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EXPERIMENTAL RESULTS ON π^--NUCLEON INTERACTIONS AT 10 GeV

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We summarize in the present paper, experimental results obtained with nuclear emulsion technique on π^--nucleus and π^--nucleon interactions at 10 GeV/c.

The stacks of Ilford G5 600 μ thick emulsions were exposed to the beam of negative particles of 10 GeV/c momentum from the CERN proton synchrotron. The emulsions were exposed at a distance of about 16 m from the internal target; pions entered through the stack edge, parallel to the plane of the emulsion. The contamination of strongly interacting particles other than pions is less than 3% and should not affect the results appreciably; the muon contamination was estimated to lie between 9 and 15%; contamination of the beam by electrons appeared to be negligible ($\lesssim$ 1%) [1].

The scanning was performed by track following method at a speed of about 12 cm per hour.

Results are summarized in Table I.

TABLE I

Track followed	No. Interact. o)	λ inelastic	λ total
296.2 m	537	55 cm	52.8 cm

o) Excluding only electromagnetic events; large angle scatterings > 5° are included.

For the calculation of the mean free paths we exclude all knock-on electrons, and 58% of interactions with three minimum tracks and no heavy or gray prong which, according to the results of Evans et al. (2), are electron pair production in the interaction of π^- with the Coulomb field of the nucleus.

In λ inelastic also all π^- proton elastic scattering have been excluded, while in λ_{tot} we include the free proton elastic scatterings (7 events) and a double number of π^--bound proton elastic scatterings (that are 7) on the hypothesis that scattering against neutrons is equally probable as against bound protons. This evaluation is in agreement with the number of 11 large angle scattering that we have found. In Figs. 3, 4 and 5 are shown the prong distributions of all stars.

In our sample of interactions we selected the π^--nucleons interactions using the same criteria as used in a previous work on proton-nucleon interactions (3).

Such analysis has given 48 π^--proton collisions and 29 π^--neutron collisions; details of such interactions are shown in Table II, where the figures are corrected for elastic and quasi-elastic scattering, p - n scattering and electromagnetic events.

TABLE II

π^--nucleon interactions

	π^- - p					π^- - n				
No. of pions	2	4	6	8	total	1	3	5	7	total
No. of stars	15	23	9	1	48	1	16	9	3	29
Per cent	31.2	48.0	18.7	2.1	100	3.4	55.2	31.0	10.4	100

Taking into account the fact that the neutrons in emulsions are on the average, 1.2 times more than the bound protons, we can calculate the number of π^--free proton interactions and we obtained $N_{\pi^- fp} = 22$.

The value of the cross-section corrected for the efficiency of detection (estimated to $\approx 90\%$) and for muon contamination is then:

$$\sigma_{in\ \pi^- fp} = (28 \pm 10)\ \text{mb}.$$

in agreement with previous results (see for instance (1)).

Multiplicities of charged prongs (including the recoil nucleon) corresponding to $\pi^- - p$ and $\pi^- - n$ interactions can be derived from Table II, obtaining:

$$\bar{n}_{(\pi^- p)} = 3.8 \pm 0.3$$

$$\bar{n}_{(\pi^- n)} = 4.0 \pm 0.3.$$

These results can be compared with the theoretical calculations by Barashenkov et al. [(4)] which predict, at this energy, for $\pi^- - p$ interactions, a multiplicity of 3.8 for all charged prongs, including also the recoil nucleon.

In order to study the average features of the π^--nucleon interaction in the c.m.s., we have limited our analysis to stars with $n_j \geq 4$, adding together $\pi^- p$ and $\pi^- n$ interactions. For that sample, the distribution of the parameter $\xi = <\log \text{cotan}\ \theta>$ shows a distribution which, in the limits of our statistics, seems to be normal around the value $\xi = 0.39$, as one would expect for a π^--nucleon interaction.

To obtain the momentum, transverse momentum spectra and angular distribution of secondaries in the c.m.s., we have used the ionization measurements and their elaboration as described in [(3)].

