ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

ЛАБОРАТОРИЯ ВЫСОКИХ ЭНЕРГИЙ

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Abstract

Elastic scattering of 2.8 and 6.8 BeV/c negative pions on carbon nuclei has been studied. The differential cross sections obtained are analysed with the aid of the optical model.

It has been shown that in the energy range under study the characteristics of elastic negative pion scattering on carbon depend only upon the transferred momentum.

The cross section for negative pion scattering on a neutron to the backward half-sphere has been also estimated to be $\sigma_{\pi n}$ $(\geqslant 90^{\circ}) \leqslant 0.4$ mb, (2.8 BeV/c) *and* $\sigma_{\pi n}$ $(\geqslant 90^{\circ}) \leqslant 0.1$ mb. (6.8 BeV/c) .

Introduction

The purpose of the present paper is to measure the total and differential cross section for elastic negative pion scattering on carbon nuclei. The data obtained enable to determine the magnitude and the sign of the spin-independent real part of the pion-nucleon with the help of the optical model.[1,2] They appear due to the interference of the Coulomb and nuclear scattering. These data allow also to get the information about the energy dependence of the differential elastic scattering cross section at the identical transferred momenta.

I Experiment

1. Measurements of 2.8 BeV/c Negative Pion Scattering

Measurements of 2.8 ± 0.15 BeV/c negative pion scattering [3] have been made by means of a $37 \times 10 \times 10\ cm^3$ propane bubble chamber without a magnetic field. Only those trackes of relativistic particles were selected for measuring which entered the chamber at an angle of not more than 2° to its horizontal axis (the angle projected along the observation plane) and lay in the effective region 28.4 cm long (60 mm on the film) where the distortions of the tracks are minimum and about the same by magnitude.

To select the scattering events more quickly we measured the deviation of the strongly magnified image of the track from the straight line drawn on a transparent ruler. It was established at the point where the track intersects with the boundaries of the effective region. This method made it possible to select the scattering events at an angle $\phi \geqslant 1^{\circ *}$ practically without losses. The use of the rule accelerated ten times the selection of the scattering events and decreased the missing of stars what happens in usual scanning. (see Appendix N 1).

The scattering events selected with the aid of the ruler were analysed twice by means of a microscope МБИ-9 under 3.5×15 magnification. A working cell 10 mm long was chosen for measurements what yielded the minimum inaccuracy in measuring the angle which is due to the multiple Coulumb scattering and to

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* The projection of the solid scattering angle θ along the observation plane is meant by the angle ϕ. In this investigation we measured the projections of the scattering angles along the photographing plane what provided a considerably higher accuracy than the measurement of solid angles.

the 'noise' from the bubbles of the track (~ 0.06°). A reliable means for separating the real scattering events from the false scattering events is the localization of the scattering point. For all the selected scattering events at an angle of $\phi \geqslant 1°$ the scattering point was visually determined within 1 mm in the chamber The scattering points are distributed uniformly along the length of the chamber. The comparison of the number of the scattering events in different directions (67 and 54) indicates that the selection of the events is independent of the sign of the scattering angle.

All in all, about $1.49 \cdot 10^5$ cm of negative pion tracks have been scanned by means of the ruler and more than 800 events were selected, out of which 121 scattering events at the angles from 1° up to 10° and 30 scattering events at the angles of more than 10° remained after the measurements made at the microscope.

2. *Measurements of 6.8 BeV/c Negative Pion Scattering.*

The measurement of elastic negative pion scattering on carbon nuclei was made by means of a 24-litre propane bubble chamber placed in the magnetic field of 13.700 oersted in strength*. The beam of negative pions incident on the chamber had the momentum of 6.8 ± 0.6 BeV/c. The admixture of negative muons constituted (5 ± 2) %. A detailed description of the experimental arrangement is given in /4/.

The effective region of the chamber 42 cm long has been chosen for measurements, where the distortions of the tracks are minimum and approximately eqnal by magnitude. The tracks passing through this region whose deviation from the beam axis did not exceed ± 0.6° were selected. The search for scattering events and the measurements were performed with the aid of the microscope МБИ-9 under the magnification of 6.3 x 15 . The length of the working cell was 6 mm on the film.

After the first measurements of all the tracks, the events with the scattering angle $\phi \geqslant 0.33°$ were measured additionally with a displaced cell. This enabled to localize the scattering point more accurately and increased the accuracy of measuring the angles from 0.15° up to 0.09° .The scanning of the scattering events by means of a reprojector has shown that for the angles $\geqslant 0.5°$ in more than 80% events there is observed a break in the region where, according to the measurements at the microscope, the scattering point must be situated. It has been shown also that the correlation between the scattering events and the scattering on neighbouring tracks is absent. The scattering points are distributed uniformly along the effective length of the chamber. The comparison of the number of scattering events in different directions (142 and

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* The authors are indebted to Wang Kan-chang's group working at the Laboratory of High Energies (Joint Institute for Nuclear Research) for providing them with the chamber photos.

