Making the best use of published SUSY searches from LHC run-2

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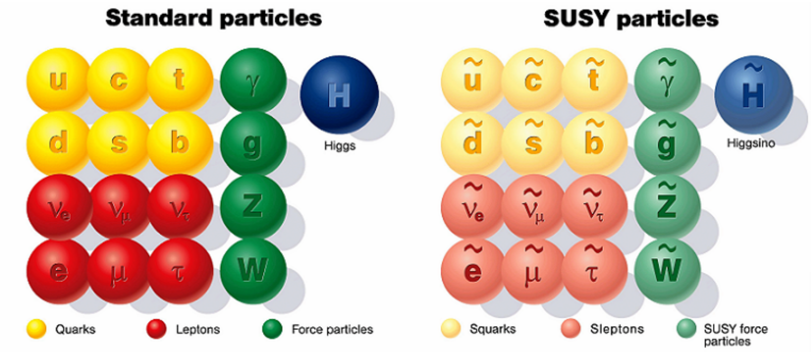
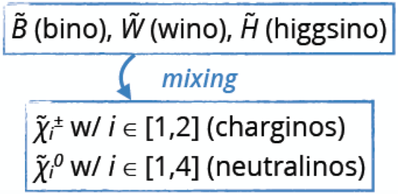
Supersymmetry (SUSY)

The standard model (SM) of particle physics is not the full picture.



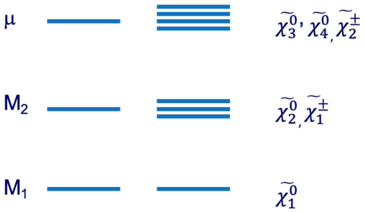
www.quebecscience.qc.ca

Electroweakino sector of the minimal supersymmetric standrad model (MSSM)

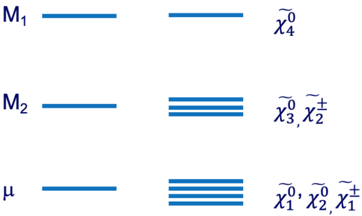


ATL-PHYS-SLIDE-2018-785

Wino-Bino scenario



Wino-Higgsino scenario



PoS(EPS-HEP2019)710

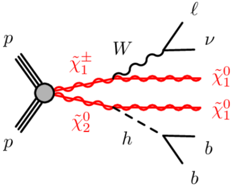
Where do we stand?

- The standard model (SM) of particle physics is not the full picture.
- The large hadron collider (LHC) has reached unprecedented (controlled) energy and luminosity.
- A huge quantity of data has been recorded by the LHC.
- No analysis of this data led to an hint on the nature of the beyond the standard model (BSM) theory.
- Either the new physics is out of reach (energy barrier, lack of sensitivity, ...) or it has been recorded but we don't know it.

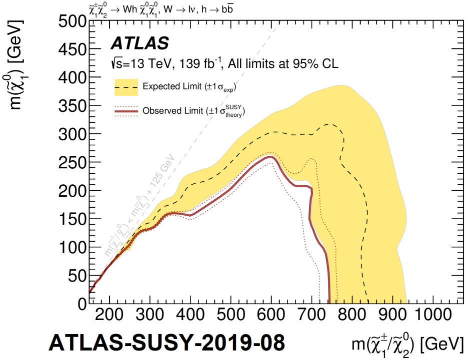
Data interpretation in LHC searches

arXiv:1105.2838

The ATLAS and CMS searches for supersymmetry (SUSY) interpret their data using a simplified model (minimal set of parameters).



TChiWH

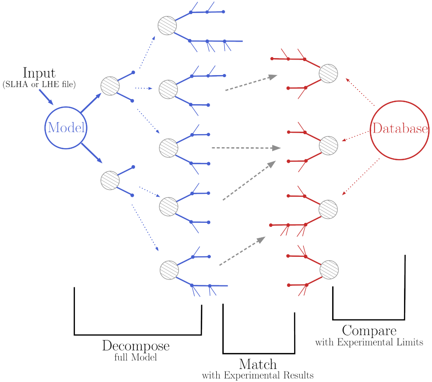


How would such results constraint a more complex model?

arXiv:2112.00769
arXiv:2009.01809
arXiv:1811.10624
arXiv:1312.4175

SModelS working principle

Public tool to confront BSM signals with a $\mathbb{Z}_2$-like symmetry against simplified model results from the LHC.



35 ATLAS and 39 CMS 13 TeV analyses in the database (v.2.2.0).

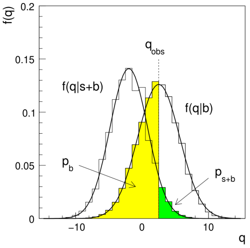
Using efficiency maps to reinterpret results

Test phase-space points and exclude it if $\boxed{r = \frac{\sigma^{\text{BSM}}}{\sigma^{\text{BSM}}_{\text{UL}}} \geqslant 1}$ with:

$\sigma^{\text{BSM}} = \epsilon \times \mathcal{A} \sum \sigma \prod \text{BR}$ per signal region $\leftarrow$ input file and exp. pub.
$\sigma^{\text{BSM}}_{\text{UL}} \leftarrow$ exp. pub. or computed through an hypothesis test:

$$\sigma^{\text{BSM}}_{\text{UL}} = \mu_{\text{UL}} \frac{n_{\text{signal}}}{\mathcal{L}}.$$

The signal strength upper limit (μ_{UL}) is reached when $\frac{p(\text{BSM})}{p(\text{SM only})} = 0.05$



arXiv:1007.1727

$$L(\mu, \theta | D) = \frac{(\mu \times s + b + \theta)^{n_{obs}} e^{-(\mu \times s + b + \theta)}}{n_{obs}!} e^{-\frac{\theta^2}{2\delta^2}}$$

Efficiency maps allow SModelS to compute likelihoods for the hypothesised signal (L_{BSM}, L_{SM}, L_{max}).

arXiv:2009.01809
arXiv:1811.10624

Using efficiency maps to reinterpret results

Signal region combination is possible using full statistical models (ATLAS). The latter is encoded in a json file and is interfaced to SModelS with pyhf. The likelihood becomes:

$$L(\mu,\theta|D) = \prod_{i=1}^{N} \frac{(\mu s_i^r + b_i + \theta_i)^{n_{obs}^i} e^{-(\mu s_i^r + b_i + \theta_i)}}{n_{obs}^i!} \prod_{\theta \in \{\theta\}} c_\theta(a_\theta|\theta).$$

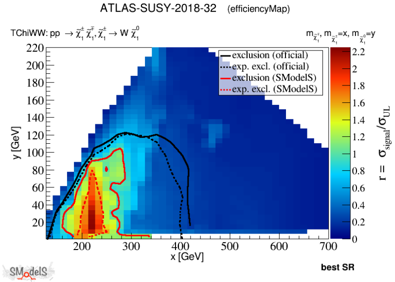
The correlations can otherwise be encoded in a covariance matrix (CMS), where

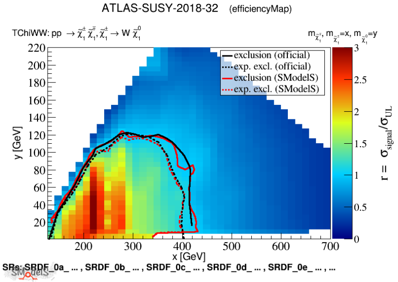
$$L(\mu,\theta|D) = \prod_{i=1}^{N} \frac{(\mu s_i^r + b_i + \theta_i)^{n_{obs}^i} e^{-(\mu s_i^r + b_i + \theta_i)}}{n_{obs}^i!} e^{-\frac{1}{2}\overrightarrow{\theta}^T V^{-1} \overrightarrow{\theta}}.$$

ATLAS-SUSY-2018-32

arXiv:1908.08215

Search for electroweak production of charginos and sleptons decaying into final states with two leptons and missing transverse momentum ($pp \to \tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm} \to WW \to l\nu l\nu$) in $\sqrt{s} = 13$ TeV pp collisions using the ATLAS detector.

