Measurement of Dijet Production in Diffractive Deep-Inelastic ep Scattering at HERA

DIS 2015
XXIII International Workshop on Deep-Inelastic Scattering and Related Subjects

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Results presented in this talk:
JHEP 1503 (2015) 092
[arXiv:1412.0928]

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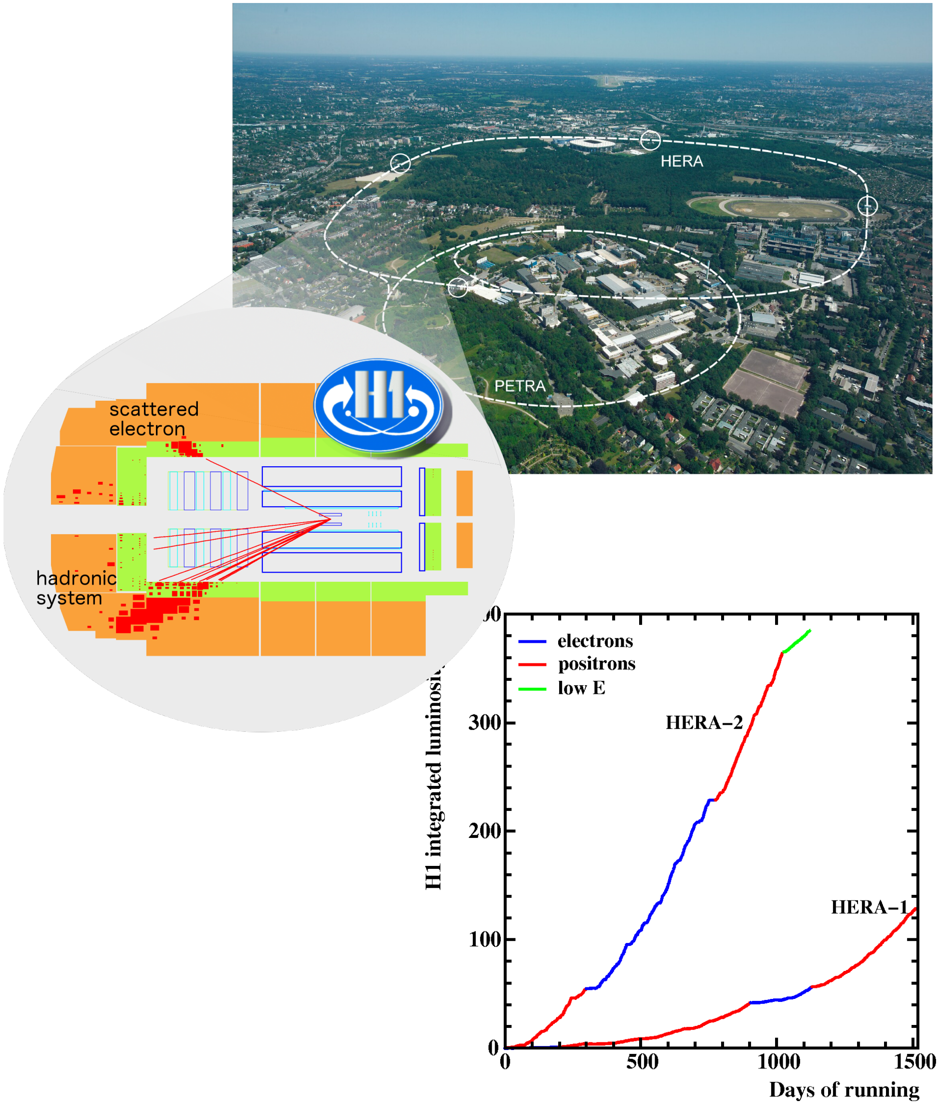
for the H1 Collaboration

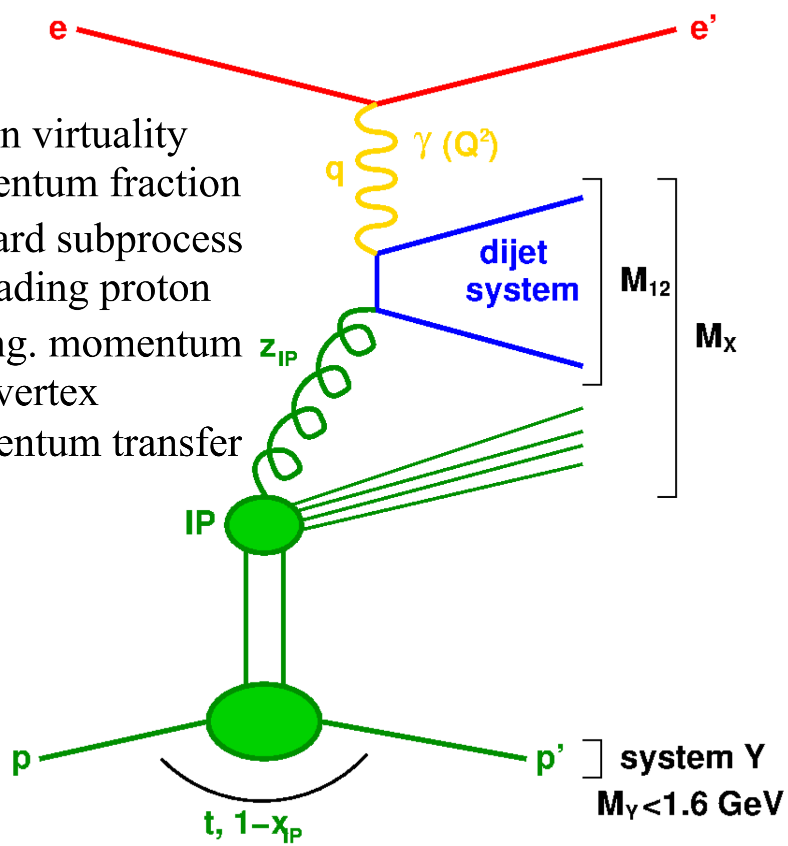
The H1 experiment at HERA

- World's only ep collider 1994-2007
- 920 x 27.6 GeV ($\sqrt{s}$=320 GeV)
- Two collider experiments, H1 and ZEUS
- Integrated Luminosity:
  ~100 pb^{-1} (HERA-I)
  ~400 pb^{-1} (HERA-II)
- This analysis: using HERA-II data



