DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 75/29
August 1975

Electroproduction of π^+ Mesons in the Resonance Region

by

J.-C. Alder, H. Behrens, F.W. Brasse, W. Fehrenbach, J. Gayler,
S.P. Goel, R. Haidan, V. Korbel, J. May, M. Merkwitz
Deutsches Elektronen-Synchrotron DESY, Hamburg

2 HAMBURG 52 · NOTKESTIEG 1

To be sure that your preprints are promptly included in the
HIGH ENERGY PHYSICS INDEX ,
send them to the following address (if possible by air mail) :

DESY
Bibliothek
2 Hamburg 52
Notkestieg 1
Germany

Electroproduction of π^+ Mesons in the Resonance Region

J.-C. Alder[+], H. Behrens[++], F.W. Brasse, W. Fehrenbach[+++], J. Gayler, S.P. Goel[++++], R. Haidan, V. Korbel[+++++], J. May[+++++], M. Merkwitz

Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Abstract

Results on the reaction $ep \to e'n\pi^+$ are presented in the mass range $1.355 \leq W \leq 1.775$ GeV at $q^2 = 1$ GeV^2 and in the range $1.415 \leq W \leq 1.595$ GeV at $q^2 = 0.6$ GeV^2.
From the angular distribution of the π^+ meson the polarization terms $\sigma_u + \varepsilon\sigma_L$, σ_p and σ_I have been determined in the range of production angles $0 < \Theta^*_{\pi^+} \leq 63^o$.

Present addresses:

+	Université de Lausanne
++	Schulbehörde Hamburg
+++	Babcock-Brown-Boveri, Mannheim
++++	On leave from Kurukshetra University, Kurukshetra, India
+++++	CERN, Geneva

INTRODUCTION

We have reported recently on an experiment on η production in the resonance region[1]. Now we report on an analysis on the data of the reaction $ep \rightarrow en\pi^+$ taken at the same experiment. Data on this channel are still rather scarce in the resonance region. The resonance structure observed by Evangelides et al.[2] at forward angles shows that there are resonant amplitudes with total helicity 1/2 of the ingoing virtual photon and proton. Photoproduction on the other hand is known to be dominated by helicity 3/2 resonance excitation. It is one of the big successes of the quark model to predict the main features of photoproduction in the resonance region, in particular the dominance of the helicity 3/2 amplitudes. The structures observed at space-like four momentum transfers can therefore be very useful to test the model more severely.

The observed angular distributions of Evangelides et al.[2] at the second resonance region do not allow to separate the polarization terms $\sigma_u+\varepsilon\sigma_L$, σ_p and σ_I. The present experiment covers the second resonance region at $q^2 = 0.6$ GeV^2 and the second and third resonance region at $q^2 = 1$ GeV^2. The obtained angular distributions have been analysed with respect to the polarization terms $\sigma_u+\varepsilon\sigma_L$, σ_p and σ_I. First results of this experiment have been reported at the Bonn Conference 1973[3].

NOTATION

We express the cross section in terms of the virtual photon absorption cross section $d\sigma/d\Omega^*_{\pi^+}$ in the CMS of the final hadrons which is related to the differential coincidence cross section $d^5\sigma/dE'\, d\Omega_e\, d\Omega^*_{\pi^+}$ by the virtual photon flux factor Γ_t (defined as usually[4]):

$$\frac{d^5\sigma}{dE'\; d\Omega_e\; d\Omega^*_{\pi^+}} = \Gamma_t \frac{d\sigma}{d\Omega^*_{\pi^+}} \qquad (1)$$

The polar and azimuthal production angles (fig. 1) in the CMS are denoted by Θ^* and Φ. The ϕ dependence of the angular distribution in CMS can be written[5] explicitly as

$$\frac{d\sigma}{d\Omega^*} = \sigma_u + \varepsilon\sigma_L + \varepsilon \cos 2\phi\ \sigma_p + \sqrt{2\ \varepsilon(\varepsilon+1)}\ \cos\phi\ \sigma_I \qquad (2)$$

The parameter ε describes the polarization of the virtual photon (e.g. ref. 4). The cross sections σ_u, σ_L, σ_p and σ_I are functions of W, the invariant mass of the final $n\pi^+$ system, the momentum transfer q^2 and the angle Θ^*.
The terms σ_u and σ_L are the cross sections of unpolarized transverse and longitudinal virtual photons. They can only be separated by changing the polarization ε, not done here. σ_p takes account of the transverse polarization of the virtual photon and σ_I is a transverse-longitudinal interference term. A study of the ϕ dependence for fixed Θ^* allows to separate the 3 terms $\sigma_u + \varepsilon\sigma_L$, σ_p and σ_I.

APPARATUS

The experimental setup is described in more detail in ref. 1. Only a short description is repeated here. The measurements are done in an external e^- beam of DESY. The primary beam hits a 12 cm liquid hydrogen target. The intensity is controlled by a secondary emission monitor, which was compared many times during the experiment to a Faraday cup.
The scattered electron is detected in a focussing vertically bending spectrometer. It is identified by a threshold CO_2-Cerenkov- and a sandwich shower counter.
The π^+ meson is detected in coincidence with the scattered e^- in a non focussing spectrometer consisting of a vertically bending magnet, a system of proportional chambers mounted at the magnet exit and a scintillator hodoscope. The trajectory is defined by the target and the intersections with the proportional chamber and the scintillator hodoscope.

DATA ANALYSIS

The π^+ mesons are distinguished from protons by time of flight[1]. The reaction $ep \to en\pi^+$ clearly shows up in the missing mass spectrum. An example is given in fig. 2. Events in the missing mass range 895 MeV to 1025 MeV have been used to calculate the cross sections of the reaction $ep \to e\pi^+ n$.

Acceptances and various corrections have been calculated by a Monte Carlo simulation of the whole experiment. The W, q^2 and Θ^* dependence of π^+ production used for the simulation was taken from a preliminary analysis of a part of the data[3,6]. Also radiative corrections have been incorporated into the simulation including internal and external radiation. In this simulation only the radiation of the electron has been taken into account according to the formulas of ref. 7. Radiation of the hadrons was taken account of in a second step: The ratio of radiative corrections with and without hadronic radiation was computed analytically according to the formulas of Bartl and Urban[8]. This latter correction was smaller than 2 % in the covered kinematic range.
Pion decay and subsequent tracing of the decay muon has also been included into the Monte Carlo calculation. The resulting corrections were smaller than 4 %.
The cross sections are corrected for empty target rate (≈ 0.5 %), nuclear absorption (≈ 1 %), dead time losses, inefficiencies, multi track events and random background.

RESULTS

All data have been taken with the central electron spectrometer angle set to 15°. The polarization parameter ε was always close to 0.9. The errors given in the figures are statistical only. An overall systematic error of 6 % should be taken into account.

The measured angular distributions cover a range from $\Theta^*_{\pi^+} = 0^o$ up to nearly 90^o. However, only in the range $0 \leq \Theta^*_{\pi^+} \leq 65^o$ a sufficient range of Φ angles was covered to separate the terms $\sigma_u + \varepsilon\sigma_L$, σ_p and σ_I. These terms have been determined by least squares fits of all differential cross sections at fixed W, q^2 and $\cos\Theta^*$ to the Φ dependence of eq. (2). The results are given in table 1 and figs. 4 to 6. The cross sections $\sigma_u + \varepsilon\sigma_L$ at $\cos\Theta^* = 0.985$ have been obtained by averaging over all events of a given W, q^2-bin with $\cos\Theta^* > 0.97$. The measured differential cross sections are given in table 2.

The results on the forward cross sections confirm the structure observed by Evangelides et al.[2] at smaller momentum transfer (fig. 3), indicating that there are resonant helicity 1/2 amplitudes. The cross section increases at $W \gtrsim 1.65$ GeV at $q^2 = 1$ GeV^2 even more than at $q^2 = 0.4$ GeV^2. This structure in W is nearly absent slightly off the forward direction at $\cos\Theta^* = 0.935$ (fig. 6). The typical resonance structure of the second and third resonance region develops then more and more distinctly as the pions are produced more off the forward direction. We conclude that the helicity 3/2 amplitudes contribute still considerably to the resonances at momentum transfers up to 1 GeV^2. The longitudinal transverse interference term σ_I is rather small everywhere, at $W \simeq 1700$ MeV it is essentially zero.

The smallness of σ_I was predicted in a recent extensive multipole analysis of pion production in the resonance region by Devenish and Lyth[9]. In this analysis preliminary data of the present experiment only at Φ angles close to 90^o have been used. The sharp rise observed above W = 1.65 GeV in the forward cross section is expected to be mainly due to σ_L from pion exchange.

Acknowledgements

The excellent performance of the Synchrotron crew, the Hallendienst and the Rechenzentrum is gratefully acknowledged. We appreciate the technical assistance of J. Koll, G. Singer, K. Thiele, H. Weiß and Mrs. K. Schmöger. We thank E. Ganßauge for his help in the early stage of the experiment. Discussions with R.C.E. Devenish and F. Gutbrod are gratefully acknowledged.

References

1. J.-C. Alder, F.W. Brasse, W. Fehrenbach, J. Gayler, R. Haidan, G. Glöe, S.P. Goel, V. Korbel, W. Krechlok, J. May, M. Merkwitz, R. Schmitz, W. Wagner, Nucl. Phys. B91 (1975)386

2. E. Evangelides, R. Meaburn, J. Allison, B. Dickinson, M. Ibbotson, R. Lawson, H.E. Montgomery, D. Baxter, F. Foster, G. Hughes, P.S. Kummer, D.H. Lyth, R. Siddle, R.C.E. Devenish, Nucl. Phys. B71 (1974)381

3. J.-C. Alder et al., Contribution to the 6th International Symposium on Electron and Photon Interactions at High Energies, Bonn 1973

   A.B. Clegg, Proceedings of the 6th International Symposium on Electron and Photon Interactions at High Energies, Bonn 1973

4. e.g. J.-C. Alder et al., Nucl. Phys. B46 (1972)573

5. K. Berkelman, Proceedings of the Int. Symposium on Electron and Photon Interactions at High Energies, Hamburg 1965

   M. Gourdin, Nuovo Cimento 21 (1961)1094

6. H. Behrens, Diplomarbeit, Universität Hamburg (1974)

7. G. Miller, Thesis, Stanford University (1971)

8. A. Bartl, P. Urban, Acta Physica Austriaca 24 (1966)139

   P. Urban, Topics in Applied QED, Springer, Wien - New York (1970)

9. R.C.E. Devenish, D.H. Lyth, Nuclear Physics B93 (1975)109

Table 1: Angular distributions of the reaction $\gamma_v p \to \pi^+ n$. The errors do not contain an overall systematic error of 6 %.