We tested the development uniformity by plotting ionization measurements performed, in all plates and at different distances from the emulsion surface, on nearly 40 primary interacting pions, counting 400 blobs on each track. We obtained a gaussian distribution with a standard deviation of $0.75\sqrt{n}$, in good agreement with what is expected from a uniform development.

We used the ionization-energy curve given by Shapiro (5) in which the calibration point is given by primary pions ($\gamma = 70$).

Measuring for each track, the grain density and the angle θ in the l.s. and elaborating the measurements as discussed in (3), we obtain in the c.m.s. the angle θ^* and the value of $\frac{p^*}{m}$ for each track.

The angular distribution in the c.m.s. is given in Fig. 1.

Assuming all measured tracks to be pions, we obtain the following mean values of momentum and transverse momentum, in the barycentric system:

$$< p^* > \; = \; (466 \pm 50) \text{ MeV/c}$$

$$< p^*_\perp > \; = \; (394 \pm 40) \text{ MeV/c.}$$

In Fig. 2 the present result is reported together with measurements performed by other authors on π or p interactions at various known energies.

For the comparison only those measurements have been reported where the selection on the interactions and on the particles measured is consistent with the present measurements.

It is evident a more or less monotone dependence of the trasverse momentum on the γ of the interaction, as one would expect because of the low energies involved in the reactions.

The inelasticity of the π-nucleon reactions at 1 GeV, can be calculated using the relation

$$K = \frac{n_\pi < E^*_\pi >}{T^*}$$

where $< E^*_\pi >$ is the average total energy of a π meson in the c.m.s., and n_π includes both charged and neutral mesons and T^* is the kinetic energy available for particle production in the c.m.s.

In our case

$$< E^*_\pi > = 485 \text{ MeV} \qquad n_\pi = 1.5\, n_{\pi^\pm} = 5.1$$

$$K = 0.73 \pm 0.10$$

where the error quoted is only the statistical error due to the number of tracks on which measurements have been performed.

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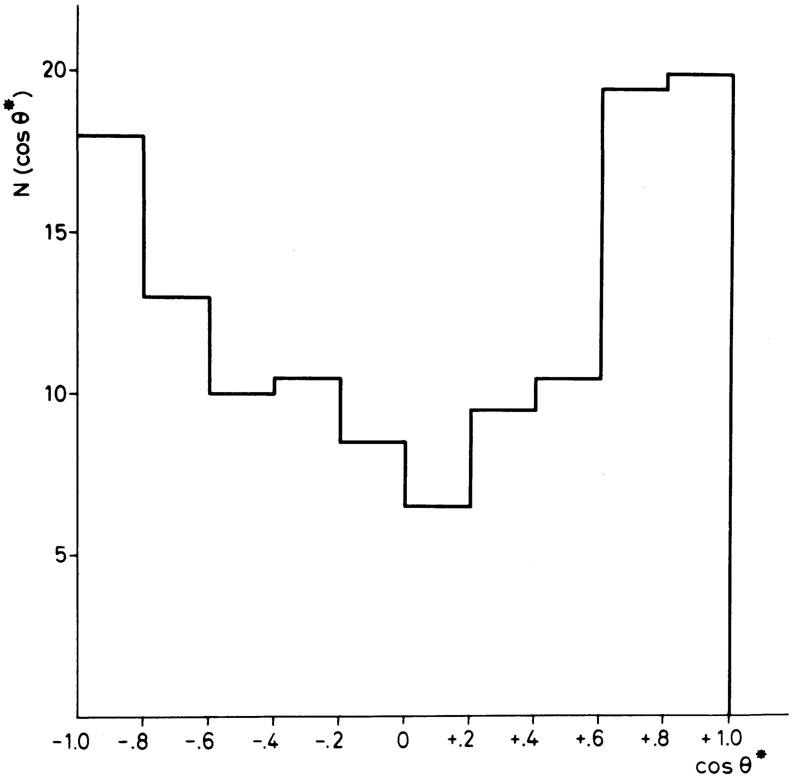

