Diffraction at HERA

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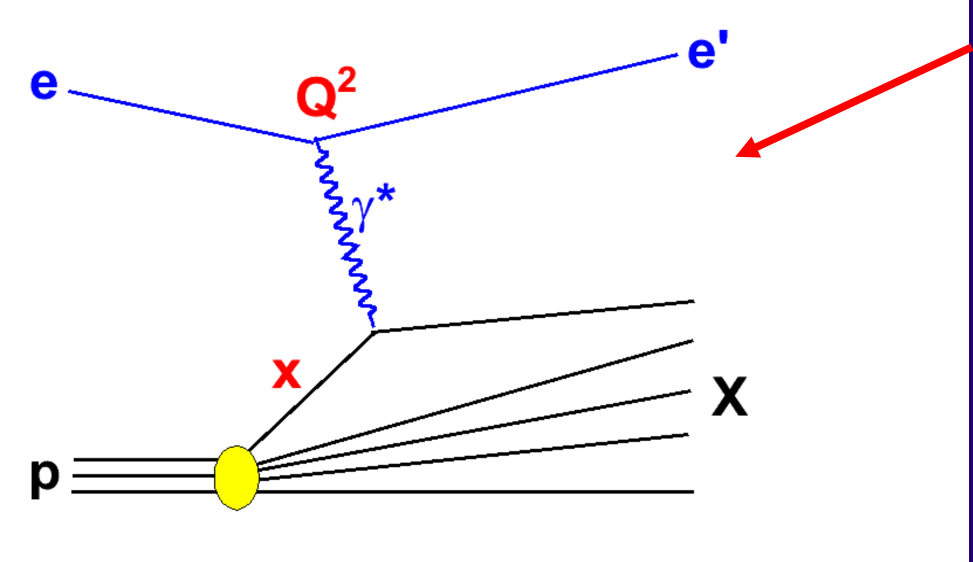
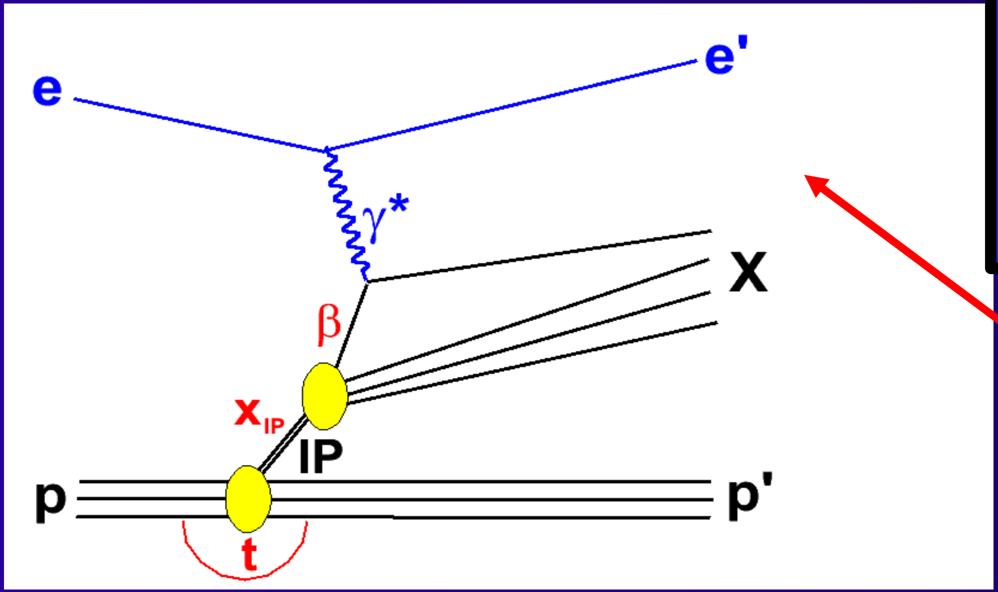
- Introduction
- Inclusive diffraction
- Diffractive parton densities



Inclusive DIS: Probe structure of the proton

~10% of low x DIS events are diffractive

- Q^2 – virtuality of the boson
- x – fraction of proton momentum carried by struck quark
- $x_{IP}(\xi)$ – fraction of proton momentum carried by diffractive exchange
- $\beta(z_{IP})$ – momentum fraction of the exchange carried by struck quark
- t – four momentum transfer of diffractive exchange



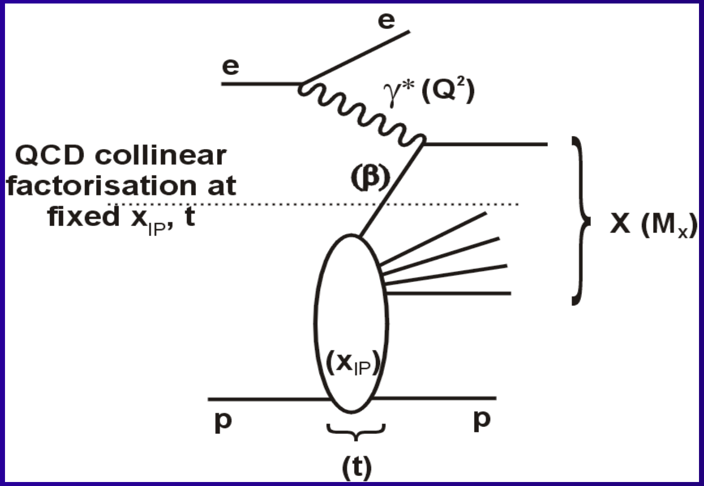
Diffractive DIS: Probe structure of the diffractive exchange (Pomeron)

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 collinear factorisation theorem (proven by Collins for diff. DIS processes):

