Snowmass LoI: Probing the Charm Yukawa coupling at the LHC

Ben Carlson [*1], Tao Han [†1], and Sze Ching Leung **(contact person)** [‡1]

[1] *PITT PACC, Department of Physics and Astronomy, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260, USA*

To date, Higgs couplings to third generation fermions have all been observed with over 5σ significance. Direct observations of the Higgs couplings to the second generation of fermions are thus of critical importance to further confirm the non-universal pattern of Yukawa couplings. More importantly, any deviations from SM predictions can direct to new physics. The purpose of this LoI is to show our interest and the on-going work in studying the loosely-constrained charm-Higgs Yukawa coupling in the future LHC experiments.

The decay $H \to c\bar{c}$ is not only difficult to trigger on, but also challenging to distinguish from large multi-jet backgrounds. There have been two experimental probes of the charm Yukawa coupling being carried out. One approach is to use Higgs association production with a leptonically decaying Z boson (ZH channel). It provides a constraint of 110 times the SM rate at 36.1 fb^{-1} [1] and a projection of 6 times the SM rate at HL-LHC [2]. Another approach uses the decay of a Higgs boson into J/ψ and a photon, giving a looser bound on charm Yukawa coupling of 50 times the SM prediction even at HL-LHC [3], due to vector meson dominance in $\gamma^* - J/\psi$ mixing.

In our study, we propose to directly probe charm Yukawa coupling via vector boson fusion (VBF) with an additional photon [4]. First, VBF channel has striking experimental signature where a central Higgs is accompanied by two light jets with large rapidity gap. It can provide complementary information to existing ZH channel. Second, the addition of the photon give an additional handle to the trigger. Third, for multi-jet final states the photon suppresses the gluon-initiated multi-jet background. In our study, we focus on is $qqH(\to c\bar{c})\gamma$. Backgrounds include non-resonant $c\bar{c}jj\gamma$ background and $Z + \text{jets} + \gamma$. Our preliminary cut-based analysis on parton-level samples with only the signal and the dominant non-resonant background showed that the sensitivity of this channel is comparable to the existing ones, which is quite promising and worth pursuing.

References

[1] M. Aaboud et al. Search for the Decay of the Higgs Boson to Charm Quarks with the ATLAS Experiment. Phys. Rev. Lett., 120(21):211802, 2018.

[2] Morad Aaboud et al. Prospects for $H \to c\bar{c}$ using Charm Tagging with the ATLAS Experiment at the HL-LHC. 2018.

[*] bcarlson@pitt.edu
[†] than@pitt.edu
[‡] szl13@pitt.edu

[3] Morad Aaboud et al. Search for the Standard Model Higgs and Z Boson decays to $J/\psi\,\gamma$: HL-LHC projections. 9 2015.

[4] Morad Aaboud et al. Search for Higgs bosons produced via vector-boson fusion and decaying into bottom quark pairs in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector. Phys. Rev. D, 98(5):052003, 2018.