

Phenomenology of SUSY models with a $U(1)_R$ baryon number

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1703.03866

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Supersymmetry

ATLAS SUSY Searches* - 95% CL Lower Limits
May 2017

ATLAS Preliminary
 $\sqrt{s} = 7, 8, 13 \text{ TeV}$

Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7, 8 \text{ TeV}$	$\sqrt{s} = 13 \text{ TeV}$	Reference	
Inclusive Searches	MSUGRA/CMSSM	0-3 e, μ /1-2 τ	2-10 jets/3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.85 TeV	$m(\tilde{q})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q}\tilde{q} \rightarrow \tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{q}	1.57 TeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}, m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	ATLAS-CONF-2017-022
	$\tilde{q}\tilde{q}, \tilde{q}\tilde{q} \rightarrow \tilde{q}\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	\tilde{q}	608 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0) < 5 \text{ GeV}$	1604.07773
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow \tilde{q}\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.02 TeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}$	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow \tilde{q}\tilde{q}\tilde{\chi}_1^0 \rightarrow \tilde{q}\tilde{q}W^\pm\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.01 TeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}, m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow \tilde{q}\tilde{q}(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	3 e, μ	4 jets	-	36.1	\tilde{g}	1.825 TeV	$m(\tilde{\chi}_1^0) < 400 \text{ GeV}$	ATLAS-CONF-2017-030
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow \tilde{q}\tilde{q}WZ\tilde{\chi}_1^0$	0	7-11 jets	Yes	36.1	\tilde{g}	1.8 TeV	$m(\tilde{\chi}_1^0) < 400 \text{ GeV}$	ATLAS-CONF-2017-033
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	3.2	\tilde{g}	2.0 TeV	$c\tau(\text{NLSP}) < 0.1 \text{ mm}$	1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	\tilde{g}	1.65 TeV	$c\tau(\text{NLSP}) < 0.1 \text{ mm}, \mu < 0$	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	\tilde{g}	1.37 TeV	$m(\tilde{\chi}_1^0) < 950 \text{ GeV}, c\tau(\text{NLSP}) < 0.1 \text{ mm}, \mu < 0$	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	\tilde{g}	1.8 TeV	$m(\tilde{\chi}_1^0) > 680 \text{ GeV}, c\tau(\text{NLSP}) < 0.1 \text{ mm}, \mu > 0$	ATLAS-CONF-2016-066
	GGM (higgsino NLSP)	2 e, μ (Z)	2 jets	Yes	20.3	\tilde{g}	900 GeV	$m(\text{NLSP}) > 430 \text{ GeV}$	1503.03290
Gravitino LSP	0	mono-jet	Yes	20.3	$R^{1/2}$ scale	865 GeV	$m(\tilde{G}) > 1.8 \times 10^{-4} \text{ eV}, m(\tilde{g})=m(\tilde{q})=1.5 \text{ TeV}$	1502.01518	
3 rd gen. \tilde{g} med.	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 b	Yes	36.1	\tilde{g}	1.92 TeV	$m(\tilde{\chi}_1^0) < 600 \text{ GeV}$	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	36.1	\tilde{g}	1.97 TeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}$	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow b\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}	1.37 TeV	$m(\tilde{\chi}_1^0) < 300 \text{ GeV}$	1407.0600
3 rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	36.1	\tilde{b}_1	950 GeV	$m(\tilde{\chi}_1^0) < 420 \text{ GeV}$	ATLAS-CONF-2017-038
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^0$	2 e, μ (SS)	1 b	Yes	36.1	\tilde{b}_1	275-700 GeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}, m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_1^0) + 100 \text{ GeV}$	ATLAS-CONF-2017-030
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\chi}_1^0$	0-2 e, μ	1-2 b	Yes	4.7/13.3	\tilde{t}_1	117-170 GeV	$m(\tilde{\chi}_1^\pm) = 2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55 \text{ GeV}$	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3/36.1	\tilde{t}_1	90-198 GeV	$m(\tilde{\chi}_1^0)=1 \text{ GeV}$	1506.08616, ATLAS-CONF-2017-020
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$	0	mono-jet	Yes	3.2	\tilde{t}_1	90-323 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)=5 \text{ GeV}$	1604.07773
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	150-600 GeV	$m(\tilde{\chi}_1^0) > 150 \text{ GeV}$	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	36.1	\tilde{t}_2	290-790 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	ATLAS-CONF-2017-019
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + h$	1-2 e, μ	4 b	Yes	36.1	\tilde{t}_2	320-880 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	ATLAS-CONF-2017-019
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell} \rightarrow \ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	36.1	$\tilde{\ell}$	90-440 GeV	$m(\tilde{\chi}_1^0)=0$	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	36.1	$\tilde{\chi}_1^\pm$	710 GeV	$m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm/\tilde{\chi}_2^0, \tilde{\chi}_1^\pm \rightarrow \tilde{\tau}\nu(\tau\tilde{\nu}), \tilde{\chi}_2^0 \rightarrow \tilde{\tau}\tau(\nu\tilde{\tau})$	2 τ	-	Yes	36.1	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)=0, m(\tilde{\tau}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2017-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow \tilde{\ell}\nu\tilde{\chi}_1^0(\ell\tilde{\nu}\tilde{\chi}_1^0), \tilde{\ell}\tilde{\nu}\tilde{\chi}_1^0(\ell\tilde{\nu}\tilde{\chi}_1^0)$	3 e, μ	0	Yes	36.1	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	1.16 TeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	36.1	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	580 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \tilde{\ell}$ decoupled	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	270 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \tilde{\ell}$ decoupled	1501.07110
	$\tilde{\chi}_2^0\tilde{\chi}_3^0, \tilde{\chi}_2^0 \rightarrow \tilde{\ell}R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_2^0, \tilde{\chi}_3^0$	635 GeV	$m(\tilde{\chi}_2^0)=m(\tilde{\chi}_3^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$	1405.5086
	GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	1 e, μ + γ	-	Yes	20.3	\tilde{W}	115-370 GeV	$c\tau < 1 \text{ mm}$	1507.05493
	GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	2 γ	-	Yes	20.3	\tilde{W}	590 GeV	$c\tau < 1 \text{ mm}$	1507.05493
	Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$	430 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0) \sim 160 \text{ MeV}, \tau(\tilde{\chi}_1^\pm)=0.2 \text{ ns}$
Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ prod., long-lived $\tilde{\chi}_1^\pm$		dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	495 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0) \sim 160 \text{ MeV}, \tau(\tilde{\chi}_1^\pm) < 15 \text{ ns}$	1506.05332
Stable, stopped \tilde{g} R-hadron		0	1-5 jets	Yes	27.9	\tilde{g}	850 GeV	$m(\tilde{\chi}_1^0)=100 \text{ GeV}, 10 \mu\text{s} < \tau(\tilde{g}) < 1000 \text{ s}$	1310.6584
Stable \tilde{g} R-hadron		trk	-	-	3.2	\tilde{g}	1.58 TeV	-	1606.05129
Metastable \tilde{g} R-hadron		dE/dx trk	-	-	3.2	\tilde{g}	1.57 TeV	$m(\tilde{\chi}_1^0)=100 \text{ GeV}, \tau > 10 \text{ ns}$	1604.04520
GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu)$		1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	537 GeV	$10 < \tan\beta < 50$	1411.6795
GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$		2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	440 GeV	$1 < \tau(\tilde{\chi}_1^0) < 3 \text{ ns}, \text{SPS8 model}$	1409.5542
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow ee/\mu\mu/\mu\nu$		displ. $ee/\mu\mu/\mu\nu$	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	$7 < c\tau(\tilde{\chi}_1^0) < 740 \text{ mm}, m(\tilde{g})=1.3 \text{ TeV}$	1504.05162
GGM $\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow Z\tilde{G}$		displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	$6 < c\tau(\tilde{\chi}_1^0) < 480 \text{ mm}, m(\tilde{g})=1.1 \text{ TeV}$	1504.05162
RPV	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e\mu/\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	1.9 TeV	$\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$	1607.08079
	Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.45 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{LSP} < 1 \text{ mm}$	1404.2500
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\nu, e\mu\nu, \mu\mu\nu$	4 e, μ	-	Yes	13.3	$\tilde{\chi}_1^\pm$	1.14 TeV	$m(\tilde{\chi}_1^0) > 400 \text{ GeV}, \lambda_{12k} \neq 0 (k=1,2)$	ATLAS-CONF-2016-075
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\nu_e, e\nu_\tau$	3 e, μ + τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV	$m(\tilde{\chi}_1^0) > 0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{133} \neq 0$	1405.5086
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow qq\tilde{q}$	0	4-5 large-R jets	-	14.8	\tilde{g}	1.08 TeV	$\text{BR}(\tilde{q})=\text{BR}(\tilde{b})=\text{BR}(\tilde{c})=0\%$	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow qq\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{q}$	0	4-5 large-R jets	-	14.8	\tilde{g}	1.55 TeV	$m(\tilde{\chi}_1^0)=800 \text{ GeV}$	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{q}$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	2.1 TeV	$m(\tilde{\chi}_1^0)=1 \text{ TeV}, \lambda_{112} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{g}\tilde{g}, \tilde{g}\tilde{g} \rightarrow \tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	1.65 TeV	$m(\tilde{t}_1)=1 \text{ TeV}, \lambda_{323} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	0	2 jets + 2 b	-	15.4	\tilde{t}_1	410 GeV	-	ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\ell}$	2 e, μ	2 b	-	36.1	\tilde{t}_1	0.4-1.45 TeV	$\text{BR}(\tilde{t}_1 \rightarrow b\ell/\mu) > 20\%$	ATLAS-CONF-2017-036
Other	Scalar charm, $\tilde{c} \rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	\tilde{c}	510 GeV	$m(\tilde{\chi}_1^0) < 200 \text{ GeV}$	1501.01325

