Latest Results on Diffractive Production of $D^*(2010)^{\pm}$ and Dijets in ep collisions at HERA

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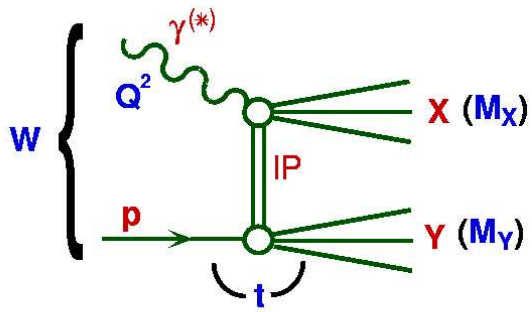
OUTLINE:

- Introduction
- Dijets in Diffractive DIS
- Diffractive Photoproduction of $D^*(2010)$
- Dijets in Diffractive Photoproduction
- Summary

Low X Physics Workshop
Sinaia, Romania, June 29 - July 2 - 2005

Introduction

Diffraction: is mediated by diffractive exchange ($I\!P$)



- ∇ quantum numbers of vacuum
- ∇ no colour transfer
- ∇ small momentum transfer in t-channel

$\Longrightarrow$ is observed as final states with large rapidity gaps (LRG)

What is $I\!P$?

- ∇ Object ?
  - $I\!R$ egge trajectory
  - Resolved $I\!P$ model ($DPDF'$s by H1 and ZEUS)
- ∇ pQCD:
  - $2g$-exchange model
  - $DPDF'$s (A.Martin, M.Ryskin, G.Watt)

Introduction

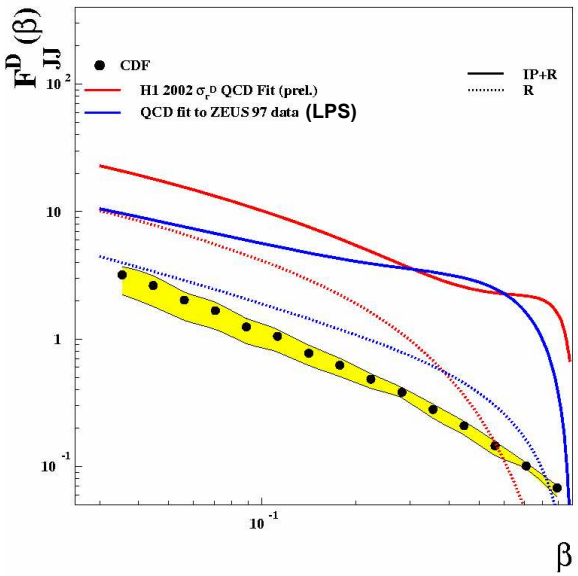
The structure of the colour singlet is studied within the QCD:

∇ QCD hard scattering factorisation theorem: (at fixed $x_{I\!P}$ and t)

$$\sigma^D(\gamma^* p \to X p) = \sum_{parton\ i} f_i^D(x, Q^2, x_{I\!P}, t) \otimes \sigma^{\gamma^* i}(x, Q^2)$$

$\sigma^{\gamma^* i}$: universal hard scattering cross section
f_i^D : universal partonic distribution functions (PDFs),
obey evolution equations

Theorem's validity is proved for diffractive DIS by J.Collins



CDF dijet rates: 5-10 times lower than expected ones using Diffractive PDF's from HERA

What this discrepancy indicates:

Diffractive PDF′s not universal ?

Factorization is not valid ?

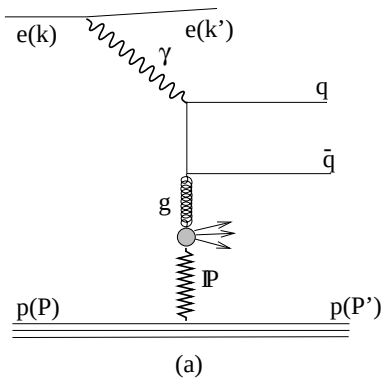
A.B.Kaidalov et al. predict suppression factor $S = 0.34$ for resolved photon at HERA

Introduction

Does diffraction obeys QCD hard scattering factorisation ?

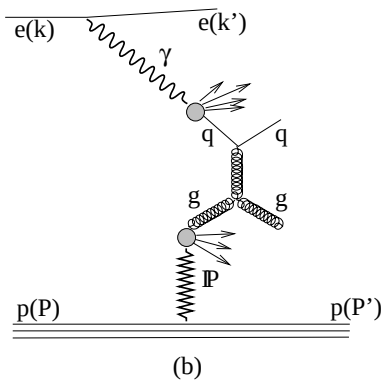
- Compare lower $Q^2 < 1$ GeV^2 (PhP) and higher $Q^2 > 1$GeV^2(DIS):
  Expected to hold for DIS and direct PhP
  Probably fails for resolved PhP
- Perform tests with identified hadronic final states using determined by H1 and ZEUS $DPDF'$s: in diffractive DIS and PhP

$x_\gamma^{obs} > 0.75$



direct PhP, DIS

$x_\gamma^{obs} < 0.75$



resolved PhP

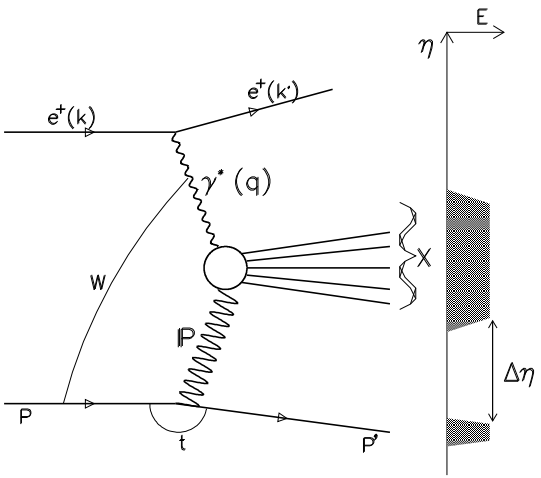
QQ
$DiJets$
etc.

