ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

ДУБНА

E1 - 11596

V.V.Arkhipov, R.G.Astvatsaturov, V.I.Ivanov, M.N.Khachaturian, V.A.Kramarenko, J.Knapic, A.I.Malakhov, G.L.Melkumov, S.N.Plyashkevich, B.M.Starchenko

DIFFERENTIAL CROSS SECTION OF THE REACTION $\pi^- p - \eta^\circ n$ AT MOMENTA OF 3.3 AND 4.75 GEV/C

1978

E1 - 11596

V.V.Arkhipov, R.G.Astvatsaturov, V.I.Ivanov,
M.N.Khachaturian, V.A.Kramarenko, J.Knapic,
A.I.Malakhov, G.L.Melkumov, S.N.Plyashkevich,
B.M.Starchenko

DIFFERENTIAL CROSS SECTION OF THE REACTION $\pi^- p - \eta^\circ n$ AT MOMENTA OF 3.3 AND 4.75 GEV/C

Submitted to the XIX International Conference on High Energy Physics (Tokyo, 1978)

Архипов В.В. и др. E1 - 11596

Дифференциальное сечение реакции при импульсах 3,3 и 4,75 ГэВ/с

Представлены результаты экспериментального исследования реакции $\pi^- p \to \eta^\circ n, \eta^\circ \to \gamma\gamma$ (1) на пучке пионов с импульсами 3,3 и 4,75 ГэВ/с. Исследования проведены с помощью 90-канального черенковского масс-спектрометра "Фотон" на протонном синхротроне ОИЯИ на 10 ГэВ. Дается краткое описание экспериментальной установки. Результатом исследования является измерение дифференциального сечения реакции (1) в области переданных импульсов от t_{min} до 0,3 (ГэВ/с)^2. В дифференциальных сечениях реакции (1) обнаружен заметный минимум в переднем направлении, указывающий на существенную роль амплитуды с изменением спиральности. Экспериментальные данные фитировались с помощью формулы: $d\sigma/dt = A(1-g^{-1}ct)e^{ct}$, где g – отношение вкладов амплитуд рассеяния без переворота и с переворотом спина. Для величин "A", "g" и "c" найдены следующие значения:

Р(ГэВ/с)	А мкб/(ГэВ/с)^2	g (%)	c (ГэВ/с)$^{-2}$
3,3	124,8$\pm$9,0	16,4$\pm$1,6	5,6$\pm$0,2
4,75	88,1$\pm$12,4	20,0$\pm$4,2	6,0$\pm$0,4.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1978

Arkhipov V.V. et al. E1 - 11596

Differential Cross Section of the Reaction at Momenta of 3.3 and 4.75 GeV/c

We present results from an experimental study of the reaction $\pi^- p \to \eta^\circ n$, $\eta^\circ \to \gamma\gamma$ (1) in a beam of 3.3 and 4.75 GeV/c pions. The studies have been performed by means of a 90-channel Cherenkov mass-spectrometer "Photon" at the 10 GeV Dubna proton synchrotron. A brief description of the experimental setup is given. The result of these studies is the measurement of the differential cross section for the reaction (1) in the region of momentum transfers from t_{min} to 0.3 (GeV/c)^2. A sizable minimum in the forward direction in the differential cross sections for the reaction (1) indicates a dominance of the helicity-flip amplitude. The experimental data were fitted by the formula: $d\sigma/dt = A(1-g^{-1}ct)e^{ct}$, where g is the ratio of the spin-nonflip and spin-flip amplitudes. The following values were found for A, g and c:

P (GeV/c)	A μB/(GeV/c)^2	g(%)	c (GeV/c)$^{-2}$
3.3.	124$\pm$9.0	16.4$\pm$1.6	5.6$\pm$0.2
4.75	88.1$\pm$12.4	20.0$\pm$4.2	6.0$\pm$0.4.

The investigation has been performed at the Laboratory of High Energies, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1978

1. INTRODUCTION

Among binary reactions, the process

$$\pi^- p \to \eta^\circ n \qquad (1)$$

is of special interest because by the Regge theory the amplitude of this reaction in the t-channel is dominated by a single A_2 pole exchange.

