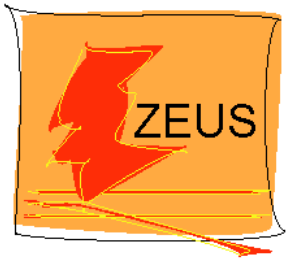
Inclusive diffraction and factorisation at HERA



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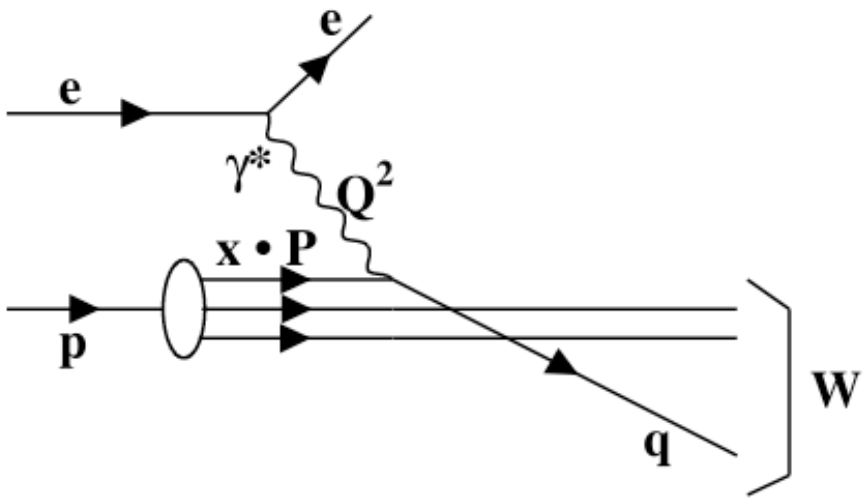
- Introduction: what is and why study diffraction?
- Results in inclusive diffraction
- Extraction of diffractive parton density functions
- Jet production in diffraction
- Conclusion

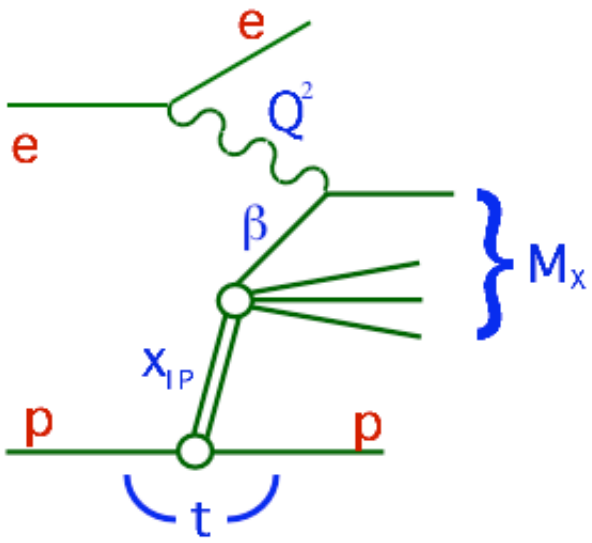
International Symposium on Multiparticle Dynamics 2008, DESY, 15-20 September

Introduction - what is diffraction?

Deep inelastic scattering



Diffractive deep inelastic scattering

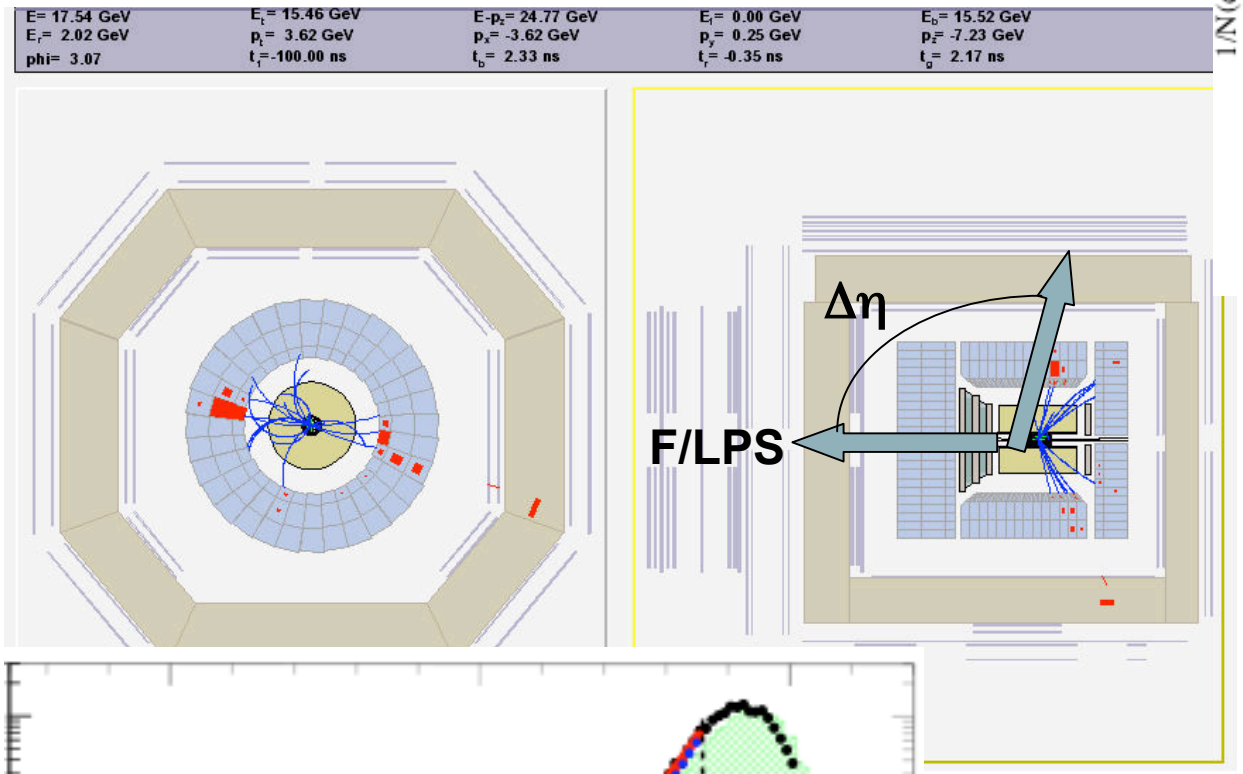


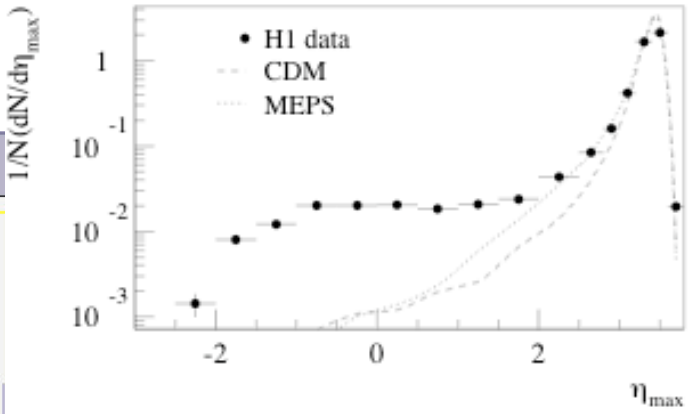
Parton densities in proton

Parton densities in "Pomeron"

