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Strange Particle Production by 8 GeV/c Positive Pions on Hydrogen

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The exposure of the 81cm Saclay hydrogen bubble chamber to an 8 GeV/c positive pion beam from the CERN Proton Synchrotron early this year has yielded about 130,000 pictures, on which the production of strange particles is being studied by the CERN and Warsaw High Energy groups. So far, 60,000 photographs have been scanned for the interactions in which two strange particles are produced and observed to decay in the chamber. A total of 204 events have been measured and identified using ionization, the decay kinematics and the kinematics of the π^+-p collision. This is a progress report presenting the results on cross sections, the two-body invariant mass distributions and the c.m. angular and momentum distribution of the secondary particles.

The classification of the events and the cross sections are presented in Table I. The total π^+ p cross section at 8 GeV/c has been assumed to be 25.8 mb, as measured by von Dardel et al[1]. The partial cross sections for strange particle production obtained for π^--p interactions at 10 GeV/c^2 are included for comparison. In π^+-p collisions, the production rate of positively charged strange particles is higher than in π^--p collisions at similar energies. It may be noted that the cross section for Σ^- production is an order of magnitude lower than with negative pions, while the cross sections for Ξ^- production by positive and negative pions are roughly the same.

In the π^+-p interactions leading to the production of kaon-hyperon pairs, neutral kaons are very frequently produced in the K^*(890 MeV) resonant state, as indicated by the K_1^o π^+ effective mass distribution of Fig. 1. The results are consistent with the production of K^*_{890} occurring in almost every event giving a K_1^o Λ^o or a K_1^o Σ^+ pair.

The (Λ^o $\pi^{\pm}$) effective mass distribution presented in Fig. 2 shows that the Y^*_{1385} resonance is produced, but no evidence is found for the production of (Σ π) resonances (see Fig. 3).

For the π^+-p interactions leading to the production of two kaons (K_1^o K_1^o pairs), there is some indication that the (3/2, 3/2) N^* isobar is produced (Fig. 4). Neutral kaons are often produced in the K^*_{890} resonant state (Fig. 5), as in the kaon-hyperon channels. No evidence is obtained for the peaking around 1 GeV in the K_1^o K_1^o effective mass distribution (Fig. 6a), that was observed in the 10 GeV/c π^--p interactions (see Fig. 6b).

The general characteristics of the high energy interactions, namely the tendency for the baryons to keep their original line of flight, can be clearly seen in Fig. 7 for Λ^o and Σ^+ hyperons, as well as for the protons accompanying the K_1^o K_1^o production. While in the 10 GeV/c π^--p experiment it was found that the backward peaking of the sigmas was less pronounced than that of the lambdas, in the present experiment both hyperons exhibit similar behaviour. Kaons are emitted forward in the c.m. system, as shown in Fig. 8.

Table II presents the average values of the transverse momentum and the c.m. longitudinal and total momentum of the indicated secondary particles, for the three channels Σ^+ K_1^o, Λ^o K_1^o, and K_1^o K_1^o. The dependence of the average value of the total c.m. momentum on the particle mass reported in Ref. 2 is observed also in the present experiment.

REFERENCES

1. G. von Dardel, D. Dekkers, R. Mermod, M. Vivargent, G. Weber and K. Winter, Phys. Rev. Lett. 8, 173 (1963).

2. a) A. Bigi, S. Brandt, A. de Marco-Trabucco, Ch. Peyrou, R. Sosnowski and A. Wroblewski, Nuovo Cimento 33, 1249 and 1265 (1964).

b) S. Brandt, Ch. Peyrou, R. Sosnowski and A. Wroblewski, Proceedings of the Sienna Conference on Elementary Particles, p. 676 (1963).

CAPTIONS FOR TABLES

TABLE I. Cross sections for various channels of strange particle production by 8 GeV/c positive pions and 10 GeV/c negative pions on protons.

TABLE II. Transverse momentum, c.m. longitudinal and total momentum of the secondary particles of the 8 GeV/c π^+-p interactions in which two strange particles are produced.

FIGURE CAPTIONS

Fig. 1 Distribution of the $(K_1^o \pi^+)$ effective mass for the reactions leading to the production of a $\Sigma^+ K_1^o$ or a $\Lambda^o K_1^o$ pair. The area representing each combination is calculated from the event weight, based on its detection probability, divided by the number of possible combinations. This procedure is used to calculate the corrected number of events in all figures.

Fig. 2 Distribution of the $(\Lambda^o \pi^{\pm})$ effective mass for the reactions in which a $\Lambda^o K_1^o$ pair is produced.

Fig. 3 Distribution of the $(\Sigma^+ \pi^-)$ and $(\Sigma^+ \pi^+)$ effective mass for the events in which a $\Sigma^+ K_1^o$ pair is produced.

Fig. 4 Distribution of the $(p \pi^+)$ effective mass for the events in which a $K_1^o K_1^o$ pair is produced.

Fig. 5 Distribution of the $(K_1^o \pi^+)$ effective mass for the events in which a $K_1^o K_1^o$ pair is produced.

Fig. 6 Distribution of the $(K_1^o K_1^o)$ effective mass for double K^o-events produced by
a) 8 GeV/c positive pions
b) 10 GeV/c negative pions.

Fig. 7 C.m. angular distribution of the baryons (Σ^+, Λ^o and p) produced in π^+ p collisions at 8 GeV/c.

