Diffractive charm and jet production

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on behalf of the H1 and ZEUS collaborations

Contents:

- $D^{*\pm}$ Meson Production in Deep-Inelastic Diffractive Scattering
  (Abstract 6-178)
- Dijets in Diffractive Photoproduction and Deep-Inelastic Scattering
  (Abstract 6-0177, 6-0249)

Diffraction at HERA

Diffractive interactions:

- interactions without exchange of color
- only exchange of quantum numbers of the vacuum

Identification in ep collisions:

- quasi-elastic scattered beam hadron with only small momentum loss
- rapidity gaps due to colorless exchange

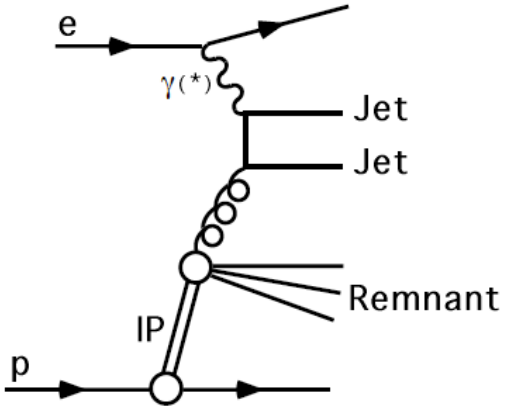
Process classification:

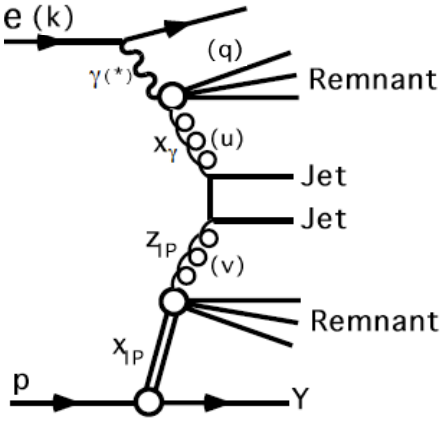
Deep-Inelastic Scattering (DIS):

- exchange of a virtual photon
- photon interacts directly with proton

Photoproduction (PhP):

- exchange of a quasi-real photon:
  - **direct PhP** (similar to DIS):
    - photon interacts directly with proton
  - **resolved PhP** (analog to $p\bar{p}$):
    - hadronic structure of photon interacts with proton



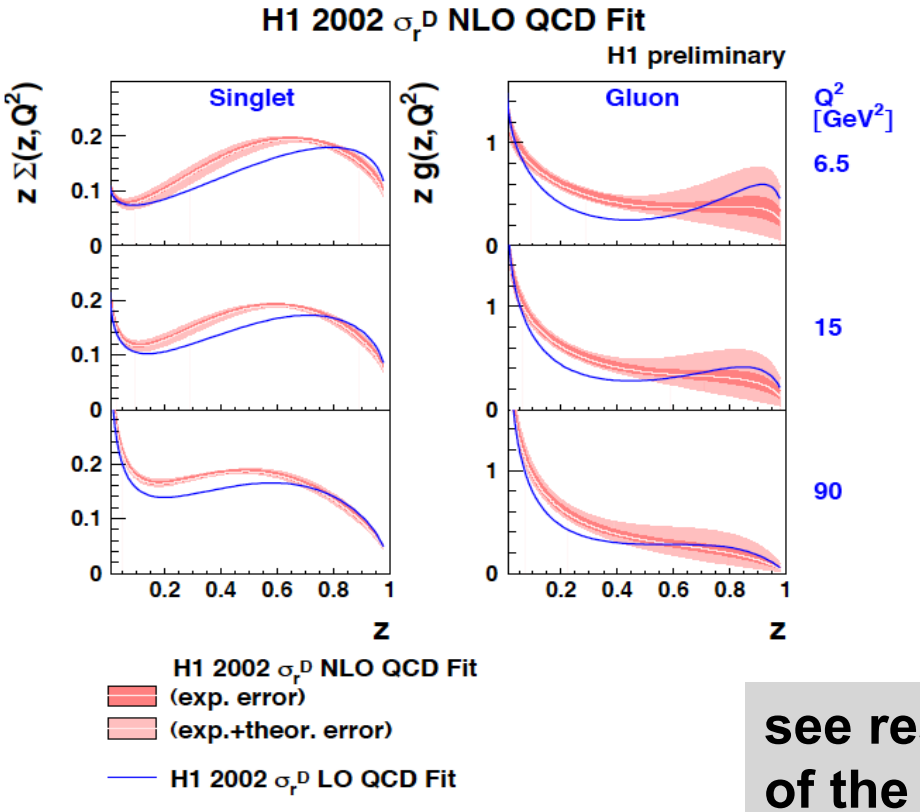


x_γ	longitudinal photon momentum fraction entering the hard subprocess
x_{IP}	longitudinal proton momentum fraction entering the diffractive interaction
z_{IP}	longitudinal momentum fraction of the diffractive exchange entering the hard subprocess (determined by the final states)
β	longitudinal momentum fraction of the parton of the diffractive exchange entering the hard subprocess

QCD factorization in diffractive DIS

Theory: diffractive processes in DIS **factorize** in **diffractive parton distributions (dPDFs)** convoluted with **hard scattering coefficients** (analog to inclusive QCD factorization):

$$\sigma(\gamma^* p \to XP) \sim p_{q/p}(x_{IP}, t, x, Q^2) \otimes \sigma_{\gamma^* q}(x, Q^2)$$



(see also talk of M. Kapishin)

