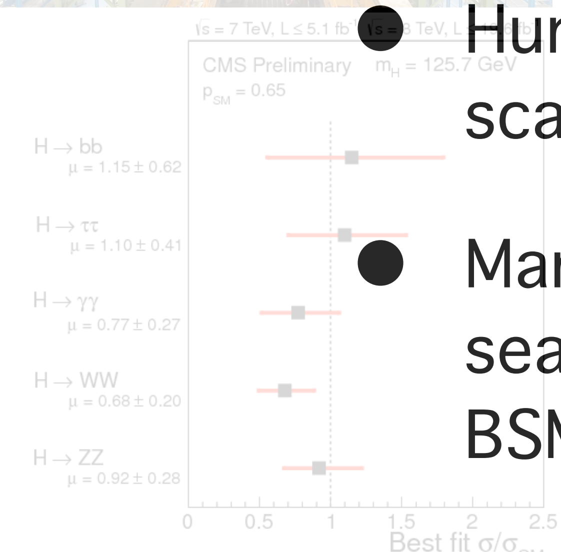
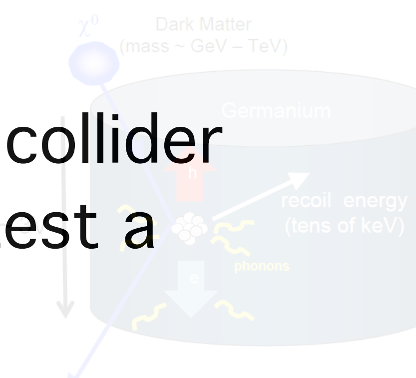
Hi!

Simplifying life with simplified models

Suchita Kulkarni (LPSC, Grenoble)

based on:
arXiv: 1312.4175
S. Kraml, U. Laa, A. Lessa, W. Magerl, D. Proschofsky, W. Waltenberger
and
arXiv: 1308.3735
G. Belanger, G. Drieu La Rochelle, B. Dumont, R. Godbole, S. Kraml

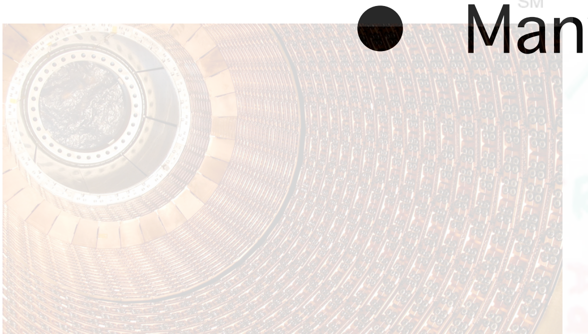
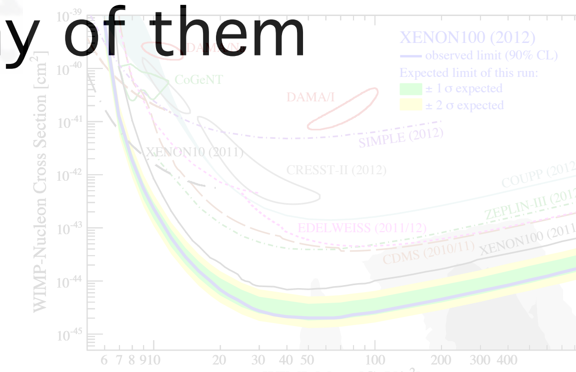
The scene

- Hunt for BSM physics is strong from the smallest to largest scales

- Many new and interesting results from astrophysics and collider searches exist and they must be taken into account to test a BSM theory

- Many BSM theories and no conclusive evidence for any of them

The LHC BSM frontier

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- Best thing - part 2: We are gearing up for 13 TeV run

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- Nice thing: The LHC works! ;)
- Good thing: We have completed our 8TeV run
- Bad thing: We don't have any sign of new physics
- Best thing - part 1: We found Higgs boson
- Best thing - part 2: We are gearing up for 13 TeV run

... is it?

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

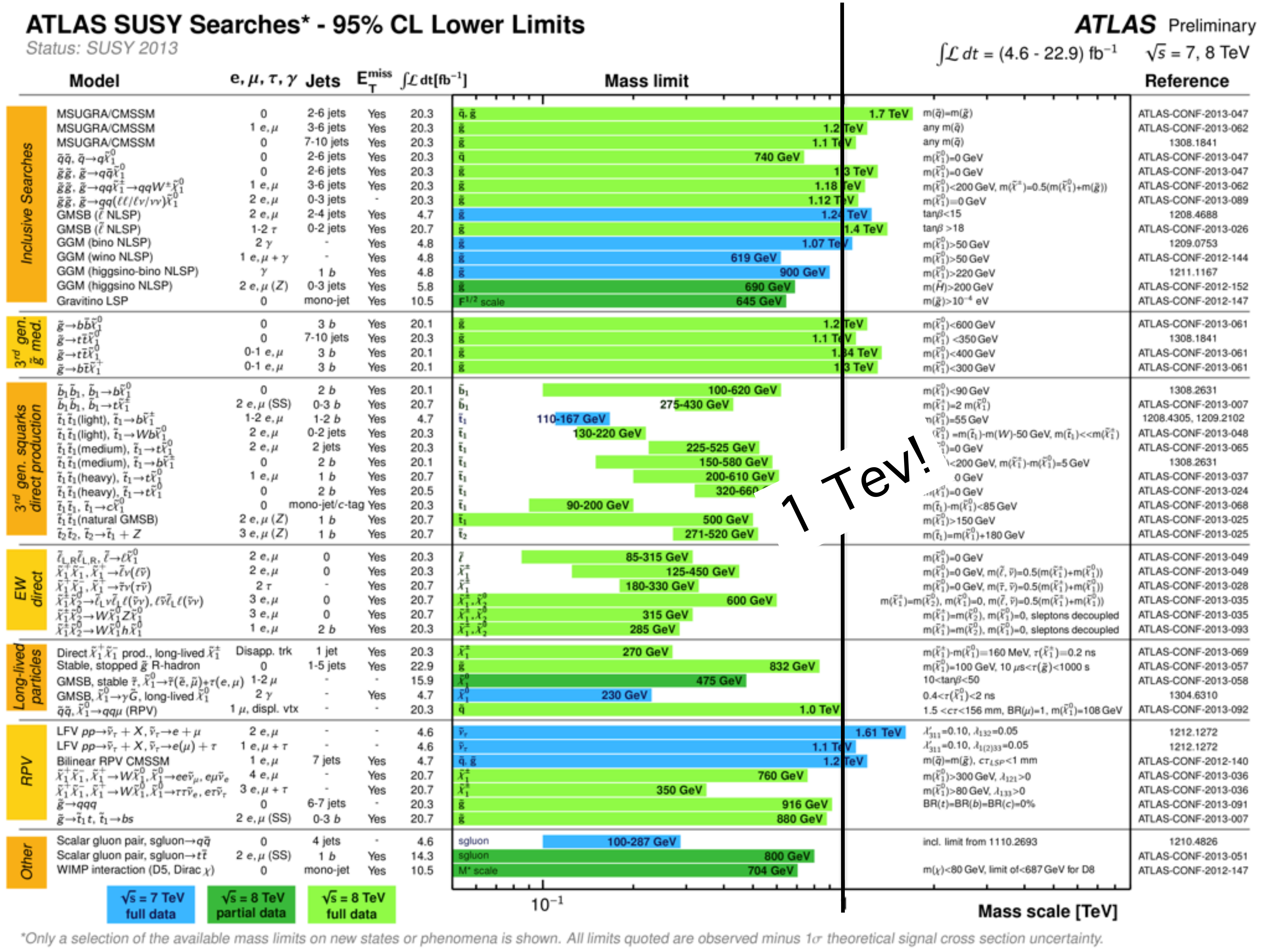
$\int \mathcal{L}\,dt = (4.6 - 22.9)$ fb^{-1} $\sqrt{s} = 7, 8$ TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\,dt$ [fb^{-1}]		Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm \to qqW^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\tau}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta$ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	4.8	$\tilde{g}$	1.07 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	1209.0753
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H})$>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	275-430 GeV	$m(\tilde{\chi}_1^\pm)$=2 $m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-220 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{t}_1)-m(W)$-50 GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	$\tilde{t}_1$	225-525 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-200 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$	500 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$	271-520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)$+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	125-450 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	315 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e, μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	285 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$	350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e, μ (SS)	1 b	Yes	14.3	sgluon	800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

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.


ATLAS SUSY Searches* - 95% CL Lower Limits
Status: SUSY 2013
ATLAS Preliminary
∫L dt = (4.6 - 22.9) fb^-1   √s = 7, 8 TeV
Model | e, μ, τ, γ | Jets | E_T^miss | ∫L dt[fb^-1] | Mass limit | Reference
Inclusive Searches
MSUGRA/CMSSM | 0 | 2-6 jets | Yes | 20.3 | q̃, g̃ 1.7 TeV | m(q̃)=m(g̃) | ATLAS-CONF-2013-047
MSUGRA/CMSSM | 1 e, μ | 3-6 jets | Yes | 20.3 | g̃ 1.2 TeV | any m(q̃) | ATLAS-CONF-2013-062
MSUGRA/CMSSM | 0 | 7-10 jets | Yes | 20.3 | g̃ 1.1 TeV | any m(q̃) | 1308.1841
q̃q̃, q̃→qχ̃1^0 | 0 | 2-6 jets | Yes | 20.3 | q̃ 740 GeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-047
g̃g̃, g̃→qq̄χ̃1^0 | 0 | 2-6 jets | Yes | 20.3 | g̃ 1.3 TeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-047
g̃g̃, g̃→qqχ̃1^±→qqW^±χ̃1^0 | 1 e, μ | 3-6 jets | Yes | 20.3 | g̃ 1.18 TeV | m(χ̃1^0)<200 GeV, m(χ̃^±)=0.5(m(χ̃1^0)+m(g̃)) | ATLAS-CONF-2013-062
g̃g̃, g̃→qq(ℓℓ/ℓν/νν)χ̃1^0 | 2 e, μ | 0-3 jets | - | 20.3 | g̃ 1.12 TeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-089
GMSB (ℓ̃ NLSP) | 2 e, μ | 2-4 jets | Yes | 4.7 | g̃ 1.24 TeV | tanβ<15 | 1208.4688
GMSB (ℓ̃ NLSP) | 1-2 τ | 0-2 jets | Yes | 20.7 | g̃ 1.4 TeV | tanβ >18 | ATLAS-CONF-2013-026
GGM (bino NLSP) | 2 γ | - | Yes | 4.8 | g̃ 1.07 TeV | m(χ̃1^0)>50 GeV | 1209.0753
GGM (wino NLSP) | 1 e, μ + γ | - | Yes | 4.8 | g̃ 619 GeV | m(χ̃1^0)>50 GeV | ATLAS-CONF-2012-144
GGM (higgsino-bino NLSP) | γ | 1 b | Yes | 4.8 | g̃ 900 GeV | m(χ̃1^0)>220 GeV | 1211.1167
GGM (higgsino NLSP) | 2 e, μ (Z) | 0-3 jets | Yes | 5.8 | g̃ 690 GeV | m(H̃)>200 GeV | ATLAS-CONF-2012-152
Gravitino LSP | 0 | mono-jet | Yes | 10.5 | F^1/2 scale 645 GeV | m(g̃)>10^-4 eV | ATLAS-CONF-2012-147
3rd gen. g̃ med.
g̃→bb̄χ̃1^0 | 0 | 3 b | Yes | 20.1 | g̃ 1.2 TeV | m(χ̃1^0)<600 GeV | ATLAS-CONF-2013-061
g̃→tt̄χ̃1^0 | 0 | 7-10 jets | Yes | 20.3 | g̃ 1.1 TeV | m(χ̃1^0) <350 GeV | 1308.1841
g̃→tt̄χ̃1^0 | 0-1 e, μ | 3 b | Yes | 20.1 | g̃ 1.34 TeV | m(χ̃1^0)<400 GeV | ATLAS-CONF-2013-061
g̃→bt̄χ̃1^+ | 0-1 e, μ | 3 b | Yes | 20.1 | g̃ 1.3 TeV | m(χ̃1^0)<300 GeV | ATLAS-CONF-2013-061
3rd gen. squarks direct production
b̃1b̃1, b̃1→bχ̃1^0 | 0 | 2 b | Yes | 20.1 | b̃1 100-620 GeV | m(χ̃1^0)<90 GeV | 1308.2631
b̃1b̃1, b̃1→tχ̃1^± | 2 e, μ (SS) | 0-3 b | Yes | 20.7 | b̃1 275-430 GeV | m(χ̃1^±)=2 m(χ̃1^0) | ATLAS-CONF-2013-007
t̃1t̃1(light), t̃1→bχ̃1^± | 1-2 e, μ | 1-2 b | Yes | 4.7 | t̃1 110-167 GeV | m(χ̃1^0)=55 GeV | 1208.4305, 1209.2102
t̃1t̃1(light), t̃1→Wbχ̃1^0 | 2 e, μ | 0-2 jets | Yes | 20.3 | t̃1 130-220 GeV | m(χ̃1^0) =m(t̃1)-m(W)-50 GeV, m(t̃1)<<m(χ̃1^±) | ATLAS-CONF-2013-048
t̃1t̃1(medium), t̃1→tχ̃1^0 | 2 e, μ | 2 jets | Yes | 20.3 | t̃1 225-525 GeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-065
t̃1t̃1(medium), t̃1→bχ̃1^± | 0 | 2 b | Yes | 20.1 | t̃1 150-580 GeV | m(χ̃1^0)<200 GeV, m(χ̃1^±)-m(χ̃1^0)=5 GeV | 1308.2631
t̃1t̃1(heavy), t̃1→tχ̃1^0 | 1 e, μ | 1 b | Yes | 20.7 | t̃1 200-610 GeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-037
t̃1t̃1(heavy), t̃1→tχ̃1^0 | 0 | 2 b | Yes | 20.5 | t̃1 320-660 GeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-024
t̃1t̃1, t̃1→cχ̃1^0 | 0 | mono-jet/c-tag | Yes | 20.3 | t̃1 90-200 GeV | m(t̃1)-m(χ̃1^0)<85 GeV | ATLAS-CONF-2013-068
t̃1t̃1(natural GMSB) | 2 e, μ (Z) | 1 b | Yes | 20.7 | t̃1 500 GeV | m(χ̃1^0)>150 GeV | ATLAS-CONF-2013-025
t̃2t̃2, t̃2→t̃1 + Z | 3 e, μ (Z) | 1 b | Yes | 20.7 | t̃2 271-520 GeV | m(t̃1)=m(χ̃1^0)+180 GeV | ATLAS-CONF-2013-025
EW direct
ℓ̃L,Rℓ̃L,R, ℓ̃→ℓχ̃1^0 | 2 e, μ | 0 | Yes | 20.3 | ℓ̃ 85-315 GeV | m(χ̃1^0)=0 GeV | ATLAS-CONF-2013-049
χ̃1^+χ̃1^-, χ̃1^+→ℓ̃ν(ℓν̃) | 2 e, μ | 0 | Yes | 20.3 | χ̃1^± 125-450 GeV | m(χ̃1^0)=0 GeV, m(ℓ̃, ν̃)=0.5(m(χ̃1^±)+m(χ̃1^0)) | ATLAS-CONF-2013-049
χ̃1^+χ̃1^-, χ̃1^+→τ̃ν(τν̃) | 2 τ | - | Yes | 20.7 | χ̃1^± 180-330 GeV | m(χ̃1^0)=0 GeV, m(τ̃, ν̃)=0.5(m(χ̃1^±)+m(χ̃1^0)) | ATLAS-CONF-2013-028
χ̃1^±χ̃2^0→ℓ̃Lνℓ̃Lℓ(ν̃ν), ℓν̃ℓ̃Lℓ(ν̃ν) | 3 e, μ | 0 | Yes | 20.7 | χ̃1^±, χ̃2^0 600 GeV | m(χ̃1^±)=m(χ̃2^0), m(χ̃1^0)=0, m(ℓ̃, ν̃)=0.5(m(χ̃1^±)+m(χ̃1^0)) | ATLAS-CONF-2013-035
χ̃1^±χ̃2^0→Wχ̃1^0Zχ̃1^0 | 3 e, μ | 0 | Yes | 20.7 | χ̃1^±, χ̃2^0 315 GeV | m(χ̃1^±)=m(χ̃2^0), m(χ̃1^0)=0, sleptons decoupled | ATLAS-CONF-2013-035
χ̃1^±χ̃2^0→Wχ̃1^0hχ̃1^0 | 1 e, μ | 2 b | Yes | 20.3 | χ̃1^±, χ̃2^0 285 GeV | m(χ̃1^±)=m(χ̃2^0), m(χ̃1^0)=0, sleptons decoupled | ATLAS-CONF-2013-093
Long-lived particles
Direct χ̃1^+χ̃1^- prod., long-lived χ̃1^± | Disapp. trk | 1 jet | Yes | 20.3 | χ̃1^± 270 GeV | m(χ̃1^±)-m(χ̃1^0)=160 MeV, τ(χ̃1^±)=0.2 ns | ATLAS-CONF-2013-069
Stable, stopped g̃ R-hadron | 0 | 1-5 jets | Yes | 22.9 | g̃ 832 GeV | m(χ̃1^0)=100 GeV, 10 μs<τ(g̃)<1000 s | ATLAS-CONF-2013-057
GMSB, stable τ̃, χ̃1^0→τ̃(ẽ, μ̃)+τ(e, μ) | 1-2 μ | - | - | 15.9 | χ̃1^0 475 GeV | 10<tanβ<50 | ATLAS-CONF-2013-058
GMSB, χ̃1^0→γG̃, long-lived χ̃1^0 | 2 γ | - | Yes | 4.7 | χ̃1^0 230 GeV | 0.4<τ(χ̃1^0)<2 ns | 1304.6310
q̃q̃, χ̃1^0→qqμ (RPV) | 1 μ, displ. vtx | - | - | 20.3 | q̃ 1.0 TeV | 1.5 <cτ<156 mm, BR(μ)=1, m(χ̃1^0)=108 GeV | ATLAS-CONF-2013-092
RPV
LFV pp→ν̃τ + X, ν̃τ→e + μ | 2 e, μ | - | - | 4.6 | ν̃τ 1.61 TeV | λ'311=0.10, λ132=0.05 | 1212.1272
LFV pp→ν̃τ + X, ν̃τ→e(μ) + τ | 1 e, μ + τ | - | - | 4.6 | ν̃τ 1.1 TeV | λ'311=0.10, λ1(2)33=0.05 | 1212.1272
Bilinear RPV CMSSM | 1 e, μ | 7 jets | Yes | 4.7 | q̃, g̃ 1.2 TeV | m(q̃)=m(g̃), cτLSP<1 mm | ATLAS-CONF-2012-140
χ̃1^+χ̃1^-, χ̃1^+→Wχ̃1^0, χ̃1^0→eeν̃μ, eμν̃e | 4 e, μ | - | Yes | 20.7 | χ̃1^± 760 GeV | m(χ̃1^0)>300 GeV, λ121>0 | ATLAS-CONF-2013-036
χ̃1^+χ̃1^-, χ̃1^+→Wχ̃1^0, χ̃1^0→ττν̃e, eτν̃τ | 3 e, μ + τ | - | Yes | 20.7 | χ̃1^± 350 GeV | m(χ̃1^0)>80 GeV, λ133>0 | ATLAS-CONF-2013-036
g̃→qqq | 0 | 6-7 jets | - | 20.3 | g̃ 916 GeV | BR(t)=BR(b)=BR(c)=0% | ATLAS-CONF-2013-091
g̃→t̃1t, t̃1→bs | 2 e, μ (SS) | 0-3 b | Yes | 20.7 | g̃ 880 GeV | | ATLAS-CONF-2013-007
Other
Scalar gluon pair, sgluon→qq̄ | 0 | 4 jets | - | 4.6 | sgluon 100-287 GeV | incl. limit from 1110.2693 | 1210.4826
Scalar gluon pair, sgluon→tt̄ | 2 e, μ (SS) | 1 b | Yes | 14.3 | sgluon 800 GeV | | ATLAS-CONF-2013-051
WIMP interaction (D5, Dirac χ) | 0 | mono-jet | Yes | 10.5 | M* scale 704 GeV | m(χ)<80 GeV, limit of<687 GeV for D8 | ATLAS-CONF-2012-147
√s = 7 TeV full data
√s = 8 TeV partial data
√s = 8 TeV full data
10^-1
Mass scale [TeV]
1 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.

The LHC frontier

- Theoretical model development is influenced by conclusions at 8 TeV, e.g. GUT scale SUSY models like cMSSM are pushed to higher scales and we are thinking of more non-minimal models

- The strategies for 13 TeV results depend on the conclusions at 8 TeV

- It is necessary to interpret the results in the most generic fashion and test as many models as possible

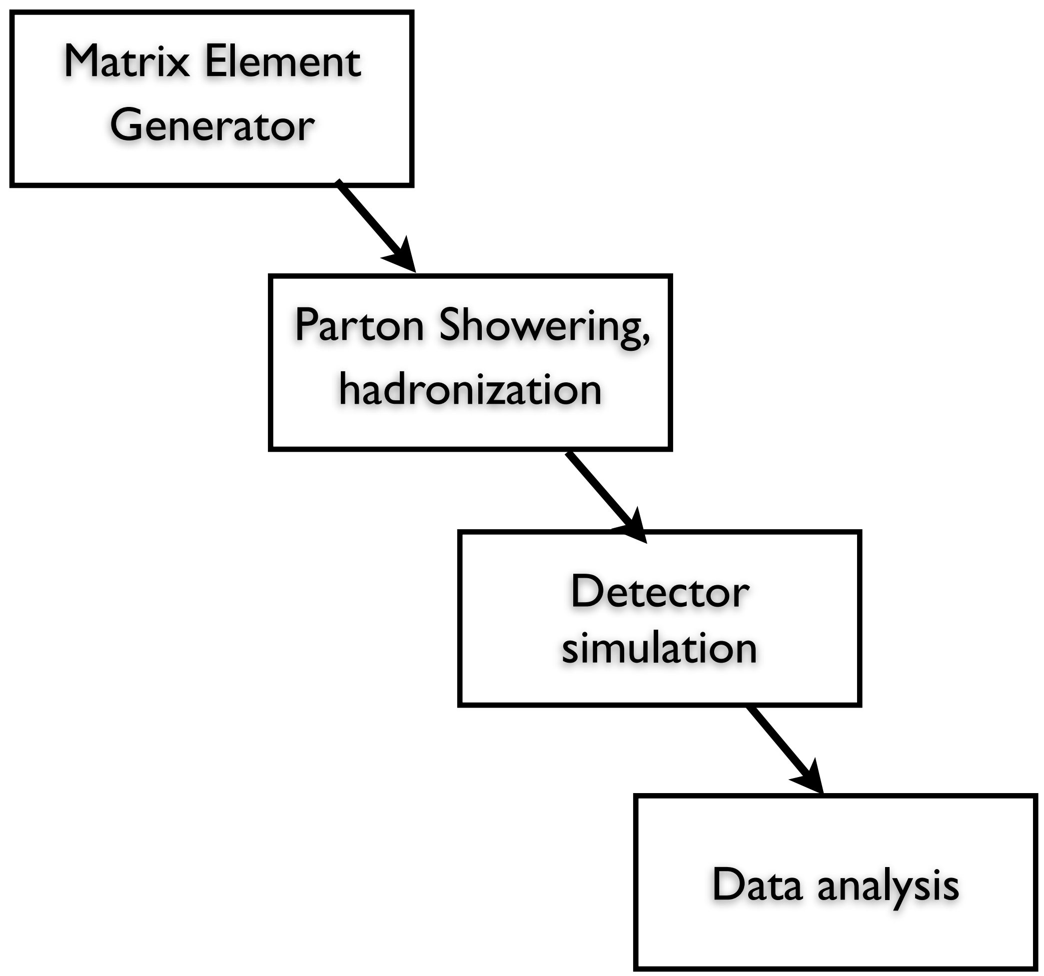
Huge number of searches
Easier said than done!

Analyses statistics (SUSY searches only)

	8 TeV (Any luminosity)	8 TeV (20 fb-1)
ATLAS	39	23
CMS	28	20

- A way to test our favorite BSM model against LHC results should exist

Traditional approach



A typical analysis re-interpretation chain

- Interpretation of LHC searches are model dependent
- Model dependence comes while converting the number of events observed to a limit on particle masses
- For a more generic case:

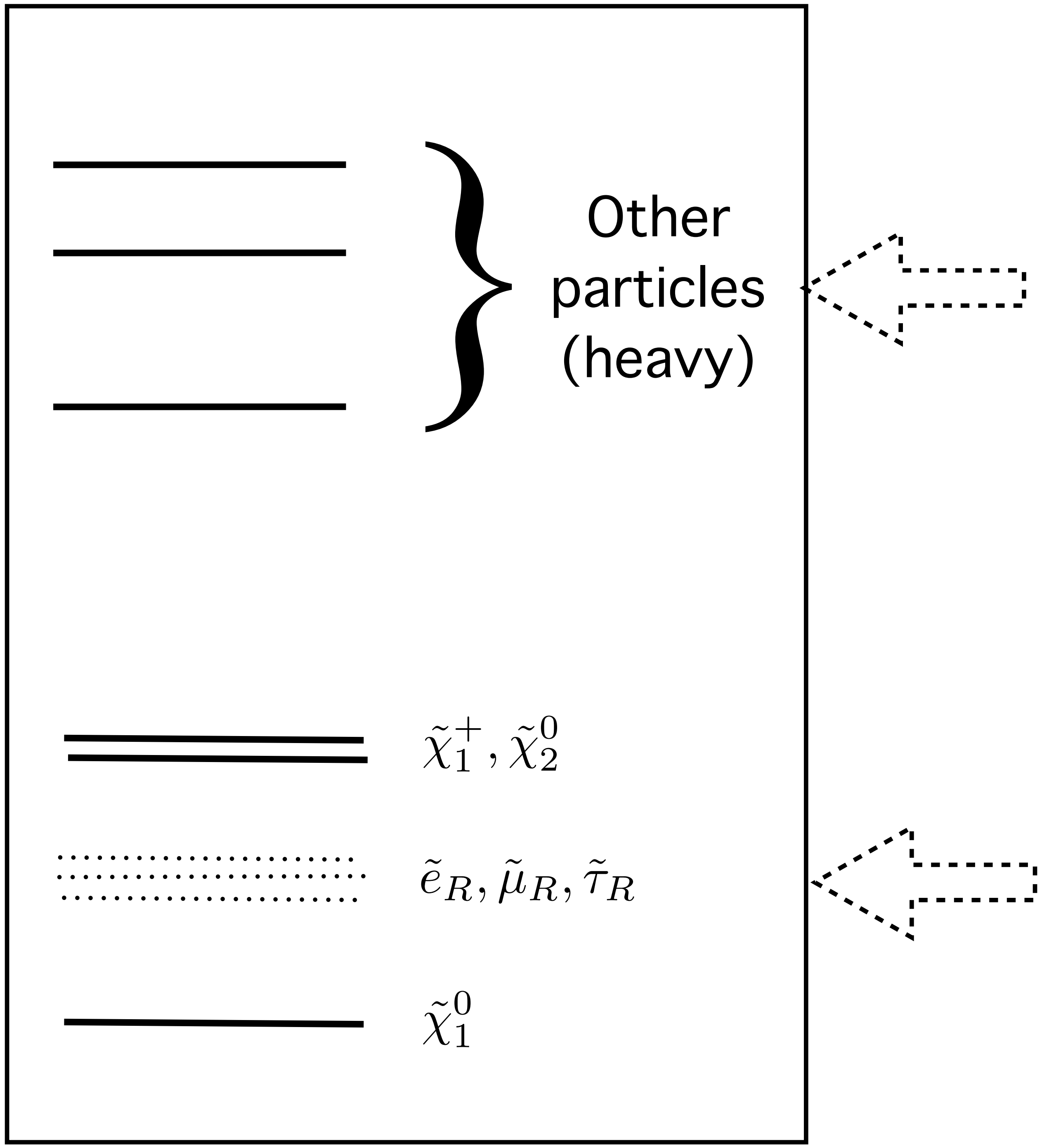
1. Re-interpret the results yourself
2. Use simplified model spectra results

- Re-interpreting the results yourself involves re-implementing the analysis, requires expertise, large computing power, time consuming
- We stick to simplified models results

What is an SMS result?

- SMS are an effective-Lagrangian description of BSM involving a limited set of new particles.

What is an SMS result?



