The rise and fall of light stops in the LHC top quark sample

2312.09794 - Emanuele Bagnaschi, Gennaro Corcella, Roberto Franceschini and Dibyashree Sengupta





https://indico.cern.ch/event/1375202/ - April 25th 2024

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LHC has excluded light new physics, period.



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1 TeV 100 GeV



LHC has excluded light new physics, period.

ATLAS SUSY Searches* - 95% CL Lower Limits

AL	igust 2023											$\sqrt{s} = 13 \text{ TeV}$
	Model	Si	ignatur	e ∫.	<i>L dt</i> [fb ⁻	¹]	Mass limit					Reference
Sé	$\tilde{q}\tilde{q},\tilde{q}{\rightarrow}q\tilde{\chi}_1^0$	0 <i>e</i> , μ mono-jet	2-6 jets 1-3 jets	$E_T^{ m miss}$ $E_T^{ m miss}$	140 140	\tilde{q} [1×, 8× Degen.] \tilde{q} [8× Degen.]		1.0 0.9	1.8	35	$m(ilde{\mathcal{X}}_1^0){<}400GeV\ m(ilde{q}){-}m(ilde{\mathcal{X}}_1^0){=}5GeV$	2010.14293 2102.10874
iclusive Searche	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q \bar{q} \tilde{\chi}_1^0$	0 <i>e</i> , <i>µ</i>	2-6 jets	$E_T^{\rm miss}$	140	ີ ເວັດ ເວັດ ເວັດ ເວັດ ເວັດ ເວັດ ເວັດ ເວັດ		Forbidden	1.15-1	2.3 .95	$\mathfrak{m}(ilde{\chi}_1^0){=}0 ext{GeV} \ \mathfrak{m}(ilde{\chi}_1^0){=}1000 ext{GeV}$	2010.14293 2010.14293
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}W\tilde{\chi}_{1}^{0}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\ell)\tilde{\chi}_{1}^{0}$	1 e,μ ee,μμ	2-6 jets 2 jets	$E_T^{\rm miss}$	140 140	ĩg ĩg				2.2 2.2	m($ ilde{\chi}_{1}^{0}$)<600 GeV m($ ilde{\chi}_{1}^{0}$)<700 GeV	2101.01629 2204.13072
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qqWZ\tilde{\chi}_1^0$	0 e,μ SS e,μ	7-11 jets 6 jets	$E_T^{\rm miss}$	140 140	ర్ లి లి		1	.15	1.97	$m(\widetilde{\chi}_1^0)$ <600 GeV $m(\widetilde{g})$ - $m(\widetilde{\chi}_1^0)$ =200 GeV	2008.06032 2307.01094
L L	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t t \tilde{\chi}_1^0$	0-1 <i>e</i> ,μ SS <i>e</i> ,μ	3 <i>b</i> 6 jets	$E_T^{ m miss}$	140 140	õg õg			1.25	2.45	$\mathfrak{m}(\tilde{\chi}_1^0) < 500 \mathrm{GeV}$ $\mathfrak{m}(\tilde{g}) - \mathfrak{m}(\tilde{\chi}_1^0) = 300 \mathrm{GeV}$	2211.08028 1909.08457
