Ecole Doctorale PNC PhD proposal 2014

Laboratory/ research team: Laboratoire Leprince Ringuet, Ecole Polytechnique. The CMS group (11 permanent physicists, 4 post-docs, 8 PhD students) is a founding member of the Collaboration. Among many responsibilities, the group has designed and built the ECAL trigger. It also has major involvement in particle reconstruction and identification (electrons, taus, particle flow) and 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 (H2 taus or H4 leptons in various production modes)

Title: Development of tau selection techniques for the Higgs boson produced through Vector Boson Fusion and decaying into tau leptons

Overview of the research: The CMS (Compact Muon Solenoid) experiment aims at studying the results of proton collisions produced by the LHC (Large Hadron Collider) at CERN. The discovery of the Higgs boson is a great leap forward as the corresponding mechanism states that particles masses are the result of an interaction with a scalar field. The nature of that field is being studied in details and this will occupy the CMS collaborators for the next years. The characterization of the Higgs sector as well as the search for new physics will require the full capabilities of the LHC. Upgrades are also foreseen along the way to reach much higher luminosities ($>5.10^{34}$ cm^{-2} s^{-1}). The CMS experiment deploys a 14000 tones detector equipped with advanced electronics to track and identify precisely all the particles produced from the collisions. Although CMS has shown excellent performance, it will undergo upgrades, which include a new data acquisition system to fully exploit high luminosity conditions. The thesis work will focus on taking advantage of the newer analysis and selection techniques to search for tau leptons coming from Higgs decay produced through Vector Boson Fusion (VBF) and to search for additional Higgs bosons predicted by Supersymmetry.

The coupling of the Higgs to tau leptons is of particular interest. It is not only essential to complete the theory but also allows to explore possible extensions of the Standard Model such as MSSM for example. The VBF production has a particular topology leading to the presence of two high pT jets in the forward regions of the detector. The analysis of the LHC Run I period (2010-2012) has demonstrated higher sensitivity to the Higgs signal in this particular production mode. The limited statistics has not allowed to fully exploit that mode that also involves the essential coupling of the Higgs to W and Z bosons. Given the mass of the Higgs, the tau decay mode is certainly favored but still represents challenging aspects in both selection and reconstruction techniques. This thesis will concentrate on the development of a dedicated tau selection algorithm, which has never been achieved with the electronics layers of the data acquisition system. The installation of this system will take place at the end of 2014 and the student will play a leading in the commissioning and the performance studies which will be performed with the first collision data in 2015. The implementation of a VBF selection will also have a large impact within the collaboration. The data collected will be used to demonstrate the Higgs signal enhancement in the tau decay mode. Physics at low-pT, relevant for SUSY searches is also envisaged within this research program. This thesis offers the opportunity to participate to very interesting physics at the energy frontier. The balance between advanced data analysis techniques and more technical aspects will allow the student to gain experience in various aspects of the field. The student contributions will be documented and presented to conferences to insure visibility among a wider scientific community. **Contact:** Alexandre Zabi, Alexandre.Zabi@cern.ch