159) points out that the selection of the events is independent of the sign of the scattering angle.

As a result, in measuring 3.25 . 10^{5}cm tracks of negative pions 301 scattering events at the angles $\phi \geqslant 0.33°$ were found (among them 218 scattering events at the angle $\phi \geqslant 0.5°$).

II Corrections to Experimental Distributions

The corrections which take into account the character of the measurement as well as the contribution of the interactions different by their nature from negative pion scattering on carbon nuclei must be introduced into the material we have obtained (see Table 1).

The correction for the one-prong stars due to multiple production of neutral pions was taken into account by extrapolating the distribution of the one-prong stars from the large angle region to small angles. The extrapolation law was determined from the angular distribution of the products of many-prong stars as the measurements made for the momentum of negative pions of 2.8 BeV/c (see Table 2) have shown a weak dependence of the angular distribution of relativistic charged particles on the number of particles in a star. A similar result has been obtained for negative pions with the momentum of 6.8 BeV/c. The estimates of the contribution from one-prong stars based on the number of γ-quanta from the decay of neutral pions generated in one-prong stars (the momentum of negative pions being 6.8 BeV/c) confirm that the correction introduced is right.

The most essential correction is connected with the elastic scattering process on quasi-free neutrons of a nucleus. It has been shown in /5,6/ that the angular dependencies of the cross sections for elastic and quasi-elastic scattering practically coincide. As long as we could not determine accurately enough the effective number of quasi-free neutrons, the correction was introduced by recalculating the background remaining after the introduction of other corrections for the region of small angles. In doing this, we started from the differential cross sections for π^{-}-p scattering measured at same energies of negative pions /4,7/. As a matter of fact, this correction takes into account the contribution of inelastic scattering of negative pions accompanied by the excitation of the carbon nucleus, since the dependence of the excitation cross section /8/ and the quasi-elastic scattering cross section on the transferred momentum are not different up to the coefficient 1.5. It is worth while noting that the introduced correction for quasi-elastic scattering corresponds to approximately one quasi-free neutron on a carbon nucleus (what coincides with the estimate made in /9/.)

The account of the corrections in another possible way (e.g., by means of the linear extrapolation of the background from the region of large angles) changes slightly the final result .

III Cross Section for Inelastic Negative Pion Interaction on Carbon

The available data made it possible to determine the cross section for inelastic interaction of 6.8 BeV/c negative pions on carbon

$$\sigma_{in}(\pi^- C) = 197 \pm 7 \text{ mb} \quad .$$

In doing this, the value of the total cross section for π^-p- interaction $\sigma_t = 28$ mb /10/ was used. The total cross section for negative pion interaction with a bound nucleon of a nucleus obtained from $\sigma_{in}(\pi^- C)$ by the optical model was found to be (28.5 ± 1.5) mb i.e., it coincides with the cross section for the interaction on a free nucleon.

This result was used for determining the admixture of negative muons in the beam of π^--mesons with the momentum of 2.8 BeV/c. We started from the total cross section for pion-nucleon interaction $\sigma_t = (30 \pm 1.5)$ mb /10/.

The calculation has shown that the cross section for inelastic scattering of negative pions on carbon is equal to (202 ± 5.6) mb at this energy. Hence, being aware of the whole number of events in the chamber, one can find that the admixture of negative muons in the 2.8 BeV/c beam was (27 ± 4) % .

IV Discussion of the Results

Figs. 1 and 2 show the experimental differential cross sections projected on the plane of observation * for elastic scattering of 2.8 and 6.8 BeV/c negative pions, respectively. In the same Figs. are indicated curves 1,2,3 calculated by the optical nuclear model under the assumption that the real part of the amplitude of the negative pion scattering on a nucleon in the forward direction is equal to:

$+3.39 \cdot 10^{-13}$cm; $-3.39 \cdot 10^{-13}$cm; 0

and $+6.9 \cdot 10^{-13}$cm; $-6.9 \cdot 10^{-13}$cm; 0 respectively ** (see Appendix II) .

At the same time, according to the optical theorem, the imaginary part of the pion-nucleon scattering amplitude is

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* It was shown that the difference between the central and orthogonal projections is not essential under our conditions.

