Inclusive Diffraction at HERA and associated QCD analyses

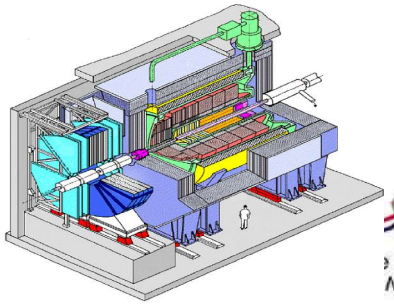
Justyna Tomaszewska – DESY
on behalf of the H1 & ZEUS Collaborations

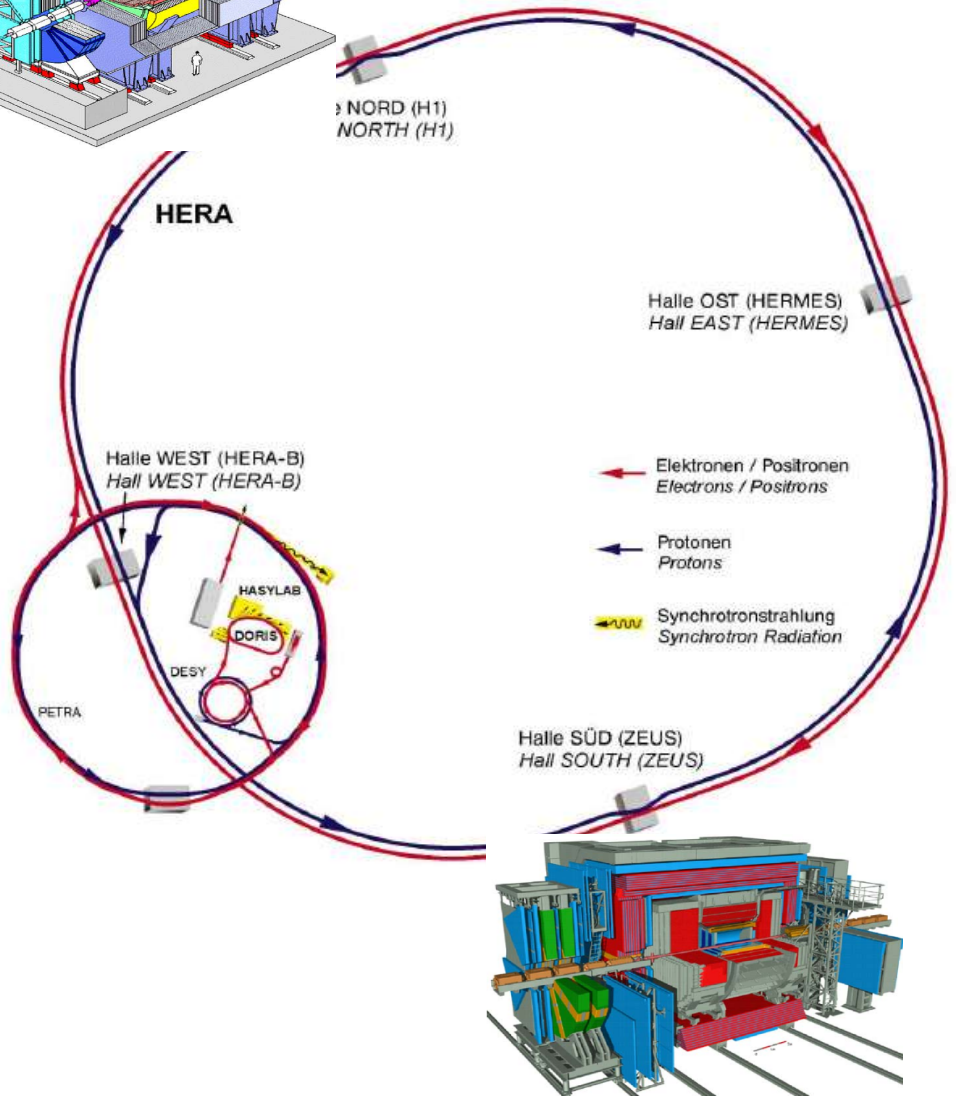
Outline:

- Diffraction
- Different experimental methods
- Diffractive PDFs

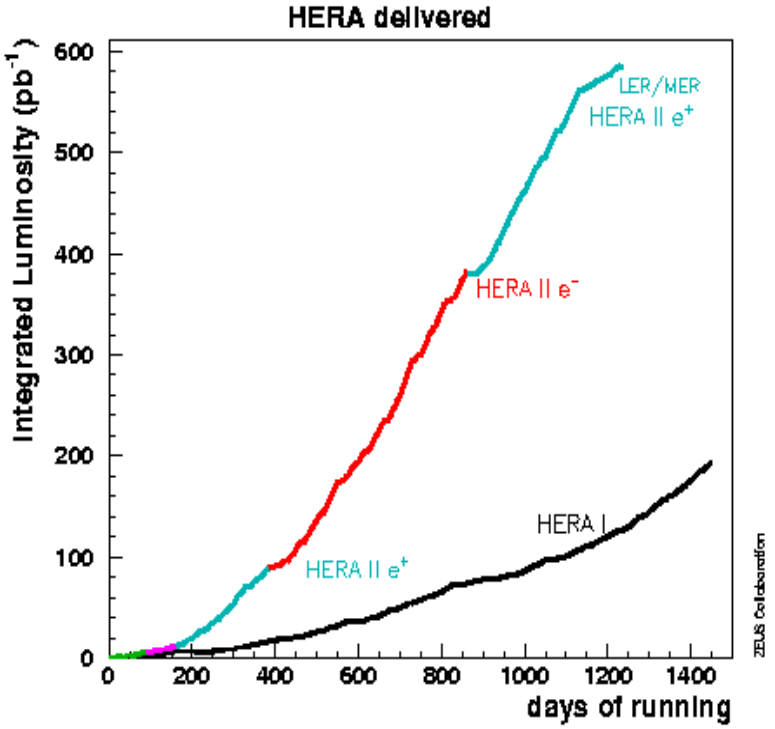
Low-x, Kavala, 24.06.2010

HERA



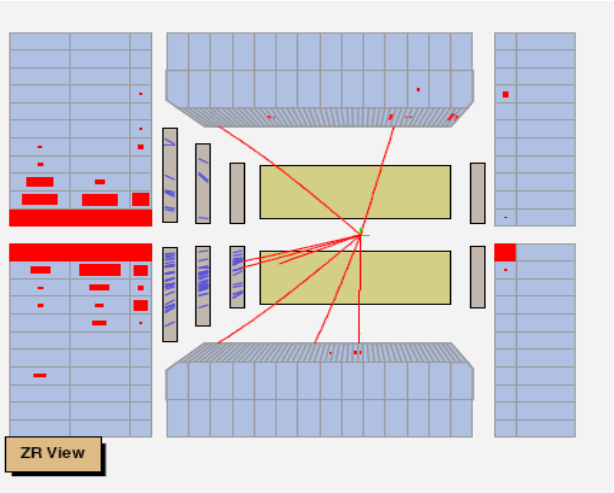


27.5 GeV ← 920GeV

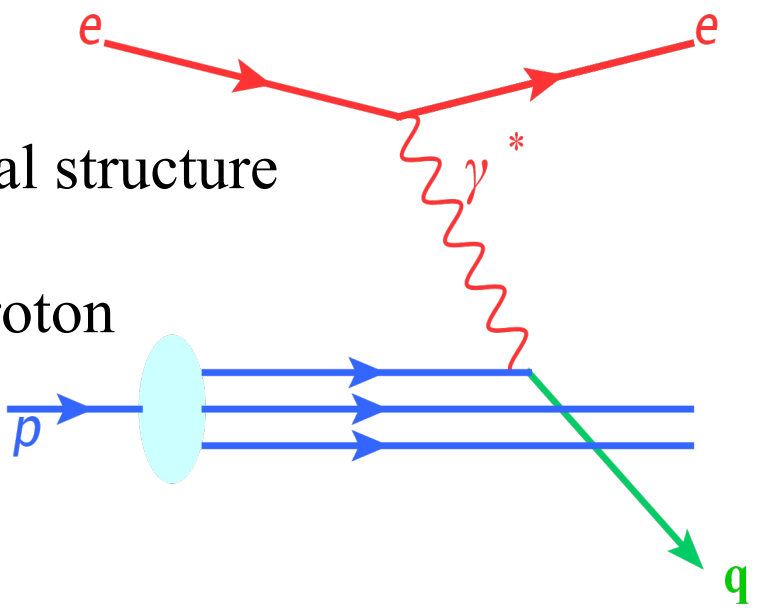


DIS & Diffraction

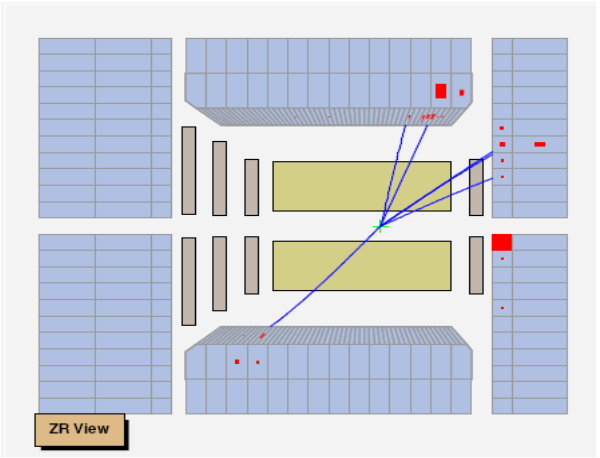
Inclusive DIS



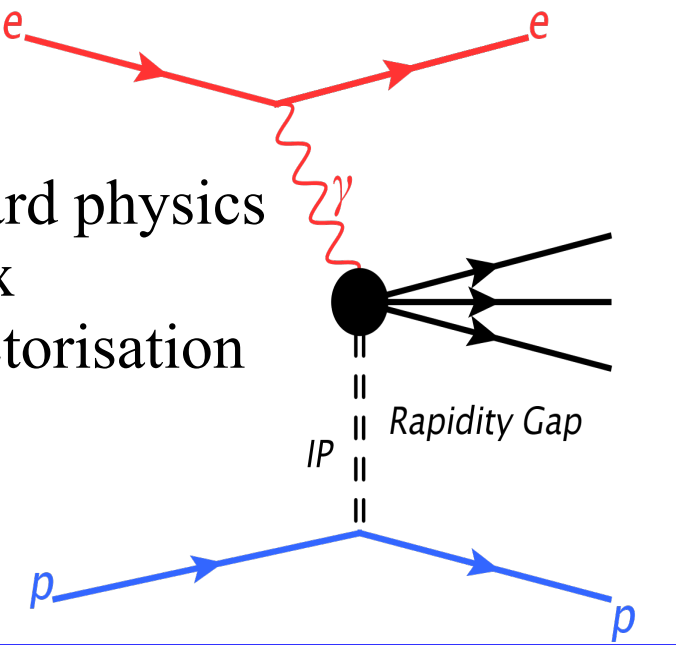
- photon probes internal structure of the proton
- parton densities in proton



