Searches for supersymmetry and dark matter signatures in the $t\bar{t} + E_{\mathrm{T}}^{\mathrm{miss}}$ final state

Nicolas Köhler[*], Krisztian Peters[**],
Michaela Queitsch-Maitland[**], Matthias Saimpert[**]

[*]Max Planck Institute for Physics (München)
[**]DESY (Hamburg)

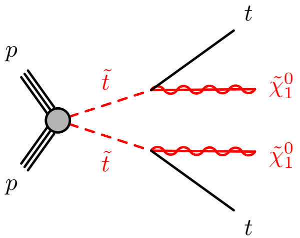
Tuesday 28th November, 2017

Final states with $t\bar{t}$+$E_{\mathrm{T}}^{\mathrm{miss}}$

- Many BSM scenarios can cause a $t\bar{t}$+$E_{\mathrm{T}}^{\mathrm{miss}}$ final state

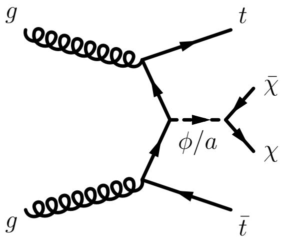
→ Consider only:

Supersymmetry (SUSY)



Neutralino as LSP is DM candidate

Generic Dark Matter (DM) scenario

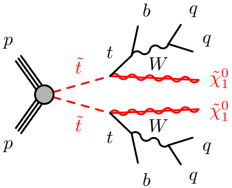


DM with associated $t\bar{t}$ production favoured

- Kinematically very similar, slightly higher p_{T}-spectra in SUSY
- Search for direct top squark pair production in the **semi-leptonic** final state with ATLAS:

  Covered by Daniela Börner and Julian Wollrath

Fully hadronic $\tilde{t}_1$-decays

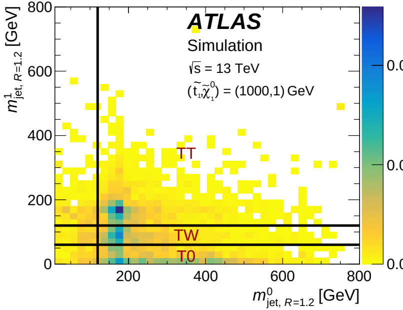


- Both top quarks are decaying hadronically

$\rightarrow$ No additional $E_{\mathrm{T}}^{\mathrm{miss}}$ from ν of leptonic top decay

- Top quarks can be fully ‚reconstructed' by the jets in the event
- Boosted topologies allow for usage of ‚fat-jets' since no leptons are involved in top decays

$\rightarrow$ Requiring top quark ‚candidates' helps to suppress non-t-like backgrounds



arXiv:1709.04183

$\rightarrow$ **TT**: 2 ‚fat-jets' with masses $\sim m_t$
TW: 1 ‚fat-jet' mass $\sim m_t$, one $\sim m_W$
T0: Only 1 ‚fat-jet' mass $\sim m_t$

Compressed region: $m_{\tilde{t}} \sim m_t + m_{\tilde{\chi}_1^0}$

- Suffering from low E_T^{miss}
- ISR jet can boost squark system

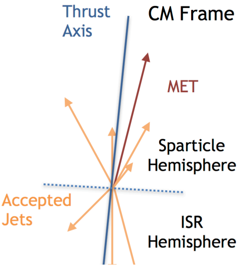
→ Di-$\tilde{\chi}_1^0$ (E_T^{miss}) strongly correlated with momenta of ISR jets

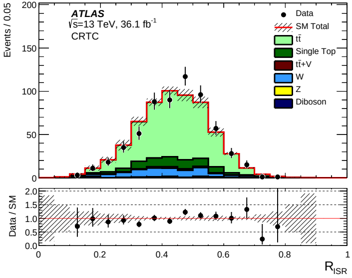
- Maximize the amount of back to back transverse momenta of the two systems

→ Divide into hemispheres (one containing the E_T^{miss}/sparticle system, one the ISR system)