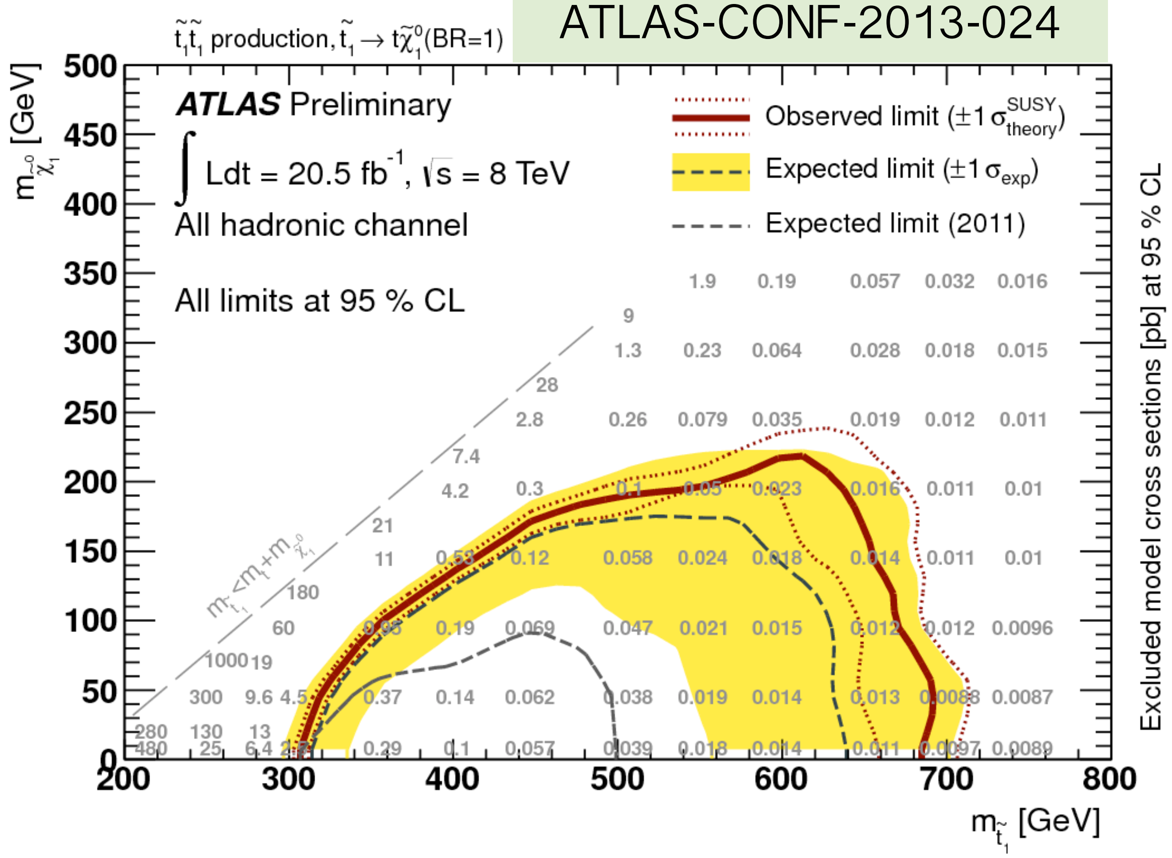
We don’t care about them

Effective theory contains only some electroweak -inos and some sleptons

What is an SMS result?

Note: the grid numbers on the plot are more important than the exclusion lines

ATLAS-CONF-2013-024

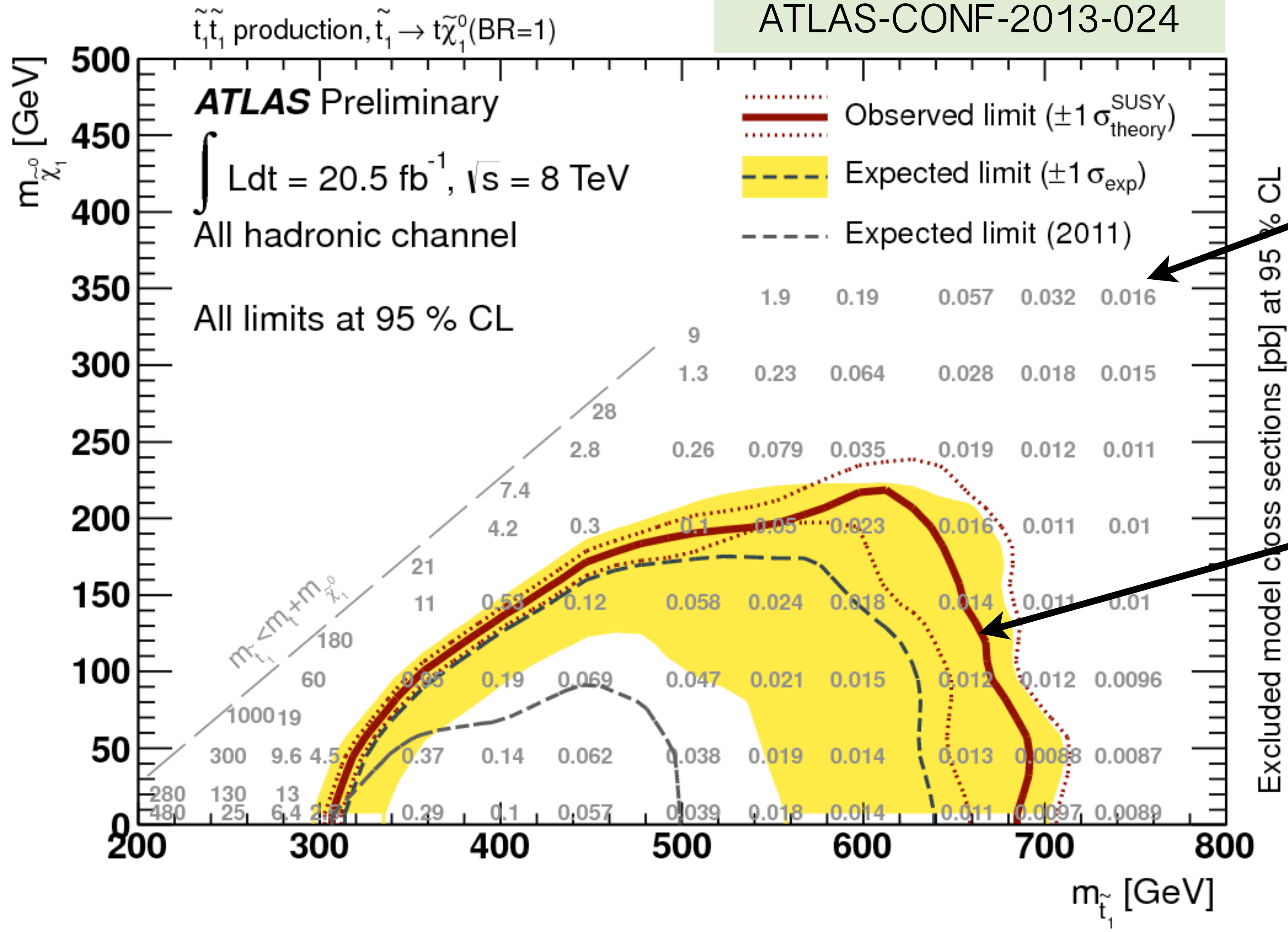


- Every SMS interpretation is based on a set of assumptions and is applicable for specific topologies e.g. ttbar + MET

- A generic point in e.g. SUSY parameter space contains many topologies and is sensitive to more than one SMS interpretation e.g. ttbar + MET, bbar + MET

How to read an SMS result

ATLAS-CONF-2013-024



We should use these numbers

Useful but not the most important outcome

- 95% CL UL is the unfolded maximum amount of cross-section allowed for a specific decay chain and a mass combination

Is sigmaXBR(ttbar + MET, Mother mass, LSP mass) of your model > the number on the plot? -- Yes, point excluded; No, point allowed

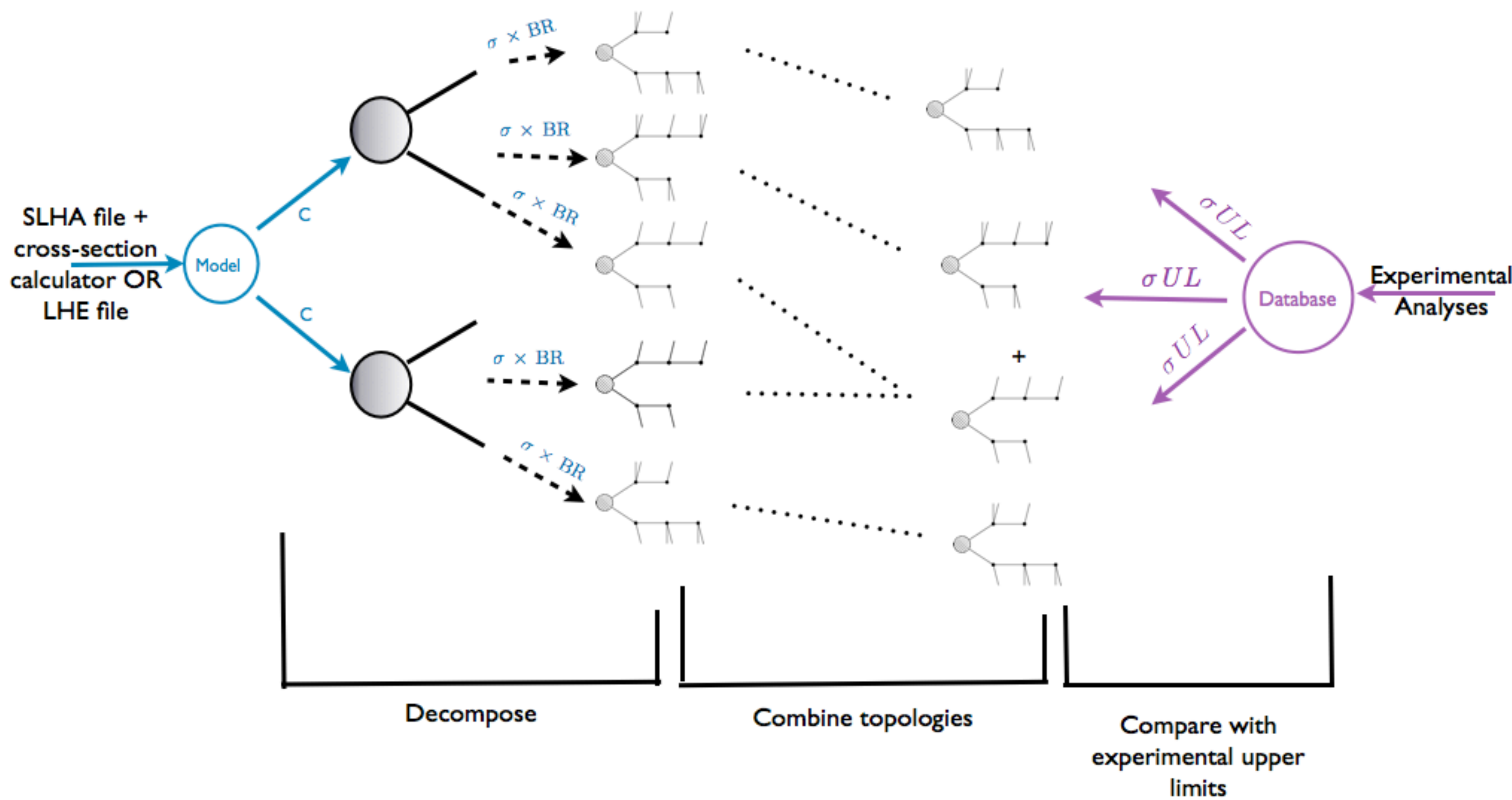
Can we have a centralized database of all the SMS results to check a given SUSY point in parameter space by decomposing it into SMS topologies?

Central concept of

SModelS

SModelS framework

- It assumes, for most experimental searches, the BSM model can be approximated by a sum over effective simplified models



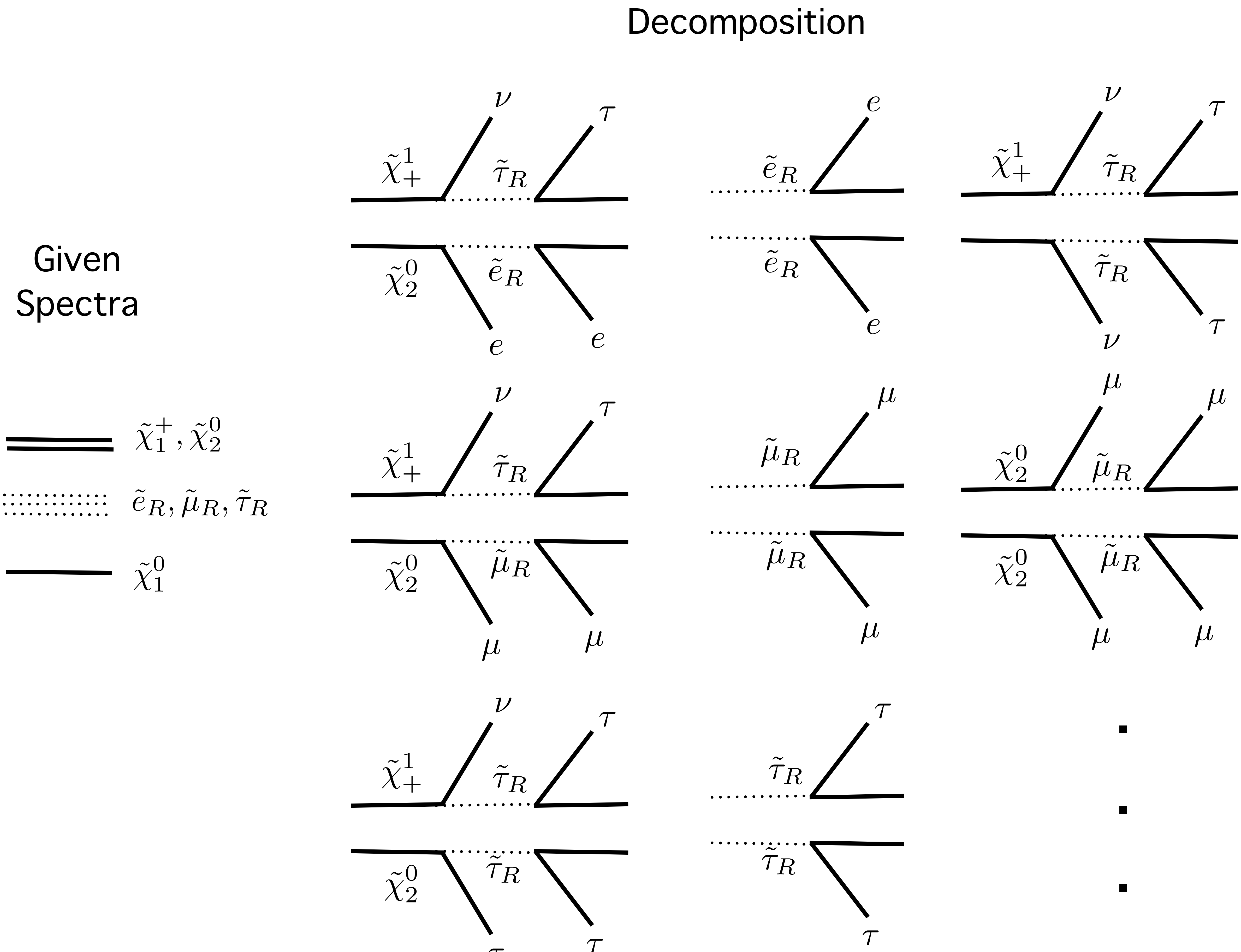
- Current implementation assumes R-parity is conserved

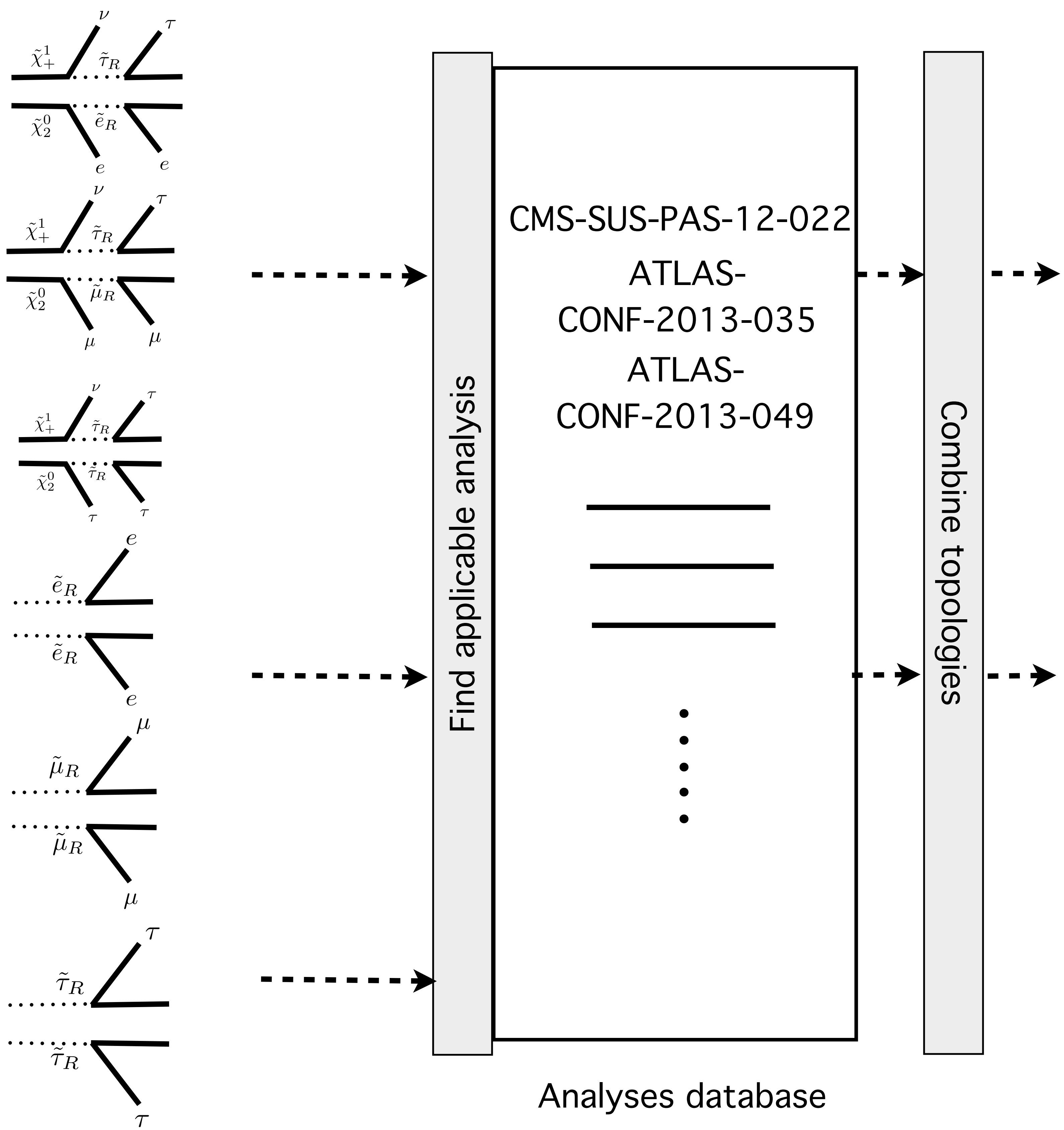
Given Spectra

$\tilde{\chi}_1^+, \tilde{\chi}_2^0$

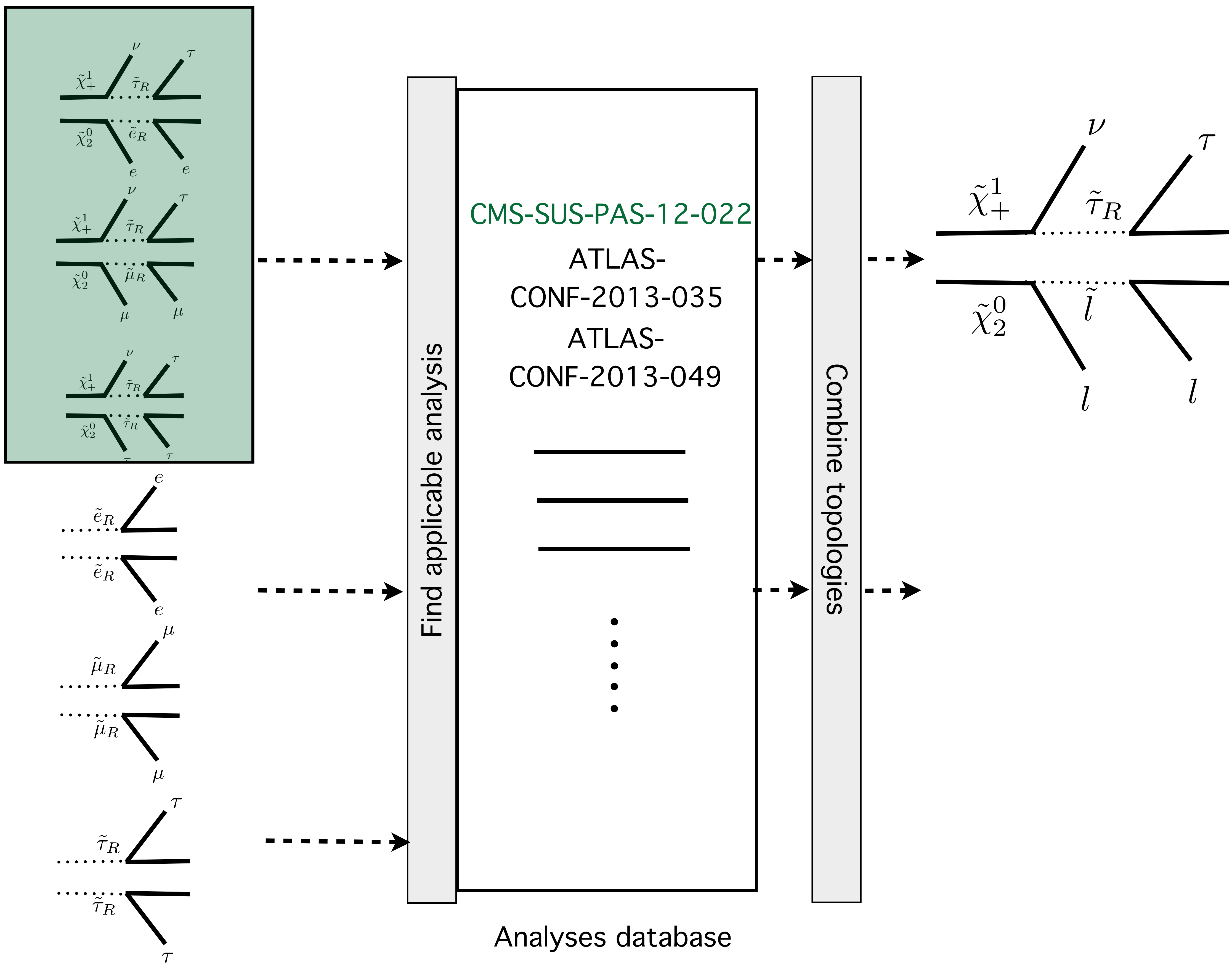
$\tilde{e}_R, \tilde{\mu}_R, \tilde{\tau}_R$

$\tilde{\chi}_1^0$


Decomposition
Given Spectra
$\tilde{\chi}_1^+, \tilde{\chi}_2^0$
$\tilde{e}_R, \tilde{\mu}_R, \tilde{\tau}_R$
$\tilde{\chi}_1^0$
$\tilde{\chi}_+^1$
$\tilde{\chi}_2^0$
$\tilde{\tau}_R$
$\tilde{e}_R$
$\tilde{\mu}_R$
ν
τ
e
μ



CMS-SUS-PAS-12-022
ATLAS-CONF-2013-035
ATLAS-CONF-2013-049
Find applicable analysis
Combine topologies
Analyses database



