Measurement of charm production in DIS with D* mesons and extraction of $F_2^{c\bar{c}}$

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on behalf of ZEUS collaboration

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The HERA collider and the ZEUS detector

Figure 1: HERA ring

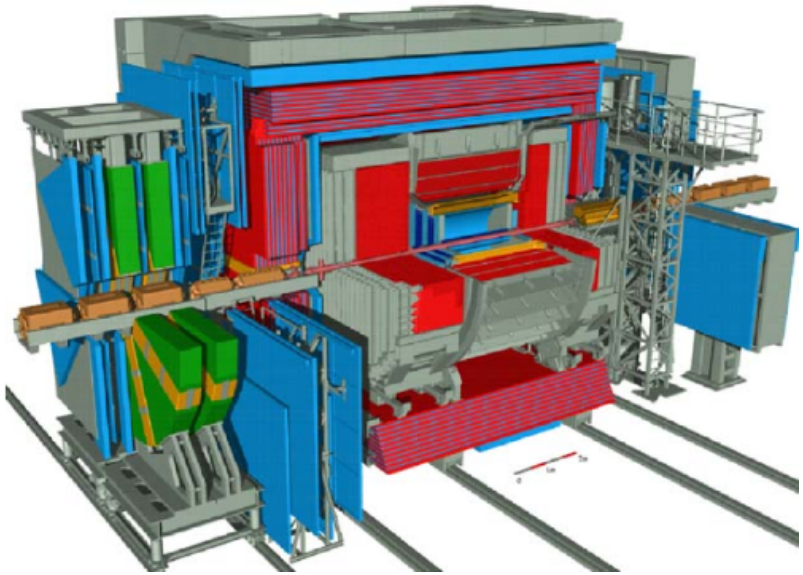
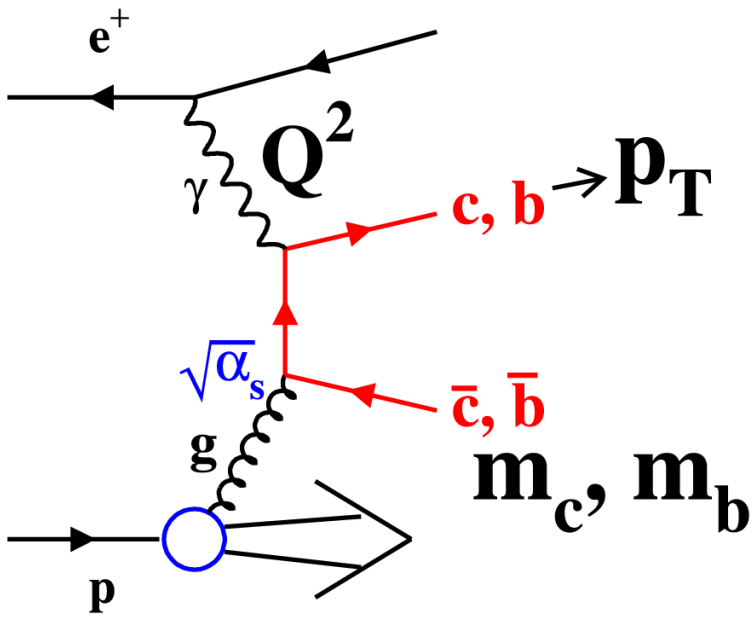


Figure 2: ZEUS detector

- Protons 920 GeV
- Electrons 27.6 GeV
- 500 pb^{-1} accumulated
- In operation 1992-2007

- ZEUS is a general purpose detector
- Measurments of c and b quarks production are both accessible at HERA,

Motivations



- Boson-gluon fusion is a dominant process for the charm creation in DIS, charm contribution to the inclusive DIS cross section is up to 30 % (sizable part of cross section)
- Multiple hard scale give us a possibility to test pQCD p_t, Q^2, m_c
- Charm production is sensitive to the gluon density of the proton

Motivations

- Measurements of the charm structure function gives:
  - Better understanding of the charm production is one of the key issues for higher energies experiments (a.e. background estimation for W/Z production)
  - Test of the different theoretical models (charm mass constraints)

$$\frac{d\sigma^{c\bar{c}}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}[1+(1-y)^2](F_2^{c\bar{c}}(Q^2,x) - \frac{y^2}{1+(1-y)^2}F_L^{c\bar{c}}(Q^2,x))$$