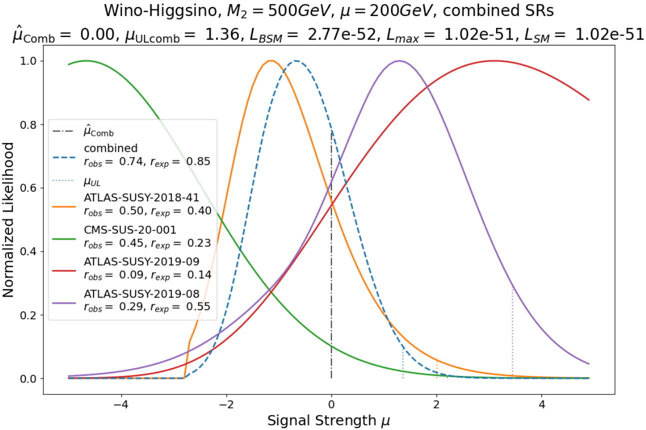




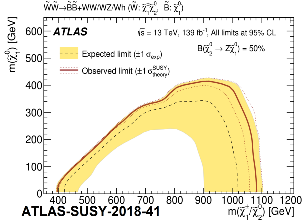
Combining uncorrelated analyses

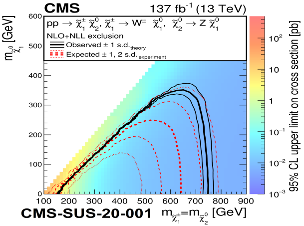
From SModelS v.2.2 on, it is possible to combine uncorrelated analyses.

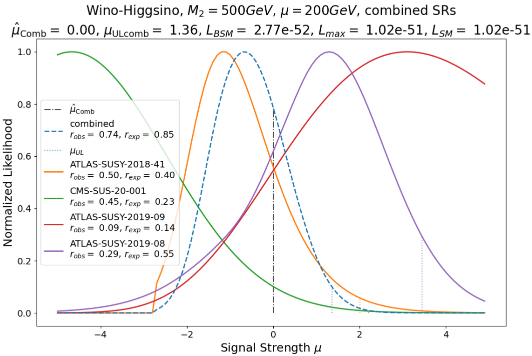
$$L_{\text{combined}}(\mu) = \prod_i L_i(\mu, \theta_i | D_i)$$



$$L_{\text{combined}}(\mu) = \prod_i L_i(\mu, \theta_i | D_i)$$

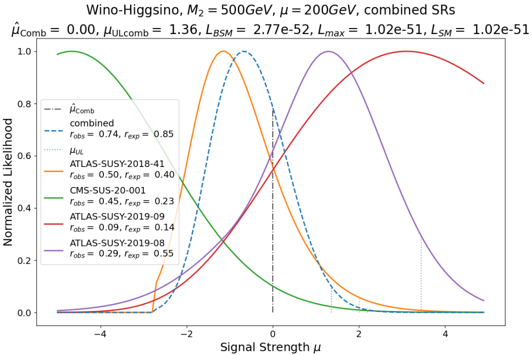


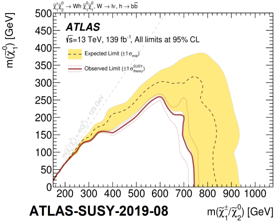


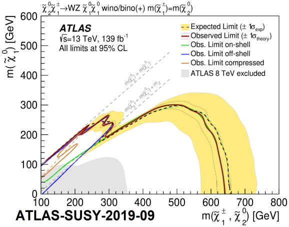


Under-fluctuation in the background leads to negative values for $\hat{\mu}$.

$$L_{\text{combined}}(\mu) = \prod_i L_i(\mu, \theta_i | D_i)$$

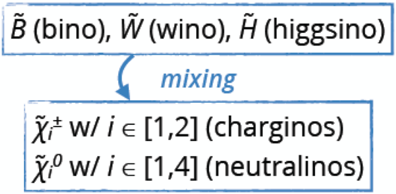






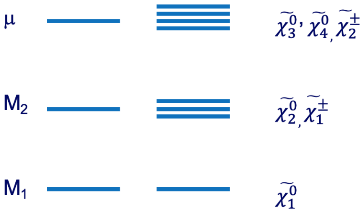
Excess in the data leads to positive values for $\hat{\mu}$.

Electroweakino Sector of the MSSM

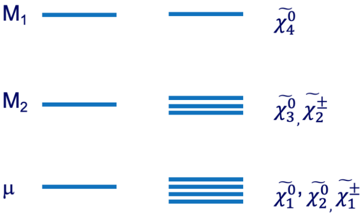


ATL-PHYS-SLIDE-2018-785

Wino-Bino scenario



Wino-Higgsino scenario



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Why EWino sector?

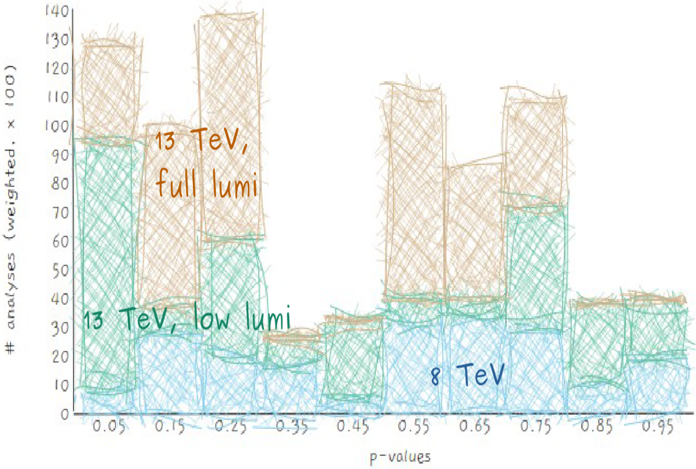
Not so constrained sector, but with some reusable published results targeting different channels and mass ranges.

