Diffractive production of charm and jets

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Measurements of $D^{*\pm}$ meson and dijets diffractive production at HERA are presented and compared with predictions which are based on diffractive parton densities. The measurements use data taken with the H1 detector during the years 1996 to 2000.

1. Introduction

In Quantum Chromodynamics (QCD) the cross sections for hadronic and ep processes factorise into universal parton densities (PDFs) and process-dependent hard scattering coefficients (collinear QCD Factorisation). This is also expected to be the case in diffractive DIS (DDIS) [1]. The diffractive PDFs (DPDFs) have been extracted from the inclusive DDIS cross section via a DGLAP QCD fit. If QCD factorisation is valid in diffractive ep scattering, these DPDFs are universal and can be used to predict cross sections for exclusive hard diffractive processes.

At the ep collider HERA diffractive production of heavy quark and dijets are directly sensitive to the dominant diffractive gluon through the boson gluon fusion process and are used to test QCD hard scattering factorisation in diffraction. QCD factorisation is tested in DIS with leading order (LO) and next-to-leading order (NLO) Monte Carlo predictions with $D^{*\pm}$ meson and dijets data. In the photoproduction regime diffractive dijets data are compared with LO and NLO predictions.

2. Kinematics

The electron exchanges a photon which interacts with the proton, which loses only a small fraction $x_{I\!P}$ of its incident momentum. The photon and proton dissociate into two distinct hadronic system X and Y. The two systems are separated by a large rapidity gap.

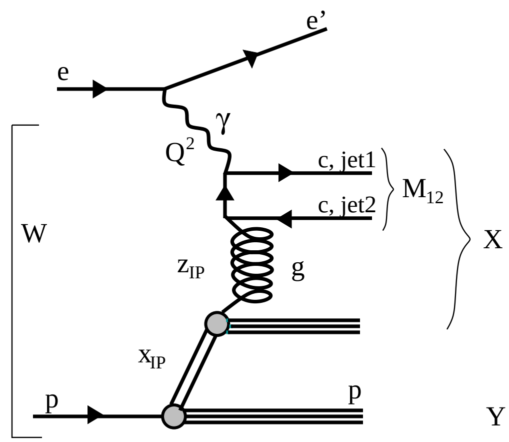

Figure 1. *Diffractive charm or jet production at HERA.*

The longitudinal momentum fraction of the parton entering the hard scattering process relative to the diffractive exchange is labelled $z_{I\!P}$. W is the photon-proton centre-of-mass energy and s correspond to the squared ep centre-of-mass energy.

3. D* Meson Production in Diffractive DIS

The D^{*+} mesons are reconstructed [2] using the decay channel $D^{*+} \to D^0\pi^+_{slow} \to (K^-\pi^+)\pi^+_{slow}$ which has a branching fraction of 2.57% [3]. The resulting number of D^* mesons 140±16 is obtained from a fit of the distribution of $\Delta m = m_{D^*} - m_{D^0}$.

Cross sections for D^* meson production [2]

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were calculated for the following kinematic range $2 < Q^2 < 100\ GeV^2$, $0.05 < y_{bj} < 0.7$, $x_{I\!P} < 0.04$ and $p_{t_{D^*}} > 2\ GeV$.

NLO QCD calculations were done using a diffractive version of the program HVQDIS [4,5] with the NLO diffractive densities. For this calculation the renormalization and factorisation scale were set to $\mu_f^2 = \mu_r^2 = Q^2 + 4m_c^2$. The Peterson fragmentation function was used with $\epsilon = 0.078$. The uncertainties on the NLO calculation correspond to a variation of the renormalization scale μ_r^2 by factors of 1/4 and 4, a variations of the charm mass within $m_c = 1.3 \cdots 1.65$ GeV and a variation of the ϵ parameter between 0.035 and to 0.1.

Figure 2 shows a comparison of this calculations with the data. The inner error band of the NLO calculation corresponds the renormalisation scale uncertainty, whereas the outer error band includes variations of m_c and ϵ.

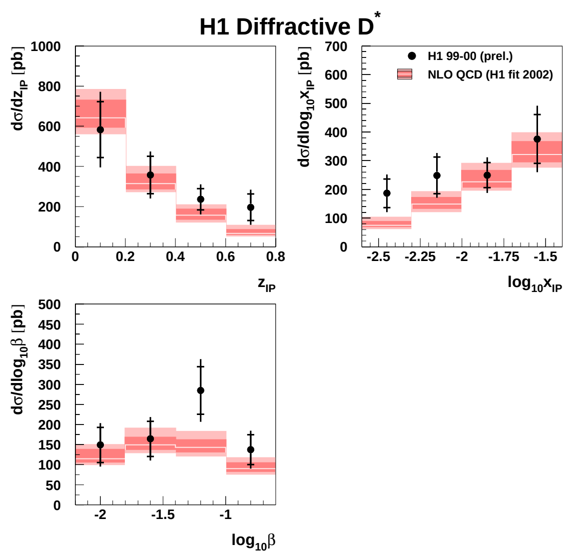

Figure 2. *Differential cross sections for diffractive DIS D^* production as a function of $z_{I\!P}$, $x_{I\!P}$ and β.*

4. Dijet Production in Diffractive DIS

In [6] H1 cross sections were measured for the kinematic range $Q^2 > 4\ GeV^2$, $x_{I\!P} < 0.03$, $E_T^{*,jet1(2)} > 5(4)\ GeV$. Jets are formed from the tracks and clusters of the hadronic final state X, using the incusive k_T cluster algorithm [7].

