Dijets in Photoproduction

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H1 Collaboration

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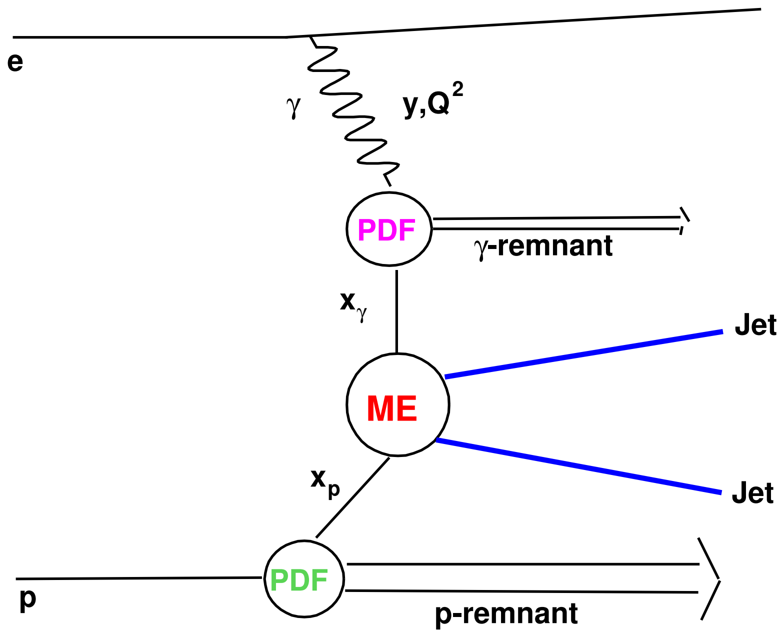
Motivation

- high E_T jets provide hard scale for perturbative QCD calculations
- soft-physics suppressed at high E_T
- Test perturbative QCD at NLO
- Test parameterizations of γ- and p-PDF
  up to very high scales (6000 GeV^2) and high x