** The value $\mathrm{Re}\, f_{\pi N}(0) = 3.39 \cdot 10^{-13}$cm ($P_\pi = 2.8$ BeV/c) and $\mathrm{Re}\, f_{\pi N}(0) = 6.9 \cdot 10^{-13}$cm ($P_\pi = 6.8$ BeV/c) corresponds to the effective potential of about 80 MeV.

$$\mathrm{Im}\, f_{\pi N}(0) = \frac{k\bar{\sigma}_t}{4\pi} = \left\{ \begin{array}{l} 3.39 \cdot 10^{-13}\mathrm{cm}\ (P_\pi = 2.8\ \mathrm{BeV/c}) \\ 7.96 \cdot 10^{-13}\mathrm{cm}\ (P_\pi = 6.8\ \mathrm{BeV/c}) \end{array} \right.$$

The anisotropy in pion scattering on nucleons at these energies was taken into account in the calculations /11,4,7/. (In Figs. 1 and 2 the dashed lines represent the results of the calculations with $\mathrm{Re}\, f_{\pi N}(0) = 0$ without taking this effect into account). The experimental and calculating values of the total elastic scattering cross sections are listed in Table 3. All the data allow to restrict the possible values of the real part of the scattering amplitude by the limits:

$$+ 3.39 \cdot 10^{-13}\ \mathrm{cm} > \mathrm{Re}\, f_{\pi N}(0) \geqslant - 3.39 \cdot 10^{-13}\mathrm{cm}\ (P_\pi = 2.8\ \mathrm{BeV/c})$$
$$+ 6.9 \cdot 10^{-13}\ \mathrm{cm} > \mathrm{Re}\, f_{\pi N}(0) \geqslant - 6.9 \cdot 10^{-13}\ \mathrm{cm}\ (P_\pi = 6.8\ \mathrm{BeV/c})$$

(The difference was considered to be essential if the experimental value was different from the theoretical one by more than two standard deviations). The corresponding values of the effective interaction potential are within the limits:

$$- 30\ \mathrm{MeV} < V_{\mathrm{eff.}} \leqslant 30\ \mathrm{MeV} \quad (P_\pi = 2.8\ \mathrm{BeV/c})$$
$$- 30\ \mathrm{MeV} < V_{\mathrm{eff.}} \leqslant 30\ \mathrm{MeV} \quad (P_\pi = 6.8\ \mathrm{BeV/c})$$

As is well-known, the conclusion about the smallness of the real part of the pion-nucleon scattering amplitude has been also obtained by means of dispersion relations /12,13/ which predict the following values of the real part of πN –scattering amplitude:

$$\mathrm{Re}\, f_{\pi N}(0) = \tfrac{1}{2} [\, \mathrm{Re}\, f_{\pi - p}(0) + \mathrm{Re}\, f_{\pi + p}(0)\,] = \left\{ \begin{array}{l} -0.49 \cdot 10^{-13}\ \mathrm{cm} \\ -0.36 \cdot 10^{-13}\ \mathrm{cm} \\ -0.33 \cdot 10^{-13}\ \mathrm{cm}\ (6.8\ \mathrm{BeV/c}) \end{array} \right. \Big\}\ (2.8\ \mathrm{BeV/c})$$

The data obtained in the present experiment are not accurate enough for a quantitative comparison with the conclusions made on the basis of dispersion relations, being however, within the experimental error in agreement with them.

The coincidence of the differential cross sections $\frac{d\sigma}{dq}$, where q is the projection of the transferred momentum along the observation plane (Fig.3), shows that within the error the elastic scattering in the energy interval under study is determined by the transferred momentum only. From the point of view of the optical model, this implies that the optical parameters of πN interaction in this region do not change with energy. Our data permit to make this concluaion for the transferred momenta from 60 up to 200 MeV/c.

The available data on πp-scattering lead to the same result in the region of the transferred momenta $\geqslant 200$ MeV/c . (see, e.g., [4]).

V Estimate of π^- n- Scattering Cross Section to the Backward Half - Sphere

Among the one-prong stars we have observed there were found no event when after the interaction a negative pion is flying to the backward half-sphere in the laboratory system. Hence, the upper limit of the cross sections for 2.8 and 6.8 BeV/c scattering by neutrons to the backward half-sphere was estimated to be $\sigma_{\pi n}(\geqslant 90^\circ) \leqslant 0.4$ mb and $\sigma\ (\geqslant 90^\circ) \leqslant 0.1$ mb, respectively, (we consider that the number of quasi-free neutrons in the carbon nucleus is not less than one [5,9]. I.J. Pomeranchuk drew his attention to the fact that there is a diagram (Fig.4) which may lead to the increase up to 1 mb, in the cross section for π^+ p- and π^- n- scattering to the backward half-sphere (in the lab. system) at high energies. The estimate made by the authors [13] and the results of the present paper show that the contribution of this diagram is very likely to compensate by other diagrams, i.e., that in backward scattering the role of the processes occurring at the distances less than $\frac{1}{M+\mu}$ (where M is the nucleon mass, μ - is the meson mass) is great.

