Anti-split SUSY

arXiv:1612.09255

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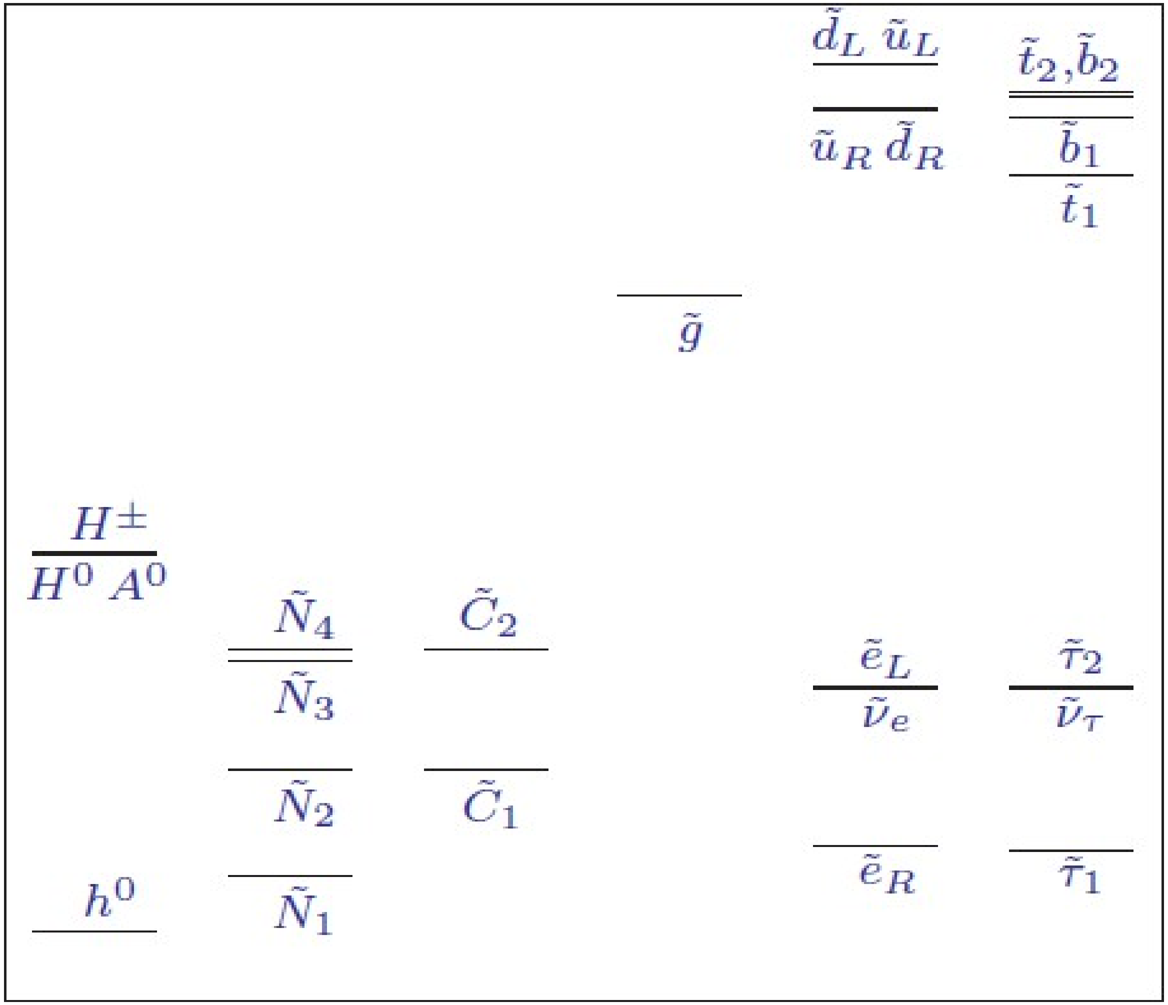
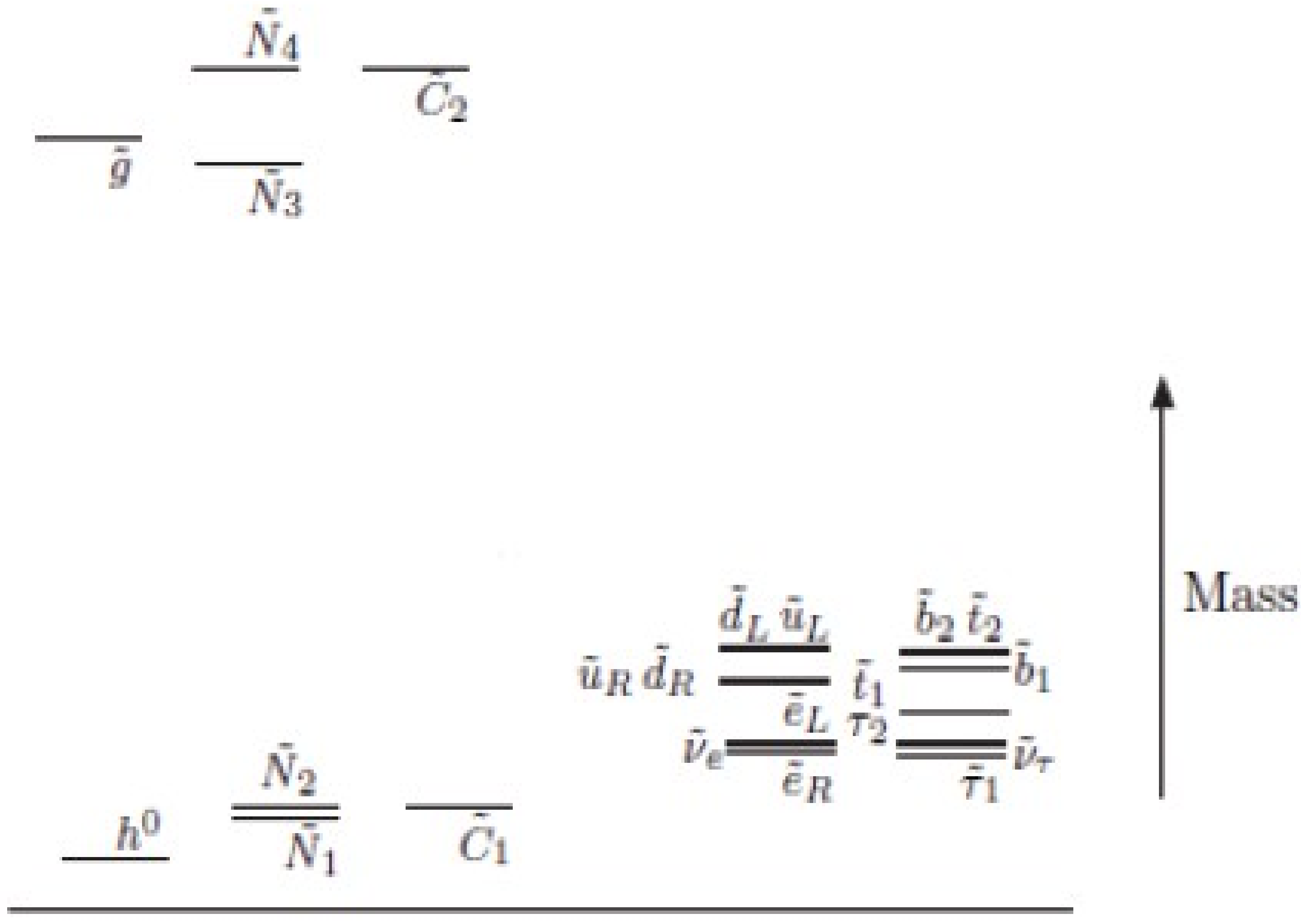
Feb 2017

