Diffractive Jets, Charm and Factorisation Tests at H1

HERA LHC Workshop
06-09.06.2006

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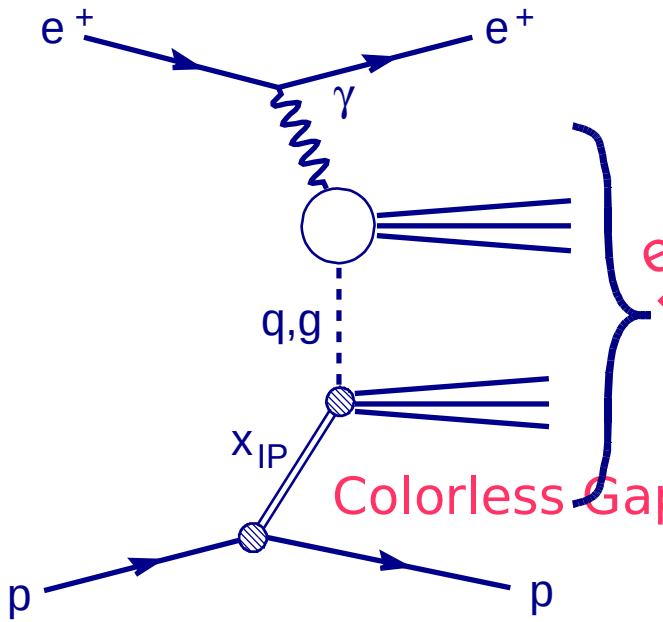
Tests of QCD Factorization in Diffraction

$$\sigma_{meas} = (\textbf{universal}\ \text{DPDFs}) \otimes (\text{Hard}\ \textbf{ME})$$

Inclusive Final States

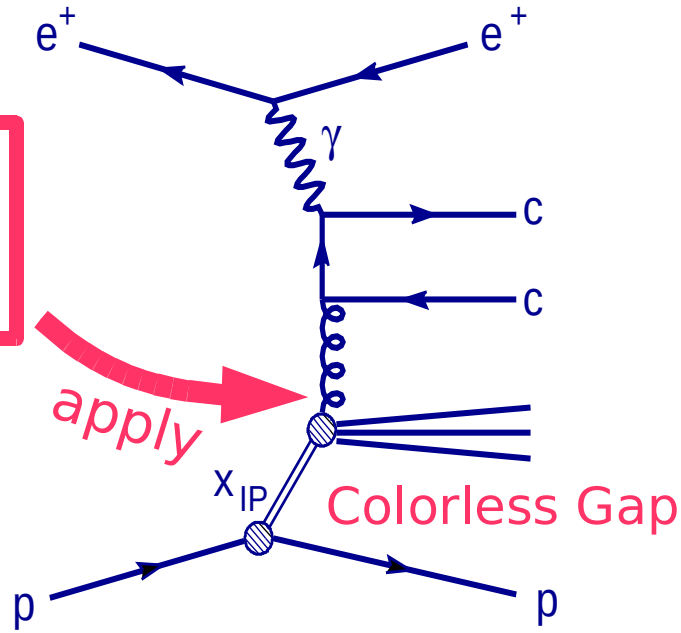


extract

DPDFs
H1 Fit 2006

apply

Exclusive Final States



- **Non-Trivial** statement
- **Solid Proof** that it is fulfilled in QCD for ep (in DIS) at 'sufficiently' large Q^2

Talk **Outline**

(1) Incl. Scatt. (F2d)

(2) DPDFs

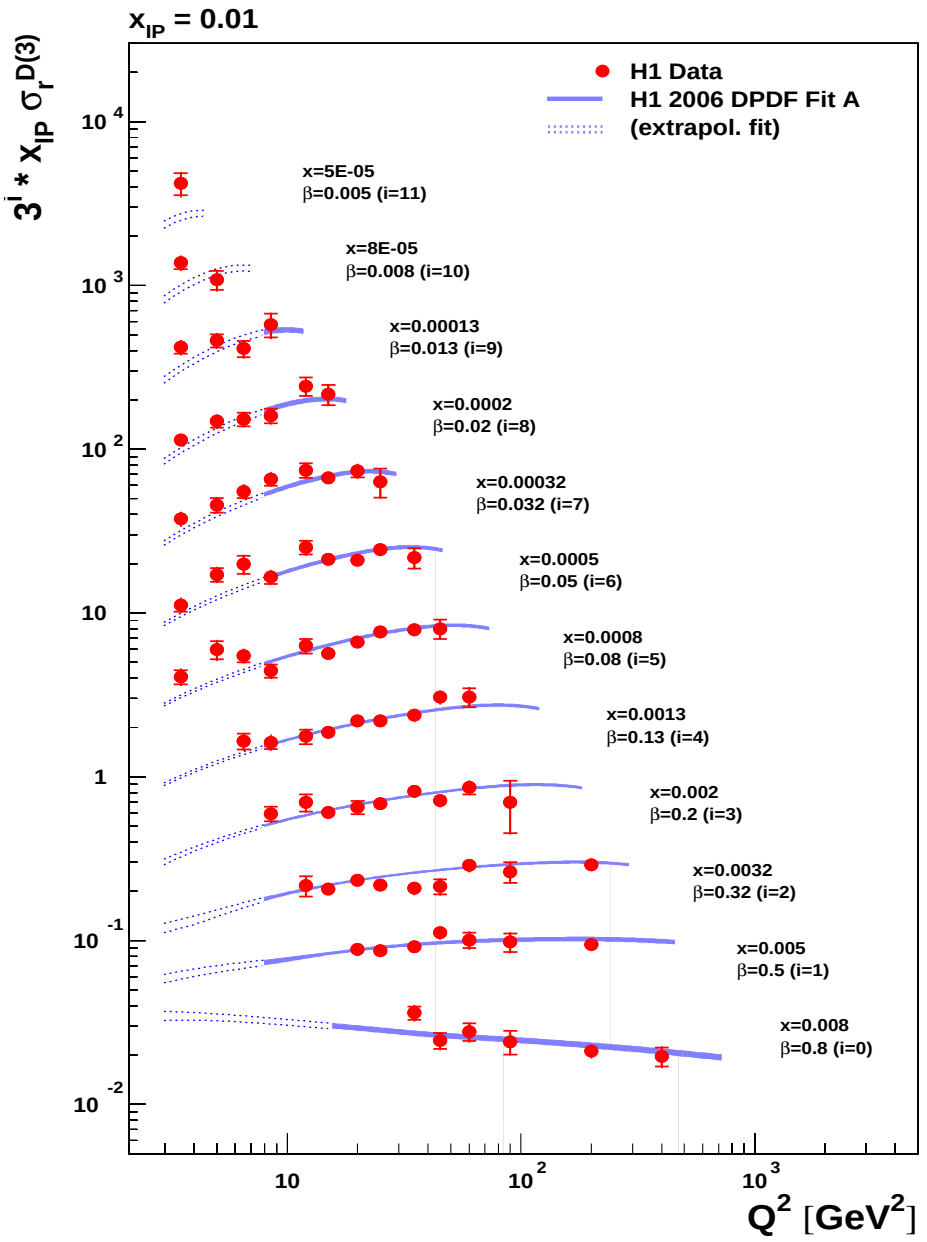
(3) Exclusive Channels

(3.1.) D* and Jets in DIS
(confirmation & improvement)

(3.2.) Jets and D* in γp
(analysis of fact. breaking)

Inclusive Scattering F2d

- In naïve QPM σ_r would **only** depend on β (=scaling)
- Rise with Q^2 is the effect of **QCD** (e.g. gluon splitting/radiation)
- Derivative **d/dlog(Q^2) ~ g(β,Q^2)**



Inclusive Scattering F2d

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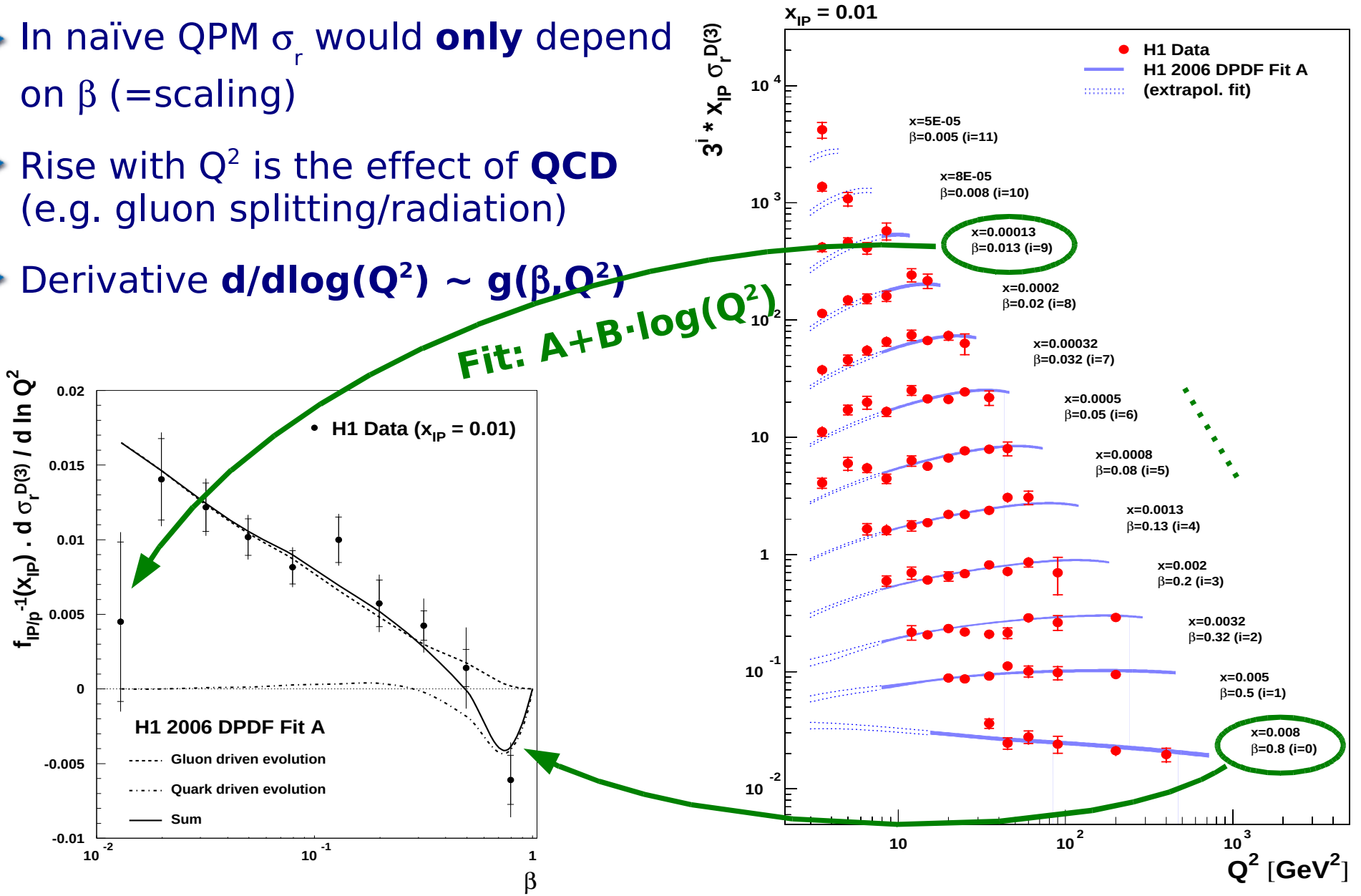
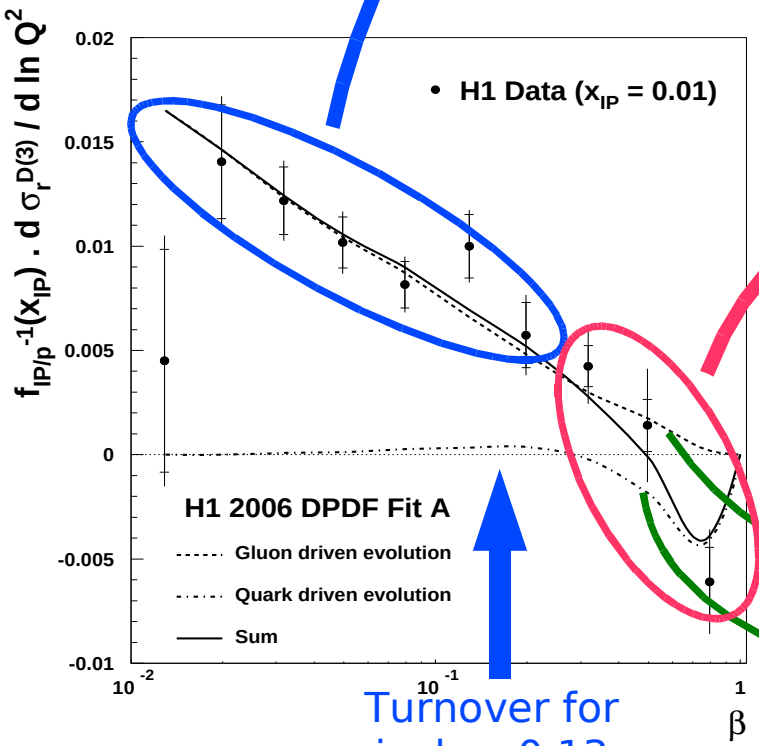


Inclusive Scattering F2d

Scaling Violations up to **very high** values of β!!!



