$D^{\pm}$ Cross Sections in DIS using the ZEUS Micro Vertex Detector

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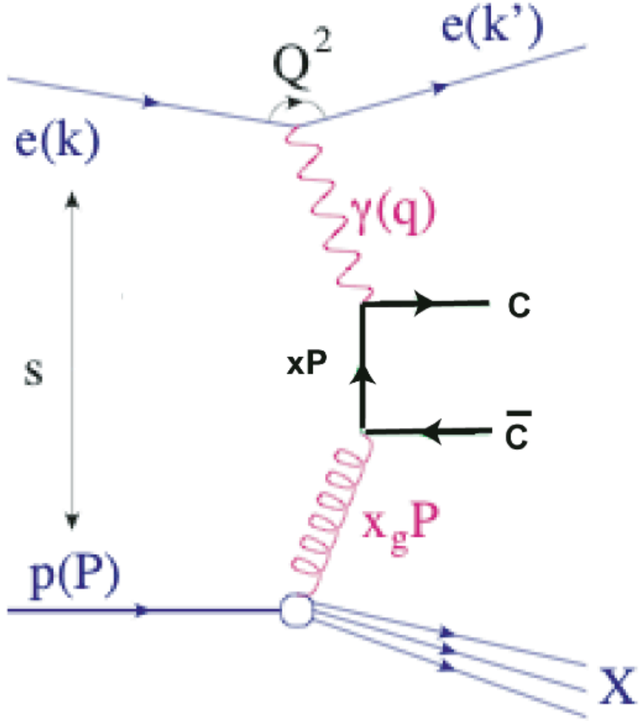
On behalf of the ZEUS collaboration

Overview

- The ZEUS Micro Vertex Detector.
- Displaced secondary vertices and event reconstruction.
- Single differential cross sections.
- Extraction of F_2^{cc}.
- Summary

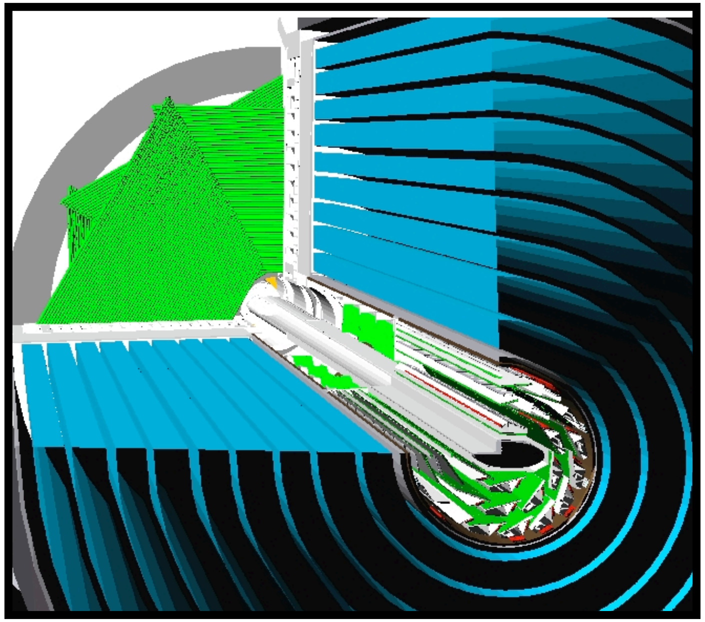
Motivation

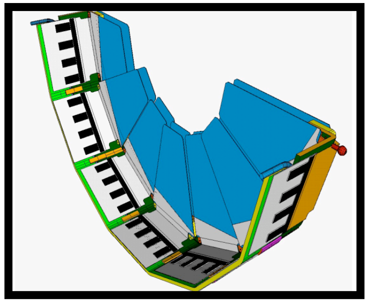
- The leading order process for charm production in DIS at HERA is boson-gluon fusion.
- Charm production in DIS is directly sensitive to the gluon content of the proton.
- Differential cross sections of charm production are a powerful test of perturbative QCD.
- The preliminary results shown here represent a first glance at the potential of the ZEUS Micro Vertex Detector (MVD).
  - First significant heavy flavour results from ZEUS at HERA II.



