EPS-0491
Submitted to Pa 10,17 and Pl 1,2,3

The Partonic Structure of Proton Diffraction

H1 Collaboration

Abstract

A recent measurement, using data taken with the H1 detector at HERA, of the diffractive contribution $F_2^{D(3)}$to the proton structure function $F_2(x, Q^2)$ in deep–inelastic ep scattering is investigated in terms of perturbative QCD. For the kinematic range $8.5 < Q^2 < 50\,\mathrm{GeV}^2$, $2.4\times10^{-4} <$ Bjorken–$x < 0.0133$, and $3.7\times10^{-4} < x_{I\!P} < 0.043$, the dependence of $F_2^{D(3)}$on the deep–inelastic scattering variables Q^2 and β $(= x/x_{I\!P})$, in the form of $\tilde{F}_2^D(\beta, Q^2)$ after removal of the universal diffractive $x_{I\!P}$ dependence, is investigated. The $\log Q^2$ dependence of $\tilde{F}_2^D$ is observed not to fall throughout the measured range of the appropriate Bjorken–x variable $0.065 \leq \beta \leq 0.65$, unlike the structure functions of all hadrons, and to be consistent with a rising dependence proportional to $(0.14 \pm 0.04) \cdot \log_{10} Q^2$ when taken to be independent of β. Using leading order DGLAP evolution, the dependence of $\tilde{F}_2^D$ on β and Q^2 is shown to favour a leading gluon QCD interpretation of diffractive exchange. Comparison is made with predictions in terms of F_2 and $F_2^{D(3)}$of an explicit partonic model of deep–inelastic diffraction.

1 Introduction

Recent measurements at HERA of deep–inelastic electron–proton (ep) scattering (DIS) in the low Bjorken–x kinematic range $5 < Q^2 < 120\,\mathrm{GeV}^2$ and $10^{-4} < x < 10^{-2}$ have demonstrated the existence of a distinct class of events in which there is no hadronic energy flow in an interval of (laboratory frame) pseudo–rapidity adjacent to the proton beam direction [1, 2]. A natural interpretation of these so called "rapidity gap" events is based on the hypothesis that the deep–inelastic scattering process involves the interaction of the virtual boson probe with a colourless component of the proton. Hence there is no chromodynamic radiation in the final state immediately adjacent to the direction of the scattered proton or any proton remnant.

A recent determination of the dependence on the kinematic variables β, Q^2 and $x_{I\!P}$ (see below) of the contribution $F_2^{D(3)}$ of these events to the proton structure function F_2 demonstrated for the first time that they are unambiguously diffractive [3], namely that in a Regge framework the colourless component of the proton is consistent with a leading exchange, the pomeron ($I\!P$). Further, at the present level of experimental accuracy, the cross section for deep–inelastic diffraction, in the form of $F_2^{D(3)}$, is observed to factorise so that the dependence of $F_2^{D(3)}$ on β and Q^2 may be interpreted in terms of the deep–inelastic structure of diffractive exchange, or equivalently of the $I\!P$. This structure is observed to be broadly of a scale invariant nature, indicative of a partonic origin.

This paper reviews briefly the main features of deep–inelastic diffraction embodied in the observed dependences of $F_2^{D(3)}$and its form $\tilde{F}_2^D$ [3] when the factorisable diffractive dependence on $x_{I\!P}$ is removed. It then assesses quantitatively in the framework of perturbative QCD, and in particular DGLAP Q^2 evolution, the conclusions which can be drawn concerning the partonic structure of diffractive exchange.

2 Experiment, Kinematics, and Measurement of $F_2^{D(3)}$

The data were taken with the H1 detector at the HERA ep collider in 1993, in which 26.7 GeV electrons were in head–on collision with 820 GeV protons, and correspond to an integrated luminosity of $272 \pm 14\,\mathrm{nb}^{-1}$. The H1 detector is described in detail in [4], and the aspects of special importance for the detection of putative diffractive events in [3].

The measurement of $F_2^{D(3)}$ presented here is made as a function of the three kinematic variables β, Q^2, and x, or equivalently β, Q^2, and $x_{I\!P}$. They are defined as follows:

$$x = \frac{-q^2}{2P \cdot q} \qquad x_{I\!P} = \frac{q \cdot (P - P')}{q \cdot P} \qquad Q^2 = -q^2 \qquad \beta = \frac{-q^2}{2q \cdot (P - P')}. \tag{1}$$

Here q, P and P' are the 4–momenta of the virtual boson, the incident proton, and the final state colourless remnant respectively. Note that

$$x = \beta x_{I\!P}. \tag{2}$$

It is convenient to write $x_{I\!P}$ and β above as

$$x_{I\!P} = \frac{Q^2 + M_X^2 - t}{Q^2 + W^2 - M_p^2} \approx \frac{Q^2 + M_X^2}{Q^2} \cdot x = x_{I\!P/p} \tag{3}$$

$$\beta = \frac{Q^2}{Q^2 + M_X^2 - t} \approx \frac{Q^2}{Q^2 + M_X^2} = x_{q/I\!\!P} \tag{4}$$

where M_X is the invariant mass of the hadronic system excluding the colourless remnant, $t = (P - P')^2$ is the 4–momentum transfer squared at the incident proton vertex, and W is the total hadronic invariant mass. In the kinematic domain of these measurements $x_{I\!\!P}$ may be interpreted as the fraction $x_{I\!\!P/p}$ of the 4–momentum of the proton carried by the diffractive exchange, that is the interacting $I\!\!P$ if such a picture is invoked, and β as the fraction $x_{q/I\!\!P}$ of the 4–momenta of the diffractive exchange, or $I\!\!P$, carried by the quark interacting with the virtual boson.