	$ ilde{b}_1 ilde{b}_1$	0 <i>e</i> , <i>µ</i>	2 <i>b</i>	$E_T^{ m miss}$	140	${egin{array}{c} { ilde b}_1 \ { ilde b}_1 \end{array}$		0.68	1.255		$m(ilde{\chi}_1^0){<}400GeV$ 10 $GeV{<}\Deltam(ilde{b}_1, ilde{\chi}_1^0){<}20GeV$	2101.12527 2101.12527
arks stion	$\tilde{b}_1 \tilde{b}_1, \tilde{b}_1 \rightarrow b \tilde{\chi}_2^0 \rightarrow b h \tilde{\chi}_1^0$	0 <i>e</i> , μ 2 τ	6 <i>b</i> 2 <i>b</i>	$E_T^{ m miss} \ E_T^{ m miss}$	140 140	<i>b</i> ₁ Forbidden <i>b</i> ₁		0. 0.13-0.85	.23-1.35	$\Delta m(ilde{\mathcal{X}}_2^0, ilde{\mathcal{X}}_2^$	$\tilde{\chi}_{1}^{0}$)=130 GeV, m($\tilde{\chi}_{1}^{0}$)=100 GeV $\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{0}$)=130 GeV, m($\tilde{\chi}_{1}^{0}$)=0 GeV	1908.03122 2103.08189
squi	$ \tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \to t \tilde{\chi}_1^0 \\ \tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \to W h \tilde{\chi}_1^0 $	0-1 e,μ 1 e,μ	≥ 1 jet 3 jets/1 b	$E_T^{ m miss} \ E_T^{ m miss}$	140 140	\widetilde{t}_1 \widetilde{t}_1	Forbidden	1.05	1.25		$m(\tilde{\chi}_1^0)=1 \text{ GeV}$ $m(\tilde{\chi}_1^0)=500 \text{ GeV}$	2004.14060, 2012.03799 2012.03799, ATLAS-CONF-2023-043
gen. ect p	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \to \tilde{\tau}_1 bv, \tilde{\tau}_1 \to \tau \tilde{G}$ $\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \to \tilde{\tau}_1 bv, \tilde{\tau}_1 \to \tau \tilde{G}$	1-2 τ 0 e μ	2 jets/1 b	E_T^{miss}	140	\tilde{t}_1		Forbidden	1.4		$m(\tilde{\tau}_1) = 800 \text{ GeV}$ $m(\tilde{\tau}_1) = 800 \text{ GeV}$	2108.07665
3 rd dir	$t_1 t_1, t_1 \rightarrow c \chi_1 / c c, c \rightarrow c \chi_1$	0 <i>e</i> , μ 0 <i>e</i> , μ	mono-jet	E_T^{miss}	140	\tilde{t}_1	0.55	0.05			$m(\tilde{t}_1, \tilde{c}) = 0 \text{ GeV}$ $m(\tilde{t}_1, \tilde{c}) - m(\tilde{\chi}_1^0) = 5 \text{ GeV}$	2102.10874
	$ \begin{aligned} \tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow t \chi_2^\circ, \chi_2^\circ \rightarrow Z/h \chi_1^\circ \\ \tilde{t}_2 \tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z \end{aligned} $	1-2 <i>e</i> ,μ 3 <i>e</i> ,μ	1-4 <i>b</i> 1 <i>b</i>	E_T^{miss} E_T^{miss}	140 140	t_1 \tilde{t}_2	Forbidden	0.067-	1.18	$m(\tilde{\chi}_{1}^{0})=3$	$m(\chi_2^\circ)=500 \mathrm{GeV}$ 60 GeV, $m(\tilde{t}_1)$ - $m(\tilde{\chi}_1^0)=40 \mathrm{GeV}$	2006.05880
