Elastic backward scattering of negative pions by protons at 25 and 38 GeV/c

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We investigated the backward elastic $\pi^- p$ scattering at primary momenta 24.7 and 37.8 GeV/c using a magnetic spectrometer with hybrid spark chambers. Experimental results are presented on the dependence of the differential cross section $d\sigma/du$ on the squared momentum transfer u, and also on the energy dependence of $d\sigma/du$ at $u = 0$.

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We investigated the backward elastic scattering π^{-1} mesons by protons at primary momenta 24.7 and 37.8 GeV/c.[1)] The experiment was performed with the Serpukhov synchrotron using a spectrometer with wire spark chambers and hybrid chambers.[1] We measured in the installation the angles of all the particles and the momentum of the scattered proton. The events were recorded on magnetic tape and reduced by a geometric-reconstruction program. The events with admissible values of χ^2 were verified for the elastic kinematics. For the events with admissible momentum of the forward-traveling particle we constructed the $\Delta N/\Delta \cos\theta$ distribution, where θ is the angle between the pion direction, calculated in accord with the elastic kinematics, and the experimentally observed direction. This distribution had a sharp peak, the shape of

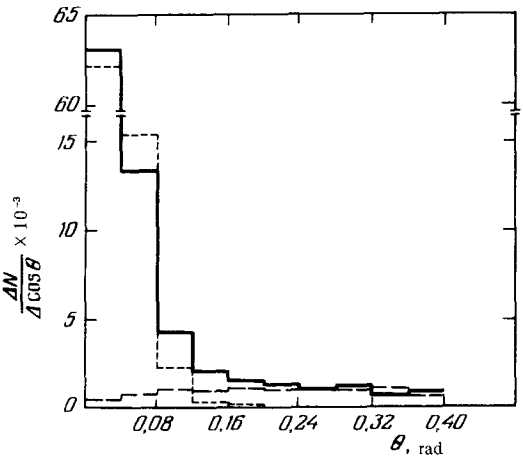

FIG. 1. Distribution of $\Delta N/\Delta \cos\theta$ vs. the angle θ between the pion direction calculated from the elastic kinematics and the measured direction. Solid line—experiment, long dashes—approximation of the background, short dashes—calculations by a Monte Carlo program.

TABLE I. Differential cross section of backward elastic $\pi^- p$ scattering at 24.7 and 37.8 GeV/c. The cited errors include the statistical ones and the systematic errors that are independent of u.

P_0 = 24.7 GeV/c				P_0 = 37.8 GeV/c			
u (GeV/c)^2	Δu	$d\sigma/du$ nb/(GeV/c)^2	error	u (GeV/c)^2	Δu	$d\sigma/du$ nb/(GeV/c)^2	error
− 0.060	0.02	199	106	− 0.100	0.02	67	50
− 0.040	0.02	146	54	− 0.080	0.02	89	38
− 0.025	0.01	105	38	− 0.060	0.02	65	22
− 0.015	0.01	228	63	− 0.045	0.01	57	23
− 0.005	0.01	200	53	− 0.035	0.01	67	23
0.005	0.01	326	72	− 0.025	0.01	84	23
0.0128	0.0055	384	135	− 0.015	0.01	117	26
—	—	—	—	− 0.005	0.01	162	29
—	—	—	—	0.005	0.01	186	41

which agreed well with the corresponding distribution obtained for the elastic events by a Monte Carlo program, and had a practically uniform background. A typical distribution is shown in Fig. 1.

The background admixture in the region of the elastic peak was estimated by extrapolation from the region 0.12—0.5 rad. The contribution of the $\pi^- p \to pp^-$ reaction was taken into account in the determination of the shape of the background. The fraction of the background in the elastic peak turned out to be 7%

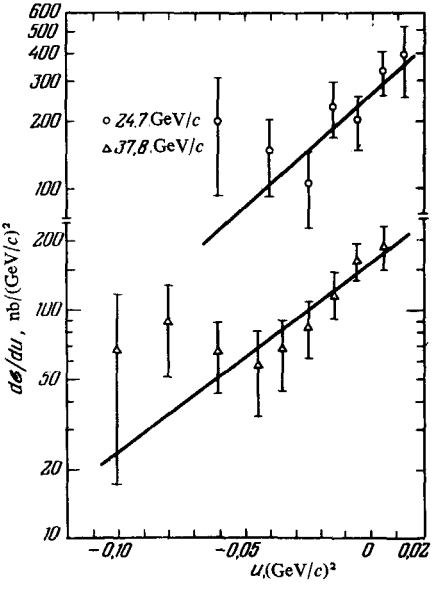

FIG. 2. Dependence of the differential cross section of $\pi^- p$ backward scattering on u. The parameters of the lines are given in the text.