Standard Spectrum



GMSB 1 set of Messengers from S. Martin's Primer

The Anti-split Spectrum



Implementations

- Dirac Gauginos
- R- symmetric Gauge mediated contributions
- Fusion with Gravity Mediation

Implications

- Compresses scalar spectrum
- Higgsino like neutralinos/chargino in spectrum
- Displaced vertex for GMSB realization
- Baroque Decay Chains

Dirac Gauginos

SM gauge Field Strength

$$W = c_i \frac{W' W_i A^i}{\Lambda}$$

Chiral field in adjoint rep of SM
Gauge group

Hidden sector U(1)' field

The U(1)' gets a D term vev
Resulting in a Dirac Gaugino mass

$$c_i \frac{D}{\Lambda} \lambda_i \psi_{Ai}$$

Aside there are many new operators for the Higgs sector coupling to Higgs fields to give mu Terms, and raise Higgs mass through loop level corrections

Scalar Masses

Are produced one loop level down

$$m_s^2 = \frac{C_i \alpha_i {m_{\lambda i}}^2}{\pi} \log(\frac{\delta_i}{m_{\lambda i}})^2$$

Mass of Real part of Chiral adjoint field

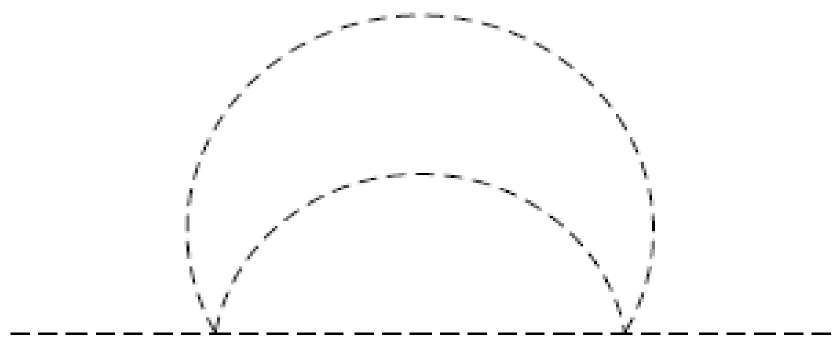
Gaugino mass

Ratio of scalar mass to gaugino mass

$$\frac{m_s}{m_\lambda} = \sqrt{\frac{2C_i\alpha_i}{\pi} \log(\frac{\delta_i}{m_{\lambda i}})}$$

There are various ways to lower this ratio

R symmetric Gauge Mediated Masses



Messengers with non zero Supertrace provide two loop gauge mediated masses for scalar fields

$$m_i^2 = -\sum_a \frac{g_a^4}{128\pi^4} S_Q C_{ai} \mathrm{Str} M_{mess}^2 \log(\frac{M^2}{\Lambda^2})$$

Positive supertrace ensures negative mass squared contribution

Two types of gauge mediated messengers

$$W = XM\overline{M} \to vM\overline{M} + \theta^2 F_X M\overline{M}$$

The normal gauge mediated mechanism results in the gaugino mass

$$m\lambda_i = \frac{\alpha_i}{4\pi} F/v.$$

While two sets of messengers contribute to scalar masses

$$m_s^2 \sim \frac{\alpha_i}{4\pi}^2 f^2/v^2 - \sum_a \frac{\alpha_i}{4\pi^2}^2 S_Q C_{ai} \mathrm{Str} M_{mess}^2 \log(\frac{M^2}{\Lambda^2})$$

Possible (N)LSPs

Neutral LSP/ NLSP

χ_1^0 Higgsino-like

$\tilde{\nu}$

Charged NLSP

$\tilde{\tau}$

The Dirac or Majorana mass parameter for gauginos is ~10 TeV, however the mu term may remain light Leaving Higgsino-like neutralino/chargino in the spectrum

For Gauge Mediated Scenarios

$$\Gamma_{\tilde{f}} = \frac{1}{16\pi}\frac{m_f^5}{F^2}(1 - \frac{m_G^2}{m_f^2})^4$$

For decay inside the detector F must not be too large , for 10 TeV gauge mediated gaugino masses, the messenger mass must not be much heavier Than the scale F.