The diffractive structure function $F_2^{D(3)}$, which is a function of three kinematic variables, is derived from a structure function $F_2^{D(4)}$ which is a function of the four kinematic variables x, Q^2, $x_{I\!\!P}$ and t. $F_2^{D(4)}$ is defined [3] by analogy with the decomposition of the unpolarised total ep cross section. It is written in terms of two structure functions $F_2^{D(4)}$ and $\frac{F_2^{D(4)}}{2x(1+R^{D(4)})}$ in the form (α is here the fine structure constant)

$$\frac{\mathrm{d}^4\sigma_{ep\to epX}}{\mathrm{d}x\mathrm{d}Q^2\mathrm{d}x_{I\!\!P}dt} = \frac{4\pi\alpha^2}{xQ^4}\left\{1 - y + \frac{y^2}{2[1 + R^{D(4)}(x, Q^2, x_{I\!\!P}, t)]}\right\} F_2^{D(4)}(x, Q^2, x_{I\!\!P}, t) \tag{5}$$

in which y is the usual DIS scaling variable given by $y = Q^2/sx$. s is the ep collision centre of mass (CM) energy squared. It is convenient to express this cross section in terms of $F_2^{D(4)}$ and $R^{D(4)}$ because the data available are predominantly at low y so that there is little sensitivity to $R^{D(4)}$.

The measurement uses data in which the final state colourless remnant is not detected. Therefore no accurate determination of t is possible and the measured cross section amounts to $\frac{d^3\sigma(ep\to epX)}{\mathrm{d}x\mathrm{d}Q^2\mathrm{d}x_{I\!\!P}}$, from which it is possible to determine only $F_2^{D(3)}(x, Q^2, x_{I\!\!P}) = \int F_2^{D(4)}(x, Q^2, x_{I\!\!P}, t)\,\mathrm{d}t$ provided that a particular choice is made for $R^{D(4)}$ and its t dependence. For this measurement, $R^{D(4)}$ is set to 0 and $F_2^{D(3)}$ is evaluated from

$$\frac{\mathrm{d}^3\sigma_{ep\to epX}}{\mathrm{d}x\mathrm{d}Q^2\mathrm{d}x_{I\!\!P}} = \frac{4\pi\alpha^2}{xQ^4}\left\{1 - y + \frac{y^2}{2}\right\} F_2^{D(3)}(x, Q^2, x_{I\!\!P}) \tag{6}$$

following the original procedure of [6, 7].

The use of a forward rapidity gap to select events in which the proton remnant is colourless also specifies the kinematic range in t of the measurement presented here. In the selected sample of events no particle from the colourless remnant, be it nucleon alone or one of the dissociation products of the proton, may be detected in the detector with the most forward sensitivity, namely FMD ($5.0 < \eta < 6.6$). It follows that $|\,t\,|$ is less than roughly $7\,\mathrm{GeV}^2$ for the range $x < x_{I\!\!P} < 0.05$ of this measurement.

The above definition of $F_2^{D(3)}(x, Q^2, x_{I\!\!P})$ renders quantitative comparison with the structure function $F_2(x, Q^2)$ of the proton straightforward [5].

Monte Carlo simulations of deep–inelastic electron–pomeron scattering [8] and vector meson production [9] were used to correct for finite acceptance and resolution effects. Details concerned with the evaluation of all sources of systematic error in the extraction of $F_2^{D(3)}$are in [10, 11].

The results of the measurement of the $(\beta, Q^2, x_{I\!\!P})$ dependence of $F_2^{D(3)}$are tabulated and plotted in [3].

3 The Partonic Structure of Diffractive Exchange

The observation that the rapidity gap events are of a predominantly diffractive nature, and the evidence for simple factorisation of the diffractive dependence on $x_{\mathbb{P}}$ [3] lead naturally to the interpretation of the β and Q^2 dependencies of $F_2^{D(3)}$as a measure of the deep–inelastic structure of diffractive exchange.

In figure 1 are shown the β and Q^2 dependencies of the integral

$$\tilde{F}_2^D(\beta, Q^2) = \int_{x_{\mathbb{P}_L}}^{x_{\mathbb{P}_H}} F_2^{D(3)}(\beta, Q^2, x_{\mathbb{P}})\, \mathrm{d}x_{\mathbb{P}}, \tag{7}$$