$\cos\theta^*$	$\sigma_u+\varepsilon\sigma_L$ (μb/sr)	σ_p (μb/sr)	σ_I (μb/sr)
W = 1.355 GeV ε = 0.93 q^2 = 1.05 GeV²			
0.585	6.06 +- 0.56		
0.650	4.70 +- 1.00	0.11 +- 0.92	-1.00 +- 0.91
0.550	3.48 +- 0.65	-0.75 +- 0.70	-0.35 +- 0.60
W = 1.385 GeV ε = 0.93 q^2 = 1.04 GeV²			
0.585	4.80 +- 0.40		
0.750	4.26 +- 0.51	-0.11 +- 0.53	-0.49 +- 0.45
0.650	4.05 +- 0.45	-0.21 +- 0.47	-0.64 +- 0.41
0.550	4.10 +- 0.52	-0.80 +- 0.62	-0.99 +- 0.42
0.450	3.55 +- 0.80	0.25 +- 1.02	-0.94 +- 0.54
W = 1.415 GeV ε = 0.93 q^2 = 1.03 GeV²			
0.585	4.13 +- 0.32		
0.535	4.75 +- 0.94	0.86 +- 1.18	-0.33 +- 0.41
0.650	4.80 +- 0.77	0.63 +- 0.91	-0.13 +- 0.42
0.750	3.43 +- 0.27	-0.90 +- 0.32	-0.08 +- 0.24
0.650	3.48 +- 0.24	-0.93 +- 0.32	-0.13 +- 0.21
0.550	3.05 +- 0.31	-0.83 +- 0.46	-0.35 +- 0.23
W = 1.445 GeV ε = 0.92 q^2 = 1.02 GeV²			
0.585	3.11 +- 0.26		
0.535	3.01 +- 0.37	-0.56 +- 0.54	0.49 +- 0.22
0.650	3.27 +- 0.32	-1.02 +- 0.40	0.42 +- 0.25
0.750	3.42 +- 0.18	-0.84 +- 0.24	0.09 +- 0.16
0.650	2.82 +- 0.17	-1.16 +- 0.26	0.06 +- 0.14
0.550	2.52 +- 0.26	-1.44 +- 0.42	0.02 +- 0.18
0.450	3.45 +- 0.84	-1.12 +- 1.15	-0.09 +- 0.45
W = 1.475 GeV ε = 0.92 q^2 = 1.01 GeV²			
0.585	3.28 +- 0.25		
0.535	3.45 +- 0.26	-0.47 +- 0.39	0.60 +- 0.18
0.650	3.55 +- 0.25	-0.84 +- 0.35	0.25 +- 0.22
0.750	3.15 +- 0.13	-1.60 +- 0.20	0.56 +- 0.11
0.650	3.45 +- 0.16	-1.29 +- 0.27	0.02 +- 0.13
0.550	2.91 +- 0.26	-1.61 +- 0.44	-0.15 +- 0.19
W = 1.505 GeV ε = 0.92 q^2 = 0.99 GeV²			
0.585	3.42 +- 0.25		
0.535	3.25 +- 0.21	-0.94 +- 0.31	0.53 +- 0.16
0.650	3.10 +- 0.15	-1.10 +- 0.23	0.43 +- 0.13
0.750	3.48 +- 0.12	-1.12 +- 0.19	0.47 +- 0.10
0.650	3.48 +- 0.17	-1.16 +- 0.28	0.13 +- 0.13
0.550	3.41 +- 0.35	-1.04 +- 0.49	0.31 +- 0.25
W = 1.535 GeV ε = 0.91 q^2 = 0.98 GeV²			
0.585	3.79 +- 0.24		
0.535	3.80 +- 0.21	0.01 +- 0.30	0.65 +- 0.17
0.650	3.00 +- 0.13	-1.07 +- 0.25	0.55 +- 0.14
0.750	2.89 +- 0.11	-0.49 +- 0.18	0.34 +- 0.09
0.650	2.56 +- 0.15	-0.89 +- 0.24	-0.00 +- 0.12
0.550	2.88 +- 0.52	-0.84 +- 0.57	0.76 +- 0.41
W = 1.565 GeV ε = 0.91 q^2 = 0.97 GeV²			
0.585	4.20 +- 0.20		
0.535	4.18 +- 0.15	-0.37 +- 0.22	0.62 +- 0.13
0.650	3.13 +- 0.08	-0.78 +- 0.15	0.49 +- 0.07
0.750	2.46 +- 0.07	-0.66 +- 0.11	0.27 +- 0.06
0.650	2.13 +- 0.10	-0.83 +- 0.15	0.17 +- 0.09
0.550	1.40 +- 0.33	-1.02 +- 0.36	-0.22 +- 0.27
0.450	1.98 +- 0.81	-0.27 +- 0.52	0.57 +- 0.66
W = 1.595 GeV ε = 0.90 q^2 = 0.95 GeV²			
0.585	4.05 +- 0.20		
0.535	3.65 +- 0.13	-0.78 +- 0.22	0.18 +- 0.12
0.650	3.30 +- 0.08	-0.71 +- 0.15	0.35 +- 0.07
0.750	2.69 +- 0.08	-0.76 +- 0.13	0.16 +- 0.06
0.650	2.12 +- 0.12	-0.95 +- 0.16	0.20 +- 0.11
0.550	0.94 +- 0.30	-1.35 +- 0.31	-0.53 +- 0.25
0.450	1.43 +- 0.57	-0.88 +- 0.39	0.01 +- 0.47
W = 1.625 GeV ε = 0.90 q^2 = 0.94 GeV²			
0.585	3.87 +- 0.19		
0.535	3.79 +- 0.13	-0.71 +- 0.19	0.53 +- 0.11
0.650	3.47 +- 0.08	-1.84 +- 0.15	0.50 +- 0.06
0.750	3.16 +- 0.10	-0.90 +- 0.17	0.47 +- 0.09
0.650	2.38 +- 0.14	-1.55 +- 0.18	0.05 +- 0.13
0.550	2.15 +- 0.53	-0.80 +- 0.47	0.13 +- 0.44
0.450	1.46 +- 0.67	-1.14 +- 0.54	-0.28 +- 0.56
W = 1.655 GeV ε = 0.90 q^2 = 0.93 GeV²			
0.585	4.26 +- 0.18		
0.535	3.64 +- 0.11	-0.83 +- 0.15	0.28 +- 0.08
0.650	3.70 +- 0.08	-1.13 +- 0.14	0.39 +- 0.06
0.750	3.15 +- 0.11	-1.45 +- 0.18	0.32 +- 0.09
0.650	2.71 +- 0.17	-1.42 +- 0.20	0.19 +- 0.16
0.550	2.58 +- 0.65	-1.40 +- 0.53	0.21 +- 0.56
0.450	0.17 +- 0.92	-2.32 +- 0.73	-1.55 +- 0.76

$\cos\theta^*$	$\sigma_u+\varepsilon\sigma_L$ (μb/sr)	σ_p (μb/sr)	σ_I (μb/sr)
W = 1.685 GeV ε = 0.89 q^2 = 0.91 GeV²			
0.585	5.26 +- 0.19		
0.535	4.32 +- 0.11	-0.76 +- 0.16	0.06 +- 0.08
0.650	3.87 +- 0.08	-0.82 +- 0.14	0.15 +- 0.06
0.750	3.36 +- 0.14	-1.22 +- 0.24	0.22 +- 0.11
0.650	2.47 +- 0.20	-1.50 +- 0.23	-0.22 +- 0.18
0.550	2.88 +- 0.68	-0.84 +- 0.53	0.56 +- 0.58
W = 1.715 GeV ε = 0.88 q^2 = 0.90 GeV²			
0.585	7.01 +- 0.24		
0.535	4.38 +- 0.11	-0.69 +- 0.17	0.00 +- 0.08
0.650	3.39 +- 0.08	-0.65 +- 0.14	-0.12 +- 0.06
0.750	2.80 +- 0.14	-0.86 +- 0.26	0.09 +- 0.11
0.650	2.17 +- 0.22	-1.06 +- 0.23	-0.07 +- 0.19
0.550	1.48 +- 0.63	-1.06 +- 0.50	-0.27 +- 0.55
0.450	1.06 +- 0.95	-0.99 +- 0.71	-0.35 +- 0.79
W = 1.745 GeV ε = 0.88 q^2 = 0.88 GeV²			
0.585	6.45 +- 0.27		
0.535	4.32 +- 0.13	-0.67 +- 0.21	-0.32 +- 0.10
0.650	2.93 +- 0.09	-0.50 +- 0.17	-0.28 +- 0.08
0.750	2.05 +- 0.14	-0.24 +- 0.23	0.01 +- 0.12
0.650	1.99 +- 0.37	-0.27 +- 0.33	0.17 +- 0.32
0.550	2.00 +- 0.65	0.16 +- 0.51	0.58 +- 0.57
0.450	0.81 +- 0.94	-0.82 +- 0.66	-0.29 +- 0.79
W = 1.775 GeV ε = 0.87 q^2 = 0.87 GeV²			
0.585	6.34 +- 0.95		
0.535	4.43 +- 0.56	1.38 +- 1.12	-0.67 +- 0.55
0.650	3.08 +- 0.45	0.10 +- 0.79	0.17 +- 0.43
0.750	3.18 +- 0.97	0.06 +- 1.70	-0.37 +- 0.89
W = 1.415 GeV ε = 0.92 q^2 = 0.63 GeV²			
0.585	7.68 +- 0.92		
0.535	7.13 +- 2.00	-1.50 +- 2.30	0.42 +- 1.55
0.650	6.66 +- 0.47	-1.09 +- 0.86	0.98 +- 0.46
0.750	5.20 +- 0.32	-2.28 +- 0.59	0.10 +- 0.27
0.650	7.21 +- 0.56	-0.12 +- 1.02	0.07 +- 0.40
W = 1.445 GeV ε = 0.92 q^2 = 0.62 GeV²			
0.585	6.93 +- 0.48		
0.535	6.11 +- 0.66	-1.76 +- 0.96	1.14 +- 0.50
0.650	6.12 +- 0.23	-1.47 +- 0.36	0.45 +- 0.20
0.750	5.51 +- 0.17	-2.09 +- 0.33	0.13 +- 0.13
0.650	5.75 +- 0.27	-2.78 +- 0.59	0.22 +- 0.21
0.550	4.89 +- 0.90	-2.82 +- 1.52	0.29 +- 0.55
W = 1.475 GeV ε = 0.91 q^2 = 0.61 GeV²			
0.585	6.36 +- 0.37		
0.535	5.91 +- 0.41	-1.00 +- 0.64	0.81 +- 0.29
0.650	6.17 +- 0.20	-1.99 +- 0.30	0.55 +- 0.16
0.750	5.91 +- 0.16	-1.66 +- 0.31	0.97 +- 0.13
0.650	6.22 +- 0.30	-2.25 +- 0.55	0.77 +- 0.24
0.550	8.49 +- 2.55	2.01 +- 3.13	2.14 +- 1.63
W = 1.505 GeV ε = 0.91 q^2 = 0.60 GeV²			
0.585	7.91 +- 0.37		
0.535	6.55 +- 0.37	-1.07 +- 0.61	1.42 +- 0.27
0.650	5.82 +- 0.18	-1.83 +- 0.26	0.90 +- 0.14
0.750	5.64 +- 0.16	-1.92 +- 0.31	0.75 +- 0.14
0.650	5.26 +- 0.34	-2.98 +- 0.52	0.43 +- 0.30
0.550	6.60 +- 2.23	-0.16 +- 2.59	1.03 +- 1.59
W = 1.535 GeV ε = 0.90 q^2 = 0.59 GeV²			
0.585	8.97 +- 0.36		
0.535	7.05 +- 0.26	-0.60 +- 0.40	0.06 +- 0.22
0.650	5.74 +- 0.22	-1.77 +- 0.35	0.55 +- 0.19
0.750	5.07 +- 0.17	-1.96 +- 0.31	0.63 +- 0.15
0.650	4.06 +- 0.36	-1.63 +- 0.46	0.38 +- 0.32
0.550	4.44 +- 1.88	-0.36 +- 1.94	0.64 +- 1.45
W = 1.565 GeV ε = 0.90 q^2 = 0.58 GeV²			
0.585	9.77 +- 0.37		
0.535	7.38 +- 0.22	-0.78 +- 0.35	0.66 +- 0.18
0.650	5.56 +- 0.26	-1.13 +- 0.46	0.26 +- 0.23
0.750	4.37 +- 0.18	-1.26 +- 0.31	0.38 +- 0.17
0.650	2.60 +- 0.43	-2.09 +- 0.48	-0.53 +- 0.40
W = 1.595 GeV ε = 0.89 q^2 = 0.57 GeV²			
0.585	8.57 +- 0.56		
0.535	7.38 +- 0.29	-1.68 +- 0.49	0.46 +- 0.22
0.650	6.60 +- 0.35	0.34 +- 0.65	0.35 +- 0.29
0.750	4.08 +- 0.30	-1.34 +- 0.51	0.17 +- 0.29
0.650	5.15 +- 2.08	-0.23 +- 1.75	1.82 +- 1.86