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

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1

Mass scale [TeV]

Going beyond the MSSM

Dirac gauginos

Fox, Nelson, Weiner '02

Allow for **supersoft** supersymmetry breaking:

Gaugino masses give threshold corrections to scalar masses

$$m^2 \sim \frac{C_i(r)\alpha_i M_D^2}{\pi}$$

Kribs, Poppitz, Weiner '07

Allow a $U(1)_R$ to be imposed: improvement for flavor

Field content need to be enlarged:



new chiral superfields in the adjoint: S, T, O

The **Higgs sector** in general also need to be enlarged as the $U(1)_R$ forbids a μ term

new chiral superfields: R_u, R_d

superpotential

$$W \subset \mu_u H_u R_d + \mu_d R_u H_d + \lambda_u^t H_u T R_d + \lambda_d^t R_u T H_d + \lambda_u^s S H_u R_d + \lambda_d^s S R_u H_d$$

R-parity violation

lepton number violating

$$\lambda' L Q D^c + \lambda L L E^c + \mu_i L_i H_u$$

baryon number violating

$$\lambda''_{ijk} U_i^c D_j^c D_k^c$$

RPV couplings are constrained to be **small** from baryon and lepton number violating processes, and from flavour physics.

Collider phenomenology is modified: **LSP is unstable.**
displaced vertices.

Dirac gauginos and RPV couplings

Can assign $U(1)_R$ charges such that the $U(1)_R$ is identified with a baryon number

Gherghetta, Pomarol '03


Frugiuele, T.G. '11

Brust, Katz, Sundrum '12

fields	$U(1)_R$ charge
Q	$4/3$
U^c	$2/3$
D^c	$2/3$
L	1
E^c	1

Frugiuele, T.G.,
Kumar, Ponton '12

SM particles have their usual baryon number. Superpartners have unusual ones

$\lambda'' U^c D^c D^c$ is allowed  Constraints are weaker.