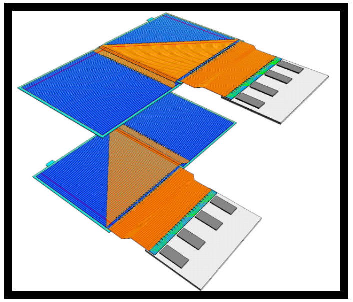
The ZEUS Micro Vertex Detector

ZEUS tracking





Half Wheel



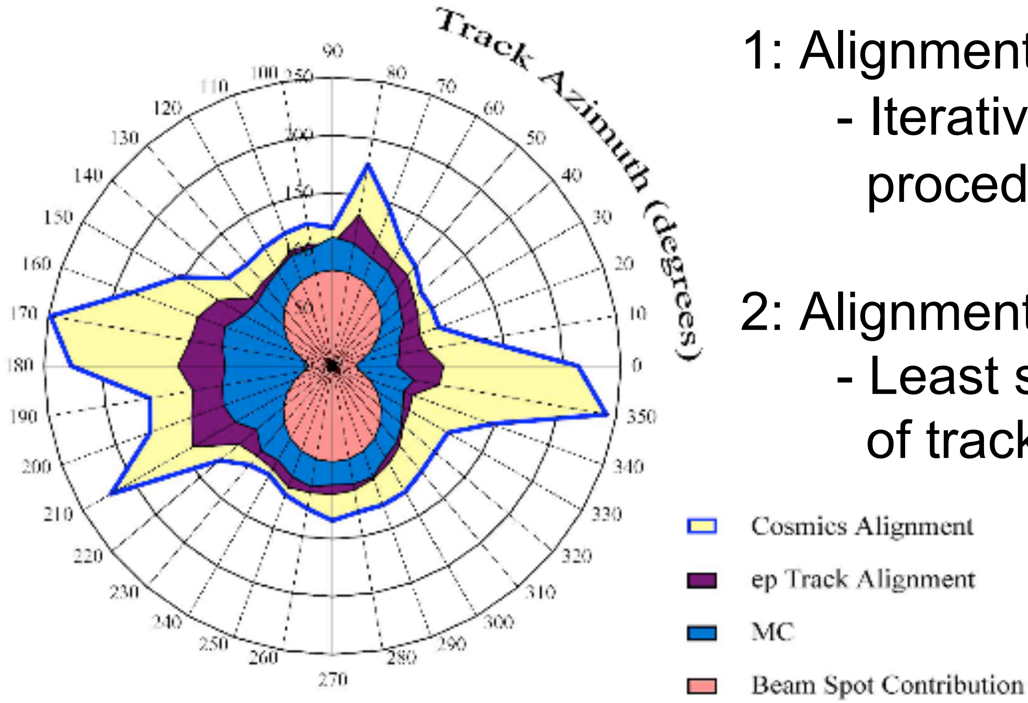
Barrel module

- For HERA II ZEUS was fitted with a silicon micro vertex detector (MVD).
- The MVD consists of forward and barrel regions.
- Barrel:
  - 30 ladders
  - 600 single sided silicon strip sensors
- Forward Wheels:
  - 4 wheels
  - 112 trapezoidal single sided silicon strip sensors
- Back to back sensors give information in (z, rϕ) for barrel tracks and (w, u) for forward tracks.

MVD Alignment

- First significant luminosity taken with MVD in 2004.
  - Alignment needed in order to reach full potential.

- Two stage alignment



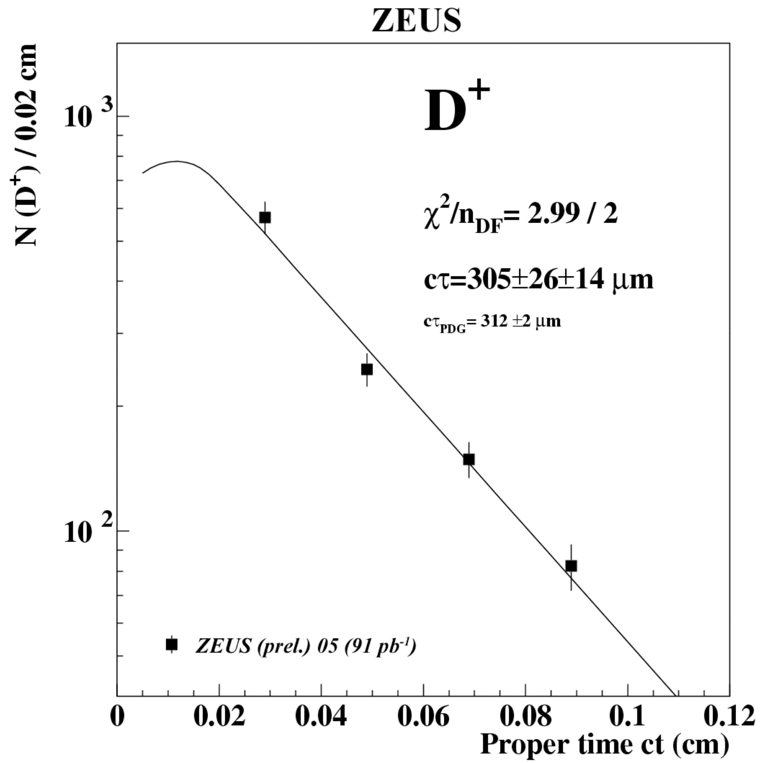
1: Alignment with cosmic tracks.
 - Iterative χ^2 minimisation procedure.