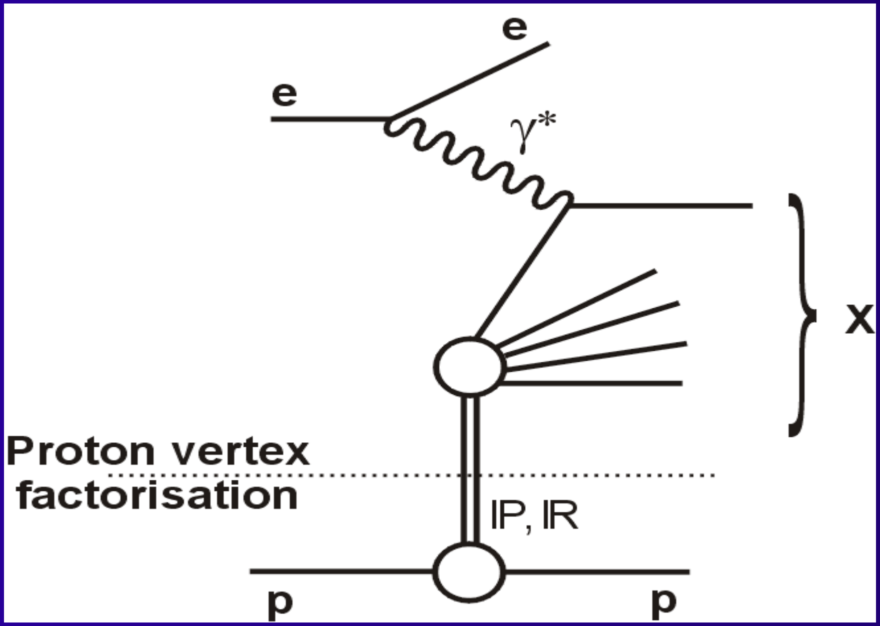
$$F_2^D = \sum_{\text{parton } i} C_i^\gamma \otimes f_i^D$$

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

Proton vertex factorisation + Regge Th.

Empirically motivated

$$f_i^D(\beta,Q^2;x_{IP},t)=F(x_{IP},t)\times f_i(\beta,Q^2)$$



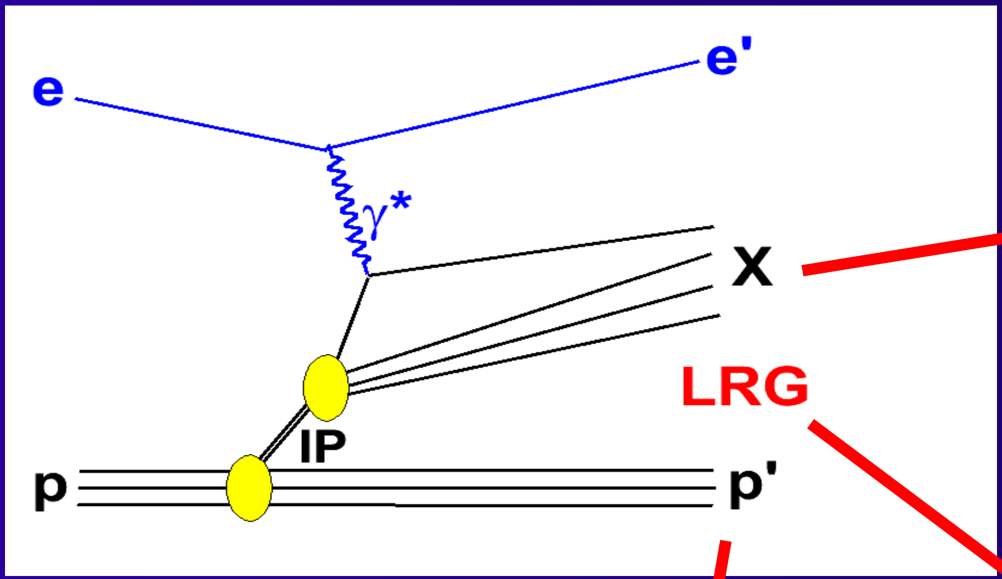
Equivalent with treating diffractive exchange as Pomeron with a partonic structure

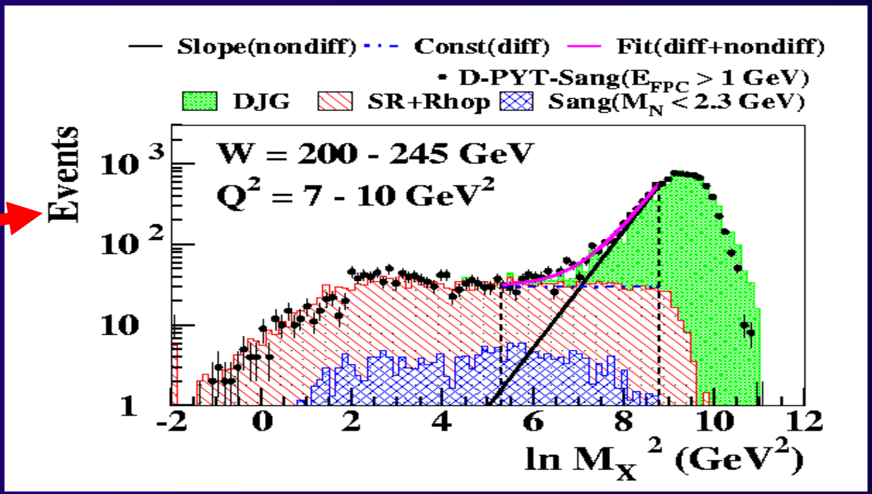
Consistent with low x_{IP} data

To obtain good description of data also at large x_{IP} additional sub-leading exchange (IR) has to be added.

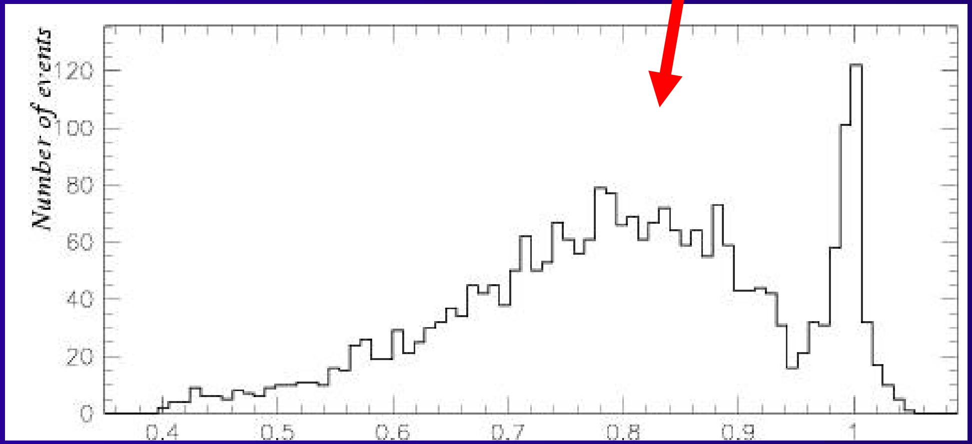
$$f_i^D(\beta,Q^2;x_{IP},t)=F_{IP}(x_{IP},t)\times f_i^{IP}(\beta,Q^2) + F_{IR}(x_{IP},t)\times f_i^{IR}(\beta,Q^2)$$

