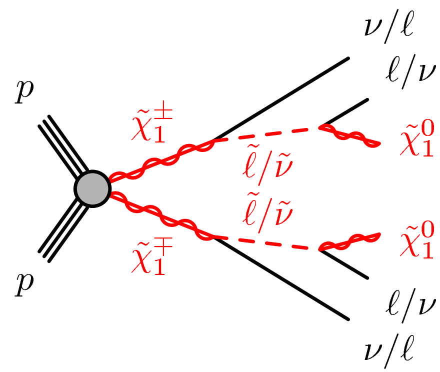
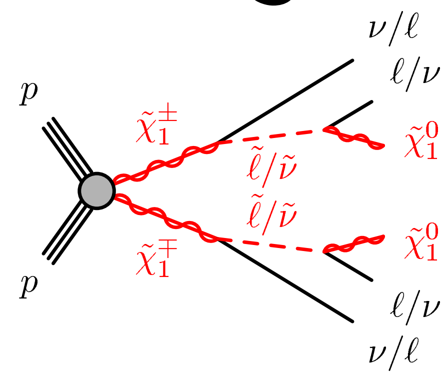
EWK compressed scenarios at LHC

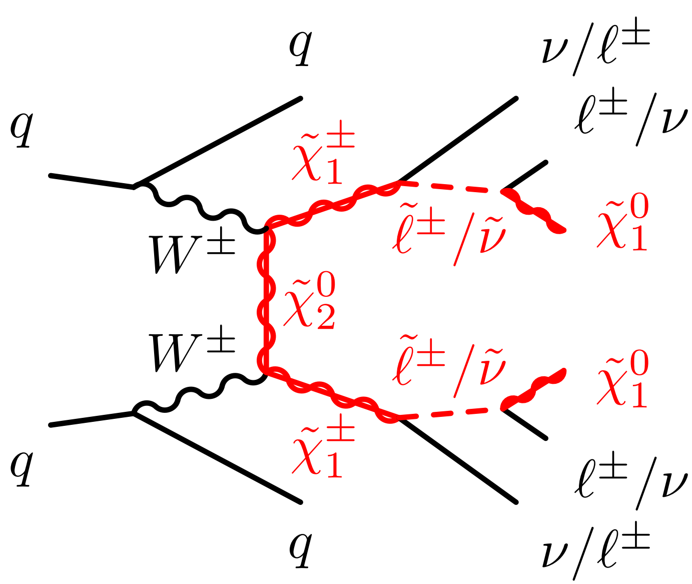
Mostly taken from
https://arxiv.org/abs/1509.07152

A number of processes targeted

➢ Examples







Event selections based on low-momentum leptons, and also on the production in association with ISR jets to provide improved sensitivity to the compressed spectra scenarios

Mostly useful in case of sleptons in the decay chain. The compressed spectra searches are less sensitive to scenarios where the $\tilde{\chi}^{\pm}_1$ /$\tilde{\chi}^0_2$ decay through SM *W*, *Z* or Higgs bosons, as the branching fraction to leptonic final states is significantly suppressed.

Selection table (1)

➢ Opposite-sign leptons analysis, relevant for chargino pair production. Where there is no pT cuts, the minimum pT is 7 GeV for electrons, 5 GeV for muons

Table 6: The selection requirements for the opposite-sign, two-lepton signal and control regions, targeting $\tilde{\chi}_1^+\tilde{\chi}_1^-$ production with small mass splittings between the $\tilde{\chi}_1^\pm$ and LSP.

