QCD Analysis of Inclusive Diffraction at HERA

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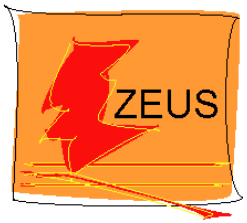
On behalf of the

and

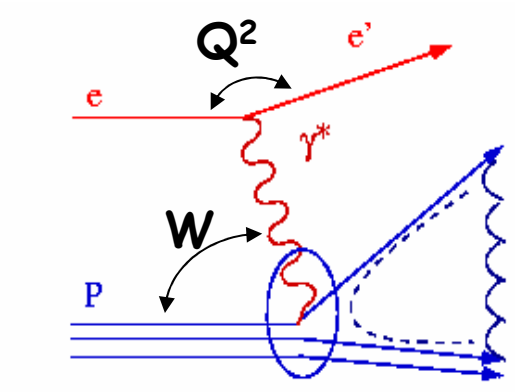


Collaborations

LowX 2009

ISCHIA ISLAND, ITALY, September 8-13 2009

Diffraction at HERA

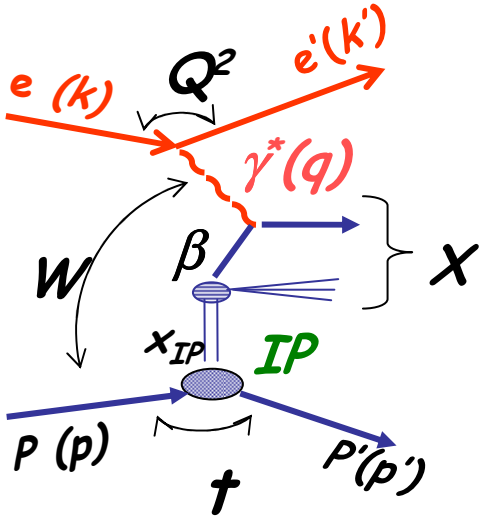


Standard Deep Inelastic Scattering

x = fraction of proton's momentum carried by struck quark ≈ Q^2/W^2

W = photon-proton centre of mass energy

→ *DIS probes the partonic structure of the proton*



Diffraction: exchange of colour singlet producing a rapidity GAP in the particle flow

Diff DIS probes the partonic structure of colour singlet exchange → *DPDFs*

Inclusive diffraction $\gamma^* p \to Xp$

diffractive structure function and reduced cross section

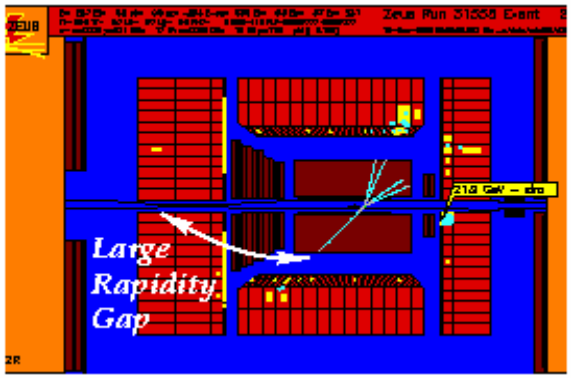
$$\frac{d^2\sigma^{ep\to e'Xp'}}{d\beta dQ^2 dx_{IP} dt} = \frac{4\pi\alpha^2}{\beta Q^4}\left[1-y+\frac{y^2}{2(1+R^D)}\right]F_2^{D(4)}(\beta,Q^2,x_{IP},t) = \frac{4\pi\alpha^2}{\beta Q^4}\left[1-y+\frac{y^2}{2}\right]\sigma_r^{D(4)}(\beta,Q^2,x_{IP},t)$$

fraction of the p momentum carried by the *IP*:

$$x_{IP} = \frac{q\cdot(p-p')}{q\cdot p} \approx \frac{Q^2+M_X^2}{Q^2+W^2}$$

fraction of the *IP* momentum carried by the struck quark:

$$\beta = \frac{Q^2}{2q\cdot(p-p')} \approx \frac{Q^2}{Q^2+M_X^2} = \frac{x}{x_{IP}}$$



→ No activity in the forward direction

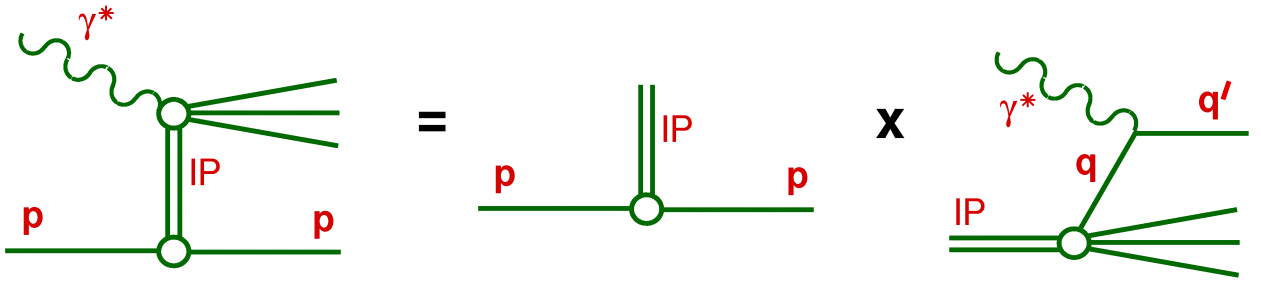
→ Proton intact after the collision

Diffractive PDFs

QCD collinear factorization theorem proven also for DDIS (Collins 1998)

$$\sigma(\gamma^* p \to Xp) \approx f_i(z, Q^2, x_{IP}, t) \otimes \hat{\sigma}_{\gamma^* i}(z, Q^2)$$

Variables describing proton vertex (x_{IP}, t) factorize from those at photon vertex (β, Q^2) to good approximation



$$\sigma(\gamma^* p \to Xp) \approx f_{IP}(x_{IP}, t) \times f_i(z, Q^2) \otimes \hat{\sigma}_{\gamma^* i}(z, Q^2)$$

Regge motivated pomeron flux

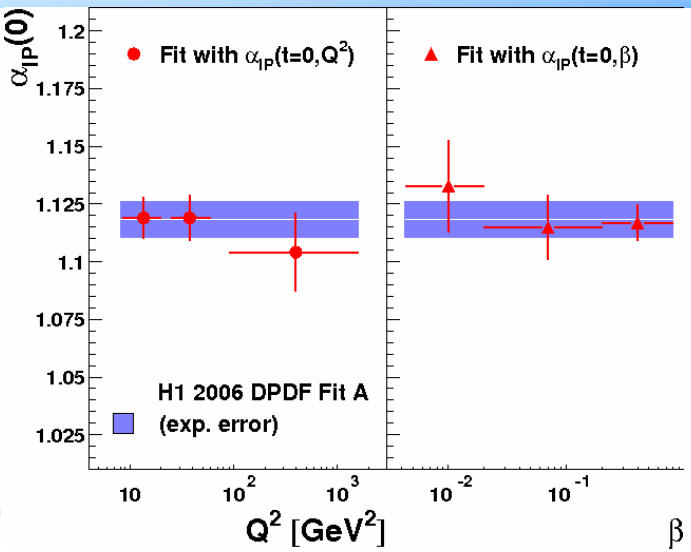
$$f_{IP}(x_{IP}, t) = \frac{e^{Bt}}{x_{IP}^{2\alpha(t)-1}}$$

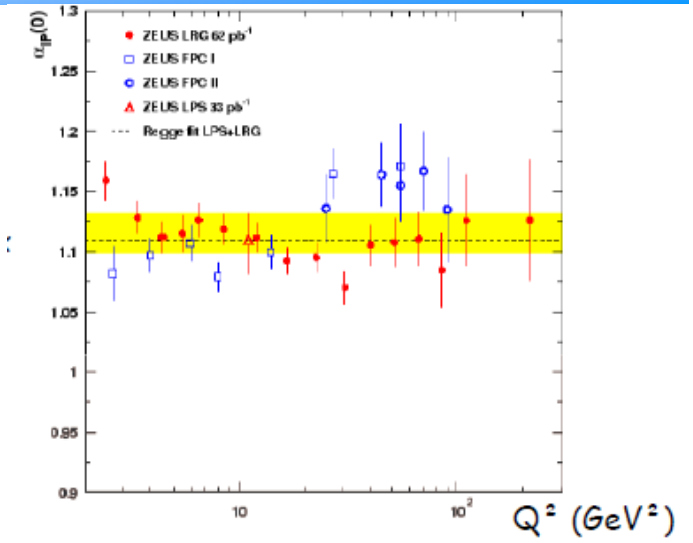
B and α(t) extracted from HERA data

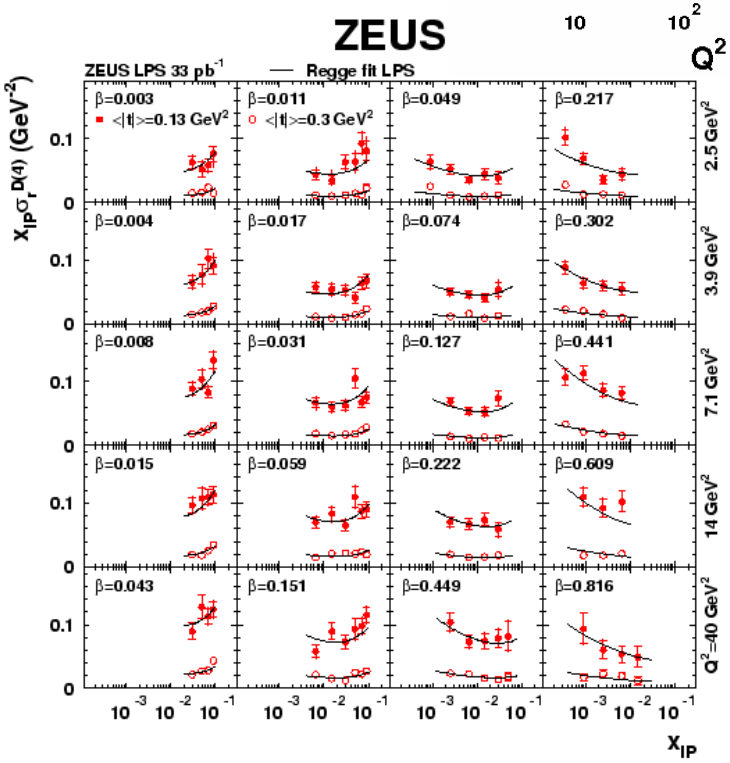
DPDFs:

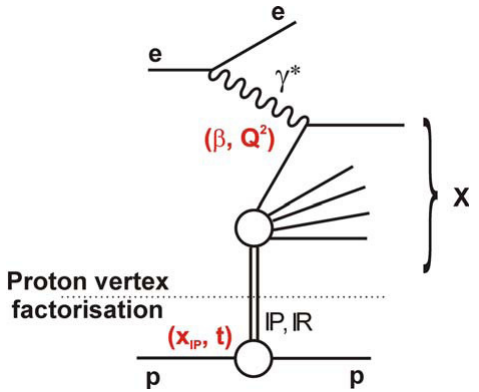
Universal parton proton conditional probability, apply when vacuum quantum numbers are exchanged

Proton vertex factorization: x_{IP} and t



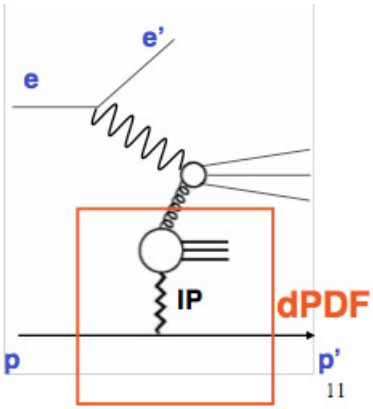






See previous talk for details

HERA Diffractive PDFs (z,Q2)



DPDFs extracted from a fit to the HERA data:

Parametrize quark and gluon densities at initial scale Q_0^2

Evolution in Q^2 with DGLAP equations

Previous QCD analyses and DPDFs from H1:

Using H1 inclusive and dijet data published: EPJ C48 (2006) JHEP 710 (2007)

New H1 data are coming!

New QCD analysis and DPDFs from ZEUS:

Using ZEUS inclusive and dijet data recently published: NPB 816 (2009) EPJ C52 (2007)

ZEUS diffractive QCD fits

Regge factorization assumption →

$$F_{2/L}^{D(4)}(x_{IP},t,Q^2,\beta)$$
$$= f(x_{IP},t)F_{2/L}^{IP}(Q^2,\beta) + f(x_{IR},t)F_{2/L}^{IR}(Q^2,\beta)$$

DGLAP evolution equations

(QCDNUM)

Heavy quarks contribution treated

within TR-VFNS scheme (H1 FFNS)

DPDFs (q and g) parametrized

at the starting scale Q_0^2=1.8 GeV^2 as: $zf_{d,u,s}(z,Q_0^2) = A_q z^{B_q}(1-z)^{C_q}$

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

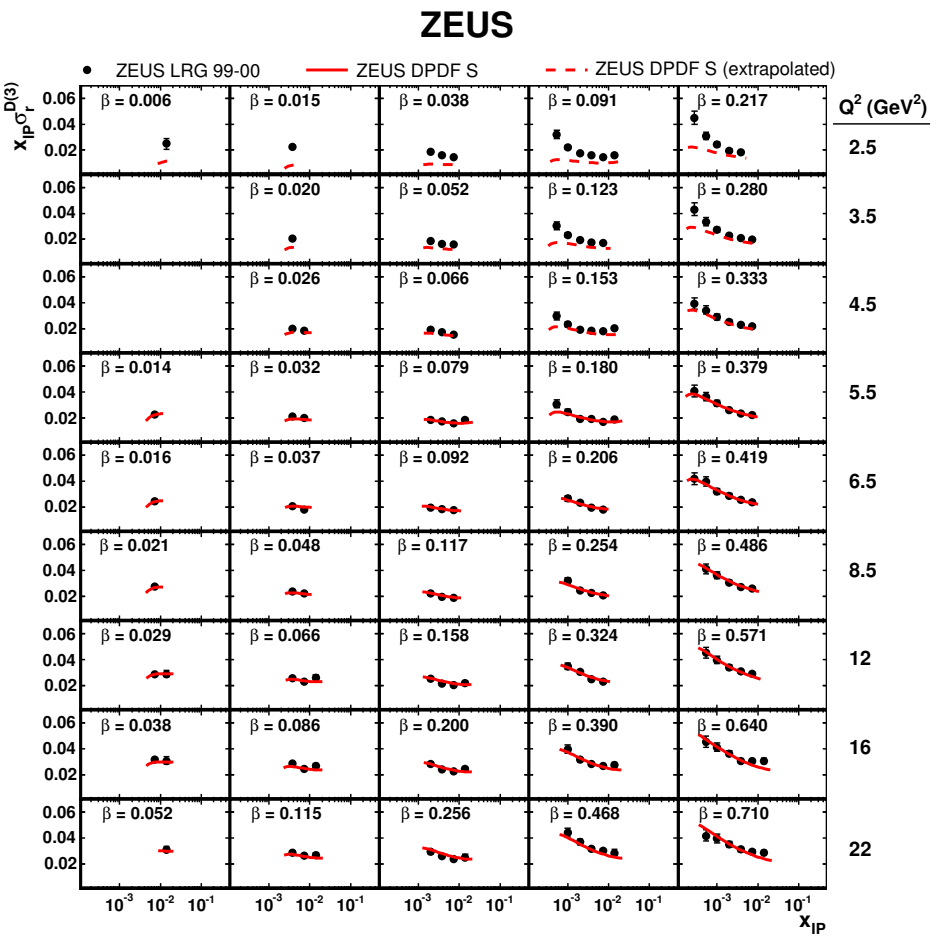
Fit *C* (constant) gluon parameters: B_g=C_g=0 (~H1 FitB)

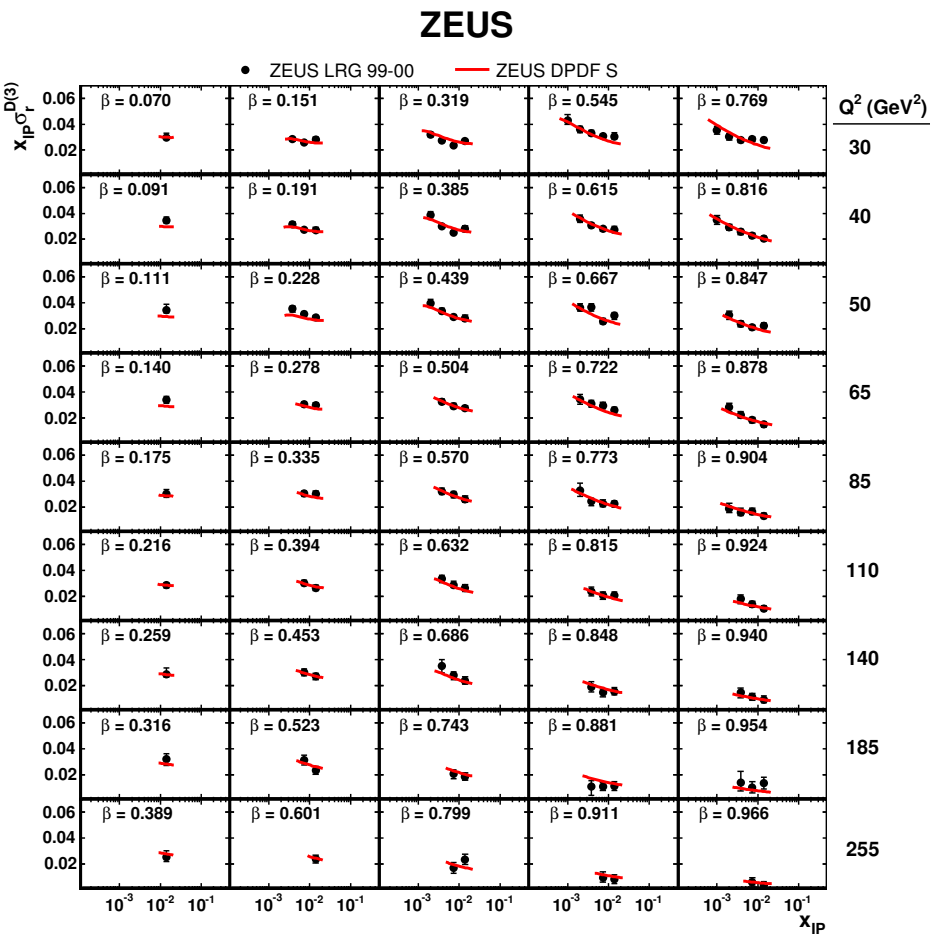
Fit S (standard) gluon parameters: B_g,C_g fitted

Fit SJ (standard+dijet) gluon parameters: B_g,C_g fitted

Q^2_{min}>5 GeV^2 (H1: Q^2_{min}>8.5 GeV^2)

