Diffractive Dijet and D* Production at HERA

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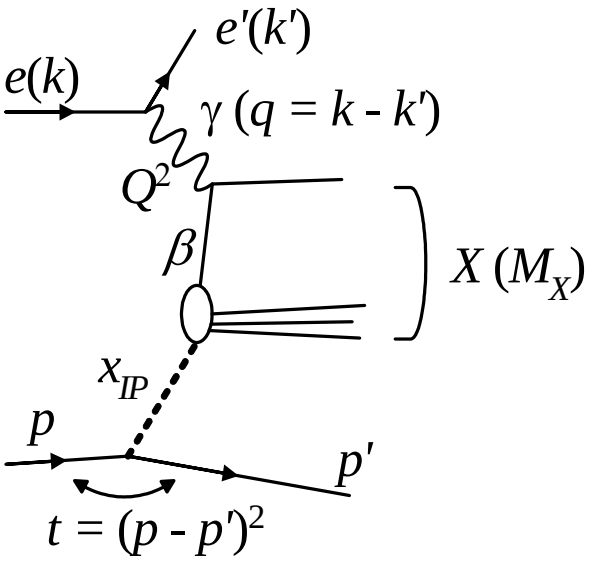
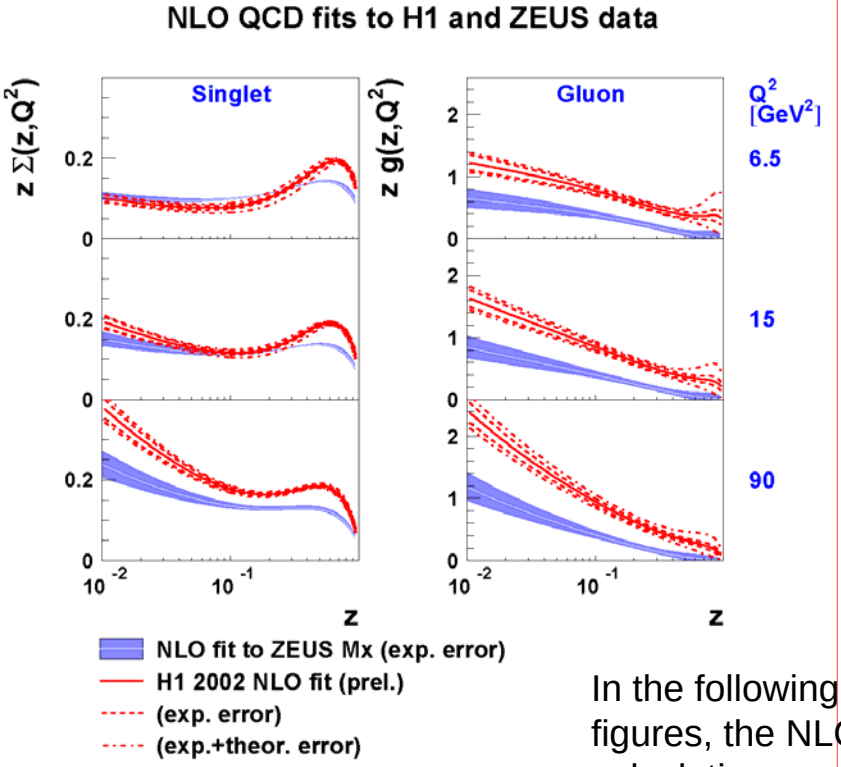
On behalf of the H1 and ZEUS collaborations

Introduction: why jet and HQ production ?

- Diffractive parton densities:
  - Extracted from $F_2^{D(3)}$ (DDIS) sensitive to quarks
- Gluons from scaling violation
  - Poorer constraint





In the following figures, the NLO calculations used the fit from the H1 data (red).

β: long. momentum fraction of the parton in the exchange

$x_{\mathbf{P}}$: long. momentum fraction of the exchange in the proton

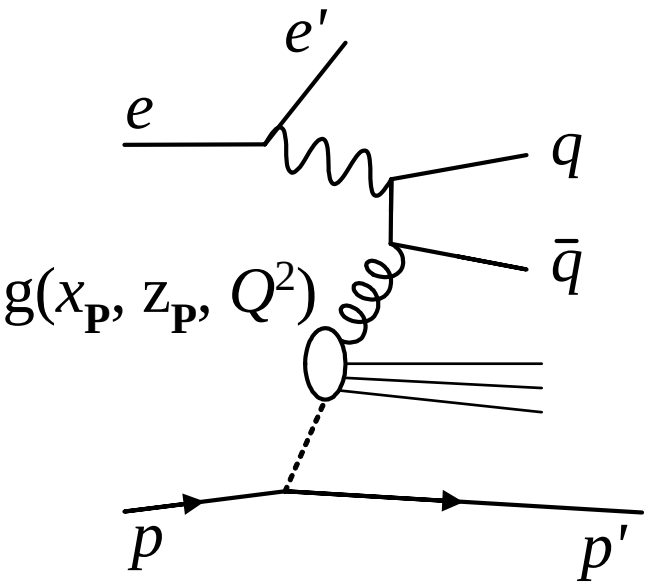
Why jet and HQ production – (1) sensitive to gluons

- Jet and HQ productions in pQCD: cross section using factorisation
  - Example: $d\sigma/dE_T$ at given $x_{\mathbf{P}}$

$$\left.\frac{d\sigma_{\gamma^* p}}{dE_T}\right|_{x_{\mathbf{P}}} = \sum_i \int_x^{x_{\mathbf{P}}} [dz \frac{d\hat{\sigma}^{i\gamma^*}(z,\mu^2,x_{\mathbf{P}})}{dE_T} f_i^D(z,\mu^2,x_{\mathbf{P}},t)]$$

