Global LHC constraints on electroweak-inos with SModelS v2.3

SciPost Phys. 16, 101 (2024)

Timothée Pascal

Laboratory of subatomic physics and cosmology, Grenoble, France

in collaboration with:

Mohammad Mahdi Altakach, Sabine Kraml, Andre Lessa,

Sahana Narasimha, Théo Reymermier, Wolfgang Waltenberger

42nd International Conference on High Energy Physics

LPSC GRENOBLE | MODANE

Université Grenoble Alpes

ICHEP 2024 PRAGUE

The Minimal Supersymmetric Standard Model

In supersymmetry (SUSY): $|\text{Boson}\rangle \leftrightarrow |\text{Fermion}\rangle$

The simplest supersymmetric extension of the Standard Model (SM) is the Minimal Supersymmetric Standard Model (MSSM). It has 2 Higgs doublets (H_u and H_d) and every SM particle has a SUSY partner (e.g. $H_u \leftrightarrow \widetilde{H}_u$).

The Minimal Supersymmetric Standard Model

In supersymmetry (SUSY): $|\text{Boson}\rangle \leftrightarrow |\text{Fermion}\rangle$

The simplest supersymmetric extension of the Standard Model (SM) is the Minimal Supersymmetric Standard Model (MSSM). It has 2 Higgs doublets (H_u and H_d) and every SM particle has a SUSY partner (e.g. $H_u \leftrightarrow \widetilde{H}_u$).

The electroweak-ino (EW-ino) sector:

Bosons: $H_u,\ H_d,\ W^{\pm},\ W^3,\ B^0 \xrightarrow[\text{breaking}]{\text{EW symmetry}} \gamma,\ Z,\ W^{\pm},\ h,\ H^0,\ H^{\pm},\ A$

Fermions: $\widetilde{H}_u,\ \widetilde{H}_d,\ \widetilde{W}^{\pm},\ \widetilde{W}^3,\ \widetilde{B}^0$

$$\mathcal{L}_{\text{mass}} \supset -\mu\left(\widetilde{H}_u\widetilde{H}_d + \widetilde{H}_u^{\dagger}\widetilde{H}_d^{\dagger}\right) - \frac{1}{2}M_2\left(\widetilde{W}^3\widetilde{W}^3 + \widetilde{W}^+\widetilde{W}^- + \widetilde{W}^-\widetilde{W}^+\right) - \frac{1}{2}M_1\widetilde{B}^0\widetilde{B}^0$$

EW symmetry breaking $\Rightarrow \widetilde{H}_u^0,\ \widetilde{H}_d^0,\ \widetilde{W}^3,\ \widetilde{B}^0 \xrightarrow[\text{diagonalise}]{\text{mix and}} \tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_4^0$

$$\widetilde{H}_u^+,\ \widetilde{H}_d^-,\ \widetilde{W}^+,\ \widetilde{W}^- \xrightarrow[\text{diagonalise}]{\text{mix and}} \tilde{\chi}_1^{\pm}, \tilde{\chi}_2^{\pm}$$

The Minimal Supersymmetric Standard Model

In supersymmetry (SUSY): $|\text{Boson}\rangle \leftrightarrow |\text{Fermion}\rangle$

The simplest supersymmetric extension of the Standard Model (SM) is the Minimal Supersymmetric Standard Model (MSSM). It has 2 Higgs doublets (H_u and H_d) and every SM particle has a SUSY partner (e.g. $H_u \leftrightarrow \widetilde{H}_u$).

The electroweak-ino (EW-ino) sector:

Bosons: $H_u,\ H_d,\ W^{\pm},\ W^3,\ B^0 \xrightarrow[\text{breaking}]{\text{EW symmetry}} \gamma,\ Z,\ W^{\pm},\ h,\ H^0,\ H^{\pm},\ A$

Fermions: $\widetilde{H}_u,\ \widetilde{H}_d,\ \widetilde{W}^{\pm},\ \widetilde{W}^3,\ \widetilde{B}^0$

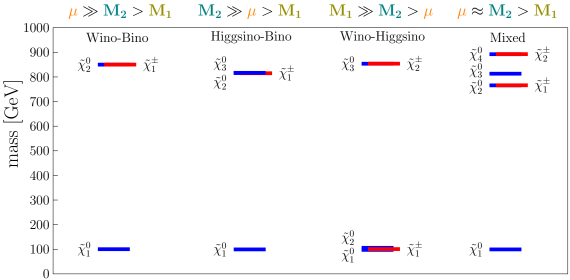
$$\mathcal{L}_{\text{mass}} \supset -\mu\left(\widetilde{H}_u\widetilde{H}_d + \widetilde{H}_u^{\dagger}\widetilde{H}_d^{\dagger}\right) - \frac{1}{2}M_2\left(\widetilde{W}^3\widetilde{W}^3 + \widetilde{W}^+\widetilde{W}^- + \widetilde{W}^-\widetilde{W}^+\right) - \frac{1}{2}M_1\widetilde{B}^0\widetilde{B}^0$$

