DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 71/61
October 1971

Inelastic Electron Proton Scattering at $q^2 < 1$ (GeV/c)^2 as a Test of Finite Energy Sum Rules

by

J. Moritz, K. H. Schmidt, D. Wegener
Institut für Experimentelle Kernphysik der Universität (TH) und des Kernforschungszentrums Karlsruhe

and

J. Bleckwenn, E. Engels Jr.
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Abstract

The twofold differential cross section for electroproduction on protons was measured for an electron scattering angle of 12^o. The kinematic region covered in this experiment was $0.3\ (GeV/c)^2 < q^2 < 1.0\ (GeV/c)^2$ and $W < 2.9$ GeV. The Bloom - Gilman as well as the constant scattering angle sum rule of Rittenberg and Rubinstein were tested and confirmed within the error limits of 5 to 15 %.

Introduction

The total absorption cross section of virtual photons by protons has been investigated in a series of experiments [1-10]. Two different ways can be used to present the cross sections [11]. One shows up the correspondence to the elastic electron proton scattering [12], the other emphasizes the analogy to photoproduction with real photons [13].

Hand [13] splits up the photoproduction cross section by virtual photons into two parts $\sigma_t(\nu,q^2)$ and $\sigma_l(\nu,q^2)$:

$$\frac{d^2\sigma}{d\Omega dE_3} = \Gamma_t \; (\sigma_t + \varepsilon\sigma_l) \qquad (1)$$

Here σ_t and σ_l are the total absorption cross sections for photons with transversal and longitudinal polarization respectively depending on the four-momentum transfer q^2 and the energy loss ν of the scattered electrons. ε represents the transverse polarization of the photons, Γ_t is a kinematical factor and measures the flux of transverse polarized virtual photons.

In the photoproduction limit $q^2 \to 0$ the longitudinal cross section $\sigma_l(\nu,q^2)$ vanishes and the transverse cross section

$$\sigma_t(\nu,q^2) \to \sigma_{tot}(q^2=0,\ \nu=E_\gamma). \qquad (2)$$

The correspondence to the Rosenbluth formula for elastic electron proton scattering is shown by the expression for the twofold differential cross section [12]

$$\frac{d^2\sigma}{d\Omega dE_3} = \sigma_{Mott} \; \{W_2(\nu,q^2) + 2W_1(\nu,q^2)\,tg^2(\Theta_e/2)\} \qquad (3)$$

$$\sigma_{Mott} = \frac{\alpha^2\cos^2(\Theta_e/2)}{4E_o^2\sin^4(\Theta_e/2)}$$

E_0 is the primary energy and Θ_e the scattering angle of the electrons. The structure functions W_1 and W_2 are related to σ_t, σ_1 by

$$W_1(\nu,q^2) = \frac{K}{4\pi^2\alpha}\,\sigma_t(\nu,q^2) \qquad (4a)$$

$$W_2(\nu,q^2) = \frac{K}{4\pi^2\alpha}\,\frac{q^2}{q^2+\nu^2}\,\{\sigma_t(\nu,q^2)+\sigma_1(\nu,q^2)\} \qquad (4b)$$

K = equivalent photon energy.

In the present experiment the twofold differential cross section $d^2\sigma/d\Omega dE_3$ was measured in a kinematical region, which is shown in fig. 1. Since the scattering angle of the electrons is $\Theta_e = 12^o$, the structure function W_2 gives the main contribution to the cross section. To take into account the contribution of W_1 the following relation was used

$$\frac{W_1}{W_2} = \frac{1 + \nu^2/q^2}{1 + R} \qquad \text{with } R = \frac{\sigma_1}{\sigma_t} \qquad (4c)$$

In the analysis we have assumed R = 0.2 which is in agreement with other data [14].

Apparatus

The scattered electrons were detected by a spectrometer (fig. 2) consisting of a bending magnet with a homogeneous field, four two-coordinate wire spark chambers with ferrite core storage [15], scintillation counters, a shower counter and a Cerenkov counter. The momentum resolution of the spectrometer was ± 0.6 % FWHM for bending angles of 16^o. The momentum acceptance as function of the radius of curvature is shown in fig. 3 where measured and calculated values are plotted, which agree within the error limits. The region of constant momentum acceptance was 42%.

The solid angle of the spectrometer of $\Delta\Omega=(0.68\pm0.01)$msterad was defined by the first scintillation counter and determined by a Monte Carlo calculation.

Electrons of an external electron beam hit a liquid hydrogen condensation target of 3 cm diameter. The intensity of the beam was measured with a Faraday cup and a secondary emission monitor [16]. The scattered electrons were bent vertically out of the scattering plane (fig. 2). The particle trajectory was determined by an arrangement of 4 spark chambers which were triggered by a fourfold coincidence of three scintillation counters and the shower counter. The shower counter consisted of four radiation length of lead combined with three layers of scintillation material connected to one multiplier.

To avoid any bias during the data taking period the Cerenkov counter was not included in the triggering coincidence. But its digital signal was stored as additional information to separate electrons from other particles in the off-line analysis.

The following information of a triggering event was recorded by an on-line computer [17] and stored on magnetic tape:

a) centroids of coordinates of all sparks in the four spark chambers
b) pulse height of the electron shower counter
c) contents of electronic scalers
d) digital information of the Cerenkov counter

The computer calculated on-line the radius of curvature, the spectrum of the shower counter and the energy spectrum of the scattered electrons allowing to test the experimental equipment during the whole data taking period.

Analysis of the data

The events which were recorded on magnetic tape were analyzed off-line after the data taking period. The contribution of pions and Dalitz pairs had to be subtracted to get pure electron spectra. The contribution of Dalitz pairs was determined by reversing the magnetic field of the bending magnet. In fig. 4 this contribution which was lower than 20 % for the highest energy losses is plotted together with the pion contamination and the measured spectrum for one primary energy.

The pion background was determined for several energy intervals in two independent ways which gave the same results. Fig. 5 shows three typical shower spectra belonging to different energy losses of the scattered electrons. The lower pulse height region is due to the tail of the electron shower spectrum and the contribution of the minimum ionizing pions. To separate these two parts the information of the Cerenkov counter was used, which allowed to determine the shape of the electron shower spectrum. On the other hand the shape of the pion spectrum was measured by stopping all electrons within a lead brick placed in front of the collimator of the electron spectrometer (fig. 2). The decomposition of the measured pulse height spectra into the pion and electron contributions was done by fitting these two spectra to the measured spectrum of the shower counter. The result of these fits is entered into fig. 5.

These contributions and the target empty rate were subtracted from the measured counting rates. Moreover the spectra were corrected for the efficiencies of the counters and the spark chambers and for the momentum acceptance of each momentum bin (fig. 3). Table I contains a compilation of these corrections and their errors.

The electron spectrometer had a low energy resolution for small bending angles, corresponding to low invariant masses. Therefore the spectra were unfolded using the energy resolution known from elastic scattering.

In addition to the corrections mentioned above radiative corrections had to be applied. This was done by first subtracting the elastic radiative tail from the measured spectra and then applying an iteration method as given by Mo and Tsai [18] to calculate the inelastic radiative contributions. The interpolation between measured data points was done along lines of constant invariant masses by a quadratic interpolation formula. For the kinematical region of low invariant masses and high four momentum transfers where no data points were taken in this experiment, results of a fit to all known electroproduction data in the resonance region [14] were used to extrapolate from the data of this experiment. The radiative corrections are of the order of 10 %.

The total error of the cross sections were obtained by adding quadratically the statistical error, the errors listed in table I and the errors resulting from the iteration procedure.

Results

The cross sections measured in this experiment are listed in table IIa-e together with the total error and some relevant kinematical parameters. In table III the cross sections for some typical masses are tabulated. Fig. 6a-c show the cross sections

$$\frac{1}{\Gamma_t} \frac{dd^2\sigma}{d\Omega dE_3} = \sigma_t + \varepsilon\sigma_1 \qquad (5)$$

for some typical invariant masses together with the results of other groups. These figures confirm the good agreement of the results of this experiment with those of former publications. For invariant masses $W < 1.8$ GeV the characteristic strong four-momentum dependance is observed, for higher invariant masses a much weaker q^2-dependance can be seen.

In fig. 7a-e the quantity

$$\nu W_2(\nu,q^2) = \frac{\nu}{\sigma_{Mott}} \frac{d^2\sigma}{d\Omega dE_3} \{1 + 2 \frac{1+\nu^2/q^2}{1 + R} tg^2 (\Theta_e/2)\}^{-1} \quad (6)$$

$$R = 0.2$$

is plotted as function of the variables

$$\omega = \frac{2M\nu}{q^2} \quad \text{and} \quad \omega' = \frac{2M\nu + M^2}{q^2} \quad (7)$$

To guide the eye the scaling function $f(\omega')$ in the deep inelastic region [19] is plotted which averages the experimental values of the resonance region. In fig. 8 the data for νW_2 measured in this experiment are shown as function of ω and ω' as well as the ratio $\nu W_2/f(\omega')$ as function of $W^2/2M$. These figures demonstrate the intimate connection of the electroproduction data in the resonance and in the deep inelastic region.

The averaging of νW_2 in the resonance region by the scaling function $f(\omega')$ can be tested quantitatively by means of finite energy sum rules. We have calculated the Bloom-Gilman sum rule [20, 21]

$$\frac{2M}{q^2} \int_0^{\nu_m} \nu W_2 \, d\nu = \int_1^{\omega'_2} f(\omega') \, d\omega' \quad (8)$$

at four-momentum transfers $0.4(\mathrm{GeV}/c)^2 < q^2 < 0.75(\mathrm{GeV}/c)^2$. To calculate the integral the measured cross sections were interpolated along lines of constant invariant masses. The values of the two functions νW_2 and $f(\omega')$ are plotted in fig. 9 for some characteristic four-momentum transfers. In table IV the two integrals are listed, integrated up to an invariant mass of $W \approx 2.5$ GeV. There are deviations of 25% to 17%, decreasing with increasing q^2. This result is in agreement with a recent analysis of Bloom and Gilman at higher momentum transfers [21].

Rittenberg and Rubinstein [22] generalized the ansatz (8) and proposed the sum rule

$$\int_{\nu_1}^{\nu_2} \{\nu W_2 - f(\omega')\}\, d\nu = 0 \qquad (9)$$

integrated along the line

$$q^2 + b\nu = c \qquad (10)$$

b and c being constant.

We have tested this sum rule for constant scattering angles. In this case the constants b, c are given by

$$\begin{aligned} b &= 4\,E_o \sin^2(\Theta_e/2) \\ c &= 4\,E_o^2 \sin^2(\Theta_e/2) \end{aligned} \qquad (11)$$

and the sum rule takes the form

$$F(\omega_1', \omega_2') = \int_{\omega_1'}^{\omega_2'} \frac{\nu W_2 - f(\omega')}{2M + 4E_o\omega' \sin^2(\Theta_e/2)}\, d\omega' \qquad (12)$$

This integral has been evaluated by using measured cross sections of this work (fig. 7a-e) and the scaling formula

$f(\omega')$ [19]. Moreover the contribution of the nucleon pole was included.

The ratio

$$g(\omega'_{elastic}, \omega'_2) = \frac{F(\omega'_{elastic}, \omega'_2)}{\displaystyle\int_{\omega'_{elastic}}^{\omega'_2} \frac{\nu W_2}{2M + 4E_o\omega'\sin^2(\Theta_e/2)}\, d\omega'} \tag{13}$$

is plotted in fig. 10a-e as a function of the upper limit ω'_2. The plot shows that the relative deviation of the two functions in equation (12) is about 5% to 15% at $\omega'_2 > 8$ giving strong support to this sum rule.

Following a proposal by Rittenberg and Rubinstein we have used the scaling variable

$$\omega'' = \frac{2M\nu + \xi^2}{q^2 + a^2} \tag{14}$$

where ξ^2, a^2 are free parameters. Also we have used the function

$$\nu\tilde{W}_2 = \frac{\omega}{\omega''}\, \nu W_2 \tag{15}$$

instead of νW_2 in the integral (12) to get rid of the zero of νW_2 at $q^2 = 0$ (see eq. 4). Varying ξ^2 and a^2 the best interpolation of the present data by the deep inelastic data [19] in the sense of the sum rule (12) is given by the scaling variable

$$\omega'' = \frac{2M\nu + 1.3}{q^2 + 0.4} \tag{16}$$

The relative difference of the two integrals over $\nu\tilde{W}_2$ and $f(\omega')$ in eq. (12) is of the order of a few percent at $\omega'_2 > 8$ as shown by fig. 11.

Acknowledgements

We are indebted to Professors A. Citron, H. Schopper and W. Jentschke for their interest in this experiment and to our earlier collaborators Drs. S. Galster, G. Hartwig and H. Klein who participated in an earlier period of this experiment.

We wish to thank the synchrotron group, the floor-service group and all the technical groups at DESY for their excellent support of this experiment.

The wholehearted support of Ing. H. Sindt in constructing, testing and carrying out the experiment is greatfully acknowledged.

This work has been supported by the Bundesministerium für Bildung und Wissenschaft.