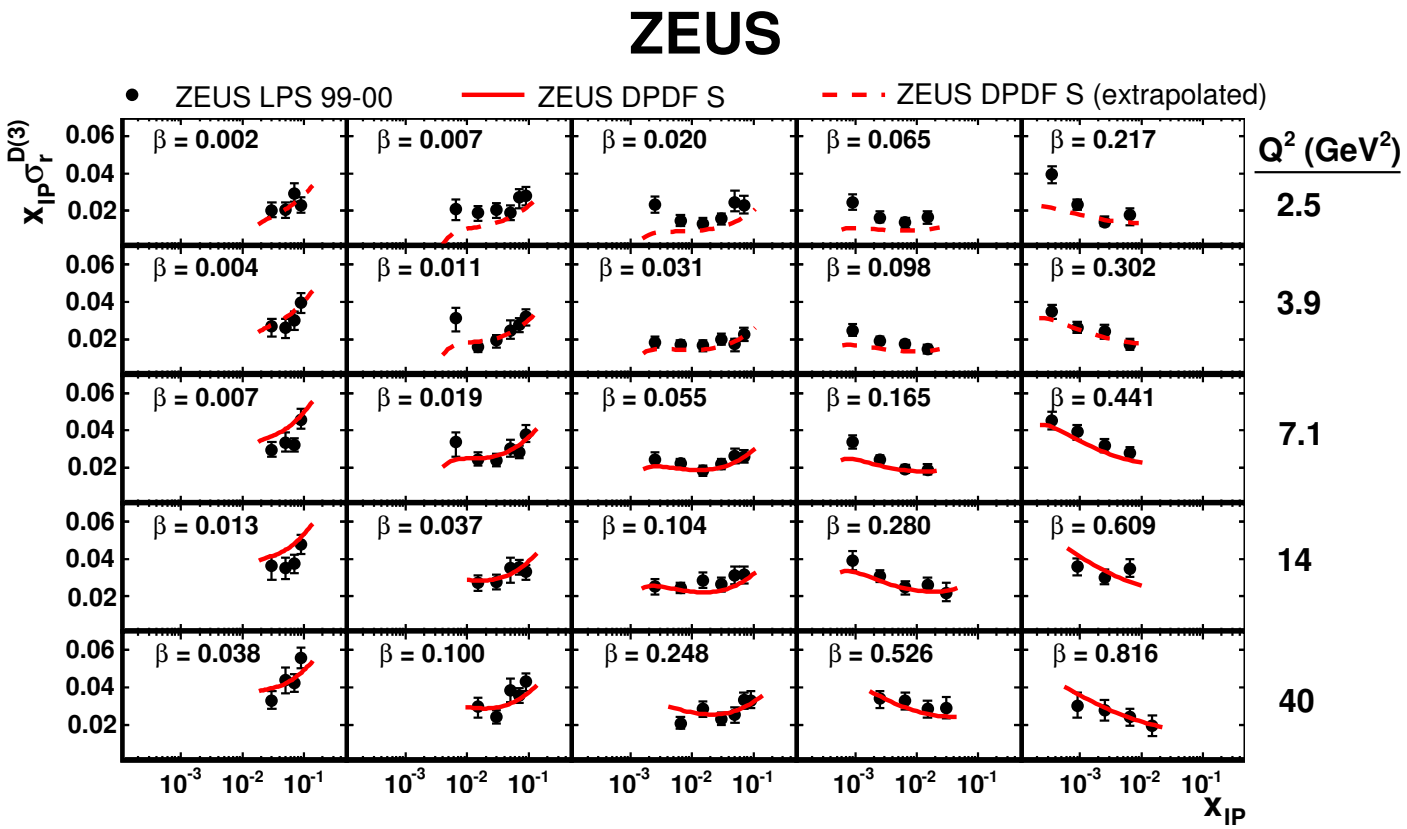
ZEUS LRG diffractive QCD fits





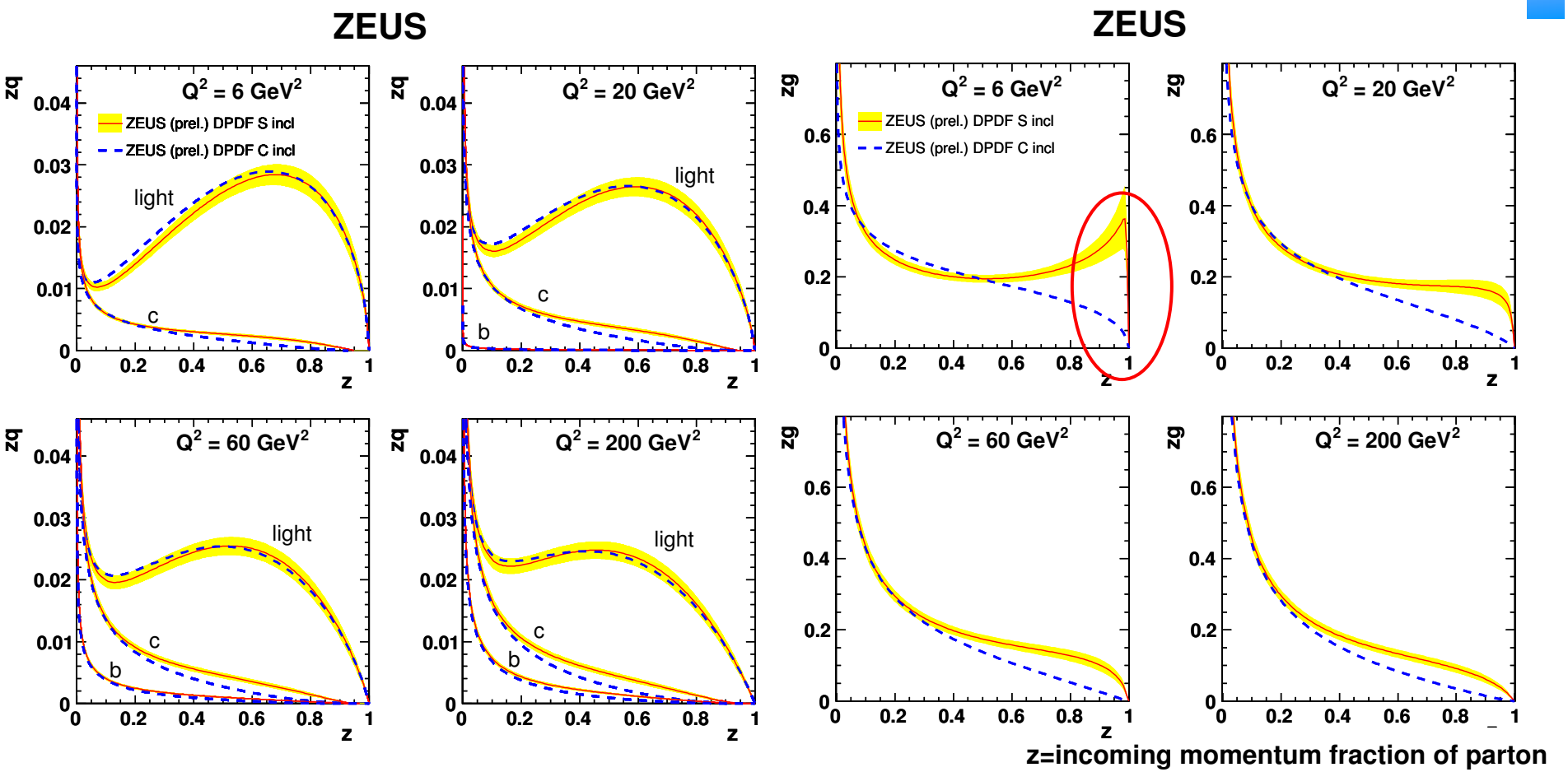
Good description (from fit C and S) of all data fitted (Q^2>5GeV^2)

ZEUS LPS diffractive QCD fits



Good description of all data fitted (Q^2>5GeV^2)

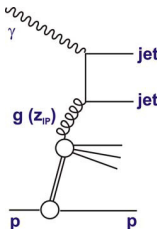
ZEUS DPDFs (inclusive data)



Quark distributions very similar for both fits. Gluons dominate (see the scale!)

Gluon densities significantly different, poor high z gluon constraint of the inclusive data

A more exclusive process is needed where photon-gluon fusion contributes



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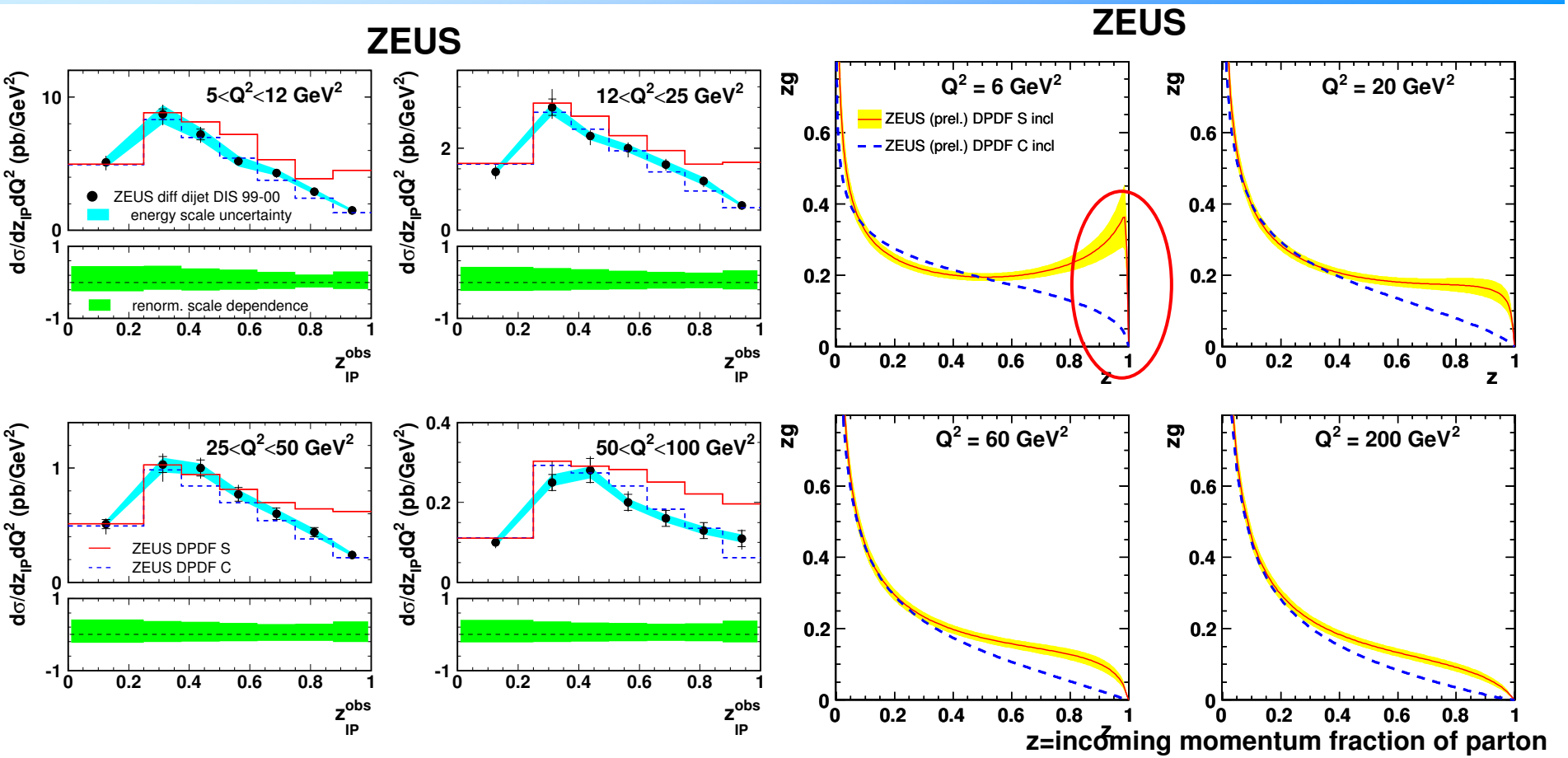