Diffractive dijet production in DIS

Q^2: photon virtuality
z_{IP}: momentum fraction in hard subprocess
$1-x_{IP}$: leading proton long. momentum
t: proton vertex momentum transfer



- QCD factorisation in diffractive DIS (Collins): proton structure can be described by DPDFs

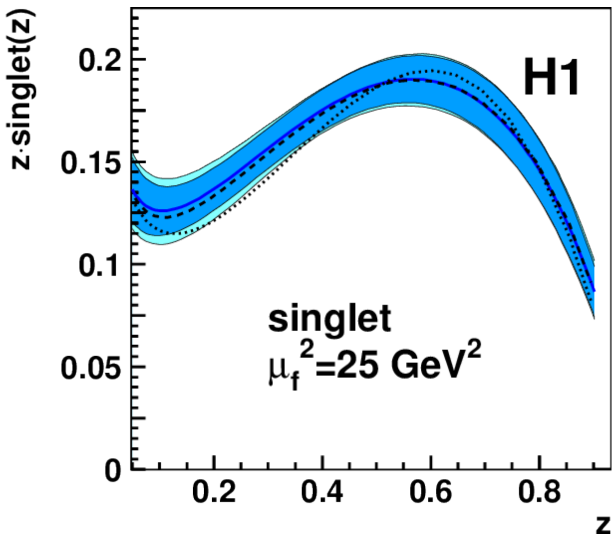
$$f_i(z_{IP}, \mu_F^2, x_{IP}, t)$$

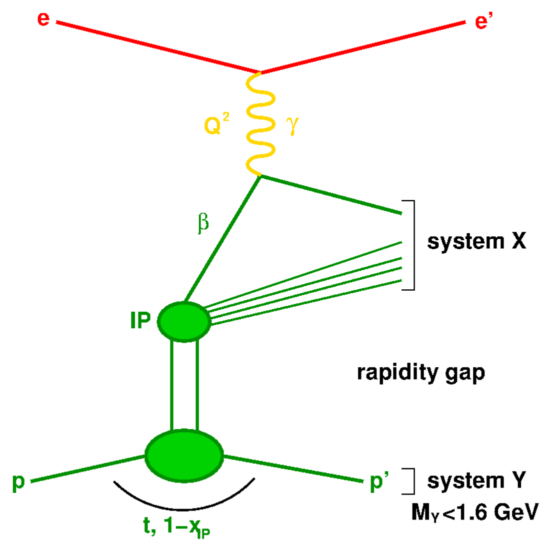
- Proton vertex factorisation: assume that DPDF factorizes into flux and pomeron PDF

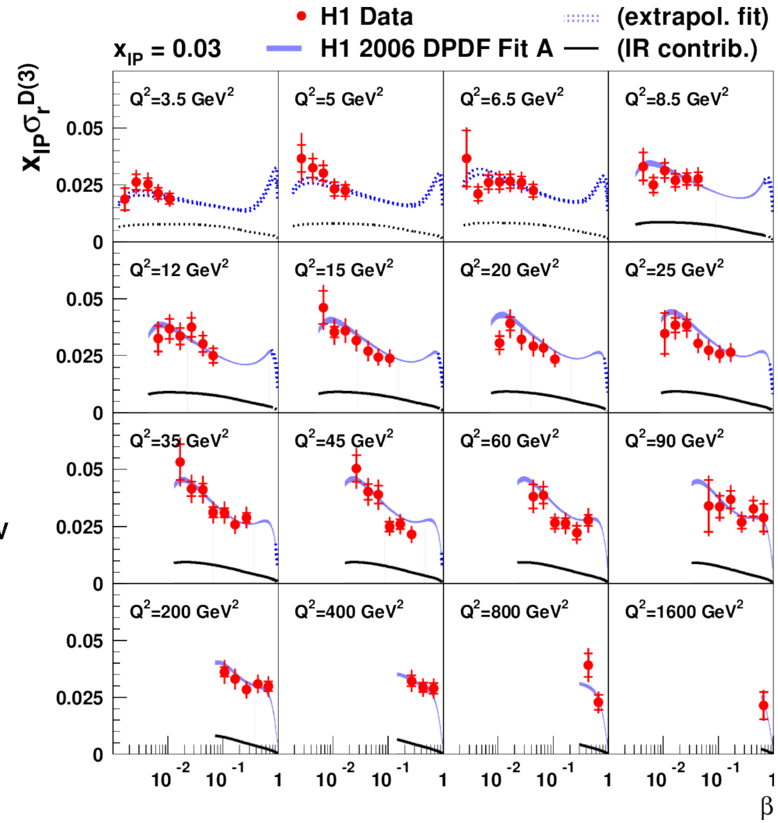
$$f_i(z_{IP}, \mu_F^2, x_{IP}, t) = f_{p/IP}(x_{IP}, t) \times f_i(z_{IP}, \mu_F^2)$$

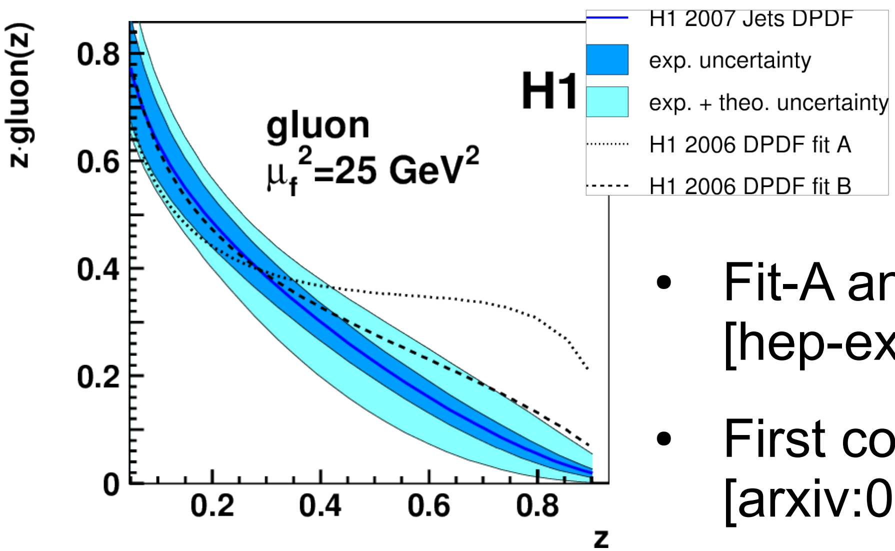
DPDFs are taken from H12006 Fit-B to incl. DDIS data

