Not to be circulated

Only for E.E.C.

PROPOSAL FOR AN EXPERIMENT TO STUDY THE SMALL ANGLE STRUCTURE AND ENERGY DEPENDENCE OF THE $\pi^- p \to \Lambda^\circ (\Sigma^\circ) K^\circ$ DIFFERENTIAL CROSS SECTION BETWEEN 4 AND 16 BeV/c

---

I.Mannelli, G.Gorini, A.Scribano Memoria, F.Sergiampietri, M.L.Vincelli - Istituto di Fisica - I.N.F.N. sez. di PISA

P.Bonamy, J.P.Guillaud, J.Schneider - Institut du Radium, ORSAY

O.Guisan - Laboratoire de Physique Corpusculaire à Hautes Energies, SACLAY

Introduction

The $\pi^- p \to \Lambda^\circ (\Sigma^\circ) K^\circ$ associated production has been extensively studied in bubble chambers at energies between threshold and ~3.0 BeV/c [1]. We propose to make a spark chamber survey study at energies higher than 4 BeV/c, where only very limited data are available [2].

The purpose of the experiment is to extend to this process the type of experimental investigation which has been carried out for the $\pi^- p \to \pi^\circ n$ charge-exchange [3][4]. The two processes are similar from the point of view of SU3 [5], Regge pole theory [6] and models such as Byers and Yang [7].

In a first run our aim would be to obtain about a thousand events at 6,8,10 Bev/c in the range of momentum transfer $.05 \leq |t| \leq .5$ $(BeV/c)^2$. An extension to lower and higher energies is straight-forward while studies of spin dependent effects, using the Λ decay asymmetry as

---

Pisa,1.December,1965

polarization analyser, could be possibly carried out as a second step with an improved experimental apparatus.

Detector and experimental method

The proposed detector is sketched in fig.1. A 10 cm liquid hydrogen target is surrounded by an anticoincidence counter S_0 , and by a cylindrical Al-foil spark chamber, with interposed lead plates for γ rays conversion.

Two thin plates spark chambers SC1, SC2 in the forward direction followed by the third "high Z" spark chamber SC3, allow a good precision in the measurement of the $K_1^0 \to \pi^+ \pi^-$ decay angles, offering at the same time high detection efficiency for γ rays.

For triggering it is required that an incoming π^- fails to produce a signal in the anticoincidence counter, while there is a coincidence with the scintillator counter S_1.

The possibility of isolating the "elastic" process $\pi^- p \to \Lambda^0 (\Sigma^0) K^0$ from other competitive "inelastic" reactions, like $K^* \to (\pi^0 K^0)$, $Y^* \to (\pi^0 \Lambda^0)$ and additional π^0 production, making use of only the angular measurements, derives essentially from a property of the $K_1^0 \to \pi^+ \pi^-$ decay kinematics: at high energy 90% of the decays have opening angles between 1 and 1.1 times the angle corresponding to the symmetrical case, with a very typical double peaked frequency distribution (fig.2). In addition, by reconstructing the intersection of the incoming beam particule with the $\pi^+ \pi^-$ plane, it is possible to measure the partial decay angles. Their knowledge is sufficient to determine the K_1^0 momentum.

In fig.2 we report typical Montecarlo distribution for the ratio $\alpha_{fit}/\alpha_{90°}$, where α_{fit} is the reconstructed opening angle and $\alpha_{90°}$ the opening angle for the symmetrical decay of a 6 BeV/c $K_1^0 \to \pi^+ \pi^-$, as obtained for the cases of $\pi^- p \to \Lambda^0 K^0$, $\Sigma^0 K^0$, $Y^*_{1385} K^0$, $\Lambda^0 K^*_{891}$ production at momentum transfer between .10 and .12 $(\mathrm{Bev/c})^2$.

Fig.3 shows the distribution of the difference Δp between the momentum of an "elastically" produced K^0 and the one reconstructed from the Montecarlo generated angles of the deaay pions, for events within the peak of the distribution in α_{fit} and angle $\Delta\Phi$ between production and decay planes larger than 30°.

The Montecarlo program includes the effect of the:

a) momentum spread of the beam;
b) uncertainty in the position of the interaction point;
c) error in the measurements of the sparks coordinates;
d) multiple scattering.

