ATLAS searches for BSM physics using taus

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Pushing the Boundaries - Standard Model and Beyond at the LHC 18th - 20th September, Durham



taus?

experimentally challenging, only leptons that decay in ATLAS



only considered in a few ATLAS analyses

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ATLAS SUSY Searches* - 95% CL Lower Limits

00	Model	Signature ∫£	dt [fb ⁻¹	Mass limit			Reference
S	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\chi}_1^0$	$\begin{array}{ccc} 0 \ e, \mu & ext{2-6 jets} & E_T^{ ext{miss}} \ ext{mono-jet} & ext{1-3 jets} & E_T^{ ext{miss}} \end{array}$	36.1 36.1		0.9 0.71	1.55 $m(\tilde{\chi}_1^0) < 100 \text{ GeV}$ $m(\tilde{q}) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$	1712.02332 1711.03301
arche	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0$	0 e, μ 2-6 jets E_T^{miss}	36.1	ັຽ ວັ ຽ	Forbidden	2.0 $m(\tilde{\chi}_1^0) < 200 \text{ GeV}$ 0.95-1.6 $m(\tilde{\chi}_1^0) = 900 \text{ GeV}$	1712.02332 1712.02332
'e Seá	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\ell)\tilde{\chi}_1^0$	$\begin{array}{ccc} 3 \ e, \mu & 4 \ { m jets} \\ e e, \mu \mu & 2 \ { m jets} & E_T^{ m miss} \end{array}$	36.1 36.1	čς čς		1.85 $m(\tilde{\chi}_1^0) < 800 \text{ GeV}$ 1.2 $m(\tilde{g}) - m(\tilde{\chi}_1^0) = 50 \text{ GeV}$	1706.03731 1805.11381
Iclusiv	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qqWZ\tilde{\chi}_1^0$	$\begin{array}{ccc} 0 \ e, \mu & \ & \ & \ & \ & \ & \ & \ & \ & \ &$	36.1 139	ğ ğ		1.8 $m(\tilde{\chi}_1^0) < 400 \text{ GeV}$ 1.15 $m(\tilde{\chi}_1^0)=200 \text{ GeV}$	1708.02794 ATLAS-CONF-2019-015
4	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$	$\begin{array}{cccc} \text{0-1} \ e,\mu & \text{3} \ b & E_T^{\text{miss}} \\ \text{SS} \ e,\mu & \text{6 jets} \end{array}$	79.8 139	0°20 0°20		2.25 $m(\tilde{\chi}_1^0) < 200 \text{ GeV}$ 1.25 $m(\tilde{g}) - m(\tilde{\chi}_1^0) = 300 \text{ GeV}$	ATLAS-CONF-2018-041 ATLAS-CONF-2019-015
	$\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{\chi}_1^0 / t \tilde{\chi}_1^{\pm}$	Multiple Multiple Multiple	36.1 36.1 139	$egin{array}{ccc} & eta_1 & & Forbidden \ & eta_1 & & Forbidden \ & eta_1 & & Forbidden \ & eta_1 & & Forbidden \end{array}$	0.9 0.58-0.82 0.74	$\begin{split} m(\tilde{\chi}^0_1) = & 300 \mathrm{GeV}, BR(b \tilde{\chi}^0_1) = 1 \\ & m(\tilde{\chi}^0_1) = & 300 \mathrm{GeV}, BR(b \tilde{\chi}^0_1) = & BR(t \tilde{\chi}^\pm_1) = 0.5 \\ & m(\tilde{\chi}^0_1) = & 200 \mathrm{GeV}, m(\tilde{\chi}^\pm_1) = & 300 \mathrm{GeV}, BR(t \tilde{\chi}^\pm_1) = 1 \end{split}$	1708.09266, 1711.03301 1708.09266 ATLAS-CONF-2019-015
urks tion	$\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{\chi}_2^0 \rightarrow b h \tilde{\chi}_1^0$	$0 e, \mu$ $6 b$ E_T^{miss}	139	$\begin{array}{c c} \tilde{b}_1 & Forbidden \\ \tilde{b}_1 & 0.23-0.48 \end{array}$	C	0.23-1.35 $\Delta m(\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{0}) = 130 \text{ GeV}, \ m(\tilde{\chi}_{1}^{0}) = 100 \text{ GeV} \\ \Delta m(\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{0}) = 130 \text{ GeV}, \ m(\tilde{\chi}_{1}^{0}) = 0 \text{ GeV}$	SUSY-2018-31 SUSY-2018-31
3 rd gen. squar direct producti	$ \tilde{t}_{1}\tilde{t}_{1}, \tilde{t}_{1} \rightarrow Wb\tilde{\chi}_{1}^{0} \text{ or } t\tilde{\chi}_{1}^{0} $ $ \tilde{t}_{1}\tilde{t}_{1}, \tilde{t}_{1} \rightarrow Wb\tilde{\chi}_{1}^{0} $ $ \tilde{t}_{1}\tilde{t}_{1}, \tilde{t}_{1} \rightarrow \tilde{\tau}_{1}b\nu, \tilde{\tau}_{1} \rightarrow \tau\tilde{G} $ $ \tilde{t}_{1}\tilde{t}_{1}, \tilde{t}_{1} \rightarrow c\tilde{\chi}_{1}^{0} / \tilde{c}\tilde{c}, \tilde{c} \rightarrow c\tilde{\chi}_{1}^{0} $	$\begin{array}{ccccccc} 0\text{-}2 \ e, \mu & 0\text{-}2 \ \text{jets}/1\text{-}2 \ b \ E_T^{\text{miss}} \\ 1 \ e, \mu & 3 \ \text{jets}/1 \ b & E_T^{\text{miss}} \\ 1 \ \tau + 1 \ e, \mu, \tau & 2 \ \text{jets}/1 \ b & E_T^{\text{miss}} \\ 0 \ e, \mu & 2 \ c & E_T^{\text{miss}} \end{array}$	36.1 139 36.1 36.1		1.0 59 0.85	$m(\tilde{\chi}_{1}^{0})=1 \text{ GeV}$ $m(\tilde{\chi}_{1}^{0})=400 \text{ GeV}$ $m(\tilde{\tau}_{1})=800 \text{ GeV}$ $m(\tilde{\chi}_{1}^{0})=0 \text{ GeV}$	1506.08616, 1709.04183, 1711.11520 ATLAS-CONF-2019-017 1803.10178 1805.01649
		$0 e, \mu$ mono-jet E_T^{miss}	36.1			$ \begin{array}{l} m(\tilde{t}_1,\tilde{c})\text{-}m(\tilde{\chi}_1^0) = 50 \text{ GeV} \\ m(\tilde{t}_1,\tilde{c})\text{-}m(\tilde{\chi}_1^0) = 5 \text{ GeV} \end{array} $	1805.01649 1711.03301
