Simplified Models and Muon $g-2$ (in the MSSM)

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Coordinating a simplified models effort
CERN - October 30th, 2013

In collaboration with the SModelS* group
*(see S. Kulkarni's talk)

$g-2$ and Simplified Models

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$\rightarrow$ Here we use the SMS experimental results (through SModels) to answer:

What is the status of g_{-2} in the (unconstrained) MSSM after the LHC Run I?

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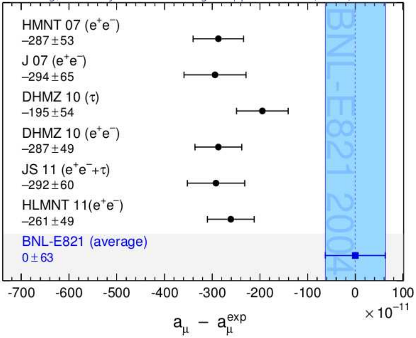
  $a_\mu^{E821} - a_\mu^{SM}(e^+e^-) = (27.8 \pm 8) \times 10^{-10}$ (3.5σ)

Z. Zhang, Nucl.Phys. B Proceedings Supplement 00 (2013)



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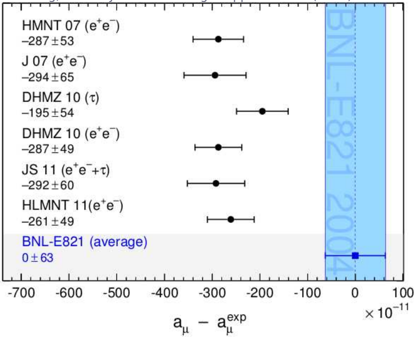

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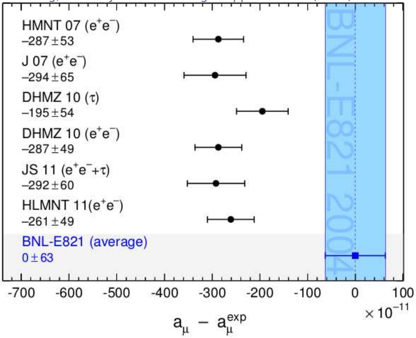

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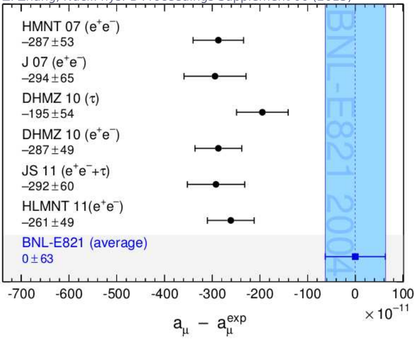

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- **Good framework for applying simplified models constraints**

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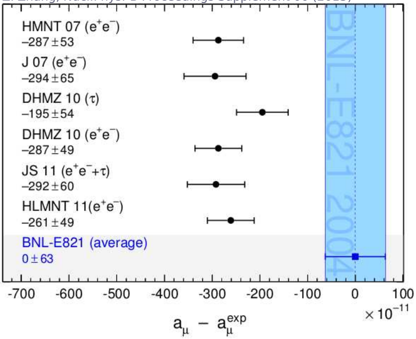
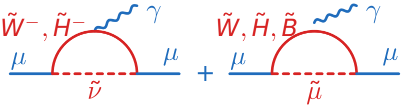


Quick Review of $g\!-\!2$ in the MSSM

- Main MSSM contributions:



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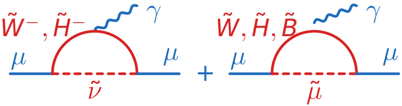

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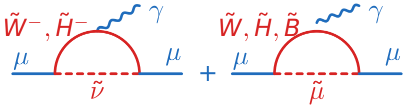

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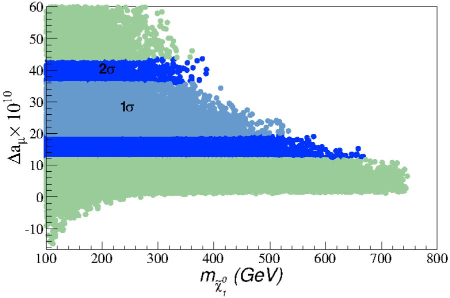
  μ, M_1, M_2, $m_{\tilde{\mu}_{L,R}}$, $\tan\beta$
- $m_{LSP} \lesssim 530$ GeV (670 GeV) at 1σ (2σ)