	$ ilde{\chi}_1^{\pm} ilde{\chi}_2^0$ via WZ	Multiple ℓ /jets $ee, \mu\mu$	≥ 1 jet	$E_T^{ m miss} \ E_T^{ m miss}$	140 140			0.96		m	$\mathfrak{m}(ilde{\chi}_1^1)=0,$ wino-bino $\mathfrak{m}(ilde{\chi}_1^\pm)-\mathfrak{m}(ilde{\chi}_1^0)=5$ GeV, wino-bino	2106.01676, 2108.07586 1911.12606
	$\tilde{\chi}_1^{\pm} \tilde{\chi}_1^{\mp}$ via <i>WW</i>	2 e, μ		E_T^{miss}	140	$ \tilde{\chi}_{1}^{\pm} $ $ \tilde{\chi}^{\pm}_{1} \tilde{\chi}^{0} $ Earbiddon	0.42	1.00			$m(\tilde{\chi}_1^0)=0$, wino-bino	1908.08215
	$\tilde{\chi}_1 \chi_2$ via $\tilde{w}h$ $\tilde{\chi}_1^{\pm} \tilde{\chi}_1^{\mp}$ via $\tilde{\ell}_L / \tilde{v}$	$2 e, \mu$	•	$E_T \\ E_T^{\text{miss}}$	140	$\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^{\pm}$ Forbidden $\tilde{\chi}_1^{\pm}$		1.0	5		$m(\tilde{\ell}, \tilde{\nu}) = 0.5 (m(\tilde{\chi}_1^{\pm}) + m(\tilde{\chi}_1^0))$	1908.08215
EW rec	$\tilde{\tau}\tilde{\tau}, \tilde{\tau} \rightarrow \tau \tilde{\chi}_{1}^{0}$	2τ	0 ista	E_T^{miss}	140	$\tilde{\tau}$ [$\tilde{\tau}_{\mathrm{R}}, \tilde{\tau}_{\mathrm{R},\mathrm{L}}$]	0.34 0.48				$m(\tilde{\chi}_1^0) = 0$	ATLAS-CONF-2023-029
<u>G</u> E	$\ell_{\mathrm{L,R}}\ell_{\mathrm{L,R}}, \ell \rightarrow \ell \chi_1^\circ$	2 e,μ ee,μμ	0 jets $\geq 1 \text{ jet}$	E_T^{miss} E_T^{miss}	140 140	${\substack{\ell\\ \widetilde{\ell}}}$ 0.2	6	0.7			$m(\tilde{\ell})=m(\tilde{\chi}_1^0)=10\;GeV$	1908.08215 1911.12606
	$\tilde{H}\tilde{H},\tilde{H}{ ightarrow}h\tilde{G}/Z\tilde{G}$	0 <i>e</i> , μ 4 <i>e</i> , μ	$\geq 3 b$ 0 jets	E_T^{miss} E_T^{miss}	140 140	Ĥ Щ	0.55	0.94			$ \begin{array}{l} BR(\tilde{\chi}^0_1 \to h\tilde{G}) = 1 \\ BR(\tilde{\chi}^0_1 \to Z\tilde{G}) = 1 \end{array} $	To appear 2103.11684
		0 e,μ ≥ 2 e,μ	≥ 2 large jet ≥ 2 jets	S E_T^{miss} E_T^{miss}	140 140	Ĥ Ĥ		0.45-0.93 0.77		BR	$BR(\tilde{\chi}^0_1 \to Z\tilde{G}) = 1$ $(\tilde{\chi}^0_1 \to Z\tilde{G}) = BR(\tilde{\chi}^0_1 \to h\tilde{G}) = 0.5$	2108.07586 2204.13072
	Direct $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	E_T^{miss}	140	$\tilde{\chi}_{1}^{\pm}$		0.66			Pure Wino	2201.02472
/ed es	Stable õ B-hadron	nixel dF/dx		Fmiss	1/0	χ_1^- 0.21 $\tilde{\sigma}$				2.05	Pure higgsino	2201.02472
