HERA and the LHC
Final Meeting
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Diffractive Photoproduction of Dijets at ZEUS

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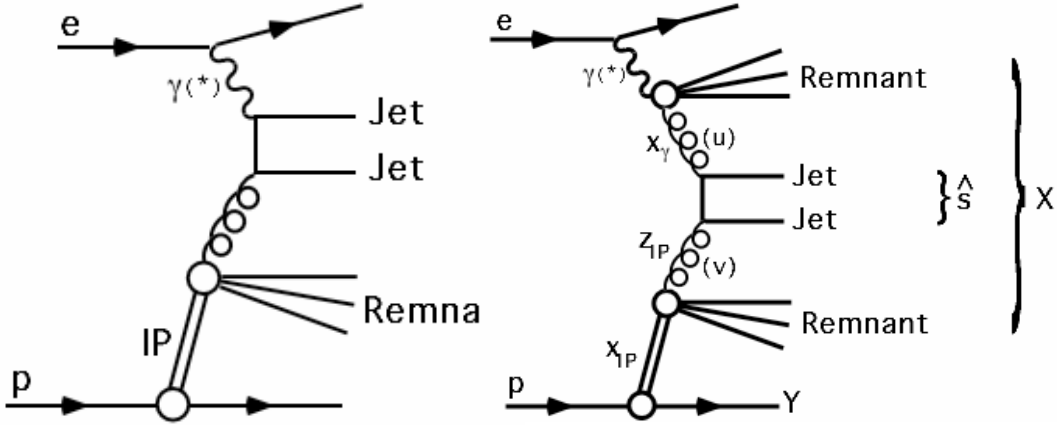
On behalf of the
ZEUS Collaboration

Test of QCD Factorization in γp collisions

direct γ
$x_\gamma \sim 1$
no photon remnant

resolved γ
$x_\gamma < 1$ (hadron – like)
photon remnant



Real photon ($Q^2 \sim 0$) can develop hadronic structure

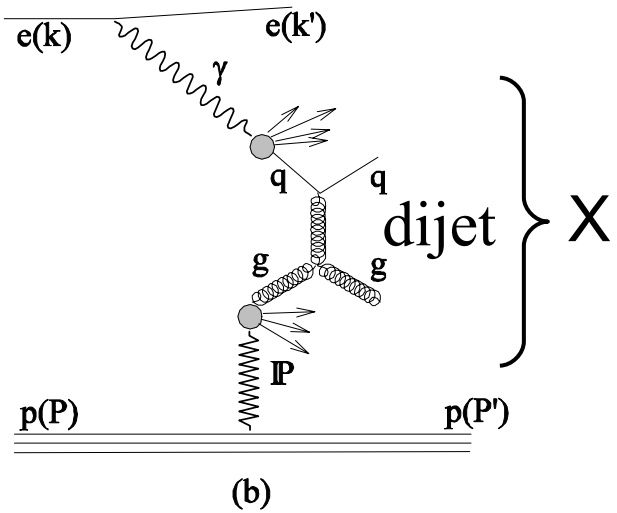
resolved γ processes are similar to hadron – hadron interaction

⇒ test of factorization breaking

Factorization theorem expected to work for direct but not for resolved

M. Klasen and G. Kramer predict suppression of only the resolved component by a factor 0.34 (motivated by calculation of Kaidalov et al.)

Kinematics



$$y_{JB} = \frac{(E - p_z)_{had}}{2E_e}$$

fraction of *e* energy taken by γ

$$x_{IP} = \frac{(E + p_z)_{had}}{2E_p}$$

momentum fraction of *p* taken by *IP*

$$x_\gamma^{obs} = \frac{\sum_{jet1,2} E_T e^{-\eta}}{(E - p_z)_{had}} = \frac{(E - p_z)_{jet1,2}}{(E - p_z)_{had}}$$

longitudinal momentum fraction of γ in hard scattering

$$z_{IP}^{obs} = \frac{\sum_{jet1,2} E_T e^{\eta}}{(E + p_z)_{had}} = \frac{(E + p_z)_{jet1,2}}{(E + p_z)_{had}}$$

longitudinal momentum fraction of *IP* taken by parton

$$M_X = \sqrt{(E - p_z)_{had} \cdot (E + p_z)_{had}}$$

invariant mass of the system X

Event selection

- Data sample: ZEUS 99 – 00 $e^{\pm} p$ (E_e = 27.5 GeV, E_p = 920 GeV)
- Integrated luminosity 77.6 pb^{-1}

Photoproduction

- $0.2 < y_{JB} < 0.85$
- no electron in the detector

Diffraction

- large rapidity gap ($\eta_{max} < 2.8$)
- $x_{IP} < 0.035$ (DIS04 and ICHEP04)
- $x_{IP} < 0.025$
  - minimize syst. uncertainties
  - reduce background

New preliminary

Dijet

- inclusive k_T algorithm in lab frame
- $E_T^{jet1(2)} > 7.5$ (6.5) GeV
- $-1.5 < \eta^{jet1(2)} < 1.5$

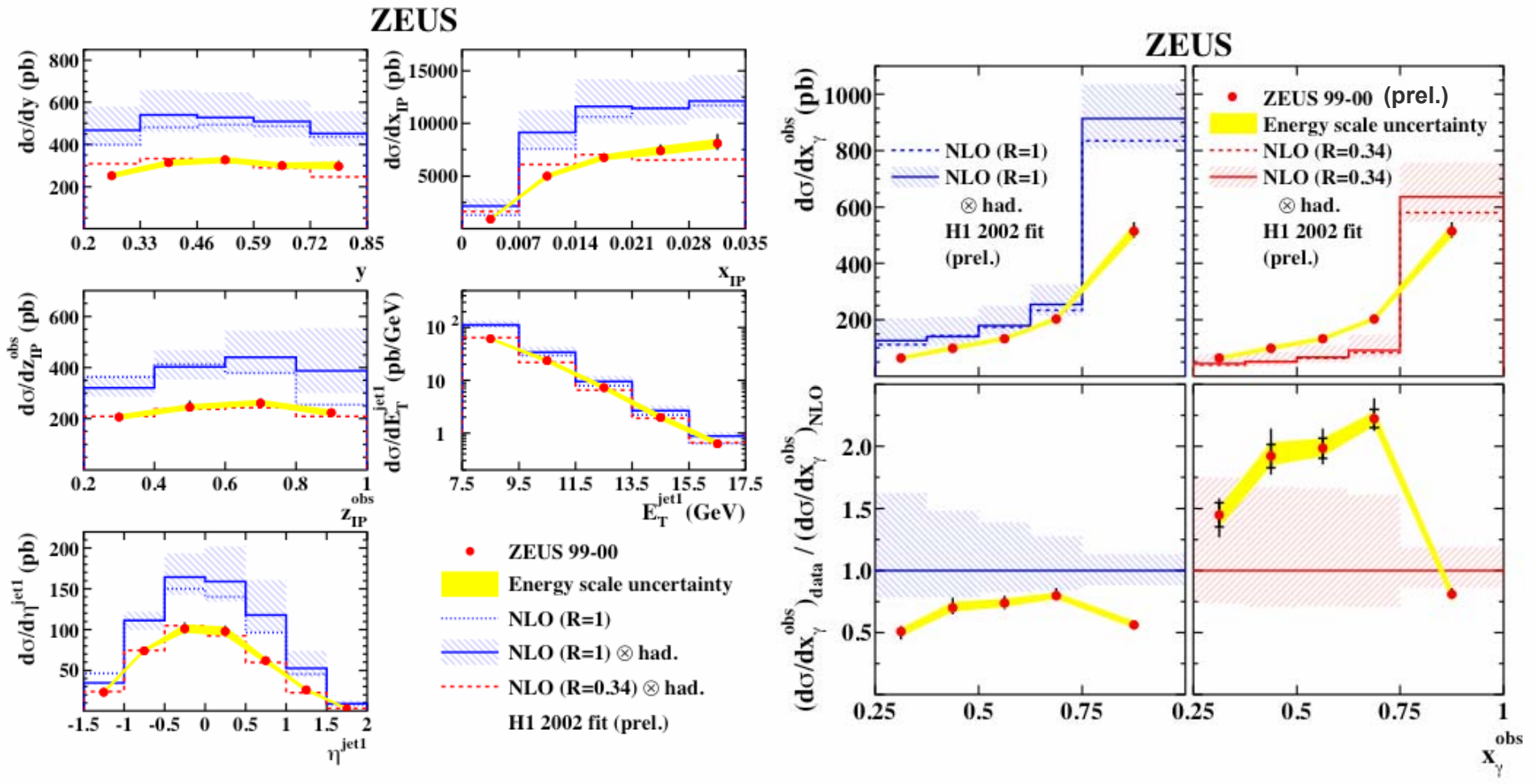
Results from ZEUS at ICHEP04 – A reminder

