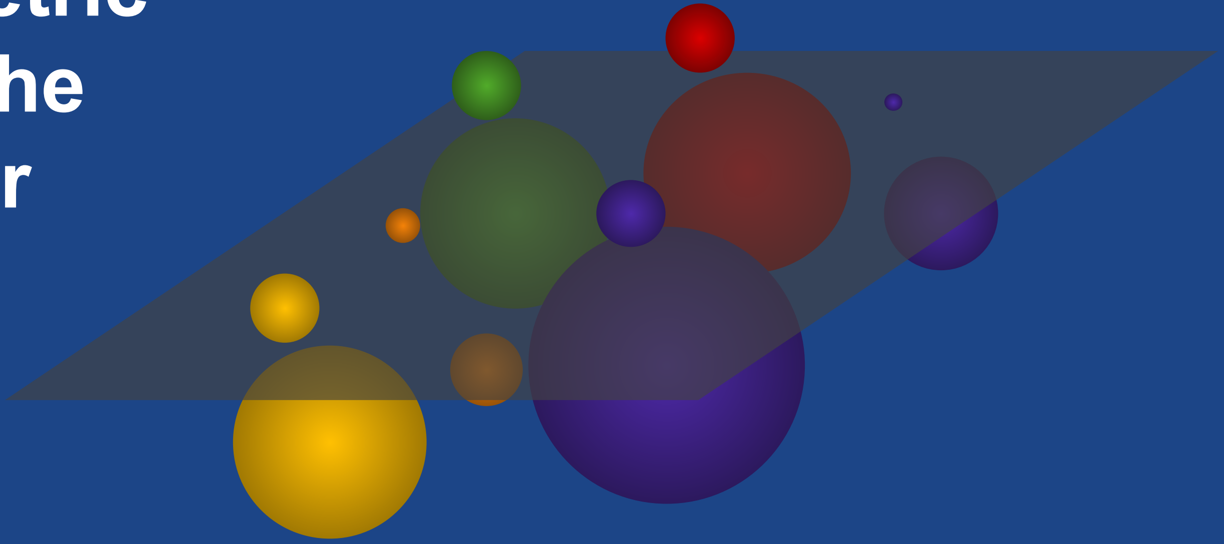
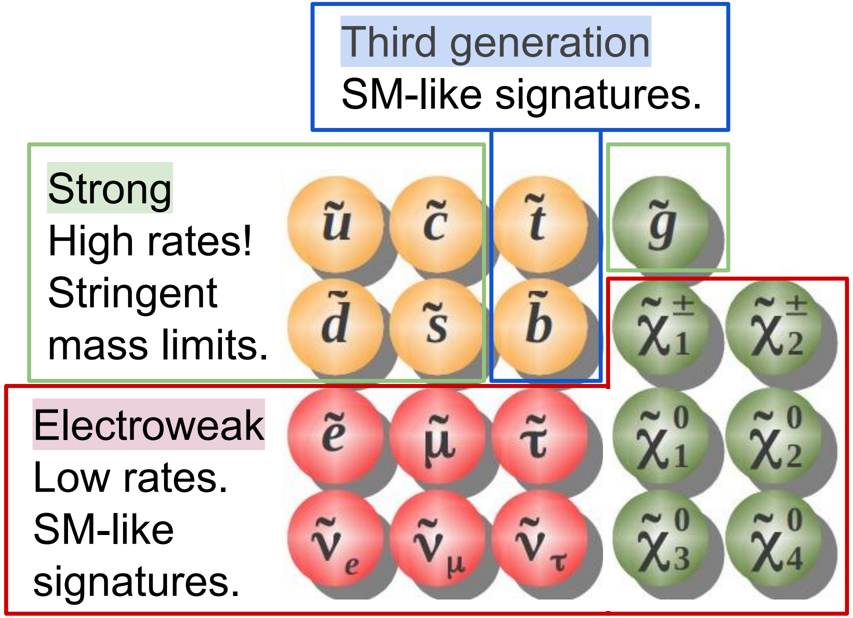
Searches for electroweak production of supersymmetric particles with the ATLAS detector



Tina Potter on behalf of the ATLAS Collaboration

Electroweak SUSY production



Searching for charginos, neutralinos, and sleptons is challenging!

Can be compatible with dark matter relic density.

Natural solution to control the Higgs mass corrections.

No evidence for SUSY particles at LHC so far.

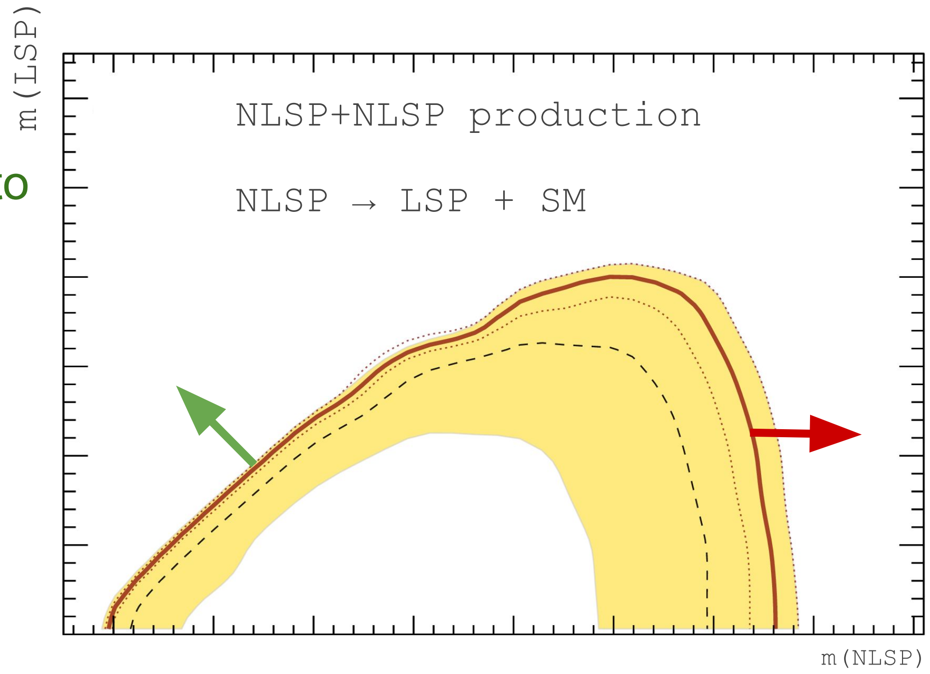
Low-hanging fruit is ruled out. Plenty of uncovered parameter space and data to analyse.

Recent ATLAS results

Late Run2 search strategy aims to

increase sensitivity to compressed SUSY scenarios.

- Soft final states
- ISR
- ML algorithms



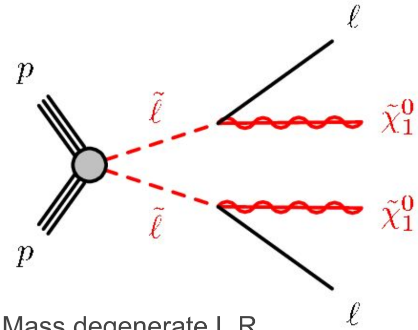
increase sensitivity to higher masses.

- Hadronic final states
- Tighter selections

(N)LSP = (Next to) Lightest SUSY Particle

Slepton and Chargino production

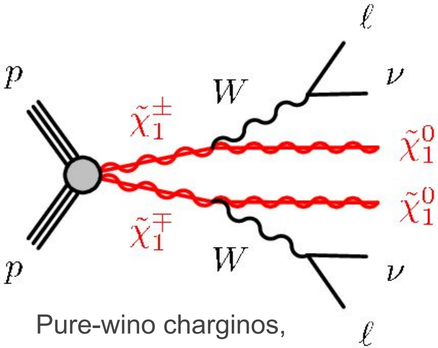
2L arXiv:2209.13935



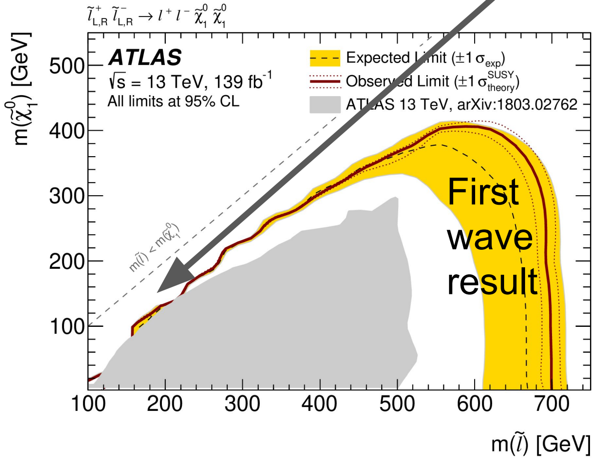
Mass degenerate L,R selectrons and smuons.

SFOS (e^+e^-, $\mu^+\mu^-$) leptons

Focus on the uncovered compressed scenarios for second wave effort

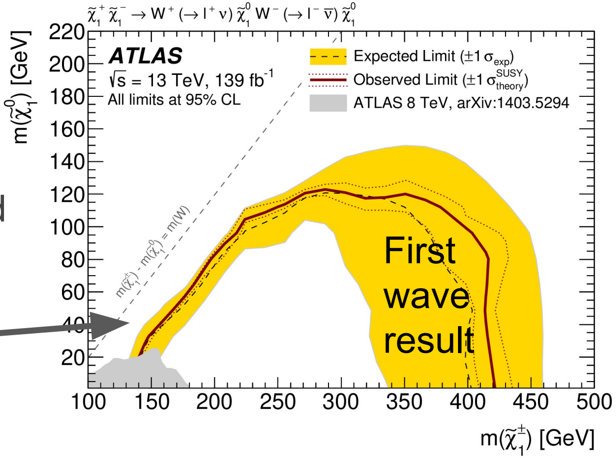


Pure-wino charginos, pure-bino neutralino.



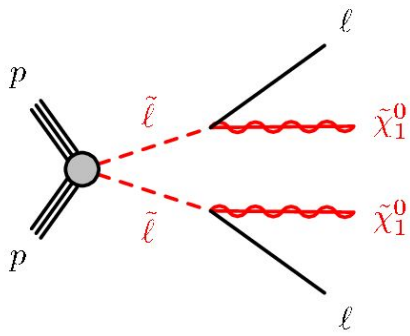
SFOS or DFOS ($e^\pm\mu^\mp$) leptons.

