Diffractive Dijet Production with LRG in DIS at HERA

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On Behalf of H1 Collaboration

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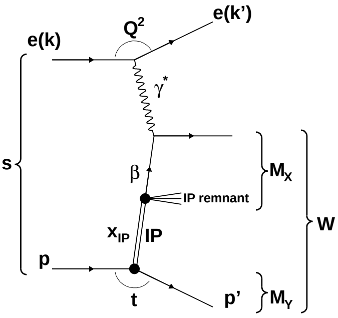


- Photon virtuality $Q^2 = -q^2 = -(k - k')^2$
- Inelasticity $y = \frac{p.q}{p.k}$
- Proton momentum fraction entering diffractive exchange $x_{I\!P} = \frac{q.(p-p')}{q.p}$
- Pomeron momentum fraction entering hard scattering $\beta = \frac{x}{x_{I\!P}}$
- Squared momentum transfer at proton vertex $t = (p - p')^2$ - not measured, cross section integrated over t

- Diffractive scattering characterized by $|t| \ll s$ and $M_X^2 \ll s$, $\sim$ 10% of DIS events observed at HERA
- Proton vertex: either outgoing proton (elastic diffraction, $M_Y = m_p$) or low mass excitation (proton dissociation, $M_Y > m_p$)

Factorization Theorem

Diffractive cross section factorizes into

- partonic cross section $\hat{\sigma}^{\gamma^* i}$ (process dependent, calculable in pQCD)
- DPDF f_i^D (process independent, DGLAP evolution)

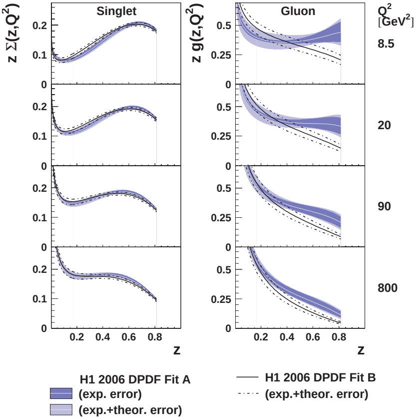
$$\sigma^{D(4)}(\gamma^* p \to Xp) \propto \sum_{parton\ i} \hat{\sigma}^{\gamma^* i}(x, Q^2) \otimes f_i^D(\beta, Q^2, x_{I\!P}, t)$$

- QCD factorization proven for inclusive and dijet diffractive DIS processes (Collins 1998).
- DPDF determined in QCD analysis of inclusive diffractive data

Assumption of factorization in proton vertex (Regge factorization),

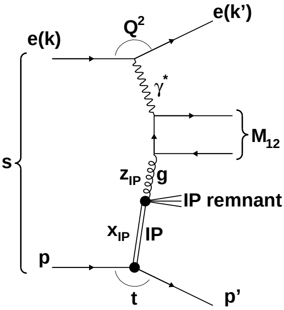
- not proven on theoretical basis, experimental "Ansatz"
- DPDF $x_{I\!P}$ and t dependence factorized into pomeron flux factor $f_{I\!P/p}$

$$f_i^D(\beta, Q^2, x_{I\!P}, t) = f_{I\!P/p}(x_{I\!P}, t) \cdot f_i^{I\!P}(\beta, Q^2)$$



From Eur. Phys. J. C48 (2006) 715-748 (hep-ex/0606004)

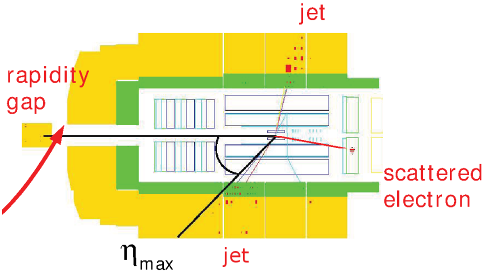
- DPDFs dominated by gluon component (75%)
- Two jets in final state mostly produced via BGF
- Dijet data provide constrain to gluon DPDF
- gluon momentum fraction $z_{I\!P} = \frac{q \cdot v}{q \cdot (p - p')}$, v denotes four-momentum of gluon



Motivation for Current Measurement

- Previous H1 and ZEUS DDIS dijet results available:
  - LRG measurement (H1), JHEP 0710:042,2007 [arxiv:0708.3217]
  - LRG measurement (ZEUS), Europ. Phys. Journal C 52 (2007) 813-832
  - Proton tagging (H1), Eur. Phys. J. C72 (2012) 1970 [arxiv:1111.0584]
  - Proton tagging (H1), presented at DIS 2014
- Presented analysis profits from the highest luminosity compared to former H1 and ZEUS measurements.
- First LRG analysis with corrections for detector effects calculated making use of detector response matrix (program TUnfolfd)

