Recent Results on Diffraction at HERA

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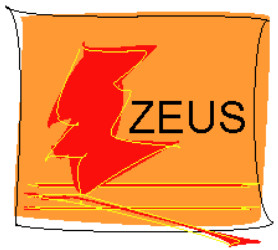
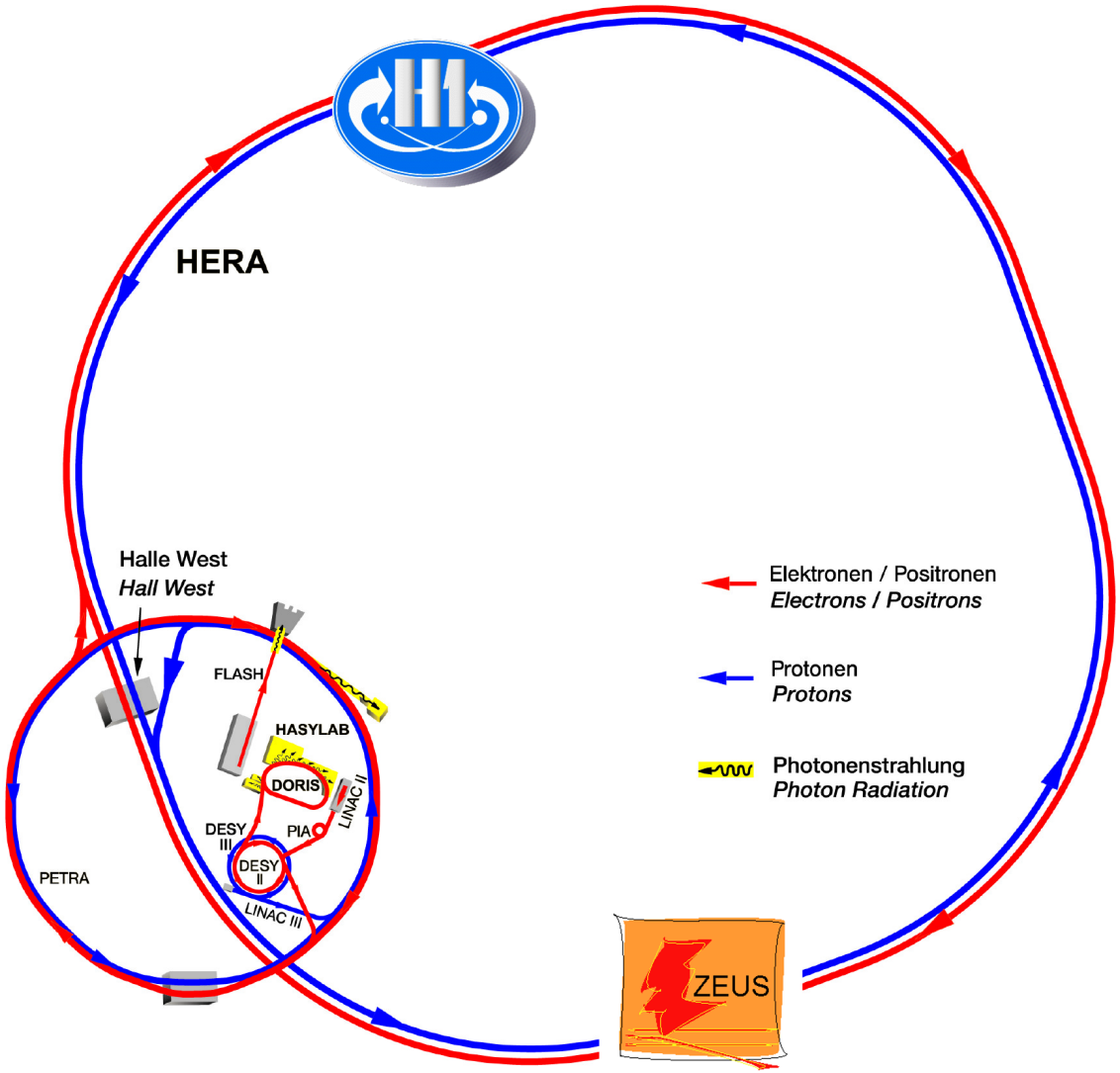
on behalf of H1 and ZEUS Collaborations

