Combination of D^* differential cross-section measurements in DIS at HERA.

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on behalf of the H1 & ZEUS collaborations

DIS2014, Warsaw

30/04/2014

HELMHOLTZ GEMEINSCHAFT

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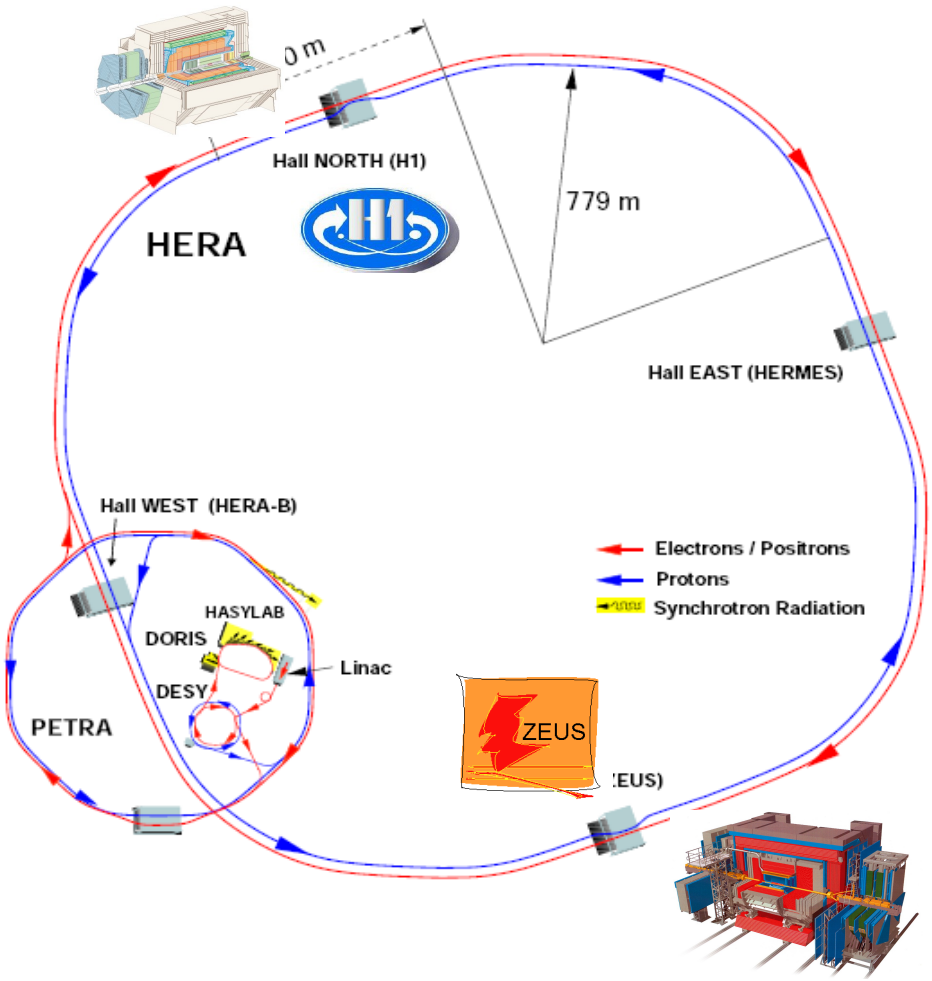
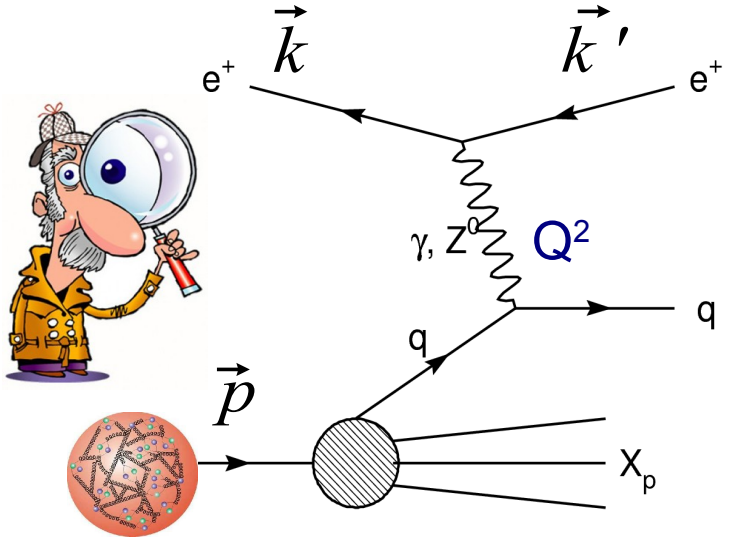
DIS at HERA.





Photon virtuality:

$$Q^2 = -q^2 = -(k - k')^2$$

Inelasticity: $y = \frac{q \cdot p}{k \cdot p}$

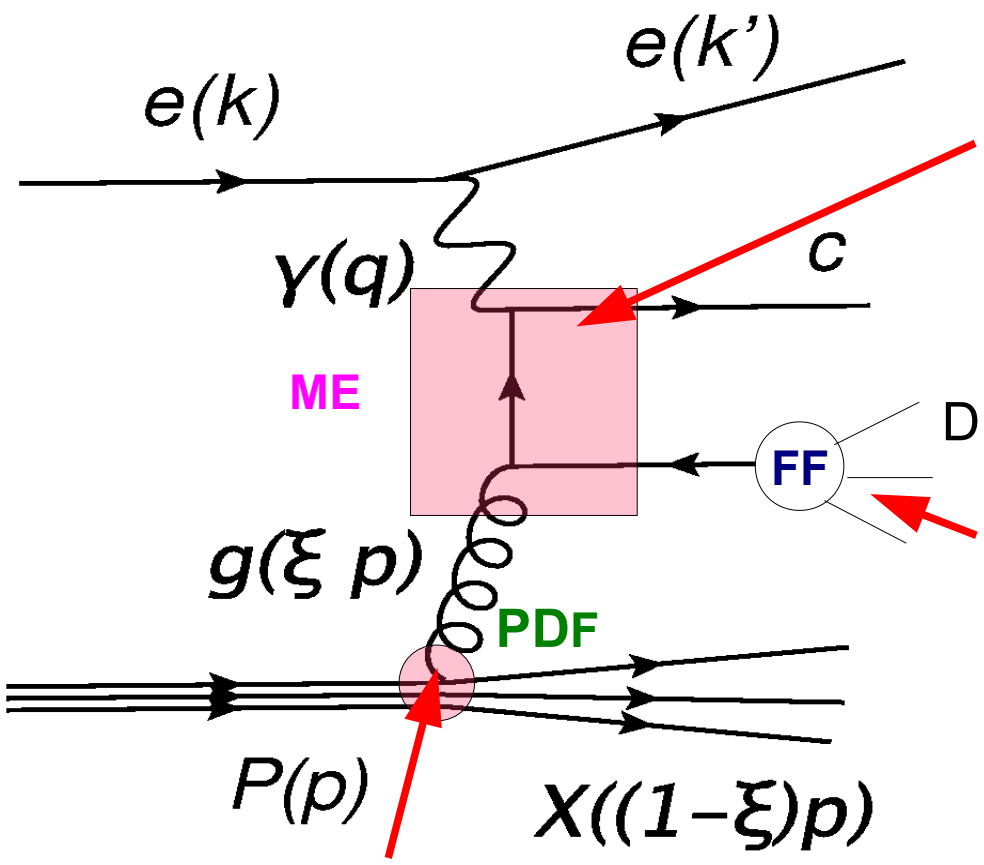
Deep Inelastic Scattering (DIS): $Q^2 > 1\ GeV^2$

$$E_p = 920\,GeV \qquad E_e = 27.5\,GeV$$

$$\sqrt{s} = 318\,GeV$$

L~0.5 fb^{-1} per experiment

Introduction to charm production @ HERA.



- Important test of QCD
- Multiple scales (Q^2, m_c, $p_T(c)$): a challenge for pQCD. Massive/fixed-order pQCD calculations: charm is produced perturpatively
- Fragmentation model c → D
- Direct probe of the gluon in the proton: predominantly via boson-gluon fusion.

$$\sigma^D = \mathrm{PDF} \otimes \mathrm{ME} \otimes \mathrm{FF}$$

Motivation.

H1prelim-13-171, ZEUS-prel-13-002

- Combine the most precise measurements of D^* visible differential cross sections in DIS by ZEUS and H1 in HERAII to get the ultimate precision. Combination was done using HERAverager.
- Minimal (negligible) theoretical uncertainties (due to extrapolation), in contrast to the recent H1+ZEUS combination of inclusive charm cross sections in the full phase space(EPJ C73 (2013) 2311).
- Provide measurements in $p_T(D^*)$, $\eta(D^*)$, $z(D^*)=(E-p_Z)^{D^*}/(2E_e y)$, Q^2, y
- Combined visible D^* cross sections[1)] were compared to the NLO QCD predictions from HVQDIS

[1)] corrected to the QED Born level with running α; include the beauty contribution

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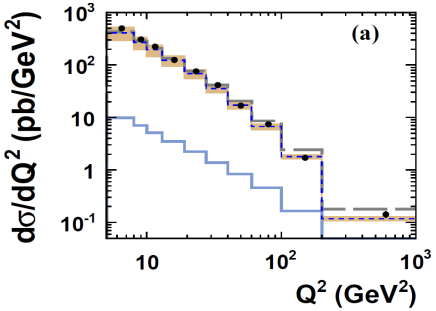
Combination inputs.

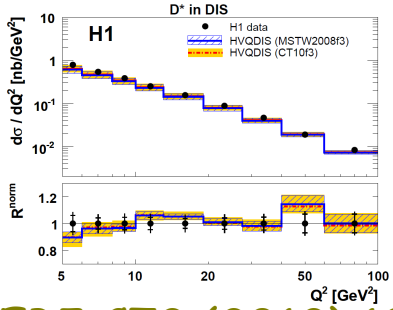
H1prelim-13-171, ZEUS-prel-13-002

ZEUS full Q^2



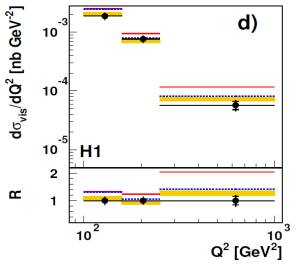
JHEP 05 (2013) 097

H1 medium Q^2



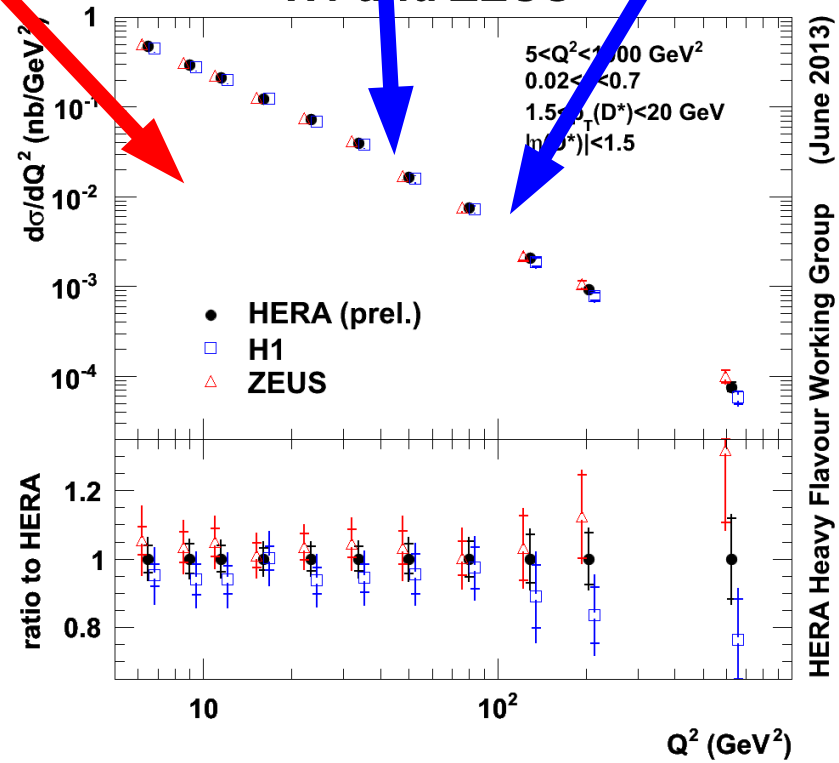
EPJ C72 (2012) 1836

H1 high Q^2



PL B686 (2010) 3989

H1 and ZEUS



- Phase space:
  - $1.5 < p_T(D^*) < 20$ GeV
  - $-1.5 < \eta(D^*) < 1.5$
  - $5 < Q^2 < 1000$ GeV^2
  - $0.02 < y < 0.7$
- Only very small extrapolation to the common phase space