Selection of diffractive events

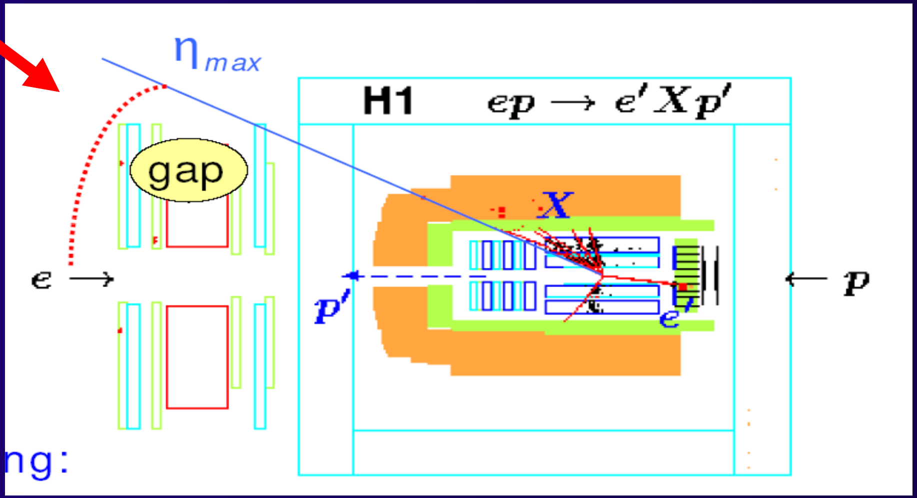




Diffractive mass distribution (M_X)



Forward proton detection (FPD)



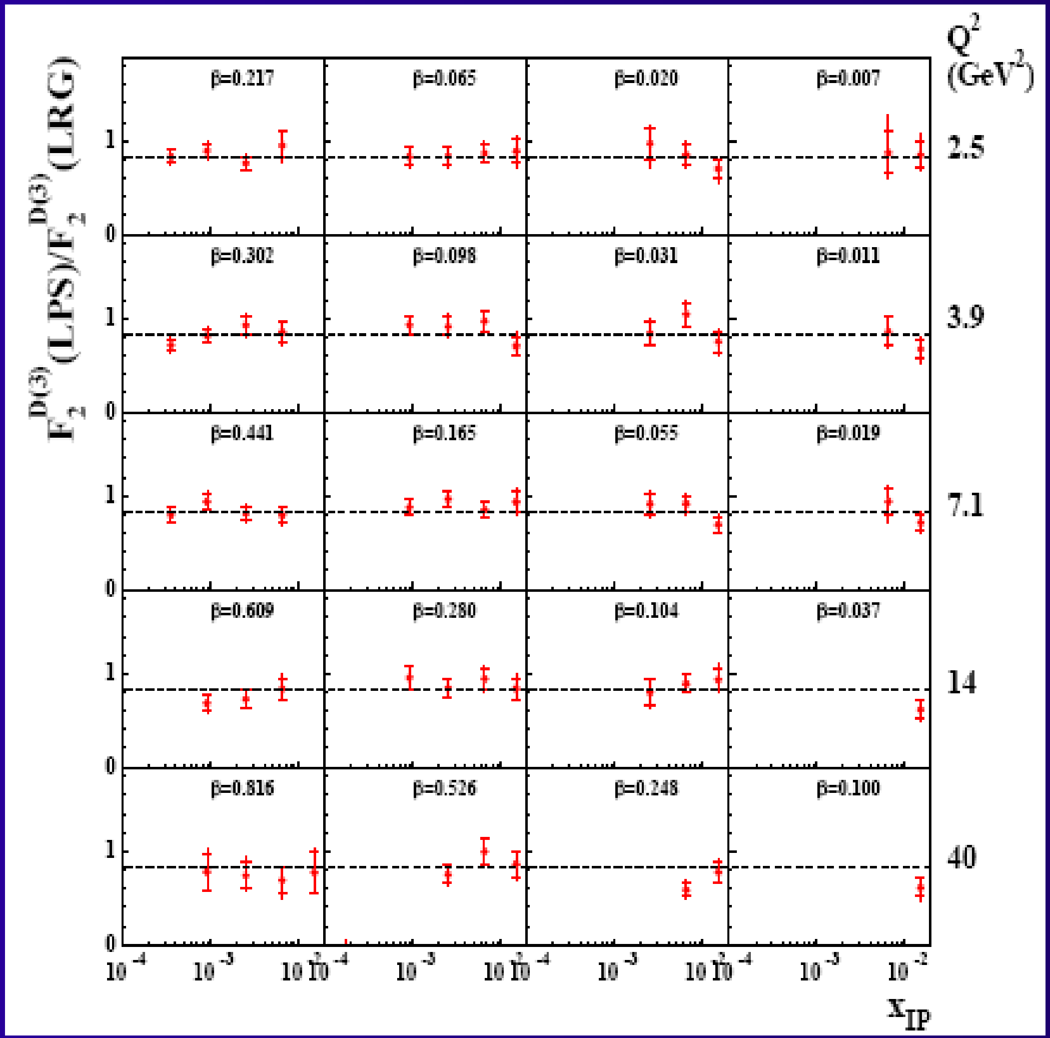
Events with large rapidity gap (LRG)