The reaction (1) has been recently studied in a series of experiments /1-5/. In this report we present preliminary results from a measurement of the differential cross section for the reaction (1) in the range from t_{min} to 0.3 $(GeV/c)^2$ for negative 3.3 and 4.75 *GeV/c* pions.

The experiment has been carried out at the Dubna 10 *GeV* proton synchrotron. In the experiment η°-mesons have been detected by means of a 90-channel Cherenkov mass-spectrometer (setup "Photon"). The experimental layout is presented on *fig. 1.* The mass-spectrometer consists of beam proportional chambers, scintillation hodoscope counters (20 elements), spark chambers for measuring the direction of γ-quanta and 90 Cherenkov lead-glass γ-spectrometers for measuring the energy of γ-quanta /6/.

2. DESCRIPTION OF THE APPARATUS

The π^- beam with $\Delta p/p \simeq \pm 1\%$ and a spill time of 0.4 *sec* is focused onto a 80 *cm* long liquid hydrogen target. The beam particles are detected by a telescope

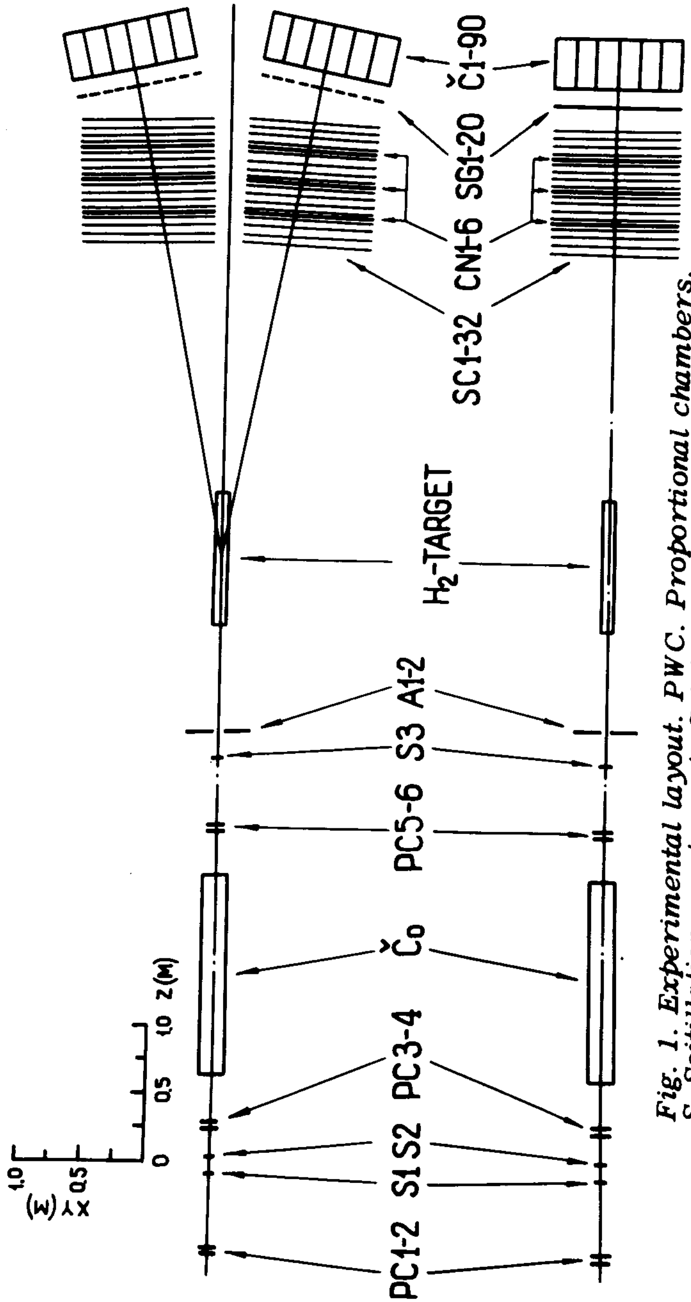

Fig. 1. Experimental layout. PWC. Proportional chambers. S. Scitillation counters. A. Scintillation anticoincidence counters. C_0. Gas Cherenkov counter. H_2. Liquid hydrogen target. SC. Wire spark chambers. SG. Hodoscope scintillation counters. C. Cherenkov lead-glass γ-spectrometer hodoscope. CN. Copper converters.

of scintillation counters S1 – S3. The pion direction is determined by means of six proportional wire chambers (PWC) with an accuracy of ±0.3 *mrad*. In order to prevent our setup from being triggered by halo particle interactions, two scintillation counters A1 and A2 forming a 5x5 cm^2 hole are used. These counters operate in anticoincidence.