Measurement of $D^* \to D^0\pi_s \to K\pi\pi_s$

- HERA II (2004-2007) 357 pb^{-1}
- $P_t(D^*) > 1.5 GeV$
  $|\eta(D^*)| < 1.5$
- $5 < Q^2 < 1000\ GeV^2$
- $0.02 < y < 0.7$
- D* from B meson origin are included in the cross sections

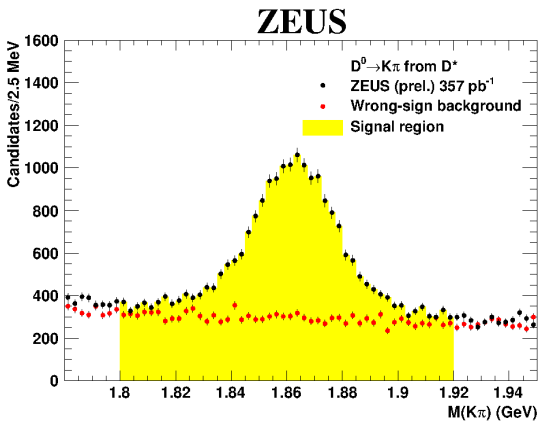


Figure 3: D^0 signal

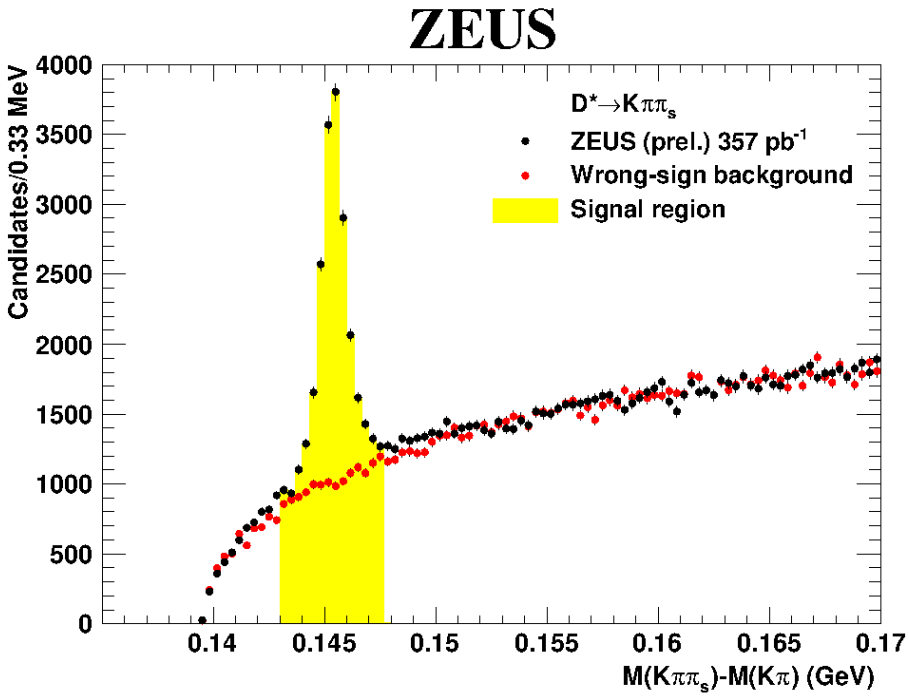
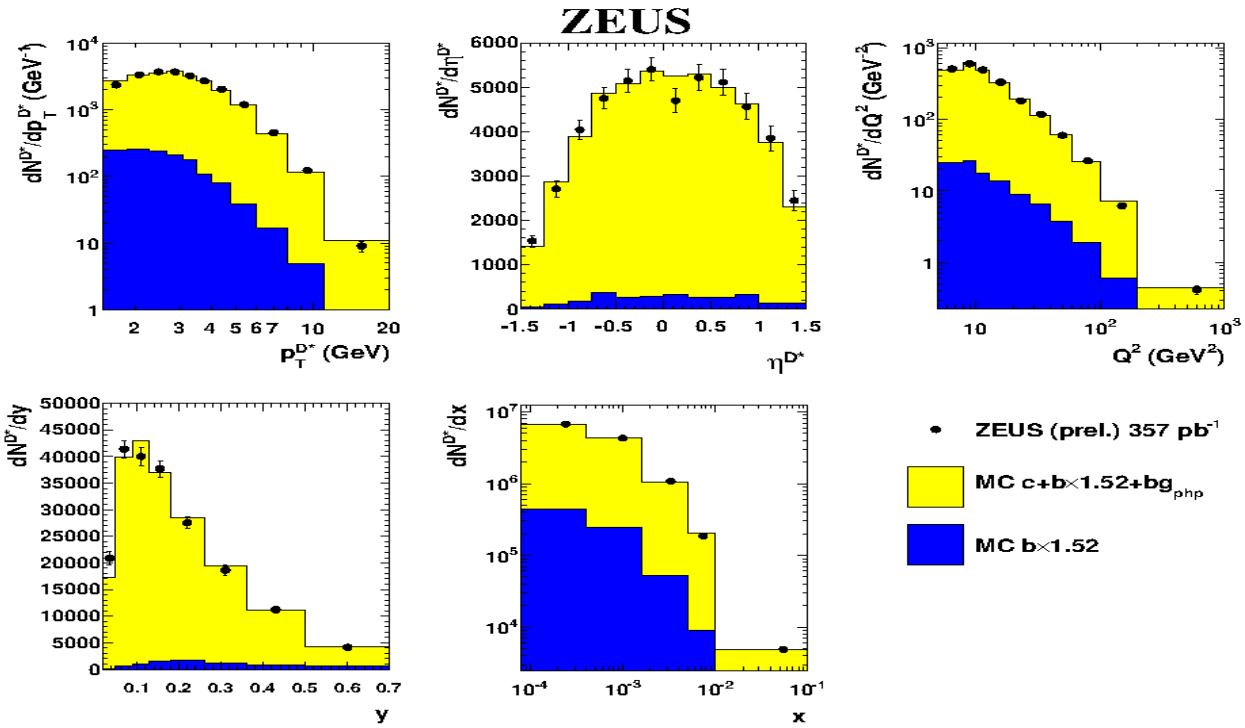


