Charm in deep inelastic scattering

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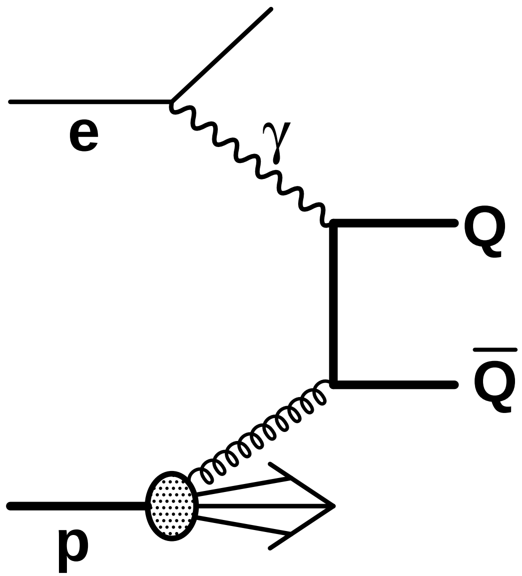
(On behalf of the ZEUS collaboration)

- Introduction
- Experimental analysis and results
- Outlook
- Summary

Introduction

To understand and probe QCD in as much detail as possible

Parton densities of proton and photon need to be precise. cf **future colliders,** pp**,** e^+e^- **and** $\gamma\gamma$**, ...**



Directly sensitive to gluon density in the proton

Analysis

Look for $D^* \rightarrow D^0\pi_s \rightarrow K\pi\pi_s$ channel with

$$1.5 < p_T(D^*) < 15\text{GeV},$$

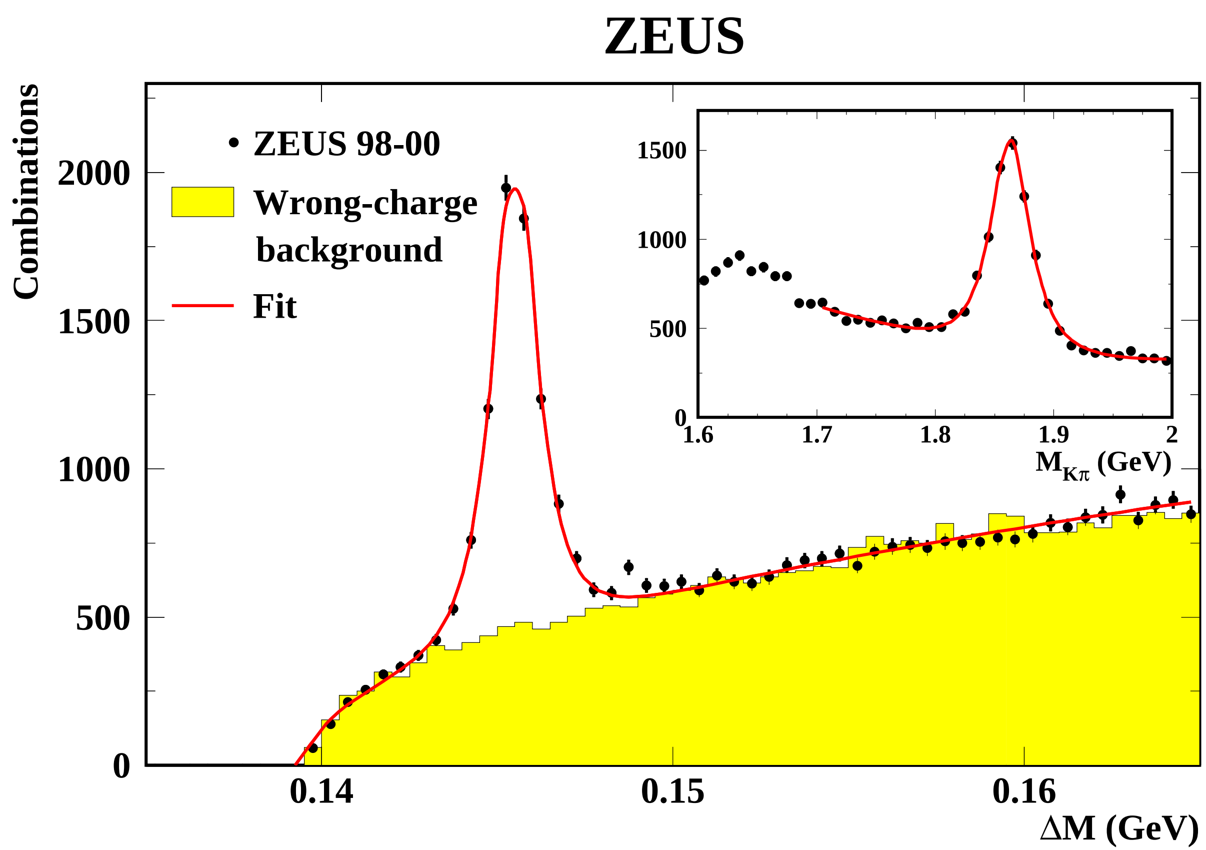
$$|\eta(D^*)| < 1.5$$

And a high energy scattered electron

$$1.5 < Q^2 < 1000\text{GeV}^2,$$

$$0.02 < y < 0.7$$

Analysis of 98-00 data, $\sim$ 82 pb^{-1}, in addition to $\sim$ 37 pb^{-1} from 96-97.



Measured 5545 D^* mesons

Measured cross section

For the production rate, $r = N/\mathcal{L}$

$r^{e^-p}/r^{e^+p} =$ **1.12±0.06 for 1.5**$<Q^2<$**1000 GeV**^{2}

and

$r^{e^-p}/r^{e^+p} =$ **1.67** $\pm$ **0.21 for 40** $< Q^2 <$ **1000 GeV**^{2}

Difference between $\sigma(e^-p)$ **and** $\sigma(e^+p)$ **data**

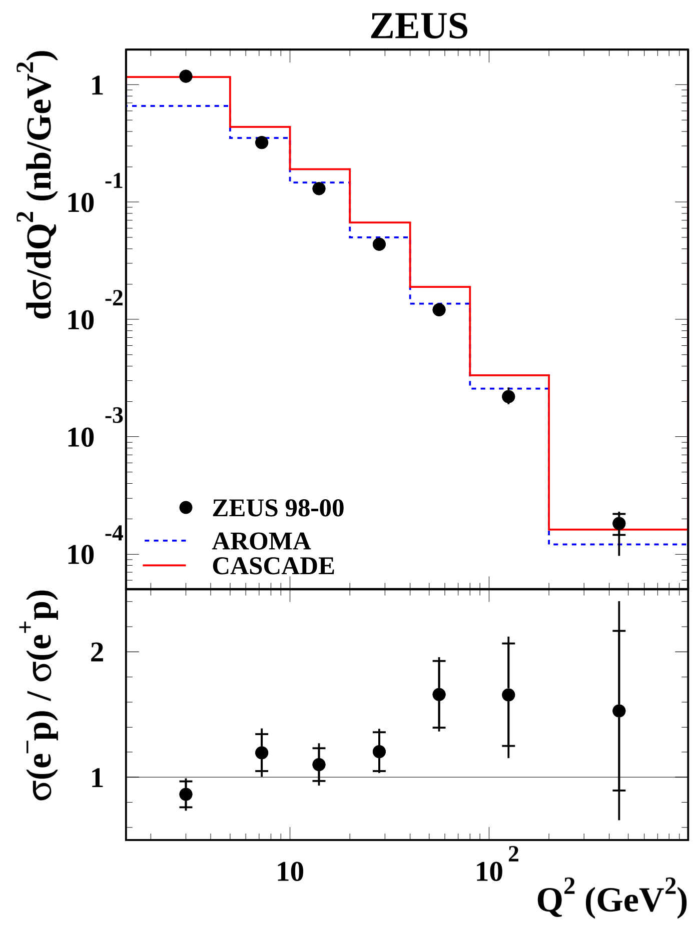
$\sigma(e^-p \to e^-D^*X) = 9.37\pm0.44$(**stat.**)$^{+0.59}_{-0.52}$(**syst.**) **nb**

