Searches for sleptons with the ATLAS detector

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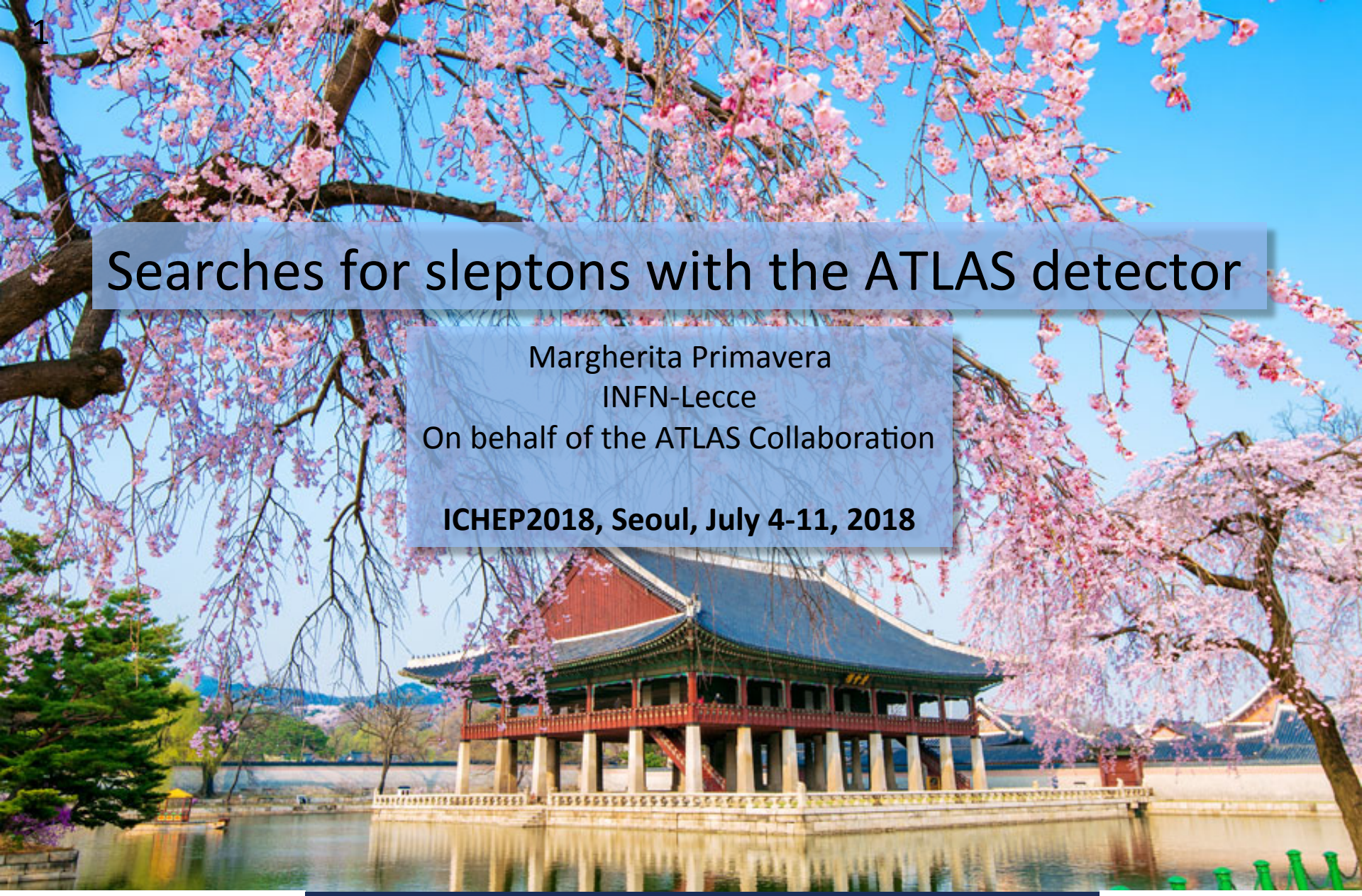
On behalf of the ATLAS Collaboration

ICHEP2018, Seoul, July 4-11, 2018



ATLAS EXPERIMENT
ICHEP2018 SEOUL
XXXIX INTERNATIONAL CONFERENCE ON high Energy PHYSICS
JULY 4 - 11, 2018 COEX, SEOUL
INFN

Electroweak SUSY

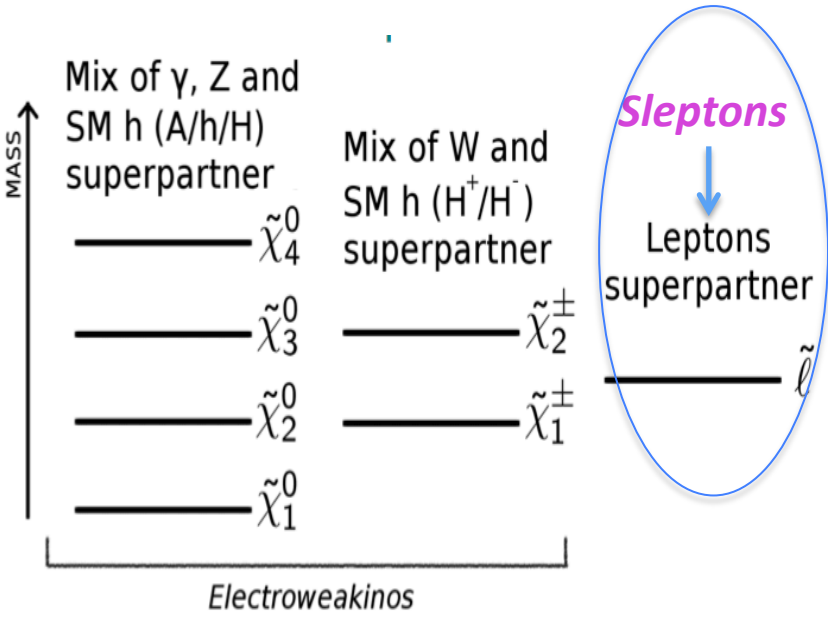
- **SUperSYmmetry (SUSY)** is one of the most popular extensions of the Standard Model (SM), predicting new particles which differ from their SM partners by ½ in spin. R-parity (=$(-1)^{3(B-L)+2S}$) conserving (RPC) or violating (RPV) models can be considered.

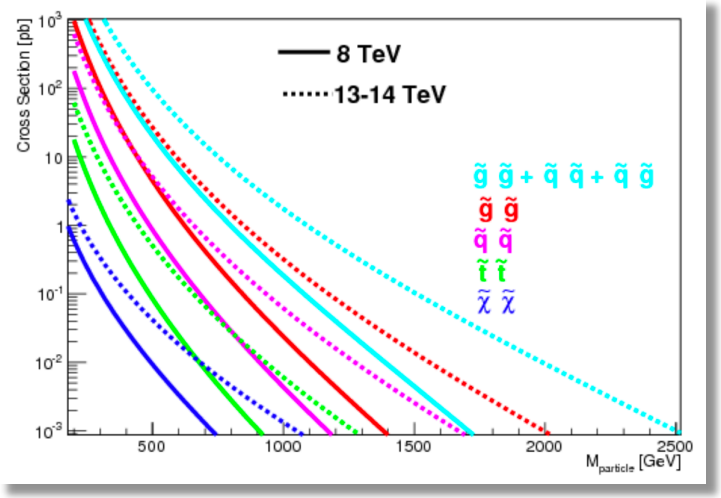
- **SUSY Electroweak (EWK)** production can dominate over the strong production at LHC if gluinos and squarks are significantly heavy. Colored sparticles already excluded up to ~1-2 TeV

- Large mass range for **sleptons and EWK-inos** still unexplored

- In Run II EWK-ino production cross sections expected to be ~5 times larger than in Run I

- Decays happen to multi-lepton final states, producing experimentally "clean" signatures, with little hadronic activity and large E_T^{miss}





Sleptons: *~ 0.5 fb (left-handed) @ 500 GeV*

General search strategy

- ***Data sample*** → analyses presented here: 36.1 fb^{-1} of pp collisions at √s = 13 TeV collected in 2015 and 2016

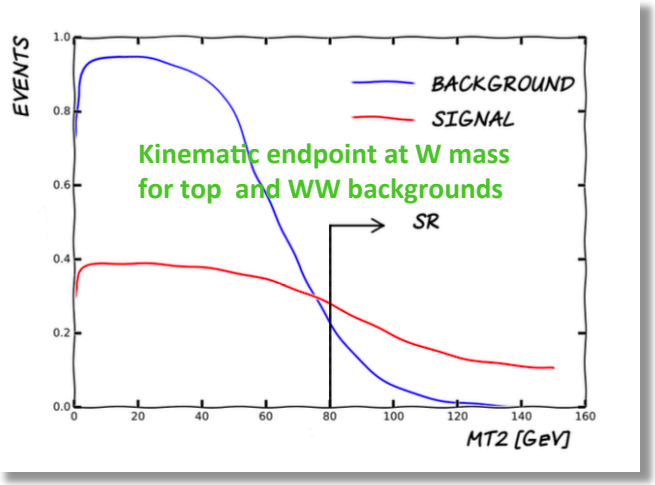
- ***SUSY Models*** → simplified models assumed, with cross sections very small compared to the SM processes and Branching Ratios (BR) of 100% in the searched decay

- ***Event selection*** → through sensitive kinematic observables, selecting regions where to maximize the signal from background discrimination (Signal Regions, SRs)

- ***Background estimate*** → with fully data driven or semi data driven techniques, in last case normalizing Monte Carlo (MC) to data in Control Regions (CRs) properly chosen for a specific background. Normalization is validated in Validation Regions (VRs).