$$\text{EW symmetry breaking} \Rightarrow \widetilde{H}_u^0,\ \widetilde{H}_d^0,\ \widetilde{W}^3,\ \widetilde{B}^0 \xrightarrow[\text{diagonalise}]{\text{mix and}} \tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_4^0$$

$$\widetilde{H}_u^+,\ \widetilde{H}_d^-,\ \widetilde{W}^+,\ \widetilde{W}^- \xrightarrow[\text{diagonalise}]{\text{mix and}} \tilde{\chi}_1^{\pm}, \tilde{\chi}_2^{\pm}$$

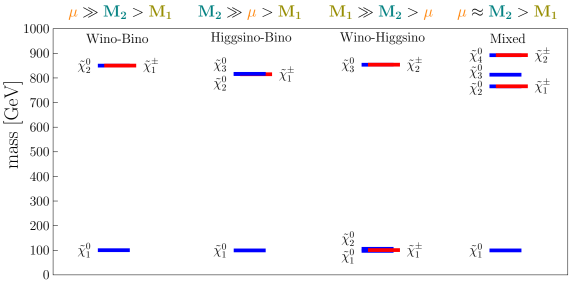
Masses depend on μ, M_2, M_1 and $\tan\beta = \langle H_u^0\rangle/\langle H_d^0\rangle$.

The electroweak-ino sector of the MSSM



$\tilde{\chi}_1^0$ is typically the lightest SUSY particle (LSP) and is stable if we assume R-parity conservation.

The electroweak-ino sector of the MSSM



$\tilde{\chi}_1^0$ is typically the lightest SUSY particle (LSP) and is stable if we assume R-parity conservation.

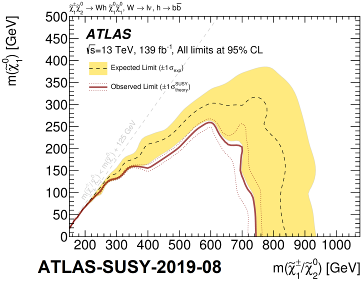
Decays:

$$\tilde{\chi}_i^0 \to Z + \tilde{\chi}_j^0, \quad h + \tilde{\chi}_j^0, \quad W^\mp + \tilde{\chi}_j^\pm$$
$$\tilde{\chi}_i^\pm \to Z + \tilde{\chi}_j^\pm, \quad h + \tilde{\chi}_j^\pm, \quad W^\pm + \tilde{\chi}_j^0$$

Data interpretation in LHC searches

J. Alwall et al. Phys. Rev. D 79, 075020
D. Alves et al 2012 J. Phys. G 39 105005
H. Okawa et al. arXiv:1110.0282
Phys. Rev. D 88, 052017

The ATLAS and CMS searches for SUSY interpret their data using simplified models (based on the m, σ and BR of a handful of accessible SUSY states).

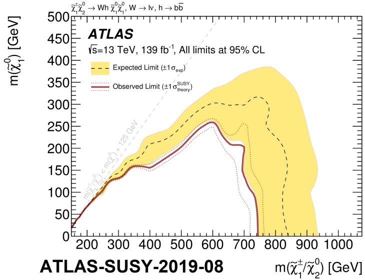


Obtained using assumptions:
- $BR(\tilde{\chi}_2^0 \to h + \tilde{\chi}_1^0) = 1$
- Pure states

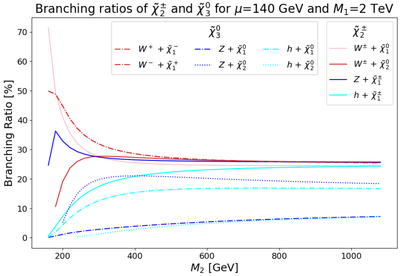
Data interpretation in LHC searches

J. Alwall et al. Phys. Rev. D 79, 075020
D. Alves et al 2012 J. Phys. G 39 105005
H. Okawa et al. arXiv:1110.0282
Phys. Rev. D 88, 052017

The ATLAS and CMS searches for SUSY interpret their data using simplified models (based on the m, σ and BR of a handful of accessible SUSY states).



