Some Complications in Analyzing Missing ET

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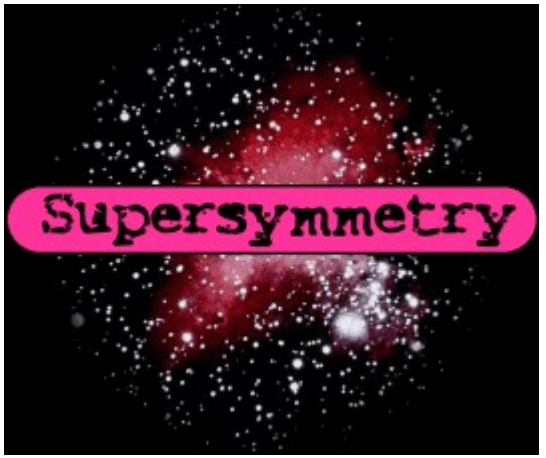
work in progress with Neal Weiner (NYU)
and with Andre DeGouvea (NEU)

The LHC Early Phase for the ILC

Missing ET Interpretations

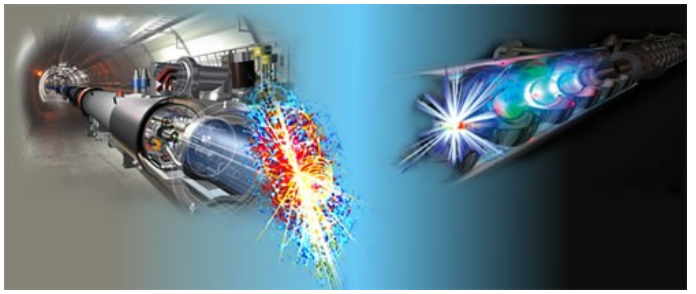


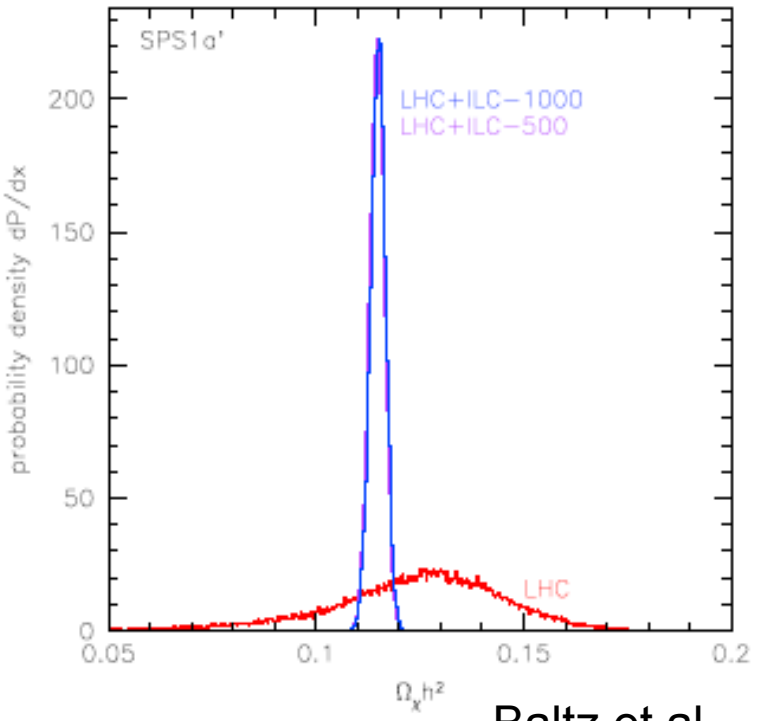
?

- Within a BTSM model
  - Discovery of new states (e.g. Superpartners)
- Is missing particle a WIMP?
  - Enough information to predict relic abundance?

Interpretation Pitfalls

- Cosmologically, LHC lacking… ILC combination ideal (Matchev et.al., Baltz et.al.)
- Looking under lamppost issues
  - Slight mods, with big effects, even within SUSY models
  - Complicated mods, standard interpretations may be poor or worse, unphysical





Baltz et.al.