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Appendix I

Selection of Scattering Events by Means of a Ruler

Let us consider the trak AOB (Fig.5) of a charged particle in the bubble chamber which undergoes single scattering (break) at the point 0 at a distance of ℓ_1 and ℓ_2 from the boundaries of the measurement region. The particle suffers also the multiple Coulumb scattering which is characterized by the angular deviation and transverse displacement of its trajectory from the original direction.

Let MN and PQ be the tangents drown from the right and left to the break point 0. The total deviation of the particle track on the segment $L = \ell_1 + \ell_2$ from the original direction AA' is composed of the following parts:

1. The transverse displacement $A'C = y$ due to the multiple Coulumb scattering on the segment ℓ_1.
2. The transverse displacement $QB = y_2$ due to the multiple scattering on the segment ℓ_2.
3. The segment $CN = \ell_2 \psi$ due to the angular deviation on the segment ψ owing to the multiple Coulumb scattering.
4. Segment $NQ = \ell_2 \phi$ due to the single scattering at the angle ϕ at the point O.

It follows from the triangles AA"B and AOK that at small scattering angles and small transverse displacements the deviation h = OK track from the straight line AB is

$$h = \ell_1 \alpha = \ell_1 \frac{y_2 + \ell_2 \phi + \ell_2 \psi - \frac{\ell_2}{\ell_1} y_1}{\ell_1 + \ell_2} = \frac{\ell_1 \ell_2}{\ell_1 + \ell_2} (\phi + \phi_K),$$

where

$$\phi_K = \psi + \frac{y_2}{\ell_2} - y_1 / \ell_1 .$$

Here ϕ corresponds to single scattering at the point 0, whereas ϕ_K is due to the multiple Coulumb scattering on the segments ℓ_1 and ℓ_2.

We estimate the root-mean-square value of ϕ_K. As far as y_2 is independent of ψ and y_1.

$$\overline{\phi_K^2} = (\psi - \frac{y_1}{\ell_1})^2 + (\frac{y_2}{\ell_2})^2 = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} (\psi - \frac{y_1}{\ell_1})^2 F (\psi_1 , y_1) \, d\psi \, dy_1 +$$

$$+ \frac{1}{\ell_2} \int_{-\infty}^{+\infty} y_2^2 H(y_2) \, dy_2$$

$$F (\psi_1 , y_1) = \frac{\sqrt{3}}{2\pi} \frac{\omega^2}{\ell_1} \exp [- \omega^2 (\frac{\psi^2}{\ell_1} - \frac{3 y_1 \psi}{\ell_1^2} + \frac{3 y_1^2}{\ell_1^3})]$$

$$H (y_2) = \frac{\sqrt{3}}{2\sqrt{\pi}} \frac{\omega}{\ell_2^{3/2}} \exp (- \tfrac{3}{4} \frac{\omega^2 y_2^2}{\ell_2^3})$$

where $\omega = \frac{2 P \beta}{E_s}$, $E_s = 21 \cdot 10^6 ev$.

The calculation of the integrals shows that $\overline{\phi_K^2} = \frac{\Phi^2}{3}$, where Φ^2 is the mean square of the angle of the multiple Coulumb scattering along the length $L = \ell_1 + \ell_2$.

If $\phi_K = 2\sqrt{\overline{\phi_K^2}}$ is set, and $\phi \geqslant 0.6^\circ$, then more than 97.5% of the events will have the deviation

$$h \geqslant h_0 = \frac{\ell_1 \ell_2}{\ell_1 + \ell_2} \left(\phi - \frac{2}{\sqrt{3}} \Phi \right)$$

The root-mean-square angle of the multiple Coulumb scattering in the effective region of the chamber is 0.0026 ster. Hence, one can easily conclude that at L = 1200 mm (twenty-fold increase of the picture) the deviation $h \geqslant 1$ mm will correspond to the angles of scattering $\geqslant 0.6^\circ$ if the false curvature and false scattering are absent under such conditions. Therefore, the scattering events at the angles $\geqslant 0.6^\circ$ are selected practically with a 100% efficiency.

Appendix II

Calculations of the total and differential cross sections for pion interaction with carbon by the optical nuclear model.

