QCD Analysis of the combined HERA inclusive data together with HERA jet and charm data

arXiv.org > hep-ex > arXiv:1506.06042

High Energy Physics - Experiment

Combination of Measurements of Inclusive Deep Inelastic $e^{\pm}p$ Scattering Cross Sections and QCD Analysis of HERA Data

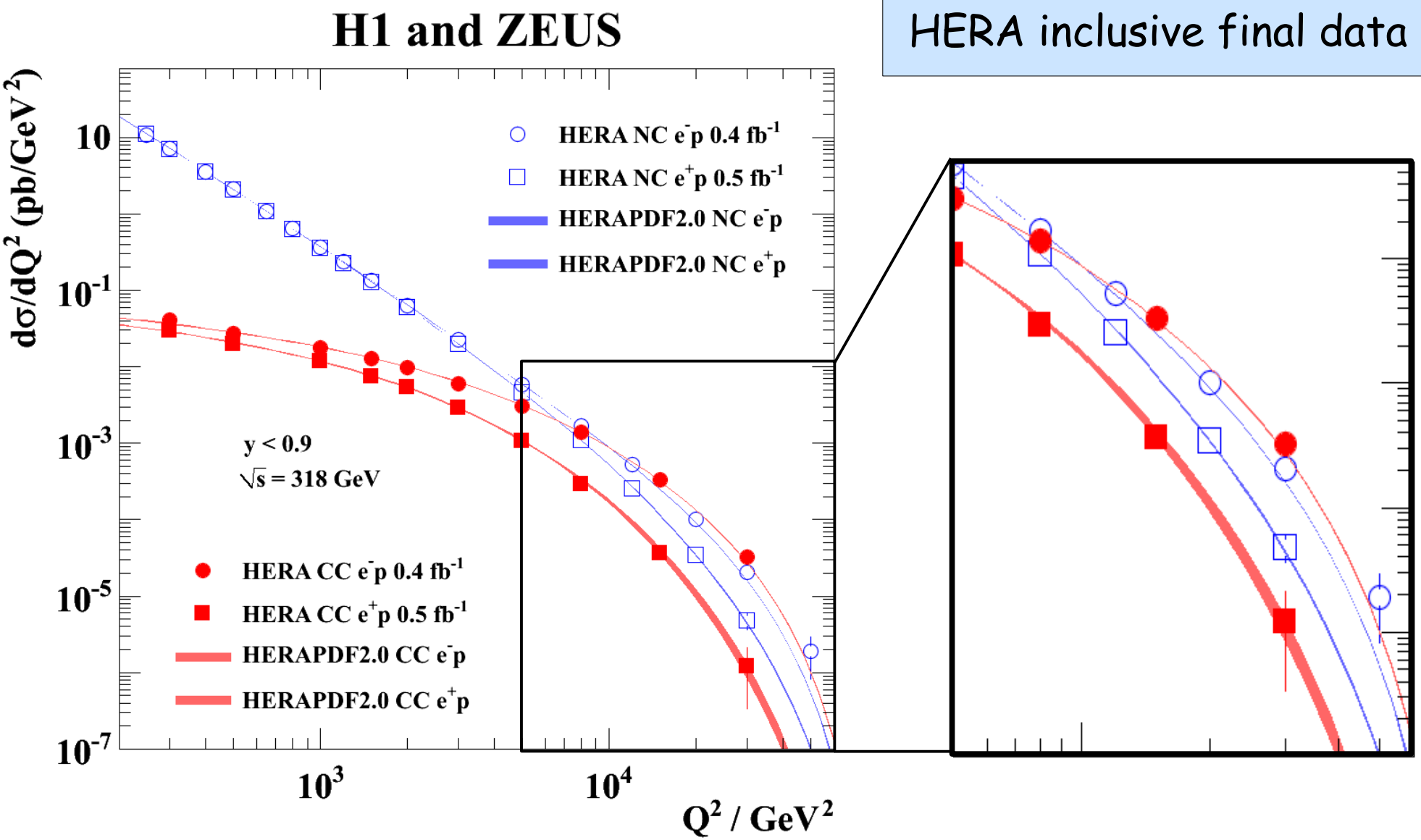
H1, ZEUS Collaborations

(Submitted on 19 Jun 2015)

Katarzyna Wichmann on behalf of the H1 and ZEUS Collaborations

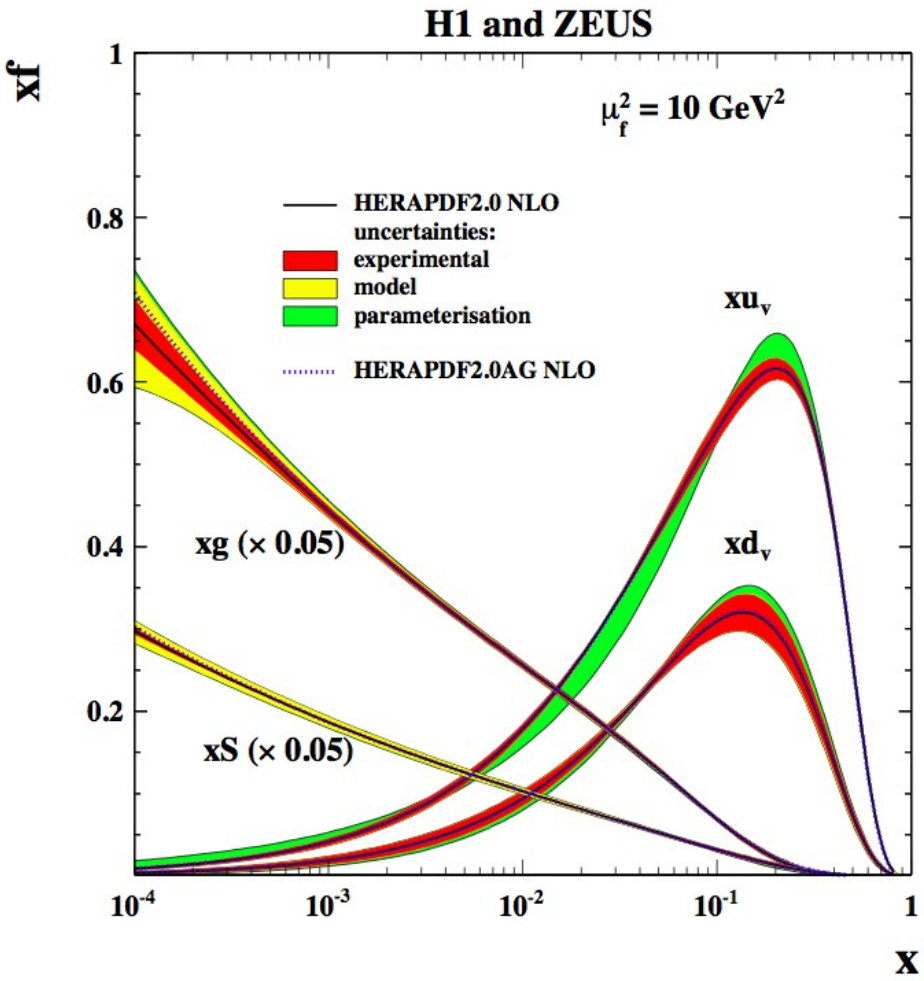
Deep Inelastic Scattering @ HERA

Fantastic precision of HERA inclusive final data

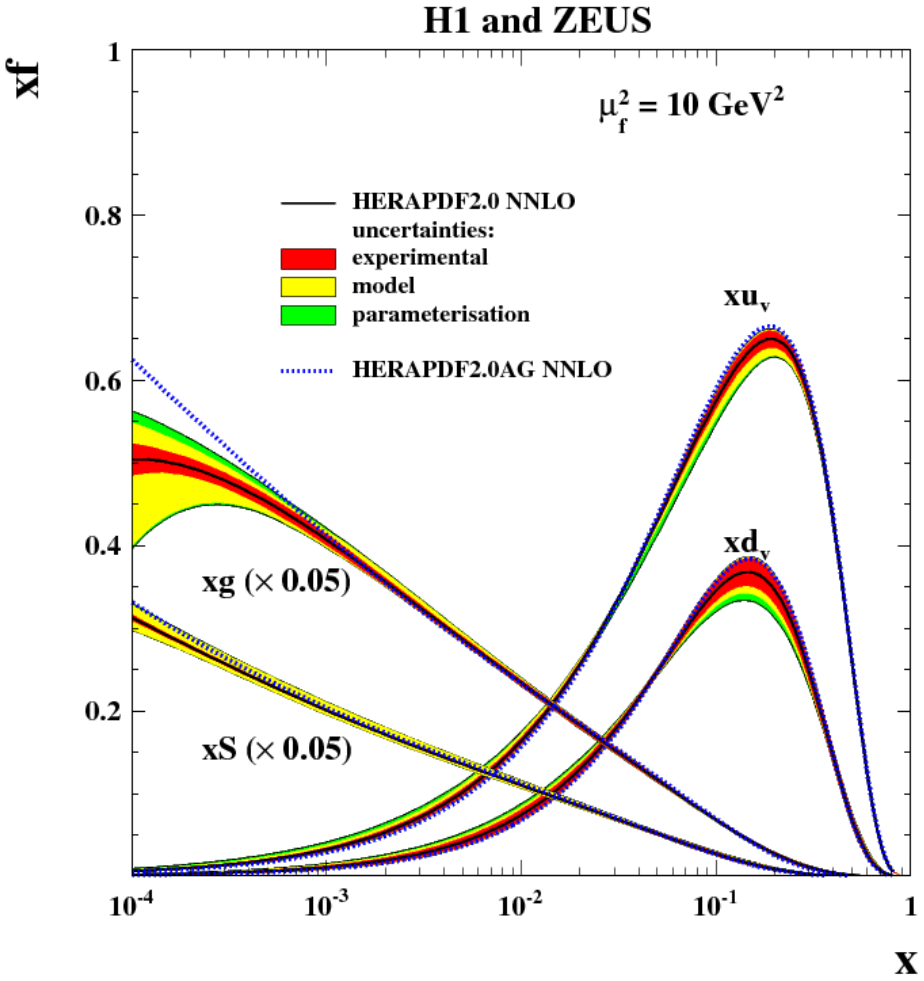


NLO & NNLO parton densities

NLO



NNLO



HERAPDF2.0 extracted

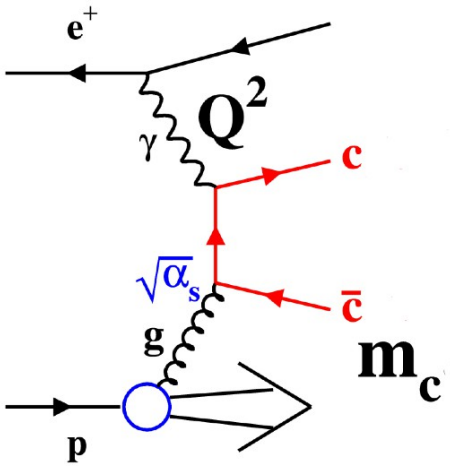
with experimental, model and parametrization uncertainties