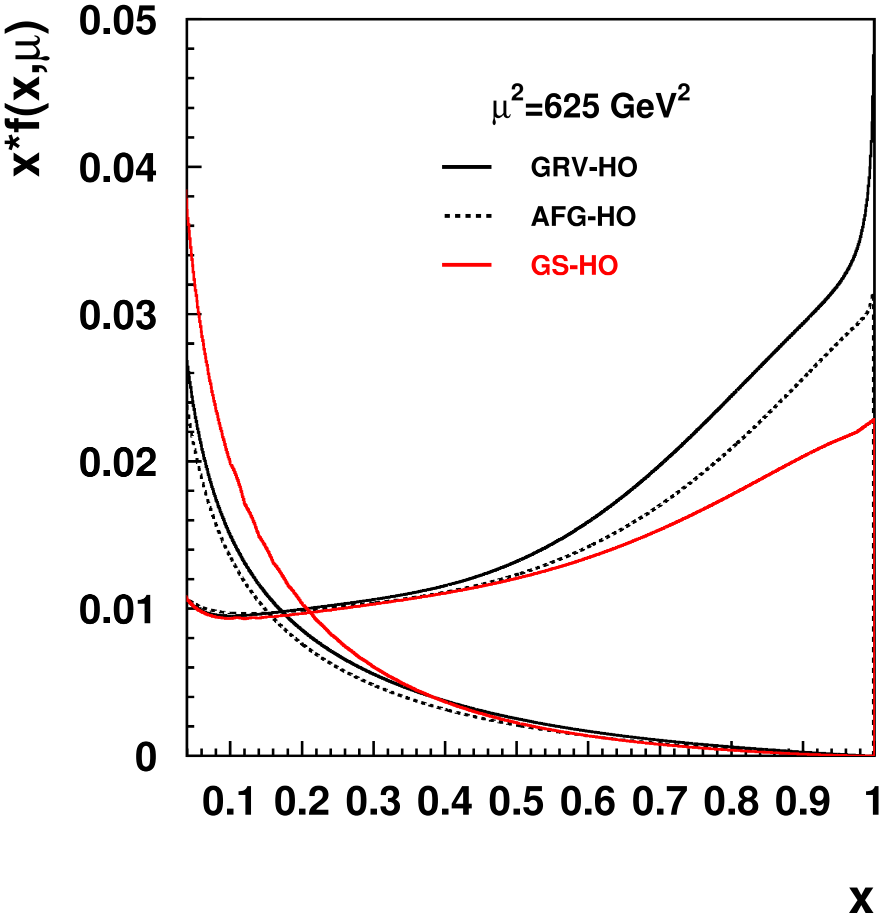
Photoproduction at HERA

- $\mathbf{Q^2}$ photon virtuality $\rightarrow \gamma P$: $Q^2 < 1$ GeV^2
- $\mathbf{y}$ fraction of longitudinal e momentum carried by γ
- $\mathbf{x_p}$ longitudinal momentum fraction carried by the partons out of the proton
- $\mathbf{x_\gamma}$ longitudinal momentum fraction carried by the partons out of the photon:
  DIRECT : $x_\gamma = 1$
  RESOLVED: $x_\gamma < 1$
- θ^* angle of the dijet system in dijet-CMS
- ME $\gamma q \rightarrow qg$, $\gamma g \rightarrow q\bar{q}$, $qq \rightarrow qq$, $qg \rightarrow qg$,...
- jets reconstructed using invariant k_T algorithm



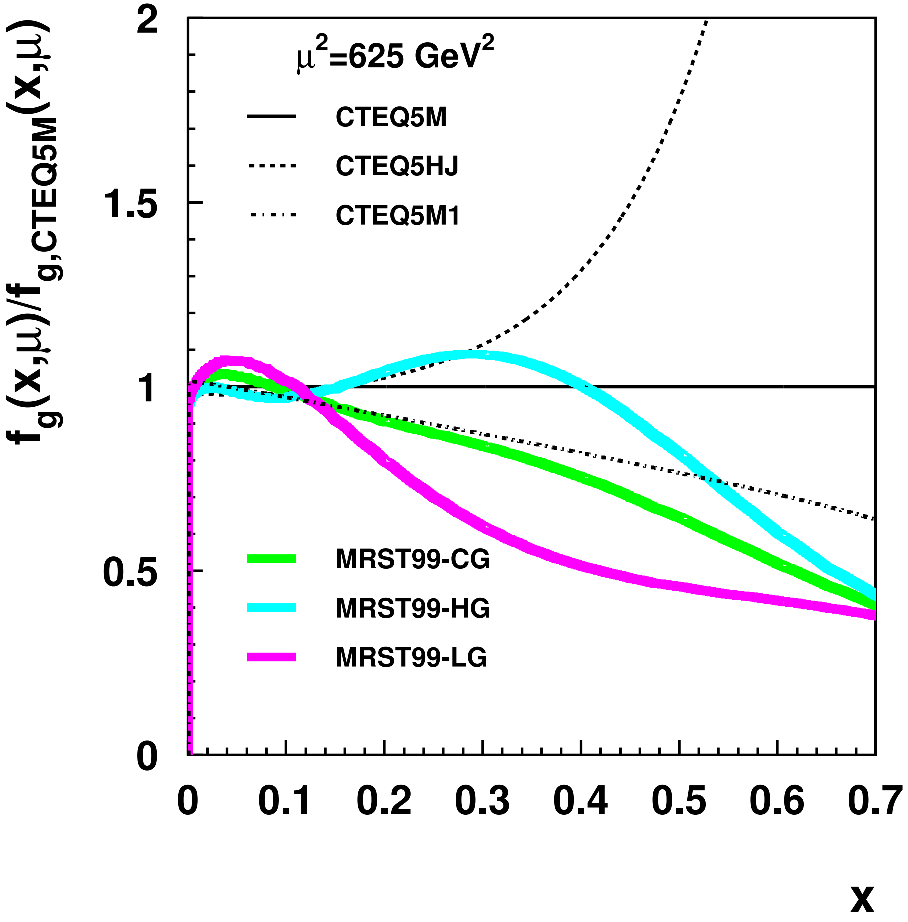
$$\sigma_{eP} = \gamma\text{-flux}(y) \otimes \gamma\text{-PDF}(x_\gamma, \mu) \otimes P\text{-PDF}(x_P, \mu) \otimes \sigma_{ij}(\theta^*, \mu)$$

Photon Structure



- Small differences between AFG-HO and GRV-HO parameterizations
- GS-HO parameterization: deviations from lnμ^2 prediction