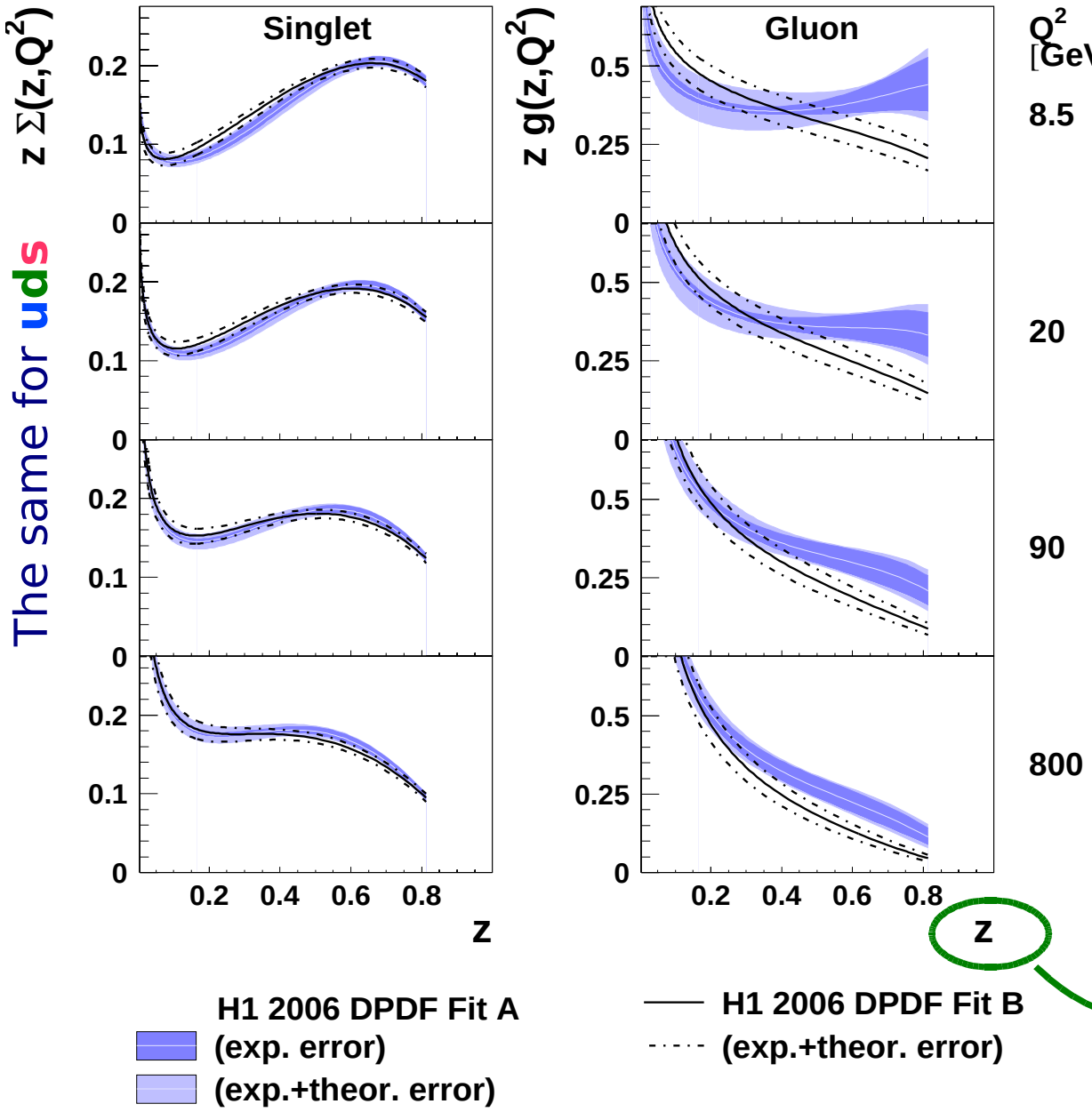
Turnover for incl x~0.13

At highest β the evolution is **NOT** driven by the gluon anymore!!!

Gluon driven evolution

Quark driven evolution

Diffractive Parton Density Functions



Input for predictions for more exclusive final states

- Well constrained **singlet**
- Weakly constrained **gluon** (esp. at high values of z)
- Significant dependence on the parametrisation (**Fit A** and **Fit B**) for gluon

z: momentum fraction of parton

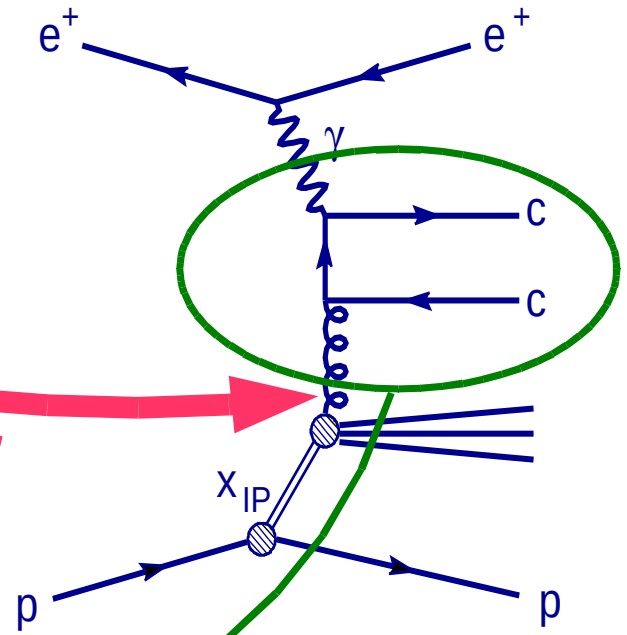
Tests of QCD Factorization

DPDFs
H1 Fit 2006

assume to be...

...valid

Exclusive Final State



calculate ME...

...from **QCD**

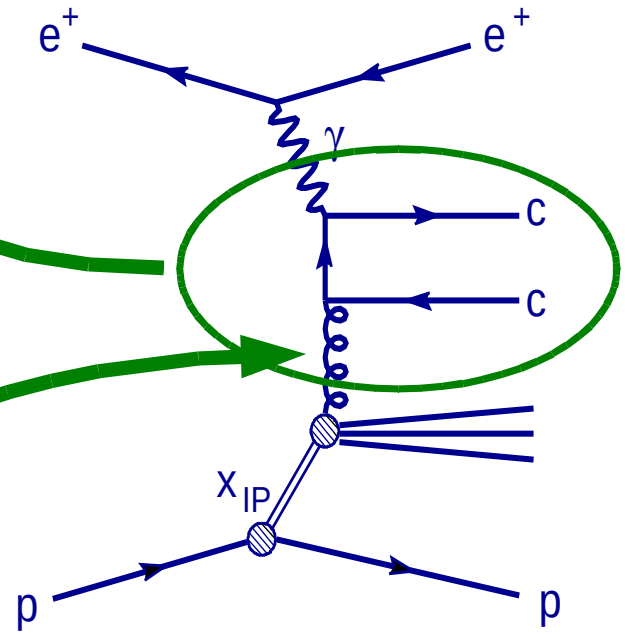
Predict Production Cross Sections for:

- diff. **Dijets**
- diff ***open charm***

Exclusive Prozess(es) (for Dijets & *charm*)

Boson Gluon Fusion

- **Dominating** process for Dijets and *open charm* at HERA
- Directely sensitive to the **gluon**
- **Characterized** by z_{IP} ($\rightarrow$z in DPDFs can be directly measured!!!)

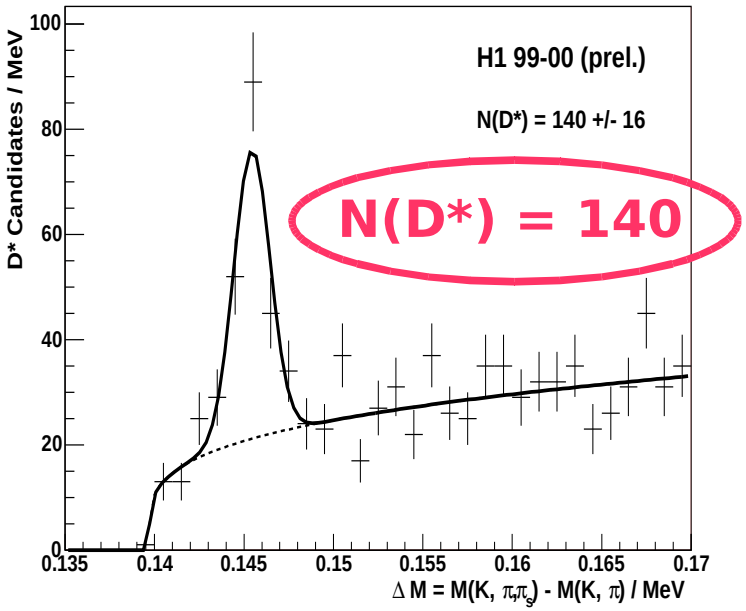


z_{IP}: Momentum fraction of the gluon rel. to the diff. exchange

Diffractive *charm* & **Dijet** Production **(DIS)**

charm Selection (prel '04, '06):

- $D^* \to K \pi \pi_s$
- $p_t(D^*)>2$GeV
- $|\eta(D^*)|<1.5$
- Displ.Vertices
- $p_t(Trk)>0.5$GeV
- $|\eta(D^*)|<1.3$
- $2<Q^2<100$ GeV^2
- $0.05<y<0.7$
- $15<Q^2<100$ GeV^2
- $0.07<y<0.7$
- $x_{IP} < 0.04$; $M_Y<1.6$ GeV, $|t|<1$GeV^2

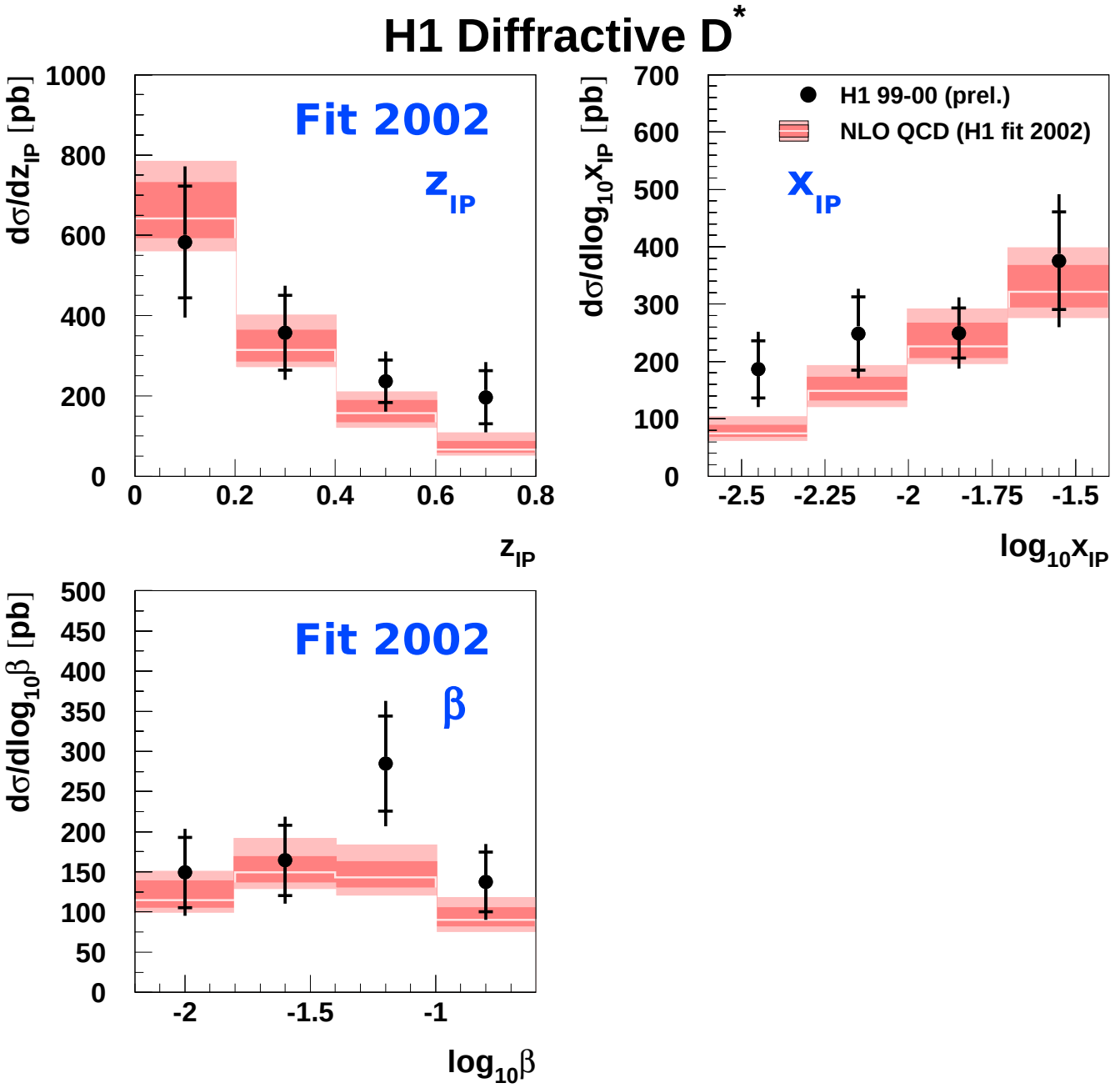


Dijet Selection (prel 2006):

