The NMSSM and Gauge Mediation

Robert Ziegler (CERN)

based on

arXiv:1304.1453, with L. Calibbi, P. Paradisi
arXiv:1502.05836, with B. Allanach, M. Badziak, C. Hugonie
arXiv:1502.05836, with B. Allanach, M. Badziak, G. Cottin, N. Desai, C. Hugonie
work in progress, with M. Badziak, N. Desai, C. Hugonie

Introduction

The LHC legacy so far:

A 125 GeV Higgs, no new physics

Don't give up yet: best candidate to protect weak scale is still low-energy SUSY!

Still room for light sparticles: explore non-minimal models

Motivate new searches: explore non-standard signals

For heavy SUSY indirect tests important: explore non-minimal sflavor structures

Going top-down

SUSY has too many parameters!

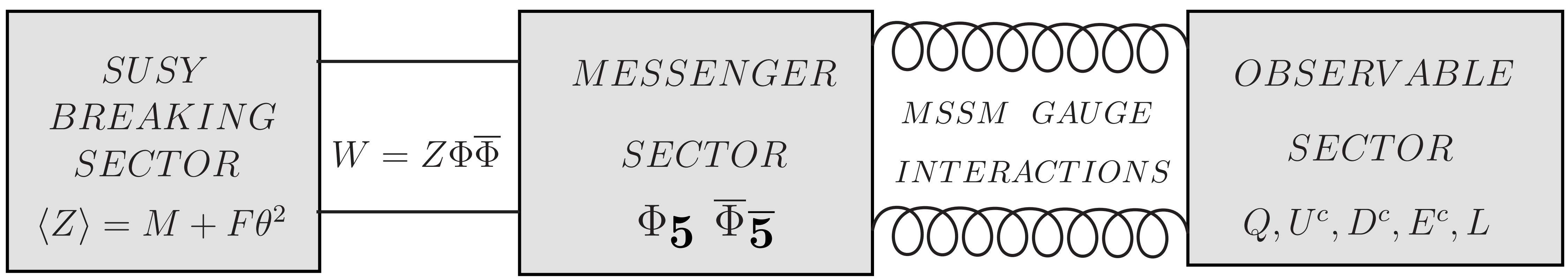
(~100 in the MSSM, mostly flavor)

Work with predictive scenario of SUSY breaking:

Gauge Mediation

(also takes care of SUSY flavor problem)

Minimal Gauge Mediation



- **Very predictive setup** (5 parameters) ✓
- **Solves SUSY Flavor Problem** (MFV) ✓
- **Heavy Higgs problematic** (small A-terms) ✗

A Heavy Higgs in Gauge Mediation

How to get a heavy Higgs in GMSB ?

Large radiative A_t

need heavy gluino & squarks

{outside LHC reach}

PART I

Large boundary A_t

need matter-messenger couplings

PART II

New tree-level Δm_h^2

need D-terms, F-terms, mixing

NMSSM!

PART I

Large boundary A_t

need matter-messenger couplings

Matter-Messenger Couplings

Messengers have same quantum number as Higgs

$$W_{\rm yuk} = y_{ij} Q_i U_j H_u \quad \Rightarrow \quad \Delta W_{\rm yuk} = \lambda_{ij} Q_i U_j \Phi^{\mathbf{5}}_{H_u}$$

Get new contributions to A-terms and soft masses

$$A_t \sim \frac{\Lambda}{16\pi^2} \lambda\lambda^\dagger y \qquad \Delta m_Q^2 \sim \frac{\Lambda^2}{256\pi^4} \left(\lambda\lambda^\dagger - g_3^2\right) \lambda\lambda^\dagger$$

New sources of flavor violation

Need hierarchical flavor structure: $\lambda_{ij} \neq \mathcal{O}(1)_{ij}$

...but very plausible since also $y_{ij} \neq \mathcal{O}(1)_{ij}$

Natural Flavor Protection

Relate new couplings to Yukawa hierarchies

$$\Delta W = \lambda_{ij} Q_i U_j \Phi^5_{H_u}$$

aligned to Yukawas through explicit mixing (Minimal Flavor Violation)

controlled by same underlying flavor model ("Flavored Gauge Mediation")

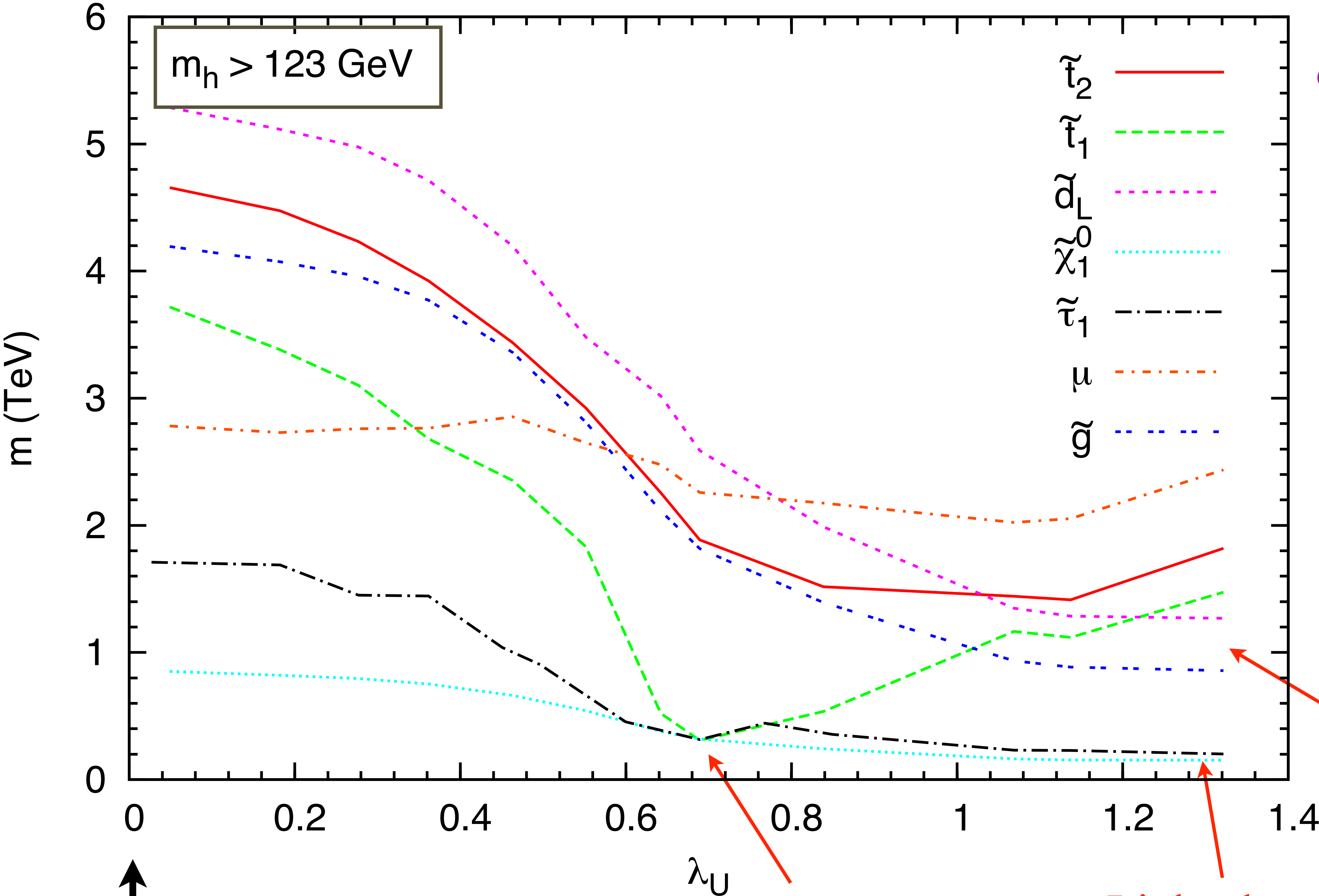
Evans, Ibe, Yanagida '11 $\lambda_{ij} \propto y^u_{ij}$

$\lambda_{ij} \sim y^u_{ij}$ Shadmi & Szabo '11

Same sparticle spectrum: only $\lambda_{33} \sim y_t$ is sizable

Different sflavor structure: close but beyond MFV!

