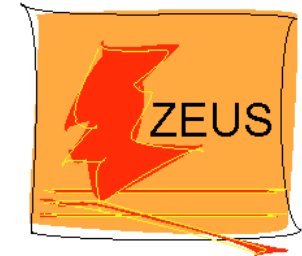


# Inclusive diffraction and factorisation at HERA



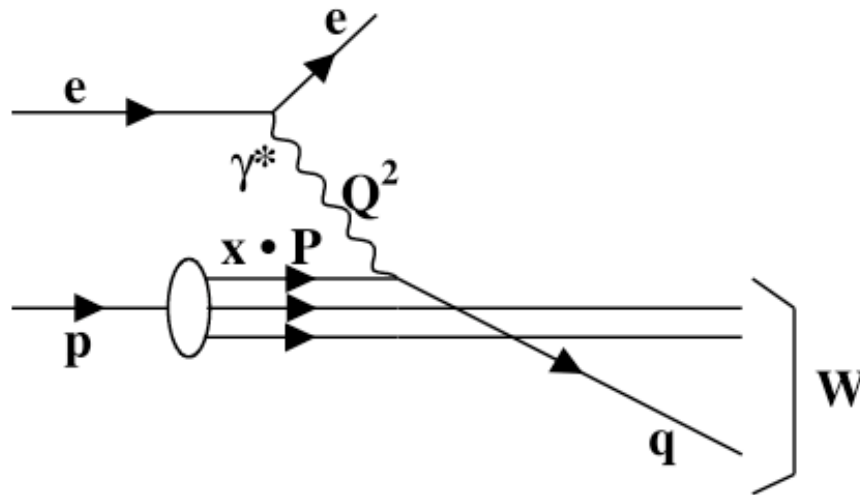
Matthew Wing  
(UCL, DESY and Universität Hamburg)



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

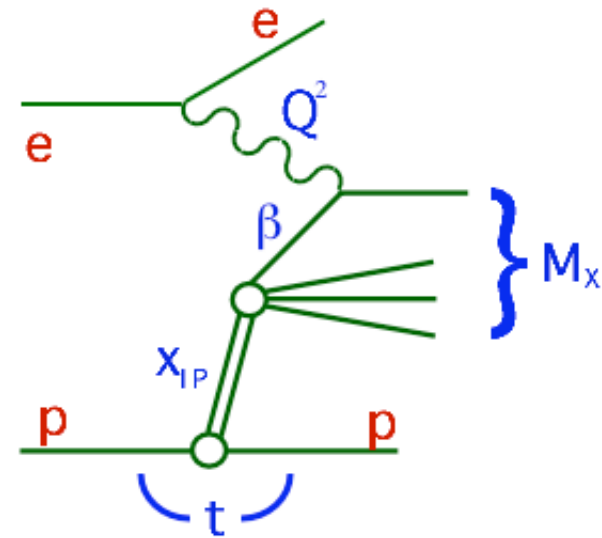
# Introduction - what is diffraction?

Deep inelastic scattering



Parton densities in proton

Diffractive deep inelastic scattering

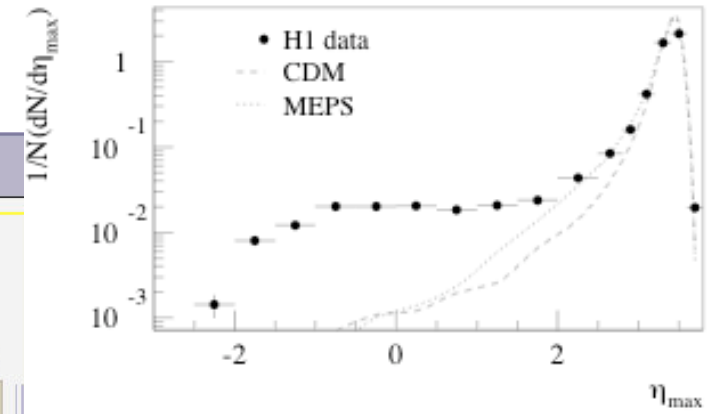
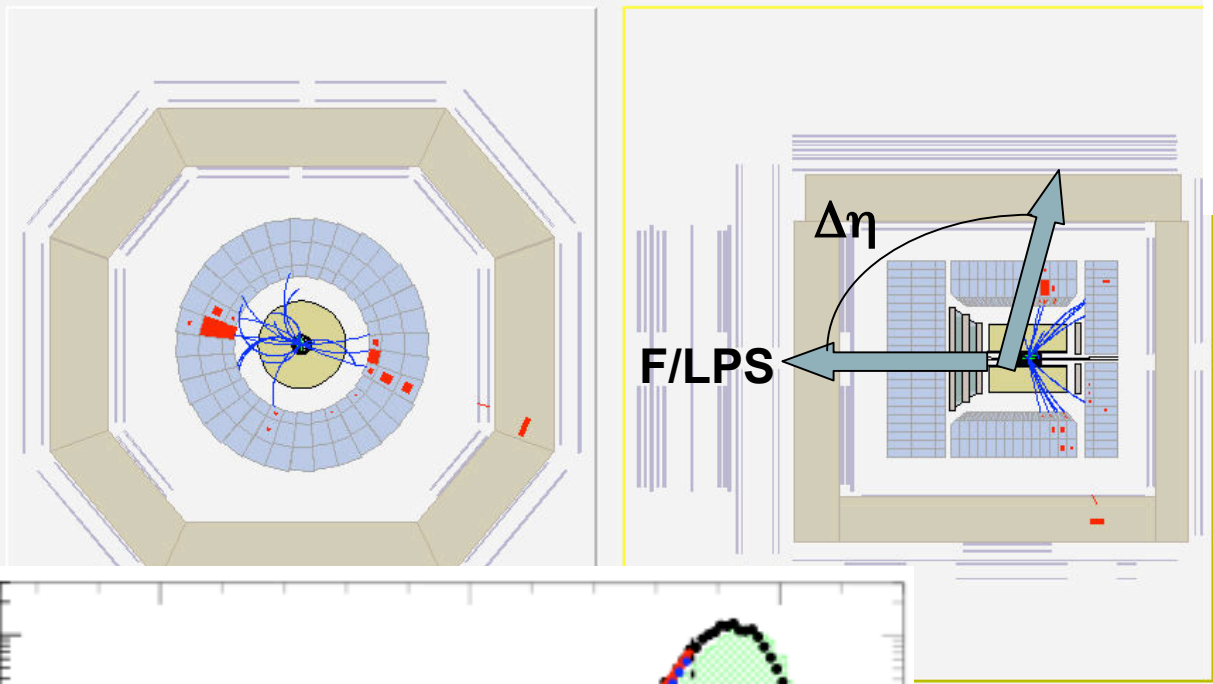


Parton densities in "Pomeron"

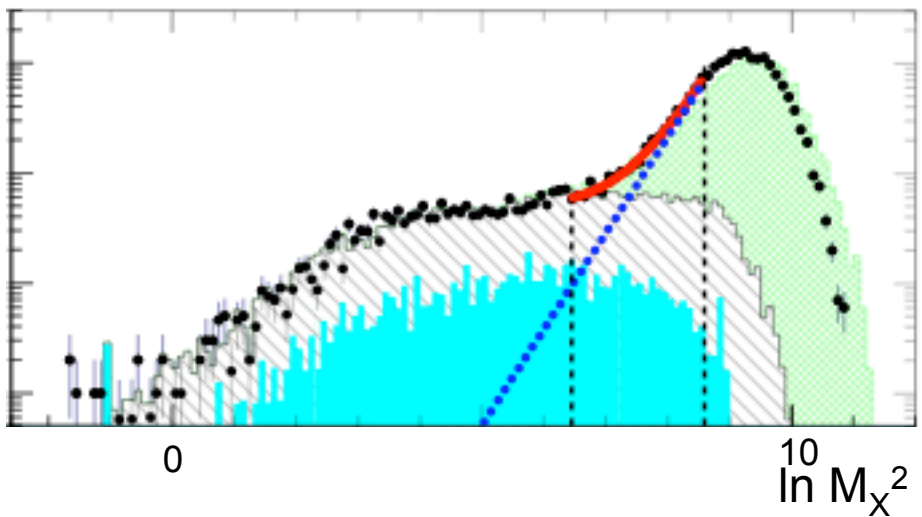
$$\sigma^{(D)}_{ep \rightarrow eX(p)} \sim f_{i/p}^{(D)} \cdot \sigma_{i\gamma \rightarrow jk}$$

