in the system with the target mass $m_t = m_\pi$ (last line in the table). In nucleon interactions, such showers occur in exceptional cases.

The observation of asymmetrical showers due to pions makes it possible to tie together a number of other features noted by us earlier [5, 6] in pion interactions.

If the nucleon-nucleon and pion-nucleon interactions are the same in the symmetrical system, then the average particle energies in the L system will obviously differ by the factor γ_s/γ_c:

$$\langle\epsilon\rangle_\pi/\langle\epsilon\rangle_p = \langle\gamma_s/\gamma_c\rangle \sim 3{,}0/1{,}2 = 2{,}5,$$

where $\langle\epsilon\rangle_\pi$ and $\langle\epsilon\rangle_p$ are the average energies of the pions in the L-system in the pion and nucleon interactions, respectively.

It follows therefore that the average multiplicity of the secondary particles in pion interaction should be smaller than in nucleon interactions. If we assume that the same fraction of energy is transferred to the common system, $\langle k\rangle = \langle k\rangle_\pi = \langle k\rangle_p$, then

$$\frac{\langle n\rangle_\pi}{\langle n\rangle_p} = \frac{\langle k\rangle_\pi \langle\epsilon\rangle_p}{\langle\epsilon\rangle_\pi \langle k\rangle_p} \sim (2{,}5)^{-1}$$

(see the table and the multiplicity distribution in Fig. 2).

It is interesting to note that an investigation [7] reported in this issue and performed with the Serpukhov accelerator at 50 GeV energy confirms the existence of showers due to pions, with properties described in the present article, is confirmed (the presence of a large percentage of showers that are asymmetrically forward and have a low multiplicity).

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CERTAIN CHARACTERISTICS OF NUCLEAR INTERACTIONS OF π^- MESONS WITH MOMENTUM 50 GeV/c

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1. Emulsions of BR-2 type 600 μ thick (measuring 10 x 10 cm) were irradiated in the accelerator of the High-energy Physics Institute by the extracted μ^- meson beam with momentum 50 GeV/c (± 0.5 GeV/c). The radiation density was $8{:}10^3$ cm^2, the angle scatter of the beam was approximately 0.1°. The beam composition was: $\pi \sim 97\%$, $K < 1\%$, $\mu \sim 0.5\%$, $\bar{p} < 0.1\%$, and $e \sim 1.5\%$.

2. In order to find the nuclear interactions, along-the-track scanning of 70.9 meters

of tracks was carried out, and 184 interactions were found. After eliminating the elastic π-N scattering and diffraction interactions on the nuclei, and taking into account the beam composition, we obtained for the mean free path of the inelastic interaction of the π^- mesons with emulsion nuclei

$$\lambda = 40.0 \pm 3.0\ \text{cm}^{1)}.$$

We consider below the characteristics of quasinucleon interactions (the selection criteria are [1]: $N_h = N_b + N_g \gtrsim 3$, $N_g \lesssim 1$, n_s arbitrary, where N_b - number of "black" tracks, N_g - number of "gray" tracks, n_s - number of relativistic particles). We eliminated from consideration both elastic scattering (events of the type $n_s = 1$ with emission angle $\theta_L \gtrsim 0.3°$) and diffraction interaction on nuclei, namely events of the type $0^+0 + 3_-$, satisfying the condition $\sum_1^3 \sin\theta_L < A^{-1/3}$, where A = 108.