Diffractive DIS



- transition from soft to hard physics
- parton dynamics at low x
- applicability of QCD factorisation approach



Kinematics of diffractive DIS

Q^2 - the negative 4-momentum squared of the virtual photon

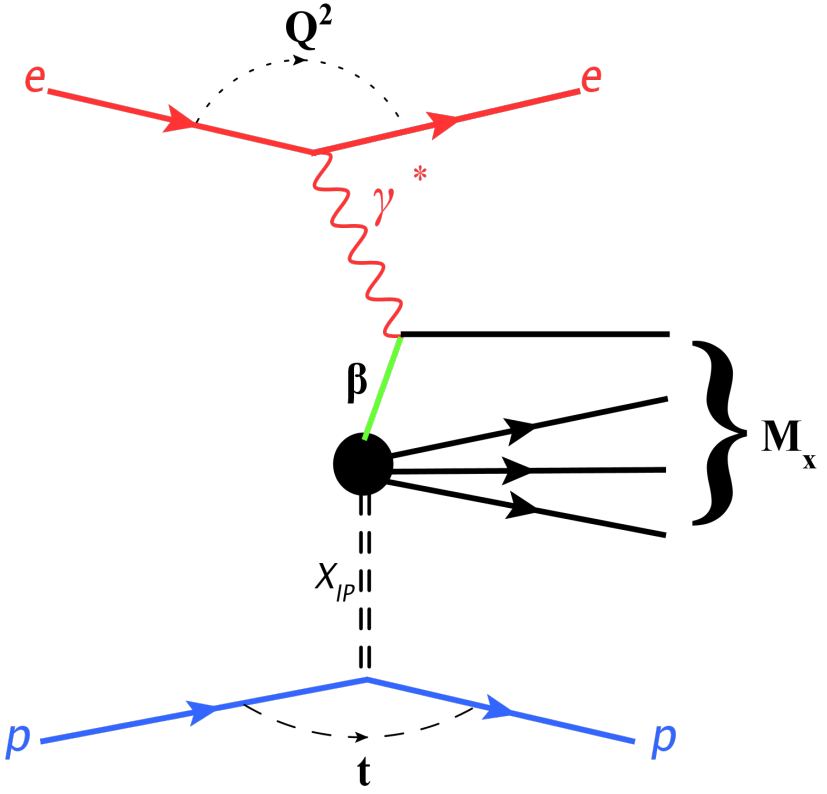
M_x – invariant mass of γ^* IP system

t – squared 4-momentum transferred at the proton vertex

x_{IP} – fraction of proton momentum carried by Pomeron

β - fraction of the Pomeron momentum carried by struck quark

z - longitudinal momentum fraction of the parton entering the hard subprocess with respect to the diffractive exchange



Diffractive cross sections

The cross section for diffractive DIS, ep→eXp:

$$\frac{d\sigma^{ep\to exp}}{d\beta\, dQ^2 dx_{IP}\, dt} = \frac{4\pi\alpha^2}{\beta Q^2}\left[1 - y + \frac{y^2}{2}\right]\sigma_r^{D(4)}(\beta, Q^2, x_{IP}, t)$$

Diffractive reduced cross section

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

Diffractive structure functions:

$$F_{2/L}^{D(4)}(\beta, Q^2, x_{IP}, t) = \sum_i \int_\beta^1 \frac{dz}{z} C_{2/L,i}\left(\frac{\beta}{z}\right) f_i^D(z, x_{IP}, Q^2, t)$$

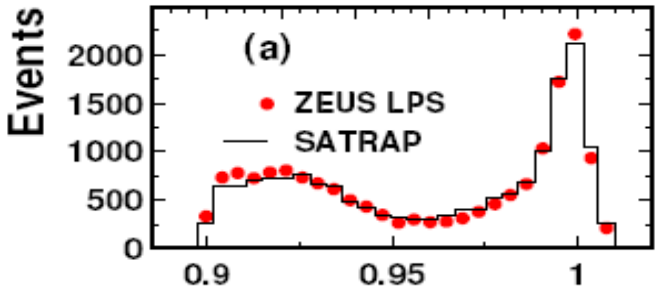
Diffractive Parton Distributions Functions

Methods to measure Inclusive Diffraction

Tagged proton:

- diffractive peak at x_L
- no contribution from proton dissociation
- contribution from Reggon exchanges
- only method to measure t-distribution

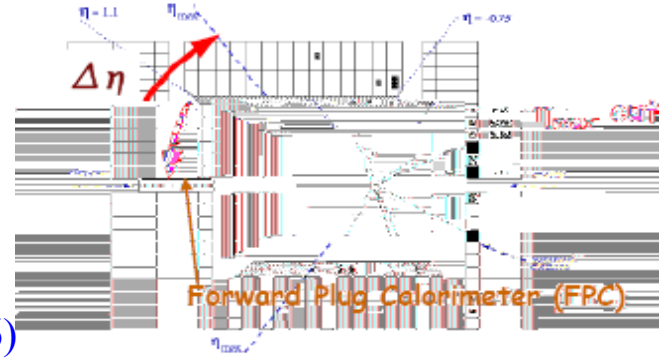
ZEUS: Nucl. Physics B816(2009) 1-61
H1: Europ. Physics Journal C 48 (2006)



$x_L = p'_z/p_z$

Large Rapidty Gap:

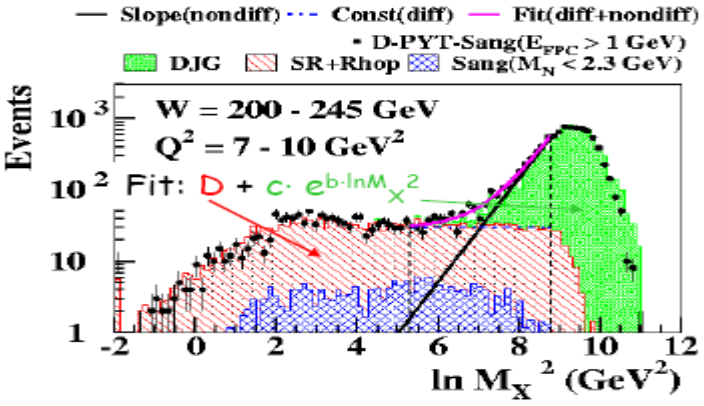
- required gap between the hadronic final state and the outgoing proton
- contribution from proton dissociation
- contribution from Reggon exchanges



H1: EPJ C 48 (2006)
ZEUS: Nucl. Physics B816(2009) 1-61

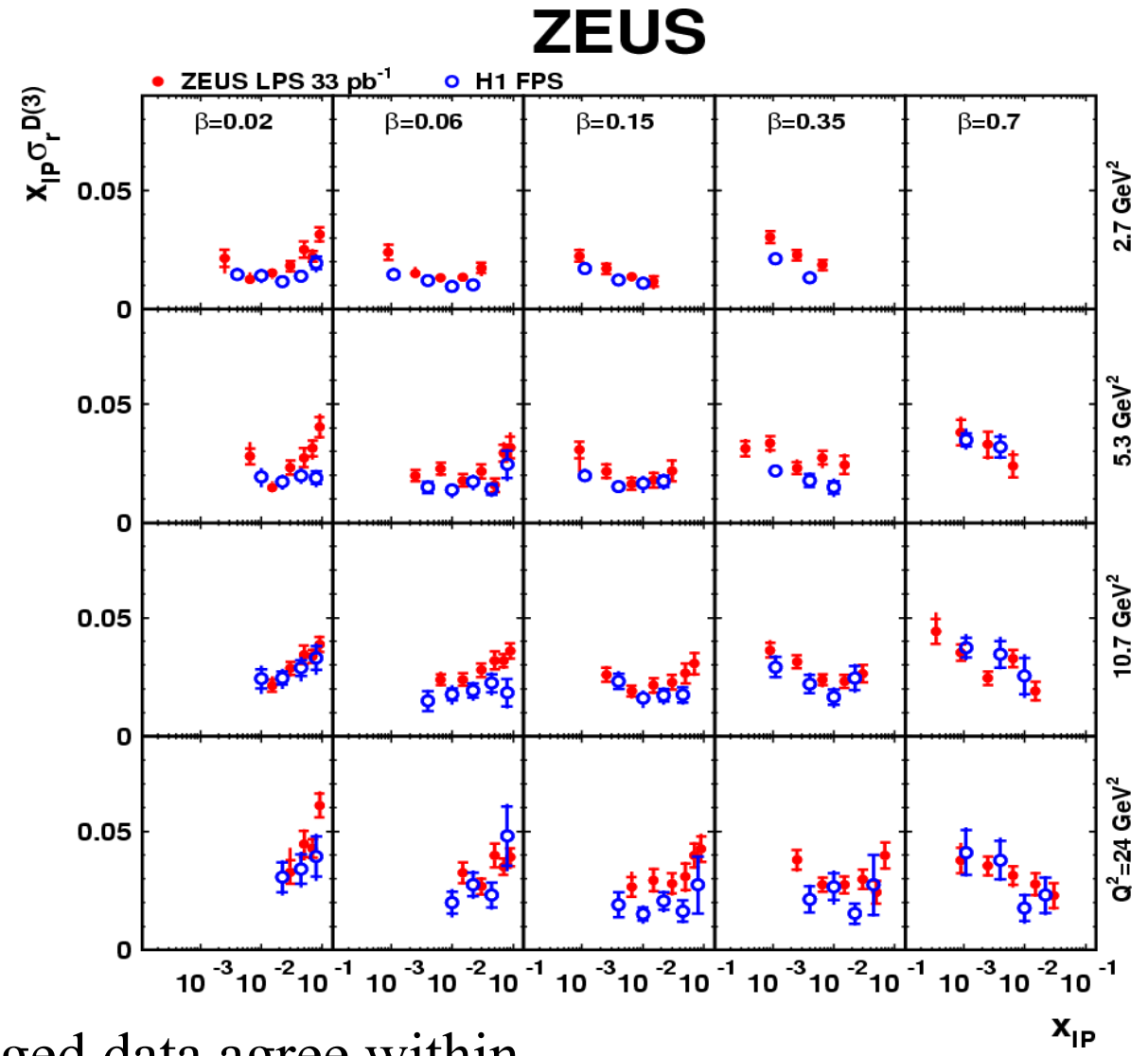
Mx Method:

- measures the mass of distribution of the diffractive system
- contribution from proton dissociation
- no contribution from Reggon exchanges



FPC I: Nucl. Phys. B713(2005) 3 / FPC II: Nucl. Phys. B800 (2008) 1

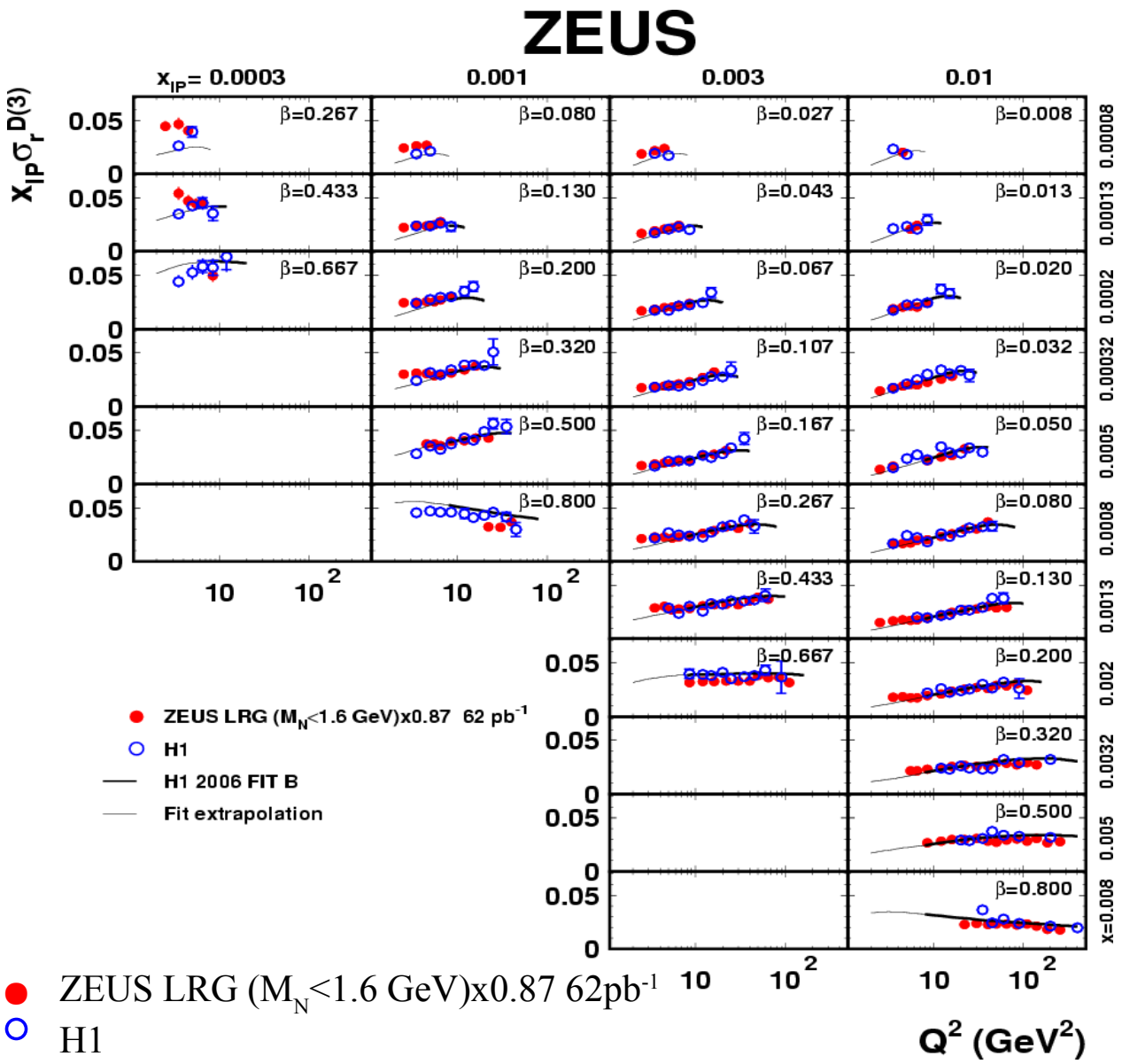
Proton tagged data – H1/ZEUS



H1 and ZEUS proton-tagged data agree within normalisation uncertainties

ZEUS: Nucl. Physics B816(2009) 1-61
H1: Eur. Phys. J. C48 (2006) 749

Large Rapidity Gap data - H1/ZEUS



ZEUS data was:

- corrected to the same M_Y
- scaled down by 13%

good agreement between H1 and ZEUS within errors

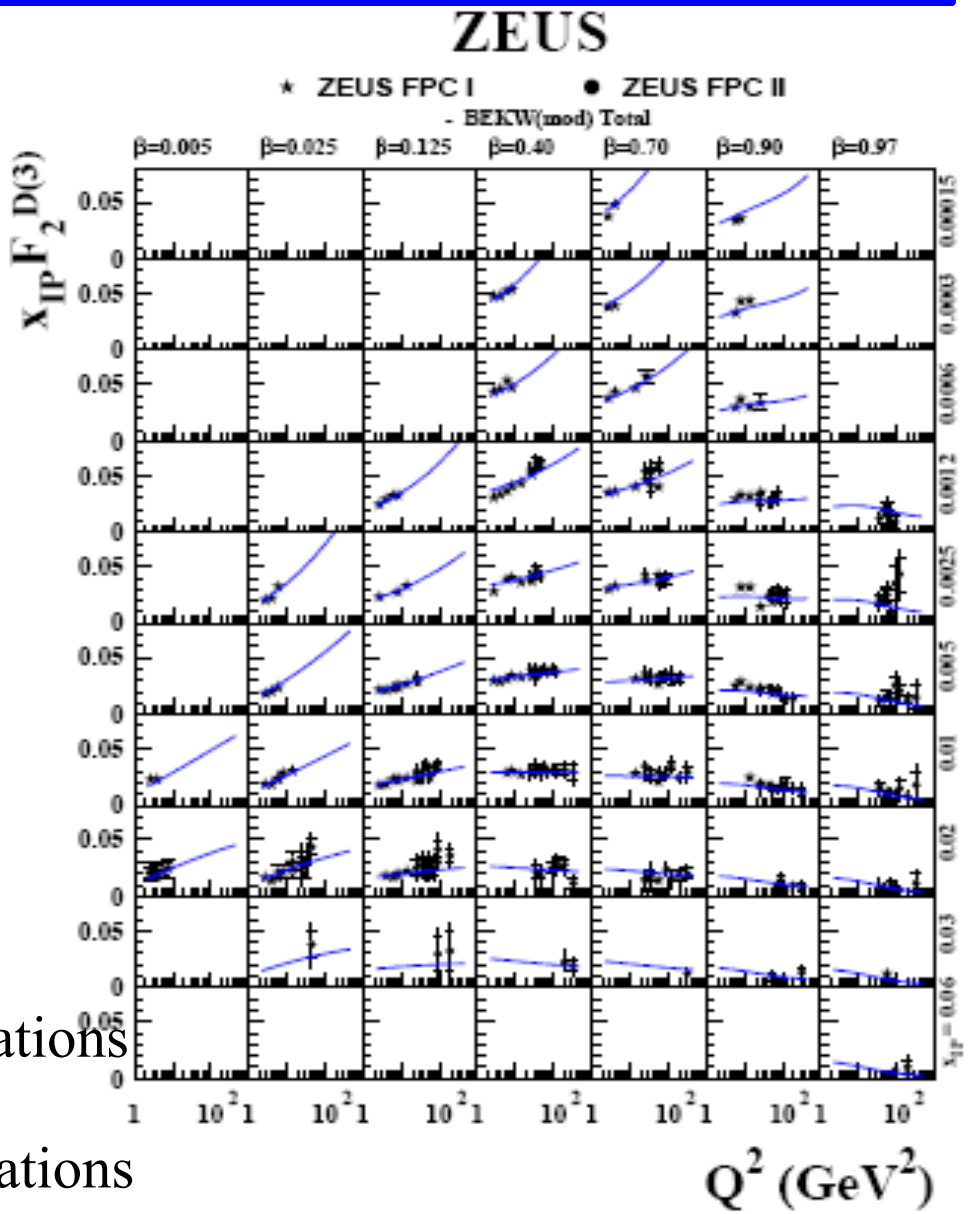
- ZEUS LRG (M_N<1.6 GeV)x0.87 62pb^{-1}
- H1
- H1 2006 FIT B
- Fit extrapolation

Nucl. Physics B816(2009) 1-61

Mx Method

BEKW model:

- general parametrisation for inclusive diffraction in DIS
- incoming virtual photon fluctuates into a $q\bar{q}$ or $q\bar{q}g$ dipole which interacts with the proton via two-gluon exchange