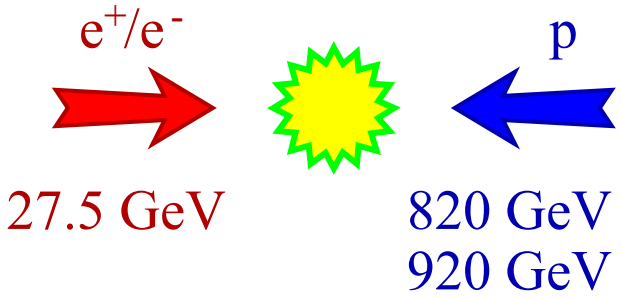
5 February 2014



HERA

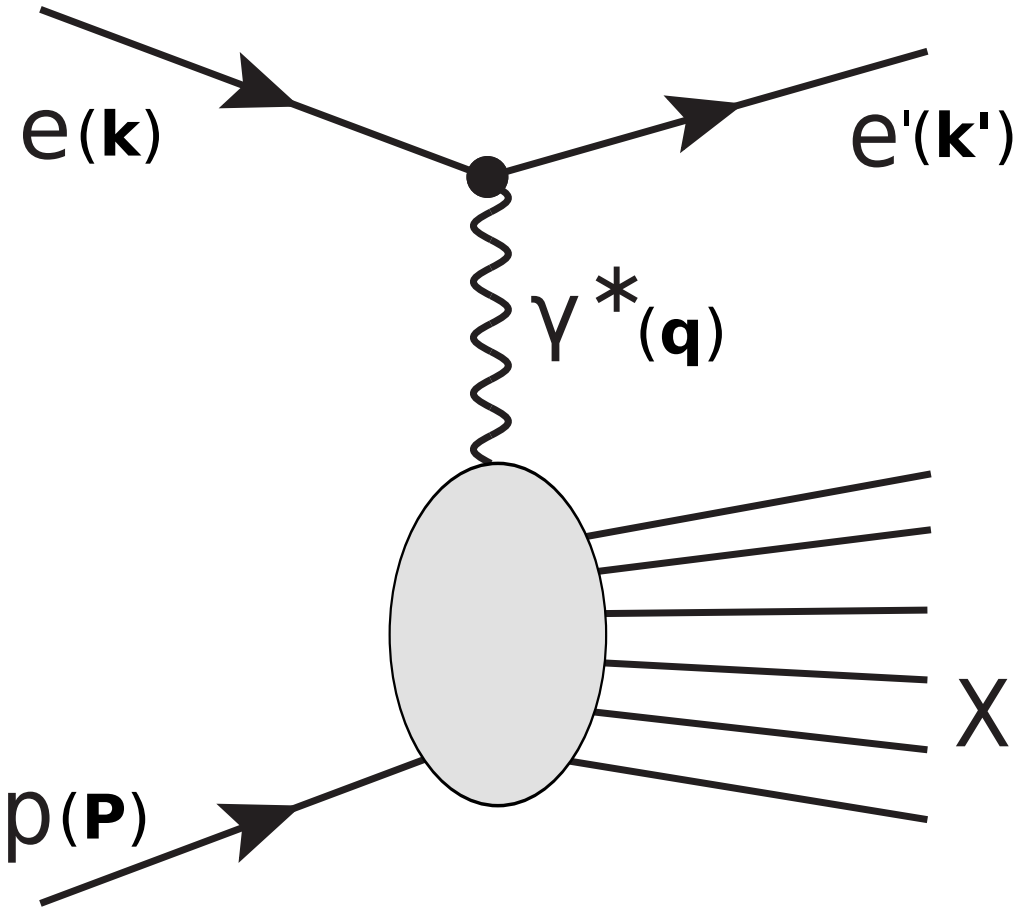


DESY, Hamburg
1992-2007



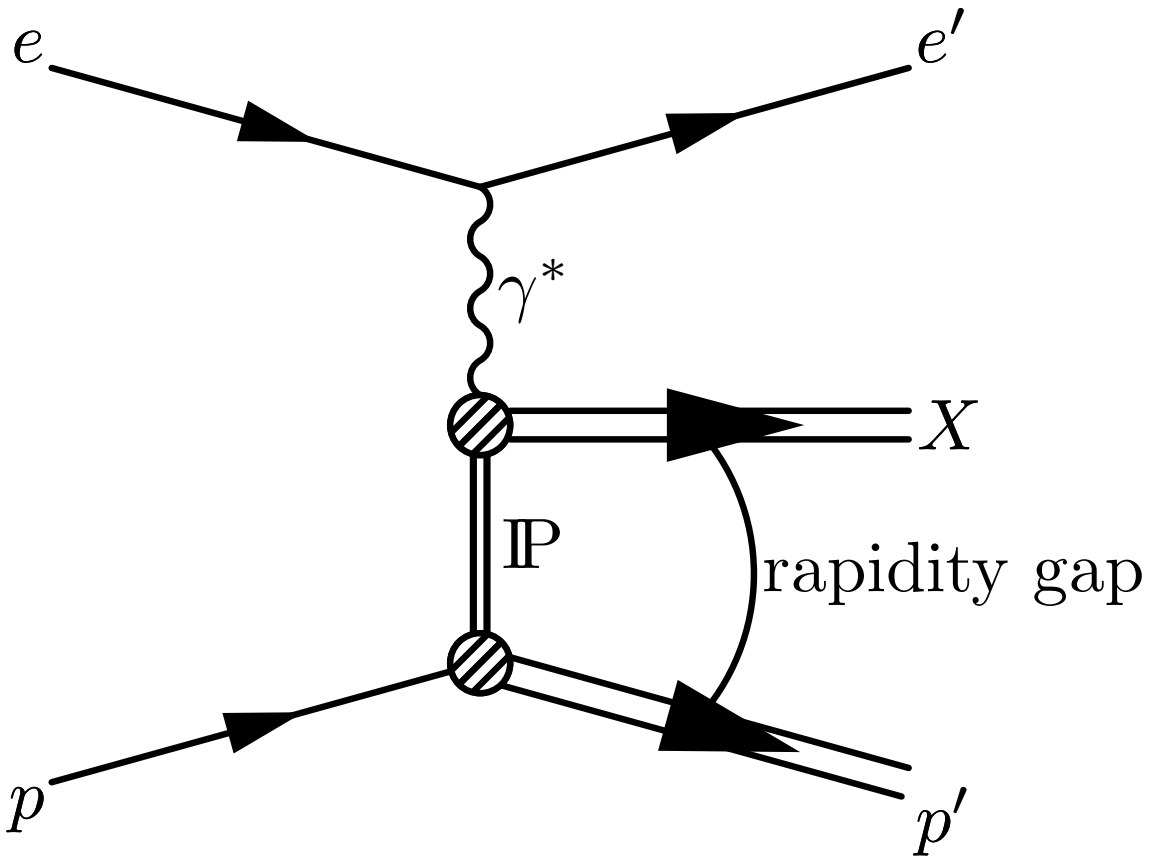
$\int Ldt = 0.5\ \mathrm{fb}^{-1}$
per experiment

NC Lepton-Proton Interaction



- $Q^2 = -(\mathbf{k} - \mathbf{k}')^2$
  virtuality of exchanged boson
  - $Q^2 \approx 0 \Rightarrow$ PHP
  - $Q^2 > 1$ GeV$^2 \Rightarrow$ DIS
- $y = \frac{\mathbf{P} \cdot \mathbf{q}}{\mathbf{P} \cdot \mathbf{k}}$
  inelasticity
- $W^2 = (\mathbf{P} + \mathbf{q})^2$
  photon-proton CME
- $s = (\mathbf{P} + \mathbf{k})^2$
  lepton-proton CME

Diffraction

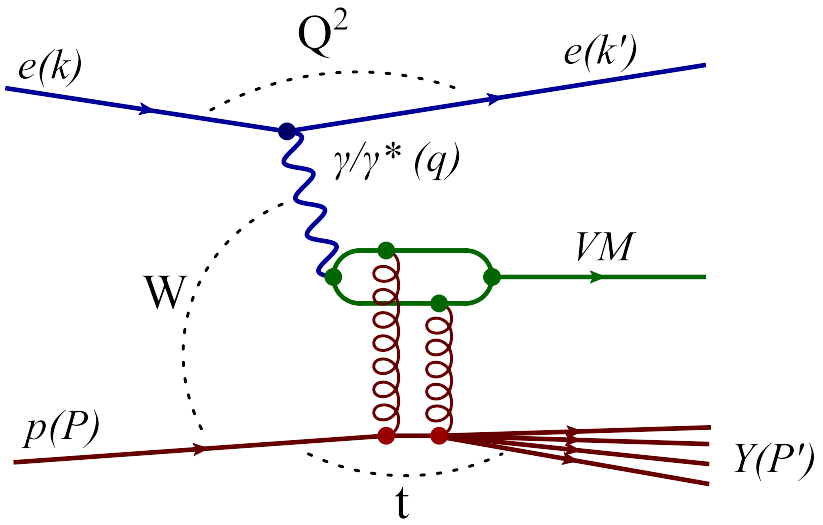


quantum numbers of:

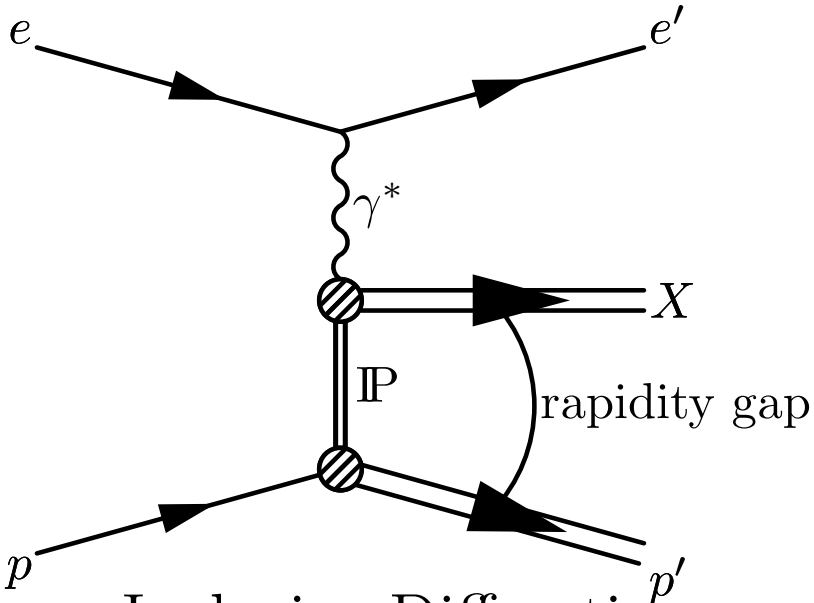
- γ^* and X are equal
- p and p' are equal

- $x_{\mathbb{P}}$ fraction of proton momentum carried by Pomeron
- $\beta = x/x_{\mathbb{P}}$ variable equivalent to the Bjorken x, but relative to the pomeron momentum

