

DEUTSCHES ELEKTRONEN – SYNCHROTRON

DESY 91-068

June 1991



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ISSN 0418-9833

NOTKESTRASSE 85 · D-2000 HAMBURG 52

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A parametrization of $\sigma_T(\gamma^*p)$ above the resonance region for $Q^2 \geq 0$

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1 Introduction

The aim of this study is to present a phenomenological and numerical description of the cross-sections for photon-proton interactions in the whole range of photon virtualities, from $Q^2 = 0$ to the highest Q^2 values available experimentally. From a purely practical point of view a parametrization of the γp cross section in a large range of Q^2 , starting from the real photon cross section, is very useful for estimating acceptance corrections and radiative corrections for all experiments on leptonproduction.

From the theoretical point of view it is of interest to see whether experimentally the interactions of virtual photons of small virtuality display similar properties as hadron-hadron interactions. The possibility of a unified description of the small (soft processes) and high (hard processes) virtuality "photoproduction" cross sections may shed some light on the transition between the soft strong interactions and the hard interactions described in terms of perturbative QCD.

There are basically two main physical ideas behind the description of high energy strong interactions. The first one makes a distinct separation between the deep inelastic scattering (DIS) and the soft processes. Soft interactions can be thought of as being governed by special confinement forces which act at large distances, while typical hard processes such as DIS are well described by perturbative QCD. In the low x region, however, the study of DIS reveals properties similar to that of soft interactions. A good example is provided by the fact that the total cross section for absorption of virtual photons grows rapidly as $x \rightarrow 0$ and becomes compatible with the geometrical size of hadrons. Shadowing observed on nuclear targets at low x and up to relatively high Q^2 [1] is another manifestation of a property typical for soft processes. A similar type of shadowing is expected theoretically in the nucleon case at low x and high Q^2 , where parton densities become very large, and it cannot be explained by miraculous confinement forces which would restore unitarity. Clearly the separation into soft and hard processes through confinement does not solve all problems, since we are faced with soft interactions also in typical hard processes such as DIS. It is thus not unnatural to expect a smooth transition from soft to

Abstract

A smooth description of the total γ^*p cross section from the deep inelastic scattering region to the real photoproduction limit is obtained with a parametrization based on a Regge type approach. The parametrization is obtained from a fit to the structure function data of BCDMS, SLAC and NA28 and the available total photoproduction cross section measurements above the resonance region, $W > 1.75$ GeV. The fit gives a reliable description of the data and provides a smooth transition from photoproduction to the deep inelastic region. Together with an earlier parametrization of the resonance region, it can be used to estimate radiative corrections over the full kinematical range.

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hard processes. This is the essence of the second picture underlying strong interactions, which we shall try to illustrate in the approach presented in this paper.

2 Phenomenology

It has been shown in [2] that the total γp photoproduction cross section can be well described by the exchange of a Pomeron and a Reggeon trajectory:

$$\sigma_{tot}(\gamma p) = \sigma_p^o s^{\alpha_P - 1} + \sigma_R^o s^{\alpha_R - 1} \quad (1)$$

where s is the center of mass energy squared, and α_P and α_R denote the Pomeron and Reggeon intercepts, respectively. The value of $(\alpha_P - 1)$ is expected to be small and positive while α_R is about 0.5. It has been pointed out [3] that the cross section for virtual photon-proton scattering can be described in a similar Regge language, provided threshold effects arising from the presence of a virtual particle in the scattering process are taken into account.

The success of these two approaches led us to believe that one could find a parametrization based on a Regge type of approach which would account for both the real and the virtual photon absorption cross section.

In the deep inelastic region, the Regge language can be translated into the parton language, in the sense that the sea content of the proton determines the Pomeron contribution to the absorption cross section and the valence content of the proton determines that of the Reggeon. Thus, the total absorption cross section for virtual photon, γ^* , scattering off the proton can be written as a sum of two contributions:

$$\sigma_{tot}(\gamma^* p) = \sigma_p^*(Q^2) + \sigma_R^*(Q^2) \quad (2)$$

Notice that the low Bjorken x region of the parton language corresponds to large energies s and small virtualities Q^2 , a region relevant for the application of the Regge language.

The relation between the total nucleon absorption cross section of transversely polarized virtual photons and the nucleon structure function F_2 is the following:

$$\sigma_T(\gamma^* p) = \frac{4\pi^2 \alpha}{Q^2} \frac{1}{1-x} \left(1 + \frac{4m_p^2 x^2}{Q^2} \right) \frac{1}{1+R(x, Q^2)} F_2(x, Q^2) \quad (3)$$

where x and Q^2 are the usual variables used in the description of DIS processes, m_p is the proton mass, $R(x, Q^2)$ determines the relation between the nucleon structure functions F_2 and $2xF_1$ and measures the level of violation of the Callan-Gross relation. This cross section is relevant for the comparison with the real photon cross section as real photons are only transversely polarized.

It has been known for a while [4] that the parton distributions in the nucleon, and thus the structure function F_2 , can be well parametrized by an expression of the type:

$$F_2 \sim x^a (1-x)^b \quad (4)$$

where both a and b are functions of a variable t defined as follows:

$$t = \ln \left(\frac{\ln \frac{Q^2}{\Lambda^2}}{\ln \frac{Q_0^2}{\Lambda^2}} \right) \quad (5)$$

Here Λ is the QCD cutoff parameter and Q_0^2 is the scale at which one defines the initial conditions for perturbative QCD to be applicable in the nucleon case. In the QCD analysis of existing experimental data, Q_0^2 is usually taken to be 4 GeV².