Focus on the uncovered scenarios with mass splittings ~m(W) for second wave effort

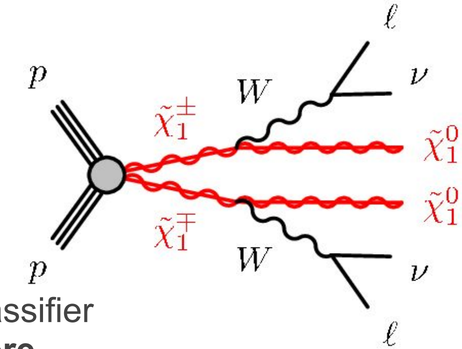


Slepton and Chargino production

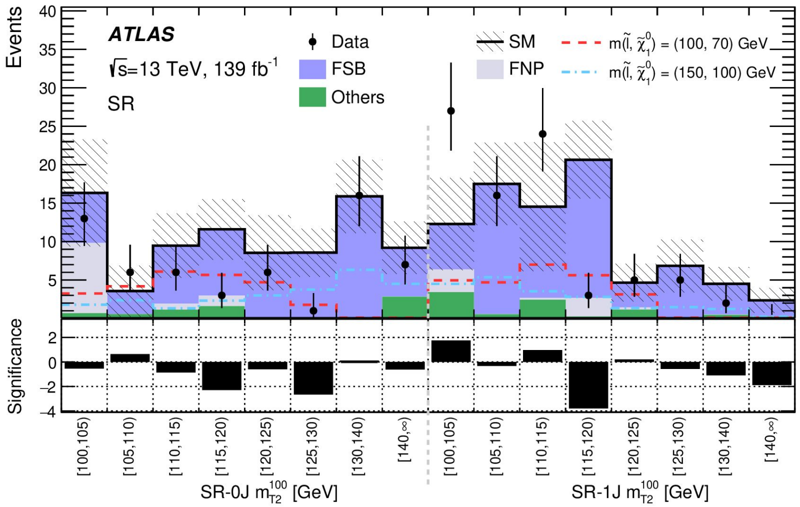
2L arXiv:2209.13935



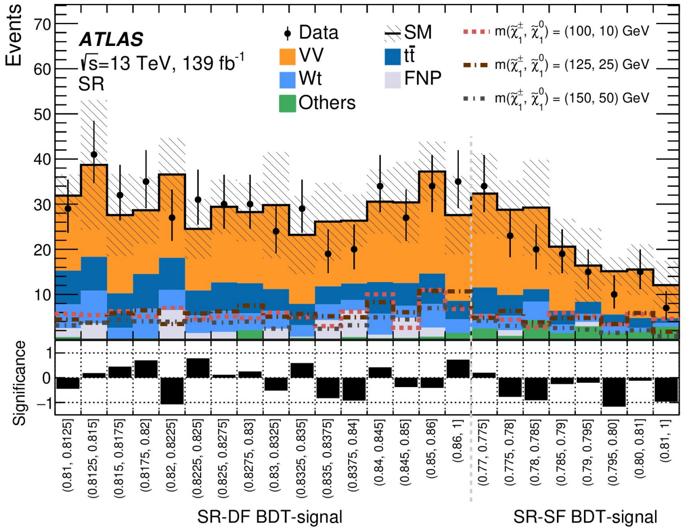
e^+e^-, $\mu^+\mu^-$ (SF)
With/without ISR jet
8 bins in m_{T2}^{100} (>100 GeV)



e^+e^-, $\mu^+\mu^-$, (SF) or $e^{\pm}\mu^{\mp}$ (DF)
Train 2 BDTs for SF and DF.
Gradient Boosted, multiclass classifier
16 (8) bins in DF (SF) BDT score

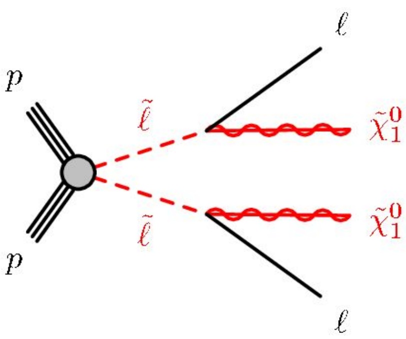


No significant excess in the binned SRs up to 1.5σ



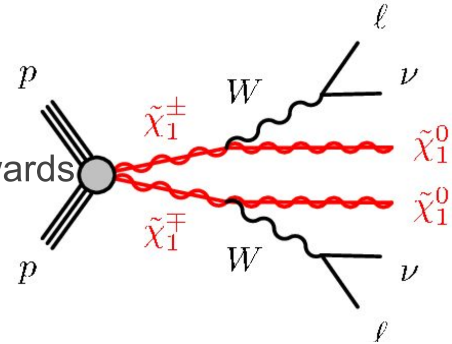
Slepton and Chargino production

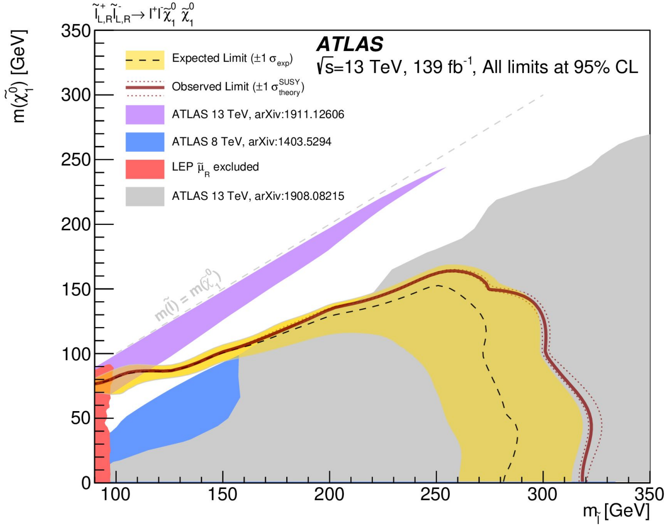
2L [arXiv:2209.13935]



Slepton gap closed for low masses

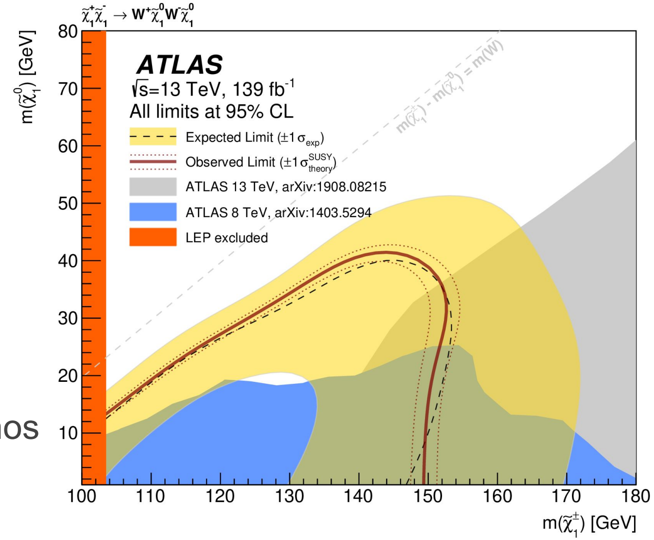
Pushing towards $\Delta m \sim m(W)$ scenarios





$\Delta m \sim 50$ GeV scenarios are excluded for sleptons to up 150 GeV.

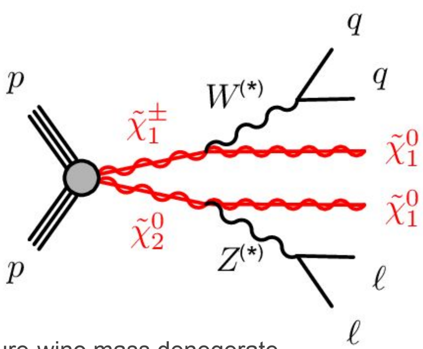
$\Delta m \sim 100$ GeV scenarios are excluded for charginos up to 140 GeV.



Chargino neutralino production

2L2J

arXiv:2204.13072

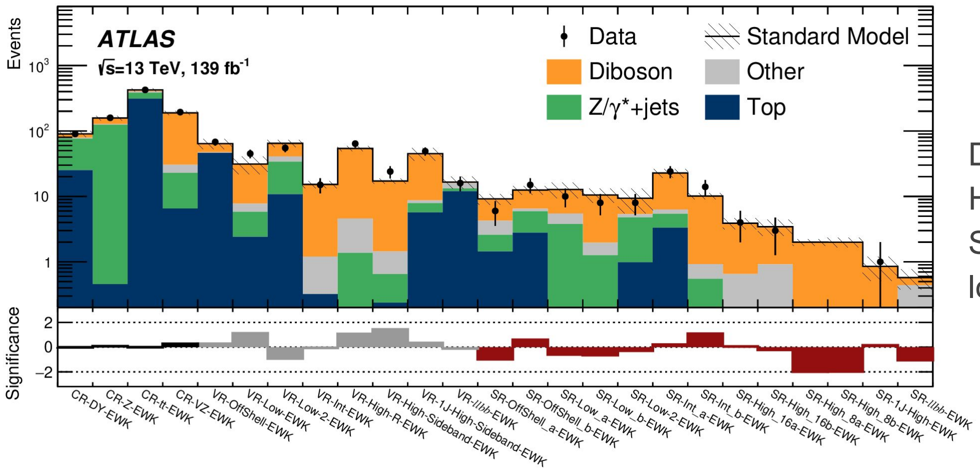


Pure-wino mass denegerate chargino-neutralino2, pure-bino neutralino1

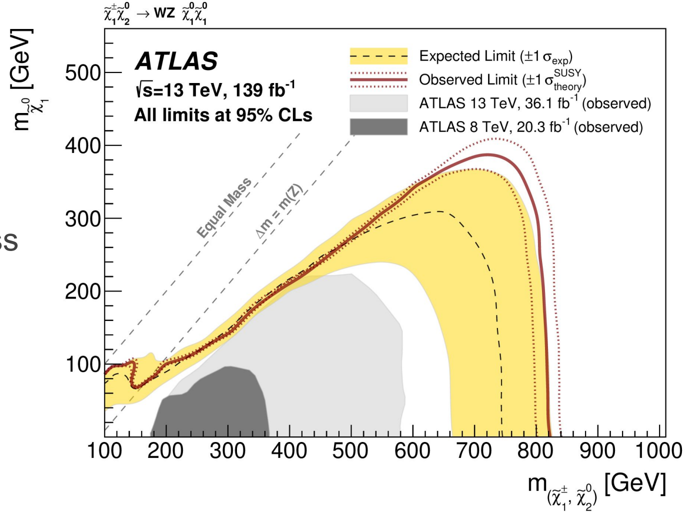
Target high mass scenarios using hadronic and leptonic boson decays.
Search for $Z \to e^+e^-/\mu^+\mu^-$, $V \to qq$ and E_T^{miss}