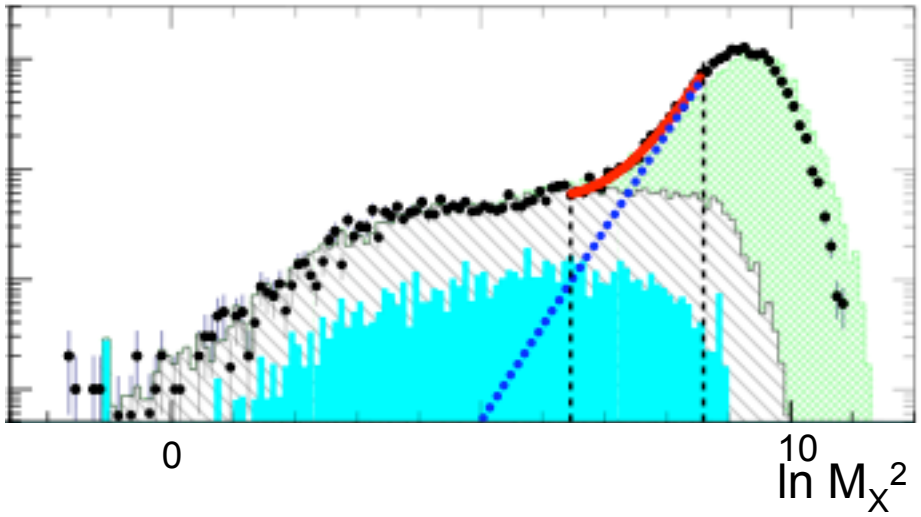
$$\sigma^{(D)}_{ep\to eX(p)} \sim f_{i/p}^{(D)} \cdot \sigma_{i\gamma\to jk}$$

Signatures of diffraction





- Forward/Leading protons (F/LPS)
- Large rapidity gap (LRG)
- "M_X method"



Pros/cons:

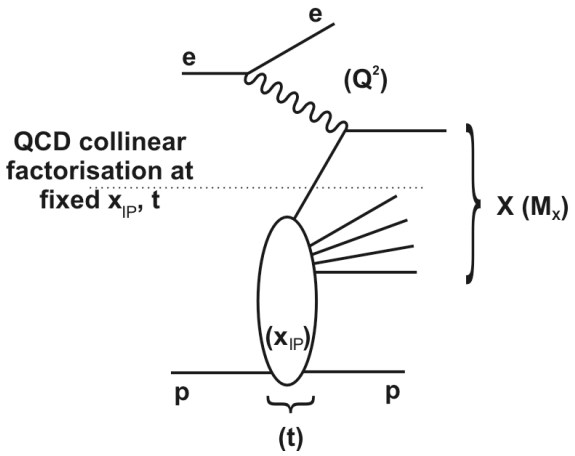
o Different kinematic regions

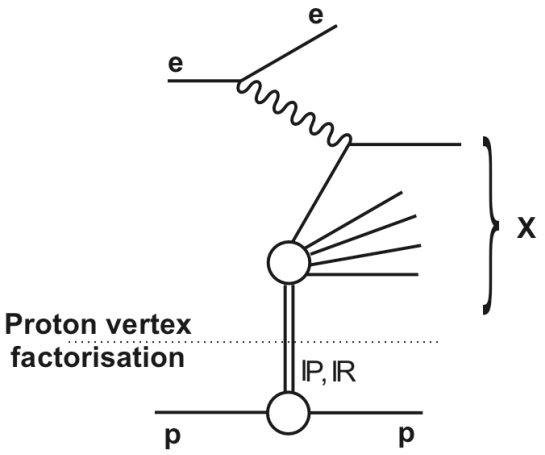
o Background contributions

o Size of sample

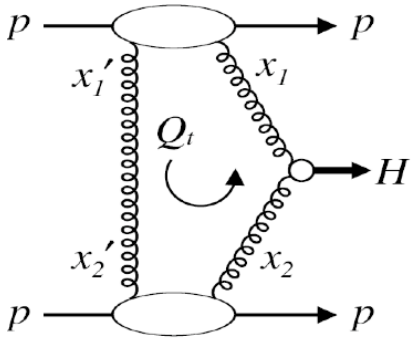
Introduction - why study diffraction?

- To understand QCD and nature of diffractive interactions
  - Transition from “soft” to “hard” regimes
  - Applicability of QCD factorisation approach a la proton PDFs
  - Significant fraction of the inclusive cross section

