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Search and Prospects for the discovery of di-Higgs production and the measurement of the Higgs boson self-interaction in the bb-gammagamma final state.

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Title: Search and Prospects for the discovery of di-Higgs production and the measurement of the Higgs boson self-interaction in the bb-gamma gamma final state.

Advisor: Gregorio Bernardi

Team: Masses and fundamental interactions. ATLAS experiment, future colliders.

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 (gammagamma 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-Â»tautau, ttH production, and H-Â»bb). Among the next major milestones, are rare decays of the Higgs boson (e.g. H-Â»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-gammagamma final state, which combines sufficient statistics, and clean signatures, in particular the gamma gamma resonance peak, which was fundamental for the Higgs boson discovery.

While it is not expected that the observation of this process can be done during the next Run of data-taking (Run 3, 2021-2023), it is crucial to improve during the shutdown the sensitivity of the search to make this discovery as soon as possible. Besides, this search will be able 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 colliders (High Energy LHC (HE-LHC), and FCC-pp). These studies will be an important input to the decision which will be taken by the community in the next years and which will shape the landscape of particle physics.

Our LPNHE team was deeply involved in the discovery and observation of H-Â»gamma gamma and H-Â»bb processes. The bb-gammagamma 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.

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