	$ \tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + h \tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z $	$\begin{array}{cccc} 1-2 \ e, \mu & 4 \ b & E_T^{\text{miss}} \\ 3 \ e, \mu & 1 \ b & E_T^{\text{miss}} \end{array}$	36.1 139	<i>t</i>₂<i>t</i>₂<i>Forbidden</i>	0.32-0.88 0.86	$m(\tilde{\chi}_{1}^{0})=0 \text{ GeV}, m(\tilde{t}_{1})-m(\tilde{\chi}_{1}^{0})=180 \text{ GeV}$ $m(\tilde{\chi}_{1}^{0})=360 \text{ GeV}, m(\tilde{t}_{1})-m(\tilde{\chi}_{1}^{0})=40 \text{ GeV}$	1706.03986 ATLAS-CONF-2019-016
	$ ilde{\chi}_1^{\pm} ilde{\chi}_2^0$ via WZ	$\begin{array}{ccc} \textbf{2-3} \ e, \mu & & E_T^{\text{miss}} \\ ee, \mu \mu & \geq 1 & E_T^{\text{miss}} \end{array}$	36.1 139	$ \begin{array}{c} \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} \\ \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} \end{array} \qquad $	0.6	$\mathfrak{m}(ilde{\chi}_1^0)=0$ $\mathfrak{m}(ilde{\chi}_1^\pm)-\mathfrak{m}(ilde{\chi}_1^0)=5~\mathrm{GeV}$	1403.5294, 1806.02293 ATLAS-CONF-2019-014
EW direct	$\begin{split} \tilde{\chi}_{1}^{\pm} \tilde{\chi}_{1}^{\mp} \text{ via } WW \\ \tilde{\chi}_{1}^{\pm} \tilde{\chi}_{2}^{0} \text{ via } Wh \\ \tilde{\chi}_{1}^{\pm} \tilde{\chi}_{1}^{\mp} \text{ via } \tilde{\ell}_{L} / \tilde{\nu} \\ \tilde{\tau} \tilde{\tau}, \tilde{\tau} \rightarrow \tau \tilde{\chi}_{1}^{0} \\ \tilde{\ell}_{L} p \tilde{\ell}_{L} p - \tilde{\ell} \rightarrow \ell \tilde{\chi}_{1}^{0} \end{split}$	$\begin{array}{cccc} 2 \ e, \mu & E_T^{\text{miss}} \\ 0-1 \ e, \mu & 2 \ b/2 \ \gamma & E_T^{\text{miss}} \\ 2 \ e, \mu & E_T^{\text{miss}} \\ 2 \ \tau & E_T^{\text{miss}} \\ 2 \ e, \mu & 0 \ \text{jets} & E_T^{\text{miss}} \end{array}$	139 139 139 139 139	$ \begin{array}{cccc} \tilde{\chi}_{1}^{\pm} & & 0.42 \\ \\ \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} & \textit{Forbidden} \\ \\ \tilde{\chi}_{1}^{\pm} & \\ \\ \tilde{\tau} & [\tilde{\tau}_{L}, \tilde{\tau}_{R,L}] & 0.16\text{-}0.3 & 0.12\text{-}0.39 \\ \\ \\ \tilde{\ell} & \end{array} $	0.74	$m(\tilde{\chi}_{1}^{0})=0$ $m(\tilde{\chi}_{1}^{0})=70 \text{ GeV}$ $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_{1}^{\pm})+m(\tilde{\chi}_{1}^{0}))$ $m(\tilde{\chi}_{1}^{0})=0$ $m(\tilde{\chi}_{1}^{0})=0$	ATLAS-CONF-2019-008 ATLAS-CONF-2019-019, ATLAS-CONF-2019-X ATLAS-CONF-2019-008 ATLAS-CONF-2019-018 ATLAS-CONF-2019-008
	$\tilde{H}\tilde{H}, \tilde{H} \rightarrow h\tilde{G}/Z\tilde{G}$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	139 36.1 36.1	<i>ℓ ℓ ℓ H H H H</i>	0.29-0.88	$m(\tilde{\ell})-m(\tilde{\chi}_1^0)=10 \text{ GeV}$ $BR(\tilde{\chi}_1^0 \to h\tilde{G})=1$ $BR(\tilde{\chi}_1^0 \to Z\tilde{G})=1$	ATLAS-CONF-2019-014 1806.04030 1804.03602
lived cles	Direct $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk 1 jet E_T^{miss}	36.1			Pure Wino Pure Higgsino	1712.02118 ATL-PHYS-PUB-2017-019
Long- partic	Stable \tilde{g} R-hadron Metastable \tilde{g} R-hadron, $\tilde{g} \rightarrow qq \tilde{\chi}_1^0$	Multiple Multiple	36.1 36.1	\tilde{g} $\tilde{g} [\tau(\tilde{g}) = 10 \text{ ns}, 0.2 \text{ ns}]$		2.0 2.05 2.4 $m(\tilde{\chi}_1^0)=100 \text{ GeV}$	1902.01636,1808.04095 1710.04901,1808.04095
Λ	$ \begin{array}{l} LFV \ pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e\mu/e\tau/\mu\tau \\ \tilde{\chi}_{1}^{\pm}\tilde{\chi}_{1}^{\mp}/\tilde{\chi}_{2}^{0} \rightarrow WW/Z\ell\ell\ell\ell\nu\nu \\ \tilde{g}\tilde{g}, \ \tilde{g} \rightarrow qq\tilde{\chi}_{1}^{0}, \ \tilde{\chi}_{1}^{0} \rightarrow qqq \end{array} $	$e\mu,e au,\mu au$ 4 e,μ 0 jets $E_T^{ m miss}$ 4-5 large- R jets Multiple	3.2 36.1 36.1 36.1	$ \begin{split} \tilde{\nu}_{\tau} \\ \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} & [\lambda_{i33} \neq 0, \lambda_{12k} \neq 0] \\ \tilde{g} & [m(\tilde{\chi}_{1}^{0}) = 200 \text{ GeV}, 1100 \text{ GeV}] \\ \tilde{g} & [\lambda_{112}^{\prime\prime} = 2e{-}4, 2e{-}5] \end{split} $	0.82	1.9 $\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$ 1.33 $m(\tilde{\chi}^0_1)=100 \text{ GeV}$ 1.31.952.0 $m(\tilde{\chi}^0_1)=200 \text{ GeV}$, bino-like	1607.08079 1804.03602 1804.03568 ATLAS-CONF-2018-003
ВР	$\begin{aligned} &\tilde{t}\tilde{t}, \ \tilde{t} \to t \tilde{\chi}_1^0, \ \tilde{\chi}_1^0 \to t bs \\ &\tilde{t}_1 \tilde{t}_1, \ \tilde{t}_1 \to bs \\ &\tilde{t}_1 \tilde{t}_1, \ \tilde{t}_1 \to q\ell \end{aligned}$	Multiple 2 jets + 2 b 2 e, μ 1 μ DV	36.1 36.7 36.1 136	\tilde{g} $[\lambda''_{323}=2e-4, 1e-2]$ 0.55 \tilde{t}_1 $[qq, bs]$ 0.42 0. \tilde{t}_1 \tilde{t}_1 $[1e-10 < \lambda'_{23k} < 1e-8, 3e-10 < \lambda'_{23k} < 3e-9]$	1.0 .61 1.0	5 m($\tilde{\chi}_1^0$)=200 GeV, bino-like 0.4-1.45 BR($\tilde{t}_1 \rightarrow be/b\mu$)>20% BR($\tilde{t}_1 \rightarrow q\mu$)=100%, cos θ_t =1	ATLAS-CONF-2018-003 1710.07171 1710.05544 ATLAS-CONF-2019-006

