



Contribution ID: 184

Type: Parallel talk

## Point-cloud based diffusion model for hadronic showers

Simulating showers of particles in highly-granular detectors is a key frontier in the application of machine learning to particle physics. Achieving high accuracy and speed with generative machine learning models can enable them to augment traditional simulations and alleviate a major computing constraint.

Recent developments have shown how diffusion based generative shower simulation approach that do not rely on a fixed structure, but instead generates geometry-independent point clouds, are very efficient. We present a novel transformer-based architecture as an extension to the CaloClouds 2 architecture that was previously used for simulating electromagnetic showers in the highly granular electromagnetic calorimeter of ILD. The attention mechanism allows to generate complex hadronic showers from pions with more pronounced substructure in the electromagnetic and hadronic calorimeter together. This is the first time that ML methods are used to generate hadronic showers in highly granular imaging calorimeters.

### AI keywords

transformers, diffusion model, fast simulations, point clouds

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**Track Classification:** Simulations & Generative Models