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TABLE I

Sources of uncertainty in the measurement of $d^2\sigma/d\Omega dE_3$

Quantity	Uncertainty (%)
Density of the target	2.0
Diameter of the target	0.5
Solid angle	1.5
Electron scattering angle	0.2
Incident electron energy	1.0
Dead time correction	0.5
Constant of Faraday-Cup Integrator	1.0
Efficiency of the spark chambers	0.5
Radiative correction	2 - 4
Shower counter correction	0.5
Statistics	2 - 10

TABLE II

(Legend)

E_3	=	energy of the scattered electrons
W	=	invariant mass
q^2	=	four-momentum transfer squared
SIGMAO	=	$(d^2\sigma/d\Omega dE_3)_{measured}$
SIGMA1	=	$(d^2\sigma/d\Omega dE_3)_{corrected}$
SIGMAT	=	$\frac{1}{\Gamma_t}$ $(d^2\sigma/d\Omega dE_3)$ = SIGMA1/Γ_t
DSIGMA	=	error of the corrected cross sections

TABLE II A

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 3.50 GEV THETA = 12.5 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN (---------) STERAD*GEV			
3.077	1.078	0.511	0.347	0.094	30.8	21.5
3.057	1.097	0.507	0.398	0.202	59.3	10.1
3.037	1.116	0.504	0.462	0.284	76.0	7.3
3.017	1.134	0.501	0.564	0.440	108.5	5.7
2.997	1.152	0.497	0.741	0.685	157.9	4.7
2.977	1.170	0.494	0.983	1.016	220.5	4.4
2.956	1.187	0.491	1.337	1.536	316.6	4.4
2.936	1.205	0.487	1.636	1.974	388.7	4.4
2.916	1.222	0.484	1.775	2.114	400.0	4.2
2.896	1.238	0.480	1.658	1.849	338.0	4.0
2.876	1.255	0.477	1.471	1.526	270.5	3.9
2.855	1.271	0.474	1.311	1.287	222.2	3.9
2.835	1.287	0.470	1.167	1.081	182.4	4.0
2.815	1.303	0.467	1.005	0.876	144.9	4.2
2.795	1.319	0.464	0.945	0.823	133.7	4.2
2.775	1.334	0.460	0.874	0.741	118.5	4.2
2.755	1.350	0.457	0.824	0.691	109.1	4.4
2.734	1.365	0.454	0.814	0.691	107.9	4.3
2.714	1.380	0.450	0.808	0.689	106.7	4.3
2.694	1.395	0.447	0.798	0.683	105.0	4.3
2.674	1.410	0.444	0.812	0.717	109.7	4.2
2.654	1.424	0.440	0.838	0.742	113.0	4.2
2.633	1.439	0.437	0.852	0.763	115.7	4.2
2.613	1.453	0.434	0.881	0.806	122.1	4.1
2.593	1.467	0.430	0.941	0.879	133.0	4.0
2.573	1.481	0.427	0.997	0.958	145.0	4.0
2.553	1.495	0.424	1.080	1.078	163.3	4.0
2.533	1.508	0.420	1.105	1.100	167.0	4.0
2.512	1.522	0.417	1.067	1.023	155.8	4.0
2.492	1.536	0.414	1.037	0.967	147.7	4.0
2.472	1.549	0.410	0.962	0.858	131.6	4.1
2.452	1.562	0.407	0.924	0.811	124.9	4.2
2.432	1.575	0.403	0.892	0.772	119.6	4.2
2.412	1.588	0.400	0.880	0.751	117.0	4.3
2.391	1.601	0.397	0.859	0.723	113.3	4.4
2.371	1.614	0.393	0.847	0.720	113.5	4.4
2.351	1.627	0.390	0.846	0.723	114.8	4.3
2.331	1.639	0.387	0.870	0.753	120.5	4.3
2.311	1.652	0.383	0.882	0.771	124.4	4.2
2.290	1.664	0.380	0.919	0.822	133.7	4.1
2.270	1.677	0.377	0.944	0.840	137.7	4.1
2.250	1.689	0.373	0.922	0.811	134.1	4.2
2.230	1.701	0.370	0.915	0.796	132.8	4.2
2.210	1.713	0.367	0.887	0.759	127.8	4.3
2.190	1.725	0.363	0.860	0.725	123.2	4.4
2.169	1.737	0.360	0.822	0.666	114.2	4.5
2.149	1.749	0.357	0.786	0.618	107.0	4.7
2.129	1.761	0.353	0.759	0.590	103.1	4.8
2.109	1.772	0.350	0.733	0.560	98.9	5.0

TABLE II A (CONTINUED)

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 3.50 GEV THETA = 12.5 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN (---------) STERAD*GEV			
2.089	1.784	0.347	0.735	0.566	100.9	4.9
2.068	1.795	0.343	0.708	0.531	95.7	5.1
2.048	1.807	0.340	0.716	0.544	99.1	5.0
2.028	1.818	0.337	0.703	0.529	97.4	5.2
2.008	1.829	0.333	0.698	0.522	97.1	5.2
1.988	1.841	0.330	0.703	0.531	99.8	5.1
1.968	1.852	0.326	0.677	0.496	94.2	5.4
1.947	1.863	0.323	0.695	0.518	99.4	5.3
1.927	1.874	0.320	0.685	0.505	98.0	5.4
1.907	1.885	0.316	0.705	0.532	104.3	5.3
1.887	1.896	0.313	0.678	0.494	98.0	5.6
1.867	1.907	0.310	0.652	0.454	91.0	6.2

TABLE II B

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 4.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0 MIKROBARN (----------) STERAD*GEV	SIGMA1 MIKROBARN (----------) STERAD*GEV	SIGMAT (MIKROBARN)	DSIGMA (%)
3.503	1.095	0.612	0.273	0.127	42.5	25.7
3.483	1.114	0.609	0.279	0.141	42.9	22.2
3.463	1.133	0.605	0.317	0.207	57.6	15.0
3.443	1.151	0.602	0.465	0.408	105.7	8.6
3.422	1.169	0.598	0.598	0.595	144.7	6.9
3.402	1.187	0.595	0.791	0.896	205.9	5.7
3.382	1.204	0.591	1.058	1.295	283.4	5.2
3.361	1.221	0.588	1.169	1.442	302.2	5.0
3.341	1.238	0.584	1.208	1.423	287.1	4.9
3.321	1.255	0.581	1.143	1.251	244.0	4.8
3.300	1.271	0.577	1.006	1.038	196.5	4.9
3.280	1.288	0.573	0.889	0.861	158.7	5.2
3.260	1.304	0.570	0.788	0.726	130.7	5.6
3.239	1.320	0.566	0.730	0.666	117.5	5.7
3.219	1.335	0.563	0.705	0.640	110.7	5.6
3.199	1.351	0.559	0.663	0.595	101.4	5.7
3.179	1.366	0.556	0.684	0.631	106.0	5.4
3.158	1.381	0.552	0.619	0.547	90.8	5.9
3.138	1.396	0.549	0.599	0.529	86.8	6.0
3.118	1.411	0.545	0.638	0.588	95.6	5.5
3.097	1.426	0.541	0.625	0.564	91.1	5.7
3.077	1.440	0.538	0.652	0.602	96.6	5.4
3.057	1.455	0.534	0.703	0.676	107.9	5.0
3.036	1.469	0.531	0.773	0.764	121.5	4.8
3.016	1.483	0.527	0.774	0.771	122.4	4.8
2.996	1.497	0.524	0.874	0.918	145.4	4.6
2.975	1.511	0.520	0.918	0.965	152.7	4.5
2.955	1.525	0.517	0.889	0.901	142.5	4.6
2.935	1.538	0.513	0.874	0.862	136.5	4.6
2.914	1.552	0.510	0.832	0.799	126.6	4.8
2.894	1.565	0.506	0.773	0.719	114.1	4.9
2.874	1.578	0.502	0.721	0.649	103.4	5.2
2.854	1.591	0.499	0.717	0.639	102.0	5.3
2.833	1.605	0.495	0.723	0.650	104.2	5.2
2.813	1.617	0.492	0.711	0.645	103.8	5.2
2.793	1.630	0.488	0.732	0.675	109.1	5.1
2.772	1.643	0.485	0.724	0.663	107.7	5.2
2.752	1.656	0.481	0.763	0.717	117.1	4.9
2.732	1.668	0.478	0.806	0.776	127.4	4.9
2.711	1.681	0.474	0.808	0.774	127.8	4.9
2.691	1.693	0.470	0.808	0.757	125.8	4.9
2.671	1.705	0.467	0.806	0.760	127.3	4.8
2.650	1.717	0.463	0.785	0.731	123.2	4.9
2.630	1.729	0.460	0.744	0.672	114.0	5.1
2.610	1.741	0.456	0.735	0.650	111.2	5.2
2.590	1.753	0.453	0.705	0.611	105.2	5.4
2.569	1.765	0.449	0.694	0.603	104.7	5.3
2.549	1.777	0.446	0.651	0.548	95.9	5.7
2.529	1.789	0.442	0.639	0.532	93.9	5.7

TABLE II B (CONTINUED)

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 4.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN (----------) STERAD*GEV			
2.508	1.800	0.438	0.649	0.547	97.2	5.6
2.468	1.812	0.435	0.640	0.539	96.8	5.7
2.468	1.823	0.431	0.632	0.530	95.9	5.7
2.447	1.835	0.428	0.596	0.483	88.2	6.1
2.427	1.846	0.424	0.607	0.500	92.0	5.9
2.407	1.857	0.421	0.596	0.484	90.0	6.1
2.386	1.868	0.417	0.605	0.497	93.1	6.0
2.366	1.880	0.414	0.591	0.479	90.6	6.1
2.346	1.891	0.410	0.599	0.491	93.8	6.0
2.325	1.902	0.407	0.613	0.511	98.5	5.7
2.305	1.913	0.403	0.589	0.472	91.9	6.2
2.285	1.923	0.399	0.567	0.440	86.4	6.6
2.265	1.934	0.396	0.571	0.448	88.9	6.5
2.244	1.945	0.392	0.578	0.458	91.7	6.3
2.224	1.956	0.389	0.556	0.428	86.5	6.5
2.204	1.966	0.385	0.579	0.460	93.8	6.3
2.183	1.977	0.382	0.588	0.472	97.3	6.2
2.163	1.987	0.378	0.565	0.436	90.7	6.6
2.143	1.998	0.375	0.573	0.448	94.1	6.4
2.122	2.008	0.371	0.576	0.452	95.9	6.4
2.102	2.018	0.367	0.537	0.398	85.2	7.0
2.082	2.029	0.364	0.530	0.385	83.2	7.4
2.061	2.039	0.360	0.526	0.384	83.9	7.4
2.041	2.049	0.357	0.528	0.385	84.9	7.4
2.021	2.059	0.353	0.520	0.373	83.0	7.7
2.001	2.069	0.350	0.551	0.414	93.1	6.9
1.980	2.079	0.346	0.515	0.367	83.3	7.8
1.960	2.089	0.343	0.517	0.369	84.6	7.8
1.940	2.099	0.339	0.504	0.347	80.4	8.1
1.919	2.109	0.336	0.493	0.330	77.2	8.9
1.899	2.119	0.332	0.479	0.314	74.1	9.6

TABLE II C

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 4.36 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN / STERAD*GEV	MIKROBARN / STERAD*GEV		
3.805	1.093	0.725	0.114	-0.002	-0.7	100.0
3.785	1.112	0.721	0.225	0.137	50.6	43.6
3.765	1.131	0.717	0.218	0.146	49.2	39.2
3.745	1.150	0.714	0.348	0.317	99.1	17.9
3.724	1.168	0.710	0.456	0.469	137.0	12.7
3.704	1.186	0.706	0.556	0.640	176.4	10.0
3.684	1.203	0.702	0.664	0.814	213.1	8.5
3.663	1.220	0.698	0.785	0.987	246.6	7.3
3.643	1.237	0.694	0.780	0.933	223.7	7.2
3.623	1.254	0.690	0.716	0.784	181.3	7.7
3.603	1.271	0.686	0.625	0.637	142.4	8.1
3.582	1.287	0.683	0.573	0.561	121.9	8.5
3.562	1.304	0.679	0.493	0.452	95.6	10.1
3.542	1.320	0.675	0.507	0.475	98.0	9.2
3.521	1.335	0.671	0.470	0.436	88.2	9.4
3.501	1.351	0.667	0.403	0.352	69.8	10.8
3.481	1.366	0.663	0.449	0.417	81.4	8.9
3.460	1.382	0.659	0.412	0.373	71.8	9.9
3.440	1.397	0.656	0.456	0.436	82.8	8.5
3.420	1.412	0.652	0.478	0.460	86.2	8.0
3.400	1.426	0.648	0.403	0.357	66.3	9.5
3.379	1.441	0.644	0.508	0.499	91.8	7.4
3.359	1.456	0.640	0.496	0.484	88.4	7.7
3.339	1.470	0.636	0.533	0.530	96.2	7.0
3.318	1.484	0.632	0.558	0.572	103.3	6.7
3.298	1.498	0.628	0.648	0.702	126.1	6.0
3.278	1.512	0.625	0.621	0.655	117.3	6.1
3.257	1.526	0.621	0.619	0.634	113.3	6.1
3.237	1.540	0.617	0.595	0.589	105.0	6.2
3.217	1.553	0.613	0.573	0.555	98.8	6.4
3.197	1.567	0.609	0.548	0.519	92.4	6.6
3.176	1.580	0.605	0.528	0.488	86.9	6.8
3.156	1.593	0.601	0.537	0.498	88.7	6.6
3.136	1.606	0.598	0.541	0.506	90.2	6.5
3.115	1.619	0.594	0.500	0.459	82.0	6.8
3.095	1.632	0.590	0.527	0.493	88.4	6.5
3.075	1.645	0.586	0.548	0.521	93.6	6.2
3.055	1.658	0.582	0.590	0.581	104.7	5.7
3.034	1.670	0.578	0.607	0.604	109.3	5.6
3.014	1.683	0.574	0.612	0.605	109.9	5.6
2.994	1.695	0.570	0.555	0.519	94.6	6.2
2.973	1.708	0.567	0.586	0.562	103.0	5.7
2.953	1.720	0.563	0.560	0.523	96.4	6.0
2.933	1.732	0.559	0.548	0.504	93.3	6.2
2.912	1.744	0.555	0.560	0.515	95.9	6.0
2.892	1.756	0.551	0.532	0.477	89.3	6.3
2.872	1.768	0.547	0.515	0.457	86.1	6.5
2.852	1.780	0.543	0.482	0.415	78.7	7.0
2.831	1.791	0.540	0.499	0.439	83.7	6.7

