NLO CORRECTIONS TO THE POLARIZED PHOTOPRODUCTION OF HEAVY FLAVORS

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The recently calculated complete QCD corrections in $\mathcal{O}(\alpha_s^2\alpha)$ are studied concerning their influence on the extraction of the polarized gluon density Δg from future COMPASS data. The stability under variations of the factorization and renormalization scales is shown to improve considerably, but the uncertainty introduced by varying the charm mass remains large.

1 Motivation and Method

The growing number of next-to-leading order (NLO) fits to (semi-)inclusive polarized data [1,2] show one common feature: the shape and size of the polarized gluon distribution Δg is hardly determined. The lack of sufficient constraints on the polarized gluon follows to a large extent from the absence of exclusive reaction data. The photoproduction of heavy quarks then seems like a good process to study, since only the gluon contributes in leading order (LO) through photon-gluon-fusion. Consequently COMPASS will provide data for open charm production [3]. But the LO results [4,5] show a strong dependence on the arbitrary factorization (μ_f) and renormalization (μ_r) scales, in the unpolarized NLO case [5] large threshold corrections were found and finally light quarks in the initial state contribute in NLO. Thus a NLO analysis [6,7] is necessary.

The known unpolarized result [5] is obtained simultaneously in the calculation, which serves as an important check, by projecting out definite initial helicities h_1 and h_2 in the squared matrix elements $|M(h_1,h_2)|^2$:

$$\text{(un)polarized}: \quad \overline{|M|}^2,\ \Delta\,|M|^2 = \frac{1}{2}\left[|M(+,+)|^2 \pm |M(+,-)|^2\right]. \qquad (1)$$

The four-dimensional quantities γ_5 and $\epsilon_{\mu\nu\rho\sigma}$ needed for this projection are dealt with in n-dimensional regularization by using the HVBM prescription [8]. The resulting additional $(n-4)$-dimensional terms drop out after phase space integration [7], introducing no further complications. Due to the lack of space I will in the following not present the published predictions for COMPASS [6] themselves, but only their inherent theoretical uncertainties.

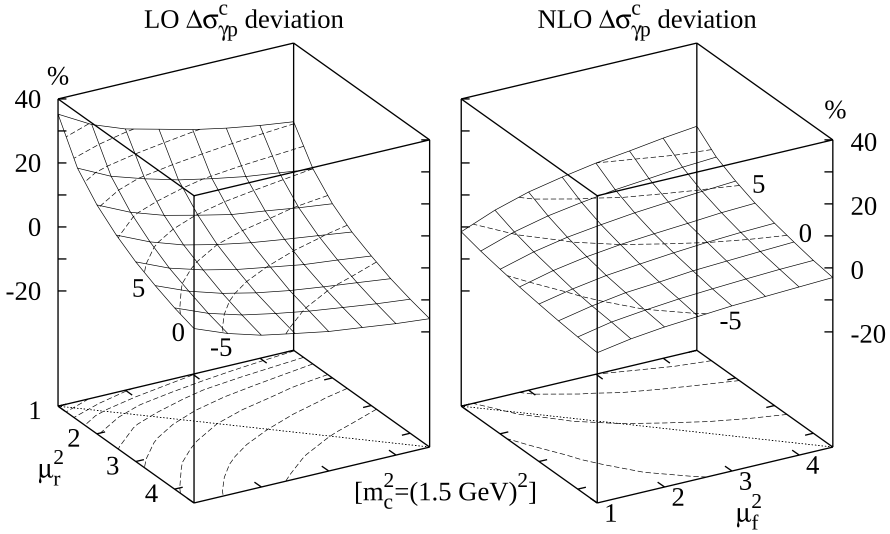

Figure 1: Deviation in percent of the LO and NLO total polarized charm photoproduction cross section at center-of-mass energy $\sqrt{S} = 10$ GeV from a central value ($\mu_r^2 = \mu_f^2 = 2.5\, m_c^2$). Contour lines in steps of 5% and a line $\mu_r = \mu_f$ at the base are included to guide the eye.

2 Theoretical Uncertainties of the Predictions

The importance of the uncertainty in the gluon distribution at large x for predictions at COMPASS energies [3] has already been discussed previously [6]. Here [a] I would like to show first the dependence on the scales μ_r and μ_f [7]. In Fig. 1 the much improved stability of the NLO result is evident, the variations are dampened by about a factor three. Also note the different orientation of the contour lines in NLO, which motivates setting $\mu_r = \mu_f$ in calculations. For center-of-mass energies higher than 10 GeV the same picture emerges.

In Fig. 2 the dependence on the uncertainty in the charm mass is explored. We see that it remains considerable at typical COMPASS energies. The experimentally relevant spin asymmetry, which is the ratio of the polarized and unpolarized cross sections, varies by about 30% for the shown charm mass range. For higher $\sqrt{S} \gg m_c$ the asymmetry is almost constant.

We can conclude that the largest theoretical uncertainties in the NLO predictions made for COMPASS [6,7] are related to the used charm quark mass (and to the large x gluon distribution not discussed here). The dependence on the arbitrary factorization and renormalization scales is less severe and

[a] The "GRSV std." polarized [2] and "GRV '94" unpolarized [9] parton distributions are used.

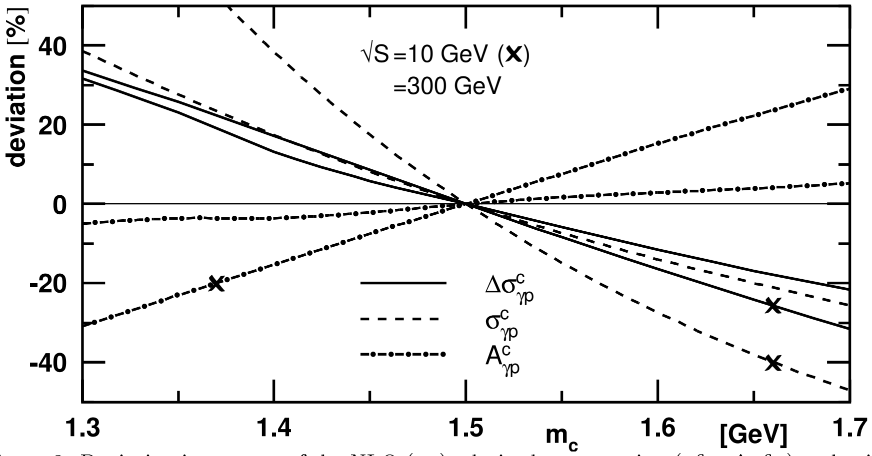

Figure 2: Deviation in percent of the NLO (un)polarized cross section ($\sigma^c_{\gamma p}$, $\Delta\sigma^c_{\gamma p}$) and spin asymmetry ($A^c_{\gamma p} \equiv \Delta\sigma^c_{\gamma p}/\sigma^c_{\gamma p}$) at $\sqrt{S} = 10,\ 300$ GeV from a central value ($m_c = 1.5$ GeV).

considerably improved over the LO case, as one could have hoped.

Acknowledgments

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