The DISENT program [8] interfaced to the H1 diffractive NLO PDFs is used for the calculation of diffractive dijet cross sections to NLO. The renormalisation scale was set to the transverse energy of the leading jet $\mu_r = E_T^{*,jet1}$, the factorization scale to $\mu_f = 6.2$ GeV. Since the calculations refer to jets of partons, whereas the measurements refer to jets of hadrons, the calculated NLO cross sections are corrected for the effect of hadronisation. The measured cross sections are in good agreement with the NLO calculations as shown in figure 3. A good agreement with the LO PAPGAP MC is also observed.

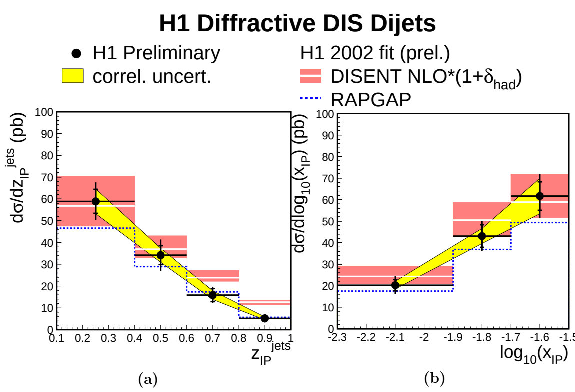

Figure 3. *Diffractive dijets cross sections compared with NLO and RAPGAP MC predictions.*

Outer error bars around the data points represent the quadratic sum of the statistical and uncorrelated systematic errors. The shaded band shows correlated normalisation uncertainties. The band around the NLO prediction indicates the uncertainty resulting from the variation of the renormalisation scale.

The D^* and dijet cross sections are in a good agreement with NLO. We conclude that in diffractive DIS collinear QCD factorisation is applicable.

5. Diffractive Dijet in Photoproduction

To obtain NLO cross sections for diffractive dijet photoproduction ($Q^2 < 0.01\ GeV^2$, $E_T^{*,jet1(2)} > 5(4)\ GeV$ and $x_{I\!P} < 0.03$) the program by Frixione et al. was used, which is also interfaced to the NLO diffractive parton distributions. The factorisation scale and the renormalisation scale were set to $\mu_r = \mu_f = E_T^{*,jet1}$.

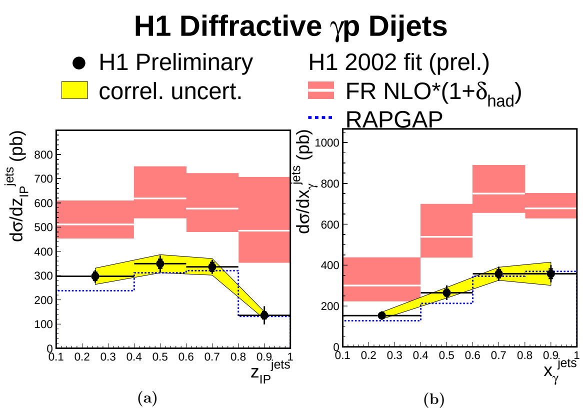

Figure 4. *Diffractive dijets photoproduction cross section differential in $z_{I\!P}$, x_γ.*

The uncertainty shown on the NLO calculation on figure 4 results from simultaneous variations of the renormalisation and factorisation scales by factors 0.5 and 2. The NLO prediction overestimates the cross section by a factor of ≈ 2.

Figure 5 presents the ratio of the measured cross section to that predicted by the NLO calculation, as a function of inelasticity variable y in the DIS and photoproduction. The range of y variable corresponds to a range of $165 < W < 242$ GeV for the γp centre-of-mass energy. Integrated over the measured kinematic range the ratio of data to NLO calculations for photoproduction is a factor 0.5 smaller than the same ratio in DIS.

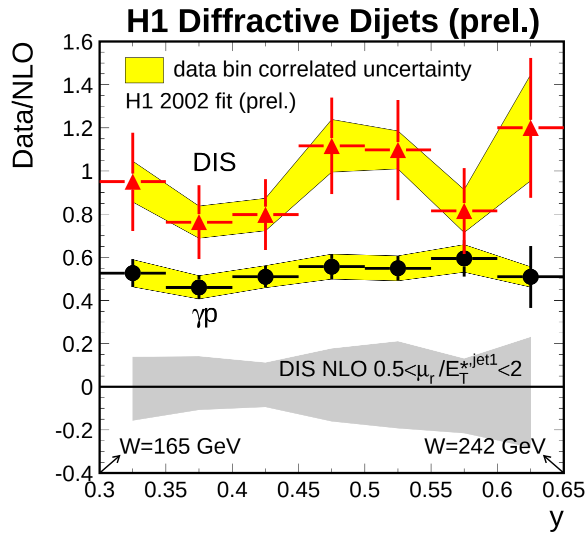

Figure 5. *Ratio of measurements to NLO predictions.*

6. Conclusions

Measurements of diffractive DIS D^* meson and dijet production cross sections are compatible with the concept of QCD factorisation. In photoproduction, the NLO calculation overestimates the dijet rate significantly, which shows a breaking of QCD factorisation in diffractive dijet photoproduction with respect to the same process in DIS.

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