$\sigma(e^+p \to e^+D^*X) = 8.20\pm0.22$(**stat.**)$^{+0.39}_{-0.36}$(**syst.**) **nb**

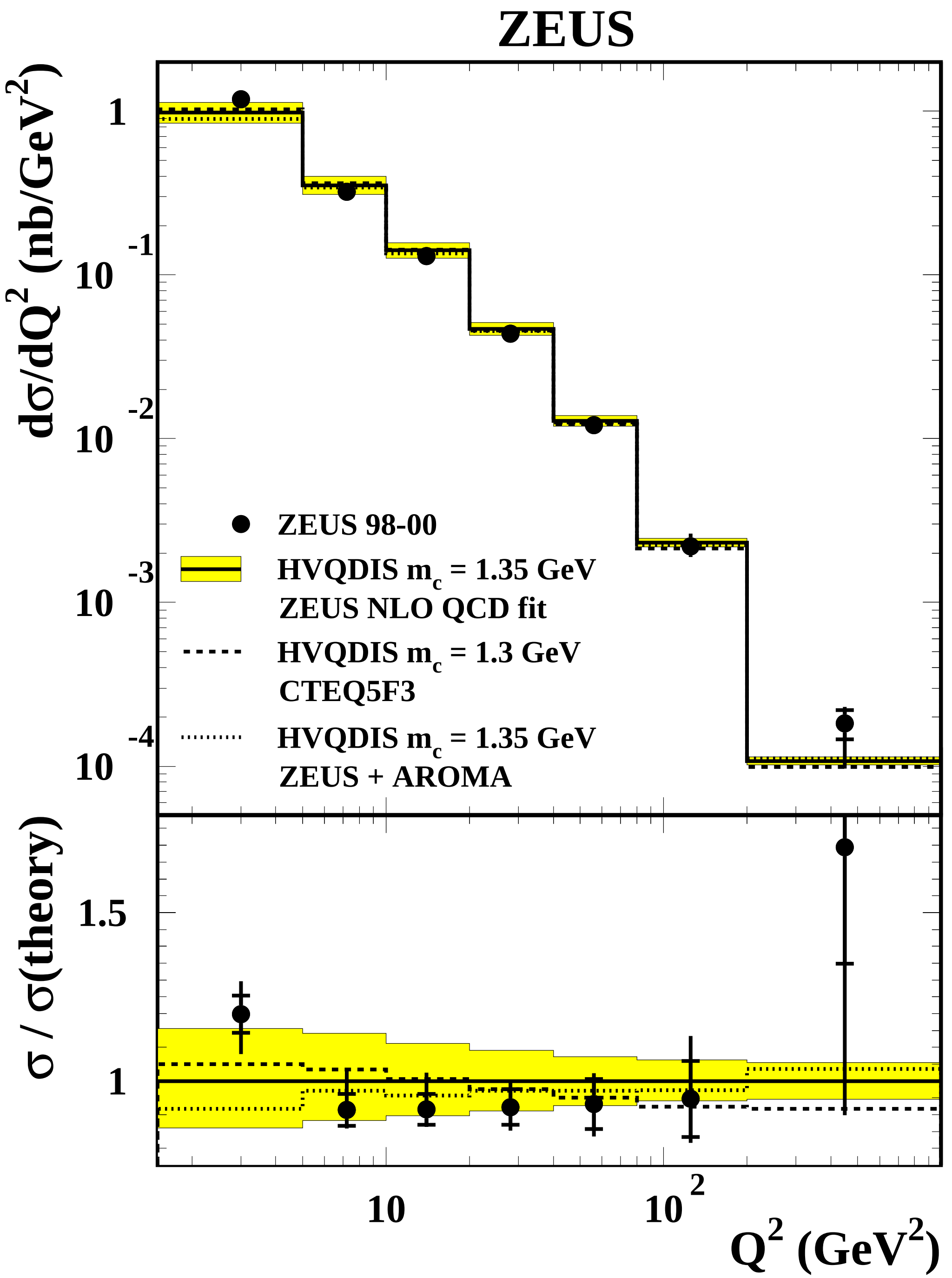
$\sigma(e^-p) > \sigma(e^+p)$ **increasing with** Q^2

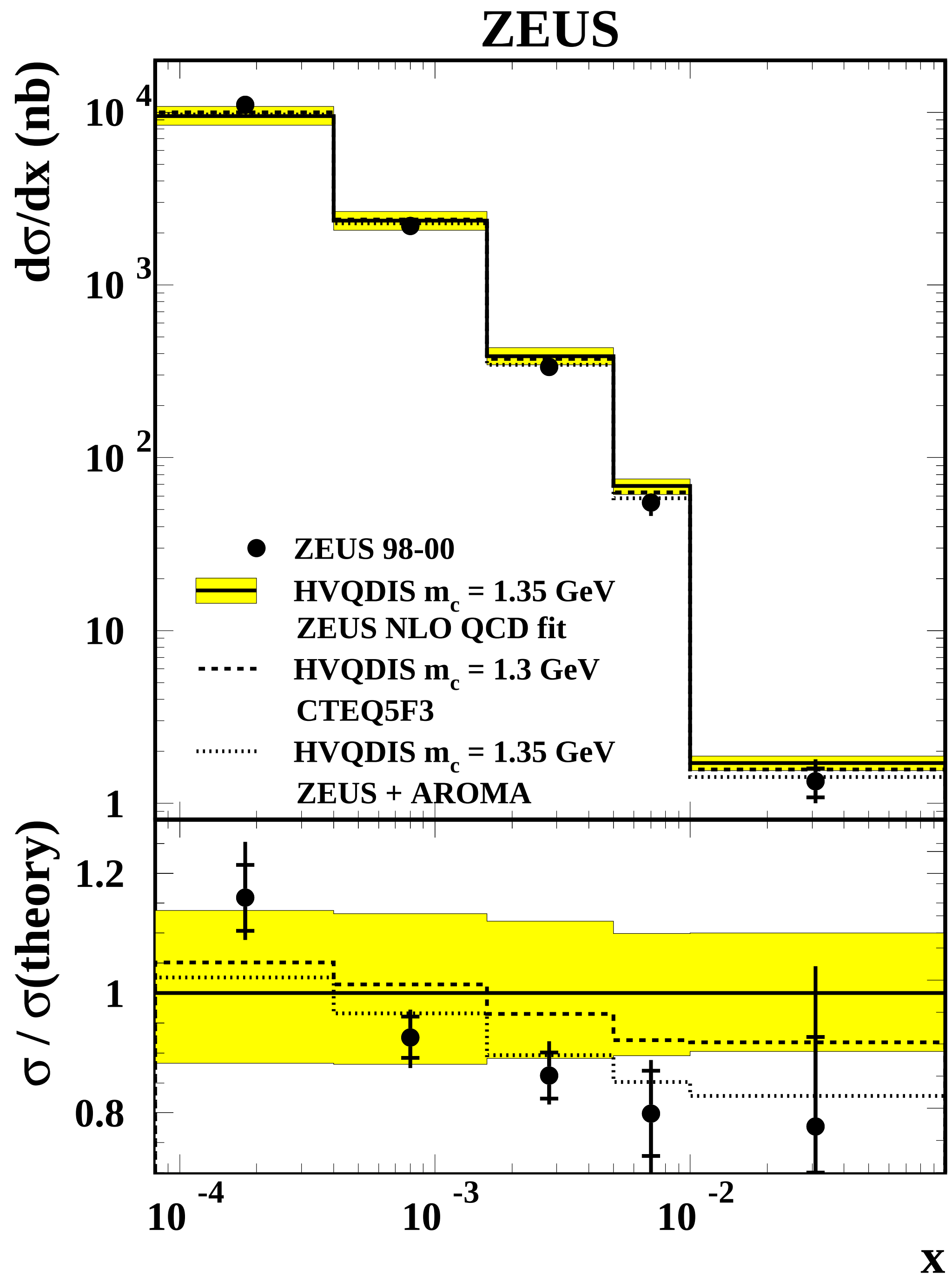
No obvious reason why, assume statistical fluctuation.