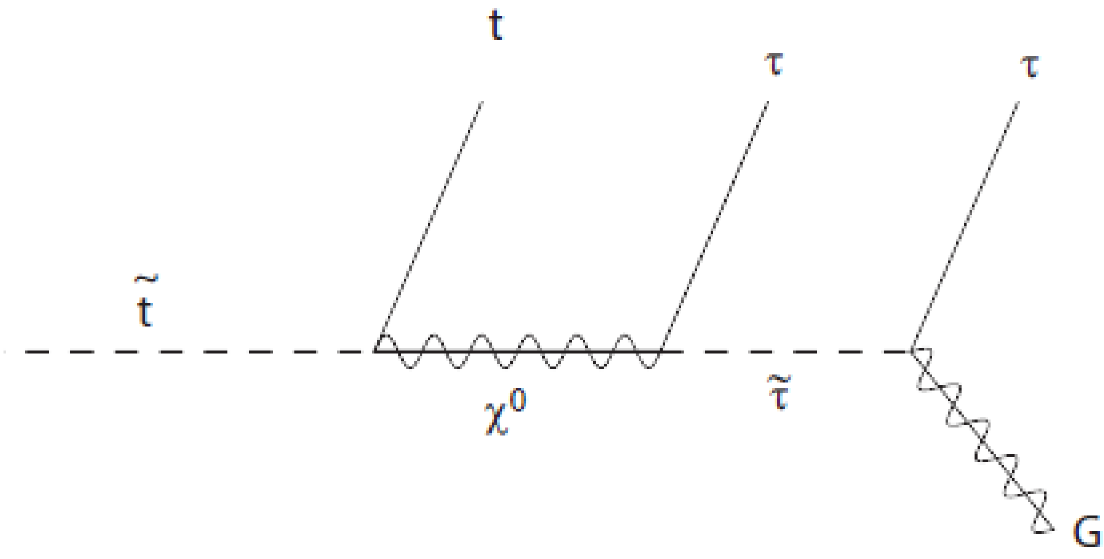
Sqrt F ~10^6 GeV uppser limit for decay inside detector

Light stau scenario

neutral gaugino	mass	chargino	mass	squark	mass	slepton	mass
m_g	6000			m_{u_l}	903	m_{e_l}	463
$m_{\chi_4^0}$	6001	$m_{\chi_2^+}$	6001	m_{d_l}	903	m_{e_r}	203
$m_{\chi_3^0}$	5000						
$m_{\chi_2^0}$	500.4	$m_{\chi_1^+}$	499.5				
$m_{\chi_1^0}$	498.9			m_{u_r}	782	m_{τ_1}	199
				m_{d_r}	784		

particle	decay	b.f.	particle	decay	b.f.
$\widetilde{u_l}$	$\chi_1^{\pm}$d	.78	$\widetilde{t_2}$	$\chi_1^{\pm}$ b	.38
-	χ_1^0 u	.20	-	χ_1^0 t	.57
-			$\widetilde{t_1}$	χ_1^0 t	.72
$\widetilde{u_r}$	χ_1^0 u	.96	-	$\chi_1^{\pm}$ b	.27
$\widetilde{d_l}$	$\chi_1^{\pm}$u	.49	$\widetilde{b_2}$	$\chi_1^{\pm}$ t	.99
-	χ_1^0 d	.49	$\widetilde{b_1}$	χ_1^0 b	.45
$\widetilde{d_r}$	χ_1^0 d	.96	-	χ_2^0	.41

