First Observation of the Production of Four Top Quarks with the ATLAS Detector and Improvement of the Readout Electronics of the Tile Calorimeter for HL-LHC

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Deadline for application: 20th of April 2017

The physics of the elementary particles and their interactions is described by the Standard Model (SM), theory which is in agreement with a large number of experimental observations. However, many questions remain open nowadays. The Large Hadron Collider (LHC) at CERN produce proton-proton collisions at a very high energy (13-14 TeV), and the ATLAS detector record them in order to keep testing the SM. In 2020, the LHC will have completed its Run 2 and the sample of collected data will allow to detect for the first time rare processes predicted by the SM, which might reveal unexpected features.

The proposed thesis focuses on the first observation of the such a process, visible only with the full Run 2 data sample : the production of four top quarks predicted by the Chromo Quantum Dynamique (QCD). The final state to be studied contains two leptons (electron or muon) having the same electric charge, as well as several jets coming from bottom quarks. The project of the candidate consists in understanding and running the current data analysis from A to Z and in a second step, to develop all the improvements needed to actually be sensitive to the four top quarks production. In case the measured rate of this process is not in agreement with the QCD prediction, this could be the first sign of a physics beyond the SM.

In addition to the data analysis project, the candidate will also work on improving one the ATLAS sub-detector in preparation for the high luminosity phase of the LHC (HL-LHC), starting in 2024. The experimental conditions of the HL-LHC require to re-design the readout electronics of the hadronic calorimeter. The LPC has developed a prototype of a readout chip fulfilling all the specifications needed by the HL-LHC and a precise estimation of its performances in realistic conditions will have to be conducted. This work requires to work in close collaboration with LPC engineers as well as a good understanding of the energy measurement from the electric pulse provided by the chip, which is the very first step in the full reconstruction of the collisions.

Basic knowledge in particle physics are required and an experience in experimental particle physics research (type research internship) would be an asset. Some basics in C++ and the analysis software ROOT are welcome. The PhD candidate will get familiar with all the techniques used in a standard high energy physics data analysis document its work and present it during ATLAS meeting (in english). In addition, the instrumental component of this thesis should give to the candidate a quite comprehensive overview of experimental particle physics.