Signatures of the Least Superymmetric Standard Model

Antonio Delgado

- Introduction
- The model: two sources of SUSY breaking
- Signatures: the third family of sfermions
- Conclusions

Worked based on:
AD and M. Quirós PRD 85 (2012) 015001
J. de Blas, AD and B. Ostdiek PRD 87 (2013) 115026

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- On the other hand that same discovery by itself makes the theory fine-tuned.
- The lack of any other experimental evidence makes us believe that either the SM is the only theory above the Fermi scale or....

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$$m_h^2 \simeq m_z^2 \cos^2 2\beta + \frac{3 y_t^2 m_t^2}{4\pi^2} \log\left(\frac{m_S^2}{m_t^2}\right) + \dots$$

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- On the other hand the stops cannot be arbitrarily heavy because of the Higgs mass.

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- Can these scenarios be realized on a top-down approach?

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  - Another one for the third family (plus gauginos)

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  - Generation of A-terms for the third family.

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  - The third family and the Higgses are uncharged under this new group.

	ψ_1	ψ_2	ψ_3	$H_{u,d}$	φ_1	φ_2	S
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- $\psi_{1,2}$ represent the first and second generation ψ_3 the third generation, $\varphi_{1,2}$ and S are needed to break the extra U(1)

- Assuming the usual superpotencial with some messengers charged under the U(1):

$$W = \Phi_2 X \Phi_1$$

- One generates the following mass for all third generation scalars (plus the extra gaugino):

$$m^2 = \frac{g^2}{128\pi^4} \frac{F^2}{M_*^2}$$

- The existence of the extra U(1) forbids some Yukawa couplings for the first and second generations but they can be generated via non-renormalizable operators.

$$\frac{1}{M_*^2}\left(y_{11}\varphi_2^2\,\psi_1 H\psi_1^c + y_{22}\varphi_1^2\,\psi_2 H\psi_2^c\right) + \frac{1}{M_*}\left(y_{13}\varphi_2\,\psi_1 H\psi_3^c + y_{23}\varphi_1\,\psi_2 H\psi_3^c\right)$$

- To reproduce the CKM one needs to break the U(1) and:

$$v/M_* \sim 10^{-2}$$

- One can break the extra U(1) group via the following superpotential:

$$W = \lambda S(\varphi_1 \varphi_2 - v^2)$$

- Once the gauge group is broken all extra fields (φ, S, gauge bosons and its superparners) get a mass of order v.

- The gravitino will get a mass (from the cancelation of the cosmological constant).

$$m_{3/2} \simeq \frac{F}{\sqrt{3}M_P}$$

- It will be comunicated to the third family via the operators:

$$\frac{1}{M_P^2}\int d^4\theta X X^\dagger Q_i^\dagger Q_j, \quad \frac{1}{M_P}\int d^2\theta X Q_i H_2 U_j^c, \quad \frac{1}{M_P}\int d^2\theta X W^A W^A \quad \int d^4\theta X^\dagger H_1 H_2, \quad \int d^4 X^\dagger X (H_1 H_2 + h.c.)$$

$$m_0 = M_{1/2} = A_0 = \mu = B = O(m_{3/2})$$

$$\Delta_{\widehat{m}^2} = \left| \frac{\widehat{m}^2}{m_Z^2} \frac{\partial m_Z^2}{\partial \widehat{m}^2} \right|$$

- To fix the scale of the first two families, a fine-tuning less than .5% is imposed.