which, assuming factorisation of the diffractive dependence on $x_{\mathbb{P}}$ (a polynomial dependence $x_{\mathbb{P}}^{-n}$ with $n = 1.19 \pm 0.06(stat.) \pm 0.07(syst.)$ [3]), is proportional to the structure function of diffractive exchange. The range of integration, $x_{\mathbb{P}_L} = 3 \times 10^{-4}$ to $x_{\mathbb{P}_H} = 0.05$, is chosen to span the entire $x_{\mathbb{P}}$ range of measurements of $F_2^{D(3)}$. The assumption is therefore made that, for certain values of β and Q^2, the observed $x_{\mathbb{P}}$ dependence is valid beyond the measured range in $x_{\mathbb{P}}$, including values which are kinematically inaccessible in this measurement. Note therefore that, unlike $F_2^{D(3)}$ or any integration of it over kinematically accessible values of β, Q^2 and $x_{\mathbb{P}}$, $\tilde{F}_2^D$ is not a measure of the diffractive contribution to F_2. The errors in the results for $\tilde{F}_2^D(\beta, Q^2)$ include the contributions from the uncertainty (both statistical and systematic) in the diffractive dependence on $x_{\mathbb{P}}$ [3]. It is convenient to extract the dependence of $F_2^{D(3)}$on β and Q^2 in this way in order to avoid the need to specify the theoretically ill–defined normalisation of the diffractive flux.

There is no evidence for any substantial Q^2 dependence of $\tilde{F}_2^D$ for any β. Deep (high Q^2) diffractive interactions are thus broadly of a scale invariant, and therefore point-like, nature. Furthermore, $\tilde{F}_2^D$ is observed to have little dependence on β with contributions throughout the measured range ($0.065 < \beta < 0.65$). Therefore the structure which is resolved by the electron in the high Q^2 diffractive interaction carries only a fraction of the $\mathbb{P}$'s momentum, implying that the $\mathbb{P}$ has its own point-like partonic sub–structure.

A fit to the hypothesis of a linear $\log_{10} Q^2$ dependence of the form

$$\tilde{F}_2^D(\beta, Q^2) = a(\beta)\log_{10}Q^2 + b(\beta) \tag{8}$$

yields values for $a(\beta)$ that are $\simeq 1.5\sigma$ above zero for all values of β. The errors in $a(\beta)$ amount to $\sigma = 0.09\,(\log_{10}\,\mathrm{GeV}^2)^{-1}$ for all β except that at $\beta = 0.065$ for which $\sigma = 0.15\,(\log_{10}\,\mathrm{GeV}^2)^{-1}$. Therefore the accuracy of this first measurement of the Q^2 dependence of $\tilde{F}_2^D$ is such that the possibility of "scaling violations", symptomatic of QCD, may be admitted.

The hypothesis that any violation of scale invariance is in the form of a $\log Q^2$ dependence of $\tilde{F}_2^D$ which is independent of β (slope parameter a in equation 8 now independent of β) provides an excellent description of $\tilde{F}_2^D$ and gives $a = 0.14 \pm 0.04$. In this and all subsequent fits below, statistical and systematic errors are added in quadrature.

The lack of any fall of $\tilde{F}_2^D$ with increasing Q^2 at large β contrasts with the violations of scale invariance exhibited by the structure function of a typical hadron. For example, the proton structure function F_2 rises with increasing Q^2 for $x \lesssim 0.15$, and falls with increasing Q^2 for $x \gtrsim 0.15$. This decreasing dependence at high x is an inevitable consequence of

DGLAP QCD evolution for an object with a structure built from the evolution of "valence" quarks in which the latter predominate at large Bjorken–x. By analogy, a structure function for which any violation of scale invariance amounts to an increase with $\log Q^2$ at high Bjorken–x (β), is likely to have a large gluon, relative to quark, parton density. The observation that the Q^2 dependence of $\tilde{F}_2^D$ is consistent with a rise proportional to $\log Q^2$ when taken to be independent of β thus suggests that a significant contribution to the structure of diffractive exchange is gluonic.

To quantify any substantive evidence for a gluonic contribution to the structure of diffractive exchange, that is to $\tilde{F}_2^D$, the DGLAP evolution equations were solved numerically in the LO and in the next–to–leading order (NLO) $\log Q^2$ approximations. The numerical technique used followed that of [12] in which, starting from a scale $Q_0^2 = 4\,\mathrm{GeV}^2$, assumed forms for the gluon and singlet quark parton densities in diffractive exchange were evolved to higher Q^2 and compared with the measurements of the β dependence of $\tilde{F}_2^D$. The parton densities which specify the structure of diffractive exchange were expressed in the usual way as functions of z, the momentum of the parton as a fraction of the momentum carried in the exchange, that is of the $I\!\!P$ ($z = x_{i/I\!\!P}$, quark $i = q$, gluon $i = g$). The basic kinematic features of the method, for example the treatment of charm, were identical to those in the QCD analysis of the proton structure function F_2 [13]. However, no momentum sum rule was imposed because it is far from clear whether one should exist for such a space–like exchange, and because the normalisation of $\tilde{F}_2^D$ does not coincide with the normalisation of the structure function of diffractive exchange without further theoretical input.

The assumption that diffractive exchange contains only a flavour singlet quark density of the form $zq(z) = A_q \cdot z(1-z)$ at $Q_0^2 = 4\,\mathrm{GeV}^2$ resulted in a description of $\tilde{F}_2^D$ in LO with a χ^2/dof of 22/14 (7%C.L.). Allowing a more flexible form for the singlet quark distribution of $zq(z) = A_q \cdot z^{B_q}(1-z)^{C_q}$ yielded an acceptable solution with a χ^2/dof of 13/12 (37%C.L.) and with a flatter distribution function $B_q \sim 0.35$ and $C_q \sim 0.35$. The result of this fit is shown in figure 1 as the dashed curve. Though numerically acceptable, such a "valence" quark based solution results in a decrease of $F_2^{D(3)}$ with increasing $\log Q^2$ at high β as is to be expected following the discussion above, a trend which is not favoured by the measurements of $\tilde{F}_2^D$.