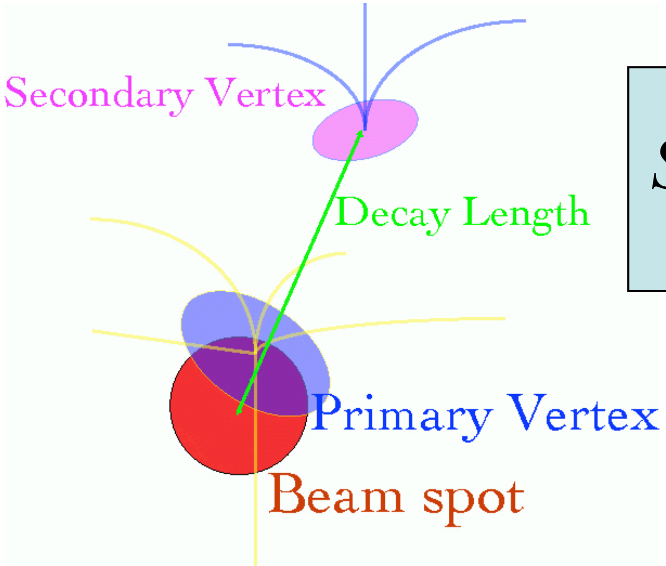
2: Alignment with ep collision tracks.
 - Least squares simultaneous fit of track and alignment parameters.

Resolution:
IP ~ 50 μm
DL ~ 150 μm

Displaced Secondary Vertices

- Due to their long lifetimes charmed mesons can have decay vertices displaced from the primary interaction point → Need precision tracking (MVD)
- We use the 2D distance from the secondary vertex to the primary interaction point projected onto the D meson momentum vector divided by the error on this distance (S_{DL}) to reject background.



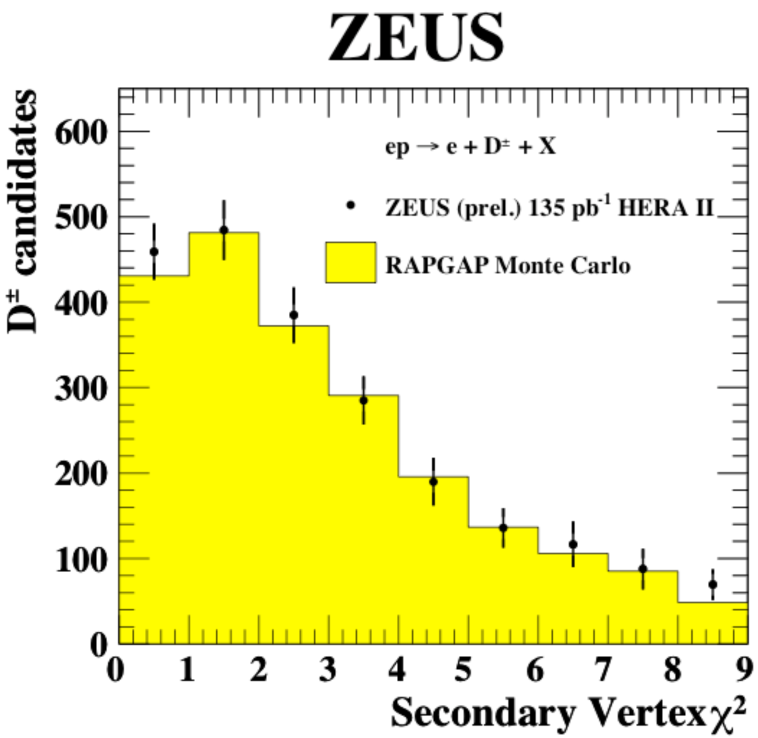


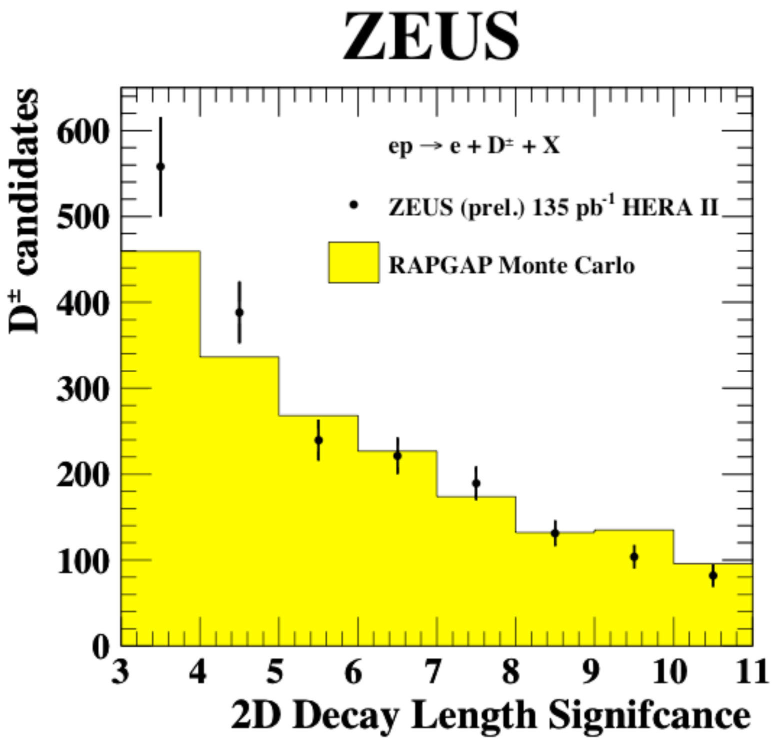
$$S_{DL} = \frac{L_{xy}}{\sigma_{L,xy}}$$

- True charm decays will occur such that the signed decay length significance will be positive.