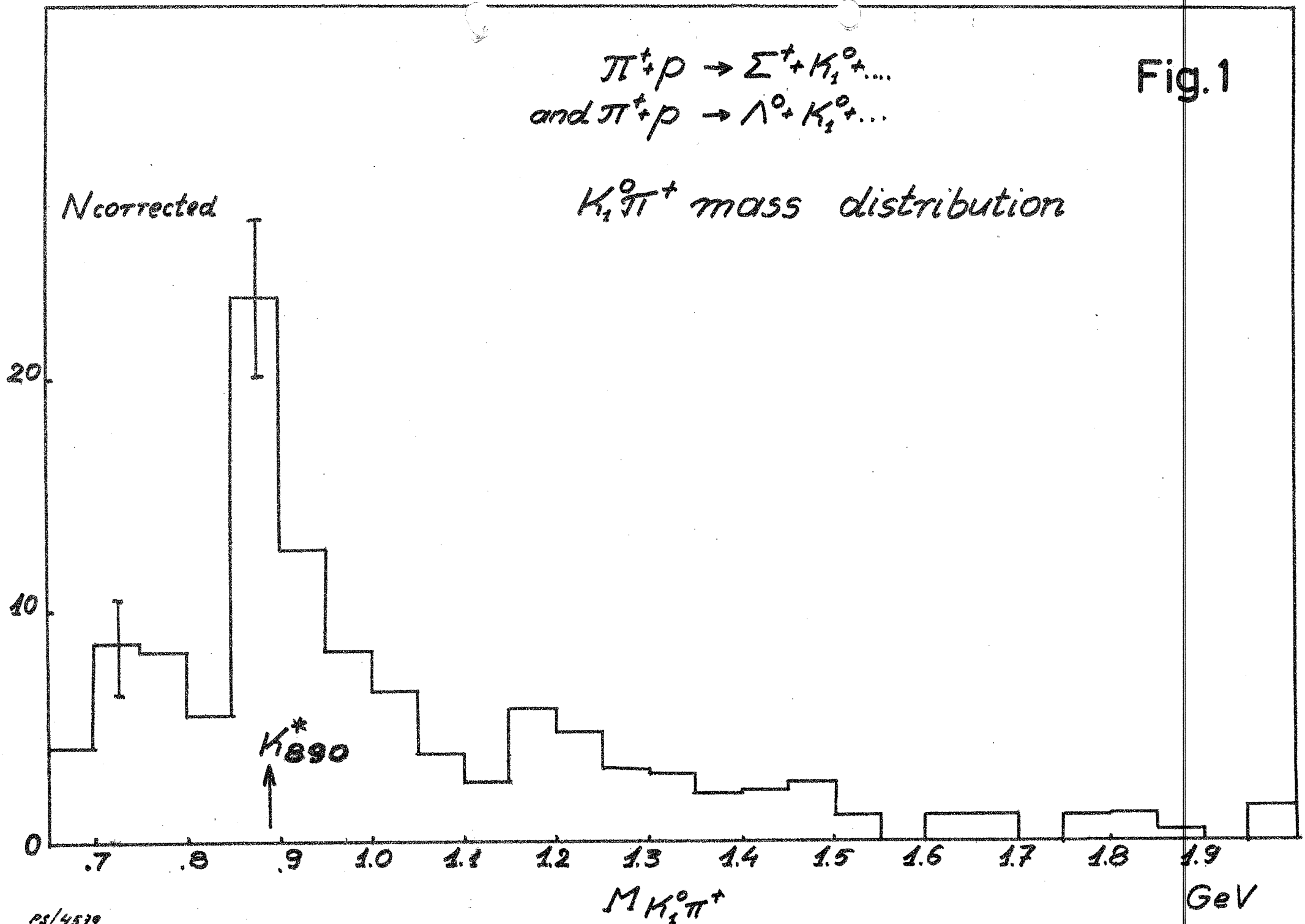
Fig. 8 C.m. angular distribution of K_1^o mesons produced in π^+ p collisions at 8 GeV/c, in which an hyperon, or another K_1^o, is also produced.