Low-energy Sparticle Spectrum



Evans, Ibe, Yanagida, '11
Calibbi, Paradisi, RZ, '13

Light 1st gen squarks & gluinos

Light stops

Light sleptons: g-2

Minimal GM

Sflavor Structure in U(1) Flavor Model

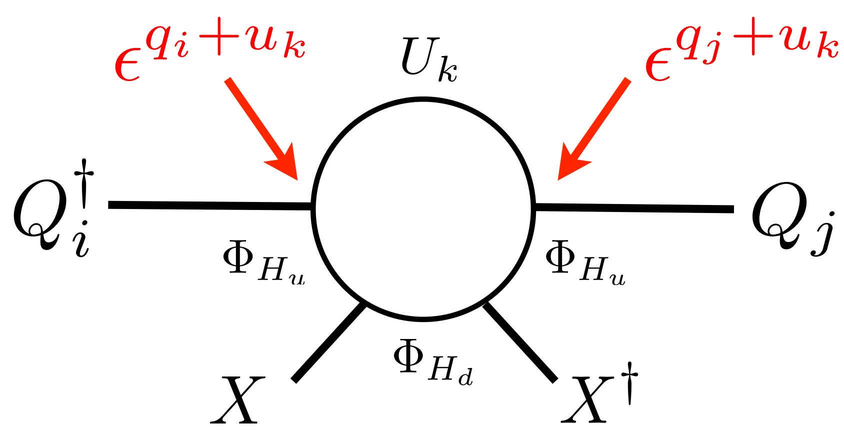
Calibbi, Paradisi, RZ, '13

If U(1) FN model controls couplings, can estimate sflavor structure in terms of masses and mixings

$$y^u_{ij} = \underbrace{x_{ij}}_{\mathcal{O}(1)} \epsilon^{q_i+u_j} \quad \Rightarrow \quad \lambda_{ij} = \underbrace{y_{ij}}_{\mathcal{O}(1)} \epsilon^{q_i+u_j}$$

Loop origin gives strong sflavor protection

$$(\tilde{m}^2_Q)_{ij} \sim \lambda_{ik}\lambda^*_{jk} \sim \epsilon^{q_i+q_j+3u_3} \sim V_{i3}V^*_{j3}y_t^2$$



cf. Gravity Mediation+U(1):
$\sim V_{i3}/V_{j3}$

Sflavor Structure between PC and MFV

	MFV	PC	$U(1)$	FGM$_{U,D} + U(1)$	FGM$_U + U(1)$
$(\delta^u_{LL})_{ij}$	$V_{i3}V^*_{j3}y_b^2$	$(\epsilon_3^q)^2 V_{i3}V^*_{j3}$	$\frac{V_{i3}}{V_{j3}}\vert_{i\leq j}$	$V_{i3}V^*_{j3}y_t^2$	$V_{i3}V^*_{j3}y_t^2$
$(\delta^d_{LL})_{ij}$	$V^*_{3i}V_{3j}y_t^2$	$(\epsilon_3^q)^2 V_{i3}V^*_{j3}$	$\frac{V_{i3}}{V_{j3}}\vert_{i\leq j}$	$V^*_{3i}V_{3j}y_t^2$	$V^*_{3i}V_{3j}y_t^2$
$(\delta^u_{RR})_{ij}$	$y_i^U y_j^U V_{i3}V^*_{j3}y_b^2$	$\frac{y_i^U y_j^U}{V_{i3}V^*_{j3}}\frac{(\epsilon_3^u)^2}{y_t^2}$	$\frac{y_i^U V_{j3}}{y_j^U V_{i3}}\vert_{i\leq j}$	$\frac{y_i^U y_j^U}{V_{i3}V^*_{j3}}$	$\frac{y_i^U y_j^U}{V_{i3}V^*_{j3}}$
$(\delta^d_{RR})_{ij}$	$y_i^D y_j^D V^*_{3i}V_{3j}y_t^2$	$\frac{y_i^D y_j^D}{V_{i3}V^*_{j3}}\frac{(\epsilon_3^u)^2}{y_t^2}$	$\frac{y_i^D V_{j3}}{y_j^D V_{i3}}\vert_{i\leq j}$	$\frac{y_i^D y_j^D}{V_{i3}V^*_{j3}}$	$y_i^D y_j^D V^*_{3i}V_{3j}y_t^2$
$(\delta^u_{LR})_{ij}$	$y_j^U V_{i3}V^*_{j3}y_b^2$	$y_j^U \frac{V_{i3}}{V^*_{j3}}$	$y_j^U \frac{V_{i3}}{V^*_{j3}}$	$y_j^U V_{i3}V^*_{j3}y_t^2 + y_i^U \frac{y_i^U y_j^U}{V_{i3}V^*_{j3}}$ $y_j^U \frac{V_{i3}}{V^*_{j3}}y_t^6$	$y_j^U V_{i3}V^*_{j3}y_t^2 + y_i^U \frac{y_i^U y_j^U}{V_{i3}V^*_{j3}}$ $y_j^U \frac{V_{i3}}{V^*_{j3}}y_t^6$
$(\delta^d_{LR})_{ij}$	$y_j^D V^*_{3i}V_{3j}y_t^2$	$y_j^D \frac{V_{i3}}{V^*_{j3}}$	$y_j^D \frac{V_{i3}}{V^*_{j3}}$	$y_j^D V^*_{3i}V_{3j}y_t^2 + y_i^D \frac{y_i^D y_j^D}{V_{i3}V^*_{j3}}$ $y_j^D \frac{V^*_{3i}}{V_{3j}}y_t^4 y_b^2$	$y_j^D V^*_{3i}V_{3j}y_t^2$

Effects mainly in LR up-sector: $\Delta C = 1$

PART II

New tree-level Δm_h^2

need D-terms, F-terms, mixing

NMSSM!

Raise Higgs mass with mixing

$$\begin{pmatrix} m_h^2 & m_{hs}^2 \\ m_{hs}^2 & m_s^2 \end{pmatrix} \xrightarrow{m_h^2 > m_s^2} m_{h_2}^2 \approx m_h^2 + \frac{m_{hs}^4}{m_h^2}$$

Can realize in NMSSM $\Delta W = \lambda S H_u H_d + \frac{\kappa}{3} S^3$

Mixing angles constrained by LEP and LHC, maximal contribution to Higgs mass for:

$m_{h_1} \approx 94\,\mathrm{GeV}$ $\cos\theta \approx 0.88$

Embedding into GMSB

Can one realize mixing scenario in GMSB?

Nice to marry NMSSM to GMSB: solves μ-B_μ problem

MSSM + GM: $\mu \sim a\frac{\Lambda}{16\pi^2}$ $B_\mu \sim a\frac{\Lambda^2}{16\pi^2} \sim 16\pi^2\mu^2$

NMSSM + GM: $\mu \sim \langle S \rangle \sim m_{\rm soft}$ $B_\mu \sim \langle F_S \rangle \sim m_{\rm soft}^2 \sim \mu^2$

...not in minimal Gauge Mediation
because singlet soft terms too small

Dine, Nelson '93
de Gouvea, Friedland, Murayama '13

The DGS Model

Simplest Model: MGM + two pairs of messengers and direct couplings to singlet

Delgado, Giudice, Slavich '07

$$W_{\mathrm{DGS}} = S\left(\xi_D \bar{\Phi}_1^D \Phi_2^D + \xi_T \bar{\Phi}_1^T \Phi_2^T\right)$$

$\xi_D(M_{\mathrm{GUT}}) = \xi_T(M_{\mathrm{GUT}}) \equiv \xi$

1-loop A-terms

$A_\lambda \sim A_\kappa \sim \tilde{m}\,\xi^2$

2-loop singlet mass

$\tilde{m}_S^2 \sim \tilde{m}^2\left(\xi^4 - g_3^2\xi^2\right)$

$\tilde{m} \equiv \Lambda/(16\pi^2) \sim m_{\tilde{g}}$

Has only **4 parameters** $\lambda,\ \tilde{m},\ \xi,\ M$

[correct EWSB fixes κ]

The DGS Model

Simplest Model: MGM + two pairs of messengers and direct couplings to singlet

Delgado, Giudice, Slavich ’07

$$W_{\mathrm{DGS}} = S\left(\xi_D \bar{\Phi}_1^D \Phi_2^D + \xi_T \bar{\Phi}_1^T \Phi_2^T\right)$$

$\xi_D(M_{\mathrm{GUT}}) = \xi_T(M_{\mathrm{GUT}}) \equiv \xi$

1-loop A-terms

$A_\lambda \sim A$

2-loop singlet mass

$(\xi^4 - g_3^2 \xi^2)$

Singlet-Higgs coupling

$\tilde{m} \equiv \Lambda/(16\pi^2) \sim m_{\tilde{g}}$

Has only **4 parameters** $\lambda,\ \tilde{m},\ \xi,\ M$

[correct EWSB fixes κ]

