GENERAL CHARACTERISTICS OF π^--NUCLEON INTERACTIONS AT 60 GeV/c OBTAINED IN NUCLEAR EMULSION

E. V. ANZON, I. Ya. CHASNIKOV, C. I. SHAKHOVA, I. S. STRELTSOV, Zh. S. TAKIBAEV, A. H. VINNITSKY and V. G. VOYNOV
Nuclear Physics Institute of the Kazakh Academy of Sciences, Alma-Ata, USSR

G. BOZOKI, E. FENYVES, E. GOMBOSI and E. NAGY
Central Research Institute for Physics, Budapest, Hungary

J. BABECKI, Z. CZACHOWSKA, B. FURMAŃSKA, J. GIERULA, R. HOŁYŃSKI, A. JURAK, G. NOWAK, K. RYBICKI and W. WOLTER
Institute of Nuclear Physics, Cracow, Poland

N. DALKHAZHAV, R. KHOSHMUKHAMEDOV*, E. S. SHABRATOVA and K. D. TOLSTOV
High-Energy Laboratory, Joint Institute for Nuclear Research, Dubna, USSR

M. M. CHERNYAVSKY, N. B. MASLENNIKOVA, M. I. TRETYAKOVA and G. B. ZHDANOV
Physics Institute of the Soviet Academy of Sciences, Moscow, USSR

K. I. ALEKSEEVA
Nuclear-Physics-Research Institute of the Moscow State University, Moscow, USSR

Kh. M. CHERNEV and P. T. TODOROV
Physics Institute of the Bulgarian Academy of Sciences, Sofia, Bulgaria

S. A. AZIMOV, U. G. GULYAMOV, T. V. RECHNITSKY and E. A. TILL
Nuclear-Physics Institute of the Uzbek Academy of Sciences, Tashkent, USSR

C. BATAAR, B. CHADRAA, D. SHARKHUU and D. TUVDENDORZH
Institute of Mathematics and Physics of the Mongolian Academy of Sciences, Ulan-Bator, Mongolia

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Interactions of 60 GeV/c π^--mesons with nucleons of the nuclear emulsion have been studied. Average prong number in π^--proton collisions is 6.64 ± 0.16. The majority of secondary particles are emitted into the forward hemisphere in the π^--proton CM system especially in low-multiplicity events.

This paper describes some general characteristics of π^--proton interactions at 60 GeV/c obtained by the collaboration organized by the Emulsion Committe of the Joint Institute for Nuclear Research. Preliminary results of this work were reported in ref. 1 and 2. Coherent interactions of 60 GeV/c π^--mesons with emulsion nuclei are described in another paper [3].

Experimental. Several stacks of N.I.I. Khim. Foto Br-2 emulsion have been irradiated by (60 ± 1) GeV/c π^--mesons at the Serpukhov accelerator. The admixture of muons and electrons was about 3%, that of kaons less than 1%. Typical dimensions of a stack were 20 × 10cm^2 × × 100 × 0.06 cm. A similar irradiation has been performed at 45 GeV/c, however, the statistic obtained was much smaller and the corresponding results will be quoted below only for comparison.

Starting close to the entrance of the pion beam into the emulsion (~1.5 cm) an along-the track

* On leave of absence from the Physical-Technical Institute, Dushambe, USSR

scanning for inelastic interactions has been performed. Of all the events found during the scanning the following have not been used for the calculation of the inelastic-interaction length λ_{int}:

i) events with a single relativistic track deflected by less than 10 mrad (these are mostly elastic scatters on emulsion nuclei),

ii) knock-on electrons,

iii) electron pairs on beam tracks.

Scanned length, number of events found and the values of λ_{int} obtained taking into account the correction for the beam contamination are shown in table 1. The errors shown here are statistical only while the systematic ones have been estimated to be at most of similar magnitude. A comparison of our results with $\lambda_{int} = (40.4 \pm 1.0)$cm obtained at 16 GeV/$c$ shows that there is no considerable change of the inelastic pion-nucleon cross section between 16 and 60 GeV/c.

Interactions with free and quasi-free nucleons have been selected as those with at most one slow charged particle appearing as a black or grey track in the forward laboratory hemisphere and without a visible recoil nucleus. Number of events selected according to these criteria are also shown in table 1. They represent about 19% of all interactions in the emulsion. For events with an even prong number n_{ch} ("π^- -p") there was an additional criterion of the absence of an accompaning electron. Nearly 40% of them correspond to collisions with free protons (i.e. the nuclei of the emulsion hydrogen); the remaining ones are collisions with quasi-free protons of the emulsion nuclei. Events with an odd prong number n_{ch} will be called "π^- -n" and correspond to collisions with quasi-free neutrons with some admixture of coherent interactions [3]. Therefore, in this work we shall deal mainly with "π^- -p" events which represent a more pure sample of π^- -nucleon interactions than "π^- -n" events.