g-liv tich	Metastable \tilde{g} R-hadron, $\tilde{g} \rightarrow qq \tilde{\chi}_1^0$	pixel dE/dx		E_T^{T} E_T^{miss}	140	\tilde{g} [$\tau(\tilde{g})$ =10 ns]				2.2	$m(ilde{\chi}_1^0)$ =100 GeV	2205.06013
par	$\tilde{\ell}\tilde{\ell},\tilde{\ell}{\rightarrow}\ell\tilde{G}$	Displ. lep		$E_T^{\rm miss}$	140	$ ilde{e}, ilde{\mu}$	0.04	0.7			$ au(\tilde{\ell}) = 0.1 \text{ ns}$	2011.07812
Γ		pixel dE/dx		$E_T^{\rm miss}$	140	τ $ ilde{ au}$	0.34 0.36				au(t) = 0.1 ns $ au(\tilde{t}) = 10 \text{ ns}$	2011.07812 2205.06013
	$\tilde{\chi}_{1}^{\pm} \tilde{\chi}_{1}^{\pm} / \tilde{\chi}_{1}^{0} , \tilde{\chi}_{1}^{\pm} \rightarrow Z\ell \rightarrow \ell\ell\ell$ $\tilde{\chi}^{\pm} \tilde{\chi}^{\pm} / \tilde{\chi}^{0} \qquad WW/Z\ell\ell\ell\ell\ell$	3 e,μ 4 e μ	0 iets	Fmiss	140 140	$\tilde{\chi}_{1}^{\mp}/\tilde{\chi}_{1}^{0} [BR(Z\tau)=1, BR(Ze)=$ $\tilde{\chi}^{\pm}/\tilde{\chi}_{1}^{0} [bre \neq 0, bre \neq 0]$	1] 0.6	25 1.05	5		Pure Wino $m(\tilde{v}^0) = 200 \text{ GeV}$	2011.10543
	$\widetilde{g}_{i}, \widetilde{g} \rightarrow aa \widetilde{\chi}_{1}^{0}, \widetilde{\chi}_{1}^{0} \rightarrow aaa$	- τ, μ	≥8 jets	L_T	140	$\tilde{g} [m(\tilde{\chi}_1^0) = 50 \text{ GeV}, 1250 \text{ GeV}]$	V]	0.33	1.6	2.25	$\operatorname{Large} \lambda_{112}''$	To appear
>	$\tilde{t}\tilde{t}, \tilde{t} \to t\tilde{\chi}^0_1, \tilde{\chi}^0_1 \to tbs$		Multiple		36.1	$\tilde{t} = [\lambda''_{323} = 2e-4, 1e-2]$	0.55	1.05	5		m $(\tilde{\chi}_1^0)$ =200 GeV, bino-like	ATLAS-CONF-2018-003
RР	$\widetilde{t}\widetilde{t}, \widetilde{t} \to b\widetilde{\chi}_1^{\pm}, \widetilde{\chi}_1^{\pm} \to bbs$		$\geq 4b$		140	\tilde{t}	Forbidden	0.95			$m(\tilde{\chi}_1^{\pm})$ =500 GeV	2010.01015
	$\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow q\ell$	$2e,\mu$	$\frac{2}{2}b$		36.1	$\tilde{t}_1 [qq, bs]$ \tilde{t}_1			0.4-1.45		$BR(\tilde{t}_1 \to be/b\mu) > 20\%$	1710.05544
	$\tilde{\chi}_{1}^{\pm}/\tilde{\chi}_{2}^{0}/\tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0}, \rightarrow tbs, \tilde{\chi}_{1}^{+} \rightarrow bbs$	1 μ 1-2 <i>e</i> ,μ	DV ≥6 jets		136 140	$\tilde{\chi}_{1}^{0}$ [1e-10< χ_{23k}^{0} <1e-8, 3e-1	0.2-0.32	1.0	1.6		BR $(t_1 \rightarrow q\mu) = 100\%$, cos $\theta_t = 1$ Pure higgsino	2003.11956 2106.09609
	1,2		-									

