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THE PROTON SPECTRUM IN INELASTIC π^--N COLLISIONS

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Abstract: Experimental data are compared with respect to spectra and average number of protons in inelastic π^-–N scattering at 7 GeV. It is shown that at present there are no sufficient data to conclude that there are two maxima in the momentum spectra of protons, the explanation of which would require a complicated resonance variation of the π–π interaction cross section with energy.

There have been experimental indications [1-3]) of two maxima in the momentum spectrum of protons from inelastic π^-–N interactions at 7 GeV/c (solid line of fig. 1).

In particular these data were used theoretically [4]) to conclude that there are two interaction mechanisms characterized by a different inelasticity of collisions. A complicated resonance variation of the π–π interaction with energy was needed [5]) to coordinate the proton spectrum given in fig. 1 with single-meson theory predictions.

Fig. 1. Momentum distribution of protons from inelastic π^-–N interactions at 7 GeV/c. from ref. [2]) (solid line) and from ref. [12]) (dashed line).

In this paper we intend to show that at present there are insufficient experimental grounds to warrant the conclusion of the "two-hunch" character of the momentum distribution of protons.

In experiments [6]) 130 protons were registered, which determined the choice of the interval 0.4 GeV/c. The spectrum is represented in fig. 2. It is clear that with this division no anomalies such as two maxima were observed.

The proton momentum distribution in the c.m.s. represented in fig. 1 (dashed line) has been given previously [1, 12]). It is clear that the position of the peaks is different from that in ref. [2]). The number of protons in ref. [12]) was 82.

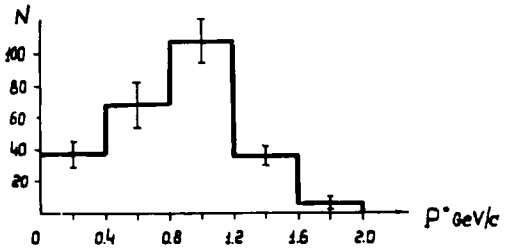

Fig. 2. Proton momentum spectrum from ref. [6]).

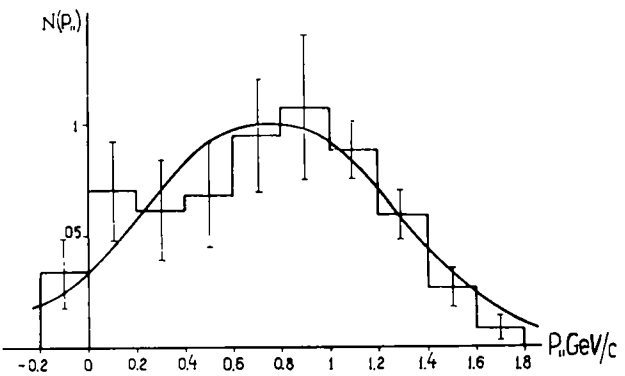

Fig. 3. Distribution of longitudinal momenta of protons from ref. [8]) compared with the Gaussian distribution.

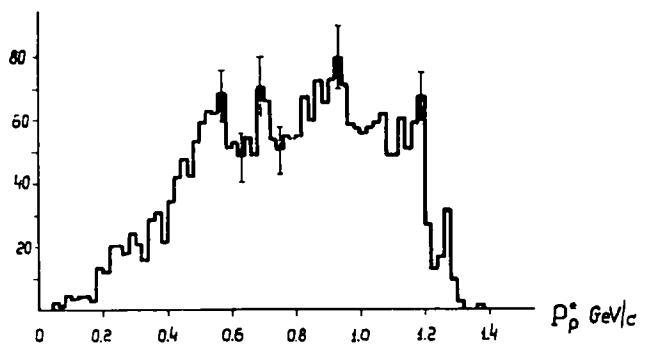

Fig. 4. Proton momentum distribution (c.m.s.) from π^-–p-interactions at 4 GeV/c according to the data of refs. [9, 10]).

Let us note that plotted on the basis of the experimental data of ref. [6]), the distribution of the longitudinal momenta of protons agrees with a Gaussian distribution (fig. 3) and the distribution of transverse momenta [6, 7]) is described by a two-dimen-

sional Maxwell distribution [8]):

$$\frac{dN}{dp_\perp} = 2p_\perp \langle p_\perp^2 \rangle^{-1} \exp(-p_\perp^2/\langle p_\perp^2 \rangle).$$

It can be supposed that apart from scanty statistics, the appearance of two maxima in the proton momentum distribution [1,3]) was also caused by a considerable loss of protons in the identification of the particles. Thus in ref. [1]), the average number of protons per event was only 0.27 compared with 0.44 ± 0.04 in ref. [6]).

Calculations for the statistical multiple production theory which agree with the experimental data for average characteristics of the events give for the π^-–p and π^-–n events 0.43 proton per interaction (0.47 for π^-–p events at 7 GeV/c).

The above considerations have been repeatedly discussed with the authors of refs. [1–3]) and have recently been confirmed by inelastic π^-–p interaction experiments for π^--meson momenta of 4.0 GeV/c (refs. [9,10])) and 10 GeV/c (ref. [11])). Fig. 4 represents the proton momentum distribution in the c.m.s. of π–N from refs. [9,10]). The distribution contains about 2500 protons. The shape of the spectrum permits no halving. Small deviations from the smooth curve perhaps reflect the influence of the resonant states ($\rho, f, \ldots$). The average number of protons (per interaction is 0.46 (refs. [9,10])) and 0.5 (ref. [11])).

On the basis of the above discussion and taking into account the fact that other characteristics of the interactions under discussion (e.g. the spectra of secondary pions) do not show any structure (to which attention was drawn also in ref. [4])), it can be concluded that there are no grounds as yet for isolating two maxima in the proton spectrum and theoretical conclusions on the basis of such a spectrum.

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