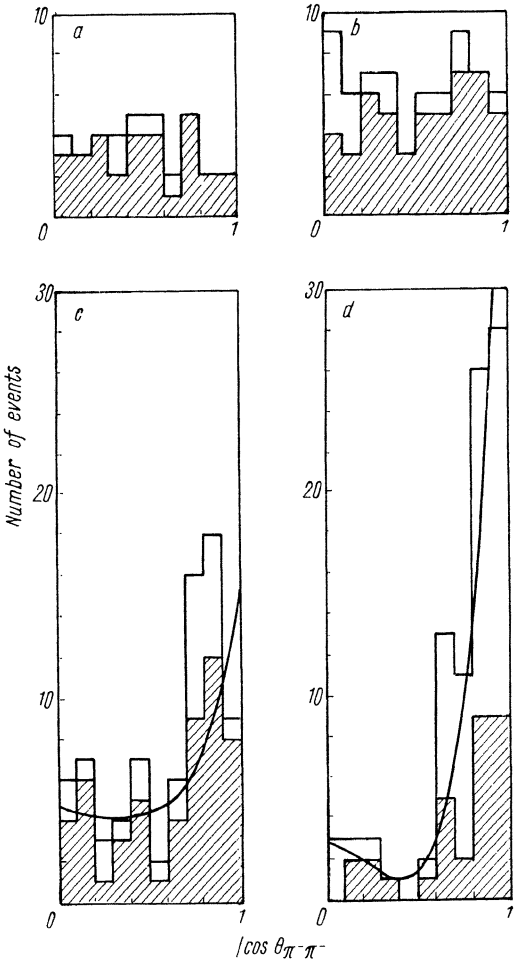

Fig. 2.

1. The Δ^2 distribution to isobar events is concentrated at low Δ^2.

2. The Treiman Yang angle distribution is isotropic.

3. The isobar decay angular distribution is compatible with $1 + 3\cos^2\theta$. Such a peripheral graph allows us to study the $\pi^-\pi^-$ elastic scattering at the pionic vertex in a pure $T = 2$ state.

Two informations have been derived:

1. The $\pi^-\pi^-$ elastic cross section has been calculated without any form factor, but with an off shell correction at the isobar vertex, it is shown on Fig. 1 as a function of the dipion energy together with the $\pi^-\pi^-$ mass spectrum for low Δ^2 isobar events.

2. The $\pi^-\pi^-$ scattering angular distributions in the dipion rest system are given in Fig. 2 for four $\pi^-\pi^-$ mass regions.

a) 280—500 MeV, b) 500—700 MeV, c) 700—900 MeV, d) 900—1200 MeV.

In the first two mass regions, the differential cross sections are consistent with a pure S-wave pion pion scattering.

For the 700—900 and 900—1200 MeV mass regions the shape of the distributions suggests an increasing contribution of a D-wave with increasing energy. The data have been fitted by a second order polynomialin $\cos^2\theta$: $A + B\cos^2\theta + C\cos^4\theta$ (only S and D-waves are considered). The corresponding phase shifts (δ_{20} and δ_{22} giving compatibility for the value of the coefficients within them have been obtained. Above 700 MeV the anlysis shows that δ_{20} and δ_{22} have same sign.

The results are summarized below (table 1).

Table 1

Mass, MeV	$\sigma_{\pi^-\pi^-}$, mb	$\lvert\sigma_{20}\rvert$	$\lvert\sigma_{22}\rvert$	Remark
280—500	9	10°	—	—
500—700	6	12°	—	—
700—900	6	5°	0°—1.5°	$\delta_{20}\times\delta_{22}>0$
800—1200	6	—	2°—3°	$\delta_{20}\times\delta_{22}>0$

The scattering length a_0 is between 0.17 and $0.25.10^{-13}$ cm. Similar results have been obtained by the European collaboration with the same reaction at 4 GeV/c and by our group with the reaction $\pi^+ p \to n\pi^+\pi^+$ at 2.75 GeV/c.

b) Three body reaction $\pi^+ p \to \pi^+ p\pi^0$.

About 13.000 two prong events have been measured at 1,6 GeV/c and 16,000 at 2.75 GeV/c.

The cross sections for the above reaction are in table 2.

The four momentum transfer distribution to the isobar (Fig. 3a) suggests a peripheral process for isobar production.

