On the coverage of the pMSSM by simplified-model results

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work in progress together with
Federico Ambrogi, Suchita Kulkarni, Ursula Laa, Andre Lessa, Wolfgang Waltenberger

IRN Terascale@Montpellier, 3-5 July 2017

Simplified Model Spectra (SMS) results

- It has become standard that ATLAS and CMS present the results of their searches in terms of `simplified models' contraints.

- SMS reduce full models with dozens of particles and a plethora of parameters to subsets with just 2-3 new states and a simple decay pattern.

  Example: gluino-neutralino simplified model
  with BR($\tilde{g} \to bb\tilde{\chi}^0_1$) = 100%: 4b+MET final state

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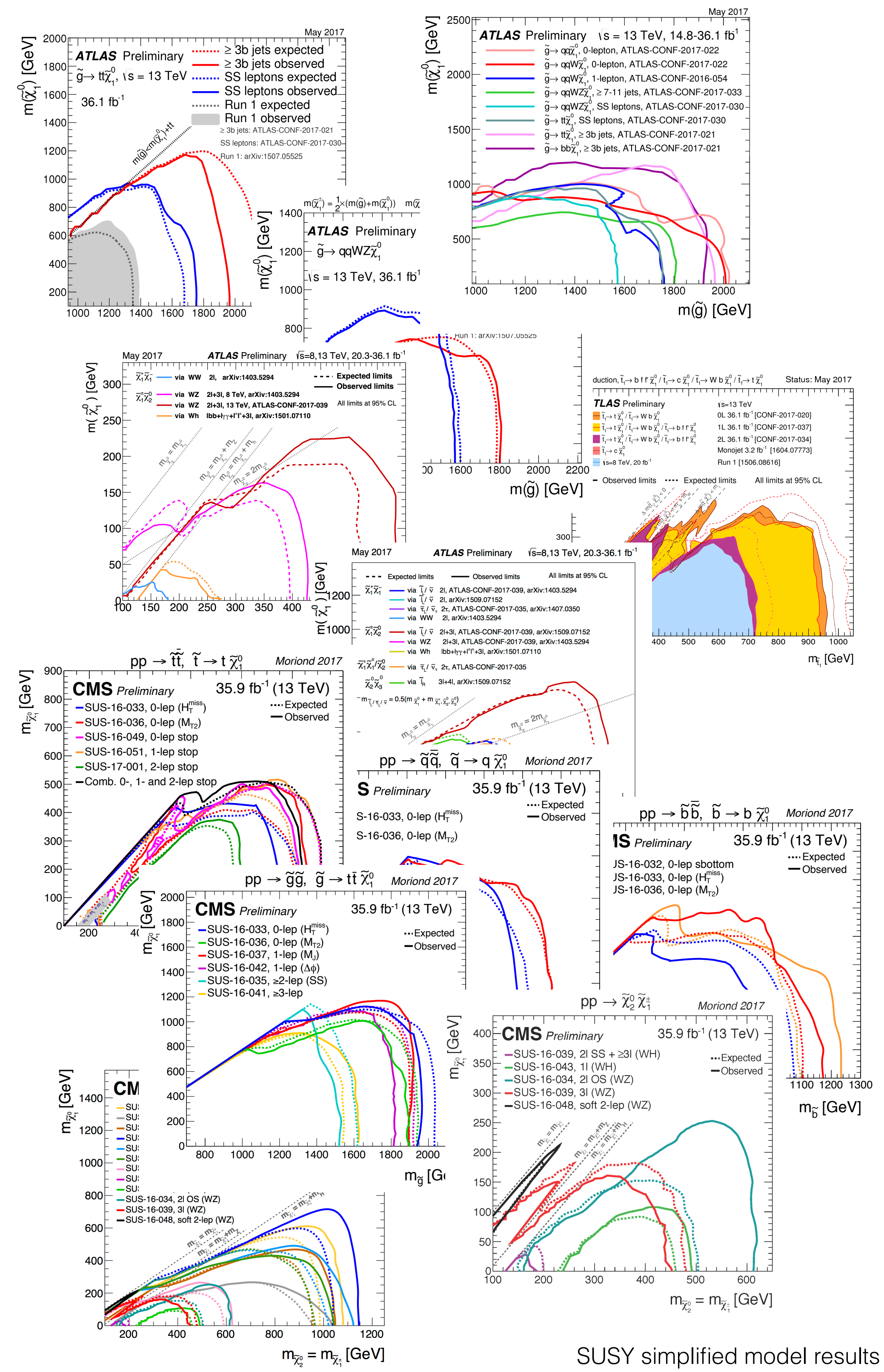
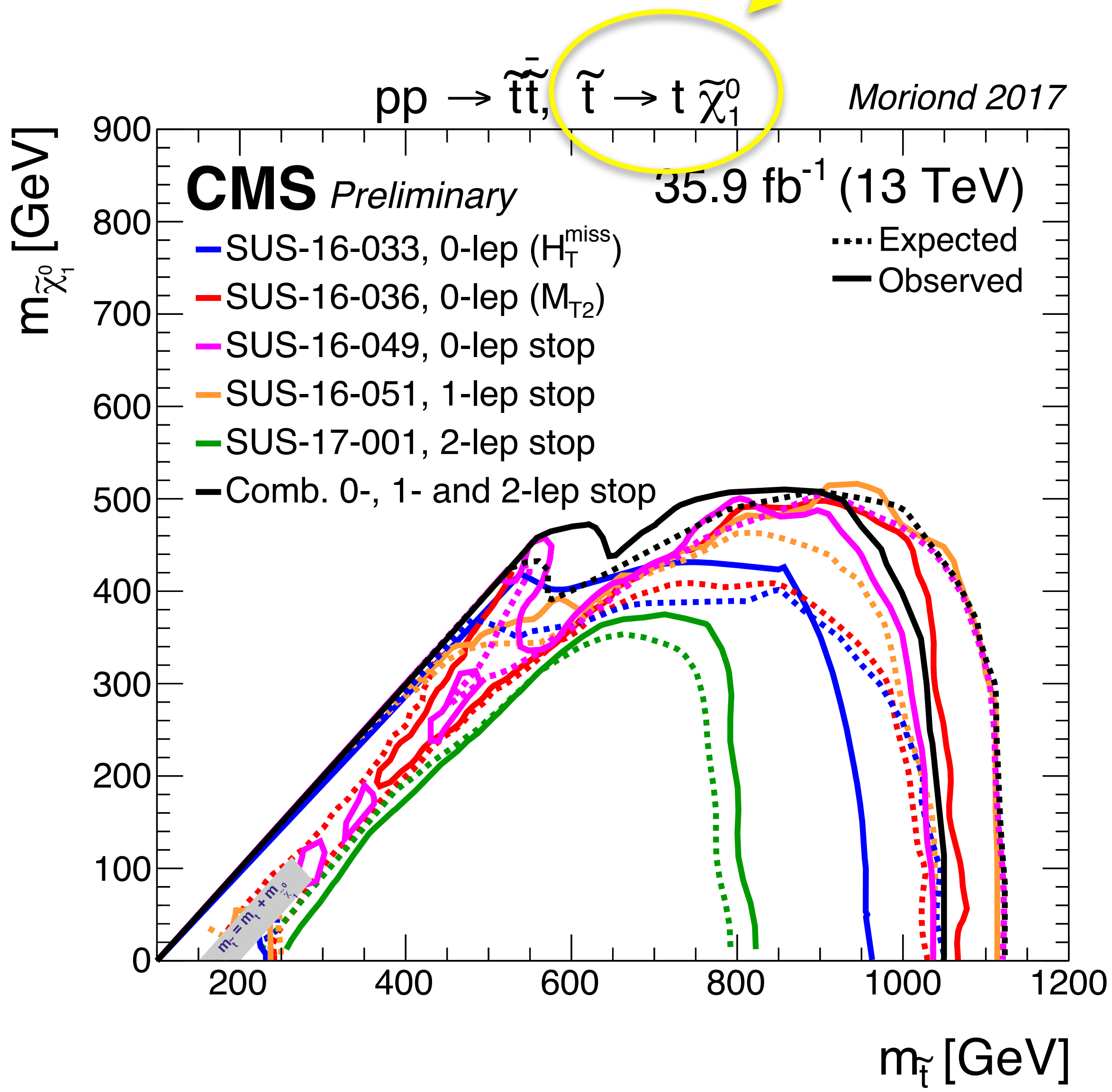
- Understanding how SMS results constrain a realistic model with a multitude of relevant production channels and decay modes is, however, a non-trivial task.



SUSY simplified model results
from ATLAS and CMS (13 TeV)

What you usually see in the experimental paper or conference talk

fixed stop decay mode, BR=100%



Interesting to compare reach of different analyses,
but what if the stop has (a mix of) different decay modes?

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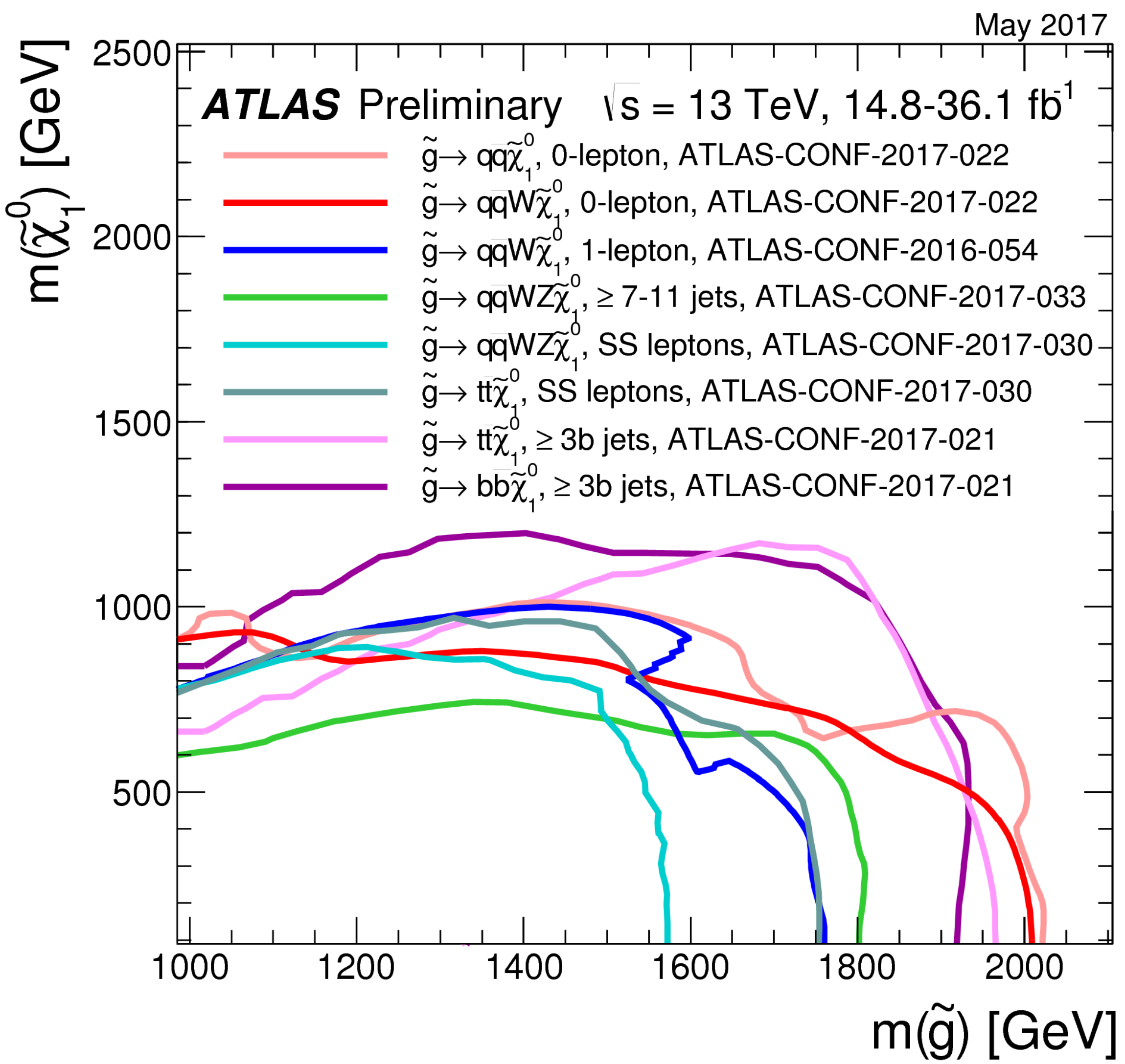
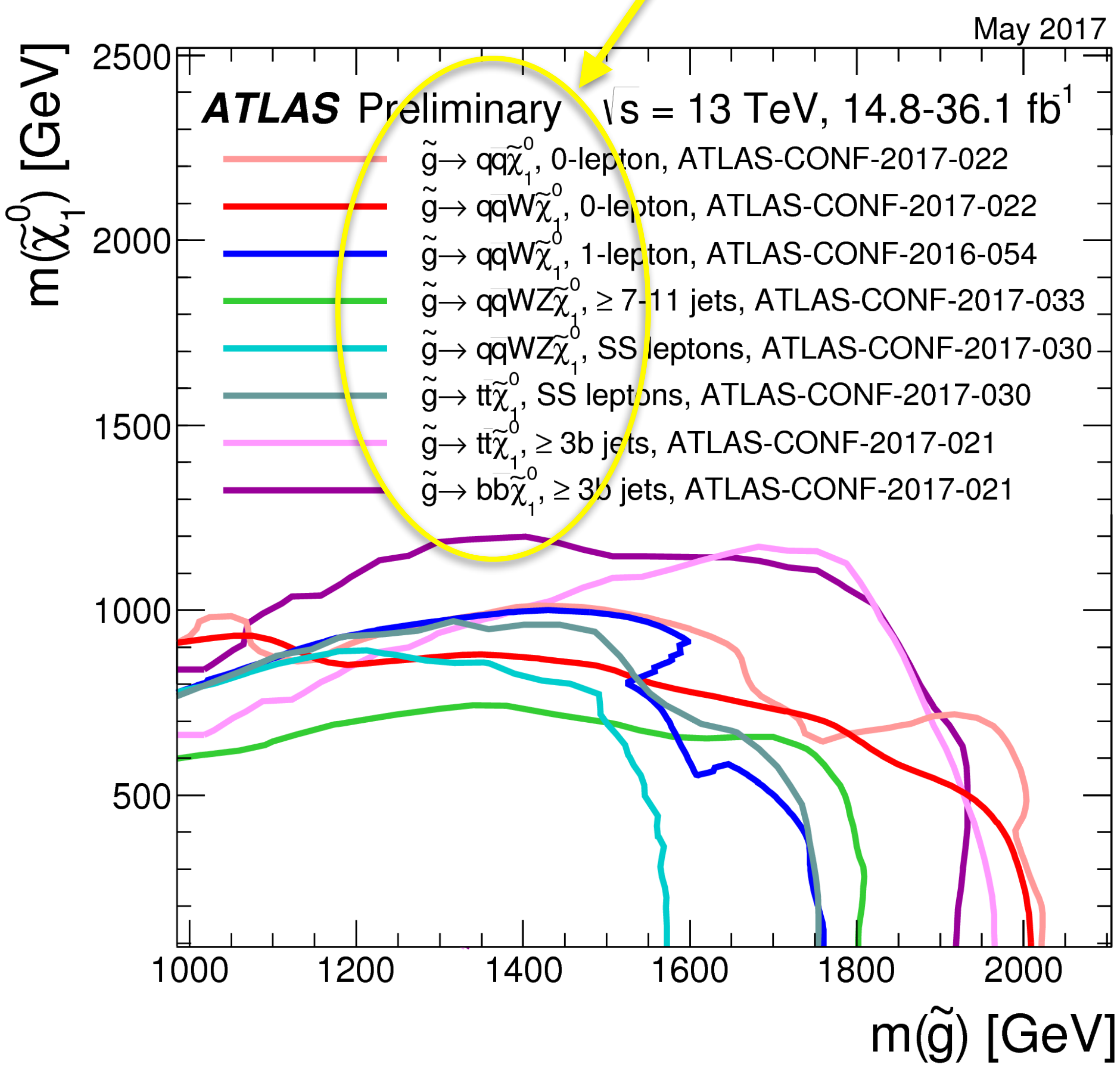


Limits vary depending on decay mode (assumed to be 100%).

What you usually see in the experimental paper or conference talk

gluino-pair production, both gluinos assumed to decay the same way, BR=100%



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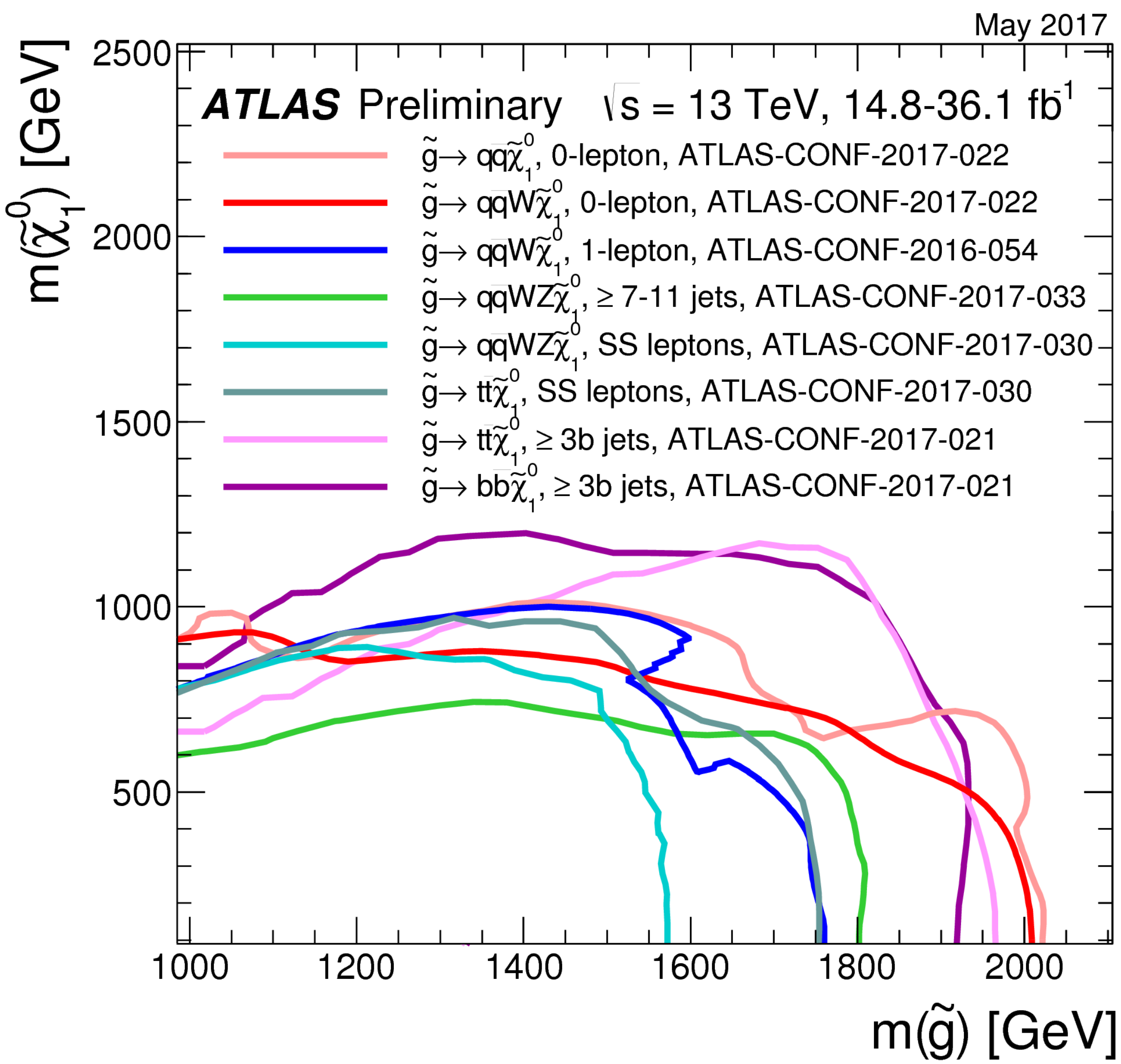

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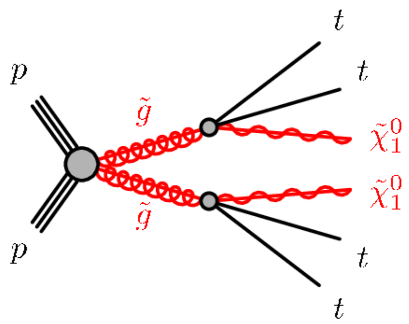

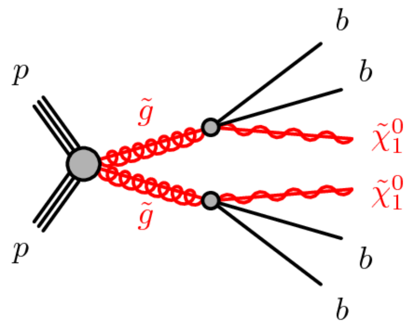

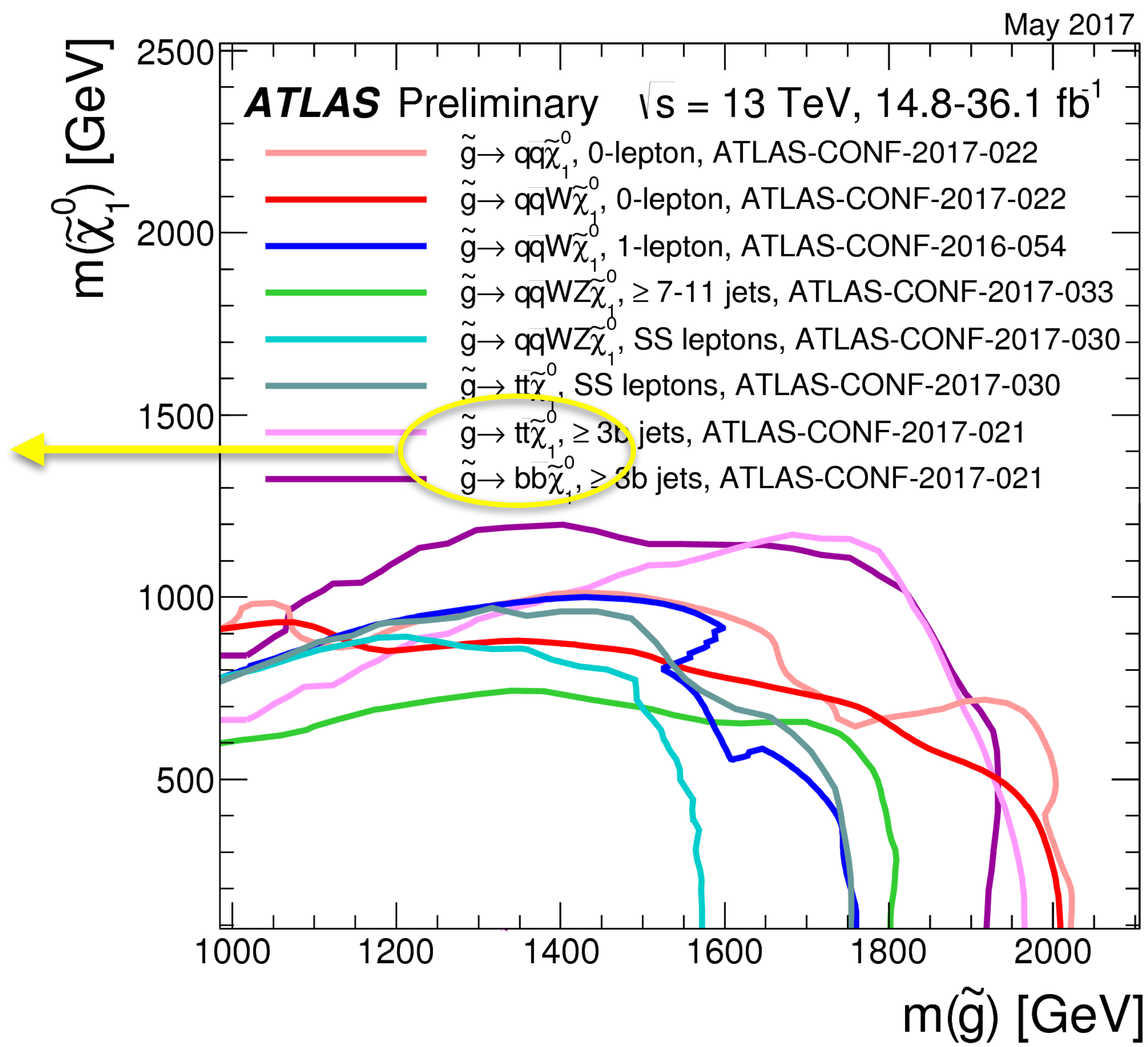

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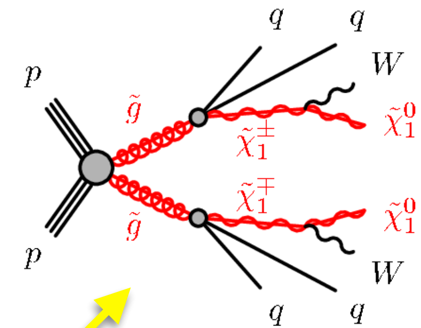
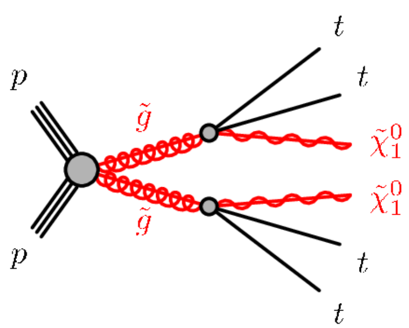
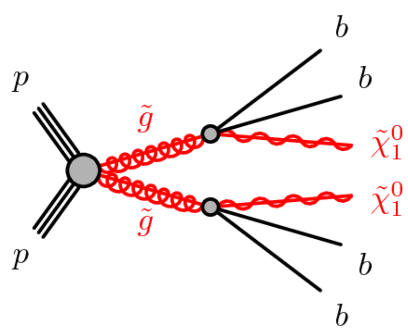
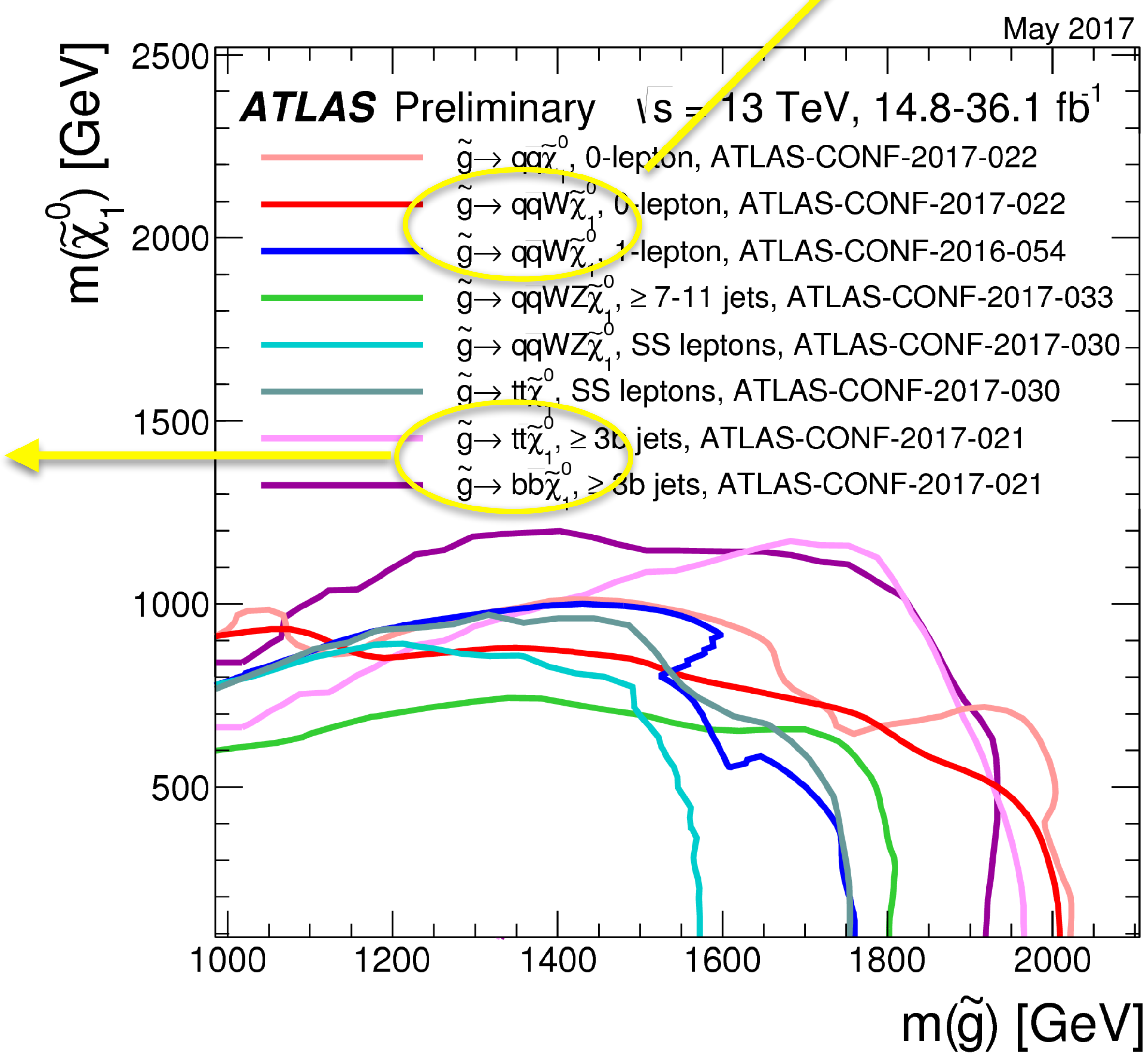