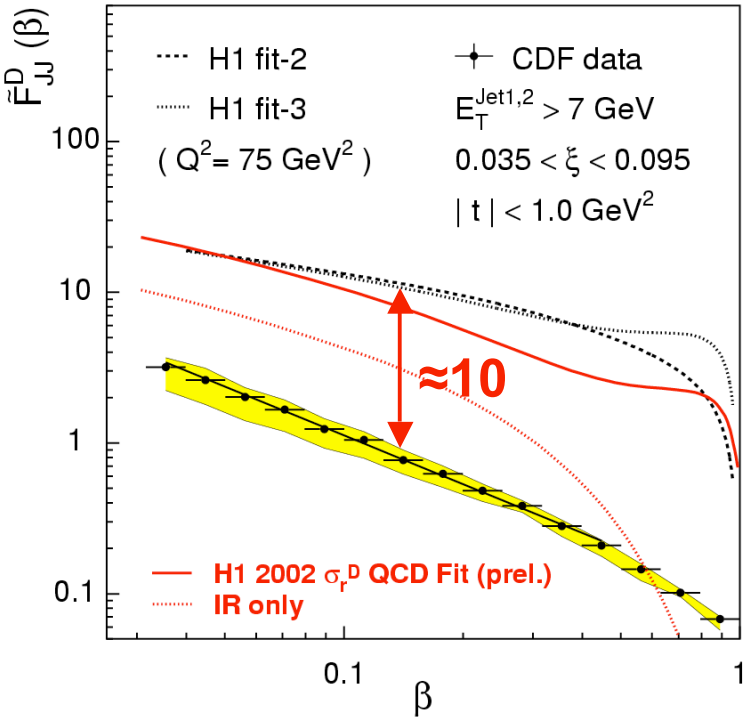
consequences:

- diffractive parton densities are **universal**
- **pQCD evolution**
- matrix elements for hard scattering are **the same** as for standard DIS processes

see rest of the talk for experimental tests of the validity of QCD factorization in DIS

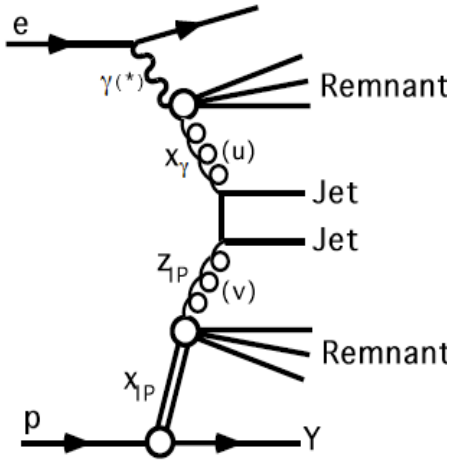
QCD factorization in $p\bar{p}$ at Tevatron and resolved PhP at HERA?

Tevatron:



- CDF dijet measurement
  ~ factor 10 lower than prediction using dPDFs from inclusive diffractive DIS

Theory expectation for HERA:



- photon interacts hadronically in resolved PhP
- expected similar suppression effect as in $p\bar{p}$-collisions

Kaidalov, Khoze, Martin and Ryskin:
Theoretical prediction of the suppression factor of the resolved contribution (rescattering effect):
R=0.34

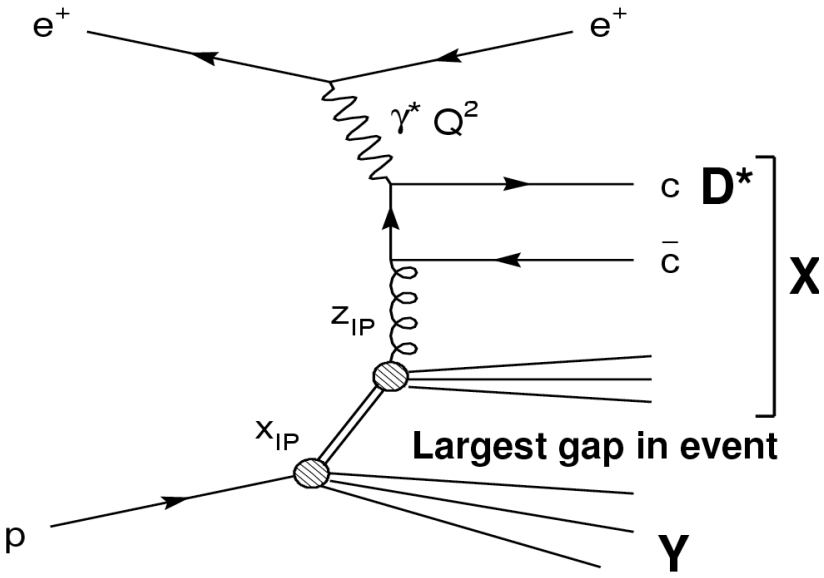
(A. B. Kaidalov, V. A. Khoze, A. D. Martin and M. G. Ryskin, "Unitarity effects in hard diffraction at HERA",Phys. Lett. B**567** (2003) 61)

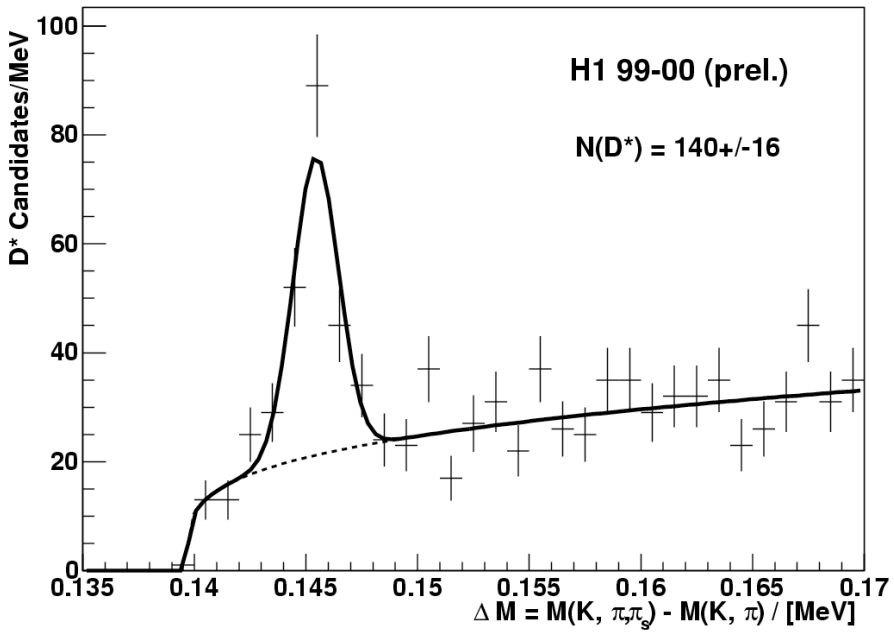
Klasen and Kramer:
In **LO no suppression,** in **NLO suppression of the resolved contribution**

(M. Klasen and G. Kramer, "Factorization breaking in diffractive photoproduction of dijets", hep-ph/0401202.)

