PHENIICS doctoral school **PhD thesis subject proposal 2018**

Laboratoire Leprince-Ringuet École Polytechnique

Unveiling the Vector Boson Fusion production mode to constrain the trilinear Higgs boson self-coupling

Overview of the research

The LHC main results after the end of Run-I and the beginning of Run-II are the firmly established observation of a Higgs boson by the ATLAS and CMS Collaborations and the subsequent property measurements. The broad picture indicates that the Higgs Boson looks Standard Model like, i.e. it is very consistent with expectations for a minimal scalar sector with one physical Higgs boson.

The Higgs boson is unlike anything we have seen before in Nature: it is a fundamental scalar particle of spin 0 (all other particles have spin 1 or 1/2), it has a potential proportional to the fourth power of its scalar field ϕ, and via the "Yukawa" interaction it is responsible of the fermion masses.

In the coming years the Higgs sector needs stress-testing. For example, it will be of utmost importance to reconstruct the scalar potential to verify that the Brout-Englert-Higgs mechanism is indeed responsible of the electroweak symmetry breaking. This requires to measure the trilinear Higgs boson self-coupling λ_{HHH}. One way to constrain it consists in measuring double-Higgs production, a second possibility consists in studying the effects that a modification of λ_{HHH} has at loop level in single-Higgs production and in particular on the Vector Boson Fusion (VBF) production mode.

Thesis project

The main objective of the PhD student is to constrain for the first time ever the trilinear Higgs boson self-coupling λ_{HHH} using the single-Higgs production.

The PhD student, who will undertake this project, will have different sub topics.

Firstly, he will use the Higgs boson "golden" channel ($H \to ZZ \to 4\ell$) to perform the first standalone observation of the VBF production mode in an exclusive final state.

Secondly, he will combine all Higgs boson final states to increase the statistical power and to improve the precision on the measurement of the VBF production mode.

Finally, he will constrain possible deviations in the trilinear Higgs boson self-coupling with the obtained VBF measurement. He will adopt an interpretation based on the Effective Field Theory (EFT) framework, in which the effects of new heavy particles are encoded in the Wilson coefficients of higher-dimensional operators (dimensions 6 - 8).

The analysis will be performed with proton-proton collisions data at $\sqrt{s}$ = 13 TeV collected with the CMS experiment at the LHC up to the end of 2018, corresponding to the whole LHC Run-II integrated luminosity up to 150 fb^{-1}.

Local team

The Thesis (or internship) will be conducted at Laboratoire Leprince-Ringuet (École Polytechnique) in the CMS group, in addition frequent stays at CERN are considered.
The group is a founding member of the CMS Collaboration. The group has designed and built the ECAL L1 trigger and it is responsible for its daily operation and monitoring. It has major involvement in particle reconstruction and identification with the e/gamma and tau Physics Object Groups. The group is strongly involved in some of the high priority Higgs analyses of CMS (e.g. $H \to 4l$ in various production modes or double-Higgs boson production in the $HH \to bb\tau\tau$ final state), and it has played a leading role in the discovery and properties measurement of a Higgs boson.

Master and doctoral school

M2 High-Energy Physics
PHENIICS doctoral school – Université Paris-Saclay

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