Diffractive Final States Dijets and Charm

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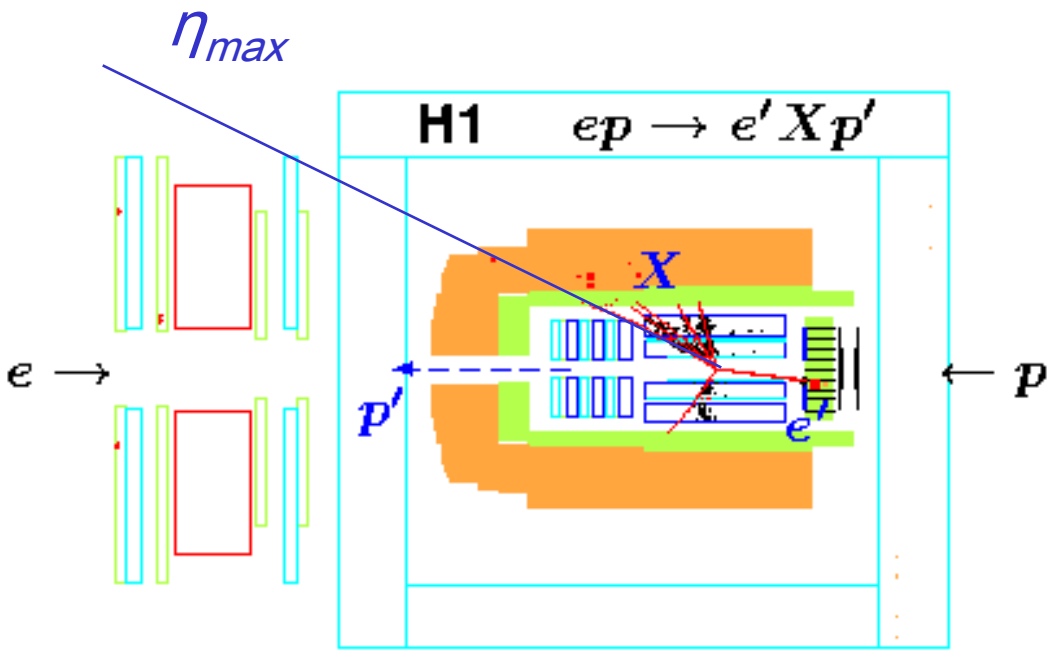
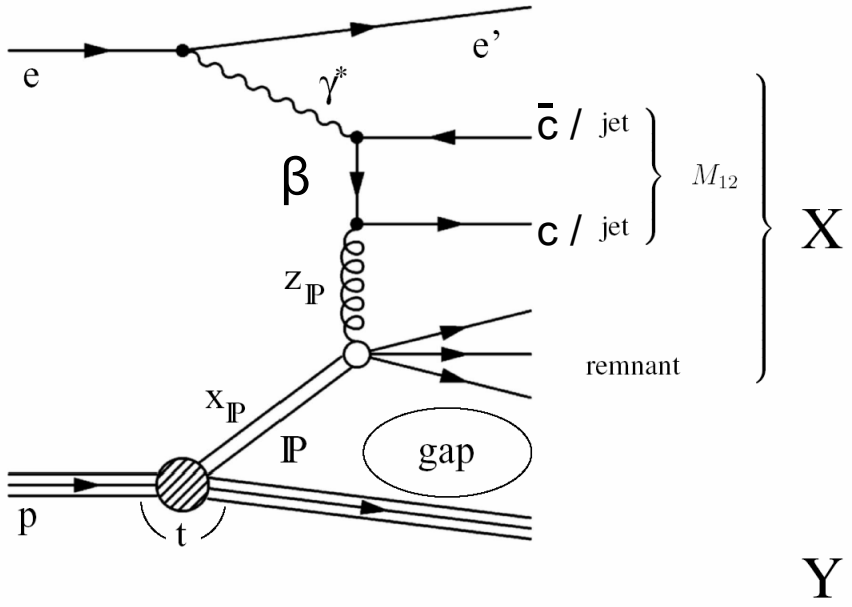
On behalf of the H1 and ZEUS Collaborations

- Factorization in Diffractive DIS
- Diffractive PDFs from combined QCD Fit to inclusive diffractive DIS and Dijets
- Dijets in photo-production
- Open Charm in DIS and photo-production
- Summary

Diffractive Final States at HERA

- Focus on LRG method: Large rapidity gap between leading proton p' and X
- X includes Diffractive Final States: Dijets, Charm





$x_{IP}<0.04$, $|t|<1$ GeV^2

x_{IP} - momentum fraction of proton carried by color singlet exchange

z_{IP} - momentum fraction of color singlet carried by parton entering hard sub-process

β - momentum fraction of color singlet carried by struck quark

Factorization in Diffractive DIS

QCD hard scattering collinear factorization:

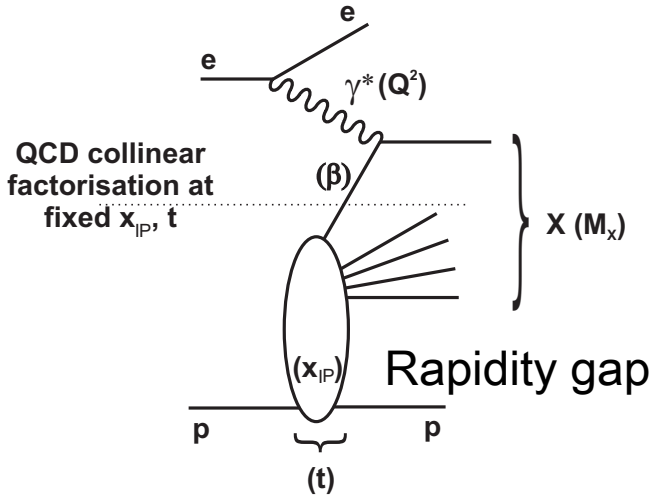
$$\sigma^D(\gamma^* p \to Xp) = \sum_{parton\_i} f_i^D(x, Q^2, x_{IP}, t) \cdot \sigma^{\gamma^* i}(x, Q^2)$$

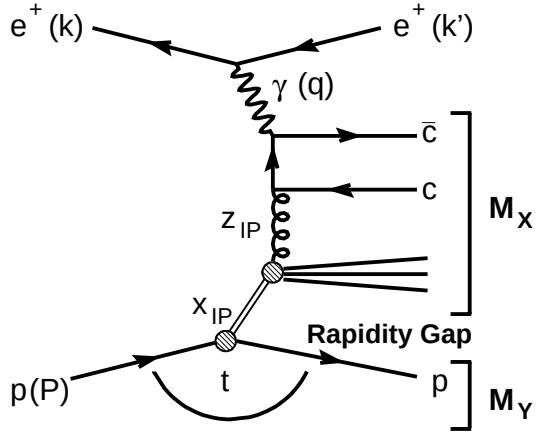
$\sigma^{\gamma^* i}$ - universal hard scattering cross section (same as in inclusive DIS)

f_i^D - Diffractive Parton Distribution Function ➔ obey DGLAP, universal for diffractive *ep* DIS (inclusive, Dijets, Charm)

❑ Extract DPDFs from QCD fit to inclusive diffractive DIS

❑ Test DPDFs in diffractive Final States (Boson Gluon Fusion)



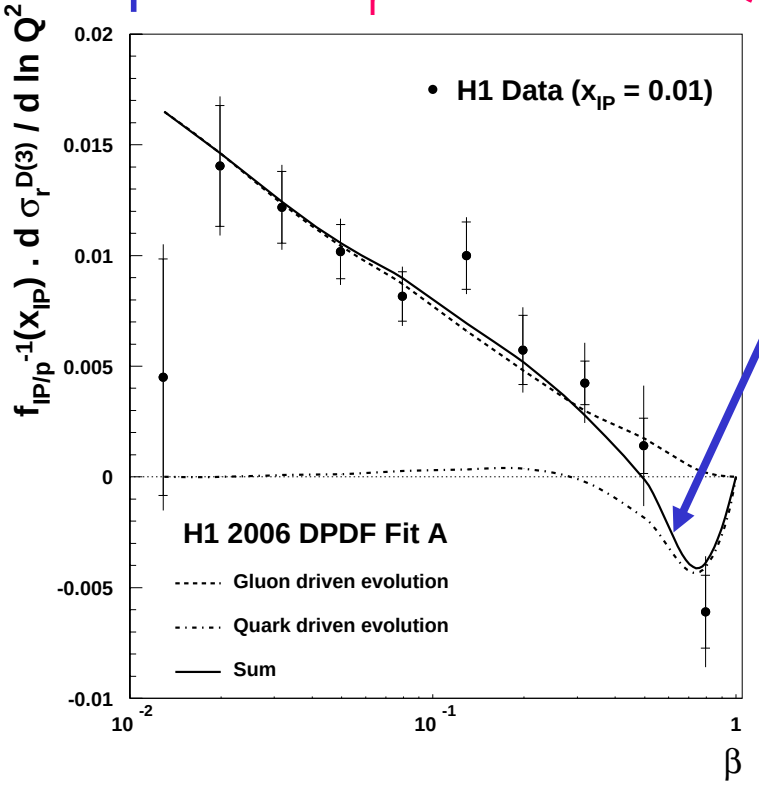


❑ Assumption: Proton vertex factorization ➔ shape of diffractive PDFs independent on x_{IP} and t