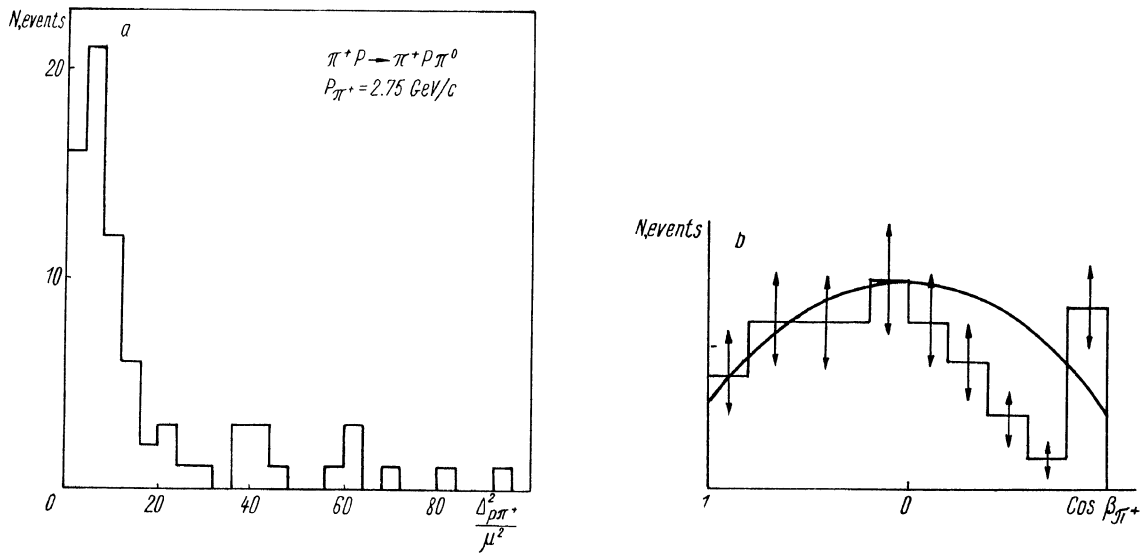
N,events
a
$\pi^+ p \to \pi^+ p \pi^0$
$P_{\pi^+} = 2.75$ GeV/c
20
10
0
20
40
60
80
$\frac{\Delta^2_{p\pi^+}}{\mu^2}$
N,events
b
1
0
Cos β_{π^+}

Fig. 3.

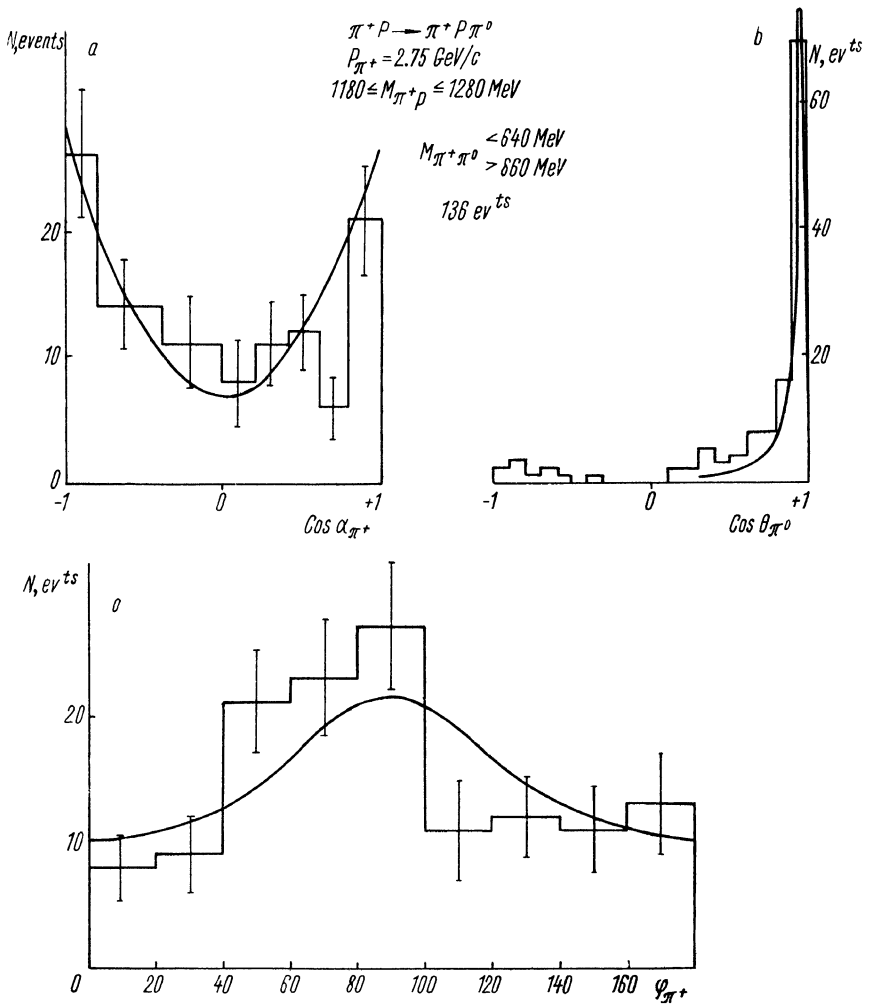
N,events
a
$\pi^+ p \to \pi^+ p \pi^0$
$P_{\pi^+} = 2.75$ GeV/c
$1180 \leq M_{\pi^+ p} \leq 1280$ MeV
$M_{\pi^+\pi^0}$ < 640 MeV
> 860 MeV
136 ev ts
20
10
0
-1
0
+1
Cos α_{π^+}
b
N, ev ts
60
40
20
-1
0
+1
Cos θ_{π^0}
N, ev ts
a
20
10
0
20
40
60
80
100
120
140
160
φ_{π^+}

Fig. 4.

