F_2^{cc} from D* production at ZEUS

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HERA - LHC Workshop

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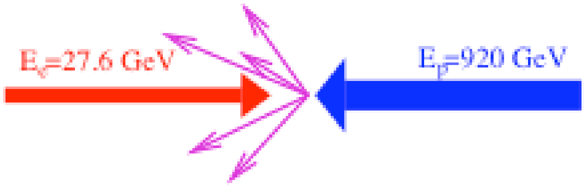
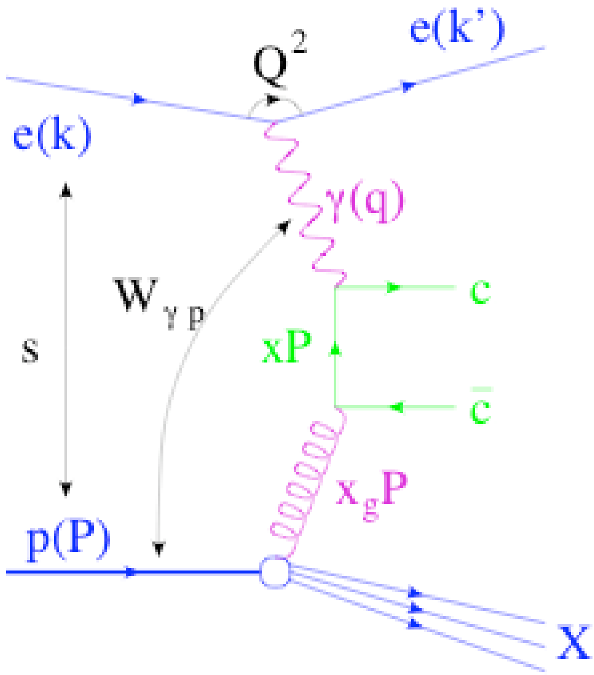
Outline of charm at HERA

- HERA and its charm
- Perturbative QCD calculations.
- D* cross sections
- F_2^{cc}.

HERA's charm production





Boson Gluon fusion

Charm directly sensitive to the proton gluon density.

Study of charm over huge kinematical ranges: $1.5 < p_T^c < 30$ GeV, $0 < Q^2 < 1000$ GeV^2.

DIS: $Q^2 > 1$ GeV^2

Charm pQCD calculations

pQCD calculations are performed in different ways: Massive (PHP S.Fixione et al) (DIS Harris and Smith), Massless(B. Kniehl et al) and a combined method (M. Cacciari et al).

The "Massive" approach, to fixed order in α_s:

$\rightarrow m_Q \neq 0$ and the heavy quarks (c and b) are not parts of the structure functions. Heavy quarks produced dynamically in the hard interaction. $\rightarrow$ reliable at $p_T \approx m_Q$

DGLAP evolution is used to obtain the quark and gluon densities.

Programs for Photoproduction: FMNR (Frixione et al.) and

DIS: HVQDIS (Harris+Smith)

