Recent results on SUSY searches in ATLAS

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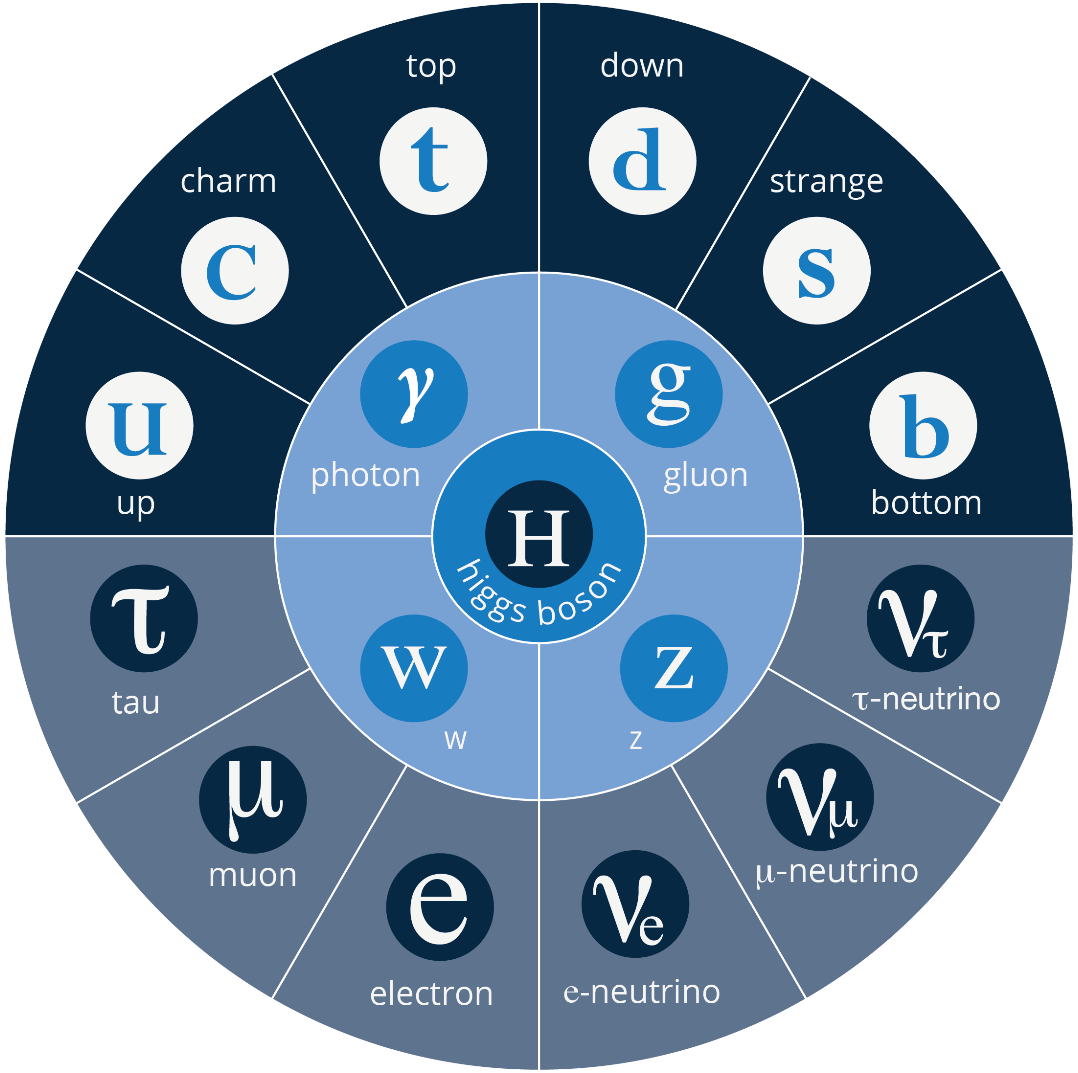
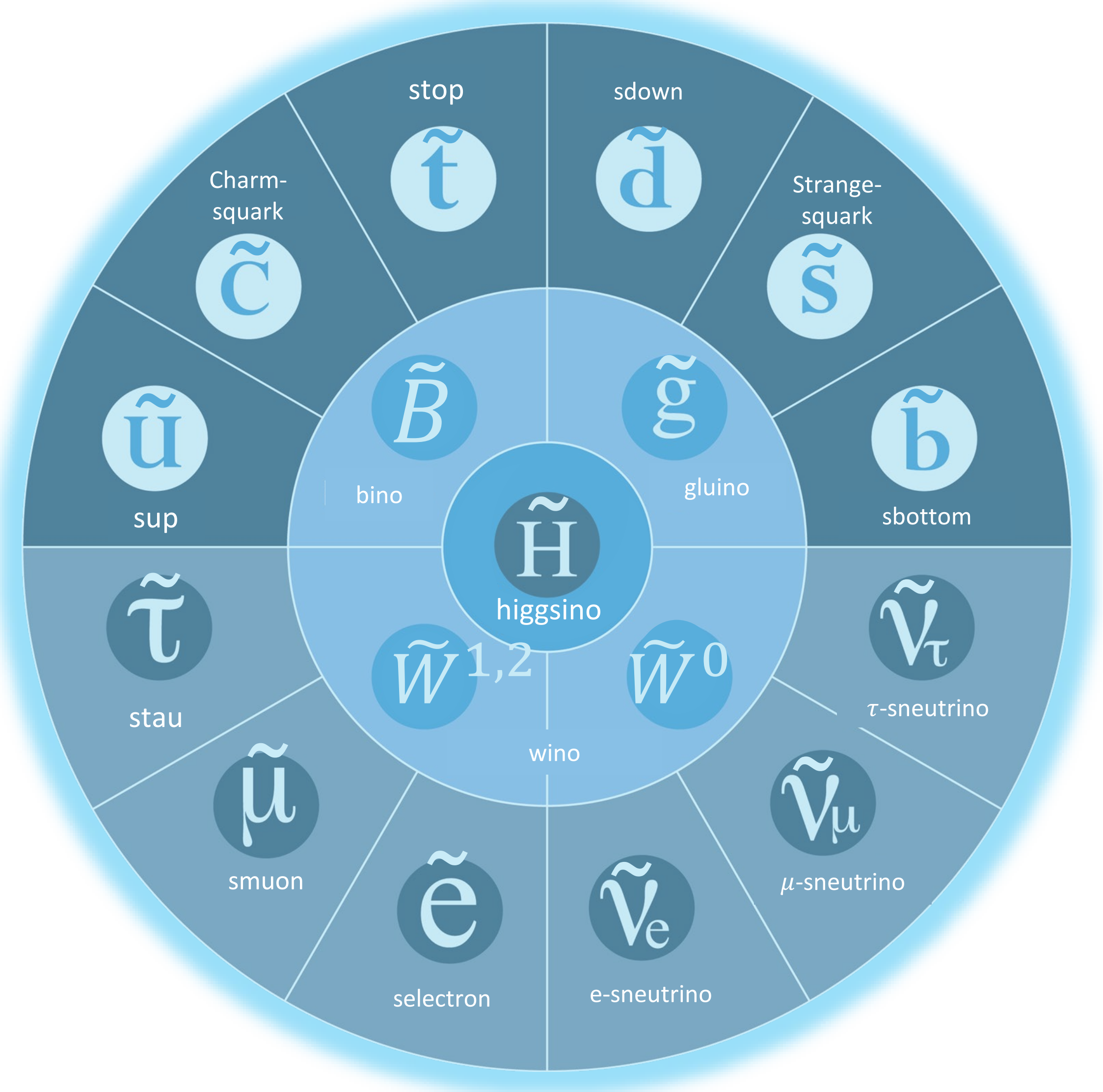
Introduction

- Supersymmetry (SUSY) introduces new partners to the SM particles with a difference in spin by $\frac{1}{2}$
  - Minimal Supersymmetric extension of the Standard Model (MSSM) contains 2-Higgs doublet model plus the SUSY partners.
  - R-parity conserving models produce a stable lightest SUSY partner (LSP), providing a natural dark-matter candidate.
- The SUSY partners of the electroweak gauge fields (wino, bino) and the 2-Higgs Doublet fields (higgsino) mix under spontaneous electroweak symmetry breaking.
  - Forming massive neutral and charged Electroweakinos, called neutralinos and charginos.
- SUSY is in general very rich in possible models. Many searches make use of simplified models with a few degrees of freedom to motivate analysis strategies.



Introduction

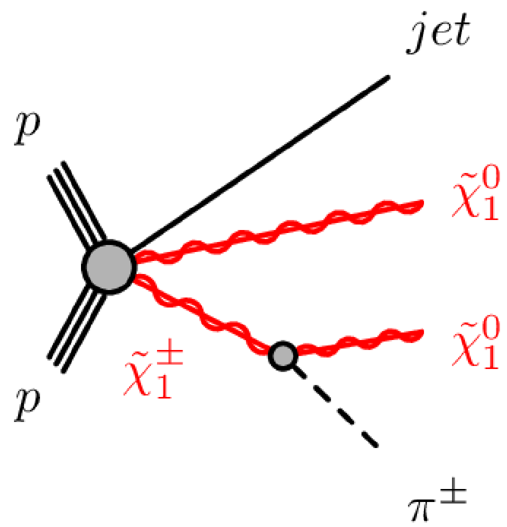


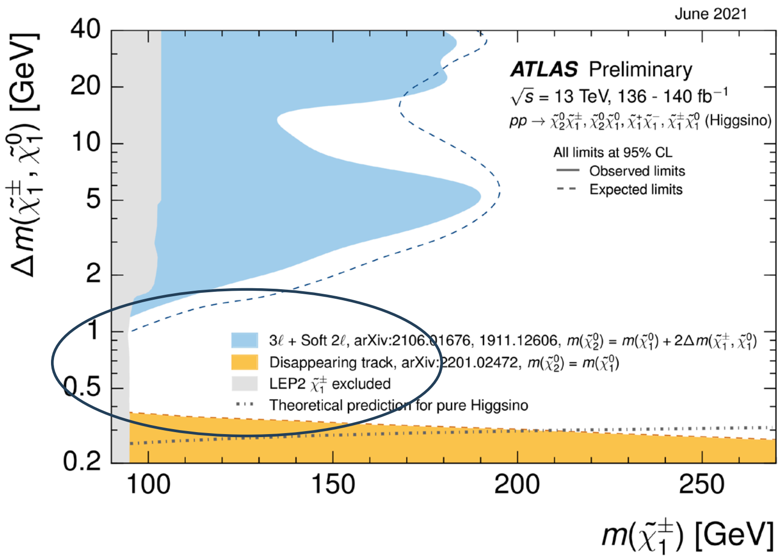
- Recent SUSY results in ATLAS involving Higgs in the decay chain or higgsino-like lightest electroweakinos include:
  - **Compressed scenarios** where the lightest charginos and neutralinos are nearly mass-degenerate higgsinos.
  - **Gauge-mediated SUSY breaking** (GMSB) models, where the lightest neutralino, $\tilde{\chi}_1^0$, is allowed to decay to a SM Higgs plus a spin-3/2 gravitino, $\tilde{G}$.
  - **Statistical combinations** of previous results and **reinterpretations** of previous analyses under the 19 parameter pMSSM.
- Data from Run 2 taken at $\sqrt{s} = 13$ TeV with Integrated Luminosity up to $140 fb^{-1}$

Compressed Scenarios

Displaced Track Search

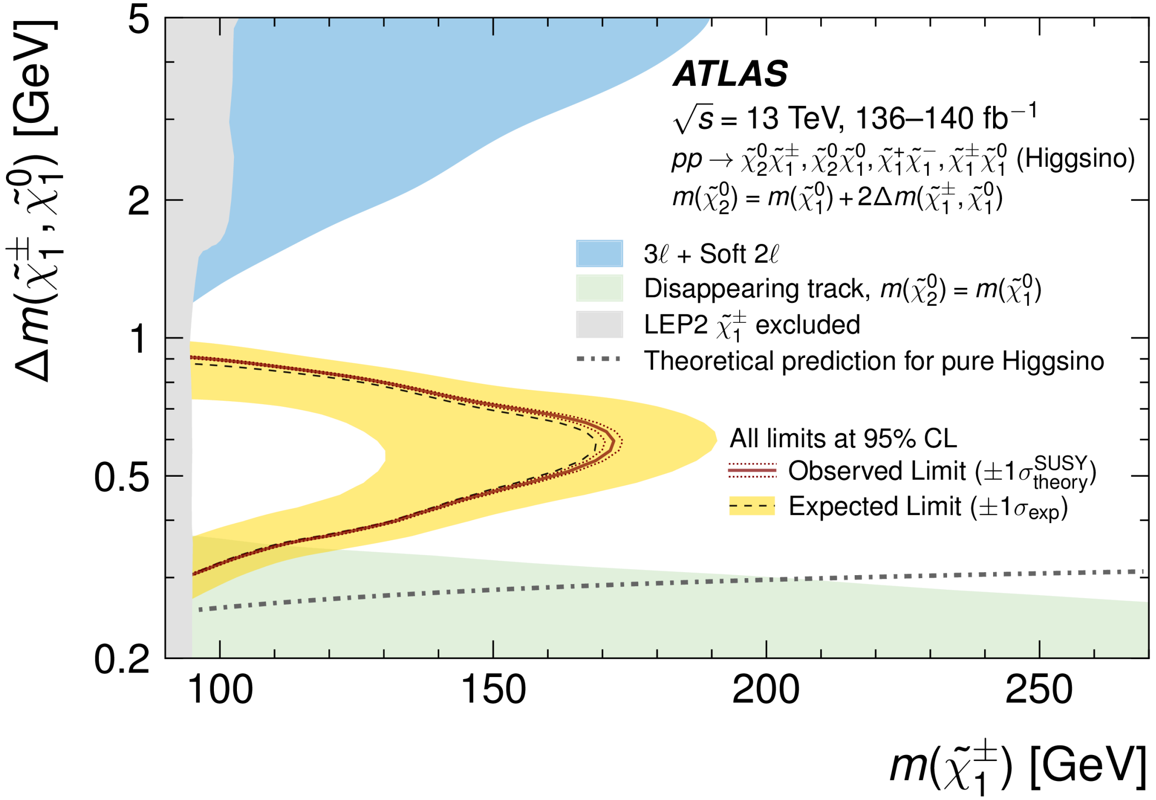
- Targeting simplified models of higgsino pair production in the gap region.
  - Higgsino-like LSP. $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\tilde{\chi}_1^0$, nearly mass-degenerate.
  - $\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0) \approx 0.3 - 1$ GeV
  - Flight length of $\tilde{\chi}_1^{\pm} \approx 0.1 - 1$ mm
- These compressed models have low sensitivity in direct detection experiments.
- Novel model signature: **Low-p_T Displaced Track, E_T^{miss}, ISR Jet**
- Discriminating variable: $\boldsymbol{S(d_0)} = |d_0|/\sigma(d_0)$
- Dominate Backgrounds:
  - $W(\rightarrow \tau\nu)$ + jets: Normalized to dedicated Control Regions
  - W/Z + jets "QCD track": Data-driven shape fit with normalization to low $S(d_0)$ bin
- Triggers: E_T^{miss} with single-electron and single-photon for background estimation.