Simulation of secondary Vertices

- In order to use the secondary vertex information the data must be well described by the Monte Carlo.
- Slightly poorer description of S_{DL} leads to larger systematic uncertainty later.





$D^{\pm}$ Reconstruction and Selection Cuts

Kinematic Region

- $5 < Q^2 < 1000$ GeV^2
- $0.02 < y < 0.7$
- $|\eta(D^{\pm})| < 1.6$
- $3 < P_T(D^{\pm}) < 20$ GeV

Data Sample

- 135 pb^{-1} HERA II e^-p data (2004/2005)

- $D^{\pm}$ candidates are reconstructed using the decay chain:

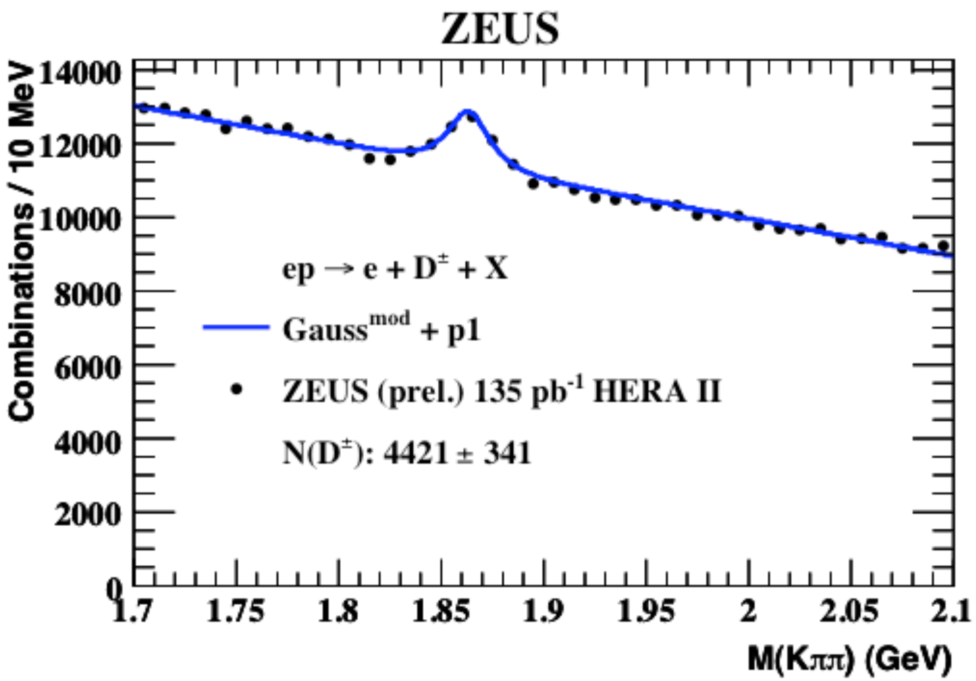
$$D^+ \rightarrow K^- \pi^+ \pi^+ + \text{c.c}$$

- The kinematic region and selection cuts are influenced primarily by the geometry of the ZEUS detector.

$D^{\pm}$ Selection Cuts

- $P_T(K) > 0.7$ GeV
- $P_T(\pi,\pi) > 0.5$ GeV
- $|\eta(K,\pi,\pi)| < 1.6$
- D^* and D_s reflections subtracted.

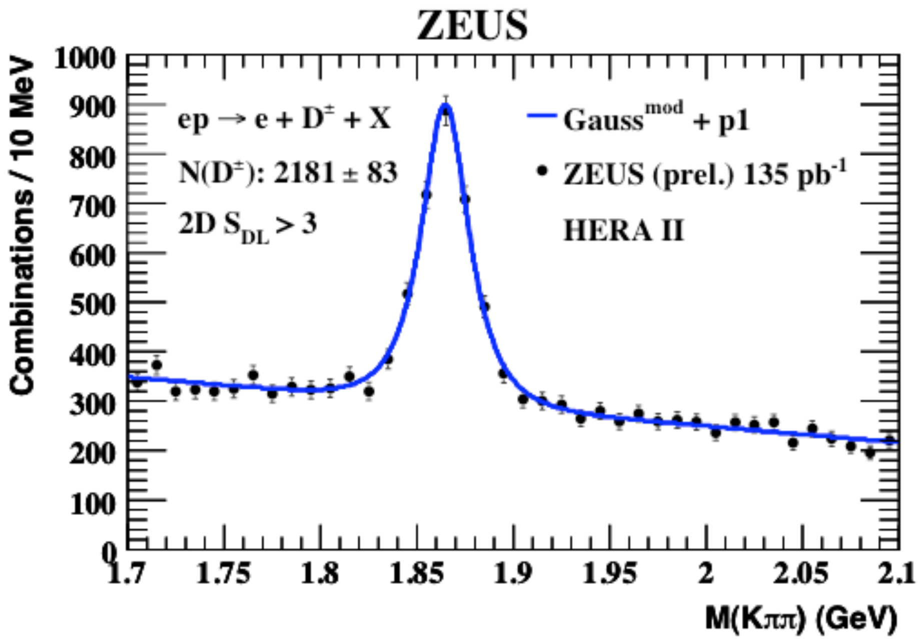
$D^{\pm}$ Meson Signal



- The $D^{\pm}$ meson is one charm meson whose signal can be improved by using the S_{DL} to reject background.

