Supersymmetry Without Prejudice

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Supersymmetry Without Prejudice

- The MSSM has ~140 parameters
- Most studies/searches incorporate simplified version
  - mSUGRA with 5 parameters
- Does mSUGRA adequately describe all possible SUSY effects?   –No!–

- The LHC is turning on, era of speculation will end, and we need to be ready for all possible signals
- Ready to determine underlying physics from LHC data

- Study the consequences of a more general set of MSSM models

SUSY Parameter Determination @ ILC

Berger, Gainer, Hewett, Lillie, Rizzo
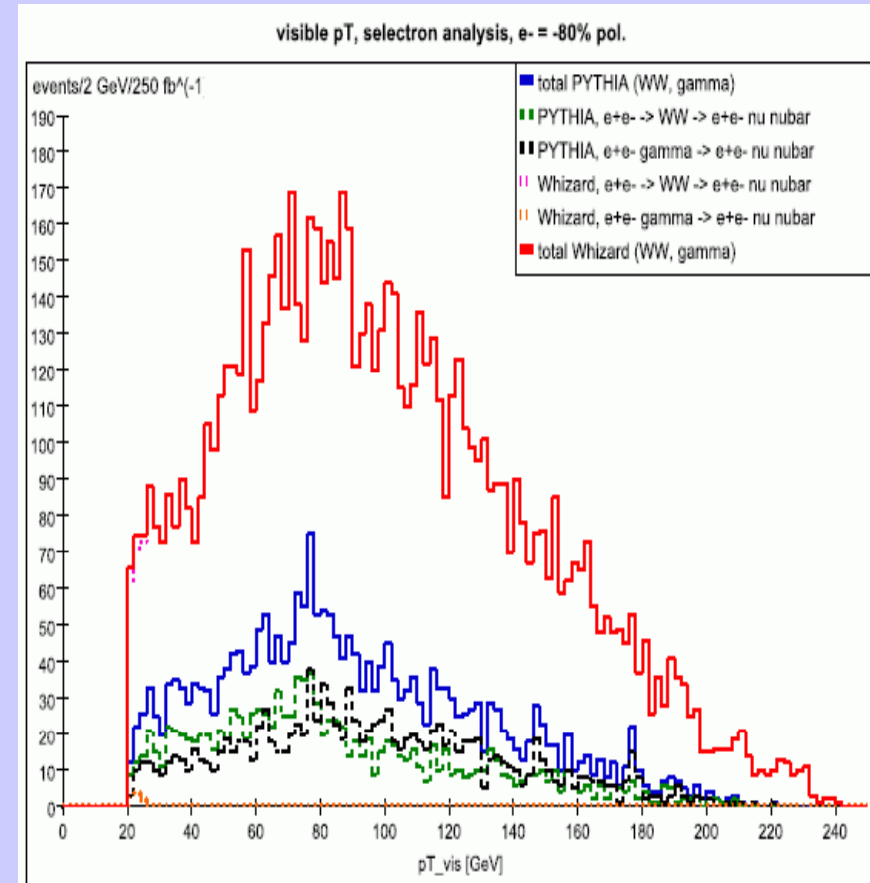arXiv:0711.1374, 0712.2965

Analysis:

- Study 242 generic models which appear in 162 pairings found to be indistinguishable @ LHC (Arkani- Hamed etal)
- 12 simultaneous SUSY channels (Pythia & CompHEP)
- Full SM background,
  - 1016 processes w/ full matrix elements (Whizard)
- ISR, ILC-design Beamstrahlung, Beam energy spread
- SiD fast detector simulation
- Analyze 500 fb^{-1} "data" at 500 GeV with 80% P_{e-} and appropriate cuts
- 1 CPU century to complete analysis!

Several iterations necessary to find best (model independent) kinematic cuts!

General Conclusions

- Generic SUSY signal smaller than SPS1a
- Many cuts designed for SPS1a(LEPII) kill generic SUSY signal
- Larger SM background than previous studies
- Forward detector coverage critical
- Some difficult cases:
  - close stau-LSP mass,
  - $\chi_1^{\pm} \rightarrow W^* \chi_1^0 \rightarrow jj\ \chi_1^0$,
  - Neutralino Production

Random SUSY signal is not a piece of cake!

visible pT, selectron analysis, e- = -80% pol.

events/2 GeV/250 fb^(-1)