Can be solved with more e^-p **data...**

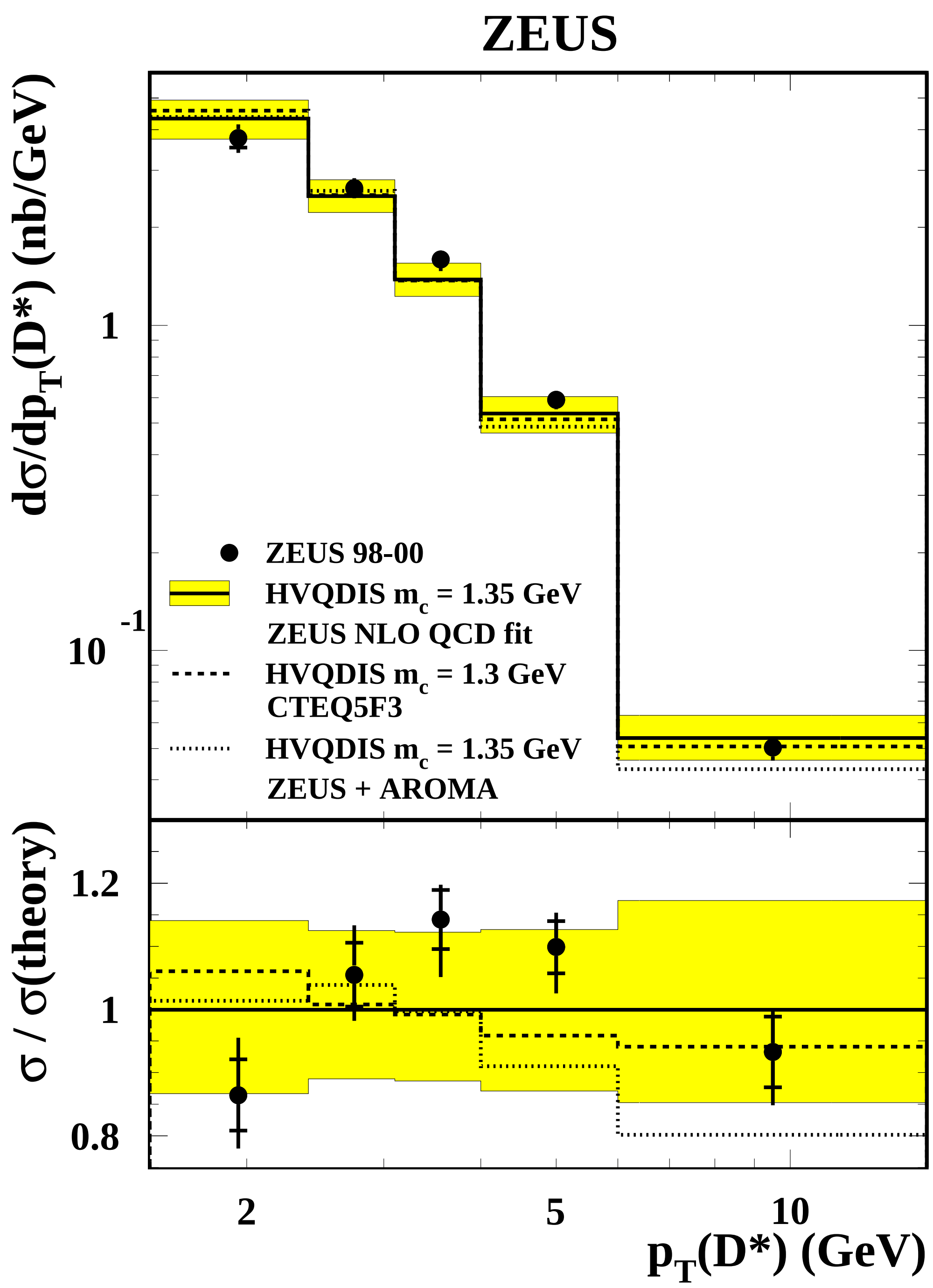


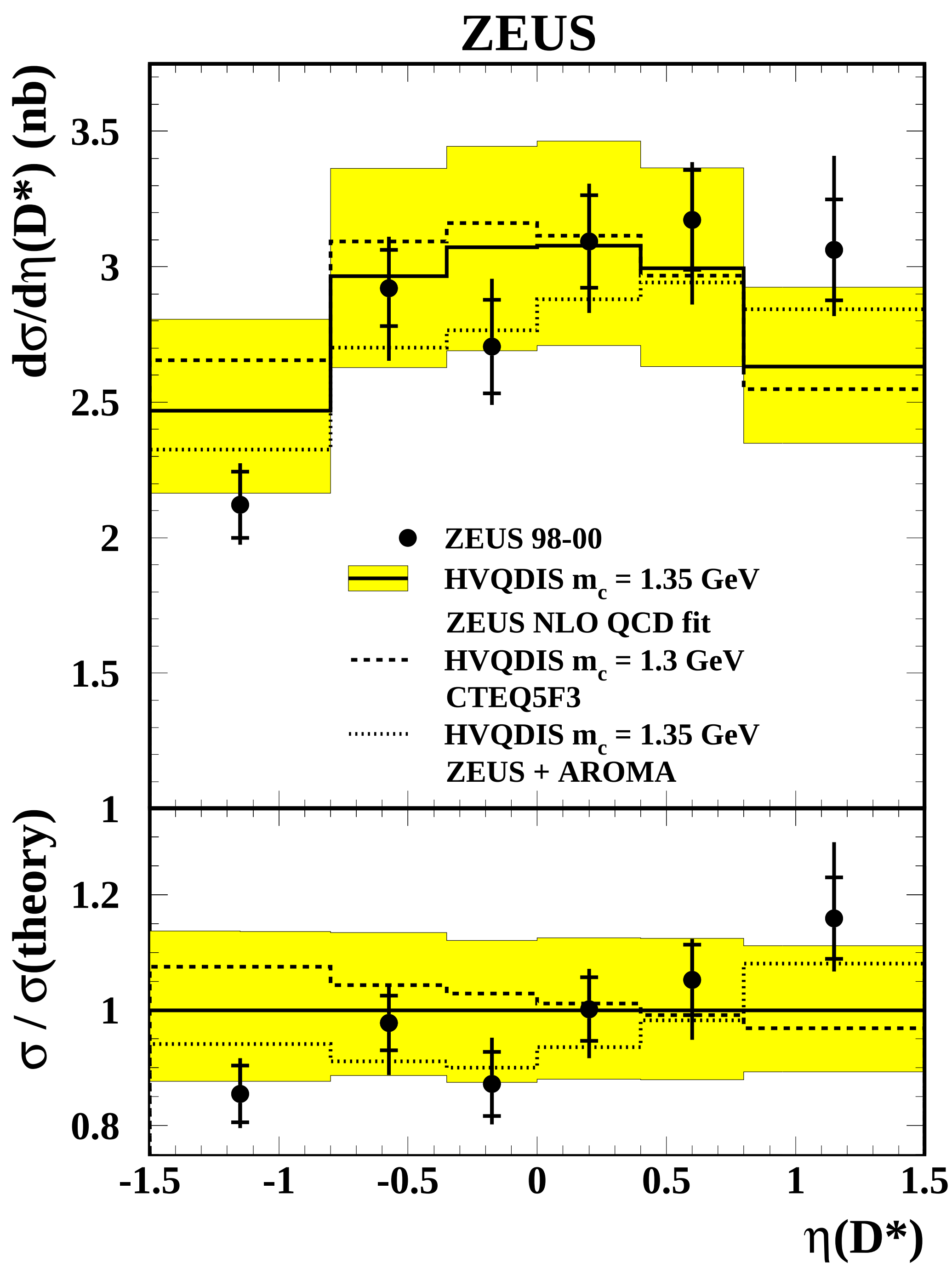
Event cross sections



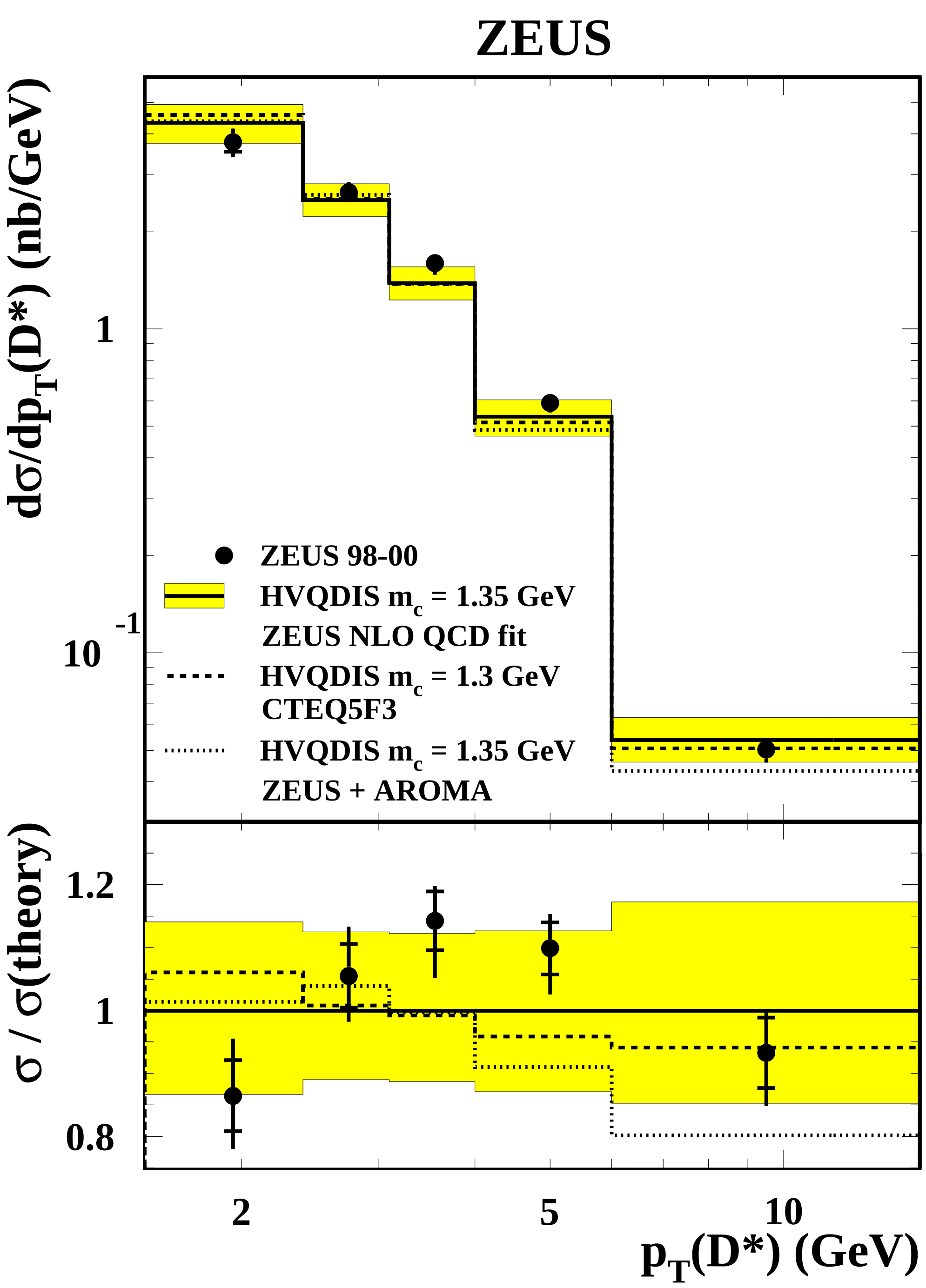


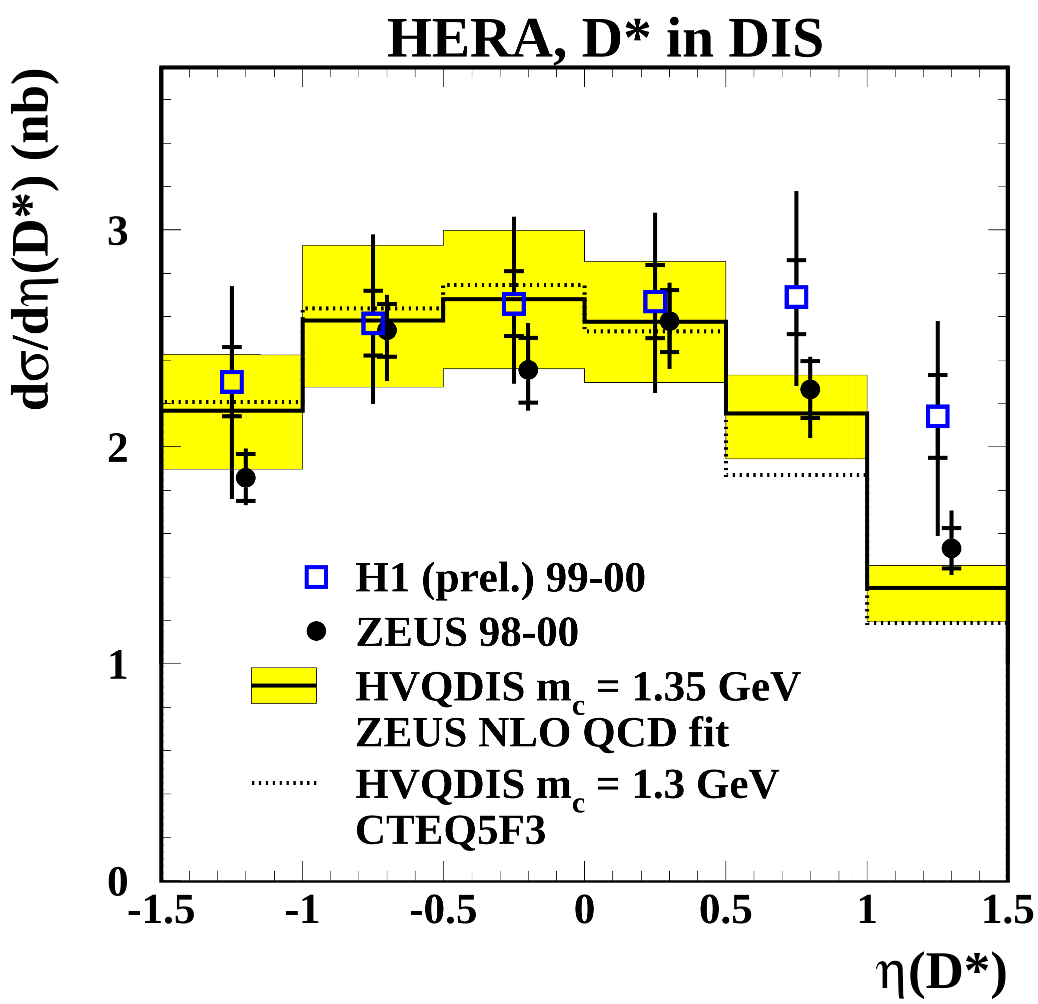
D* cross sections





D* cross sections





Extraction of $F_2^{c\bar{c}}$

Extraction of (extrapolation to) $F_2^{c\bar{c}}$ performed in fully consistent way

$$F_{2,\text{meas}}^{c\bar{c}}(x_i, Q_i^2) = \frac{\sigma_{i,\text{meas}}(ep \to D^* X)}{\sigma_{i,\text{theo}}(ep \to D^* X)} F_{2,\text{theo}}^{c\bar{c}}(x_i, Q_i^2)$$

The ZEUS NLO QCD fit was used with:

- **three active quark flavours**
- $m_c =$ **1.35 GeV**
- $\mu = \sqrt{4m_c^2 + Q^2}$

in calculation of $F_2^{c\bar{c}}$ and in HVQDIS for calculation of $\sigma(x, Q^2)$