Violation of the $U(1)_R$

Anomaly mediation will generate gaugino Majorana mass terms and A-terms

$$A \sim M_m \sim \frac{1}{16\pi^2} m_{3/2}$$

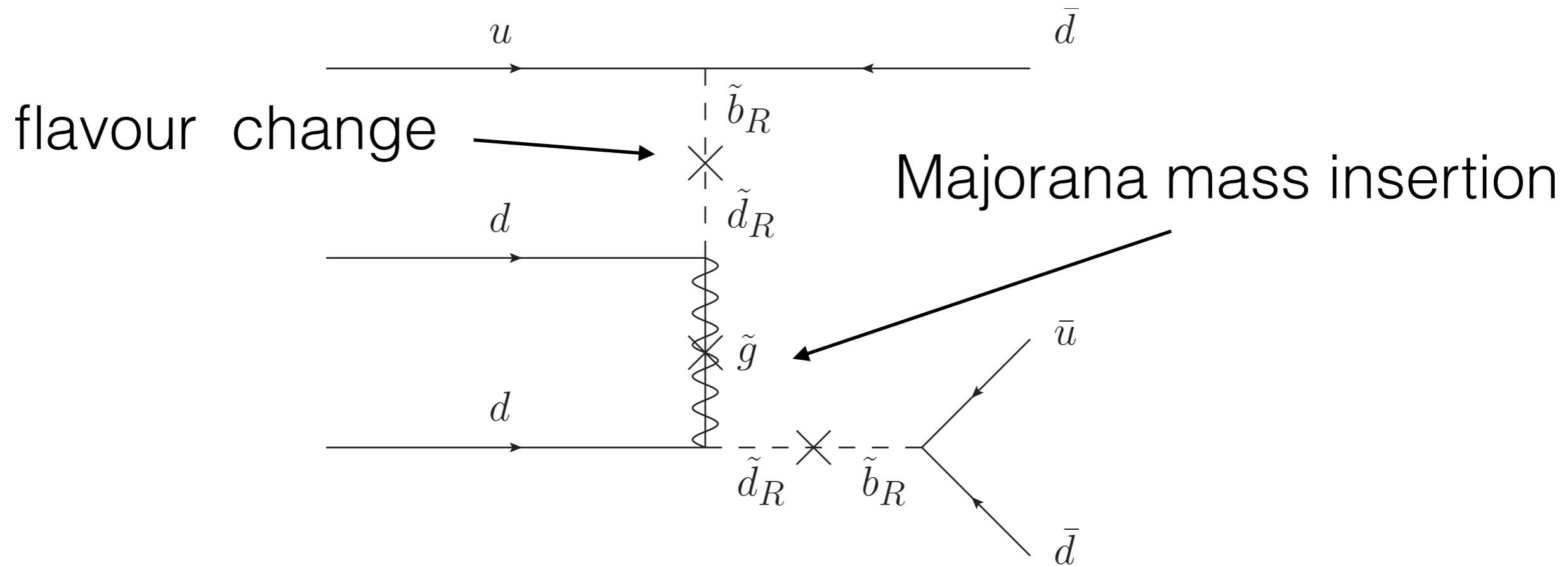
Contributions to baryon number violating processes will be suppressed by that scale.

In principle by choosing a low $m_{3/2}$ we can avoid bounds on λ'' from those processes.

however: proton can decay to gravitino and kaon

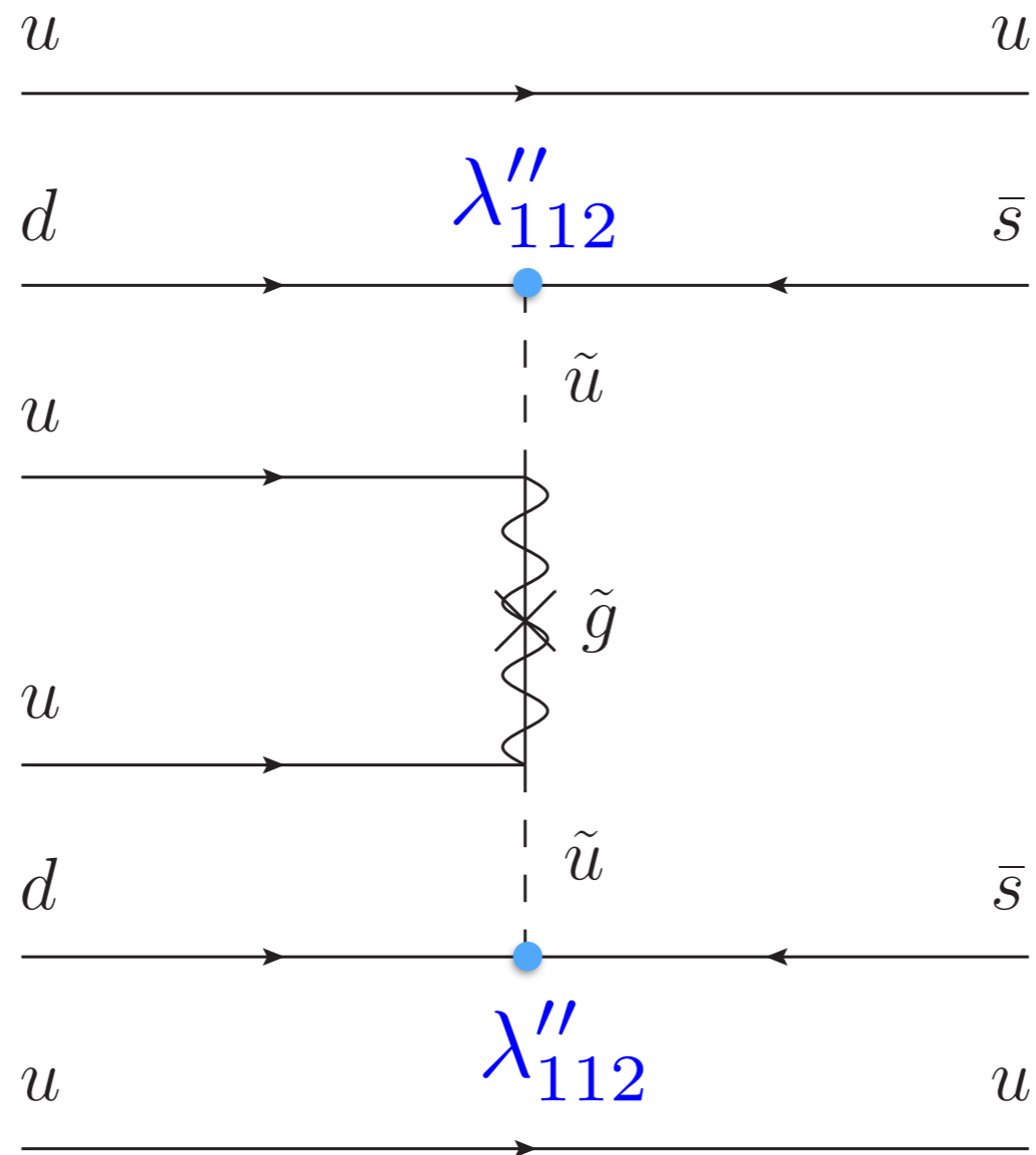
choose $m_{3/2} \gtrsim 1 \text{ GeV}$

neutron - anti-neutron oscillation



$$\lambda''_{11i} \lesssim 2 \times 10^{-5} \left(\frac{1}{\delta_{i1}^{RR}} \right) \left(\frac{M_3^D}{1\text{TeV}} \right) \left(\frac{1\text{GeV}}{m_{3/2}} \right)^{1/2} \left(\frac{m_{\tilde{q}}}{1\text{TeV}} \right)^2 \left(\frac{250\text{MeV}}{\Lambda} \right)^3$$

double nucleon decay: $^{16}\text{O} \rightarrow ^{14}\text{C} K^+ K^+$



$$\lambda''_{112} \lesssim 2 \times 10^{-4} \left(\frac{M_3^D}{1\text{TeV}} \right) \left(\frac{1\text{GeV}}{m_{3/2}} \right)^{1/2} \left(\frac{m_{\tilde{q}}}{1\text{TeV}} \right)^2 \left(\frac{150\text{MeV}}{\tilde{\Lambda}} \right)^{5/2}$$