- <u>Assuming the factorisation holds,</u> the jet and HQ cross sections give better constraint to the gluon density
- Dijet events can reconstruct $z_{\mathbf{P}}$
  - longitudinal momentum of the parton to the hard scattering

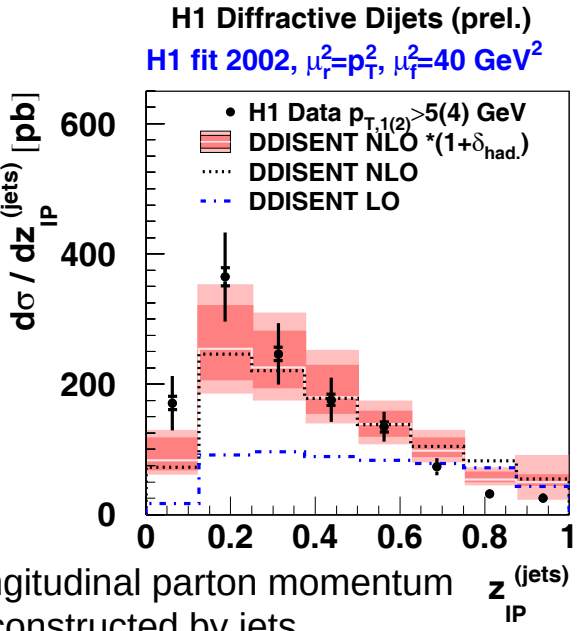
Hard scale is given by E_{Tjet} or HQ mass



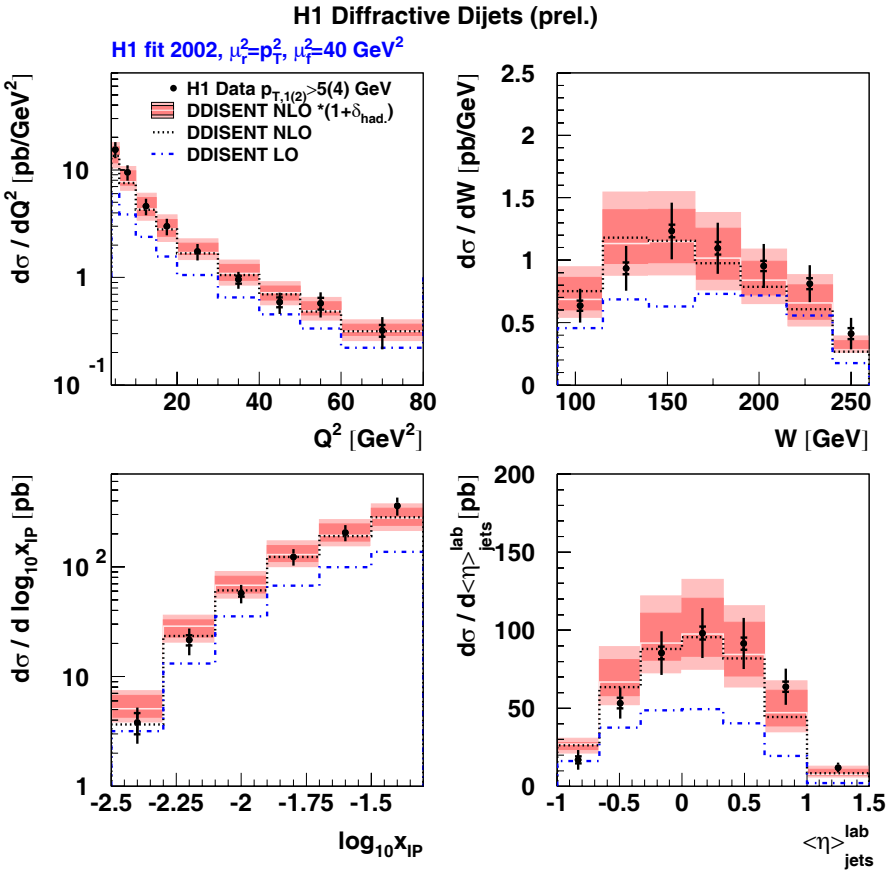
Jets in DIS

- Cone algorithm R = 1.0, γ*p frame
- $E_{T1} > 5$ GeV, $E_{T2} > 4$ GeV
- $4 < Q^2 < 80$ GeV^2, $0.1 < y < 0.7$
- $x_{\mathbf{P}} < 0.05$

- Agree with NLO using H1 2002 fit
- Factorisation works
  if the PDFs are correct, or
- Data constrain PDFs
  if factorisation holds



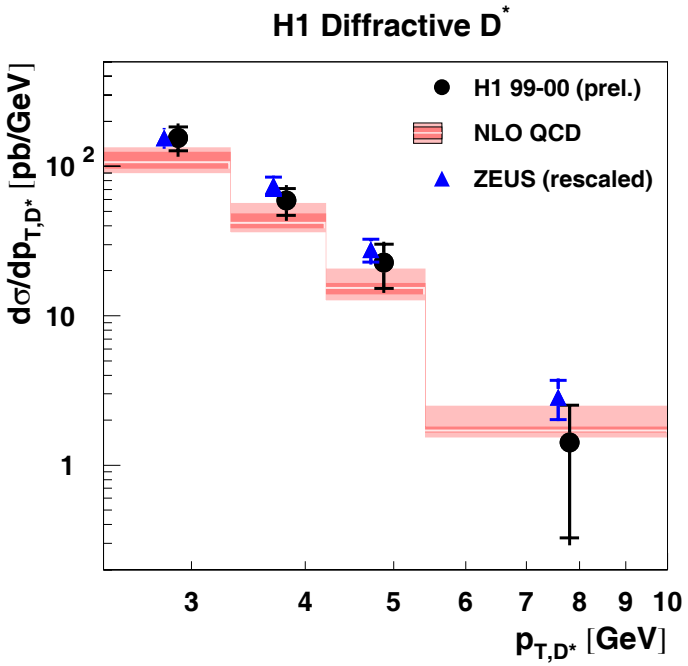
longitudinal parton momentum reconstructed by jets

