$D^{*\pm}$ Meson Production and Charm Structure Function in Deep Inelastic Scattering at Hera.

C. Adloff [a*]

[a]Fachbereich Physik, Universität Wuppertal,
Gaußstraße 20, D-42097 Wuppertal, Germany

Inclusive $D^{*\pm}$ differential cross sections have been measured in deep inelastic scattering at the ep collider HERA using data collected with the H1 detector over the kinematic range 2 GeV$^2 < Q^2 <$ 100 GeV^2, $0.05 < y < 0.7$, $p_{TD^{*\pm}} >$1.5 GeV and $|\eta_{D^{*\pm}}| < 1.5$. The good agreement with the Next-to-Leading Order QCD prediction allows the extraction of the charm contribution $F_2^c(x, Q^2)$ to the proton structure function.

1. INTRODUCTION

In deep inelastic lepton nucleon scattering the study of charm allows to learn about its production mechanism as well as to access the charm structure function. First results on inclusive charmed mesons production from the H1 94 data [1] have shown a clear dominance of the BGF process in charm production. F_2^c was therefore extracted with help of NLO QCD calculations based on the BGF process [2]. In this paper results, partially preliminary, on inclusive $D^{*\pm}$ meson production and F_2^c in an extended kinematic range are presented using the data taken in 1996 at HERA by the H1 experiment.

2. DIS EVENT SELECTION

During the 1996 running period HERA has been operated with 27.5 GeV positrons colliding with 820 GeV protons at a center of mass energy of $\sqrt{s}=300$ GeV. The data collected with the H1 detector [3] and analysed here correspond to a integrated luminosity of $\mathcal{L}_{int} = 7.18$ pb^{-1}.
The kinematics were restricted to

$$2 \text{ GeV}^2 < Q^2 < 100 \text{ GeV}^2 \qquad (1)$$

for the four momentum transfer squared and to

$$0.05 < y < 0.7 \qquad (2)$$

for the inelasticity. Q^2 and y are calculated from the scattered positron energy and polar angle. The scattered positron is detected and identified in the backward calorimeter of the H1 detector, the Spacal, a lead-scintillating fiber spaghetti type calorimeter.

3. $D^{*\pm}$ SELECTION

$D^{*\pm}$ mesons where reconstructed via the decay $D^{*\pm} \to D^0\pi^{\pm}_{slow} \to (K^{\mp}\pi^{\pm})\pi^{\pm}_{slow}$. Basis track quality is required from the experience acquired in [1]. Combinatorial background was reduced by asking the K and π to have transverse momenta larger than 300 MeV and the π_{slow} to have transverse momentum larger than 120 MeV. Further suppression of the combinatorial background is achieved by making use of the hard fragmentation of charm quarks with the following cuts:

$$p_{TD^{*\pm}} > 3.0 \text{ GeV or } x_{D^{*\pm}} > 0.2, \qquad (3)$$

where $x_{D^{*\pm}} = \left(\frac{|\vec{p}_{D^{*\pm}}|}{|\vec{p}_p|}\right)^{\gamma^* p}$.
The reconstructed D^* has to lie well within the central tracker device acceptance corresponding to

$$p_{TD^{*\pm}} > 1.5 \text{ GeV and } |\eta_{D^{*\pm}}| < 1.5. \qquad (4)$$

The best resolution and signal to background ratio are obtained in the $\Delta m = m(D^{*+}) - m(D^0)$ distribution due to the small mass difference between D^* and D^0 mesons. 407$\pm$28 D^* are observed from a χ^2 fit of the Δm distribution for candidates where the $K\pi$ mass has to correspond to the nominal D^0 mass within $\pm$70 MeV.