Parameter space for the LHC study

- λ''_{3ij} non zero
- Heavy gluino
- bino or Higgsino LSP

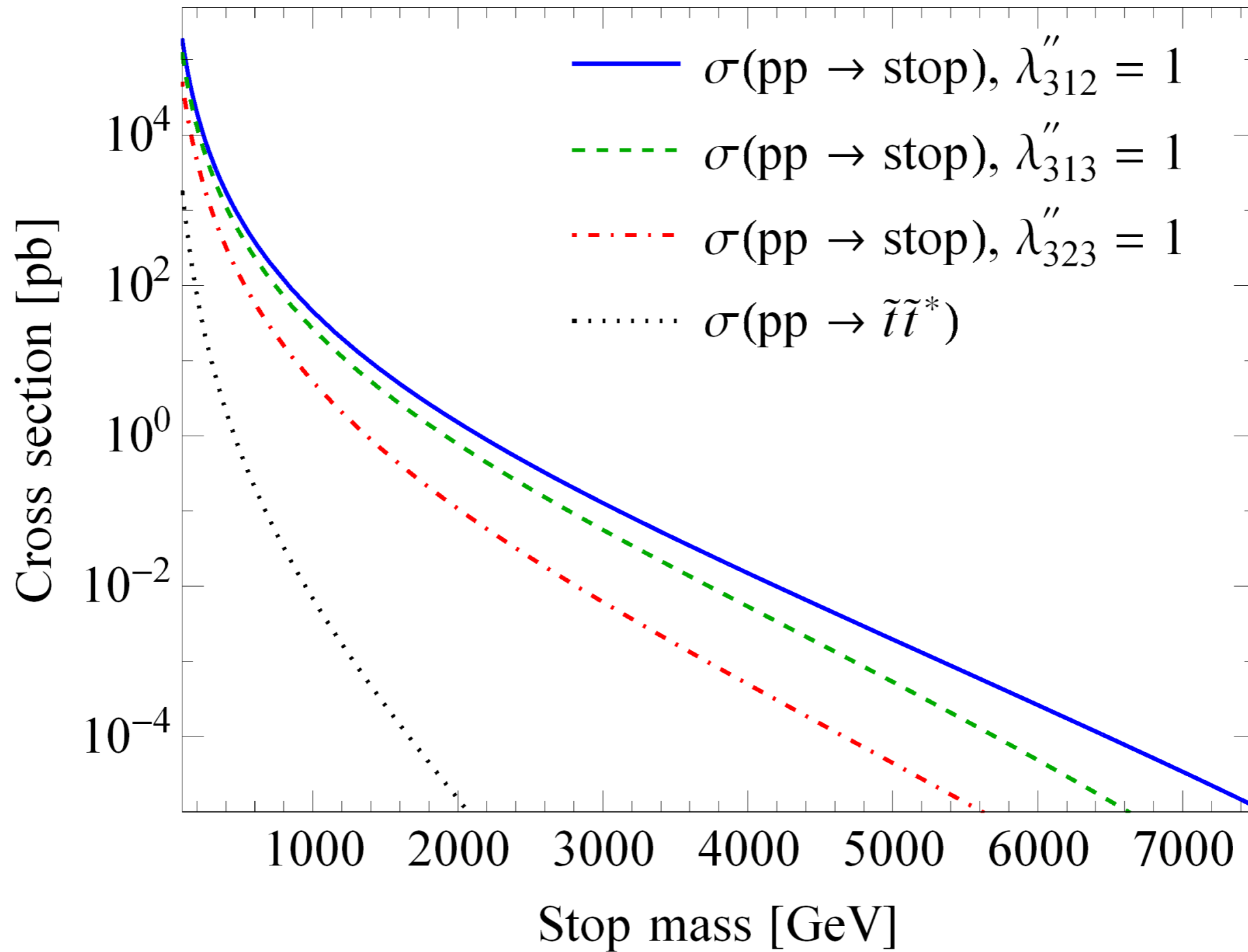
Stops can be singly or pair produced

$$pp \rightarrow \tilde{t} \quad pp \rightarrow \tilde{t}\tilde{t}^*$$

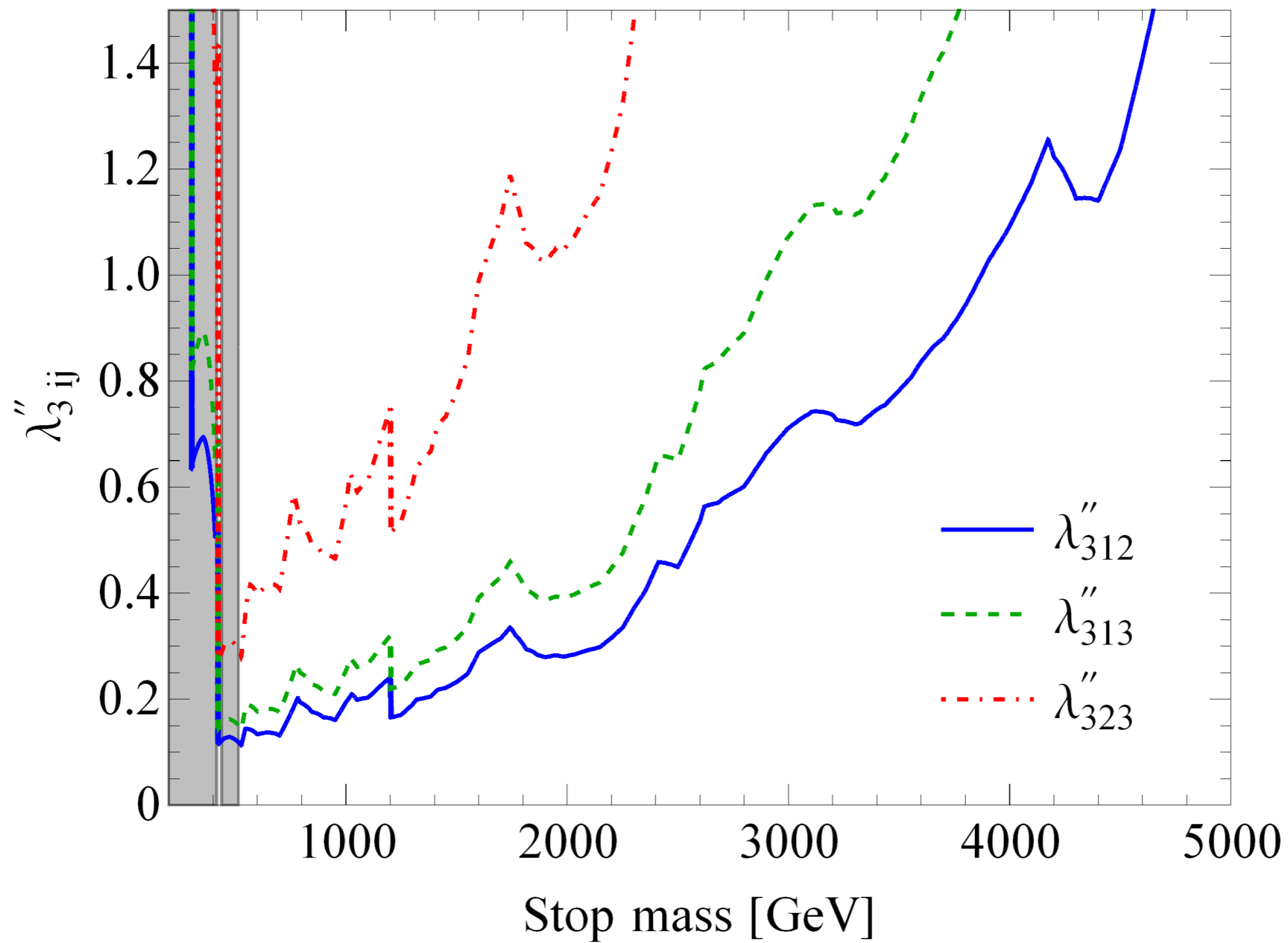
decay to 2 jets, or top-neutralino

$$\tilde{t} \rightarrow d_i d_j \quad \tilde{t} \rightarrow t\chi_0 \rightarrow t\bar{t}d_i d_j$$