chargino1 mass fixed as
m_ch1 = 0.5(m_gl + m_nt1)







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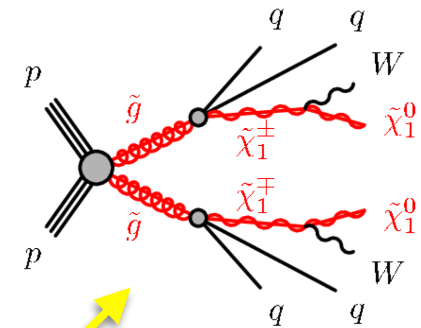

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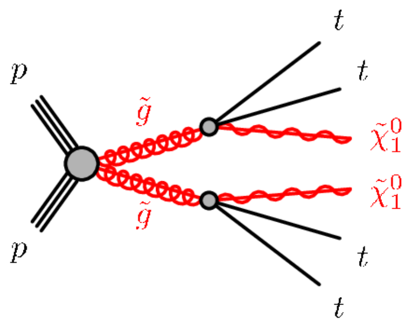

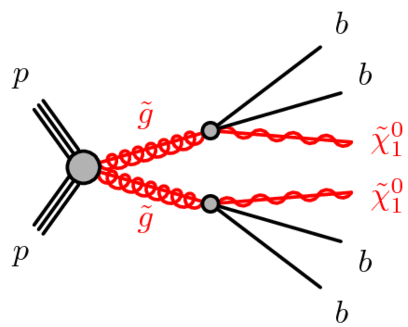

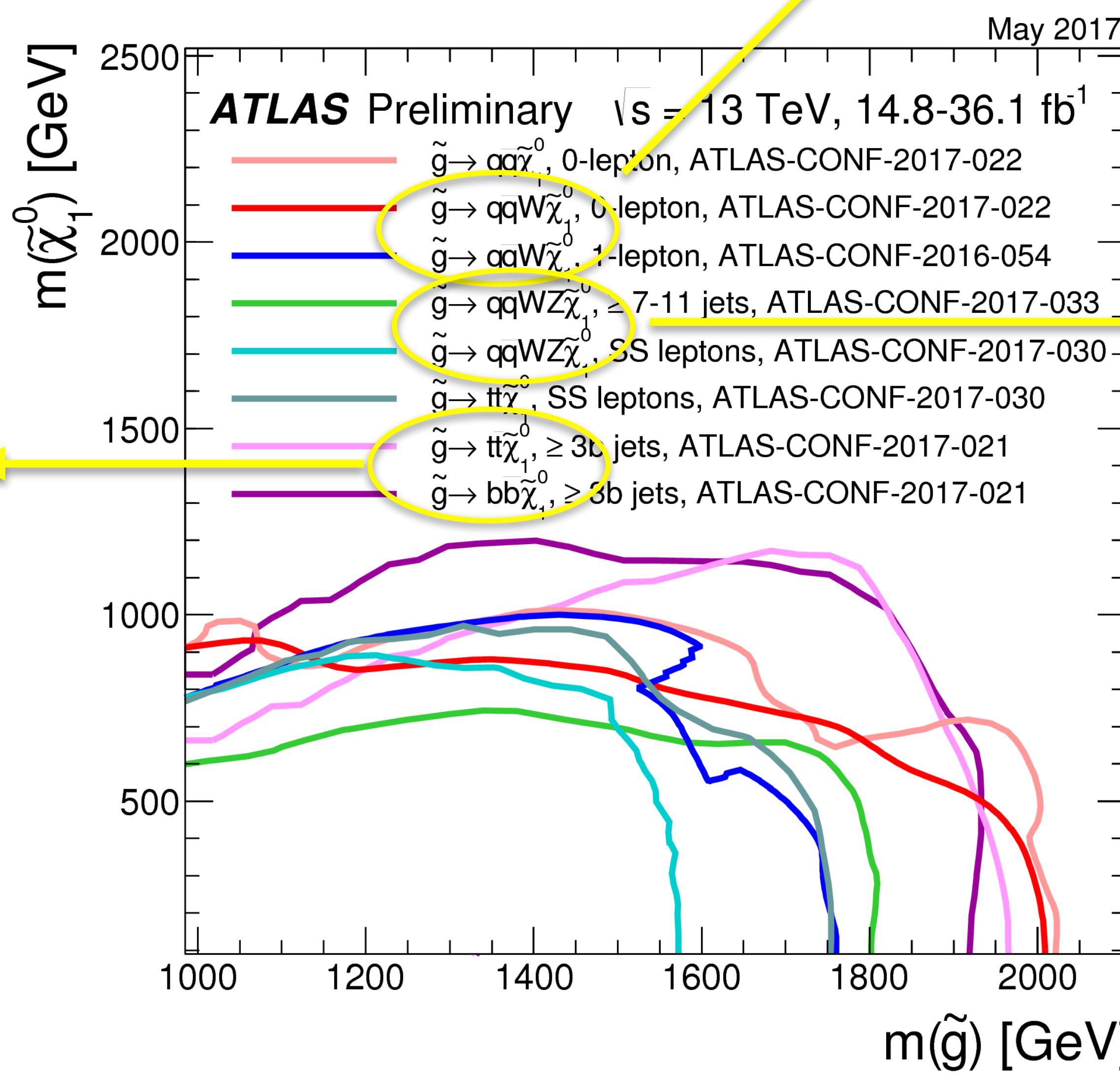

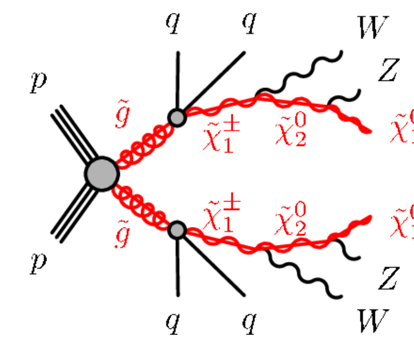

ch1 **and** nt2 masses fixed:

m_ch1 = 0.5(m_gl + m_nt1),
m_n2 = 0.5(m_ch1 + m_nt1)

Limits vary depending on decay mode (assumed to be 100%).

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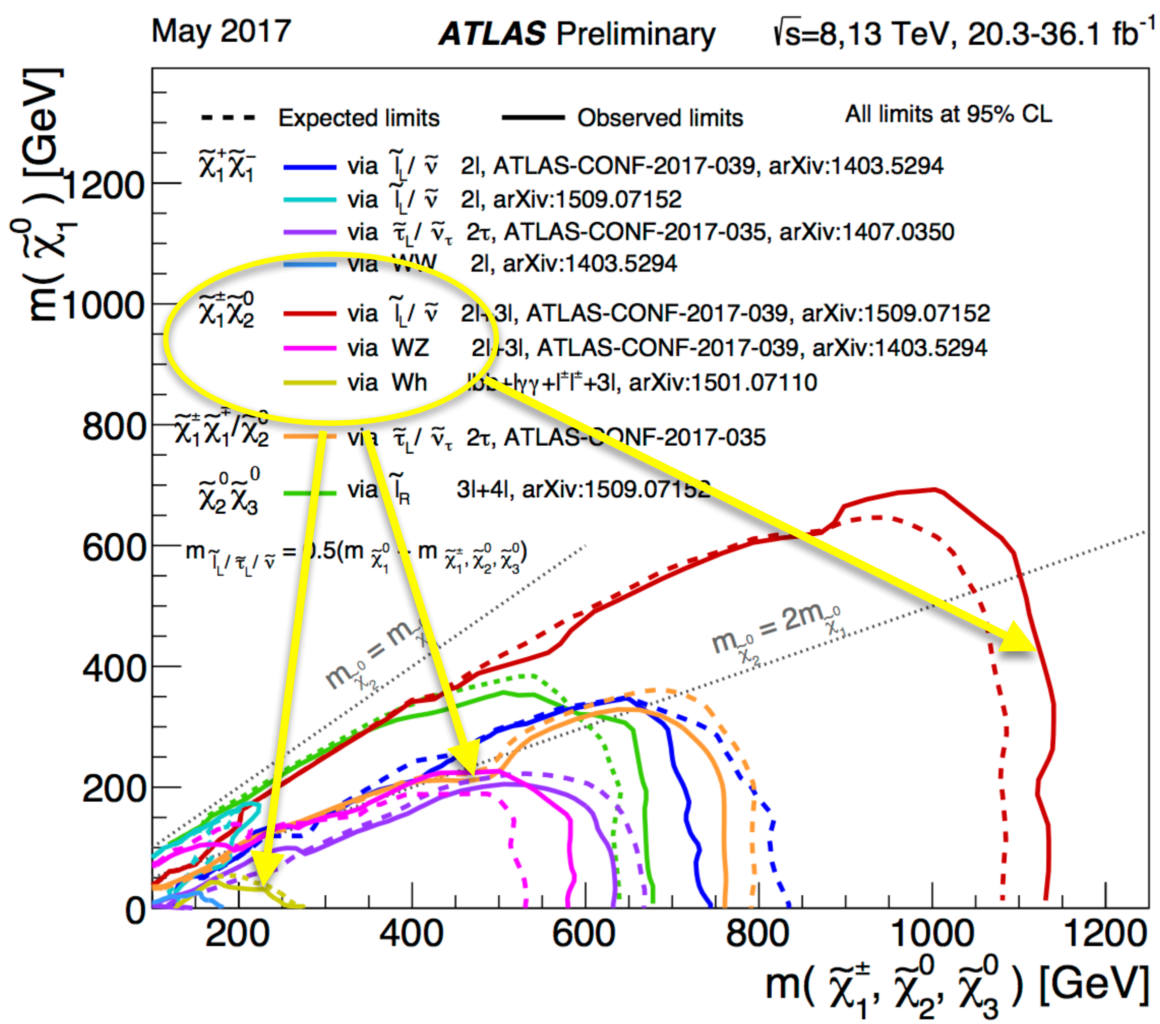

Dependence on decay mode very pronounced for EW-inos.
Moreover, mass limits assume pure Wino production Xsections !

Simplified Model Spectra (SMS) results

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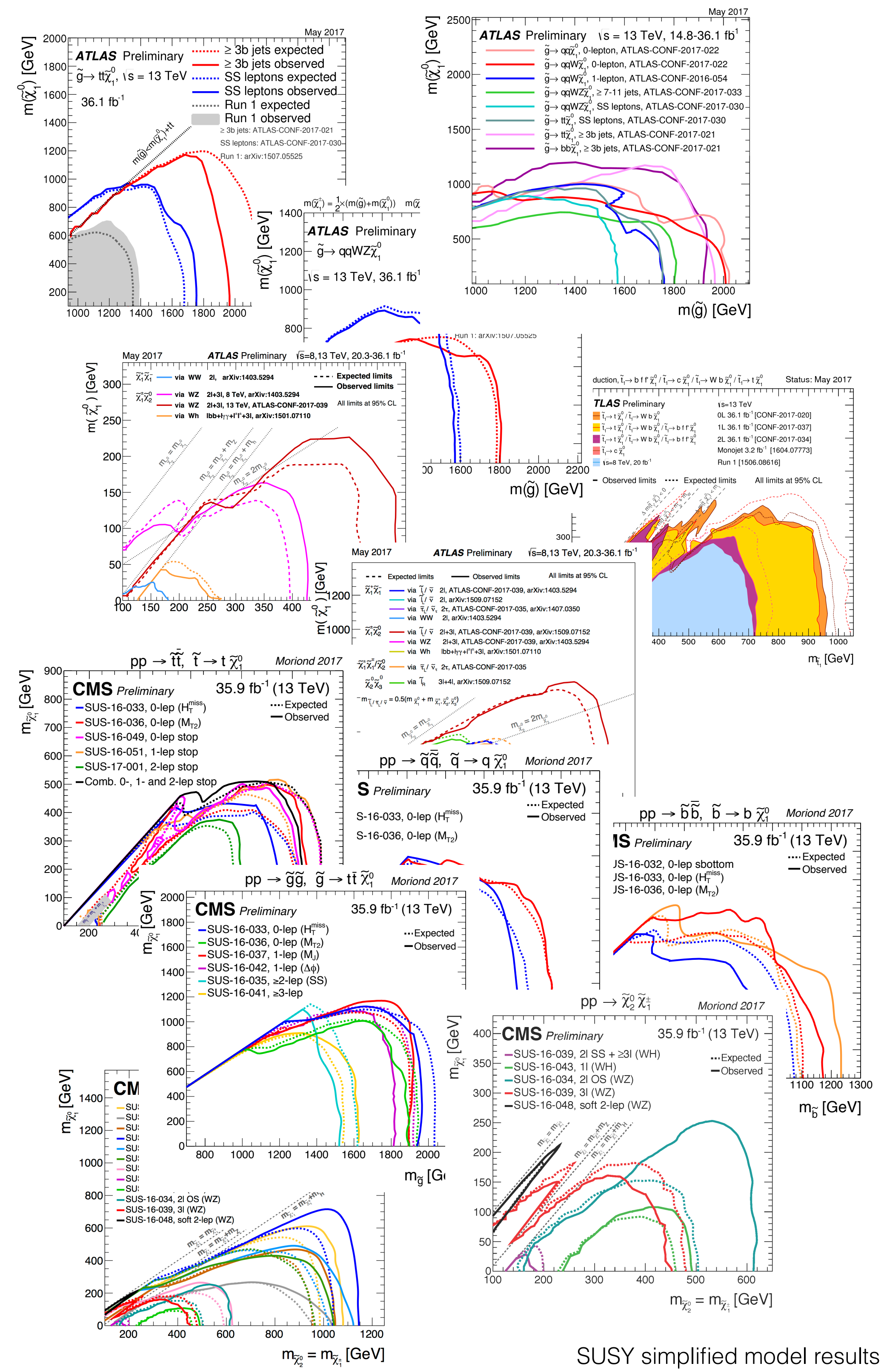
  → automated tools



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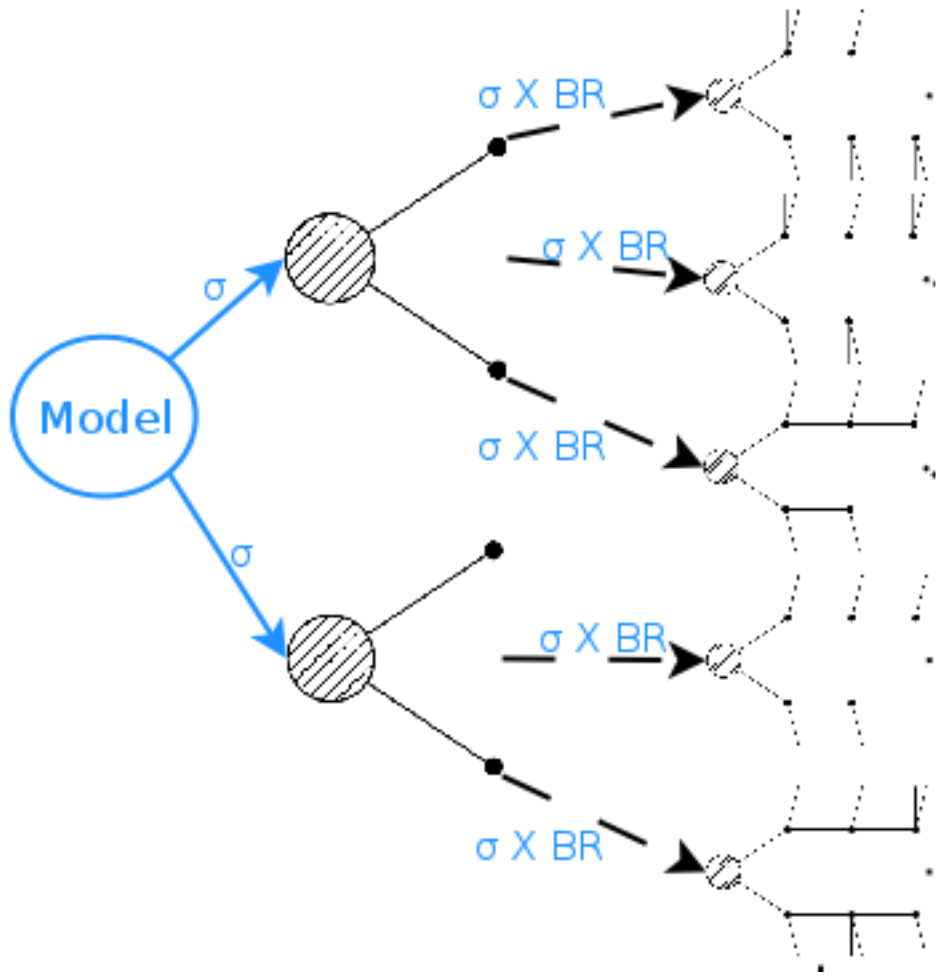
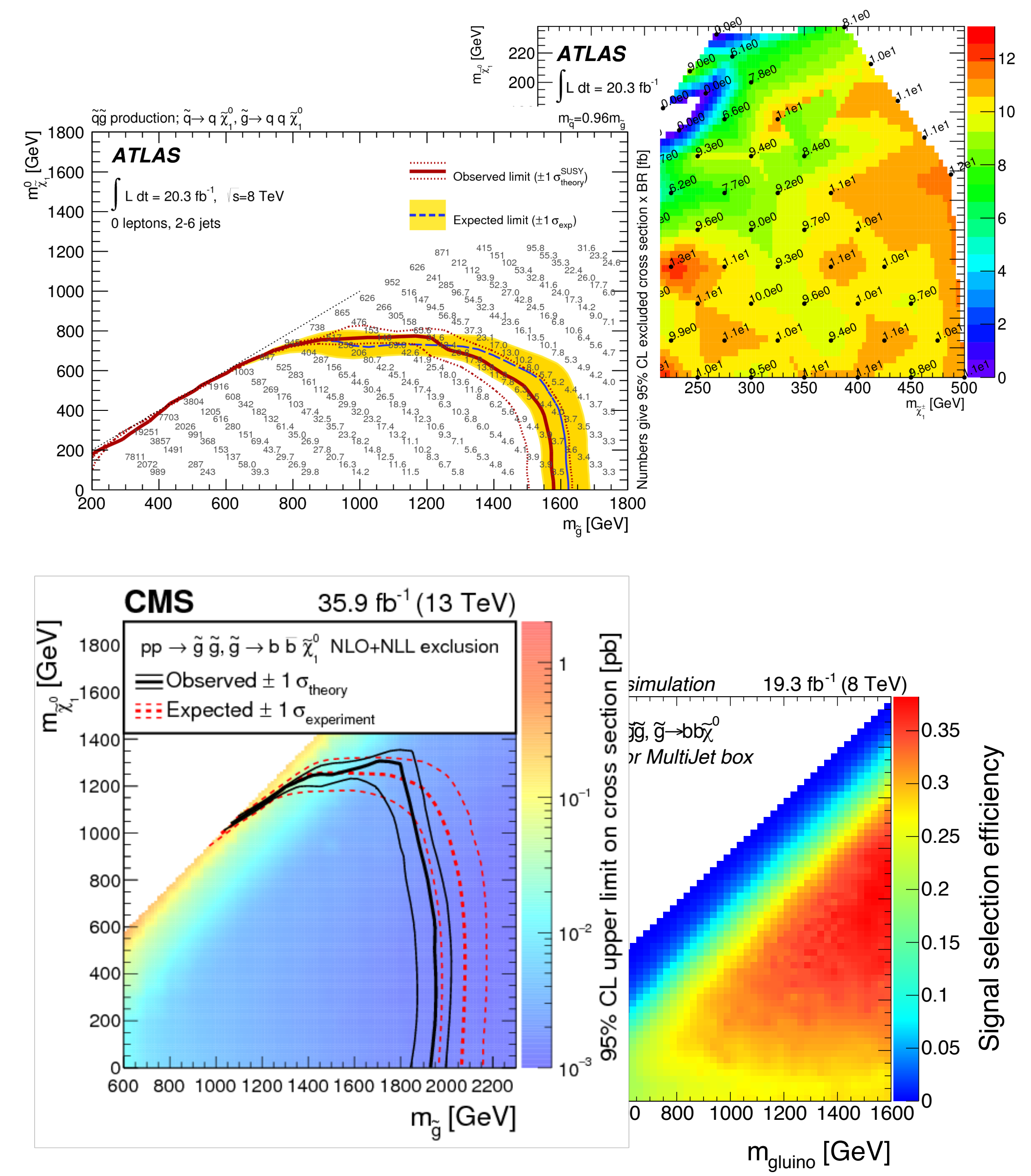
arXiv:1312.4175

SModelS

http://smodels.hephy.at





Decompose signatures of full model into SMS elements

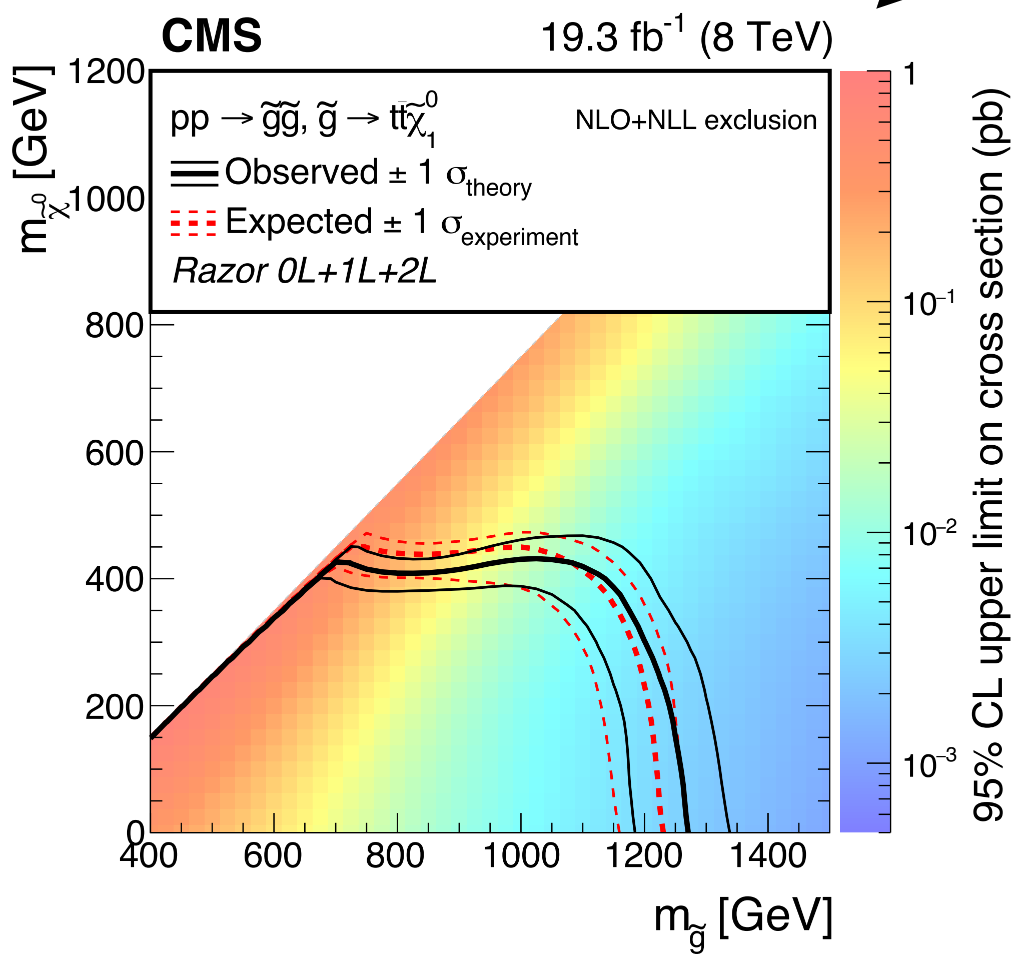
Compare with experimental constraints in SModelS database