Since for large s , $x \rightarrow Q^2/s$, and since the term $(1-x)^b$ can be thought of as a kinematical threshold factor (as only part of the total γp phase space is available for parton interaction), the expression (4) looks similar to the Regge type of expression with a being proportional to the relevant intercept [5]. We thus assume that F_2 can be decomposed into two terms, one related to Pomeron exchange and the other to Reggeon exchange:

$$F_2 = F_2^P + F_2^R \quad (6)$$

with each of them expressed as follows:

$$F_2^r = C_r(t) x^{\alpha_r(t)} (1-x)^{b_r(t)} \quad (7)$$

where r stands either for the Pomeron \mathcal{P} or the Reggeon \mathcal{R} and C_r represent the normalization factors.

A few comments are in order. There are at least two arguments against using an approximation of the type $x^{\alpha(t)}$ for the small x behavior of structure functions. The first, demonstrated by Lopez and Yndurain [5] and also Martin [6], is that QCD evolution equations require in such an approximation α to be Q^2 independent as $x \rightarrow 0$. The other is that in the limit of $x \rightarrow 0$ the solution of the QCD evolution equations behaves as [7,8]:

$$F_2 = \frac{1}{Q^2} \exp \sqrt{\frac{16N_c}{b} \ln \ln \frac{Q^2}{\Lambda^2} \ln \frac{1}{x}} \quad (8)$$

where N_c is the number of colors and

$$b = \frac{11}{3} N_c - \frac{2}{3} n_f \quad (9)$$

with n_f the number of flavors. This behavior cannot be easily reduced to a power like dependence of F_2 on x . On the other hand, shadowing corrections to parton distributions at low x may change crucially the x and Q^2 dependence of F_2 , and the conclusion drawn by [5] may not be valid.

Thus, although there is no strong argument for using a parametrization of the type (7), it can be treated as a simple approximation which could be valid in a limited range of x . This is similar to the case of the energy dependence of the γp cross section, where there are no strong arguments for the Regge type of behavior with a power law for the Pomeron contribution and yet it is consistent with the data [2]. A clear advantage is that the structure of the $\sigma_{\mathcal{T}}(\gamma^* p)$ remains the same as that of σ_T for real photons.

In order for formula (3) to describe the γp cross section both at $Q^2 = 0$ and for $Q^2 > 0$, an appropriate choice of variables is needed. Although at $Q^2 = 0$ gauge invariance requires $F_2(x, Q^2) = 0$ and thus formula (3) remains valid, it is not appropriate for numerical applications. The solution

to this problem [9,10] is to introduce a mass scale, m_0 , in such a way that the cross section remains $\sim 1/Q^2$ at large Q^2 , and Q^2 independent at low Q^2 . We thus replace the term

$$\frac{4\pi^2\alpha}{Q^2} \rightarrow \frac{4\pi^2\alpha}{Q^2 + m_0^2} \quad (10)$$

The physical meaning of m_0^2 is that of the typical size of a real photon, or even better, that of the typical size of partons inside a real photon.

The next problem encountered in the application of formula (3) to the real photon data is related to the energy variables. While the real photon data are governed by s , the deep inelastic data are described in terms of x , with x defined through the following relation:

$$\frac{1}{x} = 1 + \frac{W^2 - m_p^2}{Q^2} \quad (11)$$

where W^2 is the invariant mass squared of the hadronic system and corresponds to s for real photon interactions.

In order to retain a consistency between the Regge picture and the parton language, it is useful to refer back to the underlying microscopic picture for Reggeon exchange which is described by a simple ladder multiperipheral diagram. While in the Regge phenomenology the ladder diagram is described in the $g\phi^3$ theory where ϕ stands for a scalar meson, in QCD the lines represent gluons. The general property of such a diagram is that for large Q^2 the cross section can be written as a series expansion in $\ln \frac{1}{x}$:

$$\sigma \sim \frac{1}{Q^2} \sum c_n (\alpha_S \ln \frac{1}{x})^n. \quad (12)$$

However for $Q^2 \rightarrow 0$, the same diagram leads to

$$\sigma \sim \frac{1}{m_r^2} \sum c_n (\alpha_S \ln \frac{s}{m_r^2})^n. \quad (13)$$

where the inverse of m_r^2 is the size of the target [8,11]. Taking into account the properties described above we choose for the energy variable

$$\frac{1}{x_r} = 1 + \frac{W^2 - m_p^2}{Q^2 + m_r^2} \quad (14)$$

where m_r is the mass scale, typical for γp interactions. In the limit of $Q^2 \gg m_r^2$

$$x_r \rightarrow x \quad (15)$$

as required, and in the limit of $Q^2 \rightarrow 0$ and large W (large s)

$$x_r \rightarrow \frac{m_r^2}{W^2} = \frac{m_r^2}{s}. \quad (16)$$

For our particular problem, since we are dealing with Pomeron and Reggeon exchanges, we introduce two mass scales, m_p and m_R , and thus two variables x_p and x_R respectively with

$$\frac{1}{x_p} = 1 + \frac{W^2 - m_p^2}{Q^2 + m_p^2} \quad (17)$$

and

$$\frac{1}{x_R} = 1 + \frac{W^2 - m_R^2}{Q^2 + m_R^2} \quad (18)$$

The energy dependence in the Regge approach is replaced by the inverse of those variables. The final formula that we fit to the data is as follows:

$$\sigma_T(\gamma^* p) = \frac{4\pi^2 \alpha}{Q^2 + m_0^2} \frac{1}{1-x} \left(1 + \frac{4m_p^2 Q^2}{(Q^2 + W^2 - m_p^2)^2} \right) (F_2^P + F_2^R) \quad (19)$$

where

$$F_2^P = C_P(t) x_p^{\alpha_P(t)} (1-x)^{b_P(t)} \quad (20)$$

$$F_2^R = C_R(t) x_R^{\alpha_R(t)} (1-x)^{b_R(t)} \quad (21)$$

and we redefine t so as to make it applicable also at $Q^2 = 0$.