- Variables: Number/p_T of (b-)jets in hemispheres

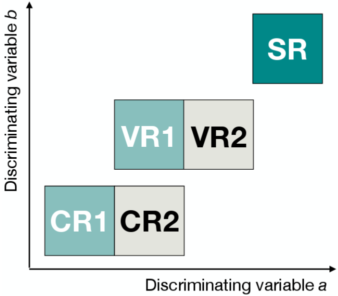
E.g. $R_{\mathrm{ISR}} = \frac{E_T^{miss}}{p_T^{\mathrm{ISR}}}$





arXiv:1709.04183

Background estimation

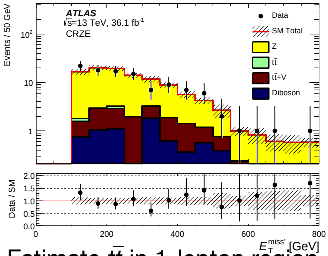


- Statistically independent *control regions* enriching a certain SM background

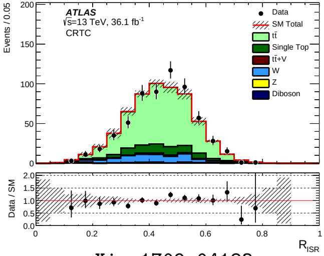
$$N_{\text{pred,SR}} = N_{\text{MC,SR}} \cdot \frac{N_{\text{Data,CR}}}{N_{\text{MC,CR}}}$$

- Validation regions (kinematically between CR and SR) to check Data/MC agreement

Estimate $Z \to \nu\nu$ in $Z \to \ell^+\ell^-$ region



Estimate $t\bar{t}$ in 1-lepton region



arXiv:1709.04183

Systematic uncertainties (in %)

arXiv:1709.04183

	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
$t\bar{t}$+V theory	2	<1	<1	1	<1	<1
Z theory	1	3	2	<1	1	<1
Single top theory	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
μ_Z	6	10	7	5	6	4
μ_W	1	1	1	2	1	2
$\mu_{\text{single top}}$	5	3	5	4	4	5
JER	10	12	4	3	4	3
JES	4	7	1	7	4	<1
b-tagging	1	3	2	5	4	4
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

Systematic uncertainties (in %)

arXiv:1709.04183

	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<1
[illegible] theory	1	3	2	<1	1	<1
[illegible]	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
μ_{Z}	6	10	7	5	6	4
μ_{W}	1	1	1	2	1	2
$\mu_{\text{single top}}$	5	3	5	4	4	5
JER	10	12	4	3	4	3
JES	4	7	1	7	4	<1
b-tagging	1	3	2	5	4	4
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

matrix-element comparisons, parton-showering models, ISR/FSR variations

Systematic uncertainties (in %)

arXiv:1709.04183

	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
$t\bar{t}$+V theory	2	<1	<1	1	<1	<1
Z theory	1	3	2	<1	1	<1
Single top theory	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
$\boxed{\mu_Z}$	6	10	7	5	6	4
[illegible]	[illegible]	[illegible]	1	2	1	2
[illegible]	[illegible]	[illegible]	5	4	4	5
JER	10	12	4	3	4	3
JES	4	7	1	7	4	<1
b-tagging	1	3	2	5	4	4
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

Normalization of Z+jets background

Systematic uncertainties (in %)

arXiv:1709.04183

	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
$t\bar{t}$+V theory	2	<1	<1	1	<1	<1
Z theory	1	3	2	<1	1	<1
Single top theory	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
μ_Z	6	10	7	5	6	4
μ_W	1	1	1	2	1	2
$\mu_{\text{single top}}$	5	3	5	4	4	5
$\boxed{\text{JER}}$	10	12	4	3	4	3
JES	4	7	1	7	4	<1
[illegible]	[illegible]	3	2	5	4	4
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

Jet energy resolution

Systematic uncertainties (in %)