H12006 DPDF Fit-A and Fit-B









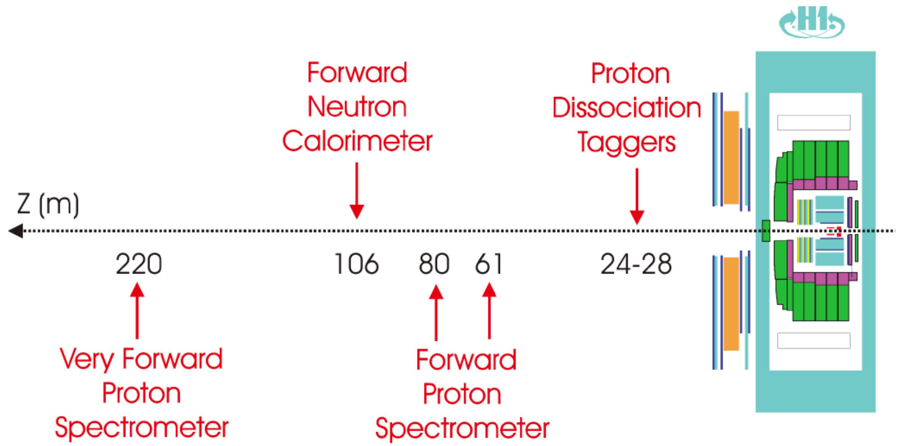
- Fit-A and Fit-B: Eur. Phys. J. C48 (2006) 715-748 [hep-ex/0606004]
- First comparison to jet data: JHEP 0710:042,2007. [arxiv:0708.3217]

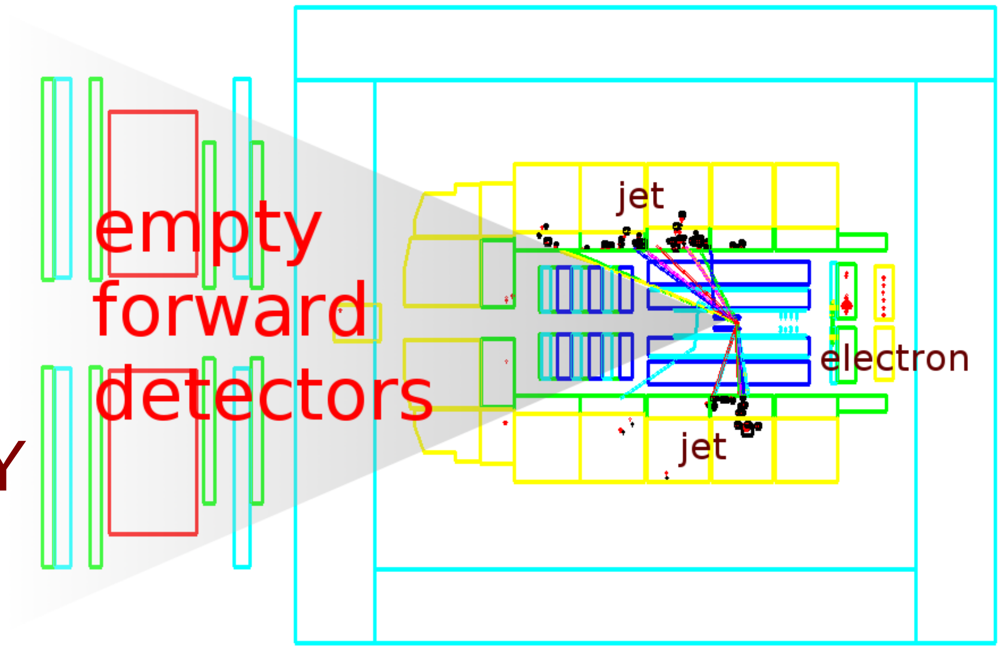
NLO predictions

- NLOJET++ with five active flavours
- Adopted to diffractive DIS using x_{IP} slicing method
- 2-loop RGE
- $\alpha_S(M_Z)=0.118$
- scale $\mu_R^2=\mu_F^2=\langle P_T^{*\,\mathrm{jet}}\rangle^2+Q^2$
- H12006 Fit-B DPDFs are used
- DPDF uncertainties are propagated to predicted cross sections
- Scale is varied by factor of 2 up and down

Detecting diffractive events

- Two methods used at HERA:
  - Proton taggers (next talk)
    - no proton dissociation
    - Direct reconstruction of Y
    - Low acceptance and/or low statistics
  - Large rapidity gap event selection (this analysis)
    - Include dissociation
    - Poor reconstruction of Y
    - High statistics