General scan ($\tilde{\chi}_1^0$ LSP):



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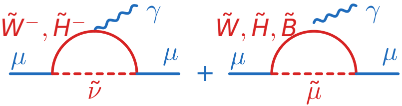

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$g\!-\!2$ by itself does not guarantee a visible spectrum at the LHC-Run I

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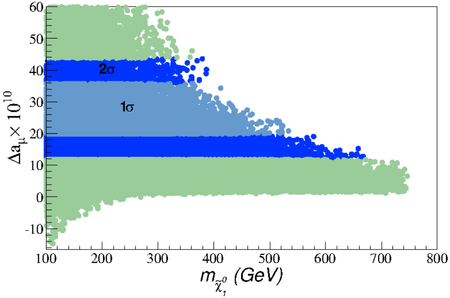
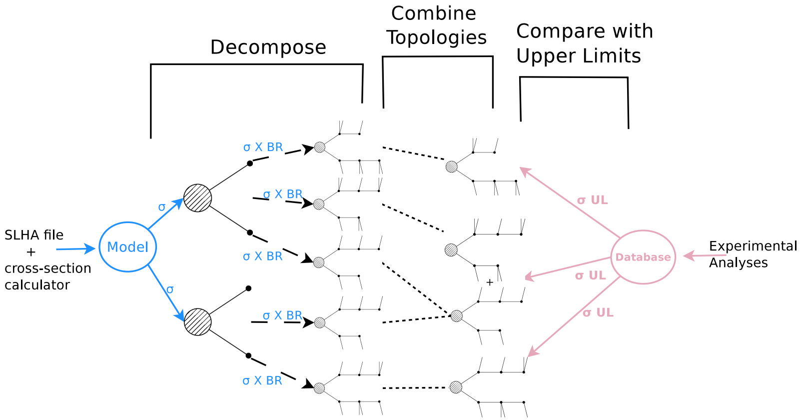


$g-2$ in the MSSM

For the results presented here:

- Simplifying assumptions:
  - $m_{\tilde{t}}, m_{\tilde{b}} \sim 1$ TeV
  - $m_{\tilde{g}} = 1.5$ TeV, $m_{\tilde{q}} = 2$ TeV
  - Degenerate sleptons (but $m_{\tilde{l}_L} \neq m_{\tilde{l}_R}$)
- No strong sector constraints ($m_{\tilde{g}} = 1.5$ TeV and $m_{\tilde{q}} = 2$ TeV)
- $\sim$ 15 LHC results for EW gauginos and sleptons
- Constraints on simplified models are implemented through SModelS

$g-2$ and SModels



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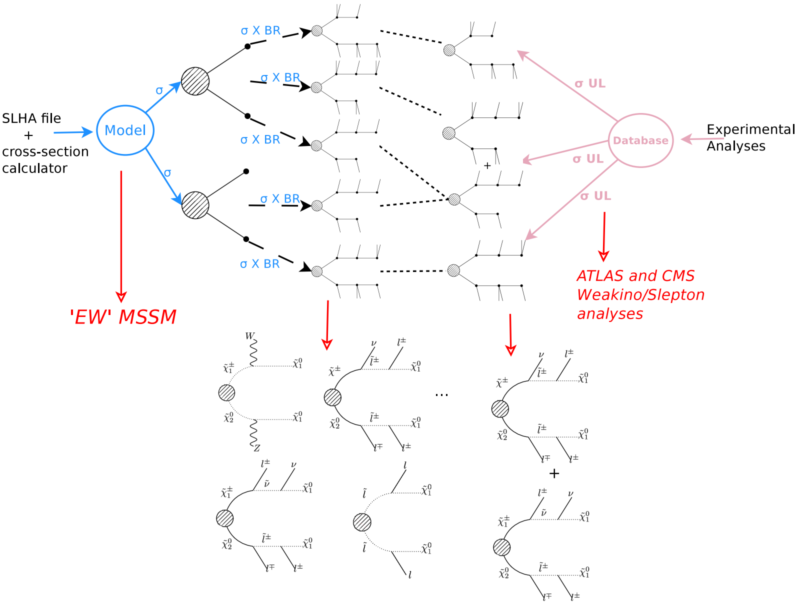
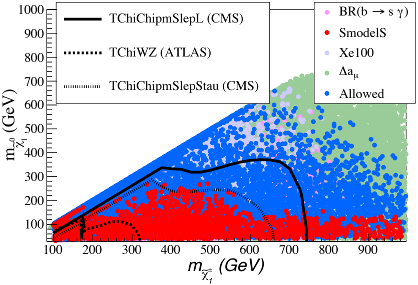
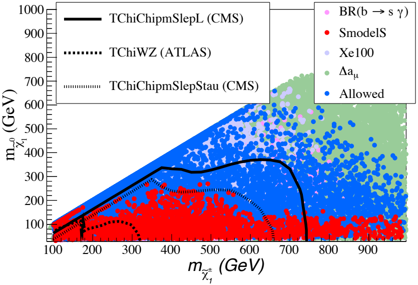