2D $S_{DL} > 3$

- By using the secondary vertex information the statistical uncertainty from the fit improves by a factor of two.

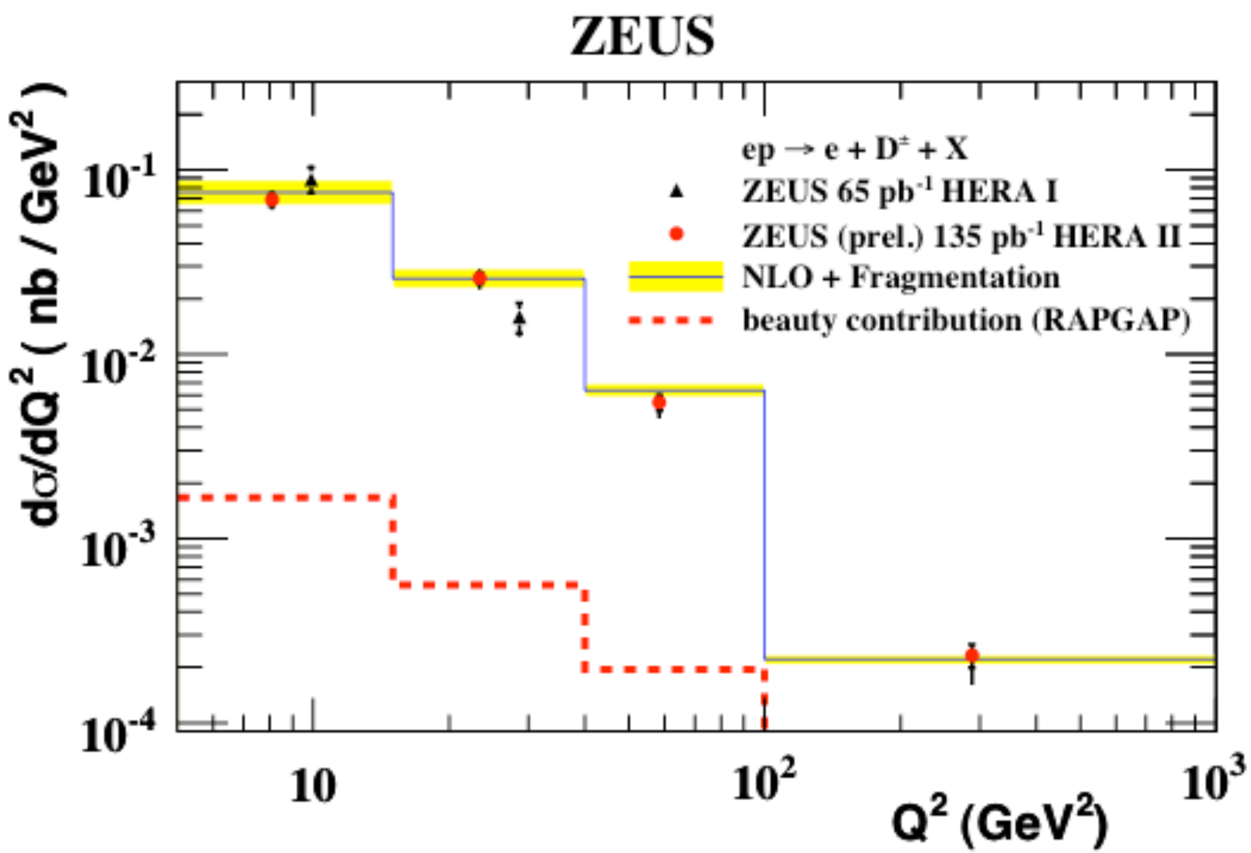


NLO QCD Prediction

- Theoretical predictions for the differential cross sections are given by the HVQDIS program.
  - A next to leading order Monte Carlo program for the calculation of heavy quark cross sections in deeply inelastic scattering in the Fixed Flavour Number (FFN) scheme. (B.W. Harris & J. Smith).
  - Input parameters and there variations are shown below.
  - Variations are such as to give maximum error on the theory.

