Lake Louise Winter Institute 2009

Inclusive diffraction in DIS

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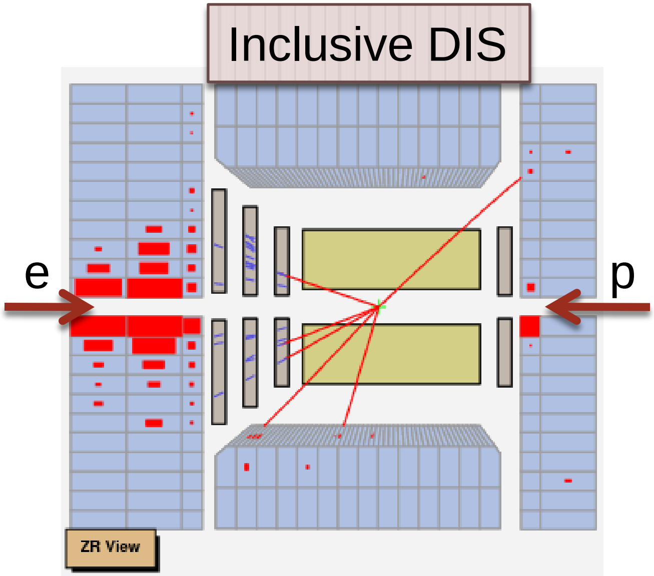
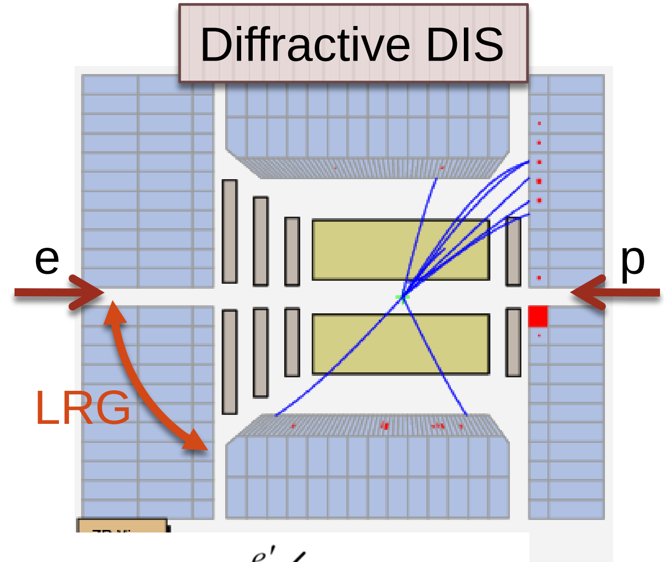
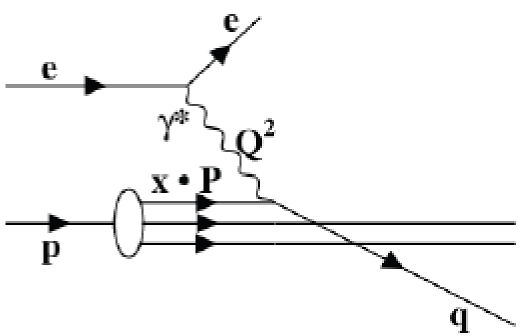
On behalf of ZEUS and H1 Collaborations

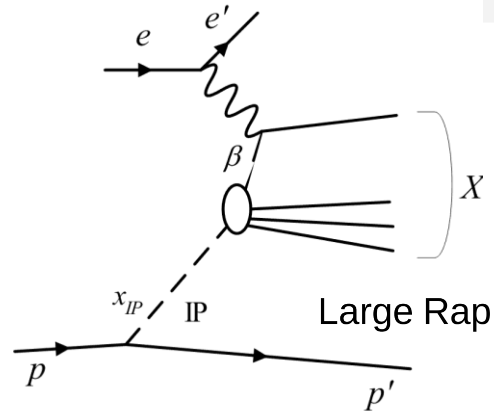
- Introduction
- Results in inclusive diffraction
- Diffractive parton density functions
- Summary

Diffractive DIS at HERA









Large Rapidity Gap

•Photon probes internal structure of proton
•Parton densities in proton

•Photon probes internal structure of colorless exchange - Pomeron
•Parton densities in Pomeron

Diffractive DIS kinematics and cross section

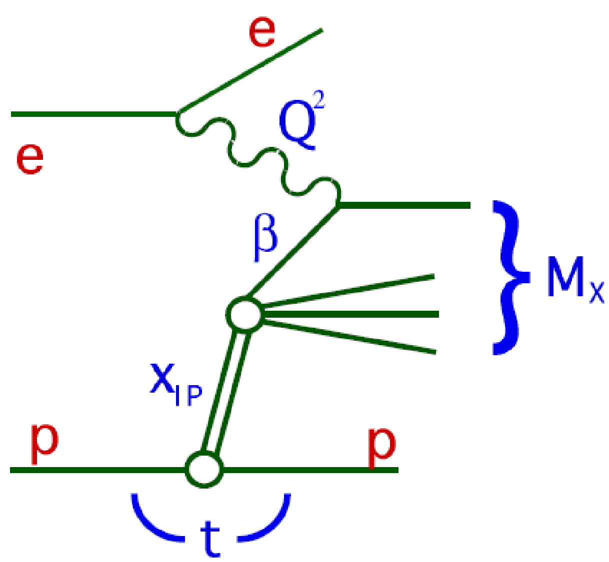
Q^2 = virtuality of photon =
= (4-momentum exchanged at e vertex)^2

