Application of Simplified Models in Exotic SUSY Searches

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Based on [Jörn Kersten, JH: 1203.1581]

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Introduction

Purpose of simplified models:

- Speed up analysis through decomposition
  (e.g. in fits)
- Accessibility of limits
- Trigger experimental analysis
  (e.g. show corners that are not covered by constraint models)

More than 3 parameters difficult

$\rightarrow$ Slicing: theoretical input

Application

Exotic SUSY searches: Long-lived sparticles

- Interesting on its own
  $\rightarrow$ Should be included
- Learn something for (more complicated) cases

Motivation:

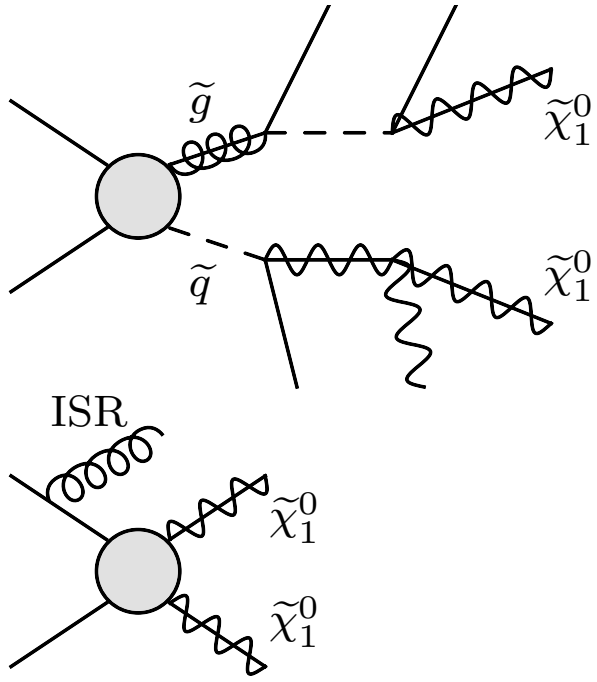
- Gravitino LSP cosmologically attractive (Leptogenesis)
- Very weak LSP coupling $\rightarrow$ NLSP long-lived
- NLSP can be charged!

Consider stau NLSP. What's the signature?

Signature of long-lived staus versus neutralino LSP

Neutralino LSP:

- Rely on $\not{E}_{\mathrm{T}}$ and SM particles
- Strong dependence on type and hardness of SM radiation
- Hard to extract model-independent bounds



Signature of long-lived staus versus neutralino LSP

Neutralino LSP:

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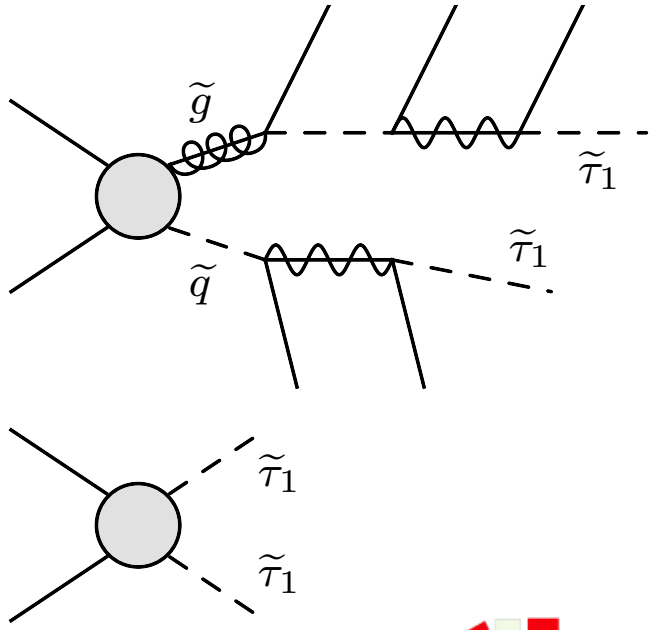
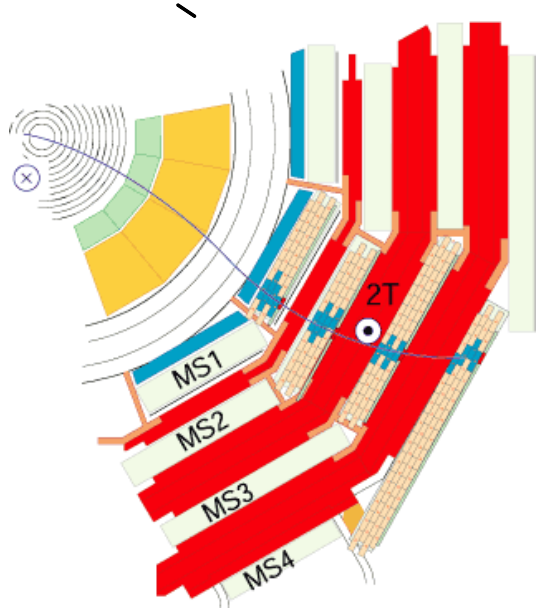
Stau NLSP:

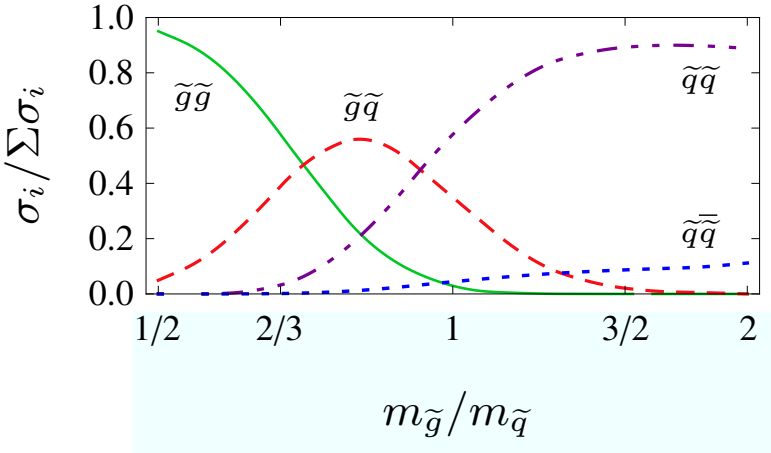
- Stau appears as a muon, background: DY, $t\bar{t}$, $b\bar{b}$, QCD
- Discrimination: Stau velocity
- $\mathrm{d}E/\mathrm{d}x$ and ToF large background rejection
- Velocity governs efficiency





Parameters

Prospino NLO



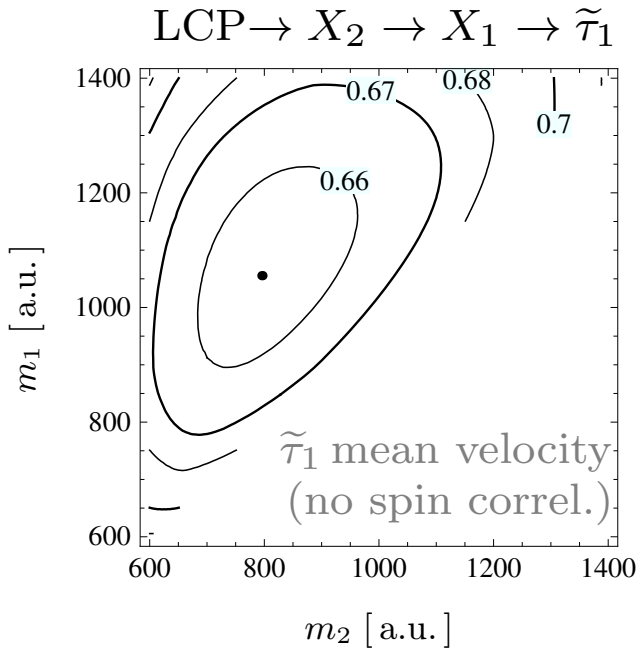
Production:

- Consider
  $\widetilde{g}\widetilde{g}$, $\widetilde{g}\widetilde{q}$, $\widetilde{q}\widetilde{q}$, $\widetilde{q}\overline{\widetilde{q}}$
- Common squark mass $m_{\widetilde{q}}$
- Depend on $m_{\widetilde{g}}$, $m_{\widetilde{q}}$

Decay:

- Velocity of staus depends strongly on mass gap:
  $\min(m_{\widetilde{g}}, m_{\widetilde{q}}) - m_{\widetilde{\tau}_1}$
  $\rightarrow m_{\widetilde{\tau}_1}$ as 3rd parameter
- What about intermediate sparticles?
- In principle large parameter space
- Consider slices. Which ones? $\rightarrow$ Limiting cases!

Extrema in stau mean velocity $\overline{\beta}_{\widetilde{\tau}_1}$ (independent of β_{LCP})



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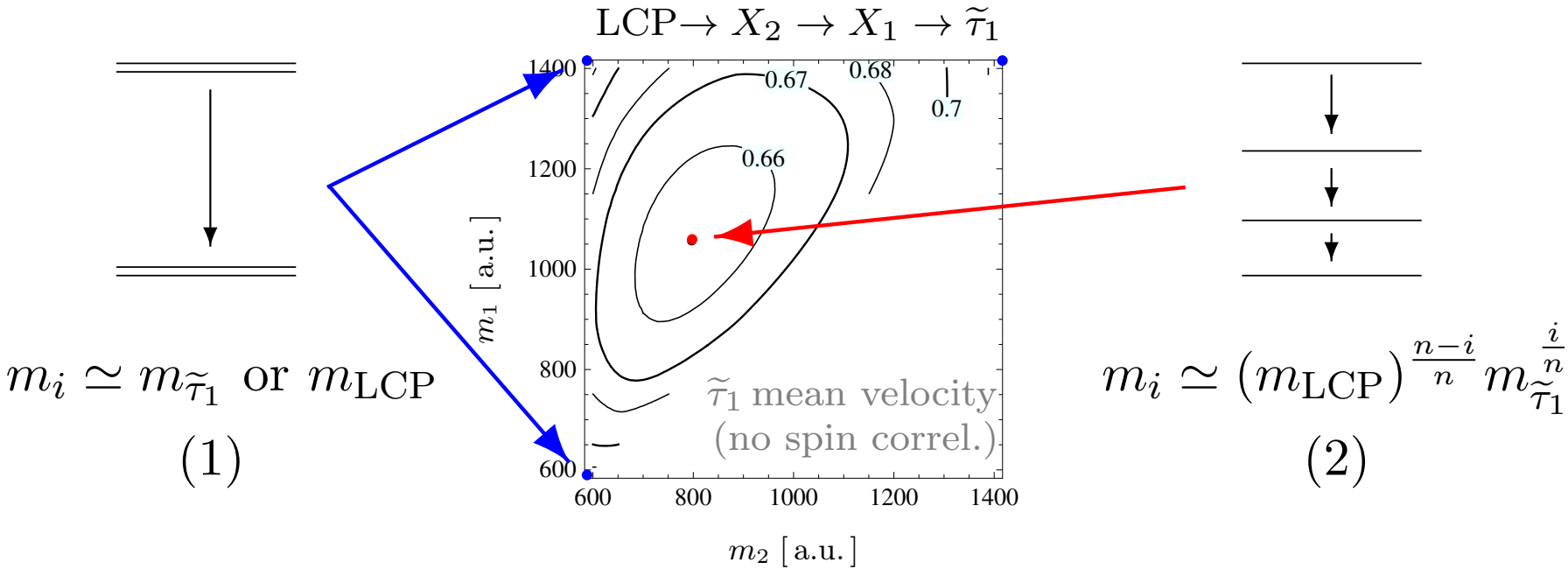