Various hard scales: Q^2, P_T, m_Q

Sensitivity to gluonic exchanges

Kinematics

$e(k) + p(p) \to e'(k') + X + p'(p')$ proceeds via $\gamma^*(q) + I\!P(P_{I\!P}) \to X$:
X may be D^*X', $Jet1Jet2X'$, etc.



$$Q^2 = -q^2$$

PhP $Q^2 < 1$ GeV^2

DIS $Q^2 \gtrsim 1$ GeV^2

$$M_X^2 = (P_{I\!P} + q)^2$$

$$x_{I\!P} = \frac{P_{I\!P} \cdot q}{p \cdot q} = \frac{M_X^2 + Q^2}{W^2 + Q^2}, \qquad x_{I\!P} \simeq \frac{M_X^2}{W^2} \text{ in PhP}$$

$$\beta = \frac{Q^2}{Q^2 + M_X^2} \quad \text{(for DIS)}$$

$$Z_{I\!P}^{obs} = \frac{\sum_{jets} E_T^{jet} \exp^{\eta_{jet}}}{2 \cdot x_{I\!P} \cdot E_p} \qquad x_\gamma^{obs} = \frac{\sum_{jets} E_T^{jet} \exp^{-\eta_{jet}}}{2 \cdot y \cdot E_e}$$

$$\Delta\eta \ , \quad \eta = -ln(tan(\theta/2))$$

Dijet production in diffractive deep-inelastic scattering

ZEUS Measured Rates of DiJet Diffractive Production in DIS

- $ep \to eXp \to eJ1J2X'p$ $98-00$ *data*
- $5 < Q^2 < 100$ GeV^2, $100 < W < 250$ GeV, e^+/e^- detected
- rapidity gap method $\Longrightarrow x_{I\!P} < 0.03$

Different models were compared to the measured cross sections:

NLO QCD calculations::

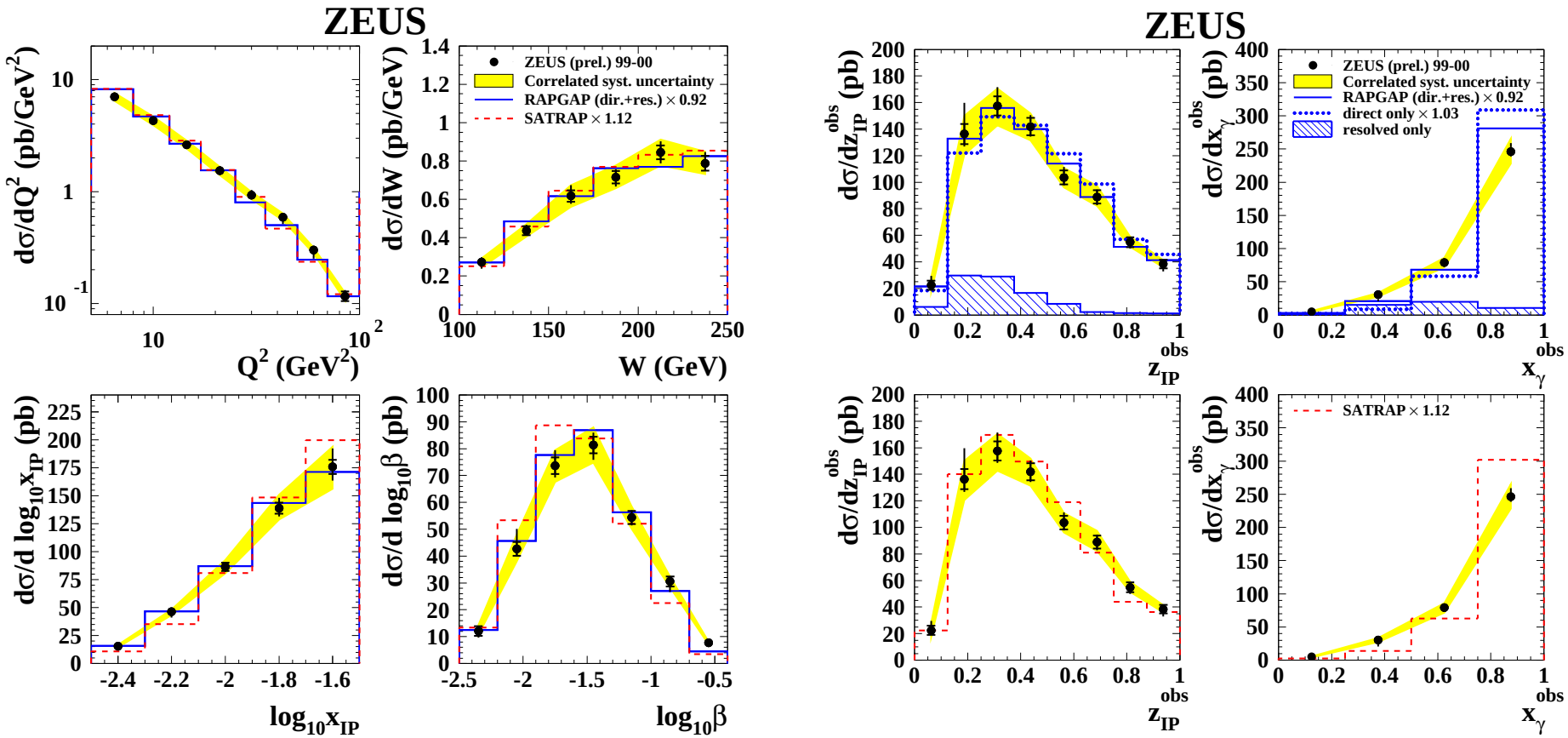
- Diffractive $PDF's$
  - ZEUS_LPS Fit $\alpha_s(M_Z) = 0.118$
  - H1 2002 Fit(prel.) $\alpha_s(M_Z) = 0.1085$

LO QCD calculations::