The target is not surrounded by anticoincidence counters in order to exclude potential systematic error sources.

Thirty two 90x90 cm^2 magnetostrictive spark chambers (SC) have been used to measure the direction of γ -quanta from the $\eta^\circ \to \gamma\gamma$ decay. They are divided into two identical arms. 16 chambers of each arm are grouped in four spark chamber modules. Each module consists of four chambers followed by 0.4 r.l. thick copper converters. Two chambers in each module are placed horizontally and two others at an angle of 17°.The total thickness of the converters is equal to 1.2 r.l. which corresponds to a 56% conversion efficiency per one γ. The direction of converted electrons is measured by a four chamber module placed just behind the convertor. The first group of chambers operates in anticoincidence.

Two identical 10-element scintillation hodoscopes (SG1-10, SG11-20), placed between the spark chambers and Cherenkov γ-spectrometers, provide a more effective trigger.

Cherenkov lead-glass γ -spectrometers (Č1-90) are located behind the hodoscope counters. The total number of spectrometers is 90. The spectrometers operate independently and are separated 45x45 into two arms. A spectrometer radiator 35 *cm* (14 r.l.) long is hexagonal in form with a 17.5 *cm* inscribed circle diameter. The radiator is viewed by a 49B photomultiplier with a photocathode 17 *cm* in diameter. A small button of NaJ containing an ^{241}Am α-source is glued to an upstream face of each lead-glass block. The light output from NaJ + α is recorded to monitor gain drifts. Absolute energy calibration of each γ-spectrometer has been obtained on an electron beam.