Find applicable analysis
CMS-SUS-PAS-12-022
ATLAS-CONF-2013-035
ATLAS-CONF-2013-049
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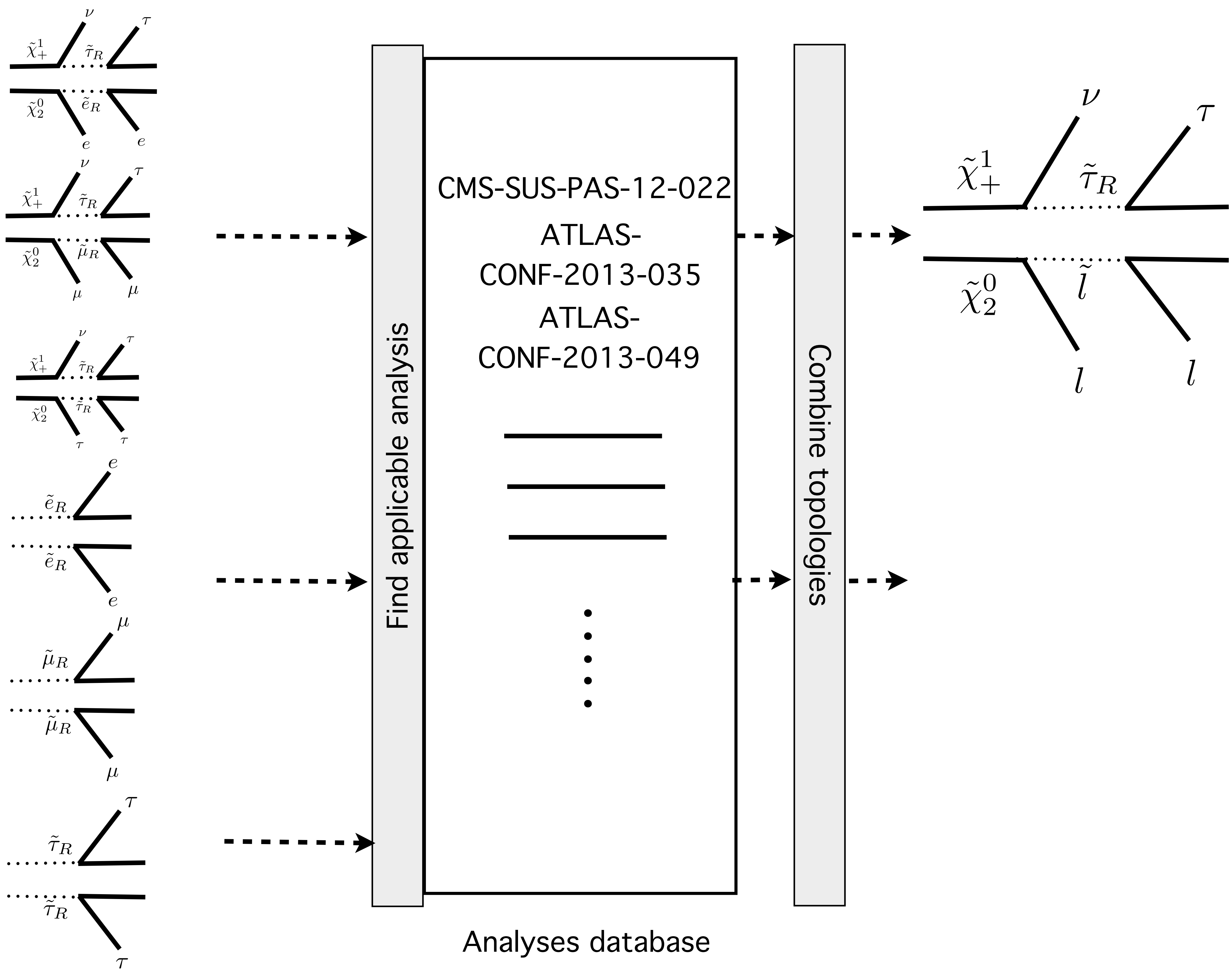
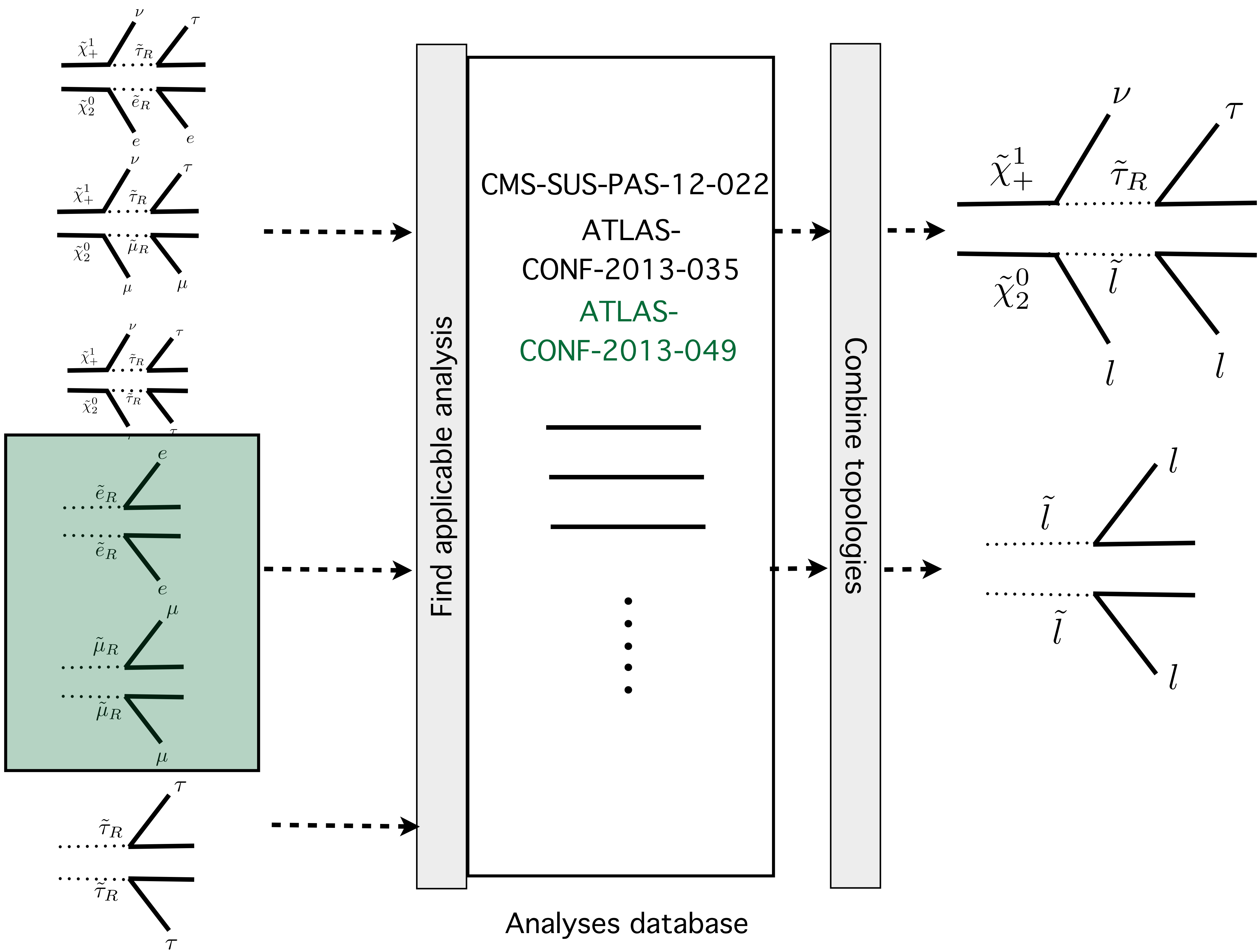
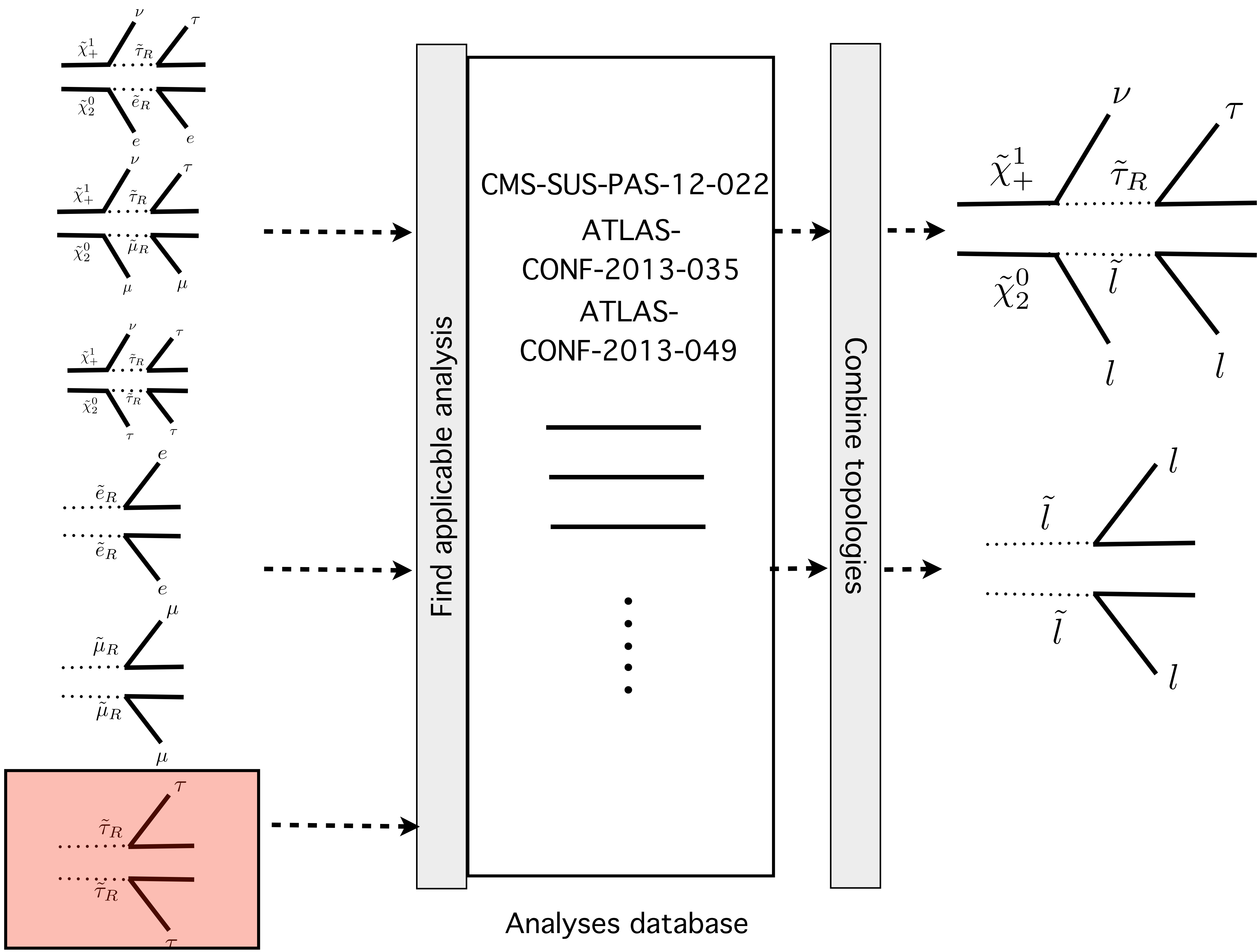
Analyses database

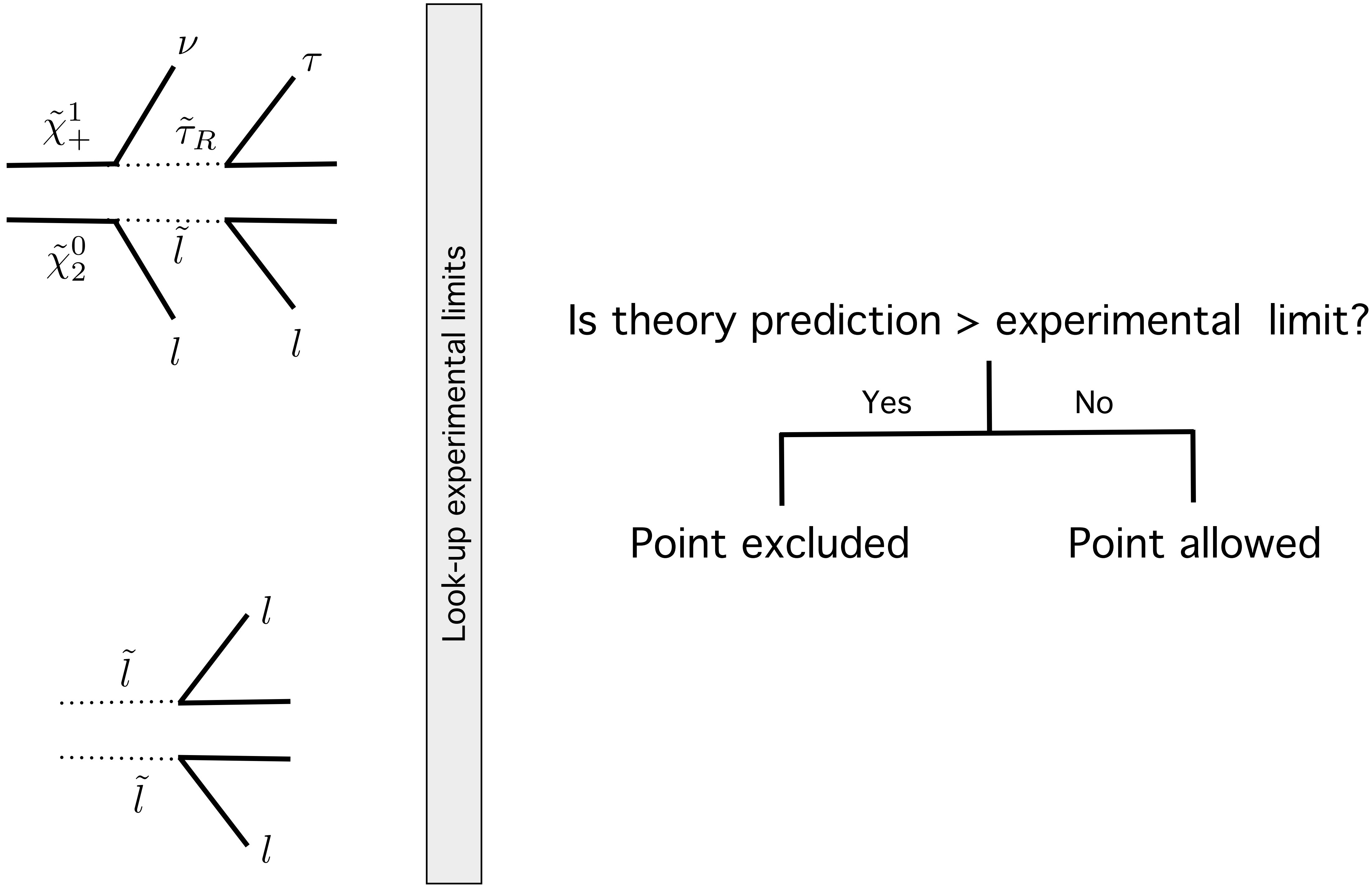


Find applicable analysis
CMS-SUS-PAS-12-022
ATLAS-CONF-2013-035
ATLAS-CONF-2013-049
Analyses database
Combine topologies



Find applicable analysis
CMS-SUS-PAS-12-022
ATLAS-CONF-2013-035
ATLAS-CONF-2013-049
Combine topologies
Analyses database


CMS-SUS-PAS-12-022
ATLAS-
CONF-2013-035
ATLAS-
CONF-2013-049
Find applicable analysis
Combine topologies
Analyses database



$\tilde{\chi}^1_+$
ν
$\tilde{\tau}_R$
τ
$\tilde{\chi}^0_2$
$\tilde{l}$
l
l
$\tilde{l}$
l
$\tilde{l}$
l
Look-up experimental limits
Is theory prediction > experimental limit?
Yes
No
Point excluded
Point allowed

SModelS framework

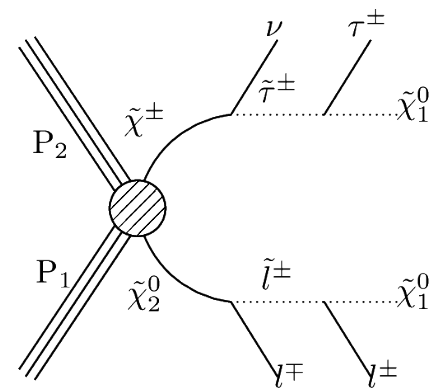
- Consider:

$\tilde{\chi}_1^+, \tilde{\chi}_2^0$

$\tilde{e}_R, \tilde{\mu}_R, \tilde{\tau}_R$

$\tilde{\chi}_1^0$

Decompose → Element



description
masses
sigma X BR

Constraint

[[[nu],[tau]],[[L],[L]]]
[[300,200,100],[320,220,100]]
Sigma X BR

Look up upper limit if

Condition

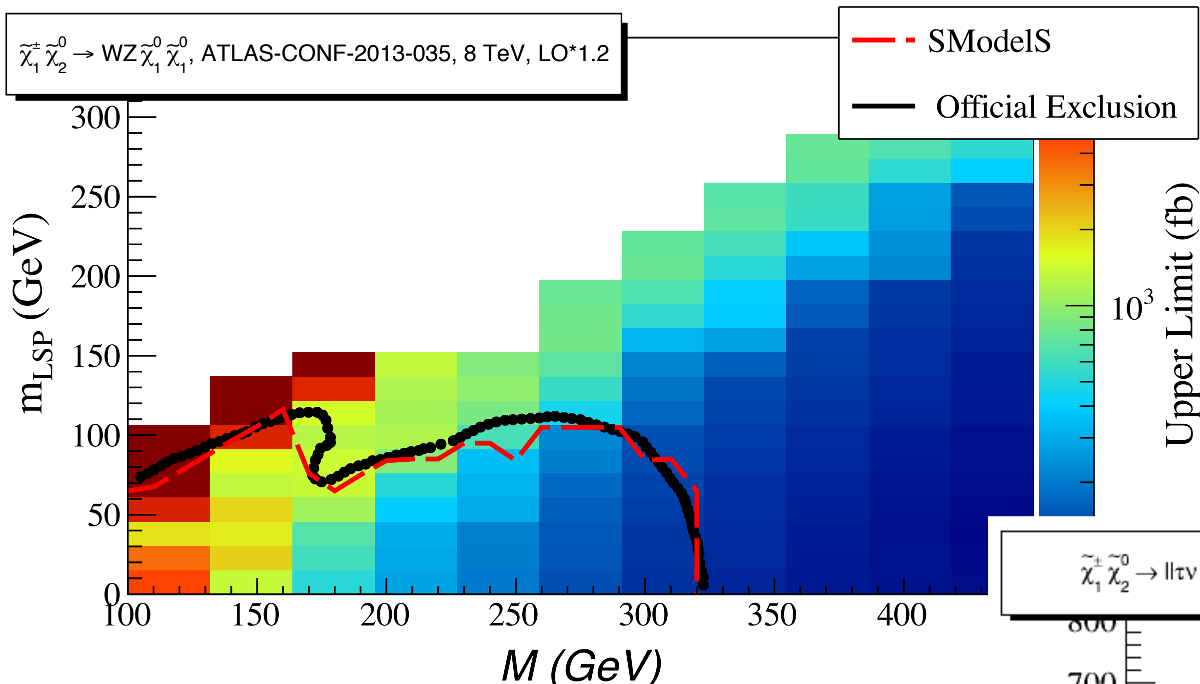
[[[nu],[tau]],[[L],[L]]] >
3* [[[nu],[tau]],[[tau],[tau]]]

- The framework does not depend on characteristics of SUSY particles, can also be applied to decompose any BSM spectra of arbitrary complexity

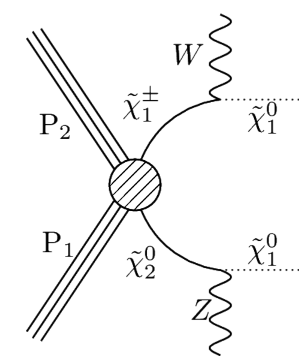
SModelS language

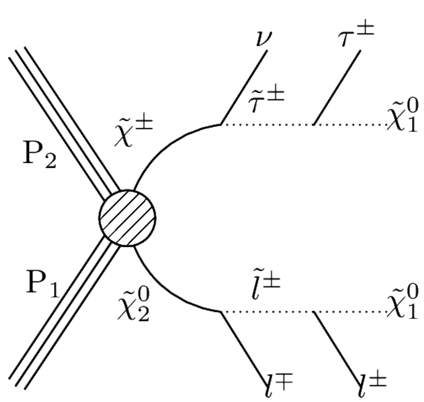
How do we know it works?

- The code has been validated through the reproduction of various SMS exclusion curves

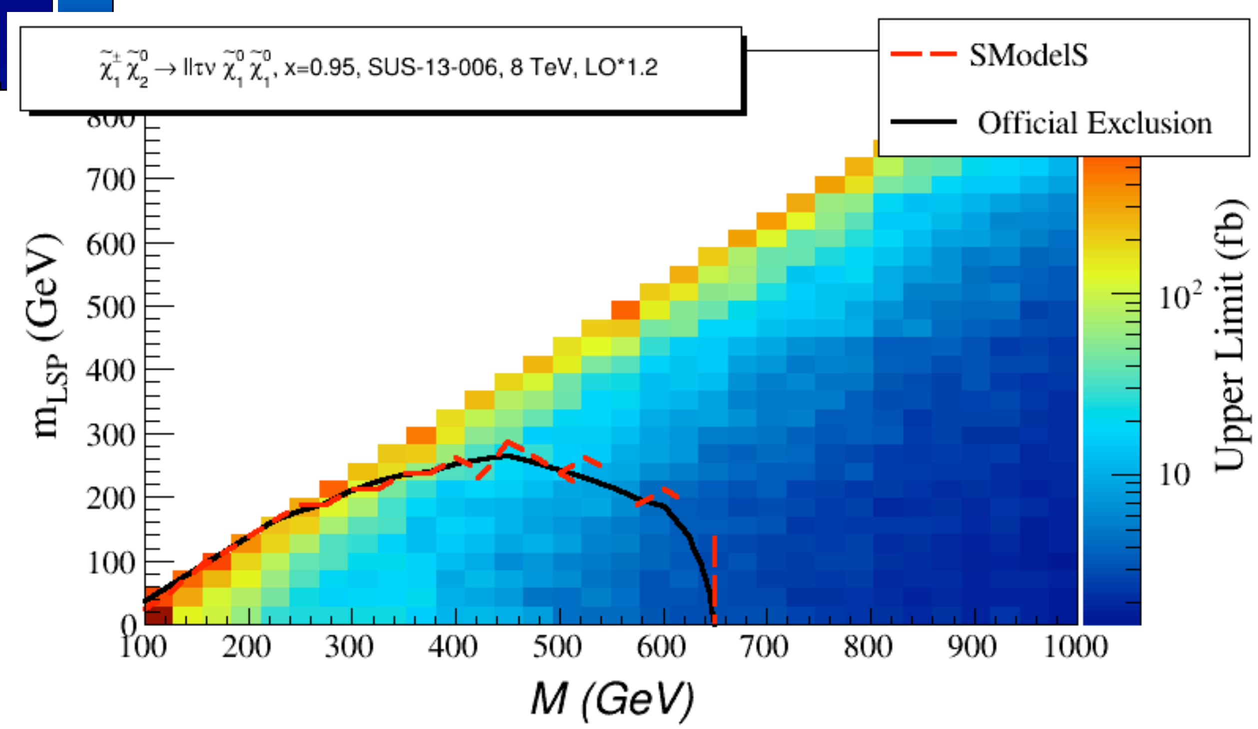


[[[W]],[[Z]]]





[[[nu],[tau]],[[L],[L]]]



Typical examples of validation plot

Salient features

- Code is equipped to decompose any BSM model with a Z2 symmetry
- It can handle compressed topologies
- It can take care of invisible decays
- It has the most comprehensive database of simplified model results, 22 CMS, 24 ATLAS (7 + 8 TeV)
- Now a web SLHA interface is available to check your point

Good, so what do you learn out of it?

based on:
arXiv: 1312.4175 [hep-ph]

SUSY scan - weak sector

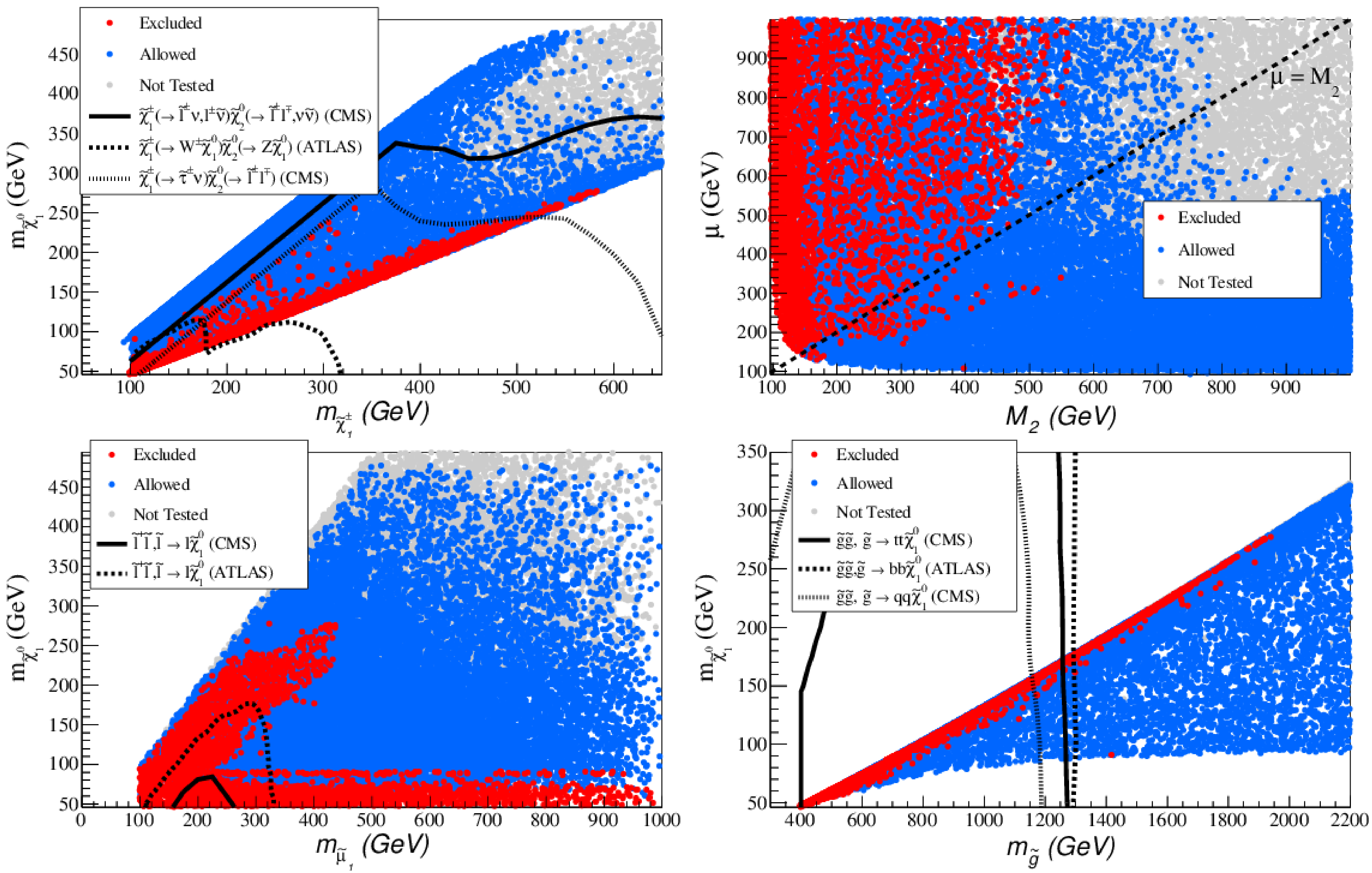
- pMSSM scan over 6 parameters
  -

M_2	μ	$\tan\beta$	$M_{\tilde{L}}$	$M_{\tilde{E}}$	A_τ
0.1–1	0.1–1	3–60	0.1–1	0.1–1	± 1

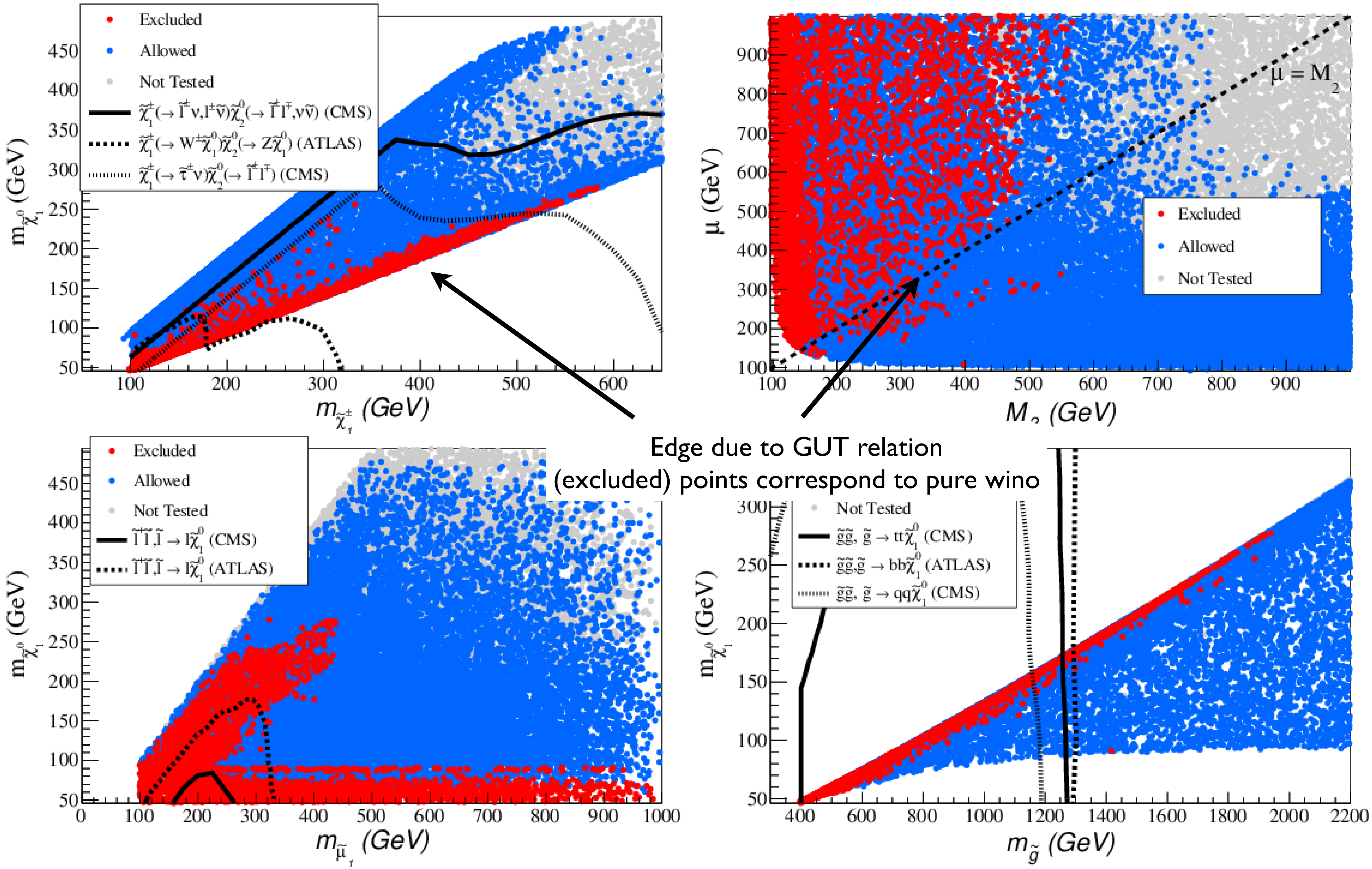
  - Gaugino masses obey GUT relation
  - Flavor constraints, invisible Z width, Higgs mass, LEP limits imposed
- Limits obtained will always be conservative
- We probe electroweak -ino decays via WZ and sleptons, direct slepton production and gluino decays