New Singlet LSP

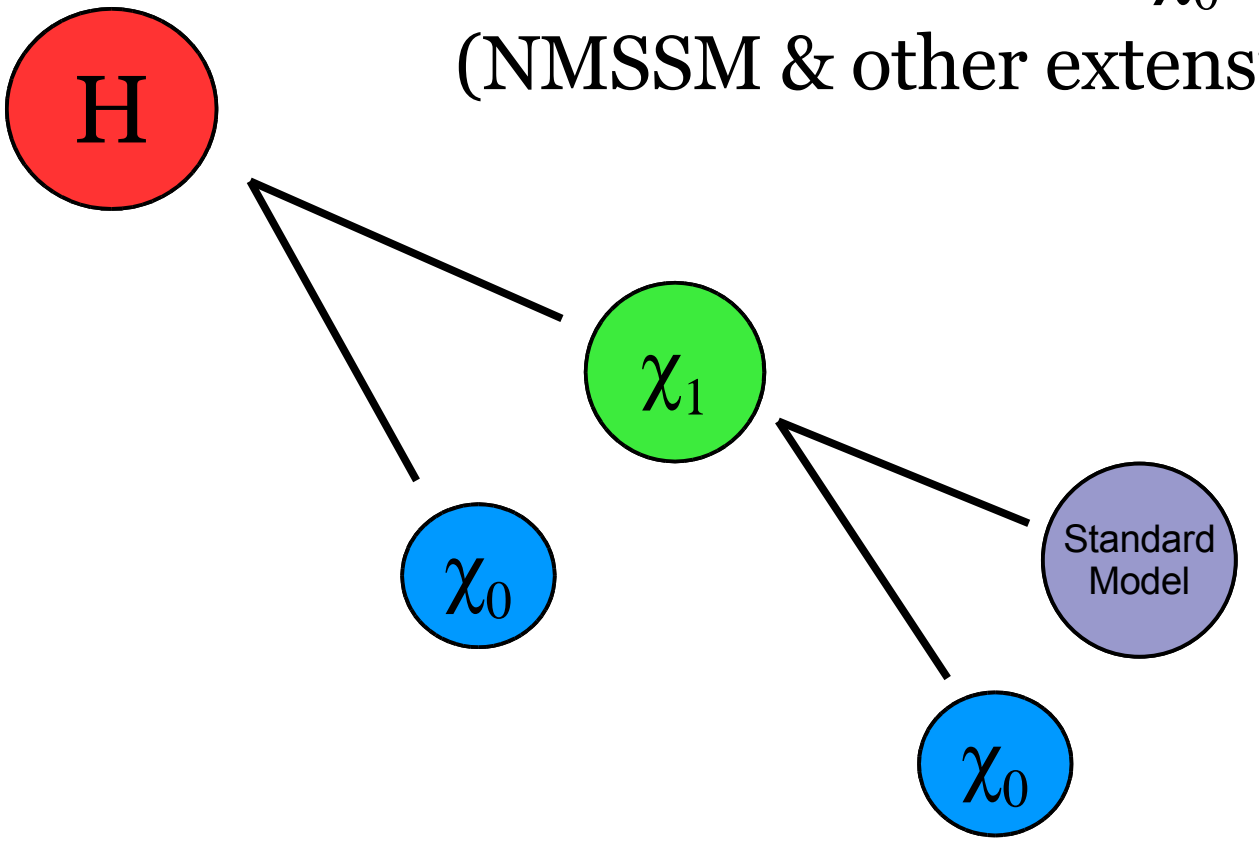
Work in progress w/ Neal Weiner

- Nonstandard Higgs motivation allowing Higgs lighter than LEP2 limit
- Sparticle search is affected
  - e.g. Weakening of Tevatron squark search
- DM abundance
  - LSP characteristics
  - New states as on-pole annhilaters?

Model Under Investigation

For motivation, see Carlos, Tim, Jack's talks in this workshop

MSSM
+
new neutralino χ_0
(NMSSM & other extensions)

