Left sneutrino LSP and same-sign trileptons at the LHC

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The central point:

If the dark matter candidate is an elementary particle not commonly thought about in that role, it may influence the search strategies in accelerator experiments, too.

A. Chatterjee, N. Chakrabarty, BM, Phys. Lett. B754, 14 (2016)

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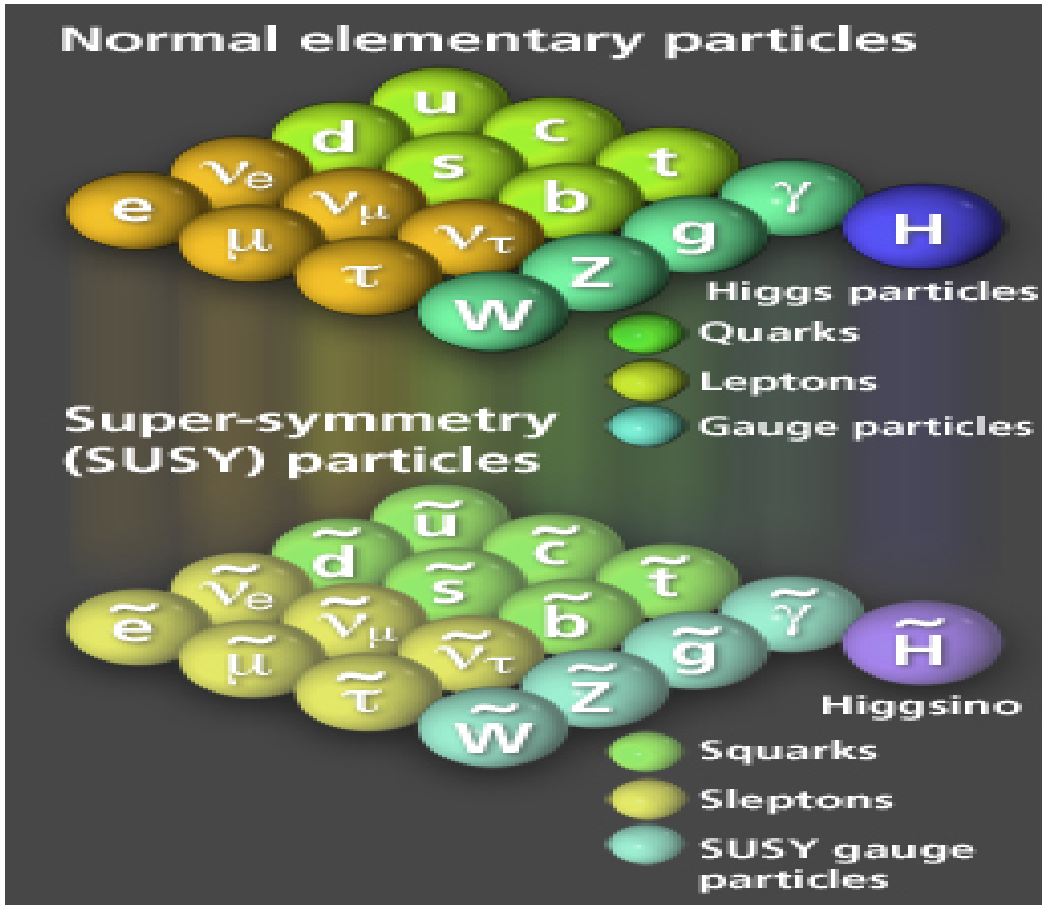
- *Example: (left) sneutrino LSP, with constraints from DM elastic scattering absent, due to some feature of the spectrum*

  $\Rightarrow$ *New collider signal(s)*

The MSSM spectrum...