Diffractive $D^{*\pm}$ in DIS - selection

- **Test of factorization** in **heavy flavour production** in diffractive DIS
- chosen flavour: **charm** by **D*-selection**





- Diffractive Selection:
  - $x_{IP} < 0.04$
- DIS Kinematic Range:
  - $2 < Q^2 < 100\ GeV^2$
  - $0.05 < y < 0.7$
- Number of selected $D^{*\pm}$:
  - **140 ± 16**

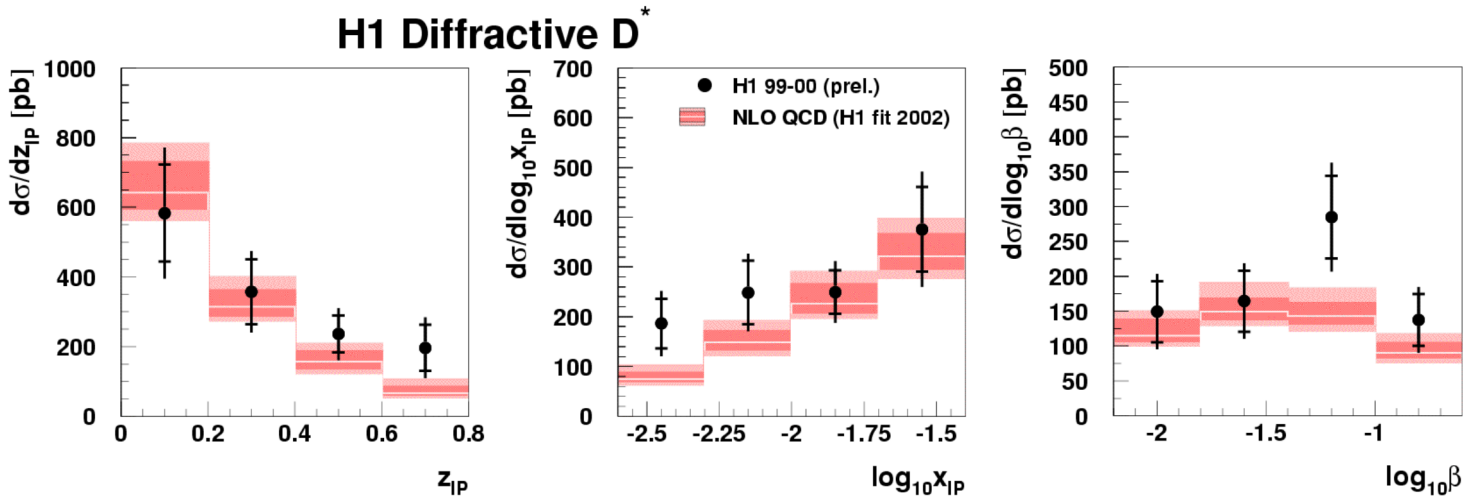
Diffractive $D^{*\pm}$ in DIS

- **total diffractive $D^{*\pm}$ cross section** $\sigma(ep \to (D^{*\pm}X)Y)$ for $x_{IP} < 0.04$:

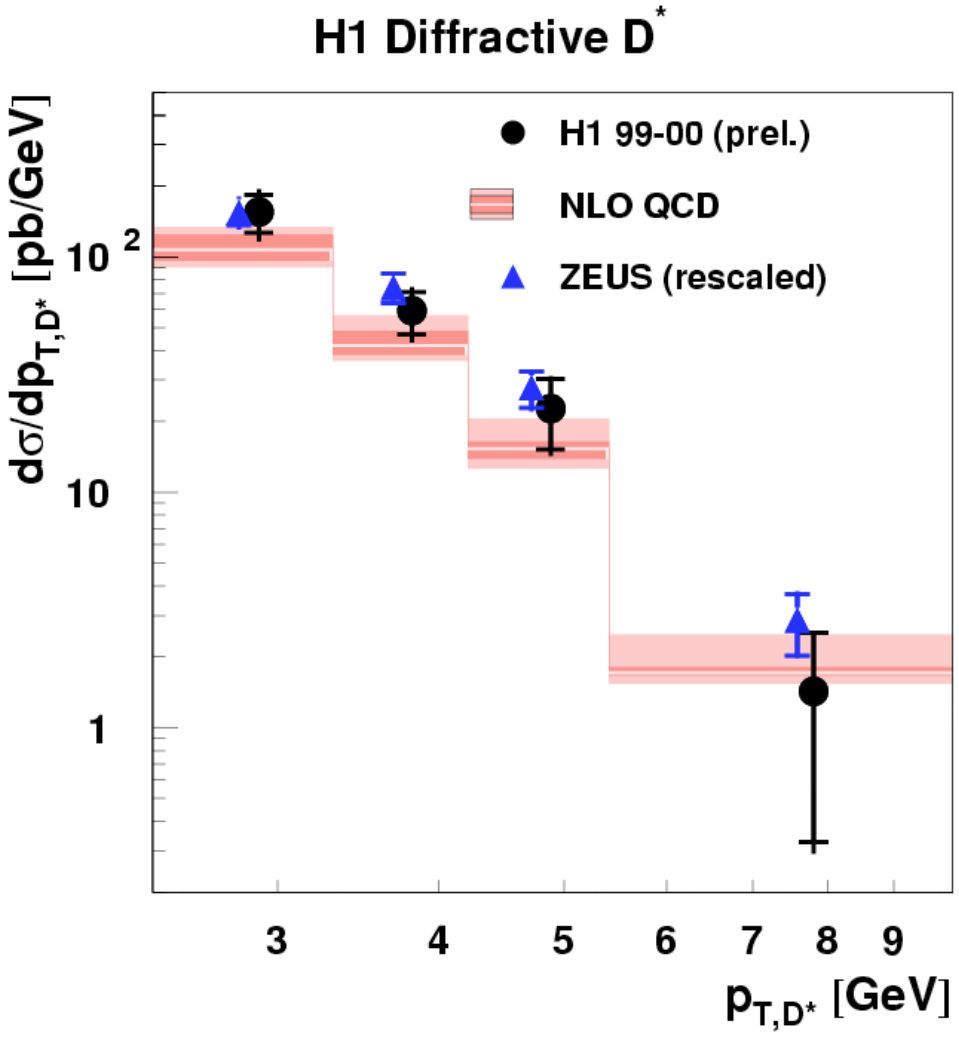
H1 data	**$333 \pm 38(stat.) \pm 57(syst.)$ pb**
H1 NLO	**241^{+66}_{-39} pb**
ZEUS Data (extrapolated from different phase space[1])	**$305 \pm 25(stat.)\ ^{+20}_{-34}(syst.)$ pb**