NB: A similar scan was also performed for strong sector particles

SUSY scan - weak sector

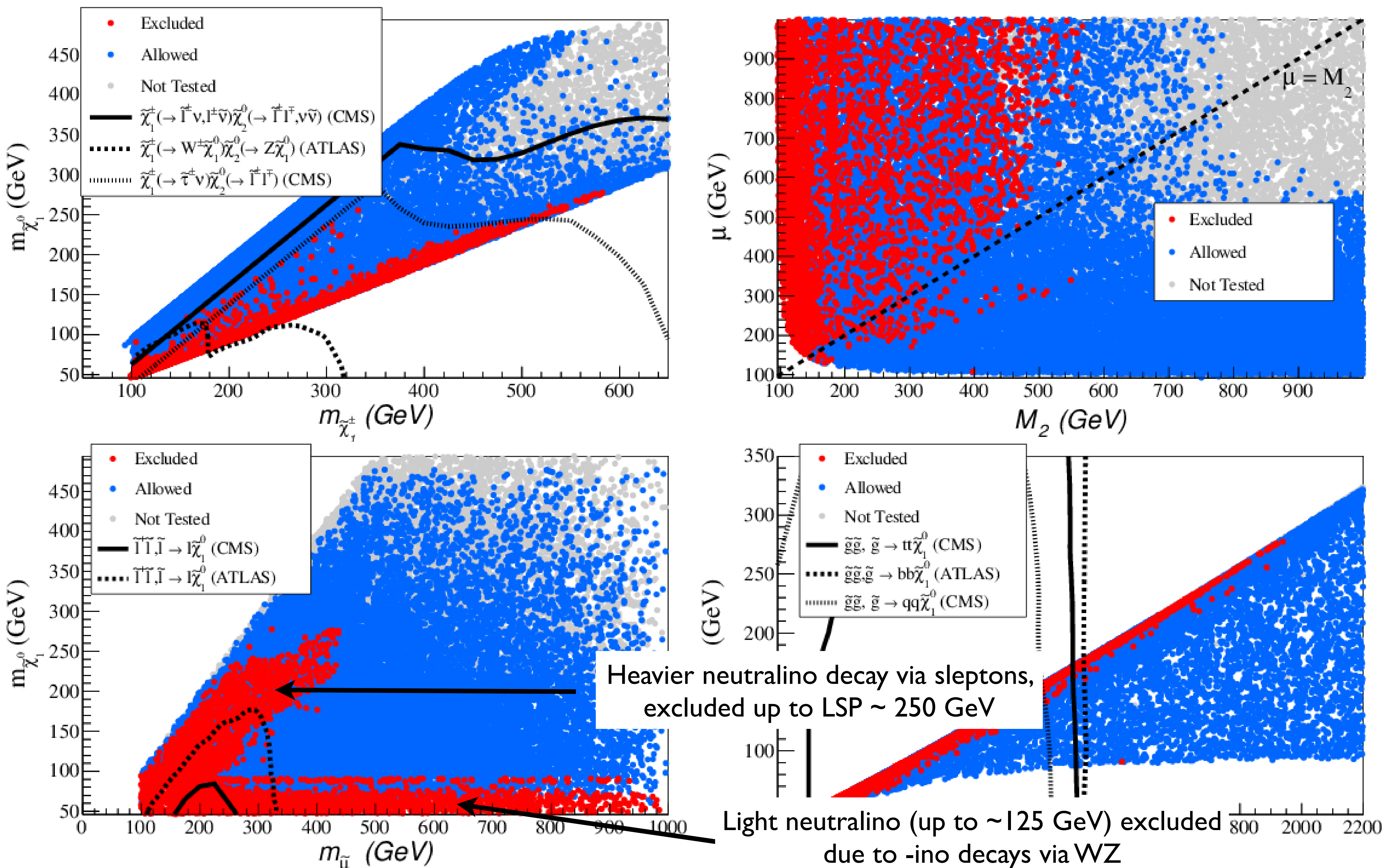


SUSY scan - weak sector

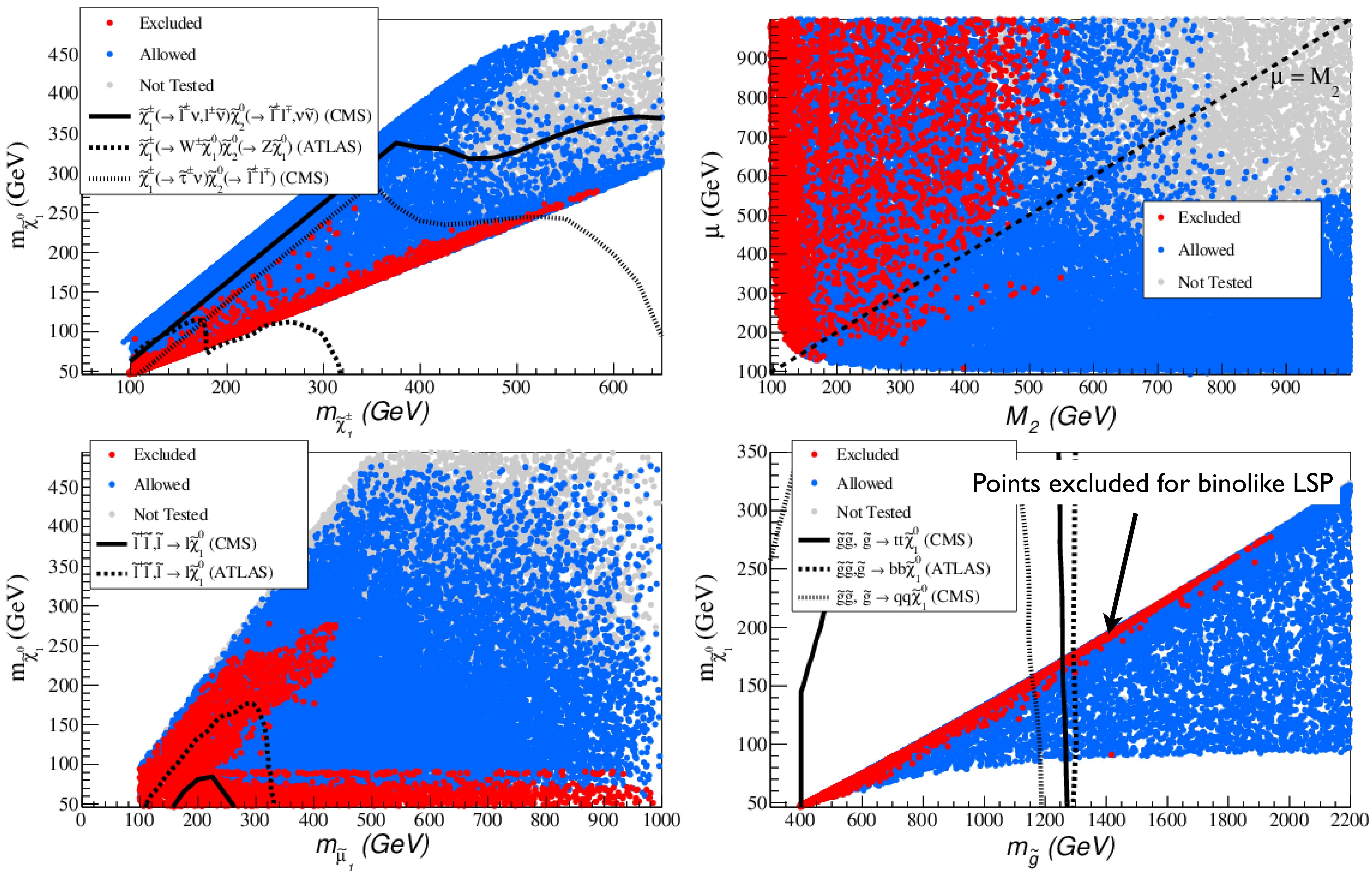


Edge due to GUT relation
(excluded) points correspond to pure wino

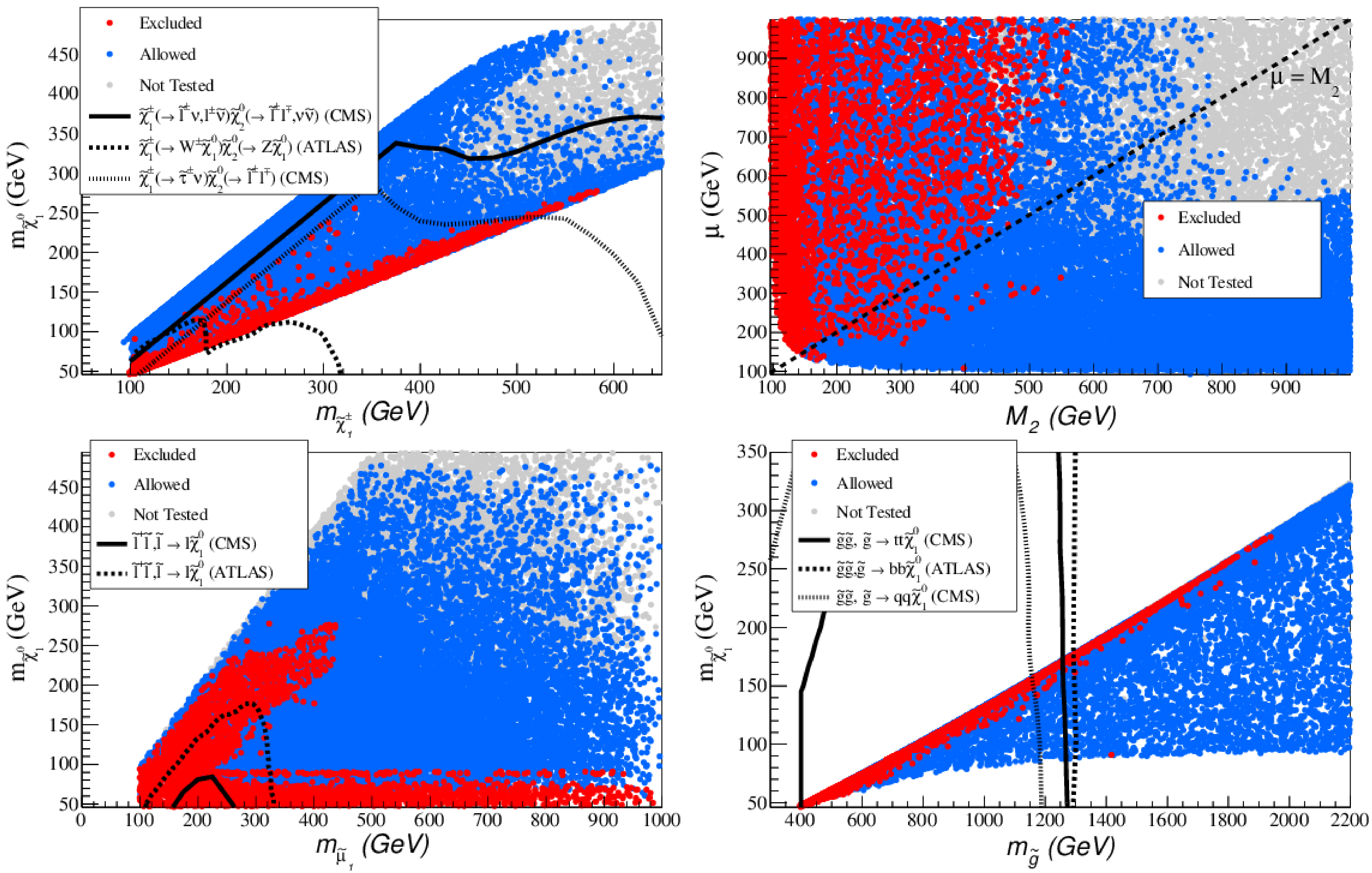
SUSY scan - weak sector



SUSY scan - weak sector

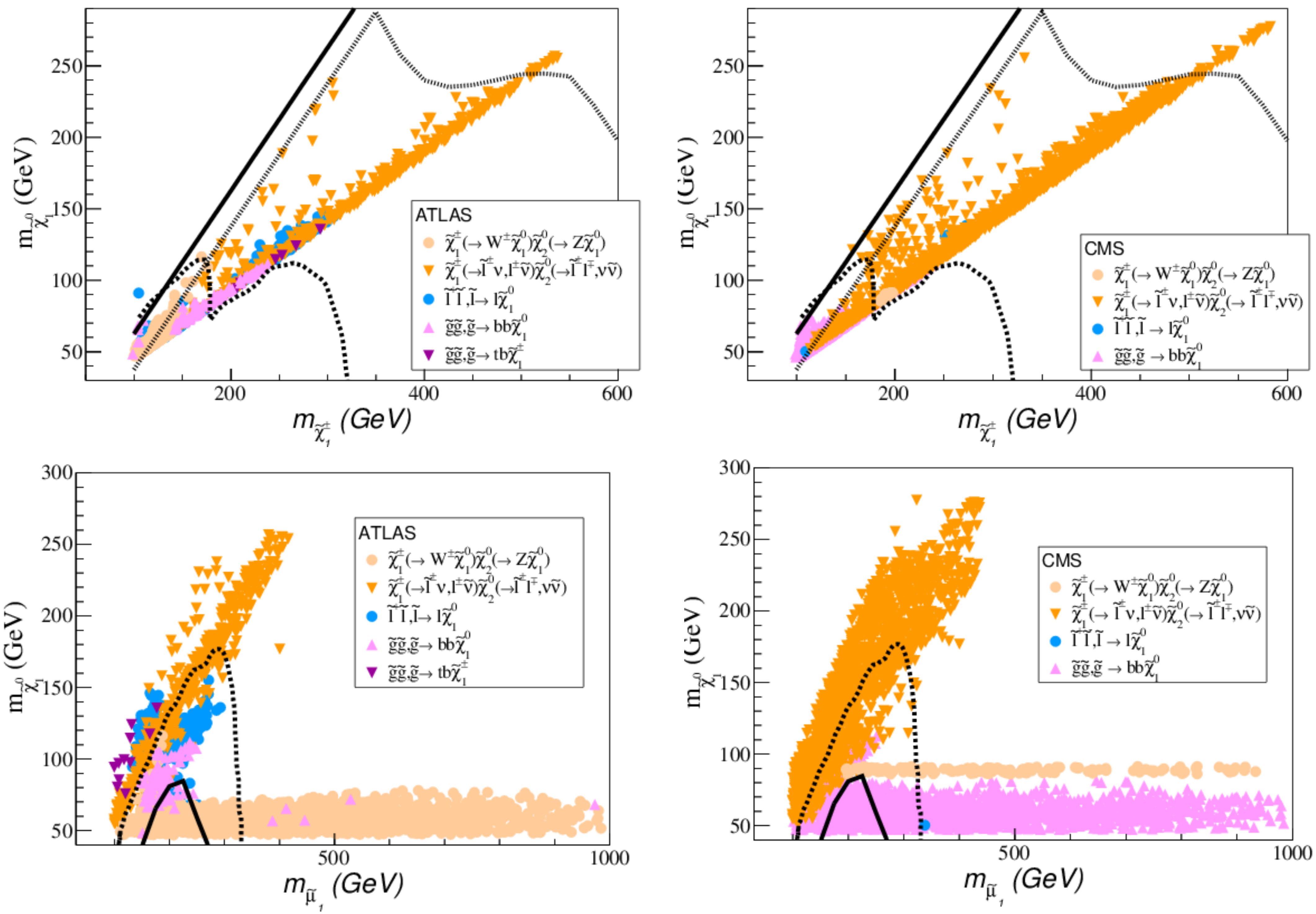


SUSY scan - weak sector



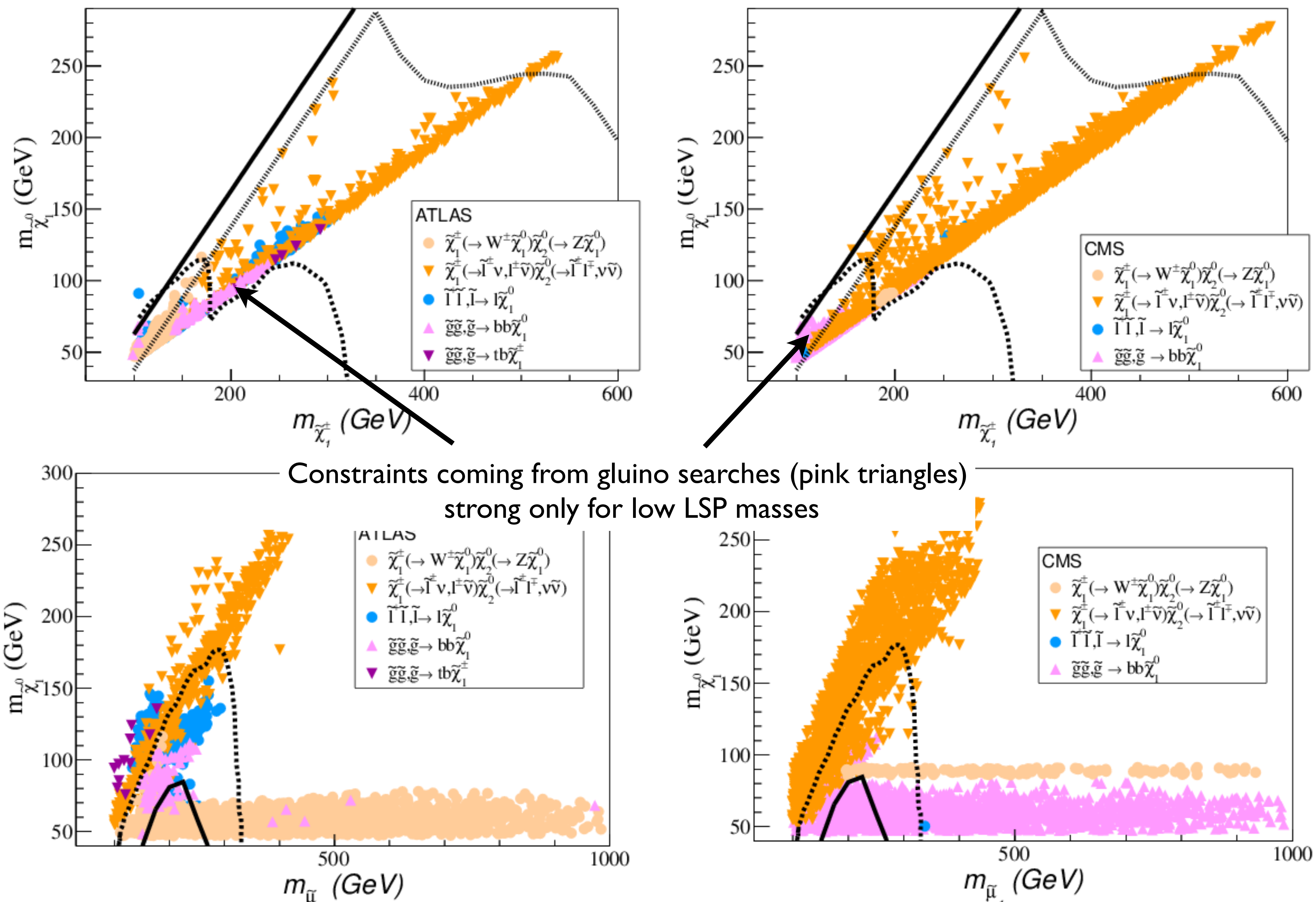
SUSY scan - weak sector

- Breakdown of the excluded parameter space by analysis



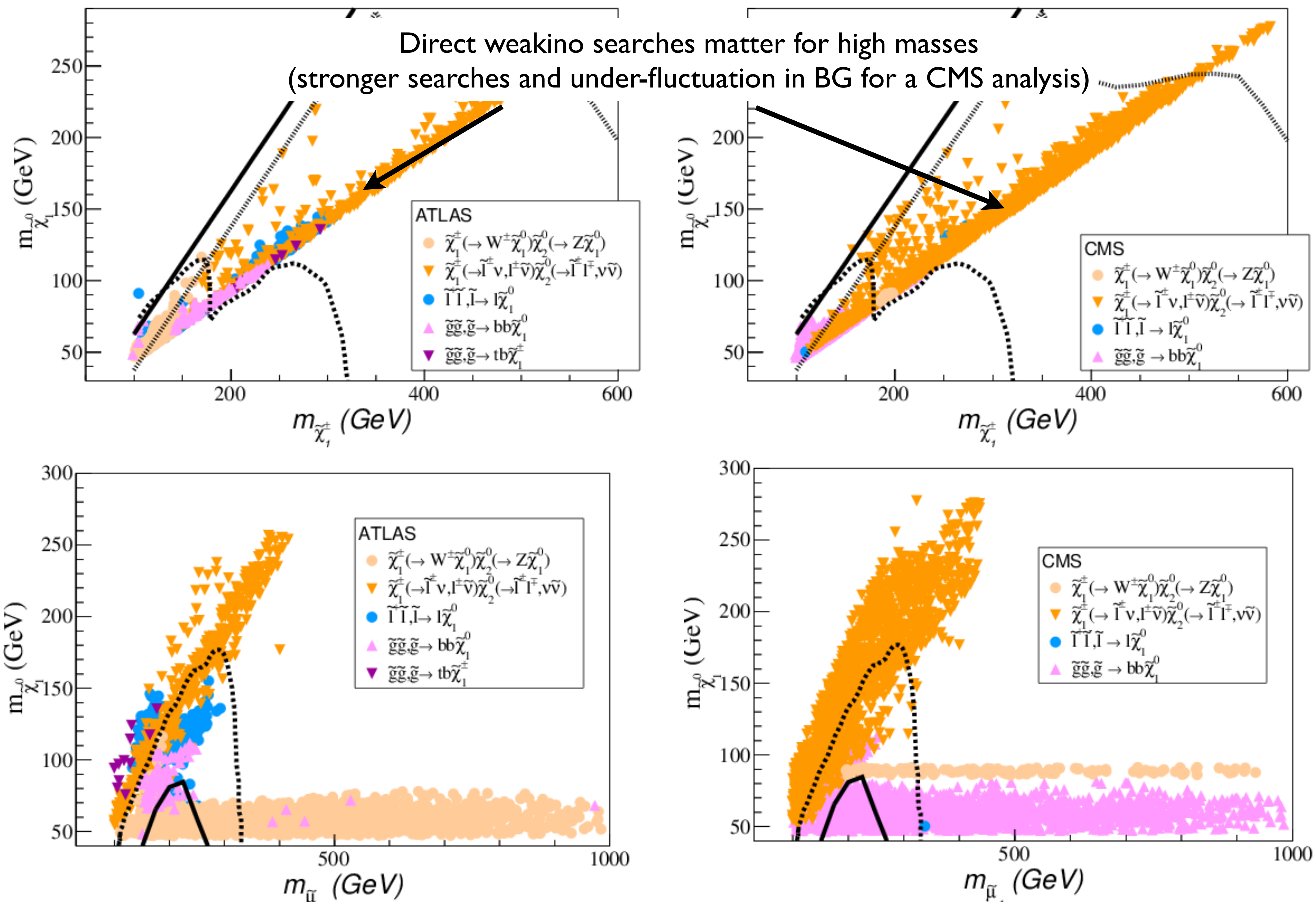
SUSY scan - weak sector

- Breakdown of the excluded parameter space by analysis



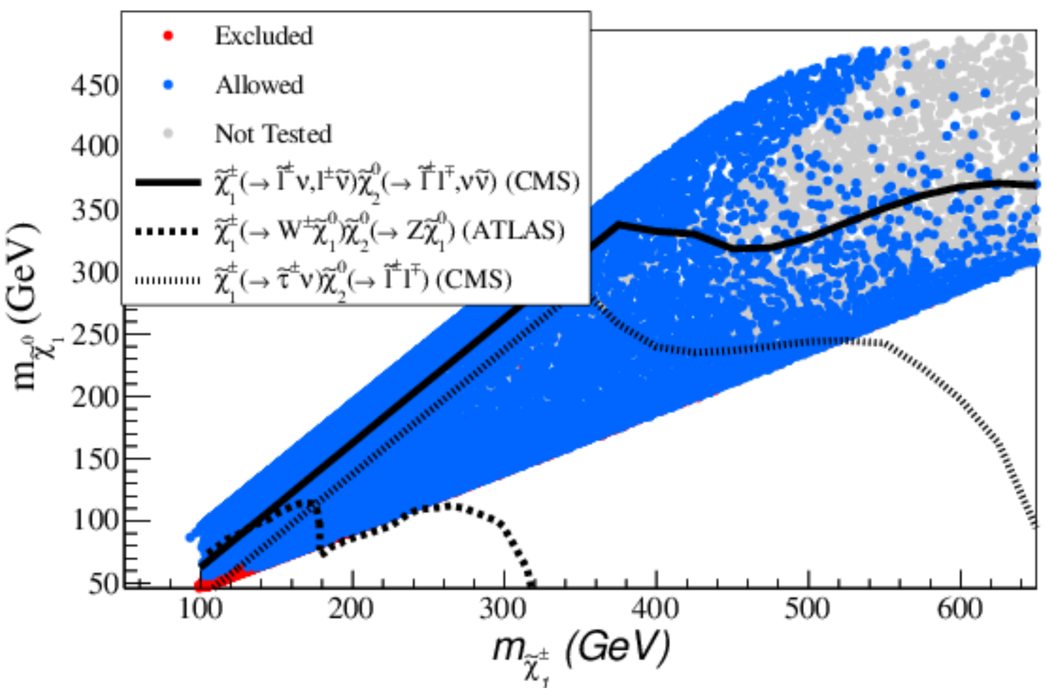
SUSY scan - weak sector

- Breakdown of the excluded parameter space by analysis



SUSY scan - weak sector

- Some allowed points may lie below excluded points

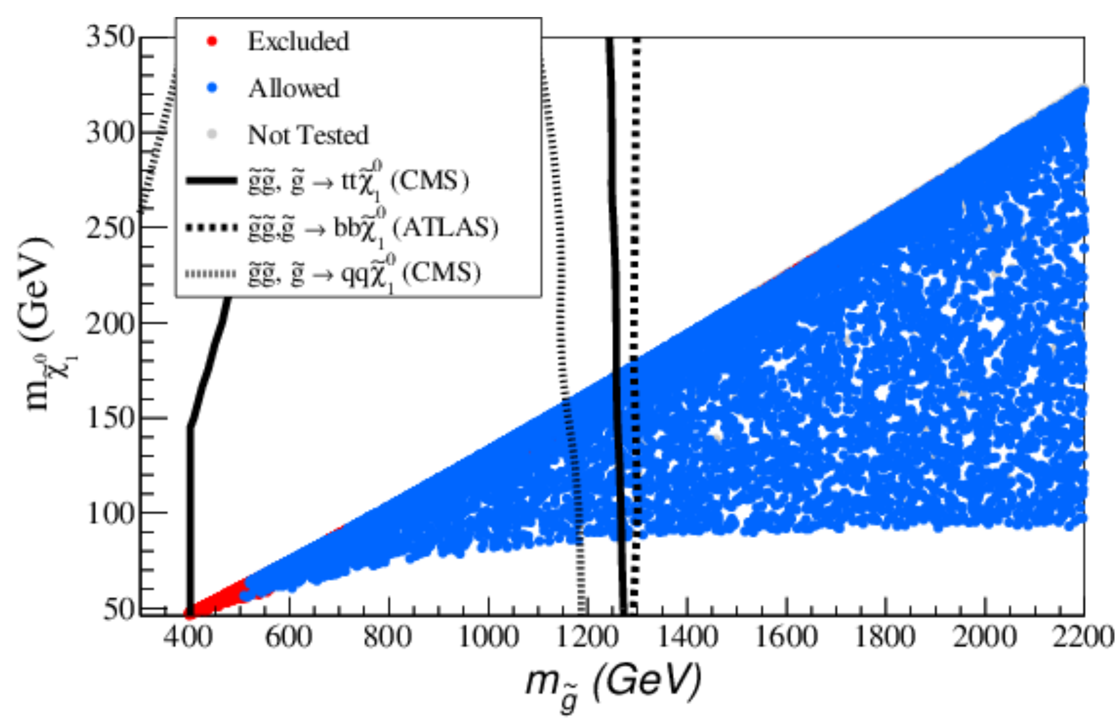


- Chargino - LSP nature, higgsino have smaller production cross-section

- Right handed sleptons have smaller production CS

- Gluino decays via on-shell squarks are kinematically forbidden for small masses

- Uncovered gluino decay topologies e.g. $BR(\tilde{g} \to \tilde{\chi}^{\pm} + tb)$



Can it be used to test parameter space for some interesting scenario?

A real life application

Do LHC results on the SUSY particles, Higgs signal strengths and constraints on DM from direct and indirect detection experiments rule out light neutralino DM?