# Signatures of diffraction

$E = 17.54 \text{ GeV}$ $E_p = 2.02 \text{ GeV}$ $\phi = 3.07$	$E_t = 15.46 \text{ GeV}$ $p_t = 3.62 \text{ GeV}$ $t_r = -100.00 \text{ ns}$	$E_{-p_z} = 24.77 \text{ GeV}$ $p_x = -3.62 \text{ GeV}$ $t_b = 2.33 \text{ ns}$	$E_t = 0.00 \text{ GeV}$ $p_y = 0.25 \text{ GeV}$ $t_r = -0.35 \text{ ns}$	$E_b = 15.52 \text{ GeV}$ $p_z = -7.23 \text{ GeV}$ $t_b = 2.17 \text{ ns}$
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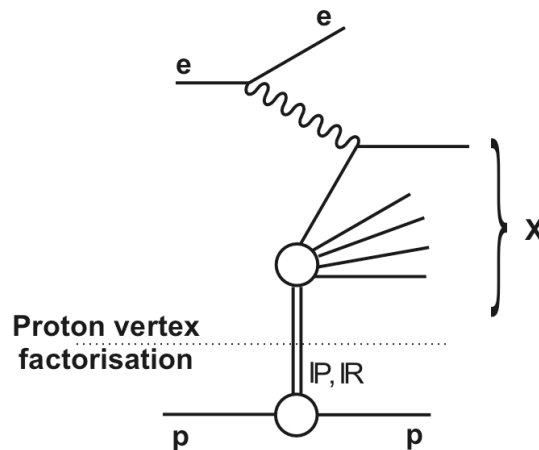
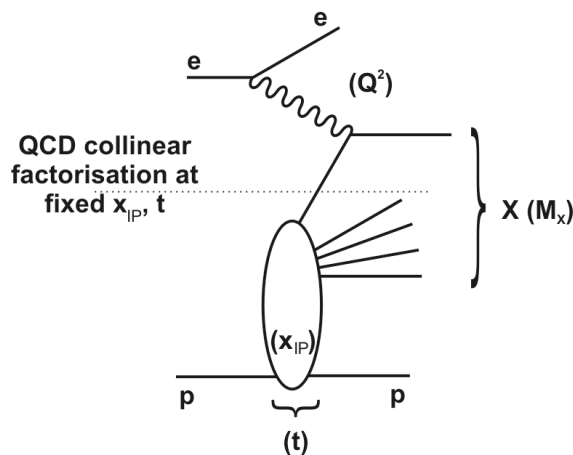
- Forward/Leading protons (F/LPS)
- Large rapidity gap (LRG)
- “ $M_X$  method”



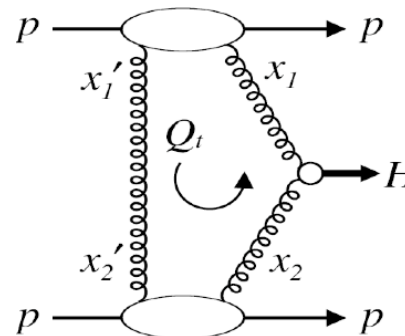
- Pros/cons:
- o Different kinematic regions
  - o Background contributions
  - o Size of sample