M_X = invariant mass of γ^* -IP system

x_{IP} = fraction of proton's momentum carried by IP

ß = Bjorken's variable for the IP
= fraction of IP momentum carried by struck quark
= x/x_{IP}

t = (4-momentum exchanged at p vertex)^2
typically: $|t|<1$ GeV^2



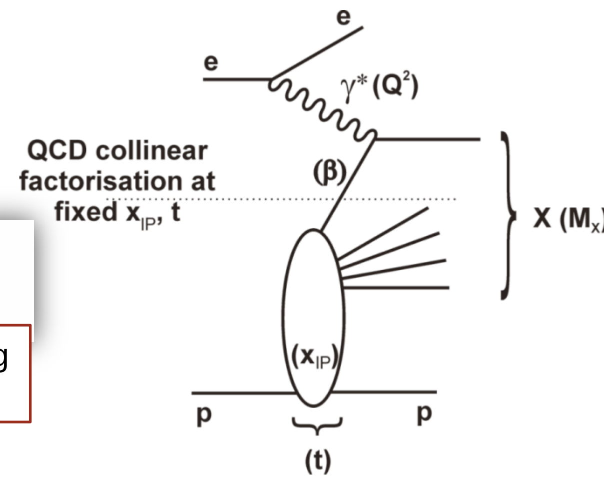
$$\frac{d^4\sigma_{\gamma^* p}}{dQ^2 dt dx_{IP} d\beta} = \frac{2\pi\alpha_{em}}{\beta \cdot Q^2}\left[1-(1-y)^2\right]\cdot \sigma_r^{D(4)}(Q^2, t, x_{IP}, \beta)$$

Reduced cross section

t is integrated over when not measured:

$$\frac{d^3\sigma_{\gamma^* p}}{dQ^2 dx_{IP} d\beta} = \frac{2\pi\alpha_{em}}{\beta Q^2}\left[1-(1-y)^2\right]\cdot \sigma_r^{D(3)}(Q^2, x_{IP}, \beta)$$

Factorisation in diffractive DIS

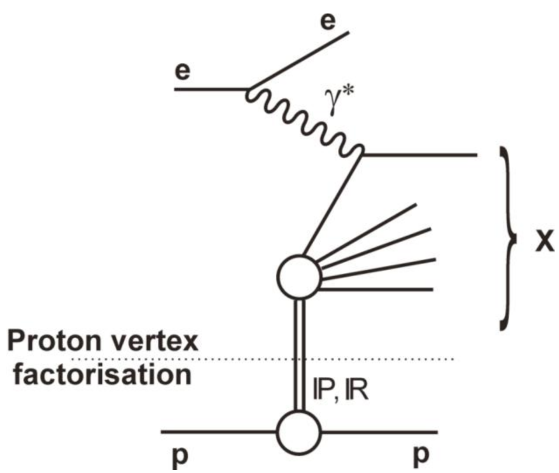


QCD factorisation at fixed x_{IP} and t (Collins)

$$d\sigma^{ep\to eXY}(x,Q^2,x_{I\!P},t) = \sum_i f_i^D(x,Q^2,x_{I\!P},t) \otimes d\hat{\sigma}^{ei}(x,Q^2)$$

Universal diffractive parton density functions

Hard scattering cross section



Proton vertex factorisation of (β, Q^2) from (x_{IP}, t)

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

Pomeron flux

Partonic structure

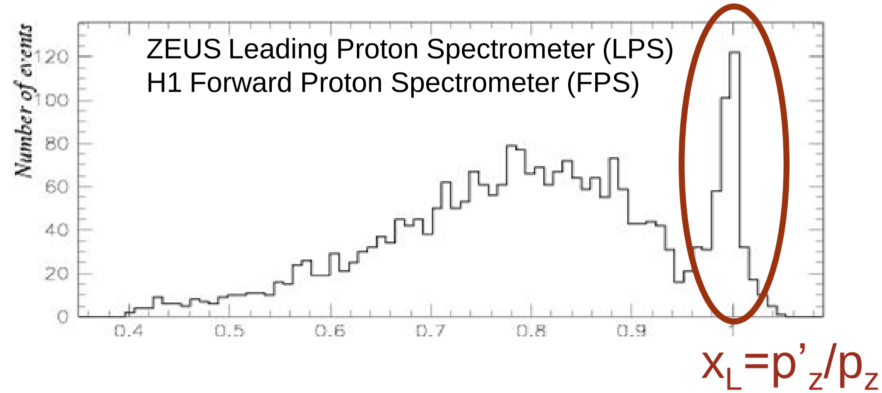
$$f_{I\!P/p}(x_{I\!P},t) = A_{I\!P} \cdot \frac{e^{B_{I\!P}t}}{x_{I\!P}^{2\alpha_{I\!P}(t)-1}}$$

This is the basis of performing Regge and NLO QCD (DGLAP) fits to extract diffractive parton distribution functions