- Incl k_t in γp cms ($y=1$)
- $p_t^{*Jet1} > 5.5$ GeV
- $p_t^{*Jet2} > 4.0$ GeV
- Jets well contained within Calo's in labframe ($-3<\eta^*_{Jet}< 0$)
- $4< Q^2 < 80$ GeV^2
- $0.1 < y < 0.7$
- $x_{IP} < 0.03$; $M_Y<1.6$ GeV, $|t|<1$GeV^2

N(Dijet) = 2723

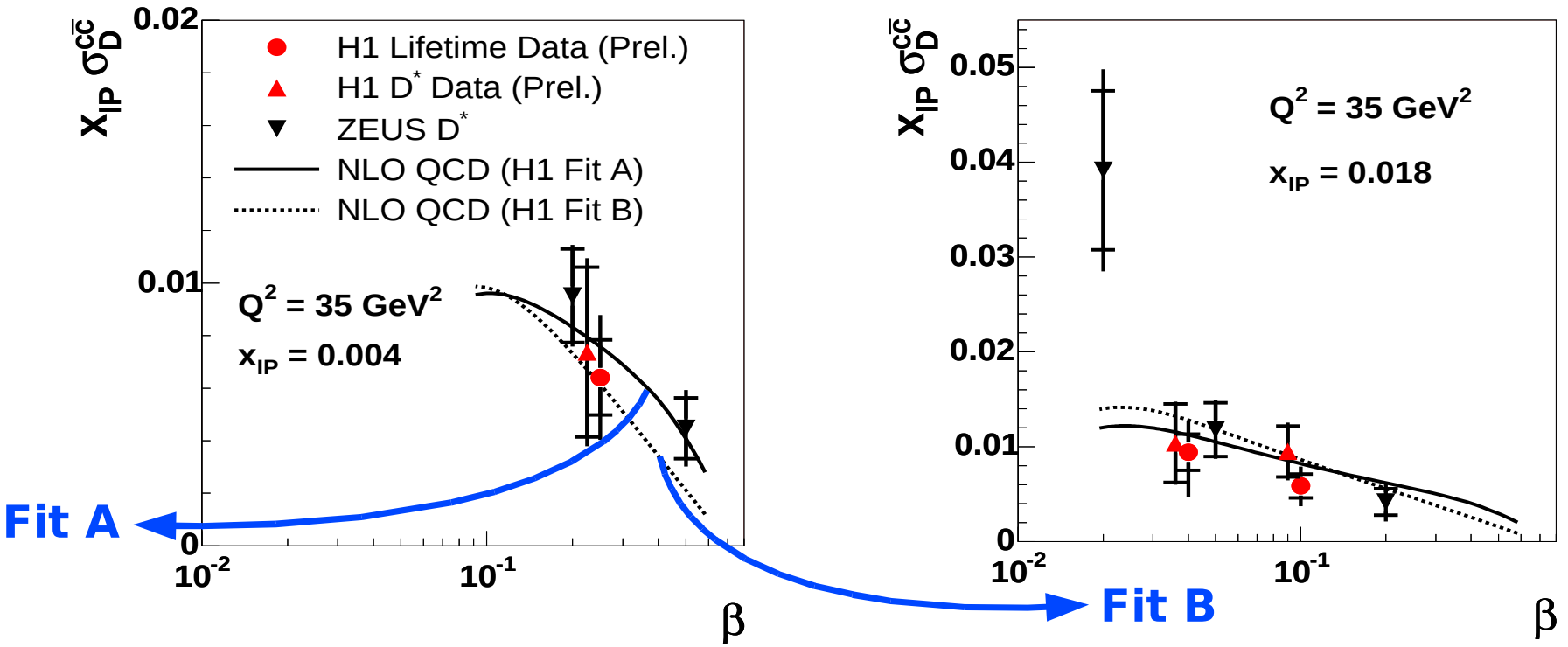
Comparison with NLO: *charm* (DIS) (prel 2004)



- **NLO**: Collins et al. (massive scheme)
- **DPDFs**: H1 fit 2002(prel.)
- $\mu^2 = (4m_c^2+Q^2)$
- $\langle\mu^2\rangle \sim$ **16 GeV²**
- $\langle z\rangle \sim$ **0.2 – 0.3**
- Overall **good** Description!

Comparison with NLO: *charm* (DIS) (prel 2006)

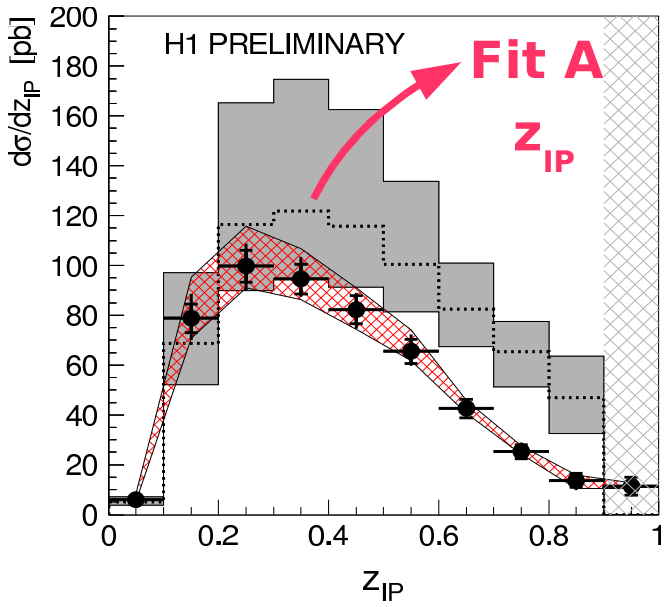
charm contribution to F2D:

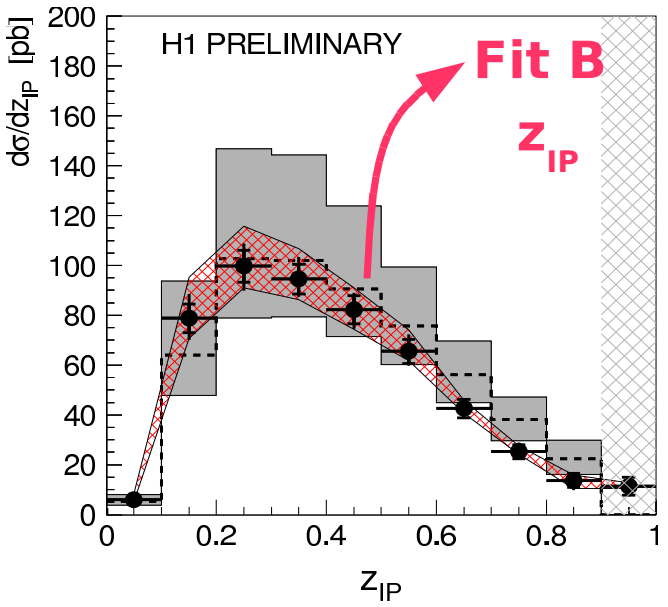


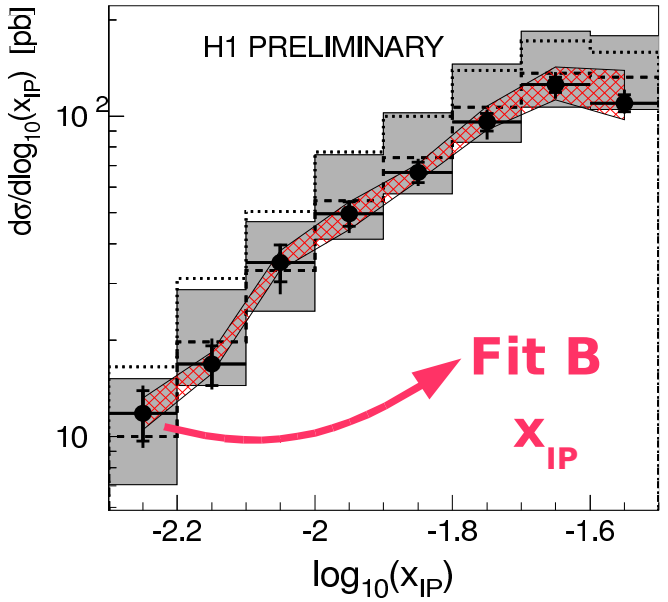
- **NLO**: direct comp. (massive scheme)
- **DPDFs**: H1 2006 DPDF Fit A & B
- $\mu^2 = (4m_c^2)$
- $\langle\mu^2\rangle$ = **5.6 GeV²**
- Overall **good** Description!

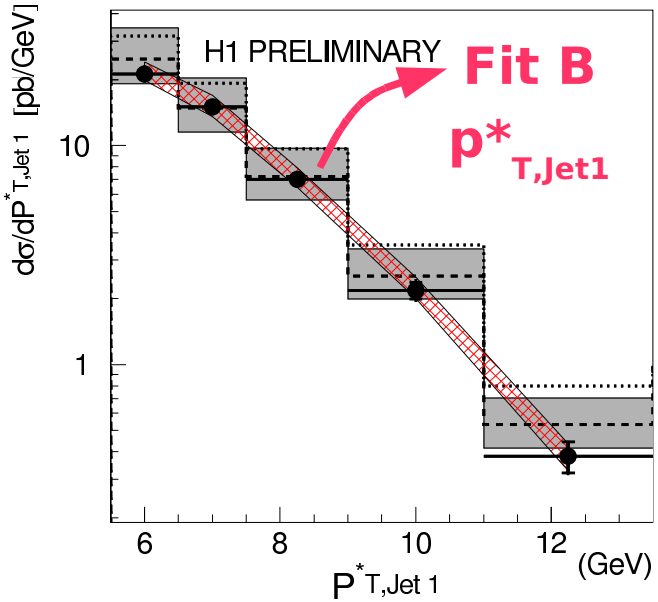
Factorization is valid for *charm* DIS

Comp with NLO: **Dijets (DIS)** (prel 2006)





