Angular dependence of the yield of low-energy $\pi^{\pm}$ mesons

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Invariant cross sections and mass spectra were measured for the photoproduction of $\pi^{\pm}$ mesons by 4.5 GeV γ-radiation on C^{12}, Cu^{63}, and Pb^{208}.

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To explain the production of cumulative particles, a number of theoretical models,[1-5] which assume, as a rule, the existence of exotic states in nuclei [such as large momenta (~ 1 GeV/c) in the single-particle state of nucleons,[1] a strong pair correlation, triple correlation, and other correlations,[2] significant accumulation of nucleons in the nucleus,[3] accumulation during interaction[4] or after it,[5] etc.] have been proposed. At present, however, the aggregate of experimental data on the cumulative production is difficult to explain by using these models. Meanwhile, the contribution of the processes not requiring special assumptions, in our view, must be evaluated in greater depth. The contribution of the interaction in the final state may be singled out as one such process. Kopeliovich[6] attempted to estimate the role of secondary rescatterings by nuclear nucleons of the cumulative particles, which lead to a "turn" to the cumulative region. However, the experimental dependences of the yield of the cumulative particles from the atomic nucleus are difficult to explain in terms of this mechanism (in the region of small A the yield must decrease greatly, since the number of rescatterings decreases with decreasing A, which was not observed experimentally).

It was assumed in Ref. 7 that the contribution to the production of cumulative protons due to reabsorption of slow particles produced in the interaction of an incident particle with a quasi-free nucleon of the nucleus (absorption of π, K, and ρ mesons) is large. If, for example, a stopped π meson is absorbed by a nucleon pair (by a quasi deuteron), then the maximum momentum of the secondary protons is $P_p^{\max} \approx 0.4$ GeV/c, and if it is absorbed by a ρ-meson pair, then $P_p^{\max} \approx 0.9$ GeV/c.

To correctly determine the contributions of the reabsorptions of the secondary slow mesons, we must know the yield of these particles, particularly their angular distributions.

In this paper we give the experimental distributions of the photoproduction yield of low-energy $\pi^{\pm}$ mesons as a result of irradiation of different nuclei by bremsstrahlung gamma-ray quanta with a maximum energy of 4.5 GeV (the experimental results[8-10] of the photoproduction of cumulative protons were obtained under the same conditions). The data are given for the back hemisphere, since the contribution of these $\pi^{\pm}$ mesons to the cumulative-proton yield seems to be small.

The $\pi^{\pm}$ mesons (without determining the sign of the charge) were identified by a range telescope[11] in the kinetic-energy region of 45–160 MeV. Figure 1 shows the mass spectra of the detectable particles from the C^{12} nucleus for different energies. As can be seen, the π mesons and protons are resolved with almost 100% efficiency. The

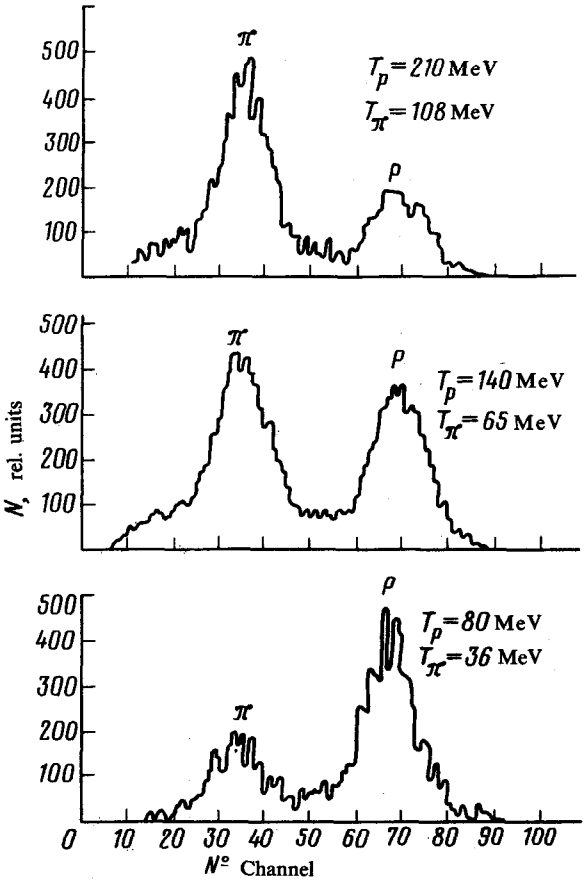

FIG. 1. Mass spectrum of the particles recorded by a range telescope: "*II*" represents the $\pi^{\pm}$—meson peak and "*P*" denotes the proton peak.

number of secondary π mesons was calculated from the area under the "*II*" peak in Fig. 1.

