

Constraints on sneutrino dark matter from LHC Run 1

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SUSY searches at the LHC

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

Model		e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	Reference		
Inclusive Searches	MSUGRA/CMSSM	0-3 e, μ /1-2 τ	2-10 jets/3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.8 TeV		$m(\tilde{q})=m(\tilde{g})$	1507.05525	
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	\tilde{q}	850 GeV		$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	1405.7875	
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	20.3	\tilde{q}	100-440 GeV		$m(\tilde{q})-m(\tilde{\chi}_1^0)<10 \text{ GeV}$	1507.05525	
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ (off-Z)	2 jets	Yes	20.3	\tilde{q}	780 GeV		$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1503.03290	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	\tilde{g}		1.33 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1405.7875	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0 \rightarrow q\tilde{q}W^\pm\tilde{\chi}_1^0$	0-1 e, μ	2-6 jets	Yes	20	\tilde{g}		1.26 TeV	$m(\tilde{\chi}_1^0)<300 \text{ GeV}, m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	1507.05525	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20	\tilde{g}		1.32 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1501.03555	
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	\tilde{g}		1.6 TeV	$\tan\beta > 20$	1407.0603	
	GGM (bino NLSP)	2 γ	-	Yes	20.3	\tilde{g}		1.29 TeV	$c\tau(\text{NLSP})<0.1 \text{ mm}$	1507.05493	
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	\tilde{g}		1.3 TeV	$m(\tilde{\chi}_1^0)<900 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu<0$	1507.05493	
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	\tilde{g}		1.25 TeV	$m(\tilde{\chi}_1^0)<850 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu>0$	1507.05493	
	GGM (higgsino NLSP)	2 e, μ (Z)	2 jets	Yes	20.3	\tilde{g}	850 GeV		$m(\text{NLSP})>430 \text{ GeV}$	1503.03290	
Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ 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.	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	\tilde{g}		1.25 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$	1407.0600	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	\tilde{g}		1.1 TeV	$m(\tilde{\chi}_1^0) < 350 \text{ GeV}$	1308.1841	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}		1.34 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$	1407.0600	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}		1.3 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	20.1	\tilde{b}_1	100-620 GeV		$m(\tilde{\chi}_1^0)<90 \text{ GeV}$	1308.2631
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^\pm$		2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{b}_1	275-440 GeV		$m(\tilde{\chi}_1^\pm)=2 m(\tilde{\chi}_1^0)$	1404.2500	
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$		1-2 e, μ	1-2 b	Yes	4.7/20.3	\tilde{t}_1	110-167 GeV	230-460 GeV	$m(\tilde{\chi}_1^\pm) = 2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55 \text{ GeV}$	1209.2102, 1407.0583	
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$		0-2 e, μ	0-2 jets/1-2 b	Yes	20.3	\tilde{t}_1	90-191 GeV	210-700 GeV	$m(\tilde{\chi}_1^0)=1 \text{ GeV}$	1506.08616	
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$		0	mono-jet/c-tag	Yes	20.3	\tilde{t}_1	90-240 GeV		$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)<85 \text{ GeV}$	1407.0608	
$\tilde{t}_1\tilde{t}_1$ (natural GMSB)		2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	150-580 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	20.3	\tilde{t}_2	290-600 GeV		$m(\tilde{\chi}_1^0)<200 \text{ GeV}$	1403.5222	
EW direct		$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell} \rightarrow \ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV		$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1403.5294
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-465 GeV		$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1403.5294	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV		$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\tau}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1407.0350	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm \rightarrow \tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	700 GeV		$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1402.7029	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	420 GeV		$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=0$, sleptons decoupled	1403.5294, 1402.7029	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	250 GeV		$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=0$, sleptons decoupled	1501.07110	
	$\tilde{\chi}_1^0\tilde{\chi}_1^0 \rightarrow \tilde{\ell}_R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_1^0$	620 GeV		$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{\chi}_1^0))$	1405.5086	
	GGM (wino NLSP) weak prod.	1 $e, \mu + \gamma$	-	Yes	20.3	\tilde{W}	124-361 GeV		$c\tau<1 \text{ mm}$	1507.05493	
	Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV		$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)\sim 160 \text{ MeV}, \tau(\tilde{\chi}_1^\pm)=0.2 \text{ ns}$	1310.3675
		Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	482 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}	832 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	-	-	19.1	\tilde{g}		1.27 TeV		1411.6795	
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	$\tilde{\chi}_1^0$	435 GeV		$2<\tau(\tilde{\chi}_1^0)<3 \text{ ns}$, SPS8 model	1409.5542	
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0 \rightarrow ee\nu/e\mu\nu/\mu\mu\nu$		displ. $ee/e\mu/\mu\mu$	-	-	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 $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e\mu/e\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$		1.7 TeV	$\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$	1503.04430
	Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{q}, \tilde{g}		1.35 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{LSP}<1 \text{ mm}$	1404.2500	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	750 GeV		$m(\tilde{\chi}_1^0)>0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{121} \neq 0$	1405.5086	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tilde{\nu}_\tau, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	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	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{q}$	0	6-7 jets	-	20.3	\tilde{g}		917 GeV	$\text{BR}(\tilde{g})=\text{BR}(\tilde{b})=\text{BR}(\tilde{c})=0\%$	1502.05686	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{q}$	0	6-7 jets	-	20.3	\tilde{g}		870 GeV	$m(\tilde{\chi}_1^0)=600 \text{ GeV}$	1502.05686	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{g}		850 GeV		1404.250	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	0	2 jets + 2 b	-	20.3	\tilde{t}_1	100-308 GeV			ATLAS-CONF-2015-026	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\ell}$	2 e, μ	2 b	-	20.3	\tilde{t}_1		0.4-1.0 TeV	$\text{BR}(\tilde{t}_1 \rightarrow b\mu/\nu e)>20\%$	ATLAS-CONF-2015-015	
Other	Scalar charm, $\tilde{c} \rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	\tilde{c}	490 GeV		$m(\tilde{\chi}_1^0)<200 \text{ GeV}$	1501.01325	

10^{-1}

1

Mass scale [TeV]

10⁻¹ 1 Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 σ theoretical signal cross section uncertainty.

SUSY searches at the LHC

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	Reference	
Inclusive Searches	Many search channels excluding light SUSY scenarios with neutralino LSP				1.8 TeV $m(\tilde{q})=m(\tilde{g})$			1507.05525	
					850 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	1405.7875		
					100-440 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0)<10 \text{ GeV}$	1507.05525		
					780 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1503.03290		
					1.33 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1405.7875		
					1.26 TeV	$m(\tilde{\chi}_1^0)<300 \text{ GeV}, m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	1507.05525		
					1.32 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1501.03555		
					1.6 TeV	$\tan\beta > 20$	1407.0603		
					1.29 TeV	$c\tau(\text{NLSP})<0.1 \text{ mm}$	1507.05493		
					1.3 TeV	$m(\tilde{\chi}_1^0)<900 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu<0$	1507.05493		
1.25 TeV	$m(\tilde{\chi}_1^0)<850 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu>0$	1507.05493							
850 GeV	$m(\text{NLSP})>430 \text{ GeV}$	1503.03290							
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.					1.25 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$	1407.0600		
					1.1 TeV	$m(\tilde{\chi}_1^0) < 350 \text{ GeV}$	1308.1841		
					1.34 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$	1407.0600		
					1.3 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	20.1	\tilde{b}_1	100-620 GeV	$m(\tilde{\chi}_1^0)<90 \text{ GeV}$	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\rightarrow\tilde{t}\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{b}_1	275-440 GeV	$m(\tilde{\chi}_1^\pm)=2 m(\tilde{\chi}_1^0)$	1404.2500
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7/20.3	\tilde{t}_1	110-167 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55 \text{ GeV}$	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow Wb\tilde{\chi}_1^0 \text{ or } t\tilde{\chi}_1^0$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3	\tilde{t}_1	90-191 GeV	$m(\tilde{\chi}_1^0)=1 \text{ GeV}$	1506.08616
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	\tilde{t}_1	90-240 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)<85 \text{ GeV}$	1407.0608
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	150-580 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	20.3	\tilde{t}_2	290-600 GeV	$m(\tilde{\chi}_1^0)<200 \text{ GeV}$	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\rightarrow\tilde{\ell}\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$	1403.5294
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow\tilde{\ell}\nu(\tilde{\ell}\bar{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-465 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\ell}, \bar{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1403.5294
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow\tilde{\tau}\nu(\tilde{\tau}\bar{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(\tilde{\tau}, \bar{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1407.0350
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow\tilde{\ell}_L\nu\tilde{\ell}_L(\tilde{\nu}\nu), \tilde{\ell}\tilde{\nu}\tilde{\ell}_L(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	700 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \bar{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	420 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \text{ sleptons decoupled}$	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h\rightarrow b\bar{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_1^0$	250 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, \text{ sleptons decoupled}$	1501.07110
	$\tilde{\chi}_1^0\tilde{\chi}_1^0\rightarrow\tilde{\ell}_R\tilde{\ell}_R$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_1^0$	620 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \bar{\nu})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{\chi}_1^0))$	1405.5086
	GGM (wino NLSP) weak prod.	1 $e, \mu + \gamma$	-	Yes	20.3	\tilde{W}	124-361 GeV	$c\tau<1 \text{ mm}$	1507.05493
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)\sim 160 \text{ MeV}, \tau(\tilde{\chi}_1^\pm)=0.2 \text{ ns}$	1310.3675
	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	482 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}	832 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	-	-	19.1	\tilde{g}	1.27 TeV		1411.6795
	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	$\tilde{\chi}_1^0$	435 GeV	$2<\tau(\tilde{\chi}_1^0)<3 \text{ ns}, \text{ SPS8 model}$	1409.5542
	$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\rightarrow e\bar{e}\nu/\mu\bar{\mu}\nu/\mu\bar{\mu}\nu$	displ. $e\bar{e}/\mu\bar{\mu}/\mu\bar{\mu}\nu$	-	-	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 $pp\rightarrow\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\rightarrow e\mu/e\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$	1.7 TeV	$\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$
Bilinear RPV CMSSM		2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.35 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{\text{LSP}}<1 \text{ mm}$	1404.2500
$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow e\bar{e}\nu_\mu, e\mu\bar{\nu}_e$		4 e, μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	750 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^\pm), \lambda_{121}\neq 0$	1405.5086
$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow\tau\bar{\tau}\nu_e, e\tau\bar{\nu}_\tau$		3 $e, \mu + \tau$	-	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
$\tilde{g}\tilde{g}, \tilde{g}\rightarrow qq\bar{q}$		0	6-7 jets	-	20.3	\tilde{g}	917 GeV	$\text{BR}(\tilde{g})=\text{BR}(\tilde{b})=\text{BR}(\tilde{c})=0\%$	1502.05686
$\tilde{g}\tilde{g}, \tilde{g}\rightarrow q\bar{q}\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow qq\bar{q}$		0	6-7 jets	-	20.3	\tilde{g}	870 GeV	$m(\tilde{\chi}_1^0)=600 \text{ GeV}$	1502.05686
$\tilde{g}\tilde{g}, \tilde{g}\rightarrow\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\bar{s}$		2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{g}	850 GeV		1404.250
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\bar{s}$		0	2 jets + 2 b	-	20.3	\tilde{t}_1	100-308 GeV		ATLAS-CONF-2015-026
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\bar{\ell}$	2 e, μ	2 b	-	20.3	\tilde{t}_1	0.4-1.0 TeV	$\text{BR}(\tilde{t}_1\rightarrow b\ell/\mu)/>20\%$	ATLAS-CONF-2015-015	
Other	Scalar charm, $\tilde{c}\rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	\tilde{c}	490 GeV	$m(\tilde{\chi}_1^0)<200 \text{ GeV}$	1501.01325

10⁻¹

1

Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

SUSY searches at the LHC

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	Reference	
Inclusive Searches	Many search channels excluding light SUSY scenarios with neutralino LSP				100-440 GeV	850 GeV	1.8 TeV	$m(\tilde{g})=m(\tilde{g})$ 1507.05525	
					780 GeV	1.33 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}, m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$ 1405.7875		
					1.26 TeV	1.32 TeV	$m(\tilde{g})-m(\tilde{\chi}_1^0)<10 \text{ GeV}$ 1507.05525		
					1.6 TeV	1.29 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ 1503.03290		
					1.3 TeV	1.25 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ 1405.7875		
					850 GeV	1.25 TeV	$m(\tilde{\chi}_1^0)<300 \text{ GeV}, m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$ 1507.05525		
					865 GeV	1.25 TeV	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ 1501.03555		
					1.25 TeV	1.1 TeV	$\tan\beta > 20$ 1407.0603		
					1.34 TeV	1.3 TeV	$c\tau(\text{NLSP})<0.1 \text{ mm}$ 1507.05493		
					1.3 TeV	1.3 TeV	$m(\tilde{\chi}_1^0)<900 \text{ GeV}, c\tau(\text{NLSP})<0.1 \text{ mm}, \mu<0$ 1507.05493		
3 rd gen. \tilde{g} med.	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow t\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}	1.25 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$ 1407.0600	
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow b\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}	1.34 TeV	$m(\tilde{\chi}_1^0)<350 \text{ GeV}$ 1308.1841	
							1.3 TeV	$m(\tilde{\chi}_1^0)<400 \text{ GeV}$ 1407.0600	
							1.3 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	20.1	\tilde{b}_1	100-620 GeV	$m(\tilde{\chi}_1^0)<90 \text{ GeV}$ 1308.2631
		$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\rightarrow t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{b}_1	275-440 GeV	$m(\tilde{\chi}_1^\pm)=2 m(\tilde{\chi}_1^0)$ 1404.2500
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7/20.3	\tilde{t}_1	110-167 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55 \text{ GeV}$ 1209.2102, 1407.0583
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow Wb\tilde{\chi}_1^0 \text{ or } t\tilde{\chi}_1^0$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3	\tilde{t}_1	90-191 GeV	$m(\tilde{\chi}_1^0)=1 \text{ GeV}$ 1506.08616
		$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	\tilde{t}_1	210-700 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)<85 \text{ GeV}$ 1407.0608
		$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	90-240 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	20.3	\tilde{t}_2	150-580 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 1403.5222	
EW direct		$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\rightarrow\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	$m(\tilde{\chi}_1^0)<90 \text{ GeV}$ 294
		$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-350 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 294
		$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 350
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\ell_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 029	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm$	100-350 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 402.7029	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0h\tilde{\chi}_1^0, h\rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm$	250 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 7110	
	$\tilde{\chi}_2^0\tilde{\chi}_2^0\rightarrow\tilde{\ell}_R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_2^0$	124-361 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 086	
	GGM (wino NLSP) weak prod.	1 $e, \mu + \gamma$	-	Yes	20.3	\tilde{W}	124-361 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 1493	
	Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 675
		Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$ 1332
Stable, stopped \tilde{g} R-hadron		0	1-5 jets	Yes	27.9	\tilde{g}	270 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 584	
Stable \tilde{g} R-hadron		trk	-	-	19.1	\tilde{g}	270 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 795	
GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0\rightarrow\tilde{\tau}(\tilde{e}, \tilde{\mu})+\tau(e, \mu)$		1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	270 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 795	
GMSB, $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$		2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	270 GeV	$m(\tilde{\chi}_1^0)>150 \text{ GeV}$ 542	
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\rightarrow e\tilde{e}\nu/\mu\tilde{\mu}\nu$		displ. $ee/\mu\mu$	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	$c\tau(\tilde{\chi}_1^0)<740 \text{ mm}, m(\tilde{g})=1.3 \text{ TeV}$ 1504.05162	
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\rightarrow e\tilde{e}\nu/\mu\tilde{\mu}\nu$		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 $pp\rightarrow\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\rightarrow e\mu/e\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$	1.7 TeV	$\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$ 1503.04430
		Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{q}, \tilde{g}	1.35 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{\text{LSP}}<1 \text{ mm}$ 1404.2500
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	750 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^\pm), \lambda_{121}\neq 0$ 1405.5086	
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	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	
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow qqq$	0	6-7 jets	-	20.3	\tilde{g}	917 GeV	$\text{BR}(\tilde{g})=\text{BR}(\tilde{b})=\text{BR}(\tilde{c})=0\%$ 1502.05686	
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow q\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow qqq$	0	6-7 jets	-	20.3	\tilde{g}	870 GeV	$m(\tilde{\chi}_1^0)=600 \text{ GeV}$ 1502.05686	
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow t\tilde{t}, \tilde{t}_1\rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{g}	850 GeV	$m(\tilde{\chi}_1^0)=600 \text{ GeV}$ 1404.250	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow bs$	0	2 jets + 2 b	-	20.3	\tilde{t}_1	100-308 GeV	$\text{BR}(\tilde{t}_1\rightarrow b\ell/\mu)>20\%$ ATLAS-CONF-2015-026	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow b\ell$	2 e, μ	2 b	-	20.3	\tilde{t}_1	0.4-1.0 TeV	$\text{BR}(\tilde{t}_1\rightarrow b\ell/\mu)>20\%$ ATLAS-CONF-2015-015	
	Other	Scalar charm, $\tilde{c}\rightarrow c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	\tilde{c}	490 GeV	$m(\tilde{\chi}_1^0)<200 \text{ GeV}$ 1501.01325

How are current searches constraining an alternative scenario, e.g. sneutrino LSP?

Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 σ theoretical signal cross section uncertainty.

Why consider right-handed sneutrino DM?

- ▶ Left-handed sneutrino LSP cannot explain measured relic abundance and is excluded by direct detection experiments
- ▶ Mostly right-handed sneutrino is an interesting candidate, addressing both the origin of neutrino masses and the nature of dark matter
- ▶ Consider simple realisation: Dirac neutrinos, no lepton number violating terms

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→ we want to explore how LHC results constrain such a sneutrino LSP scenario

The MSSM+RN model

- superpotential for Dirac RH neutrino superfield

$$W = \epsilon_{ij} (\mu \hat{H}_i^u \hat{H}_j^d - Y_l^{IJ} \hat{H}_i^d \hat{L}_j^I \hat{R}^J + Y_\nu^{IJ} \hat{H}_i^u \hat{L}_j^I \hat{N}^J)$$

- additional terms in the soft-breaking potential

$$V_{\text{soft}} = (M_L^2)^{IJ} \tilde{L}_i^{I*} \tilde{L}_j^J + (M_N^2)^{IJ} \tilde{N}^{I*} \tilde{N}^J \\ - [\epsilon_{ij} (\Lambda_l^{IJ} H_i^d \tilde{L}_j^I \tilde{R}^J + \Lambda_\nu^{IJ} H_i^u \tilde{L}_j^I \tilde{N}^J) + \text{h.c.}]$$

- the sneutrino mass eigenstates are then given by

$$\begin{pmatrix} \tilde{\nu}_{k_1} \\ \tilde{\nu}_{k_2} \end{pmatrix} = \begin{pmatrix} -\sin \theta_{\tilde{\nu}}^k & \cos \theta_{\tilde{\nu}}^k \\ \cos \theta_{\tilde{\nu}}^k & \sin \theta_{\tilde{\nu}}^k \end{pmatrix} \begin{pmatrix} \tilde{\nu}_L^k \\ \tilde{N}^k \end{pmatrix}$$

$$\text{with } \sin 2\theta_{\tilde{\nu}}^k = \sqrt{2} \frac{A_{\tilde{\nu}}^k v \sin \beta}{(m_{\tilde{\nu}_{k_2}}^2 - m_{\tilde{\nu}_{k_1}}^2)}$$

Borzumati & Nomura, hep-ph/0007018
Arkani-Hamed et al., hep-ph/0006312

Parameters and constraints

Sample parameter space using MultiNest

- set of free parameters, allowing for non-universalities in gaugino and scalar sector:

$$M_1, M_2, M_3, m_L, m_R, m_N, m_Q, m_H, A_l, A_{\tilde{\nu}}, A_q, \tan \beta, \text{sgn} \mu$$

- constraints implemented in the likelihood function:

$$m_h, \text{BR}(B \rightarrow X_s \gamma), \text{BR}(B_s \rightarrow \mu^+ \mu^-), \Omega_{\text{DM}} h^2,$$

$$\Delta\Gamma_Z^{\text{invisible}}, \text{BR}(h \rightarrow \text{invisible}), m_{\tilde{\tau}_1^-}, m_{\tilde{\chi}_1^+}, m_{\tilde{e}}, m_{\tilde{\mu}}, m_{\tilde{g}}, \sigma_n^{\text{SI}}$$

for discussion of resulting parameter space
see Arina & Cabrera, hep-ph/1311.6549

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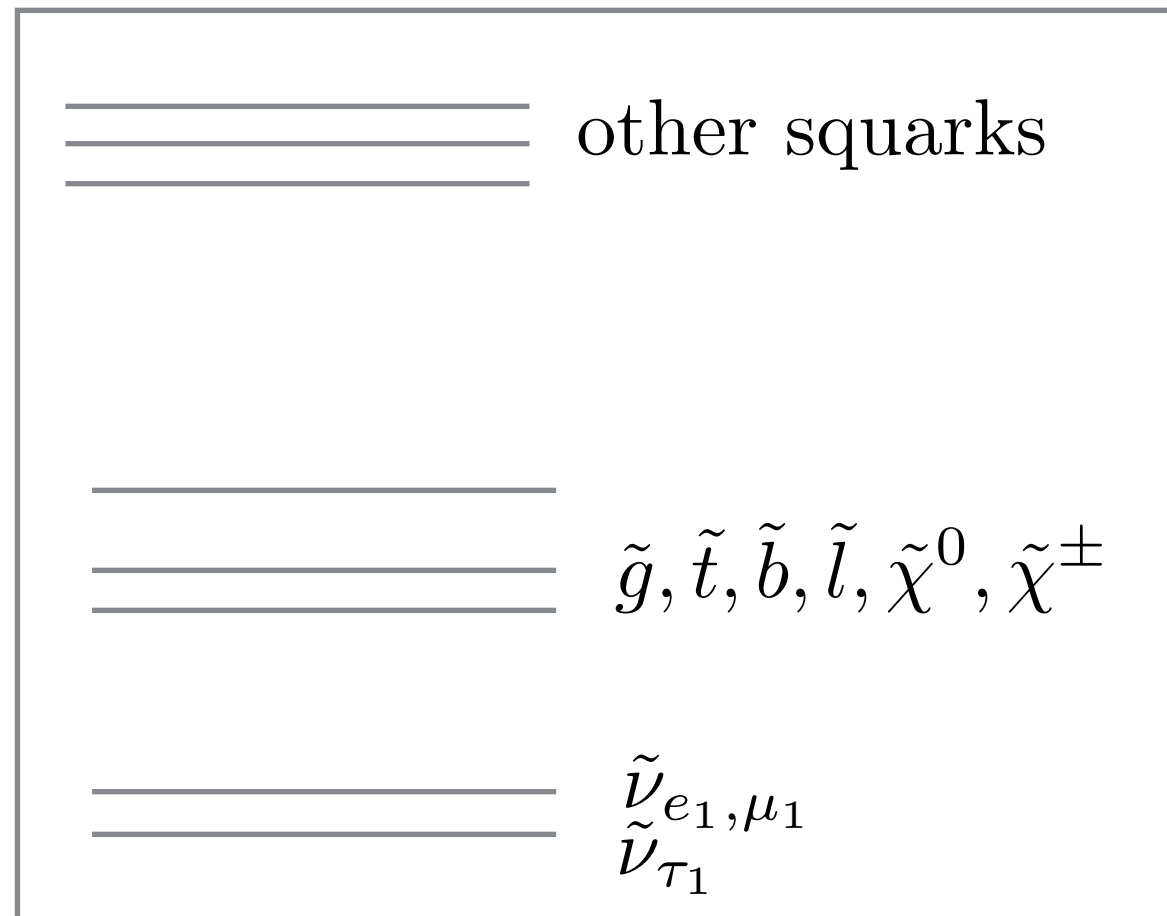
$$m_h, \text{BR}(B \rightarrow X_s \gamma), \text{BR}(B_s \rightarrow \mu^+ \mu^-), \Omega_{\text{DM}} h^2,$$