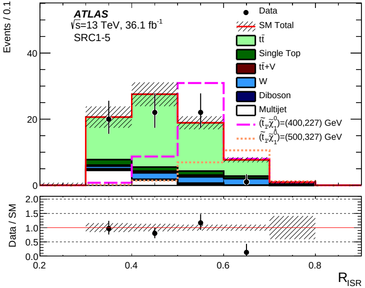
arXiv:1709.04183

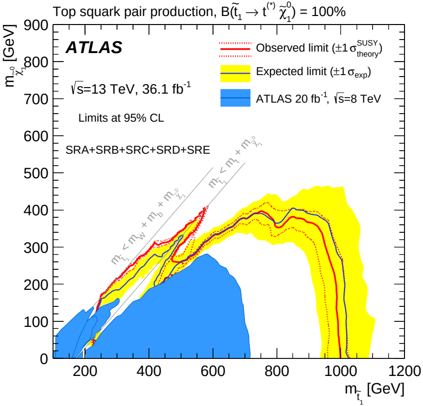
	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
$t\bar{t}$+V theory	2	<1	<1	1	<1	<1
Z theory	1	3	2	<1	1	<1
Single top theory	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
μ_Z	6	10	7	5	6	4
μ_W	1	1	1	2	1	2
$\mu_{\text{single top}}$	5	3	5	4	4	5
JER	10	12	4	3	4	3
JES	4	7	1	7	4	<1
b-tagging	1	3	2	5	4	4
[illegible]	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

Jet energy scale

Results

- Looking into the signal region:



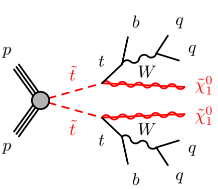


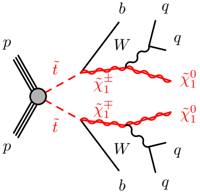
- No excess above SM expectation found
- Exclude $m_{\tilde{t}_1} < 1$ TeV
- Also 3-body decays considered

arXiv:1709.04183 → Significantly improved limits from LHC Run-1

Results

- Looking for $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$ decays:

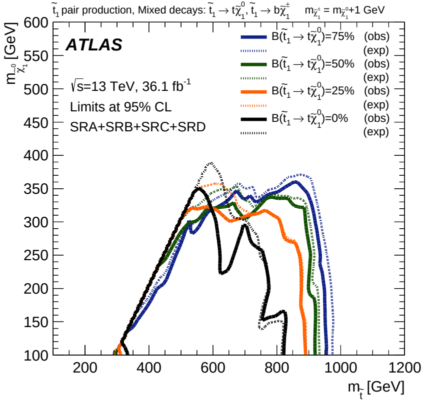




- No excess above SM expectation found
- Exclude $m_{\tilde{t}_1} < 800$ GeV for $\mathcal{BR}(\tilde{t}_1 \to b + \tilde{\chi}_1^{\pm}) = 100\%$

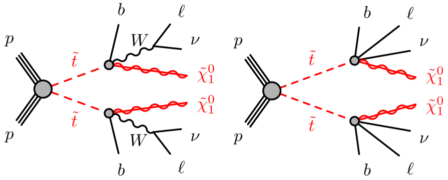
$\to$ Many more interpretations (incl. pMSSM-inspired models) done

Scanning $\mathcal{BR}(\tilde{t}_1 \to t + \tilde{\chi}_1^0)$



arXiv:1709.04183

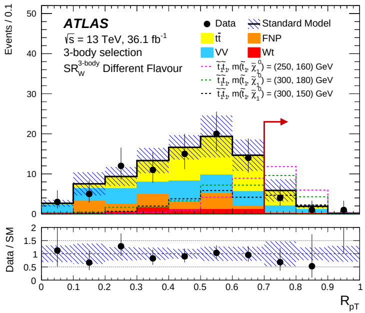
Final states with 2 leptons

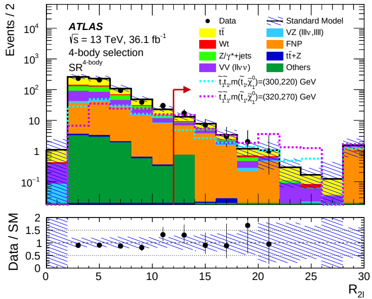


- 3- or 4-body decays result in softer objects
- Lepton p_T-thresholds are much lower than for jets, **but**:

  Branching fraction of $W^{\pm}$ into leptons is much smaller than into jets
- More precise energy and angular resolution possible

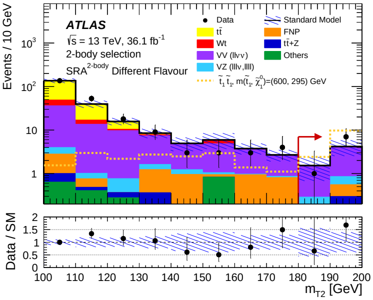
  Use e.g. $R_{2\ell} = E_T^{\text{miss}}/(p_T(\ell_1) + p_T(\ell_2))$