Charm Tagging

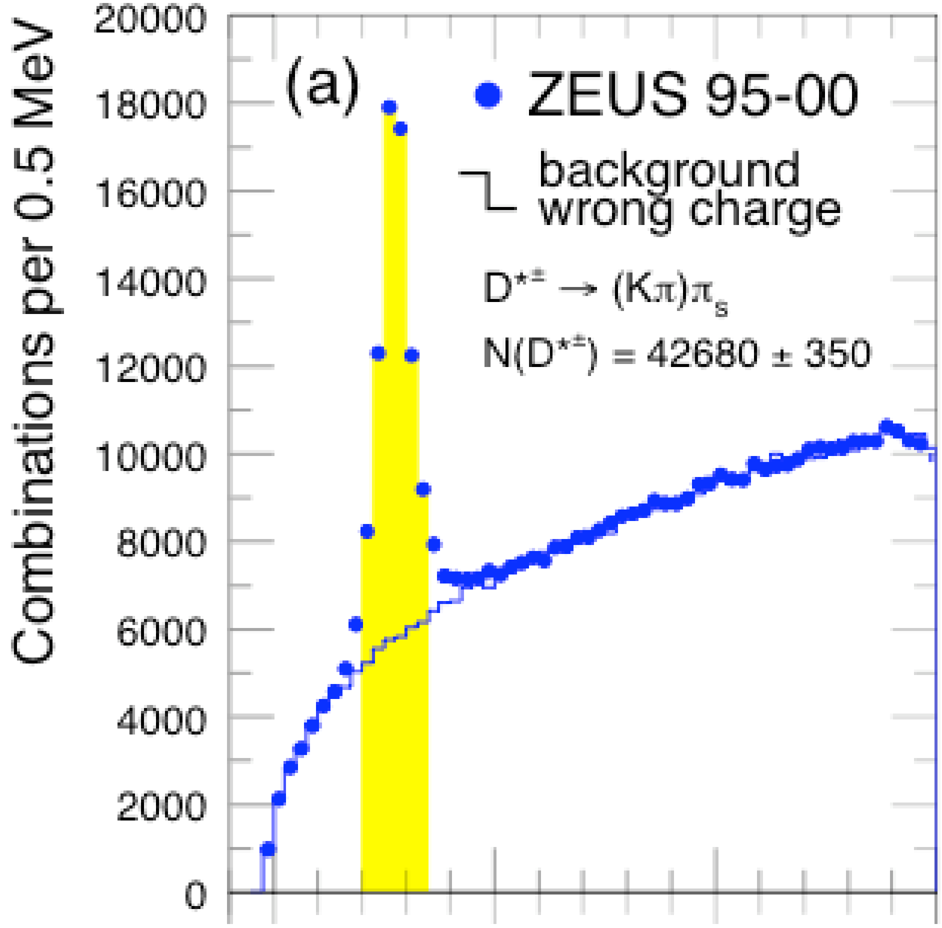
Charm tagging via D* meson

$D^* \rightarrow D^0, \pi$ Where $D^0 \rightarrow K, \pi$

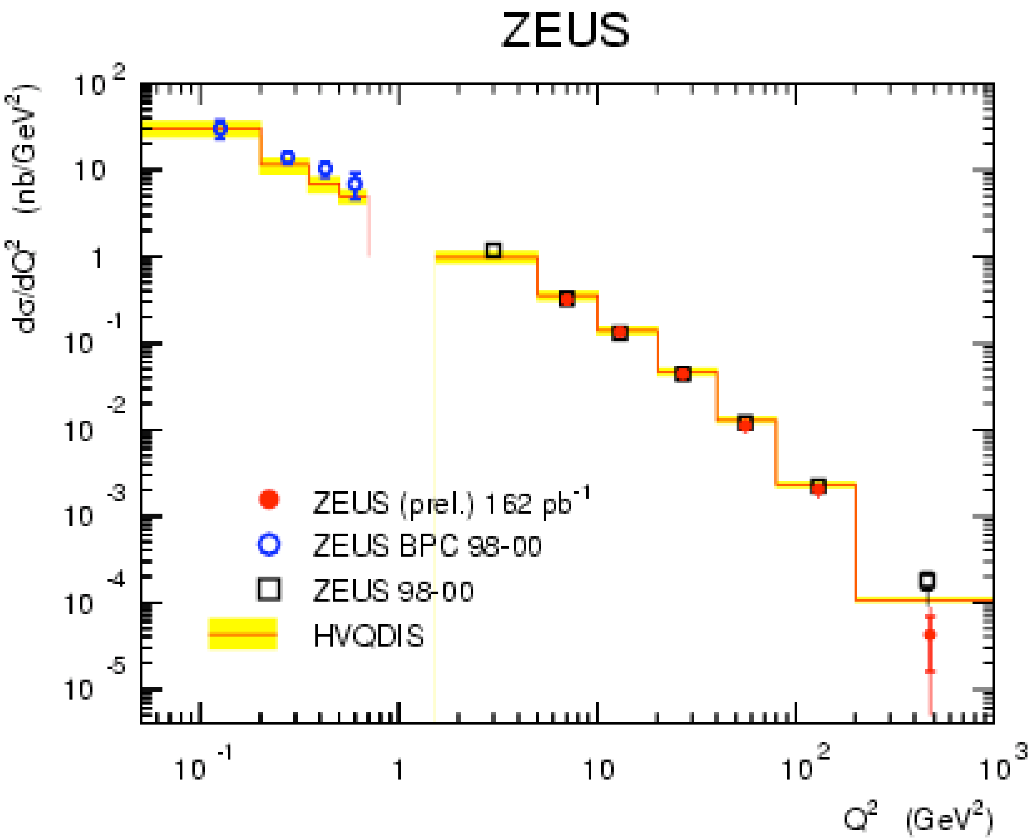
HERA is a charm factory

42680 ± 350 D* mesons.