# 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

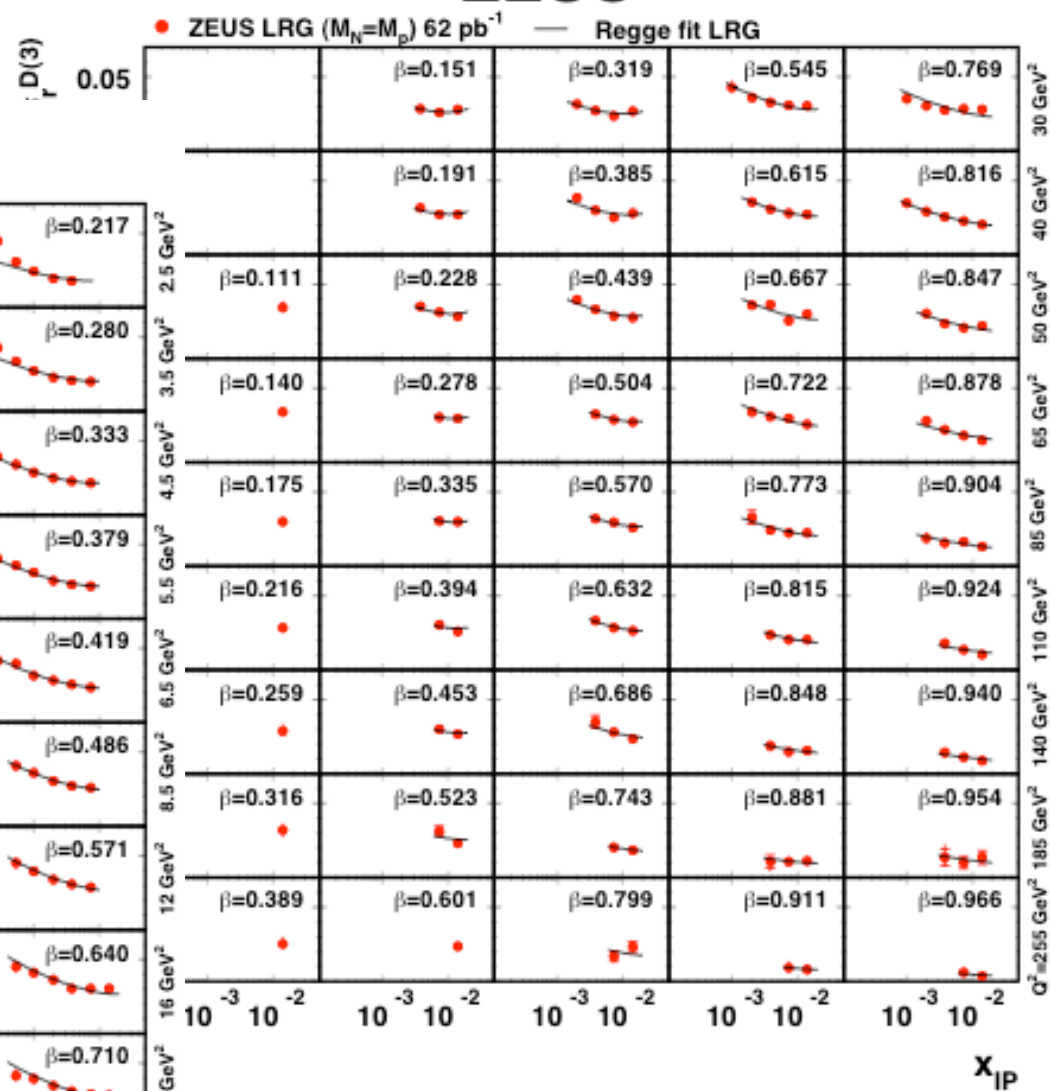
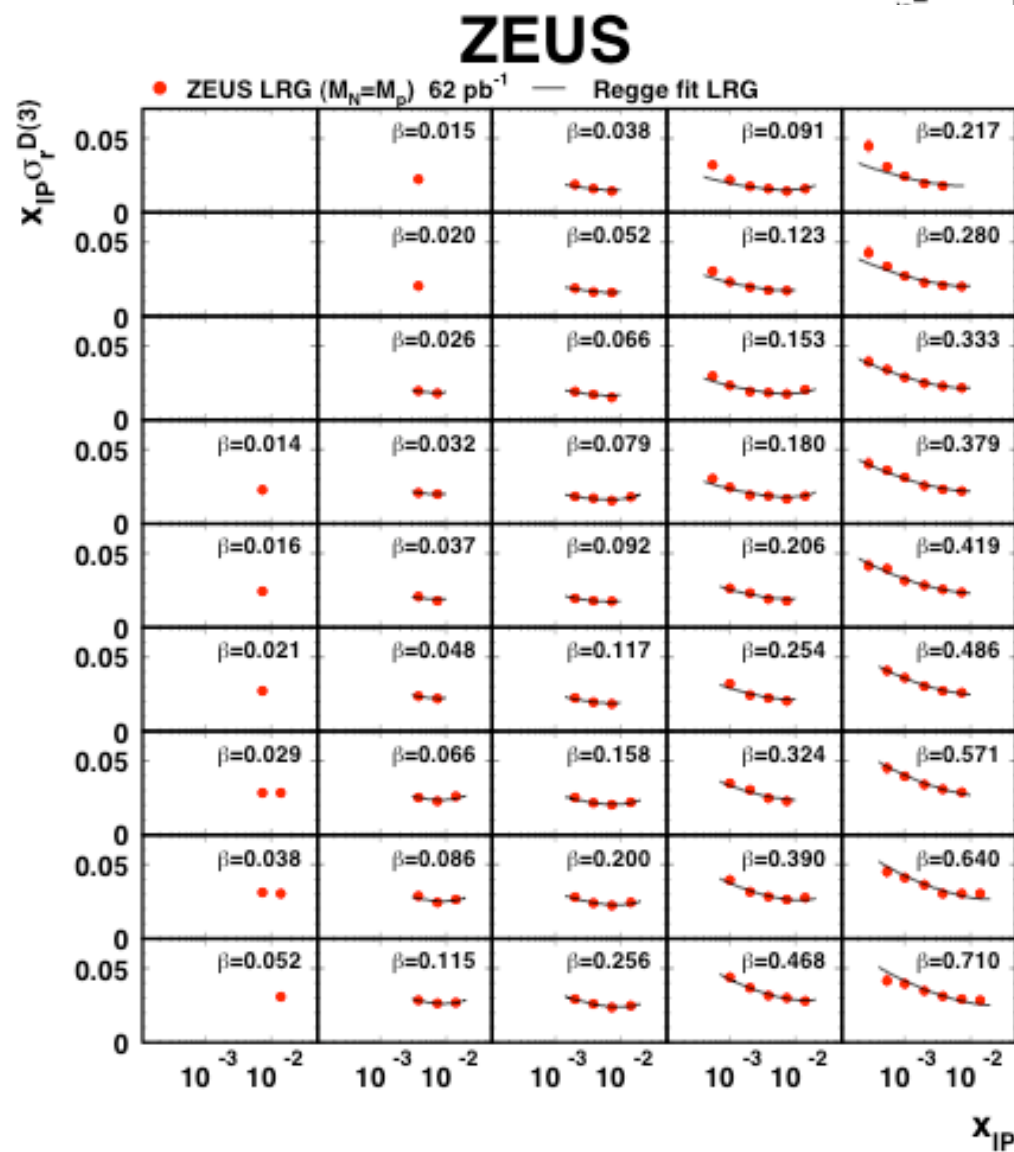