Proton Structure



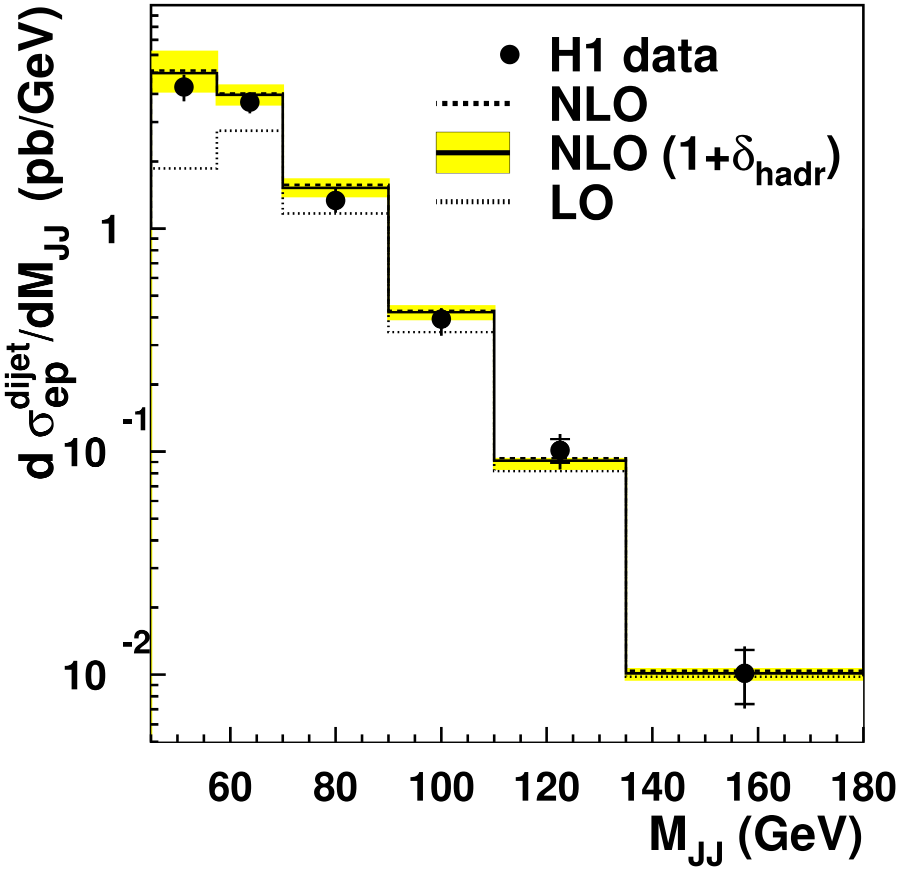
- Increasing differences with increasing x
- PDF at high x interesting for Tevatron, LHC

Data Selection/NLO calculations

- asymmetric cuts:
  $E_{T,max} > 25$ GeV ,$E_{T,second} > 15$ GeV
  $\Longrightarrow$ inclusive dijets
- if cut on $E_{T,second}$ is varied by ± 5 GeV, the ratio of measured crossections to NLO predictions varies by 10% for $x_\gamma < 0.8$, 3% for $x_\gamma > 0.8$
  $\Longrightarrow$ smaller than NLO scale uncertainties
- $-0.5 < \eta^{Jet} < 2.5$
- $0.1 < y < 0.9$
- $E_{T,miss} < 20$ GeV
- **Luminosity: 34.9pb^{-1}**