TABLE II C (CONTINUED)

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 4.36 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN (---------) STERAD*GEV			
2.811	1.803	0.536	0.498	0.435	83.6	6.7
2.791	1.815	0.532	0.473	0.405	78.3	7.1
2.770	1.826	0.528	0.477	0.411	79.9	7.0
2.750	1.838	0.524	0.502	0.446	87.4	6.5
2.730	1.849	0.520	0.518	0.465	91.8	6.3
2.710	1.860	0.516	0.472	0.399	79.4	7.2
2.689	1.872	0.512	0.504	0.444	88.9	6.5
2.669	1.883	0.509	0.450	0.372	75.2	7.5
2.649	1.894	0.505	0.481	0.416	84.6	6.9
2.628	1.905	0.501	0.471	0.405	83.2	7.0
2.608	1.916	0.497	0.467	0.397	82.2	7.0
2.588	1.927	0.493	0.461	0.387	80.6	7.0
2.567	1.938	0.489	0.490	0.425	89.2	6.6
2.547	1.949	0.485	0.441	0.359	76.0	7.7
2.527	1.959	0.481	0.474	0.402	85.9	7.0
2.507	1.970	0.478	0.434	0.350	75.4	7.9
2.486	1.981	0.474	0.465	0.391	84.9	7.0
2.466	1.991	0.470	0.434	0.350	76.7	7.7
2.446	2.002	0.466	0.435	0.351	77.6	7.7
2.425	2.012	0.462	0.418	0.328	73.2	8.2
2.405	2.022	0.458	0.449	0.365	82.1	7.3
2.385	2.033	0.454	0.441	0.354	80.3	7.6
2.364	2.043	0.451	0.404	0.302	69.1	8.9
2.344	2.053	0.447	0.425	0.329	75.8	8.0
2.324	2.064	0.443	0.414	0.315	73.2	8.4
2.304	2.074	0.439	0.413	0.313	73.5	8.5
2.283	2.084	0.435	0.411	0.312	73.9	8.2
2.263	2.094	0.431	0.411	0.313	74.8	8.4
2.243	2.104	0.427	0.405	0.302	72.6	8.8
2.222	2.114	0.423	0.397	0.290	70.5	8.9
2.202	2.124	0.420	0.415	0.313	76.8	8.4
2.182	2.134	0.416	0.396	0.286	70.7	9.3
2.162	2.143	0.412	0.428	0.329	82.1	8.1
2.141	2.153	0.408	0.381	0.263	66.0	9.9
2.121	2.163	0.404	0.426	0.323	81.9	8.2
2.101	2.172	0.400	0.393	0.275	70.4	9.6
2.080	2.182	0.396	0.353	0.219	56.5	11.8
2.060	2.192	0.393	0.382	0.261	67.9	10.0
2.040	2.201	0.389	0.341	0.209	54.8	11.9
2.019	2.211	0.385	0.374	0.250	66.2	10.3
1.999	2.220	0.381	0.370	0.243	64.9	10.9
1.979	2.230	0.377	0.374	0.245	66.2	10.6
1.959	2.239	0.373	0.349	0.211	57.5	12.5
1.938	2.248	0.369	0.363	0.238	65.4	11.3
1.918	2.258	0.365	0.332	0.192	53.0	14.5
1.898	2.267	0.362	0.375	0.250	69.9	11.4

TABLE II D

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 5.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
			MIKROBARN (----------) STERAD*GEV			
4.071	1.316	0.890	0.252	0.241	65.3	23.2
4.051	1.333	0.885	0.222	0.197	52.2	22.1
4.030	1.349	0.881	0.202	0.171	44.2	22.0
4.009	1.365	0.876	0.218	0.196	49.5	17.4
3.989	1.381	0.872	0.266	0.264	65.4	12.3
3.968	1.396	0.867	0.253	0.253	61.5	12.4
3.947	1.412	0.863	0.264	0.262	62.8	11.2
3.926	1.427	0.858	0.275	0.270	63.8	10.6
3.906	1.442	0.853	0.299	0.301	70.2	9.6
3.885	1.457	0.849	0.354	0.376	86.5	8.0
3.864	1.472	0.844	0.369	0.395	90.1	7.4
3.844	1.487	0.840	0.380	0.417	94.2	7.0
3.823	1.501	0.835	0.427	0.484	108.4	6.3
3.802	1.516	0.831	0.401	0.440	97.9	6.2
3.781	1.530	0.826	0.395	0.422	93.3	6.2
3.761	1.544	0.822	0.353	0.357	78.5	6.6
3.740	1.558	0.817	0.334	0.326	71.4	6.6
3.719	1.572	0.813	0.338	0.327	71.2	6.3
3.699	1.586	0.808	0.316	0.297	64.6	6.3
3.678	1.599	0.804	0.309	0.292	63.3	6.3
3.657	1.613	0.799	0.346	0.343	74.1	6.1
3.636	1.626	0.795	0.336	0.332	71.8	5.8
3.616	1.640	0.790	0.343	0.338	73.0	5.8
3.595	1.653	0.786	0.382	0.391	84.5	5.3
3.574	1.666	0.781	0.397	0.418	90.2	5.2
3.553	1.679	0.777	0.406	0.426	92.1	5.0
3.533	1.692	0.772	0.406	0.419	90.6	5.0
3.512	1.704	0.767	0.409	0.421	91.0	5.0
3.491	1.717	0.763	0.389	0.392	85.1	5.0
3.471	1.730	0.758	0.377	0.371	80.7	5.1
3.450	1.742	0.754	0.363	0.345	75.1	5.3
3.429	1.755	0.749	0.361	0.342	74.6	5.1
3.408	1.767	0.745	0.340	0.316	69.3	5.3
3.388	1.779	0.740	0.336	0.311	68.5	5.3
3.367	1.791	0.736	0.343	0.318	70.1	5.3
3.346	1.803	0.731	0.334	0.315	69.9	5.1
3.326	1.815	0.727	0.321	0.293	65.3	5.4
3.305	1.827	0.722	0.341	0.320	71.6	4.9
3.284	1.839	0.718	0.319	0.291	65.4	5.3
3.263	1.851	0.713	0.324	0.297	67.0	5.2
3.243	1.863	0.709	0.363	0.351	79.5	4.7
3.222	1.874	0.704	0.330	0.304	69.3	5.0
3.201	1.886	0.700	0.342	0.319	73.0	4.9
3.181	1.897	0.695	0.349	0.330	76.0	4.8
3.160	1.909	0.690	0.336	0.310	71.8	4.9
3.139	1.920	0.686	0.340	0.314	73.2	4.9
3.118	1.931	0.681	0.341	0.314	73.5	4.9
3.098	1.942	0.677	0.322	0.288	67.8	5.2
3.077	1.954	0.672	0.330	0.297	70.3	5.1

TABLE II D (CONTINUED)

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 5.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0 MIKROBARN (---------) STERAD*GEV	SIGMA1	SIGMAT (MIKROBARN)	DSIGMA (%)
3.056	1.965	0.668	0.330	0.298	71.1	5.1
3.035	1.976	0.663	0.326	0.293	70.3	5.2
3.015	1.987	0.659	0.328	0.296	71.4	5.0
2.994	1.998	0.654	0.329	0.298	72.4	5.2
2.973	2.008	0.650	0.339	0.310	75.9	5.0
2.953	2.019	0.645	0.318	0.274	67.6	5.4
2.932	2.030	0.641	0.292	0.243	60.2	5.8
2.911	2.041	0.636	0.313	0.268	67.0	5.4
2.890	2.051	0.632	0.303	0.261	65.6	5.6
2.870	2.062	0.627	0.313	0.273	69.2	5.4
2.849	2.072	0.623	0.312	0.271	69.3	5.4
2.828	2.083	0.618	0.309	0.267	68.7	5.5
2.808	2.093	0.614	0.306	0.264	68.3	5.5
2.787	2.103	0.609	0.308	0.265	69.0	5.5
2.766	2.114	0.604	0.296	0.248	65.2	5.7
2.745	2.124	0.600	0.303	0.257	68.0	5.7
2.725	2.134	0.595	0.303	0.258	68.7	5.7
2.704	2.144	0.591	0.297	0.251	67.2	5.7
2.683	2.154	0.586	0.303	0.259	70.0	5.7
2.663	2.164	0.582	0.297	0.247	67.3	5.8
2.642	2.174	0.577	0.298	0.247	67.8	5.9
2.621	2.184	0.573	0.296	0.246	68.0	5.9
2.600	2.194	0.568	0.304	0.254	70.7	5.7
2.580	2.204	0.564	0.296	0.244	68.4	5.9
2.559	2.214	0.559	0.286	0.229	64.7	6.3
2.538	2.224	0.555	0.289	0.233	66.3	6.1
2.517	2.234	0.550	0.287	0.228	65.3	6.6
2.497	2.243	0.546	0.282	0.220	63.6	6.4
2.476	2.253	0.541	0.275	0.211	61.3	6.6
2.455	2.262	0.537	0.289	0.230	67.5	6.3
2.435	2.272	0.532	0.282	0.219	64.8	6.6
2.414	2.282	0.527	0.274	0.209	62.1	7.0
2.393	2.291	0.523	0.271	0.203	60.9	7.0
2.372	2.301	0.518	0.278	0.214	64.7	6.7
2.352	2.310	0.514	0.272	0.205	62.3	7.0
2.331	2.319	0.509	0.277	0.211	64.6	6.9
2.310	2.329	0.505	0.275	0.206	63.5	7.1
2.290	2.338	0.500	0.261	0.184	57.3	7.9
2.269	2.347	0.496	0.260	0.185	57.9	7.8
2.248	2.356	0.491	0.265	0.192	60.5	7.6
2.227	2.366	0.487	0.273	0.201	63.9	7.2
2.207	2.375	0.482	0.275	0.203	65.0	7.2
2.186	2.384	0.478	0.261	0.181	58.5	8.0
2.165	2.393	0.473	0.255	0.172	55.9	8.3
2.145	2.402	0.469	0.261	0.182	59.7	7.9
2.124	2.411	0.464	0.255	0.174	57.4	8.3
2.103	2.420	0.460	0.253	0.171	57.0	8.7
2.082	2.429	0.455	0.255	0.173	58.0	8.6
2.062	2.438	0.451	0.252	0.166	56.1	9.2
2.041	2.447	0.446	0.241	0.149	50.8	10.2

TABLE II E

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 6.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0	SIGMA1 MIKROBARN (---------) STERAD*GEV	SIGMAT (MIKROBARN)	DSIGMA (%)
3.866	1.967	1.014	0.156	0.131	37.8	30.7
3.846	1.978	1.009	0.164	0.144	41.6	23.8
3.826	1.989	1.003	0.182	0.170	49.4	18.5
3.805	2.000	0.998	0.154	0.131	38.3	19.4
3.785	2.011	0.993	0.166	0.150	43.9	16.3
3.765	2.022	0.987	0.148	0.123	36.3	17.4
3.745	2.032	0.982	0.154	0.133	39.4	14.6
3.724	2.043	0.977	0.138	0.112	33.2	16.5
3.704	2.054	0.971	0.135	0.107	31.9	15.8
3.684	2.064	0.966	0.142	0.118	35.4	13.9
3.663	2.075	0.961	0.159	0.142	42.7	11.1
3.643	2.085	0.955	0.143	0.121	36.6	11.7
3.623	2.095	0.950	0.132	0.105	31.8	13.1
3.603	2.106	0.945	0.147	0.125	38.1	10.7
3.582	2.116	0.939	0.158	0.140	42.8	9.4
3.562	2.126	0.934	0.157	0.145	44.4	9.1
3.542	2.137	0.929	0.143	0.123	37.8	9.9
3.521	2.147	0.923	0.144	0.123	38.2	9.5
3.501	2.157	0.918	0.143	0.121	37.7	9.6
3.481	2.167	0.913	0.150	0.133	41.6	8.6
3.460	2.177	0.907	0.152	0.135	42.5	8.5
3.440	2.187	0.902	0.146	0.124	39.3	8.8
3.420	2.197	0.897	0.156	0.138	43.8	8.0
3.400	2.206	0.891	0.146	0.124	39.6	8.7
3.379	2.216	0.886	0.143	0.121	38.8	8.8
3.359	2.226	0.881	0.151	0.131	42.3	8.0
3.339	2.236	0.875	0.155	0.134	43.5	7.8
3.318	2.245	0.870	0.157	0.139	45.3	7.4
3.298	2.255	0.865	0.152	0.130	42.6	7.7
3.278	2.265	0.860	0.159	0.138	45.6	7.2
3.257	2.274	0.854	0.150	0.126	41.8	7.8
3.237	2.284	0.849	0.151	0.128	42.5	7.7
3.217	2.293	0.844	0.150	0.126	42.2	7.6
3.197	2.303	0.838	0.151	0.126	42.5	7.4
3.176	2.312	0.833	0.158	0.135	45.8	7.1
3.156	2.322	0.828	0.155	0.132	44.9	7.1
3.136	2.331	0.822	0.149	0.122	41.8	7.4
3.115	2.340	0.817	0.155	0.131	44.9	7.1
3.095	2.349	0.812	0.149	0.122	42.4	7.4
3.075	2.359	0.806	0.164	0.143	49.6	6.5
3.055	2.368	0.801	0.155	0.129	45.1	7.0
3.034	2.377	0.796	0.150	0.122	42.8	7.4
3.014	2.386	0.790	0.154	0.126	44.5	7.0
2.994	2.395	0.785	0.160	0.134	47.8	6.7
2.973	2.404	0.780	0.156	0.127	45.5	7.0
2.953	2.413	0.774	0.147	0.117	42.0	7.6
2.933	2.422	0.769	0.166	0.143	51.8	6.5
2.912	2.431	0.764	0.152	0.121	44.2	7.4
2.892	2.440	0.758	0.153	0.122	44.6	7.3