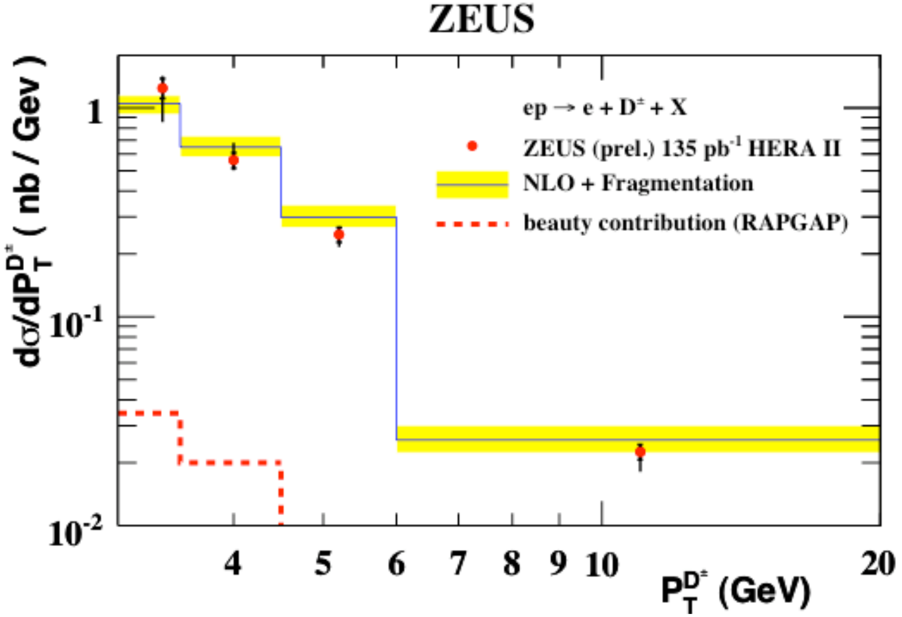
Quantity	Value	Variation
Renormalisation & Factorisation scale (μ_R, μ_F)	$\mu_R = \mu_F = \sqrt{Q^2 + 4M_c^2}$	$2\sqrt{Q^2 + 4M_c^2}$ Larger of: $\frac{1}{2}\sqrt{Q^2 + 4M_c^2}$ and $2M_c$
Peterson Parameter (ε)	0.035	± 0.015
Charm Mass (M_c)	1.35 GeV	±0.15 GeV
Input PDF	ZEUS NLO PDF	Upper and lower predictions of ZEUS NLO PDF.

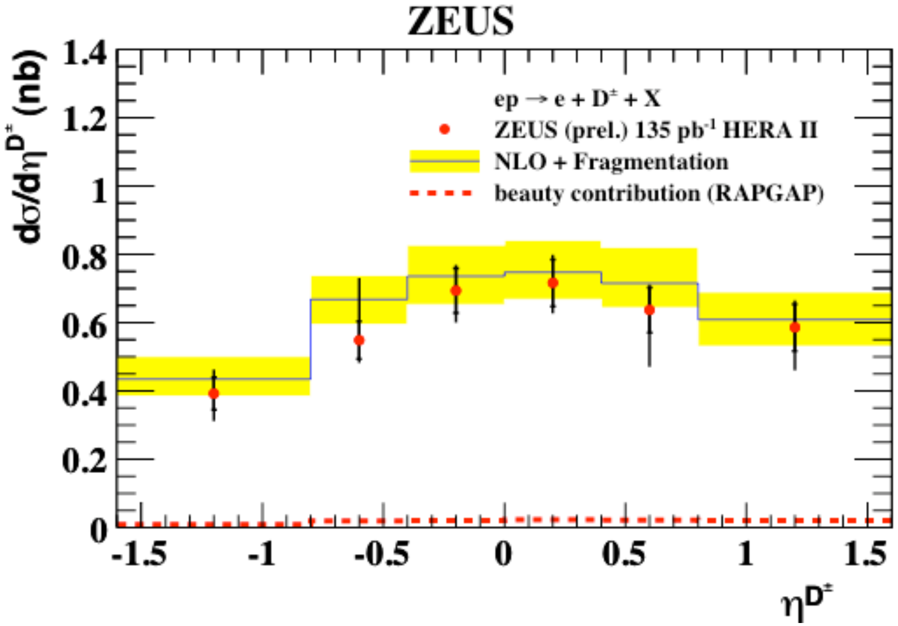
Q^2 Cross Section

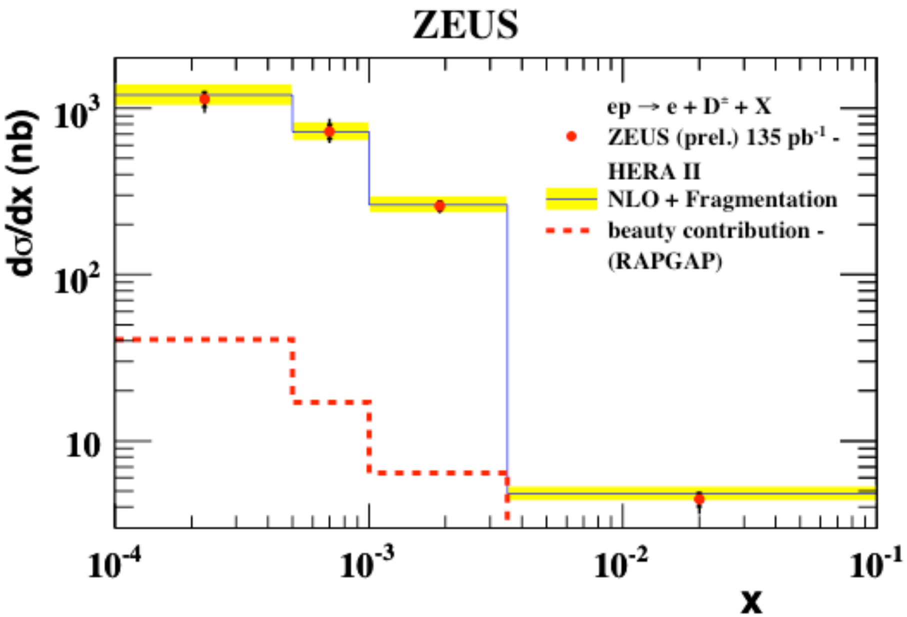


- Results agree with NLO and final HERA I ZEUS results.
- Smaller uncertainty than HERA I measurements.