ID	Short Description	$\mathcal{L}$ [fb^{-1}]	likelihoods	UL$_{\mathrm{obs}}$	UL$_{\mathrm{exp}}$	EM	comb.
CMS-EXO-19-010	disappearing track	101.0	yes			✓	
CMS-SUS-20-001	2 OSSF l's	137.0	yes	✓	✓		
CMS-SUS-20-004	search for higgsinos	137.0	yes	✓	✓	✓	Cov.
CMS-SUS-21-002	Hadronic EWK searches	137.0	yes	✓	✓	✓	Cov.

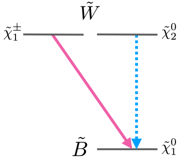
ID	Short Description	$\mathcal{L}$ [fb^{-1}]	likelihoods	UL$_{\mathrm{obs}}$	UL$_{\mathrm{exp}}$	EM	comb.
ATLAS-SUSY-2018-05	2L + jets + $E\!\!\!/_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-06	3 l's EW-ino	139.0	yes	✓	✓	✓	
ATLAS-SUSY-2018-23	EWK WH	139.0	yes	✓	✓		
ATLAS-SUSY-2018-32	2 OS l's + $E\!\!\!/_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-41	Boosted hadronic EWK searches	139.0	yes	✓	✓	✓	Cov.
ATLAS-SUSY-2018-42	charged LLPs, dE/dx	139.0	yes	✓	✓		
ATLAS-SUSY-2019-02	2L + $E\!\!\!/_T$	139.0	yes	✓	✓	✓	Cov.
ATLAS-SUSY-2019-08	1ℓ + higgs + $E\!\!\!/_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2019-09	3 l's EW-ino	139.0	yes	✓	✓	✓	JSON

Why EWino sector?

This sector tends to reject the SM hypothesis.

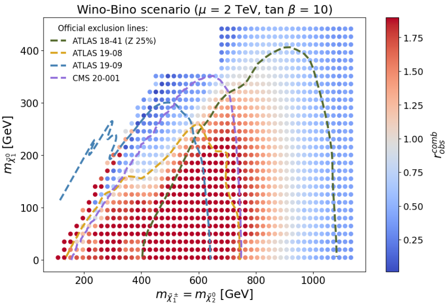


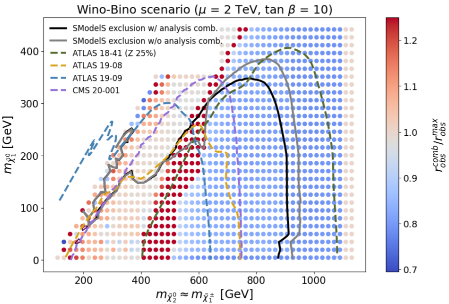
The wino-bino scenario



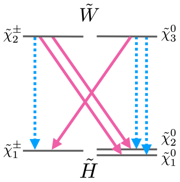
Scan over: $M_1 \; < \; M_2 \; \ll \; \mu = 2\,\text{TeV}$

All other SUSY particles are assumed heavy (beyond LHC reach).
Mass spectra and branching ratios computed with SOFTSUSY 4.1.12.
Next-to-leading-order cross-sections computed with Prospino 2.1.
The kind of result we expect (with the 4 previously mentioned analyses):

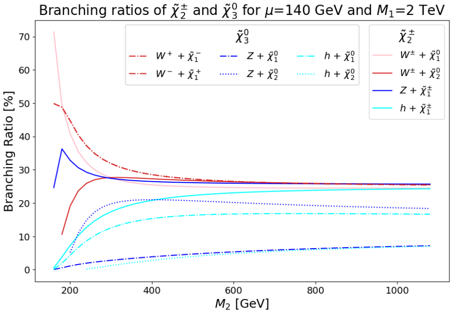


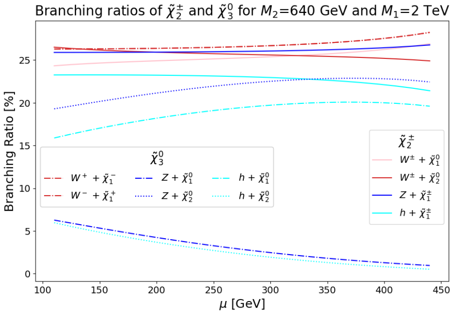


The wino-higgsino scenario



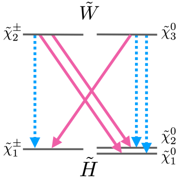
Scan over: $\mu < M_2 \ll M_1 = 2\,\mathrm{TeV}$



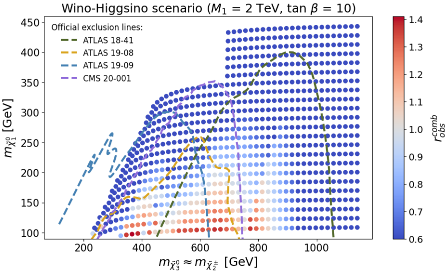


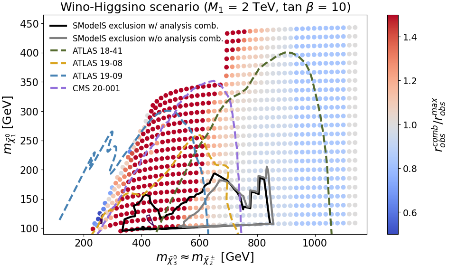
There are more branching ratios and no dominant decay.

The wino-higgsino scenario



Scan over: $\mu < M_2 \ll M_1 = 2\,\mathrm{TeV}$

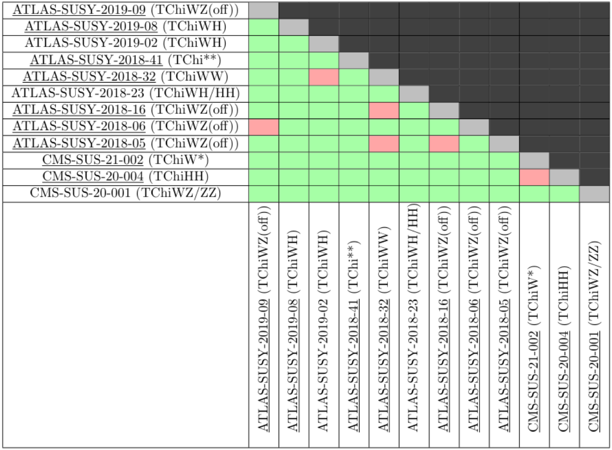




The ATLAS and CMS contour lines are obtained by making the assumption of a pure wino-bino scenario. Here, with more decays the sensitivity becomes much less.