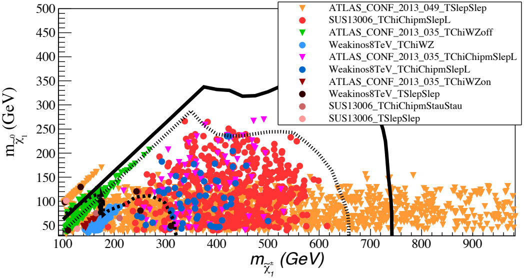
LHC Constraints



- Scan parameters: $M_1, M_2, \mu, m_{\tilde{l}_L}, m_{\tilde{l}_R}, \tan\beta$

A point is excluded if at least one topology has $\sigma \times BR$ > analysis upper limit (at 95% C.L.)





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- Most relevant analyses:
  - ATLAS $\tilde{l}\tilde{l} \rightarrow (l\tilde{\chi}_1^0)(l\tilde{\chi}_1^0)$
  - CMS $\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow (l\nu\tilde{\chi}_1^0)(ll\tilde{\chi}_1^0)$ (flavor democratic)
  - ATLAS $\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow (W^*\tilde{\chi}_1^0)(Z^*\tilde{\chi}_1^0)$
  - ...

Results X-Ray

Why points with low masses/high cross-sections are no excluded?

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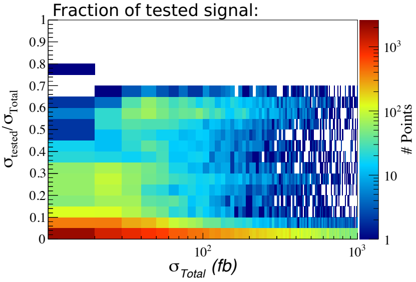
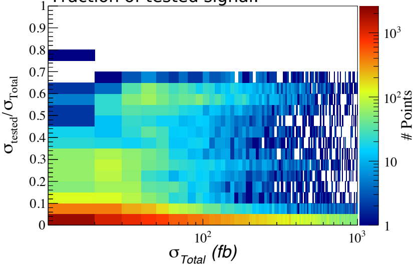
- Some possibilities:
  - Several competing topologies (low $\sigma \times BR$ for a single SMS topology)
  - Masses fall outside upper limits range
  - Small signal efficiencies (mass compressed scenarios)
  - Long cascade decay topologies (no SMS results so far)
  - Signal topologies do not match any analysis

Results X-Ray: Allowed Points



Results X-Ray: Allowed Points

Fraction of tested signal:



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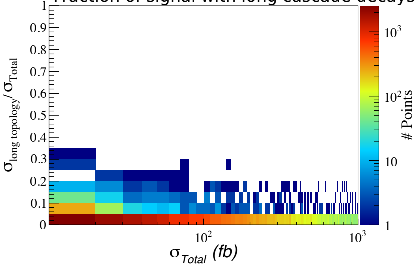