1. Inelastic Processes

According to the optical model the cross section for inelastic pion interaction with carbon for the Gaussian nucleon density distribution in a nucleus

$$\rho(r) = 12\pi^{-3/2} a^{-3} e^{-r^2/a^2} \qquad (1)$$

is of the form[1]

$$\sigma_{in}(\pi, C_6^{12}) = \pi a^2 \left[C + \ell n \frac{12\,\overline{\sigma_{\pi N}}}{\pi a^2} - Ei\left(- \frac{12\,\overline{\sigma_{\pi N}}}{\pi a^2} \right) \right]^* \qquad (2)$$

Here Ei – is the integral exponent, C = 0.577... – is the Euler constant. The form of the distribution (1) and the parameter a= (1.96 ± 0.4) . 10^{-13} cm are known from the experiments on electron scattering on carbon nuclei[15]. The results of the calculations have shown that the variation of a by 2% (experimental error) gives rise to a change in the total inelastic cross section by 1.5%, while the variation of $\overline{\sigma}_{\pi N}$ by 5% results in changing the cross section by 3%. The value $\overline{\sigma}_{\pi N}$ = (28.5 ± 1.5) mb which was used in further calculations has been found from the quantity $\sigma_{in}(\pi^-, C_6^{12})$ = 197 ± 7 mb at 6.8 BeV/c measured experimentally.

* A possible anisotropy in πN-scattering[12] is not taken into account in this formula. The account of this effect affects the quantity $\sigma_{in}(\pi, C_6^{12})$ insignificantly.

2. Elastic Scattering

One can show that for distribution (1) and Re $f_{\pi N}(0) = 0$ the total elastic cross section for pion interaction with a nucleus will have the form

$$\sigma_{el}(\pi, C^{12}_6) = \pi a^2 \left[C + \ell n \frac{3\bar{\sigma}_{\pi N}}{\pi a^2} - 2 Ei\left(-\frac{6\bar{\sigma}_{\pi N}}{\pi a^2}\right) + Ei\left(-\frac{12\bar{\sigma}_{\pi N}}{\pi a^2}\right)\right]. \qquad (3)$$

The calculations performed by this formula have shown that the variation of the parameter within 2% leads to the change $\sigma_{el}(\pi, C^{12}_6)$ by 1%, while the variation pf $\bar{\sigma}_{\pi N}$ within ± 5% (experimental error) leads to the change in the cross section by ± 7%. Similar results were obtained from the calculations taking into account different from zero Re $f_{\pi N}(0)$.

3. Differential Cross Section for Elastic Scattering

The differential cross section for elastic pion scattering on carbon was calculated by usual formulae of the optical model /2/ for different values of the parameters: $\bar{\sigma}_{\pi N}$, a, and Re $f_{\pi N}(0)$.

The results of the calculations have shown that the change of $\bar{\sigma}_{\pi N}$ within the experimental error (±5%) leads to the change in the differential cross section (in the range up to the first minimum) by 7%. The variation of the parameter a by ± 2% lead to the change in the cross section by ± 2%.

Since the incident pion beam has the momentum spread of 6.8 ± 0.6 BeV/c , the calculations of the differential scattering cross section were made for 'extreme' values of the momentum (6.2 and 7.4 BeV/c) and added to the weights ½. It was found out, that they yielded the same result within the limit 1–2% as well as the calculations for the mean momentum. Therefore, all the calculations were performed only at the pion momentum of 6.8 BeV/c.

The account of the Coulumb interaction was made by the Bethe formulae /1/ with the use of the calculations on the optical model for nuclear scattering.

The anisotropy in πN-scattering /11/ was also taken into account. This was made by introducing the factor $\frac{\sigma_{\pi N}(\theta)}{\sigma_{\pi N}(0)}$ into the results of the calculations on the usual optical model. The value of this factor was taken from the experiments on πN-scattering /4,7/. It should be noted that in the angle region we need $\sigma_{\pi N}(\theta)$ was measured only at two points. Therefore, the accuracy of introducing the correction is not great. However, for different models of πN-interaction this coefficient is about the same. The account of this effect decreases essentially the theoretical curves. (see Figs. 1 and 2).

Table VI

Corrections to the experimental distribution of the scattering events and the differential cross section for elastic π^--meson scattering on carbon*) a) 2,8 GeV/c π^--meson momentum

The interval of angle projections along the observation plane	The number of one-prong stars	Corrections to the experimental distribution: The transition from one angular interval to another	Geometrical corrections	Coulomb scattering of μ^--mesons	Elastic and quasi-elastic π^-p-scattering	Inelastic one-prong stars	Quasi-elastic π^-n-scattering and the scattering accompanied by the nucleus excitation	The total correction in the given angular interval	The number of elastic π^--meson scattering events on carbon nuclei	The differential cross section for elastic π^--meson scattering on carbon in mb/rad
I	2	3	4	5	6	7	8	9	I0	II
$0,6^0$-I^0	56									
I^0 -$I,4^0$	28	-I,2	-	-0,5	-I	-0,5	-I,5	-4,7	23,3	$I380 \pm 330$
$I,4^0$-$I,8^0$	I4	-0,7	-	-0,2	-0,7	-0,5	-I,5	-3,6	I0,4	620 ± 240
$I,8^0$-$2,2^0$	2I	-0,9	-I,8	-	-0,3	-0,5	-I,5	-5	I6	950 ± 300
$2,2^0$-$2,6^0$	I4	-0,6	-I,2	-	-0,2	-0,5	-I,5	-4	I0	600 ± 250
$2,6^0$-$3,0^0$	II	-0,4	-0,9	-	-0,2	-0,5	-I,5	-3,5	7,5	$450 \pm 2I0$
$3,0^0$-$3,4^0$	I0	-0,4	-0,8	-	-0,2	-0,5	-I,7	-3,6	6,4	$380 \pm 2I0$
$3,4^0$-$3,8^0$	3	-	-0,2	-	-	-0,4	-I,8	-2,4	0,6	36^{+I20}_{-36}
$3,8^0$-$4,2^0$	2	-	-0,2	-	-	-0,4	-I,4	-2	0	0 +I20
$4,2^0$-$4,6^0$	3	-	-0,3	-	-	-0,4	-I,5	-2,2	0,8	48^{+I30}_{-48}