The addition of a gluon density of the form $zg(z) = A_g \cdot z^{B_g}(1-z)^{C_g}$ at $Q_0^2 = 4\,\mathrm{GeV}^2$ to the singlet quark density resulted in an excellent description of $\tilde{F}_2^D(\beta, Q^2)$ (χ^2/dof = 4/9, 91%C.L. at a single stable minimum in χ^2) which reproduces the rise with $\log Q^2$ at higher β. In this solution, shown by the solid curve in figure 1, at $Q_0^2 = 4\,\mathrm{GeV}^2$ the gluons carry $\sim$ 90% of the momentum of diffractive exchange, and the fitted gluon density is very hard, tending to $z = 1$, indicating both that the structure of diffraction is consistent with a gluon content which predominates at higher fractional momenta $z = x_{g/I\!\!P}$ and that diffraction may involve the leading exchange of a single gluon (figure 2).

The preference for the solution with a leading gluon density in diffractive exchange is only slight. Because the evidence for a rise of $\tilde{F}_2^D$ with $\log Q^2$ at high β is of marginal significance and amounts to no more than evidence against a falling $\log Q^2$ dependence, a fact which has also been confirmed recently by the ZEUS experiment [14], the gluon density which is necessary to reproduce the high β behaviour is not well constrained. A fit in which both the quark and gluon densities have a form $\propto z(1-z)$ at the starting scale

$Q_0^2 = 4\,\mathrm{GeV}^2$ also produces an acceptable solution ($\chi^2/\mathrm{dof} = 8/13$, 84%C.L.), with the gluons carrying $\sim 80\%$ of the total momentum in the diffractive exchange at $Q_0^2 = 4\,\mathrm{GeV}^2$.

In all cases in which a finite gluon density is included in the diffractive exchange at the starting scale $Q_0^2 = 4\,\mathrm{GeV}^2$, repeating the fits in NLO DGLAP reduces somewhat the fractional momentum carried by the gluons.

In summary, the Q^2 dependence of deep–inelastic diffraction in the form of $\tilde{F}_2^D(\beta, Q^2)$ is consistent statistically with the hypotheses either of only quark structure or of quark and gluon structure in DGLAP evolution at a starting scale $Q_0^2 = 4\,\mathrm{GeV}^2$. However the tendency for the Q^2 dependence of $\tilde{F}_2^D$ not to show a decrease at high β, and the consistency of this Q^2 dependence with the hypothesis of a logarithmic rise, suggest that gluons contribute significantly to the partonic structure of diffraction. An excellent description of $\tilde{F}_2^D$ in the framework of LO DGLAP is achieved with a gluon density which predominates at larger fractional momenta $z = x_{g/\mathbb{P}}$, which carries approximately 80% to 90% of the momentum in diffractive exchange at $Q_0^2 = 4\,\mathrm{GeV}^2$, and which supports a leading gluon interpretation.

4 Comparison with a Partonic Model of Diffraction

An attempt has been made by Buchmüller and Hebecker [15] to develop a partonic model of diffraction with the assumption that the underlying partonic process is electron–gluon scattering. The motivation is derived from the importance of such dynamics in low–x deep–inelastic ep scattering, and by implication therefore it requires diffractive exchange to be predominantly a leading gluon phenomenon. It is hypothesised that the quark–antiquark pair produced in the hard electron–gluon interaction undergoes colour rotation so that the colour quantum numbers of the initial quark–antiquark system are completely decorrelated. Then the probabilities of obtaining a colour singlet or octet configuration in the final state are simply $\frac{1}{9}$ and $\frac{8}{9}$ respectively. When the quark–antiquark pair emerge in a colour singlet state, there is no longer any colour connection between it and the proton remnant, and so a "rapidity gap" is expected.

The approach leads to a set of simple, parameter free, predictions for the relationship between the structure functions $F_2(x, Q^2)$ and $F_2^{D(3)}$.

A simple scaling law of the form

$$\xi\ F_2^{D(3)}(\beta, Q^2, x_{\mathbb{P}} = \xi)\Big|_{Q^2} \propto\ F_2(x = \xi, Q^2)\Big|_{Q^2} \qquad (9)$$

is predicted which should hold for any β to the extent that the model predicts little or no β dependence of $F_2^{D(3)}$. This expectation is tested in figure 3 in which the measurements of $F_2^{D(3)}$for different β are included together with the measurements of $\frac{F_2(x)}{x}$ scaled by a factor 0.04. This factor corresponds to the proportion overall of deep–inelastic diffraction being $\frac{1}{9}$, following the colour rotation assumption in [15].