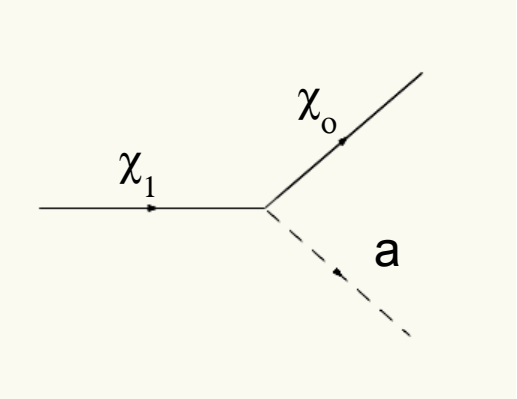


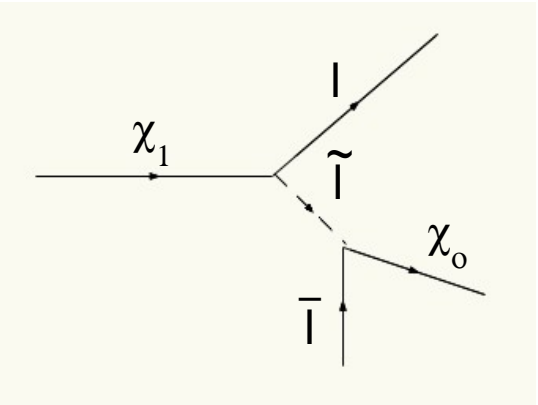
Nonstandard decays should be into neutral states, neutralinos?

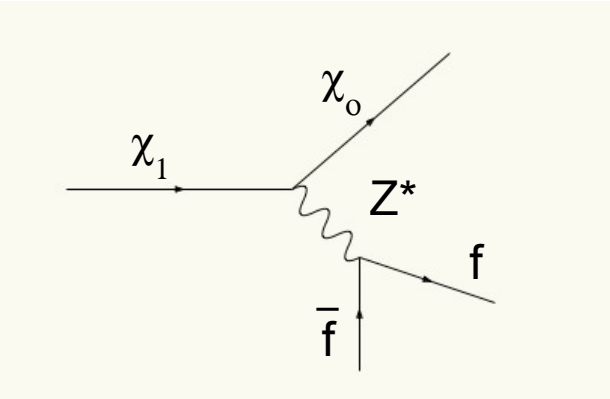
Invisible $2\chi_0$ decay strongly constrained

Higgs Mixed Neutralino Decay

- LEP2 – Higgs produced with Z
- Constraints depend on decays of χ_1







- Depends on non-Higgs searches with similar topologies, so constraints are only estimates
- Different signal assumptions: 1) optimized cuts or 2) use likelihoods based on signal

Higgs Limit

Strongest constraints from LEP2 sparticle searches

Upshot: 100 GeV Higgs seems allowed for

$BR(\chi_1 \chi_0) \sim 1$ for decays into light quarks, leptons, suggests Z*?

$BR(\chi_1 \chi_0) \sim .3$ for all modes

Neutralino Properties

h 90-110 GeV χ_1 40-60 GeV χ_0 1-20 GeV

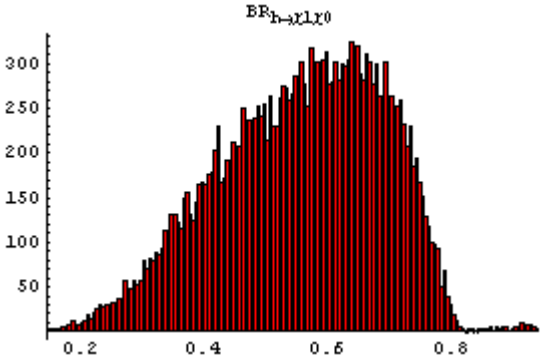
- Chargino search constraint, > 100 GeV
  - Requires a new singlet Weyl Fermion (Singlino) → NMSSM?
- Z Invisible Width and Neutralino Production at LEP
  - If $\tan\beta > 1$, χ_1 is mostly bino and χ_0 is mostly singlino Barger et.al.
- Dark Matter Abundance: No Overclosure
  - A new light scalar of mass about $2m\chi_0$

Belanger et.al.
Gunion et.al.
Barger et.al.