7 signal regions targeting **high/low mass** scenarios and **on/off-shell** boson decays
m_{T2} m_{ll} m_{jj} and E_T^{miss} significance main discriminating variables
On-shell SRs binned in E_T^{miss} significance (& ΔR_{jj} for SR-High). Offshell binned in m_{ll}

FNP backgrounds from data (MM). Z+jets, Top, VV: MC normalised to data in CRs
MC simulation otherwise

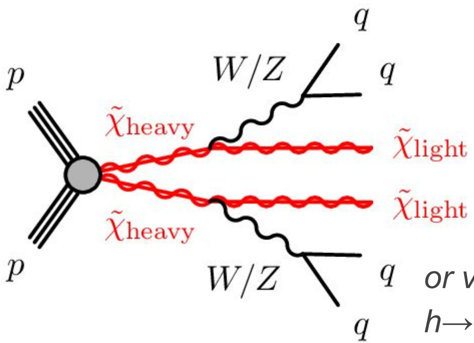


Deficit in High mass SRs with low ΔR_{jj}



Chargino neutralino production

AllHad [PRD 104 (2021) 112010]

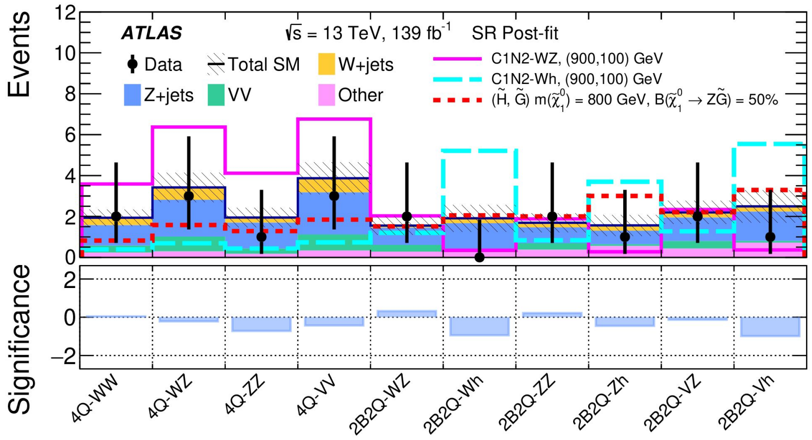


or via $h \to bb$

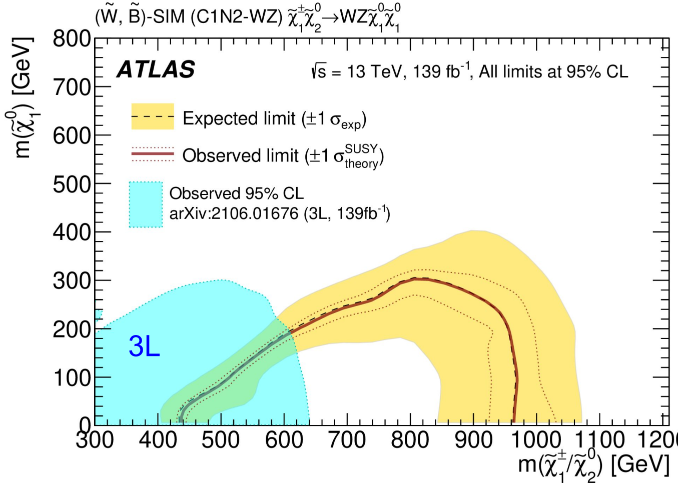
Target very high mass scenarios using all hadronic boson (W,Z,h) decays.
Large mass splittings Δm>400 GeV lead to **boosted topologies**.
Use large-R jets (R=1.0, p_T>200 GeV) with boson-tagging algorithms.
- 4Q: 2 large-R jets, no b-tagged jets inside
- 2B2Q: 2 large-R jets, one contains 2 b-tagged jets

High E_T^{miss} > 200 GeV (trigger), m_{eff}
$Z \to \nu\nu$ background from data, fake boson jets (2 collimated ISR jets faking large-R jet)
- MC normalised to data in dedicated CR

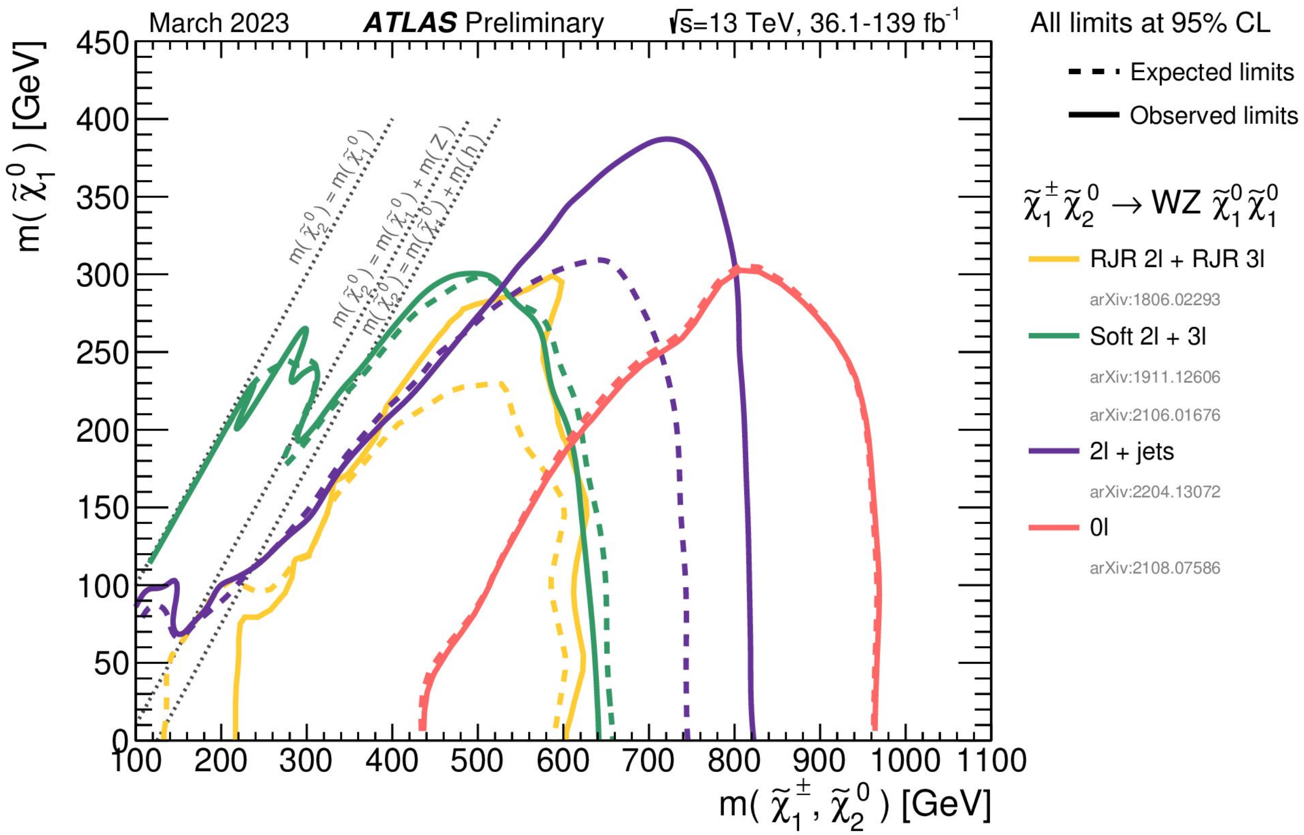
All other backgrounds from MC simulation.

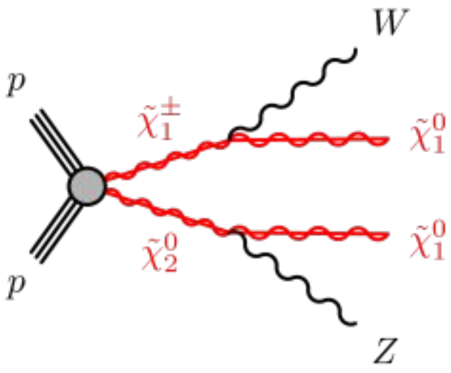


Good agreement in SRs



Chargino neutralino production



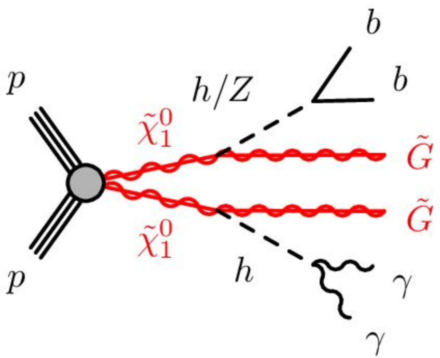


Traditionally the 3-lepton final state is the “golden” channel for this signal.

Using hadronic decays of one or both intermediate bosons extends the reach to very high masses.

