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ЛАБОРАТОРИЯ ВЫСОКИХ ЭНЕРГИЙ

THE $\pi^- p \to \eta n$ CROSS SECTION IN A SMALL TRANSFER RANGE AT 4 GEV/C

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Исследование сечения реакции $\pi^- p \to \eta n$ в области малых передач при импульсе π^--мезонов 4 Гэв/с

Приводятся результаты исследования дифференциального сечения рождения η-мезонов в реакции $\pi^- p \to \eta n$ при импульсе π^--мезонов 4 Гэв/с в области малых переданных импульсов с помощью метода искровых камер и черенковских γ-спектрометров полного поглощения.

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The $\pi^- p \to \eta n$ Cross Section in a Small Transfer Range at 4 Gev/c

The reaction $\pi^- + p \to \eta + n$, $\eta \to 2\gamma$ has been studied in a $0 \leq |t| \leq 0.24$ (Gev/c)^2 range at 4.0 Gev/c using spark chambers and Cherenkov total absorption gamma-spectrometers.

The coefficients $a = (4.3 \pm 0.8)/(\text{Gev/c})^{-2}/$ and $b = (190 \pm 18)/\mu b$ / (Gev/c)^2/ from the equation $d\sigma/dt = b \exp(at)$ were estimated.

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Dubna, 1969

A programme of experiments on the observation of the electromagnetic decays of meson resonances is being performed using the JINR proton-synchrotron in Dubna. As a part of this programme, the $\eta \to 2\gamma$ decay was observed.

In this paper the results from the reaction

$$\pi^- + p \to n + \eta , \quad \eta \to 2\gamma \tag{1}$$

at a π^--meson momentum of 4Gev/c $\pm$ 1.5% in the range of the transfer momentum $0 \leq |t| \leq 0.24$ (Gev/c)^2 are discussed. The preliminary data have been presented at the Lund Conference /1/. This paper has three improvements in comparison with the preliminary one: 1) the statistics was enlarged by about of 50 %; 2) the number of Monte-Carlo events in the detection probability calculations was also increased by a factor of five. The precise knowledge of this parameter is of great importance. For such a reason the data from the Monte-Carlo programme were tested by the other one, being used in JINR for many years /2/. Making these tests, the good agreement has been obtained. Finally, the interval for the $d\sigma/dt$ histogram was diminished, in order to have the possibility for better studying the differential cross section plot structure.

The reaction (1) is very interesting from the point of view of the simple Regge-pole model, especially in the range of $|t| \to 0$ (Gev/c)^2 because it involves only the A_2-trajectory.

In practice, the only experimental data from the reaction (1) treated in all theoretical papers are given in /3/, when the reaction(1) was investigated in wide ranges of π^--meson energies and squared momentum transfers. The forward peak in the differential cross section $d\sigma/dt$ and its flattening between $|t| = 0.2$ and 0 $(Gev/c)^2$ was observed at all momenta.

Our experimental arrangement using spark chambers and Cerenkov total absorption gamma-spectrometers has been described elsewhere /4/. Measuring the opening angle of the $\eta \to 2\gamma$ decay and the energy of each gamma, we get the accuracy Δt in $|t|$:

$$\Delta t = \pm 0.015\ (Gev/c)^2 \quad \text{at} \quad |t| \to 0\ (Gev/c)^2 \quad \text{and}$$

$$\Delta t = \pm 0.030\ (Gev/c)^2 \quad \text{at} \quad |t| \to 0.24\ (Gev/c)^2 \ .$$

It permitted us to investigate the reaction (1) at $|t| \to 0$ $(Gev/c)^2$ with the better Δt accuracy than in /3/.

After two time scanning procedure, about 9000 pictures containing the only conversion of the neutral particle in each channel were found. A part of about 4200 two-gamma events was measured with a half-automatical device, and the tape was handled by a computer. The geometrical reconstruction programme determines the point of the track intersection and fits the angular parameters of the tracks. For a future analysis only two-gamma decays having the intersection point within the effective target volume were selected. Only events with $P(\chi^2) \geq 1\%$ were taken. The kinematic selection of the two-gamma events was made by the reaction-channel identification programme. Thus, about 1500 events were determined to fulfil the reaction (1).

There are practically two sources of the background in our spectrum:

a) $\pi^- + p \to n + \pi^0 + \pi^0 \to n + 2\gamma$

and

b) $\pi^- + p \to n + \omega \to n + \pi^0 \gamma \to n + 2\gamma$.

The background is formed when two- or one-gamma from four- or three-gamma decays are not converted in a spark chamber converter or are escaped. The main source of the background is of the first kind. The subtraction of this background was made using the experimental three-gamma events, detected in the same runs, as follows: each three-gamma event was splitted into the two-gamma events handled by the same way as natural two-gamma events. Multiplying their spectra by the $(1-K)/K$ conversion factor (here K is the probability of one-gamma conversion in the spark chamber assembly), the background of about 25% has been obtained and subtracted. The background, a) and b), when a part of gammas are escaped, was estimated using the Monte-Carlo calculations, to be about 5%.

