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Sensitivity estimates of the VH(cc) process in the Lorentz-boosted regime

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Following the first measurements of the Higgs couplings to vector bosons and third-generation fermions at the LHC, it is essential to probe the Higgs couplings to second-generation fermions, such as the charm quark. Motivated by the increased performance of flavour identification algorithms, this work presents the first sensitivity estimates of the VH(cc) process in the Lorentz-boosted regime, utilizing Run-2 simulation samples at 13 TeV. As a baseline approach, we developed an indirect boosted flavour-tagger by tagging variable-radius track-jets using the state-of-the-art Run-2 flavour-tagger DL1r, which led to an estimated 18% significance improvement at pTV > 400 GeV. To improve upon this, the deployment of the next-generation boosted flavour-tagger GN2X allows for higher signal efficiency with increased background rejection. We further improved event selection by optimizing the GN2X-based Hcc-discriminant, resulting in up to 10% sensitivity gain. Additionally, the application of a boosted decision tree using six event-level and six subjet-level variables resulted in sensitivity gains up to 50%. To correct for differences between the flavour-tagger efficiency in simulation and data, we applied an in-situ calibration, increasing the VH(cc) signal strength uncertainty by an additional 8.5%. Accounting for the calibration, the expected VH(cc) signal strength is found to be 1.00 ± 4.98. Overall, the boosted approach demonstrates substantial improvements over resolved methods in the high-pT regime. Numerous opportunities for further advancements remain, including (pseudo-)continuous flavour-tagging, advanced MVA techniques, and the integration of Run-3 collision data.

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