

On the Tau Polarization Estimation in One-Prong Hadronic Decays at the LHC

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The Standard Model (SM) remains the most successful framework for describing particle interactions, yet it leaves key questions unresolved, including possible Lepton Flavor Universality (LFU) violation. Many proposed extensions of the SM predict new particles that couple preferentially to tau leptons, such as S1 and U1 leptoquarks, Z'_{B-L} bosons, and Type-II Two-Higgs-Doublet Models. Testing these scenarios requires precise reconstruction of tau polarization, a key observable for distinguishing between scalar and vector particles in both resonant and non-resonant signatures with taus in the final state.

This work focuses on improving the distributions used to estimate the likelihood of tau polarization in events with one charged-prong hadronic tau decay by refining existing maximum-likelihood techniques, such as those used by the ATLAS collaboration, through machine learning approaches—specifically Boosted Decision Trees (BDTs). These enhanced polarization estimators enable more accurate discrimination between different particle hypotheses and increase the sensitivity to new physics. Monte Carlo simulations are employed to evaluate their performance in the context of the proposed models, assessing how background effects and model-specific kinematics influence the reconstructed polarization.

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