1: ZEUS Collaboration, S. Chekanov et al, Nucl. Phys. **B672** (2003) 3

- **differential diffractive $D^{*\pm}$ cross section**:



Diffractive $D^{*\pm}$ in DIS

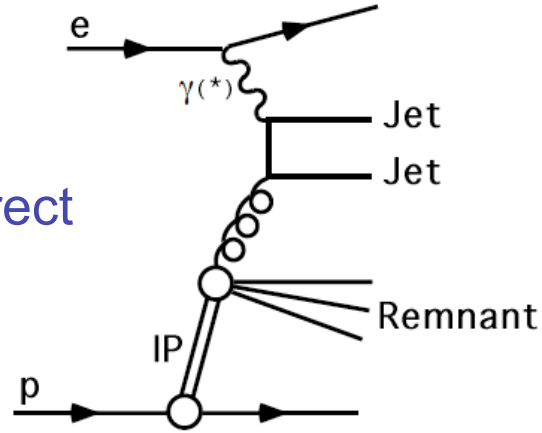


- **NLO** predictions below the data **but agreement within errors**
- **shapes well described**
- agreement with published **ZEUS** results
- agreement suggests **validity** of QCD factorization in diffractive DIS

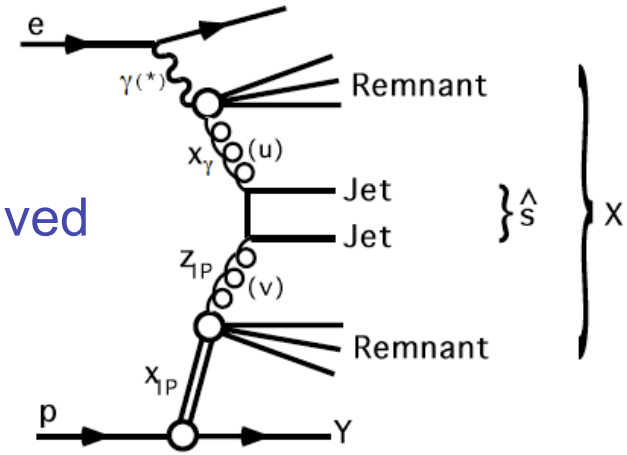
Diffractive dijets in DIS and PhP - selection

Test of factorization in dijet events in diffractive DIS (H1) and diffractive PhP (H1 and ZEUS)

direct

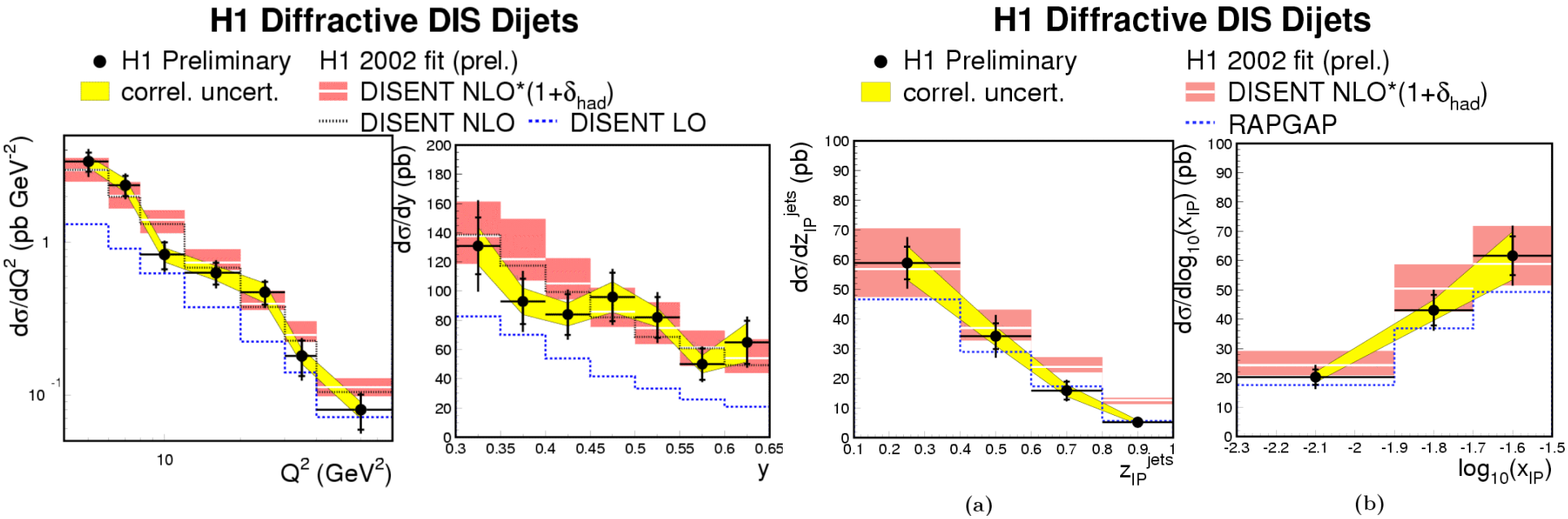


resolved



	diffractive selection	dijet selection	DIS selection	PhP selection
H1	$x_{IP} < 0.03$	• $E_T^{*,1(2)} > 5\ (4)$ GeV	$4 < Q^2 < 80$ GeV^2	• $Q^2 < 0.01$ GeV^2 • $0.3 < y < 0.65$
ZEUS	$x_{IP} < 0.035$	• $E_T^{1(2)} > 7.5\ (6.5)$ GeV		• $Q^2 < 1.0$ GeV^2 • $0.2 < y < 0.85$