Single and pair stop production cross-section at 13 TeV



Exclusion from di-jet search

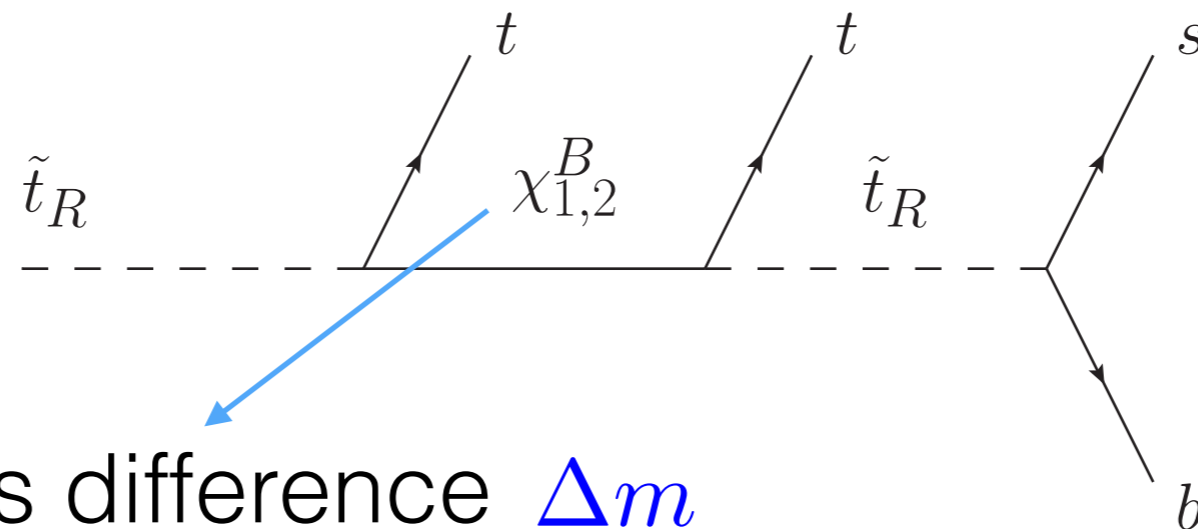


decay mode with same-sign lepton

$$\tilde{t} \rightarrow t\chi_0 \rightarrow tt d_i d_j$$

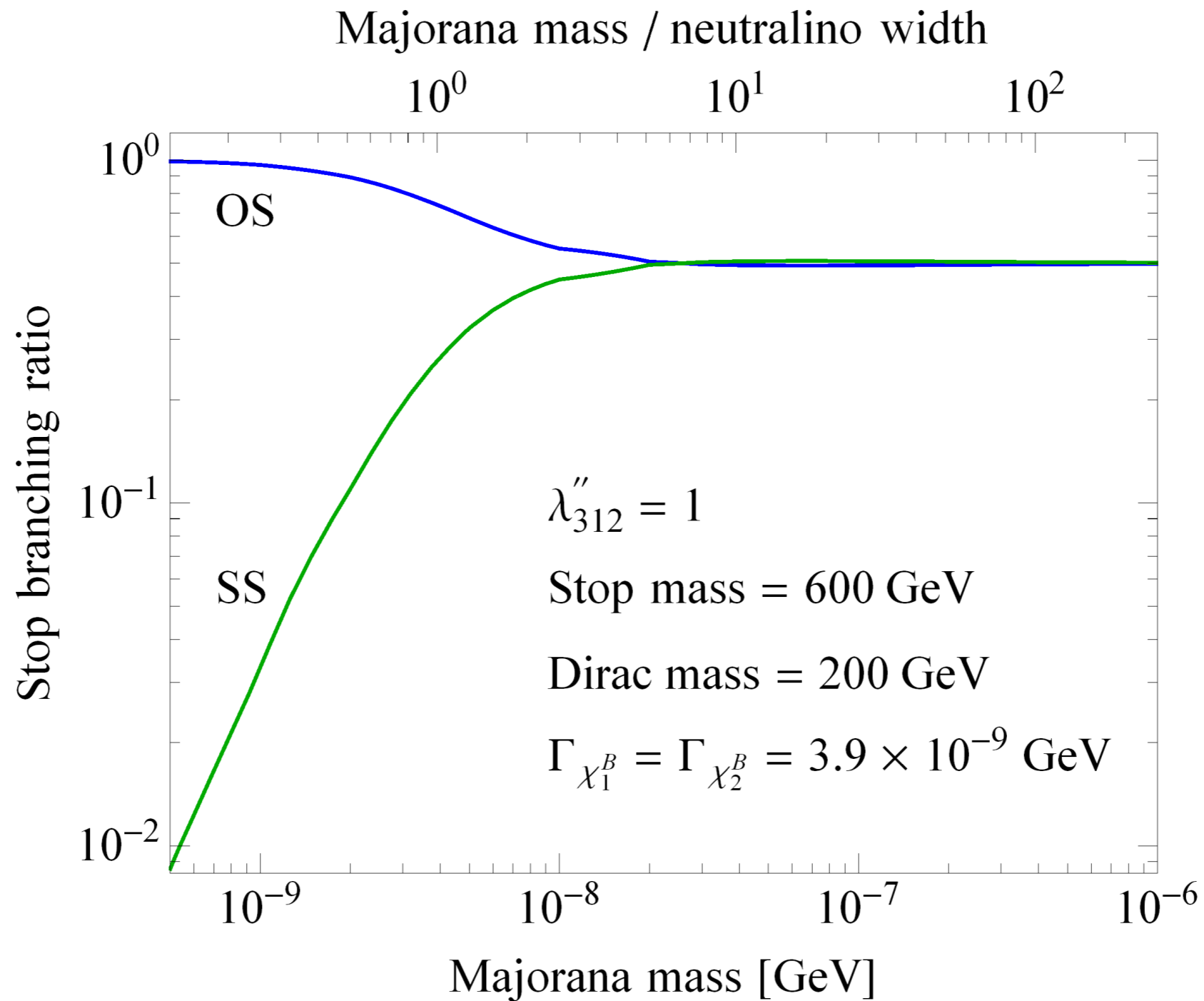
Forbidden with an exact $U(1)_R$ but allowed if the $U(1)_R$ is broken