Inspection of fig.s 2 and 3 insures that, using reasonable cuts in Δp, the information on the angles of the decay pions is sufficient to isolate the $\pi^- p \to \Lambda^0 (\Sigma^0) K^0$ events; the residual contamination from Y^*_{1385} is of a few percent in case the production cross section are of the same order of magnitude, while the K^*_{891} contribution should be negligible. The high efficiency for γ rays detection in SC3 will be an additional help in rejecting "inelastic" events.

The lead plates in the cylindrical S.C. should allow the detection of the γ rays from the $\Sigma^0 \to \Lambda^0 \gamma$ decay in about 30% of the $\Sigma^0 K^0$ production cases. The charged decay mode of the Λ^0 should produce at last one visible prong and in general the information from the cylindrical S.C. could be used to further reduce the background.

Finally we estimate that about 8% of all "elastic" events produced in the target will be measured, reconstructed and accepted within the limits indicated in fig.s 2 and 3.

It should be noticed that, for K^0 produced at nearly 180°, the corresponding Λ^0 charged decay is detected by the forward spark chambers. For $\Lambda^0 K^0$ production, the Λ^0 has a momentum about 8% higher than the K^0 emitted at the same angle in the lab. system. Its maximum opening angle is slightly smaller than our lower limit for K^0 acceptance. For $\Sigma^0 K^0$ production, the Λ^0 from the $\Sigma^0 \to \Lambda^0 + \gamma$ decay does not, in general, differ enough in opening angle from the corresponding K^0. However, in about 50% of the cases, the accompaning γ ray would be detected in SC3, allowing the reaction to be identified. The time distribution of the Λ^0 decays is an additional statistical chek for the procedure used in separating the events.

In conclusion the same exposure, primirary intended to study the small angle structure of the associated production cross section, could yield meaningful information also on the backward region behaviour

Expected rate and time schedule

Supposing that the differential cross section for associated production at high energy is of the same magnitude as the one for pi-minus proton charge-exchange*), we calculate that with a beam of intensity and characteristics like d22 the rate of good events, to be used for the angular distribution, would be 80-120 events per hour at 6 BeV/c.

After setting up and test time (which obviously could be reduced substantially if the experiment could be done in the same location as S_{35}) we would need therefore about 2-3 days running time at each momentum setting.

The cylindrical and thin Al-foil spark chambers, together with the anticoincidence counters are being built in Pisa and will be ready before next May.

The triggering electronics, hydrogen target and high-Z spark chamber will be those presently used by the Falk-Vairant Group.

---

*) See Ref. 5. It should also be noticed that this is compatible with the present experimental information.

REFERENCES

1) D.H. Miller et al. : "Strange particles production in 2.7 GeV/c $\pi^- p$ interaction" (Purdue University preprint-Coo-1428-12)

2) A.Bigi et al. : "On the associated production of K-Y pairs by 10 GeV/c π^- in the Hydrogen Bubble Chamber" N.C.,33(1964), 1265 and refer.therein

3) I.Mannelli et al. : " $\pi^- p \rightarrow \pi^0 n$ change-exchange scattering at high energies" P.R.L.,14 (1965), 408

4) A.V.Stirling et al. : "Small angle charge-exchange of π^- meson between 6 and 18 GeV/c" P.R.L., 14(1965), 763

5) A.Logunov et al. : "Higher symmetries of strong interactions and asymptotic relations between mesonbaryion scattering cross sections" Phys.Lett.,10(1964) 130

6) R.G.N. Phillips et al. : "Regge-pole model for high-energy πN, KN and $\bar{K}N$ scattering" P.R. 139 B 1339 (1965)

