Matter and the Universe

Fundamental Particles and Forces

New Physics Parameter Determination @ ILC

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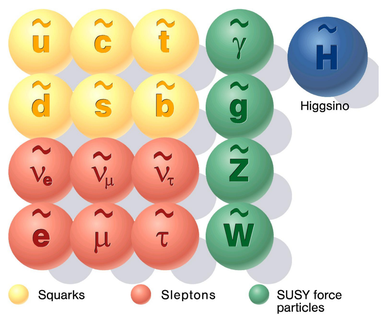
Motivation

There are many reasons to search for physics beyond the standard model. Supersymmetry (SUSY) is a prominent theory to describe such physics.
Today, large parts of the SUSY parameters space have been excluded by the LHC, especially in constraint models.

Still, many possibilities for light SUSY remain. One example are pMSSM scenarios with light sleptons and electroweakinos, but heavy gluinos and 1st / 2nd generation squarks.
In this case, parts of the spectrum could be discovered at the LHC, leaving further discoveries and property determinations for the ILC.

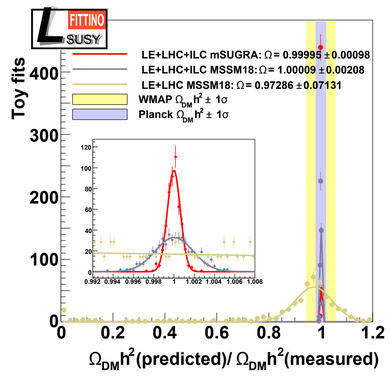


SUSY particles

Example Scenario: SPS1a'

One point which has been extensively studied is the SPS1a' scenario. In a study using combined LHC and ILC observables, most parameters of this MSSM18 model could be determined with precisions of a few percent or better. [arXiv:0907.2589]
An agreement of the resulting predictions for $\Omega_{CDM}h^2$ with cosmological measurements would hint that SUSY LSPs make up the majority of DM and allow predictions for direct detection experiments, with better precision than current cosmological measurements.

While this specific point was excluded by the LHC, many similar SUSY scenarios are still good candidates for physics beyond the standard model.



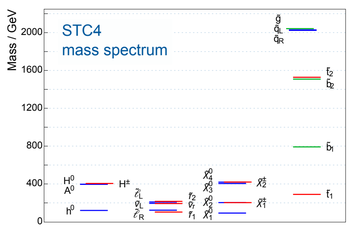
Ratio of predicted to nominal value of Ωh^2 in the SPS1a scenario for a variety of toy fits.

The new STC4 benchmark point

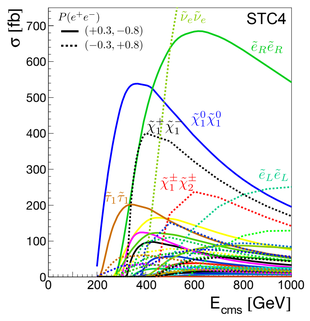
As an example for SUSY a model consistent with recent observations, a pMSSM benchmark model called "STC4" (for $\tilde{\tau}$ co-annihilation model 4) is studied:

- Higgs sector parameters: $\tan(\beta) = 10$, $\mu = 400$ GeV, $m_A = 400$ GeV,
- trilinear couplings: $A_t = A_b = A_\tau = -2.1$ TeV,
- gaugino mass parameters: $M_3 = 2$ TeV, $M_2 = 210$ GeV, $M_1 = 100$ GeV,
- slepton mass parameters: $m_L(1,2,3) = 205$ GeV, $m_E(1,2,3) = 117.5$ GeV,
- squark mass parameters: $m_Q(1,2) = m_D(1,2) = m_U(1,2) = 2$ TeV, $m_Q(3) = 1.5$ TeV, $m_U(3) = 500$ GeV, $m_D(3) = 800$ GeV.

[arXiv:1307.0782]



Full spectrum of STC4.

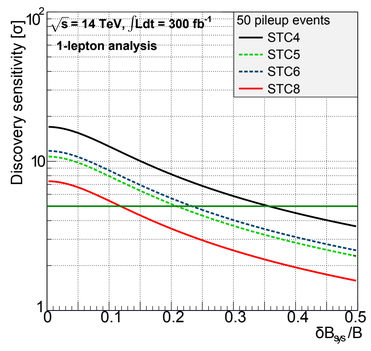


STC4 cross sections for sparticle production.

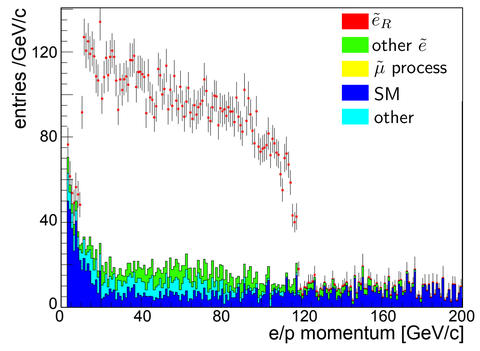
STC4: discovery and measurements

If STC4 could be observed at LHC14 depends strongly on the systematic uncertainty on the background. At the ILC, nearly all sleptons and elektroweakinos are accessible at the ILC in this model, and several of them could be discovered. [arXiv:1307.8076]

A remaining question is whether the measurable observables would allow to determine the underlying model parameter. If yes, it should be studied which observable precision is required.



Discovery sensitivity at LHC14 with 300 fb^{-1}.
The horizontal green line indicates the 5-σ-level.



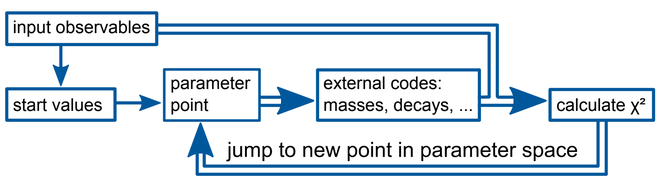
Contributions to e^+e^- + missing 4-momentum signature at ILC500 with 10 pb^{-1} (one week of data taking at design luminosity).

Parameter reconstruction with Fittino

To determine the SUSY parameters from measured quantities, the fit program Fittino can be used. [arXiv:0412012]
The parameter determination is done in three steps:

1. find a starting point using tree level estimates,
2. find the central values of the parameters,
3. evaluate the parameter correlations and uncertainties.

This procedure was previously applied to SPS1a. Now the analysis is being repeated for the STC4 point.

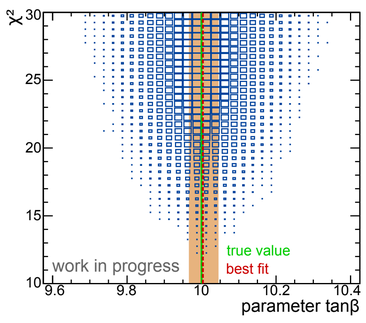


Iterative estimation of parameters with Fittino.

STC4 Fittino analysis

Currently, the global fit to reconstruct the STC4 parameters using LHC + ILC observables is in progress.

Once the has been shown that the parameter values can be successfully determined, the next step will be to investigate which observables are needed for this, and with which precision respectively. This will allow to determine the requirements for the luminosity at different ILC-energies and for threshold scans to reconstruct the parameters of a model like STC4.



Example: χ^2 of scanned points vs. tanβ around the fit minimum (SPS1a plot, STC4 is work in progress).