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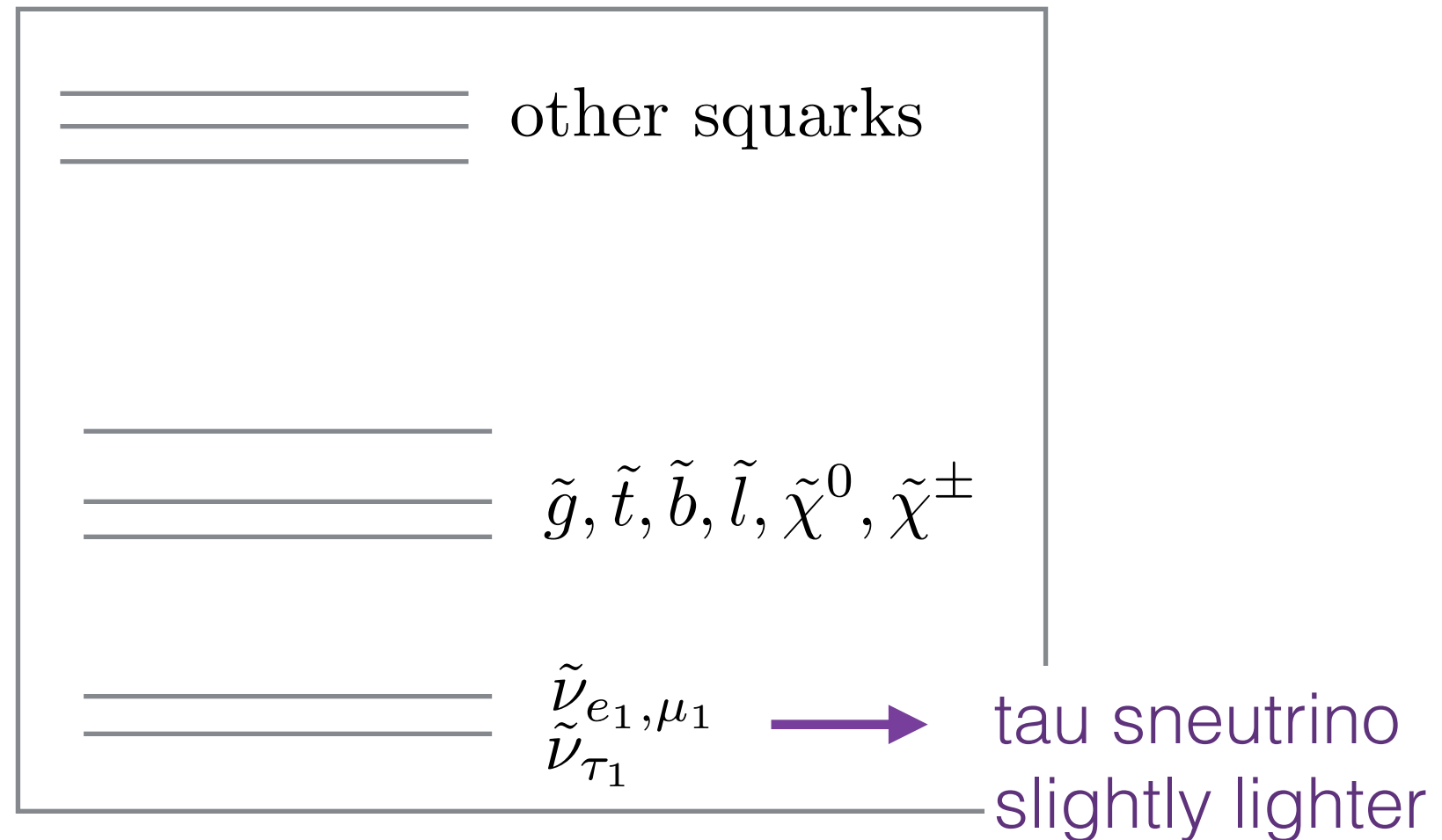
$$0.1186 \pm 0.0031(\text{exp}) \pm 20\% (\text{theo})$$

Typical spectrum



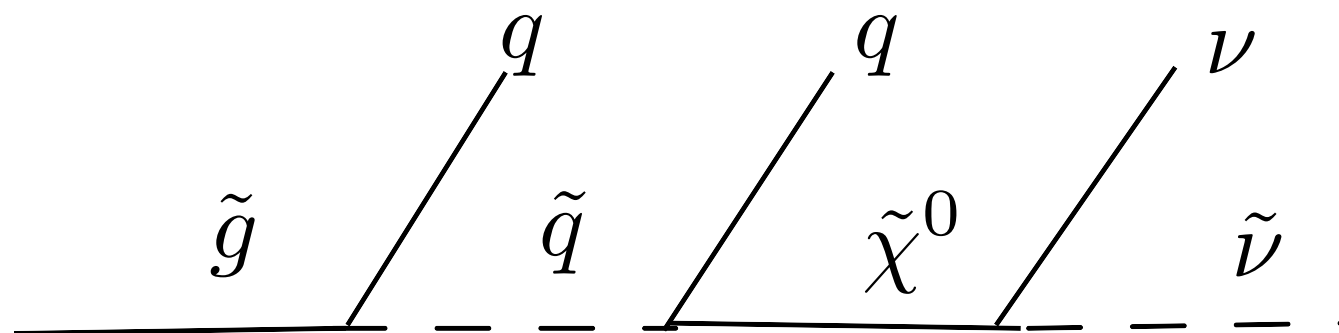
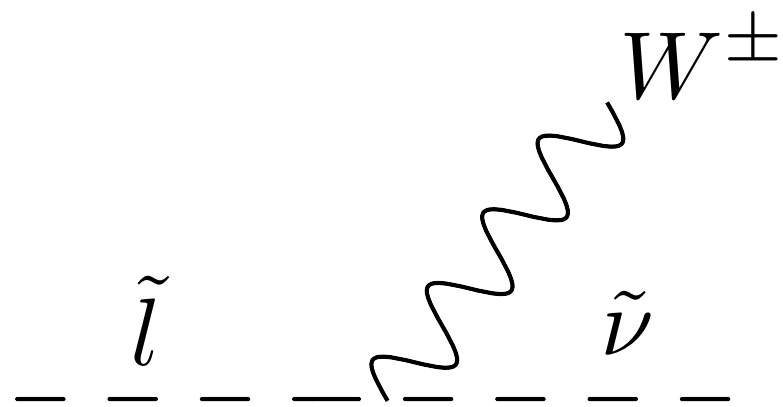
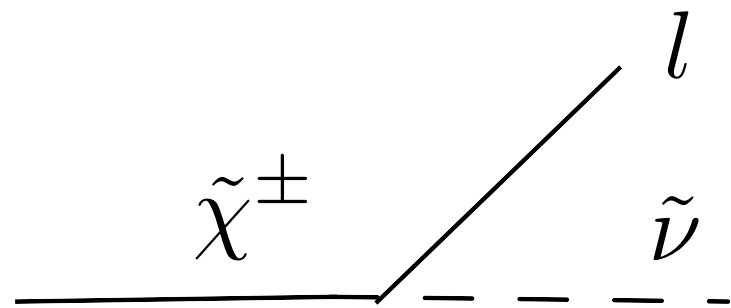
Sampling the parameter space such that we cover different scenarios, requiring either light gluinos or squarks, light gauginos or light sleptons

Typical spectrum



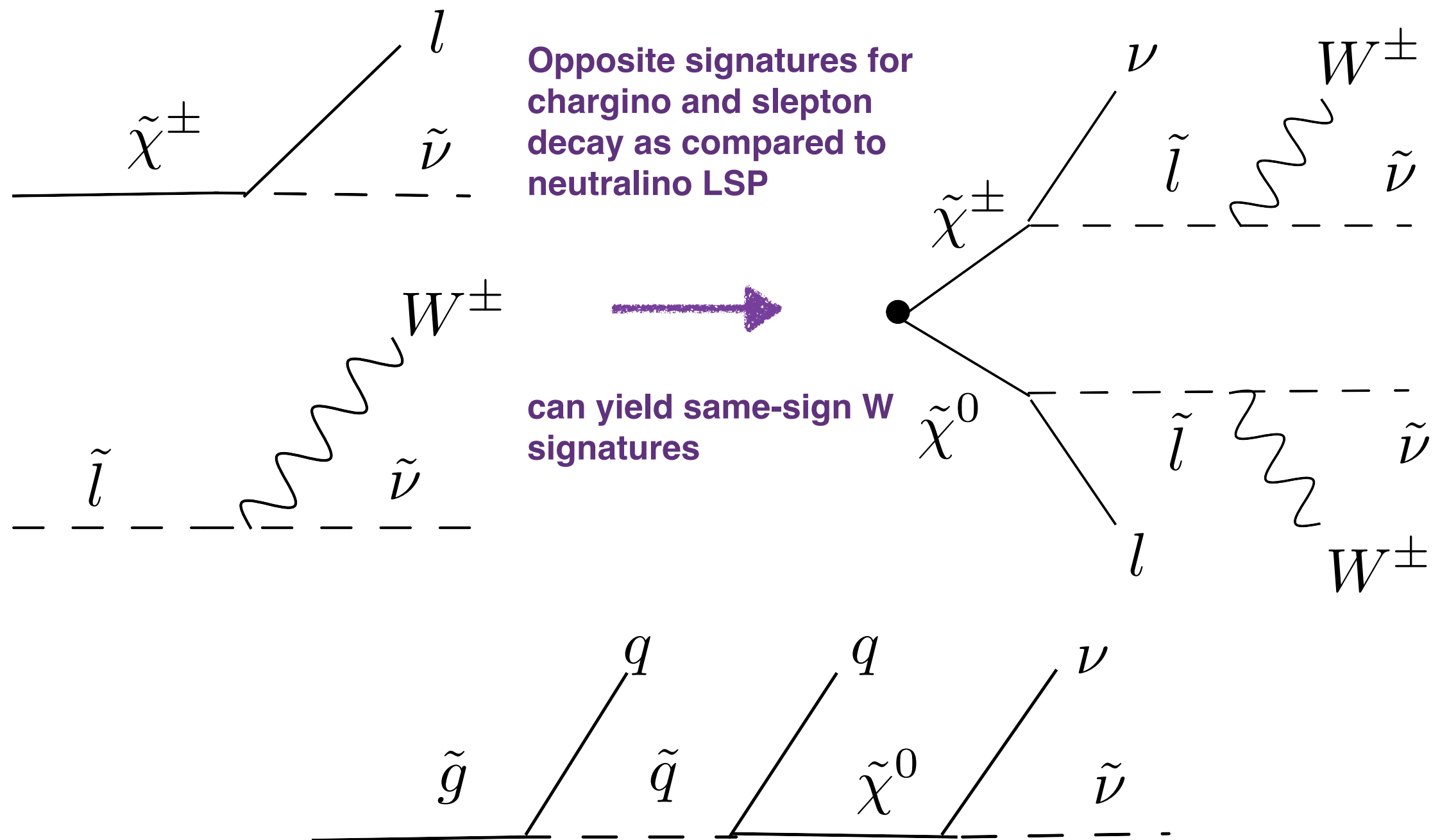
Sampling the parameter space such that we cover different scenarios, requiring either light gluinos or squarks, light gauginos or light sleptons

Typical signatures



gluino decay indistinguishable from neutralino LSP scenario

Typical signatures

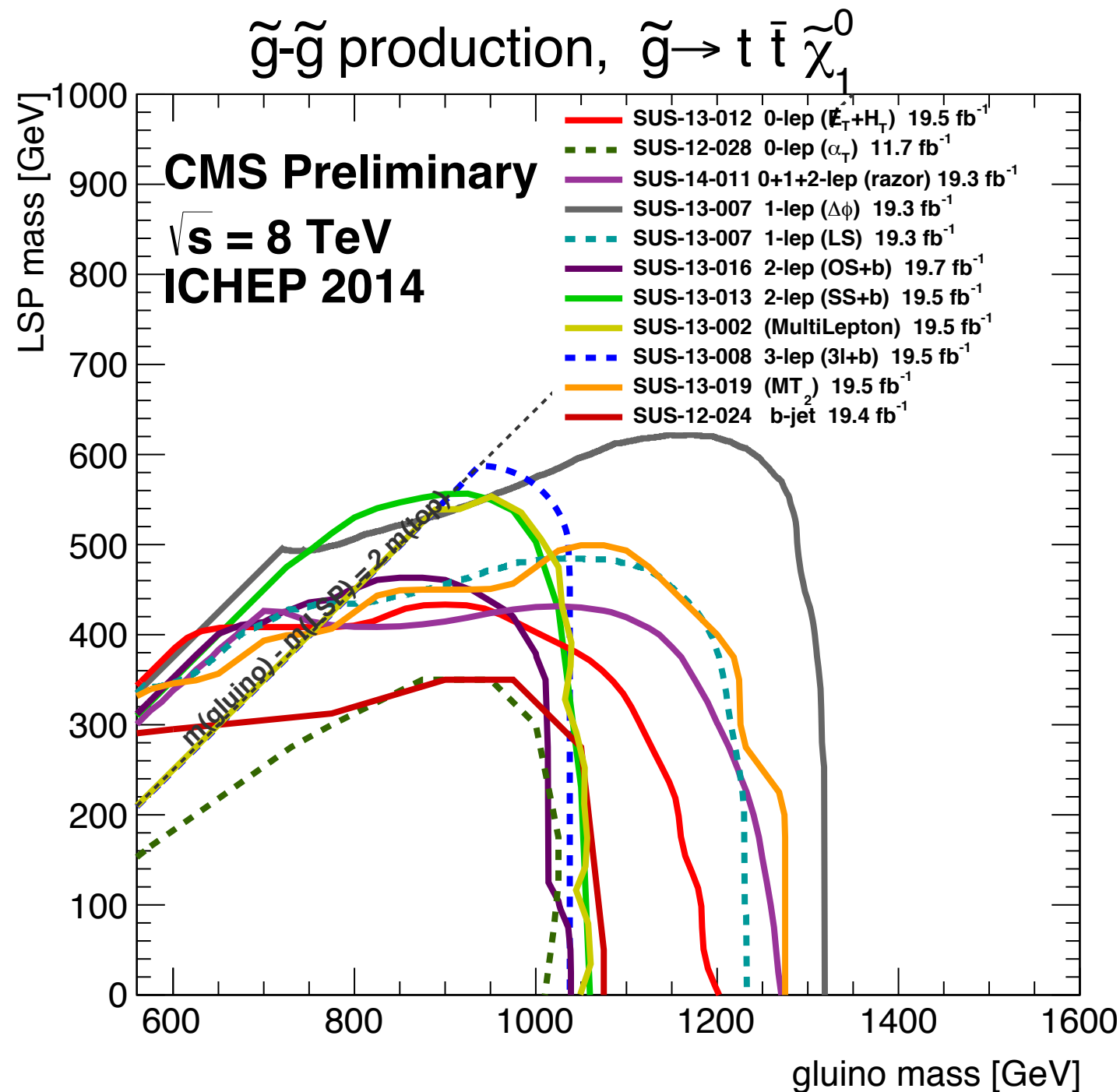


gluino decay indistinguishable from neutralino LSP scenario

Testing the model against LHC constraints

- ▶ To test against large number of results we make use of Simplified Model Spectra (SMS) interpretation of LHC searches

Simplified Models



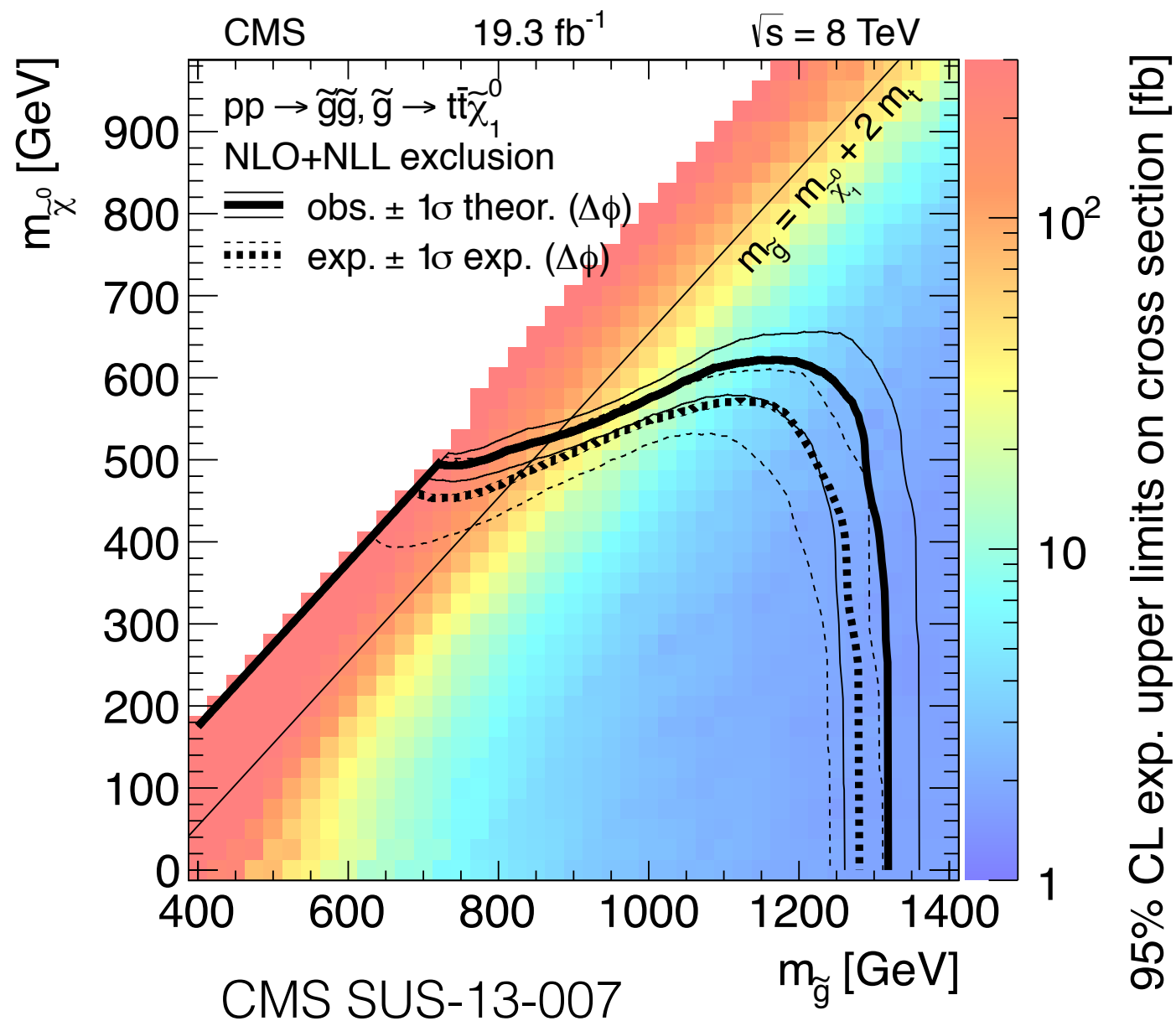
SMS are an effective Lagrangian description, containing only a few particles, 100% BR

The masses of the new particles are the free parameters of the Simplified Model

Testing the model against LHC constraints

- ▶ To test against large number of results we make use of Simplified Model Spectra (SMS) interpretation of LHC searches
- ▶ Decompose realistic model into SMS components which can be tested against limits presented by ATLAS and CMS

Using SMS results



To test realistic models,
 use upper limits on $\sigma \times BR$
 (exclusion line only valid in
 the simplified model)

Assumption:
 upper limits on $\sigma \times BR$
 are mainly a function of
 the masses of the
 new particles

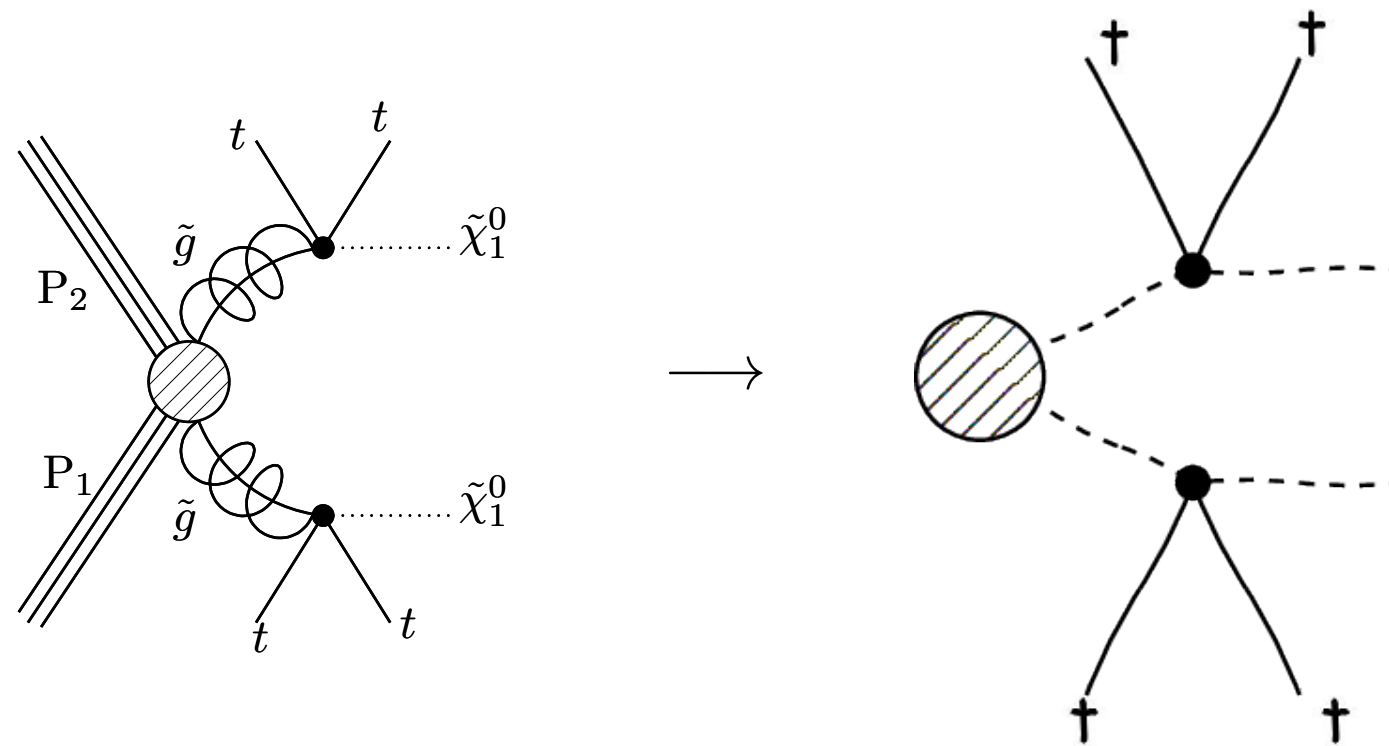
other quantum
 numbers may be
 neglected in first
 approximation

Testing the model against LHC constraints

- ▶ To test against large number of results we make use of Simplified Model Spectra (SMS) interpretation of LHC searches
- ▶ Decompose realistic model into SMS components which can be tested against limits presented by ATLAS and CMS
- ▶ Additional assumption: these results depend mainly on the mass spectrum of the new particles, not on specifics of the model (spin structure, production process, ...)