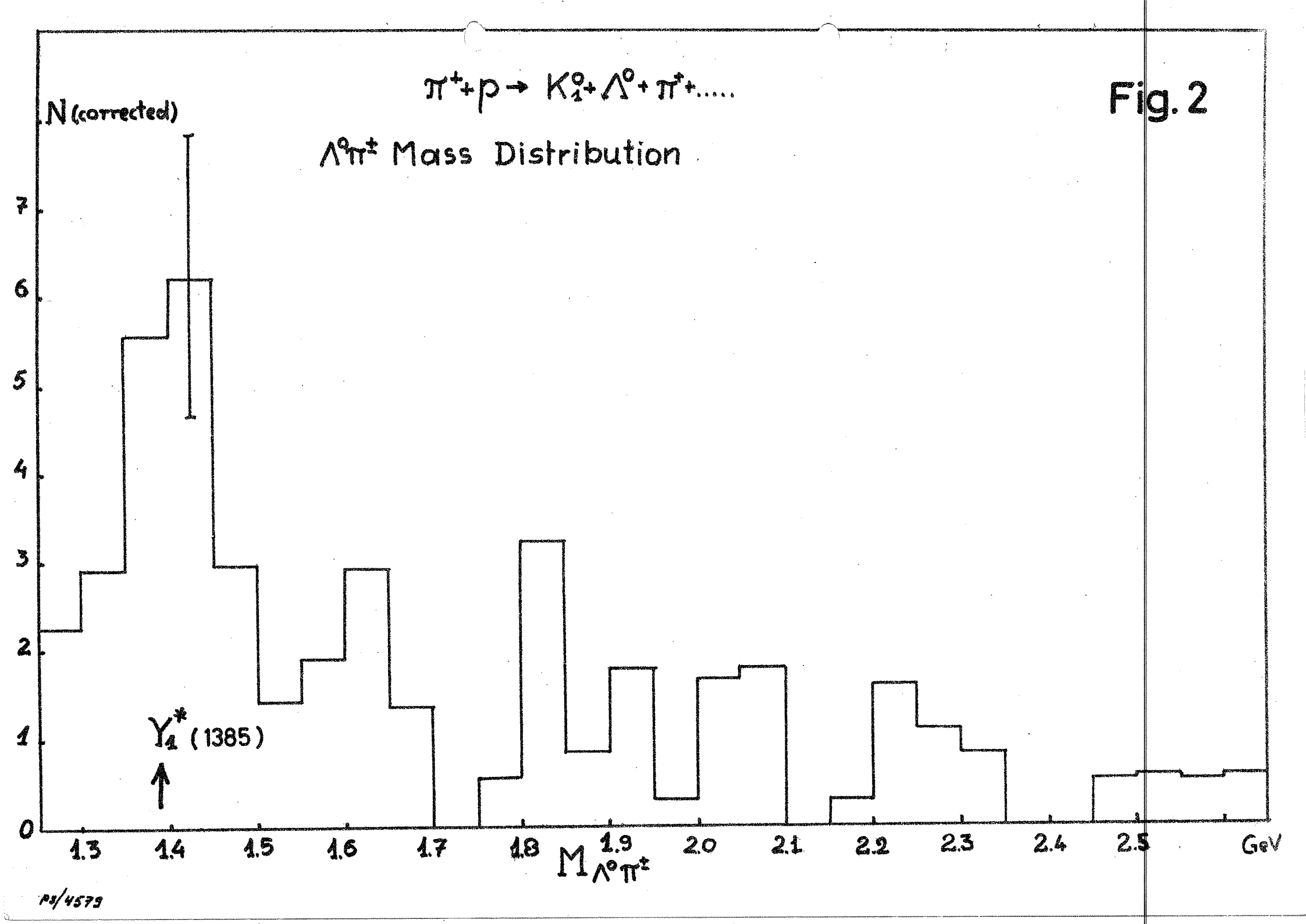
TABLE I

Type of events	Number of events observed	Cross sections (mb) 8 GeV/c π^+ (present work)	10 GeV/c π^- (ref 2)
$\Lambda^0 K^0$	44	0.33 ± 0.05	0.47 ± 0.05
$\Lambda^0 K^+$	13	0.76 ± 0.20	0.42 ± 0.13
$\Sigma^+ K^0$	45	0.26 ± 0.04	0.10 ± 0.02
$\Sigma^+ K^+$	16	0.60 ± 0.15	0.09 ± 0.04
$\Sigma^- K^0$	5	0.020 ± 0.008	0.16 ± 0.02
$\Sigma^- K^+$	—	—	0.16 ± 0.05
Ξ^-	4	0.010 ± 0.005	0.016 ± 0.005
$K^0 K^0$	49	0.74 ± 0.11	0.50 ± 0.06
$K^0 K^+$	16	$\geq$ 1.9 ± 0.5	0.7 ± 0.3
$K^0 K^-$	1	~ 0.3	0.7 ± 0.3
$K^+ K^-$	1	~ 0.1	~ 0.9
identification ambiguous	10	/	/

TABLE II

		$\bar{p}_L$ (MeV/c)	$\bar{p}_L^{cms}$ (MeV/c)	$\bar{p}^{cms}$ (MeV/c)
$K^\circ K^\circ$	π	292 ± 20	63 ± 30	444 ± 40
	K°	397 ± 30	168 ± 45	575 ± 45
	p	393 ± 40	-768 ± 50	911 ± 60
	$p\cdot\pi/p$	424 ± 30	-565 ± 45	825 ± 50
$\Lambda^\circ K^\circ$	π	320 ± 20	114 ± 35	495 ± 40
	K°	392 ± 30	188 ± 45	609 ± 45
	Λ°	311 ± 25	-578 ± 45	804 ± 50
$\Sigma^+ K^\circ$	π	289 ± 20	94 ± 30	442 ± 40
	K°	404 ± 30	329 ± 40	660 ± 45
	Σ^+	451 ± 35	-739 ± 45	1039 ± 50


$\pi^+ p \to \Sigma^+ + K_1^0 + \ldots$
and $\pi^+ p \to \Lambda^0 + K_1^0 + \ldots$
$K_1^0 \pi^+$ mass distribution
Fig. 1
N corrected
20
10
0
K^*_{890}
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
$M_{K_1^0 \pi^+}$
GeV
PS/4539

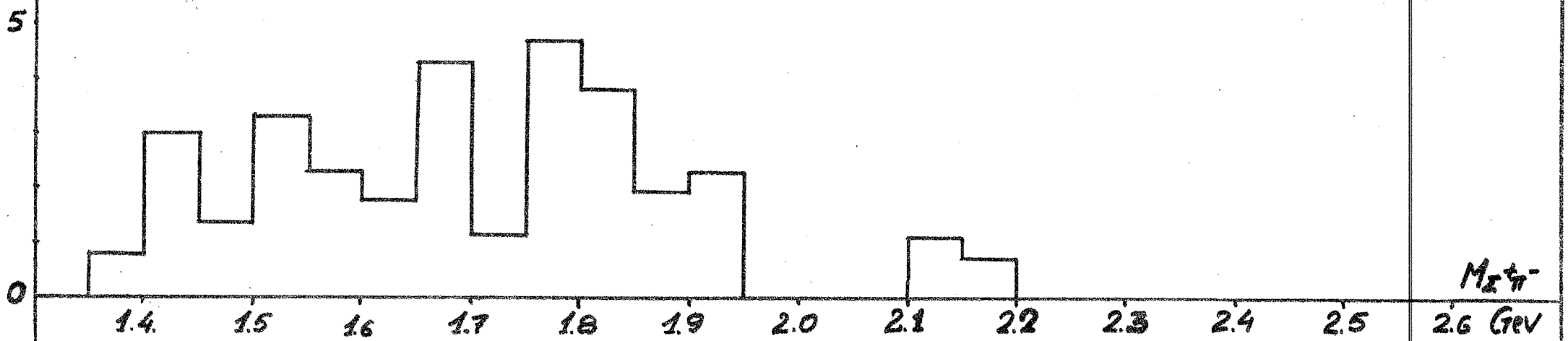

$\pi^+ + p \rightarrow K^0_1 + \Lambda^0 + \pi^+ + \ldots\ldots$
Fig. 2
N (corrected)
$\Lambda^0\pi^\pm$ Mass Distribution
7
6
5
4
3
2
1
0
Y^*_1 (1385)
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
GeV
$M_{\Lambda^0\pi^\pm}$
PS/4579