Figure 4: D^* signal

- N(D*) were obtained by substraction of the wrong-sign background

Data/MC comparison



Rapgap Monte Carlo samples were re-weighted in η and $p_t(D^*)$, Q^2 to describe the data in order to have acceptance correction reliable

Main sources of systematical error

- Tracking efficiency up to 6%
- D* mass window variaton up to 3%
- QED correction error up to 3%
- MC samples reweighting up to 2%

QCD predictions details

NLO HVQDIS by Harris and Smith :

- Fixed-flavour-number scheme:
  - c is massive, m_c=1.50 GeV
  - only 3 flavours (u,d,s) in the proton, c is produced directly in BGF
- PDF : ZEUS-S NLO QCD fit
- Renormalization and factorization scale

$$\mu_R = \mu_F = \sqrt{(Q^2 + 4m_c^2)}$$

- Peterson fragmentation function in laboratoric frame with $\epsilon = 0.079$ as the nominal value was used

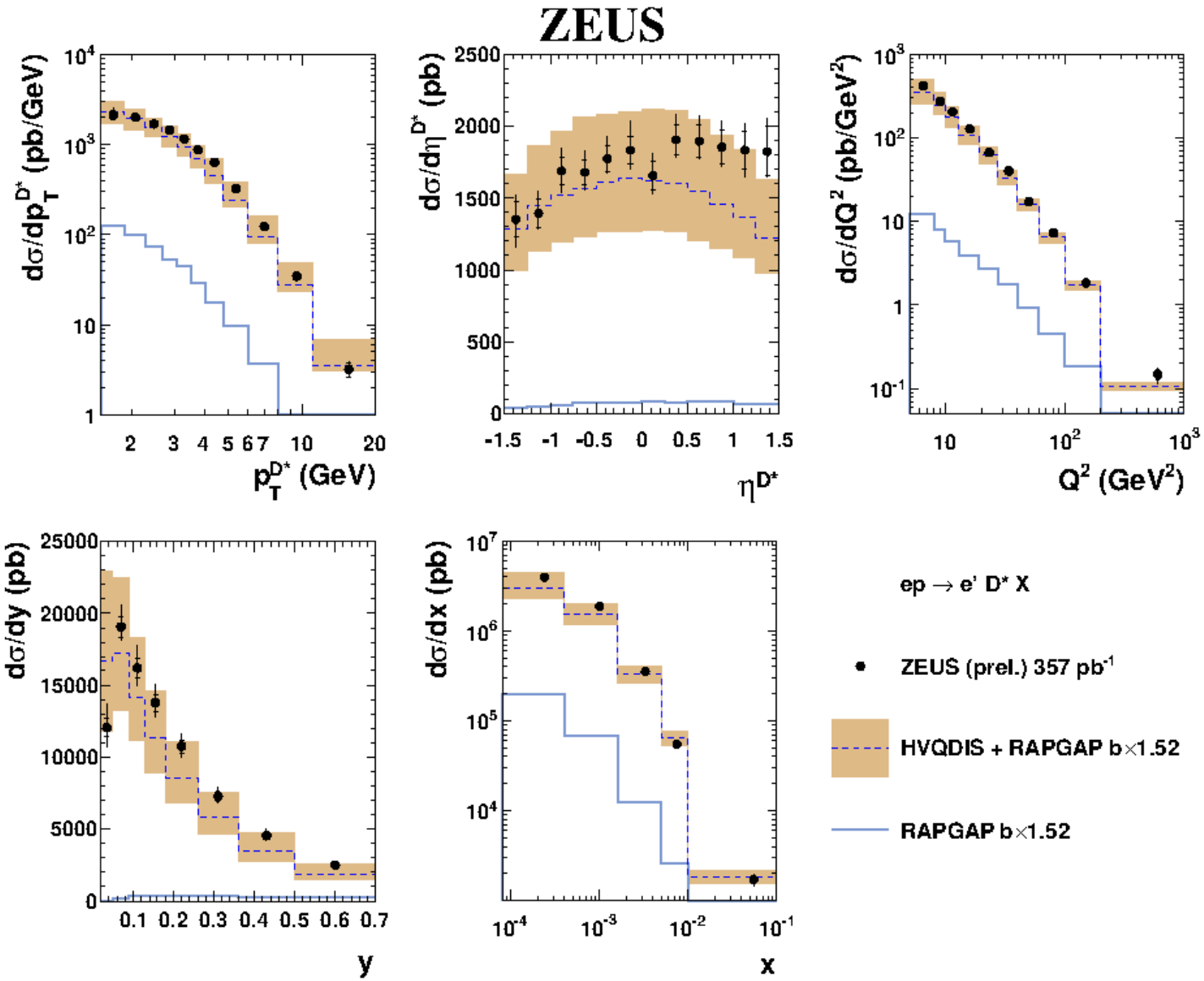
$$F_{Pet.} \propto \frac{1}{[z(1 - 1/z - \epsilon/(1-z))^2]}$$