- **Comparison with NLO QCD predictions**

  - parton level NLO QCD calculations by Klasen and Kramer
  - hadronization corrections determined with RAPGAP MC

→ global suppression of both direct and resolved favoured by data
→ similar results from H1

Comparison to NLO QCD (ICHEP04)



- Shape well described
- Normalization of data below predictions
- Indication of a global suppression of both direct and resolved

New results from ZEUS

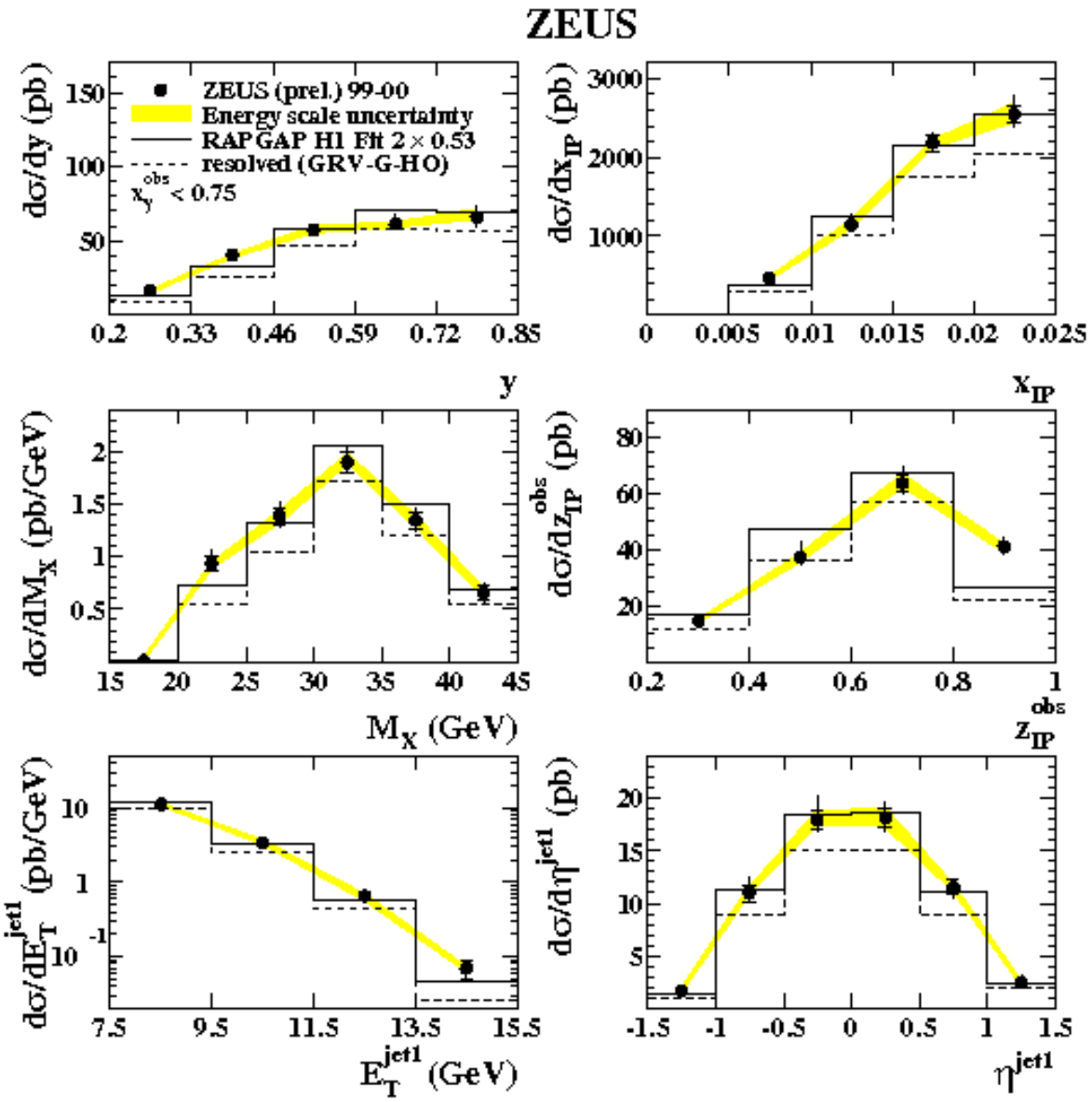
- **Double differential cross sections**

  - resolved enriched photoproduction ($x_\gamma < 0.75$)
  - direct enriched photoproduction ($x_\gamma > 0.75$)

- **Comparison with LO RAPGAP MC**
  - Parton showers
  - GRV – G – HO (γ)
  - H1 – fit2 (IP) (preliminary)

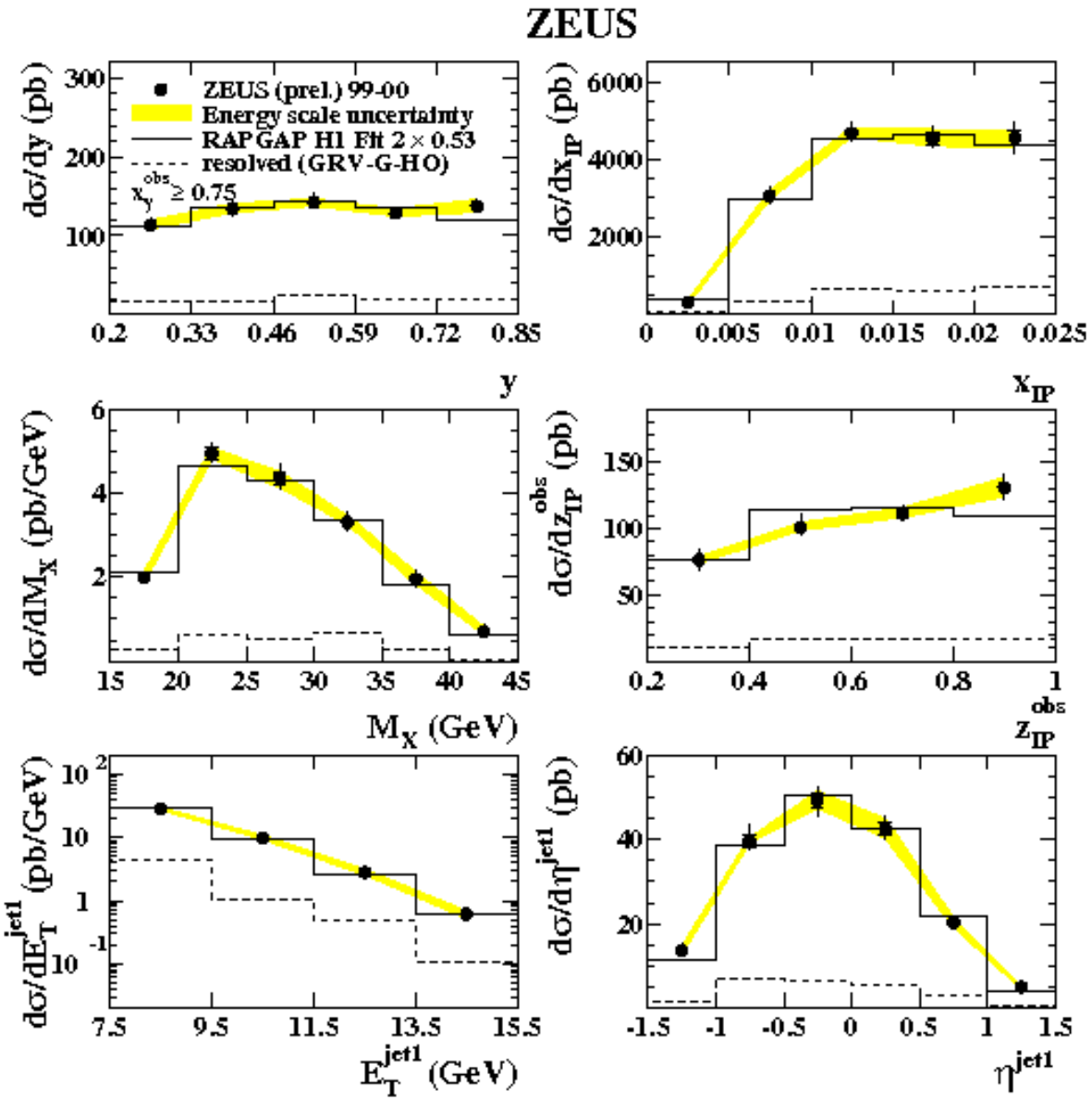
- **Comparison with NLO QCD predictions**
  - parton level NLO QCD calculations by Klasen and Kramer
  - hadronization corrections determined with RAPGAP MC
  - H1 2002 Fit diffractive PDFs (preliminary)