Physical states important in phenomenology being

Charginos: $\chi^{\pm}_{1,2} = (...)\tilde{W}^{\pm} + (...)\tilde{H}^{\pm}$

Neutralinos: $\chi^{0}_{1,2,3,4} = (...)\tilde{B} + \tilde{W}^{3} + (...)\tilde{H}^{0}_{1} + (...)\tilde{H}^{0}_{2}$

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- *Expected signal of SUSY with a DM candidate:*
  Largely MET + jets, also leptons
  Trileptons and same-sign dileptons: 'cleanly' probe some features of the spectrum

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- *Problem with direct DM search: unsuppressed coupling with the Z implies high elastic scattering rates*
- *A possibility:* $\tilde{\nu}_L = \tilde{\nu}_1 + i\tilde{\nu}_2$

  Suppose, $\tilde{\nu}_1$ *and* $\tilde{\nu}_2$ *are split in mass. A tiny* $\Delta L = 2$ *mass term can do it*

  L. Hall, T. Moroi, H. Murayama (1998); E. Ma, U. Sarkar (2012); A. Chatterjee, N. Sahu (2014)

  $Z - \tilde{\nu}_1 - \tilde{\nu}_2$ *coupling is required for DM scattering: a mass split* ≈ 300 *keV can prevent it for* $\Delta m > m v_{esc}^2/2$

  D. Smith, N. Weiner (2001)

  Direct search constraints thus evaded $\Rightarrow \tilde{\nu}_L$ *LSP possible*

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- *Also possible: $\tilde{\nu}_L$ at the bottom of the MSSM spectrum + lighter gravitino*
  ($\tilde{\nu} \longrightarrow \nu \tilde{G}$ is all invisible)
  A gravitino (warm) dark matter candidate
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- *A distinctive signal at the LHC: same-sign trileptons (SS3L)*
  A. Chatterjee, N. Chakrabarty, BM (PLB, 2016)

Same sign trileptons (SS3L)...

Suppressed in R-parity conserving SUSY
Negligible standard model background

In this case,
Any cascade to $\chi_1^0 \Rightarrow \tilde{l}_L$ *produced in* $\approx$ *50% cases*

The two associated leptons are of same sign in 50% events

One more ℓ *from the cascade produces SS3L*

SM background $\leq 10^{-}3$ *fb, fakes removed by a hard MET cut* (≥ 100 *GeV*)

- *In general,*
  both $\tilde{g}\tilde{g} \longrightarrow t_1 \tilde{t}_1 t_1 \tilde{t}_1$
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- *Mostly, SS3L* $\Rightarrow$ *SS4L, though with smaller rate*

Same sign trileptons (SS3L)...

With $\tilde{\nu}_L$ at the bottom, one predicts
$\approx$ 25-30 (35-40) events in LHC@13 TeV (14 TeV),
with $\int \mathcal{L} dt = 100 fb^{-1}$, for
$m_{\tilde{g}} = 1.6\,TeV, \qquad m_{\tilde{t}_1} = 1.0\,TeV,$
$m_{\chi_1^0} = 600\,GeV, \qquad m_{\tilde{\nu}_L} \approx 300\,GeV$
The main SUSY signal, namely, jets $+$ 0ℓ $+$ MET,
reduced by more than a factor of 2

