Search for long lived decays of new massive particles in the CMS experiment 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 this spring 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 main purpose of the proposed internship is to optimize the signal search strategy, in order to disentangle the rare signal from the large SM background. Indeed, 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 can be distinguished from the searched signal. The secondary vertex reconstruction and selection has to be adapted in order to retain at best the signal, while preserving a good handling of the SM background. The large amount of data already registered at Run 2 is available for this study, as well as signal and SM background simulations. The results obtained will allow one to prepare and pursue such researches at Run 3, where the collected data are expected to be twice as large.

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

Bibibliography:
Search for long-lived particles using displaced jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV, CMS Collaboration, *Phys. Rev. D 104 (2021) 012015*

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