The DGS Model

Simplest Model: MGM + two pairs of messengers and direct couplings to singlet

Delgado, Giudice, Slavich '07

$$W_{\mathrm{DGS}} = S\left(\xi_D \bar{\Phi}_1^D \Phi_2^D + \xi_T \bar{\Phi}_1^T \Phi_2^T\right)$$

$\xi_D(M_{\mathrm{GUT}}) = \xi_T(M_{\mathrm{GUT}}) \equiv \xi$

1-loop A-terms

$A_\lambda \sim A_\kappa \sim$

2-loop singlet mass

$g_3^2\xi^2)$

Singlet-Messenger coupling

$/(16\pi^2) \sim m_{\tilde{g}}$

Has only **4 parameters** $\lambda,\ \tilde{m},\ \xi,\ M$

[correct EWSB fixes κ]

The DGS Model

Simplest Model: MGM + two pairs of messengers and direct couplings to singlet

Delgado, Giudice, Slavich ’07

$$W_{\mathrm{DGS}} = S\left(\xi_D \bar{\Phi}_1^D \Phi_2^D + \xi_T \bar{\Phi}_1^T \Phi_2^T\right)$$

$\xi_D(M_{\mathrm{GUT}}) = \xi_T(M_{\mathrm{GUT}}) \equiv \xi$

1-loop A-terms

$A_\lambda \sim A_\kappa \sim$ ...

2-loop singlet mass

... $\tilde{m}^2\left(\xi^4 - g_3^2\xi^2\right)$

Soft SUSY scale

$\tilde{m} \equiv \Lambda/(16\pi^2) \sim m_{\tilde{g}}$

Has only **4 parameters** $\lambda, \tilde{m}, \xi, M$

[correct EWSB fixes κ]

The DGS Model

Simplest Model: MGM + two pairs of messengers and direct couplings to singlet

Delgado, Giudice, Slavich '07

$$W_{\rm DGS} = S\left(\xi_D \bar{\Phi}_1^D \Phi_2^D + \xi_T \bar{\Phi}_1^T \Phi_2^T\right)$$

$\xi_D(M_{\rm GUT}) = \xi_T(M_{\rm GUT}) \equiv \xi$

1-loop A-terms

$A_\lambda \sim A_\kappa \sim$

2-loop singlet mass

$\tilde{m}^2\left(\xi^4 - g_3^2\xi^2\right)$

Messenger scale

$\tilde{m} \equiv \Lambda/(16\pi^2) \sim m_{\tilde{g}}$

Has only **4 parameters** $\lambda,\ \tilde{m},\ \xi,\ M$

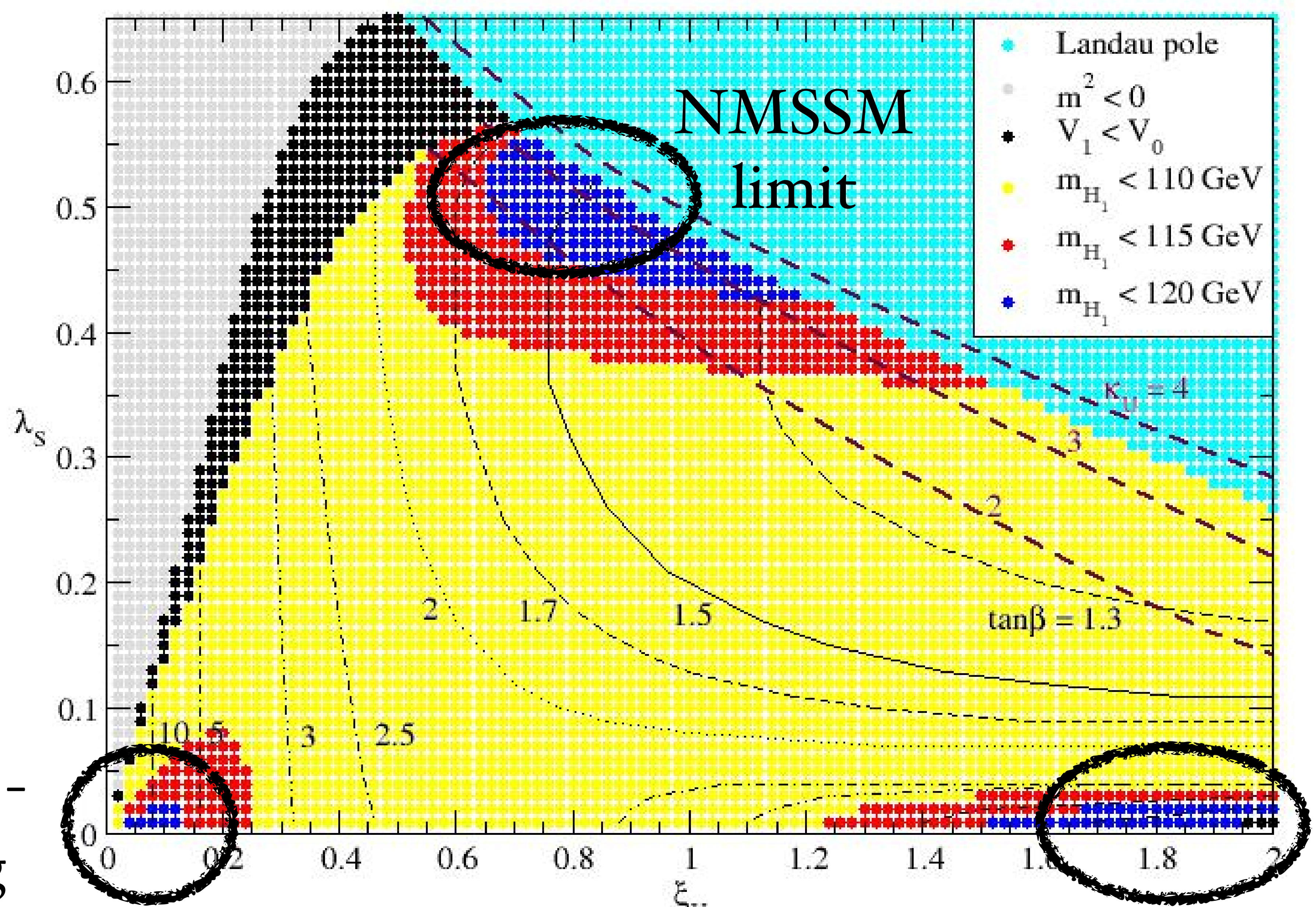
[correct EWSB fixes κ]

DGS Parameter Space

Only 3 regions with sizable Higgs mass

$$m_h^2 = M_Z^2 \cos^2 2\beta + \lambda^2 v^2 \sin^2 2\beta + m_{h,\mathrm{mix}}^2 + m_{h,\mathrm{loop}}^2$$

Sum bounded by M_Z^2 (perturbativity)



