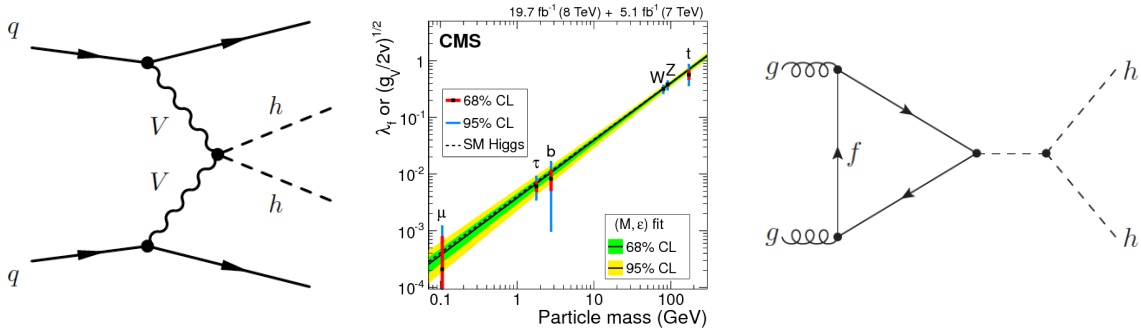
Probing electroweak symmetry breaking with Higgs pair production

Master project, Theoretical Physics and GRAPPA tracks, MSc Physics and Astronomy

The measurement of Higgs pair production will be a cornerstone of the LHC program in the coming years. Double Higgs production provides a crucial window upon the mechanism of electroweak symmetry breaking, and has a unique sensitivity to a number of currently unknown Higgs couplings, like the Higgs self-coupling λ and the coupling between a pair of Higgs bosons and two vector bosons.

In this project, the student will explore the feasibility of the measurement of Higgs pair production in the $b\bar{b}b\bar{b}$ final state both at the LHC and at future 100 TeV collider [1]. A number of production modes will be considered, including gluon-fusion [2,3], vector-boson-fusion [4], as well as Higgs pair production in association with a top-quark pair. A key ingredient of the project will be the exploitation of multivariate techniques such as Artificial Neural Networks and other multivariate discriminants to enhance the ratio of di-Higgs signal over backgrounds. The use of these modern techniques based on Machine Learning is instrumental for this project due to the combination of small event rates and large QCD backgrounds for the $b\bar{b}b\bar{b}$ final state.

The project involves to estimate the precision that can be achieved in the extraction of the Higgs self-coupling λ for a number of assumptions about the performance of the LHC detectors, and in particular to quantify the information that can be extracted from the Run II dataset with $\mathscr{L} = 300$ fb^{-1}. A similar approach will be applied to the determination of other unknown properties of the Higgs sector, such as c_{VV}, the coupling between two Higgs bosons and two weak vector bosons, as well as the Wilson coefficients of higher-dimensional operators in the Standard Model Effective Field Theory (SM-EFT), which encode the sensitivity to New Physics at higher scales not directly accessible at the LHC.



For more information about this project, please contact Dr. Juan Rojo at j.rojo@vu.nl.

References

[1] R. Contino et al., Physics at a 100 TeV pp collider: Higgs and EW symmetry breaking studies, arXiv:1606.09408.

[2] J. K. Behr, D. Bortoletto, J. A. Frost, N. P. Hartland, C. Issever, and J. Rojo, Boosting Higgs pair production in the $b\bar{b}b\bar{b}$ final state with multivariate techniques, Eur. Phys. J. C76 (2016), no. 7 386, [arXiv:1512.08928].

[3] M. Gouzevitch, A. Oliveira, J. Rojo, R. Rosenfeld, G. P. Salam, and V. Sanz, Scale-invariant resonance tagging in multijet events and new physics in Higgs pair production, JHEP 07 (2013) 148, [arXiv:1303.6636].

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