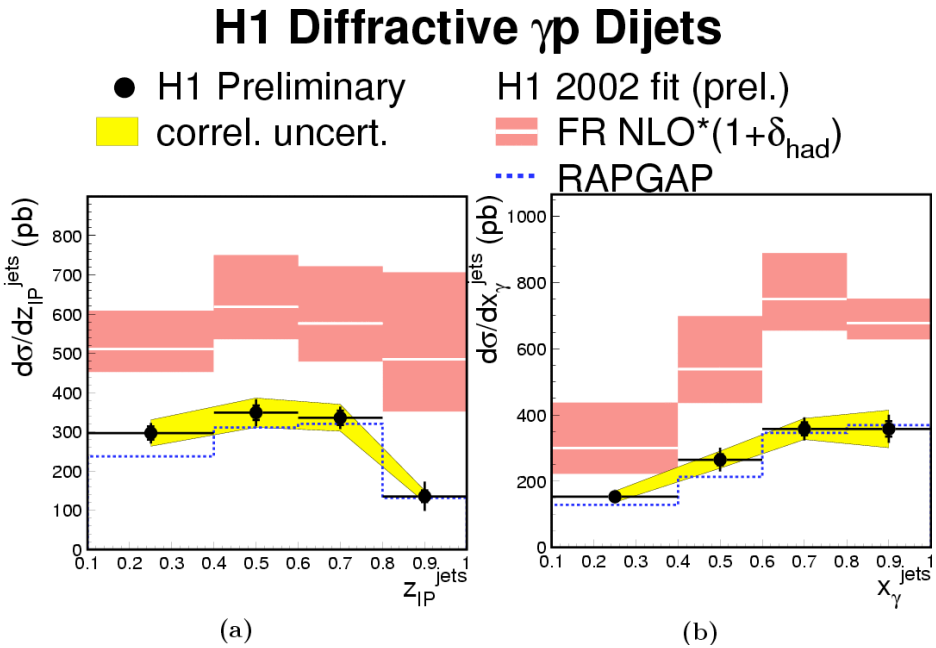
Diffractive dijets in DIS

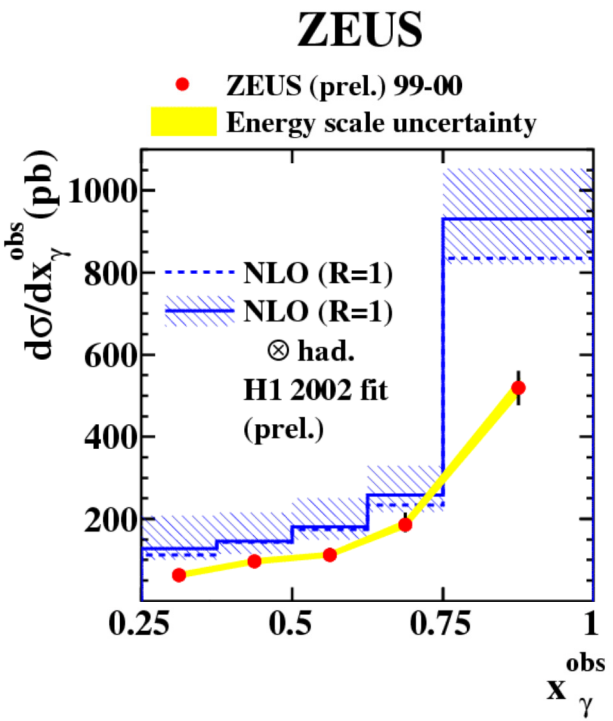


(a) (b)

- **Uncertainties** of the **gluon density in the diffractive PDFs** are not shown
- **NLO** prediction in **good agreement** with measurement
- measurements **support QCD factorization in diffractive DIS**

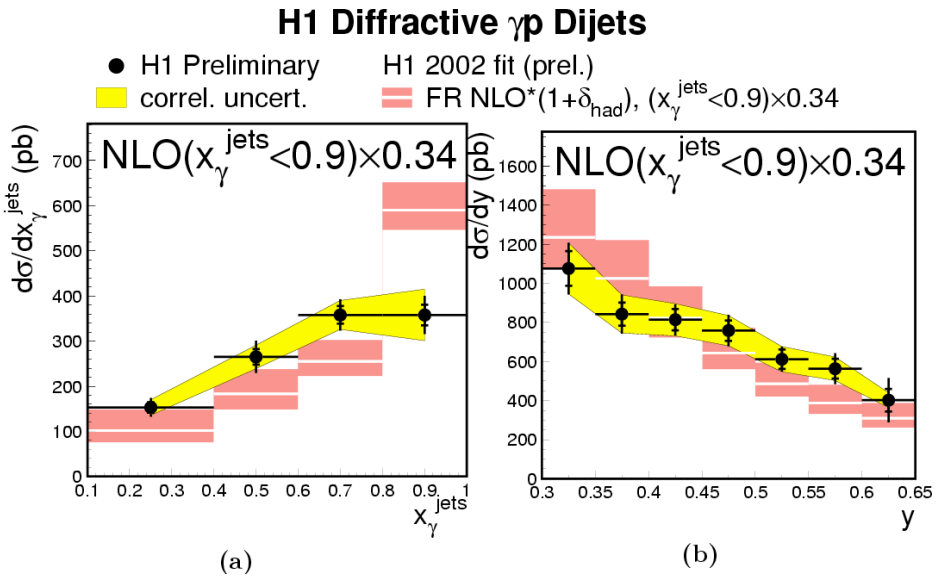
Diffractive dijets in photoproduction

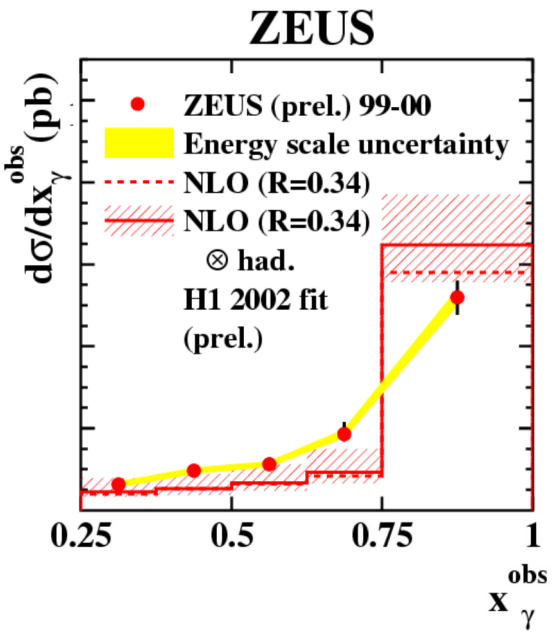




- **NLO** prediction using diffractive PDFs is **above data** by **factor ~ 2** compared to a factor ~ 10 at the Tevatron