- total PYTHIA (WW, gamma)
- PYTHIA, e+e- -> WW -> e+e- nu nubar
- PYTHIA, e+e- gamma -> e+e- nu nubar
- Whizard, e+e- -> WW -> e+e- nu nubar
- Whizard, e+e- gamma -> e+e- nu nubar
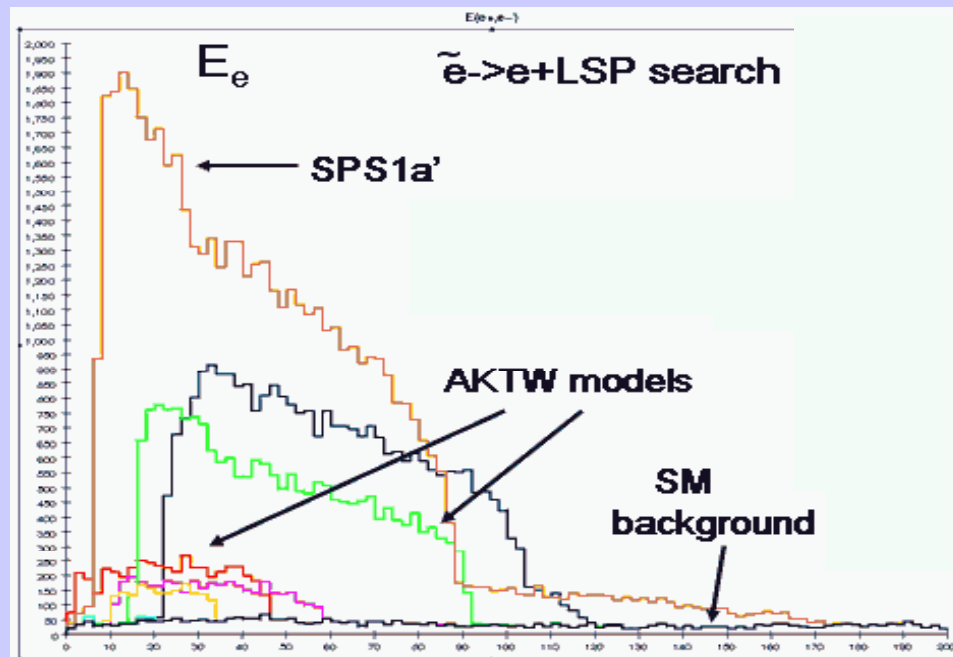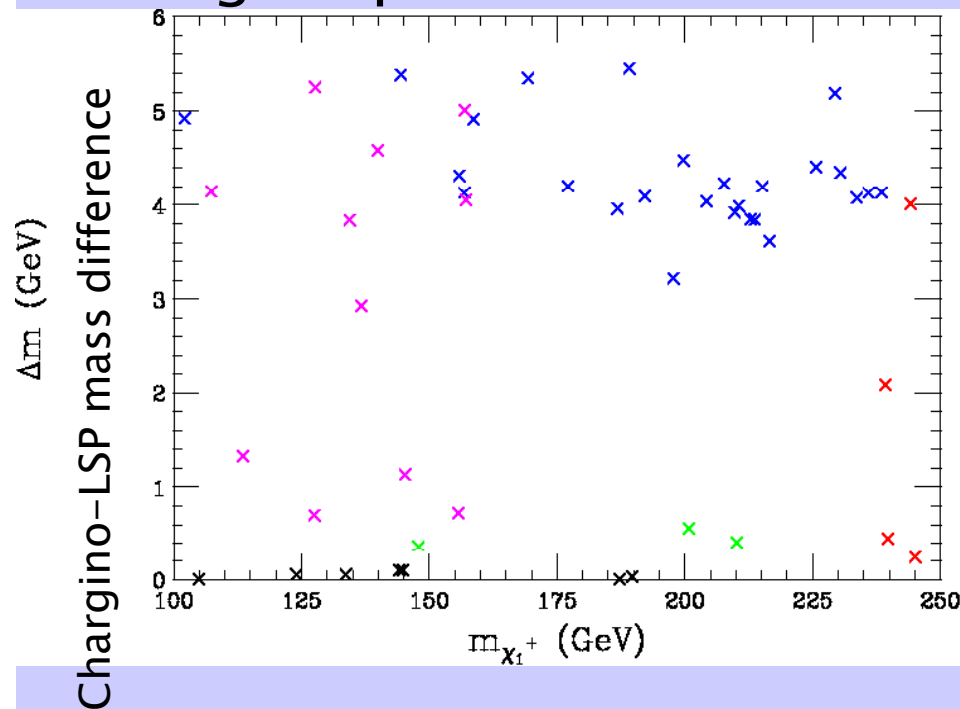- total Whizard (WW, gamma)

pT_vis [GeV]

Sample Results

Selectron Production

Generic signal is much smaller than SPS1a'

Chargino production

Many times charginos have small mass splitting with the LSP requiring many different searches: stable particles, photon tagging, soft jets, or a combination. Four are missed due to tiny phase space

Overview of Results

Visibility: ILC can see

- 78/85 AKTW models w/ at least one charged sparticle
- 17/96 models w/ neutral sparticles only
- 82/161 models w/ any accessible sparticle
- 82/242 of all models

Particle	Number Visible
$\tilde{e}_L$	8/9
$\tilde{e}_R$	12/15
$\tilde{\mu}_L$	9/9
$\tilde{\mu}_R$	12/15
$\tilde{\tau}_{1,2}$	21/28
$\tilde{\nu}_{e,\mu}$	0/11
$\tilde{\nu}_\tau$	0/18
$\tilde{\chi}_1^\pm$	49/53
$\tilde{\chi}_1^0$	17/180
$\tilde{\chi}_2^0$	5/46

Model Distinguishability:

- 57(63)/72 pairs w/ at least one charged sparticle at 5(3)σ
- 0/90 model pairs with only neutral spartners accessible
- 57(63)/162 of all model pairs

MSSM Model Generation

Berger, Gainer, Hewett, Rizzo
In progress

- Goal: Generate 1000's of MSSM models, consistent with all known data, not tied to any specific SUSY breaking mechanism, and study them

- Scan 19-parameter CP-conserving MSSM (the PMSSM), accessible to LHC

- Expect to populate new regions of parameter space with different or potentially difficult signatures

- Using this model set, we will perform model independent collider studies (LHC & ILC), make predictions for direct & indirect DM searches (GLAST), and more

- We will make this model set public

Take a Random Point in MSSM Parameter Space

microOMEGAs 2.10
SuSpect 2.34

* Check B_u -> τ ν
* Check to see if any sparticles excluded by LEP direct search limits
* Check invisible width of the Z

DarkSUSY

* Generate Spectrum
* Check for Tachyons
* Check CCB and UFB
* Check b-> sγ
* Check LSP
* Check Δρ
* Check muon g-2
* Check B_s -> muons