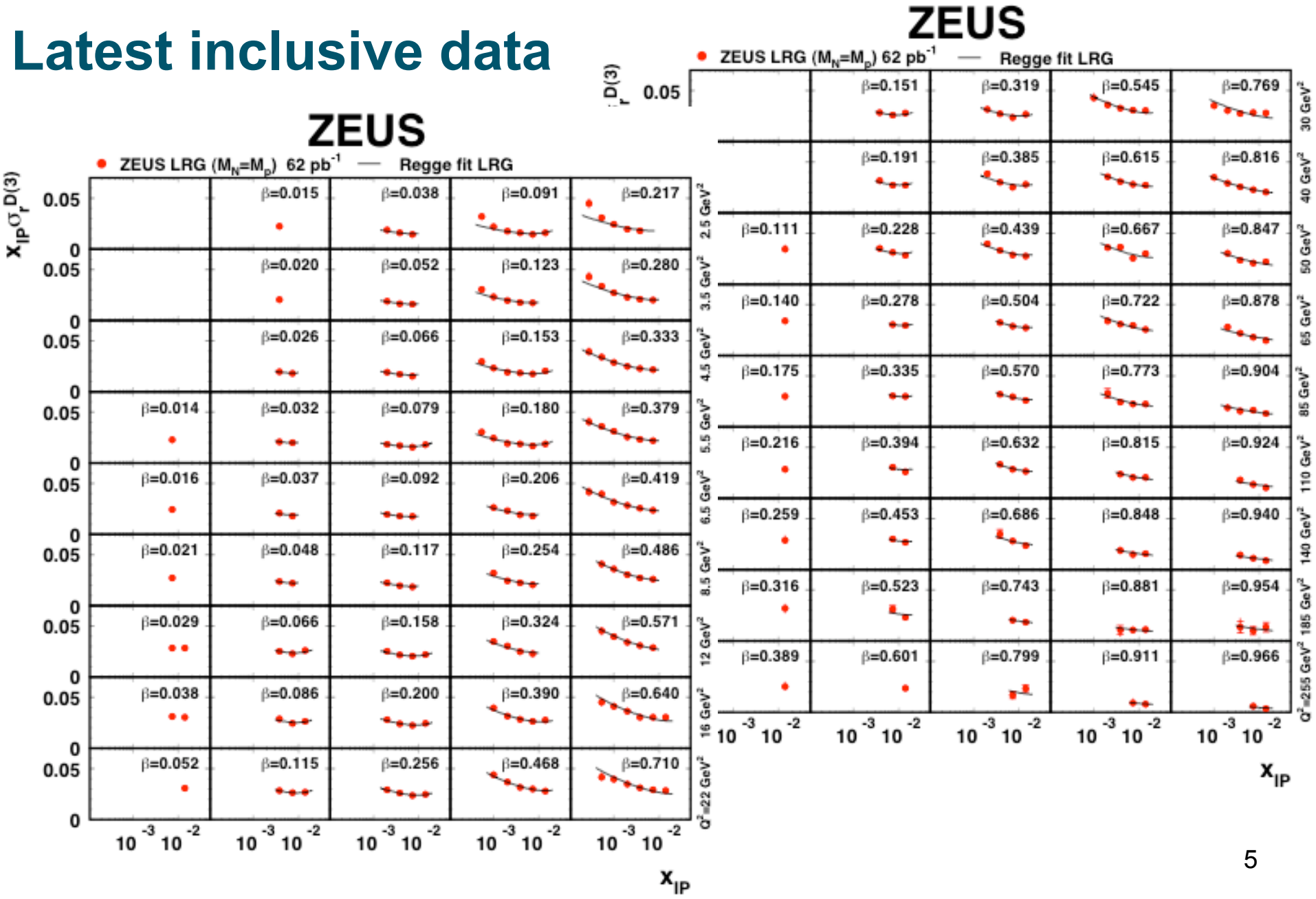




- All essential to predict potential search channels at the LHC

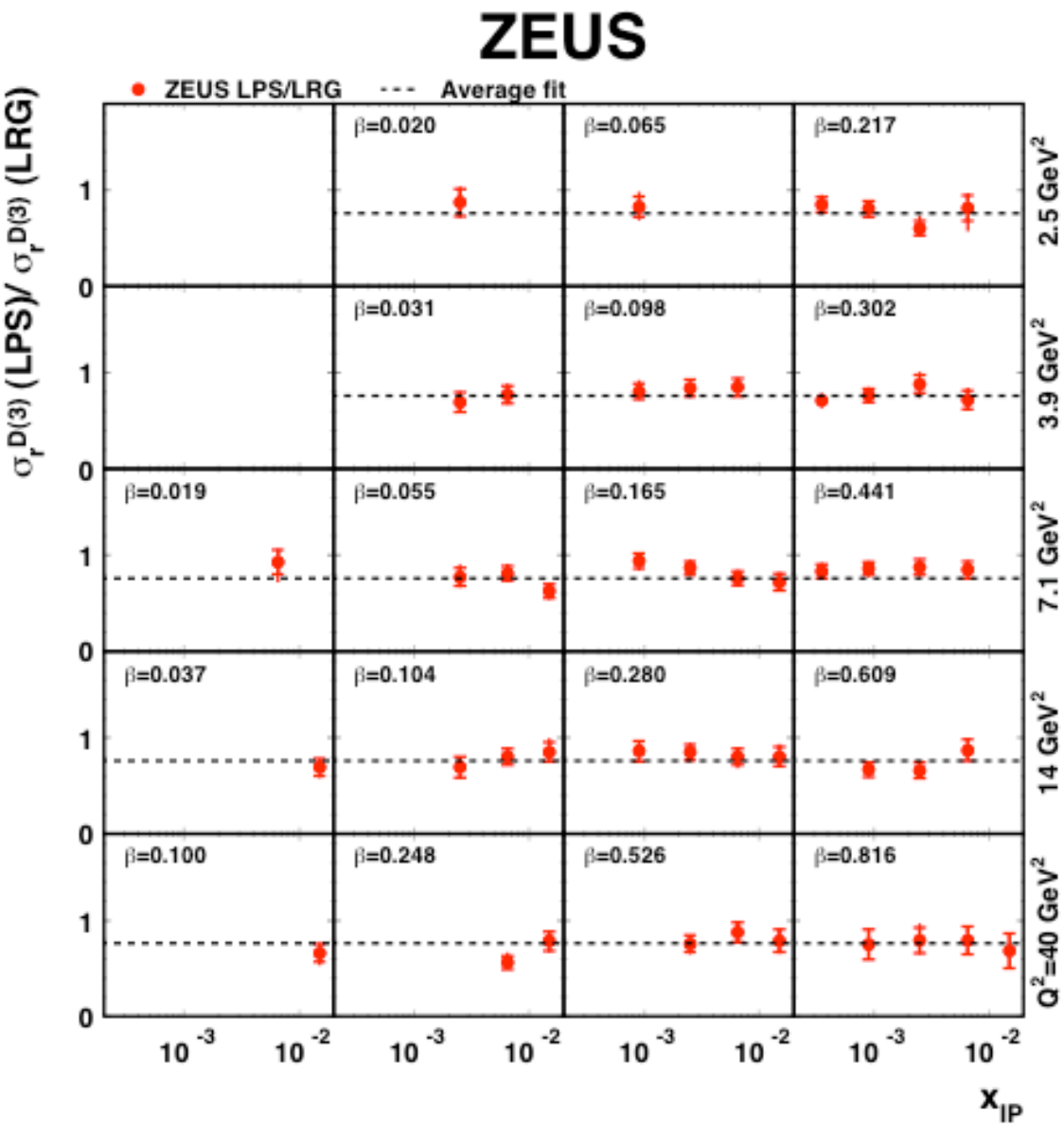


Latest inclusive data

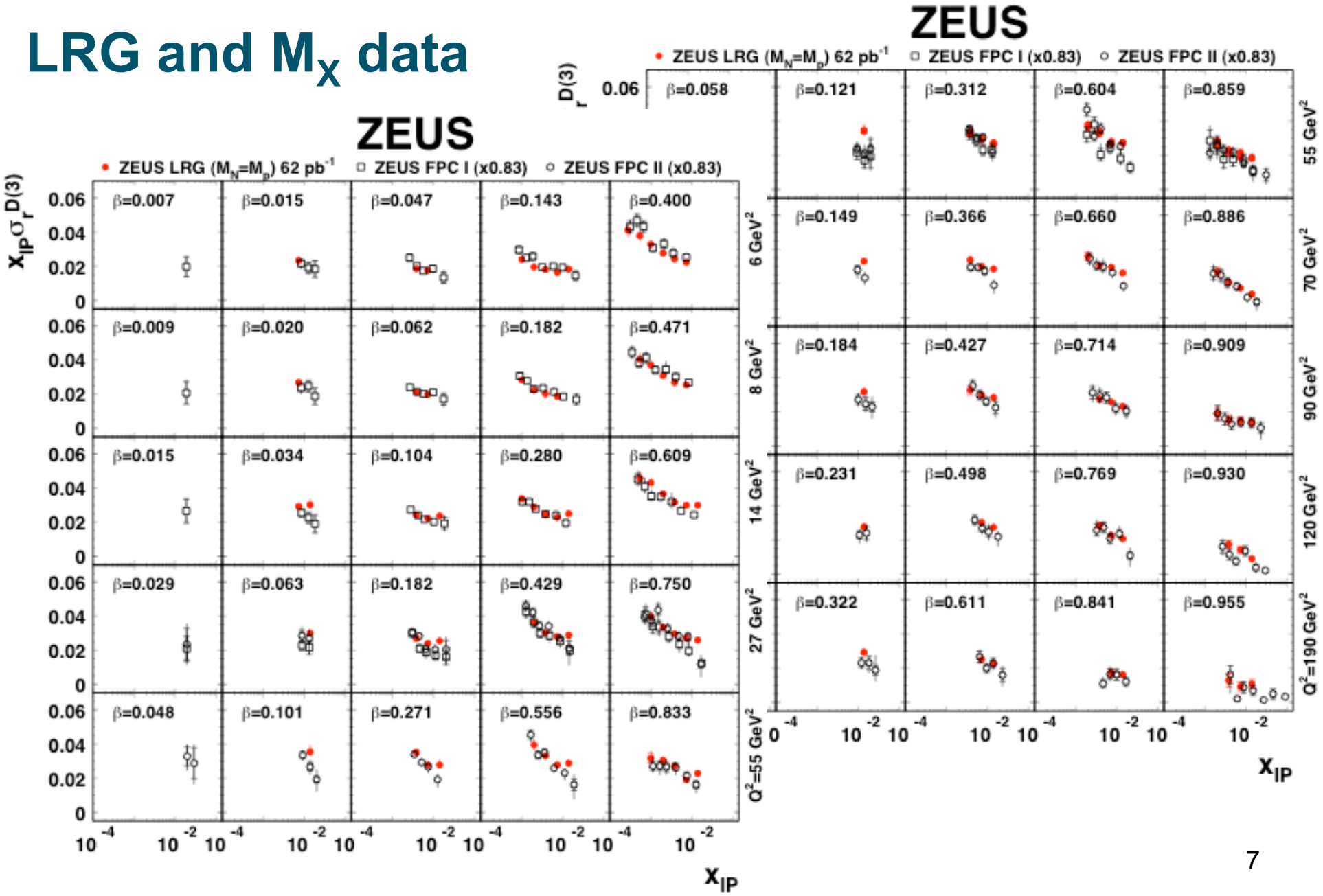


LRG and LPS data

- LRG data contains sizeable proton dissociation background (24%)
- Value independent of kinematic variables
- Similar value from H1