Already many studies exist in literature, I'll not list them here

based on:
arxiv:1308.3735 [hep-ph] (published PLB)

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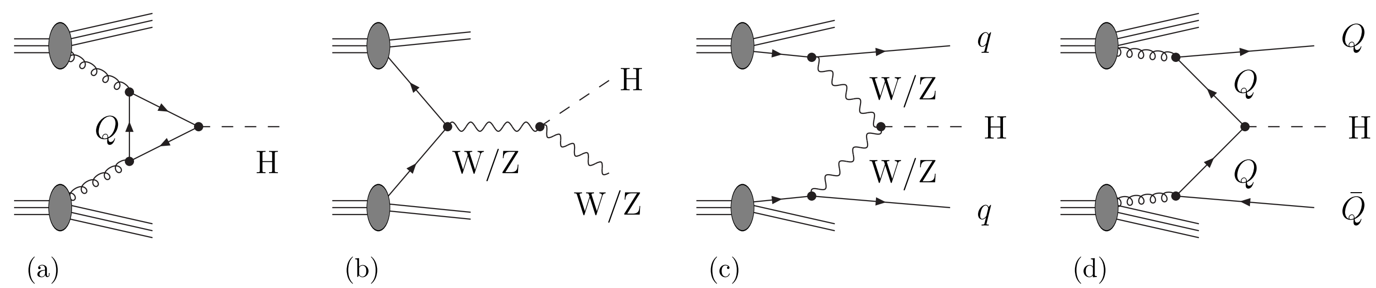
126 GeV Higgs at the LHC

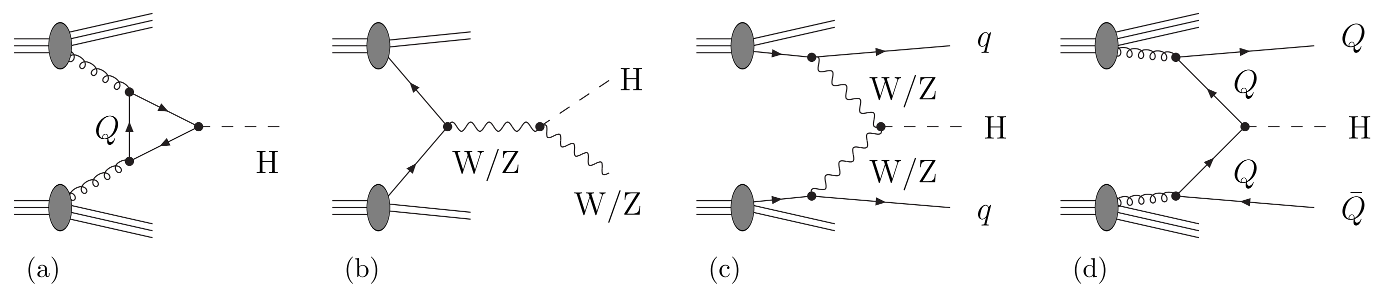


- Four production modes ggF, VH, VBF, and ttH
- Five final states: $\gamma\gamma,\ ZZ^{(*)},\ WW^{(*)},\ b\bar{b}$ and $\tau\tau$. only four are independent - ZZ and WW related by custodial symmetry
- Loop induced ggF production and $\gamma\gamma$ final state are susceptible to BSM contributions - in case of SUSY light staus and neutralino contribute
- Experimentally we get information on the signal strengths

$$\mu_i \equiv (\sigma \times \mathrm{BR})_i / (\sigma \times \mathrm{BR})_i^{\mathrm{SM}},$$

for each final state

126 GeV Higgs at the LHC



- Higgs effective Lagrangian:

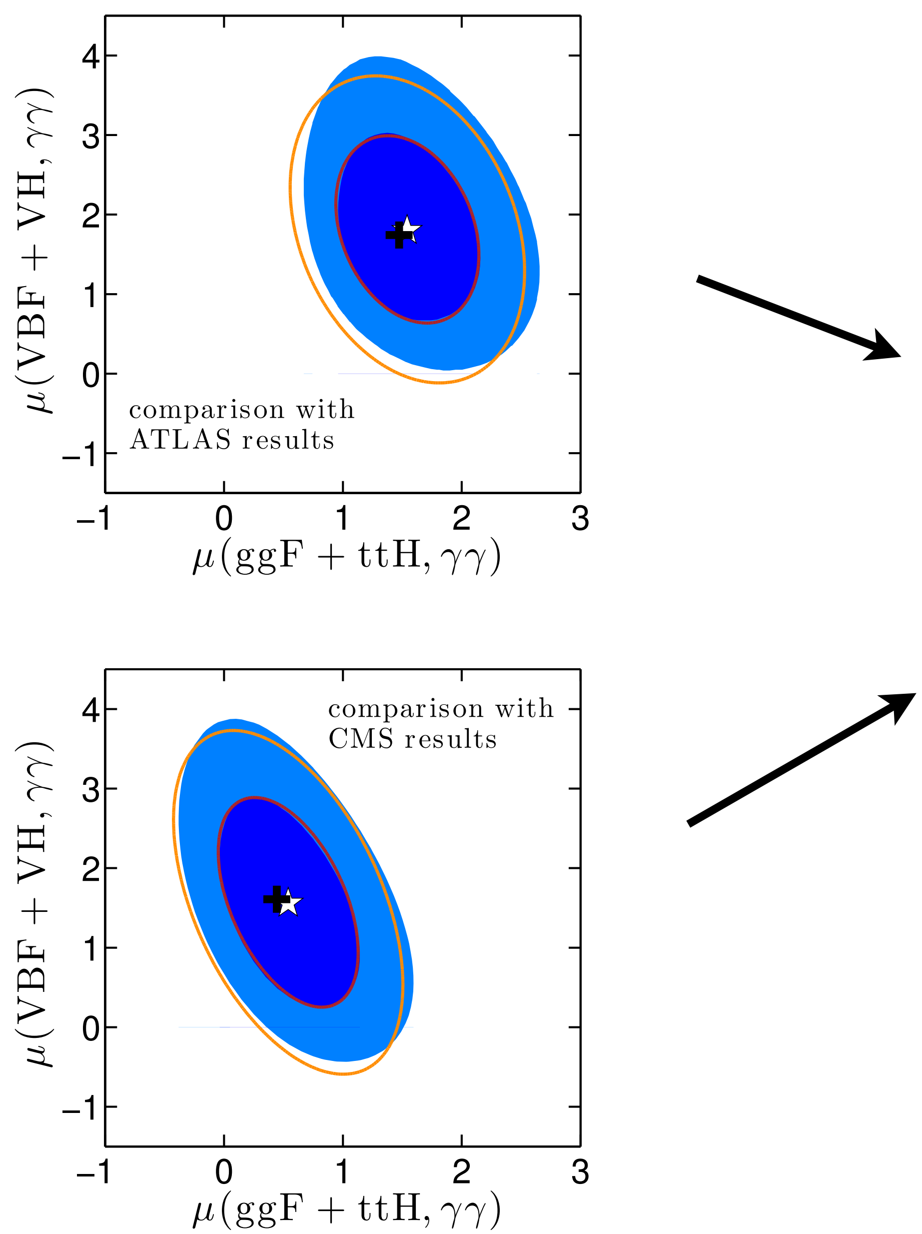
$$\mathcal{L} = g\left[C_V\left(M_W W_\mu W^\mu + \frac{M_Z}{\cos\theta_W} Z_\mu Z^\mu\right) - C_U \frac{m_t}{2M_W}\bar{t}t - C_D \frac{m_b}{2M_W}\bar{b}b - C_D \frac{m_\tau}{2M_W}\bar{\tau}\tau\right] H \, .$$

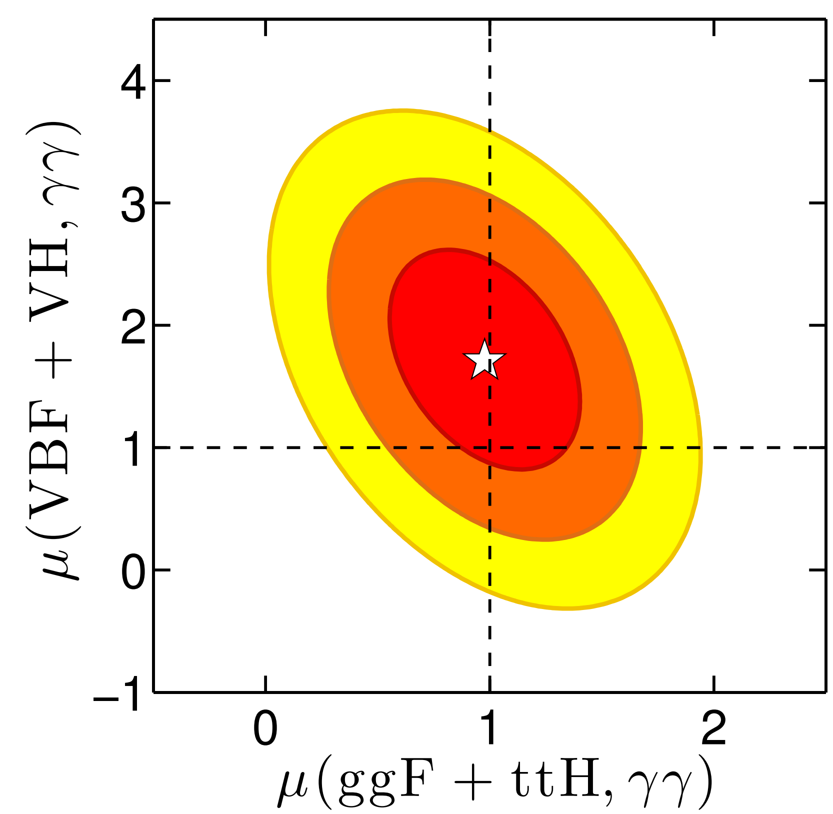
C's scale couplings relative to SM ones; $C_U = C_D = C_V = 1$ is SM.

- Additional loop contribution modify the couplings to gluons and photons

126 GeV Higgs at the LHC

- A combined likelihood in (ggF+ttH) and (VBF+VH) planes was derived using ATLAS, CMS and Tevatron results

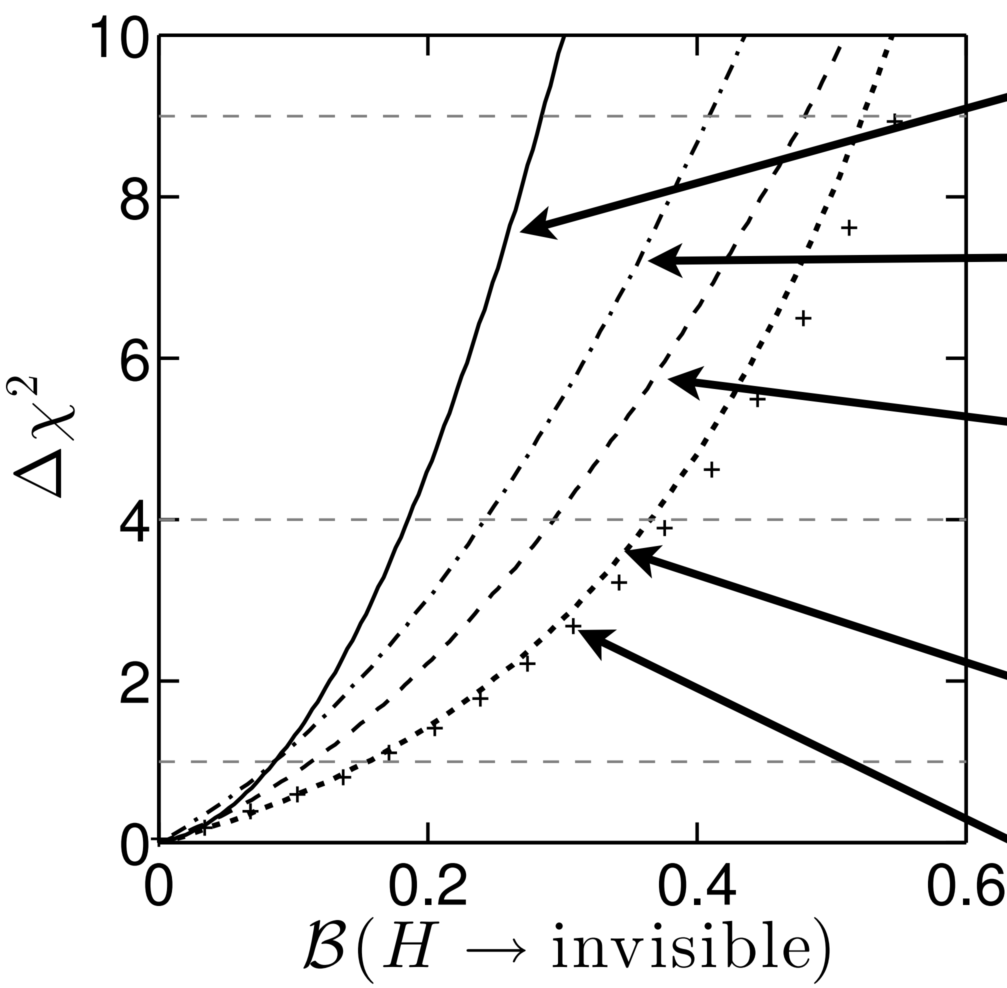




G. Belanger, B. Dumont, U. Ellwanger, J. Gunion, S, Kraml
arXiv:1306.2941

126 GeV Higgs at the LHC

- How much invisible Higgs decay is allowed?



SM+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.19$ at 95% CL

$C_U + C_D + (C_V \leq 1)$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.24$ at 95% CL

SM+$\Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.29$ at 95% CL

$C_U + C_D + C_V$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.36$ at 95% CL

$C_U + C_D + C_V + \Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.38$ at 95% CL

G. Belanger, B. Dumont, U. Ellwanger, J. Gunion, S, Kraml
arXiv:1306.2941

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A real life application

Do LHC results on the SUSY particles, Higgs signal strengths and constraints on DM from direct and indirect detection experiments rule out light neutralino DM?

Already many studies exist in literature, I'll not list them here

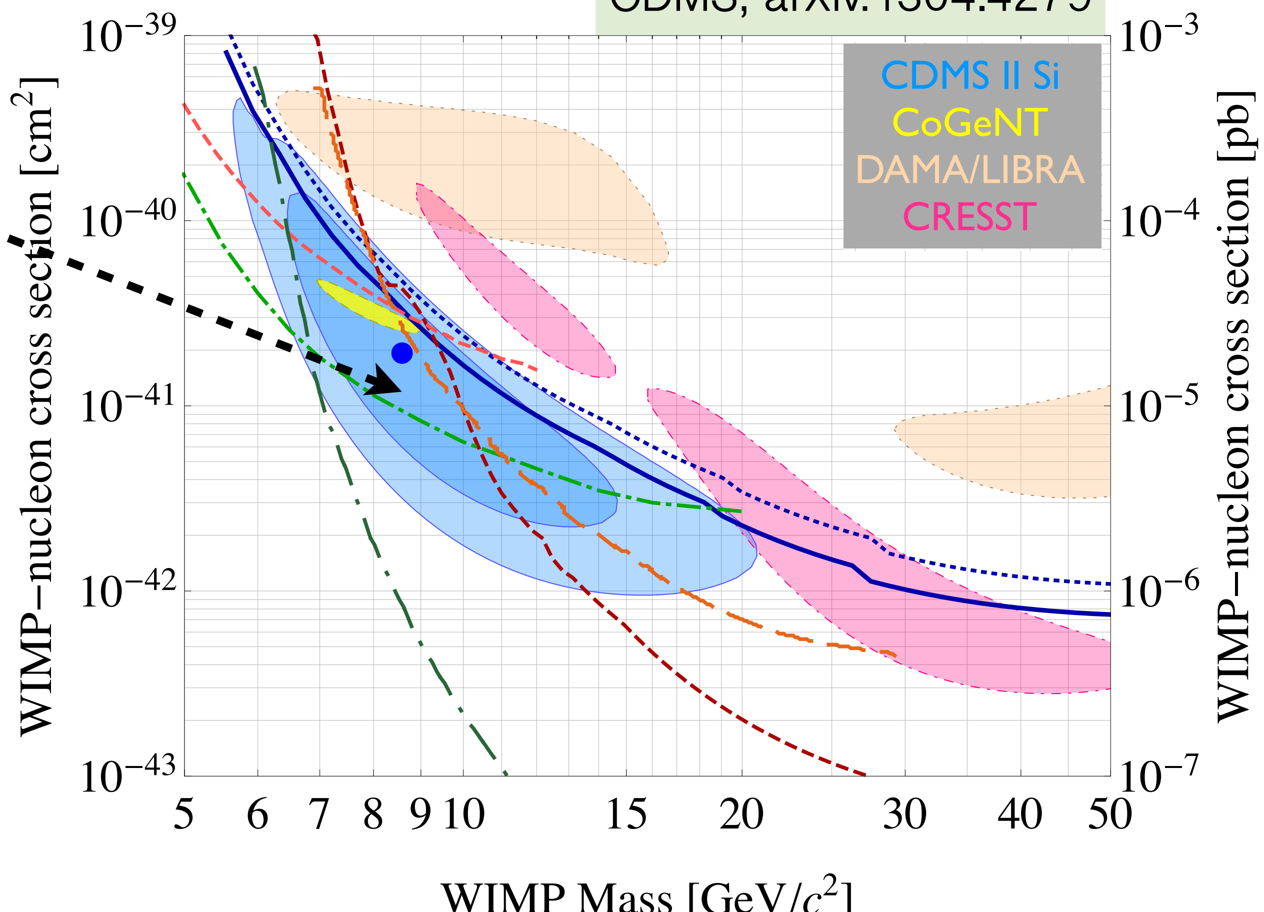
based on:
arXiv:1308.3735 [hep-ph] (published PLB)

Why light neutralino?

- Light SUSY spectrum
- Hints from direct (and may be indirect detection) ~ 10 GeV

CDMS, arXiv:1304.4279

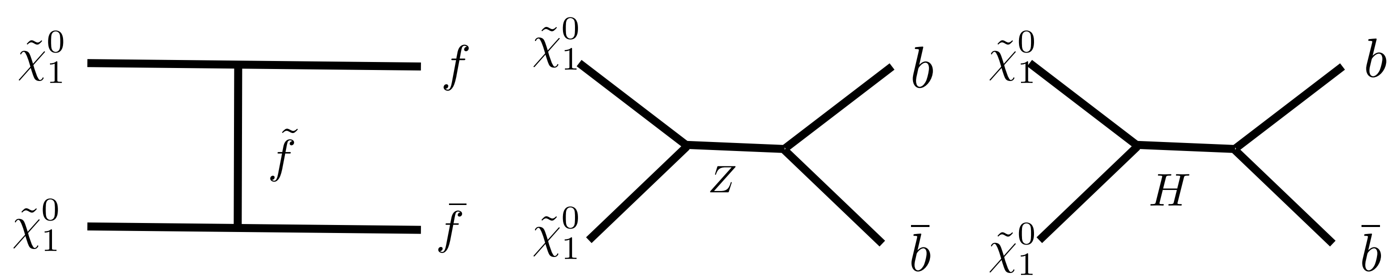
Light dark matter?



- Easy to exclude region
  - No resonance below 45 GeV (Mz/2)
  - No co-annihilation under 100 GeV (LEP limits) (counter example light sbottoms) arXiv:1308.2153

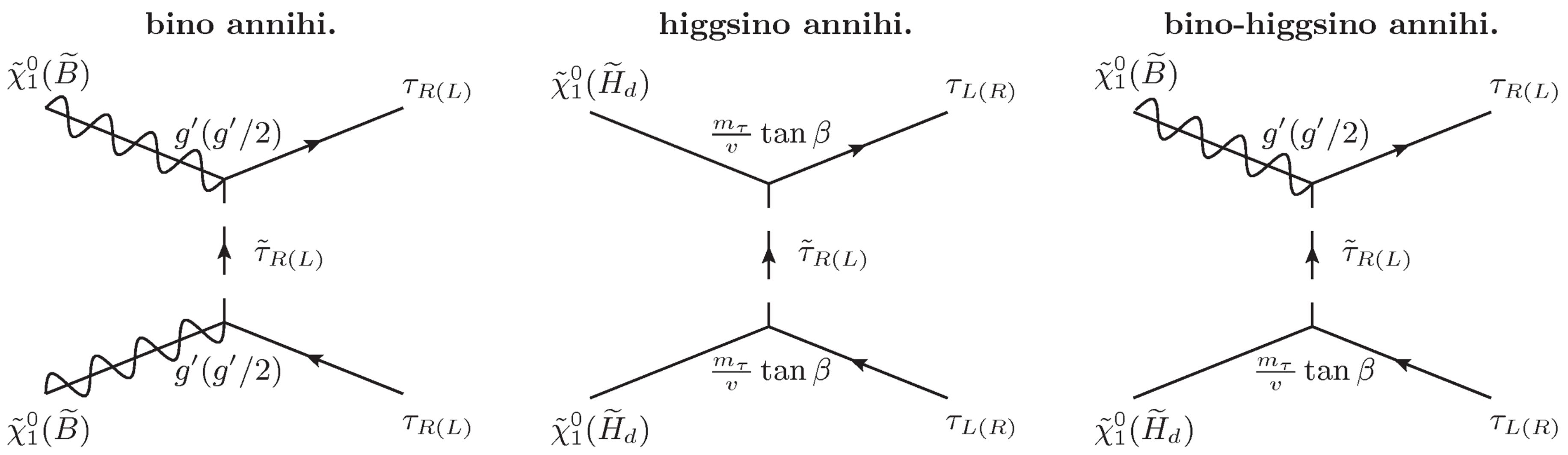
How light is light?

- Relaxing gaugino universality: few collider constraints
  - Z width, LEP bounds, invisible Higgs decays
- Most important annihilation channels:



- Region of interest: $m_{\tilde{\chi}_1^0} < m_h/2$ - Z and H exchange not effective
- Light slepton exchange of interest to us here

How light is light?

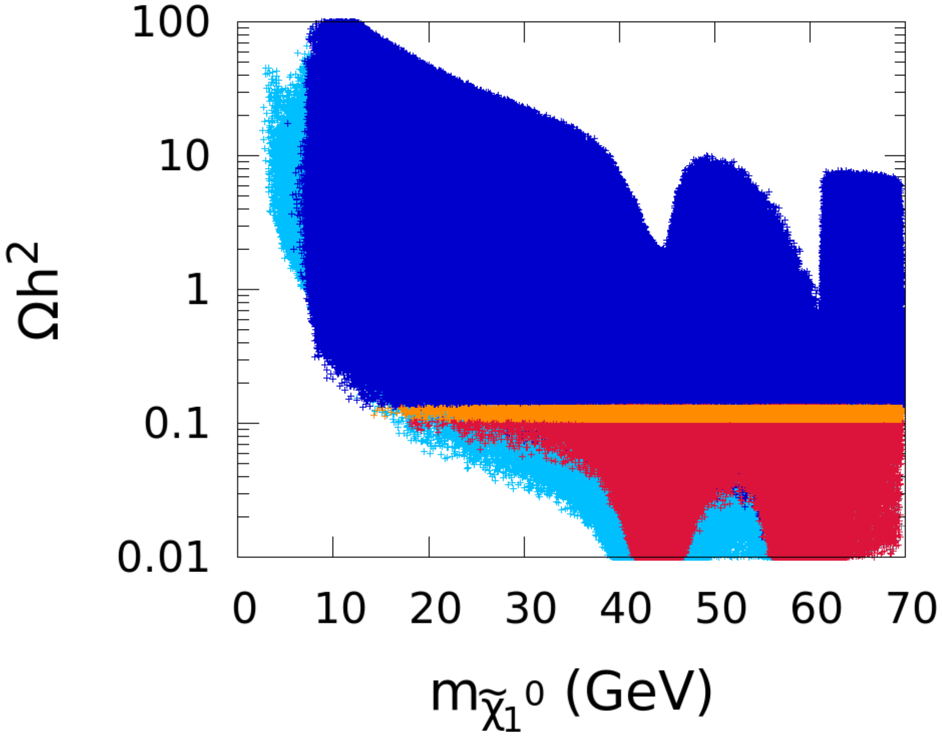


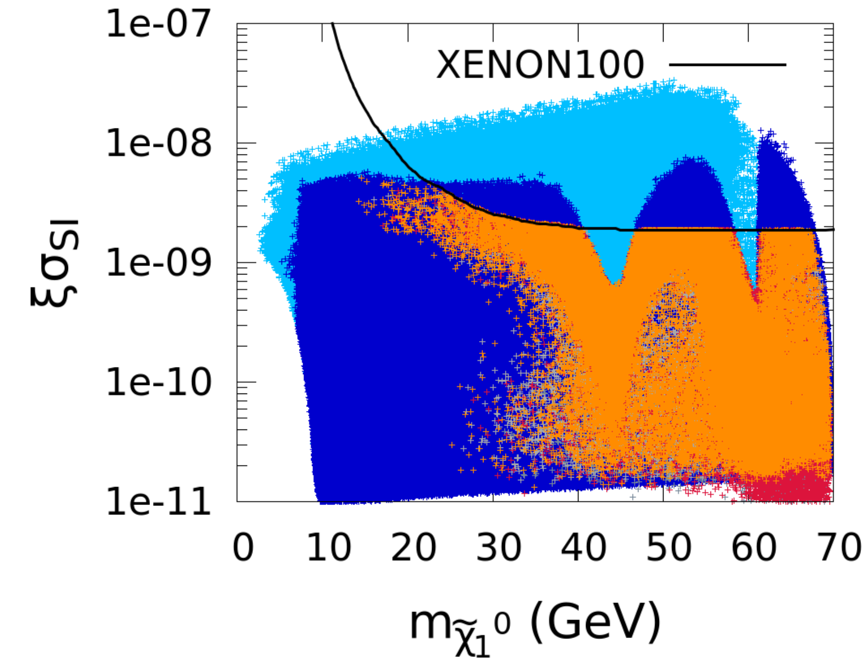
- RH stau annihilation is more efficient, also get enhancements for high tan(beta) and higgsino LSP

Light chargino	LEP and LHC	✓
Invisible Z, Higgs decays	LEP and LHC	✓
Light neutralino 2	LEP $\sigma(e^+ e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0)$	✓
Slepton and stau	LEP and LHC	✓

How light is light?

- pMSSM scan over 11 parameters
  - $M_1, M_2, \mu, tan\beta, M_A, A_t, M_{1L}.M_{1R}, M_{3L}, M_{3R}, A_\tau$
  - LEP limits, Z width, flavor physics, heavy Higgs searches @LHC, Higgs mass, Higgs couplings, Xenon100



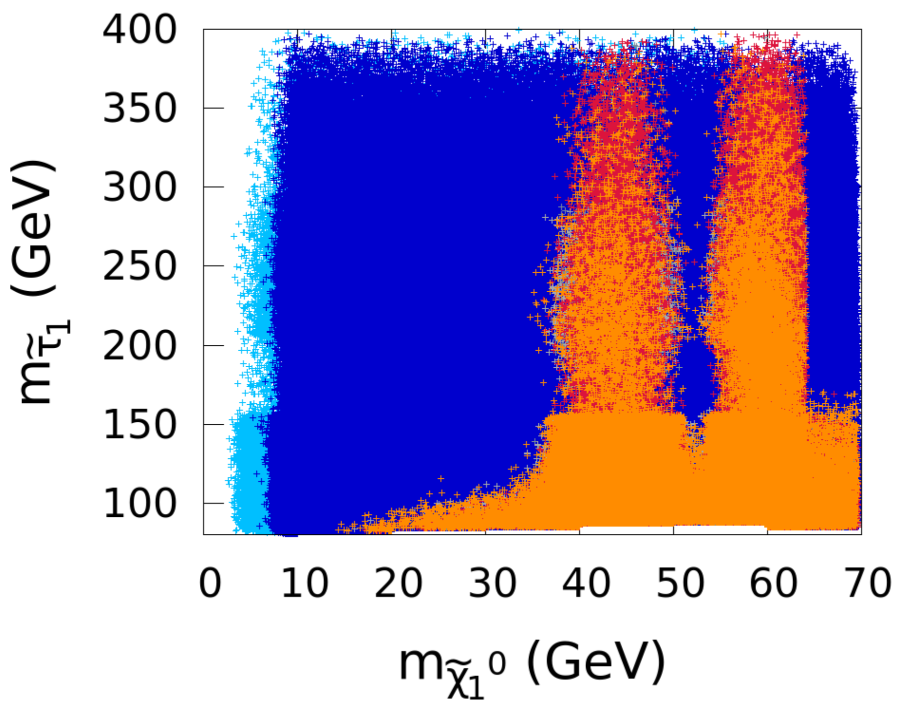


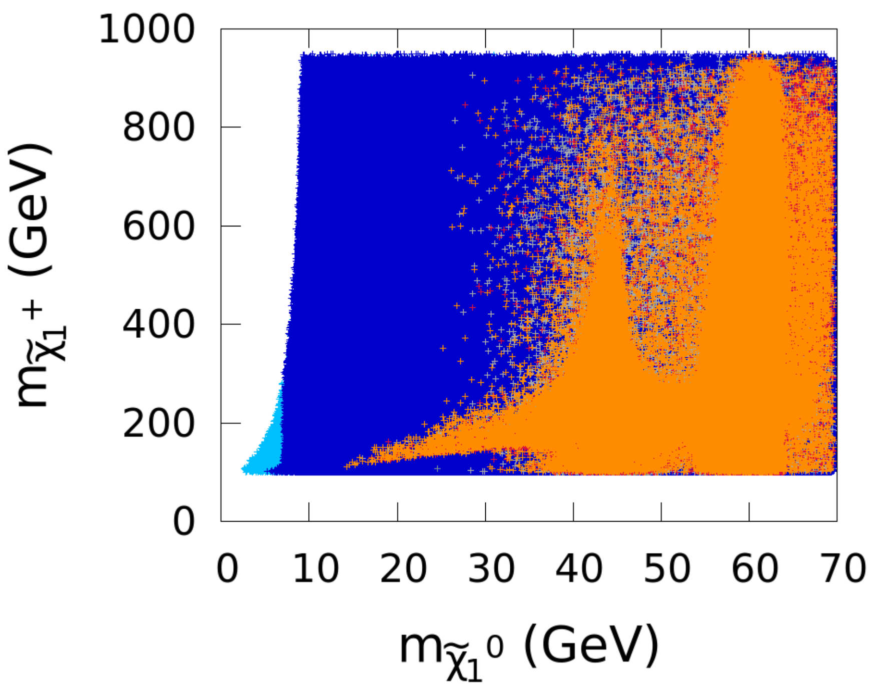
Basic constraints
Higgs couplings fits

LHC results + upper limit of relic
LHC results + exact relic

How light is light?

