Diffractive Final States and Tests of QCD Factorisation*†

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Measurements of hard diffractive final states performed with the H1 experiment at HERA are presented and confronted with predictions based on diffractive parton densities.

1 Introduction

The diffractive structure function of the proton has been measured in inclusive diffractive deep-inelastic ep scattering (DDIS) by the H1 collaboration [1, 2, 3]. The data are compatible with the decomposition of the structure function into a flux factor and the structure function of a colourless exchange (pomeron). In DGLAP fits, leading order (LO) and next-to-leading order pomeron parton densities (PPDFs) have been extracted and found to be dominated by the gluon distribution [1, 2, 3].

It has been proven within QCD [4] that in DDIS the cross section can be written as a convolution of the diffractive parton densities of the proton with the hard parton-photon cross section. Diffractive dijet and D^* meson (heavy quark) production are directly sensitive to the dominant diffractive gluon through the boson gluon fusion production mechanism (Fig. 1) and are used to test QCD hard scattering factorisation in diffraction. A photon of virtuality Q^2 undergoes a hard scatter with a diffractive gluon forming a $q\bar{q}$ pair. The centre-of-mass energy of the hard scattering process is labelled M_{12}. The gluon carries a fraction $z_{I\!P}$ of the pomeron momentum. The pomeron carries a fraction $x_{I\!P}$ of the proton momentum. The γp and pomeron-proton centre-of-mass energies are denoted by W and M_X, respectively. The data are compared to the LO

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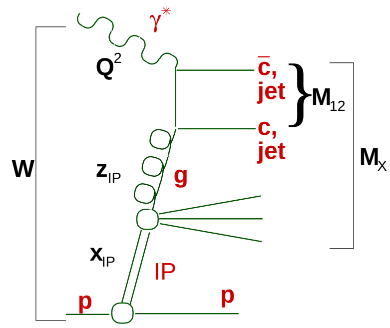

Figure 1: Boson gluon fusion process in DDIS.

predictions of the Monte Carlo program RAPGAP [5]. Higher-order effects are modelled by using parton showers. The predictions are based on the pomeron model [6] with flux factor and LO PPDFs as extracted in inclusive DDIS. The PPDFs from the 'H1 fit 2' [1] and the new 'H1 2002 fit' [2] to more precise data are used.

2 Hard Final States in Diffractive Deep-Inelastic Scattering

In Fig. 2, differential cross sections for D* production in DDIS ($2 < Q^2 < 100$ GeV^2, $x_{I\!P} < 0.04$, $E_T^{D^*} > 2$ GeV) are shown [2, 7]. The new 'H1 2002 fit' based prediction describes the data well. The 'H1 fit 2' predicts a ≈25% larger rate. This difference is of the order of the uncertainty arising through the precision with which the gluon density is known. Differential cross sections for dijet production in DDIS ($4 < Q^2 < 80$ GeV^2, $x_{I\!P} < 0.01$, $E_T^{\mathrm{jet}1,2} > 4$ GeV) [2, 8] are shown in Fig. 3. Both predictions give a good description of the shapes and normalisation of the data. The predictions based on PPDFs extracted in inclusive DDIS describe DDIS dijet and D* production within the uncertainties of the PPDFs. At the present level of accuracy, QCD hard scattering factorisation holds in DDIS.

3 Dijets in Diffractive Photoproduction

In diffractive dijet photoproduction ($Q^2 < 0.01$ GeV^2, $x_{I\!P} < 0.03$, $E_T^{\mathrm{jet}1} > 5$ GeV, $E_T^{\mathrm{jet}2} > 4$ GeV) at HERA [9], the quasi-real photon can fluctuate into a hadronic system of which a parton with momentum fraction x_γ undergoes the hard scatter ('resolved photon' process). In 'direct photon' processes (x_γ=1),

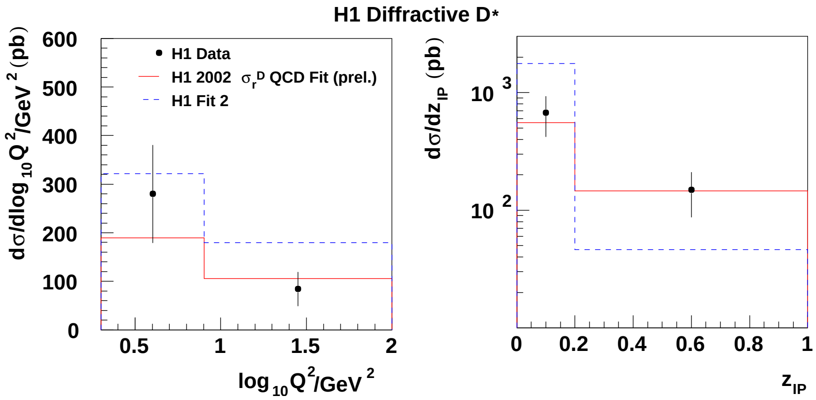

Figure 2: Differential cross sections for D* production in DDIS.

