Search for heavy stable charged particles with the CMS experiment at the LHC

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Successful with the discovery of the Higgs boson in 2012, the LHC scientific program has extended our knowledge of particle physics in several sectors. However, despite large efforts made by the collaborations, the LHC did not yet succeed in one of its main goal: observing phenomena beyond the Standard Model (SM) predictions. After having performed numerous searches of signatures motivated by models beyond the SM, the collaborations are trying to enlarge their coverage by giving emphasis on hypotheses which were not sufficiently covered. While most of the searches focused on promptly decaying new particles, we will search for long-lived exotic particles.

The internship subject is devoted to the search of new particles with an electrical charge, a high mass (>200 GeV/c^2) and a lifetime large enough to render the particle stable at the scale of the detector (typically greater than few nanoseconds). Many well-motivated models can predict such particles. It is notably the case for the supersymmetry (SUSY) where new particles such as the gluinos, staus or charginos are likely to be long-lived in some SUSY models (e.g., gluinos in Split SUSY).

If such particles exist, due to their large mass, they will be produced with a speed lower than c (typically <0.9 c) and consequently their interaction with the active volume of the detector will lead to signals much larger than the typically ultra-relative particles. Then by combining the measurements of the track momenta and the ratio of dE/dx (energy loss per unit of length) obtained by the silicon strip detector, it is possible to estimate the mass of the searched particle which will be its striking signature. Moreover, the external layers of the CMS apparatus have the ability to measure the time-of-flight with a resolution of about few ns. This measurement gives a direct estimate of the velocity and thus offer a unique feature for the searched signal.

The current sensitivity already reached up to the 2 TeV scale for the gluino mass (lower bound). However, such high mass particles would be produced with a very small velocity (as well as a low cross-section) and former studies have shown a drop of signal efficiency.

The main goal of the internship is to study in detail the origins of this signal efficiency reduction and try to propose solutions to recover. An attention will be given on the ability to trigger on events in which such particles could be produced. Indeed, in order to reduce the bandwidth, the CMS experiment uses since the beginning of data-taking a two-level trigger system composed of an hardware level (composed of electronic boards) and a software level (ran on a computer farm). Consequently, it is really important to verify that the signal events that may be produced during the next period of data-taking (Run III: 2022-2024) will be triggered and stored.

The conclusions of this internship will help us to adapt the trigger strategy if needed, adjust the level of required information to be stored in the data accessed by physicists and more generally give a guidance to prepare the analysis of the incoming data.

A PhD subject extending this internship is proposed.