$\pi^- p \to \Sigma^+ K_1^0 \ldots\ldots$

Fig. 3

N (corrected)

$\Sigma^+\pi^-$ mass distribution



$\Sigma^+\pi^+$ mass distribution

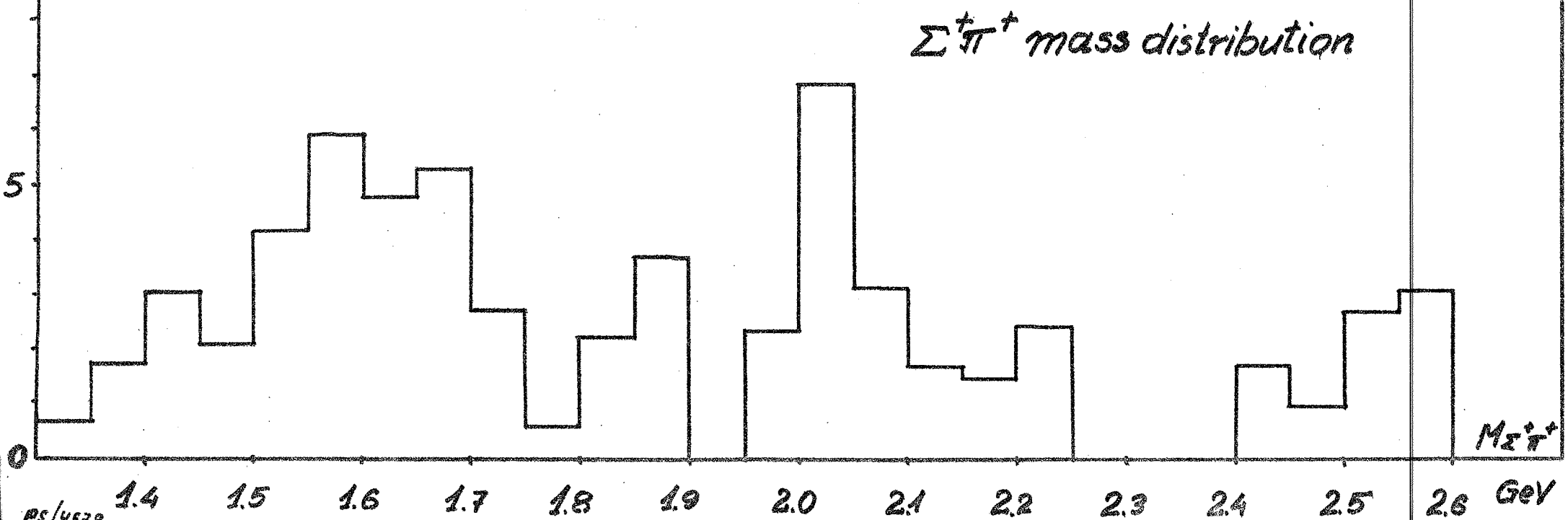


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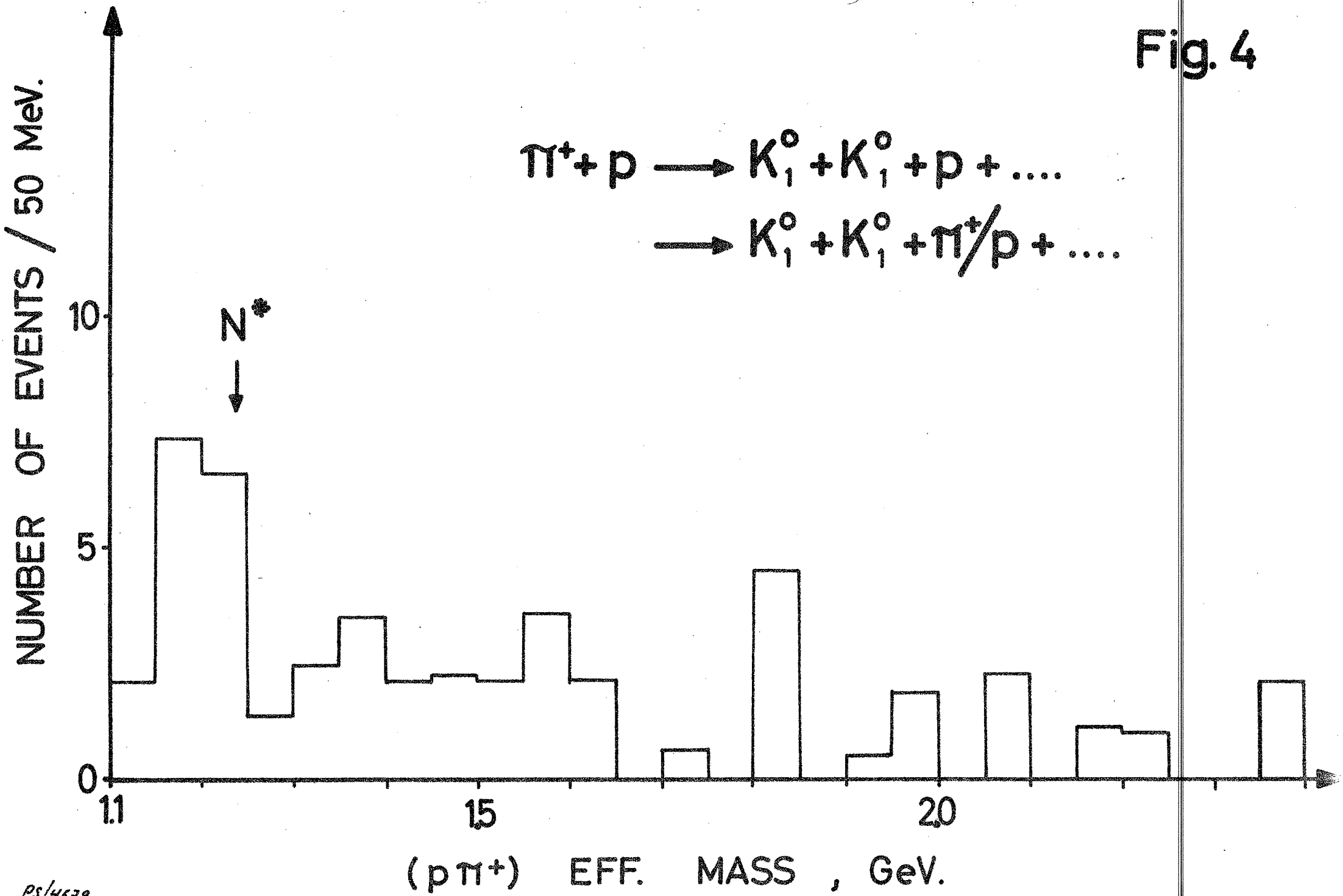
Fig. 4