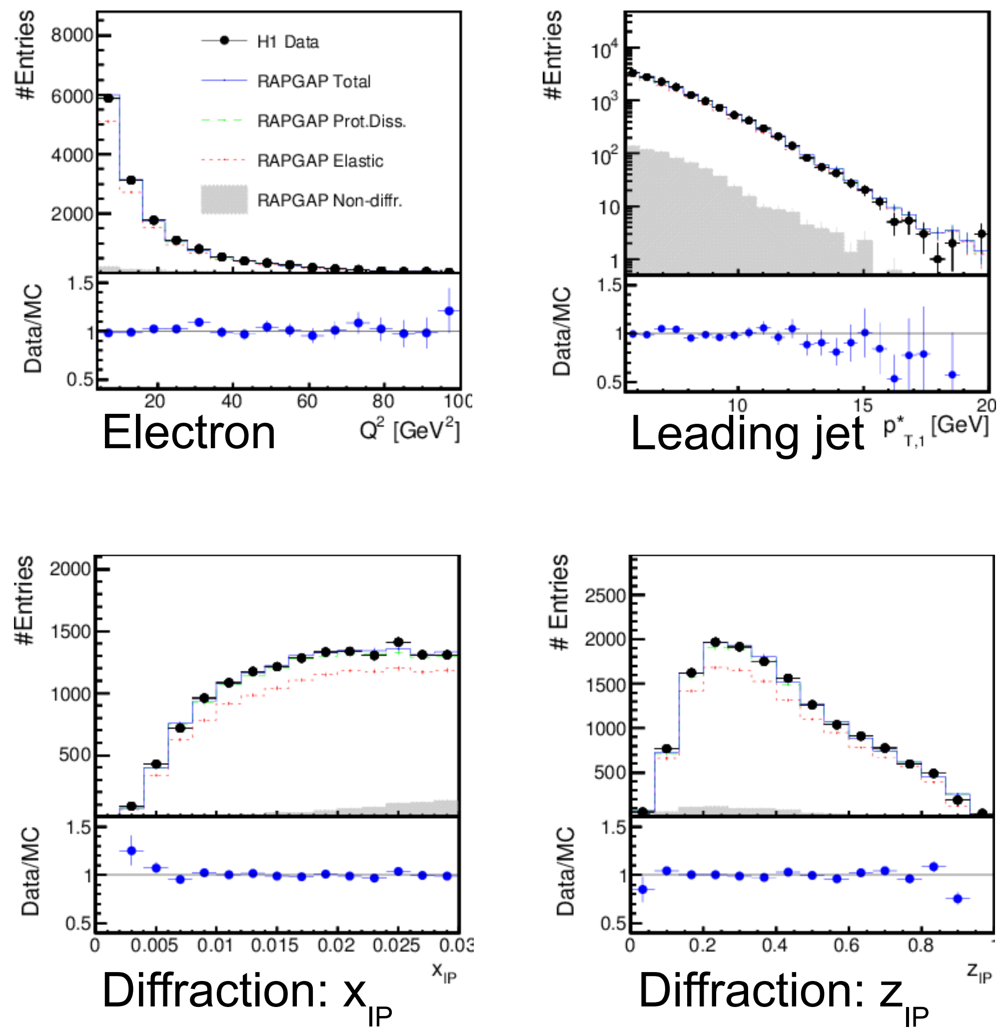
Diffractive dijet selection

	Extended Analysis Phase Space	Measurement Cross Section Phase Space
DIS	$3 < Q^2 < 100\ \mathrm{GeV}^2$ $y < 0.7$	$4 < Q^2 < 100\ \mathrm{GeV}^2$ $0.1 < y < 0.7$
Diffraction	$x_{\mathbb{P}} < 0.04$ LRG requirements	$x_{\mathbb{P}} < 0.03$ $\|t\| < 1\ \mathrm{GeV}^2$ $M_Y < 1.6\ \mathrm{GeV}$
Dijets	$p^*_{\mathrm{T},1} > 3.0\ \mathrm{GeV}$ $p^*_{\mathrm{T},2} > 3.0\ \mathrm{GeV}$ $-2 < \eta^{\mathrm{lab}}_{1,2} < 2$	$p^*_{\mathrm{T},1} > 5.5\ \mathrm{GeV}$ $p^*_{\mathrm{T},2} > 4.0\ \mathrm{GeV}$ $-1 < \eta^{\mathrm{lab}}_{1,2} < 2$

- Most requirements are related to detector capabilities
- Asymmetric P_T jet cuts ensure reliable NLO calculation
- Extended analysis phase space to control migration effects

Control distributions

- Simulation: RAPGAP+DPDF fit B, reweighted to describe data
- Reconstructed quantities are well described by reweighted MC → can be used for unfolding detector effects
- Regularized unfolding (TUnfold) to correct for migrations



Experimental uncertainties

Electron angle	1%
Electron energy	1%
Hadronic energy	4%
Model uncertainty	5%
Normalisation	8%
Total	10%