Description of SMS topologies

describe topology by vertex structure and outgoing SM particles in each vertex



$[[[t, t]], [[t, t]]]$

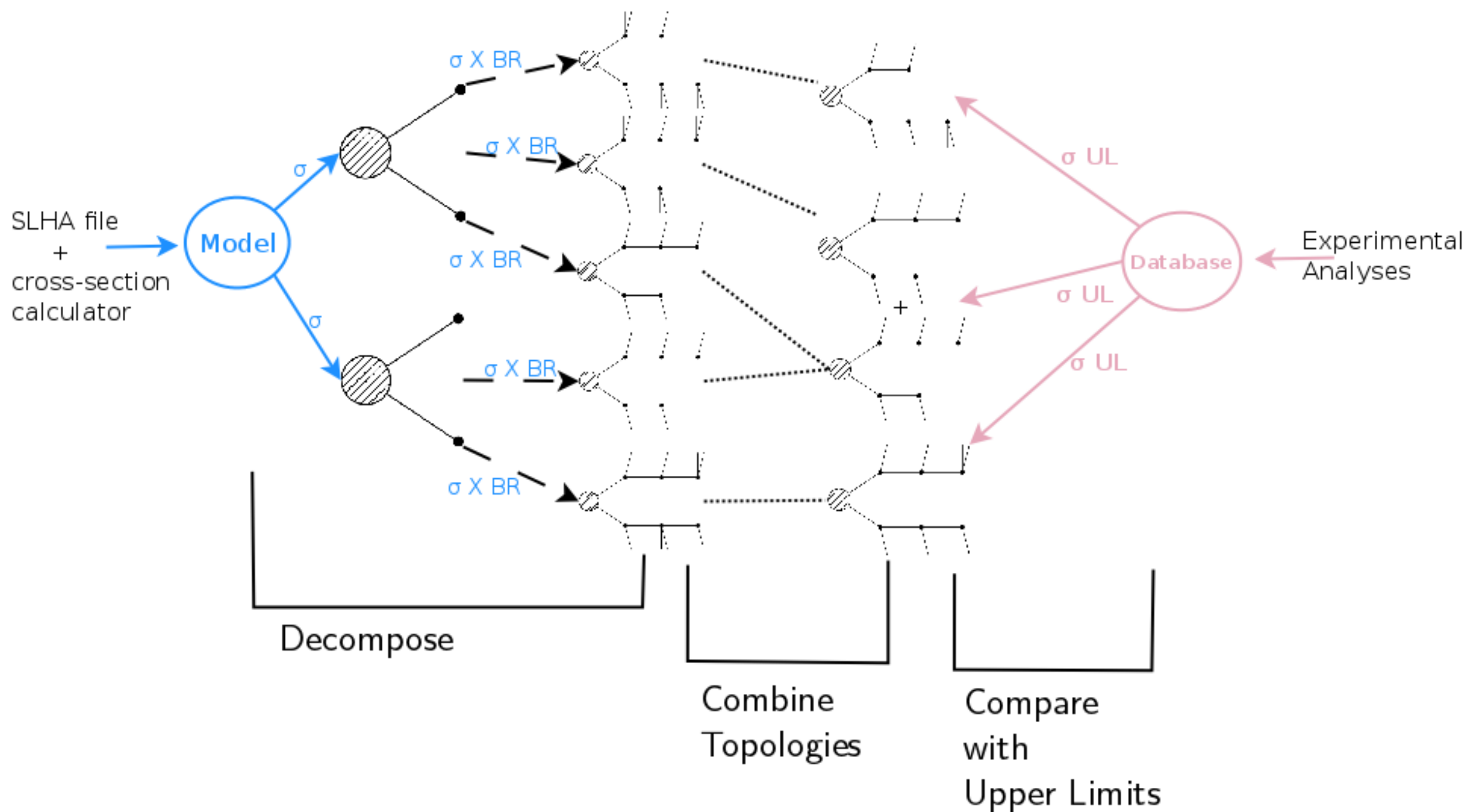
Testing the model against LHC constraints

- ▶ To test against large number of results we make use of Simplified Model Spectra (SMS) interpretation of LHC searches
- ▶ Decompose realistic model into SMS components which can be tested against limits presented by ATLAS and CMS
- ▶ Additional assumption: these results depend mainly on the mass spectrum of the new particles, not on specifics of the model (spin structure, production process, ...)



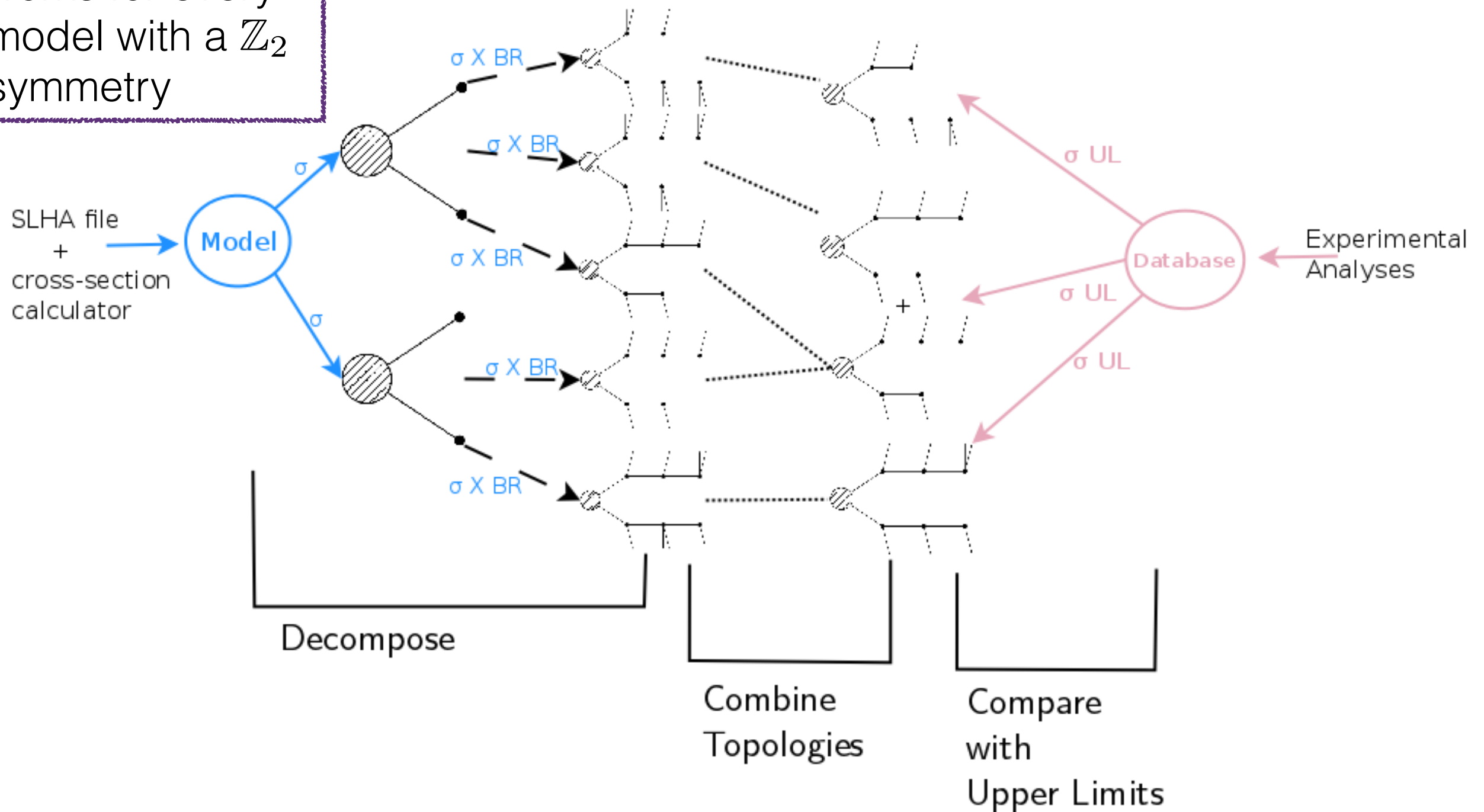
Kraml, Kulkarni,
UL, Lessa et al.,
hep-ph/1312.4175

SModels



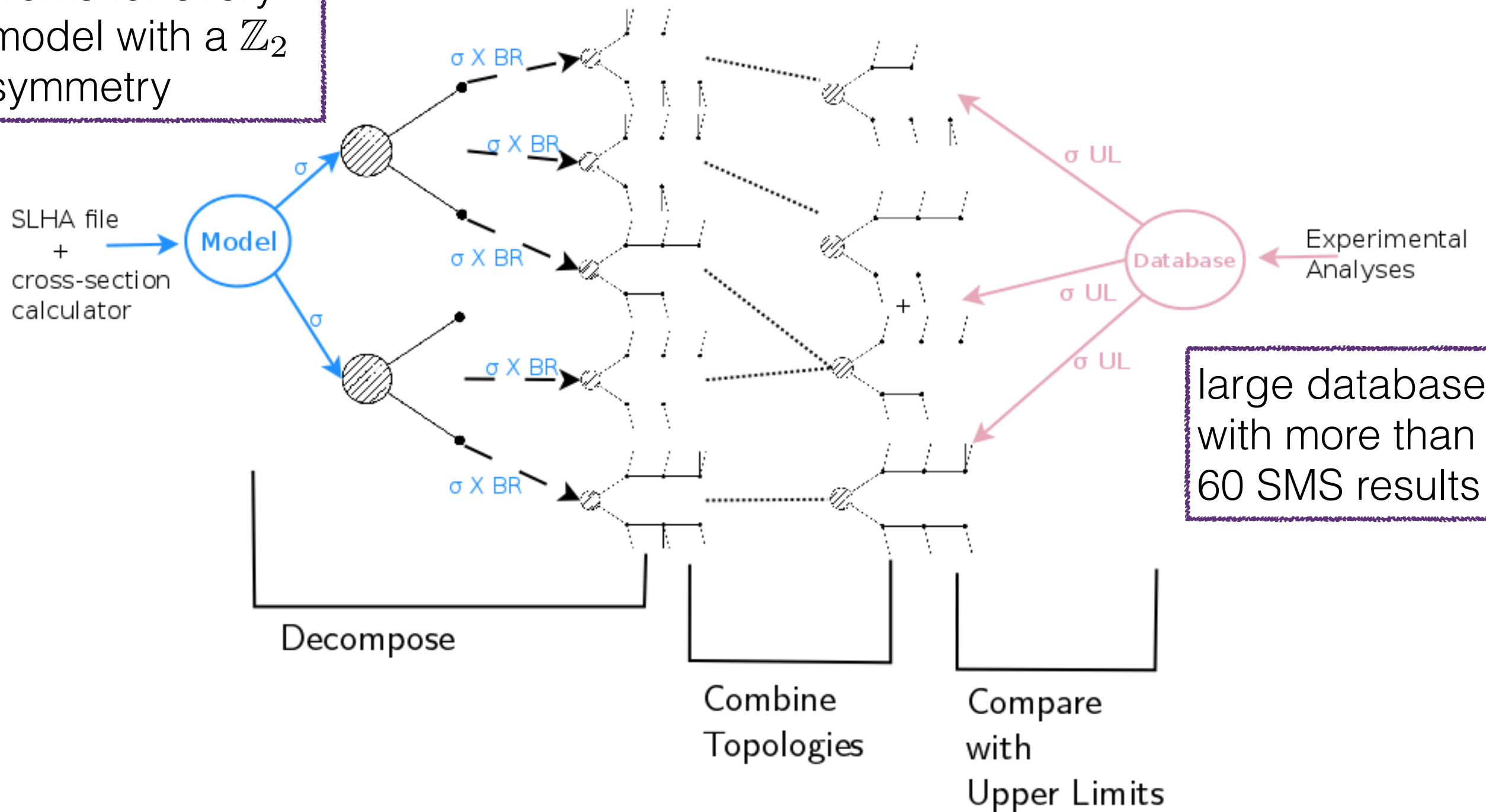
SM_{odels}

works for every
model with a \mathbb{Z}_2
symmetry



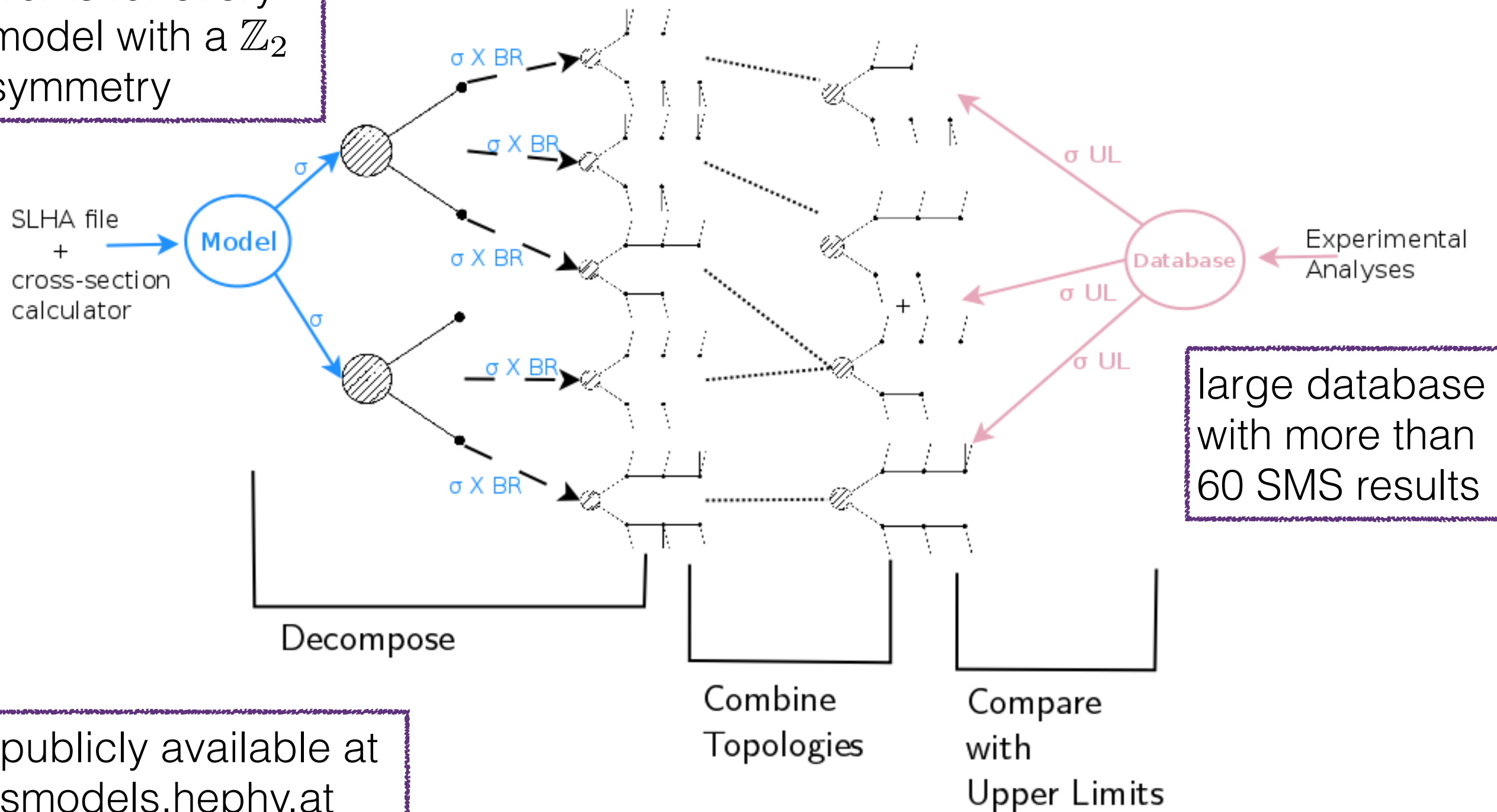
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model with a \mathbb{Z}_2
symmetry



publicly available at
smodels.hephy.at

SM_{odels}

works for every
model with
symmetry

**see talk by Jonathan Da
Silva for application to
UMSSM**

SLHA file
+
cross-section
calculator

Model

σ

$\sigma \times BR$

$\sigma \times BR$

$\sigma \times BR$

Decompose

Combine
Topologies

Compare
with
Upper Limits

σ UL

σ UL

σ UL

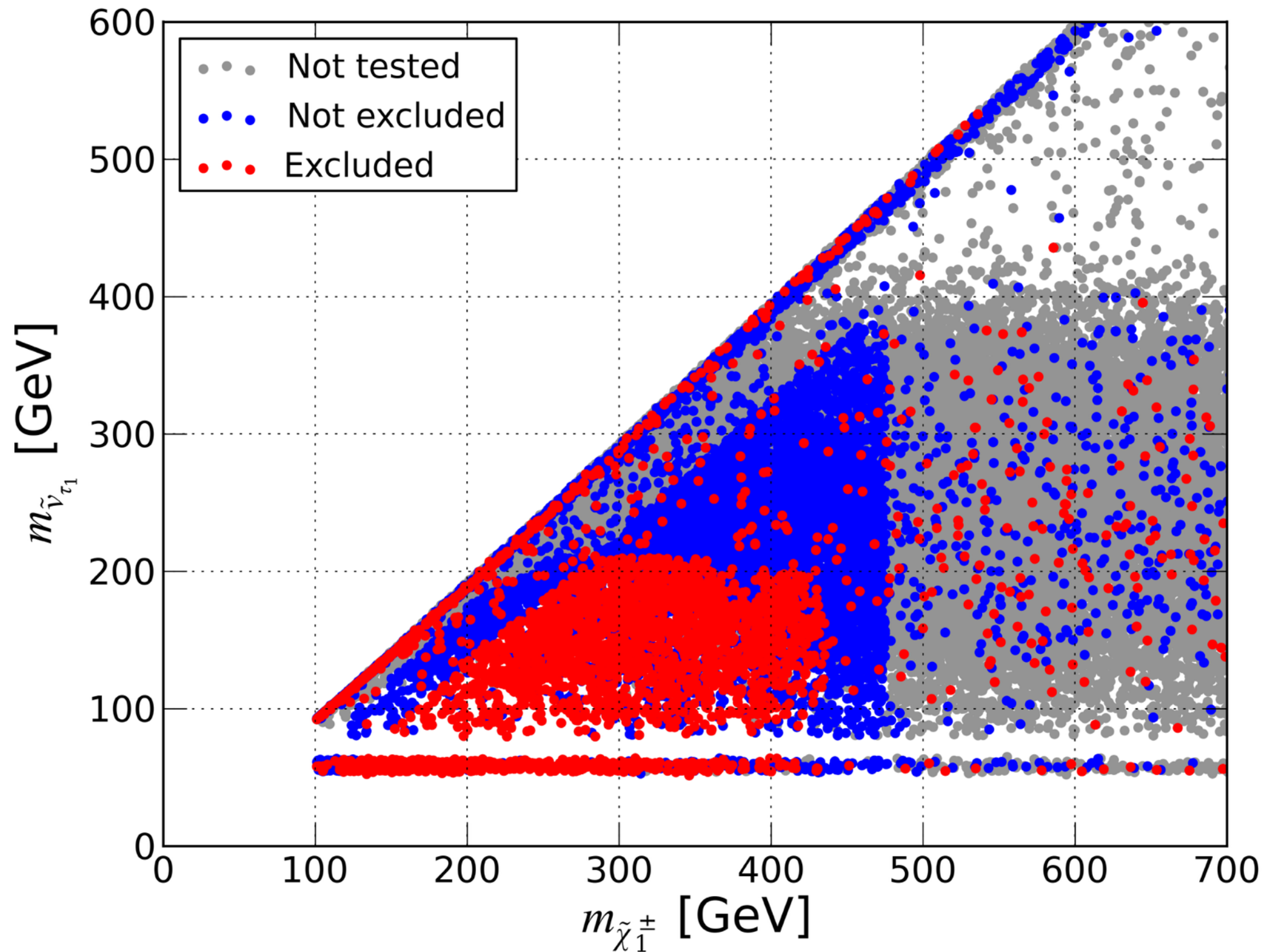
Database

Experimental
Analyses

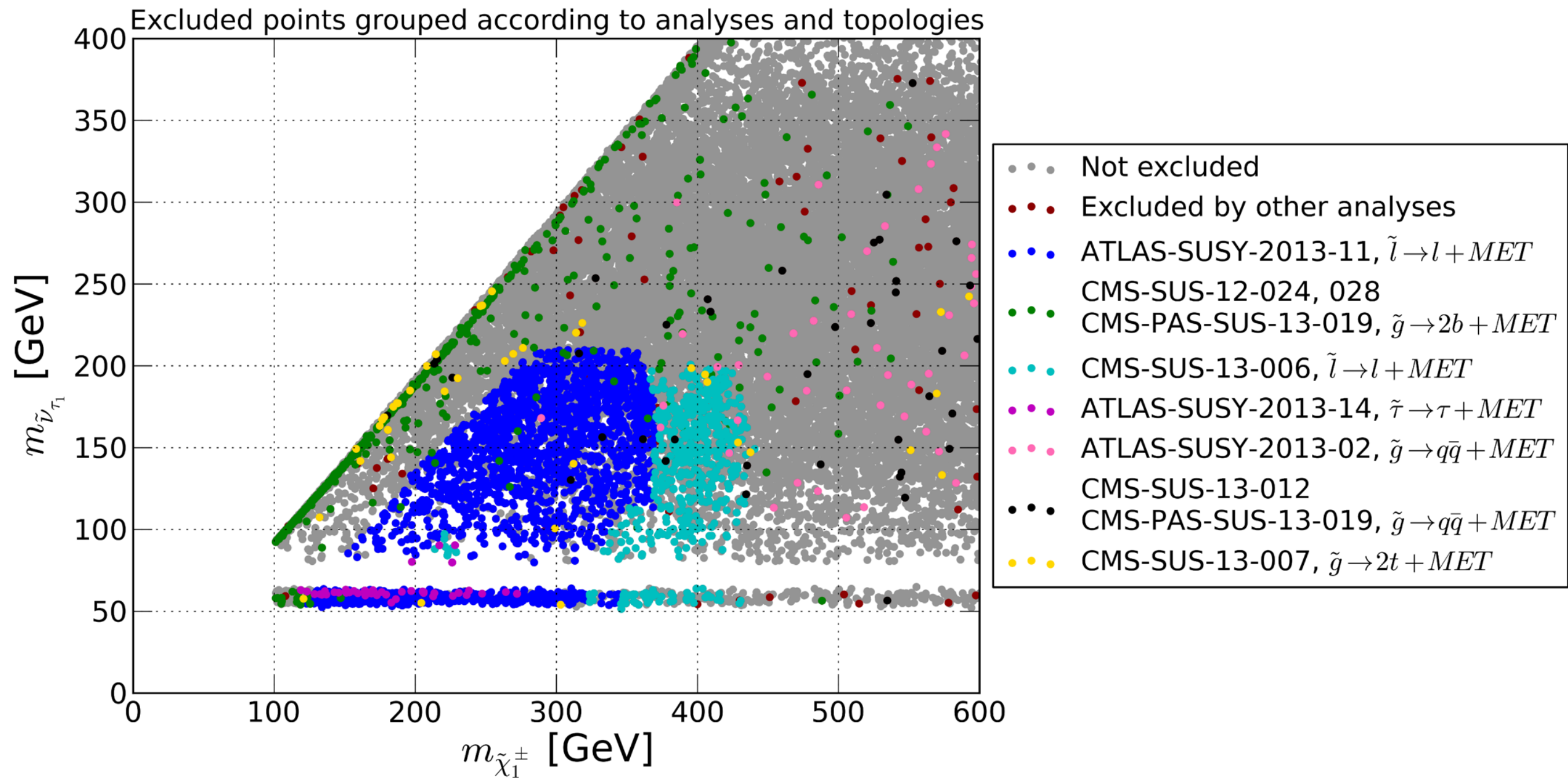
large database
with more than
60 SMS results