SModelS v1.1.1 now available, user manual: arXiv:1701.06586

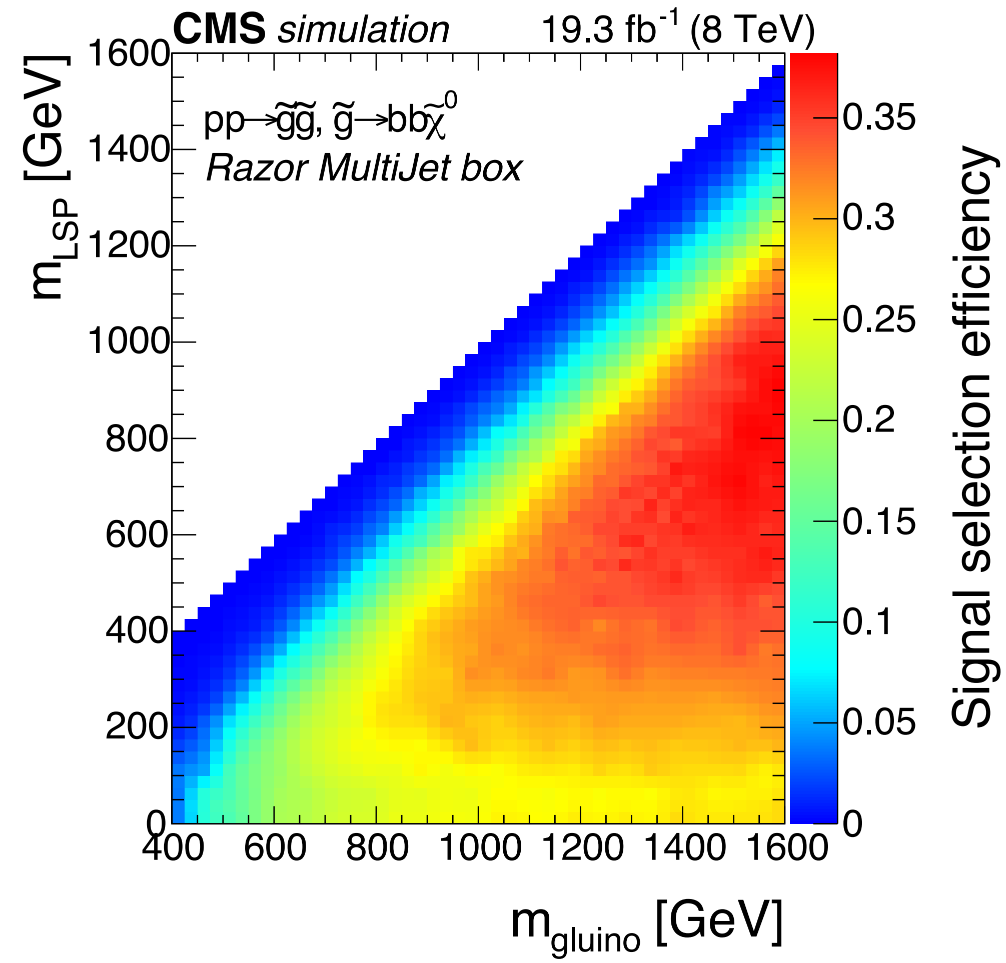
Experimental constraints

Great if these are available in numerical form!

Upper Limit (UL) maps



Efficiency maps (EM)



Upper Limit maps give the 95% CL upper limit on cross section x branching ratio for a specific SMS.

The UL values can be based on the best SR (for each point in parameter space), a combination of SRs or more involved limits from other methods.

Efficiency maps correspond to a grid of simulated acceptance x efficiency values for a specific signal region for a specific simplified model.

Together with the observed and expected #events in each SR, this allows to compute a likelihood.

Limit on σ×BR

Limit on Σε×σ×BR

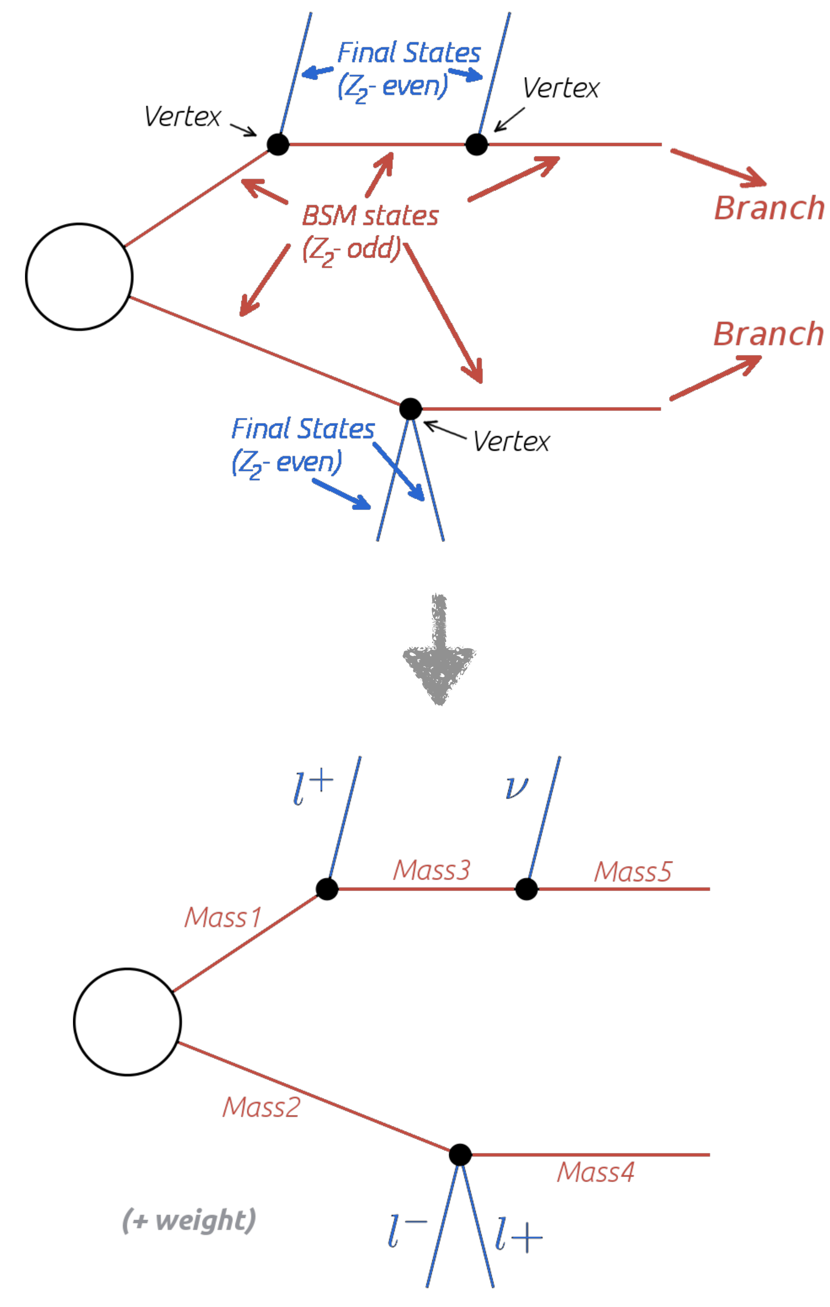
NB: the 95%CL exclusion curve is not used, cannot be re-interpreted

SMS assumptions in SModelS

- BSM particles are described only by their masses, production cross sections and branching ratios.
- Underlying assumption is that differences in the event kinematics from, e.g., different production mechanisms or the spins of the BSM particles, do not significantly affect the signal selection efficiencies.
- Can be used for testing any BSM scenario with a Z2-like symmetry as long as all heavier odd particles decay promptly to the lightest one.
- Successfully applied to minimal and non-minimal SUSY (NMSSM, UMSSM, sneutrino LSP), as well as extra quark, UED models …

SK et al, 1312.4175; Belanger et al, 1308.3735;
Barducci et al., 1510.00246; Arina et al., 1503.02960;
Edelhauser et al., 15 01.03942; SK et al,1607.02050.

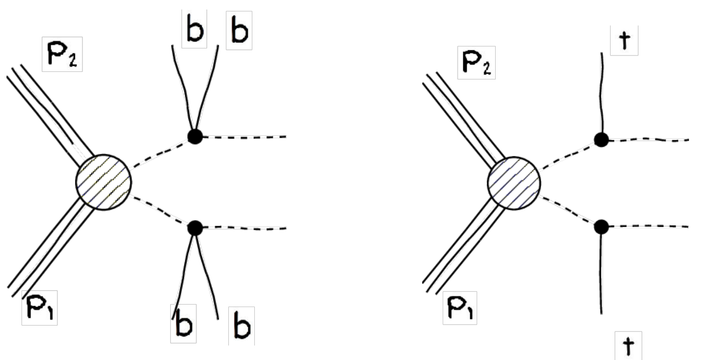
- How well a full model is actually covered by SMS constraints is, however, still an open question.



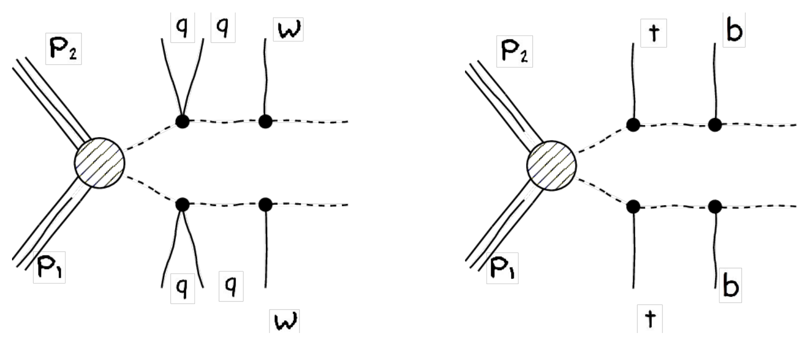
Information used to classify topologies

Notes

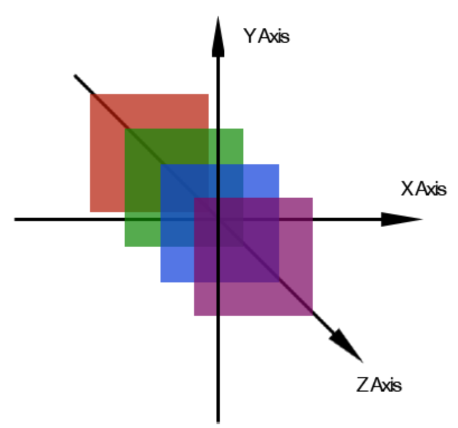
- The simplest SMS have just 2 free parameters, mother and `LSP' mass.
- For more complicated topologies, the results can only be used if an interpolation in all free parameters is possible.
- E.g. if the decay chain proceeds via an intermediate chargino, we need maps (=mass planes) for several different chargino masses.
- If only one plane is given for an SMS with >2 parameters, the result cannot be generalised.



2 parameters



3 parameters



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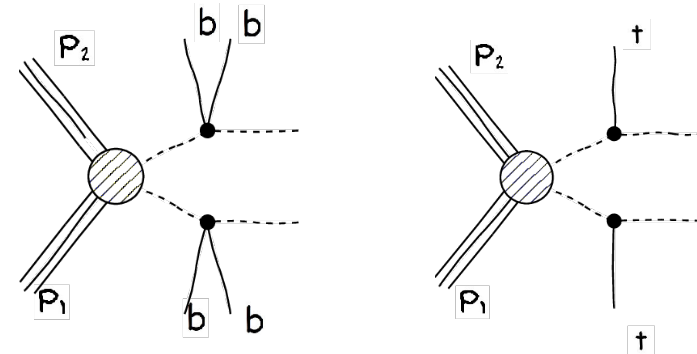
- If only one plane is given for an SMS with >2 parameters, the result cannot be generalised.
- Sometimes ATLAS/CMS publish "simplified model" constraints on long decay chains but with all intermediate masses fixed → cannot use these
- Likewise, we cannot use results for mixed decays with fixed BRs (mix of different topologies)



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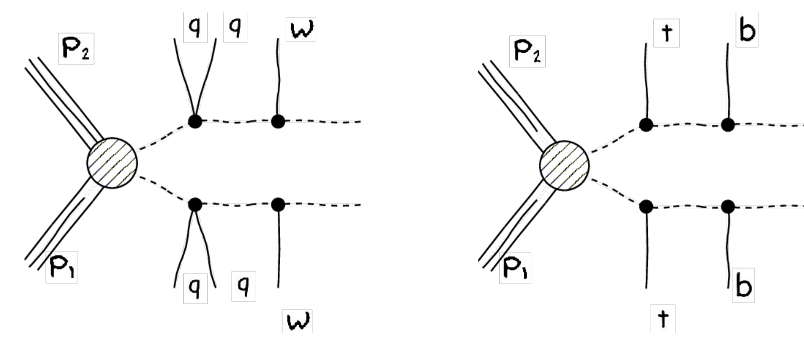

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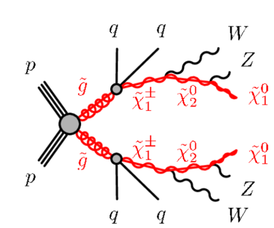
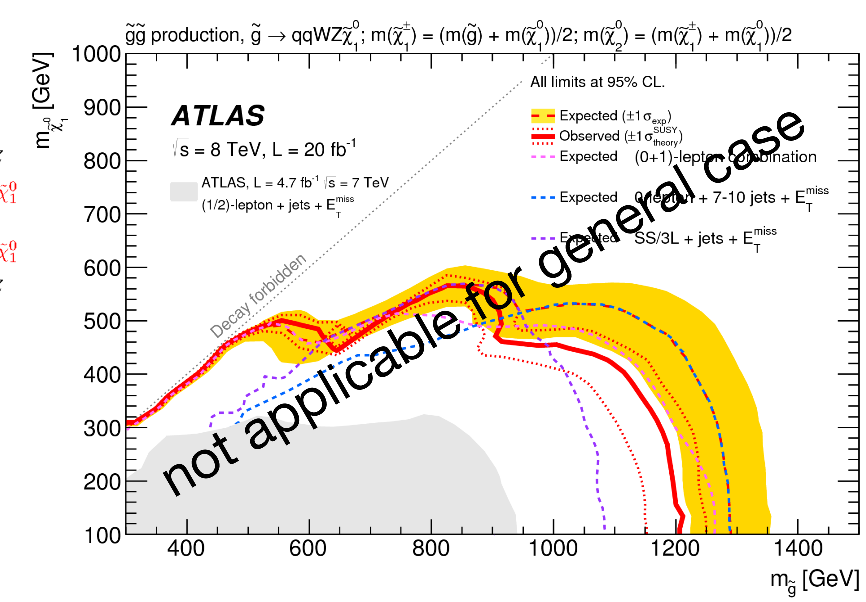
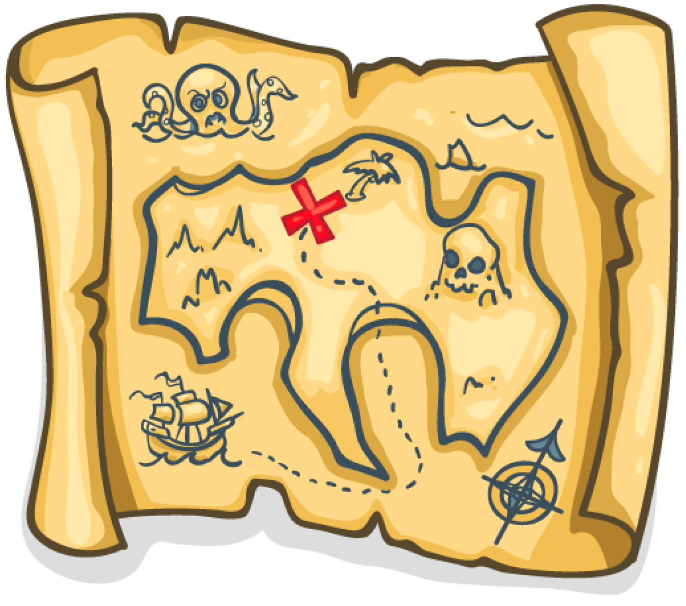


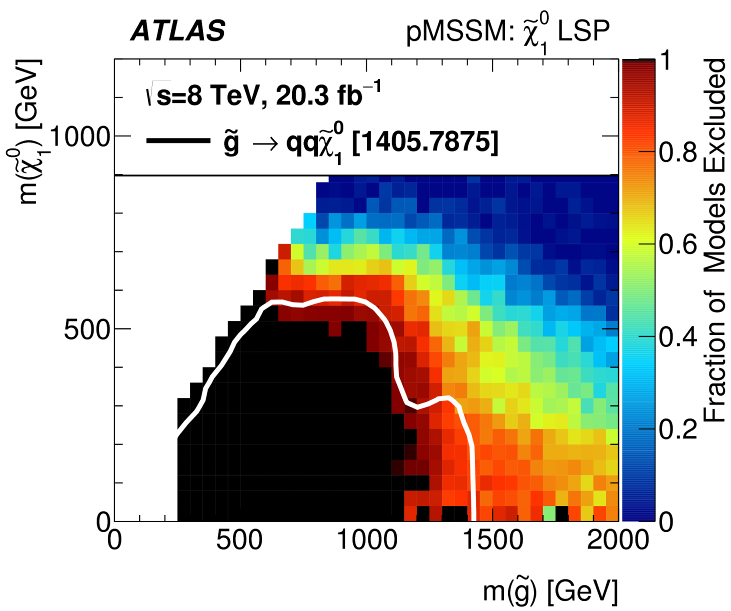


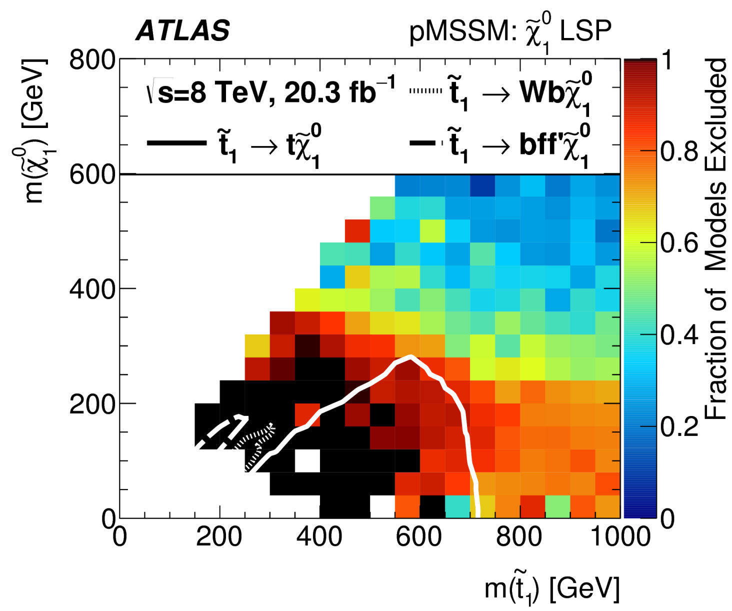
So how do simplified model results constrain realistic models?

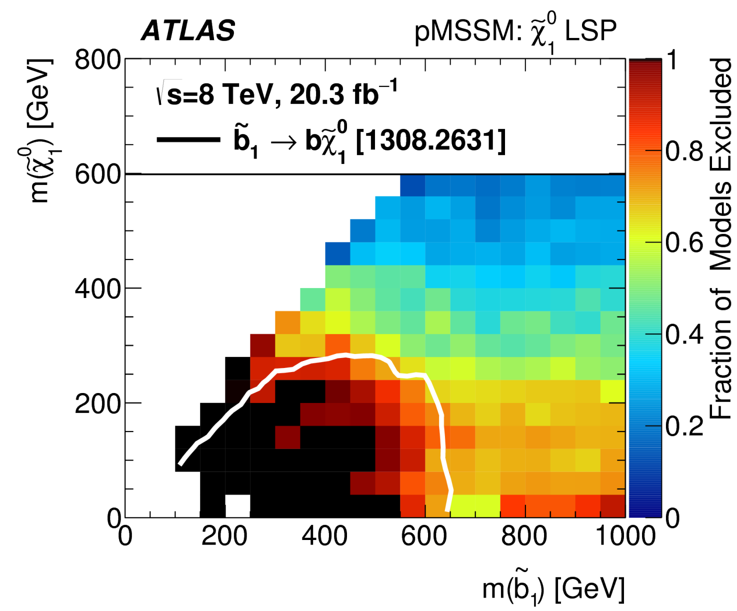


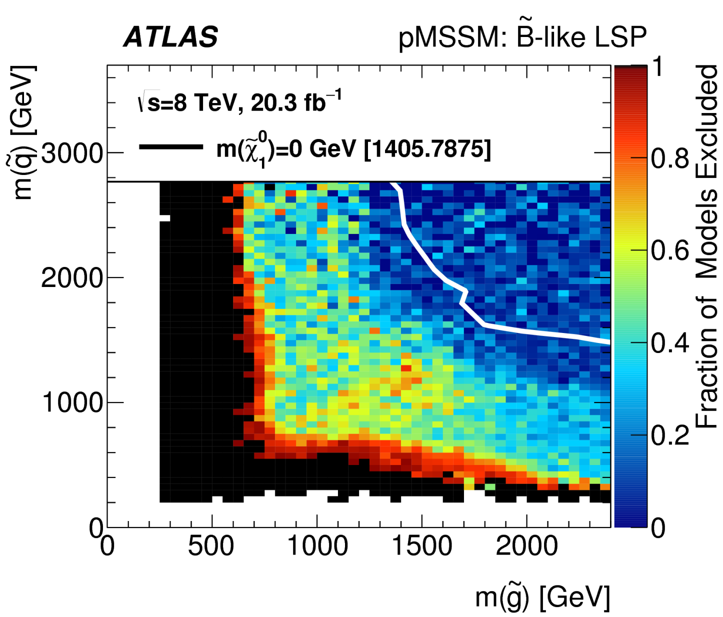
ATLAS pMSSM study

In 1508.06608, ATLAS interpreted the results from 22 separate ATLAS searches in the context of the 19-parameter phenomenological MSSM (pMSSM) [vast scan]









LSP type	Definition	Sampled	Simulated Number	Simulated Fraction	Weight
'Bino-like'	$N_{11}^2 > \max(N_{12}^2, N_{13}^2 + N_{14}^2)$	480×10^6	103,410	35%	1/24
'Wino-like'	$N_{12}^2 > \max(N_{11}^2, N_{13}^2 + N_{14}^2)$	20×10^6	80,233	26%	1
'Higgsino-like'	$(N_{13}^2 + N_{14}^2) > \max(N_{11}^2, N_{12}^2)$		126,684	39%	1
Total		500×10^6	310,327		

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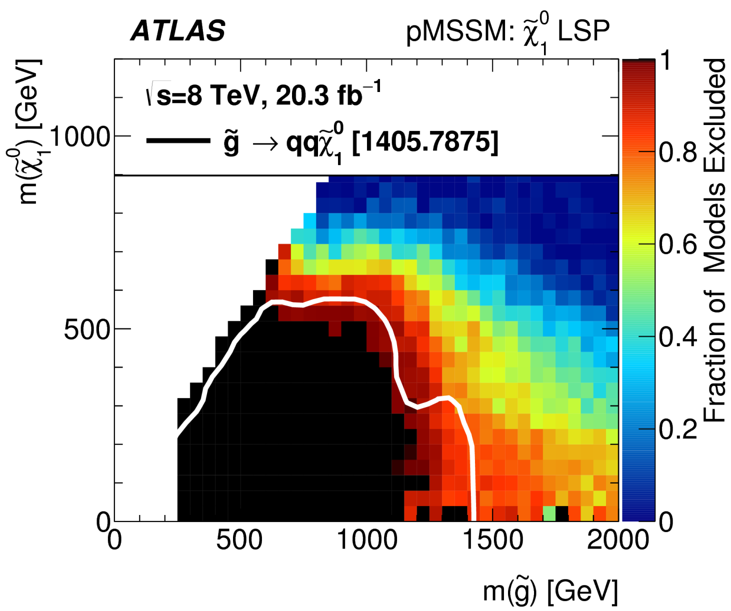

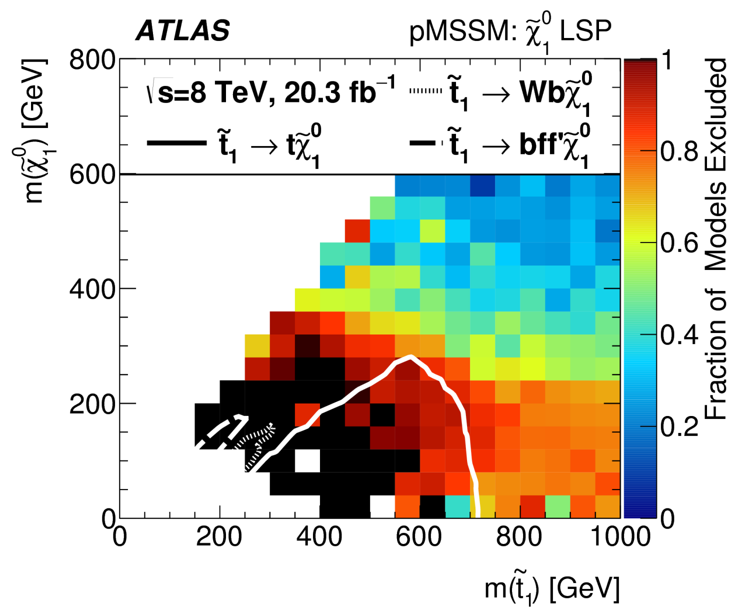

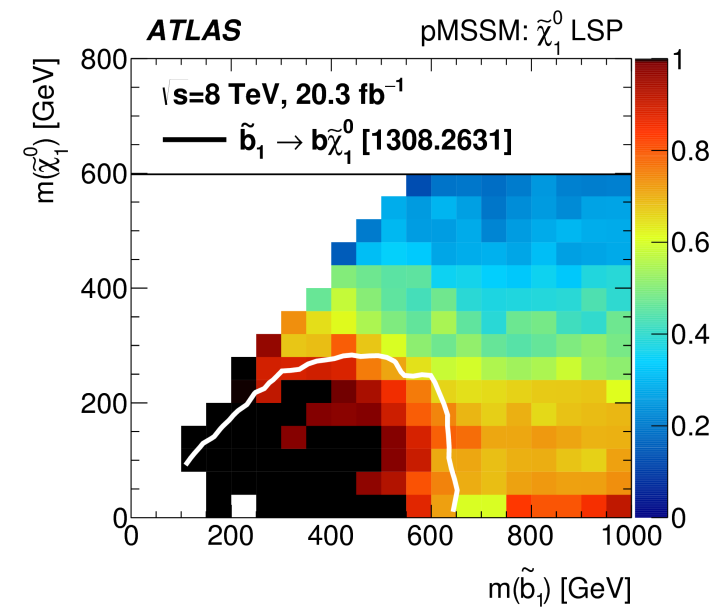

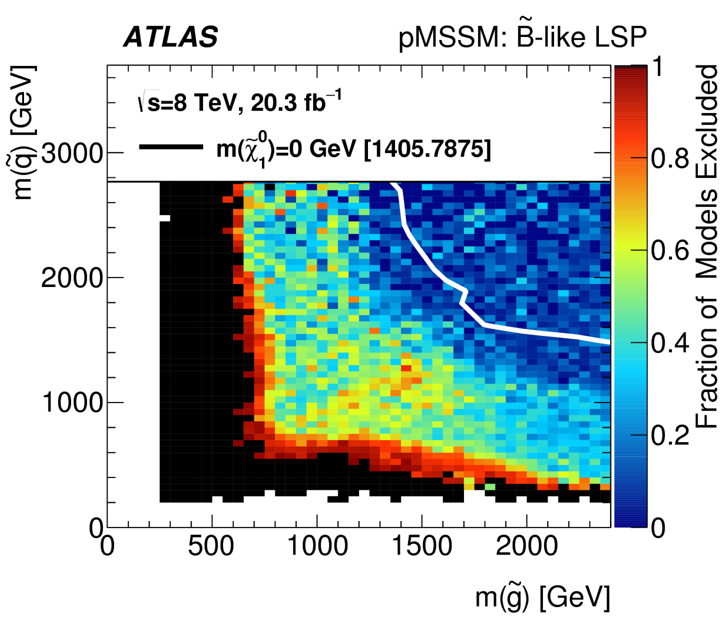

How well can we reproduce the ATLAS exclusion by using simplified model results?