H1 & ZEUS for HERA I



Charm over all Q^2



Comparison of low Q^2 data, using the beam pipe calorimeter (BPC) to tag the scattered electron.

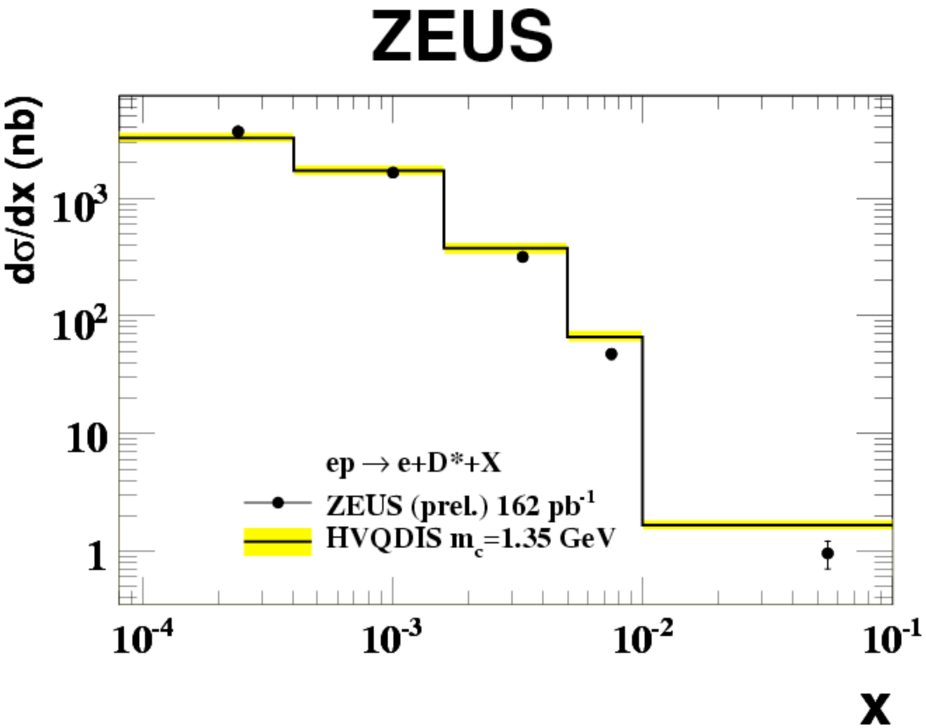
NLO charm production tested across the transition region from DIS to Photoproduction.

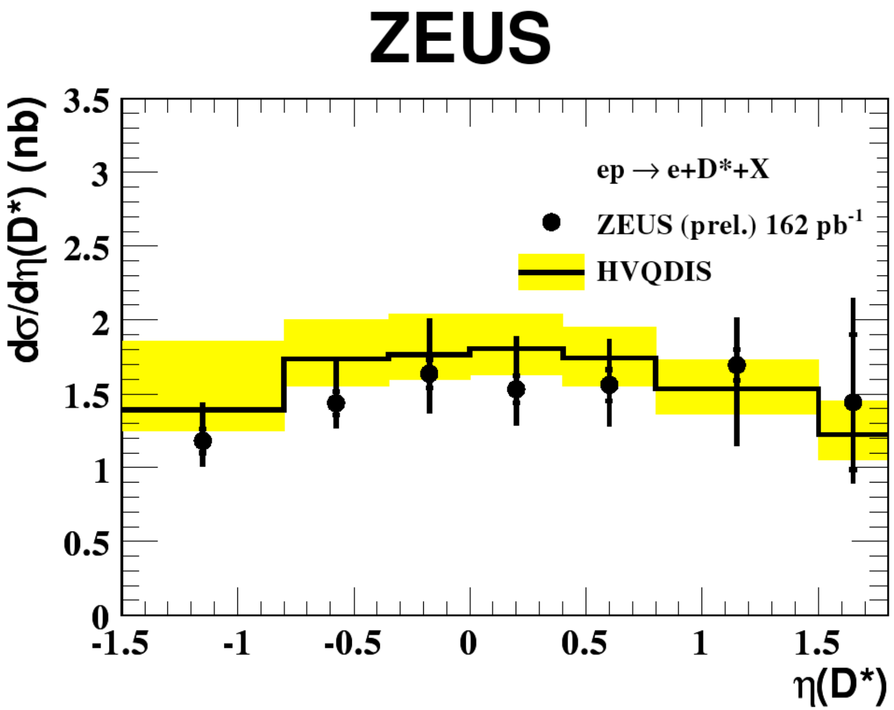
Low Q^2 is much smaller than charm mass.