- All essential to predict potential search channels at the LHC



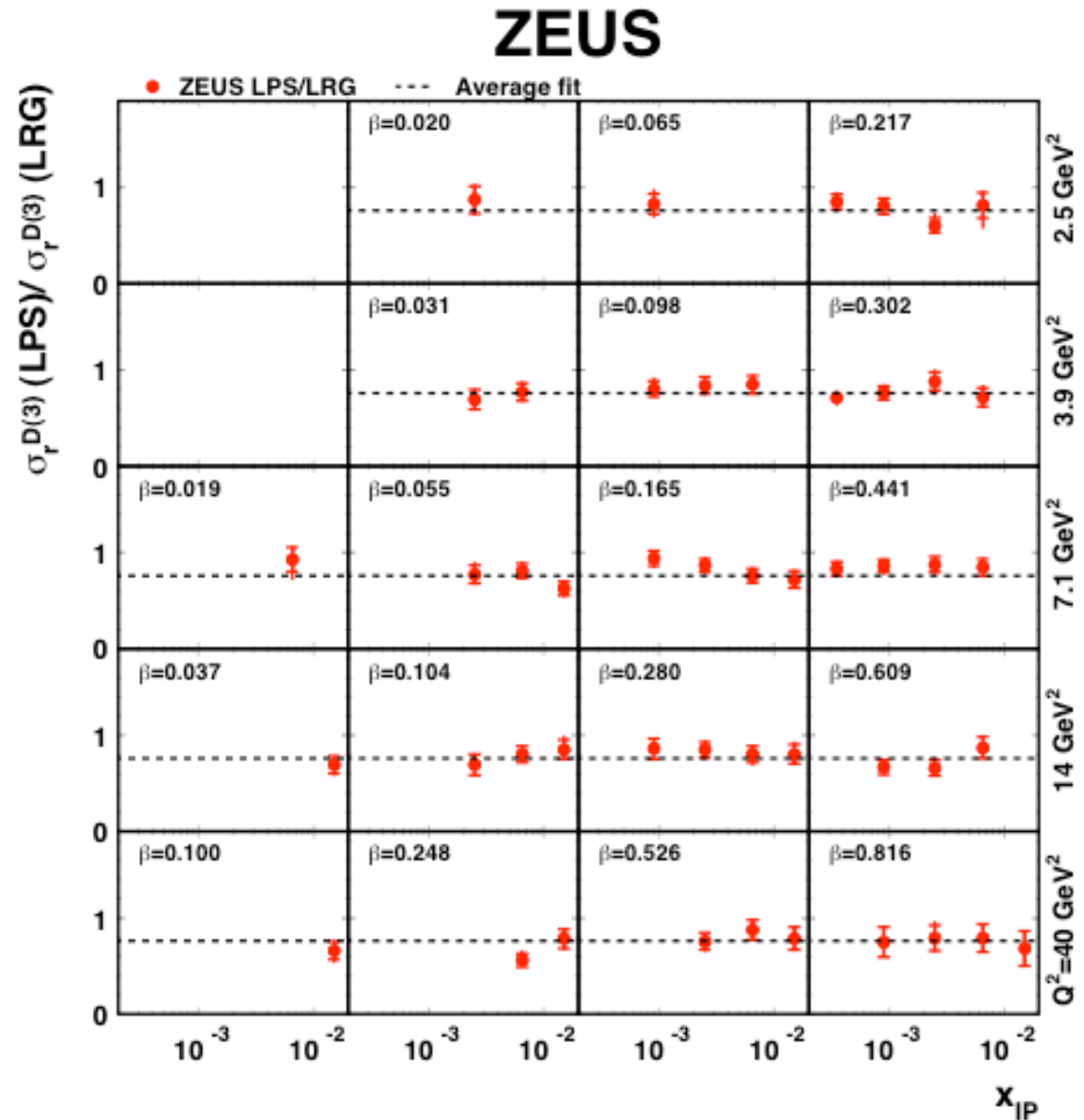
# Latest inclusive data

## ZEUS



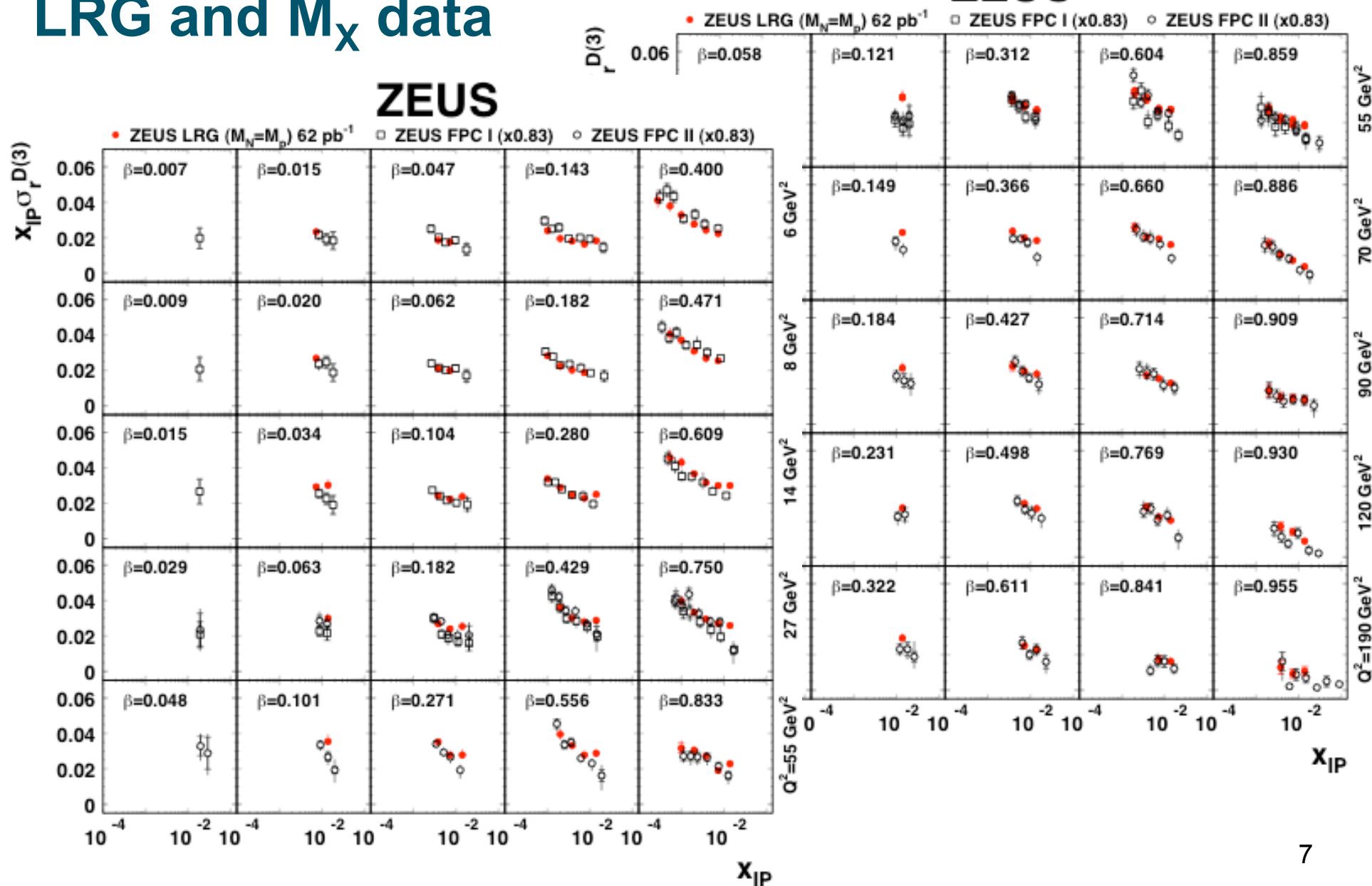
# LRG and LPS data

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



# LRG and $M_x$ data

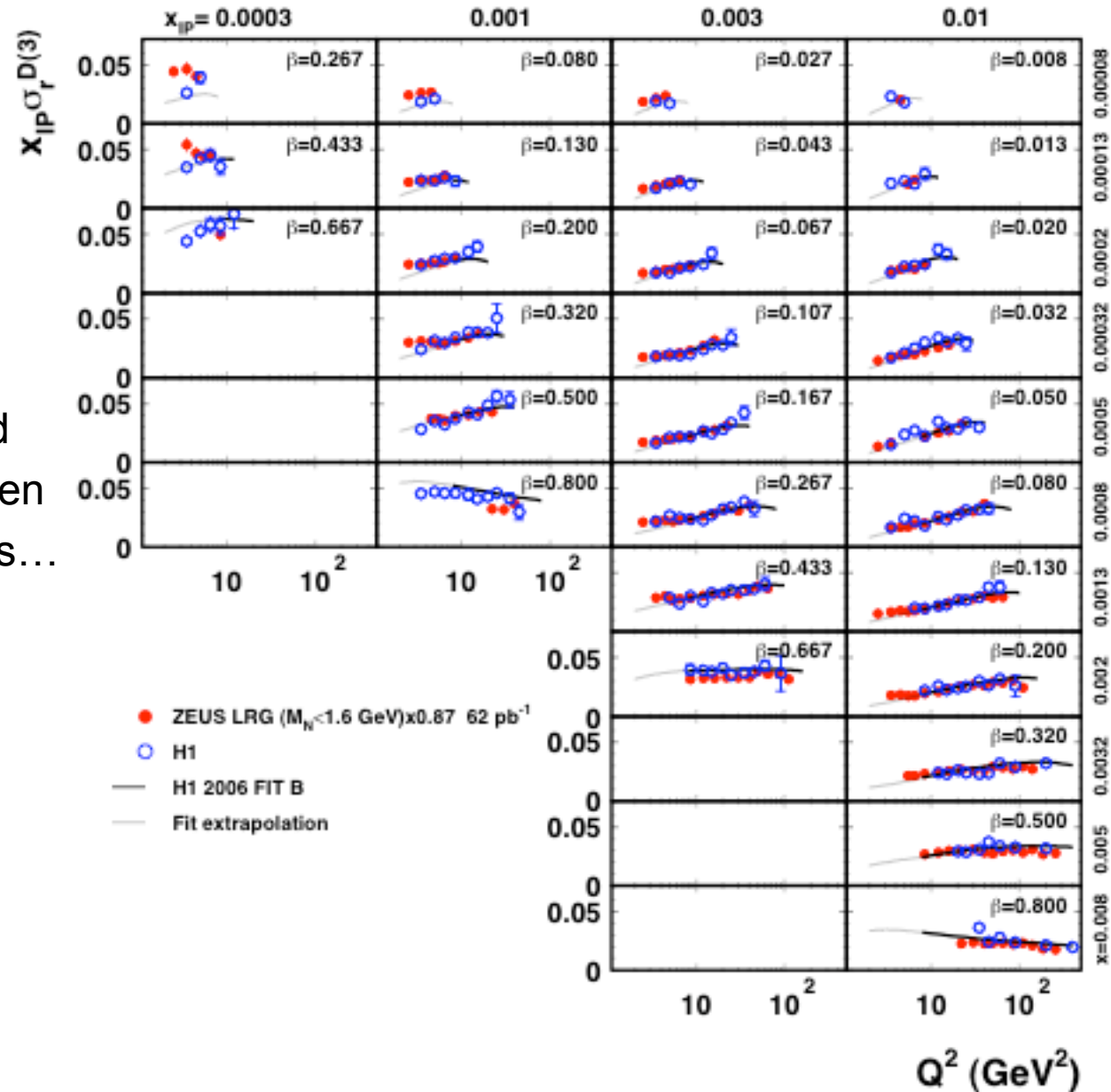