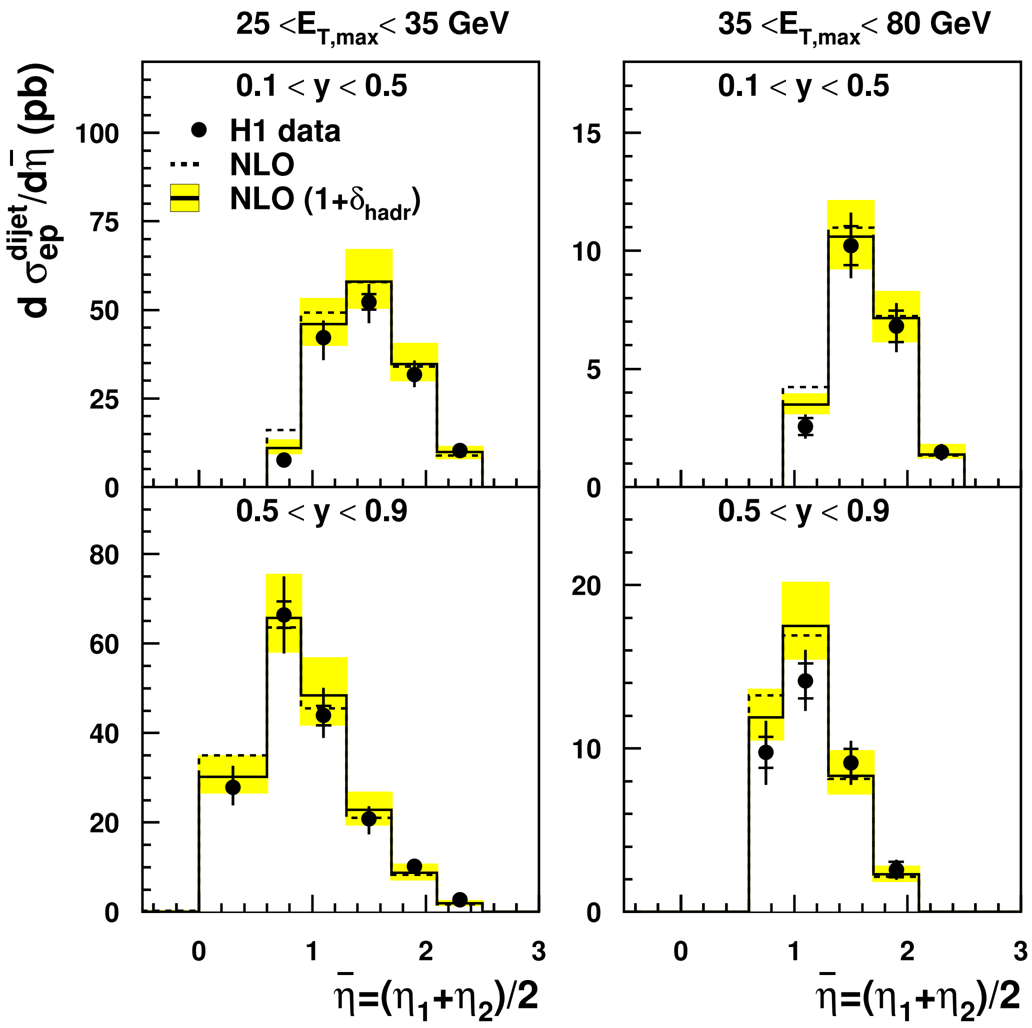
- perturbative QCD:
  (NLO by Frixione/Rudolfi (Subtraction method)
  Harris/Owen, Klasen/Kramer, Aurenche et al.
  (phase space slicing))
- CTEQ5M and GRV-HO chosen,
  MRST-sets and AFG-HO used for tests
- **Scale**: $E_{T,mean}$
  Scale uncertainty: variation 0.5-2 $E_{T,mean}$

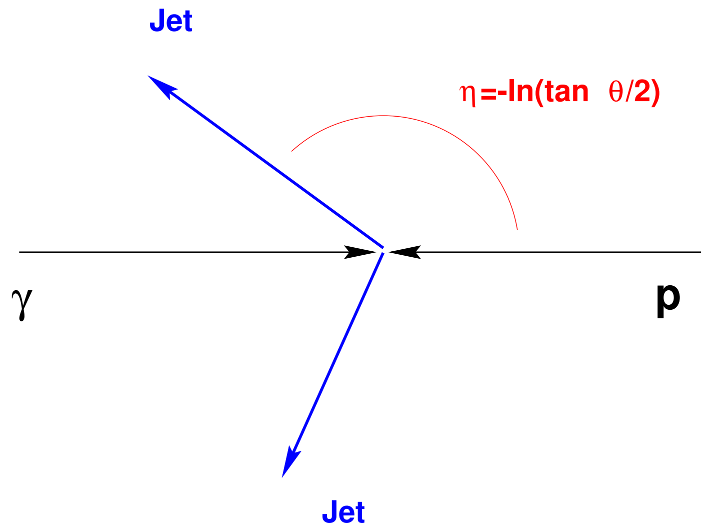
Results: Dijet mass M_{JJ}



- NLO: Good description up to 160 GeV using CTEQ5M p-PDF and GRV-HO γ-PDF
- Hadronization effects $\delta_{\text{hadr}} < 5\%$ in all bins
- Hadronic energy scale uncertainty $\pm 2\%$ $\longrightarrow$ 10%
- NLO scale uncertainty (varied from 0.5 to 2) $\longrightarrow$ 20%

