

LHC Phenomenology of a Benchmark SUSY Hidden Valley

arXiv:1105.xxxx

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TRIUMF, Vancouver

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Background & Motivation

Hidden Valleys, SUSY & You!

- New Heavy (TeV) stuff
- New Light (GeV) stuff
- “No” SM—Light coupling

Concept too(?) general

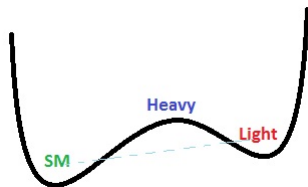
Offer concrete and broad SUSY implementation

- \sim GeV-scale $U(1)_X$
- SUSY partners
- $-\frac{\epsilon}{2} B^{\mu\nu} X_{\mu\nu}$
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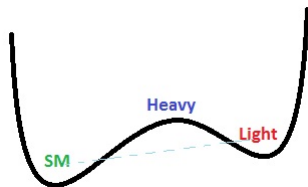
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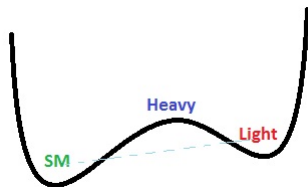
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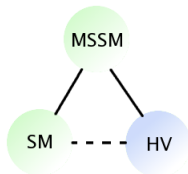
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The Model

Or, How I Learned to Stop Worrying and Love Kinetic Mixing

Extend MSSM By ...

- $U(1)_X$ Gauge Group
- Chiral Superfields H, H'
- Superpotential:

$$W = W_{MSSM} - \mu' H H'$$

- Gauge Kinetic Term:

$$\mathcal{L} \supset \frac{\epsilon}{2} \int d^2\theta B^\alpha X_\alpha$$

- Agnostic Hidden SUSY
Real, $\mathcal{O}(\text{GeV})$ & General



- New fields:

$$X_\mu, h_{ix}, A_x, \chi_j^x$$

- New parameters:

$$g_x, \epsilon, \mu', m_X, m_{A_x}, \tan \alpha, M_x$$

- Mass Matrices structurally similar to MSSM

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Cascading Beyond the MSSM

An Unstable “LSP”

- Production of Hidden States ϵ^2 suppressed
- Phenomenology same as MSSM ...
- ... Till reach would-be LSP, which is **unstable!**

$$\tilde{B} \rightarrow \frac{1}{\sqrt{1-\epsilon^2}} \tilde{B}$$
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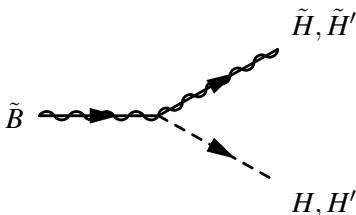
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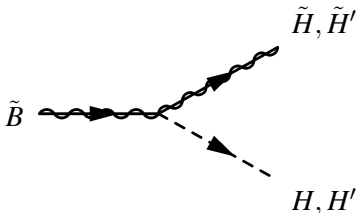
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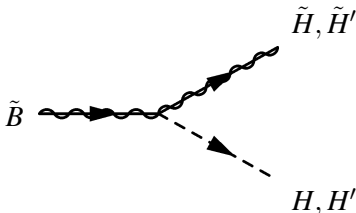
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Hidden Sector Phenomenology

Nunc ne Vides, Nunc id Vides

Hidden States must Decay back to SM, else just ~~E_T~~

$$X_\mu \rightarrow X_\mu + \epsilon s_W Z_\mu;$$

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Signal

- Hidden States Highly Boosted, $m_{MSSM}/m_{HS} \sim 10^2$
- SM States **Also** Highly Boosted
- Collinear Leptons ($\Delta\theta \sim 10^{-2}$), poss. plus Jets
- Possible Long-Lived Hidden States
(Degenerate Hidden Higgsinos, $\tilde{H} \rightarrow \tilde{H}' l^+ l^-$)

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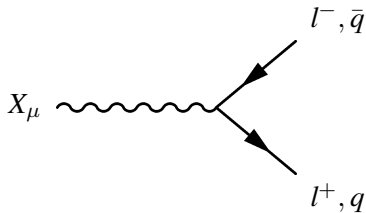
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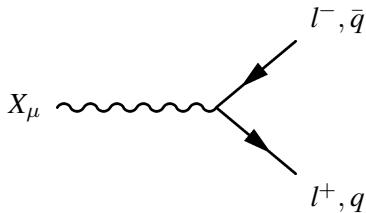
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Hidden Sector Parameter Scan I