The yield of the $\pi^{\pm}$ mesons was corrected for the nuclear absorption (9–48%) and for the multiple scattering ($53 \pm 72\%$) in the target and in the telescope, for the decrease of the number of primary gamma-ray quanta due to paraproduction in the target (1.5% for C^{12} and 15% for Pb^{208}), for the decay on the film (8.6–12%), and for the recording efficiency of the telescope.

Figure 2 shows the dependences of the invariant cross section

$$f = \frac{E}{p^2}\frac{d^2\sigma}{d\Omega dp}$$

for photoproduction of $\pi^{\pm}$ mesons on the recording angle in the laboratory system.

The statistical errors are not larger than the values of the symbols.

The given angular distributions are fairly close to those of the photoprotons recorded under the same conditions.[8]

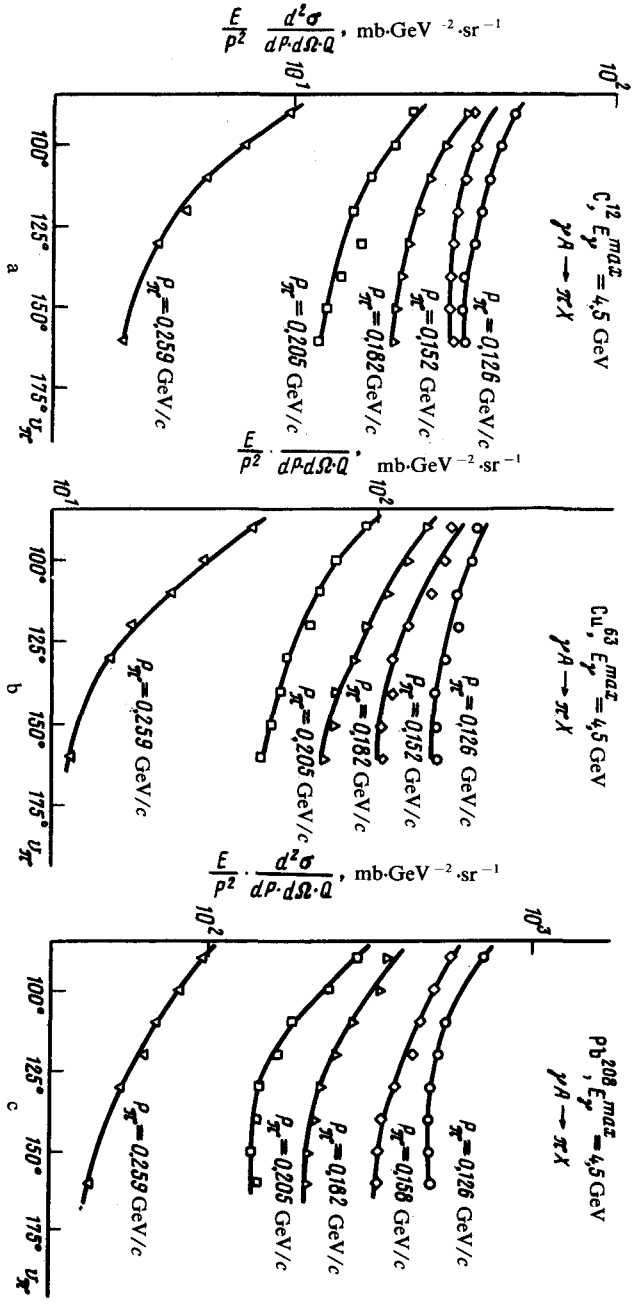

FIG. 2. Angular dependence of the invariant cross section $f = \frac{E}{p^2}\frac{d^2\sigma}{d\Omega dp}$ of the $\gamma A \to \pi X$ reaction induced by nuclei at the maximum energy of 4.5 GeV of the bremsstrahlung γ-ray quanta: a, b, c, cross sections for C^{12}, Cu^{63}, and Pb^{208} nuclei, respectively. ○, 0.126-GeV/c momentum of the $\pi^\pm$ mesons; ◇, 0.152 GeV/c; Δ, 0.182 GeV/c; □, 0.205 GeV/c; ▽, 0.259 GeV/c.

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