[Phys. Rev. Lett. 132 (2024) 221801](https://doi.org/)

Displaced Track Search



95% CL exclusion contour covers simplified models with mass splitting from $0.3 < \Delta m(\tilde{\chi}_1^\pm, \tilde{\chi}_1^0) < 0.9$ GeV

Excluding $m(\tilde{\chi}_1^\pm)$ up to ≈ 170 GeV at $\Delta m \approx 0.6$ GeV

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Gauge-Mediated SUSY Breaking (GMSB) Models

- 2 Searches targeting GMSB models where:
  - $\tilde{\chi}_1^0$ is higgsino-like.
    - $\tilde{\chi}_1^0$ is the next-to-lightest SUSY particle.
  - $\tilde{G}$ is the nearly massless LSP of the model
    - These simplified models set $\mathrm{m}(\tilde{G}) = 1$ MeV
  - $\tilde{\chi}_1^0$ may decay to $h\tilde{G}$ or $Z\tilde{G}$ with different BR.
  - Assumes that $\tilde{\chi}_1^0$ is generated in pairs.
- Each search is using different signatures
  - $hh(\to \bar{b}b\bar{b}b)$
  - $h(\to \gamma\gamma) + h/Z(\to \bar{b}b)$
- Orthogonal signatures allow independent tests of GMSB models!

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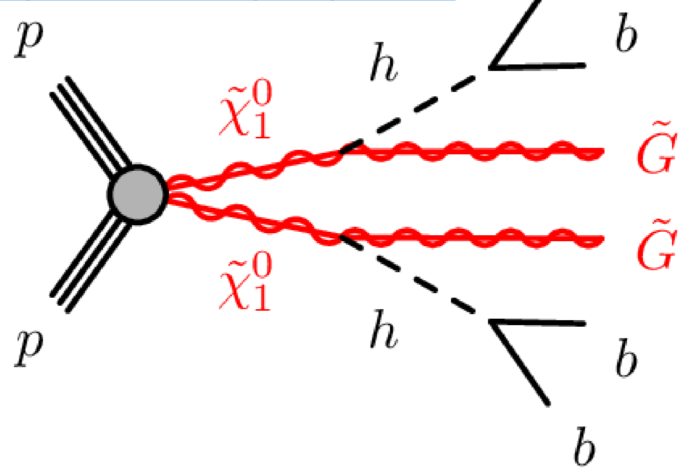

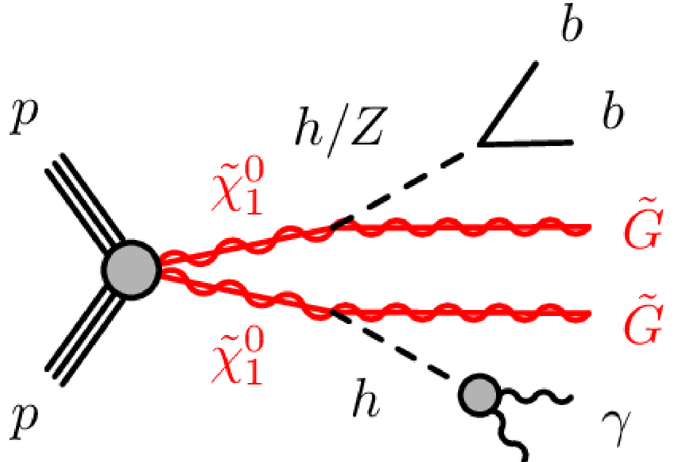

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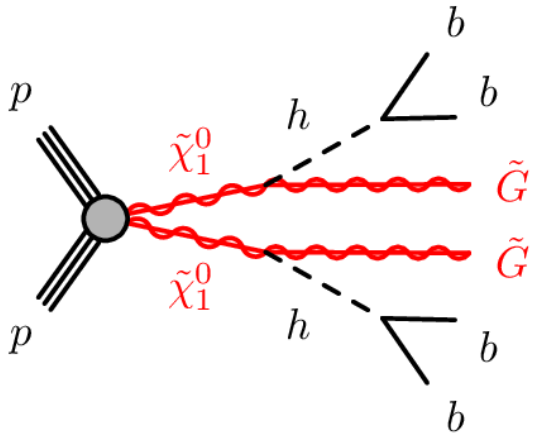
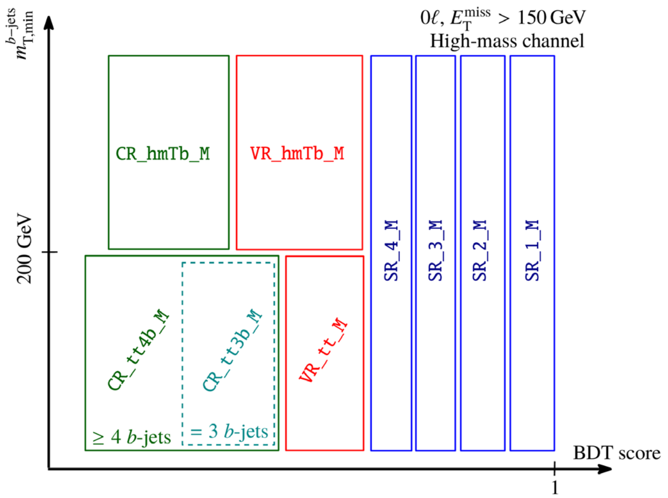
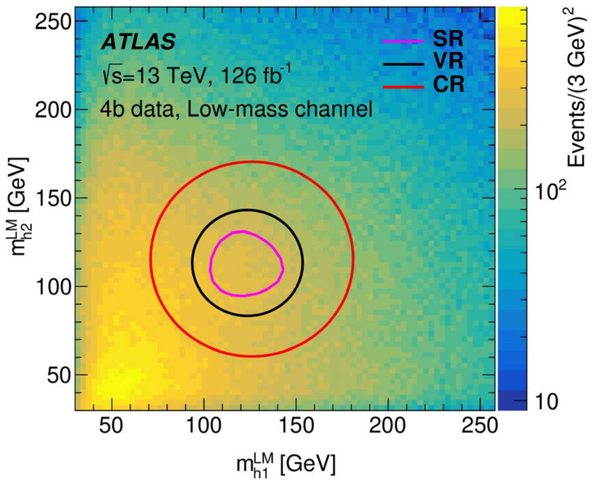
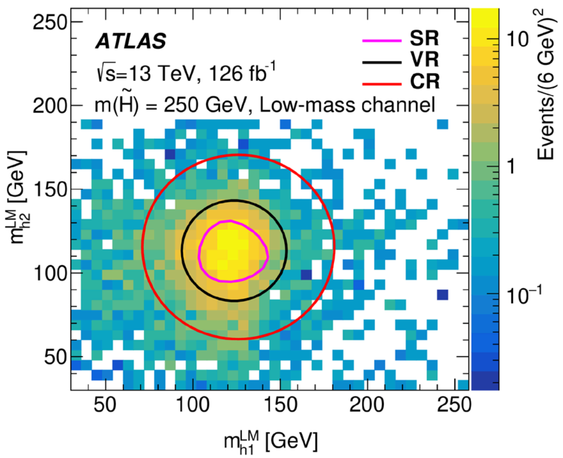
$hh(\rightarrow \bar{b}b\bar{b}b)$ Search

- Signature: **2 SM-Higgs, E_T^{miss}, $hh(\rightarrow \bar{b}b\bar{b}b)$**
- 2 Signal Regions defined
  - High-mass channel (Sensitive to $m_{\tilde{H}} > 250$ GeV models)
  - Low-mass channel (Sensitive to $m_{\tilde{H}} < 250$ GeV models)
- High-mass channel has significant E_T^{miss} and uses E_T^{miss}-based triggers.
  - Discriminating variable: **BDT score**
  - Can take advantage of boosted Higgs topology.
  - $t\bar{t}$, Z + jets, single top backgrounds: Normalization of MC from CRs
  - QCD multijet background: Data-driven template with NN reweighting.
- Low-mass channel relies on b-jet triggers.
  - Binned in 2-dimensions: $E_T^{miss} \times m_{eff}$
  - QCD multijet background: Data-driven extrapolation from 2-b regions with BDT reweighting.









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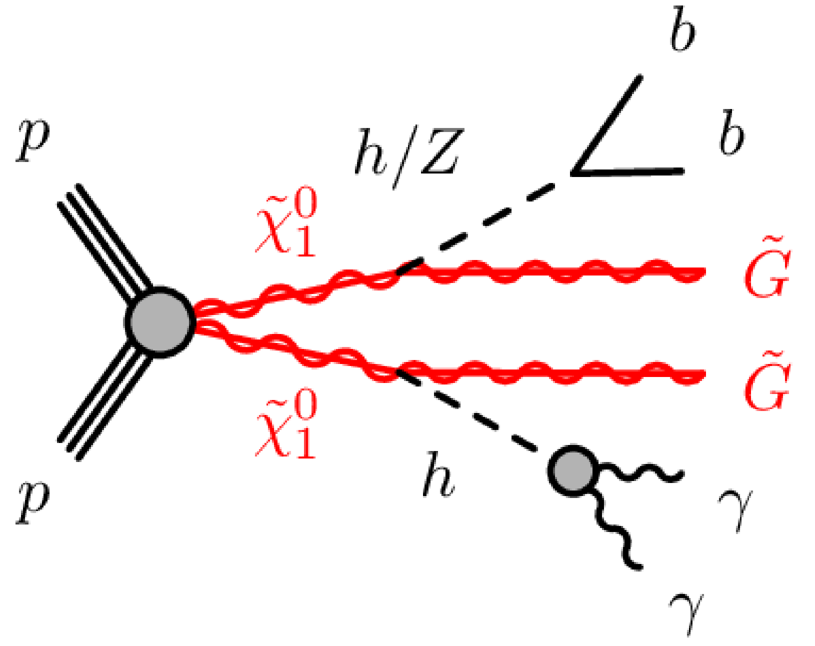
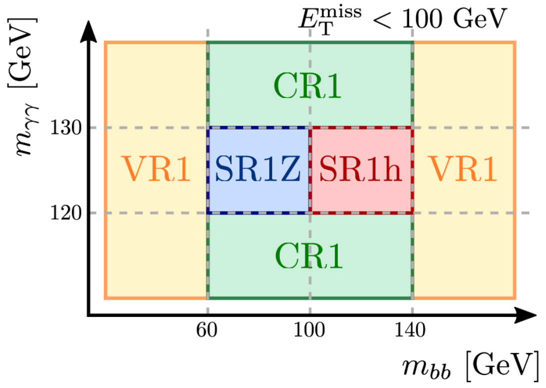
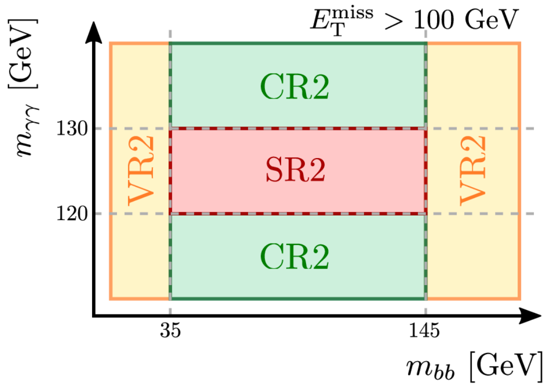
- Signature: $\boldsymbol{h(\rightarrow \gamma\gamma), h/Z(\rightarrow \bar{b}b), E_T^{miss}}$
- 3 Signal Regions defined targeting orthogonal signatures.
  - SR1h: A low E_T^{miss}, $hh(\rightarrow \bar{b}b\gamma\gamma)$ channel
  - SR1Z: A low E_T^{miss},$h(\rightarrow \gamma\gamma)Z(\rightarrow \bar{b}b)$ channel
  - SR2: A high E_T^{miss}, $h(\rightarrow \gamma\gamma)h/Z(\rightarrow \bar{b}b)$ channel
- Discriminating variable: $\boldsymbol{m_{\gamma\gamma}}$
- Dominant background: Non-resonant diphoton
  - Constrained with 2x2D side-band method.
- Diphoton triggers.







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Model-Dependent Limits

- Low-mass channel used for $m_{\tilde{H}} < 250$ GeV limits while high-mass channel used for $m_{\tilde{H}} > 250$ GeV.
- Higgsino masses between 130 and 940 GeV excluded at 95% confidence level under the $\mathrm{BR}(\tilde{H} \to h\tilde{G}) = 100\%$ hypothesis.