Can be far from realistic models, e.g. for $\widetilde{W} \rightarrow \widetilde{H}$:



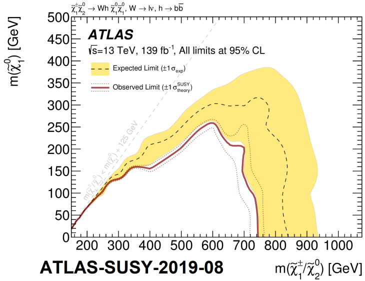
Obtained using assumptions:

- $BR(\tilde{\chi}_2^0 \rightarrow h + \tilde{\chi}_1^0) = 1$
- Pure states

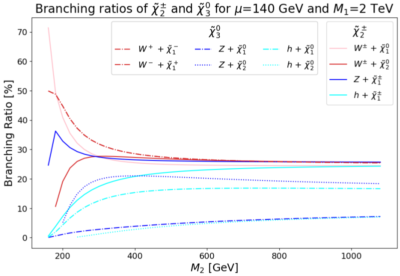
Data interpretation in LHC searches

J. Alwall et al. Phys. Rev. D 79, 075020
D. Alves et al 2012 J. Phys. G 39 105005
H. Okawa et al. arXiv:1110.0282
Phys. Rev. D 88, 052017

The ATLAS and CMS searches for SUSY interpret their data using simplified models (based on the m, σ and BR of a handful of accessible SUSY states).



Can be far from realistic models, e.g. for $\widetilde{W} \to \widetilde{H}$:

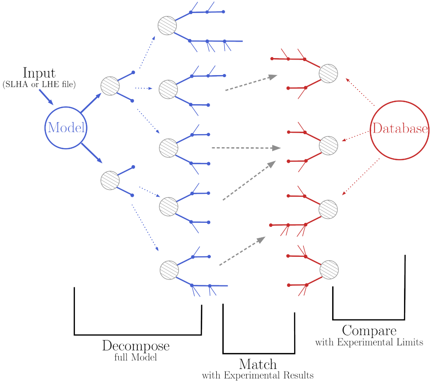


Obtained using assumptions:
- $BR(\tilde{\chi}_2^0 \to h + \tilde{\chi}_1^0) = 1$
- Pure states

How would such results constrain more complex models?

SModelS working principle

Public tool to confront BSM signals with a $\mathbb{Z}_2$-like symmetry against simplified model results from the LHC.
No MC simulation is required, making it a good tool for large scans.



Code and documentation available online: *https://smodels.github.io/*

Model points from the EW-ino sector of the MSSM

Random scan over:
(all other scales decoupled)

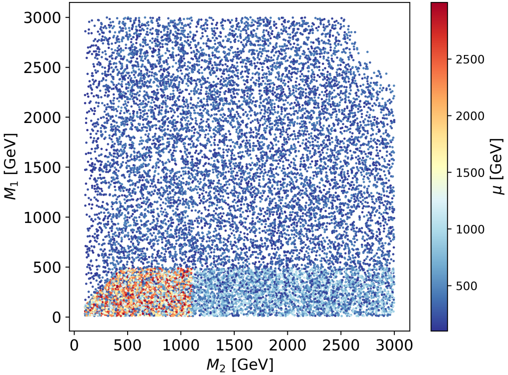
$$10\text{ GeV} < M_1 < 3\text{ TeV}$$
$$100\text{ GeV} < M_2 < 3\text{ TeV}$$
$$100\text{ GeV} < \mu < 3\text{ TeV}$$
$$5 < \tan\beta < 50$$

SUSY spectrum: SoftSUSY 4.1.11

NLO x-sec: Resummino 3.1.2

$$m_{\tilde{\chi}_1^0} < 500\text{ GeV}$$
$$m_{\tilde{\chi}_1^\pm} < 1200\text{ GeV}$$
$$\Gamma_{\tilde{\chi}_1^\pm} > 10^{-11}\text{ GeV}$$

