CHARM RECONSTRUCTION IN ZEUS HERA II DATA*

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First HERA II measurements of the cross-section ratio between D^* production in e^-p and e^+p scattering are consistent with 1. In addition, the reconstruction of charm mesons in the ZEUS HERA II data uses secondary vertices reconstructed with the aligned Micro Vertex Detector. The signed decay length significance in case of D^0s was studied and in case of $D^\pm$s used to enrich the signal in DIS.

1. Introduction

The main process in deep inelastic scattering (DIS) for D^* production is the Boson gluon fusion (fig. 1). That process creates an open-charm pair. The charm quark can fragment into a the excited D^* meson state. De-excitation takes place into a charm ground state D^0 according to Zweig rule under the emission of a pion. The charm ground state can decay into a kaon pion pair with weak interaction. In the Golden Channel three charged final state particles appear and are detected $D^{*\pm}(2010) \rightarrow D^0(K^\mp + \pi^\pm) + \pi_s^\pm$. All relevant forces of particle physics are covered in that process. The weak decay of the D^0 has a rather long life-time $c\tau = 123\,\mu m$. The detection is very close to the resolution limit. The strong decay of the D^* is not detectable, since strong interactions are much faster than weak decays. The phase space for de-excitation of the D^* suits for a pion rest mass and little additional energy what makes that particle very slow. In case of $D^\pm$ no phase space is left for a charm resonance and it decays weakly $D^\pm \rightarrow \mathrm{K}^\mp + \pi^\pm + \pi^\pm$ with rather long life-time of $c\tau = 314\,\mu m$.

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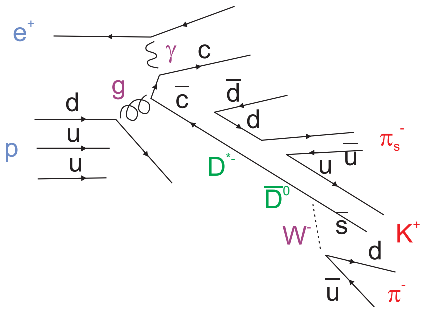

C	quark
2/3	u c t
-1/3	d s b
1/3	$\bar{d}$ $\bar{s}$ $\bar{b}$
-2/3	$\bar{u}$ $\bar{c}$ $\bar{t}$

Figure 1. $D^{*\pm}$ production in e^+p scattering. Boson gluon fusion is the dominant process in deep inelastic scattering. Charges of the quarks are given in a little table for better understanding. An open-charm pair can fragment into a $D^{*\pm}$ with de-excitation into a D^0 with successive weak decay.

2. Cross-section ratio

The first HERA II data was used to check the cross-section ratio for $e^+p \rightarrow D^* + X$ and $e^- + p \rightarrow D^* + X$. Only tracks from primary vertex are used for that particular analysis with standard cuts. The HERA I data showed a slight excess[1] at $Q^2 > 40\,GeV^2$. The excess could not be confirmed[2]. The cross-section ratio is compatible with 1.

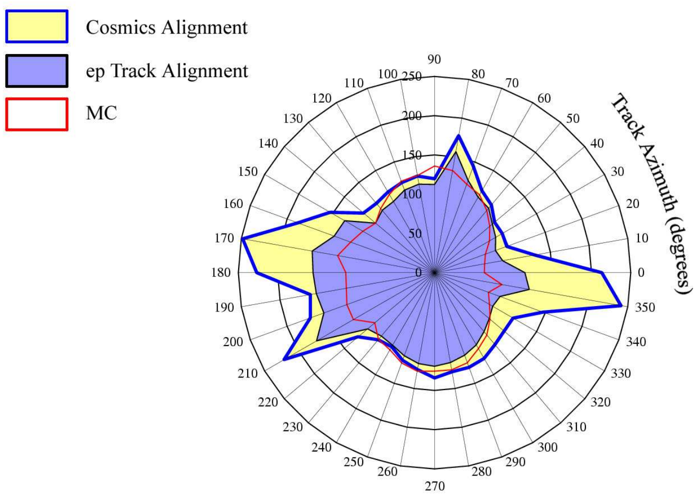

Figure 2. The radial impact parameter resolution in microns for *ep* collision tracks for Monte Carlo simulation and different alignments. Kinks in the MC line are due to geometric distribution of the MVD modules. The MC line reflects the natural spread of *ep* collision tracks.