Higgsino GGM

ɣɣbb ATLAS-CONF-2023-009

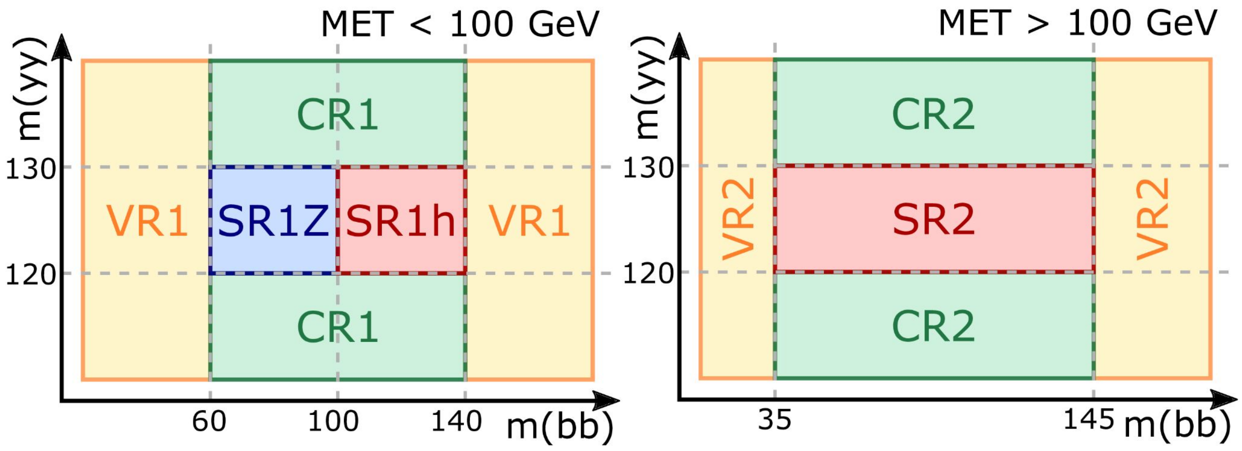


Pure-higgsino, mass denegerate chargino1, neutralino2, neutralino1 Gravitino LSP

Search using **mix of common and rare decays** of SM bosons

High E_T^{miss} from invisible gravitinos

Two high p_T photons (trigger) + 2 b-tagged jets

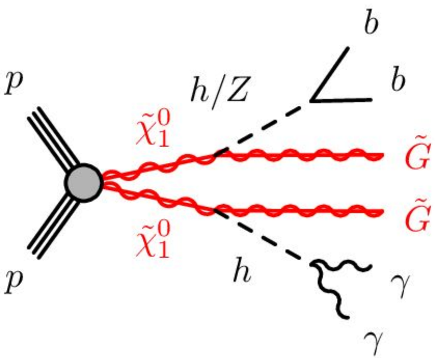


Non-resonant backgrounds determined from a **2x2D sideband method** & tested in VRs

- loosen photon isolation & id to "jets"→ 16 categories of ɣɣ, ɣ-jet, jet-ɣ events
- parametrise category yields using photon efficiencies and fake factors
- fit performed in $|m_{\gamma\gamma} - m_h|$ >5 GeV CRs to obtain category parameters – applied to loose photon SRs.

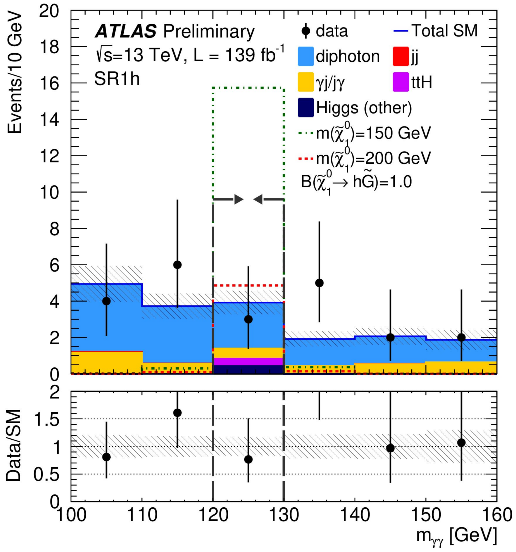
Higgsino GGM

γγbb ATLAS-CONF-2023-009



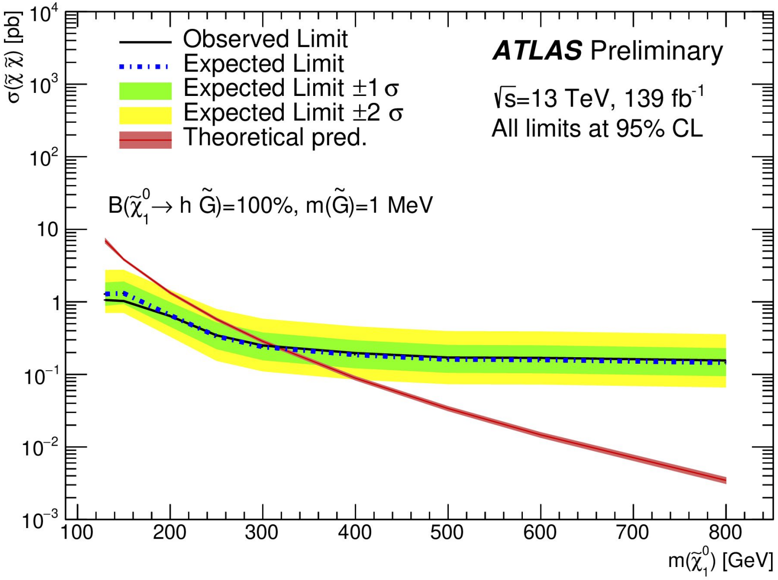
Pure-higgsino, mass denegerate chargino1, neutralino2, neutralino1 Gravitino LSP

Data agrees well with SM prediction.

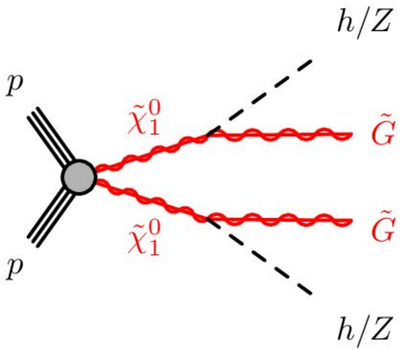


Channel	SR1h	SR1Z	SR2
Observed events	3	5	2
Total SM events	3.9 ± 0.6	6.4 ± 1.0	1.7 ± 0.7

For 100% branching fraction to higgs, Higgsino masses are excluded up to 320 GeV



Higgsino GGM

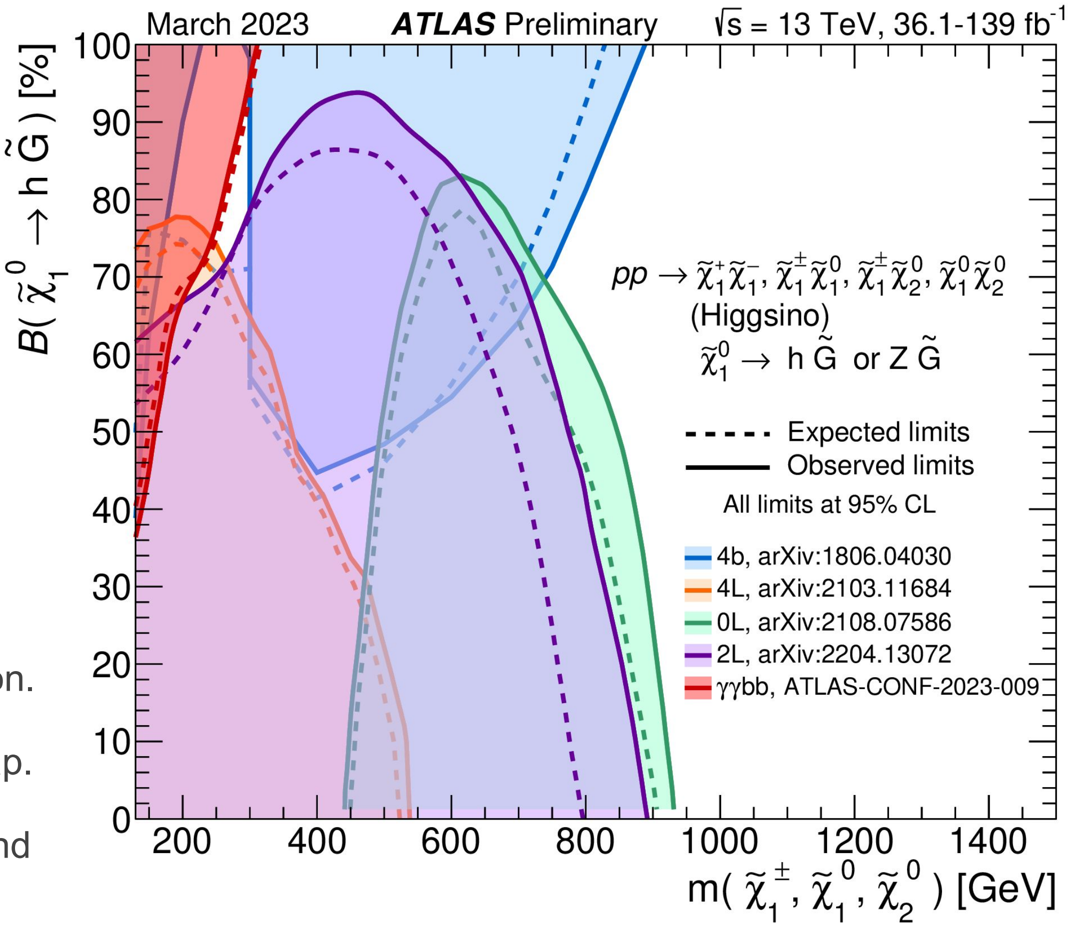


Pure-higgsino, mass denegerate chargino1, neutralino2, neutralino1 Gravitino LSP

~2σ excess from 4b search left 200-300 GeV scenarios in question.

γγbb result partially covers this gap.

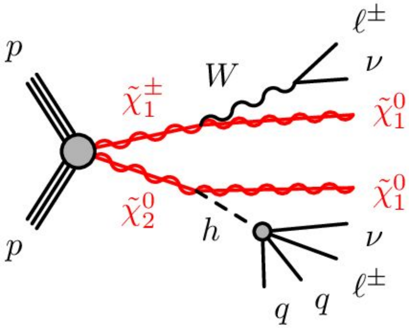
High mass coverage from 2L2J and AllHadronic analyses.

