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In the collisions of π^+ mesons with nucleons in a composed nucleus two charged π -mesons can result from the following reactions:

$$\pi^+ + p \rightarrow \pi^+ + \pi^+ + n \qquad (I)$$

$$\pi^+ + n \rightarrow \pi^+ + \pi^- + p \qquad (II)$$

A comfortable method for studying these processes is the registration of mesons which are stopping within the emulsion stack, as it was done for instance in |1|. The method of photoemulsion stacks permits to observe the pion production acts resulting from the interactions between π mesons and photoemulsion nuclei. In the present work the authors tried to study the reactions (I) and (II) in the cases in which fast positive π -mesons interact with photoemulsion nuclei.

The emulsion stack including 10 NIKFI"R" 400 μ pelicules with a diameter of 80 mm. was exposed at the 307 MeV π^+ meson beam of the Laboratory of Nuclear Problems of the JINR. Considering the slowing down mesons suffer in the emulsion the results are related to an incident energy of (280 $\pm$ 20) MeV. The exposure was chosen such as to obtain a density for the incident mesons beam of about 2,5 x 10^5 1/cm^2 in the emulsion stack. In order to permit the tracking of charged particles from one plate to another, on the surface of each emulsion pelicule a coordinate grid was printed |2|. The grain density on the initial pion tracks was of (22.7 $\pm$ 0.5) grains/100 μ .

In the nuclear desintegrations registered by means of plate scanning, charged π - mesons were seeked for. The meson tracks were distinguished from proton ones using grain density measurements. For this purpose auxiliary measurements were performed on elastic(π^+-p) scattering events found in the same stack. The results are shown in Fig.1, where curves a and b represent the dependence between the grain density related to the minimum one for protons and π -mesons respectively and their exit angle. One can see the good agreement of experimental points with the theoretically computed curves. The grain density on meson and proton tracks differ more than two times. In an elastic (π^+-p) scattering a proton having an exit angle near to 90° carries a relatively small energy. But in the interaction of π -mesons and nucleons in composed nuclei two consecutive elastic (π-N) scatterings can occur. In this case, if the meson after a first scattering collides a second time with a nucleon and knocks it out at a small angle, protons can exit the nucleus having angles more than 90° and carrying a significant energy. The curve representing the dependence between the proton grain density related to n_{min} and the exit angle for such events is shown in Fig.Ic. Furtherly, one considered that all tracks having a grain density smaller than $2 \times n_{min}$ are meson tracks. The identification of tracks with grain density between (2 and 5)$\times n_{min}$ was done by means of grain density gradient measurements |3|. For tracks with ionization