SHLA files from the scan are public on HepData together with the information whether or not they are excluded, and by which search. So let's run them through SModelS …

Analyses considered (ATLAS)

Used by ATLAS | **available in SModelS v1.1.1**

	Analysis	ID	SModelS database
Inclusive	0-lepton + 2–6 jets + $E_T^{\rm miss}$	SUSY-2013-02*	6 UL, 2 EM
	0-lepton + 7–10 jets + $E_T^{\rm miss}$	SUSY-2013-04*	1 UL, 10 EM‡
	1-lepton + jets + $E_T^{\rm miss}$	SUSY-2013-20*	1 UL from CONF-2013-089
	$\tau(\tau/\ell)$ + jets + $E_T^{\rm miss}$	SUSY-2013-10	—
	SS/3-leptons + jets + $E_T^{\rm miss}$	SUSY-2013-09	1 UL (+5 UL, CONF-2013-007)
	0/1-lepton + 3b-jets + $E_T^{\rm miss}$	SUSY-2013-18*	2 UL, 2 EM
	Monojet	—	— (but monojet stop, see below)
Third generation	0-lepton stop	SUSY-2013-16*	1 UL, 1 EM
	1-lepton stop	SUSY-2013-15*	1 UL, 1 EM
	2-leptons stop	SUSY-2013-19*	2 UL
	Monojet stop	SUSY-2013-21	4 EM
	Stop with Z boson	SUSY-2013-08	1 UL
	2b-jets + $E_T^{\rm miss}$	SUSY-2013-05*	3 UL, 1 EM‡
	tb+$E_T^{\rm miss}$, stop	SUSY-2014-07	—
Electroweak	ℓh	SUSY-2013-23*	1 UL
	2-leptons	SUSY-2013-11	4 UL, 4 EM‡
	2-τ	SUSY-2013-14	—
	3-leptons	SUSY-2013-12	5 UL
	4-leptons	SUSY-2013-13	—
	Disappearing Track	SUSY-2013-01	*n.a. in current framework*
Other	Long-lived particle	—	*n.a. in current framework*
	$H/A \to \tau^+\tau^-$	—	*n.a. in current framework*

* plus Fastlim EMs for preliminary version (conf note) of the analysis.
‡ incl. 'home-grown' EMs produced with MadAnalysis5 or CheckMATE recasting.

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	1-lepton + jets + E_T^{miss}	SUSY-2013-20*	1 UL from CONF-2013-089
	$\tau(\tau/\ell)$ + jets + E_T^{miss}	SUSY-2013-10	—
	SS/3-leptons + jets + E_T^{miss}	SUSY-2013-09	1 UL (+5 UL, CONF-2013-007)
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	tb+E_T^{miss}, stop	SUSY-2014-07	—
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	2-leptons	SUSY-2013-11	4 UL, 4 EM‡
	2-τ	SUSY-2013-14	—
	3-leptons	SUSY-2013-12	5 UL
	4-leptons	SUSY-2013-13	—
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several EM produced by us with MadAnalysis5/CheckMATE

Dark matter simplified model results are very model dependent (note also mono-jet analysis is largely overlapping with multi-jet one)

no SMS interpretation available in exp. publication

Current SModelS framework requires MET signature

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	tb+E_T^{miss}, stop	SUSY-2014-07	—
Electroweak	ℓh	SUSY-2013-23*	1 UL
	2-leptons	SUSY-2013-11	4 UL, 4 EM‡
	2-τ	SUSY-2013-14	—
	3-leptons	SUSY-2013-12	5 UL
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no SMS interpretation available in exp. publication

Current SModelS framework requires MET signature

Fastlim-1.0 [arXiv:1402.0492] efficiency maps converted to SModelS format; target "natural SUSY" scenarios

Analyses considered (CMS)

CMS 8 TeV **available in SModelS v1.1.1**

	Analysis	ID	SModelS database
Gluino, Squark	jets + E_T^{miss}, α_T	SUS-12-028	4 UL
	3(1b-)jets + E_T^{miss}	SUS-12-024	2 UL, 3 EM
	jet multiplicity + H_T^{miss}	SUS-13-012	4 UL, 20 EM‡
	$\geq$ 2 jets + E_T^{miss}, M_{T2}	SUS-13-019	8 UL
	$\geq 1b$ + E_T^{miss}, Razor	SUS-13-004	5 UL
	1 lepton + $\geq 2b$-jets + E_T^{miss}	SUS-13-007	3 UL, 2 EM
	2 OS lept. + $\geq$4(2b-)jets + E_T^{miss}	PAS-SUS-13-016	2 UL
	2 SS leptons + b-jets + E_T^{miss}	SUS-13-013	4 UL, 2 EM
	b-jets + 4 Ws + E_T^{miss}	SUS-14-010	2 UL
Third gen.	0 lepton + $\geq$ 5(1b-)jets + E_T^{miss}	PAS-SUS-13-015	2 EM
	0 lepton + $\geq$ 6(1b-)jets + E_T^{miss}	PAS-SUS-13-023	4 UL
	1 lepton + $\geq$ 4(1b-)jets + E_T^{miss}	SUS-13-011	4 UL, 2 EM
	b-jets + E_T^{miss}	PAS-SUS-13-018	1 UL
	soft leptons, few jets + E_T^{miss}	SUS-14-021	2 UL
EW	multi-leptons + E_T^{miss}	SUS-13-006	6 UL

‡ incl. 'home-grown' EMs produced with MadAnalysis5 or CheckMATE recasting.

large number of `home-grown' EM; cover additional topologies

Very similar to ATLAS analyses, comparable reach,
but (in part) complementary SMS topologies in SModelS database

Number of points

	bino-like LSP	higgsino-like LSP
tested by ATLAS	103,410	126,684
excluded by ATLAS	41,570 (40.2%)	48,266 (38.1%)
of these, tested in SModelS*	38,575	45,594
excluded by SModelS	21,151 (55%)	28,669 (63%)

* discarded points which cannot be tested in SModelS: points with long-lived particles and points which are excluded only by searches for heavy Higgses

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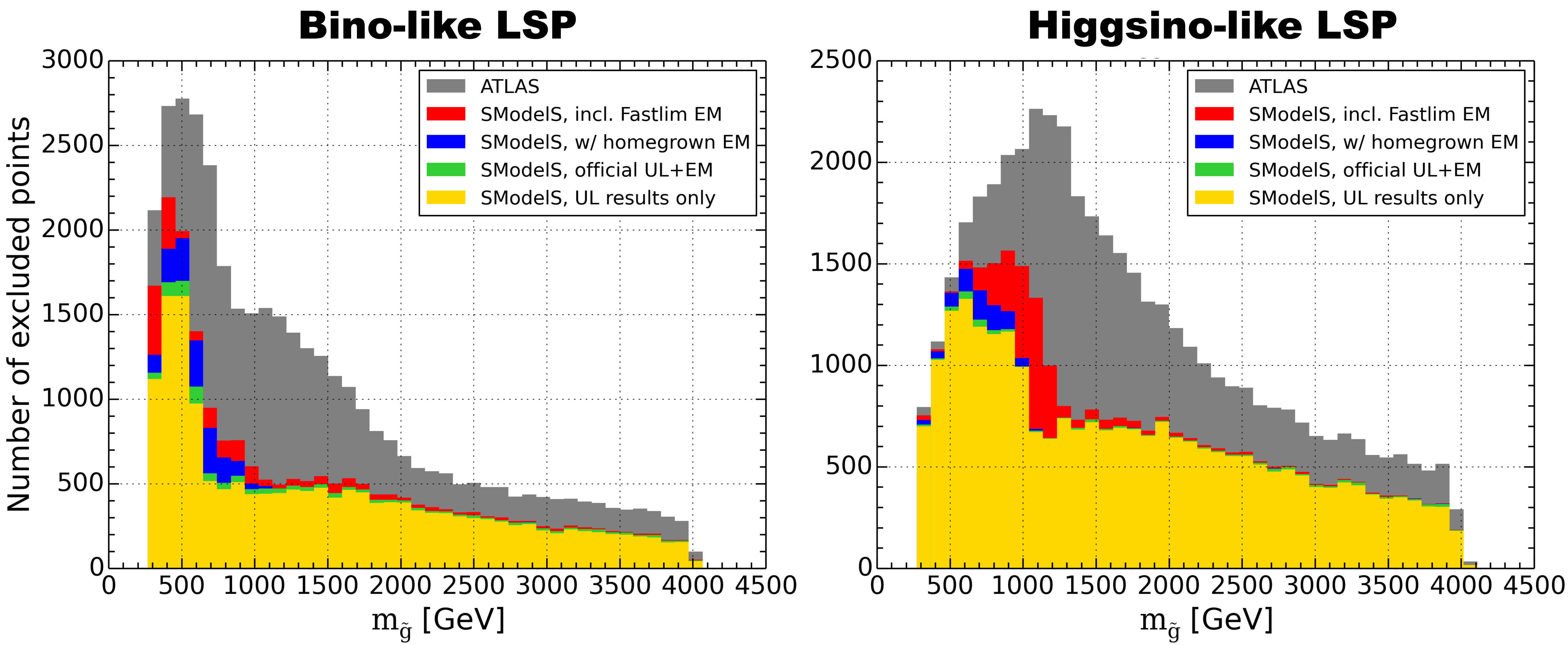
Coverage in terms of gluino mass

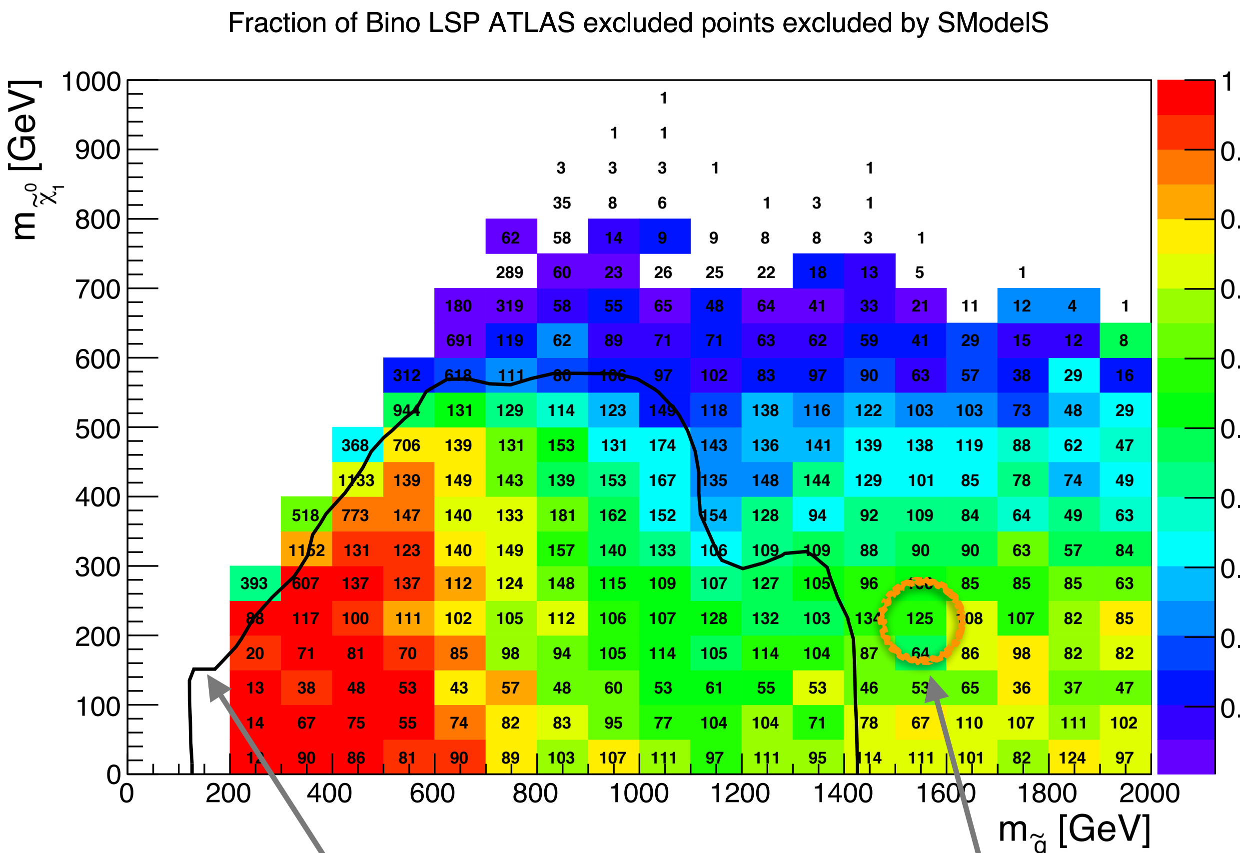


Fraction of excluded points w.r.t. ATLAS (after filtering)

	bino LSP	higgsino LSP
m(gluino) < 600 GeV	80 %	97 %
m(gluino) < 1400 GeV	60 %	74 %

Gluino vs. neutralino mass plane

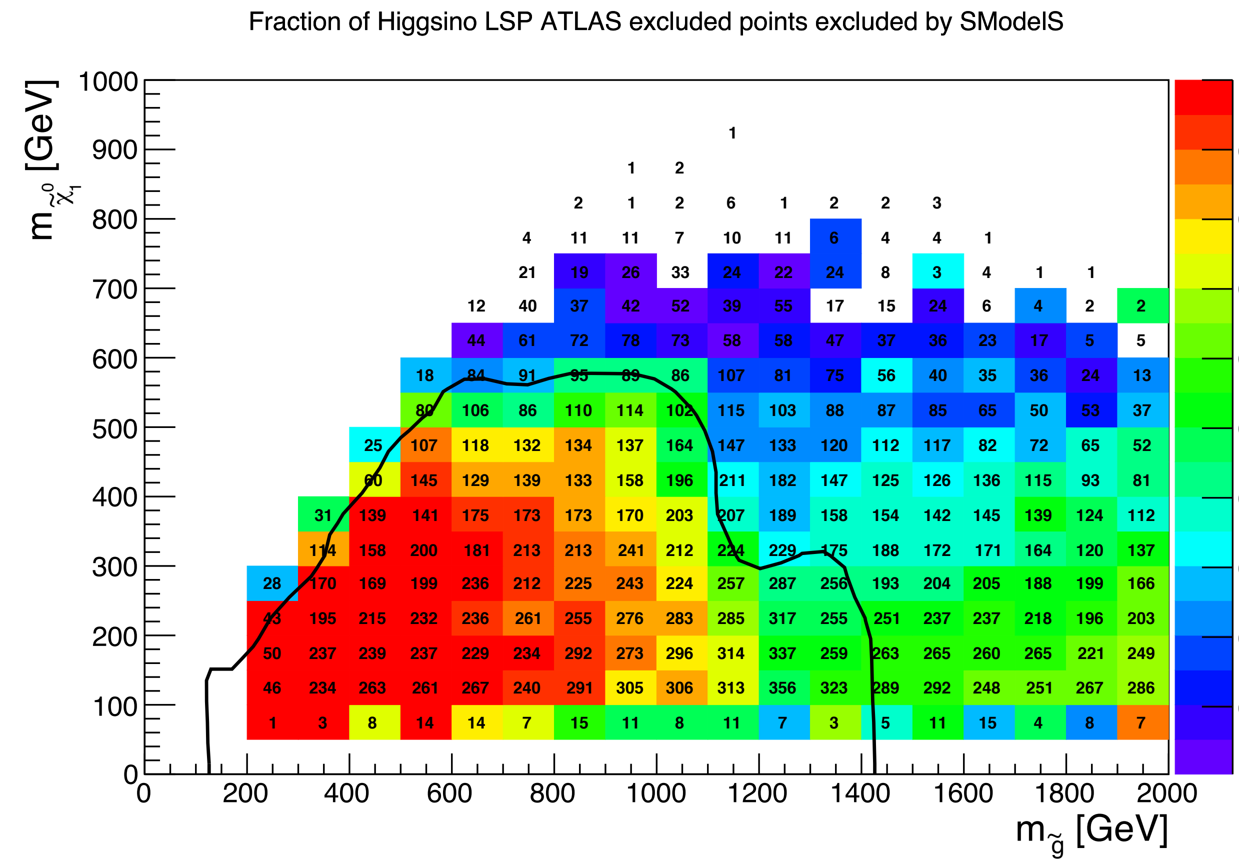
Bino-like LSP



$\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$ exclusion line from ATLAS 1405:7875

number of points tested (excluded by ATLAS)

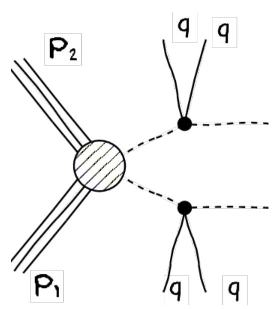
Higgsino-like LSP



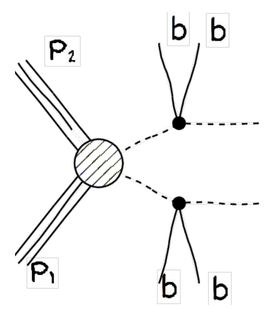
- Coverage drops for intermediate gluino masses, where a larger variety of decay channels becomes available; more pronounced for bino than for higgsino LSP.
- Coverage also drops in compressed region and for heavy LSP.

Why are SMS results missing light gluinos?

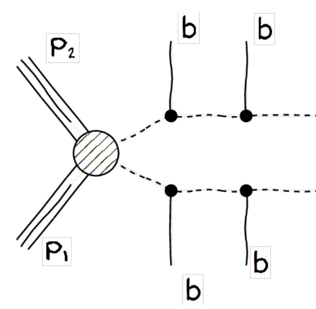
- Most SMS results assume pair production followed by the same simple cascade decay on either branch.



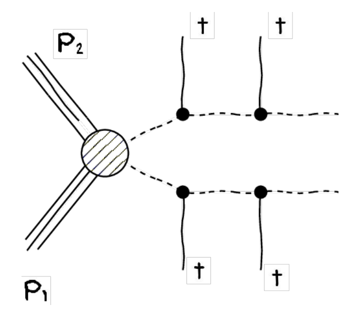
$\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$



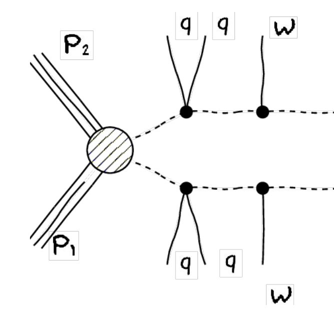
$\tilde{g} \to b\bar{b}\tilde{\chi}_1^0$



$\tilde{g} \to b\tilde{b},\ \tilde{b} \to b\tilde{\chi}_1^0$

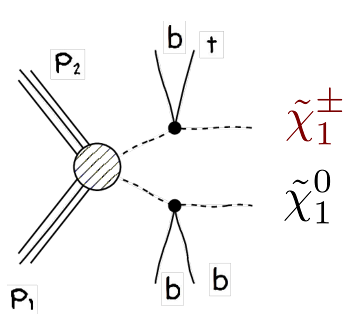


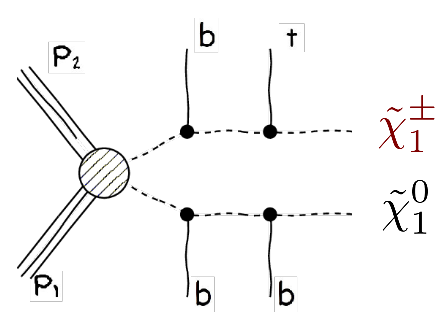
$\tilde{g} \to t\tilde{t},\ \tilde{t} \to t\tilde{\chi}_1^0$



$\tilde{g} \to q\bar{q}'\tilde{\chi}_1^\pm,\ \tilde{\chi}_1^\pm \to W\tilde{\chi}_1^0$

- Fastlim efficiency maps contain also some asymmetric topologies, e.g.





assumes decay products of chargino decay are too soft too be visible (very small mass difference of chargino-neutralino; typical higgsino-LSP case)

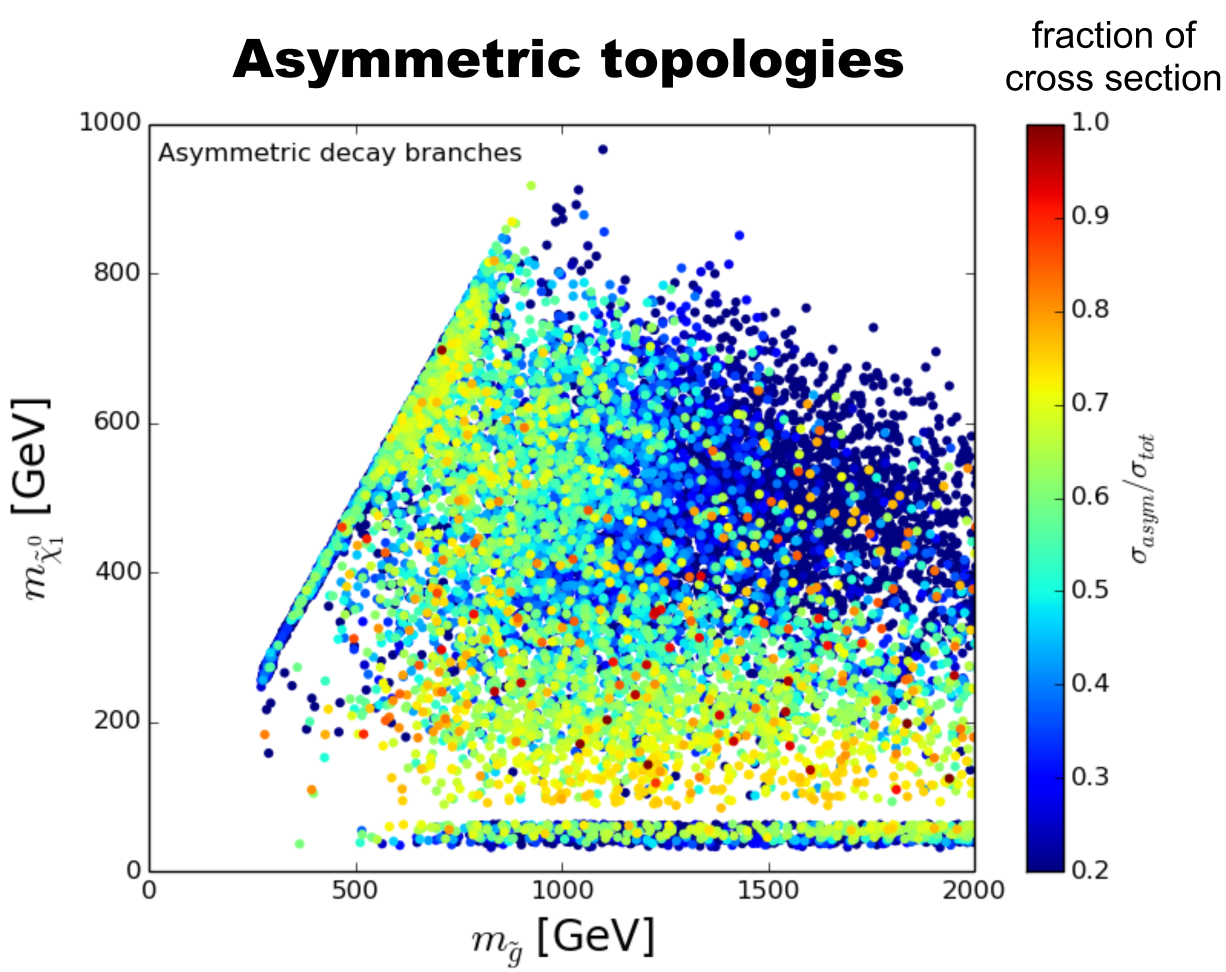
- In general much more variety possible, including mixed decays via heavy neutralinos, longer cascades, asymmetric branches from associated production, etc.