TABLE II E (CONTINUED)

KINEMATIC VALUES AND CROSS-SECTIONS FOR THE MEASUREMENT
E0 = 6.00 GEV THETA = 12.0 DEGREES

E3 (GEV)	W (GEV)	Q**2 (GEV**2)	SIGMA0 MIKROBARN/(STERAD*GEV)	SIGMA1 MIKROBARN/(STERAD*GEV)	SIGMAT (MIKROBARN)	DSIGMA (%)
2.872	2.449	0.753	0.158	0.130	48.0	7.0
2.852	2.458	0.748	0.159	0.130	48.3	7.2
2.831	2.467	0.742	0.153	0.119	44.5	7.7
2.811	2.475	0.737	0.142	0.106	39.6	8.7
2.791	2.484	0.732	0.152	0.119	45.0	7.9
2.770	2.493	0.726	0.152	0.119	45.0	8.0
2.750	2.502	0.721	0.154	0.121	46.0	7.7
2.730	2.510	0.716	0.159	0.129	49.5	7.4
2.710	2.519	0.711	0.151	0.117	45.2	8.1
2.689	2.527	0.705	0.150	0.114	44.4	8.4
2.669	2.536	0.700	0.152	0.116	45.3	8.1
2.649	2.545	0.695	0.151	0.115	45.0	8.3
2.628	2.553	0.689	0.152	0.115	45.6	8.3
2.608	2.562	0.684	0.146	0.107	42.5	8.8
2.588	2.570	0.679	0.151	0.114	45.7	8.3
2.567	2.578	0.673	0.150	0.112	44.9	8.6
2.547	2.587	0.668	0.158	0.121	48.8	8.1
2.527	2.595	0.663	0.151	0.110	44.6	9.1
2.507	2.604	0.657	0.151	0.111	45.3	9.0
2.486	2.612	0.652	0.147	0.105	43.0	9.4
2.466	2.620	0.647	0.155	0.115	47.4	8.6
2.446	2.628	0.641	0.139	0.092	38.2	10.6
2.425	2.637	0.636	0.154	0.111	46.5	9.1
2.405	2.645	0.631	0.145	0.099	41.8	10.0
2.385	2.653	0.625	0.144	0.096	40.5	10.6
2.364	2.661	0.620	0.143	0.095	40.2	11.0
2.344	2.669	0.615	0.146	0.100	42.8	10.3
2.324	2.678	0.609	0.143	0.093	40.1	11.2
2.304	2.686	0.604	0.141	0.091	39.2	11.7
2.283	2.694	0.599	0.145	0.099	43.2	10.4
2.263	2.702	0.593	0.136	0.082	35.8	13.1
2.243	2.710	0.588	0.149	0.100	44.1	10.7
2.222	2.718	0.583	0.138	0.084	37.0	12.5
2.202	2.726	0.577	0.147	0.094	41.9	11.3
2.182	2.734	0.572	0.148	0.096	43.0	11.6
2.162	2.742	0.567	0.148	0.095	42.6	11.7
2.141	2.750	0.561	0.146	0.091	41.0	12.4
2.121	2.757	0.556	0.143	0.086	39.0	13.2
2.101	2.765	0.551	0.148	0.092	42.2	12.4
2.080	2.773	0.546	0.149	0.094	43.0	12.7
2.060	2.781	0.540	0.146	0.088	40.9	13.5
2.040	2.789	0.535	0.143	0.085	39.3	13.8
2.019	2.796	0.530	0.142	0.083	38.6	14.1
1.999	2.804	0.524	0.140	0.080	37.4	15.1
1.979	2.812	0.519	0.147	0.088	41.5	14.0
1.959	2.820	0.514	0.137	0.070	33.0	18.0
1.938	2.827	0.508	0.146	0.082	38.9	15.7
1.918	2.835	0.503	0.152	0.089	42.8	14.8
1.898	2.843	0.498	0.143	0.073	35.3	18.2
1.877	2.850	0.492	0.149	0.081	39.2	16.5

TABLE III

Measured cross sections for some typical masses

W (MeV)	θ (degree)	E_o (GeV)	E_3 (GeV)	q^2 $(GeV/c)^2$	$\vec{q}^{\,2}$ $(GeV/c)^2$	$\frac{d^2\sigma}{d\Omega dE_3}$ (μb/sterGeV)	$\frac{1}{\Gamma_t}\cdot\frac{d^2\sigma}{d\Omega dE_3}$ (μb)	$\frac{1}{\Gamma_t}\frac{d^2\sigma}{d\Omega dE_3}\cdot\frac{1}{G_{ep}^2}$ (μb)	Error (%)
1220	12.5	3.50	2.918	0.484	0.823	2.120	402	3306	4.2
	12.0	4.00	3.363	0.588	0.994	1.442	302	3394	5.0
	12.0	4.36	3.664	0.698	1.183	0.989	247	3761	7.2
1510	12.5	3.50	2.530	0.420	1.360	1.100	167	1117	3.9
	12.0	4.00	2.977	0.520	1.567	0.965	153	1406	4.5
	12.0	4.36	3.281	0.625	1.790	0.669	119	1486	6.0
	12.0	5.00	3.810	0.833	2.248	0.452	102	2189	6.2
1688	12.5	3.50	2.251	0.373	1.902	0.850	139	800	4.1
	12.0	4.00	2.700	0.472	2.132	0.822	130	1036	4.9
	12.0	4.36	3.006	0.572	2.375	0.611	111	1202	5.5
	12.0	5.00	3.538	0.773	2.874	0.435	93	1733	5.0
1920	12.5	3.50	1.842	0.306	3.055	0.495	102	456	6.3
	12.0	4.00	2.291	0.401	3.321	0.490	95	596	6.6
	12.0	4.36	2.601	0.496	3.591	0.420	85	734	7.0
	12.0	5.00	3.139	0.686	4.149	0.313	73	1077	4.9
	12.0	6.00	3.952	1.036	5.229	0.152	44	1504	29.0
2250	12.0	4.36	1.935	0.369	6.250	0.280	76	427	10.3
	12.0	5.00	2.482	0.542	6.882	0.230	65	638	6.7
	12.0	6.00	3.309	0.868	8.110	0.127	43	1004	7.5
2500	12.0	5.00	1.915	0.419	9.933	0.159	57	380	12.3
	12.0	6.00	2.754	0.722	11.261	0.119	45	730	7.6

TABLE IV

Values of the sum rule of Bloom-Gilman

$$I_1 = \frac{2M}{q^2} \cdot \int_0^{\nu_m} \nu W_2 \, d\nu \quad ; \quad I_2 = \int_1^{\omega_2'} f(\omega') \, d\omega' \quad ; \quad \omega_2' = \frac{2M\nu_m + M^2}{q^2}$$

q^2 $(GeV/c)^2$	ν_m (GeV)	ω_2'	I_1	I_2	$I_1 - I_2$	$\frac{I_1 - I_2}{I_2}$
0.40	3.07	16.6	3.27	4.48	- 1.19	- 0.26
0.45	3.10	14.9	3.01	4.01	- 1.00	- 0.25
0.50	3.13	13.5	2.80	3.60	- 0.80	- 0.22
0.55	3.16	12.4	2.62	3.28	- 0.66	- 0.20
0.60	3.18	11.4	2.39	2.98	- 0.59	- 0.22
0.65	3.20	10.6	2.22	2.74	- 0.52	- 0.19
0.70	3.23	9.9	2.08	2.51	- 0.43	- 0.17
0.75	3.26	9.3	1.94	2.33	- 0.39	- 0.17

Figure captions

Fig. 1 Kinematical region covered by this experiment, shown in the q^2-ν-plane.

Fig. 2 Experimental set-up.

Fig. 3 Momentum acceptance in % as a function of the radius of curvature, measured and calculated values.

Fig. 4 Electron spectrum for E_o=4.0 GeV and $\Theta_e=12^o$ as a function of the scattered energy E_3 together with the pion- and Dalitz-pair contribution.

Fig. 5 Measured pulse height spectra of the shower counter for different energy intervals and their decomposition into electron- and pion-contributions.

Fig. 6a-c Values of $1/\Gamma_t \cdot d^2\sigma/d\Omega dE_3$ as a function of q^2 for the invariant masses W=1220, 1510, 1688, 1920, 2250 and 2500 MeV.

Fig. 7a-e Values of νW_2 and the scaling function $\nu W_2 = f(\omega')$ as function of ω and ω'.

Fig. 8 a) Values of νW_2 as function of ω (hand-drawn fits) and the prediction $\nu W_2 = f(\omega')$ of Ref. 23 (ooo).

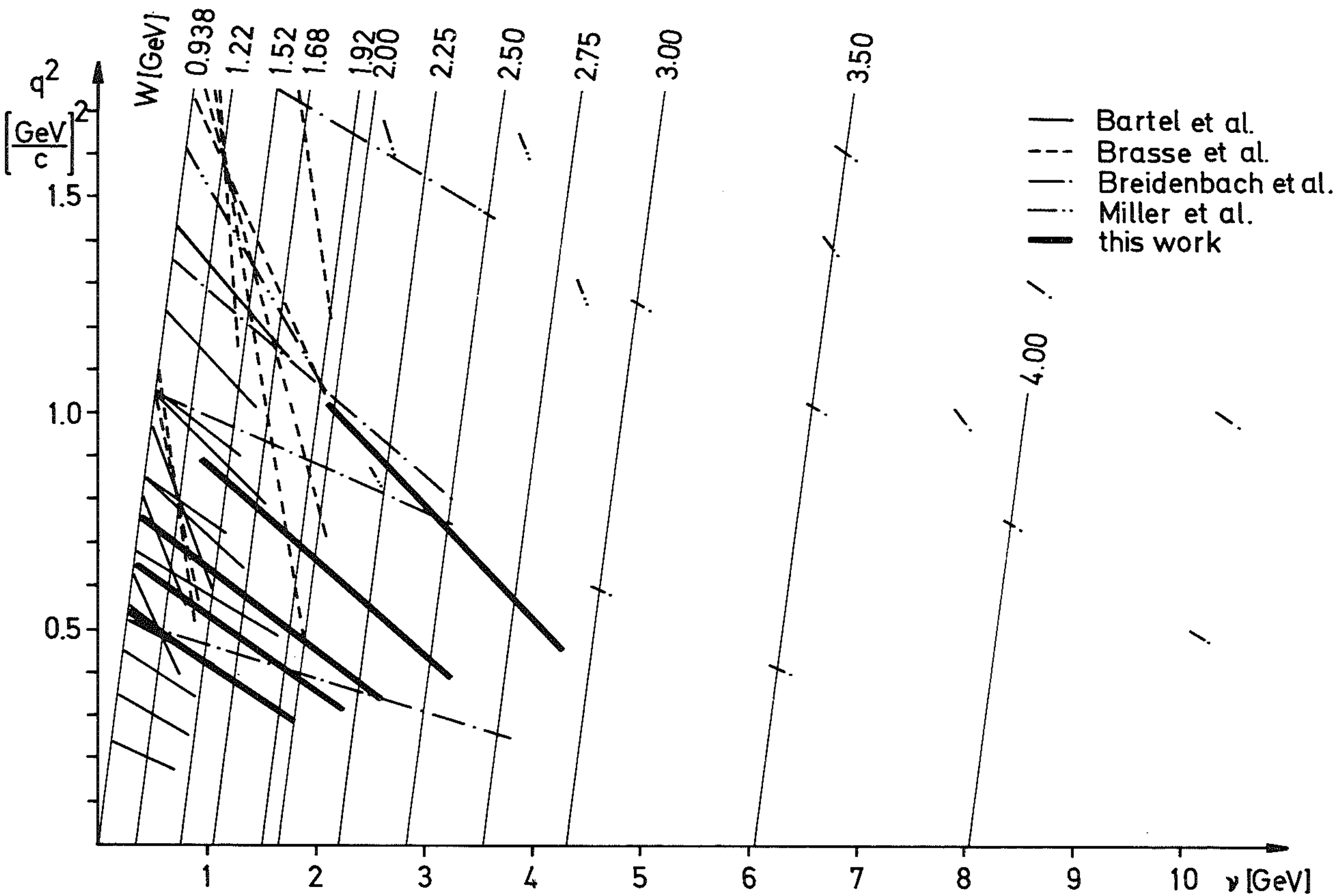
b) Values of νW_2 as function of ω' (hand-drawn fits) and the scaling function $\nu W_2 = f(\omega')$ (+++).

c) Values of $\nu W_2/f(\omega')$ as a function of $W^2/2M$ (hand-drawn fits).

Fig. 9a-c Interpolated values of νW_2 at constant four-momentum transfers q^2 and the scaling function $\nu W_2 = f(\omega')$ as function of ν and ω'.

Fig. 10a-e Values of $g(\omega'_{el}, \omega'_2)$ as function of ω'_2, as defined in formula (13).