Selection Methods

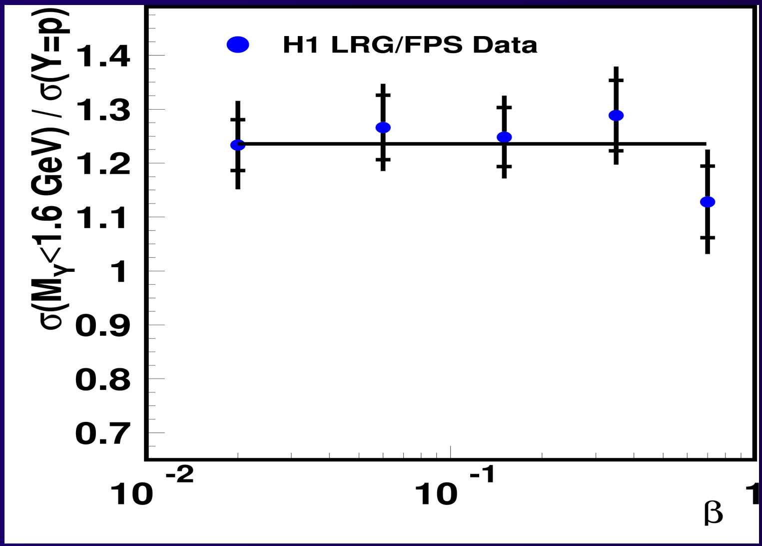
- FPD
  - small acceptance, large normalization uncertainty
  - free of proton dissociation bkg.
  - contribution from Reggeon exchange
  - the only method to measure t-distribution
- LRG
  - high statistics
  - contributions from proton dissociation and Reggeon exchange
- M_X
  - high statistics
  - free of Reggeon exchange contribution
  - contribution from proton dissociation bkg.