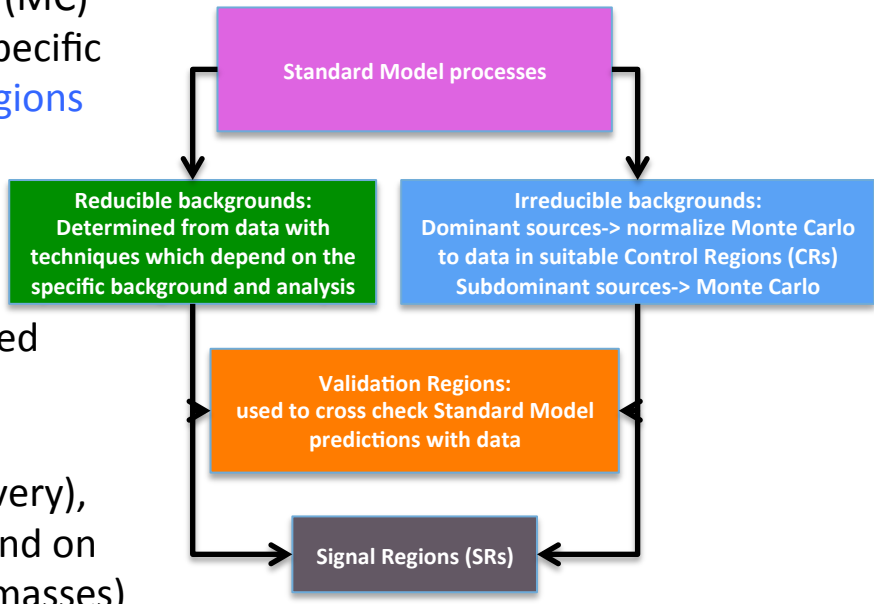
- ***Results*** → expected to "unblind" results and compare data to expected background in SRs only after that a reliable background estimate strategy has been developed

- ***Interpretation*** → if a large excess over the expected background observed in data, claim for evidence (discovery), otherwise set upper limits on the signal cross sections and on the parameters of the tested model (e.g. SUSY particle masses)

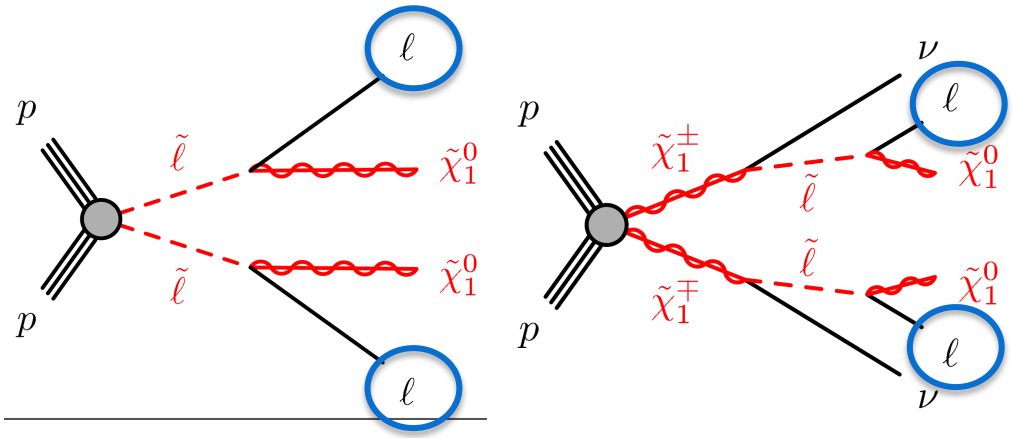


$$m_{T2} = \min_{\mathbf{q}_T}\left[\max\left(m_T(\mathbf{p}_T^{\ell 1}, \mathbf{q}_T), m_T(\mathbf{p}_T^{\ell 2}, \mathbf{p}_T^{\text{miss}} - \mathbf{q}_T)\right)\right]$$

$$m_T(\mathbf{p}_T, \mathbf{q}_T) = \sqrt{m_p^2 + m_q^2 + 2(p_T q_T - \mathbf{p}_T \cdot \mathbf{q}_T)}$$



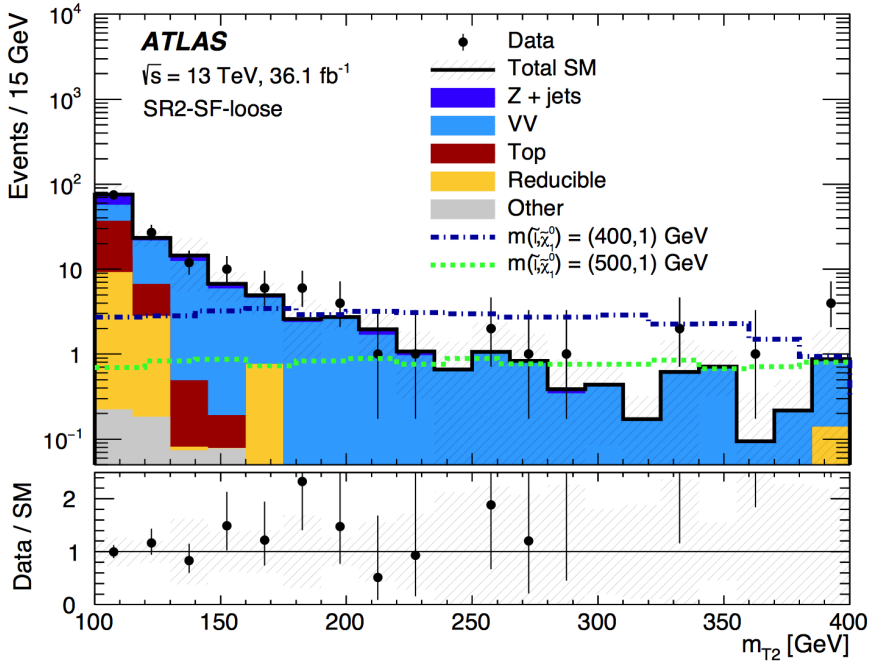
Slepton direct production or via chargino decays

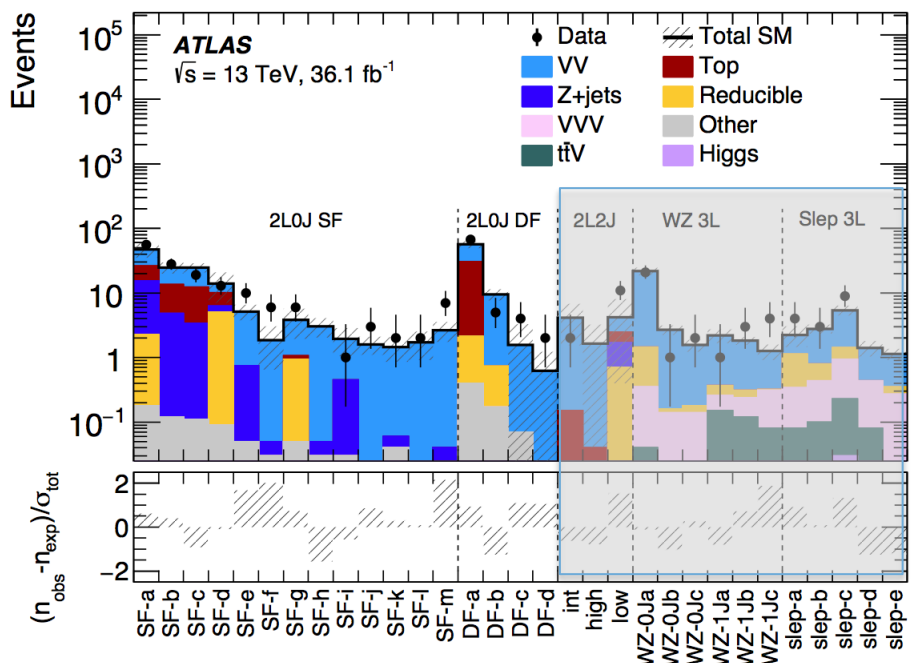


$\tilde{\chi}_1^0$ Lightest SUSY Particle (LSP)