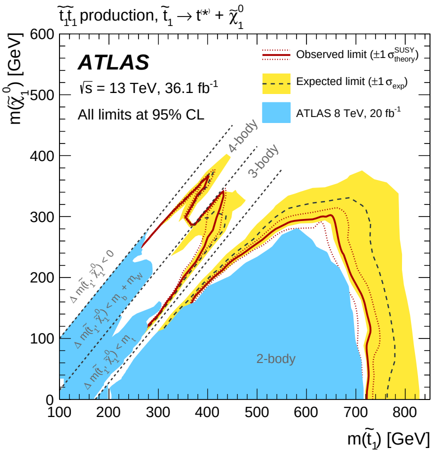


Final states with 2 leptons

- Also 2-body decay scenarios targeted
- Use stransverse mass m_{T2} of the leptons



$\longrightarrow$ No excess above SM found



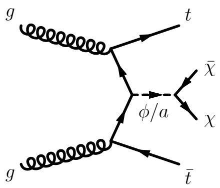
arXiv:1708.03247

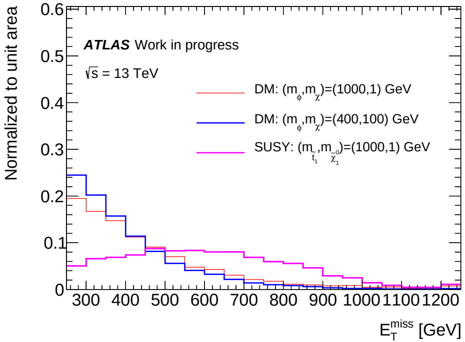
$\longrightarrow$ Good coverage for 3-/4-body decay scenarios

Interpret results in generic Dark Matter scenario

- Using simplified models with a scalar (ϕ) or pseudoscalar (*a*) mediator
- Only consider fermionic WIMPs χ
- Final state objects are kinematically similar to top squark decays
- Slightly softer p_T-spectra than in SUSY

→ Selections are very similiar, but not as tight as for SUSY



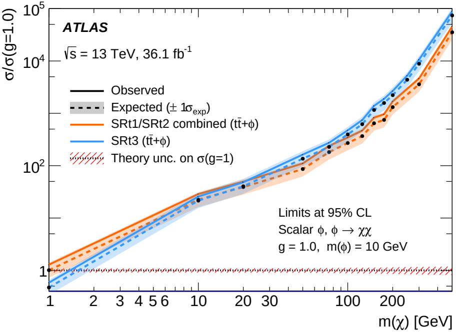


Limits on DM+$t\bar{t}$ production

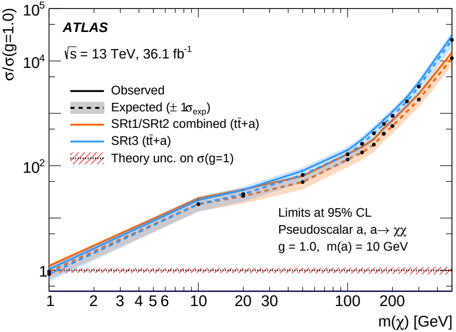
- Define SUSY-like signal regions with slightly softer objects

$\rightarrow$ Combining fully-hadronic and 2-lepton final states in exclusion fit:

Scalar mediator



Pseudoscalar mediator

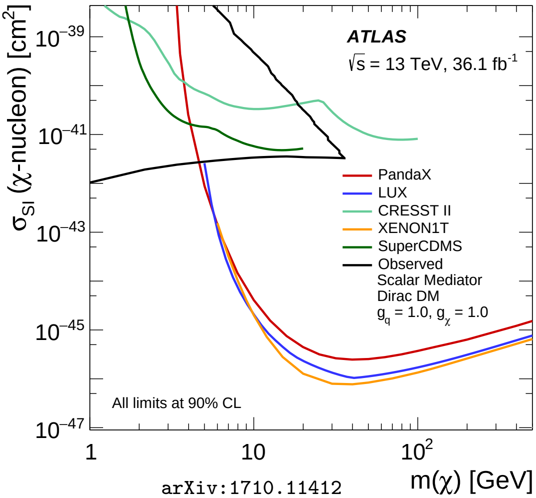


arXiv:1710.11412

Limits on DM+$t\bar{t}$ production

- Compare DM limits to direct detection experiments
- Use limits from 2L SR for a scalar mediator ϕ
- Convert into spin-independent DM–nucleon scattering cross-section (cf. `arXiv:1603.04156`)

