

# Intrinsic charm in the nucleon, forward production of charm meson and high-energy neutrino flux

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We discuss the role of intrinsic charm (IC) in the nucleon for forward production of open charm meson in proton-proton collisions at low and high energies. The calculations are performed in collinear-factorization approach with on-shell partons,  $T$ -factorization approach with off-shell partons as well as in a hybrid approach using collinear charm distributions and unintegrated (transverse momentum dependent) gluon distributions. The distributions in rapidity and transverse momentum of charm quark/antiquark as well as of open charm meson are shown for a few different models of IC. Forward charm meson production is dominated by  $c\bar{c}$ -fusion processes. The IC contribution dominates over the standard pQCD (extrinsic)  $c\bar{c}$ -fusion mechanism of  $c\bar{c}$ -pair production at large rapidities or Feynman- $x$ . At high energies and large rapidities of charm meson one tests gluon distributions at extremely small  $x$ . We show that the IC contribution can be, to some extent, tested at the LHC by the FASER and at the SPS by the SHIP experiments by studies production of the  $\nu_\tau$  neutrinos coming from the decay of open charm meson.

In addition, we will show that the IC contribution to forward production of open charm meson has important consequences for understanding high-energy neutrino flux measured by the IceCube Neutrino Observatory. We will present our new constrain on the size of the intrinsic charm content in the nucleon coming from the IceCube data. The results of relevant numerical studies with off-shell small- $x$  partons will be shown. Both scenarios with and without saturation effects will be discussed.

Based on:

[1] R. Maciuła, and A.Szczurek, "Intrinsic charm in the nucleon and charm production at large rapidities in collinear, hybrid and  $T$ -factorization approaches", J. High Energy Phys. 10 (2020) 135.

[2] V.P. Goncalves, R. Maciuła, and A.Szczurek, a paper in prepration.

## Collaboration

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