Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Precision Measurement in the Top Quark Sector and Effective Field Theory Interpretation

Supervisor: Romain MADAR
Laboratory : LPC
University : UCA
Email and Phone : romain.madar@clermont.in2p3.fr
Possible co-supervisor : none
Laboratory: LPC University : UCA

Summary:
The success of the Standard Model (SM) of particle physics over the last few decades, continues with LHC experiments with in particular the Higgs boson discovery. This demonstrates the impressive robustness of this theory but also suggests that new phenomena, expected from the known SM incompleteness, seem to be out of LHC energy reach. In addition, hundreds of direct beyond the SM (BSM) searches keep pushing exclusion limits to higher energy scales. In this context, interpretations of precision measurements in term of *effective theories* offers an appealing strategy to move forward, especially with the largest data sample of proton-proton collision data to be recorded during LHC Run 3. *Effective Field Theory* (EFT) is a generic theoretical approach which predicts how BSM theories would manifest at LHC energy, independently from the detailed structure of the underlying theory. This overall strategy is then strongly motivated by the current experimental landscape, and actual developments related to EFT interpretations have already started in the theory and - more recently – in experimental communities.

The thesis project focuses on precision measurement in the top quark sector and the associated EFT interpretation, aligned with the strong expertise of the group on top quark physics. The first goal is to finalize the most accurate measurement of a angular properties of pair-produced top quarks, using the full Run 2 dataset. These properties represent a fine probe of how the top quark interacts with other particles, and can be sensitive to any modification of this dynamic. The second goal is to understand the BSM effects (as described by EFT) on these properties, in order to derive global constraints on generic BSM phenomena in the top quark sector. Finally, there is the possibility to explore the potential of future colliders to constrain EFT operators and more precisely, their complementarity with the LHC.

In addition to the data analysis project, the candidate can also work the *High Granularity and Timing Detector* (HGTD), planned to be installed in ATLAS for the high luminosity phase of the LHC (HL-LHC), starting in 2025. The experimental conditions of the HL-LHC require a good identification of parasite collisions overlaied with the collision of interest.

The role of HGTD is to exploit timing information to infer the position of particle emission, and identifiy interaction points spatially separated from the interesting one. The LPC group is invovled in both the electronics of this detector and its time calibration procedure.

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.