	Common			
Central light-flavor jets	=1			
Forward jets	veto			
M_Δ^R [GeV]	> 20			
	SR2ℓ-1a		SR2ℓ-1b	
ℓ flavor/sign	$\ell^\pm\ell^\mp$	$\ell^\pm\ell'^\mp$	$\ell^\pm\ell^\mp$	$\ell^\pm\ell'^\mp$
Central b-tagged jets	veto			
m_{SFOS} [GeV]	veto 81.2–101.2			
$p_{\mathrm{T}}^{\ell\ell}$ [GeV]	–	–	< 40	< 50
$p_{\mathrm{T}}^{\mathrm{jet}}$ [GeV]	> 80	> 80	> 60	> 80
R_2	> 0.5	> 0.7	> 0.65	> 0.75
$\Delta\phi_R^\beta$ [rad]	> 2	> 2.5	> 2	> 2.5
$p_{\mathrm{T}}^{\mathrm{central\ light\ jet}}$ [GeV]	–	–	–	–

SR	SR2ℓ-1a		SR2ℓ-1b	
ℓ flavor/sign	$\ell^\pm\ell^\mp$	$\ell^\pm\ell'^\mp$	$\ell^\pm\ell^\mp$	$\ell^\pm\ell'^\mp$
Expected background				
WW	67 ± 27	12 ± 5	22 ± 9	5.7 ± 2.4
Top	69 ± 19	12 ± 4	21 ± 7	5.0 ± 2.0
ZV	7.3 ± 3.4	1.7 ± 0.8	2.4 ± 1.5	0.6 ± 0.4
Reducible	12 ± 6	5.8 ± 2.0	10 ± 4	2.8 ± 1.1
Others	18 ± 5	2.1 ± 1.3	9.4 ± 3.4	1.0 ± 0.7
Total	173 ± 23	34 ± 5	65 ± 9	15.0 ± 2.5
Observed events	153	24	73	8
Predicted signal				
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (100, 35)$	81 ± 16	25 ± 7	44 ± 8	14 ± 4
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0}) = (100, 80)$	41 ± 10	23 ± 6	31 ± 7	18 ± 5
p_0	0.50	0.50	0.26	0.50
S_{obs}^{95}	35.7	9.3	30.8	5.6
S_{exp}^{95}	46^{+18}_{-12}	15^{+6}_{-4}	25^{+10}_{-7}	$9.4^{+4.2}_{-2.8}$
$\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$ [fb]	1.76	0.46	1.52	0.27
CL_b	0.22	0.09	0.73	0.07

Selection table (2)

- In case of chargino-neutralino pair production – expect up to 3 leptons. Selection used is for same-sign leptons (low SM background)
- Done with multivariate analysis, with or without ISR-jet signature

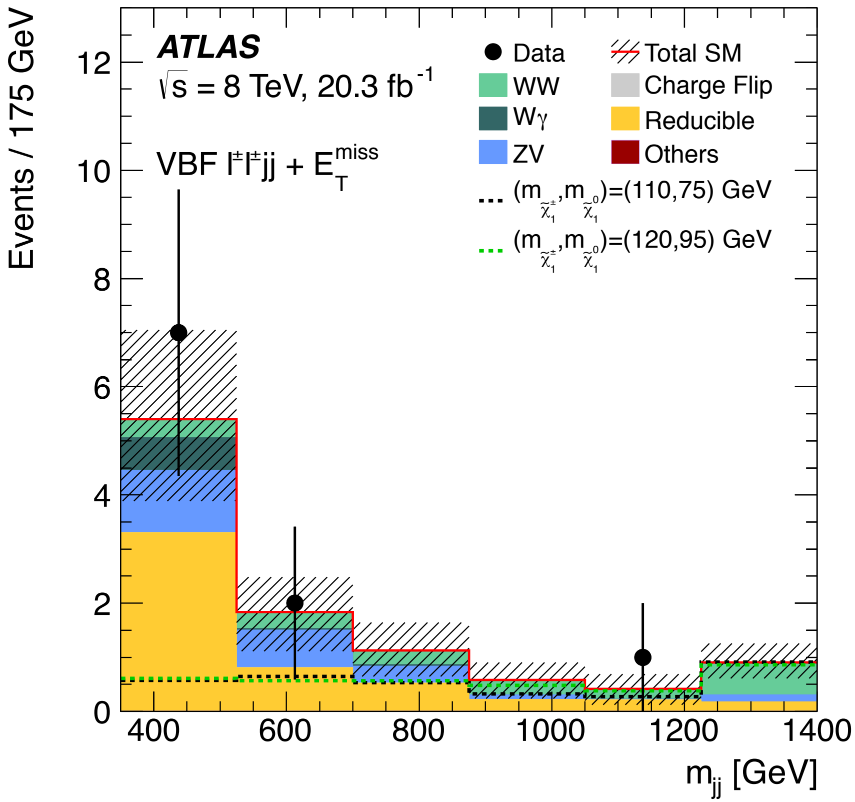
Table 10: Same-sign, two-lepton MVA signal region BDT requirements, targeting $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ production with small mass splittings between the $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ and LSP. The selection on the BDT output, t_{cut}, is independent for each SR.