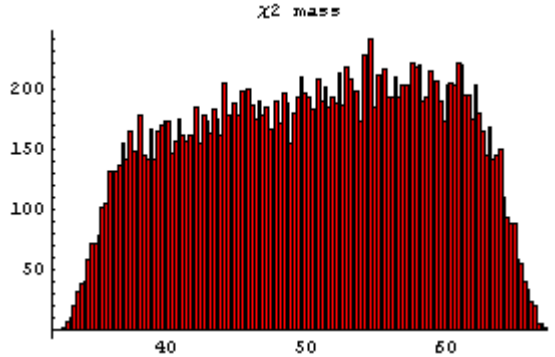
NMHDECAY Scan

Ellwanger, Gunion, and Hugonie

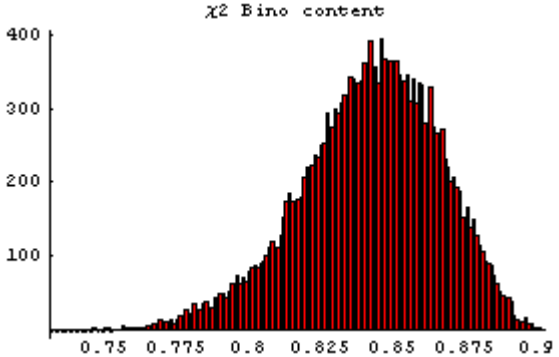
BR($h \rightarrow \chi_0\chi_1$) [0, 1]



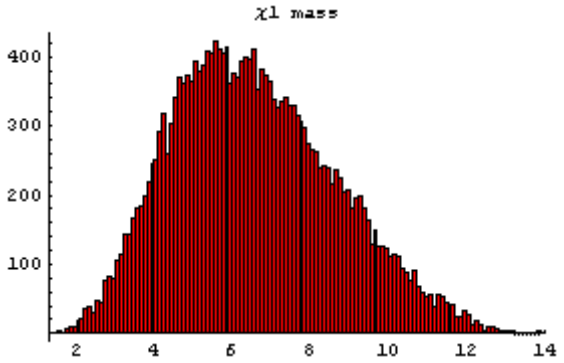
χ_1 mass [35, 65] GeV



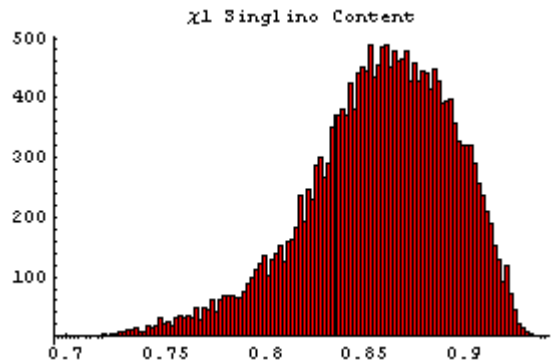
χ_1 Bino content [.75, .9]



χ_0 mass [0, 14] GeV



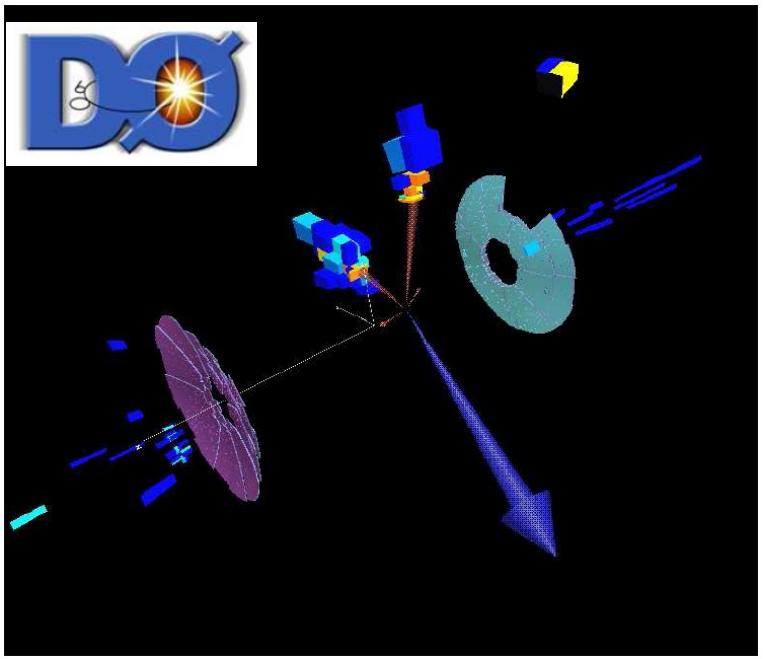
χ_0 Singlino content [.7,.95]



