The Spectrum of the R-Parity Violating mSUGRA

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Outline

Intro: mSUGRA

- MSSM most widely studied extension of the SM.
- Unification of the three SM gauge couplings at $M_X = \mathcal{O}(10^{16}\ \mathrm{GeV}) \rightarrow$ embedding in unified model.

simplest such model: mSUGRA

- SUSY breaking occurs in hidden sector and communicated to visible sector via gravity.
- especially, large number of MSSM parameters reduced to

$$M_0\ ,\ M_{1/2}\ ,\ A_0\ ,\ \tan\beta\ ,\ \mathrm{sgn}\mu$$

  at scale of unification.
- RPC $\rightarrow$ LSP stable $\rightarrow$ neutralino–LSP

Snowmass Points and Slopes

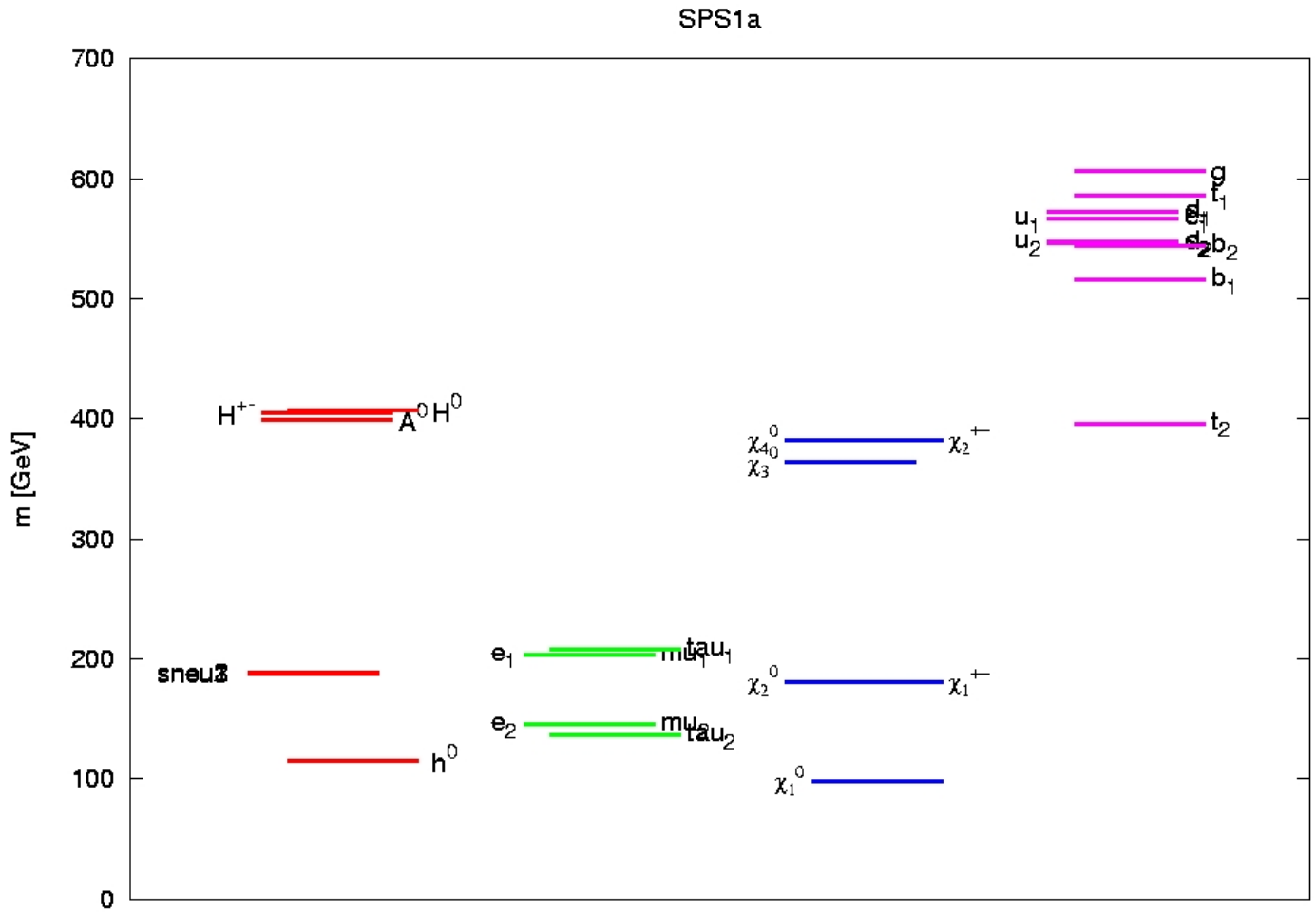
- because MSSM is widely studied, agreement on SPS–benchmark scenarios for comparism.