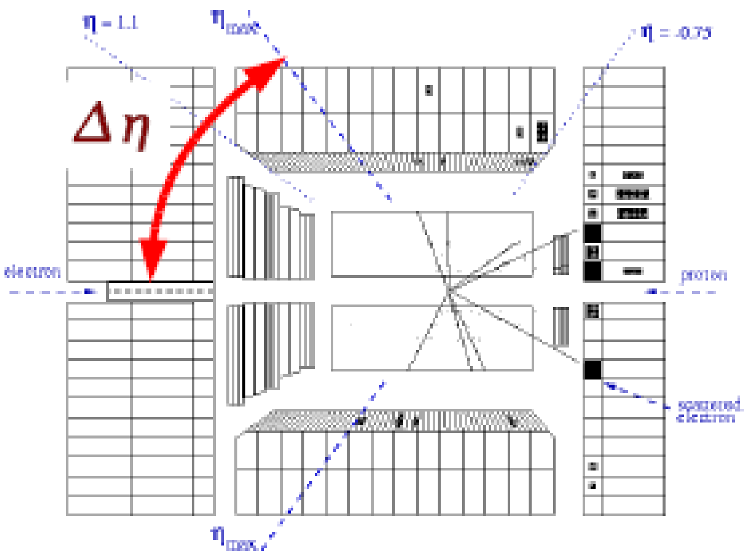
Experimental signatures of diffraction

LPS method

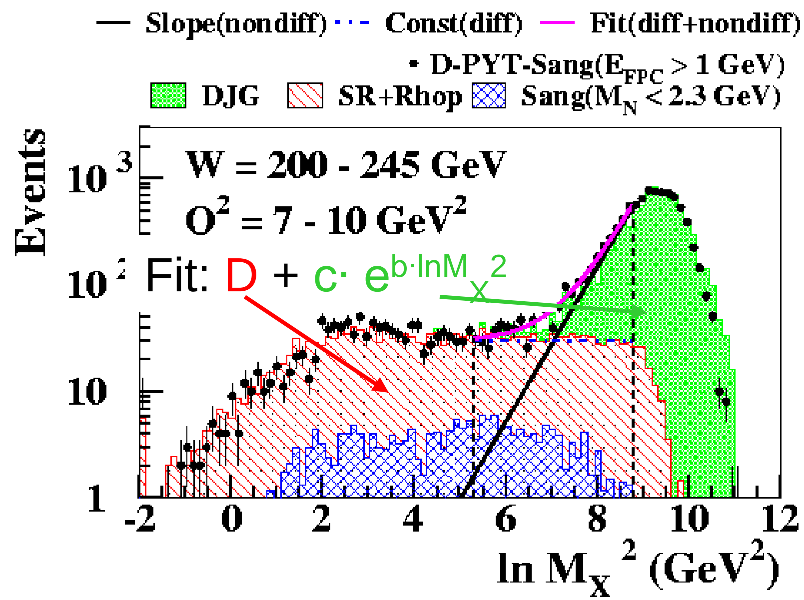
Pros: no proton-diss. background
direct measurement of t and x_{IP}
Cons: limited statistics



Large rapidity gap (LRG) method



M_X method



Pros: large acceptance
Cons: proton diss. background

Data sets

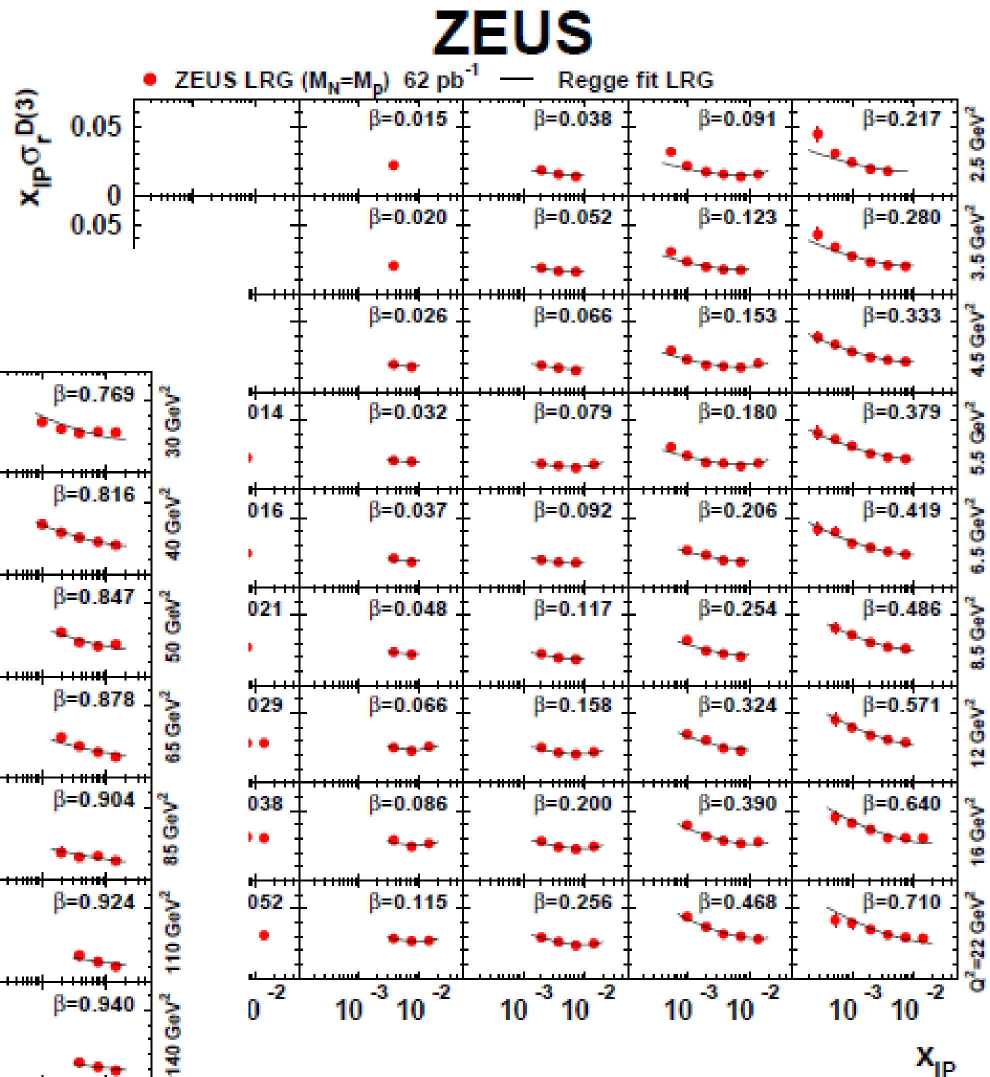
ZEUS	"ZEUS LPS" [arXiv:0812.2003, submitted to NPB]	x_{IP} up to 0.1	
	"ZEUS LRG" [arXiv:0812.2003, submitted to NPB]	x_{IP} up to 0.02	$M_N = m_p$
	"ZEUS FPC II" (M_X method) [NPB 800 (2008)]	IR suppressed	$M_N < 2.3$ GeV
	"ZEUS FPC I" (M_X method) [NPB 713 (2005)]	IR suppressed	$M_N < 2.3$ GeV