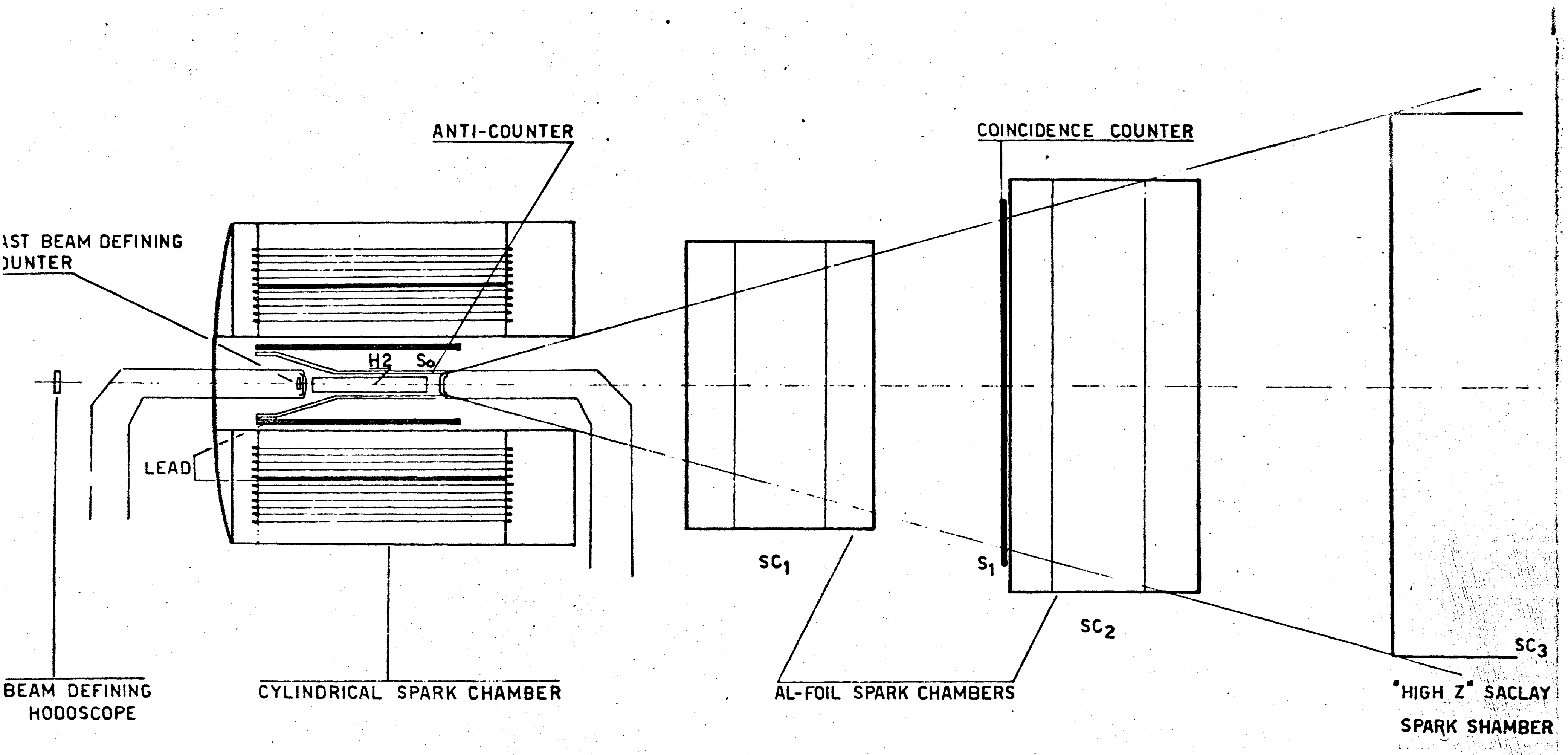
7) N.Byers et C.N.Yang : " π^- p charge exchange scattering and a 'coherent droplet' model of high energy exchange process" Preprint. Institute for the advanced study, Princeton, New Jersey.