SUSY-HIT

* Tevatron Constraints
  * jets + missing energy
  * **trileptons**

* Check Relic Density
* Check Direct WIMP Detection Cross Sections
* Check meson mixing

* LEP Stable Particle Check
* Tevatron Stable Particle Check
* LEP Higgs Search
* Tevatron Higgs contraints

PGS

PYTHIA

PROSPINO

Our Procedure

Preliminary Results: Model Properties

23,652 models have passed the constraints
thus far….(more to come!)
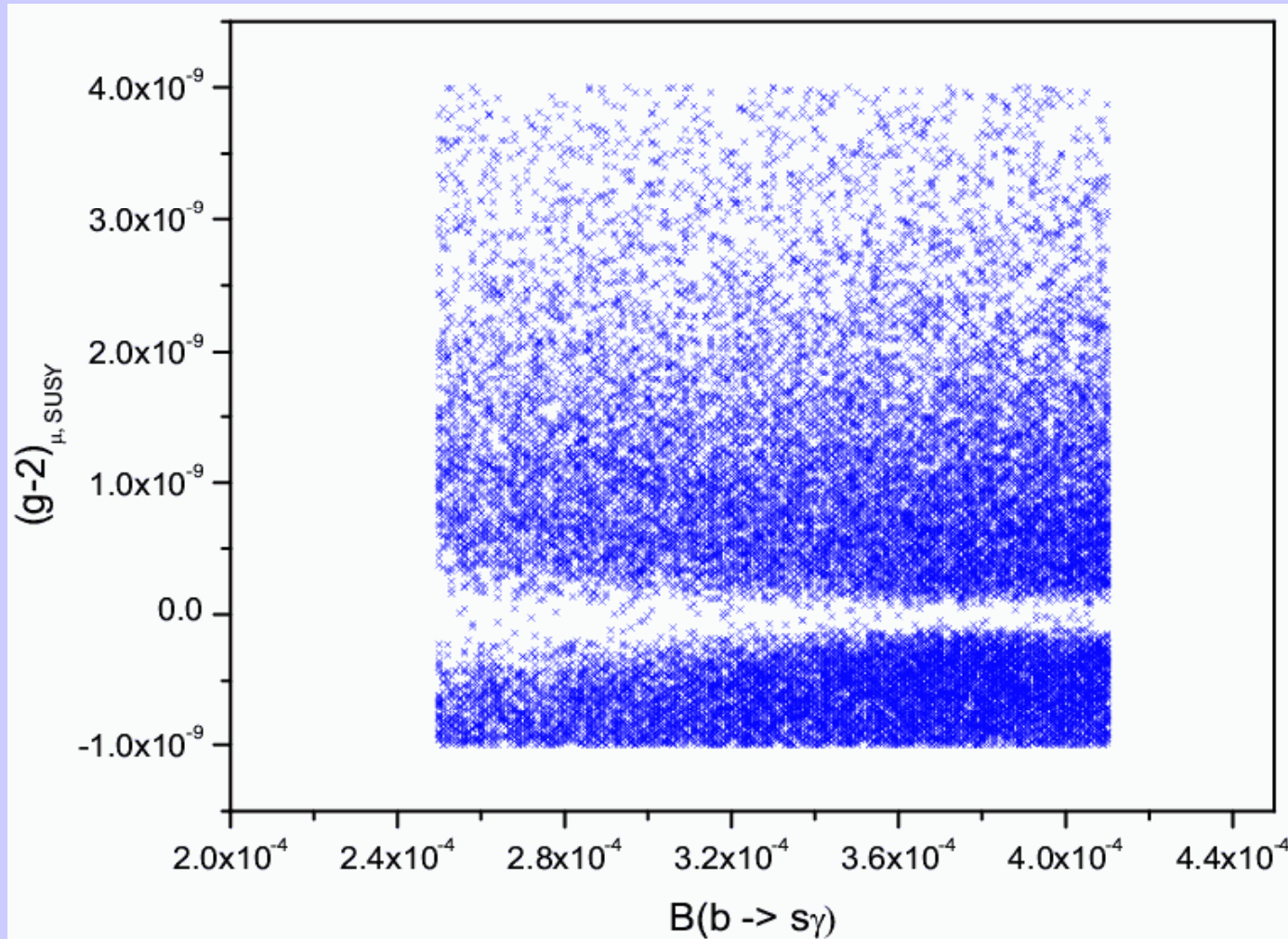
NLSP
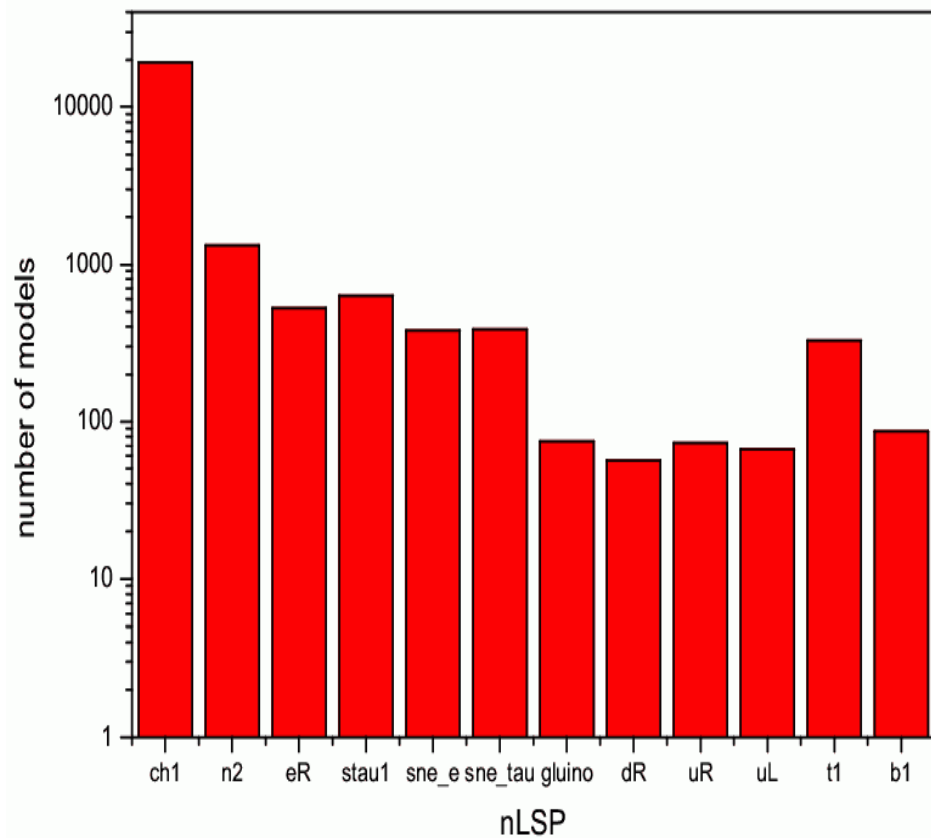
NLSP – LSP mass difference
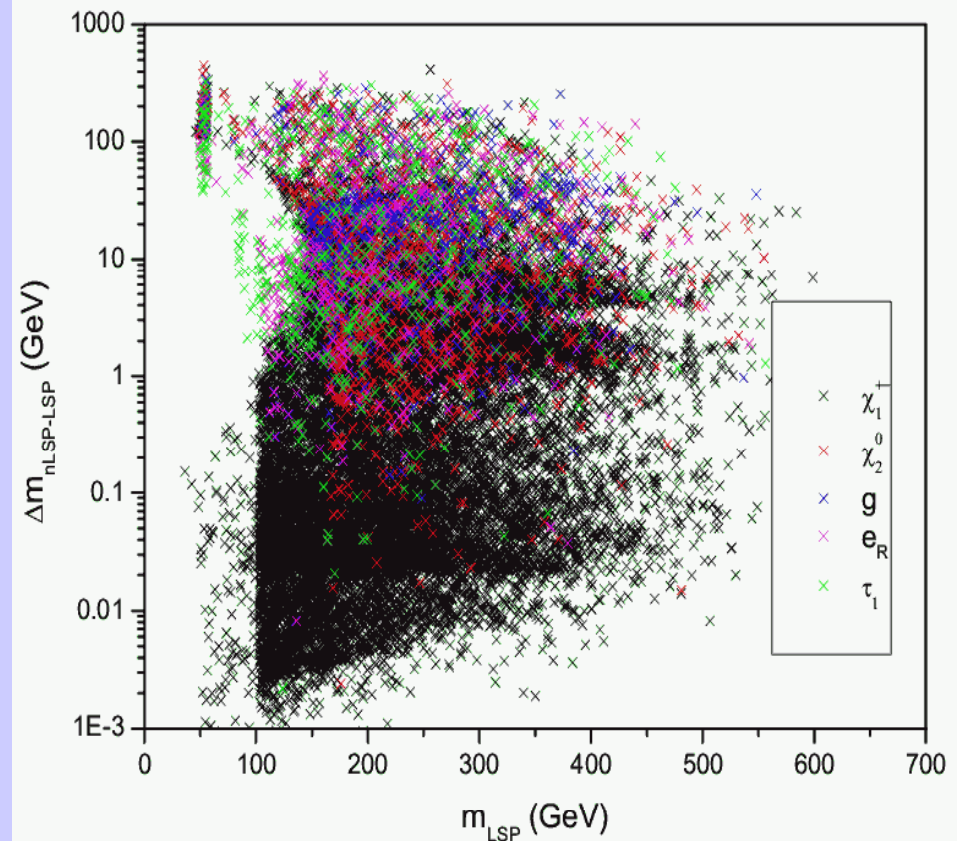
Many models with tiny mass
differences