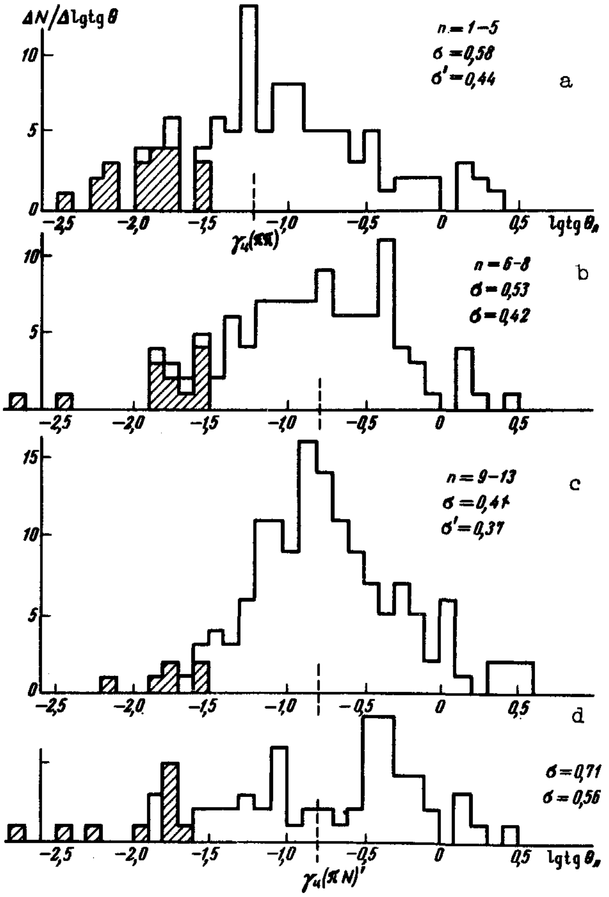

Fig. 1. Angular distributions of secondary particles at different multiplicities n: a) 37 events, b) 16 events, c) 50 events, d) n = 5 - 8 and σ_i > 0.5 (per interaction) - 11 events. (σ - dispersion of angular distribution); σ' - the same when the energetically favored particle is eliminated (shaded parts of the histograms)).

3. The mean values of n_s and N_g for π-N and π-nucleus interactions are listed in the table.

	$\bar{n}_s$	$\bar{N}_g$
π-N interactions[2]	5,9 ±0,4	0,23 ±0,06
π-nucleus (all stars)	7,6 ±0,4	2,20 ±0,2
π-nucleus (except π-N)	9.5 ±0.5	4,00 ±0,3

4. The angular distributions of the secondary charged particles for different multiplicities ($n = n_s + N_g$) are shown in Figs. 1a - c. We see that at small multiplicities (n = 1 - 5), an appreciable forward asymmetry is observed in the angular distribution of the relativistic particles in the π-N c.m.s., but this angular distribution is symmetrical in the π-π system.

For events with n ≥ 6, the angular distributions are symmetrical in the π-system. In addition, for events with n = 5 - 8 and σ_i > 0.5 (Fig. 1d), the character of the angular distributions corresponds to the emission of particles from at least two centers

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[1] For the interactions of the protons with the emulsion nuclei we obtained λ = (35.0 ± 0.6) cm at a proton momentum 21 GeV/c

[2] $\bar{n}$ = 4.9 ± 0.1 for π^-p interactions at 25 GeV/c [2].

