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On x-independence of $R^Q = F_L^Q/F_2^Q$ ratio at low x

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An important new data on the cross sections for the open charm and beauty production in deep inelastic electron-proton scattering (DIS) have appeared [1] by combining the results of research from the H1 and ZEUS collaborations at HERA. Measurements have shown that the production of heavy flavor Q in DIS occurs predominantly due to the photon-gluon fusion process $\gamma g \to Q\overline{Q}$ and therefore depend strongly on gluon density in the proton and mass m_Q of produced heavy quark ($Q = c$, b and t). Theoretical studies usually serve to confirm that available HERA data can be described by perturbative heavy flavor generation in QCD (see, for example, review [2] and references therein). Further investigations are planned at future lepton-hadron and hadron-hadron colliders [3–5], such as eIC, LHeC, FCC-eh and FCC-hh, where the measurements can be performed with much increased precision and extended to much smaller x and high Q^2 values.

In our previous consideration [6, 7] we have analyzed latest experimental data [1] taken by the H1 and ZEUS Collaborations at HERA. In particular, we have studied the heavy quark contributions to the proton structure function (SF) $F_2(x,Q^2)$ and reduced charm and beauty cross sections $\sigma_{\rm red}^{c\overline{c}}(x,Q^2)$ and $\sigma_{\rm red}^{b\overline{b}}(x,Q^2)$ measured mostly at small values of the Bjorken variable x in a wide region of Q^2 [8–11]. An additional important result of the evaluations [7] is that the compact analytical expressions for these DIS coefficient functions have been presented up to next-to-next-to-leading order (NNLO) accuracy. These expressions were used very recently to investigate the top quark production in the FCC-he kinematical regime [12, 13]. Here we continue our study [6, 7]. Using the previously derived expressions for DIS coefficient functions, we study the ratio $R^Q(x,Q^2) = F_L^Q(x,Q^2)/F_2^Q(x,Q^2)$ in the first three orders of perturbation theory. We demonstrate an approximate x-independence of this ratio for non-large Q^2 values, namely, $Q^2 \leq 8 \div 10 m_Q^2$. Moreover, we show a very slow ratio's dependence on the choice of used gluon density.

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