SOURCE (OR PART OF THE FOLLOWING SOURCE):
Type Dissertation
Title Measurement of charm production in deep inelastic scattering at HERA II
Author T.G. Grigorescu
Faculty Faculty of Science
Year 2008
Pages vi, 168
ISBN 9789064880308

FULL BIBLIOGRAPHIC DETAILS:
http://dare.uva.nl/record/271134

Chapter 9

Conclusions

The aim of the analysis presented in this thesis is the measurement of the production of charm quarks in deep inelastic scattering. The measurement was performed on data recorded by the ZEUS collaboration in 2005, having a total luminosity of 127.35 pb^{-1}. The present analysis relies both on the performance of the ZEUS microvertex detector as well as on analysis-dependent vertexing techniques.

More than 95% of the HERA II data recorded in 2005 has MVD information. The vertex detector improves greatly the quality of the reconstructed tracks and vertices. A key issue for a good MVD performance is the MVD alignment. Great progress has been made by using tracks from $e^{-}p$ collisions to align all ladders of the MVD with equal accuracy. Previously, only alignment based on cosmic tracks was used. The new alignment procedure based on $e^{-}p$ tracks improves hit resolution ($\sim 25 - 30\,\mu m$ for all ladders now) and impact parameter w.r.t. the interaction point ($\sim 100 - 150\,\mu m$). This analysis takes advantage of these improvements in the alignment.

Charm was reconstructed using the decay channel $D^0 \rightarrow K + \pi$ which accounts for 3.8% of charm D^0 meson decays. As more than 50% of charm hadronizes to D^0 mesons either directly or via D^* decays (a large fraction of D^* decay to D^0), the decay channel $D^0 \rightarrow K + \pi$ is a prolific channel for charm signal. There are disadvantages, however, such as the short D^0 lifetime and the fact that the K and the π are not uniquely identified, leading to a reflected signal.

For this analysis, specific vertexing was performed, by vertexing separately combinations of two tracks of opposite charge. Good vertices were selected by the vertex χ^2. The D^0 invariant mass at the vertex was reconstructed. The best reduced primary vertex was created using all other tracks in the event. In this way, the charm meson decay was tagged. Information about the decay length and decay length significance, the momentum vector at the decay vertex and the charm meson lifetime were optimized for producing the smallest relative error on the signal and the highest purity. A neutral pseudotrack was built using knowledge of the decay vertex, the K and π tracks and their errors. The pseudotrack was then refitted to the primary vertex, producing a new primary vertex position and a χ^2 increase. An attempt was made to further improve the relative error on the signal by selecting events using the primary vertex χ^2 increase cut. This provided no improvement essentially because the D^0 meson is a difficult particle to tag. It is the shortest lived particle whose decay can be tagged by the ZEUS detector. Its decay length is comparable to the flightpath resolution which makes it difficult to distinguish the genuine decays from background combinations, which also decrease in number with increasing decay lengths. In total, there were 7440 ± 233 D^0 candidates found for the kinematic range $5 < Q^2 < 1000\,\mathbf{GeV^2}$, $3 < P_T(D^0) < 20\,\mathbf{GeV}$. Among them, 1668 ± 46 candidates were additionally tagged as coming from a D^{*+} decay, $D^{*+} \rightarrow D^0 + \pi_s$. The rest were either directly produced in the hadronization process of the charm quark or came from a strong/electromagnetic D^{*0} decay. The improvement in track and vertex resolution, due to the microvertex detector, allowed signal reconstruction of D^0 mesons at transverse momenta less than $3\,\mathbf{GeV}$. An additional number of 5483 ± 473 D^0 candidates were reconstructed with a transverse momentum in the range of $1.5 < P_T(D^0) < 3\,\mathbf{GeV}$. This was the first charm meson signal reconstructed at ZEUS at $P_T(D^0) < 3\,\mathbf{GeV}$ and it increased significantly the statistics.

The extracted signal was used to perform two similar measurements, for the kinematic ranges of $1.5 < P_T(D^0) < 20\,\mathbf{GeV}$ and $3 < P_T(D^0) < 20\,\mathbf{GeV}$ respectively. The higher P_T measurement acted as a check with respect to previous HERA I measurements while the measurement in the expanded kinematic range increased statistics. The differential cross-sections as functions of Q^2 of the event, $\eta(D^0)$, $P_T(D^0)$ and Bjorken x were measured. They were compared to the next to leading order theoretical prediction. For both measurements, the differential cross-section shapes were well reproduced, for all variables, but the predicted overall normalization was higher by a factor of $20 - 30\%$. It was shown that the NLO prediction describes the data well at low transverse momenta of the charm meson. The main input parameters to the theoretical prediction software package HVQDIS are: the ZEUS parton density functions, the charm mass $M_c = 1.35\,\mathbf{GeV}$, the Peterson fragmentation parameter $\epsilon = 0.035$ and the renormalization and factorization scales $\mu_R = \mu_F = \sqrt{Q^2 + 4M_c^2}$. Also, the double differential cross-section $d^2\sigma/dQ^2dy$ was measured. This cross-section was used to extract the charm structure function $F_2^{c\bar{c}}$. A good agreement with the theoretical prediction of $F_2^{c\bar{c}}$ was found. When measuring $F_2^{c\bar{c}}$, the increased statistics allowed finer granularity and reduced the extrapolation by a factor of ~ 3.

The vertexing techniques used in this analysis can be applied with great success to charm or beauty meson tagging. Selecting charm candidates by their decay length significance and/or by the χ^2 increase of the charm pseudotrack on the primary vertex have already proved to be great tools for enhancing the signal purity and reducing the signal relative error in the tagging of D^+ mesons at ZEUS. Also, the accuracy of the measurement presented here will be increased by including the entire HERA II data set with a luminosity of $\approx 400\,pb^{-1}$.

This measurement confirms that theoretical predictions performed with gluon distributions extracted from inclusive DIS are certainly trustworthy within $\sim 25\%$.