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Investigating the dominant regions of the phase space associated with $c\bar{c}$ production relevant for the prompt atmospheric neutrino flux

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A detailed mapping of the dominant kinematical domains contributing to the prompt atmospheric neutrino flux at high neutrino energies is presented by studying their sensitivity to the cuts on several kinematical variables crucial for charm production in cosmic ray scattering in the atmosphere. This includes the maximal center-of-mass energy for proton-proton scattering, the longitudinal momentum fractions of partons in the projectile (cosmic ray) and target (nucleus of the atmosphere), the Feynman x_F variable, and the transverse momentum of charm quark/antiquark. We find that the production of neutrinos with energies larger than $E_\nu > 10^7$ GeV is particularly sensitive to the c.m. energies larger than the ones at the LHC and to the longitudinal momentum fractions in the projectile $10^{-8} < x < 10^{-5}$. We also analyze the characteristic theoretical uncertainties in the charm production cross section coming from its QCD modeling. The precision data on the prompt atmospheric neutrino flux can efficiently constrain the mechanism of heavy quark production and underlying QCD dynamics in kinematical ranges beyond the reach of the current collider measurements.

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