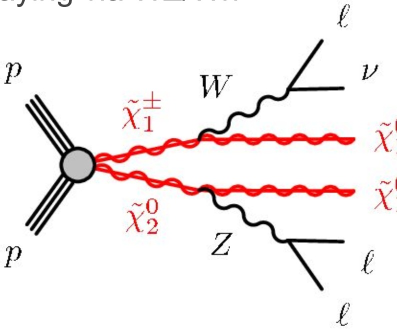


RPC & RPV signatures

SS/3L ATLAS-CONF-2022-057

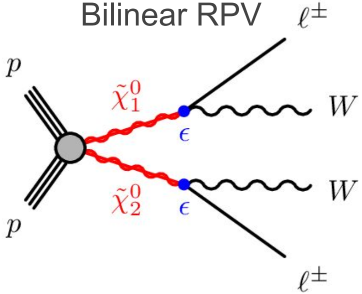
RPC Wino production decaying via WZ/Wh



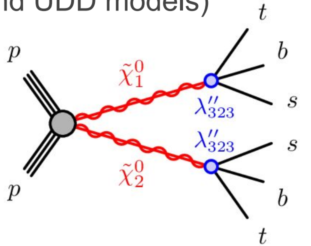


RPV Mass degenerate higgsino production

Bilinear RPV



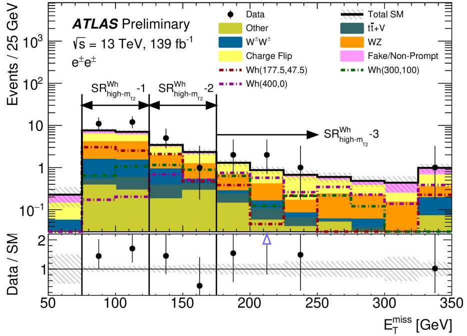
(and UDD models)



2lepton OR E_T^{miss} triggers, SS (3L SR for bRPV model), ≥ 1 jet

<u>Wh SRs</u> $e^\pm e^\pm$, $\mu^\pm\mu^\pm$, $e^\pm\mu^\pm$

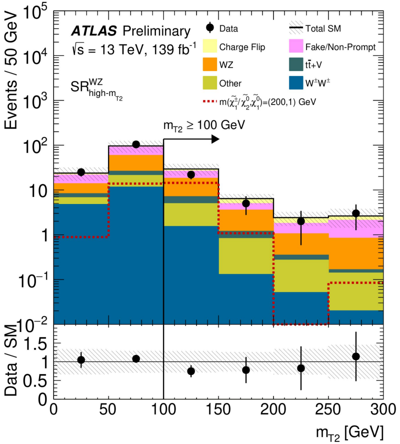
- low and high mass (E_T^{miss} binned) scenarios
- using m_{jj}, m_{T2}, m_T, E_T^{miss}, E_T^{miss}signf

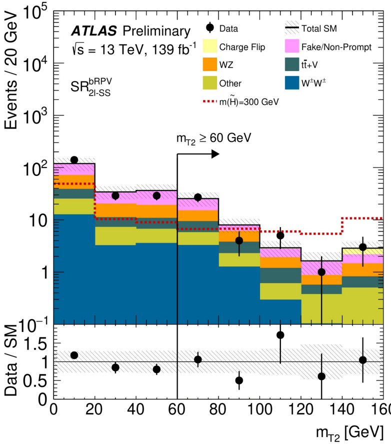


<u>WZ SRs</u>

- low and high mass (E_T^{miss}signf, Spread, ΔR_{ll} binned)

- using m_{jj}, m_{T2}, m_T, E_T^{miss}, m_{eff}, ΔR_{ll}





<u>bRPV SRs</u>

- SS (4 jets)

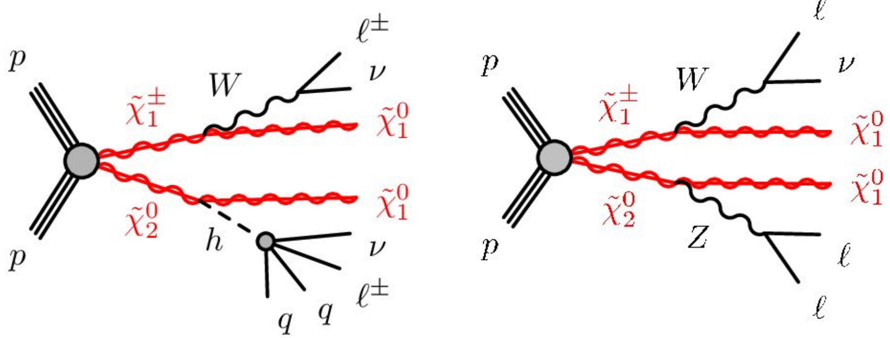
- or 3L (Zveto)

- high m_{T2}, E_T^{miss}

RPC & RPV signatures

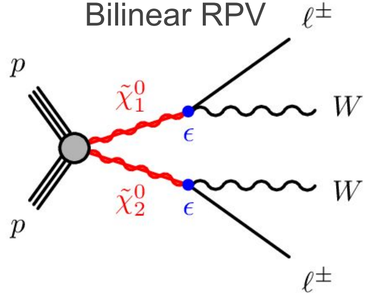
SS/3L ATLAS-CONF-2022-057

RPC Wino production decaying via WZ/Wh

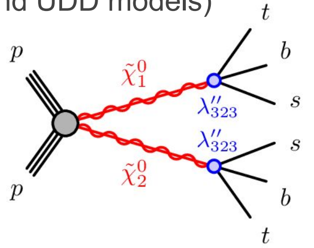


RPV Mass degenerate higgsino production

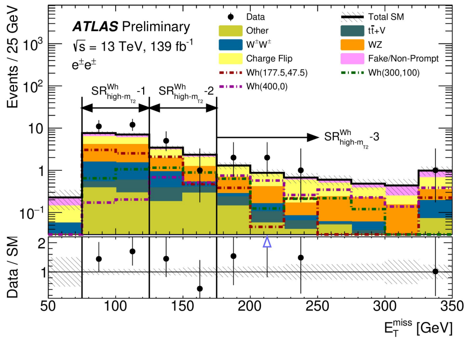
Bilinear RPV



(and UDD models)



Irreducible backgrounds WZ, $W^\pm W^\pm$ dominate. MC normalised to data in dedicated CRs.

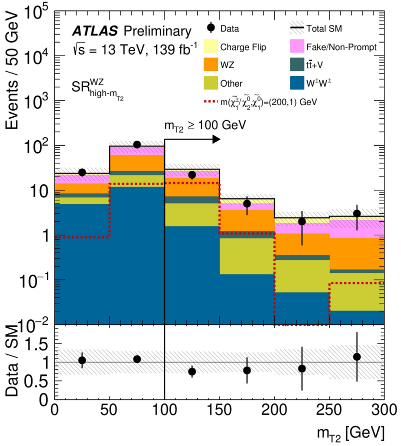


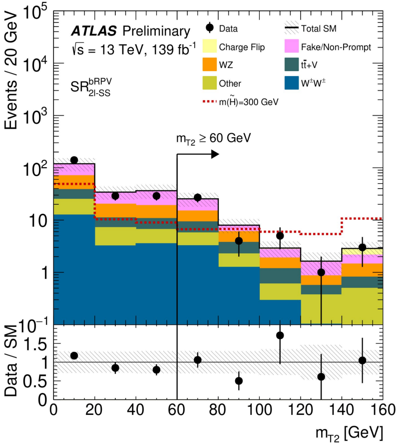
Reducible backgrounds

Misidentified leptons or charge mis-id backgrounds (V+jets)

Estimated from data.

Typically dominates total uncertainty in SRs.





RPC & RPV signatures

SS/3L ATLAS-CONF-2022-057

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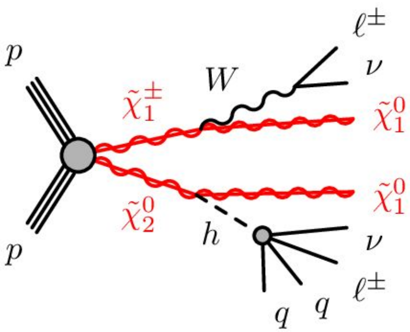
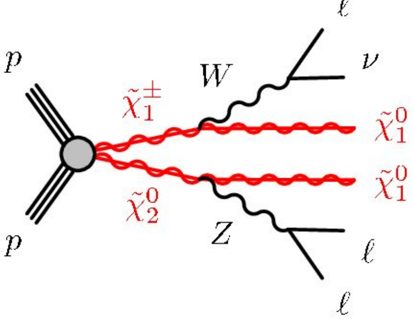
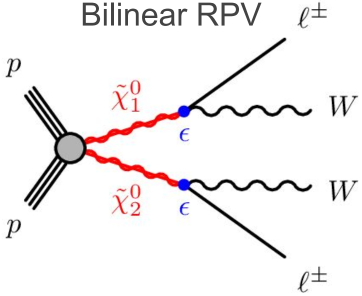




RPV Mass degenerate higgsino production

Bilinear RPV



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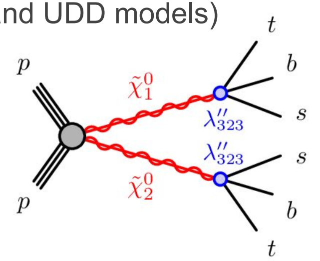