MSSM - mixing

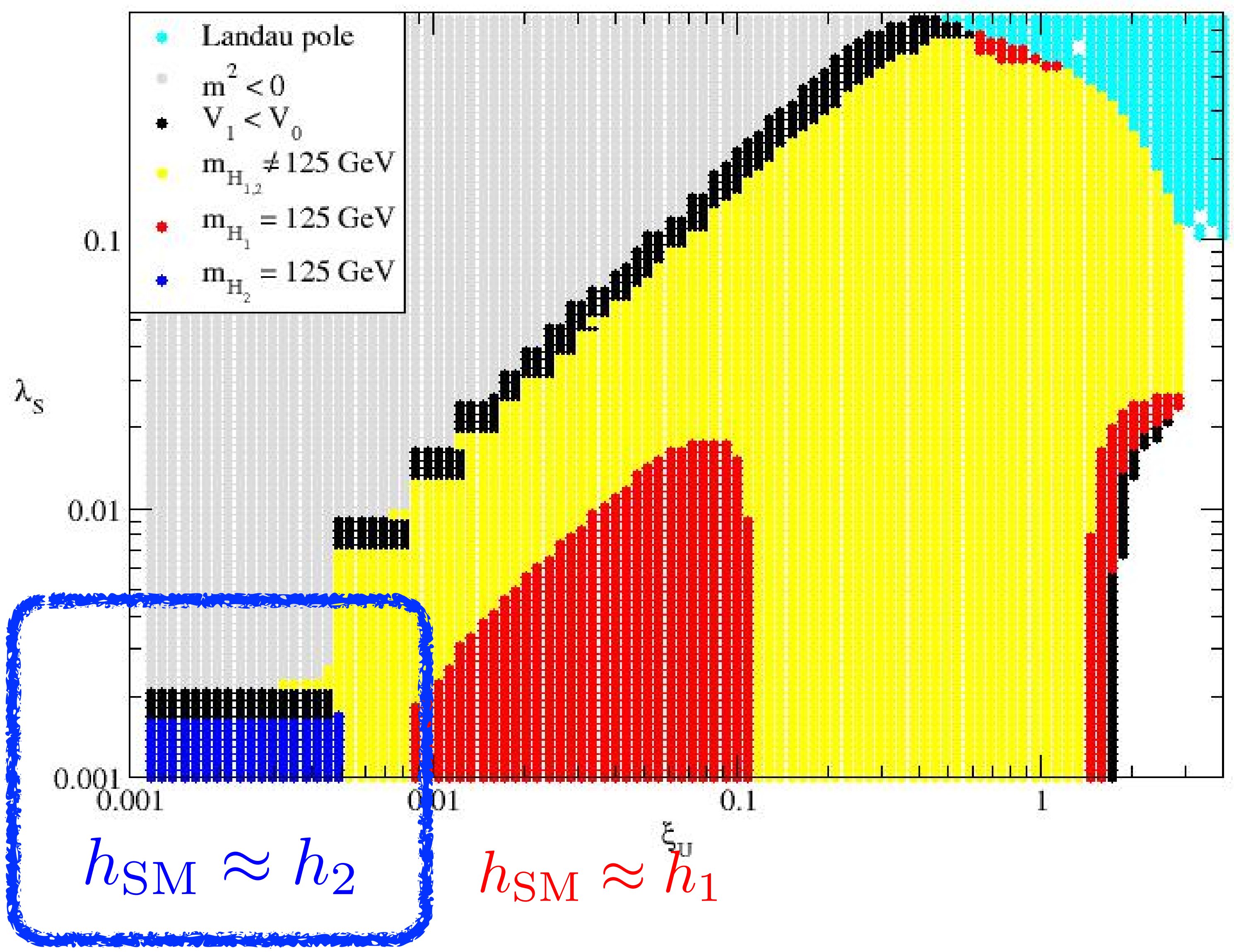
MSSM limit

The Push-up Region

"...even in these regions the lightest Higgs mass is not larger than the maximal value attainable in the usual GMSB."

Delgado, Giudice, Slavich '07

But MSSM + mixing region exists! (though hard to find)



The Maximal Push-up Region

Allanach, Badziak, Hugonie, RZ '15

Maximize tree-level Higgs contribution from mixing

$m_{h_1} \approx 94\,\mathrm{GeV}$ $\cos\theta \approx 0.88$

$m_{h_2} \approx 125\,\mathrm{GeV}$

Fixes 3/4 parameters, only messenger scale free

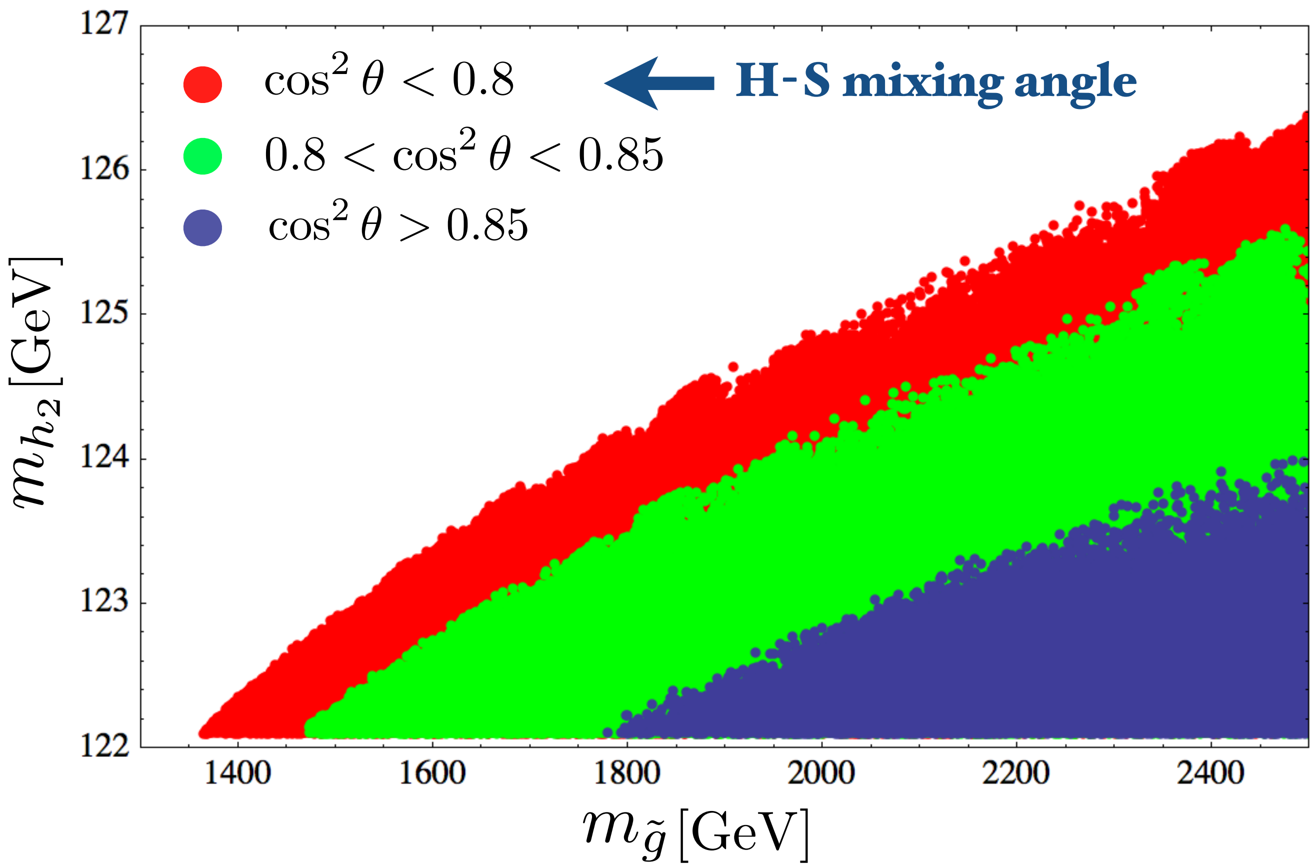
λ, ξ $\sim 10^{-2}$

$\tilde{m}$ $\sim 1\,\mathrm{TeV}$

M determines gravitino phenomenology

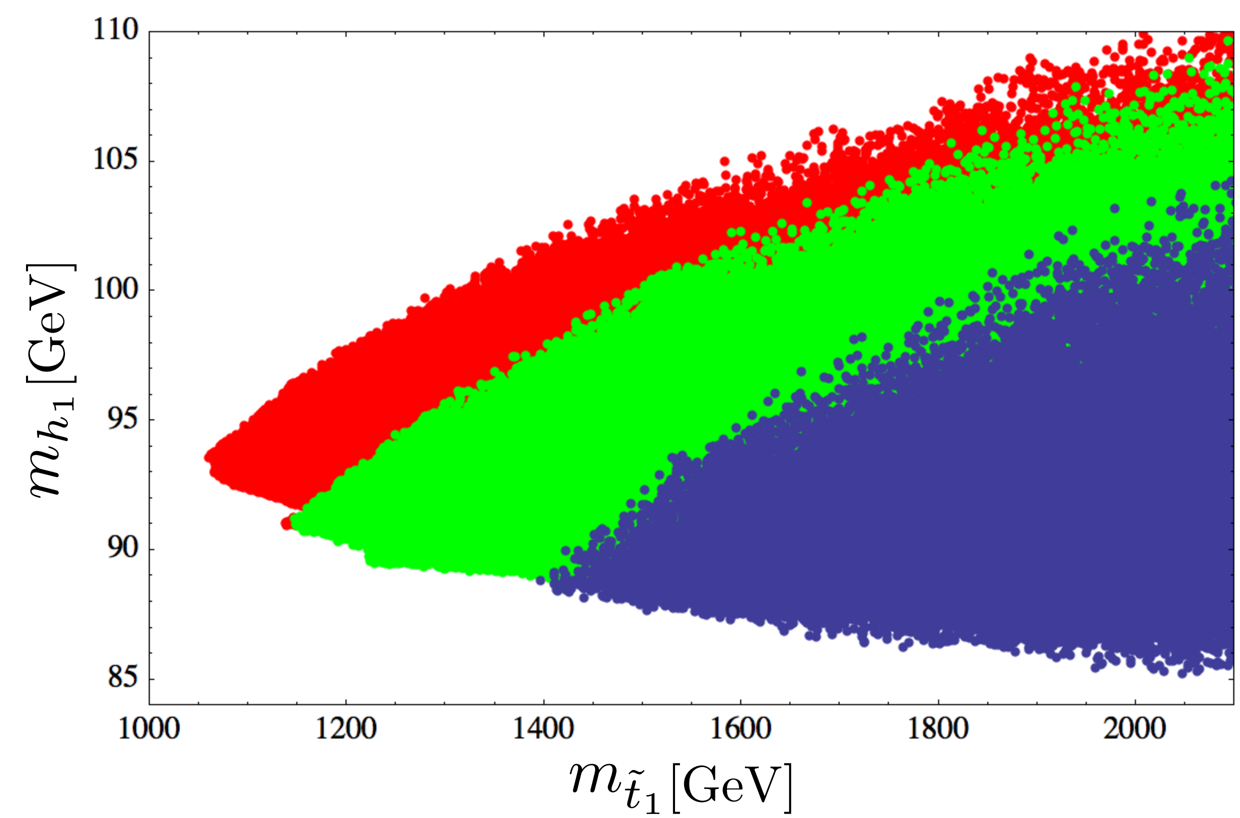
Higgs mass still drives lower bounds on sparticles, but can be close to direct exclusion bounds