Using additional HERA data

QCD fits performed using open source HERAFitter package www.herafitter.org

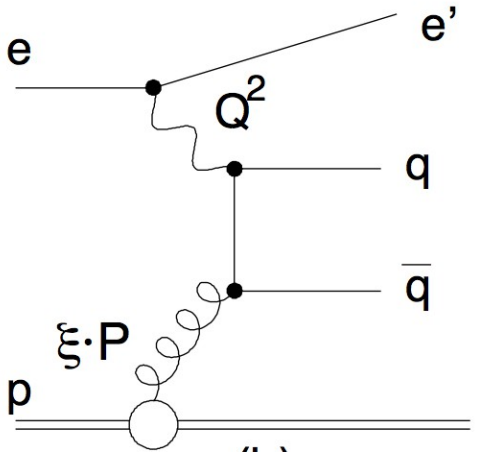
Charm and jet data from HERA

Charm production

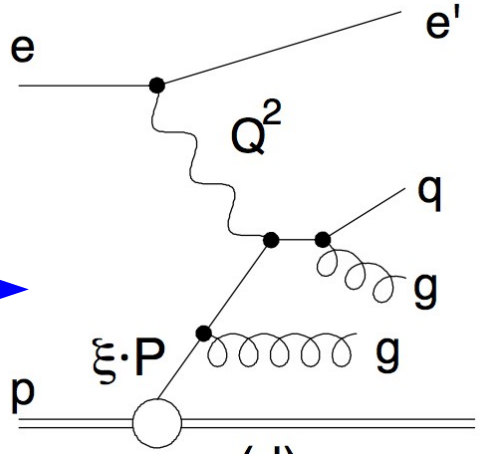


Boson-Gluon Fusion

Jet production

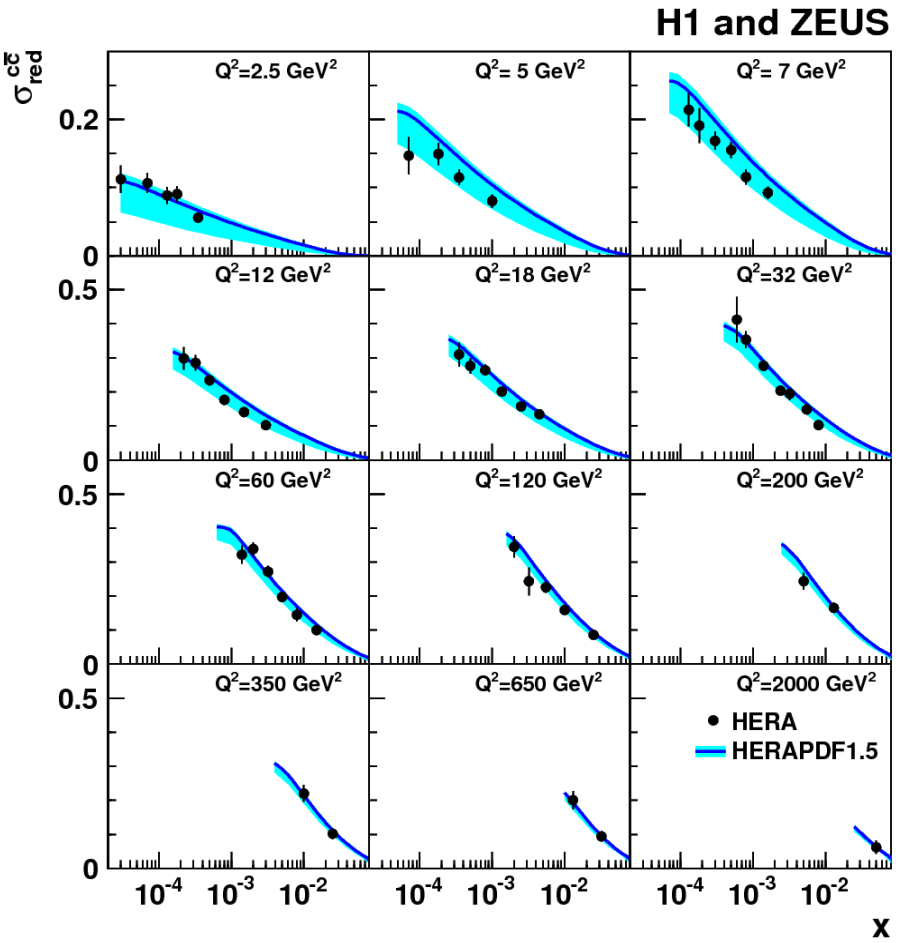


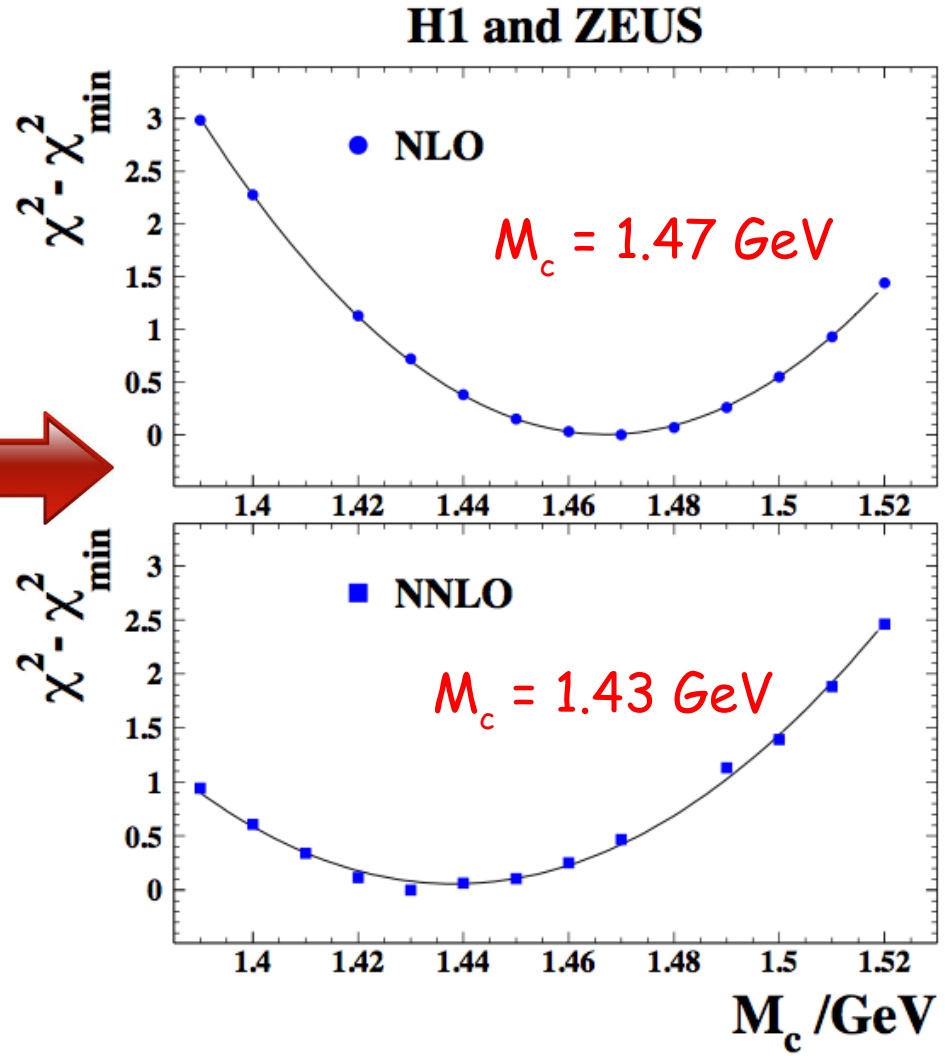
- Charm and jet data sensitive to gluon/α_s
  - At high Q^2 up to 30% of charm
- Trijets most sensitive to α_s



- Additionally charm and beauty data sensitive to M_c and M_b

Estimation of charm mass parameter

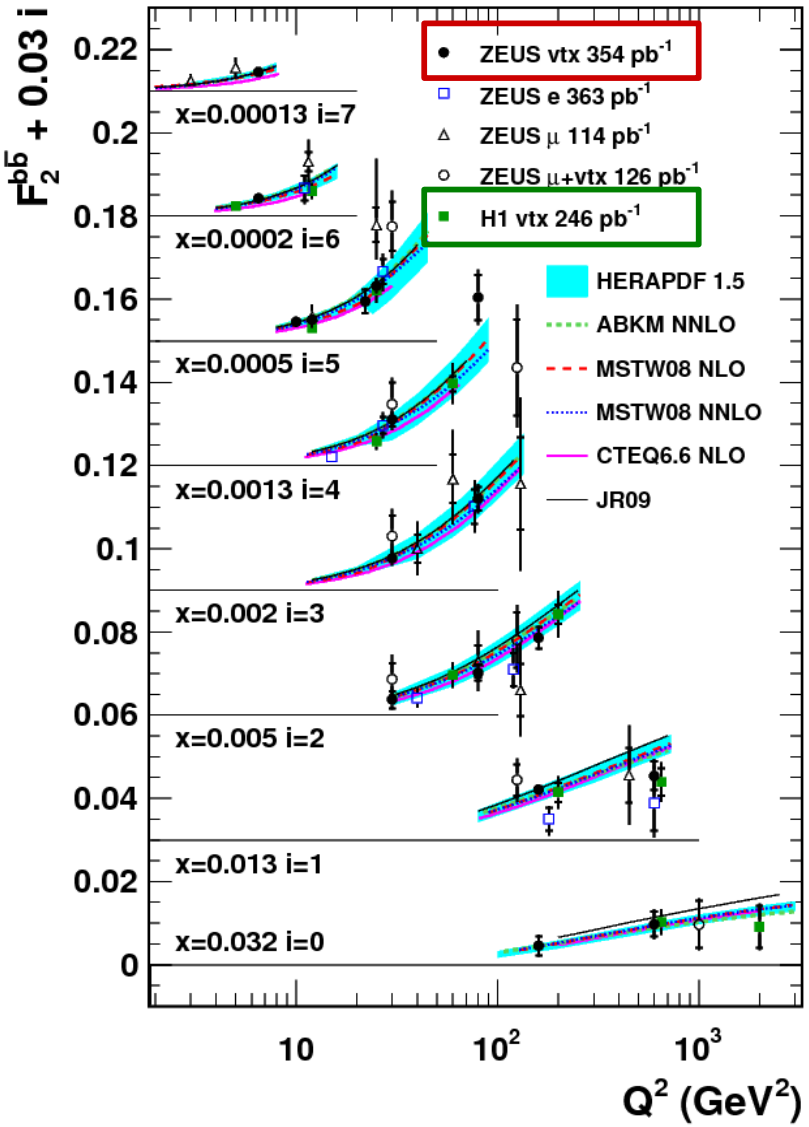


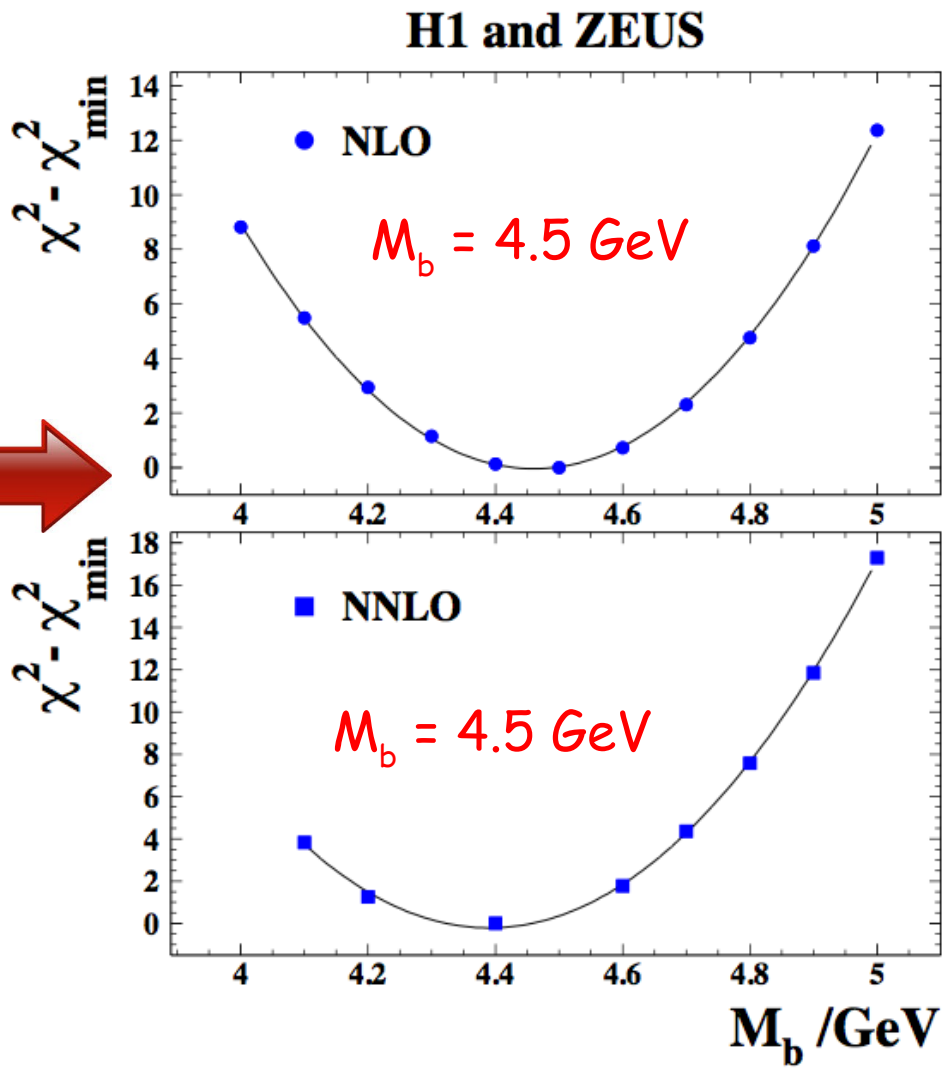


→ M_c determined from inclusive data + charm data arXive:1211.1182

Method comes from the HERA charm combination (Eur. Phys. J. C73 (2013) 2311)