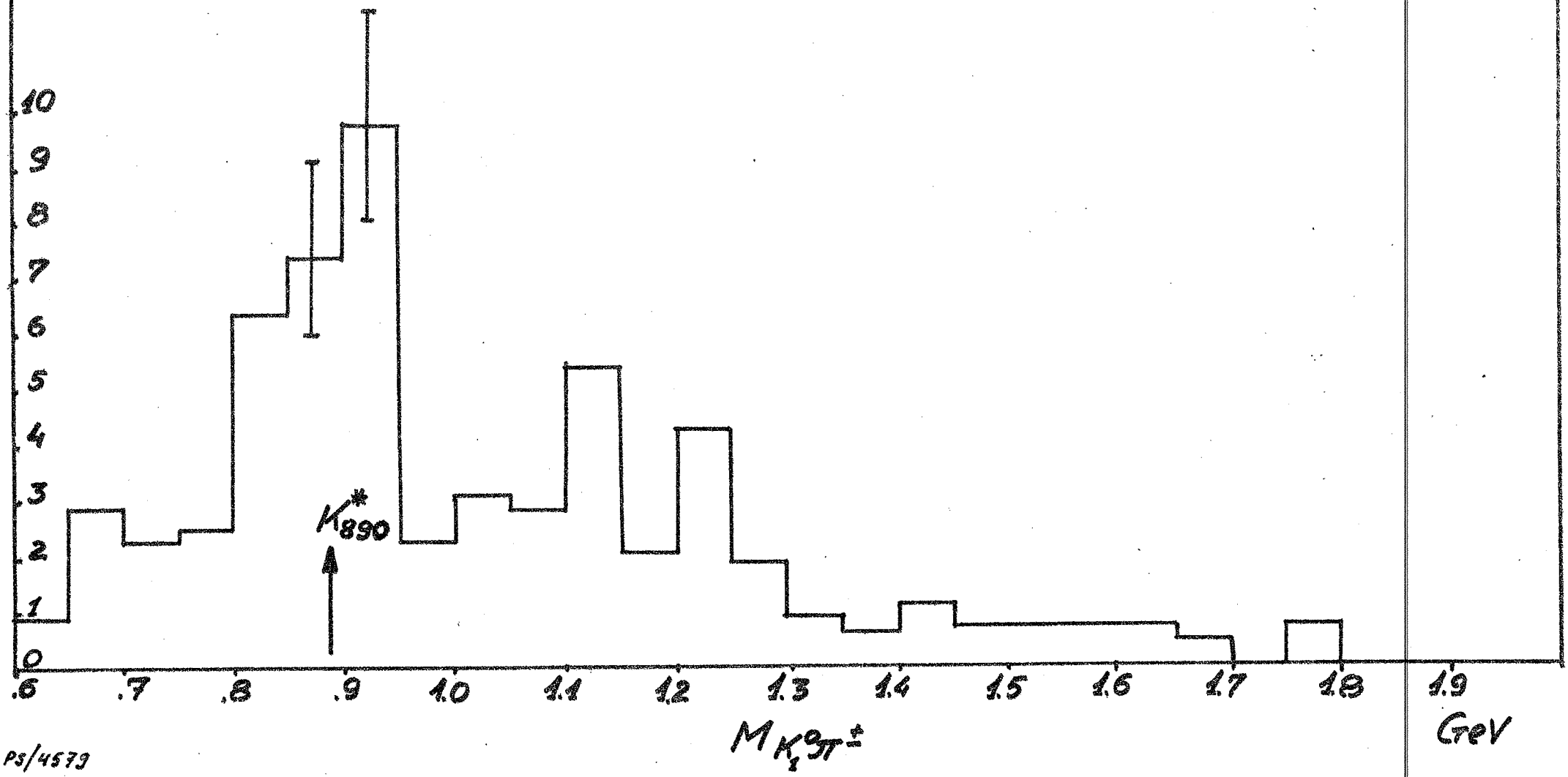

$\pi^+ + p \longrightarrow K_1^0 + K_1^0 + p + \ldots$
$\longrightarrow K_1^0 + K_1^0 + \pi^+/p + \ldots$
NUMBER OF EVENTS / 50 MeV.
10
5
0
N*
1.1
1.5
2.0
$(p\pi^+)$ EFF. MASS , GeV.