DATA vs LO MC – resolved enriched ($x_\gamma < 0.75$)



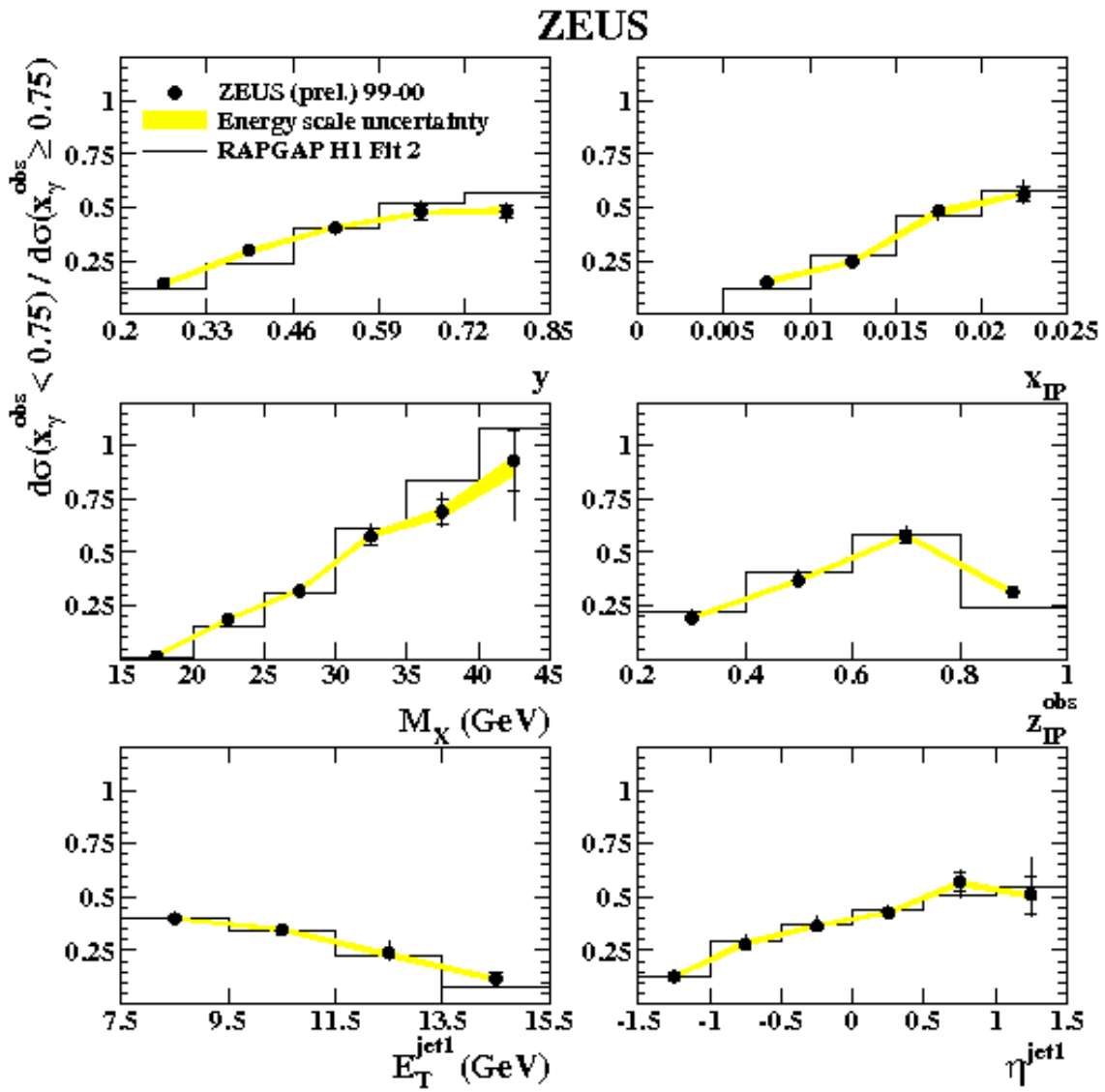
Cross sections well described by RAPGAP (scaled by a factor of 0.53)

DATA vs LO MC – direct enriched ($x_\gamma > 0.75$)



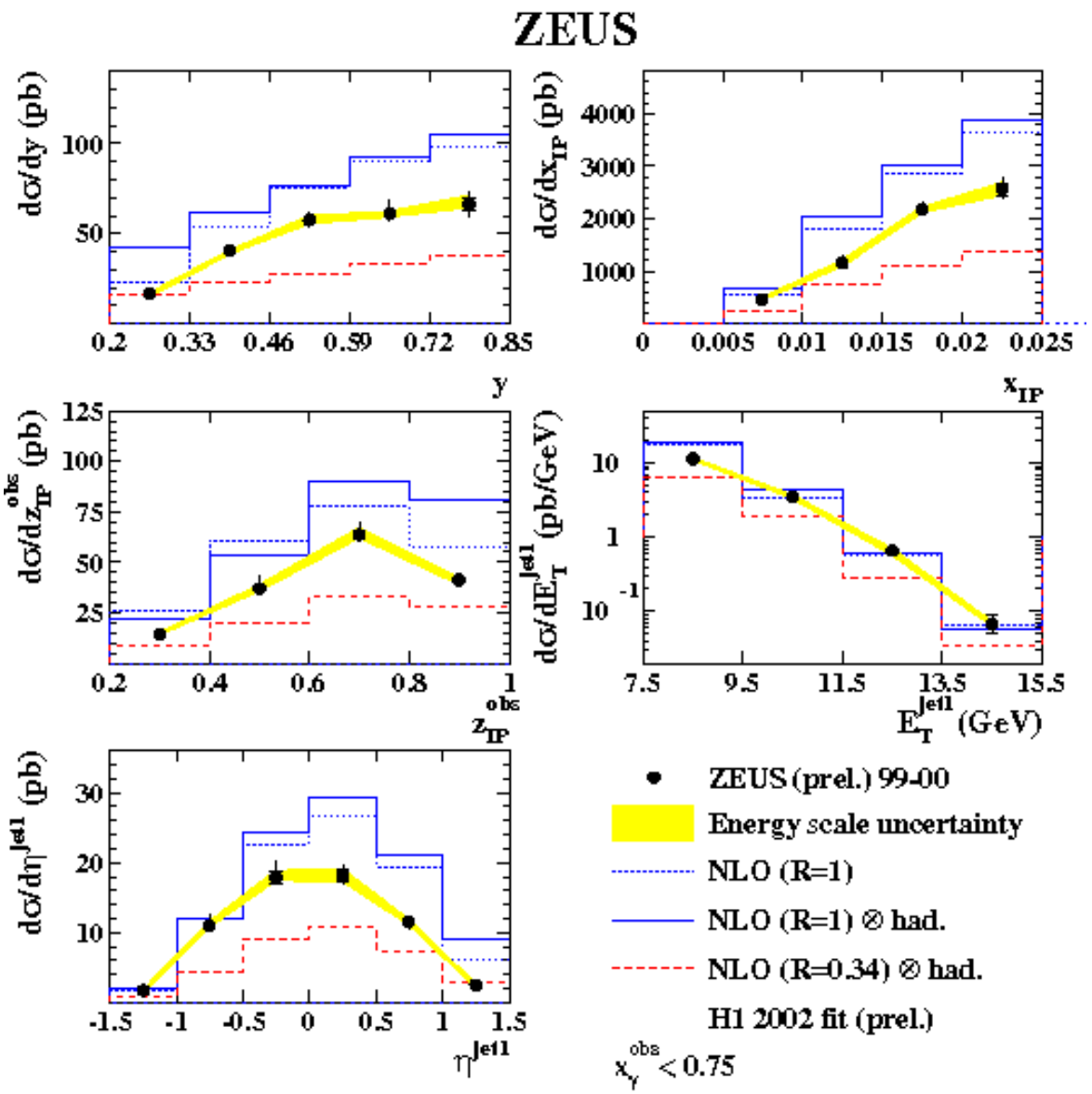
Cross sections well described by RAPGAP (scaled by a factor of 0.53)