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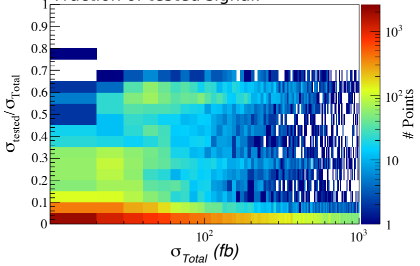

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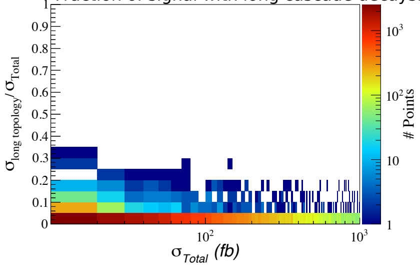
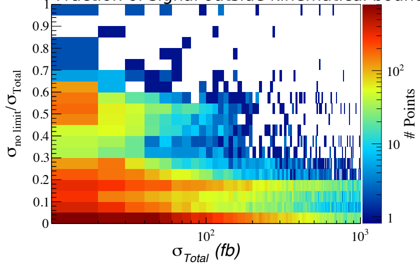


Fraction of signal outside kinematical bounds:



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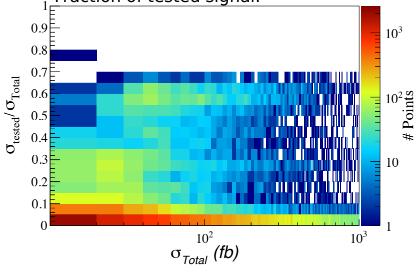

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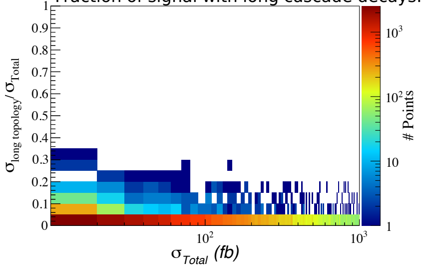

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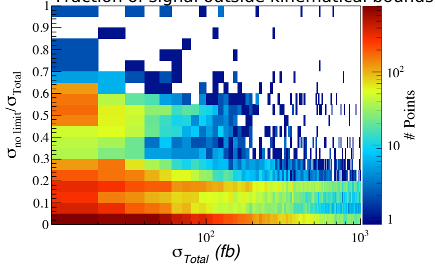
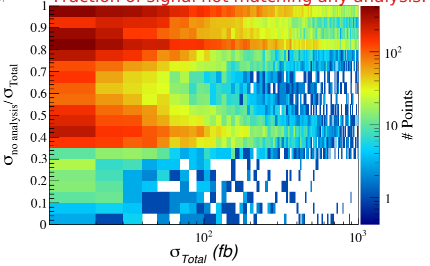


Fraction of signal not matching any analysis:



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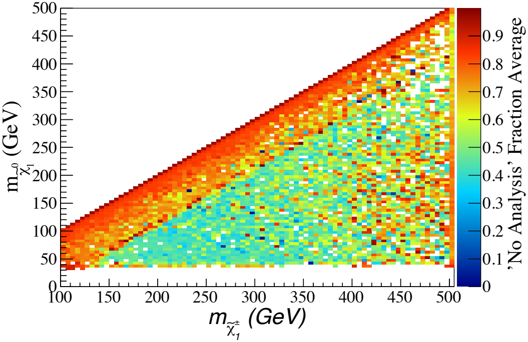

- Current analyses mostly fail in the 'compressed mass' spectrum region

- $m_{\tilde{\chi}_1^0} \sim m_{\tilde{\chi}_1^+}$:
  - asymmetric decays: $\tilde{\chi}_1^+ \tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \tilde{\chi}_1^0$ production
  - distinct final states: $\tilde{\chi}_1^\pm \tilde{\chi}_2^0 \to W^\pm \gamma \tilde{\chi}_1^0 \tilde{\chi}_1^0$

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- The resulting LHC constraints already exclude a significant part of the g_{-2} consistent MSSM
- SModels provides a framework to consistently test models using the full range of (SMS) experimental results
- Despite being 'conservative', SModelS can be a first step tool to...
  - identify the most relevant analyses for specific scenarios
  - identify 'holes' in the parameter ranges of existing analyses
  - identify the relevant missing analyses