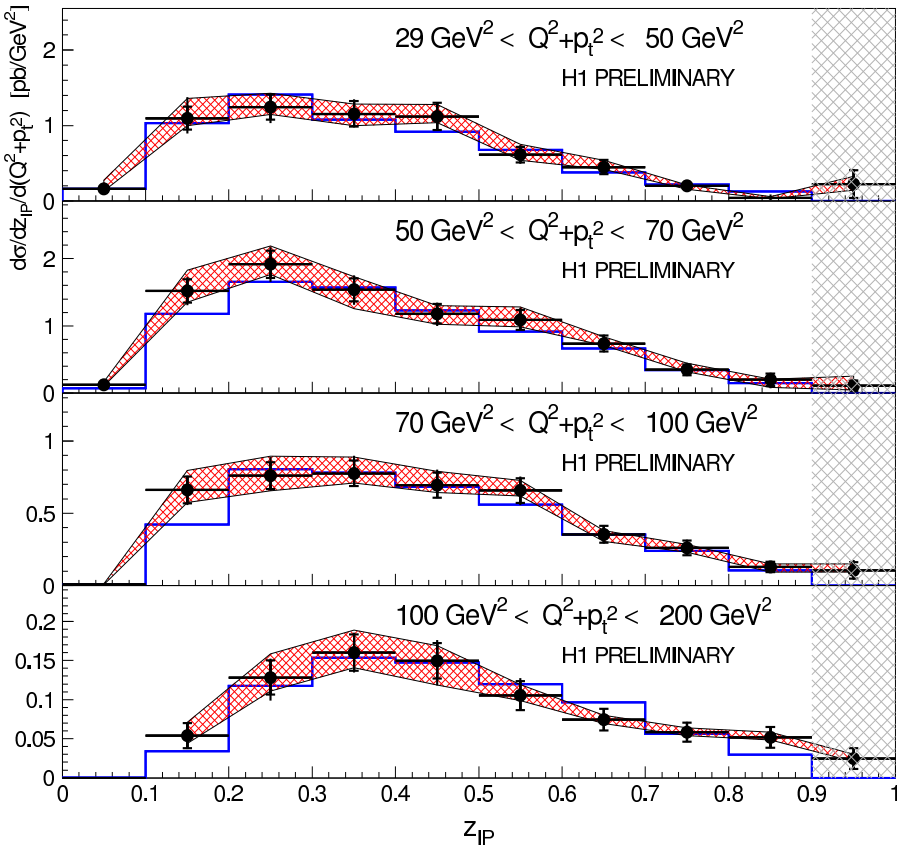


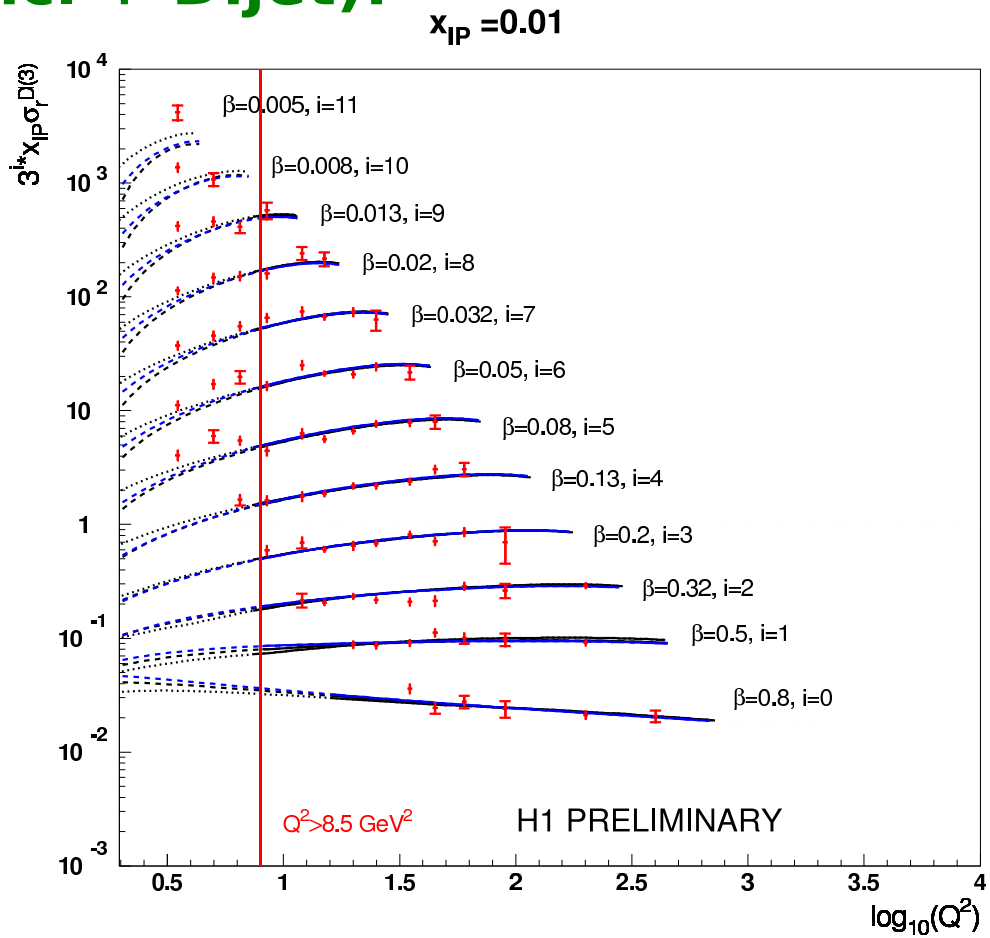


- **NLO**: Nagy et al.
- **DPDFs**: H1 2006 DPDF Fit A & B
- $\mu^2 = (p_t^2+Q^2)$
- $\langle\mu^2\rangle \sim$ **36 GeV²**
- $\langle z\rangle \sim$ **0.4 – 0.5**
- **Problems** esp. with z_{IP}
- BUT **Fit B does better** than Fit A

Combined Fit (Incl + Dijet) (DIS) (prel 2006)

Combined Fit (Incl + Dijet):

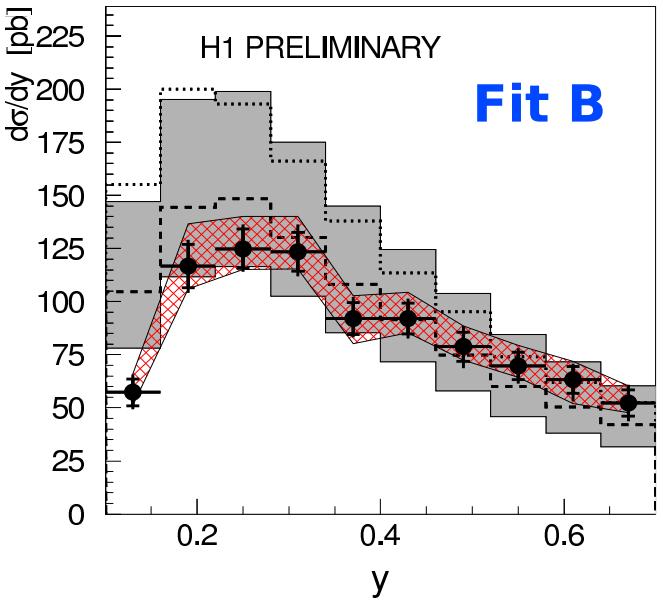


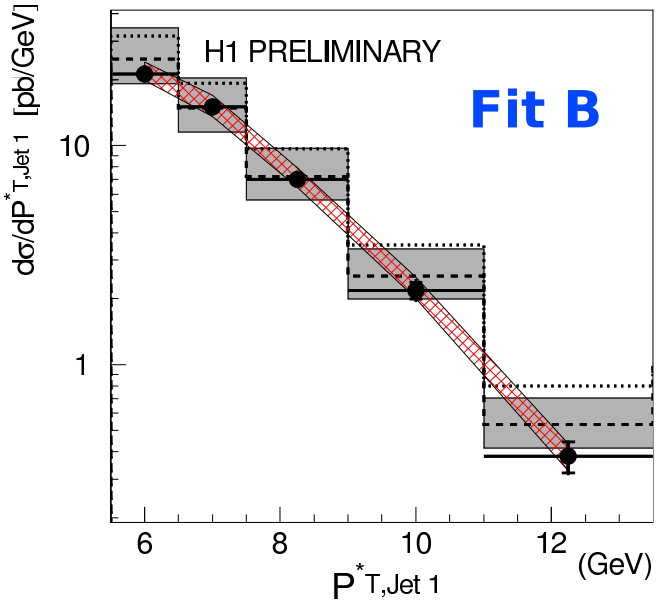


- **Excellent** Fit Results
- χ^2/ndf **= 0.89** (27/36 Dijet + 169/190 Incl)
- Hardly any pull to the incl data (**complementary** datasets)
- **Less sensitive** to the choice of parametrisation

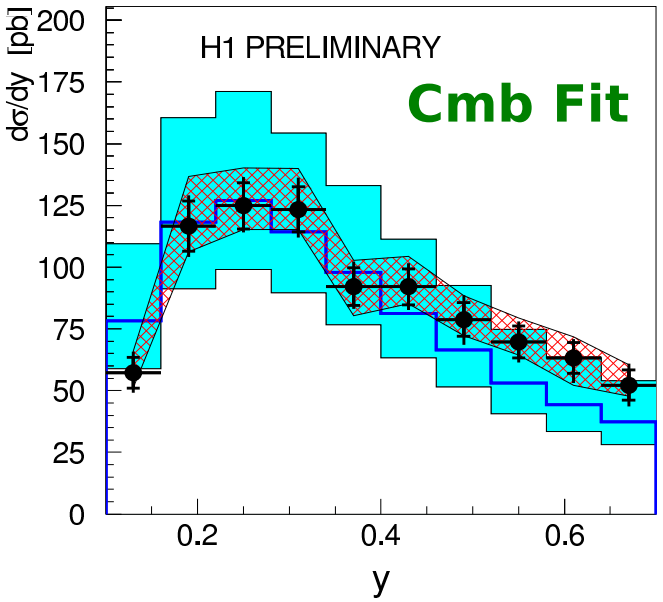
Fit B vs Cmb Fit (DIS) (prel 2006)

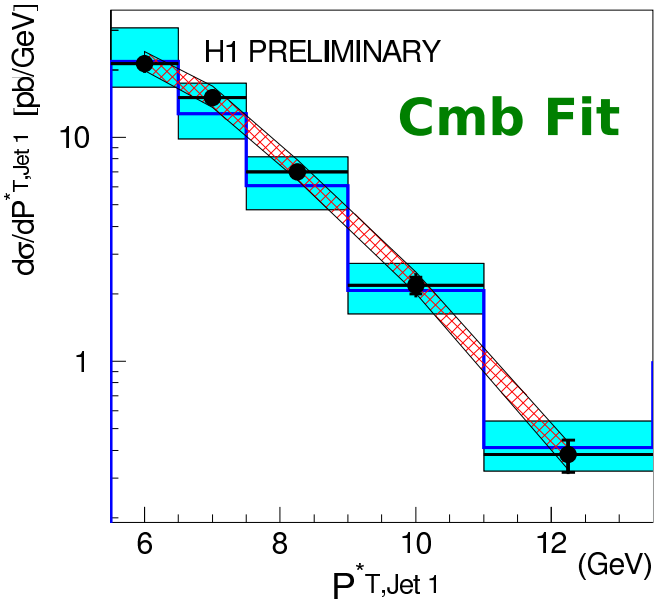
Before Combined Fit



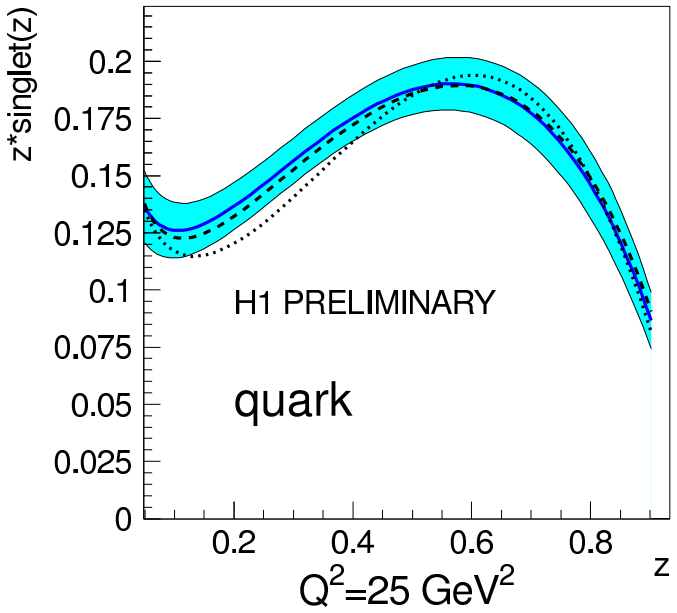


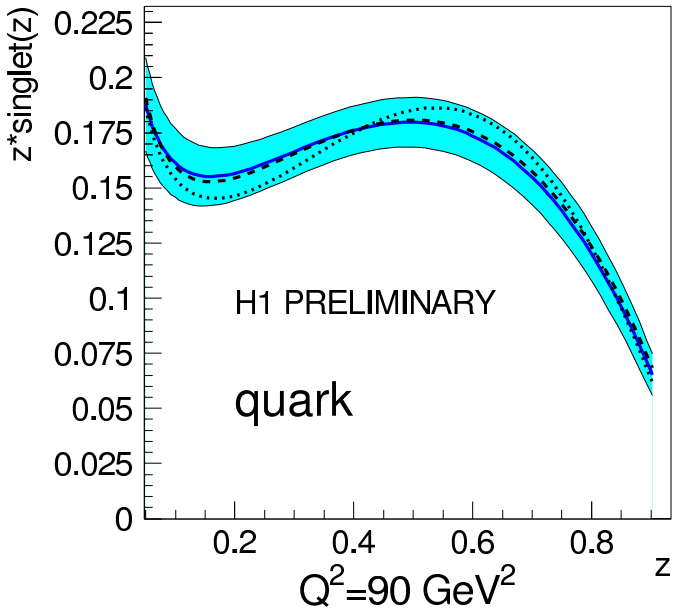
After Combined Fit

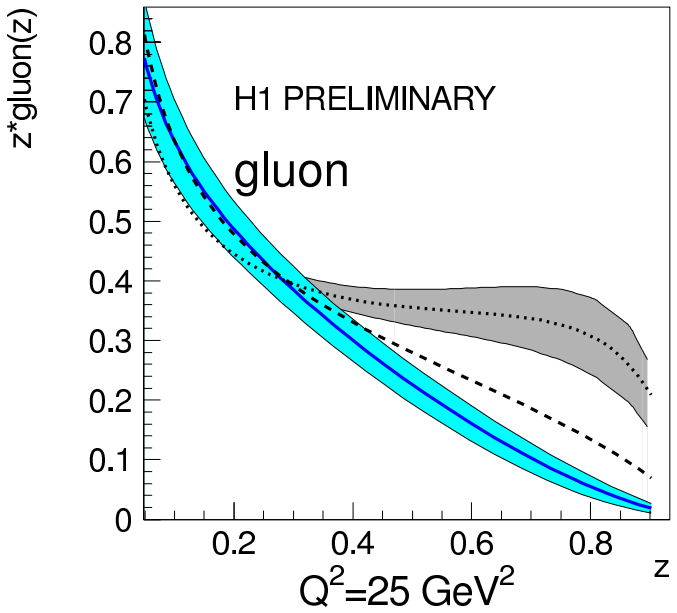


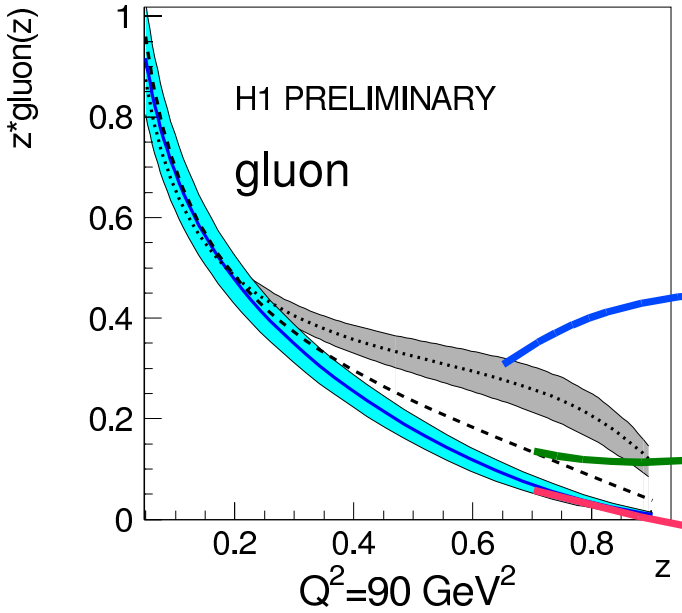


Combined Fit Results (DIS) (prel 2006)