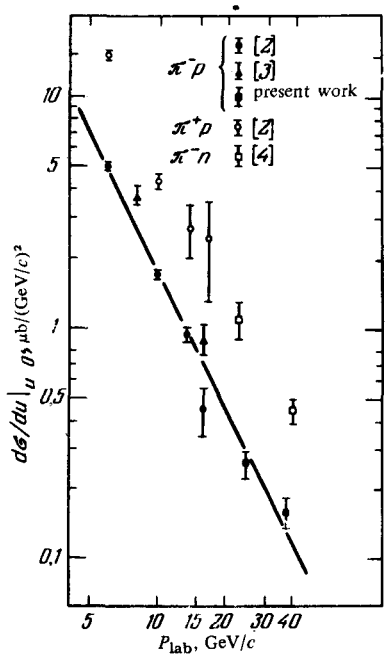

FIG. 3. Dependence of $d\sigma/du$ ($u=0$) on the primary momentum (our data together with the data of[3–5].

in both energies. The efficiency of the installation was calculated in accord with the Monte Carlo program. Besides the geometric limitations, we took into account the Coulomb scattering and absorption of the particles in the apparatus material, the efficiencies of the electronic circuitry and of the chambers, and also the efficiency of the reduction programs. In addition, in the calculation of the differential cross section we introduced a radiative correction[2] to account for the event loss due to violation of the elastic kinematics on account of bremsstrahlung.[2)] The radiative correction was calculated for the given geometry of the installations and the kinematic-selection criteria. It turned out to be independent of u in the investigated range of u and equal to 42 and 46% respectively for the primary momenta 24.7 and 37.8 GeV/c, respectively.

The obtained differential cross section are listed in Table I and shown in Fig. 2. The errors indicated there do not include the uncertainty of the absolute normalization, which is equal to 30% at both energies. The differential cross sections were approximated by a function in the form $d\sigma/du = A\exp(Bu)$ in the ranges $|u| \leq 0.06$ and $|u| \leq 0.1$ (GeV/c)^2, respectively. The following parameter values were obtained:

$A = 262 \pm 37$ and 160 ± 22 nb/(GeV/c)^2,

$B = 23 \pm 8$ and 19 ± 5 (GeV/c)$^{-2}$ at momenta 24.7 and 37.8 GeV/c, respectively.

Our data point to a large slope B in the indicated narrow range of u in comparison with the data of[3,4], which were obtained at lower energies and in a wider range of u. The slopes turned out to be close to the slope in backward π^-n scattering,[3)] 26 ± 6 (GeV/c)$^{-2}$ at 40 GeV energy.[5] Figure 3 shows the en-

ergy dependence of $d\sigma/du$ $(u=0)$. For comparison we show also the π^-p, π^+p, and π^-n data.[3,5] Our results continue the previously observed energy dependence of $d\sigma/du$ $(u=0)$ in the π^-p reaction. If it is assumed that the cross section $d\sigma/du$ $(u=0)$ of the reaction $\pi^-p\to p\pi^-$ is proportional to P^n_{1ab}, then the exponent turns out to be $n\approx 2.0$ (from our data jointly with those of[3]). The corresponding line is shown in Fig. 3.

In models with straight-line Regge trajectories it is predicted that the cross section of ^+p backward scattering decreases more rapidly than that of backward ^-p scattering. It was predicted in[6], in particular, that at energies ~ 35—50 GeV the cross section for elastic π^-p scattering through 180° exceeds the backward π^+p scattering cross section. As seen from Fig. 3, the differential cross section of the elastic π^-p and π^+p backward scattering do not intersect in the indicated energy interval and show no tendency to come closer together.

It has also been predicted[7] Within the framework of the quark model that at high energies the ratio of $d\sigma/du$ $(u=0)_{\pi+p}$ to $d\sigma/du$ $(u=0)_{\pi-p}$ is equal to four; this does not contradict our results.

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[1)]Preliminary results were reported at the Palermo 1975 international conference on high-energy physics.
[2)]We are grateful to Professor K. Winter for pointing out the problem of radiative corrections in backward hadron scattering.
[3)]It is the same isotopic channel as π^+p.

[1]A.I. Babaev *et al.*, Materialy seminara po obrabotke fizicheskoĭ informatsii (Proc. of Seminar on the Reduction of Physical Information), Agveran, September 1975, p. 94.
[2]M.R. Sogard, Phys. Rev. **D9**, 1486 (1974).
[3]D.P. Owen *et al.*, Phys. Rev. **181**, 1794 (1969).
[4]E.W. Anderson *et al.*, Phys. Rev. Lett. **20**, 1529 (1968).
[5]A. Babaev *et al.*, Phys. Lett. **38B**, 342 (1972).
[6]V. Barger and D. Cline, Phys. Rev. Lett. **21**, 392 (1968); E.L. Berger and G.C. Fox, Nucl. Phys. **B26**, 1 (1971).
[7]A.L. Lyubimov, JINR Preprint R 2-8588, Dubna, 1975.