Comparing Parton-Shower Models in Top-Quark Production and Reweighting Between Models with Machine Learning

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Abstract

Accurate modeling of parton-shower dynamics is essential for precision studies of top-quark production. In our setup, next-to-leading-order matrix-element events are generated with POWHEG, which can be interfaced with different parton-shower approaches. These include the transverse-momentum-ordered dipole shower of Pythia8 and the antenna-based shower implemented in Vincia. Their distinct approximations can lead to notable differences in jet and jet-substructure observables.

In this work, we study $pp \to t\bar{t} \to$ semileptonic events produced with POWHEG+Pythia8 and POWHEG+Vincia, comparing the $t\bar{t}$ system kinematics, jet characteristics, and jet-substructure variables such as N-subjettiness, generalised angularities, and energy-correlation functions. Furthermore, we use the DCTR (Deep neural networks using Classification for Tuning and Reweighting) technique to reweight Pythia8 events such that they reproduce Vincia-like distributions, without requiring the computationally expensive step of re-running the full detector simulation. This study highlights key differences between parton-shower models and demonstrates the potential of machine-learning-based reweighting to efficiently bridge them.