NB some ATLAS/CMS results available for long cascades, but not applicable in general because only one mass plane with fixed intermediate masses.

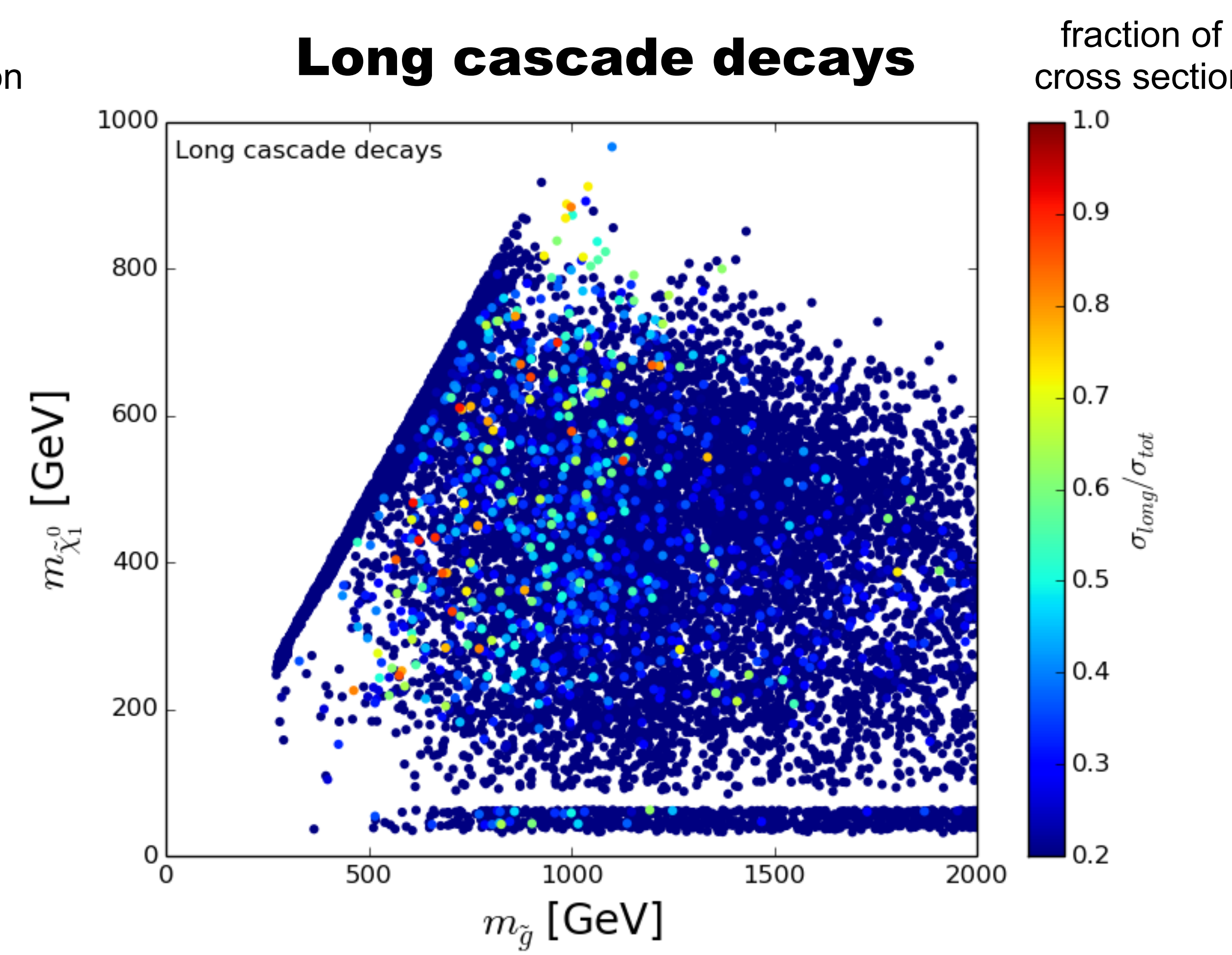
Asymmetric or long cascade decays?

Points excluded by ATLAS but not by SModelS: how much of the cross section goes into asymmetric branches or long cascade decays for which we have no SMS results?

Asymmetric topologies



Long cascade decays



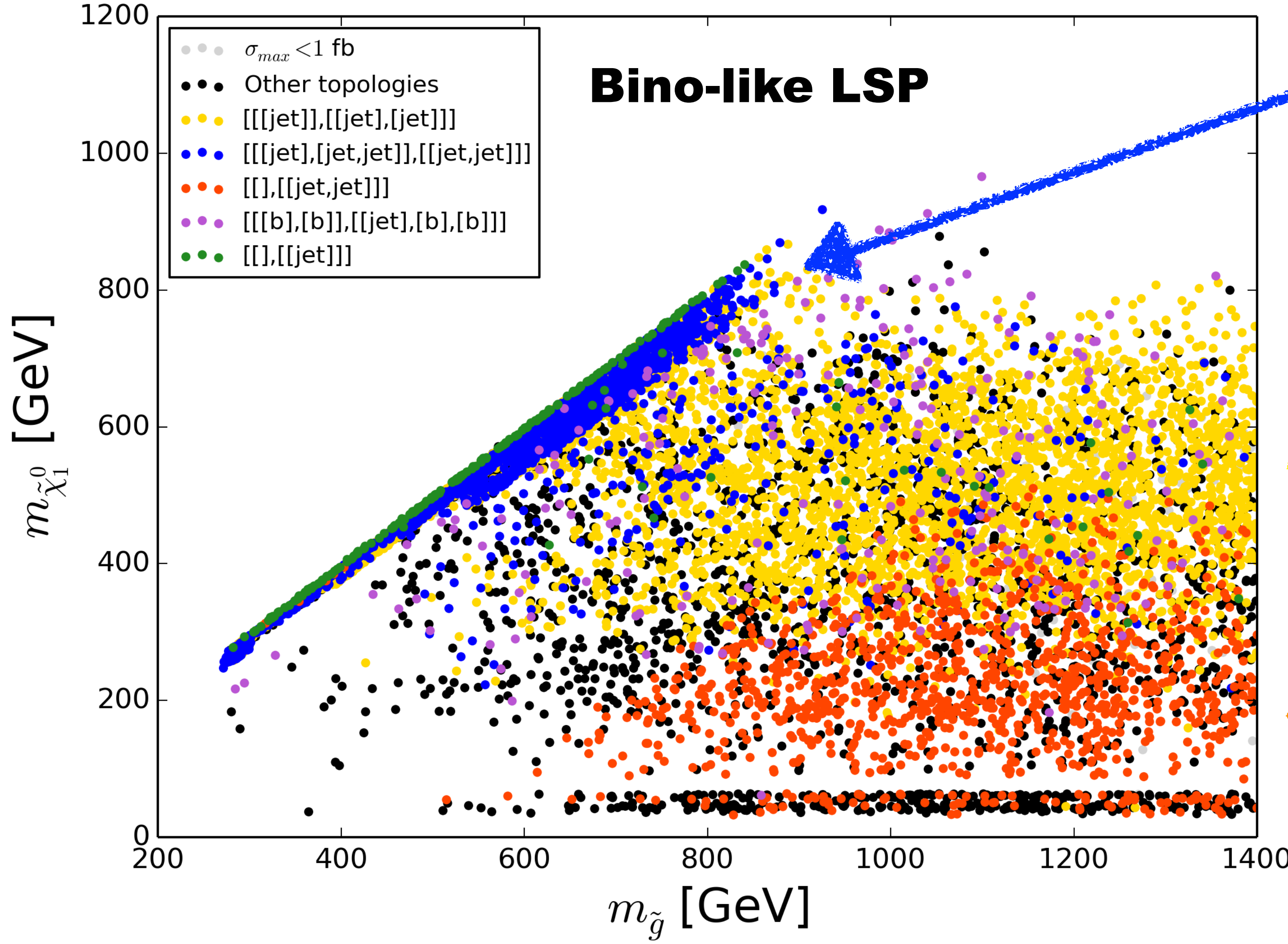
Asymmetric topologies: short decays (max. one intermediate particle) but different final states from the two branches

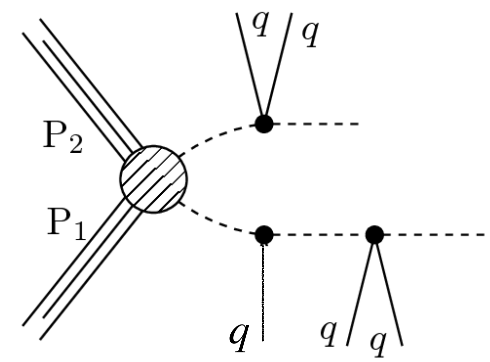
Long cascade decays: more than one intermediate SUSY particle in the decay chain (4 or more mass parameters).

Plots are for bino-like LSP case, but look similar for higgsino-like LSP.

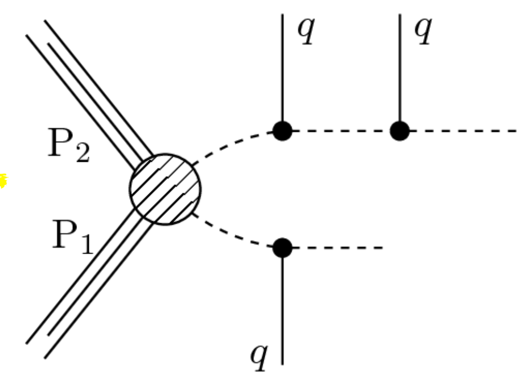
Most important missing topologies

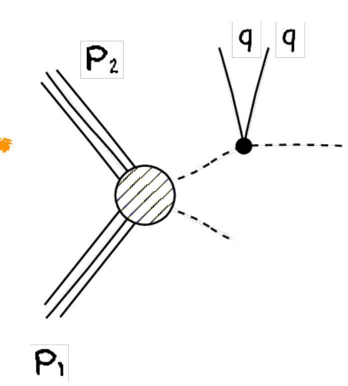
i.e. topologies for which no SMS results are available





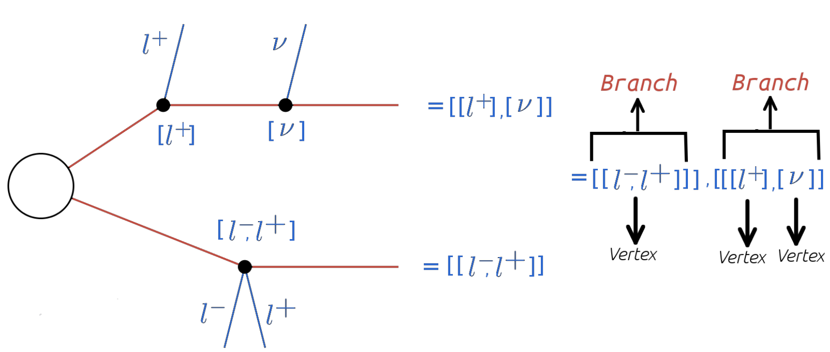
gluino-squark assoc.production





assoc. production with LSP

Bracket notation:



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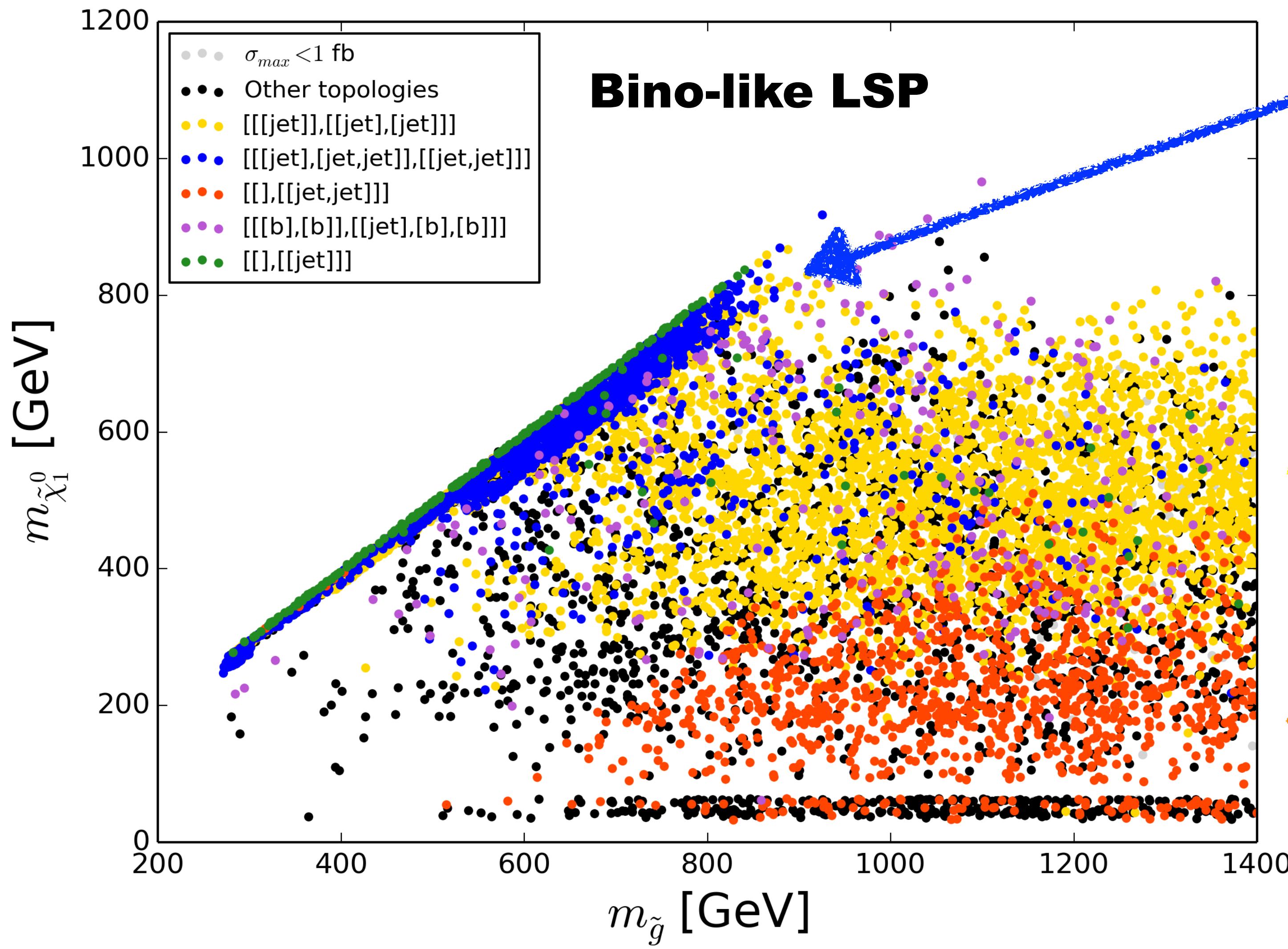

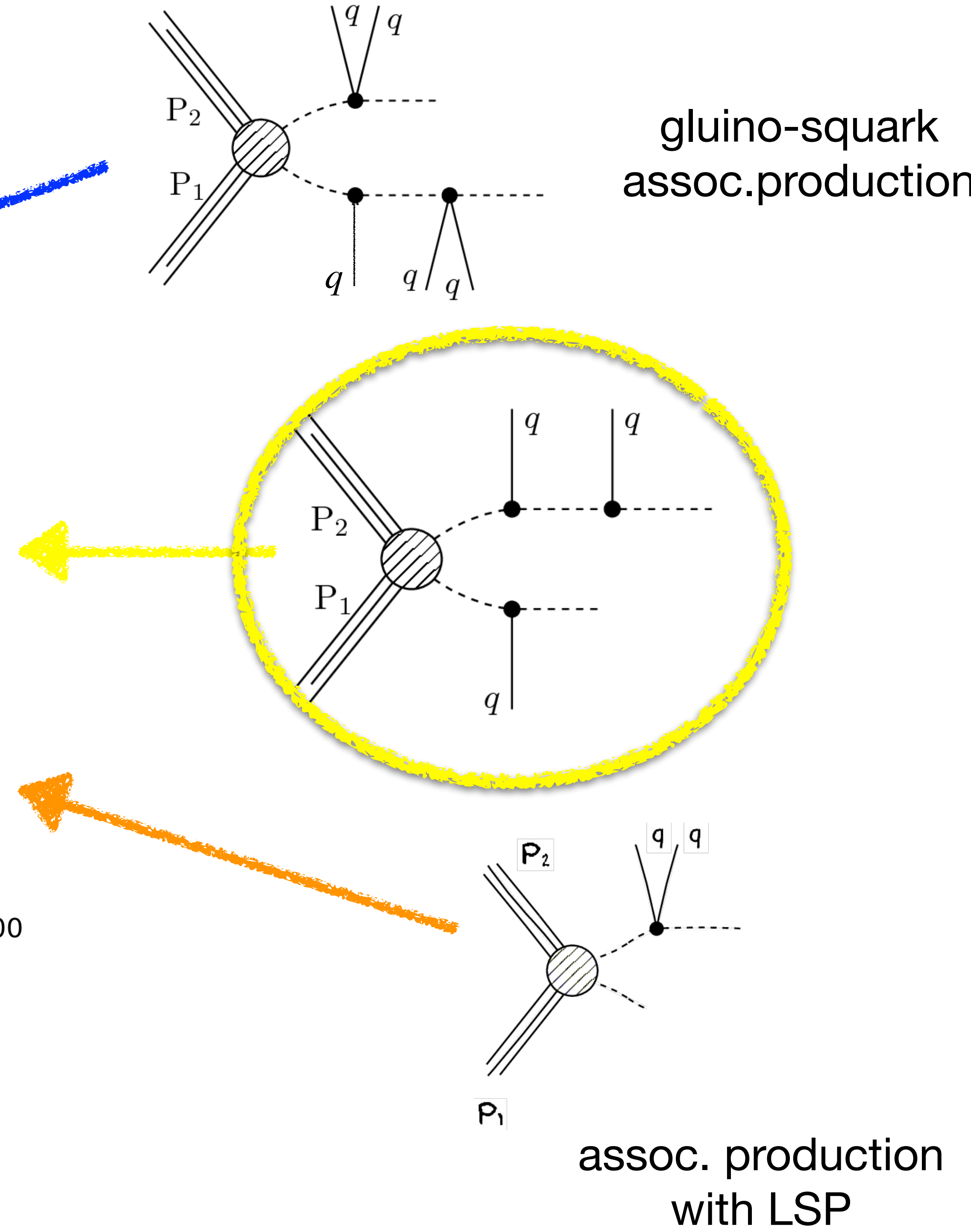

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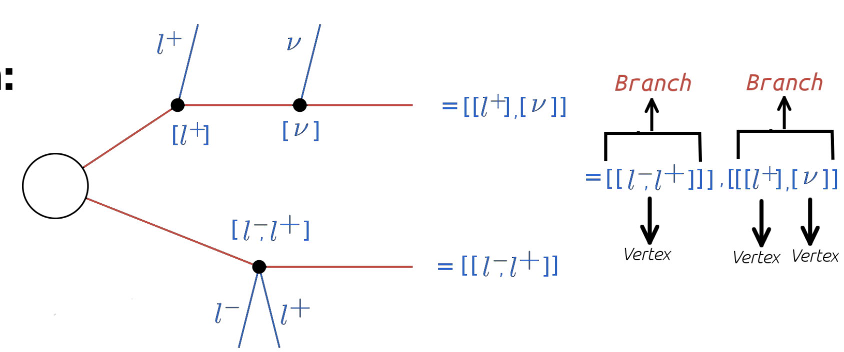
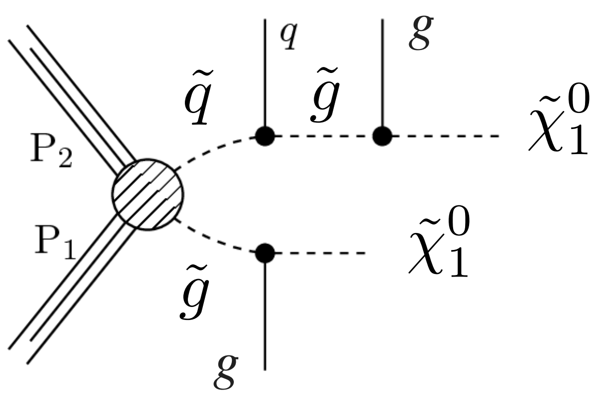


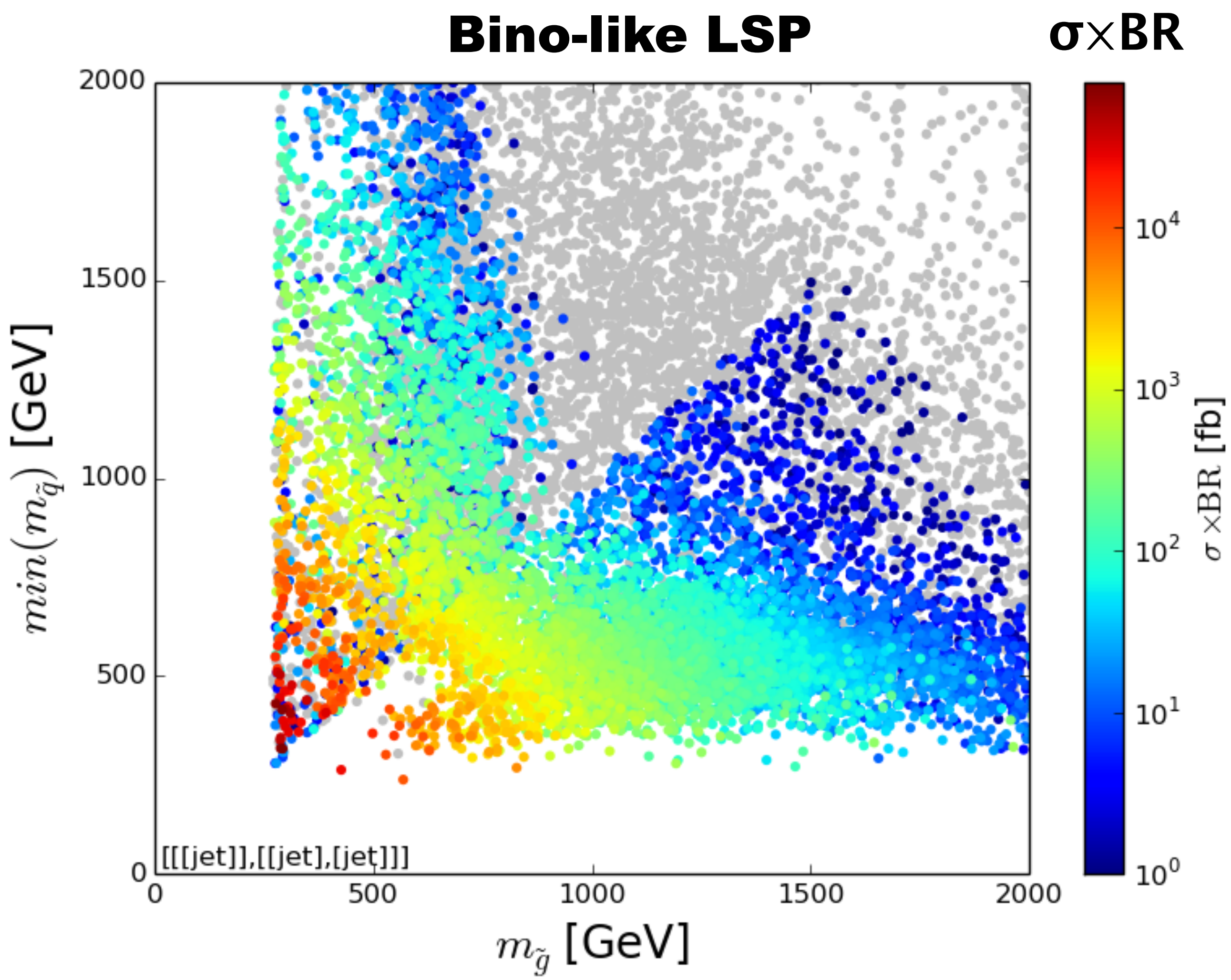
Gluino-squark associated production

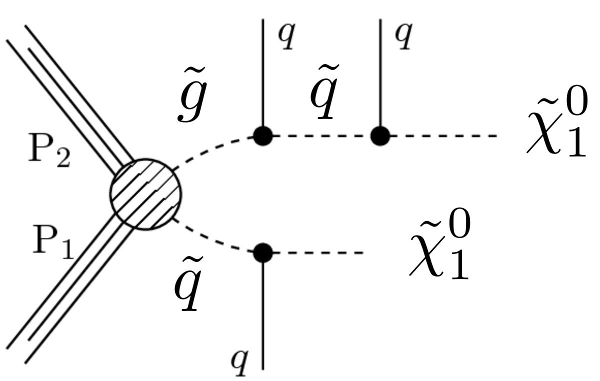
particularly important missing topology when one squark is lighter than the others

can have very large cross section



NB: gluino loop decay more important than 3-body decay via highly split squarks.