- Describes **Incl+Dijets(+*charm*)**
- **Improves** incl fit at high z
- **Constraines** quark+gluon over a wide range $(0.05<z_{IP}<0.9)$

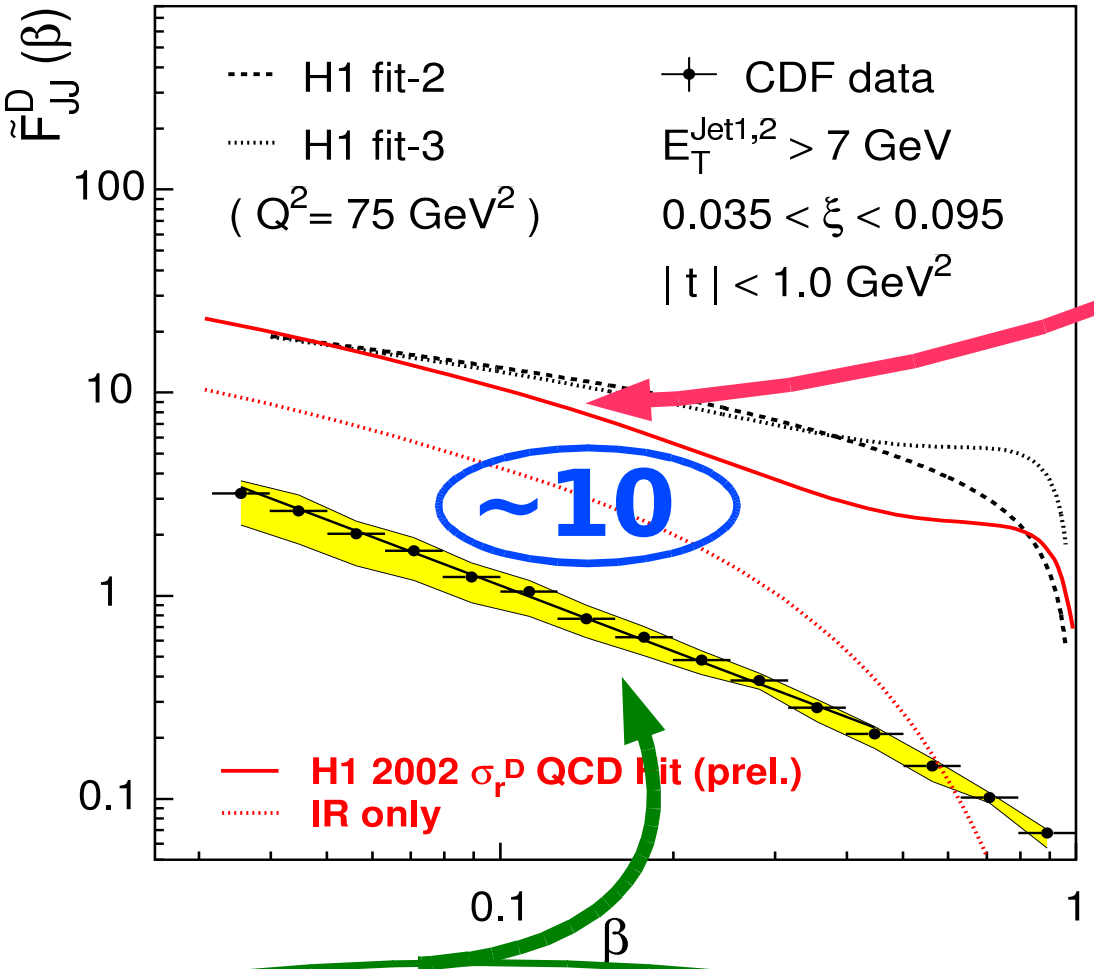
Factorization is valid for Dijets DIS

Fit A

Fit B

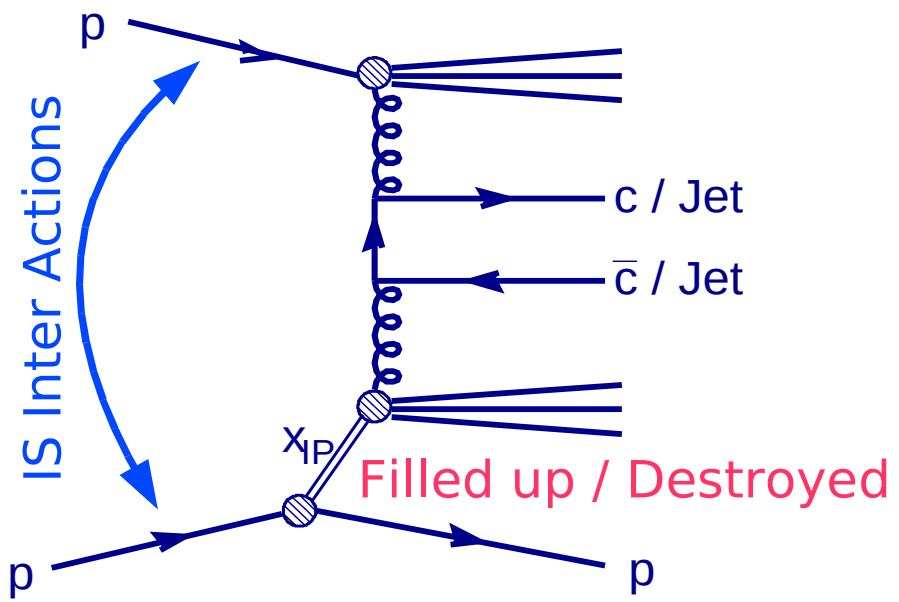
Cmb Fit

Breakdown of Factorisation



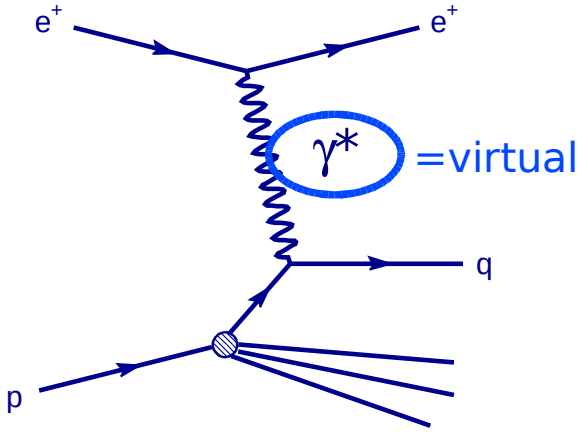
DPDFs H1 Fit 2002 (prel.)

Diff. Dijet Data from **CDF**



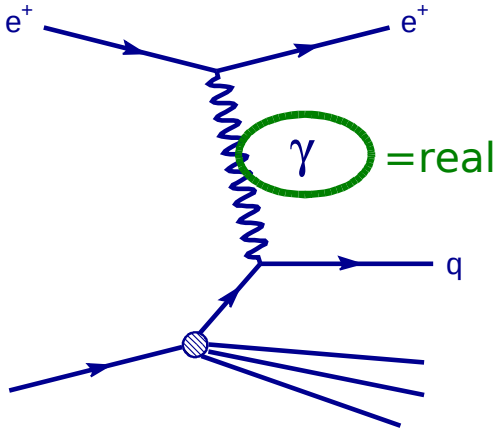
Transition from **ep** to **Hadron-Hadron**

DIS

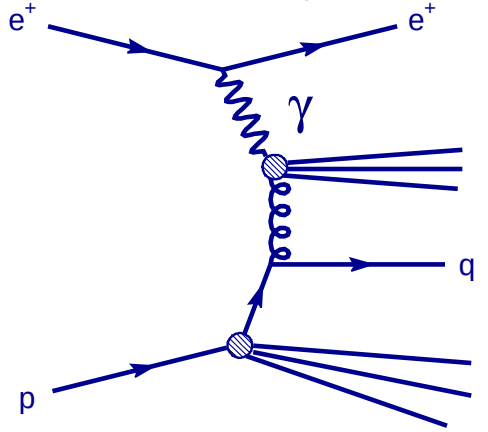


Lepton-Hadron

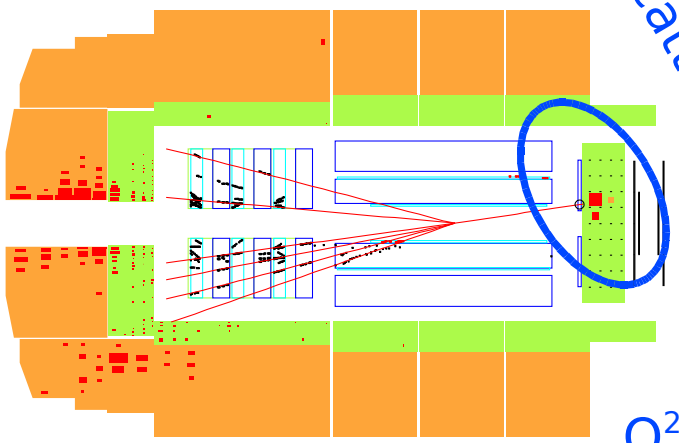
Photoproduction (γp)