- DM < 35 GeV associated with light stau + light chargino





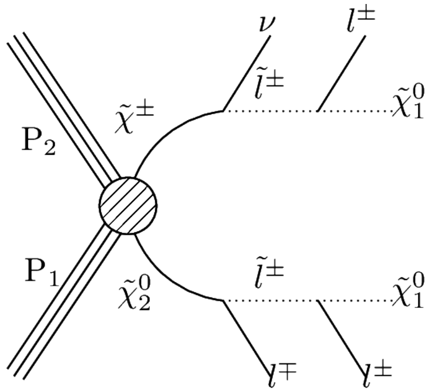
- LHC searches put constraints on light electroweak -ino and slepton production

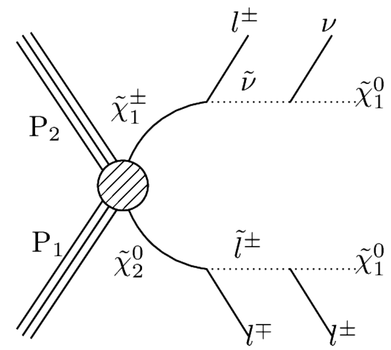
Basic constraints
Higgs couplings fits

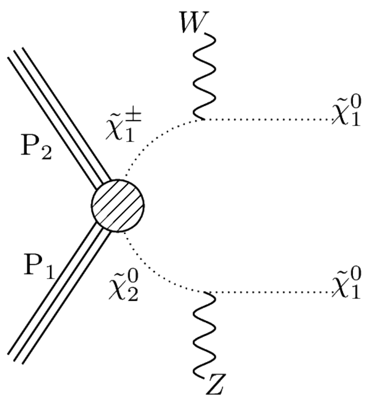
LHC results + upper limit of relic
LHC results + exact relic

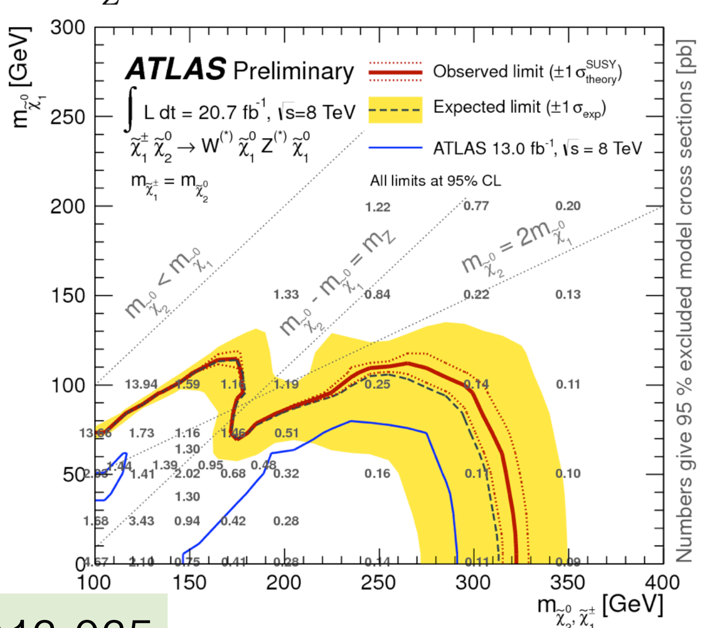
LHC searches

- Direct electroweak -ino production



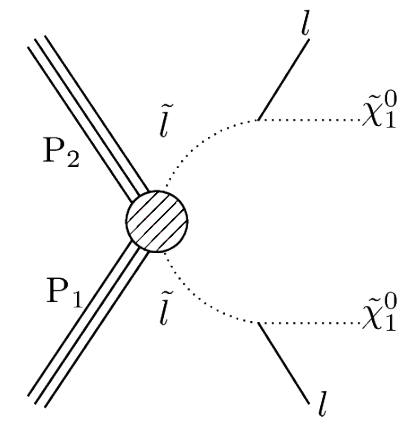


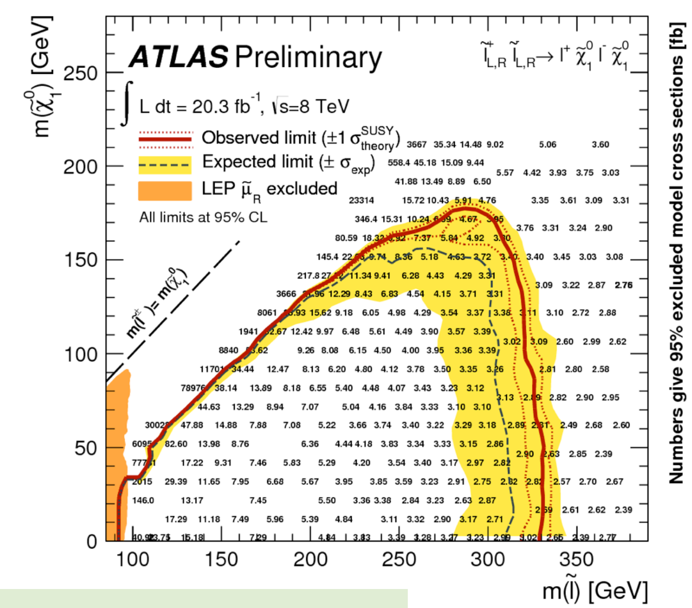




ATLAS-CONF-2013-035

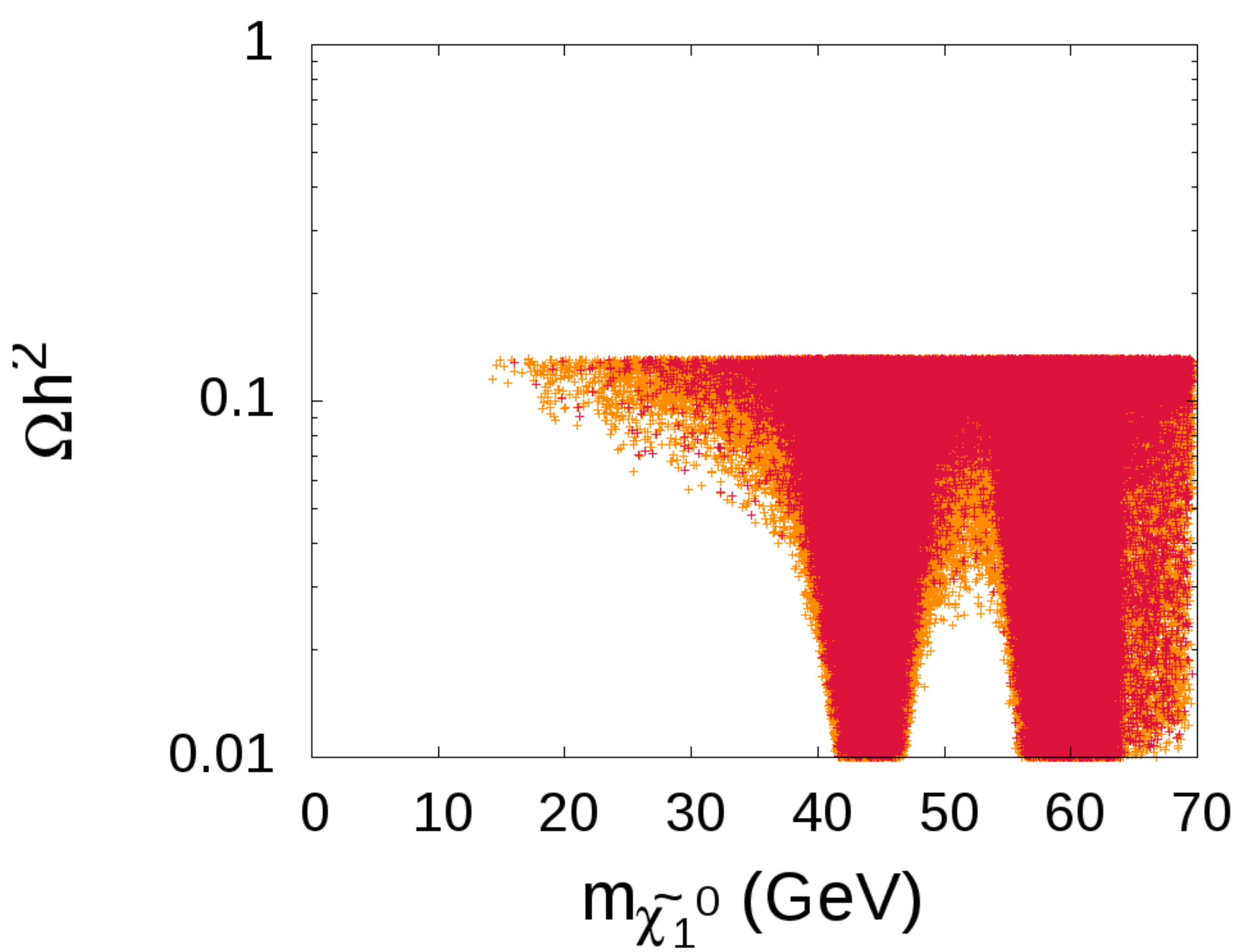
- Direct slepton production





ATLAS-CONF-2013-049

Applying SModelS

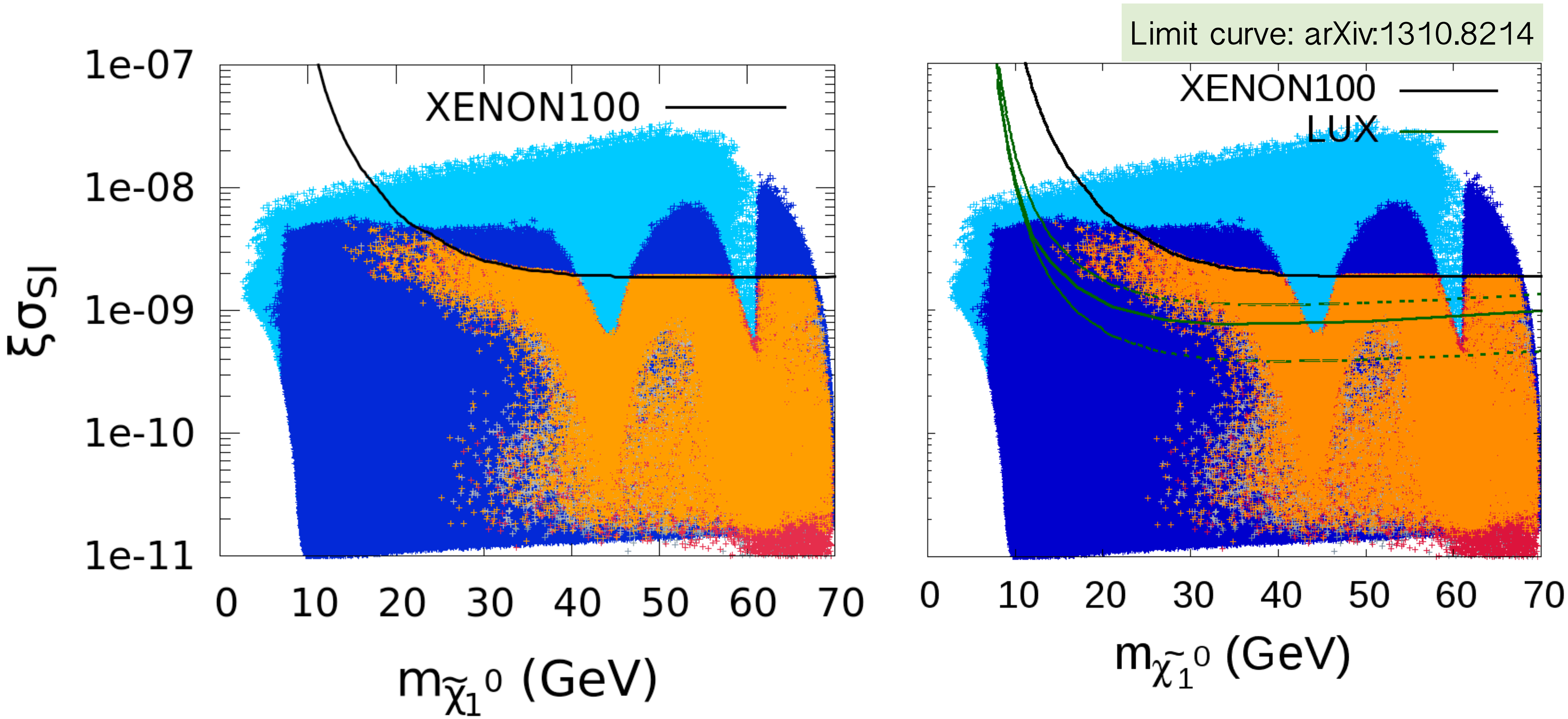


All points passing relic density upper limits

Points excluded by the LHC limits

- SMS results used from ATLAS-CONF-2013-049, CMS-PAS-SUS-12-022, ATLAS-CONF-2013-035
- Density of points reduced - LHC SMS results do rule out some scenarios
- In general light neutralino still possible

LUX limits



- Neutralino DD CS is driven by higgsino component, suppressed when LSP has small higgsino component

- LUX disfavors the light neutralino DM region we had identified to be viable

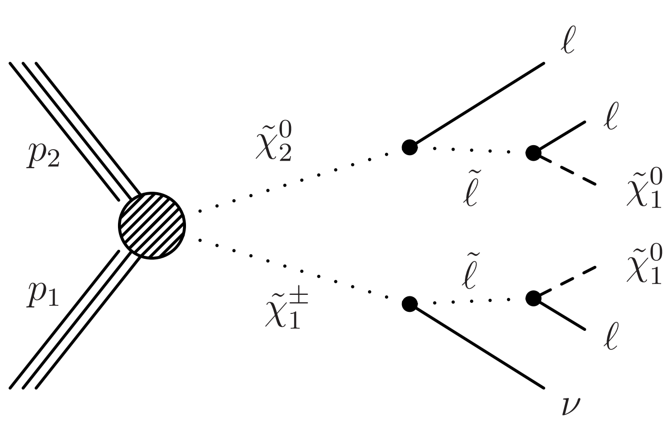
Basic constraints
Higgs couplings fits

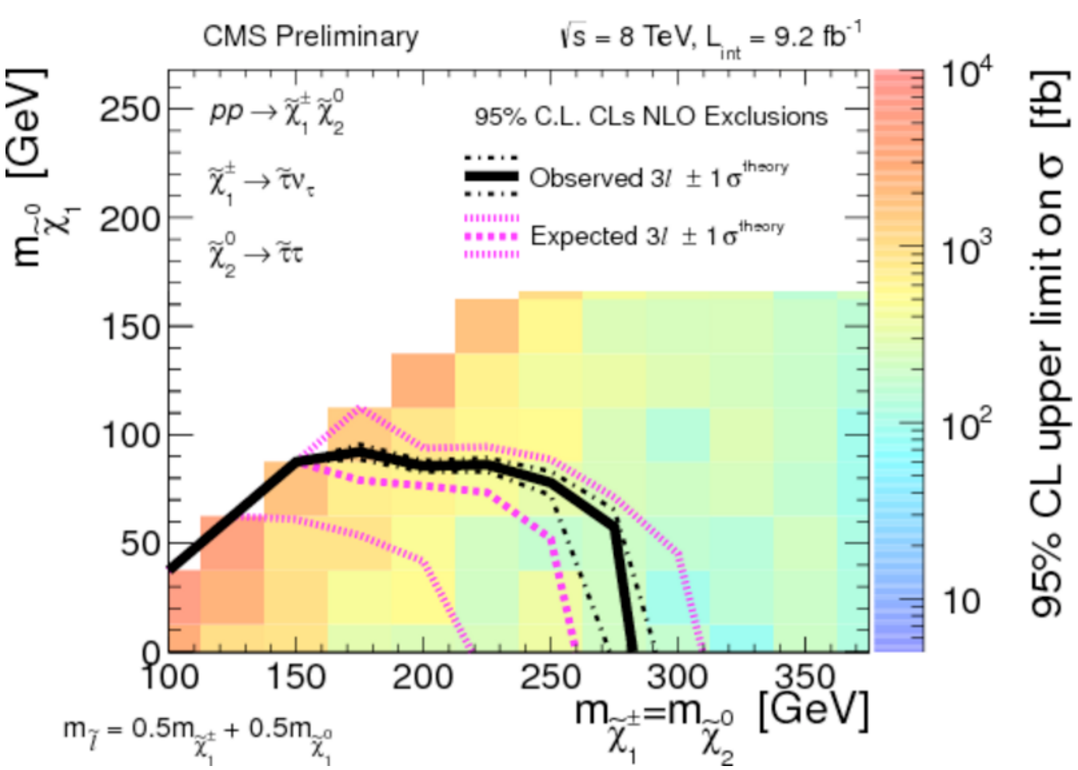
LHC results + upper limit of relic
LHC results + exact relic

SMS approach - what's next?

- SMS approach is not perfect yet
- Not all SMS topologies are present
- It is not always possible to use experimental SMS results, sometimes the results have a coarse grid or in case of a one step decay, only one mass slice is given

CMS - SUS -12-022



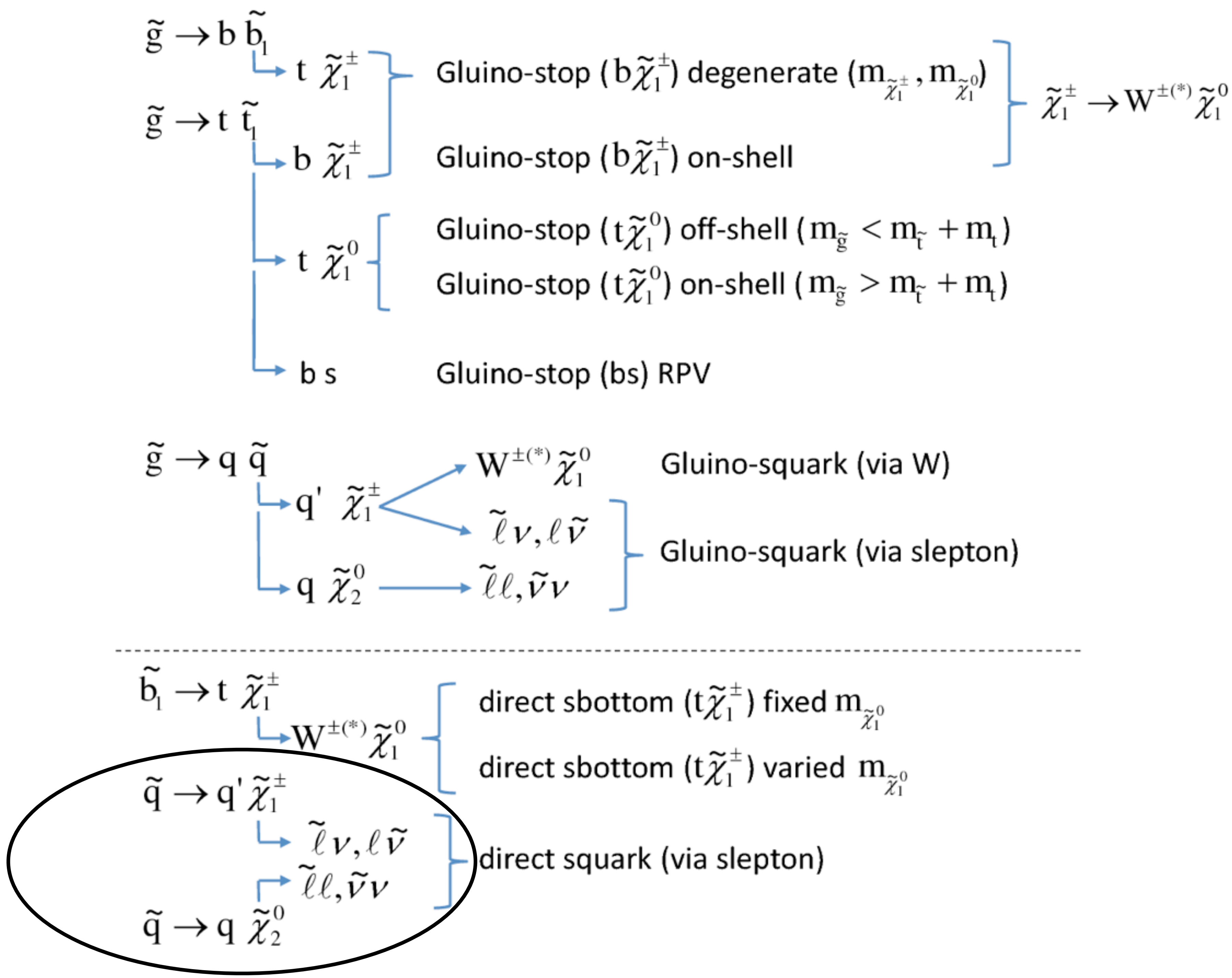


SMS approach - what's next?

- Results presented are not always usable
- My nightmare SMS analysis: ATLAS-CONF-2013-007
  - Involves topologies with more than four SUSY particles
  - Plots often include strong assumptions on the masses involved
  - Binning is not uniform

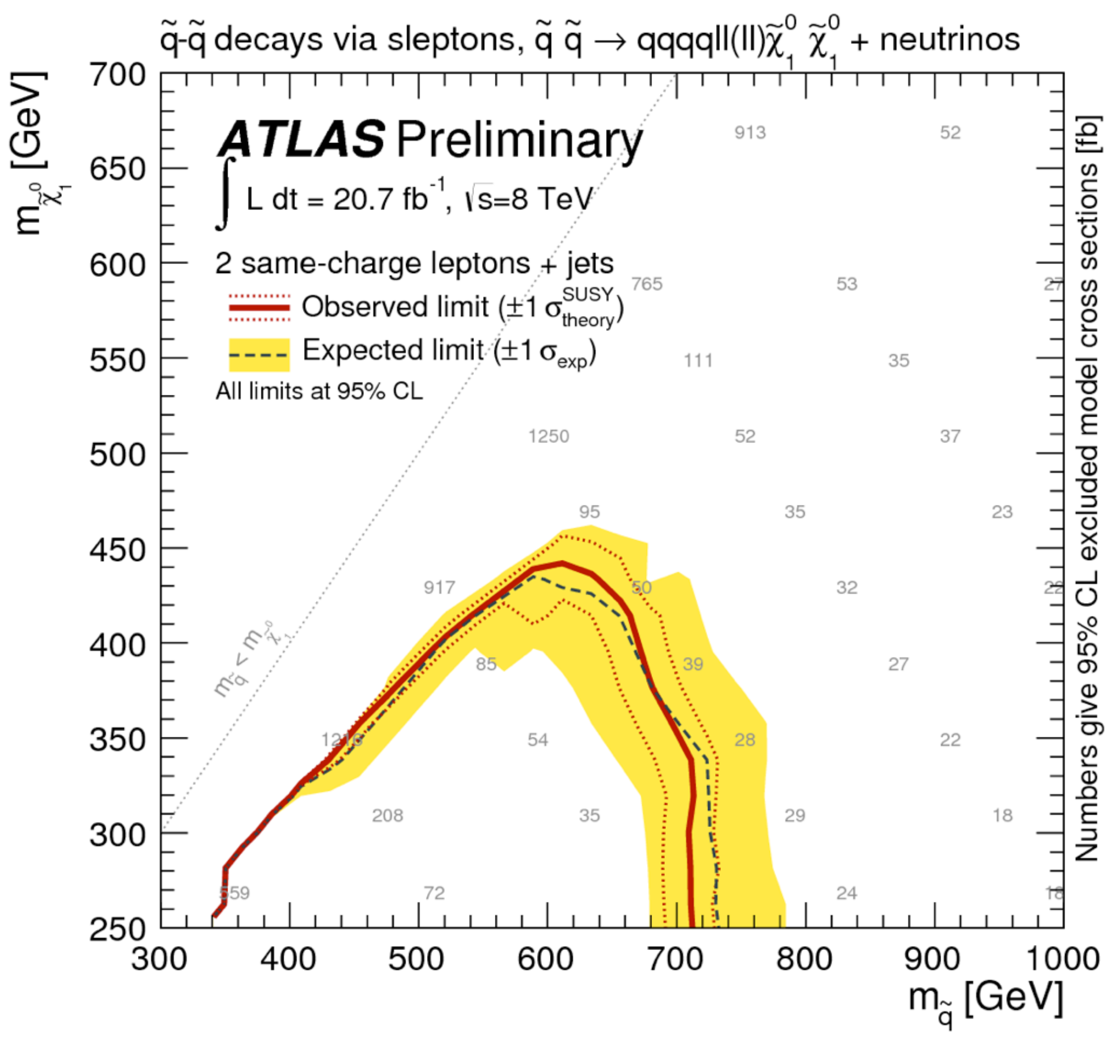
SMS approach - what's next?

ATLAS-CONF-2013-007



SMS approach - what's next?

ATLAS-CONF-2013-007

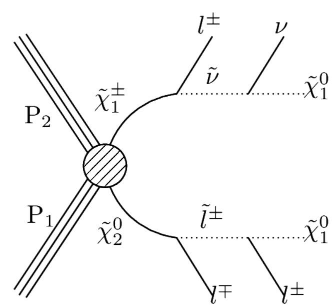


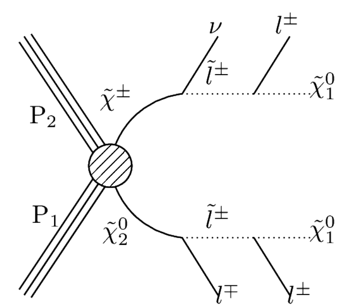
- Two of the four masses fixed
- Only democratic slepton decays
- Irregular binning (less severe)

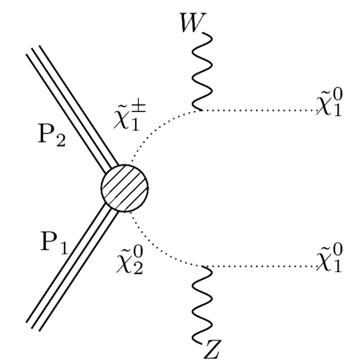
SMS approach - what's next?

- In principle several topologies can contribute to the same final state with different efficiencies

Tri-lepton final state: ATLAS-CONF-2013-035





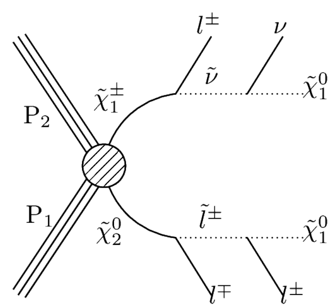


SMS approach - what's next?

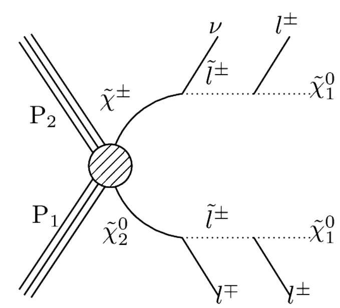
- In principle several topologies can contribute to the same final state with different efficiencies

Tri-lepton final state: ATLAS-CONF-2013-035

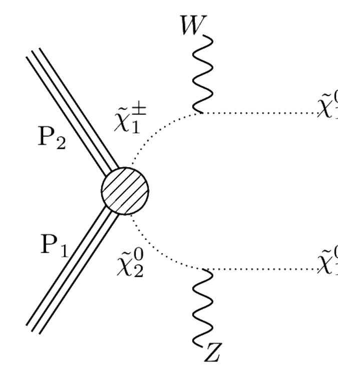
Real life ϵ_1



$+ \; \epsilon_2$



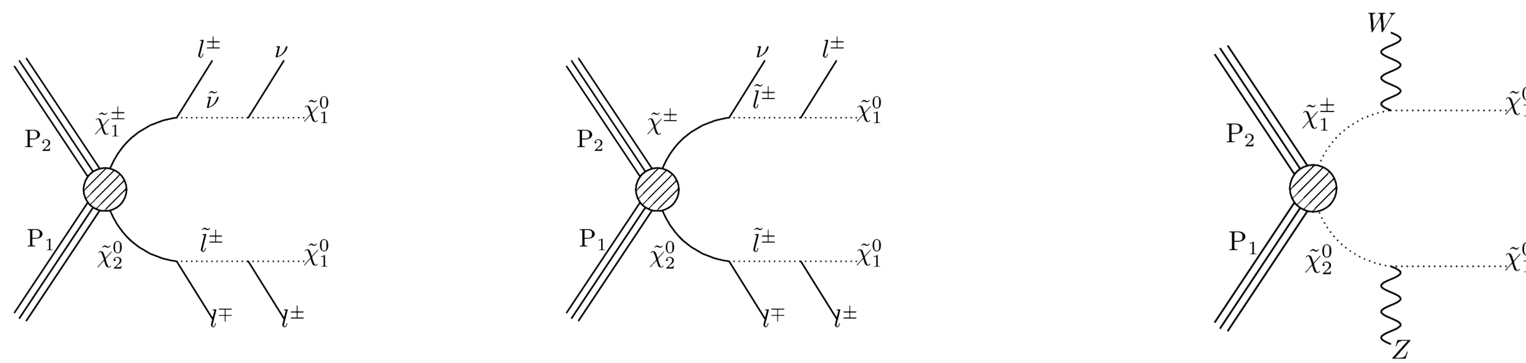
$+ \; \epsilon_3$



SMS approach - what's next?