Light Gluinos and Stops



Allows for 1.4 TeV Gluinos

...and 1.1 TeV stops



Phenomenology

	P1	P2	P3	P4	P5
$\tilde{m}$	$7.5 \cdot 10^{2}$	$8.7 \cdot 10^{2}$	$9.3 \cdot 10^{2}$	$5.9 \cdot 10^{2}$	$9.3 \cdot 10^{2}$
M	$1.4 \cdot 10^{6}$	$2.8 \cdot 10^{6}$	$3.3 \cdot 10^{7}$	$8.3 \cdot 10^{14}$	$3.4 \cdot 10^{14}$
λ	$1.0 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	$9.2 \cdot 10^{-3}$	$6.9 \cdot 10^{-3}$
ξ	$1.2 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$2.2 \cdot 10^{-2}$	$2.0 \cdot 10^{-2}$
$\tan\beta$	25	28	24	26	21
m_{h_1}	92	93	98	94	94
m_{h_2}	122.1	123.4	122.9	122.1	125.0
m_{a_1}	26	26	28	40	32
$m_{\tilde{N}_1}$	101	102	106	104	104
$m_{\tilde{N}_2}$	322	377	400	251	379
$m_{\tilde{e}_1}$	303	358	406	449	676
$m_{\tilde{\tau}_1}$	284	333	376	432	637
$m_{\tilde{g}}$	1.73	1.98	2.09	1.37	2.06
$m_{\tilde{u}_R}$	1.79	2.06	2.15	1.36	2.07
$m_{\tilde{t}_1}$	1.64	1.87	1.90	1.06	1.63
$[m]$ $c\tau_{\tilde{N}_1}$	$6.4 \cdot 10^{-2}$	0.34	48	$1.9 \cdot 10^{16}$	$6.0 \cdot 10^{15}$
$\sigma^{13\text{TeV}}_{\tilde{q}\tilde{q}}$	9.35	2.99	1.98	59.7	2.63
$\sigma^{13\text{TeV}}_{\tilde{q}\tilde{g}}$	11.9	3.30	2.01	91.1	2.48
$[fb]$ $\sigma^{13\text{TeV}}_{\text{strong}}$	25.2	7.28	4.58	190	5.95
$\sigma^{8\text{TeV}}_{\text{strong}}$	0.51	0.07	0.03	10.1	0.05
$\sigma^{13\text{TeV}}_{\text{EW}}$	27	12	7.5	6.7	5.6
$\sigma^{8\text{TeV}}_{\text{EW}}$	5.5	2.1	1.2	1.3	0.7

- Large tan beta

Phenomenology

	P1	P2	P3	P4	P5
$\tilde{m}$	$7.5 \cdot 10^2$	$8.7 \cdot 10^2$	$9.3 \cdot 10^2$	$5.9 \cdot 10^2$	$9.3 \cdot 10^2$
M	$1.4 \cdot 10^6$	$2.8 \cdot 10^6$	$3.3 \cdot 10^7$	$8.3 \cdot 10^{14}$	$3.4 \cdot 10^{14}$
λ	$1.0 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	$9.2 \cdot 10^{-3}$	$6.9 \cdot 10^{-3}$
ξ	$1.2 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$3.2 \cdot 10^{-2}$	$2.0 \cdot 10^{-2}$
$\tan\beta$	25	28	24	26	21
m_{h_1}	92	93	98	94	94
m_{h_2}	122.1	123.4	122.9	122.1	125.0
m_{a_1}	26	26	28	40	32
$m_{\tilde{N}_1}$	101	102	106	104	104
$m_{\tilde{N}_2}$	322	377	400	251	379
$m_{\tilde{e}_1}$	303	358	406	449	676
$m_{\tilde{\tau}_1}$	284	333	376	432	637
$m_{\tilde{g}}$	1.73	1.98	2.09	1.37	2.06
$m_{\tilde{u}_R}$	1.79	2.06	2.15	1.36	2.07
$m_{\tilde{t}_1}$	1.64	1.87	1.90	1.06	1.63
$[m]$ $c\tau_{\tilde{N}_1}$	$6.4 \cdot 10^{-2}$	0.34	48	$1.9 \cdot 10^{16}$	$6.0 \cdot 10^{15}$
$\sigma_{\tilde{q}\tilde{q}}^{13\text{TeV}}$	9.35	2.99	1.98	59.7	2.63
$\sigma_{\tilde{q}\tilde{g}}^{13\text{TeV}}$	11.9	3.30	2.01	91.1	2.48
$[fb]$ $\sigma_{\text{strong}}^{13\text{TeV}}$	25.2	7.28	4.58	190	5.95
$\sigma_{\text{strong}}^{8\text{TeV}}$	0.51	0.07	0.03	10.1	0.05
$\sigma_{\text{EW}}^{13\text{TeV}}$	27	12	7.5	6.7	5.6
$\sigma_{\text{EW}}^{8\text{TeV}}$	5.5	2.1	1.2	1.3	0.7

- Large tan beta
- Light pseudoscalar ~25 GeV

Phenomenology

		P1	P2	P3	P4	P5
	$\tilde{m}$	$7.5 \cdot 10^2$	$8.7 \cdot 10^2$	$9.3 \cdot 10^2$	$5.9 \cdot 10^2$	$9.3 \cdot 10^2$
	M	$1.4 \cdot 10^6$	$2.8 \cdot 10^6$	$3.3 \cdot 10^7$	$8.3 \cdot 10^{14}$	$3.4 \cdot 10^{14}$
	λ	$1.0 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	$9.2 \cdot 10^{-3}$	$6.9 \cdot 10^{-3}$
	ξ	$1.2 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$3.2 \cdot 10^{-2}$	$2.0 \cdot 10^{-2}$
	$\tan\beta$	25	28	24	26	21
	m_{h_1}	92	93	98	94	94
	m_{h_2}	122.1	123.4	122.9	122.1	125.0
	m_{a_1}	26	26	28	40	32
	$m_{\tilde{N}_1}$	101	102	106	104	104
	$m_{\tilde{N}_2}$	322	377	400	251	379
	$m_{\tilde{e}_1}$	303	358	406	449	676
	$m_{\tilde{\tau}_1}$	284	333	376	432	637
	$m_{\tilde{g}}$	1.73	1.98	2.09	1.37	2.06
	$m_{\tilde{u}_R}$	1.79	2.06	2.15	1.36	2.07
	$m_{\tilde{t}_1}$	1.64	1.87	1.90	1.06	1.63
$[m]$	$c\tau_{\tilde{N}_1}$	$6.4 \cdot 10^{-2}$	0.34	48	$1.9 \cdot 10^{16}$	$6.0 \cdot 10^{15}$
	$\sigma^{13\text{TeV}}_{\tilde{q}\tilde{q}}$	9.35	2.99	1.98	59.7	2.63
	$\sigma^{13\text{TeV}}_{\tilde{q}\tilde{g}}$	11.9	3.30	2.01	91.1	2.48
$[fb]$	$\sigma^{13\text{TeV}}_{\text{strong}}$	25.2	7.28	4.58	190	5.95
	$\sigma^{8\text{TeV}}_{\text{strong}}$	0.51	0.07	0.03	10.1	0.05
	$\sigma^{13\text{TeV}}_{\text{EW}}$	27	12	7.5	6.7	5.6
	$\sigma^{8\text{TeV}}_{\text{EW}}$	5.5	2.1	1.2	1.3	0.7