  [*Snowmass Points and Slopes*, *hep − ph* / 0202233]

- SPS consists of 10 characteristic points and 7 slopes.
- most well known (SUGRA point): SPS1a:

$$M_0 = 100\,,\; M_{1/2} = 250\,,\; A_0 = -100\,,\; \tan\beta = 10\,,\; \mu > 0\,.$$

SPS1a spectrum



What happens with R-Parity Violation?

- new couplings in superpotential:

$$\begin{aligned} \mathbf{W}_{\not{R}_P} &= \epsilon_{ab}\left[\frac{1}{2}\lambda_{ijk}L_i^a L_j^b \bar{E}_k + \lambda'_{ijk}L_i^a Q_j^{bx}\bar{D}_{kx}\right] \\ &\quad + \frac{1}{2}\epsilon_{xyz}\lambda''_{ijk}\bar{U}_i^x \bar{D}_j^y \bar{D}_k^z - \epsilon_{ab}\kappa^i L_i^a H_2^b . \end{aligned}$$

- RGEs change.
- what happens to the spectrum?
- restriction to no-scale mSUGRA ($A_0 = M_0 = 0$) with squark-mixing in down sector.

Changes in Spectrum

- the allowed RPV-couplings λ' and λ' are $\mathcal{O}(10^{-2\cdots-6})$ too small to change the spectrum.
  - neutrino mass bounds and tachyons:

    [*Allanach* , *Dedes* , *Dreiner* : *Phys Rev D* 69, 115002 (2004)]

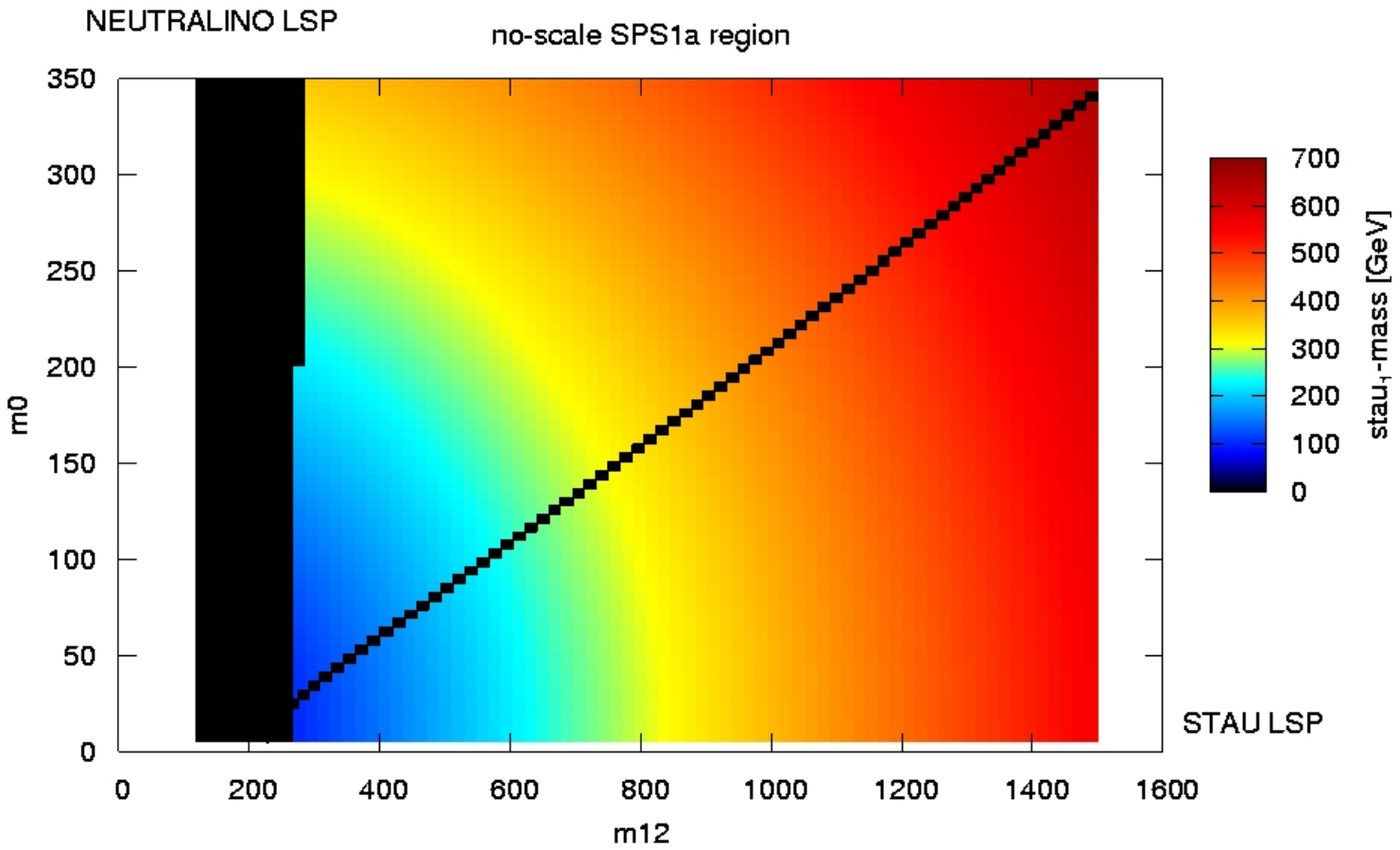
  - low energy pheno:

    [*Allanach* , *Dedes* , *Dreiner* : *hep – ph* / 9906209]

- only larger RPV couplings still allowed are λ''_{2jk} s (UDD).

Change in Philosophy I

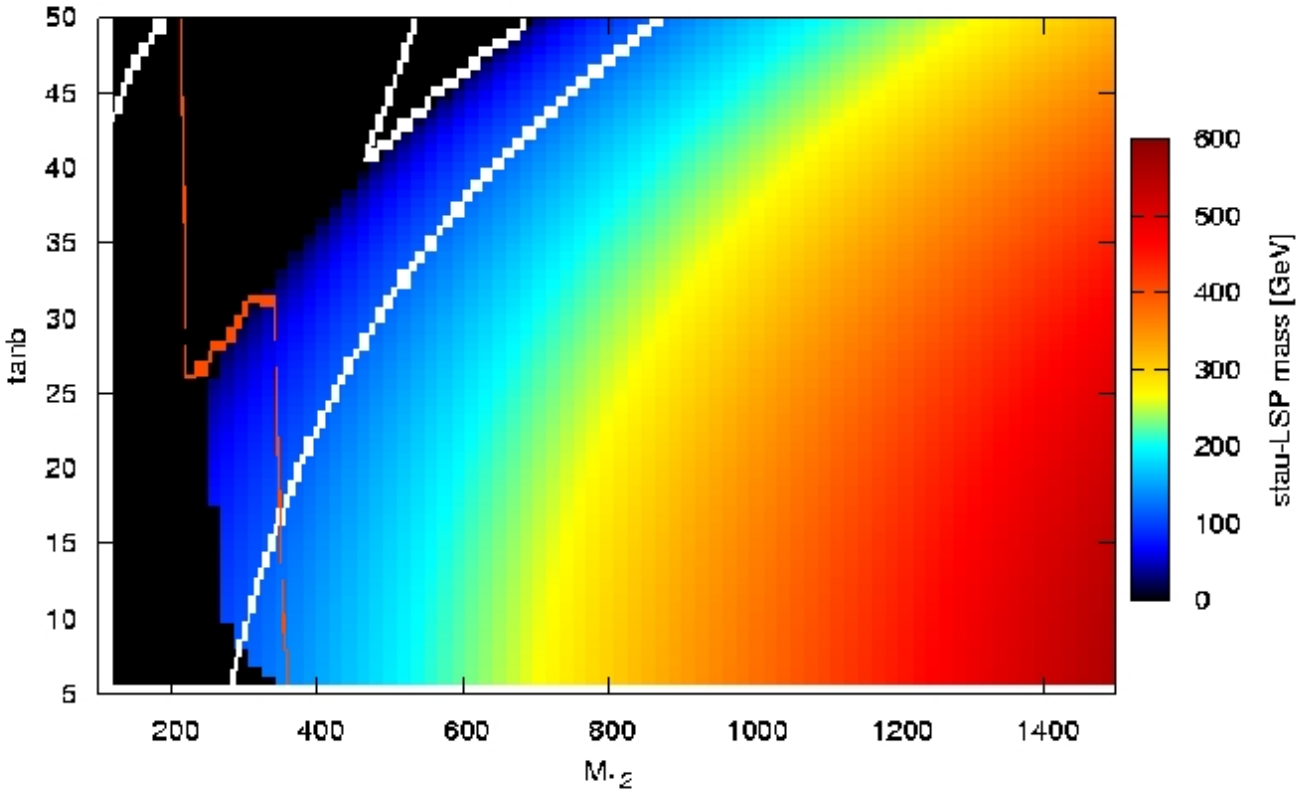
- possibility of a $\tilde{\tau}$–LSP $\rightarrow$ changes phenomenology



Change in Philosophy II

- possibility of neutralino not even NLSP.