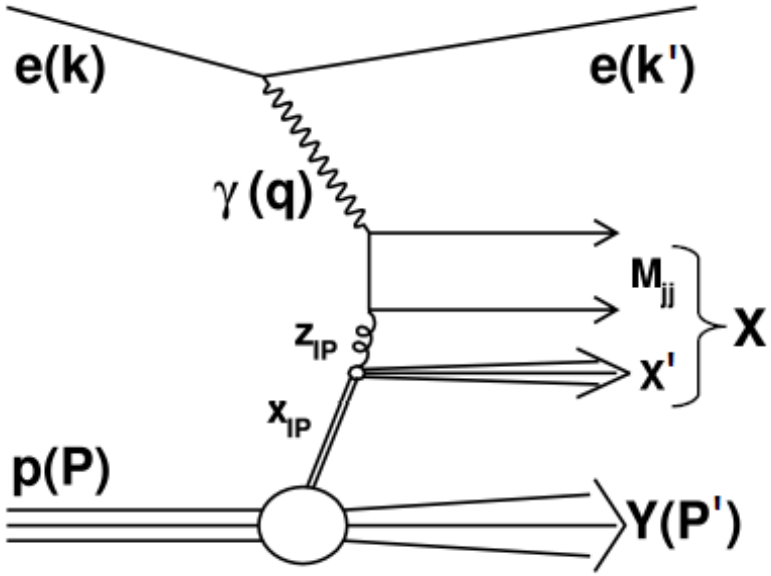
Outline



Diffractive Vector Meson Production

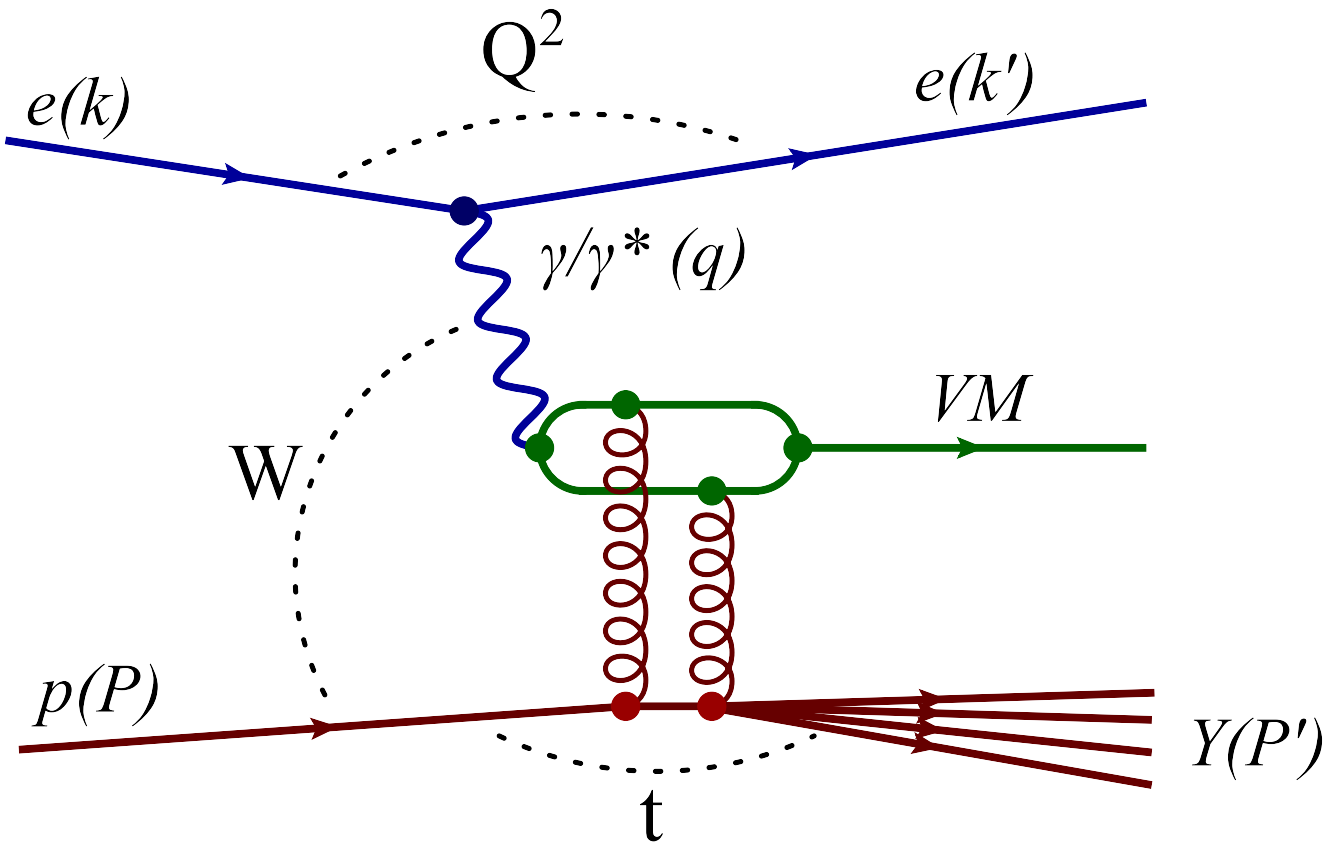


Inclusive Diffraction

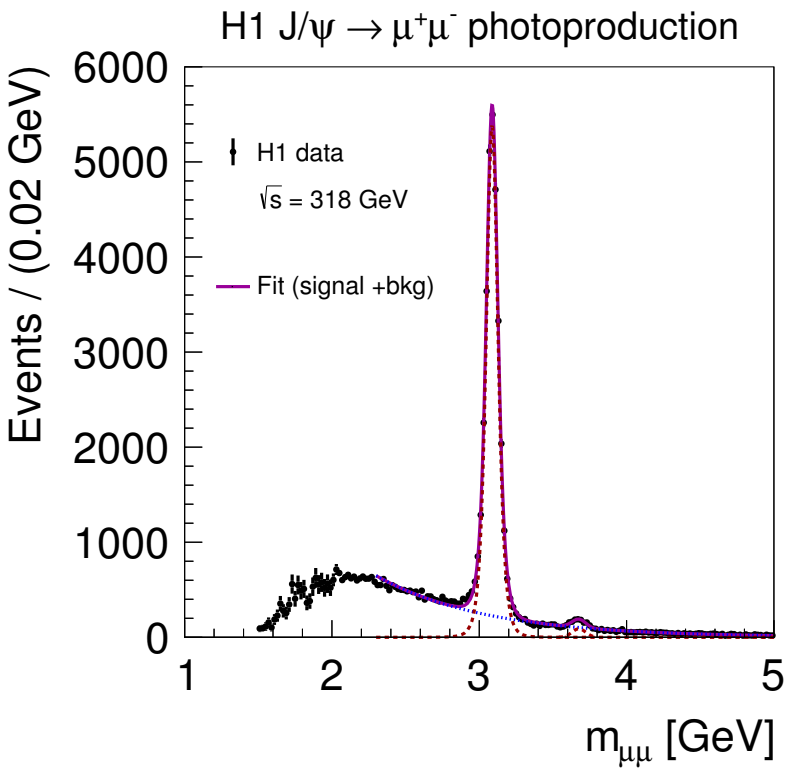


Diffractive Dijet Production

Diffractive Vector Meson Production



Diffractive Vector Meson Production



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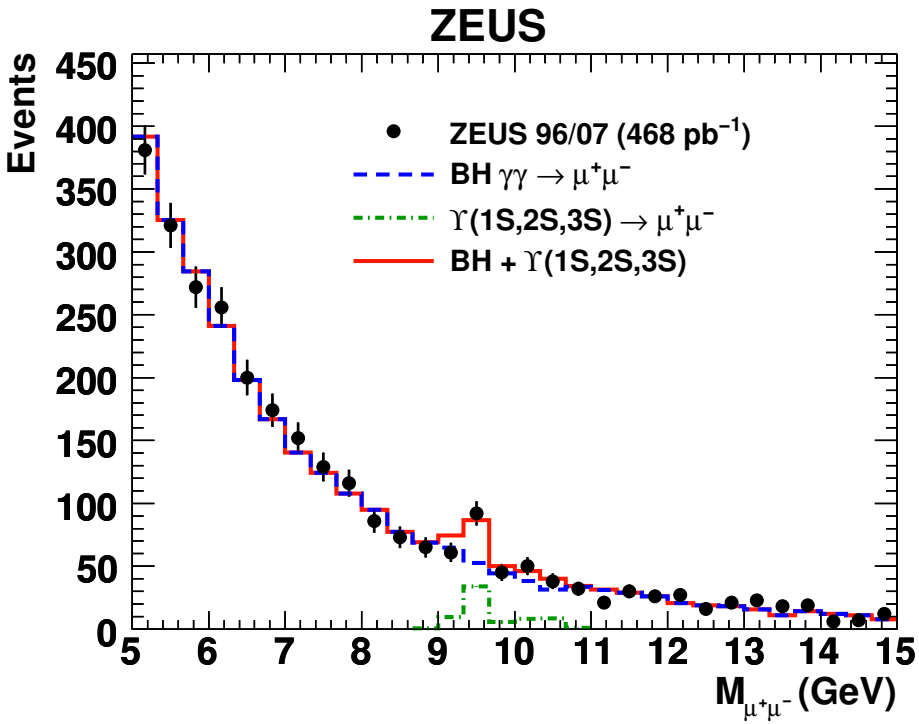