- $LO\ MC's$
  - RAPGAP MEPS H1FIT2 LO
  - SATRAP CDM Saturation model

DiJet Production in Diffractive Deep-Inelastic Scattering

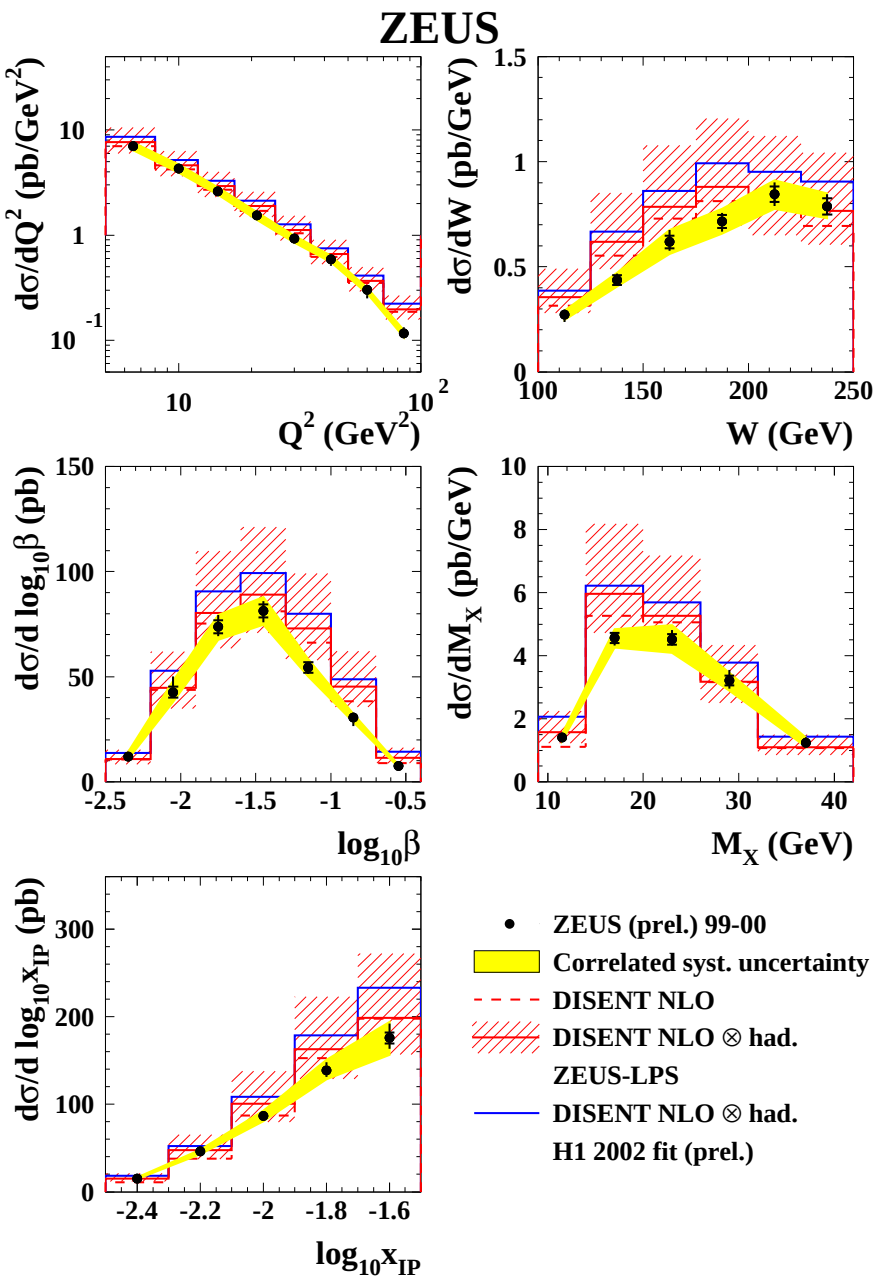
LO MC



Both LO MC (dir+res) consistent with data in shapes and approximately in normalization: 0.92*RAPGAP, 1.12*SATRAP

A small contribution from resolved photon processes essential for a better shape agreement with data. No change in normalization: (1.03→0.92)*RAPGAP

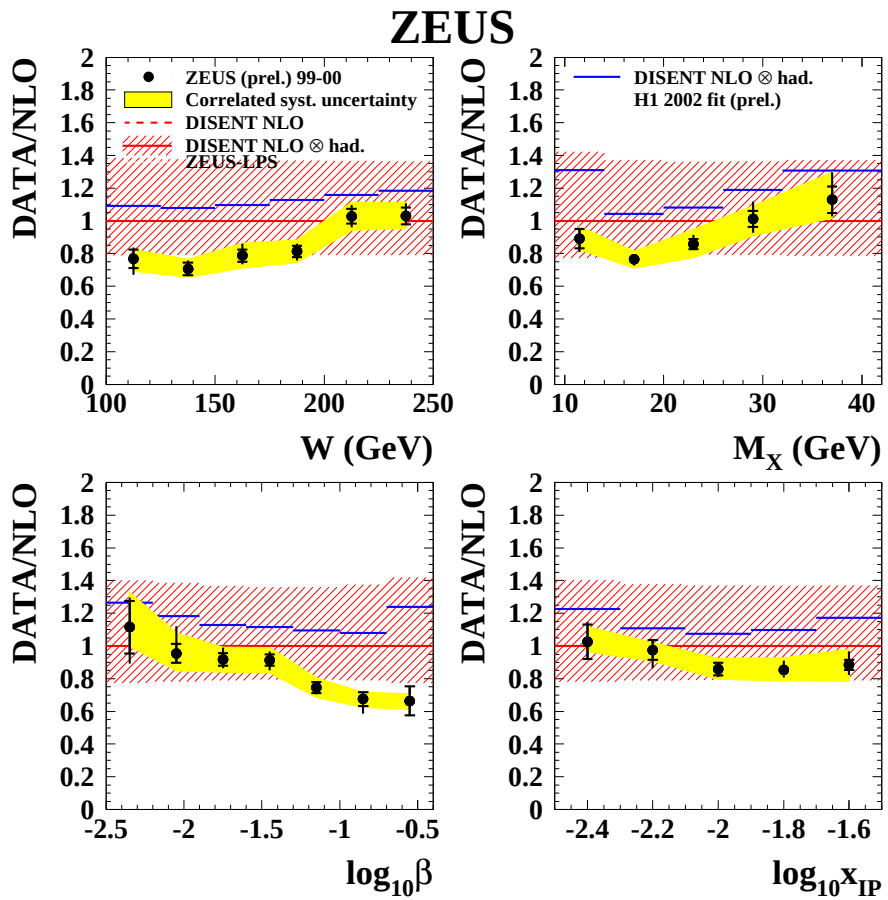
DiJet Production in Diffractive Deep-Inelastic Scattering



