PRODUCTION OF CHARGED MESONS BY 290 Mev π^- MESONS ON HYDROGEN

Yu. A. BATUSOV, S. A. BUNYATOV, V. M. SIDOROV, and V. A. YARBA

Joint Institute for Nuclear Research

Submitted to JETP editor September 1, 1960

J. Exptl. Theoret. Phys. (U.S.S.R.) **40**, 460-463 (February, 1961)

The $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ reaction is investigated. The experimental data are compared with the theoretical calculations.

THE present communication is a continuation of an investigation of the momentum and angular distribution of secondary particles in the reaction

$$\pi^- + p \rightarrow \pi^+ + \pi^- + n \qquad (1)$$

at primary-meson energy of (290 ± 15) Mev.[1]

We present here an analysis of 250 cases of reaction (1) with the same primary-meson energy. The experiment was performed in the synchrocyclotron of the Laboratory for Nuclear Problems of the Joint Institute for Nuclear Research, using nuclear emulsions. The procedure for the detection of meson production and the selection criteria are described in reference 1.

The momentum spectra and the distributions of the angles between the momenta of the secondary particles are compared with the calculations based on the Fermi statistical model and on the Lindenbaum and Steinheimer isobar model. The calculations were carried out by the "random star" method,[2] using an electronic computer. The average accuracy of the theoretical histograms is 5 percent. The results of the calculations, together with the experimental data, are shown in Figs. 1 and 2.*

The comparison shows that although the statistical theory and the isobar model predict correctly the main features of the spectra and the distributions of the angles between the momenta of the secondary particles, no satisfactory quantitative agreement with experiment is observed. Thus, the maximum of the neutron spectrum (Fig. 1) is noticeably shifted towards the lower momenta. The distribution of the angles between the momenta of the secondary pions (Fig. 2) indicates that the mesons have a greater probability of diverging by larger angles than given by the theoretical calculations. We list below the average scattering angles (in degrees).

	Experiment	Statistical theory	Isobar model
$\bar{\theta}^*_{\pi^+\pi^-}$	116.7 ± 2.4	102.2	98.1
$\bar{\theta}^*_{\pi^+ n}$	113.4 ± 2.5	128.6	123.9
$\bar{\theta}^*_{\pi^- n}$	129.3 ± 2.4	129.4	141.0

The angular distributions of the secondary particles relative to the direction of the primary meson are shown in Fig. 3. It should be noted that the statistical theory and the isobar model do not make it possible to calculate these distributions.

It was shown in an earlier paper[3] that the distribution over the relative momenta of the secondary particles agrees with the theoretical distribution obtained by Ansel'm and Gribov for reactions in which an additional meson is produced near threshold.[4] One can hope that this theory, which takes account of the interaction of the particles in the final state, will produce better agreement with experiment at our energy. Thus, for example, the average scattering angles between the secondary particles, calculated by the Kopylov method[5] with the aid of a matrix element of the form[4] $S^2 = 1 + ck_{12} + dk_{13}$, with parameters c and d as determined in reference 3, are

$$\bar{\theta}^*_{\pi^+\pi^-} = 109.0°, \quad \bar{\theta}^*_{\pi^+ n} = 119.0°, \quad \bar{\theta}^*_{\pi^- n} = 131{,}0°$$

and are in better agreement with the experimental data.

We plan to carry out calculations with variation of the coefficients c and d (within the limits of the experimental errors).

The authors express their gratitude to Prof. V. P. Dzhelepov and L. I. Lapidus for interest and attention to the work, and also to G. I. Kopylov for great help in the computations and evaluation.

*In comparing the experimental results with the calculations based on the isobar model it was assumed that the negative pion is always of isobaric origin, and the positive pion is always due to recoil. The momentum spectrum of the neutrons and the distribution of the angles between the meson momenta are independent of this assumption.

