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Estimates for Bc meson production at LHCb

Among the B mesons, the B_c meson is unique as it is the only one composed of two different heavy flavors, b and c, making its production and detection more challenging than other b-flavored mesons. This results in significant uncertainties in its dynamic properties. Consequently, rather than reporting its differential production cross-section, the LHCb collaboration [1] provides the transverse momentum dependence of the ratio between the production of B_c mesons and the combined production of B^+ and B^0 mesons, showing an increase at small transverse momentum that indicates a violation of heavy-quark symmetry. To constrain the uncertainties and understand better the B_c meson production, we use Non-Relativistic QCD (NRQCD), a non-relativistic effective field theory based on a perturbative expansion in the relative velocity of heavy quarks. Within this framework, we apply two common approaches to calculate the production of heavy-quark bound states, referred to here as the *Fragmentation Approach* and the *Direct Approach.*

The first approach is based on the principles of Collinear Factorization, where fragmentation functions (FFs) are used as tools to describe the hadronization of single partons. Contributions from this method are know as *Leading Power*, because they are dominant at large transverse momentum. While FFs are typically fitted to experimental data, for mesons composed of heavy quarks, NRQCD allows us to estimate their values theoretically. Using the already calculated NRQCD fragmentation functions for the B_c and B_c^* bound states [2], we have found that the contribution from fragmentation alone fails to reproduce the observed increase at small transverse momentum.

To improve our results in this kinematic region, we aim to compare to compare the previous findings with the *Direct Approach.* In this method, hadrons are produced directly from the hard scattering process without relying on a fragmentation function. While this approach performs better at small transverse momentum, it fails at large values due to its inability to resum collinear emissions to all orders, as achieved through DGLAP evolution. Nevertheless, we expect it to provide an accurate description of the behavior at small transverse momentum, complementing the fragmentation approach.

References:

[1] R. Aaij et al. (LHCb Collaboration) Phys. Rev. D 100, 112006.
[2] Xu-Chang Zheng, Chao-Hsi Chang, Tai-Fu Feng, and Xing-Gang Wu
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Author: BARATTINI, Franco (Universidad Tecnica Federico Santa Maria)

Co-authors: BENJAMIN, guiot (Universidad frederico santa maria); DIB, Claudio (Federico Santa Maria Technical University (CL)); KOPELIOVICH, Boris

Presenter: BARATTINI, Franco (Universidad Tecnica Federico Santa Maria)

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