$$t = \ln \left(\frac{\ln \left(\frac{Q^2 + Q_0^2}{\Lambda^2} \right)}{\ln \left(\frac{Q_0^2}{\Lambda^2} \right)} \right) \quad (22)$$

Note that $1-x$, where x is defined by equation (11), is equal to 1 at $Q^2 = 0$, and does not need to be redefined.

3 Data

We have used the available total γp cross section data above $W = 1.75$ GeV to avoid the resonance region. For $\gamma^* p$ interactions we have used the NA28 [12] and the BCDMS [13] data on μp scattering and the SLAC [14] data on ep scattering. The kinematical range in the $\frac{1}{x}$ and Q^2 plane covered by these data is presented in figure 1. The NA28 experiment has measured the nucleon structure function F_2 in μd interactions. In order to infer from the data the proton structure function we have used the measurement of F_2^d/F_2^p performed by the NMC Collaboration [15] over a large x and Q^2 range. We have used formula (3) to transform the data on F_2 into $\sigma_T(\gamma^* p)$. In order to do so we have relied on the measurement of R performed by SLAC [14,16] and their parametrization based on all existing data and claimed to be valid above $Q^2 = 0.3$ GeV.

4 Fitting procedure

The fitting procedure consisted of two steps. In the first step formula (19) was fitted to the data on the absorption cross section for transversely polarized real and virtual photons. In the second step, we have performed a separate fit to $\sigma_T(\gamma^* p)(1+R)$, which depends only on the measurements of F_2 . If not for numerical uncertainties, the ratio of the results obtained in those fits could in principle shed some light on the value of R in the region not yet accessible experimentally.

The results of our fits required a distinction between the parameters C_R, b_R, α_R and b_P which increase with Q^2 and were assumed to be of the form

$$f(t) = f^1 + f^2 t^{\nu} \quad (23)$$

and C_P and α_P , both decreasing functions of Q^2 , which were assumed in the form

$$f(t) = f^1 + (f^1 - f^2) \left(\frac{1}{1+tf^3} - 1 \right). \quad (24)$$

All together there were 694 data points and 23 free parameters, including 3 mass scales $-m_0^2, m_p^2$ and m_R^2 , Q_0^2 and Λ^2 and 18 parameters describing the Pomeron and Reggeon terms.

In order to speed up the convergence of the fit the following procedure was adopted. First only the real photon data were fitted in order to determine the starting values for the 3 mass scales and C_P^1, C_R^1, a_p^1 and a_R^1 . The next step was to fix these parameters and determine the other terms by using all the DIS data. Once a good fit was achieved all parameters were allowed to vary and a global fit was performed on the complete set of data. We have also allowed for a variation of the normalization of the NA28 and BCDMS data relative to the SLAC data. We found that an overall 2.5% increase of the NA28 measurement, well within the 7% normalization uncertainty quoted by the experiment, improves the χ^2 . (The same result was found in another attempt to parametrize the same set of data on DIS [17]). For the sake of the fit statistical and systematic errors were added in quadrature. For 694 data points and 24 free parameters (including the rescaling of the NA28 data) we find a total χ^2 of 661, equivalent to $\chi^2/\text{ndf} = 0.98$. The comparison between the data and the curves obtained from the fit are shown in figure 2 for the real photon cross section and in figure 3 for $F_2/(1+R)$. In order to obtain a parametrization of $\sigma_T(\gamma^*p)(1+R)$, we have fitted the data on F_2 , keeping most of the parameters not involving t as well as Λ fixed at the values determined previously. We have allowed all parameters describing $b_P(t), b_R(t)$ and Q_0^2 to vary, assuming that F_2 may be affected by non-perturbative effects differently from $2xF_1$. In this case, for 467 data points and 15 free parameters we obtain a χ^2 of 410, equivalent to $\chi^2/\text{ndf} = 0.91$. We have also tried the inverse procedure, in which the real photon data and the F_2 data were fitted first and then only the F_2 data corrected by the $(1+R)$ term. The results were in agreement with the procedure described above.

5 Results

The results of our fits are presented in table 1. The error analysis for this large amount of parameters is very involved. We have checked that, for fixed

values of Λ , the values of the mass scales vary within about 25%, while all the other parameters vary within 15% to 30%. The interesting observation is that both a_p^1 and a_R^1 are consistent with the expectation for the intercepts of the appropriate trajectories. Also the value of Λ of 255 MeV is compatible with values previously obtained in the standard QCD analysis of structure functions. It seems thus that one can extrapolate smoothly from $Q^2 = 0$ to higher values of Q^2 without loosing the nice interpretation valid for real photons and the QCD interpretation for high Q^2 .