The Dirac state splits into 2 nearly degenerate Majorana states



2 states with mass difference Δm

if $\Delta m \lesssim \Gamma$ branching fraction to same-sign top is small



General exclusion from various ATLAS and CMS searches:

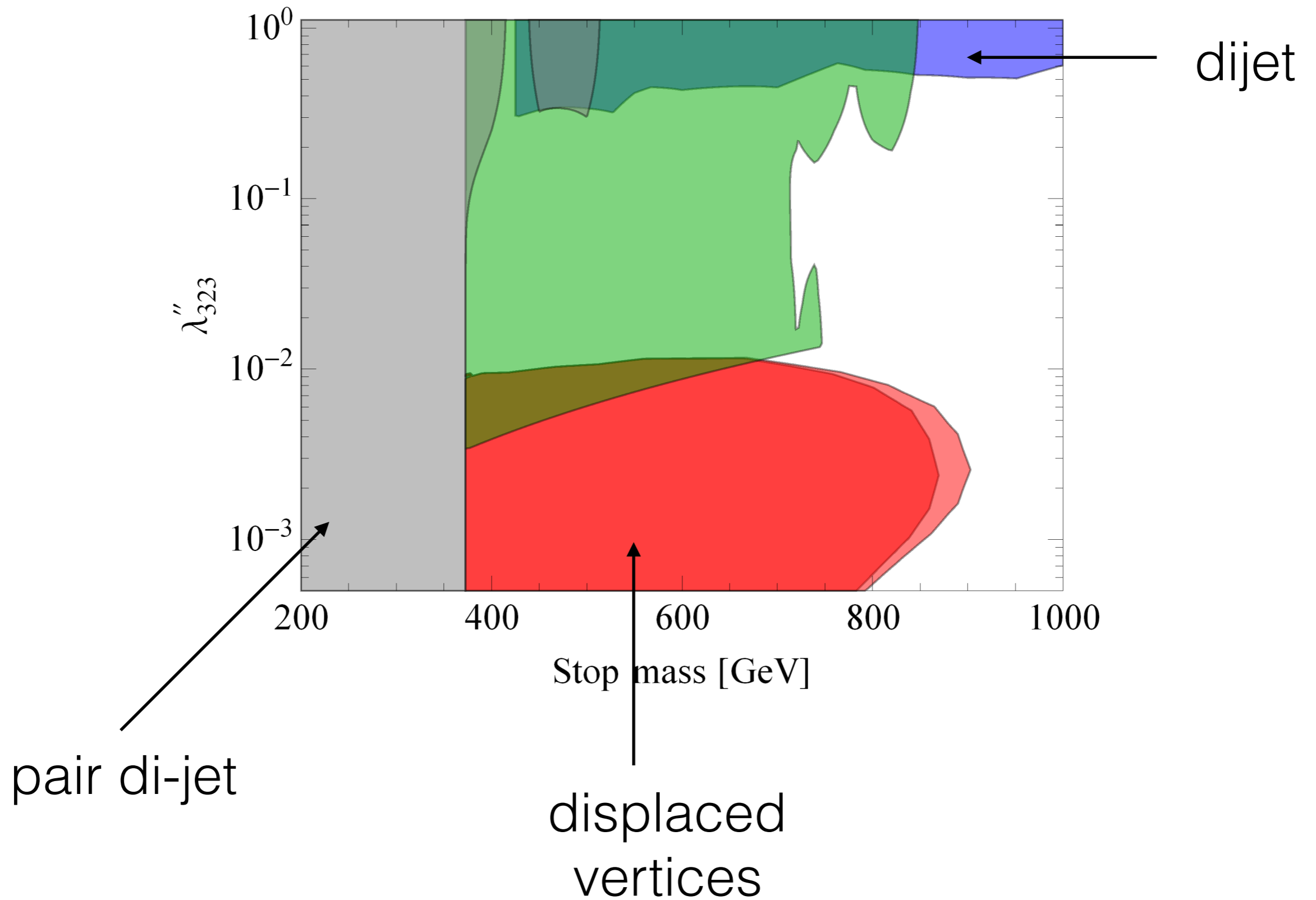
$$\sqrt{s} = 13\text{TeV} \quad \mathcal{L} \sim 15\text{fb}^{-1}$$