- Normalisation uncertainty is dominating

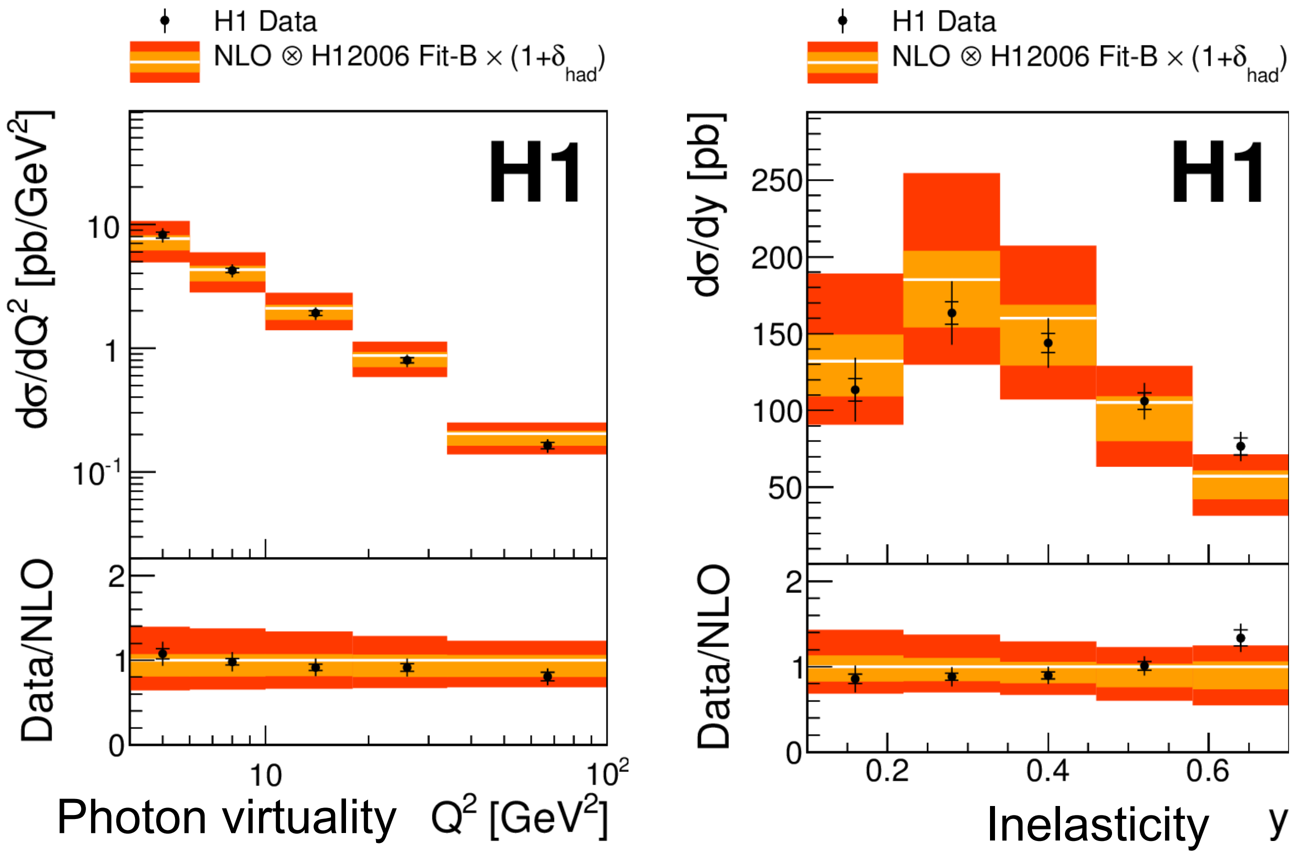
Integrated cross section

$$\sigma^{dijet}_{meas}(ep \to eXY) = 73 \pm 2(stat) \pm 7(syst)$$

Predicted at NLO:

$$\sigma^{dijet}_{theo}(ep \to eXY) = 77\ ^{+25}_{-20}(scale)\ ^{+4}_{-14}(DPDF) \pm 3(had)$$

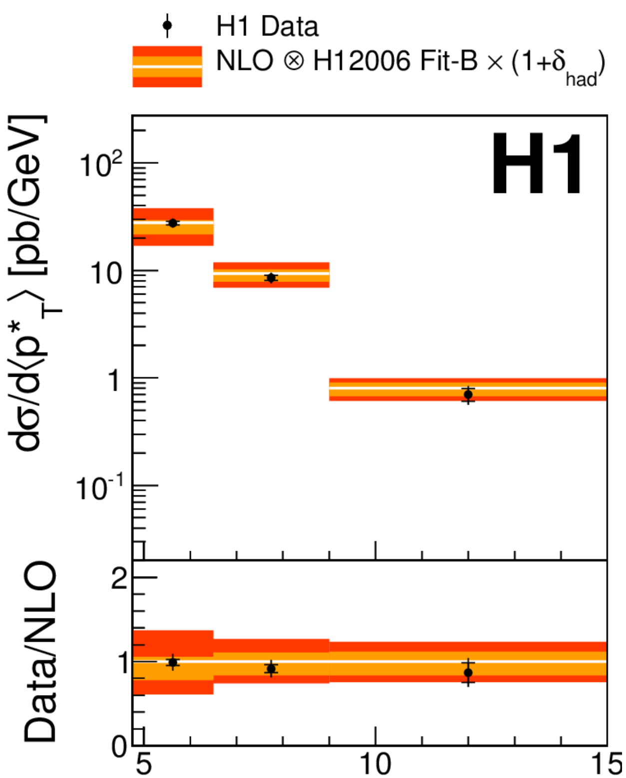
Cross sections: DIS variables



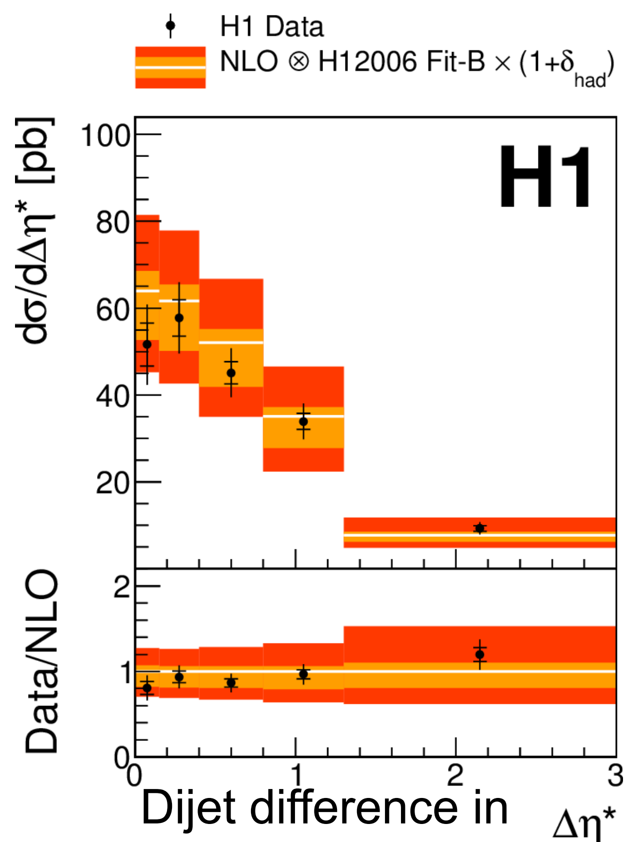
- Prediction: NLOJET++ ⊗H12006 Fit-B
- Orange band: DPDF uncertainty
- Red band: total uncertainty

- Variables at electron vertex are well described
- Data are more precise than NLO prediction