The measurement of $F_2^{D(3)}$has been used to measure the total contribution of diffraction to F_2 as a function of x and Q^2 and thereby to demonstrate explicitly the prediction of the relative normalisations of F_2 and $F_2^{D(3)}$. Diffraction is defined to be for $x_{\mathbb{P}} \leq 0.05$ so that the contribution can be expressed as $F_2^D(x, Q^2)$ which is related to $F_2^{D(3)}$according to

$$F_2^D(x,Q^2) = \int_x^{0.05} F_2^{D(3)}(x,Q^2,x_{I\!P})\mathrm{d}x_{I\!P} \tag{10}$$

The results are shown in figure 4 both as (x,Q^2) and as the proportion $r^D(x,Q^2) = F_2^D/F_2$. Note that both F_2^D and r^D tend to zero as $x \to x_{I\!P}$. Away from this kinematic limit, r^D is rather insensitive to x and Q^2 and is about 10%. The prediction based on colour rotation in [15] that $r^D = \frac{1}{9}$ is thus shown to be consistent with measurement.

The approach of Buchmüller and Hebecker [15] is thus in remarkable agreement with experiment, given the simplicity of the first model calculation in this approach. It adds weight to the picture in which diffractive exchange is a leading gluon phenomenon.

5 Conclusions

A first QCD analysis of the deep–inelastic structure of diffraction has been attempted using the β and Q^2 dependences of $F_2^{D(3)}$ in the form of $\tilde{F}_2^D(\beta,Q^2)$ after factorisation out of the universal diffractive $x_{I\!P}$ dependence.

The dependence of $\tilde{F}_2^D(\beta,Q^2)$ on β and Q^2 is shown to be well described with a rising dependence proportional to $(0.14\pm0.04)\cdot\log_{10}Q^2$ when it is assumed to be independent of β. This suggests that a significant contribution to the structure of diffractive exchange is gluonic. An excellent description of $\tilde{F}_2^D$ in the framework of LO DGLAP is achieved with a gluon density which predominates at larger fractional momenta $z = x_{g/I\!P}$, which carries approximately 80% to 90% of the momentum in diffractive exchange at $Q_0^2 = 4\,\mathrm{GeV}^2$, and which supports a leading gluon interpretation.

A partonic model of deep–inelastic diffraction (Buchmüller et al. [15]) in which the leading partonic exchange is a gluon, and in which the colour isolation arises by means of "colour rotation", predicts a scaling relationship between $F_2^{D(3)}$and F_2 which is observed in the data.

Acknowledgements

We are grateful to the HERA machine group whose outstanding efforts made this experiment possible. We appreciate the immense effort of the engineers and technicians who constructed and maintained the detector. We thank the funding agencies for their financial support of the experiment. We wish to thank the DESY directorate for the support and hospitality extended to the non-DESY members of the collaboration. We thank W. Buchmüller and A. Hebecker for many instructive discussions, and A. Vogt for confirming a misapprehension which led to incorrect interpretive statements in an earlier version of this paper.

References

[1] M. Derrick et al. (ZEUS Collaboration) Phys. Lett. **B315** (1993) 481.

[2] T. Ahmed et al. (H1 Collaboration), Nucl. Phys. **B429** (1994) 477.

[3] T. Ahmed et al. (H1 Collaboration) Phys. Lett. **B348** (1995) 681.

[4] I. Abt et al. (H1 Collaboration), "The H1 Detector at HERA", DESY preprint DESY 93–103 (1993).

[5] T. Ahmed et al. (H1 Collaboration), Nucl. Phys. **B439** (1995) 471.

[6] G. Ingelman and K. Janson–Prytz, "The Pomeron Structure Function and QCD at Small–x", in Proceedings of the Workshop "Physics at HERA", p. 233, October 1991, ed. W. Buchmüller and G. Ingelman.

[7] G. Ingelman and K. Prytz, Zeit. Phys. **C58** (1993) 285.

[8] H. Jung, Comput. Phys. Commun. **86** (1995) 147.

[9] B. List, "Diffraktive J/ψ–Produktion in Elektron–Proton–Stößen am Speicherring HERA", Diploma Thesis (Tech. Univ. Berlin), 1993 (unpublished).

[10] A. Mehta, "Measurement of the Diffractive Proton Structure Function and Calibration of the Forward Muon Detector at H1", PhD thesis (University of Manchester), 1994 (unpublished).

[11] J. Phillips, "The Deep–Inelastic Structure of Diffraction", PhD thesis (University of Manchester), 1995 (unpublished).

[12] C. Pascaud, F. Zomer, LAL preprint LAL/94-42.

[13] T. Ahmed et al. (H1 Collaboration), "The Gluon Density of the Proton at Low x from a QCD Analysis of F_2", DESY preprint DESY 95–081 (1995).

[14] M. Derrick et al. (ZEUS Collaboration), "Measurement of the diffractive structure function in deep–inelastic scattering at HERA", DESY 95–093, submitted to Zeit. Phys. **C**.

[15] W. Buchmüller, A. Hebecker, "A Parton Model for Diffractive Processes in Deep–Inelastic Scattering", DESY preprint DESY 95–077 (1995).