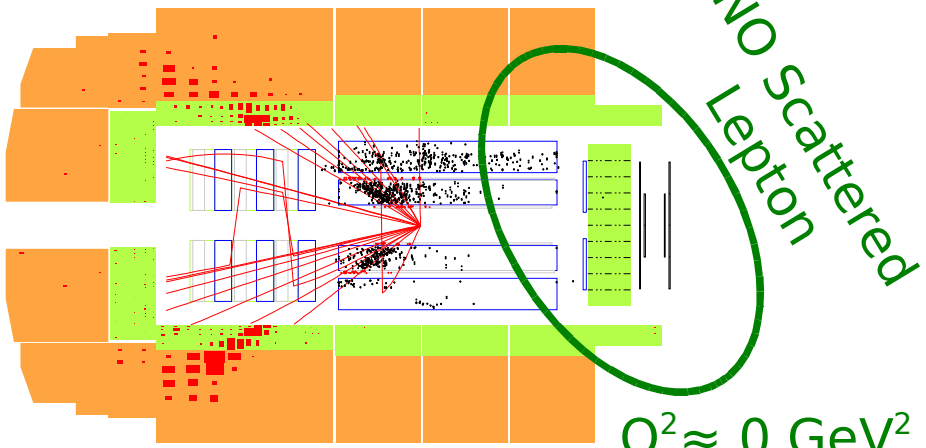
Photon-Hadron



Hadron-Hadron



$Q^2 >> 1$ GeV^2



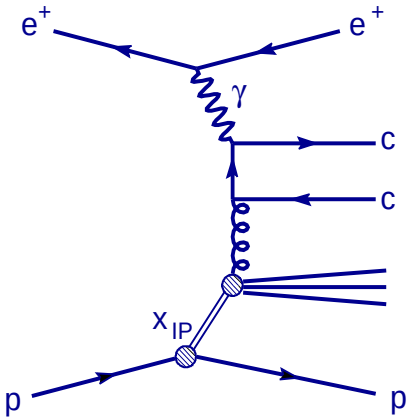
$Q^2 \approx 0$ GeV^2

Disentangle **Direct** & **Resolved** in γp

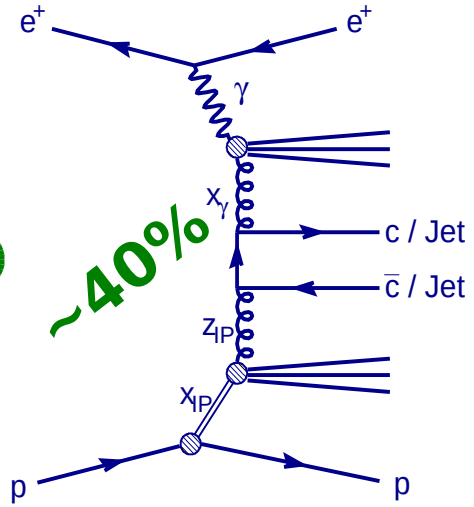
Direct γp

Resolved γp

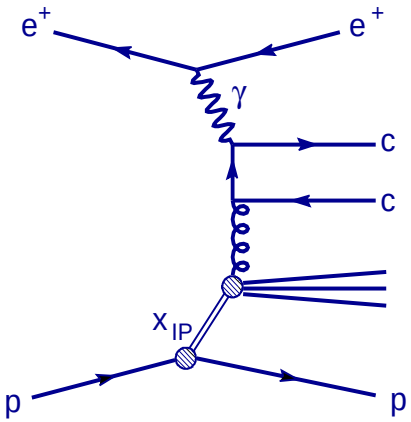
Dijets



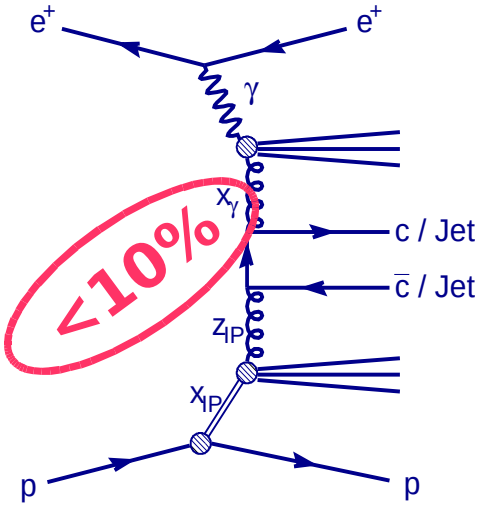
$1 > x_\gamma > 0$



charm



x_γ: can not be reconstructed

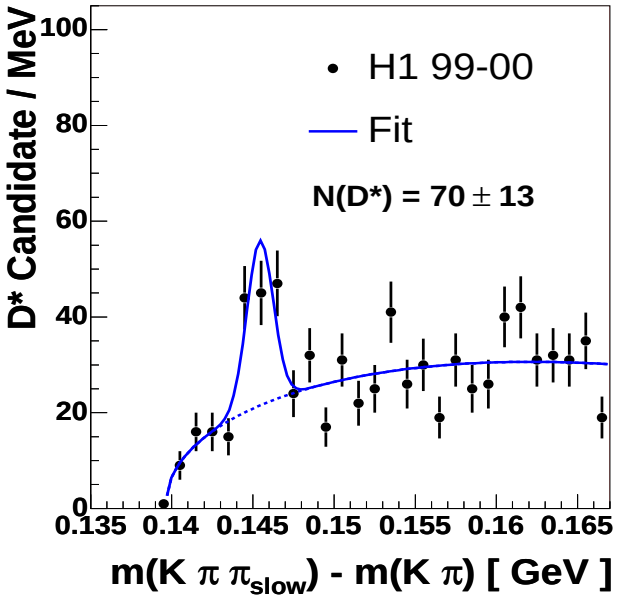


Diffractive *charm* & **Dijet** Production (γp)

charm Selection (prel 2006):

- $D^* \rightarrow K \pi \pi_s$
- $p_t(D^*) > 2$ GeV
- $|\eta(D^*)| < 1.5$
- $Q^2 < 0.01$ GeV^2
- $0.3 < y < 0.65$
- $x_{IP} < 0.04$; $M_Y < 1.6$ GeV, $|t| < 1$GeV^2

N(D*) = 70

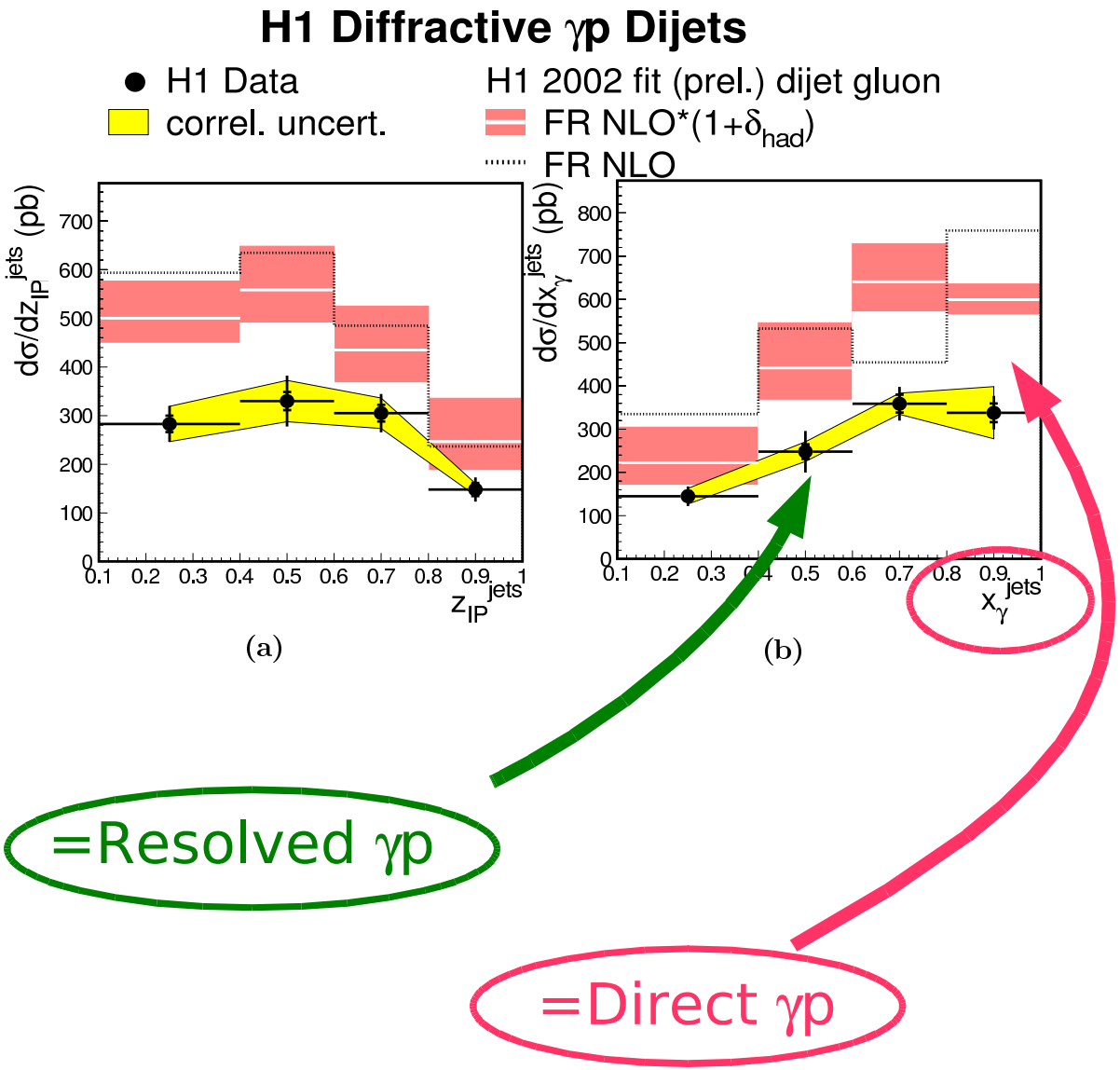


Dijet Selection (prel 2004):

- Incl k_t in γp cms (y=1)
- $p_t^{*Jet1} > 5$ GeV
- $p_t^{*Jet2} > 4$ GeV
- Jets well contained within Calo's in labframe ($-3 < \eta^{*lab}_{Jet} < 0$)
- $Q^2 < 0.01$ GeV^2
- $165 < W_{\gamma p} < 242$ GeV
- $x_{IP} < 0.03$; $M_Y < 1.6$ GeV, $|t| < 1$GeV^2

N(Dijet) = 1365

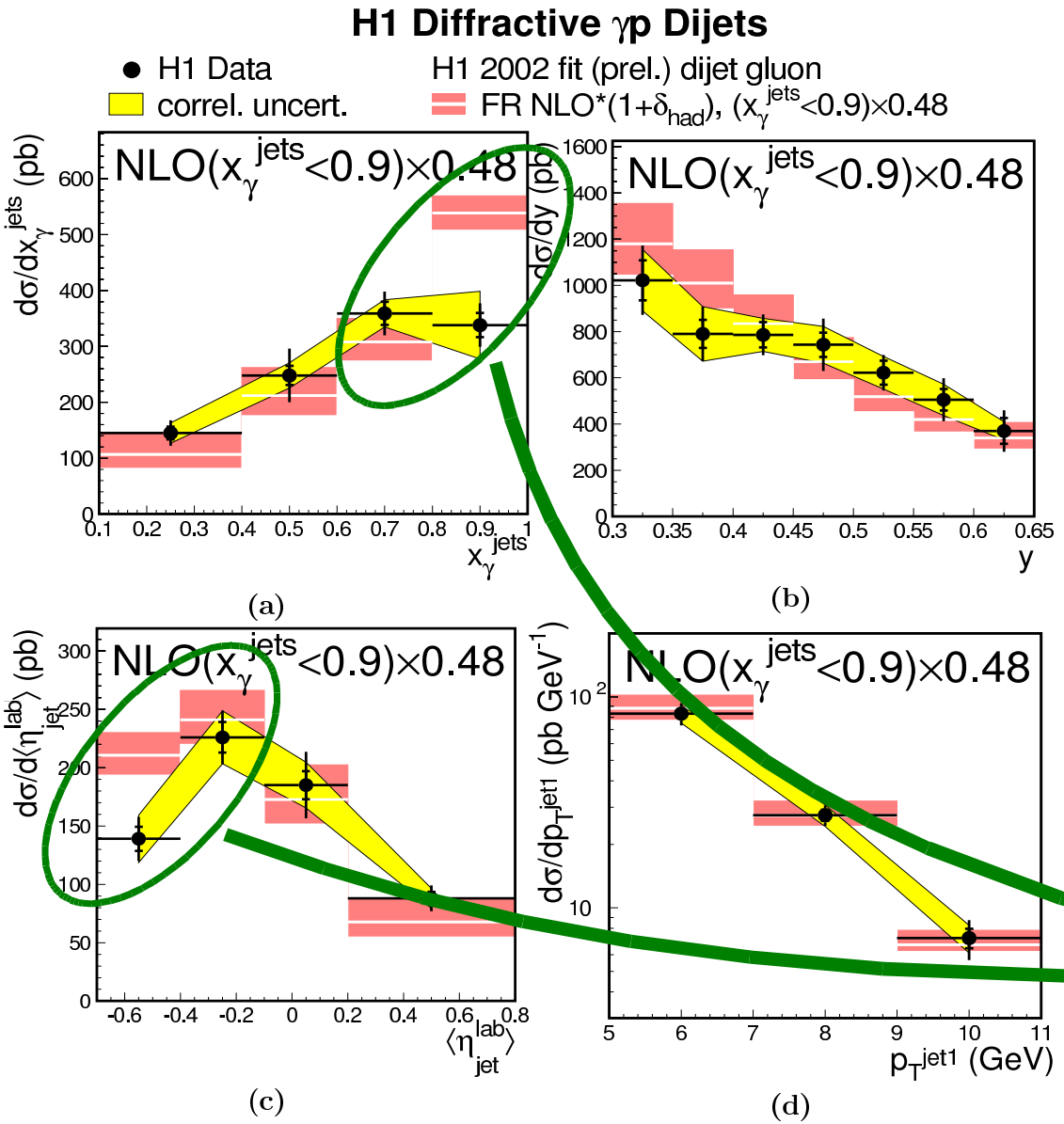
Comp with NLO: **Dijets (γp)** (prel 2004)



- **NLO**: Frixione et al.
- **DPDFs**: H1 fit 2002 (prel.)
- $\mu^2 = E^{*2}_{t\ Jet1}$
- $\langle\mu^2\rangle \sim$ **36 GeV²**
- $\langle z\rangle \sim$ **0.4 – 0.5**
- NLO overestimates data by ~**2** !!!