publicly available at
smodels.hephy.at

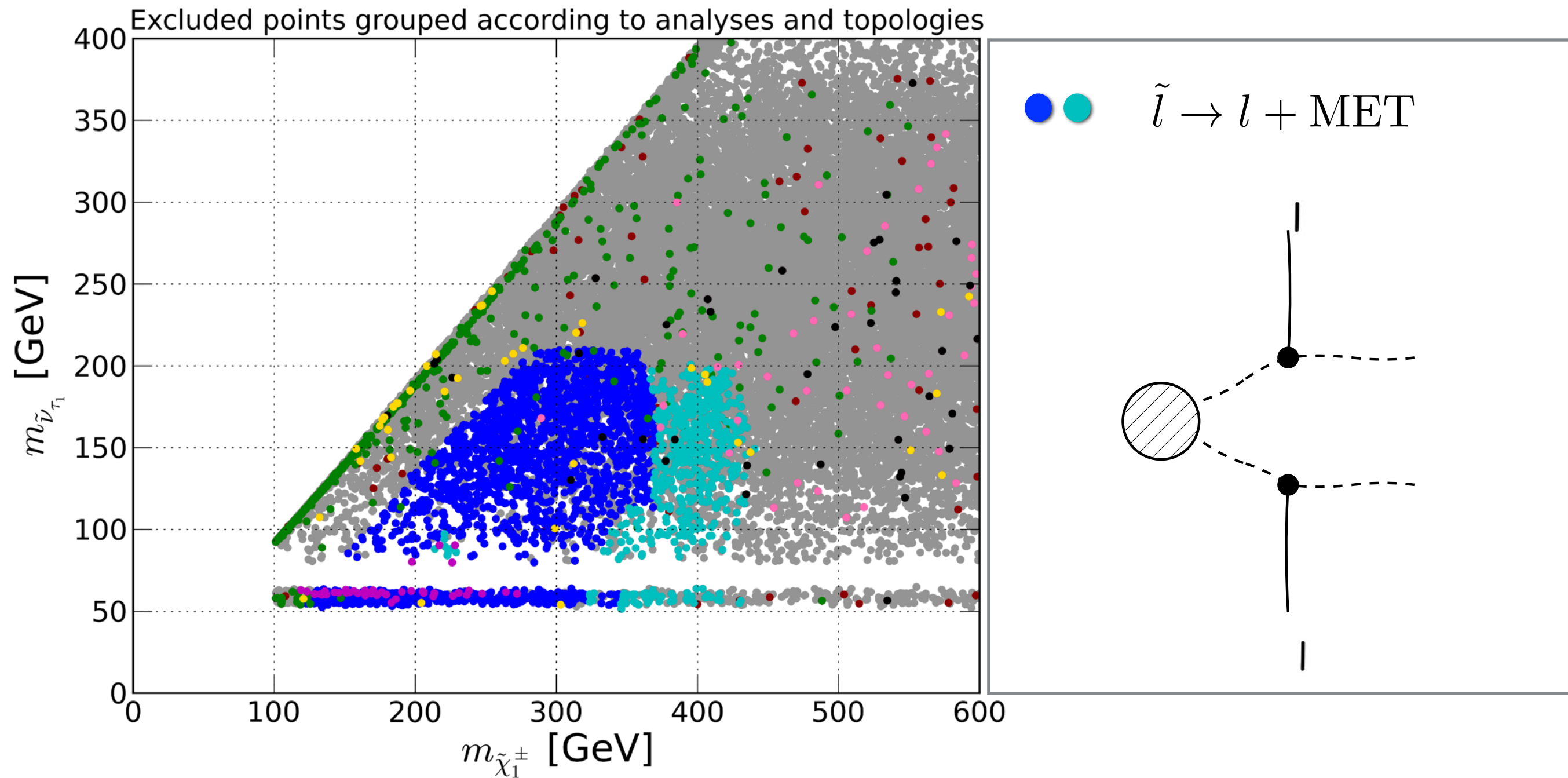
The results in the chargino - LSP mass plane



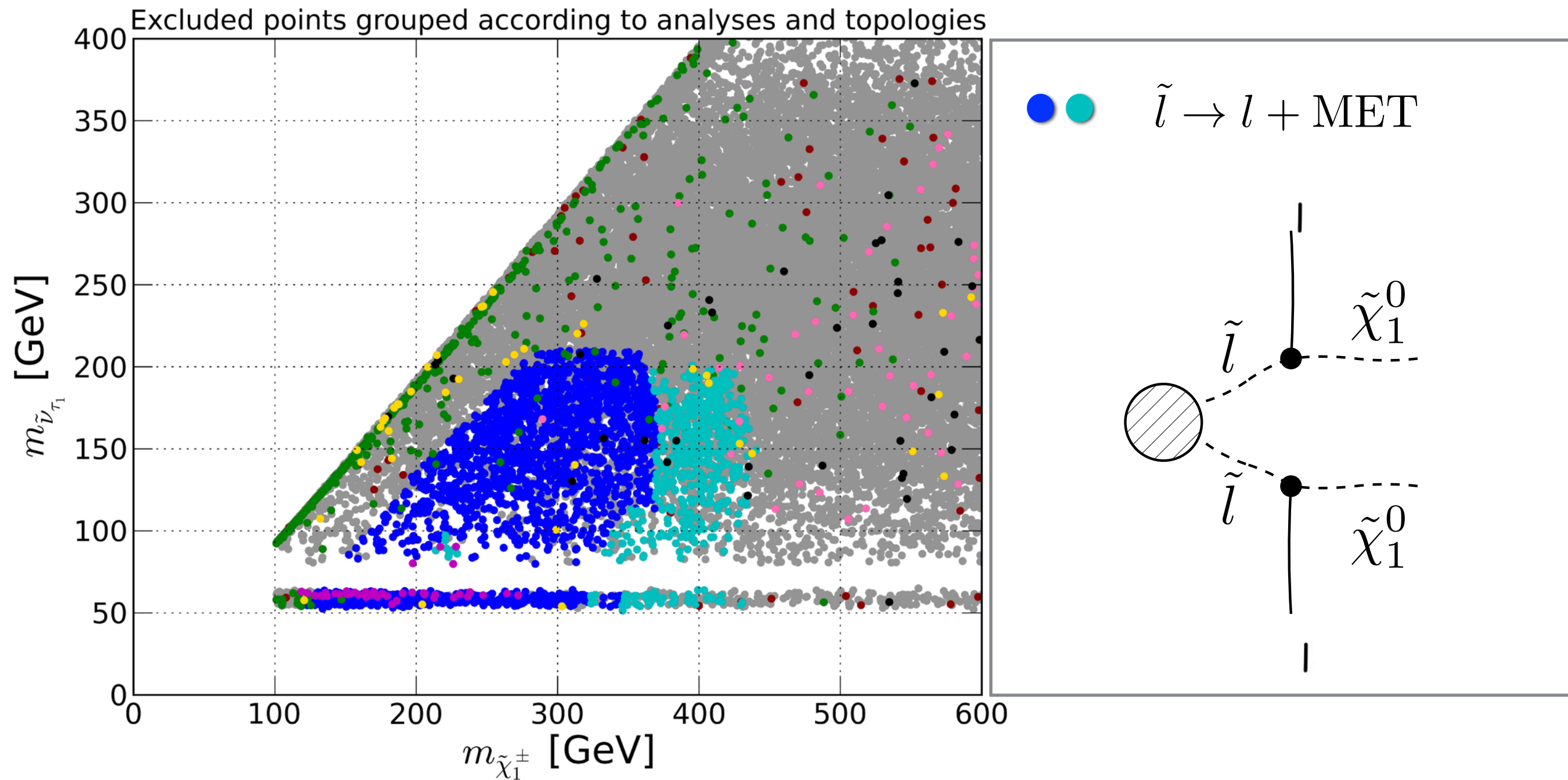
Which analyses give the most important constraints?



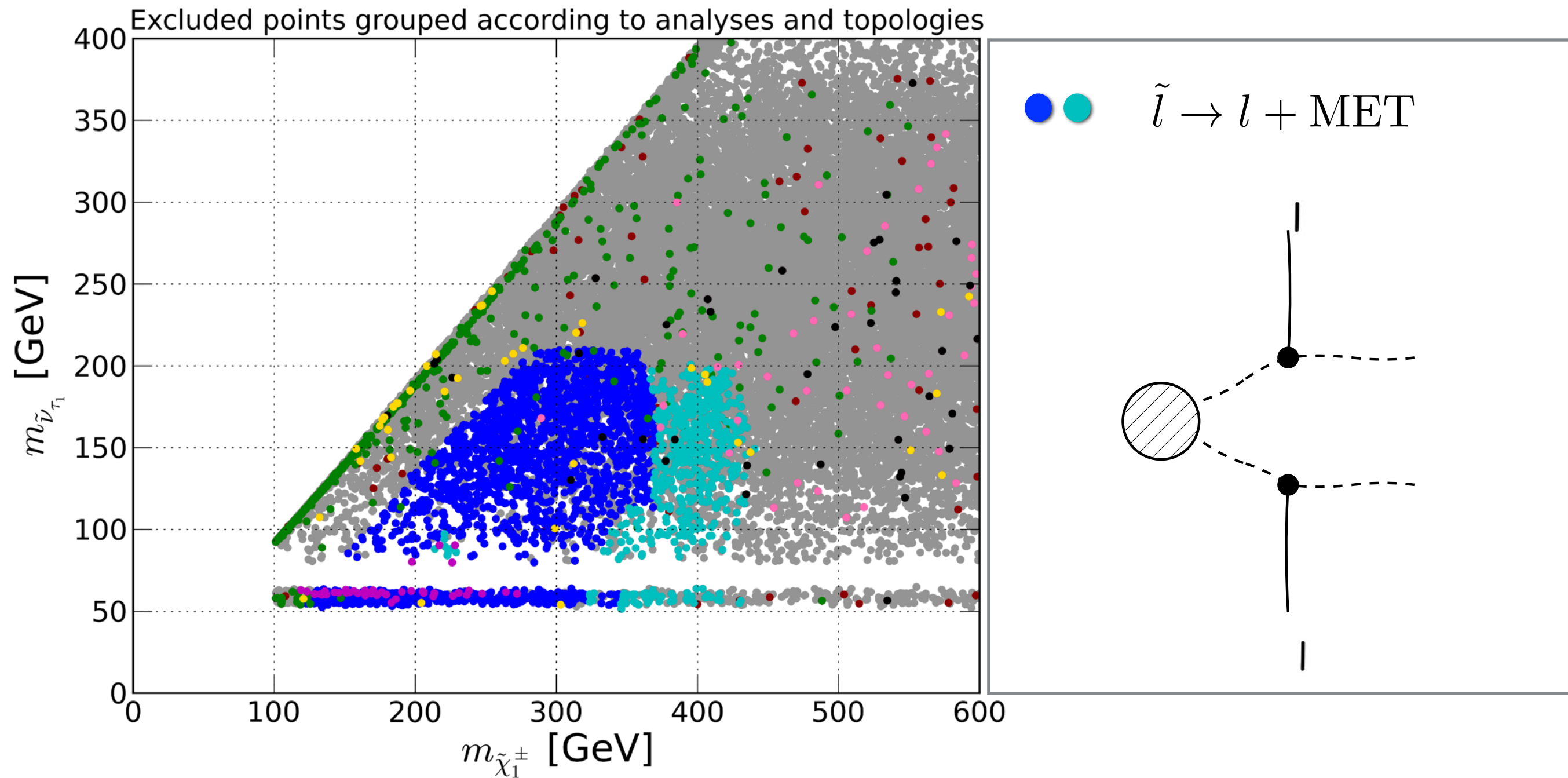
Which analyses give the most important constraints?



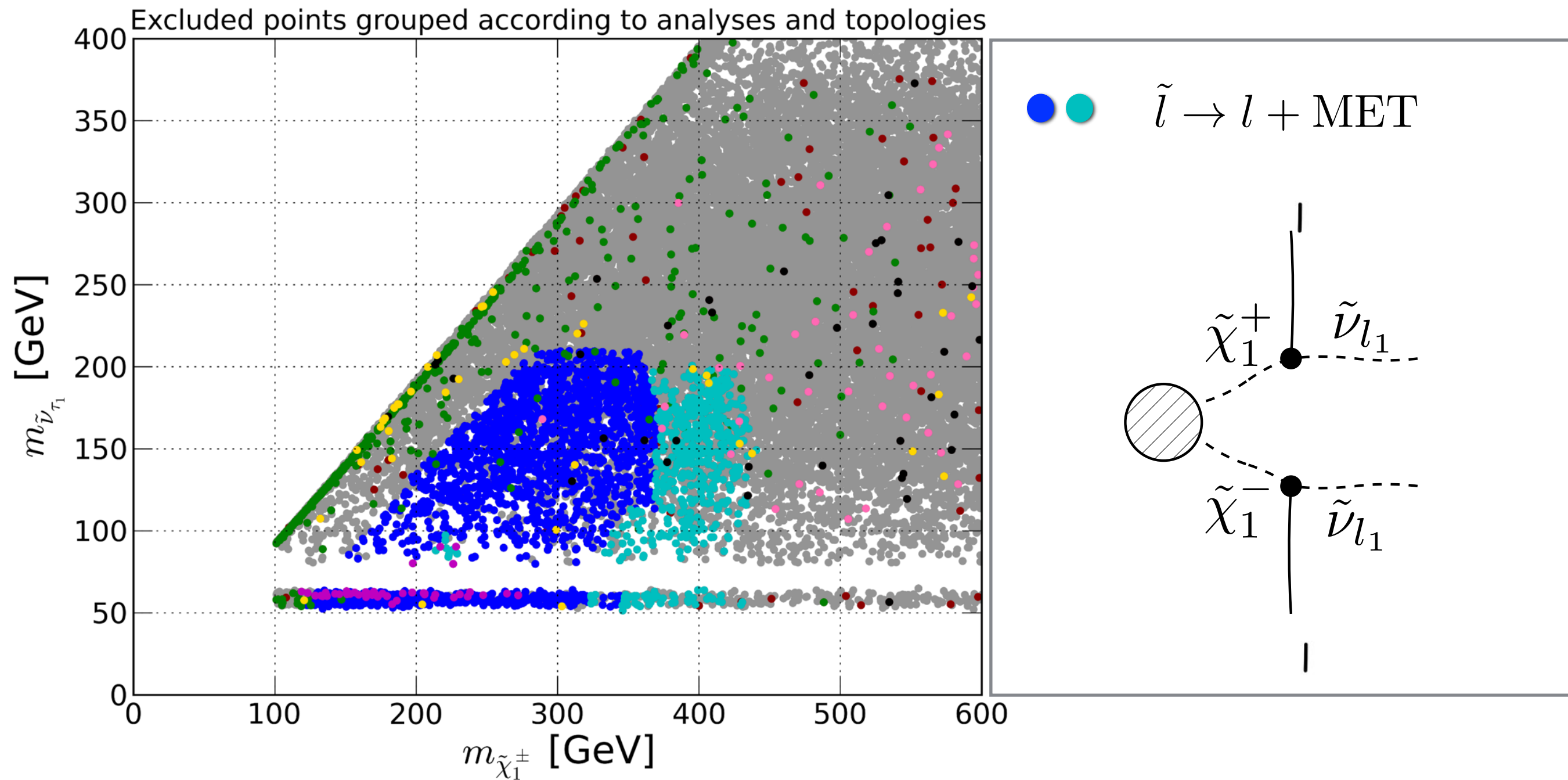
Which analyses give the most important constraints?