Cross sections: jet variables



Average jet transverse momentum



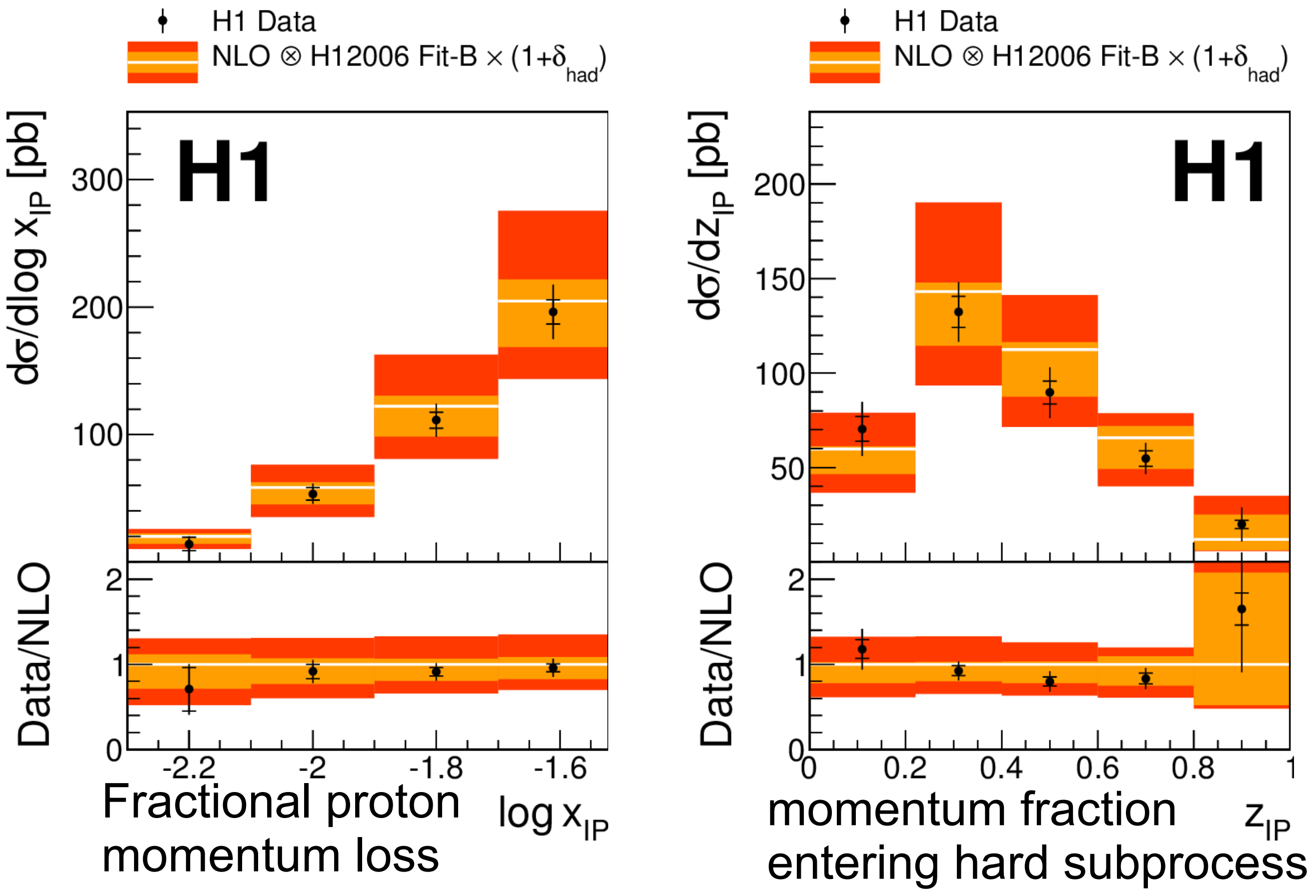
Dijet difference in pseudorapidity

- Prediction: NLOJET++ ⊗H12006 Fit-B
- Orange band: DPDF uncertainty
- Red band: total uncertainty

- Jet variables are well described: NLO QCD is applicable

Leading and subleading jet transverse momentum: see backup

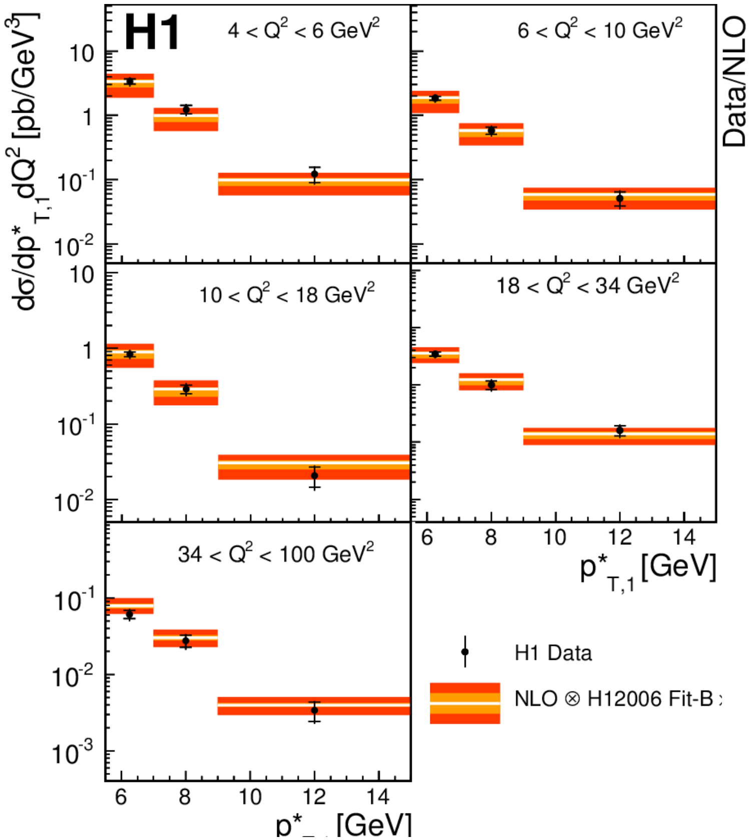
Cross sections: diffractive exchange

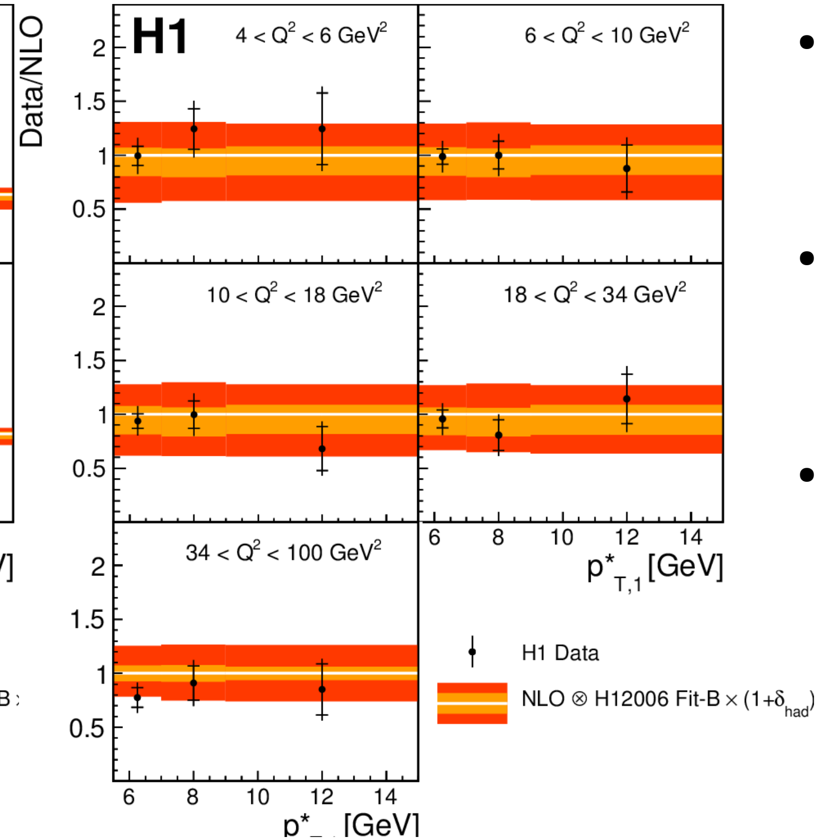


- Prediction: NLOJET++ ⊗H12006 Fit-B
- Orange band: DPDF uncertainty
- Red band: total uncertainty