Factorization breaking for Dijets in γp

Downscaling of Resloved: **Dijets (γp)** (prel 2004)



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- $\mu^2 = E^{*2}_{t,\,Jet1}$
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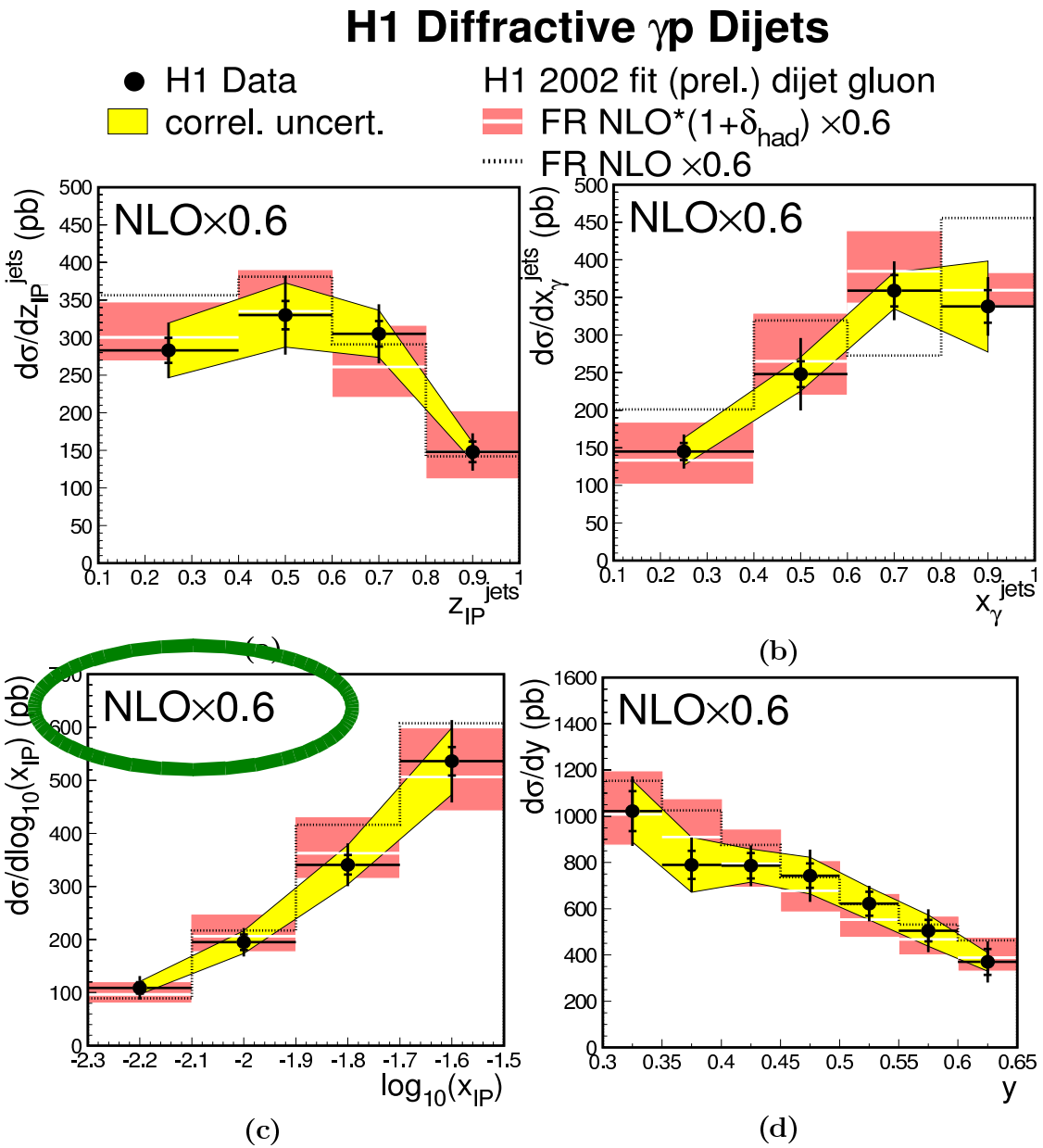
- NLO overestimates data by factor **2** !!!

Downscaling only of resolved γp

Cannot describe data

Global Downscaling: **Dijets (γp)** (prel 2004)



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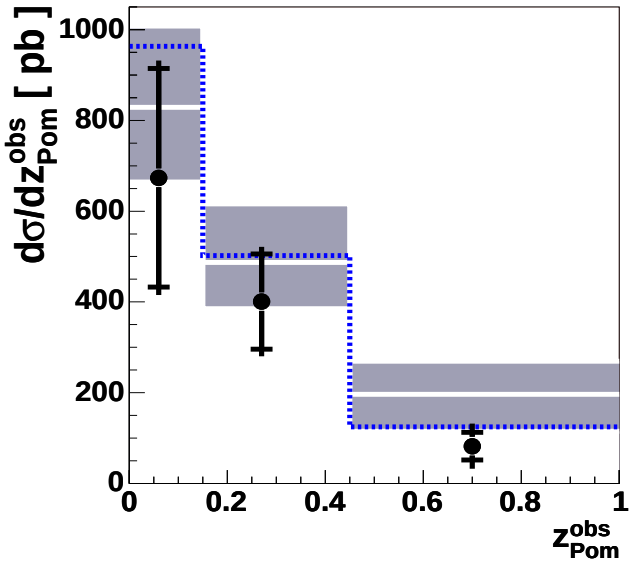
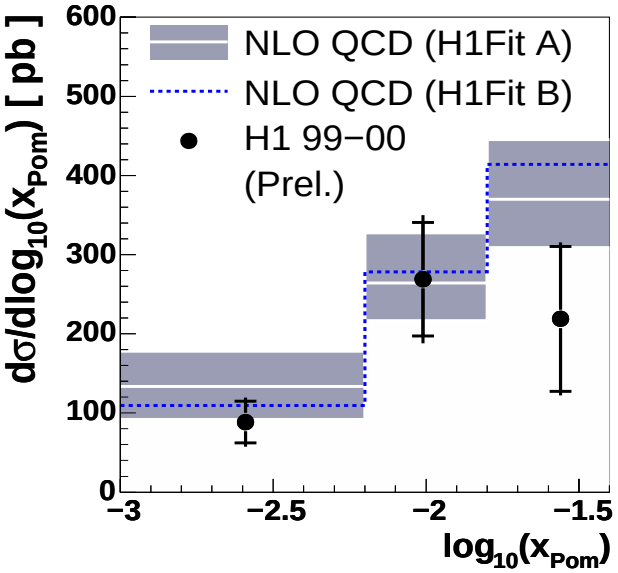
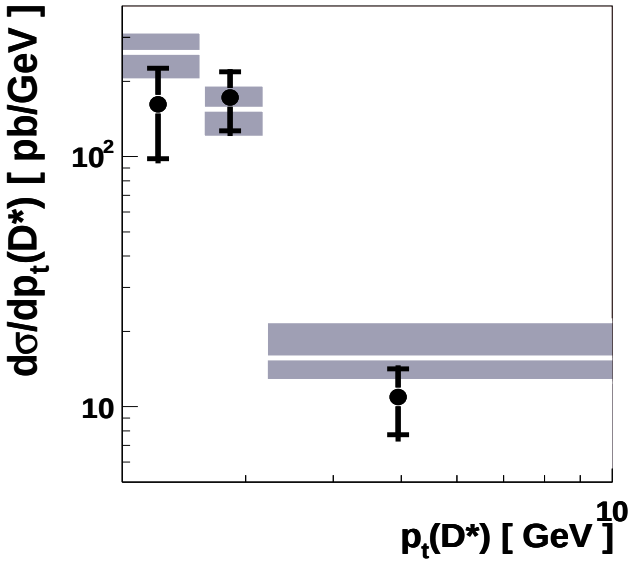
Downscaling of direct + resolved γp

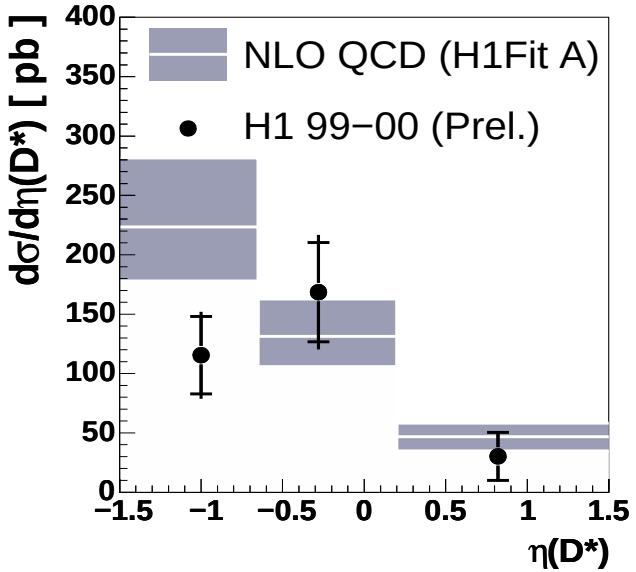
Does much better!!!

Comparison with NLO: *charm* (γp) (prel 2006)









- **NLO**: Frixione et al. (massive scheme)
- **DPDFs**: H1 2006 DPDF Fit A & B
- $\mu^2 = (4m_c^2 + p_t^2)$
- $\langle\mu^2\rangle \sim$ **11 GeV²**
- $\langle z\rangle \sim$ **0.2 – 0.3**
- Good description!

Factorization seems to be valid for D*'s in γp

Summary

Current News from HERA:

New DPDFs from semi-Inclusive diff. scattering are available!

Apply to more exclusive final states @ HERA

QCD Factorization:

	DIS	γp
charm	+	+
Dijets	+	-

Low statistics + large NLO uncert.'s at low scales

Dijets provide **BIG improvement** of DPDFs for gluon at high z

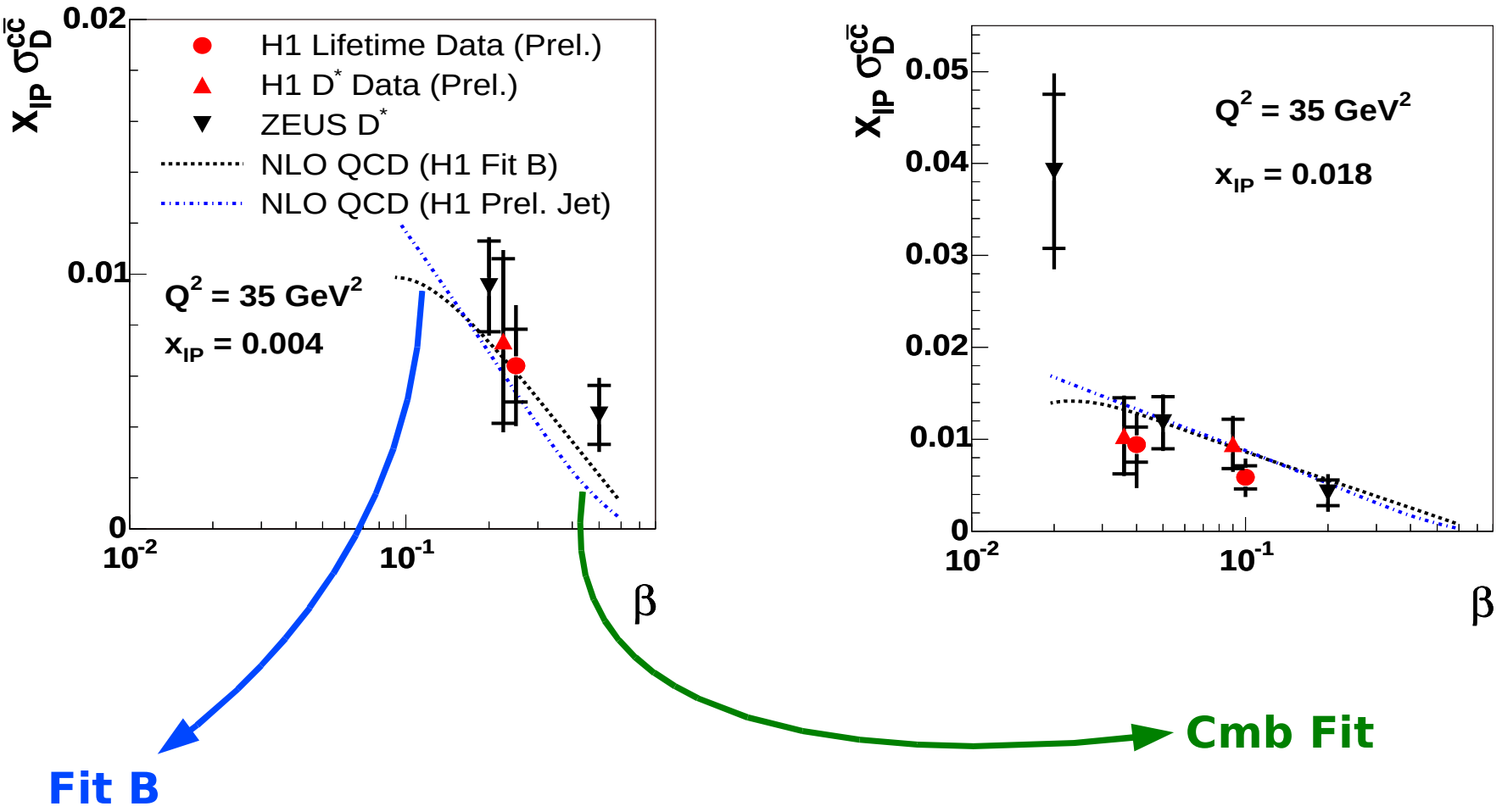
Breakdown of factorisation both in **direct** & **resolved** γp