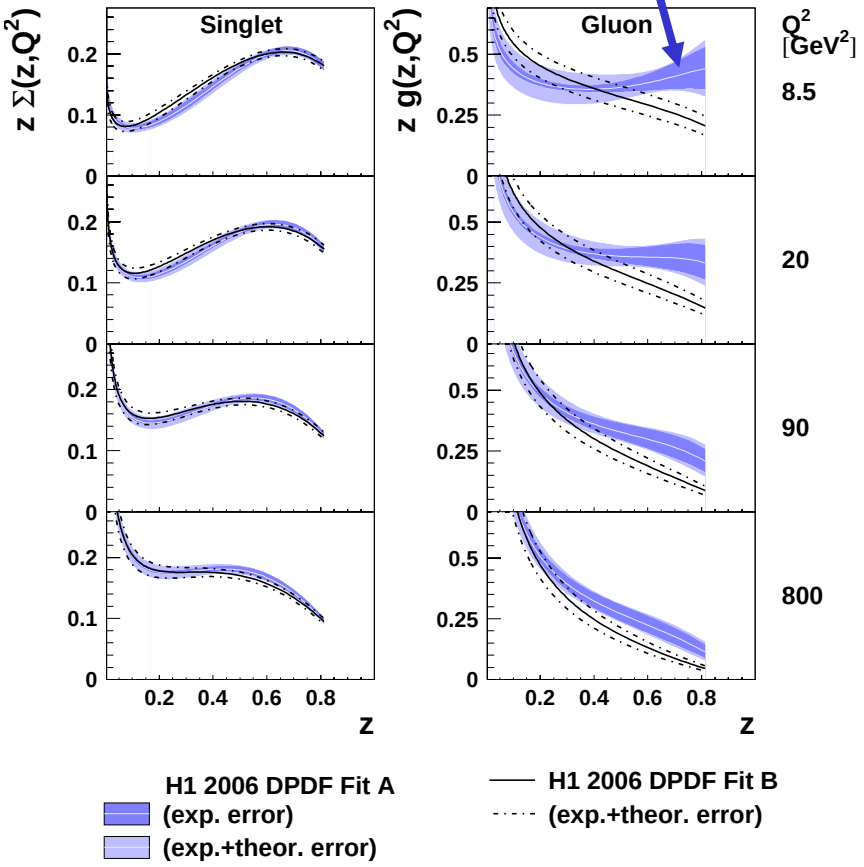
DPDFs from Inclusive Diffractive DIS

- Gluon DPDF ➔ from positive scaling violations ➔ larger uncertainty

Slope B: $\sigma_r^D = A + B \ln Q^2$



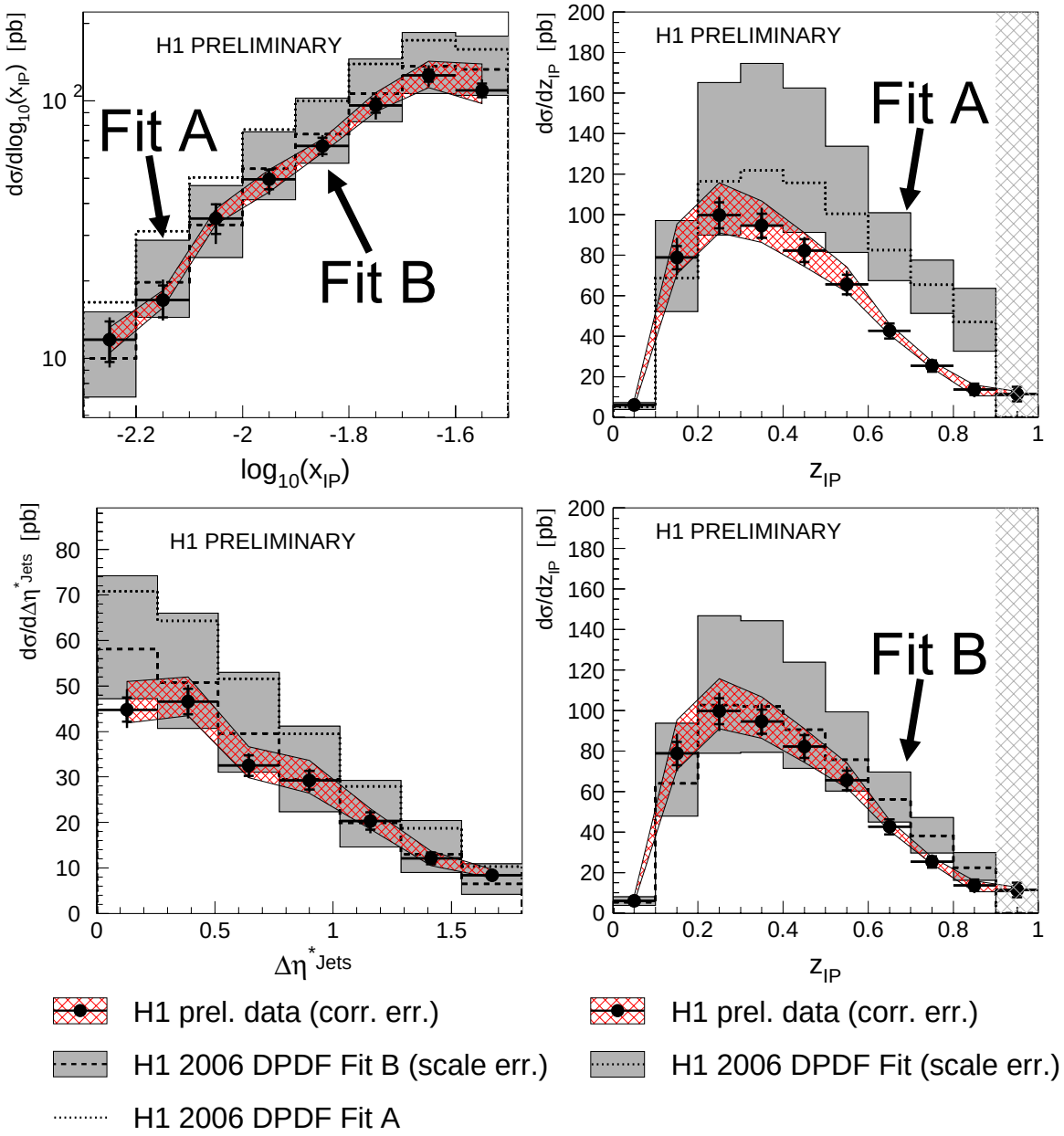
- At high momentum fraction QCD evolution is driven by quark radiation ➔ no sensitivity to gluon DPDF



- Fit constrains quark singlet DPDF and gluon DPDF at low z

→see talk of F.P.Schilling

Fit to Inclusive Diffractive Data vs Dijets



- New H1 data: 2723 Dijet DIS events
- z_{IP} distribution is the most sensitive to gluon DPDF
  ➔difference between NLO Fit A and Fit B at high z_{IP}
- H1 Dijet data are in better agreement with NLO predictions based on Fit B
- Statistics sufficient to make combined QCD Fit to inclusive diffractive DIS and Dijets