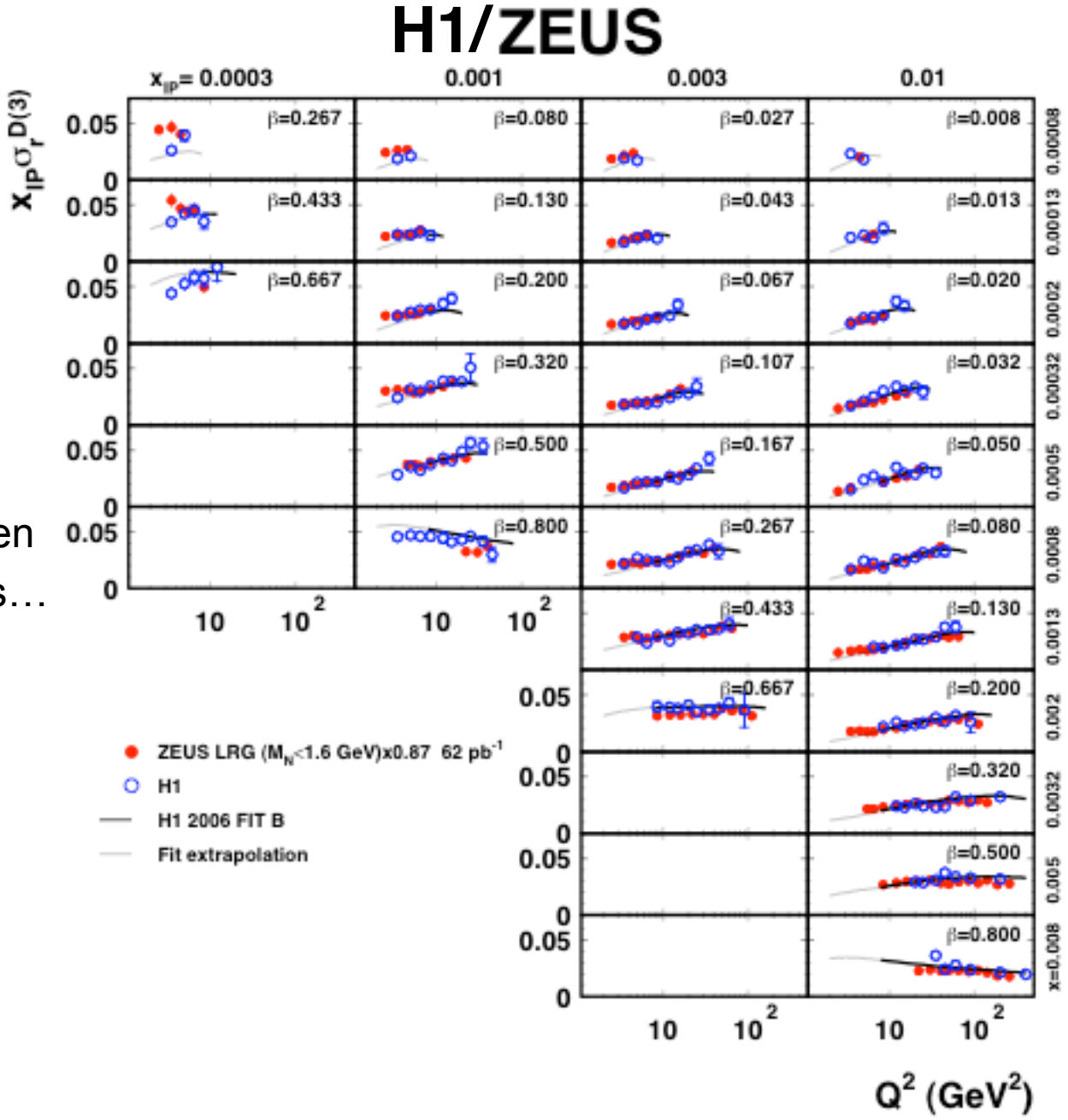


LRG and M_X data



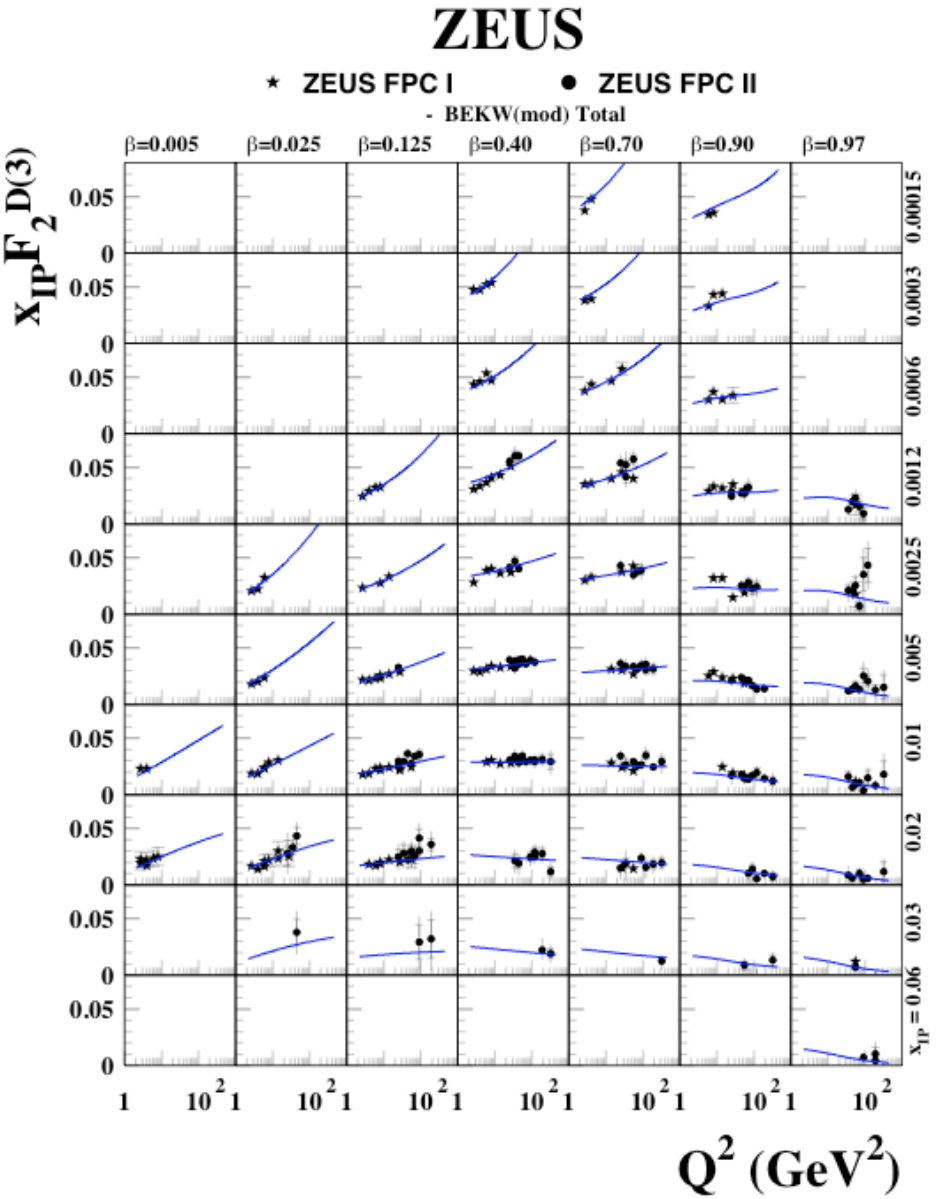
H1 and ZEUS

- H1 and ZEUS data for LRG method
- Good agreement
- (Note absolutely normalised)
- Better comparison (and more improvements) when combining cross sections…



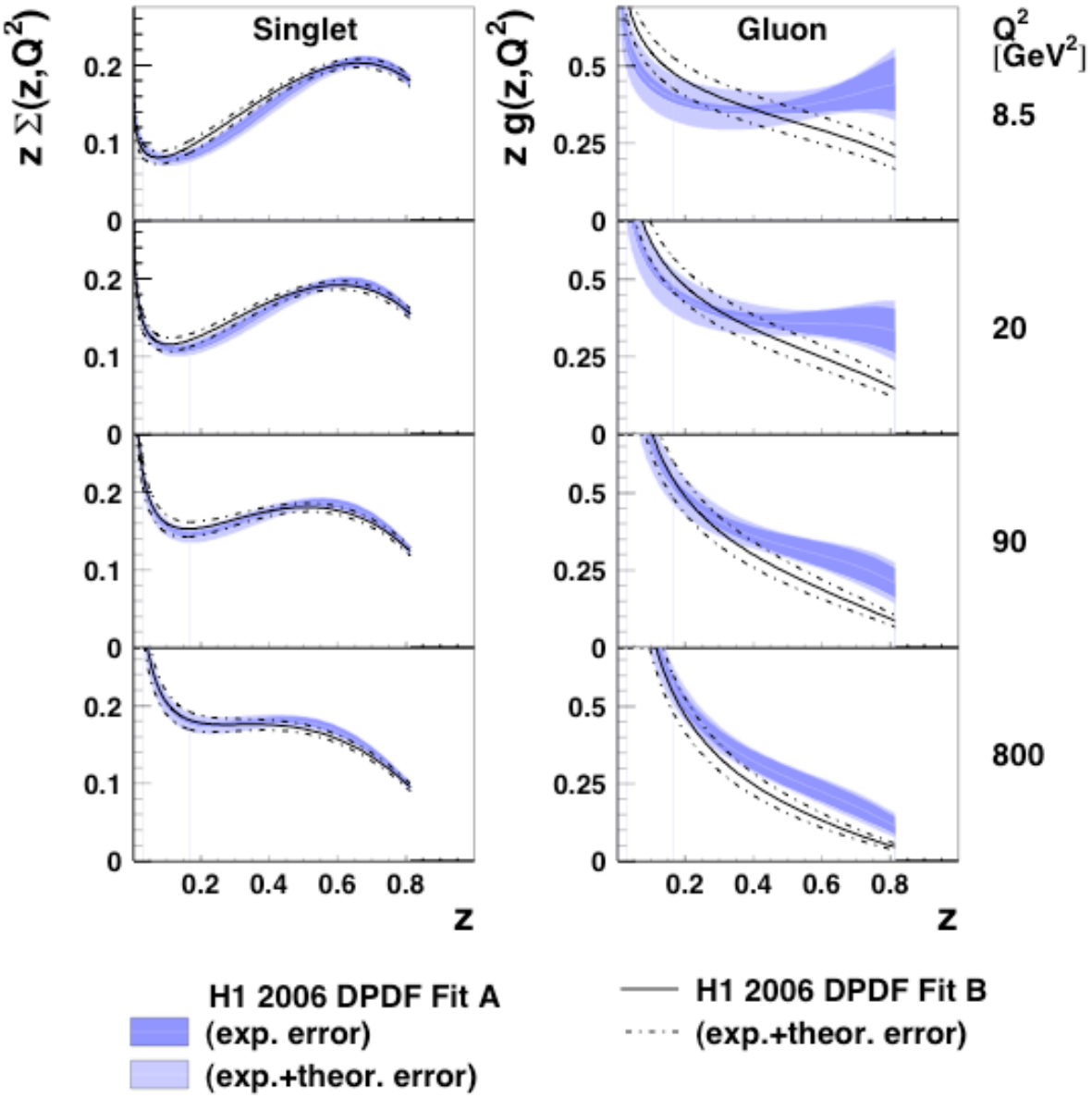
Closer look at Q^2 dependence

- For fixed β, dependence on x_{IP} seen, e.g. $\beta = 0.4$
- Regge (proton vertex) factorisation is broken
- Also seen in other data
- Mild effect should not strongly affect QCD fits which assume this



Diffractive PDFs

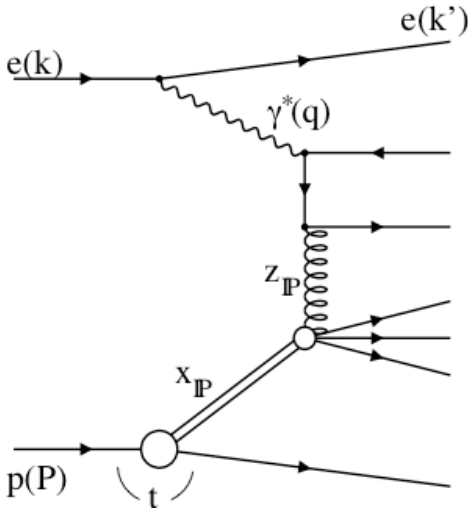
- NLO QCD (DGLAP) fits to inclusive cross sections as in inclusive DIS for proton
- Different parametrisation of gluon density
- Quark distributions well constrained, but gluon needs further input