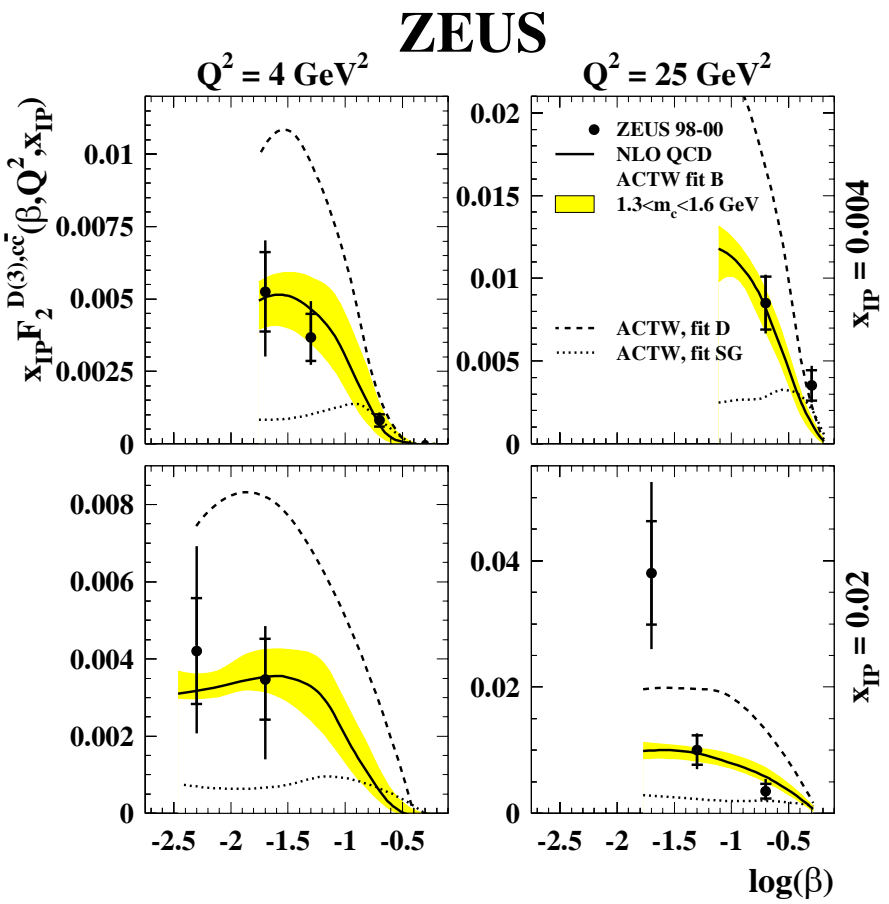


D* cross sections (open charm)

H1 ZEUS
- $2[1.5] < Q^2 < 100[200]$ GeV^2
- $|\eta_{D^*}| < 1.5$,
- $p_{TD^*} > 2.0[1.5]$ GeV ($\gamma^* p$ frame)
- $x_{\mathbf{P}} < 0.04[0.035]$ etc.

- Giving constraints to PDFs
- H1 and ZEUS consistent

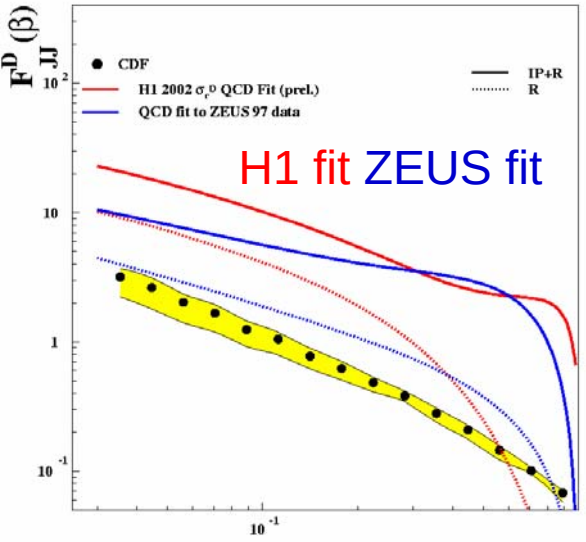




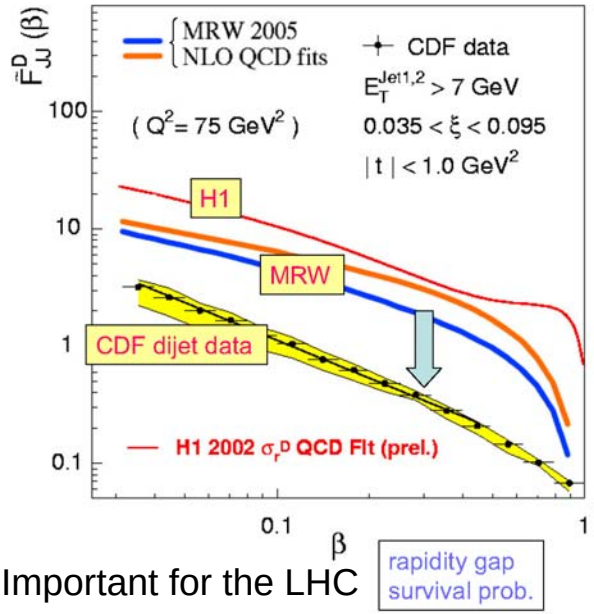
Why jet and HQ production – (2) factorisation test