*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.

 10^{-1}

ATLAS Preliminary $\sqrt{s} = 13$ TeV

Mass scale [TeV]

1

SUSY searches including taus in the final state

1.16

1.9

ger ct J	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow \tilde{\tau}_1 b \nu, \tilde{\tau}_1 \rightarrow \tau \tilde{G}$	$1 \tau + 1 e, \mu, \tau$	2 jets/1 b	$E_T^{ m miss}$	36.1	\tilde{t}_1			
3 rd						<i>c̃</i> ∼			
din	$ ilde{ au} ilde{ au}, ilde{ au} ightarrow au^0_1$	2 τ		$E_T^{\rm miss}$	139	$ ilde{ au} = [ilde{ au}_L, ilde{ au}_{R, ilde{ au}}]$	L] 0.16-0.3	3 0.12-0.39	
	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \ \tilde{\ell} \rightarrow \ell \tilde{\chi}_1^0$			$E_T^{ m miss} \ E_T^{ m miss}$		$\tilde{\ell}$ $\tilde{\ell}$			
	LFV $pp \rightarrow \tilde{\nu}_{\tau} + X, \tilde{\nu}_{\tau} \rightarrow e\mu/e\tau/\mu\tau$	$e\mu,e au,\mu au$			3.2	$\tilde{\nu}_{ au}$			
	$\tilde{\chi}_1^{\pm} \tilde{\chi}_1^{\mp} / \tilde{\chi}_2^0 \to WW/Z\ell\ell\ell\ell\nu\nu$					$\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0 = [\lambda_{i3}]$			

EW direc	$\begin{split} &\tilde{\chi}_{1}^{\pm}\tilde{\chi}_{1}^{\mp} \text{ via } \tilde{\ell}_{L}/\tilde{\nu} \\ &\tilde{\chi}_{1}^{\pm}\tilde{\chi}_{1}^{\mp}/\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{+} \rightarrow \tilde{\tau}_{1}\nu(\tau\tilde{\nu}), \tilde{\chi}_{2}^{0} \rightarrow \tilde{\tau}_{1}\tau(\nu\tilde{\nu}) \end{split}$	2 e,μ 2 τ	$E_T^{ m miss} \ E_T^{ m miss}$	139 36.1	$ \tilde{\chi}_{1}^{\pm} \\ \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} \\ \tilde{\nu}^{\pm} / \tilde{\nu}^{0} $ 0.22	0.7	1.0 $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\ell}_{1}^{\pm})+m(\tilde{\ell}_{1}^{0}))$ $m(\tilde{\ell}_{1}^{0})=0, m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\ell}_{1}^{\pm})+m(\tilde{\ell}_{1}^{0}))$ $m(\tilde{\nu}^{\pm}), m(\tilde{\nu}^{0})=100 \text{ GeV}, m(\tilde{\pi},\tilde{\nu})=0.5(m(\tilde{\nu}^{\pm})+m(\tilde{\nu}^{0}))$
J					 <i>ℓ ℓ</i>		$m(\tilde{\chi}_{1}^{0}) = 0$ $m(\tilde{\chi}_{1}^{0}) = 0$ $m(\tilde{\chi}_{1}^{0}) = 5 \text{ GeV}$









