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SUPA: A Lightweight Diagnostic Simulator for Machine Learning in Particle Physics.

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Deep learning methods have gained popularity in high energy physics for fast modeling of particle showers in detectors. Detailed simulation frameworks such as the gold standard GEANT4 are computationally intensive, and current deep generative architectures work on discretized, lower resolution versions of the detailed simulation.
The development of models that work at higher spatial resolutions is currently hindered by the complexity of the full simulation data, and by the lack of simpler, more interpretable benchmarks.

Our contribution is SUPA, the SUrrogate PArticle propagation simulator, an algorithm and software package for generating data by simulating simplified particle propagation, scattering and shower development in matter. The generation is extremely fast and easy to use compared to GEANT4, but still exhibits the key characteristics and challenges of the detailed simulation. We support this claim experimentally by showing that performance of generative models on data from our simulator reflects the performance on a dataset generated with GEANT4. The proposed simulator generates thousands of particle showers per second on a desktop machine, a speed up of up to 6 orders of magnitudes over GEANT4, and stores detailed geometric information about the shower propagation. SUPA provides much greater flexibility for setting initial conditions and defining multiple benchmarks for the development of models. Moreover, interpreting particle showers as point clouds creates a connection to geometric machine learning and provides challenging and fundamentally new datasets for the field.

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