Estimation of beauty mass parameter





→ M_b determined from inclusive data + beauty data arXive:1405.6916 and arXive:0907.2643

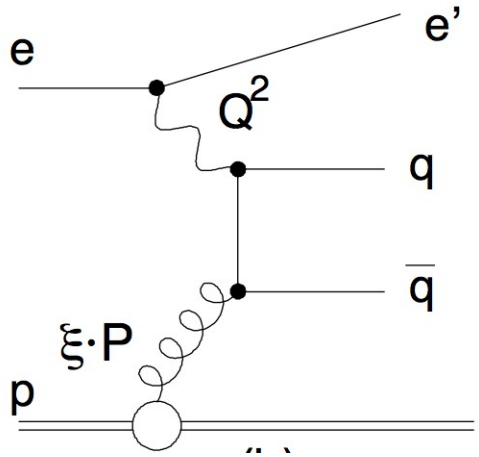
Method comes from the HERA charm combination (Eur. Phys. J. C73 (2013) 2311)

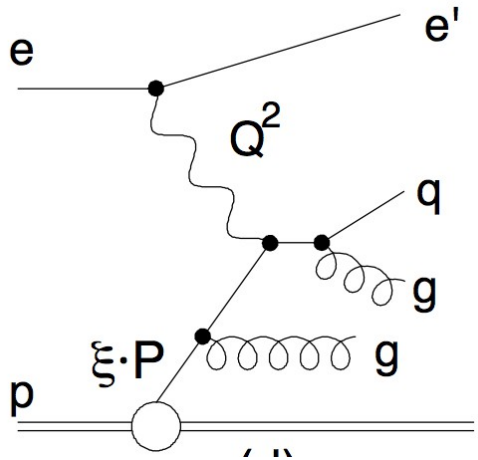
Jets add information on GLUON

- 7 HERA jet samples added to global QCD fit
  - ZEUS inclusive jet data hep-ex/0208037
  - H1 HERAI normalised inclusive jet data arXive:0706.3722
  - H1 low-Q^2 data arXive:0911.5678
  - ZEUS dijet data arXive:1010.6167
  - H1 new multi-jet samples **arXive:1211.1182**
    - normalised inclusive, dijet and trijet data