1803.10178

TLAS-CONF-2019-019, ATLAS-CONF-2019-X' $m{p}$

ATLAS-CONF-2019-018

1607.08079

[|]

 λ'_{311} =0.11, $\lambda_{132/133/233}$ =0.07

 $m(\tilde{\tau}_1)=800 \text{ GeV}$

 $m(\tilde{\chi}_1^0)=0$

1708.07875

1708.07875

[2]

SUSY searches including taus in the final state

EW irect	$\tilde{\chi}_{1}^{\pm} \tilde{\chi}_{2}^{0}$ via Wh $\tilde{\chi}_{1}^{\pm} \tilde{\chi}_{1}^{\mp}$ via $\tilde{\ell}_{L} / \tilde{\nu}$ $\tilde{\chi}_{2}^{\pm} \tilde{\chi}_{1}^{\pm}$ via $\tilde{\ell}_{L} / \tilde{\nu}$	0-1 e,μ 2 e,μ 2 τ	E_T^{miss} E_T^{miss} F^{miss}	139 139 139	$\tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{2}^{0} \text{Forbidden}$ $\tilde{\chi}_{1}^{\pm}$ $\tilde{\tau} [\tilde{\tau}_{\text{L}}, \tilde{\tau}_{\text{P},\text{L}}] 0.16-0.3$	0.74	$m(\tilde{\chi}_{1}^{0}) = 70 \text{ GeV}$ $m(\tilde{\ell}, \tilde{\nu}) = 0.5 (m(\tilde{\chi}_{1}^{\pm}) + m(\tilde{\chi}_{1}^{0}))$ $m(\tilde{\ell}^{0}) = 0$	ATLAS-CONF-2019-019, ATLAS-CONF-2019-X ATLAS-CONF-2019-008 ATLAS-CONE-2019-018
0	$\begin{aligned} &\tau\tau, \tau \to \tau \lambda_1 \\ &\tilde{\ell}_{\mathrm{L,R}} \tilde{\ell}_{\mathrm{L,R}}, \ \tilde{\ell} \to \ell \tilde{\chi}_1^0 \end{aligned}$	2 e, μ 2 e, μ	E_T E_T^{miss} E_T^{miss}	139 139	Ĩ 0.10-0.3 Ĩ 0.256	0.7	$m(\tilde{\chi}_{1}^{0})=0$ $m(\tilde{\ell})-m(\tilde{\chi}_{1}^{0})=10 \text{ GeV}$	ATLAS-CONF-2019-008 ATLAS-CONF-2019-014
						0.46	Pure Wino Pure Higgsino 2.0 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1	
					$ \vec{\lambda}_{1}^{\pm} / \vec{\lambda}_{2}^{0} [\lambda_{03} \neq 0, \lambda_{12k} \neq 0] \vec{\xi} [m(\vec{\lambda}_{1}^{0}) = 200 \text{ GeV}] \vec{\xi} [m(\vec{\lambda}_{1}^{0}) = 200 \text{ GeV}] $	ED SELEC	TIONE 1.3 1.3 1.4 $\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$ $m(\tilde{\chi}^0_1)=100 \text{ GeV}$ Large λ''_{112} $m(\tilde{\chi}^0_1)=200 \text{ GeV, bino-like}$	
				36.7 SM	ALL BIAS		0.4-1.45 0.4-1.45 1.6 $m(\tilde{\chi}_{1}^{0})=200 \text{ GeV, bino-like}$ $BR(\tilde{t}_{1} \rightarrow be/b\mu)>20\%$ $BR(\tilde{t}_{1} \rightarrow q\mu)=100\%, \cos\theta_{t}=1$	
								[1]

*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.

, t			$E_T^{ m miss}$		$ ilde{\chi}_1^{\pm}$		
ire($\tilde{\chi}_{1}^{\pm} \tilde{\chi}_{1}^{\mp} / \tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{+} \rightarrow \tilde{\tau}_{1} \nu(\tau \tilde{\nu}), \tilde{\chi}_{2}^{0} \rightarrow \tilde{\tau}_{1} \tau(\nu \tilde{\nu})$	2 τ	$E_T^{\rm miss}$	36.1	$\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$		0.76
d L					$\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$	0.22	



p

au

au

 $ilde{\chi}_1^0$

1403.5294, 1806.02293 1712.08119

1812.09432

ATLAS-CONF-2019-008

1708.07875 1708.07875

ATLAS-CONF-2019-008 1712.08119

> 1806.04030 1804.03602

$ \begin{array}{l} m(\tilde{\chi}_1^0) = 0, \ m(\tilde{\tau}, \tilde{\nu}) = 0.5(m(\tilde{\chi}_1^{\pm}) + m(\tilde{\chi}_1^0)) \\ 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)) \end{array} $