Phys. Lett. B 708 (2012) 14

J/ψ Photoproduction

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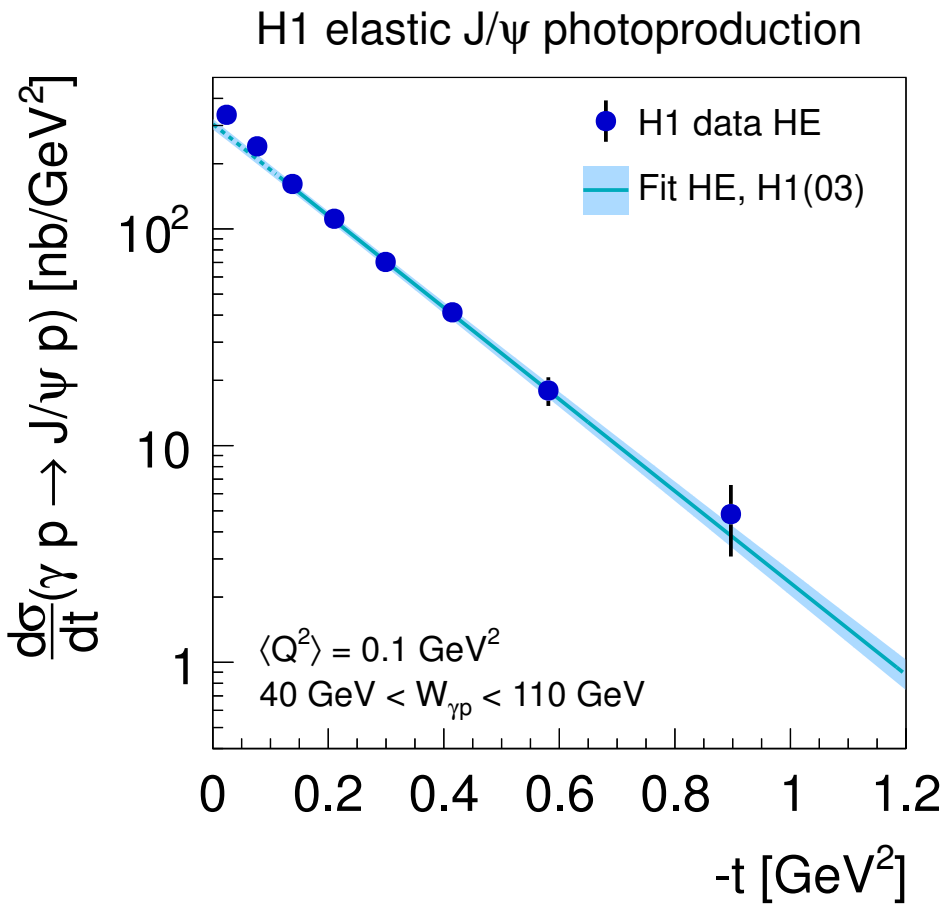
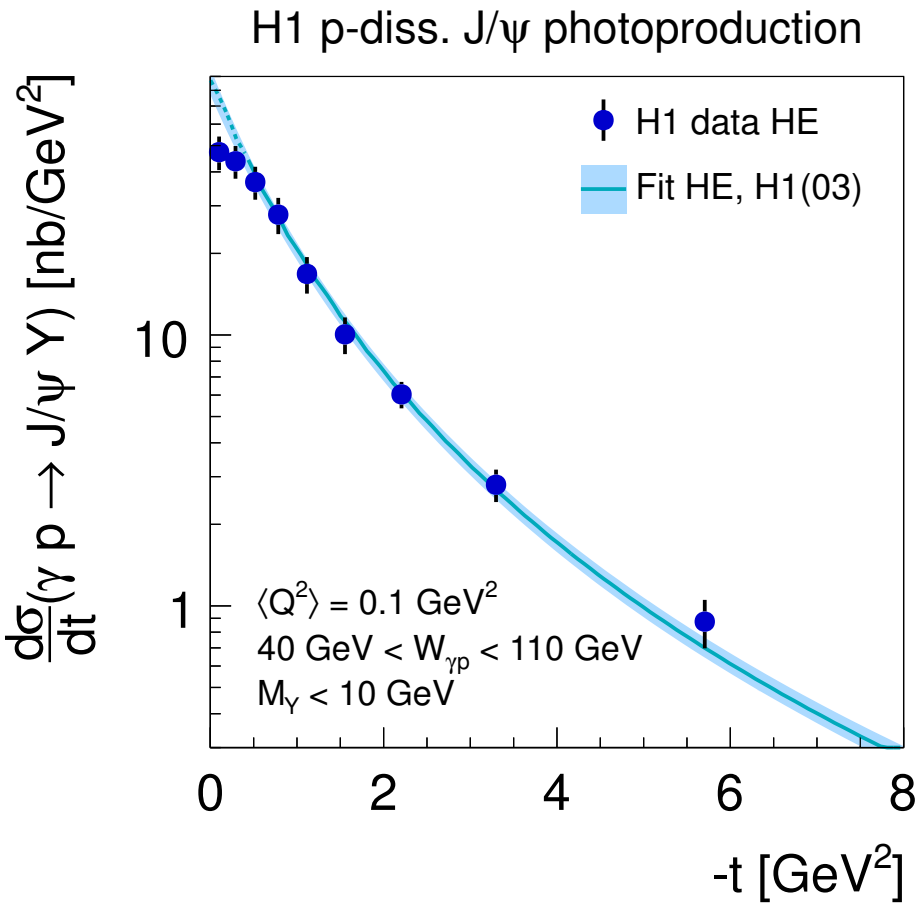




$$\frac{d\sigma_{el}}{dt} = N_{el}\exp(-b_{el}|t|)$$

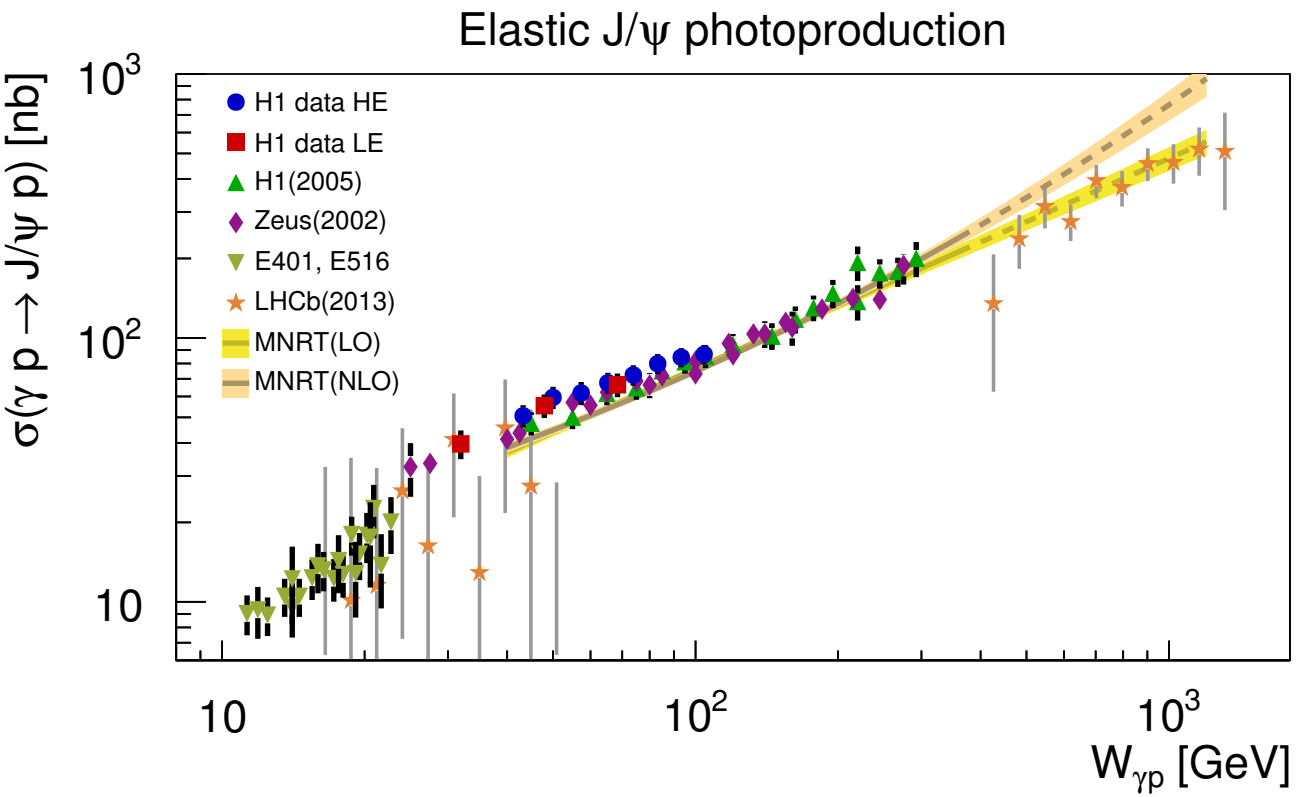
$$b_{el} = (4.88 \pm 0.15)\mathrm{GeV}^{-2}$$