- HERA data 2005/2006e^- and 2006/2007e^+ with integrated luminosity $\sim 290\text{pb}^{-1}$
- DIS events selected by identification of scattered electron (positron)
- Diffraction - presence of Large Rapidity Gap (LRG) required
- Events with at least two jets of transverse momentum above threshold in $\gamma^* p$ frame are selected



DDIS Dijet Selection
$4 < Q^2 < 80$ GeV^2 $0.1 < y < 0.7$
$p^*_{T,1} > 5.5$ GeV $p^*_{T,2} > 4.0$ GeV $-1 < \eta_{1,2} < 2$
$x_{I\!P} < 0.03$ $\lvert t\rvert < 1$ GeV^2 $M_Y < 1.6$ GeV

- $\sim$ 14000 events accepted
- Data unfolded to hadron level using TUnfold, response matrix determined from MC generator RAPGAP
- QED radiation effects corrections applied to data, determined by means of RAPGAP

Theoretical Predictions

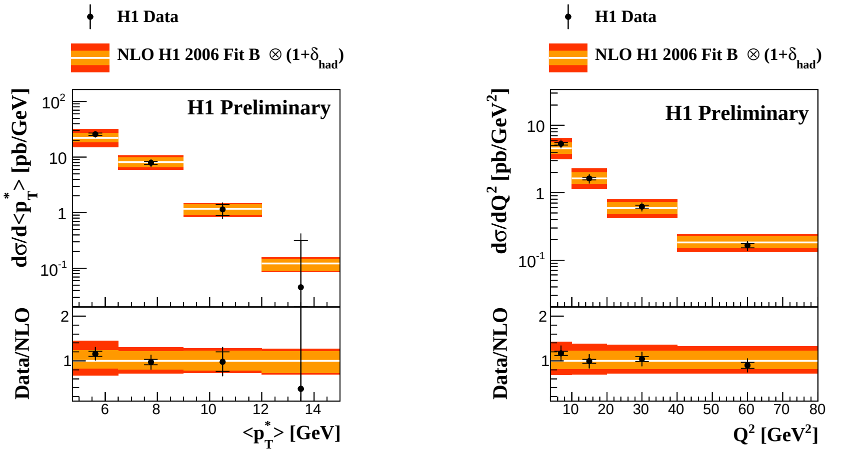
- Measured cross sections are compared to NLO QCD calculations

  $\mu_r^2 = \mu_f^2 = p_{T,1}^{*2} + Q^2$
  $N_f = 5$
  $\Lambda_{QCD} = 0.22$ MeV

- Program NLOJET++ with DPDF H1 2006 Fit B
- Results compared at level of stable hadrons
- Hadronization corrections calculated by means of LO MC generator with parton showers (RAPGAP)
- Uncertainty: scale variation $(0.5\mu_{f,r}, 2\mu_{f,r})$, DPDF uncertainty, hadronization

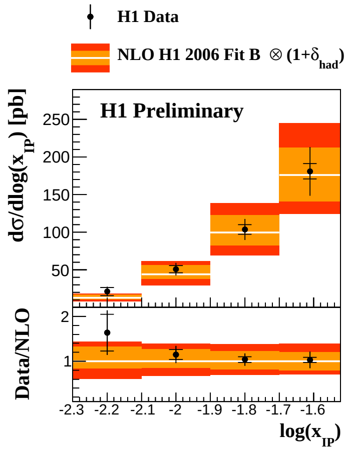
Results

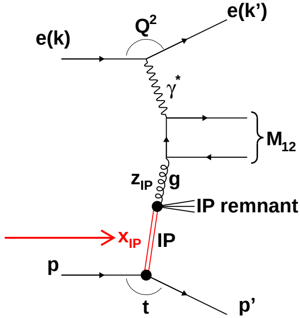
Cross Section in $\langle p_T^* \rangle$ and Q^2



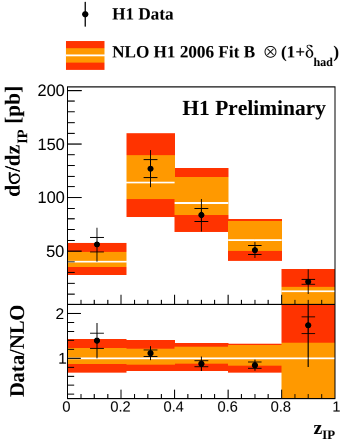
- Inner error bars of data points represent statistical uncertainty, outer error bars include systematic uncertainties added in square
- NLO QCD prediction inner band - uncertainty of hadronization and DPDF fit added in square, outer band - includes QCD scale uncertainty

