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CaloFlow for CaloChallenge

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Simulating particle detector response is the single most computationally expensive step in the Large Hadron Collider computational pipeline. Recently it was shown that normalizing flows can accelerate this process while achieving unprecedented levels of accuracy (CaloFlow).

Applying CaloFlow to the photon and charged pion GEANT4 showers of Dataset 1 of the Fast Calorimeter Simulation Challenge 2022, we are able to produce samples of high-fidelity with a sampling time less than 0.1ms per shower. We demonstrate the fidelity of the samples using calorimeter shower images, histograms of high level features, and aggregate metrics such as a classifier trained to distinguish generated from GEANT4 samples.

Scaling this approach up to higher resolutions relevant for future detector upgrades introduces prohibitive memory constraints. We introduce a fast detector simulation based on an inductive series of normalizing flows which overcomes this problem. By training the flow on the pattern of energy deposition in both the current and previous layer of a GEANT event, Inductive CaloFlow is capable of efficiently generating new events even for large calorimeter geometries. We demonstrate our architecture using CaloChallenge Datasets 2 and 3, and demonstrate they reproduce GEANT-like events at higher fidelity than previously possible.

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Session Classification: Generative Models – Detector Level