Fig. 11a-e Values of $g(\omega'_{el}, \omega'_2)$ as function of ω'_2, using $\nu\tilde{W}_2$ instead of νW_2.



q^2
$\left[\frac{GeV}{c}\right]^2$
1.5
1.0
0.5
W [GeV]
0.938
1.22
1.52
1.68
1.92
2.00
2.25
2.50
2.75
3.00
3.50
4.00
Bartel et al.
Brasse et al.
Breidenbach et al.
Miller et al.
this work
1
2
3
4
5
6
7
8
9
10
ν [GeV]

Fig.1

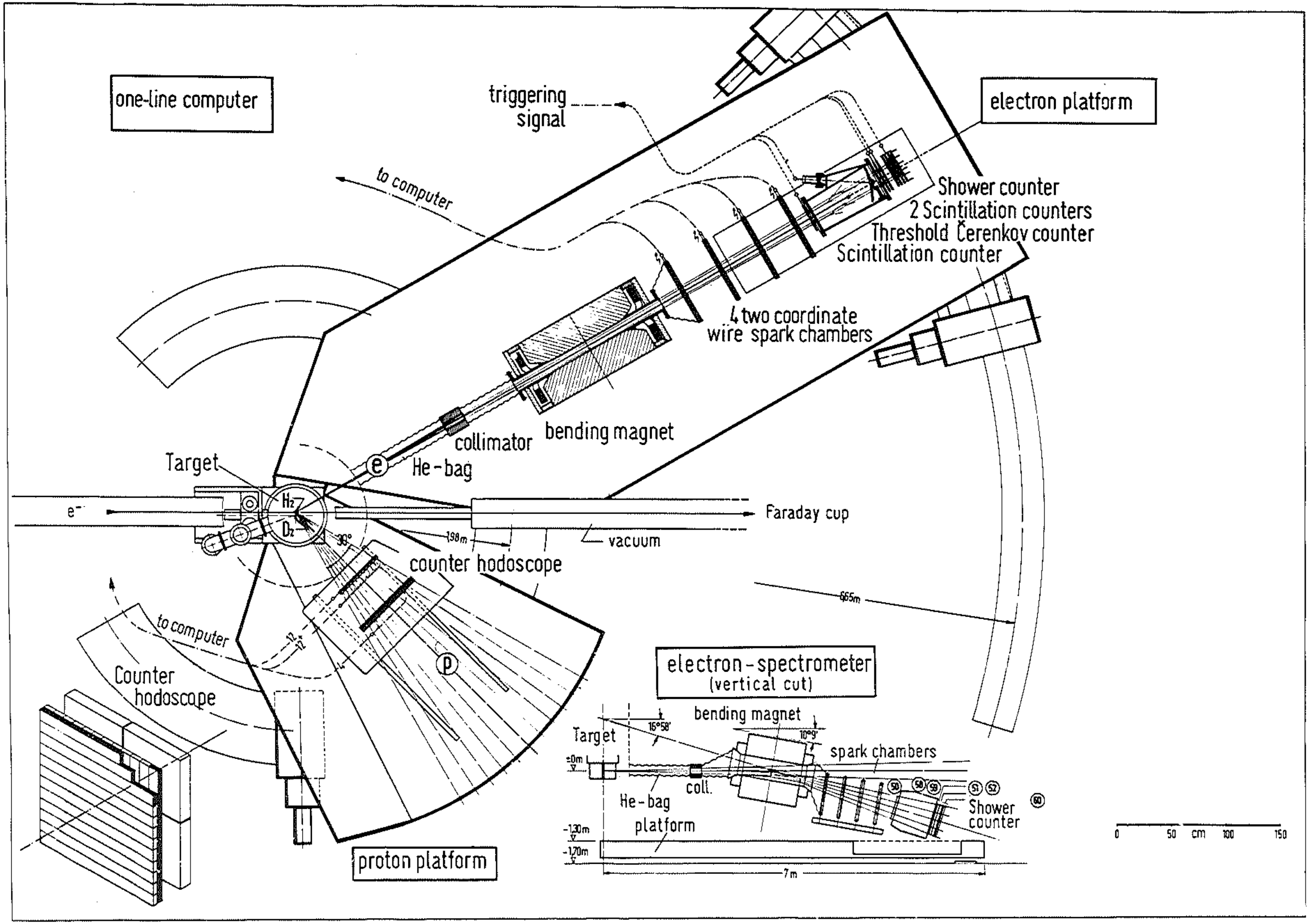

one-line computer
triggering signal
electron platform
to computer
Shower counter
2 Scintillation counters
Threshold Čerenkov counter
Scintillation counter
4 two coordinate wire spark chambers
bending magnet
collimator
He-bag
Target
H2
D2
e⁻
Faraday cup
vacuum
counter hodoscope
to computer
Counter hodoscope
p
proton platform
electron-spectrometer (vertical cut)
bending magnet
Target
spark chambers
coll.
He-bag
Shower counter
platform
7m
0 50 cm 100 150

Fig. 2

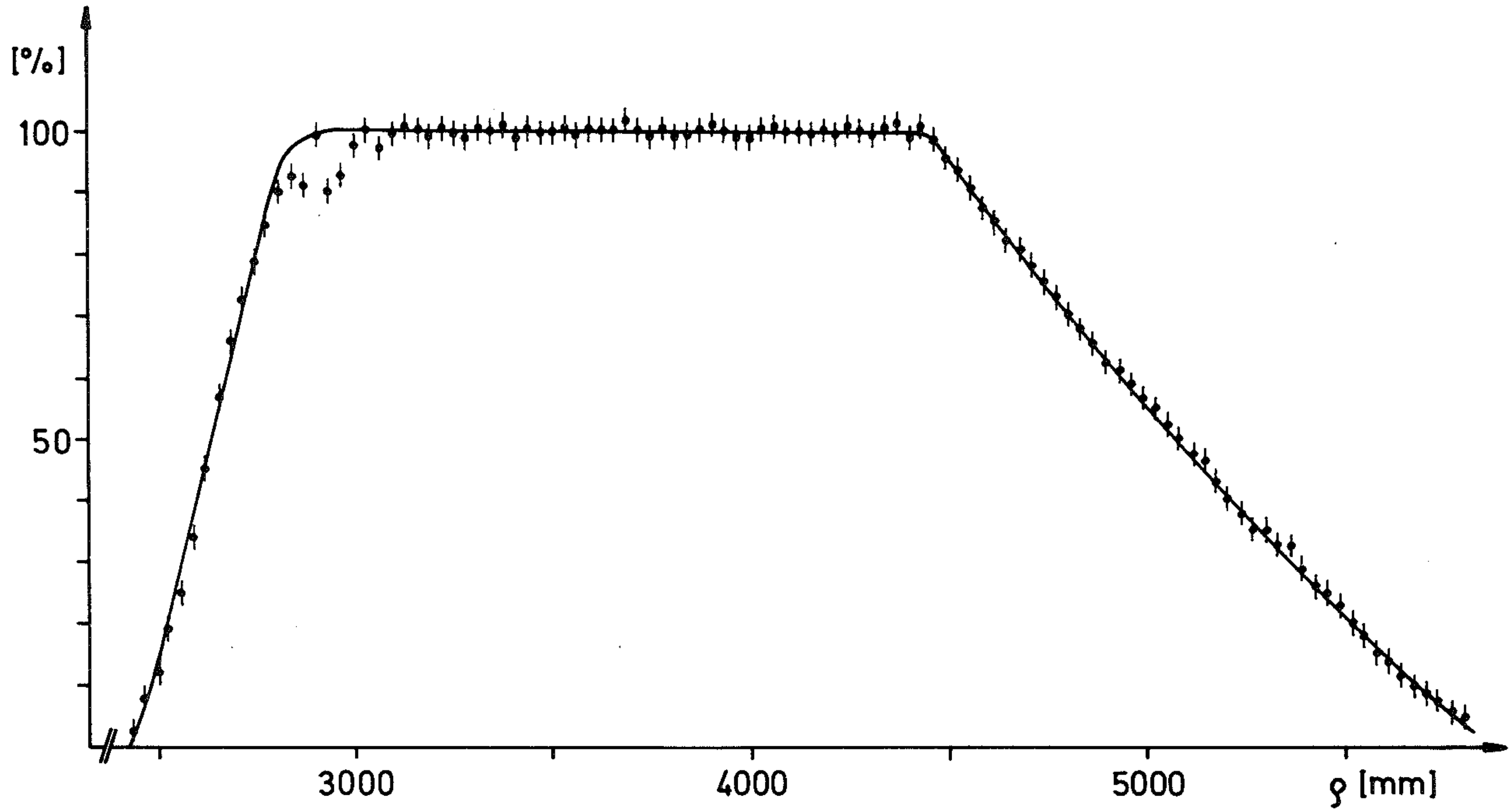
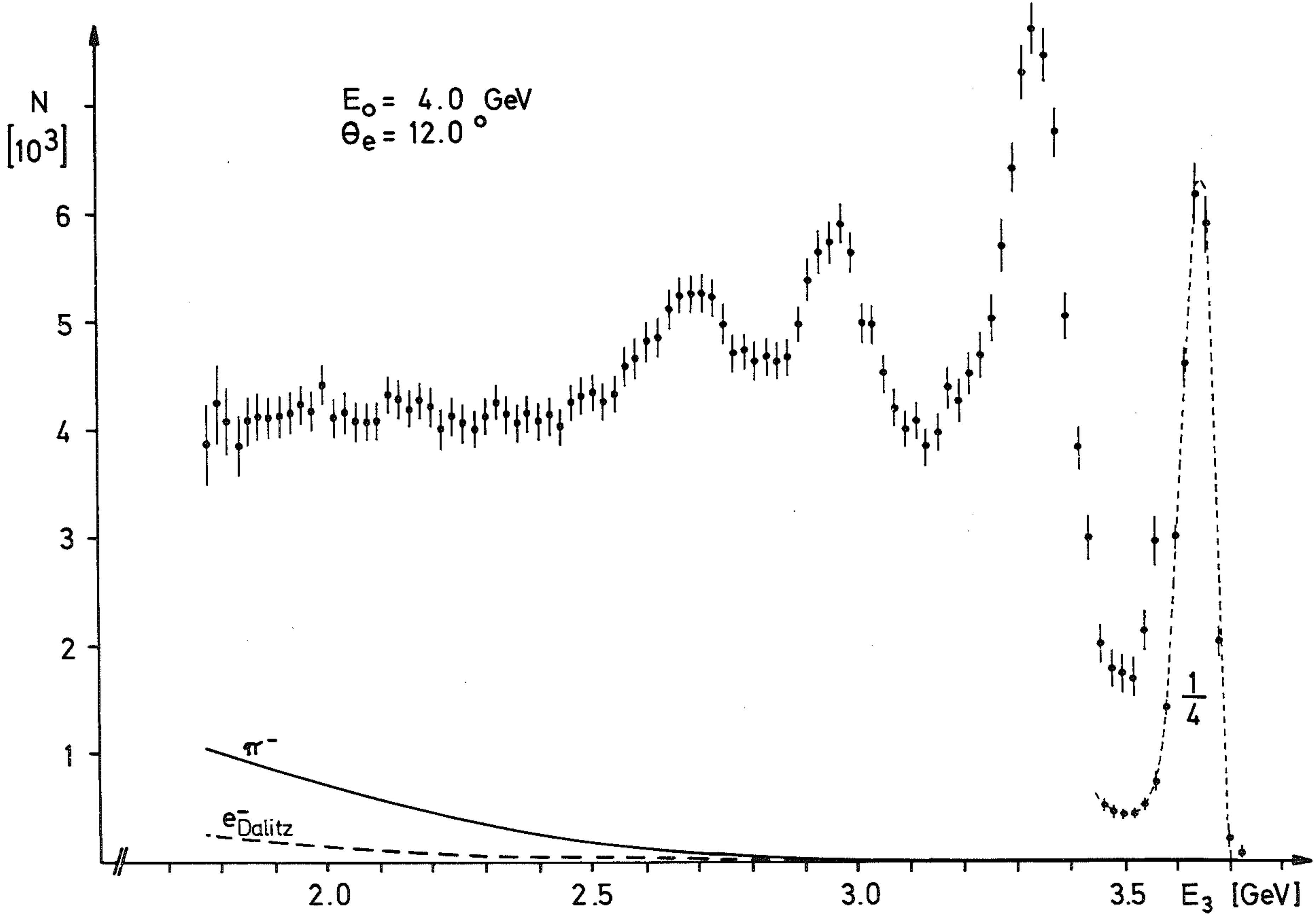
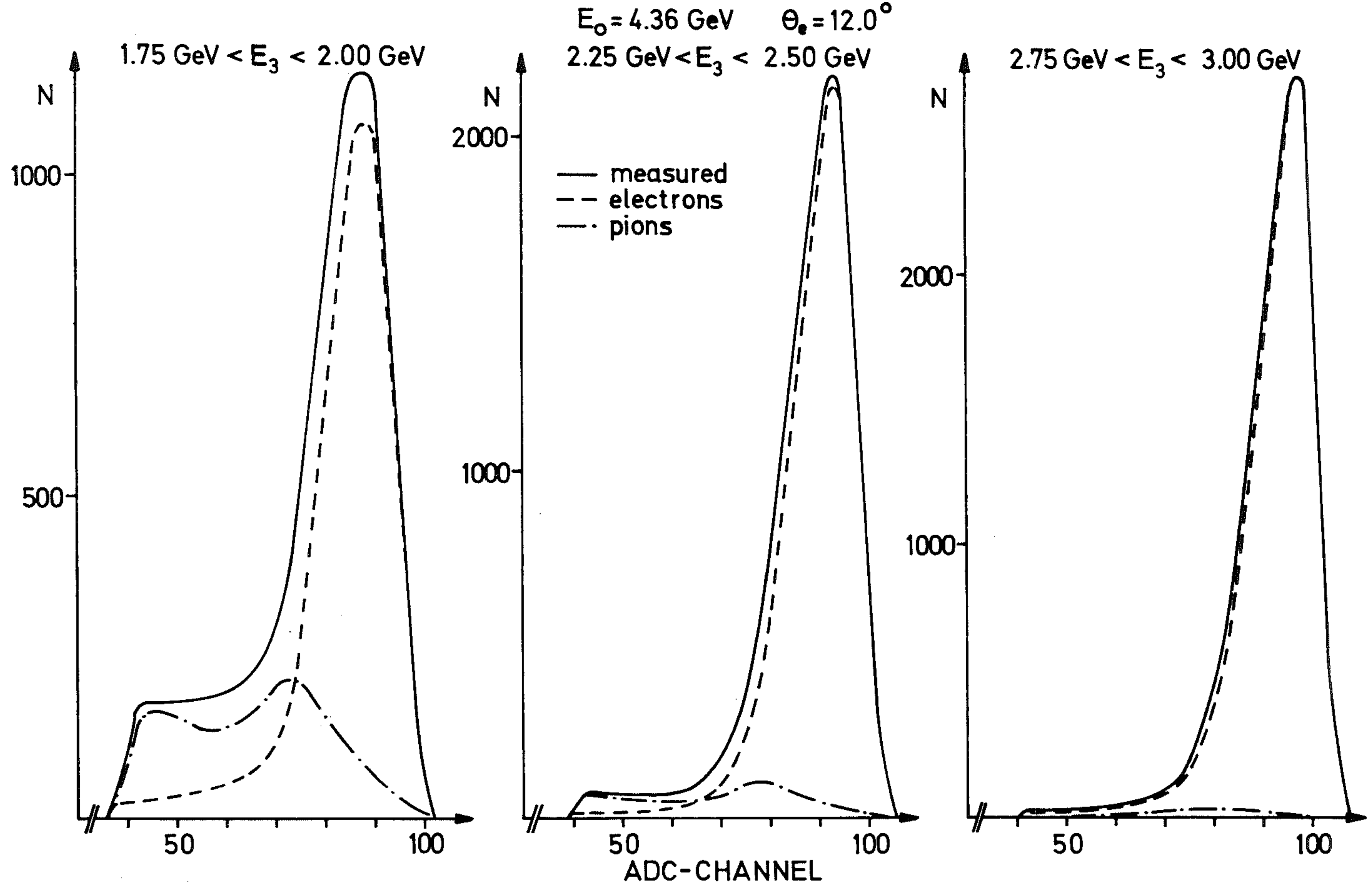