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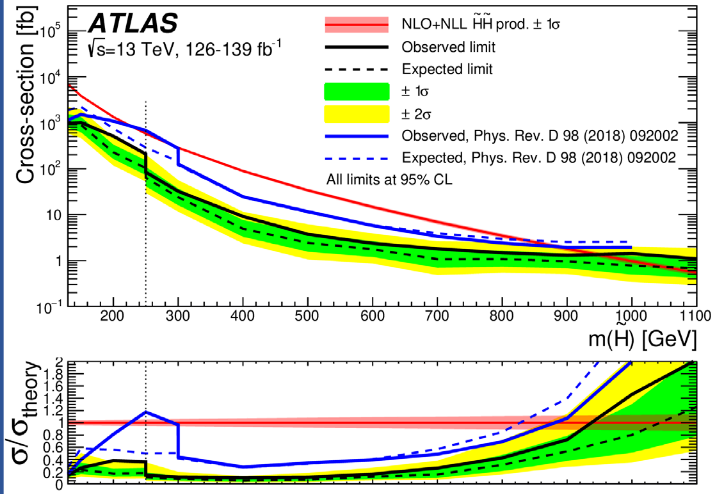
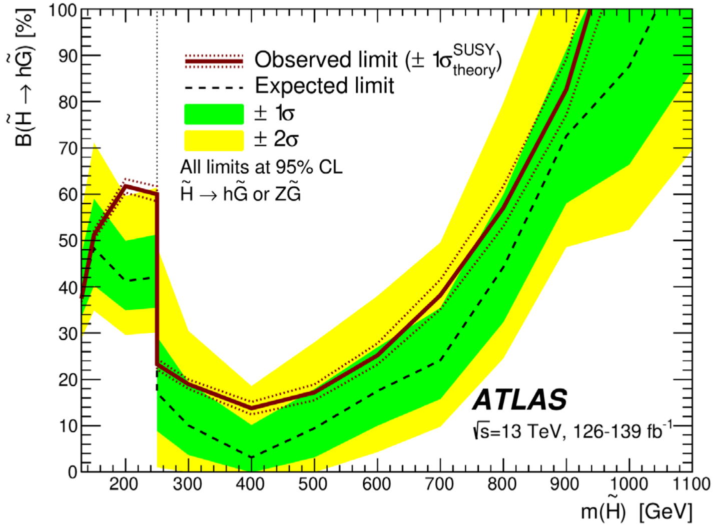
$\bar{b}b\bar{b}b$





- 95% exclusion up to $m(\tilde{\chi}_1^0) = 320$ GeV assuming $BR(\tilde{\chi}_1^0 \to h\tilde{G})$ =100%
- 95% exclusion of $BR(\tilde{\chi}_1^0 \to h\tilde{G})$ down to 36% for $m(\tilde{\chi}_1^0) = 130$ GeV

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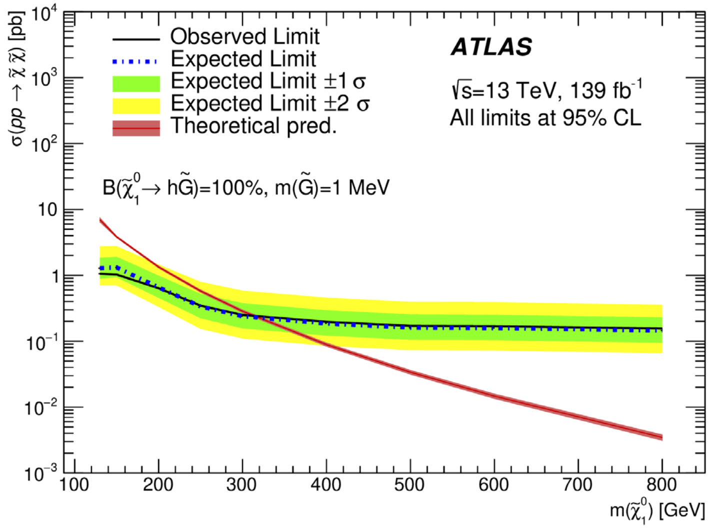
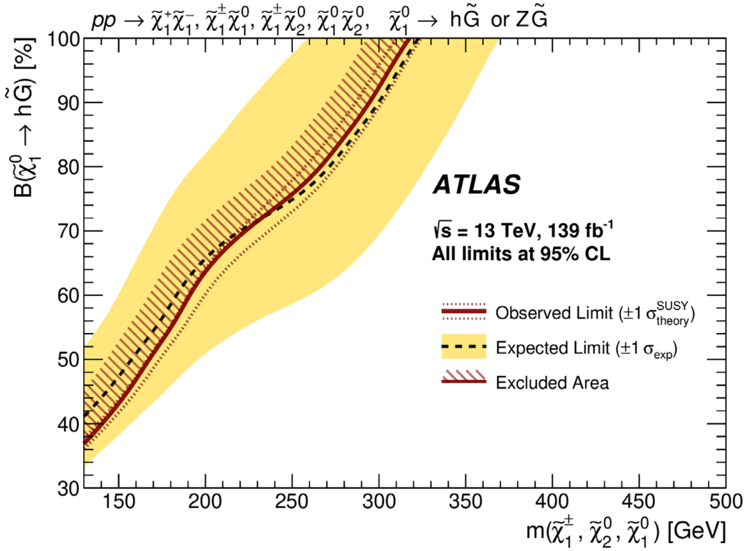
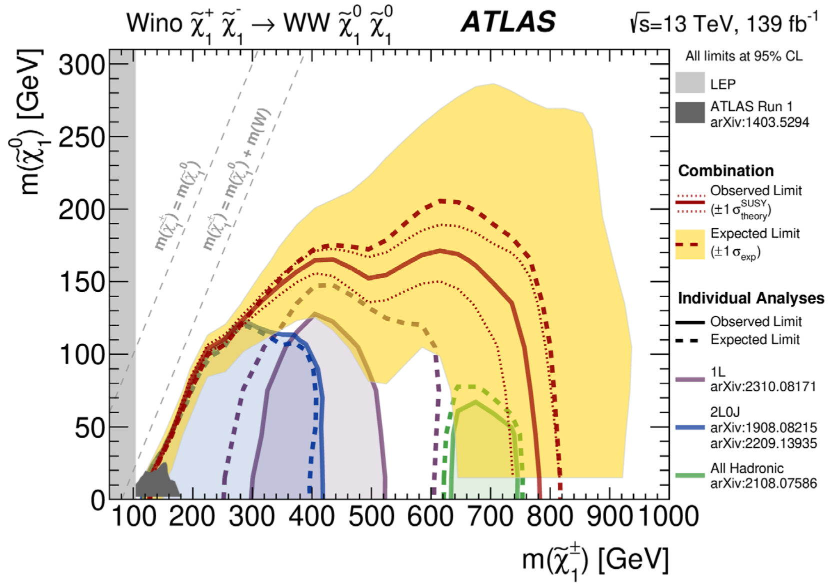
$\bar{b}b\gamma\gamma$

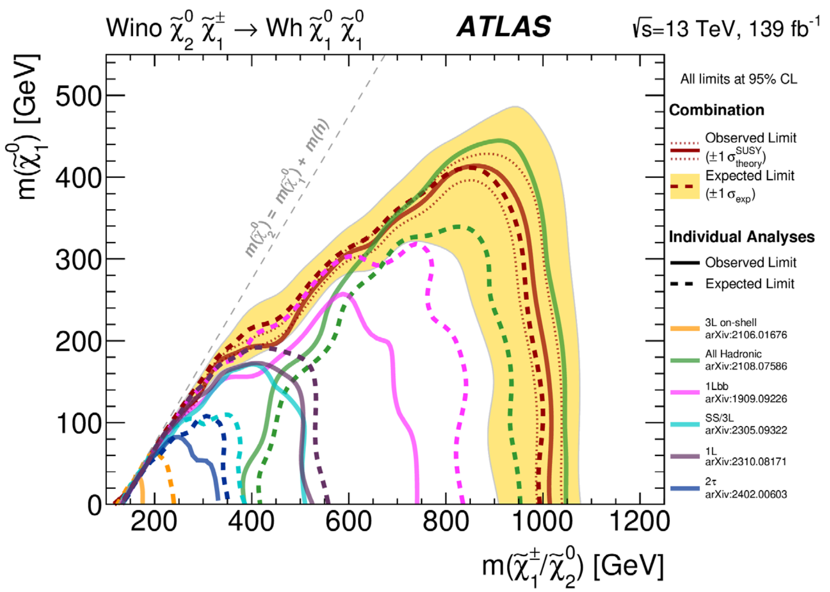


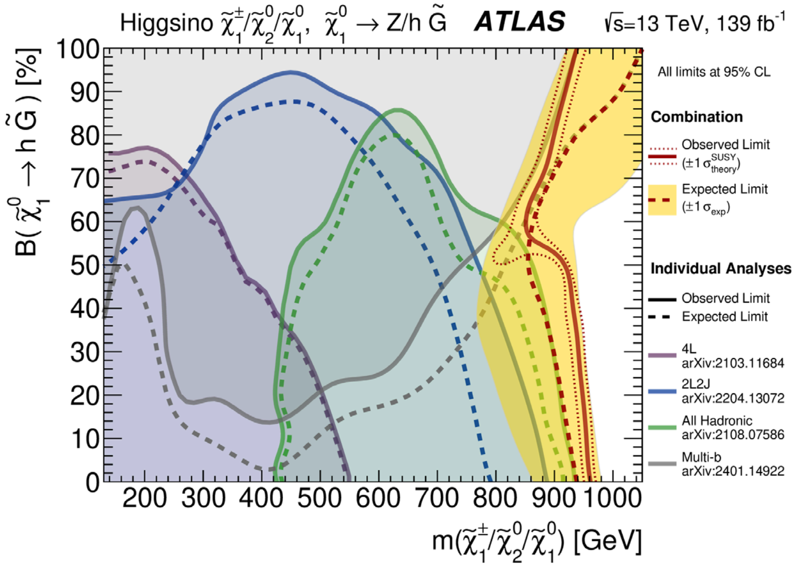


Combinations and Reinterpretations

Statistical Combinations







- Significant additional coverage to exclusion of the wino $\tilde{\chi}_1^\pm \to W^\pm \tilde{\chi}_1^0$ models from the combination.

- Improved production cross-section upper limits for simplified wino $\tilde{\chi}_2^0 \to h\tilde{\chi}_1^0$ by 20-30% for $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ masses below 600 GeV.

- Extends exclusion of GMSB higgsino models $\tilde{\chi}_1^0 \to h\tilde{G}$ by ~ 60 GeV.
- Improves upper-limits on production cross-section of modes with $BR(\tilde{\chi}_1^0 \to h\tilde{G}) < 80\%$ by 15%-40%.

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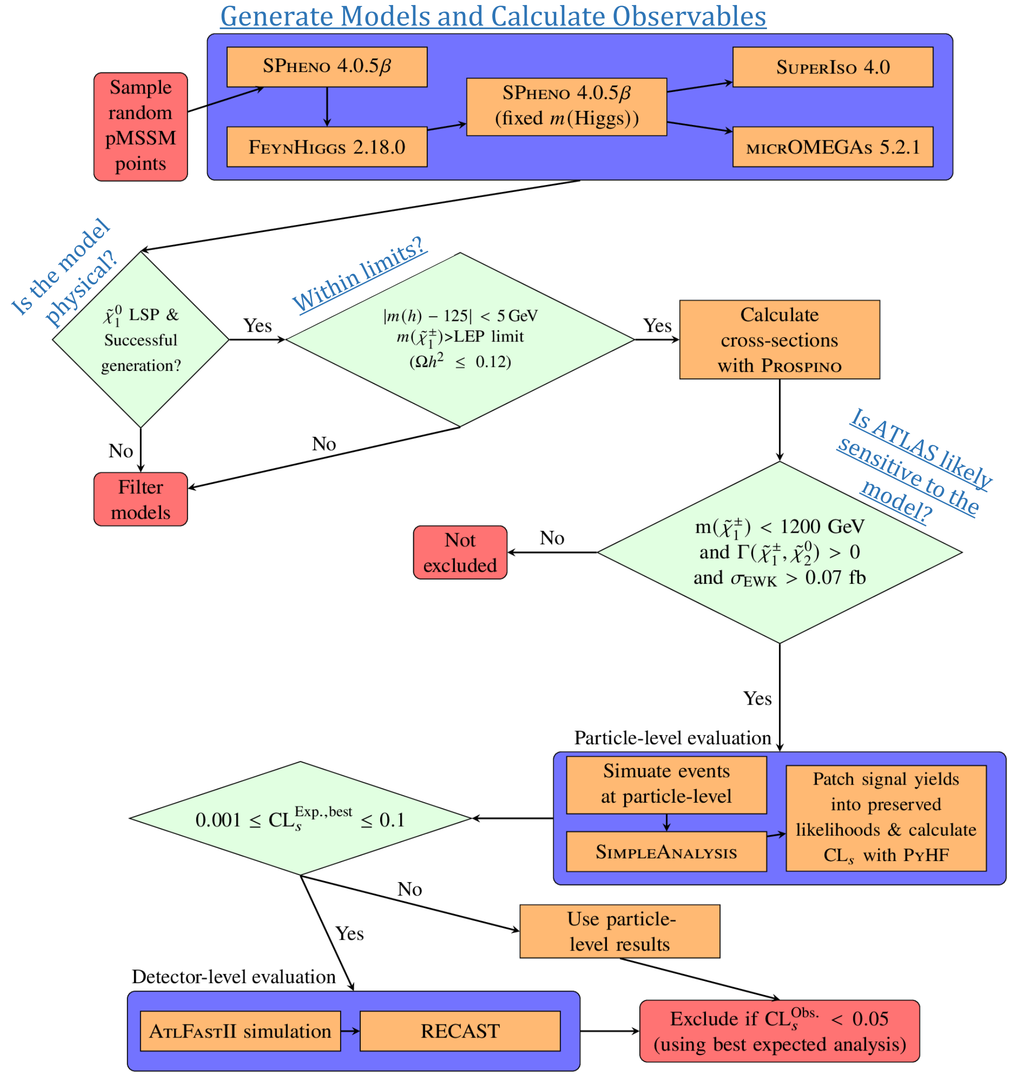
ATLAS pMSSM Reinterpretations