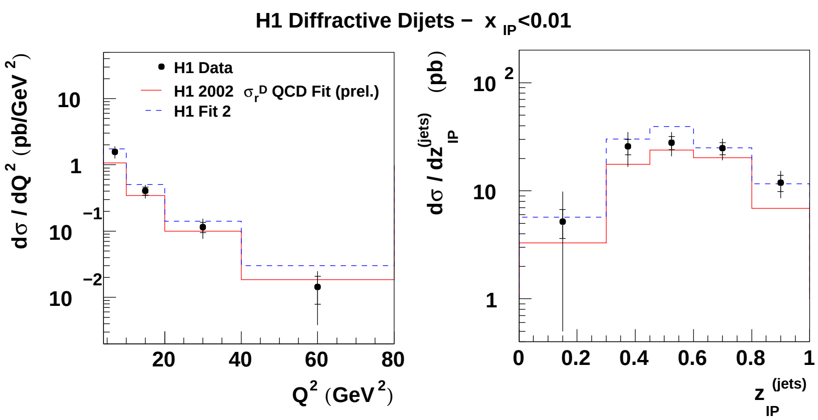

Figure 3: Differential cross sections for dijet production in DDIS.

the photon itself enters the hard scatter. The cross section for dijet production is shown in Fig. 4a[1] as a function of x_γ. The prediction based on the 'H1 2002 fit' gives a good description both in shape and normalisation throughout the x_γ range. The cross section is shown in Fig. 4b as a function of $z_{I\!P}$. The 'H1 fit 2' prediction overestimates the normalisation of the data by a factor ≈1.4. The difference of the predictions is of the order of the uncertainty arising from that of the gluon distribution. Both predictions give good descriptions of the measured shape. Normalised differential cross sections in other characteristic

[1]In the comparisons shown at the DIS'03 conference, incorrect values for α_s were used for the predictions, resulting in dijet cross sections which were too large by a factor ≈1.4.

variables are shown in Fig. 5. The variable y relates the ep and γp centre-of-mass energies $\sqrt{s}$ and W via $W = \sqrt{y\,s}$. All shapes are described by the predictions.

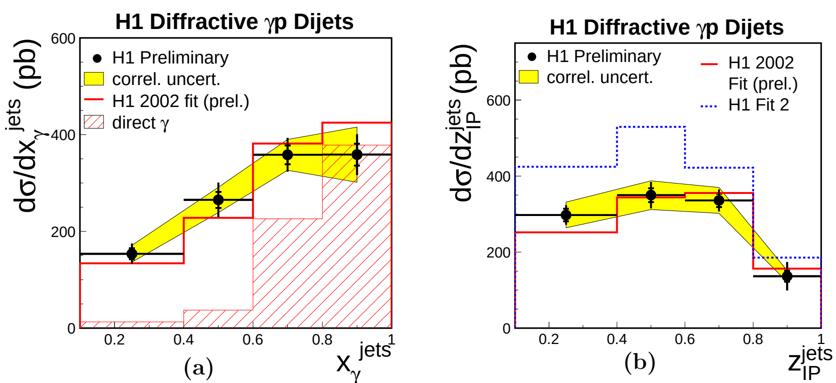

Figure 4: Differential cross sections for diffractive dijet photoproduction.

Using the pomeron model to relate the measurements, diffractive dijet cross sections in DIS and photoproduction can be compared. In photoproduction a suppression relative to DIS is found of 1.3±0.3 (exp.), where the uncertainty is estimated from the total experimental errors of both measurements only. The factor is independent of the PPDFs used. The suppression is not significant at the present level of precision and there is no evidence that it differs between direct and resolved photon processes.

4 Conclusions

In diffractive DIS, measured dijet and D* production cross sections are in agreement with predictions which rely on QCD factorisation. For diffractive dijet photoproduction, an overall suppression factor relative to DIS of 1.3±0.3 (exp.) is found which does not differ between direct and resolved photon processes. The diffractive γp dijet cross sections are compatible with the predictions within the relatively large uncertainties of the data. This is in contrast to the situation in hadron-hadron collisions at Fermilab where a large suppression of the single-diffractive dijet cross section relative to predictions using DIS pomeron parton densities is observed.

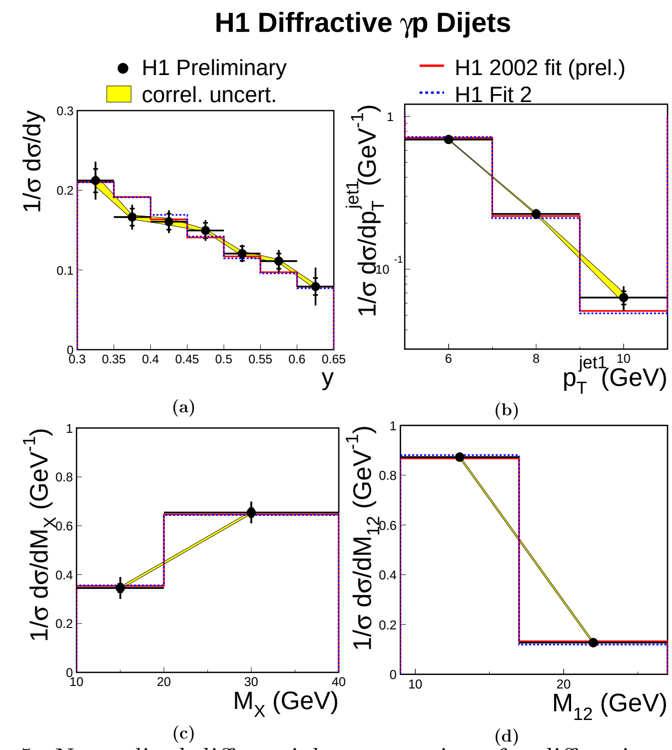

Figure 5: Normalised differential cross sections for diffractive dijet photoproduction.

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