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Unveiling Light-Quark Yukawa Flavor Structure via Dihadron Fragmentation at Lepton Colliders

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Directly probing light-quark Yukawa couplings and their flavor structure remains a major challenge due to their smallness and overwhelming QCD backgrounds. In this Letter, we propose a theoretical framework to access these couplings at future lepton colliders through transverse spin dependent azimuthal modulations in dihadron fragmentation.

These modulations arise from the interference between Higgs mediated and Standard Model (SM) amplitudes in $e^-e^+ \to q\bar{q}Z$, producing angular structures that are linearly sensitive to the Yukawa couplings y_q, in contrast to conventional observables that scale as y_q^2. By combining channels with an identified accompanying single hadron, $h' = \pi^{\pm}, K^{\pm}$, and $p/\bar{p}$, this approach cleanly disentangles the up- and down-quark Yukawa contributions, yielding typical limits at the $\mathcal{O}(10^{-3})$ level and establishing fragmentation dynamics as a novel and complementary probe of the Higgs flavor structure.

Primary author: Prof. YAN, Bin (IHEP)

Presenter: Prof. YAN, Bin (IHEP)

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