- Systematics uncorrelated between ZEUS and H1

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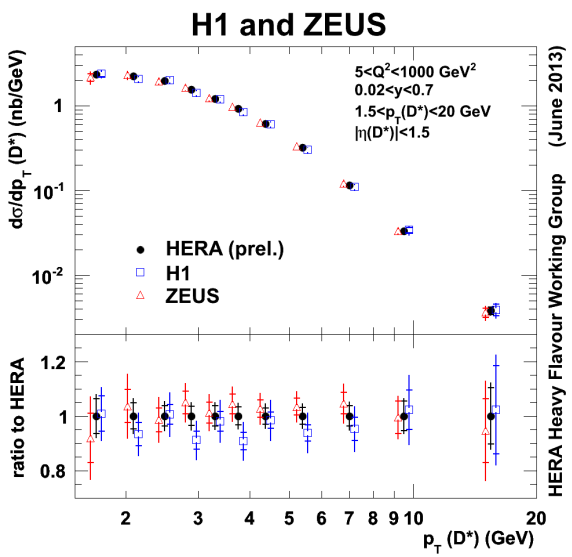
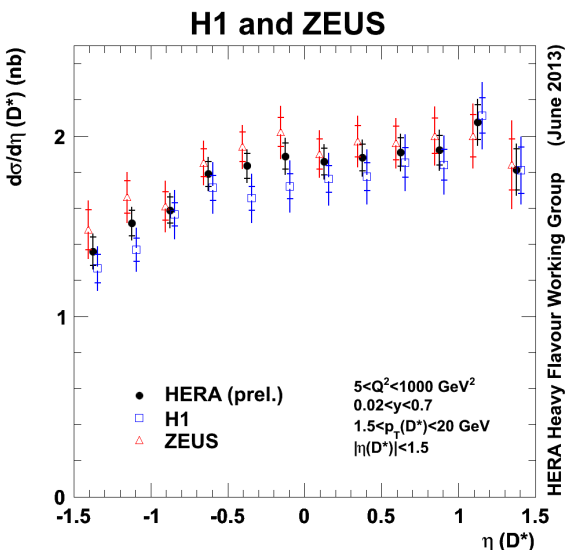
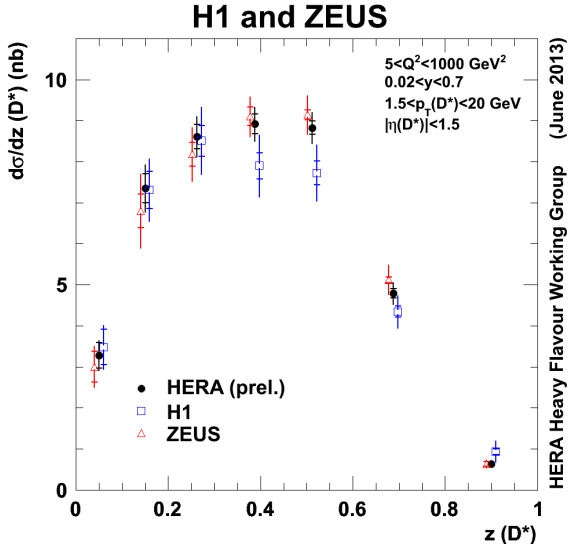
Data combination.

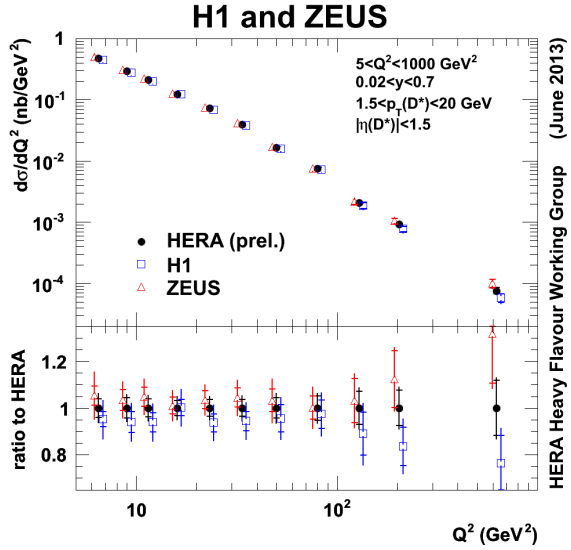
H1prelim-13-171, ZEUS-prel-13-002

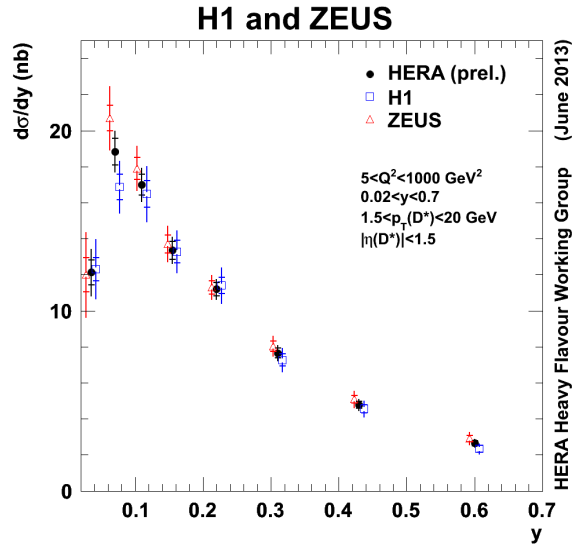






- Good agreement between measurements: the χ^2 probability varies between 0.15 and 0.86
- Significant improvement in precision
- Theory unc. is only up to 10% of the input unc.



