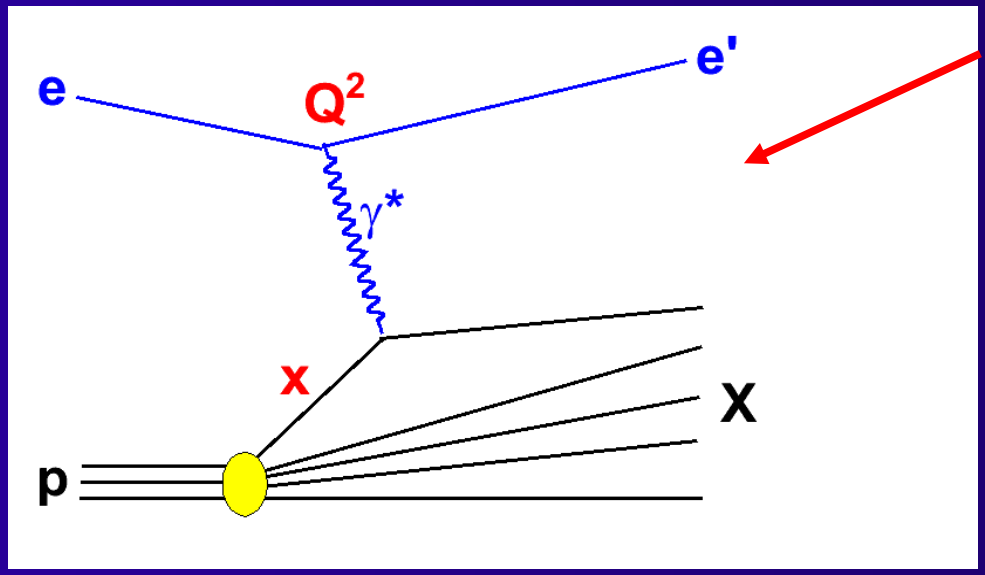
Diffraction and diffractive final states at HERA

Leszek Adamczyk
UST Cracow

On behalf of the
H1 & ZEUS
Collaborations

- Introduction
- Diffractive parton densities
- Tests of QCD factorization at HERA

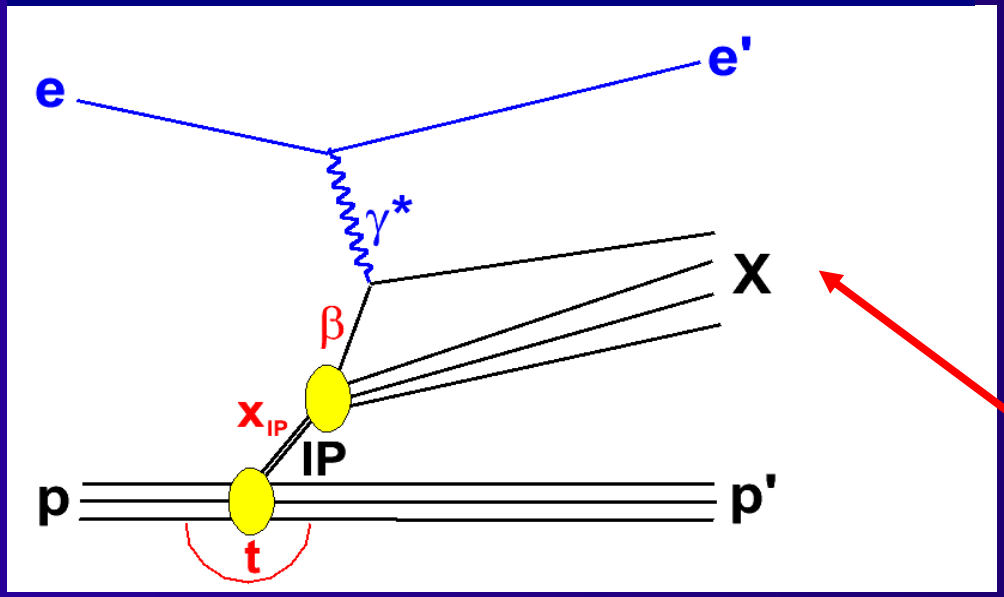
Diffractive DIS at HERA



Inclusive DIS: Probe structure of the proton

- Q^2- virtuality of the boson
- x - fraction of proton momentum
- carried by struck quark
- x_{IP}- fraction of proton momentum carried by diffractive exchange
- β – momentum fraction of the exchange carried by struck quark
- t – four momentum transfer of diffractive exchange

~10% of low x DIS events are diffractive



Diffractive DIS: Probe structure of the diffractive exchange (Pomeron)

QCD factorization in diffractive DIS

In one-photon exchange approximation:

$$\frac{d\sigma^{e\,p\to X\,p}}{dx_{IP}\,dt\,d\beta\,dQ^2} = \frac{4\pi\alpha_{em}^2}{\beta\,Q^4}\left[\left(1-y+\frac{y^2}{2}\right)F_2^D - \frac{y^2}{2}F_L^D\right]$$

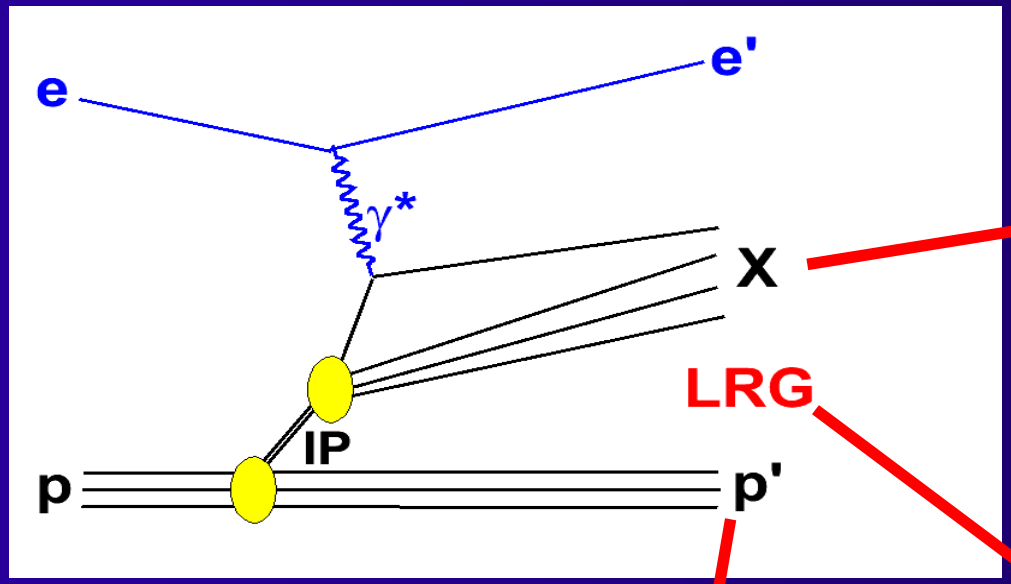
Similar to the way the DIS cross section is related to the F_2