- Diffractive variables well described, large NLO uncertainties
- Data have the potential to further constrain DPDFs

Double-differential cross sections



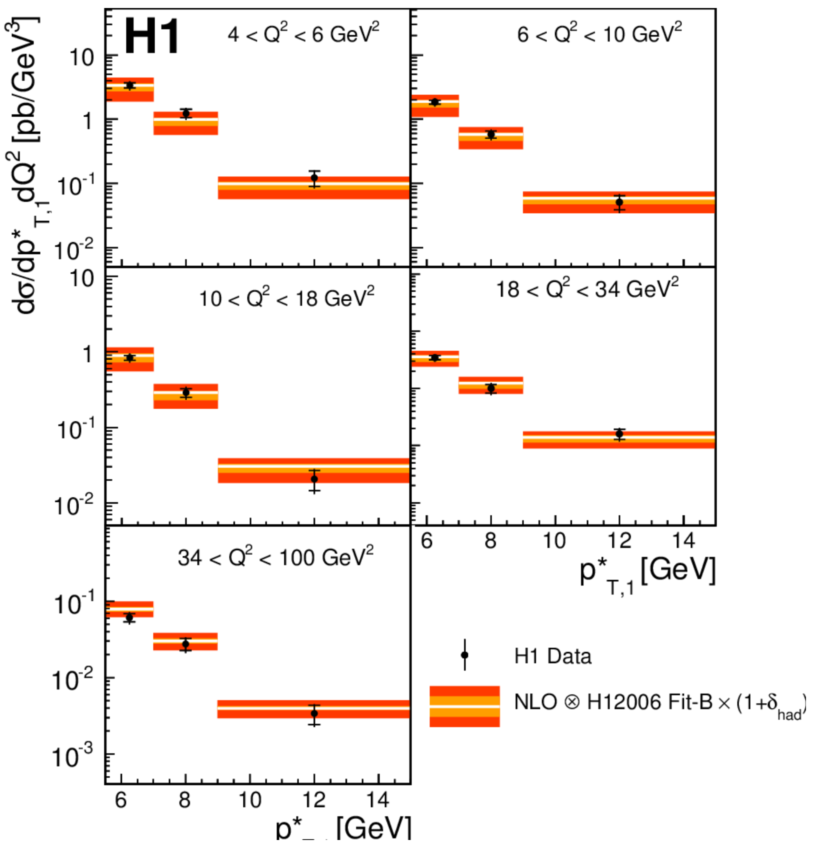


- Prediction: NLOJET++ ⊗H12006 Fit-B
- Orange band: DPDF uncertainty
- Red band: total uncertainty

- Dependencies on two hard scales Q^2 and P_T measured
- NLO seems to work → try to extract α_S

Double-diff cross section in Q^2 and z_{IP} in backup

Determination of α_s



- Fit to double-differential cross sections
- Fixed DPDF H12006 Fit-B
- NLO prediction for fit obtained using fastNLO
- Fit result $\chi^2/n_{d.o.f} = 16.7/14$

$$\alpha_s = 0.119 \pm 0.004\,(\text{exp}) \pm 0.002\,(\text{had}) \pm 0.005\,(\text{DPDF}) \pm 0.010\,(\mu_r) \pm 0.004\,(\mu_f)$$

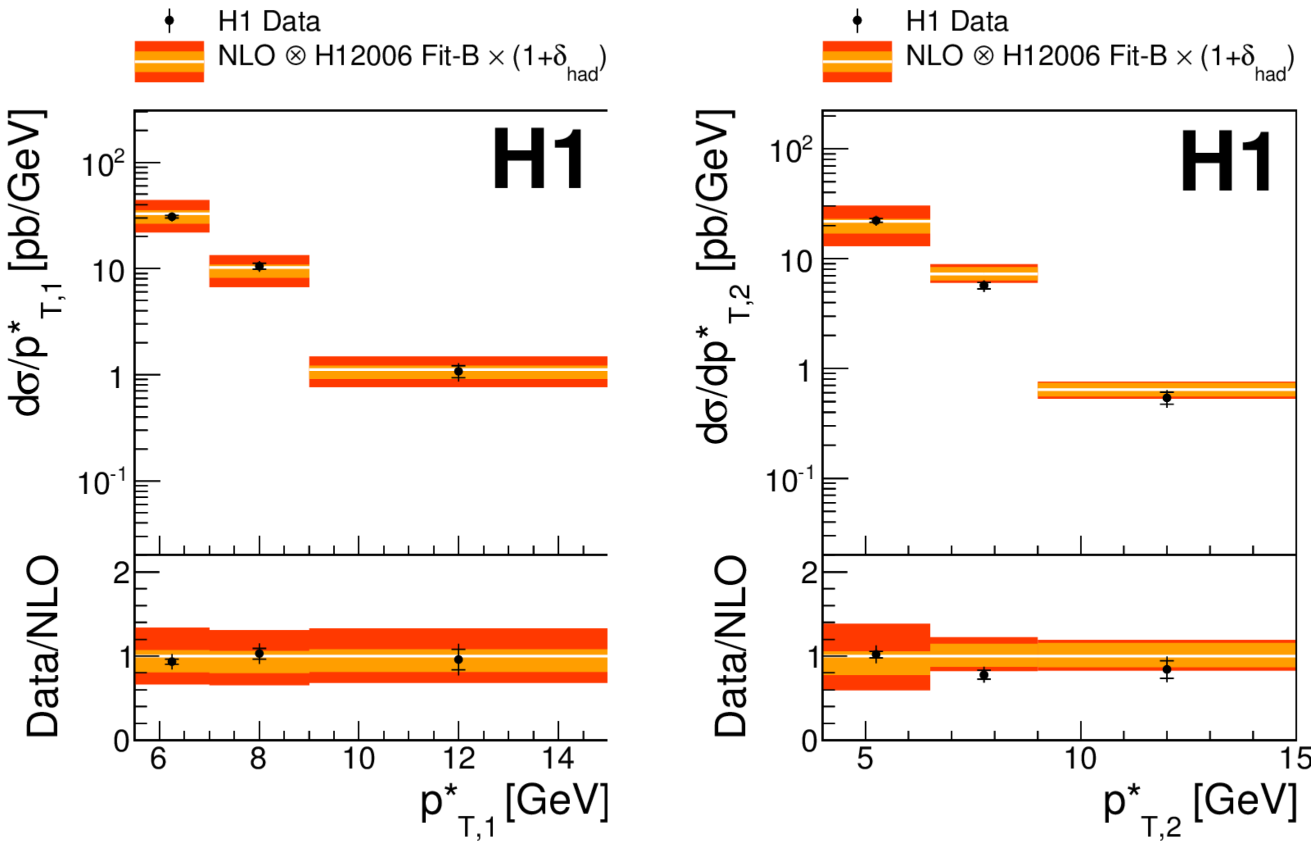
- Framework applied here (DPDF+NLO) gives consistent results
- First extraction of α_s in diffractive jet production