For both scenarios

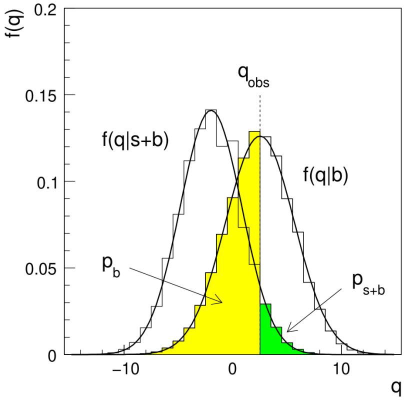
Next step: find the most sensible set of combinable analyses among a set of analyses. Combination matrix of the ATLAS and CMS EWino searches during run-2 with (almost) full lumi:



arXiv:1007.1727

Switch the test statistic to discovery mode

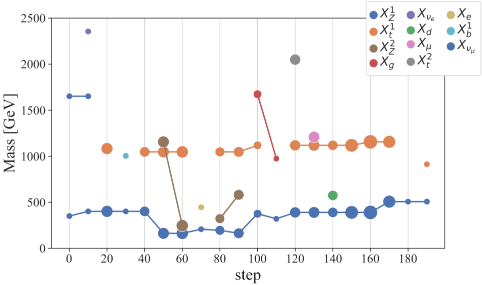
$$q_\mu = \begin{cases} -2\ln\left(\frac{L(\mu,\hat{\hat{\vec{\theta}}})}{L(\hat{\mu},\hat{\vec{\theta}})}\right) & \hat{\mu} \leqslant \mu \\ 0 & \hat{\mu} > \mu \end{cases} \quad \rightarrow \quad q_0 = \begin{cases} -2\ln\left(\frac{L(0,\hat{\hat{\vec{\theta}}})}{L(\hat{\mu},\hat{\vec{\theta}})}\right) & \hat{\mu} \geqslant 0 \\ 0 & \hat{\mu} < 0 \end{cases}$$



arXiv:2012.12246
https://smodels.github.io/protomodels/videos/

The proto-model builder

The number of particles, branching ratios values and cross-sections values are not fixed. Perform a MCMC-type walk over the parameter space and test the proto-model against the SM hypothesis by using the results (likelihoods) in the database. One has to choose the analyses entering in the combined likelihood, but the non-combined analyses can still be used to constraint the proto-model.



Conclusion

- Reinterpreted LHC results may differ from the simplified model picture.
- For precise statistical statement, one needs to evaluate likelihoods.
- Combining analyses can lead to more robust constraints.
- We hope to soon have new interesting results using SModelS in the anomaly detection regime.

Acknowledgments

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Backup Slides

Run 2 - 13 TeV

In total, we have results from 35 ATLAS and 39 CMS 13 TeV searches.

- ATLAS upper limits: 32 analyses, 80 (of which 4 LLP) results
- ATLAS efficiency maps: 21 analyses, 65 (of which 11 LLP) results, 599 individual maps
- CMS upper limits: 36 analyses, 143 (of which 3 LLP) results
- CMS efficiency maps: 8 analyses, 53 results, 3186 individual maps

Run 1 - 8 TeV

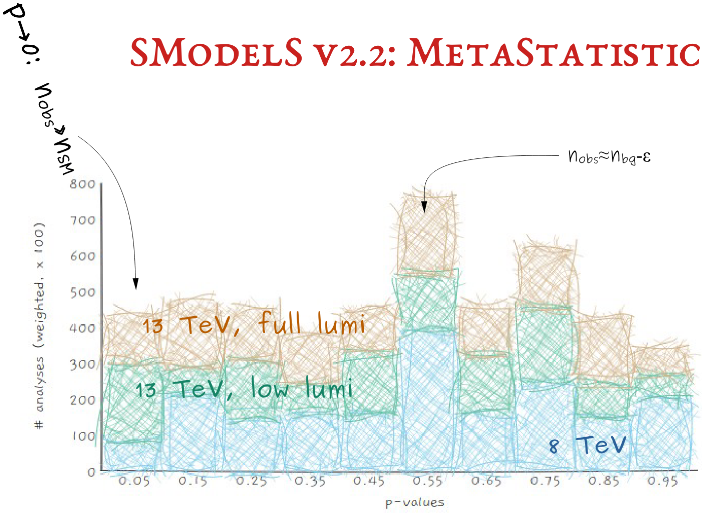
In total, we have results from 15 ATLAS and 18 CMS 8 TeV searches.

- ATLAS upper limits: 13 analyses, 34 results
- ATLAS efficiency maps: 10 analyses, 31 results, 269 individual maps
- CMS upper limits: 16 analyses, 56 (of which 3 LLP) results
- CMS efficiency maps: 9 analyses, 47 (of which 9 LLP) results, 980 individual maps