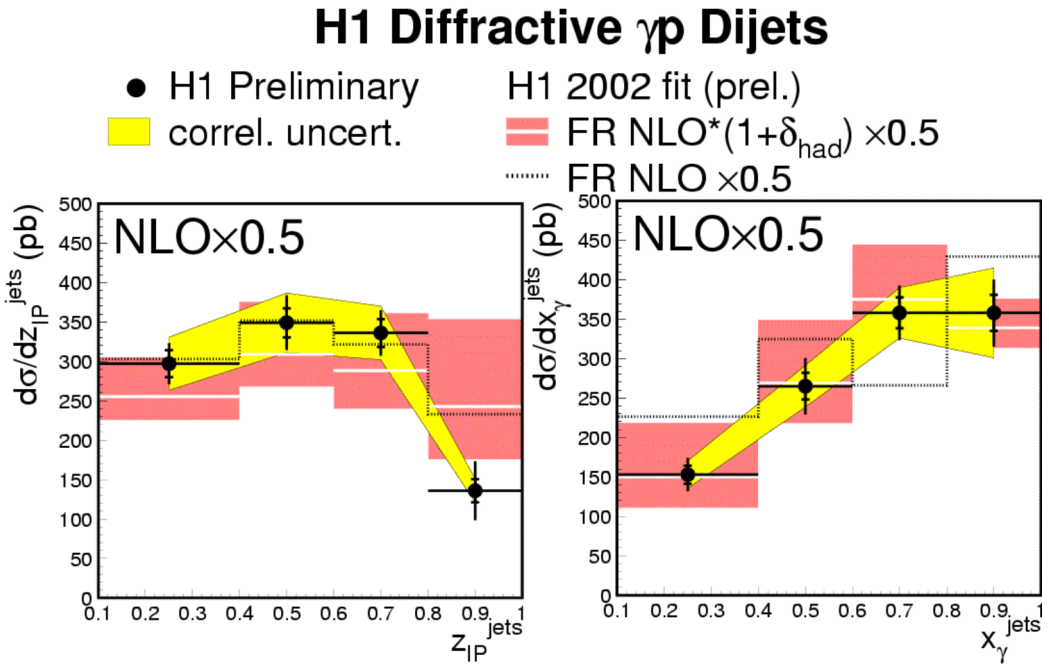
Diffractive dijets in photoproduction





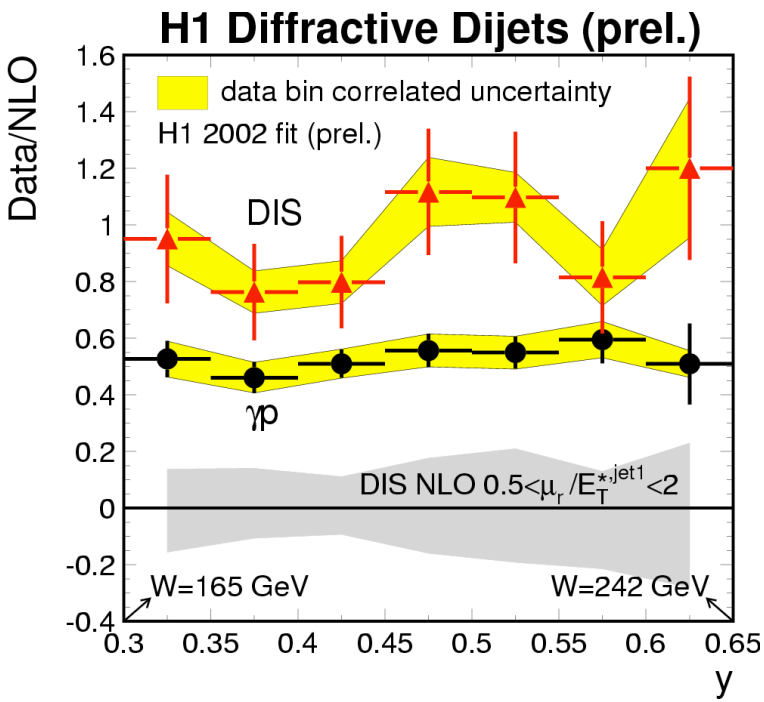
- suppression of only the resolved contribution by **a factor 0.34 is disfavored** by the measurements

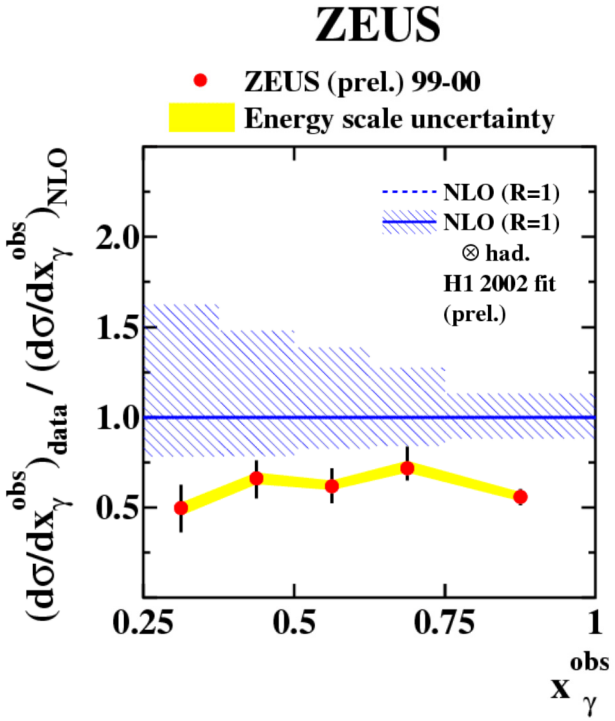
Diffractive dijets in photoproduction



- **good agreement** with NLO prediction using diffractive PDFs **suppressed globally by a factor of 0.5**