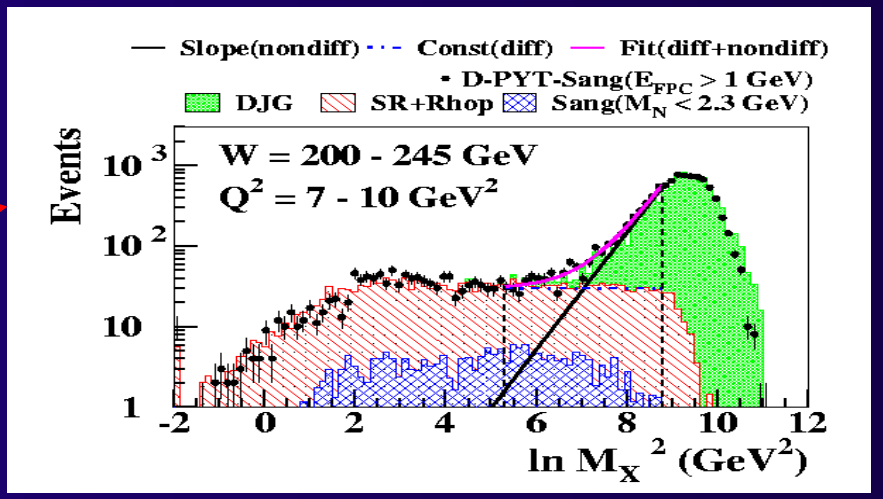
QCD factorization theorem (proven by Collins for diff. DIS processes):

$$F_2^D = \sum_{\text{parton i}} C_i^\gamma \otimes f_i^D$$

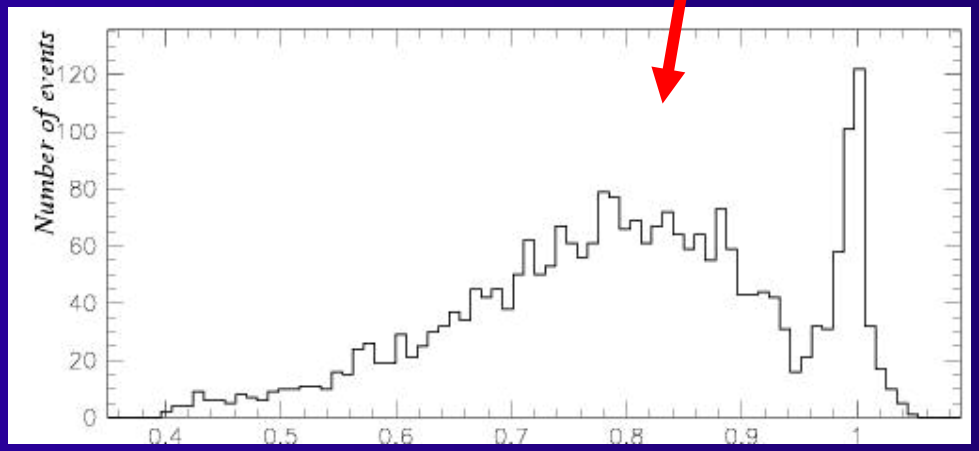
Convolution of the function describing photon parton interaction (exactly the same as in odinary DIS) with diffractive parton distribution functions dPDF (which obey the same DGLAP evolution equation as ordinary parton density)

Selection of diffractive events

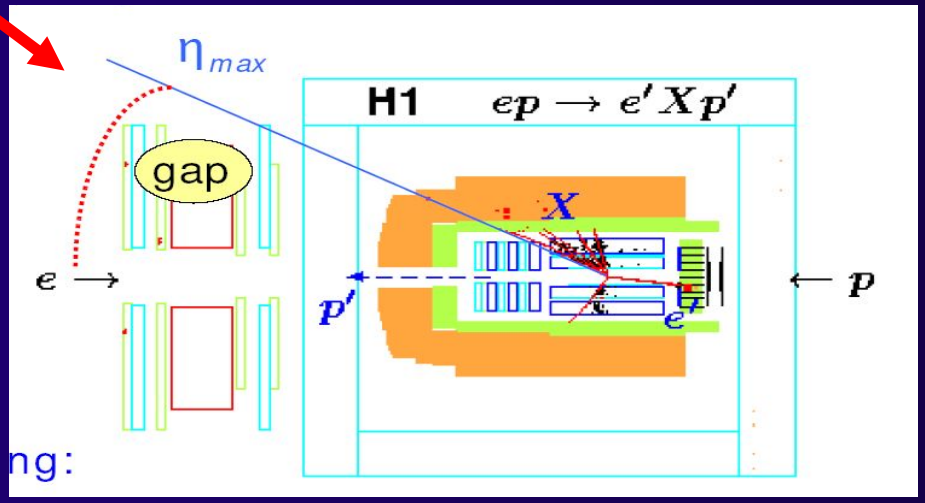




Diffractive mass distribution (M_X)



Use of proton spectrometer (LPS)