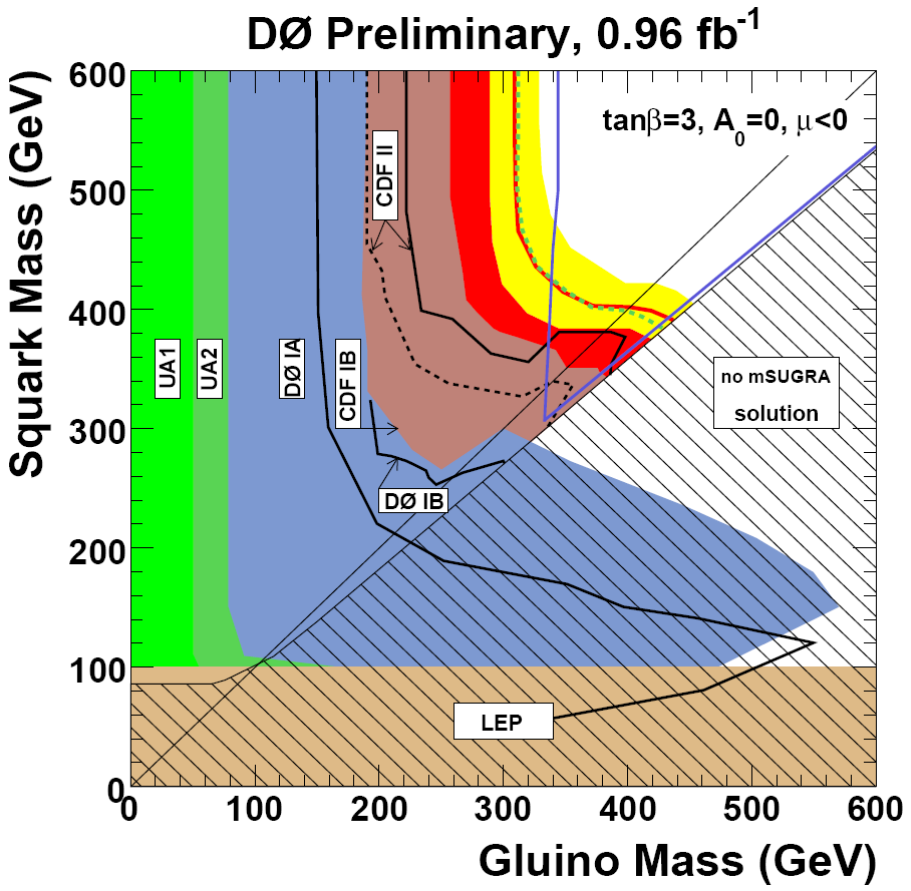
Impact on SUSY Pheno

Ellwanger,Hugonie
Strassler

- Dominant singlino LSP implies longer cascades
- Longer cascades mean more visible energy (jets, leptons) and reduced missing energy
- Tevatron searches normally expect:
  - Squark⟶ jet + MET
  - Gluino⟶ 2jets + MET
- Effects degrade search esp. with optimized MET cuts

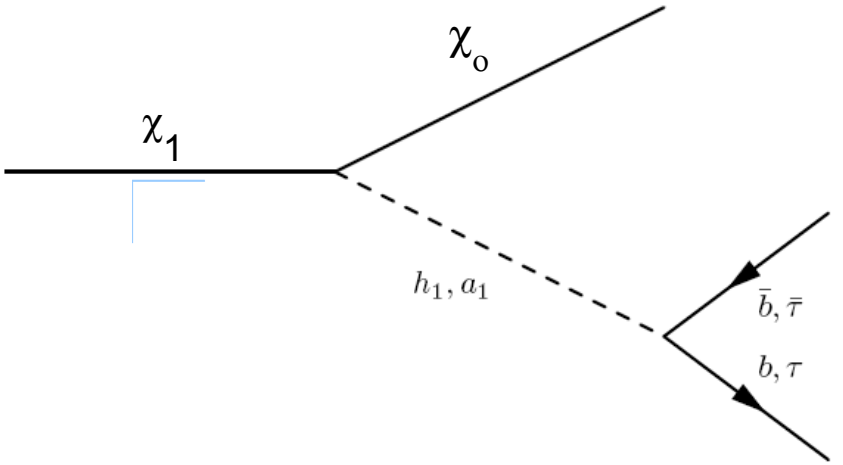


Tevatron Limits



Squark decays are actually more sensitive to dedicated gluino search

Missing Energy signature suppressed, e.g.



As m_a approaches m_{χ_1}, missing energy is reduced

Estimate of Squark Limits

- In progress: Using PYTHIA to ascertain current squark search limits applied to this scenario
- Appears that there is a 50-70 GeV decrease in limit
- Working on direct comparison via an MSUGRA like neutralino spectra + singlino

Squark Handles

Higgs constraints suggest additional leptons and/or light jets, perhaps through offshell Z's
Perhaps b's at reduced rate

Will searches be able to adapt to including potential tags?