- Dijet cross section at TeVatron: **factor 5-10 lower** than the QCD calculation using the HERA diffractive PDFs
- Multi-parton scattering (re-scattering) ?

$$F_{jj}^{D}(\beta) = \beta\left(g(\beta) + \frac{4}{9} q(\beta) \right)$$

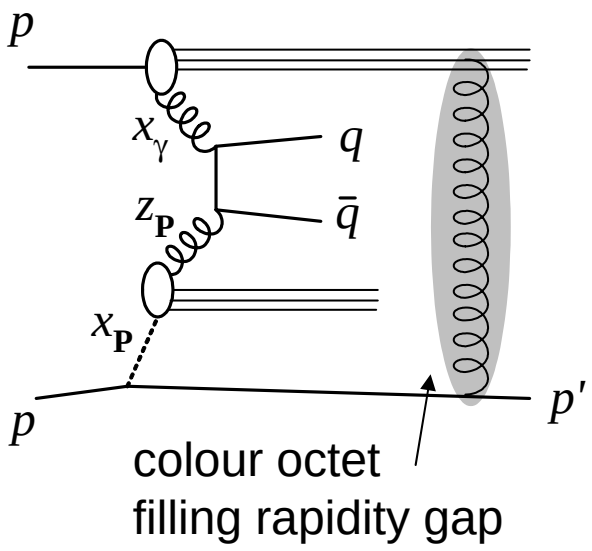


A.D. Martin, talk in DIS05



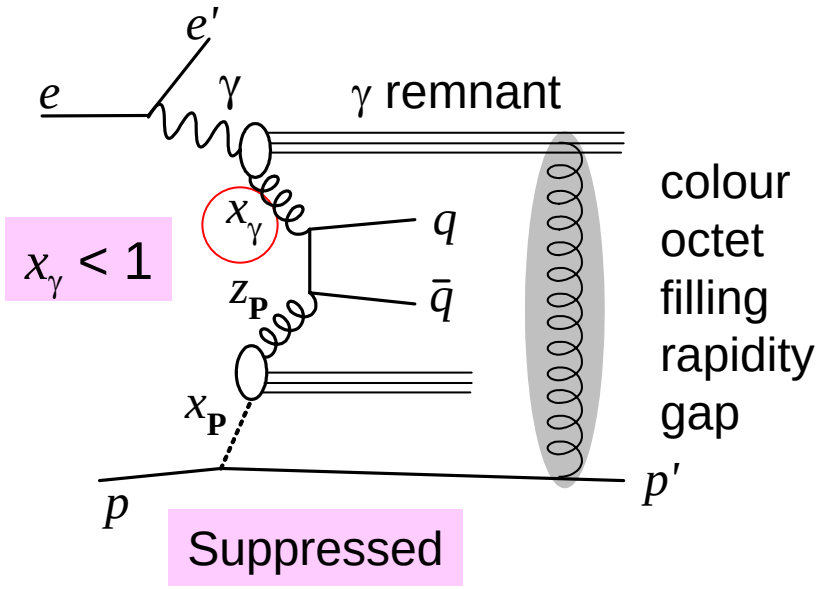
Important for the LHC

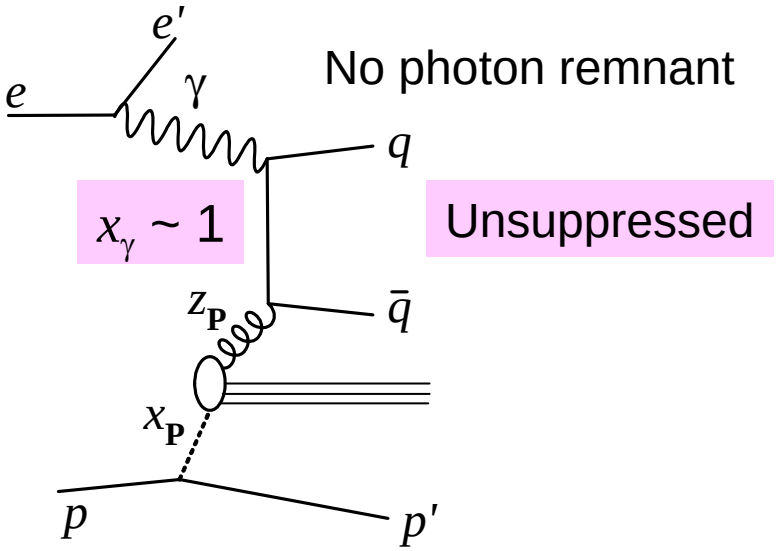
rapidity gap survival prob.