$\chi_1^{\pm}$	$\nu_\tau\ \widetilde{\tau^{\pm}}$	.94	$\widetilde{\ell}_L$	$\ell\ \ell'^{\mp}\ \widetilde{\ell^{\pm}}'_R$	.632
χ_1^0	$\tau^{\mp}\ \widetilde{\tau^{\pm}}$	.79	-	$\ell\ \tau^{\mp}\ \widetilde{\tau}_R^{\pm}$	.316
-	$\ell^{\mp}\widetilde{\ell^{\pm}}$	.17	$\widetilde{\ell}_R$	$\ell\ \tau^{\mp}\ \widetilde{\tau}_R^{\pm}$	1
χ_2^0	$\tau^{\mp}\ \widetilde{\tau^{\pm}}$	.96	$\widetilde{\tau_R}$	$\tau\ \widetilde{G}$	1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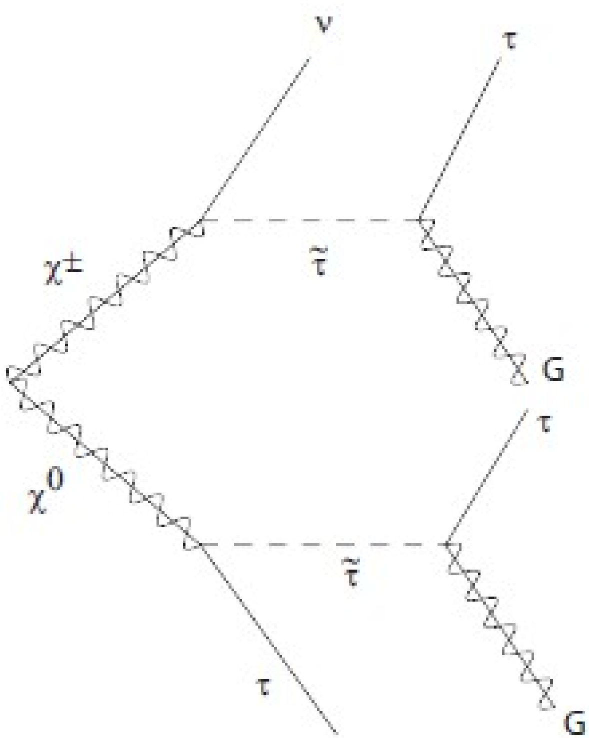
ν
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G
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χ^0
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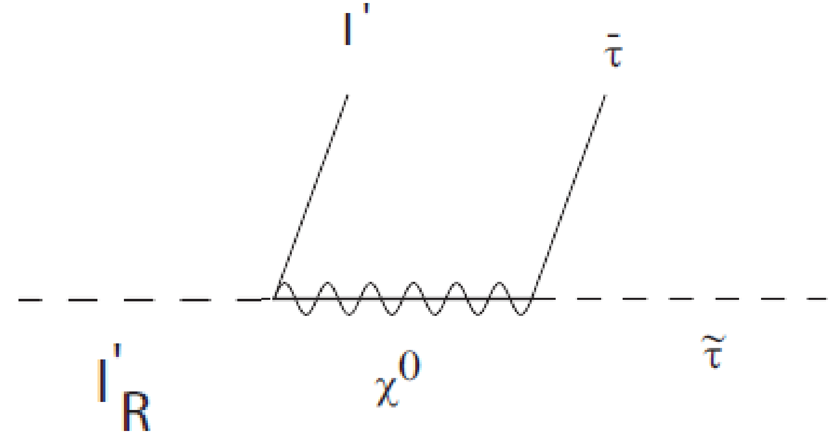
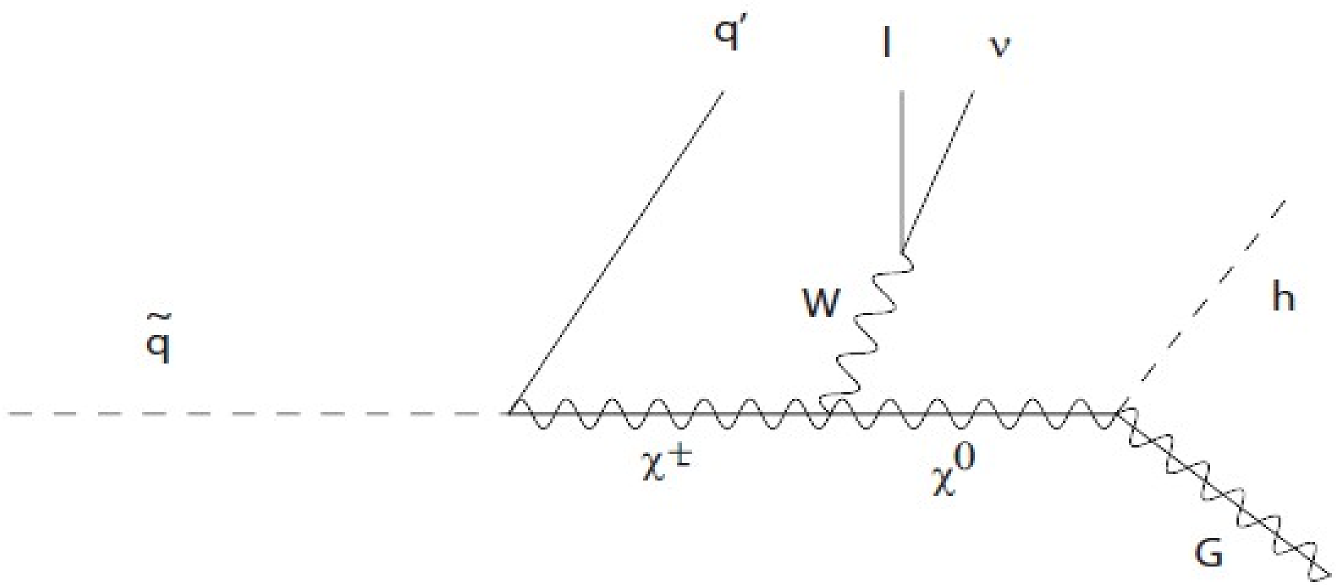
τ
G


