DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 71/2
January 1971

Fits to Electroproduction Data in the Resonance Region and Consequences for σ_ℓ/σ_t

by

F. W. Brasse, W. Fehrenbach, W. Flauger
K. H. Frank, J. Gayler, V. Korbel, J. May and P. D. Zimmerman

Deutsches Elektronen-Synchrotron DESY, Hamburg

and

E. Ganßauge

Physikalisches Institut der Universität Marburg

2 HAMBURG 52 · NOTKESTIEG 1

Fits to Electroproduction Data in the Resonance Region and Consequences for σ_ℓ/σ_t

by

F. W. Brasse, W. Fehrenbach, W. Flauger,
K. H. Frank, J. Gayler, V. Korbel, J. May and P. D. Zimmerman

Deutsches Elektronen-Synchrotron DESY, Hamburg

and

E. Ganßauge
Physikalisches Institut der Universität Marburg

Abstract

We have used all published measurements of electroproduction cross sections, where only the scattered electron was detected, to get some information for the ratio σ_ℓ/σ_t in the resonance region. The experimental cross sections have been fitted in the absolute value of the three momentum transfer $|\vec{q}|$ independently for small bins of W across the range $1.11 \leq W \leq 1.99$ GeV. This was made for two ranges of the polarization ε of the virtual photon. In one range ε was restricted to $\varepsilon \geq 0.9$, in another one to $\varepsilon \leq 0.6$. By comparing cross sections resulting from these fits for the two ranges of ε, but for the same values of q^2 and W , we do not find a significant σ_ℓ - contribution. Taking into account the size of errors we can put upper limits on $R = \sigma_\ell/\sigma_t$. These are about $R \leq 0.2$ for $0.5 \leq q^2 \leq 2.0$ $(\mathrm{GeV/c})^2$ and $R \leq 0.35$ for $2.0 < q^2 \leq 4.0$ $(\mathrm{GeV/c})^2$ over the whole range of W as indicated above.

Many experiments[1-8] have been performed on inelastic electron proton scattering in the region of the main nucleon resonances, where only the scattered electron was detected. The result of these experiments is the knowledge of the total cross section $\Sigma_t(q^2,W)$ for the absorption of virtual photons on protons as a function of the four momentum transfer q^2 and the mass W of the outgoing hadronic system. Σ_t is given in the usual way by

$$\Sigma_t(q^2,W) = \frac{1}{\Gamma_t} \cdot \frac{d^2\sigma}{d\Omega dE'} \quad ,$$

where Γ_t is the number of virtual photons for this process per incoming electron.

The total cross section Σ_t can be separated into two parts according to

$$\Sigma_t = \sigma_t + \varepsilon\sigma_\ell \quad ,$$

where σ_t belongs to transverse and σ_ℓ to longitudinal photons. The parameter ε gives the degree of polarization of the virtual photons. In order to separate σ_t and σ_ℓ one has to know Σ_t for at least two different values of ε but for the same values of W and q^2. Above the resonance region and at the first resonance such corresponding measurements exist and the separation has been made. For $W > 2$ GeV the ratio $R = \sigma_\ell/\sigma_t$ is small, probably around 0.2, and independent from q^2 and W.[7,9] At the first resonance R is different from zero for $0 < q^2 < 0.5\ (\mathrm{GeV}/c)^2$ with a maximum value of perhaps 0.3 , but goes to zero for larger values of q^2.[10] The errors are rather large.

For the region of the higher resonances no corresponding measurements of $d^2\sigma/d\Omega dE'$ exist, which would allow a direct separation of σ_ℓ and σ_t . Since producing new sets of measurements would be a major undertaking, we have fitted all existing cross sections with $W < 2$ GeV and have used these fits to get information on R . As shown in earlier reports[2-6] the cross section has the behaviour

$$\Sigma_t \approx G_D^2(q^2) \cdot A(W) \cdot |\vec{q}|^{b(W)} \quad , \qquad (1)$$

where $G_D(q^2)$ is the dipole form factor of the nucleons and $\vec{q}$ the three momentum transfer to the hadronic system. The parameters A and b depend only on W. For Eq.(1) to hold it is necessary, that $|\vec{q}|$ is sufficiently small. For large values of $|\vec{q}|$ Σ_t goes to values, which are smaller than those from Eq.(1). In the case of a final hadronic system with a definite total angular momentum Eq.(1) represents the threshold behaviour of the cross section for $|\vec{q}| \to 0$. If one plots $\log(\Sigma_t/G_D^2)$ versus $\log|\vec{q}|$ Eq.(1) gives a straight line. Deviations from this behaviour at higher momentum transfers can be taken into account by quadratic, cubic or higher powers of $\log|\vec{q}|$. It was found that one additional term is sufficient. Therefore the following equation was used to fit the data:

$$\log(\Sigma_t/G_D^2) = a(W) + b(W) \cdot \log(|\vec{q}|/|\vec{q}|_o) +$$

$$+ c(W) \cdot \left(\log(|\vec{q}|/|\vec{q}|_o)\right)^{d(W)} \qquad . \qquad (2)$$

Here $|\vec{q}|_o$ is the value of $|\vec{q}|$ at $q^2 = 0$ for the same W.

Since we are interested in the dependence of Σ_t on ε, we have made in general two sets of fits, one using all available cross sections with $\varepsilon \geq 0.9$ and another one, where only cross sections with $\varepsilon \leq 0.6$ were used. In the first case data are from Refs. 6,7, and 8, in the second case from Refs. 3,4,5 and 8. Ref.1 has measurements only at low values of W and in Ref.2 ε lies mainly between 0.6 and 0.9. Therefore data from those measurements were not used. Ref.8 contains cross sections at very small values of q^2, which have been extrapolated by the authors to $q^2 = 0$. We have used only these extrapolated values. Since at $q^2 = 0$ σ_ℓ should be zero, we have included these values in both ranges of ε. The bin size used for W is $\Delta W = 0.015$ GeV across the bumps of the resonances up to $W = 1.755$ GeV and $\Delta W = 0.020$ GeV for $1.770 \leq W \leq 1.990$. In Figs.1 and 2 the measured values of Σ_t/G_D^2 are shown in a double logarithmic plot as a function of $|\vec{q}|^2$ for four different values of W and for the two different ranges of ε. Also shown is in each case the scale of q^2. Generally there is a lack of data between $q^2 = 0$ and $q^2 = 0.5$ $(\mathrm{GeV}/c)^2$.

For the range $\varepsilon \leq 0.6$ the amount of data is not sufficient to determine the four parameters in Eq.(2) for each W bin. In addition b and c cannot be separated if d is around 1. This happens for some W-bins in the case $\varepsilon \leq 0.6$, when cross sections for high values of q^2 are missing or when the errors are too large. Therefore in a first step d was left free for $\varepsilon \geq 0.9$ only. From these fits an average value of $d = 3.0$ for all bins of W and both ranges of ε was taken for the final fits. The choice of d turned out not to be critical for the cross sections resulting from the fits.

The errors as given by the authors in the various references ought to be increased to include possible systematic errors, since most of the papers give only statistical errors. Furthermore, the final bin size in W introduces an error, which is not negligible around the resonances, where the cross section changes rapidly with W. Finally there may be differences in the absolute normalization of the measurements from different experimental arrangements. Therefore to the errors of the cross sections in the range $\varepsilon \leq 0.6$ and to those in the range $\varepsilon \geq 0.9$ with $W \leq 1.755$ a 10% error has been added quadratically, to the rest a 5% error. The χ^2 per degree of freedom of the fit may be used as an indicator for the choice of the right size of the additional errors. Using the above errors the cross sections resulting from the fits were practically not different from those, where only the original errors were used, but the χ^2 was improved.