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on

10⁻¹

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ATLAS Preliminary

Mass scale [TeV]

LHC has excluded light new physics, period.



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THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Measurements of W^+W^- production in decay topologies inspired by searches for electroweak supersymmetry

ATLAS Collaboration*

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Abstract This paper presents a measurement of fiducial and differential cross-sections for W^+W^- production in proton–proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS experiment at the Large Hadron Collider using a dataset corresponding to an integrated luminosity of 139 fb $^{-1}$. Events with exactly one electron, one muon and no hadronic jets are studied. The fiducial region in which the measurements are performed is inspired by searches for the electroweak production of supersymmetric charginos decaying to twolepton final states. The selected events have moderate values of missing transverse momentum and the 'stransverse mass' variable m_{T2} , which is widely used in searches for supersymmetry at the LHC. The ranges of these variables are chosen so that the acceptance is enhanced for direct W^+W^- production and suppressed for production via top quarks, which is treated as a background. The fiducial cross-section and particle-level differential cross-sections for six variables are measured and compared with two theoretical SM predictions from perturbative QCD calculations.

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Table 4 Chi-squared per number of degrees of freedom χ^2 /NDF for a comparison of unfolded distributions with different theory predictions. The calculation takes into account bin-by-bin correlations of systematic

and statistical uncertainties. Uncertainties in the theory predictions are not considered

	$ y_{e\mu} $	$ \Delta \phi_{e\mu} $	$\cos heta^*$	$p_{\mathrm{T}}^{\mathrm{lead}\ell}$	$m_{e\mu}$
POWHEG BOX V2+PYTHIA8 $(q\bar{q})$ and SHERPA 2.2.2+OPEN LOOPS (gg)	14.4/8	10.1/10	13.3/7	15.4/6	2.8/6
SHERPA 2.2.2 $(q\bar{q})$ and SHERPA 2.2.2 + OPEN LOOPS (gg)	18.3/8	17.9/10	24.5/7	24.1/6	2.5/6

Regular Article - Experimental Physics

Measurements of W^+W^- production in decay topologies inspired by searches for electroweak supersymmetry

ATLAS Collaboration*

CERN, 1211 Geneva 23, Switzerland

"This is one example of reaching the finest control and the highest scrutiny for a measurement of SM final states Abstract This paper presents a measure and differential cross-sections for W^+W^- production in proton-proton collisions at $\sqrt{s} = 13$ T (In the observation by the production of the proton of

responding to an integrated luminosity of 139 fb^{-1} . Events with exactly one electron, one muon and no hadronic jets are studied. The fiducial region in which the measurements are performed is inspired by searches for the electroweak production of supersymmetric charginos decaying to twolepton final states. The selected events have moderate values of missing transverse momentum and the 'stransverse mass' variable m_{T2} , which is widely used in searches for supersymmetry at the LHC. The ranges of these variables are chosen so that the acceptance is enhanced for direct W^+W^- production and suppressed for production via top quarks, which is treated as a background. The fiducial cross-section and particle-level differential cross-sections for six variables are measured and compared with two theoretical SM predictions from perturbative QCD calculations.

	<i>y</i> _e µ	$ \Delta \phi_{e\mu} $	$\cos heta^*$	$p_{\mathrm{T}}^{\mathrm{lead}\ell}$	m _{eµ}
POWHEG BOX V2+PYTHIA8 $(q\bar{q})$ and Sherpa 2.2.2+Open Loops (gg)	14.4/8	10.1/10	13.3/7	15.4/6	2.8/6
SHERPA 2.2.2 $(q\bar{q})$ and SHERPA 2.2.2 + OPEN LOOPS (gg)	18.3/8	17.9/10	24.5/7	24.1/6	2.5/6

2.5 3

 $|\Delta \phi_{e\mu}|$

3.9/5

4.1/5

This is a valuable lesson.

- Every SM measurement is a new physics search.
- Every BSM search is a SM measurement.

- **Observed limits**
- **Expected** limits
- 2015–2018 data, $\sqrt{s} = 13$ TeV, 139 fb⁻¹ Monojet, $\tilde{t}_1 \rightarrow bff' \tilde{\chi}_1^0$ (34) $= 1L, \widetilde{t}_1 \to t \widetilde{\chi}_1 / \widetilde{t}_1 \to b W \widetilde{\chi}_1^0 / \widetilde{t}_1 \to b f f' \widetilde{\chi}_1^0 \quad (36)$ $= 2L, \widetilde{t}_1 \to t \widetilde{\chi}_1^0 / \widetilde{t}_1 \to b W \widetilde{\chi}_1^0 / \widetilde{t}_1 \to b f f' \widetilde{\chi}_1^0 \quad (37)$
- 2015–2016 data, $\sqrt{s} = 13$ TeV, 36.1 fb⁻¹ $\widetilde{t_1} \to t \widetilde{\chi}_1^0 / \widetilde{t_1} \to b W \widetilde{\chi}_1^0 / \widetilde{t_1} \to b f \widetilde{\chi}_1^0 \quad (38-41)$ $---- t\bar{t}, \ \tilde{t}_1 \rightarrow t\tilde{\chi}_1^0 \quad (42)$
- 2012 data, $\sqrt{s} = 8 \text{ TeV}$, 20.3 fb⁻¹ $\widetilde{t_1} \to t \widetilde{\chi}_1^0 / \widetilde{t_1} \to b W \widetilde{\chi}_1^0 / \widetilde{t_1} \to b f \widetilde{\chi}_1^0 \quad (43)$