Direct stau production



asy 75

Final state with two hadronic taus and missing transverse energy

ATLAS-CONF-2019-018

SR-lowMass	SR-highMass
2 tight τ s (OS)	2 medium τ s (OS), \geq 1 tight
mmetric di-tau trigger	di-tau+ $E_{\rm T}^{\rm miss}$ trigger
$5 < E_{\rm T}^{\rm miss} < 150 {\rm GeV}$	$E_{\rm T}^{\rm miss} > 150 {\rm GeV}$
tau $p_{\rm T}$ and $E_{\rm T}^{\rm miss}$ cu	ts described in Section 5
light lepton veto a	and 3rd medium $ au$ veto
<i>b</i> -	jet veto
Z/H veto (m($(\tau_1, \tau_2) > 120 \text{ GeV})$
$\Delta R(au$	$(\tau_1, \tau_2) < 3.2$
$ \Delta \phi(au) $	$ \tau_1, \tau_2) > 0.8$
m_{T2}	> 70 GeV

$$m_{\mathrm{T2}} = \min_{\mathbf{q}_{\mathrm{T}}} \left[\max \left(m_{\mathrm{T},\tau_{1}}(\mathbf{p}_{\mathrm{T},\tau_{1}},\mathbf{q}_{\mathrm{T}}), m_{\mathrm{T},\tau_{2}}(\mathbf{p}_{\mathrm{T},\tau_{2}},\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}}) \right) \right]$$







Direct stau - SM backgrounds

real tau lepton backgrounds MC simulation, validated in validation regions



one fake tau

control region to normalize, validation region

W+jets

two fake taus estimated in ABCD method

multi-jet

ATLAS-CONF-2019-018









Multijet background estimation





ATLAS-CONF-2019-018

ATLAS searches for BSM physics using taus

Direct stau - Interpretation

 $m(\widetilde{\chi}_{1}^{0})$ [GeV]

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first limit on left/right handed stau non-degenerate

CIN2/CICI via staus to taus

1708.07875

	SE	R-highMass				
At least one	e opposite-sign tau pair					
	b-jet veto					
	Z-veto					
dium tau candidates	At least one medium and one tight tau candidates					
	$m(\tau_1, \tau_2) > 110 {\rm GeV}$					
	m_{T}	$_2 > 90 \text{ GeV}$				
gger	di-tau+ $E_{\rm T}^{\rm miss}$ trigger	Asymmetric di-tau trigger				
V	$E_{\rm T}^{\rm miss} > 150 {\rm GeV}$	$E_{\rm T}^{\rm miss} > 110 {\rm GeV}$				
r	$p_{\mathrm{T},\tau_1} > 80 \mathrm{GeV}$	$p_{\mathrm{T},\tau_1} > 95 \mathrm{~GeV}$				
r	$p_{\rm T} > 40 {\rm GeV}$	$p_{\rm T} > 65 {\rm GeV}$				