Table 2: Differential cross sections of the reaction $\gamma_V p \to \pi^+ n$.
The errors do not contain an overall systematic error of 6 %.

W = 1.415 GeV ε = 0.92 q^2 = 0.63 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		7.68 +- 0.92
0.935	32.	6.16 +- 1.25
	46.	9.19 +- 1.25
	65.	8.93 +- 1.12
	88.	7.39 +- 1.01
	106.	8.96 +- 1.32
0.850	36.	5.54 +- 3.03
	51.	8.25 +- 1.02
	65.	7.31 +- 0.82
	85.	8.02 +- 0.85
	102.	10.05 +- 1.37
	135.	4.30 +- 1.05
	149.	4.56 +- 0.66
	166.	4.45 +- 1.07
0.750	34.	4.66 +- 0.37
	49.	5.43 +- 1.04
	65.	7.02 +- 0.80
	85.	7.18 +- 0.92
	101.	5.32 +- 1.74
	131.	5.66 +- 0.69
	148.	4.50 +- 0.56
	165.	2.10 +- 0.97
0.650	36.	7.07 +- 1.36
	43.	8.14 +- 1.37
	71.	6.72 +- 0.92
	88.	7.51 +- 0.98
	116.	9.09 +- 1.95
	128.	7.11 +- 0.68
	143.	6.06 +- 2.04
0.550	70.	11.63 +- 2.27
	88.	14.13 +- 3.50
	115.	5.39 +- 1.21
	126.	5.53 +- 0.86
0.450	116.	3.57 +- 1.59
	122.	4.49 +- 2.14

W = 1.445 GeV ε = 0.92 q^2 = 0.62 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		6.93 +- 0.48
0.935	15.	9.21 +- 2.41
	32.	7.45 +- 0.85
	49.	7.15 +- 0.63
	68.	8.31 +- 0.69
	89.	8.00 +- 0.62
	108.	6.68 +- 0.60
	123.	5.53 +- 1.17
0.850	31.	5.44 +- 0.64
	52.	8.21 +- 0.76
	69.	7.67 +- 0.55
	89.	7.35 +- 0.49
	104.	5.85 +- 0.68
	136.	7.38 +- 1.54
	150.	5.28 +- 0.49
	168.	3.49 +- 0.57
0.750	32.	4.80 +- 0.38
	45.	5.86 +- 0.50
	70.	7.56 +- 0.57
	89.	7.21 +- 0.50
	103.	6.02 +- 0.99
	132.	5.80 +- 0.48
	149.	4.41 +- 0.36
	166.	3.40 +- 0.64
0.650	36.	6.46 +- 0.80
	44.	5.11 +- 0.55
	72.	8.82 +- 0.76
	89.	8.45 +- 0.65
	112.	6.58 +- 1.08
	130.	5.80 +- 0.41
	144.	5.16 +- 0.76
0.550	42.	4.22 +- 1.73
	72.	8.72 +- 1.33
	88.	6.67 +- 1.21
	115.	6.00 +- 0.82
	127.	5.37 +- 0.48
0.450	116.	6.75 +- 1.35
	123.	6.57 +- 1.38

W = 1.475 GeV ε = 0.91 q^2 = 0.61 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		6.36 +- 0.37
0.935	14.	8.25 +- 2.32
	32.	6.90 +- 0.92
	49.	7.47 +- 0.60
	68.	6.11 +- 0.52
	89.	7.38 +- 0.55
	108.	6.61 +- 0.53
	126.	4.91 +- 0.69
	146.	3.65 +- 1.51
0.850	18.	4.29 +- 1.27
	30.	6.73 +- 0.47
	50.	6.19 +- 0.67
	69.	7.88 +- 0.52
	89.	7.93 +- 0.48
	107.	7.65 +- 0.56
	121.	10.92 +- 5.23
	151.	4.60 +- 0.49
	168.	3.12 +- 0.52
0.750	32.	7.56 +- 0.47
	45.	6.50 +- 0.43
	71.	7.05 +- 0.55
	89.	8.24 +- 0.50
	104.	6.76 +- 0.71
	134.	4.80 +- 0.49
	149.	3.49 +- 0.28
	167.	2.89 +- 0.41
0.650	37.	5.24 +- 1.31
	45.	7.69 +- 0.65
	74.	8.53 +- 0.81
	89.	7.96 +- 0.57
	105.	9.01 +- 1.18
	130.	5.50 +- 0.37
	146.	4.37 +- 0.47
0.550	73.	8.71 +- 1.45
	89.	6.14 +- 0.93
	116.	6.64 +- 0.95
	128.	5.43 +- 0.39
	141.	6.70 +- 2.25
0.450	115.	5.01 +- 0.97
	125.	5.50 +- 0.76

W = 1.505 GeV ε = 0.91 q^2 = 0.60 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		7.91 +- 0.37
0.935	15.	8.05 +- 3.48
	31.	9.49 +- 1.44
	51.	8.55 +- 0.72
	69.	8.56 +- 0.64
	88.	7.29 +- 0.58
	105.	7.70 +- 0.57
	128.	5.28 +- 0.52
	147.	4.35 +- 0.81
0.850	18.	8.91 +- 1.44
	30.	6.18 +- 0.36
	46.	7.23 +- 0.62
	71.	7.80 +- 0.52
	89.	7.23 +- 0.44
	106.	7.09 +- 0.45
	123.	3.89 +- 1.01
	153.	4.10 +- 0.76
	166.	2.47 +- 0.47
0.750	33.	6.82 +- 0.54
	47.	6.21 +- 0.36
	73.	7.76 +- 0.67
	85.	7.73 +- 0.48
	106.	7.35 +- 0.60
	135.	3.20 +- 0.60
	150.	3.47 +- 0.27
	167.	3.08 +- 0.36
0.650	47.	6.09 +- 0.70
	75.	7.29 +- 0.83
	89.	8.05 +- 0.56
	104.	8.41 +- 0.94
	132.	4.61 +- 0.37
	148.	3.71 +- 0.31
	166.	1.62 +- 0.66
0.550	75.	7.13 +- 1.44
	90.	6.37 +- 0.97
	113.	5.64 +- 1.17
	130.	5.42 +- 0.36
	142.	4.96 +- 0.91
0.450	116.	7.09 +- 1.25
	127.	5.37 +- 0.57
0.350	123.	7.70 +- 2.47

W = 1.535 GeV ε = 0.90 q^2 = 0.59 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		8.97 +- 0.36
0.935	16.	5.54 +- 1.55
	28.	5.62 +- 0.77
	52.	10.31 +- 1.10
	69.	8.98 +- 0.59
	88.	6.49 +- 0.49
	109.	7.23 +- 0.51
	128.	7.22 +- 0.51
	147.	7.12 +- 0.71
	168.	6.10 +- 1.07
	187.	8.99 +- 3.43
0.850	17.	6.36 +- 0.87
	30.	5.77 +- 0.31
	46.	6.20 +- 0.40
	72.	8.05 +- 0.61
	89.	7.51 +- 0.45
	109.	6.47 +- 0.43
	124.	5.47 +- 0.64
	169.	3.62 +- 0.35
0.750	35.	6.50 +- 0.79
	49.	5.87 +- 0.33
	74.	6.52 +- 0.74
	89.	6.93 +- 0.47
	107.	6.20 +- 0.47
	135.	6.50 +- 1.38
	151.	3.16 +- 0.29
	168.	2.12 +- 0.29
	182.	5.00 +- 1.80
0.650	49.	4.11 +- 0.73
	76.	6.09 +- 1.00
	89.	6.44 +- 0.48
	105.	4.38 +- 0.54
	134.	3.29 +- 0.37
	149.	2.72 +- 0.23
	167.	2.45 +- 0.36
0.550	76.	4.94 +- 1.55
	90.	4.61 +- 0.84
	106.	5.42 +- 1.16
	121.	3.62 +- 0.30
	145.	3.52 +- 0.47
0.450	117.	4.88 +- 1.13
	126.	3.73 +- 0.39
0.350	125.	1.32 +- 0.61

