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Deep learning jet modifications in heavy-ion collisions

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Jet interactions with the hot QCD medium created in heavy-ion collisions are conventionally assessed by measuring the modification of the distributions of jet observables with respect to a proton-proton baseline. However, the steeply falling production spectrum introduces a strong bias toward small energy losses that obfuscates a direct interpretation of the impact of medium effects in the measured jet ensemble.

To tackle this issue, we employ a convolutional neural network, trained on jet images from the hybrid strong/weak coupling model, in order to extract the "original" or "initial'" transverse momentum of a given jet. Relying on the time scale separation between highly-virtual vacuum like processes and medium induced ones, one can define this "initial" energy as the energy of a jet within a cone of R as determined by the early times vacuum-like evolution, before medium effects become relevant. Despite many sources of fluctuations, we achieve good performance. Furthermore, by making use of alternative setups of networks and inputs, we are able to discuss the interpretability of our results.

With a well-predicted energy loss ratio, we study a set of jet substructure observables to estimate their sensitivity to selection bias effects and reveal their medium modifications when compared to a more equivalent jet population, i.e. a set of jets with similar initial energy. We show how this new technique provides unique access to the initial configuration of jets over the transverse plane of the nuclear collision, both with respect to their production points and initial orientations. As a relevant example, we demonstrate the capability of our method to locate with precision the production point of a dijet pair in the nuclear overlap region, in what constitutes an important step forward towards the long term quest of using jets as tomographic probes of the quark-gluon plasma. Finally, we also discuss the classification task of quark- versus gluon-initiated jets in heavy ion collisions with deep learning.

[1] Yi-Lun Du, Daniel Pablos, Konrad Tywoniuk, Deep learning jet modifications in heavy-ion collisions, arXiv:2012.07797 [hep-ph], JHEP. 2021, 206 (2021)

[2] Yi-Lun Du, Daniel Pablos, Konrad Tywoniuk, Jet tomography in heavy ion collisions with deep learning, arXiv:2106.11271 [hep-ph], Phys. Rev. Lett. 128, 012301 (2022)

[3] Yi-Lun Du, Daniel Pablos, Konrad Tywoniuk, Classification of quark and gluon jets in hot QCD medium with deep learning, arXiv: 2112.00681 [hep-ph],
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