Backup

- Comparison of F2D(charm) with cmb fit
- Comparison of D*'s in photoproduction with cmb fit
- *charm* vs Dijets in comparison of the different DPDFs
- Old Dijet data vs new Dijet data

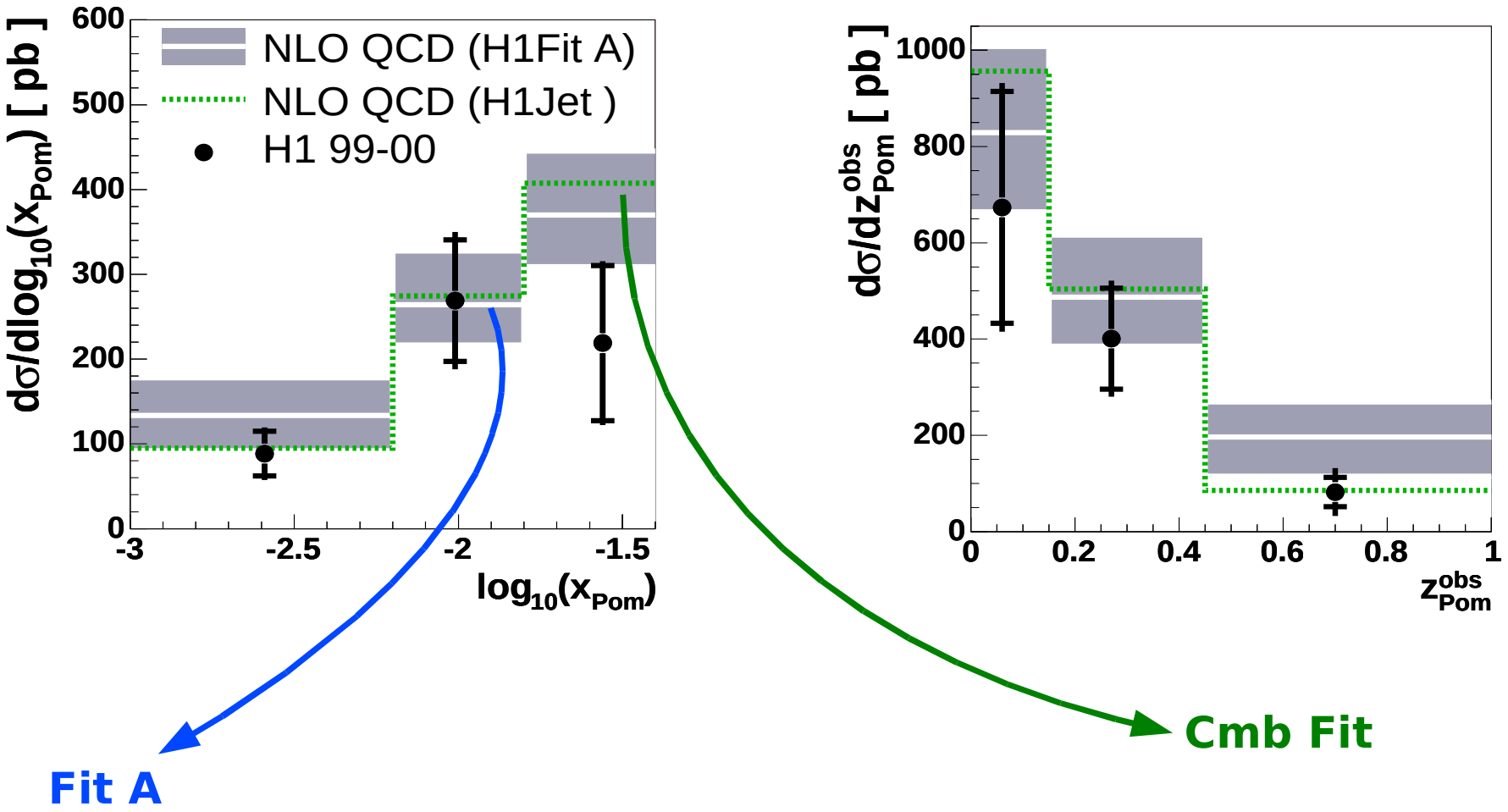
Comparison with **Cmb Fit**: ***charm*** **(DIS)**

charm **contribution to F2D:**

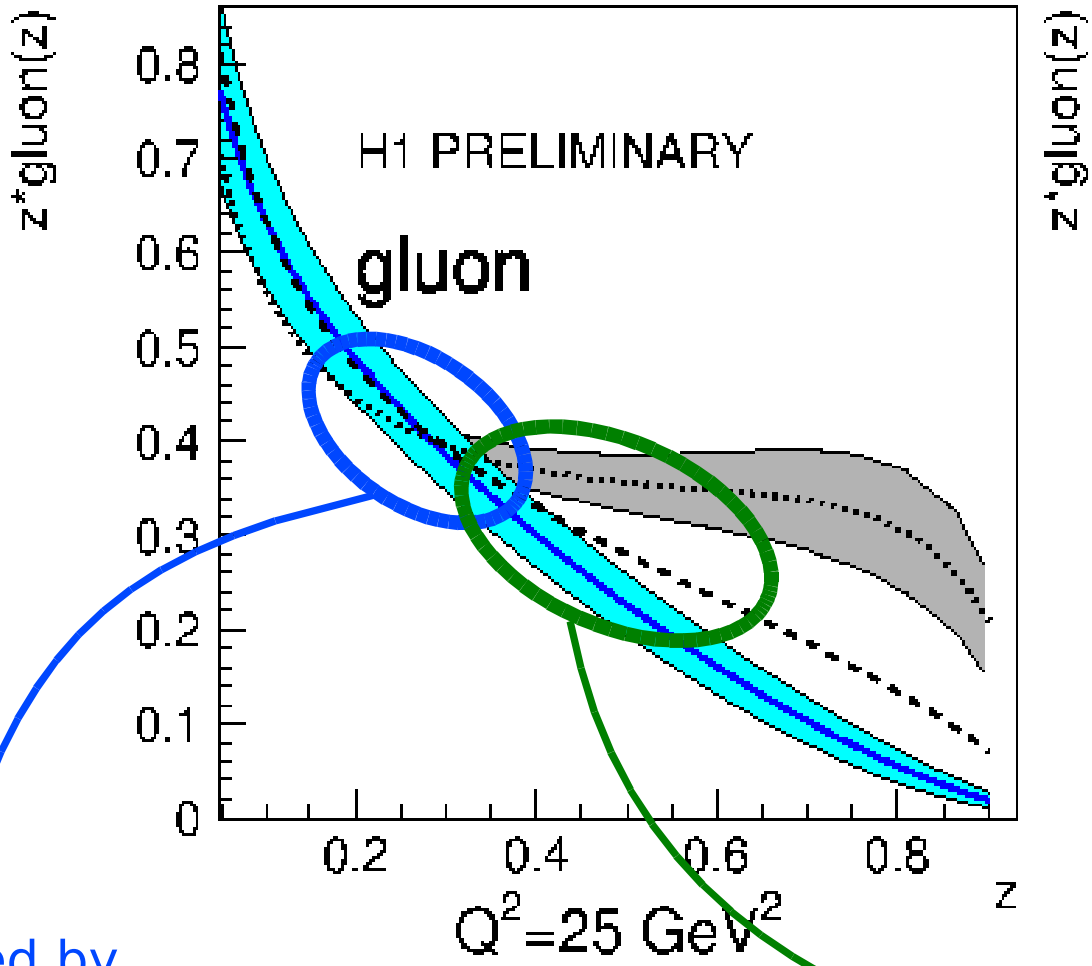


Comparison with **Cmb Fit**: ***charm*** **(γp)**

Diffractive D*:



charm vs **Dijets**

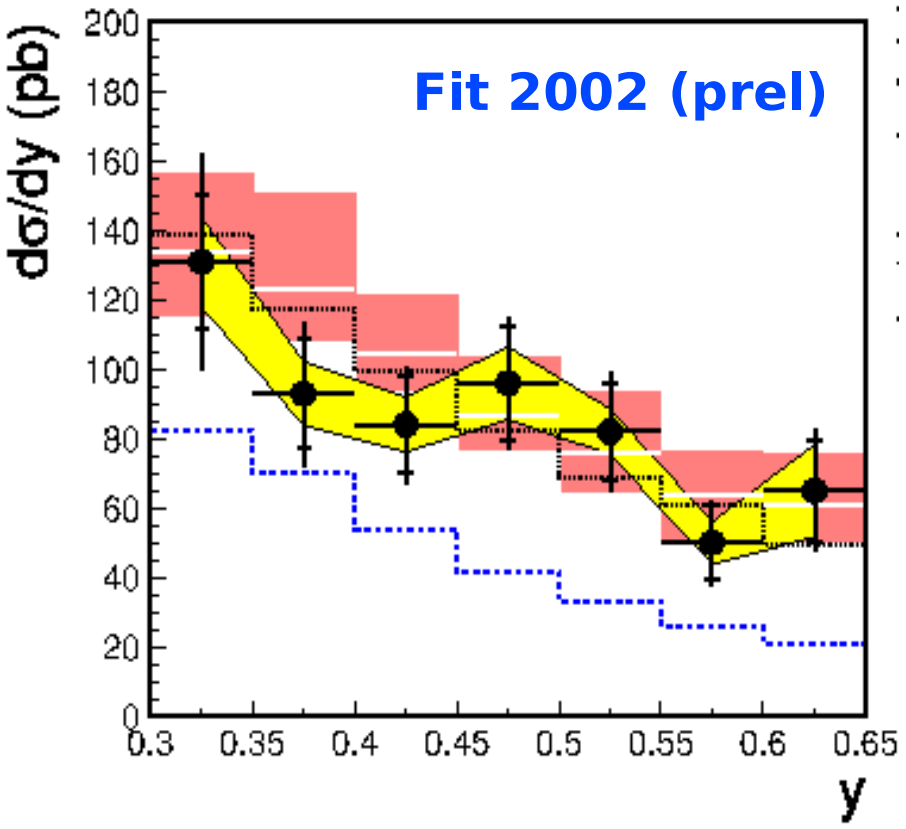


This region probed by ***charm*** measurement

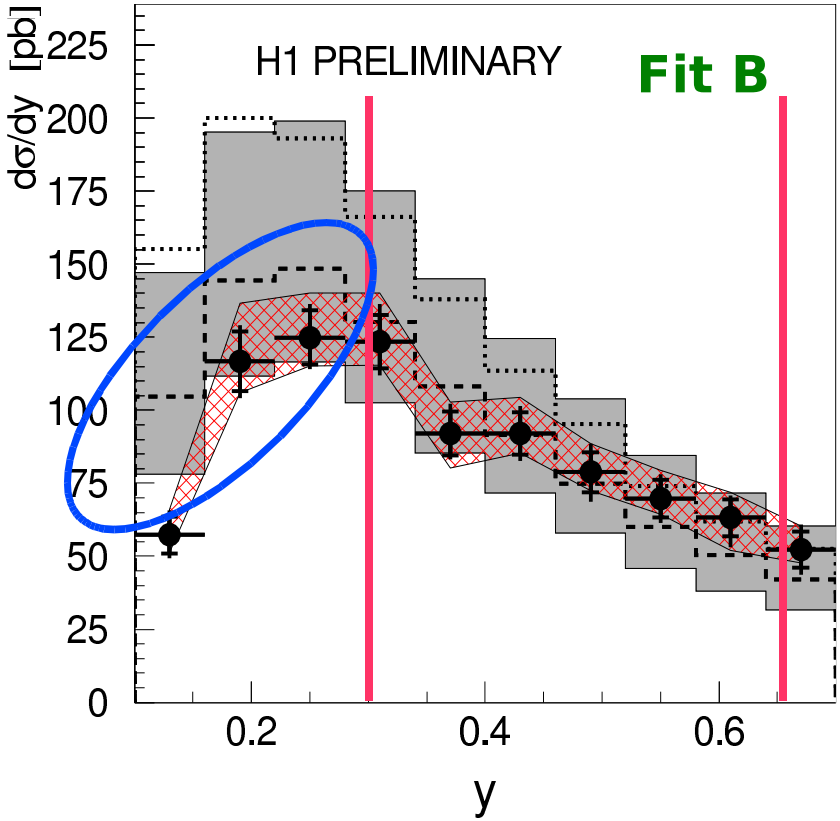
This region probed by **Dijet** measurement

Old Dijet Data vs **new Dijet** Data

Old Dijet Data:



New Dijet Data:



- **Also Problems** with z_{IP} for old data sample
- Problems are **enhanced** by larger y range (0.05<y<0.3)