W = 1.565 GeV ε = 0.90 q^2 = 0.58 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		9.77 +- 0.37
0.935	15.	8.30 +- 1.21
	29.	6.08 +- 0.59
	48.	7.46 +- 1.21
	70.	8.26 +- 0.63
	86.	8.18 +- 0.56
	109.	8.14 +- 0.58
	129.	6.36 +- 0.46
	149.	5.73 +- 0.52
	169.	6.59 +- 0.80
	187.	4.66 +- 1.55
0.850	17.	5.02 +- 0.91
	31.	5.73 +- 0.33
	48.	5.71 +- 0.30
	72.	6.48 +- 0.65
	89.	6.65 +- 0.44
	109.	6.46 +- 0.39
	126.	5.26 +- 0.46
	142.	6.31 +- 2.51
0.750	38.	6.52 +- 1.64
	51.	5.01 +- 0.33
	69.	5.44 +- 0.69
	89.	5.15 +- 0.40
	109.	5.50 +- 0.41
	121.	6.56 +- 1.61
	153.	2.72 +- 0.34
	169.	2.85 +- 0.31
	182.	2.35 +- 0.92
0.650	51.	2.89 +- 0.89
	77.	4.36 +- 1.11
	89.	4.03 +- 0.41
	107.	4.59 +- 0.47
	136.	3.92 +- 0.53
	150.	2.57 +- 0.21
	167.	1.69 +- 0.25
0.550	89.	5.44 +- 0.87
	105.	3.75 +- 0.80
	132.	2.63 +- 0.28
	146.	1.91 +- 0.27
0.450	118.	4.81 +- 1.68
	130.	2.34 +- 0.27
	142.	1.91 +- 0.75
0.350	127.	2.12 +- 0.64

W = 1.595 GeV ε = 0.89 q^2 = 0.57 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		8.57 +- 0.56
0.935	15.	7.97 +- 1.23
	29.	6.64 +- 0.62
	45.	7.87 +- 1.17
	73.	8.54 +- 1.29
	89.	8.44 +- 0.89
	108.	7.94 +- 0.89
	129.	7.48 +- 0.83
	149.	5.47 +- 0.72
	168.	4.72 +- 0.91
0.850	16.	8.71 +- 1.87
	31.	6.92 +- 0.60
	49.	7.19 +- 0.45
	69.	6.78 +- 1.00
	89.	5.71 +- 0.64
	109.	6.78 +- 0.64
	128.	5.93 +- 0.64
	145.	6.11 +- 1.66
0.750	53.	4.79 +- 0.53
	65.	4.05 +- 0.82
	90.	5.65 +- 0.62
	109.	4.88 +- 0.60
	123.	3.96 +- 1.09
	154.	3.32 +- 0.85
	168.	2.63 +- 0.51
0.650	90.	5.69 +- 0.75
	108.	3.75 +- 0.62
	136.	2.99 +- 0.96
	150.	2.40 +- 0.31
	168.	1.51 +- 0.31
0.550	96.	4.96 +- 2.26
	133.	2.15 +- 0.44
	148.	2.67 +- 0.40
0.450	131.	2.70 +- 0.45
	142.	2.00 +- 0.82
0.350	128.	4.19 +- 1.09

Table 2 (continued)

W = 1.355 GeV ε = 0.93 q^2 = 1.05 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		6.06 +- 0.56
0.935	33.	7.24 +- 3.31
	52.	5.12 +- 1.10
	68.	5.98 +- 0.68
	88.	5.39 +- 0.64
	102.	6.16 +- 1.91
0.850	56.	18.75 +- 9.28
	71.	4.84 +- 0.50
	88.	5.05 +- 0.44
	101.	5.35 +- 2.45
0.750	8.	2.67 +- 0.92
	56.	5.41 +- 1.71
	73.	3.70 +- 0.44
	88.	4.42 +- 0.38
0.650	10.	2.75 +- 0.45
	28.	3.50 +- 0.69
	57.	7.45 +- 3.41
	72.	4.02 +- 0.47
	88.	4.45 +- 0.41
	115.	5.93 +- 2.06
	126.	6.41 +- 2.94
0.550	12.	2.23 +- 0.74
	30.	2.55 +- 0.51
	71.	3.75 +- 0.48
	87.	4.14 +- 0.44
	114.	5.66 +- 1.35
	124.	3.01 +- 1.38
0.450	34.	2.45 +- 0.84
	71.	4.14 +- 0.66
	86.	4.11 +- 0.77
	112.	3.46 +- 1.42
0.350	68.	7.48 +- 2.58

W = 1.385 GeV ε = 0.93 q^2 = 1.04 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		4.80 +- 0.40
0.935	51.	6.23 +- 1.72
	71.	4.44 +- 0.48
	89.	5.20 +- 0.47
	106.	3.80 +- 0.53
0.850	53.	5.56 +- 0.88
	72.	4.33 +- 0.40
	89.	4.44 +- 0.31
	102.	3.84 +- 0.58
0.750	10.	3.19 +- 0.56
	25.	3.39 +- 0.89
	55.	3.88 +- 0.68
	71.	4.27 +- 0.41
	89.	4.17 +- 0.29
	101.	5.37 +- 1.34
	128.	5.08 +- 1.00
0.650	11.	2.52 +- 0.40
	25.	3.06 +- 0.40
	48.	4.64 +- 1.26
	71.	4.01 +- 0.36
	88.	4.06 +- 0.29
	115.	6.11 +- 1.46
	126.	4.91 +- 0.90
0.550	31.	2.60 +- 0.48
	43.	2.19 +- 0.72
	71.	3.64 +- 0.41
	88.	4.05 +- 0.36
	115.	4.07 +- 0.71
	126.	7.07 +- 1.32
0.450	36.	2.18 +- 1.07
	42.	4.27 +- 1.52
	71.	2.98 +- 0.55
	87.	3.65 +- 0.62
	112.	4.68 +- 0.87
	124.	4.47 +- 1.35
0.350	65.	3.61 +- 1.56
	110.	3.92 +- 1.35

W = 1.415 GeV ε = 0.93 q^2 = 1.03 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		4.13 +- 0.32
0.935	37.	10.59 +- 4.83
	51.	3.91 +- 0.86
	72.	3.88 +- 0.42
	89.	4.00 +- 0.35
	108.	4.23 +- 0.36
	125.	4.99 +- 1.39
0.850	38.	3.45 +- 1.70
	52.	4.69 +- 0.56
	71.	4.35 +- 0.35
	90.	4.08 +- 0.26
	104.	4.56 +- 0.41
	146.	4.60 +- 2.24
0.750	11.	2.73 +- 0.41
	28.	2.52 +- 0.42
	56.	4.48 +- 0.67
	70.	3.64 +- 0.34
	85.	4.58 +- 0.28
	102.	3.58 +- 0.52
	131.	3.88 +- 0.65
	144.	2.86 +- 1.25
0.650	12.	2.80 +- 0.53
	31.	2.95 +- 0.33
	45.	2.53 +- 0.47
	70.	4.40 +- 0.35
	85.	4.28 +- 0.28
	108.	4.36 +- 0.76
	126.	3.41 +- 0.52
	145.	2.99 +- 1.37
0.550	34.	2.51 +- 0.59
	44.	2.15 +- 0.41
	71.	4.17 +- 0.42
	88.	3.42 +- 0.31
	115.	4.40 +- 0.65
	127.	3.57 +- 0.49
0.450	72.	3.57 +- 0.57
	88.	3.33 +- 0.46
	112.	3.15 +- 0.53
	125.	3.38 +- 0.63
0.350	69.	5.74 +- 1.73
	111.	3.10 +- 0.62
	123.	2.94 +- 1.35

W = 1.445 GeV ε = 0.92 q^2 = 1.02 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		3.11 +- 0.26
0.935	34.	3.44 +- 0.88
	50.	2.57 +- 0.60
	70.	3.39 +- 0.35
	90.	3.54 +- 0.31
	109.	2.85 +- 0.27
	125.	2.88 +- 0.40
0.850	5.	1.99 +- 0.69
	52.	5.16 +- 0.59
	69.	4.32 +- 0.37
	90.	4.06 +- 0.25
	106.	3.78 +- 0.27
	148.	3.07 +- 0.97
0.750	-2.	4.17 +- 1.67
	11.	3.15 +- 0.39
	40.	2.49 +- 0.30
	54.	4.41 +- 0.72
	65.	4.26 +- 0.39
	90.	4.21 +- 0.26
	107.	3.79 +- 0.38
	132.	3.71 +- 0.54
	147.	2.88 +- 0.60
0.650	13.	2.35 +- 0.85
	33.	2.31 +- 0.28
	44.	3.03 +- 0.36
	71.	4.09 +- 0.41
	90.	3.64 +- 0.26
	105.	3.60 +- 0.50
	125.	3.86 +- 0.42
	145.	1.65 +- 0.48
0.550	38.	2.38 +- 0.65
	44.	2.47 +- 0.39
	72.	3.40 +- 0.42
	89.	3.89 +- 0.33
	111.	3.90 +- 0.55
	128.	2.73 +- 0.33
0.450	43.	3.22 +- 1.56
	73.	4.42 +- 0.67
	89.	4.27 +- 0.51
	114.	4.58 +- 0.59
	125.	3.74 +- 0.50
0.350	113.	3.33 +- 0.61
	123.	4.11 +- 1.13
0.250	115.	2.66 +- 1.13

W = 1.475 GeV ε = 0.92 q^2 = 1.01 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		3.28 +- 0.25
0.935	34.	4.25 +- 0.83
	51.	4.64 +- 0.53
	68.	3.86 +- 0.42
	90.	3.58 +- 0.33
	109.	3.41 +- 0.26
	127.	3.22 +- 0.33
	145.	1.66 +- 0.66
0.850	11.	3.91 +- 0.60
	27.	3.07 +- 0.55
	54.	3.22 +- 0.45
	69.	4.65 +- 0.38
	90.	4.46 +- 0.28
	108.	3.86 +- 0.24
	122.	3.72 +- 1.07
	150.	3.38 +- 0.96
0.750	12.	2.58 +- 0.38
	30.	3.44 +- 0.27
	44.	3.05 +- 0.43
	70.	4.93 +- 0.43
	90.	4.72 +- 0.29
	105.	3.92 +- 0.31
	134.	2.41 +- 0.55
	148.	1.43 +- 0.31
0.650	33.	3.08 +- 0.32
	45.	3.43 +- 0.32
	72.	4.34 +- 0.45
	90.	4.57 +- 0.30
	104.	4.68 +- 0.46
	131.	3.66 +- 0.39
	147.	2.68 +- 0.44
0.550	45.	2.71 +- 0.40
	74.	4.20 +- 0.51
	90.	4.30 +- 0.35
	107.	4.16 +- 0.57
	129.	3.53 +- 0.34
	143.	2.29 +- 0.73
0.450	74.	5.43 +- 0.84
	95.	4.24 +- 0.53
	115.	2.72 +- 0.57
	127.	3.11 +- 0.41
0.350	114.	4.66 +- 0.72
	124.	3.54 +- 0.74