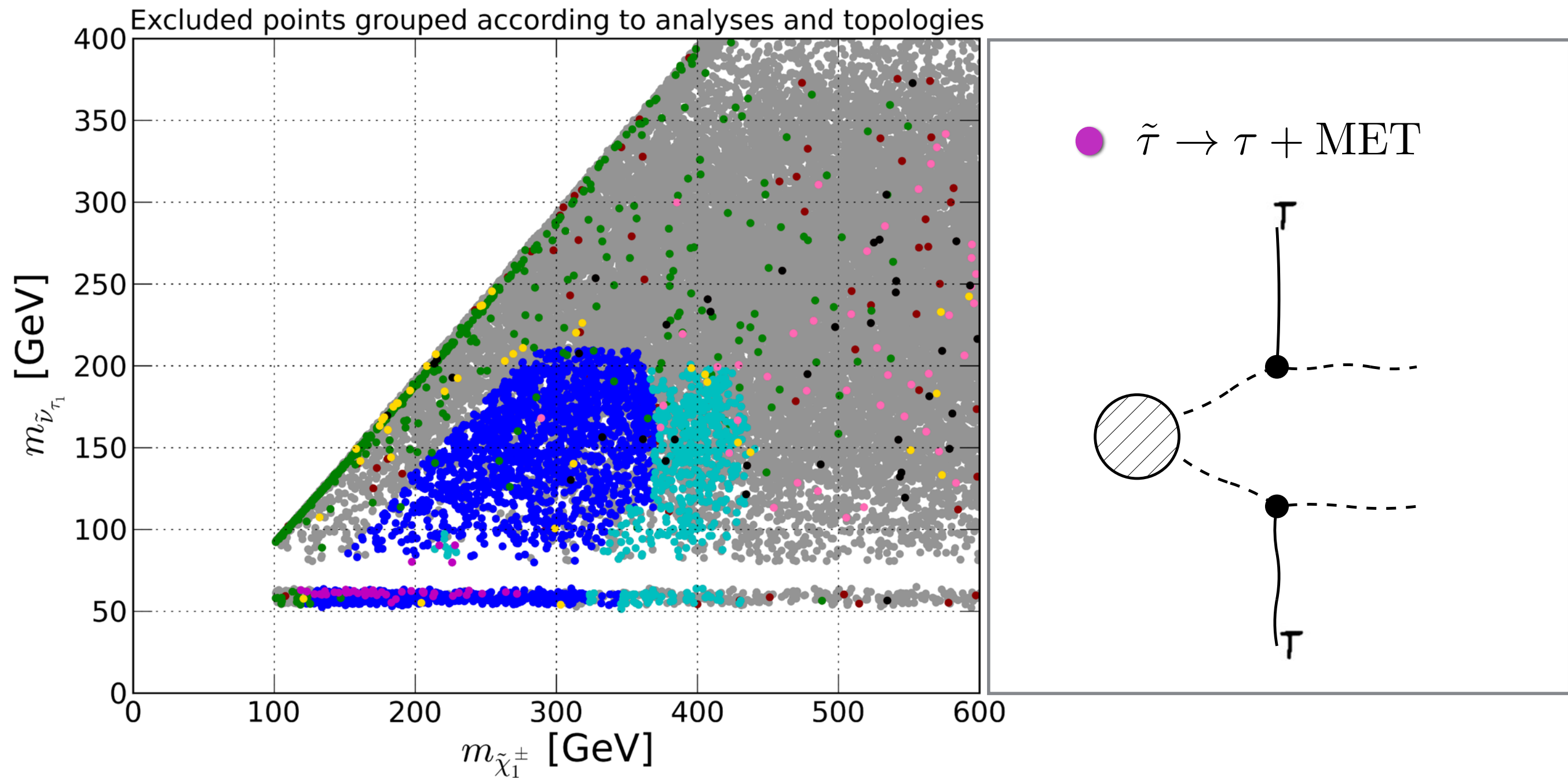
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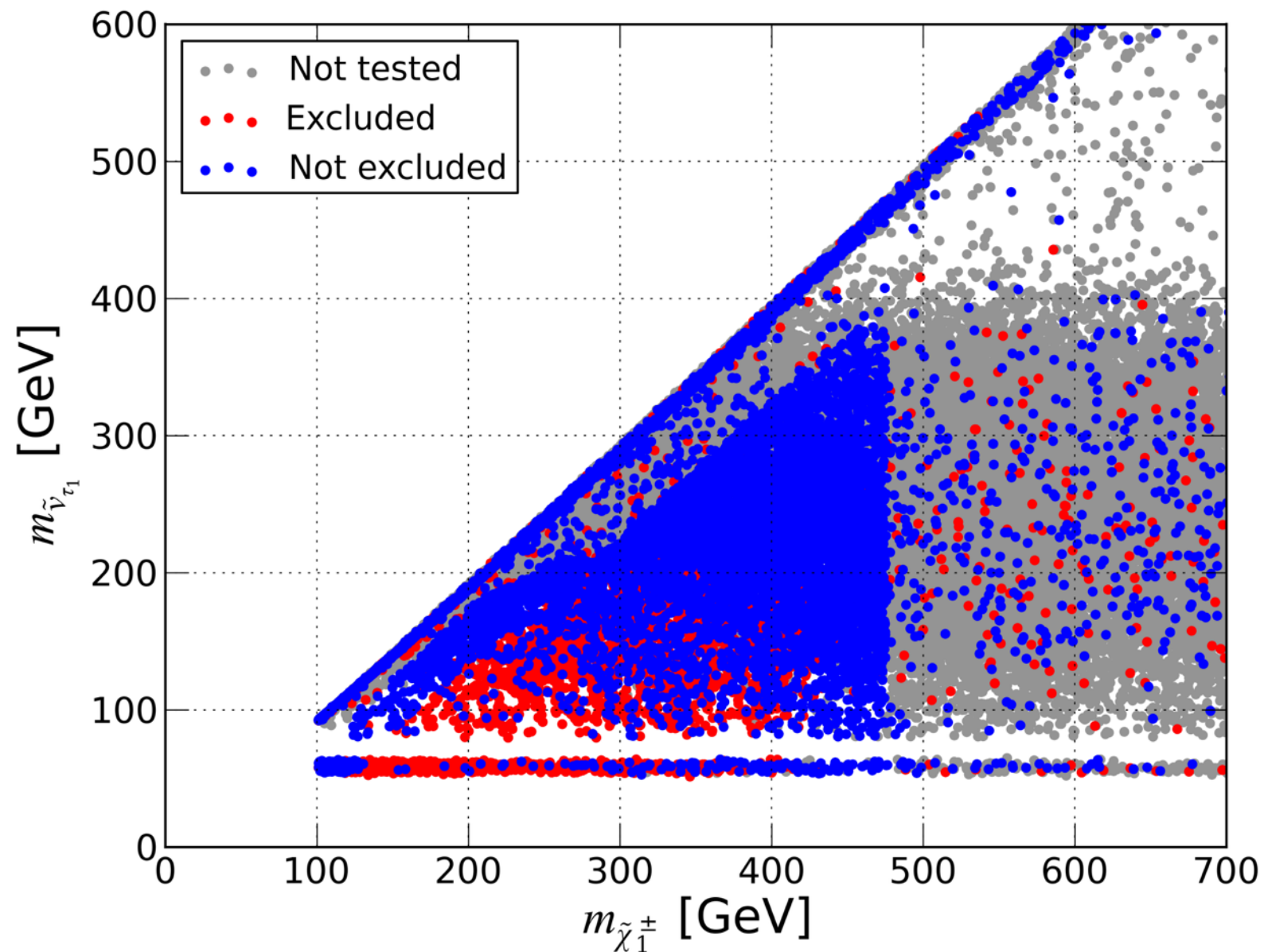
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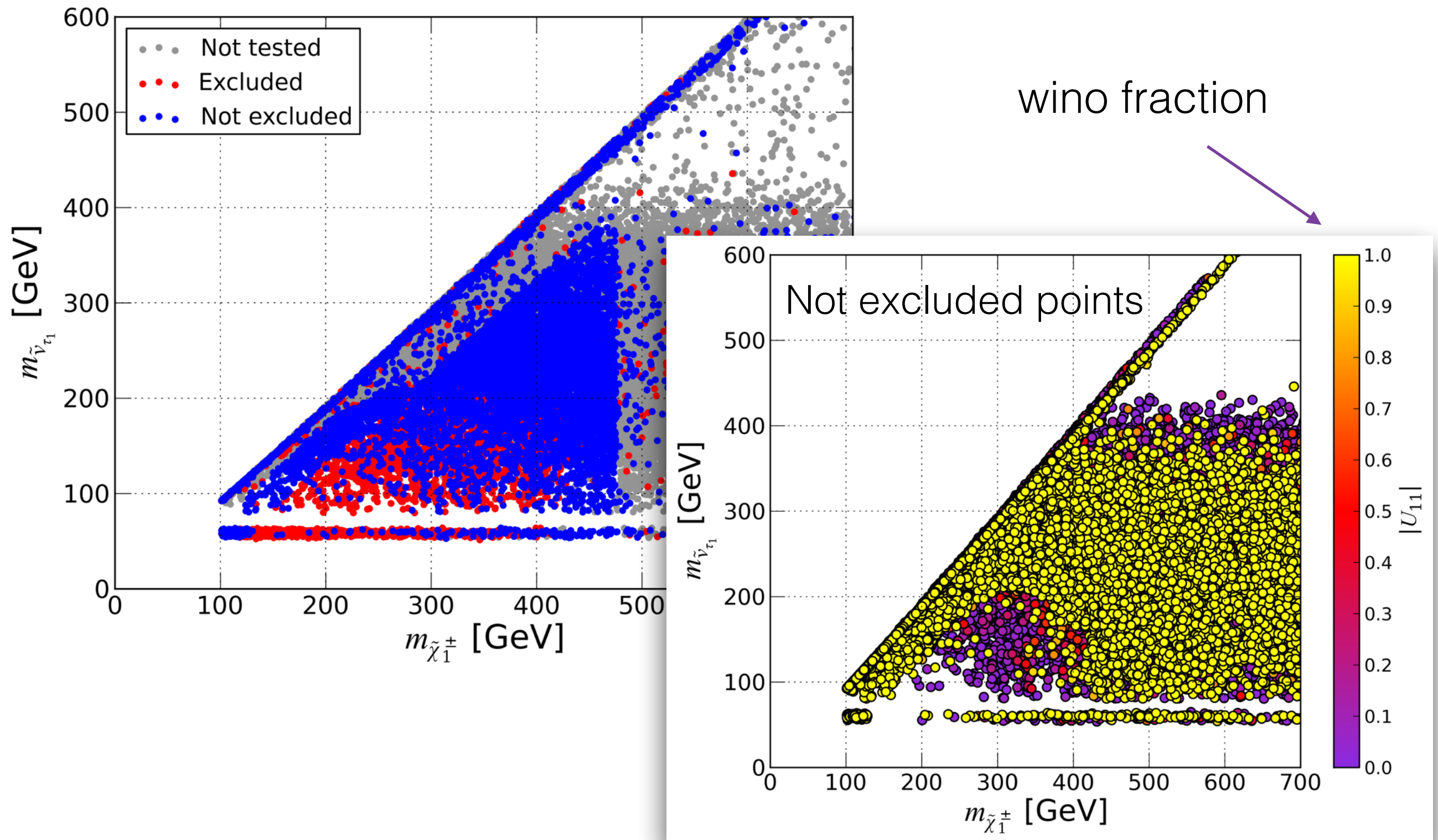
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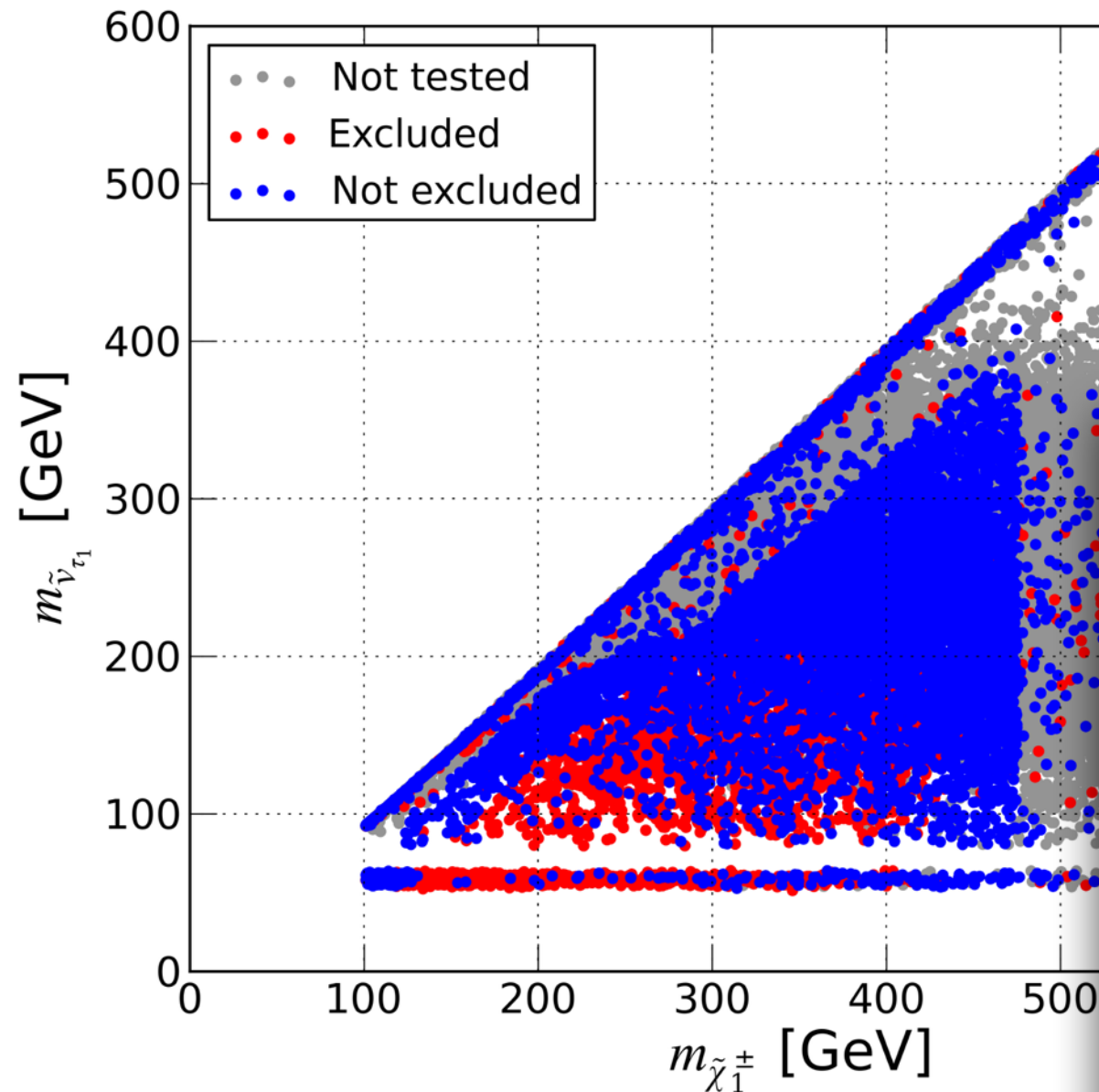
However, many points remain allowed



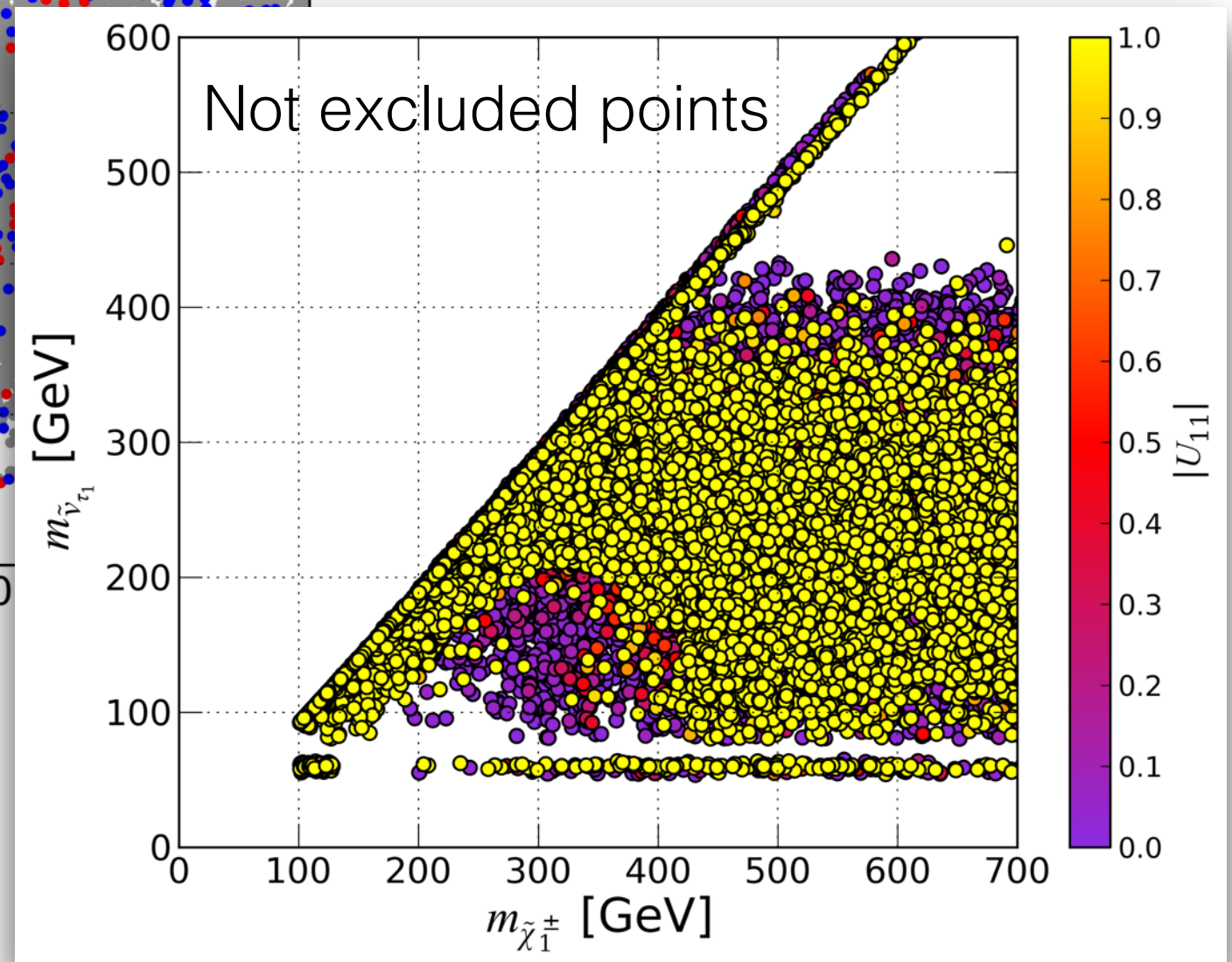
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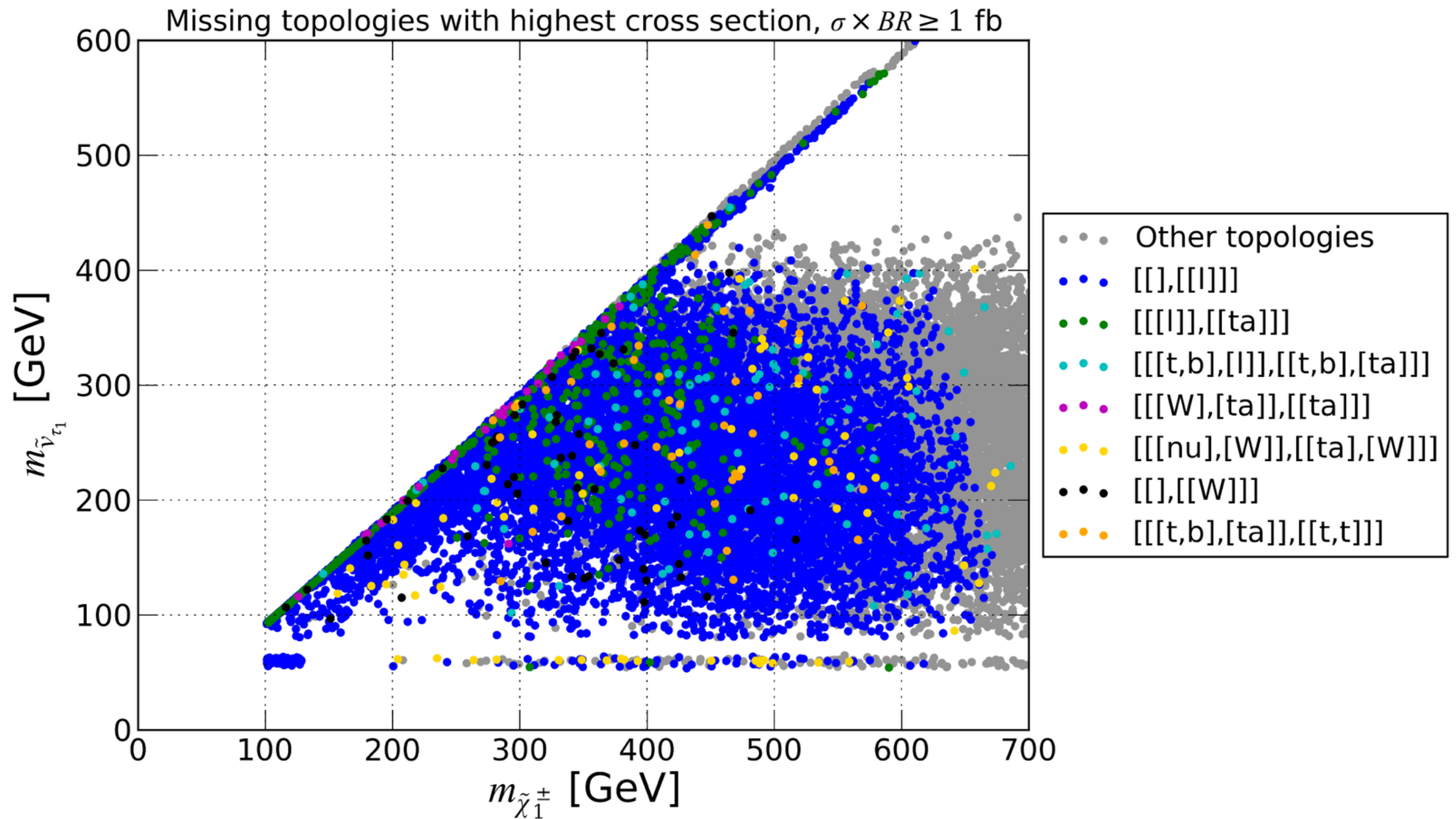


wino fraction

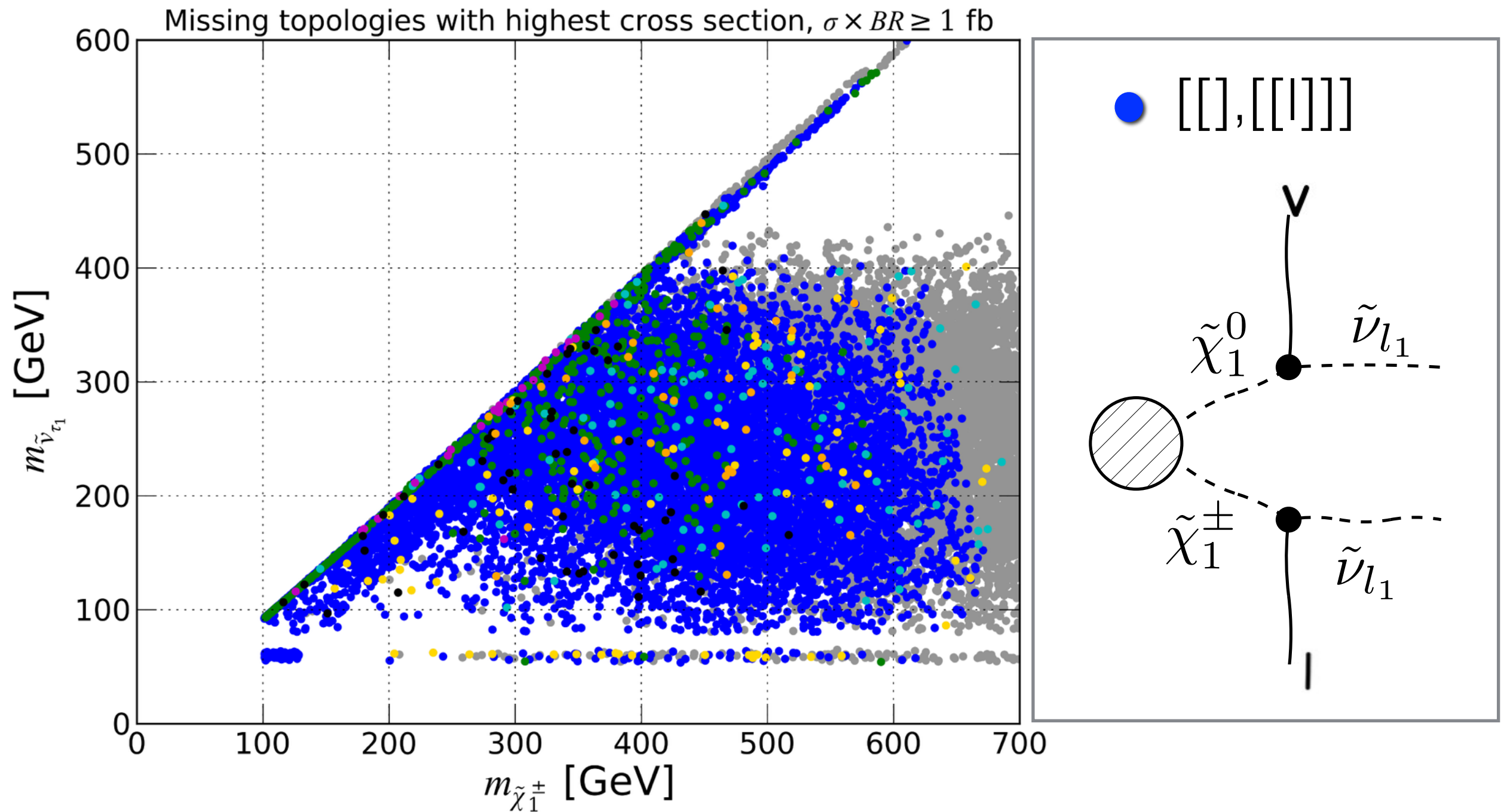


- higgsino-like charginos
- ▶ smaller production cross section
- ▶ larger branching to tau final states