$x_{IP}\beta = x$

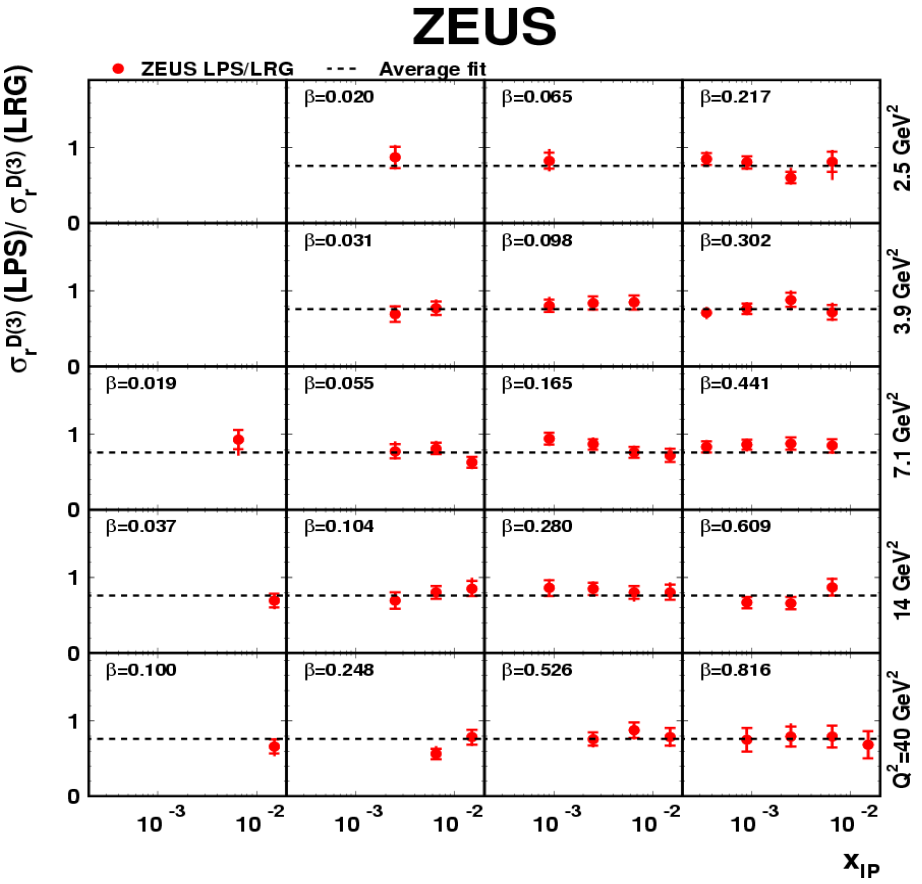
→ $x < 1 \cdot 10^{-3}$ positive scaling violations

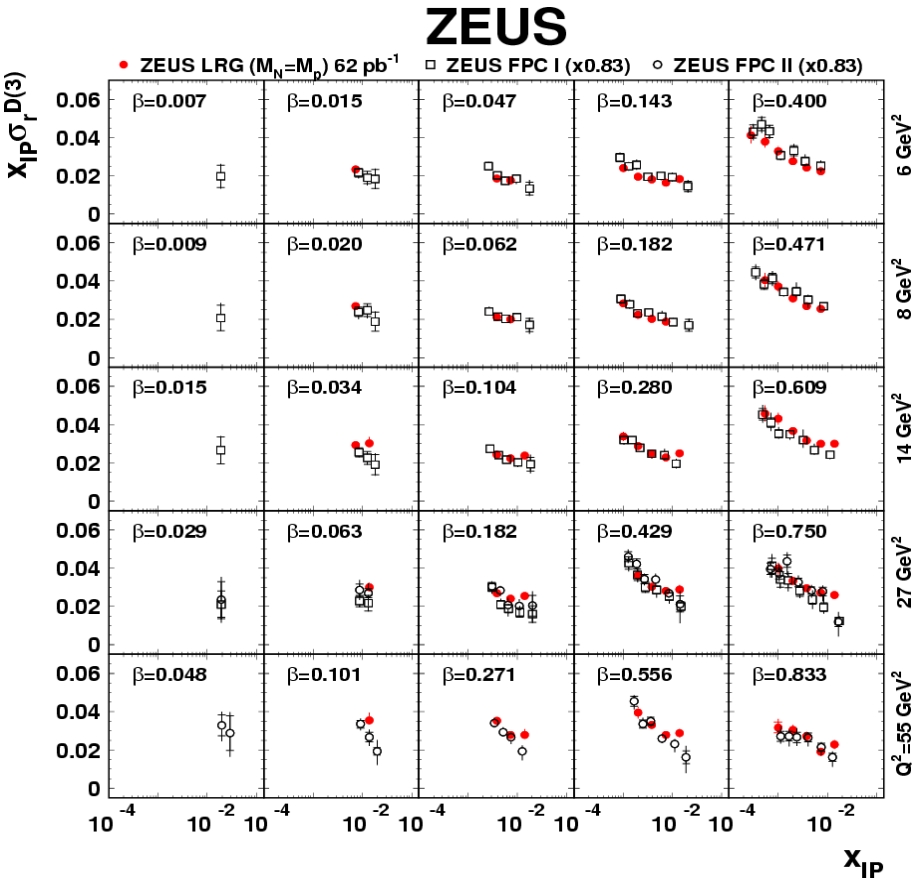
→ $1 \cdot 10^{-3} < x < 5 \cdot 10^{-3}$ constant

→ $x > 5 \cdot 10^{-3}$ negative scaling violations

Nucl. Phys. B800 (2008) 1

Comparison of different methods





- LPS/LRG (before the subtraction of proton-dissociative background)
- Average fit

→ FPC I/FPC II results corresponds to M_X method

→ scaling factor because proton dissociative background in M_X data

Nucl. Physics B816(2009) 1-61

Diffractive PDFs

Assuming Regge factorisation:

$$f_i^D(z, x_{IP}, Q^2, t) = f_{x_{IP}}(x_{IP})\, f_i(z, Q^2) + f_{x_{IR}}(x_{IP})\, f_i^{IR}(z, Q^2)$$

$$f_{IP,IR}(x_{IP}, t) = \frac{A_{IP,IR}\, e^{B_{IP,IR}\, t}}{x^{2\alpha_{IP,IR}(t)-1}}$$

Parametrisation derived from fits to pion structure function*

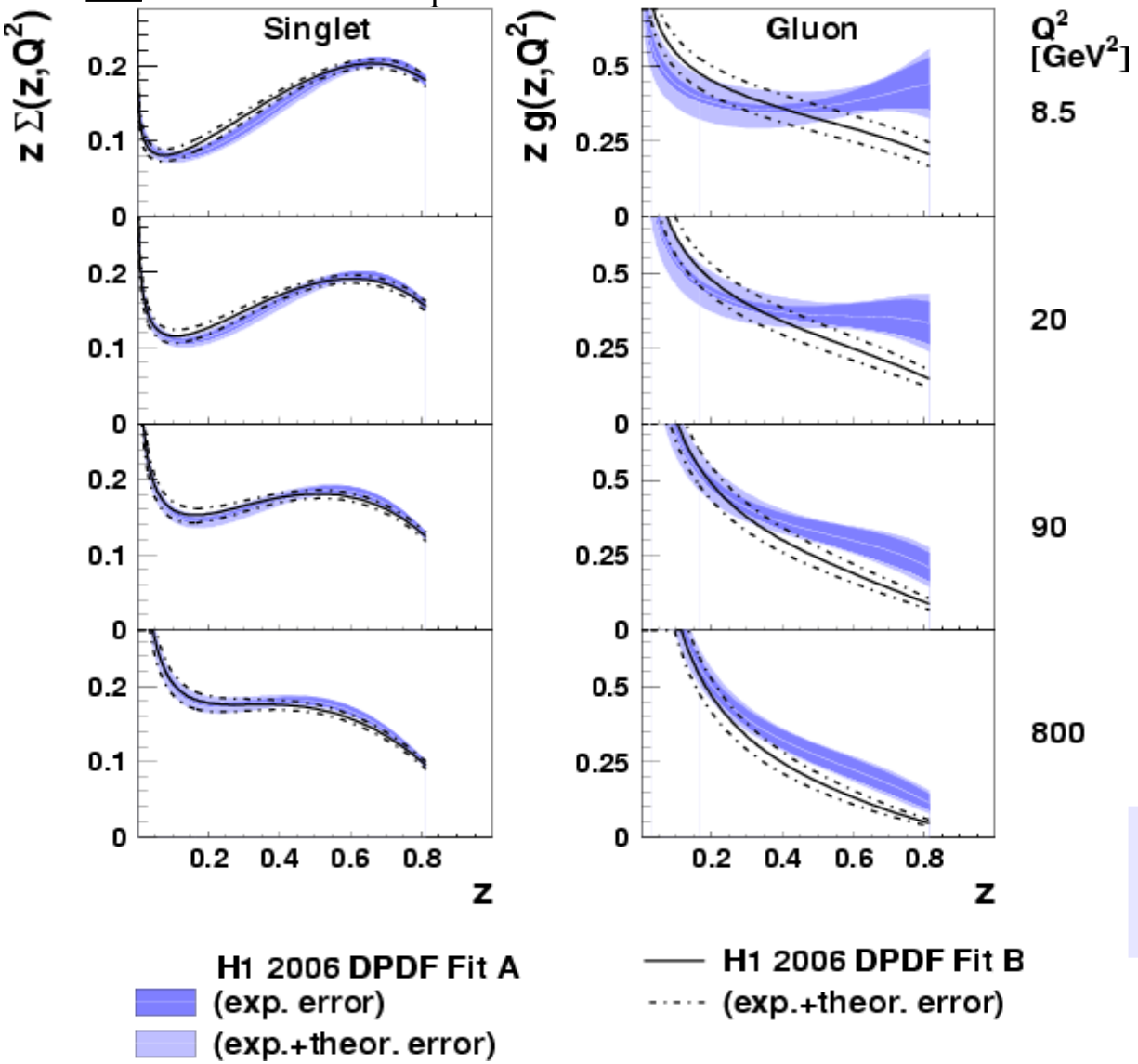
DPDFs:

- allow the investigation of low-momentum partons in the proton,
- are an essential input to predictions of hard diffractive processes at the LHC

*M.Gluck, E.Reya and A.Vogt, Z. Phys. C 53, 127 (1992)

H1 DPDFs

$$z\sum(z,Q_0^2)=A_q z^{B_q}(1-z)^{C_q}$$



Fit A & Fit B differ in the parametrisation chosen for the gluon density at the starting scale for QCD evolutions.

