Ecole Doctorale PNC PhD proposal 2014

- Laboratory : Laboratoire Leprince-Ringuet (Ecole Polytechnique/CNRS), Palaiseau.

- Research team :
  CMS group (11 permanent physicists, 4 post-docs, 8 PhD students).

The group is a founding member of the CMS Collaboration. It has designed and built the ECAL L1 trigger and it is responsible for its daily operation and monitoring. It has major involvement in particle reconstruction and identification (electrons, taus, particle flow). It is involved in Electroweak (di-bosons, triple gauge couplings, etc...), Heavy Ions and Higgs physics.
The group is one of the main protagonists for the discovery of a Higgs boson and the first measurement of its properties, playing a leading role in some of the high priority Higgs analysis of CMS (H→2 taus or H→4 leptons in various production modes).

- Title : Measurement of the Higgs boson properties in the 4 leptons channel with the CMS detector.

- Overview of the research :

The discovery of a Higgs boson (H) with mass around 125 GeV with the ATLAS and CMS experiments operating at the Large Hadron Collider (LHC) is a major breakthrough in the understanding of the fundamental interactions. The precise measurements of its properties (mass, width, quantum numbers, couplings to the fundamental fields,…) is the only way to reveal its nature and understand if it is responsible of the electroweak symmetry breaking in the standard model (SM).

The H→ZZ→4 leptons (electrons or muons) channel was the “golden” mode for the discovery. Thanks to the precise reconstruction of the full final state, it also offers the best opportunities for an exhaustive study of the properties of the Higgs boson. Therefore, the subject of this thesis is to develop innovative analyses techniques to extract the properties of the Higgs boson with unprecedented precision.

From 2010 to 2012, the LHC provided collisions at 7 and 8 TeV in the center of mass. At the beginning of 2015, it will deliver collisions at 13 TeV, with instantaneous luminosity and pile-up conditions beyond the initial design. Therefore, the first part of this thesis will be dedicated to the preparation of the new data taking period. The first data collected will be used for validation and commissioning of the detector and software. In particular, the successful candidate is expected to work on the triggering system. A stay of several months at CERN is foreseen during this intense and exciting period.

Work will be then devoted to develop algorithms exploiting the full kinematics (including the recoil of the Higgs) of the H→ZZ→4 leptons process, based on Next-to-Leading Order Matrix Element methods. These techniques are expected to provide additional discrimination between the Higgs boson and the backgrounds as well as new handles to separate the main Higgs production mode (gluon fusion) from the rare ones (vector boson fusion, associated production with W or Z). Additional information about the spin and parity can also be extracted.

The last part of the thesis will focus on the analysis of the data and measurements of the properties (mass, spin-parity, cross-section, couplings, …), using the tools previously developed. Depending on the integrated luminosity reached at the end of 2016, emphasis could be ultimately put on studying the HZZ tensor structure, thus constraining (or discovering) anomalous couplings of the Higgs to gauge bosons.

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