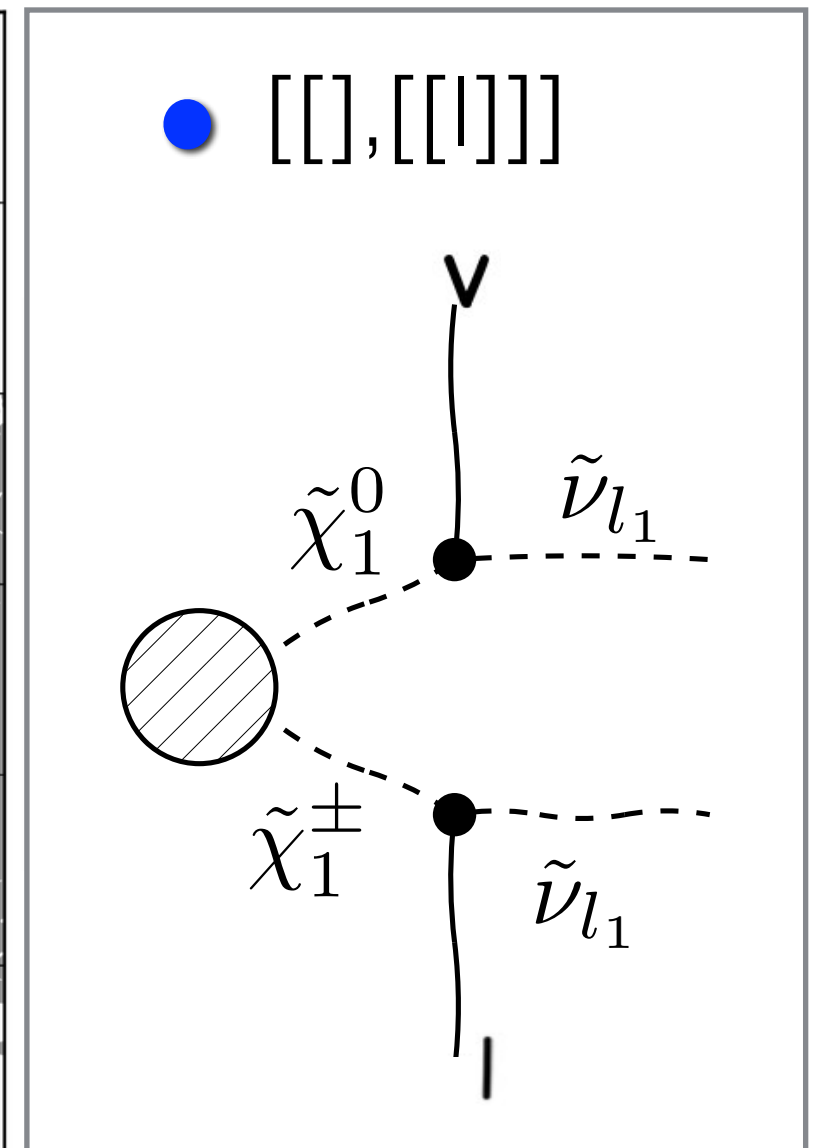
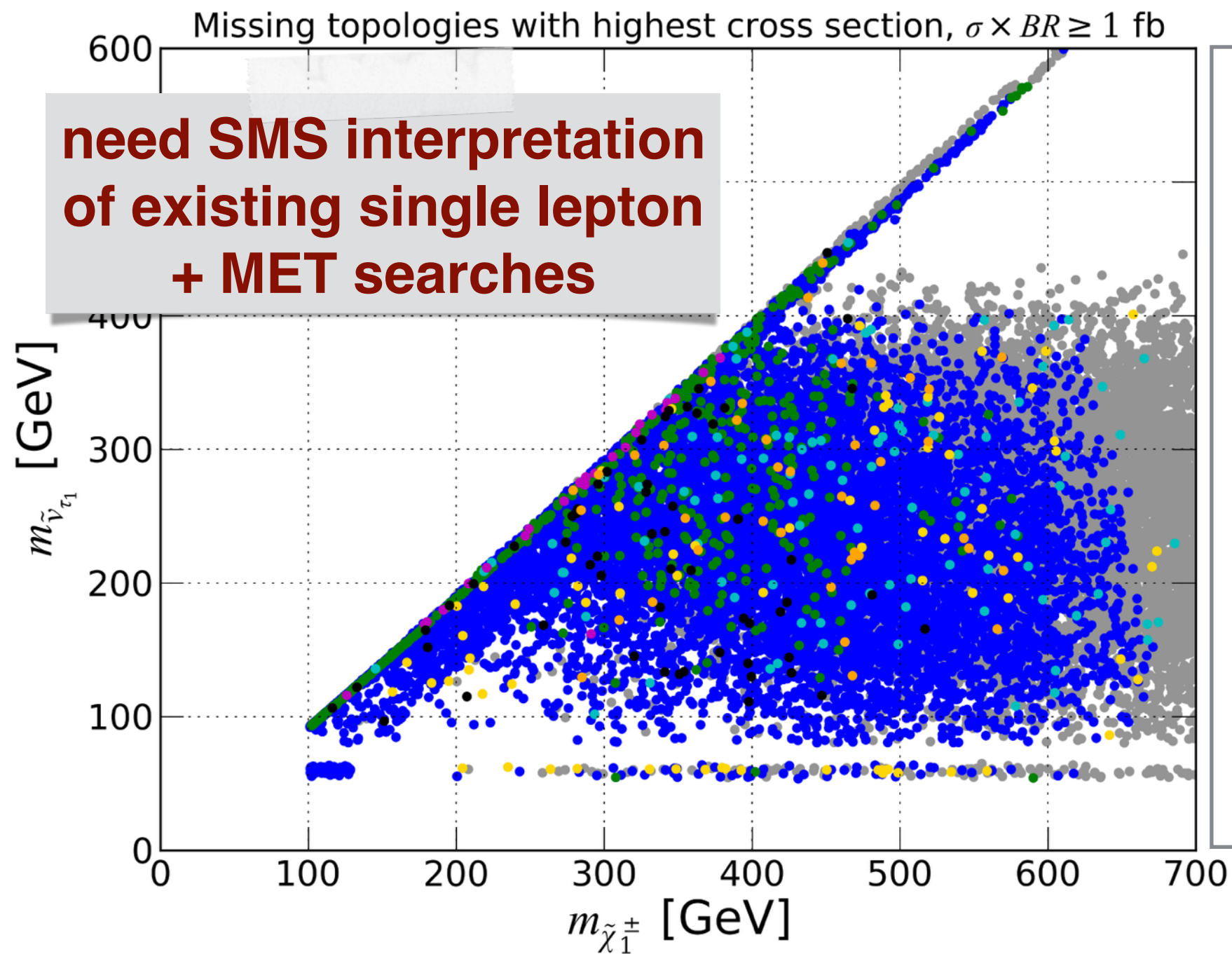
Those can be tested by topologies not yet considered by ATLAS and CMS



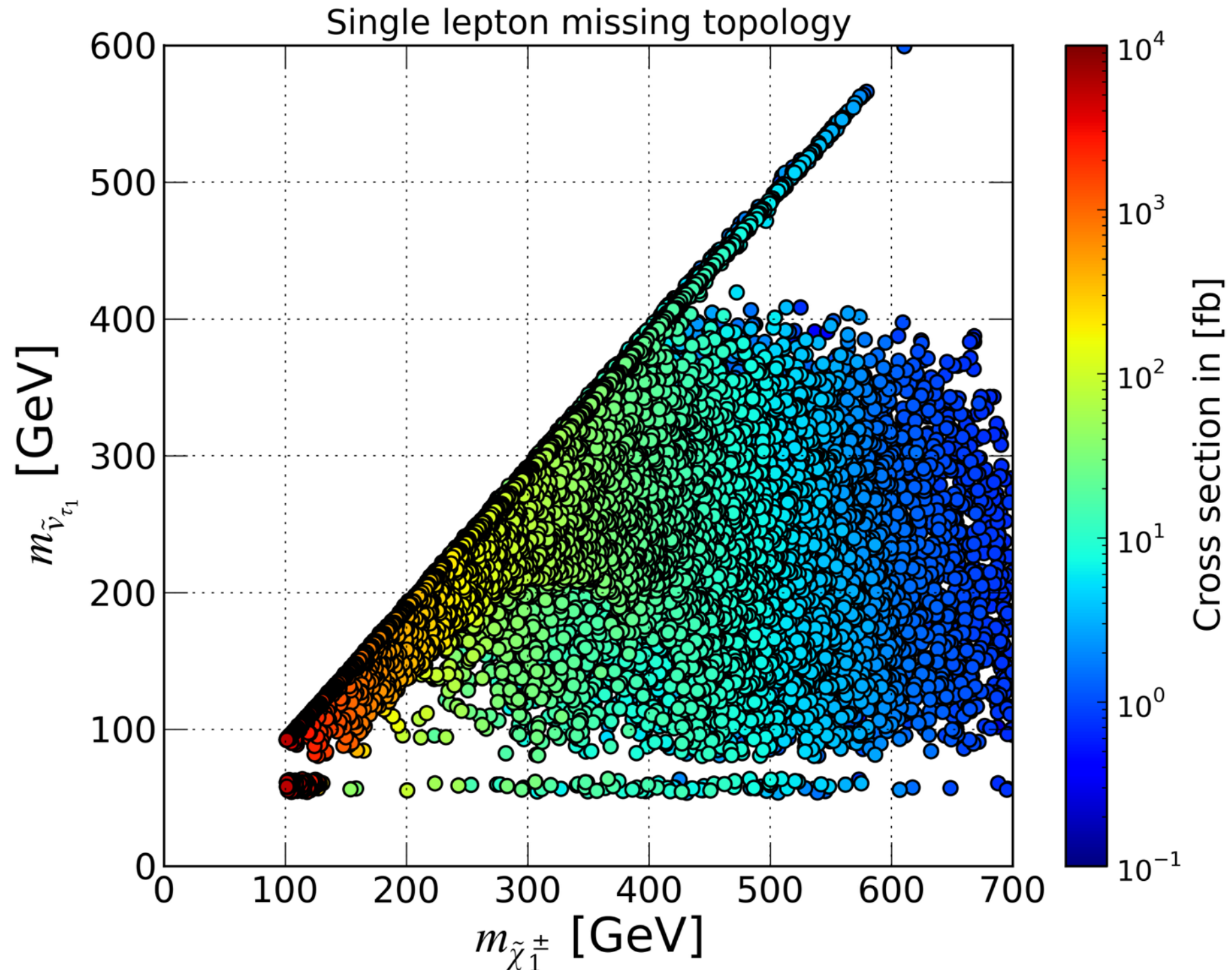
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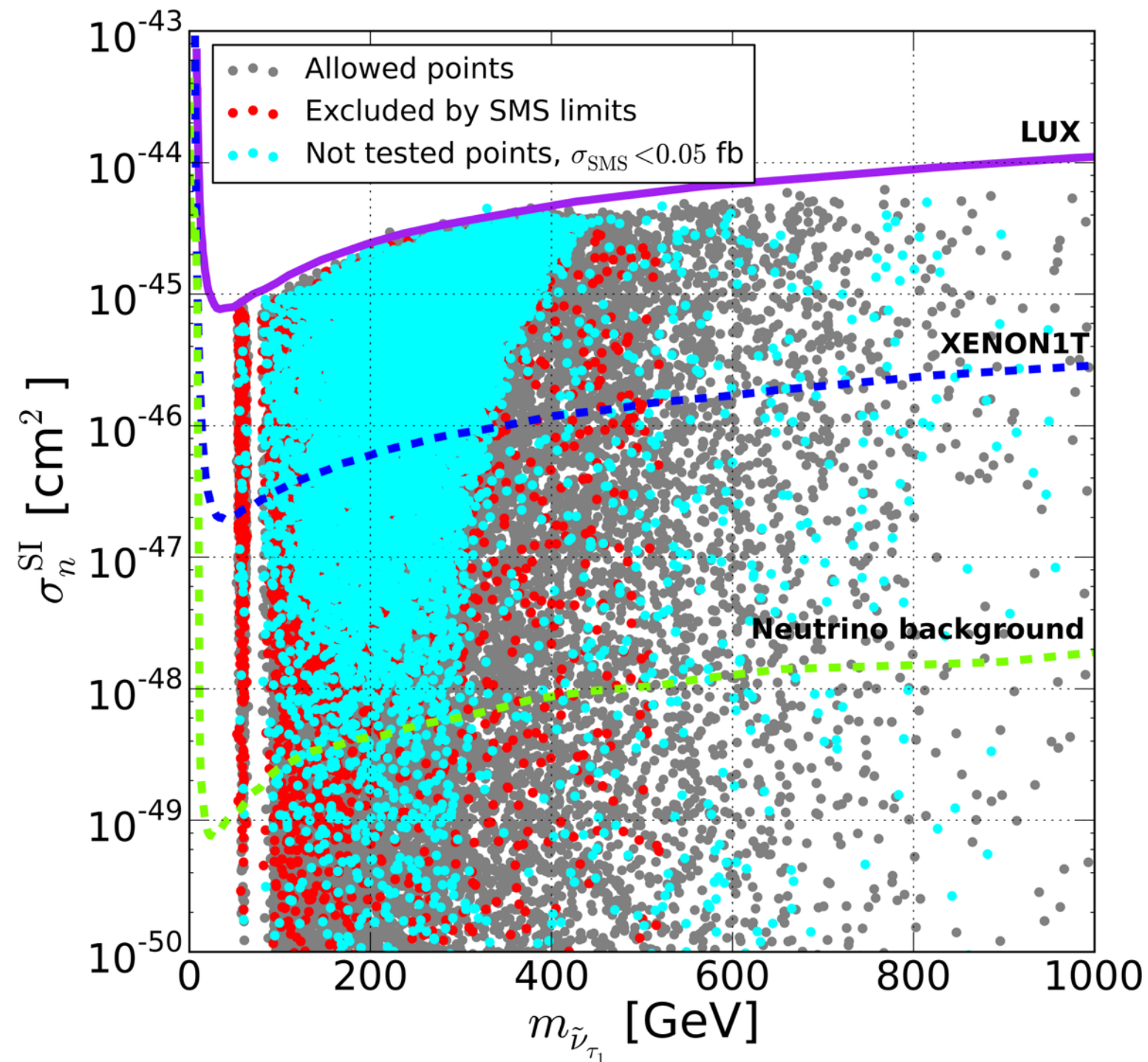
Those can be tested by topologies not yet considered by ATLAS and CMS



The single lepton topology can have a large cross section

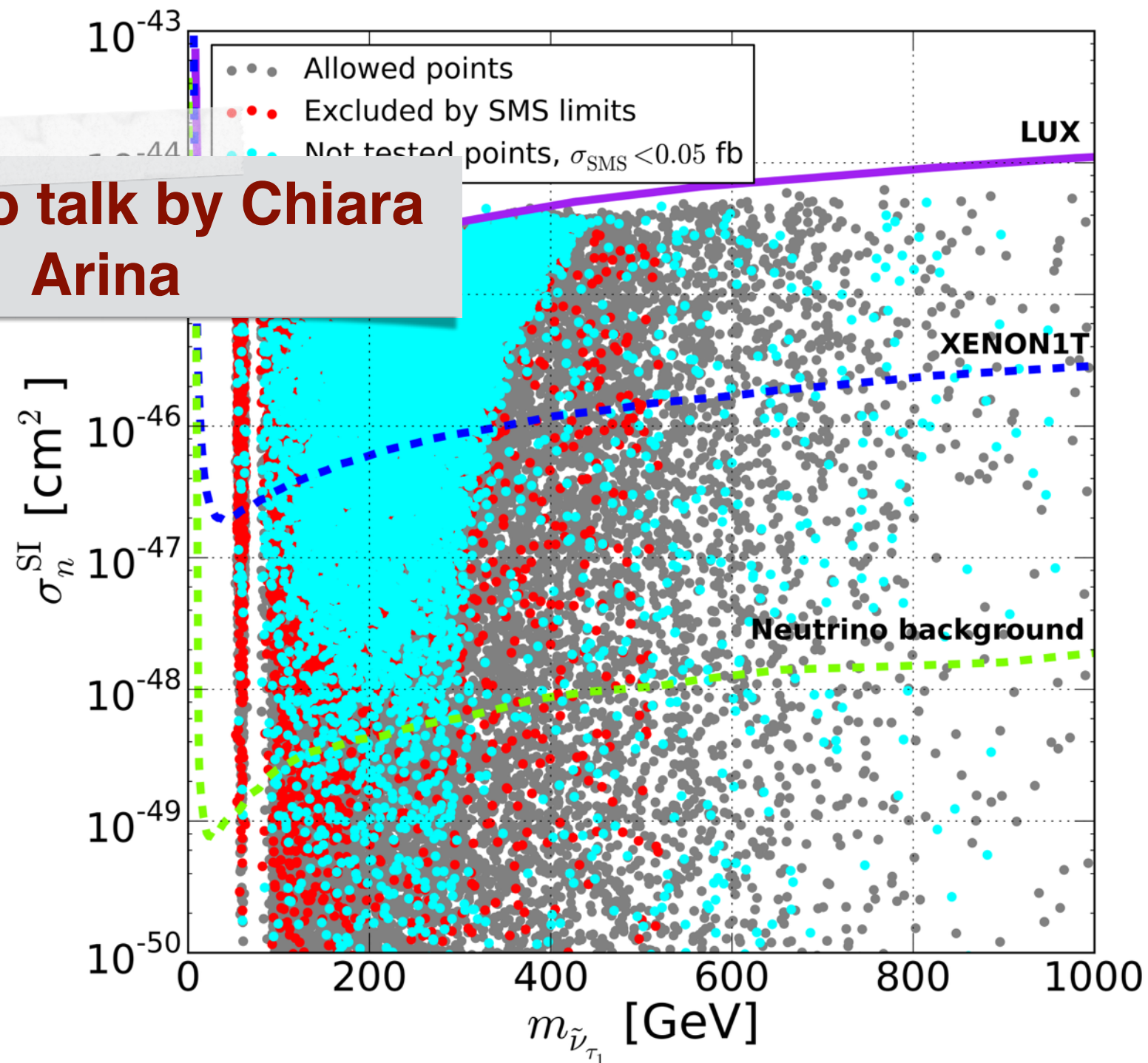


LHC searches and direct dark matter detection experiments are complementary



LHC searches and direct dark matter detection experiments are complementary

see also talk by Chiara Arina



Conclusion

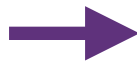
- ▶ Existing LHC results can constrain the MSSM+RN
- ▶ In particular dilepton+MET searches constrain chargino pair production
- ▶ Constraints obtained for slepton production (followed by a decay to a neutralino) apply to pair produced charginos (decaying to a sneutrino)
- ▶ Single lepton searches considering chargino-neutralino production followed by a decay to sneutrino would test the model further
- ▶ LHC constraints are complementary to direct dark matter searches
- ▶ Many points feature long-lived gluinos (especially if it is the NLSP), those points were excluded from the study

Backup

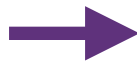

We used MultiNest to sample the parameter space

GUT scale Parameters	Prior range
M_1, M_2	(-4000, 4000) GeV
$\log_{10}(M_3/\text{GeV})$	(-4, 4)
$\log_{10}(m_Q/\text{GeV})$	(2, 5)
m_L, m_R	(1, 2000) GeV
m_N	(1, 2000) GeV
$\log_{10}(A_Q/\text{GeV})$	(-5, 5)
A_L	(-4000, 4000) GeV
$A_{\tilde{\nu}}$	(-1000, 1000) GeV
$\log_{10}(m_H/\text{GeV})$	(1, 5)
$\tan \beta$	(3, 50)

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using the following observables and constraints

Observable	Value / constraint
m_h	$125.85 \pm 0.4 \text{ (exp)} \pm 4 \text{ (theo)} \text{ GeV}$
$\text{BR}(B \rightarrow X_s \gamma) \times 10^4$	$3.55 \pm 0.24 \pm 0.09 \text{ (exp)}$
$\text{BR}(B \rightarrow \mu^+ \mu^-) \times 10^9$	$3.2 (+1.4 -1.2) \text{ (stat)} (+0.5 -0.3) \text{ (sys)}$
$\Omega_{\text{DM}} h^2$	$0.1186 \pm 0.0031 \text{ (exp)} \pm 20\% \text{ (theo)}$
$\Delta\Gamma_Z^{\text{invisible}}$	$< 2 \text{ MeV (95\% CL)}$
$\text{BR}(h \rightarrow \text{invisible})$	$< 20\% \text{ (95\% CL)}$
$m_{\tilde{\tau}_1^-}$	$> 85 \text{ GeV (95\% CL)}$
$m_{\tilde{\chi}_1^+}, m_{\tilde{e}, \tilde{\mu}}$	$> 101 \text{ GeV (95\% CL)}$
$m_{\tilde{g}}$	$> 308 \text{ GeV (95\% CL)}$
σ_n^{SI}	$< \sigma_{\text{LUX}}^{SI} \text{ (90\% CL)}$

Measurements

Limits

To use SModelS with a non-MSSM scenario, just define all new particles as r-Even or r-Odd

You can then use SModelS to decompose a point in your BSM scenario, using as input

- an **LHE file** containing simulated events, or
- an **SLHA file** containing the full mass spectrum, decay tables and the SUSY production cross sections

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additional checks, in particular SModelS can flag points with long-lived particles, where current SMS limits do not apply

Using SModelS for non-MSSM scenarios

Simply declare all new particles as
R-even or R-odd in `smodels/particles.py`

Example

```
rOdd = {9000000 : "newROdd",  
        100021  : "gluino",  
        100022  : "N1",  
        ...  
rEven = {8000000 : "newREven",  
         25      : "higgs",  
         ...
```


Additional feature for SLHA input files

SModelS can test the consistency of an SLHA input file

In particular

Current experimental constraints require final states containing missing transverse energy

→ results apply only for prompt decays

points with visible displaced vertices or heavy charged particle tracks cannot be tested against existing SMS results

→ we flag points with long-lived particles ($c\tau > 10\text{ mm}$)