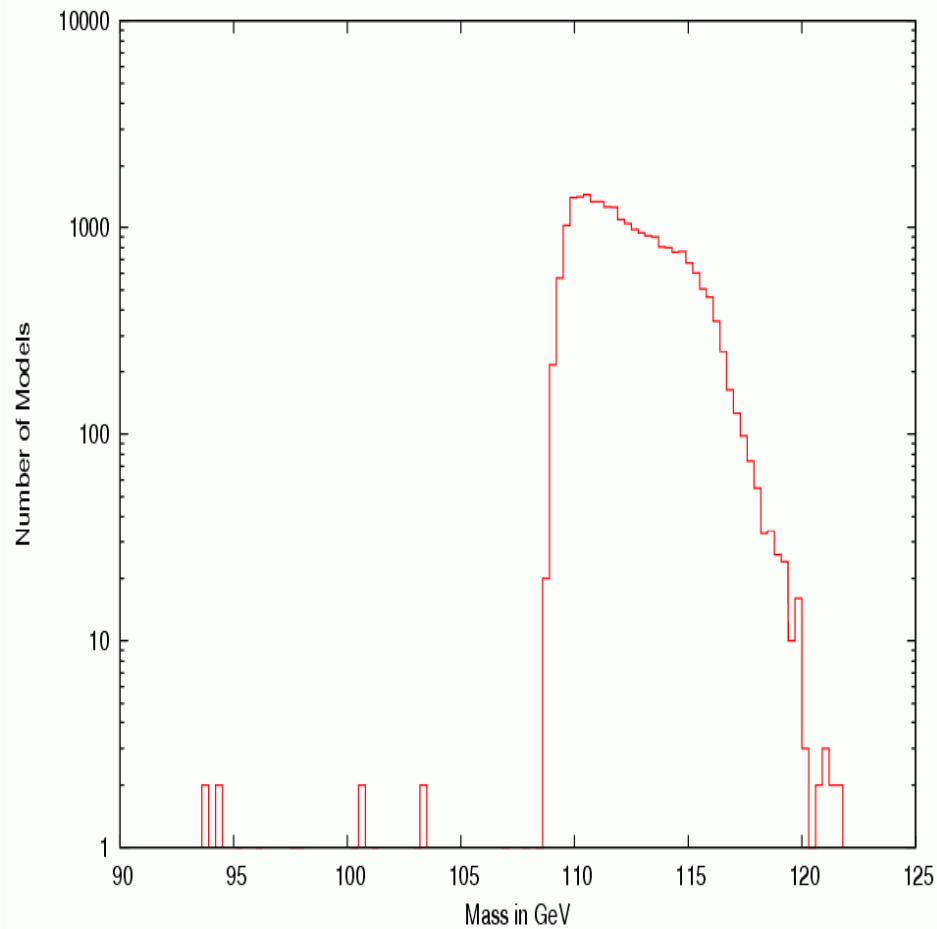# Preliminary Results: LSP Fractional Content
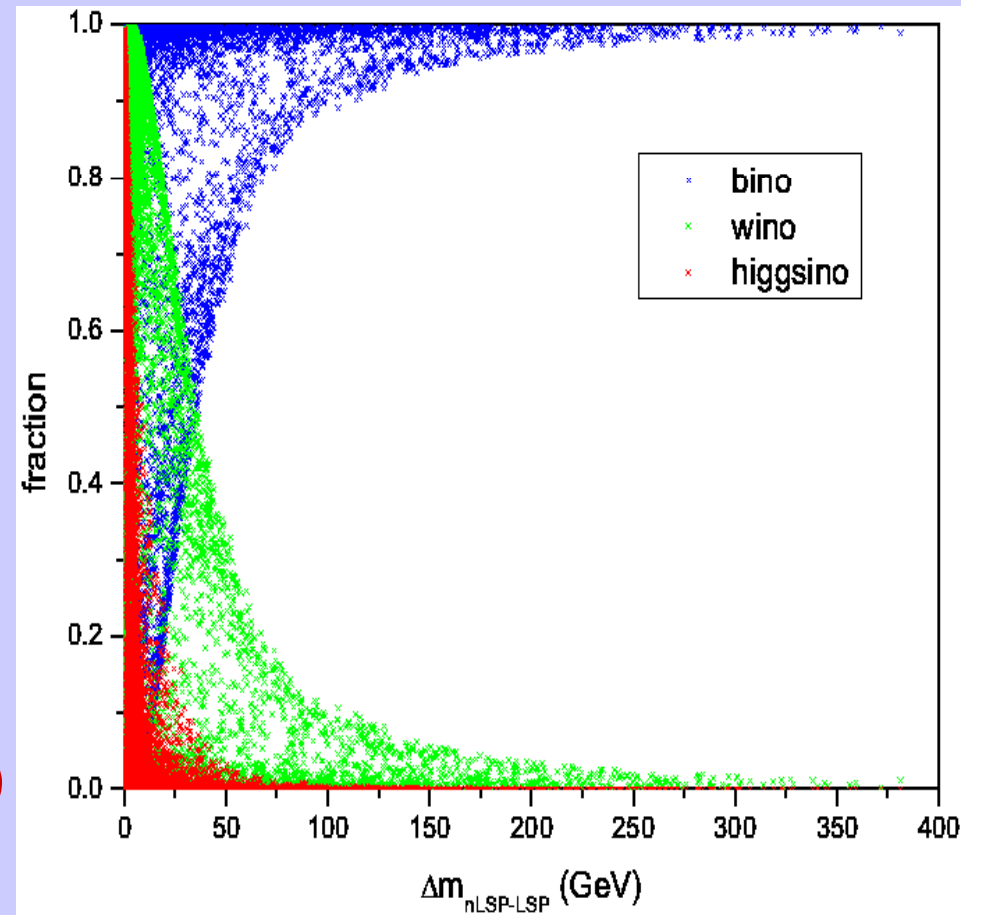