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Search and prospects for the discovery of di-Higgs production and measurement of the Higgs boson self-interaction in the bb-γγ final state

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Title: Search and prospects for the discovery of di-Higgs production and measurement of the Higgs boson self-interaction in the bb-^{33} final state

Supervisor: Gregorio Bernardi

Team: Masses et interactions fondamentales; group ATLAS

Description:

The ATLAS experiment is installed at CERN's Large Hadron Collider (LHC) in Geneva. There have been already two long Runs of data taking: a) Run 1, 2011-2012, at 7-8 TeV in the center of mass (c.o.m.), which led to the discovery by ATLAS and CMS of a 125 GeV Higgs boson (H) mainly through its most sensitive bosonic (^{33} and ZZ) decays. b) Run 2, 2015-2018, at 13 TeV c.o.m. energy, with much larger integrated luminosity which allowed for the clear observation of the main fermionic interactions of the Higgs boson (H'tautau, ttH production, and H'bb). Among the next major milestones, are rare decays of the Higgs boson (e.g. H' mumu) and the measurement of the fundamental Higgs boson self-coupling, which would validate the standard model predictions. The subject of this thesis is the search for the process which will allow for the self-coupling measurement, namely the di-Higgs production, more specifically in the bb-^{33} final state, which combines the large branching ratio of the bb decay with the clean signature (narrow resonant invariant mass peak) of the ^{33} decay, which was fundamental for the Higgs boson discovery. While it is not expected that the observation of this HH process can be done during the next Run of data-taking (Run 3, 2021-2023), it is crucial to improve as soon as possible the sensitivity of the search to make this discovery when there is enough statistics. To validate this search, a search and a study of ZH going to the same final state will also be done. Since this process has a higher production rate, the new analysis techniques could allow to have evidence for this process for the first time. Besides, the HH search will allow us to put strong limits on new physics models which would predict a higher di-Higgs production cross-section. As the measurement of this process is the next known major milestone in High Energy Physics, the candidate will also study in parallel the sensitivity to this process of the future machines under discussion, in particular the e+e- colliders (the international linear collider (ILC) foreseen in Japan, the circular Electron Positron collider (CEPC) foreseen in China, the future circular collider (FCC-ee) foreseen at CERN), and the pp collider (FCC-pp). Our LPNHE team was deeply involved in the discovery and observation of H' ^{33} and H' bb processes. The bb-^{33} final state which will be studied in this thesis will thus greatly benefit from the expertise of the team. The team is also expert in b-jet identification and photon identification, which are central in the foreseen analysis. Besides, the team is also strongly involved in the detector upgrades for the High Luminosity phase of the LHC, so the candidate will also be able to contribute to these detector upgrades, hence develop a significant instrumental expertise, in particular those on the Inner Tracking system, since they will allow in the end better b-quark identification.

Work location: LPNHE, Paris

Possible trips: regular trips to CERN for ATLAS and future colliders collaboration meetings, analysis group meetings, data taking shifts and qualification work. Presentation at international conference and participation to a High Energy Physics summer school.

Contact: Gregorio Bernardi, +33 (0) 6 22 11 59 29

