Charm Fragmentation in Neutral and Charged Current DIS

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Charm fragmentation is considered for neutral current and charged current DIS as a means of investigating the charm production dynamics and of measuring nonperturbative quantities from experiment, respectively. For this contribution to the proceedings I restrict myself to HERA-related applications.

1. NEUTRAL CURRENT DIS

In present global parton distribution analyses [1–3] several competing charm production scenarios [4–8] are in use which seem to have a strong feedback onto the entire set of PDFs [2]. I will here mainly distinguish between fixed order perturbation theory [fixed order gluon fusion (GF)] and collinearly resummed scenarios represented by the ACOT formalism. The technical details of implementing the resummation, which differ e.g. between the schemes of Ref. [5] and [6], are, however, not relevant for my considerations. From recent PDF analyses within the individual schemes we know that all schemes are capable of describing inclusive deep inelastic charm production measurements (F_2^c). For a discriminative measurement it is therefore worthwhile to see for quantities which are more sensitive to the details of the charm production dynamics — like the charm fragmentation spectrum in Fig. 1 (z is the scaled energy of the charmed hadron produced in DIS). Indeed the experimental analysis in [9] could exclude a mere partonic charm production channel at the 5% level. To investigate the impact of the latter analysis on collinearly resummed production schemes — which do comprise of a partonic charm component — we have to consider the full $\mathcal{O}(\alpha_s)$ of QCD perturbation theory where further important production channels enter the game (Fig. 2). The difference between QCD corrected ACOT dynamics and GF is then not within presently achievable experimental accuracy. Fixed order GF and ACOT are even closer together if radiative corrections to the quark scattering (QS) channel (i.e. $QS^{(1)}$) are not taken into account — as suggested in the second paper of [5] for the perturbative level considered here. The tendency of the data to exceed theory at low z need therefore not be discussed within any *un*physical scheme dependence but can be considered fully within physical meaningful terms as e.g. color dragging effects [10].

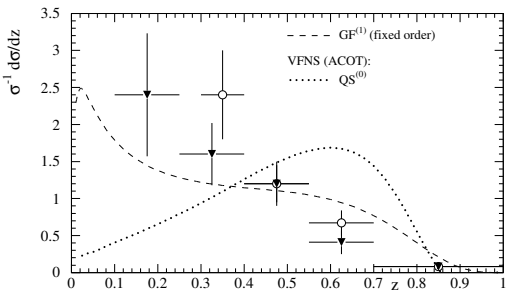

Figure 1. NC charm fragmentation spectrum from fixed order boson gluon fusion and from a scattering event on a partonic charm quark. Throughout, the upper bracketed indices count the perturbative order.

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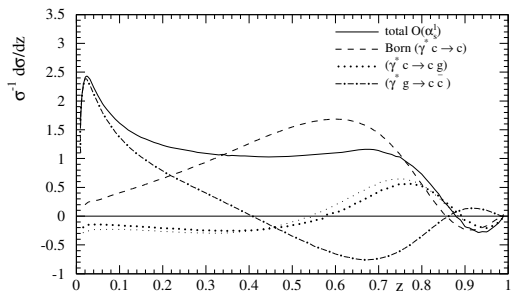

Figure 2. NC charm fragmentation spectrum within ACOT. Total $\mathcal{O}(\alpha_s)$ result along with the individual contributions.

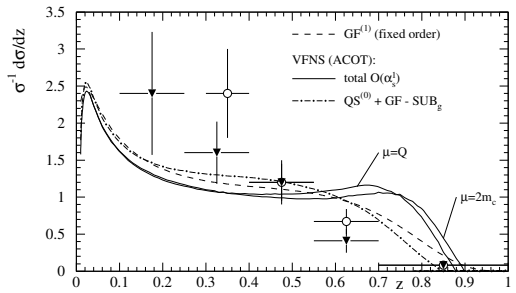

Figure 3. The fixed order GF result and the full as well as partial $\mathcal{O}(\alpha_s)$ ACOT based calculation compared to the H1 [9] data.

2. CHARGED CURRENT DIS

Charged current deep inelastic production of charm has up to now been analyzed in neutrino scattering on fixed iron targets. From the LO production cross section $d\sigma_{LO} \propto s(\xi)D(z)$ it is clear that the process measures directly the strange sea and the charm fragmentation function — up to quark — and gluon-initiated NLO corrections which have of course to be considered for a reliable analysis. Charged current charm production on fixed targets has been formulated and analyzed to NLO accuracy in [11] — see [12] for a summary. For compactness I will restrict this note to possible future HERA applications [13] which may be possible with the forthcoming luminosity upgrade. According to [11] fixed target neutrino-production data seems to be in agreement with a perturbative GRV [14] type strange sea and a hard Peterson [15] fragmentation function with $\varepsilon_c \simeq 0.06$. A HERA measurement would be an important test of the QCD evolution of CC charm production from fixed target to collider scales. Due to the high HERA Q^2 scales the strong

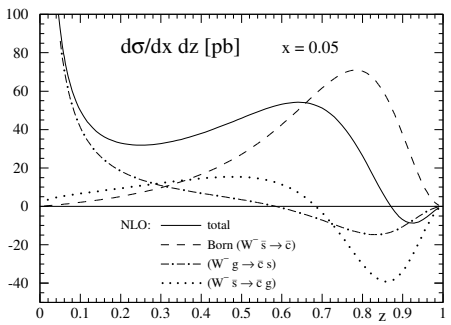

Figure 4. The fragmentation spectrum of charm quarks at HERA: $Q^2 > 500$ GeV^2.

$g \to c\bar{c}$ production channel becomes increasingly important, see Fig. 4. Since the dominance of the latter channel is located at low z we can, however, minimize the unwanted gluonic contribution by a suitable $z_{\min}$ (or $p^T_{\min}$) cut to maximize the information on the strange sea. By the same cut we would also minimize the NLO corrections to the $s \to c$ Born term (Fig. 5). Furthermore the cut excludes precisely that region in phase space the integration of which leads to a potentially dangerous $\sim \ln(Q^2/m_c^2)$ term which would afford considerations of in principle *un*physical scheme dependence and therefore might render a discussion in terms of physical quantities like the strange sea or the charm fragmentation function somewhat ambiguous.

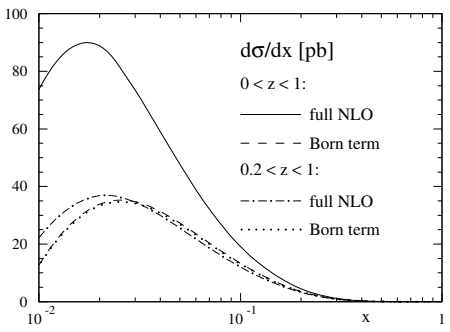

Figure 5. z-integrated charged current charm production rates for HERA with and without $z_{\min}$ cut.

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