- Fragmentation fraction f(c $\rightarrow D^*$) = 0.235

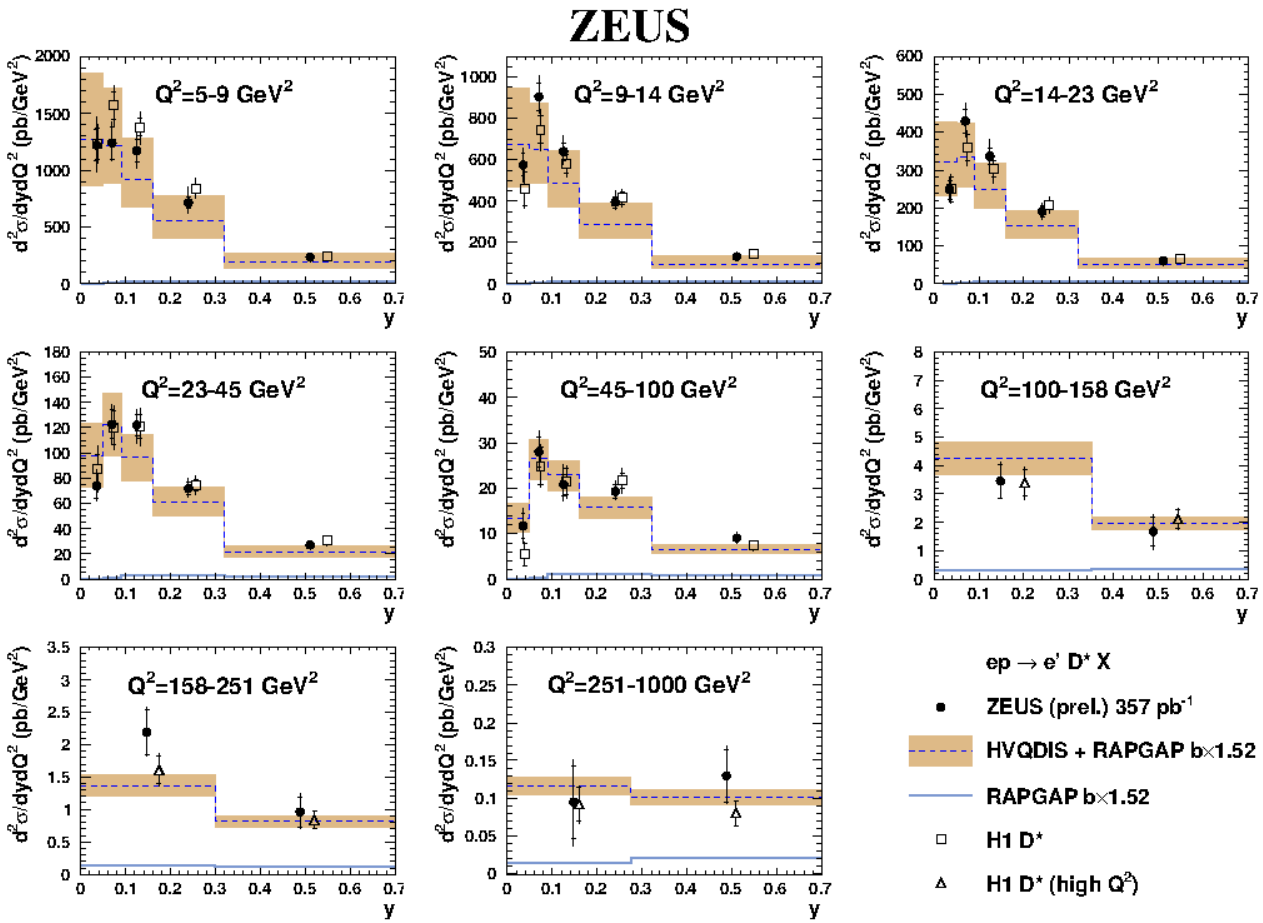
QCD predictions uncertainty

- Uncertainty:
  - experimental error on PDF
  - varying charm mass by 10 %
  - varying renormalization and factorization scales by factor 2
  - varying parameters of the fragmentation function