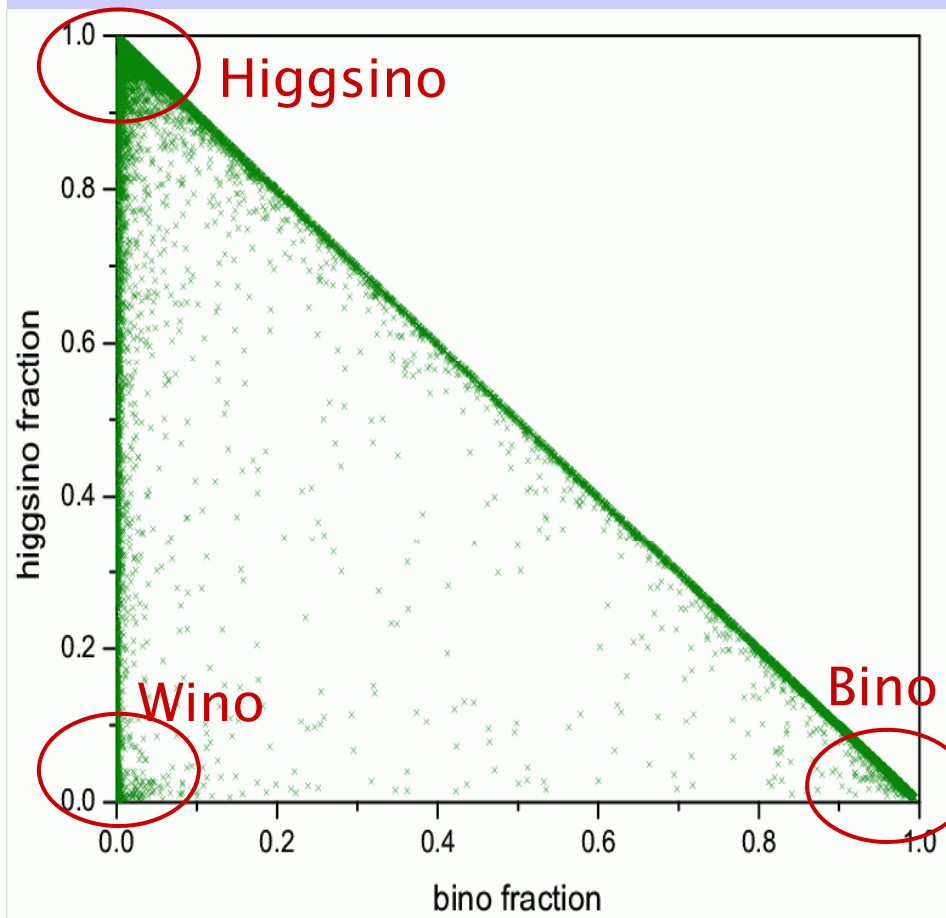
Preliminary Results: Exp't Constraints
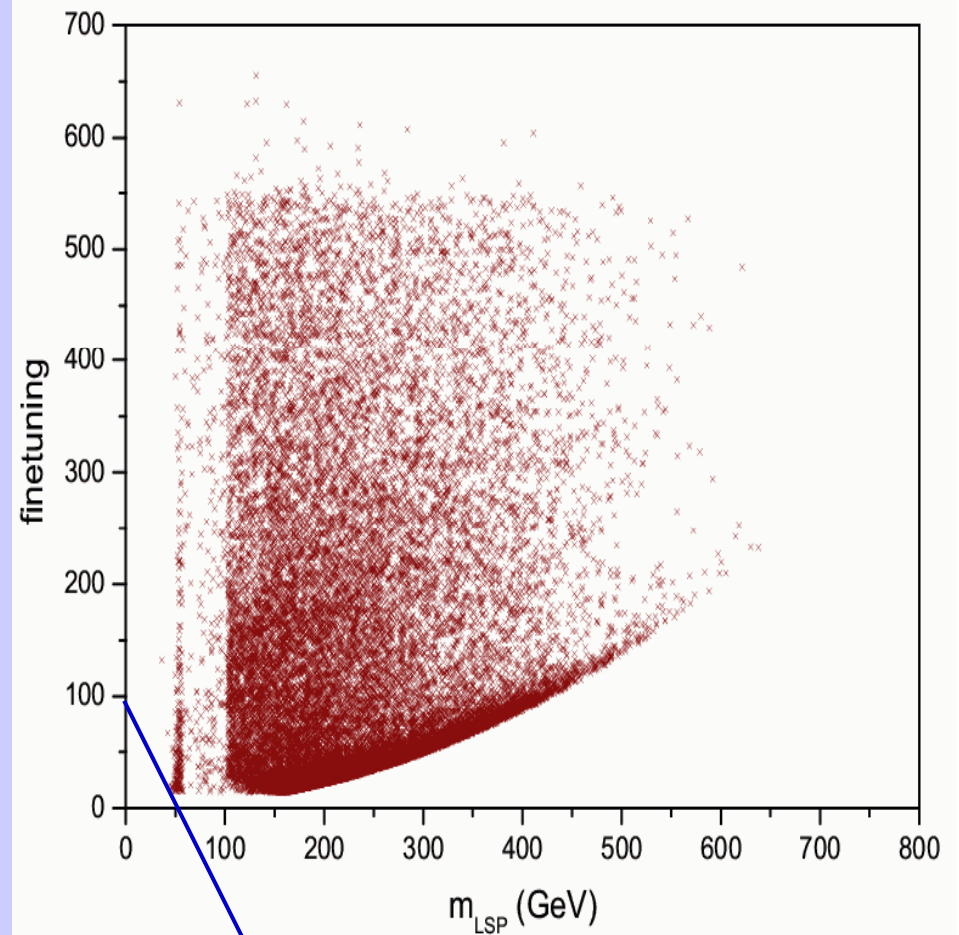