MODEL

EASURE

in l + mET

CEARCH **WEASURE** in l + mET

In this talk I will elaborate on this theme and provide directions on how to use the measurements of m_{bl} to test new physics scenarios

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The message can be spread to other observables: 1D distributions of $p_{T,\ell}, m_{T2}, E_b, \ldots$; 2D distributions as well; a full likelihood study in principle

Targeted new physics scenario

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Due to small mass differences between the NP states each energy release gives "soft" leptons and/or (b-)jets.

New physics that gives only "soft" leptons and (b-)jets is not the target of "Search for ..."

Targeted new physics scenario

 $\tilde{t} \rightarrow b \chi^+ \rightarrow b \ell v \chi^0$

 $t \rightarrow hW \rightarrow hlv$

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Due to small mass differences between the NP states each Ideally one would have to devise a search analysis that can deal with O(10) GeV p_T leptons and (bottom) jets (b-)jets.

All the accurate work on these leptons and jets is already in place for the measurements of top quark properties!"

Recast bounds on the NP scenario

A point that made the development of this idea in practice very difficult for years is the objective difficulty to test if a new physics scenario is excluded by present searches that were not tailored for that scenario.

SLHA or LHE input

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1312.2591

Recast bounds on the NP scenario using all analyses included in SModelS

ing 5744 individual maps from 1152 distinct signal regions, 100 different SMS topologies, from a total of 111 analyses

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There are scenarios in the **MSSM** that cannot be excluded by the searches presently included in **SModelS**

(they even give the right Higgs boson mass at 1-loop, but never mind)

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Recast bounds on the NP scenario analysis by analysis

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ATLAS SUSY-2019-09

Table 8: Summary of the preselection criteria applied in the SRs of the off-shell WZ selection. In rows where only one value is given it applies to all regions. '-' indicates no requirement is applied for a given variable/region.

Variable	$SR_{low \not \! E_T}^{off WZ} - 0j$	$SR_{low \not \! E_T}^{off WZ}$ -nj		$SR_{highE_T}^{offWZ}$ -0j	SR ^{offWZ} high∉ _⊤ -nj
$n_{\rm lep}^{\rm baseline}, n_{\rm lep}^{\rm signal}$			= 3		
n _{SFOS}			≥ 1		
$m_{\ell\ell}^{\rm max}$ [GeV]			< 75		
$m_{\ell\ell}^{\min}$ [GeV]			∈ [1,75]]	
<i>n</i> _{b-jets}			= 0		
$\min \Delta R_{3\ell}$			> 0.4		
Resonance veto $m_{\ell\ell}^{\min}$ [GeV]		∉ [3, 3.2], ∉ [9	,12]		-
Trigger	(multi-)lepton		((multi-)lepton $ E_{\rm T}^{\rm miss}$)
$n_{\rm jets}^{30 { m GeV}}$	= 0	≥ 1		= 0	≥ 1
$E_{\rm T}^{\rm miss}$ [GeV]	< 50	< 200		> 50	> 200
$E_{\rm T}^{\rm miss}$ significance	> 1.5	> 3.0		> 3.0	> 3.0
$p_{\rm T}^{\ell_1}, p_{\rm T}^{\ell_2}, p_{\rm T}^{\ell_3}$ [GeV]		> 10			$> 4.5(3.0)$ for $e(\mu)$
$ m_{3\ell} - m_Z $ [GeV]	$> 20 \ (\ell_{\rm W}$	= e only)			-
$\min \Delta R_{SFOS}$	[0.6, 2.4] (8	$\mathcal{E}_{W} = e \text{ only}$			-

Table 2: Summary of the preselection criteria applied in the SRs of the on-shell WZ and Wh selections. In rows where only one value is given it applies to all regions. '-' indicates no requirement is applied for a given variable/region.