Peterson function used in HVQDIS calculation

Component expected from b production subtracted from data

Unfolding depending on scheme, i.e. massive scheme

Uncertainties in extrapolation

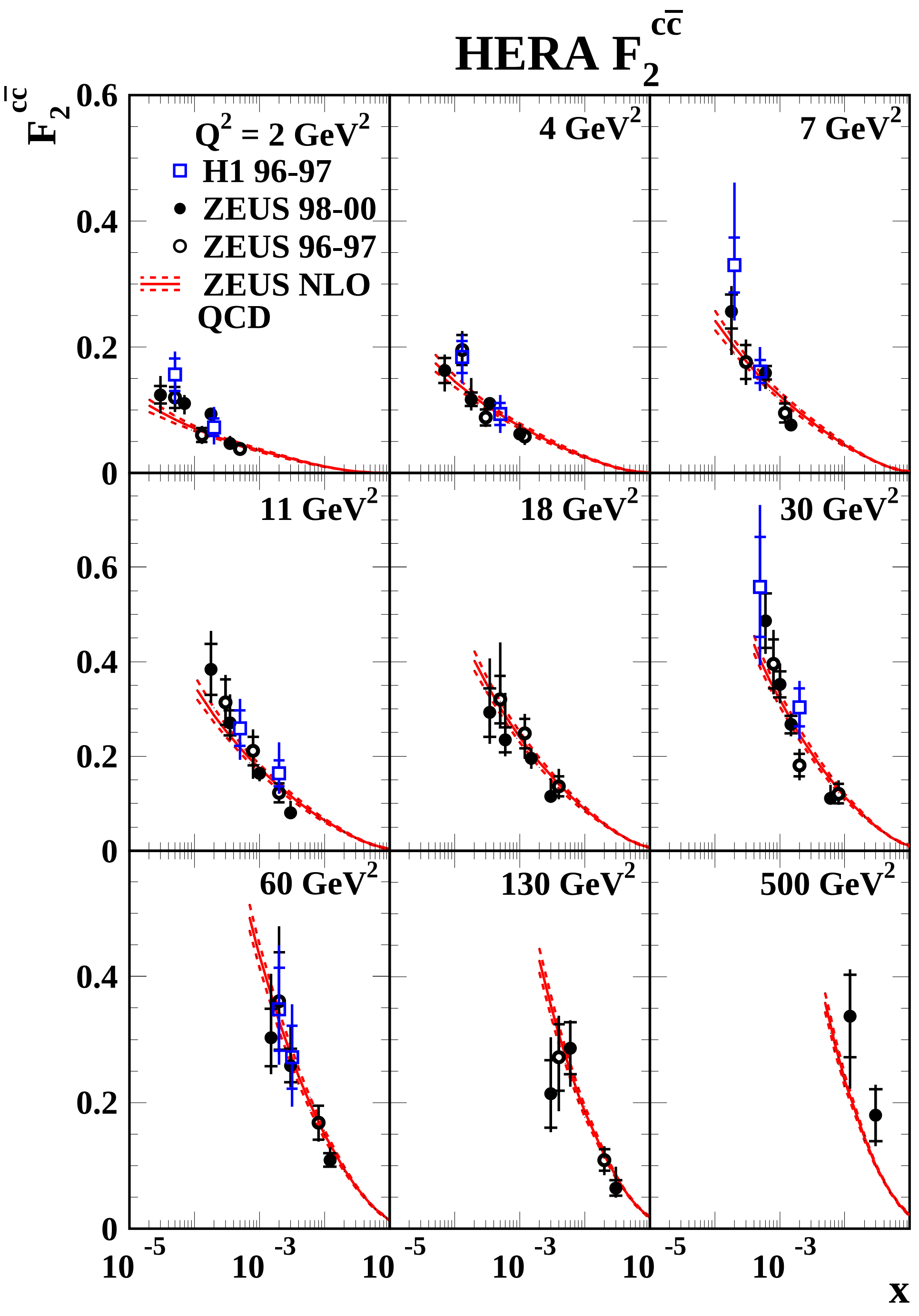
Factors for extrapolating to full phase space in $p_T(D^*)$ and $\eta(D^*)$ are 4.7 at low Q^2 and 1.5 at high Q^2

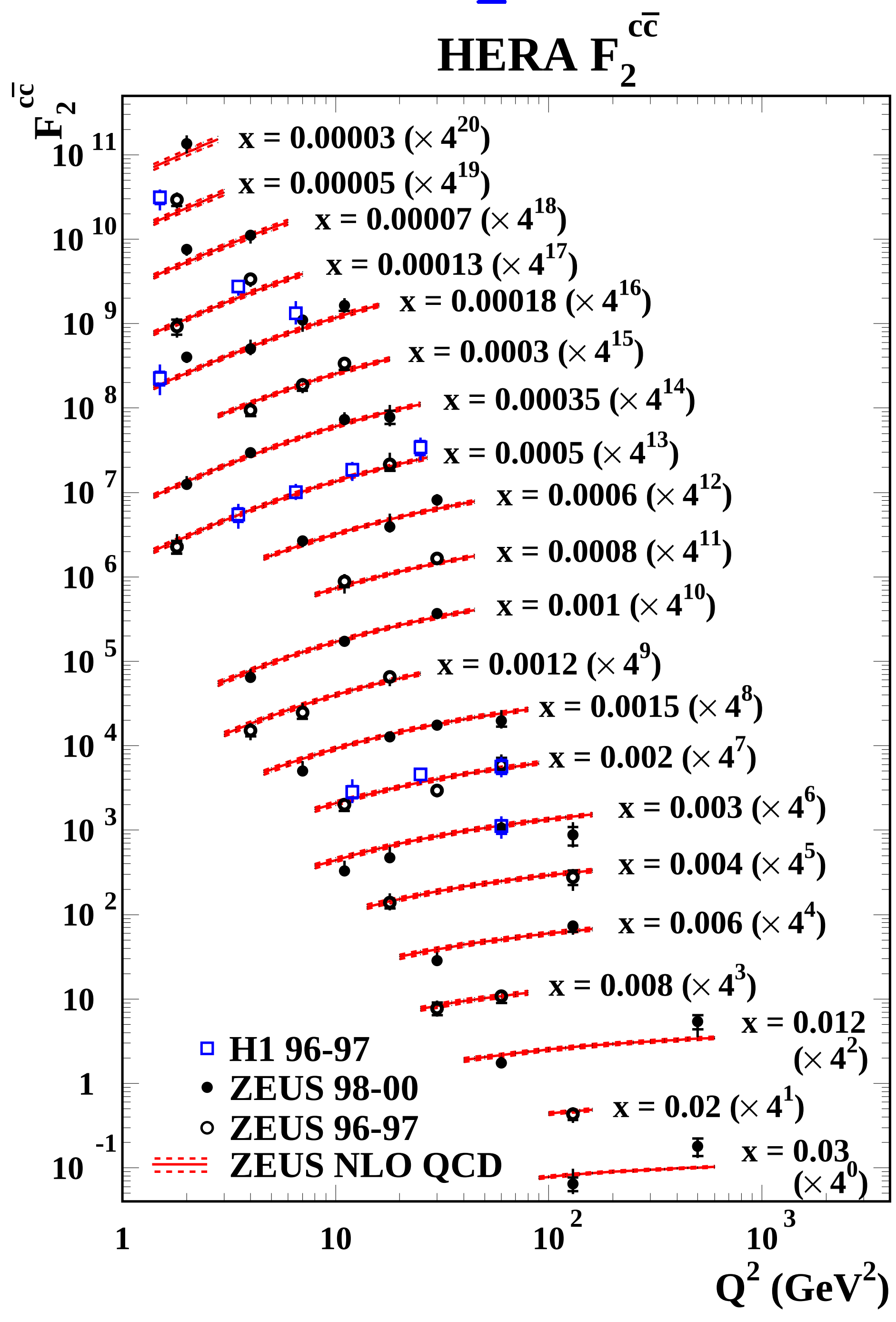
Uncertainties in the extrapolation are:

- using AROMA fragmentation instead of Peterson fragmentation - typically less than 10%, but less than 20%. Most significant at high x for given Q^2
- changing the charm mass by $\pm$ 0.15 GeV - differences of 5% at lower x and negligible elsewhere
- upper and lower predictions from the uncertainty on the ZEUS NLO PDF - typically less than 1%
- varying the b component by factor of 2 - typically less than 1$-$2% and 8% at high Q^2

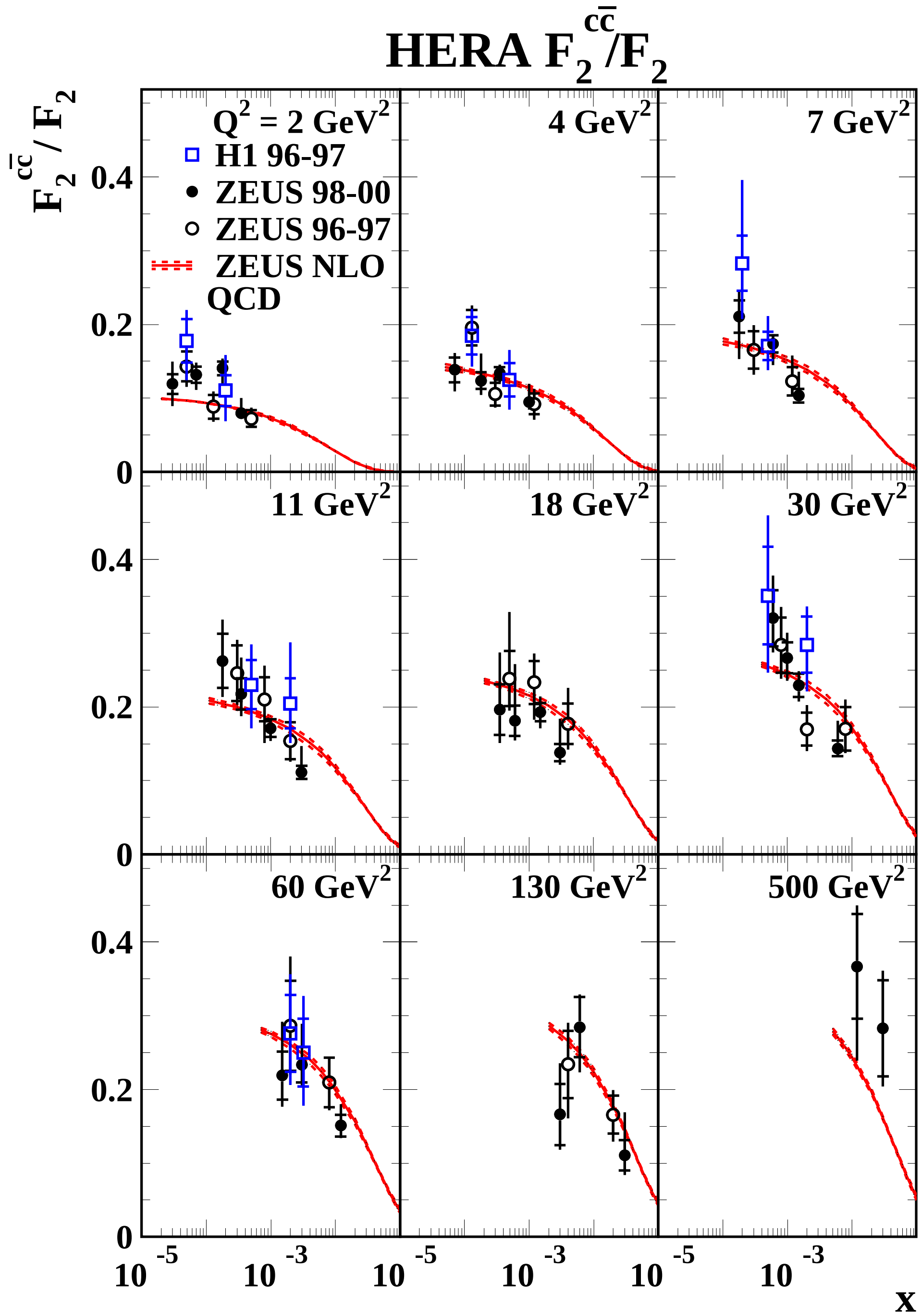
Using CTEQ5F3 gave uncertainties of less than 10% for low Q^2 and less than 5% for $Q^2 > 11$ GeV^2