Left handed squarks decay into chargino which decay into onshell W's into χ_0

Relic Abundance at LHC

- Need to measure a_1 mass
  - Possible to measure $a_1 \rightarrow 2b$ in $h \rightarrow 2a_1 \rightarrow 4b$, $\chi_1 \rightarrow a_1 \chi_0$?
  - Higgs decays crucial
- χ_0's gauge composition
  - If cascades are MSSM+final step?
    - Little info in the branching ratios of final decay
    - Phase space often more important than coupling strengths
    - Need to have higher neutralino decays reaching LSP

ILC Discovery Duties

- Understand Higgs sector
  - Potential discovery!
  - Masses and couplings of any new light degrees of freedom
- A precise understanding of other necessary components
  - Any other Electroweak particles, esp. neutralinos and possibly sleptons
- Enough for precision comparison to Ω_{DM}

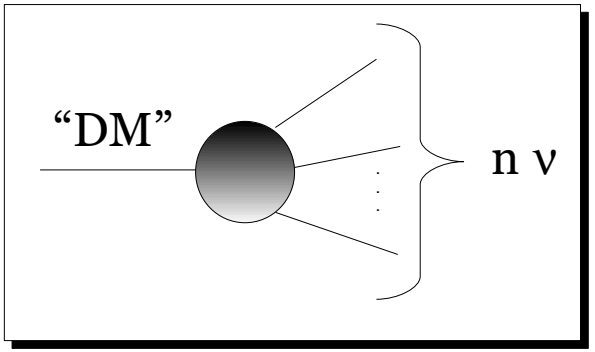
Other Possibilities

- Other new LSPs: e.g. RH sneutrino
- Highly displaced vertices from weak R-parity violation
  - UDD leading to $h \rightarrow 2\chi_1 \rightarrow 6$ (displaced?) jets
  - Hidden Valley Models (Strassler et.al.)
- R-parity violation into neutrinos: Fake Dark Matter

Fake DM

Work in progress w/ Andre DeGouvea

- SM already has source of missing energy in neutrinos
- Collider signals unchanged for:
  - WIMP if decays WIMP $\longrightarrow$ n ν
  - GMSB with charged NLSP if $Y^+ \longrightarrow \tau^+ \nu$
- Any associated signals?
  - LHC: Modification potentially leads to changes in decays and branching ratio
  - ILC: Neutrino fusion? (Model building difficult)



Global Analysis Best?

Squarks
Higgs & Other Scalars
Neutralinos

MARMOSET: The Path from LHC Data to the New Standard Model via On-Shell Effective Theories

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Abstract

We describe a coherent strategy and set of tools for reconstructing the fundamental theory of the TeV scale from LHC data. We show that On-Shell Effective Theories (OSETs) effectively characterize hadron collider data in terms of masses, production cross sections, and decay modes of candidate new particles. An OSET description of the data strongly constrains the underlying new physics, and sharply motivates the construction of its Lagrangian. Simulating OSETs allows efficient analysis of new-physics signals, especially when they arise from complicated production and decay topologies. To this end, we present MARMOSET, a Monte Carlo tool for simulating the OSET version of essentially any new-physics model. MARMOSET enables rapid testing of theoretical hypotheses suggested by both data and model-building intuition, which together chart a path to the underlying theory. We illustrate this process by working through a number of data challenges, where the most important features of TeV-scale physics are reconstructed with as little as 5 fb^{-1} of simulated LHC signals.

Conclusions

- LHC connection to cosmology is strong, but interpretation is difficult
- ILC already known to be important for this in MSSM
- In general, a light singlet LSP that just extends cascades is a simple mod w/ larger complications
  - Higgs and Squark search
  - Dark Matter Abundance?
    - Mass eigenstate charge composition
    - On-pole annhilators

Conclusions (cont.)

- ILC's role
  - Light Higgs pheno related to cosmology
  - In general, could be the discovery machine (higgs, states necessary for DM abundance)
- More exotic possibilities w/ more pitfalls for interpretations of DM
- Analysis issues suggest a need for a global analysis that is adaptable and not wedded to a model (MARMOSET?)
- Cautious analysis is best – i.e. Avoid model priors until necessary