NLO QCD:

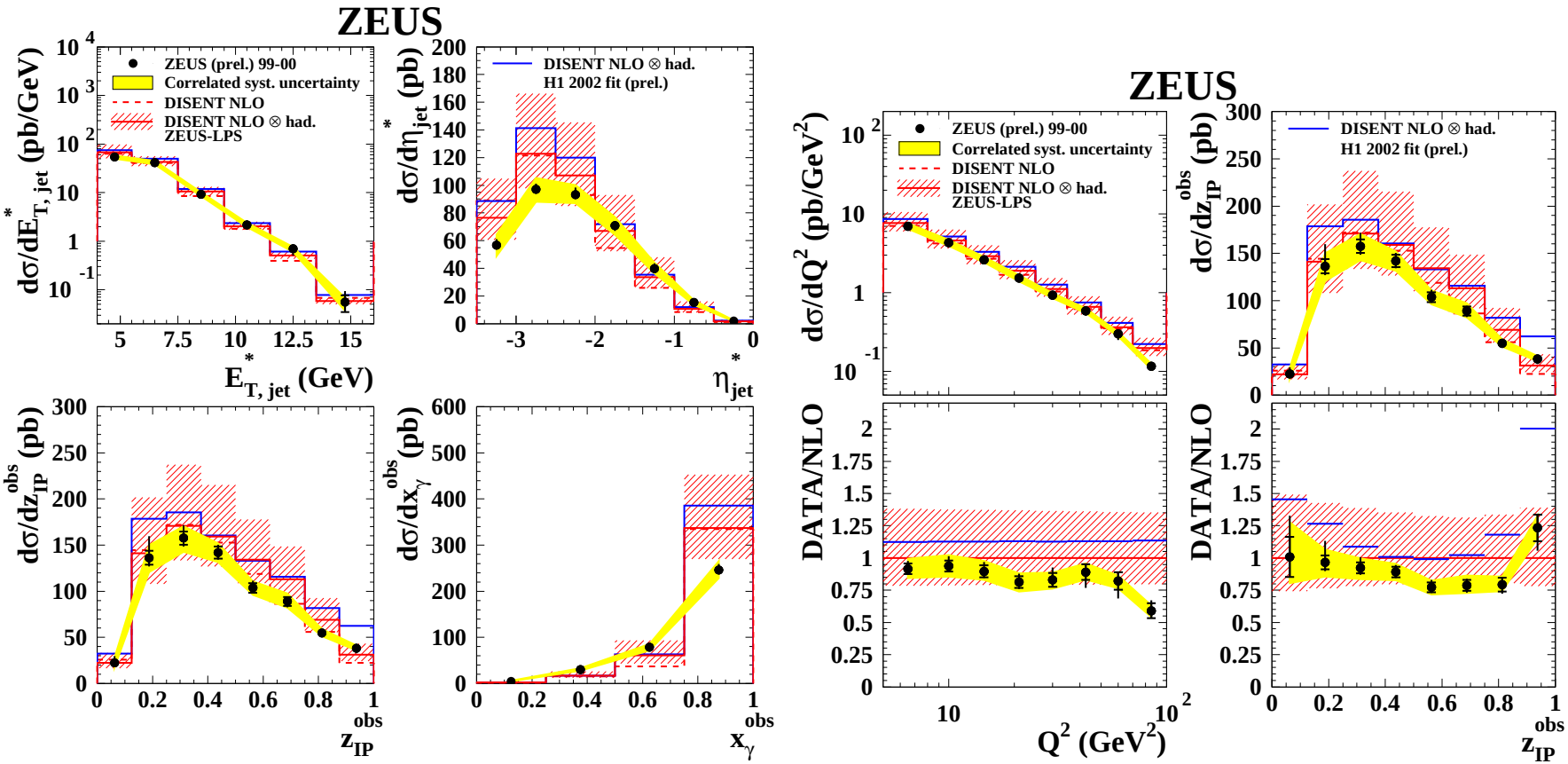
Shapes reproduced

Normalization close to 1



Dijet Production in Diffractive Deep-Inelastic Scattering

NLO



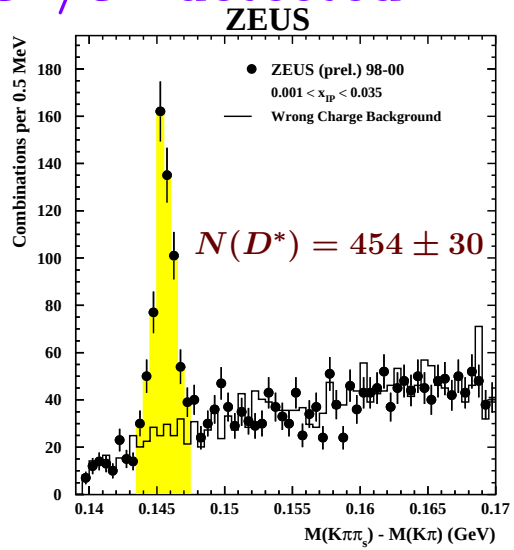
Diffractive DIS: new DiJet data consistent with previous D^* data

