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Observable Optimization for Precision Theory: Machine Learning Energy Correlators

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The practice of collider physics typically involves the marginalization of multi-dimensional collider data to uni-dimensional observables relevant for some physics task. In any cases, such as classification or anomaly detection, the observable can be arbitrarily complicated, such as the output of a neural network. However, for precision measurements, the observable must correspond to something computable systematically beyond the level of current simulation tools. In this work, we demonstrate that precision-theory-compatible observable space exploration can be systematized by using neural simulation-based inference techniques from machine learning. We illustrate this approach by exploring the space of marginalizations of the energy 3-point correlator to optimize sensitivity to the the top quark mass. We first learn the energy-weighted probability density from simulation, then search in the space of marginalizations for an optimal triangle shape. Although simulations and machine learning are used in the process of observable optimization, the output is an observable definition which can be then computed to high precision and compared directly to data without any memory of the computations which produced it

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