- di-jets resonance
- pair of di-jets
- multijets and no MET
- 1 lepton + jets with or without MET
- same-sign lepton

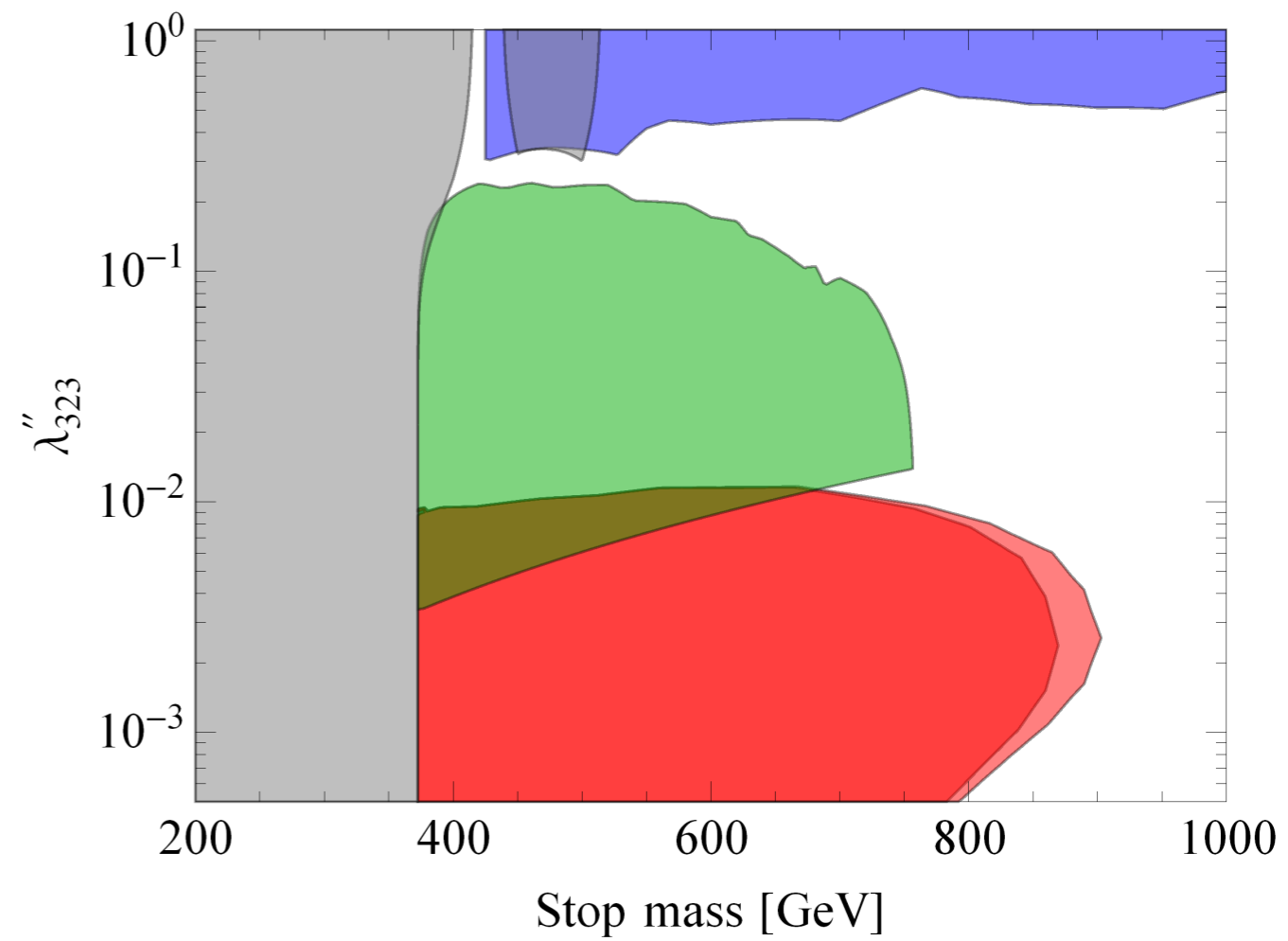
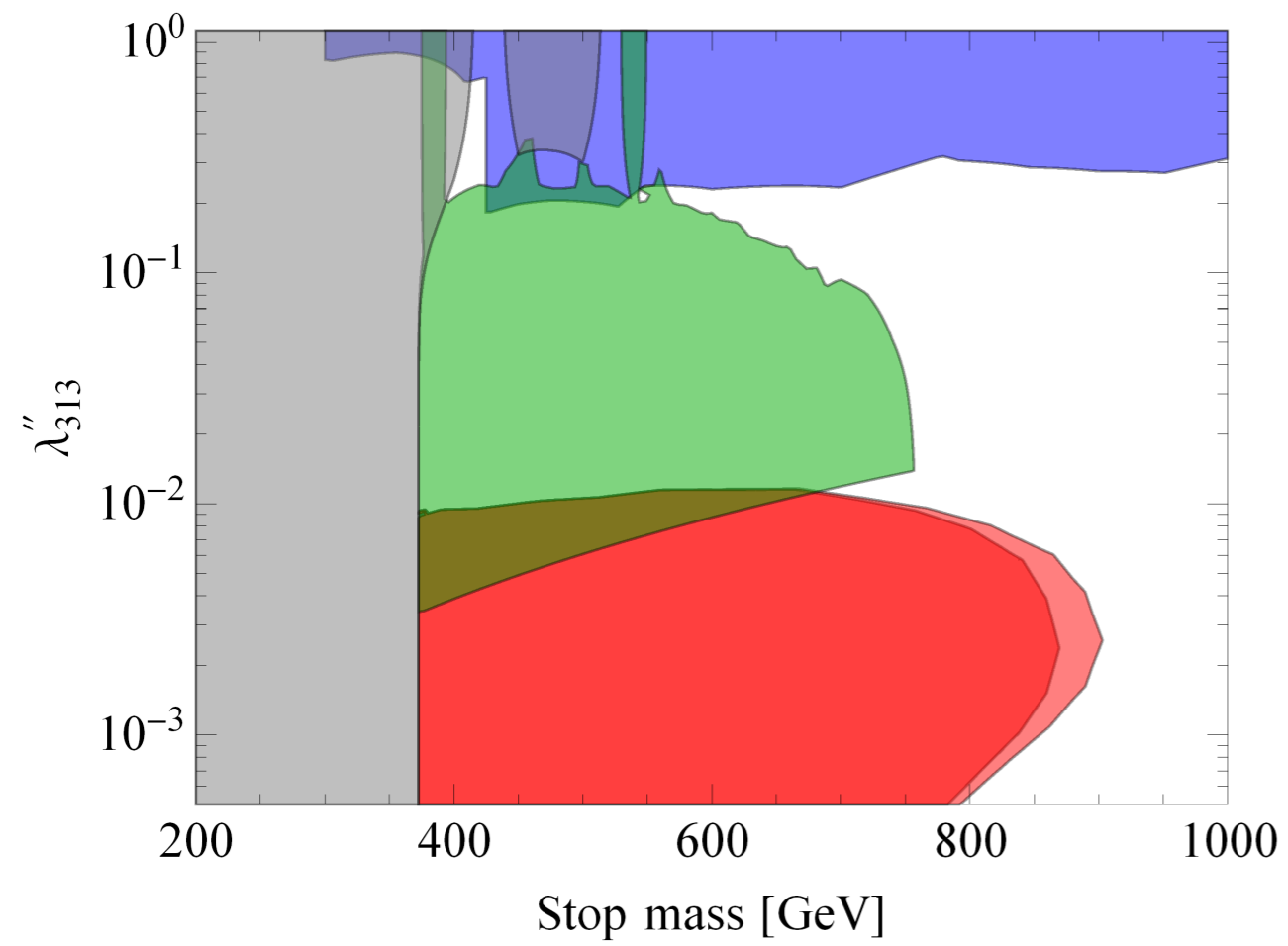
Pheno similar to RPVMSSM (Monteux 1601.03737)