Requires additional information on the quantum numbers of the new states to decide if a displaced vertex is visible or not

this is also defined in `smodels/particles.py`

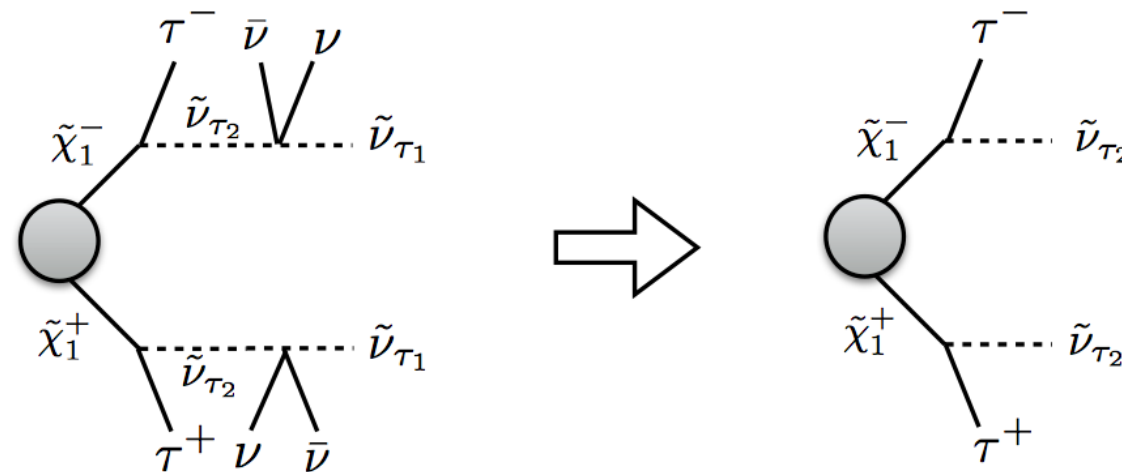
```
qNumbers={  
    35: [0, 0, 1],  
    36: [0, 0, 1],  
    37: [0, 3, 1],  
    1000024: [1, 3, 1],  
    ...  
}
```

giving 2*spin, 3*electrical charge, colour dimension

Compression of final states

Invisible compression

compress fully invisible vertices at the end of a decay chain



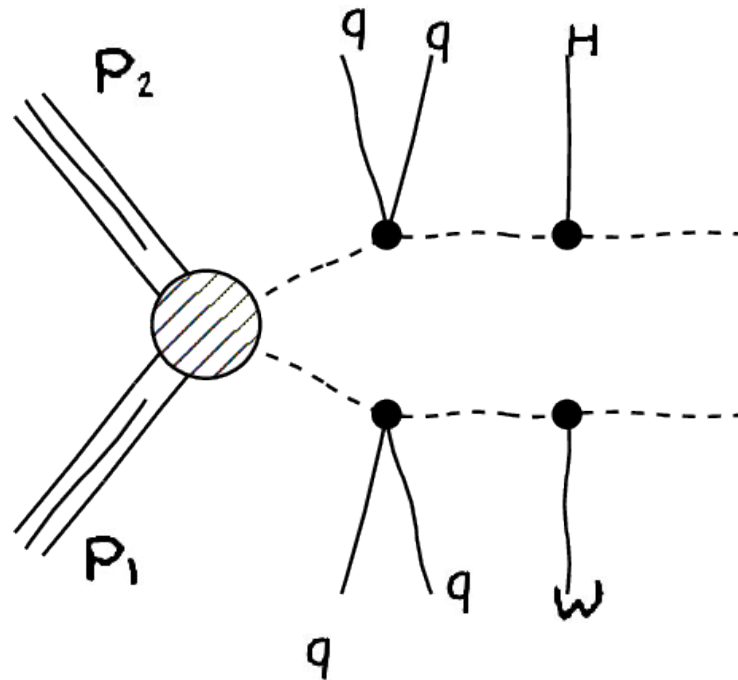
Mass compression

compress vertices where the mass splitting is small, decay products will be too soft to be detected

we used 5 GeV as the threshold value

How to read the element description

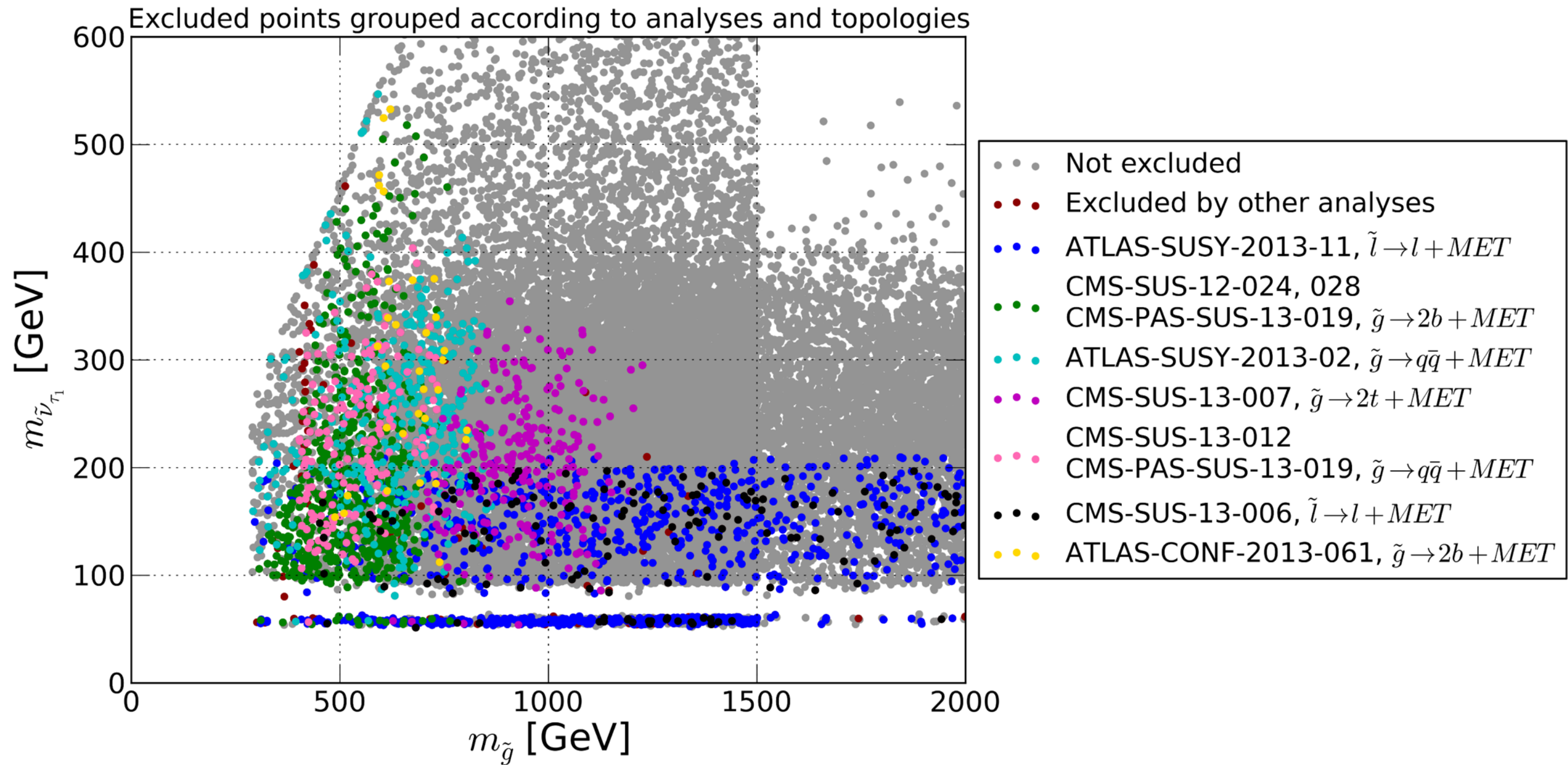
Example: gluino production, decay via chargino/neutralino



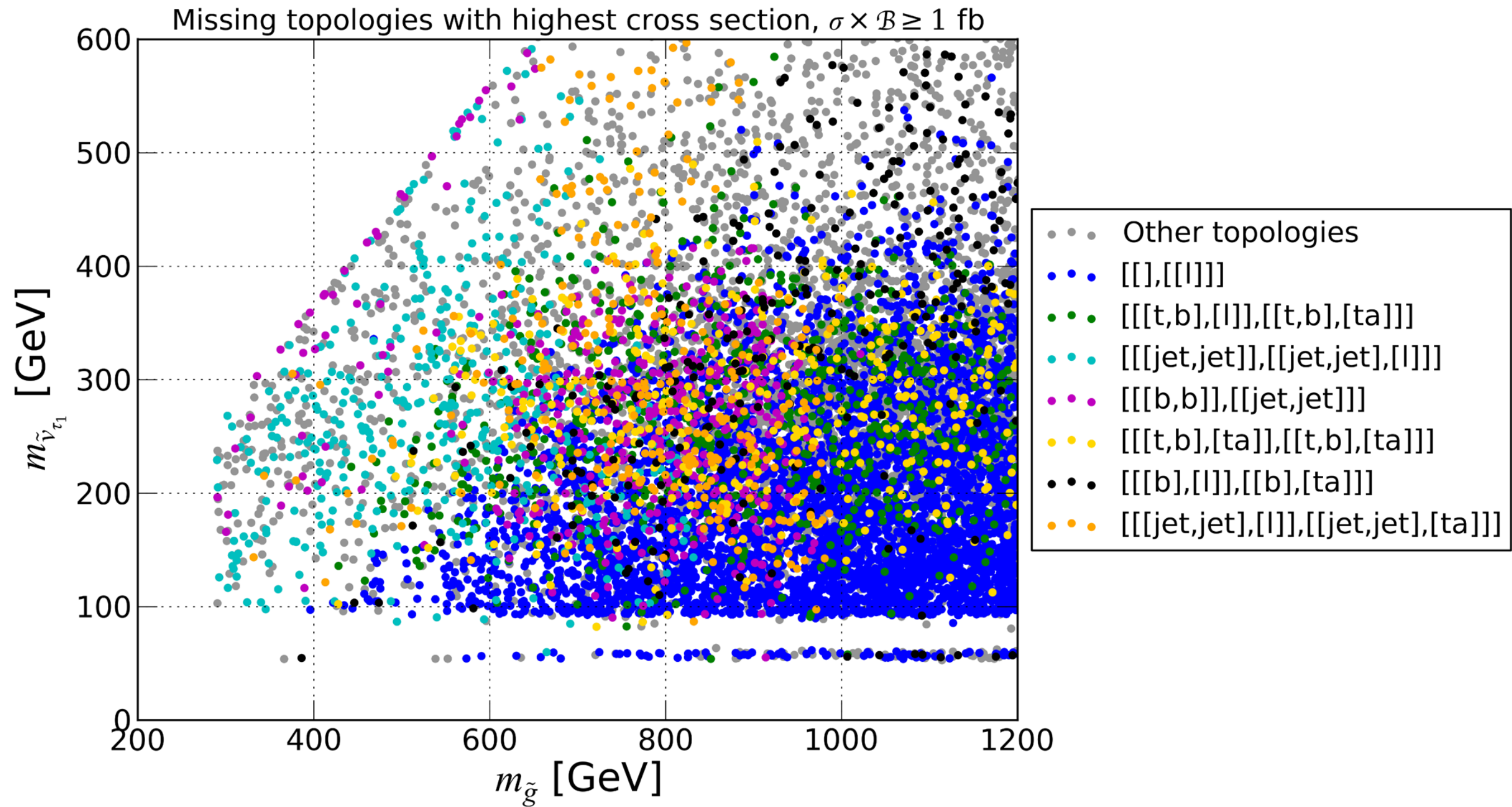
in SModelS language this is

[[[jet,jet],[H]],[[jet,jet],[W]]]