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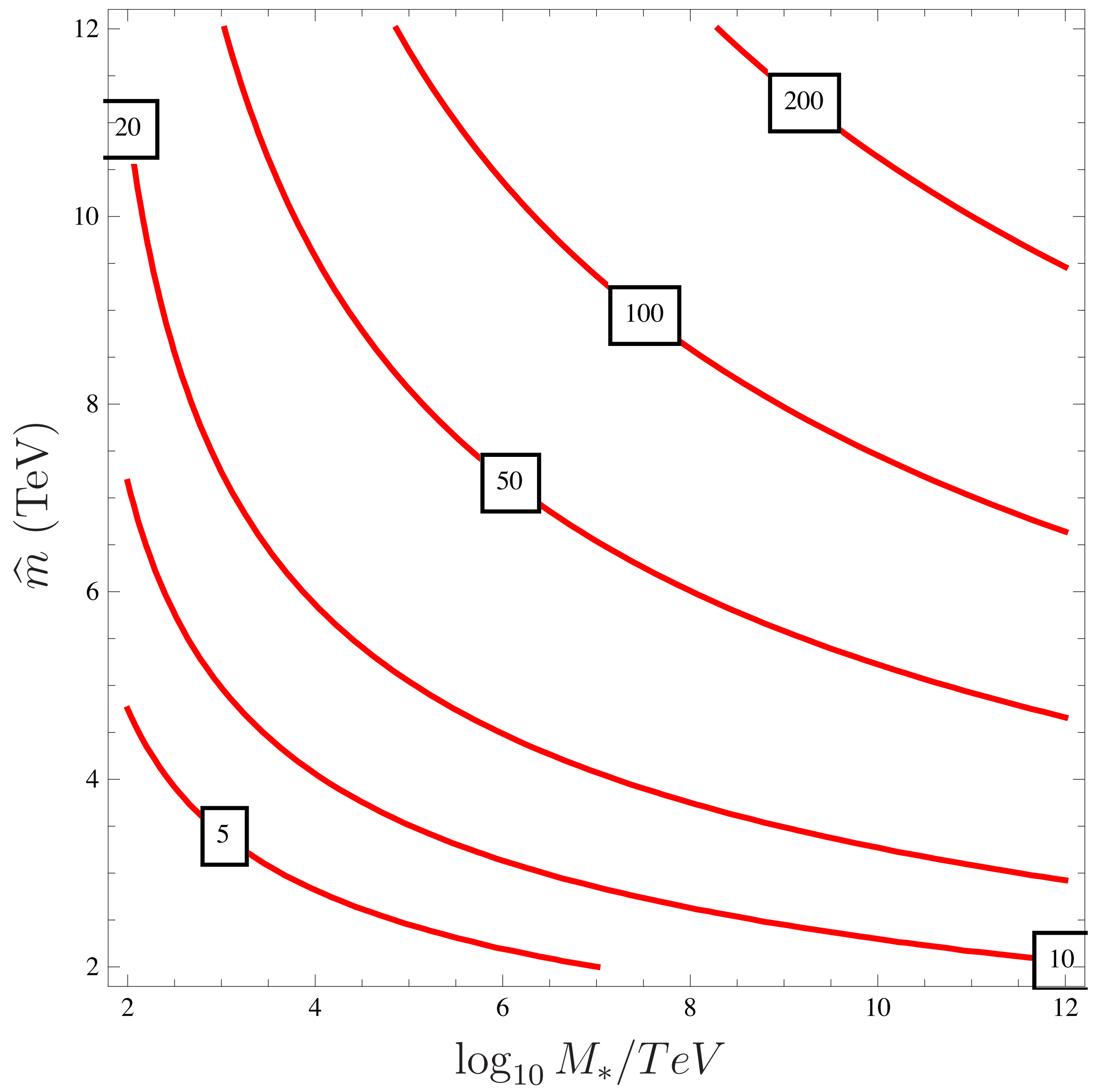