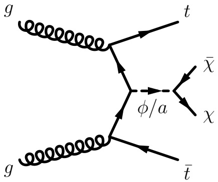
$\rightarrow$ Model-dependent, thus valid only for the specific signal models considered

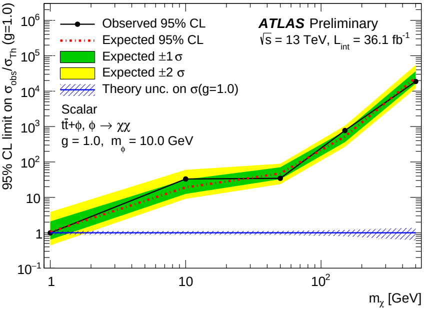


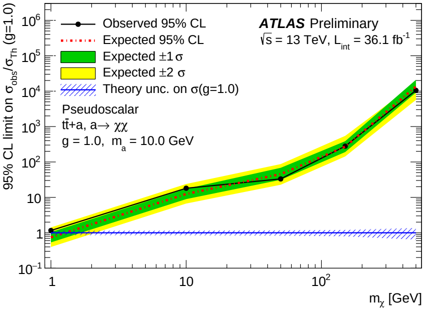
`arXiv:1710.11412`

Final states with one lepton

Results of the **semi-leptonic** final state mentioned by Daniela Börner and Julian Wollrath interpreted in DM scenario







ATLAS-CONF-2017-037

$\rightarrow$ Comparable results wrt. the 0-/2-lepton final states

$\rightarrow$ Summarized in ATLAS DM summary paper (incl. reinterpretation with 2HDM+pseudoscalar model)

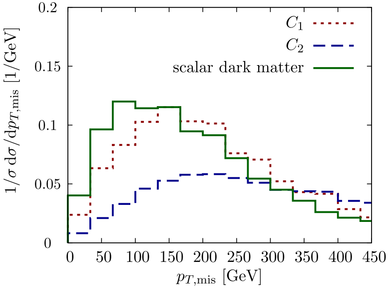
Outlook: Seach for dark energy at ATLAS

- Simple EFT-approach claims sensitity of $t\bar{t}$+$E_{\mathrm{T}}^{\mathrm{miss}}$ final state for stable dark energy scalar ϕ ($m_\phi = 0.1$ GeV) on collider distances
  (Phys. Rev. D 94, 084054 (2016))
  $$\mathcal{L}_{\mathrm{BSM}} = \mathcal{L}_{\mathrm{SM}} + \sum_i C_i \mathcal{L}_i + \frac{1}{2} m_\phi^2 \phi^2 \text{ (with } C_i = 1\text{)}$$
- Only consider operators $\mathcal{L}_1$ and $\mathcal{L}_2$

- Dark Energy signatures have harder p_{T}-spectra than DM

→ Similar to SUSY signal regions

→ Re-interpretations are ongoing



Phys. Rev. D 94, 084054 (2016)

Conclusions

- ATLAS has a broad search program for final states with $t\bar{t}$+$E_{\mathrm{T}}^{\mathrm{miss}}$:
  - Supersymmetric top squark pair production
  - Dark Matter in associated production with top quark pairs
- Searches with fully-hadronic, semi-leptonic and fully-leptonic top quark decays
- No excess above SM expectation was observed
- Significantly increased LHC Run-1 exclusion limits
- Combination of decay channels for DM scenarios currently ongoing

Conclusions

- ATLAS has a broad search program for final states with $t\bar{t}+E_T^{miss}$:
  - Supersymmetric top squark pair production
  - Dark Matter in associated production with top quark pairs
- Searches with fully-hadronic, semi-leptonic and fully-leptonic top quark decays
- No excess above SM expectation was observed
- Significantly increased LHC Run-1 exclusion limits
- Combination of decay channels for DM scenarios currently ongoing