PS/4579

$\pi^+ p \rightarrow K_1^0 + K_1^0 + \ldots$

Fig. 5

$K_1^0 \pi^\pm$ mass distribution



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$\pi^+ + p \rightarrow K_1^0 + K_1^0 + \ldots$

Fig. 5

$K_1^0 \pi^\pm$ mass distribution

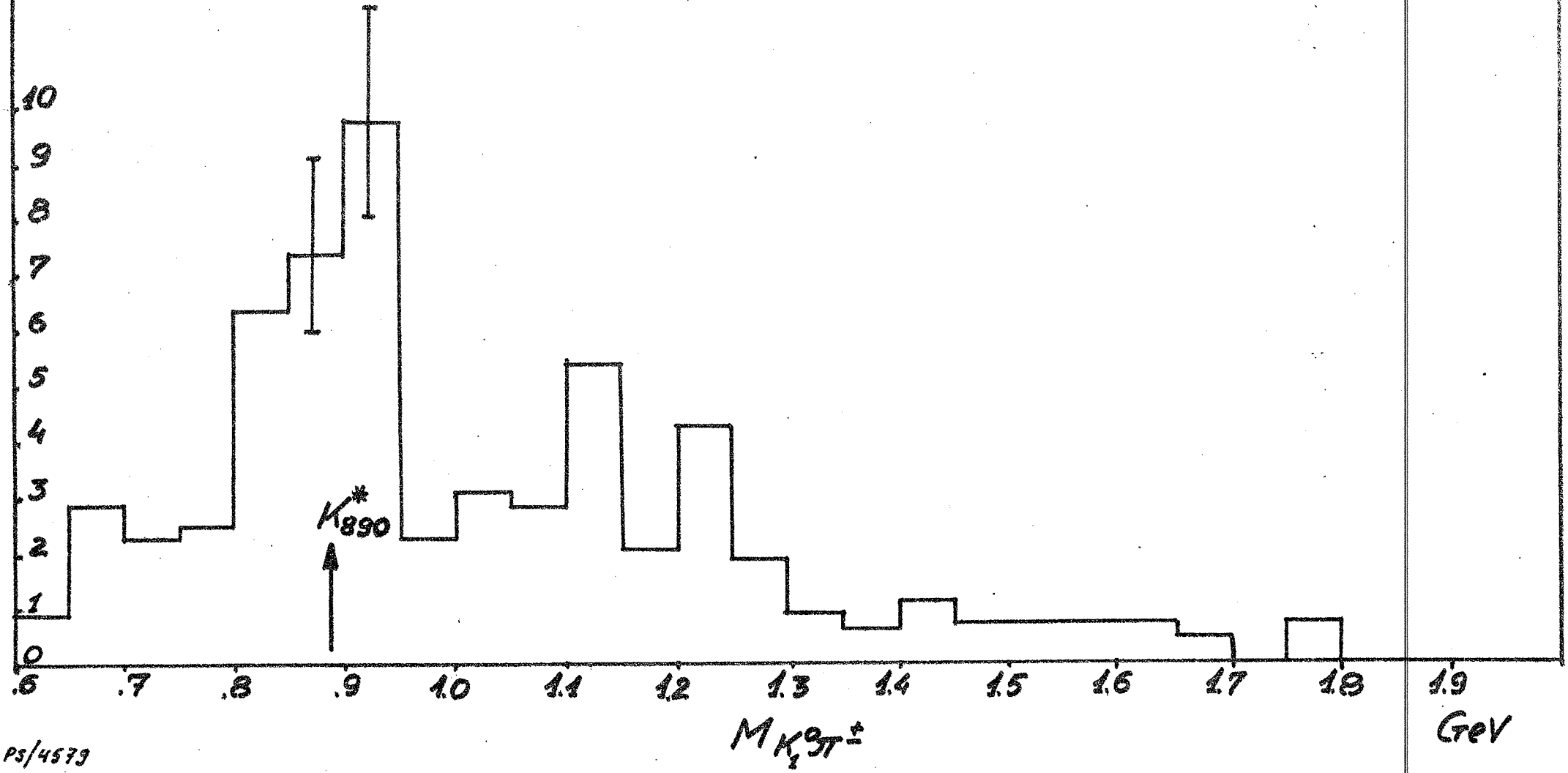

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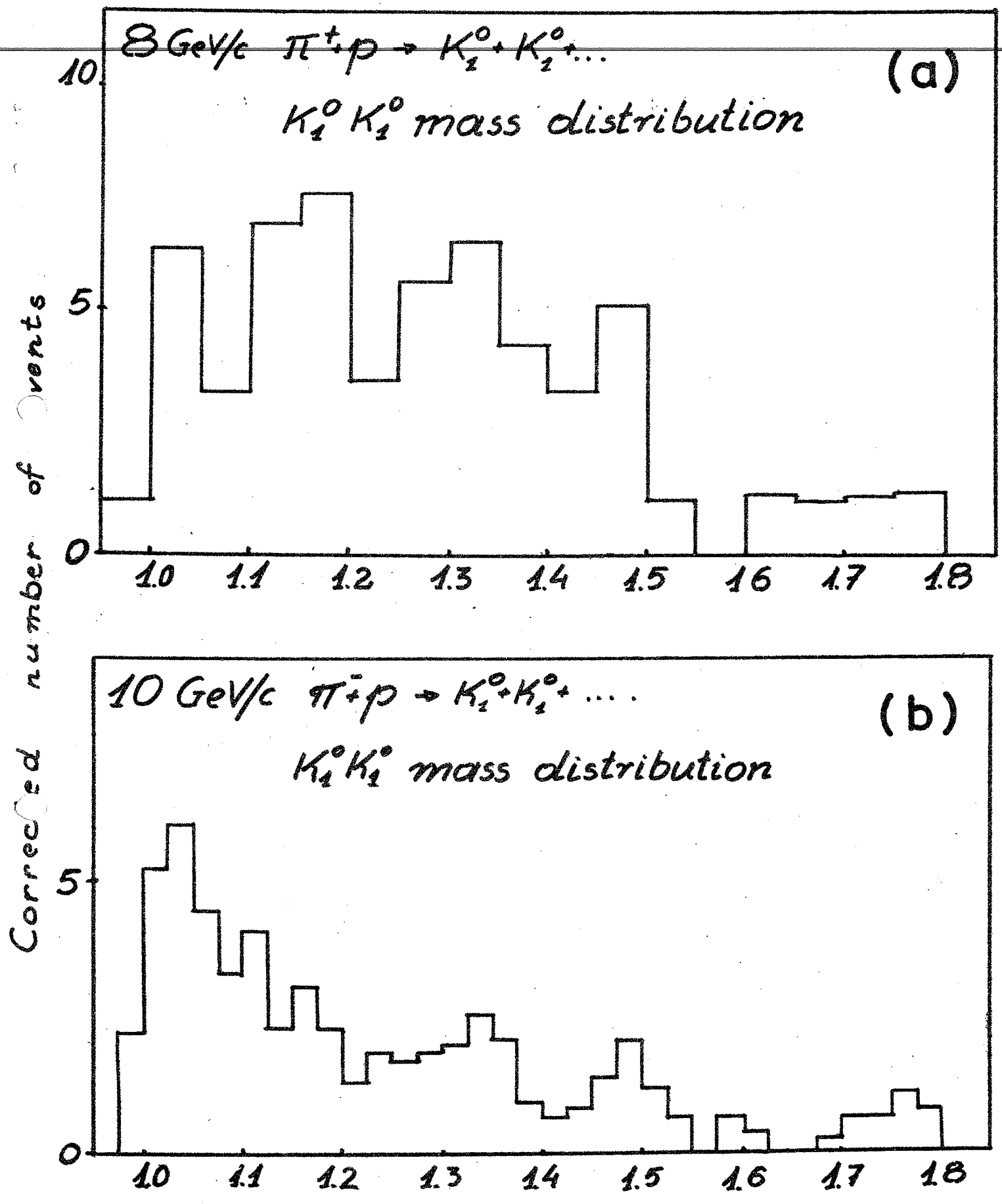
Fig.6


8 GeV/c $\pi^+ p \to K_1^0 + K_1^0 + \ldots$
(a)
$K_1^0 K_1^0$ mass distribution
10
5
0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
10 GeV/c $\pi^- p \to K_1^0 + K_1^0 + \ldots$
(b)
$K_1^0 K_1^0$ mass distribution
5
0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
Corrected number of events
$K_1^0 K_1^0$ effective mass, GeV