l'
$\bar{\tau}$
l'_R
χ^0
$\tilde{\tau}$

Higgsino NLSP

neutral gaugino	mass	chargino	mass	squark	mass	slepton	mass
m_g	6000			m_{u_l}	903	m_{e_l}	463
$m_{\chi_4^0}$	6001	$m_{\chi_2^+}$	6001	m_{d_l}	903	m_{e_r}	203
$m_{\chi_3^0}$	5000						
$m_{\chi_2^0}$	-170.4	$m_{\chi_1^+}$	169.5				
$m_{\chi_1^0}$	169			m_{u_r}	782	m_{τ_1}	199
				m_{d_r}	784		



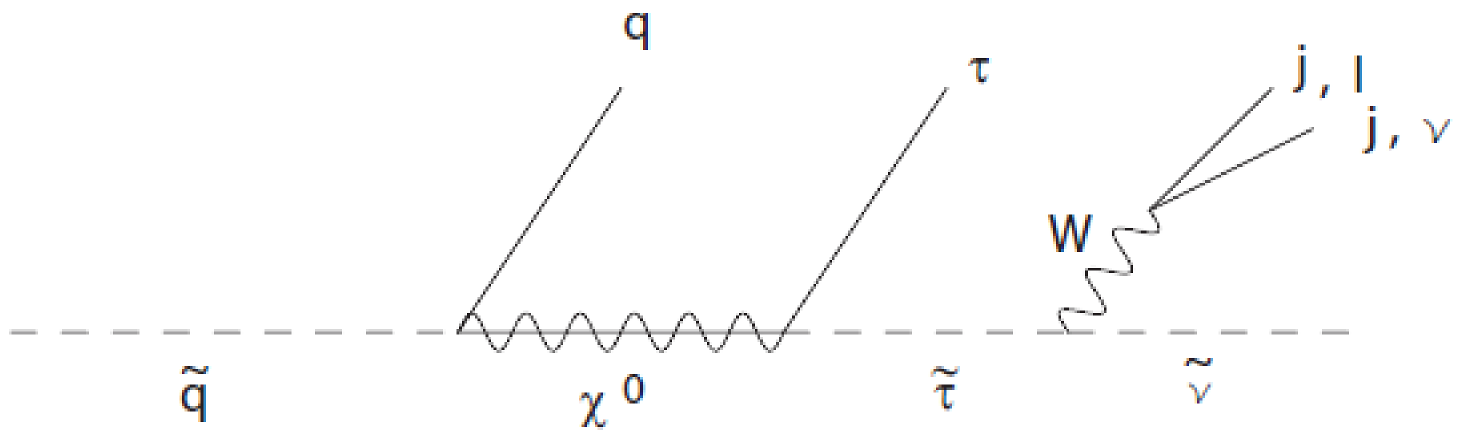
$\chi_0 \rightarrow Z/h$ Where tanb and the mu term will determine the ratio of final states