Table 2

The angular distribution of high-energy secondary prongs in inelastic many-prong stars produced by 2.8 BeV/c π^--mesons in propane

Stars		The percentage of the events in the angular interval			The number of events in the angular interval of 0 – 180°.
The number of prongs					
black and grey	relativistic	0-5^0	5-I0^0	I0-I80^0	
0	2	I7,0	I4,7	68,5	40I
I	2	II,I	I3,5	75,5	I26
2,3,4	2	I4,5	I0,0	75,5	200
0	3,4	I4,6	I2,6	73,0	302
I,2,3,4	3,4,5,6	I2,6	II,8	75,5	508
All the stars 0,I,2,3,4	2,3,4,5,6	I4,2	I2,6	73,2	I537

Table 3

The comparison of the experimental and theoretical integral cross sections for elastic π^--meson scattering on carbon.

the momentum of the incident π^--meson the interval of plane angles	$\frac{Re\, f_{\pi N}(0)}{Im\, f_{\pi N}(0)}$ / the experimental cross section	The calculation by the optical model			
		0,9 ($V_{ef.} \approx -30$ MeV)	0,5 ($V_{ef} \approx -15$ MeV)	0 ($V_{ef} = 0$)	-0,9 ($V_{ef} \approx +30$ MeV)
2,8 BeV/c 1^0-5^0	$(31,1 \pm 5,1)$ mb	51,2 mb	36,5 mb	25,3 mb	40 mb
6,8 BeV/c $0,5^0-1,9^0$	$(26,5 \pm 2,4)$ mb	43 mb	30,4 mb	21,3 mb	34 mb

I	2	3	4	5	6	7	8	9	I0	II
4,6^0-5^0	I	-	-0,I	-	-	-	-0,9	-I	0	0 ± 80
I^0-5^0	I07	-4,2	-5,5	-0,7	-2,6	-4,2	-I4,8	-32	75	(3I,I ±5,I) mb
5^0-I0^0	I4	-	-I,2	-	-	-4,7	- 8,I	-I4	0	0
I0^0-I80^0	30	-	-2,6	-	-	-27,0	- 0,4	-30	0	0
I^0-I80^0	I5I	-4,2	-9,3	-0,7	-2,6	-35,9	-23,3	-76	75	(3I,I ±5,I) mb

b) The 6.8 BeV/c momentum of π^--mesons.

0,33^0-0,5^0	59	-								
0,5^0-0,7^0	62	+I,5	-	-	-I,7	-I,2	-I,7	-3,I	58,9	2940 ±400
0,7^0-0,9^0	46	-0,2	-	-	-I,5	-0,9	-I,9	-4,5	4I,5	2080 ±360
0,9^0-I,I^0	26	-0,2	-	-	-I,0	-0,5	-2,0	-3,7	22,3	II20 ±270
I,I^0-I,3^0	I5	-0,2	-	-	-	-0,3	-I,6	-2,I	I2,9	640 ±2I0
I,3^0-I,5^0	I0	-0,2	-	-	-	-0,2	-I,6	-2	8	400 ±I70
I,5^0-I,7^0	I0	-	-	-	-	-0,2	-I,5	-I,7	8,3	4I0 ±I70
I,7^0-I,9^0	2	-	-	-	-	-	-I,4	-I,4	0,6	30 $^{+90}_{-30}$
0,5^0-I,9^0	I7I	+0,7	-	-	-4,2	-3,3	-II,7	-I8,5	I52,5	(26,5±2,4) mb
I,9^0-5^0	3I	-	-	-	-	-6,8	-24,2	-3I	0	-
5^0 -I80^0	40	-	-	-	-	-40	-	-40	0	-
0,5^0-I80^0	242	-	-	-	-4,2	-50,I	-35,9	-89,5	I52,5	(26,5±2,4) mb

*) The errors in the cross sections are statistial.