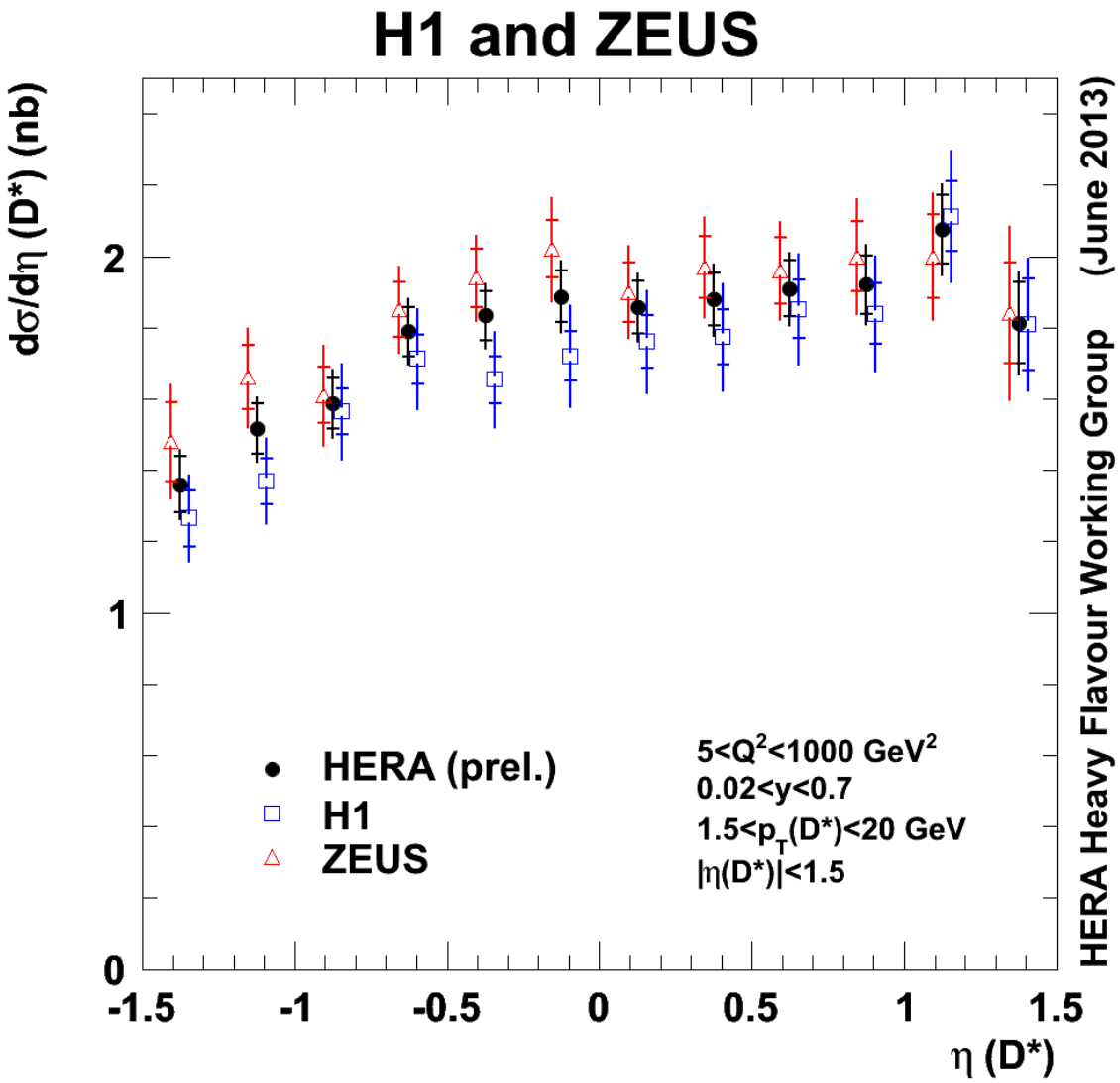


DESY

Data combination.

H1prelim-13-171, ZEUS-prel-13-002

- Significant improvement in precision.
- Precision of the combined data is ~5% in a large fraction of the phase space.



NLO O(α_s^2) QCD predictions.

H1prelim-13-171, ZEUS-prel-13-002

NLO QCD predictions: the same as in the ZEUS D^* paper : HVQDIS and RAPGAP b x 1.6

HVQDIS setup

- $m_c = 1.5 \pm 0.15\ GeV$
- $\mu_R = \mu_F = \sqrt{Q^2 + 4m_c^2}$, varied **independently** by factor 2
- $\alpha_s^{n_f=3}(M_Z) = 0.105 \pm 0.02$
- HERAPDF1.0
- Fragmentation:
  - Kartvelishvili fragmentation function parametrised as step function with α_k and bin boundaries variations
  - Transverse fragmentation: $f(k_T) = k_T exp(\frac{-2k_T}{<k_T>})$, $k_T = 0.35 \pm 0.15\ GeV$
  - $f(c \to D^*) = 0.2287 \pm 0.0056$

