Measurement of charm fragmentation fractions in photoproduction at HERA

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The production of D^*, D^+, D^0, D_s and Λ_c charm hadrons in ep scattering at HERA was studied with the ZEUS detector, and the fractions of c quarks hadronizing as a particular charm hadron were derived. The measurement has been performed in the photoproduction regime, using the full HERA II data set with a total integrated luminosity of 372 pb^{-1}. The obtained fractions are compared to previous results from HERA and from e^+e^- experiments.

1 Introduction

Charm quark production provides an important testing of perturbative QCD (pQCD) and has been extensively studied in *ep* collisions at HERA. One thing which cannot be predicted by pQCD are the fragmentation fractions of charm quarks into specific charmed hadrons. It is usually assumed that these fractions are universal, i.e. the same for charm quarks produced in e+e- annihilation, in *ep* collisions and also in *pp* or other hadronic collisions. However, the charm production mechanisms are not the same. In e+e- collisions, cc pairs are produced dominantly in a colour-singlet state, which is not the case for *ep* scattering. Thus, measurements of charm fragmentation characteristics at HERA can provide important input to a stringent test of charm-fragmentation universality.

The fractions of quarks hadronizing as a particular charm hadron have been measured in previous studies at HERA [1, 2, 3, 4, 5]. In this paper the measurement of fragmentation fractions in photoproduction with the ZEUS detector is presented with much improved statistics compared to a previous ZEUS publication [1].

2 Hadron reconstruction

The production of D^*, D^+, D^0, D_s and Λ_c charm hadrons was measured in the range of transverse momentum $p_T(D, \Lambda_c) > 3.8GeV$ and pseudorapidity $|\eta(D, \Lambda_c)| < 1.6$.

Charm hadrons were reconstructed using tracks from ZEUS tracking system. The tracks were assigned to the reconstructed event vertex. The hadrons were reconstructed from the following decays: $D^0 \to K^-\pi^+$, $D^{*+} \to D^0\pi_s^+$, $D^+ \to K^-\pi^+\pi^+$, $D_s^+ \to \phi\pi^+$ with $\phi \to K^+K^-$ and $\Lambda_c^+ \to K^-p\pi^+$.

The relatively long life time of the D can result in a decay vertex that is spatially separated from the primary interaction point. This property can be used to improve the statistical

precision of the D mesons' signal by reducing the combinatorial background. The corresponding variable was the decay length significance $S_l = l/\sigma_l$ where l is a decay length in the transverse plane and σ_l is the uncertainty assosiated with the distance. The cut on the decay length significance was chosen to maximize the signal-to-background ratio. For the D^0 meson it was chosen as $S_l > 1$, for the D^+ - $S_l > 3$ and for the D_s - $S_l > 0$.

Reflections from D_s^+ and Λ_c^+ decays to three charged particles were subtracted from the D^+ mass spectrum using the simulated reflection shapes normalized to the measured D_s^+ and Λ_c^+ production rates. The same was done also for $M(KK\pi)$ distribution for D_s^+ candidates and for $M(Kp\pi)$ distribution for Λ_c^+ candidates.

3 Charm fragmentation fractions

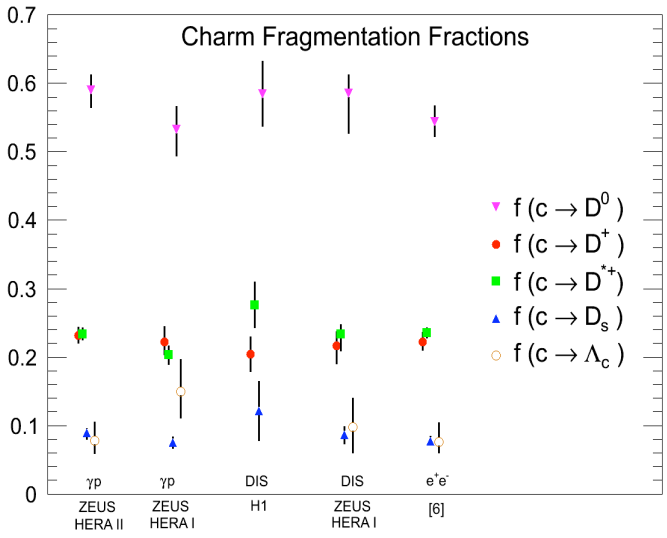

Figure 1: The fractions of c-quark hadronizing as a particular charmhadron. The photoproduction measurements presented here are shown (first column) and compared to previous HERA results in photoproduction (second column) and DIS (third and fourth column) and to e^+e^- data (last column)

The fragmentation fraction $f(h)$ for a specific charm hadron h was computed from

$$f(h) = \sigma(h)/\sigma_g \tag{1}$$

where $\sigma(h)$ is the cross section of the charm hadron and σ_g is the sum

$$\sigma_g = \sigma(D^+) + \sigma(D^0) + \sigma(D_s) + 1.14 \cdot \sigma(\Lambda_c) \tag{2}$$

The factor 1.14 accounts for unobserved heavier charm baryons, and $\sigma(D^0)$ and $\sigma(D^+)$ include both direct decays plus decays originating from D^*.

Figure 1 shows the result. A comparison with other HERA experiments from H1 [2] and ZEUS in DIS [3, 4] and in photoproduction [1] and with experiments at e^+e^- storage rings [5, 6] is also shown. The date support the hypothesis that fragmentation proceeds independently of the hard sub-process.

4 Conclusions

The production of charm hadrons D^{*+}, D^+, D^0, D_s^+ and Λ_c^+ has been measured in the kinematic range $p_T(D, \Lambda_c) > 3.8GeV$ and $|\eta(D, \Lambda_c)| < 1.6$.

The fractions of c quarks hadronizing as D^{*+}, D^+, D^0, D_s^+ and Λ_c^+ hadrons have been calculated in the accepted kinematic range. The measured open-charm fragmentation fractions are consistent with previous HERA results [1, 2, 3, 4] and with those obtained in e^+e^- annihilations [5, 6].

These measurements support the hypothesis that fragmentation proceeds independently of the hard sub-process.

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