$$\frac{d\sigma_{pd}}{dt} = N_{pd}(1 + b_{pd}|t|/n)^{-n}$$

$$b_{pd} = (1.79 \pm 0.12)\mathrm{GeV}^{-2}$$

J/ψ Photoproduction

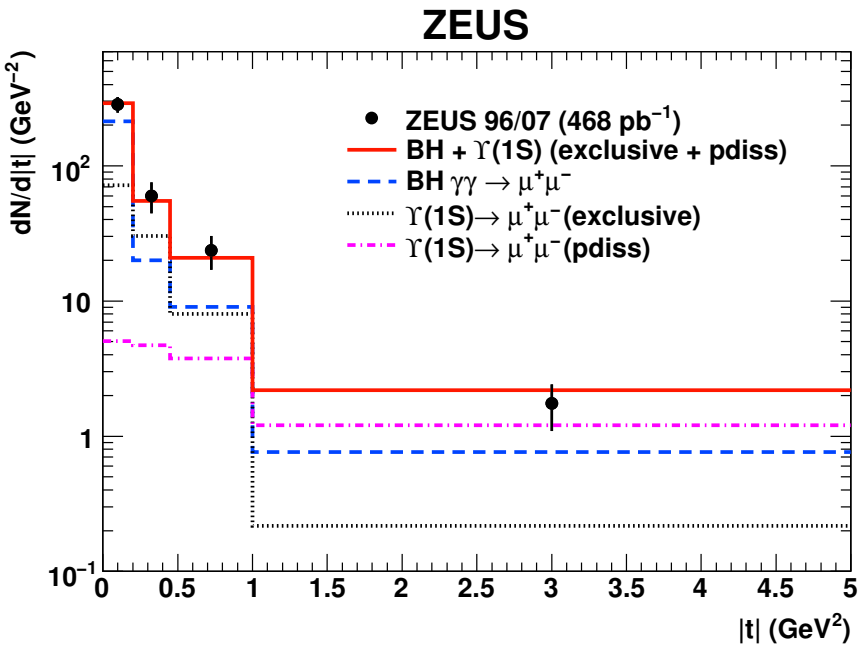
Eur. Phys. J. C73 (2013) 2466

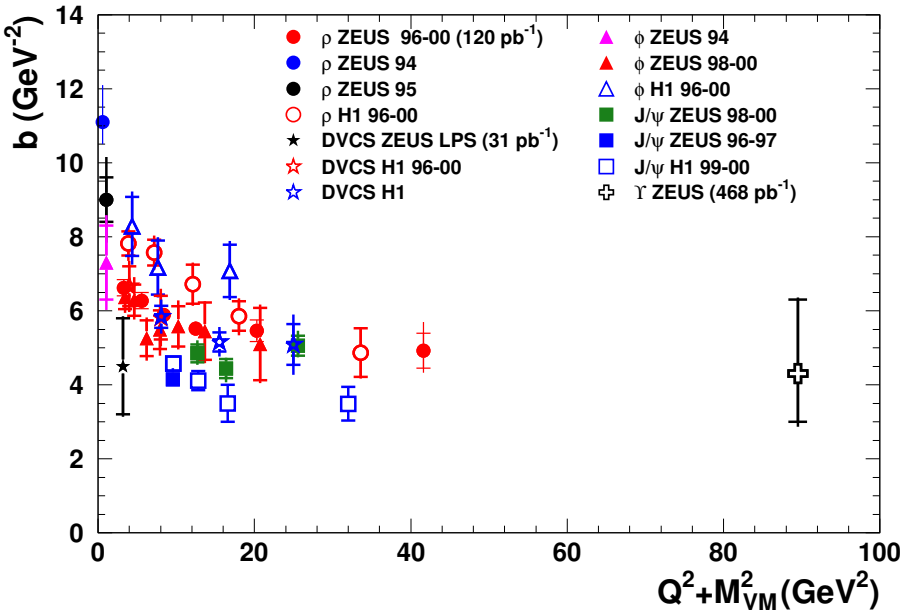


- LO fits describe all (including LHCb) data well
- NLO fits overestimate LHCb data

Upsilon (1S) Exclusive Photoproduction

Phys. Lett. B 708 (2012) 14

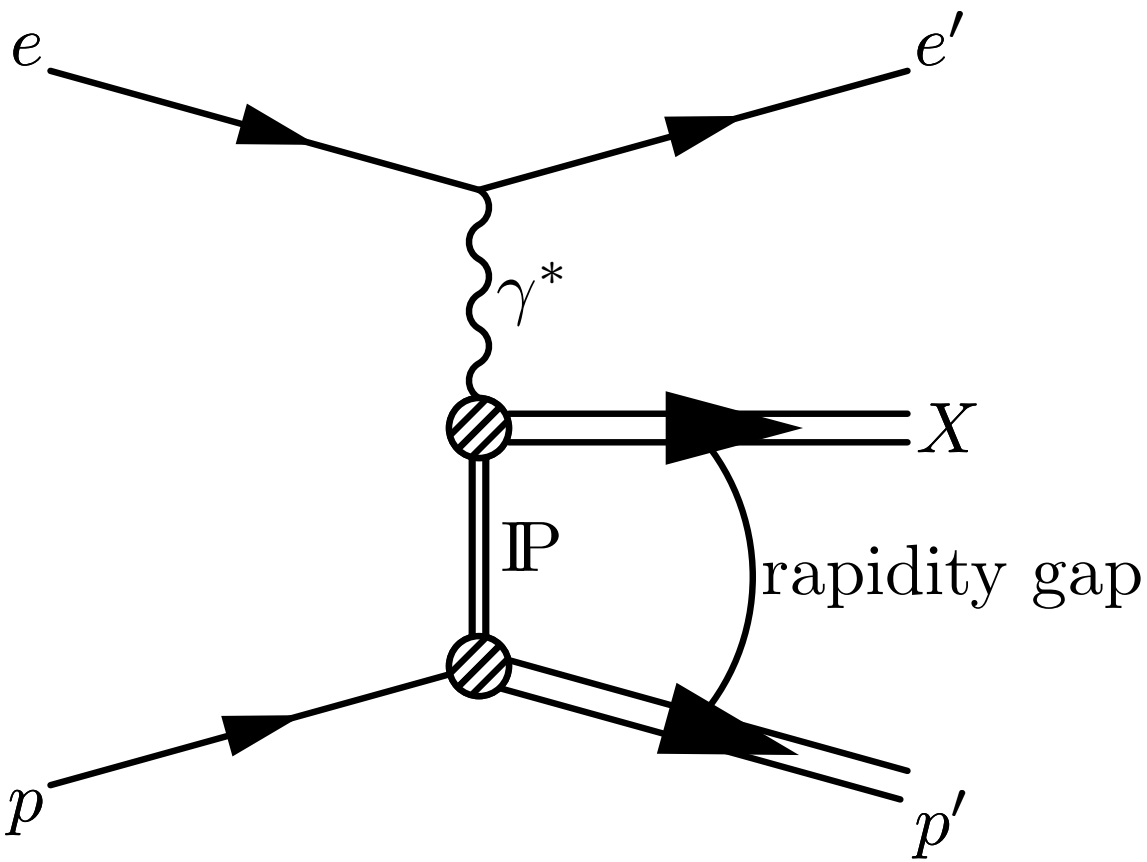




$$b = 4.3^{+2.0}_{-1.3}(stat.)^{+0.5}_{-0.6}(syst.)\mathrm{GeV}^{-2}$$

- first determination of $\Upsilon(1S)$ $|t|$ slope
- $|t|$ slope measurement extended to $Q^2 + M^2_{VM} \approx 90$ GeV^2

Inclusive Diffraction



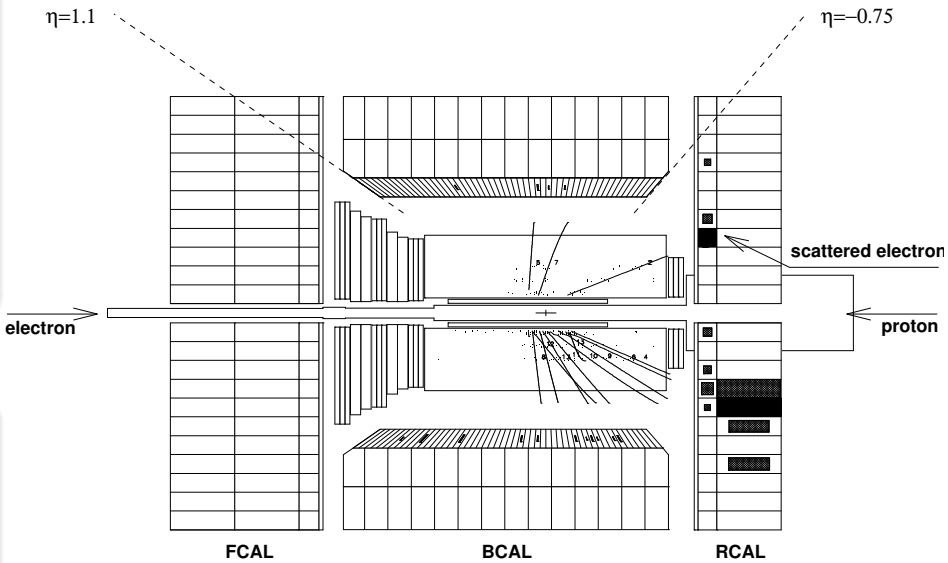
Diffractive Selection

Proton Spectrometer

- clean measurement - no double dissociative background
- low statistics

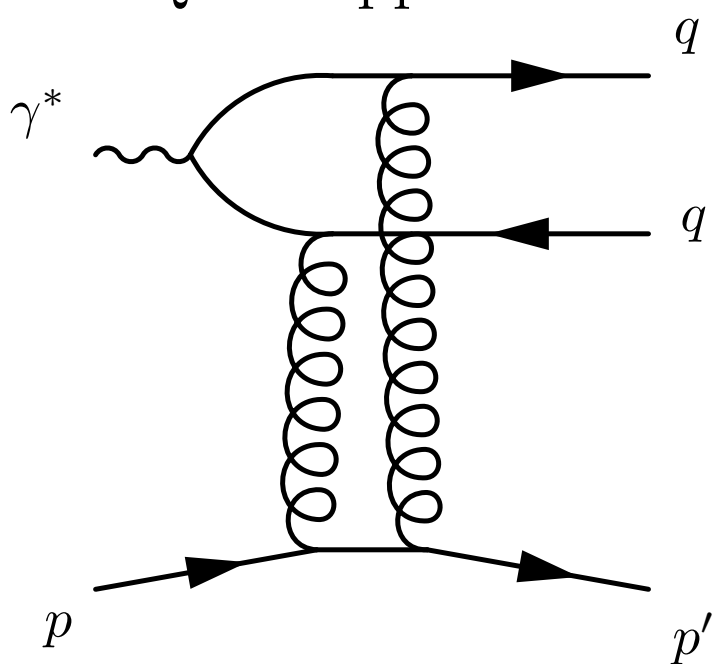
Large Rapidity Gap

- high statistics
- contains double dissociative background



Factorisation

QCD Approach



colour singlet gluon system is exchanged

QCD Factorisation

$$\sigma^D(\gamma^* p \to Xp) \sim$$
$$f_i^D(x, Q^2, x_{\mathbb{P}}, t) \times \sigma_{\gamma^* i}(x, Q^2)$$
$$\Downarrow$$
universal diffractive parton densities