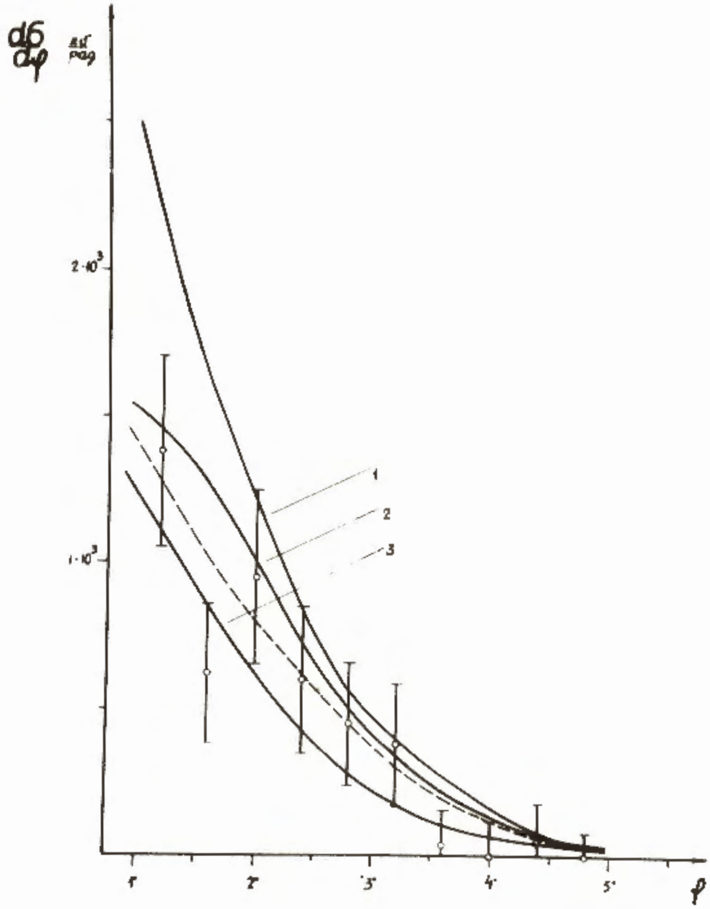

Fig. 1. $P_{\pi} = 2.8$ BeV/c .

