Combine LHC and Cosmological observables to Better Constrain Dark Matter

Master Research Internship

Laboratoire de Physique Corpusculaire (LPC, Clermont-Ferrand)
Partnership: theoretical physics group of IPNL (Lyon)
Advisor: Romain Madar (chargé de recherche, CNRS)
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Deadline: January 2017

Scientific Motivations

The current theory describing the elementary particles and their interactions, the Standard Model (SM), is validated by a huge number of experimental results, including the recent Higgs boson discovery. However, the SM does not describe everything. In particular, there is no explanation of about 85% of the matter indirectly observed in the Universe, called dark matter. Discovering the nature of this new type of matter is then one of the most important goals in modern science.

There are several approaches to extend the SM in order to include dark matter. The first one consists of simply adding a fermionic field and mediator carrying its interaction with SM fields. This minimal approach, called *simplified*, allows to describe a large variety of phenomena with only few parameters (cf Fig 1, but does not necessarily respect the SM symmetries. Therefore, a complementary approach is to study a more complete model which is naturally embedded in the SM structure. In particular, idendifying new prediction with respect to the simplified models might lead to additional handles to better charaterize the nature of the dark matter.

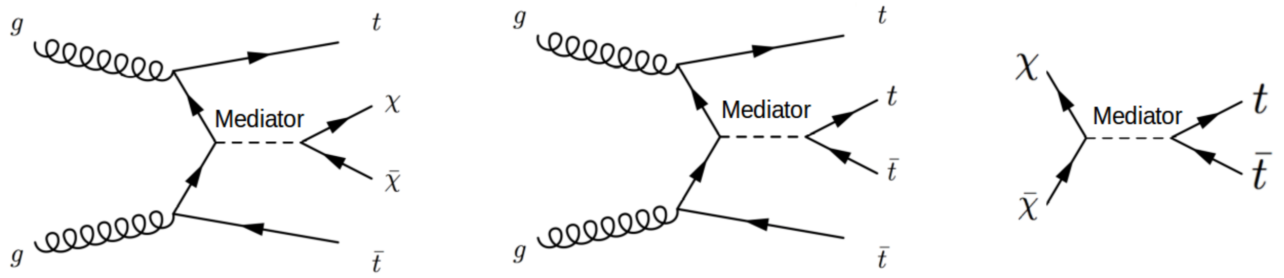

Figure 1: Different dark matter signatures at the LHC (visible and invisible decay) and in cosmology (via the relic density determined by dark matter annihilation cross-section).

Student Activities

The candidate will perform a phenomenological study on a model where the dark matter is coupled to the top quark, the heaviest known particle. First, the student will construct a relevant model embedded in the SM and not yed excluded by the current set of observations. Then, the relevant processes for the LHC will have to be scrutinized in the context of the model together with the cosmological signatures (cross-section, relative importance depending of the model parameters values, etc ...). Finally, a sensitivity estimate can be derived to quantify the discovery potential of the studied model.

Basic knowledge in particle physics is required and first experiences in C++ and analysis software ROOT are welcome. The student will be able to get familiar with two important aspect of high energy physics: phenomenology and data analysis. This internship will be done in partnership with theoretical physics group of IPNL (Lyon). The ATLAS@Clermont team will propose a thesis subject for the 2017-2020 period as a continuation of this subject.