courtesy of S. Zenaiev

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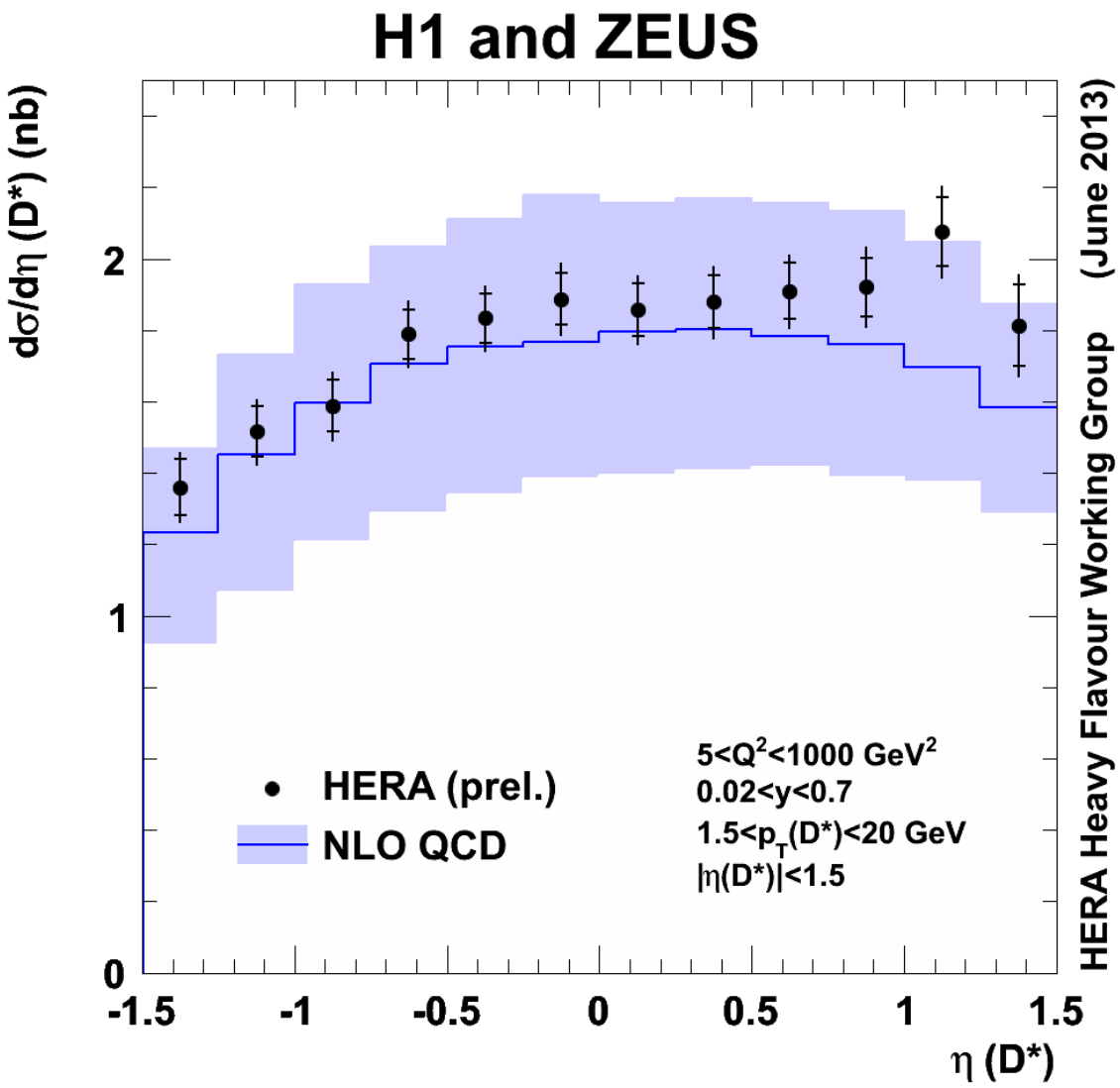
η(D*): NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

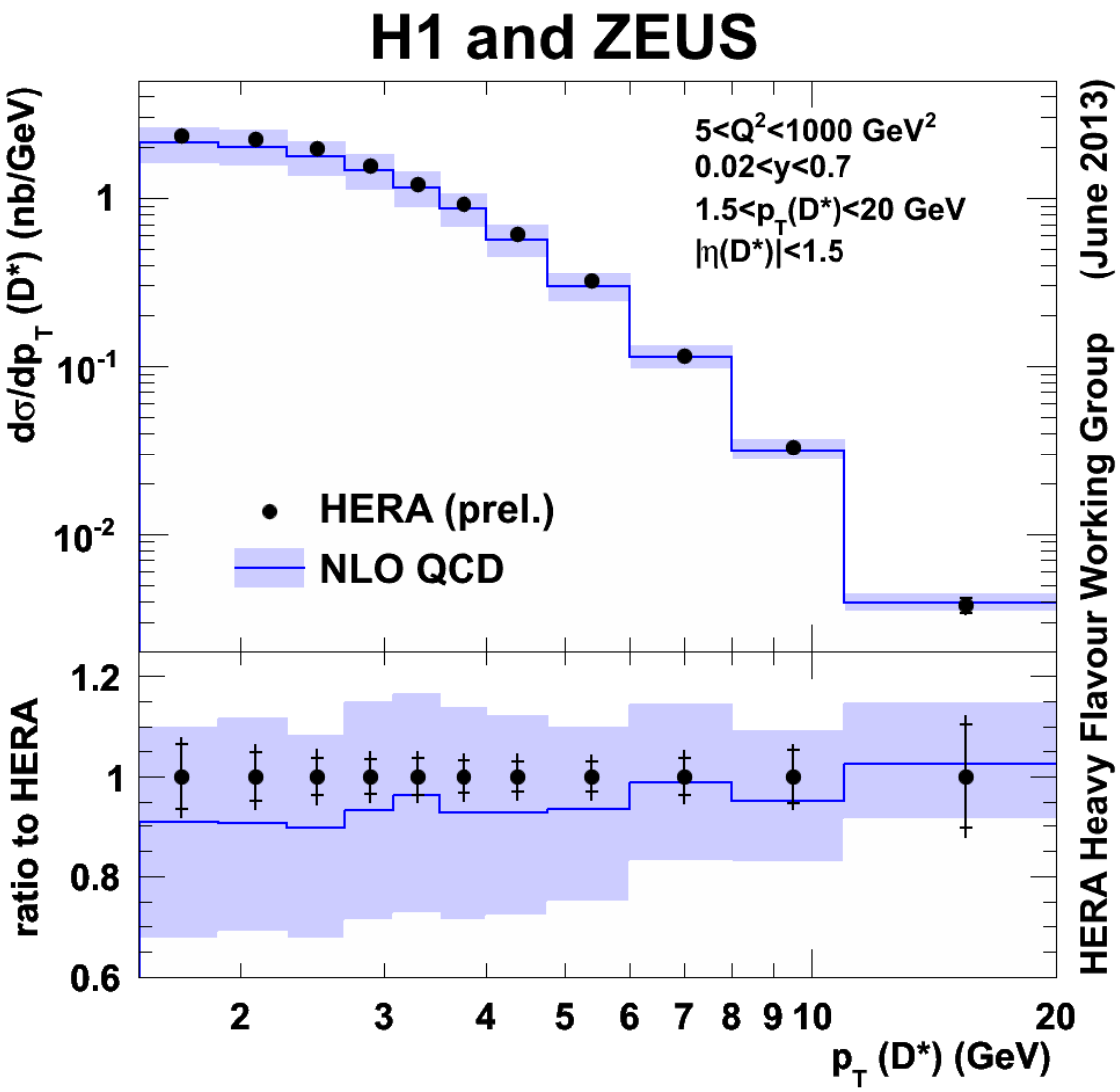
- Predictions describe the data very well.
- Theory uncertainties are much larger than data uncertainties.
- NNLO calculations and improved fragmentation models would be helpful!