Fit A:

$$zg(z,Q_0^2)=A_g(1-z)^{C_g}$$

Fit B:

$$z\,g(z,Q_0^2)=A_g$$

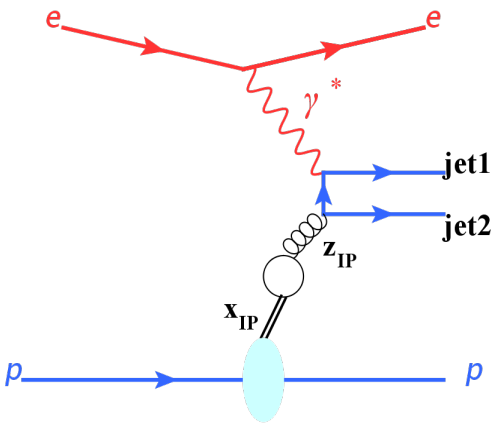
quark distribution is well constrain

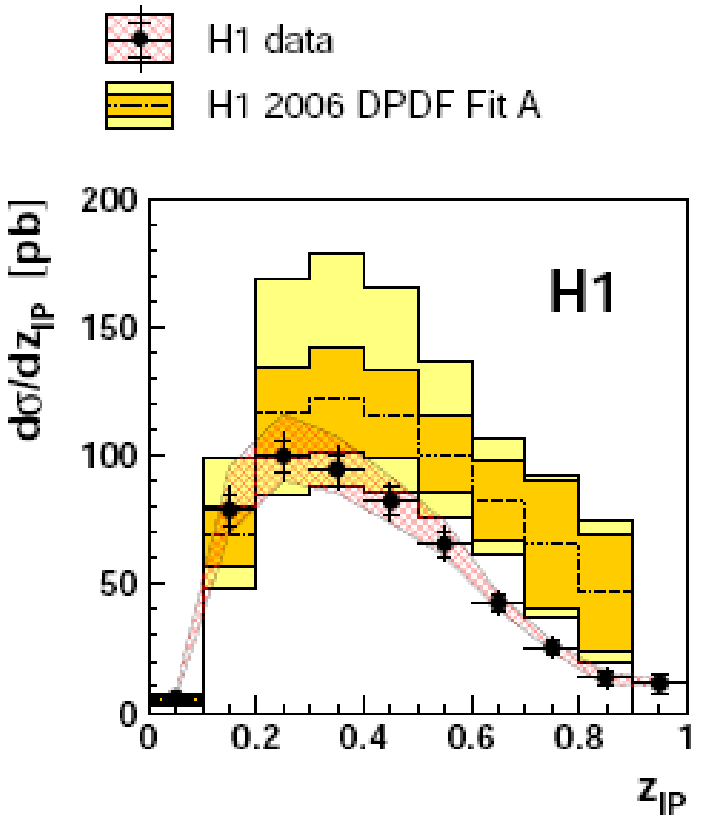
Europ. Phys. Journal C48(2006) 715

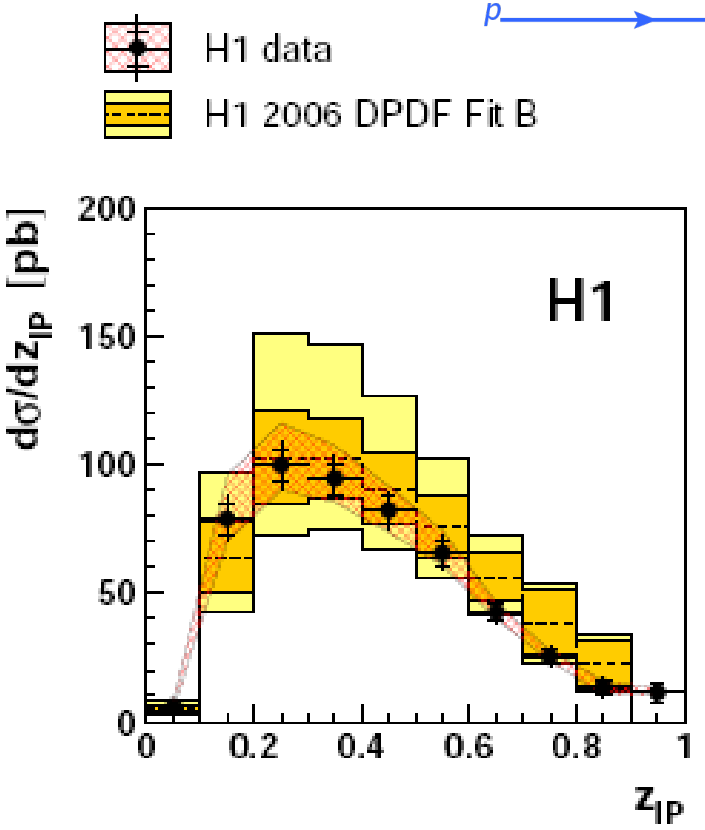
DPDFs compared to H1 dijets data

Dijets production:

- two jets are detected in the detector
- allows to test DPDF on independent sample
- is sensitive to the gluon distributions

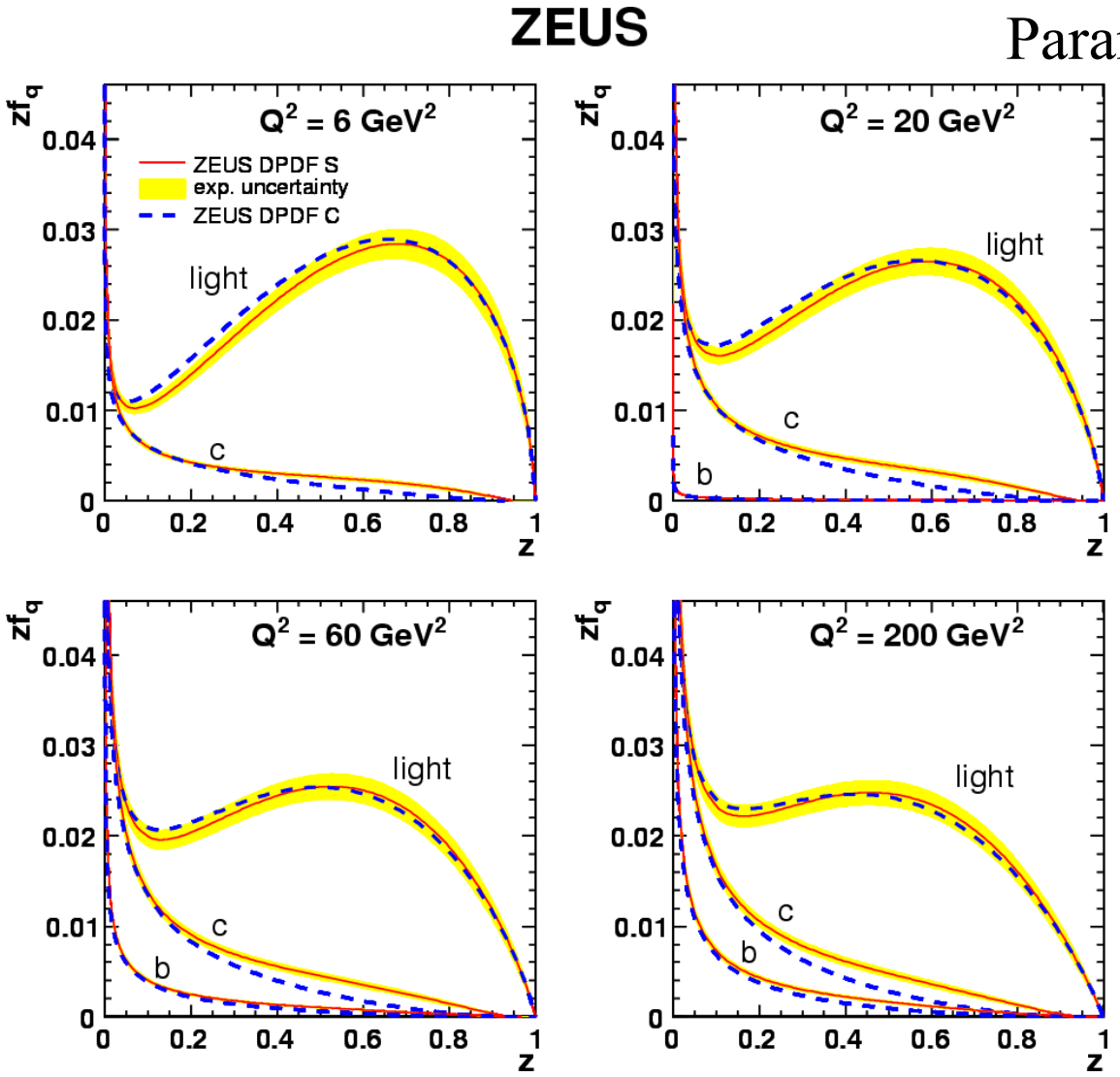






J. High Energy Phys.10(2007) 042

Quarks distributions function at ZEUS



Parametrisation of quark functions

$$zf_q = A_q z^{B_q} (1-z)^{C_q}$$

Fits to LRG+LPS data:

Fit "ZEUS DPDF S"