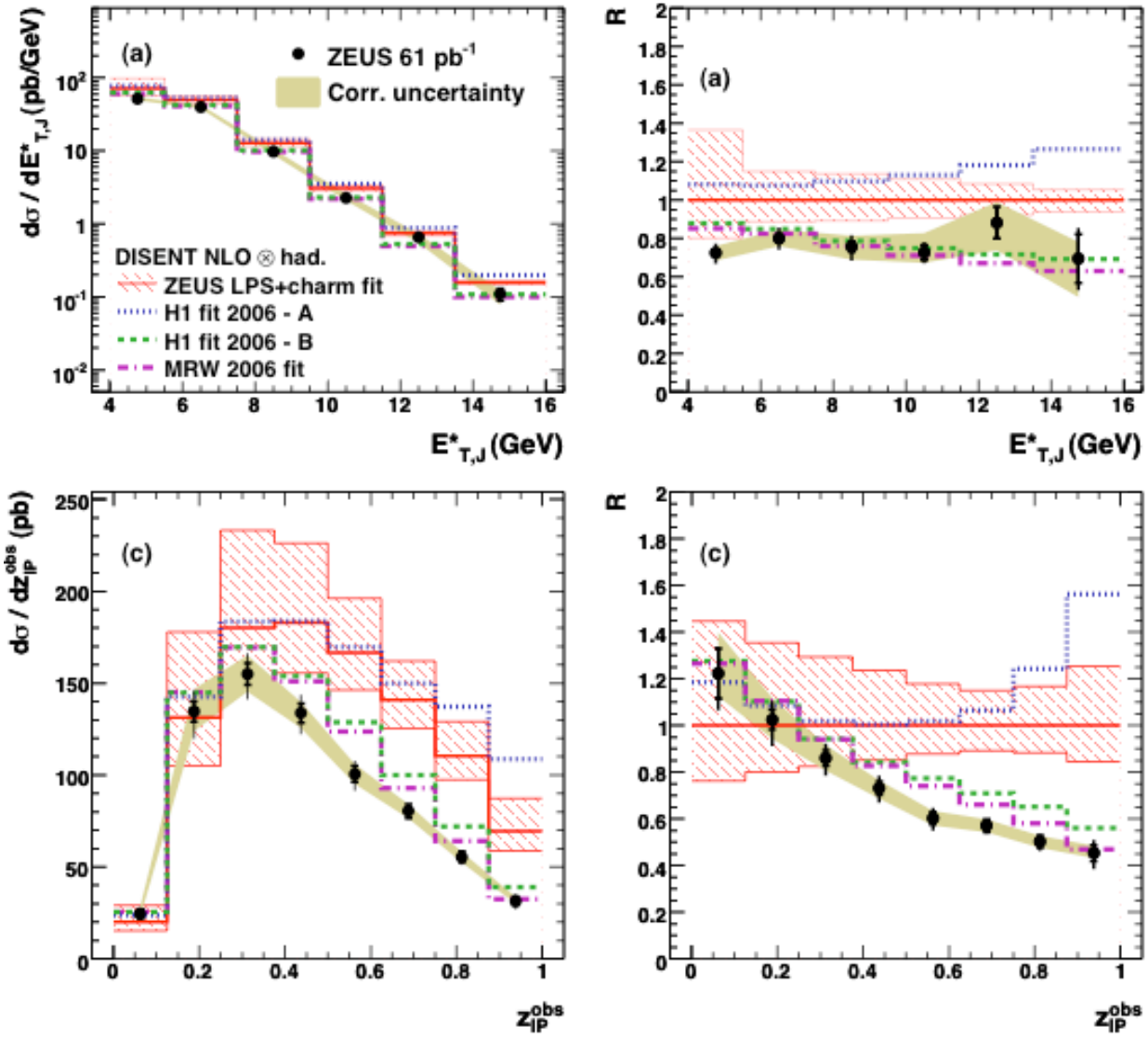


Comparison to jet data

ZEUS

- Compare to dijets in DIS
- Data well described by dPDFs
- But data clearly sensitive to the choice of dPDF
- Wide spread in predictions
- z_{IP} is a particularly powerful variable
- H1 have gone one better…

