MEASUREMENT AND ANALYSIS OF THE DIFFRACTIVE STRUCTURE FUNCTION $F_2^{D(3)}$

T.C. NICHOLLS
DESY FH1, Notkestrasse 85, 22603 Hamburg, Germany
E-mail: nicholls@mail.desy.de

REPRESENTING THE H1 COLLABORATION

A measurement of the diffractive structure function $F_2^{D(3)}$ in the kinematic domain $0.4 \leq Q^2 \leq 5$ GeV^2, $0.001 \leq \beta \leq 0.65$, and $x_{I\!P} \leq 0.05$ is presented. A Regge-inspired analysis indicates that the data require both a dominant diffractive exchange and an additional sub-leading contribution. A fit, based on a QCD model in which parton distributions are assigned to both exchanges, yields results consistent with those published for higher Q^2 data. A fit to the data of a model based on two-gluon exchange indicates a significant higher twist contribution at high β.

1 Introduction

We present a measurement of the cross section for the process $ep \rightarrow eXY$ in diffractive deep-inelastic scattering, given in terms of the differential structure function $F_2^{D(3)}(x_{I\!P}, \beta, Q^2)$. This analysis represents a significant extension of the kinematic range of the previous publication, based on 1994 data [1], to lower Q^2 and β. The combined results are compared to several models motivated by Regge theory and QCD.

2 Experimental Method

The measurement is based on positron-proton data taken by the H1 experiment during 1995, corresponding to an integrated luminosity of 121 nb^{-1}. The analysis exploits the upgrade of the backward[a] region of the detector, which consists of a new electromagnetic and hadronic calorimeter (SPACAL) [2] and backward drift chamber (BDC). The new configuration, in combination with an interaction vertex shifted by 70 cm in the proton beam direction, extends the region of good acceptance to considerably lower Q^2 than was previously accessible.

The cross section for the process $ep \rightarrow eXY$ is measured, where the two hadronic systems X and Y are separated by the largest gap in the pseudo-

[a] The backward direction is defined to be that of the outgoing electron beam.

rapidity distribution of final state hadrons and Y is the system closest to the outgoing proton beam direction.

The scattered positron is selected by requiring the presence of a well-formed electromagnetic cluster in SPACAL with an energy of greater than 8 GeV and an associated BDC track. According to the cross section definition given above, diffractive events are then selected by requiring an absence of hadronic activity in the forward region of the detector in the pseudo-rapidity range $3.2 < \eta \lesssim 7.5$. The kinematic variables x, y, and Q^2, defined as before [1], are reconstructed using the electron and sigma methods and M_X, the invariant mass of the hadronic system X, is calculated from calorimeter and track information.

The cross section is determined in the kinematic region $0.4 \leq Q^2 \leq 5\,\mathrm{GeV}^2$, $0.001 \leq \beta \leq 0.65$, and $x_{I\!P} \leq 0.05$ and corrected to the region $M_Y < 1.6$ GeV and $|t| < 1.0\,\mathrm{GeV}^2$. The diffractive structure function $F_2^{D(3)}(x_{I\!P}, \beta, Q^2)$ is then extracted directly from the measured cross section [3,4].

3 Results and Discussion

Figure 1 shows the measured structure function $F_2^{D(3)}$ multiplied by $x_{I\!P}$ for clarity. The results obtained with the electron and sigma kinematic reconstruction methods are in good agreement; the data presented here use the electron method at high y ($0.2 \leq y \leq 0.7$) and the sigma method at lower y ($0.05 \leq y < 0.2$). Furthermore, in the region of overlap, there is excellent agreement with the previously published data [1].

The results are used to further constrain the Regge phenomenological model investigated previously [1]. A fit to the combined 1994/1995 points of a single pomeron trajectory with intercept $\alpha_{I\!P}(0)$ is not able to describe the data. Addition of a sub-leading (reggeon) trajectory with independent normalisation yields a significantly better description ($\chi^2 \simeq 1.1/\mathrm{d.f}$). The role of the two contributions is shown in Figure 1. The intercept trajectories found here are consistent with the published values [1]. Fits with zero and maximal interference between the two trajectories describe the data equally well. An extension to the fit in which the pomeron intercept takes the form $\alpha_{I\!P}(0) = a + b \log Q^2$ gives a value of b compatible with zero.