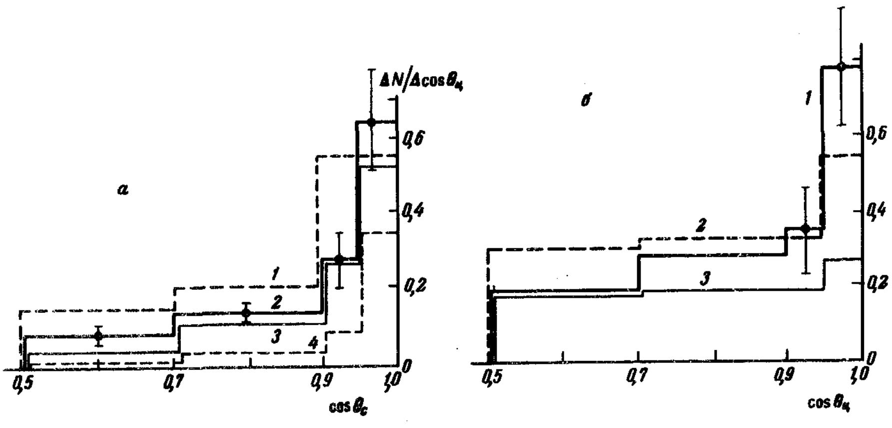

Fig. 2. Angular distributions of secondary particles (per interaction) in the c.m.s.: a) for the interactions: 1) π^-p, 16 GeV/c, reaction $\pi^-p \to p2\pi^+3\pi^-$, 2) π^-N, 50 GeV/c, n = 1-5 (37 events); 3) pN, 24 GeV/c, n = 1-5 (124 events, including those for protons, distribution 4); b) for the interactions: 1) π^-N, 50 GeV/c, $n \geq 6$ (31 events), 2) the same, $n \geq 9$ (15 events); 3) pN, 24 GeV/c, n = 6-11 (28 events)

(since the probability that the true angular distribution in the region log tan $\theta_L = 2.0 - 0.3$ has no dips does not exceed 0.5% ($P(\chi^2) = 4 \times 10^{-3}$).

5. Energetically favored particle. The angular distributions of the charged particles in the π-N c.m.s.[3] for different values of n are shown in Figs. 2a - b. It follows from Fig. 2a that for small multiplicities (≤ 5) in the angle interval $\cos\theta_c > 0.95$ ($\theta_L < 1.8°$) there is on the average an excess of about 0.5 particle per star. In approximately half of the events (20 out 37) there is an energetically favored particle that carries away at least 20% and on the average (54 ± 6)% of the initial energy. As seen from the same figure, a preferred angle is possessed by a small number of particles, to approximately the same degree, also in π^- interactions at 16 GeV/c with total multiplicity n = 6 [3] (in our case n = 3.2 for some charged particles) and for quasinucleon pN interactions at 24 GeV/c with multiplicity n = 1 - 5. Direct measurements have shown (in both cases) that this effect is connected precisely with the presence of a preferred energy (and not with fluctuations of the transverse momenta), and approximately 2/3 of the preferred particles are protons in the pN interactions. It follows from Fig. 2b that when $n \geq 9$, only about 20% of the events include a particle with a preferred angle.

6. Momentum carried away by neutral particles. Let us consider the total momentum carried away by all the charged particles. It can be determined from the formula

$$P_\pm = \bar{p}_\perp \sum_1^{n_s} \sin\theta_L^{-1}.$$

Direct measurements of the transverse momenta were made by us for 40 particles in the angle interval $\theta_L = 0.5 - 10°$ and yielded the value $\bar{p}_\perp = 0.3$ GeV/c (± 10%). This quantity agrees with the data on π^-p interactions at 16 GeV/c. This momentum carried away by the neutral

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[3] The conversion to the c.m.s. was made under the assumption that the transverse momentum of the particle is constant, $\bar{p}_\perp = 0.3$ GeV/c (see below), and the subsequent energy estimates are made under the same assumption.

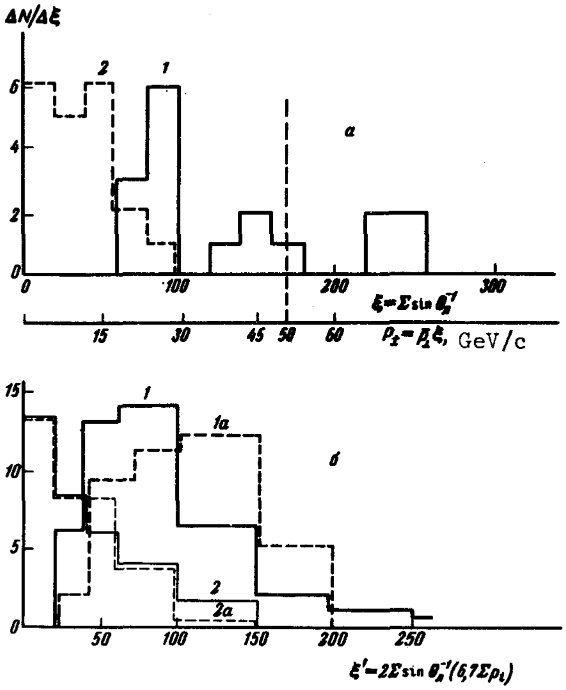

Fig. 3. Distribution with respect to the total energies of the charged particles (assuming $p_\perp = 0.3$ GeV/c): a) π^-N, 50 GeV/c, n = 1 - 5, in the presence (distribution 1) and absence (distribution 2) of particles with $\theta_L < 1.8^\circ$; b) pN, 24 GeV/c, n = 1 - 5, in the presence (distribution 1) and absence (distribution 2) of a fast secondary proton ($\theta_C < 90^\circ$); dashed lines-corresponding distributions obtained by direct measuremeent of the particle momenta.

