Internship Proposal

Using ATLAS and CMS measurements to constraint new physics models

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The Standard Model of particle physics is the best description of the building blocks of the universe we have so far. Decades of scrutiny at particle colliders have demonstrated its unprecedented agreement with experimental data. However, it has some major shortcomings which suggest that there must exist physics beyond the Standard Model (BSM). In the last few decades, many theories have emerged in an attempt to account for these deficiencies. But for the first time in fifty years, there is no single guiding theory that can motivate new experiments and discoveries. This poses a problem to the field of particle physics: because of the large number of candidate theories to replace the Standard Model, it is unviable to test all of them exhaustively through direct searches at collider experiments. The analyses that need to be designed to do so can take years, and are only suitable for testing a few theories at a time. In addition, they only probe specific values of the parameters of the model, such as the width or mass of their new particles, or the strength of the interaction between them.

However, there is a silver lining. The Large Hadron Collider (LHC) data set is one of the largest in scientific history. Hundreds of measurements have already been made in a wide variety of final states. New tools, such as "CONTUR", can harness the power of these measurements to efficiently discard those theories that are incompatible with past observations. Indeed, the addition of new particles and particle interactions in BSM theories often causes deviations from the predictions of the Standard Model in well-measured processes. The CLs technique [13] can be used to quantify the incompatibility between a theory the observed data.

To achieve this goal, the CONTUR project has formalised a methodology for testing a wide array of candidate new-physics models. It simulates model behaviour by generating events using Monte Carlo methods, and compares these results with hundreds of differential cross-section measurements from ATLAS CMS and LHCb. The method applies to arbitrarily complex models, and yields comparable results to direct searches, so long as measurements of relevant final states have been preserved the RIVET format and made public by the LHC experiments.

The objective of this internship project will be to use CONTUR to investigate a new class of models, such as Heavy Neutral Leptons, and see what constraints can be derived from the existing measurements.

Students applying to this internship should be comfortable using a terminal, and have strong skills in python (or other major computing language), a good knowledge of high energy physics, and a willingness to develop and test new ideas.