Tables I and II give for the two different ranges of ε the coefficients a, b and c together with their errors as obtained from the least squares fits of Eq.(2) with $d = 3.0$. Also given are the weighted average values of ε for each W bin, the χ^2 per degree of freedom and the number of degrees of freedom. Fig.3 shows the exponent d as a function of W, when d was left free for the range $\varepsilon \geq 0.9$. It is remarkable that d has a broad bump with a maximum around $W = 1.4$ GeV.

We have also made fits using the equation

$$\log \Sigma_t = \alpha(W) + \beta(W)\sqrt{q^2} + \gamma(W)q^2 + \delta(W)q^4 .$$

However it turned out that it is difficult to fit the range of small values of q^2 for values of W up to the second resonance. The reason for this is the threshold behaviour in $|\vec{q}|$, which requires for $\log \Sigma_t$ a strong nonlinear behaviour in q^2 for small values of q^2 and W.

In Figs.4-8 we show the cross section Σ_t for fixed values of $q^2 = 0.5, 1.0, 2.0, 3.0$ and $4.0\ (\mathrm{GeV}/c)^2$ across the range $1.11 \leq W \leq 1.99$ GeV as computed from our fits. We also compare in these figures Σ_t of the two ranges of ε.

The errors are calculated with the complete error matrix of the coefficients a, b and c. The errors of these coefficients as given in Table I and II cannot be used for this alone, since there are significant correlations between them. We think that the fits are not sufficient to calculate cross sections much beyond $q^2 = 4.0\ (\mathrm{GeV/c})^2$. Also below $q^2 = 0.5\ (\mathrm{GeV/c})^2$ there are uncertainties because of the lack of data in this range. For $\varepsilon \le 0.6$ and $q^2 > 2\ (\mathrm{GeV/c})^2$ no cross section is plotted in Fig.7 or 8 at some values of W. In these cases there are no measurements in this range of W and q^2. Around the first resonance at $q^2 = 0.5$ and $1.0\ (\mathrm{GeV/c})^2$, where the cross section is changing very rapidly with W, there is a shift in energy visible between the two groups of measurements. The cross sections on both sides of the peak differ by about the same amount but with opposite signs.

The difference between $\Sigma_{t,\varepsilon \ge 0.9}$ and $\Sigma_{t,\varepsilon \le 0.6}$ is a direct measure of σ_ℓ and is very close to $1/2 \cdot \sigma_\ell$, since the average values of ε in the two cases are close to 1.0 and 0.5. Therefore the comparison in the Figs.4-8 allows one to determine σ_ℓ. For $q^2 = 0.5$, 1.0 and $2.0 (\mathrm{GeV/c})^2$ there is no significant difference outside the error bars visible between the two sets of cross sections except for the sides of the first resonance, which was explained already above. Taking into account the error bars one can conclude that in the range $0.5 \le q^2 \le 2.0\ (\mathrm{GeV/c})^2$ σ_ℓ is not larger than 20% of σ_t. At small ranges of W as for example around the second resonance the upper limit for σ_ℓ is even more likely smaller than 20%. For $q^2 = 3.0$ and $4.0\ (\mathrm{GeV/c})^2$ the error bars are larger. There is still no significant difference between the two groups of cross sections, however above the second resonance and at the minimum between the first and the second resonance $\Sigma_{t,\varepsilon \ge 0.9}$ is systematically higher than $\Sigma_{t,\varepsilon \le 0.6}$. The conclusion is, that σ_ℓ can be in these ranges of W at most 25-30% at $q^2 = 3\ (\mathrm{GeV/c})^2$ and 30-35% at $q^2 = 4\ (\mathrm{GeV/c})^2$.

In Figs.1 and 2 besides the experimental cross section we have also shown the fit for $\varepsilon \ge 0.9$. Whereas at W = 1.69 and 1.89 GeV, the fit is going through the error bars of the experimental points for $q^2 = 0$, at W = 1.23 and 1.53 the fit is about two standard deviations below the experimental points. This is in agreement with the fact, that also the fit to photoproduction data[11] is lower than the cross sections extrapolated from data at $q^2 > 0$ in Ref.8. We want to emphasize, that the cross sections at $q^2 = 0$ used in our fits do not influence the result of the fit for $q^2 \ge 0.5\ (\mathrm{GeV/c})^2$. Only the range $q^2 < 0.5\ (\mathrm{GeV/c})^2$, where not many other data exist, is somewhat uncertain.

The result of this work for σ_ℓ is in contradiction to some theoretical models,[12,13,14] where quite large contributions of σ_ℓ to the cross sections at the second and third resonance are predicted. A very interesting aspect however is, that in the resonance region R has about the same size as it has in the deep inelastic continuum. If local duality has some importance for νW_2,[15] this would also be true then for $\frac{q^2}{\nu} W_1$.

Figure Captions:

Fig.1 and 2: The total photoabsorption cross section divided by the dipole form factor squared from various experiments as a function of the three momentum transfer squared in a double logarithmic plot for various values of W, the mass of the pion nucleon system. The curves are our fit with Eq.(2) and with the parameters in Table I for $\varepsilon \geq 0.9$. Parameter d was set to 3.0. q^2 and $|\vec{q}|^2$ are in $(GeV/c)^2$. Error bars are only given for points, which have extrem position.

Fig.3: Parameter d of Eq.(2), fitted to the experimental cross sections for $\varepsilon \geq 0.9$.

Fig.4 - 8: The total photoabsorption cross section, calculated from our fits for $\varepsilon \geq 0.9$ and $\varepsilon \leq 0.6$, as a function of W for constant values of the four momentum transfer q^2.

References:

1. H. L. Lynch, J. W. Allaby and D. M. Ritson;
HEPL-494 B (1967)

2. A. A. Cone, K. W. Chen, J. R. Dunning, G. Hartwig, N. F. Ramsey, J. K. Walker, R. Wilson;
Phys. Rev. 156, 1490 (1967)

3. F. W. Brasse, J. Engler, E. Ganßauge, M. Schweizer;
Nuovo Cim. X, 55A, 679 (1968) and DESY 67/34

4. W. Albrecht, F. W. Brasse, H. Dorner, W. Flauger, K. Frank, J. Gayler, H. Hultschig, J. May, E. Ganßauge;
Phys. Lett. 28B, 225 (1968) and DESY 68/48

5. W. Albrecht, F. W. Brasse, H. Dorner, W. Flauger, K. H. Frank, J. Gayler, H. Hultschig, J. May, E. Ganßauge;
Nuclear Phys. B13, 1 (1969) and DESY 69/7

6. W. Bartel, B. Dudelzak, H. Krehbiel, J. McElroy, U. Meyer-Berkhout, W. Schmidt, V. Walther, G. Weber;
Phys. Letters 28B, 148 (1968) and Thesis W. Bartel

7. E. D. Bloom, G. Buschhorn, R. L. Cottrell, D. H. Coward, H. DeStaebler, J. Drees, C. L. Jordan, G. Miller, L. Mo, H. Piel, R. E. Taylor, M. Breidenbach, W. R. Ditzler, J. I. Friedman, G. C. Hartmann, H. W. Kendall, J. S. Poucher;
SLAC-PUB-795 (1970); Thesis M. Breidenbad; R. E. Taylor, private communication