In the end: 18247 points



Prompt EW-ino searches in SModelS database v2.3

ID	Run	lumi	Final State (+ MET)	EMs (+ MET)	SRs	comb.
ATLAS-SUSY-2013-11	1	20.3	2 lept., 0 or $\geqslant$ 2 jets, $0b$	$WW^{(*)}$	13	–
ATLAS-SUSY-2013-12	1	20.3	3 lept. (0–2 τ's), $0b$	$WZ^{(*)}$, Wh	2	–
ATLAS-SUSY-2016-24	2	36.1	2–3 lept., 0 or $\geqslant$ 2 jets, $0b$	WZ	9	–
ATLAS-SUSY-2017-03	2	36.1	2–3 lept., 0 or $\geqslant$ 1 jets, $0b$	WZ	8	–
ATLAS-SUSY-2018-05	2	139	2 lept., $\geqslant$ 1 jets	$WZ^{(*)}$	13	full
ATLAS-SUSY-2018-06	2	139	3 lept., 0 or 1–3 jets, $0b$	$WZ^{(*)}$	2	–
ATLAS-SUSY-2018-32	2	139	2 lept., 0 or 1 jets, $0b$	WW	36	full
ATLAS-SUSY-2018-41	2	139	4 jets or $2b$ + 2 jets, 0 lept.	WW, WZ, Wh, Zh, ZZ, hh	3	cov.
ATLAS-SUSY-2019-02	2	139	2 lept., 0 or 1 jets, $0b$	WW	24	cov.
ATLAS-SUSY-2019-08	2	139	1 lept., $(h \rightarrow) b\bar{b}$	Wh	9	full
ATLAS-SUSY-2019-09	2	139	3 lept., 0 or $\geqslant$ 1 jets, $0b$	$WZ^{(*)}$	20+31	full
CMS-SUS-13-012	1	19.5	0 lept., $\geqslant$ 3 jets (q or b)	WW, WZ, ZZ	36	–
CMS-SUS-16-039	2	35.9	2+ lept., 0–2 hadr. τ's, $0b$	$WZ^{(*)}$	11	cov.
CMS-SUS-16-048	2	35.9	2 soft lept., $\geqslant$ 1 jets, $0b$	WZ^{*}	12+9	cov.
CMS-SUS-20-004	2	137	0 lept., 2 $h(\rightarrow b\bar{b})$	hh	22	cov.
CMS-SUS-21-002	2	137	$\geqslant$ 2 AK8 jets, 0 or $\geqslant 1b$'s 0 lept.	WW, WZ, Wh	35	cov.

Combination of signal regions (SRs):

full = full HistFactory model   cov. = covariance matrix

If no SR combination is possible (–), the result from the most sensitive SR is used.

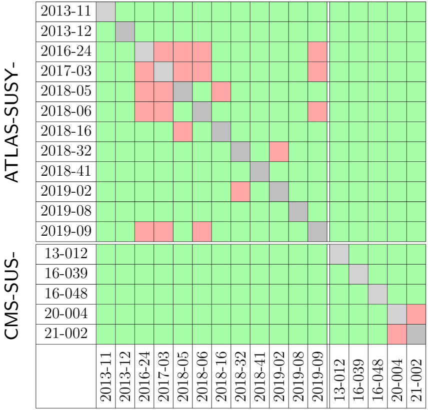
Global constraints = analysis combination

There are 3 benefits to combine analyses:

- ▷ To increase the results' robustness (more statistics).
- ▷ To enable the combination of search channels.
  (LHC searches typically adopt a channel-by-channel approach.)
- ▷ To account for both excesses and under-fluctuations in a consistent way.

Combinability matrix

<u>Not a SModelS feature</u>



<u>Approximation:</u>

We assume two analyses can be combined if they do not share any event in their SRs

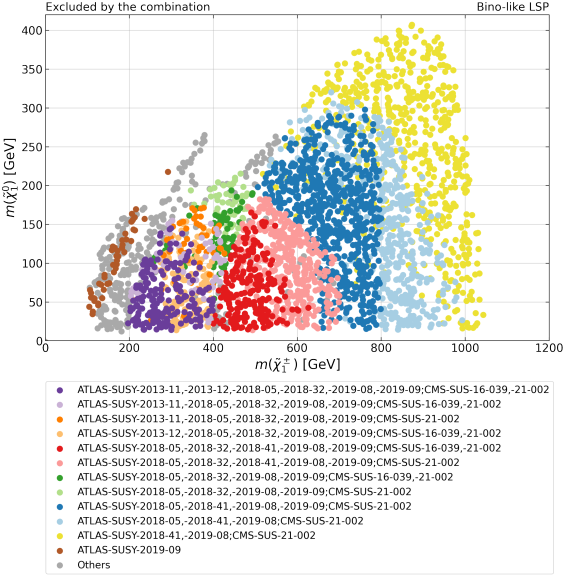
Two analyses from two different runs or experiments are automatically combinable

For each model point, find the most sensitive combination:

▷ List all the allowed combinations (if an analysis can enter a combination, it does)

▷ The most sensitive combination is the one with the lowest $\frac{L^{\text{exp}}_{\text{BSM}}}{L^{\text{exp}}_{\text{SM}}}$

Bino-like LSP



Mostly

$$pp \to \widetilde{H}\widetilde{H} \to \widetilde{B}^0\widetilde{B}^0$$
$$\widetilde{H} \in \{\tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_1^\pm\}$$
$$\widetilde{B}^0 = \tilde{\chi}_1^0$$