No correlation

Preliminary Results: Model Properties
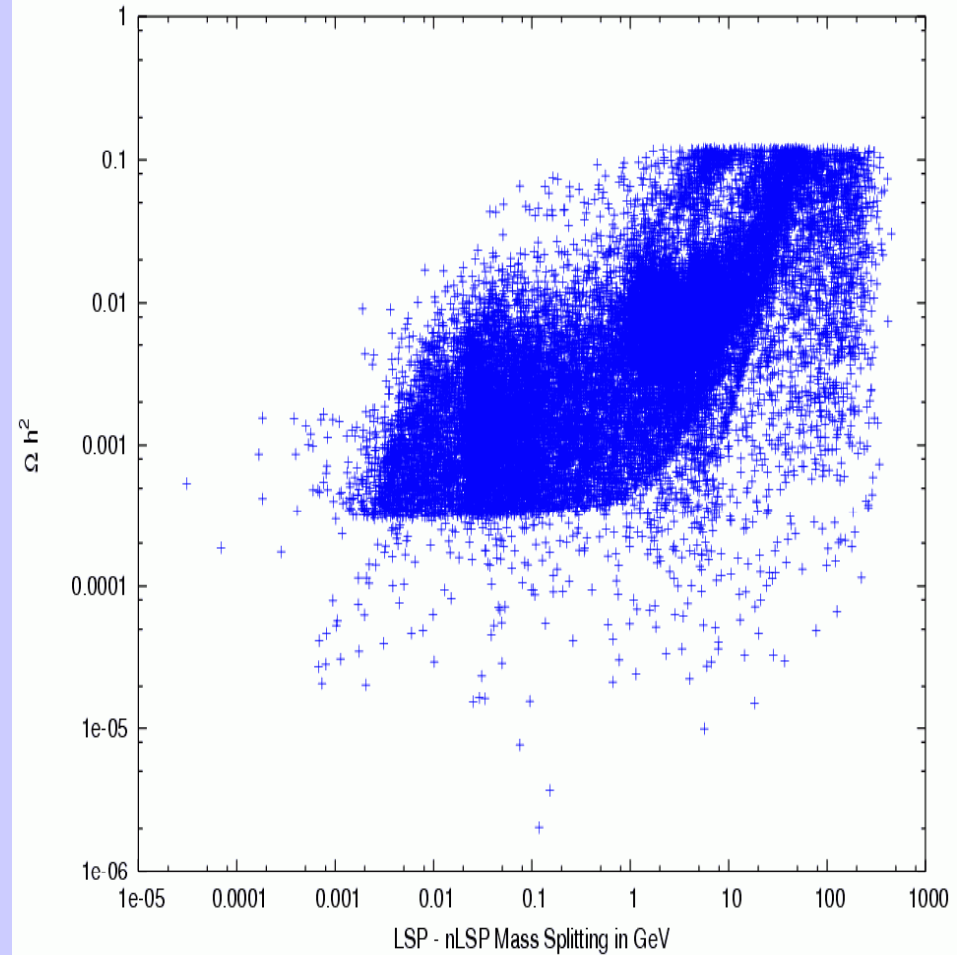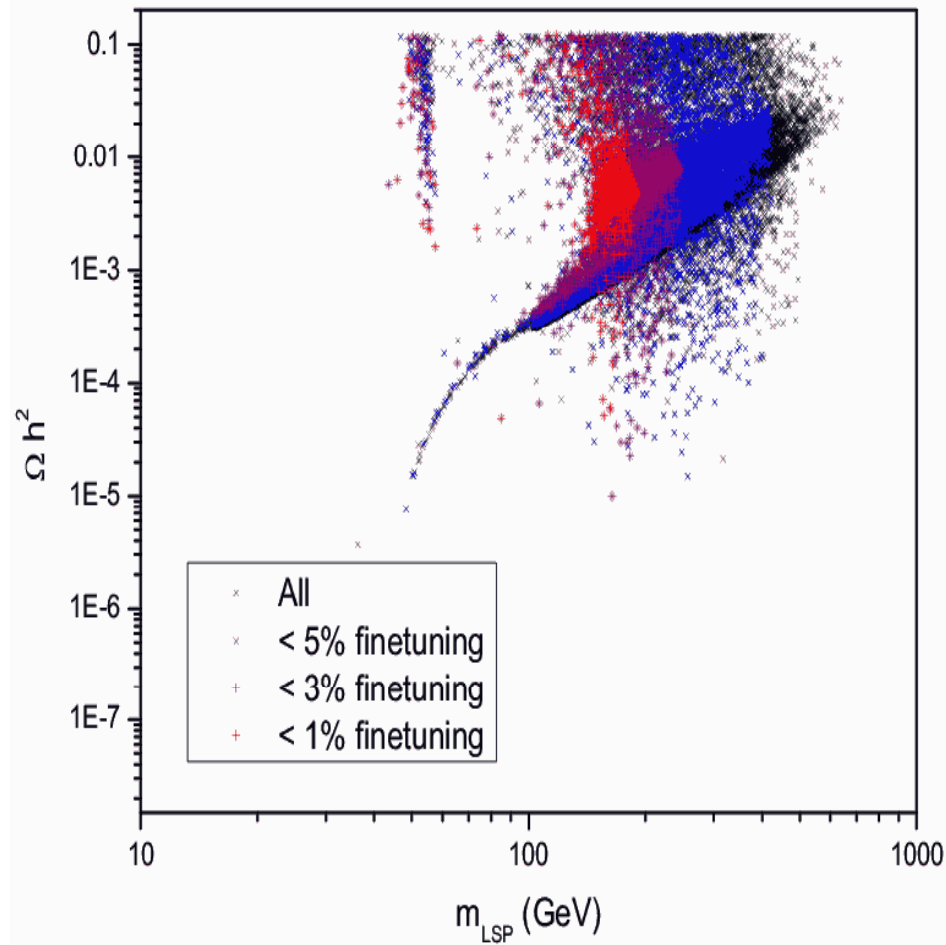
Higgs mass prediction