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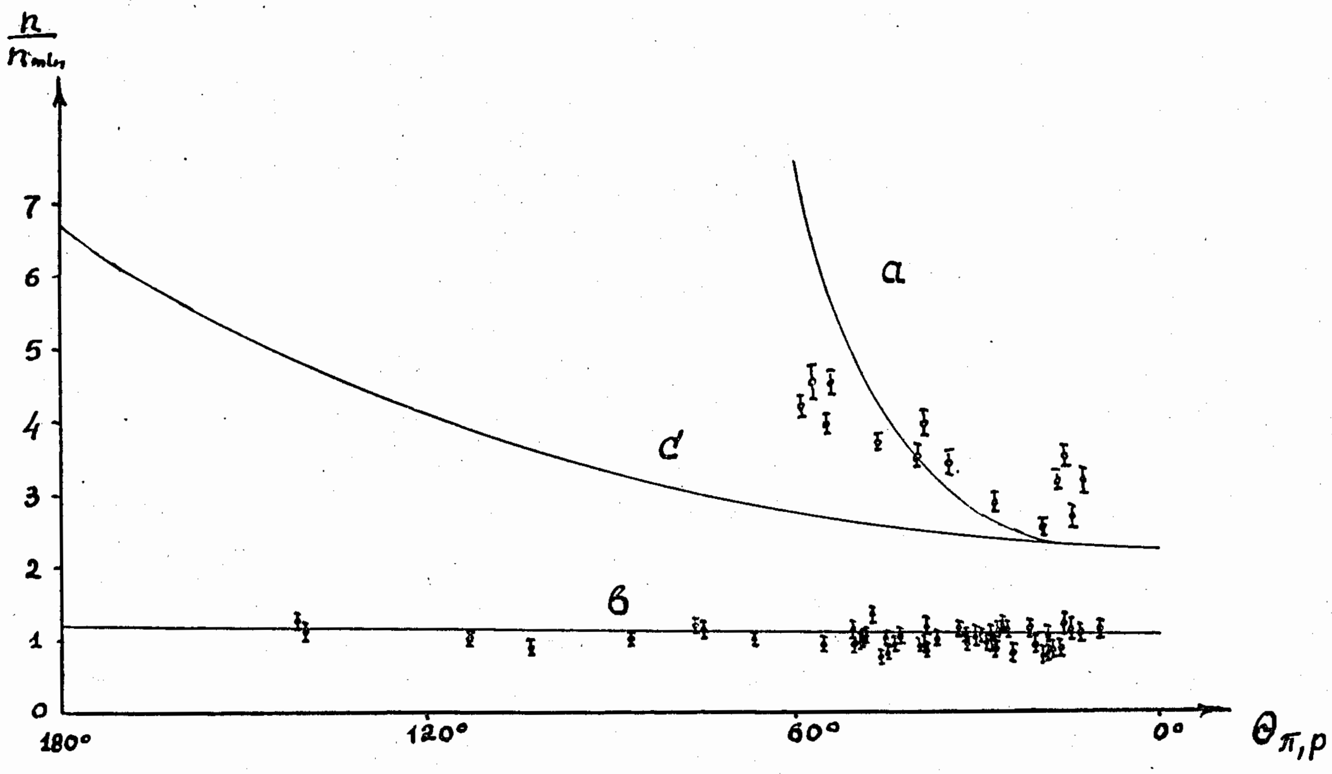


Fig. I.

more than $5 \times n_{min}$ mesons were distinguished from protons only from the aspect of their tracks.

Among 3000 "stars" found by means of area scanning 13 (+4 possiblė) events with two emitted meson tracks were found. Consequently in approximatively 0.5% of the nuclear desintegrations produced by π^+-mesons with 280 MeV energy, there are two charged mesons emitted. Only one charged meson track was observed in about 40% of all events.

Comparing the present results with other works |4-7|, we may conclude that in the collisions with photoemulsion nuclei the 280 MeV π^+-mesons are absorbed as frequently as π^--mesons.

By means of area scanning meson stoppings were also registered and their tracks followed through the stack, up to the nuclear desintegration in which they were produced; 92 desintegration events with π^- mesons stopping within the stack and 106 with π^+-mesons, were found. Among these 198 desintegrations 39 events were found -after further measurements - in which two charged mesons were emitted. The energetical distribution of mesons emitted in desintegration events with two secondary meson tracks is given in Fig.2. Their energy was determined from range and grain density measurements. 112 meson were included in this distribution; out of them 7 have an energy higher than 60 MeV. Corrections for the finite dimensions of the stack were performed according to |8|, both for energy and angular distributions. The energetical spectrum has a maximum for about 30-40 MeV. The main part of the secondary mesons have an energy not higher than 60 MeV; their average energy is equal to 30 MeV. Out of the whole kinetic energy included in the reaction, 40-50% is carried in the average by the two emitted mesons.

In Fig.3 the spectrum for π^--mesons is given. This energetical distribution consists in 92 events in which π^--emitted mesons were considered indifferently if they were or not accompanied by another meson. It is analogous to the spectrum shown in Fig.2, but appreciably translated towards smaller energies. The average energy of π^--mesons is equal to 16 MeV. In Fig.3 there is also given the spectrum of the π^+-mesons stopping within the emulsion stack. The difference between the average energy of π^+ and π^- mesons (~14MeV) is caused by the Coulomb field of the nucleus. It is in agreement with the value of the Coulomb barrier for the photoemulsion nuclei |8|.