[arXiv:1803.02762]

- **2 leptons** (e or μ, in events passing dilepton triggers) Opposite Sign (OS), Same Flavour (SF) or Different Flavour (DF), high p_T^{l1} (p_T^{l2}) >25 (20) GeV
- No jet, Large E_t^{miss}
- 17 Exclusive SRs, requiring large dilepton m_{T2} → to reject $t\bar{t}$, WW and invariant mass (m_{ll}) →high m_{ll} in SF strongly rejects the Z



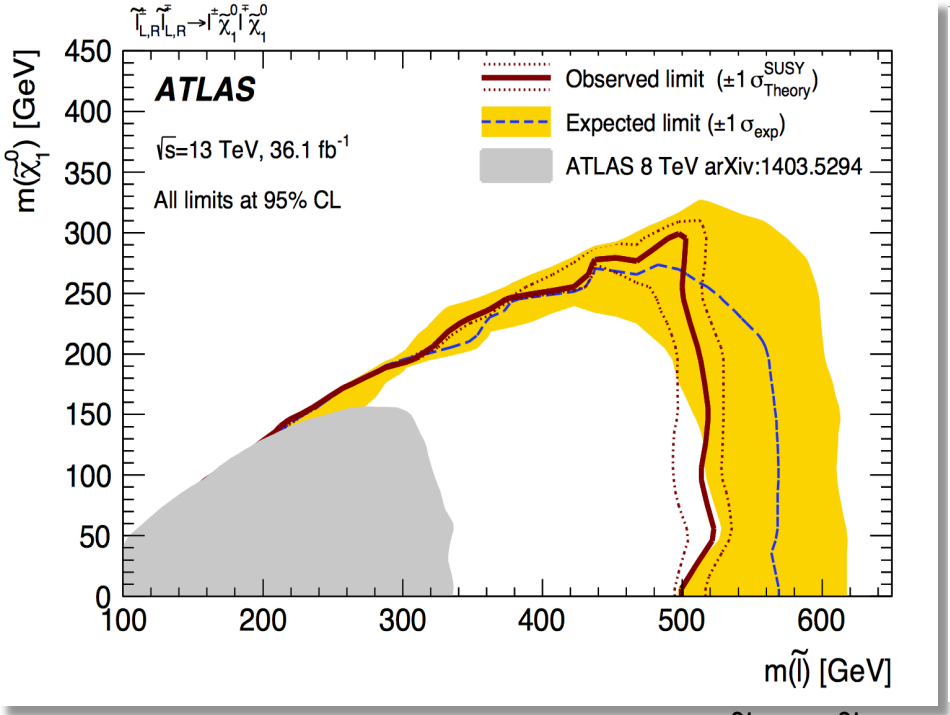


Slepton direct production or via chargino decays

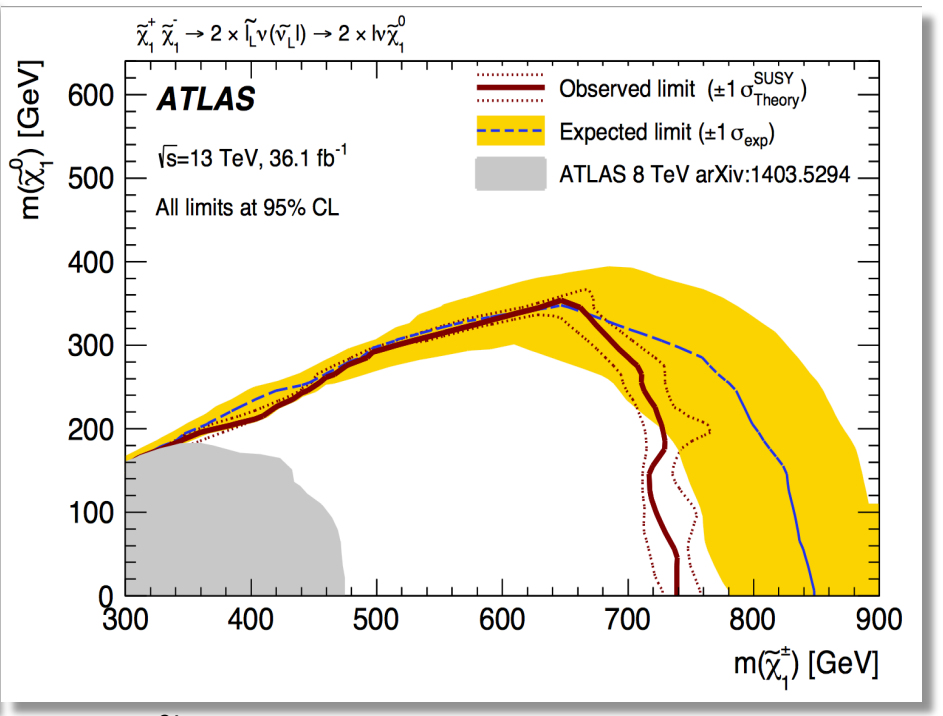
[arXiv:1803.02762]

- Assuming s-electron$_{L/R}$, s-muon$_{L/R}$ and s-tau$_{L/R}$ to be mass-degenerate

2ℓ+0 jets:
direct $\tilde{\ell}\tilde{\ell}$ production



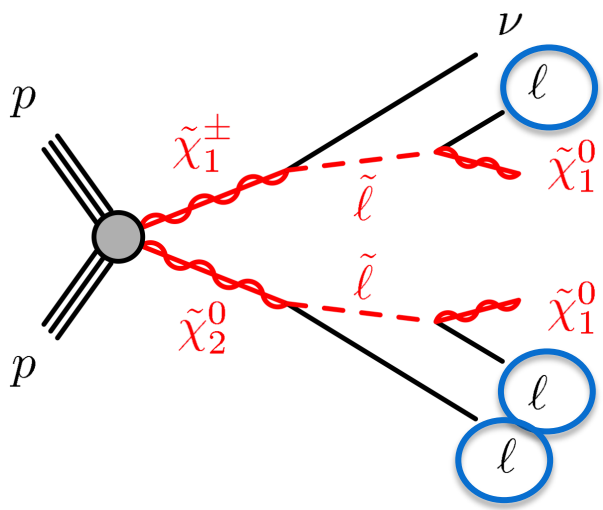
2ℓ+0 jets:
direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ with $\tilde{\ell}$ mediated decays



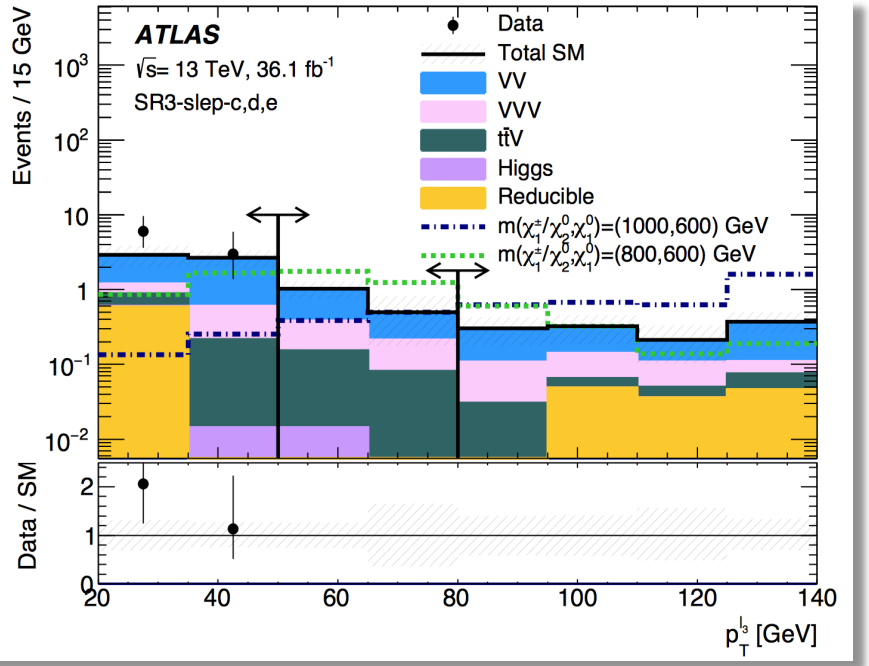
- 95% C.L. exclusion limits in the m($\tilde{\ell}$)-m($\tilde{\chi}_1^0$) plane → $\tilde{\ell}$ excluded up to ~**500 GeV**
- $\tilde{\chi}_1^+\tilde{\chi}_1^-$ with $\tilde{\ell}$ mediated decays → excluded up to **~750 GeV**