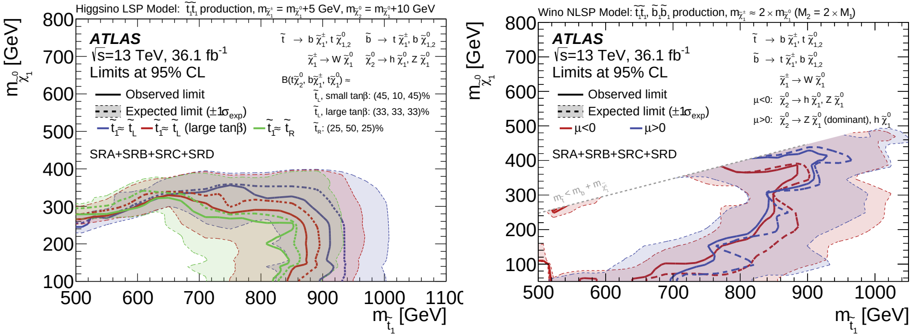
Thank you for your attention!

BACKUP

Backup

Top squark: Fully hadronic final state: pMSSM-inspired models

Higgsino-like $\tilde{\chi}_1^0$ Wino-like $\tilde{\chi}_1^0$

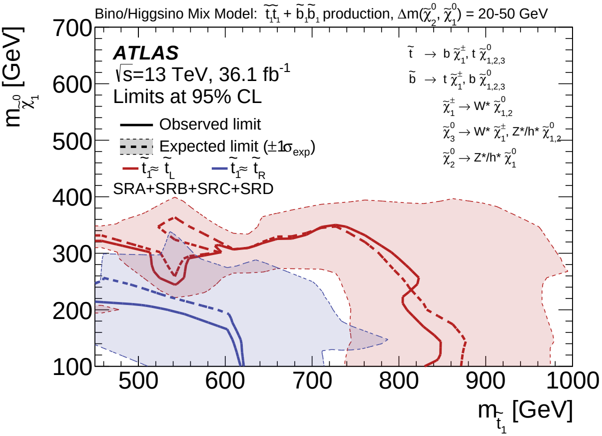


arXiv:1709.04183

Backup

Top squark: Fully hadronic final state: pMSSM-inspired models

Well-tempered pMSSM

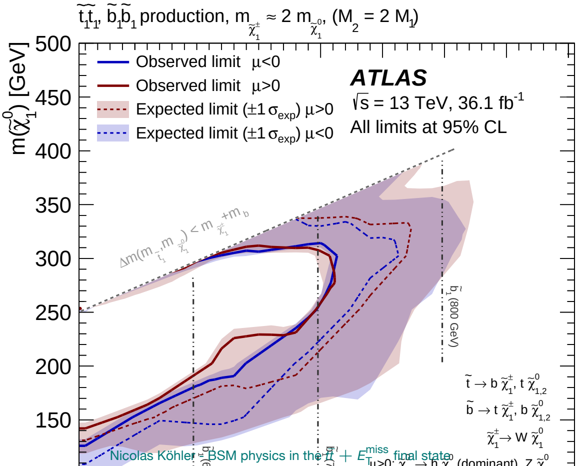


arXiv:1709.04183

Backup

Top squark: 2-lepton final state: pMSSM-inspired models

Well-tempered pMSSM



Backup

Top squark: Fully hadronic final state event selection (1)

Signal Region		TT	TW	T0
	$m^{0}_{\text{jet},R=1.2}$	> 120 GeV		
	$m^{1}_{\text{jet},R=1.2}$	> 120 GeV	$[60, 120]$ GeV	< 60 GeV
	$m_{\text{T}}^{b,\min}$	> 200 GeV		
	$N_{b-\text{jet}}$	≥ 2		
	τ-veto	yes		
	$\left\lvert\Delta\phi\left(\text{jet}^{0,1,2}, \mathbf{p}_{\text{T}}^{\text{miss}}\right)\right\rvert$	> 0.4		
A	$m^{0}_{\text{jet},R=0.8}$	> 60 GeV		
	$\Delta R\left(b, b\right)$	> 1	-	
	$m_{\text{T2}}^{\chi^2}$	> 400 GeV	> 400 GeV	> 500 GeV
	$E_{\text{T}}^{\text{miss}}$	> 400 GeV	> 500 GeV	> 550 GeV
B	$m_{\text{T}}^{b,\max}$	> 200 GeV		
	$\Delta R\left(b, b\right)$	> 1.2		

arXiv:1709.04183

Backup

Top squark: Fully hadronic final state event selection (2)