DATA vs LO MC – Ratio resolved / direct enriched



- Ratio well reproduced by RAPGAP (scaling factors cancel)
- no evidence of suppression of resolved with respect to direct photoproduction

DATA vs NLO QCD – resolved enriched ($x_\gamma < 0.75$)

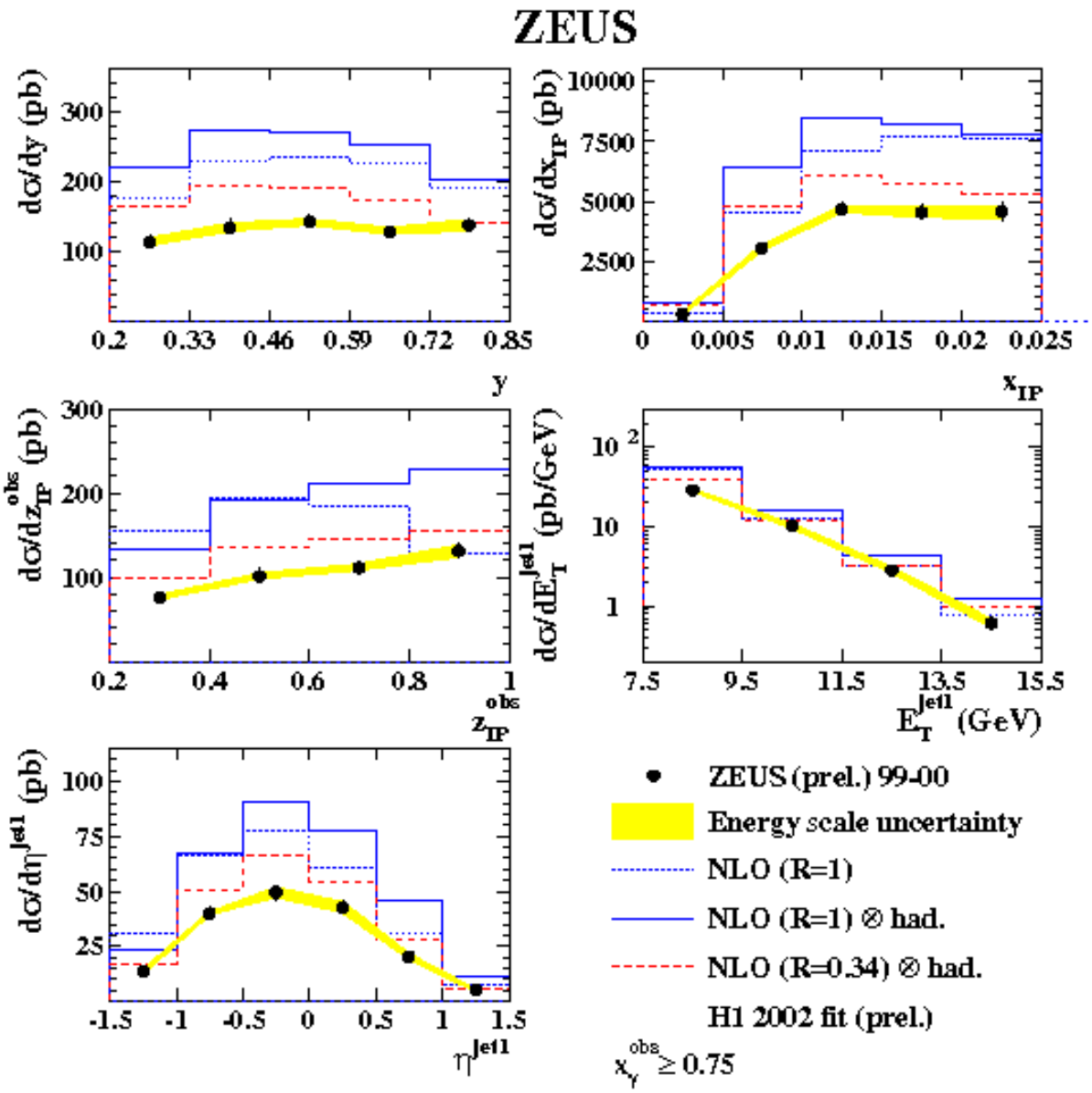


NLO QCD predictions

- describe the shape
- both, unsuppressed and suppressed, do not reproduce the normalization :

- too high for unsuppressed (R = 1)
- too low for suppressed (R = 0.34)

DATA vs NLO QCD – direct enriched ($x_\gamma > 0.75$)