➔ Fit A uncertainty not shown

Combined Fit to Diffractive DIS and Dijets

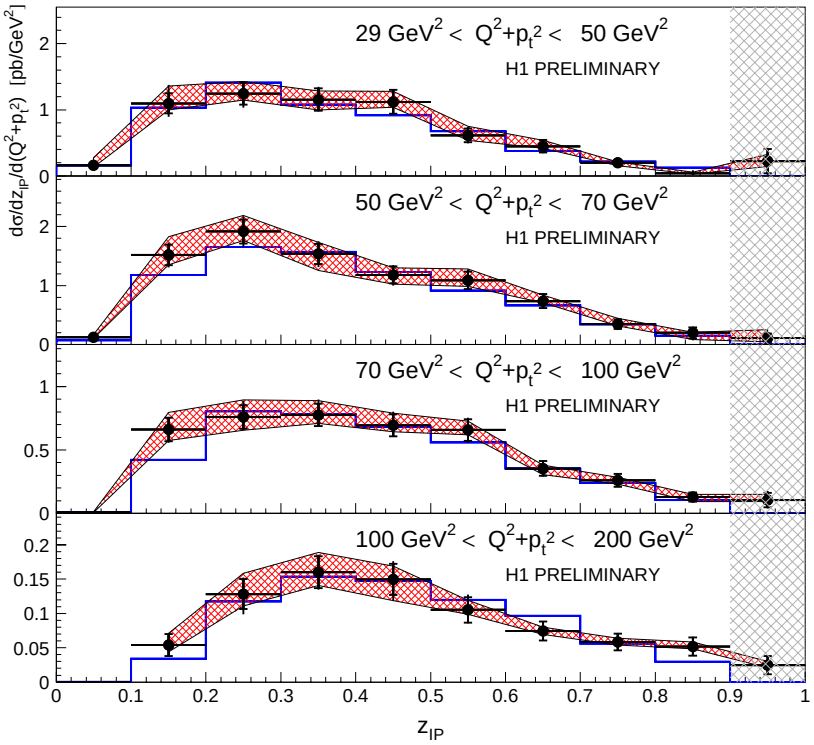
Aim: one set of NLO DPDFs which describes inclusive and Dijet data

- Parameterization of quark and gluon DPDFs at Q_0^2:

$$PDF(z,Q_0^2) = Az^B(1-z)^C$$

$\mu_r = Q^2+p_t^2$

- NLO DGLAP evolution:



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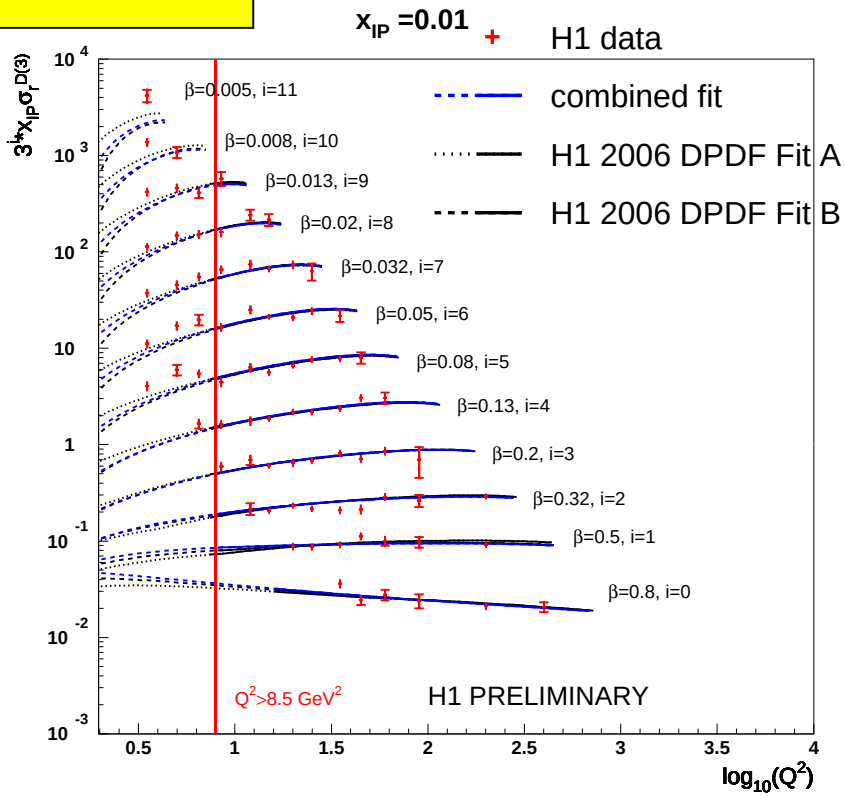