8. E. D. Bloom, R. L. Cottrell, D. H. Coward, H. DeStaebler, Jr., J. Drees, G. Miller, L. W. Mo, R. E. Taylor, J. I. Friedman, G. C. Hartmann, H. W. Kendall;
SLAC-PUB-653 (1969)

9. W. Albrecht, F. W. Brasse, H. Dorner, W. Flauger, K. H. Frank, J. Gayler, H. Hultschig, V. Korbel, J. May; DESY 69/46 (1969)

10. W. Bartel, B. Dudelzak, H. Krehbiel, J. McElroy, U. Meyer-Berkhout, W. Schmidt, V. Walther, G. Weber; Phys. Lett. 27B, 660 (1968)

11. J. T. Beale, S. D. Ecklund, R. L. Walker; Report CTSL-42, CALT-68-108 (1966)

12. J. D. Walecka, P. A. Zucker; Phys. Rev. 167, 1479 (1968)

13. P. L. Pritchett, P. A. Zucker; Phys. Rev. D1 175 (1970)

14. N. S. Thornber; Phys. Rev. 169, 1096 (1968).

15. E. D. Bloom, F. J. Gilman; SLAC-PUB-779 (1970).

Table I: Results of the fits for $\varepsilon \geq 0.9$ with $d = 3.0$

W	$\bar{\varepsilon}$	a	Δa	b	Δb	c	Δc	$\frac{\chi^2}{NF}$	NF
1.110	0.969	4.27	0.28	1.29	0.23	0.02	0.02	1.61	38
1.125	0.964	4.66	0.20	1.46	0.18	-0.02	0.02	5.44	38
1.140	0.965	5.11	0.15	1.37	0.14	-0.00	0.02	1.56	41
1.155	0.962	5.36	0.12	1.53	0.12	-0.03	0.02	1.93	36
1.170	0.963	5.74	0.10	1.55	0.10	-0.04	0.01	1.85	41
1.185	0.961	5.92	0.09	1.75	0.09	-0.07	0.01	0.71	43
1.200	0.964	6.13	0.09	1.73	0.10	-0.06	0.01	0.73	41
1.215	0.959	6.24	0.08	1.78	0.09	-0.06	0.01	0.39	42
1.230	0.960	6.06	0.08	1.93	0.09	-0.07	0.01	0.69	40
1.245	0.960	6.00	0.07	1.89	0.08	-0.05	0.01	0.76	45
1.260	0.959	5.74	0.07	2.00	0.09	-0.05	0.02	1.12	45
1.275	0.961	5.44	0.08	2.23	0.10	-0.07	0.02	0.63	42
1.290	0.958	5.15	0.08	2.40	0.10	-0.07	0.02	1.09	45
1.305	0.955	4.97	0.08	2.50	0.10	-0.07	0.02	1.21	50
1.320	0.957	4.93	0.07	2.58	0.10	-0.09	0.02	0.98	47
1.335	0.958	4.81	0.07	2.65	0.10	-0.06	0.02	0.97	49
1.350	0.955	4.80	0.07	2.75	0.11	-0.08	0.03	1.36	44
1.365	0.958	4.84	0.07	2.73	0.10	-0.07	0.02	1.49	52
1.380	0.955	4.86	0.06	2.79	0.10	-0.07	0.02	1.25	50
1.395	0.953	4.92	0.06	2.81	0.09	-0.08	0.02	1.28	46
1.410	0.956	5.15	0.06	2.60	0.09	-0.03	0.03	0.95	53
1.425	0.953	5.10	0.06	2.73	0.10	-0.06	0.03	1.21	53
1.440	0.955	5.16	0.06	2.85	0.10	-0.10	0.03	1.13	45
1.455	0.954	5.27	0.06	2.93	0.10	-0.13	0.03	1.09	51
1.470	0.954	5.29	0.06	3.09	0.10	-0.13	0.03	0.99	45
1.485	0.952	5.39	0.06	3.26	0.10	-0.18	0.03	0.90	46
1.500	0.954	5.51	0.07	3.25	0.11	-0.18	0.04	0.56	43
1.515	0.954	5.51	0.07	3.32	0.12	-0.18	0.03	0.45	39
1.530	0.952	5.40	0.07	3.47	0.12	-0.22	0.03	0.63	45
1.545	0.953	5.34	0.07	3.52	0.13	-0.24	0.04	0.81	37
1.560	0.951	5.30	0.07	3.53	0.12	-0.26	0.04	0.67	42
1.575	0.950	5.31	0.07	3.49	0.14	-0.27	0.05	0.67	36
1.590	0.953	5.22	0.07	3.63	0.14	-0.26	0.05	0.66	32
1.605	0.950	5.22	0.08	3.75	0.14	-0.33	0.05	0.68	32
1.620	0.951	5.32	0.08	3.72	0.15	-0.31	0.06	1.03	30

Continuation of Table 1:

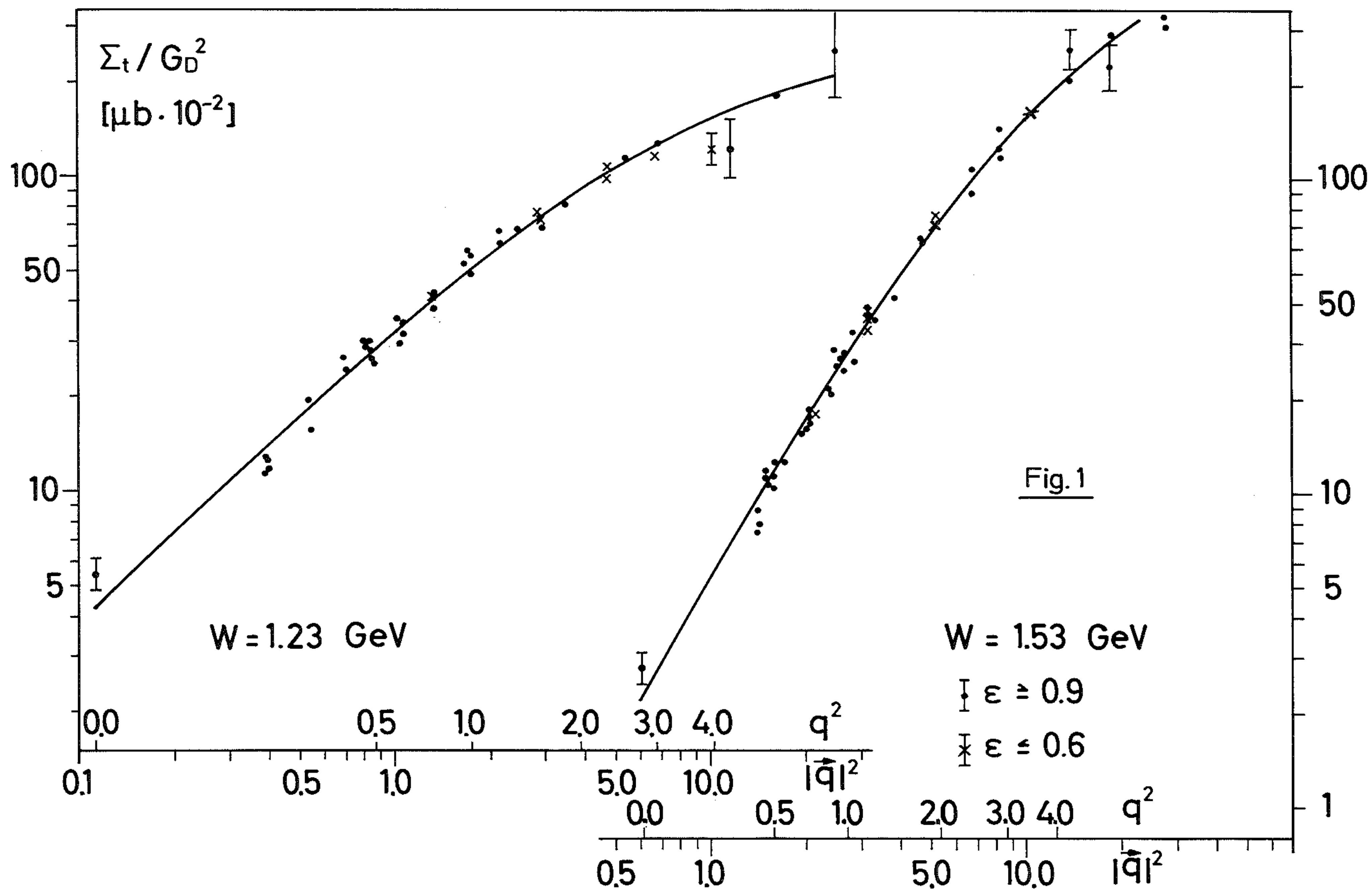
W	$\bar{\varepsilon}$	a	Δa	b	Δb	c	Δc	$\frac{\chi^2}{NF}$	NF
1.635	0.950	5.40	0.07	3.76	0.14	-0.31	0.05	0.41	31
1.650	0.949	5.47	0.07	3.79	0.15	-0.35	0.06	0.43	30
1.665	0.949	5.52	0.07	3.96	0.14	-0.36	0.05	0.61	31
1.680	0.950	5.46	0.07	4.24	0.14	-0.45	0.06	0.54	31
1.695	0.947	5.47	0.07	4.34	0.14	-0.53	0.06	0.44	29
1.710	0.949	5.40	0.07	4.56	0.14	-0.57	0.06	0.76	29
1.725	0.949	5.42	0.07	4.53	0.14	-0.49	0.06	0.42	27
1.740	0.949	5.29	0.07	4.66	0.15	-0.51	0.06	0.33	27
1.755	0.949	5.22	0.07	4.84	0.17	-0.64	0.08	0.64	27
1.770	0.951	5.26	0.05	4.77	0.11	-0.58	0.05	0.98	27
1.790	0.949	5.19	0.05	5.03	0.11	-0.65	0.06	0.90	36
1.810	0.948	5.21	0.04	5.04	0.11	-0.74	0.06	1.01	36
1.830	0.946	5.27	0.04	5.04	0.10	-0.68	0.05	1.12	37
1.850	0.948	5.22	0.05	5.39	0.13	-0.95	0.09	1.04	40
1.870	0.948	5.25	0.04	5.44	0.12	-0.88	0.07	1.55	36
1.890	0.948	5.36	0.05	5.30	0.13	-0.79	0.07	0.85	38
1.910	0.946	5.39	0.04	5.40	0.11	-0.86	0.07	1.14	28
1.930	0.945	5.23	0.04	5.93	0.11	-1.18	0.08	0.86	32
1.950	0.945	5.34	0.04	5.69	0.12	-1.05	0.09	1.14	34
1.970	0.943	5.26	0.04	5.98	0.12	-1.07	0.08	0.94	34
1.990	0.941	5.25	0.04	6.19	0.12	-1.30	0.09	1.12	36

Table II: Results of the fits for $\varepsilon \leq 0.6$ with d = 3.0

W	$\bar{\varepsilon}$	a	Δa	b	Δb	c	Δc	$\frac{\chi^2}{NF}$	NF
1.110	0.504	4.05	0.41	1.83	0.30	−0.05	0.03	13.45	5
1.125	0.504	4.79	0.28	1.17	0.25	0.06	0.03	1.67	7
1.140	0.479	5.14	0.20	1.58	0.20	−0.05	0.03	2.14	8
1.155	0.504	5.32	0.17	1.56	0.15	−0.04	0.02	3.48	7
1.170	0.529	5.78	0.13	1.28	0.15	0.02	0.03	0.60	9
1.185	0.482	5.97	0.13	1.44	0.16	0.01	0.04	2.60	8
1.200	0.507	6.19	0.11	1.67	0.11	−0.05	0.02	1.43	12
1.215	0.459	6.25	0.11	1.77	0.11	−0.06	0.02	0.84	7
1.230	0.508	6.28	0.11	1.84	0.12	−0.08	0.02	0.27	10
1.245	0.472	6.17	0.11	1.82	0.14	−0.06	0.04	0.75	10
1.260	0.471	5.91	0.11	1.97	0.12	−0.07	0.02	1.59	12
1.275	0.484	5.66	0.13	1.99	0.15	−0.03	0.03	0.91	12
1.290	0.502	5.47	0.14	1.97	0.18	0.05	0.04	0.83	12
1.305	0.449	5.26	0.13	2.30	0.15	−0.07	0.02	0.75	14
1.320	0.495	5.15	0.12	2.24	0.16	0.01	0.05	0.94	13
1.335	0.484	5.23	0.15	1.96	0.22	0.15	0.07	0.71	11
1.350	0.449	4.98	0.13	2.52	0.16	−0.05	0.03	1.08	17
1.365	0.485	5.13	0.13	2.23	0.22	0.11	0.09	0.35	10
1.380	0.493	5.15	0.12	2.61	0.16	−0.11	0.05	1.20	12
1.395	0.461	5.23	0.11	2.41	0.14	−0.03	0.04	1.30	13
1.410	0.453	5.31	0.12	2.50	0.17	−0.05	0.05	0.50	10
1.425	0.469	5.41	0.11	2.39	0.19	0.02	0.08	0.67	11
1.440	0.463	5.40	0.10	2.58	0.14	−0.09	0.04	0.99	14
1.455	0.435	5.45	0.11	2.29	0.20	0.19	0.09	0.97	13
1.470	0.462	5.51	0.11	2.77	0.17	−0.11	0.07	0.61	10
1.485	0.444	5.59	0.11	3.00	0.15	−0.19	0.05	0.76	12
1.500	0.481	5.60	0.11	3.20	0.18	−0.22	0.08	1.77	9
1.515	0.440	5.65	0.11	3.23	0.16	−0.18	0.06	0.20	8
1.530	0.486	5.57	0.11	3.23	0.19	−0.15	0.09	0.74	8
1.545	0.484	5.55	0.11	3.24	0.19	−0.13	0.10	0.20	7
1.560	0.426	5.39	0.11	3.52	0.17	−0.29	0.07	0.88	10
1.575	0.474	5.41	0.11	3.27	0.22	−0.12	0.12	0.64	7
1.590	0.432	5.38	0.11	3.39	0.20	−0.25	0.09	1.02	6
1.605	0.424	5.31	0.12	3.28	0.23	−0.02	0.13	0.13	7
1.620	0.481	5.45	0.12	3.50	0.41	−0.31	0.47	0.41	5