NLO QCD predictions

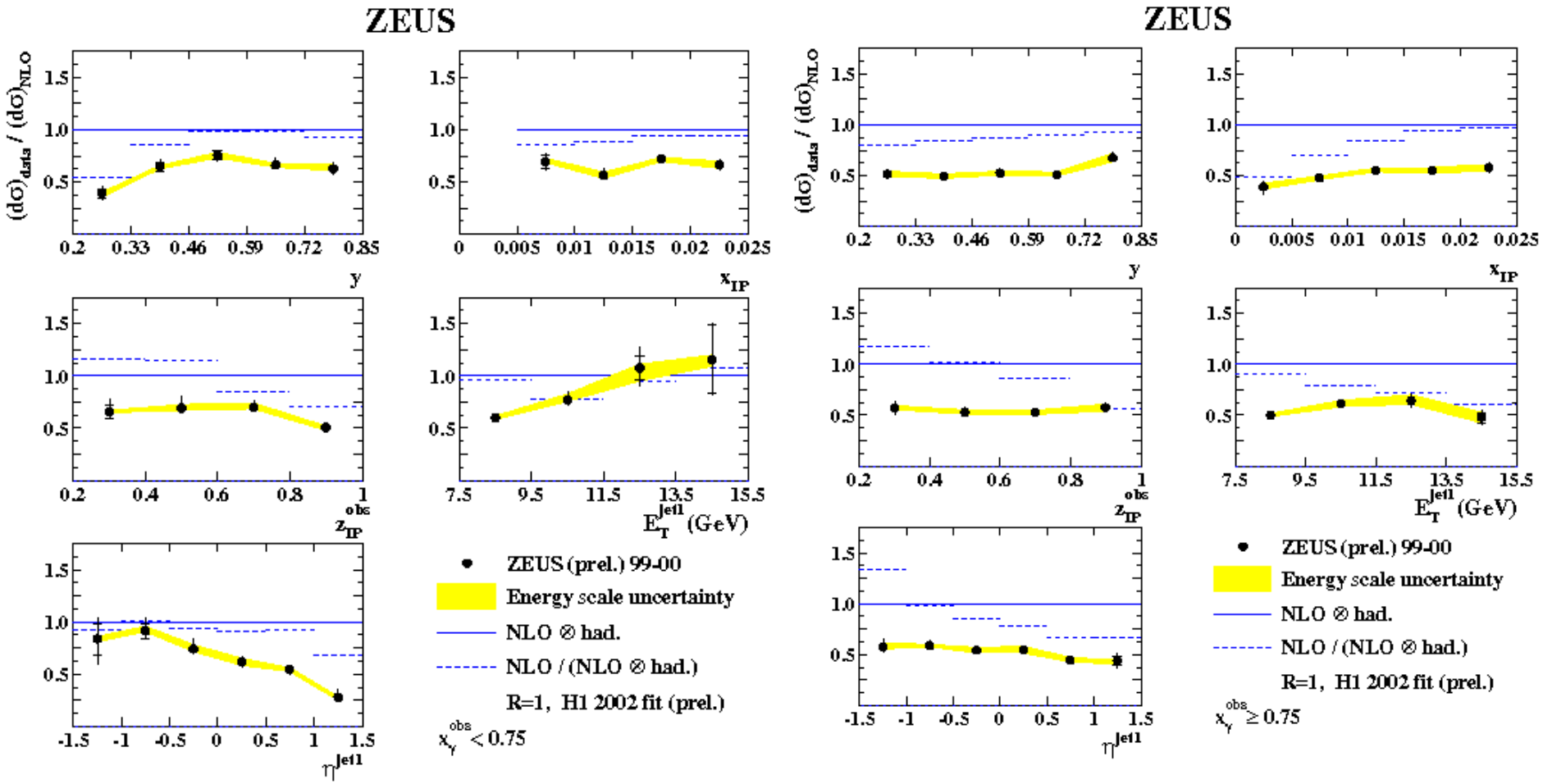
- describe the shape
- both, unsuppressed and suppressed, do not reproduce the normalization :

- too high for both

→ suggestive of global suppression direct + resolved

Ratio data / NLO (unsuppressed)

Resolved $x_\gamma < 0.75$ Direct $x_\gamma > 0.75$



- Photon PDF uncertainties at high E_T, η^{jet}
- Data lower by a factor ~ 0.5 vs NLO QCD model

Diffractive dijets in PHP - Summary

- New ZEUS measurements of double differential cross section in two bins of x_γ,
  - resolved enriched photoproduction $x_\gamma < 0.75$
  - direct enriched photoproduction $x_\gamma > 0.75$

- Data well described in shape by LO MC RAPGAP scaled by a factor 0.53

- NLO QCD predictions without suppression
  describe the shape of cross sections
  overestimate the measurement by a factor ~ 2

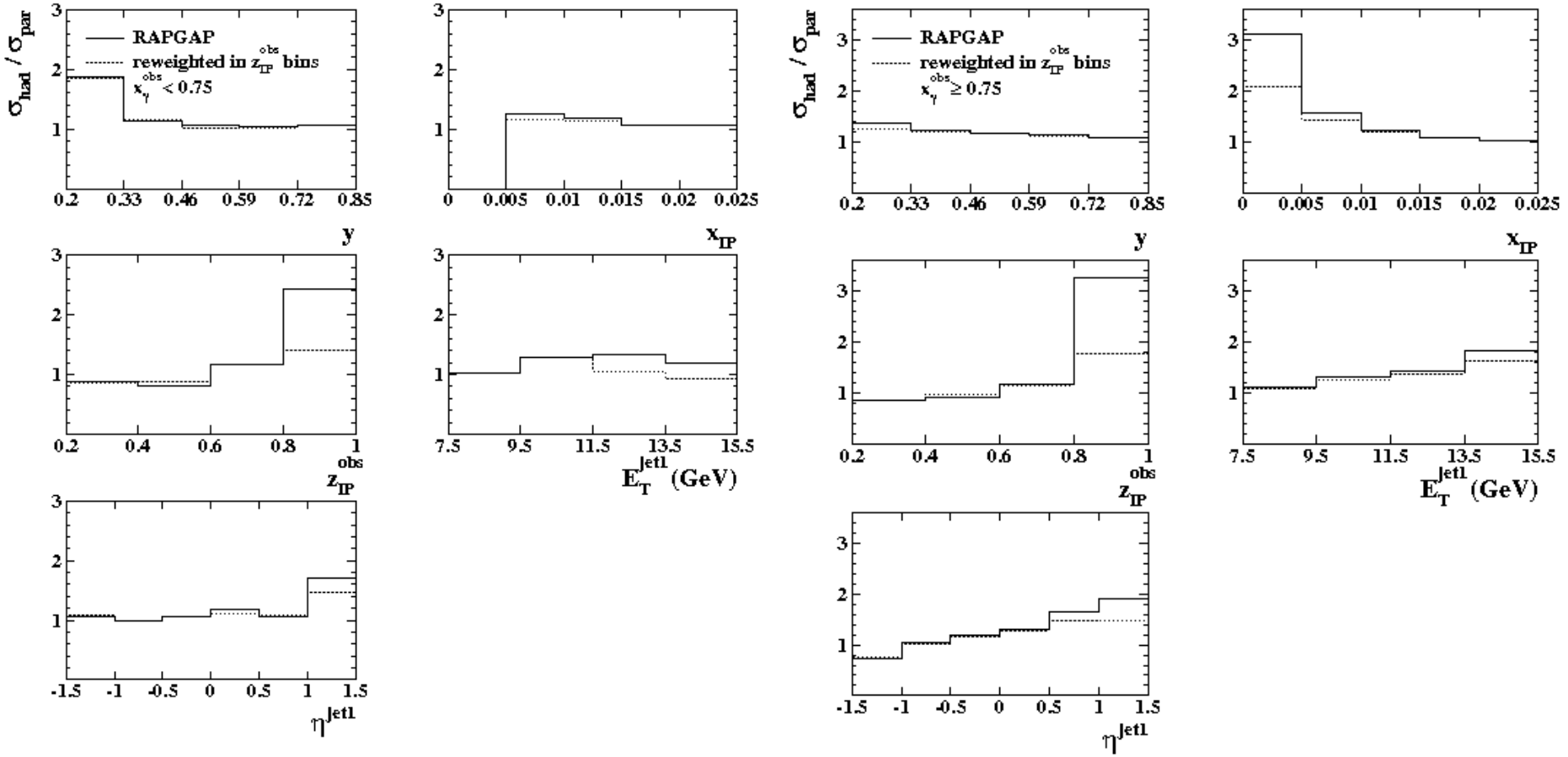
- Data show indication of a global suppression of both direct and resolved