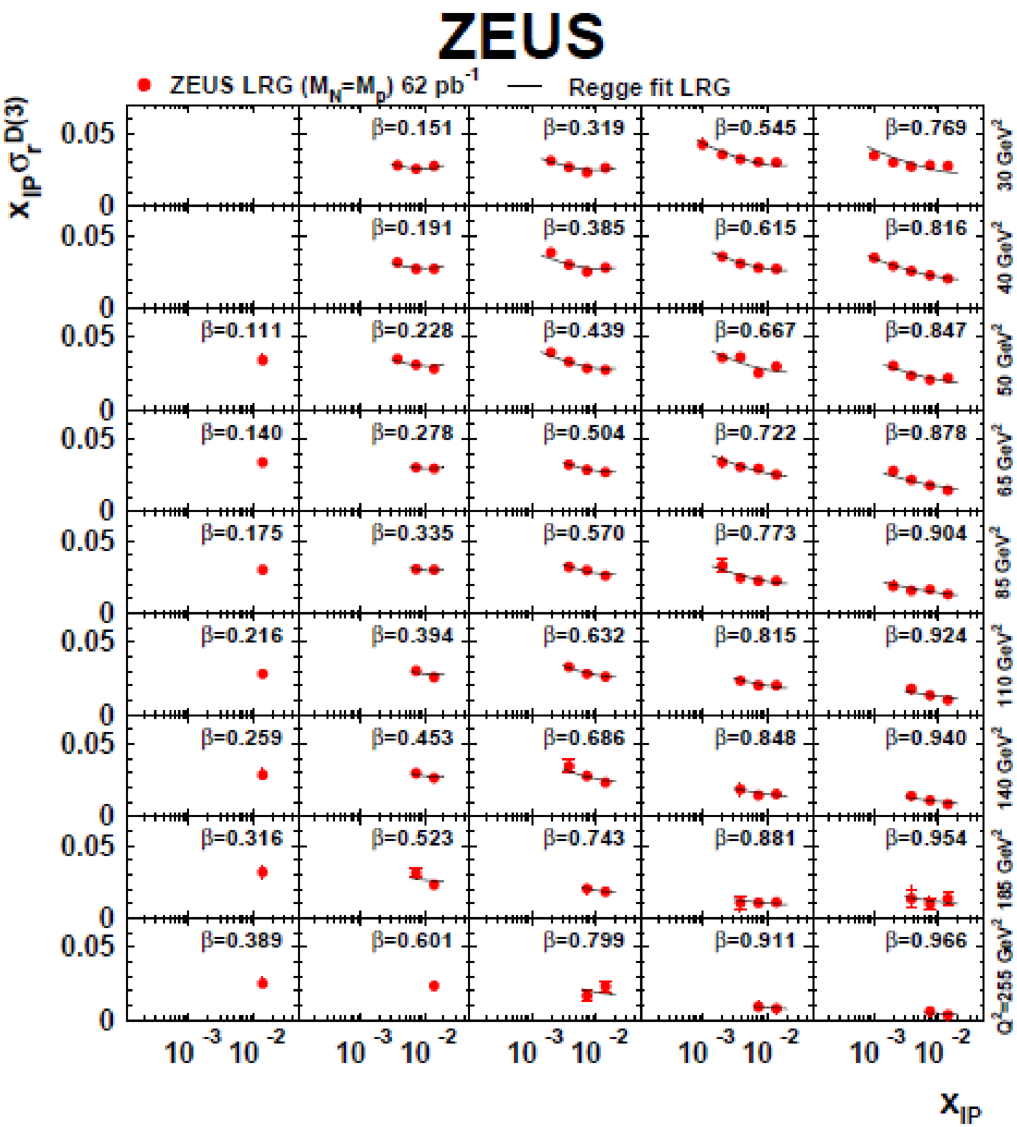
35% of LPS events selected by LRG
Overlap LRG-M_X ~75%

H1	"H1 FPS" [EPJ C48 (2006)]	x_{IP} up to 0.1	
	"H1 LRG" [EPJ C48 (2006)]	x_{IP} up to 0.03	$M_N < 1.6$ GeV

FPS and LRG measurements statistically independent and only very weakly correlated through systematics

