MAP-fis Essay Proposal, 2016-2017

(*please write in English*)

Supervisor

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Title

Search for vector-like quarks at the ATLAS experiment

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

Experimental High Energy Physics

Summary of Proposal

A cornerstone of the Standard Model (SM) of Particle Physics is the formulation of the electroweak interactions as arising from a spontaneously broken gauge symmetry. Experiments over the past four decades have confirmed this hypothesis with precision, most notably the LEP and SLC collider programs. The ATLAS and CMS collaborations reported in 2012 observations of a new particle produced at the CERN Large Hadron Collider (LHC) possessing properties so far consistent with those predicted for the SM Higgs boson. It should be noted, nonetheless, that the exact nature of the symmetry-breaking mechanism is not yet determined. Furthermore, regardless of the many experimental validations of the SM, it is known that it cannot be regarded as a final theory, given the many problems it fails to solve, namely the hierarchy problem, the lack of a dark matter candidate, matter-antimatter asymmetry, and others. Attempting to solve these problems, many beyond the SM theories were built. Vector-like quarks (VLQ) are featured in some of these models, as spin 1/2 fermions, color triplets with the same left and right quantum numbers, mixing with SM quarks.

The current proposal foresees the development and implementation of a search for vector-like quarks decaying through a Z boson and a third generation quark, using data collected by the ATLAS experiment during the run-2 of the LHC. This search will take into account the different topologies and production mechanisms. Given the multitude of final states that vector-like quark production can have, it is important to branch out the searches, profiting from the distinctive kinematics that these quarks are expected to have, and improving the final results with a combination of these multiple topologies and their respective sensitivities. In this project, the focus will be set on the dileptonic channel, searching for events with a pair of opposite-sign, same flavor leptons that may

serve as a Z boson reconstruction, and a number of b-tagged jets. A selection based on the kinematics of these objects will be laid out, taking advantage of the high mass of the VLQ and how their decays are expected to be more boosted than objects from background processes. We propose to define a strategy in which signal and control regions are built and optimized, systematic uncertainties are studied and all the steps necessary to set limits are done, including the definition of discriminant variables that allow to distinguish signal from background, so that an evidence of signal can be searched, or, in case none is found, to significantly improve the current exclusion limits. The phenomenological consequences of the experimental results will be also be studied, making the most of the LHC data.

References

(t*o allow students first look at topic*)

- J. A. Aguilar-Saavedra, Identifying top partners at LHC, JHEP 0911, 030 (2009).

- J. P. Araque, N. F. Castro and J. Santiago, Interpretation of Vector-like Quark Searches: Heavy Gluons in Composite Higgs Models, JHEP 1511, 120 (2015).

- ATLAS Collaboration, Search for pair and single production of new heavy quarks that decay to a Z boson and a third-generation quark in pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector, JHEP 1411, 104 (2014).