In the parton model the relation between the absorption cross section and the nucleon structure function is described by equation (3) with F_2 depending only on x . The relatively small value of $m_0^2 = 0.3 \text{ GeV}^2$, implies that the parton language can be applied already at low values of Q^2 , but the large value of $m_p^2 = 10 \text{ GeV}^2$ introduces scaling violation of F_2 even at large values of Q^2 . The Q^2 dependence of F_2 induced by the presence of m_p is typical for higher twist effects. Judging from the value of $Q_0^2 = 0.3 \text{ GeV}^2$, QCD should be applicable at low Q^2 , but again the large value of m_p^2 indicates that higher twist effects are important even at relatively high Q^2 . Our result, that m_p^2 is much bigger than m_R^2 , shows that higher twist effects affect the sea (Pomeron) contribution in a larger Q^2 domain than the valence (Reggeon) contribution. The higher twist contribution to F_2 from the Pomeron is negative due to the negative sign of a_P , while that of the Reggeon is positive but small. The importance of higher twist effects in the sea contribution has been pointed out by Donnachie and Landshoff [18].

We have checked that our parametrization extrapolates smoothly into the resonance region, $W < 1.75 \text{ GeV}$, described by the parametrization of Brasse et al. [19]. It is also of interest to compare the extrapolation of our parametrization to higher values of Q^2 , where no data are available, to the predictions of some parametrizations obtained as a result of the evolution of parton densities through the standard QCD evolution equations. The only parametrization valid at low Q^2 is the dynamical parametrization of Glück, Reya and Vogt (GRV) [20] which is applicable above $Q^2 = 0.3 \text{ GeV}^2$. For the sake of comparison, among the various other parametrizations [21] we have chosen the KMRS one [22], based on the BCDMS data with an $x^{-0.5}$ behavior for the gluon distribution at low x and a MT parametrization [23] with a sharp rise of all parton distributions at low x as well. Those

two, valid above $Q^2 = 4 \text{ GeV}^2$, are the ones that predict the fastest rise of F_2 with Q^2 at low x . All the parametrizations to which we compare ourselves have been obtained in a next to leading order approximation. The comparison of the four parametrizations is presented in figure 4. The largest differences between the various parametrizations are observed for $x < 0.015$. The GRV parametrization predicts too fast a rise at low Q^2 , while no constraints from the data exist for the standard parametrizations. In general, at higher Q^2 the KRMS parametrization lies below the other three, which agree among themselves at least in magnitude. In the intermediate x region, $0.024 < x < 0.275$, the agreement between the various parametrizations is quite good, but for the low Q^2 region, where that of GRV lies above the data. At the highest Q^2 values our parametrization predicts a faster dependence on Q^2 , but our extrapolation, based on an *ad hoc* Q^2 dependence of some of the terms in the fit, may be unreliable, since no constraints exist from the data in this region. In the high x region, only our parametrization describes properly the whole region of x and Q^2 . Clearly, the simple phenomenological picture that underlies our approach may not be sufficient to describe the whole of the $[x, Q^2]$ plane, especially since the functional Q^2 dependence of some terms used in our parametrizations is unknown. The fact that it extrapolates smoothly into the region of higher Q^2 values, where the standard approach may take over, makes it, together with the existing parametrization of the resonance region [19], a very useful tool for estimates in which the low Q^2 region plays an important role.

Another practical consequence of this parametrization is that it can be used to set initial conditions for the standard QCD evolution equations. Indeed, both the absolute value of F_2 and its logarithmic derivative $dF_2/d\ln Q^2$ can be determined at any value of Q^2 suitable to start a QCD type of evolution. The fact that higher twist contributions can be handled is another asset. The indication that our parametrization may provide good initial conditions can be inferred from figure 5, where a_P and a_R have been plotted as a function of Q^2 . From the solution of the evolution equations $F_2(x, Q^2)$ at low x is expected to be proportional to $x^{-\omega_0}$ with $\omega_0 \sim \alpha_S$ whenever the sea (Pomeron) contribution becomes dominant. In our case, that seems to happen above $Q^2 = 10 \text{ GeV}^2$ where one expects $\omega_0 \sim 0.4-0.5$ which seems to be the case.

Another interesting conclusion arises from the study of $\sigma_T(x_P, Q^2)$ as a function of Q^2 for various values of x_P , shown in figure 6. After a sharp decrease the cross section flattens off in the region of Q^2 between 1 and 10 GeV^2 , before it starts falling slowly down again. If the region where the cross section flattens off is interpreted as due to some intermediate confined quark states, as appear in some hadron models [24], the radius of a confined quark would be of the order of 0.2 fm, in accordance with other estimates.

It should also be mentioned that our parametrization offers the unique possibility to solve the evolution equation in $\ln \frac{1}{x}$ [8] which, for initial conditions, requires the knowledge of $F_2(x, Q^2)$ at a fixed value of $x = x_0$ in the whole of the Q^2 range. For the first time this Q^2 dependence can be derived from the experimental data.

6 Conclusions

Besides a practical advantage of having a parametrization of F_2 that interpolates smoothly between $Q^2 = 0$ and the DIS region, the fact that one could obtain such a parametrization, based on phenomenological arguments, may indicate that there is indeed a smooth transition between the nonperturbative and perturbative regime described by a Regge type of approach.

The fact that some properties of our parametrization seem to fulfil the general expectations is very encouraging and we hope that this kind of approach that we intend to pursue may lead to a better understanding of the connection between the phenomenology and theoretical predictions, especially in the region of small x . The forthcoming HERA results, which are expected to populate the low x region at relatively high Q^2 values will certainly be very valuable.

Acknowledgements

We are indebted to G. Wolf for a careful and critical reading of this paper. We are grateful to K. Charchula for providing us with the curves

for the standard QCD and the dynamical parametrizations. Three of us (HA, EML, AL) would like to thank the DESY Directorate for supporting their stays at DESY. One of us (UM) would like to thank the Minerva Foundation for the financial support which made his stay at DESY possible. This work was partly supported by the German Israeli Foundation (GIF I-149-110.7/89) and by the Polish Ministry of Education (GMEN 133/90).