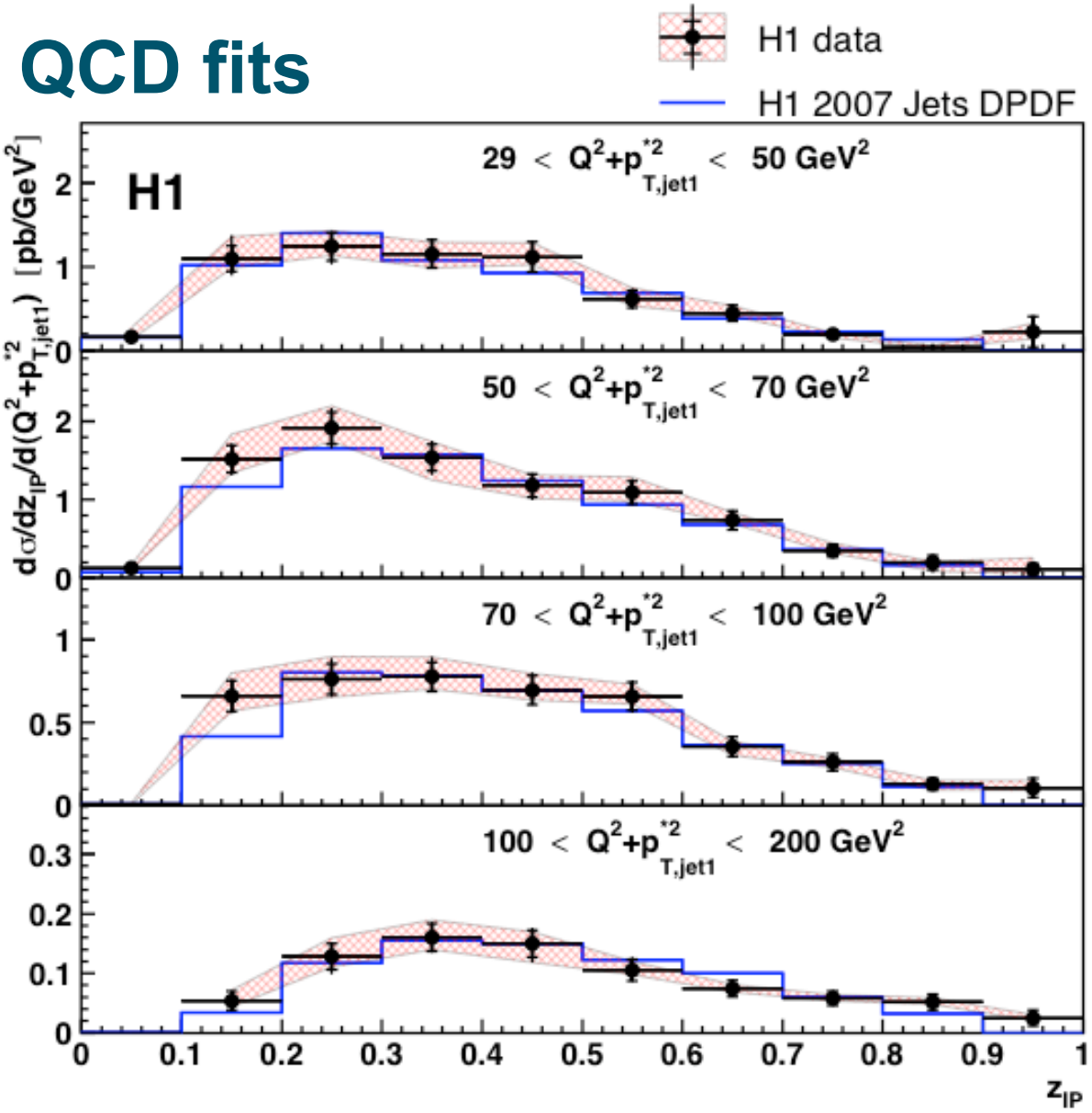




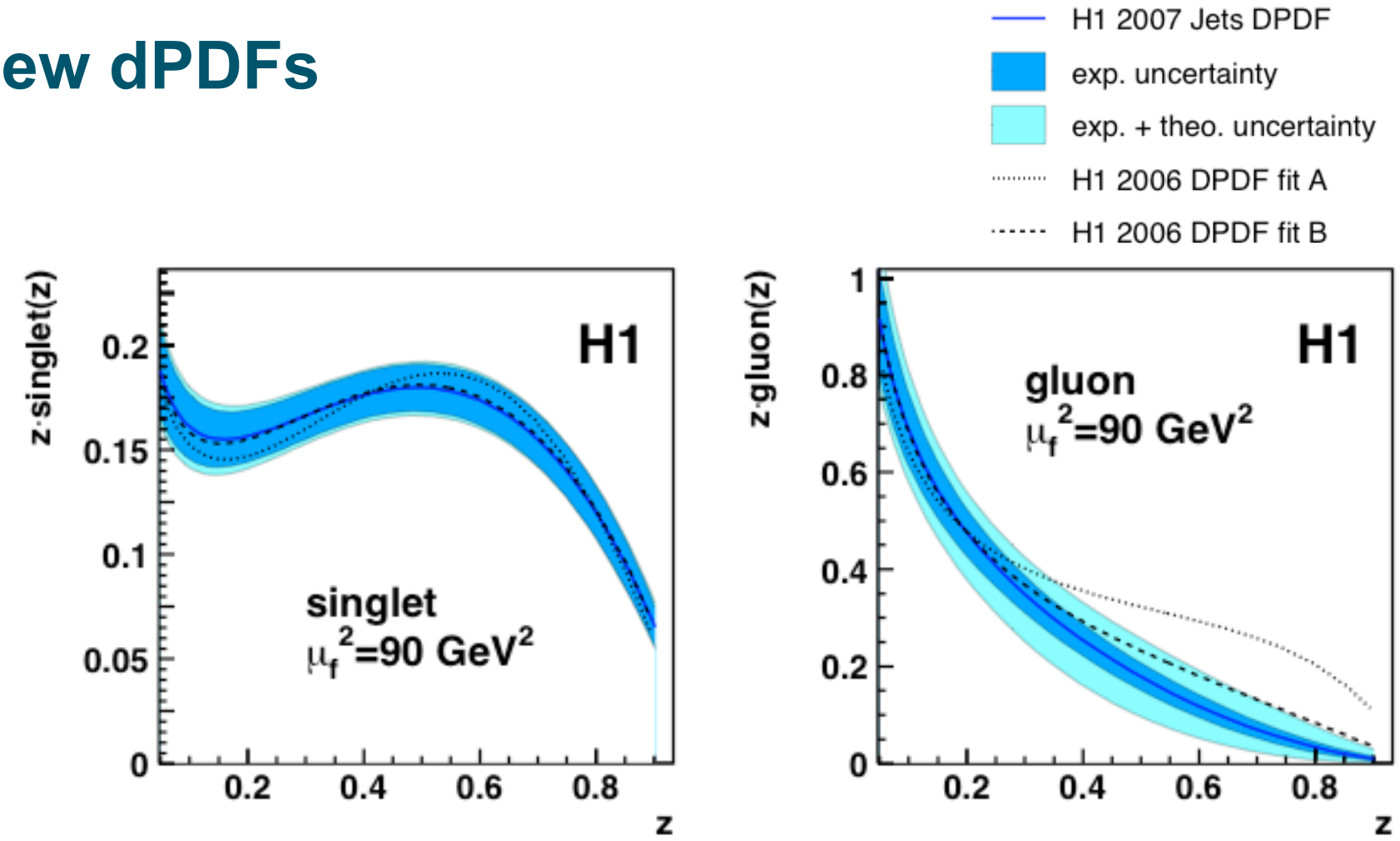
$z_{IP} = (Q^2+M_{jj}^2)/(Q^2+M_X^2)$

Use of jet data in QCD fits

- Good description of data by QCD fit
- More freedom in gluon parametrisation which is then constrained
- Agreement with inclusive data maintained

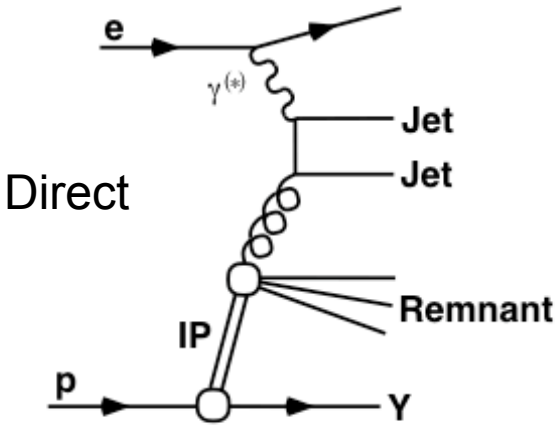


New dPDFs

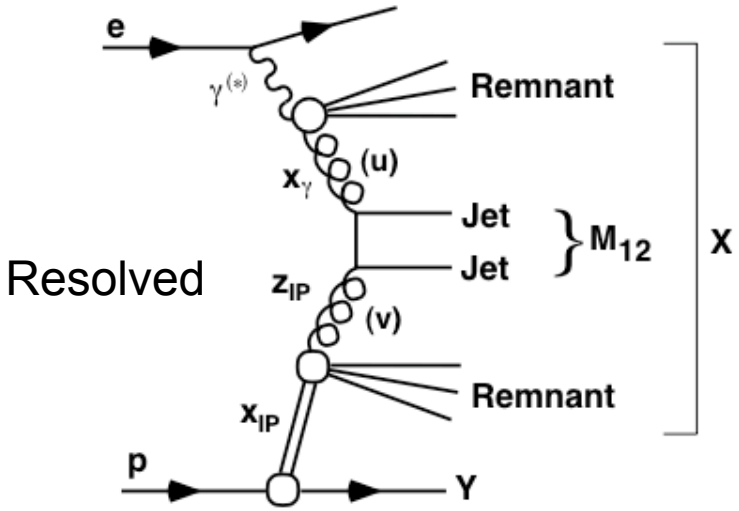


- New dPDF similar to “fit B” and different from “fit A”
- Gluon now constrained as well as quark density over whole kinematic range