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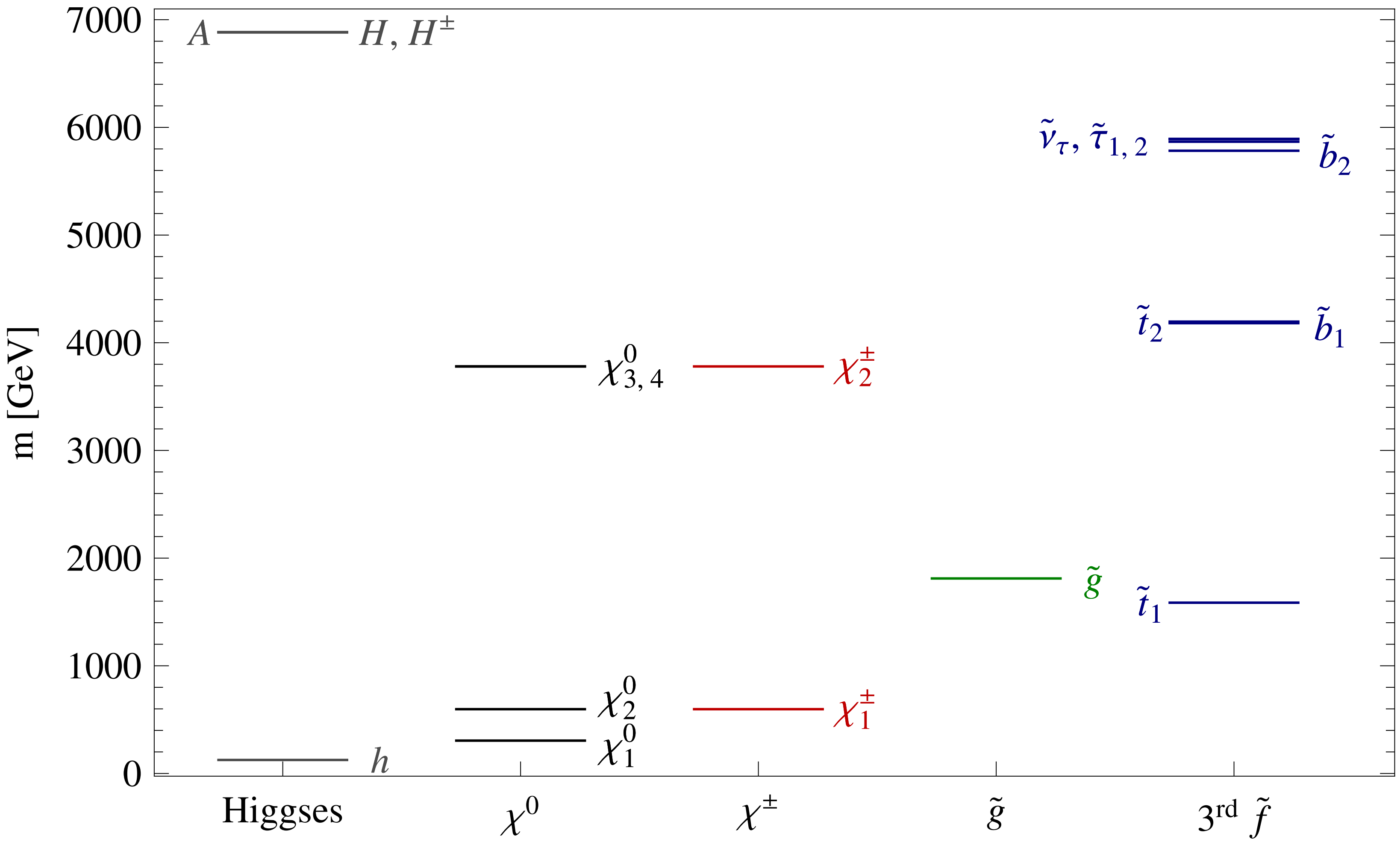

tan β=10

- This is scenario A, scenario B is similar but with the mass of the gluino of 2.25 TeV

Phenomenology of the LSSM

- Not having the first of second generation makes most of the cascade decays unavailable
- For EWinos we have the following processes:

$$\chi' \to \begin{cases} \chi\ W/Z \\ \chi\ h \\ f\tilde{f}\ (f = \tau, t, b) \end{cases}$$

- But the cross-section is too low:

$$\sigma(pp \to \chi + X) = 0.7\ \mathrm{ab}$$

- We are left with either direct production of stops or production of gluinos which then decay into stops (sbottoms are heavier)

- But:

$$\sigma(pp \to \tilde{g}\tilde{g}) = 1.612 \text{ fb}, \ \sigma(pp \to \tilde{t}\tilde{t}) = 0.1 \text{ fb}$$

- Therefore the signal we will look for is:

$$pp \to \tilde{g}\tilde{g}, \ \tilde{g} \to t\tilde{t} \to b\bar{b}W^+W^-\chi$$

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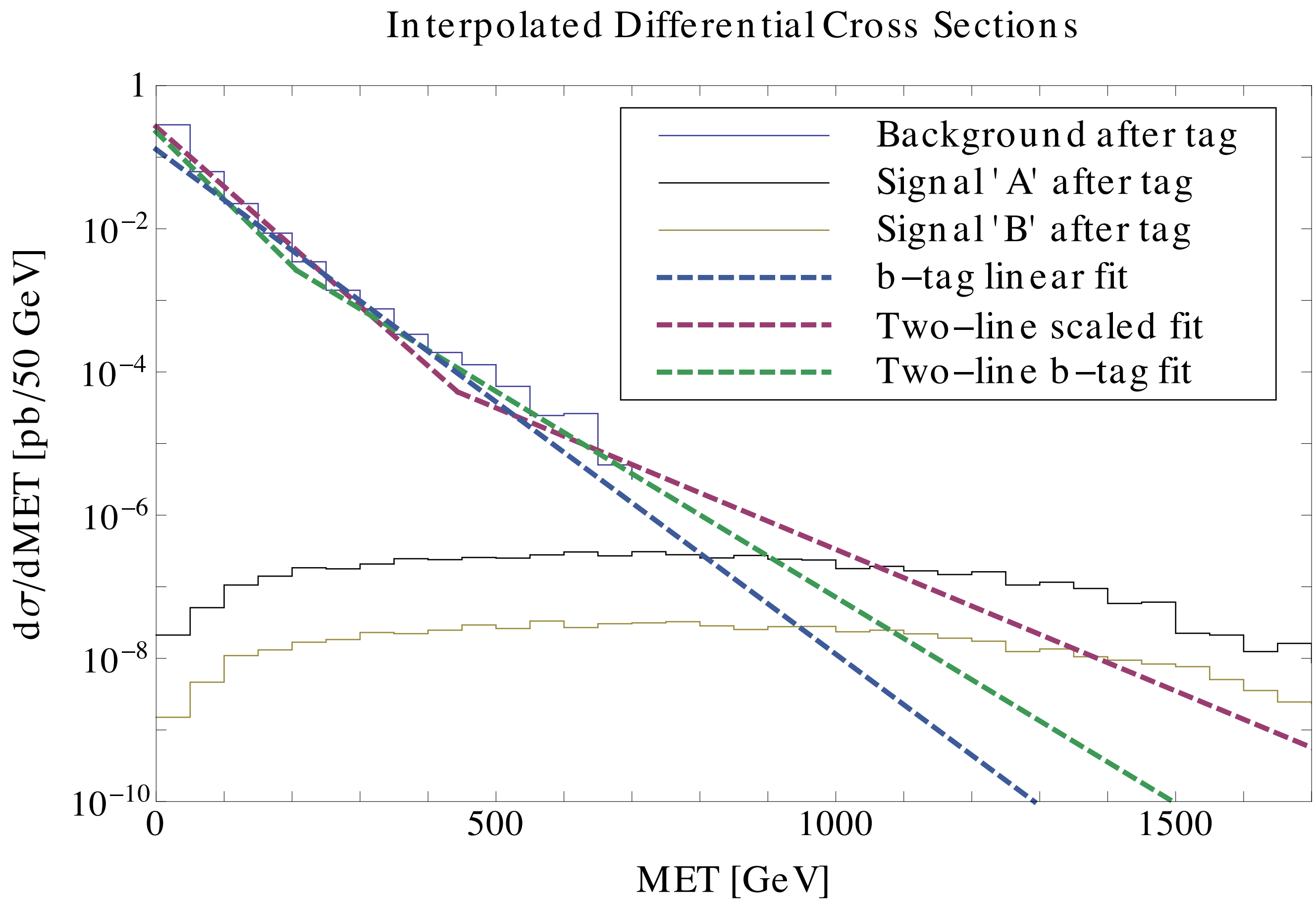
- We will demand four other jets and no photons in the final state.



- Due to lack of computing power we had to extrapolate the background

Estimation Method	$\not{E}_T^{\text{Cut}}$ [GeV]	$\sigma_{\text{B}}^{\text{Estimated}}$ [ab]	σ_{S} [ab]	S	B	$\text{S}/\sqrt{\text{B}}$
				$\mathcal{L} = 200\ \text{fb}^{-1}$ (1000 fb^{-1})		
Linear	850 (950)	17.1 (3.73)	106.6 (10.8)	21 (11)	3 (4)	11.5 (5.6)
Two-Line	950 (1100)	10.4 (1.43)	80.7 (7.01)	16 (7)	2 (1)	11.2 (5.9)
Two-Line (Scaled)	1100 (1400)	14.7 (0.96)	50.3 (2.26)	10 (2)	3 (1)	5.9 (2.3)

- Whereas a gluino of 1.75 TeV (A) seems feasible in LHC14, a 2.25 (B) seems more doubtful in this conservative analysis.

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- In this talk I have introduced a realization for 'natural susy' based on two sources of susy breaking
  - Gauge mediation for the first two families
  - Gravity mediation for the third family, gauginos and Higgses
- In this top-down approach I have shown the prospects for discovery at the LHC producing gluinos that decays to stops. The reach seems to be for masses around 2 TeV.