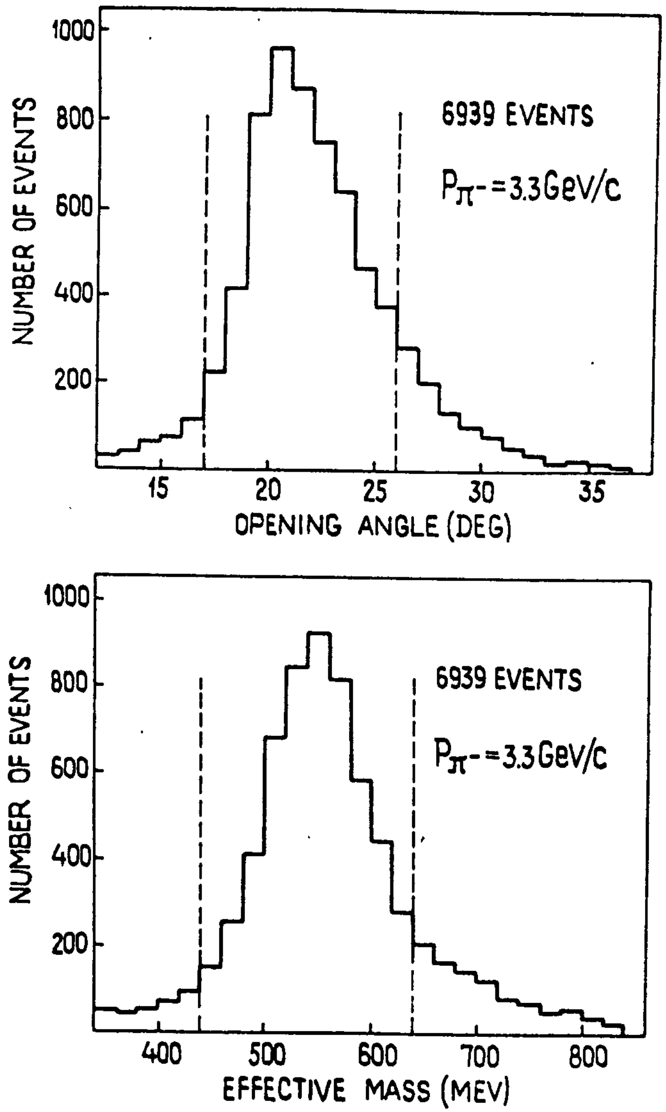

Fig. 2. Experimental distributions of $\gamma\gamma$ opening angles ($\theta_{\gamma\gamma}$) and $\gamma\gamma$ effective mass ($M_{\gamma\gamma}$) for $P_{\pi^-} = 3.3$ GeV/c.

Data collection, control and on-line analysis have been performed by a HEWLETT-PACKARD 2116B computer interfaced to the experiment through CAMAC electronics.

To trigger the setup, coincidence between $(SG1\text{-}10) \times (SG11\text{-}20) \cdot (\check{C}1\text{-}45) \cdot (\check{C}46\text{-}90) \cdot S1 \cdot S2 \cdot S3 \cdot \overline{A1} \cdot \overline{A2}$ is required provided that the particle energy deposition $E_{\gamma 1}$, $E_{\gamma 2}$ and $E_{\gamma 1} + E_{\gamma 2}$ exceeds some threshold determined by the kinematics of the investigated process and the geometry of the experiment.

In our experiment we have the following thresholds: $E_{\gamma 1} = E_{\gamma 2} \geq 300$ *MeV* and $(E_{\gamma 1} + E_{\gamma 2}) > 2500$ *MeV*.

An off-line analysis of the experimental data written on magnetic tape has been done on a CDC 6500 computer using the event reconstruction program /7/.

Two-gamma events have been selected according to the following criteria:

1. There are no tracks in the chambers SC1–4 and SC17–20 .
2. The charged particle track (or shower) produced in an i-th converter (i = 1,2,3) is observed in the chambers SC5–16 and SC21–32.
3. There is a corresponding signal from the hodoscope scintillation counters SG1–10 , SG11–32.
4. There are signals in the γ-spectrometers Č1–45 and Č46–90 satisfying the conditions:

a) 400 *MeV* $\leq E_{\gamma 1} (E_{\gamma 2}) \leq 2800$ *MeV*,
b) 3000 *MeV* $\leq (E_{\gamma 1} + E_{\gamma 2}) \leq 3500$ *MeV*,
c) $E_\gamma^{M} / E_\gamma^{\text{Б}} > 0.2$
at P=3.3 *GeV/c*;

a) 400 *MeV* $\leq E_{\gamma 1} (E_{\gamma 2}) \leq 4200$ *MeV*,
b) 4400 *MeV* $\leq (E_{\gamma 1} + E_{\gamma 2}) \leq 5000$ *MeV*,
c) $E_\gamma^{M} / E_\gamma^{\text{Б}} > 0.1$.
at 4.75 *GeV/c*.

Here E_γ^{M} and $E_\gamma^{\text{Б}}$ are lesser and greater energies of the two γ-quanta.

For a final selection of the events (1) the following cuts were applied:

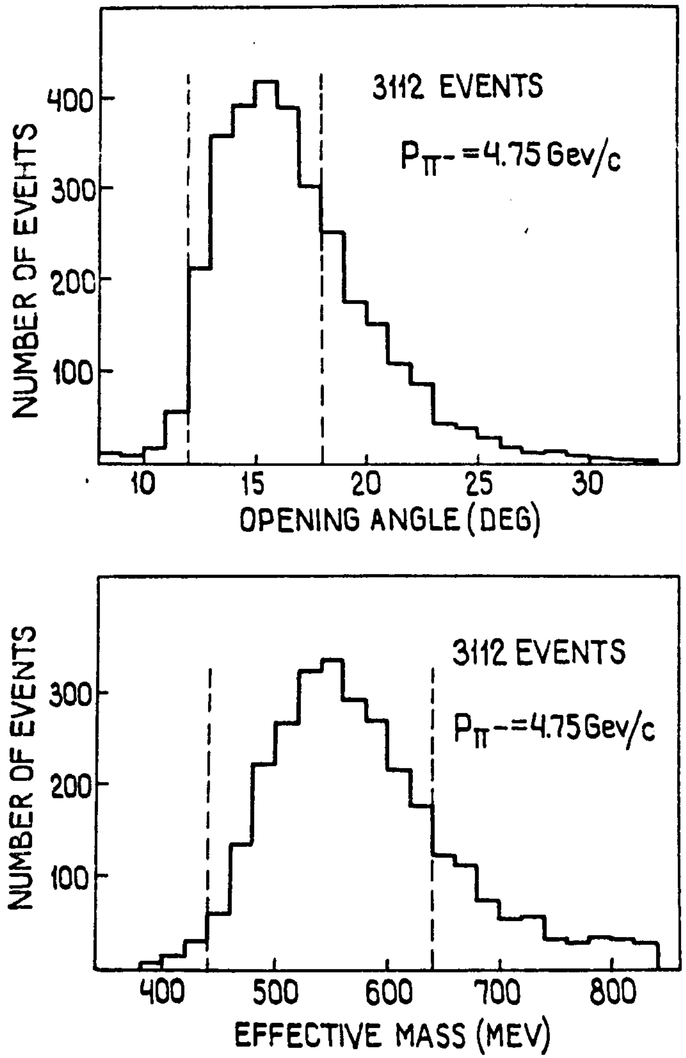

Fig. 3. Experimental distributions of $\gamma\gamma$ opening angle ($\theta_{\gamma\gamma}$) and $\gamma\gamma$ effective mass ($M_{\gamma\gamma}$) for $P_{\pi^-} = 4.75$ GeV/c.

(i) opening angle: $17° \le \theta_{\gamma\gamma} \le 26°$,
(ii) missing mass: 600 *MeV* $\le M_n \le$ 1100 *MeV*,
(iii) effective mass: 440 *MeV* $\le M_{\gamma\gamma} \le$ 640 *MeV* at $P_{\pi^-} = 3.3$ *GeV/c*;
(i) opening angle: $12° \le \theta_{\gamma\gamma} \le 18°$,
(ii) missing mass: 600 *MeV* $\le M_n \le$ 1100 *MeV*,
(iii) effective mass: 440 *MeV* $\le M_{\gamma\gamma} \le$ 640 *MeV* at $P_{\pi^-} = 4.75$ *GeV/c*.

4618 events of the reaction (1) at 3.3 *GeV/c* and 1440 events of the same reaction at 4.75 *GeV/c* were identified using the above criteria.

The selection criteria were calculated by the Monte-Carlo simulation of the experiment taking into account the angular and energy resolutions of the equipment [8].

The experimental distributions of $\gamma\gamma$ opening angle ($\theta_{\gamma\gamma}$), missing mass (M_n) and $\gamma\gamma$ effective mass ($M_{\gamma\gamma}$) are presented in *figs. 2-5*. The cuts are marked by vertical lines.

In estimating the background and its influence on the differential cross section of the reaction (1), the following processes were considered:

$$\pi^- p \to \eta^\circ \Delta^\circ , \qquad (2)$$

$$\pi^- p \to \omega^\circ n , \qquad (3)$$

$$\pi^- p \to \pi^\circ \pi^\circ n . \qquad (4)$$

The analysis of the background processes has shown that relative contributions of the events from the reactions (2), (3) and (4), satisfying the selection criteria, are 12%, 1% and 0.8% at 3.3 *GeV/c* and 14%, 4% and 0.4% at 4.75 *GeV/c*, respectively.

Event losses from the reaction (1) due to all cuts are equal to 28% at 3.3 *GeV/c* and 40% at 4.75 *GeV/c*. The background event contribution to the differential cross section of the process (1) was calculated by the Monte-Carlo simulation program for various selection and cut levels.

The results of such an analysis have shown that the influence of background events on the behaviour of the differential cross section is negligible within the errors.