FIGURE CAPTIONS

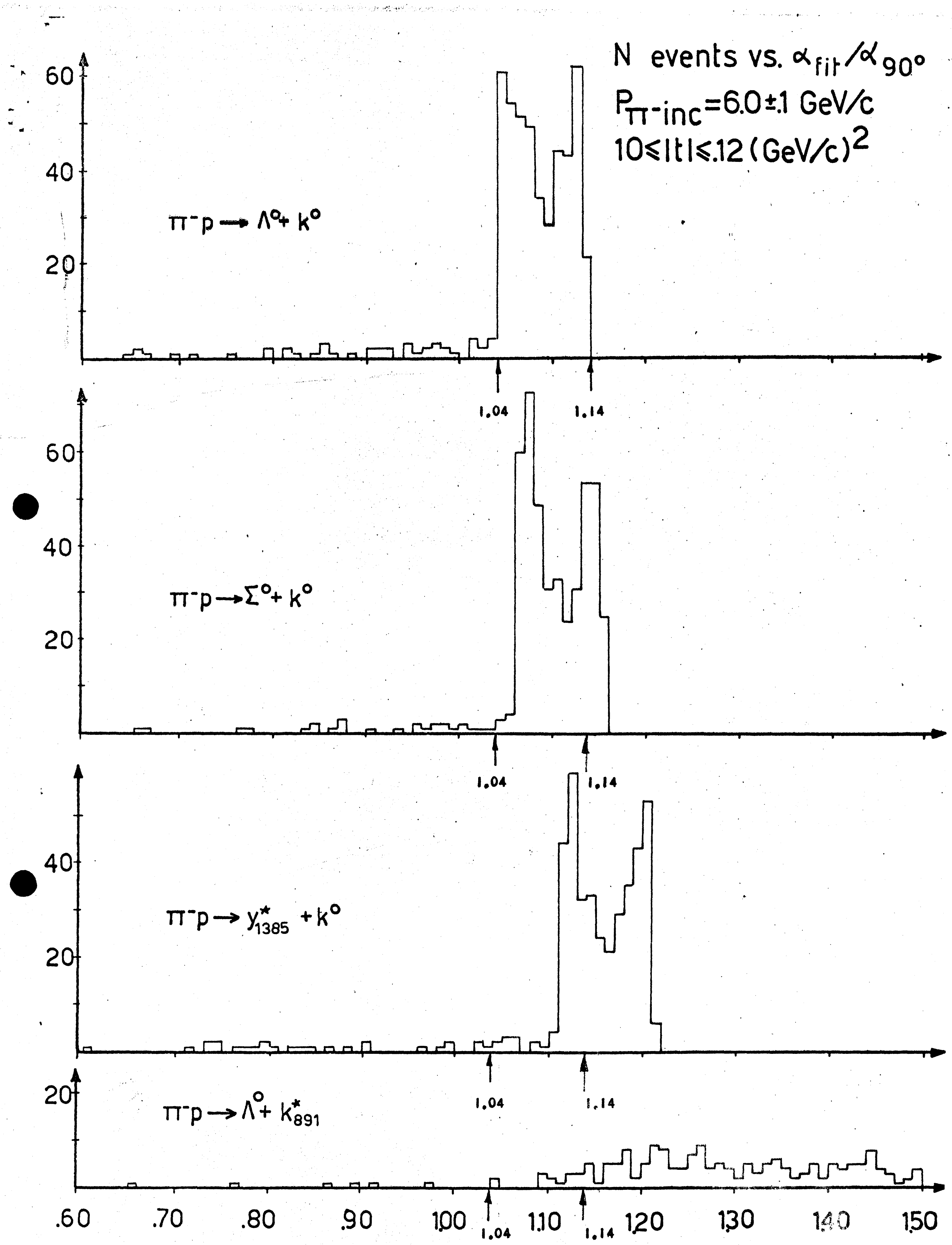
Fig. 1 Schematic experimental layout.

Fig. 2 Distributions in the ratio $\alpha_{fit}/\alpha_{90°}$, where α_{fit} is the reconstructed $K_1^0 \rightarrow \pi^+ \pi^-$ opening angle in the lab. system and $\alpha_{90°}$ the lab. opening angle for a 6.0 GeV/c K^0 decaying at 90° in its C.M., for events produced at a momentum transfer t with $.10 \leq |t| \leq .12$ $(GeV/c)^2$, for the case of $\pi^- p \rightarrow \Lambda^0 + K^0$, $Y^*_{1385} + K^0$, $\Lambda^0 + K^*_{981} \rightarrow \pi^0 + K^0$ production.

Fig. 3 Distributions in the difference Δp between the momentum of the K^0 reconstructed from its Montecarlo generated decay pions angles,and the momentum of a K^0 produced, at the same angle of emission, in $\pi^- p \rightarrow \Lambda^0 K^0$ interaction with a 6 GeV/c incident π^-. The dotted lines are the distribution for the events which miss to decay before SCl.



SCHEMATIC LAYOUT
SCALE 1:5



N events vs. α fit /α 90°
P π-inc = 6.0±1 GeV/c
10 ≤ |t| ≤ .12 (GeV/c)²
π⁻p → Λ° + k°
π⁻p → Σ° + k°
π⁻p → y*1385 + k°
π⁻p → Λ° + k*891
60
40
20
1.04
1.14
.60
.70
.80
.90
1.00
1.10
1.20
1.30
1.40
1.50