Results: $\bar{\eta}$





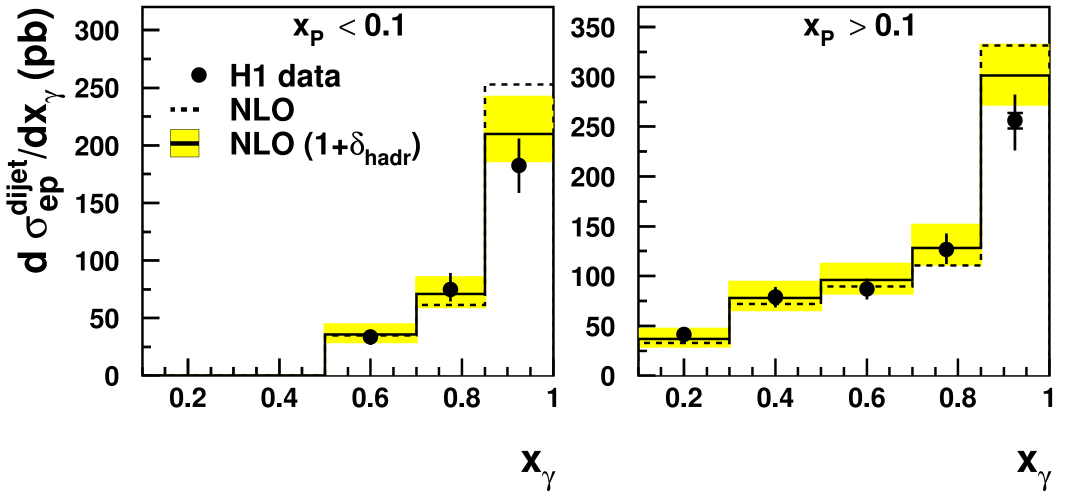
$\bar{\eta}$ sensitive to x:

$x_\gamma \approx 1/y \cdot e^{-\bar{\eta}} \cdot E_T$

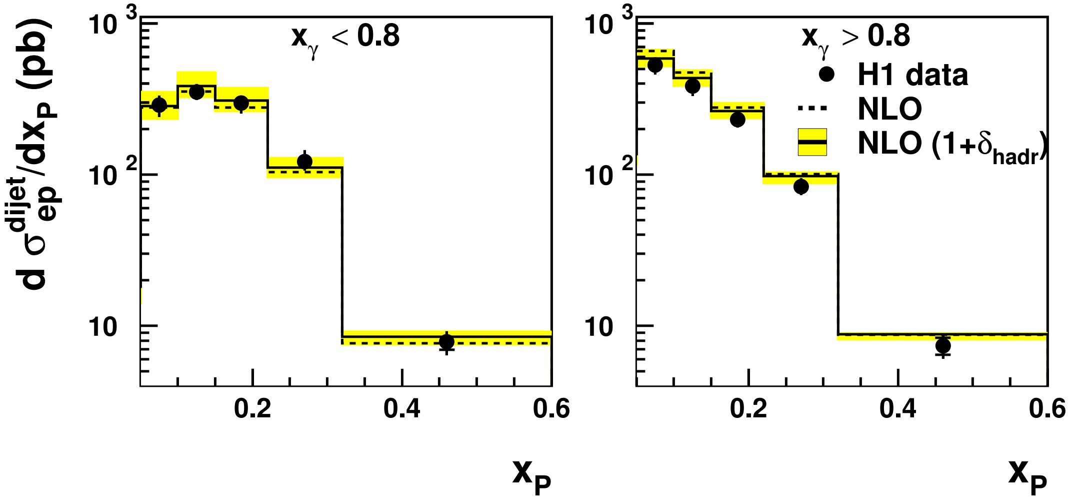
$x_p \approx e^{+\bar{\eta}} \cdot E_T$

$\Longrightarrow$ PDF sensitivity

Results: x_γ,x_p



calculation exceeds data only for $x_\gamma > 0.85$ but
compatible within uncertainties