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Analyses

Analysis	Relevant simplified models targeted
FullHad	Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via WZ, Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via Wh, Wino $\tilde{\chi}_1^\pm\tilde{\chi}_1^-$ via WW
1Lbb	Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via Wh
2L0J	Wino $\tilde{\chi}_1^+\tilde{\chi}_1^-$ via WW, slepton pairs
2L2J	Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via WZ
3L	Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via WZ, Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via Wh, higgsino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0\tilde{\chi}_1^0$
4L	Higgsino GGM
Compressed	Wino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via WZ, higgsino $\tilde{\chi}_1^\pm\tilde{\chi}_2^0\tilde{\chi}_1^0$
Disappearing-track	Wino $\tilde{\chi}_1^+\tilde{\chi}_1^-$ and $\tilde{\chi}_1^\pm\tilde{\chi}_1^0$

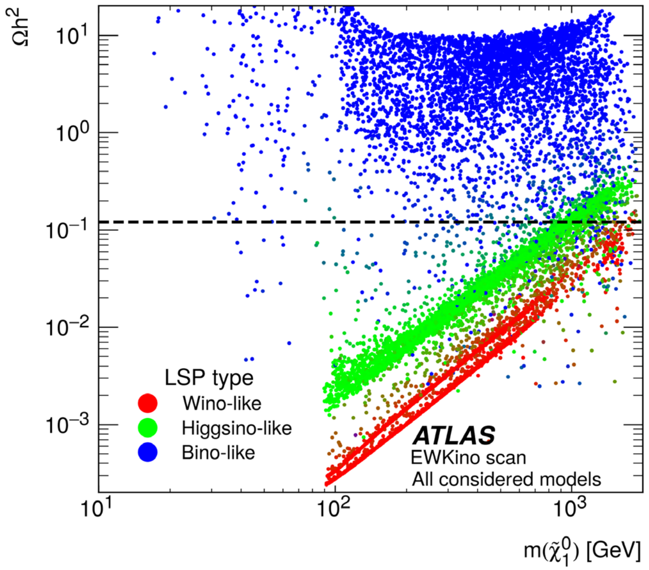
EWKino Parameter Scan Ranges

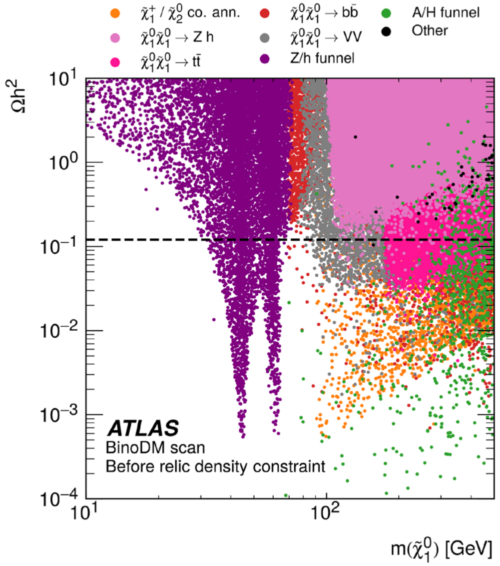
Parameter	Min	Max	Note
$M_{\tilde{L}_1}$ $(=M_{\tilde{L}_2})$	10 TeV	10 TeV	Left-handed slepton (first two gens.) mass
$M_{\tilde{e}_1}$ $(=M_{\tilde{e}_2})$	10 TeV	10 TeV	Right-handed slepton (first two gens.) mass
$M_{\tilde{L}_3}$	10 TeV	10 TeV	Left-handed stau doublet mass
$M_{\tilde{e}_3}$	10 TeV	10 TeV	Right-handed stau mass
$M_{\tilde{Q}_1}$ $(=M_{\tilde{Q}_2})$	10 TeV	10 TeV	Left-handed squark (first two gens.) mass
$M_{\tilde{u}_1}$ $(=M_{\tilde{u}_2})$	10 TeV	10 TeV	Right-handed up-type squark (first two gens.) mass
$M_{\tilde{d}_1}$ $(=M_{\tilde{d}_2})$	10 TeV	10 TeV	Right-handed down-type squark (first two gens.) mass
$M_{\tilde{Q}_3}$	2 TeV	5 TeV	Left-handed squark (third gen.) mass
$M_{\tilde{u}_3}$	2 TeV	5 TeV	Right-handed top squark mass
$M_{\tilde{d}_3}$	2 TeV	5 TeV	Right-handed bottom squark mass
M_1	−2 TeV	2 TeV	Bino mass parameter
M_2	−2 TeV	2 TeV	Wino mass parameter
μ	−2 TeV	2 TeV	Bilinear Higgs boson mass parameter
M_3	1 TeV	5 TeV	Gluino mass parameter
A_t	−8 TeV	8 TeV	Trilinear top coupling
A_b	−2 TeV	2 TeV	Trilinear bottom coupling
A_τ	−2 TeV	2 TeV	Trilinear τ-lepton coupling
M_A	0 TeV	5 TeV	Pseudoscalar Higgs boson mass
$\tan\beta$	1	60	Ratio of the Higgs vacuum expectation values

Two scans of the pMSSM parameters performed.

- EWKino scan performed over parameters on previous slide.
- BinoDM scan optimized to produce viable Bino-like LSP models.

Models that pass through initial filters are then considered to be excluded by ATLAS reinterpretations and external constraints set by other measurements separately.





External Constraints

Category	Constraint	Lower bound	Upper bound
Flavour	$\mathcal{B}(b \to s\gamma)$	3.11×10^{-4}	3.87×10^{-4}
	$\mathcal{B}(B_s \to \mu\mu)$	1.87×10^{-9}	4.31×10^{-9}
	$\mathcal{B}(B^+ \to \tau\nu)$	6.10×10^{-5}	1.57×10^{-4}
Precision electroweak	$\Delta\rho$	-0.0004	0.0018
	$\Gamma_{\text{inv}}^{\text{BSM}}(Z)$	–	2 MeV
	$m(W)$	80.347 GeV	80.407 GeV
DM	Relic density	–	0.12
	Direct detection $\sigma_{\text{Spin-independent}}$		
	Direct detection $\sigma_{\text{Spin-dependent}}$		

Scan name	EWKino	BinoDM
$\lvert M_1\rvert$ range	0 – 2 TeV	0 – 500 GeV
LSP type	Neutralino	Bino-like neutralino
Number of models generated:		
Sampled	20 000	437 500
Successful generation	16 667	370 017
Correct LSP type	15 321	286 267
Satisfy DM relic density constraint $\Omega h^2 \leq 0.12$	N/A	11 122
Satisfy LEP chargino mass constraint	13 969	10 174
120 GeV $< m(h) <$ 130 GeV	12 280	8 897
Satisfy non-DM external constraints	7 956	5 752
Satisfy all external constraints	2 460	1 769

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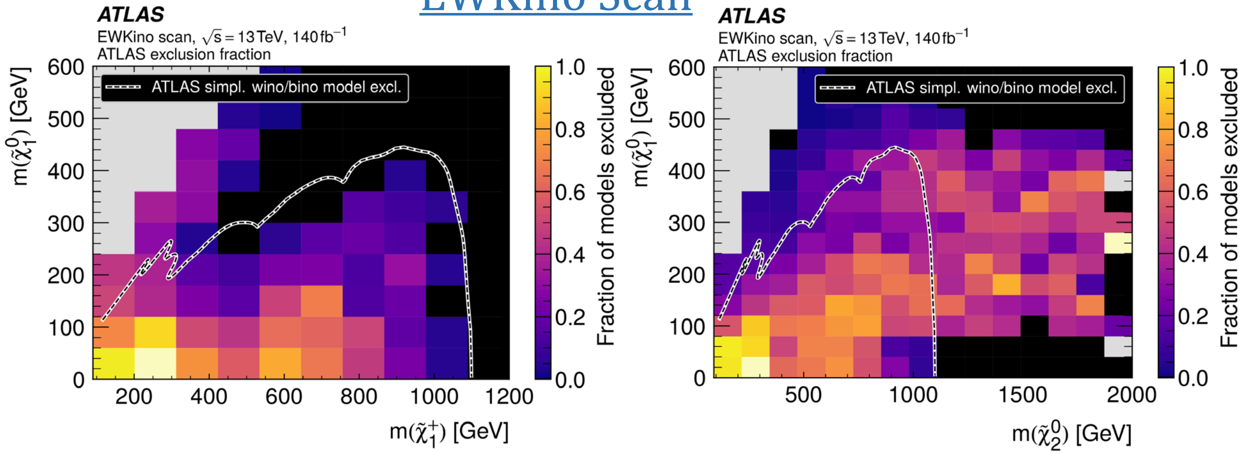
Results in $m(\tilde{\chi}_1^{\pm}), m(\tilde{\chi}_1^0)$ and $m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)$ planes

EWKino Scan



↑ ATLAS exclusion fraction before external constraints ↑

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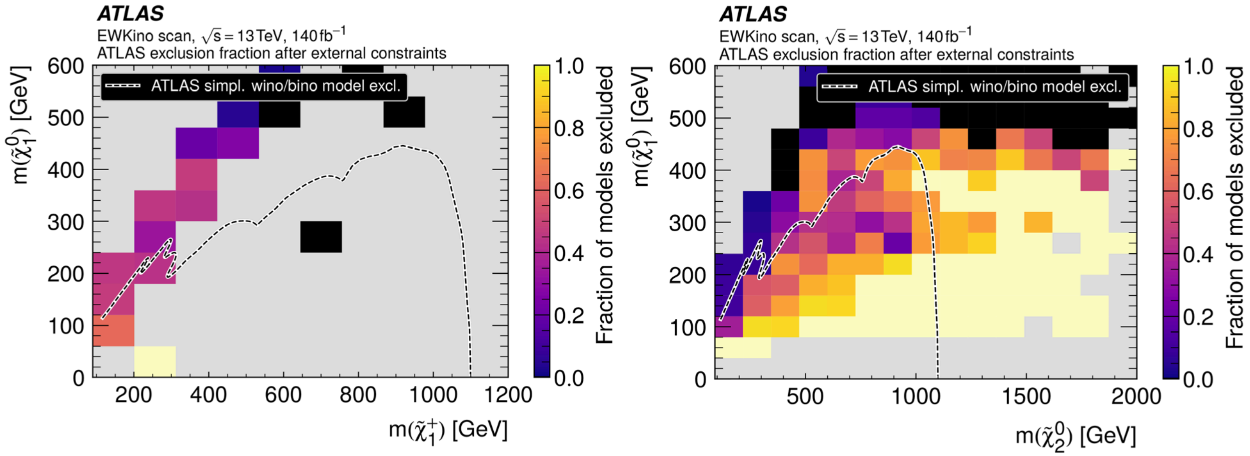
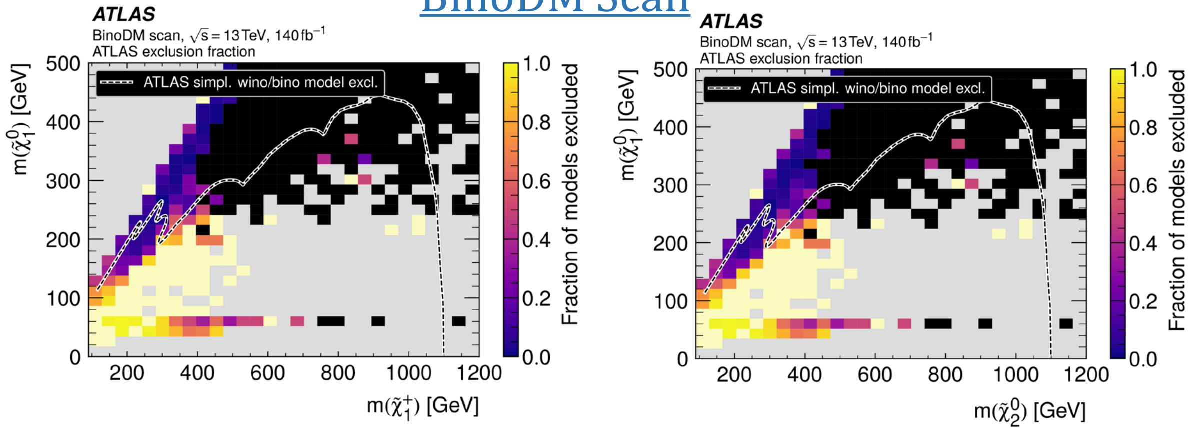