Sleptons via gaugino decays

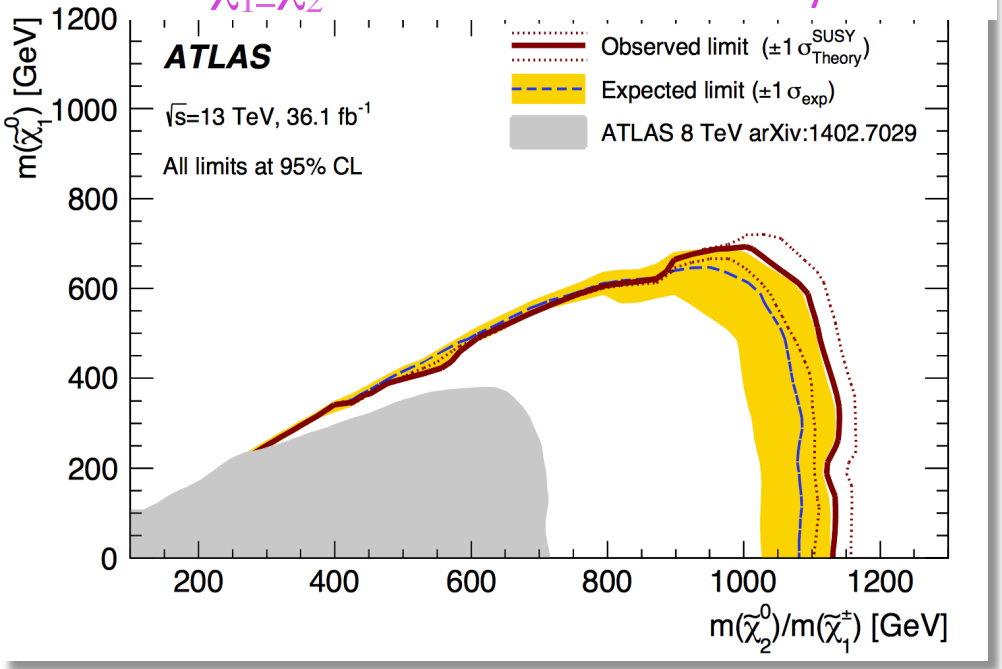
[arXiv:1803.02762]



- **3 leptons** (e or μ) in the final state
- Large E_t^{miss} (> 130 GeV)
- 1 SF-Opposite Sign (SFOS) lepton pair with m_{ll} far away from the Z mass peak to suppress WZ dominant background
- 5 SRs, with definition based on m_{SFOS} and p_T^{l3}
- Main systematic uncertainties -> detector-related (e.g. E_t^{miss} modelling), theory (e.g. MC modelling, cross sections)

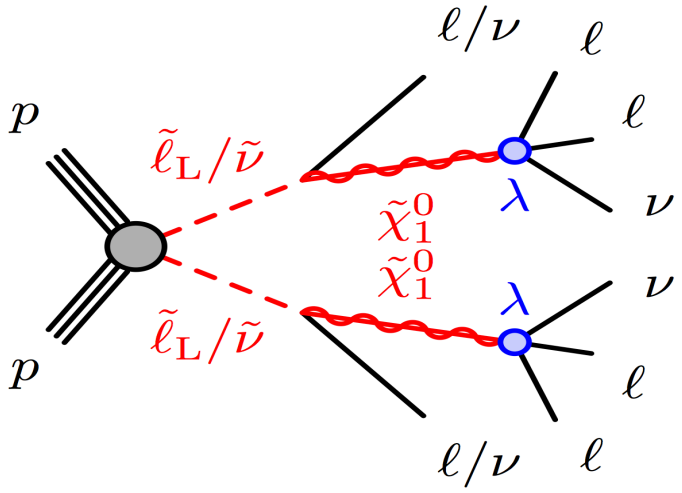


3ℓ: $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ with $\tilde{\ell}$ mediated decays



- $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ (assumed to be mass degenerate) with $\tilde{\ell}$ mediated decays → excluded **~1100 GeV**

Sleptons in RPV scenarios

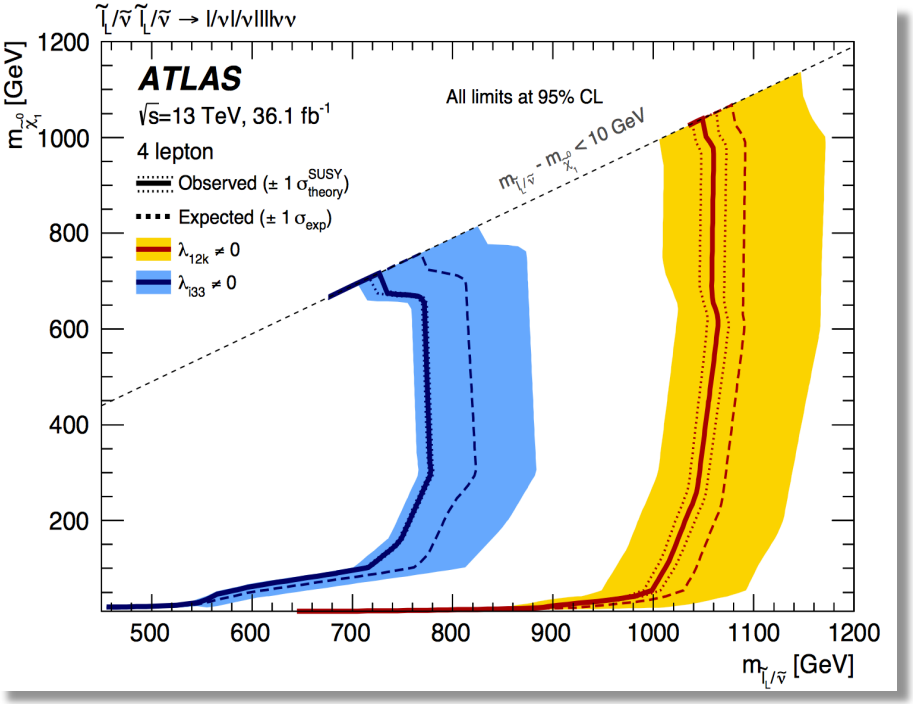


[arXiv:1804.03602]

- RPC pair production of NLSP followed by RPV decays of LSP (100% BR in $\ell\ell\nu$)
- **>= 4 leptons** (e,μ or hadronically decaying τ) in the final state
- SR definition based on τ multiplicity, Z veto and meff $=E_T^{miss} + \Sigma_i p_T^{li} + \Sigma_i p_T^{ji}$ ($p_T^{ji} > 40$ GeV)

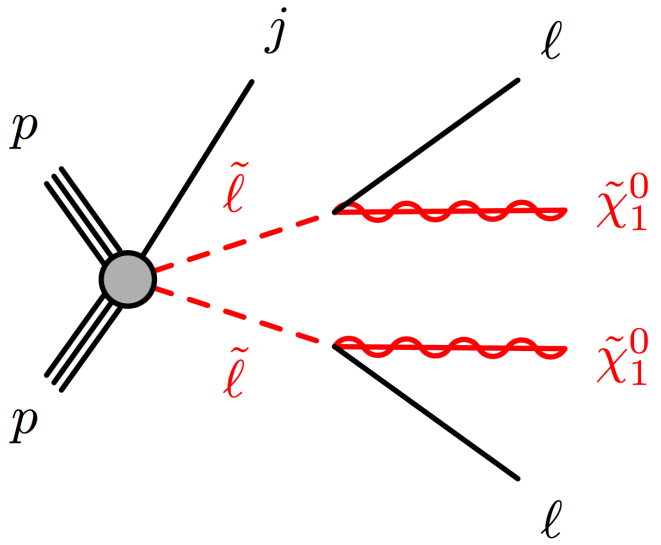
$\tilde{\ell}_L/\tilde{\nu}$ Next Lightest SUSY Particle (NLSP): mass-degenerate left-handed sleptons and sneutrinos

- 95% C.L. exclusion limits for RPV NLSP $\tilde{\ell}_L/\tilde{\nu}$ models → $\tilde{\ell}_L/\tilde{\nu}$ excluded up to **~1.06 TeV** for $LL\bar{E}$ 12*k* (allowed only decays to e or μ) and up to **780 GeV** for $LL\bar{E}$ i33 models (allowed decays to e, μ, τ)