QCD factorisation does not contradict to data

Diffractive Photoproduction of D^*

ZEUS measured Cross Sections of Diffractive Photoproduction of D^*

- $ep \to eXp \to eD^*X'p$ $\quad D^*(2010)^\pm \to K\pi\pi$ Mode $\quad$ (98-00 data)
- $Q^2 < 1.0$ GeV^2 $\quad 0.17 < y < 0.89$ $\quad$ no e^+/e^- detected
- rapidity gap method



$130 < W < 300$ GeV,
$0.001 < x_{I\!P} < 0.035$

$P_t^{D^*} > 1.9$ GeV,
$|\eta^{D^*}| < 1.6$

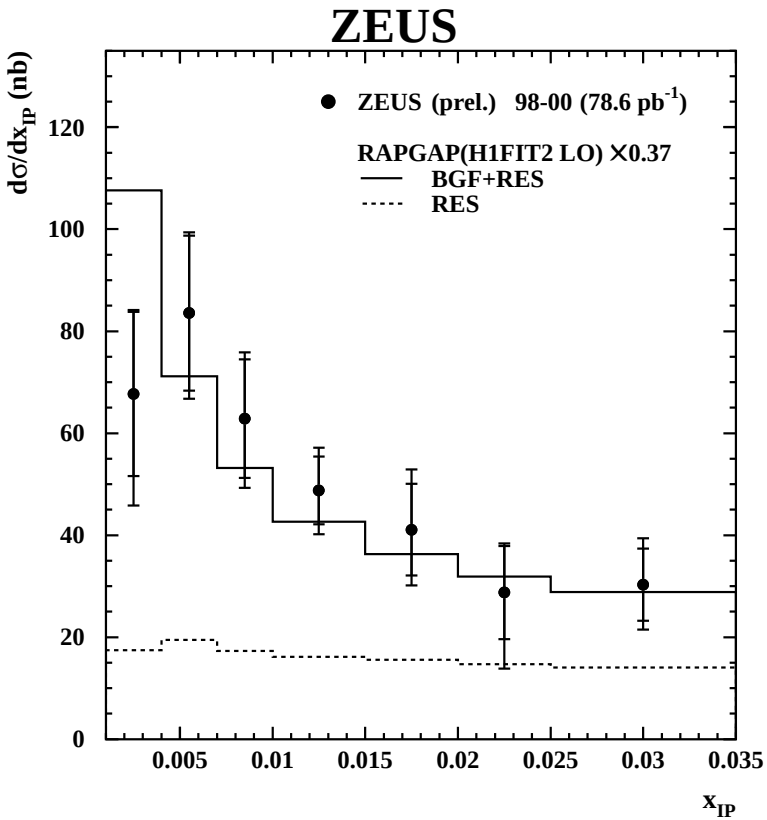
$$\sigma_{ZEUS} = 1.57 \pm 0.12(stat)^{+0.20}_{-0.22}(syst) \pm 0.08(pdiss)\ nb$$

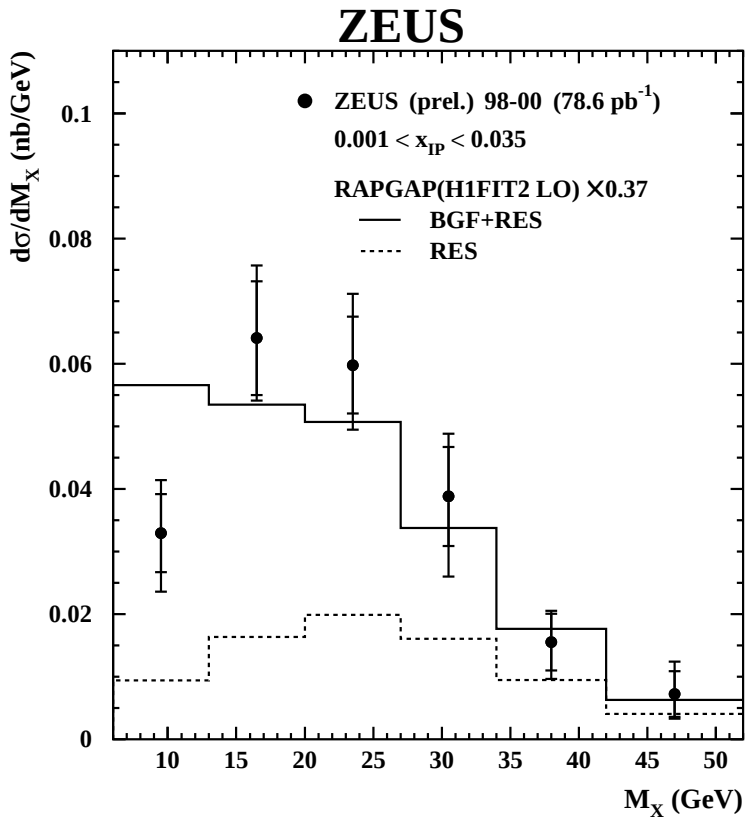
RAPGAP MC: $\sigma_{H1FIT2LO} = 4.27$ nb

