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Low-p_T b-jet tagging with machine learning and graph neural networks for Z'->bb- searches

Identifying jets originating from bottom quarks is essential for precision measurements of the Standard Model and searches for physics beyond it. The task becomes particularly challenging in the low-transverse-momentum regime, where conventional b-tagging observables become less discriminating. In this work, we develop and evaluate machine-learning-based b-jet classifiers specifically targeting low-p_T jets and study their application to the reconstruction of a light Z'->bb- resonance.

Monte Carlo samples containing b, c, gluon and light-flavor jets are generated using MadGraph5_aMC@NLO, PYTHIA8 and DELPHES. Jets are reconstructed with the anti-k_T algorithm using R=0.4. Jet-level and track-level information, including transverse momentum, multiplicities and impact-parameter-related observables, is used as input to several classifiers. Random Forest and Boosted Decision Tree models are used as baselines, while a graph neural network based on the HMPNet architecture represents each jet as a graph whose nodes correspond to reconstructed tracks.

The models are evaluated at both jet and event level using ROC curves, AUC, efficiency, purity and confusion matrices. The HMPNet-based classifier reaches an AUC of approximately 0.915 in the current validation setup. An event-level working point is defined by requiring at least one jet in the event to exceed a fixed b-tagging score threshold.

The selected classifier is subsequently applied to simulated Z'->bb- samples with Z' masses between 30 and 80 GeV. The signal samples are generated at sqrt{s}=13.6 TeV with generator-level jet requirements p_T>5 GeV, eta|<5, Delta R>0.4, and dynamically computed Z' widths. Preliminary studies investigate how b-tagging affects the reconstructed dijet invariant-mass distribution, its peak position and resolution. These results provide a framework for assessing the potential of specialized low-p_T b-tagging techniques in searches for light resonances decaying to bottom quarks.

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