References

- [1] R.J.M.Covolan and E.Predazzi, in 'Problems of Fundamental Modern Physics', eds. R.Cherubini, P.Daloz and B.Minetti,90. World Scientific, 1991, p.85.
- [2] G. Wolf, Proc. of the 1971 Int. Symp. on Electron and Photon Interactions at High Energies, Cornell 1971, p. 189.
- [3] A. Levy, U. Maor, Phys. Lett. 182(1986)108.
- [4] A. J. Buras, K. J. F.Gacmiers, Nucl. Phys. B132(1978)249
- [5] C. Lopez, F. J. Yndurain, Nucl. Phys. B171(1980)231 and B183(1981)157.
- [6] F. Martin, Phys. Rev. D19(1979)1382.
- [7] Yu. L. Dokshitzer, D. I. Dyakonov, S. I. Troyan, Phys. Rep. 58(1980)269
- [8] L. V. Gribov, E. M. Levin, M. G. Ryskin, Phys. Rep. 100(1983)1.
- [9] U. Maor, E. Gotsman, Phys. Rev. D28(1983)2149.
- [10] A. Donnachie, P. V. Landshoff, Nucl. Phys. B224(1984)322.
- [11] V. S. Fadin, E. A. Kuraev, L. N. Lipatov, Phys. Lett. B60(1975)50, JETP 72(1977)377.
- [12] M. Arnedo et al., Nucl. Phys. B333(1990)1.
- [13] A. C. Benvenuti et al., Phys. Lett. B223(1989)485.
- [14] L. W. Whitlow, Ph.D. Thesis, SLAC-Report--357(1990).
- [15] D. Allasia et al., Phys. Lett. B249(1990)366.
- [16] L. W. Whitlow et al., Phys. Lett. B250(1990)193.
- [17] A. Milsztajn et al., CERN-PPE/90-135.
- [18] A. Donnachie, P. V. Landshoff, Phys. Lett. B207(1988)319.

- [19] F. W. Brasse et al., Nucl. Phys. B110(1976)413.
[20] M. Glück, E. Reya, A. Vogt, DO-TH-91/07, submitted to Z. Phys.
[21] K. Charchula, M. Krawczyk, H. Abramowicz, A. Levy, DESY 90-019.
[22] J. Kwieciński, A. D. Martin, R. G. Roberts, W. J. Stirling, Phys. Rev. D42(1990)3645.
[23] J. G. Morfin, Wu-Ki Tung, Fermilab-Pub-90/74.
[24] E. M. Levin, M. G. Ryskin, Phys. Rep. 189(1990)267.

Table 1: Results of the fit (see text for details)¹. The error estimates have been obtained from a MINOS analysis of the MINUIT program. When the errors are either very asymmetric (denoted by an additional sign) or very different for the Pomeron and Reggeon terms two numbers are quoted.

parameters	$\sigma_T(\gamma p) + \sigma_T(\gamma^* p)$		$\sigma_T(\gamma^* p)(1 + R)$		error estimate [%]
	Pomeron	Reggeon	Pomeron	Reggeon	
m_0^2		0.30508 [GeV ²]			15
m_p^2		10.67564 [GeV ²]			30
m_R^2		0.20623 [GeV ²]			+60, -25
Λ^2		0.06527 [GeV ²]			-
Q_0^2	0.27799 [GeV ²]		0.27001 [GeV ²]		20
a_1	-0.04503	0.60408		idem	15
a_2	-0.36407	0.17353	-0.41254	0.08144	10(P), 40(R)
a_3	8.17091	1.61812	7.54998	2.18355	30
b_1	0.49222	1.26066	0.34131	1.21849	20
b_2	0.52116	1.83624	0.58400	1.82378	20
b_3	3.55115	0.81141	3.25216	0.71033	15
C_1	0.26550	0.67639		idem	15
C_2	0.04856	0.49027	0.10525	0.52072	100(P), 25(R)
C_3	1.04682	2.66275	5.55143	1.90782	15

¹ Because of the nonlinearity of the problem, the rounding errors can increase the χ^2/ndf up to 1.5.