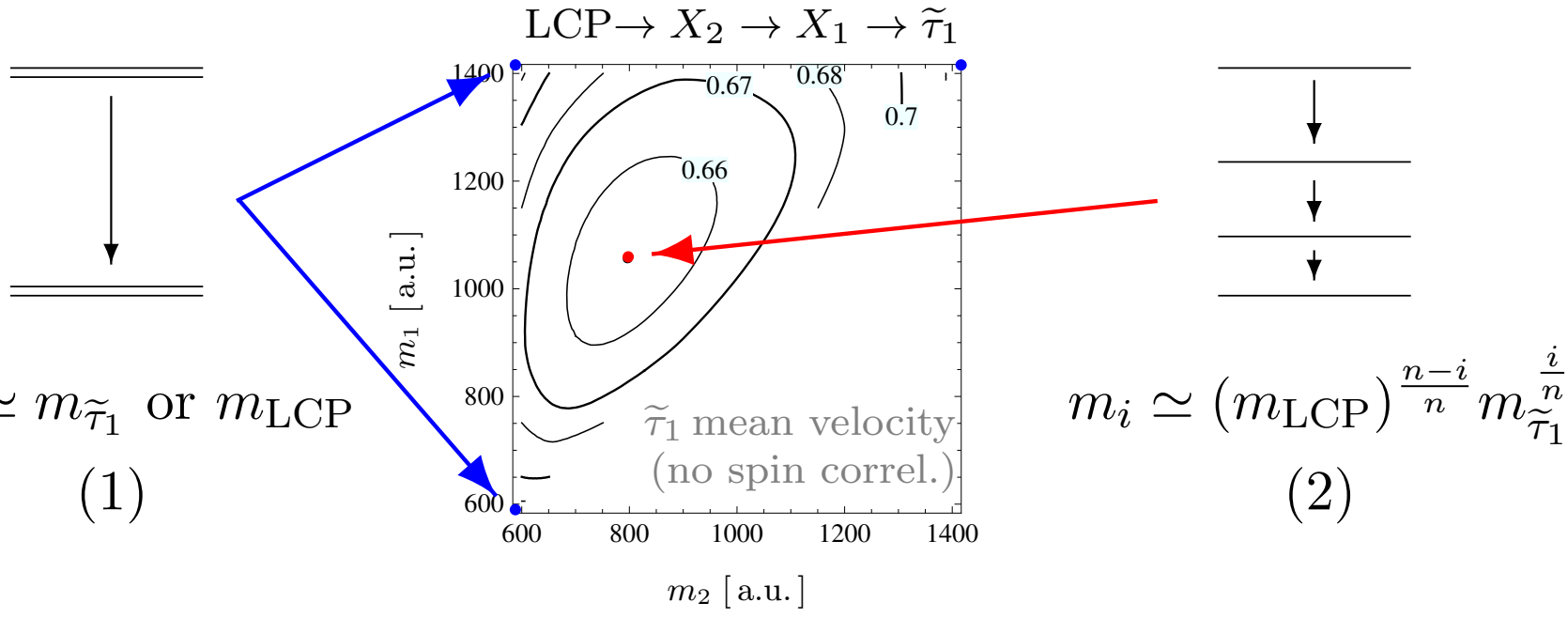
$m_i \simeq m_{\widetilde{\tau}_1}$ or m_{LCP}

(1)

$m_i \simeq (m_{\mathrm{LCP}})^{\frac{n-i}{n}} m_{\widetilde{\tau}_1}^{\frac{i}{n}}$

(2)

Extrema in stau mean velocity $\overline{\beta}_{\widetilde{\tau}_1}$ (independent of $\beta_{\rm LCP}$)