W = 1.505 GeV ε = 0.92 q^2 = 0.99 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		3.42 +- 0.25
0.935	34.	3.33 +- 0.90
	51.	4.21 +- 0.47
	68.	4.41 +- 0.41
	90.	3.72 +- 0.35
	105.	3.92 +- 0.29
	128.	2.74 +- 0.26
	147.	2.04 +- 0.33
	169.	1.69 +- 0.72
0.850	-2.	3.83 +- 1.39
	11.	3.50 +- 0.42
	28.	2.70 +- 0.34
	55.	4.94 +- 0.85
	70.	4.00 +- 0.35
	90.	4.24 +- 0.29
	109.	3.63 +- 0.21
	124.	2.53 +- 0.35
	153.	1.46 +- 0.59
	169.	2.88 +- 1.22
0.750	12.	4.18 +- 0.55
	31.	3.48 +- 0.25
	45.	4.24 +- 0.38
	72.	5.04 +- 0.47
	91.	4.31 +- 0.29
	107.	4.10 +- 0.28
	135.	3.11 +- 0.64
	149.	2.59 +- 0.36
	164.	1.13 +- 0.50
0.650	35.	3.68 +- 0.50
	46.	3.60 +- 0.33
	74.	4.38 +- 0.53
	91.	4.15 +- 0.29
	105.	5.24 +- 0.44
	132.	3.70 +- 0.37
	148.	2.51 +- 0.35
0.550	46.	3.93 +- 0.66
	75.	4.03 +- 0.61
	90.	4.53 +- 0.37
	106.	4.00 +- 0.51
	130.	3.21 +- 0.30
	145.	2.65 +- 0.49
0.450	76.	4.48 +- 0.94
	90.	2.80 +- 0.50
	112.	3.43 +- 0.56
	128.	3.33 +- 0.37
0.350	115.	4.52 +- 0.77
	125.	3.38 +- 0.58
0.250	122.	3.36 +- 1.61

W = 1.535 GeV ε = 0.91 q^2 = 0.98 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		3.79 +- 0.24
0.935	34.	3.87 +- 1.02
	52.	4.35 +- 0.48
	69.	4.54 +- 0.38
	88.	4.30 +- 0.41
	110.	3.18 +- 0.24
	128.	3.00 +- 0.24
	148.	2.73 +- 0.28
	166.	3.37 +- 0.63
	191.	2.69 +- 1.17
0.850	-2.	3.81 +- 1.19
	12.	2.75 +- 0.32
	29.	3.62 +- 0.27
	45.	3.73 +- 0.67
	71.	4.02 +- 0.34
	90.	3.71 +- 0.28
	109.	3.65 +- 0.21
	126.	2.59 +- 0.22
0.750	13.	4.20 +- 0.93
	31.	3.37 +- 0.25
	46.	3.01 +- 0.26
	74.	3.55 +- 0.40
	91.	3.27 +- 0.27
	105.	3.19 +- 0.21
	129.	1.93 +- 0.63
	150.	2.27 +- 0.31
	165.	1.59 +- 0.44
0.650	37.	4.23 +- 0.94
	48.	2.47 +- 0.28
	75.	2.92 +- 0.48
	90.	3.46 +- 0.27
	106.	3.27 +- 0.29
	134.	3.03 +- 0.38
	149.	1.93 +- 0.24
	165.	2.93 +- 0.84
0.550	47.	4.58 +- 1.21
	76.	3.42 +- 0.69
	90.	3.81 +- 0.35
	135.	2.76 +- 0.36
	131.	2.46 +- 0.25
	145.	1.20 +- 0.25
0.450	77.	3.33 +- 0.98
	90.	3.48 +- 0.56
	109.	2.11 +- 0.45
	129.	2.56 +- 0.27
	170.	4.78 +- 2.09
0.350	115.	2.86 +- 0.65
	127.	1.60 +- 0.33
0.250	123.	2.83 +- 1.24
	148.	3.07 +- 1.46

W = 1.565 GeV ε = 0.91 q^2 = 0.97 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		4.20 +- 0.20
0.935	11.	7.93 +- 1.63
	34.	4.27 +- 0.73
	52.	4.91 +- 0.37
	69.	4.93 +- 0.31
	87.	4.64 +- 0.31
	111.	3.93 +- 0.25
	129.	3.55 +- 0.19
	148.	3.17 +- 0.21
	168.	2.50 +- 0.31
	188.	3.80 +- 1.25
0.850	-2.	5.36 +- 2.32
	13.	3.48 +- 0.30
	29.	3.50 +- 0.20
	45.	3.57 +- 0.36
	71.	3.98 +- 0.24
	88.	4.01 +- 0.24
	110.	3.32 +- 0.16
	128.	2.74 +- 0.15
	145.	2.11 +- 0.28
	169.	1.85 +- 0.65
0.750	16.	2.41 +- 0.63
	32.	2.89 +- 0.19
	47.	2.51 +- 0.16
	74.	3.23 +- 0.27
	89.	3.31 +- 0.22
	109.	2.62 +- 0.14
	124.	2.52 +- 0.26
	151.	2.04 +- 0.18
	166.	1.15 +- 0.19
0.650	36.	2.70 +- 0.73
	49.	2.43 +- 0.21
	75.	2.80 +- 0.34
	90.	2.79 +- 0.19
	108.	2.68 +- 0.16
	134.	2.11 +- 0.21
	149.	1.51 +- 0.12
	166.	1.05 +- 0.20
0.550	47.	2.49 +- 0.94
	76.	1.67 +- 0.34
	90.	2.37 +- 0.20
	107.	2.37 +- 0.20
	132.	1.81 +- 0.15
	147.	1.33 +- 0.14
0.450	91.	2.60 +- 0.42
	107.	1.45 +- 0.27
	130.	1.40 +- 0.12
	147.	1.09 +- 0.22
	169.	0.66 +- 0.13
	183.	0.69 +- 0.30
0.350	116.	1.65 +- 0.41
	128.	1.57 +- 0.19
	152.	0.98 +- 0.15
	169.	1.03 +- 0.16
	182.	1.17 +- 0.54
0.250	137.	1.68 +- 0.62
	150.	0.93 +- 0.17
0.150	144.	1.37 +- 0.44

W = 1.595 GeV ε = 0.90 q^2 = 0.95 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		4.05 +- 0.20
0.935	11.	3.43 +- 0.85
	32.	3.78 +- 0.77
	52.	4.14 +- 0.36
	69.	4.12 +- 0.26
	88.	4.45 +- 0.27
	111.	3.88 +- 0.37
	129.	3.62 +- 0.22
	148.	3.23 +- 0.23
	168.	2.40 +- 0.28
0.850	14.	3.58 +- 0.31
	29.	3.47 +- 0.20
	46.	3.54 +- 0.34
	71.	4.19 +- 0.27
	88.	3.96 +- 0.24
	111.	3.58 +- 0.20
	129.	2.94 +- 0.15
	147.	2.56 +- 0.24
	167.	2.41 +- 0.63
0.750	17.	4.35 +- 1.12
	32.	2.60 +- 0.22
	48.	2.95 +- 0.18
	74.	3.33 +- 0.30
	88.	3.23 +- 0.22
	110.	3.24 +- 0.18
	125.	2.77 +- 0.24
	152.	2.12 +- 0.21
	167.	1.70 +- 0.21
0.650	50.	2.69 +- 0.24
	76.	2.71 +- 0.37
	89.	2.60 +- 0.20
	109.	2.88 +- 0.17
	133.	2.19 +- 0.22
	150.	1.42 +- 0.11
	166.	0.86 +- 0.14
0.550	49.	2.17 +- 0.83
	76.	1.35 +- 0.35
	89.	2.05 +- 0.20
	108.	2.20 +- 0.18
	132.	2.04 +- 0.16
	148.	1.13 +- 0.12
	164.	0.73 +- 0.31
0.450	77.	1.58 +- 0.64
	90.	2.78 +- 0.51
	110.	2.05 +- 0.30
	130.	1.55 +- 0.12
	146.	1.06 +- 0.20
	170.	0.66 +- 0.12
	184.	0.87 +- 0.33
0.350	117.	1.41 +- 0.42
	128.	1.17 +- 0.14
	153.	0.88 +- 0.15
	165.	0.69 +- 0.12
0.250	129.	1.15 +- 0.29
	151.	0.90 +- 0.13
	167.	0.99 +- 0.22
0.150	136.	0.70 +- 0.35
	147.	1.02 +- 0.26

Table 2 (continued)

W = 1.625 GeV ε = 0.90 q^2 = 0.94 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		3.87 ± 0.19
0.935	13.	3.52 ± 0.57
	26.	4.74 ± 0.75
	53.	4.94 ± 0.57
	70.	4.91 ± 0.31
	88.	4.27 ± 0.27
	106.	3.79 ± 0.37
	131.	3.31 ± 0.25
	149.	2.75 ± 0.21
	168.	2.22 ± 0.25
	184.	1.90 ± 0.57
0.850	14.	3.63 ± 0.35
	30.	3.85 ± 0.21
	46.	3.68 ± 0.31
	73.	4.58 ± 0.32
	88.	4.88 ± 0.27
	112.	3.65 ± 0.23
	129.	2.94 ± 0.15
	148.	2.32 ± 0.17
	168.	1.90 ± 0.32
0.750	34.	4.50 ± 0.42
	45.	3.54 ± 0.21
	72.	4.29 ± 0.41
	89.	3.78 ± 0.25
	111.	3.59 ± 0.21
	127.	3.05 ± 0.20
	153.	1.53 ± 0.24
	168.	1.68 ± 0.24
0.650	51.	2.71 ± 0.27
	77.	4.31 ± 0.63
	89.	3.62 ± 0.26
	110.	3.46 ± 0.19
	129.	2.61 ± 0.26
	150.	1.60 ± 0.12
	167.	1.03 ± 0.15
0.550	77.	2.47 ± 0.55
	89.	3.07 ± 0.27
	105.	2.57 ± 0.15
	133.	2.05 ± 0.17
	149.	1.64 ± 0.13
	165.	1.25 ± 0.27
0.450	77.	2.38 ± 0.90
	89.	2.40 ± 0.40
	107.	2.52 ± 0.34
	131.	1.93 ± 0.15
	144.	1.55 ± 0.23
	170.	1.01 ± 0.22
0.350	117.	1.86 ± 0.51
	129.	1.61 ± 0.17
	154.	0.96 ± 0.17
	169.	1.08 ± 0.15
	183.	0.57 ± 0.23
0.250	127.	1.19 ± 0.26
	151.	1.06 ± 0.15
	168.	0.99 ± 0.17
0.150	137.	1.25 ± 0.51
	148.	0.92 ± 0.18

