Laboratoire de Physique de Clermont-Ferrand, Université Clermont-Auvergne - CNRS/IN2P3

Master 2 Internship proposal

Study of the Higgs self-coupling with the ATLAS detector at LHC

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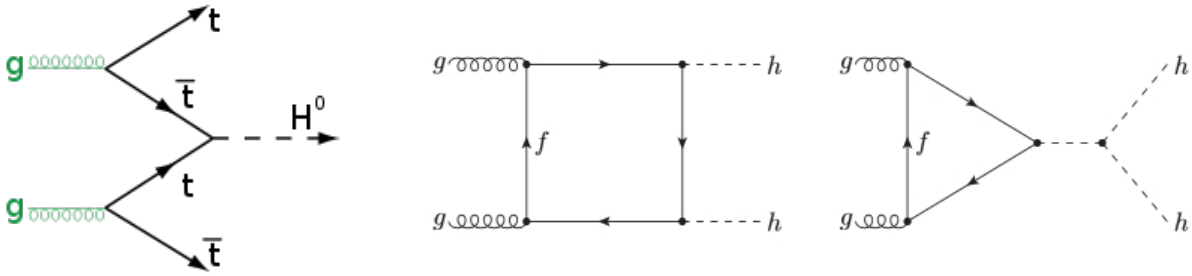
The Standard Model, the theory that describes forces and matter, predicts the existence of the Higgs boson and six quarks, the heaviest one being the Top quark. This particle plays a significant role in the Standard Model (SM). Its coupling to the Higgs boson is the most important one. Its value has a significant impact on the running of the Higgs self-coupling and on the stability of the Electro-Weak vacuum [1].

The discovery of the Higgs boson in 2012 opened the road to the study of its properties. The observation of its production and of its decay provides inputs to the test of the SM Higgs sector.
An evidence of the associated production of a Top quark pair with a Higgs boson (ttH) was reported in October 2017 by the ATLAS collaboration [2]. It was interpreted as an evidence for the Top Yukawa coupling at the tree level. This test has to be completed by a direct measurement of the Higgs self-coupling (λ_{hhh}). The measurement of λ_{hhh} gives a direct access to the Higgs potential and is considered as a key measurement of the High Luminosity LHC (Large Hadron Collider) program.



The ATLAS experiment is one of the large experiments of the LHC at CERN. The increased beam energy and the high luminosity, which is delivered by the collider since 2016, will

allow to perform direct measurements of several Higgs couplings. The Higgs self-coupling is accessible through the double Higgs production (HH).

The Higgs boson pair decay modes lead to a large variety of final states mainly combining W bosons, Z bosons, *b* quarks, photons and τ [3]. From an experimental point of view, several signatures can be used to identify an HH production and to discriminate it from background processes.

The trainee is expected to review possible HH signatures taking into account the experimental constraints: performance of objects identification by the detector (jets, leptons…).

After having experienced the different steps of a search analysis using ATLAS data, analysis optimisations will be performed on Monte Carlo simulations using statistical approaches. Final states based on leptonic signatures, with 2 same-charge or 3 leptons, on which the ATLAS team of Clermont-Ferrand has expertise, could be considered and compared to other approaches.

During this internship, in addition to the general development of an experimental analysis of particle physics data, the operation and understanding of statistical methods is foreseen.

The ATLAS team will propose a PhD thesis in 2018 whose details will be published soon.

[1] Why should we care about the top quark Yukawa coupling? Fedor Bezrukov, Mikhail Shaposhnikov J.Exp.Theor.Phys. 120 (2015) 3, 335-343; ZhETF 147 (2015) 3, 389 (arXiv:1411.1923)
[2] Evidence for the associated production of the Higgs boson and a top quark pair with the ATLAS detector, the ATLAS collaboration, ATLAS-CONF-2017-077
[3] Searches for Higgs boson pair production in the hh$\rightarrow bb\tau\tau$, $\gamma\gamma$WW$*$, $\gamma\gamma bb$, $bbbb$ channels with the ATLAS detector (arXiv:1509.04670)