$P_T(D^{\pm})$, $\eta(D^{\pm})$ and x Cross Sections







- In all cross sections measured the data is described by the NLO prediction.

- HERA I points not shown due to incompatible kinematic region.

F_2^{cc} extraction

- Cross sections are measured in bins of (Q^2, y) and converted to an appropriate (Q^2, x) value.

$$\frac{d^2\sigma^{cc}(x,Q^2)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}[1+(1-y)^2]F_2^{cc}(x,Q^2)$$

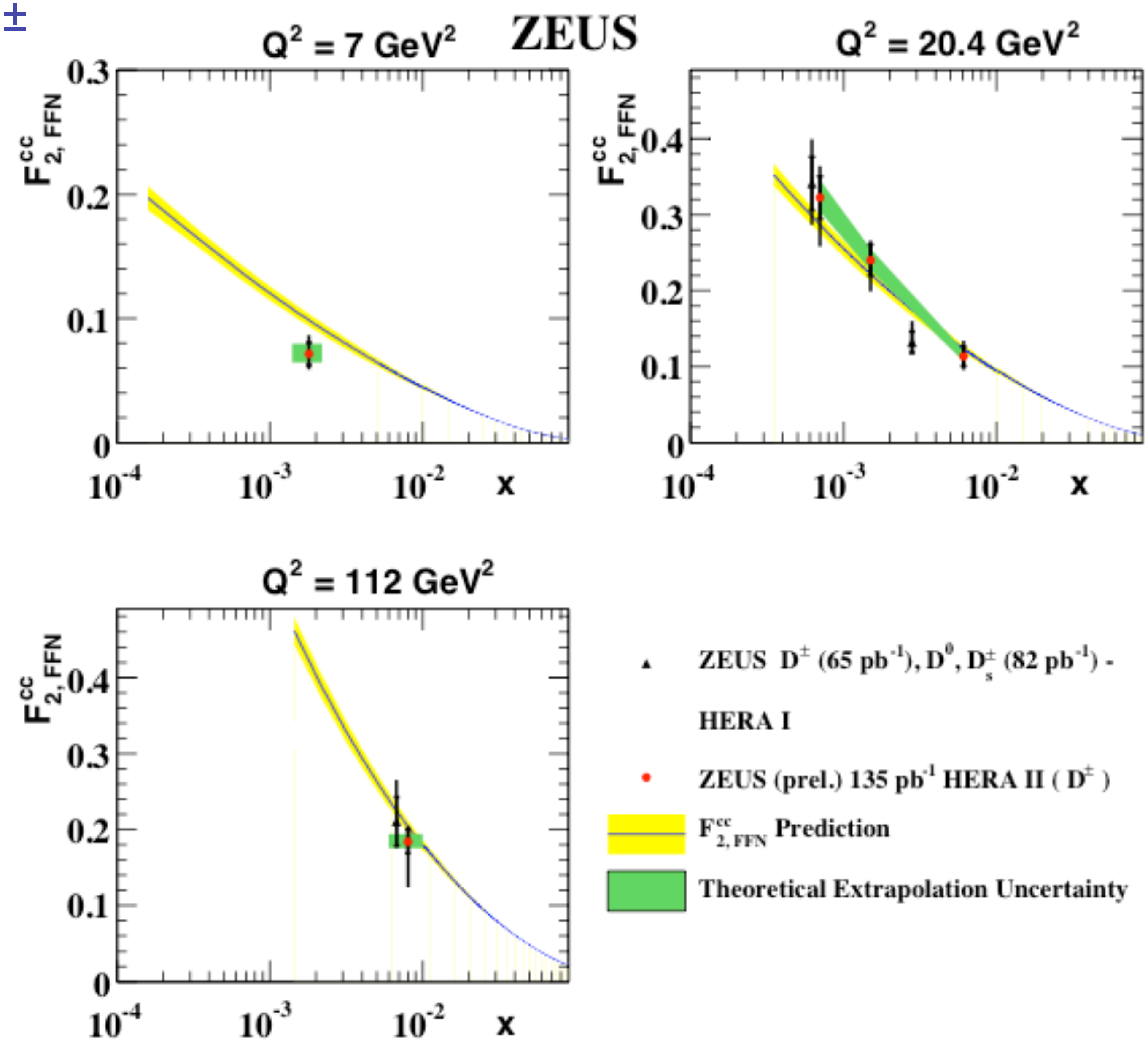
- The beauty prediction is subtracted from each bin.
- The measured cross sections are extrapolated to the full phase space using the following relation:
- The extrapolation is performed at the centre of gravity of the bin.