$p_T(D^*)$: NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

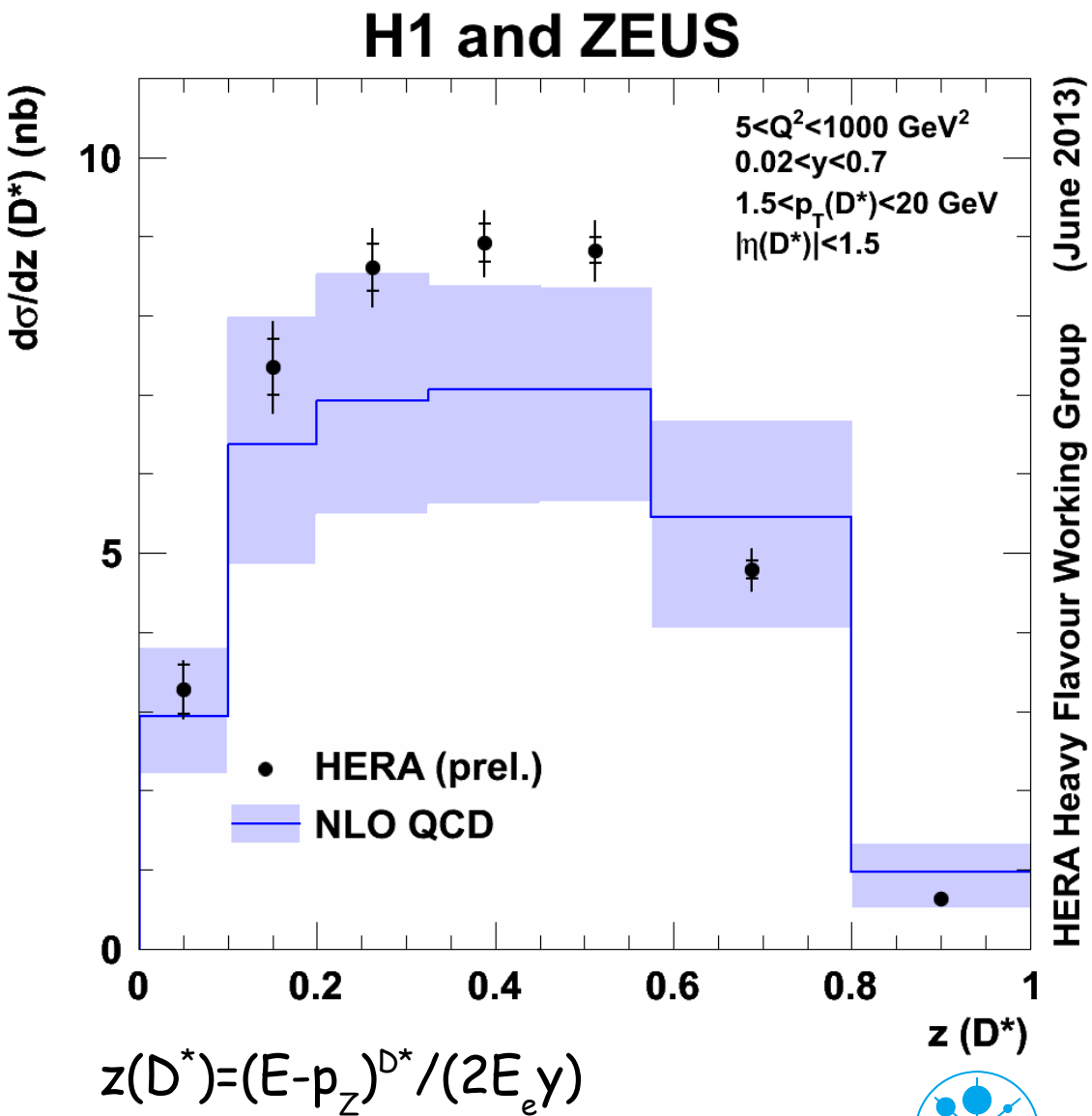
- Predictions describe the data very well.
- Theory uncertainties are mostly much larger than data uncertainties.
- NNLO calculations and improved fragmentation models would be helpful!



z(D*): NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

- Predictions describe the data reasonably well.
- Theory uncertainties are much larger than data uncertainties.
- NNLO calculations and improved fragmentation models would be helpful!