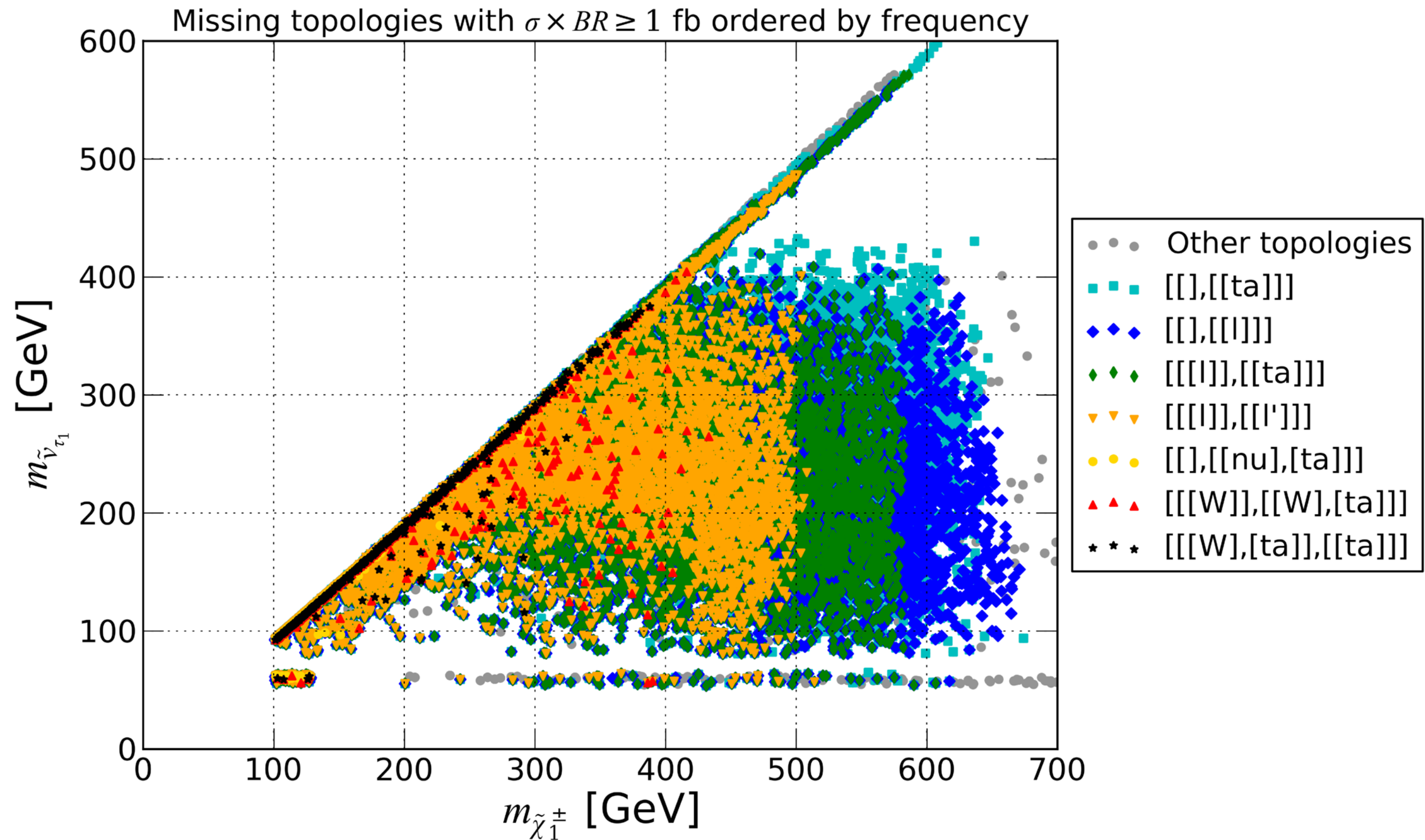
Constraints on the strong sector



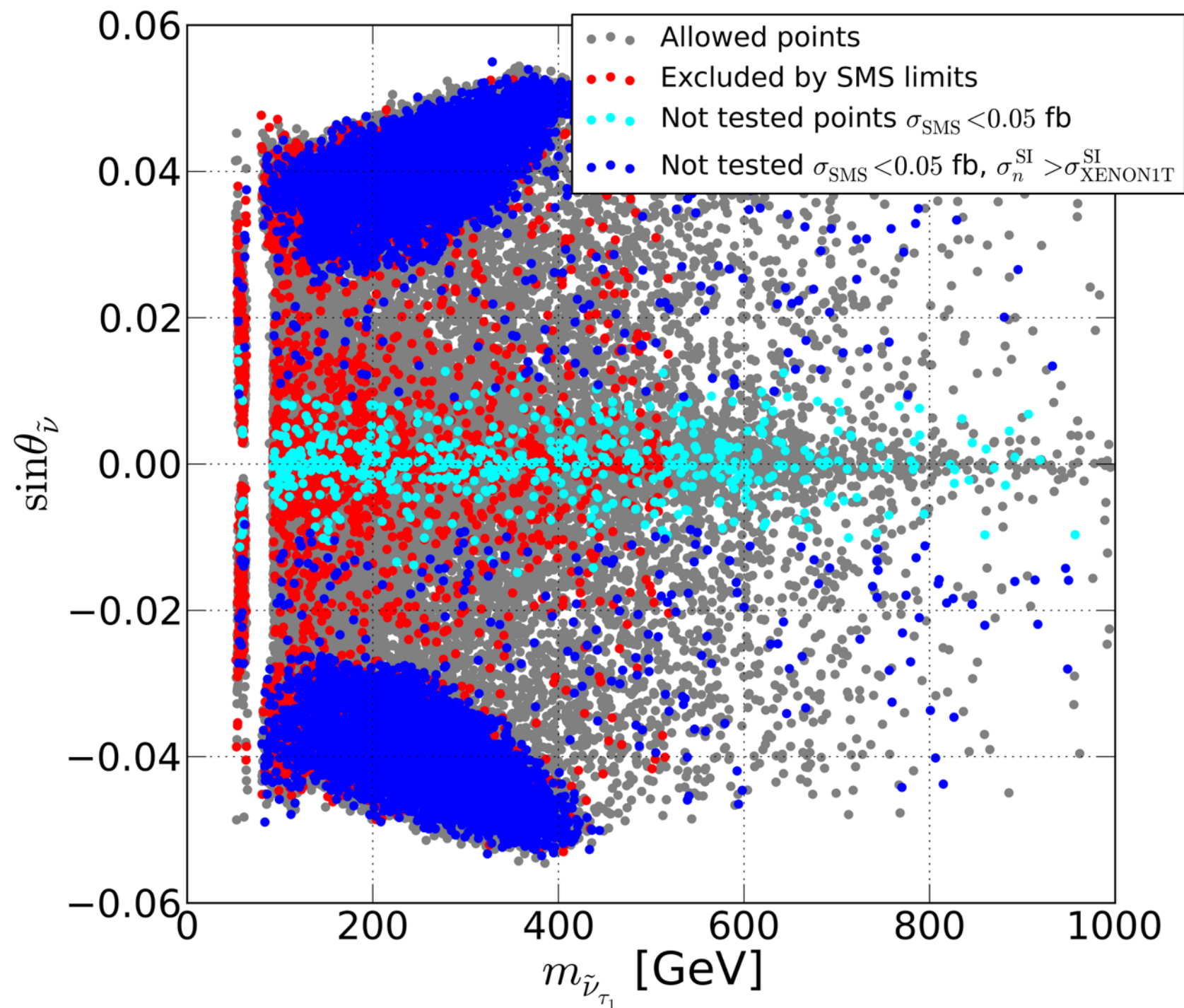
Missing topologies



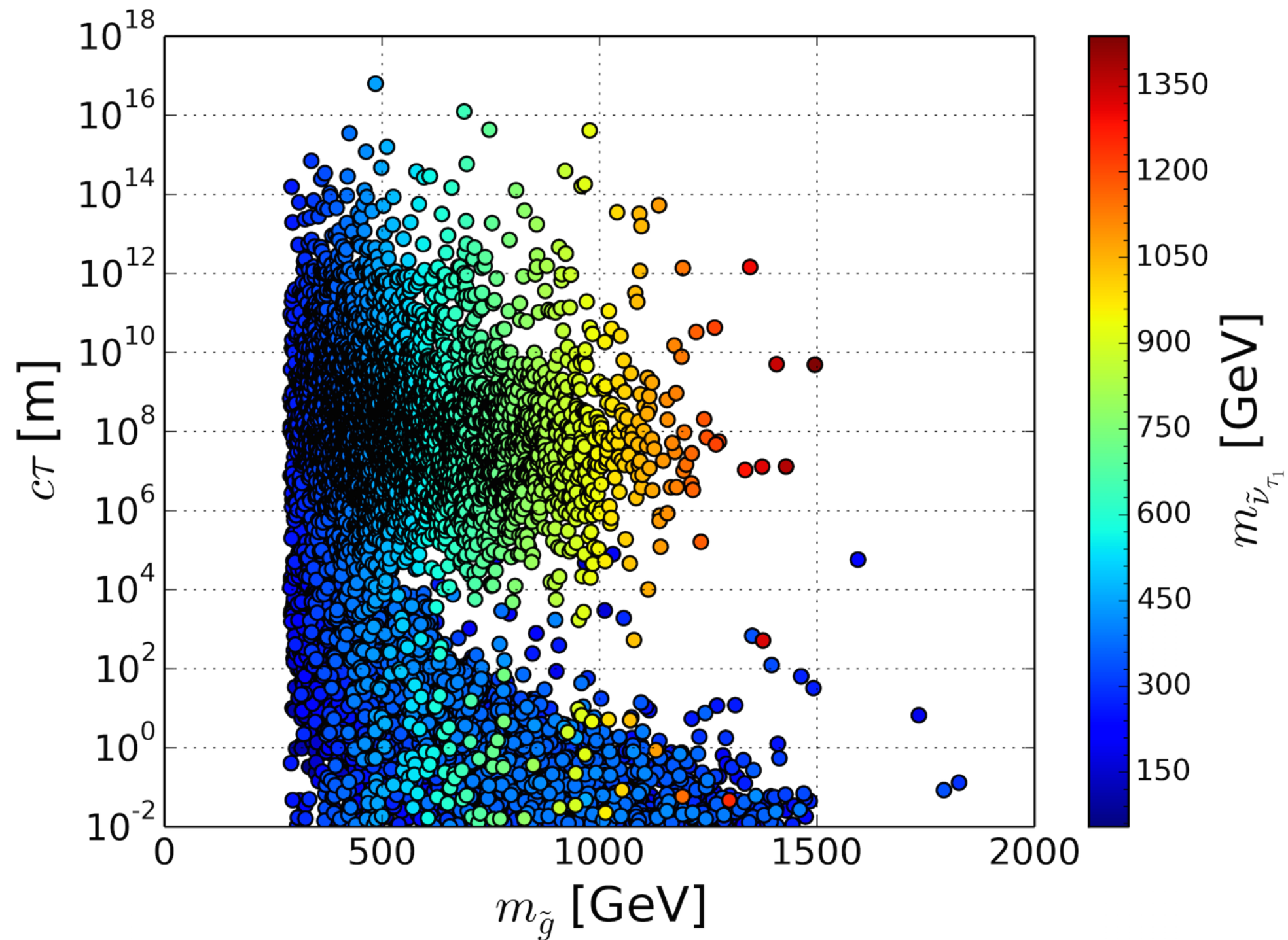
Most frequent missing topologies



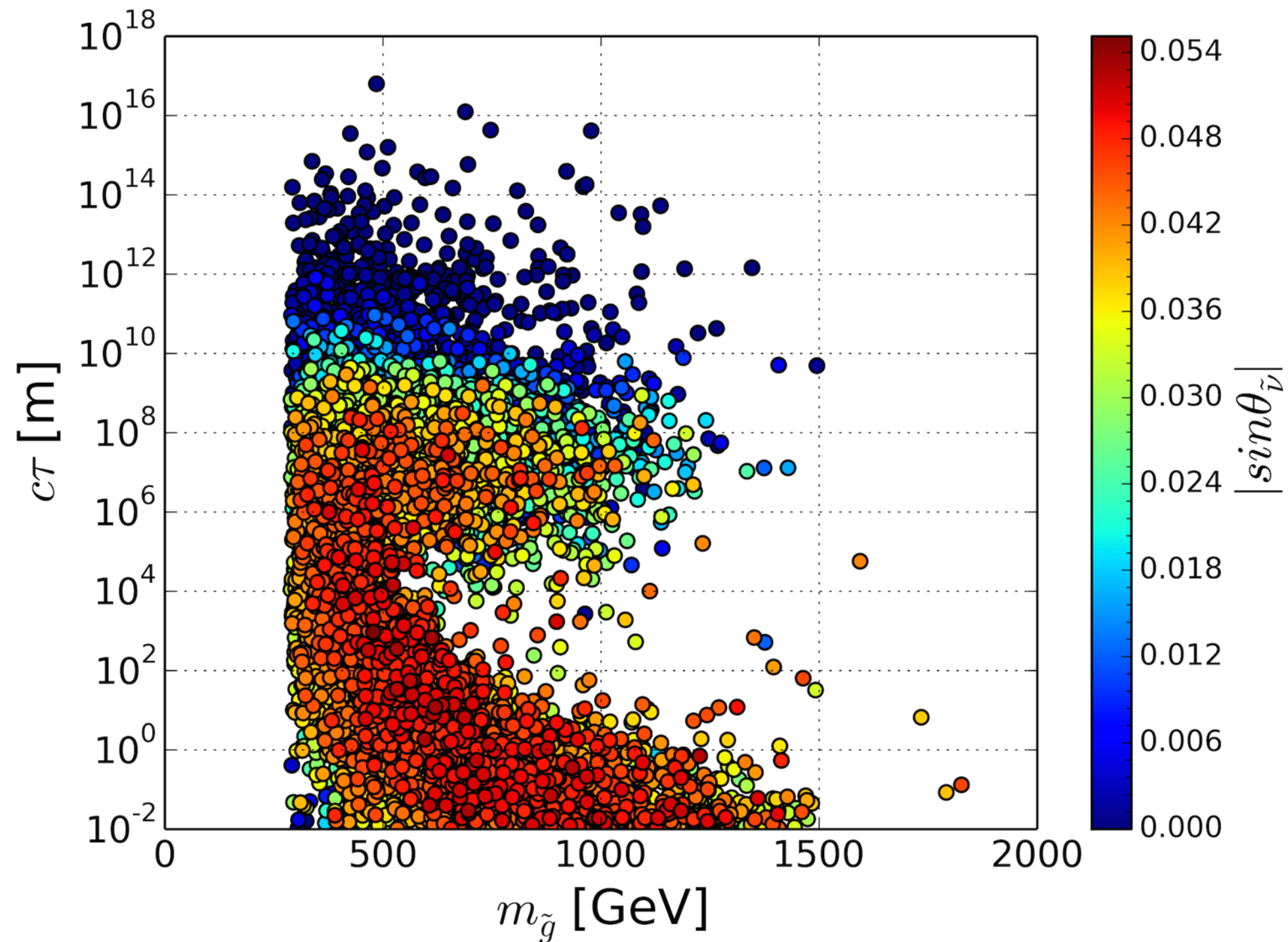
Dependence on the mixing angle



Many points feature long-lived gluinos



Many points feature long-lived gluinos

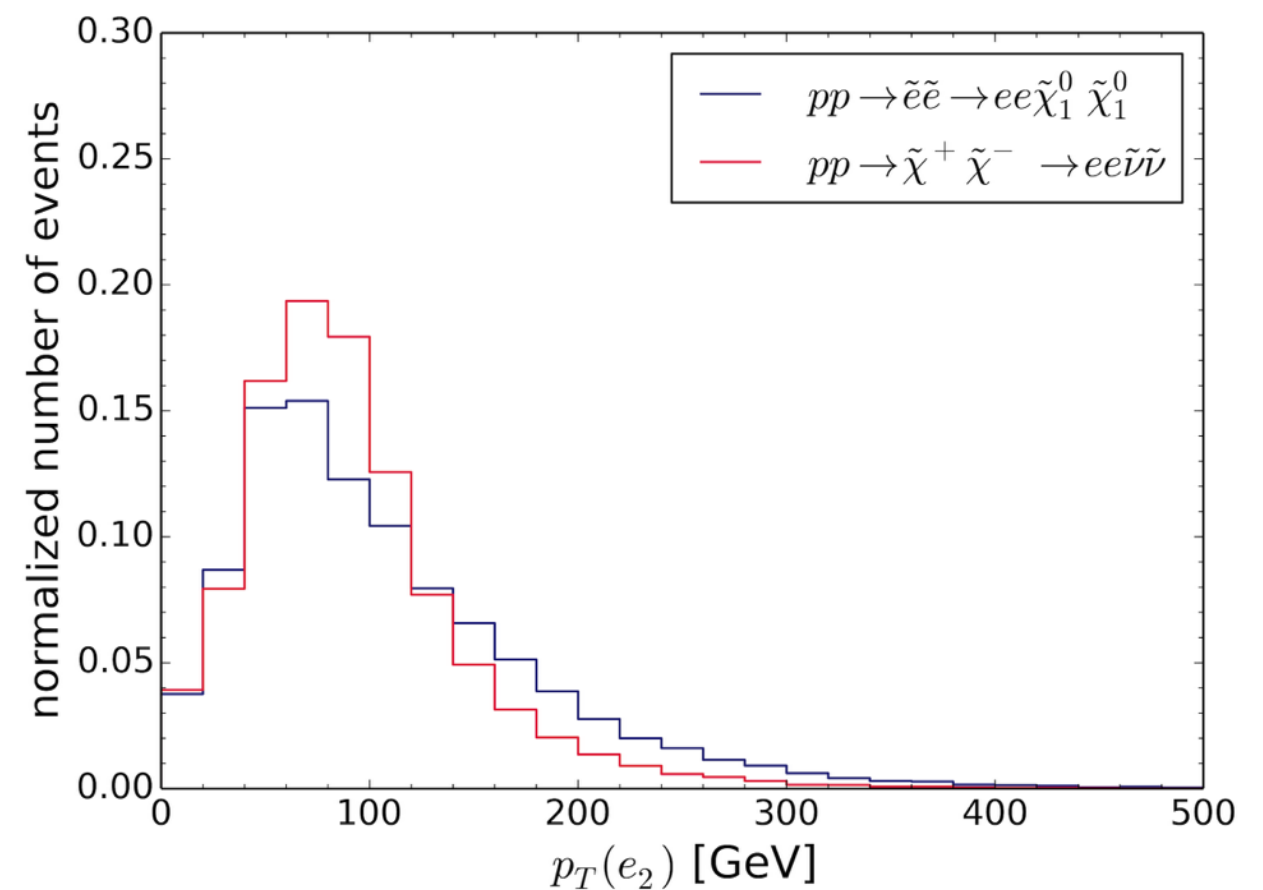
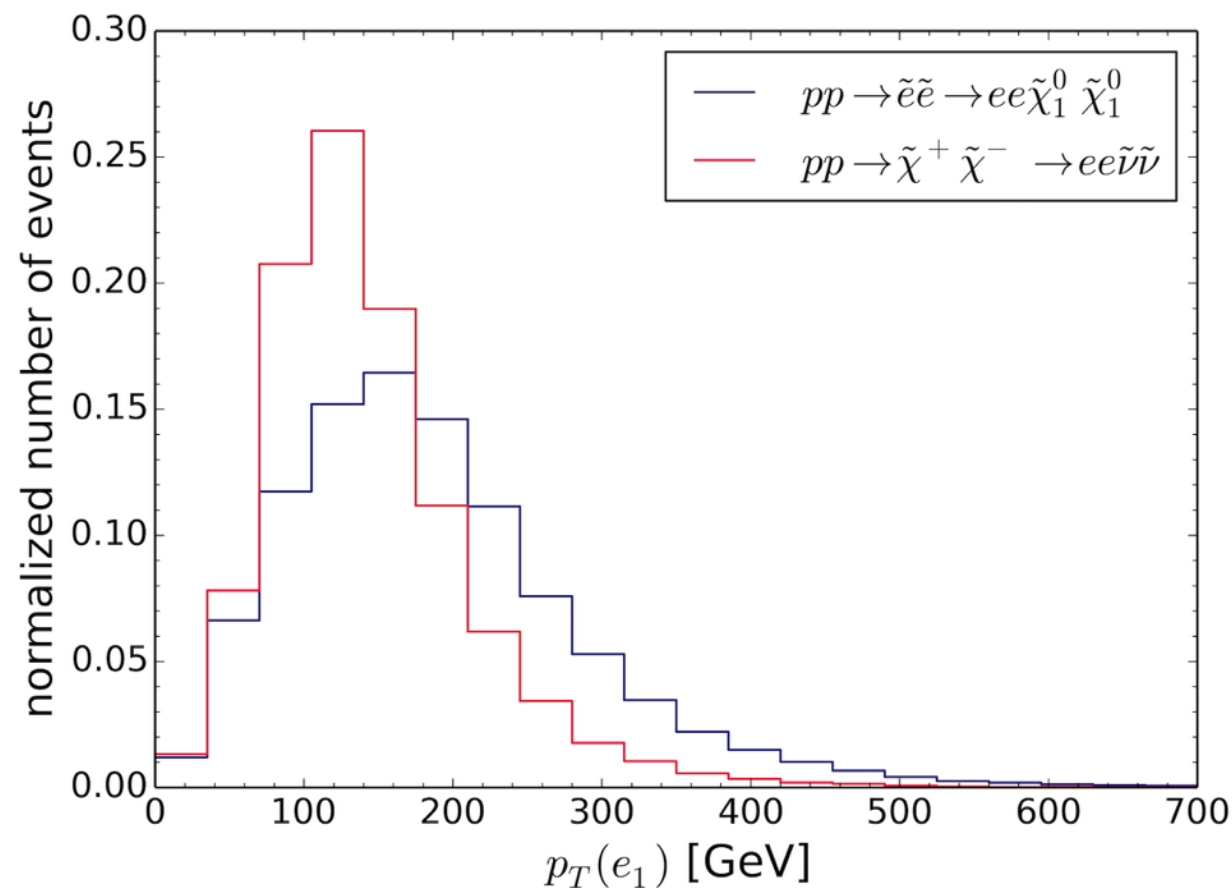


Do the slepton limits apply to chargino production?

test this for ATLAS-SUSY-2013-11, using the MadAnalysis 5 implementation
(B. Dumont, INSPIRE-1326686)

Compare the corresponding efficiencies in a benchmark scenario with

$$m_{mother} = 270 \text{ GeV}, m_{LSP} = 100 \text{ GeV}$$

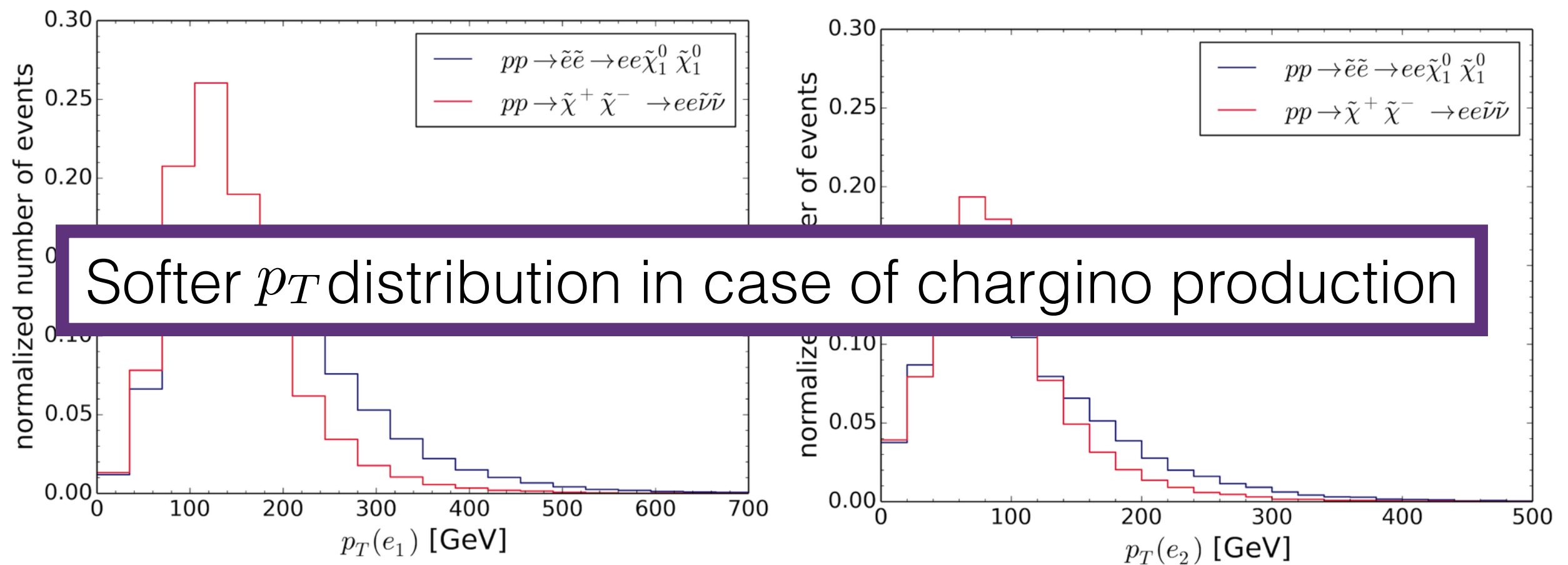


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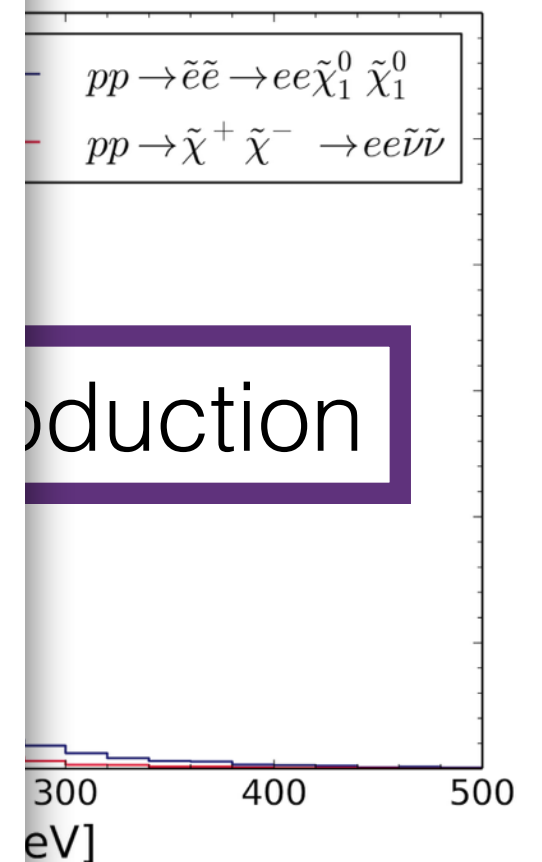
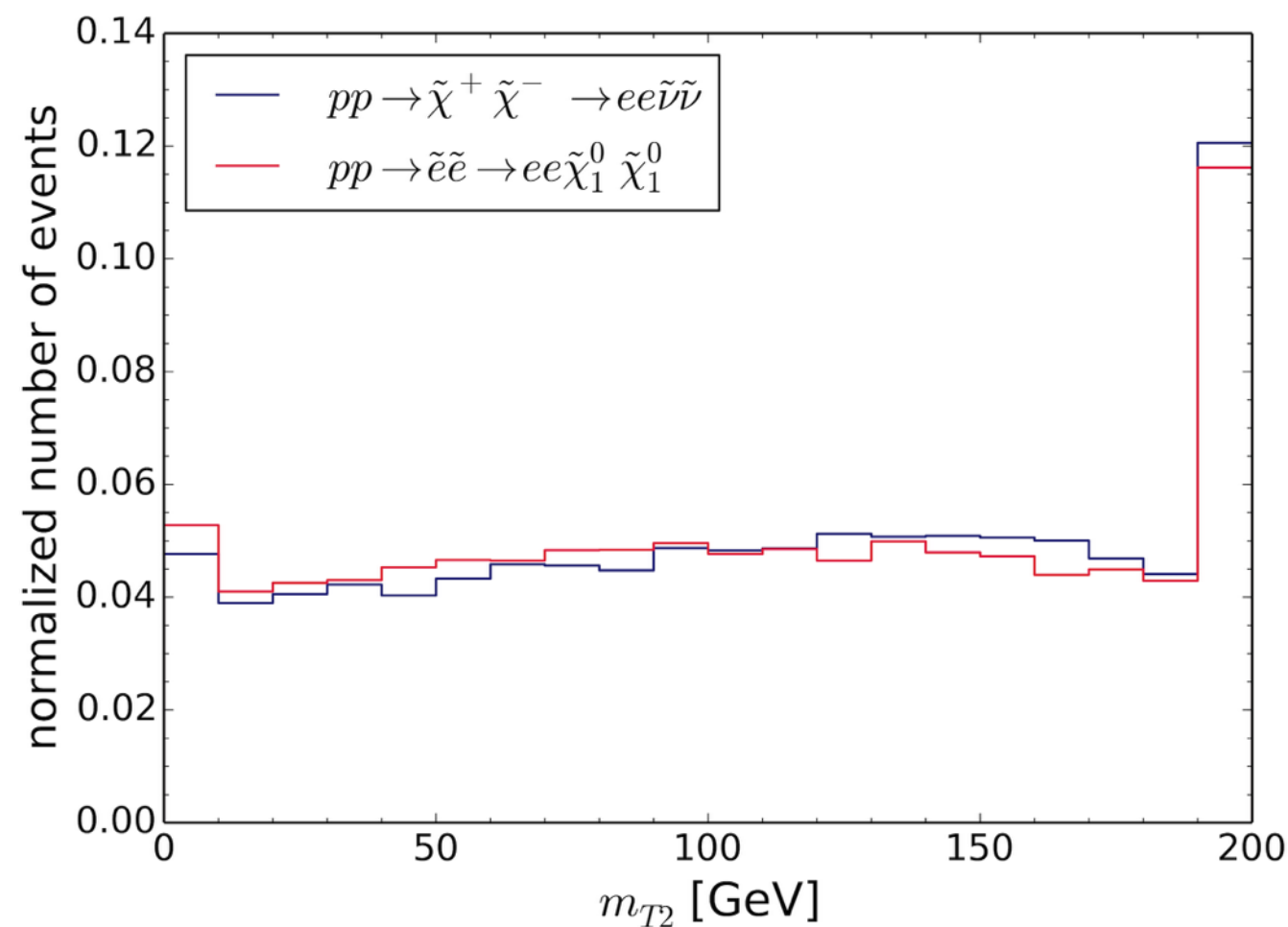
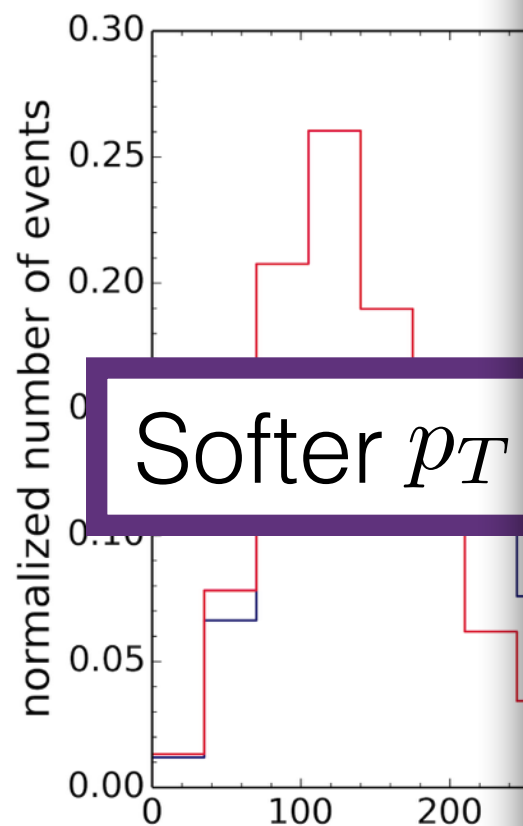


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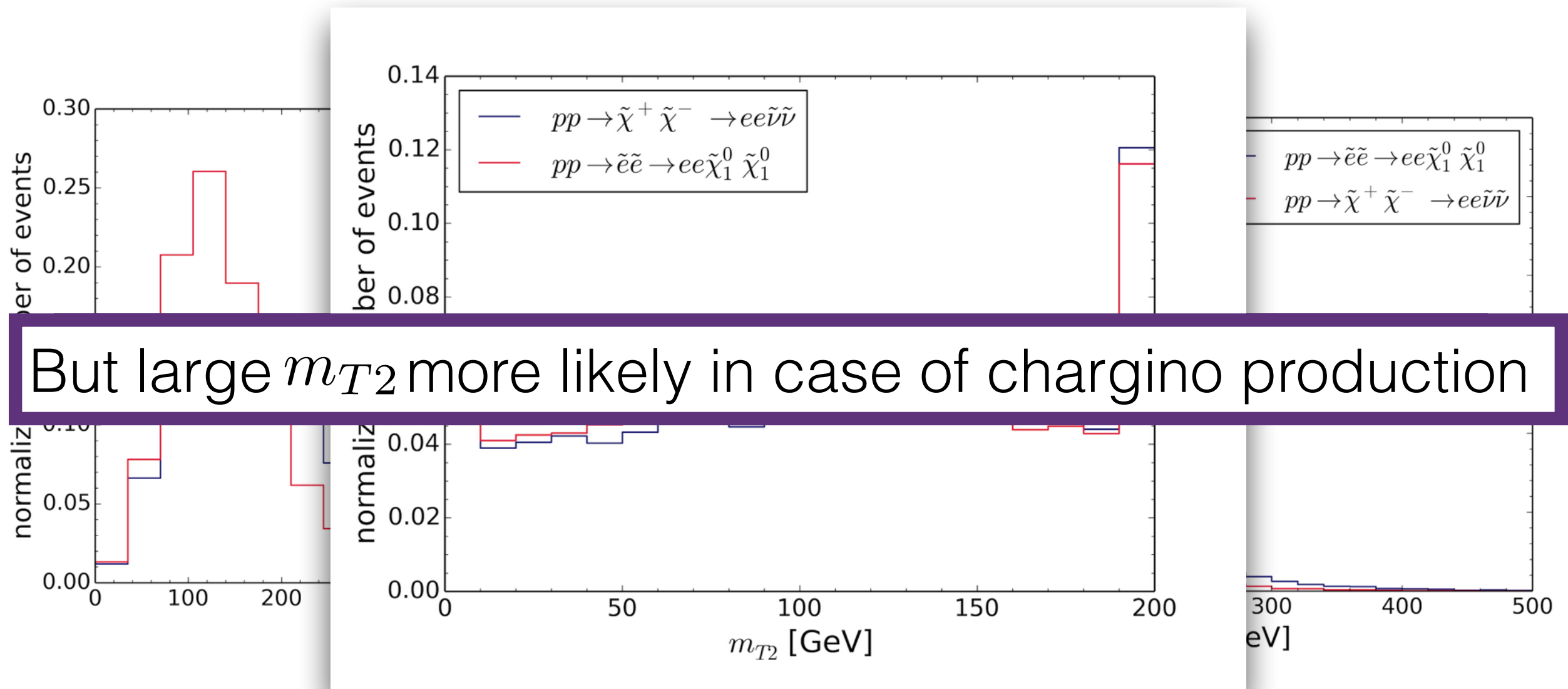


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Cutflow shows that final efficiencies are comparable

Cut	Slepton production	Chargino production
Common preselection		
Initial number of events	50000	50000
2 OS leptons	35133	33464
$m_{ll} > 20$ GeV	35038	33337
τ veto	35007	33318
ee leptons	35007	33318
jet veto	20176	19942
Z veto	19380	18984
Different m_{T2} regions		
$m_{T2} > 90$ GeV	11346	11594
$m_{T2} > 120$ GeV	8520	8828
$m_{T2} > 150$ GeV	5723	5926

→ We can safely use the results
to constrain chargino production

Cutflow comparison for

$$m_{mother} = 270 \text{ GeV}, m_{LSP} = 200 \text{ GeV}$$

Cut	Slepton production	Chargino production
Common preselection		
Initial number of events	50000	50000
2 OS leptons	29291	27244
$m_{ll} > 20 \text{ GeV}$	29082	26964
τ veto	29050	26956
ee leptons	29050	26956
jet veto	16834	16114
Z veto	15281	14025
Different m_{T2} regions		
$m_{T2} > 90 \text{ GeV}$	3028	3198
$m_{T2} > 120 \text{ GeV}$	85	140
$m_{T2} > 150 \text{ GeV}$	0	0