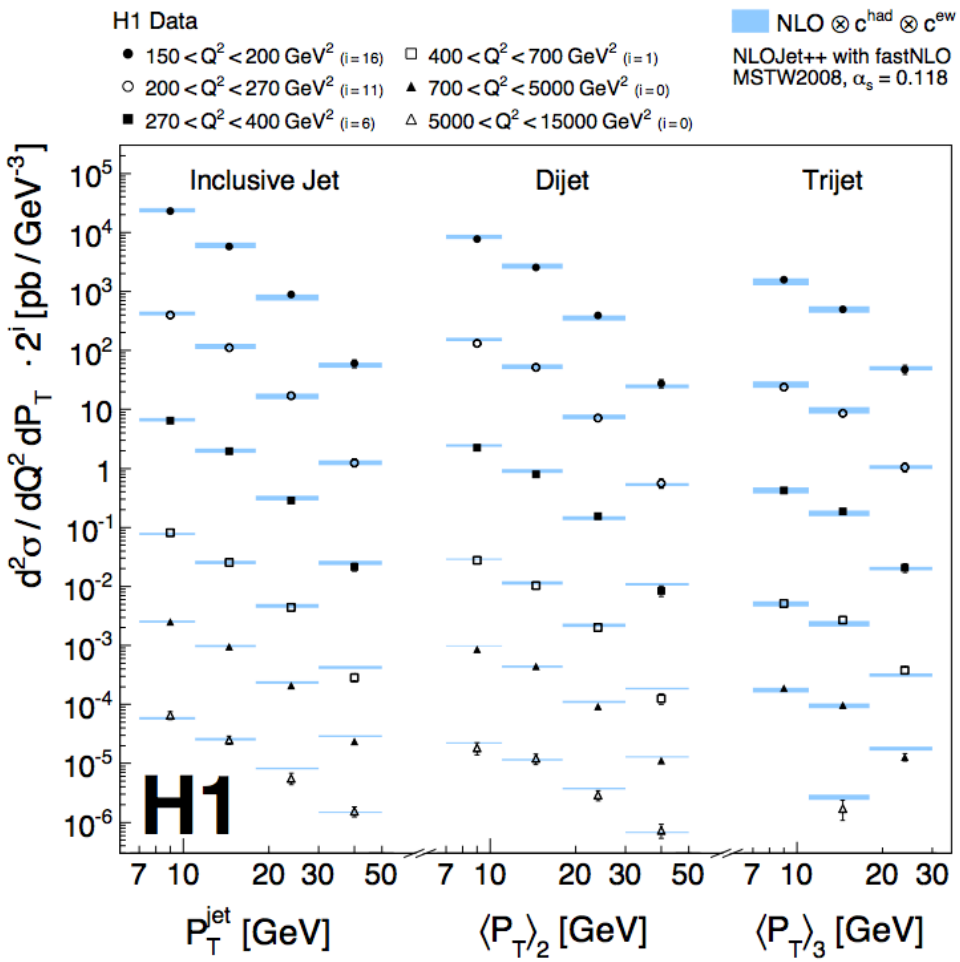
+ combined charm data arXive:1211.1182

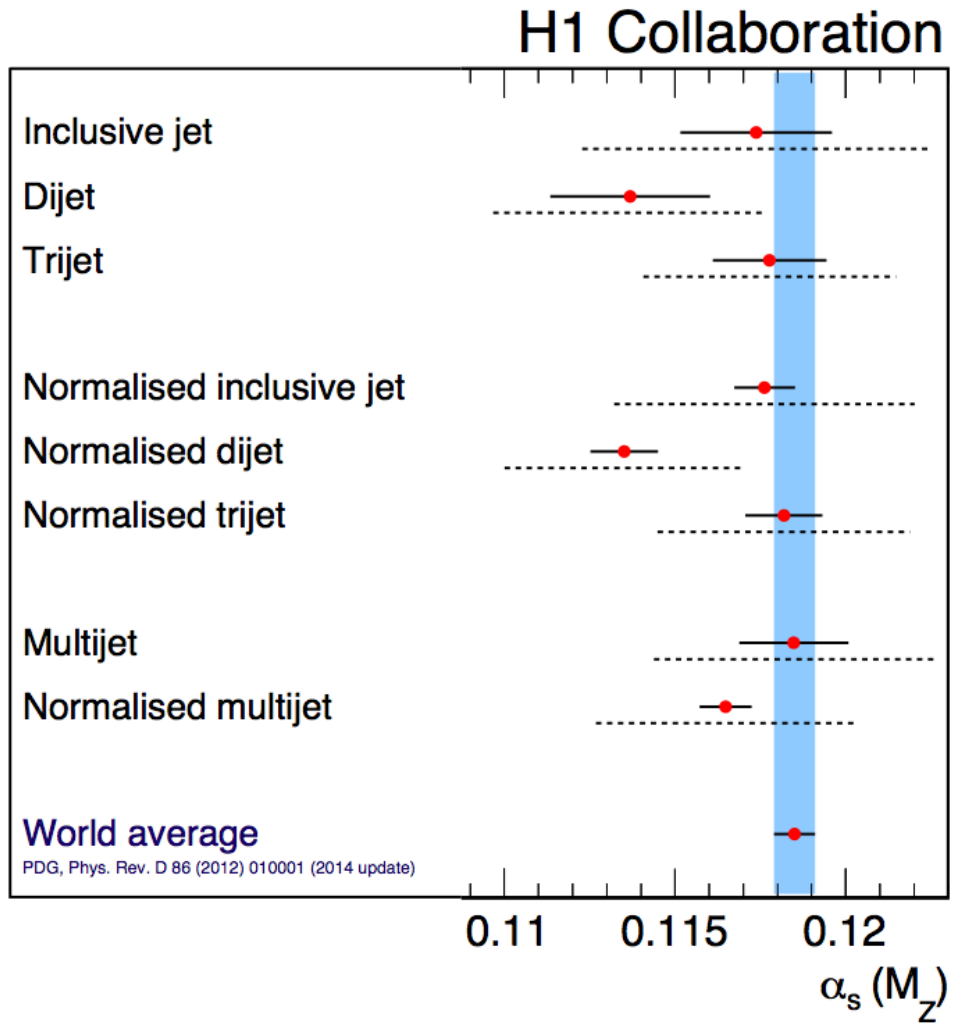
→ HERAPDF2.0Jets



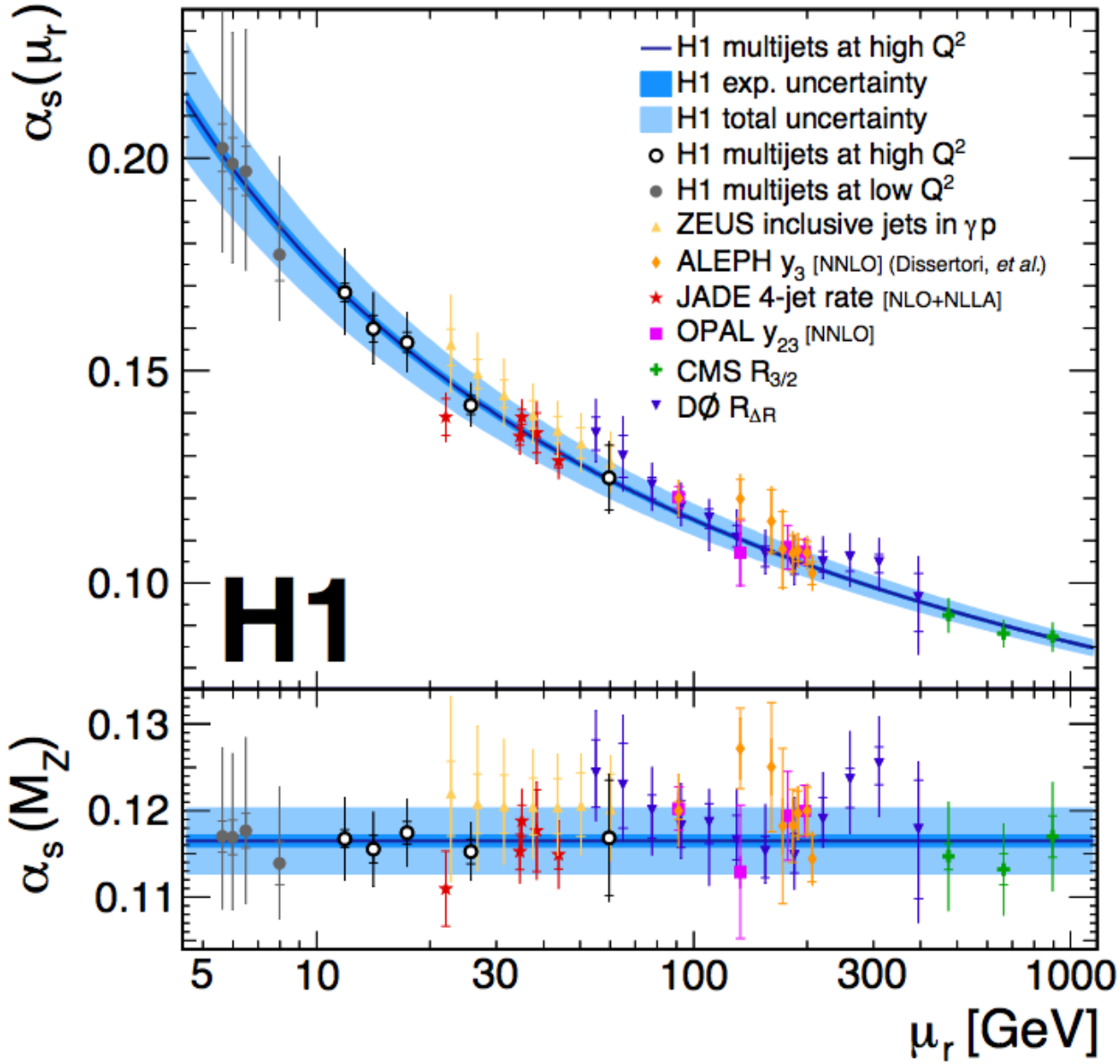


H1 multi-jet production

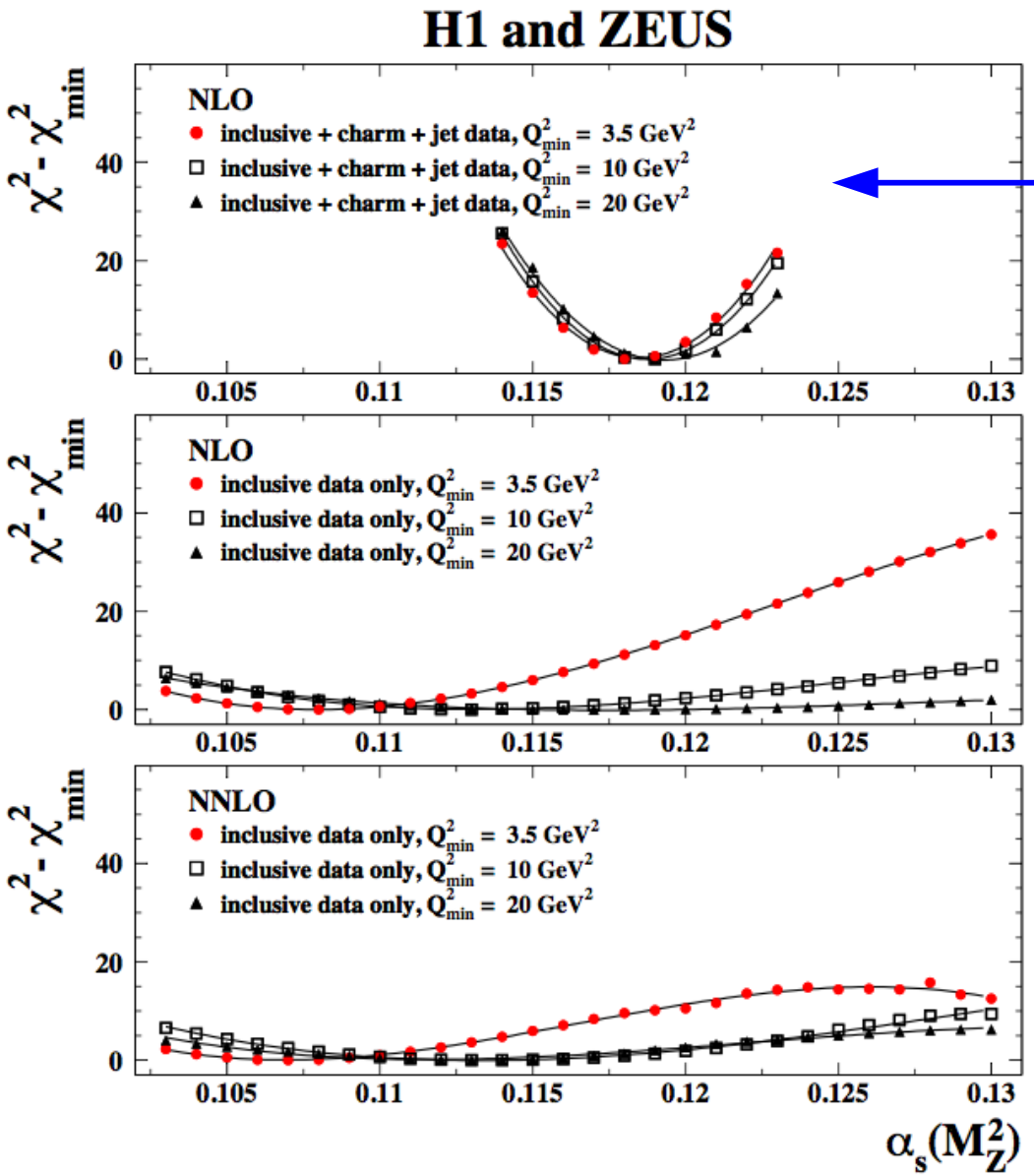




H1 multi-jet production: α_s running



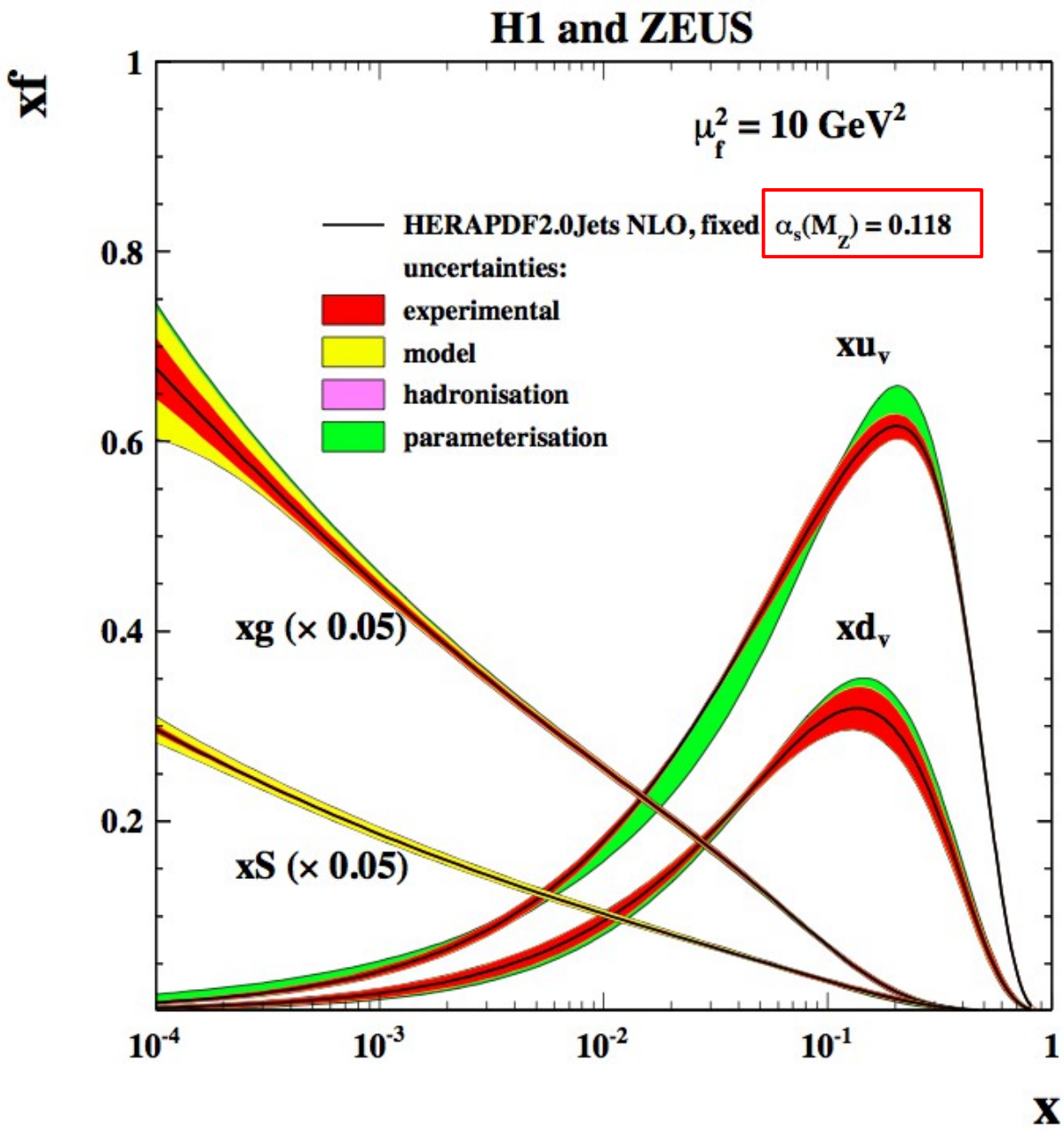
Including HERA jets in QCD global fits



- HERA combined charm data
- 7 H1 and ZEUS jet samples
  → good sensitivity to α_s
- Validated choice of α_s = 0.118

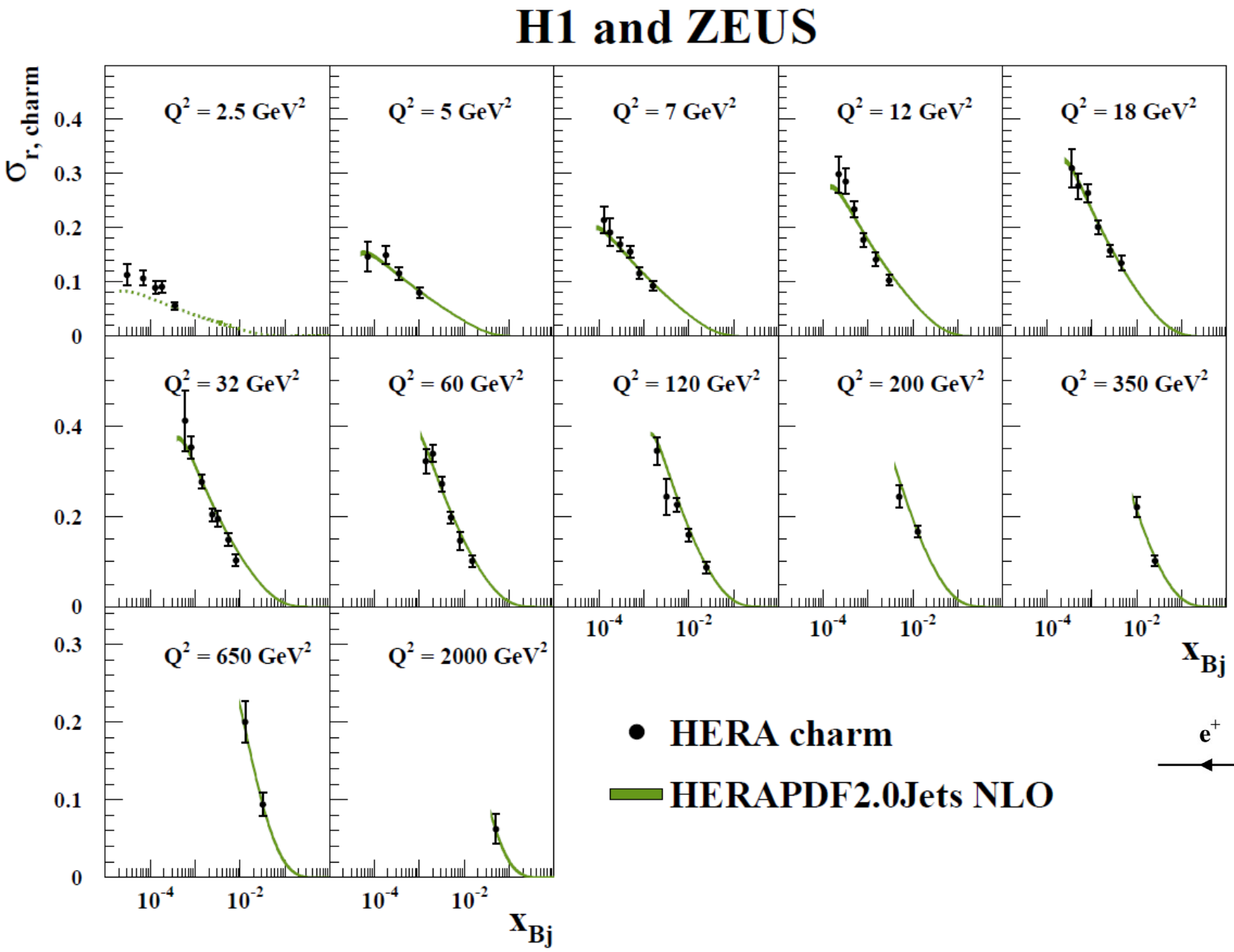
→ Inclusive data only not sensitive to α_s

