Royal Holloway
University of London

Physics Department
Project for MSc/MSci (PH4100)

Search for evidence of supersymmetry at the LHC

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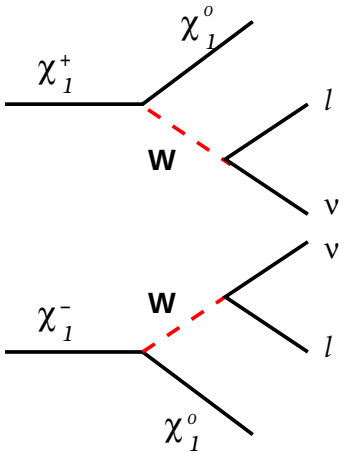
Brief description

The aim of this project is to investigate the observability of supersymmetric particle production in proton-proton collisions, at the Large Hadron Collider (LHC). In particular, the signal to be investigated is pair-production of charginos and their subsequent decay leading to a final state with large missing energy and two charged leptons: $\mathrm{p\,p} \to \chi_1^+ \chi_1^- \to \chi_1^0 \chi_1^0 \ell^+ \ell^- \nu \nu$.



For **Phase I** of this project, the student will investigate the background processes that are likely to mimic the signal signature: events with large missing energy and two high-p_T leptons in the final state. Standard Model processes such as pp$\to$ $\mathrm{t\bar{t}}, \mathrm{b\bar{b}}$ WW, ZZ and WZ are likely to be significant background processes. As part of this preparatory investigation, the student will estimate the numbers of events with the above signature expected to be produced at the LHC, originating from the signal process and from each one of the background processes.

In **Phase II** of the project the student will use a standard Monte-Carlo (MC) event generator (such as PYTHIA) to simulate high-statistics signal and background event samples. Using the event samples, the student can then investigate which observable event properties are indicated in order to statistically discriminate between signal events and background events. Observables such as the measured missing energy in the event, the momenta of the charged leptons and their isolation, and the presence of hadronic jets, are likely to be discriminant variables.

Having identified the main observables to discriminate between signal and background the event selection cuts have to be optimized in order to maximize the significance of an eventual discovery using this channel.

Extensions / Variations

- The masses of the charginos and neutralinos are not predicted by theory. One possible extension of the project is therefore to simulate signals with different values of the masses $m(\chi_1^\pm)$ and $m(\chi_1^0)$, and investigate the dependency of the signal selection efficiency over large areas of the ($m(\chi_1^\pm)$,$m(\chi_1^0)$) parameter space.
- In addition, it could be investigated if information on the value of the $m(\chi_1^\pm) - m(\chi_1^0)$ mass difference can be extracted from the signal event sample.

A possible variation on the theme of this project, is to study the final state with one lepton, hadronic jets, and missing energy. This signature will be produced when one of the charginos decays leptonically (as above) and the other decays hadronically: $\chi_1^+ \to \chi_1^0 \mathrm{W}^\pm \to \chi_1^0 \mathrm{q\bar{q}}'$.

Requirements

This project has a very strong computational component. Very good programming skills are essential for the successful completion of the project. The analysis of the data will require programming in C++. Some knowledge of the Unix/Linux environment would be an advantage.

Keywords and concepts

Particle physics, new particle search, supersymmetry, Large Hadron Collider, Monte Carlo method.

(p.t.o.)

References

An overview of supersymmetry and supersymmetric particle searches with the ATLAS detector at the LHC can be found in "ATLAS detector and physics performance" TDR, Chapter 20.

PYTHIA event generator, see documentation at
`http://www.thep.lu.se/ torbjorn/Pythia.html`

PTD, October 2003.