Fig. 3



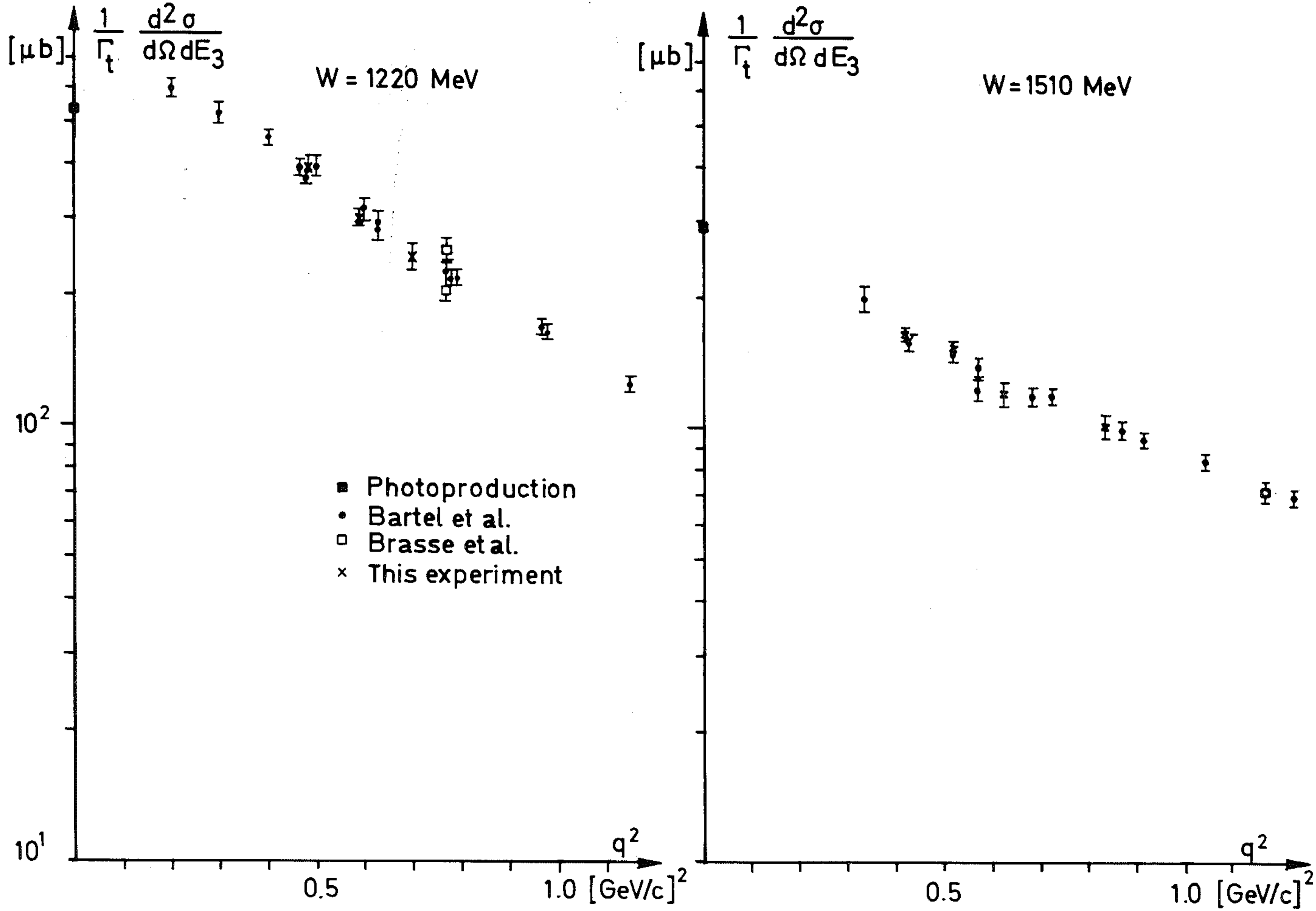
N
[10^3]
E_o = 4.0 GeV
Θ_e = 12.0 °
6
5
4
3
2
1
π^-
e^-_{Dalitz}
1/4
2.0
2.5
3.0
3.5
E_3 [GeV]

Fig.4



$E_o = 4.36$ GeV $\Theta_e = 12.0°$
1.75 GeV < E_3 < 2.00 GeV
2.25 GeV < E_3 < 2.50 GeV
2.75 GeV < E_3 < 3.00 GeV
N
1000
500
2000
measured
electrons
pions
50
100
ADC-CHANNEL

Fig.5



[μb]
$\frac{1}{\Gamma_t} \frac{d^2\sigma}{d\Omega dE_3}$
W = 1220 MeV
10^2
10^1
Photoproduction
Bartel et al.
Brasse et al.
This experiment
q²
0.5
1.0 [GeV/c]²
[μb]
$\frac{1}{\Gamma_t} \frac{d^2\sigma}{d\Omega dE_3}$
W = 1510 MeV
q²
0.5
1.0 [GeV/c]²

Fig. 6a

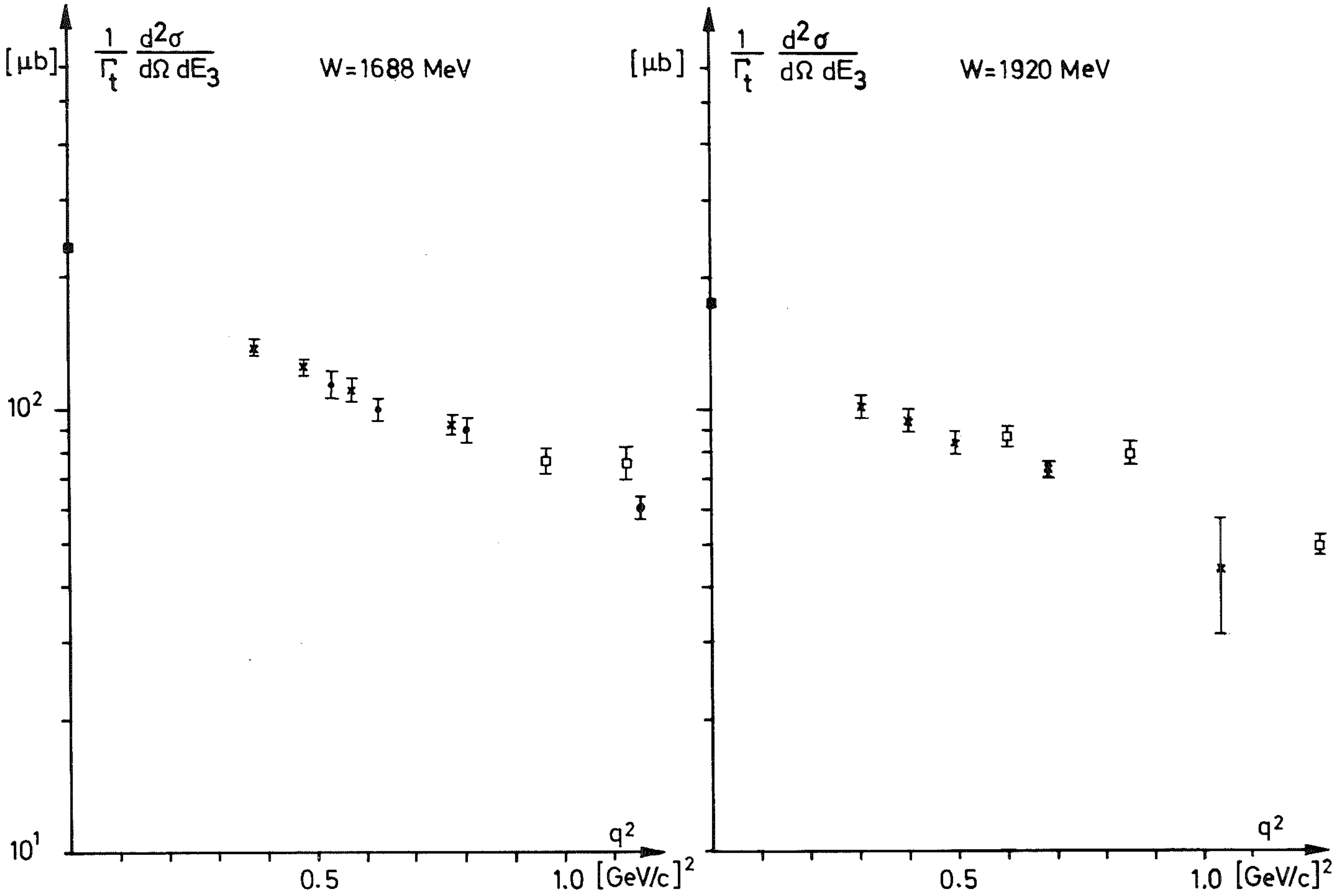
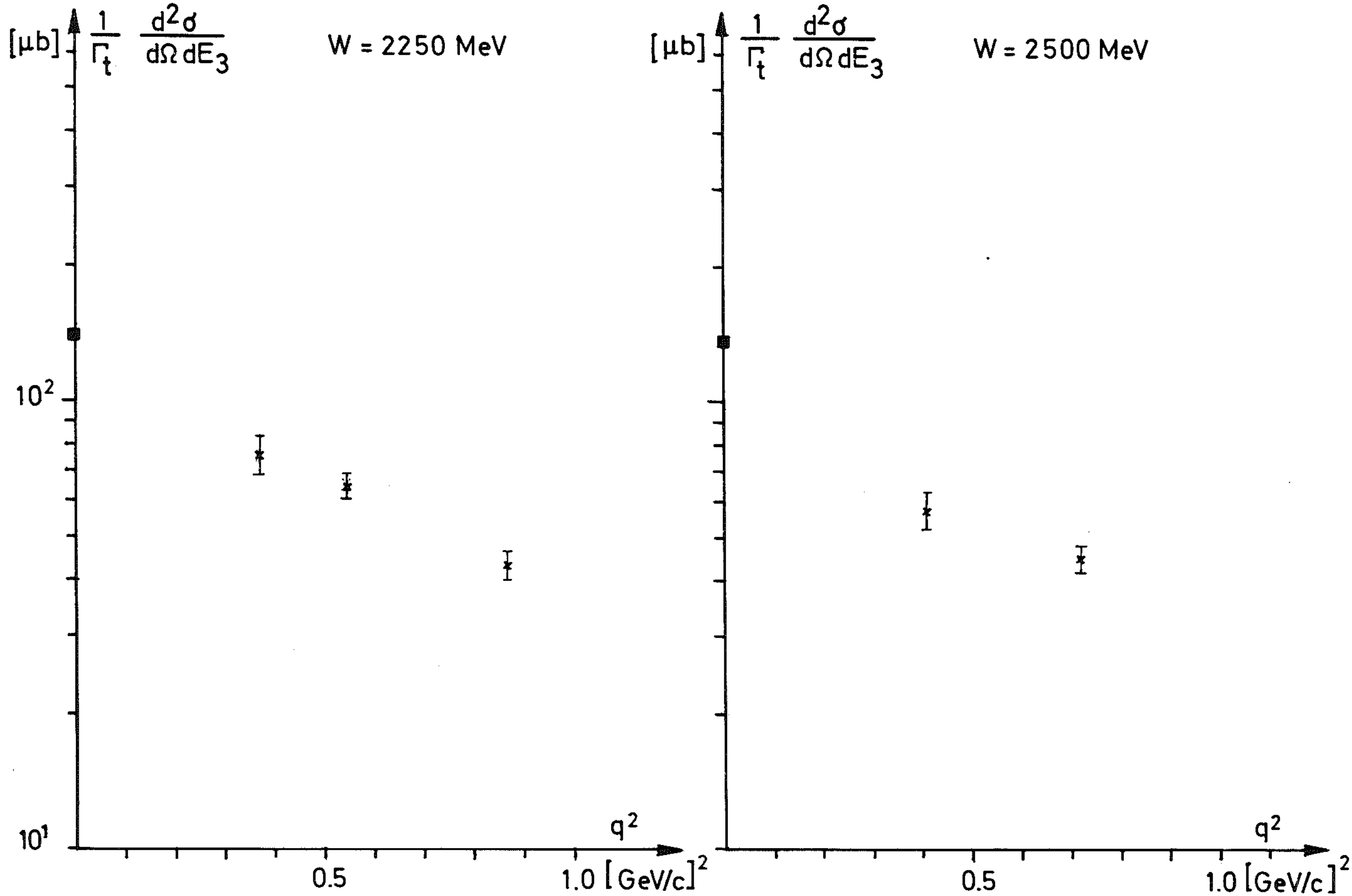
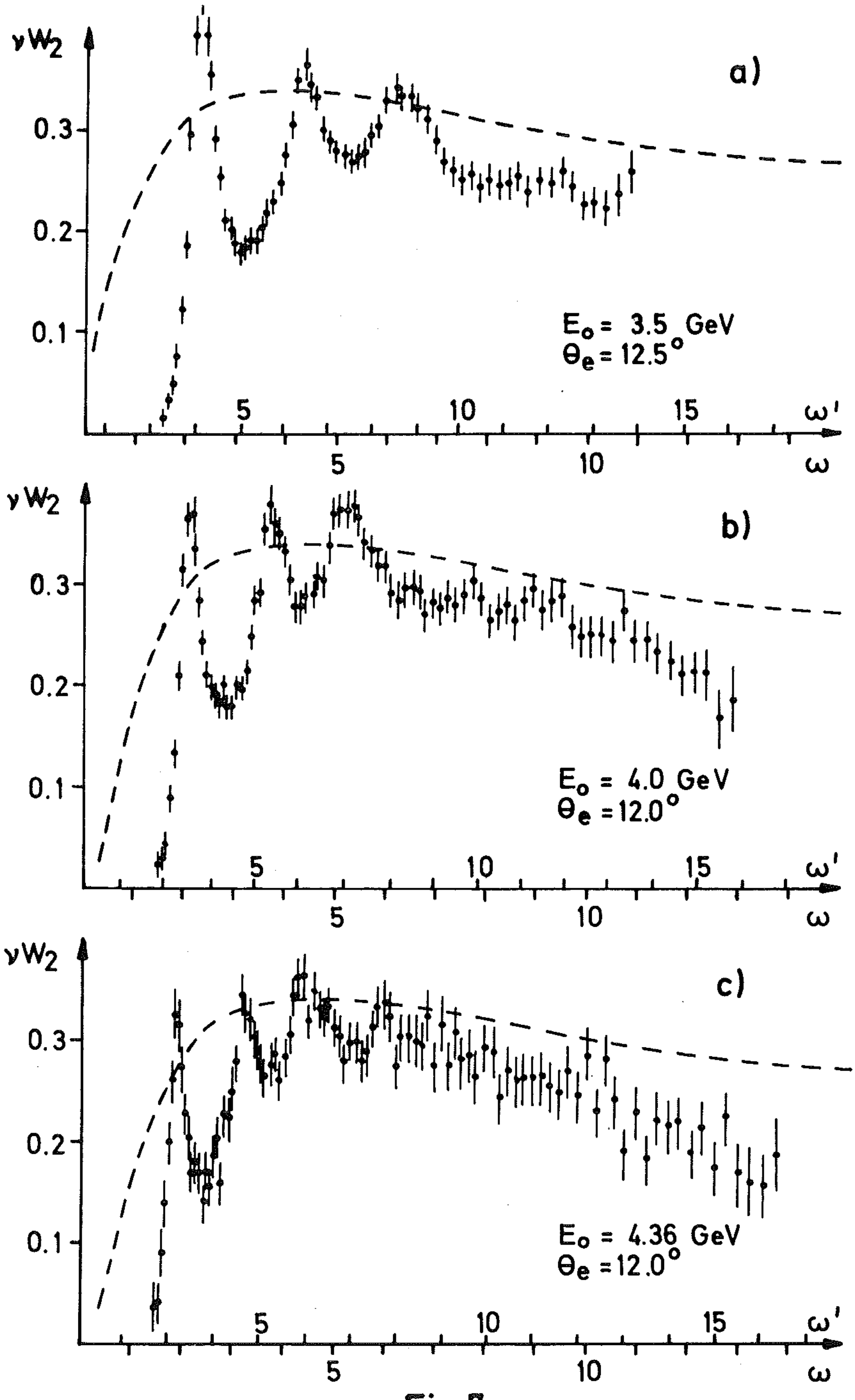