The white contour shows $m_h = m_{\tilde{\tau}}$. The orange contour $m_{\tilde{\chi}_1^0} = m_{\tilde{e}_1}$.



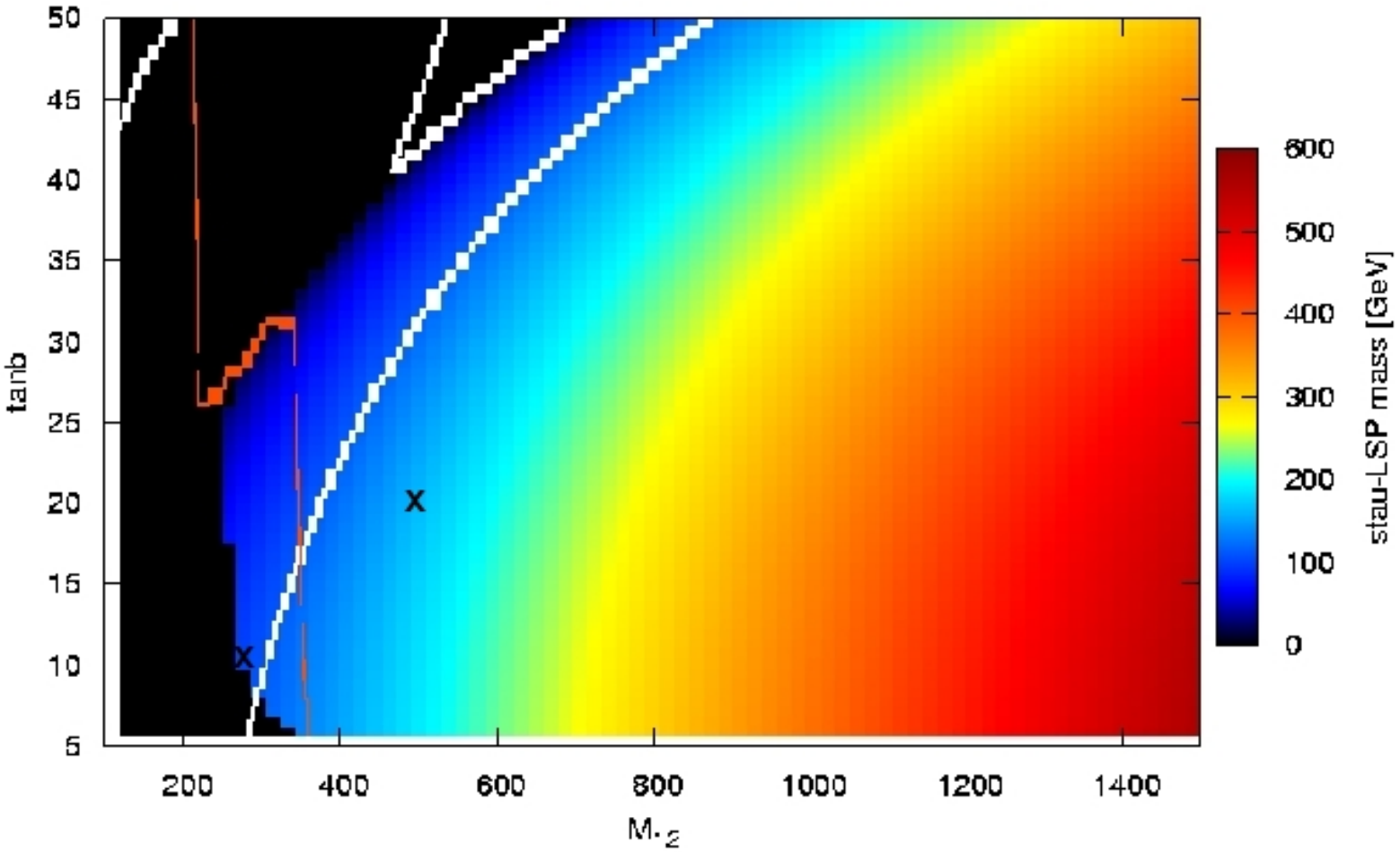
Benchmark Evaluation

- constraints to take into account:
  - $(g-2)_\mu$.
  - $b \to s\gamma$.