The scaling violations of $F_2^{D(3)}$ as a function of Q^2 observed in the previous analysis [1] extend into the lower Q^2 region and motivate an analysis of the data in which the Q^2 and β dependence of $F_2^{D(3)}$ is understood in terms of parton distribution functions for the pomeron, evolved with perturbative QCD. The quark flavour-singlet and gluon distributions are parameterized at a starting scale of $Q_0^2 = 3\,\mathrm{GeV}^2$ using Chebychev polynomials, evolved in Q^2 with the

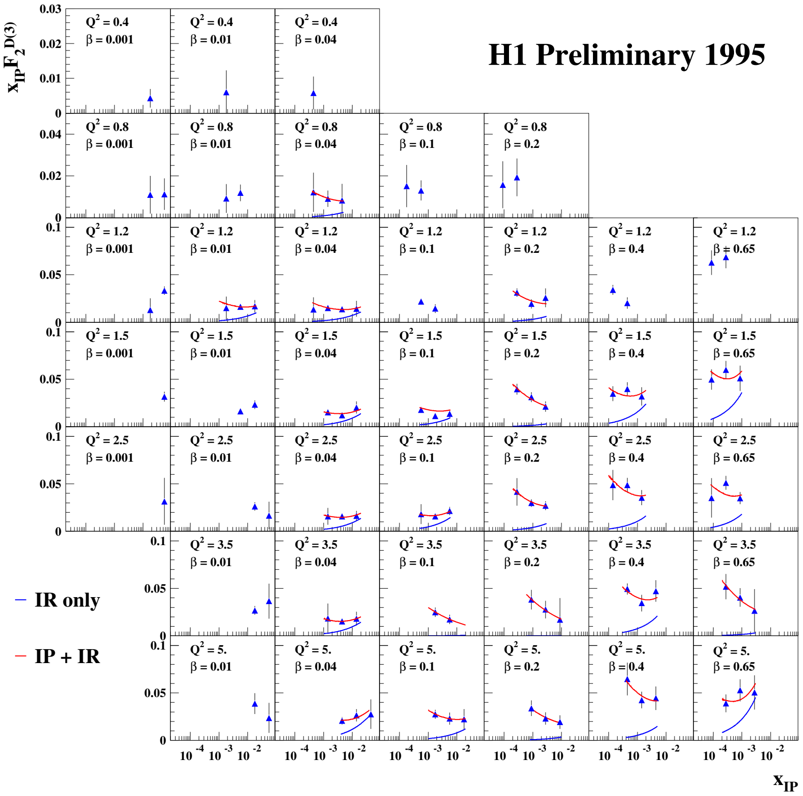

Figure 1: The measured values of $x_{I\!P}F_2^{D(3)}$ against $x_{I\!P}$ for various Q^2 and β values. Also shown are the reggeon ($I\!R$) and total ($I\!P + I\!R$) contributions derived from the fit described in Section 3.

NLO DGLAP equations and fitted, in combination with a reggeon contribution, to the combined data. The results are consistent with the previous fit to 1994 data alone and the extracted parton density functions indicate a large gluonic content ($80-90\%$) of the pomeron. Analyses of diffractive final states by H1 [5,6] are consistent with these observations.

The data are also confronted with a model which describes diffraction in terms of the exchange of two gluons from the proton [7]. Contributions from transverse $q\bar{q}$, transverse $q\bar{q}g$ and longitudinal, higher twist $q\bar{q}$ production are considered. The relative normalisation and $x_{I\!P}$ dependence of each term is left free and the β dependence of the $q\bar{q}g$ term is parameterized as $(1-\beta)^{\gamma}$, where γ is left free. A fit to the combined data yields two possible solutions having high (8.5) and low (0.16) values of γ. This is in contrast to the analysis of ZEUS data [7] where only one solution is found with large γ. The contribution of the higher twist term is significant in both solutions.

4 Conclusions

We have presented an extension of the H1 measurement of the diffractive structure function $F_2^{D(3)}$ to significantly lower Q^2 and β. Comparisons of the data with various models yield results compatible with previous H1 analyses. No significant Q^2 dependence of the pomeron intercept is observed, even at low values of Q^2. A fit to a model based on two-gluon exchange indicates a significant higher twist contribution and yields two solutions, the interpretation of which will certainly merit further investigation.

References

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