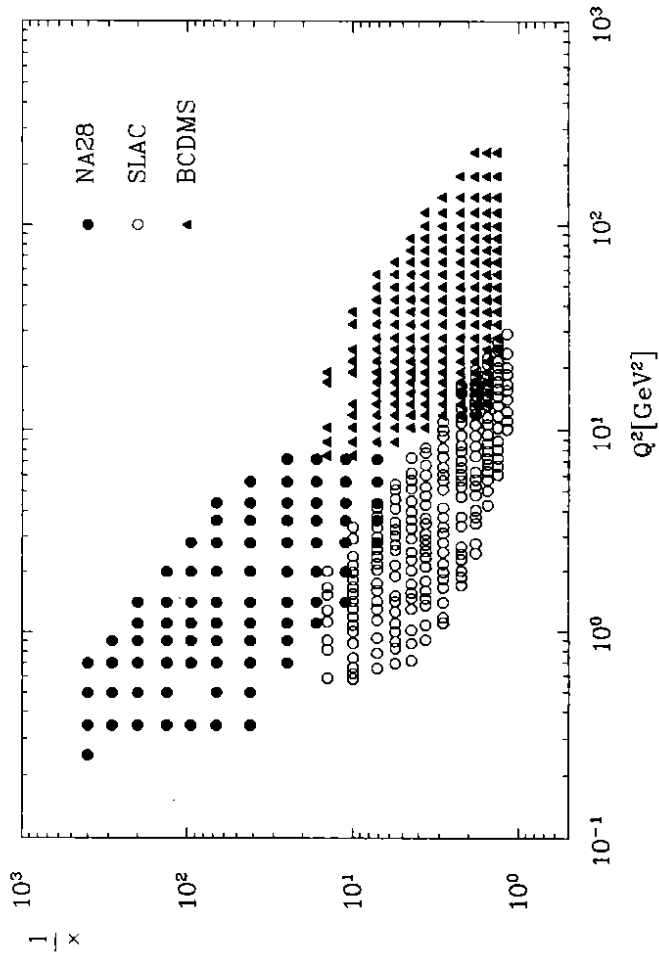


Figure 1: Kinematical range in $\frac{1}{x}$ and Q^2 covered by deep inelastic scattering data.

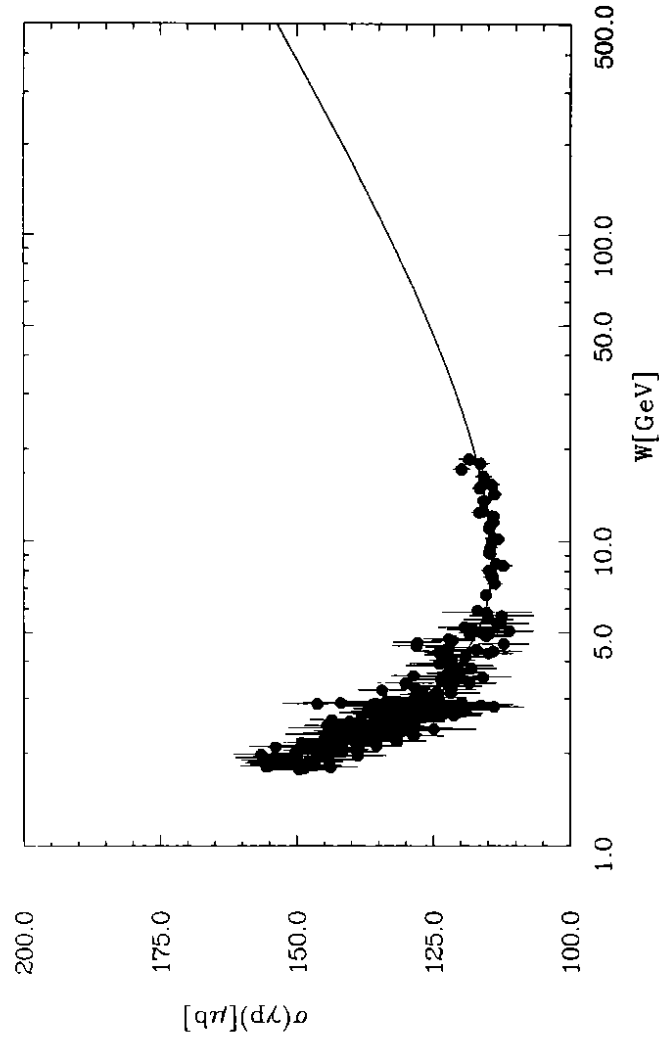


Figure 2: Comparison between the total γp cross section as measured for the real photon and the results of the fit, presented as a function of the center of mass energy W .