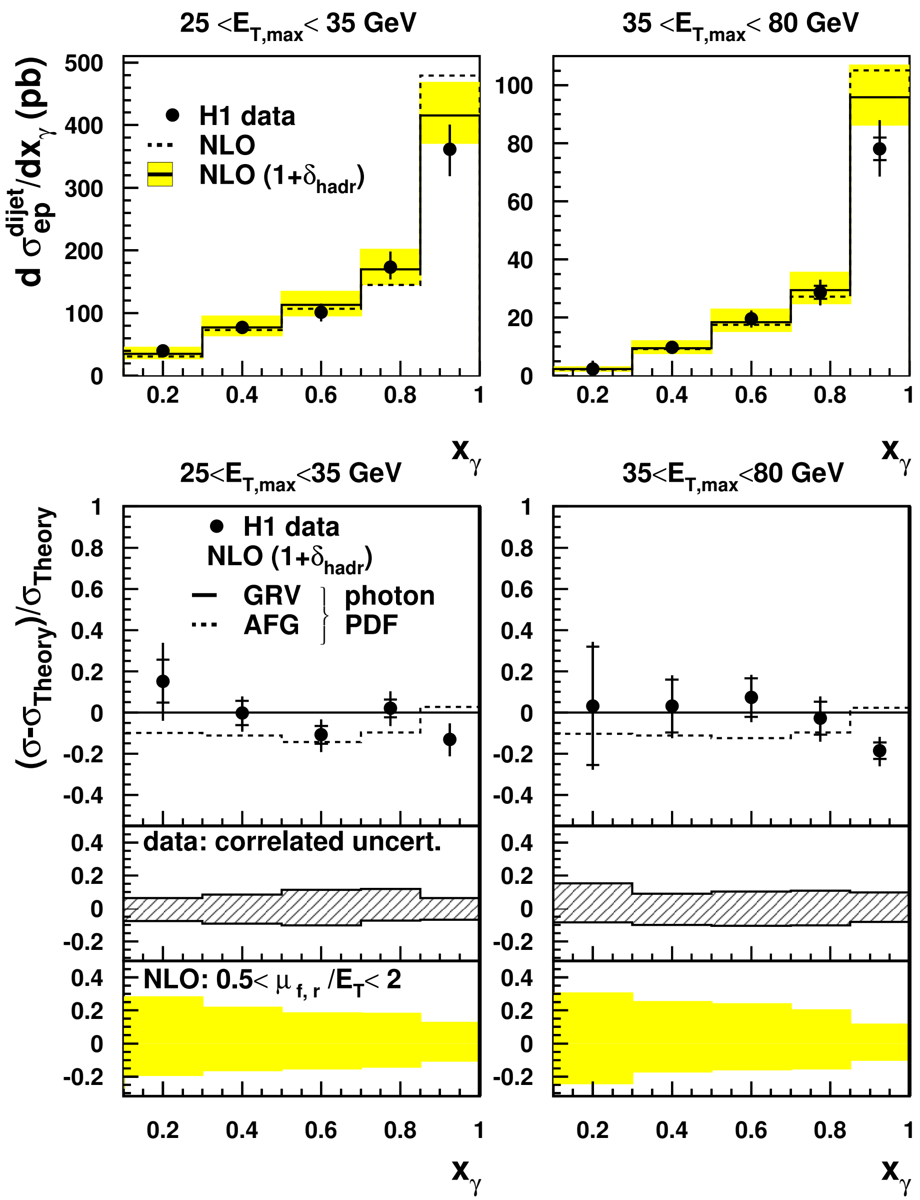


sensitive to proton PDF
Difference δ between CTEQ5M/MRST-sets
(large gluon variation at high x_p)

$x_p < 0.1$: $\delta < 5\%$
$\longrightarrow$ smaller than **scale uncertainties**