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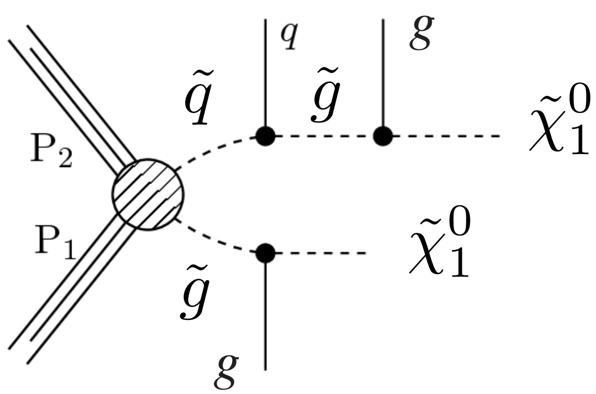

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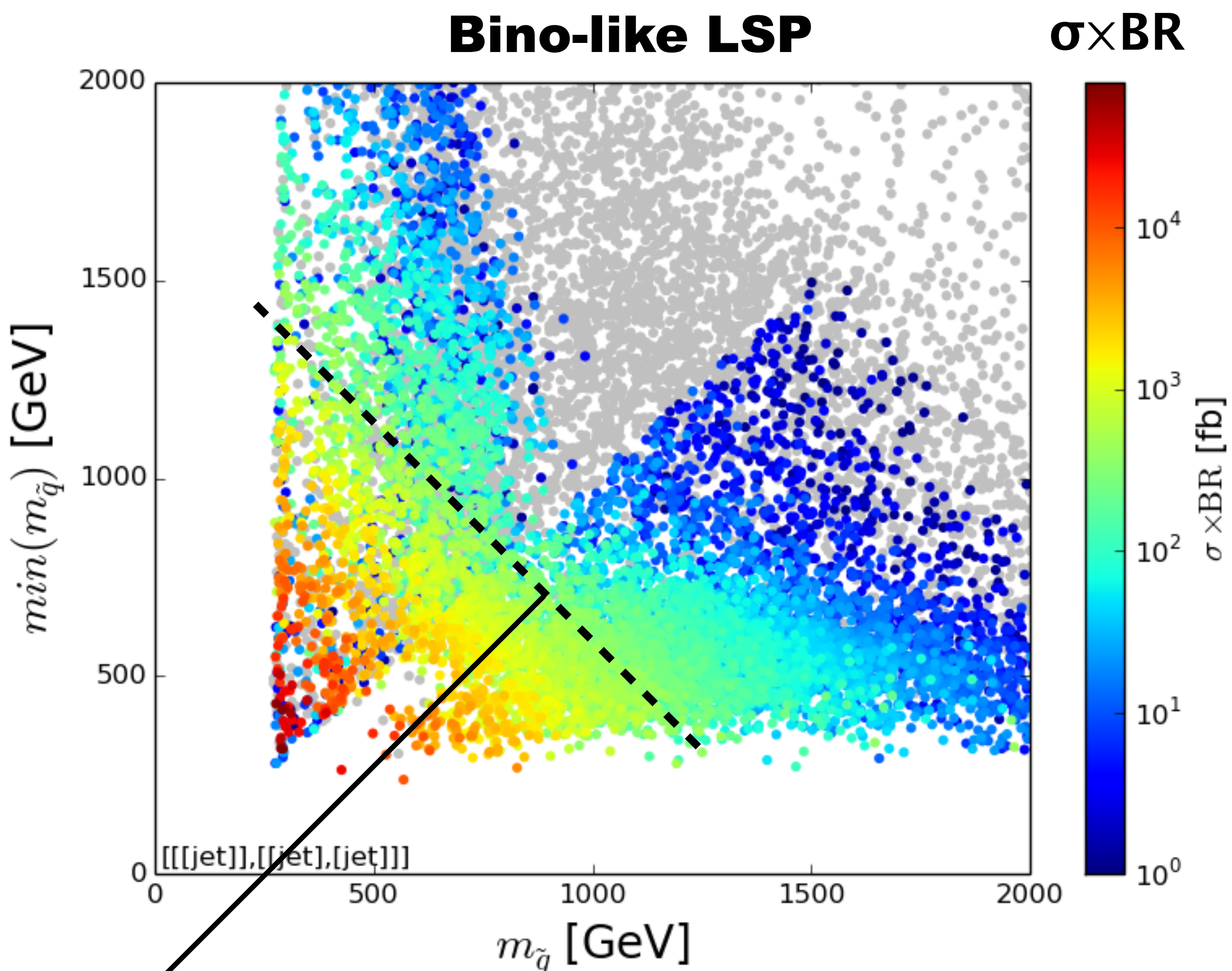
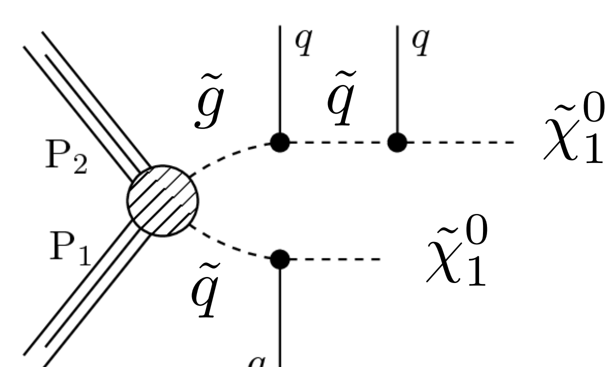


could likely cover this region if the relevant SMS results existed

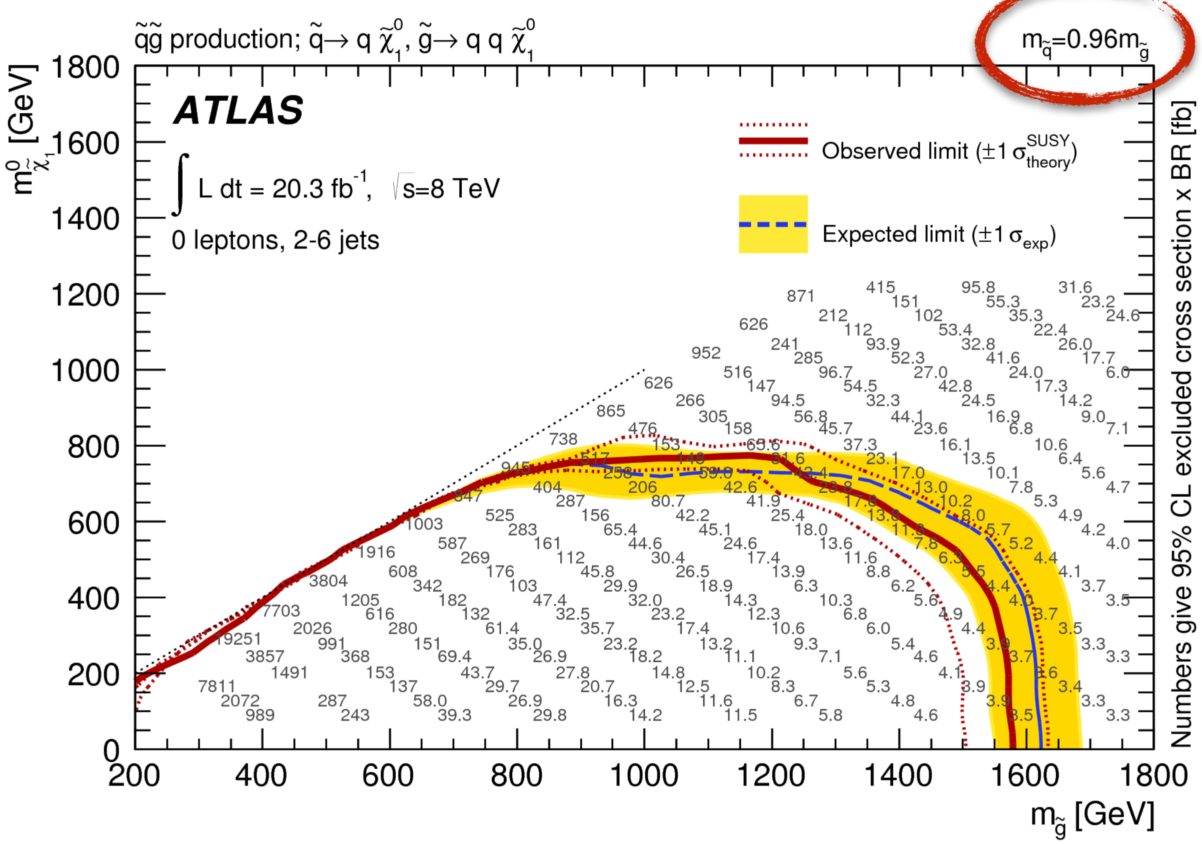


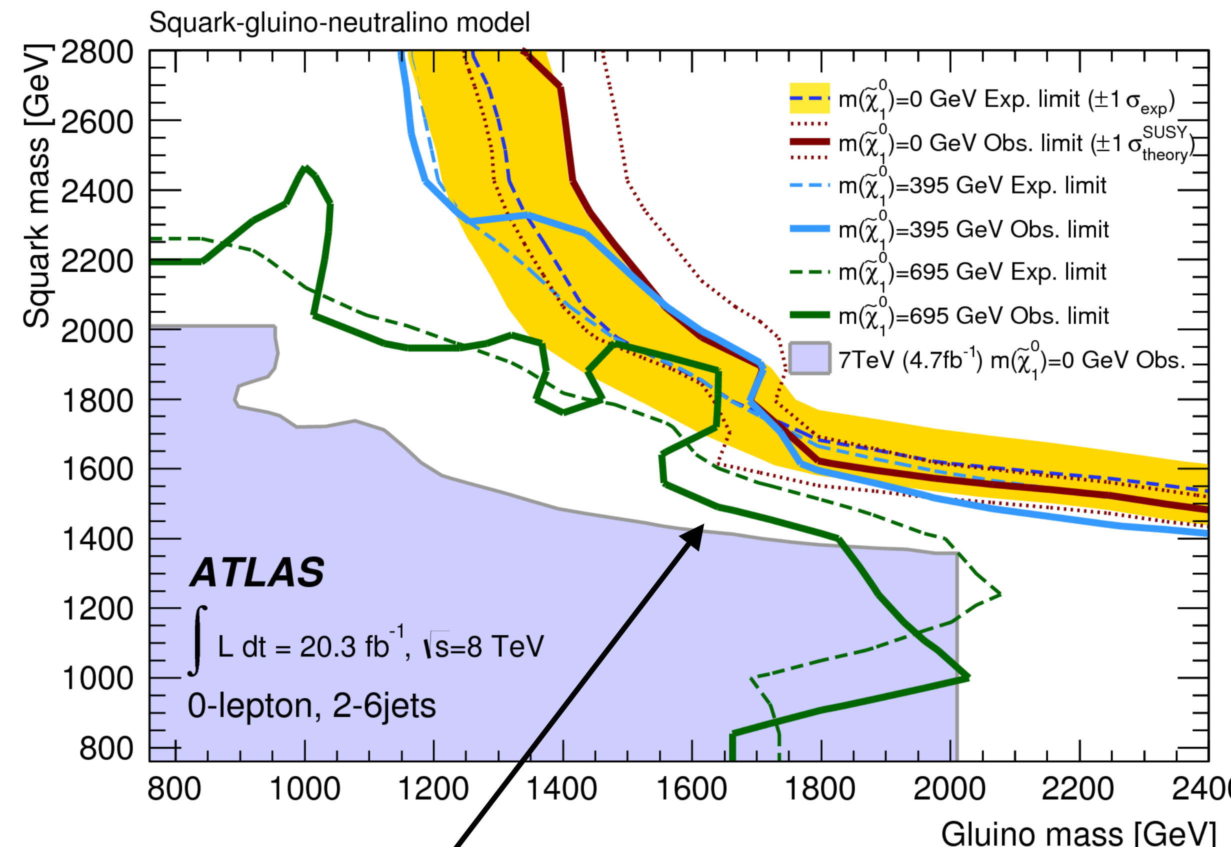
Gluino-squark simplified model in ATLAS

assumes 8 degenerate squarks

ATLAS-SUSY-2014-06
arXiv:1507.05525

fixed mass relation



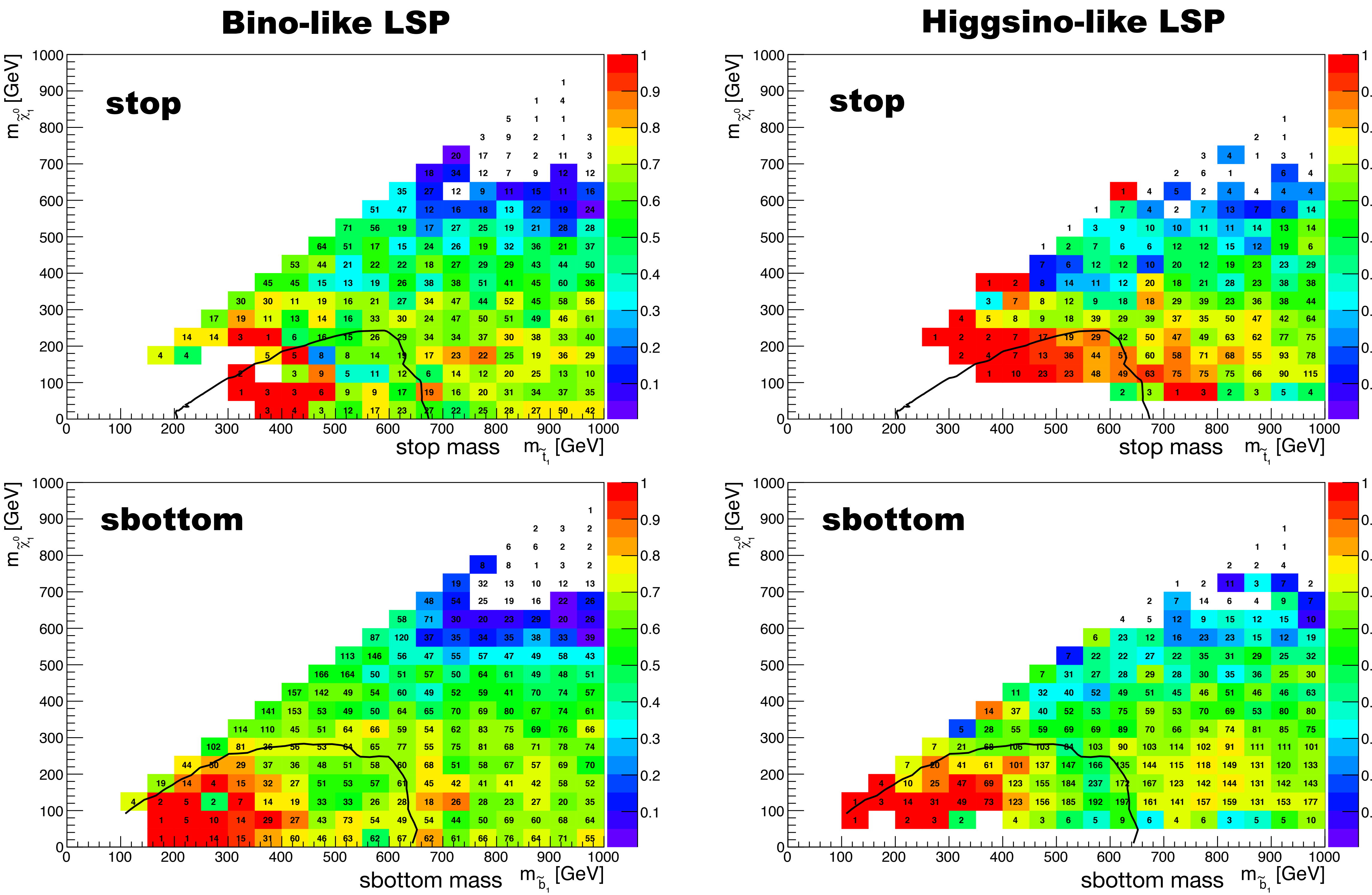


gluino-squark mass limits for 3 different LSP masses

But no cross section upper limits or efficiency maps available for these :-(

Coverage of 3rd generation

note small number of points in each bin

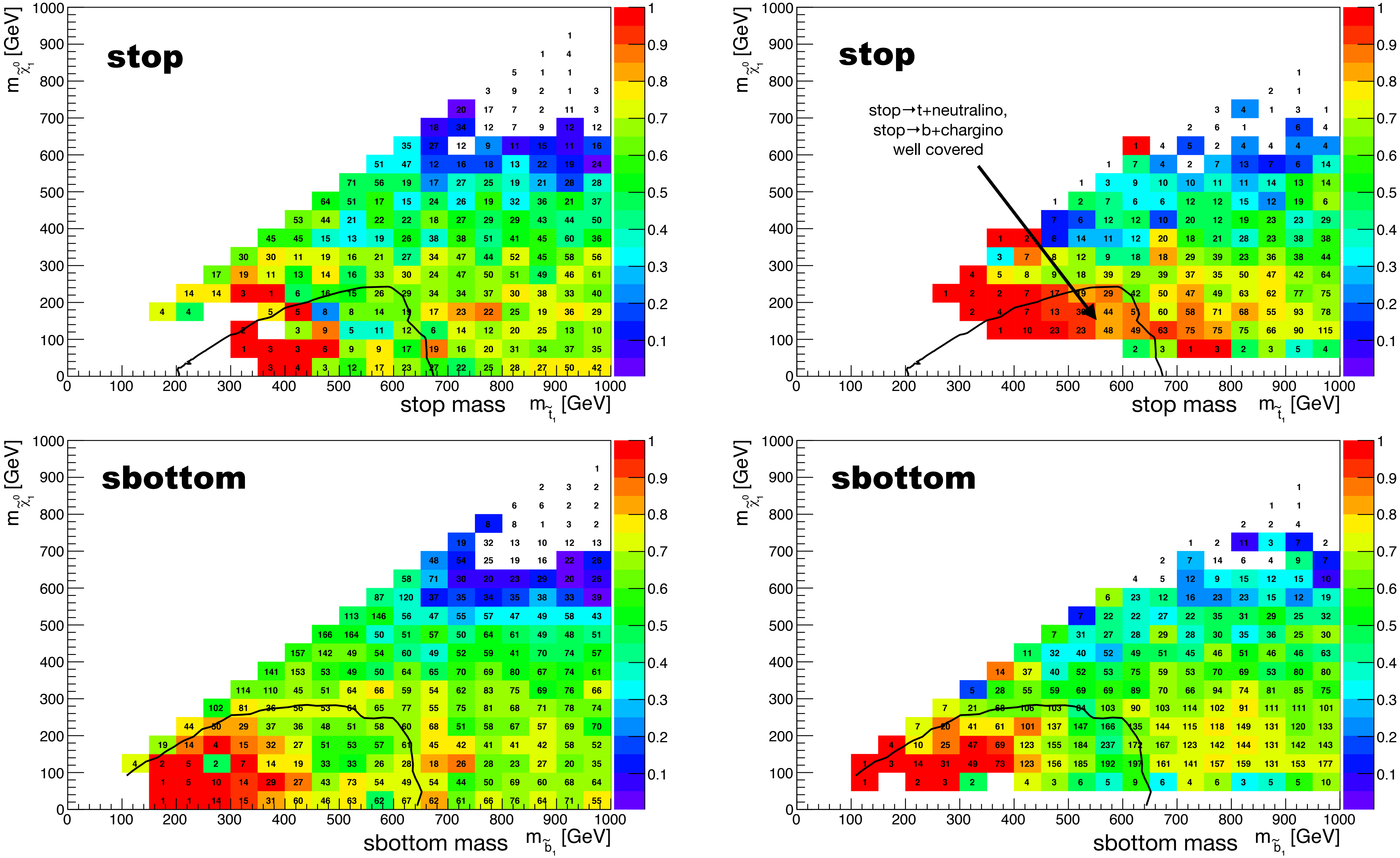


missing: SMS for decays via heavier EW-inos with visible decays to LSP

Coverage of 3rd generation

note small number
of points in each bin

Bino-like LSP | **Higgsino-like LSP**



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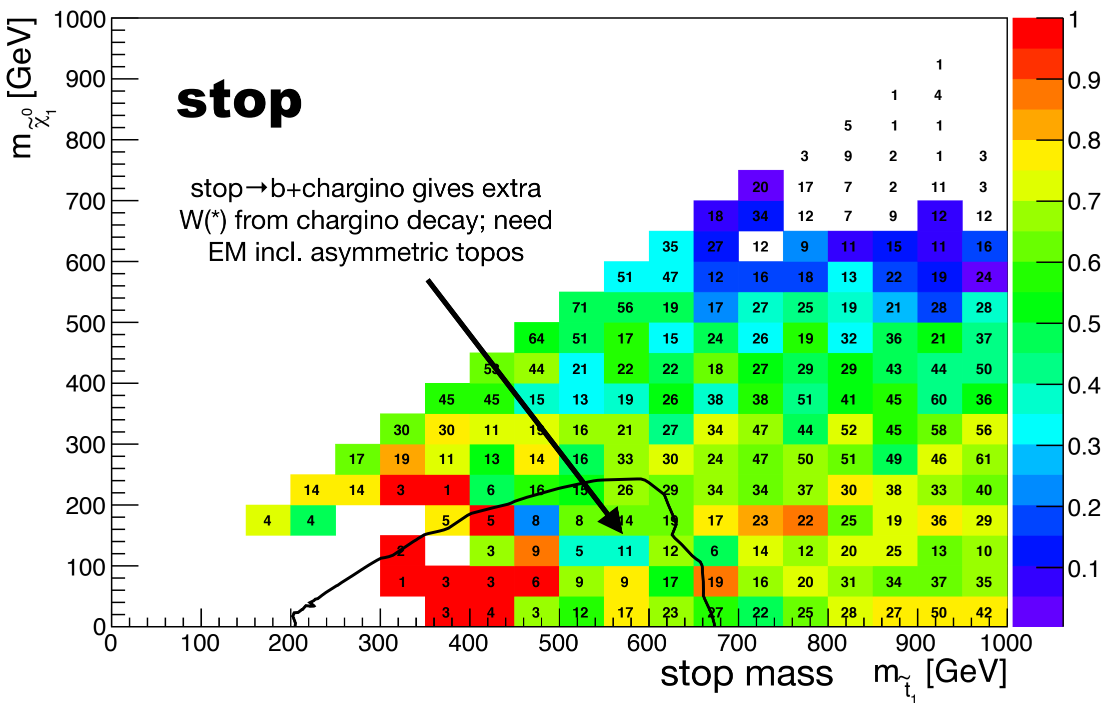
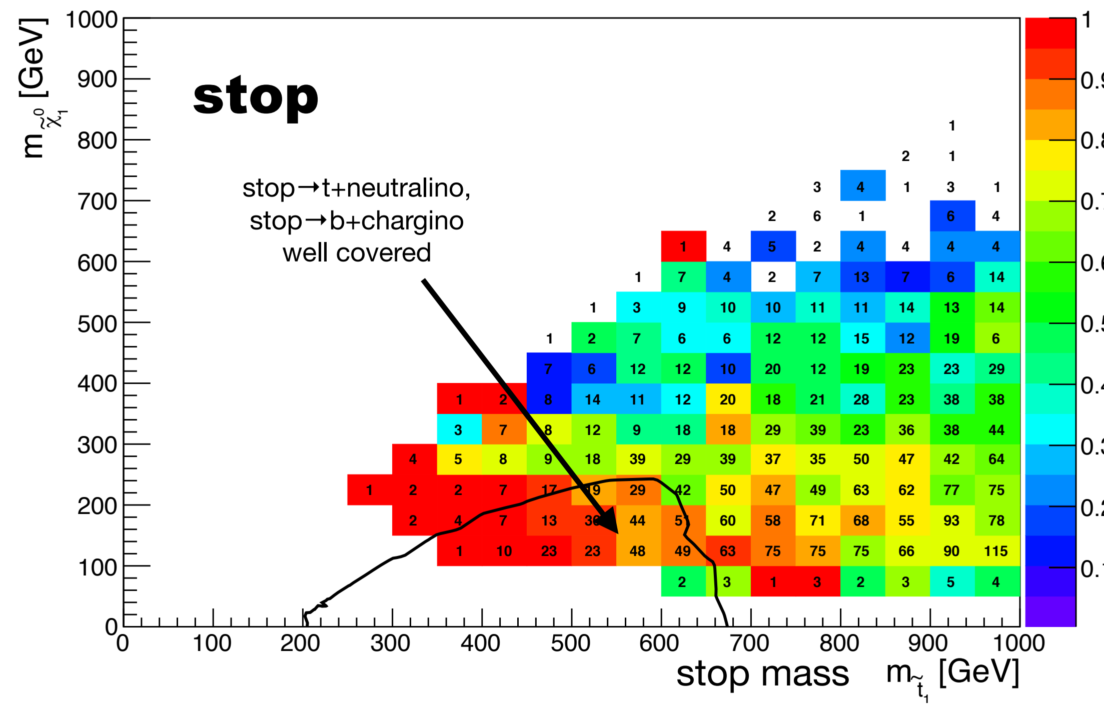
Coverage of 3rd generation