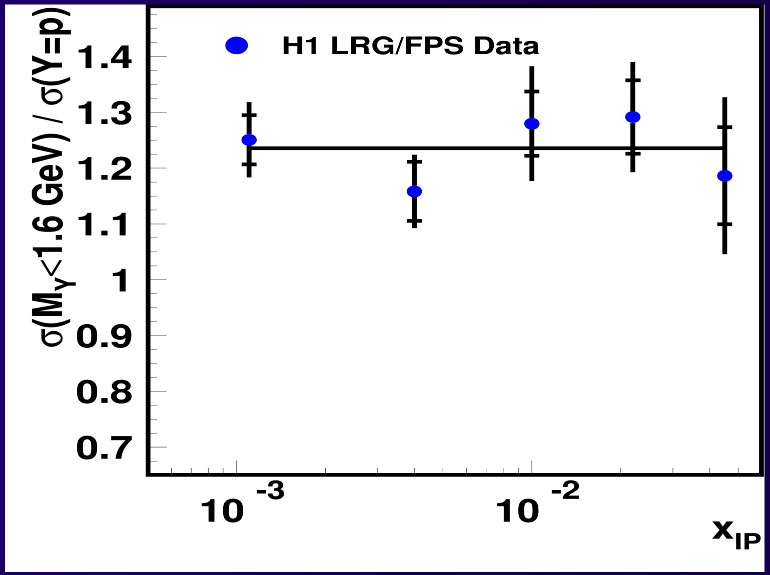
FPD versus LRG Methods

ZEUS Preliminary



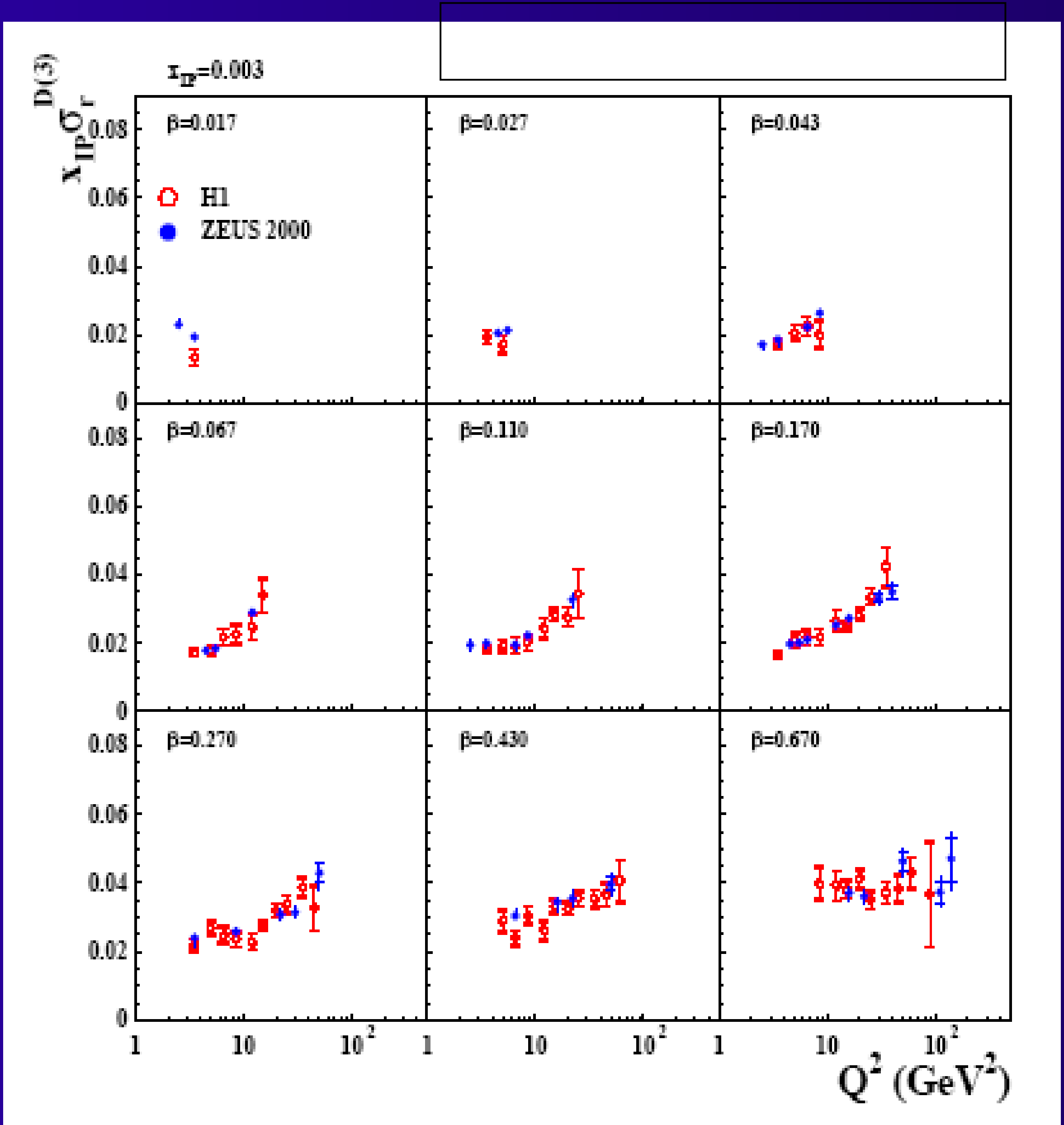
H1





Good agreement between methods.
Normalization differences due to the proton dissociation.

