H1 F_2^D and Diffractive Charged Current Results

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Abstract. The high precision measurements of inclusive diffractive deep inelastic scattering are presented with the NLO DGLAP QCD fits to this data. The first differential measurements of the diffractive charged current cross-section are also presented and compared with the predictions of the fit to the neutral current data.

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INTRODUCTION

At H1 inclusive diffractive DIS events are selected on the basis of a large rapidity gap being present in the final state due to the diffractive exchange [1]. Figure 1 shows a diagram of the generic diffractive DIS process at HERA. The kinematics of DIS are given in equation 1.

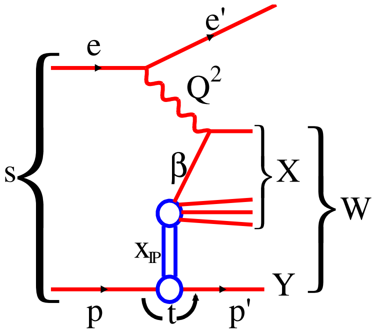

FIGURE 1. A schematic of the generic diffractive DIS process.

$$Q^2 = -q^2 = -(k-k')^2,\ x = \frac{Q^2}{2p\cdot q},\ y = \frac{p\cdot q}{p\cdot k} \tag{1}$$

Here Q^2 is the virtuality of the exchange boson, x is the Bjorken scaling variable and y is the inelasticity. They are related to the ep centre of mass energy $\sqrt{s}$ by the equation $Q^2 = sxy$. In addition to these standard DIS variables and the Mandelstam variables (t,s) the kinematic variables x_{IP} and β are useful in describing the diffractive DIS interaction. They are defined as:

$$\beta = \frac{Q^2}{Q^2+M_X^2-t}, \qquad x_{IP} = \frac{Q^2+M_X^2-t}{Q^2+W^2} \tag{2}$$

where M_X is the invariant mass of the hadronic system X and $W^2 = (q+p)^2$ is the square of the centre of mass of the photon-proton system. Assuming that the diffractive exchange can be attributed to a QCD object, i.e. a pomeron, then x_{IP} is the fractional momentum of the pomeron with respect to the proton and β is the fractional momentum of the struck parton with respect to the pomeron.

The diffractive reduced cross-section $\sigma_r^{D(3)}(\beta, Q^2, x_{IP})$ can be defined using:

$$\frac{d^3\sigma_{ep\to eXp}}{d\beta dQ^2 dx_{IP}} = \frac{4\pi\alpha_{em}^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^{D(3)}(\beta, Q^2, x_{IP}) \tag{3}$$

and can be related to the structure functions by:

$$\sigma_r^{D(3)}(\beta, Q^2, x_{IP}) = F_2^{D(3)}(\beta, Q^2, x_{IP}) - \frac{y^2}{1+(1-y)^2} F_L^{D(3)}(\beta, Q^2, x_{IP}). \tag{4}$$

and for most of the measured phase space $\sigma_r^{D(3)} = F_2^{D(3)}$ is a good approximation.

Measurements of the inclusive diffractive DIS process now cover most of the accessible kinematic range of HERA, as shown in figure 2. Also shown in figure 2 is the good agreement between the cross-sections obtained using the large rapidity gap method and measurements made by H1 [1] and ZEUS [2] where the complete final state, including the elastically scattered proton, is detected. The agreement is seen to be very good across the overlapping kinematic range[1].

Factorisation and NLO QCD

It has been proven by Collins [3] that the diffractive $\gamma^* p$ cross-section can be written in terms of diffractive PDFs, $q(x, Q^2, x_{IP}, t)$, which are dependent on four kinematic variables, convoluted with a hard-scattering cross-section:

$$\sigma(\gamma^* p \to Xp) \;\sim\; q(x_{IP}, t, x, Q^2) \;\otimes\; \hat{\sigma}_{\gamma^* q}(x, Q^2) \tag{5}$$

At fixed x_{IP} and t these PDFs will evolve with Q^2 and x in exactly the same way as the inclusive proton PDFs. Such a proof allows a full QCD fit to the data with no additional assumptions. At the present time the necessary technical knowledge is as yet unavailable to make such a fit. Instead the H1 Collaboration proceed via an assumption supported by the data that the x_{IP} dependence of the data can be modelled using a Regge-motivated parameterisation [1] (flux factor). This allows the extraction of the diffractive PDFs shown in figure 3. Also shown in figure 3 is the diffractive reduced cross-section divided by the flux factor as a function of β for different Q^2 and x_{IP} bins. The agreement between overlaid x_{IP} bins supports the ansatz that the flux factor contains all of the x_{IP} dependence of the data.