Table 1

Primary momentum		60 GeV/c	45 GeV/c	25 GeV/c
Traced length (m)		3147	512	-
No of events found		7012	1196	-
λ_{int}(cm)		43.7 ±0.6	41.3 ±1.3	-
No of π^- -nucleon events		1332	233	-
$\langle n_{ch} \rangle$ for "π^- -n"	uncorrected	5.41 ±0.12	4.90 ±0.23	-
	corrected	6.24 ±0.15	5.23 ±0.27	-
"π^- -p"	$\langle n_{ch} \rangle$	6.64 ±0.16	6.10 ±0.28	4.87 ±0.07
	$\langle n_{ch} \rangle / \sigma_n$	2.12 ±0.10	2.20 ±0.16	2.30 ±0.09

Prong number distribution. Our prong-number distribution for 45 GeV/c and 60 GeV/c is shown in fig. 1. The prong number distribution obtained by Elbert et al.[4] at 25 GeV/c is also shown. In our distribution an overabundance of $n_{ch} = 3$ events is clearly seen apart from the fairly smooth distribution peaking at $n_{ch} = 5 \div 6$. This overabundance is interpreted in terms of the coherent interactions imitating "π^- -n" events [3]. The average multiplicities are shown in table 1 for "π^- -p" events as well for "π^- -n" events with and without correction for the coherent events. The errors given here are purely statistical and the systematic ones are of similar magnitude. Since

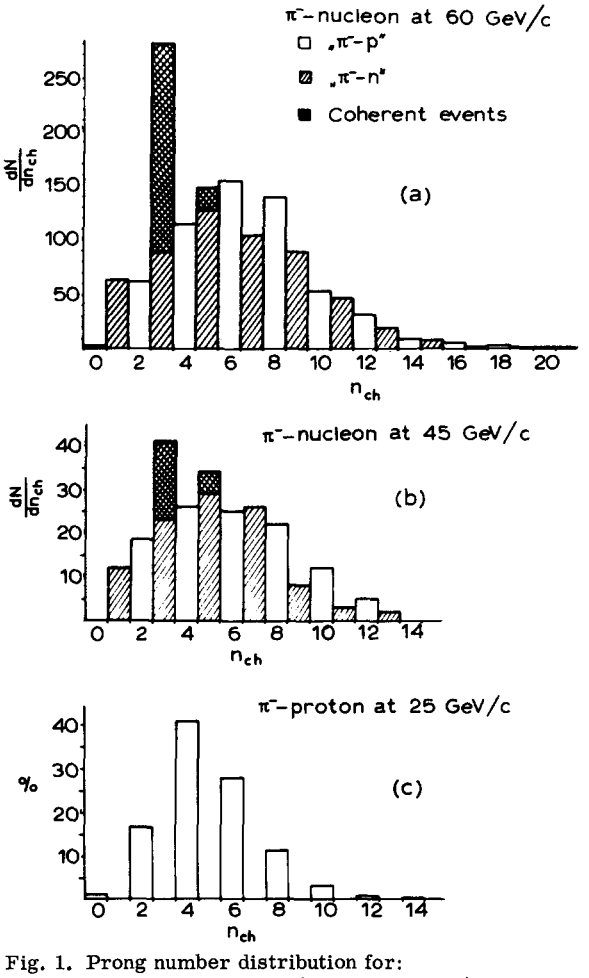

Fig. 1. Prong number distribution for:
a) π^- -nucleon events in emulsion at 60 GeV/c,
b) π^- -nucleon events in emulsion at 45 GeV/c,
c) π^- -p events in the hydrogen bubble chamber at 25 GeV/c. After Elbert et al. [4].
Dashed and cross-hatched areas correspond to "π^--n" and coherent events, respectively.

in majority of cases we are dealing with bound nucleons the average values may be slightly overestimated. The shape, however, of our multiplicity distribution appears to be similar to those at lower energy. This can be illustrated by the constancy of the ratio $\langle n_{ch}\rangle/\sigma_n$ where σ_n is a dispersion of the prong-number distribution. The values of this ratio are also shown in table 1.

A comparison of our average multiplicity $\langle n_{ch}\rangle$ in "π^--p" events with the hydrogen-bubble-chamber ones at lower energy [4 ÷ 9] is shown in fig. 2. Our results seem to prefer the $\langle n_{ch}\rangle \propto E_o^{0.35}$ dependence but, since they can be overestimated, the logarithmic dependence cannot be ruled out.

Angular distribution of secondary particles. The angular distribution of relativistic secondaries in cos θ_{CM}- coordinates is shown in fig. 3. It is seen that pions are emitted predominantly into the forward hemisphere in the π^--nucleon CM system. The strongest forward asymmetry is observed at the lowest multiplicities. With the increasing multiplicity the asymmetry decreases but remains significant. Only in the highest-multiplicity stars ($n_{ch} \geq 14$) is the angular distribution symmetric (but still anisotropic).