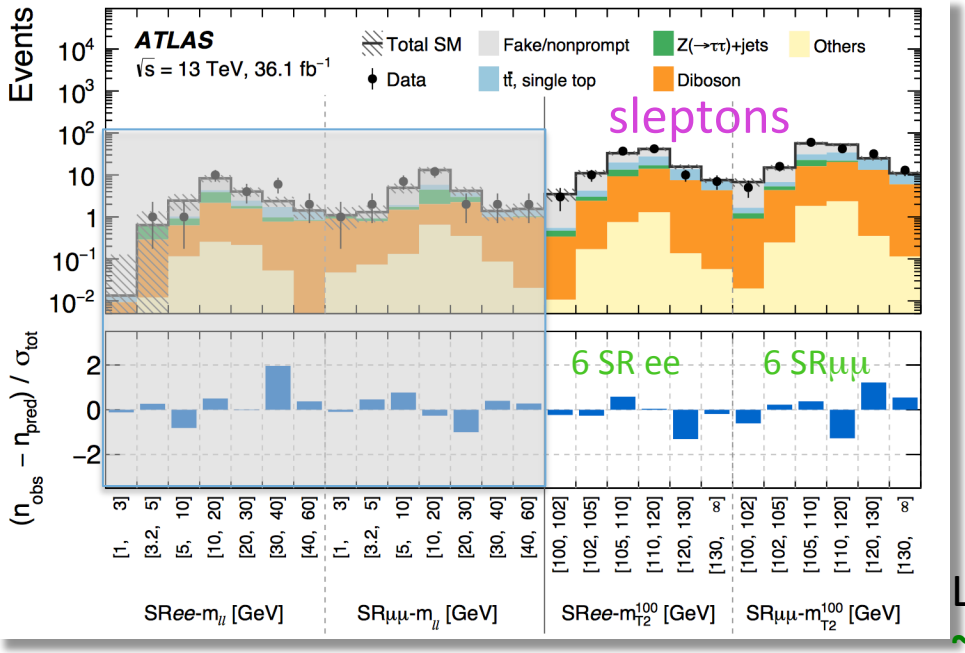


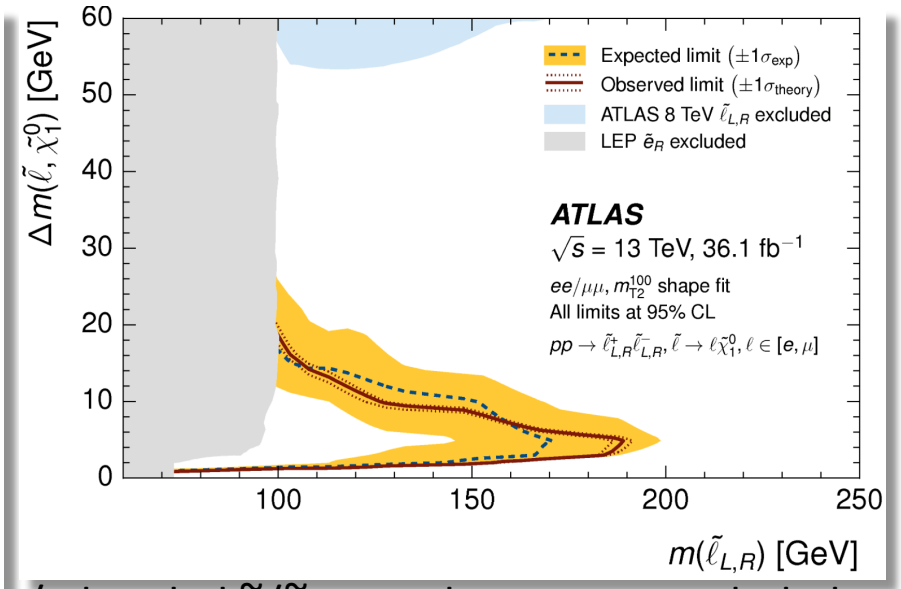
Sleptons with soft leptons

[arXiv:1712.08119]



- Compressed scenario → sleptons have masses near the weak scale and just above the mass of a pure bino LSP.
- **SF OS soft leptons** (e or μ, >4-5 GeV, m_{ll} [1,60] excluding J/ψ) and E_T^{miss} (> 200 GeV)
- Initial state radiation jet to boost the system (>100 GeV, no b-jet), large $E_t^{miss}/(p_T^{l1} + p_T^{l2})$ requested
- 6 exclusive SRs, definition based on large dilepton m_{T2} (>100 GeV), largely affected by "fake"/non-prompt leptons reducible background (the largest source of experimental systematics)

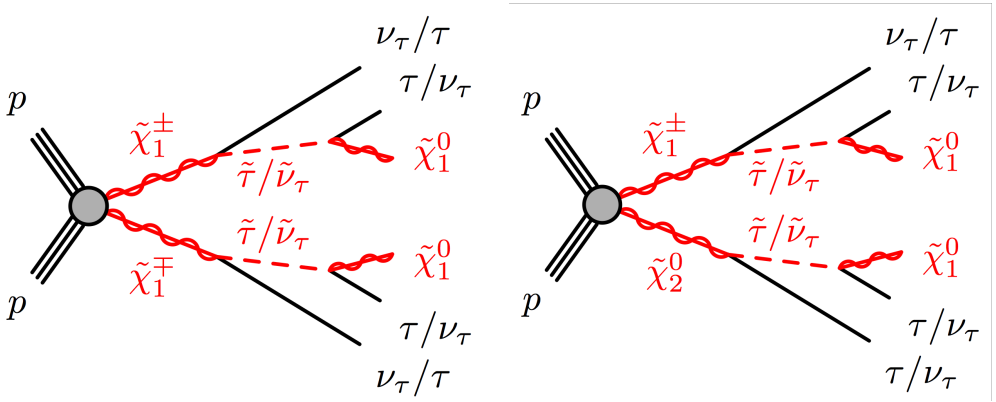




L/R handed ẽ/μ̃ mass degenerate excluded up to **~ 190 GeV** for low mass splittings (~5 GeV)

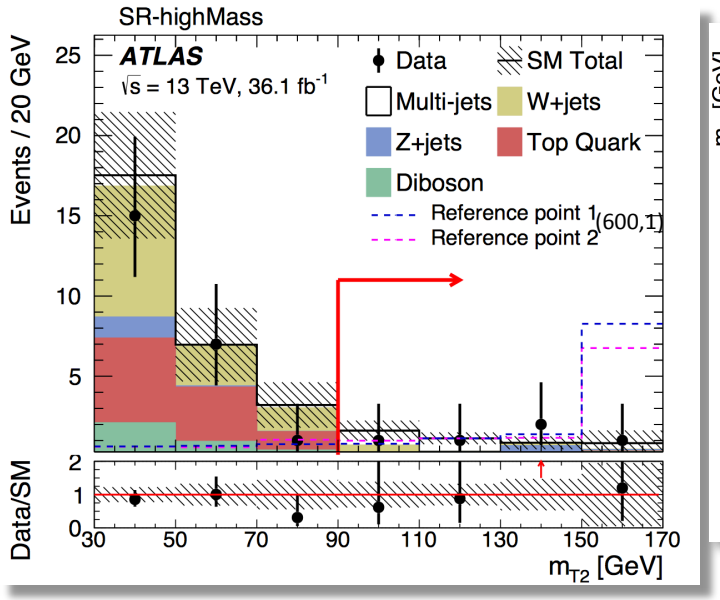
Staus via gaugino decays

[arXiv:1708.07875]

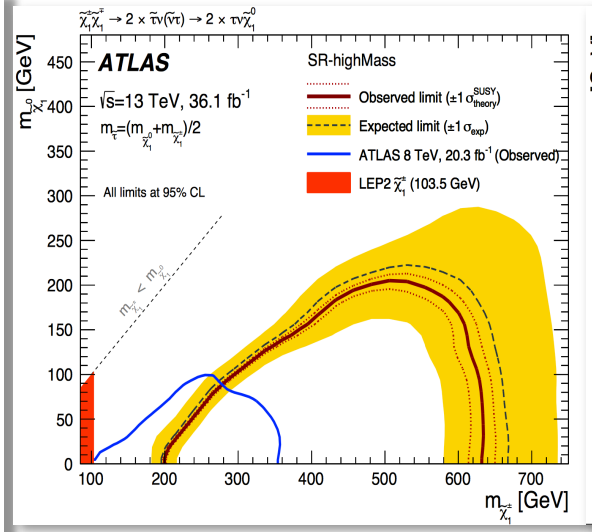


Only these sparticles are assumed to be enough light in the model to be produced at LHC

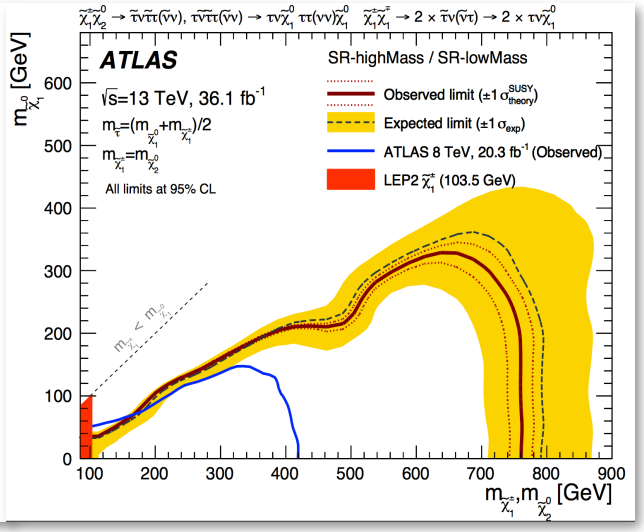
- $\tilde{\tau}_1$ assumed to be purely $\tilde{\tau}_l$
- On-shell stau and tau sneutrino, assumed to be mass-degenerate
- $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ are assumed to be pure wino and mass-degenerate
- **>= 2 OS hadronically decaying τ** (dedicated triggers + id. based on Boosted Decision Tree) and E_T^{miss} in the final state,b-jet veto, Z veto
- 2 SRs with large m_{T2} (>70/90 GeV for low/ high mass)



direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ with $\tilde{\tau}$ mediated decays