one fake tau control region estimated in ABCD validation region

two fake taus method

diboson

W+jets

multi-jet

Interpretation

1708.07875

ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits

Status: May 2019

	Model	<i>ℓ</i> , γ	Jets†	E_{T}^{miss}	∫£ dt[fb	⁻¹] Limit	Reference
Extra dimensions	ADD $G_{KK} + g/q$ ADD non-resonant $\gamma\gamma$ ADD QBH ADD BH high $\sum p_T$ ADD BH multijet RS1 $G_{KK} \rightarrow \gamma\gamma$ Bulk RS $G_{KK} \rightarrow WW/ZZ$ Bulk RS $G_{KK} \rightarrow WW \rightarrow qqqq$ Bulk RS $g_{KK} \rightarrow tt$ 2UED / RPP	$\begin{array}{c} 0 \ e, \mu \\ 2 \ \gamma \\ - \\ \geq 1 \ e, \mu \\ - \\ 2 \ \gamma \\ multi-channe \\ 0 \ e, \mu \\ 1 \ e, \mu \\ 1 \ e, \mu \end{array}$	1 - 4 j - 2 j $\ge 2 j$ $\ge 3 j$ - = 2 J $\ge 1 b, \ge 1 J$ $\ge 2 b, \ge 3$	Yes - - - - /2j Yes j Yes	36.1 36.7 37.0 3.2 3.6 36.7 36.1 139 36.1 36.1	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	1711.03301 1707.04147 1703.09127 1606.02265 1512.02586 1707.04147 1808.02380 ATLAS-CONF-2019-003 1804.10823 1803.09678
Gauge bosons	$\begin{array}{l} \mathrm{SSM}\ Z' \to \ell\ell \\ \mathrm{SSM}\ Z' \to \tau\tau \\ \mathrm{Leptophobic}\ Z' \to bb \\ \mathrm{Leptophobic}\ Z' \to tt \\ \mathrm{SSM}\ W' \to \ell\nu \\ \mathrm{SSM}\ W' \to \ell\nu \\ \mathrm{HVT}\ V' \to WZ \to qqqq \ \mathrm{mode} \\ \mathrm{HVT}\ V' \to WZ \to qqqq \ \mathrm{mode} \\ \mathrm{HVT}\ V' \to WH/ZH \ \mathrm{model}\ \mathrm{B} \\ \mathrm{LRSM}\ W_R \to tb \\ \mathrm{LRSM}\ W_R \to \mu N_R \end{array}$	$2 e, \mu$ 2τ - $1 e, \mu$ 1τ $1 B 0 e, \mu$ multi-channe multi-channe 2μ	_ 2 b ≥ 1 b, ≥ 1J _ _ 2 J el el 1 J	– – /2j Yes Yes –	139 36.1 36.1 139 36.1 139 36.1 36.1 80	Z' mass5.1 TeVZ' mass2.42 TeVZ' mass2.1 TeVZ' mass3.0 TeVY' mass3.0 TeVW' mass 6.0 TeV V' mass 3.7 TeV V' mass 3.6 TeV V' mass $g_V = 3$ V' mass 2.93 TeV V' mass 3.25 TeV W _R mass 5.0 TeV	1903.06248 1709.07242 1805.09299 1804.10823 CERN-EP-2019-100 1801.06992 ATLAS-CONF-2019-003 1712.06518 1807.10473 1904.12679
CI	CI qqqq CI ℓℓqq CI tttt	_ 2 e,μ ≥1 e,μ	2 j ≥1 b, ≥1	– – j Yes	37.0 36.1 36.1	Λ 21.8 TeV $\eta_{LL}^ \Lambda$ 40.0 TeV $\eta_{LL}^ \Lambda$ 2.57 TeV $ C_{4t} = 4\pi$	1703.09127 1707.02424 1811.02305
MQ	Axial-vector mediator (Dirac DM Colored scalar mediator (Dirac $VV_{\chi\chi}$ EFT (Dirac DM) Scalar reson. $\phi \rightarrow t\chi$ (Dirac DM	M) 0 e, μ DM) 0 e, μ 0 e, μ M) 0-1 e, μ	1 – 4 j 1 – 4 j 1 J, ≤ 1 j 1 b, 0-1 J	Yes Yes Yes Ves	36.1 36.1 3.2 36.1	mmed 1.55 TeV $g_q=0.25, g_\chi=1.0, m(\chi)=1 \text{ GeV}$ mmed 1.67 TeV $g=1.0, m(\chi)=1 \text{ GeV}$ M_* 700 GeV $m(\chi) < 150 \text{ GeV}$ m_{\phi} 3.4 TeV $y = 0.4, \lambda = 0.2, m(\chi) = 10 \text{ GeV}$	1711.03301 1711.03301 1608.02372 1812.09743
ГØ	Scalar LQ 1 st gen Scalar LQ 2 nd gen Scalar LQ 3 rd gen Scalar LQ 3 rd gen	1,2 e 1,2 μ 2 τ 0-1 e,μ	≥ 2 j ≥ 2 j 2 b 2 b	Yes Yes – Yes	36.1 36.1 36.1 36.1	LQ mass1.4 TeVLQ mass1.56 TeVLQ ^u mass1.03 TeVLQ ^d mass970 GeV $\beta = 1$ $\mathcal{B}(LQ^d_3 \to b\tau) = 1$ $\mathcal{B}(LQ^d_3 \to t\tau) = 0$	1902.00377 1902.00377 1902.08103 1902.08103
Heavy quarks	$\begin{array}{c} VLQ \ TT \rightarrow Ht/Zt/Wb + X\\ VLQ \ BB \rightarrow Wt/Zb + X\\ VLQ \ T_{5/3} \ T_{5/3} \ T_{5/3} \rightarrow Wt + X\\ VLQ \ Y \rightarrow Wb + X\\ VLQ \ B \rightarrow Hb + X\\ VLQ \ QQ \rightarrow WqWq \end{array}$	multi-channe multi-channe 2 $2(SS)/\ge 3 e,\mu$ 1 e,μ 0 $e,\mu, 2 \gamma$ 1 e,μ	el $u \ge 1 ext{ b, } \ge 1 ext{ }$ $\ge 1 ext{ b, } \ge 1 ext{ }$ $\ge 1 ext{ b, } \ge 1 ext{ }$ $\ge 2 ext{ b, } \ge 1 ext{ }$	j Yes j Yes j Yes Yes	36.1 36.1 36.1 36.1 79.8 20.3	T mass1.37 TeVSU(2) doubletB mass1.34 TeVSU(2) doublet $T_{5/3}$ mass1.64 TeV $\mathcal{B}(T_{5/3} \rightarrow Wt) = 1, c(T_{5/3} Wt) = 1$ Y mass1.85 TeV $\mathcal{B}(Y \rightarrow Wb) = 1, c_R(Wb) = 1$ B mass1.21 TeV $\kappa_B = 0.5$ Q mass690 GeV $\mathcal{B}(Y \rightarrow Wb) = 1, c_R(Wb) = 1$	1808.02343 1808.02343 1807.11883 1812.07343 ATLAS-CONF-2018-024 1509.04261
Excited fermions	Excited quark $q^* \rightarrow qg$ Excited quark $q^* \rightarrow q\gamma$ Excited quark $b^* \rightarrow bg$ Excited lepton ℓ^* Excited lepton ν^*	- 1 γ - 3 e,μ 3 e,μ,τ	2 j 1 j 1 b, 1 j –	- - - -	139 36.7 36.1 20.3 20.3	q* mass 6.7 TeV only u^* and d^* , $\Lambda = m(q^*)$ q* mass 5.3 TeV only u^* and d^* , $\Lambda = m(q^*)$ b* mass 2.6 TeV $\Lambda = 3.0 \text{ TeV}$ ℓ^* mass 3.0 TeV $\Lambda = 3.0 \text{ TeV}$ ν^* mass 1.6 TeV $\Lambda = 1.6 \text{ TeV}$	ATLAS-CONF-2019-007 1709.10440 1805.09299 1411.2921 1411.2921
Other	Type III Seesaw LRSM Majorana v Higgs triplet $H^{\pm\pm} \rightarrow \ell \ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell \tau$ Multi-charged particles Magnetic monopoles $\sqrt{s} = 8 \text{ TeV}$	1 <i>e</i> , μ 2 μ 2,3,4 <i>e</i> , μ (SS 3 <i>e</i> , μ, τ - - - - - - - - -	≥ 2 j 2 j 5) – – – – √s = 1 full d	Yes – – – 3 TeV lata	79.8 36.1 36.1 20.3 36.1 34.4	N° mass560 GeVN _R mass3.2 TeVH±± mass870 GeVH±± mass400 GeVmulti-charged particle mass1.22 TeVmonopole mass2.37 TeV10^{-1}110Mass scale [TeV]	ATLAS-CONF-2018-020 1809.11105 1710.09748 1411.2921 1812.03673 1905.10130

*Only a selection of the available mass limits on new states or phenomena is shown. †Small-radius (large-radius) jets are denoted by the letter j (J).