$$\sigma_{ZEUS} \sim 0.37 \cdot \sigma_{H1FIT2LO}$$

Diffractive Photoproduction of D^*

Differential Cross Sections of Diffractive Photoproduction of D^*



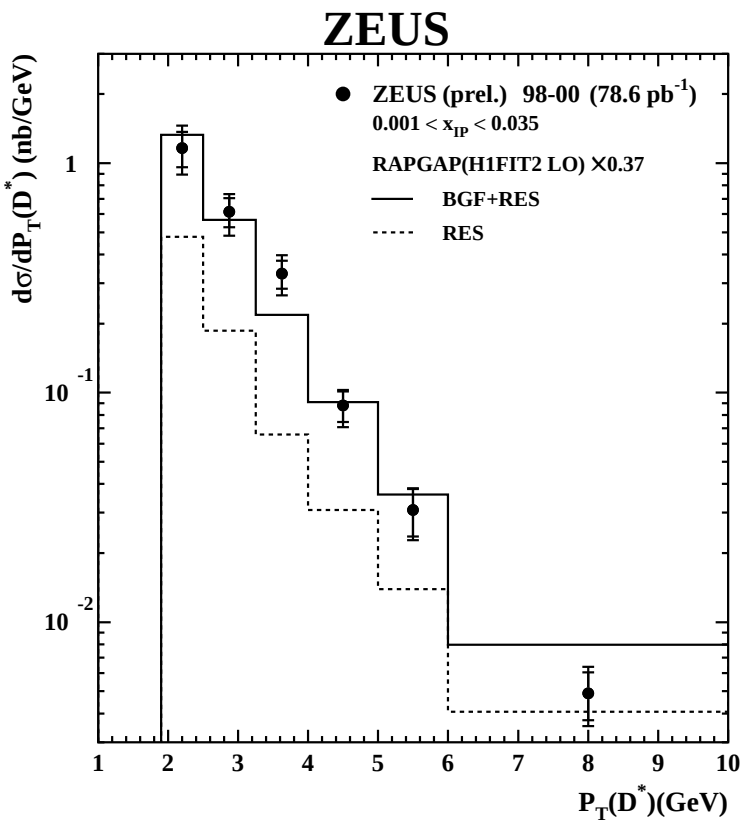


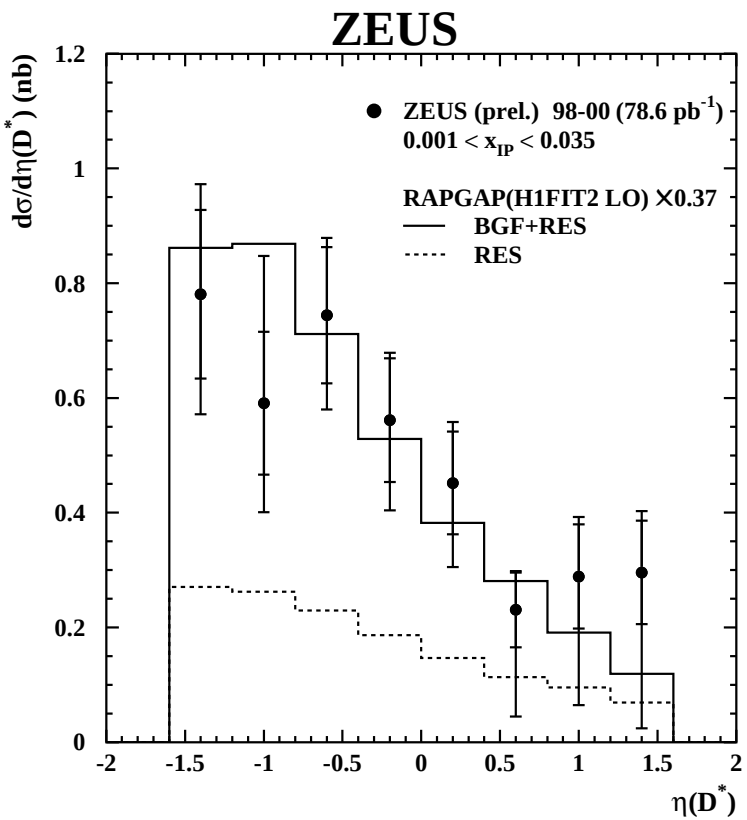
Shapes well described by DIR+RES, MC being scaled by 0.37

$$R = \frac{\sigma_{res}}{\sigma_{bgf+res}} = 0.35$$

Diffractive Photoproduction of D^*

Differential Cross Sections of Diffractive Photoproduction of D^*





Scaling the resolved component by 0.34 would not give a significantly better description of the data in both shape and normalisation.

Diffractive Photoproduction of DiJets

ZEUS Measured Rates of Diffractive Photoproduction of DiJets

- $ep \to eXp \to eJ1J2X'p \;\; 99-00\ data$
- $Q^2 < 1$ GeV^2, $0.2 < y < 0.85$, no e^+ detected
- rapidity gap method $\Longrightarrow x_{I\!P} < 0.025$

Different models were compared to the measurement:

NLO QCD calculations::

- $DPDF's$
  - H1 2002 Fit(prel.) $\alpha_s(M_Z) = 0.1085$
- $R_{res} = 1\ or\ 0.34$