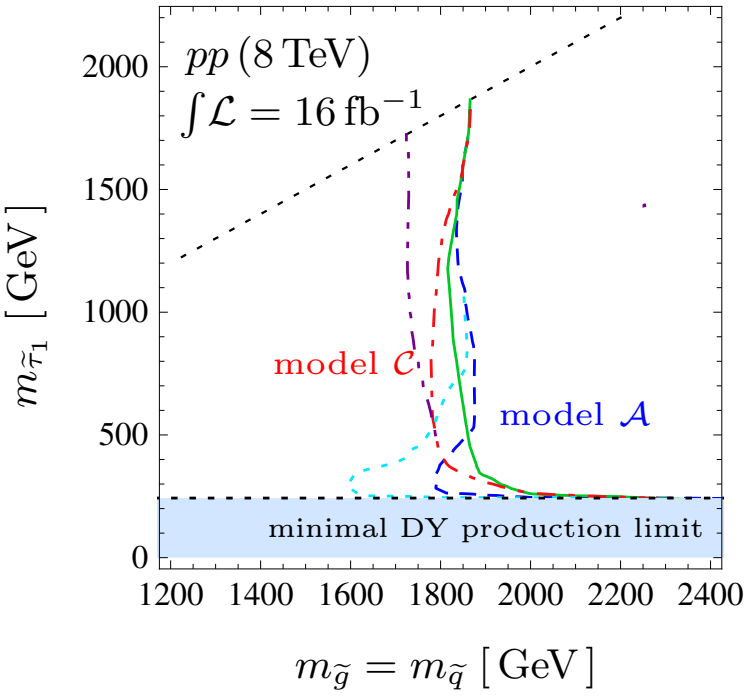
Model $\mathcal{A}$: The 'direct decay' (1)

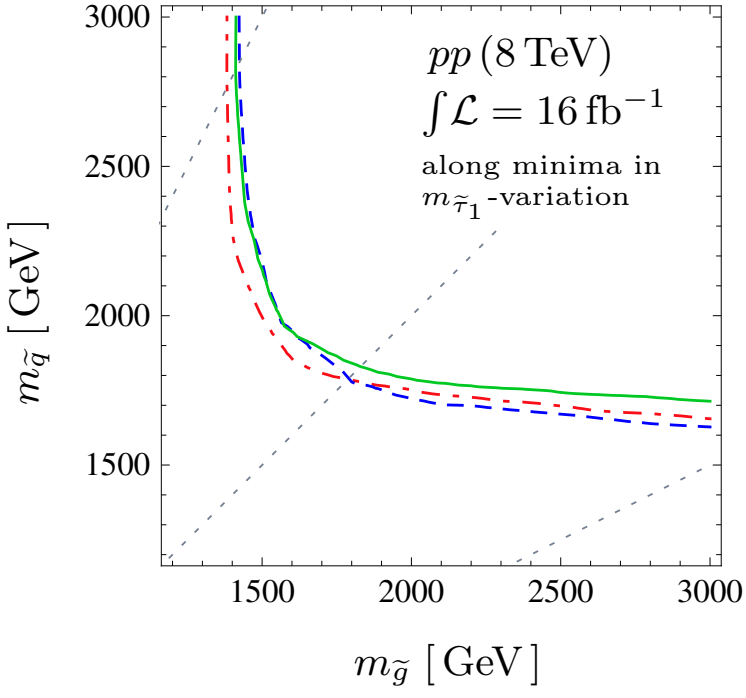
Model $\mathcal{B}$: (2) for the 1-step decay LCP $\to \widetilde{\chi}^0 \to \widetilde{\tau}_1$

Model $\mathcal{C}$: (2) for the 3-step decay LCP $\to \widetilde{\chi}_2^0 \to \widetilde{\ell} \to \widetilde{\chi}_1^0 \to \widetilde{\tau}_1$

Projected exclusion limits

[1203.1581]





- Models $\mathcal{A}$-$\mathcal{C}$ lie within narrow band
- Conservative limits on squark and gluino masses
  $16\,\mathrm{fb}^{-1}$@8 TeV: $m_{\tilde{g}} \gtrsim 1.4\,\mathrm{TeV}$, $m_{\tilde{q}} \gtrsim 1.6\,\mathrm{TeV}$, $m_{\tilde{t}_1} \gtrsim 950\,\mathrm{GeV}$
- Direct DY ‘saves’ model-independent approach

Conclusions

- Simplified models works well with small # of parameters
- Capture more parameters: Slicing
- Good description of scenarios with HSCPs, reason:
  Hierarchy in importance of parameters
- Model-independent bounds possible
- MET searches more complicated
  Similar slicing possible?

Thank you for your attention!