Variable	SRC1	SRC2	SRC3	SRC4	SRC5
$N_{b-\text{jet}}$	≥ 1				
$N^{\text{S}}_{b-\text{jet}}$	≥ 1				
$N^{\text{S}}_{\text{jet}}$	≥ 5				
$p^{0,\text{S}}_{\text{T},b}$	> 40 GeV				
m_{S}	> 300 GeV				
$\Delta\phi(\text{ISR}, \mathbf{p}^{\text{miss}}_{\text{T}})$	> 3.0				
$p^{\text{ISR}}_{\text{T}}$	> 400 GeV				
$p^{4,\text{S}}_{\text{T}}$	> 50 GeV				
R_{ISR}	0.30–0.40	0.40–0.50	0.50–0.60	0.60–0.70	0.70–0.80

arXiv:1709.04183

Backup

Top squark: Fully hadronic final state event selection (3)

Variable	SRD-low	SRD-high
$\left\|\Delta\phi\left(\mathrm{jet}^{0,1,2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 0.4	
$N_{b-\mathrm{jet}}$	≥ 2	
$\Delta R\,(b, b)$	> 0.8	
$p_{\mathrm{T}}^{0,b} + p_{\mathrm{T}}^{1,b}$	> 300 GeV	> 400 GeV
τ-veto	yes	
p_{T}^{1}	$> 150 GeV$	
p_{T}^{3}	$> 100 GeV$	$> 80 GeV$
p_{T}^{4}	$> 60 GeV$	
$m_{\mathrm{T}}^{b,\mathrm{min}}$	$> 250 GeV$	$> 350 GeV$
$m_{\mathrm{T}}^{b,\mathrm{max}}$	$> 300 GeV$	$> 450 GeV$

Variable	SRE
$\left\|\Delta\phi\left(\mathrm{jet}^{0,1,2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}\right)\right\|$	> 0.4
$N_{b-\mathrm{jet}}$	≥ 2
$m_{\mathrm{jet},R=0.8}^{0}$	> 120 GeV
$m_{\mathrm{jet},R=0.8}^{1}$	> 80 GeV
$m_{\mathrm{T}}^{b,\mathrm{min}}$	> 200 GeV
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 550 GeV
H_{T}	> 800 GeV
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 18\sqrt{GeV}$

arXiv:1709.04183

Backup

Top squark: 2-lepton final state event selection (1)

Table 2: *Two-body selection* signal region definitions.

	$\mathrm{SRA}^{\text{2-body}}_{180}$		$\mathrm{SRB}^{\text{2-body}}_{140}$		$\mathrm{SRC}^{\text{2-body}}_{110}$	
Lepton flavour	SF	DF	SF	DF	SF	DF
$p_{\mathrm{T}}(\ell_1), p_{\mathrm{T}}(\ell_2)$ [GeV]	$> 25, > 20$		$> 25, > 20$		$> 25, > 20$	
$m_{\ell\ell}$ [GeV]	> 111.2	> 20	$[20, 71.2]$ or > 111.2	> 20	$[20, 71.2]$ or > 111.2	> 20
$R_{2\ell 2j}$	> 0.3	–	–		–	
$R_{2\ell}$	–		–		> 1.2	
Δx	< 0.07		–		–	
$\Delta\phi_{\mathrm{boost}}$	–		< 1.5		–	
n_{jets}	–		≥ 2		≥ 3	
$n_{b\text{-jets}}$	$= 0$		≥ 1		≥ 1	
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	–		–		> 200	
$m_{\mathrm{T2}}^{\ell\ell}$ [GeV]	> 180		> 140		> 110	

arXiv:1708.03247

Backup

Top squark: 2-lepton final state event selection (2)

Table 3: *Three-body selection* signal region definitions.