Fit "ZEUS DPDF C" $B_g = C_g = 0$

Quark distributions are very similar for fit DPDF S and DPDF C

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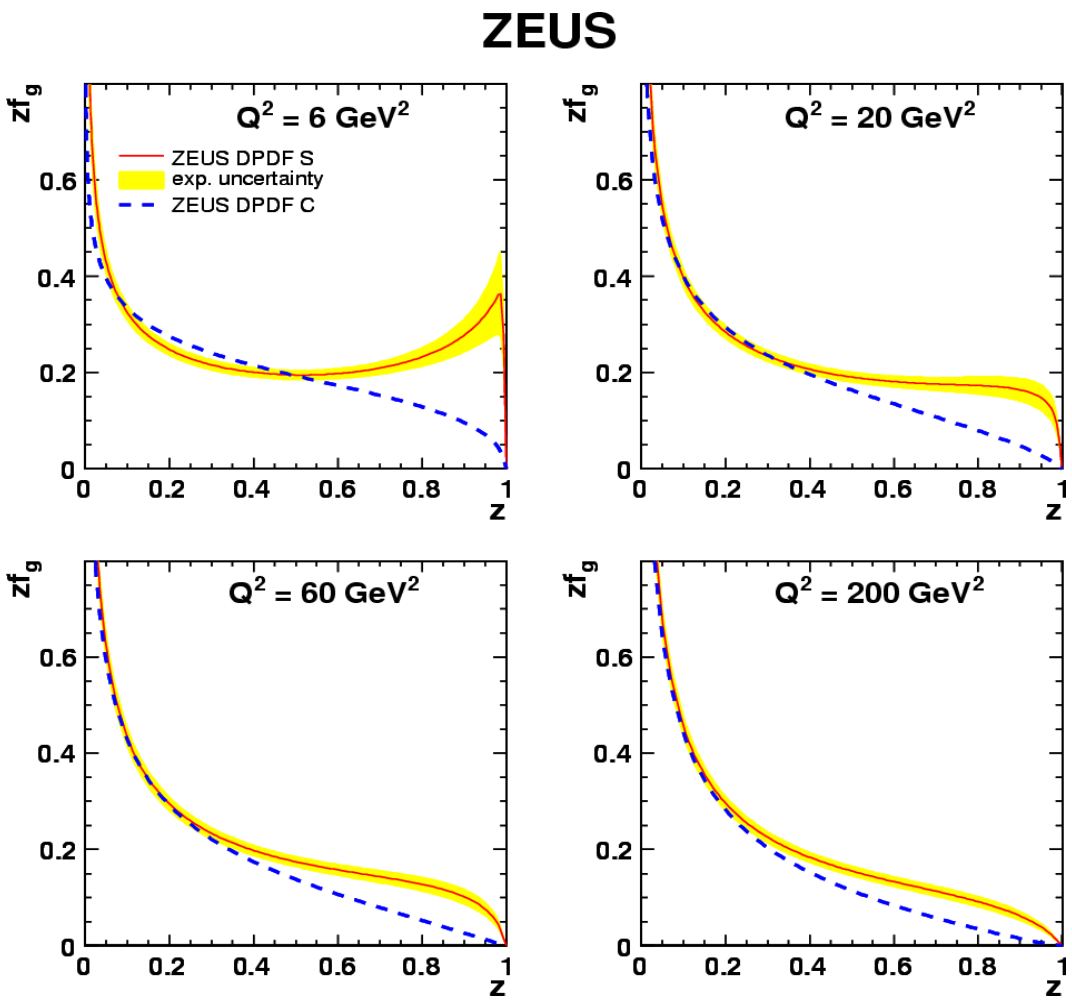
Gluons distribution functions at ZEUS



$$z f_g(z, Q_0^2) = A_g z^{B_g} (1-z)^{C_g}$$

Fits to LRG+LPS data:

Fit "ZEUS DPDF S"

Fit "ZEUS DPDF C" $B_g = C_g = 0$

→Gluons from fit DPDF S grow rapidity at high z

→Gluons from fit DPDF C vanish as z–>1 in smooth way

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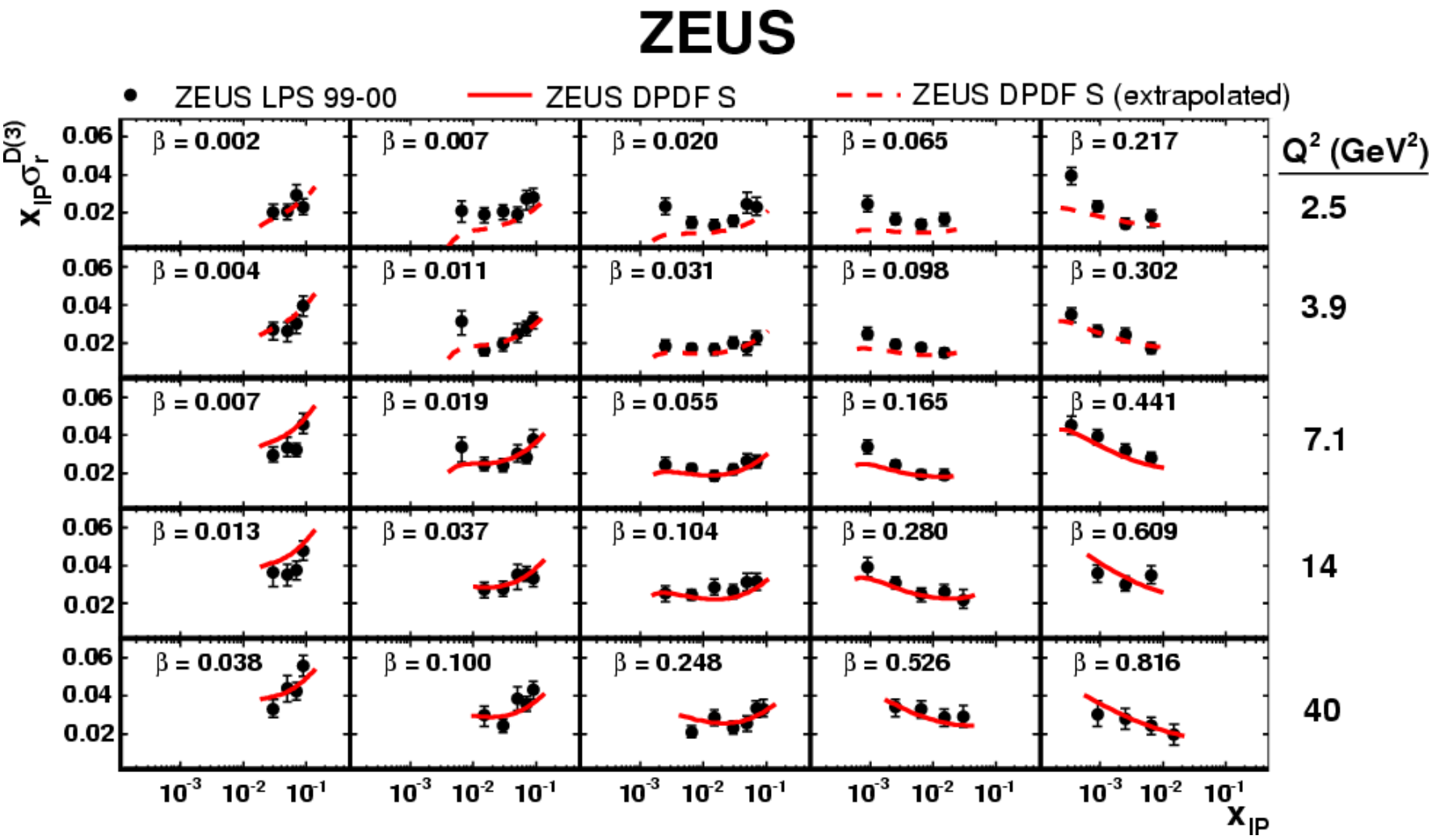
ZEUS LPS with DPDF S fit



Fits ZEUS DPFDF C and S are of equally good quality and the predicted reduced cross sections are indistinguishable

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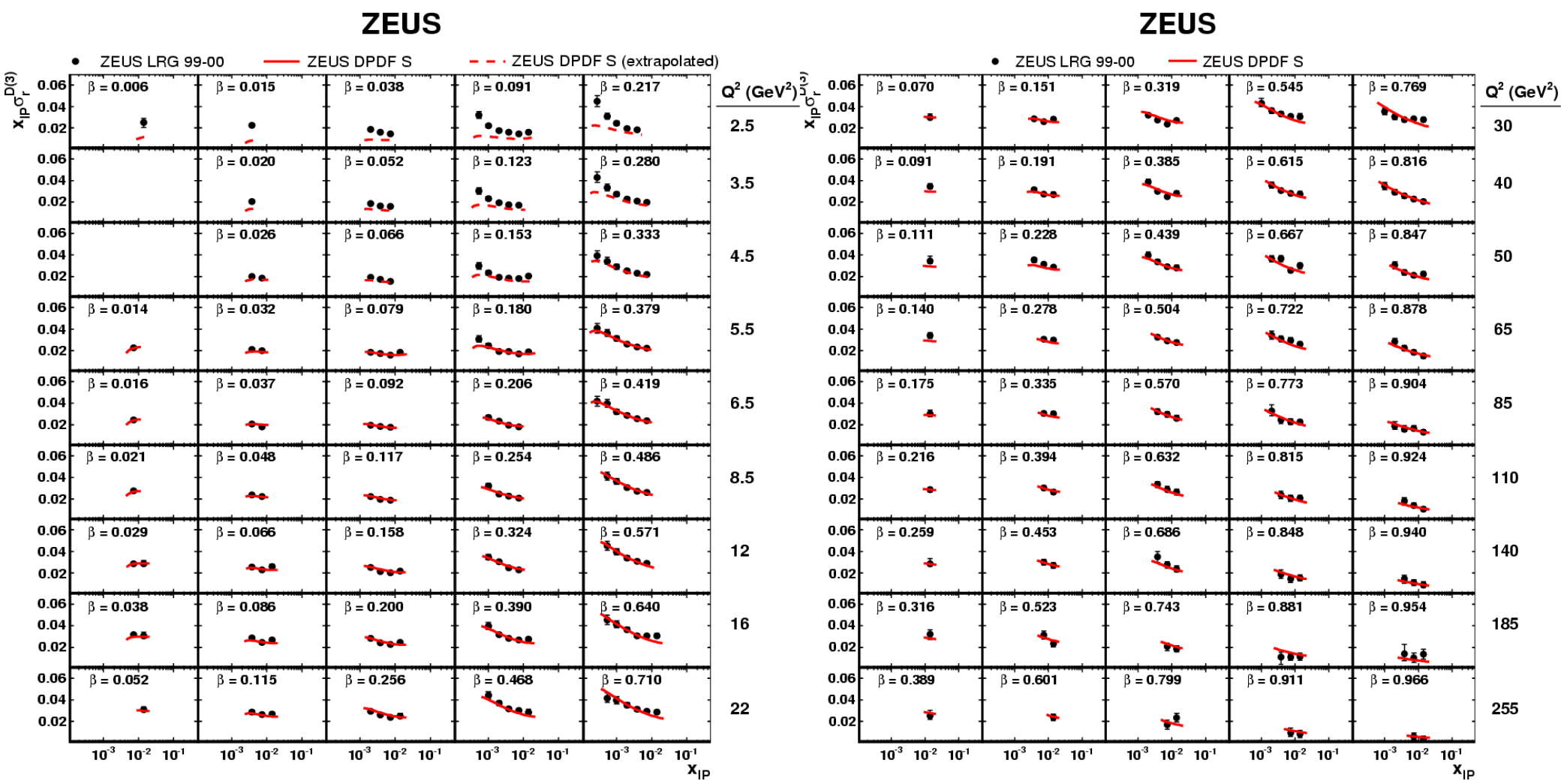
ZEUS LRG with DPDF S fit