Additional slides

Hadronization corrections

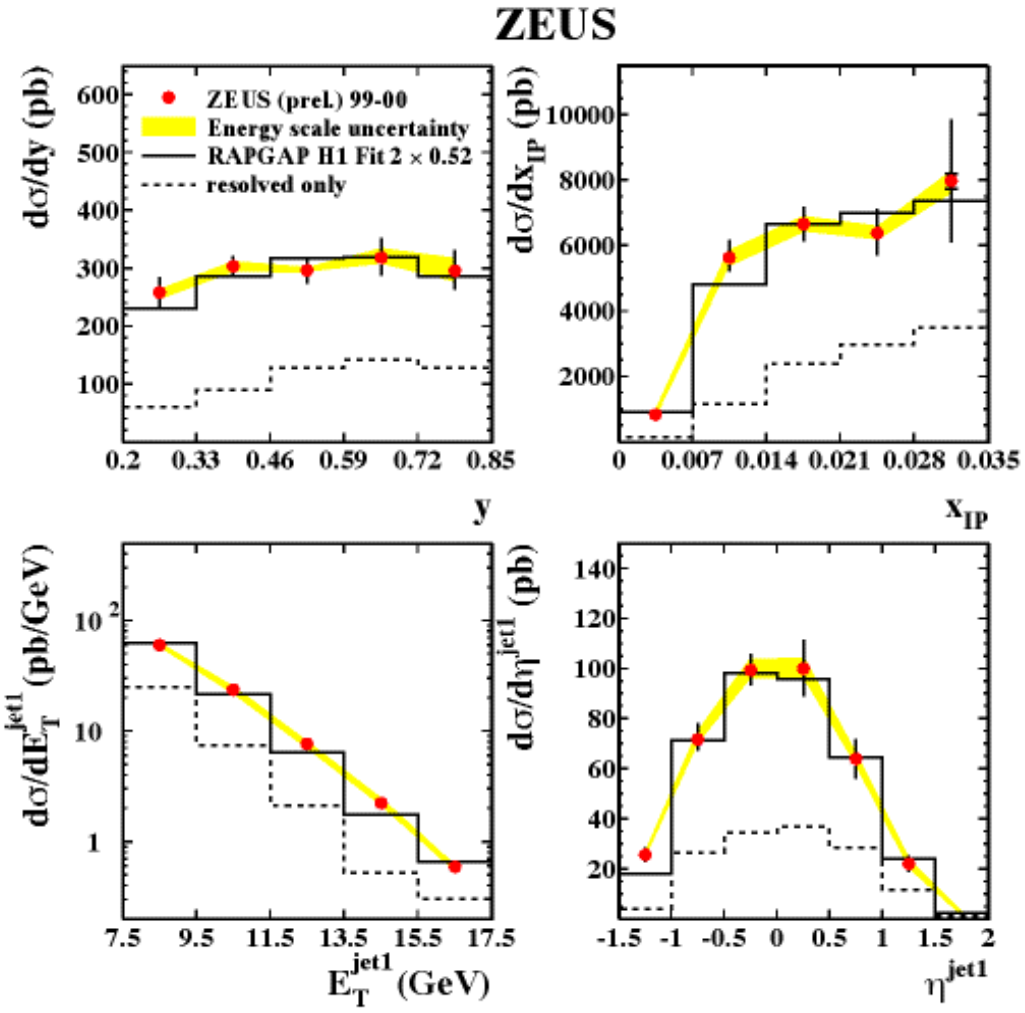
Resolved photoproduction $x_\gamma < 0.75$

Direct photoproduction $x_\gamma > 0.75$



- hadronization corrections estimated using RAPGAP MC
- reweighted in z_{IP}^{obs}
- flatter after reweighting

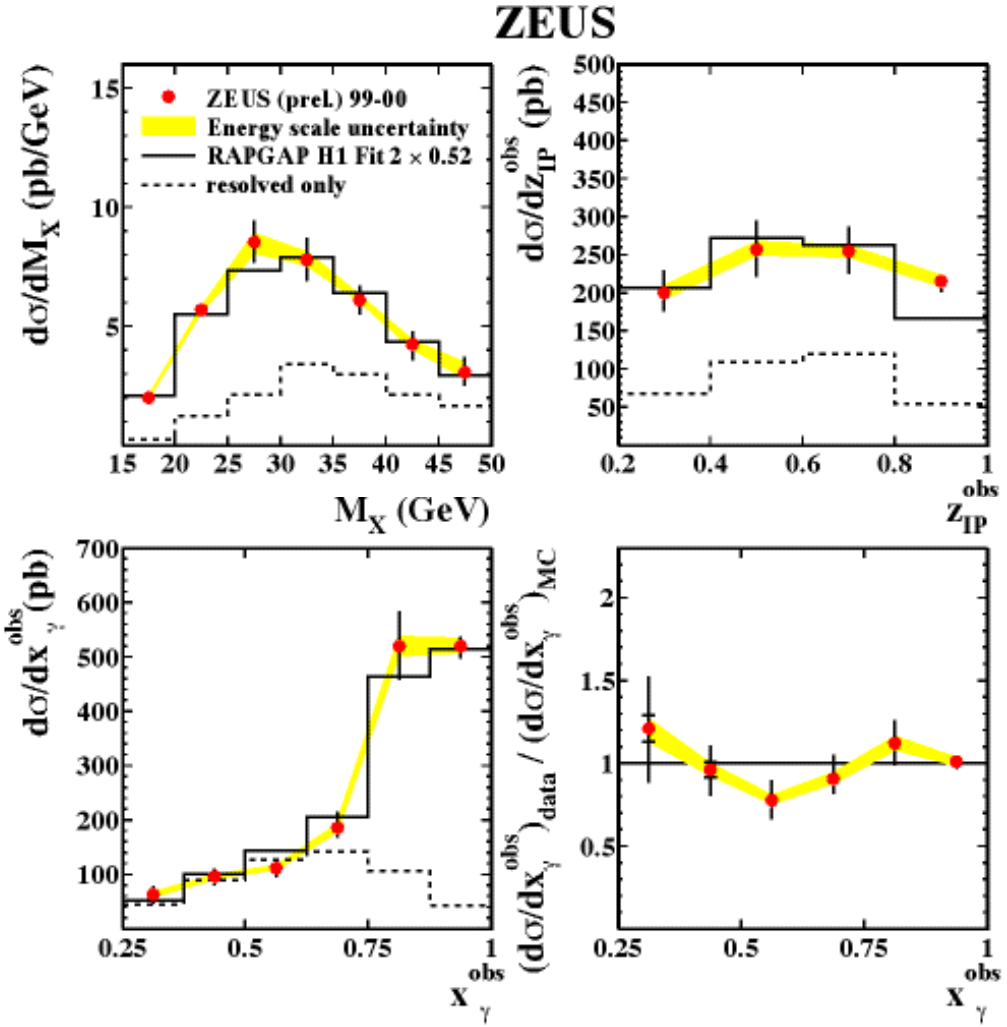
Comparison to LO Monte Carlo (DIS04)



Data well described by LO MC RAPGAP v3.00 (direct + resolved)

- Parton showers
- Structure functions:
  MRSG - *p*
  GRV - G - LO (γ)
  H1 - fit2 (*IP*)

Comparison to LO Monte Carlo (DIS04)