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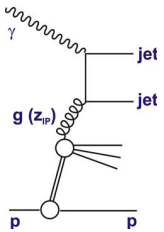
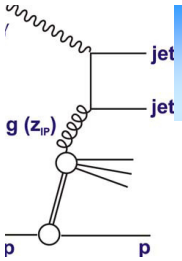
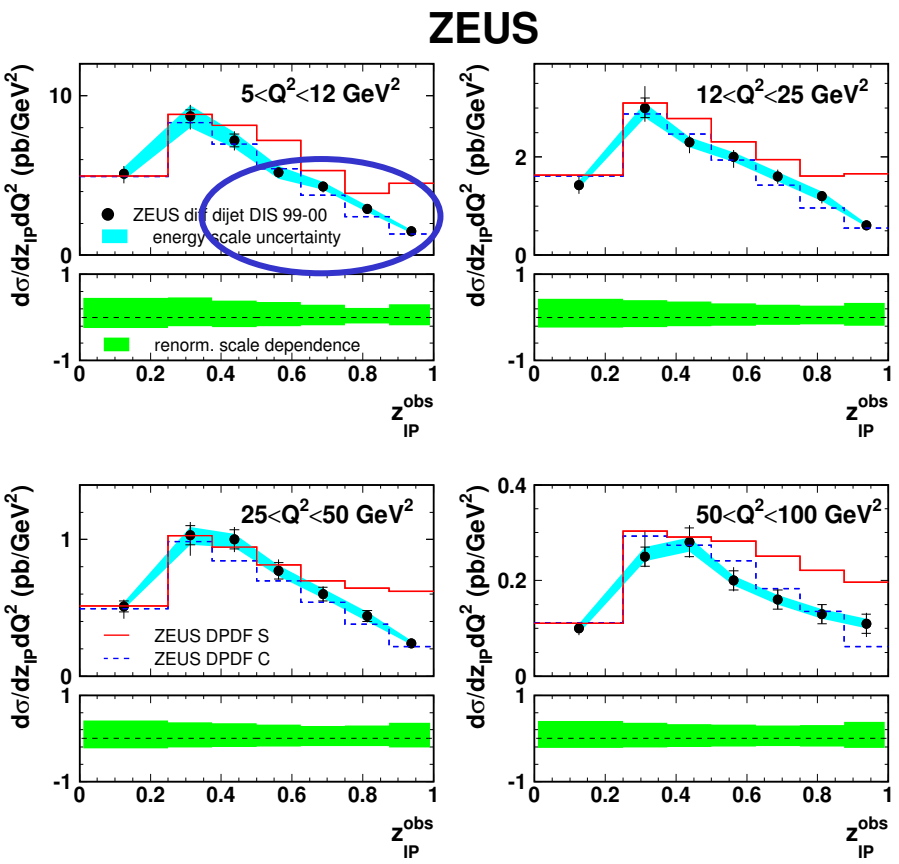


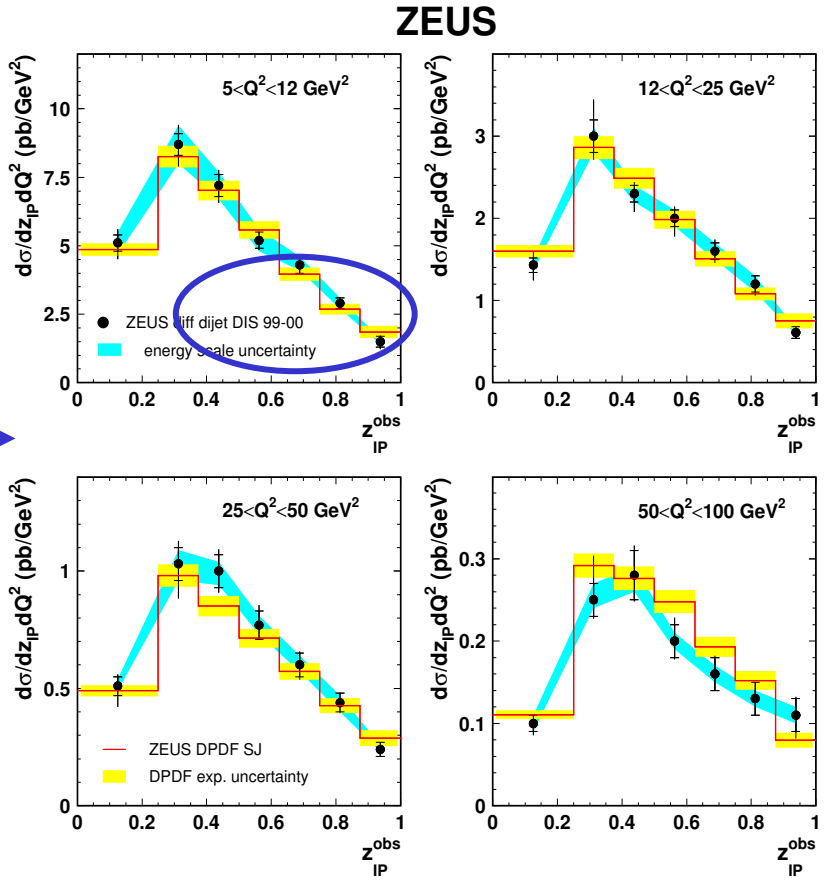


ZEUS DPDFs (inclusive+dijet)

NLO QCD predictions performed at NLO with DISENT

(NLOJET++ used used a cross check)





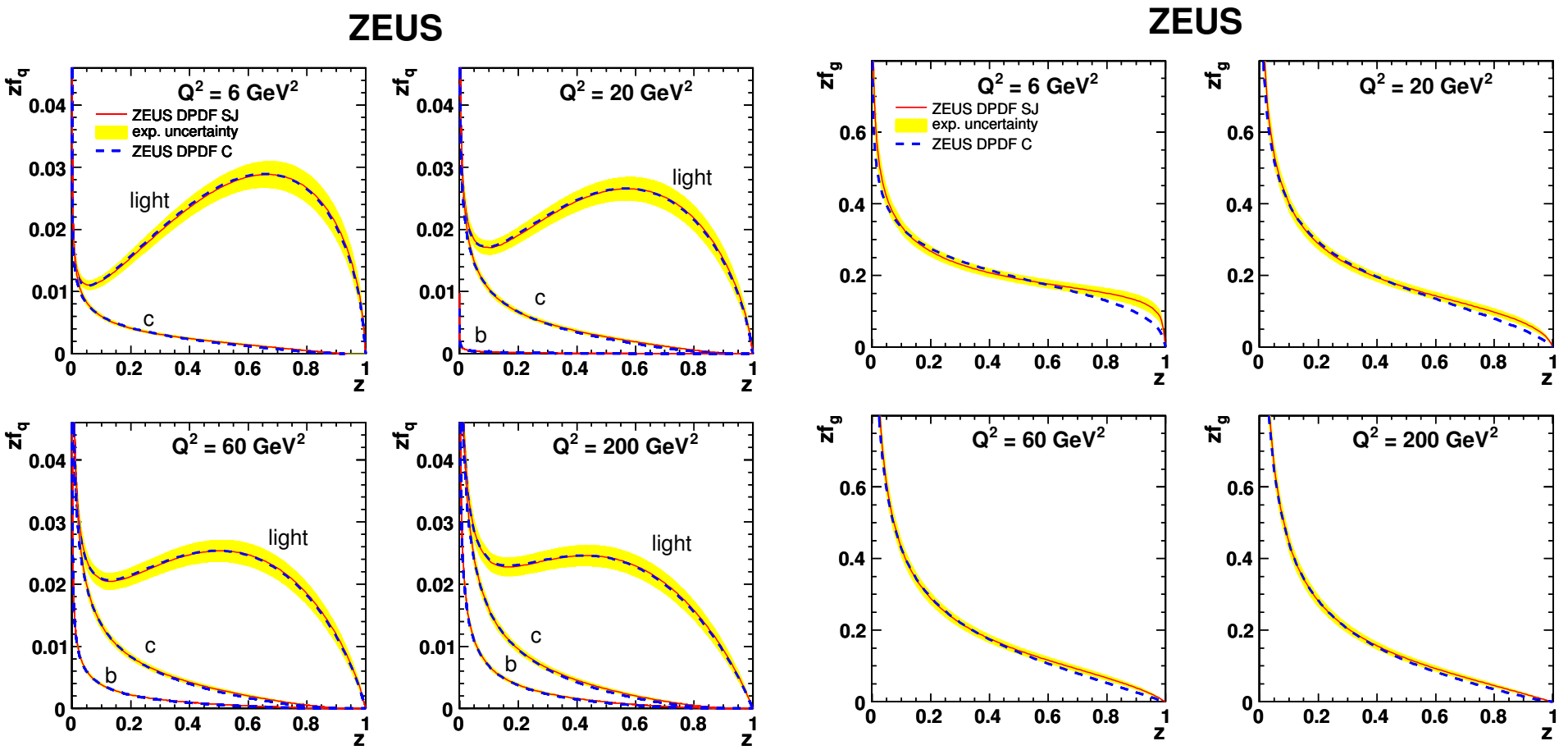
The predictions based on fit C on inclusive data are ok.