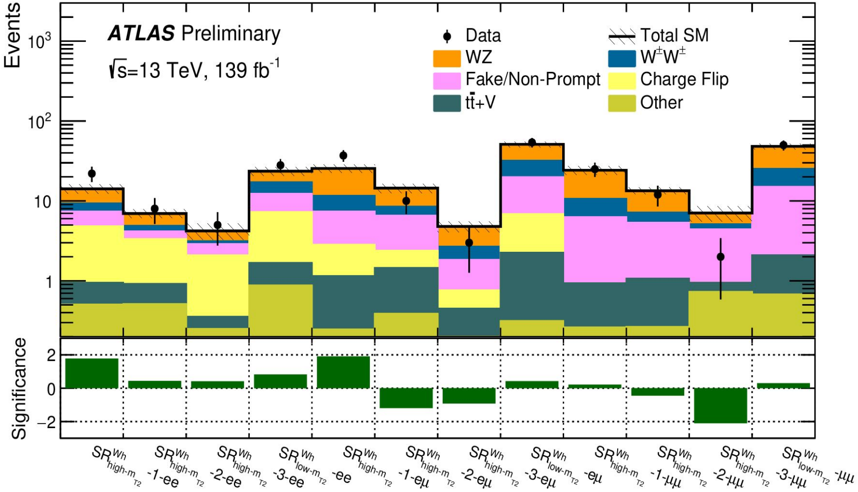

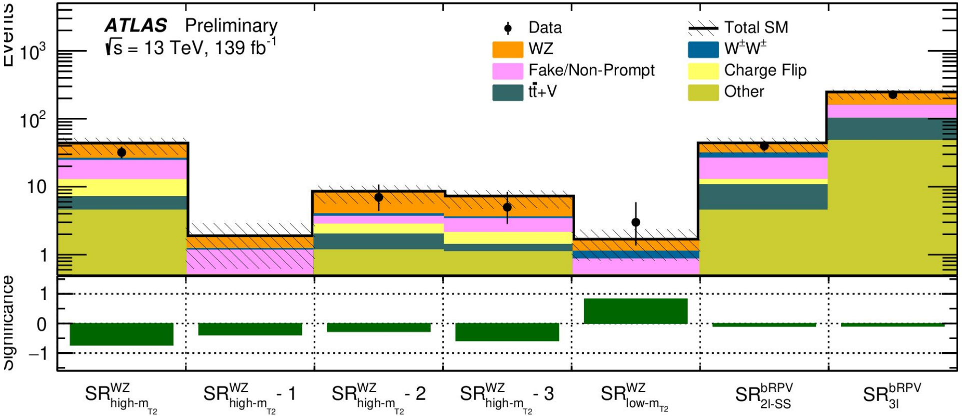

RPC & RPV signatures

SS/3L ATLAS-CONF-2022-057

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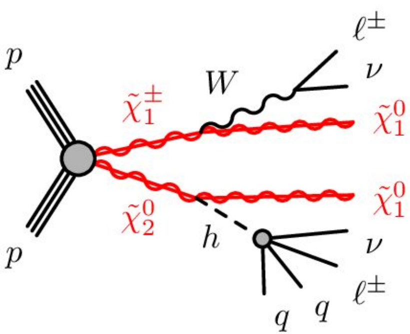
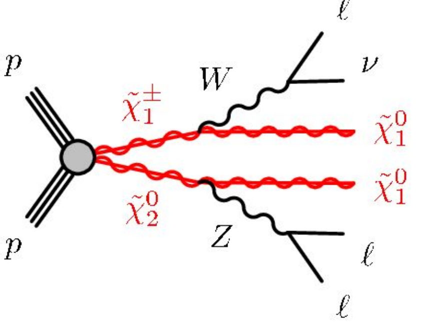
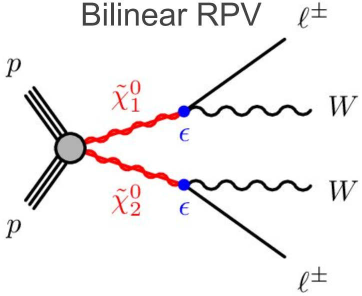
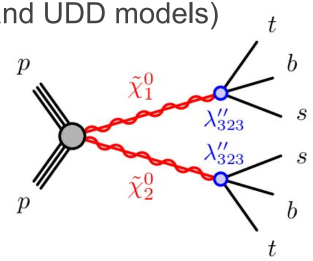



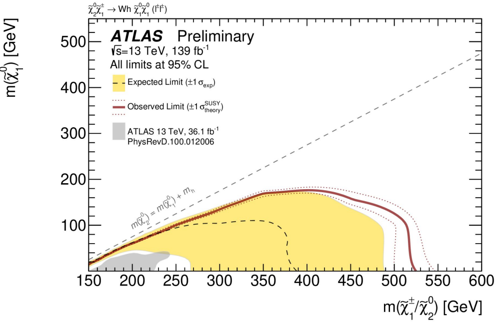
RPV Mass degenerate higgsino production

Bilinear RPV



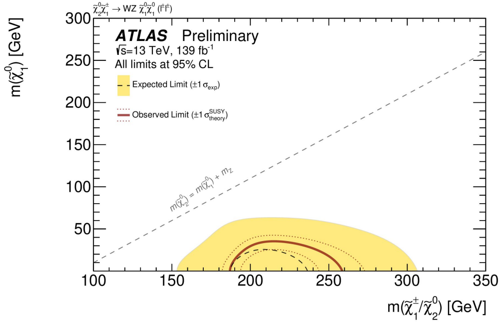
(and UDD models)

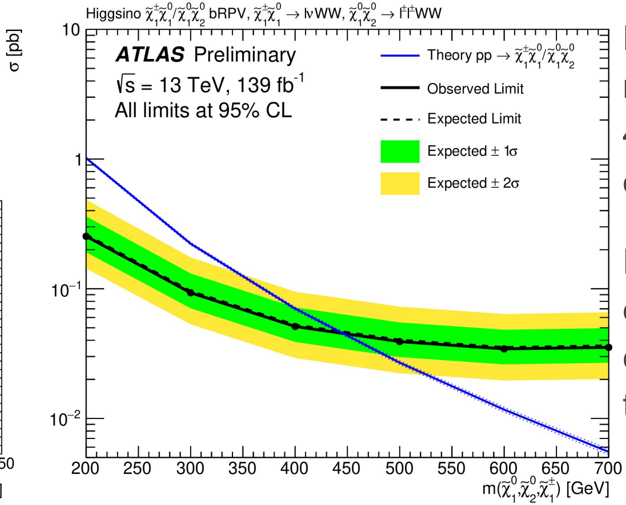




Large improvement on partial Run2 result.

First sensitivity to this model using SS channel





Higgsino masses below 440 GeV excluded.

First experimental constraint on this model

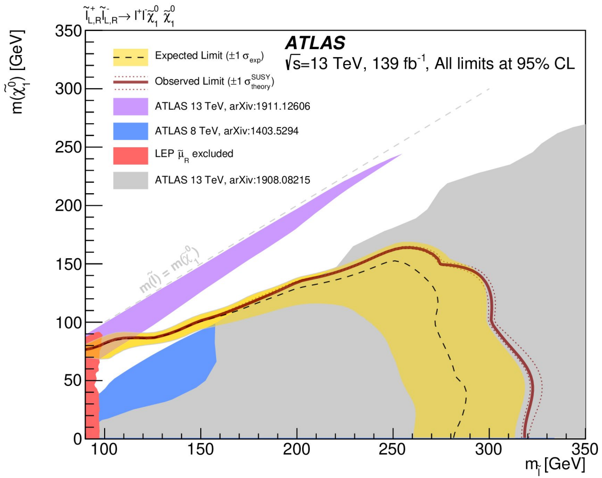
Summary

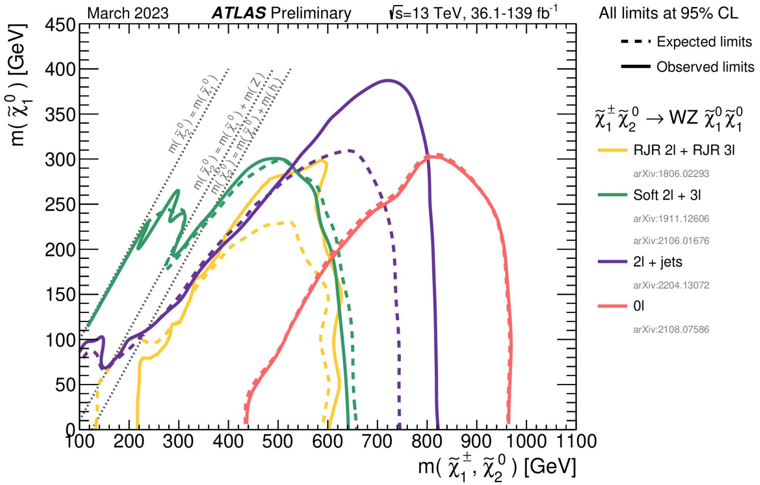
EWK SUSY searches are experimentally challenging.

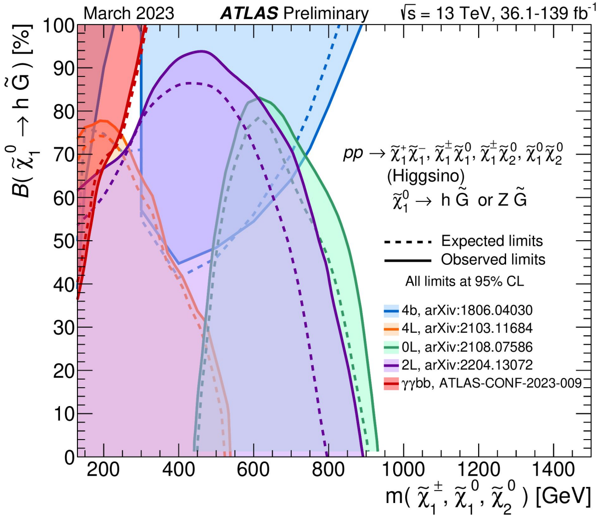
Leaps in sensitivity using improved analysis techniques and hadronic final states.

Closing up some difficult parameter space.

Continue to push for our Run3 searches.