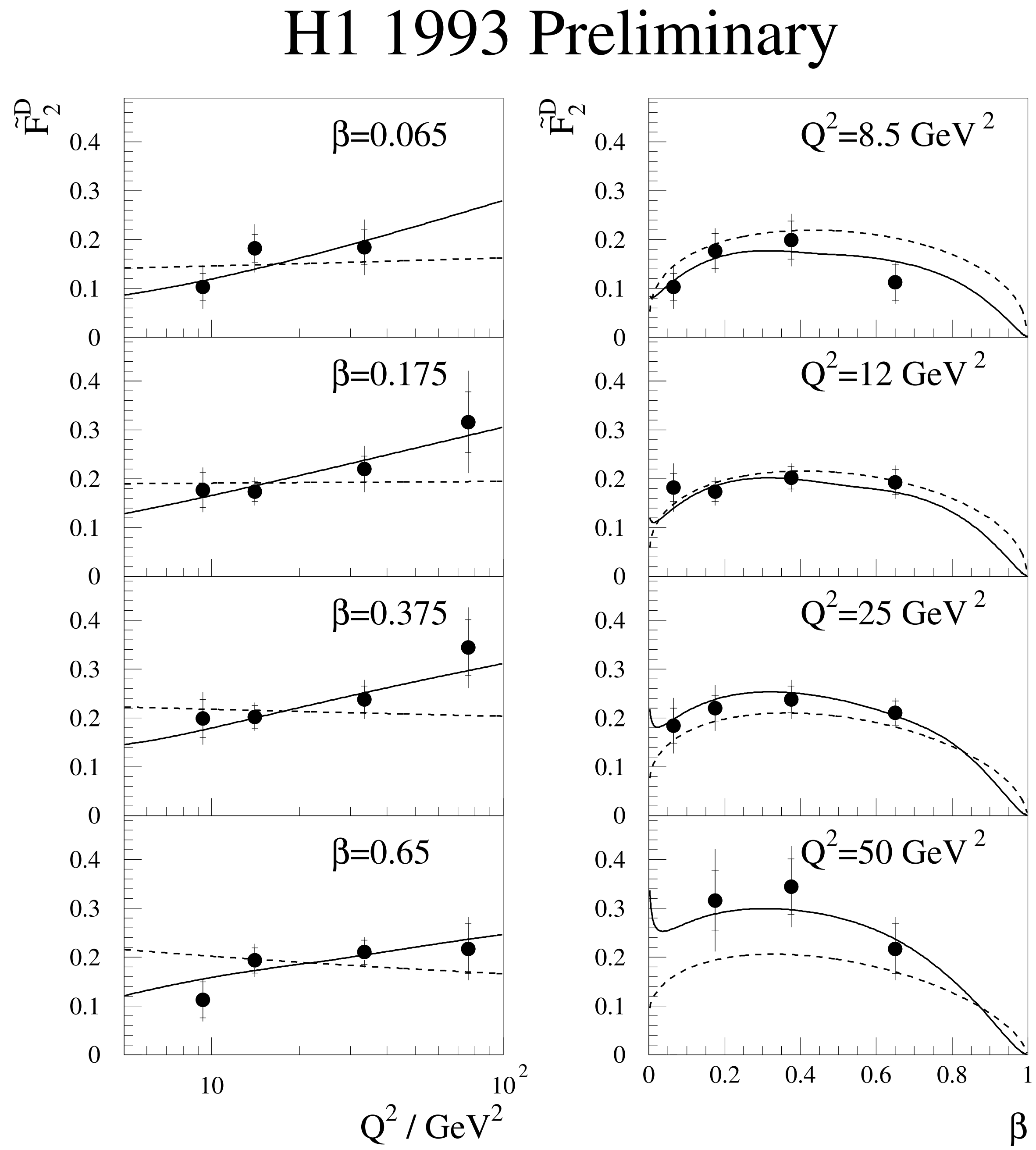

Figure 1: Dependence of $\tilde{F_2^D}$ on Q^2 and β; superimposed are the results of two LO $\log Q^2$ DGLAP QCD fits. The dashed line shows a fit in which at the starting scale, $Q_0^2 = 4\,\mathrm{GeV}^2$, diffraction is attributed to the exchange of only quarks (χ^2/dof of 13/12, 37%C.L.). The solid line shows a fit in which both quarks and gluons may contribute to the diffractive mechanism at $Q_0^2 = 4\,\mathrm{GeV}^2$ ($\chi^2/\mathrm{dof} = 4/9$, 91%C.L.). In the latter, the gluons carry $\sim 90\%$ of the momentum of the pomeron at $Q_0^2 = 4\,\mathrm{GeV}^2$.