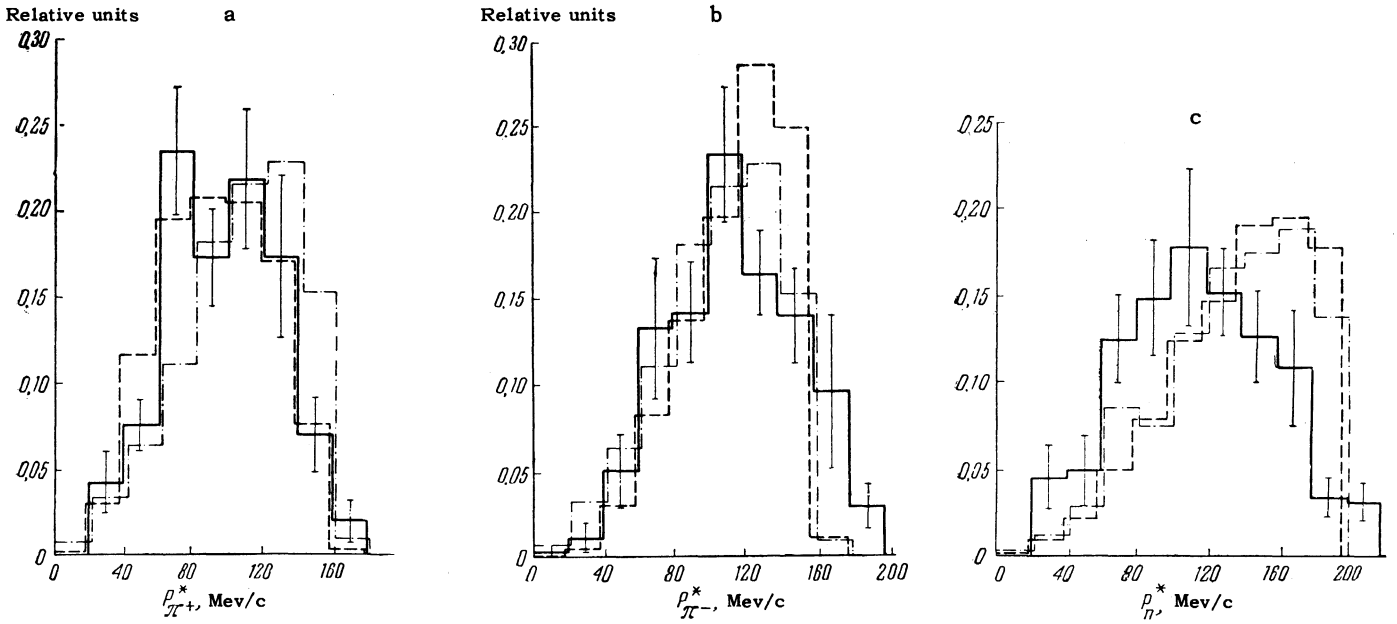

FIG. 1. Momentum distributions in the c.m.s. for secondary particles from the reaction $\pi^- + p \to \pi^+ + \pi^- + n$ (250 events); a – positive pions, b – negative pions, c – neutrons. Solid line – experiment, dotted line – calculated by the isobar model, dash-dot line – calculated by statistical theory.