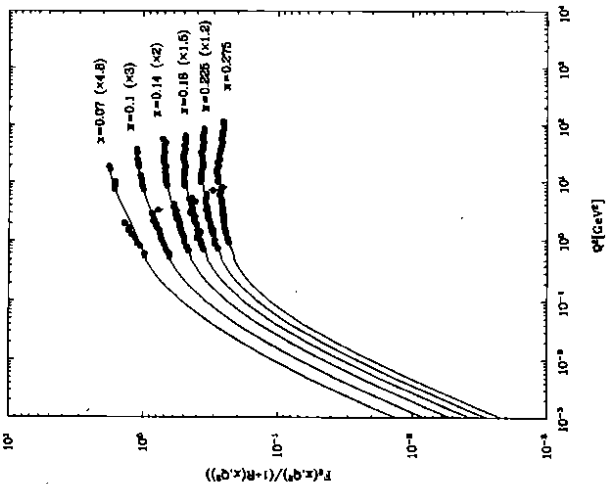
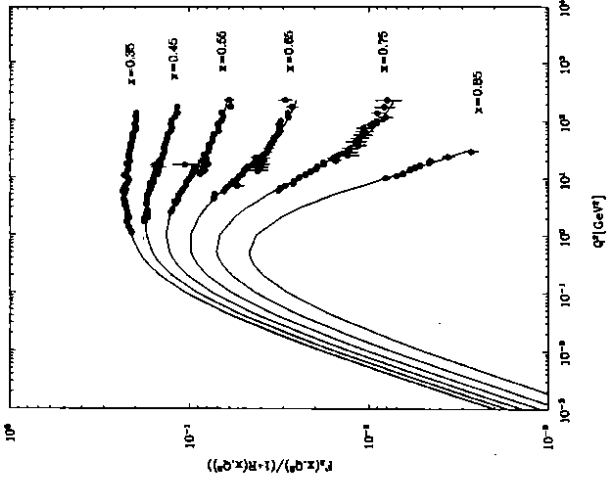
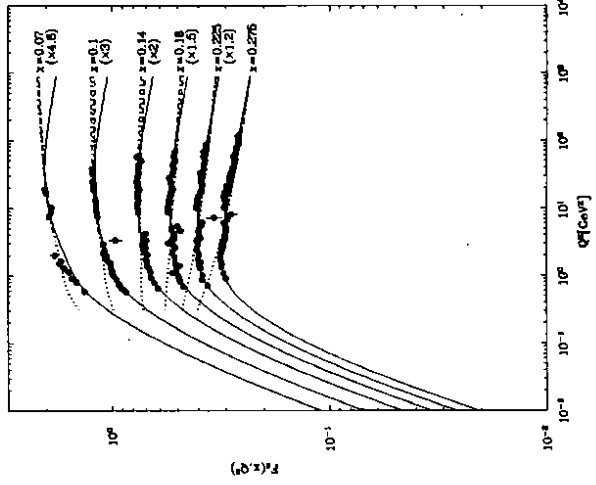
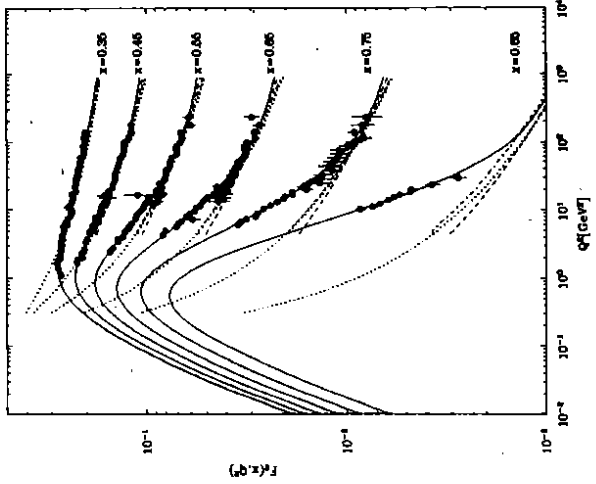
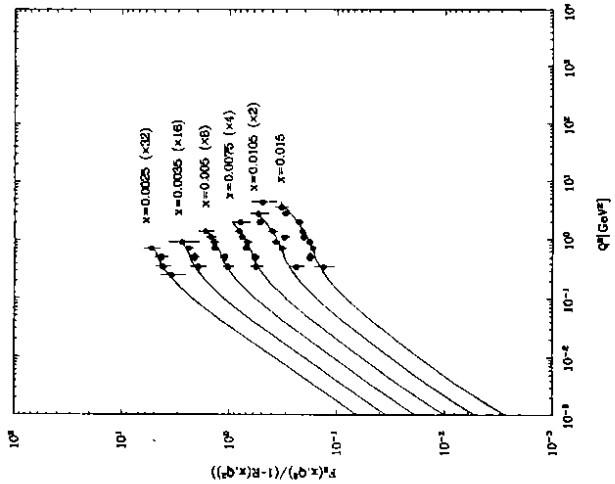
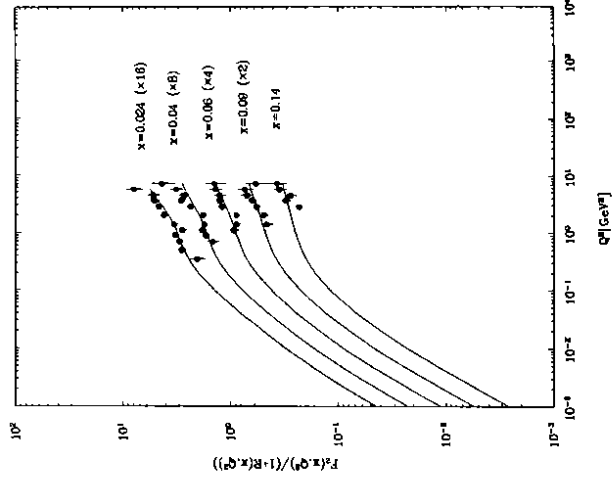
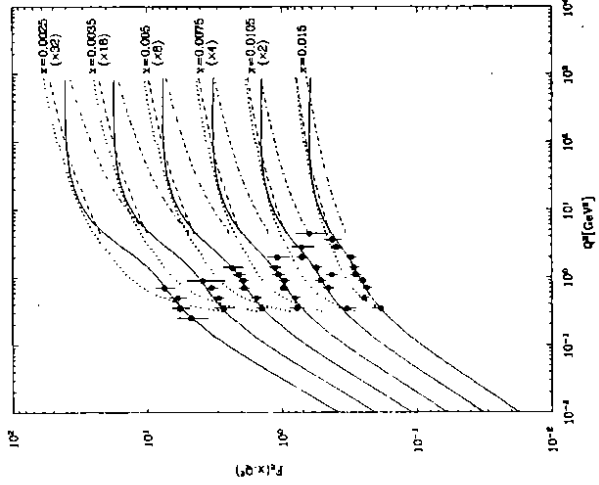
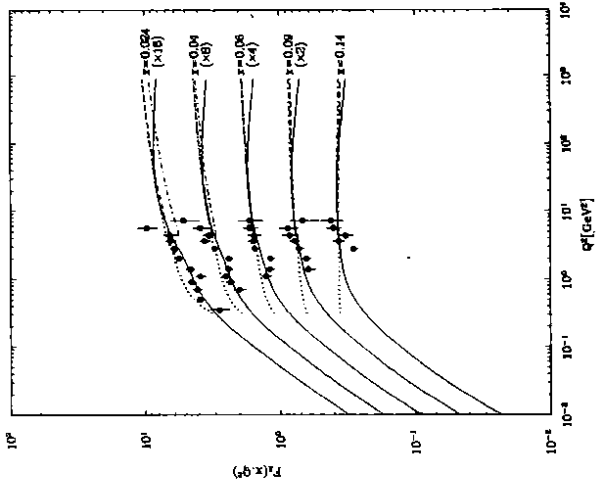


Figure 4: Comparison of the prediction of our parametrization (full line) with the predictions of the dynamical GRV (dotted line), the KMRS (dashed-dotted line) and the MT (dashed line) parametrizations for F_2 as a function of Q^2 , for fixed values of x (see text for more details). The data are superimposed to underline the kinematical region probed by measurements.