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[1] A factor of 1.1 is applied to the elastic proton data to scale it to the same M_Y range as the large rapidity gap data

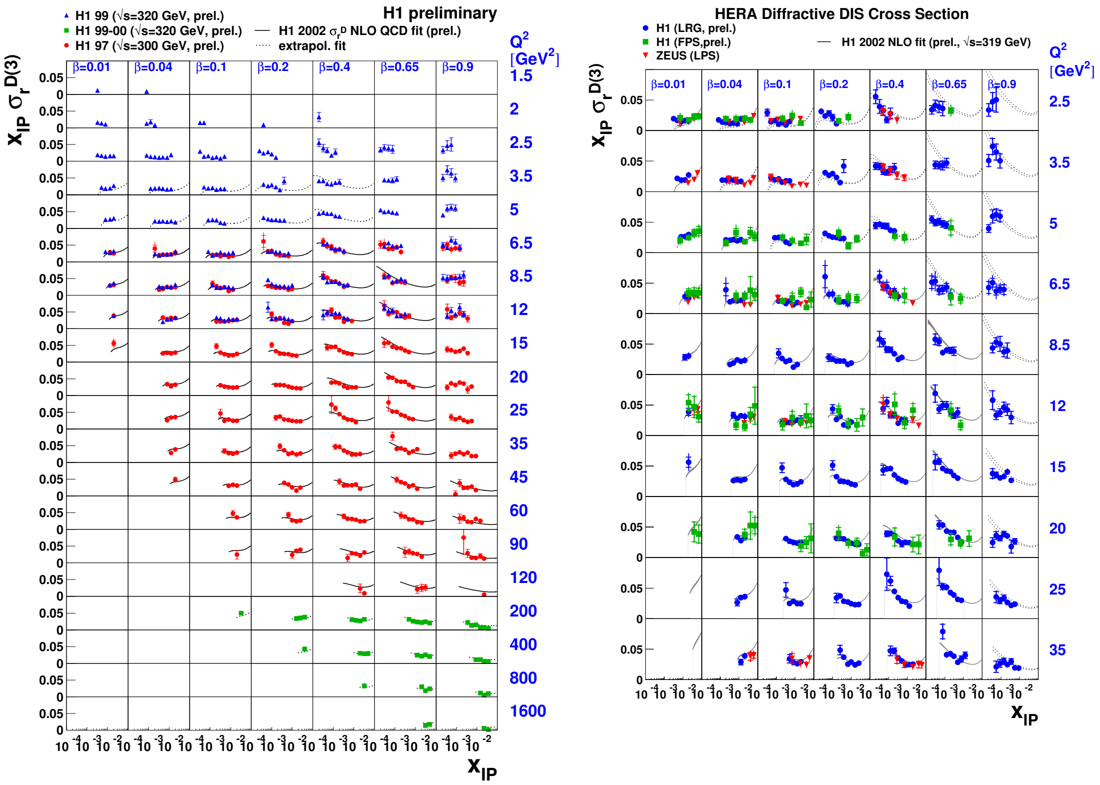

FIGURE 2. Measurements from H1 of the inclusive diffractive cross-section across the full kinematic range at HERA (left) and (right) a comparison of the large rapidity gap data with elastic proton data from both H1 and ZEUS; good ageement is seen between the two experimental techniques.