High Q^2 is much larger than charm mass

Good agreement with massive theory.

Charm cross sections





- Good agreement with massive theory HVQDIS.
- Scale choices: renormalisation and factorisation scale $\sqrt{(Q^2 + 4m_c^2)}$
- Uncertainties come from the mass of the charm, the scales doubled and halved and different fragmentation function parameters.

Extraction of F_2^{cc}

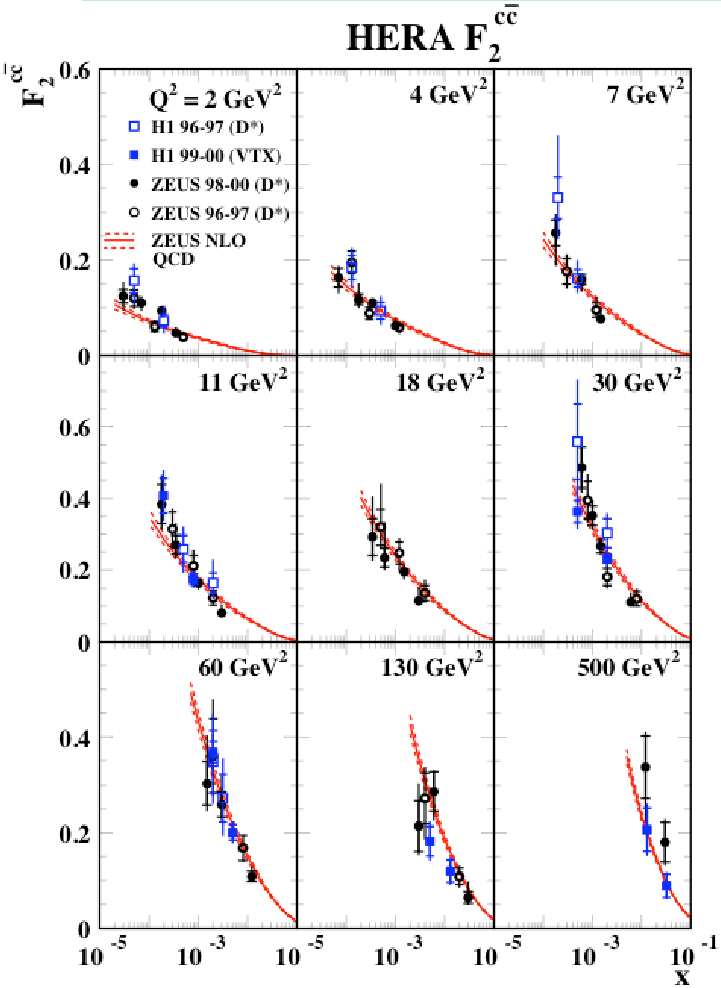
$$F_2^{c\bar{c}}{}_{\text{meas}}(x, Q^2) = \frac{\sigma_{\text{meas}}(ep \to D^* X)}{\sigma_{\text{theory}}(ep \to D^* X)} F_2^{c\bar{c}}{}_{\text{theory}}(x, Q^2)$$

