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Femtoscale Imaging of Nuclei Using High-performance Computing

Wednesday 22 March 2023 11:30 (10 minutes)

Subatomic particles have a size of about one femtometer and are studied through measurement of scattering events at various particle accelerator facilities around the world. An experimental event is a particle collision that triggers a detector response, which then collects various signals that allows the properties of the measured final state particles to be reconstructes. For imaging quarks and gluons at the femtoscale the challenge is they never reach a detector. This is a unique challenge in all of science, because the elementary degrees of freedom (quarks and gluons) are not those directly accessible in experiment. Our project aims to develop a framework that can extract the maximum amount of information on a quark and gluon tomography of nucleons and nuclei from high-energy scattering data. To achieve this goal of maximal information it is essential to compare theory and experiment at the most fundamental level. We are developing a workflow for the extraction of QCFs from an event-level analysis of experimental data with four connected modules. Module 1 generates QCFs using a deep neural network. Module 2 constructs particle momentum distributions (PMDs) and generates idealized theory events using Markov chain Monte Carlo. Module 3 incorporates detector effects to create simulated events. Module 4 compares the simulated and measured events using a discriminator. This process repeats until the simulated and experimental events correspond to the same theory by a given measure. The complexity of this workflow can increase dramatically because module 2 can represent many processes giving different PMDs and idealized events that correspond to the same QCFs. Then module 3 can represent many detectors from different experiments generating a larger set of simulated events that must be compared with experimental events from different sources. This is a new computational paradigm for the field and several possibilities of collaboration and innovation exist.

JLESC topic

Numerical methods and algorithms

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