particles is $P_0 = P - P_\pm$ and the corresponding inelasticity coefficient is $K_0 = P_0/P$ (P - momentum of primary π^- meson). From an analysis of the data shown in Fig. 3a, it follows that for interactions with $n \leq 5$ we have in approximately half the cases $K_0 > 0.65$ and $\bar{K}_0 \approx 0.80 \pm 0.03$.

As seen from Fig. 3b, a perfectly analogous picture is obtained also for quasinucleon pN interactions with momentum 24 GeV/c subject, however, to the condition that the number of neutral particles include also the fast neutrons. When the "leading" particle is the proton, on the other hand, events with $K_0 > 0.65$ are very rare. In exactly the same manner, for πN interactions with n = 6 - 13, the values $K_0 > 0.65$ are encountered quite rarely, in approximately 15% of the cases (Fig. 3b).

The foregoing analysis of the angular distributions makes it possible to formulate the following main conclusions concerning the properties of the inelastic interactions of 50 GeV/c π^- mesons with quasi-free nucleons of emulsion nuclei:

1) In the meson-nucleon c.m.s., the angular distribution of the produced charge particles has an appreciable forward asymmetry in approximately 50% of the cases.

2) In a noticeable fraction of all cases (approximately 25%), the interactions are characterized by a transfer of an appreciable fraction of the energy (on the average about 80%) to the neutral mesons (which in these cases include one or more energetically favored particles).

3) At a multiplicity $n \leq 5$, one particle with a preferred emission angle ($\cos\theta_c > 0.95$) appears among the charged secondary particles, with a probability of approximately 50%, and carries away more than 20% (on the average approximately 50%) of the initial energy.

4) When the multiplicity increases to 6 and more charged particles, all the foregoing singularities of the process are gradually lost.

Comparison with accelerator data on π^-p interactions at 8 and 16 GeV/c[3] and with data on cosmic rays (for interactions of pions with light nuclei) at an average energy 200 GeV [4] offers evidence that the indicated effects increase with increasing energy of the primary pion.

However, to obtain more definite information on the "leading" particle and on the energy characteristics of the remaining secondary particles, and to permit comparison with the theoretical interaction models, it is necessary to know the signs of the charges and also the exact values of the momenta of at least the charged mesons. Such data can be obtained with emulsions irradiated in pulsed magnetic fields of 200 - 300 kOe intensity.

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ANTIFERROMAGNETIC RESONANCE IN $NiCl_2$

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Layered halides of transition metals of the iron group are characterized by the prescence of a strong ferromagnetic interaction in the layers of the magnetic ions and relatively weak antiferromagnetic interaction between the layers; their magnetic properties were first predicted by Landau [1].

In anhydrous nickel chloride ($NiCl_2$), the Ni ions are arranged in layers that alternate with the halide layers; the symmetry axis C_3 is perpendicular to the layers, and three twofold axes lie in the plane of the layer (the crystal structure of $NiCl_2$ is of the type D_{3d}^5).

$NiCl_2$ becomes antiferromagnetic at $T_N \sim 52°$ K, and is fully isotropic below T_N [2]. It can therefore be assumed that the spins lie in the basal plane of the crystal, where the anisotropy is small and the magnetizations of the sublattice are perpendicular to the field in a relatively weak field.

As shown by the theory [3], in layered antiferromagnets with anisotropy of the "easy plane" axis, as well as in ordinary antiferromagnets with a sublattice magnetization lying in