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

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Charm production has been measured with the ZEUS detector in deep inelastic *ep* scattering at HERA. The measurement is based on the full reconstruction of the decay chain $D^* \to D^0\,\pi$, $D^0 \to$ K π and exploits the full HERA II statistics with integrated luminosity $L = 357$ pb^{-1} . Differential cross-sections have been measured. The kinematic range is 1.5 GeV $< P_t$(D*) < 20 GeV, $|\eta$(D*)$| < 1.5$, $5 < Q^2 < 1000$ GeV^2 and 0.02 < y < 0.7. The observed cross sections were extrapolated to the full P_t(D*) and η(D*) range in order to determine the open-charm contribution, $F_2^{c\bar{c}}$(x,Q^2) to the proton structure function F_2.

1 Introduction

The production of heavy quarks at HERA proceeds dominantly via the direct boson-gluon fusion (BGF) process $\gamma g \to c\bar{c}\,(\gamma g \to b\bar{b})$. The measurement of processes involving heavy flavour production gives a test of perturbative QCD calculations and information on the gluon content of proton. The measurement of the charm contribution $F_2^{c\bar{c}}$ to the proton structure function allows to test parton density functions. Information about gluon and heavy quark distribution in the region of low Bjorken x is important for measurement of Standard Model and new physics processes at hadron-hadron colliders such as LHC.

In this paper recent measurements on the charm production in neutral current deep inelastic scattering (NC DIS) obtained from the reconstruction of D* mesons at HERA by the ZEUS experiment are presented. The analysis is based on e^+p and e^-p data collected by ZEUS from 2004 to 2007 at a center of mass energy $\sqrt{s} = 318$ GeV .

2 Analysis Techniques

In this analysis charmed hadrons were detected by reconstructing the decay products of $D^{*\pm}$ mesons in the central tracking detector using $D^* \to K\pi\pi$ decay channel. The kinematic range of measurement is $5 < Q^2 < 1000$ GeV^2, $|\eta(D^*)| <$1.5, 1.5 < P_t (D*) < 20 GeV, 0.02 < y < 0.7. The invariant mass difference M(K$\pi\pi$) - M(Kπ) for D^0 candidates in the range 1.8 < M(Kπ) <1.92 GeV is shown in Fig.1. Background was estimated by using combination of tracks with wrong charge of reconstructed D^0. Both combinations, right and wrong charge were normalized in background region [150,168] MeV. The shaded area indicates the signal mass window. D* mesons can also originate from beauty hadrons, but contribution is only a

few %. For acceptance calculation RAPGAP Monte Carlo samples (charm and beuaty) were used.

3 D* differential cross-sections

On Fig.2 measured double-differential cross-sections (black dots) are compared to NLO QCD calculation made with the HVQDIS program [1] (dashed line) and measurements of the H1 collaboration [2] (empty symbols). The beauty contribution to $D^{*\pm}$ production (continuous line) was calculated with the RAPGAP [3] Monte Carlo, scaled by 1.52 in agreement with ZEUS measurements. For all cross-sections QED corrections were applied. Presented measurements are in good agreement with theoretical prediction.

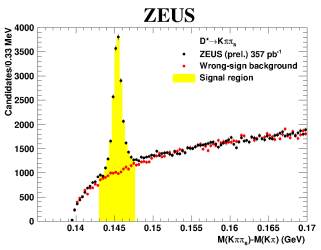

Figure 1: D* signal

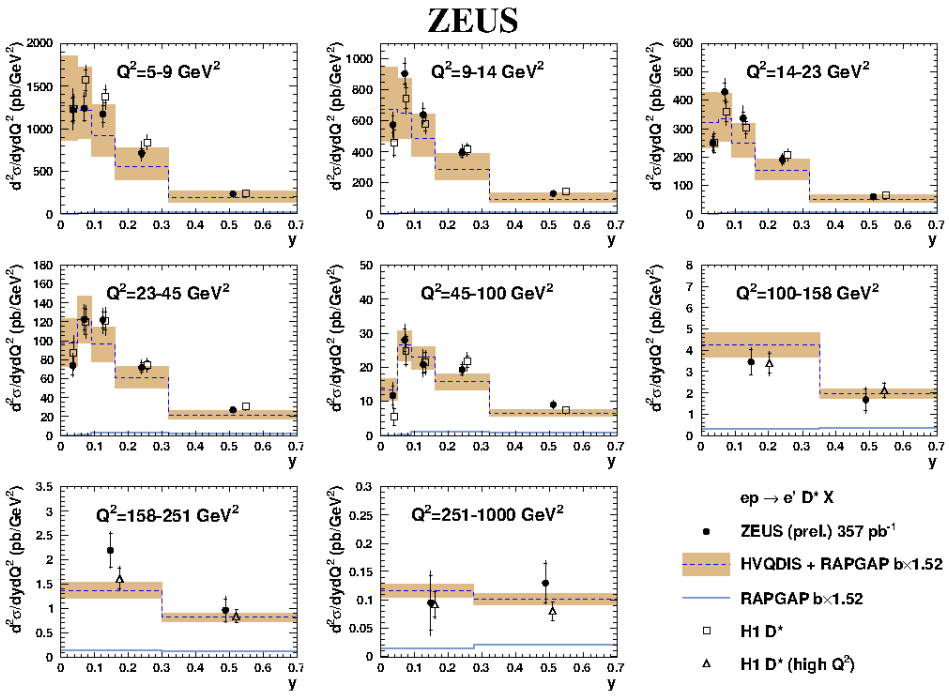

Figure 2: Double-differential cross-sections in bins of Q^2 and y, compared to recent H1 data [?] and to the HVQDIS calculation.