- In principle several topologies can contribute to the same final state with different efficiencies

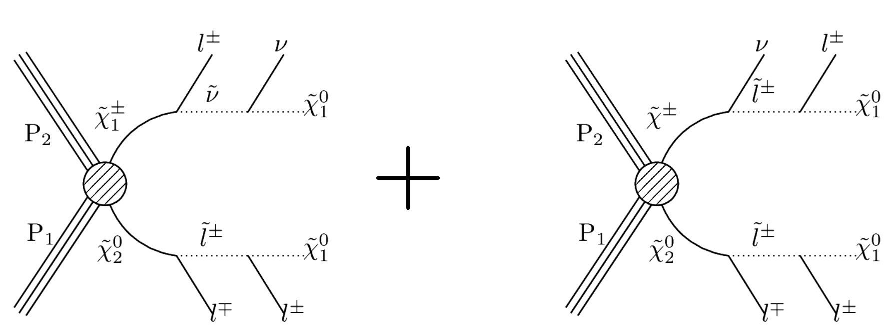
Tri-lepton final state: ATLAS-CONF-2013-035

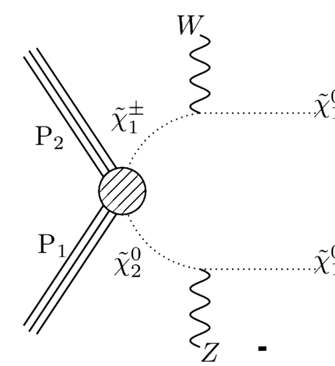


SMS approach - what's next?

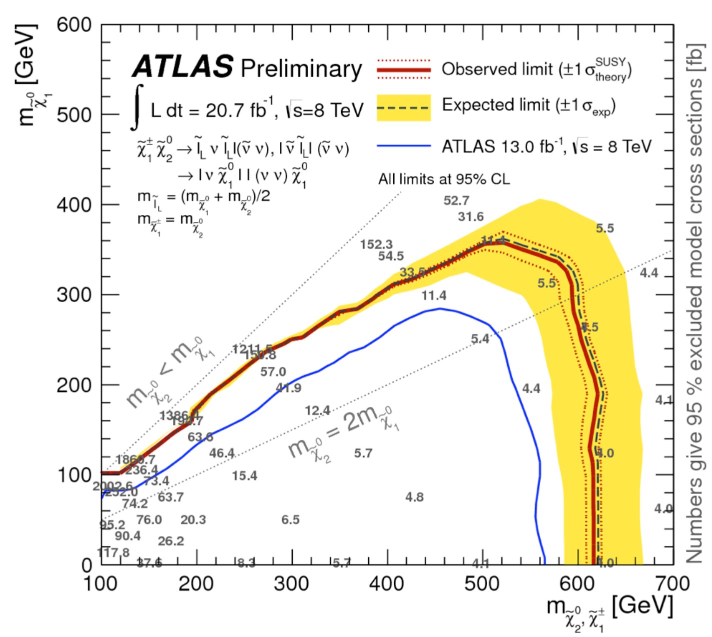
- In principle several topologies can contribute to the same final state with different efficiencies

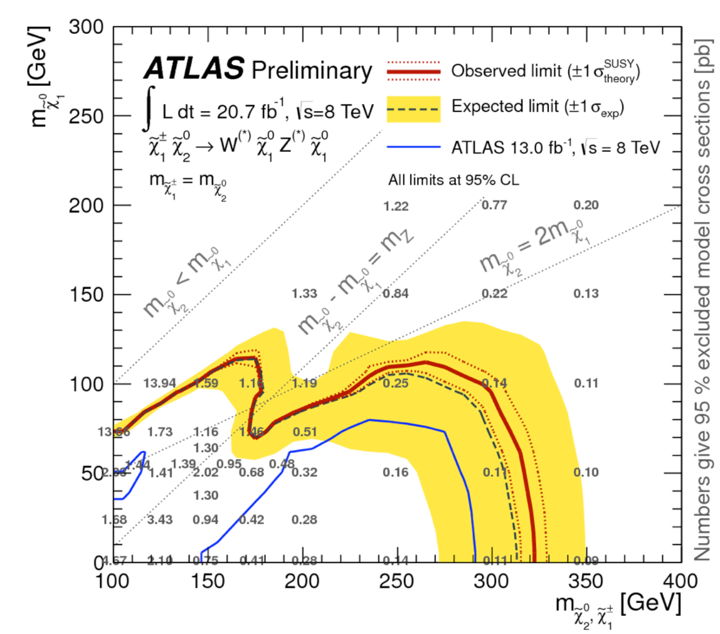
Tri-lepton final state: ATLAS-CONF-2013-035





Current SMS results





SMS approach - what's next?

- To utilize this approach one needs to develop efficiency maps for each analysis and for each topology that can potentially contribute to the final state
- Need to re-implement the analysis - requires manpower and availability of information from experimental collaborations in a systematic manner
- FastLim is developing the efficiency maps, aim is to reconstruct the number of events for each signal region
- SModelS is also capable of supporting efficiency maps approach, and in future we might consider exploiting this feature

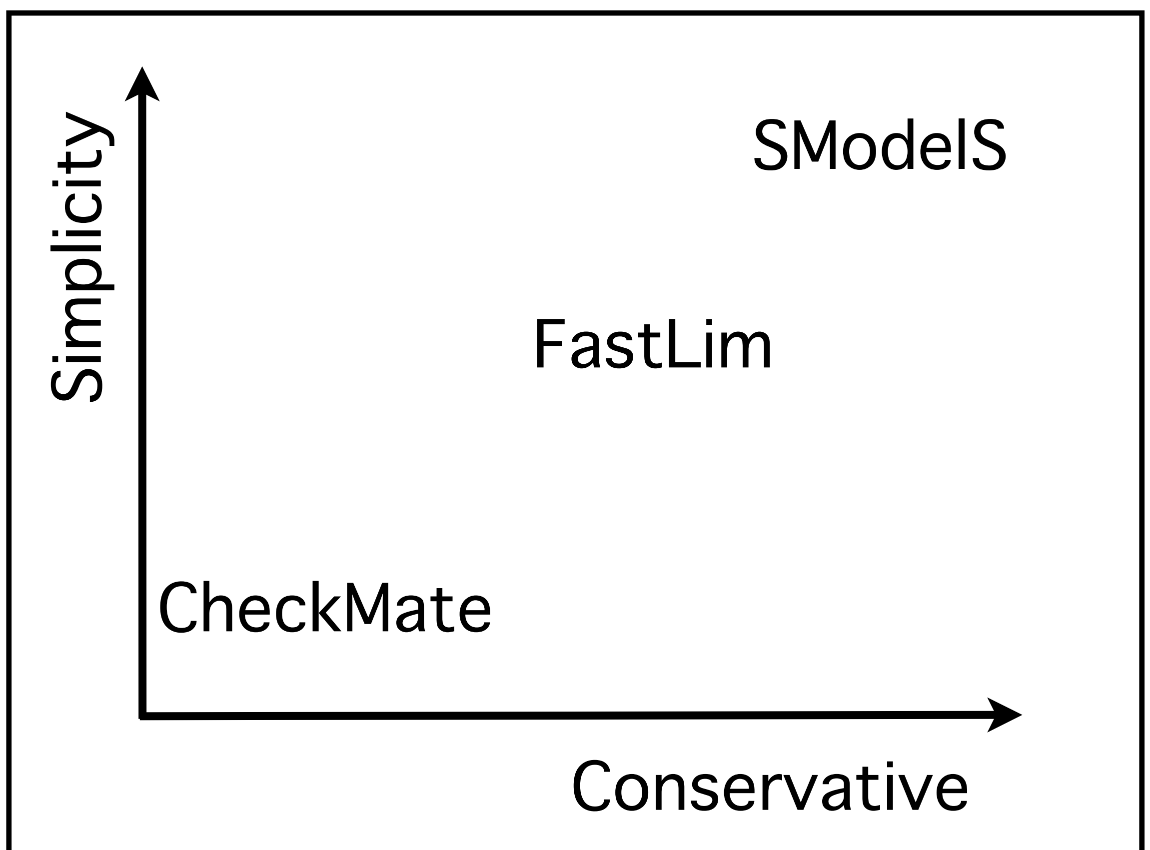
FastLim arXiv:1402.0492

SMS approach - what's next?

- Generally the development will be slow - a community effort to contribute to the efficiency maps is underway, this effort should also make the re-implemented analysis publicly available
- Also need to develop a reasonable likelihood in order to be able to combine several signal regions - e.g. CMS-SUS-PAS-13-011 has 16 signal regions

SMS approach - what's next?

- It will be difficult to tackle long cascade decays with SMS approach
- A completely different approach is being taken by checkMATE
- The tool identifies the most sensitive topology and then tests it via Monte Carlo simulation



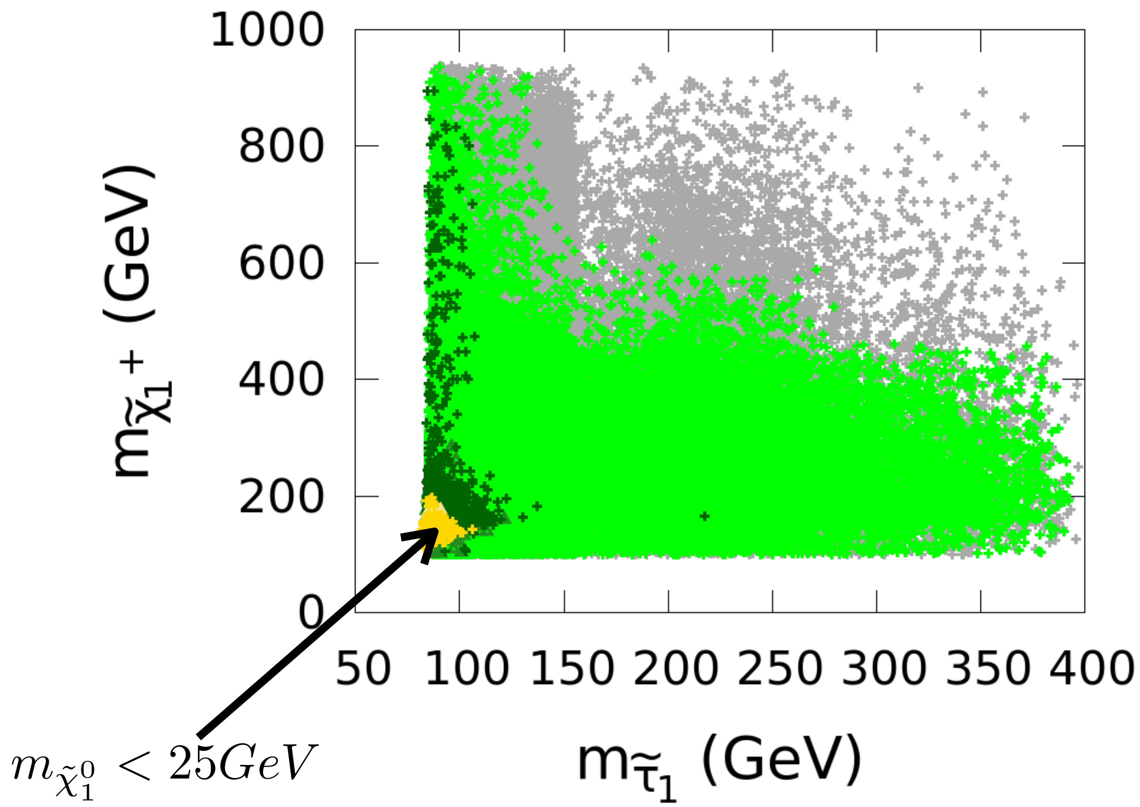
CheckMATEarXiv:1312.2591

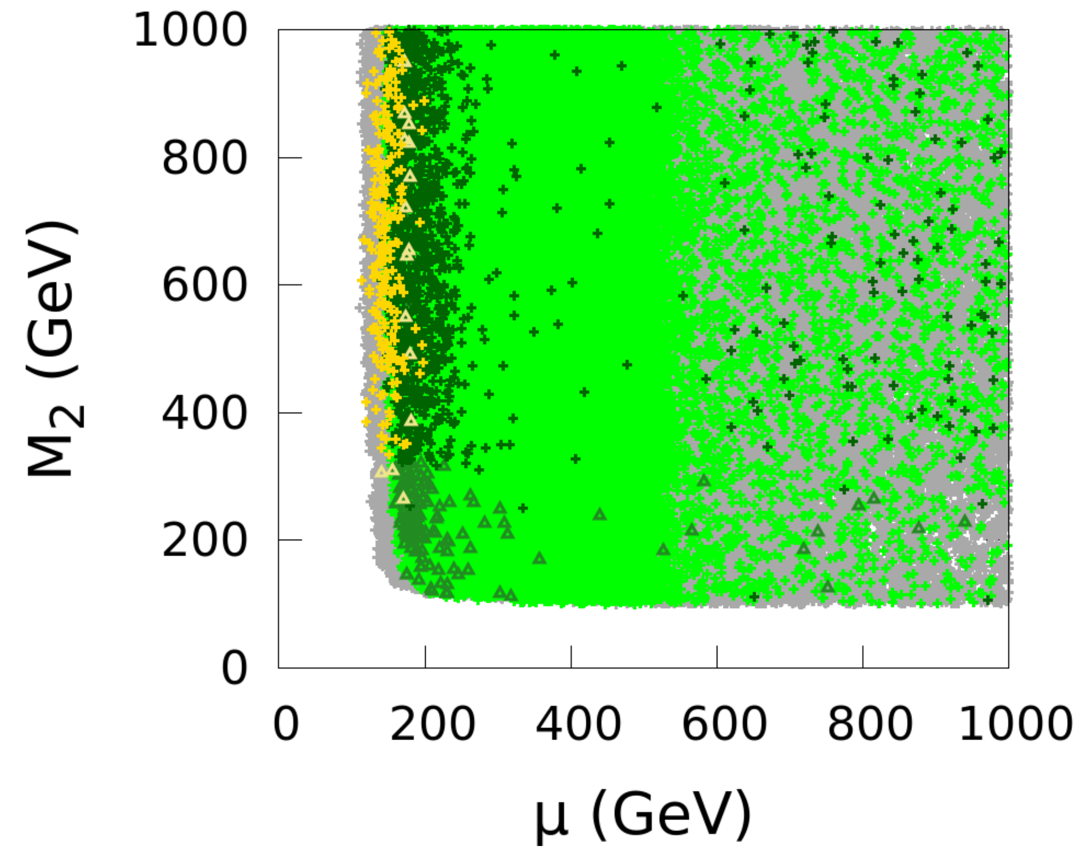
Conclusions

- SMS results are a good way to test BSM theories and can have a good constraining power
- SModelS is designed to utilize this power and constrain BSM scenarios
- The formalism of the code is generic and can be applied to any BSM spectra for which SMS results are applicable
- Currently, the code can handle scenarios with Z2 parity
- It contains the most comprehensive database of SMS SUSY results
- It can be used in order to understand the features of parameter space under consideration, it can also be used to study viability of an interesting BSM scenario
- Stay tuned applying LHC searches to your favorite BSM model is being made easy!

Back-up

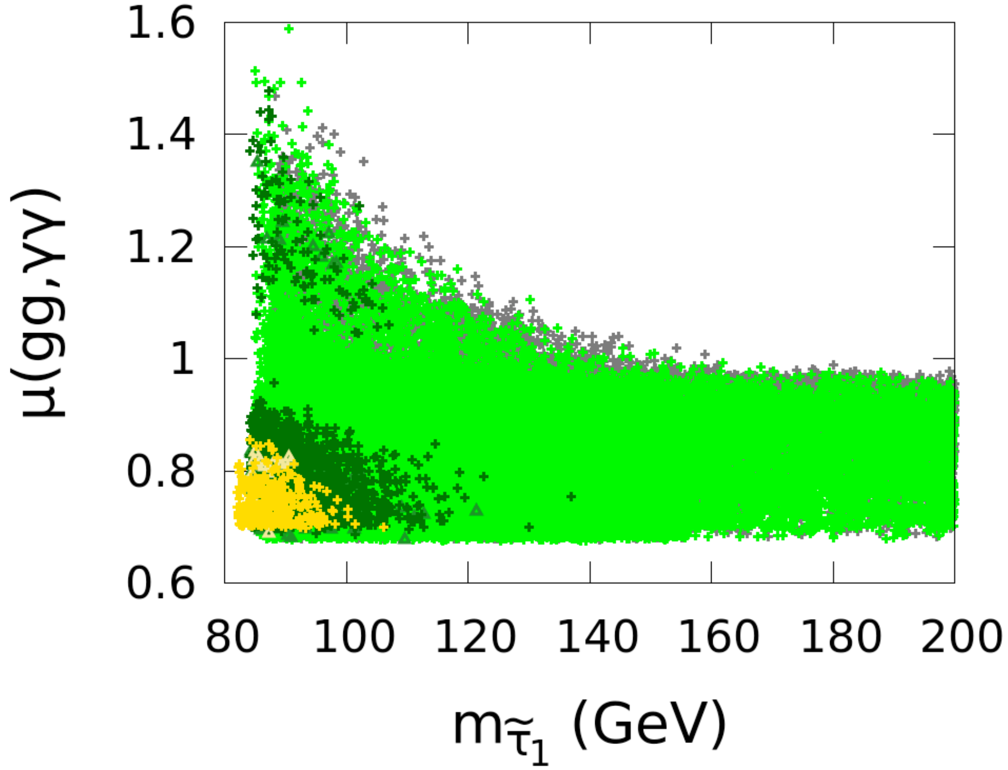
Applying SModelS

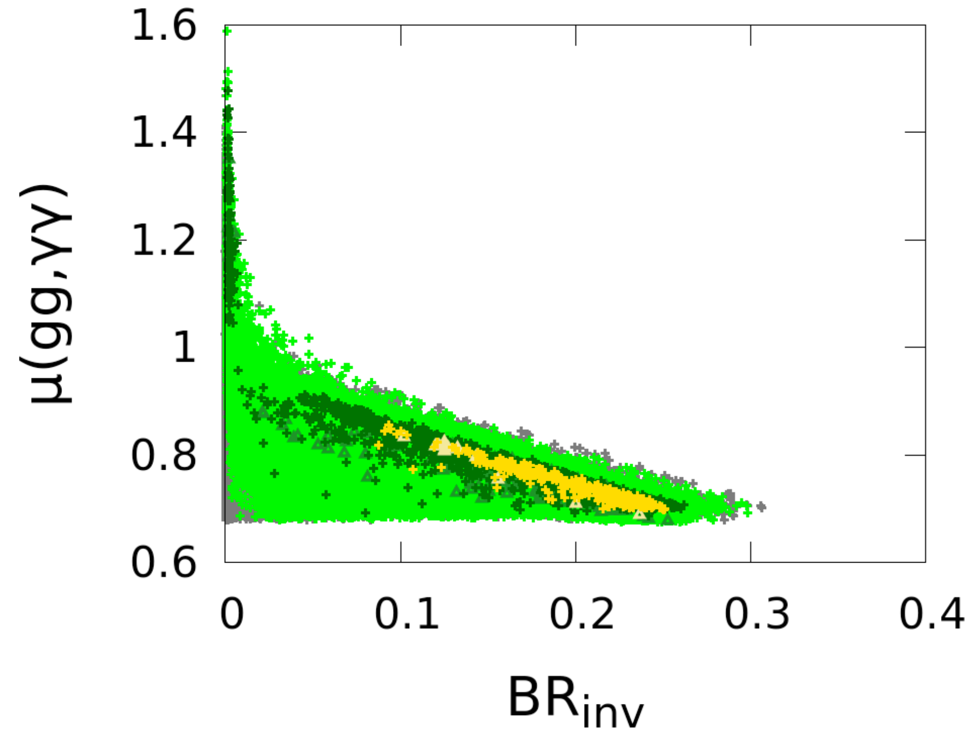




- Mass slices 10-15; 25-35; 35-50; 50-60 GeV
- Density of points reduced - LHC does rule out some scenarios
- In general light neutralino still possible

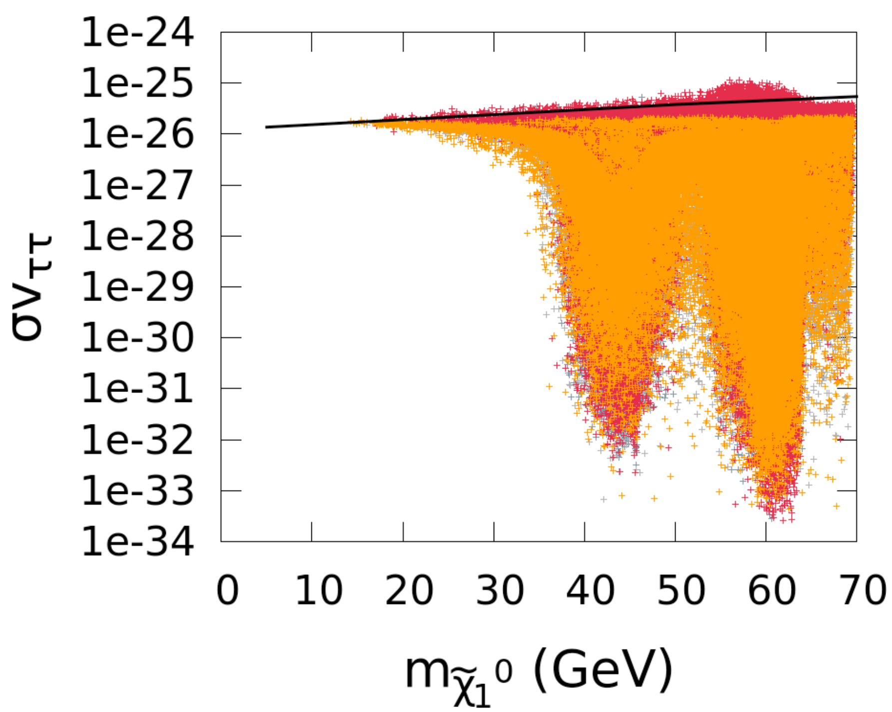
Higgs signal strengths

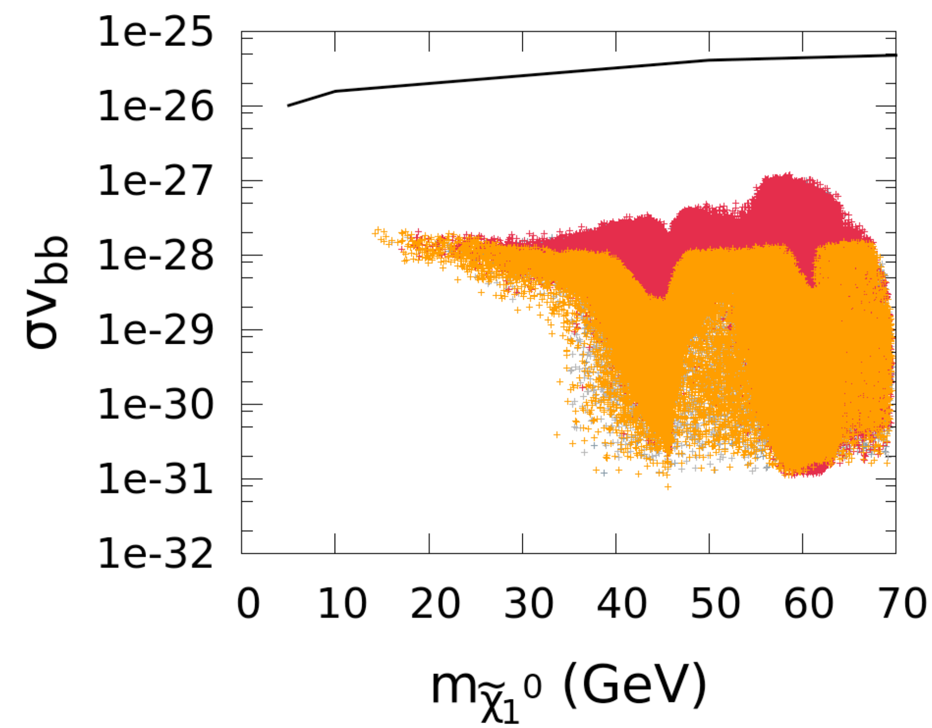




- Mass slices 10-15; 25-35; 35-50; 50-60 GeV
- Light neutralino and light stau lead to modifications
- Heavily mixed stau increases diphoton rate
- Lightest neutralino associated with some invisible Higgs decays
- At 14 TeV with ZH -> invisible, better sensitivity expected

Indirect detection limits





- We test for FERMI-LAT limits - photons produced from DM annihilation in dwarf spheroidal galaxies in bbar or tautau channel
- Large fraction of LSP < 30 GeV points are several orders of magnitude below the limit

Why not use monojet channel?