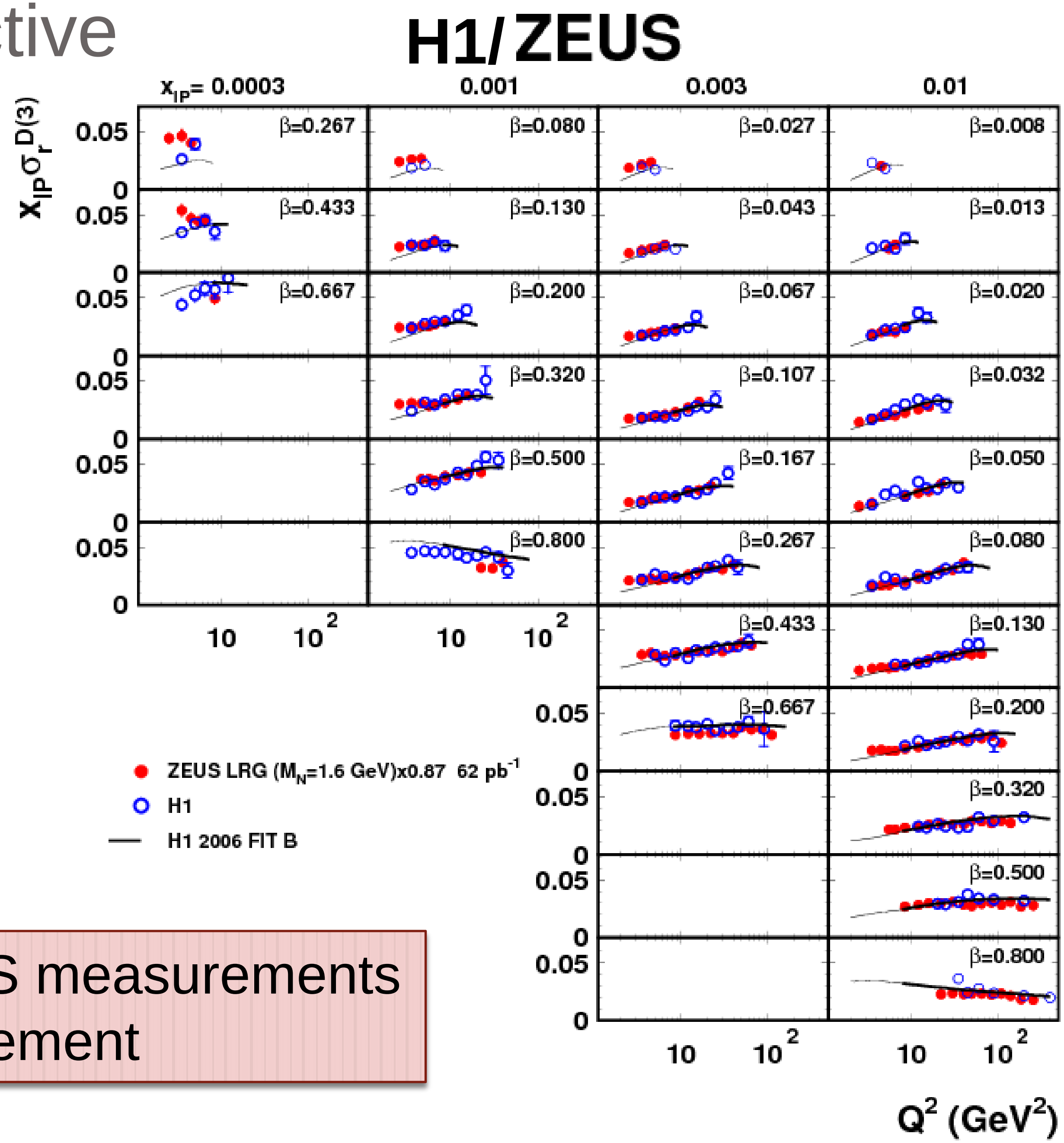
New LRG ZEUS results





Wide kinematic coverage and very good precision

Inclusive diffractive cross section

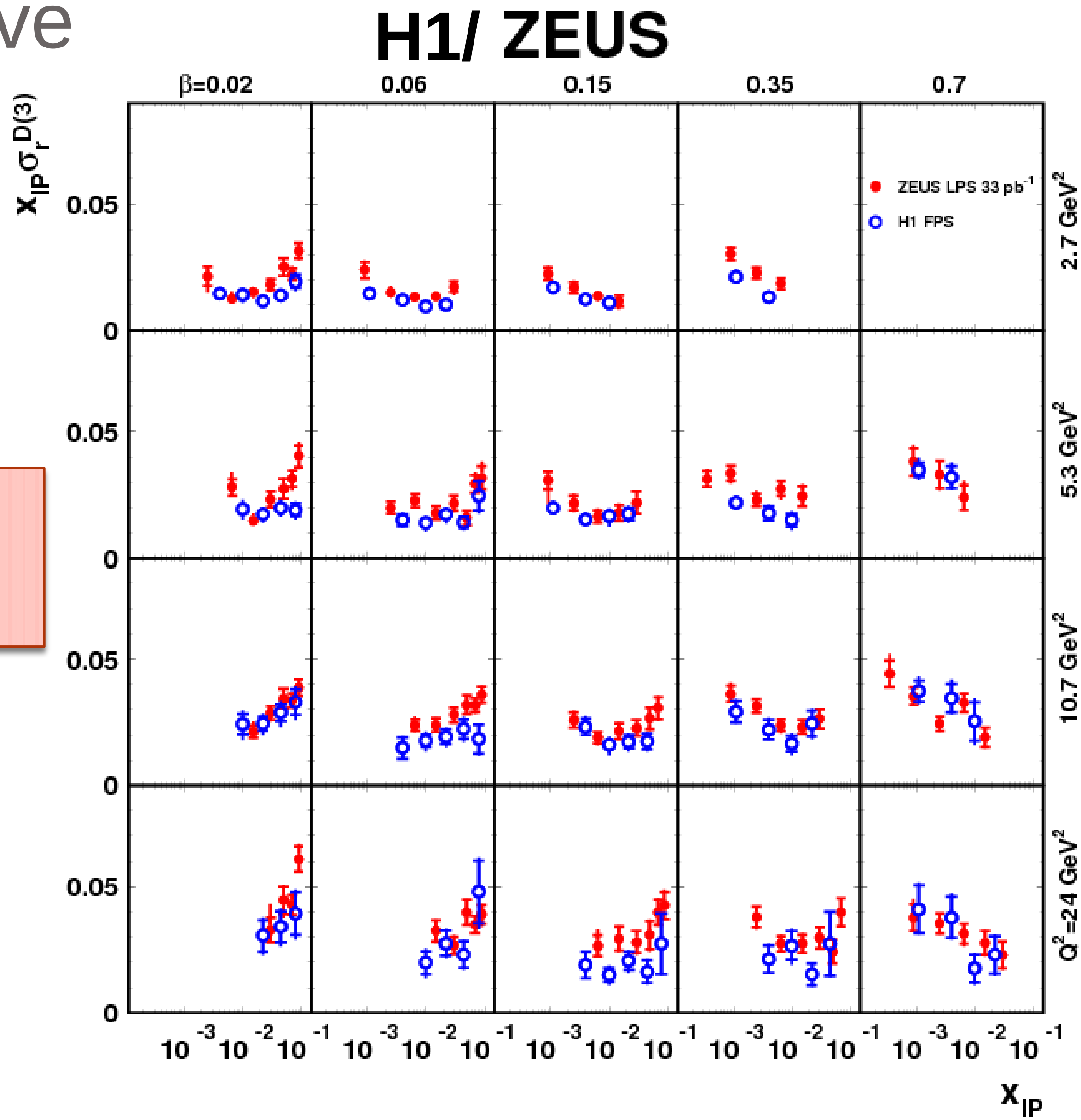


ZEUS cross section scaled by 13% to account for normalization and proton dissociation background uncertainties

H1 and ZEUS measurements in good agreement

Inclusive diffractive cross section (2)