Proton Vertex Factorisation

$$f_i^D(x, Q^2, x_{\mathbb{P}}, t) \sim$$
$$f_{\mathbb{P}/p}(x_{\mathbb{P}}, t) \times \quad f_{i/\mathbb{P}}^D(x/x_{\mathbb{P}}, Q^2)$$
$$\| \qquad\qquad\qquad \|$$
pomeron flux — pomeron parton densities

$$\frac{d^4\sigma^{ep\to e'Xp'}}{d\beta dQ^2 dx_{\mathbb{P}} dt} = \frac{2\pi\alpha^2}{\beta Q^4} y_+ \left[F_2^{D(4)}(\beta, Q^2, x_{\mathbb{P}}, t) - \frac{y^2}{y_+} F_L^{D(4)}(\beta, Q^2, x_{\mathbb{P}}, t) \right]$$
$$\|$$
$$\sigma_r^{D(4)}(\beta, Q^2, x_{\mathbb{P}}, t)$$

HERA Combined Cross Sections

Eur. Phys. J. C72 (2012) 2175

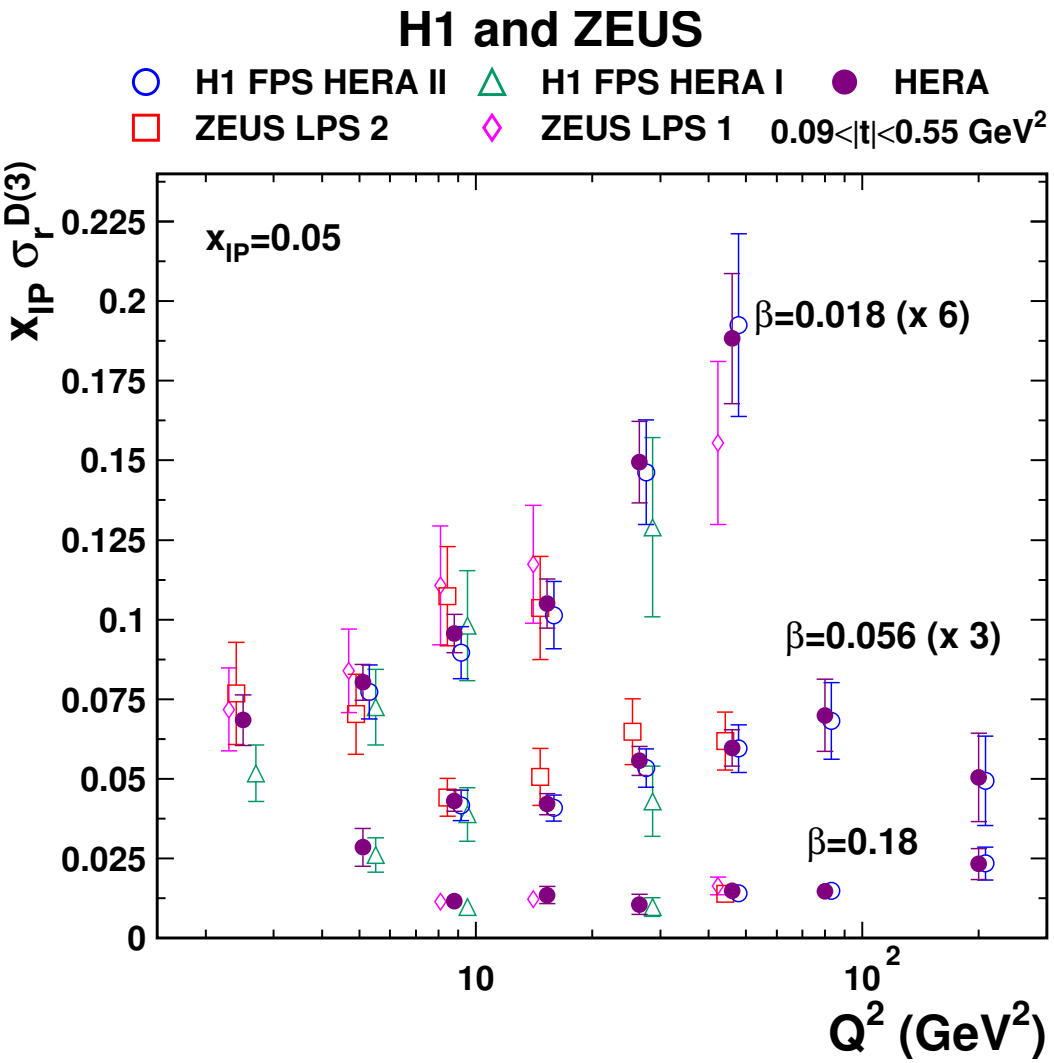
$$
\begin{aligned}
2.5 \leq \quad & Q^2 \quad \leq 200\ \mathrm{GeV}^2, \\
0.0018 \leq \quad & \beta \quad \leq 0.816, \\
0.00035 \leq \quad & x_{\mathbb{P}} \quad \leq 0.09, \\
0.09 < \quad & |t| \quad < 0.55\ \mathrm{GeV}^2
\end{aligned}
$$

ZEUS

- EPJ C38, 43 (2004)
- Nucl. Phys. B816, 1 (2009)

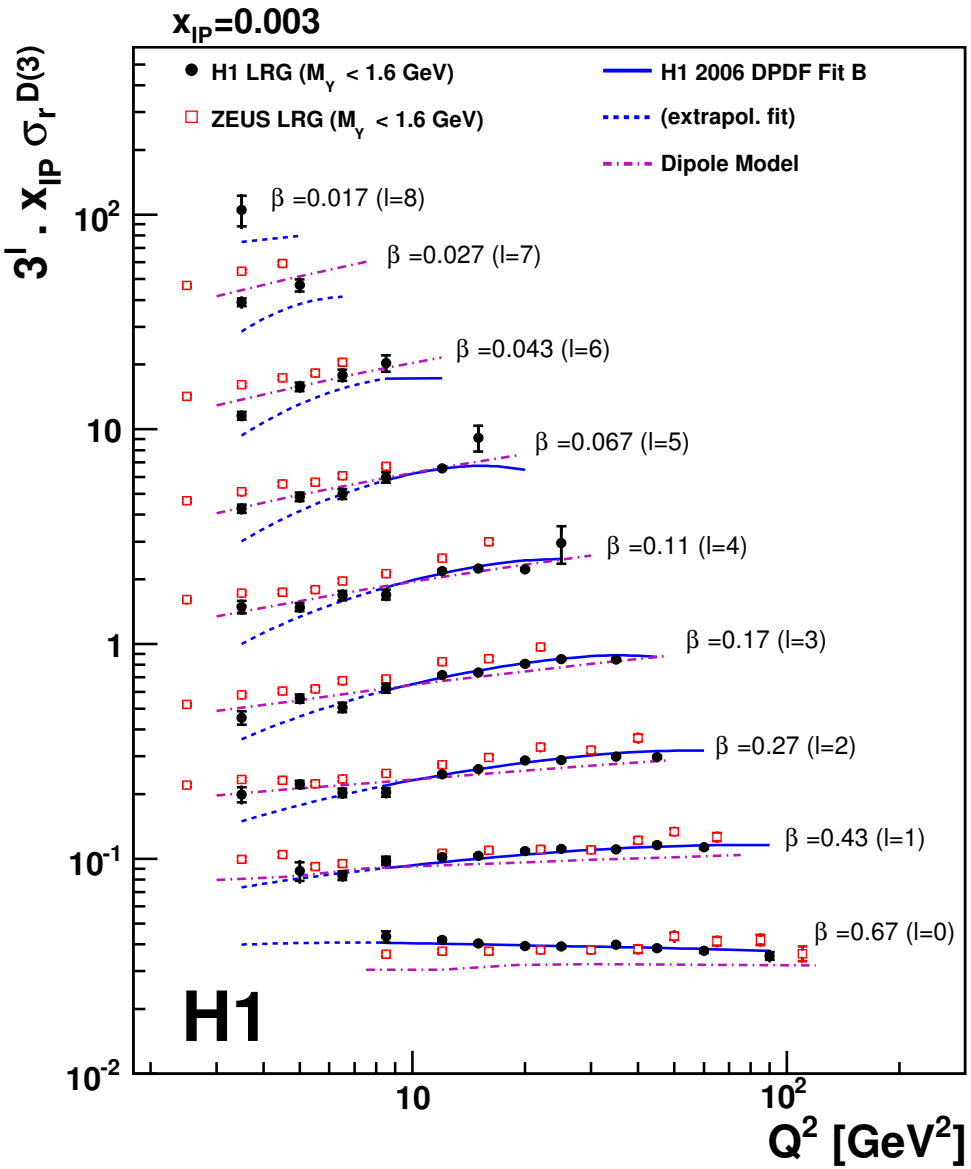
H1

- EPJ C48, 749 (2006)
- EPJ C71, 1578 (2011)