Qualitatively similar results were obtained previously at lower energies (cf ABBCCHW collaboration [5]).

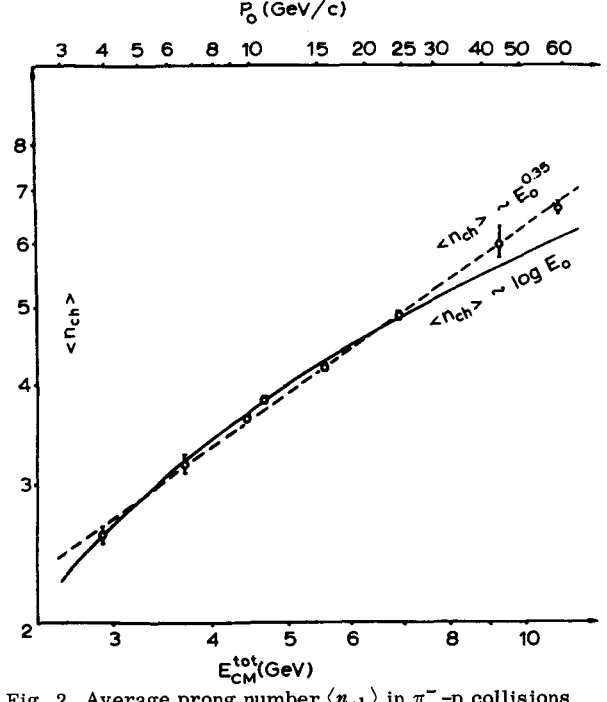

Fig. 2. Average prong number $\langle n_{ch}\rangle$ in π^--p collisions as a function of the total primary energy E_{CM}^{tot} in CM system and of the primary momentum p_o.

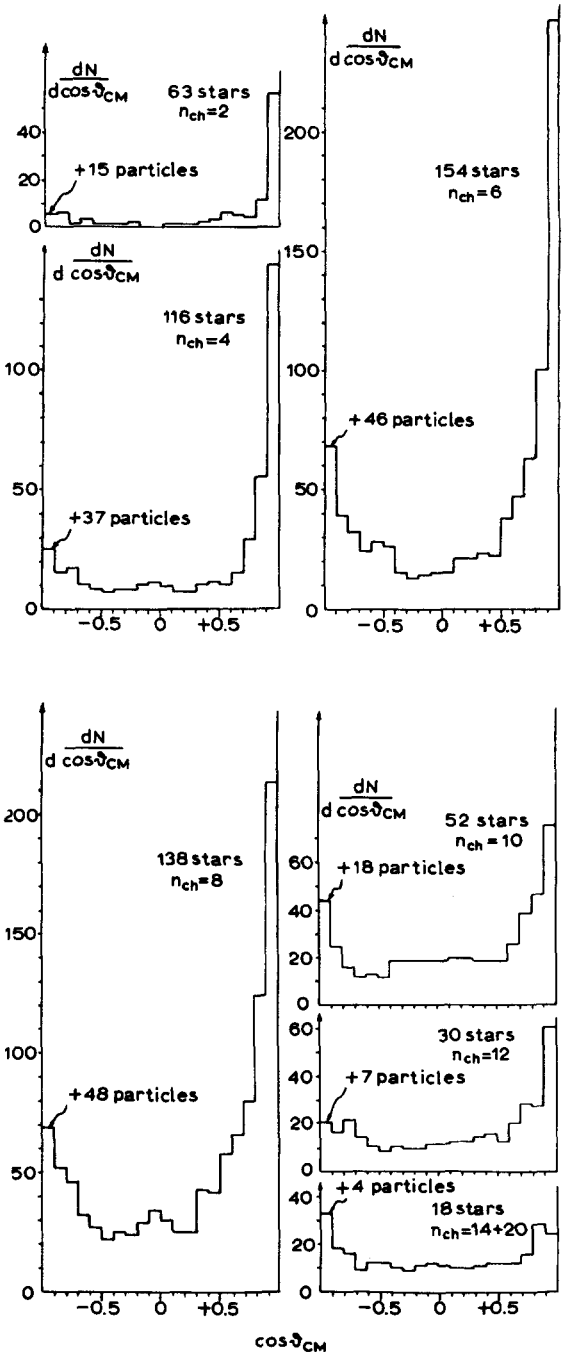

Fig. 3. Angular distribution of secondaries in "π^--p" interactions at 60 GeV/c for various multiplicities n_{ch}. Only secondaries which are relativistic in the laboratory system have been included in the distribution; the number of the remaining ones is shown in each distribution.

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