BinoDM Scan



↑ ATLAS exclusion fraction before external constraints

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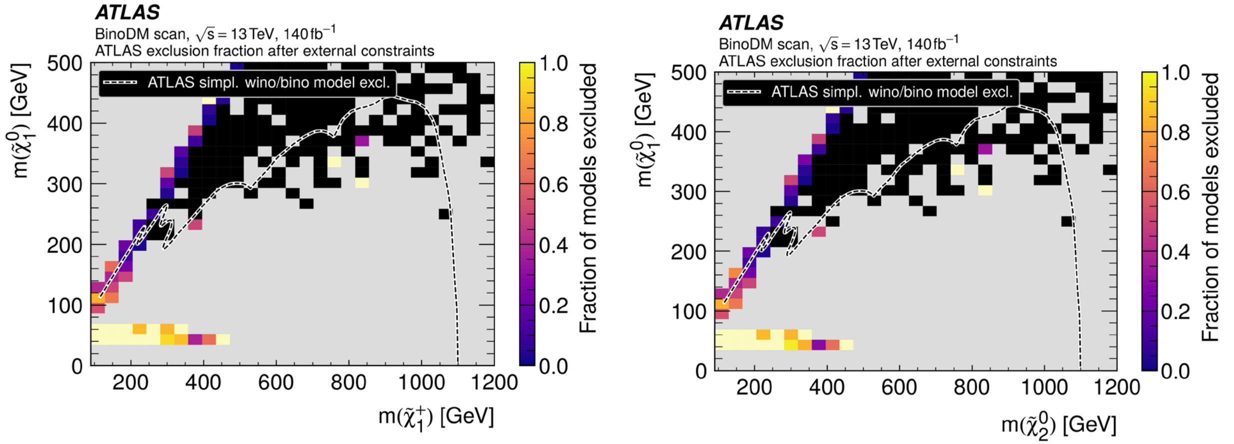

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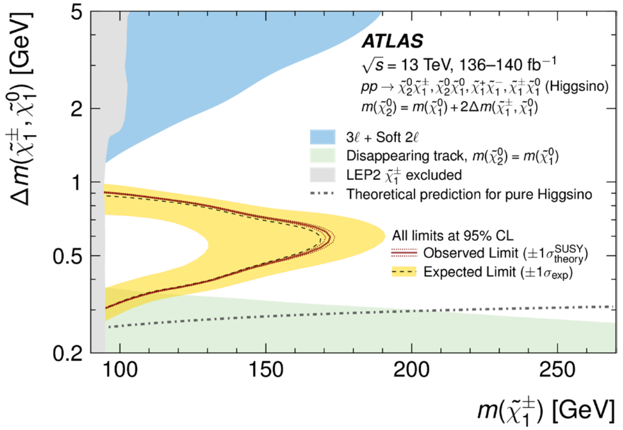
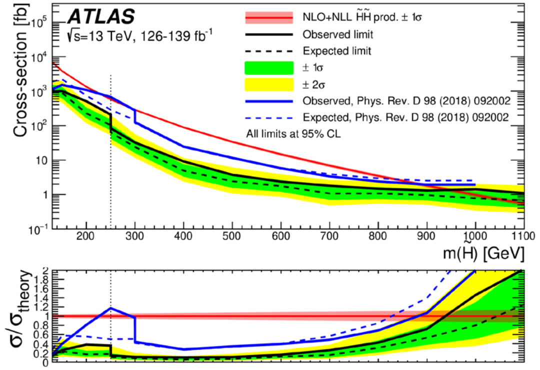
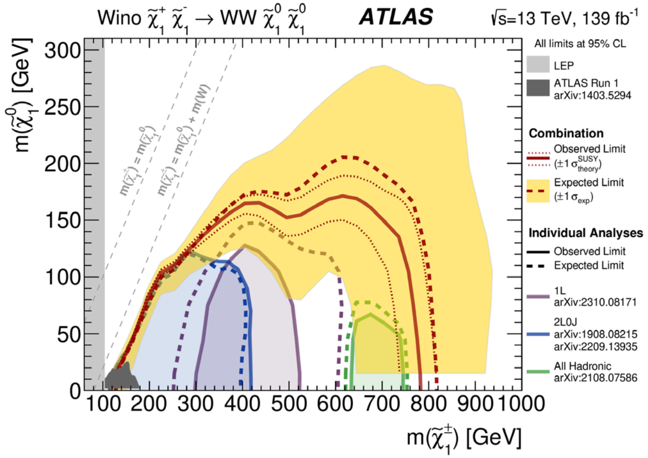
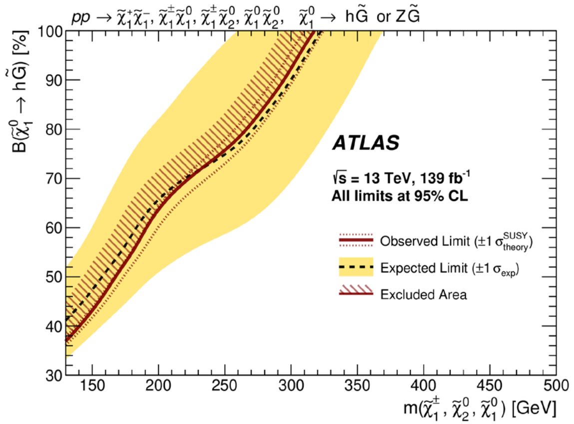
Conclusion

- New SUSY searches in ATLAS targeting **compressed models** and **GMSB models** provide new sensitivity to simplified SUSY models.
- Statistical combinations of previous ATLAS results **expand exclusion** of simplified SUSY models and provide **stronger production cross-section limits.**
- Reinterpretations of previous analysis under pMSSM demonstrates the **sensitivity of ATLAS SUSY searches** to more general SUSY models **complementary to external constraints**.
- Run 3 at ATLAS well underway and SUSY searches continue to progress.







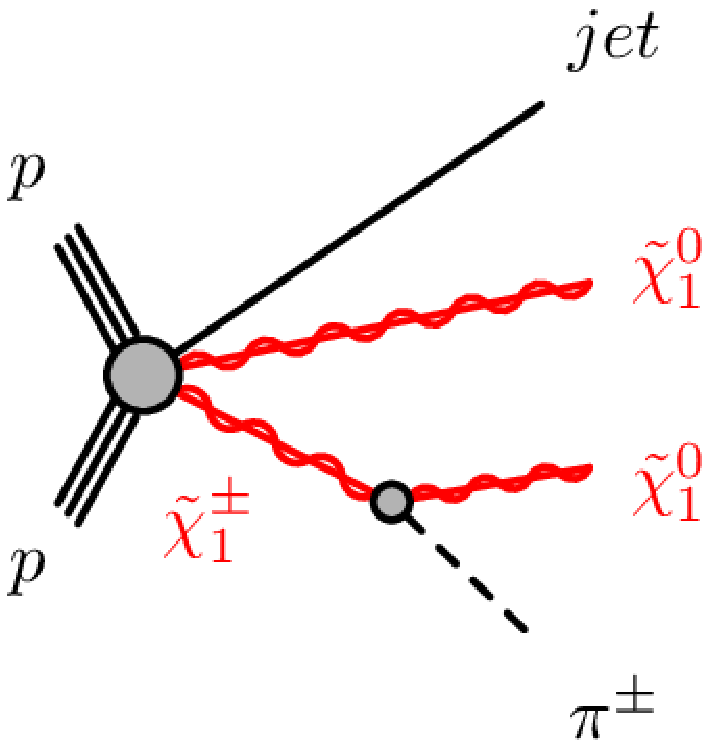


Backup

Backup: Displaced Track

Displaced Track Search

- Targeting simplified models with Higgsino-like $\tilde{\chi}_1^0$.
  - Higgsino-like $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, nearly mass-degenerate.
  - $\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0) \approx 0.3 - 1$ GeV (Compressed mass spectra)
  - Flight length of $\tilde{\chi}_1^{\pm} \approx 0.1 - 1$ mm
  - Production of $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^0, \tilde{\chi}_1^{+}\tilde{\chi}_1^{-}, \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0, \tilde{\chi}_2^0\tilde{\chi}_1^0$ considered.
- Novel model signature: **Low-$\boldsymbol{p_T}$ Displaced Track, $\boldsymbol{E_T^{miss}}$, ISR Jet**
- Discriminating variable: $\boldsymbol{S(d_0)} = |d_0|/\sigma(d_0)$
- Signal Regions selection
  - At least 1 jet with: $p_T > 250$ GeV & $|\eta| < 2.4$
  - No more than 4 jets, no leptons
  - $\Delta\phi(j, \boldsymbol{p}_T^{miss}) > 0.4$ for all jets
  - $E_T^{miss} > 600$ GeV
  - Low p_T track: $2 < p_T < 5$ GeV, $|\eta| < 1.5$, $|d_0| < 10$ mm, $|z_0 \sin\theta| < 3$ mm
  - SR-Low: $8 < S(d_0) < 20$
  - SR-High: $S(d_0) > 20$
- Triggers: E_T^{miss} with single-electron and single-photon for background estimation.



Dominate Backgrounds:

- $W(\rightarrow \tau\nu) + $ jets
- $W/Z + $ jets “QCD track”

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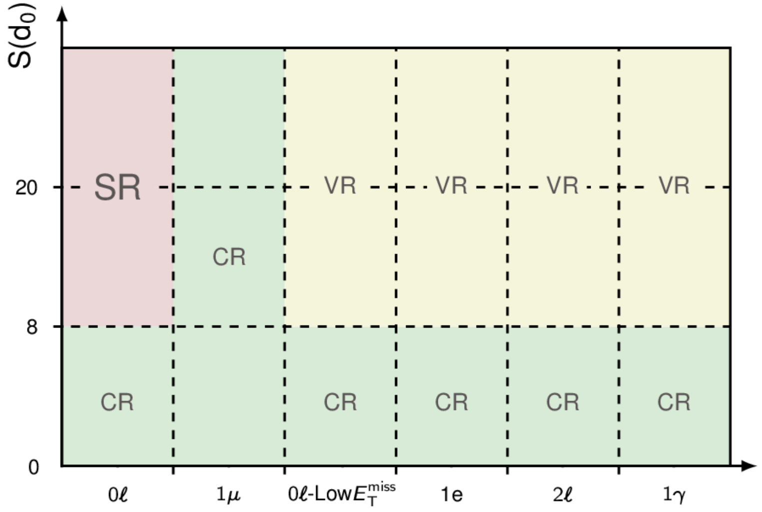
Displaced Track Search

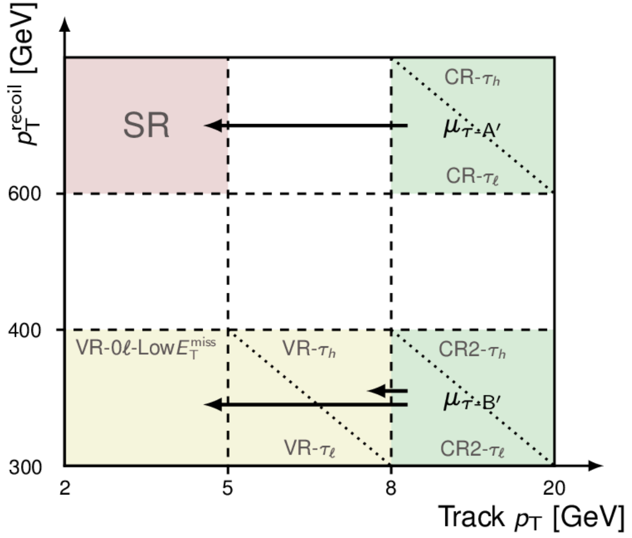
$W(\to \tau_h \nu / \tau_\ell \nu)$ + jets:

- Dedicated control regions for tau decay modes.
- Hadronic tau decay CR
  - Track p_T: $8 < p_T < 20$ GeV
  - $S(d_0) > 3$
- Leptonic tau decay CR
  - 1 lepton
  - $m_T < 50$ GeV
  - Track p_T: $8 < p_T < 20$ GeV
  - $S(d_0) > 3$

QCD Track:

- Fully data-driven background estimation.
  - Shape derived from CR-1μ
  - Normalized to $0 < S(d_0) < 8$ yield
- CR-1μ:
  - 1 muon
  - $p_T^{recoil} > 300$ GeV
    - ($p_T^{recoil} = |\boldsymbol{p_T}(\mu) + \boldsymbol{p_T^{miss}}|$)
  - Contributions other than $W(\to \mu\nu)$+jets subtracted out.
- Dedicated validation regions show good agreement of modeling to data.





