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Deep learning for flow observables in ultrarelativistic heavy-ion collisions

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We train a deep convolutional neural network to predict hydrodynamic results for flow coefficients, average p_T and charged particle multiplicities in ultrarelativistic heavy-ion collisions from the initial energy density profiles event-by-event [1]. We show that the network can be trained accurately enough so that it can reliably predict the hydrodynamic results for the flow coefficients and, remarkably, also their correlations like normalized symmetric cumulants, mixed harmonic cumulants and flow-p_T correlations. At the same time the required computational time decreases by several orders of magnitude. To demonstrate the effectiveness of the neural network, we train it using 5k hydro events, and validate it using 90k events per collision energy. The events are computed from the pQCD + saturation + hydrodynamics -based EKRT framework supplemented with a dynamical decoupling condition that improves the description of peripheral collisions [2]. We then generate 10M events using neural network and show that increasing the number of events from 90k to 10M can have significant effects on certain statistics-expensive flow correlations. Neural networks will therefore enable adding statistics-expensive flow correlations to the global Bayesian analysis with a fraction of computation time compared to the current state-of-the-art procedures [3].

[1] H. Hirvonen, K. J. Eskola and H. Niemi, arXiv:2303.04517 [hep-ph]
[2] H. Hirvonen, K. J. Eskola and H. Niemi, Phys. Rev. C 106, no.4, 044913 (2022)
[3] H. Hirvonen, J. Auvinen, K. J. Eskola and H. Niemi, in preparation

Category

Theory

Collaboration (if applicable)

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