Combined Fit vs Dijet data

χ^2 / ndf (Dijet data) = 27/36

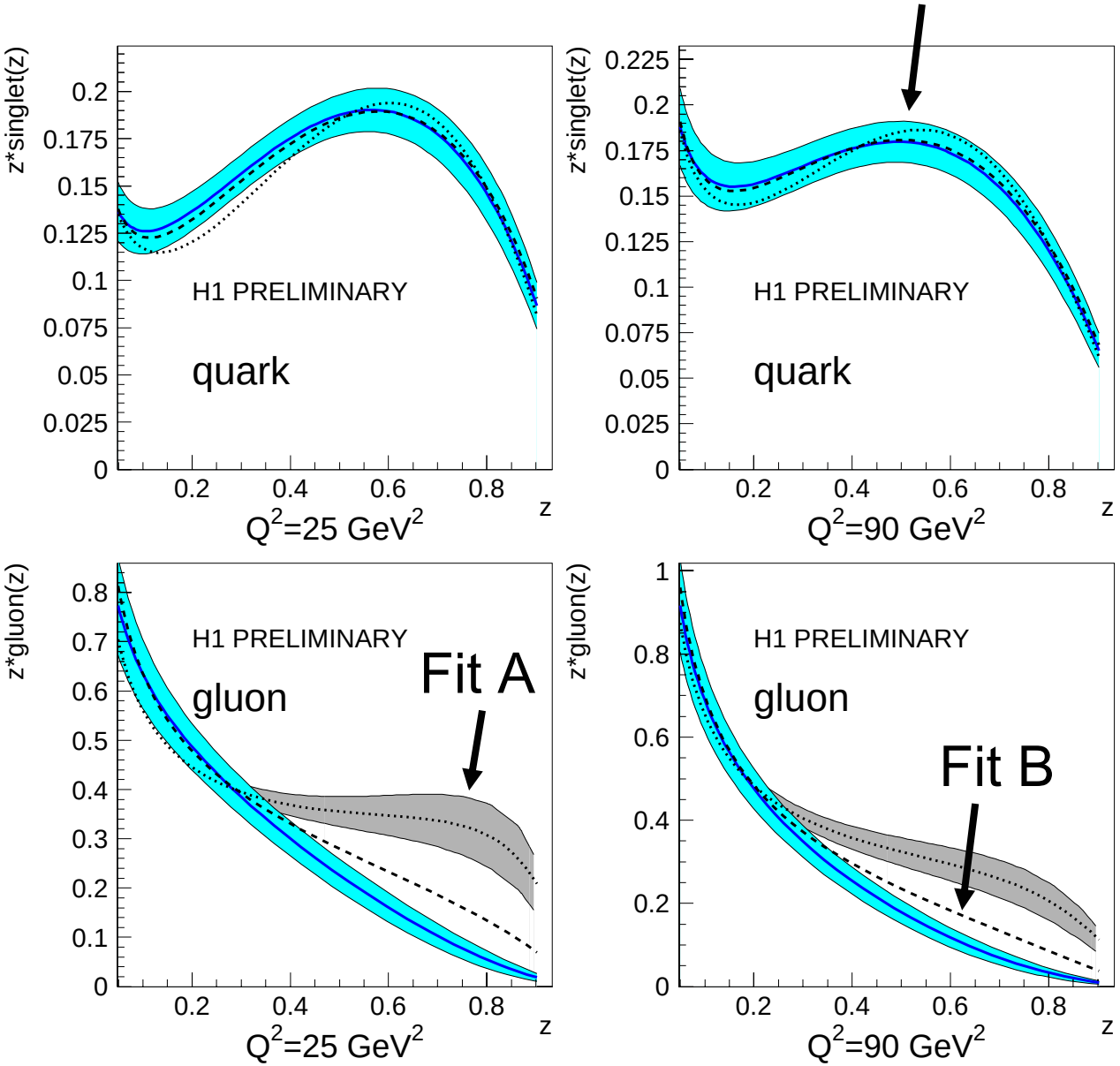
Combined Fit vs inclusive data

χ^2 / ndf (inclusive data)= 169/190

➔ Data are consistent with QCD collinear factorization

DPDFs from Diffractive DIS and Dijets

Combined Fit to inclusive and Dijet data



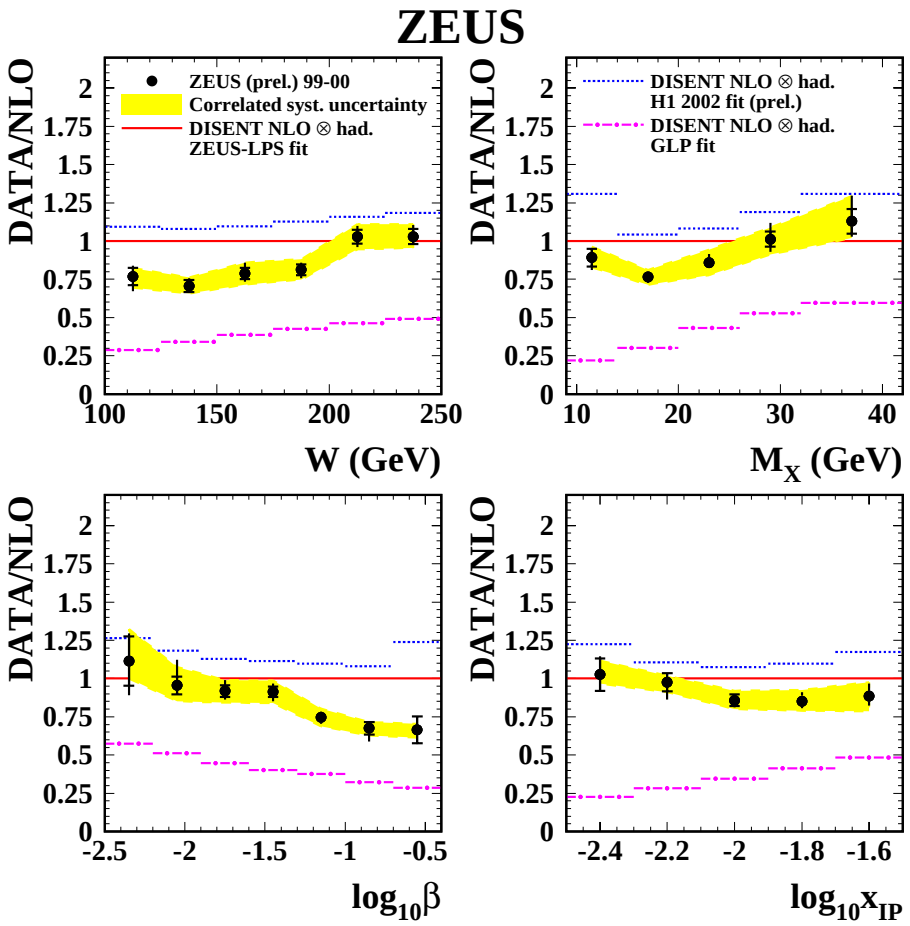
combined fit (exp. err.)

H1 2006 DPDF Fit A

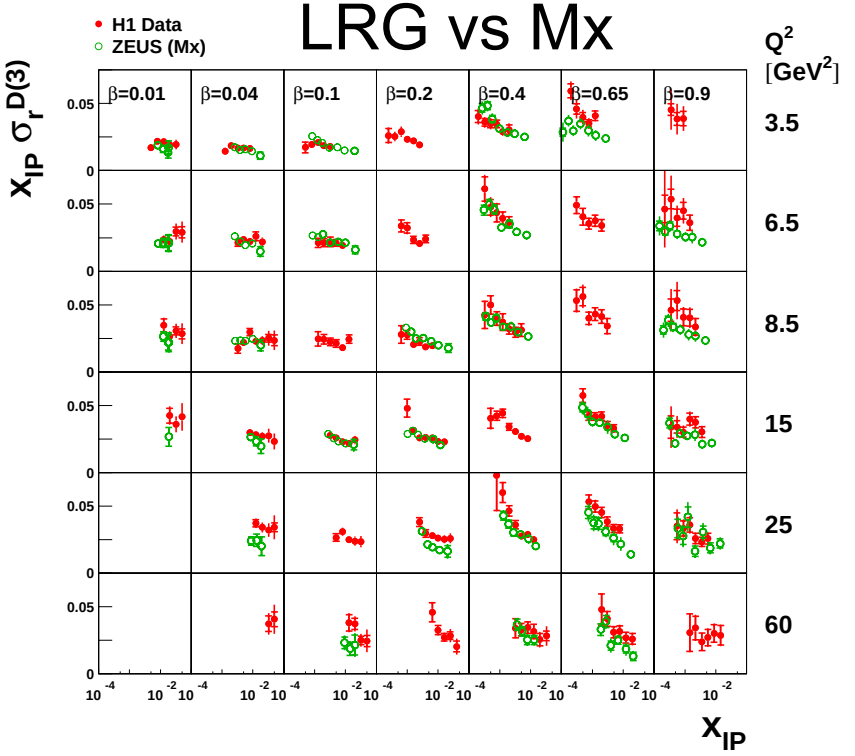
H1 2006 DPDF Fit B

- H1 Combined Fit constrains quark and gluon densities over wide range on z_{IP}
- Gluon density from Combined Fit is close to result of Fit B to inclusive diffractive data

Diffractive Dijets in DIS



- ZEUS Dijet data are consistent with DPDFs from LRG DIS (H1 2002 Fit) and LPS data (ZEUS LPS Fit)
- Dijet data are a factor ~2 above predictions from ZEUS Mx GLP Fit ➔ weaker Q^2 dependence in ZEUS diffractive Mx data ➔ smaller gluon

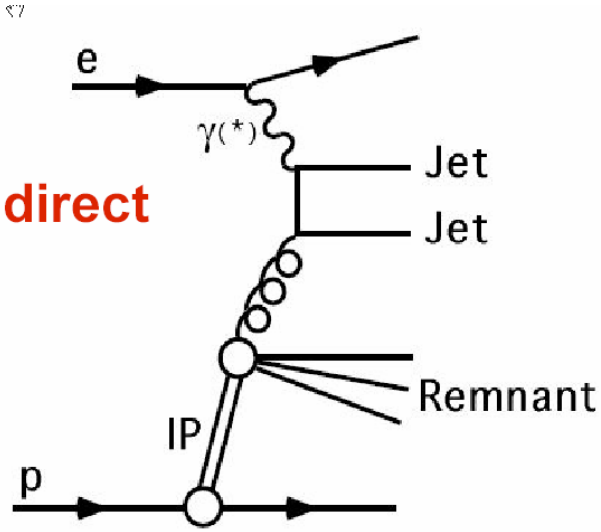


NLO QCD predictions: H1 2002 Fit, ZEUS LPS Fit, ZEUS Mx GLP Fit

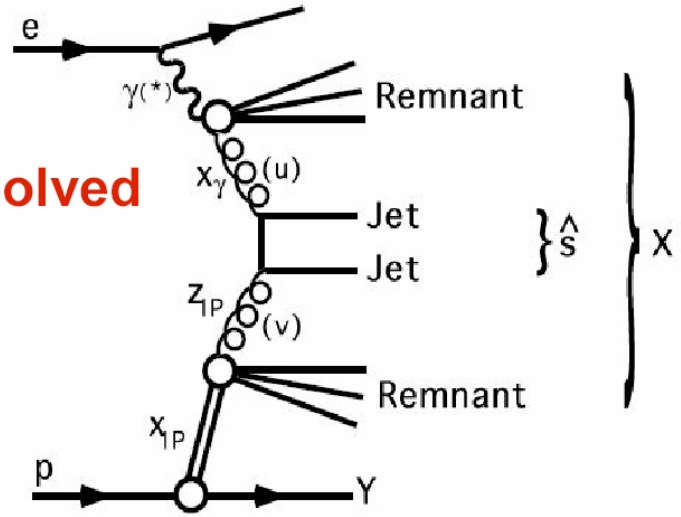
Test of Factorization: Dijet Photo-production