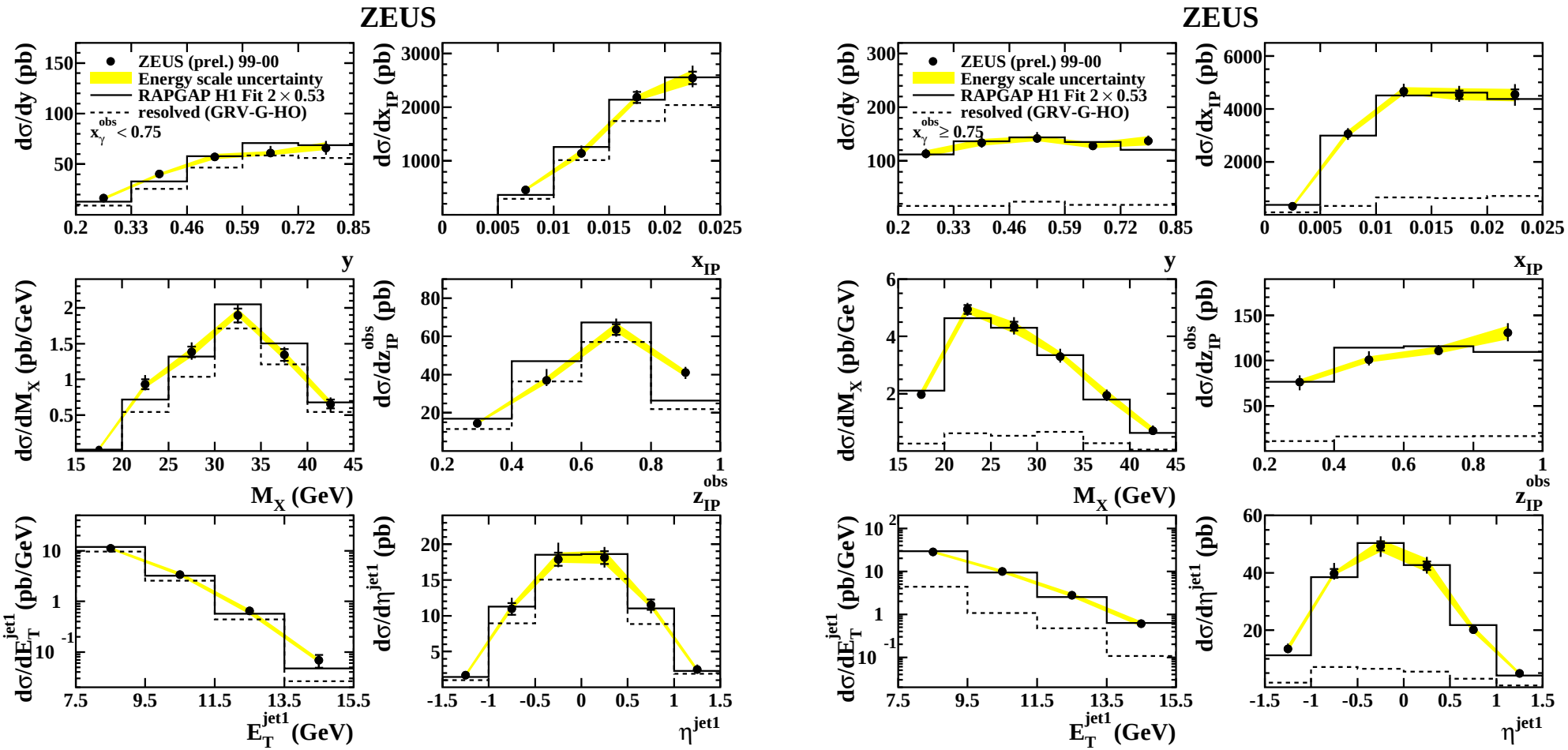
LO QCD calculations:

- $LO\ MC's$
  - RAPGAP MEPS H1FIT2 LO

  GRV-G-HO

Diffractive Photoproduction of DiJets

$x_\gamma^{obs} < 0.75$ LO*0.53 $x_\gamma^{obs} > 0.75$

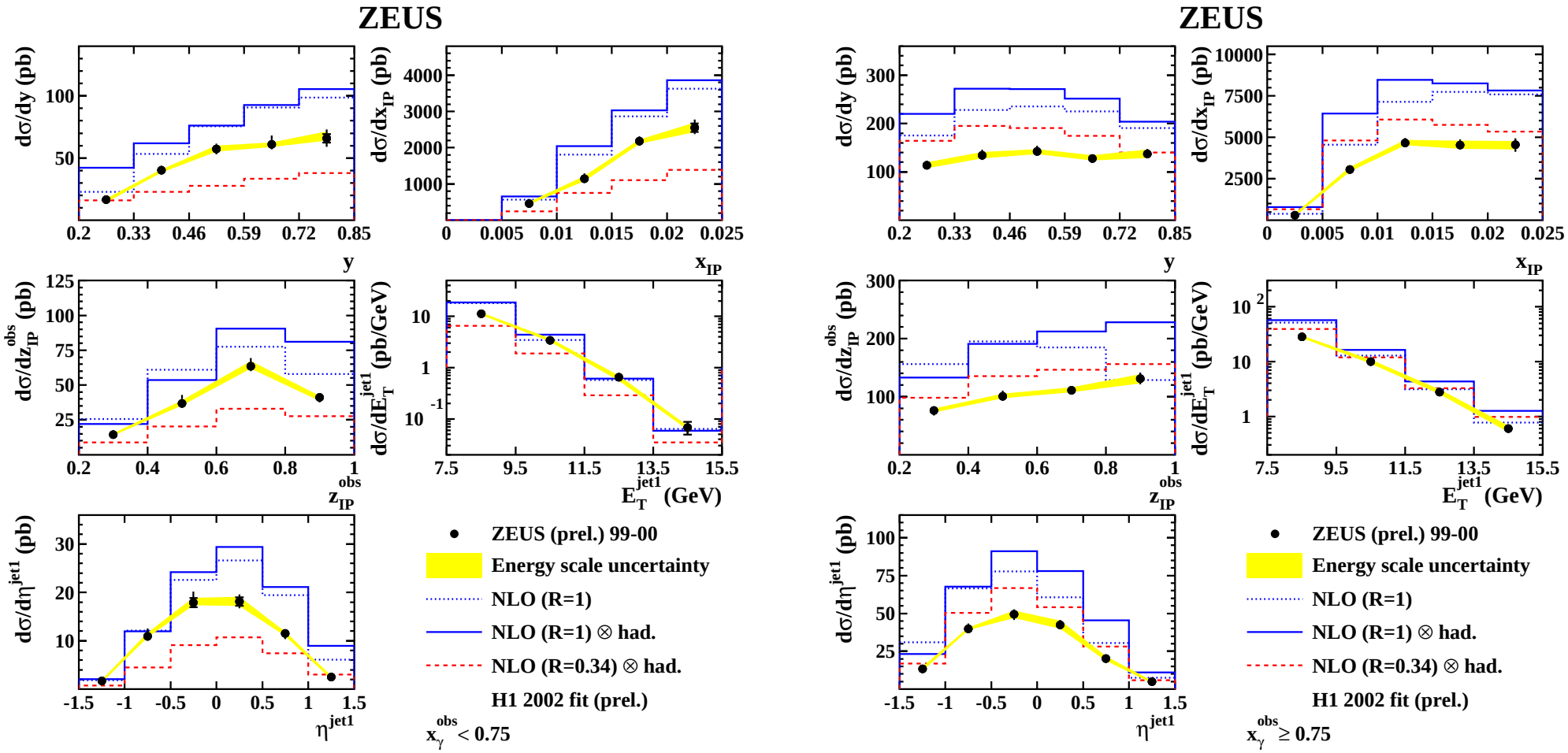


LO MC H1FIT2: consistent with data in shapes for full range of x_γ^{obs}

MC being scaled by 0.53 $\Longrightarrow$ compare with 0.37 for D^* and ~ 1 for DiJets in DDIS