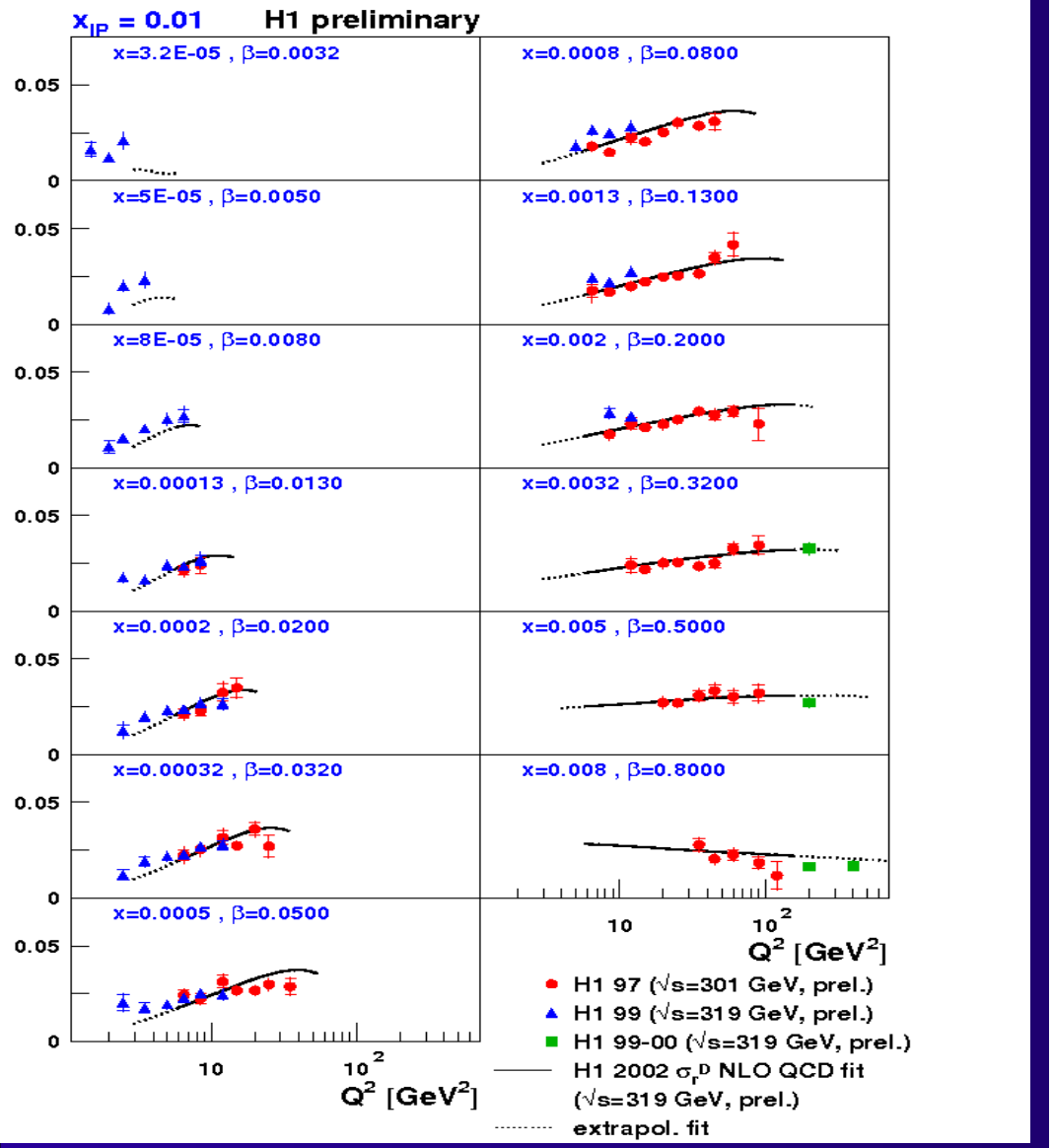


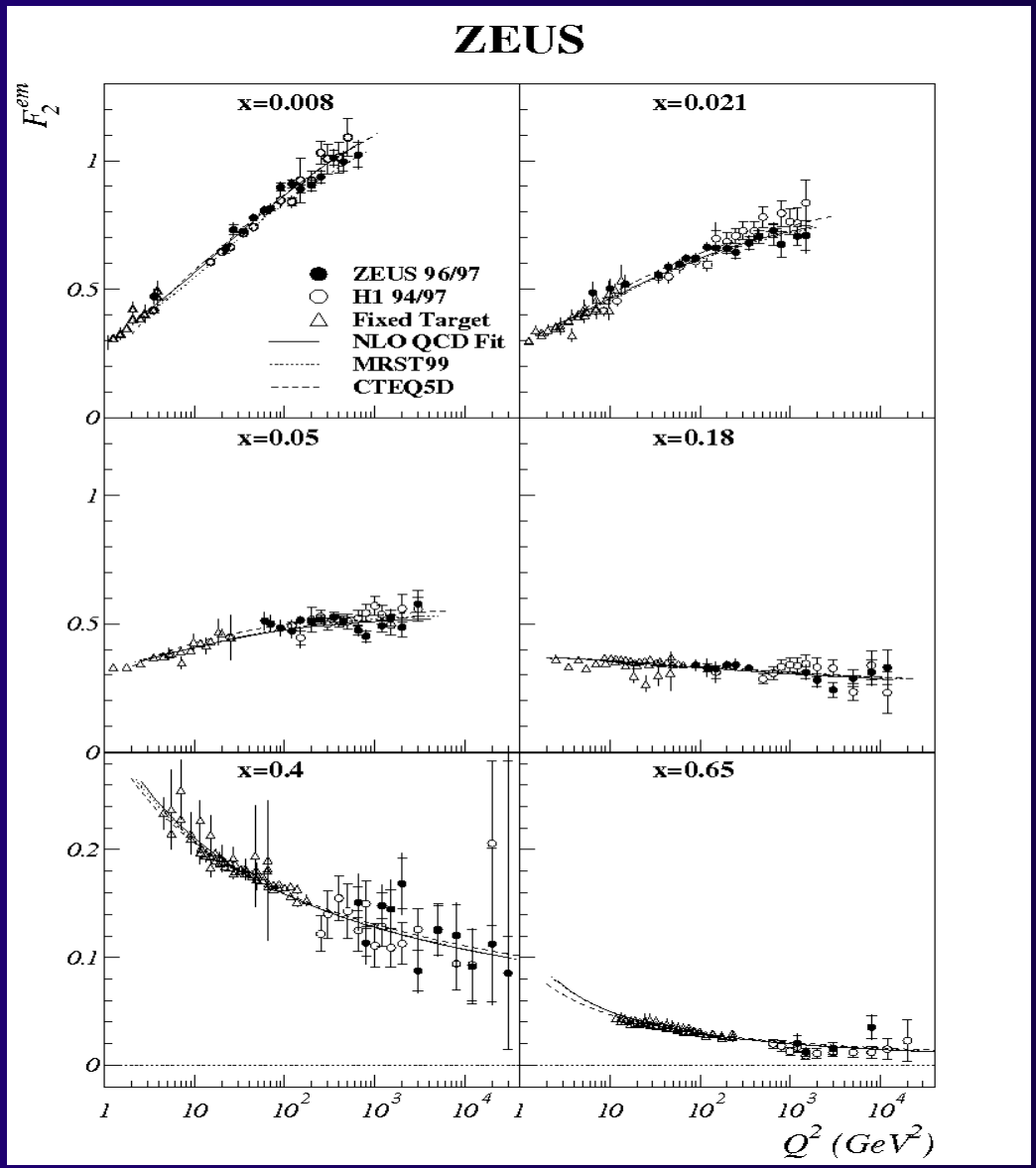
Events with large rapidity gap (LRG)

Diffractive structure function F_2^d

Pomeron

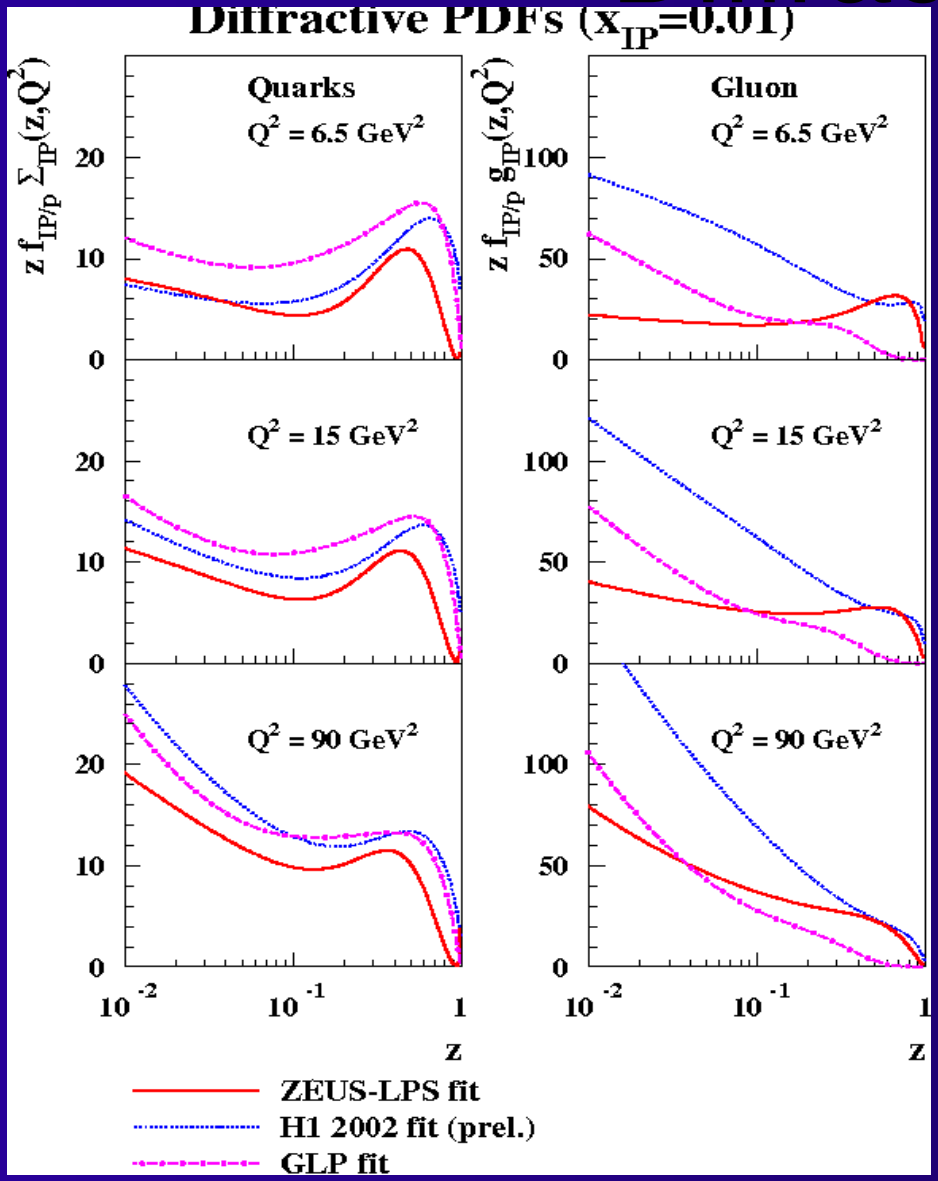
Proton





Positive scaling violations in diffraction: a lot of gluons inside Pomeron

Diffractive PDF's



DGLAP evolution NLO fits allow extraction of 3 dPDF's sets:

-ZEUS-LPS fit to ZEUS 1997 LPS data

-H1 2002 fit to H1 1997 LRG data

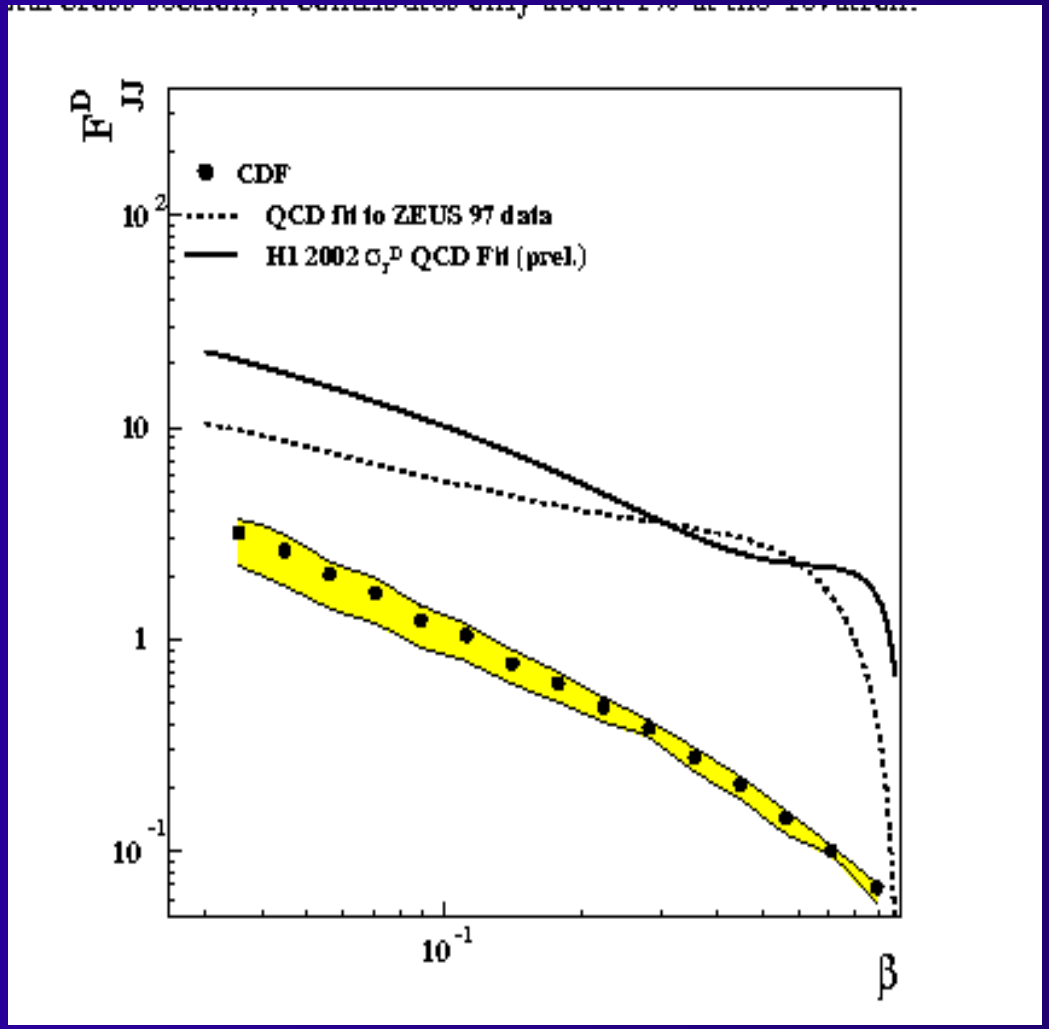
-GLP (Groys-Levy-Proskuryakov) fit to ZEUS 1998-99 M_X data

- Discrepancies evident and larger than experimental errors
- Not fully understood
- Estimate of the uncertainty on dPDF's

Need more work for precise and consistent determination of dPDF's

Test of QCD factorization

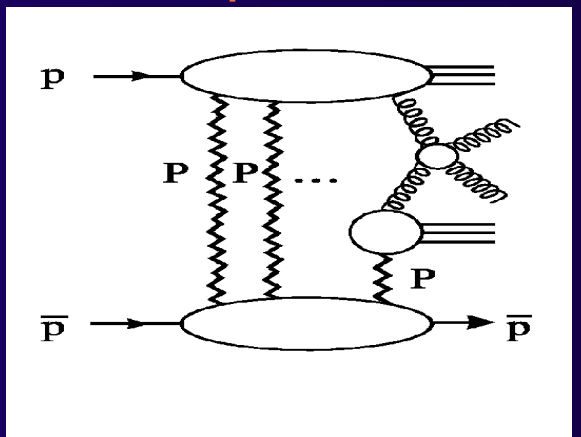
DPDF's are process-independent functions. They can be used to evaluate cross section for other diffractive processes where QCD factorization holds.



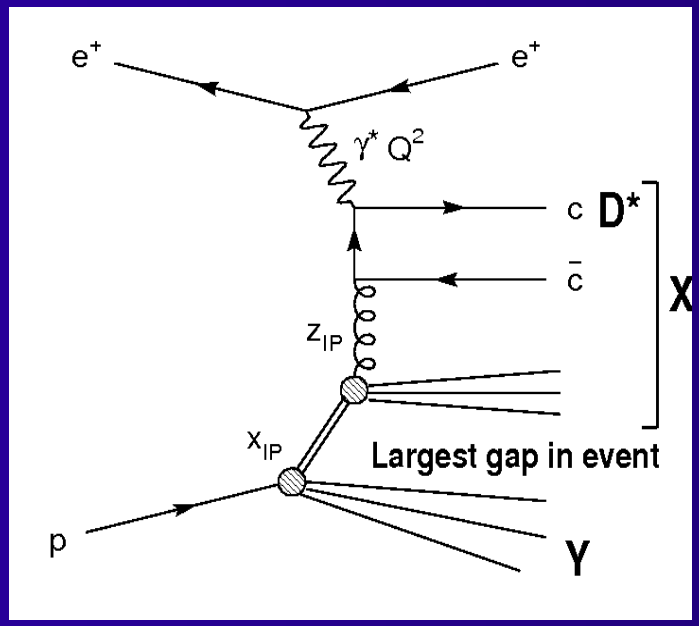
Dijet cross section at Tevatron 3-10 lower than expected using HERA dPDF's. QCD factorization broken for diffractive hadron-hadron processes

Explenetion:

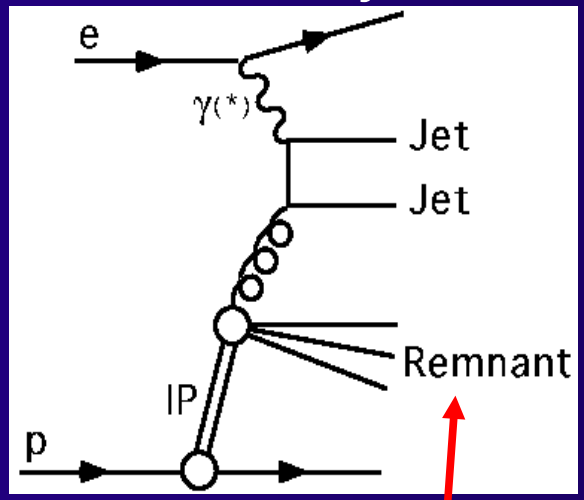
suppression due to the secondary interactions between spectator partons