Not true for fit S at high z

ZEUS DPDF SJ fit including dijets data.

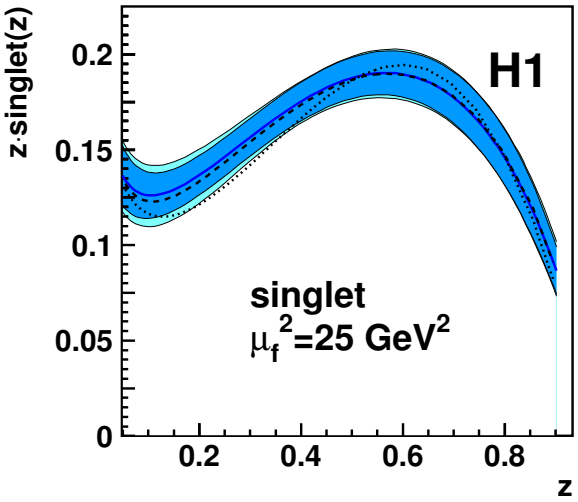
Very good agreement!

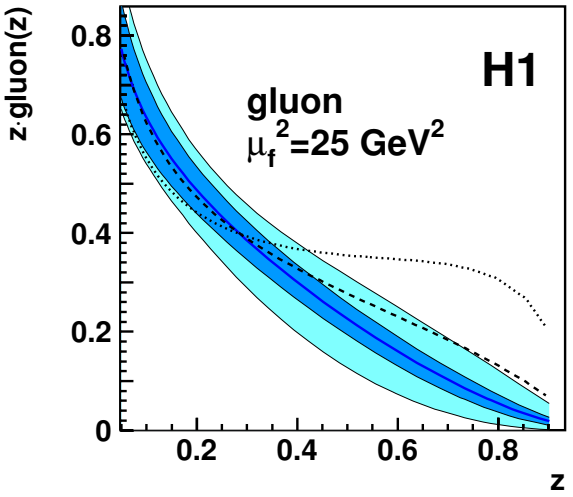
ZEUS DPDFs (inclusive+dijet)

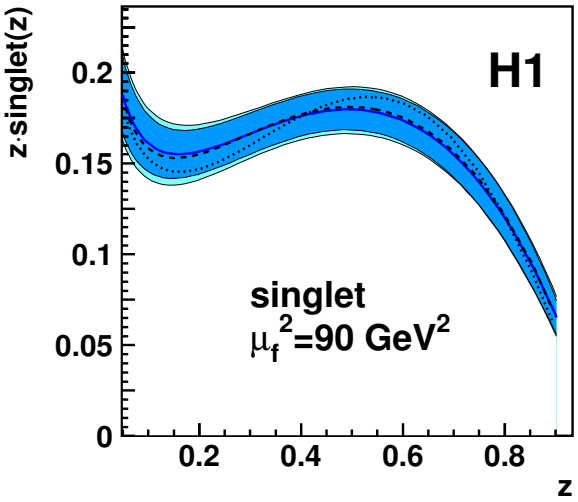


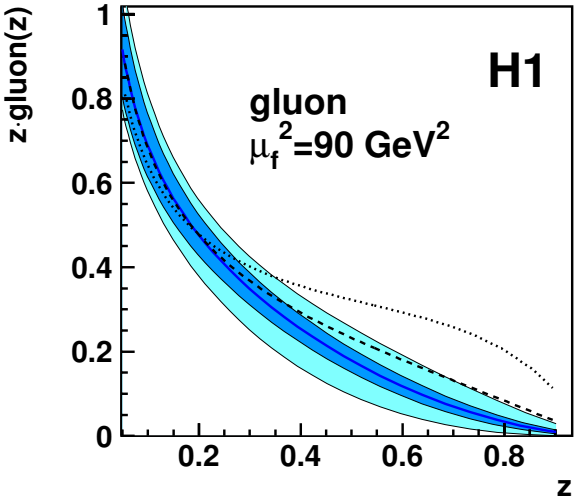
Combing inclusive and dijet data constrains the gluon and quark densities with a comparable precision for all z

H1 DPDFs (inclusive+dijet)









H1 2007 Jets DPDF

exp. uncertainty

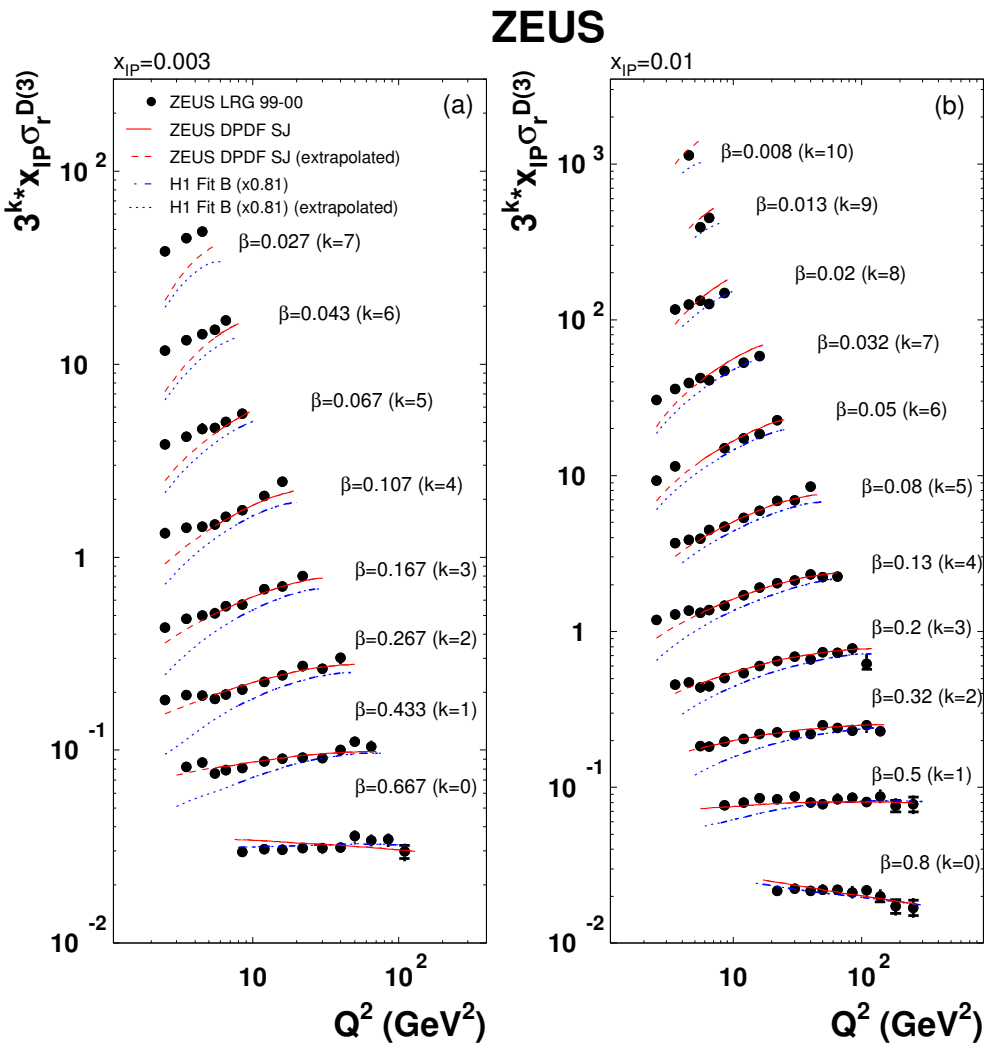
exp. + theo. uncertainty

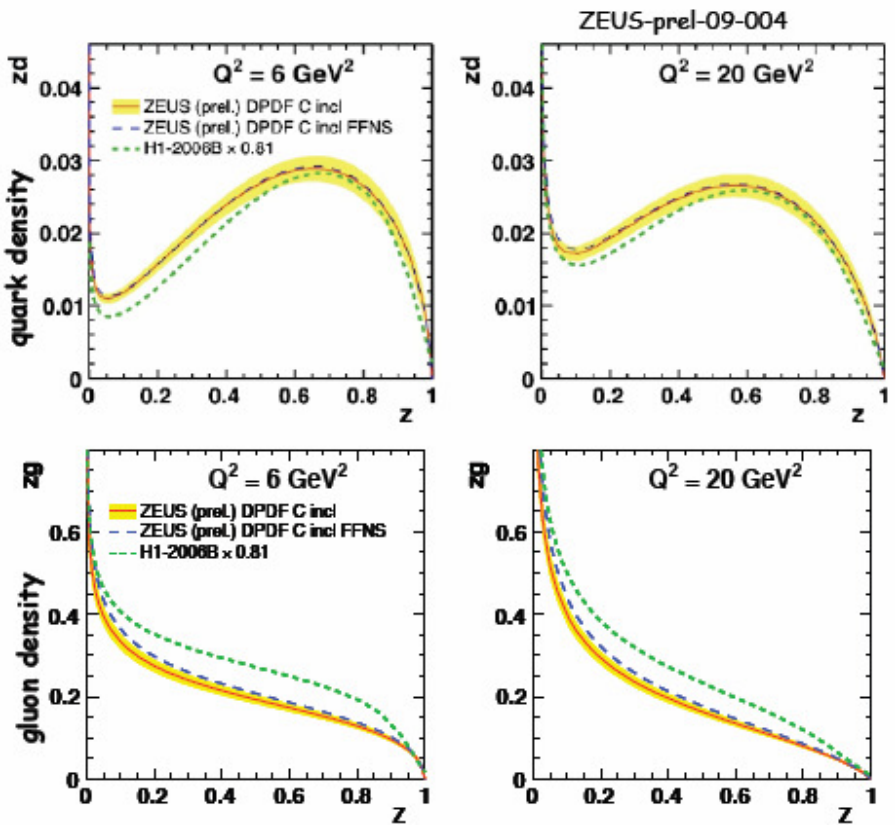
H1 2006 DPDF fit A

H1 2006 DPDF fit B

Several DPDF fits from H1 as well (and from theorists: MRW, Royon et al.)