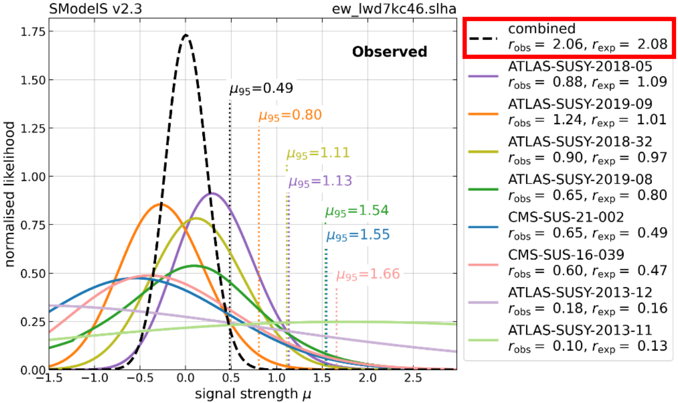
or

$$pp \to \widetilde{W}\widetilde{W} \to \widetilde{B}^0\widetilde{B}^0$$
$$\widetilde{W} \in \{\tilde{\chi}_2^0, \tilde{\chi}_1^\pm\}$$
$$\widetilde{B}^0 = \tilde{\chi}_1^0$$

Many combination sets

Bino-like LSP

For low $m(\tilde{\chi}_1^{\pm})$, fluctuations are typically cancelled by the large number of analyses:



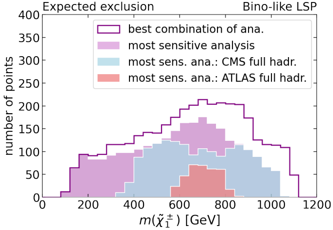
$r = 1/\mu_{95}$

μ = signal strength

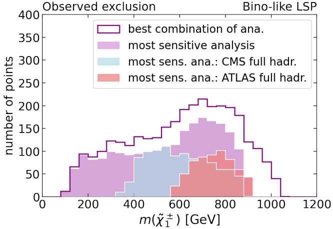
$M_1 \approx 42$ GeV	$m(\tilde{\chi}_2^{\pm}) \approx 488$ GeV	$\sigma(\tilde{\chi}_2^{\pm}\tilde{\chi}_2^{\mp}) \approx 22.2$ fb	$BR(\tilde{\chi}_2^{\pm} \to W^{\pm} + \tilde{\chi}_1^0) \approx 0.007$
$M_2 \approx 394$ GeV	$m(\tilde{\chi}_4^0) \approx 488$ GeV	$\sigma(\tilde{\chi}_2^{\pm}\tilde{\chi}_4^0) \approx 46.2$ fb	$BR(\tilde{\chi}_4^0 \to Z + \tilde{\chi}_1^0) \approx 0.003$
$\mu \approx 277$ GeV	$m(\tilde{\chi}_3^0) \approx 293$ GeV	$\sigma(\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}) \approx 94.2$ fb	$BR(\tilde{\chi}_4^0 \to h + \tilde{\chi}_1^0) \approx 0.004$
$\tan\beta \approx 18$	$m(\tilde{\chi}_2^0) \approx 274$ GeV	$\sigma(\tilde{\chi}_1^{\pm}\tilde{\chi}_3^0) \approx 111.7$ fb	$BR(\tilde{\chi}_3^0 \to Z + \tilde{\chi}_1^0) \approx 0.78$
	$m(\tilde{\chi}_1^{\pm}) \approx 274$ GeV	$\sigma(\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0) \approx 167.9$ fb	$BR(\tilde{\chi}_2^0 \to h + \tilde{\chi}_1^0) \approx 0.65$
	$m(\tilde{\chi}_1^0) \approx 52$ GeV		

Bino-like LSP

For $m(\tilde{\chi}_1^\pm) \gtrsim 600$ GeV, only few analyses enter the combination. One can have a qualitative insight using the 2 most sensitive analyses in this region: ATLAS and CMS hadronic searches.

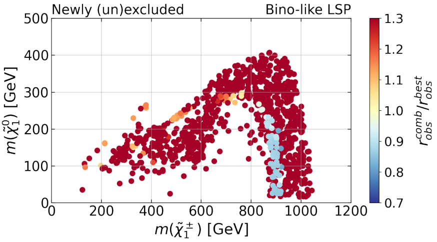


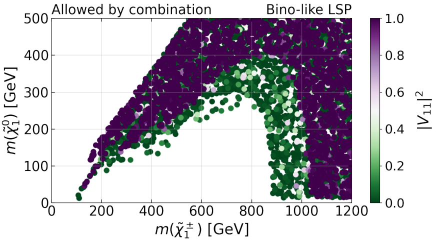
- ▷ The combination increases the sensitivity (as expected)
- ▷ Most sensitive analysis: CMS hadronic search
- ▷ 2^{nd} most sensitive analysis: ATLAS hadronic search



- ▷ But the CMS hadronic search recorded excesses, and the ATLAS one under-fluctuations
- ▷ Overall, the combination increases the exclusion power
- ▷ However, the combination can also un-exclude points