## ZEUS



# H1 and ZEUS

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

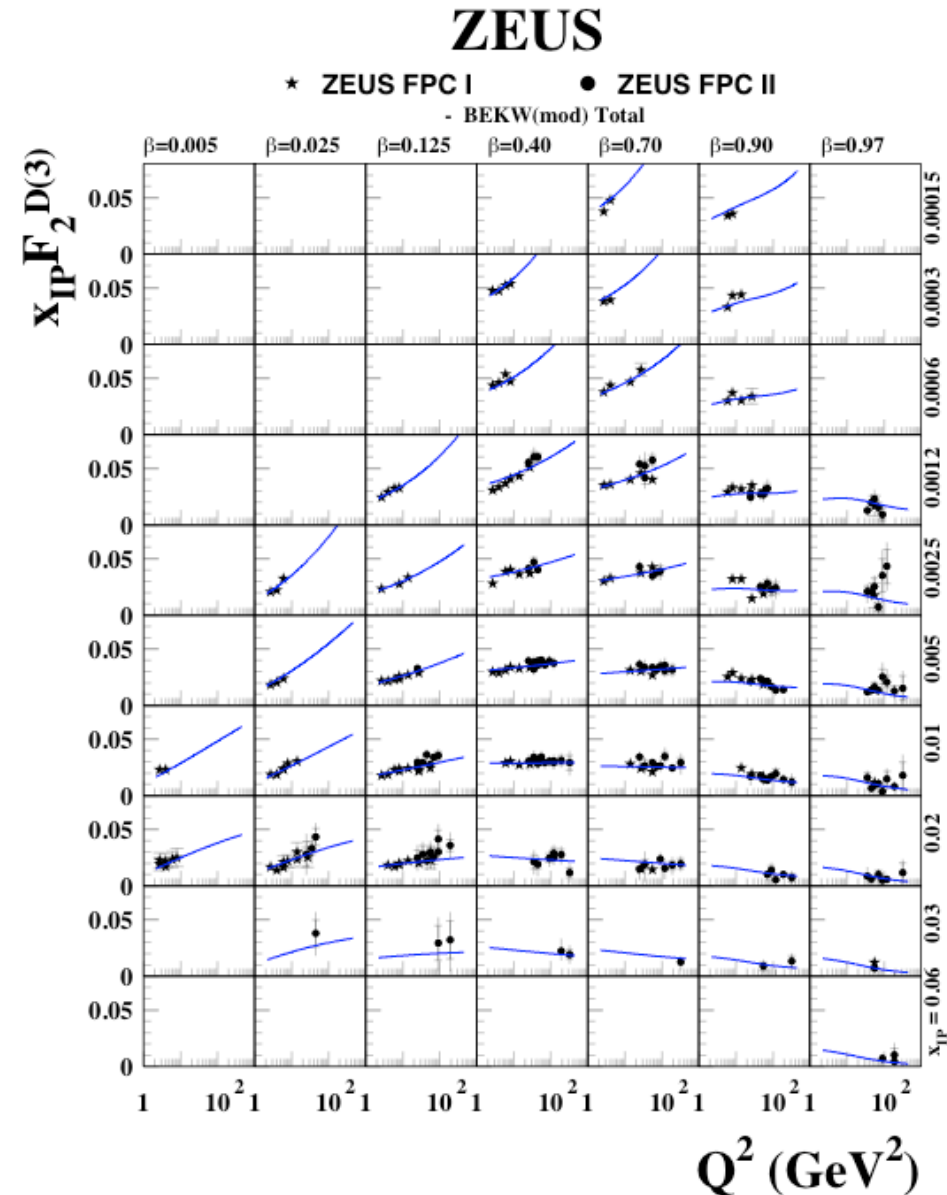
## H1/ZEUS





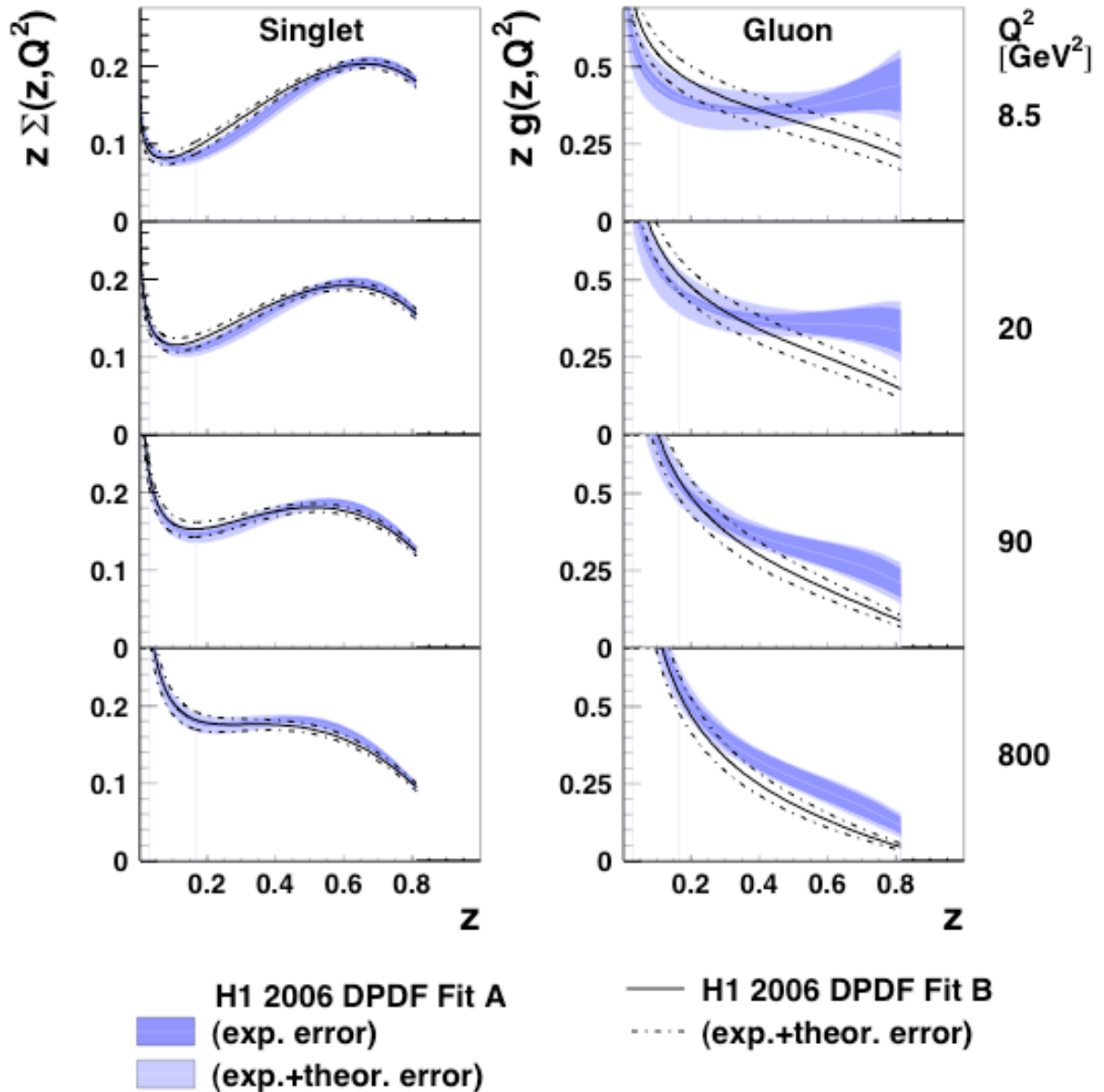
# Closer look at $Q^2$ dependence

- For fixed  $\beta$ , 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



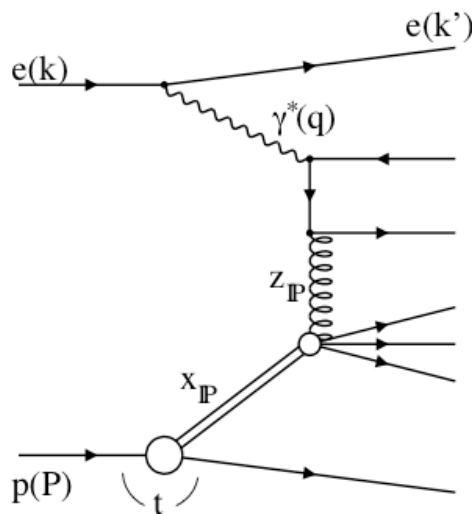