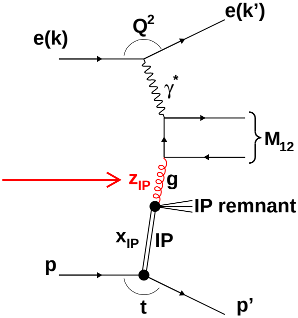
Cross Section in $x_{I\!P}$





- Pomeron momentum fraction - data well described by prediction within experimental and theory uncertainty





- Experimental uncertainty of measurement in $z_{I\!P}$ lower than DPDF fit uncertainty, gluon DPDF might be further constrained
- NLO prediction at high $z_{I\!P}$ consistent with zero due to DPDF fit uncertainty, DPDF extrapolated for $z_{I\!P} > 0.8$

- Diffractive dijet cross sections in DIS measured using LRG method
- Analysis with unprecedentedly high statistics, more elaborated treatment of detector effects corrections
- Precise measurement in $z_{I\!P}$ - possible constrain of gluon DPDF
- NLO QCD predictions describe data within uncertainties, further experimental evidence on factorization theorem validity

Backup

Reconstruction of Kinematic Variables

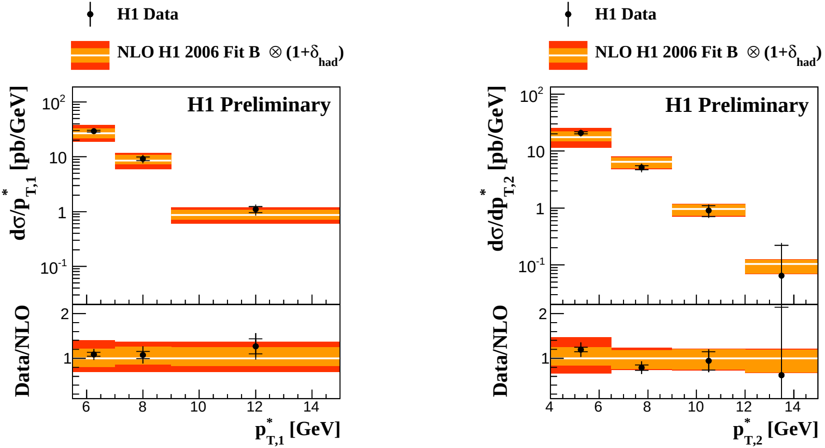
$$Q_e^2 = E_e E_{e'} (1 + \cos\theta_e)$$

$$y_{e\Sigma} = \frac{Q_e^2}{x_\Sigma \cdot s}$$

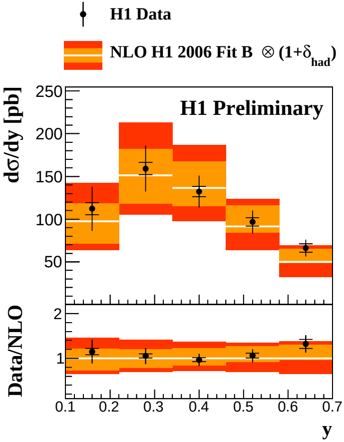
$$M_X^2 = (\sum_X p)^2$$

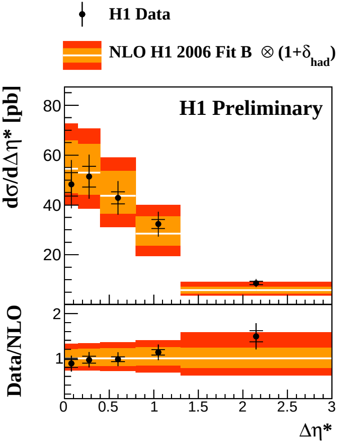
$$x_{I\!P} = \frac{Q^2 + M_X^2}{Q^2 + W^2}$$

$$z_{I\!P} = \frac{Q^2 + M_{12}^2}{Q^2 + M_X^2}$$


H1 Data
NLO H1 2006 Fit B ⊗ (1+δ_had)
H1 Preliminary
dσ/p*_T,1 [pb/GeV]
Data/NLO
p*_T,1 [GeV]
H1 Data
NLO H1 2006 Fit B ⊗ (1+δ_had)
H1 Preliminary
dσ/dp*_T,2 [pb/GeV]
Data/NLO
p*_T,2 [GeV]

Cross Section in y and $\Delta\eta^*$





Correction for Detector Effects

- $\tilde{y}_i$ - data at detector level measured in bin i (expected average count)
- $\tilde{x}_j$ - cross section at hadron level in bin j
- b_i - background contribution, determined from MC simulation
- A_{ij} - detector response matrix, determined from MC simulation, includes migrations beyond phase space limits

$$\tilde{y}_i = \sum_{j=1}^{m} A_{ij}\tilde{x}_j + b_i,\ 1 \leq i \leq n,\ m \leq n \tag{1}$$

- True distribution $\tilde{x}_j$ found by means of least square method, Tikhonov regularization involved (response matrix singular in general)
- Method implemented in software package TUnfold