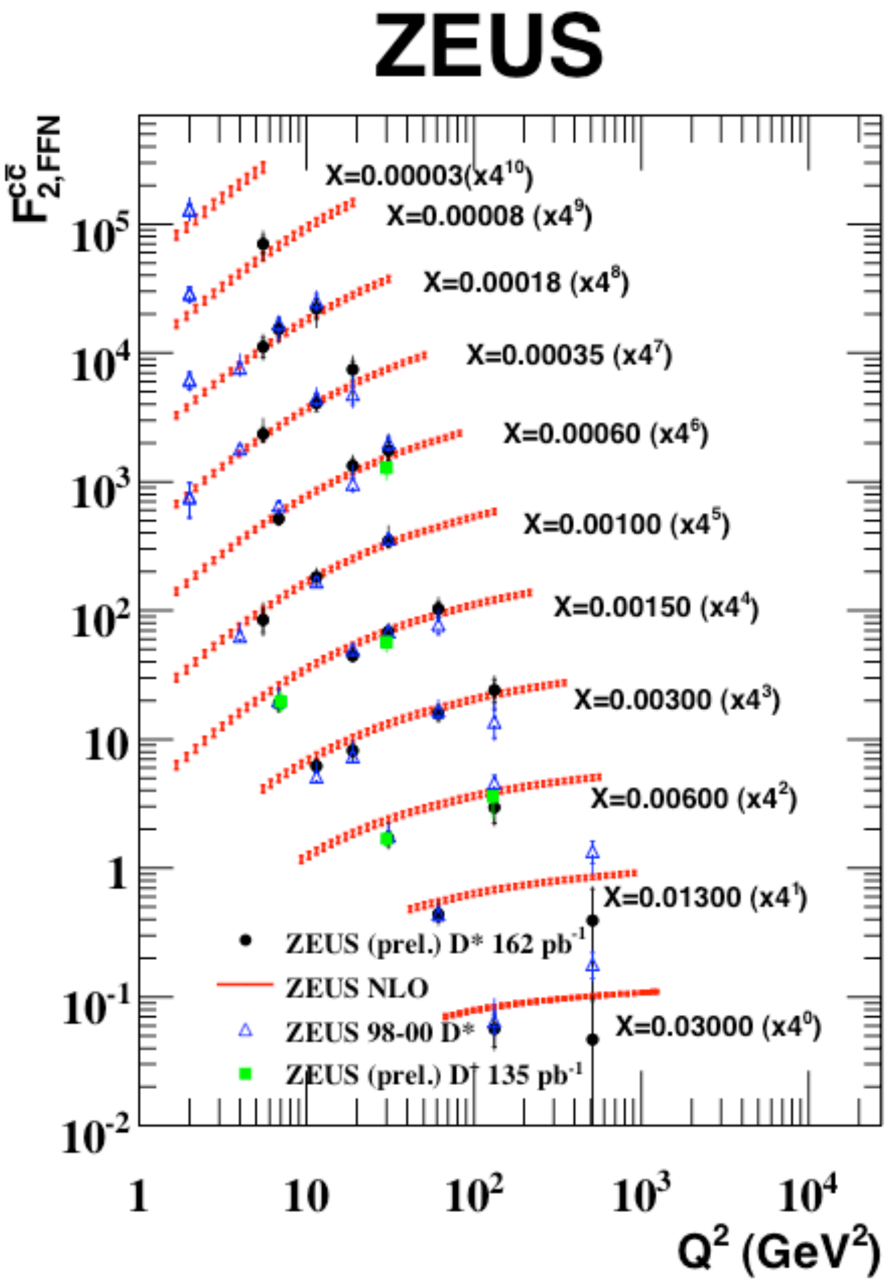
$$F_{2,meas}^{c\bar{c}}(x_i,Q_i^2) = \frac{\sigma_{2,meas}^{c\bar{c}}(ep \to D^{\pm}X)}{\sigma_{2,theo}^{c\bar{c}}(ep \to D^{\pm}X)} F_{2,theo}^{c\bar{c}}(x_i,Q_i^2)$$

- Theoretical cross sections are taken a NLO calculation.
- ZEUS FFN PDFs were used throughout.

F_2^{cc} from D±

- HERA I results combined measurements of F_2^{cc} from 3 mesons ($D^{\pm}$, D^0, D_s) to reduce uncertainty.
- These results are comparable but use a single meson.





F_2^{cc} from $D^{\pm}$

- Reconstructed D* mesons have previously been used to measure F_2^{cc}.
- Results compare well with recent F_2^{cc} from D* measurements.
- Combination of D* results from HERA I and HERA II is currently a work in progress.

Summary

- Single differential cross sections for the production of $D^{\pm}$ mesons in ep collisions have been measured using $135pb^{-1}$ of HERA II ZEUS data.
  - Lifetime tags were used to reduce the combinatorial background and improve the statistical uncertainty.

- The measurements are well described by the NLO prediction.

- F_2^{cc} has been extracted and compared to the final HERA I ZEUS results and the QCD prediction
  - The results agree well with both.
  - Using the new cuts the precision from $D^{\pm}$ alone is as good as that from the previous D^0, $D^{\pm}$ and D_s combined result.
  - These results can be further improved by combining measurements from several reconstructed mesons.
  - HERA II recently finished high energy running. The full data set ($\sim 350pb^{-1}$) can be included to further improve the statistical and systematic uncertainty .