# Diffractive PDFs

- 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

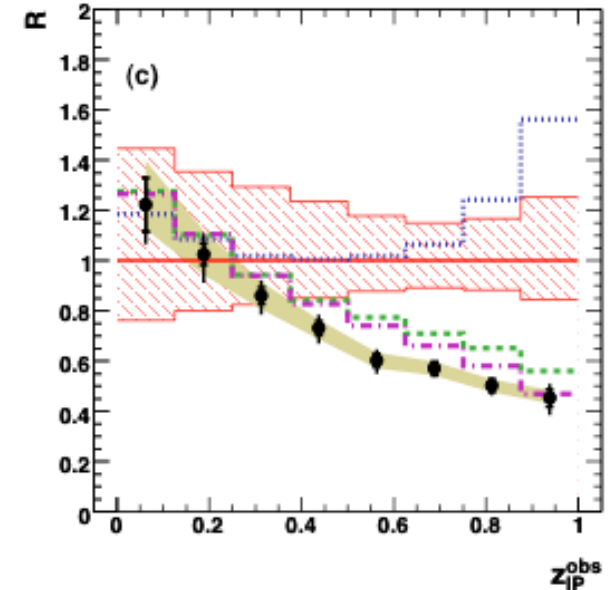
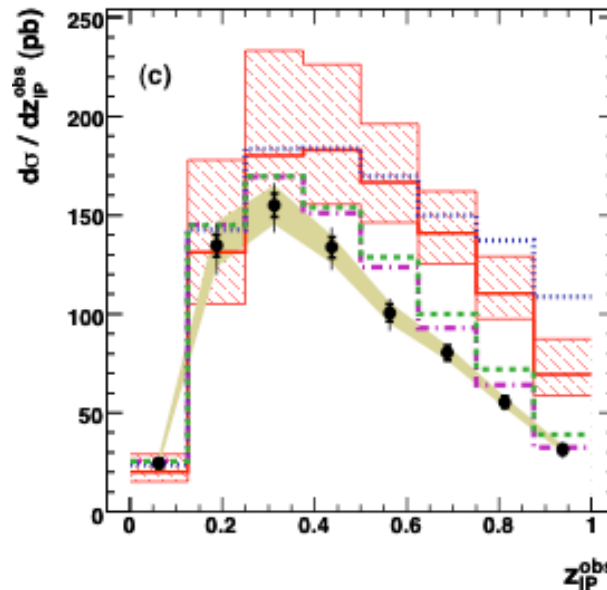
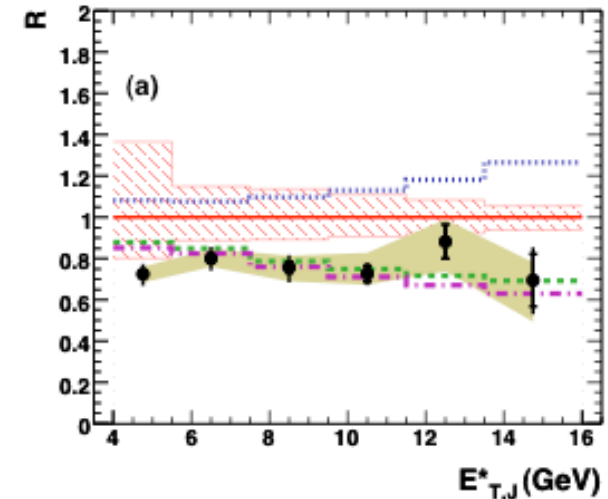
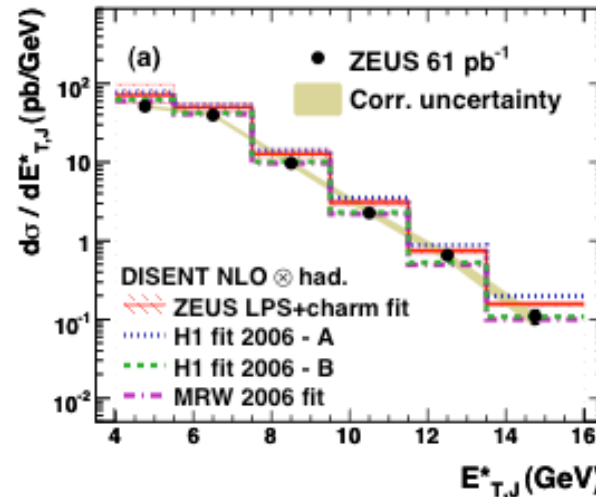


# Comparison to jet data

- 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...