HERA DPDFs

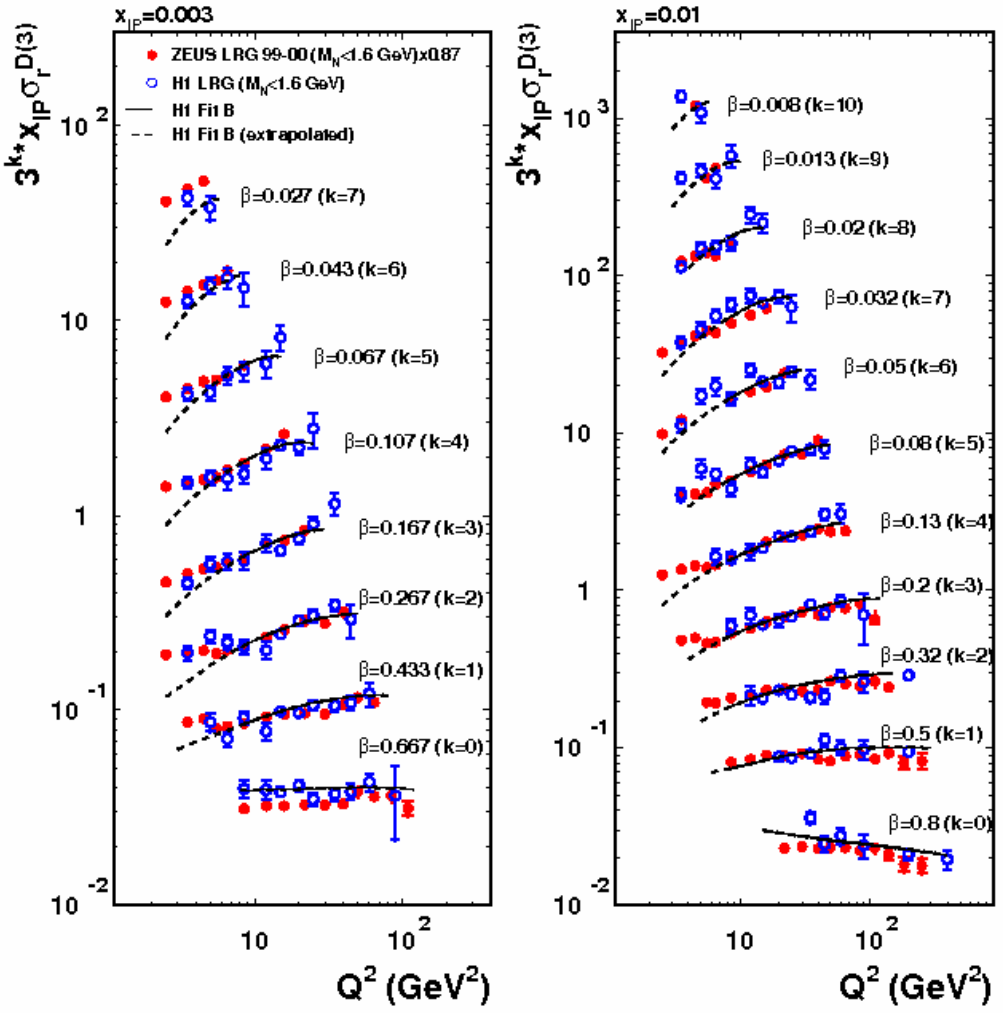


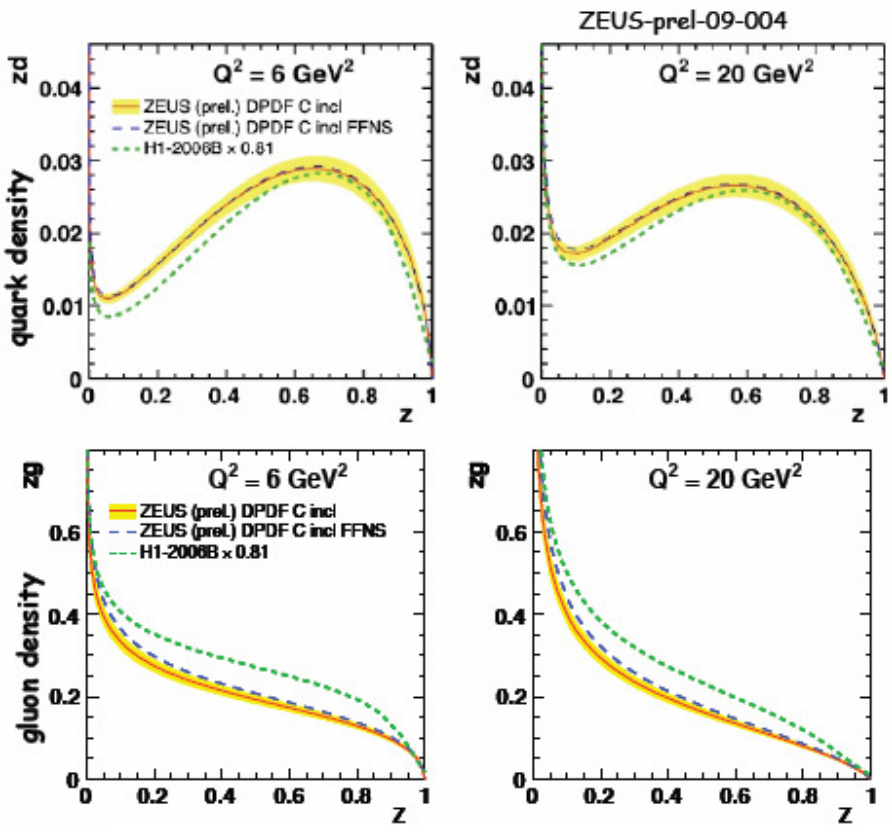


Reasonable agreement with H1

Plan to extract HERA DPDFs for H1+ZEUS data combination

HERA DPDFs



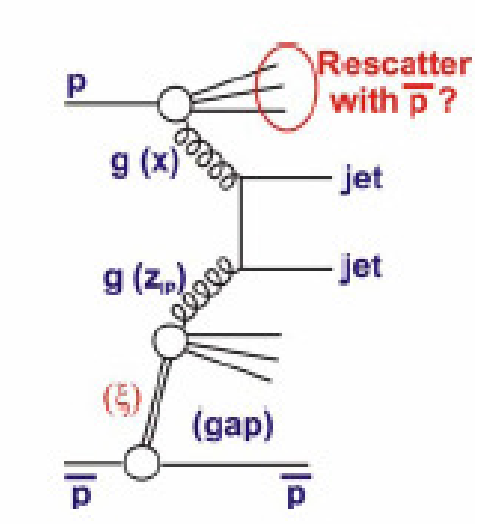


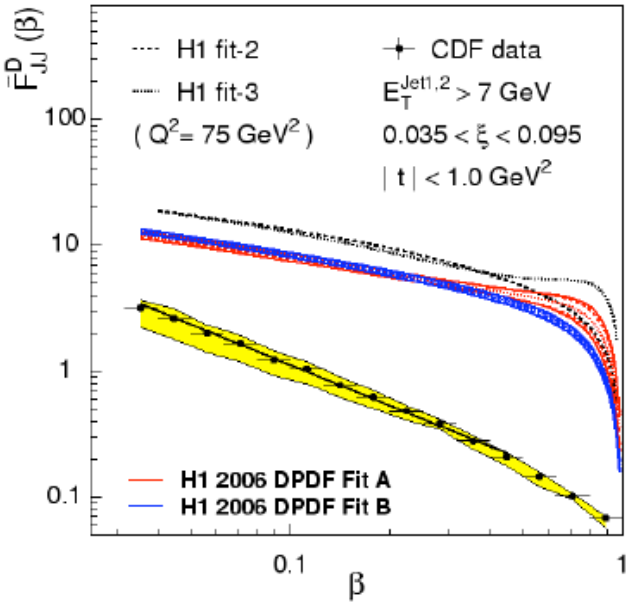
Reasonable agreement with H1

Plan to extract HERA DPDFs for H1+ZEUS data combination

DPDFs to predict Dijet Photoproduction

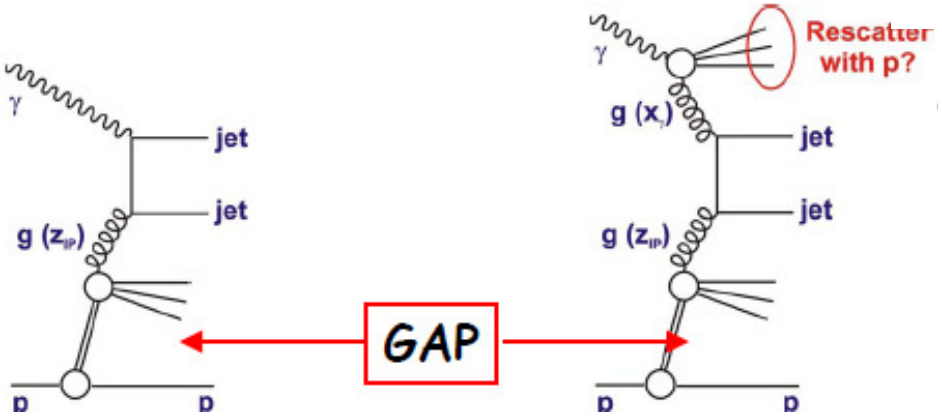
TEVATRON →





'Direct" photon ($x_\gamma \to 1$)