W = 1.655 GeV ε = 0.90 q^2 = 0.93 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		4.26 ± 0.18
0.935	12.	3.66 ± 0.41
	27.	3.30 ± 0.34
	55.	4.05 ± 0.99
	71.	5.21 ± 0.34
	89.	4.13 ± 0.25
	106.	4.09 ± 0.31
	131.	3.24 ± 0.29
	149.	2.90 ± 0.21
	169.	2.38 ± 0.23
	186.	3.46 ± 0.70
0.850	13.	3.84 ± 0.34
	30.	3.80 ± 0.21
	47.	4.09 ± 0.25
	74.	4.48 ± 0.39
	89.	4.70 ± 0.24
	110.	4.38 ± 0.29
	130.	3.55 ± 0.17
	149.	2.58 ± 0.15
	168.	1.98 ± 0.23
	184.	1.81 ± 0.70
0.750	36.	3.80 ± 0.57
	50.	3.66 ± 0.21
	68.	4.45 ± 0.43
	85.	4.33 ± 0.25
	111.	3.53 ± 0.22
	128.	3.14 ± 0.17
	150.	2.09 ± 0.32
	168.	1.30 ± 0.21
0.650	53.	3.34 ± 0.33
	69.	3.23 ± 0.55
	89.	4.02 ± 0.26
	111.	3.74 ± 0.21
	126.	2.55 ± 0.22
	151.	1.90 ± 0.14
	167.	1.16 ± 0.13
0.550	78.	4.36 ± 1.12
	89.	3.88 ± 0.29
	110.	3.26 ± 0.21
	133.	2.43 ± 0.21
	149.	1.74 ± 0.12
	166.	0.94 ± 0.15
0.450	88.	2.32 ± 0.44
	108.	2.55 ± 0.29
	132.	2.36 ± 0.18
	146.	1.81 ± 0.18
	173.	0.86 ± 0.32
0.350	114.	3.09 ± 0.74
	130.	1.80 ± 0.16
	150.	0.92 ± 0.19
	169.	0.99 ± 0.13
	183.	1.48 ± 0.46
0.250	117.	1.32 ± 0.56
	127.	1.34 ± 0.25
	152.	1.18 ± 0.16
	168.	1.13 ± 0.16
	184.	1.45 ± 0.61
0.150	137.	2.30 ± 1.13
	149.	1.36 ± 0.23
	164.	2.87 ± 1.23

W = 1.685 GeV ε = 0.89 q^2 = 0.91 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		5.26 ± 0.19
0.935	-3.	4.85 ± 1.84
	11.	3.70 ± 0.31
	28.	4.46 ± 0.32
	44.	3.45 ± 0.55
	73.	4.35 ± 0.37
	89.	5.26 ± 0.28
	108.	4.90 ± 0.29
	129.	4.61 ± 0.41
	150.	3.73 ± 0.27
	168.	3.76 ± 0.32
	184.	3.09 ± 0.55
0.850	13.	3.99 ± 0.39
	31.	3.70 ± 0.23
	48.	3.93 ± 0.21
	70.	4.27 ± 0.43
	90.	5.05 ± 0.25
	107.	4.23 ± 0.26
	130.	3.68 ± 0.18
	149.	3.37 ± 0.16
	168.	2.96 ± 0.23
	185.	2.37 ± 0.54
0.750	37.	7.48 ± 2.10
	51.	3.82 ± 0.24
	65.	4.39 ± 0.37
	90.	4.16 ± 0.25
	110.	4.12 ± 0.25
	129.	3.38 ± 0.17
	145.	3.42 ± 0.36
	169.	1.25 ± 0.36
0.650	54.	2.82 ± 0.38
	66.	3.70 ± 0.68
	90.	3.47 ± 0.23
	111.	3.68 ± 0.21
	126.	3.57 ± 0.25
	152.	1.94 ± 0.16
	168.	1.65 ± 0.16
	181.	1.65 ± 0.74
0.550	90.	3.65 ± 0.29
	111.	3.07 ± 0.21
	130.	2.27 ± 0.21
	150.	1.67 ± 0.11
	167.	1.17 ± 0.13
0.450	88.	3.84 ± 0.68
	110.	2.93 ± 0.31
	133.	1.87 ± 0.17
	148.	1.45 ± 0.13
0.350	114.	1.77 ± 0.50
	131.	1.89 ± 0.16
	147.	1.19 ± 0.21
	170.	0.93 ± 0.14
	183.	1.02 ± 0.35
0.250	125.	1.77 ± 0.25
	153.	0.85 ± 0.13
	169.	1.01 ± 0.12
	183.	0.91 ± 0.43
0.150	150.	1.20 ± 0.18
	166.	1.06 ± 0.27
0.050	146.	1.23 ± 0.39

W = 1.715 GeV ε = 0.88 q^2 = 0.90 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		7.01 ± 0.24
0.935	-3.	4.64 ± 1.01
	11.	4.21 ± 0.29
	29.	3.79 ± 0.25
	46.	3.84 ± 0.38
	76.	5.75 ± 0.88
	90.	5.14 ± 0.29
	109.	4.98 ± 0.28
	128.	4.36 ± 0.35
	150.	3.84 ± 0.31
	169.	3.95 ± 0.35
	186.	4.07 ± 0.68
0.850	13.	3.44 ± 0.49
	31.	3.11 ± 0.25
	49.	3.17 ± 0.18
	65.	3.08 ± 0.35
	91.	3.93 ± 0.23
	107.	4.30 ± 0.26
	132.	3.70 ± 0.20
	149.	3.34 ± 0.15
	169.	3.02 ± 0.20
	185.	2.33 ± 0.47
0.750	53.	3.12 ± 0.25
	64.	3.36 ± 0.27
	91.	3.42 ± 0.24
	109.	3.65 ± 0.25
	130.	2.79 ± 0.14
	147.	2.30 ± 0.18
	167.	3.13 ± 0.84
0.650	55.	2.45 ± 0.46
	63.	2.35 ± 0.54
	92.	3.23 ± 0.24
	111.	3.03 ± 0.21
	127.	2.36 ± 0.16
	154.	1.78 ± 0.23
	166.	1.46 ± 0.15
	181.	1.65 ± 0.81
0.550	91.	2.39 ± 0.24
	111.	2.45 ± 0.19
	127.	1.84 ± 0.20
	150.	1.49 ± 0.11
	167.	1.08 ± 0.12
0.450	90.	1.84 ± 0.42
	111.	2.04 ± 0.23
	132.	1.53 ± 0.16
	149.	1.19 ± 0.10
	166.	1.01 ± 0.24
0.350	110.	2.07 ± 0.64
	132.	1.68 ± 0.15
	144.	1.22 ± 0.21
	170.	0.59 ± 0.13
0.250	130.	1.33 ± 0.19
	154.	1.08 ± 0.17
	169.	0.78 ± 0.11
	182.	0.76 ± 0.33
0.150	152.	0.94 ± 0.16
	168.	0.69 ± 0.15
0.050	146.	0.74 ± 0.23

W = 1.745 GeV ε = 0.88 q^2 = 0.88 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		6.49 ± 0.27
0.935	-3.	3.71 ± 0.90
	11.	3.67 ± 0.30
	29.	3.31 ± 0.25
	47.	3.43 ± 0.32
	62.	4.07 ± 1.36
	91.	5.30 ± 0.38
	109.	4.93 ± 0.32
	128.	5.20 ± 0.40
	149.	4.33 ± 0.47
	165.	4.13 ± 0.46
	184.	4.23 ± 1.15
0.850	16.	5.01 ± 1.55
	32.	2.33 ± 0.32
	50.	2.54 ± 0.19
	64.	3.19 ± 0.31
	92.	3.41 ± 0.26
	108.	3.48 ± 0.25
	132.	3.29 ± 0.25
	150.	3.12 ± 0.17
	168.	3.06 ± 0.22
	184.	3.38 ± 0.67
0.750	54.	2.26 ± 0.28
	66.	2.07 ± 0.22
	92.	2.36 ± 0.25
	108.	2.08 ± 0.21
	130.	2.16 ± 0.14
	148.	1.90 ± 0.16
	167.	1.78 ± 0.42
0.650	63.	2.09 ± 0.56
	93.	2.30 ± 0.24
	110.	2.07 ± 0.19
	128.	1.78 ± 0.15
	156.	1.80 ± 0.35
	168.	1.45 ± 0.19
0.550	92.	1.79 ± 0.23
	111.	1.63 ± 0.18
	125.	1.20 ± 0.17
	151.	1.22 ± 0.12
	168.	1.06 ± 0.14
0.450	91.	1.60 ± 0.43
	112.	1.49 ± 0.22
	133.	1.21 ± 0.17
	150.	0.94 ± 0.10
	166.	0.64 ± 0.14
0.350	112.	1.69 ± 0.60
	133.	1.34 ± 0.16
	145.	1.17 ± 0.18
	171.	0.84 ± 0.30
0.250	131.	0.98 ± 0.16
	156.	0.82 ± 0.22
	165.	0.57 ± 0.11
0.150	153.	0.47 ± 0.12
	167.	0.53 ± 0.13
0.050	149.	1.06 ± 0.32

W = 1.775 GeV ε = 0.87 q^2 = 0.87 GeV^2

$\cos\theta^*$	ϕ [°]	$d\sigma/d\Omega^*$ [μb/sr]
0.985		6.34 ± 0.99
0.935	14.	4.57 ± 1.48
	30.	3.69 ± 0.99
	47.	3.82 ± 1.11
	93.	2.89 ± 1.11
	108.	4.44 ± 1.03
	129.	4.31 ± 1.15
	149.	7.78 ± 3.01
0.850	50.	3.88 ± 1.00
	66.	2.50 ± 0.80
	94.	2.93 ± 0.87
	110.	3.71 ± 0.86
	135.	2.60 ± 0.92
	150.	2.43 ± 0.61
	170.	3.67 ± 0.99
0.750	66.	2.83 ± 0.93
	107.	3.68 ± 1.19
	131.	3.38 ± 0.92
	151.	3.58 ± 1.01
	169.	5.21 ± 2.26
0.650	105.	1.62 ± 0.81
	129.	1.58 ± 0.54
0.550	92.	1.45 ± 0.57
	114.	1.79 ± 0.87
	168.	0.96 ± 0.48

Figure captions

Fig. 1: Definition of angles

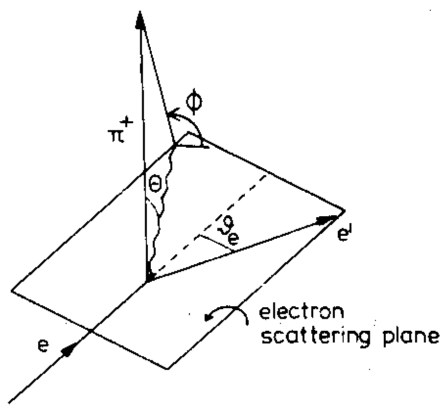
Fig. 2: Example of a missing mass distribution for π^+ detected in coincidence with electrons

Fig. 3: Forward π^+ production cross section at $q^2 = 0.4$ from DNPL and at $q^2 = 0.6$ and 1 GeV^2 from DESY.