*DESY, Notkestr.85, D-22607 Hamburg, Germany

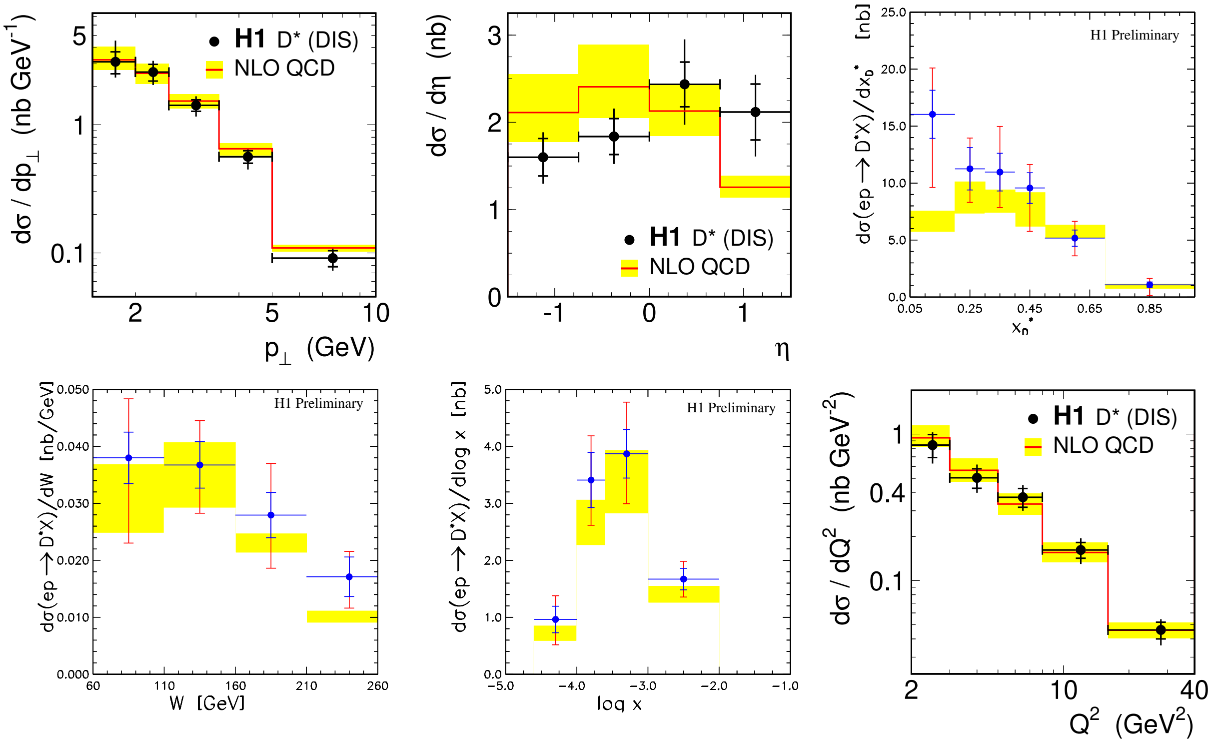

Figure 1. Inclusive $D^{*\pm}$ differential cross sections (full dots) and NLO QCD prediction (shaded area).

4. INCLUSIVE $D^{*\pm}$ CROSS SECTIONS

Inside the kinematic range (1) and (2) and the visible range (4) the total cross section is found to be

$$\sigma_{vis} = (5.75 \pm 0.35 \pm 0.79)\ \text{nb}. \tag{5}$$

The efficiency for the reconstruction, the acceptance of the apparatus and the selection cuts is calculated from the LO Monte Carlo AROMA which describes reasonably well the observed differential distributions of the $D^{*\pm}$.

From the results of Likelihood fits in bins of $p_{TD^{*\pm}}$, $\eta_{D^{*\pm}}$, $x_{D^{*\pm}}$, W, x, and Q^2 the differential cross sections are evaluated and represented in fig.1. The distributions which do not carry the label 'H1 preliminary' have already been published [4]. The inner error bars represent the statistical errors and the total error bars are the result of adding the statistical and the systematic errors in quadrature. The systematic errors take into account the uncertainties coming from the analysis, from different detector effects and from the variation in the efficiency determined with different settings of the AROMA Monte Carlo. QED radiations are estimated from the HECTOR program, resulting in a 7% contribution over the full kinematic range. They are included in the results in the form of a bin by bin correction. The data is compared to the results of the HVQDIS program [5]. This program is based on NLO QCD calculations using the GRVHO-94 parton density parameterizations and convoluting the charm cross section with the Peterson fragmentation function taking $\epsilon = 0.78$ to obtain the inclusive $D^{*\pm}$ cross sections. The shaded band on figure 1 represents the change in the predicted cross section when varying the charm mass from 1.3 to 1.7 GeV. This NLO QCD prediction compares well to the data except for the slight excess at small $x_{D^{*\pm}}$ which is correlated with the small excess at large $\eta_{D^{*\pm}}$.