D* Cross Sections in bins of $p_t(D^*)$, $\eta(D^*)$, Q^2, y, x



D* Double Differential Cross Sections



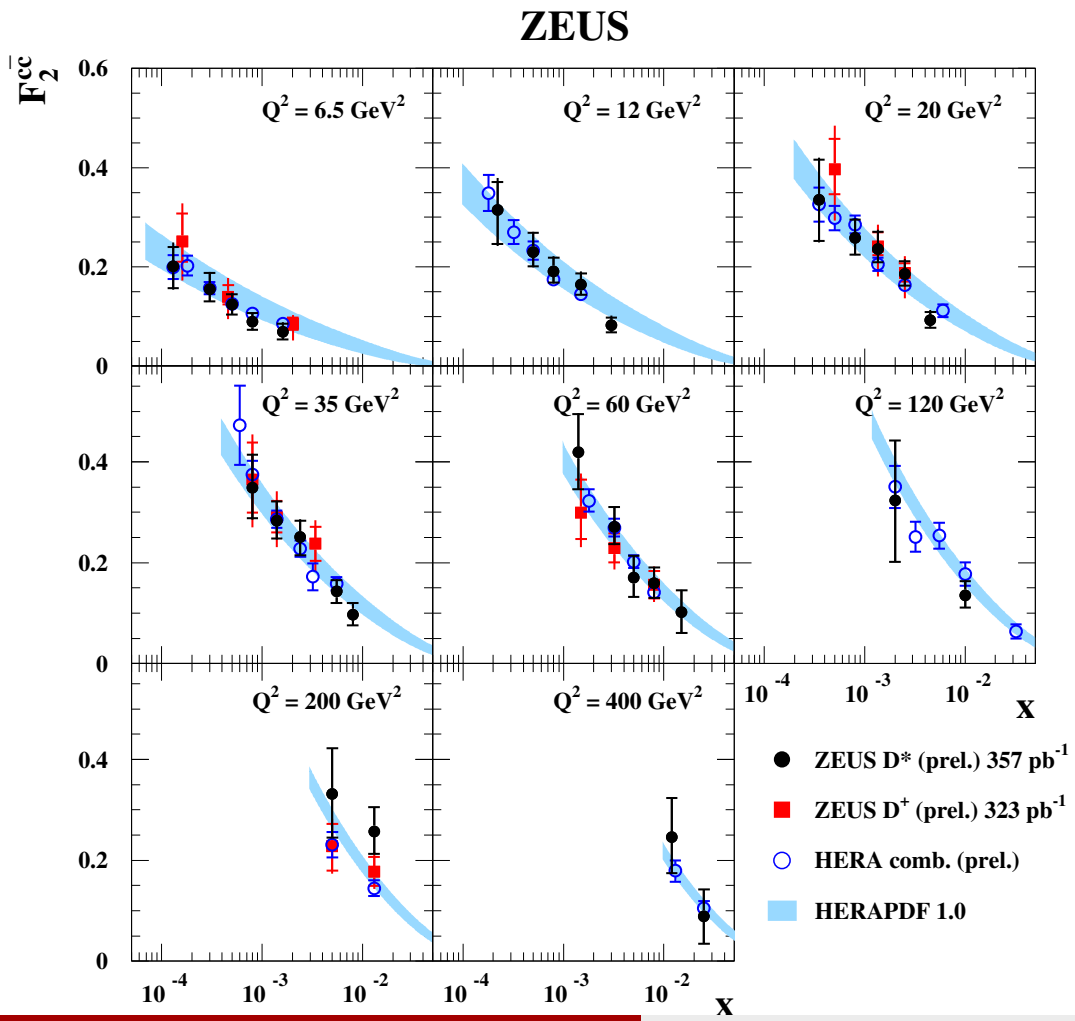
- Measurements are described by NLO QCD predictions
- Measurements are in agreement with H1 results
- All Cross Sections corrected for QED processes

F_2^{cc} measurment

$$F_{2,\text{meas.}}^{c\bar{c}}(x_i, Q_i^2) = \frac{\sigma^{meas.,i}}{\sigma^{theo.,i}} \times F_{2,theo.}^{c\bar{c}}(x_i, Q_i^2)$$

- F_2^{cc} is a part of F_2 structure function with a charm quark in the final state
- Measurments are done in a restricted kinematic region
- Extrapolation is being done with NLO
- Theoretical calculation is being done with HVQDIS program

F_2^{cc} measurment



- Measurments are in good agreement with previous results
- HERAPDF 1.0 is obtained with Thorne-Roberts GM-VFNS. Band corresponds to m_c variaton from 1.3 to 1.7 GeV. No charm data inside.

Summary

- Measurements of the charm quark in DIS using the "golden D* decay channel" at the HERA collider with the ZEUS detector were done :
  - Measurement of D* mesons in a wide Q^2 region
  - QCD predictions describe measured cross sections giving us a positive test of the theory
  - Charm structure function was extracted from D* cross sections. It will improve the combined HERA result

Backup slides

Backup

HVQDIS setup for $F_2^{c\bar{c}}$ extraction

- Fixed-flavour-number scheme:
  - c is massive, m_c=1.50 GeV
  - only 3 flavours (u,d,s) in the proton, c is produced directly in BGF
- PDF : HERAPDF 1.0
- Renormalization and factorization scale

$$\mu_R = \mu_F = \sqrt{(Q^2 + 4m_c^2)}$$

(varied simultaniously)

- Kartevilishvili fragmentation function in γp frame with variable α parameter was used ($s_{cut} = 70 \pm 40\ GeV^2$)
- Fragmentation fraction f(c $\rightarrow D^*$) = 0.2287