$\int \mathcal{L} dt = (3.2 - 139) \text{ fb}^{-1}$

ATLAS Preliminary

 \sqrt{s} = 8, 13 TeV

								$3.2 - 139) \text{ fb}^{-1}$	
						Limit			
ADD $G_{KK} + g/q$ ADD non-reson ADD QBH ADD BH high Σ ADD BH multije RS1 $G_{KK} \rightarrow \gamma\gamma$ Bulk RS $G_{KK} \rightarrow WW/ZZ$ Bulk RS $G_{KK} \rightarrow WW \rightarrow qqqq$ Bulk RS $g_{KK} \rightarrow tt$ 2UED / RPP	$0 e, \mu$ The set of an equation 2γ multi-channel $0 e, \mu$ $1 e, \mu \ge$ $1 e, \mu$	1-4j ear 2J $1 b, \ge 1J/2$ $\ge 2 b, \ge 3j$	Yes ch j Yes Yes	36.1 CS 36.7 36.1 139 36.1 36.1	MD includin Grik mass Grik mass Grik mass Brik mass KK mass	ng taus in the fil 2.3 TeV 1.6 TeV 3.8 Te 1.8 TeV	nal sta	$n = 2$ ILZ NLO $M_D = 3 \text{ TeV, rot BH}$ $M_D = 3 \text{ TeV, rot BH}$ $k/M_{PI} = 0.1$ $k/\overline{M}_{PI} = 1.0$ $k/\overline{M}_{PI} = 1.0$ $\Gamma/m = 15\%$ Tier (1,1), $\mathcal{B}(A^{(1,1)} \rightarrow tt) = 1$	
SSM $Z' \rightarrow \ell\ell$ SSM $Z' \rightarrow \tau\tau$ Leptophobic $Z' \rightarrow bb$ Leptophobic $Z' \rightarrow tt$ SSM $W' \rightarrow \ell\nu$ SSM $W' \rightarrow \tau\nu$ HVT $V' \rightarrow WZ \rightarrow qqqq$ model HVT $V' \rightarrow WH/ZH$ model B LRSM $W_R \rightarrow tb$ LRSM $W_R \rightarrow \mu N_R$	$2 e, \mu$ 2τ - $1 e, \mu \geq$ $1 e, \mu$ 1τ I B $0 e, \mu$ multi-channel multi-channel 2μ	_ 2 b : 1 b, ≥ 1J/2 _ 2 J 1 J	Yes Yes Yes	139 36.1 36.1 139 36.1 139 36.1 36.1 36.1 80	Z' mass Z' mass Z' mass Z' mass W' mass W' mass V' mass V' mass V' mass W _R mass W _R mass	2.42 TeV 2.1 TeV 3.0 TeV 3.7 Te 3.6 Te 2.93 TeV 3.25 TeV	5.1 TeV 6.0 TeV V V 5.0 TeV		1903.06248 1709.07242 1805.09299 1804.10823 CERN-EP-2019-100 1801.06992 ATLAS-CONF-2019-003 1712.06518 1807.10473 1904.12679
Scalar LQ 1 st gen Scalar LQ 2 nd gen Scalar LQ 3 rd gen Scalar LQ 3 rd gen	1,2 e 1,2 μ 2 τ 0-1 e,μ	≥ 2 j ≥ 2 j 2 b 2 b	Yes Yes Yes	36.1 36.1 36.1 36.1	LQ mass LQ mass LQ ^u mass LQ ^d mass	1.4 TeV 1.56 TeV 1.03 TeV 970 GeV		$egin{aligned} η &= 1 \ η &= 1 \ &\mathcal{B}(\mathrm{LQ}_3^u o b au) &= 1 \ &\mathcal{B}(\mathrm{LQ}_3^d o t au) &= 0 \end{aligned}$	1902.00377 1902.00377 1902.08103 1902.08103
Excited quark $q^* \rightarrow qg$ Excited quark $q^* \rightarrow q\gamma$ Excited quark $b^* \rightarrow bg$ Excited lepton ℓ^* Excited lepton ν^*	1 γ 3 e, μ 3 e, μ, τ	2 j 1 j 1 b, 1 j		139 36.7 36.1 20.3 20.3	q* mass q* mass b* mass <i>(</i> * mass <i>v</i> * mass	2.6 TeV 3.0 TeV 1.6 TeV		only u^* and d^* , $\Lambda = m(q^*)$ only u^* and d^* , $\Lambda = m(q^*)$ $\Lambda = 3.0 \text{ TeV}$ $\Lambda = 1.6 \text{ TeV}$	ATLAS-CONF-2019-00 1709.10440 1805.09299 1411.2921 1411.2921
Type III Seesaw LRSM Majorana v Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$ Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$ Multi-charged particles Magnetic monopoles	1 e, μ 2 μ 2,3,4 e, μ (SS) 3 e, μ, τ	≥ 2 j 2 j) - _	Yes 	79.8 36.1 36.1 20.3 36.1 34.4	N ⁰ mass N _R mass H ^{±±} mass H ^{±±} mass multi-charged particle mass monopole mass	560 GeV 3.2 TeV 870 GeV 400 GeV 3 1.22 TeV 2.37 TeV		$m(W_R) = 4.1$ TeV, $g_L = g_R$ DY production DY production, $\mathcal{B}(H_L^{\pm\pm} \rightarrow \ell \tau) = 1$ DY production, $ q = 5e$ DY production, $ g = 1g_D$, spin 1/2	ATLAS-CONF-2018-02 1809.11105 1710.09748 1411.2921 1812.03673 1905.10130

