Contribution ID: **111** Type: **not specified**

How large can the light Yukawa couplings be?

Tuesday 27 May 2025 15:00 (20 minutes)

The couplings of the Higgs boson to the massive gauge bosons, the third-generation quarks, the tau and the muon leptons have been measured and found to be in agreement with the predictions of the Standard Model. In contrast, the couplings to the first and second quark generations and to the electron are beyond experimental reach: the combination of their smallness and, for the quarks, the difficulty of tagging the particles in the detectors make the measurement of the Yukawa couplings of the light fermions experimentally challenging.

In our study we identify simplified UV models involving pairs of vector-like quarks which can generate significant enhancements of the quark Yukawa couplings. These models generate operators of the Standard Model Effective Field Theory at the tree-level and one-loop which are constrained by electroweak precision observables, Higgs data, and flavor physics. Accounting for such bounds, as well as the results of direct searches for vector-like quarks, considerable deviations in the Yukawa couplings of the light quark generations can still be obtained: first-generation quark Yukawa couplings are found to be enhanced up to several hundred times their Standard Model value, while the Higgs couplings to charm (strange) quarks can be increased by factors of a few (few tens). Electroweak Physics is found to play a significant role and we therefore also discuss projections for future measurements at the FCC-ee machine. In a similar spirit, we also consider how large deviation in the electron Yukawa coupling can become in concrete models in the light of the possibility of probing it in a dedicated run at the Higgs pole mass at the FCC-ee.

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Session Classification: Collider Higgs Physics