Diffractive dijets in photoproduction



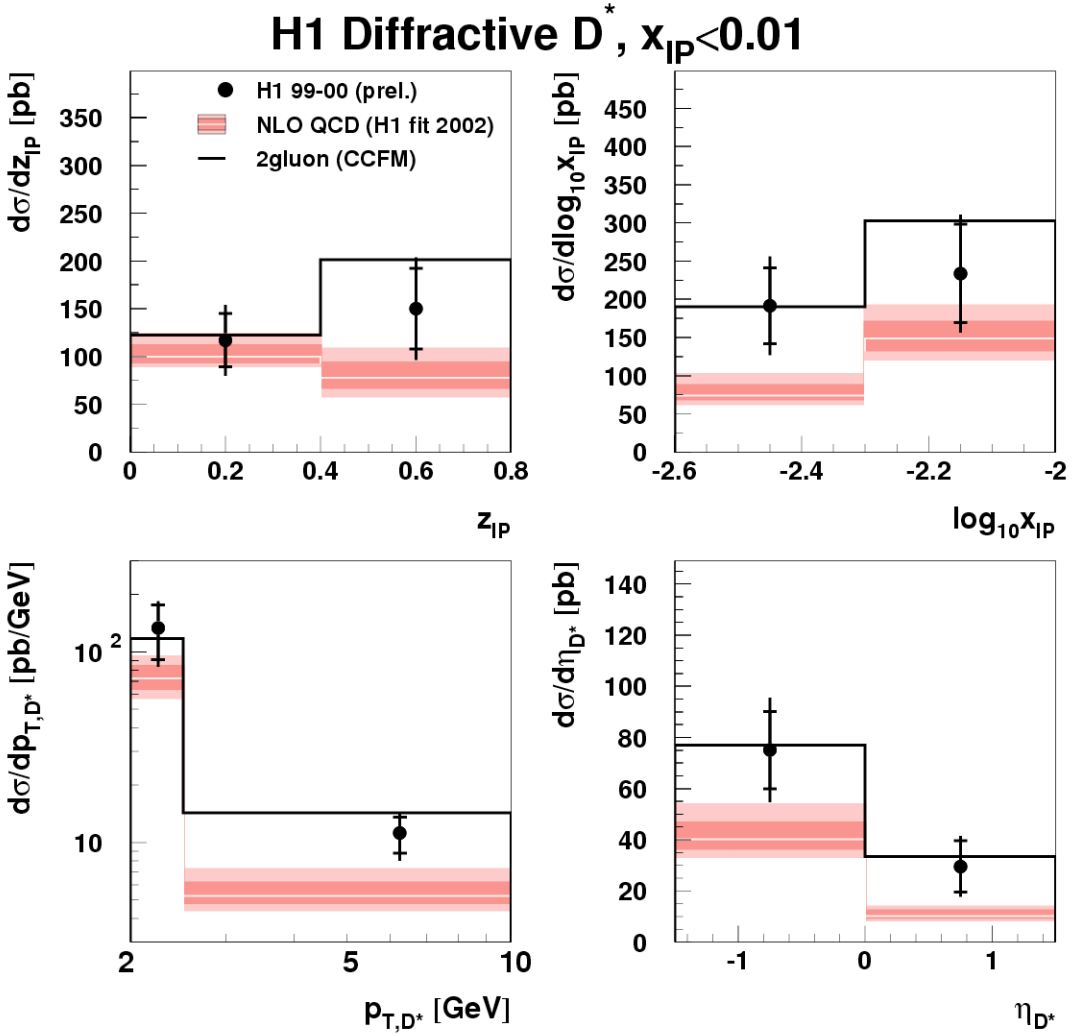


- **DIS:**
  - ratio of **data over NLO** is compatible with **1**
- **Photoproduction:**
  - ratio of **data over NLO** is **around 0.5**
  - compatible between ZEUS and H1

Summary & Conclusion

- **diffractive DIS:**
  - **$D^{*\pm}$** measurements by H1 and ZEUS suggest **validity of QCD factorization**
  - **dijet** measurement by H1 also **supports QCD factorization**
- **Diffractive Photoproduction:**
  - dijet measurements by ZEUS and H1 are compatible
  - both show that the **NLO prediction** is **above** the data **by a factor ~2**
  - H1 and ZEUS **favor a global suppression** of the QCD factorization rather than a suppression of only the resolved component