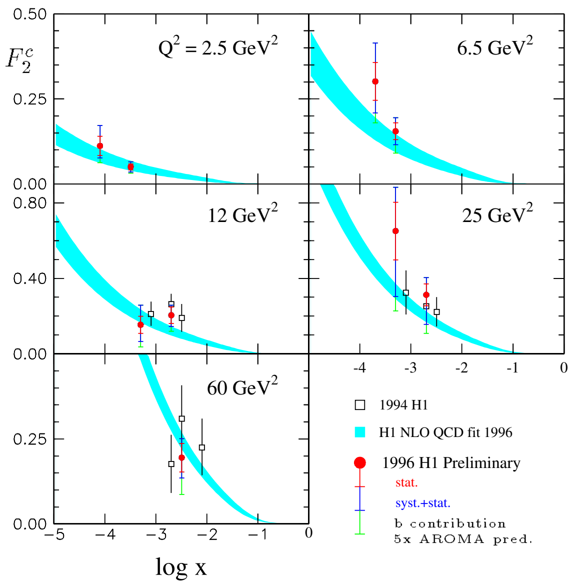

Figure 2. Charm contribution $F_2^c(x,Q^2)$ to the proton structure function (full dots) together with the results from the 94 inclusive $D^{*\pm}$ and D^0 analysis (open boxes) and the NLO prediction using gluon density from the 96 H1 NLO fit to the F_2 measurement (shaded area).

5. CHARM STRUCTURE FUNCTION

The inclusive $D^{*\pm}$ visible differential cross sections are converted to a bin center corrected charm structure function as follows:

$$F_2^{c\,\exp}(\langle x\rangle\langle Q^2\rangle) = \frac{\left(\dfrac{d^2\sigma_{\rm vis}^{D^*\exp}}{dxdQ^2}\right)}{\left(\dfrac{d^2\sigma_{\rm vis}^{D^*\rm theo}}{dxdQ^2}\right)} \cdot F_2^{c\,\rm theo}(\langle x\rangle\langle Q^2\rangle) \quad (6)$$

where $F_2^{c\,\rm theo}$ is the result of the NLO calculation. This procedure is possible under the assumption that the the F^c is proportional to the cross section at $\langle x\rangle$ and $\langle Q^2\rangle$ which holds when $F_L^c = 0$. This is justified because the NLO QCD calculation predicts only a 2% contribution of F_L^c to the charm cross section.

The resulting $F_2^{c\,\exp}$ for the current analysis is shown in figure 2 together with the previous results from the 94 inclusive $D^{*\pm}$ and D^0 analysis. For the 96 points the inner and middle error bars refer to the statistical and the total errors, respectively. The difference between the outer and the middle error bars is the quantity one should subtract if the beauty contribution would be five times the contribution predicted by the LO AROMA program. This is motivated by H1 results on beauty studies in photoproduction [6]. The systematic error includes the uncertainties on the $D^{*\pm}$ cross sections, the effect on $F_2^{c\,\exp}$ due to the change of $F_2^{c\,\rm theo}$ when varying the charm mass from 1.3 to 1.7 GeV, the scale, the partons densities as well as the effect on $F_2^{c\,\exp}$ due to the change of $\sigma_{\rm vis}^{D^*\rm theo}$ when varying the hardness of the fragmentation.

Thanks to the new backward calorimeter the 96 results are extended to $Q^2 = 2.5$ GeV^2 compared to our previous measurement. In the overlapping region the two data sets are in a good agreement. The direct measurement of F_2^c is also found in good agreement with the NLO predicted F_2^c using the gluon density from the fit to the H1 inclusive 96 F_2 data.

6. CONCLUSION

Inclusive $D^{*\pm}$ differential cross sections and charm contribution to the proton structure function have been measured with the 1996 taken by the H1 detector. All differential cross sections are in agreement with the NLO QCD expectation both in shape and absolute value. A good agreement is found between the extracted F_2^c, which was extended down to $Q^2 = 2.5$ GeV^2, and the NLO QCD prediction using the gluon density from the NLO fit to the H1 inclusive F_2 data.

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