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Computing the Matrix Element Method with generative machine learning

The Matrix Element Method (MEM) is a powerful technique for computing the event-by-event likelihood for a given theory hypothesis, simultaneously accounting for both detector effects and theoretical models. Despite its strong theoretical foundation, MEM is seldom used in analyses involving final states with many jets due to the complex, multi-dimensional integrals required to accurately model detector reconstruction effects through precise transfer functions. In this contribution, we implement a new approach leveraging Transformers and generative ML models to sample parton-level events for efficient numerical MC integration and to encode the complex transfer function which models showering, hadronization, and detector reconstruction. We demonstrate this strategy on a complex final state, the ttH(bb) process in the semileptonic decay channel, using the full CMS detector simulation and reconstruction. Furthermore, we show that this method can be generalized and applied to multiple physics processes using a single ML model.

AI keywords

Transformers; generative ML models;simulation-based inference

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