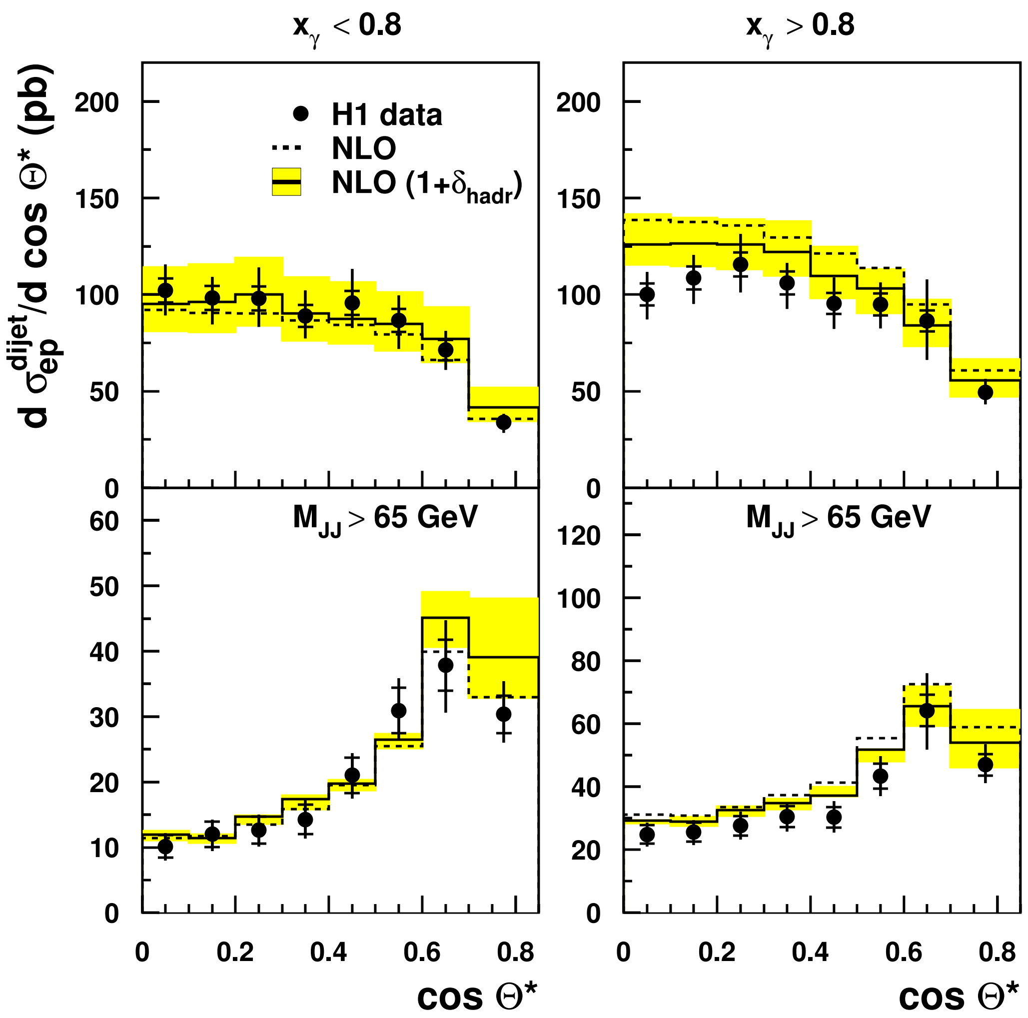
$x_p > 0.1$: $\delta \approx 10 - 15\%$
$\longrightarrow$ similar to **scale uncertainties**

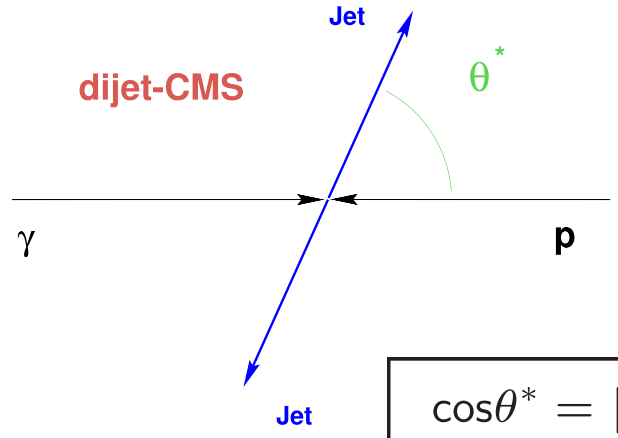
Results: x_γ



- two regions of $E_{T,max}$:
  different factorization scales for γ- and p-PDF
- AFG-HO,GRV-HO describe the data well
- NLO **scale uncertainty** significant effect
- **Hadronization corrections** sizeable at high x_γ
- NLO **scale uncertainty** are the dominant source of uncertainties
- NLO pQCD exceeds data only at high x_γ and high E_T