HERA measurements of $F_2^{c\bar{c}}$ I

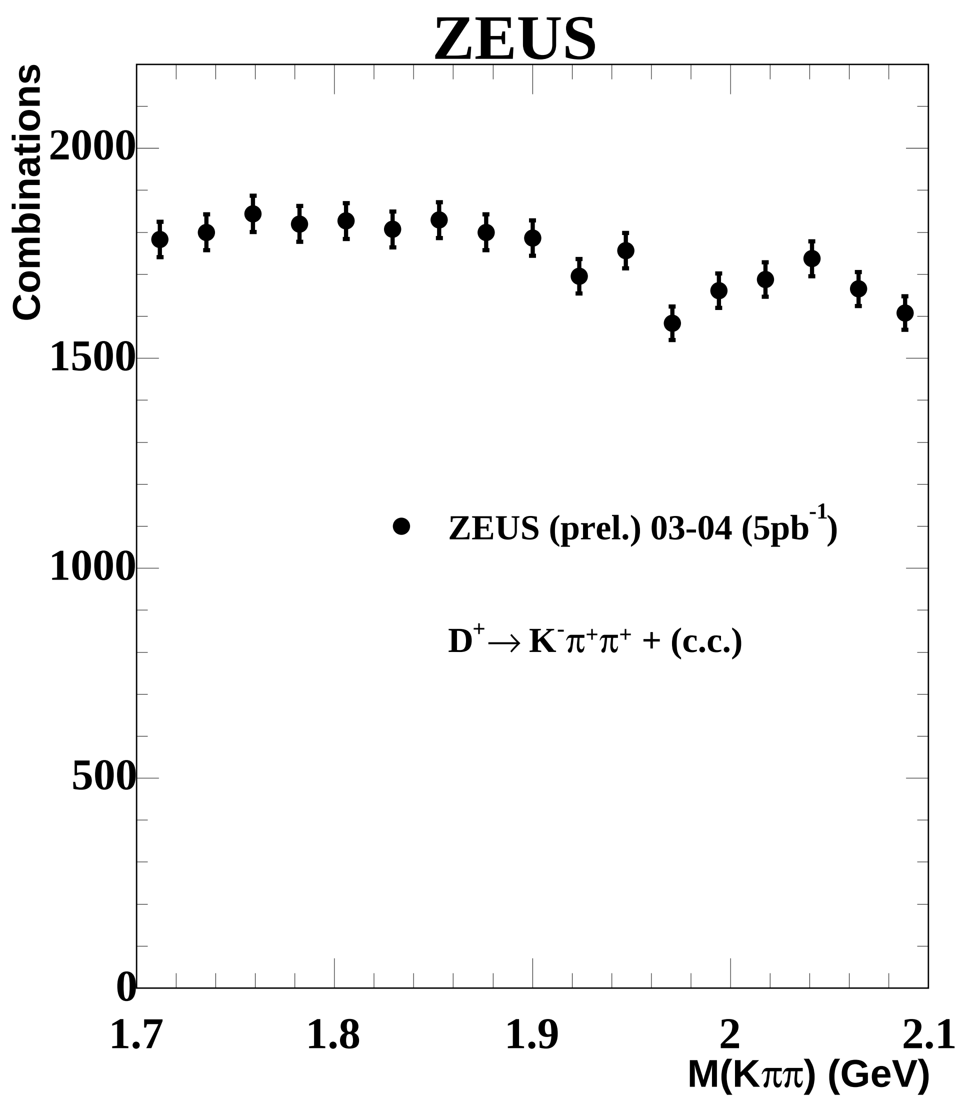


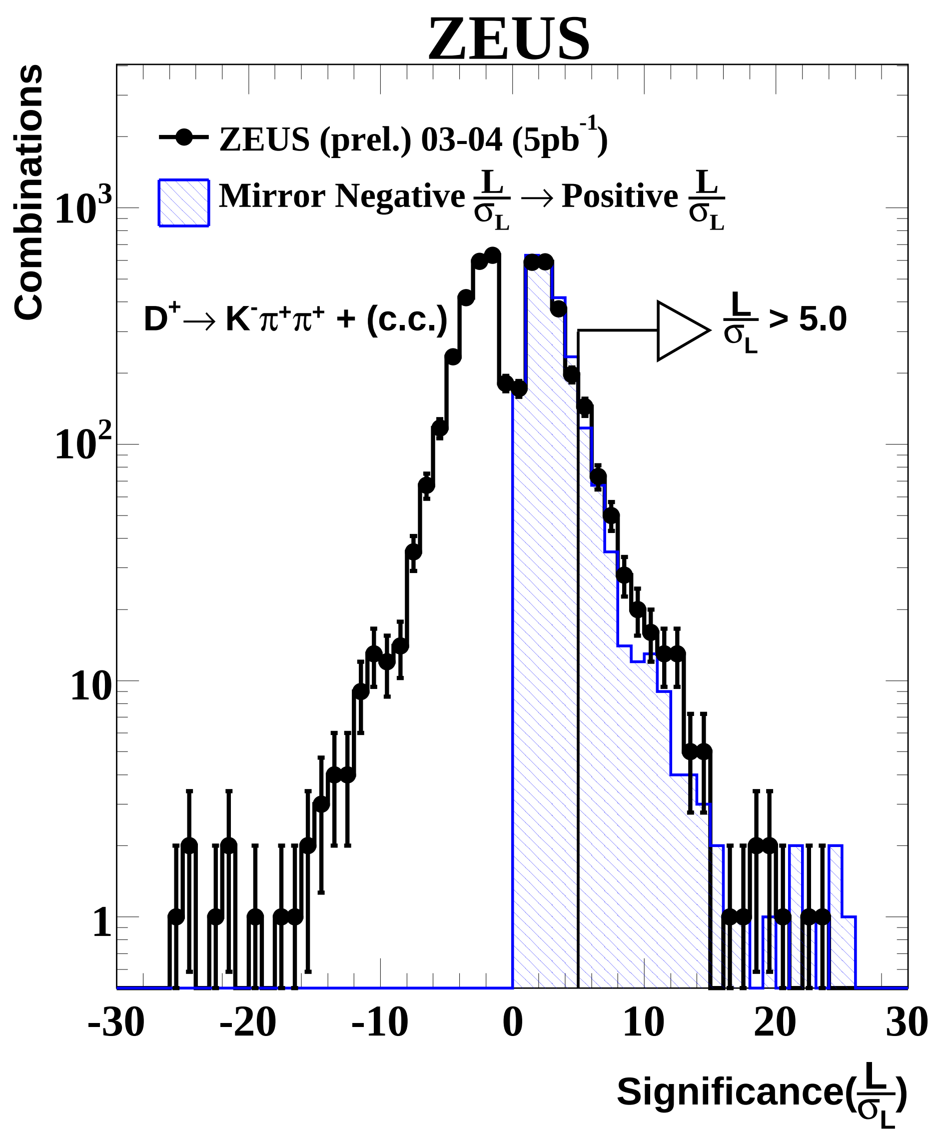


HERA measurements of $F_2^{c\bar{c}}$ II

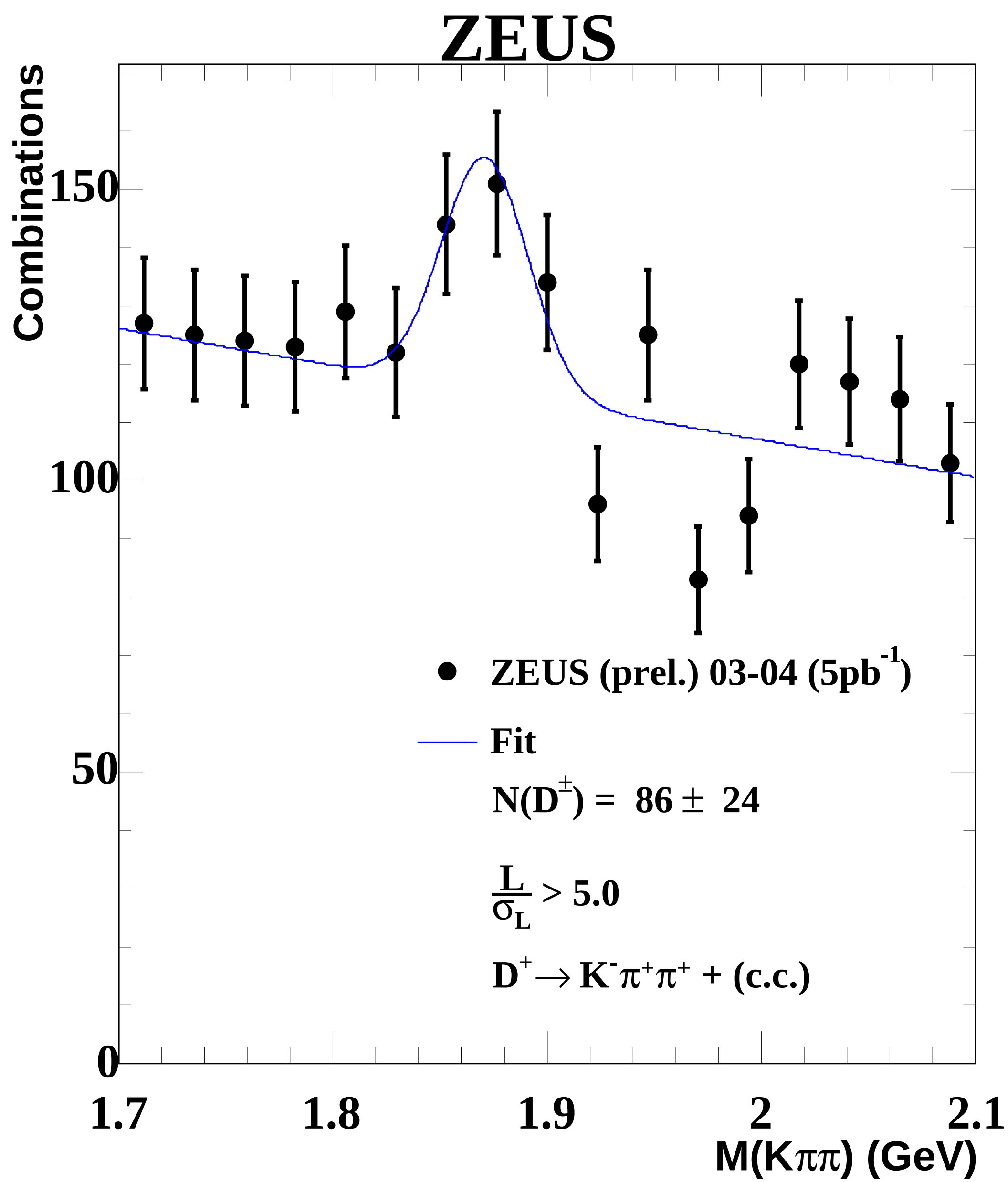


Outlook


ZEUS
Combinations
2000
1500
1000
500
0
1.7
1.8
1.9
2
2.1
M(Kππ) (GeV)
ZEUS (prel.) 03-04 (5pb-1)
D+→ K-π+π+ + (c.c.)


