

# Transverse-momentum-dependent wave functions and soft functions at one-loop in large momentum effective theory

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In large-momentum effective theory (LaMET), the transverse-momentum dependent (TMD) light-front wave functions and soft functions can be extracted from the simulation of a four-quark form factor and equal-time correlation functions. In this work, using expansion by regions we provide a one-loop proof of TMD factorization of the form factor. For the one-loop validation, we also present a detailed calculation of  $O(\alpha_s)$  perturbative corrections to these quantities, in which we adopt a modern technique for the calculation of the TMD form factor based on the integration by part and differential equation. The one-loop hard functions are then extracted. Using lattice data from Lattice Parton Collaboration on quasi-TMDWFs, we estimate the effects from the one-loop matching kernel and find that the perturbative corrections depend on the operator to define the form factor, but are less sensitive to transverse separation. These results will be helpful in precisely extracting the soft functions and TMD wave functions from the first principle in the future.

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