Backup: 2L0J SR selection

sleptons

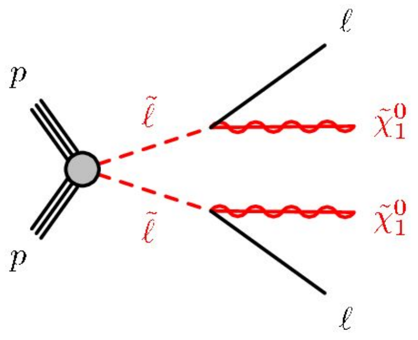
Signal region (SR)	SR-0J	SR-1J
$n_{b\text{-tagged jets}}$	$= 0$	
$E_{\mathrm{T}}^{\mathrm{miss}}$ significance	>7	
$n_{\text{non-}b\text{-tagged jets}}$	$= 0$	$= 1$
$p_{\mathrm{T}}^{\ell_1}$ [GeV]	> 140	> 100
$p_{\mathrm{T}}^{\ell_2}$ [GeV]	> 20	> 50
$m_{\ell\ell}$ [GeV]	> 11	> 60
$p_{\mathrm{T,boost}}^{\ell\ell}$ [GeV]	< 5	-
$\lvert\cos\theta^{*}_{\ell\ell}\rvert$	< 0.2	< 0.1
$\Delta\phi_{\ell,\ell}$	> 2.2	> 2.8
$\Delta\phi_{p_{\mathrm{T}}^{\mathrm{miss}},\ell_1}$	> 2.2	-
Binned SRs		
m_{T2}^{100} [GeV]	∈[100,105) ∈[105,110) ∈[110,115) ∈[115,120) ∈[120,125) ∈[125,130) ∈[130,140) ∈[140,∞)	
Inclusive SRs		
m_{T2}^{100} [GeV]	∈[100,∞) ∈[110,∞) ∈[120,∞) ∈[130,∞) ∈[140,∞)	

charginos

Signal region (SR)	SR-DF	SR-SF
$n_{b\text{-tagged jets}}$	$= 0$	
$n_{\text{non-}b\text{-tagged jets}}$	$= 0$	
$E_{\mathrm{T}}^{\mathrm{miss}}$ significance	>8	
m_{T2}^{0} [GeV]	>50	
BDT-other		< 0.01
Binned SRs		
BDT-signal	∈(0.81,0.8125] ∈(0.8125,0.815] ∈(0.815,0.8175] ∈(0.8175,0.82] ∈(0.82,0.8225] ∈(0.8225,0.825] ∈(0.825,0.8275] ∈(0.8275,0.83] ∈(0.83,0.8325] ∈(0.8325,0.835] ∈(0.835,0.8375] ∈(0.8375,0.84] ∈(0.84,0.845] ∈(0.845,0.85] ∈(0.85,0.86] ∈(0.86,1]	∈(0.77,0.775] ∈(0.775,0.78] ∈(0.78,0.785] ∈(0.785,0.79] ∈(0.79,0.795] ∈(0.795,0.80] ∈(0.80,0.81] ∈(0.81,1]
Inclusive SRs		
BDT-signal	∈(0.81,1] for DF and ∈(0.77,1] for SF	
	∈(0.81,1] ∈(0.82,1] ∈(0.83,1] ∈(0.84,1] ∈(0.85,1]	∈(0.77,1] ∈(0.78,1] ∈(0.79,1] ∈(0.80,1]

Slepton and Chargino production

2L arXiv:2209.13935



e^+e^-, $\mu^+\mu^-$ (SF)
Zero or one jet (0J or 1J)
8 bins in m_{T2}^{100} (>100 GeV)
(5 for discovery)

Use DF events in data to estimate Flavour Symmetric Backgrounds (FSB):
ttbar, single top, WW, $Z\rightarrow\tau\tau$.

Common

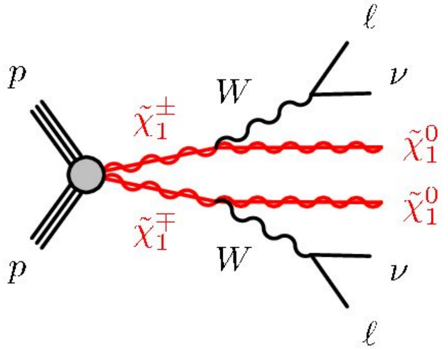
2 e/μ (single lep trigger)
Veto Z & low mass resonances, bjets
Moderate E_T^{miss} significance (>7 or 8)

m_{T2} and $\cos\theta^*_{ll} = \tanh(\Delta\eta_{ll}/2)$ main discriminating variables

Fake lepton backgrounds from data using Matrix Method (FNP)

Minor SM backgrounds from MC simulation.

Backgrounds validated in dedicated regions (VRs)



e^+e^-, $\mu^+\mu^-$, (SF) or $e^\pm\mu^\mp$ (DF)
Zero jets

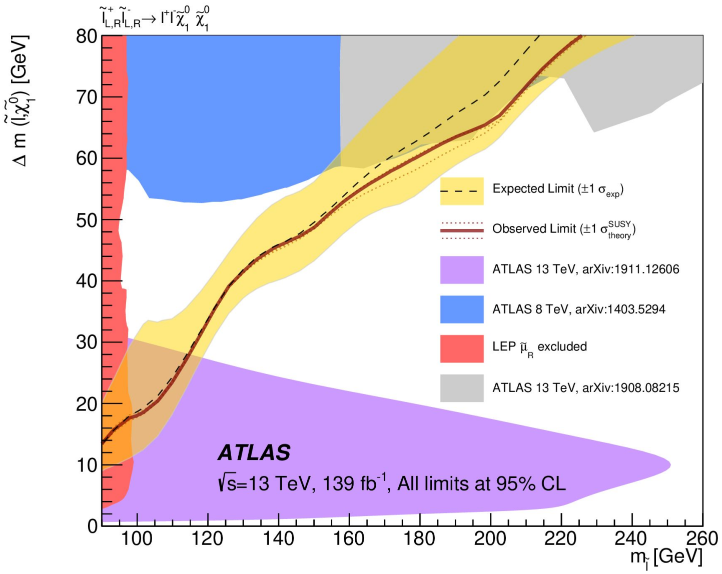
Train 2 BDTs for SF and DF.
Gradient Boosted, multiclass classifier (signal, VV, top, other)

16 (8) bins in DF (SF) BDT score
(reduced for discovery)

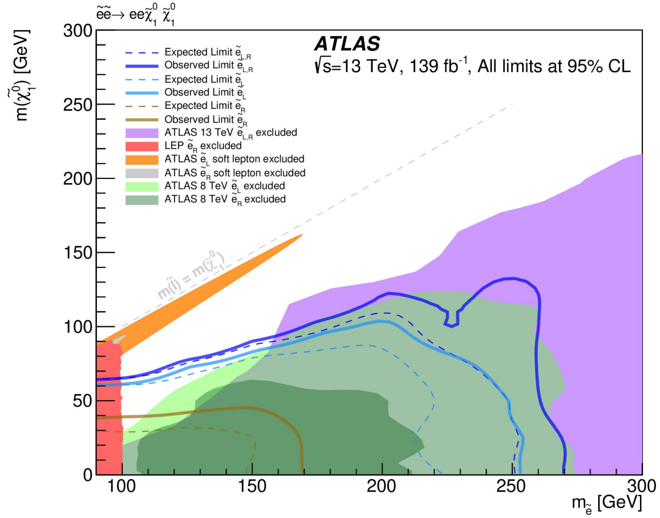
CRs used to normalise MC to data for VV (μ_{VV} = 1.38 ± 0.08) and top (μ_{top} = 1.09 ± 0.03)

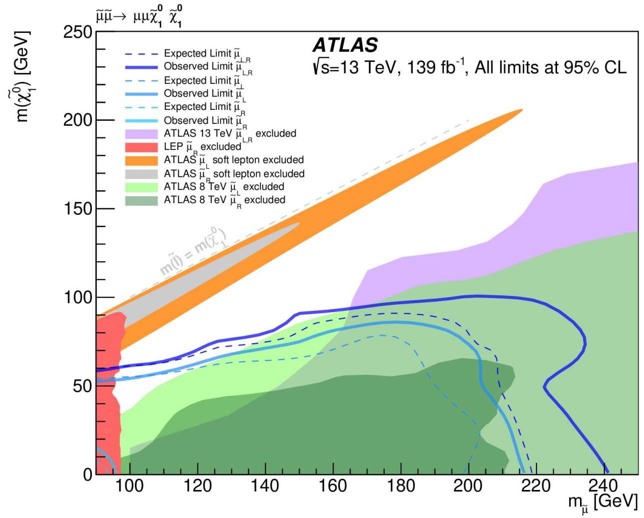
Backup: Other slepton interpretations

Mass degenerate L,R selectrons and smuons



Split by flavour and handedness





Backup: 2L2J SR selection

high mass

Region	n_{jets}	$n_{\text{jets}}^{b\text{-tag}}$	$\mathcal{S}(E_{\text{T}}^{\text{miss}})$	$m_{\ell\ell}$ [GeV]	m_X [GeV]	m_{T2} [GeV]	ΔR_X	$p_{\text{T}}^{j_1}$ [GeV]
SR-High-EWK	≥ 2	≤ 1	$(18, 21, \infty)$	71–111	$60 < m_{jj} < 110$	> 80	$\Delta R_{jj} \in (0, 0.8, 1.6)$	–
VR-High-Sideband-EWK	≥ 2	≤ 1	> 18	71–111	$\mathbf{20 < m_{jj} < 60 \cup m_{jj} > 110}$	> 80	$\Delta R_{jj} < 1.6$	–
VR-High-R-EWK	≥ 2	≤ 1	> 18	71–111	$\mathbf{m_{jj} > 20}$	> 80	$\mathbf{\Delta R_{jj} > 1.6}$	–
SR-1J-High-EWK	1	≤ 1	> 12	71–111	$60 < m_{j_1} < 110$	> 80	–	–
VR-1J-High-Sideband-EWK	1	≤ 1	> 12	71–111	$\mathbf{20 < m_{j_1} < 60 \cup m_{j_1} > 110}$	> 80	–	–
SR-$\ell\ell bb$-EWK	≥ 2	≥ 2	> 18	71–111	$60 < m_{bb} < 150$	> 80	–	–
VR-$\ell\ell bb$-EWK	≥ 2	≥ 2	**12–18**	71–111	$60 < m_{bb} < 150$	> 80	–	–

intermediate mass

Region	n_{jets}	$n_{\text{jets}}^{b\text{-tag}}$	$\mathcal{S}(E_{\text{T}}^{\text{miss}})$	$m_{\ell\ell}$ [GeV]	m_X [GeV]	m_{T2} [GeV]	ΔR_X	$p_{\text{T}}^{j_1}$ [GeV]
SR-Int-EWK	≥ 2	0	$(12, 15, 18)$	81–101	$60 < m_{jj} < 110$	> 80	–	> 60
VR-Int-EWK	≥ 2	0	12–18	81–101	$60 < m_{jj} < 110$	> 80	–	$\mathbf{< 60}$
CR-VZ-EWK	≥ 2	0	12–18	81–101	$\mathbf{20 < m_{jj} < 60 \cup m_{jj} > 110}$	> 80	–	**–**
CR-tt-EWK	≥ 2	$\mathbf{\geq 1}$	**9–12**	81–101	$\mathbf{m_{jj} > 20}$	> 80	–	> 60

