Study of supersymmetry at the next International Linear Collider

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(Dated: June 28, 2007)

Supersymmetry is a new symmetry enlarging the usual Lie algebra used in the Standard Model, in order to solve some of the many tiny problems found in our current theory of elementary particles and their interactions. Roughly, it exchanges bosons and fermions and thus groups them in what is called a supermultiplet. One of the key consequences of supersymmetry is the apparition of supersymmetric partners of the standard particles, which enlarge the Standard Model at least to what is named the MSSM : Minimal Supersymmetric Standard Model - its name meaning that it is the minimal extension in term of fields. Detailed studies have been conducted for hadronic colliders searches. The goal of my internship is to be part of a study on leptonic collider, in order to quantify precision mesures and to study supersymmetric models which cannot be distinguished at LHC.

I. GENERAL STUDY OF SUPERSYMMETRIC SIGNATURES : NEUTRALINOS AND CHARGINOS

The first part of my internship, from the April 13^{th} to the end of May, was devoted to the learning of some theoretical backgrounds and the tools used in phenomenology studies. I have mainly learnt how to use Pythia [1], a Fortran programm which simulates events in high-energy physics, and what is the basics of supersymmetry : its fundamental structure, the particle content of MSSM, the mass mixing matrix for neutralinos and charginos, etc... I have been able to test Pythia with benchmarks models, as [2], which is a very important part of a theoretical study. My main studies were done on ILC at $E_{cm} = 500$ GeV, in :

1. neutralino mixing, as neutralinos are mass eigenstates but not supersymmetric eigenstates of the superpartners of Higgs, gluon and electroweak bosons

2. chargino production and the resulting signal in hard photons at the end of the process

3. chargino decay, using missing energy and missing transverse momentum

4. mass splitting, that is to say $\Delta m = m_{\tilde{\chi}^-} - m_{\tilde{\chi}^0}$ influence on signatures, at smallish values

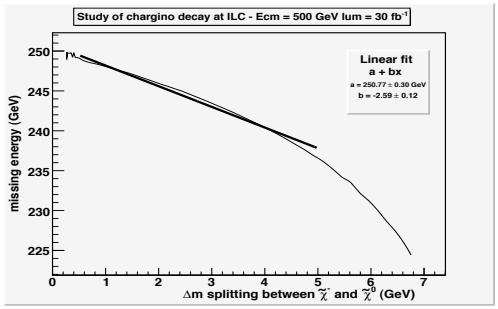

FIG. 1: Missing energy versus mass splitting in chargino decay

Fig. (1) above is an example of chargino study done with Pythia and ROOT.

II. THE LHC INVERSE PROBLEM

1. *The Harvard group study - hep-ph/0512190*

The second part of my internship has began on June, 13^{th}. The work of our group is based on what is called "The Harvard group study" [3] and deals with the LHC inverse problem.

Experiments at collider seek for signatures and observables, thus they scan the signature space ; theorists on the other side scan the parameter space, they produce signatures and observables possibilities from their models. How could we come back from signature space to parameter space and thus discover what is the correct model describing an experiment ?

The Harvard group has studied different random parameter points in parameter space of the MSSM and have discovered that there exist numerous pair of models which will not be distingable at LHC : they give exactly the same signature. That is the LHC inverse problem.

2. *Our goal : a study at ILC*

The goal of our group is to start with the results of the Harvard group and see if pairs could be distinguished at ILC. We use complete Standard Model background, what was not done in the Harvard study.

In parallel, we want to build a complete set of parameters which can produce realistic models, that is to say which pass all experimental constraints : thus in the Harvard group study, numerous models were already ruled out and that may reduce the number of indistingable pairs. This is the main part of my work : using DarkSUSY [4] I am to build a complete set of test for MSSM models. The first step, that is to say the update of easy bounds, has been completed.

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III. WHAT REMAINS TO BE DONE

This internship will end on the August, 28th. There are lots of problems unsolved yet : how to build constraints on gluino and squarks, as many experimental studies are model-dependant ? What kind of distribution in our scan should we use ? This is our part two of the test of models, and no doubt it will not be finished before the end of my internship. We also are all looking forward to the LHC data !

[1] S. Mrenna et al., *Pythia 6.4 : Physics and Manual* (2006), arXiv:hep-ph/0603175.

[2] B. Allanach et al., Eur. Phys. J.C. **25**, 113 (2002).

[3] N. Arkani-Hamed et al., *Supersymmetry and the LHC inverse problem* (2005), arXiv:hep-th/0512190.

[4] P. Gondolo et al., JCAP **008** (2004), hep-th/0106109.