Bino-like LSP

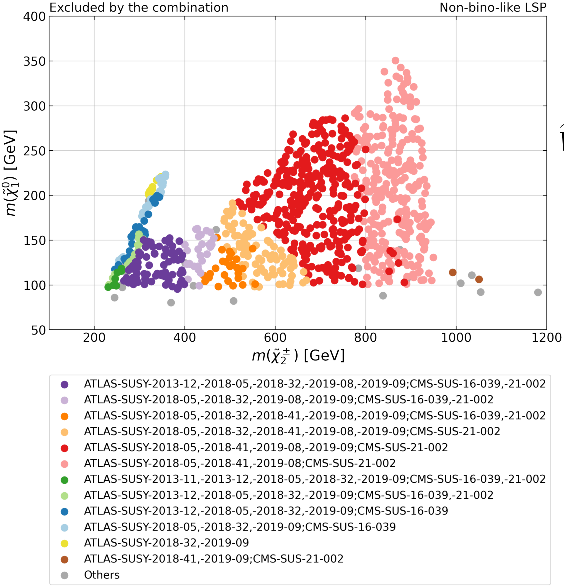




- ▷ Red = excluded by the combination only
  Mostly CMS hadronic search most sensi. ana., and the ATLAS under-fluctuations "win"
- ▷ Blue = un-excluded by the combination
  ATLAS hadronic search most sensi. ana. to higgsino → bino, and the CMS excesses "win"
- ▷ Upper arc = wino Next-to-LSP (NLSP)
- ▷ Lower arc = higgsino NLSP (lower cross section)

- ▷ Violet = wino-like NLSP
- ▷ Green = higgsino-like NLSP
- ▷ Clean excluded region!

Non-bino-like LSP



Mostly

$$pp \to \widetilde{W}\widetilde{W} \to \widetilde{H}\widetilde{H}$$

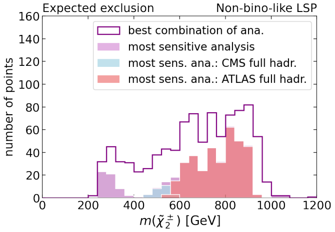
$$\widetilde{W} \in \{\tilde{\chi}_3^0, \tilde{\chi}_2^\pm\} \text{ or } \{\tilde{\chi}_4^0, \tilde{\chi}_2^\pm\}$$

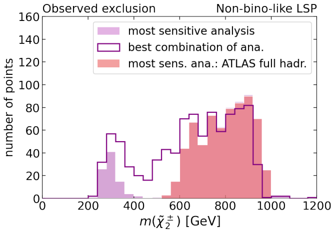
$$\widetilde{H} \in \{\tilde{\chi}_2^0, \tilde{\chi}_1^0, \tilde{\chi}_1^\pm\}$$

Only sensitive when direct decay to the LSP

Similar to bino-like LSP points

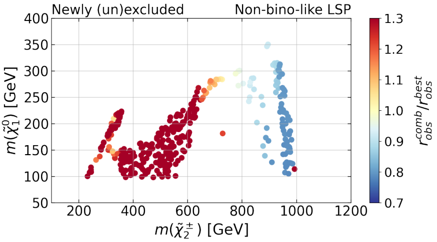
Non-bino-like LSP



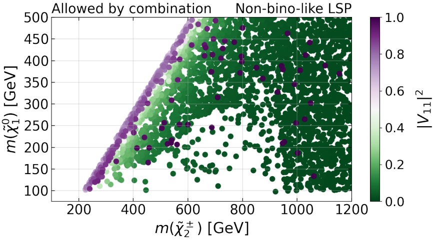


- Less sensitive than bino-like LSP scenarios because of longer decay chains not matching any result
- Most sensitive analysis:
  ATLAS hadronic search
- 2^{nd} most sensitive analysis:
  CMS hadronic search
- For high $m(\tilde{\chi}_2^\pm)$, the combination excludes less points compared to the most sens. ana.
  (same reasons as for bino-like LSP points)

Non bino-like LSP

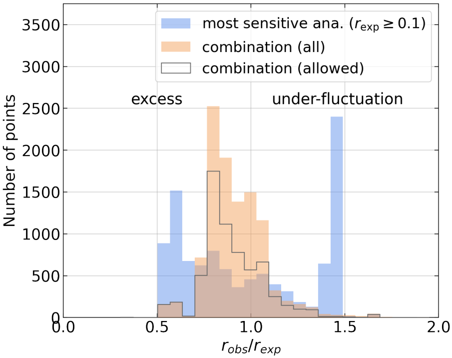


- $\triangleright$ Red = excluded by the combination only
  Many combined analyses increase the exclusion power
- $\triangleright$ Blue = un-excluded by the combination
  ATLAS hadronic search most sensi. ana. to $pp \to \widetilde{W}\widetilde{W} \to \widetilde{H}\widetilde{H}$, and the CMS excesses "win"
- $\triangleright$ In proportion, more un-excluded points
- $\triangleright$ Only 1 arc (no $pp \to \widetilde{B}^0\widetilde{B}^0 \to \widetilde{H}\widetilde{H}$)



- $\triangleright$ Violet = wino-like LSP
- $\triangleright$ Green = higgsino-like LSP
- $\triangleright$ No clean excluded region!