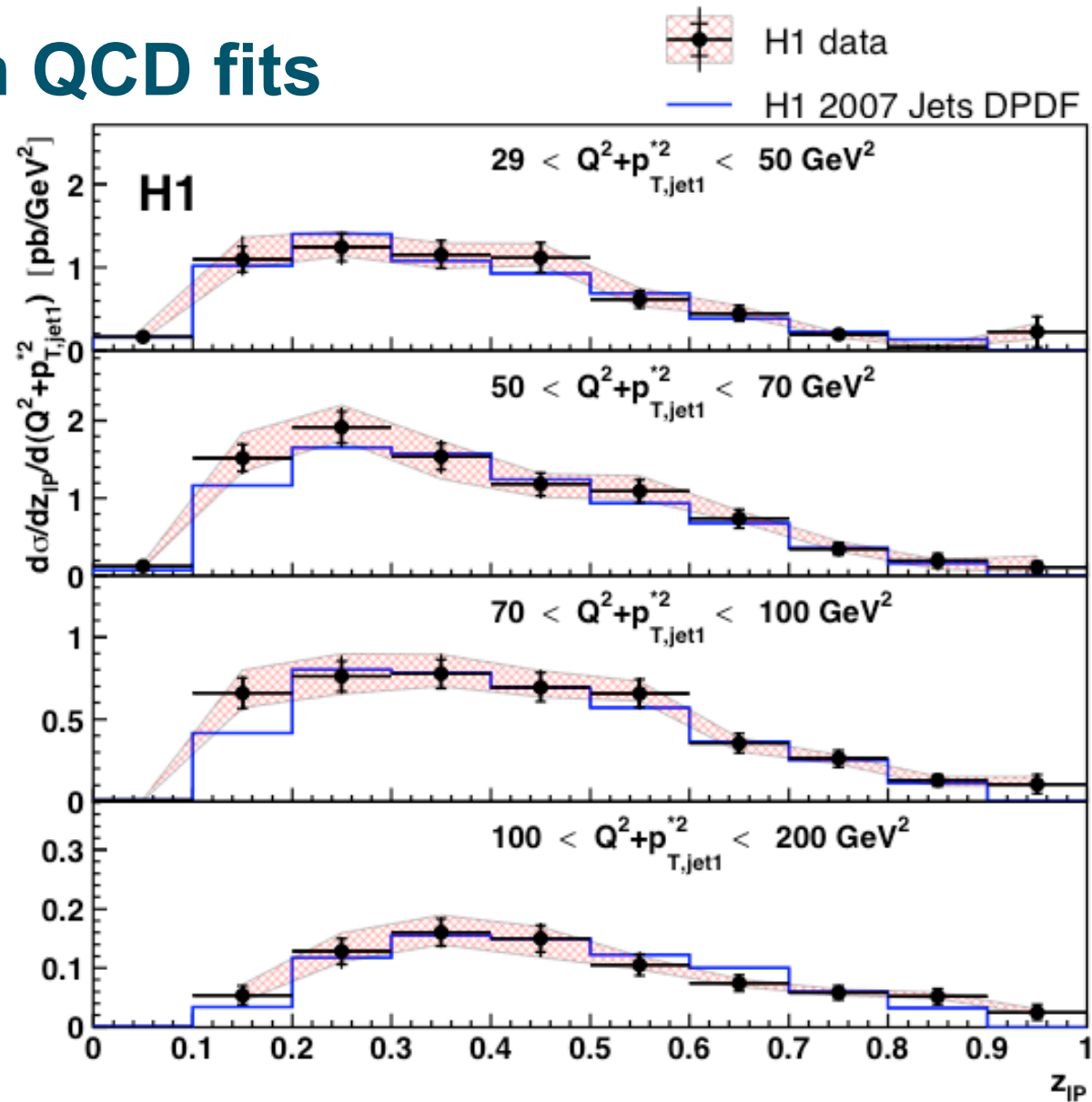
## ZEUS



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

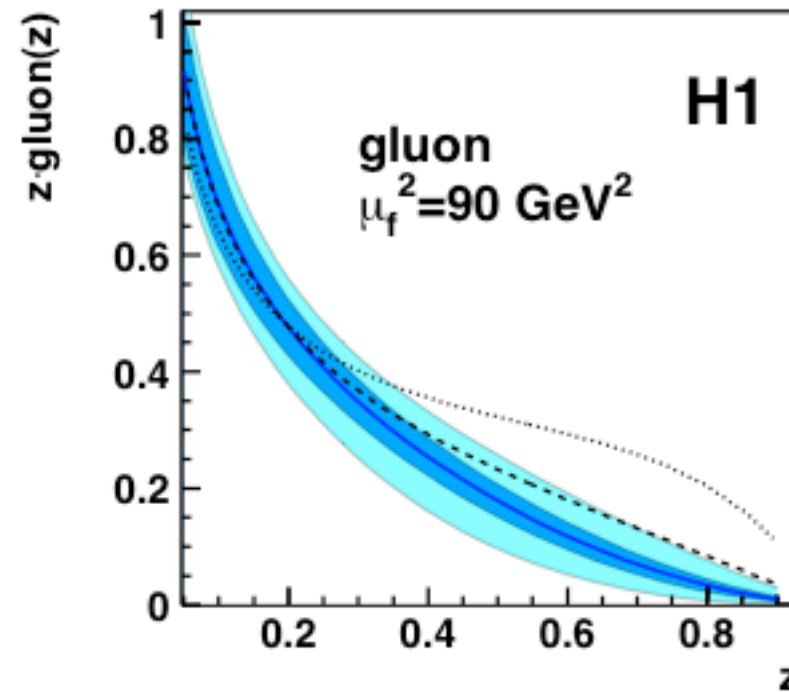
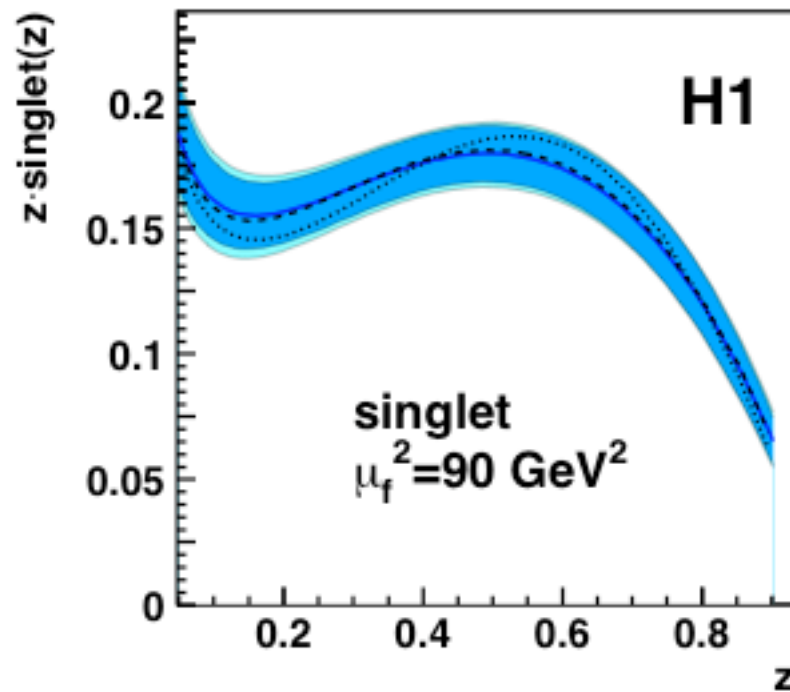
# Use of jet data in QCD fits

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



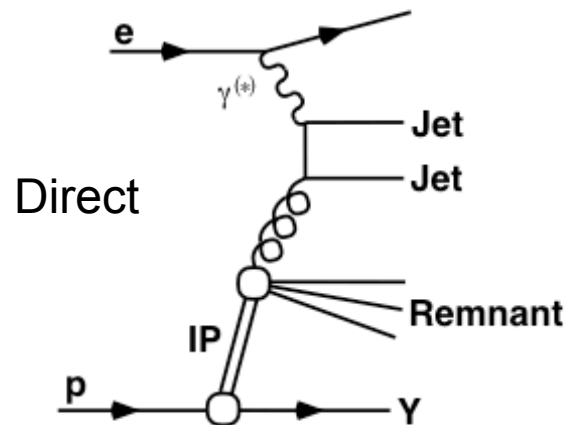
# New dPDFs

- H1 2007 Jets DPDF
- exp. uncertainty
- exp. + theo. uncertainty
- H1 2006 DPDF fit A
- H1 2006 DPDF fit B

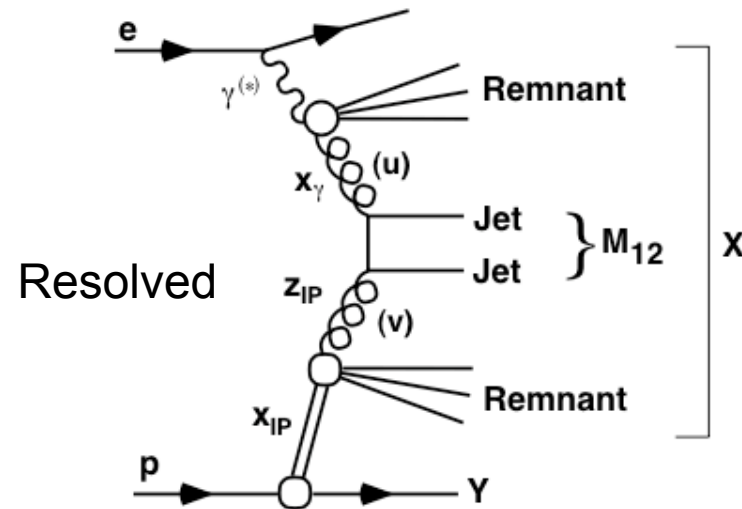


- New dPDF similar to “fit B” and different from “fit A”
- Gluon now constrained as well as quark density over whole kinematic range