$\tilde{\chi}_1^+\tilde{\chi}_1^-/\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ with $\tilde{\tau}$ mediated decays

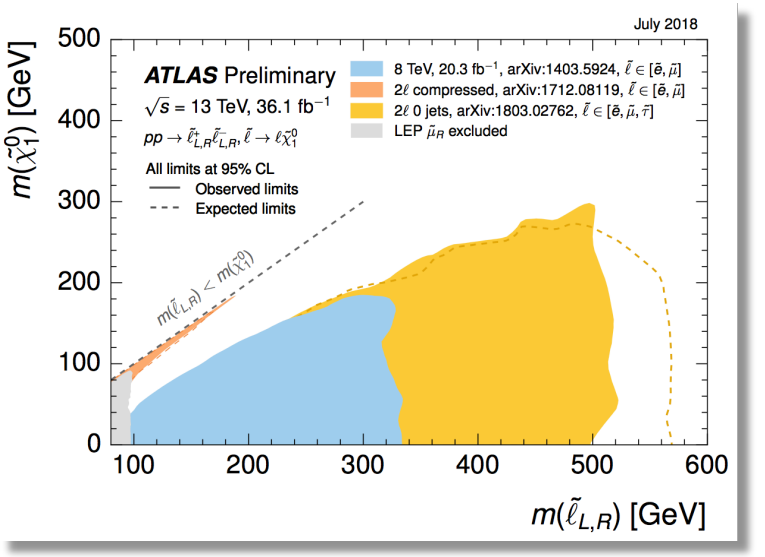


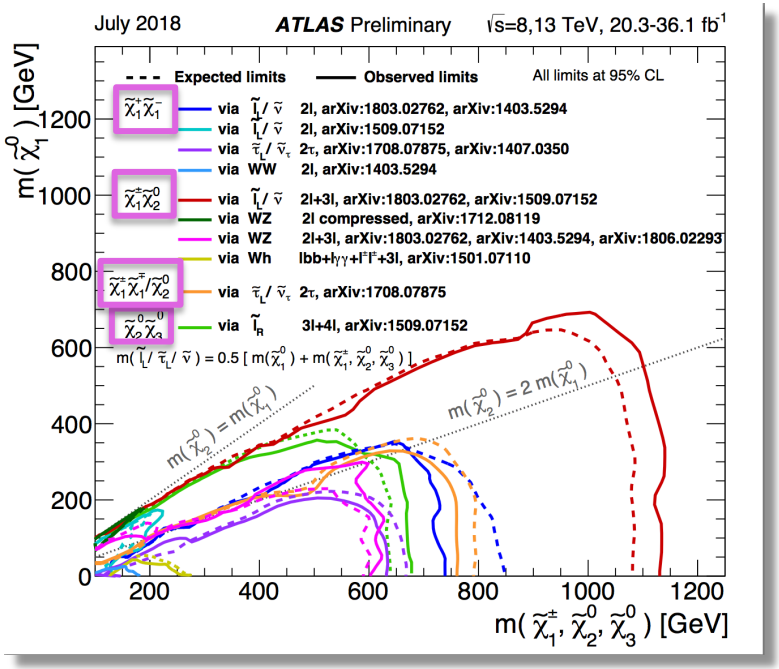
$\tilde{\chi}_1^{\pm}$ with $\tilde{\tau}$ mediated decays → excluded up to **~630 GeV**

$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ with $\tilde{\tau}$ mediated decays → excluded up to **~760 GeV**

Conclusions

- Searches for direct, or from gaugino decay, production of sleptons in ATLAS presented in several final states
- No significant excess above the Standard Model predictions observed in data corresponding to 36.1 fb^{-1}
- 95% CL exclusion limits on the SUSY particle masses set, largely improving the Run I results
- The search continues, aiming to new results from the full data set at the end of Run II (~140 fb^{-1} expected)
- All results in https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

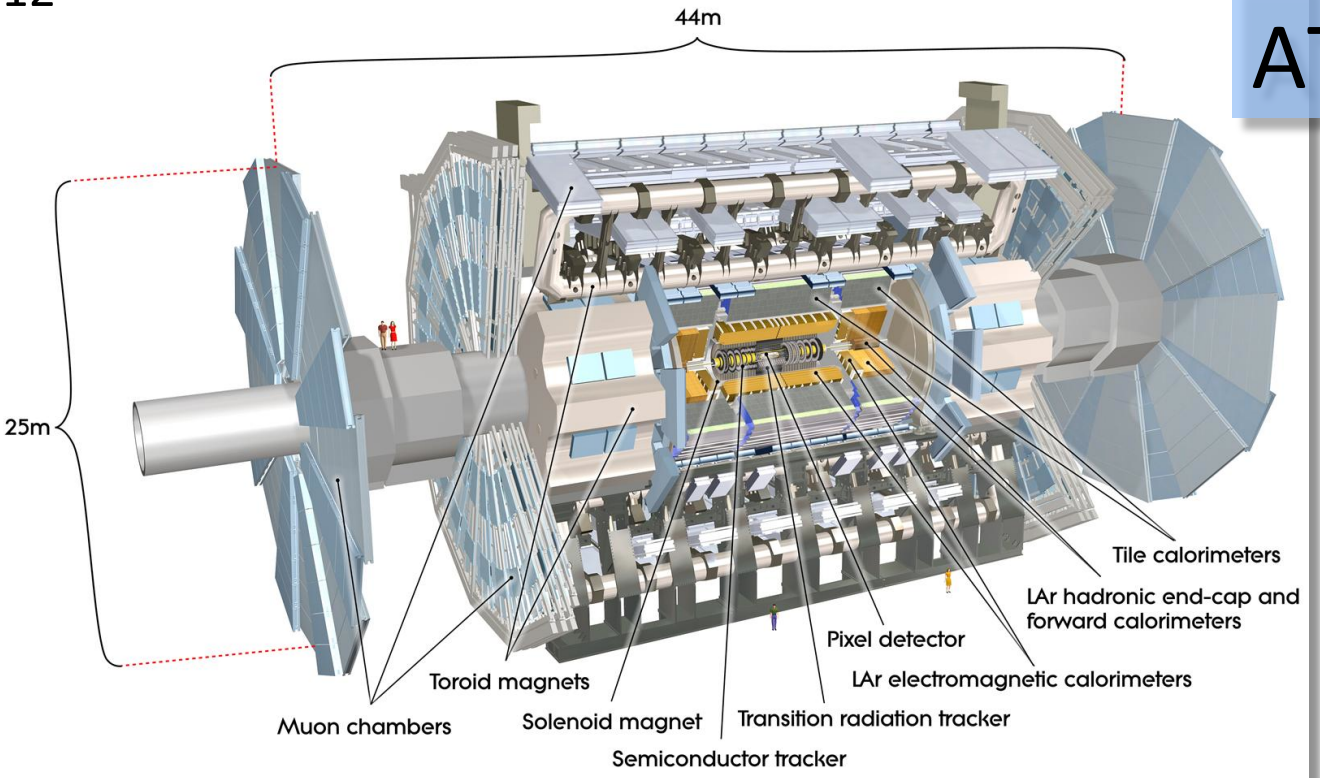




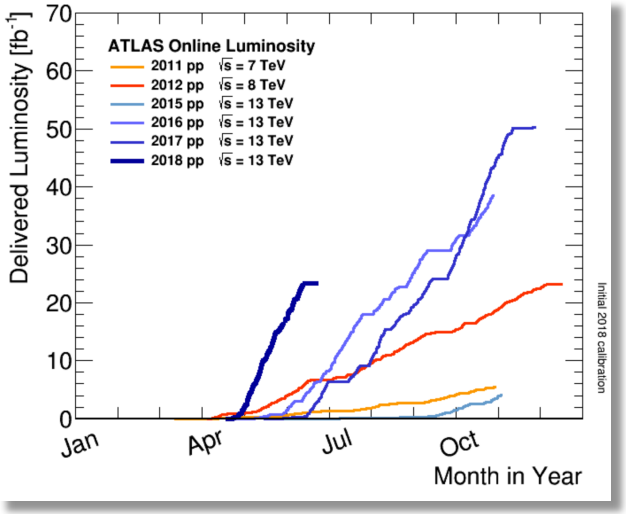
Thank you for your attention!