Overall fluctuations



- $r_{\mathrm{obs}}/r_{\mathrm{exp}} < 1$ = excess
- $r_{\mathrm{obs}}/r_{\mathrm{exp}} > 1$ = under-fluctuation
- Large spread for most sensitive analysis (excesses slightly outweigh under-fluctuations)
- When combining, large fluctuations are suppressed and distribution more centered around one
- A small excess remains, but mostly for non-excluded points, for which only few analyses are combined

Summary

- ▷ Model points were randomly sampled from the Lagrangian parameters of the electroweak-ino sector of the MSSM.
- ▷ The most sensitive analysis combination was dynamically found for each of these points among 11 ATLAS and 5 CMS prompt searches for SUSY.
- ▷ Overall, the exclusion power increases with the combination (the fluctuations tend to compensate for each other), but this is not always true (some points are even un-excluded).
- ▷ A clear excluded region appears when the LSP is bino-like. The size of the region depends on the nature of the NLSP.
- ▷ Such region does not appear as clearly for points featuring a non-bino-like LSP (this is mainly due to long decay chains producing experimental signatures difficult to probe).
- ▷ The compressed mass regions are less constrained because fewer analyses probing this region are implemented in the SModelS database v2.3 (because of a lack of reinterpretation material or a difficulty to reproduce experimental limits).

Acknowledgments

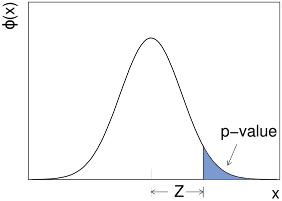
Many thanks to the ICHEP 2024 organizers and to the conveners of the Beyond the Standard Model session.

This work was funded thanks to the ANR-15-IDEX-02 (APM@LHC), ANR-21-CE31-0023 (PRCI SLDNP) and IN2P3 master project "Théorie – BSMGA".

Backup Slides

Building a global likelihood through SModelS

$$L_{\mathsf{C}}(\mu) = \prod_i L_i(\mu)$$



$\mu_{\mathsf{UL}} = \mu_{95}$ when p-value $\approx$ 0.05

(not the higgsino scale μ!)

(More technically, we use the $\mathsf{CL_s}$ prescription through the q_μ test statistic defined in *G. Cowan et al. Eur. Phys. J. C 71, 1554 (2011)*)

A model point is excluded if $r = \frac{\sigma^{\mathsf{BSM}}}{\sigma^{\mathsf{BSM}}_{\mathsf{UL}}} = \frac{1}{\mu_{\mathsf{UL}}} \geqslant 1$

Building a global likelihood through SModelS

$$L_{\mathsf{C}}(\mu) = \prod_i L_i(\mu)$$

For each individual likelihood (analysis), signal regions combination is possible using a full HistFactory models (ATLAS), encoded in a json file:

$$L_i(\mu) = \prod_{j=1}^{N} \mathrm{Pois}(n_j^{obs} | \mu s_j + b_j + \theta_j) \prod_{\theta \in \{\theta\}} c_\theta(a_\theta | \theta)$$

where $s_j = \epsilon_j \mathcal{A}_j \sum \sigma \prod BR * \mathcal{L}$ | $b_j =$ bkg | $\theta_j =$ nuisance parameters

Building a global likelihood through SModelS

$$L_C(\mu) = \prod_i L_i(\mu)$$

For each individual likelihood (analysis), signal regions combination is possible using a full HistFactory models (ATLAS), encoded in a json file:

$$L_i(\mu) = \prod_{j=1}^{N} \mathrm{Pois}(n_j^{obs}|\mu s_j + b_j + \theta_j) \prod_{\theta \in \{\theta\}} c_\theta(a_\theta|\theta)$$

where $s_j = \epsilon_j \mathcal{A}_j \sum \sigma \prod BR * \mathcal{L}$ | $b_j =$ bkg | $\theta_j =$ nuisance parameters

Simplified likelihood encoded in a covariance matrix (CMS):

$$L_i(\mu) = \prod_{j=1}^{N} \mathrm{Pois}(n_j^{obs}|\mu s_j + b_j + \theta_j) \prod_{\theta \in \{\theta\}} e^{-\frac{1}{2}\overrightarrow{\theta}^T V^{-1} \overrightarrow{\theta}}$$