PS/4579

Fig. 7

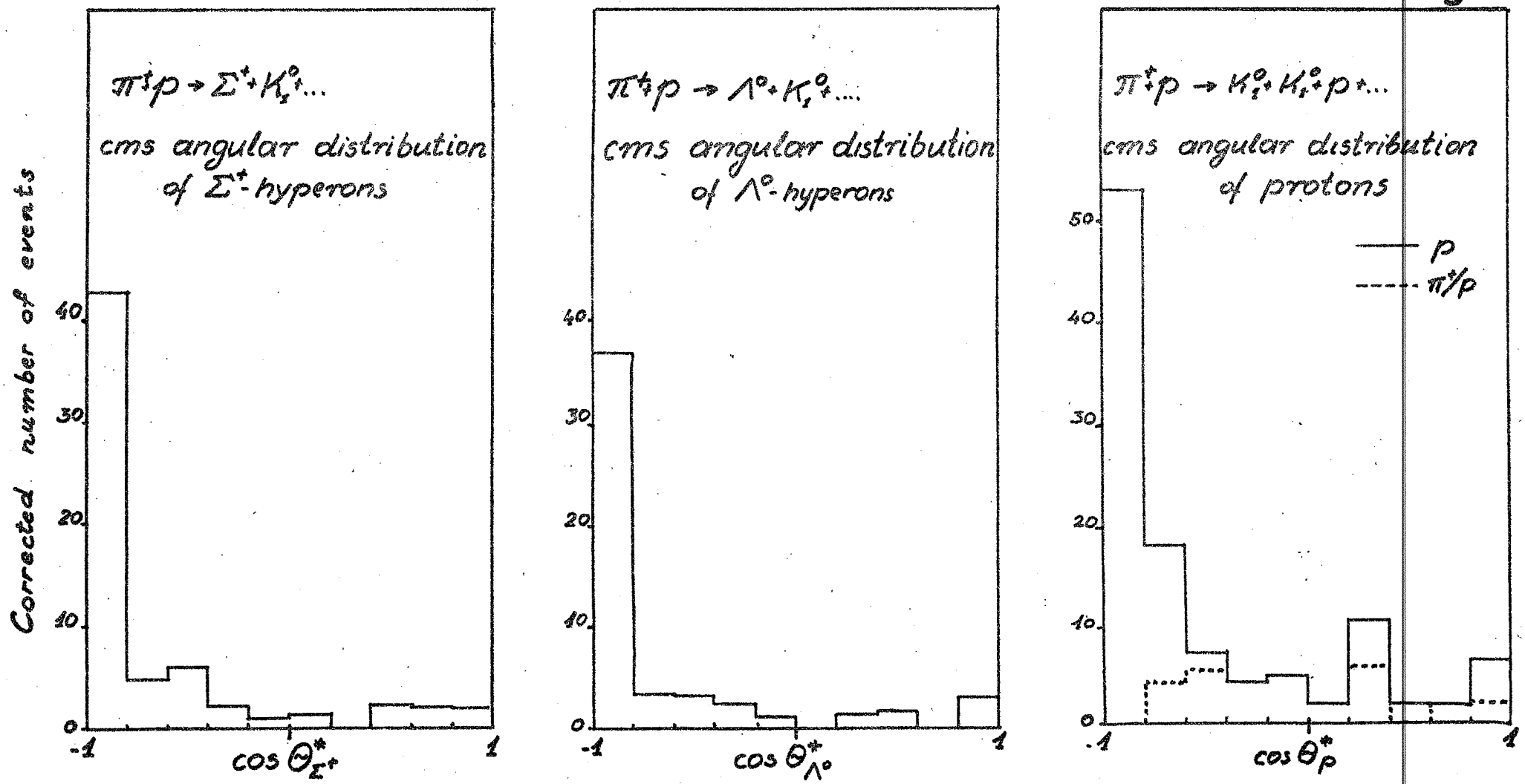
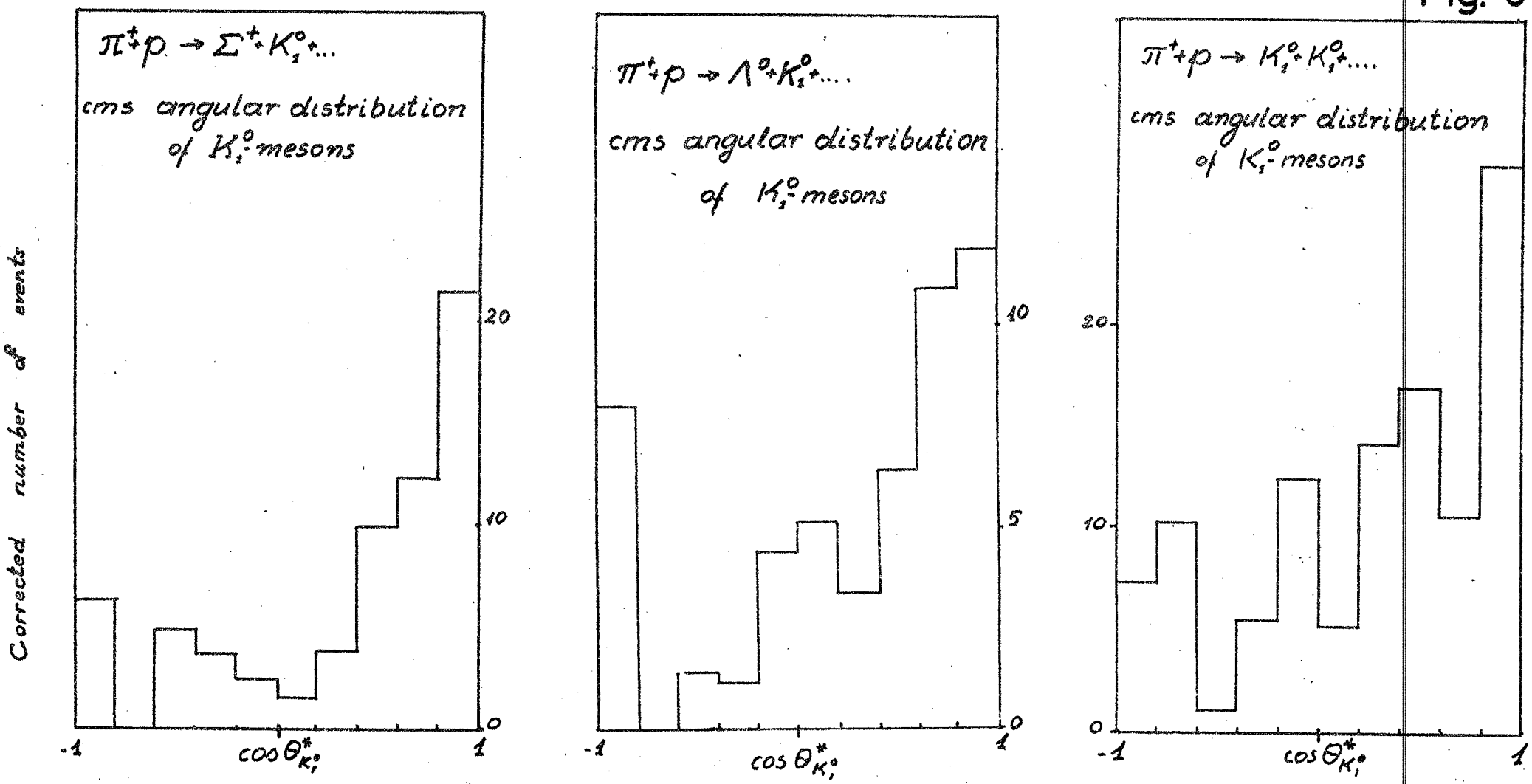

$\pi^+ p \to \Sigma^+ + K_1^0 + \ldots$
cms angular distribution of Σ^+-hyperons
$\pi^+ p \to \Lambda^0 + K_1^0 + \ldots$
cms angular distribution of Λ^0-hyperons
$\pi^+ p \to K_1^0 + K_1^0 + p + \ldots$
cms angular distribution of protons
p
π^+/p
Corrected number of events
0
10
20
30
40
50
-1
1
$\cos\Theta^*_{\Sigma^+}$
$\cos\Theta^*_{\Lambda^0}$
$\cos\Theta^*_p$

Fig. 8


$\pi^+ p \to \Sigma^+ K_1^0 +\ldots$
cms angular distribution of K_1^0 mesons
$\pi^+ p \to \Lambda^0 K_1^0 +\ldots$
cms angular distribution of K_1^0 mesons
$\pi^+ p \to K_1^0 K_1^0 +\ldots$
cms angular distribution of K_1^0 mesons
Corrected number of events
20
10
0
5
-1
1
$\cos\theta^*_{K_1^0}$

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