Common		$\ell^{\pm}\ell^{\pm}$ pair, b-jet veto				
		SR ΔM20	SR ΔM35	SR ΔM65	SR ΔM100	VR
ISR	t_{cut}	> 0.071	> 0.087	> 0.103	> 0.119	$-0.049 - 0.051$
no-ISR	t_{cut}	> 0.071	> 0.087	> 0.135	> 0.135	$-0.049 - 0.051$

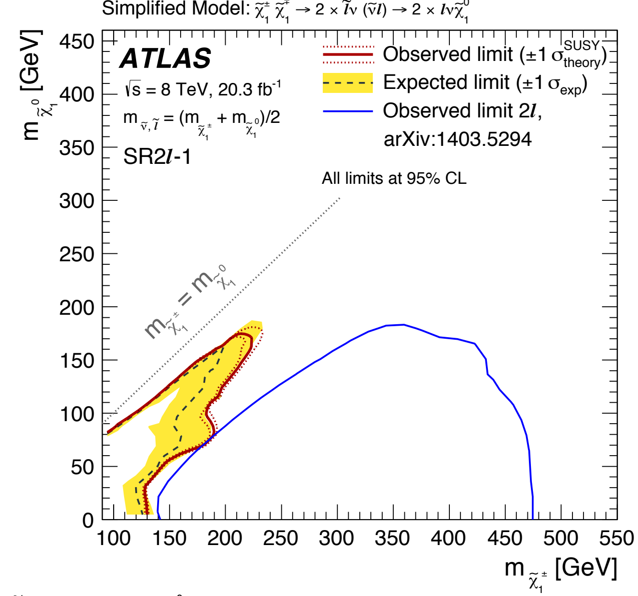
Selection table (3): VBF selection

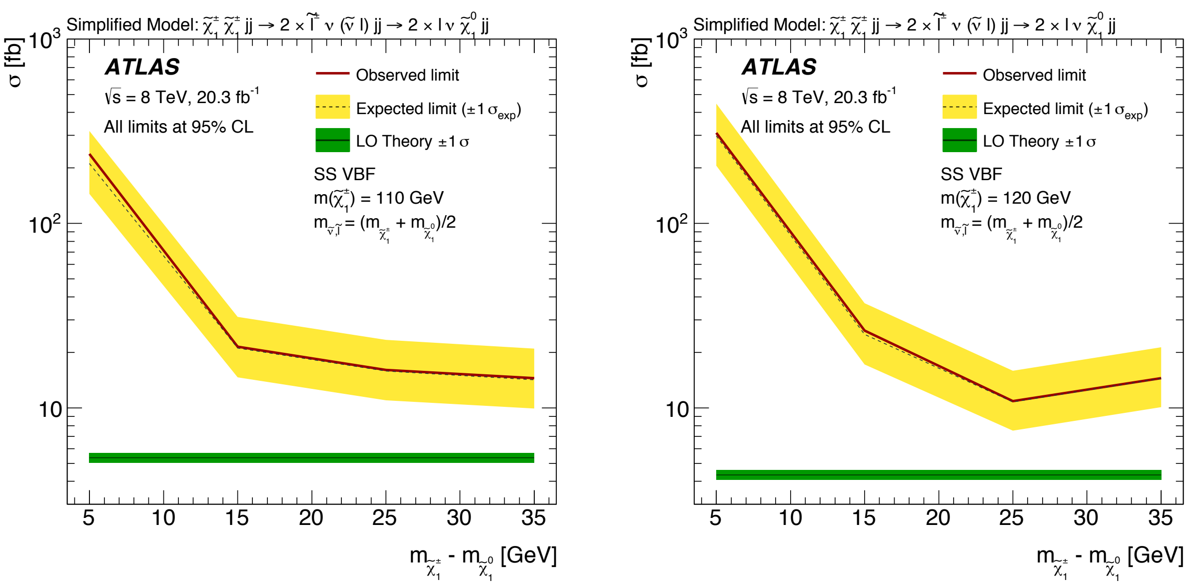
➢ Used for very compressed scenarios

	SR2ℓ-2
ℓ flavor/sign	$\ell^{\pm}\ell^{\pm}$, $\ell^{\pm}\ell'^{\pm}$
Jets	$\geq$ 2
Central b-jets	veto
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	$>$ 120
m_{T2} [GeV]	$<$ 40
$m_{\ell\ell}$ [GeV]	$<$ 100
$p_{\mathrm{T}}^{\mathrm{jet\,1}}$ [GeV]	$>$ 95
m_{jj} [GeV]	$>$ 350
$\eta^{\mathrm{jet1}} \cdot \eta^{\mathrm{jet2}}$	$<$ 0
$\lvert\Delta\eta_{jj}\rvert$	$>$ 1.6
$p_{\mathrm{T}}^{\ell\ell}/E_{\mathrm{T}}^{\mathrm{miss}}$	$<$ 0.4
$p_{\mathrm{T}}^{\mathrm{jet\,1}}/E_{\mathrm{T}}^{\mathrm{miss}}$	$<$ 1.9
$p_{\mathrm{T}}^{\ell\ell}/p_{\mathrm{T}}^{jj}$	$<$ 0.35