ZEUS
Combinations
10^3
10^2
10
1
-30
-20
-10
0
10
20
30
Significance(L/σL)
ZEUS (prel.) 03-04 (5pb-1)
Mirror Negative L/σL → Positive L/σL
D+→ K-π+π+ + (c.c.)
L/σL > 5.0

D+ signal with HERA II data



Summary

Have precise measurements of charm in DIS

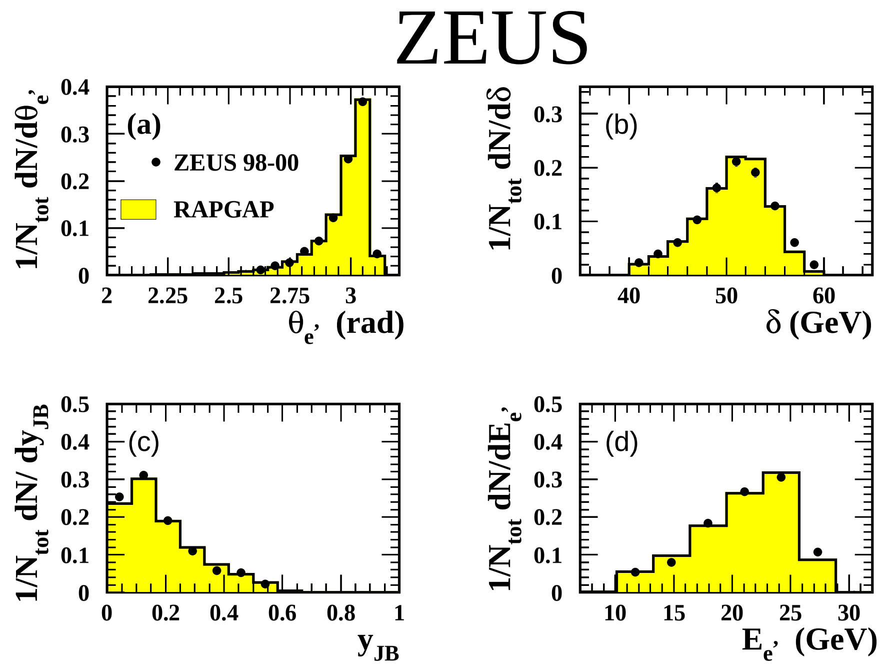
Good description of the data by NLO QCD using a modern PDF

Double differential cross sections can be used to further constrain the gluon in the proton

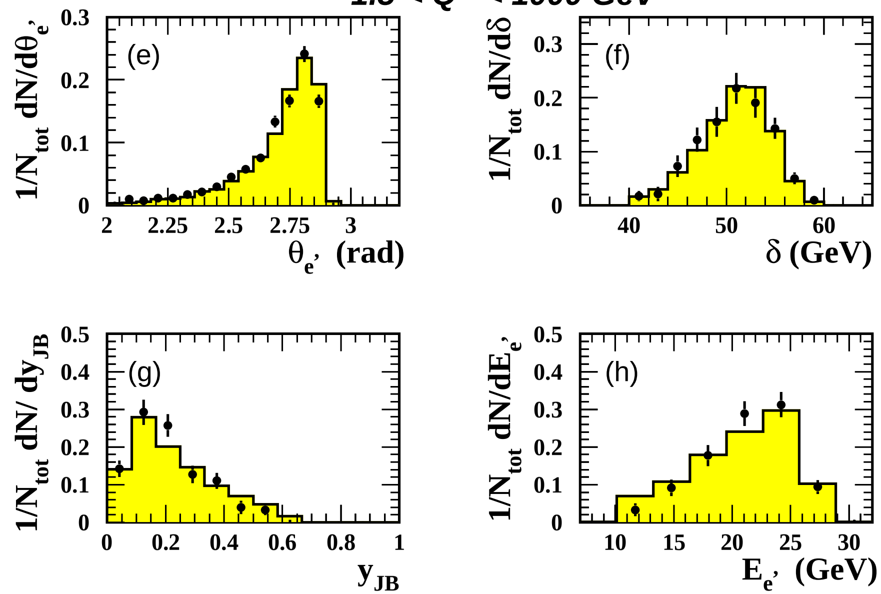
Can use other channels from HERA I data; e.g. $c \to e$ or other D mesons - all together they can be as significant as the D^* measurement

HERA II: increased statistics, secondary vertex, forward tracking
$\Rightarrow$ higher p_T and Q^2
$\Rightarrow$ lower p_T and more forward η
$\Rightarrow$ greatly reduce extrapolation to $F_2^{c\bar{c}}$
$\Rightarrow$ measurements at higher x

Extra slides - MC description

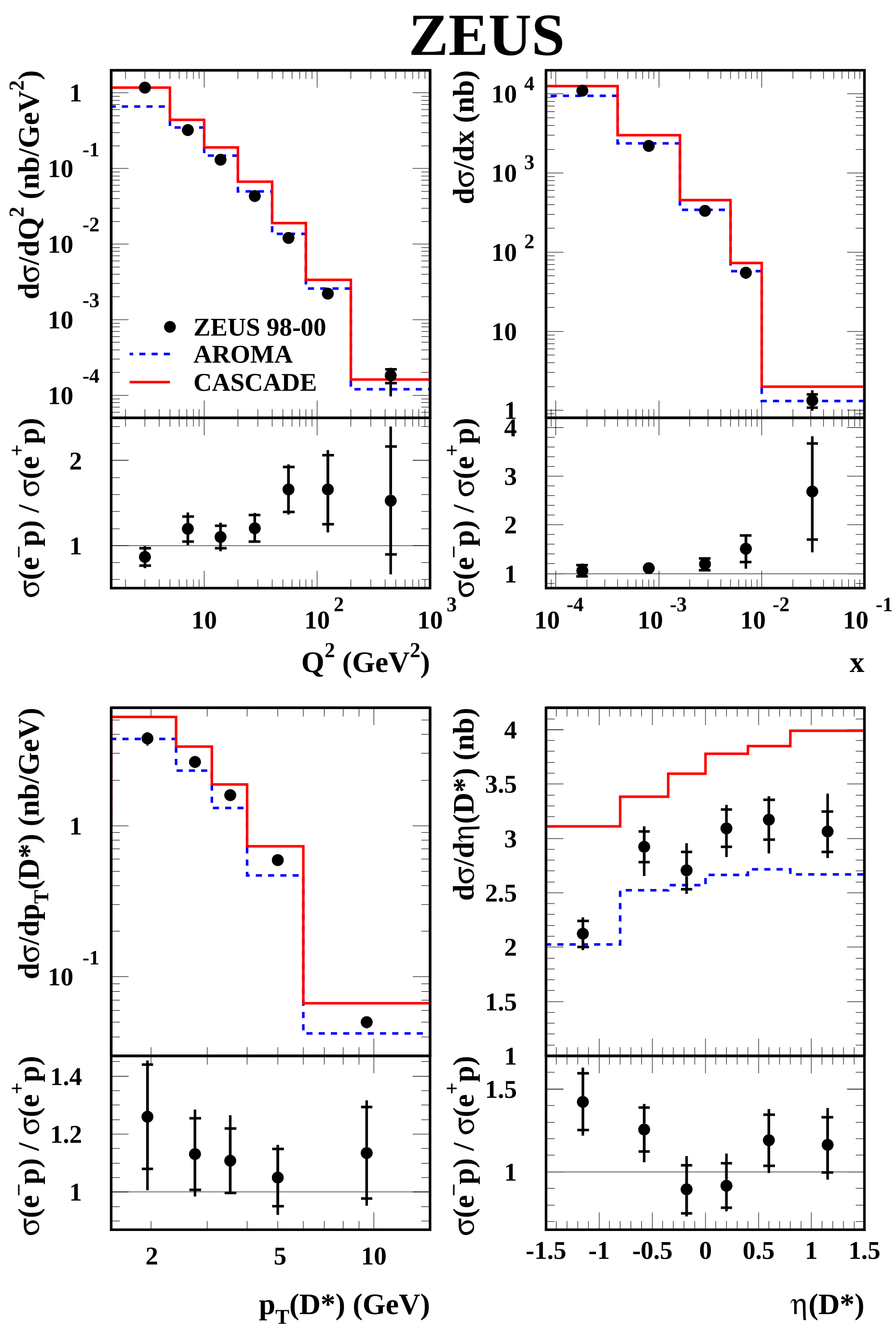


$1.5 < Q^2 < 1000$ GeV^2



$40 < Q^2 < 1000$ GeV^2

Extra slides - e+/e-



Extra slides - e+/e-