[μb]
$\frac{1}{\Gamma_t}\frac{d^2\sigma}{d\Omega\, dE_3}$
W=1688 MeV
10^2
10^1
q^2
0.5
1.0 $[GeV/c]^2$
[μb]
$\frac{1}{\Gamma_t}\frac{d^2\sigma}{d\Omega\, dE_3}$
W=1920 MeV
q^2
0.5
1.0 $[GeV/c]^2$

Fig. 6 b



[μb]
$\frac{1}{\Gamma_t} \frac{d^2\sigma}{d\Omega\, dE_3}$
W = 2250 MeV
10^2
10^1
q^2
0.5
1.0 [GeV/c]^2
[μb]
$\frac{1}{\Gamma_t} \frac{d^2\sigma}{d\Omega\, dE_3}$
W = 2500 MeV
q^2
0.5
1.0 [GeV/c]^2

Fig.6c



a)
νW_2
0.3
0.2
0.1
E_o = 3.5 GeV
Θ_e = 12.5°
5
10
15
ω'
5
10
ω
b)
νW_2
0.3
0.2
0.1
E_o = 4.0 GeV
Θ_e = 12.0°
5
10
15
ω'
5
10
ω
c)
νW_2
0.3
0.2
0.1
E_o = 4.36 GeV
Θ_e = 12.0°
5
10
15
ω'
5
10
ω

Fig. 7

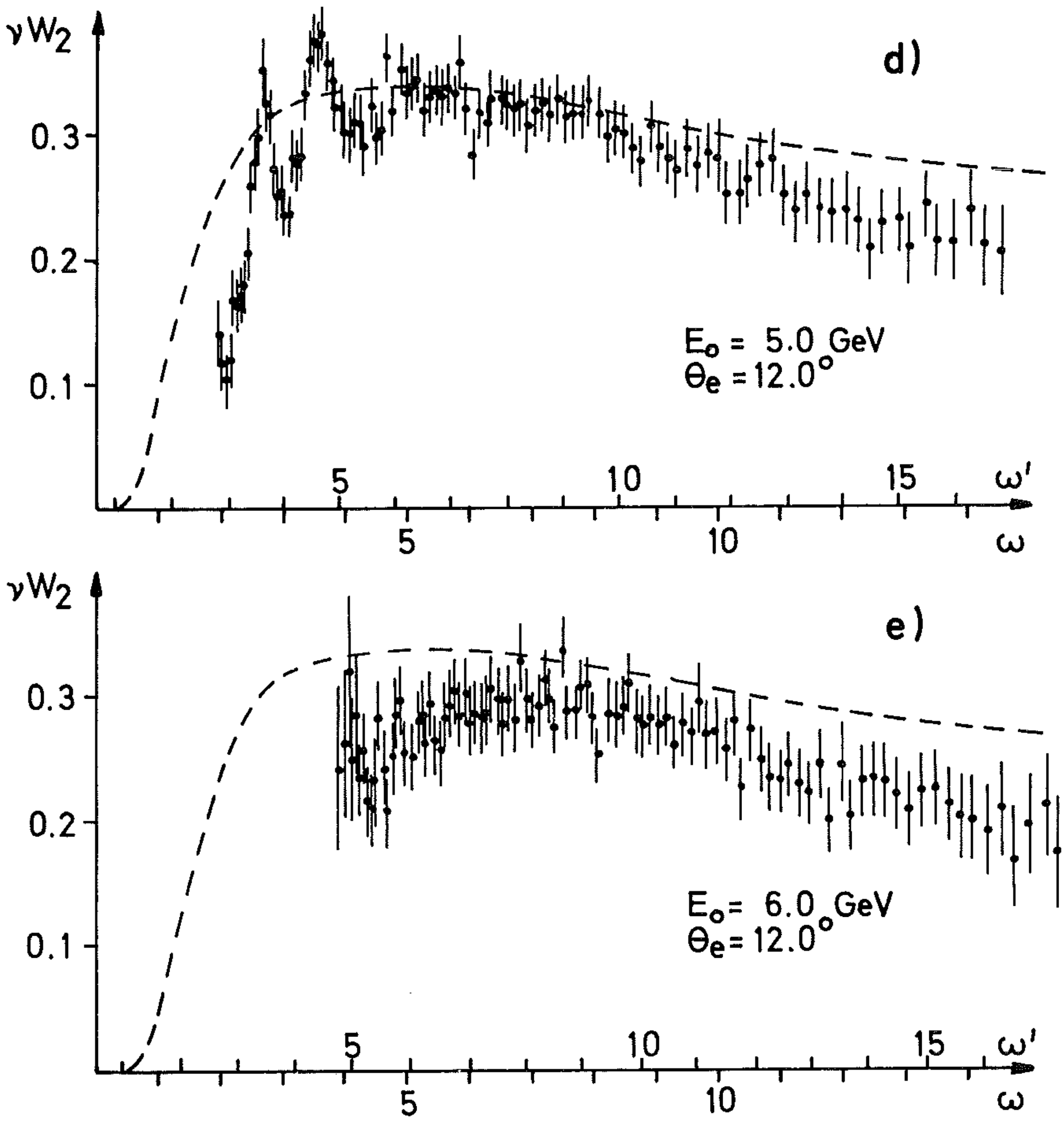
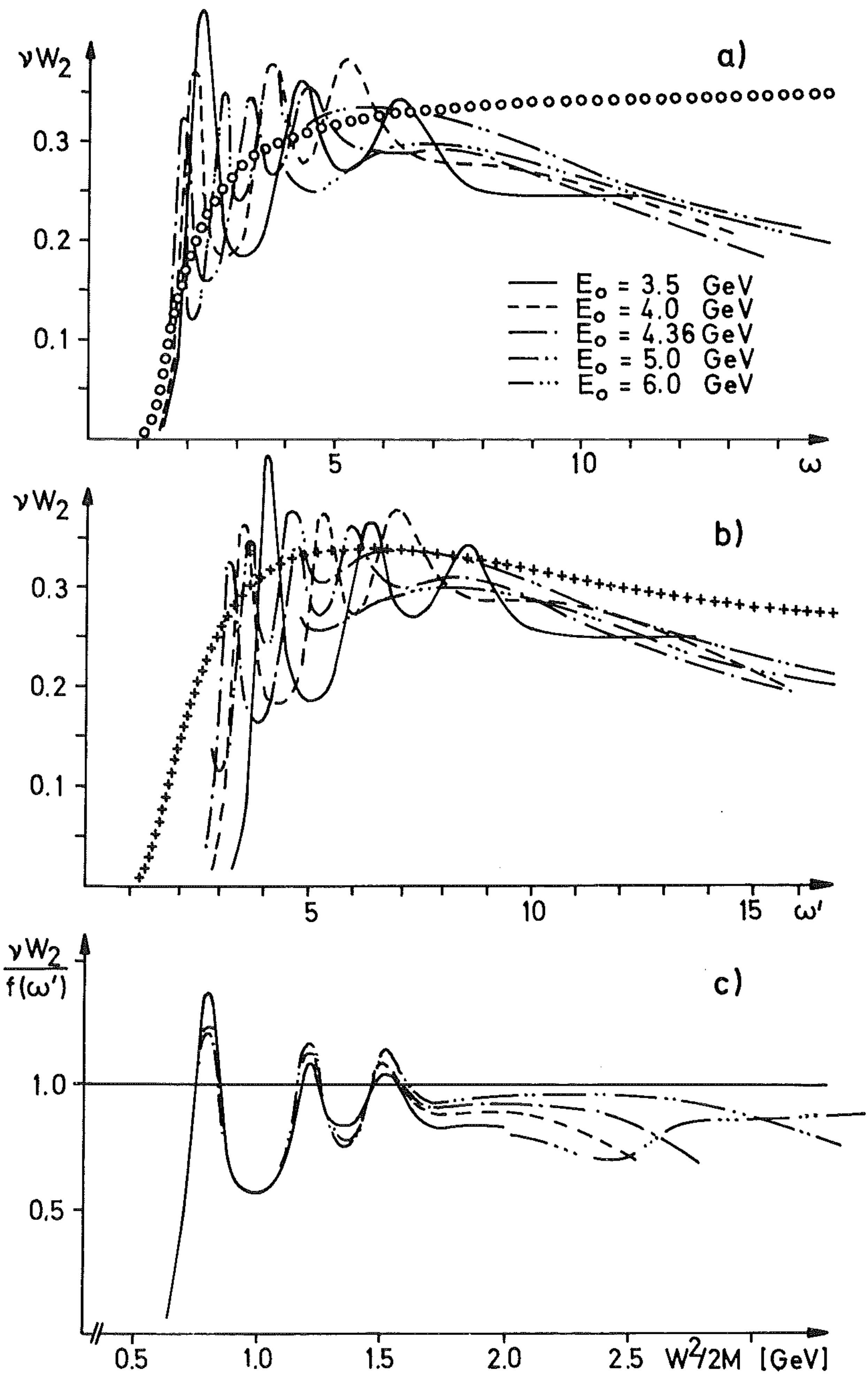