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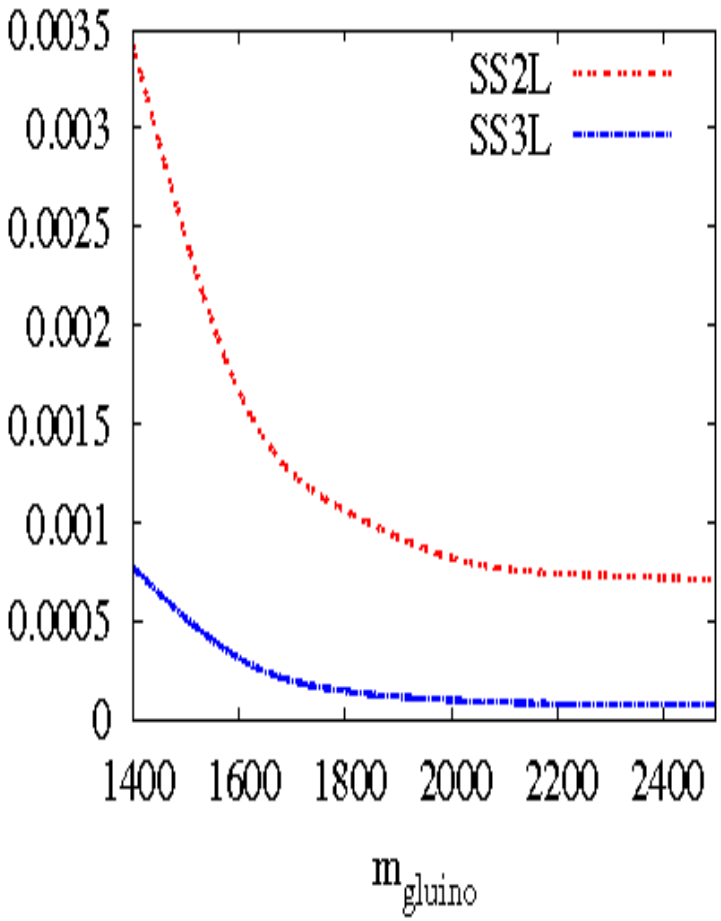

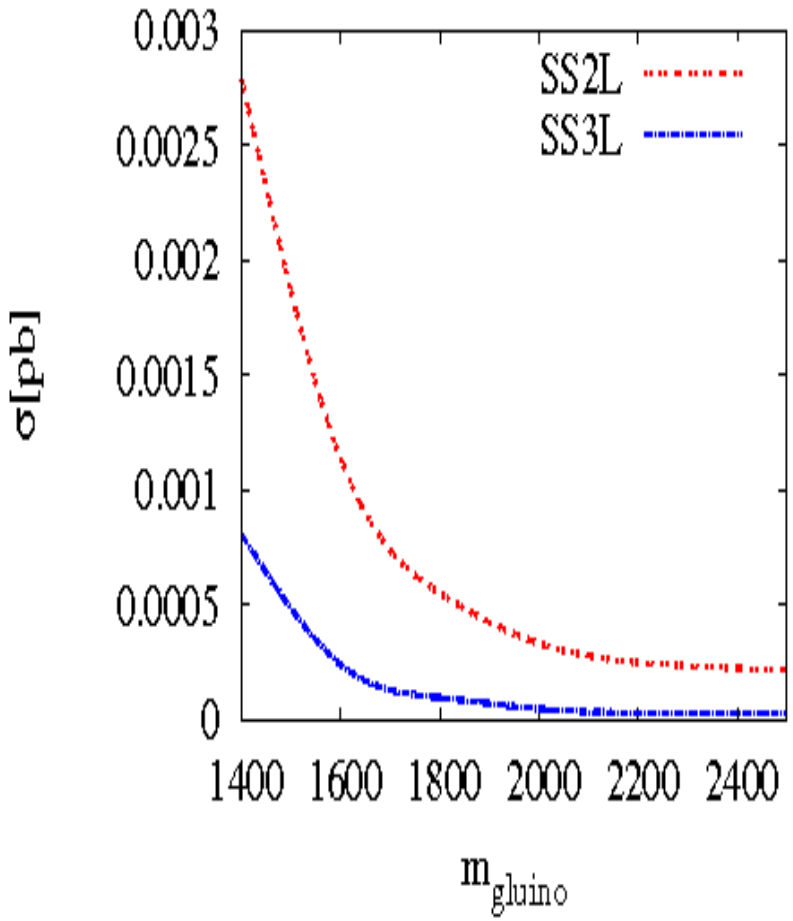

Left (Right) : $m_{\tilde{t}_1} = 1000\ (1200)$ GeV
$\sqrt{s} = 14$ TeV

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- *Highly compressed spectrum*
- $2\ell/0\ell$ *ratios can be useful in such cases*

Concluding remark...

To verify any dark matter scenario in a terrestrial (read accelerator) experiment, it may be too restrictive to think in terms of stereotypes!