Jets in photoproduction: controlling the size of the "hadron" = photon

- Jets in photoproduction (PHP):
  thought to be an ideal testing ground for rescattering
  - large (resolved) : hadron-like small (direct) : point-like

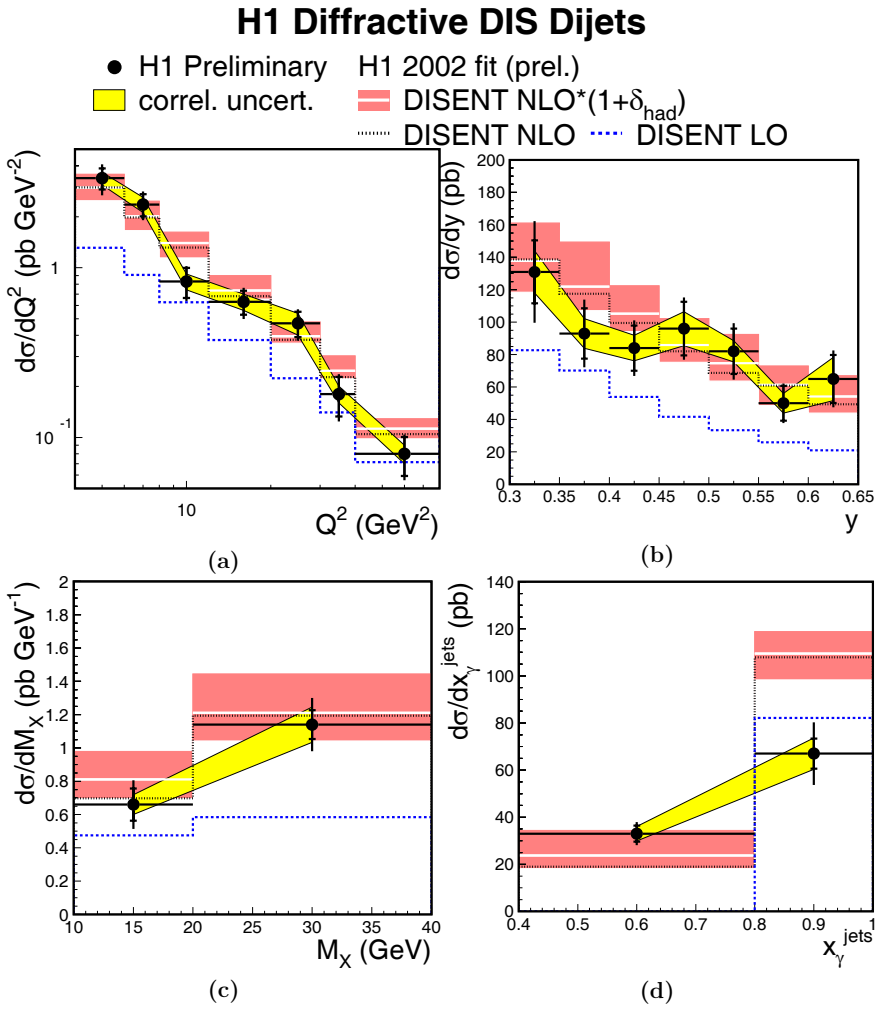




x_γ is reconstructed by jets: $x_\gamma^{jets} = x_\gamma^{OBS} = \dfrac{\sum (E - Pz)_{jets}}{(E - Pz)_{hadrons}}$

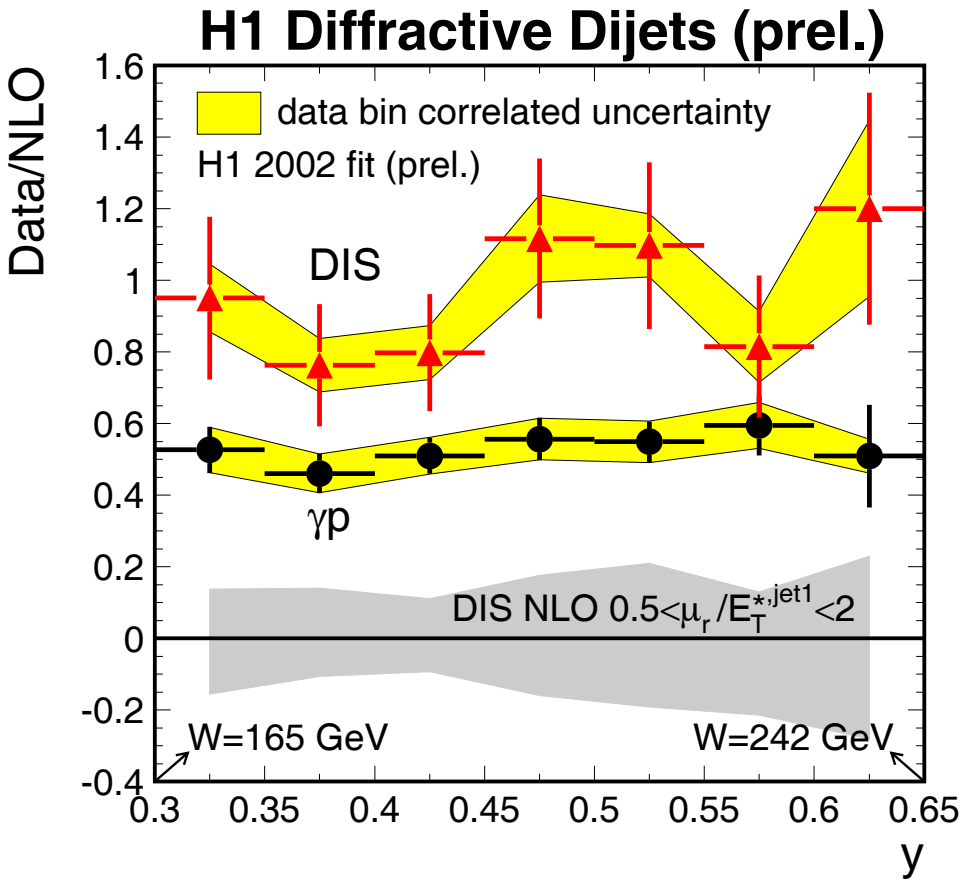
New measurement in DIS: as close to the kinematical range of PHP