- Direct LSP production probed via monojet signature at the LHC
- Limits given on the spin-independent interactions of DM
- Limits applicable for models involving heavy mediators
- Not applicable for MSSM since the mediators are not heavy enough

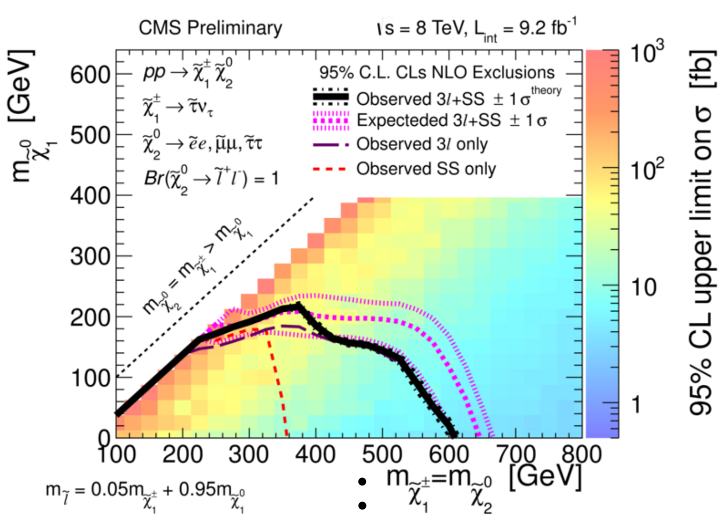
Light neutralino DM - scan details

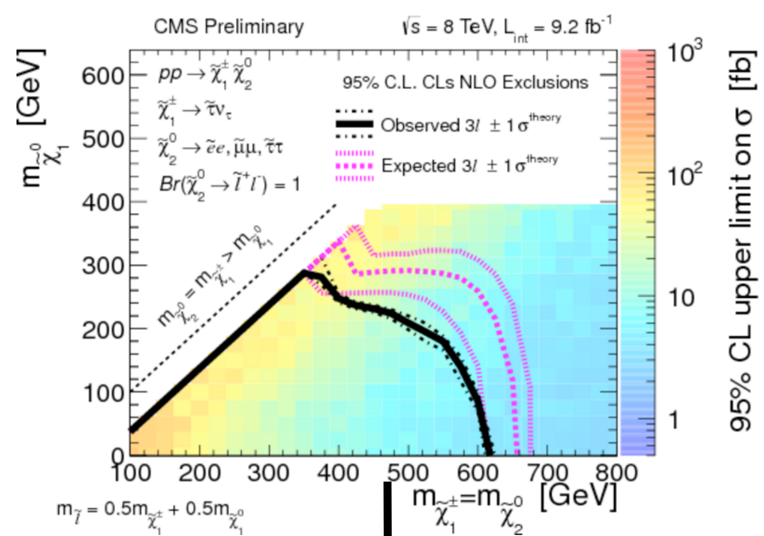
$\tan\beta$	$[5, 50]$	M_{L_3}	$[70, 500]$
M_{A^0}	$[100, 1000]$	M_{R_3}	$[70, 500]$
M_1	$[10, 70]$	A_τ	$[-1000, 1000]$
M_2	$[100, 1000]$	M_{L_1}	$[100, 500]$
μ	$[100, 1000]$	M_{R_1}	$[100, 500]$

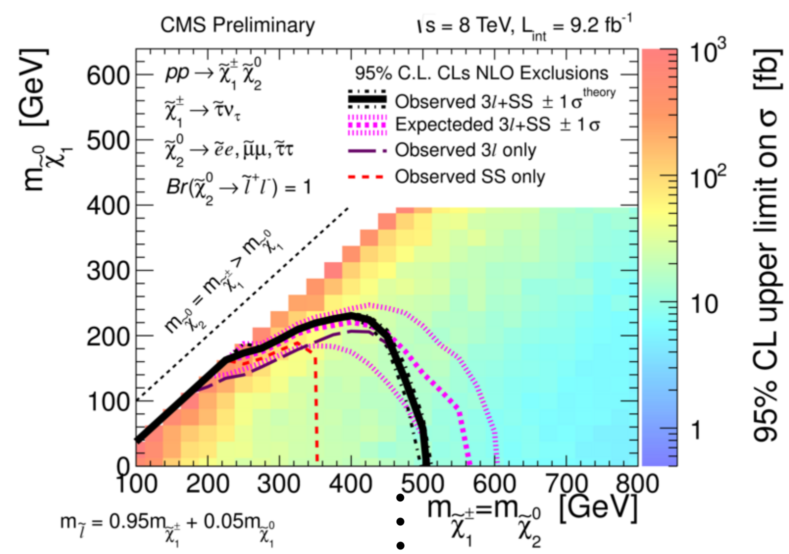
LEP limits	$m_{\tilde{\chi}_1^\pm} > 100$ GeV $m_{\tilde{\tau}_1} > 84 - 88$ GeV (depending on $m_{\tilde{\chi}_1^0}$) $\sigma(e^+e^- \to \tilde{\chi}_{2,3}^0\tilde{\chi}_1^0 \to Z^{(*)}(\to q\bar{q})\tilde{\chi}_1^0) \lesssim 0.05$ pb
invisible Z decay	$\Gamma_{Z\to\tilde{\chi}_1^0\tilde{\chi}_1^0} < 3$ MeV
μ magnetic moment	$\Delta a_\mu < 4.5 \times 10^{-9}$
flavor constraints	$\mathrm{BR}(b \to s\gamma) \in [3.03, 4.07] \times 10^{-4}$ $\mathrm{BR}(B_s \to \mu^+\mu^-) \in [1.5, 4.3] \times 10^{-9}$
Higgs mass	$m_{h^0} \in [122.5, 128.5]$ GeV
$A^0, H^0 \to \tau^+\tau^-$	CMS results for $\mathcal{L} = 17$ fb^{-1}, $m_h^{\max}$ scenario
Higgs couplings	ATLAS, CMS and Tevatron global fit, see text
relic density	$\Omega h^2 < 0.131$ or $\Omega h^2 \in [0.107, 0.131]$
direct detection	XENON100 upper limit
indirect detection	Fermi-LAT bound on gamma rays from dSphs
$pp \to \tilde{\chi}_2^0\tilde{\chi}_1^\pm$ $pp \to \tilde{\ell}^+\tilde{\ell}^-$	Simplified Models Spectra approach, see text

Tau dominated scenario

- For topologies involving an intermediate particles, three mass slices are given. We interpolate over these slices



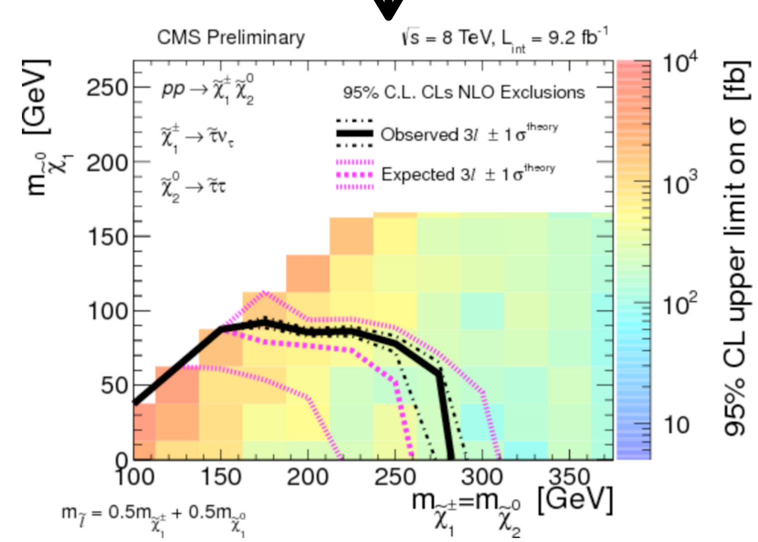




interpolate using k-factors

interpolate and derive k-factors

interpolate using k-factors



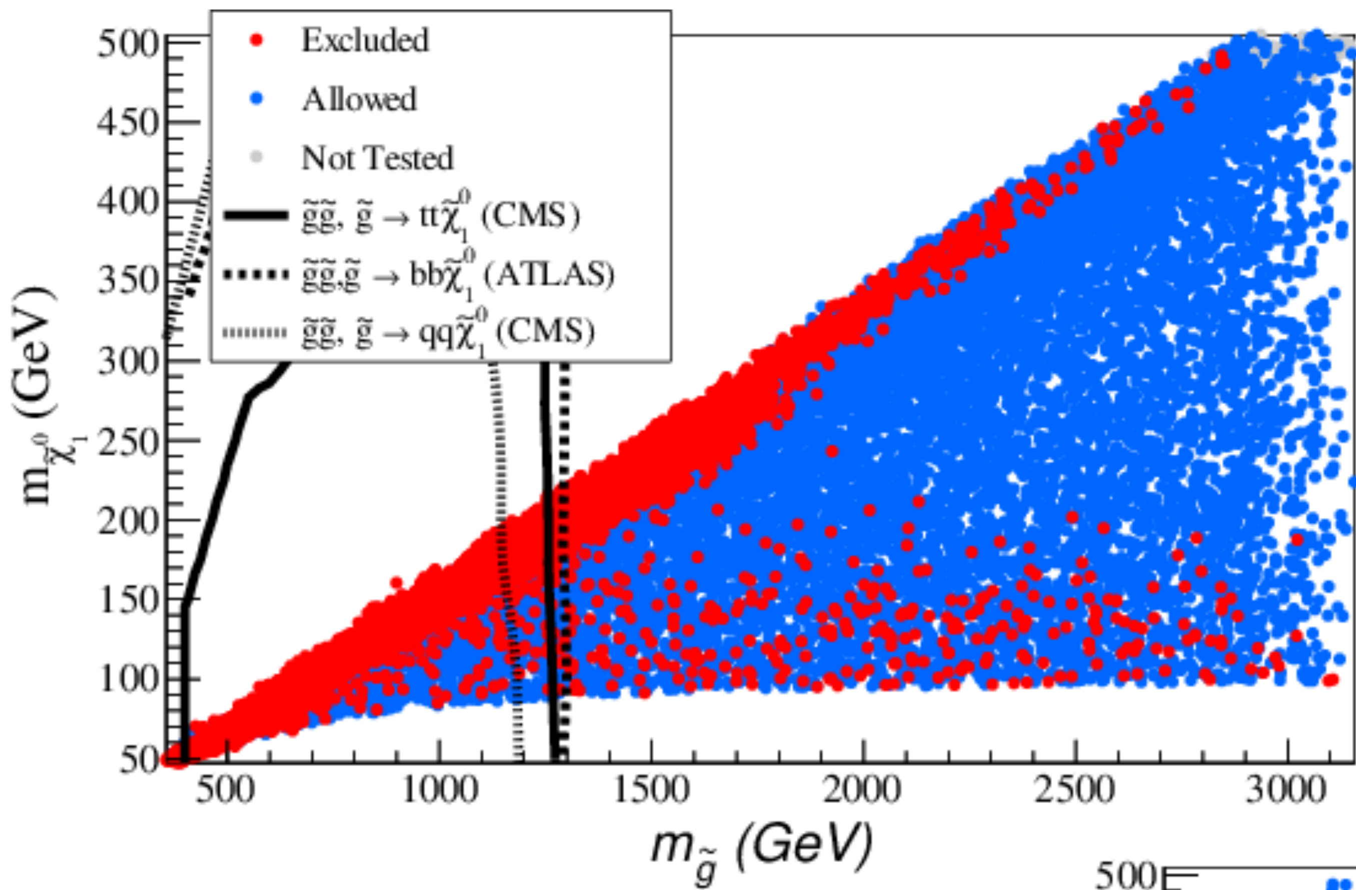
SModelS scan - strong focus

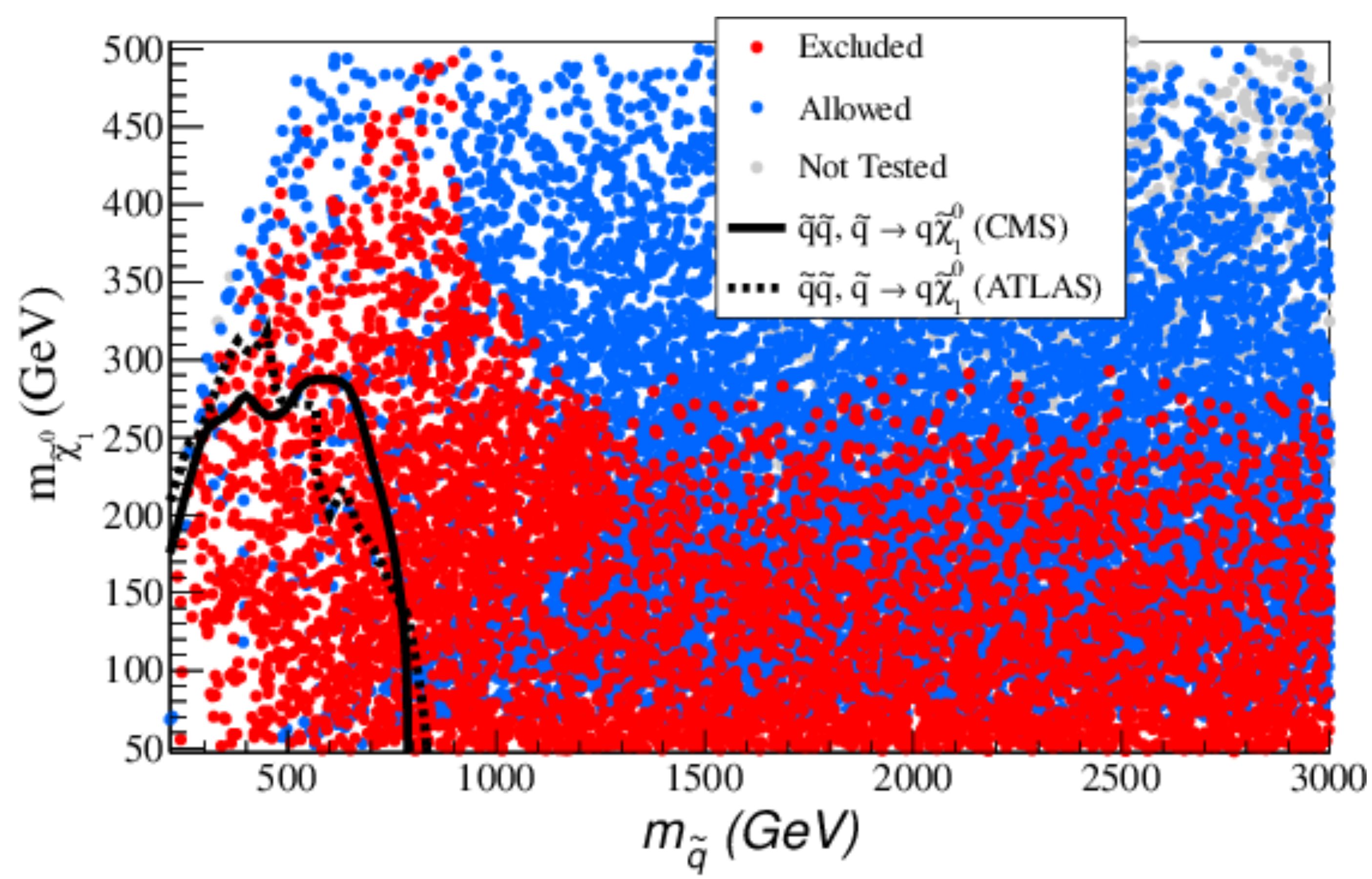
- pMSSM scan over 6 parameters

- Gaugino masses obey GUT relation
- Flavor constraints, invisible Z width, Higgs mass, LEP limits imposed
- Scan ranges

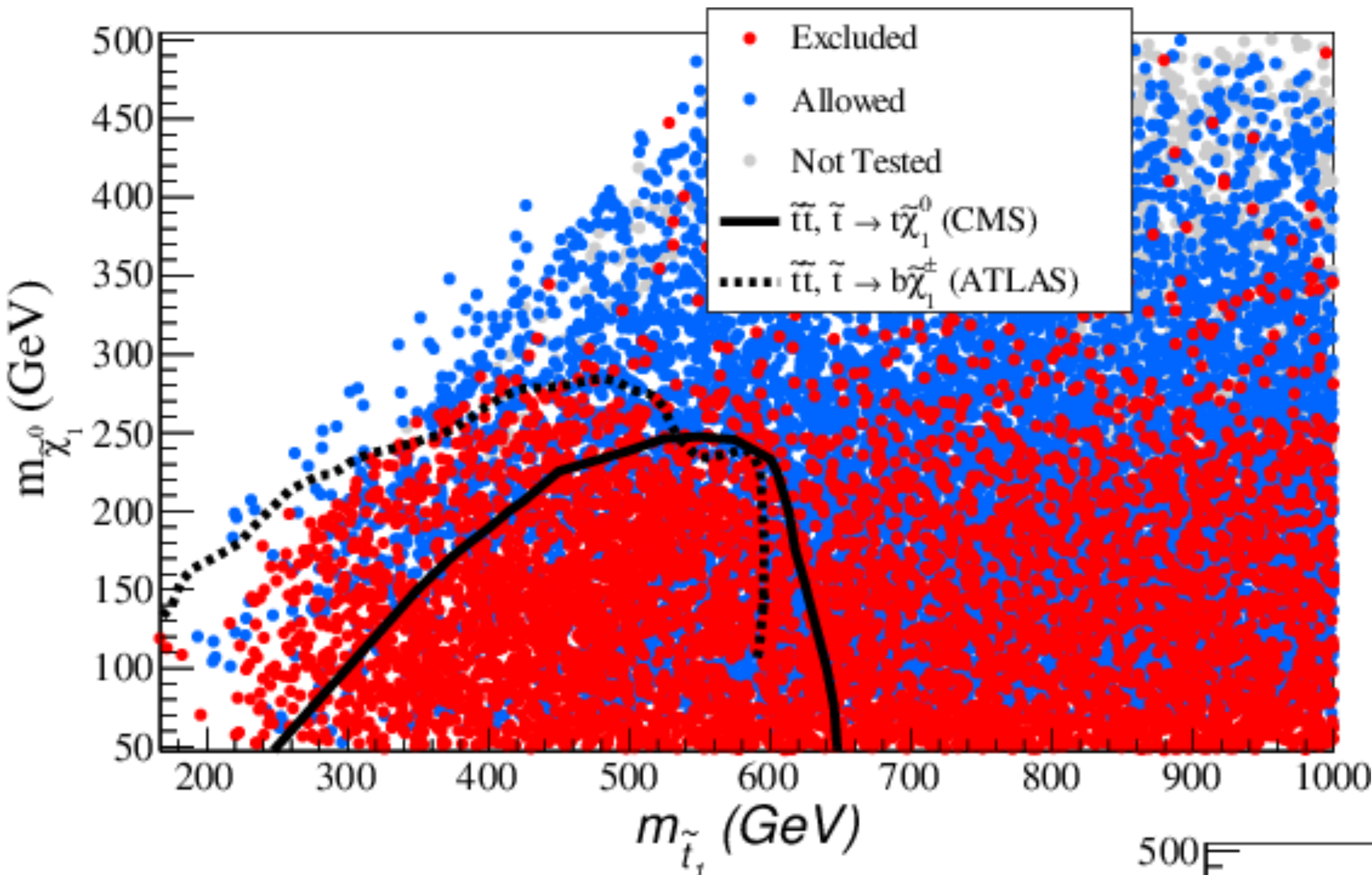
M_2	μ	$\tan\beta$	$M_{\tilde{q}}$	$M_{\tilde{Q}_3}$	$M_{\tilde{D}_3}$	$M_{\tilde{U}_3}$	A_t	A_b
0.1–1	0.1–1	3–60	0.1–5	0–2	0–2	0–2	$[1,3]\max(M_{\tilde{Q}_3}, M_{\tilde{Q}_3})$	± 1

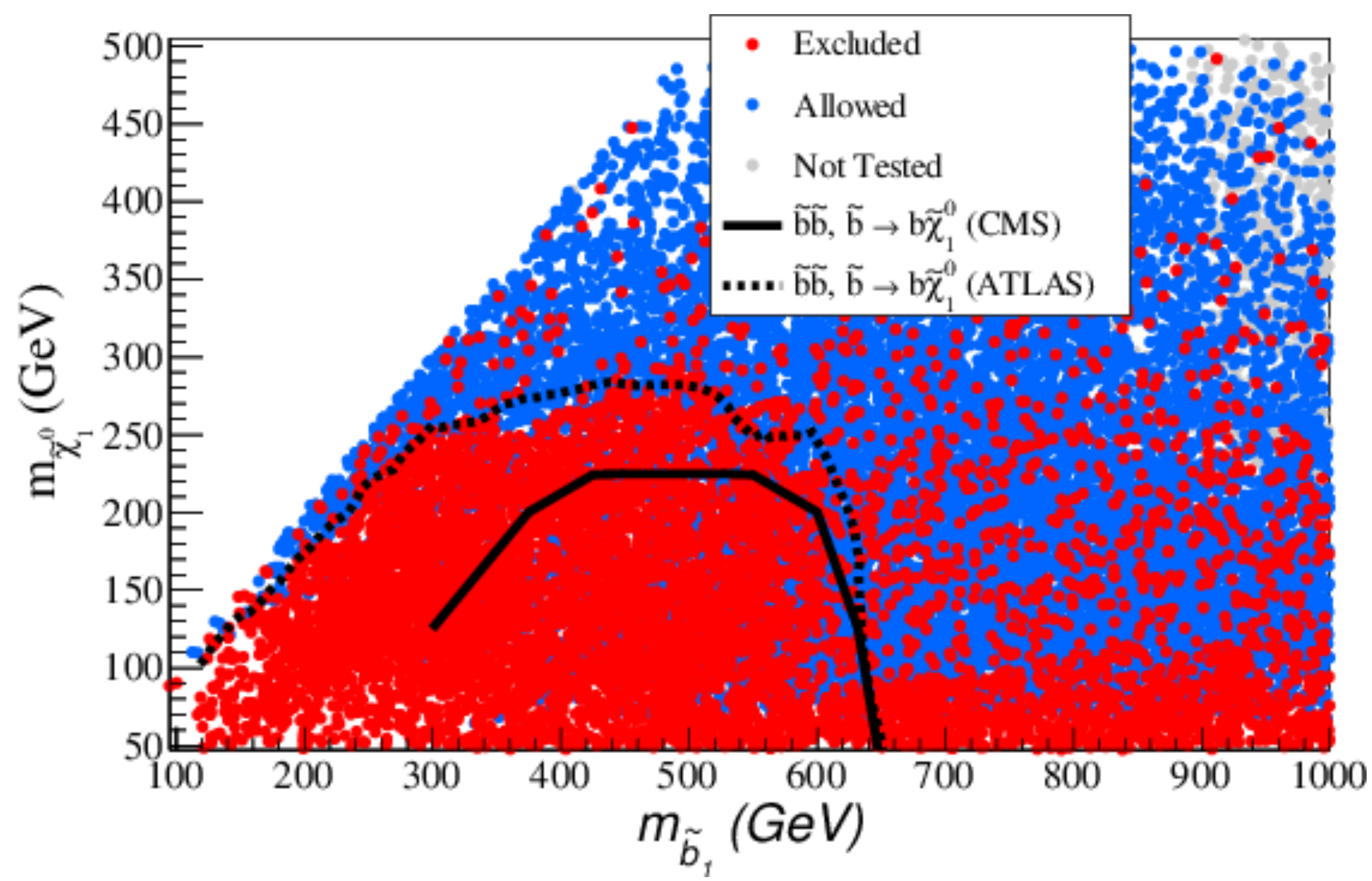
SModelS scan - strong focus



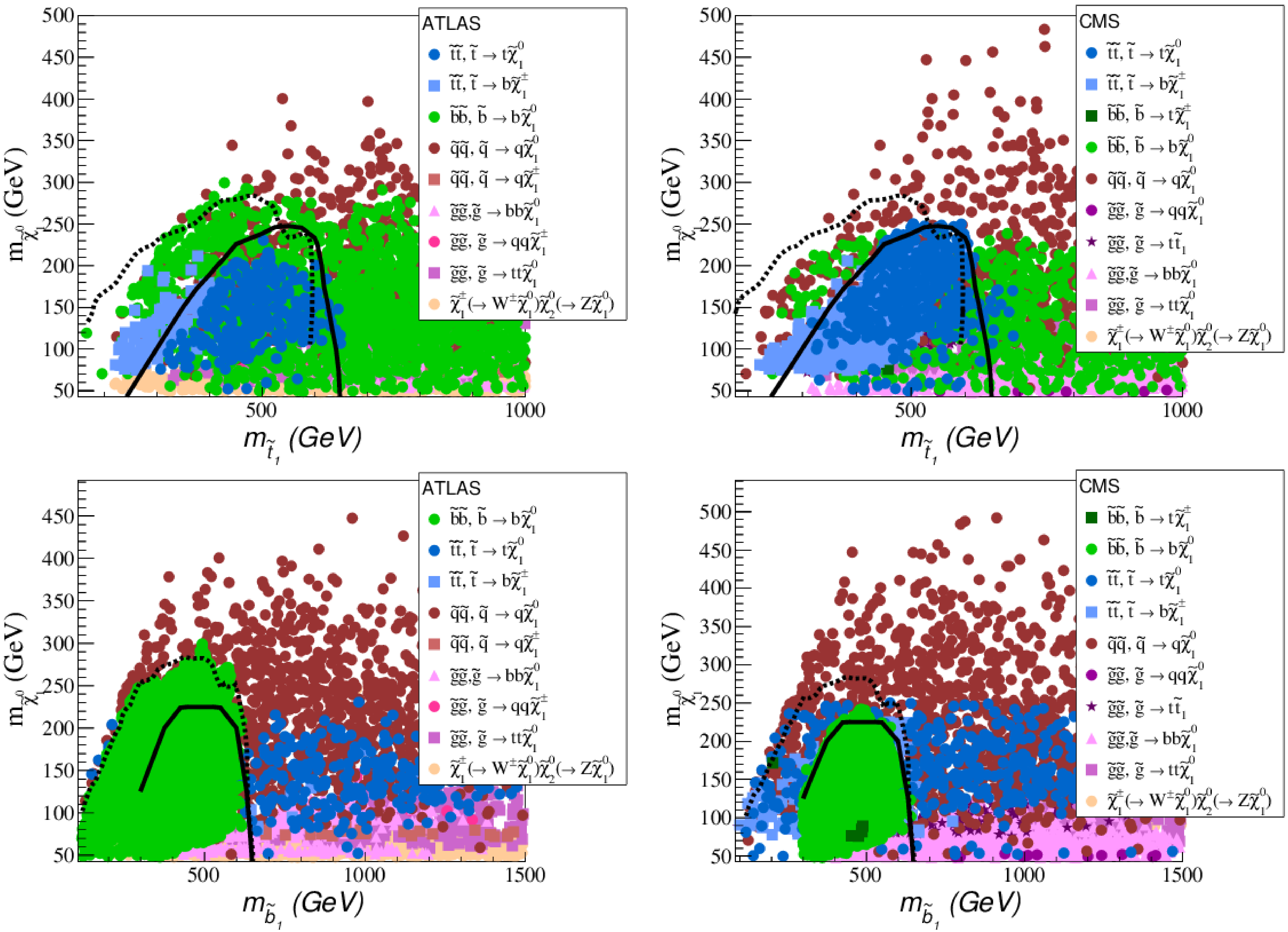


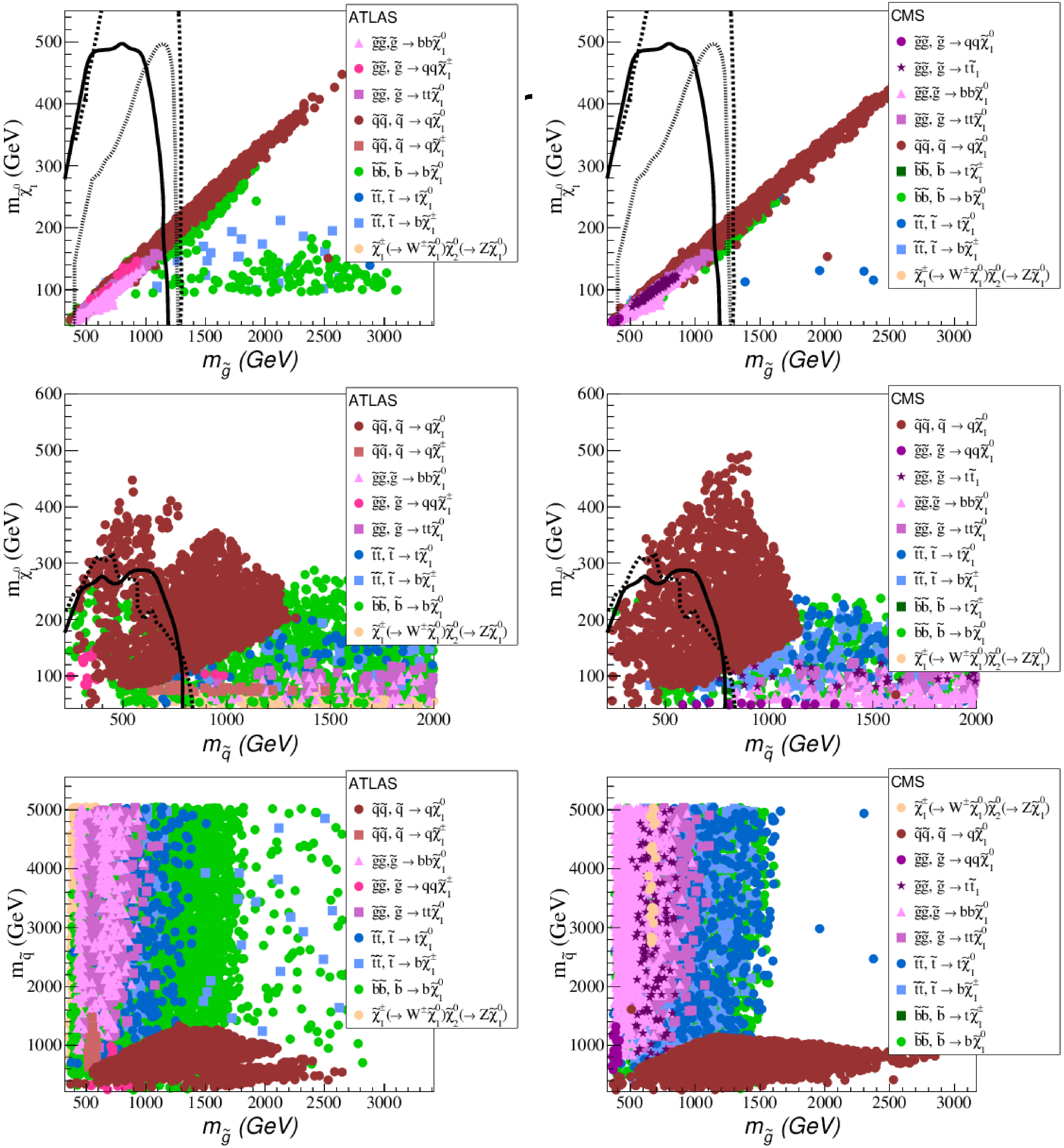
SModelS scan - strong focus





SModelS scan - strong focus





ATLAS
$\tilde{g}\tilde{g}, \tilde{g} \to bb\tilde{\chi}_1^0$
$\tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}_1^\pm$
$\tilde{g}\tilde{g}, \tilde{g} \to tt\tilde{\chi}_1^0$
$\tilde{q}\tilde{q}, \tilde{q} \to q\tilde{\chi}_1^0$
$\tilde{q}\tilde{q}, \tilde{q} \to q\tilde{\chi}_1^\pm$
$\tilde{b}\tilde{b}, \tilde{b} \to b\tilde{\chi}_1^0$
$\tilde{t}\tilde{t}, \tilde{t} \to t\tilde{\chi}_1^0$
$\tilde{t}\tilde{t}, \tilde{t} \to b\tilde{\chi}_1^\pm$
$\tilde{\chi}_1^\pm(\to W^\pm\tilde{\chi}_1^0)\tilde{\chi}_2^0(\to Z\tilde{\chi}_1^0)$
$m_{\tilde{\chi}_1^0}$ (GeV)
$m_{\tilde{g}}$ (GeV)
CMS
$\tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}_1^0$
$\tilde{g}\tilde{g}, \tilde{g} \to t\tilde{t}_1$
$\tilde{b}\tilde{b}, \tilde{b} \to t\tilde{\chi}_1^\pm$
$m_{\tilde{q}}$ (GeV)