4 $F_2^{c\bar{c}}$ measurement

The $F_2^{c\bar{c}}$ ratio was evaluated as :

$$F_2^{c\bar{c}} = \sigma_{bin}^{vis} \times \left(\frac{F_2^{c\bar{c}}(x,Q^2)}{\sigma_{bin}^{vis}} \right)_{theory}$$

where σ_{bin}^{vis} is the D* visible cross-section in a Q^2, y bin after substraction of the beauty contribution. On Fig.3 is measured charm structure function $F_2^{c\bar{c}}$ (filled circles) compared to the recent D^+ [4] ZEUS result (filled squares) and preliminary combination of H1 and ZEUS data [5] (empty circles).

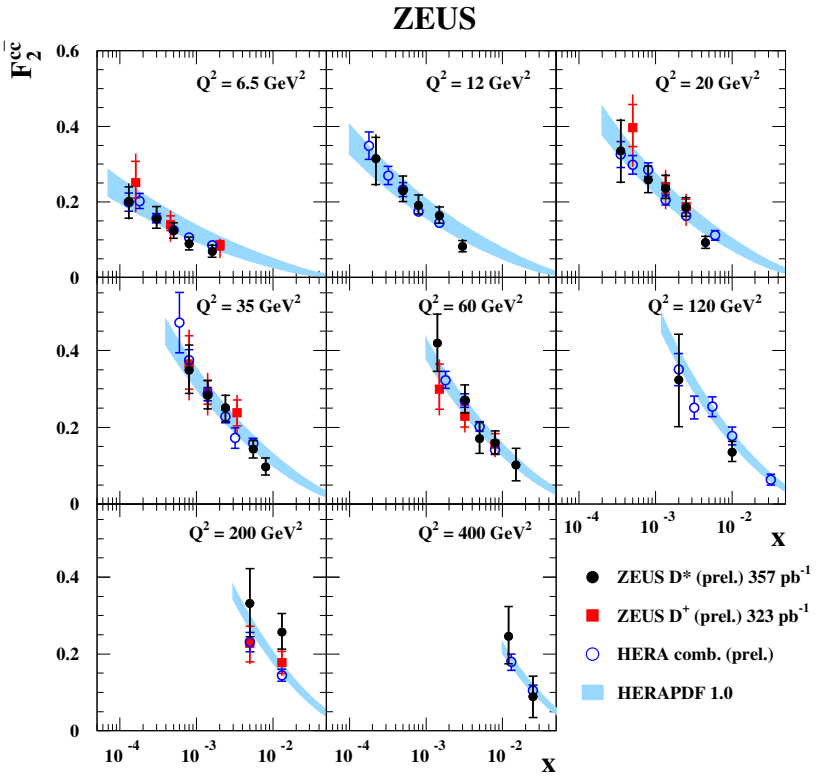

Figure 3: Measured charmed structure function $F_2^{c\bar{c}}$ compared to previous HERA results and HERAPDF 1.0

$\left(\frac{F_2^{c\bar{c}}(x,Q^2)}{\sigma_{bin}^{vis}} \right)_{theory}$ ratio were obtained using HVQDIS program and cross-section extrapolation on full phase space were performed with following parameters :

Scales: the renormalization (μ_R) and factorization (μ_F) scales set to μ_F=μ_R=$\sqrt{Q^2 + 4m_c^2}$

and varied simultaneously by a factor two up and down. The scales were varied both in HVQDIS and in the PDF fit.

Mass: the charm quark mass (m_c) is set to 1.5 $\pm$ 0.15 GeV, varied simultaneously in HVQDIS and in the PDF fit.

PDF: the HERAPDF 1.0 PDF fit performed with the fixed flavour number scheme (FFNS) , with scales and masses in agreement with those used in HVQDIS.

Fragmentation function: fragmentation is performed in the γ^* - p frame using Kartvelishvili fragmentation function with the parameter α_K dependent on the photon-parton center of mass energy squared, based on [6] and [7].

Fragmentation fraction: the probability that a c quark produces a D^{*+} meson is set to f(c $\rightarrow D^{*+}$) = 0.2287.

The theoretical band shown in Fig.3 is RT GM-VFNS heavy flavour scheme at NLO based on the HERAPDF 1.0 densities. The band corresponds to a variation of m_c from 1.3 to 1.65 GeV.

5 Summary

A measurement of the heavy flavour content of the proton in DIS at HERA have been presented. D* cross-sections and $F_2^{c\bar{c}}$ measurements were made using information from ZEUS detector with D* $\rightarrow$ K π π_{slow} decay channel. The D* cross-sections are found to be well described by the predictions of perturbative QCD at NLO. Measured $F_2^{c\bar{c}}$ are in good agreement with previous HERA measurements and HERAPDF 1.0. Measured $F_2^{c\bar{c}}$ will improve precision of H1-ZEUS combination.

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