$$\Gamma_Z/\Gamma_H = \frac{(N_{13}c\beta - N_{14}s\beta)^2}{(N_{13}c\beta + N_{14}s\beta)^2}\frac{(1-m_Z^2/m_{\chi_0}^2)^4}{(1-m_h^2/m_{\chi_0}^2)^4}$$

neutral gaugino	mass	chargino	mass	squark	mass	slepton	mass
m_g	6250			m_{u_l}	807	m_{v_l}	250
$m_{\chi_4^0}$	8002	$m_{\chi_2^+}$	6001	m_{d_l}	807	m_{e_r}	394
$m_{\chi_3^0}$	6001						
$m_{\chi_2^0}$	500.4	$m_{\chi_1^+}$	499.5				
$m_{\chi_1^0}$	499			m_{u_r}	792	m_{e_l}	255
				m_{d_r}	800		

particle	decay	b.f.	particle	decay	b.f.
$\widetilde{u}_l$	$\chi_1^{\pm}$d	.78	$\widetilde{t}_1$	$\chi_1^{\pm}$ b	.38
-	χ_1^0 u	.20	-	χ_1^0 t	.51
$\widetilde{u}_r$	χ_1^0u	.96	$\widetilde{t}_2$	$\chi_1^{\pm}$ b	.38
			-	χ_1^0 t	.57
$\widetilde{d}_l$	$\chi_1^{\pm}$u	.48	$\widetilde{b}_1$	$\chi_1^{\pm}$ t	.13
-	χ_1^0 d	.49	-	χ_1^0 b	.41
$\widetilde{d}_r$	χ_1^0d	.96	-	χ_2^0 b	.45
			$\widetilde{b}_2$	$\chi_1^{\pm}$ t	.99

$\chi_1^{\pm}$	$\widetilde{\nu}_\tau\ \tau$	.73	$\widetilde{\ell}_R$	$\widetilde{\ell}_L\ \ell^{\mp}\ell^{\pm}$	.32
-	$\nu_\tau\ (\widetilde{\tau})_2$	.16	-	$\widetilde{\nu}_\ell\ \ell\nu_\ell$	.619
-	$\nu_\tau\ (\widetilde{\tau})_1$	.01	$\widetilde{\ell}_L$	$\widetilde{\nu}_\ell\ jj'$	.69
χ_1^0	$\tau^{\mp}\ \widetilde{\tau}^{\pm}$	.93	-	$\widetilde{\nu}_\ell\ \ell\nu_\ell$	.30
χ_2^0	$\tau^{\mp}\ \widetilde{\tau}^{\pm}$	.97			


q
τ
j , l
j , ν
W
q̃
χ 0
τ̃
ν̃

Smoking Gun SUSY processes

process	$\tilde{\nu} NLSP$	Higgsino $NLSP$	$\tilde{\tau} NLSP$
$\tilde{q}\tilde{q}$	$6j + 2\tau + \not{E}_T$ $4j + 2\tau + \ell + \not{E}_T$	$6j + 4b + \not{E}_T$ $4j + \ell + 4b + \not{E}_T$	$2j + 4\tau + \not{E}_T$ $2j + 2\tau + \not{E}_T$
$\chi_1^+ \chi_1^-$	$2\tau + \not{E}_T$	$4j + 4b + \not{E}_T$	$2\tau + \not{E}_T$
$\chi^0 \chi^0$	$2\tau + 4j + \not{E}_T$ $2\tau + 2j + \ell + \not{E}_T$	$4b + \not{E}_T$	$4\tau + \not{E}_T$
$\tilde{\ell}\tilde{\ell}$	$4j + \not{E}_T$ $\ell' \ell'' + \not{E}_T$	$2\ell + 4b + \not{E}_T$	$2\ell + 2\tau + \not{E}_T$ $6\ell + 4\tau + \not{E}_T$