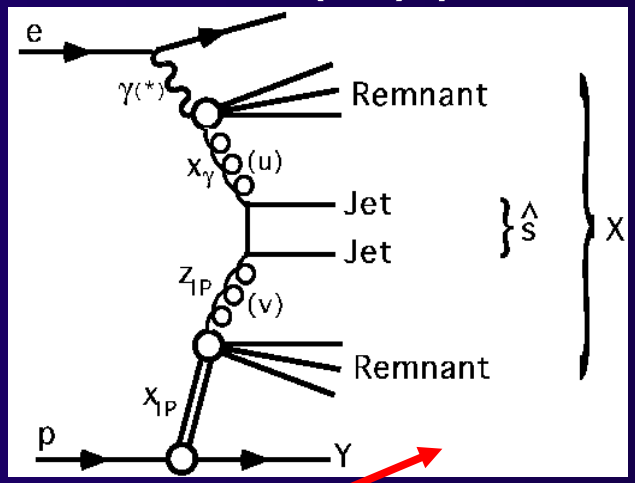


Test of QCD factorization at HERA



Diffractive dijet and open charm (D*) production





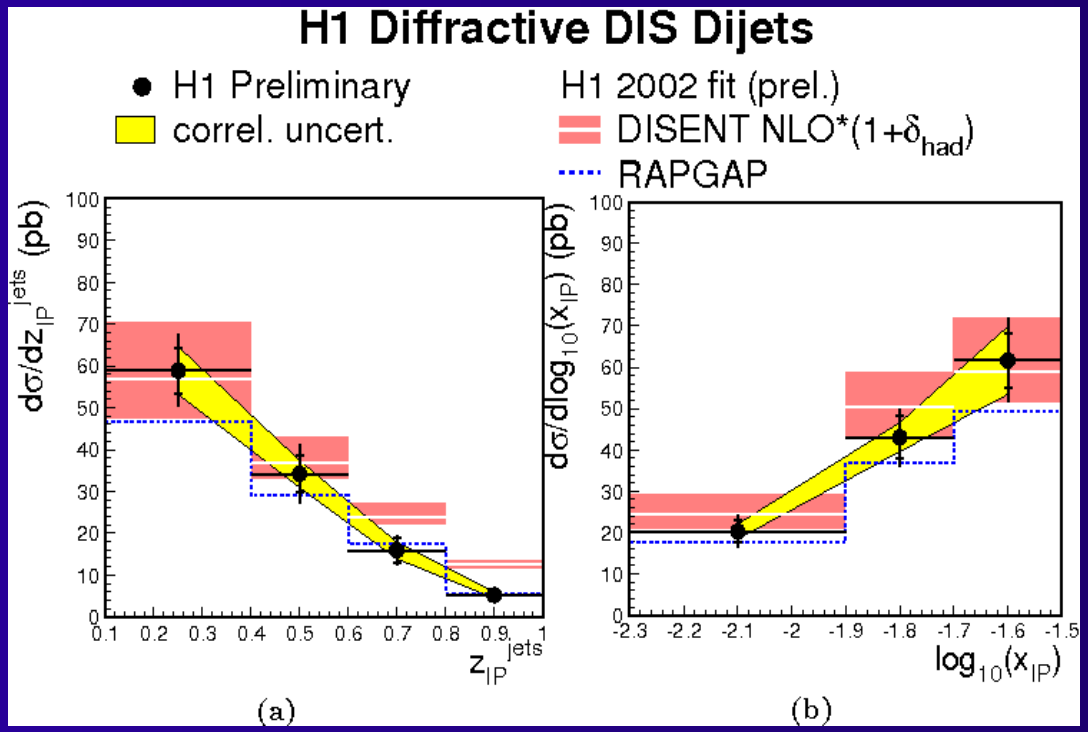
In PHP “direct” and “resolved” component hard scale given by E_T of jets or charm mass

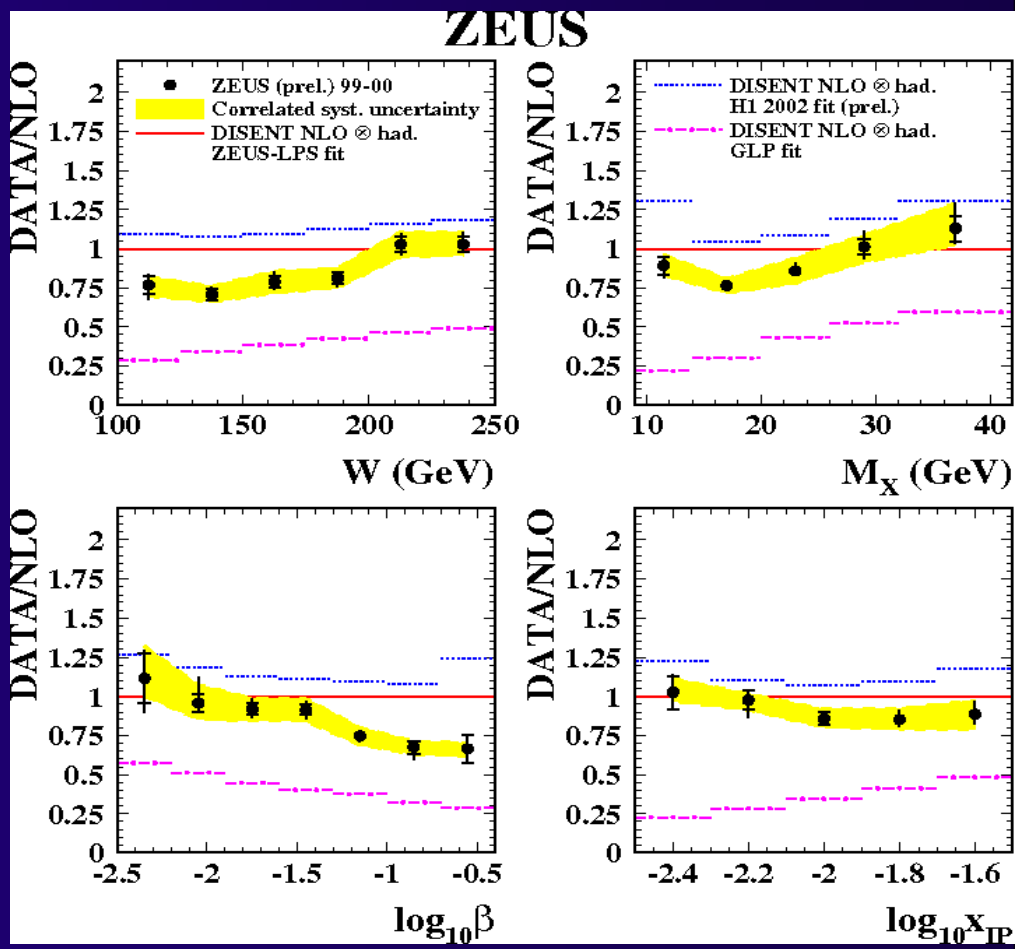
If factorization breaking due to the rescattering:

- no suppression in DIS and “direct” PHP processes
- suppression of “resolved” component in PHP

by 0.34 [Kaidalov et al.]