Building a global likelihood through SModelS

$$L_{\mathsf{C}}(\mu) = \prod_i L_i(\mu)$$

For each individual likelihood (analysis), signal regions combination is possible using a full HistFactory models (ATLAS), encoded in a json file:

$$L_i(\mu) = \prod_{j=1}^{N} \mathrm{Pois}(n_j^{obs} | \mu s_j + b_j + \theta_j) \prod_{\theta \in \{\theta\}} c_\theta(a_\theta | \theta)$$

where $s_j = \epsilon_j \mathcal{A}_j \sum \sigma \prod BR * \mathcal{L}$ | $b_j =$ bkg | $\theta_j =$ nuisance parameters

Simplified likelihood encoded in a covariance matrix (CMS):

$$L_i(\mu) = \prod_{j=1}^{N} \mathrm{Pois}(n_j^{obs} | \mu s_j + b_j + \theta_j) \prod_{\theta \in \{\theta\}} e^{-\frac{1}{2} \overrightarrow{\theta}^T V^{-1} \overrightarrow{\theta}}$$

If the combination of signal regions (SRs) is not possible, use the most sensitive one (" best SR "), i.e. lowest μ_{UL} obtained with $n_j^{obs} = b_j$.

Procedure to find the most sensitive combination

Many combinations are possible, which one to choose?

- List of all the analyses that give $\mu_{\mathrm{UL}}^{\mathrm{exp}} \leqslant 10$ for the tested model point:

  e.g.: "ATLAS-SUSY-2018-05", "CMS-SUS-20-004", "CMS-SUS-21-002"

Procedure to find the most sensitive combination

Many combinations are possible, which one to choose?

- List of all the analyses that give $\mu_{\mathrm{UL}}^{\mathrm{exp}} \leqslant 10$ for the tested model point:

  e.g.: "ATLAS-SUSY-2018-05", "CMS-SUS-20-004", "CMS-SUS-21-002"

- Build all the possible combinations:

  ↳ If two analysis belong to a different experiment or a different run, they are combinable, otherwise need to check with the combination matrix

  e.g.:
  - ["ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-20-004"]
  - ["CMS-SUS-21-002"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-20-004"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-21-002"]

Procedure to find the most sensitive combination

Many combinations are possible, which one to choose?

- List of all the analyses that give $\mu_{\mathrm{UL}}^{\mathrm{exp}} \leqslant 10$ for the tested model point:

  e.g.: "ATLAS-SUSY-2018-05", "CMS-SUS-20-004", "CMS-SUS-21-002"

- Build all the possible combinations:

  ↳ If two analysis belong to a different experiment or a different run, they are combinable, otherwise need to check with the combination matrix

  e.g.:
  - ["ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-20-004"]
  - ["CMS-SUS-21-002"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-20-004"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-21-002"]

- Remove the subsets, e.g.:
  - ["CMS-SUS-20-004", "ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-21-002", "ATLAS-SUSY-2018-05"]

Procedure to find the most sensitive combination

Many combinations are possible, which one to choose?

- List of all the analyses that give $\mu_{\mathrm{UL}}^{\mathrm{exp}} \leqslant 10$ for the tested model point:

  e.g.: "ATLAS-SUSY-2018-05", "CMS-SUS-20-004", "CMS-SUS-21-002"

- Build all the possible combinations:

  ↳ If two analysis belong to a different experiment or a different run, they are combinable, otherwise need to check with the combination matrix

  e.g.:
  - ["ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-20-004"]
  - ["CMS-SUS-21-002"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-20-004"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-21-002"]

- Remove the subsets, e.g.:
  - ["CMS-SUS-20-004", "ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-21-002", "ATLAS-SUSY-2018-05"]

- For each remaining combination, compute $\frac{L_{\mathrm{BSM}}^{\mathrm{exp}}}{L_{\mathrm{SM}}^{\mathrm{exp}}}$

Procedure to find the most sensitive combination

Many combinations are possible, which one to choose?

- List of all the analyses that give $\mu_{\mathrm{UL}}^{\mathrm{exp}} \leqslant 10$ for the tested model point:

  e.g.: "ATLAS-SUSY-2018-05", "CMS-SUS-20-004", "CMS-SUS-21-002"

- Build all the possible combinations:
  ↳ If two analysis belong to a different experiment or a different run, they are combinable, otherwise need to check with the combination matrix

  e.g.:
  - ["ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-20-004"]
  - ["CMS-SUS-21-002"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-20-004"]
  - ["ATLAS-SUSY-2018-05", "CMS-SUS-21-002"]

- Remove the subsets, e.g.:
  - ["CMS-SUS-20-004", "ATLAS-SUSY-2018-05"]
  - ["CMS-SUS-21-002", "ATLAS-SUSY-2018-05"]

- For each remaining combination, compute $\dfrac{L_{\mathrm{BSM}}^{\mathrm{exp}}}{L_{\mathrm{SM}}^{\mathrm{exp}}}$

- The combination with the lowest ratio is chosen (most likely to be the most sensitive)