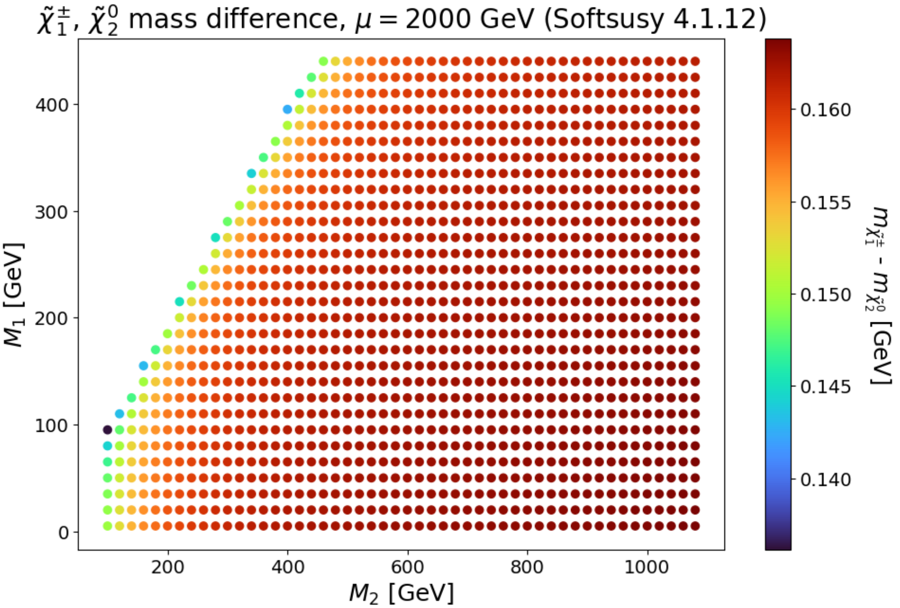
ID	Short Description	$\mathcal{L}$ [fb^{-1}]	likelihoods	UL$_{\text{obs}}$	UL$_{\text{exp}}$	EM	comb.
CMS-EXO-19-001	displaced vertices	137.0	yes			✓	
CMS-EXO-19-010	disappearing track	101.0	yes			✓	
CMS-PAS-EXO-16-036	hscp search	12.9	no	✓			
CMS-PAS-SUS-16-052	soft l, <= 2 jets	35.9	yes	✓		✓	Cov.
CMS-SUS-16-009	multijets + $\not\!\!E_T$, top tagging	2.3	yes	✓	✓		
CMS-SUS-16-032	Sbottom and compressed stop	35.9	no	✓			
CMS-SUS-16-033	0ℓ + jets + $\not\!\!E_T$	35.9	yes	✓	✓	✓	
CMS-SUS-16-034	2 OSSF l's	35.9	no	✓			
CMS-SUS-16-035	2 SS l's	35.9	no	✓			
CMS-SUS-16-036	0ℓ + jets + $\not\!\!E_T$	35.9	yes	✓	✓		
CMS-SUS-16-037	1ℓ + jets + $\not\!\!E_T$ with MJ	35.9	no	✓			
CMS-SUS-16-039	multi-l EWK searches	35.9	yes	✓		✓	Cov.
CMS-SUS-16-039	multi-l EWK searches	35.9	yes			✓	Cov.
CMS-SUS-16-041	multi-ls + jets + $\not\!\!E_T$	35.9	no	✓			
CMS-SUS-16-042	1ℓ + jets + $\not\!\!E_T$	35.9	no	✓			
CMS-SUS-16-043	EWK WH	35.9	no	✓			
CMS-SUS-16-045	Sbottom to bHbH and H $\rightarrow \gamma\gamma$	35.9	no	✓			
CMS-SUS-16-046	γ + $\not\!\!E_T$	35.9	no	✓			
CMS-SUS-16-047	γ + HT	35.9	no	✓			
CMS-SUS-16-048	two soft OS l's	35.9	yes			✓	Cov.
CMS-SUS-16-050	0ℓ + top tag	35.9	yes	✓	✓	✓	Cov.
CMS-SUS-16-050	0ℓ + top tag	35.9	yes			✓	Cov.
CMS-SUS-16-051	1ℓ stop	35.9	yes	✓	✓		
CMS-SUS-17-001	Stop search in dil + jets + $\not\!\!E_T$	35.9	no	✓			
CMS-SUS-17-003	2 taus + $\not\!\!E_T$	35.9	no	✓			
CMS-SUS-17-004	EW-ino combination	35.9	no	✓			
CMS-SUS-17-005	1ℓ + multijets + $\not\!\!E_T$, top tagging	35.9	yes	✓	✓		
CMS-SUS-17-006	jets + boosted H(bb) + $\not\!\!E_T$	35.9	yes	✓	✓		
CMS-SUS-17-009	SFOS l's + $\not\!\!E_T$	35.9	yes	✓	✓		
CMS-SUS-17-010	2L stop	35.9	yes	✓	✓		
CMS-SUS-18-002	γ, jets, b-jets+ $\not\!\!E_T$, top tagging	35.9	yes	✓	✓		
CMS-SUS-18-004	two or three soft l's	137.0	yes	✓	✓		
CMS-SUS-18-007	H	77.5	yes	✓	✓		
CMS-SUS-19-006	0ℓ + jets, MHT	137.0	yes	✓	✓	✓	Cov.
CMS-SUS-19-006	0ℓ + jets, MHT	137.0	yes			✓	Cov.
CMS-SUS-19-008	2-3L + jets	137.0	yes	✓	✓		
CMS-SUS-19-009	1ℓ + jets, MHT	137.0	yes	✓	✓		
CMS-SUS-19-010	Jets + top and W tag	137.0	yes	✓	✓		
CMS-SUS-19-011	Stop search in dil + jets + $\not\!\!E_T$	137.0	yes	✓	✓		
CMS-SUS-19-013	High momentum Z Boson+ $\not\!\!E_T$	137.0	yes	✓	✓		
CMS-SUS-20-001	2 OSSF l's	137.0	yes	✓	✓		
CMS-SUS-20-002	combined stop search	137.0	yes	✓	✓		
CMS-SUS-20-004	search for higgsinos	137.0	yes	✓	✓	✓	Cov.
CMS-SUS-21-002	Hadronic EWK searches	137.0	yes	✓	✓	✓	Cov.

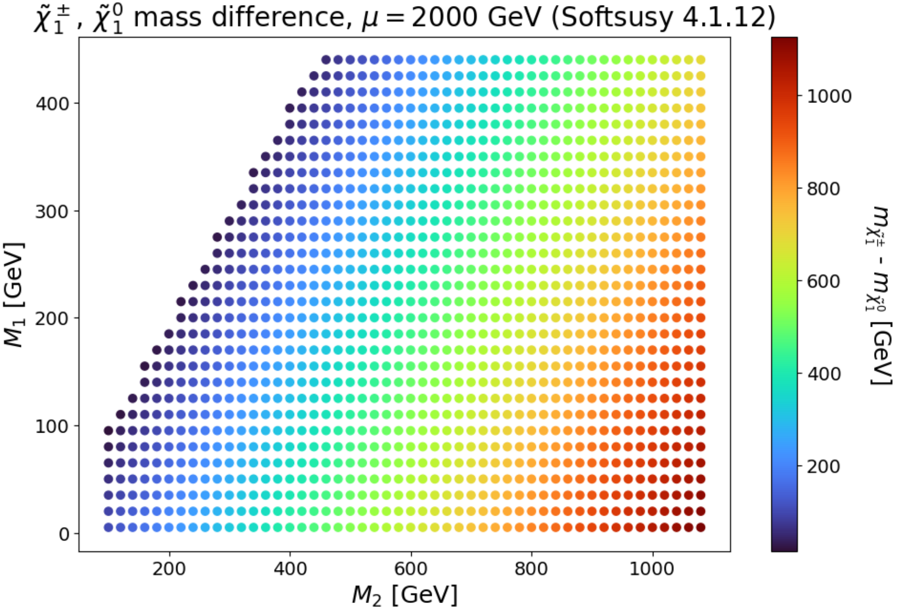
ID	Short Description	$\mathcal{L}$ [fb^{-1}]	likelihoods	UL_{obs}	UL_{exp}	EM	comb.
ATLAS-SUSY-2015-01	2 b-jets + $\not\!\!E_T$	3.2	no	✓			
ATLAS-SUSY-2015-02	single l stop	3.2	yes	✓		✓	
ATLAS-SUSY-2015-06	0 l's + 2-6 jets + $\not\!\!E_T$	3.2	yes			✓	
ATLAS-SUSY-2015-09	jets + 2 SS l's or >=3 l's	3.2	no	✓			
ATLAS-SUSY-2016-06	disappearing track	36.1	yes			✓	
ATLAS-SUSY-2016-07	0ℓ + jets + $\not\!\!E_T$	36.1	yes	✓		✓	
ATLAS-SUSY-2016-08	displaced vertices	32.8	no	✓			
ATLAS-SUSY-2016-14	2 SS or 3 l's + jets + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2016-15	0ℓ stop	36.1	no	✓			
ATLAS-SUSY-2016-16	1ℓ stop	36.1	yes	✓		✓	
ATLAS-SUSY-2016-17	2 opposite sign l's + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2016-19	stops to staus	36.1	no	✓			
ATLAS-SUSY-2016-24	2-3 l's + $\not\!\!E_T$, EWino	36.1	yes	✓		✓	
ATLAS-SUSY-2016-26	>=2 c jets + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2016-27	jets + γ + $\not\!\!E_T$	36.1	yes	✓		✓	
ATLAS-SUSY-2016-28	2 b-jets + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2016-32	hscp search	31.6	yes	✓	✓	✓	
ATLAS-SUSY-2016-33	2 OSSF l's + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2017-01	EWK WH(bb) + $\not\!\!E_T$	36.1	no	✓			
ATLAS-SUSY-2017-02	0ℓ + jets + $\not\!\!E_T$	36.1	yes	✓	✓		
ATLAS-SUSY-2017-03	multi-l EWK searches	36.1	yes	✓		✓	
ATLAS-SUSY-2018-04	2 hadronic taus	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-05	2L + jets + $\not\!\!E_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-05	2L + jets + $\not\!\!E_T$	139.0	yes			✓	
ATLAS-SUSY-2018-06	3 l's EW-ino	139.0	yes	✓	✓	✓	
ATLAS-SUSY-2018-08	OS l's	139.0	yes	✓		✓	
ATLAS-SUSY-2018-10	1ℓ + jets + $\not\!\!E_T$	139.0	yes	✓		✓	
ATLAS-SUSY-2018-12	0 l's + jets + $\not\!\!E_T$	139.0	yes	✓	✓	✓	
ATLAS-SUSY-2018-14	displaced vertices	139.0	yes			✓	JSON
ATLAS-SUSY-2018-22	jets + $\not\!\!E_T$	139.0	yes	✓		✓	
ATLAS-SUSY-2018-23	EWK WH	139.0	yes	✓	✓		
ATLAS-SUSY-2018-31	2b + 2H(bb) + $\not\!\!E_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-32	2 OS l's + $\not\!\!E_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2018-40	Sbottom to bH	139.0	yes	✓	✓	✓	
ATLAS-SUSY-2018-41	Boosted hadronic EWK searches	139.0	yes	✓	✓	✓	Cov.
ATLAS-SUSY-2018-42	charged LLPs, dE/dx	139.0	yes	✓	✓		
ATLAS-SUSY-2019-02	2L + $\not\!\!E_T$	139.0	yes	✓	✓	✓	Cov.
ATLAS-SUSY-2019-08	1ℓ + higgs + $\not\!\!E_T$	139.0	yes	✓		✓	JSON
ATLAS-SUSY-2019-09	3 l's EW-ino	139.0	yes	✓	✓	✓	JSON