The character of the spectrum for π^--mesons is in accordance with the supposition that they are produced in the nucleus in the process (II). It is probable that in the nuclear desintegrations in which out of the "star" only one π^--meson is emitted, the second π^+-meson has been absorbed in the composed nucleus. It must be said that in each particular event, taking into account the Coulomb shift, there was not observed a great difference between the energy of the two emitted pions.

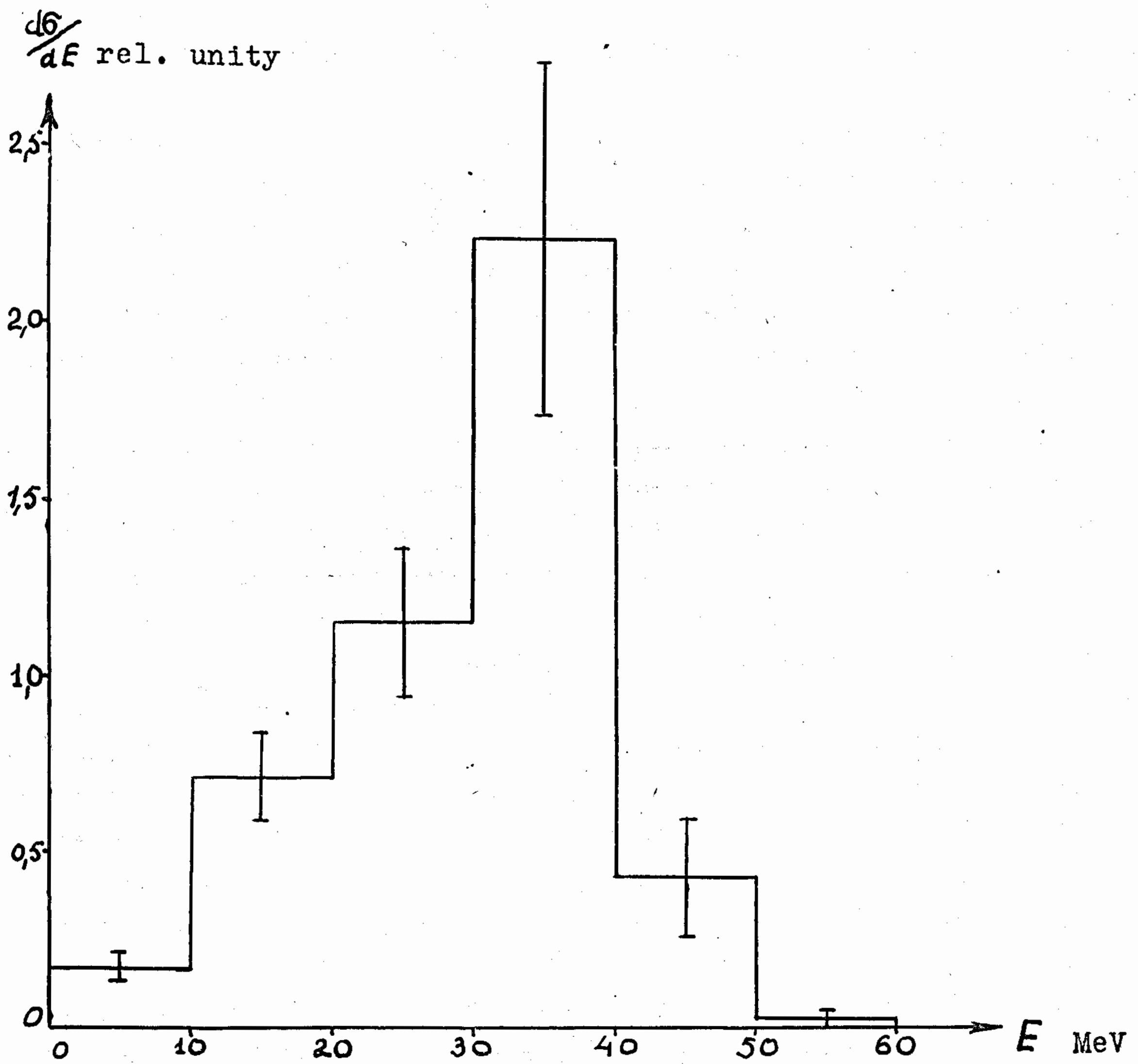


Fig.2. Energetical distribution of the mesons produced in the reaction $\pi^{+} + A \begin{smallmatrix} \nearrow \pi^{-} + \pi^{+} + B \\ \searrow \pi^{+} + \pi^{+} + C \end{smallmatrix}$ for initial energy 280 MeV.

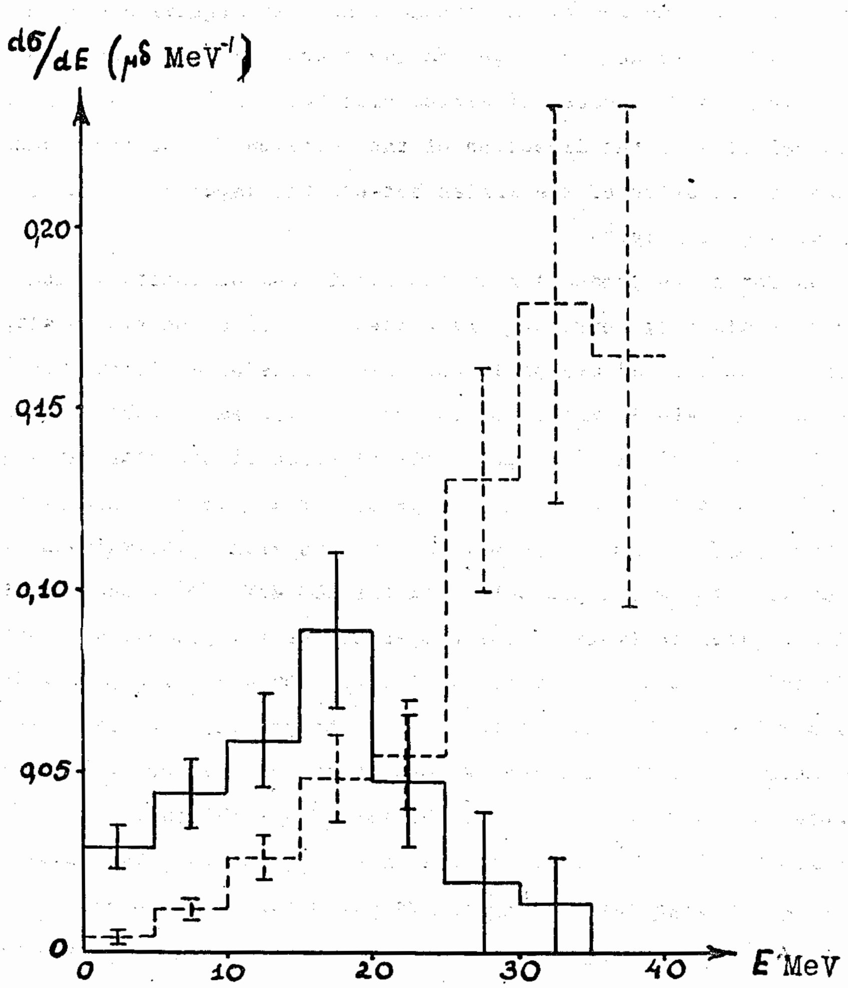


Fig.3. Energetical distribution of the charged mesons produced in the interactions of the 280 MeV π^+-mesons with the photoemulsion nuclei.

— spectrum of π^--mesons

--- spectrum of π^+-mesons.