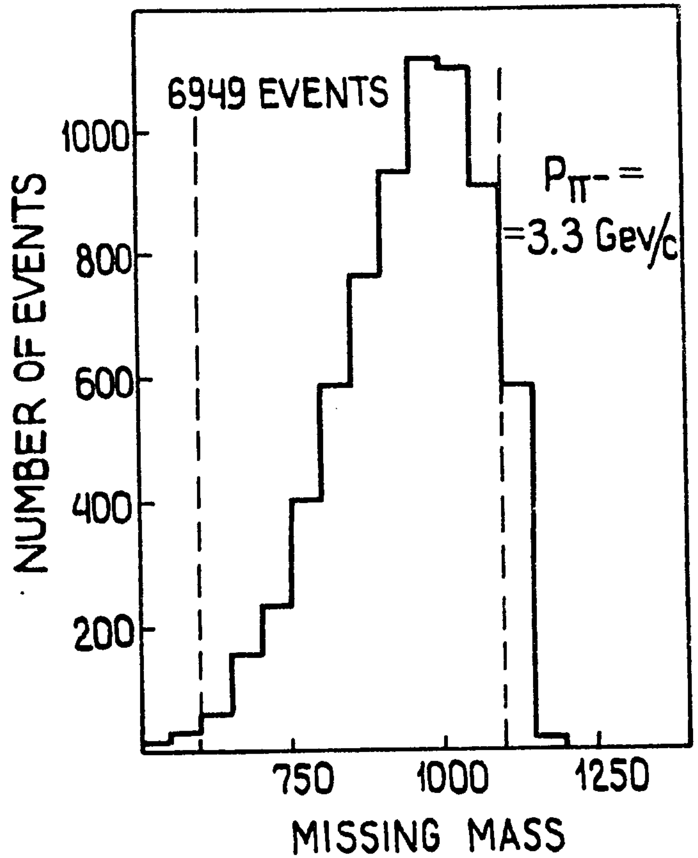

Fig. 4. Experimental missing mass (M_n) *distribution for* $P_{\pi^-} = 3.3$ *GeV/c.*

Figure 6 shows the differential cross sections for the reaction $\pi^- p \to \eta^\circ n$ as a function of $-t$ at 3.3 and 4.75 *GeV/c*. The bin width is equal to the experimental - t resolution.The errors in *fig*.6 are statistical. In this figure we also present the data from ref.[1] used to make an absolute normalization.

As is seen from *fig. 6* in the range of $-t$ from 0.01 to 0.1 $(GeV/c)^2$ the differential cross section increases more that by a factor of two. A sizable minimum in the

forward direction indicates a dominance of the helicity-flip amplitude. The first data on the minimum existence in the forward direction in the differential cross section for $\pi^- p \to \eta^\circ n$ at 4 *GeV/c* have been obtained in ref.[2].

The experimental data were fitted by the formula $d\sigma/dt = A(1-g^{-1}ct)e^{ct}$, where g is the ratio of the spin-nonflip and spin-flip amplitudes. The following values were found for A, g and c.

P (*GeV/c*)	A[μB(*GeV/c*)^2]	g(%)	c(*GeV/c*)^2
3.3	124.9±9.0	16.4±1.6	5.6±0.2
4.75	88.1±12.4	20.0±4.2	6.0±0.4

Together with the results of this paper, the data[1] for $-t = 0.4$ $(GeV/c)^2$ and $-t = 0.6$ $(GeV/c)^2$ were used. The values g and c at 3.3 and 4.75 *GeV/c* are in agreement, within errors, with the results obtained at 6 *GeV/c*[9].