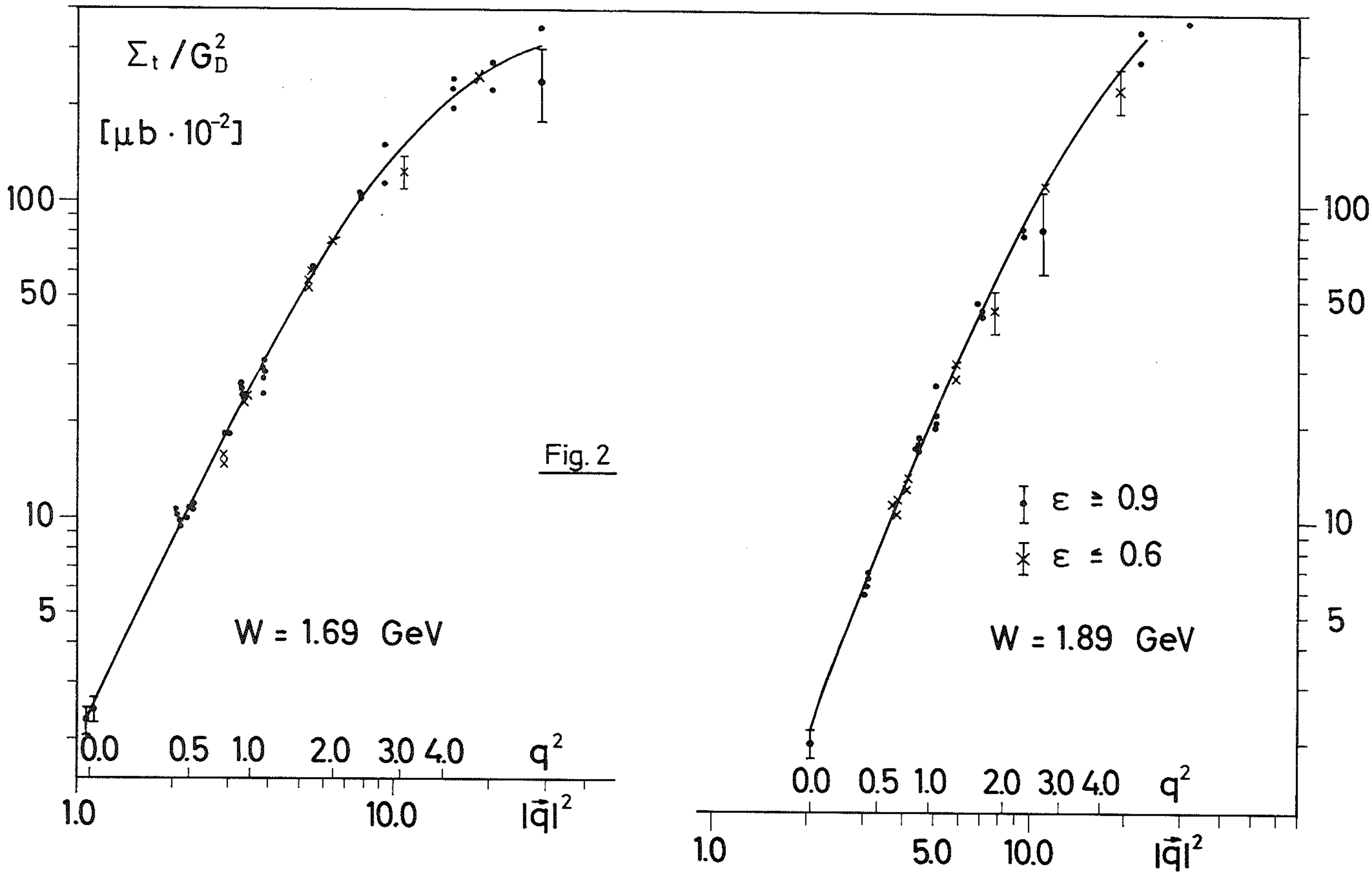
Continuation of Table II:

W	$\bar{\varepsilon}$	a	Δa	b	Δb	c	Δc	$\frac{\chi^2}{NF}$	NF
1.635	0.437	5.31	0.11	3.93	0.20	-0.51	0.10	0.47	8
1.650	0.422	5.35	0.11	4.12	0.23	-0.55	0.16	0.89	8
1.665	0.433	5.43	0.11	4.01	0.21	-0.40	0.10	0.23	5
1.680	0.449	5.39	0.11	4.39	0.24	-0.68	0.17	0.17	7
1.695	0.417	5.42	0.10	4.35	0.21	-0.54	0.11	1.32	9
1.710	0.365	5.43	0.12	4.27	0.40	-0.28	0.53	0.97	4
1.725	0.409	5.40	0.11	4.35	0.24	-0.39	0.13	0.14	8
1.740	0.440	5.33	0.11	4.83	0.30	-0.83	0.25	0.14	4
1.755	0.382	5.09	0.12	4.99	0.25	-0.66	0.14	0.62	9
1.770	0.418	5.18	0.13	5.01	0.33	-0.38	0.27	0.26	6
1.790	0.371	5.17	0.11	4.99	0.25	-0.68	0.16	0.38	9
1.810	0.402	5.00	0.09	5.60	0.22	-1.04	0.17	0.37	10
1.830	0.398	5.23	0.12	5.13	0.33	-0.84	0.32	0.60	7
1.850	0.359	5.21	0.11	5.49	0.28	-1.10	0.20	1.41	10
1.870	0.396	5.00	0.09	6.19	0.24	-1.48	0.20	0.62	9
1.890	0.342	5.33	0.10	5.39	0.28	-0.97	0.23	0.58	11
1.910	0.356	5.19	0.10	6.03	0.33	-1.46	0.29	0.48	9
1.930	0.345	5.17	0.08	6.32	0.32	-2.11	0.50	2.47	10
1.950	0.352	5.18	0.10	6.35	0.40	-1.57	0.37	0.37	7
1.970	0.341	5.26	0.09	6.38	0.35	-1.82	0.37	0.90	9
1.990	0.338	5.21	0.07	6.59	0.28	-2.19	0.33	2.11	10



Σt / GD²
[μb · 10⁻²]
100
50
10
5
W = 1.23 GeV
0.0
0.5
1.0
2.0
3.0
4.0
q²
0.1
0.5
1.0
5.0
10.0
|q|²
100
50
10
5
1
W = 1.53 GeV
ε ≥ 0.9
ε ≤ 0.6
0.0
0.5
1.0
2.0
3.0
4.0
q²
0.5
1.0
5.0
10.0
|q|²

Fig. 1



Σ_t / G_D^2
[μb · 10^-2]
100
50
10
5
W = 1.69 GeV
0.0 0.5 1.0 2.0 3.0 4.0 q^2
1.0 10.0 $|\vec{q}|^2$
100
50
10
5
ε ≥ 0.9
ε ≤ 0.6
W = 1.89 GeV
0.0 0.5 1.0 2.0 3.0 4.0 q^2
1.0 5.0 10.0 $|\vec{q}|^2$