The angular distributions of π-mesons are given in Fig.4 and and 5. In the transformation to the center of mass system of the incident meson and the nucleon, the movement of nucleons within the nucleus was not taken into account. The angular distribution of the π^- mesons in the c.m. system is not isotrope, having a broad maximum for angles of about 180^o. The angular distribution for mesons of events with two meson tracks is given in Table I. A noticeable correlation in the direction of the emission of the two secondary mesons has been observed: the distribution of the angles between the impulses of the two mesons has a maximum for great angles (Fig.5).

The cross sections for meson production in the collisions of positive pions with photoemulsion nuclei were obtained by comparing the number of production events with the number of "stars" caused by the initial mesons in the same volume of emulsion. The mean free path of π^+-mesons for "star" production in the emulsion was established from along track scanning to be (32.4 ± 2.3) cm. (The prong distribution of the stars is given in Table 2.) The value for the mean free path coincides, within measurement accuracies with the results of |9| where interactions of 300 MeV π^--mesons with photoemulsion nuclei were studied. The cross sections for meson production in the 280 MeV π^+-meson collisions with photoemulsion nuclei are given in Table 3. The comparison of the present work data with the results of |1,10| indicate that the cross section for charged meson production in the processes π^++nucleus$\rightarrow\pi^-$ and π^-+ nucl$\rightarrow\pi^+$ are near to one another. From the experimental data about the number of events in which two mesons are emitted or only one is emitted and the second absorbed, we may compute the probability of absorbtion in the composed nucleus of the produced meson, α. The ratio of the probabilities that two mesons should be emitted or only one of given sign is: $\frac{1-\alpha}{\alpha} = 0.24$ and hence, $\alpha = 0.81 \pm 0.04$. Using the obtained value of α and assuming that the absorbition probability is the same for π^+ and π^--mesons we can write:

a) The probability of exit for one meson of the produced "pair" out of the nucleus:

$$\alpha(1-\alpha) = 0,15$$

b) The probability of exit for both mesons: $(1 - \alpha)^2 = 0.04$.

Thus, the main part of the produced mesons are absorbed in the same nucleus. This points out the fact that the π^+ and π^--mesons produced as a result of the interaction between the initial π^+-meson and the nuclei of photoemulsion, very probably suffer secondary collisions with the nucleons of the same nucleus. About 10% of the nuclear desintegrations caused by the 280 MeV positive π-mesons in the emulsion are events in which two charged mesons are produced according to the reactions (1) and (II); out of them in 15% cases one meson is emitted, and only in 4% both.

Table I.

Angular Distributions of the Mesons Produced in the Reactions

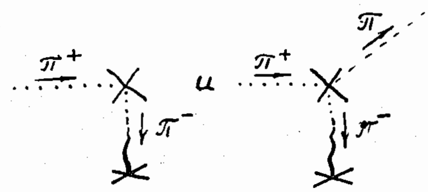
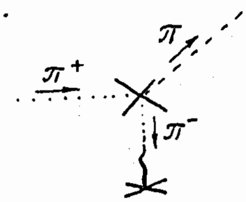
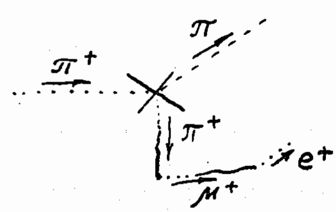
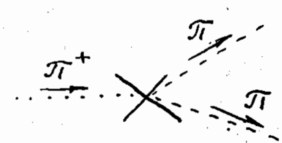
$$\pi^+ + A < \begin{matrix} \pi^- + \pi^+ + B \\ \pi^+ + \pi^+ + C \end{matrix}$$ (112 events)

$\cos\Theta$	$d\sigma/d\Omega$ (rel.unity) in the lab syst. of coordinates	$d\sigma/d\Omega$ (rel.Unity) in the center of mass system
1,0 - 0,6	236 ± 25	139 ± 31
0,6 - 0,2	40 ± 10	81 ± 17
0,2 - -0,2	91 ± 29	32 ± 7
-0,2 - -0,6	75 ± 18	88 ± 24
-0,6 - -1,0	36 ± 9	139 ± 22

Table 2.