$z(D^*)=(E-p_Z)^{D^*}/(2E_e y)$

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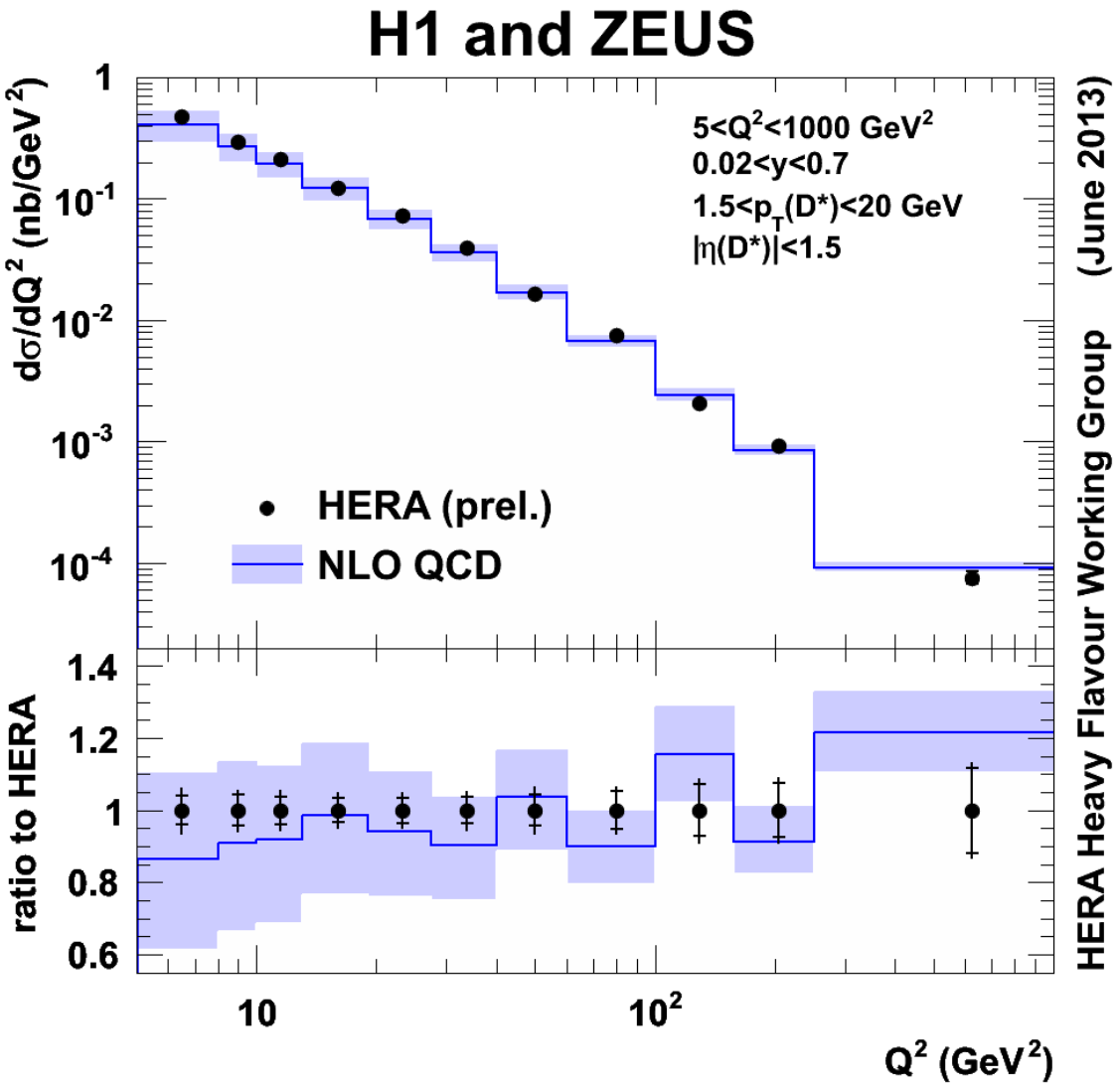
Q^2: NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

- Predictions describe the data very well.
- Theory uncertainties are mostly larger than data uncertainties.
- NNLO calculations and improved fragmentation models would be helpful!



y: NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

- Predictions describe the data very well.
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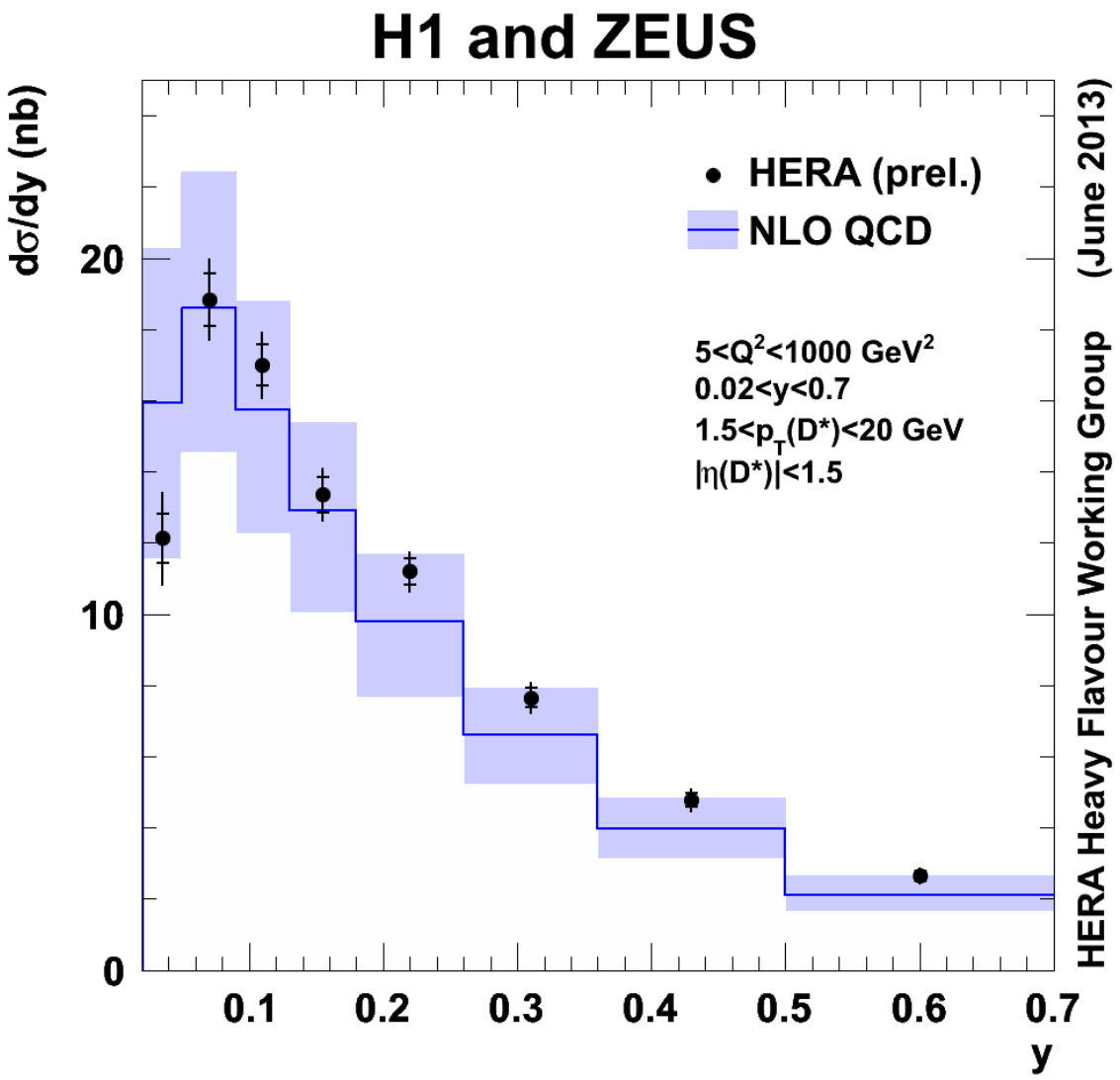