FIG. 2

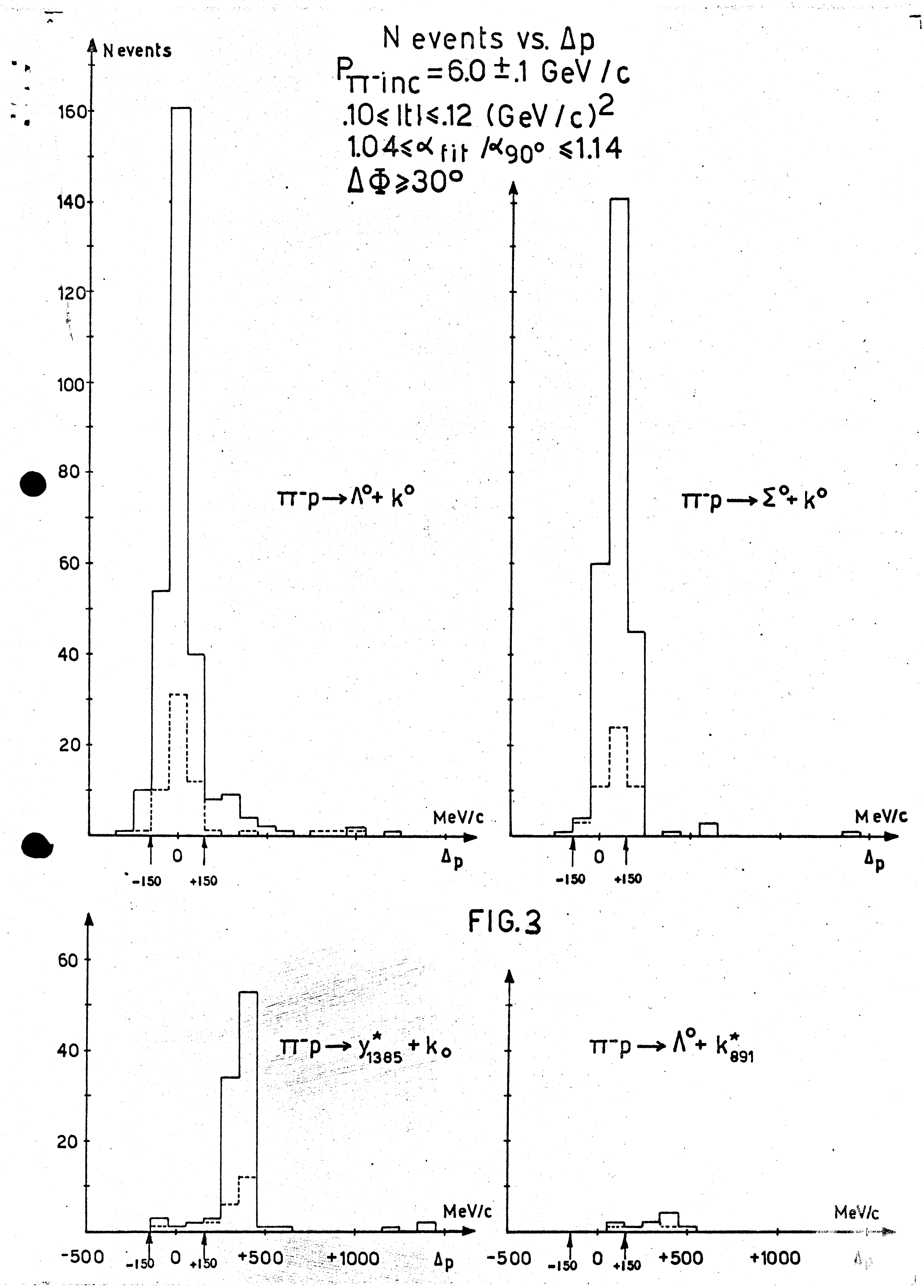

N events vs. Δp
$P_{\pi^- inc} = 6.0 \pm .1$ GeV / c
$.10 \leq |t| \leq .12$ $(GeV/c)^2$
$1.04 \leq \alpha_{fit} / \alpha_{90°} \leq 1.14$
$\Delta\Phi \geq 30°$
N events
160
140
120
100
80
60
40
20
$\pi^- p \rightarrow \Lambda^0 + k^0$
$\pi^- p \rightarrow \Sigma^0 + k^0$
MeV/c
Δp
-150
0
+150
60
40
20
$\pi^- p \rightarrow y^*_{1385} + k_0$
$\pi^- p \rightarrow \Lambda^0 + k^*_{891}$
-500
+500
+1000

FIG. 3