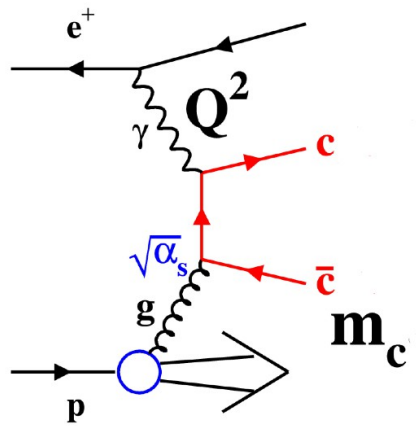
HERAPDF2.0Jets α_s = 0.118



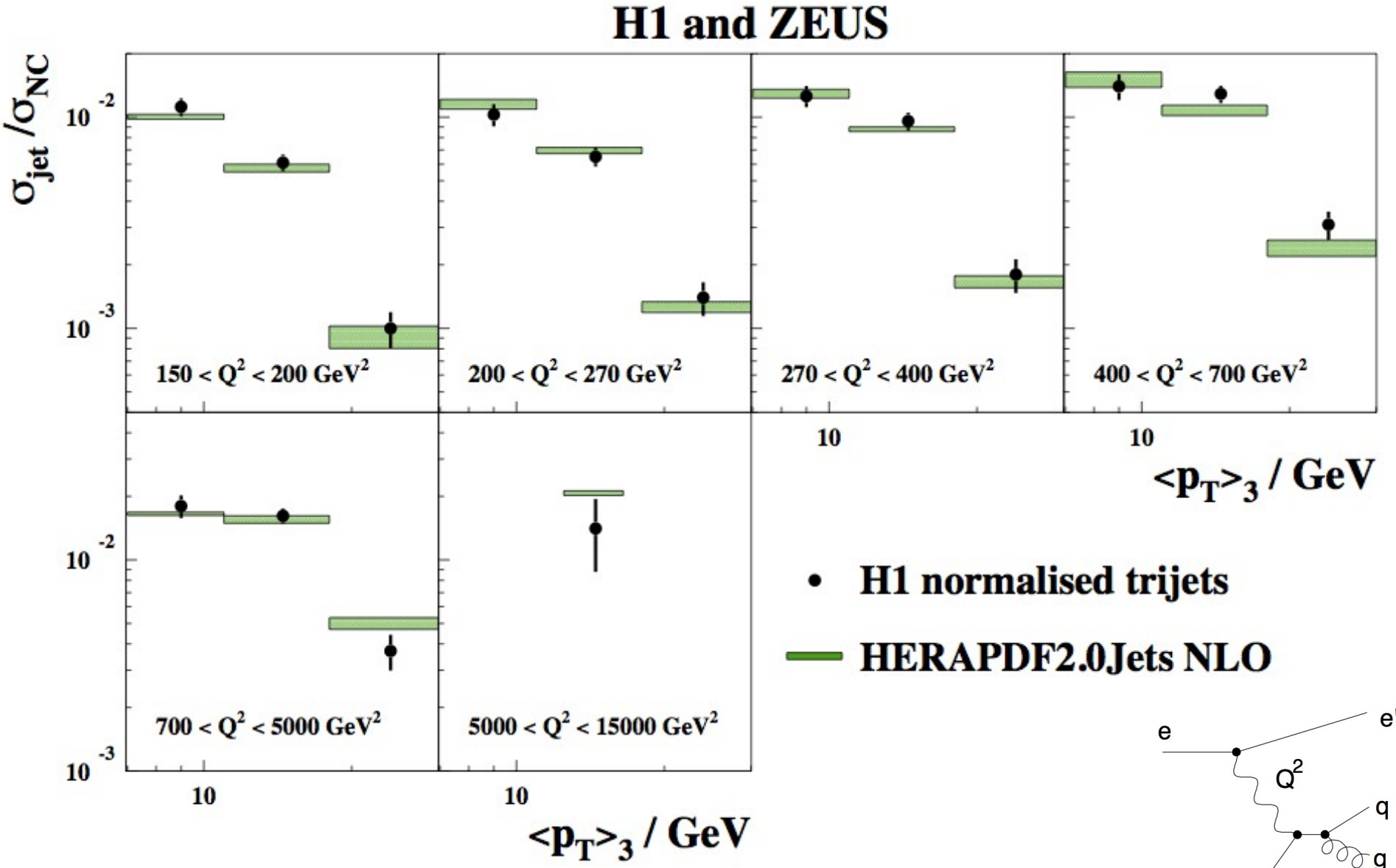
- Charm and all jet data well described

HERAPDF2.0Jets $\alpha_s = 0.118$



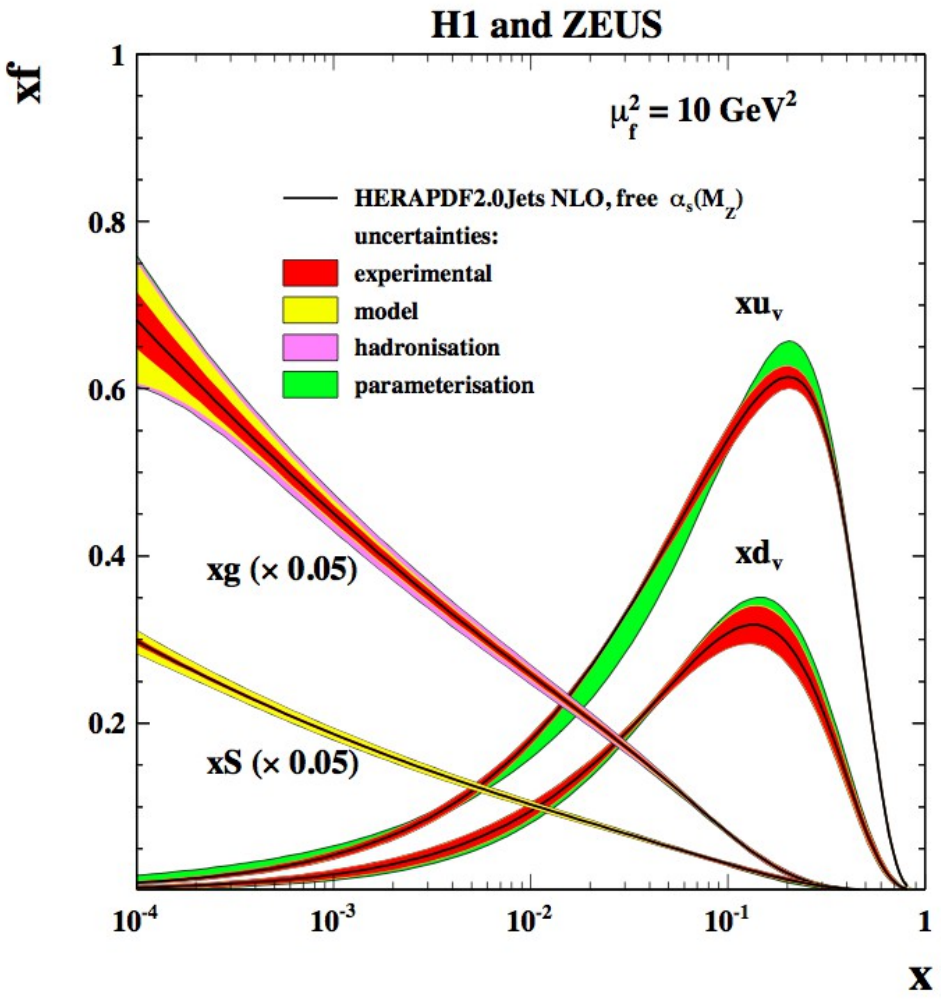


HERAPDF2.0Jets α_s = 0.118



- All comparisons in additional material slides

HERAPDF2.0Jets α_s free



α_s determined from QCD fit

$$\alpha_s(M_Z^2) = 0.1183 \pm 0.0009(\text{exp})$$

Experimental uncertainty below 1%

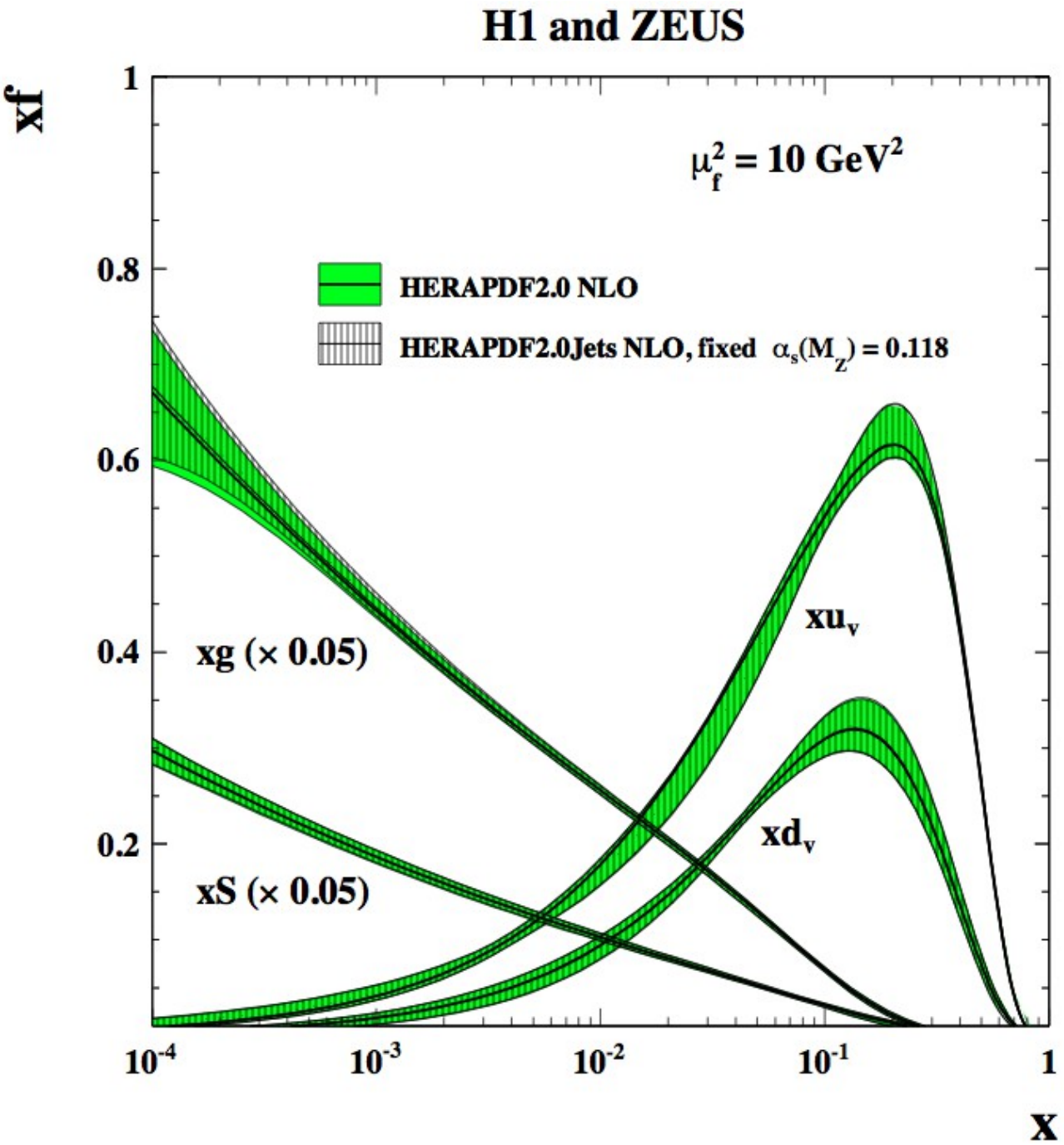
$$\pm\, 0.0005(\text{model/parameterisation})$$