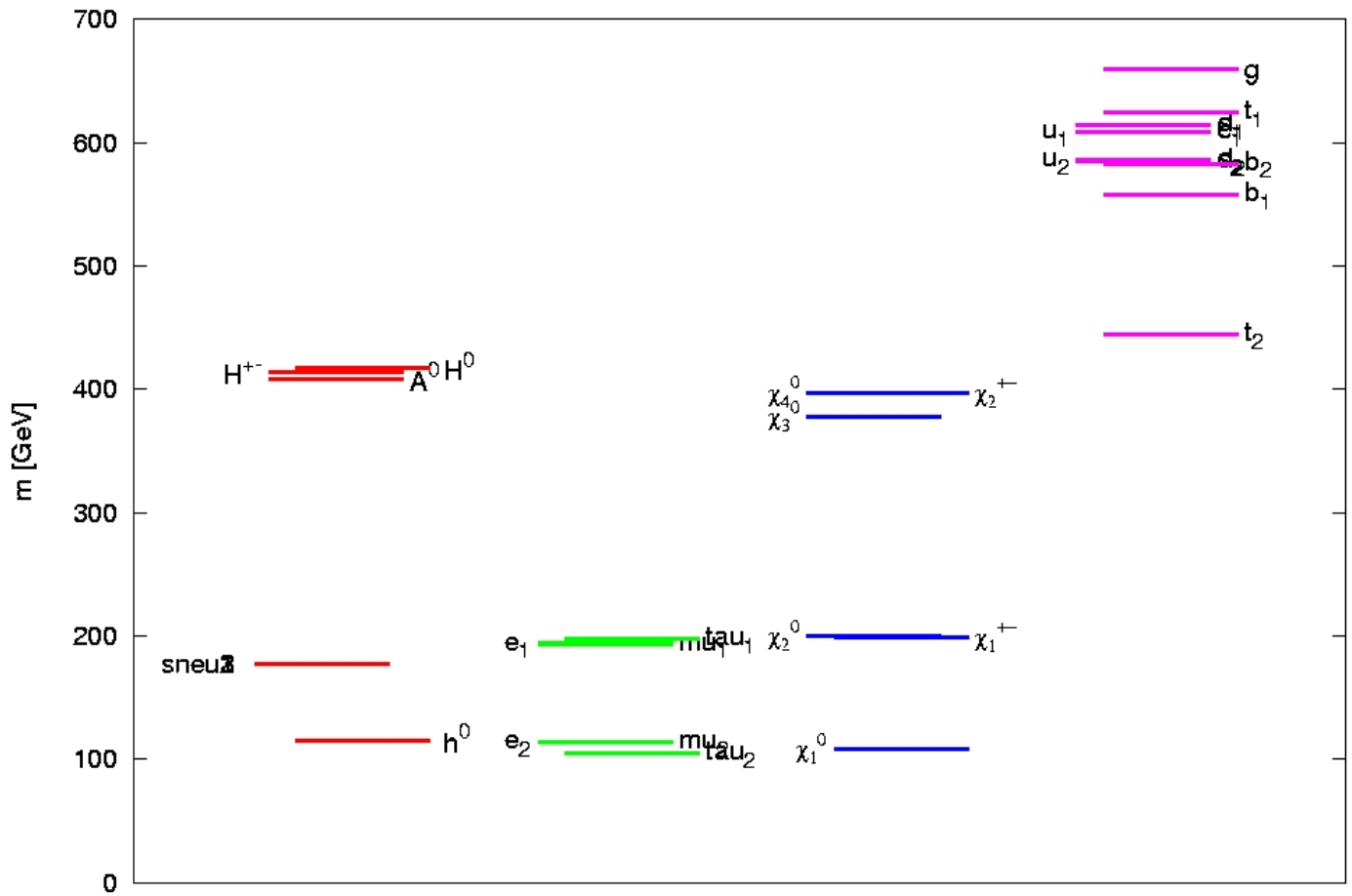
[*Besmer*, *Steffen* : *hep – ph* / 0004067]

  - $\mathcal{B}(B_s \to \mu^+\mu^-)$ with new calculation of the RPV-contribution.
- changes in sparticle mass hierarchy.
- different squark-mixing scenarios.