when $U(1)_R$ is exact, no same sign lepton

Bino LSP



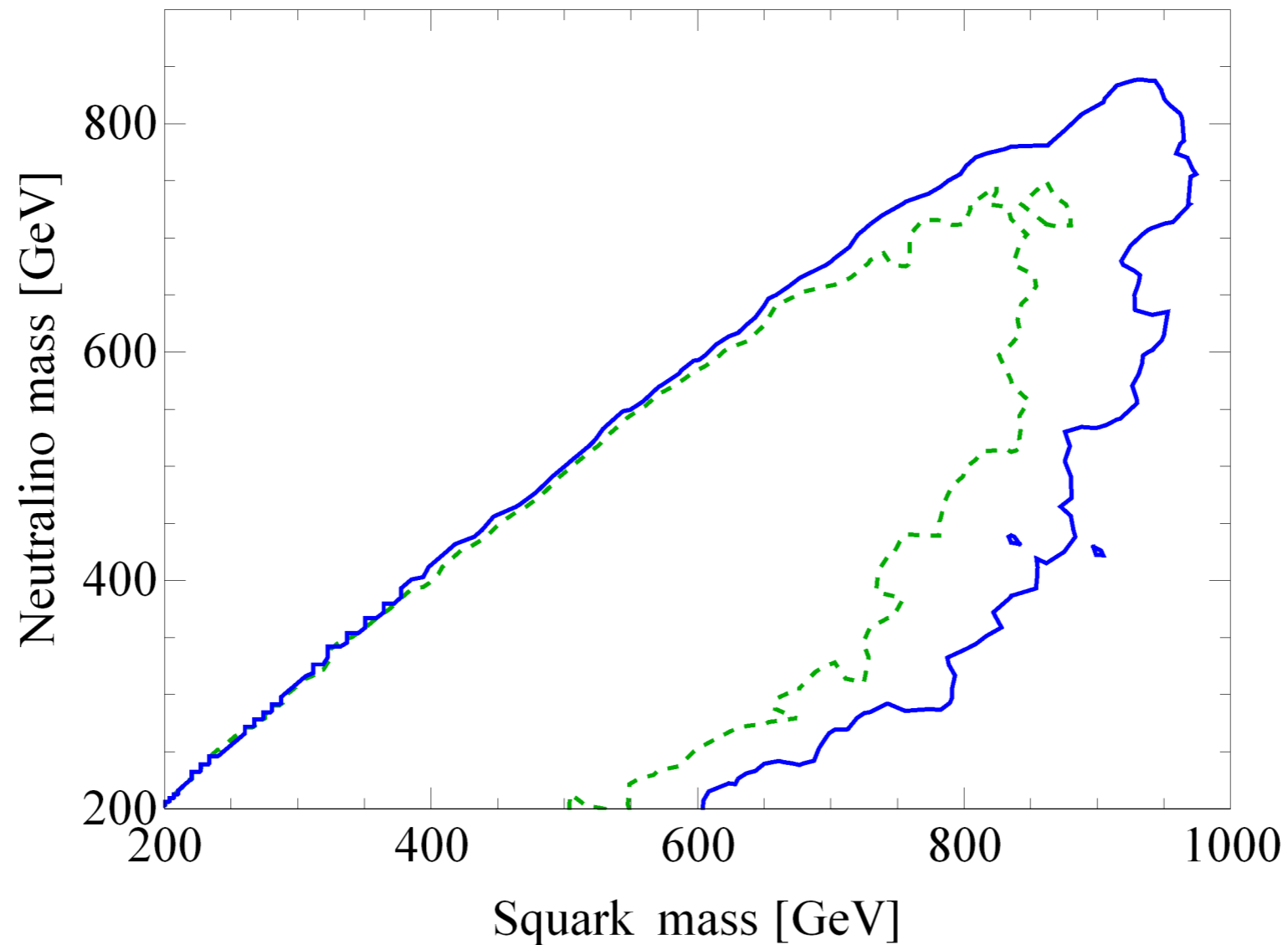
'exact' $U(1)_R$



1st and 2nd generation of squarks

production cross section lower in models with a $U(1)_R$

$$\lambda''_{312} = 1$$



Baryogenesis

Out-of-equilibrium decay of neutralino

mechanism exists in the RPVMSSM

requires split-spectrum

Cui '13

Cui, Sundrum'12

Arcadi, Covi, Nardecchia

1312.5703

new diagrams exists with Dirac gauginos

requires a large breaking of the $U(1)_R$