small point-like photon

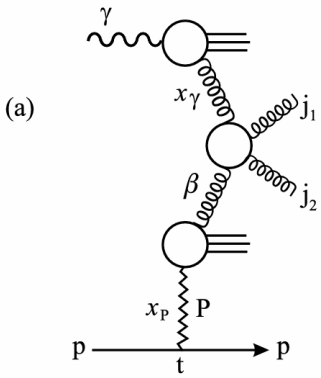
large hadron-like photon



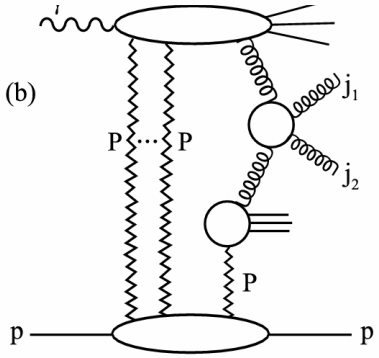
$x_\gamma = 1$



$x_\gamma < 1$



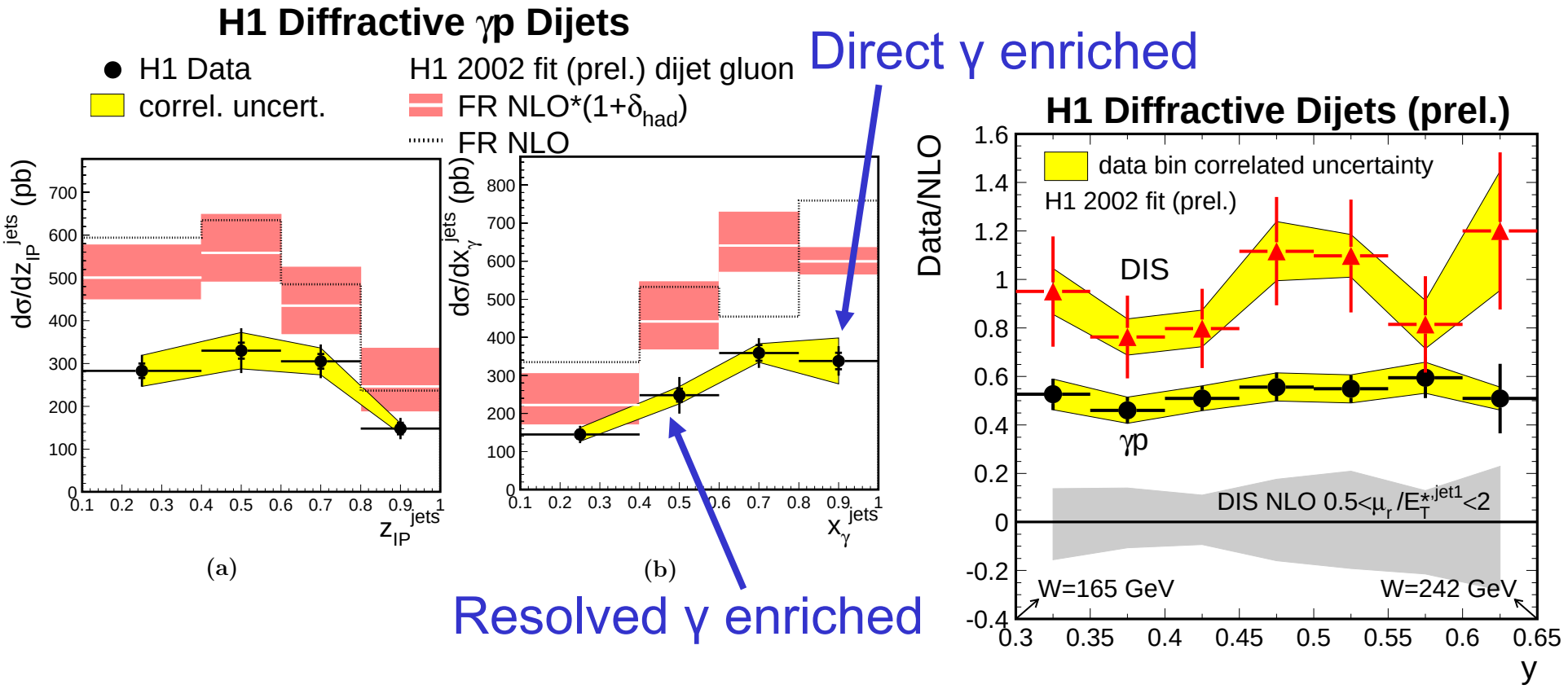
direct



resolved

- $Q^2 \sim 0$, hard scale → E_t^{jet} process sensitive to gluon density
- Factorization in Dijet PhP expected to be valid in direct photo-production but broken in resolved photo-production (secondary re-scattering, multi-pomeron exchanges)

Diffractive Dijet Photo-production

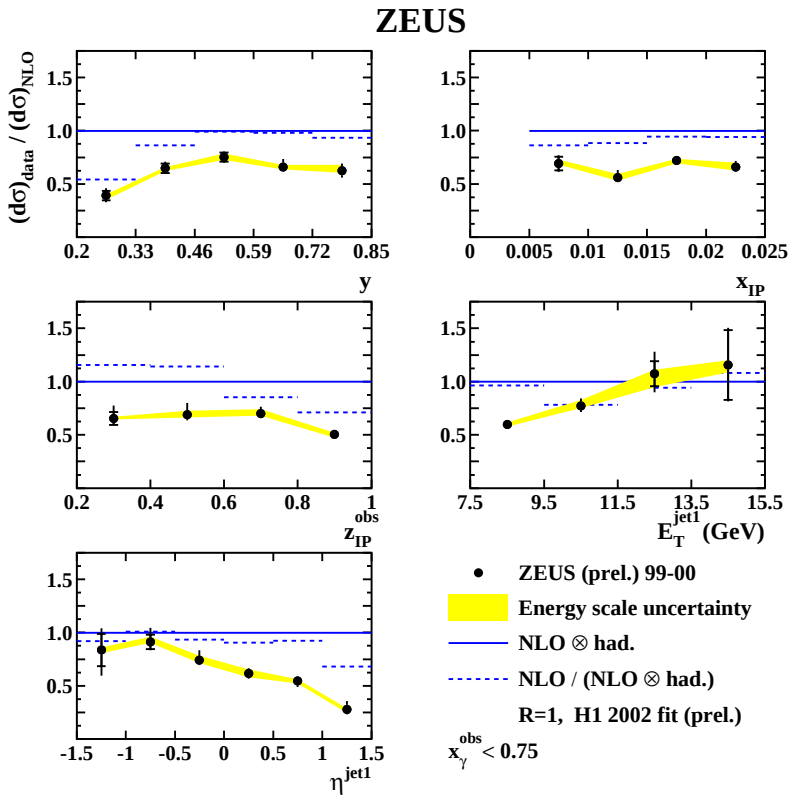


- NLO QCD: H1 2002 Fit; $\mu^2 = (E_t^*)^2$
- Dijets in PhP are described in shape by NLO QCD predictions, but suppressed by a factor ~0.6 for direct and resolved γ

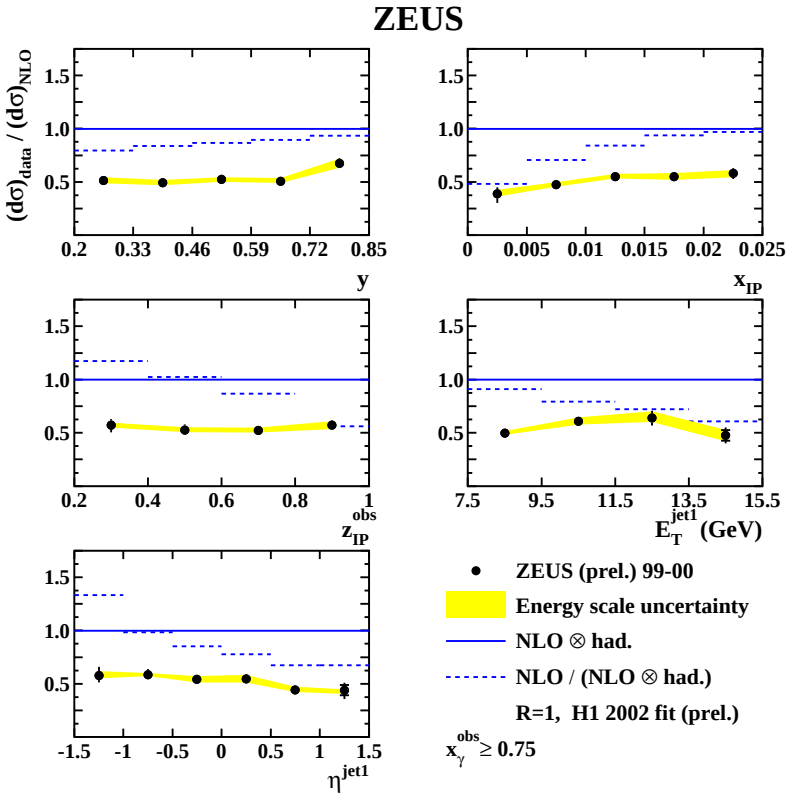
➔Factorization breaking for Dijets in PhP

