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Deep learning jet modifications in heavy-ion collisions

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Jet interactions in a hot QCD medium created in heavy-ion collisions are conventionally assessed by measuring the modification of the distributions of jet observables with respect to the 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. In this talk, we will explore the power of deep learning techniques to tackle this issue on a jet-by-jet basis.

Toward this goal, we employ a convolutional neural network (CNN) to diagnose such modifications from jet images where the training and validation is performed using the hybrid strong/weak coupling model. By analyzing measured jets in heavy-ion collisions, we extract the original jet transverse momentum, i.e., the transverse momentum of an identical jet that did not pass through a medium, in terms of an energy loss ratio. Despite many sources of fluctuations, we achieve good performance and put emphasis on the interpretability of our results. We observe that the angular distribution of soft particles in the jet cone and their relative contribution to the total jet energy contain significant discriminating power, which can be exploited to tailor observables that provide a good estimate of the energy loss ratio.

With a well-predicted energy loss ratio, we study a set of jet observables to estimate their sensitivity to 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. Then, 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 point and initial orientation. Finally, we demonstrate the capability of our new method to locate with unprecedented 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.

[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)

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