RECHERCHE DE NOUVELLE PHYSIQUE DANS LE SECTEUR DU QUARK TOP AVEC LE DETECTEUR ATLAS

SEARCH FOR NEW PHYSICS IN THE TOP QUARK SECTOR WITH THE ATLAS DETECTOR

DESCRIPTION ET PROBLÉMATIQUE

The top quark plays a particular role in the Standard Model (SM) of particle physics. Due to its very high mass, this quark strongly couples with the recently discovered Higgs boson. Even if not yet directly measured, its Yukawa coupling is expected to be close to unity. This feature makes the top quark a unique window to search for new processes beyond the SM, such as compositeness, that predict the existence of top-partner quarks that play a key role in stabilizing the Higgs boson mass against quantum corrections. These top partners could, for instance, look like heavy top quarks or particles with an electric charge 5/3. Also strongly coupled models of compositeness can enhance the tiny SM cross section for the production of four top quarks. This channel could be the most promising process for new physics discovery.

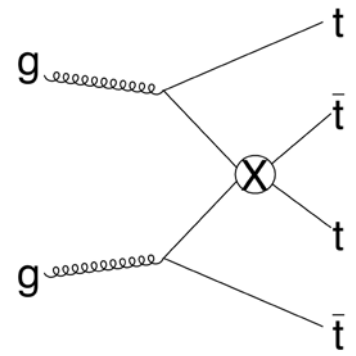
After two years of shutdown, the LHC resumed operation at the highest ever-achieved centre-of-mass energy of 13 TeV in 2015. With the amount of data expected to be accumulated by the ATLAS detector after a few year, the PhD candidate will be able to search for top partners in a yet-unexplored region of phase-space as well as perform the challenging measurement of the production of four-top quarks.

Top partners postulated by compositeness models can be produced singly or in pairs. The lightest top partner is expected to have a mass between 500 GeV to 1.5 TeV. These new particles can decay to Wb, Wt, Zt, Zb, Ht or Hb. This gives rise to several decay signatures. One of the most promising ways to discover top partners common to these decay modes is to search for a pair of same-sign leptons because the contamination from the SM background is low.

Among the many interesting final states that may be produced at the LHC, four-top production is one of the most spectacular. As in the case of top partners, searching for two same-sign leptons is relevant for the four-top final state. In order to reach the SM cross section sensitivity for this process, the three lepton final state should be added. The background uncertainties will also have to be stringently controlled, in particular the background originating from top-antitop production in association with one or two vector bosons. These processes were not yet observed at the LHC because of the lack of statistics.

DESCRIPTION GROUPE/LABO/ENCADREMENT

The particle physics division, Service de Physique des Particules (SPP), is a major French laboratory in experimental High Energy Physics, with a broad range of activities in both accelerator and non accelerator particle physics experiments. Irfu has been contributing to the ATLAS experiment, beginning with the design, more than twenty years ago, to the stage of installation and commissioning up to the data analysis. The Irfu-SPP ATLAS group is formed of around 20 permanent physicists. Top quark and Higgs physics are some of the group research topics. Henri Bachacou and Frédéric Déliot are members of the ATLAS experiment since many years. They are expert in exotic and top-quark physics.



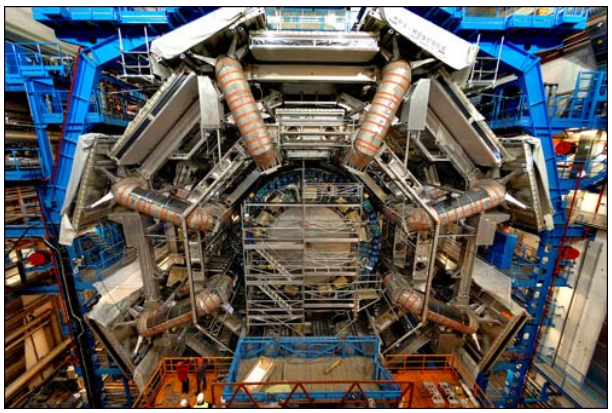


Figure 1 : Feynam diagram (top) that produces four top quarks in new physics models that can be analyzed by the ATLAS detector (bottom)

TRAVAIL PROPOSE

- understand the phenomenological models of new physics relevant to the top quark sector ;
- study the SM background for top partners and four top production both in the same-sign and three-lepton channels;
- data analysis during the first years of 13 TeV running to search for top partners and four top production.

FORMATION ET COMPÉTENCES REQUISES

- Master 2 in high energy physics
- some knowledge in C++ programming

COMPÉTENCES ACQUISES

- strong experience in modern analysis tools (object oriented programming in C++, handling of large dataset, neural network, advanced statistical tools, …)

- phenomenology of new physics models relevant to the top quark sector

- work inside large international teams

COLLABORATIONS/PARTENARIATS

- frequent travel to CERN

- collaboration with several ATLAS colleagues outside CEA

- collaboration with theorists from CEA-IPhT and LPT-Orsay

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