$$\pm\, 0.0012(\text{hadronisation})$$

$$^{+0.0037}_{-0.0030}(\text{scale})$$

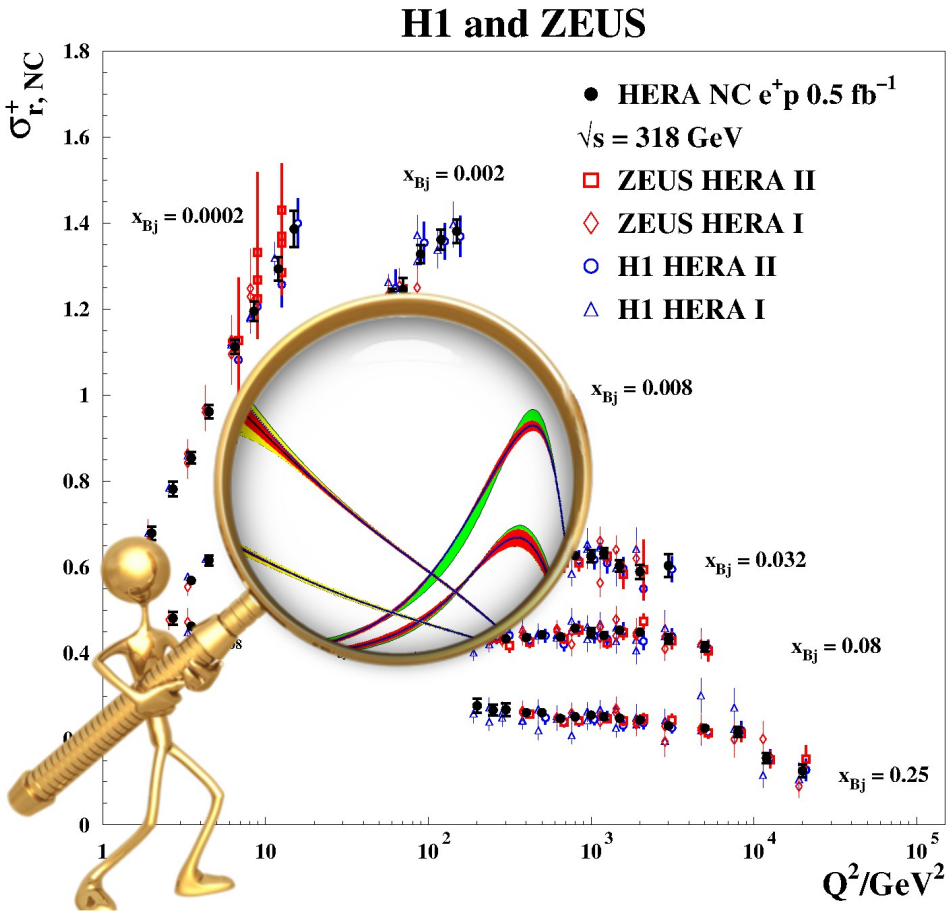
Uncertainty dominated by theory
NNLO ep jet calculations needed

HERAPDF2.0Jets



Summary

- Combined HERA data set provides ultimate sample for inclusive neutral and charged current cross section studies in wide kinematic range
- HERAPDF2.0 extracted solely from HERA final data
- HERA charm/beauty and jet data supply additional information in global QCD fit
  - Estimation of charm/beauty mass parameters
  - Additional constraints on gluon/α_s



→ HERAPDF2.0Jets

- α_s measured with experimental uncertainty below 1%

$$\alpha_s(M_Z^2) = 0.1183 \pm 0.0009(\text{exp})$$

$$\pm\, 0.0005(\text{model/parameterisation})$$

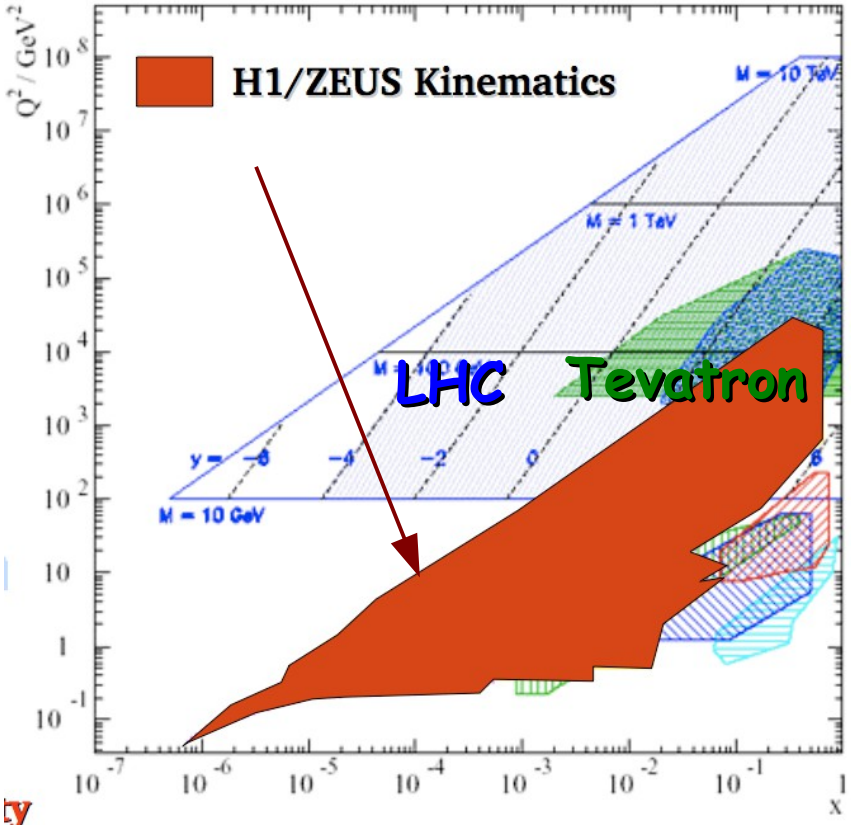
$$\pm\, 0.0012(\text{hadronisation})\ {}^{+0.0037}_{-0.0030}(\text{scale})$$

Additional slides

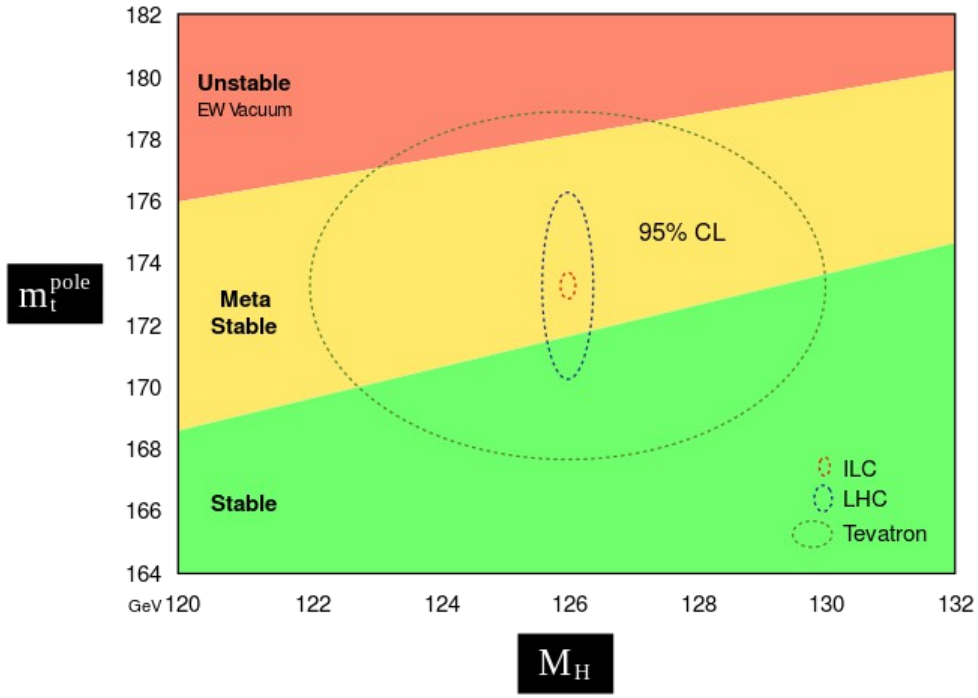
Proton structure important!

Inclusive measurements from HERA are core of every parton density extraction: HERAPDF2.0 uses exclusively 1fb^{-1} HERA data

- PDFs used in interactions with proton: LHC, Tevatron, HERA
- Precision of many measurements often limited by PDF uncertainty
  - Higgs/top properties



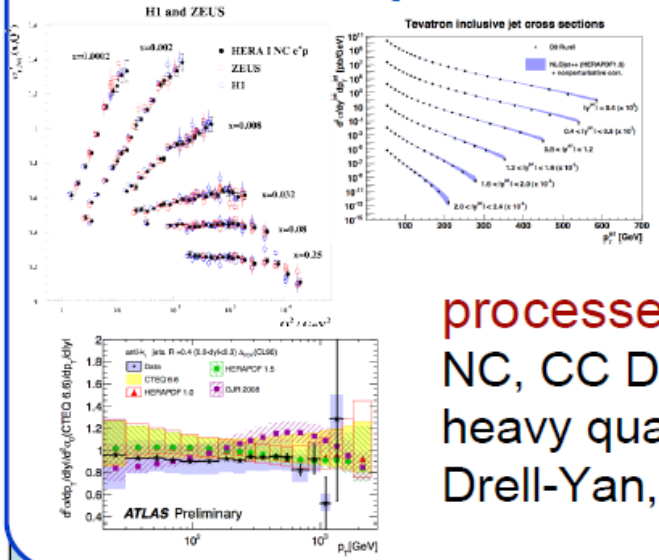
Will we tunnel?...