Data are good described by the fit

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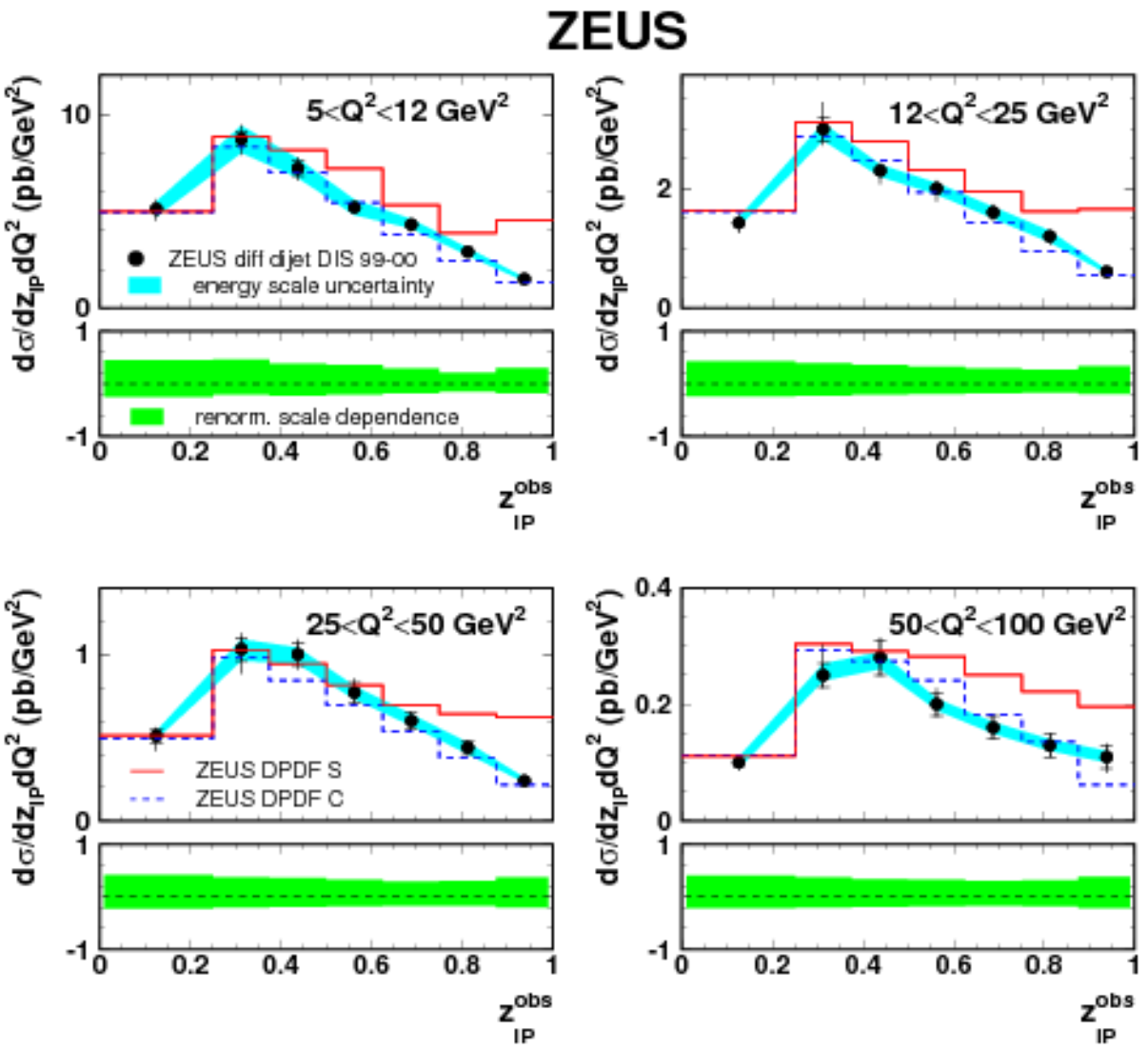
DPDFs compared to ZEUS dijets data



ZEUS DPDF S

ZEUS DPDF C

Dijets data are sensitive to gluon density

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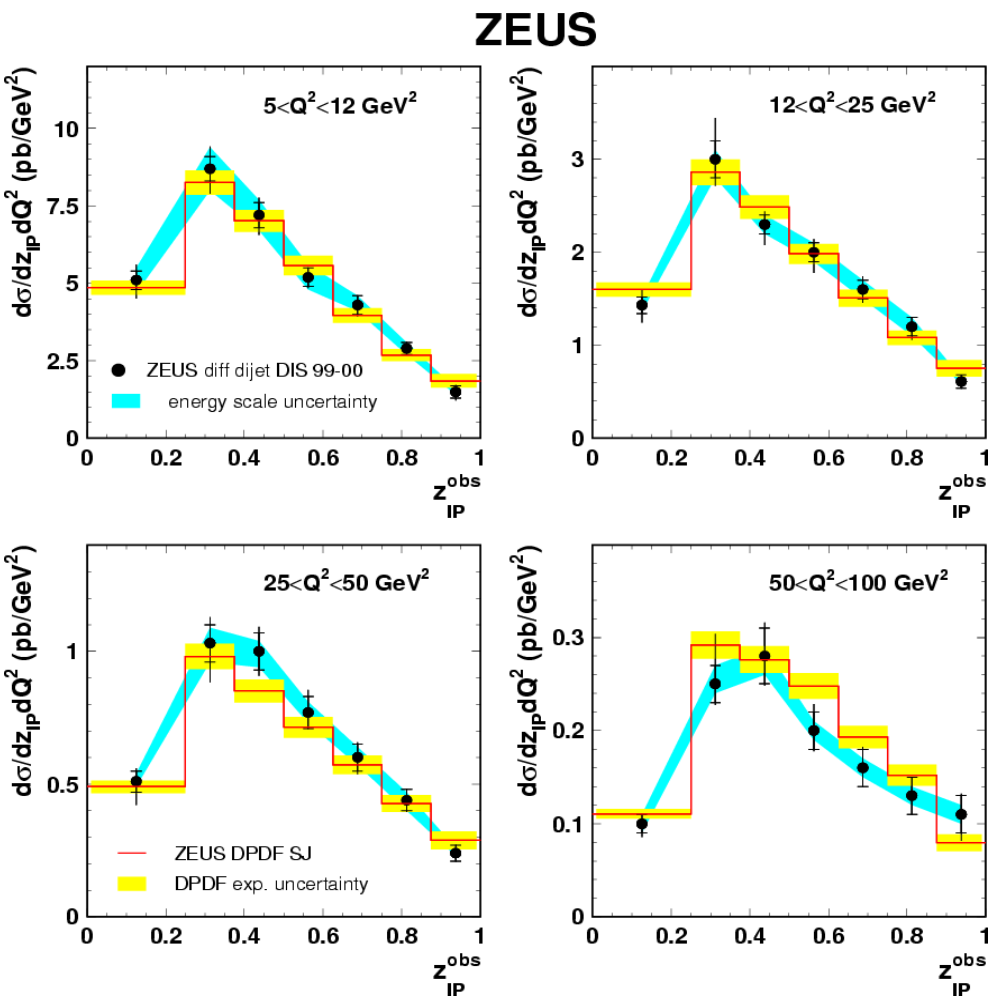
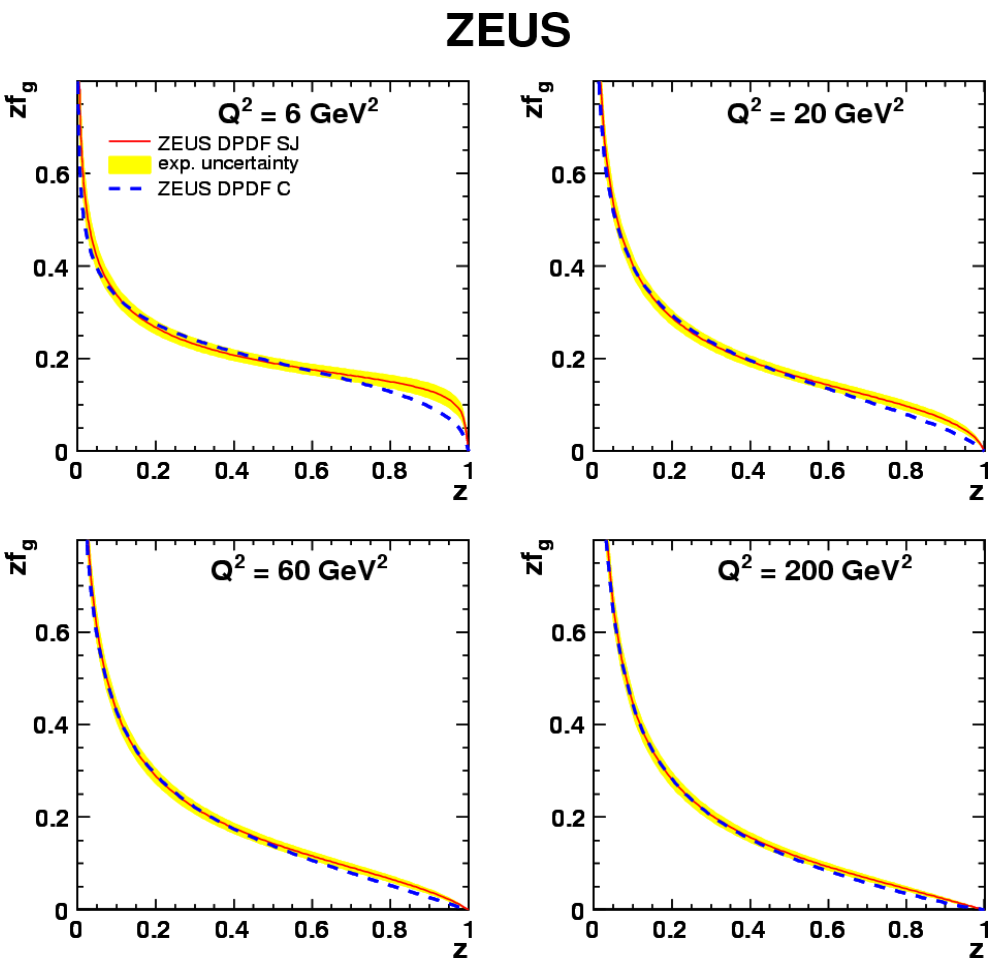
ZEUS DPDF SJ