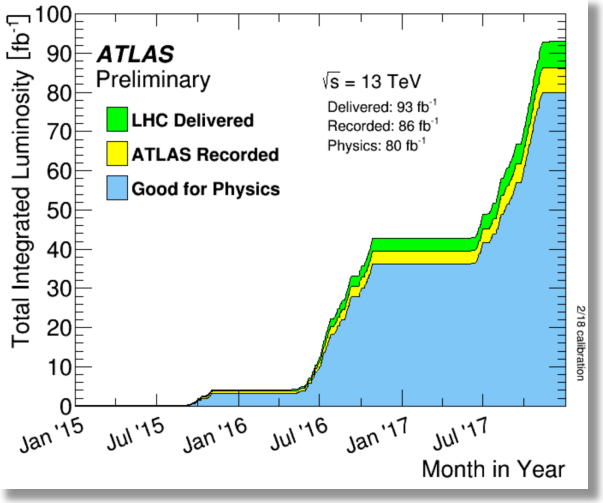
Backup slides

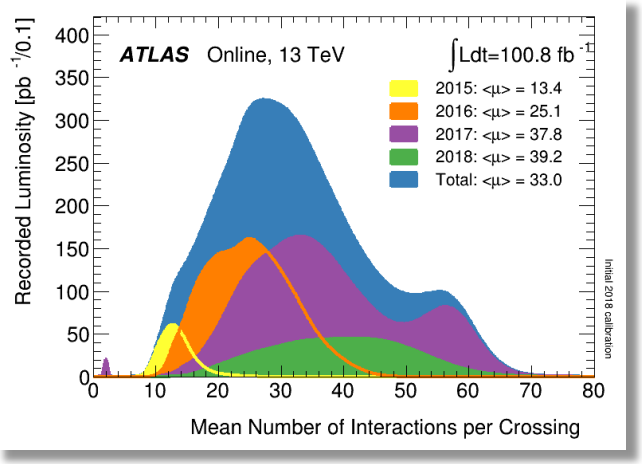
ATLAS detector



LHC Peak instantaneous luminosity of 2.14×10^{34} cm^{-2}s^{-1}







ATLAS SUSY Searches* - 95% CL Lower Limits

July 2018

ATLAS Preliminary

$\sqrt{s}$ = 7, 8, 13 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit	$\sqrt{s}$ = 7, 8 TeV	$\sqrt{s}$ = 13 TeV	Reference
Inclusive Searches	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{q}$ [2x, 8x Degen.]	0.9	1.55	$m(\tilde{\chi}_1^0)$<100 GeV	1712.02332
		mono-jet	1-3 jets	Yes	36.1	$\tilde{q}$ [1x, 8x Degen.]	0.43	0.71	$m(\tilde{q})$-$m(\tilde{\chi}_1^0)$=5 GeV	1711.03301
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$		2.0	$m(\tilde{\chi}_1^0)$<200 GeV	1712.02332
						$\tilde{g}$ Forbidden		0.95-1.6	$m(\tilde{\chi}_1^0)$=900 GeV	1712.02332
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}(\ell\ell)\tilde{\chi}_1^0$	3 e,μ	4 jets	-	36.1	$\tilde{g}$		1.85	$m(\tilde{\chi}_1^0)$<800 GeV	1706.03731
		$ee,\mu\mu$	2 jets	Yes	36.1	$\tilde{g}$		1.2	$m(\tilde{g})$-$m(\tilde{\chi}_1^0)$=50 GeV	1805.11381
	$\tilde{g}\tilde{g}, \tilde{g}\to qqWZ\tilde{\chi}_1^0$	0	7-11 jets	Yes	36.1	$\tilde{g}$		1.8	$m(\tilde{\chi}_1^0)$ <400 GeV	1708.02794
		3 e,μ	4 jets	-	36.1	$\tilde{g}$	0.98		$m(\tilde{g})$-$m(\tilde{\chi}_1^0)$=200 GeV	1706.03731
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	36.1	$\tilde{g}$		2.0	$m(\tilde{\chi}_1^0)$<200 GeV	1711.01901
		3 e,μ	4 jets	-	36.1	$\tilde{g}$	1.25		$m(\tilde{g})$-$m(\tilde{\chi}_1^0)$=300 GeV	1706.03731
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0/t\tilde{\chi}_1^\pm$		Multiple		36.1	$\tilde{b}_1$ Forbidden		0.9	$m(\tilde{\chi}_1^0)$=300 GeV, BR($b\tilde{\chi}_1^0$)=1	1708.09266, 1711.03301
			Multiple		36.1	$\tilde{b}_1$ Forbidden	0.58-0.82		$m(\tilde{\chi}_1^0)$=300 GeV, BR($b\tilde{\chi}_1^0$)=BR($t\tilde{\chi}_1^+$)=0.5	1708.09266
			Multiple		36.1	$\tilde{b}_1$ Forbidden	0.7		$m(\tilde{\chi}_1^0)$=200 GeV, $m(\tilde{\chi}_1^\pm)$=300 GeV, BR($t\tilde{\chi}_1^\pm$)=1	1706.03731
	$\tilde{b}_1\tilde{b}_1, \tilde{t}_1\tilde{t}_1, M_2 = 2\times M_1$		Multiple		36.1	$\tilde{t}_1$	0.7		$m(\tilde{\chi}_1^0)$=60 GeV	1709.04183, 1711.11520, 1708.03247
			Multiple		36.1	$\tilde{t}_1$ Forbidden	0.9		$m(\tilde{\chi}_1^0)$=200 GeV	1709.04183, 1711.11520, 1708.03247
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e,μ	0-2 jets/1-2 b	Yes	36.1	$\tilde{t}_1$	1.0		$m(\tilde{\chi}_1^0)$=1 GeV	1506.08616, 1709.04183, 1711.11520
	$\tilde{t}_1\tilde{t}_1$, $\tilde{H}$ LSP		Multiple		36.1	$\tilde{t}_1$	0.4-0.9		$m(\tilde{\chi}_1^0)$=150 GeV, $m(\tilde{\chi}_1^+)$-$m(\tilde{\chi}_1^0)$=5 GeV, $\tilde{t}_1 \approx \tilde{t}_L$	1709.04183, 1711.11520
			Multiple		36.1	$\tilde{t}_1$ Forbidden	0.6-0.8		$m(\tilde{\chi}_1^0)$=300 GeV, $m(\tilde{\chi}_1^+)$-$m(\tilde{\chi}_1^0)$=5 GeV, $\tilde{t}_1 \approx \tilde{t}_L$	1709.04183, 1711.11520
	$\tilde{t}_1\tilde{t}_1$, Well-Tempered LSP		Multiple		36.1	$\tilde{t}_1$	0.48-0.84		$m(\tilde{\chi}_1^0)$=150 GeV, $m(\tilde{\chi}_1^+)$-$m(\tilde{\chi}_1^0)$=5 GeV, $\tilde{t}_1 \approx \tilde{t}_L$	1709.04183, 1711.11520
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$ / $\tilde{c}\bar{c}$, $\tilde{c}\to c\tilde{\chi}_1^0$	0	2c	Yes	36.1	$\tilde{t}_1$	0.85		$m(\tilde{\chi}_1^0)$=0 GeV	1805.01649
						$\tilde{t}_1$	0.46		$m(\tilde{t}_1,\tilde{c})$-$m(\tilde{\chi}_1^0)$=50 GeV	1805.01649
		0	mono-jet	Yes	36.1	$\tilde{t}_1$	0.43		$m(\tilde{t}_1,\tilde{c})$-$m(\tilde{\chi}_1^0)$=5 GeV	1711.03301
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1 + h$	1-2 e,μ	4 b	Yes	36.1	$\tilde{t}_2$	0.32-0.88		$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$= 180 GeV	1706.03986
EW direct	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via WZ	2-3 e,μ	-	Yes	36.1	$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$	0.6		$m(\tilde{\chi}_1^0)$=0	1403.5294, 1806.02293
		$ee,\mu\mu$	≥ 1	Yes	36.1	$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$ 0.17			$m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=10 GeV	1712.08119
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ via Wh	$\ell\ell/\ell\gamma\gamma/\ell bb$	-	Yes	20.3	$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$ 0.26			$m(\tilde{\chi}_1^0)$=0	1501.07110
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp/\tilde{\chi}_2^0, \tilde{\chi}_1^\pm\to\tilde{\tau}\nu(\tau\tilde{\nu}), \tilde{\chi}_2^0\to\tilde{\tau}\tau(\nu\tilde{\nu})$	2 τ	-	Yes	36.1	$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$	0.76		$m(\tilde{\chi}_1^0)$=0, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1708.07875
						$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$ 0.22			$m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=100 GeV, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1708.07875
	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	36.1	$\tilde{\ell}$	0.5		$m(\tilde{\chi}_1^0)$=0	1803.02762
		2 e,μ	≥ 1	Yes	36.1	$\tilde{\ell}$ 0.18			$m(\tilde{\ell})$-$m(\tilde{\chi}_1^0)$=5 GeV	1712.08119
	$\tilde{H}\tilde{H}, \tilde{H}\to h\tilde{G}/Z\tilde{G}$	0	≥ 3b	Yes	36.1	$\tilde{H}$ 0.13-0.23		0.29-0.88	BR($\tilde{\chi}_1^0\to h\tilde{G}$)=1	1806.04030
		4 e,μ	0	Yes	36.1	$\tilde{H}$ 0.3			BR($\tilde{\chi}_1^0\to Z\tilde{G}$)=1	1804.03602
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$	0.46		Pure Wino	1712.02118
						$\tilde{\chi}_1^\pm$ 0.15			Pure Higgsino	ATL-PHYS-PUB-2017-019
	Stable $\tilde{g}$ R-hadron	SMP	-	-	3.2	$\tilde{g}$		1.6		1606.05129
	Metastable $\tilde{g}$ R-hadron, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$		Multiple		32.8	$\tilde{g}$ [$\tau(\tilde{g})$ =100 ns, 0.2 ns]		1.6 2.4	$m(\tilde{\chi}_1^0)$=100 GeV	1710.04901, 1604.04520
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$ 0.44			1<$\tau(\tilde{\chi}_1^0)$<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{g}$		1.3	6 <$c\tau(\tilde{\chi}_1^0)$< 1000 mm, $m(\tilde{\chi}_1^0)$=1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$		1.9	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1607.08079
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp/\tilde{\chi}_2^0\to WW/Z\ell\ell\ell\ell\nu\nu$	4 e,μ	0	Yes	36.1	$\tilde{\chi}_1^\pm/\tilde{\chi}_2^0$ [$\lambda_{i33}\neq 0, \lambda_{12k}\neq 0$]	0.82	1.33	$m(\tilde{\chi}_1^0)$=100 GeV	1804.03602
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$	0	4-5 large-R jets	-	36.1	$\tilde{g}$ [$m(\tilde{\chi}_1^0)$=200 GeV, 1100 GeV]		1.3 1.9	Large λ''_{112}	1804.03568
			Multiple		36.1	$\tilde{g}$ [λ''_{112}=2e-4, 2e-5]	1.05	2.0	$m(\tilde{\chi}_1^0)$=200 GeV, bino-like	ATLAS-CONF-2018-003
	$\tilde{g}\tilde{g}, \tilde{g}\to tbs$ / $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0, \tilde{\chi}_1^0\to tbs$		Multiple		36.1	$\tilde{g}$ [λ''_{323}=1, 1e-2]		1.8 2.1	$m(\tilde{\chi}_1^0)$=200 GeV, bino-like	ATLAS-CONF-2018-003
	$t\bar{t}, t\to b\tilde{\chi}_1^0, \tilde{\chi}_1^0\to tbs$		Multiple		36.1	$\tilde{g}$ [λ''_{323}=2e-4, 1e-2]	0.55	1.05	$m(\tilde{\chi}_1^0)$=200 GeV, bino-like	ATLAS-CONF-2018-003
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$	0	2 jets + 2 b	-	36.7	$\tilde{t}_1$ [qq, bs]	0.42	0.61		1710.07171
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$	2 e,μ	2 b	-	36.1	$\tilde{t}_1$		0.4-1.45	BR($\tilde{t}_1\to be/b\mu$)>20%	1710.05544