➤ Current limits

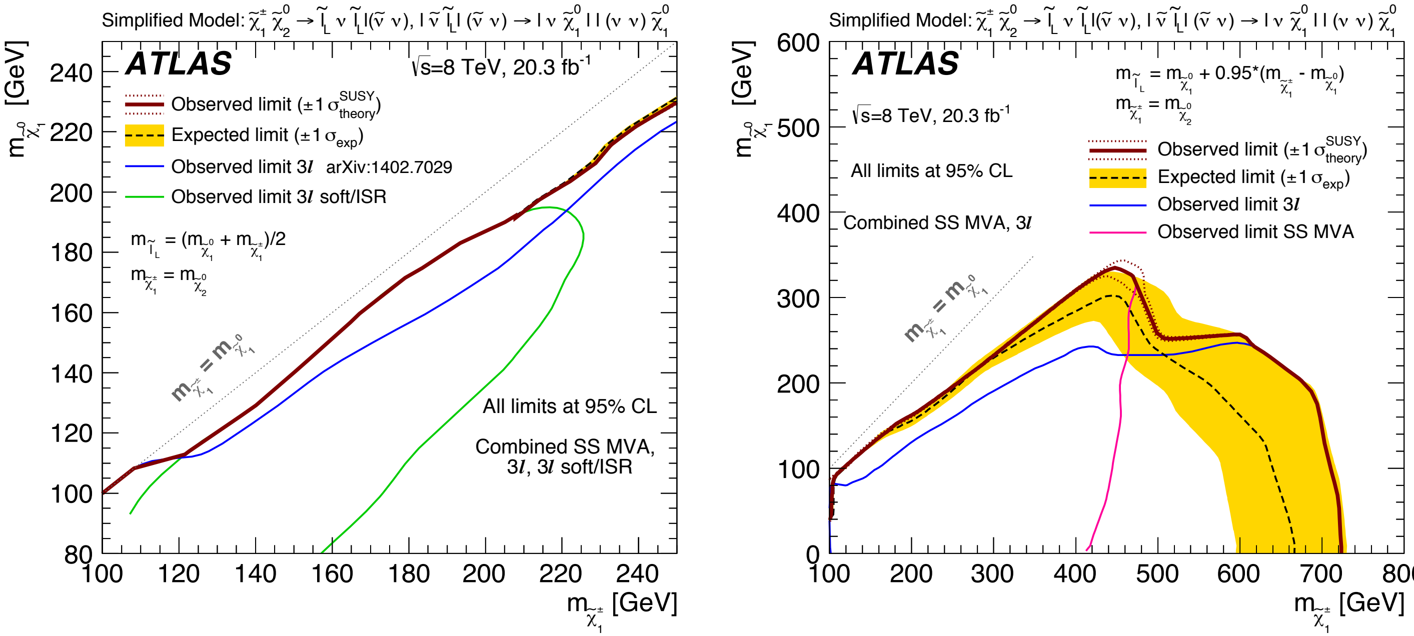




(a) (b)

Figure 14: The 95% CL upper limit on the signal cross-section for VBF $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm}$ production for (a) $m(\tilde{\chi}_1^{\pm})$ = 110 GeV and (b) $m(\tilde{\chi}_1^{\pm})$ = 120 GeV. The limits are set with respect to the mass difference between the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^0$, and use the results from the same-sign, two-lepton VBF analysis.