Figure 3: Comparison between $F_2(x, Q^2)/(1 + R(x, Q^2))$ from the data and the results of the fit, for various constant values of x as a function of Q^2 .

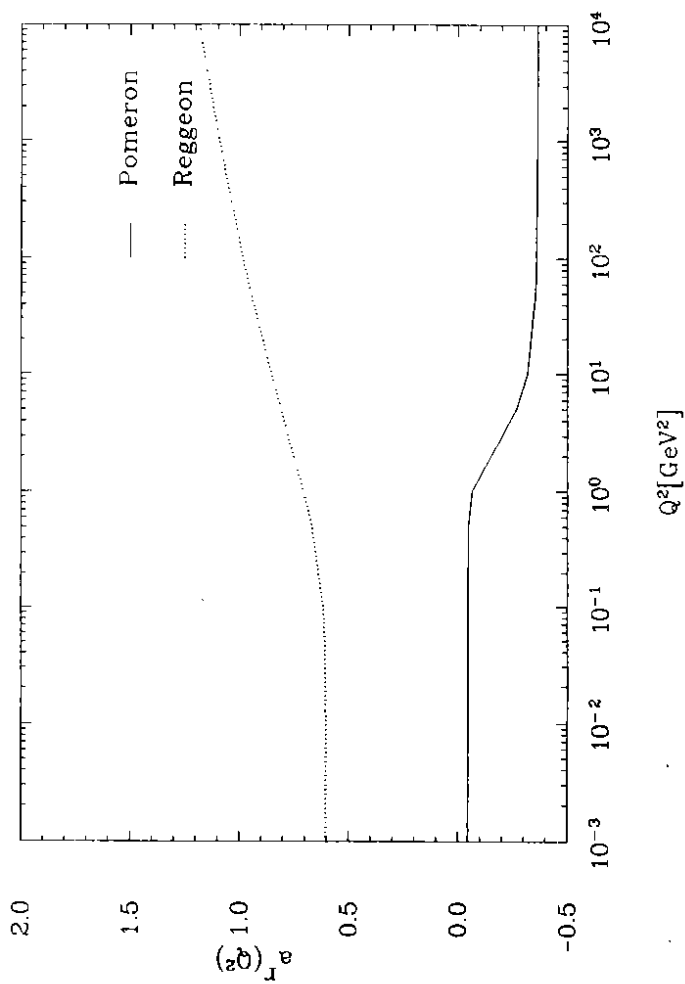


Figure 5: The Q^2 dependence of the power of x_r in the parametrization of the structure function contribution to the cross section for γp interactions - a^r , where r stands for either the Pomeron or the Reggeon as indicated on the figure.

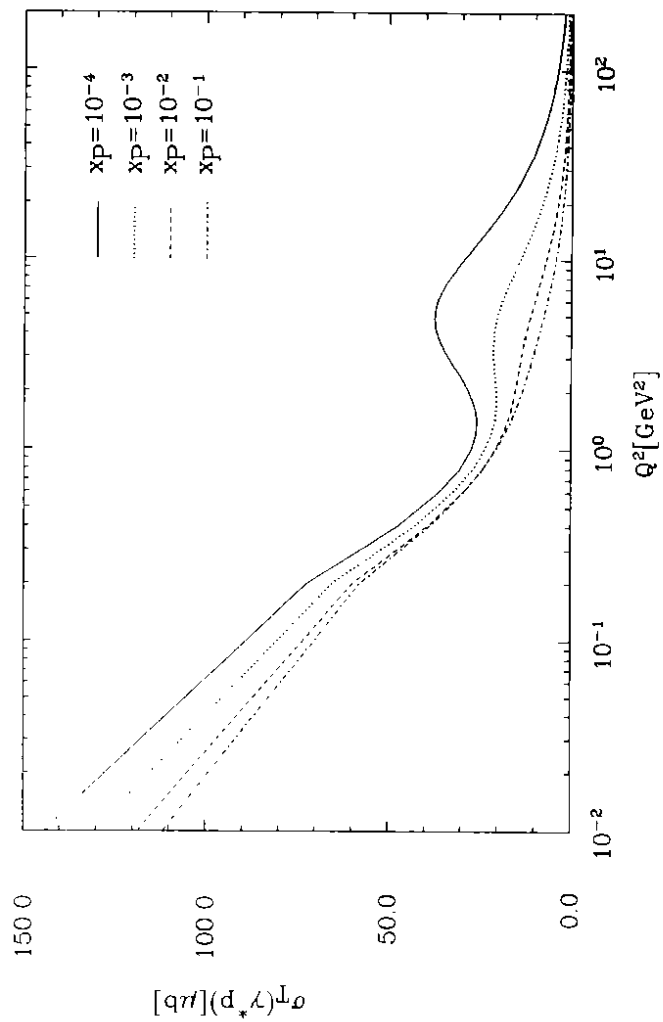


Figure 6: The Q^2 dependence of the total γp absorption cross section for transversely polarized virtual photons γ^* inferred from our parametrization for fixed values of x_p (defined by formula (16)).