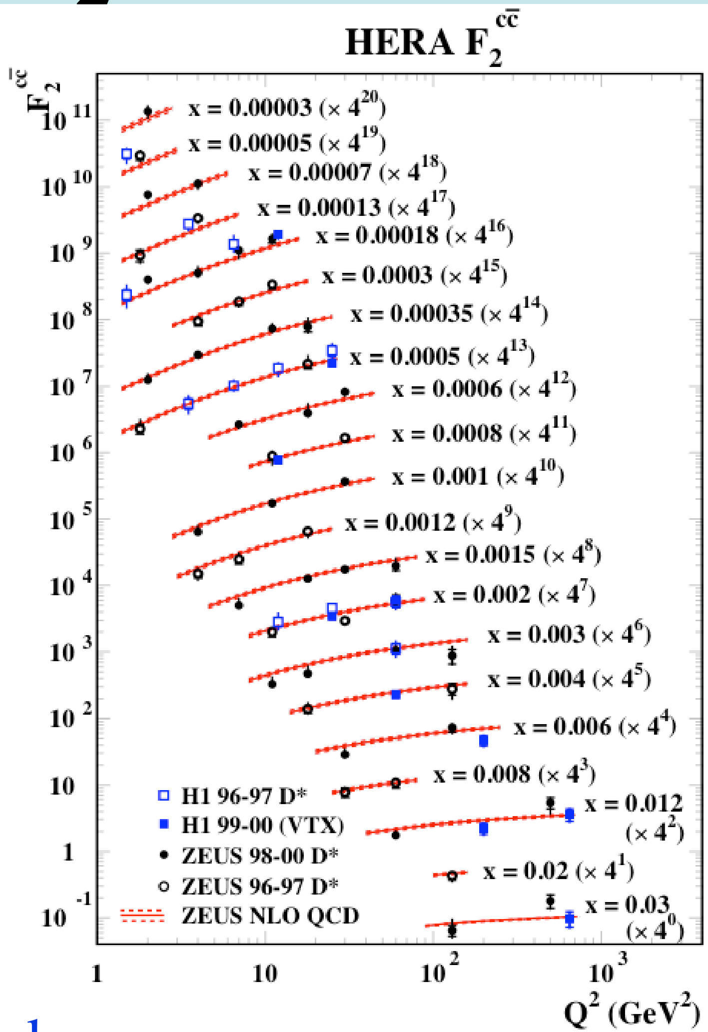
- Extraction of F_2^{cc} from measured D* meson cross sections to full phase space using consistent 'massive' NLO QCD scheme (HVQDIS program)

- Extrapolation factors (4.7 - 1.5) in p_T and η decreasing with Q^2. Sensitivity $p_T(D^*) > 1.5$ GeV and $|\eta(D^*)| < 1.5$.

- Uncertainties in extrapolation due to fragmentation, charm mass, PDF's typically around 10% and less than 20%.