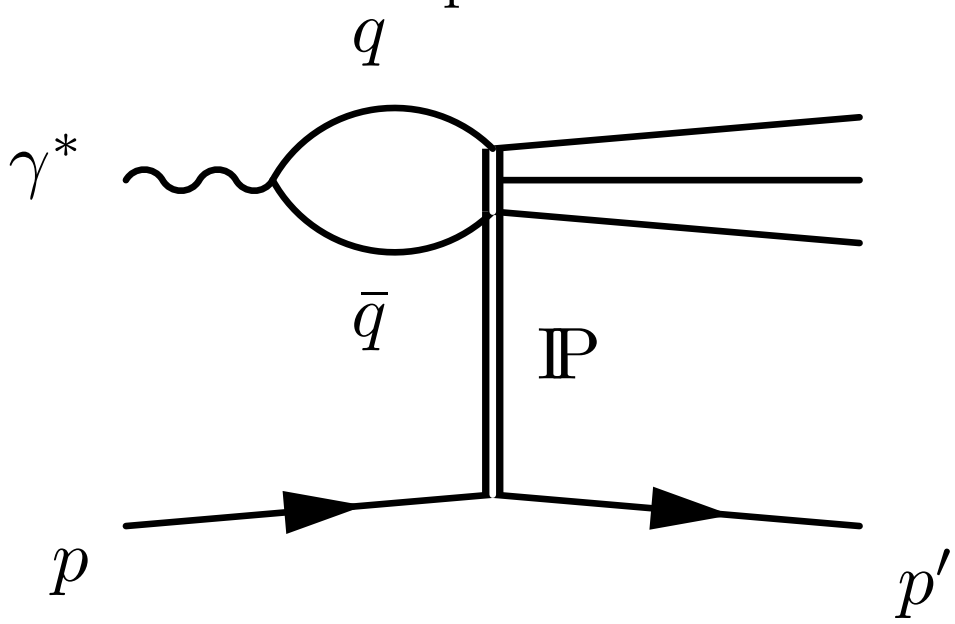
Inclusive Diffractive DIS at HERA

EPJ C72 (2012) 2074



- DPDF model describe data at $Q^2 > 10$ GeV^2
- the dipole model is better at low Q^2

Color Dipole Model



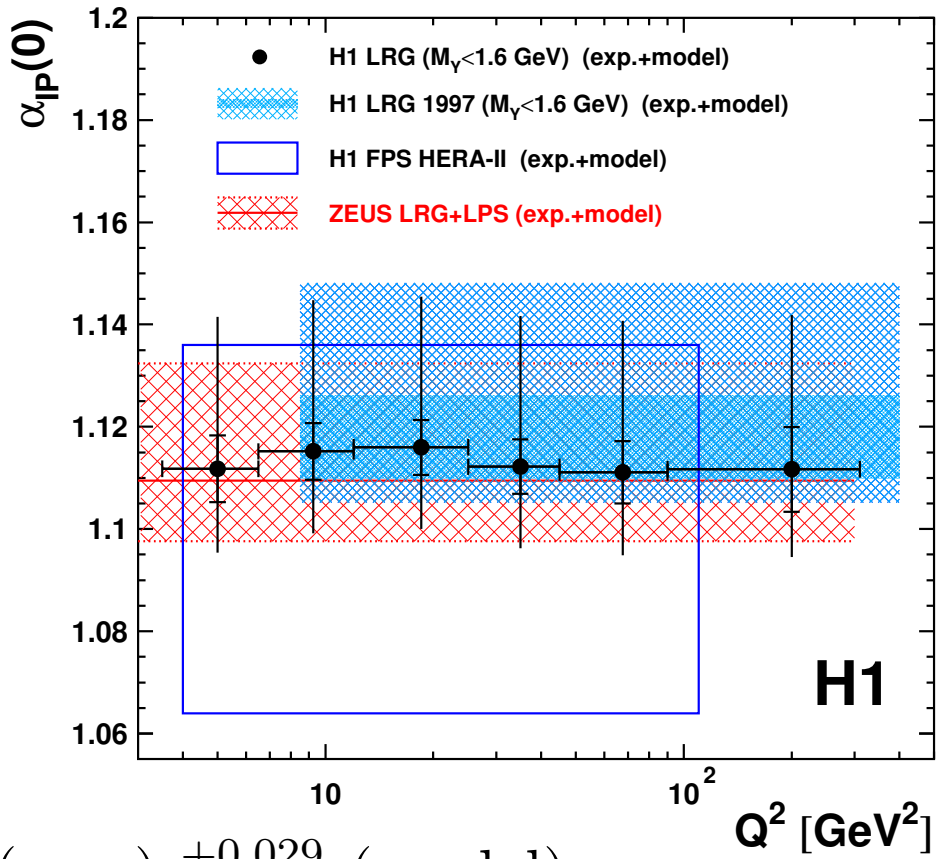
Inclusive Diffractive DIS at HERA

EPJ C72 (2012) 2074

$$F_2^{D(3)}(Q^2,\beta,x_{I\!P}) = f_{I\!P/p}(x_{I\!P})\ F_2^{I\!P}(Q^2,\beta) + n_{I\!R}\ f_{I\!R/p}(x_{I\!P})F_2^{I\!R}(Q^2,\beta)$$

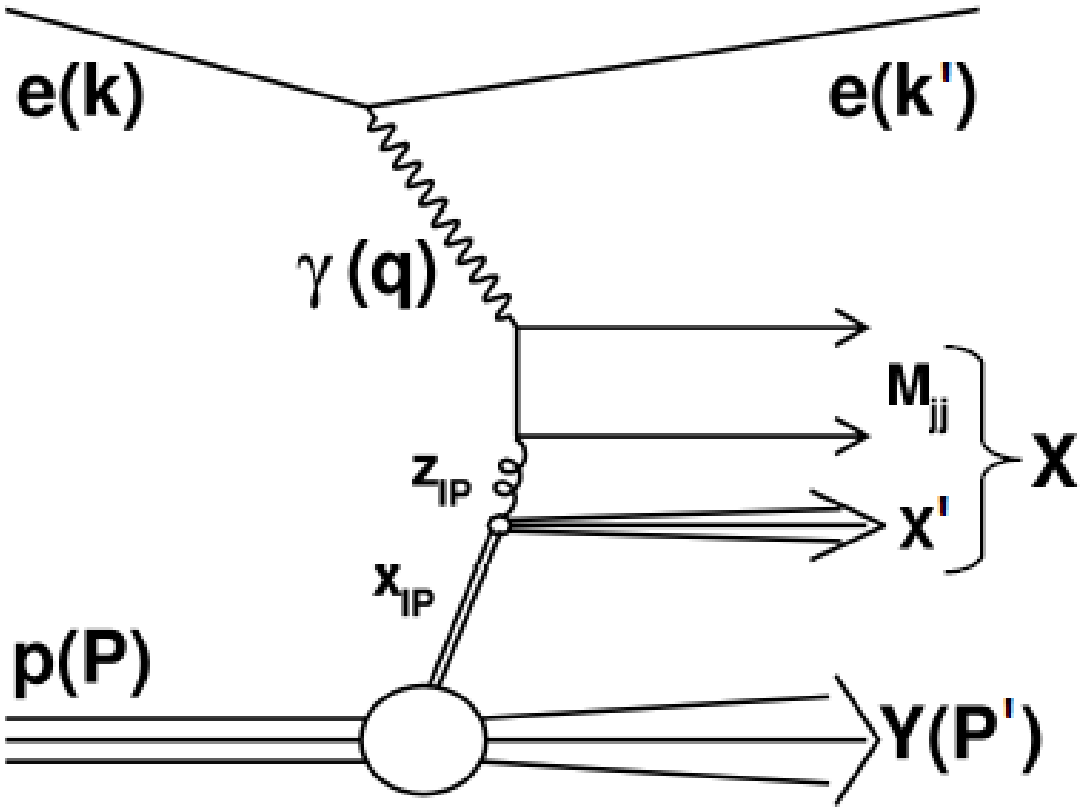
$$f_{I\!P/p}(x_{I\!P}) = \int_{t_{cut}}^{t_{min}} \frac{e^{B_{I\!P}t}}{x_{I\!P}^{2\alpha_{I\!P}(t)-1}}\,dt$$