	Preselection requirements						
Variable	SR ^{WZ}	$SR^{\mathtt{Wh}}_{\mathtt{SFOS}}$	SR_{DFOS}^{Wh}				
$n_{\rm lep}^{\rm baseline}, n_{\rm lep}^{\rm signal}$		= 3					
Trigger		dilepton					
$p_{\rm T}^{\ell_1}, p_{\rm T}^{\ell_2}, p_{\rm T}^{\ell_3}$ [GeV]		> 25, 20, 10					
$E_{\rm T}^{\rm miss}$ [GeV]		> 50					
n _{b-jets}		= 0					
Resonance veto $m_{\ell\ell}$ [GeV]	> 12	> 12	-				
n _{SFOS}	≥ 1	≥ 1	= 0				
$m_{\ell\ell}$ [GeV]	∈ [75, 105]	∉ [75, 105]	-				
$ m_{3\ell} - m_Z $ [GeV]	> 15	> 15	-				

dedicated analyses for compressed scenarios are included in the recast

0. 1.6 0.2 1.8 0.4 2. 0.6 **0.8 1**. 1.2 1.4

1.6 0. 0.2 1.8 0.4 2. 0.6 8.0 **1**. 1.2 1.4

Recast bounds on the NP scenario

at several stop quark mass values

neutralino mass

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2 0.6 0.8 1.2

Recast bounds on the NP scenario

at several stop quark mass values

Compute the sensitivity for the NP scenario find two analyses measuring the $m_{h\ell}$ distribution with published 0

- uncertainty
- compute the expected $m_{b\ell}$ shape and rate from the NP scenario using the same selection as the experimental paper
- the putative NP signal with a template χ^2 analysis

use the published uncertainty to compute the expected significance for

Workflow Easily reproducible with well known codes. SLHA-based \rightarrow can be injected in Pythia in your experiment software framework(!)

- Generate MSSM model in SPheno 4.0.1 \rightarrow SLHA file
- Elaborate the SLHA file with SModelS 2.3.3 (using SR combination)
- in their top quark property measurements)
- Pythia SLHA interface) \rightarrow compute any distribution after selection cuts

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• Find r < 1 or r > 1 (soon available on Zenodo for those who want to inject signals

• Run Pythia 8.3 to generate SM $t\bar{t}$ "background" and $pp \rightarrow \tilde{t}\tilde{t}$ signal events (relies on

For simplicity we compute the correctly paired $m_{h\ell}$, which is different from CMS and ATLAS choices (interesting question to find out what is the best pairing strategy)

Significance estimator $z = \sqrt{\sum_{i} \left(\frac{S_i}{\delta B_i}\right)^2}, m_{\tilde{t}} \simeq 200 \text{ GeV}$

200

injecting MSSM signals in the $m_{b\ell}$ analyses we expect to obtain <u>new</u> bounds on new physics

S.//indico.cern.ch/event/13/5202/ - April 25th 2024 - Roberto Franceschint-LH Ctop & G

 $m_{\chi^{\pm}}$

Significance ATLAS-CONF-2019-038-PreFit

unlike standard searches that suffer from the softness of the leptons and jets, this analysis leverages the softness of ℓ and jets

200

2

160

180

ATLAS post-fit

140

 $m_{\chi^{\pm}}$

 $(m_{1}^{2} - m_{2}^{2})(m_{1}^{2} - m_{2}^{2})$

Significance ATLAS-CONF-2019-038-PostF

 $n_{\tilde{\star}} = 200 \,\,\mathrm{Ge}$

100

120

200

180

Significance estimator $z = \sqrt{\sum}$ $m_{\tilde{t}} \simeq 200 \text{ GeV}$ the presence of the BSM signal is in general limited to low $m_{b\ell}$, because of the massive invisible χ^0 (or other invisibile state) x

150

post-fit

Significance estimator $z = \sqrt{\sum_{i=1}^{\infty} \left(\frac{S_i}{\delta R_i}\right)^2}$ $m_{\tilde{t}} \simeq 200 \text{ GeV}$ the presence of the BSM signal is in general limited to low $m_{b\ell}$, because of the massive invisible χ^0 (or other invisibile state) x

and fall (end-point) 22

post-fit

Conclusion and outlook

The (HL)LHC will give us more and more data. If we want to exploit them at best we need to