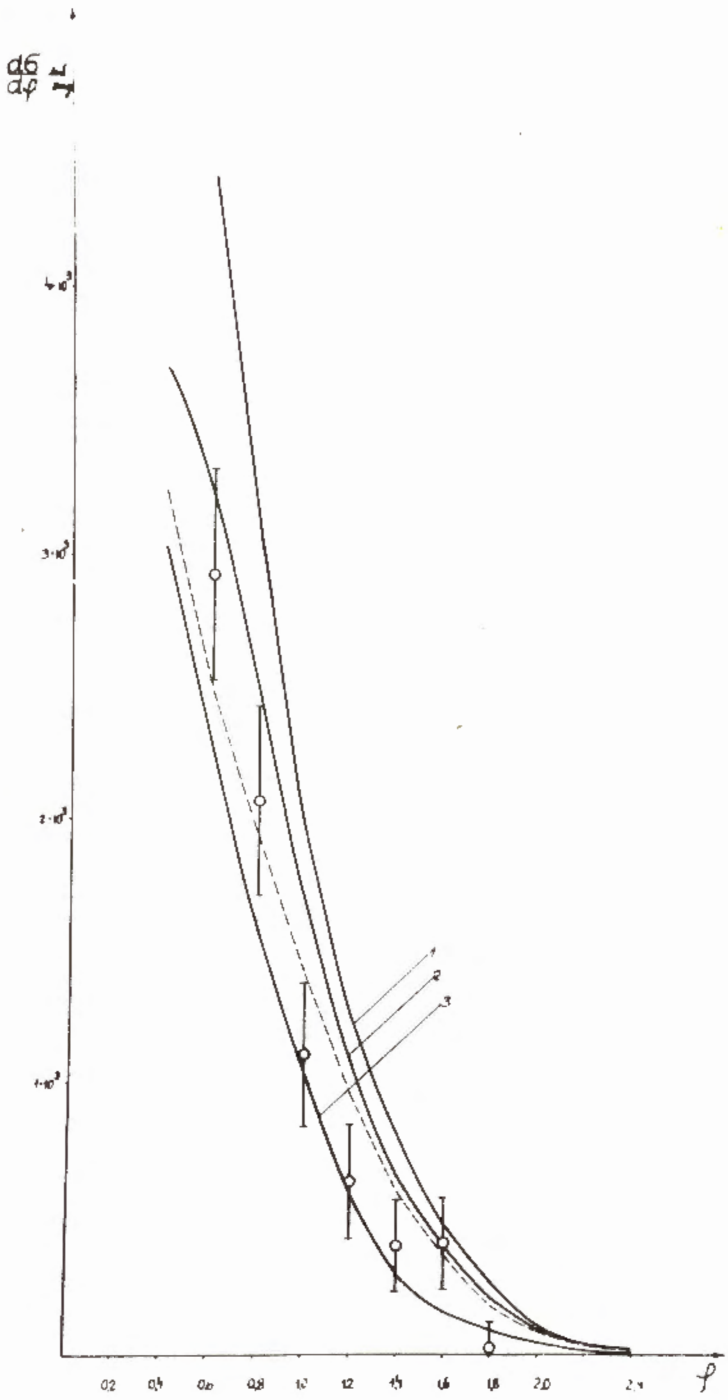

Fig.2. P_{π} = 6.8 BeV/c.

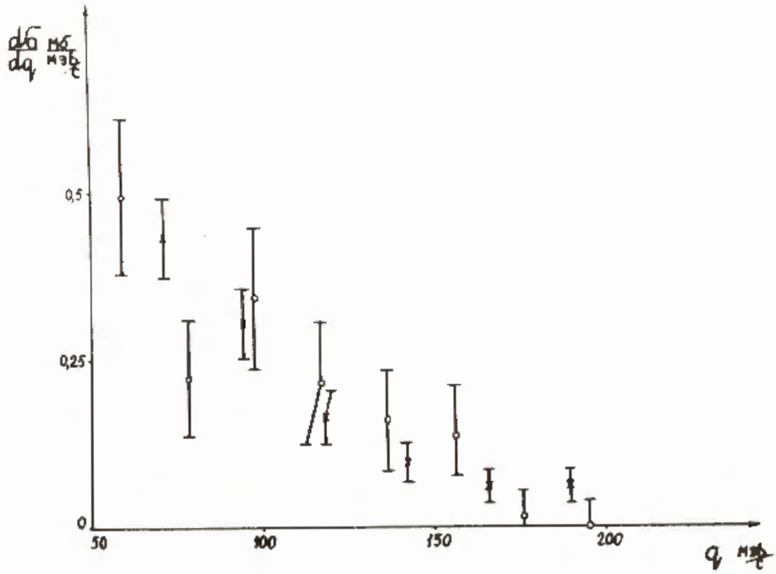

Fig. 3. – P_π = 2.8 BeV/c.
– P_π = 6.8 BeV/c.

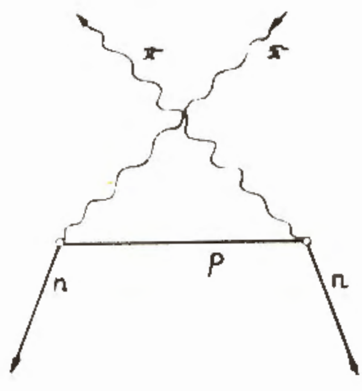

Fig. 4.

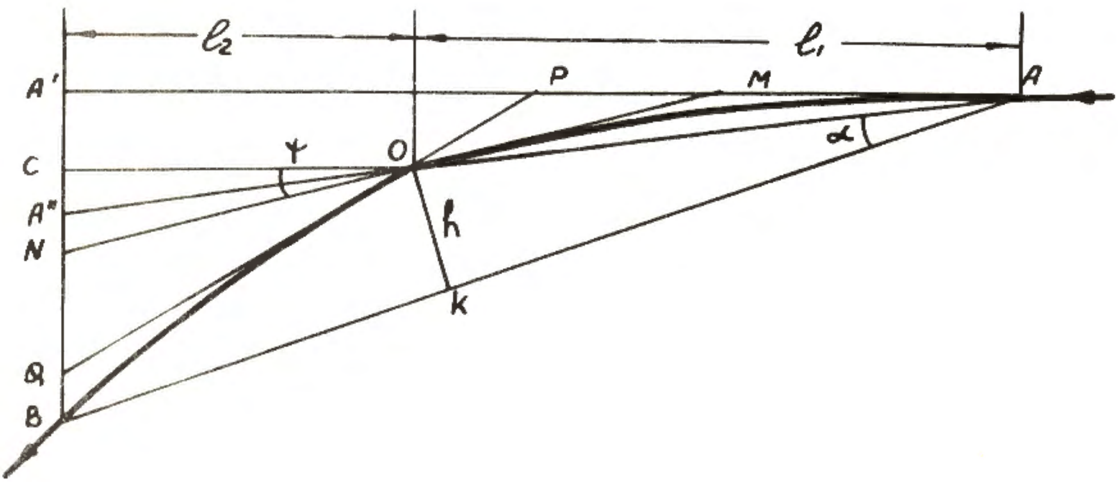

Fig. 5.

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