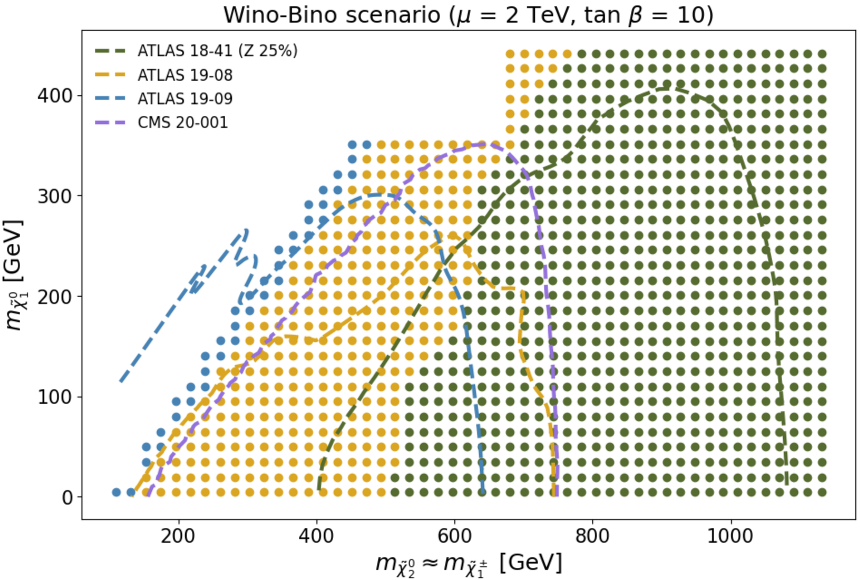
SModelS v2.2: MetaStatistics

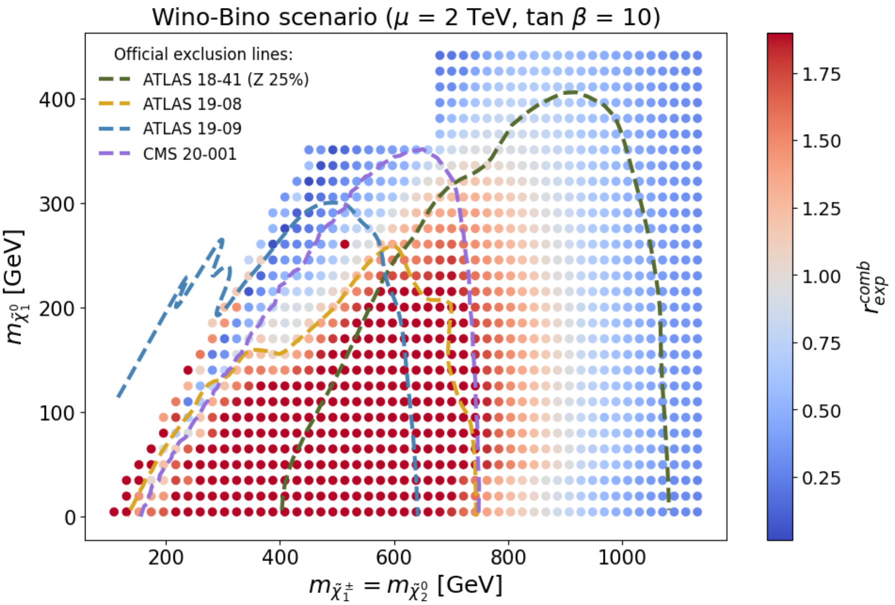


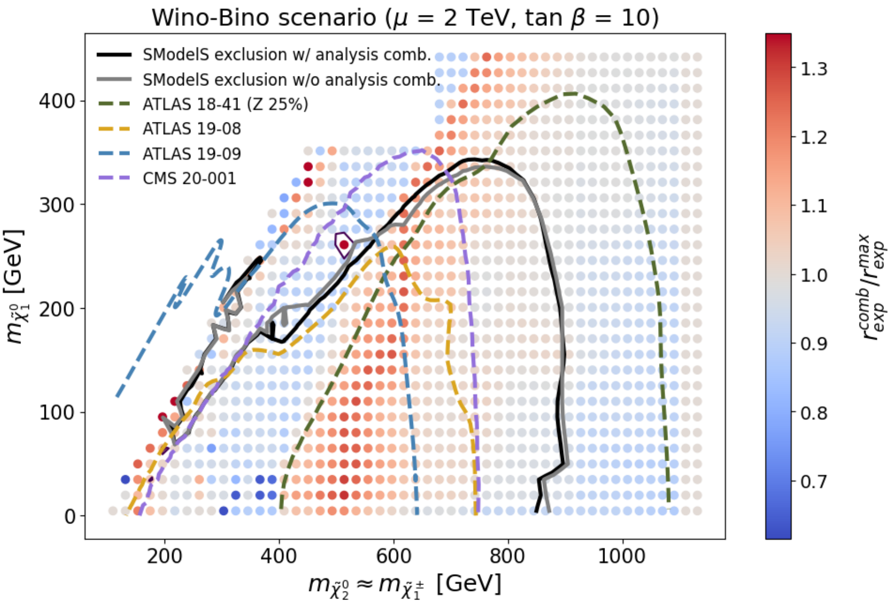
Distribution of p-values of standard model hypothesis in the entire SmodelS database