Fit to LRG + LPS+ DIS dijet data:

Fit "DPDF SJ"

Good description of ZEUS dijets data

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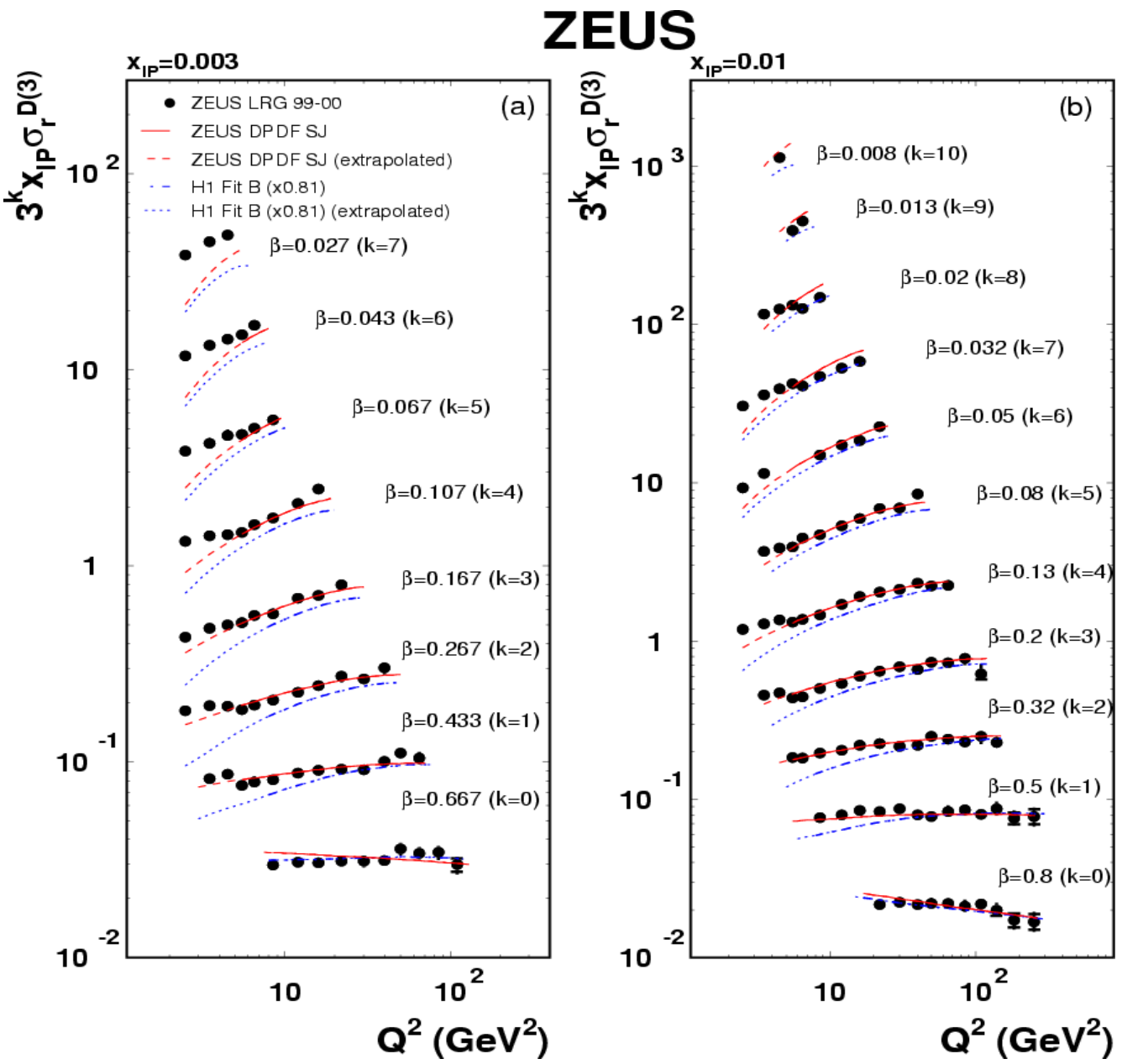
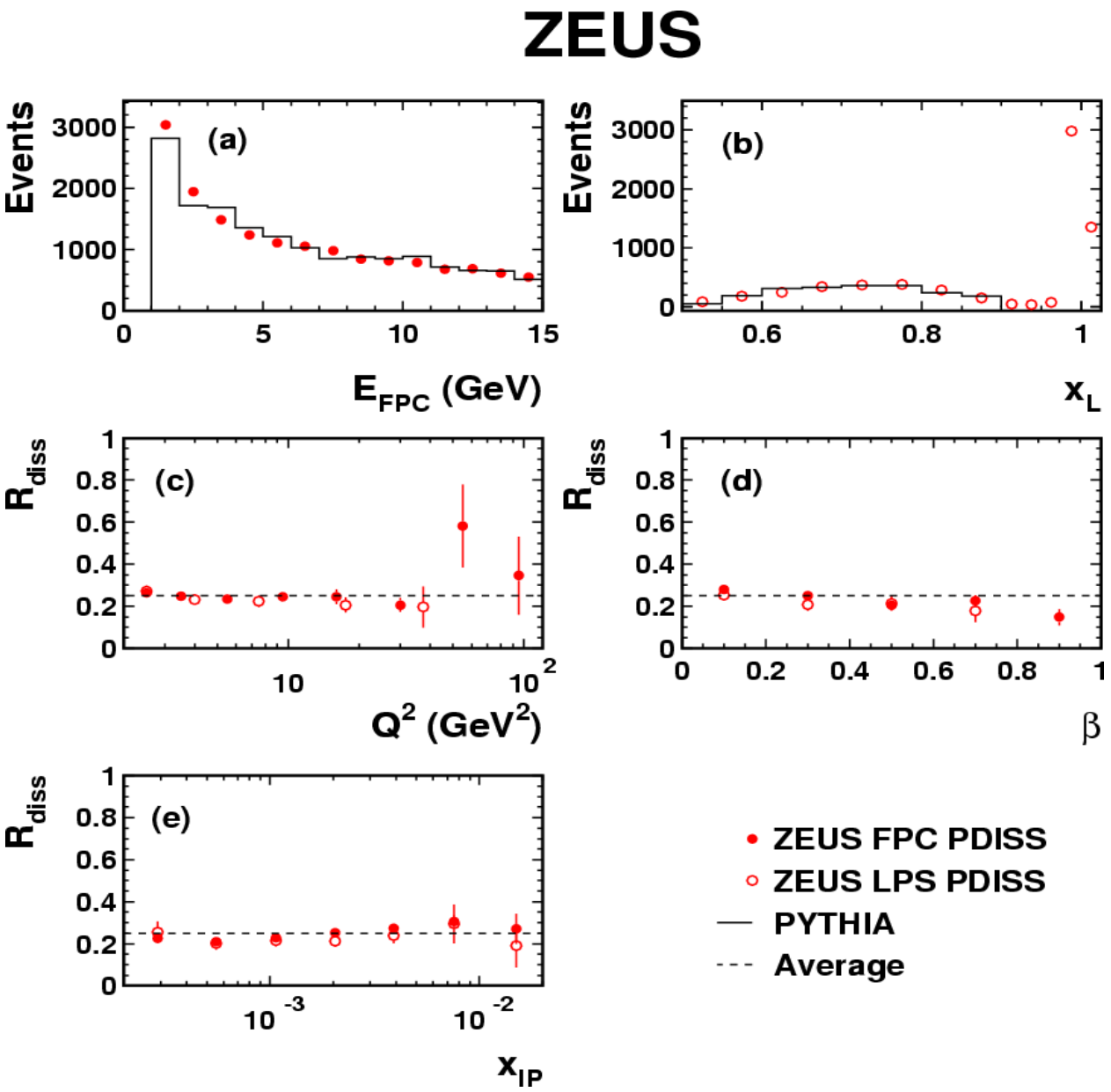
Comparison between HERA data and DPDFs



Summary

- The inclusive diffraction has been explored by HERA experiments H1 and ZEUS
- Good agreement is observed:
  - between both experiments
  - between data and Regge factorisation assumption
- The DPDFs were measured by H1 and ZEUS

Proton dissociation – backup slide



LPS data – t measurement