China Scholarship Council / Université de Lyon Scholarships for doctoral mobility

Call for Thesis subjects: 2024

RESEARCH SUBJECT TITLE: Search for a second low-mass (m_h<110 GeV) Higgs boson and measurement of the properties of the 125 GeV Higgs boson, decaying to two photons with the CMS experiment at the LHC Run 3

Name of the laboratory: Institut de physique des deux infinis de Lyon (IP2I Lyon)
Website: https://www.ip2i.in2p3.fr/

Name of the research team: CMS group
Website: https://www.ip2i.in2p3.fr/equipes/cms/?cn-reloaded=1

Name of the supervisor: GASCON-SHOTKIN Suzanne
University / Institution: Université Claude Bernard Lyon 1/ Université de Lyon
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Doctoral School: 52 –ED PHAST (physique et astrophysique Université de Lyon)

Lab Language: French or English

Minimum language level required:

- English : B2
- French :
- Other :

Abstract : CMS ("Compact Muon Solenoid"), one of the two general-purpose experiments at the LHC ("Large Hadron Collider") at CERN, has as its goals the search for new phenomena beyond the Standard Model, as well as the precision measurement of Standard Model processes. The thesis supervsion team contributed significantly to the discovery in 2012 [1] of a Brout-Englert-Higgs boson (commonly known as a 'Higgs boson') in the diphoton decay channel. Since the Standard Model predicts only one Higgs boson, a natural pathway towards the discovery of new physics is therefore the search for a second Higgs boson. The thesis supervision team leads the search within CMS in the

search for a second Higgs boson lighter than that observed in 2012, in the diphoton decay channel. An excess of 2.9σ at an invariant mass of 95.4 GeV has been observed in the data of 2012 and 2016-2018 [2, 3]. But it will be Run 3 of the LHC (2022-2025) which will allow a final response, as well as permit an increase in sensitivity of the search by a factor ~3, thanks to the doubling in the volume of data available. The doctoral student will arrive during the middle of Run 3, and thus will have a crucial role in the analysis of this important data and in the improvement of analysis techniques. He/she could also participate in the eventual interpretation of results within the context of theoretical models in collaboration with our theoretical physics group at the laboratory.

At the same time, the team continues to contribute to the measurement of the properties of the Higgs boson discovered in 2012. In particular, the amount of data in Runs 2 and 3 will allow the placement of a constraint on its width through the diphoton decay channel. In effect, the interference between the Higgs boson production process by gluon fusion $gg \rightarrow H \rightarrow \gamma\gamma$ and the diphoton background production process $gg \rightarrow \gamma\gamma$ introduces a shift in the reconstructed invariant diphoton mass which depends on the natural width of the H. Through the study of this interference, the doctoral student will be able to develop an analysis which will furnish an upper limit on the width through a method totally independent from that exploiting the 'off-shell' production cross section of the interaction $H \rightarrow ZZ^* \rightarrow 4$ leptons [4]. Finally, the observation of a mass shift in the positive direction would be evidence of interference of a constructive nature, indicating physics beyond the Standard Model. This subject is all the more interesting thanks to new higher-order theoretical calculations [5, 6] the authors of which are in contact with us and wish to collaborate.

[1] Phys. Lett. B 716 (2012) 30
[2] Phys. Lett. B 793 (2019) 320
[3] https://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/HIG-20-002/
[4] Phys.Rev. D 92 (2015) 7, 072010
[5] Phys. Rev. Lett. 119, 181801 (2017)
[6] Phys. Rev. D 96, 054003 (2017)

Expected duration of the thesis: (36 or 48 months): 48 months

Keywords : Higgs, BSM, diphoton, CMS, LHC, CERN