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Interpretable machine learning for probing kinematic shapes

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The associated production of a $b\bar{b}$ pair with a Higgs boson could provide an important probe to both the size and the phase of the bottom-quark Yukawa coupling, y_b. However, the signal is shrouded by several background processes including the irreducible $Zh, Z \to b\bar{b}$ background. We show that the analysis of kinematic shapes provides us with a concrete prescription for separating the y_b-sensitive production modes from both the irreducible and the QCD-QED backgrounds using the $b\bar{b}\gamma\gamma$ final state. We draw a page from game theory and use Shapley values to make Boosted Decision Trees interpretable in terms of kinematic measurables and provide physics insights into the variances in the kinematic shapes of the different channels that help us complete this feat. Adding interpretability to the machine learning algorithm opens up the black-box and allows us to cherry-pick only those kinematic variables that matter most in the analysis. We resurrect the hope of constraining the size and, possibly, the phase of y_b using kinematic shape studies of $b\bar{b}h$ production with the full HL-LHC data and at FCC-hh.

Presenter: PAUL, Ayan (T (Phenomenology))

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