- Common phase space: DIS measurement was restricted to
  - $0.3 < y < 0.65$
  - PHP: $Q^2 < 0.01$ GeV
    $-1 < \eta_{jet}^{lab} < 2$
  - DIS: $4 < Q2 < 80$ GeV
    $-3 < \eta_{jet}^{*} < 0$
- Good agreement with NLO
- Comparison with PHP through NLO calculation



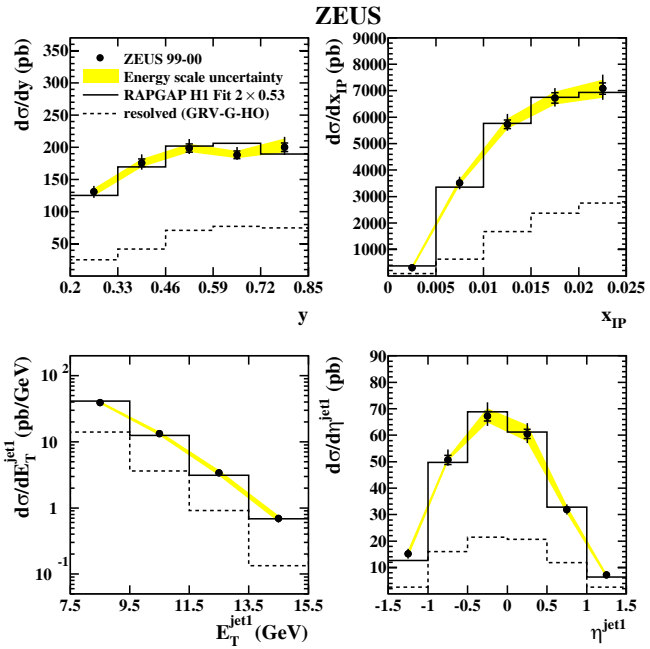
The ratio data/NLO using the same PDF

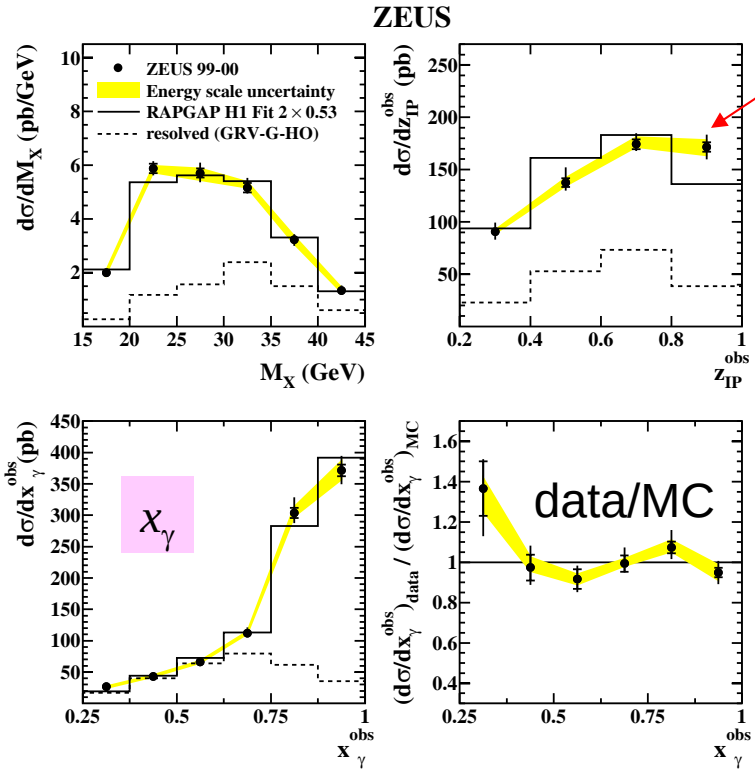
- Cross sections are compared through the ratio to the NLO using the same PDFs
- PHP cross section is lower (w.r.t. the NLO calculation)
- Resolved suppressed ?
  → look more in detail...