Diffractive Dijet Photo-production

Resolved γ enriched: x_γ<0.75



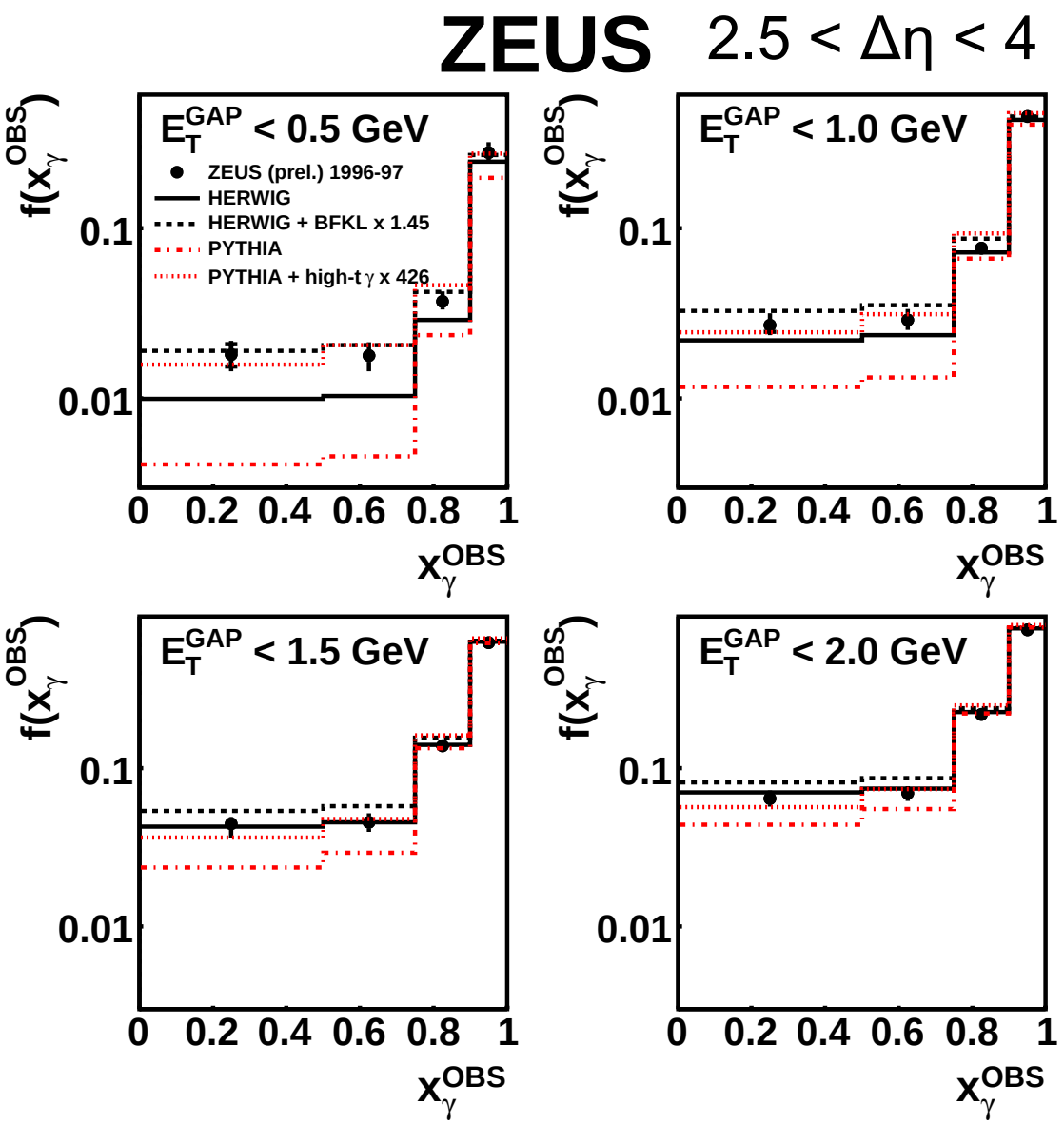
Direct γ enriched: x_γ>0.75



- NLO QCD predictions: H1 2002 Fit; $\mu^2 = (E_t^*)^2$
- Dijets in PhP are suppressed by a factor ~0.6 for direct and resolved γ

➔ expected that secondary re-scatterings fill rapidity gap in resolved processes, but not in direct photo-production

LRG between Jets in Photo-production

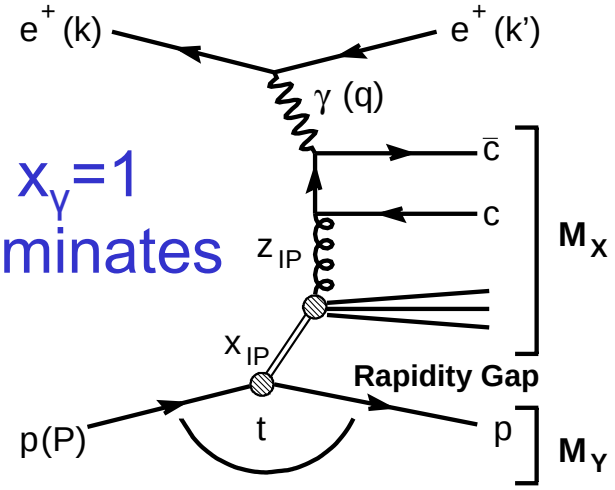


- High E_t of jets provide hard scale at each end of color singlet exchange ➔ pQCD process
- Color-non-singlet models: PYTHIA, HERWIG (LO+PS+MPI)
- Color singlet contribution:
- LLA BFKL in HERWIG

➔ Fit gives color singlet contribution of 2-3% in resolved γ

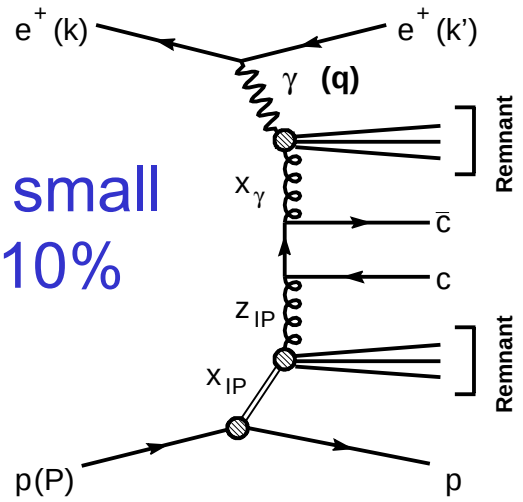
Test of Factorization: Charm in DIS and PhP

