# Higgs boson trilinear self-coupling measurement at HL-LHC

Laboratoire Leprince-Ringuet

llr.in2p3.fr

LLR École Polytechnique
Route de Saclay
F – 91128 PALAISEAU Cedex

T. (33) 1 69 33 55 00
F. (33) 1 69 33 55 08
UMR 7638

**Claude Charlot**

T. (33) 1 69 33 55 42
charlot@llr.in2p3.fr

The measurement of the **Higgs boson trilinear self-coupling** is one of the major goal in current Higgs physics. While its value is fully determined in the standard model of particle physics once the Higgs boson mass is known, it determines the shape of the Higgs potential and its minimum at a non-zero average value of the Higgs field, which is at the heart of the electroweak symmetry breaking that gives mass to the W and Z weak bosons. The Higgs boson trilinear self-coupling can be experimentally determined at the CERN large hadron collider (LHC) from the **double Higgs (HH) production**, where the main contributions arise from an amplitude involving the Higgs trilinear self-coupling and another amplitude that involves a double Higgs boson production from top or bottom quark loops. One of the key feature of the HH production is the important destructive interference between the two above amplitudes. While studies have already been conducted at the LHC to measure the Higgs boson trilinear self-coupling with run 2 data, yielding constraints on the production cross-section of 3.4 times the standard model cross-section at 95% confidence level, a first measurement will be obtained at the HL-LHC that is expected to start in 2026 and to provide an order of magnitude more data. While prospective studies have been conducted to assess the sensitivity to the Higgs trilinear self-coupling at the HL-LHC, none has considered to date to try to separate the **background contribution involving top and bottom quark loops** from the contribution involving the trilinear self-coupling .

The student will conduct a **phenomenological study** of the HH production at the HL-LHC. He will study the possibility **to improve the sensitivity** to the Higgs boson self-coupling measurement at the HL-LHC, by studying the kinematic properties of the two main amplitudes contributing to the HH production and of the interference, in order to understand how best to separate the trilinear self-coupling contribution from the double Higgs production arising from top and bottom quarks couplings. The student will simulate signal and background events using the MadGraph Monte Carlo generator and the Delphes fast simulation package. He will search for ways to separate the two contributions, and will optimise the separation between the signal and interference contributions from the background contribution from top and bottom quarks coupling. The proposed phenomenology study is ideal for a master internship, whether or not it is followed by a PhD on the topic.

The student will benefit from the expertise of the **LLR CMS group** in the HH measurements at the LHC. The internship will be conducted within the LLR CMS group and a presentation of the results will be given at the end of the internship within the CMS LLR group and possibly within the CMS world-wide Higgs working group. A short **stay at CERN** will be foreseen during which the student will come to grip with the CMS experiment at CERN and will get in touch with physicists from the CMS collaboration world-wide working on Higgs measurements. Should the student continue for a PhD thesis in our group, he will be involved in the experimental measurements and searches conducted at LLR to better understand the nature of the Higgs boson and of the electroweak symmetry breaking.

Interested candidates should send an email to Claude Charlot (charlot@llr.in2p3.fr).

Sous la co-tutelle de

cnrs IN2P3 Les deux infinis

ÉCO PO UNIV