ZEUS and H1 proton-tagged data agree within normalisation uncertainties

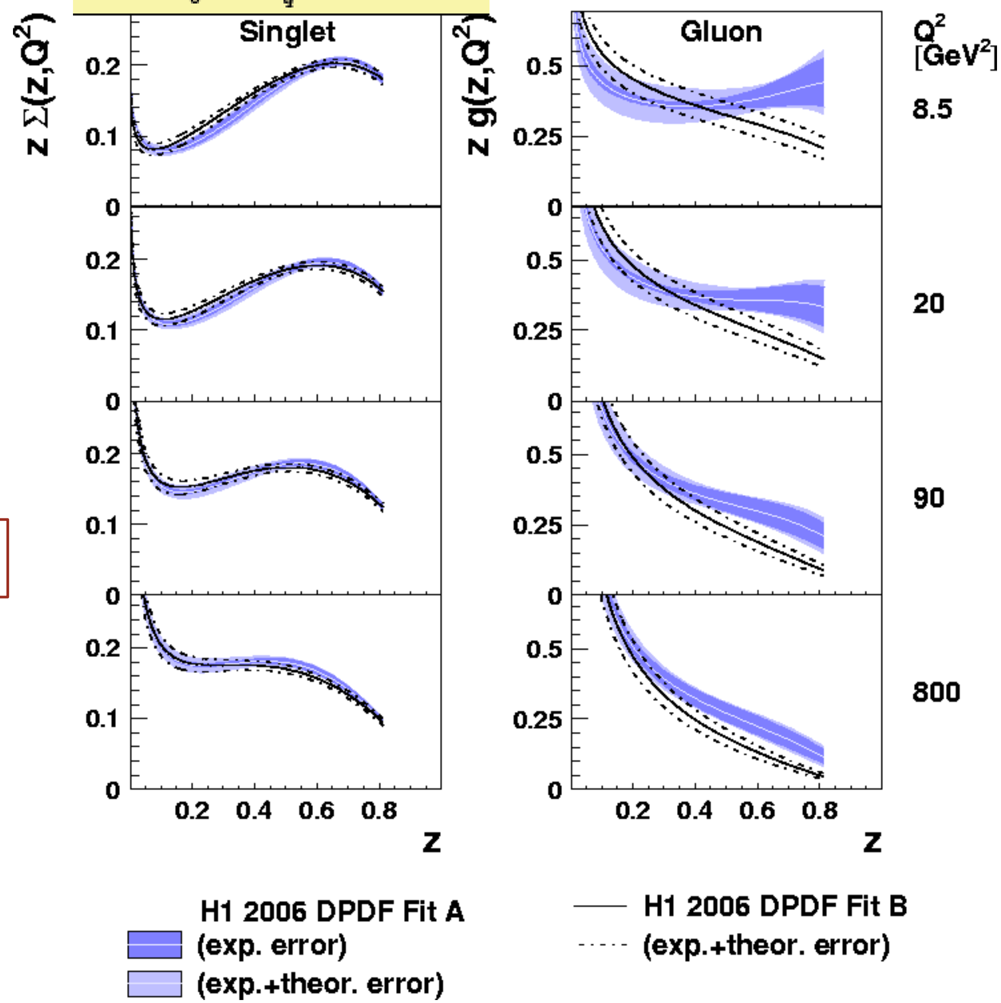


Diffractive PDFs

z = fractional momentum of the diffractive exchange participating to the hard scattering

- NLO QCD (DGLAP) fits to inclusive cross sections – as in proton PDFs extraction from inclusive DIS
- Different gluon density parameterisations: Fit A and Fit B
- Quark distributions are well constrained
- Gluons weakly constrained especially at high z – need further input

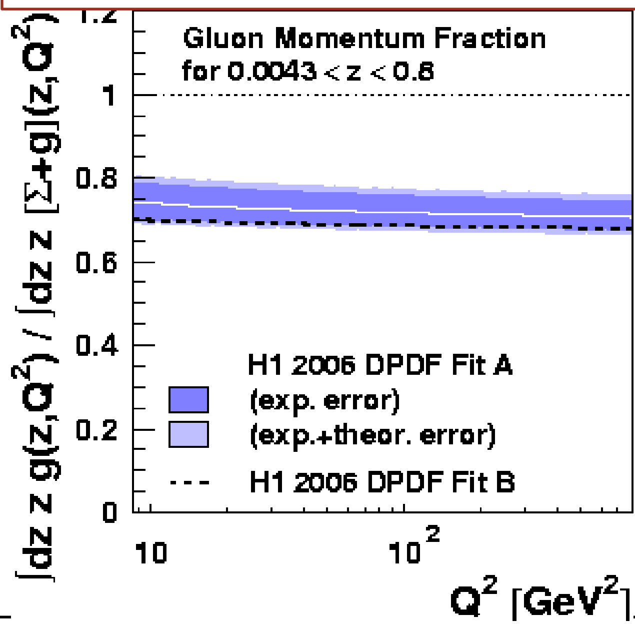
$$z\Sigma(z,Q_0^2) = A_q z^{B_q}(1-z)^{C_q}$$