Jet photoproduction



Analogous to DIS



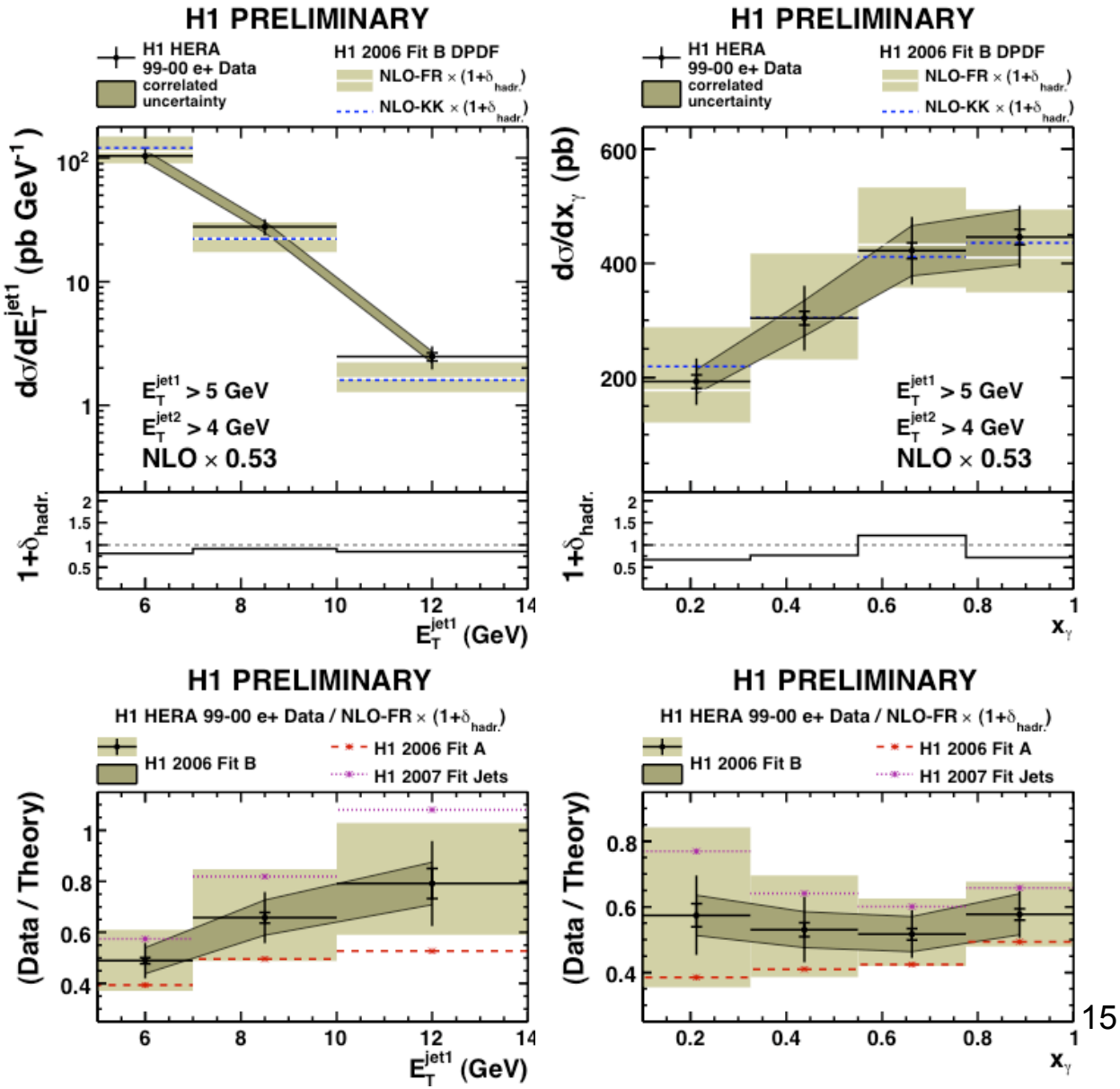
Analogous to hadron-hadron collision

- Use dPDFs in comparison to photoproduction
- If we can isolate resolved events, we can test factorisation “in” a hadron-hadron collision whilst having a “calibration, DIS-like” sample
- Look at cross sections for many variables, but in particular, E_T^{jet} and

$$x_\gamma^{obs} = [E_T^{jet1}\exp(-\eta^{jet1}) + E_T^{jet2}\exp(-\eta^{jet2})]/\Sigma(E-p_Z)$$

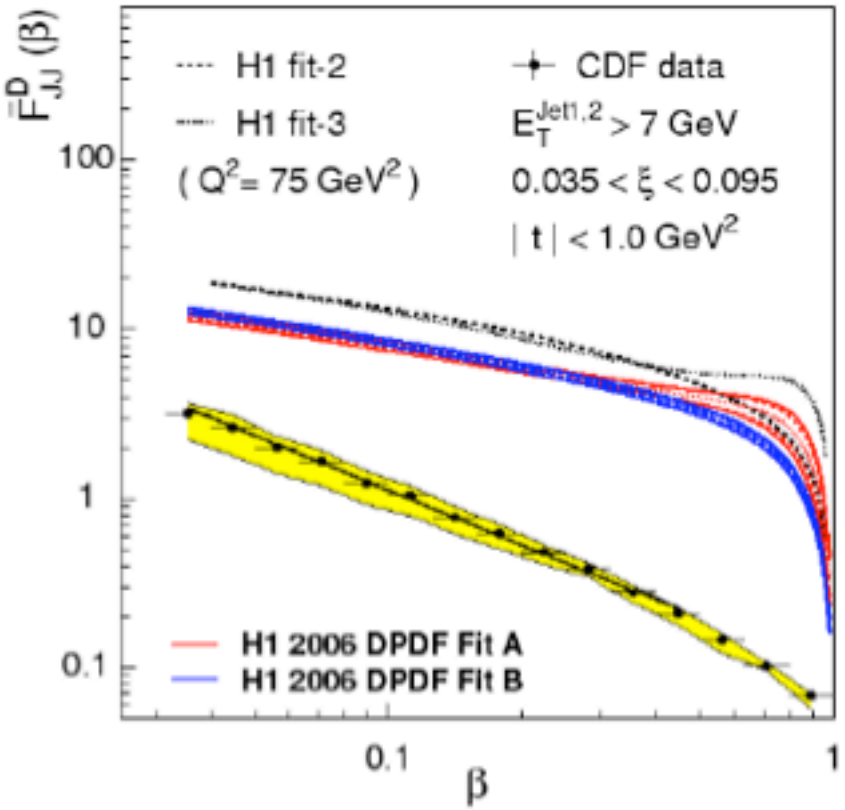
Data-theory comparison

- Data/theory comparison same for all x_γ
- "Suppression" factor of ~0.5
- Indications of E_T dependence (ZEUS sees weaker global suppression at higher E_T)
- Sensitive to choice of dPDF



Hadron-hadron collisions

- Predictions of diffraction at Tevatron do not work when using HERA dPDFs
- Expect secondary interactions which “fill” the gap (Kaidalov, Khoze et al.)
- Reprise: factorisation works in DIS, but is not clear in photoproduction and has not solved this problem
- We would expect models of secondary interactions to be relevant for resolved photoproduction



Predictions of e.g. Higgs production at the LHC are affected by these issues

Summary

- A wealth of inclusive data in diffraction using different methods which all give a generally consistent picture.
- Diffractive parton density functions have been extracted which can be used to predict other processes.
- Jet production in DIS is well predicted (and indeed used in parton distribution fits).
- Jet photoproduction and even more so jet hadroproduction is not well reproduced.
    - In photoproduction a possible E_T, but no x_γ, dependence.

- Higher precision expected through combining H1 and ZEUS data, using other jet data, and future measurements.