Alexander von Humboldt Stiftung/Foundation

https://www.herafitter.org

experimental input



experiments:
HERA, Tevatron, LHC, fixed target

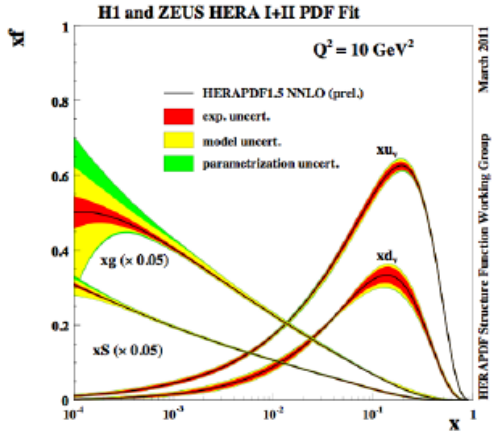
processes:
NC, CC DIS, jets, diffraction, heavy quarks (c,b,t)
Drell-Yan, W production

theoretical calculations/tools

Heavy quark schemes:	MSTW, CTEQ, ABM
Jets, W, Z production:	fastNLO, Applgrid
Top production	NNLO (Hathor)
QCD Evolution	DGLAP (QCDNUM)
	k_T factorisation
Alternative tools	NNPDF reweighting
Other models	Dipole model

+ Different error treatment models
+ Tools for data combination (HERAaverager)

HERAFitter



PDF or uPDF or DPDF

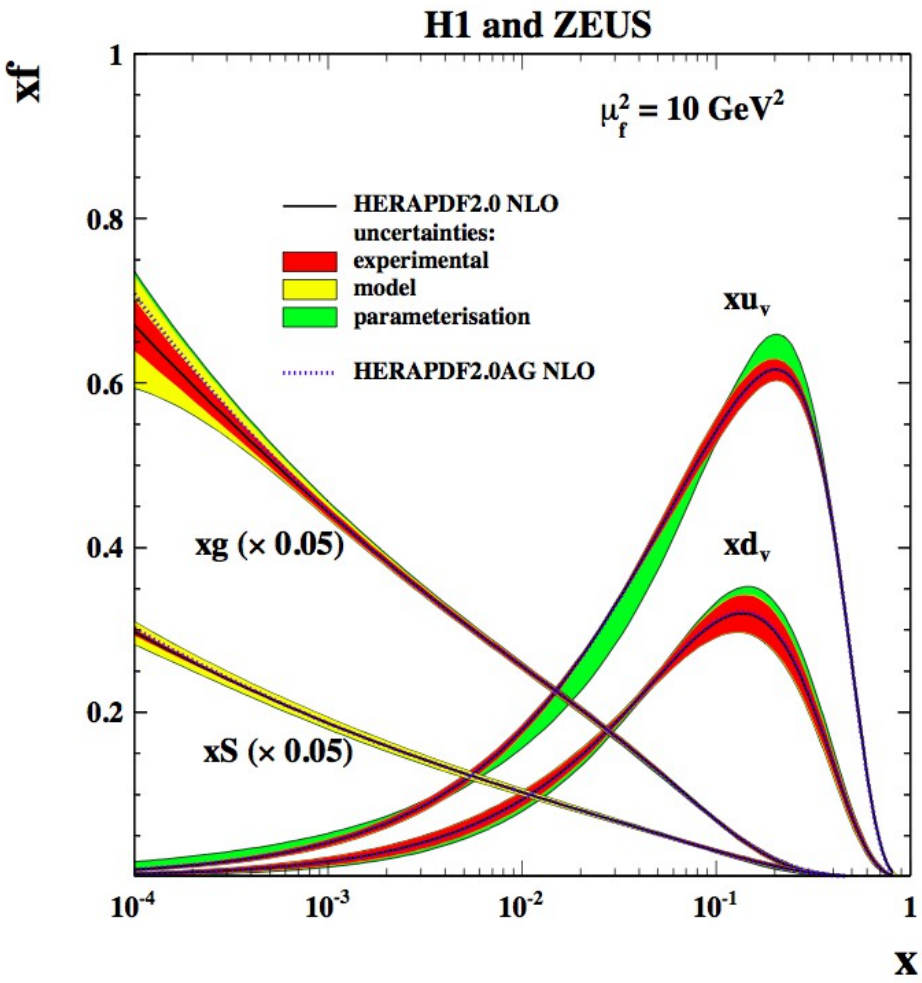
$\alpha_S(M_Z), m_c, m_b, m_t, f_s, ..$

Theory predictions

Benchmarking

Comparison of schemes

Color decomposition of uncertainties



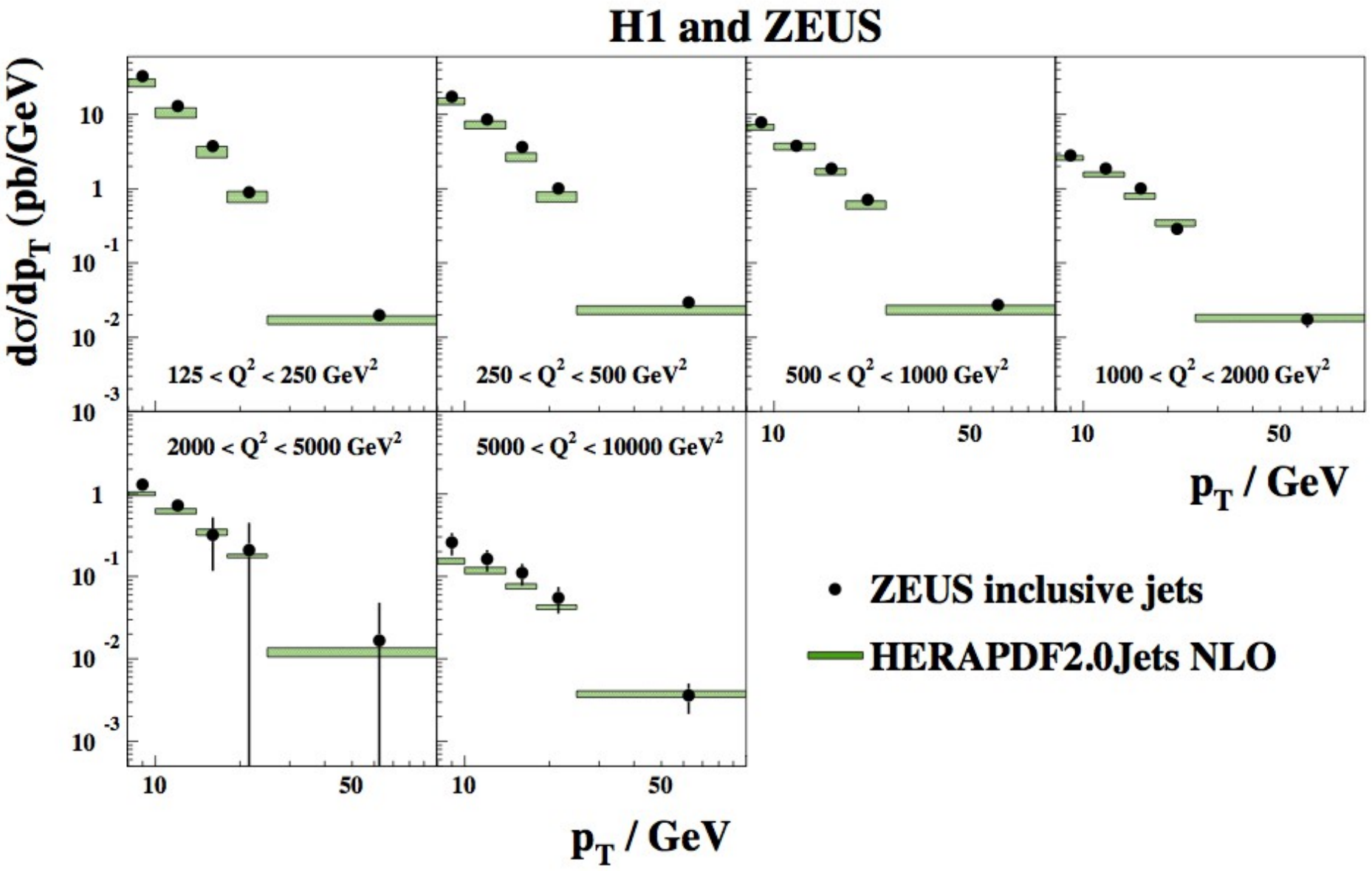
- Experimental uncertainties:
  - Hessian method
  - Conventional $\Delta\chi^2 = 1$ => 68% CL

Variation	Standard Value	Lower Limit	Upper Limit
Q^2_{min} [GeV^2]	3.5	2.5	5.0
Q^2_{min} [GeV^2] HiQ2	10.0	7.5	12.5
M_c(NLO) [GeV]	1.47	1.41	1.53
M_c (NNLO) [GeV]	1.43	1.37	1.49
M_b [GeV]	4.5	4.25	4.75
f_s	0.4	0.3	0.5
μ_{f_0} [GeV]	1.9	1.6	2.2

Adding D and E parameters to each PDF

- Parametrisation uncertainties
  - largest deviation
- Model uncertainties
  - all variations added in quadrature

HERAPDF2.0Jets α_s = 0.118



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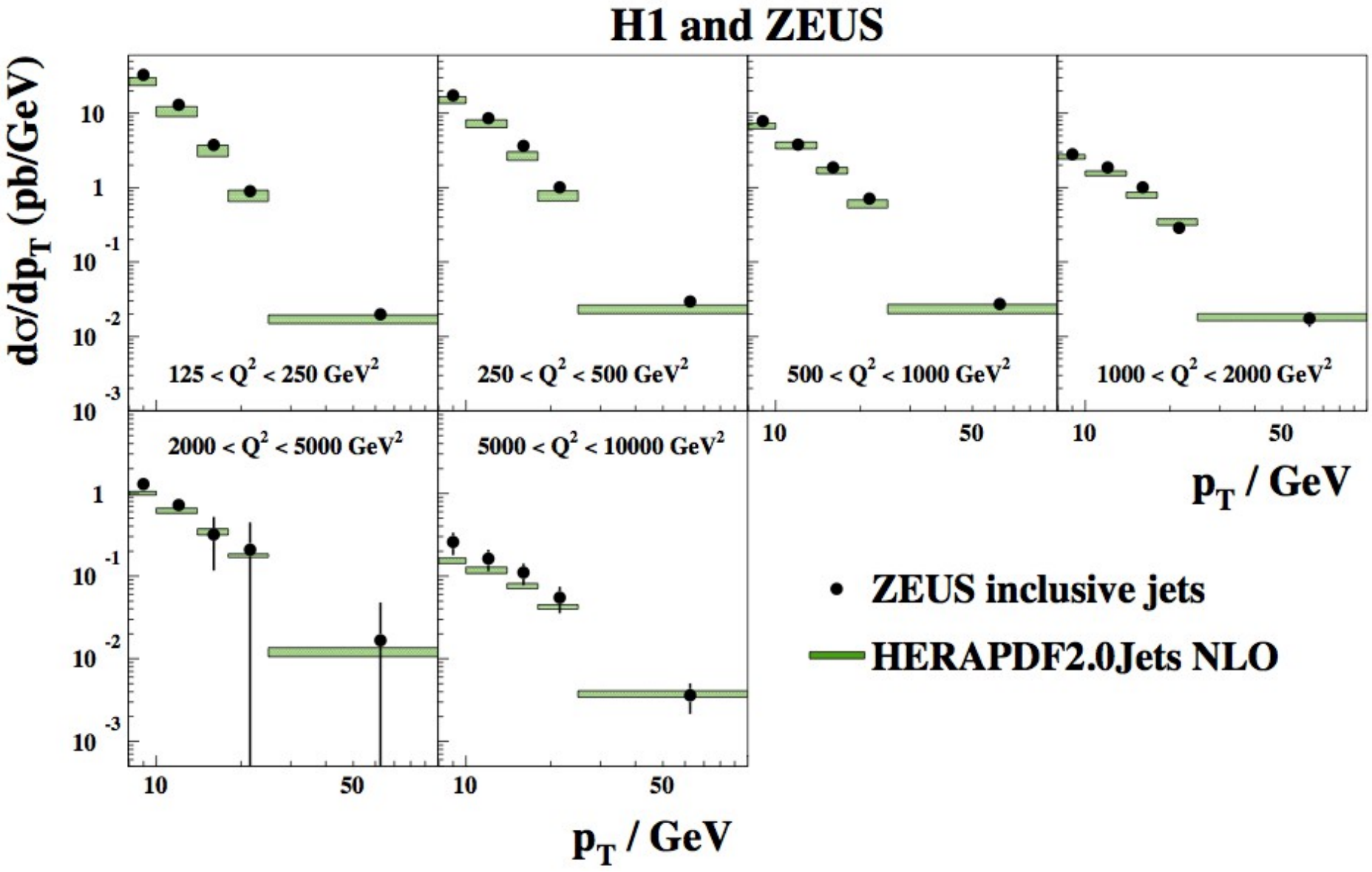