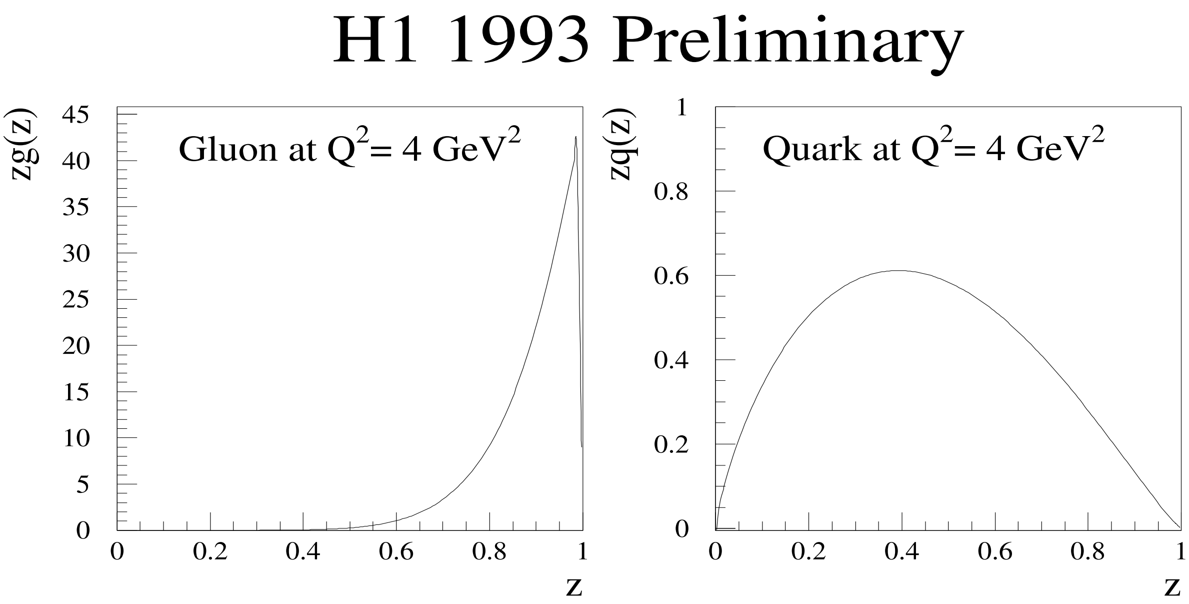

Figure 2: The quark flavour–singlet $zq(z)$ and the gluon $zg(z)$ densities at the starting scale $Q_0^2 = 4\,\mathrm{GeV}^2$ in the LO QCD description of $\tilde{F}_2^D$ which describes the well the tendency for a rise with increasing $\log Q^2$ at high β by means of a leading gluon density. The gluons account for $\sim 90\%$ of the total momentum in diffractive exchange. The normalisation is taken from the measurement of $\tilde{F}_2^D$ which itself is proportional to the structure function of diffractive exchange. The statistical preference for this solution is slight, a symmetric dependence $zg(z) = z(1-z)$ for example being consistent overall with the measurement of $\tilde{F}_2^D$ but failing to describe the tendency of the data to rise with increasing $\log Q^2$ at $\beta = 0.65$.