LRG H1 versus ZEUS(Prel.) Data

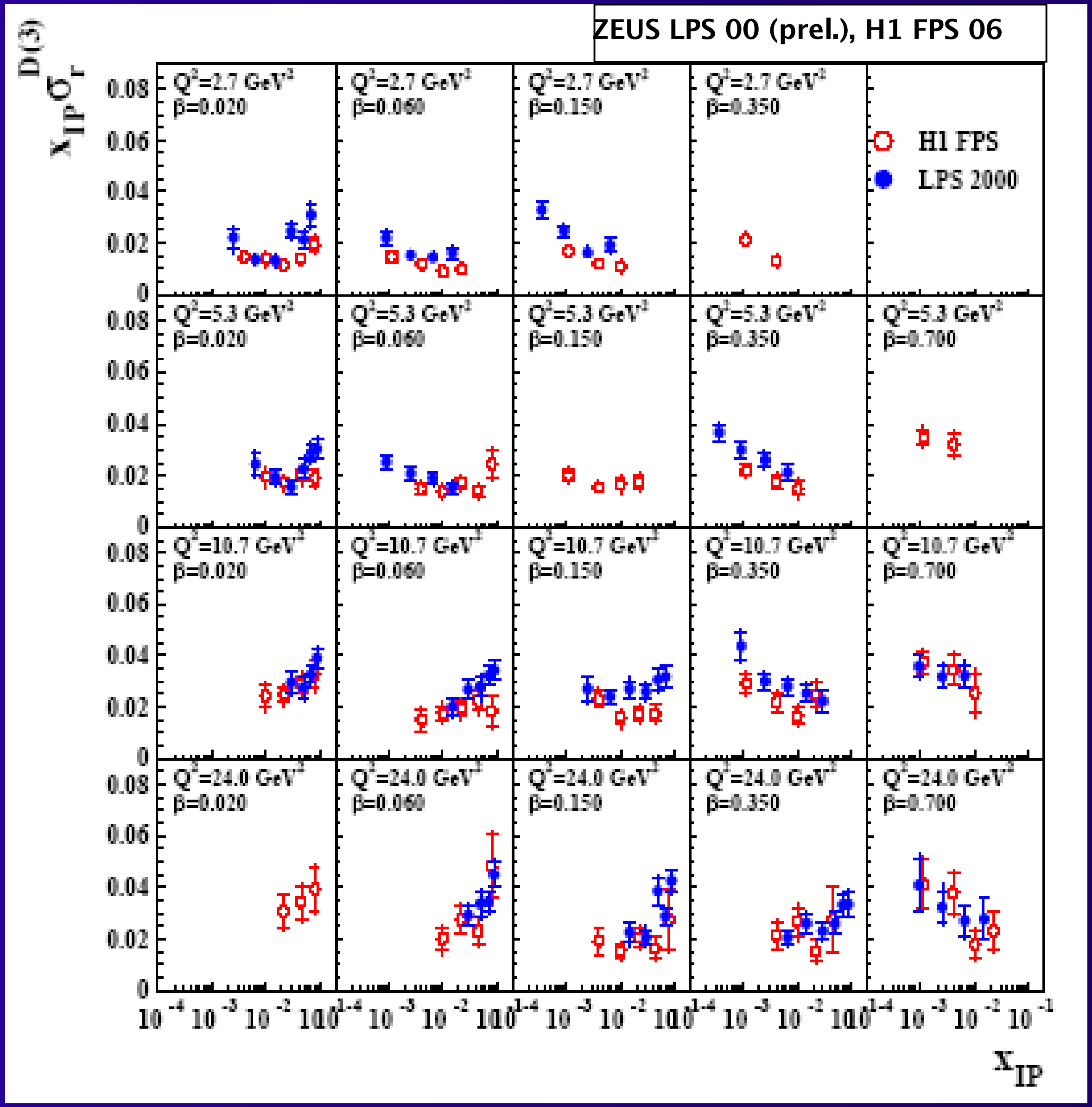


Fraction of proton dissociation different for ZEUS and H1

ZEUS data normalized to H1 data

Fair agreement

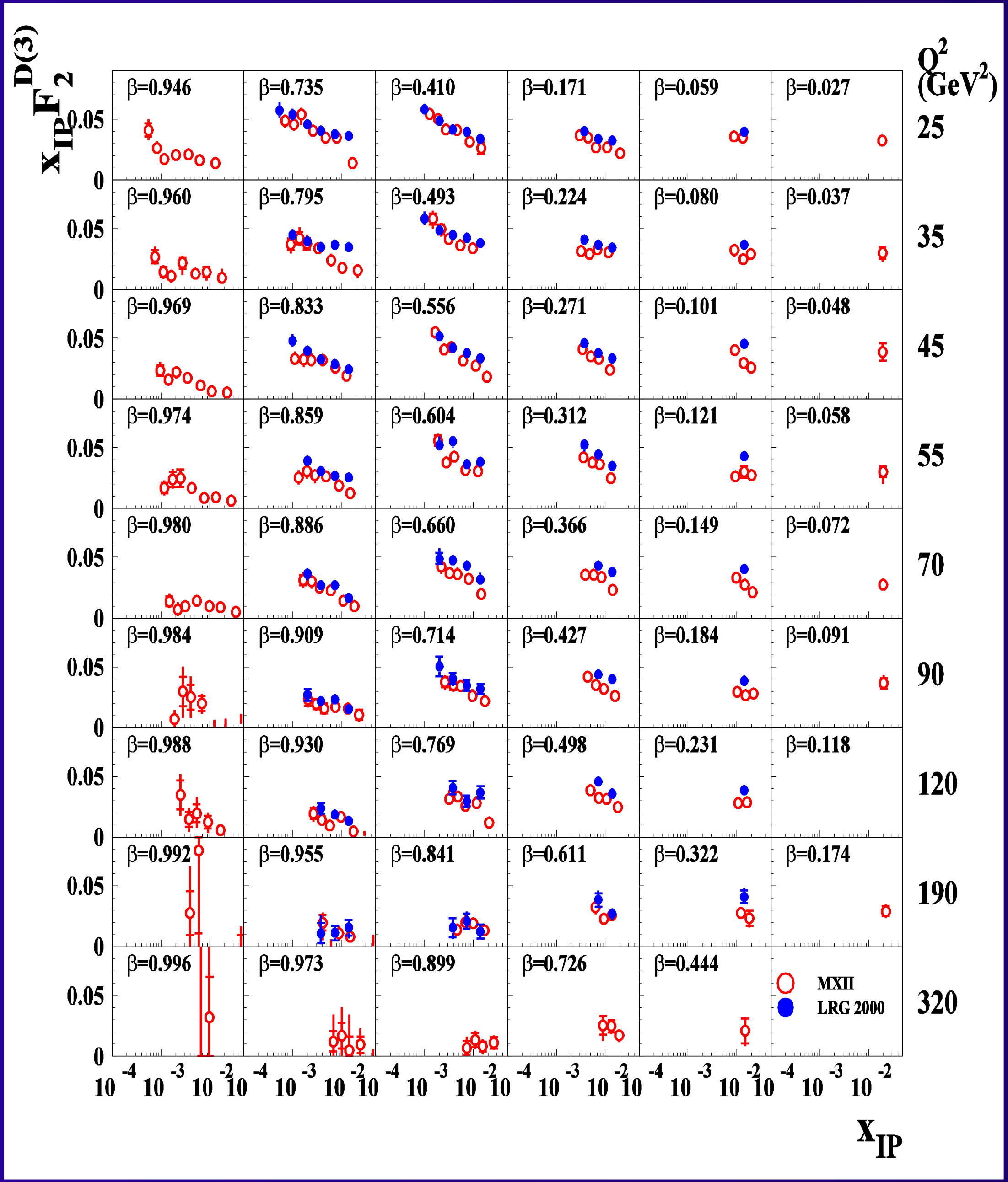
FPD H1 versus ZEUS(Prel.) Data



Normalization uncertainties of ~10% not shown

Fair agreement

LRG versus M_x Methods



ZEUS Preliminary data

Relative agreement for $x_{IP}<0.01$

For $x_{IP}>0.01$ one can expect differences due to the Regeon contribution to LRG data

Comparison between data sets

LRG / FPD (H1 & ZEUS) – good agreement with shape

H1/ ZEUS (LRG & FPD) – good agreement with shape

LRG/M_X (H1 & ZEUS) – relative agreement

Data sets respecting shapes are coherent.
Common H1/ZEUS investigation on normalization.

Extraction of DPDFs

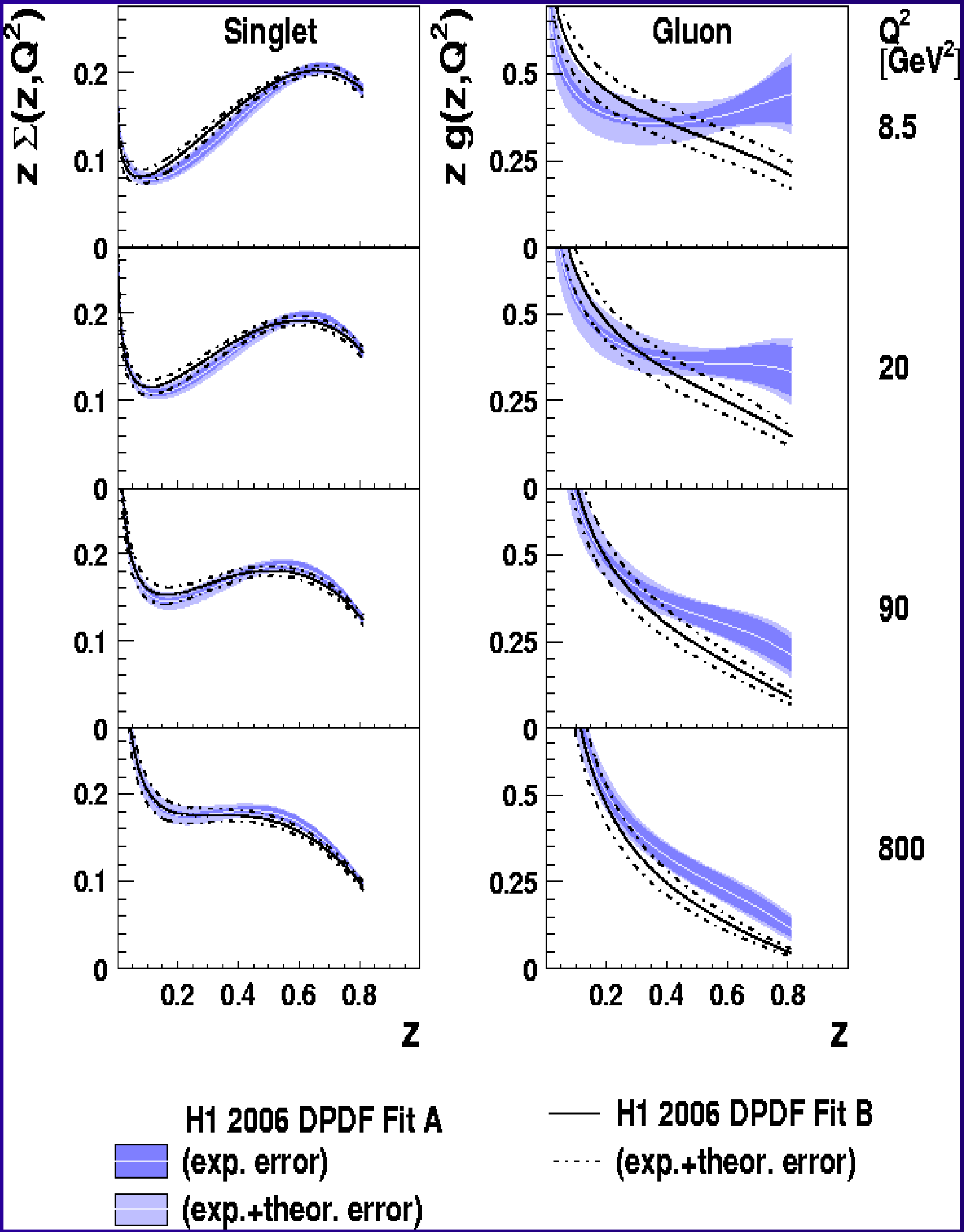
Procedure similar to ordinary PDFs:

- parameterize f_q and f_g distributions at same initial scale Q_0^2
- evolve f_q and f_g to larger Q^2 using DGLAP equations
- find parameters which fit best diffractive cross sections

Several fits possible which may differ in:

- data samples (LRG,M_x, FPD ; H1, ZEUS)
- kinematical range
- parameterization of f_q and f_g
- choice of the initial scale Q_0^2
- treatment of the Reggeon contribution

H1 2006 fits



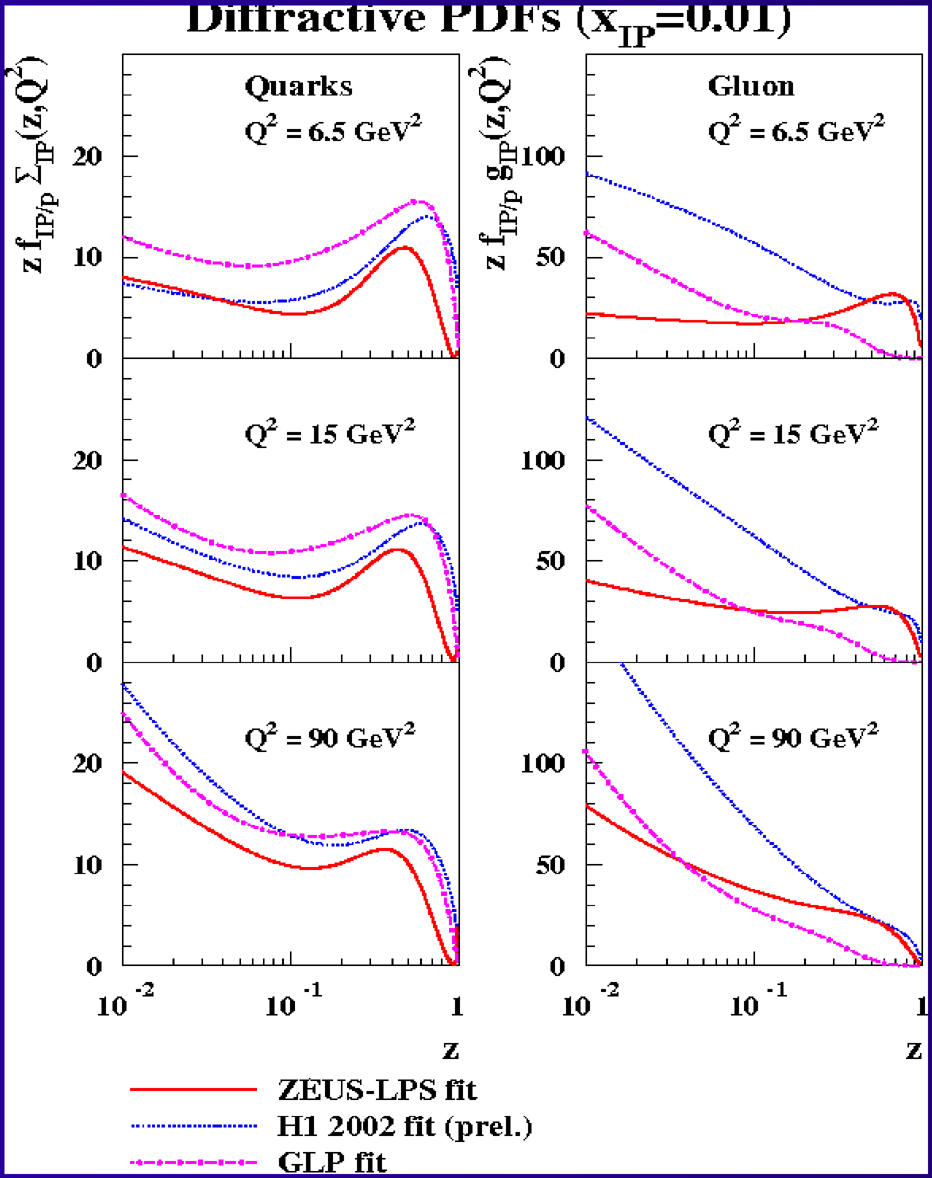
Fit A : $f_g = A(1-z)^B$

Fit B : $f_g = A$

- equally good quality of the fits
- quark distribution very stable
- large change of the gluon distribution at large z

Lack of sensitivity to the gluon distribution at large z

ZEUS fits to published data



- ZEUS-LPS fit to ZEUS 1997 LPS data
- GLP (Groys-Levy-Proskuryakov) fit to ZEUS 1998-99 M_X data

- Discrepancies evident and larger than experimental errors
- Estimate of the uncertainty on dPDF