Fig. 1

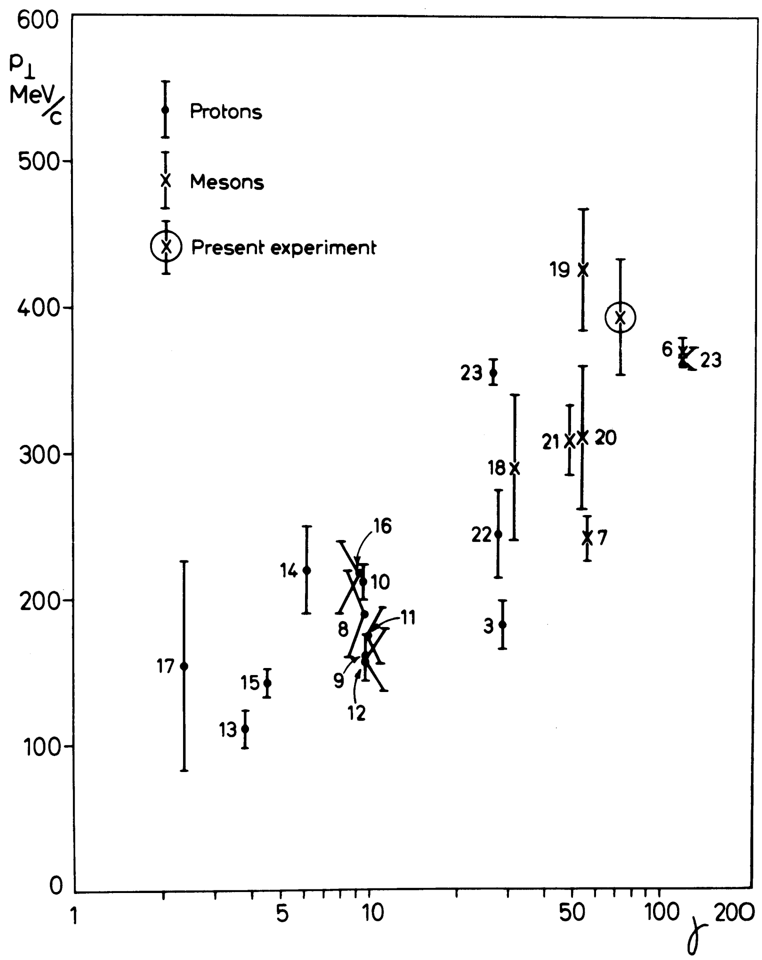

Fig. 2

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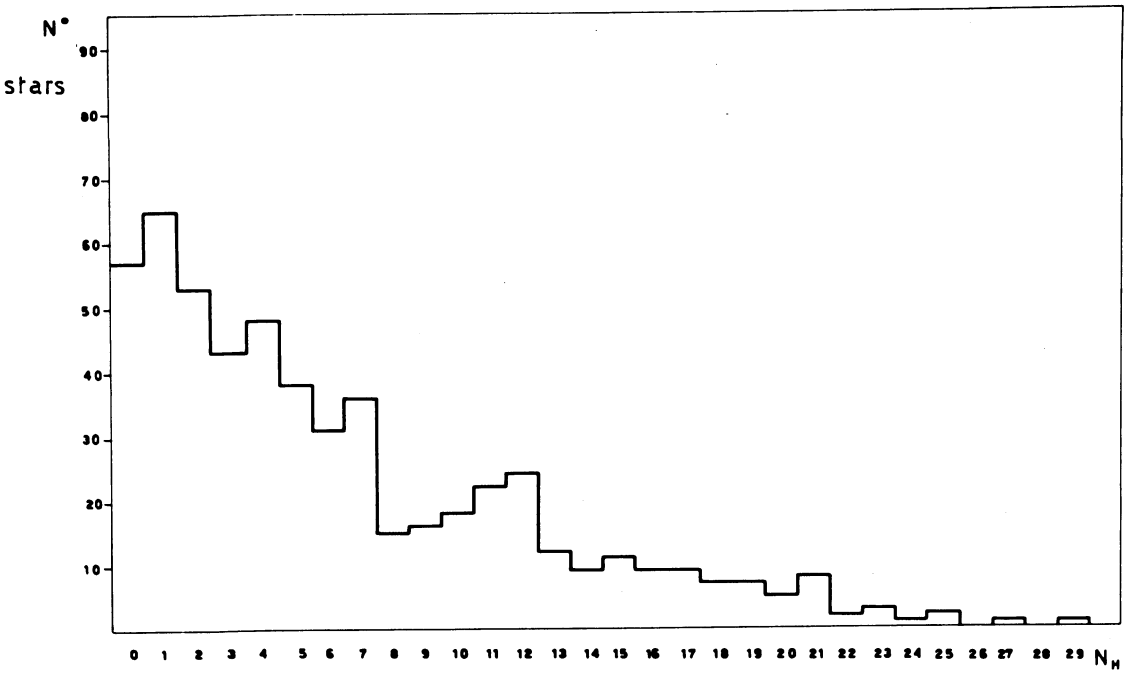

N° stars
90
80
70
60
50
40
30
20
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 N_H

