Sneutrino NLSP at the LHC

Parallel session Planck '10 talk

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work done with Brock Tweedie

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Outline

$\tilde{\nu}$ NLSP - theoretical motivation

- Do we understand collider signatures of MSSM?
- Can we expect more surprises from "abandoned" parts of the MSSM parameter space?
- Can we effectively distinguish between different SUSY scenarios at the LHC?

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These questions are especially relevant for SUSY w/ $\tilde{\nu}$ NLSP and Gravitino LSP. The last step of the cascade $\tilde{\nu} \to \nu \tilde{G}$ is invisible. Can we distinguish this possibility from an "ordinary" SUSY, e.g. w/ $\tilde{\chi}$ NLSP?

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- Even easier: high scale mediation with **negative** $m_{\bar{5}}^2$
- other ways...

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Example: for $m_{\tilde{l}} = 150\ \mathrm{GeV}$, $\tan\beta = 10$ we get the splitting $\Delta m \approx 20 GeV$. This is a typical value for the splitting.

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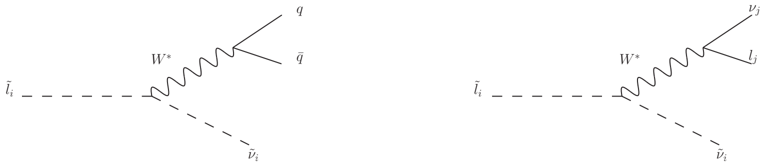

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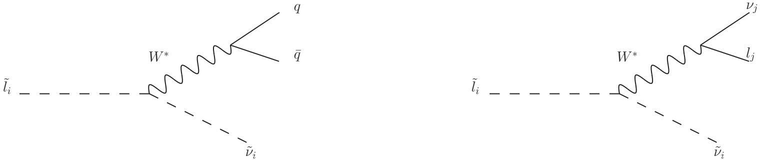

Remarks about $\tilde{l}_L$ decay:

- ≈20% of time emits a lepton
- the lepton is flavor uncorrelated w/ its parent
- the lepton might be relatively soft

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We find suggestive signals in following channels:

- ratio 2l:3l (almost generic)
- 2l channel (almost generic)
- 3l channel (almost generic, gives a beautiful and background-free confirmation of the signals in the 2l channel). **Skip in this talk**
- multi-lepton channel (model-dependent)
- strong $e - \mu$ assymetry in signal (model-dependent)

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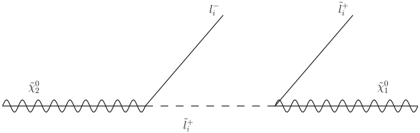

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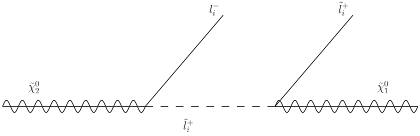

Our case is different. The LH sleptons sits at the bottom of the spectrum and cannot mediate this decay. We might or might not have a RH slepton between the gauginos. The fate of the OSSF excess depends on the place of the RH selectron in the spectrum.

2l channel in RH-inactive spectra

Define a RH inactive spectra:

Spectrum in which $m(\tilde{B}) < m(\tilde{e}_R)$

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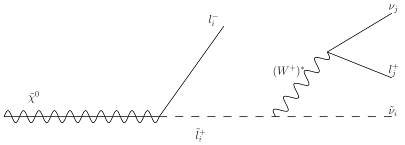
- One decay chain from the LH slepton decay - sign, but not flavor correlated



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- Squarks (and gluinos) almost exclusively decay into gaugino
- gauginos have $\approx 1/3$ chance to produce a lepton $\Rightarrow$ big population of sign and flavor uncorrelated leptons. Same-sign dileptons can be good early discovery channel.
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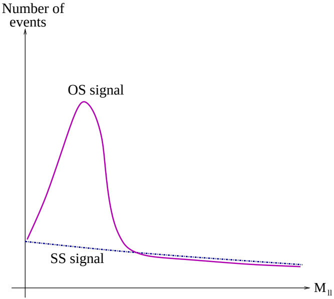

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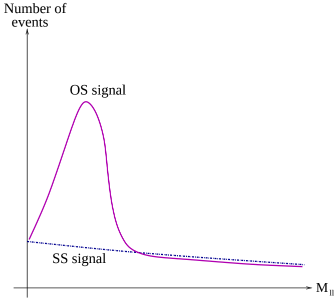