Summary

- Measurement of diffractive dijet production in deep-inelastic scattering
- Integrated cross section precision 3% statistical, 10% systematic uncertainties
- Single- and double differential cross sections measured in several observables
- Potential to constrain future DPDF fits or do other detailed QCD studies. Example: α_s fit

Backup

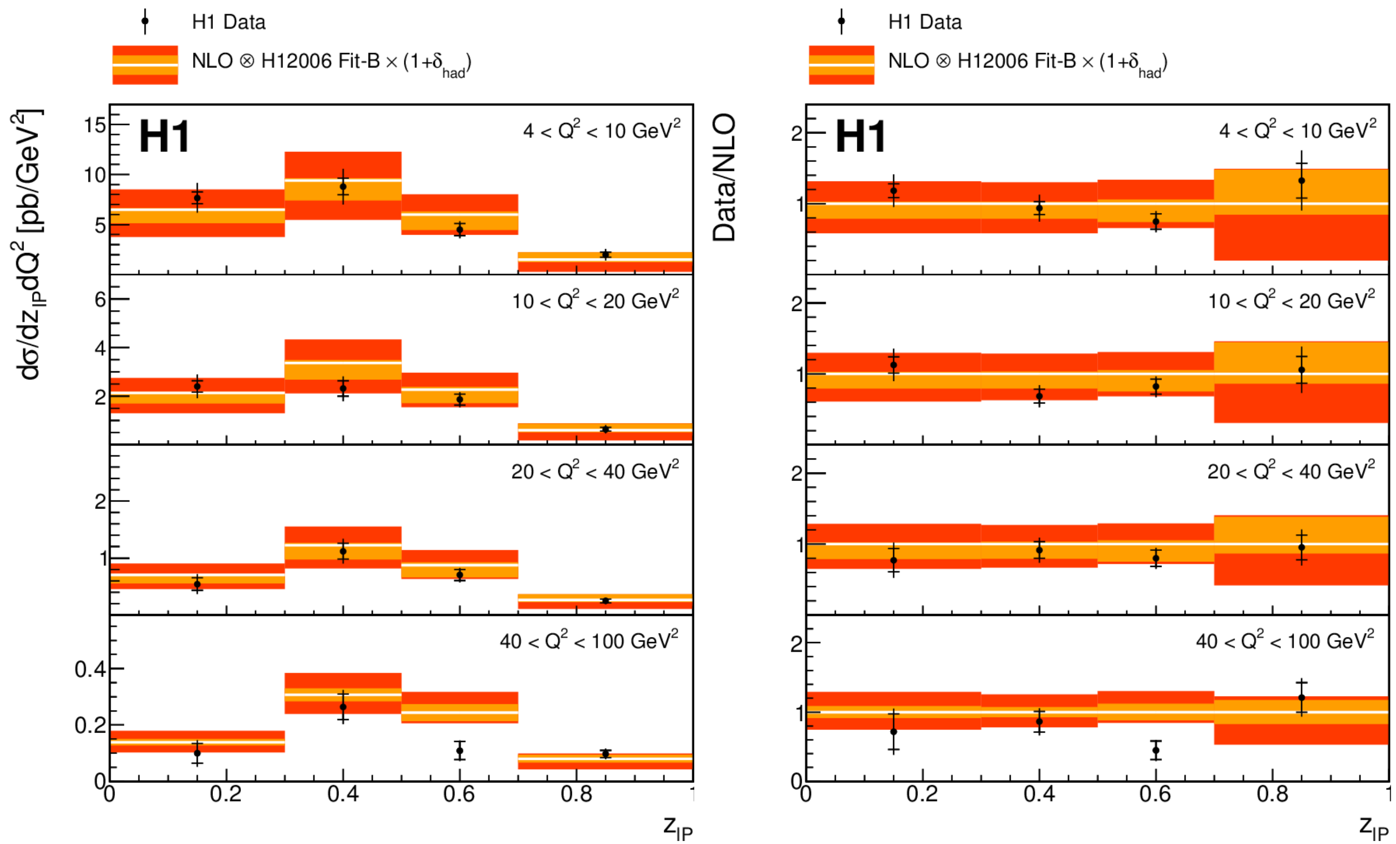
Single-differential cross sections (4)



- NLO prediction: NLOJET++ ⊗H12006 Fit-B
- Orange: DPDF uncertainty
- Red: total uncertainty

- Leading and subleading jet momenta

Double-differential: Q^2 and z_{IP}



- NLO prediction: NLOJET++ ⊗H12006 Fit-B
- Orange: DPDF uncertainty
- Red: total uncertainty

- Dependency on Q^2 and z_{IP} measured: possible input for a new DPDF fit