Fig. 2

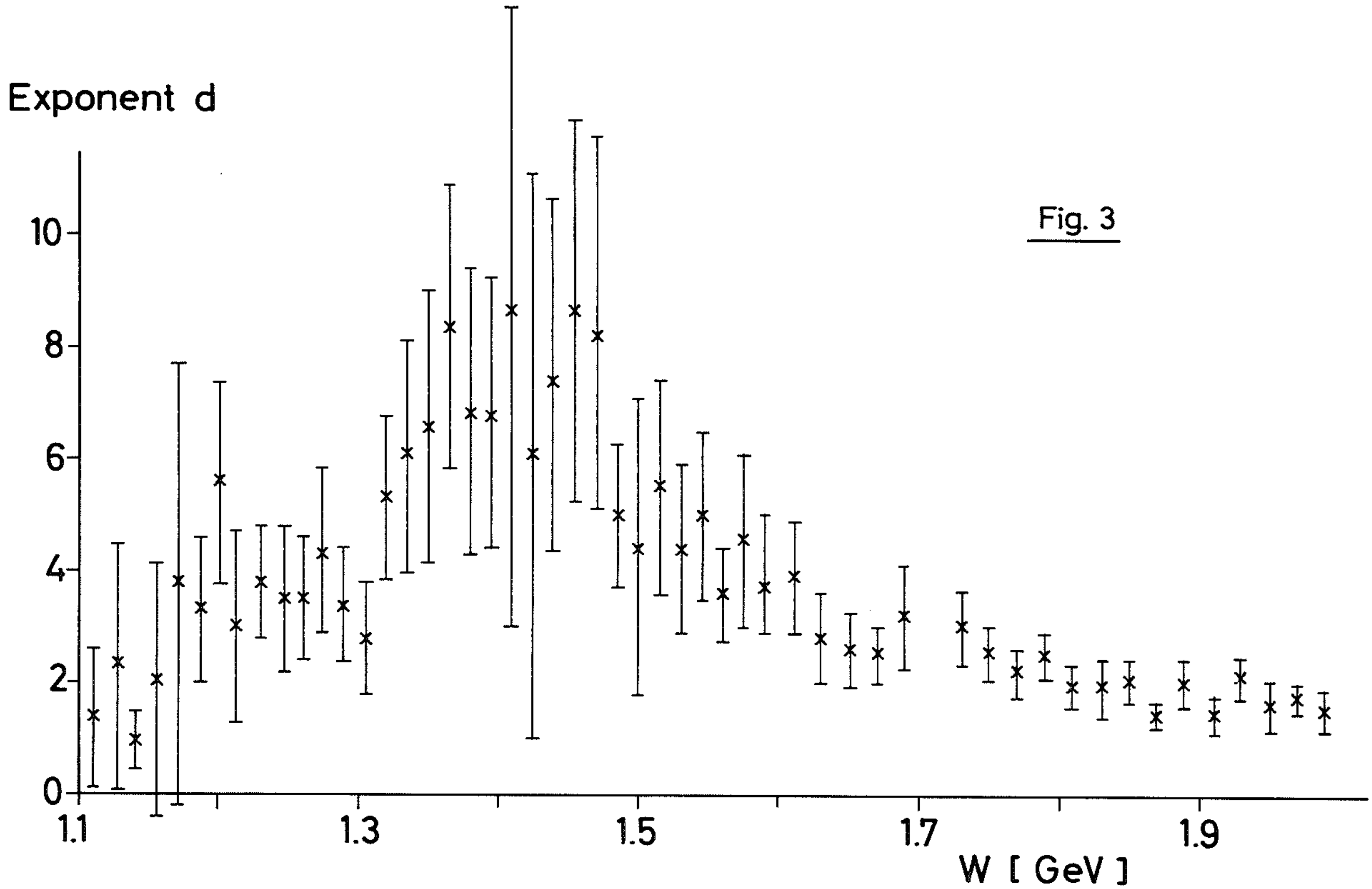


Fig. 3

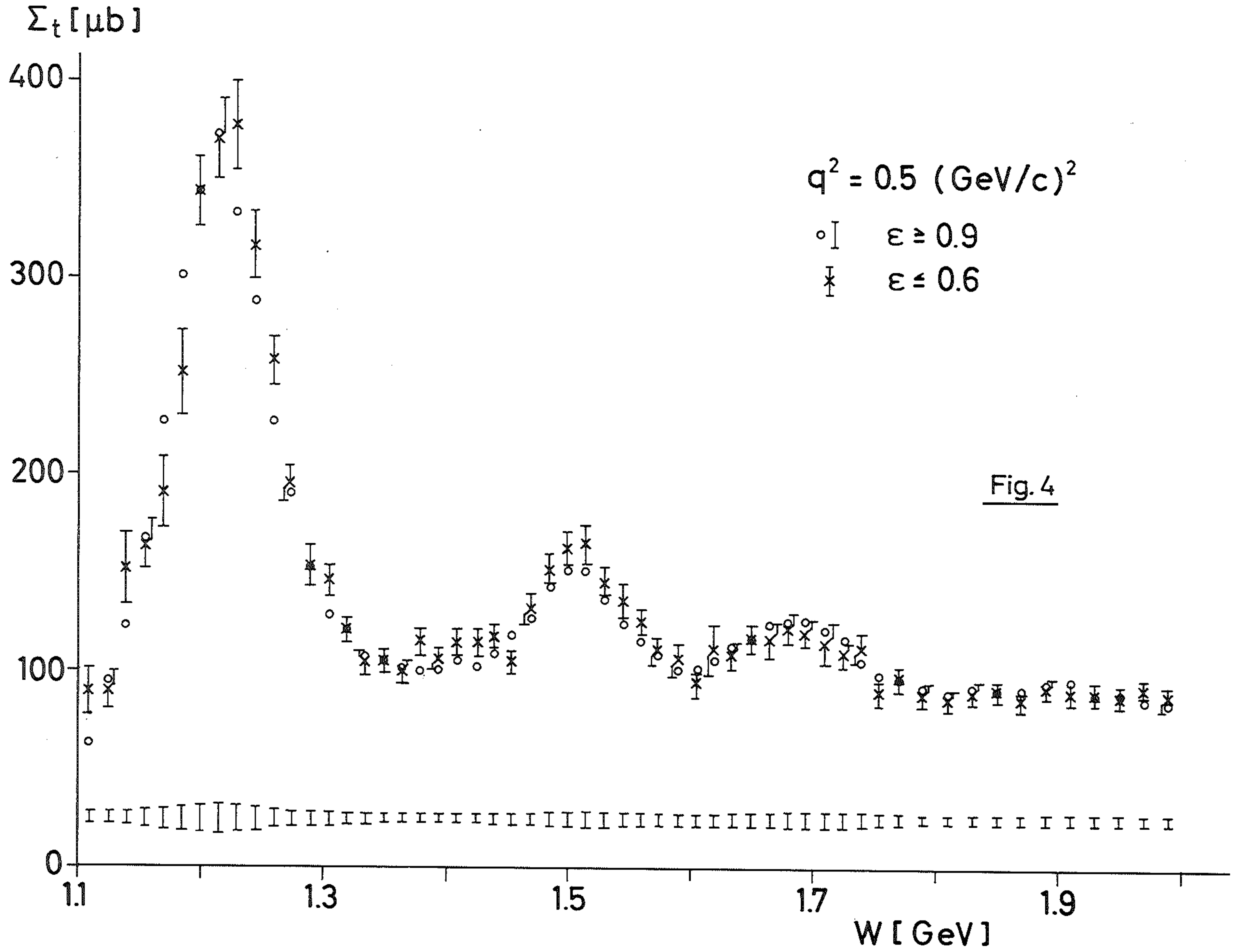


Fig. 4

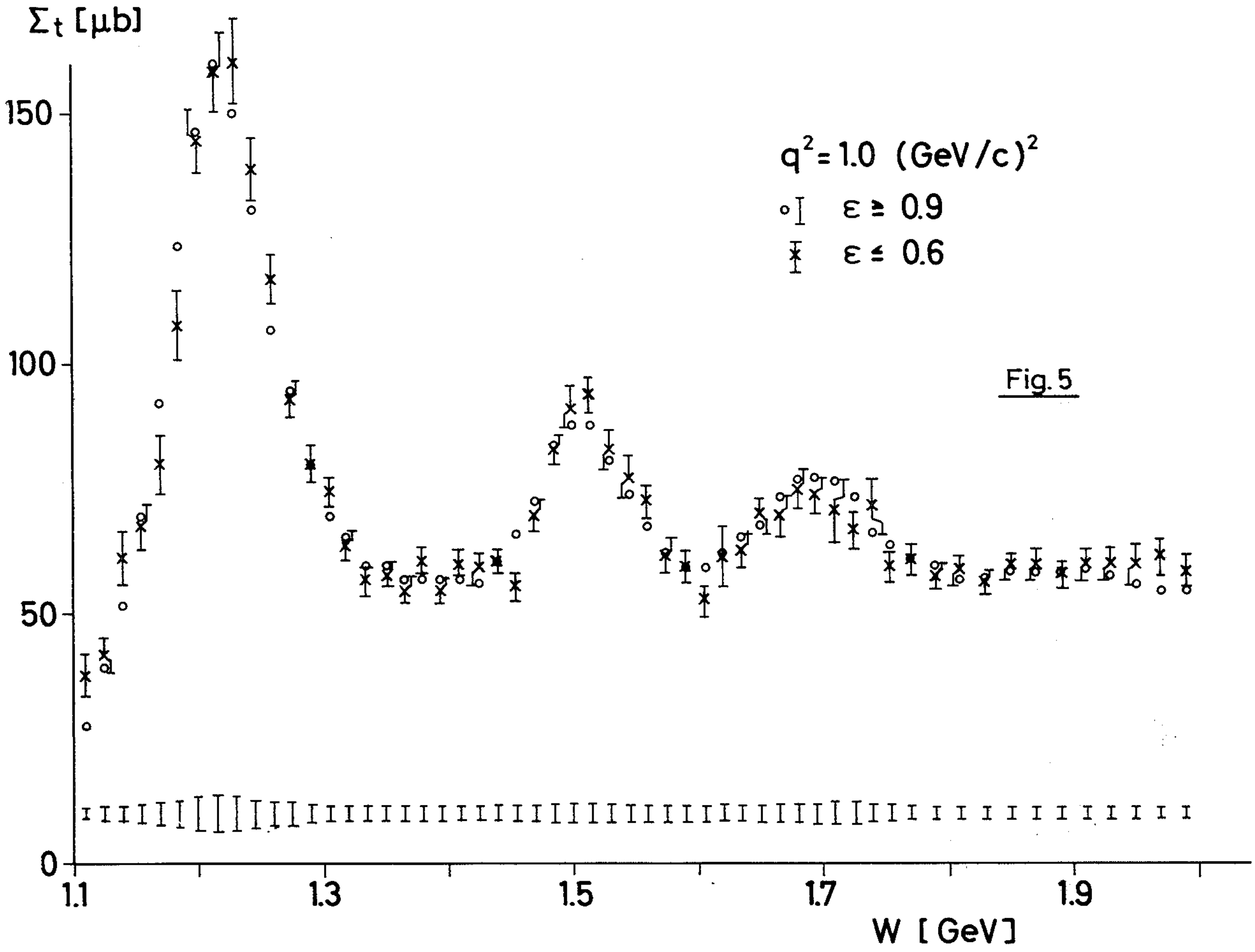