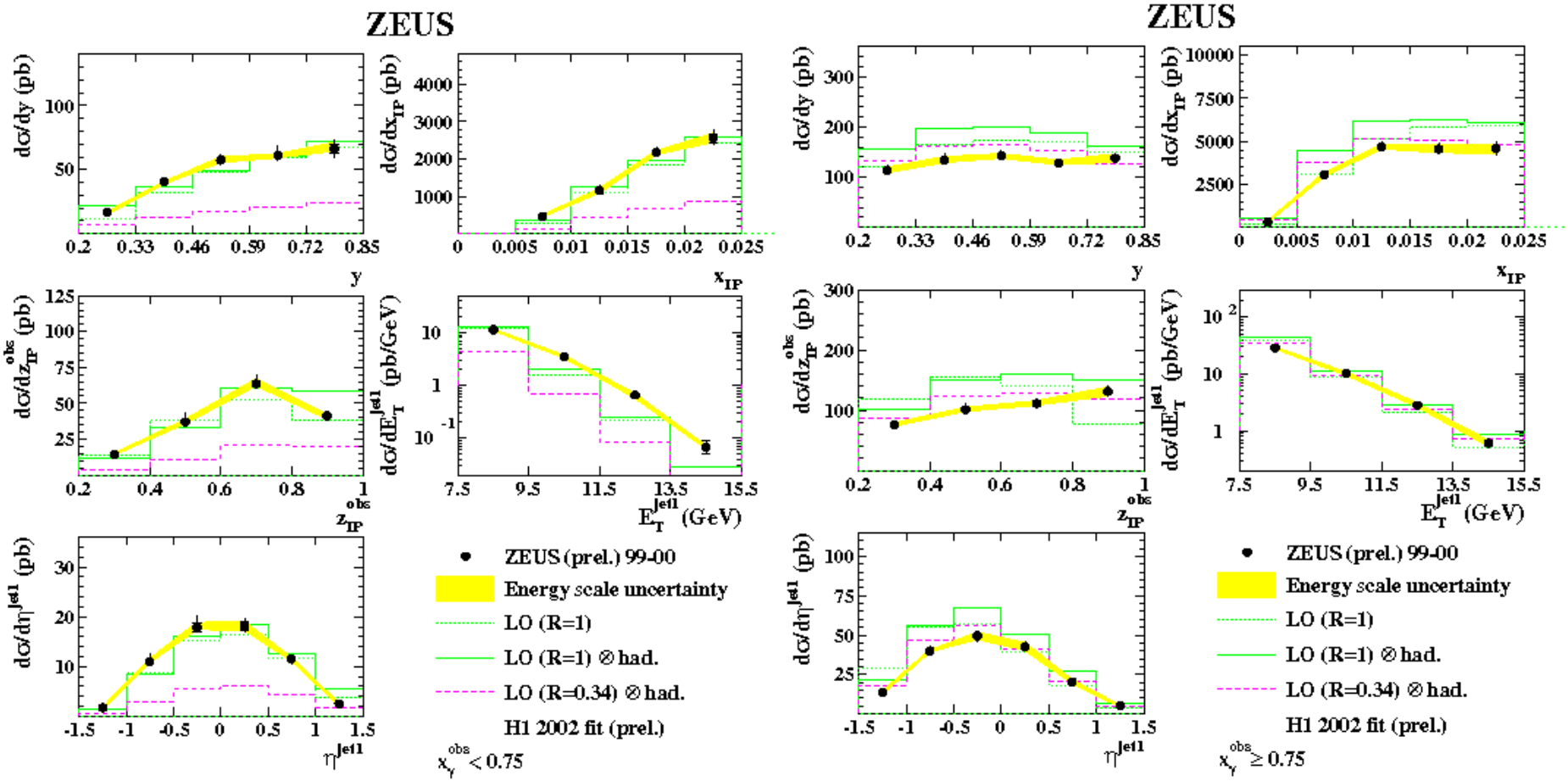


Data well described by LO MC RAPGAP v3.00 (direct + resolved)

- Ratio data/MC ~ flat
  → no evidence of a resolved suppression with respect to direct at LO

