PhD research proposal

Higgs boson decays to WW as a probe for new physics at CMS

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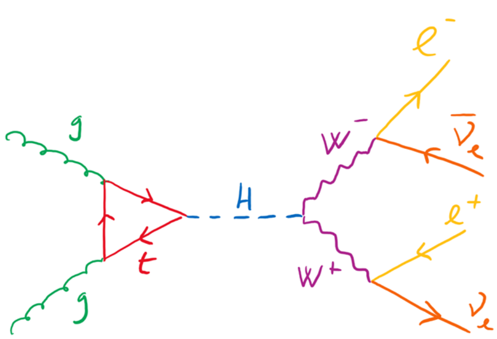
After the Higgs boson discovery announced by the CMS and ATLAS collaborations in 2012, the precision measurement of its properties has become one of the main priorities of the two experiments.
The proton-proton collisions at a center-of-mass energy of 13 TeV delivered during the Run 2 of the CERN Large Hadron Collider (LHC) allowed the collection of a large data sample, which opened new frontiers to study the details of Higgs boson physics and represented a change of paradigm: from seeking the Higgs boson to performing precision measurements. The large available data sample also made it possible to extend the experiments' physics potential by using the Higgs boson as a probe for new physics, such as searches for dark matter or new high mass resonances.
These are key measurements to expand our knowledge of the Higgs boson sector and of particle physics in general.
Moreover, the LHC very recently restarted breaking the new proton collision energy world record of 13.6 TeV. This marked the beginning of a new data taking period known as Run 3, extending even further the new physics reach of the CMS experiment.



Among the Higgs boson decay channels, the one to a W boson pair (H→WW) followed by the leptonic W boson decays is characterized by a large branching ratio and a good signal sensitivity, besides the significant contamination of background processes sharing a similar final state. These features make the H→WW channel the perfect candidate both for precision measurements and for new physics searches.

The evidence of dark matter particles is provided by astrophysical and cosmological observations. Nevertheless, the Higgs boson production at the LHC can serve as a unique portal to the dark sector. The typical signature in this case would be a Higgs boson decaying to a W boson pair, recoiling against large missing energy associated with the non-interacting dark matter particles.

In addition, the search for production of Higgs boson-like resonances with high mass (up to several TeV) is also an extremely important direct probe of new physics, and the WW decay channel can be exploited in this case to achieve a very good sensitivity.

The goal of the PhD research proposal is to exploit the H->WW process as a probe for new physics in a wide range of models.

The PhD student will exploit the new LHC Run 3 data to study these processes at the unprecedented center-of-mass energy of 13.6 TeV. The PhD student is expected to contribute to the understanding and calibration of the relevant physics objects (electrons, muons, missing transverse energy, b-jets), the development of the analysis strategy leveraging Machine Learning techniques and generally take ownership of the responsibility of the analysis. They are also expected to spend a fraction of their time at CERN, to both carry out the analysis and participate and contribute to the data taking.

References and further reading

[1] Search for a heavy Higgs boson decaying to a pair of W bosons in proton-proton collisions at √s = 13 TeV, JHEP03(2020)034, doi: 10.1007/jhep03(2020)034

[2] Search for dark matter particles produced in association with a dark Higgs boson decaying into W^+W^- in proton-proton collisions at √s = 13 TeV with the CMS detector, CMS-PAS-EXO-20-013, https://cds.cern.ch/record/2776774

The research group

The hired PhD student will work in the context of the CMS Florence group. The group consists of 17 people, and includes staff personnel from the University and the INFN as well as five PhD students. The group is deeply involved in the upgrade of the CMS detector and in the data analysis. For the latter the reference persons are the ones mentioned at the beginning. Data analysis conducted in Florence revolves around final states with leptons, especially in the context of the characterization of the Higgs boson decay to W bosons. This context is ideal for the development of the proposed research, as it provides rich experience with all the physics objects that are relevant.