Fig. 4: Examples of angular distributions at $q^2 = 0.6$ and 1 GeV^2.

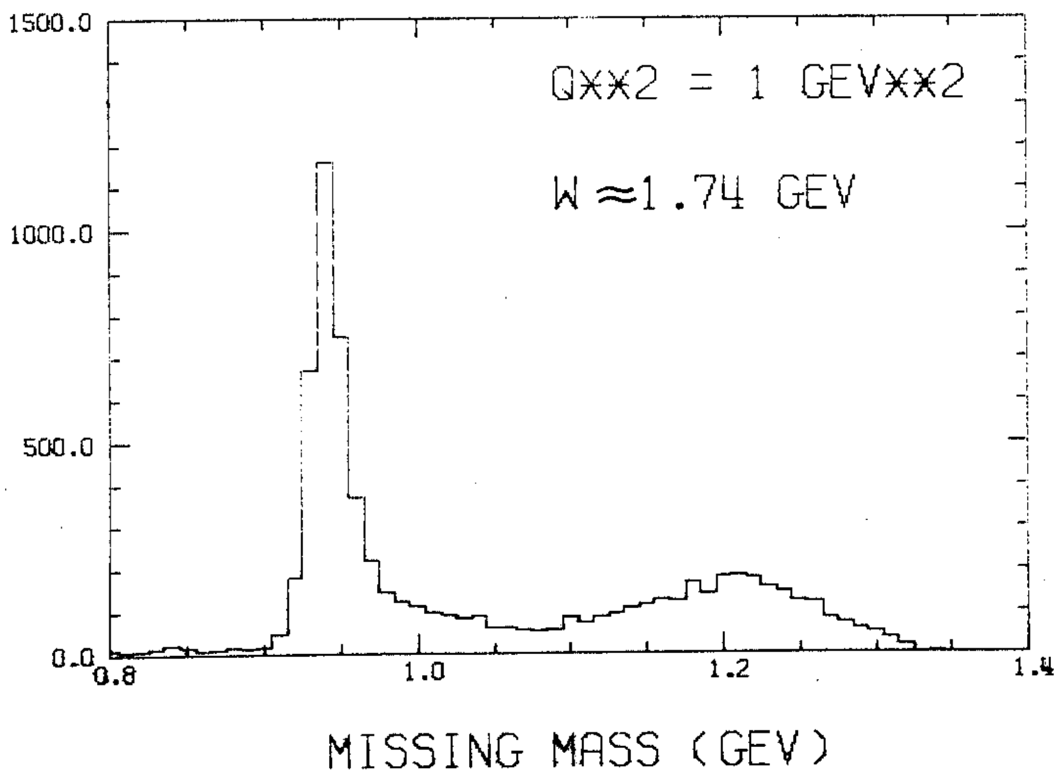
Fig. 5: $\sigma_u + \varepsilon\sigma_L$ (Δ), σ_p ($\square$) and σ_I ($\circ$) at different values of $\cos\Theta^*$ as a function of W at $q^2 = 0.6$ GeV^2.

Fig. 6: $\sigma_u + \varepsilon\sigma_L$ (Δ), σ_p ($\square$) and σ_I ($\circ$) at different values of $\cos\Theta^*$ as a function of W at $q^2 = 1$ GeV^2.



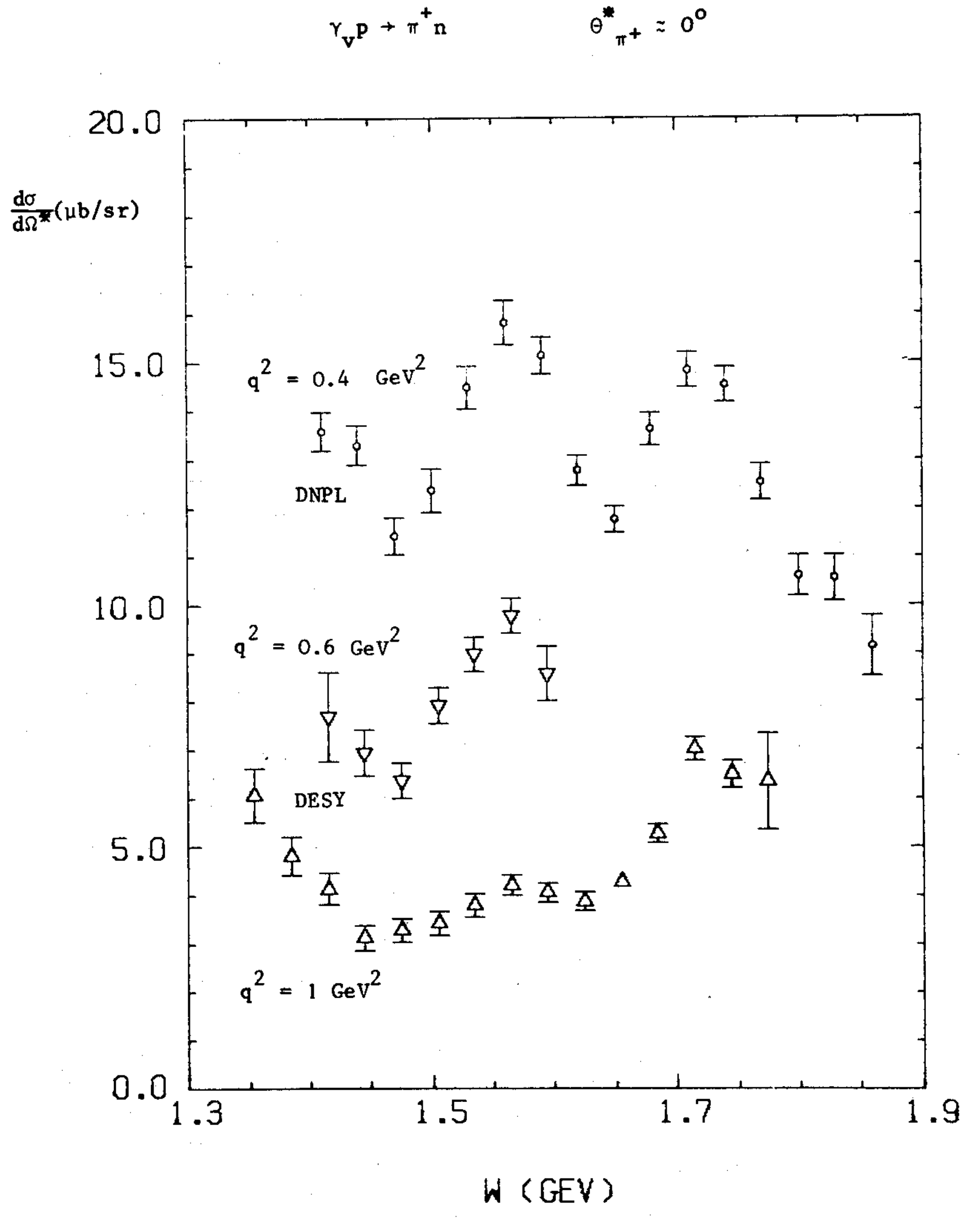
π+
Φ
Θ
ϑe
e'
e
electron
scattering plane

Fig. 1



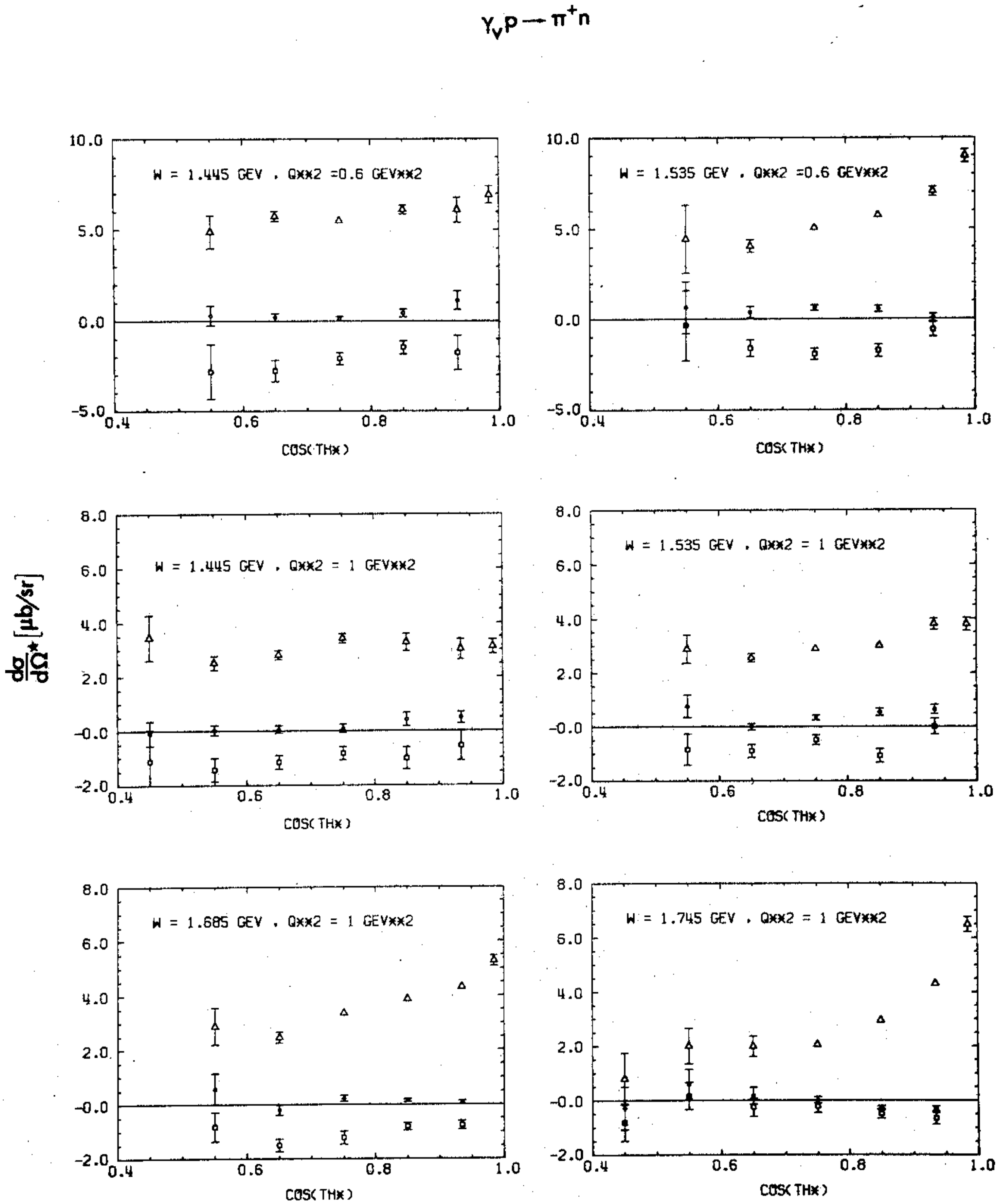
1500.0
1000.0
500.0
0.0
0.8
1.0
1.2
1.4
Q**2 = 1 GEV**2
W ≈1.74 GEV
MISSING MASS (GEV)