Extraction of F_2^{cc} - HERA I

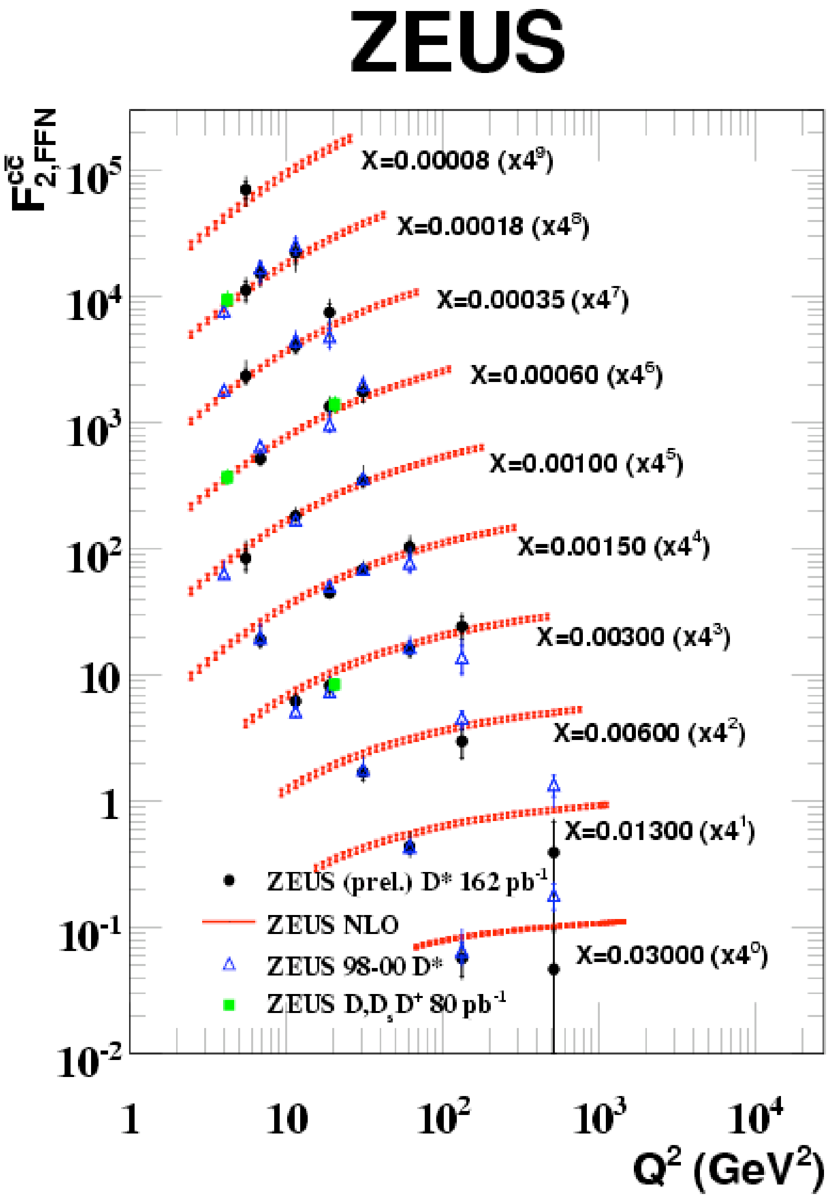




Lots of data, comparable methods.

→ Gluon density visible. Good agreement with NLO QCD.

Extraction of F_2^{cc} - HERA II



HERA II(162 pb^{-1}) data analysed

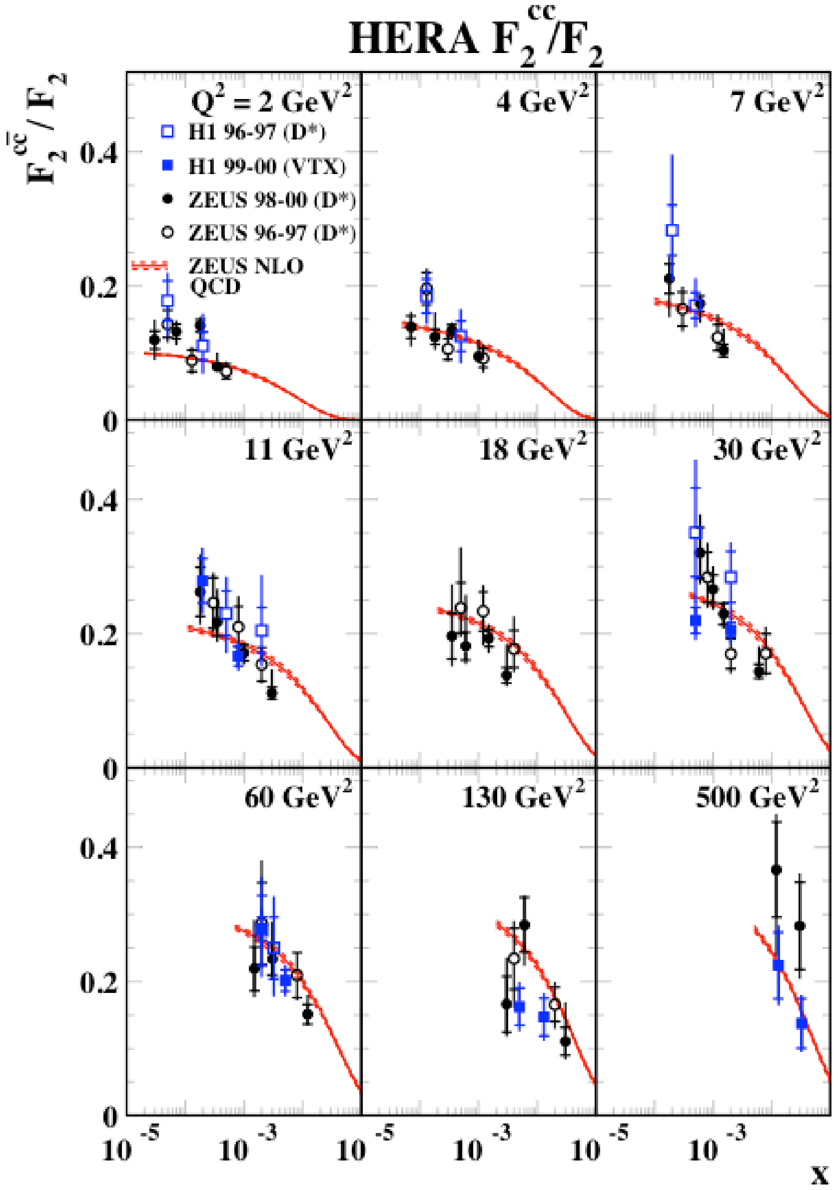
Similar errors to the HERA I analysis. ⇒ Total HERA II set will be ~ 450 pb^{-1}.