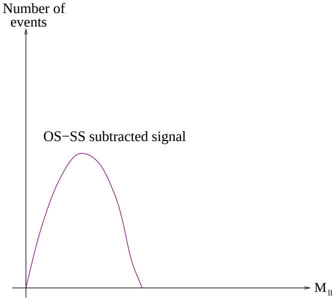

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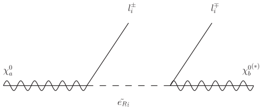
Dileptons can come from

- Different decay chain
- LH slepton 3-body decay (sign correlated)
- bino decay through RH slepton (**OSSF**):



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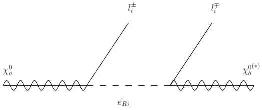

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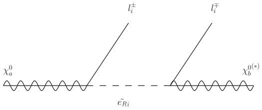

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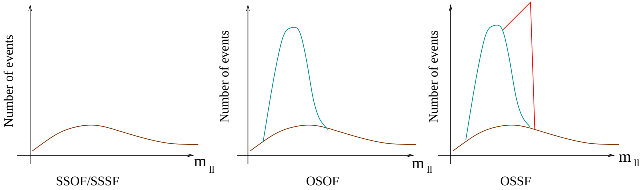

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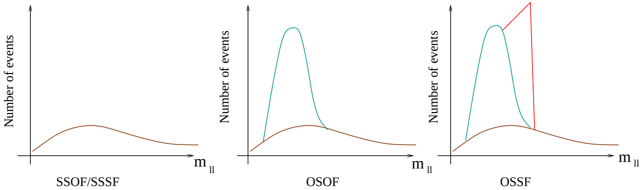

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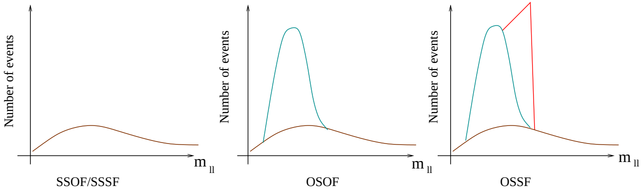

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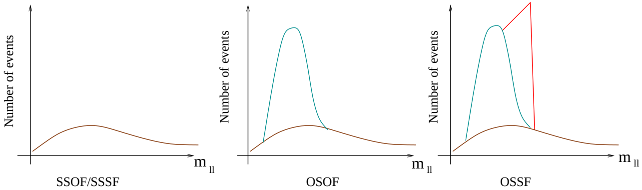

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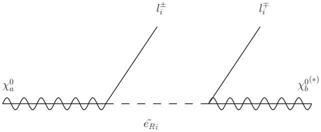
- Perform OSOF-SSOF subtraction. Since OSOF excess is merely due to $\tilde{l}$ decays, the shape will carry the information about $\tilde{\chi} \to \tilde{l} \to \tilde{\nu}$ transition. This channel and the shape of the excess is very hard to "fake" in other supersymmetric spectra.

Flavor violating signals from flavor universal spectrum

$\tilde{\nu}$ NLSP can be responsible for even more surprising signatures. Consider the spectrum where all gauginos are heavier than scalars, and $m(\tilde{e_R}) > m(\tilde{l})$. Bino-like neutralino, produced in the cascade will more often decay into $\tilde{e_R}$, but this selectron is "trapped". It should undergo 3-body decay through neutralino off-shell:



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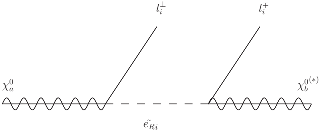

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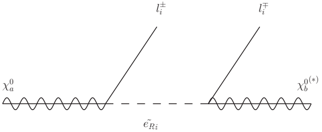

Can any other mechanism mediate $\tilde{e_R}$ decay more efficiently?

The only candidate is LR mixing. We usually assume that this mixing is tiny. But 3-body rate is also suppressed. Can they compete if $\tilde{e_R}$ can undergo 2-body decay through LR mixing? Namely when

$$m(\tilde{e_R}) > m(W) + m(\tilde{\nu})$$

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- $\tilde{e}_R$ decays through 3-body decay, leads always to $e^+ e^-$ pair
- $\tilde{\mu}_R$ decays mostly to $W \tilde{\nu}$, mostly without leptons
- more $e^+ e^-$ than $\mu^+ \mu^-$ in the signal

Conclusions and Outlook

- $\tilde{\nu}$ NLSP is a well motivated possibility with interesting collider signatures
- signals of $\tilde{\nu}$ NLSP are distinctive and not easy to fake within MSSM
- $\tilde{\nu}$ can be a source of exciting and unusual phenomenology ("flavor-violating" signal)