H1 1993 Data

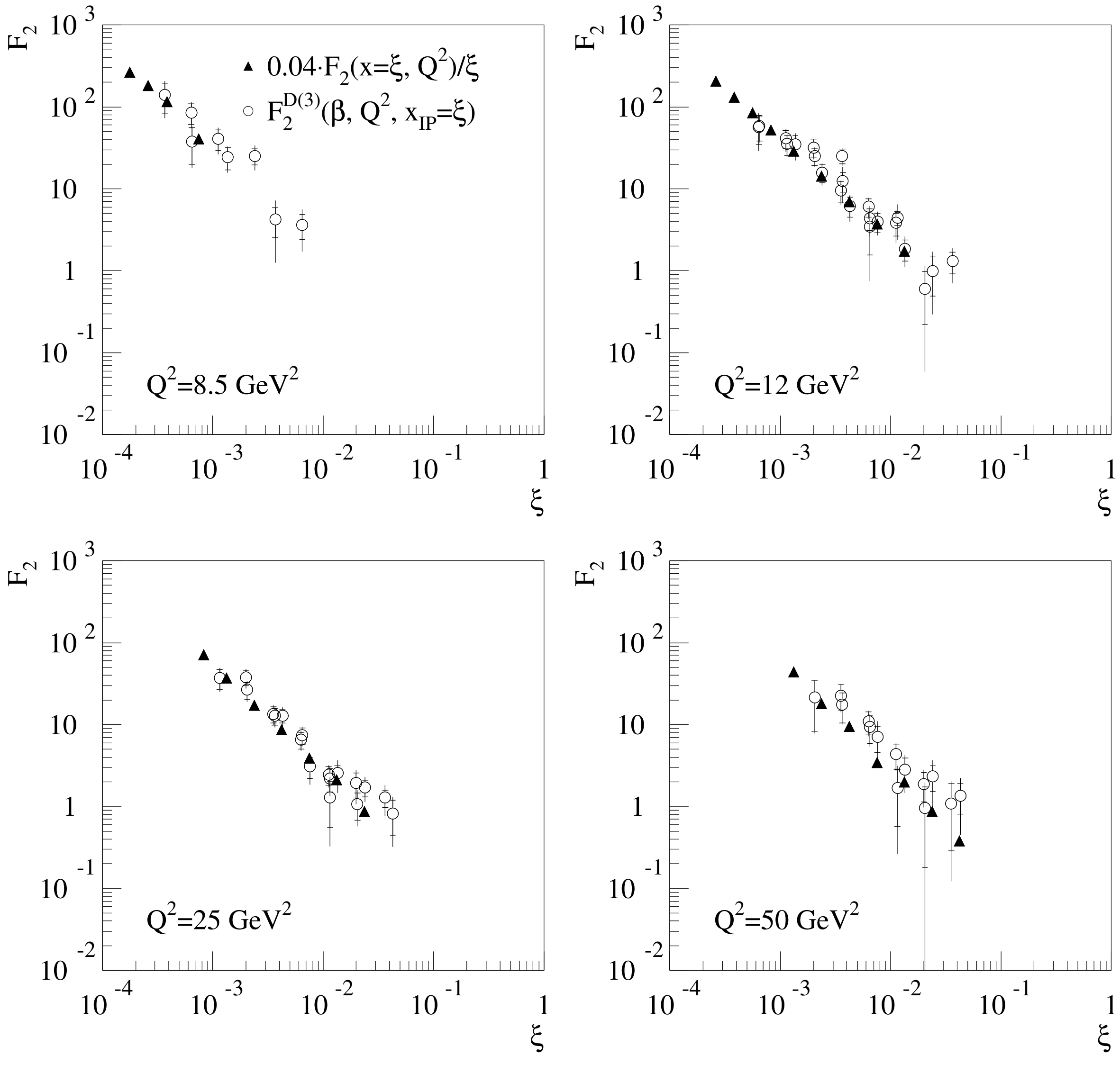

Figure 3: $F_2^{D(3)}(\beta, Q^2, x_{I\!P} = \xi)\Big|_{Q^2}$ and $0.04 \cdot F_2(x = \xi, Q^2)|_{Q^2}/\xi$ as a function of ξ for different values of Q^2 to test the scaling law of Buchmüller et al. (see text); note that the $F_2^{D(3)}$are plotted in each plot for different β.

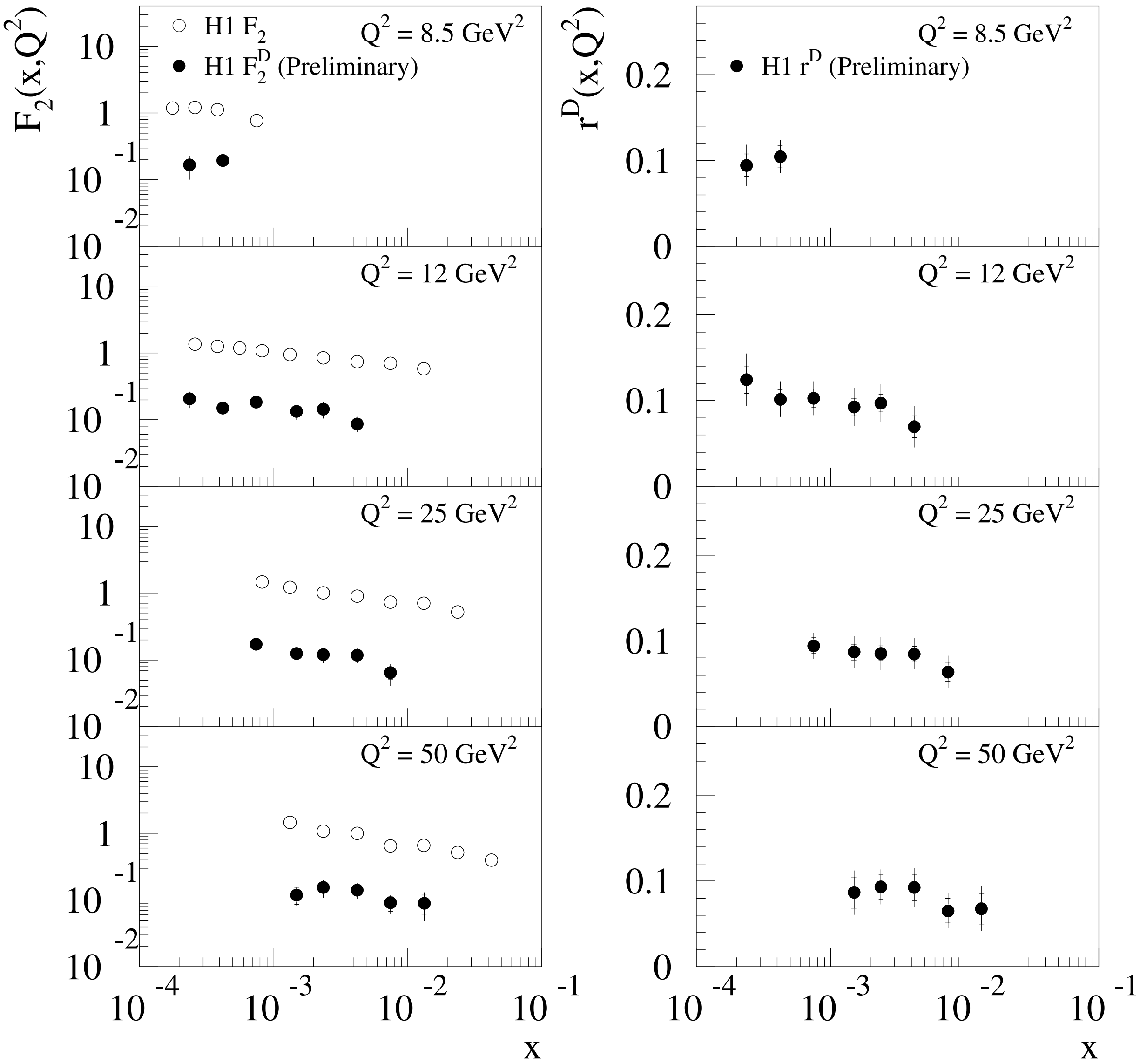

Figure 4: The structure function $F_2^D(x, Q^2)$ and the ratio $r^D = F_2^D(x, Q^2)/F_2(x, Q^2)$ for $x_{\mathbb{P}} < 0.05$ The measurement is for deep–inelastic diffraction in which the proton does not dissociate.