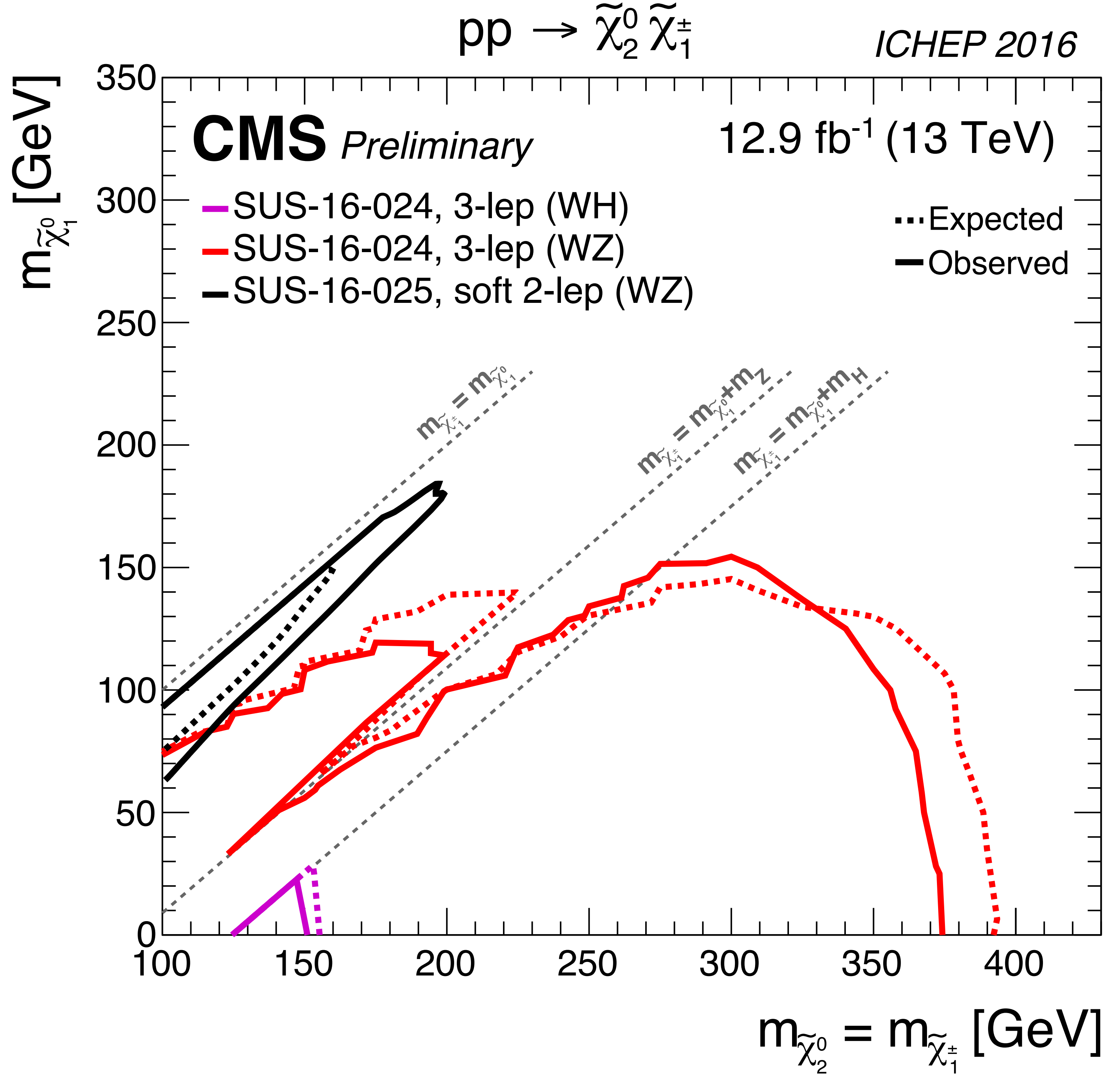
➤ Current limits



(a) (b)

Figure 17: The 95% CL exclusion limits on $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ production with $\tilde{\ell}_L$-mediated decays, as a function of the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^0$ masses, where the intermediate slepton mass is set to the $\tilde{\chi}_1^0$ mass plus (a) 50% or (b) 95% of the difference between the $\tilde{\chi}_1^{\pm}$ and the $\tilde{\chi}_1^0$ masses. The limits in (a) are set using a combination of the 3ℓ analysis from Ref. [20] and the same-sign, two-lepton anaysis from this article, while the limits in (b) use the combination of the three-lepton and same-sign, two-lepton anayses from this article.

➢ CMS limits



$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm$
ICHEP 2016
CMS Preliminary
12.9 fb^{-1} (13 TeV)
SUS-16-024, 3-lep (WH)
SUS-16-024, 3-lep (WZ)
SUS-16-025, soft 2-lep (WZ)
Expected
Observed
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}+m_Z$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}+m_H$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_2^0} = m_{\tilde{\chi}_1^\pm}$ [GeV]
0
50
100
150
200
250
300
350
400

Table 23: Searches used to probe each of the models described in Section 2.

Model	Wh [23]	$2\ell^{\dagger}$ [19]	$2\tau^{*}$ [22]	$3\ell^{\diamond}$ [20]	4ℓ [21]	2τ MVA*	SR2ℓ-1†	SS MVA§	SR3ℓ-0/1$^{\diamond}$	SR2ℓ-2§