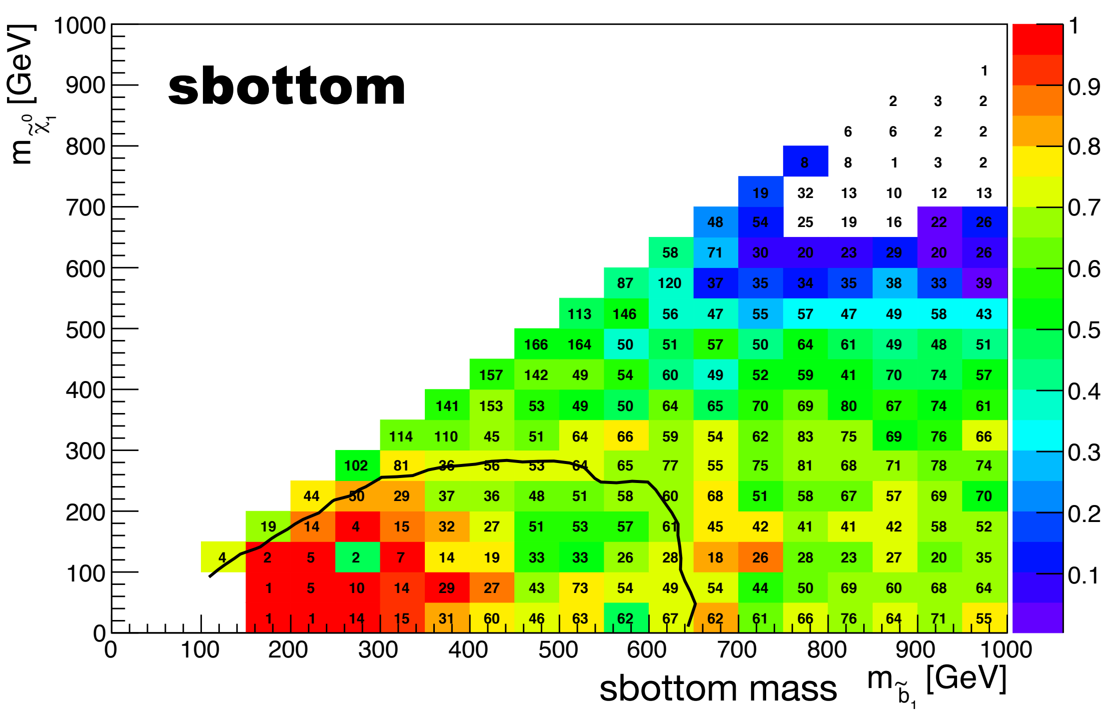
note small number of points in each bin

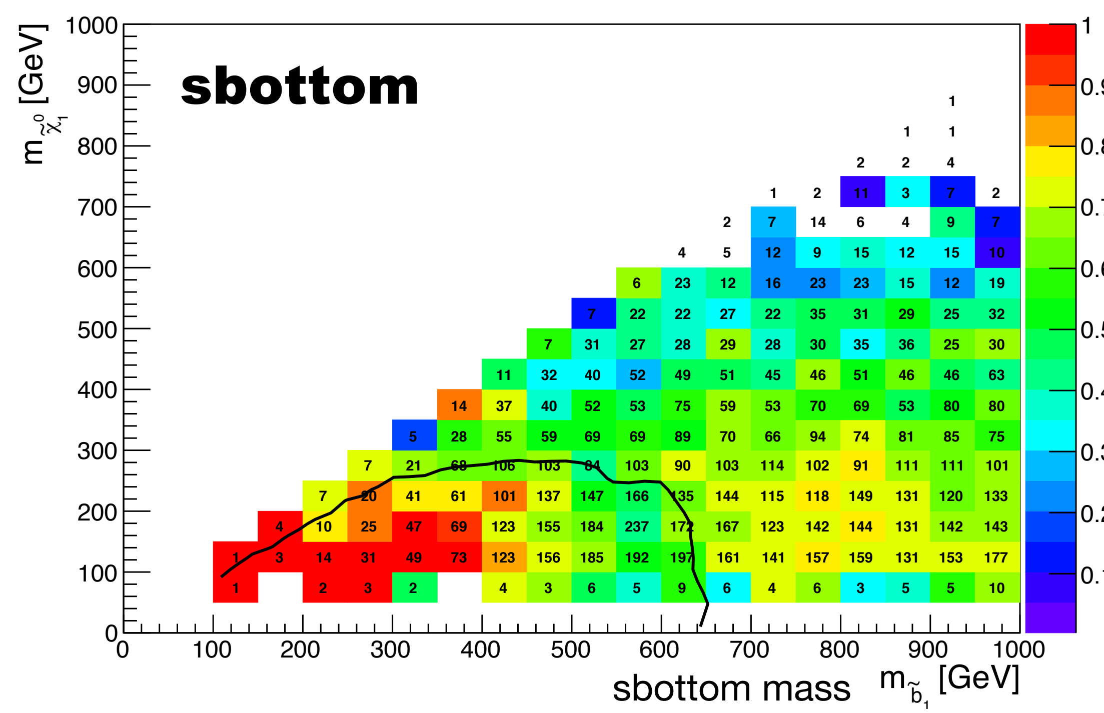
Bino-like LSP



Higgsino-like LSP

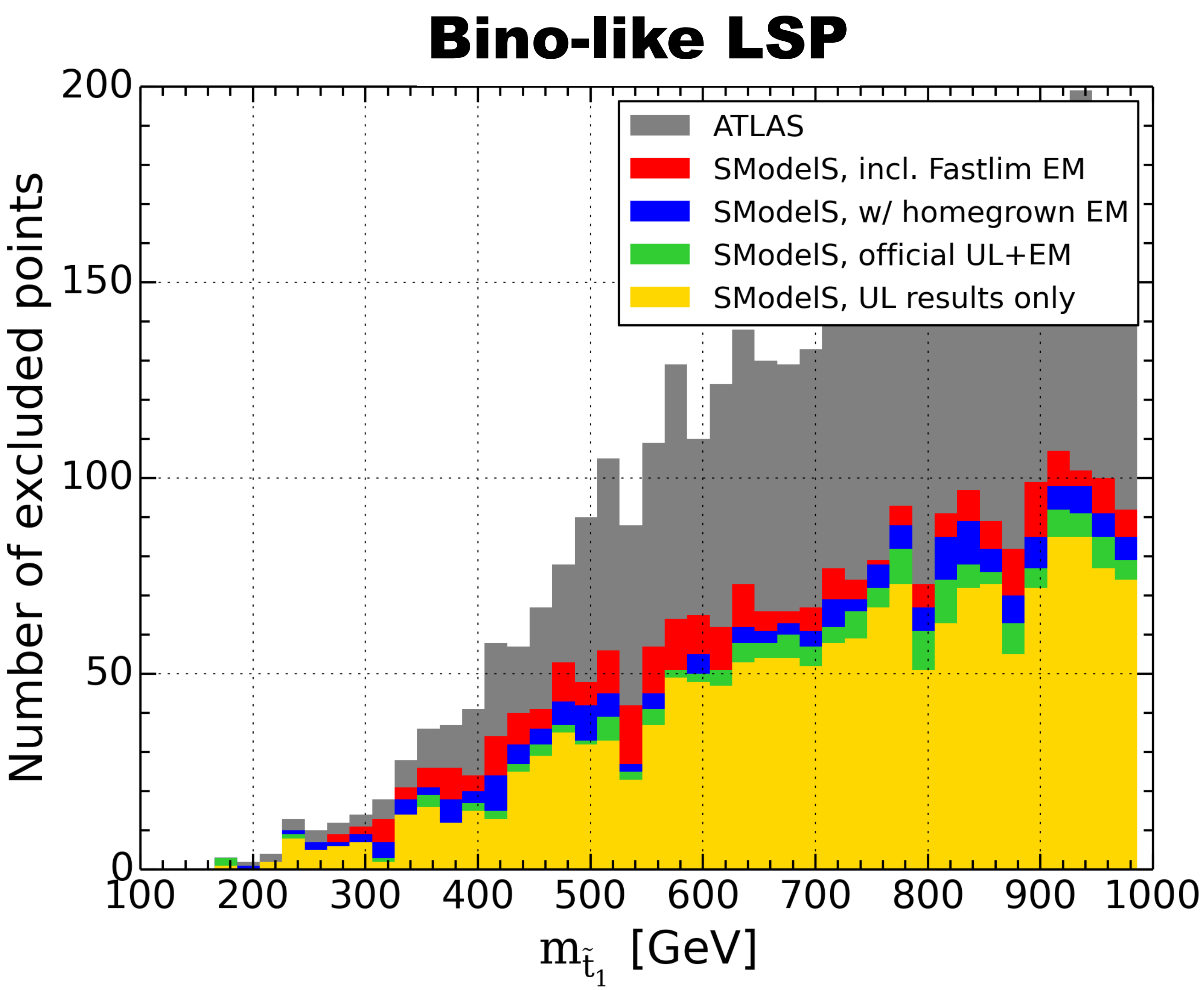


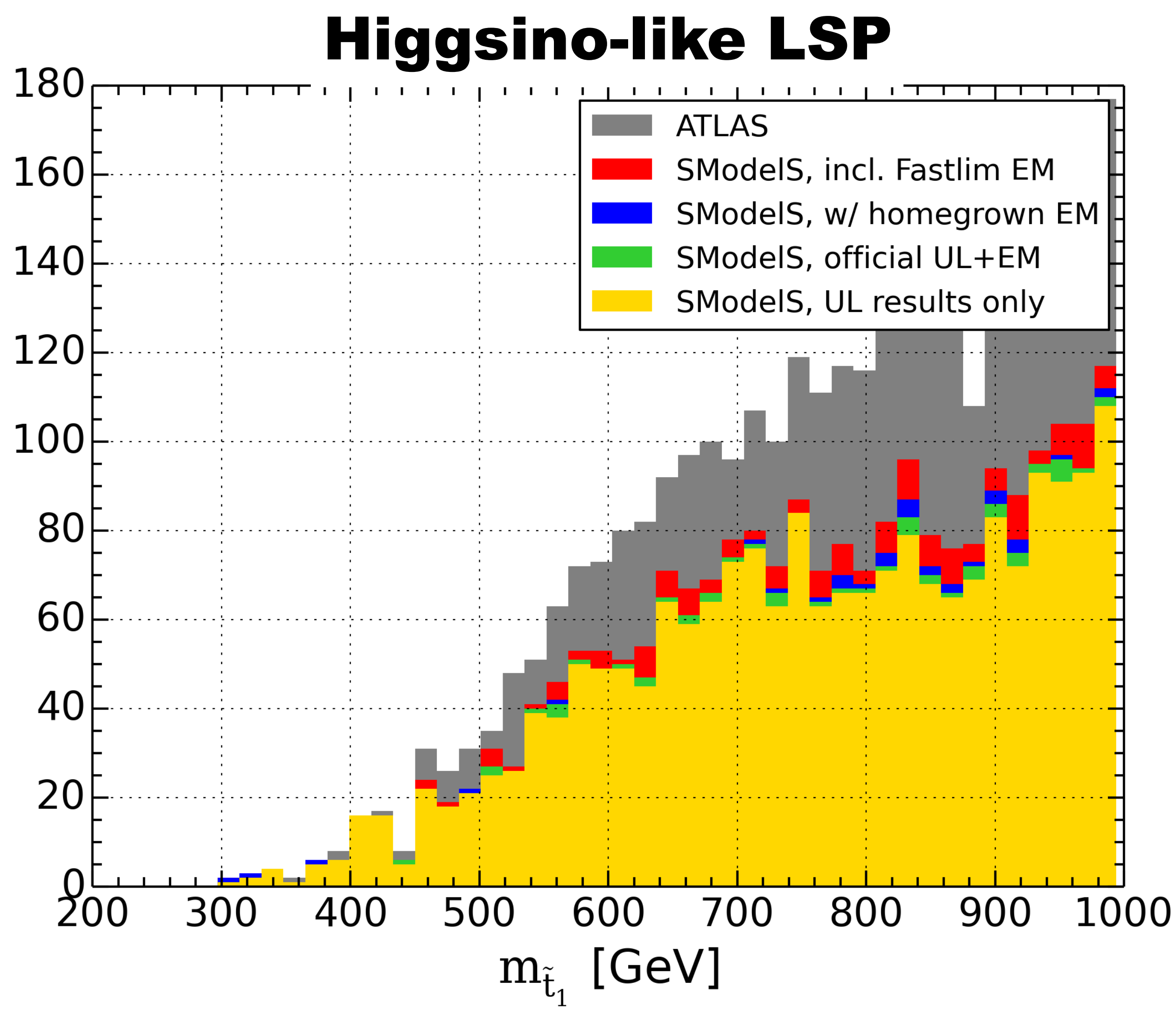




missing: SMS for decays via heavier EW-inos with visible decays to LSP

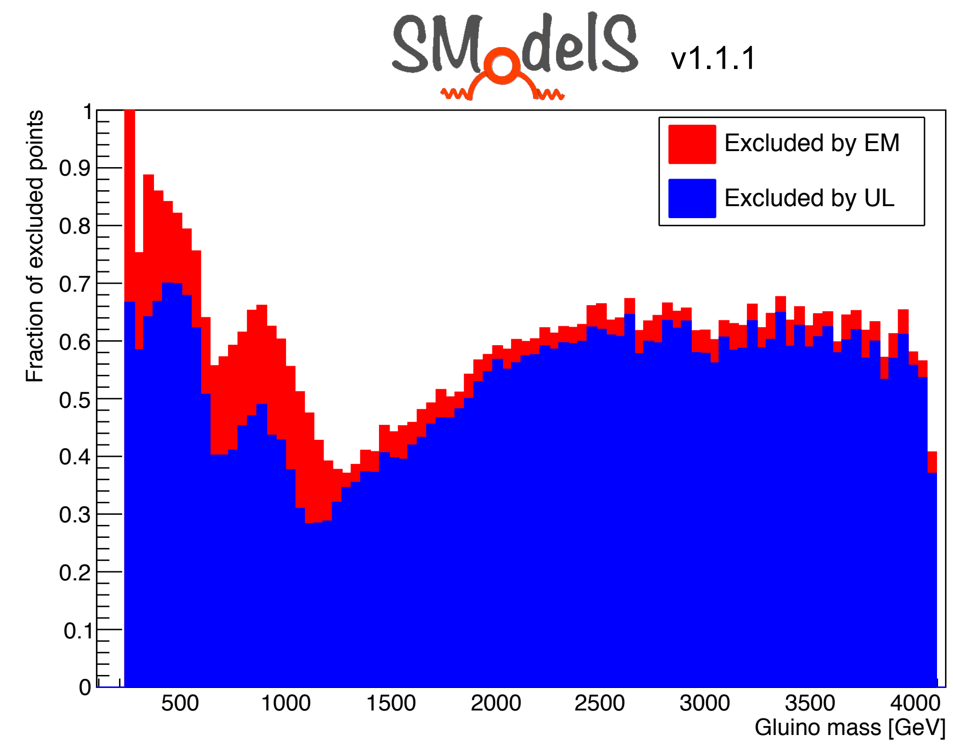
Coverage of light stops (1D)





Conclusions

- SMS constraints allow to exclude 55% (63%) of bino (higgsino) LSP points excluded by ATLAS.
- Efficiency maps provide more powerful constraints because they allow to combine contributions from different topologies to the same signal region
- Many points with gluino mass <1.4 TeV escape exclusion by SMS constraints; sharp drop in coverage as larger variety of decay channels opens



- To improve the coverage, we need results for asymmetric topologies, in particular gluino-squark associated production with arbitrary mass hierarchies (3 free param.)
- For stops/sbottoms, need efficiency maps for decays via heavier EW-inos, which in turn decay visibly into the LSP.
- If not provided by ATLAS/CMS, produce our own with MadAnalysis5 or Checkmate.

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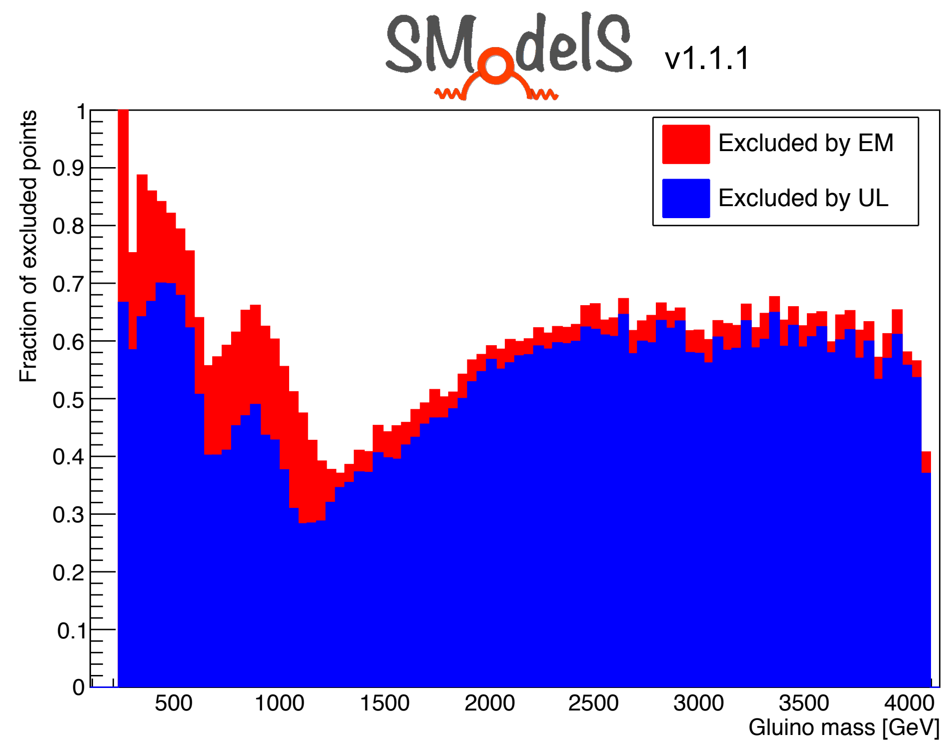


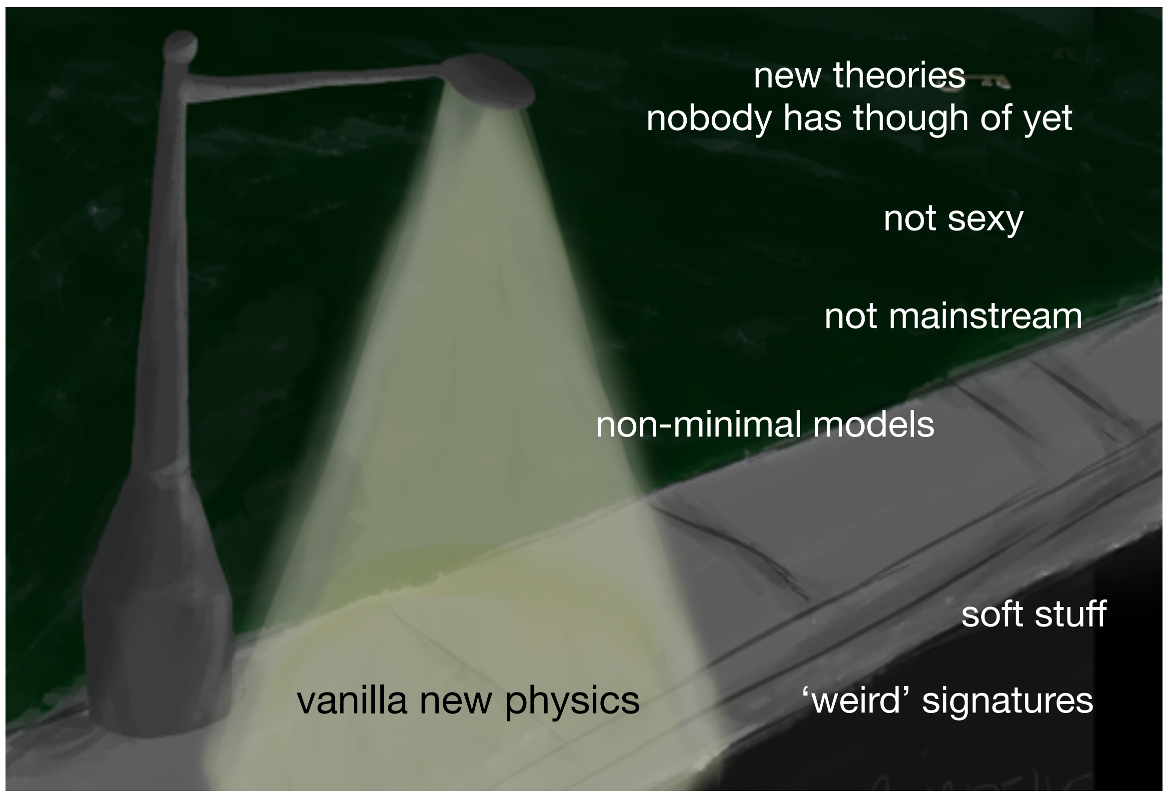
Complex models can be decomposed into SMS components, but SMS do **not** fully map a complex model.

Nonetheless, SMS constraints can provide a **fast first filter** before going for time-consuming, dedicated simulations

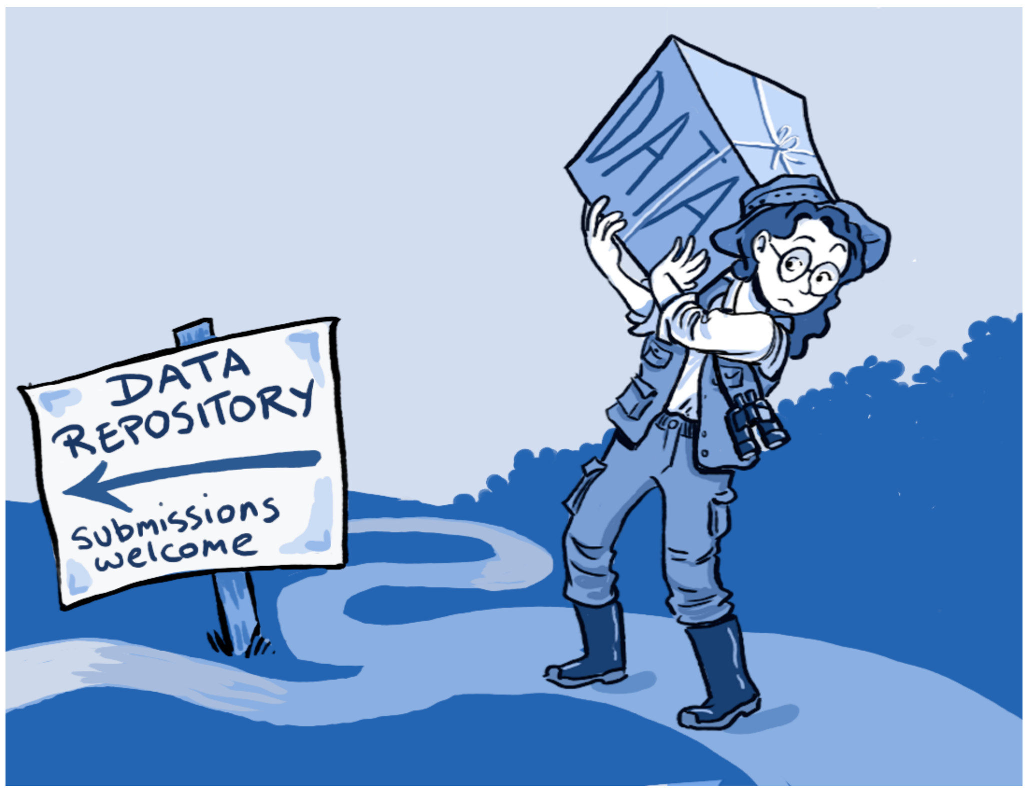
BACKUP

Theory-experiment interaction, building tools for (re)interpretation

Search beyond the streetlight



Ensure long-term impact of results, use in global analyses, etc.



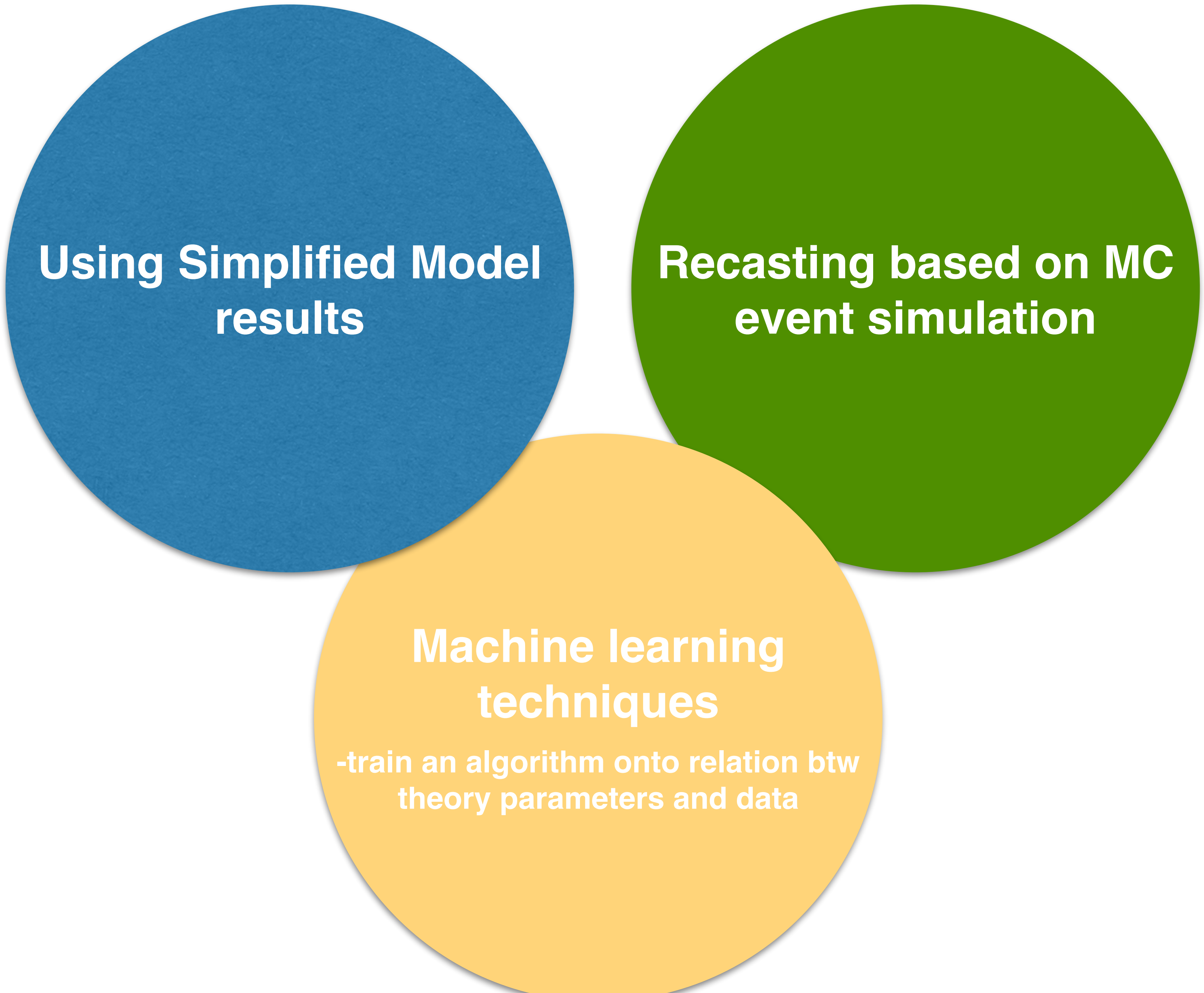
GitHub: "…. understand what someone outside your research project (or you in 5-10 years) would need to know about your data in order to build on your work."