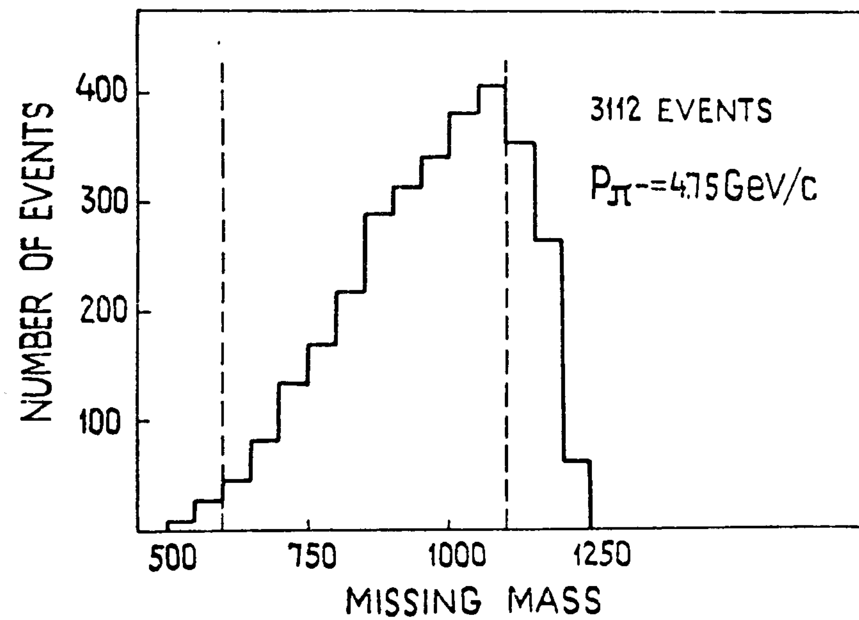

Fig. 5. Experimental missing mass (M_n) *distribution for* $P_{\pi^-} = 4.75$ *GeV/c.*

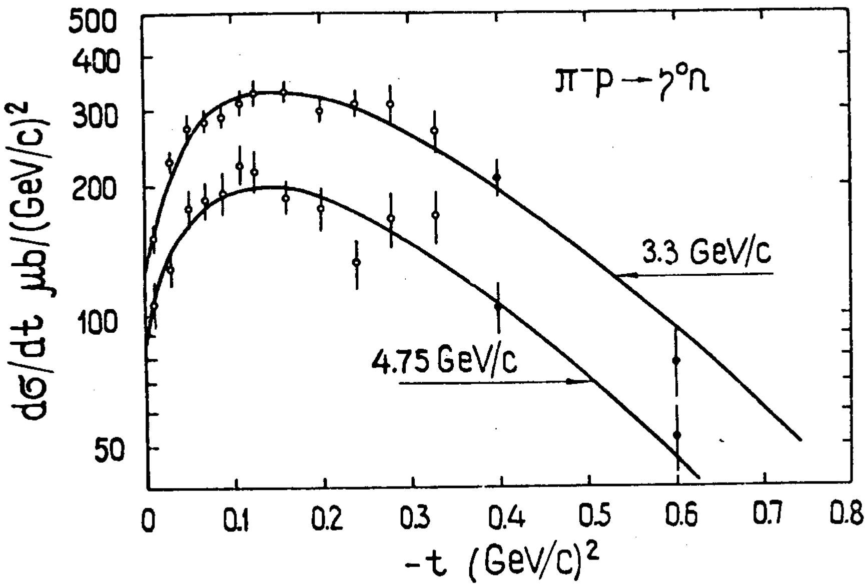

Fig. 6. Differential cross section for the reaction $\pi^- p \to \eta^\circ n$ as a function of $-t$ at 3.3 and 4.75 GeV/c. Points: o - data of this paper; • - data of ref. /1/ .

REFERENCES

1. *Guissan O. et al. Phys.Lett., 1965, 18, p.200.*
2. *Hladky J. et al. Phys.Lett., 1970, 31B, p.475.*
3. *Adamovich M.I. et al. Comm. on Phys., Lebedev Inst. of Physics, AN USSR, 1972, No. 1, p.48.*
4. *Adamovich M.I. et al. Comm. on Phys., Lebedev Inst. of Physics, AS USSR, 1972, No. 5.*
5. *Astvatsaturov R.G. et al. JINR, P1-10600, Dubna,1977.*
6. *Astvatsaturov R.G. et al. Nukleonika,1974,19,NR6,p.575.*
7. *Melkumov G.L., Khachaturian M.N. JINR, 10-8170, Dubna, 1974.*
8. *Melkumov G.L., Khachaturian M.N. JINR, 10-7960, Dubna, 1974.*
9. *Shaevitz M.N. et al. Phys.Lett., 1976, 36, p.5.*

Received by Publishing Department
on April 25 1978.