Diffractive dijets in DIS





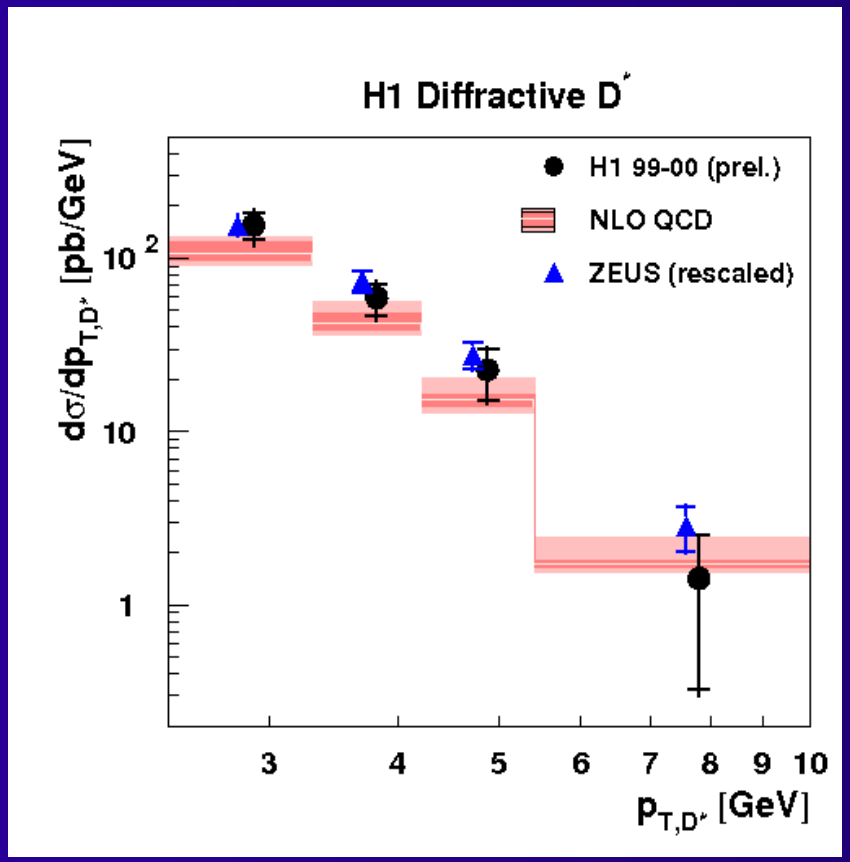
-dPDF uncertainty not shown

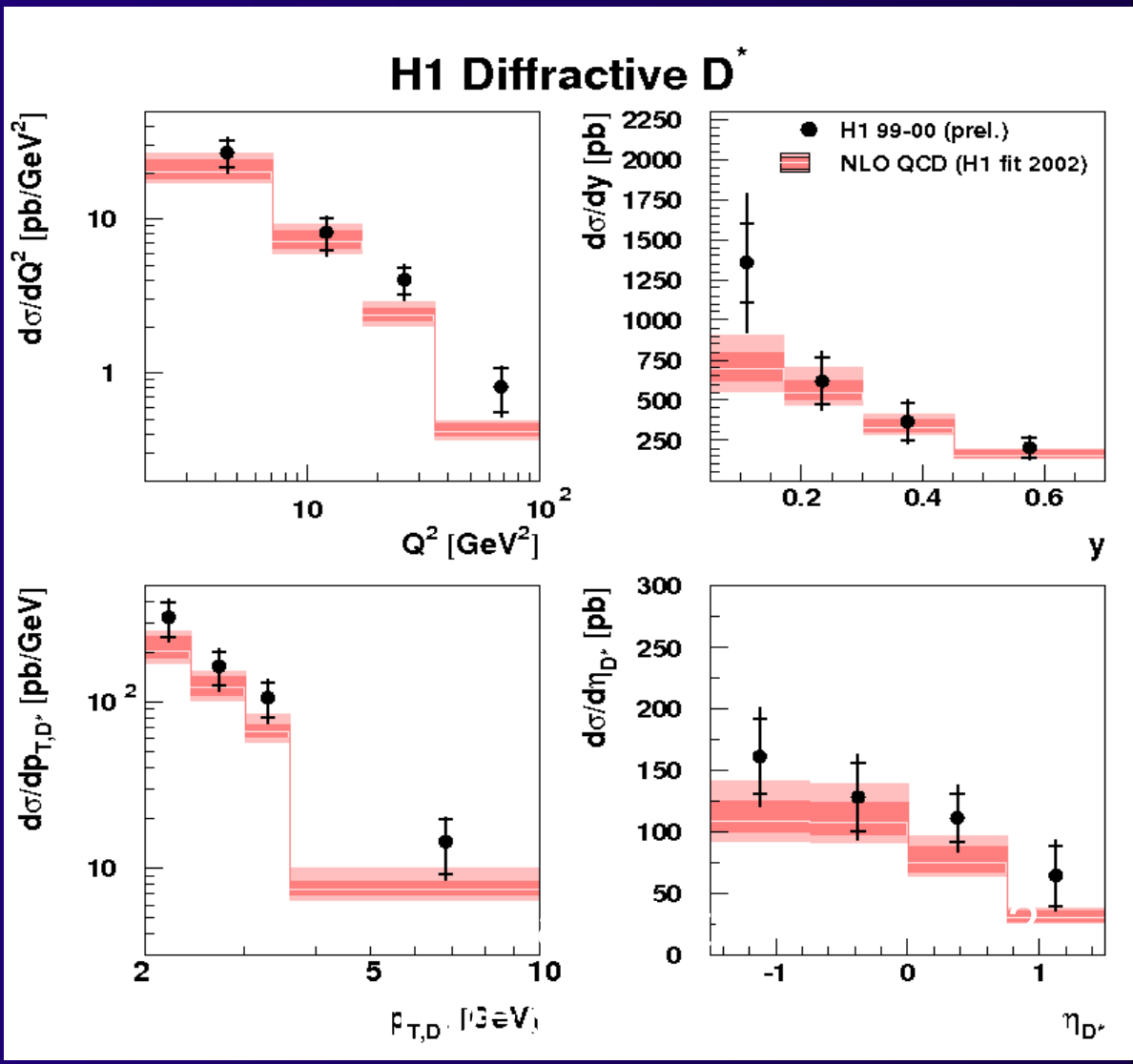
-good agreement between data and NLO predictions based on ZEUS-LPS and H1 2002 fits