"S^2 = 1"

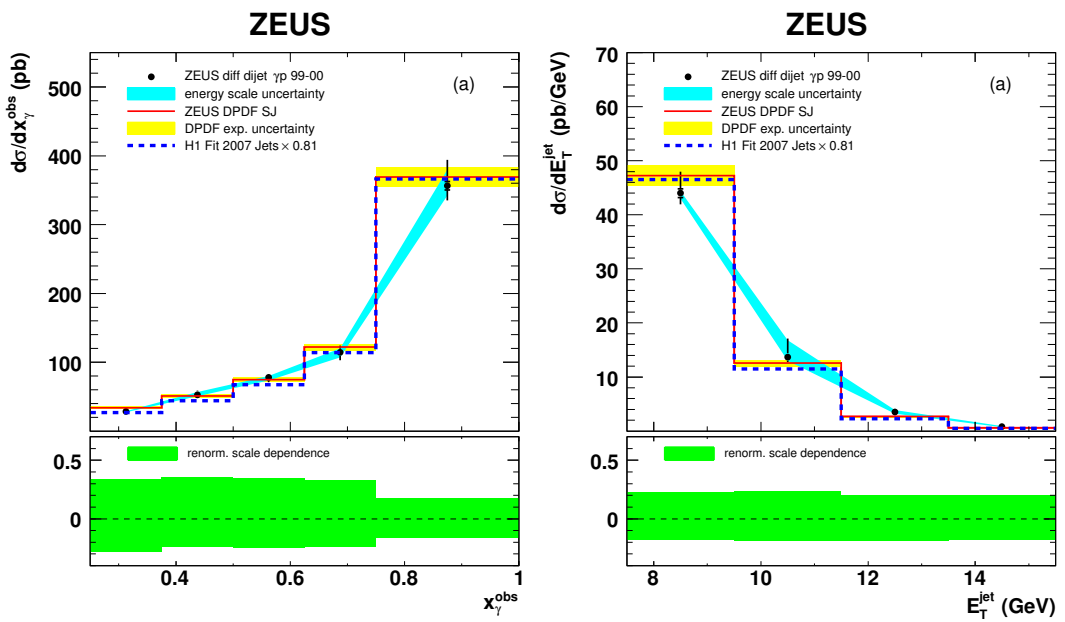


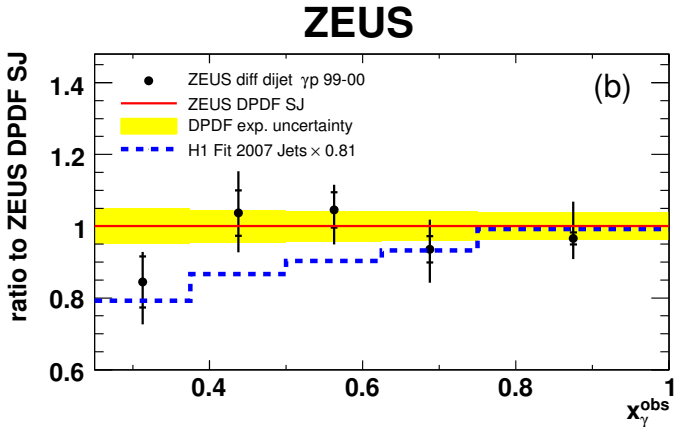
→ HERA

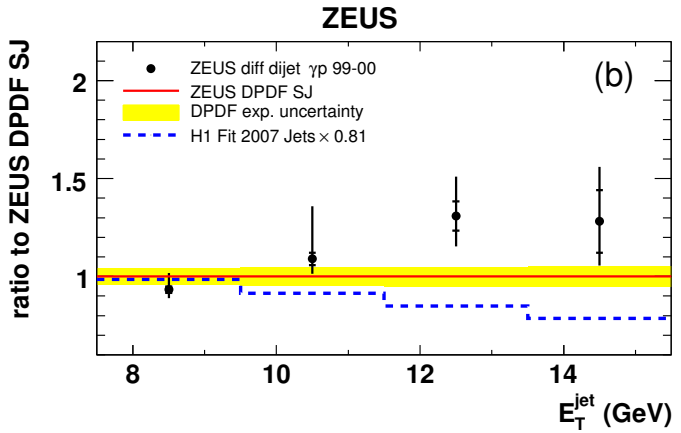
The strong suppression observed at Tevatron can be studied also at HERA using dijet cross sections in resolved dijet PHP

DPDFs to predict Dijet PHP

NLO QCD predictions by Klasen and Kramer



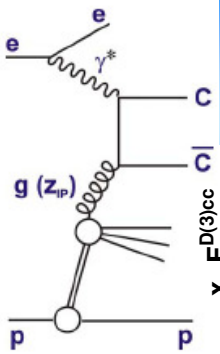




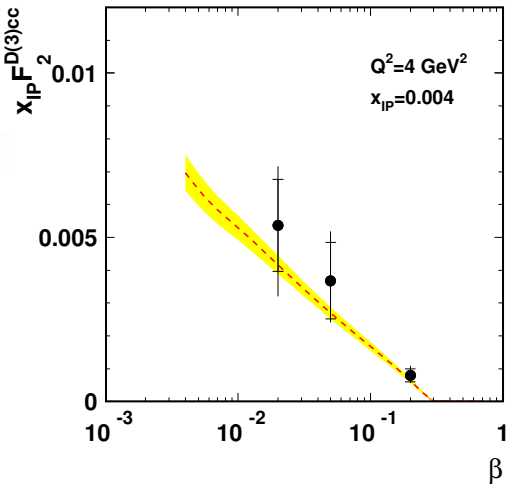
Very good description and no evidence for suppression

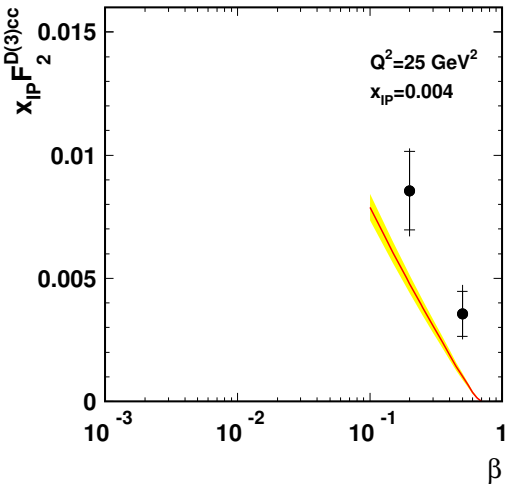
Both for the fraction of the photon energy and for the transverse energy of the leading jet

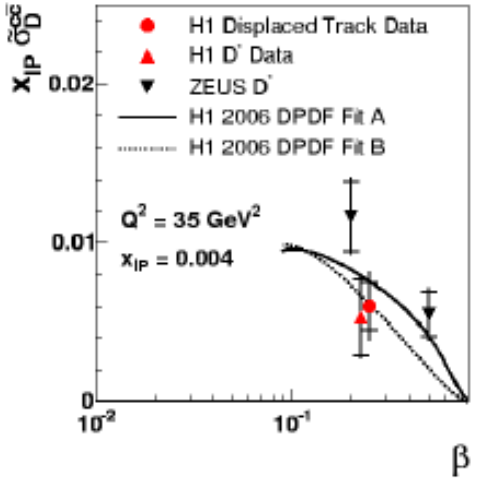
DPDFs to predict charm production

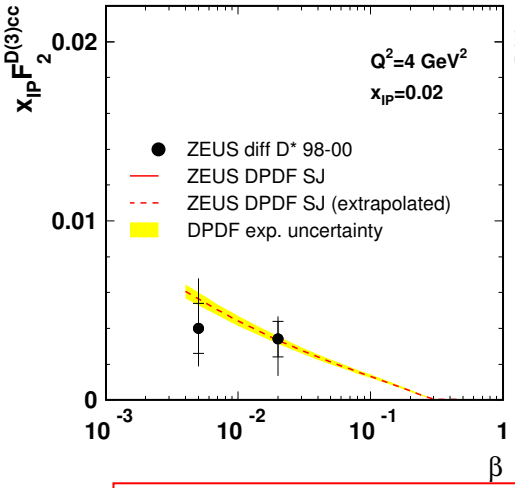


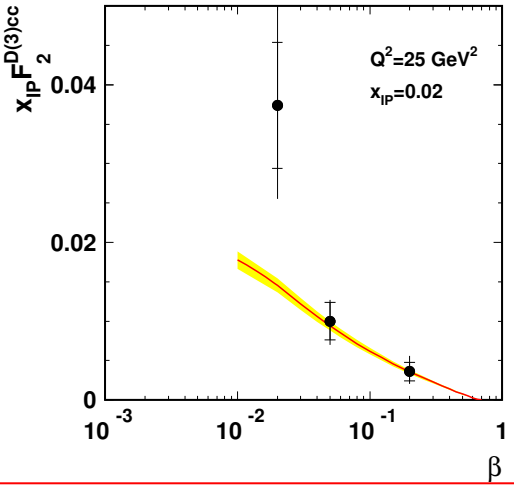
ZEUS

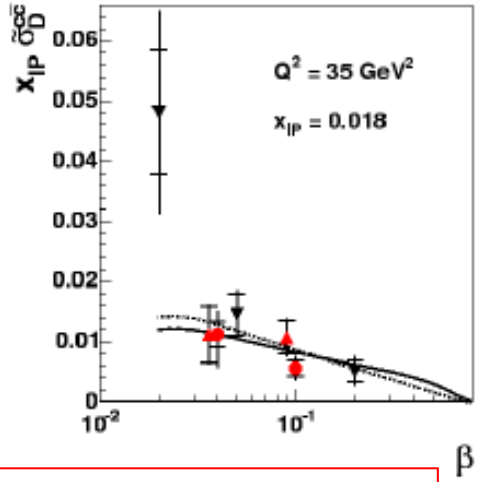












ZEUS DPDF SJ and H1 Fit describe well the diffractive charm data although still statistically limited

The factorization holds in DDIS!