Results: cos θ^*

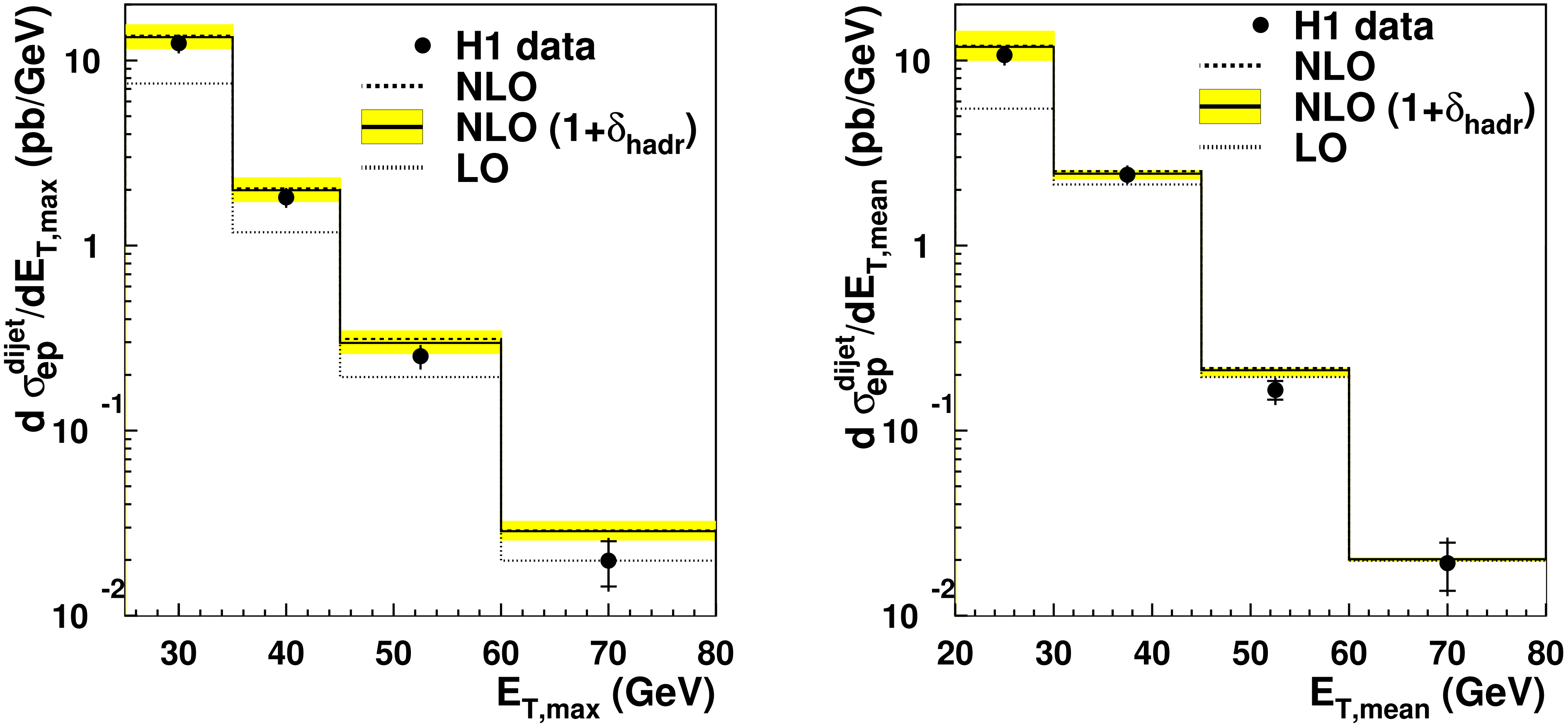




$$\cos\theta^* = |\tanh \Delta\eta/2|$$

- sensitive to dynamics
- $x_\gamma < 0.8$: well described
  $x_\gamma > 0.8$: NLO QCD overshoots data at small cos θ^*
- high M_{JJ}: phase space effect reduced, shape follows ME expectation

Results: $E_{T,\mathrm{max}}$, $E_{T,\mathrm{mean}}$



NLO pQCD describes data up to highest scales

Remarkable:NLO scale uncertainty **less** $< 5\%$ **at highest** $E_{T,\mathrm{mean}}$**-bin**

Summary and Outlook

- Dijet photoproduction: additional/complementary information to DIS, $p\bar{p}$, e^+e^- on PDF's

- Overall agreement of NLO QCD in various dijet-observables measured in γP at different x, different values of the scale E_T

- Precise data due to small hadronic energy scale uncertainty:
  Exp. uncertainty $\approx$ theor. uncertainty

- HERA data should be included in the fits for the PDF's.
  HERA-II with higher luminosity will be able to further constrain the p-PDF at even higher x.