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End-to-end optimization of a Muon Collider calorimeter

Setup design is a critical aspect of experiment development, particularly in high-energy physics, where decisions influence research trajectories for decades. Within the MODE Collaboration, we aim to generalize Machine Learning methodologies to construct a fully differentiable pipeline for optimizing the geometry of the Muon Collider Electromagnetic Calorimeter.

Our approach leverages Denoising Diffusion Probabilistic Models (DDPMs) for signal generation and Graph Neural Networks (GNNs) for photon reconstruction in the presence of Beam-Induced Background from muon decays. Through automatic differentiation, we integrate these components into a unified framework that enables end-to-end optimization of calorimeter configurations. We present the structure of this pipeline, discuss key generation and reconstruction techniques, and showcase the latest results on proposed geometries.

AI keywords

generative models; graph neural networks; automatic differentiation; simulation-based optimization

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