Conclusions and outlook

- ZEUS inclusive diffractive measurement have been used to extract the DPDFs

- Adding diffractive dijet in DIS measurement constrain the gluon density at high z

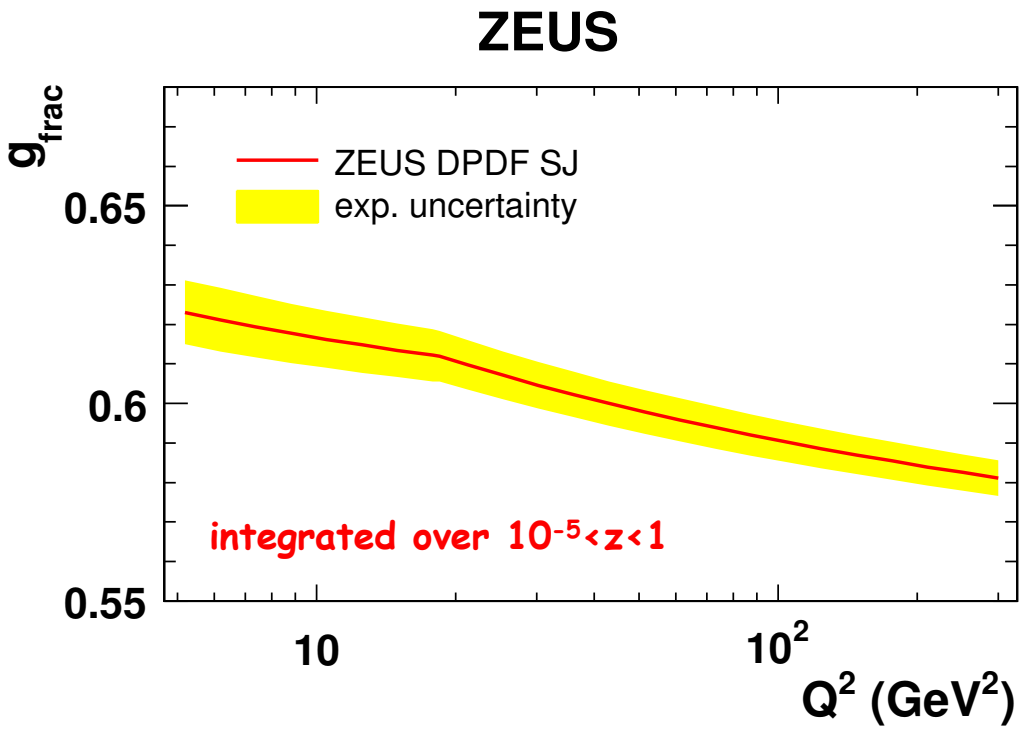
- NLO predictions using new ZEUS DPDFs agree very well with the data (see charm, dijet PHP)

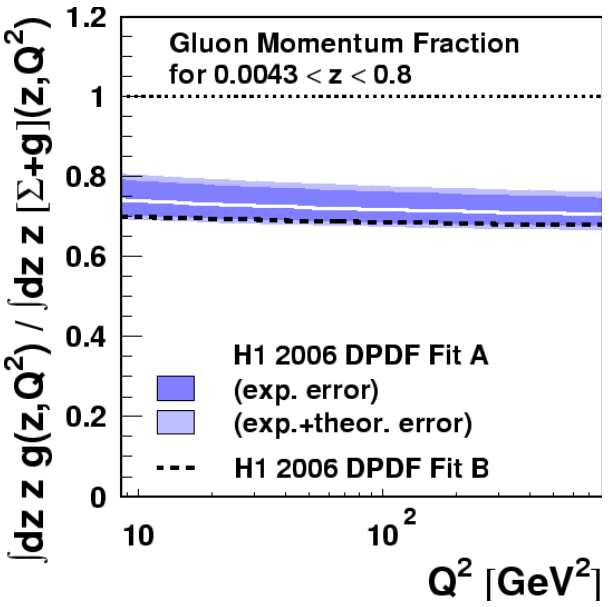
- No evidence for suppression in PHP from ZEUS (small suppression seen by H1 but still compatible with ZEUS)

- A lot of data analysed and new measurements are coming

- Combinations of H1 and ZEUS results underway

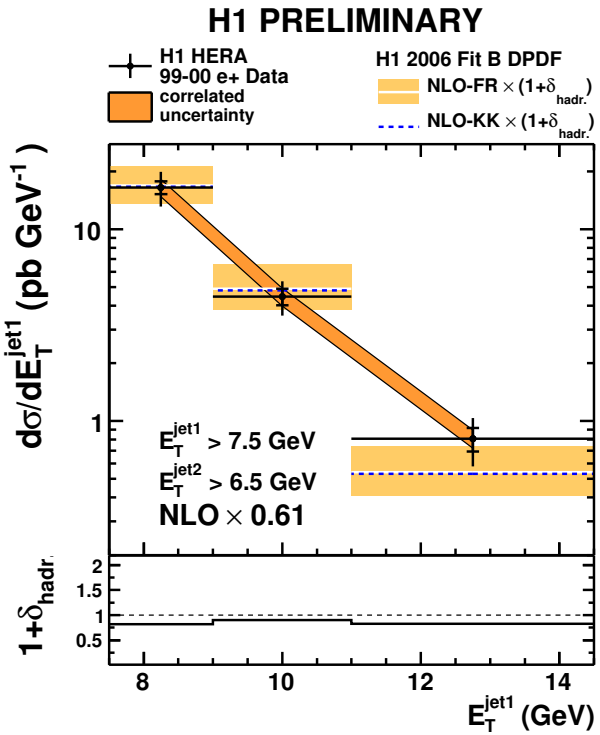
Gluons fractional momentum

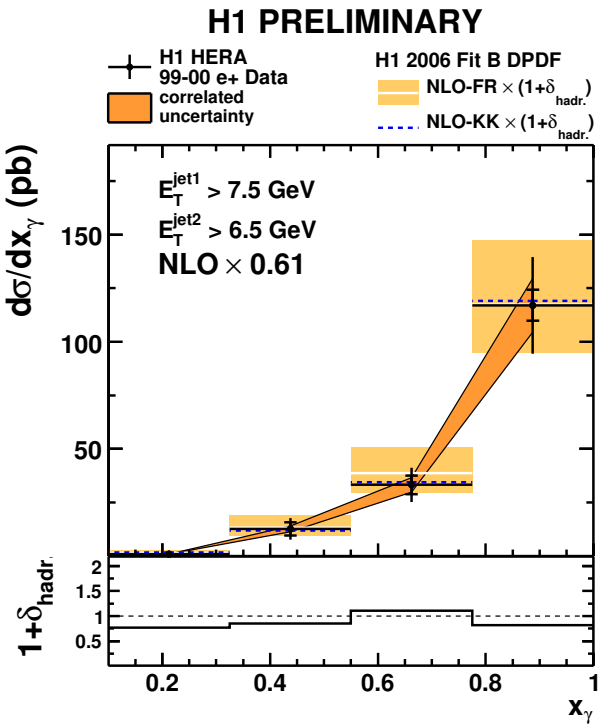


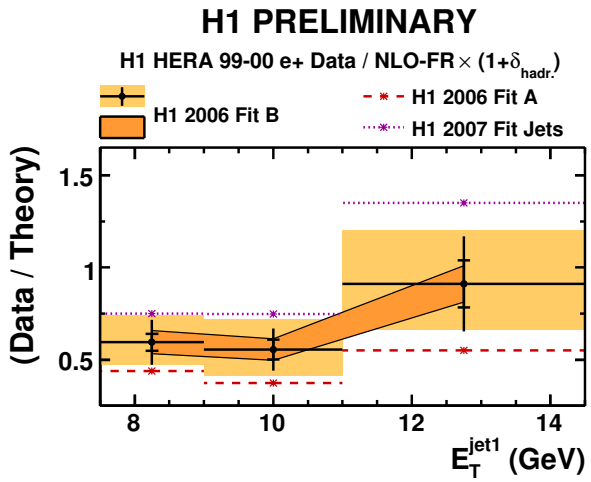


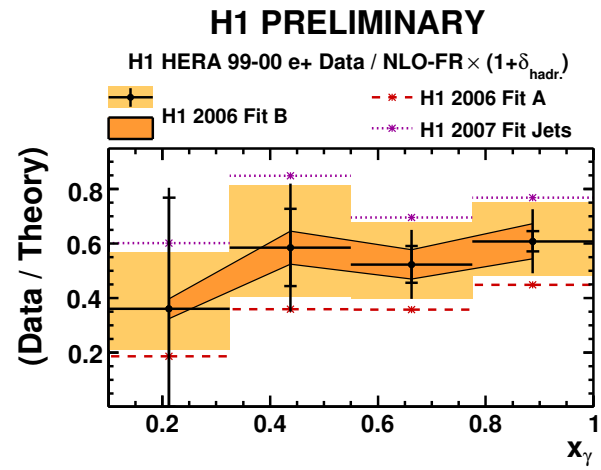
Q2 dep of the fraction of the longitudinal momentum of the diffractive exchange carried by the gluons

DPDFs to predict Dijet PHP









Similar kinematic regions

small suppression in H1 but compatible with ZEUS

no evidence for x_γ dependence

small suppression in H1 for the low E_T region both data still compatible (within errors)