10^{-1} 1 **Mass scale [TeV]**

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

ABCD method to estimate multi-jet background [arXiv:1708.07875]

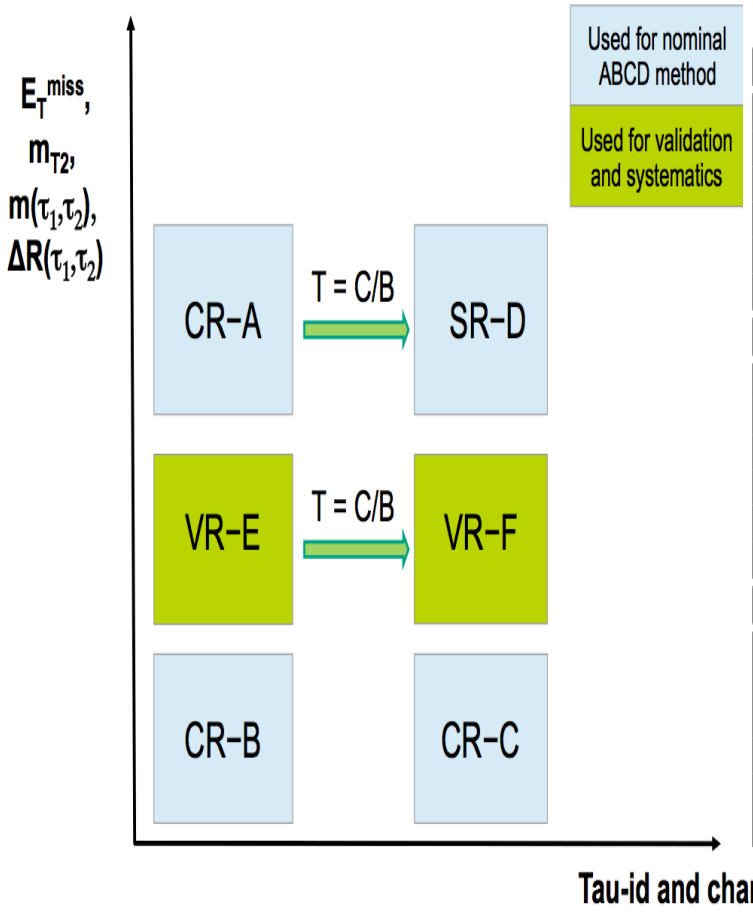


Table 2: Definition of the regions used in the ABCD method for the multi-jet estimation in SR-lowMass (left) and SR-highMass (right). Only those requirements that are different in the CRs/VRs with respect to the SRs are listed.

CR-A	SR-D (SR-lowMass)
Di-tau+E_T^{miss} trigger	
≥ 2 loose tau leptons (SS)	≥ 2 medium tau leptons (OS)
$m(\tau_1,\tau_2) < 250$ GeV	–
$\Delta R(\tau_1,\tau_2) > 1.5$	–
$E_T^{miss} > 150$ GeV	$E_T^{miss} > 150$ GeV
$m_{T2} > 70$ GeV	$m_{T2} > 70$ GeV
VR-E	**VR-F**
Di-tau trigger	
≥ 2 loose tau leptons (SS)	≥ 2 medium tau leptons (OS)
$m(\tau_1,\tau_2) < 250$ GeV	–
$\Delta R(\tau_1,\tau_2) > 1.5$	–
$E_T^{miss} > 40$ GeV	$E_T^{miss} > 40$ GeV
$50 < m_{T2} < 70$ GeV	$50 < m_{T2} < 70$ GeV
CR-B	**CR-C**
Di-tau trigger	
≥ 2 loose tau leptons (SS)	≥ 2 medium tau leptons (OS)
$m(\tau_1,\tau_2) < 250$ GeV	–
$\Delta R(\tau_1,\tau_2) > 1.5$	–
$E_T^{miss} > 40$ GeV	$E_T^{miss} > 40$ GeV
$20 < m_{T2} < 50$ GeV	$20 < m_{T2} < 50$ GeV

CR-A	SR-D (SR-highMass)
Di-tau+E_T^{miss} or asymmetric di-tau trigger	
≥ 2 loose tau leptons (OS)	≥ 2 medium tau leptons (OS)
< 1 medium tau < 1 tight tau leptons	≥ 1 tight tau lepton
$\Delta R(\tau_1,\tau_2) > 1.8$	–
$E_T^{miss} > 110$ GeV	$E_T^{miss} > 110$ GeV
$m_{T2} > 90$ GeV	$m_{T2} > 90$ GeV
VR-E	**VR-F**
Di-tau or asymmetric di-tau trigger	
≥ 2 loose tau leptons (OS)	≥ 2 medium tau leptons (OS)
< 1 medium tau < 1 tight tau leptons	≥ 1 tight tau lepton
$\Delta R(\tau_1,\tau_2) > 1.8$	–
$E_T^{miss} > 40$ GeV	$E_T^{miss} > 40$ GeV
$60 < m_{T2} < 90$ GeV	$60 < m_{T2} < 90$ GeV
CR-B	**CR-C**
Di-tau or asymmetric di-tau trigger	
≥ 2 loose tau leptons (OS)	≥ 2 medium tau leptons (OS)
< 1 medium tau < 1 tight tau leptons	≥ 1 tight tau
$\Delta R(\tau_1,\tau_2) > 1.8$	–
$E_T^{miss} > 40$ GeV	$E_T^{miss} > 40$ GeV
$10 < m_{T2} < 60$ GeV	$10 < m_{T2} < 60$ GeV