3. MVD alignment

The alignment of the MVD was done with cosmic muons in a first approach. Horizontal cosmic muons are unlikely to be triggered what gives rather low statistics to align the vertical barrel part of the MVD. In a next approach *ep* collision tracks are taken to align. They are distributed uniformly in ϕ. The alignment fits almost the Monte Carlo simulation. Preselected tracks with a cosmic muon aligned MVD still suffer from the lack of statistics for vertical MVD modules if there are used for *ep* alignment. Comparisons between these two alignments can be seen in fig. 2.

4. D^0 decay length significance

D^0s from D^*s are taken to reconstruct the 2D decay length projected on the D^0 momentum $L_{xy} = \frac{(\vec{s}_{xy} - \vec{P}_{xy}) \cdot \vec{p}(D^0)}{p_T(D^0)}$. The full luminosity 2003-5 of HERA II data was used to create the D^* peak (fig. 3). The decay length significance $\frac{L_{xy}}{\sigma(L_{xy})}$ for the signal and the background is shown in fig. 3. The background peaks around zero. The signal curve shows a shift what comes from the D^0 decay length. The exponential decay length distribution is hidden by resolution effects, what is not surprising since the decay length is at the edge of MVD is capable to resolve.

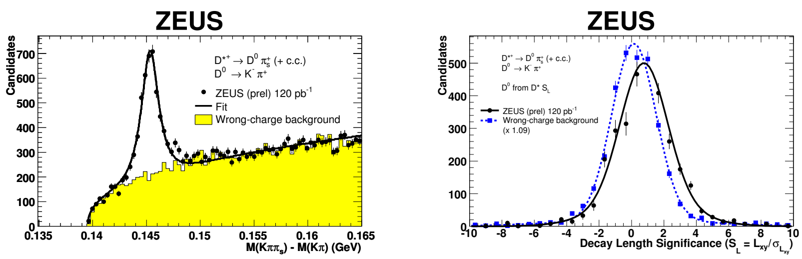

Figure 3. HERA II luminosity of $\mathcal{L}(e^-p) = 120\,\mathrm{pb}^{-1}$ was used to reconstruct D^*s in DIS (left) to tag D^0s. The decay length significance of D^0s candidates from these D^* candidates show a shift between the background subtracted signal (black curve) and wrong charge background (blue curve) (right). Background peaks around zero ideally.

5. $D^{\pm}$ decay length significance

A slightly different approach was used with the signed decay length significance $L = |\vec{L}|\mathrm{sign}(\vec{L_{xy}} \cdot \vec{p_T}(D^{\pm}))$. A significance cut reduces the background by a factor of 30 (fig. 4), what confirms a previous measurement[3] with current luminosity and results and a similar measurement from the H1 experiment[4].

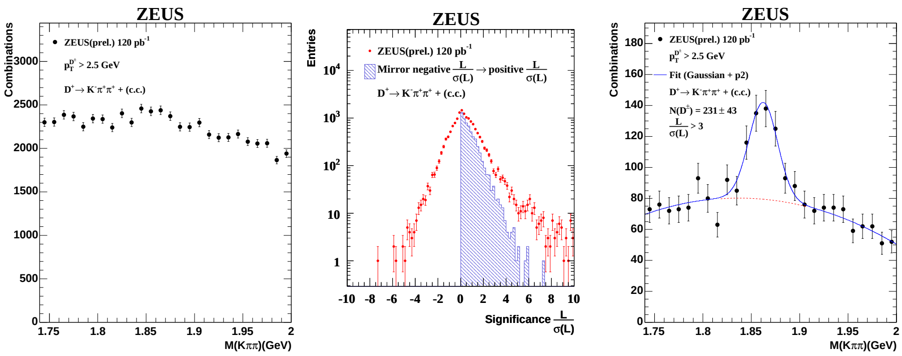

Figure 4. The $D^{\pm}$ signal in DIS is hardly visible with standard cuts (left). A decay length significance (middle) cut is used to enrich the signal (right). The background is reduced by a factor of 30 with that cut.

6. Summary

First HERA II data was used to measure a cross-section ratio for D^* production in DIS for e^+p and e^-p collisions. The ratio is compatible with 1. The projected decay length significance for D^0s from D^*s was shown. A shift between the curves for signal and background is visible. The signed decay length significance cut reduces the background by a factor of 30 for $D^{\pm}$ production in DIS.

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