- Large tan beta
- Light pseudoscalar ~25 GeV
- **Singlino NLSP ~ 100 GeV**
  displaced/stable

Phenomenology

		P1	P2	P3	P4	P5
	$\tilde{m}$	$7.5 \cdot 10^2$	$8.7 \cdot 10^2$	$9.3 \cdot 10^2$	$5.9 \cdot 10^2$	$9.3 \cdot 10^2$
	M	$1.4 \cdot 10^6$	$2.8 \cdot 10^6$	$3.3 \cdot 10^7$	$8.3 \cdot 10^{14}$	$3.4 \cdot 10^{14}$
	λ	$1.0 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	$9.2 \cdot 10^{-3}$	$6.9 \cdot 10^{-3}$
	ξ	$1.2 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$3.2 \cdot 10^{-2}$	$2.0 \cdot 10^{-2}$
	$\tan\beta$	25	28	24	26	21
	m_{h_1}	92	93	98	94	94
	m_{h_2}	122.1	123.4	122.9	122.1	125.0
	m_{a_1}	26	26	28	40	32
	$m_{\tilde{N}_1}$	101	102	106	104	104
	$m_{\tilde{N}_2}$	322	377	400	251	379
	$m_{\tilde{e}_1}$	303	358	406	449	676
	$m_{\tilde{\tau}_1}$	284	333	376	432	637
	$m_{\tilde{g}}$	1.75	1.98	2.09	1.37	2.06
	$m_{\tilde{u}_R}$	1.79	2.06	2.15	1.36	2.07
	$m_{\tilde{t}_1}$	1.64	1.87	1.90	1.06	1.63
$[m]$	$c\tau_{\tilde{N}_1}$	$6.4 \cdot 10^{-2}$	0.34	48	$1.9 \cdot 10^{16}$	$6.0 \cdot 10^{15}$
	$\sigma_{\tilde{q}\tilde{q}}^{13\mathrm{TeV}}$	9.35	2.99	1.98	59.7	2.63
	$\sigma_{\tilde{q}\tilde{g}}^{13\mathrm{TeV}}$	11.9	3.30	2.01	91.1	2.48
$[fb]$	$\sigma_{\mathrm{strong}}^{13\mathrm{TeV}}$	25.2	7.28	4.58	190	5.95
	$\sigma_{\mathrm{strong}}^{8\mathrm{TeV}}$	0.51	0.07	0.03	10.1	0.05
	$\sigma_{\mathrm{EW}}^{13\mathrm{TeV}}$	27	12	7.5	6.7	5.6
	$\sigma_{\mathrm{EW}}^{8\mathrm{TeV}}$	5.5	2.1	1.2	1.3	0.7

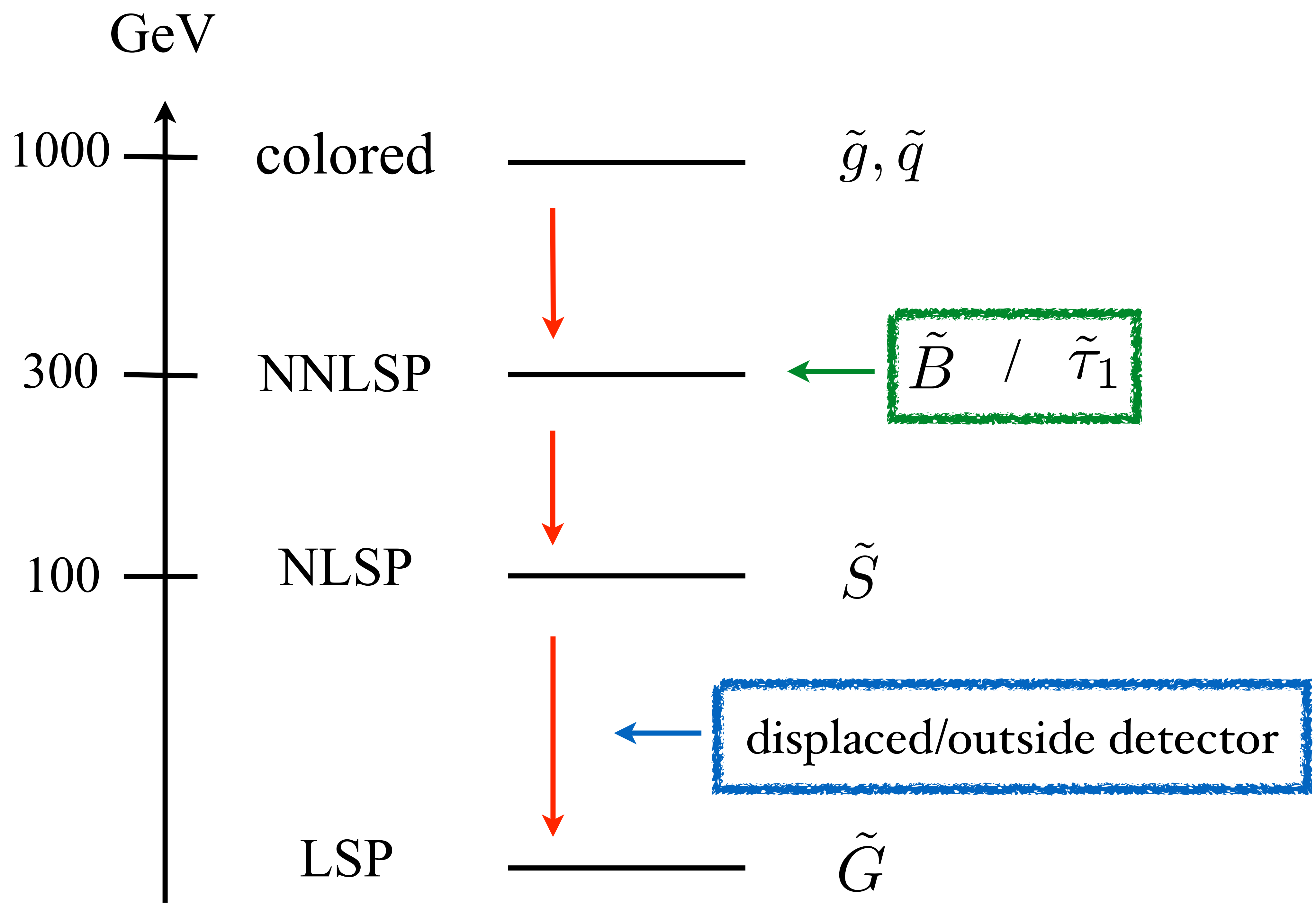
- Large tan beta
- Light pseudoscalar ~25 GeV
- **Singlino NLSP ~ 100 GeV displaced/stable**
- **stau/bino NNLSP ~ 300 GeV**