→Good agreement with NLO QCD.

Combine results from HERA I and HERA II in the near future.

⇒ Impact of charm data on PDF fits.

Extraction of F_2^{cc}



Contribution of F_2^{cc} can be as large as 30%.

Different methods of extraction agree.

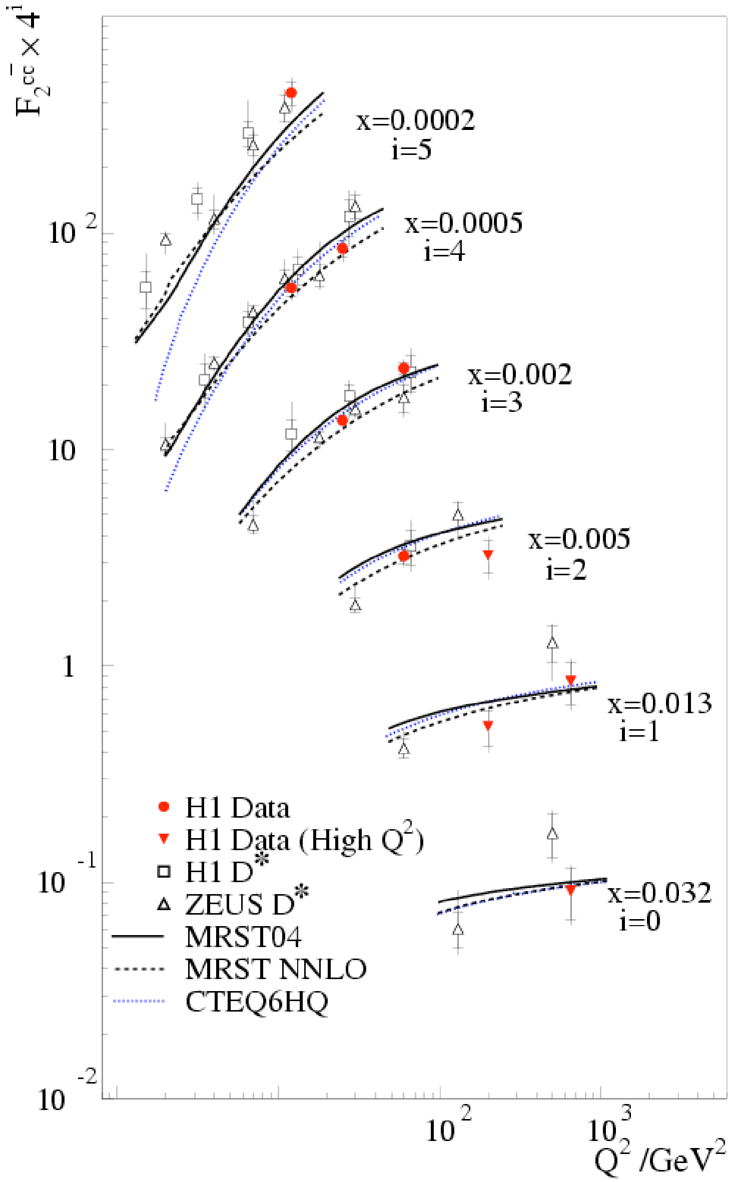
Good description by NLO QCD calculation.

Extraction of F_2^{cc}

QCD calculations fit the data reasonably well.

NNLO calculations → different from NLO in some regions.

At smallest x and low Q^2 MRST NLO and NNLO differ from CTEQ6HQ.



Summary

HERA errors small compared to theoretical uncertainties.

Need to understand which scales to used in the calculations why they differ by such large amounts. (Scales, masses, etc..)

Future charm prospects:

- Higher Q^2, and highest x, F_2^{cc} to a precision of better than 10%.
- Extend phase space to lower P_T^c and into the forward region ⇒ Reduce the extrapolation factors.
- Impact of charm data on PDF fits.

Combining of the HERA I and HERA II results is in progress!