Each event was weighted by its inverse detection probability calculated by the Monte-Carlo method. The differential cross-section (after background subtraction) for the reaction (1) as a function of the squared momentum transfer $(-t)$ is given in Table I. The errors are only due to statistics. These results are also plotted in Fig.1. For comparison, the data from/3/ at the momentum 3.72 Gev/c are also presented. As is seen, there is no wide flattening in the forward peak. For the hypothesis of flattening in the range $0 \leq |t| \leq 0.24$ $(\mathrm{Gev/c})^2$ the value of $\chi^2 = 28$ by 9 degrees of freedom was obtained. It corresponds $P(\chi^2)$ to be less than 10^{-3}.

In the first interval, until $|t| = 0.02$ $(\mathrm{Gev/c})^2$, the differential cross-section decreases with $|t| \to 0$. The value $d\sigma/dt$ in the first interval was systematically lower in all the runs of our experiment indicating the change of the slope for small values of $|t|$. In the range $0.02 \leq |t| \leq 0.24$ $(\mathrm{Gev/c})^2$ (e.g. when the first point is excluded) the data were approximated by

$$d\sigma/dt = b \cdot \exp(at) . \tag{2}$$

The following results have been obtained by the best fit procedure

$a = (4.3 \pm 0.8)$ /$(\mathrm{Gev/c})^{-2}$ /, $b = (190 \pm 18)$/ $\mu b/(\mathrm{Gev/c})^2$ /

by $\chi^2 = 2.1$ (9 degrees of freedom).

TABLE I.

Differential Cross Section for the Reaction (1)

Number of intervals	$\|t\|$ $(Gev/c)^2$	$d\sigma/dt$ /μb/ $(Gev/c)^2$/
1	0.01	82 ± 18
2	0.03	158 ± 19
3	0.05	155 ± 18
4	0.07	143 ± 20
5	0.09	144 ± 17
6	0.11	108 ± 15
7	0.13	112 ± 17
8	0.15	106 ± 17
9	0.17	94 ± 18
10	0.19	76 ± 18
11	0.21	69 ± 19
12	0.23	74 ± 19

The slope a is in good agreement with the slope from/3/ obtained in the range of some greater t : $0.2 \le |t| \le 0.7$ $(Gev/c)^2$.

The measurements of the reaction (1) in the range of small $|t|$ values are very important for the parametrization of the residue function in the Regge-pole model. A series of analyses/5-7/ using both experimental and theoretical data from πN and KN interactions, in the Regge-pole model parametrization was performed during recent years. The data in the high energy region were completed by the data in the low energy region on the basis of the finite energy sum rules/8/. It is possible to analyse the data for the reaction (1), where only A_2 -meson contributes, on the basis of one-pole exchange formula:

$$d\sigma/dt = F(t) \cdot E^{2\alpha(t)-2} \qquad (3)$$

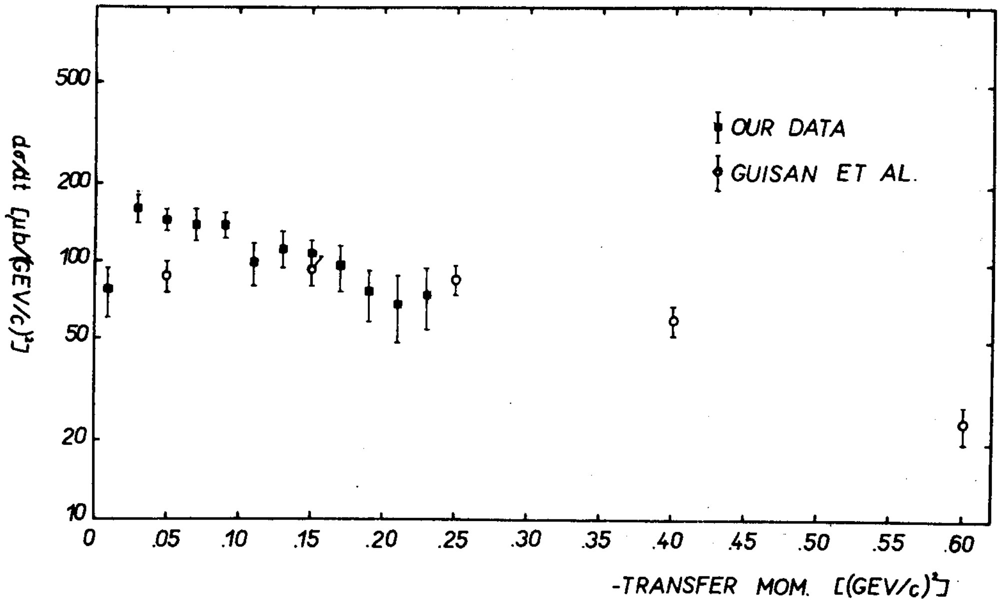

Fig.1. The differential cross section for the reaction
$\pi^- + p \to n + \eta , \quad \eta \to 2\gamma .$
The squares are from the present paper. The circles are from /3/ at 3.72 Gev/c.

The function $F(t)$ is strongly dependent on the model used. It contains the helicity flip and non-flip amplitudes and ghost-killing factors. The main uncertainty of $F(t)$ is the exponential factor for the amplitudes of the $\exp(ct)$ type. It is impossible to explore the αA_2 -trajectory without their determination. Unfortunately, till now, there are no experimental data in the range of small $|t|$ at several π^- -meson energies E with the proper accuracy for such analyses.

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