Fig. 2



$\gamma_v p \rightarrow \pi^+ n$
$\theta^*_{\pi^+} \simeq 0^o$
20.0
$\frac{d\sigma}{d\Omega^*}$(μb/sr)
15.0
q^2 = 0.4 GeV^2
DNPL
10.0
q^2 = 0.6 GeV^2
DESY
5.0
q^2 = 1 GeV^2
0.0
1.3
1.5
1.7
1.9
W (GEV)

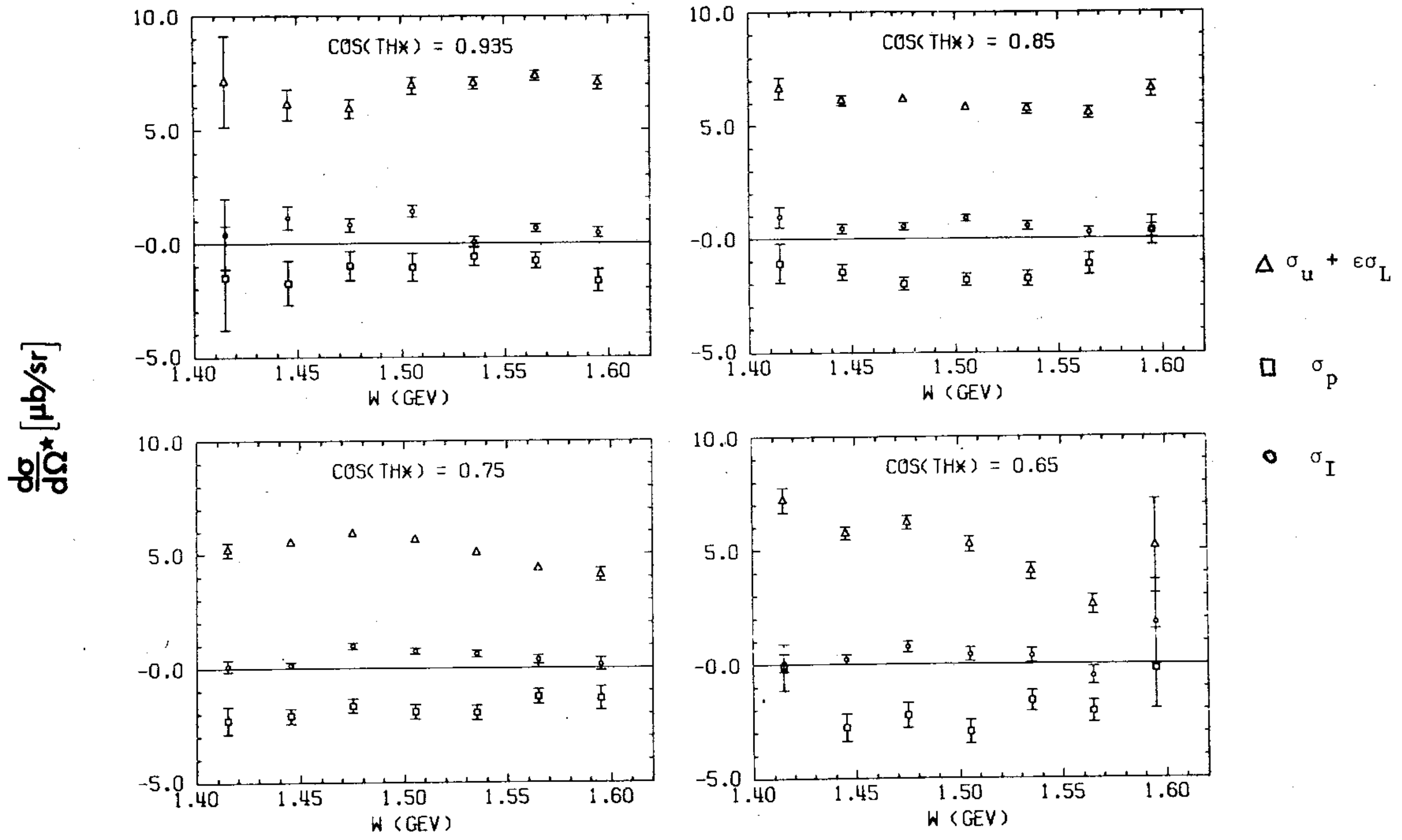
Fig. 3



Δ $\sigma_u + \varepsilon\sigma_L$, $\square$ σ_p , $\circ$ σ_I

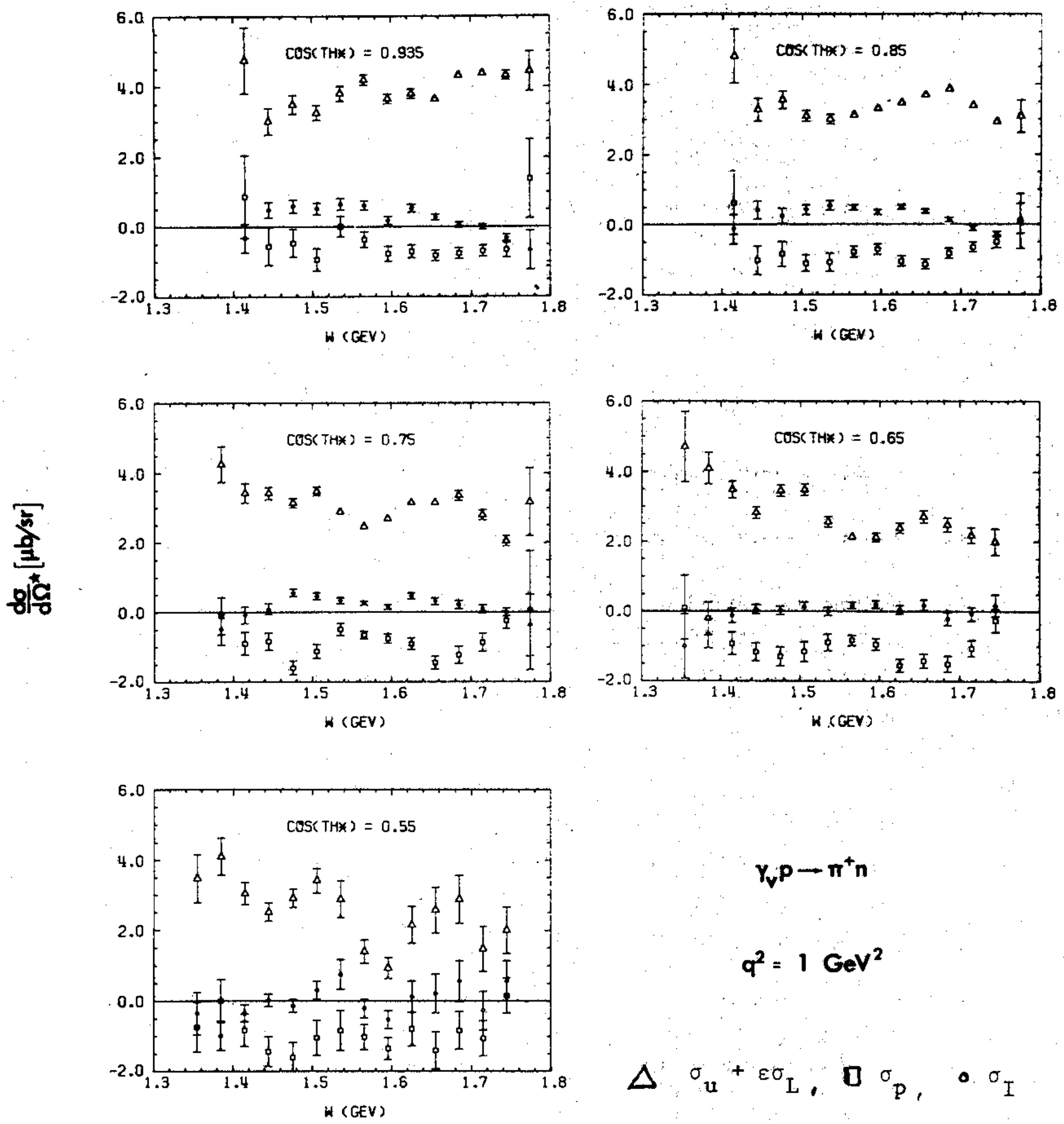
Fig. 4

$\gamma_v p \rightarrow \pi^+ n$



$q^2 = 0.6$ GeV^2

Fig. 5



COS(THX) = 0.935
COS(THX) = 0.85
COS(THX) = 0.75
COS(THX) = 0.65
COS(THX) = 0.55
W (GEV)
$\frac{d\sigma}{d\Omega^*}$ [μb/sr]
$\gamma_v p \to \pi^+ n$
$q^2 = 1\ GeV^2$
△ $\sigma_u + \varepsilon\sigma_L$, □ σ_p, ∘ σ_I

Fig. 6