Phenomenology

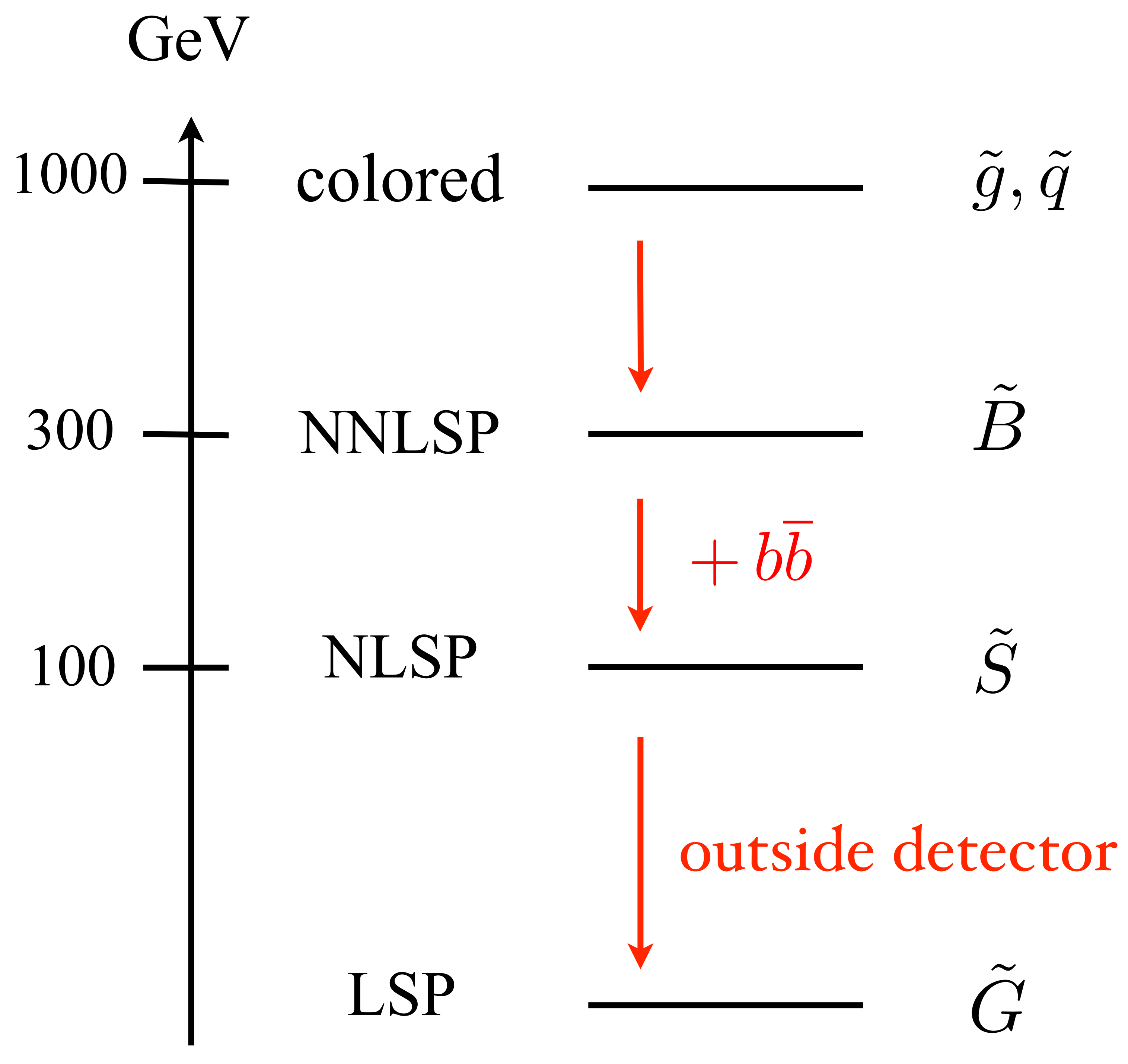
		P1	P2	P3	P4	P5
	$\tilde{m}$	$7.5 \cdot 10^2$	$8.7 \cdot 10^2$	$9.3 \cdot 10^2$	$5.9 \cdot 10^2$	$9.3 \cdot 10^2$
	M	$1.4 \cdot 10^6$	$2.8 \cdot 10^6$	$3.3 \cdot 10^7$	$8.3 \cdot 10^{14}$	$3.4 \cdot 10^{14}$
	λ	$1.0 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	$9.2 \cdot 10^{-3}$	$6.9 \cdot 10^{-3}$
	ξ	$1.2 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$1.3 \cdot 10^{-2}$	$3.2 \cdot 10^{-2}$	$2.0 \cdot 10^{-2}$
	$\tan\beta$	25	28	24	26	21
	m_{h_1}	92	93	98	94	94
	m_{h_2}	122.1	123.4	122.9	122.1	125.0
	m_{a_1}	26	26	28	40	32
	$m_{\tilde{N}_1}$	101	102	106	104	104
	$m_{\tilde{N}_2}$	322	377	400	251	379
	$m_{\tilde{e}_1}$	303	358	406	449	676
	$m_{\tilde{\tau}_1}$	284	333	376	432	637
	$m_{\tilde{g}}$	1.73	1.98	2.09	1.37	2.06
	$m_{\tilde{u}_R}$	1.79	2.06	2.15	1.36	2.07
	$m_{\tilde{t}_1}$	1.64	1.87	1.90	1.06	1.63
[m]	$c\tau_{\tilde{N}_1}$	$6.4 \cdot 10^{-2}$	0.34	48	$1.9 \cdot 10^{16}$	$6.0 \cdot 10^{15}$
[fb]	$\sigma^{13\mathrm{TeV}}_{\tilde{q}\tilde{q}}$	9.35	2.99	1.98	59.7	2.63
	$\sigma^{13\mathrm{TeV}}_{\tilde{q}\tilde{g}}$	11.9	3.30	2.01	91.1	2.48
	$\sigma^{13\mathrm{TeV}}_{\mathrm{strong}}$	25.2	7.28	4.58	190	5.95
	$\sigma^{8\mathrm{TeV}}_{\mathrm{strong}}$	0.51	0.07	0.03	10.1	0.05
	$\sigma^{13\mathrm{TeV}}_{\mathrm{EW}}$	27	12	7.5	6.7	5.6
	$\sigma^{8\mathrm{TeV}}_{\mathrm{EW}}$	5.5	2.1	1.2	1.3	0.7

- Large tan beta
- Light pseudoscalar ~25 GeV
- **Singlino NLSP ~ 100 GeV displaced/stable**
- **stau/bino NNLSP ~ 300 GeV**
- Singlino essentially decoupled SUSY decays through NNLSP