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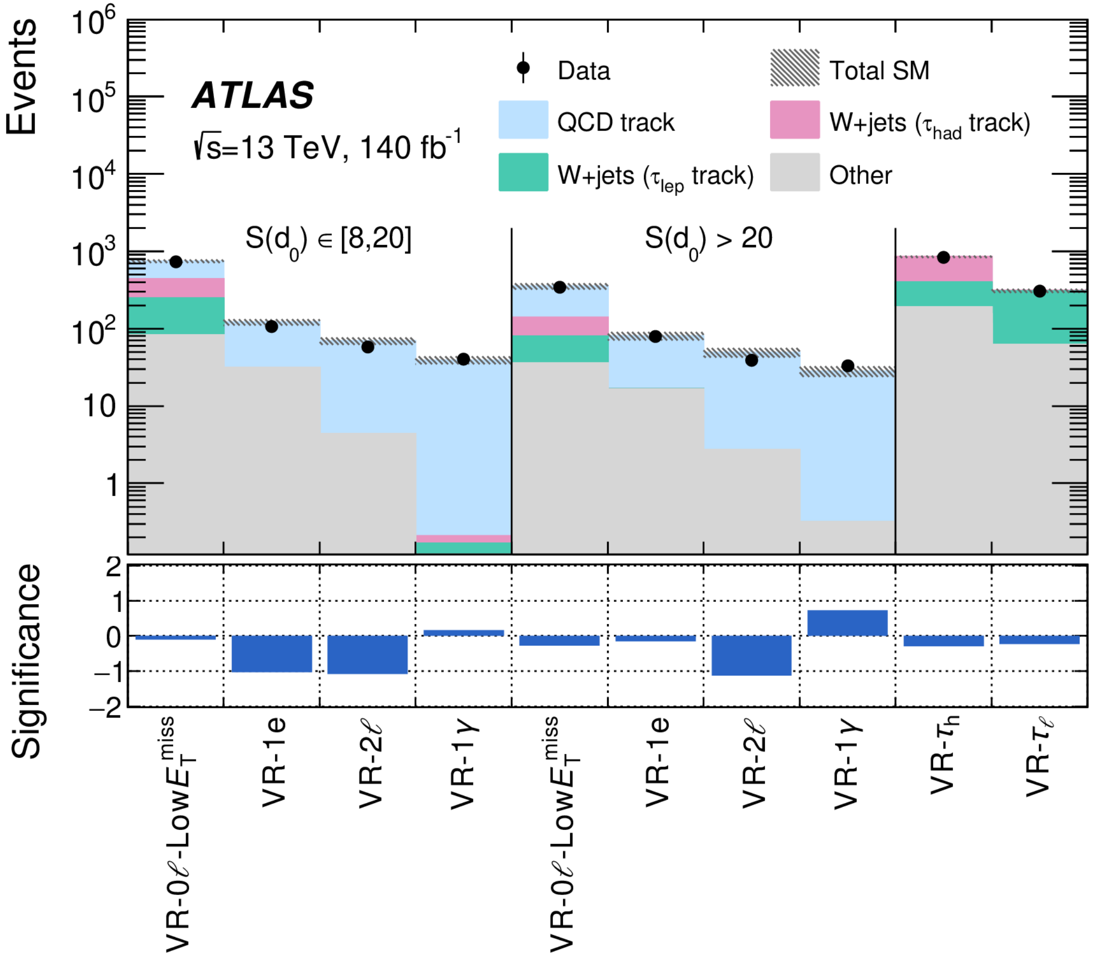
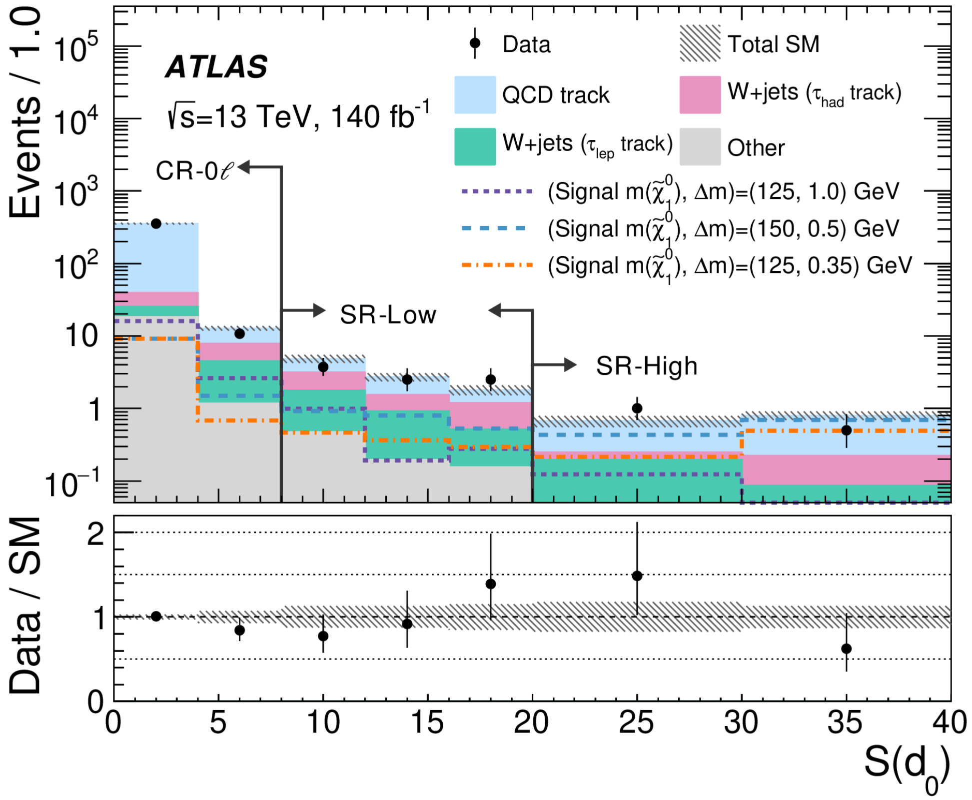
Displaced Track Search: Results





Backup: GMSB $hh(\rightarrow \bar{b}b\bar{b}b)$

Search for SUSY in $hh(\rightarrow \bar{b}b\bar{b}b)$

Common Selections:

- Veto events with signal-quality leptons
- Veto events with >1 loose lepton with $p_T > 8$ GeV

Trigger selections:

Category	Year	Online selections	Offline selections
		Low-mass channel	
$2b1j$	2016	1 jet ($p_{\mathrm{T}} > 100$ GeV), 2 b-jets (60% b-jet efficiency, $p_{\mathrm{T}} > 55$ GeV)	$p_{\mathrm{T},j1} > 150$ GeV
	2017	1 jet ($p_{\mathrm{T}} > 150$ GeV), 2 b-jets (70% b-jet efficiency, $p_{\mathrm{T}} > 55$ GeV)	$p_{\mathrm{T},j1} > 350$ GeV
	2018		$p_{\mathrm{T},j1} > 500$ GeV
$2bH_{\mathrm{T}}$	2017	$H_{\mathrm{T}} > 300$ GeV, 2 b-jets (50% b-jet efficiency, $p_{\mathrm{T}} > 55$ GeV)	$p_{\mathrm{T},j1} < 350$ GeV, $H_{\mathrm{T}} > 850$ GeV
	2018		$p_{\mathrm{T},j1} < 500$ GeV, $H_{\mathrm{T}} > 700$ GeV
$2b2j$	2016	2 jets ($p_{\mathrm{T}} > 35$ GeV), 2 b-jets (60% b-jet efficiency, $p_{\mathrm{T}} > 35$ GeV)	$p_{\mathrm{T},j1} < 150$ GeV
	2017	2 jets ($p_{\mathrm{T}} > 35$ GeV), 2 b-jets (40% b-jet efficiency, $p_{\mathrm{T}} > 35$ GeV)	$p_{\mathrm{T},j1} < 350$ GeV, $H_{\mathrm{T}} < 850$ GeV
	2018	2 jets ($p_{\mathrm{T}} > 35$ GeV), 2 b-jets (60% b-jet efficiency, $p_{\mathrm{T}} > 35$ GeV)	$p_{\mathrm{T},j1} < 500$ GeV, $H_{\mathrm{T}} < 700$ GeV
		High-mass channel	
$E_{\mathrm{T}}^{\mathrm{miss}}$	2015	$E_{\mathrm{T}}^{\mathrm{miss}}$ (μ inv.) > 70 GeV	$E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV
	2016	$E_{\mathrm{T}}^{\mathrm{miss}}$ (μ inv.) > 90 GeV	
	2017	$E_{\mathrm{T}}^{\mathrm{miss}}$ (μ inv.) > 100 GeV	
	2018	$E_{\mathrm{T}}^{\mathrm{miss}}$ (μ inv.) > 110 GeV	

Higgs candidate construction:

- Events with at least 4 b-tagged jets:
  - Construct all 3 pairs Higgs candidates from 4 highest p_T b-tagged jets.
  - Build $\Delta R_{max}^{bb}(\mathrm{h}_1, \mathrm{h}_2) = \max(\Delta R(h_1), \Delta R(h_2))$ for each pair.
  - Select the pairing which minimizes $\Delta R_{max}^{bb}(h_1, h_2)$.
- Events with 3 b-tagged jets:
  - If one b-tagged jet has a mass greater than 100 GeV:
    - Consider the largest p_T jet to be a boosted-Higgs candidate.
    - Pair the other two b-tagged jets as a Higgs candidate.
  - Otherwise:
    - Follow the 4 b-tagged jet procedure and use the untagged small-radius jet which minimizes the value of $m(h_1)$ as the fourth jet for constructing Higgs candidates.

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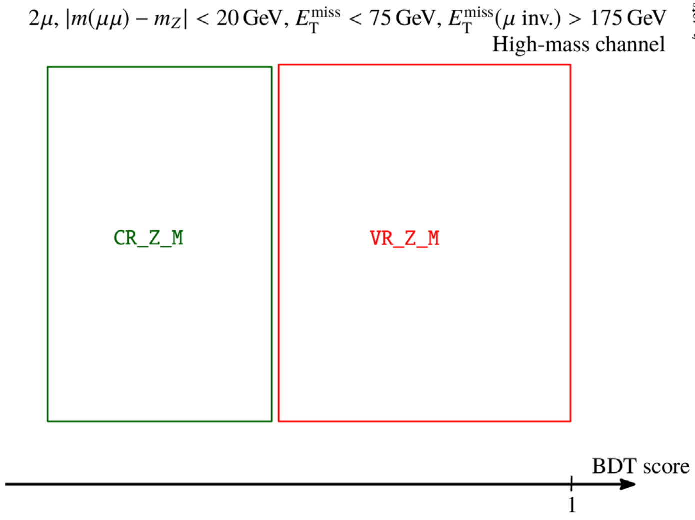
High-Mass Channel

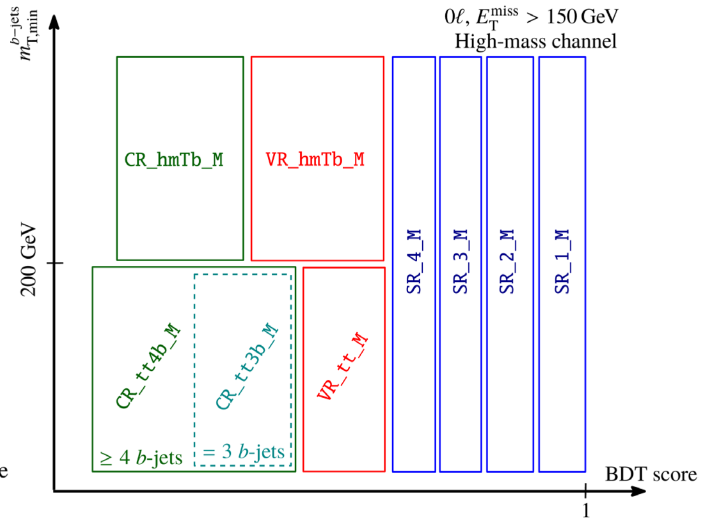
Signal Event Selection

- $E_T^{miss} > 150$ GeV
- ≥ 3 b-tagged jets
- Between 4 and 7 small radius jets with $p_T > 25$ GeV
- $\Delta\phi_{min}^{4j} = \min_{j\in\{1,2,3,4\}}\left(\Delta\phi\left(j_i, E_T^{miss}\right)\right) > 0.4$

BDT trained and SRs defined in BDT score for 11 mass hypotheses.

- $m_{\tilde{H}}$ ={200,250,300,400,500,600,700,800,900,1000,1100} GeV





Dominate Backgrounds and Modeling Strategy:

- $t\bar{t}$, Z + jets, single top: Normalization of MC from CRs
- QCD multijet: Data-driven template with NN reweighting.

SRs defined by BDT score for each mass hypothesis iteratively, such that.

- $n_{bkg} > 0.5$
- Optimize significance, Z. If Z < 1, cease iterative procedure.
- If more than 4 SRs are generated, merge lowest score SRs until 4 remain.

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Low-Mass Channel

Signal Event Selection:

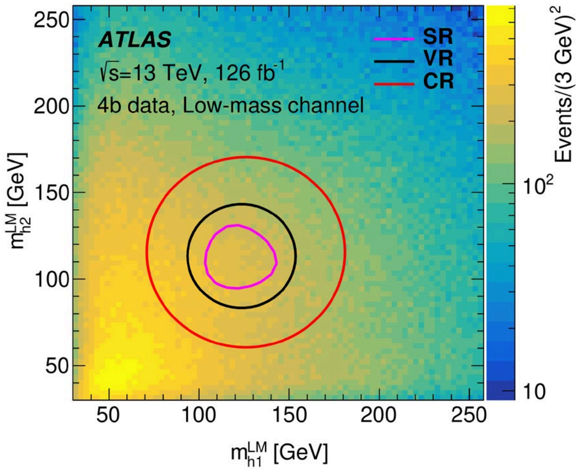
- ≥ 4 b-tagged jets
- Veto events with > 2 loose leptons
- Veto events with $X_{Wt} < 1.8$; $X_{Wt} = \sqrt{\left(\frac{m_{jj}-m_W}{0.1*m_{jj}}\right)^2 + \left(\frac{m_{jjb}-m_t}{0.1*m_{jjb}}\right)^2}$
- $X_{hh}^{SR} < 1.6$; $X_{hh}^{SR} = \sqrt{\left(\frac{m(h_1^{LM})-120\ GeV}{0.1*m(h_1^{LM})}\right)^2 + \left(\frac{m(h_2^{LM})-110\ GeV}{0.1*m(h_2^{LM})}\right)^2}$

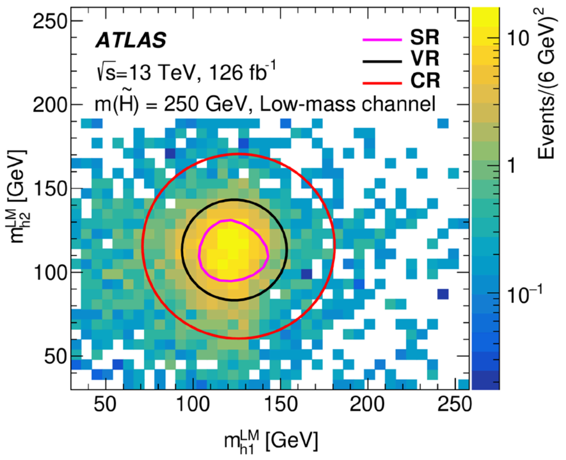
The last veto is to reduce hadronic $t\bar{t}$ contributions and is calculated by constructing top quark and W boson candidates from the jets in the event.