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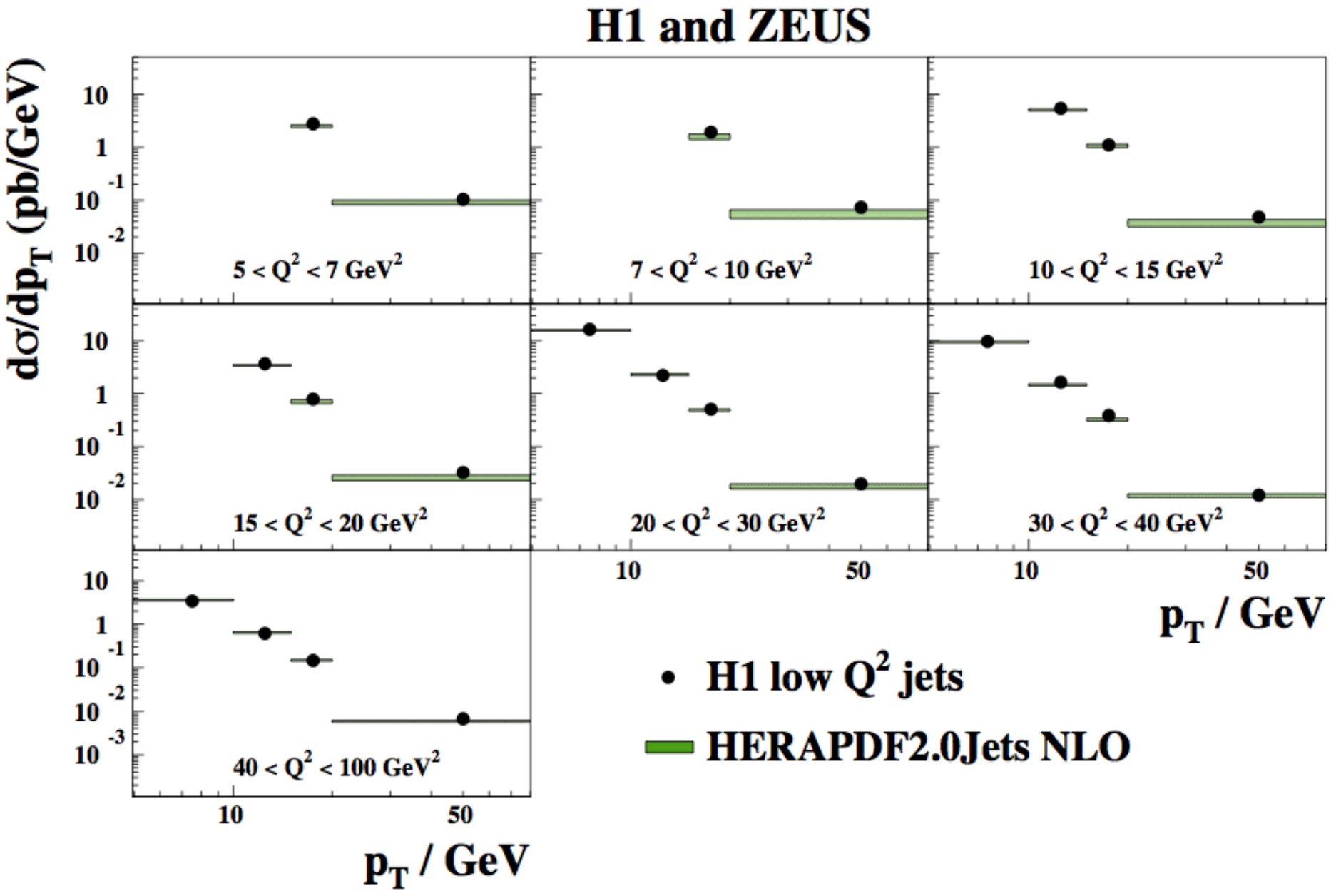

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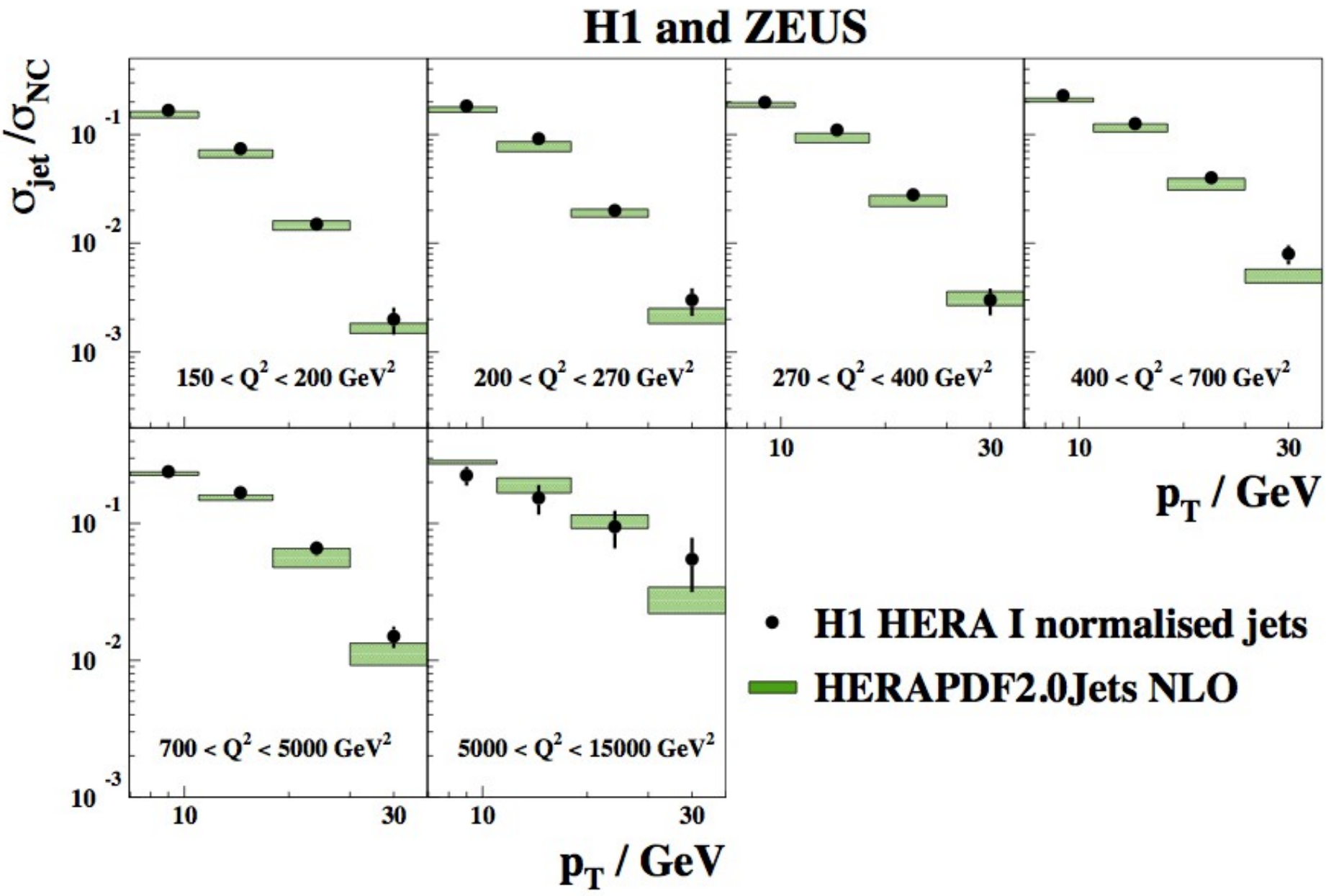

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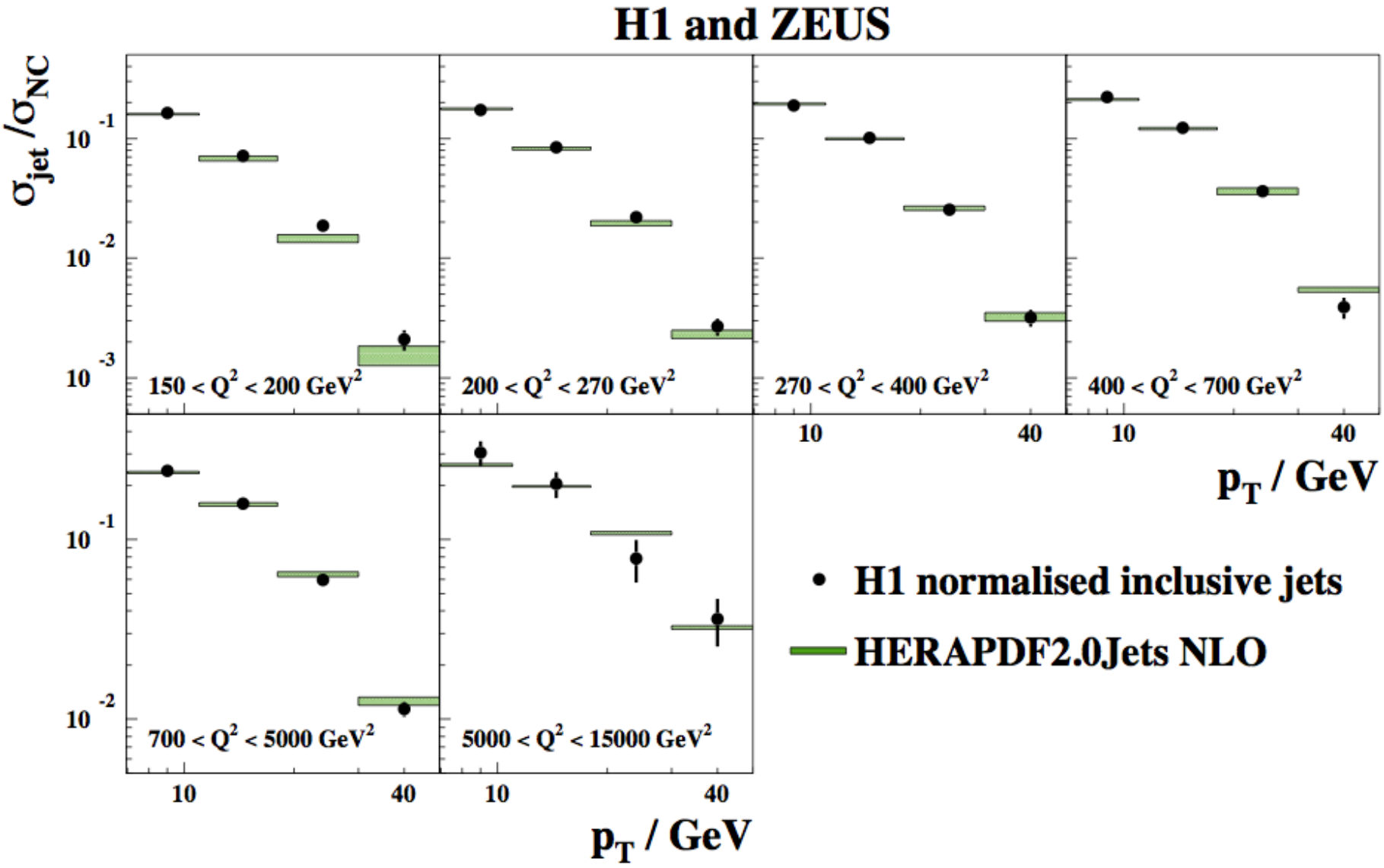

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