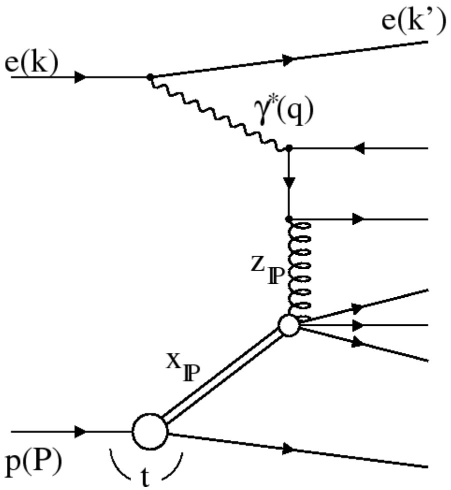
$$z_g(z,Q_0^2) = A_g(1-z)^{C_g}$$

$$z_g(z,Q_0^2) = A_g$$

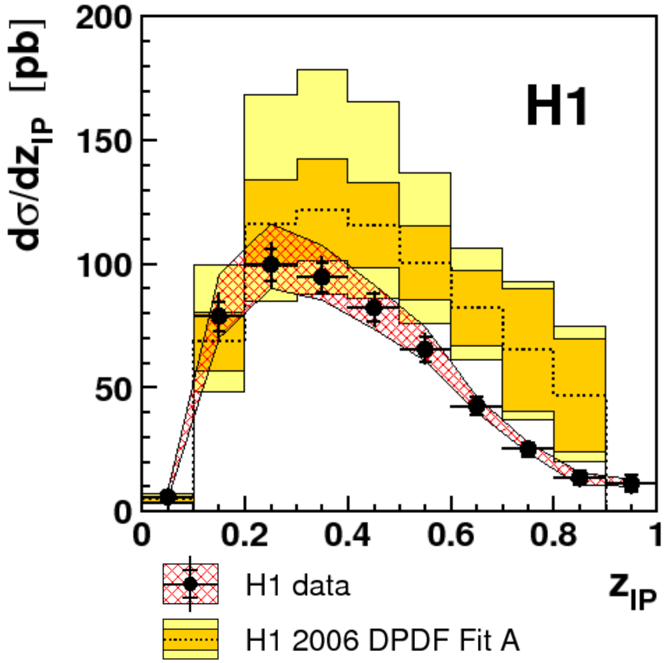
Pomeron is dominated by gluons

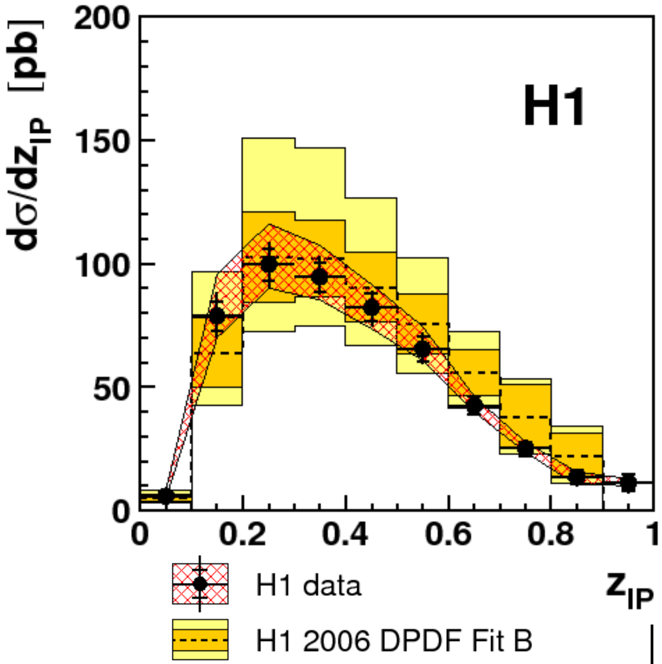


Comparison with diffractive dijet in DIS



Sensitive to gluon

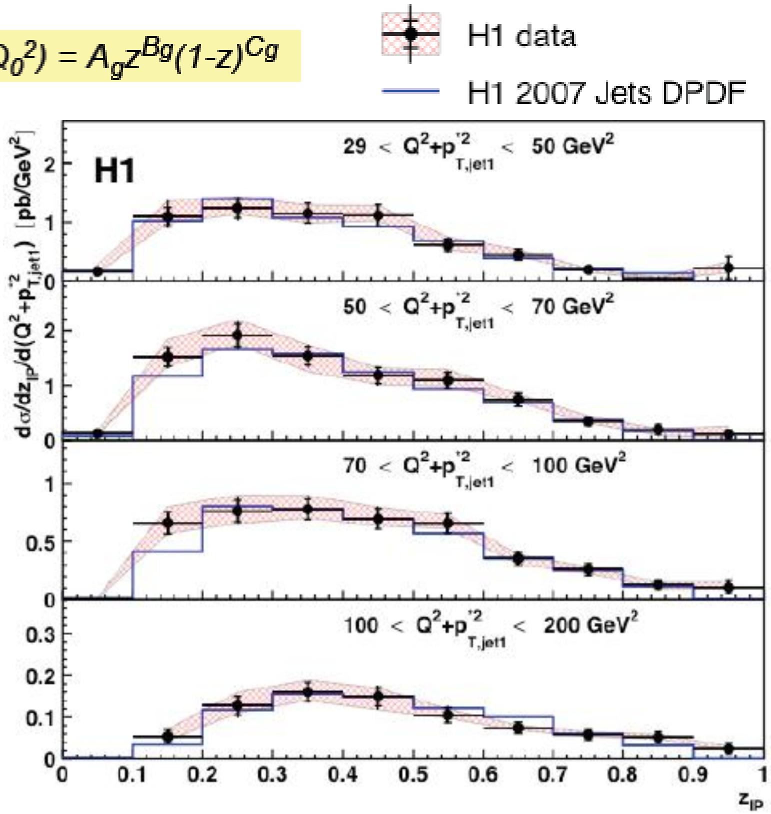


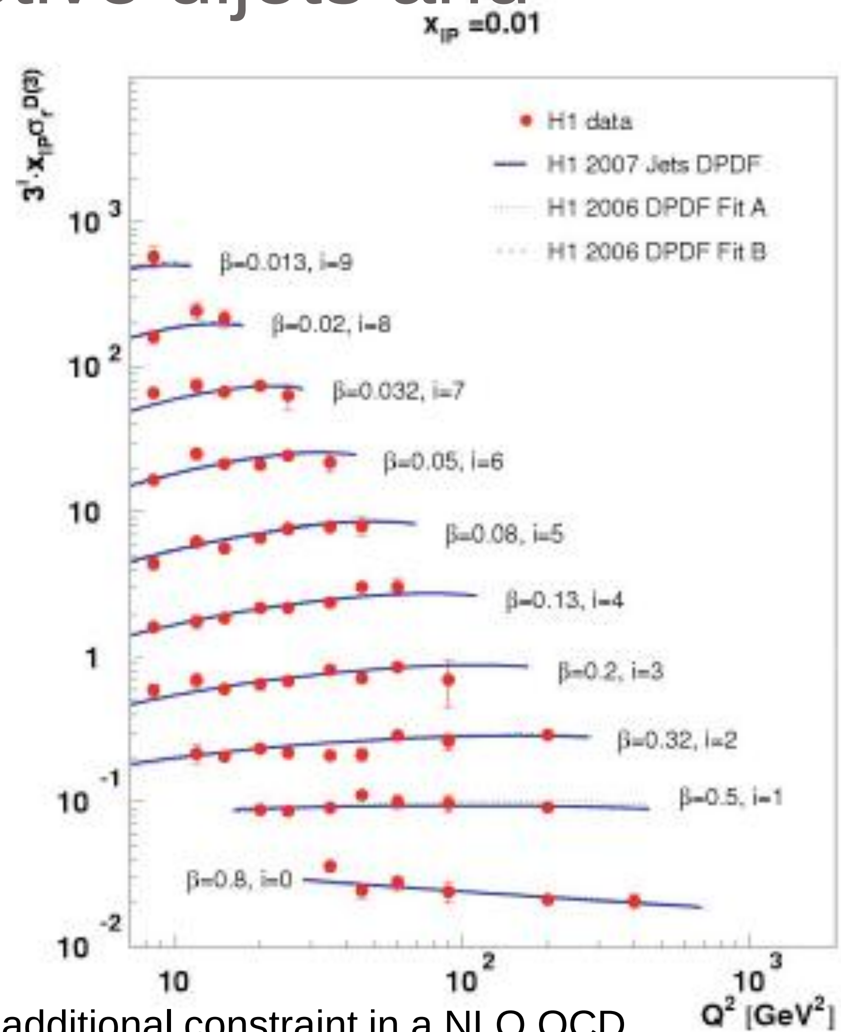


- At low z_{IP} (< 0.3) Fit A and Fit B are similar
- At high z_{IP} the diffractive dijet data clearly prefer Fit B
- Include the diffractive dijet in DIS in simultaneous fit with inclusive diffraction data

Combined fit of diffractive dijets and inclusive DIS data

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

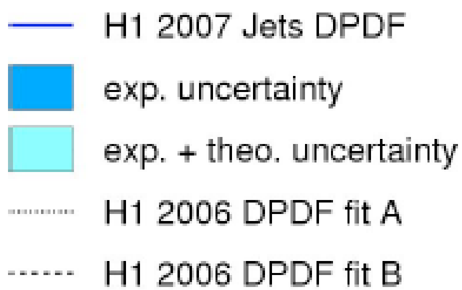




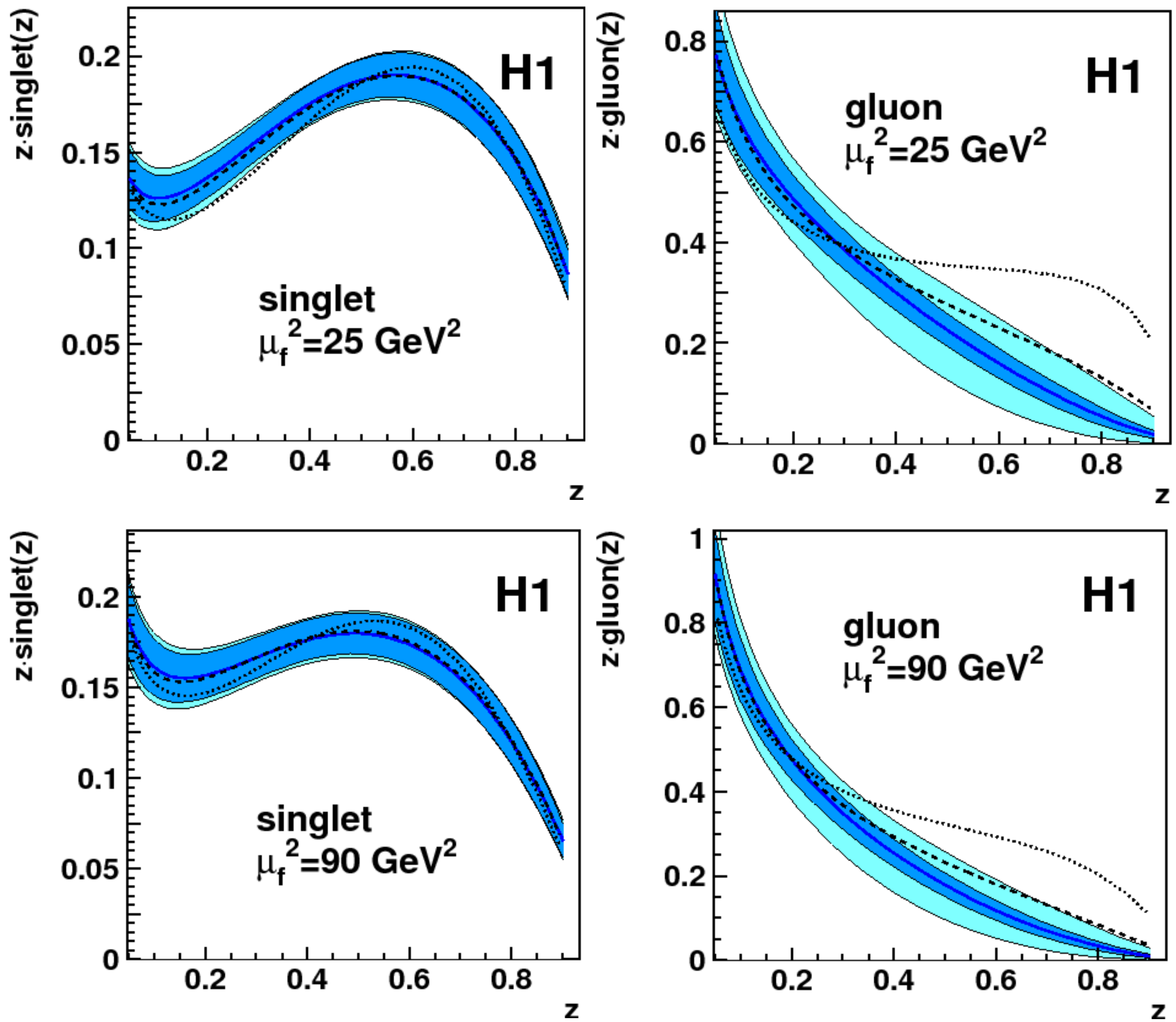
- The diffractive dijet data can be used as an additional constraint in a NLO QCD fit procedure
- Details of a fit similar to the inclusive case but can now constrain 3 parameters for the gluon

Very good simultaneous fit of both inclusive and dijet data achieved

Combined fit



- New PDFs are similar to Fit B but different from Fit A
- Quarks and gluons are constrained with similar precision over the whole kinematic range



Summary

- A wealth of diffractive data from ZEUS and H1 using Leading Proton, LRG and MX methods
  - Consistency reached for different experiments and methods
- Inclusion of dijets data into in the QCD fits provides a much better constraint of the gluon density at high fractional momentum
- Higher precision expected through combining H1 and ZEUS data