Goal: Find Distinctive Benchmark Points

Method: Parameter Scan



- Fix MSSM Parameter Space (SPS1a for simplicity)
- Fix g_x, ϵ (only affect overall rates)
- Scan with Logarithmic Priors:

$$P(\mu, \sigma, \tau, \tilde{g}_1, \tilde{g}_2, \tilde{g}_3, \tilde{g}_4, \tilde{g}_5, \tilde{g}_6, \tilde{g}_7, \tilde{g}_8, \tilde{g}_9, \tilde{g}_{10}, \tilde{g}_{11}, \tilde{g}_{12}, \tilde{g}_{13}, \tilde{g}_{14}, \tilde{g}_{15}, \tilde{g}_{16}, \tilde{g}_{17}, \tilde{g}_{18}, \tilde{g}_{19}, \tilde{g}_{20}, \tilde{g}_{21}, \tilde{g}_{22}, \tilde{g}_{23}, \tilde{g}_{24}, \tilde{g}_{25}, \tilde{g}_{26}, \tilde{g}_{27}, \tilde{g}_{28}, \tilde{g}_{29}, \tilde{g}_{30}, \tilde{g}_{31}, \tilde{g}_{32}, \tilde{g}_{33}, \tilde{g}_{34}, \tilde{g}_{35}, \tilde{g}_{36}, \tilde{g}_{37}, \tilde{g}_{38}, \tilde{g}_{39}, \tilde{g}_{40}, \tilde{g}_{41}, \tilde{g}_{42}, \tilde{g}_{43}, \tilde{g}_{44}, \tilde{g}_{45}, \tilde{g}_{46}, \tilde{g}_{47}, \tilde{g}_{48}, \tilde{g}_{49}, \tilde{g}_{50}, \tilde{g}_{51}, \tilde{g}_{52}, \tilde{g}_{53}, \tilde{g}_{54}, \tilde{g}_{55}, \tilde{g}_{56}, \tilde{g}_{57}, \tilde{g}_{58}, \tilde{g}_{59}, \tilde{g}_{60}, \tilde{g}_{61}, \tilde{g}_{62}, \tilde{g}_{63}, \tilde{g}_{64}, \tilde{g}_{65}, \tilde{g}_{66}, \tilde{g}_{67}, \tilde{g}_{68}, \tilde{g}_{69}, \tilde{g}_{70}, \tilde{g}_{71}, \tilde{g}_{72}, \tilde{g}_{73}, \tilde{g}_{74}, \tilde{g}_{75}, \tilde{g}_{76}, \tilde{g}_{77}, \tilde{g}_{78}, \tilde{g}_{79}, \tilde{g}_{80}, \tilde{g}_{81}, \tilde{g}_{82}, \tilde{g}_{83}, \tilde{g}_{84}, \tilde{g}_{85}, \tilde{g}_{86}, \tilde{g}_{87}, \tilde{g}_{88}, \tilde{g}_{89}, \tilde{g}_{90}, \tilde{g}_{91}, \tilde{g}_{92}, \tilde{g}_{93}, \tilde{g}_{94}, \tilde{g}_{95}, \tilde{g}_{96}, \tilde{g}_{97}, \tilde{g}_{98}, \tilde{g}_{99}, \tilde{g}_{100})$$

- Compute Hidden Sector Masses & Mixings
- Calculate Branching Fractions using BRIDGE

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- Scan with Logarithmic Priors:
 - $\tan \alpha: 0.1-10$
 - $|\mu|, M_0, m_X, m_A: 0.1-10$ GeV
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 - $\tan \alpha$: 0.1—10
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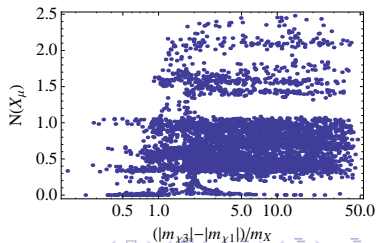
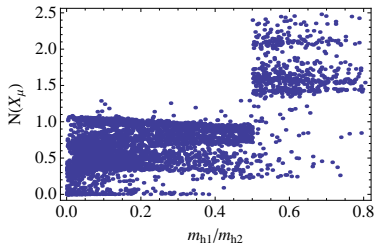
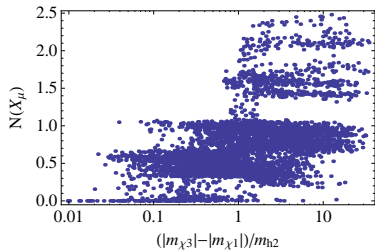
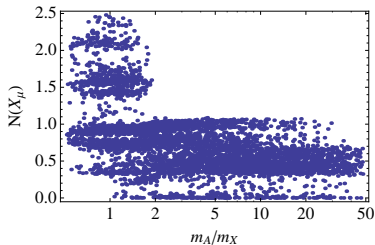
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Hidden Sector Parameter Scan II



Conclusions

- 1 Constructed **explicit** SUSY Hidden Valley;
Implemented in FeynRules, MadGraph & BRIDGE
- 2 Phenomenology includes CHAMPS, R-Hadrons,
Lepton Jets & Displaced Vertices
- 3 Exploring Parameter Space
- 4 Intend to Identify **Benchmark Points**