DIFFERENTIAL DIFFRACTIVE CHARGED CURRENT CROSS-SECTIONS

The large rapidity gap method can also be applied to charged current data to select a sample of events with a large rapidity gap in the final state [4]. The total cross-section for this process, for the kinematic range $Q^2 > 200\,\mathrm{GeV}^2$, $y < 0.9$ and $x_{IP} < 0.05$ is $0.42 \pm 0.13(\mathrm{stat}) \pm 0.09(\mathrm{sys})$pb, in good agreement with the prediction of 0.43pb obtained from the NLO DGLAP QCD fit to neutral current data described above. The ratio of this diffractive charged current process to the inclusive charged current process (for $x_{Bjorken} < 0.05$) for the kinematic range defined above is $2.5 \pm 0.8 \pm 0.6\%$.

The differential cross-section as a function of x_{IP} is shown for this event class in figure 4 compared to the prediction of the fit. Figure 4 also shows the differential cross-sections as a function of Q^2 and β. Reasonable agreement is seen between the data and the fit prediction for all three kinematic variables.

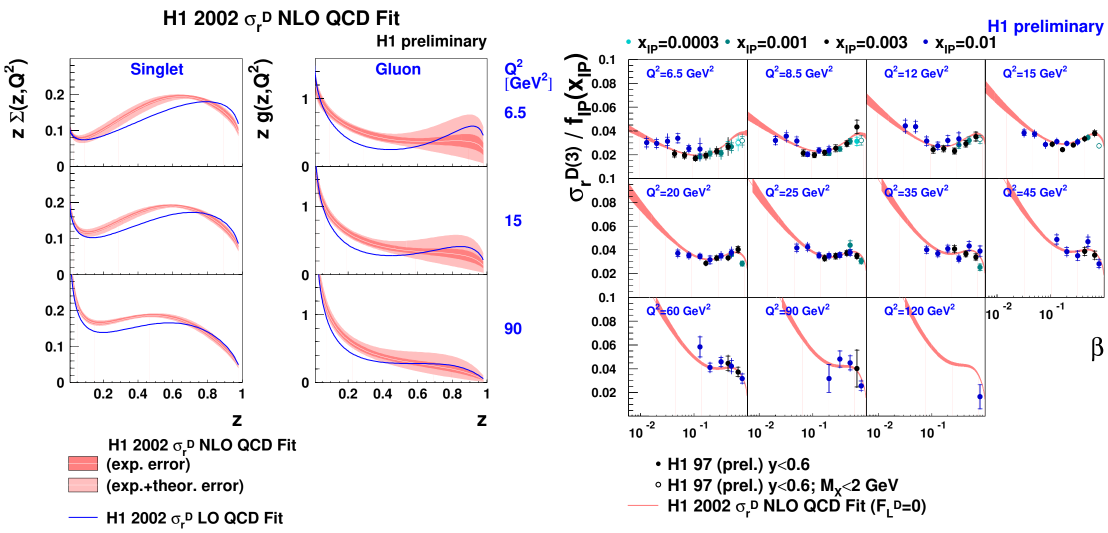

FIGURE 3. Diffractive PDFs extracted by H1 from their inclusive cross-section measurements (left) and (right) the diffractive reduced cross-section divided by the flux factor as a function of β for different Q^2 and x_{IP} bins.

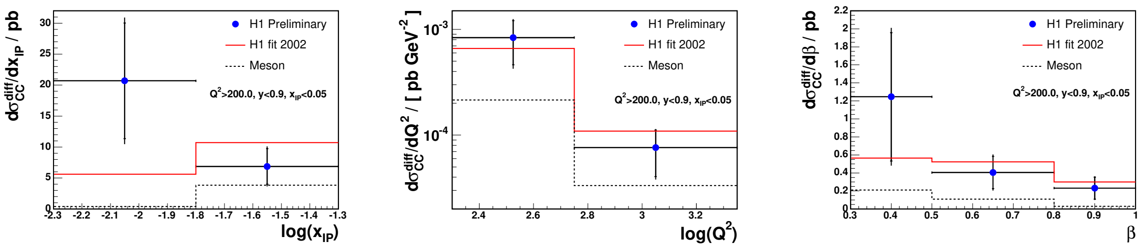

FIGURE 4. The Differential Diffractive Charged Current Cross-section as a function of x_{IP}, Q^2 and β

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