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A Library for ML-based Fast Calorimeter Shower Simulation at Future Collider Experiments and Beyond

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Experiments at current and future colliders rely fundamentally on precise detector simulation. While traditional simulation approaches based on Monte Carlo techniques provide a high degree of physics fidelity, they place an enormous burden on the available computational resources. This is particularly true of particle showers created in the calorimeters, which have been a focus of fast simulation efforts. Approaches based on deep generative models have proved to be particularly promising options to provide significant reductions in computing times, while also being sufficiently accurate.

While numerous generative models designed for this task have been studied in the literature, less attention has been given to interfacing these models with the existing software ecosystems. This is an essential step if a model is to be eventually deployed in a production environment. It also provides a means to evaluate the physics performance of a fast shower simulation model after reconstruction, which ultimately dictates its suitability as a fast simulation tool.

In this contribution we describe DDFastShowerML, a library now available in Key4hep. This generic library provides a means of combining inference of generative models trained to simulate calorimeter showers with the DD4hep toolkit, using the fast simulation hooks that exist in Geant4. This makes it possible to simulate showers in realistically detailed detector geometries, such as those proposed for use at future colliders and for community challenges, while seamlessly combining full and fast simulation. The flexibility of the library will be demonstrated through examples of different models that have been integrated, and different detector geometries that have been studied. An overview of future plans will also be presented.

Track

Detector simulation & event generation

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