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ELASTIC BACKWARD SCATTERING OF NEGATIVE PIONS ON NEUTRONS AT 23 AND 40 GeV/c

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Abstract

The differential cross sections of the elastic backward scattering reaction $\pi^- n \to n \pi^-$ has been measured at 23 and 40 GeV/c in the u-interval $-0.07 \leq u \leq 0.01$ $(GeV/c)^2$.

In this letter we present the results of the measurement of elastic reaction

$$\pi^- + n \rightarrow n \text{ (forward) } + \pi^- \text{ (backward)}$$

at 23 and 40 GeV/c *). The experiment was performed at Serpukhov Synchrotron by the optical spark chamber technique. The method used allowed one to select elastic events by reconstruction of the event kinematics using the angular measurements. On the other hand, the detection system was arranged so that to detect all particles (charged or not) coming from the target. Thus, one could pick up elastic events without making use of any kinematical constraints [1].

The experimental layout is shown in Fig.1. The pion beam incident on the D_2 target was defined by a scintillation counter telescope. A typical beam intensity was 5×10^5 particles per 500 msec burst. The one meter long cooled by liquid helium solid deuterium target was surrounded by 5 optical spark chambers to detect the backward scattered pion as well as any other particles or gammas coming from the target. All events with charged particles and γ's produced in forward direction were rejected by an anticoincidence system. Two spark chambers and scintillation counters were used to detect the forward going neutron. The beam particles were removed

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*) Preliminary results were reported at the XV-th International Conference on High energy Physics, Kiev, 1970.

from the neutron detector by a 6 m-sweeping magnet. The spark chambers were triggered by a coincidence between the beam telescope, pion counter and neutron detector and a veto of the anticoincidence system *).

After taking the data the pictures were scanned and all events with at least one particle going from the target area were taken for coordinate measurements.

For the final analysis the computer program for geometry and kinematics reconstruction was used. After reconstruction some events (8%) with the interaction pion falling outside the fixed target volume were rejected. The events (9%) with more than one particle going out of the target were also rejected.

For the reconstructed events the elastic kinematics check has been made: the measured neutron coordinate (neutron star vertex) was compared to the calculated one. The relevant distribution has shown almost Gaussian shape with no visible inelastic background **), thus no more selection criteria turned out to be necessary. In the events taken as elastic we evaluate the inelastic background contamination being less than 1 or 2%.

The apparatus acceptance was calculated by a Monte Carlo program. After taking into account all necessary corrections***) the overall uncertainty in the cross section values

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*) The detailed description of the apparatus will be given elsewhere.

**) The rejected events with more than one track coming from the target have not shown elastic kinematics.

***) The Glauber correction being small (less than 1÷2%) was unnecessary.

is 20%.

The results of the experiment are listed in the Table.

In Fig.2 the angular distribution at 40 GeV/c is shown One can clearly see the sharp backward peak. The straight line shown in Fig.2 is a least square fit of the differential cross section values to the exponential law

$$d\sigma/du = A \exp(Bu)$$

The value of B is (26 ± 6) $(\text{GeV/c})^{-2}$; $A = .444 \pm .053$ $\mu b/(\text{GeV/c})^2$.

Fig.3 shows the energy dependence of $(d\sigma/du)_{u=0}$. For comparison the $\pi^+ p$ (the same isotopic state as $\pi^- n$) data [3] at 5.9, 10, 13.7, 17.1 GeV/c are also shown. The comparison of our data with the Cornell-BNL results [3] indicates that the S-dependence at higher energies becomes less steep.

One can try to understand this result from the point of view of Regge pole model. The analysis of the existed data on pion backward elastic scattering below 20 GeV/c has been made [4] and the outcome was that one can fit the experimental results [3,5] to the Regge pole formulae by introducing the $N(T = 1/2)$ and Δ $(T = 3/2)$ baryon exchange. The obtained intercept values for the two trajectories involved ($\alpha_\Delta(0) \cong +0.2$, $\alpha_N(0) \cong -0.35$) were in no contradiction with linear extrapolations on Chew-Frautschi plot. It was also concluded from this analysis that the $\pi^+ p$ backward scattering below 20 GeV/c is mostly determined by N-exchange.

