# Phenomenology of the Higgs and flavour in the Standard Model and beyond

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Since the discovery of the Higgs boson in 2012 at the Large Hadron Collider (LHC), most of its properties have been already measured with increasing accuracy. However, few of the Higgs's main features are yet to be probed. The future runs of the LHC holds a lot of potential for further understanding of the Higgs boson's properties.

One of the challenges for the future runs of the LHC is that many of Higgs production processes are plagued by large theoretical uncertainties. In order to reduce them, these processes need to be computed at higher precision. One of such processes is the production of the Higgs with another particle called the $Z$ boson. This is a key process in measuring both the Higgs mass and its coupling to the $Z$ boson with more precision. My collaborators and I have preformed such calculation using a novel method that can be used alongside other calculations via Padé approximants and then incorporated into Monte Carlo simulations [1].

In an another project, we have studied the correlations between the Higgs self-interaction and other set of interactions involving four heavy quarks. Both interaction classes are equally weakly constrained from current LHC data. Using Markov-chain Monte Carlo (MCMC) Bayesian analysis, we have seen that there is a strong correlations amongst these observables. Revealing many challenges to probing Higgs self-coupling using current Higgs measurements [2].

The only direct way to study the Higgs self-coupling is to search for Higgs bosons produced in pairs. A process that is sought after in the High-Luminosity (HL)-LHC. We have used interpretable machine learning to improve upon the expected sensitivity of the HL-LHC and future colliders to this process. We were able to constrain both the Higgs's self interaction and its interaction with light quarks, and show that they are uncorrelated from this process [3, 4].

Since 2015, experimental data was hinting towards an anomaly involving the decay of composite particles known as $B$-mesons that could be a result of new physics beyond the Standard Model. We have used (MCMC) Bayesian analysis to show that the parameters characterising new physics in these decays are strongly related to other set of parameters in the Standard Model related to the interaction between the $Z$ and Higgs bosons, and muons [5].

# Publications


[1] L. Alasfar, G. Degrassi, P. P. Giardino, R. Gröber, and M. Vitti, "Virtual corrections to $gg \to ZH$ via a transverse momentum expansion," *JHEP* **05** (2021) 168, arXiv:2103.06225 [hep-ph].

[2] L. Alasfar, J. de Blas, and R. Gröber, "Trilinear Higgs self-coupling and four quark operators from single Higgs data," To be published [hep-ph].

[3] L. Alasfar, R. Corral Lopez, and R. Gröber, "Probing Higgs couplings to light quarks via Higgs pair production," *JHEP* **11** (2019) 088, arXiv:1909.05279 [hep-ph].

[4] L. Alasfar, C. Grojean, R. Gröber, A. Paul, and Q. Zhuoni, "Machine learning augmented probes of light-quark Yukawa and trilinear couplings from Higgs pair production," To be published [hep-ph].

[5] L. Alasfar, A. Azatov, J. de Blas, A. Paul, and M. Valli, "$B$ anomalies under the lens of electroweak precision," *JHEP* **12** (2020) 016, arXiv:2007.04400 [hep-ph].