(Q^2,y): NLO QCD vs. combined data.

H1prelim-13-171, ZEUS-prel-13-002

- Predictions describe the data very well.
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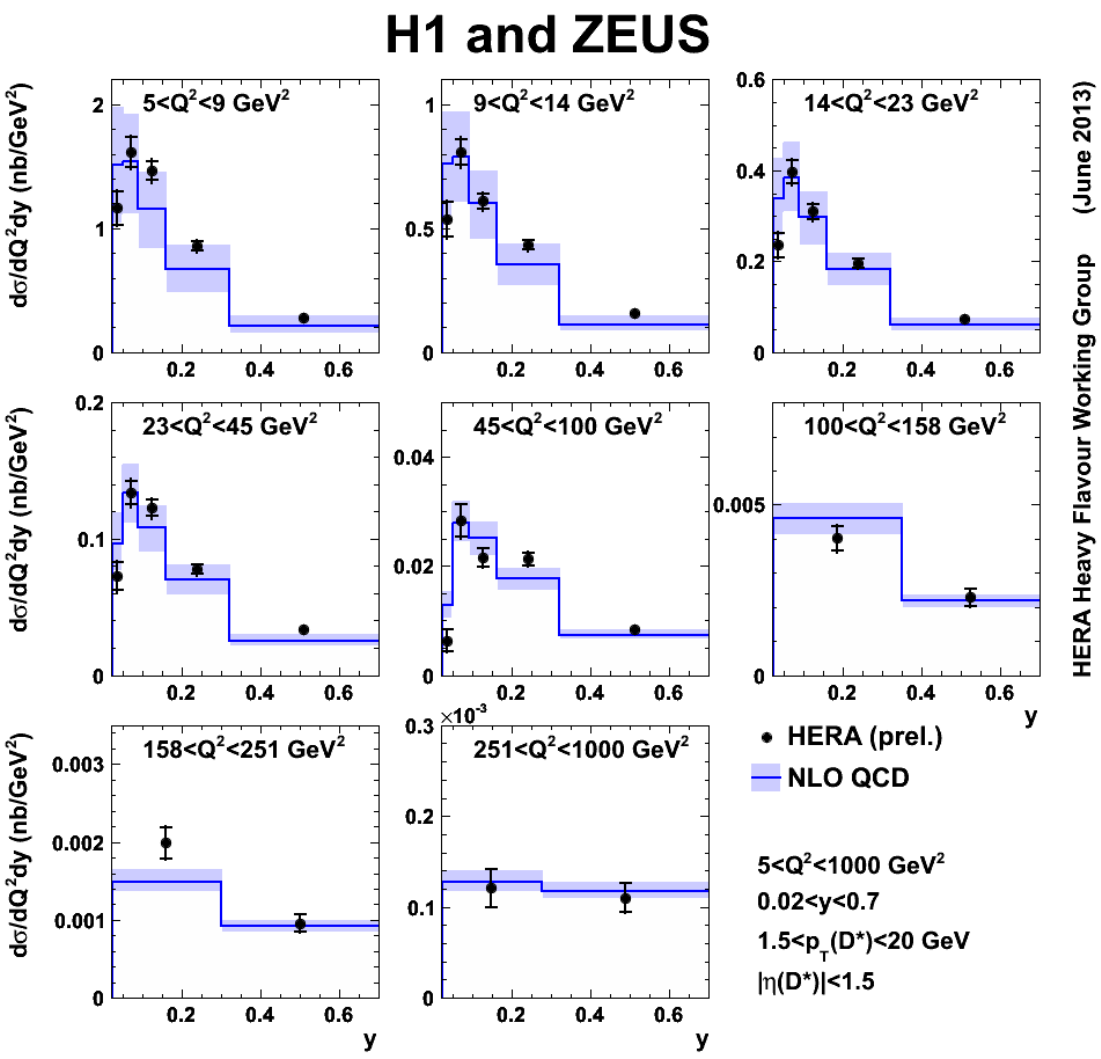
- NNLO calculations and improved fragmentation models would be helpful!



Summary.

- Most precise D* measurements in DIS by ZEUS and H1 were combined in the visible phase space.
- Significant improvement of the data precision.
- Negligible component of the theoretical uncertainty (up to 10% of the total uncertainty) due to small extrapolation to the common phase space.
- NLO QCD calculations describe the combined data well.
- Uncertainties of the predictions are typically much larger than those of the data => higher-order calculations and improved fragmentation model would be very helpful.

Backup

NLO QCD predictions.

H1prelim-13-171, ZEUS-prel-13-002

- Fixed-order $O(\alpha_s^2)$ calculations using HVQDIS.
- Set-up follows closely the one used in the combination of inclusive charm cross sections (EPJ C73 (2013) 2311) (see back-up). Only μ_R and μ_F are varied independently.
- Small beauty contribution is estimated with RAPGAP and normalised following original analyses.