νW2
d)
0.3
0.2
0.1
Eo = 5.0 GeV
Θe = 12.0°
5
10
15
ω'
5
10
ω
νW2
e)
0.3
0.2
0.1
Eo = 6.0 GeV
Θe = 12.0°
5
10
15
ω'
5
10
ω

Fig. 7



a)
νW2
0.3
0.2
0.1
Eo = 3.5 GeV
Eo = 4.0 GeV
Eo = 4.36 GeV
Eo = 5.0 GeV
Eo = 6.0 GeV
5
10
ω
b)
νW2
0.3
0.2
0.1
5
10
15
ω'
c)
νW2 / f(ω')
1.0
0.5
0.5
1.0
1.5
2.0
2.5
W2/2M [GeV]

Fig. 8

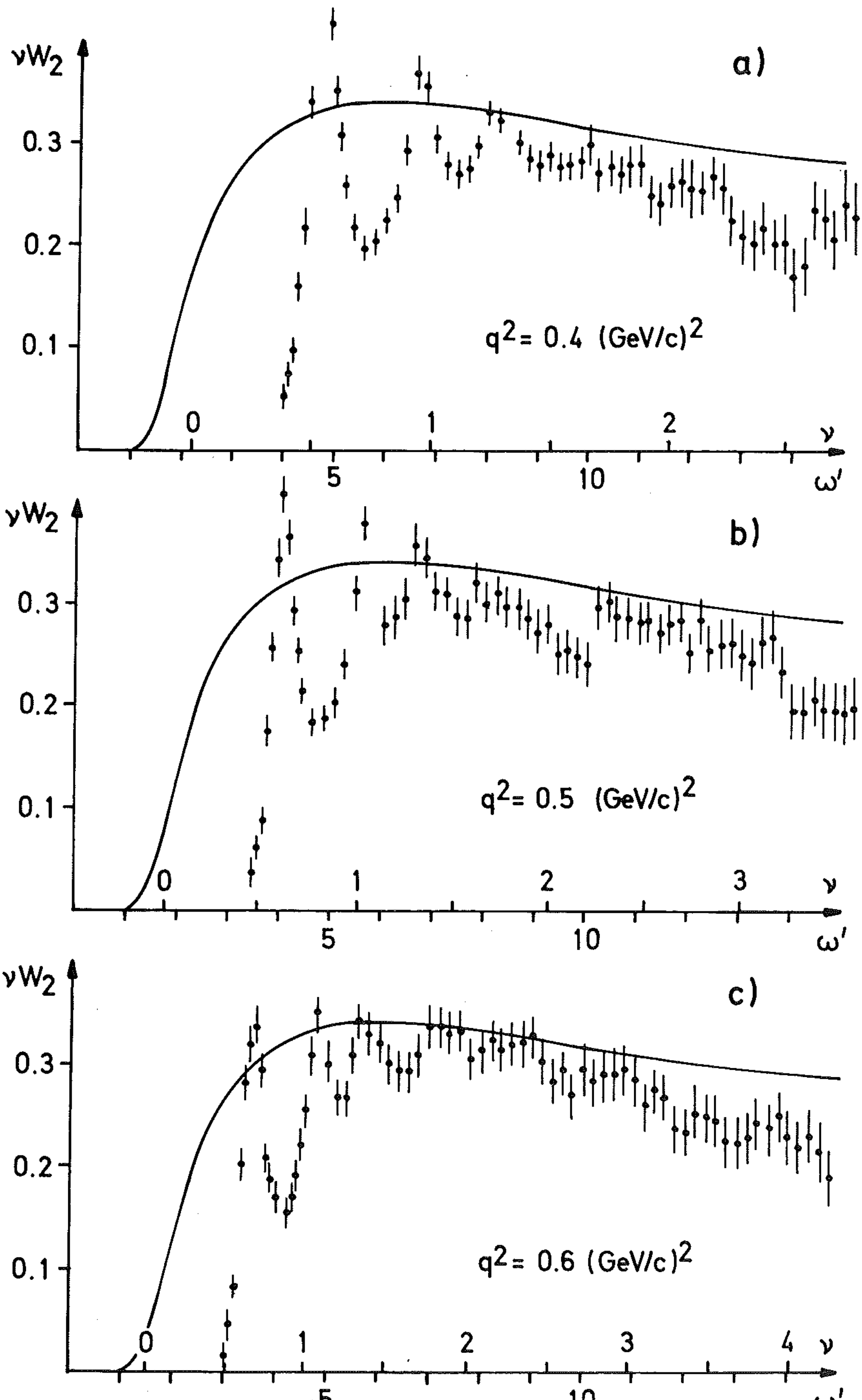

νW2
a)
0.3
0.2
0.1
q2= 0.4 (GeV/c)2
0
1
2
ν
5
10
ω'
νW2
b)
0.3
0.2
0.1
q2= 0.5 (GeV/c)2
0
1
2
3
ν
5
10
ω'
νW2
c)
0.3
0.2
0.1
q2= 0.6 (GeV/c)2
0
1
2
3
4
ν
5
10
ω'

Fig.9

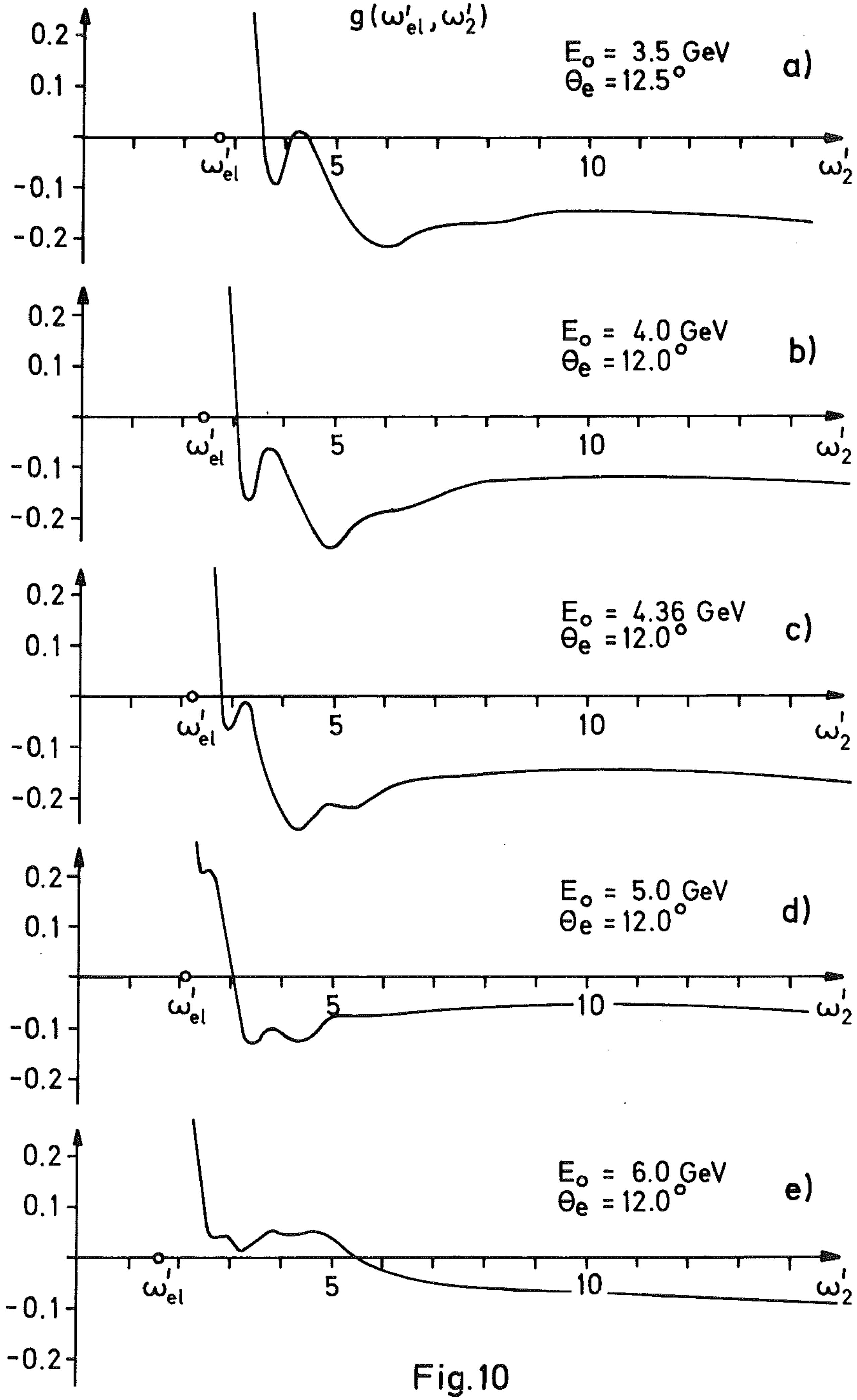
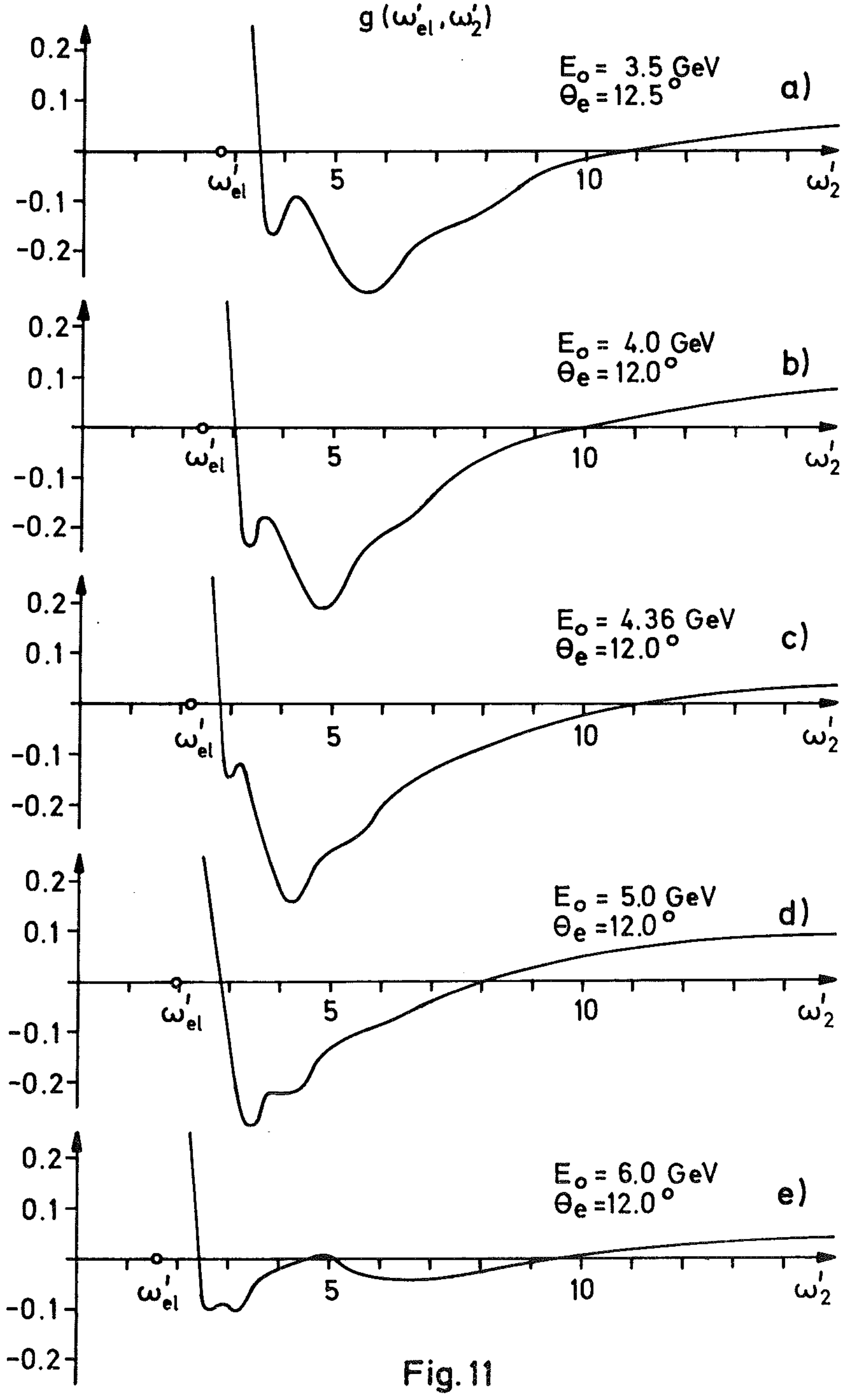

g(ω'el, ω'2)
E0 = 3.5 GeV
Θe = 12.5°
a)
E0 = 4.0 GeV
Θe = 12.0°
b)
E0 = 4.36 GeV
Θe = 12.0°
c)
E0 = 5.0 GeV
Θe = 12.0°
d)
E0 = 6.0 GeV
Θe = 12.0°
e)
0.2
0.1
-0.1
-0.2
ω'el
5
10
ω'2

Fig.10



g (ω'el , ω'2)
0.2
0.1
-0.1
-0.2
ω'el
5
10
ω'2
E_o = 3.5 GeV
Θe = 12.5°
a)
E_o = 4.0 GeV
Θe = 12.0°
b)
E_o = 4.36 GeV
Θe = 12.0°
c)
E_o = 5.0 GeV
Θe = 12.0°
d)
E_o = 6.0 GeV
Θe = 12.0°
e)

Fig. 11