						Limit				
	ADD $G_{KK} + g/q$ ADD non-reson ADD QBH ADD BH high Σ ADD BH multije RS1 $G_{KK} \rightarrow \gamma\gamma$ Bulk RS $G_{KK} \rightarrow WW/ZZ$ Bulk RS $G_{KK} \rightarrow WW \rightarrow qqq$ Bulk RS $g_{KK} \rightarrow tt$ 2UED / RPP	0 e, μ 5 5 5 5 5 5 5 5	1 – 4 j earc _ _2 J _1 b, ≥ 1J/2j ≥ 2 b, ≥ 3 j	Yes 36.1 ches - 36.7 - 139 Yes 36.1 Yes 36.1	MD includ GKK MASS GKK MASS GKK MASS GKK MASS KK MASS	ing taus	in the fir 4.1 Te 2.3 TeV 1.6 TeV 3.8 TeV 1.8 TeV	nal sta	n = 2 ILZ NLO $M_D = 3 \text{ TeV, rot BH}$ $M_D = 3 \text{ TeV, rot BH}$ $k/M_{PI} = 0.1$ $k/\overline{M}_{PI} = 1.0$ $\Gamma/m = 15\%$ Tier (1,1), $\mathcal{B}(A^{(1,1)} \rightarrow tt) = 1$	
Gau <mark>ge</mark> bosons	$\begin{array}{l} \text{SSM } Z' \to \ell\ell \\ \text{SSM } Z' \to \tau\tau \\ \text{Leptophobic } Z' \to bb \\ \text{Leptophobic } Z' \to tt \\ \text{SSM } W' \to \ell\nu \\ \\ \text{SSM } W' \to \tau\nu \\ \text{HVT } V' \to WZ \to qqqq \mod 0 \\ \text{HVT } V' \to WH/ZH \mod 0 \\ \\ \text{LRSM } W_R \to tb \\ \\ \text{LRSM } W_R \to \mu N_R \end{array}$	$2 e, \mu$ 2τ - $1 e, \mu \geq$ $1 e, \mu$ 1τ lel B $0 e, \mu$ multi-channel multi-channel 2μ	- 2 b 1 b, ≥ 1J/2j - 2 J 1 J	- 139 - 36.1 - 36.1 Yes 36.1 Yes 139 Yes 36.1 - 139 36.1 36.1 - 80	Z' mass Z' mass Z' mass Z' mass W' mass W' mass V' mass V' mass W _R mass W _R mass		5. 2.42 TeV 2.1 TeV 3.0 TeV 3.7 TeV 3.6 TeV 2.93 TeV 3.25 TeV 5.0	1 TeV 6.0 TeV		1903.06248 1709.07242 1805.09299 1804.10823 CERN-EP-2019-100 1801.06992 ATLAS-CONF-2019-003 1712.06518 1807.10473 1904.12679
							2.57 TeV			
			≥ 2 j ≥ 2 j 2 b 2 b	Yes 36.1 Yes 36.1 - 36.1	LO mass	ASED SE				
			$\geq 1 \text{ b}, \geq 1$ $\geq 1 \text{ b}, \geq 1$ $\geq 1 \text{ b}, \geq 1$ $\geq 2 \text{ j}$ $\geq 4 \text{ j}$	SM Yes 36.1 Yes 20.3	Ts/3 mass B mass Q mass	690 GeV	1.37 TeV 1.34 TeV 1.64 TeV 1.85 TeV 1.21 TeV			

Exotic searches with taus - W'

final state with **one** hadronically decaying tau, missing transverse energy

$$m_{\rm T}^2 \equiv 2p_{\rm T}^{\tau} E_{\rm T}^{\rm miss} (1 - \cos \Delta \phi)$$

 $\mathcal{W} \rightarrow \tau \nu$, estimated from MC

Jet background (taus faked from q/g jet) data driven estimation

'Others' (diboson, top, .)

801.06992

Exotic searches with taus - W'

801.06992

Conclusions

taus present challenging final states in ATLAS

ongoing SUSY searches for stau productions leading to taus in final state

> several efforts in exotics including tauonic final states

still room for many more analyses

SUSY searches including taus in the final state

	Exoti	cs s	sear	ch	es	including	g taus in t	he fina:	state	
	55M 2" → 17	21	-	÷	36.1	2 rus		2.42 %	$F_{\rm c} = -2.5$	1709.4
20	SSM W [*] → rv	17	ċ.	10	36.1	W run		3.7 %¥	2 1 2 1	1801.0
្ឋ	Scalar LO 3 rd gen	21	26	11	36.1	102	1.00 TeV		$S(0.05 \rightarrow br) = 1$	1902.0
firebox	Excited lepton v*	34,4.7			20.3	2	141	24 Ter. 10	A=16W	1411
£	Higgs triplet $H^{aa} \rightarrow \ell \tau$	34,4,7	20 20 1 1	1	20.3	No. of the second secon			Of production, $\Re(\mathbb{M}_{L}^{n+} \to \ell r) = 1$	1411.

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, [†]		
~	$\hat{x}_{1}^{0}$	
~	$\tilde{\chi}^0_1$	
T		
	1/A, 1/A,	$\nu_{\tau}/\tau$ $\tau/\nu_{\tau}$ $\tilde{\chi}_{1}^{0}$ $\tilde{\chi}_{1}^{0}$ $\nu_{\tau}/\nu_{\tau}$

67242

# References

[2] Mass reach of the ATLAS searches for Supersymmetry., March 2019 https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/SUSY/ ATLAS_SUSY_Summary/ATLAS_SUSY_Summary_201903.pdf

[3]Reach of ATLAS searches for new phenomena other than Supersymmetry https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/ EXOTICS/ATLAS Exotics Summary/ATLAS Exotics Summary.png

#### [1] Mass reach of the ATLAS searches for Supersymmetry. <u>https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2019-022/fig_23.png</u>

![](_page_17_Figure_7.jpeg)

![](_page_17_Picture_8.jpeg)