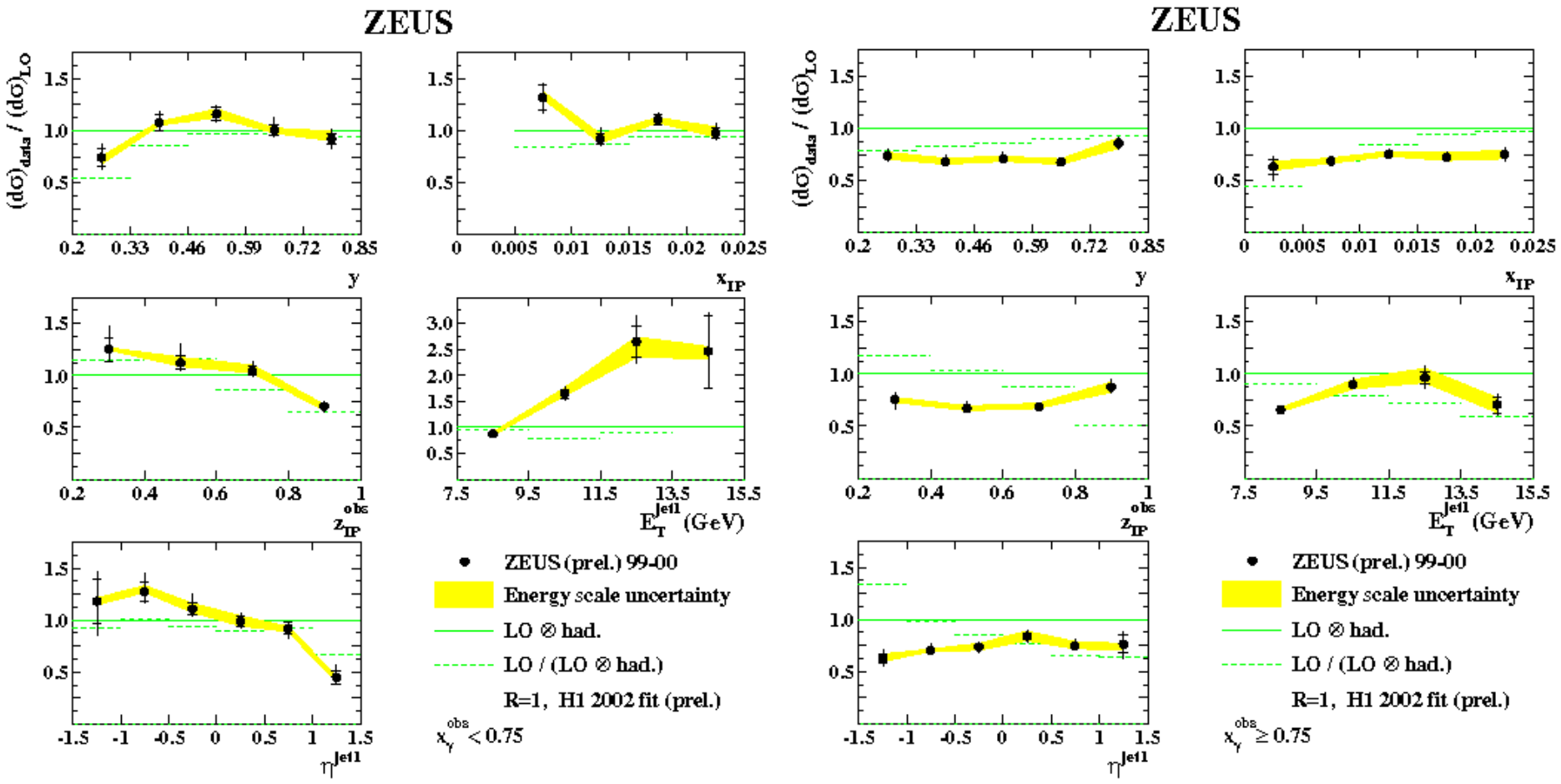
Comparison to LO QCD

Double differential cross sections



Comparison to LO QCD

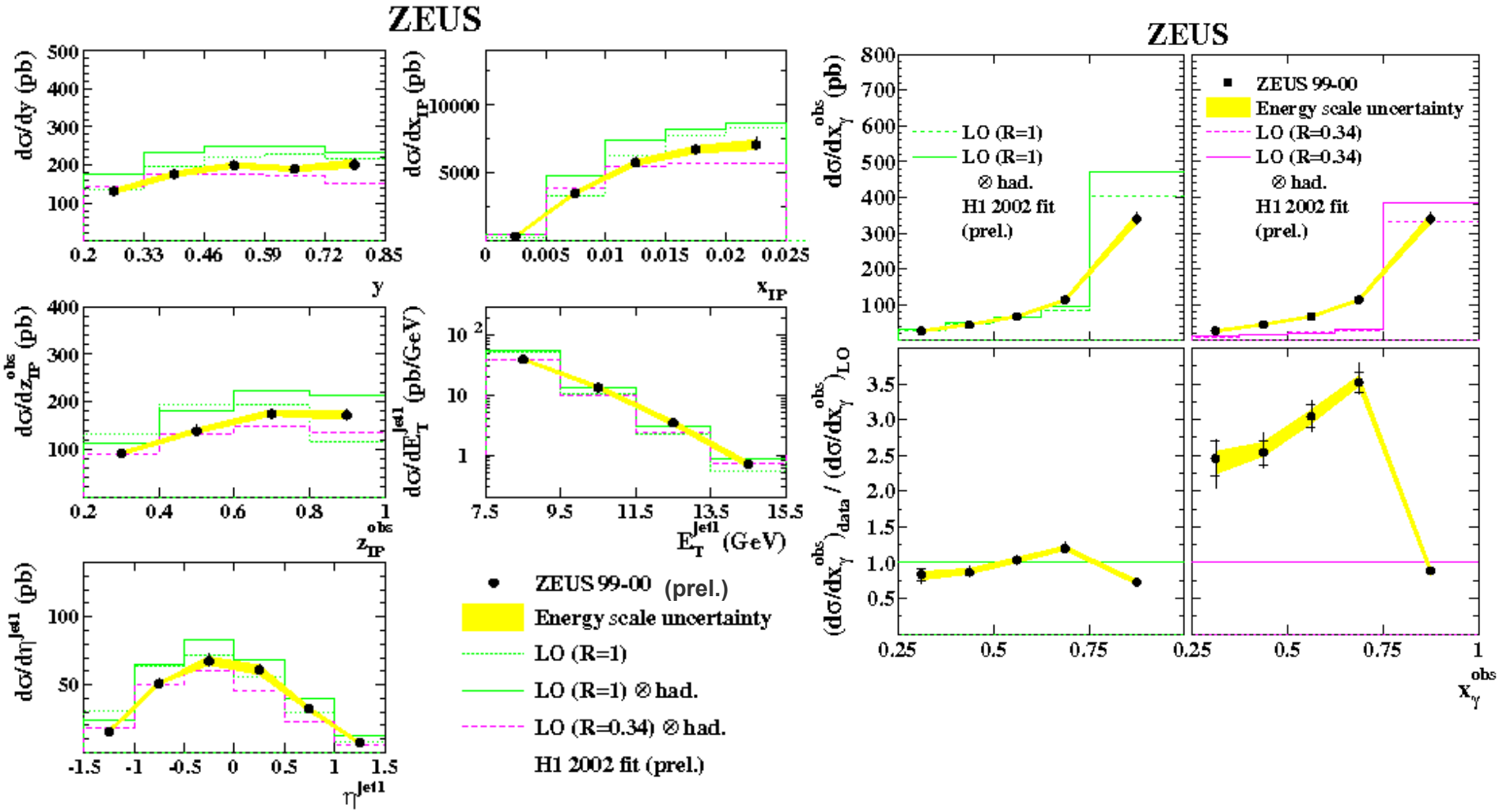
Ratio DATA / LO QCD



Single differential cross sections

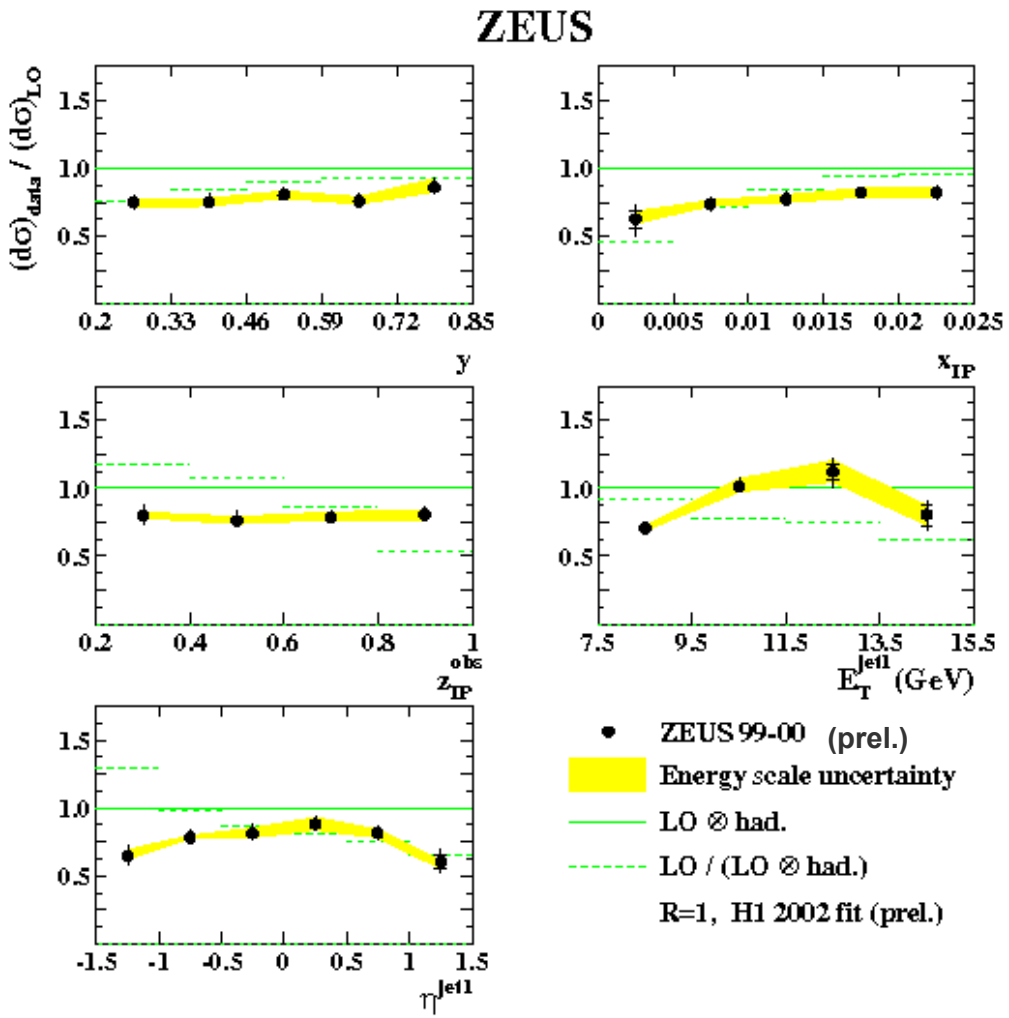
Comparison to LO QCD

Single differential cross sections



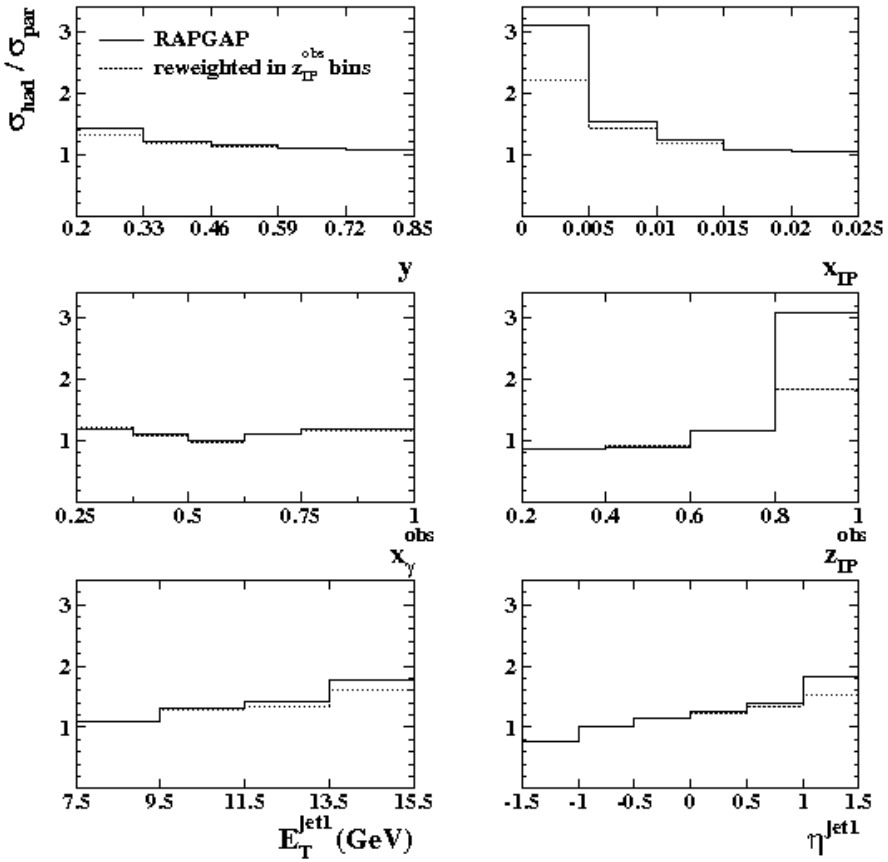
Comparison to LO QCD

Ratio DATA / LO QCD



Hadronization corrections

LO QCD



NLO QCD