$\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$ mass difference, $\mu = 2000$ GeV (Softsusy 4.1.12)
M_1 [GeV]
M_2 [GeV]
$m_{\tilde{\chi}_1^{\pm}}$ - $m_{\tilde{\chi}_2^0}$ [GeV]
0
100
200
300
400
200
400
600
800
1000
0.160
0.155
0.150
0.145
0.140

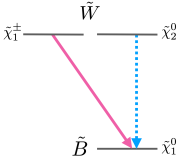

$\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_1^0$ mass difference, $\mu = 2000$ GeV (Softsusy 4.1.12)
M_1 [GeV]
M_2 [GeV]
$m_{\tilde{\chi}_1^{\pm}}$ - $m_{\tilde{\chi}_1^0}$ [GeV]
0
100
200
300
400
200
400
600
800
1000
200
400
600
800
1000


Wino-Bino scenario (μ = 2 TeV, tan β = 10)
ATLAS 18-41 (Z 25%)
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_2^0} \approx m_{\tilde{\chi}_1^\pm}$ [GeV]
0
100
200
300
400
600
800
1000


Wino-Bino scenario (μ = 2 TeV, tan β = 10)
Official exclusion lines:
ATLAS 18-41 (Z 25%)
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$ [GeV]
r_{exp}^{comb}
0
100
200
300
400
200
400
600
800
1000
0.25
0.50
0.75
1.00
1.25
1.50
1.75

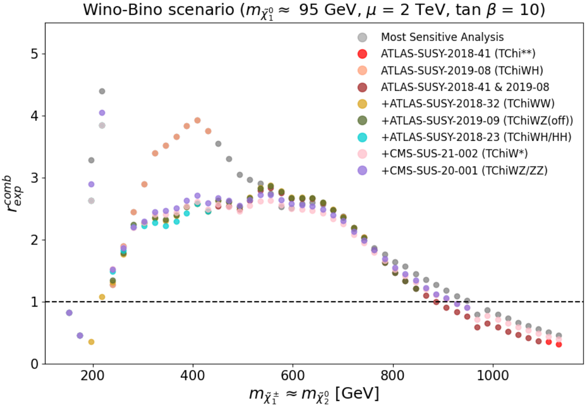

Wino-Bino scenario (μ = 2 TeV, tan β = 10)
SModelS exclusion w/ analysis comb.
SModelS exclusion w/o analysis comb.
ATLAS 18-41 (Z 25%)
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_2^0} \approx m_{\tilde{\chi}_1^\pm}$ [GeV]
$r_{exp}^{comb}/r_{exp}^{max}$
0
100
200
300
400
200
400
600
800
1000
0.7
0.8
0.9
1.0
1.1
1.2
1.3

The wino-bino scenario

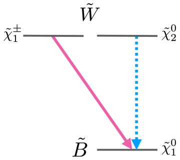


Scan over: $M_1 < M_2 \ll \mu = 2\,\mathrm{TeV}$

When combining more analyses, the exclusion power becomes harder to quantify.

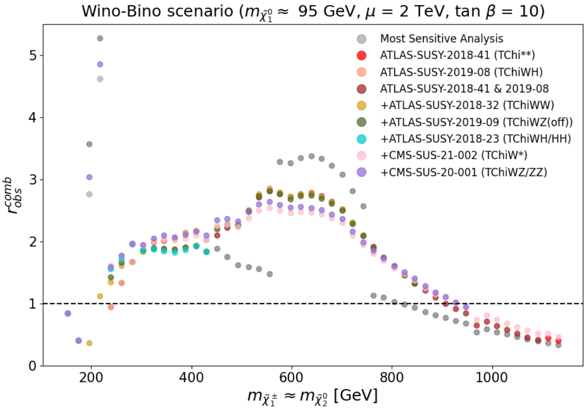


The wino-bino scenario

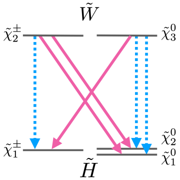


Scan over: $M_1 < M_2 \ll \mu = 2\,\mathrm{TeV}$

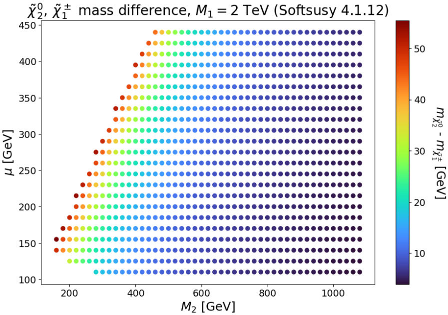
When combining more analyses, the exclusion power becomes harder to quantify.