DIS and direct photo-production

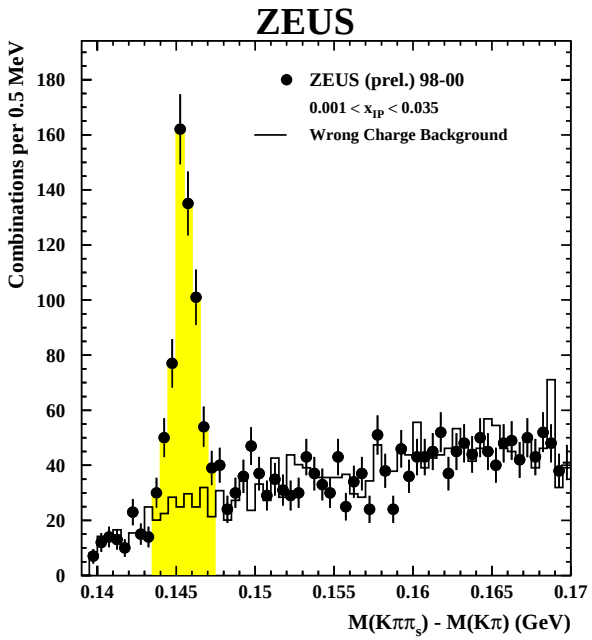


x_γ=1 dominates

Resolved photo-production

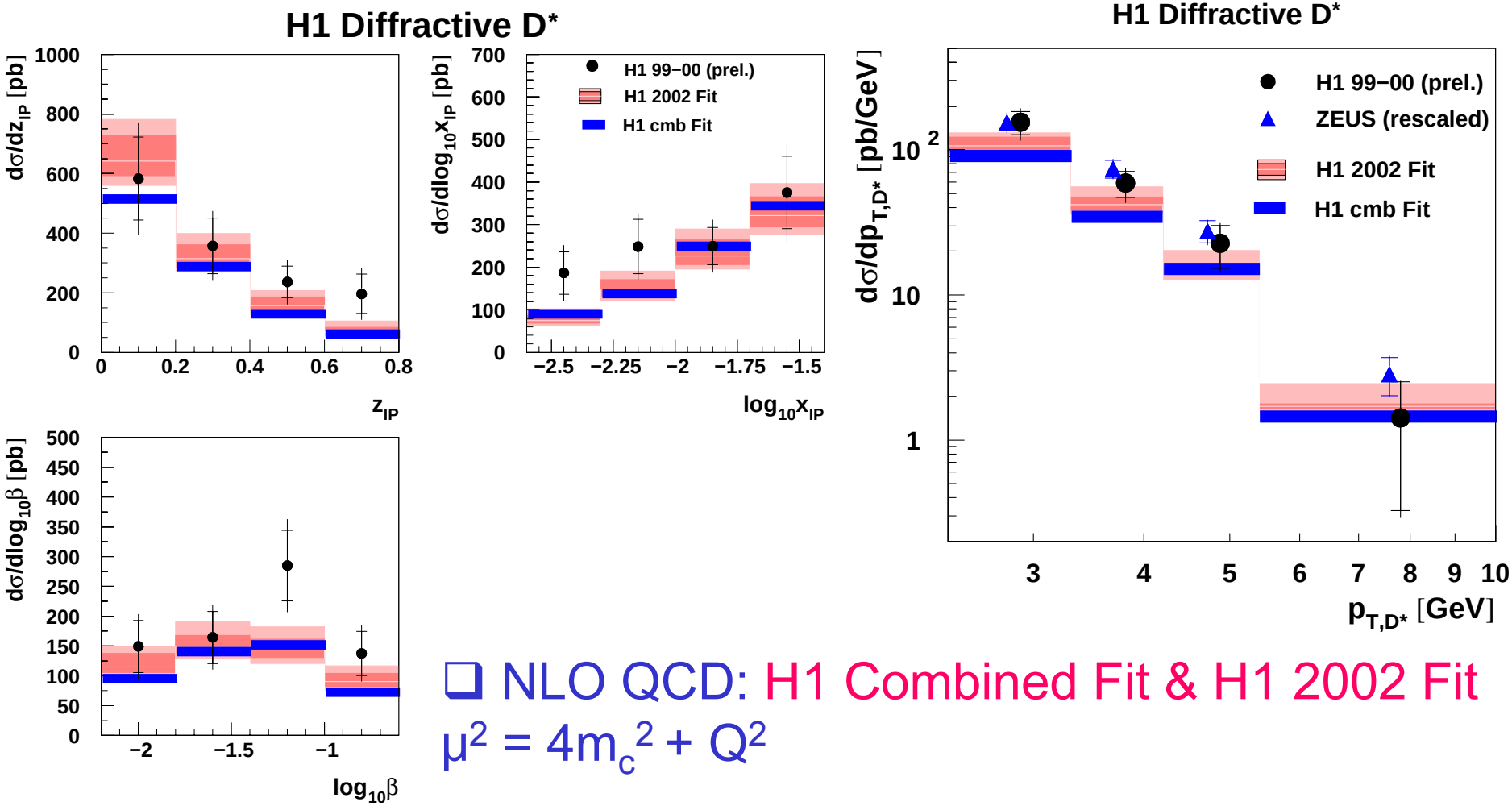


$0<x_\gamma<1$ → small fraction <10%



- Dominating process: Boson Gluon Fusion
  ➔ directly sensitive to gluon DPDF
- Hard scale is provided by mass of Charm quark
  ➔ probing low and medium range on z_{IP}
- H1 and ZEUS: Diffractive D*
- H1: First measurement of diffractive Charm using complimentary Life Time method (impact parameter to primary vertex)

Diffractive Charm in DIS



❑ NLO QCD: H1 Combined Fit & H1 2002 Fit

$\mu^2 = 4m_c^2 + Q^2$

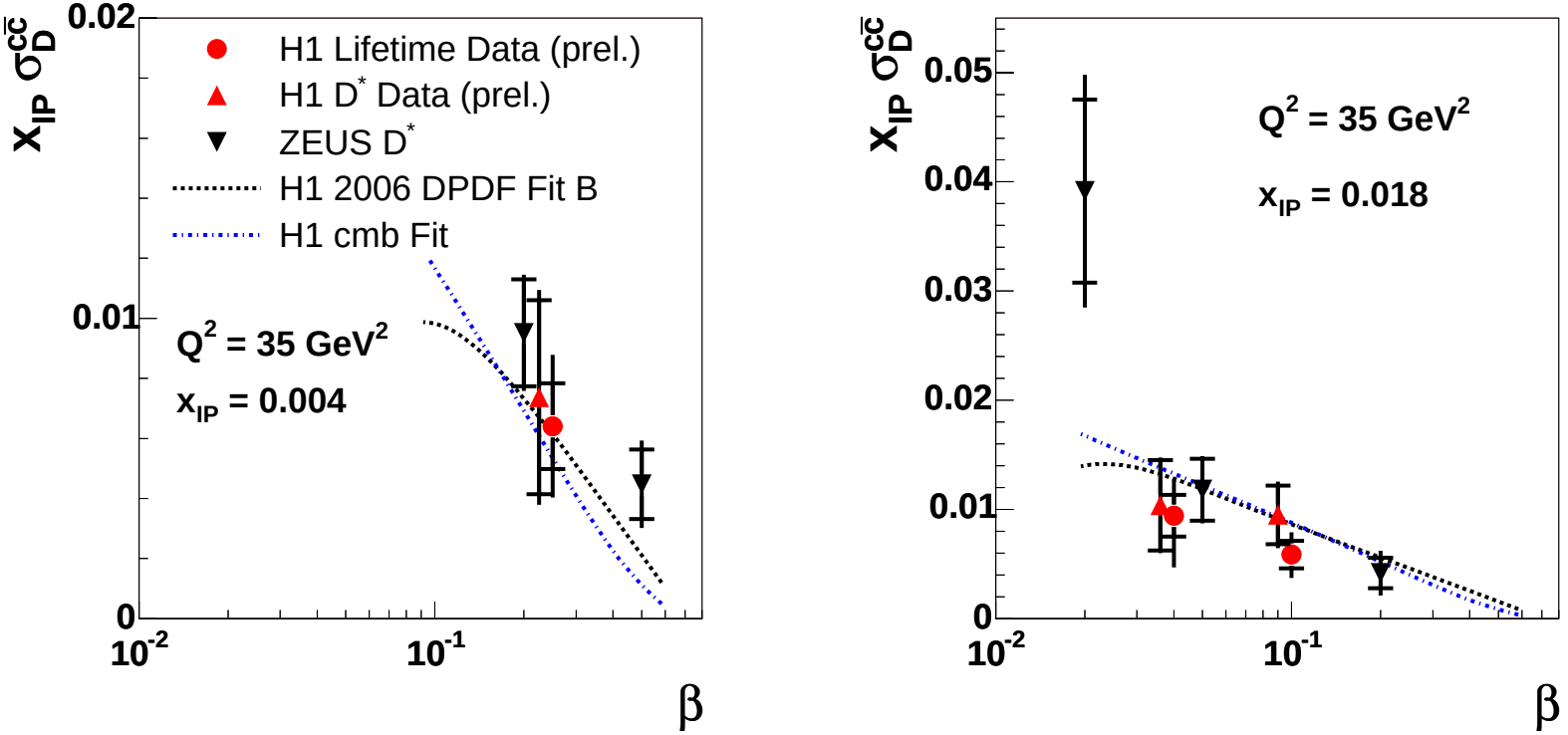
❑ Diffractive Charm (D*) in DIS:

- data consistent with NLO predictions in shape and normalization

➔ support QCD collinear factorization

Diffractive Charm in DIS

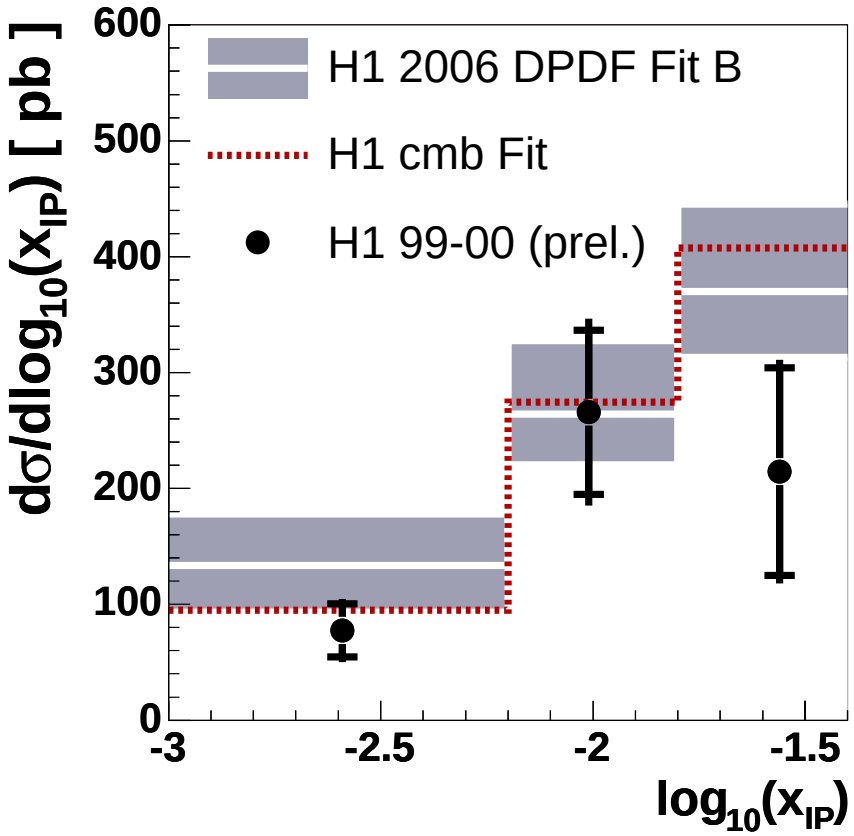
Charm contribution to F_2^D ~20% ➔ comparable with charm fraction in inclusive DIS