- Top quark candidate constructed from three jets.
  - One must be from a Higgs candidate and is considered the b-jet from the top decay.
  - The other two form the W-boson candidate.
- W boson candidate must have one jet which is not associated a Higgs candidate.
- The quantity X_{Wt} is then calculated for each combination of jets which fit the criteria and if any combination has $X_{Wt} < 1.8$ the event is vetoed.

SRs are binned in two dimensions with lower bins of:

- E_T^{miss} ={0,20,40,60,80,100,120,140,160,180,200} GeV
- m_{eff} ={160,200,260,340,440,560,700,860} GeV
  - m_{eff} is E_T^{miss} plus the scalar sum p_T of jets associated with Higgs candidates.





Dominate background and modeling strategy:

- QCD multijet: Data-driven with BDT reweighting.
  - 2-b jet and 4-b jet regions defined the same way for CRs, VRs, and SRs.
  - Normalization factors defined by data-taking period for each CR bin.

Signal Event Selection:

- ≥ 4 b-tagged jets
- Veto events with > 2 loose leptons
- Veto events with $X_{Wt} < 1.8$; $X_{Wt} = \sqrt{\left(\frac{m_{jj}-m_W}{0.1*m_{jj}}\right)^2 + \left(\frac{m_{jjb}-m_t}{0.1*m_{jjb}}\right)^2}$
- $X_{hh}^{SR} < 1.6$; $X_{hh}^{SR} = \sqrt{\left(\frac{m(h_1^{LM})-120\ GeV}{0.1*m(h_1^{LM})}\right)^2 + \left(\frac{m(h_2^{LM})-110\ GeV}{0.1*m(h_2^{LM})}\right)^2}$

The last veto is to reduce hadronic $t\bar{t}$ contributions and is calculated by constructing top quark and W boson candidates from the jets in the event.

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  - The other two form the W-boson candidate.
- W boson candidate must have one jet which is not associated a Higgs candidate.
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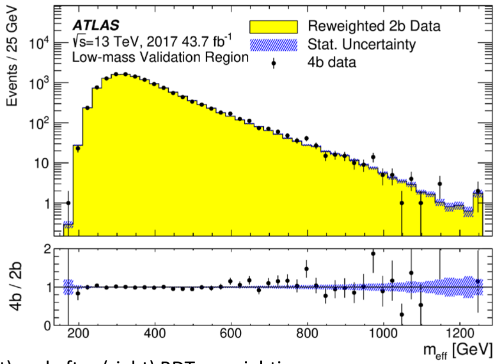
SRs are binned in two dimensions with lower bins of:

- E_T^{miss} ={0,20,40,60,80,100,120,140,160,180,200} GeV
- m_{eff} ={160,200,260,340,440,560,700,860} GeV
  - m_{eff} is E_T^{miss} plus the scalar sum p_T of jets associated with Higgs candidates.



m_{eff} distribution before (left) and after (right) BDT reweighting

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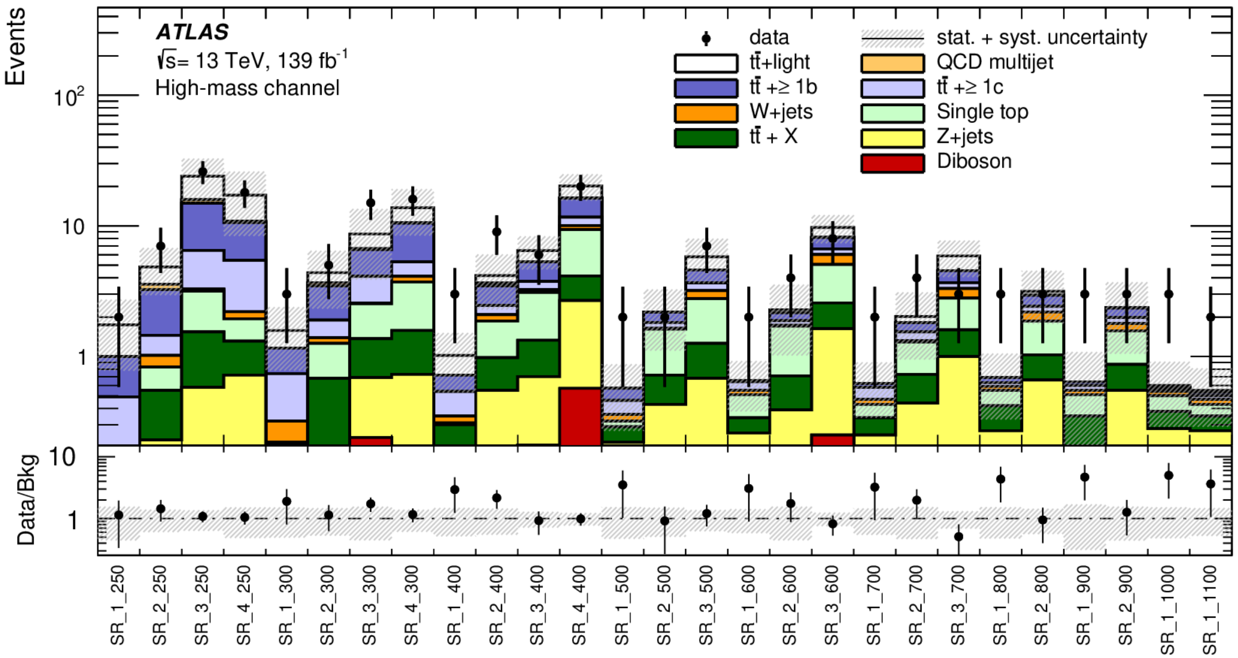
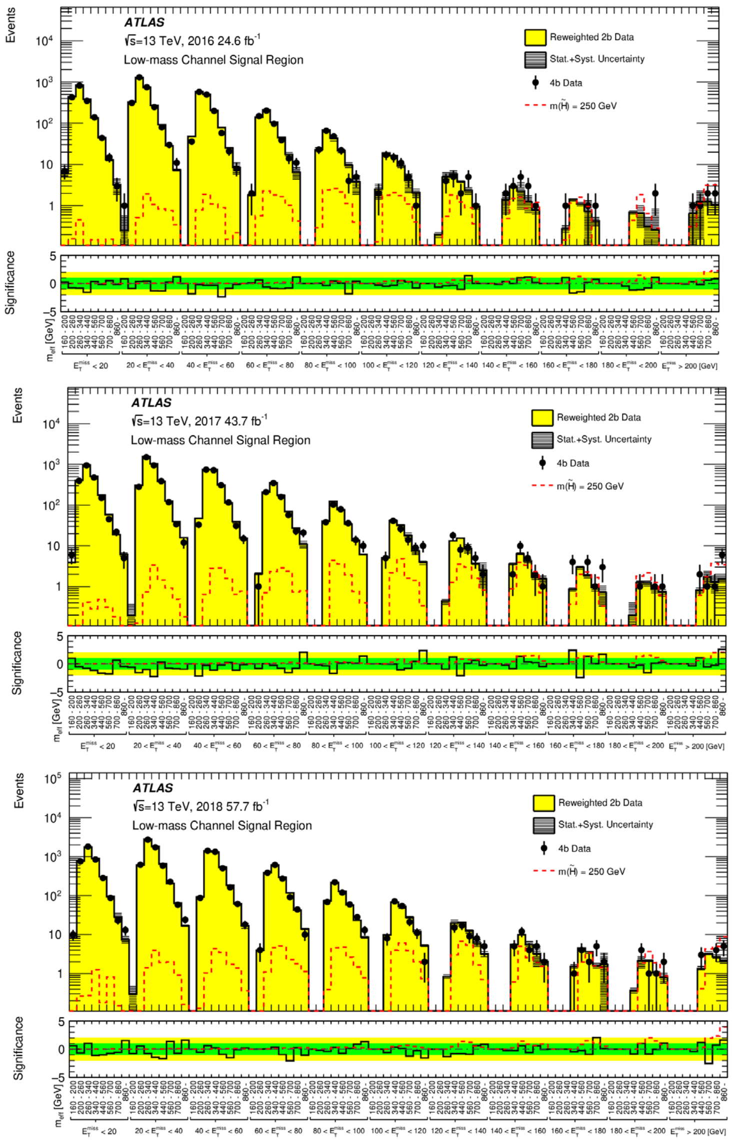
Search for SUSY in $hh(\to \bar{b}b\bar{b}b)$: SR Results





Backup: GMSB $hh(\rightarrow \bar{b}b\gamma\gamma)$

Search for SUSY in $hh(\to \bar{b}b\gamma\gamma)$

Common Event Selection:

- Exactly 2 signal photons
  - Leading photon $p_T > 35$ GeV
  - Sub-leading photon $p_T > 25$ GeV
  - Both photons must have $\frac{p_T}{m_{\gamma\gamma}} > 0.2$
- 95 GeV $< m_{\gamma\gamma} <$ 160 GeV
- Exactly 2 b-tagged jets
- Lepton veto

Requirement	**SR1h**	**SR1Z**	**SR2**
$m_{\gamma\gamma}$	$\in (120, 130)$ GeV		
E_T^{miss}	≤ 100 GeV		> 100 GeV
m_{bb}	$\in (100, 140)$ GeV	$\in (60, 100)$ GeV	$\in (35, 145)$ GeV
$p_T^{\gamma\gamma}$	≥ 90 GeV		–
$p_T^{\gamma\gamma}/m_{\gamma\gamma}$	≥ 0.4		≥ 0.2

Dominant backgrounds and modeling strategy:

- Non-resonant diphoton: 2x2D side-band method.

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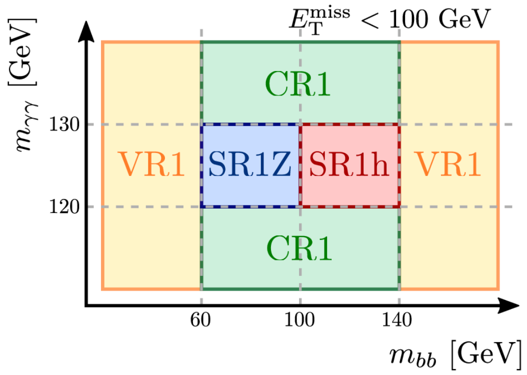
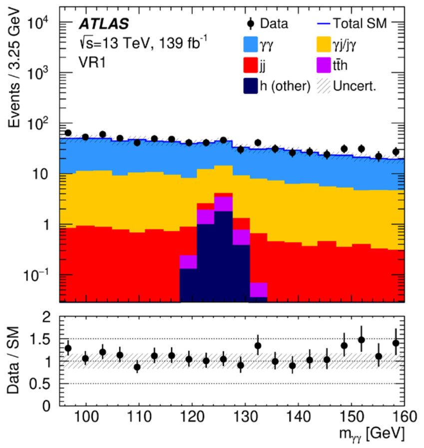
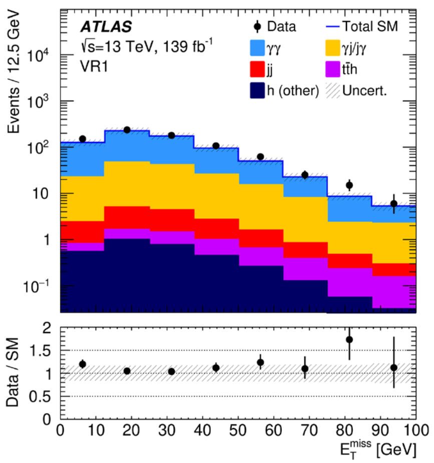
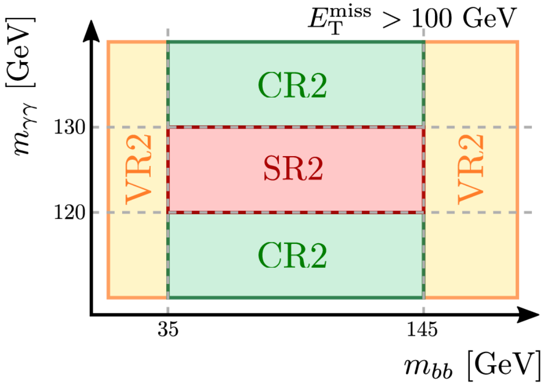
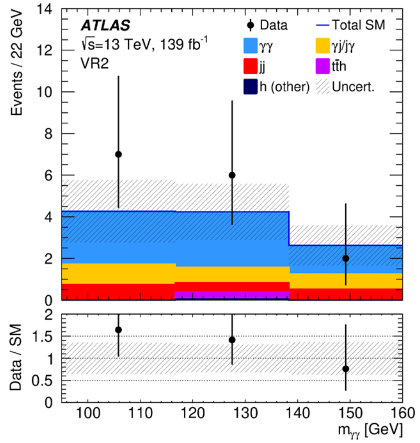
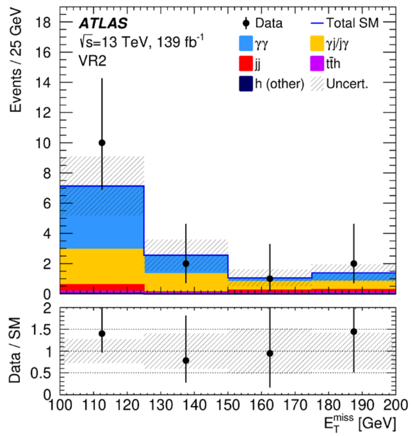




