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Advancing Generative Modelling of Calorimeter Showers on Three Frontiers

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Traditional physics simulations are fundamental in the field of particle physics. Common simulation tools like Geant4, are very precise, but comparatively slow. Generative machine learning can be used to speed up such simulations.
Calorimeter data can be represented either as images or as point clouds, i.e. permutation-invariant lists of measurements.
We advance the generative models for calorimeter showers on three frontiers:
1) increasing the number of conditional features for precise energy- and angle-wise generation with the bounded bottleneck auto-encoder (BIB-AE),
(2) improving generation fidelity using a normalizing flow model, dubbed Layer-to-Layer-Flows" (L2LFlows),
(3) developing a diffusion model for geometry-independent calorimeter point cloud scalable to $\mathcal{O}(1000)$ points, called CaloClouds, and distilling it into a consistency model for fast single-shot sampling.

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