Our data at 23 and 40 GeV/c when compared with the data [3] above $\sim$ 10 GeV/c indicate that the slope of the energy dependence of the cross section $(d\sigma/du)_{u=0}$ corresponds to some positive value of effective $\alpha(0)$ as if the Δ-exchange would likely to be essential. But if one assumes to have almost pure Δ-exchange in $\pi^- n(\pi^+ p)$ backward scattering above ~ 10 GeV/c one immediately runs into contradiction with isotopic relation. For T = 3/2 exchange one should have the $\pi^- p$ backward scattering cross section to become nine times more than $\pi^+ p$ cross section while in the experiment $\sigma(\pi^- p) / \sigma(\pi^+ p) \sim 1/5$ (at 10-16 GeV/c). On the other hand, the backward peak at 40 GeV/c (see Fig.3) as in $\pi^+ p$ scattering below 20 GeV/c turns out to be several times sharper than the peak obtained in $\pi^- p$ scattering (pure T = 3/2 exchange)[3,5]. Thus again indicates that up to 40 GeV/c the $\pi^- n(\pi^+ p)$ backward scattering is still governed by the T = ½ exchange. Thus we should admit the nucleon trajectory is essentially nonlinear, when reaching u=0 it runs far above the Chew-Frautschi plot linear extrapolation.

We would like to thank the Serpukhov machine staff for providing the good beam for the experiment.

We are indebted to our technicians who have much contributed to success of the experiment.

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T A B L E

P GeV/c	u $(GeV/c)^2$	$d\sigma/du$ $\mu b/(GeV/c)^2$
	+ 0,013	2,3 ± 0,6
	+ 0,004	1,7 ± 0,5
23	- 0,011	0,35 ± 0,13
	- 0,030	0,27 ± 0,11
	0,000	1,1 ± 0,2
	+ 0,005	0,462 ± 0,085
	- 0,005	0,439 ± 0,077
	- 0,015	0,317 ± 0,069
40	- 0,025	0,223 ± 0,075
	- 0,035	0,157 ± 0,064
	- 0,050	0,171 ± 0,069
	- 0,070	0,065 ± 0,065
	0,000	0,444 ± 0,053

Figure Captions

Fig.1. The experimental layout

$C_1C_2C_3C_4$ beam telescope counters

C_π pion counter

C_{n_1}, C_{n_2} neutron detector counters

$A_1A_2A_3A_4A_n$ veto counters interspersed with lead (Pb)

K_{1-5}, $K_{n\,1,2}$ optical spark chambers

D_2 deuterium target

Fe iron shielding

M sweeping magnet

Fig.2. The backward elastic $\pi^- n$ differential cross section at 40 GeV/c incident pion momentum as function of u.

Fig.3. The incident momentum dependence of $(d\sigma/du)_{u=0}$ Our. data together with the Cornell-BNL results.