PHP dijet: shape comparison with LO+PS

k_T algorithm in lab, E_{T1}>7.5, E_{T2}>6.5 GeV





possible sensitivity to DPDF

x_γ flat

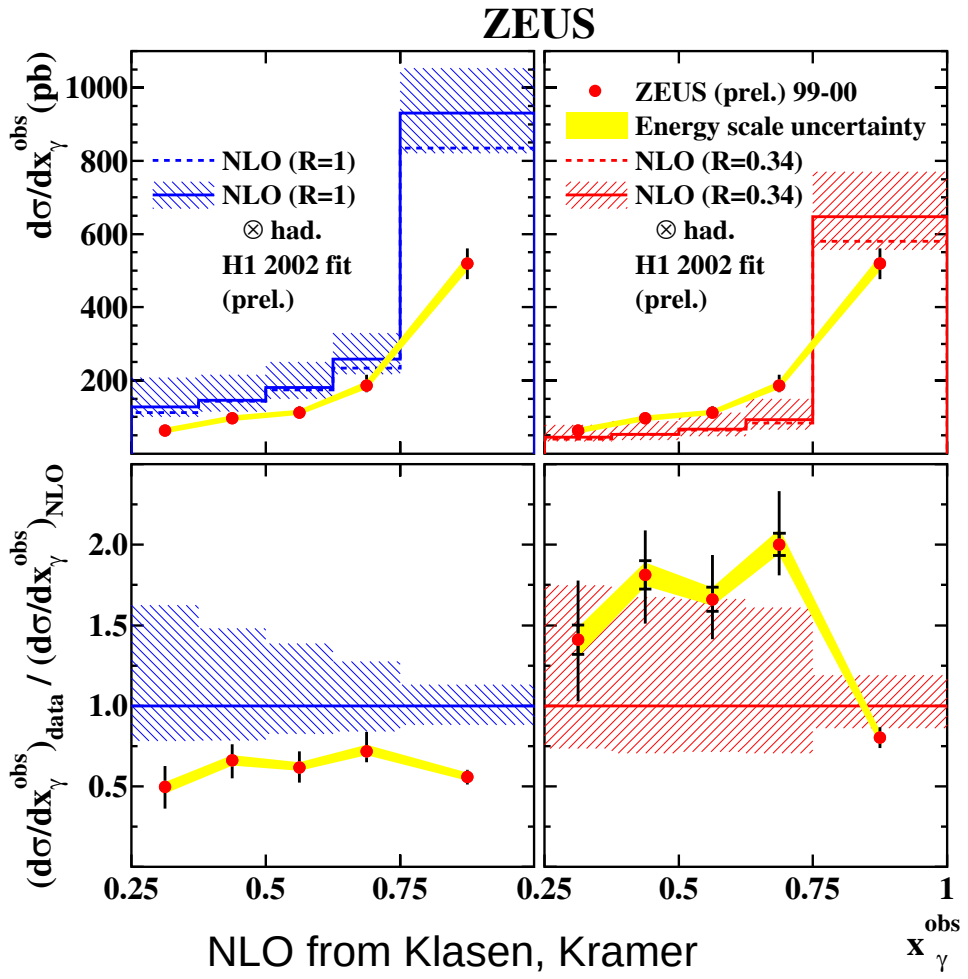
- Shape of the cross section is well described by RAPGAP 3.00
  - MC normalised to the data
- Data/MC flat in x_γ: **no indication of resolved suppression**
- Some excess at highest z_P: sensitivity to the diffractive PDFs

Comparison with NLO

- NLO suppose to give stable prediction in normalisation
  - absolute cross section comparison
  - scale uncertainty in band
- **Result: flat in x_γ**
  - Consistent with LO+PS
- However, the data is **lower than NLO by ~0.6**
  - **Both direct & resolved are suppressed**
  - PDF uncertainty ? unlikely – DIS described by NLO with H1 fit 2002

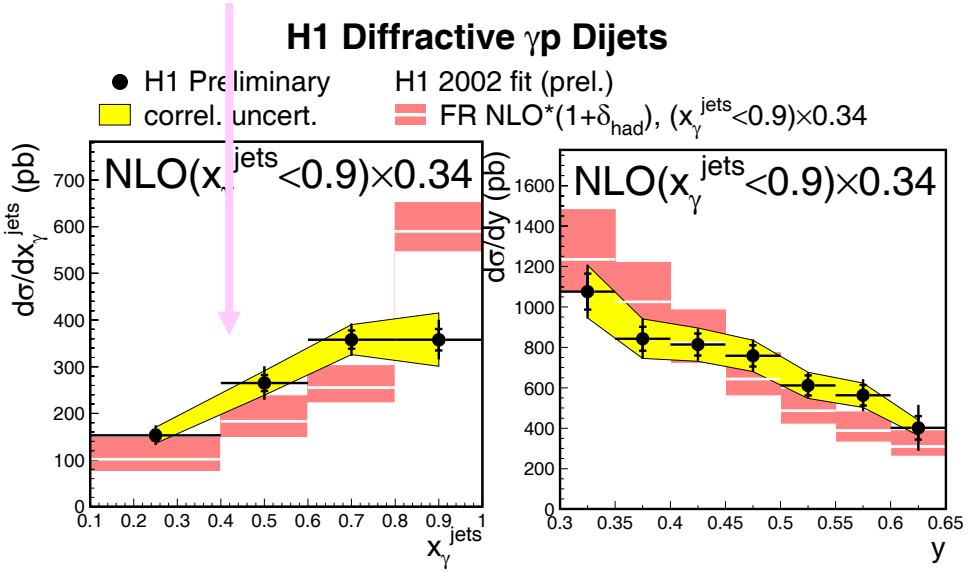
NLO, no resolved suppression (R = 1)

NLO, resolved suppressed Factor calculated from the CDF-H1 and fit 2002 comparison: R = 0.34 by Kaidalov et al.