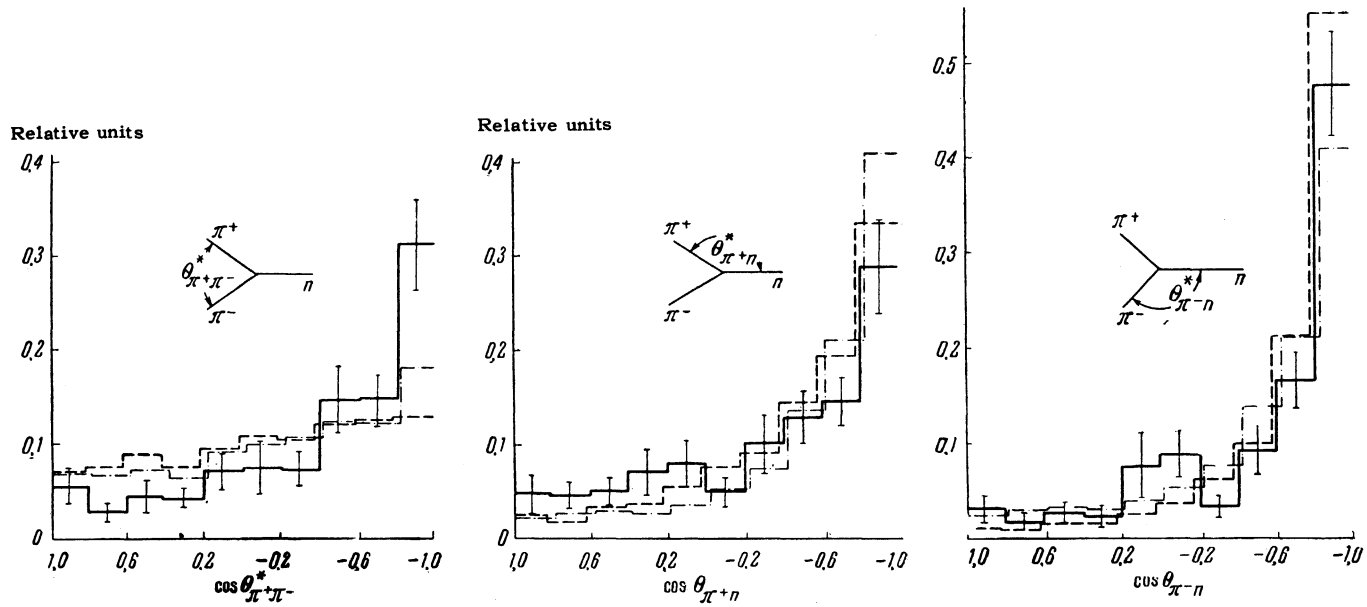

FIG. 2. Distributions of the angles between the momenta of the particles from the reaction $\pi^- + p \to \pi^+ + \pi^- + n$ in the c.m.s. (250 events). Solid line – experiment, dotted line – calculated by the isobar model, dash-dot line – calculated by the statistical theory.

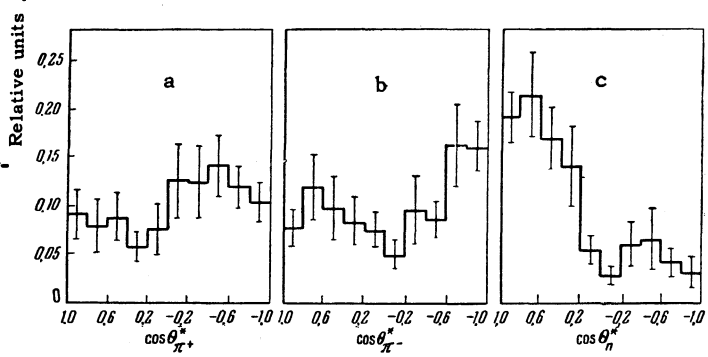

FIG. 3. Angular distribution in the c.m.s. for secondary particles from the reaction $\pi^- + p \to \pi^+ + \pi^- + n$ (250 events): a – positive pions, b – negative pions, c – neutrons.

[1]Batusov, Bogachev, Bunyatov, Sidorov, and Yarba, Dokl. Akad. Nauk SSSR **133**, 52 (1960), Soviet Phys.-Doklady **5**, 731 (1961).

[2]G. I. Kopylov, JETP **35**, 1426 (1958), Soviet Phys. JETP **8**, 996 (1959).

[3]Batusov, Bunyatov, Sidorov, and Yarba, JETP **39**, 506 (1960), Soviet Phys. JETP **12**, 354 (1961).

[4]A. A. Ansel'm and V. N. Gribov, JETP **37**, 501 (1959), Soviet Phys. JETP **10**, 354 (1960).

[5]G. I. Kopylov, JETP **39**, 1091 (1960), Soviet Phys. JETP **12**, 761 (1961).

Translated by J. G. Adashko
69