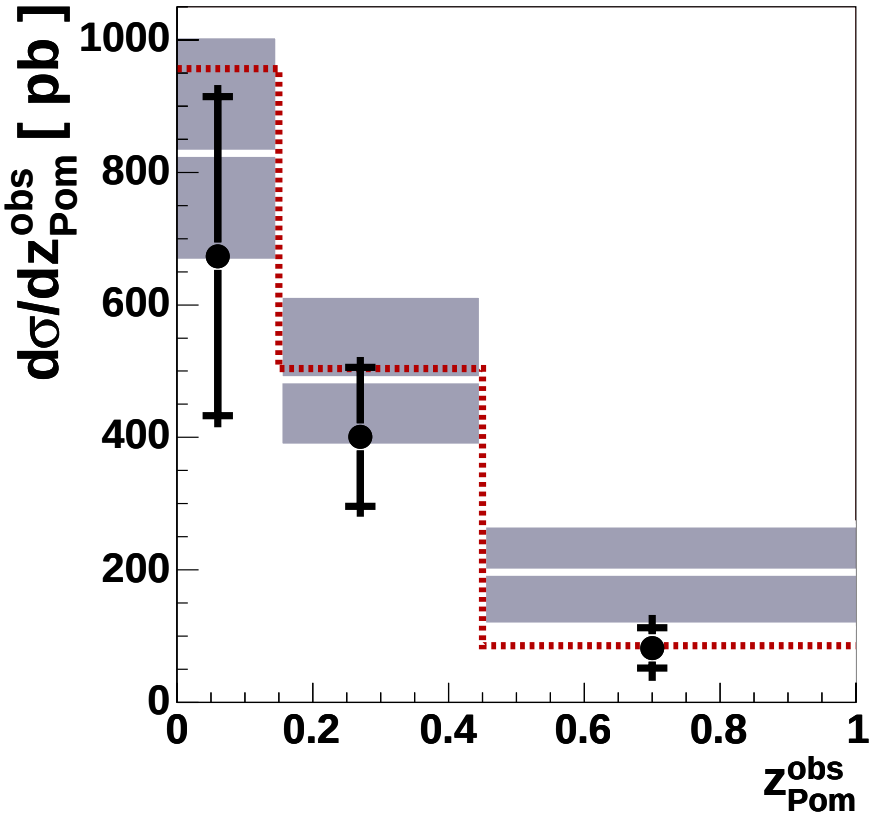


- NLO QCD: H1 Combined Fit & H1 2006 Fit B; $\mu^2 = 4m_c^2$
- Diffractive Charm in DIS (D* and Life Time method):
  - data consistent with NLO QCD predictions

➔ support QCD collinear factorization

Diffractive Charm in Photo-production

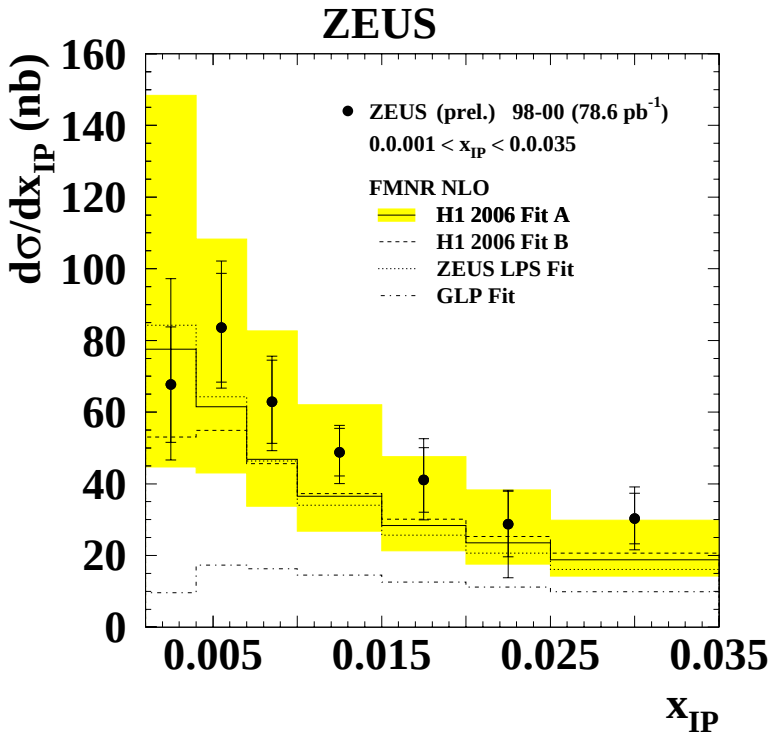


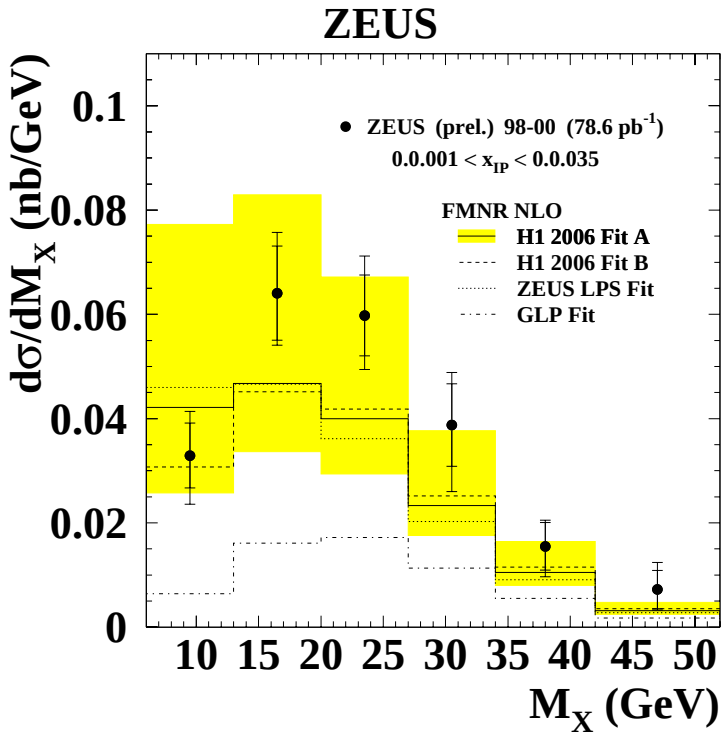


- NLO QCD: H1 Combined Fit & H1 2006 Fit B; $\mu^2 = 4m_c^2 + p_t^2$
- Diffractive Charm (D*) in photo-production:
  - data consistent with NLO QCD predictions within scale uncertainties

➔ no evidence for suppression of Charm direct photo-production

Diffractive Charm in Photo-production





- NLO QCD: H1 2006 Fit A & B, ZEUS LPS Fit, ZEUS Mx GLP Fit
  $\mu^2 = m_c^2 + p_t^2$
- Diffractive Charm (D*) in photo-production:
  - data consistent with NLO QCD predictions within scale uncertainties

➔ no evidence for suppression of Charm direct photo-production, but large NLO uncertainties

Summary

- H1 Combined QCD Fit to inclusive diffractive DIS and Dijets constrains quark and gluon diffractive PDFs in a wide range on fractional momentum

➔consistent picture of diffractive inclusive DIS and Dijets within QCD factorization approach

➔Dijets provide big improvement in precision of gluon density

- Diffractive Dijet photo-production data are suppressed by a factor 2 relative to NLO QCD predictions for direct and resolved processes

➔breaking of QCD factorization in Diffractive Dijet photo-production

➔"suppression" of Dijet direct photo-production should be understood

- Diffractive Charm DIS data are consistent with predictions based on NLO QCD Fit to inclusive diffractive DIS

- No evidence for breaking of QCD factorization in Charm photo-production