- make the result available in a most reusable way • Recast Exercises are very useful!
- start leveraging the strategies not pursed much so far measure SM in places we had not traditionally Ο
 - done it
 - o search BSM where is not usually sought for
- m_{bl} is a clear example where a Search&Measure approach works that brings new BSM models under the scope, plus it strengthens the "precision" of the SM measurement carried out with the same data more precision observables can be used

Thank you

Backup slides

Next we simulate the contribution to $m_{b\ell}$ for each parameter space point using Pythia 8.3 [42] in the region of phase space identified by the following selection:

$$p_T(\ell) \ge 25 \text{ GeV}, \ |\eta(\ell)| < 2.5,$$

 $p_T(j) \ge 25 \text{ GeV}, \ |\eta(j)| < 2.5,$ (1)

for jets made with anti-kT [43] algorithm with R = 0.4and separations between jets and leptons $\Delta R(\ell, j) > 0.2$, $\Delta R(j, j) > 0.4$ and $\Delta R(\ell, \ell) > 0.1$. This is a selection closely following that of the experimental collaborations, e.g. [16, 18, 36], except for minor differences in the selection for $\ell = e$ and $\ell = \mu$ that we do not pursue. We have considered variations of the cuts and found

BM	$\mid \mu$	M_1	A_t	m_{χ^+}	m_{χ^0}	z [31]	z [16]	r		
				$m_{ ilde{t}}$	= 200) GeV				
ON1	185	95	2820.5	186.6	85.6	[0.8, 1.7]	[2.7, 14.3]	0.9		
OFF1	155	160	2857.5	156.4	123.3	[0.9, 1.8]	[2.6, 14.8]	0.7		
OFF2	175	145	2839.5	176.6	123.5	[1.5,3.]	[5.1, 25.5]	0.8		
T1	135	65	2895.5	136.2	54.	$[4.,\!7.7]$	[10.7, 61.3]	0.8		
T2	135	60	2895.5	136.2	49.9	[4.1, 7.9]	[10.8, 60.6]	0.8		
				$m_{ ilde{t}}$	= 220	GeV				
OFF3	155	150	3140.5	156.4	118.6	[0.7, 1.4]	[1.9, 10.9]	0.8		
OFF4	170	160	3122	171.5	130.8	[0.9, 1.8]	[2.5, 13.7]	0.6		
ON2	190	95	3104	191.7	86.1	[2.1, 4.3]	[6.1, 32.8]	0.7		
OFF5	190	145	3104	191.7	127.7	[1.4, 2.8]	[4.2, 22.5]	0.6		
ON3	190	65	3104	191.7	58.9	[1.9, 3.7]	[5.3, 28.7]	0.8		
				$m_{ ilde{t}}$	= 180	GeV				
OFF6	165	115	2570.5	166.5	99.2	[1.2, 2.5]	[4.8, 22.9]	0.8		
OFF7	160	105	2580	161.5	90.4	[2.2, 4.5]	[7.2, 36.3]	0.8		
OFF8	160	170	2570	161.5	130.3	[0.6, 1.2]	[2.4, 11.2]	0.6		
OFF9	155	150	2579.5	156.4	118.5	[1.6, 3.2]	[5.3, 27.2]	0.8		
OFF10	145	175	2598.5	146.3	122.2	[0.8, 1.6]	[2.4, 12.7]	0.8		

TABLE I. Chargino and neutralino masses, input parameters μ , M_1 and A_t , all given in GeV for few benchmarks (BM). Resulting value of r computed from SModelS 2.2.1 and the range of the significance eq. (2) expected from the $m_{b\ell}$ spectrum analysis using ATLAS [16] or CMS [31] measurements. The low (high) end the significance range corresponds to uncertainties on the $m_{b\ell}$ spectrum before(after) a fit using SM predictions for the known backgrounds.