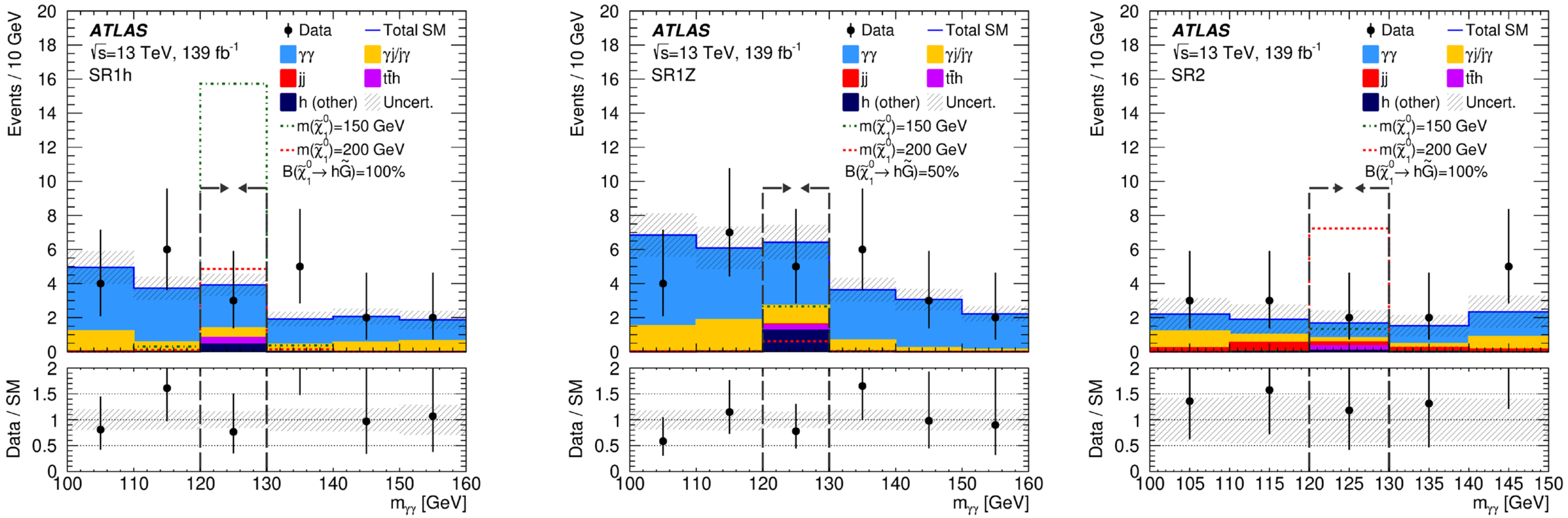


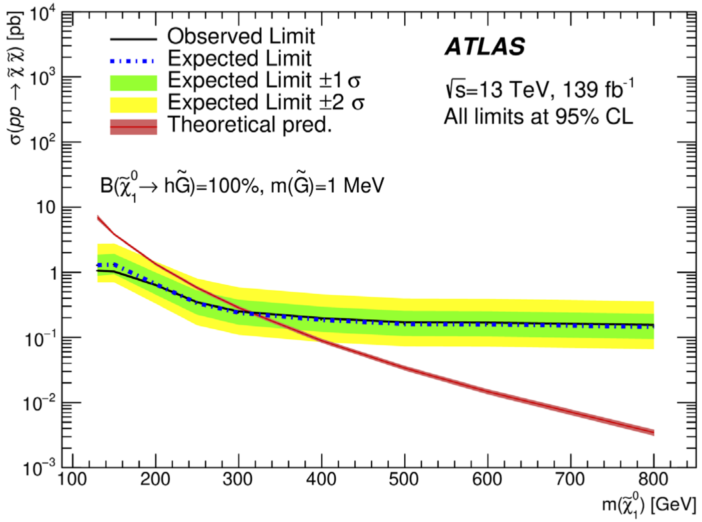




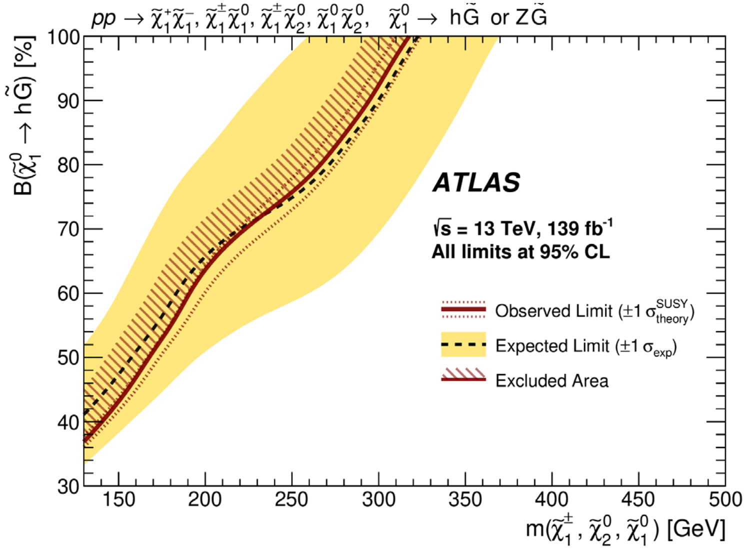


Model-Dependent Limits





95% exclusion up to $m(\tilde{\chi}_1^0) = 320$ GeV assuming $\mathrm{B}(\tilde{\chi}_1^0 \to h\tilde{G}) = 100\%$



95% exclusion of $\mathrm{B}(\tilde{\chi}_1^0 \to h\tilde{G})$ down to 36% for $m(\tilde{\chi}_1^0) = 130$ GeV

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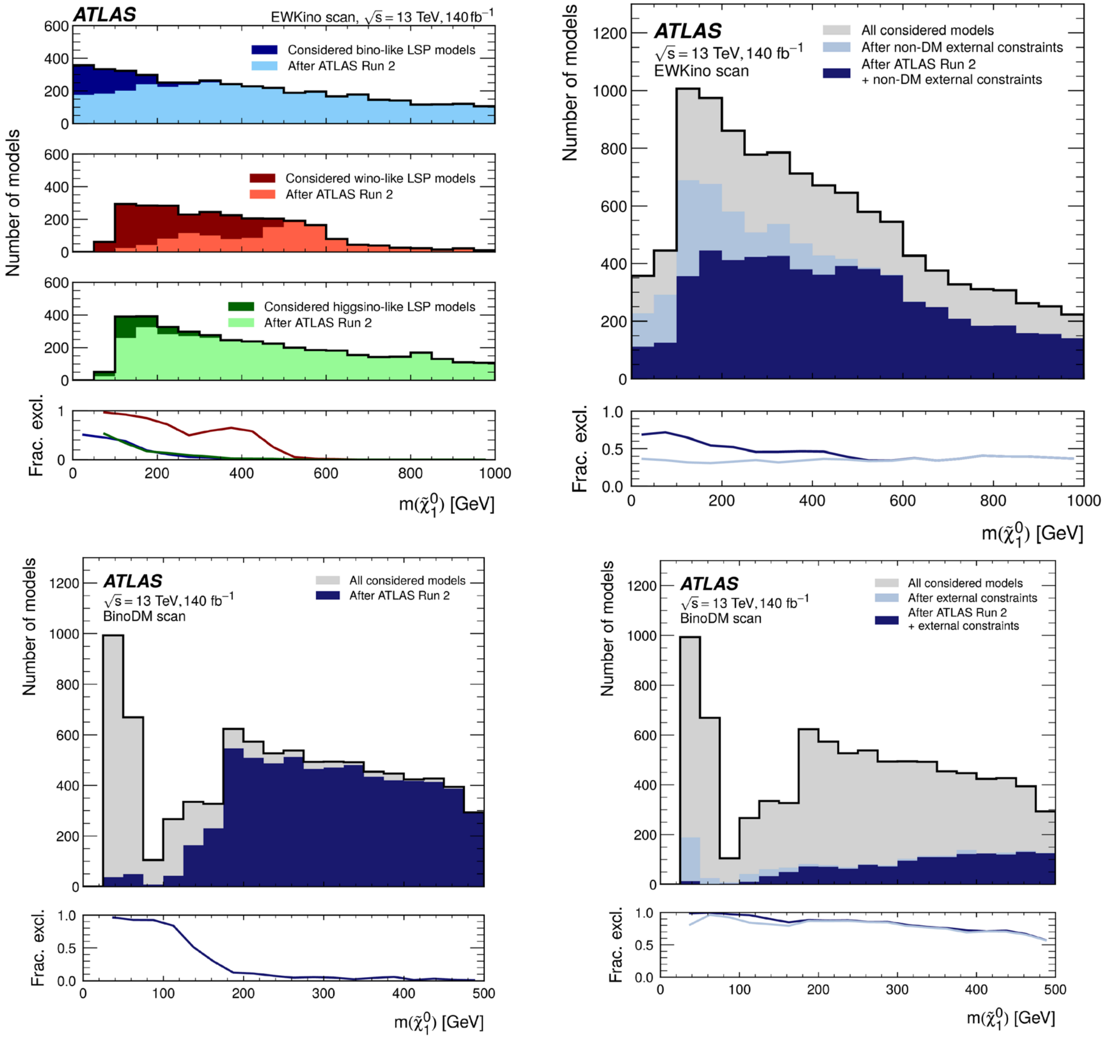
Backup: pMSSM reinterpretations

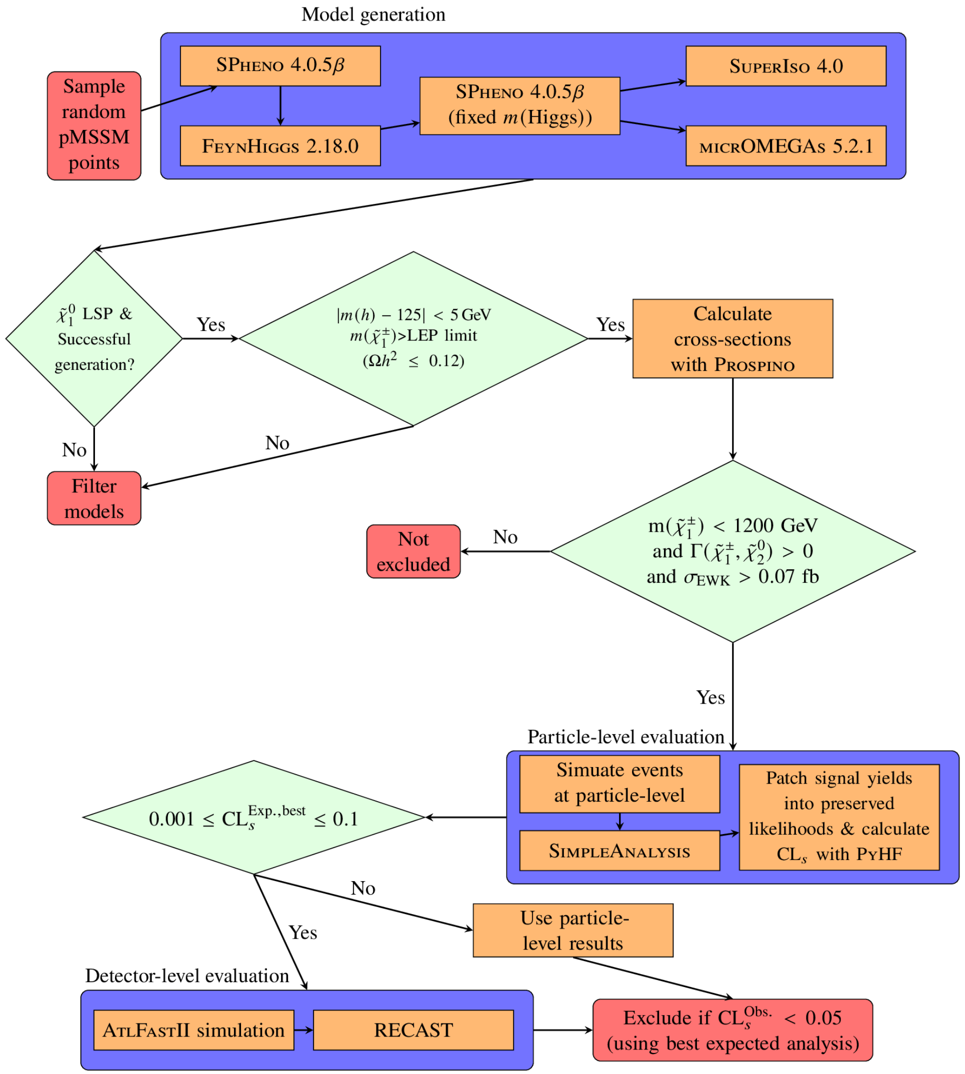
pMSSM results in $m(\tilde{\chi}_1^0)$



ATLAS pMSSM Interpretations

Analysis	Relevant simplified models targeted
FullHad	Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via WZ, Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via Wh, Wino $\tilde{\chi}_1^{+}\tilde{\chi}_1^{-}$ via WW
1Lbb	Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via Wh
2L0J	Wino $\tilde{\chi}_1^{+}\tilde{\chi}_1^{-}$ via WW, slepton pairs
2L2J	Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via WZ
3L	Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via WZ, Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via Wh, higgsino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\tilde{\chi}_1^0$
4L	Higgsino GGM
Compressed	Wino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via WZ, higgsino $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\tilde{\chi}_1^0$
Disappearing-track	Wino $\tilde{\chi}_1^{+}\tilde{\chi}_1^{-}$ and $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^0$

- 8 ATLAS analyses targeting simplified models reinterpreted under pMSSM.
- Models generated by random sampling of pMSSM parameter space.
  - Software suite used to calculate SUSY mass spectra, decays, Higgs sector observables, DM relic density, WIMP-nucleon cross-sections, flavour observables.
- Non-physical models, those incompatible with established LEP limits, and models with Higgs mass outside of the 120 GeV $< m(h) <$ 130 GeV range are filtered out.
- Additional external constraints on flavour, precision EWK, and DM physics used to exclude additional models.



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pMSSM Scan Exclusion Fraction by Sparticle Mass