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Generative AI for full-detector, whole-event simulation of heavy ion collisions

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Artificial intelligence (AI) generative models, such as generative adversarial networks (GANs), have been explored as alternatives to traditional simulations but face challenges with training instability and sparse data coverage. This study investigates the effectiveness of denoising diffusion probabilistic models (DDPMs) for full-detector, whole-event heavy-ion collision simulations as a surrogate model for the traditional Geant4 simulation method. DDPM performance in sPHENIX calorimeter simulation data is compared with GANs. DDPMs outperform GANs and exhibit superior stability and consistency across central and peripheral heavy-ion collision events. Additionally, DDPMs offer a substantial speedup, being approximately 100 times faster than the traditional Geant4 simulation method.

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