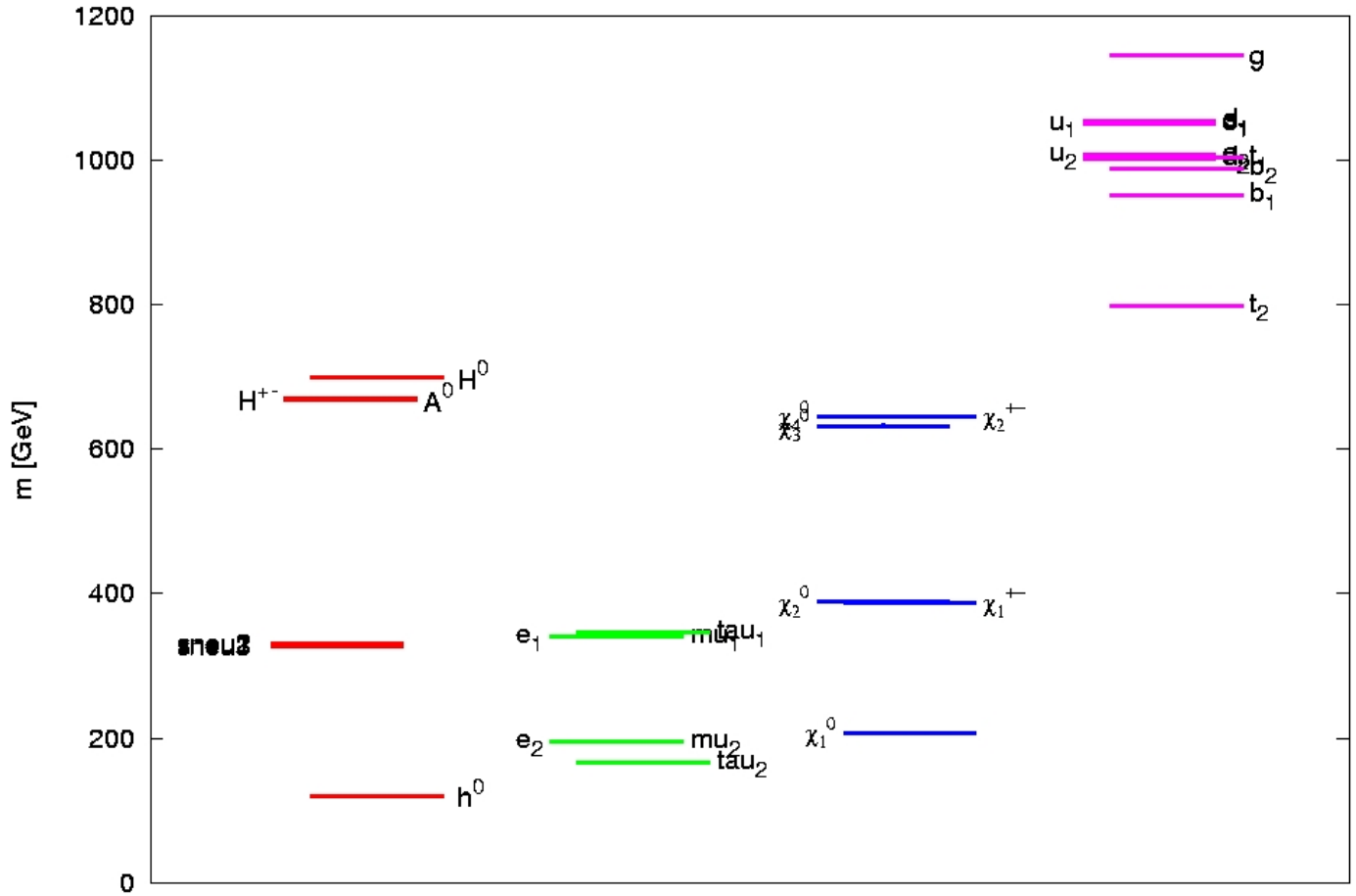
Two Example Spectra



Spectrum with $\tilde{\tau}$ – LSP



Spectrum with $\tilde{e}$ – NLSP



Summary & Outlook

- mSUGRA benchmark scenarios with RPV.
  - LSP, NLSP, NNLSP.
  - different roles of the lightest neutralino.
- overview: phenomena taken into account.
- next step: evaluate benchmarks.