low mass

Region	n_{jets}	$n_{\text{jets}}^{b\text{-tag}}$	$\mathcal{S}(E_{\text{T}}^{\text{miss}})$	$m_{\ell\ell}$ [GeV]	m_X [GeV]	m_{T2} [GeV]	ΔR_X	$\Delta\phi(\boldsymbol{p}_{\text{T}}^{\ell\ell}, \boldsymbol{p}_{\text{T}}^{\text{miss}})$
SR-Low-EWK	2	0	$(6, 9, 12)$	81–101	$60 < m_{jj} < 110$	> 80	$\Delta R_{\ell\ell} < 1$	–
VR-Low-EWK	2	0	6–12	81–101	$60 < m_{jj} < 110$	> 80	$\mathbf{1 < \Delta R_{\ell\ell} < 1.4}$	–
SR-Low-2-EWK	2	0	6–9	81–101	$60 < m_{jj} < 110$	< 80	$\Delta R_{\ell\ell} < 1.6$	< 0.6
VR-Low-2-EWK	2	0	6–9	81–101	$\mathbf{20 < m_{jj} < 60 \cup m_{jj} > 110}$	< 80	$\Delta R_{\ell\ell} < 1.6$	< 0.6
CR-Z-EWK	2	0	6–9	81–101	$\mathbf{20 < m_{jj} < 60 \cup m_{jj} > 110}$	$\mathbf{> 80}$	**–**	**–**

off-shell

Region	n_{jets}	$n_{\text{jets}}^{b\text{-tag}}$	$\mathcal{S}(E_{\text{T}}^{\text{miss}})$	$m_{\ell\ell}$ [GeV]	m_{T2} [GeV]	$p_{\text{T}}^{j_1}$ [GeV]	$\Delta\phi(\boldsymbol{p}_{\text{T}}^{j_1}, \boldsymbol{p}_{\text{T}}^{\text{miss}})$
SR-OffShell-EWK	≥ 2	0	> 9	$(12, 40, 71)$	> 100	> 100	> 2
VR-OffShell-EWK	≥ 2	0	> 9	12–71	**80–100**	> 100	> 2
CR-DY-EWK	≥ 2	0	**6–9**	12–71	> 100	**–**	**–**

Backup: AllHad SR selection

Boson-tagging categories

	$n(W_{qq})$	$n(Z_{qq})$	$n(V_{qq})$	$n(Z_{bb})$	$n(h_{bb})$
4Q-WW	$= 2$	-	$= 2$	$= 0$	$= 0$
4Q-WZ	≥ 1	≥ 1	$= 2$	$= 0$	$= 0$
4Q-ZZ	-	$= 2$	$= 2$	$= 0$	$= 0$
4Q-VV	-	-	$= 2$	$= 0$	$= 0$
2B2Q-WZ	$= 1$	-	$= 1$	$= 1$	$= 0$
2B2Q-ZZ	-	$= 1$	$= 1$	$= 1$	$= 0$
2B2Q-Wh	$= 1$	-	$= 1$	$= 0$	$= 1$
2B2Q-Zh	-	$= 1$	$= 1$	$= 0$	$= 1$
2B2Q-VZ	-	-	$= 1$	$= 1$	$= 0$
2B2Q-Vh	-	-	$= 1$	$= 0$	$= 1$

Kinematics

	SR(CR0L)		VR(CR)1L	
	4Q	2B2Q	4Q	2B2Q
$n_{\text{Large-}R\text{ jets}}$	≥ 2		≥ 2	
n_{lepton}	$= 0$		$= 1$	
$p_{\text{T}}(\ell_1)$ [GeV]	-		> 30	
n_{photon}	-		-	
$n(V_{qq})$	$= 2\ (= 1)$	$= 1\ (= 0)$	$= 2\ (= 1)$	$= 1\ (= 0)$
$n(!V_{qq})$	$= 0\ (= 1)$	$= 0\ (= 1)$	$= 0\ (= 1)$	$= 0\ (= 1)$
$n(J_{bb})$	$= 0$	$= 1$	$= 0$	$= 1$
$m(J_{bb})$ [GeV]	-	$\in [70, 135\ (150)]$	-	$\in [70, 150]$
$n_{b\text{-jet}}^{\text{unmatched}}$	$= 0$		$= 0$	
$n_{b\text{-jet}}$	≤ 1	-	$= 0$	-
$E_{\text{T}}^{\text{miss}}$ [GeV]	> 300	> 200	> 50	
$p_{\text{T}}(W)$ [GeV]	-		> 200	
$p_{\text{T}}(\gamma)$ [GeV]	-		-	
m_{eff} [GeV]	> 1300	$> 1000\ (> 900)$	> 1000	> 900
$\min \Delta\phi(E_{\text{T}}^{\text{miss}}, j)$	> 1.0		> 1.0	
m_{T2} [GeV]	-	> 250	-	> 250

Backup: SS3L SR selection

RPC Wh

	$SR^{Wh}_{high-m_{T2}}$			$SR^{Wh}_{low-m_{T2}}$		
	$e^{\pm}e^{\pm}$	$e^{\pm}\mu^{\pm}$	$\mu^{\pm}\mu^{\pm}$	$e^{\pm}e^{\pm}$	$e^{\pm}\mu^{\pm}$	$\mu^{\pm}\mu^{\pm}$
$N_{BL}(\ell)$	$= 2$					
$N_{Sig}(\ell)$	$= 2$					
Charge(ℓ)	same-sign					
$p_T(\ell)$	≥ 25 GeV					
n_{jets} ($p_T > 25$ GeV)	≥ 1					
$n_{b\text{-jets}}$	$= 0$					
m_{jj}	< 350 GeV					
m_{T2}	≥ 80 GeV			< 80 GeV		
m_T^{min}	–			≥ 100 GeV		
$\mathcal{S}(E_T^{miss})$	≥ 7			≥ 6		
E_T^{miss}	≥ 75 GeV			≥ 50 GeV		
E_T^{miss} binning (GeV)[a]	$SR^{Wh}_{high-m_{T2}}$-1: $\in [75, 125)$ $SR^{Wh}_{high-m_{T2}}$-2: $\in [125, 175)$ $SR^{Wh}_{high-m_{T2}}$-3: $\in [175, +\infty)$			–		

[a] The E_T^{miss} binning applies separately to each flavour channel of $SR^{Wh}_{high-m_{T2}}$.

RPC WZ

	$SR^{WZ}_{high-m_{T2}}$	$SR^{WZ}_{low-m_{T2}}$
$N_{BL}(\ell)$	$= 2$	
$N_{Sig}(\ell)$	$= 2$	
Charge(ℓ)	same-sign	
$p_T(\ell)$	≥ 25 GeV	
n_{jets} ($p_T > 25$ GeV)	≥ 1	
$n_{b\text{-jets}}$	$= 0$	
m_{jj}	≤ 350 GeV	
m_{T2}	≥ 100 GeV	≤ 100 GeV
m_T^{min}	≥ 100 GeV	≥ 130 GeV
E_T^{miss}	≥ 100 GeV	≥ 140 GeV
m_{eff}	–	≤ 600 GeV
$\Delta R(\ell^{\pm}, \ell^{\pm})$	–	≤ 3
Bins	$\mathcal{S}(E_T^{miss})$: $\in [0, 10)$ Spread(Φ) ≥ 2.2	–
	$\mathcal{S}(E_T^{miss})$: $\in [10, 13)$	
	$\mathcal{S}(E_T^{miss})$: $\in [13, +\infty]$ $\Delta R(\ell^{\pm}, \ell^{\pm}) \geq 1$	

Backup: SS3L SR selection

bRPV

	$SR^{bRPV}_{2\ell-SS}$	$SR^{bRPV}_{3\ell}$
$N_{BL}(\ell)$	–	
p_T (ℓ)	≥ 20 GeV for (sub)leading leptons	
n_{jets} $(p_T > 25$ GeV$)$	≥ 1	
$N_{Sig}(\ell)$	$= 2$	$= 3$
Charge(ℓ)	same-sign	–
m_{T2}	≥ 60 GeV	≥ 80 GeV
E_T^{miss}	≥ 100 GeV	≥ 120 GeV
m_{eff}	–	≥ 350 GeV
$n_{b\text{-jets}}$	$= 0$	–
n_{jets} $(p_T > 40$ GeV$)$	≥ 4	–
$m_{e^\pm e^\mp}$, $m_{\mu^\pm \mu^\mp}$	–	$\notin [81, 101]$ GeV

UDD

	$SR^{RPV}_{2\ell 1b}$		$SR^{RPV}_{2\ell 2b}$			$SR^{RPV}_{2\ell 3b}$		
	L	M	L	M	H	L	M	H
$N_{BL}(\ell)$	$= 2$							
$N_{Sig}(\ell)$	$= 2$							
Charge(ℓ)	same-sign							
$p_T(\ell)$	> 25 GeV							
n_{jets} $(p_T > 25$ GeV$)$	≥ 1							
$n_{b\text{-jets}}$	$= 1$		$= 2$			$= 3$		
$\sum p_T(\ell)$	≥ 100 GeV		–			–		
E_T^{miss}	≥ 100 GeV	≥ 50 GeV	≥ 80 GeV			≥ 20 GeV		
n_{jets} $(p_T > 25$ GeV$)$	≤ 2	$= 2$ or $= 3$	≤ 3	$=3$ or $= 4$	≥ 5 and ≤ 6	≤ 3	≤ 3	≤ 6
$\sum p_T^{b\text{-jet}} / \sum p_T^{jet}$	≥ 0.7	≥ 0.45	≥ 0.9	≥ 0.75	–	≥ 0.8	≥ 0.8	≥ 0.5
$\sum p_T^{jet}$	≥ 120 GeV	≥ 400 GeV	≥ 300 GeV	≥ 420 GeV	≥ 420 GeV	–	–	≥ 350 GeV
$\Delta R(\ell_1, \text{jet})_{min}$	≤ 1.2	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.5	–	≤ 1.0
$\Delta R(\ell^\pm, \ell^\pm)$	≥ 2.0	≥ 2.5	≥ 2.5	≥ 2.5	≥ 2.0	≥ 2.0	–	≥ 2.0