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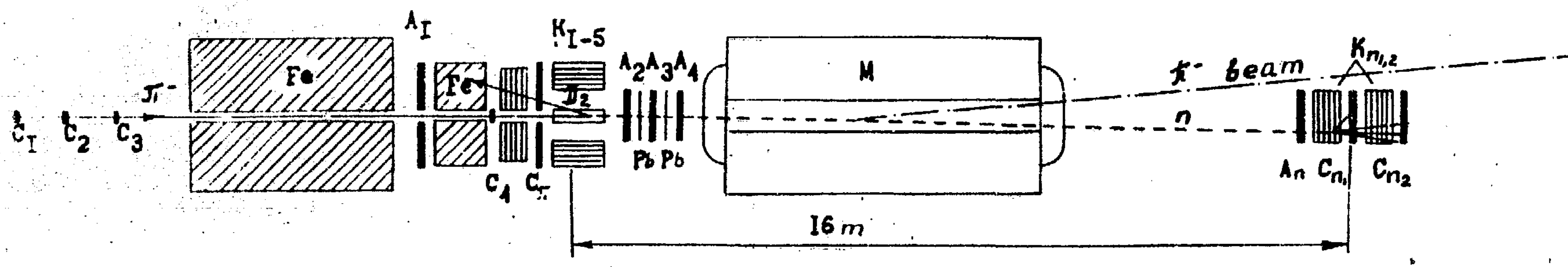
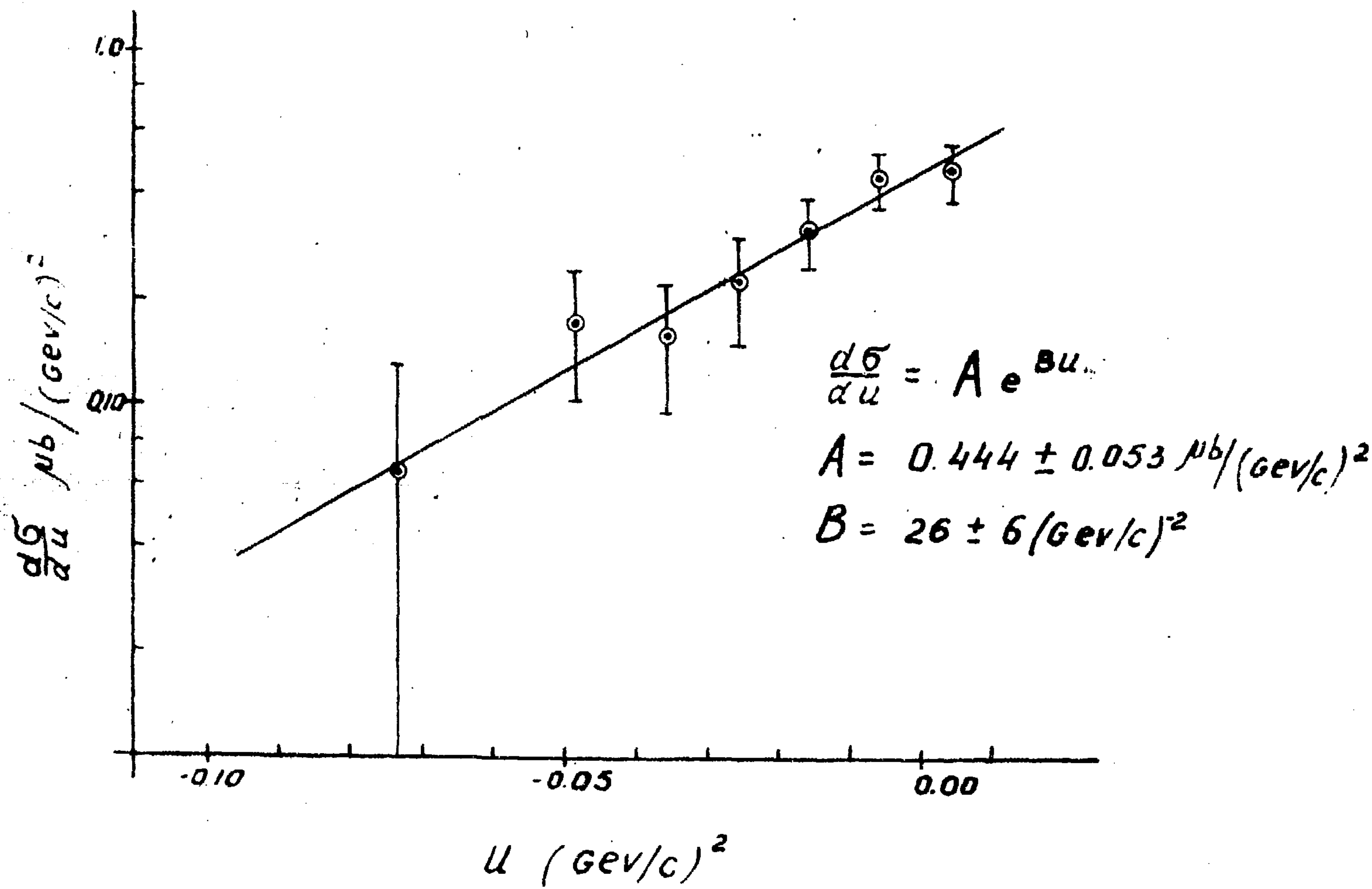

