Search for long lived decays of new massive particles and tracker upgrade of the CMS detector at the LHC

The CMS experiment is devoted to the study of proton-proton collisions at the Large Hadron Collider (LHC) at CERN. The LHC is the highest energy collider: 13 TeV proton-proton collisions delivered during Run 2 in 2015-2018, and 13.6 TeV expected at Run 3 starting in summer 2022. Many detailed tests of the Standard Model (SM) of particle physics have been performed by the four large collaborations at the LHC (Atlas, Alice, CMS and LHCb). Notably, Atlas and CMS discovered the Higgs boson in 2012 at Run 1, a fundamental particle at the origin of the mass of all other SM elementary particles. Although verified with high precision and despite its high predictive properties, the SM has well known limitations and could just be the effective model of a more general theory.

With the high energy and high luminosity available at the LHC, new physics could emerge through the production of new particles, beyond the SM description. Despite tremendous efforts, no direct hint of new particles has been observed so far. New research areas have thus to be considered, not fully investigated or even not explored yet. In this respect, the search for new heavy particles with a long lifetime allow the detector capabilities to be fully exploited. Models of new physics, as Super-Symmetry (SUSY), predict the existence of such long lived particles (LLP). If the lifetime of the LLP is long enough, its decay vertex can lie inside the silicon tracker volume. Depending on its mass and decay mode, many charged particles can be produced in the LLP decay, providing a clean signature for the expected signal. Several signal models can be considered, as those developed in our group with displaced top quarks. The aim of this thesis is to search for displaced top quark hints of new physics, available with the accumulated data in Run 2 and expected in Run3 (corresponding to a total integrated luminosity of more than 300 fb^{-1}). Depending on the production and decay scenario, the challenge will be to look for displaced vertices far away within the tracker volume, and constituted of either rather isotropic soft tracks, or very collimated energetic particles. In contrast, most of the SM particles are produced close to the proton-proton collision points along the beam line, but secondary interactions can occur in the material of the surrounding detectors layers, and some SM particles (as K^0_S or Λ) have also a long lifetime. Those processes give however few secondary particles and appropriate analysis tools will need to be developed to distinguish the searched signal from the large background.

The Strasbourg group is also strongly involved in the construction of the new silicon tracker for the high luminosity LHC. We are in charge at the laboratory of the integration of half of the barrel outer detector (TB2S), which will be realized during the thesis years. Many tests will be operated to ensure to deliver fully functional silicon detectors. In particular we benefit at the laboratory of an intense source of low energy protons and of a dedicated beam line for quality tests of the modules and irradiation studies. The PhD student will contribute to this effort of the CMS team.

Further informations: http://www.iphc.cnrs.fr/-CMS-.html

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