Table 2

	1.6 GeV/c	2.75 GeV/c
$\pi^+p \longrightarrow p\pi^+\pi^0$	7.4 mb	2.8 mb
$\pi^+p \longrightarrow N^{*++}\pi^0$	1.2 mb	0.30 mb
$\pi^+p \longrightarrow p\varrho_+$	3.0 mb	0.89 mb

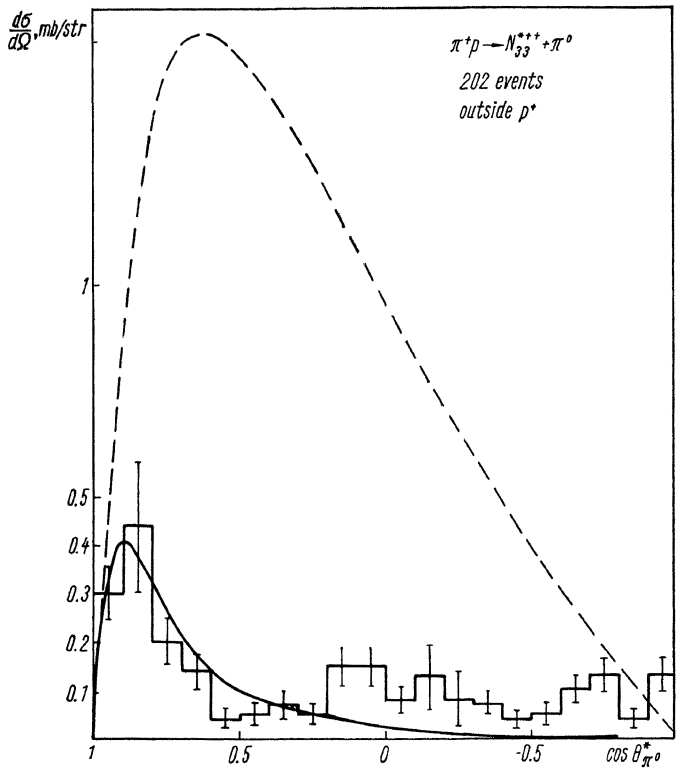

Fig. 5.

Stodolsky and Sakurai have proposed a vector meson exchange model for N^{*++} production and have predicted the form of several angular distributions which can be investigated in our sample of events. If $\mathbf{p}$, $\mathbf{p}'$, $\mathbf{k}$, $\mathbf{q}$ are the vector momenta of the incident π^+ the final π^0, the exchanged ϱ and the final π^+ in the isobar center of mass, and if $\mathbf{n} = (\mathbf{p} \times \mathbf{p}')/|\mathbf{p} \times \mathbf{p}'|$ represents the normal to the production plane, then:

1. the distribution of $\mathbf{q} \times \mathbf{n}$ should be $1 + 3\,(\mathbf{q}\cdot\mathbf{n})^2$;
2. the distribution of the angle φ analogous to that proposed by Yang = Treiman given by $\cos\varphi = \mathbf{n}\frac{(\mathbf{k}\times\mathbf{q})}{|\mathbf{k}\times\mathbf{q}|}$ should be $1 + 2\sin^2\varphi$.
3. the distribution of the Adair angle $\mathbf{q} \times \mathbf{p}$ should have the form $5 - 3\,(\mathbf{q} \times \mathbf{p})^2$.

In Figs. 3 and 4 the observed angular distributions are shown; they are in good agrument with the theoretical predictions.

Disagreements arise when the absolute and differential cross sections are compared with the initial theory (Fig. 5).

A form factor of the form $F(\Delta^2) = \frac{M^2}{M^2+\Delta^2}$ was proposed by Selleri to fit the data but, unfortunately it appears to be energy dependent at
1.6 GeV/c — $M^2 = 0.15$ GeV^2
2.75 GeV/c — $M^2 = 0.03$ GeV^2
The conclusion is that angula correlation support ϱ-exchange for isobar production but that a unique form factor cannot be found to fit the absolute and differential cross sections. Absorption of low partial waves in the initial and final states as proposed by Jackson and Qottfried would possibly reduce this disagreement.