C_I
C_2
C_3
π⁻
Fe
A_I
Fe
C_4
C_π
K_I-5
π_2
A_2 A_3 A_4
Pb Pb
M
π⁻ beam
n
K_n1,2
A_n
C_n1
C_n2
16 m

Fig.1



1.0
0.10
dσ/du µb/(Gev/c)²
-0.10
-0.05
0.00
u (Gev/c)²
dσ/du = A e^Bu
A = 0.444 ± 0.053 µb/(Gev/c)²
B = 26 ± 6 (Gev/c)⁻²

Fig.2

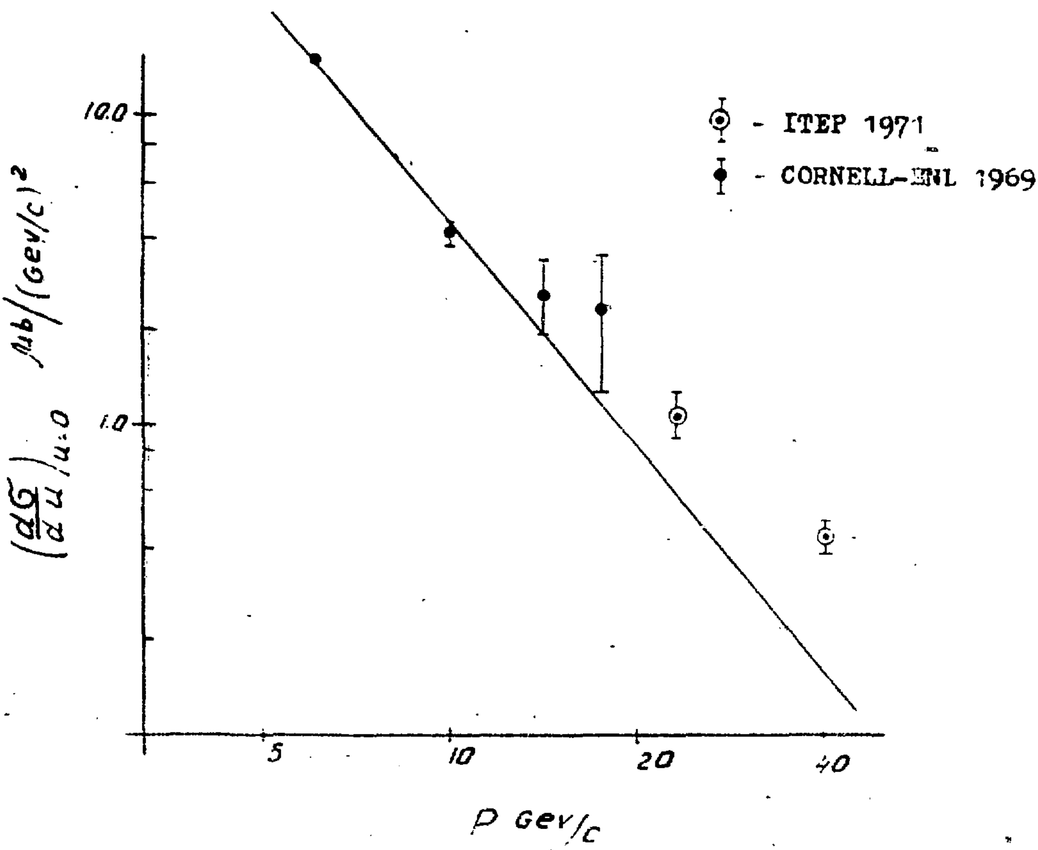

10.0
1.0
$\left(\frac{d\sigma}{du}\right)_{u=0}$ μb/(GeV/c)²
5
10
20
40
P GeV/c
- ITEP 1971
- CORNELL-BNL 1969

Fig. 3

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Responsible Yu.V.Galaktionov