Fig. 5

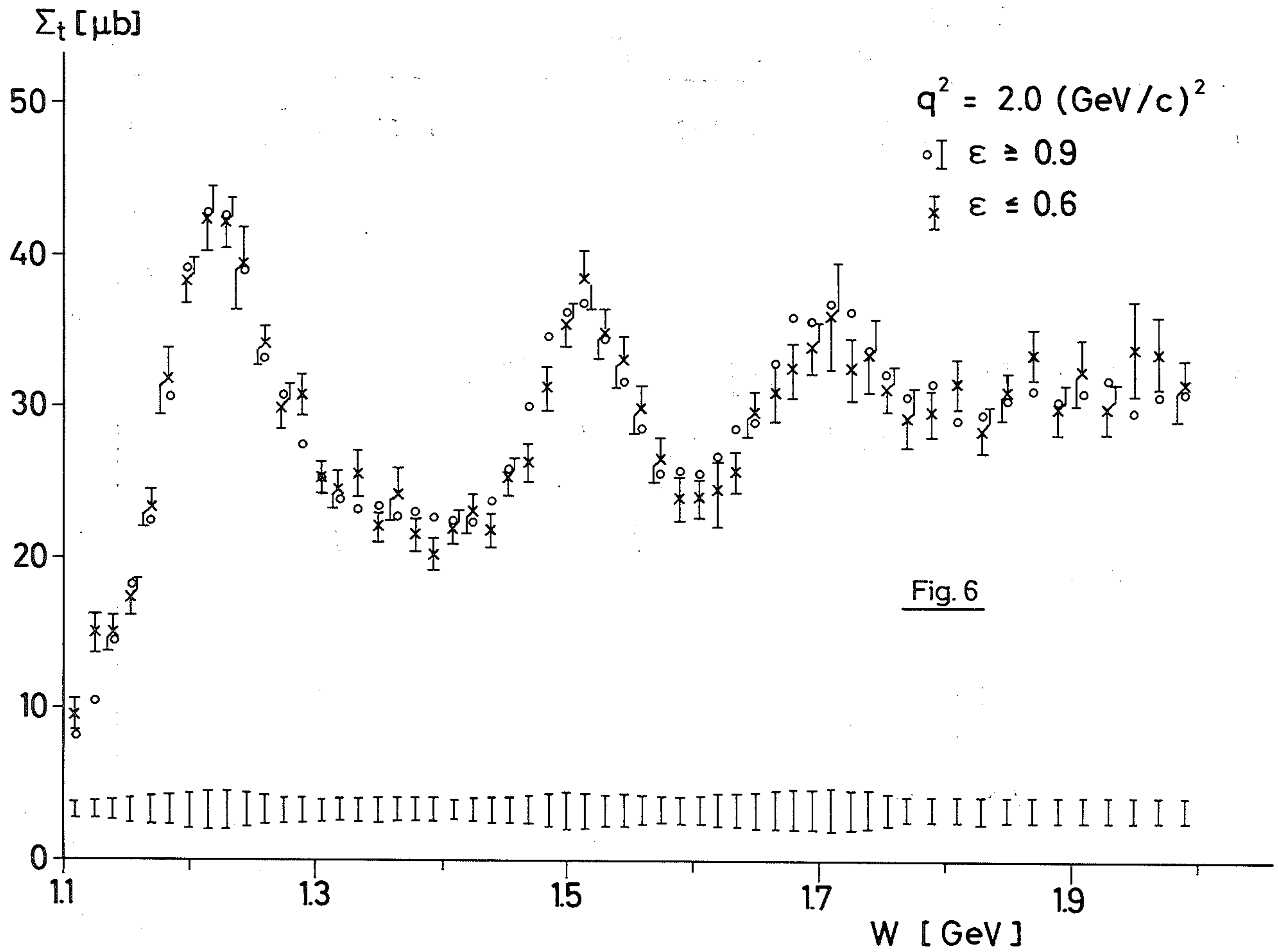


Fig. 6

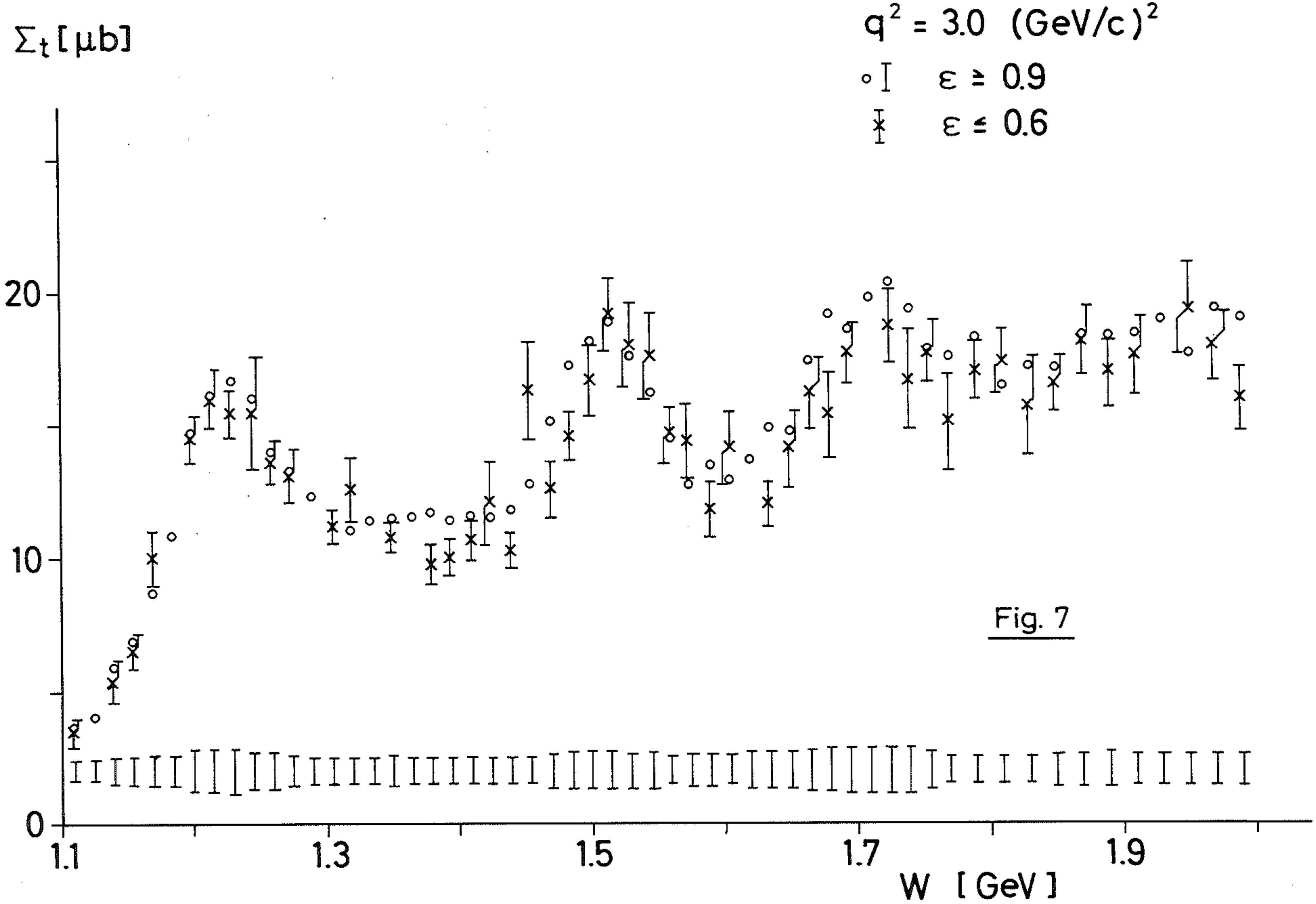
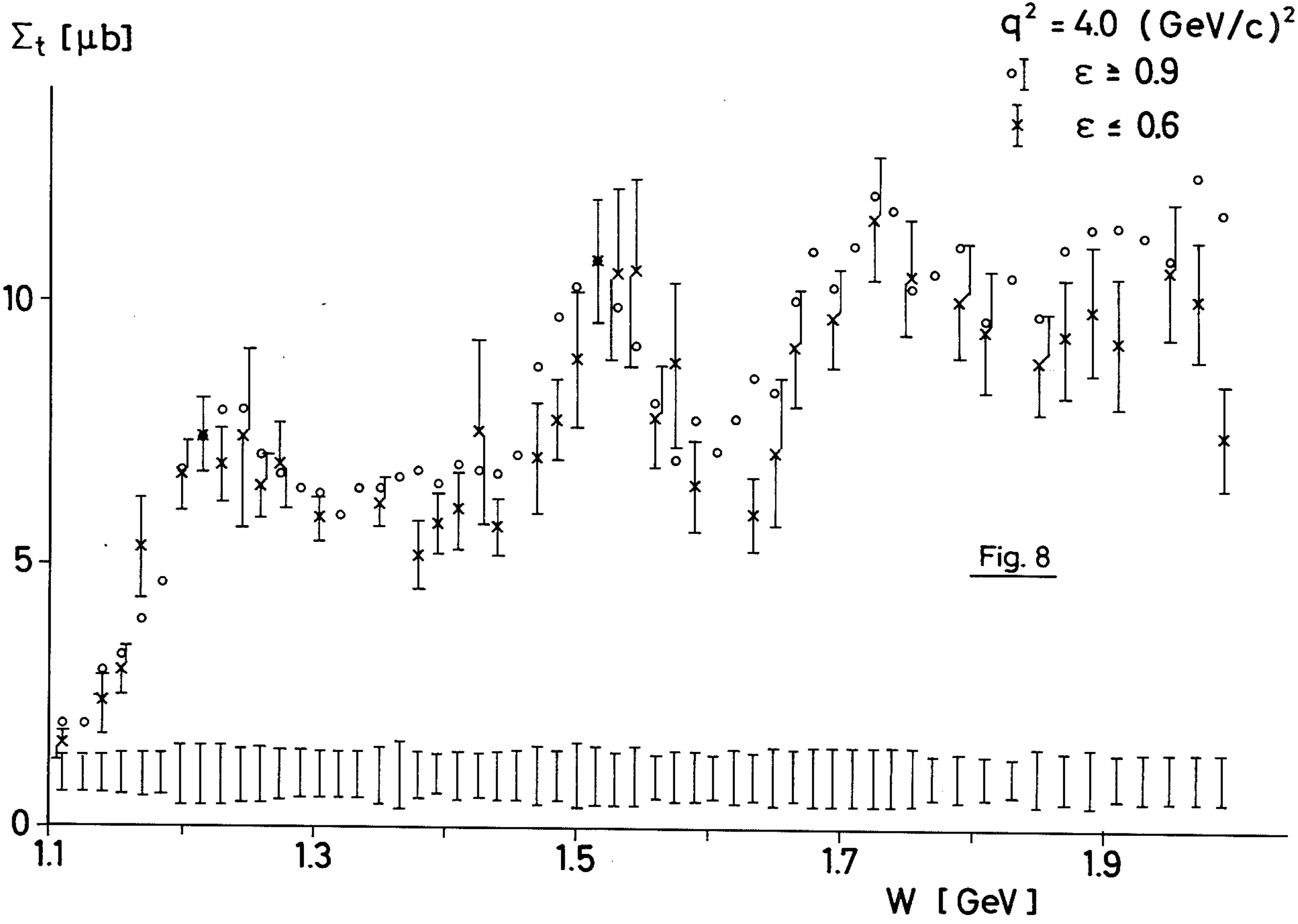


Fig. 7



Σ_t [μb]
$q^2 = 4.0$ $(GeV/c)^2$
$\varepsilon \geq 0.9$
$\varepsilon \leq 0.6$
10
5
0
1.1
1.3
1.5
1.7
1.9
W [GeV]

Fig. 8