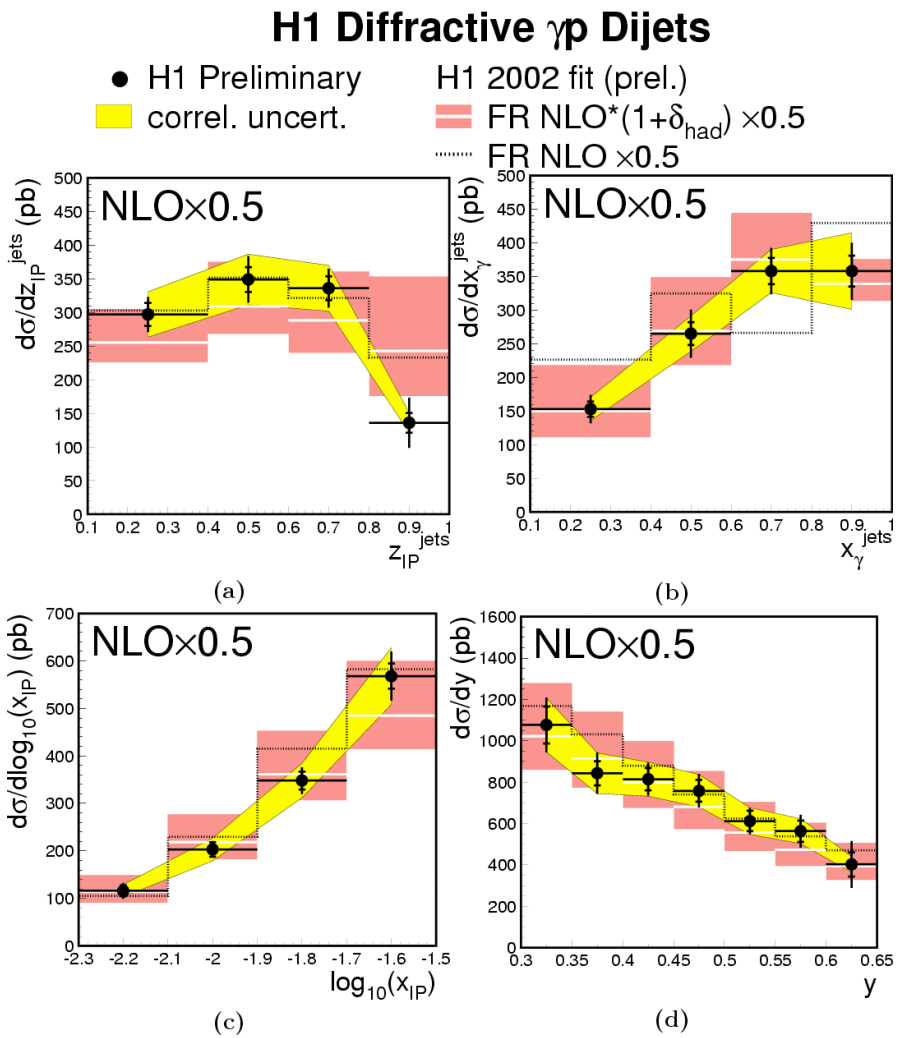
BACKUP: Diffractive $D^{*\pm}$ in DIS



perturbative 2-gluon approach

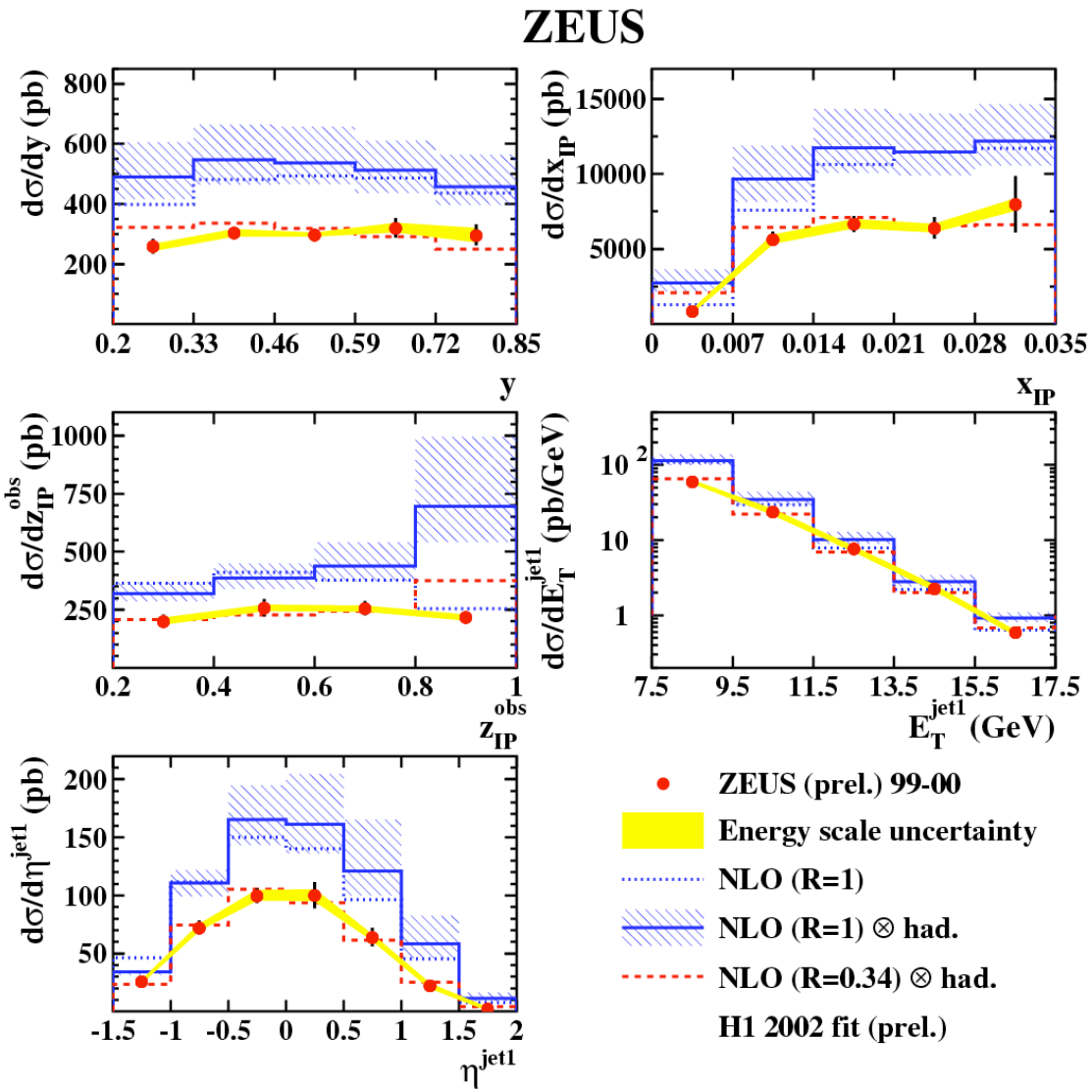
- combination of the non-diffractive un-integrated gluon densities in the proton ⇒ **2-gluon state**
- couples directly to $c\bar{c}$ or $c\bar{c}g$ without diffractive remnant
- difference to factorization approach:
  - gluon not part of the diffractive remnant
  - part of the hard process with significant transverse momentum

BACKUP: Diffractive dijets in photoproduction



- **good agreement** with applied **global scale factor of 0.5**

BACKUP: Diffractive dijets in photoproduction



- **NLO** prediction **without suppression describes shapes** of distribution