- no Q^2 dependence supports the proton vertex factorisation hypothesis



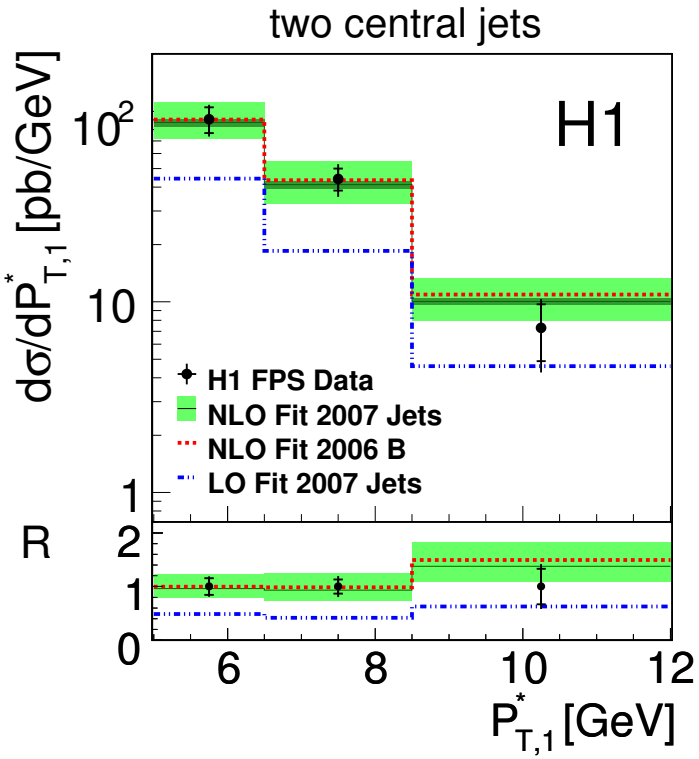
$$\alpha_{I\!P}(0) = 1.113\ \pm 0.002\ (\text{exp.})\ ^{+0.029}_{-0.015}\ (\text{model})$$

Diffractive Dijet Production

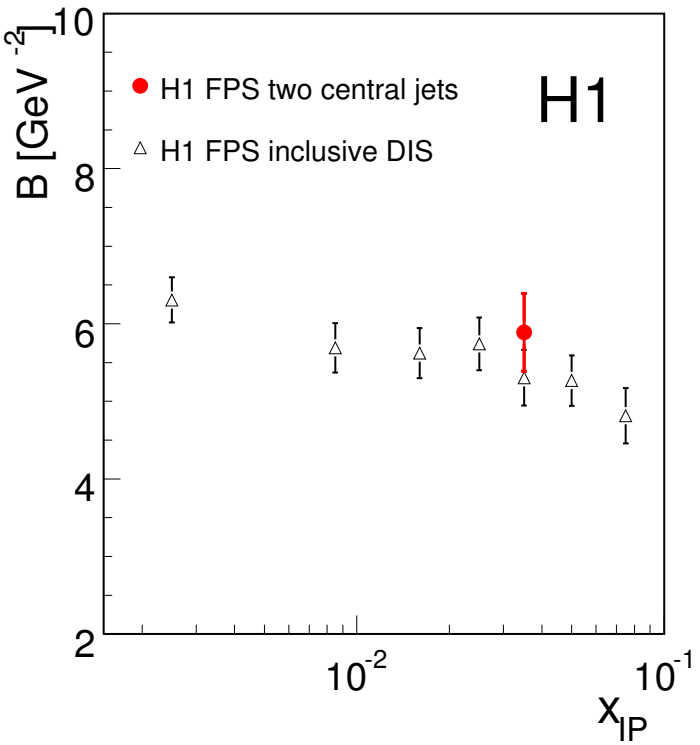


Diffractive Dijets in DIS

EPJ C72 (2012) 1970



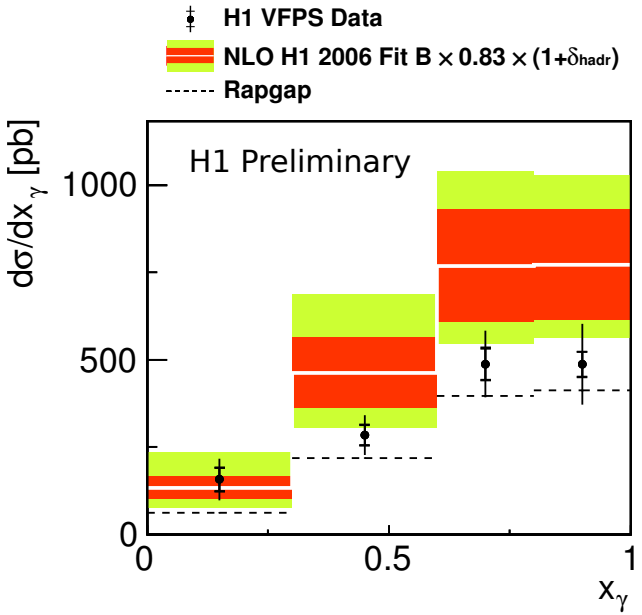
- dijet cross sections reproduced with inclusive DPDF, support universality of DPDF



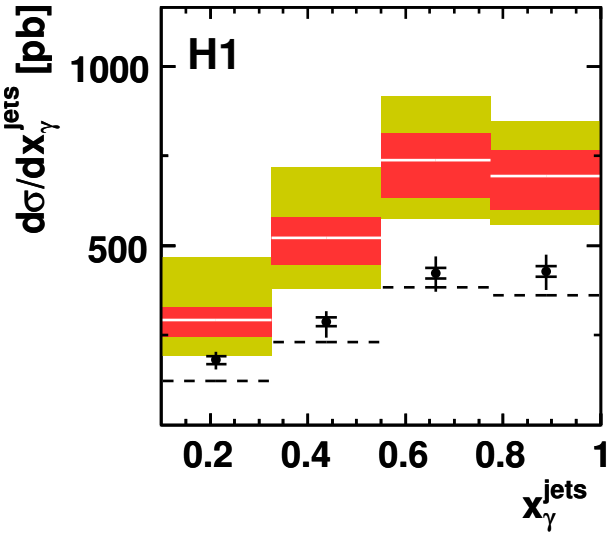
- consistency in t-slope supports validity of the proton vertex factorisation

Diffractive Dijets in Photoproduction

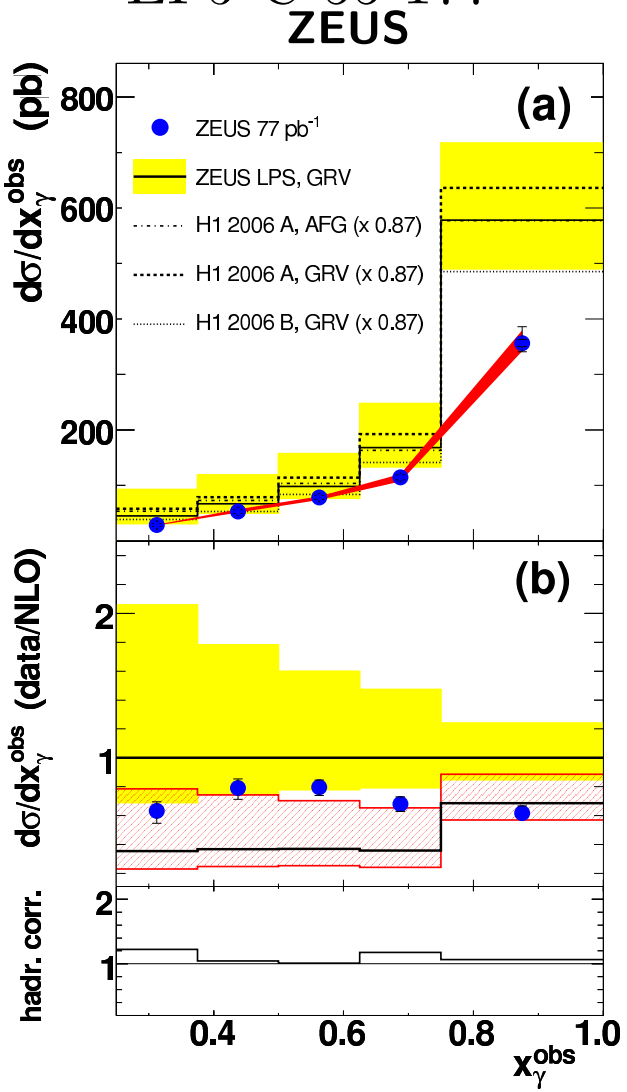
H1prelim-013-011



EPJ C70 15



EPJ C 55 177



- H1 measured cross sections significantly smaller than NLO QCD predictions
- ZEUS measured cross sections insignificant smaller than NLO QCD predictions due to large theoretical uncertainties

Summary

- Vector Meson Production
  - elastic and proton dissociative t slopes measured in J/Ψ production
  - first measurement of Υ (1S) t slope
- Inclusive Diffraction
  - H1 and ZEUS result combination provide unprecedented precision
  - measurements support proton vertex factorisation in DIS
- Diffractive Dijet Production
  - DIS - good agreement between data and theory
  - PHP - measured cross sections can be below theoretical predictions

Thank You for Your Attention!