$\tilde{\tau}\,\tilde{\tau}$			✓			✓				
$\tilde{\chi}_1^+\tilde{\chi}_1^-$ via $\tilde{\ell}_L$ with $x = 0.5$		✓					✓			
$\tilde{\chi}_1^+\tilde{\chi}_1^-$ via $\tilde{\ell}_L$ with variable x		✓								
$\tilde{\chi}_1^+\tilde{\chi}_1^-$ via WW		✓								
$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\pm}$ via VBF										✓
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via $\tilde{\tau}_L$			✓	✓						
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via $\tilde{\ell}_L$ with $x = 0.5$				✓				✓	✓	
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via $\tilde{\ell}_L$ with variable x				✓						
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via WZ		✓		✓						
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ via Wh	✓	✓		✓						
$\tilde{\chi}_2^0\tilde{\chi}_3^0$ via $\tilde{\ell}_L$ with $x = 0.5$				✓	✓					
$\tilde{\chi}_2^0\tilde{\chi}_3^0$ via $\tilde{\ell}_L$ with variable x				✓	✓					
pMSSM	✓	✓		✓						
NUHM2		✓		✓	✓					
GMSB					✓					

† The opposite-sign, two-lepton signal regions in Ref. [19] and Section 8.1 overlap.

∗ The two-tau signal regions in Ref. [22] and Section 7 overlap.

◇ The three-lepton signal regions in Ref. . [20] and Section 8.3 overlap.

§ The same-sign, two-lepton signal regions in Section 8.2 and Section 9 overlap.