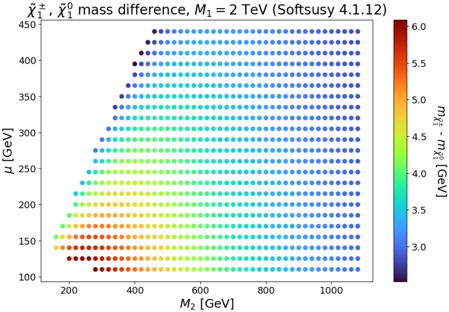


The wino-higgsino scenario

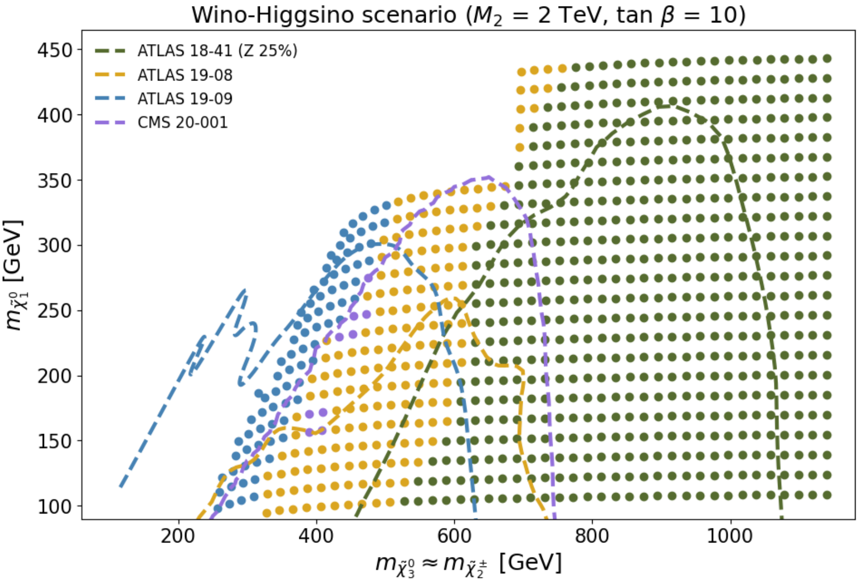


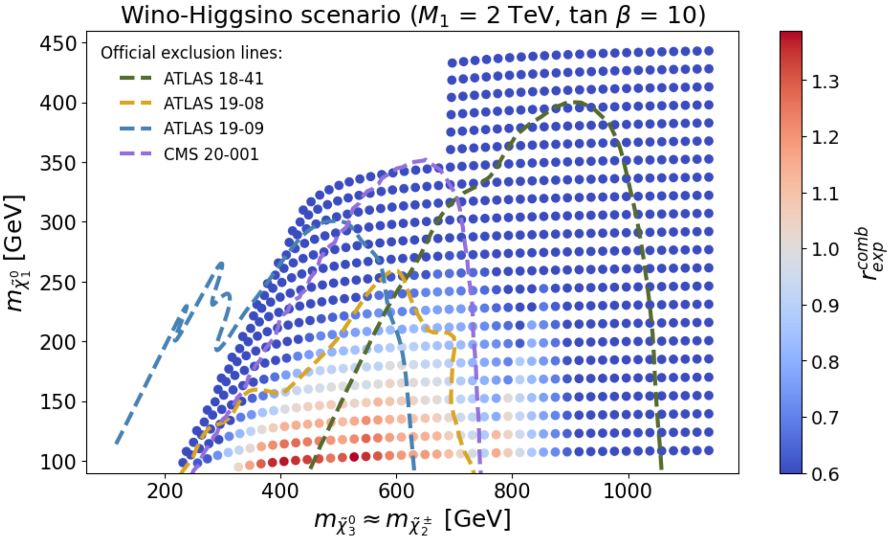
Scan over: $\mu < M_2 \ll M_1 = 2\,\mathrm{TeV}$

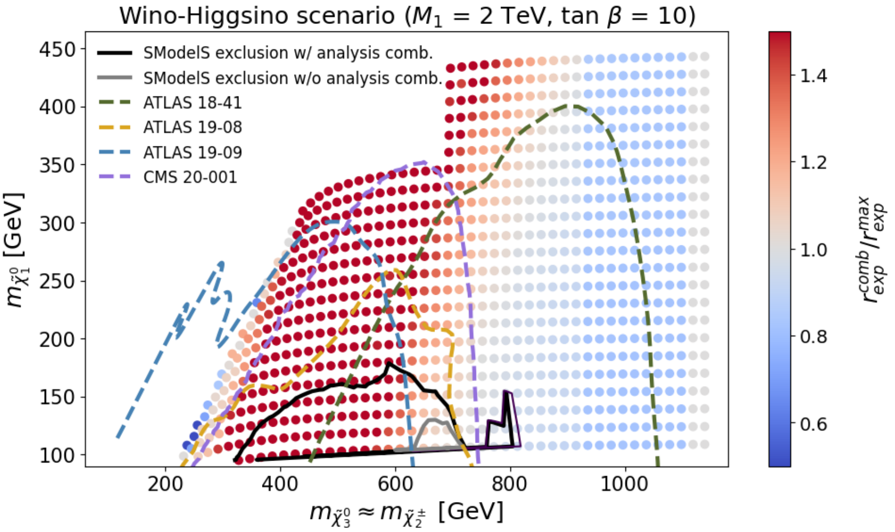




3.9 GeV $< m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^{\pm}} < 55.5$ GeV and 2.5 GeV $< m_{\tilde{\chi}_1^{\pm}} - m_{\tilde{\chi}_1^0} < 6.1$ GeV

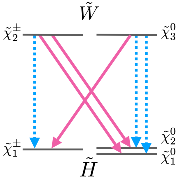

Wino-Higgsino scenario (M_2 = 2 TeV, tan β = 10)
ATLAS 18-41 (Z 25%)
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_3^0} \approx m_{\tilde{\chi}_2^\pm}$ [GeV]
100
150
200
250
300
350
400
450
200
400
600
800
1000


Wino-Higgsino scenario (M_1 = 2 TeV, tan β = 10)
Official exclusion lines:
ATLAS 18-41
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_3^0} \approx m_{\tilde{\chi}_2^\pm}$ [GeV]
r_{exp}^{comb}
450
400
350
300
250
200
150
100
200
400
600
800
1000
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6

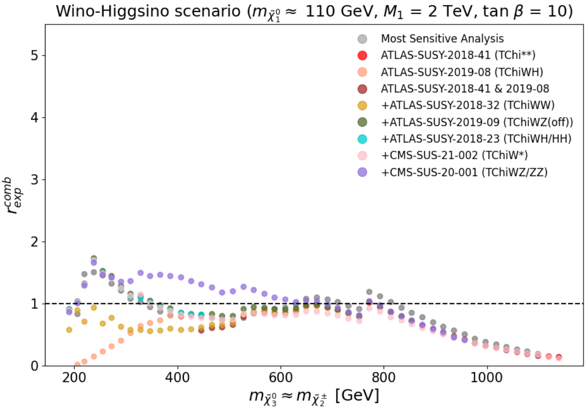

Wino-Higgsino scenario (M_1 = 2 TeV, tan β = 10)
SModelS exclusion w/ analysis comb.
SModelS exclusion w/o analysis comb.
ATLAS 18-41
ATLAS 19-08
ATLAS 19-09
CMS 20-001
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_3^0} \approx m_{\tilde{\chi}_2^\pm}$ [GeV]
$r_{exp}^{comb}/r_{exp}^{max}$
100
150
200
250
300
350
400
450
200
400
600
800
1000
0.6
0.8
1.0
1.2
1.4

The wino-higgsino scenario

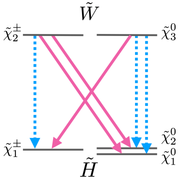
Scan over: $\mu < M_2 \ll M_1 = 2\,\mathrm{TeV}$



When combining more analyses, the exclusion power becomes harder to quantify.

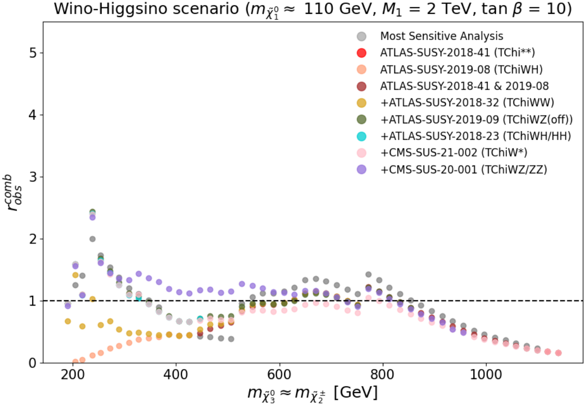


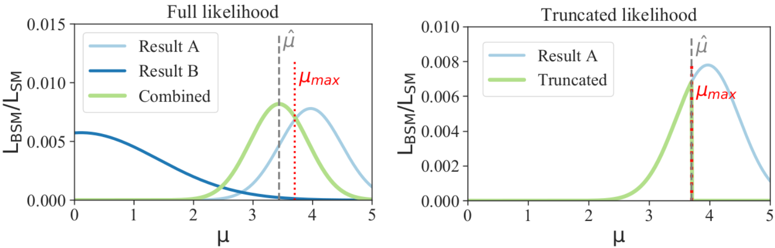
The wino-higgsino scenario



Scan over: $\mu < M_2 \ll M_1 = 2\,\text{TeV}$

When combining more analyses, the exclusion power becomes harder to quantify.





arXiv:2012.12246