Fine-tuning

1% fine-tuned

Preliminary Results: Dark Matter
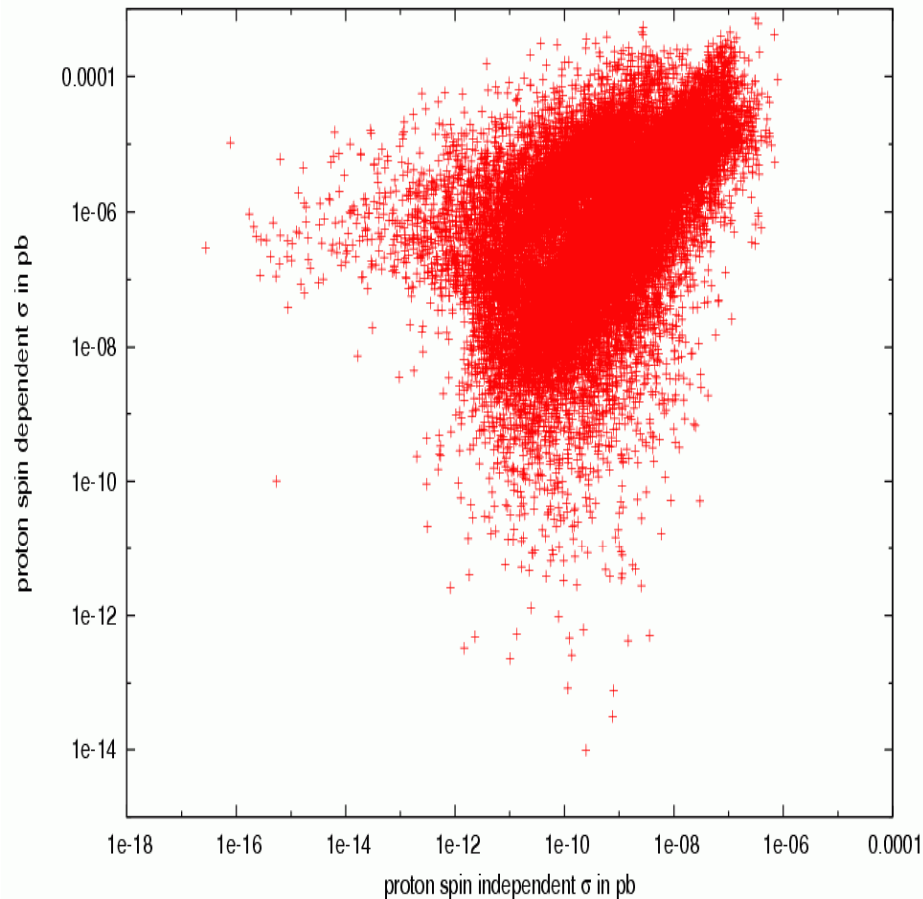
Preliminary Results: Dark Matter

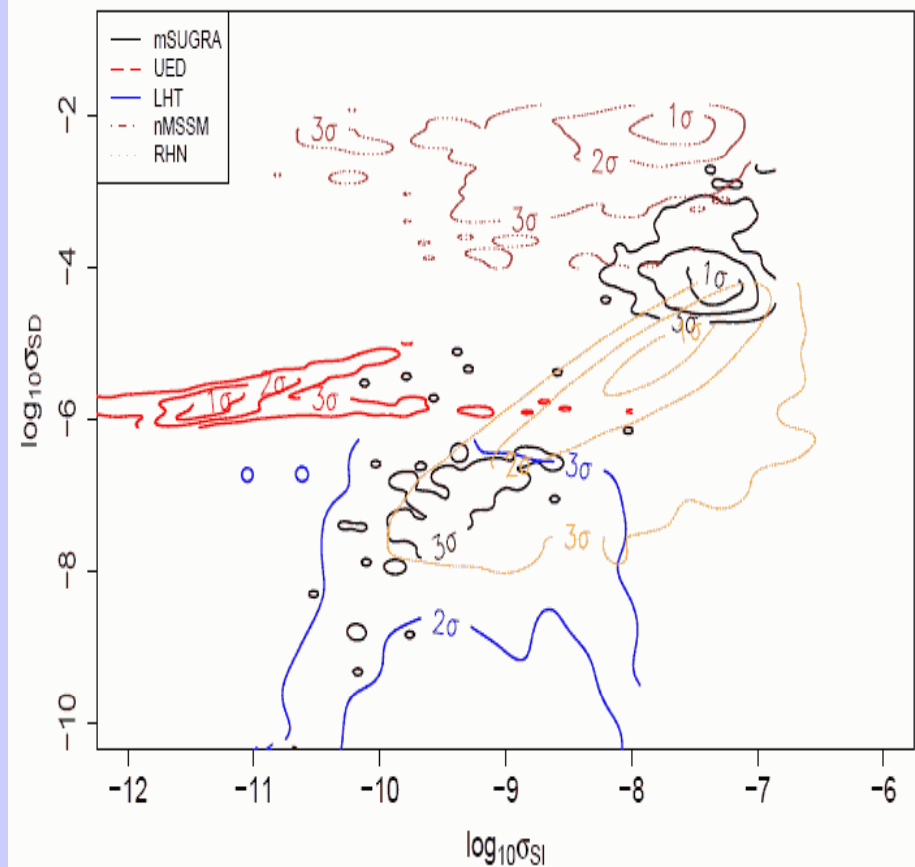Spin dependent vs independent Direct Detection cross sections

PMSSM

Various Models

Barger etal
arXiv:0806.1962

Summary

- MSSM @ ILC is more difficult than previously thought

- More to come for the PMSSM analysis

- The general MSSM can behave very differently than mSUGRA

- The LHC era is starting and we need to be prepared!