# Jet photoproduction



Direct  
Analogous to DIS



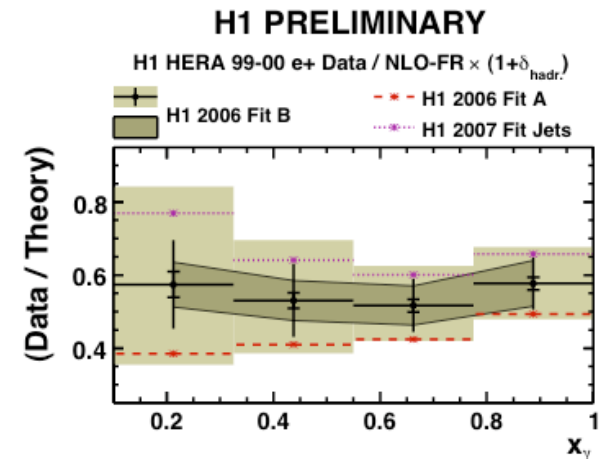
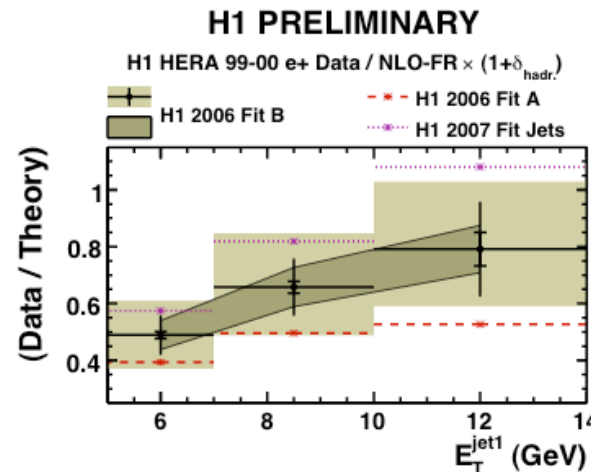
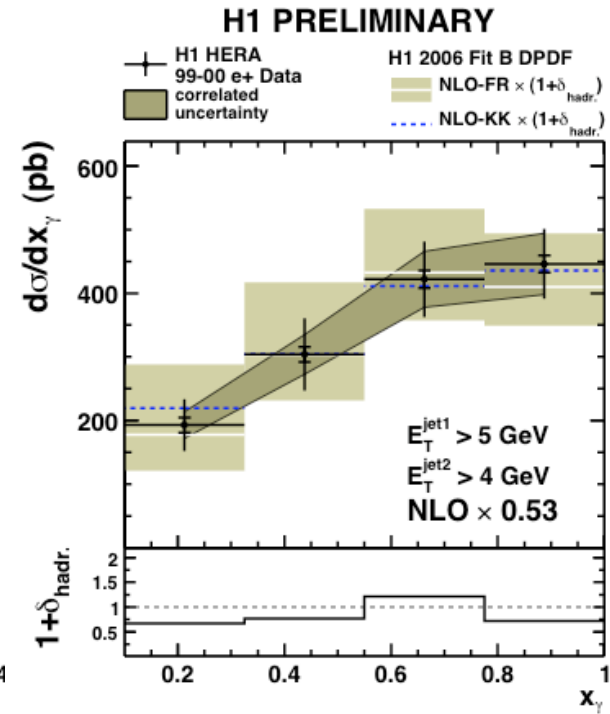
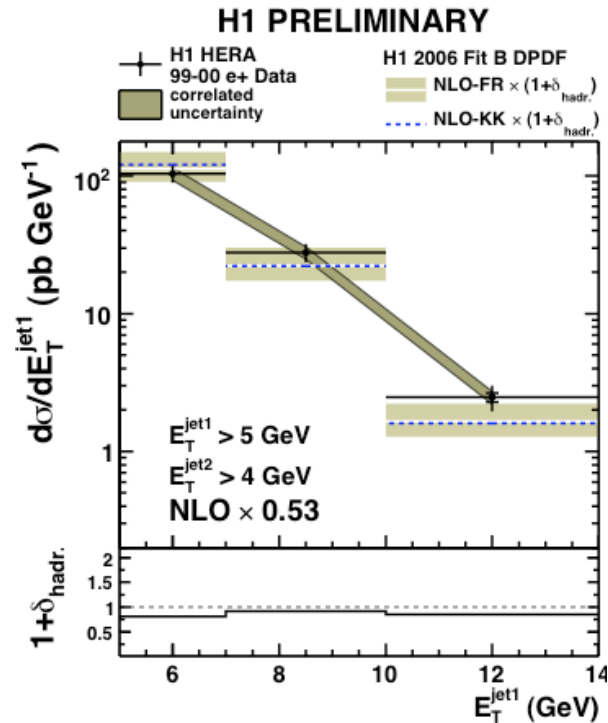
Resolved  
Analogous to hadron-hadron collision

- 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,  $E_T^{\text{jet}}$  and

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

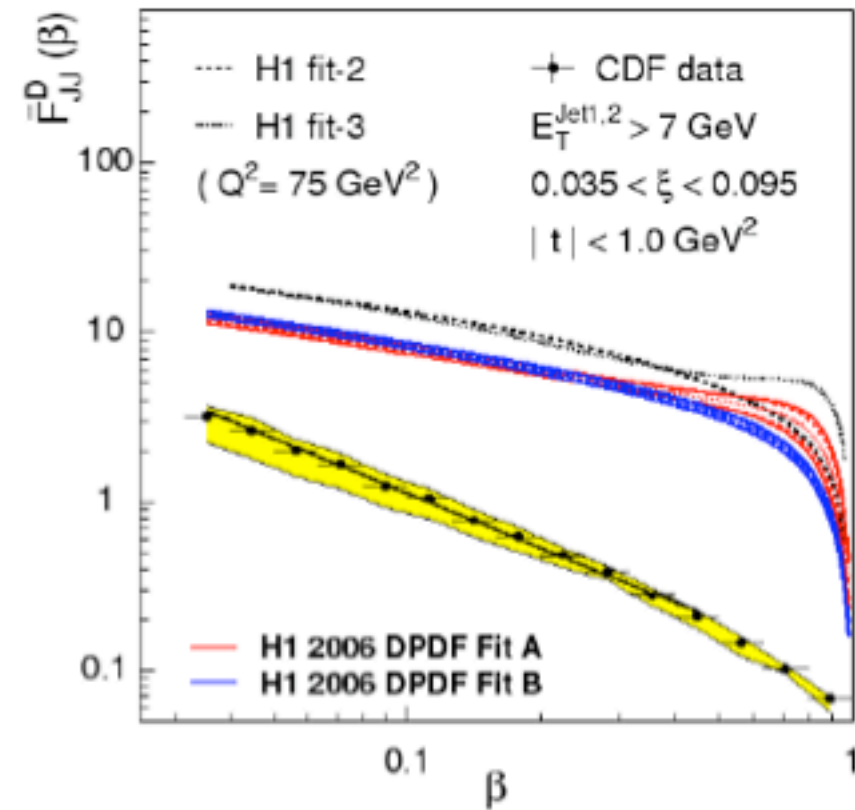
# Data-theory comparison

- Data/theory comparison same for all  $x_\gamma$
- “Suppression” factor of  $\sim 0.5$
- 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  $x_\gamma$ , dependence.
- Higher precision expected through combining H1 and ZEUS data, using other jet data, and future measurements.