Fig. 3

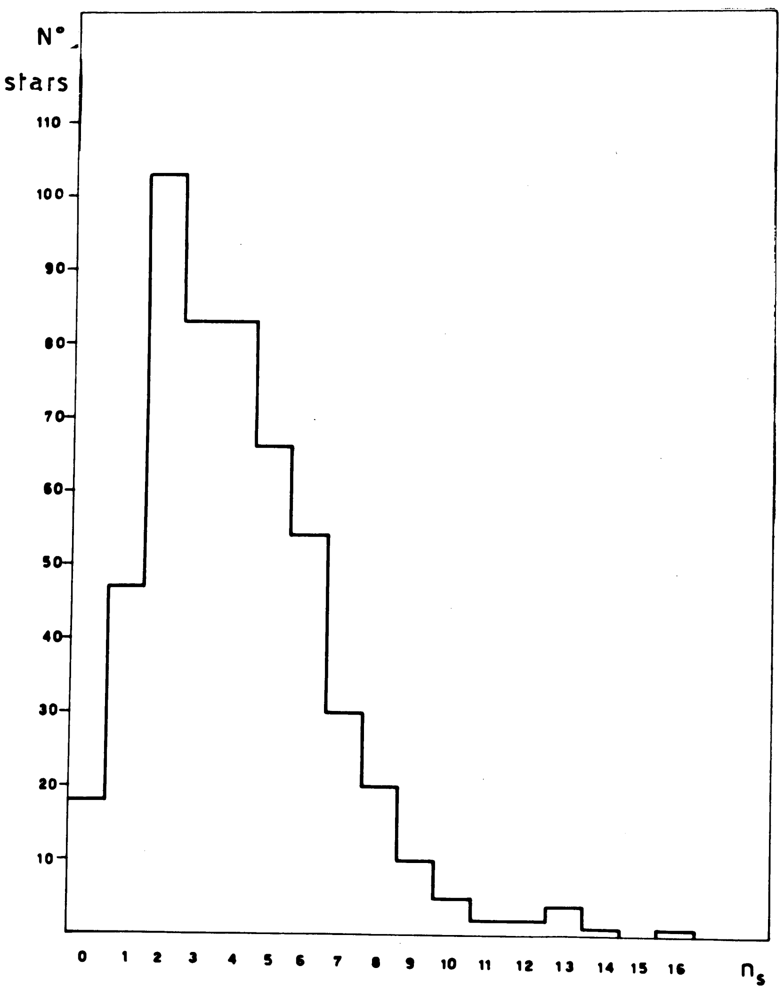
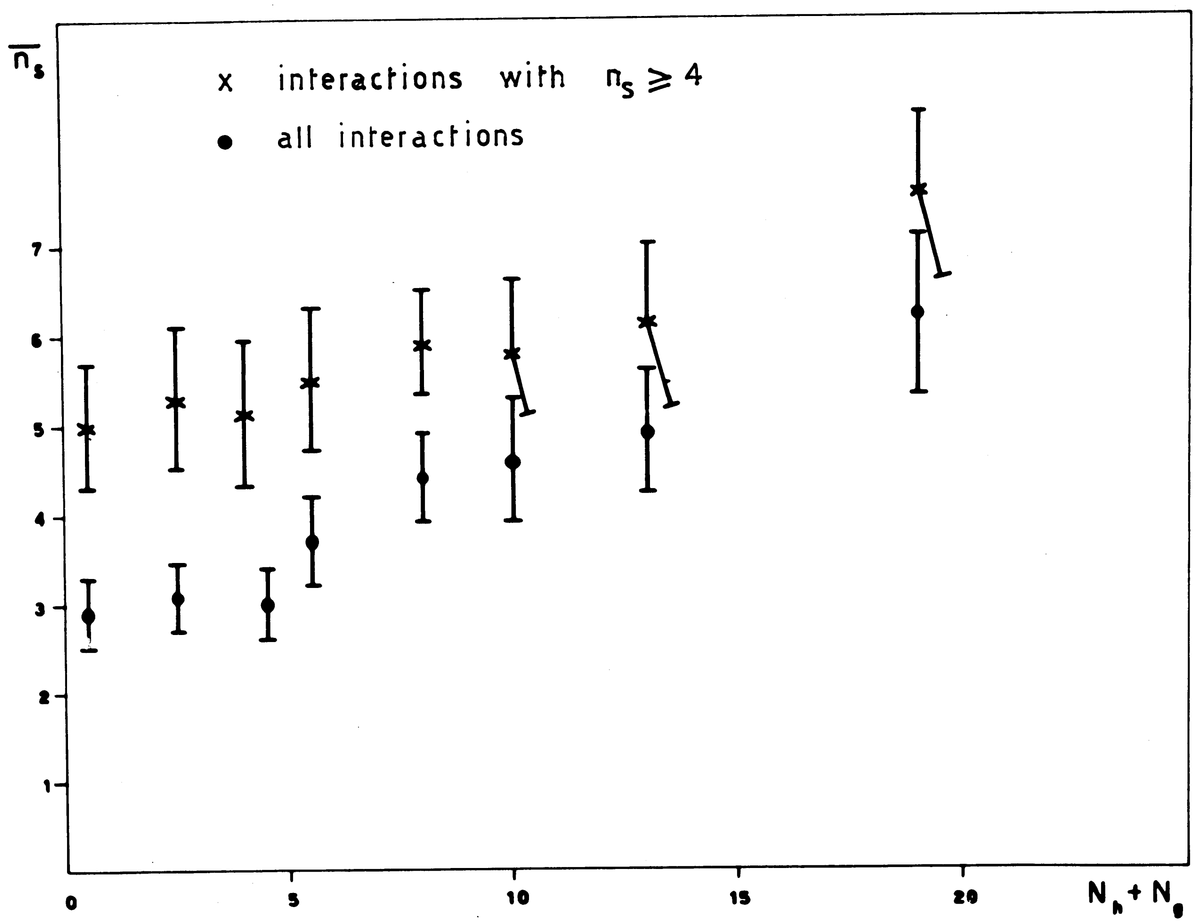

N° stars
110
100
90
80
70
60
50
40
30
20
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 n_s

Fig. 4



$\overline{n_s}$
x interactions with $n_s \geqslant 4$
• all interactions
7
6
5
4
3
2
1
0
5
10
15
20
$N_h + N_g$

Fig.5