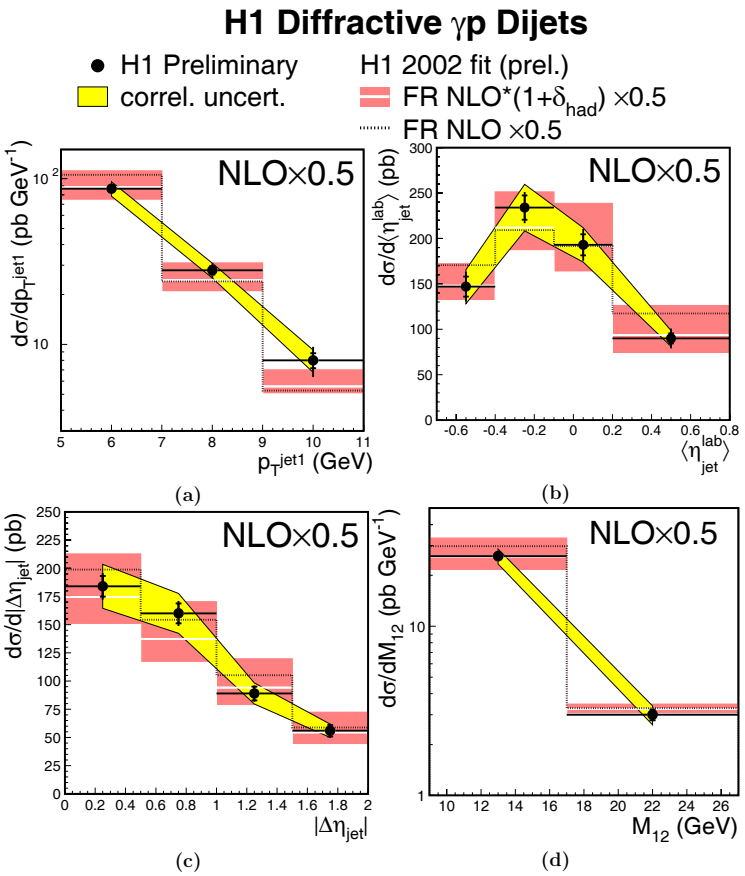


PHP comparison with NLO – other variables

- Global suppression (both dir+res) with factor ~0.5 works also for other kinematical variables
- R = 0.34 resolved-only suppression fails clearly

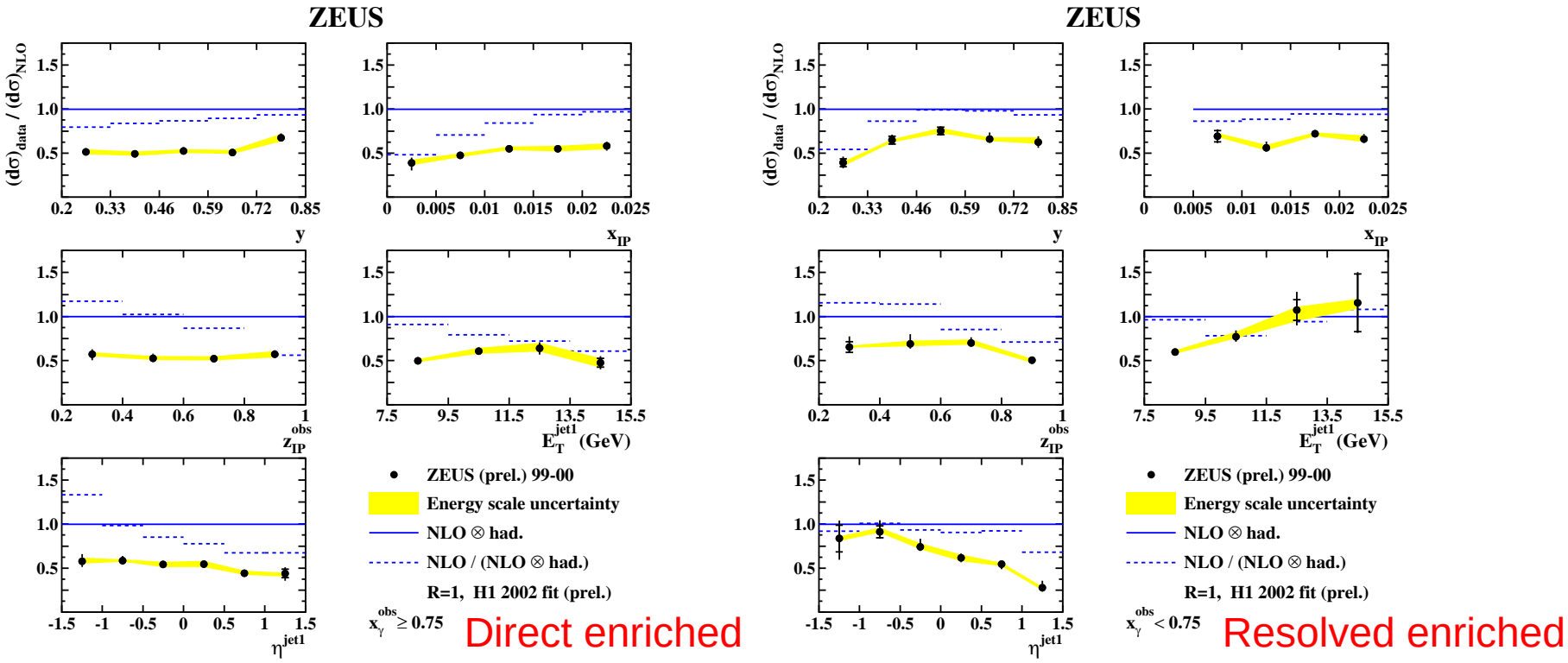


(a) NLO: Frixione, Ridolfi (b)



Both dir+res suppressed by ~0.5
Both in H1 and ZEUS !

Detailed comparison in PHP: $x_\gamma > 0.75$ and $x_\gamma < 0.75$ with NLO



- Data / NLO is flat, suppressed by ~0.6
  - Exception in high-E_T for $x_\gamma > 0.75$: resolved enhanced ? Could also be photon PDFs

Conclusion

- Dijets in DIS and D* cross sections:
  - Agree with the NLO prediction with the H1 2002 diffractive PDFs
  - Factorisation holds (assuming the PDF is correct)
- PHP dijet cross sections are measured
  - to investigate the puzzle of Tevatron/HERA ~ 1/5 – 1/10
    Expectation: resolved PHP is suppressed while direct is not
  - Data agree with LO and NLO **in shape, also in x_γ**
  - But **data ~half of the NLO** (with the H1 2002 PDFs)
    $\rightarrow$ **both resolved and direct suppressed**
    in conflict with theoretical expectation
- Need more ideas to understand this !
  - Jet calculation from saturation, SCI etc....