Whole number of "stars"	Scanning	Nº of prongs in the "stars"											Average Nº of prongs pro "spar"
		1	2	3	4	5	6	7	8	9	10	11	
		Nº of "stars" %											
142	Along the track	6	19	21	18	13	13	5	~1	~1	<1	<1	3,8
3258	Area	2	18	17	21	18	14	6	3	~1	<1	<1	4,2

T a b l e 3.

№№ пп	The interaction process π^+ - nucleus	Cross Sect. mb.	Scheme of the "star" registered in the photo-emulsion stack
1.	$\pi^+ +$ ядро $\to \pi^-$	$1,5 \pm 0,4$	
2.	$\pi^+ +$ ядро $\to \pi^- + \pi^+$	$0,3 \pm 0,1$	
3.	$\pi^+ +$ ядро $\to \begin{cases} \pi^+ + \pi^- \\ 2(\pi^+ + \pi^+) \end{cases}$	$0,7 \pm 0,2$ *	
4.	$\pi^+ +$ ядро $\to \pi + \pi$	~ 1	

* The value of the cross section was measured in the interval of energy for the stopping π^+-mesons from 0 to 40 MeV.

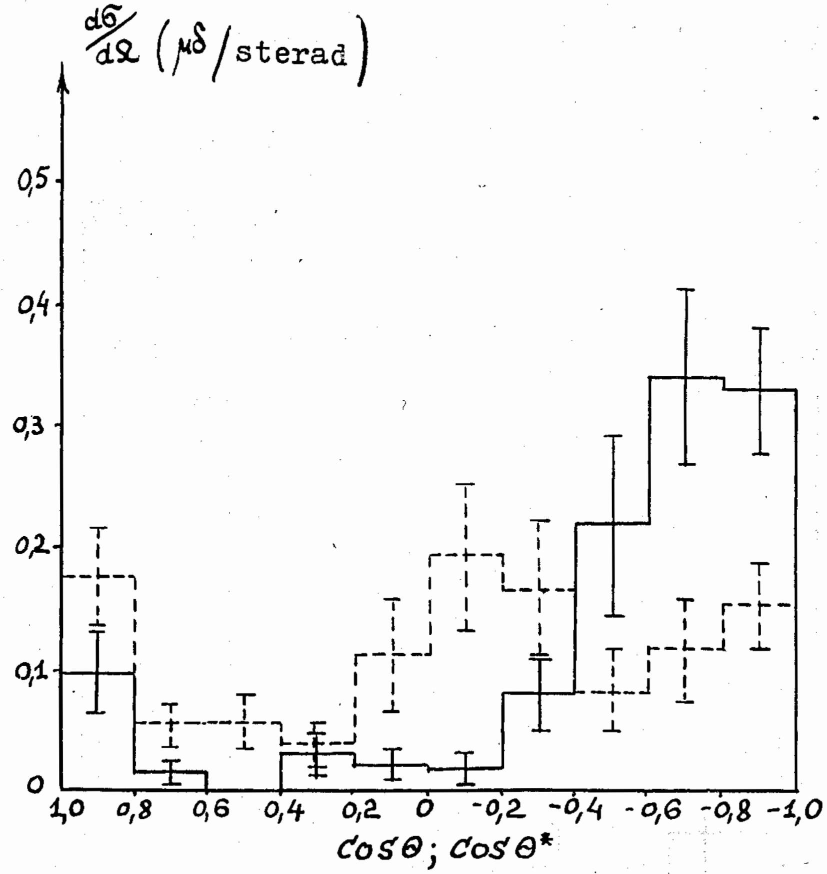


Fig.4. Angular distribution of the π^--mesons produced in the processes $\pi^+ + A \rightleftarrows {\pi^- + \pi^+ + B \atop \pi^- + B'}$

—— c.m.s.

- - - lab.syst.