We want to know what all(!) the LHC and other data tell us about the TeV scale and beyond

Methods

Plus
- Fast, suitable for scans and model surveys
- Easy classification of uncovered signatures

Minus
- Only simple topologies
- Availability of multiple mass planes for interpolation
- Validity of SMS assumptions



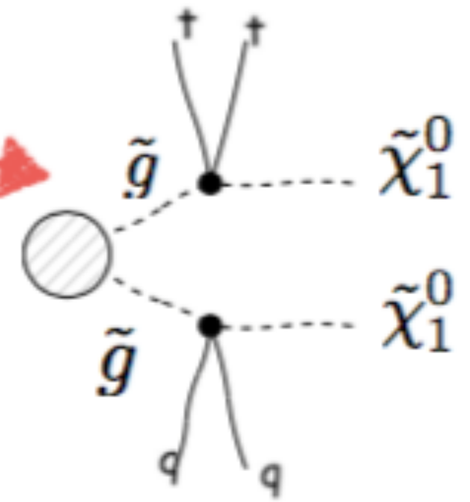
Plus
- More general, more precise
- Can test prospects of improving an analysis

Minus
- Very CPU time consuming
- Need detailed information from experiment about each analysis
- So far only cut&count analyses

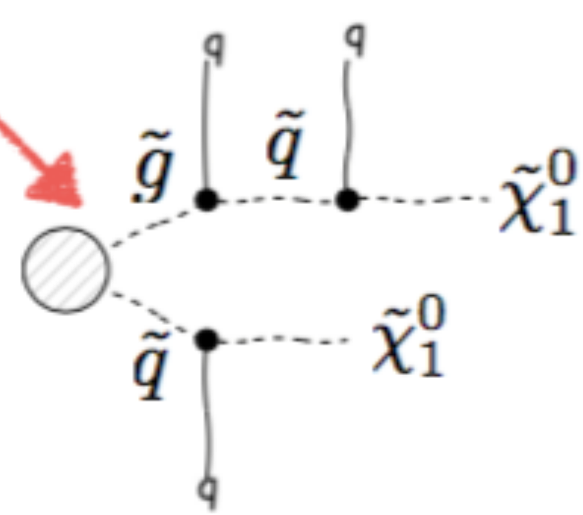
Fast and precise, but so far model-specific

Asymmetric decay branch examples

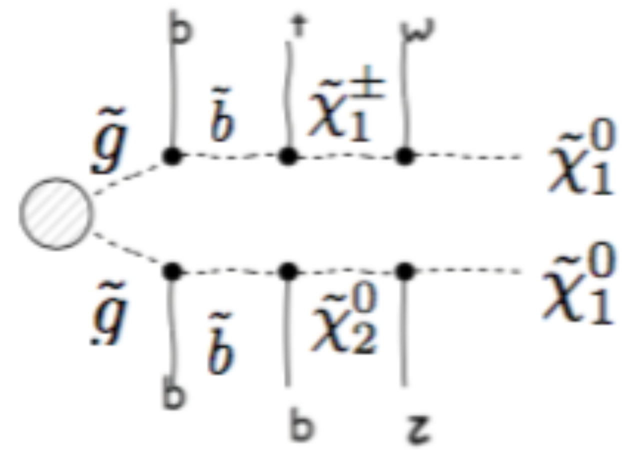
covered by Fastlim EMs (incl. in SModelS)

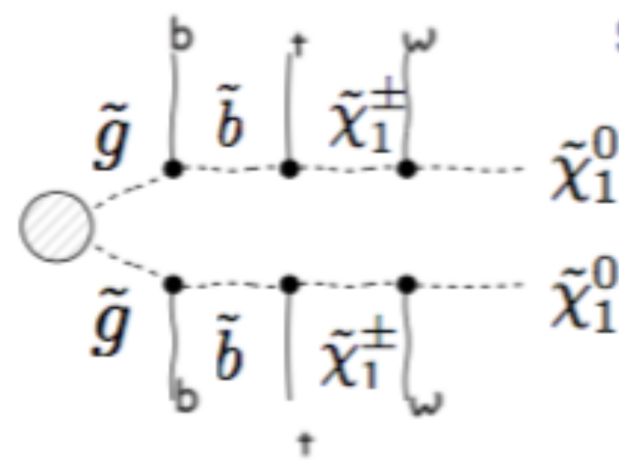


important topology but no SMS results available!



Long cascade decay examples





at least 4 free mass parameters, not viable Simplified Model

curtesy Ursula Laa

8 TeV results in SModelS v1.1.1 database

ATLAS

	Analysis	ID	SModelS database
Inclusive	0-lepton + 2–6 jets + E_T^{miss}	SUSY-2013-02*	6 UL, 2 EM
	0-lepton + 7–10 jets + E_T^{miss}	SUSY-2013-04*	1 UL, 10 EM‡
	1-lepton + jets + E_T^{miss}	SUSY-2013-20*	1 UL from CONF-2013-089
	$\tau(\tau/\ell)$ + jets + E_T^{miss}	SUSY-2013-10	—
	SS/3-leptons + jets + E_T^{miss}	SUSY-2013-09	1 UL (+5 UL, CONF-2013-007)
	0/1-lepton + 3b-jets + E_T^{miss}	SUSY-2013-18*	2 UL, 2 EM
	Monojet	—	— (but monojet stop, see below)
Third generation	0-lepton stop	SUSY-2013-16*	1 UL, 1 EM
	1-lepton stop	SUSY-2013-15*	1 UL, 1 EM
	2-leptons stop	SUSY-2013-19*	2 UL
	Monojet stop	SUSY-2013-21	4 EM
	Stop with Z boson	SUSY-2013-08	1 UL
	2b-jets + E_T^{miss}	SUSY-2013-05*	3 UL, 1 EM‡
	tb+E_T^{miss}, stop	SUSY-2014-07	—
Electroweak	ℓh	SUSY-2013-23*	1 UL
	2-leptons	SUSY-2013-11	4 UL, 4 EM‡
	2-τ	SUSY-2013-14	—
	3-leptons	SUSY-2013-12	5 UL
	4-leptons	SUSY-2013-13	—
	Disappearing Track	SUSY-2013-01	*n.a. in current framework*
Other	Long-lived particle	—	*n.a. in current framework*
	$H/A \to \tau^+\tau^-$	—	*n.a. in current framework*

* plus Fastlim EMs for preliminary version (conf note) of the analysis.
‡ incl. 'home-grown' EMs produced with MadAnalysis5 or CheckMATE recasting.

CMS

	Analysis	ID	SModelS database
Gluino, Squark	jets + E_T^{miss}, α_T	SUS-12-028	4 UL
	3(1b-)jets + E_T^{miss}	SUS-12-024	2 UL, 3 EM
	jet multiplicity + H_T^{miss}	SUS-13-012	4 UL, 20 EM‡
	$\geq$ 2 jets + E_T^{miss}, M_{T2}	SUS-13-019	8 UL
	$\geq$ 1b + E_T^{miss}, Razor	SUS-13-004	5 UL
	1 lepton + $\geq$ 2b-jets + E_T^{miss}	SUS-13-007	3 UL, 2 EM
	2 OS lept. + $\geq$4(2b-)jets + E_T^{miss}	PAS-SUS-13-016	2 UL
	2 SS leptons + b-jets + E_T^{miss}	SUS-13-013	4 UL, 2 EM
	b-jets + 4 Ws + E_T^{miss}	SUS-14-010	2 UL
Third gen.	0 lepton + $\geq$ 5(1b-)jets + E_T^{miss}	PAS-SUS-13-015	2 EM
	0 lepton + $\geq$ 6(1b-)jets + E_T^{miss}	PAS-SUS-13-023	4 UL
	1 lepton + $\geq$ 4(1b-)jets + E_T^{miss}	SUS-13-011	4 UL, 2 EM
	b-jets + E_T^{miss}	PAS-SUS-13-018	1 UL
	soft leptons, few jets + E_T^{miss}	SUS-14-021	2 UL
EW	multi-leptons + E_T^{miss}	SUS-13-006	6 UL

incl. 'home-grown' EMs produced with MadAnalysis5 or CheckMATE recasting.

Coverage of pMSSM by SMS results

Result Summary

Analysis	All LSPs	Bino-like	Wino-like	Higgsino-like
0-lepton + 2–6 jets + E_T^{miss}	32.1%	35.8%	29.7%	33.5% ✔
0-lepton + 7–10 jets + E_T^{miss}	7.8%	5.5%	7.6%	8.0% ✔
0/1-lepton + 3b-jets + E_T^{miss}	8.8%	5.4%	7.1%	10.1% ✔
1-lepton + jets + E_T^{miss}	8.0%	5.4%	7.5%	8.4% ✔
Monojet	9.9%	16.7%	9.1%	10.1% ✗
SS/3-leptons + jets + E_T^{miss}	2.4%	1.6%	2.4%	2.5% ✔
$\tau(\tau/\ell)$ + jets + E_T^{miss}	3.0%	1.3%	2.9%	3.1% ✔
0-lepton stop	9.4%	7.8%	8.2%	10.2% ✔
1-lepton stop	6.2%	2.9%	5.4%	6.8% ✔
2b-jets + E_T^{miss}	3.1%	3.3%	2.3%	3.6% ✔
2-leptons stop	0.8%	1.1%	0.8%	0.7% ✔
Monojet stop	3.5%	11.3%	2.8%	3.6% ✔
Stop with Z boson	0.4%	1.0%	0.4%	0.5% ✔
tb+E_T^{miss}, stop	4.2%	1.9%	3.1%	5.0% ✔
ℓh, electroweak	0	0	0	0 ✔
2-leptons, electroweak	1.3%	2.2%	0.7%	1.6% ✔
2-τ, electroweak	0.2%	0.3%	0.2%	0.2% ✔
3-leptons, electroweak	0.8%	3.8%	1.1%	0.6% ✔
4-leptons	0.5%	1.1%	0.6%	0.5% ✔
Disappearing Track	11.4%	0.4%	29.9%	0.1% ✗
Long-lived particle	0.1%	0.1%	0.0%	0.1% ✗
$H/A \to \tau^+\tau^-$	1.8%	2.2%	0.9%	2.4% ✗
Total	40.9%	40.2%	45.4%	38.1%

Multijet + MET

Monojet
(mostly overlapping with Multijet exclusion)

Stop searches
(less important, stop mostly heavy following Higgs constraints)

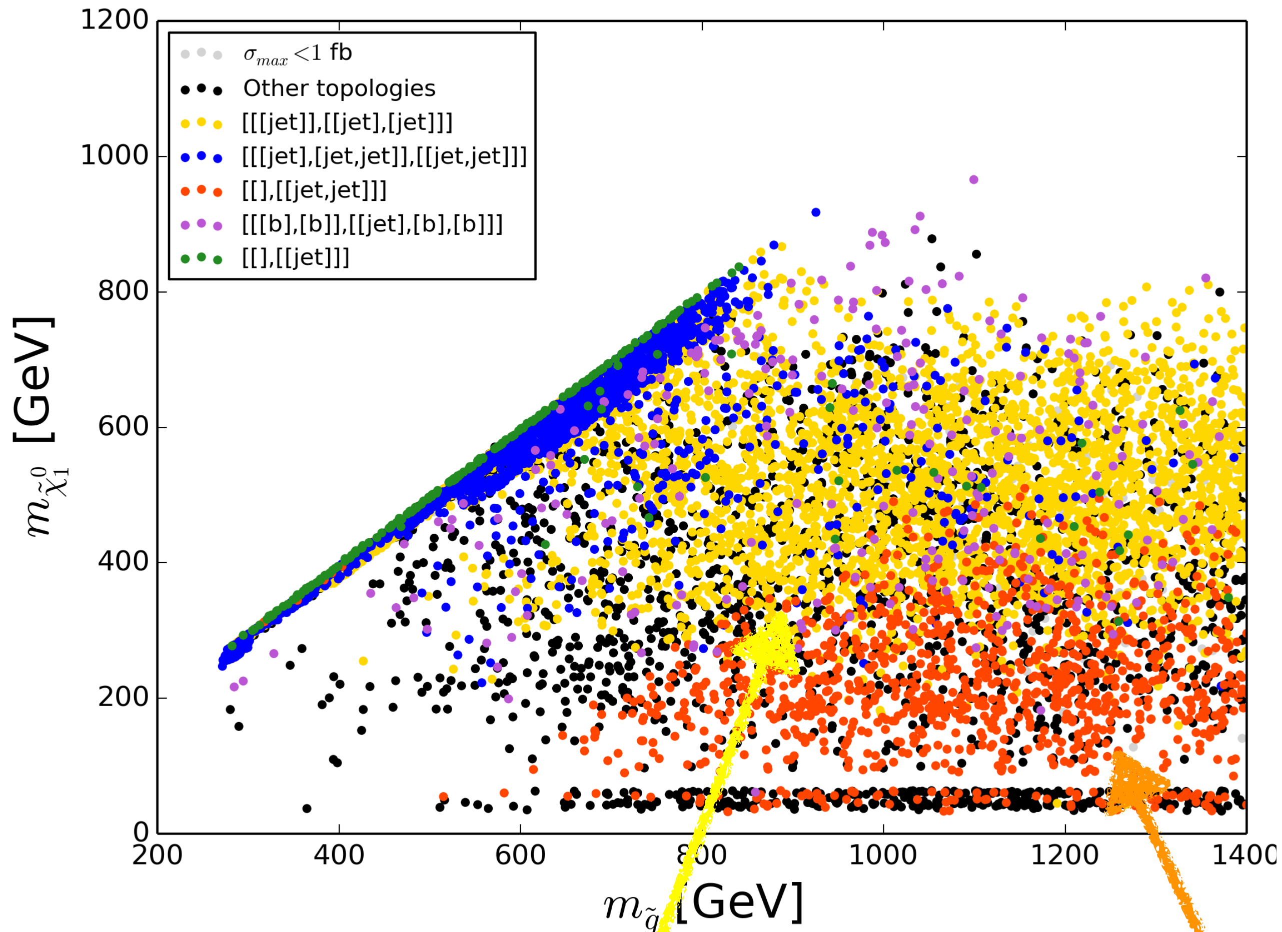
Disappearing tracks
(important for Wino-like LSP!)

41% of the points excluded by ATLAS → How well can they be covered using Simplified Models?

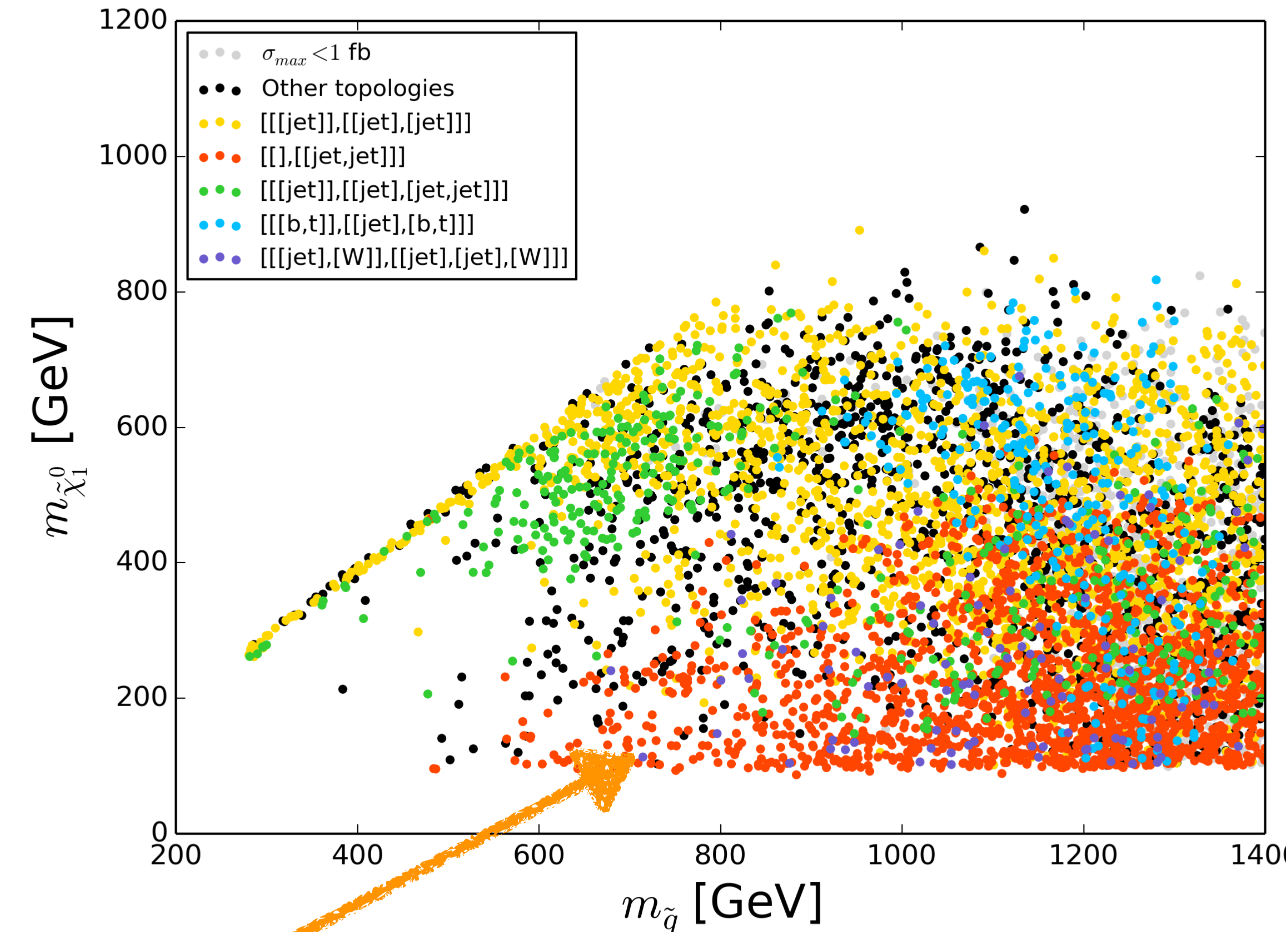
slide by Ursula Laa, CERN re-interpretation workshop, June 2016

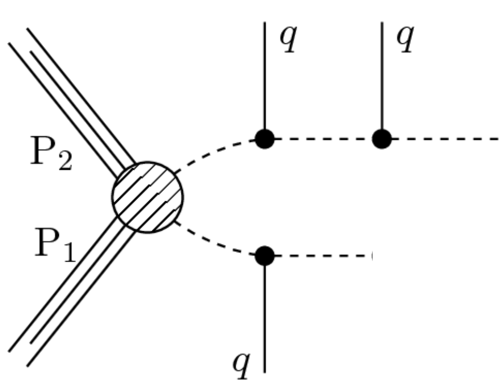
Most important missing topologies

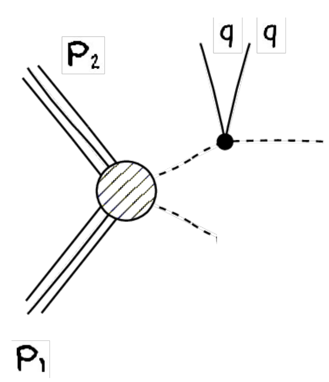
Bino-like LSP

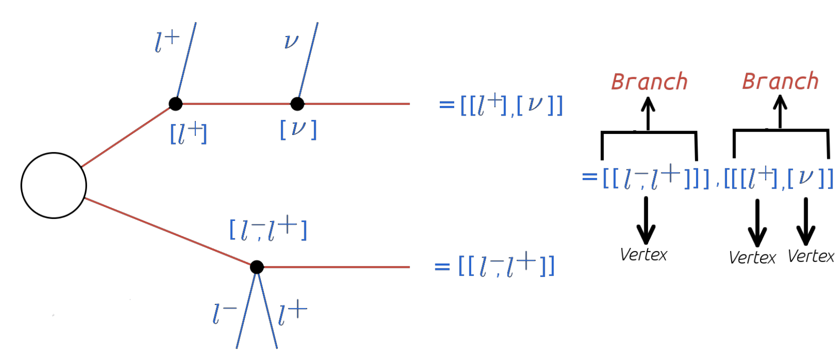


Higgsino-like LSP

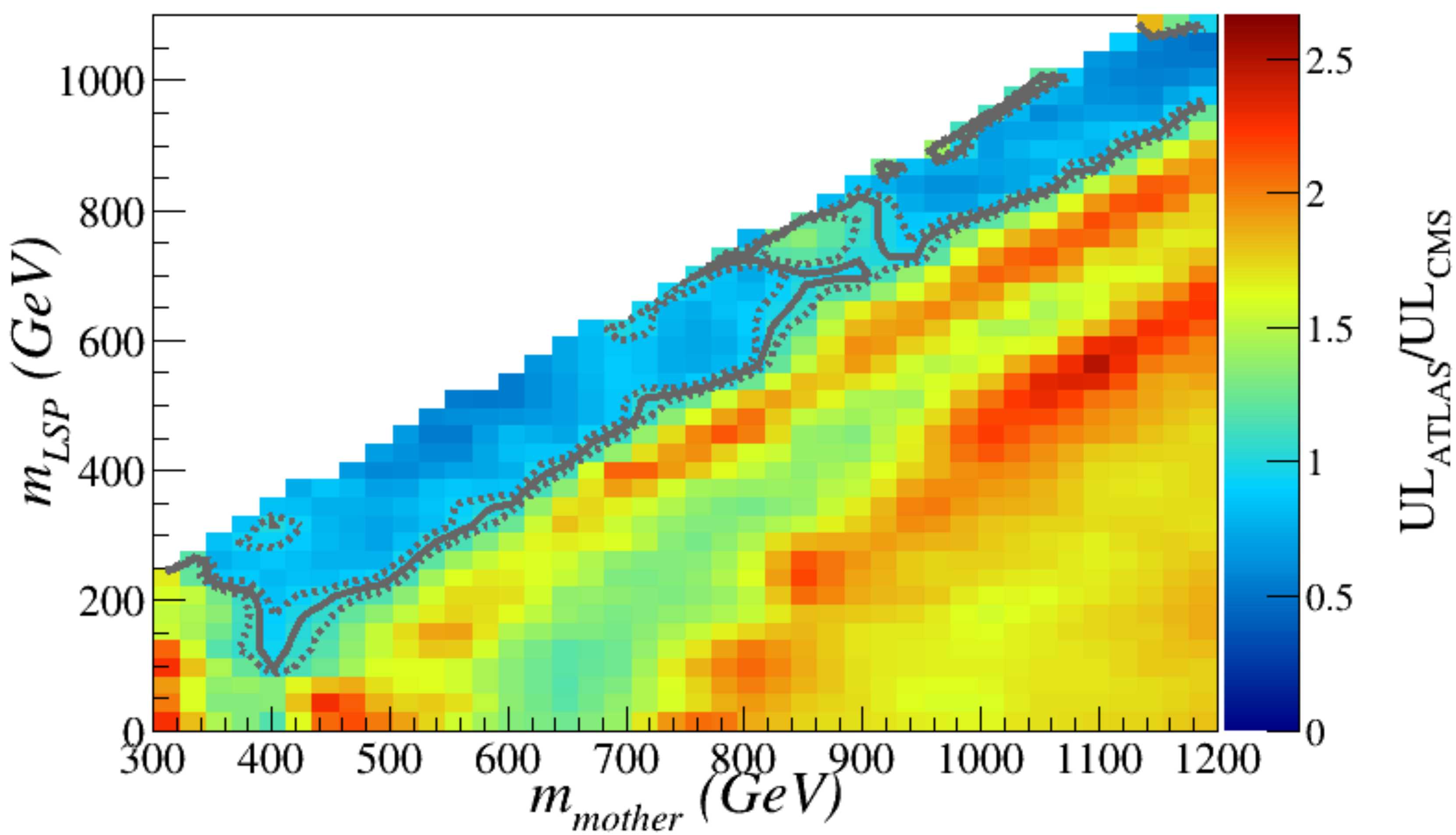








T2 upper limit ratio



≥ 2 jets + MET: CMS excludes a bit more than ATLAS

Tools for using SMS results

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/RecastingTools

- **Fastlim** : a tool to analyze BSM models based on the mass spectrum and branching ratios using simplified topologies. Limits from direct SUSY searches at the LHC are obtained from pre-calculated cross-section and efficiency maps. Can also quickly identify the important decay chains of the model by listing the dominant event topologies based on [cross section]x[branching ratio].

  Limited to MSSM

  11 ATLAS CONF note results from Run 1

- **SModelS** : general procedure to decompose the collider signatures of BSM models presenting a Z2 symmetry into SMS topologies, which are then confronted with the relevant experimental constraints. Also identifies the most important 'missing topologies' for which no experimental result is available. Version 1.0 is based on the use of UL maps. SModelS v1.1, released in January 2017, includes the use of efficiency maps, likelihood and χ2 calculations, an extended database of experimental results as well as major speed upgrades for both the code and the database.

  Any BSM with a Z2 symmetry

  results from 21 ATLAS and 23 CMS SUSY analyses, mostly Run 1+ some Run 2

- **XQCAT** (eXtra Quark Combined Analysis Tool) : a tool for the determination of exclusion confidence levels for scenarios with one or multiple heavy extra quarks (XQs) which interact with the SM quarks. The code uses a database of efficiencies for pre-simulated processes of QCD-induced pair production of the XQs and their subsequent on-shell decays in the narrow-width approximation. The recasting is performed upon 6 SUSY searches and 1 search for vector-like quarks (all of them from CMS, Run 1).

  Limited to extra heavy quarks

  6 SUSY + 1 VLQ search from Run 1