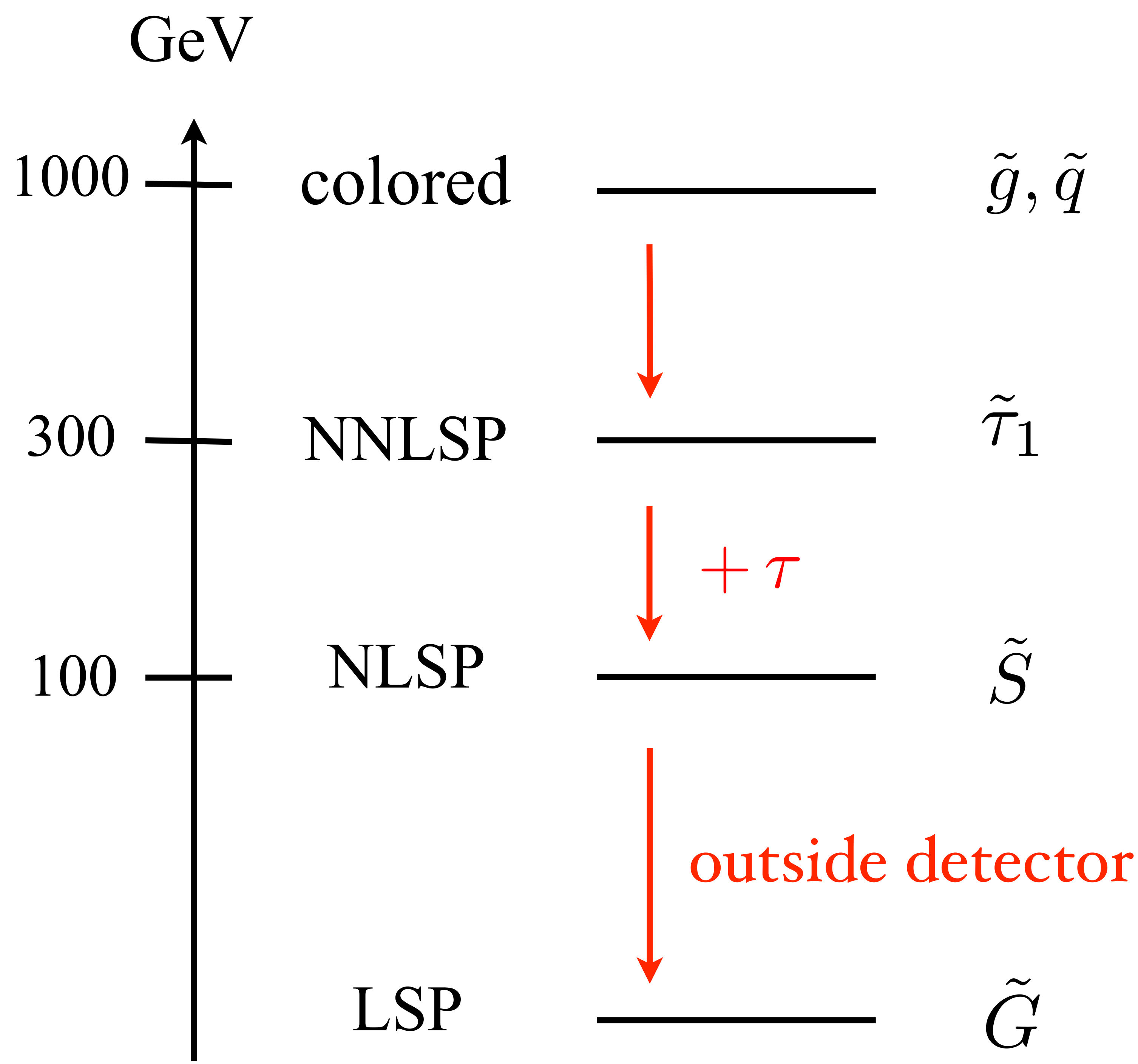
Signals: NNLSP & Singlino decay



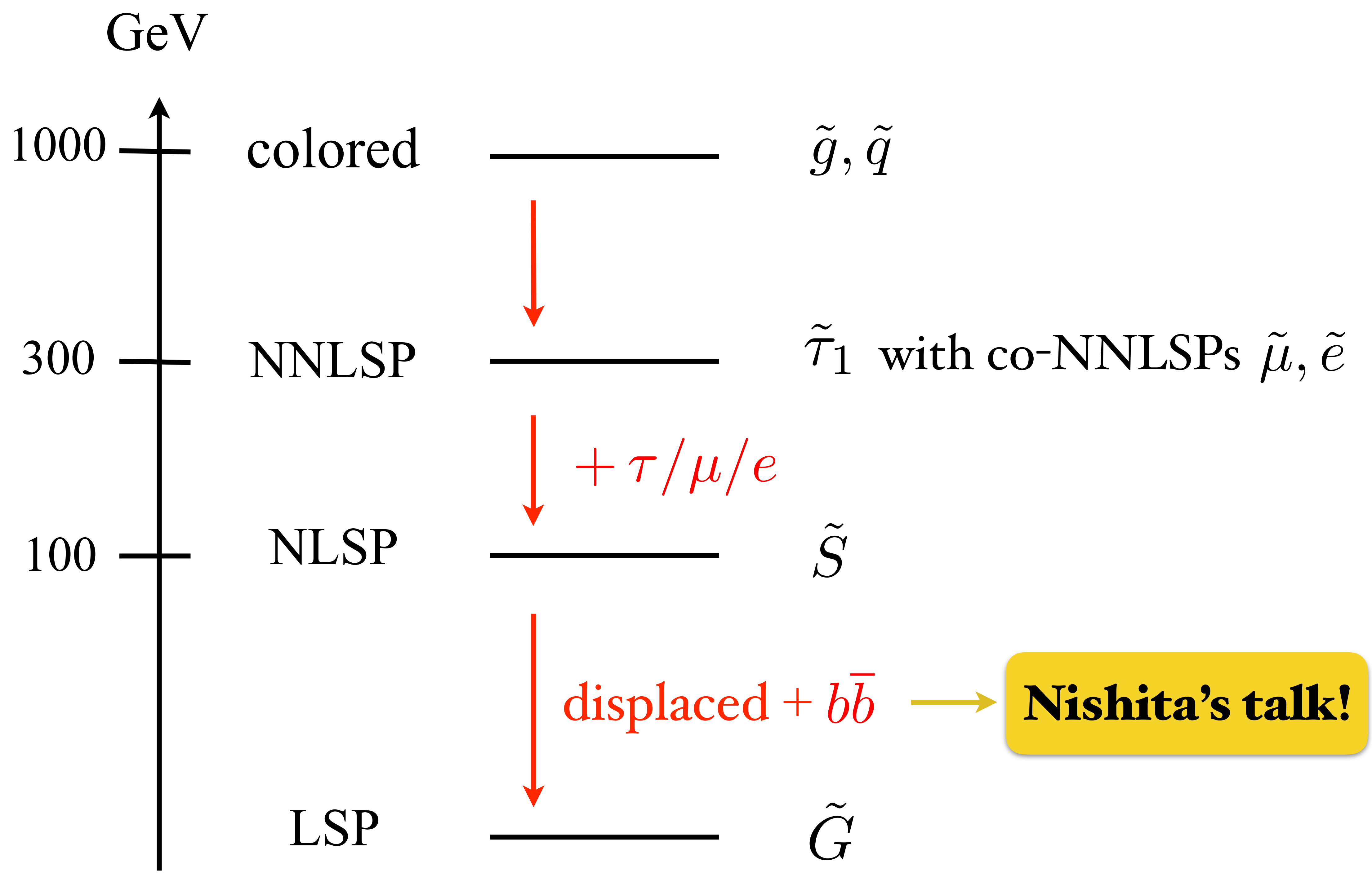
Large-M Region: M > 10⁹ GeV



Medium-M Region: M ~ 10^{7-9} GeV



Low-M Region: M < 10^7 GeV



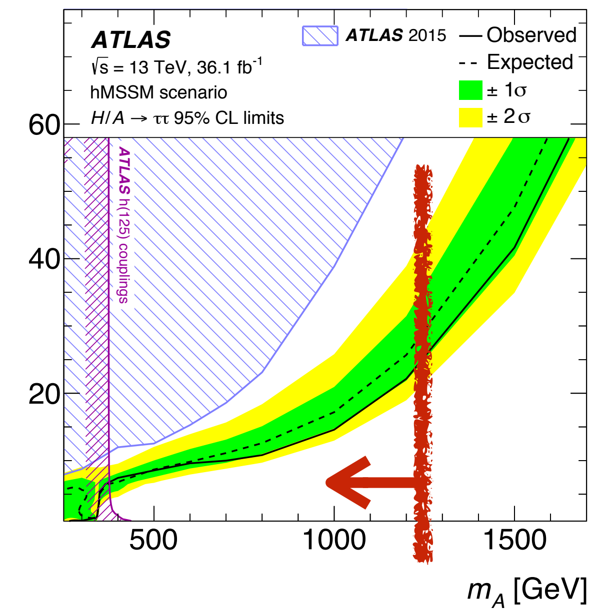
Outlook

Problem for DGS: NLPS a_2

Since tanβ large, need $m_{a_2} \gtrsim 1.2\,\mathrm{TeV}$

$m_{a_2}^2 \approx m_{H_d}^2 - m_{H_u}^2$

→ Heavy SUSY spectrum!



Need extra contribs to m_{a_2} !

1) Combine DGS with Messenger-Matter couplings

$$W_{\mathrm{DGSU}} = S\left(\xi_D \Phi_u^{(1)}\Phi_d^{(2)} + \xi_T \Phi_T^{(1)}\Phi_{\overline{T}}^{(2)}\right) + \lambda_u Q_3 U_3 \Phi_u^{(2)} + \lambda_{S_d} S \Phi_u^{(2)} H_d$$

2) Just single Messenger-Matter couplings enough!?

$$W_{\mathrm{U}} = X\left(\Phi_u \Phi_d + \Phi_T \Phi_{\overline{T}}\right) + \lambda_u Q_3 U_3 \Phi_u + \lambda_{S_d} S \Phi_u H_d$$

…

work in progress, with M. Badziak, N. Desai, C. Hugonie

Summary

- A 125 GeV Higgs in Minimal Gauge Mediation requires colored sparticles out of LHC reach: motivates extensions of minimal model
- Flavored messenger matter-couplings generate large A-terms: leads to rich (but viable) flavor pheno between MFV and SUSY PC
- Minimal model for NMSSM + Gauge Mediation allows for light sparticles thanks to Higgs-Singlet mixing: very predictive framework with new collider signatures

Backup

Flavor constraints

Most constraints automatically satisfied for $\tilde{m} \sim 1\,\text{TeV}$

$(\delta^D_{XX})_{12}$	9.2×10^{-2} [Re]	1.2×10^{-2} [Im]
$\langle\delta^D_{12}\rangle$	1.9×10^{-3} [Re]	2.6×10^{-4} [Im]
$(\delta^D_{LR})_{12}$	5.6×10^{-3} [Re]	4.0×10^{-5} [Im]
$(\delta^U_{XX})_{12}$	1.0×10^{-1} [Re]	6.0×10^{-2} [Im]
$\langle\delta^U_{12}\rangle$	6.2×10^{-3} [Re]	4.0×10^{-3} [Im]
$(\delta^U_{LR})_{12}$	1.6×10^{-2} [Re]	1.6×10^{-2} [Im]
$(\delta^D_{XX})_{13}$	2.8×10^{-1} [Re]	6.0×10^{-1} [Im]
$\langle\delta^D_{13}\rangle$	4.2×10^{-2} [Re]	1.8×10^{-2} [Im]
$(\delta^D_{LR})_{13}$	6.6×10^{-2} [Re]	1.5×10^{-1} [Im]
$(\delta^D_{LR})_{11}$	2.0×10^{-6}	
$(\delta^U_{LR})_{11}$	4.0×10^{-6}	
[illegible]	[illegible]	[illegible]

$D - \overline{D}$ mixing

$$(\delta^u_{RR})_{12} \sim (\lambda^*_U)_{31}(\lambda_U)_{32}$$

Neutron EDM

$$(\delta^u_{LR})_{11} \sim (\lambda_U)_{13}(\lambda_U)_{31}$$