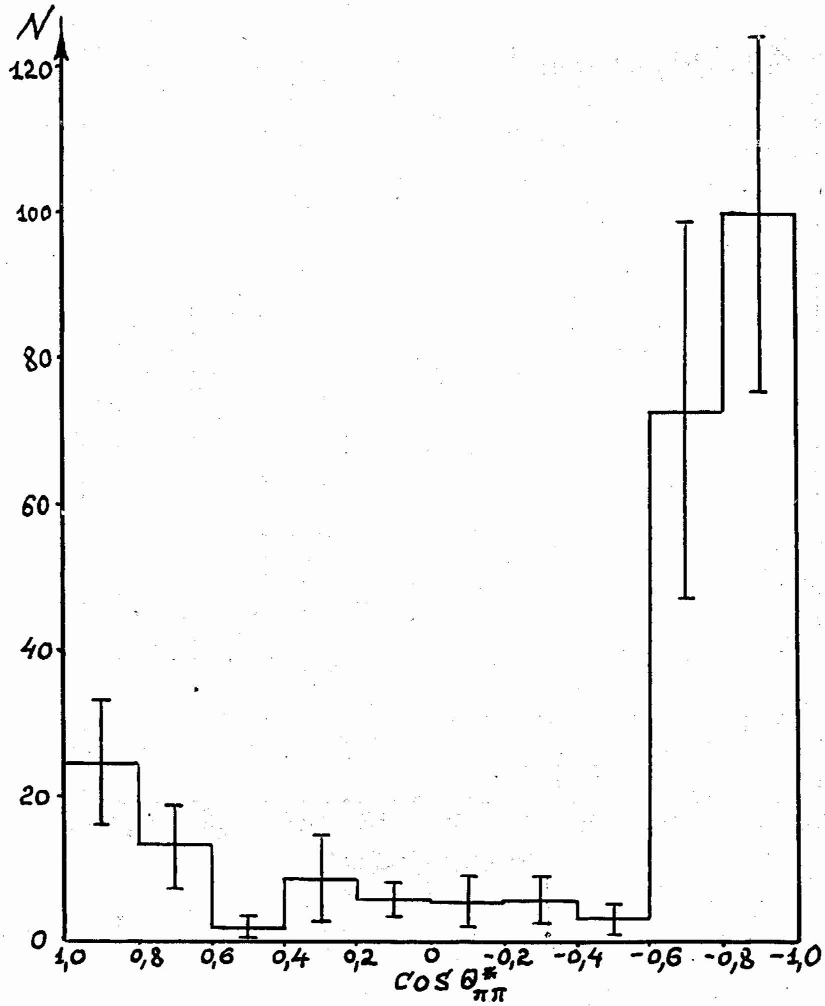


Fig.5. Distribution of the angles between the impulses of secondary mesons.

Estimating the cross seotion for the reaotion $\pi^+ + n \rightarrow \pi^+ + \pi^- + p$ from the data of the cross seotion for π^- and π^+ produotion in the reactions (1) and (2) (see Table 3) and taking into acoount the absorbtion of mesons, we obtain the value (0.3 $\pm$ 0.2) mb.* The value of the cross seotion for the reaotion $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ computed theoretioally in |11| and |12| for an incident energy of the π -meson of 280 MeV is approximately equal to 0.I mb.

Out of 106 desintegrations with at least one π^+ -meson, there were observed 3 events $\pi^+ + p \rightarrow \pi^+ + \pi^+ + n$ and two events $\pi^+ + p \rightarrow \pi^+ + \pi^\circ + p$. The cross section for these processes at an incident energy of 280 MeV was estimated for being about 10^{-28} cm^2.

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* The oalcullus for the cross seotion on one nucleon as well as the value of the absorbtion probability are performed supposing that the part of π^- -mesons with an energy of (0 $\div$ 40) MeV, produced from the double charge-exchange of a π^+ -meson according to the scheme: $\pi^+ \rightarrow \pi^\circ \rightarrow \pi^-$ is not considerable.