-predictions with GLP (ZEUS M_X data) dPDF lower than ZEUS data

Possibly no suppression , need dPDF consistency to draw conclusion

Diffractive D* in DIS





-dPDF uncertainty not shown

-good agreement between data and NLO predictions based on H1 2002 fit

Possibly no suppression , need dPDF consistency to draw conclusion

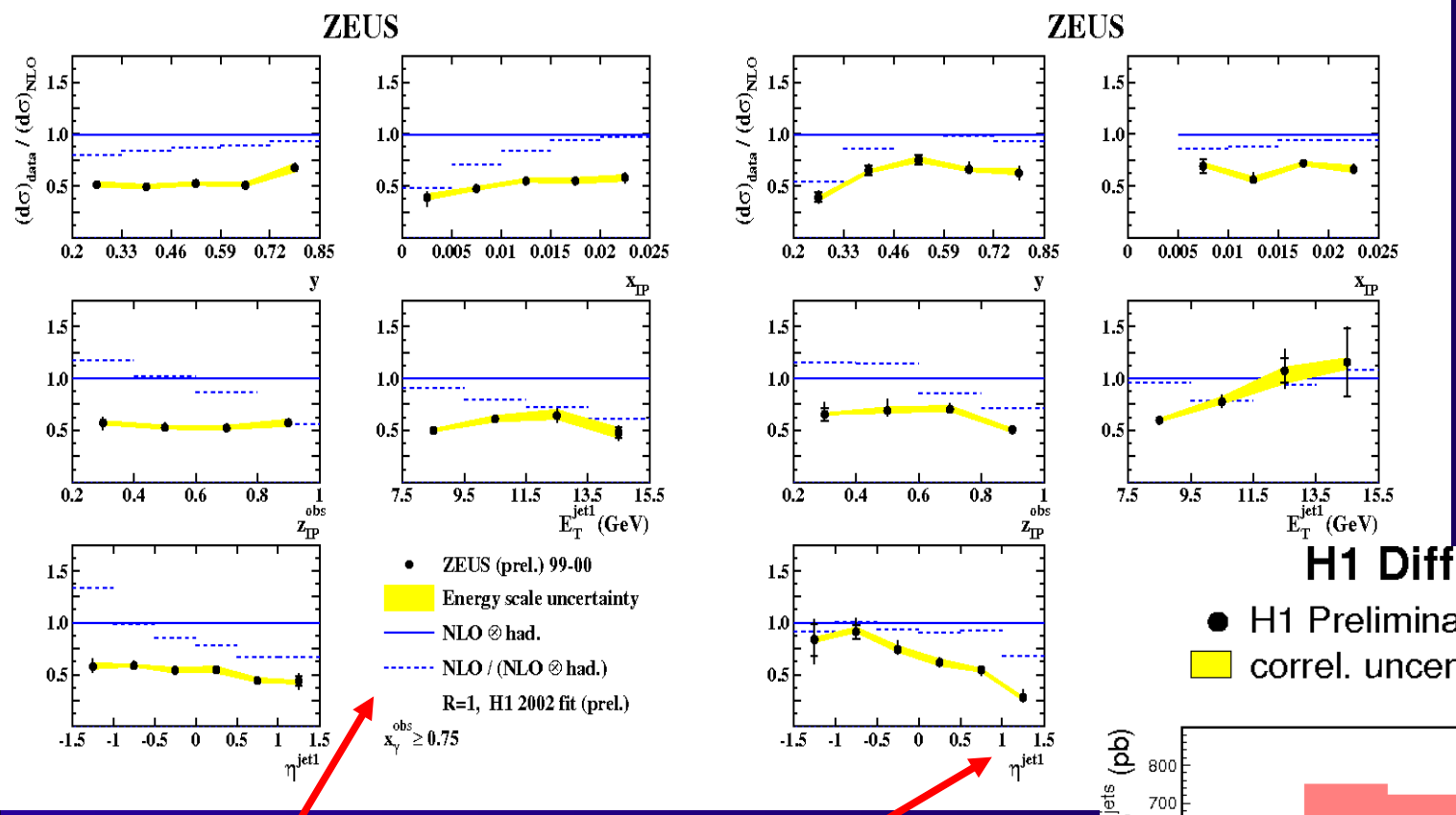
Diffractive dijets in PHP

ZEUS

NLO Klasen/Kramer with H1 2002 dPDF

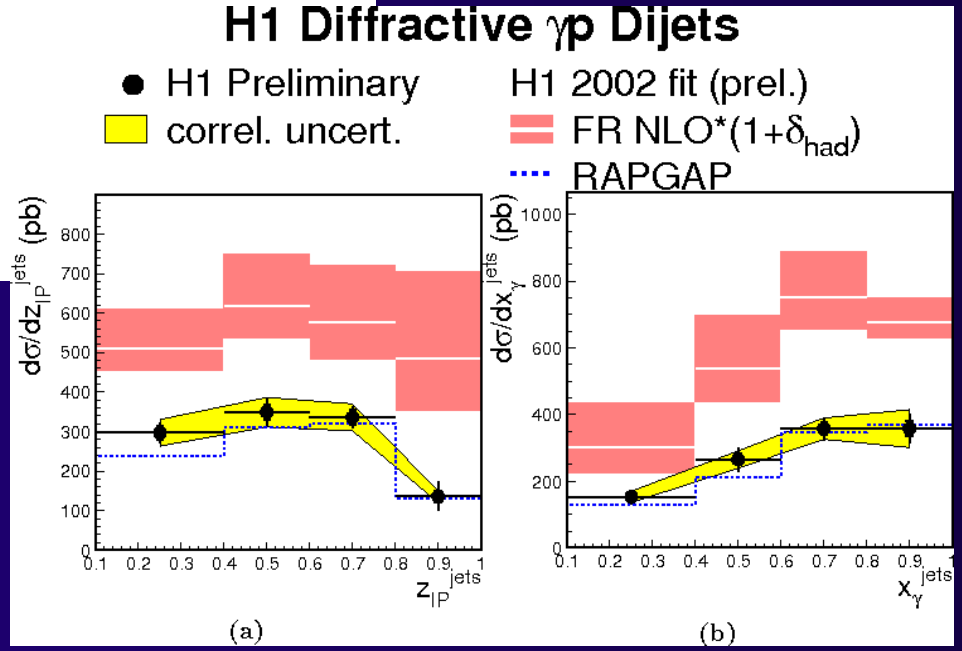
H1

NLO Frixione program



Direct enriched

Resolved enriched

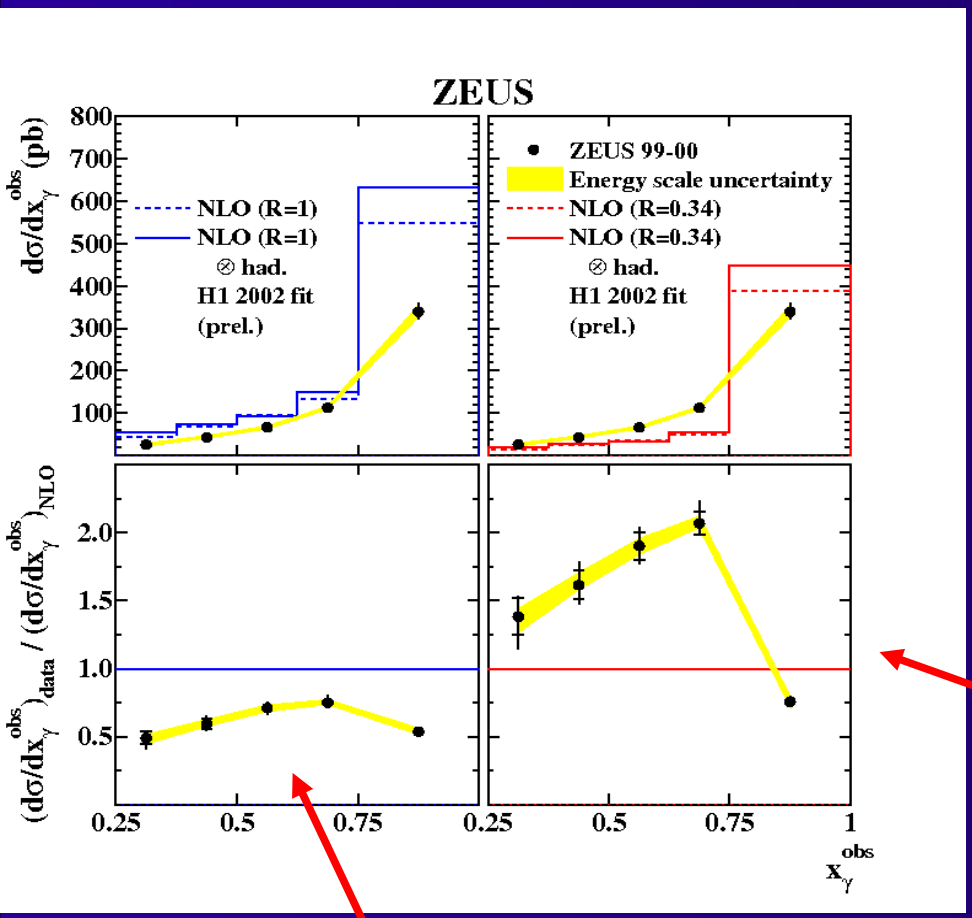


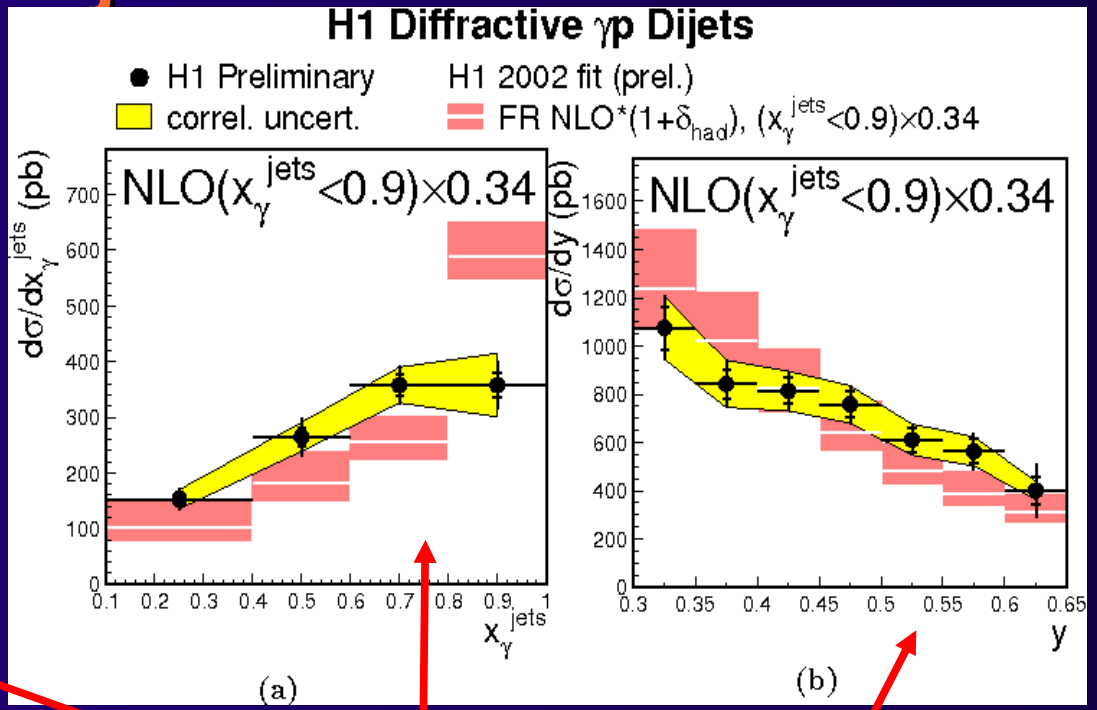
-dPDF uncertainty not shown

-NLO predictions based on H1 2002 fit factor of 1.6 below data

Possibly suppression, need better estimate of dPDF uncertainty to conclude

Diffractive dijets in PHP II

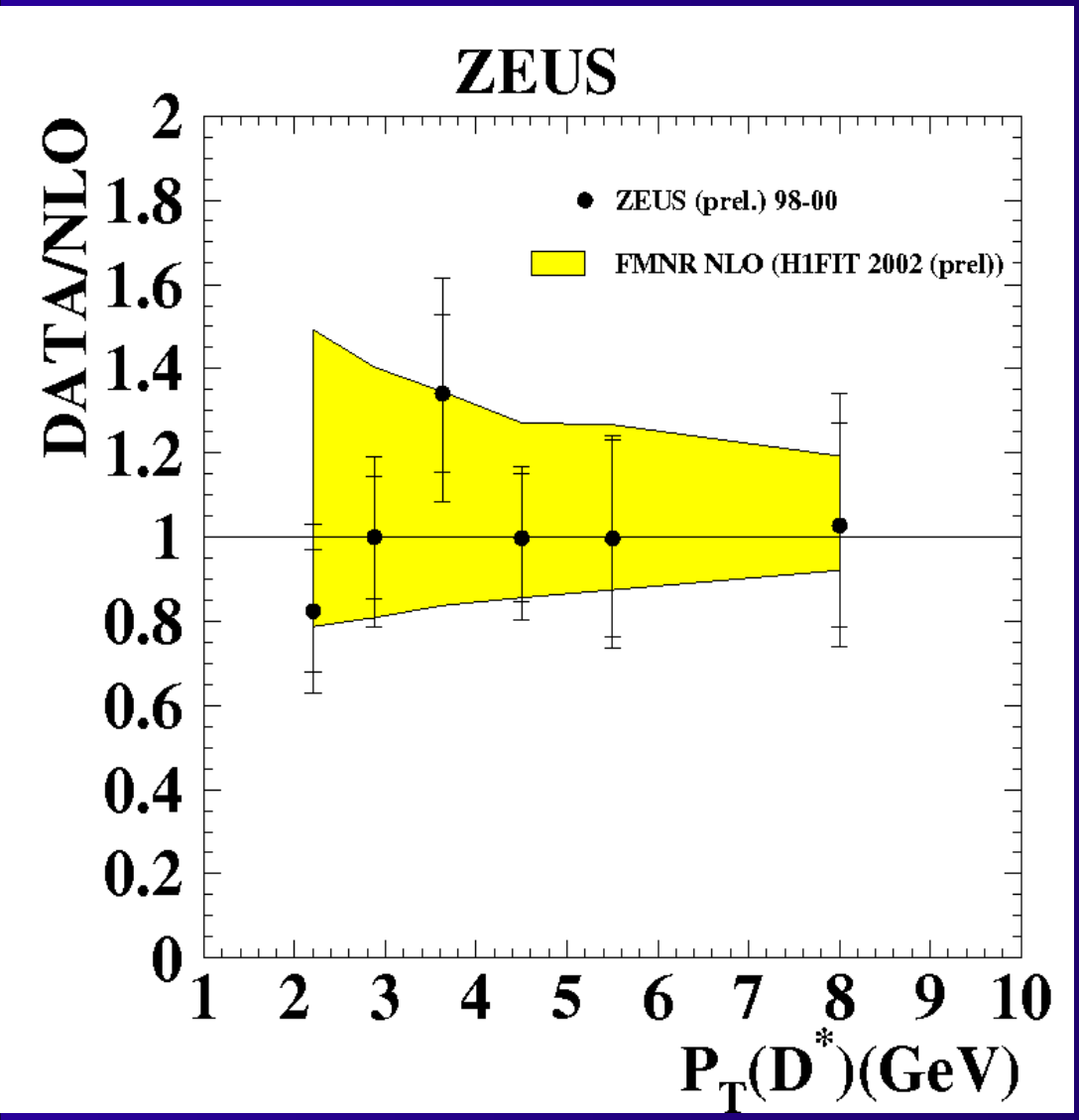




Scaling only resolved part by 0.34 does not describe the data

Global suppression independent of kinematics preferred

Diffractive D^* in PHP



-dPDF uncertainty not shown

-NLO prediction based on H1 2002 fit describes the data

Inconsistent with dijet results ?

However NLO underestimates inclusive D*production in PHP by factor of 1.6

Ratio diffractive/inclusive the same for D* and dijet in PHP

Summary

- Diffractive PDF's extracted from DGLAP NLO fits to H1 and ZEUS data. Discrepancies between them not fully understood.
- NLO calculations based on H1 2002 and ZEUS-LPS fits:
  - -consistent with dijet and D* DIS data
  - -overestimate dijet PHP data
  - -consistent with D* PHP data but underestimate inclusive D*

  BUT NLO calculations based on M_X data:
  - -inconsistent with DIS data

  More work on dPDF needed for conclusion on QCD factorization in diffractive hard scattering at HERA