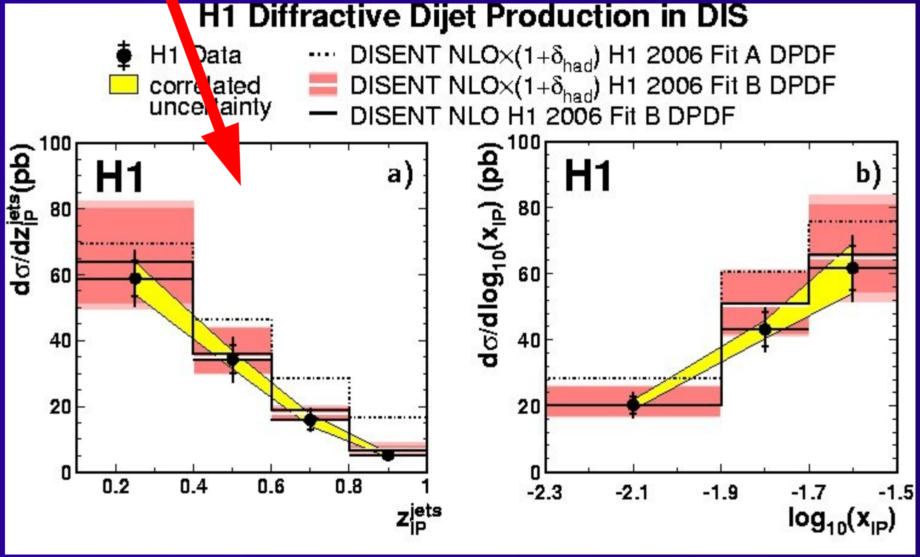
Need more work for precise and consistent determination of dPDF's

Test of QCD factorisation in Diffraction

Apply universal DPDF's to predict cross sections for inclusive diffractive processes (dijet, D^* production in DIS and PHP).

This will be discussed by next speaker but:
- QCD collinear factorization proven by Collins in DIS regime and supported by H1 and ZEUS production of dijet in DIS.

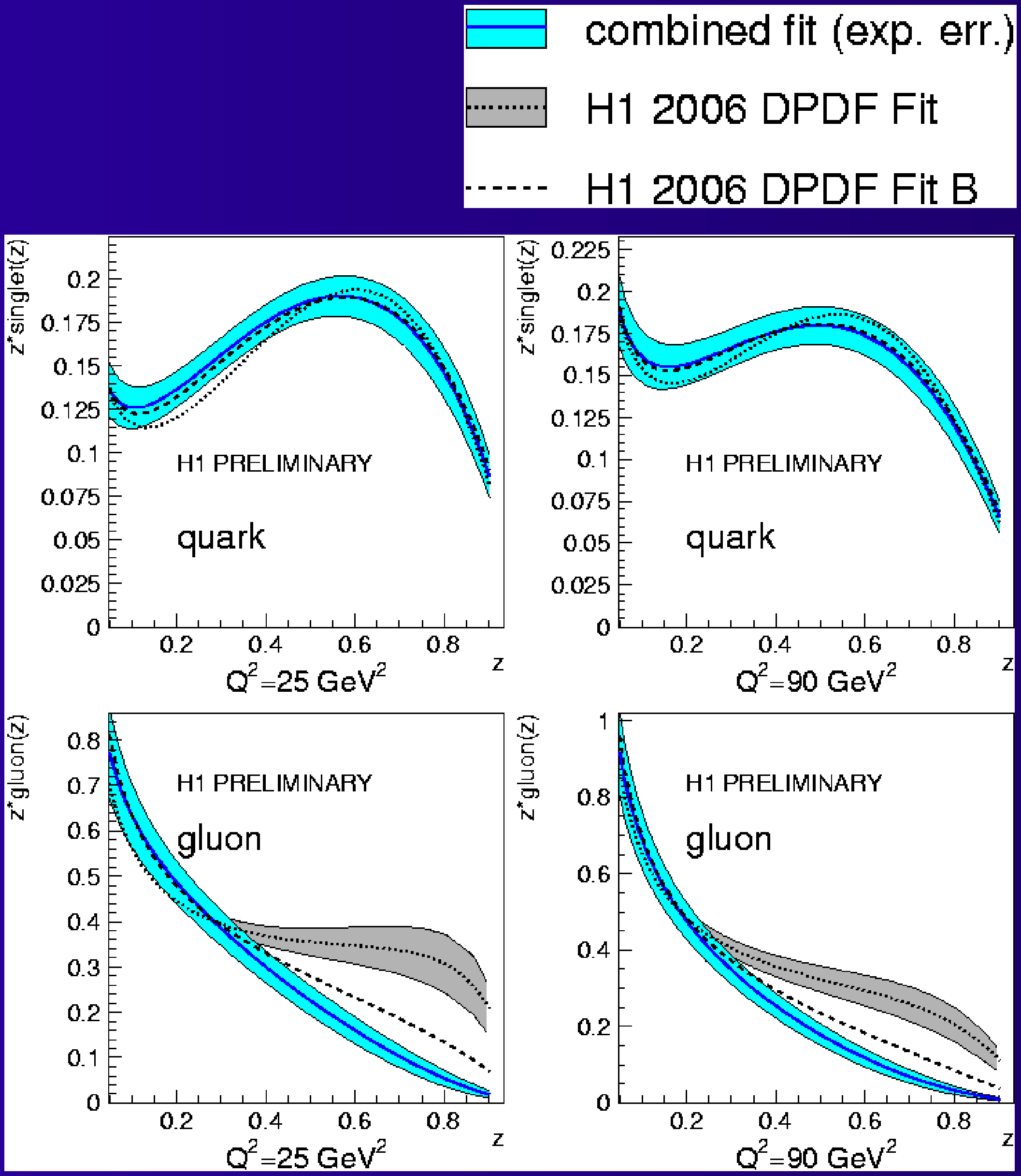
z_{IP} distribution directly sensitive to gluon distribution



dijet data prefers H1 2006 fit B.

high statistics allows to make combined fit inclusive and dijet data

Combined fit to inclusive and dijet data



Combined fit reduces uncertainty on gluon density

Summary

- At HERA inclusive diffraction is studied within the framework of QCD by two experiments with several methods (LRG, FPD, M_X)

  Generally good agreement with some open points (normalization, LRG/ M_X)

- Several sets of DPDFs available to test hard scattering factorization, to make predictions ...

  Inclusion of dijet data improved precision on DPDF's