Diffractive Photoproduction of DiJets

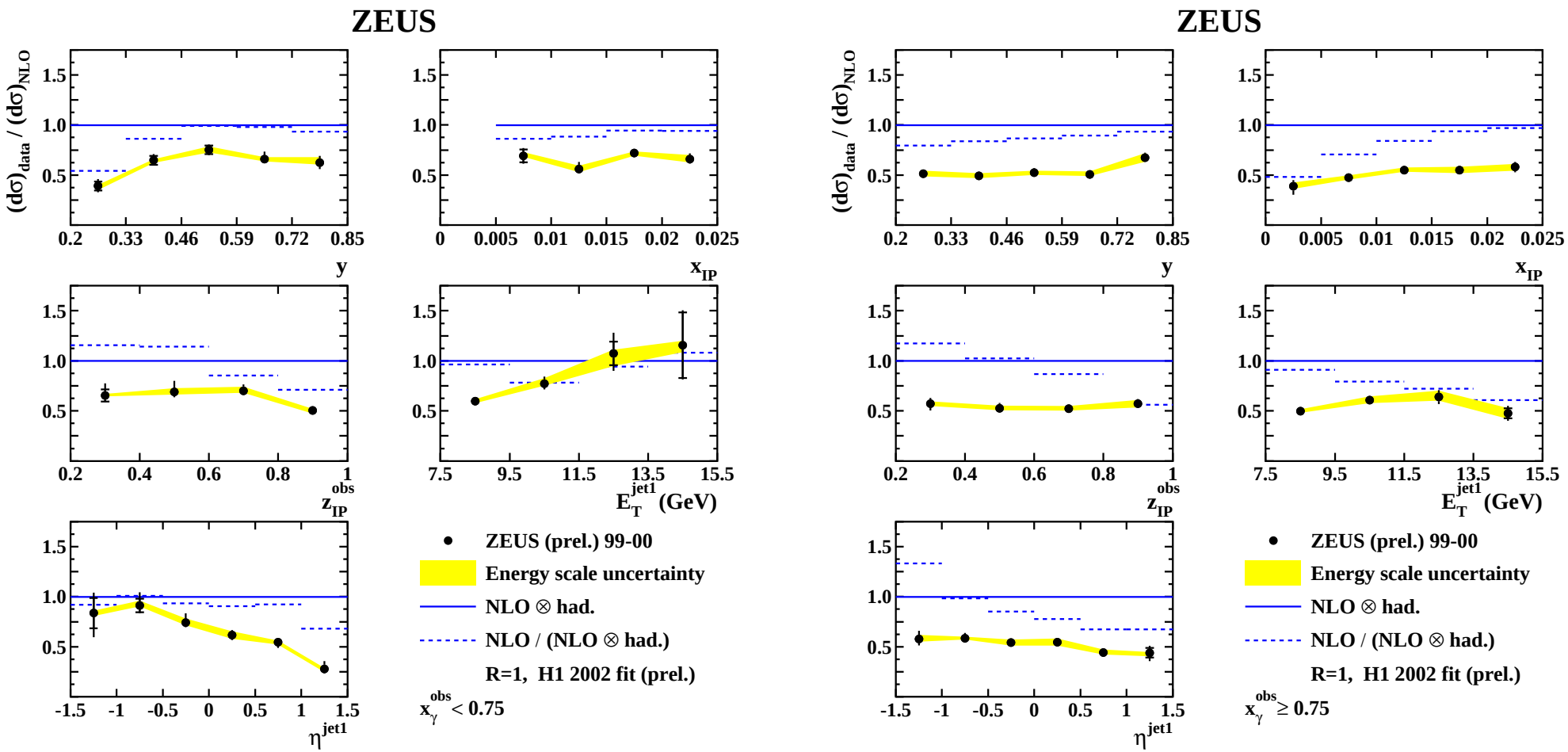
$x_\gamma^{obs} < 0.75$ ~0.5*NLO $x_\gamma^{obs} > 0.75$



No evidence observed for a suppression of resolved photon processes relative to direct photon processes

Diffractive Photoproduction of DiJets

$x_\gamma^{obs} < 0.75$ ~0.5*NLO $x_\gamma^{obs} > 0.75$



NLO QCD needs to be scaled by ~ 0.5 to reproduce the shapes of the cross sections

Summary

- ∇ Cross sections of dijet production in diffractive DIS were measured
  - * LO MC describe well shapes of measured distributions
  - * Account for resolved photon contribution essential though small
  - * NLO predictions with H1 2002 fit(prel.) or ZEUS_LPS fit describe data well
  - * Using H1 2002 fit(prel.) or ZEUS_LPS fit, QCD factorization keeps consistent to data.
- ∇ Double differential cross sections of diffractive photoproduction of dijets were measured for direct enriched ($x_\gamma^{obs} > 0.75$) and resolved ($x_\gamma^{obs} < 0.75$) enriched samples
  - * LO MC and NLO QCD reproduce shapes of cross sections being scaled by factor ∼0.5 for both resolved and direct enriched samples.
  - * no evidence for suppresion of resolved processes compared to direct ones is found.
- ∇ Cross sections of diffractive photoproduction of D^* were measured
  - * LO RAPGAP MC in the framework of resolved Pomeron model reasonably describes shapes of differential distributions
  - * Account for both direct and resolved reactions important for reasonable description of shapes of differential distributions
  - * Scaling the resolved component by 0.34 would not give a significantly better description of the data in both shape and normalisation.
  - * Newer theoretical estimations are much welcome!