	$\mathrm{SR}_W^{\text{3-body}}$		$\mathrm{SR}_t^{\text{3-body}}$	
Lepton flavour	SF	DF	SF	DF
$p_\mathrm{T}(\ell_1), p_\mathrm{T}(\ell_2)$ [GeV]	$> 25, > 20$		$> 25, > 20$	
$m_{\ell\ell}$ [GeV]	[20, 71.2] or > 111.2	> 20	[20, 71.2] or > 111.2	> 20
$n_{b\text{-jets}}$	$= 0$		≥ 1	
M_Δ^R [GeV]	> 95		> 110	
R_{p_T}	> 0.7		> 0.7	
$1/\gamma_{\mathrm{R}+1}$	> 0.7		> 0.7	
$\Delta\phi_\beta^\mathrm{R}$	$> 0.9\lvert\cos\theta_b\rvert + 1.6$		$> 0.9\lvert\cos\theta_b\rvert + 1.6$	

arXiv:1708.03247

Backup

Top squark: 2-lepton final state event selection (3)

Table 4: *Four-body selection* signal region definition.

	SR^{4-body}
Lepton flavour	SF and DF
E_T^{miss} [GeV]	> 200
$p_T(\ell_1)$ [GeV]	[7, 80]
$p_T(\ell_2)$ [GeV]	[7, 35]
$m_{\ell\ell}$ [GeV]	> 10
n_{jets}	≥ 2
$p_T(j_1)$ [GeV]	> 150
$p_T(j_2)$ [GeV]	> 25
$p_T(j_3)/E_T^{miss}$	< 0.14
$R_{2\ell 4j}$	> 0.35
$R_{2\ell}$	> 12
$n_{b\text{-jets}}$	veto on j_1 and j_2

arXiv:1708.03247

Backup

DM+$t\bar{t}$: 0-/2-lepton final states event selection

arXiv:1710.11412

Observable	SRt1	SRt2	SRt3
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$		2ℓ
$\mathcal{N}_j$	≥ 4		≥ 1
$\mathcal{N}_b^{\mathrm{M}}$	≥ 2		≥ 1
$\mathcal{N}_\ell^{\mathrm{B}}$	0		-
$\mathcal{N}_\ell^{\mathrm{M}}$	-		2 OS
$\mathcal{N}_\tau$	0		-
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 300		-
$p_{\mathrm{T}}(bj_1)$ [GeV]	> 20		> 30
$p_{\mathrm{T}}(j_1, j_2)$ [GeV]	$> 80, 80$		> 30
$p_{\mathrm{T}}(j_3, j_4)$ [GeV]	$> 40, 40$		-
$p_{\mathrm{T}}(\ell_1, \ell_2)$ [GeV]	-		$> 25, 20$
$m_{\ell\ell}$ [GeV]	-		> 20
$\lvert m_{\ell\ell}^{\mathrm{SF}} - m_Z \rvert$ [GeV]	-		> 20
$m_{\mathrm{R}=0.8}^{\mathrm{jet}\ 1,2}$ [GeV]	$> 80, 80$	-	-
$m_{\mathrm{R}=1.2}^{\mathrm{jet}\ 1,2}$ [GeV]	-	$> 140, 80$	-
$m_{\mathrm{T}}^{b,\mathrm{min}}$ [GeV]	> 150	> 200	-
$m_{\mathrm{T}}^{b,\mathrm{max}}$ [GeV]	> 250	-	-
ΔR_{bb}	> 1.5	> 1.5	-
$E_{\mathrm{T}}^{\mathrm{miss,\ sig}}$ [$\sqrt{GeV}$]	-	> 12	-
$\Delta\phi_{\mathrm{boost}}$ [rad]	-		< 0.8
$m_{b2\ell}^{\mathrm{min}}$ [GeV]	-		< 170
ξ^+ [GeV]	-		> 170
$m_{\mathrm{T2}}^{\ell\ell}$ [GeV]	-		> 100
Multi-jet rejection specific			
$\Delta\phi(\mathrm{j}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})$ [rad]	> 0.4		-
$E_{\mathrm{T}}^{\mathrm{miss,track}}$ [GeV]	> 30		-
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \vec{p}_{\mathrm{T}}^{\mathrm{miss,track}})$ [rad]	$< \pi/3$		-

Backup

DM+$t\bar{t}$: 1-lepton final state event selection

Signal region	DM_low_loose	DM_low	DM_high
Preselection	high-$E_{\mathrm{T}}^{\mathrm{miss}}$ preselection		
Number of (jets, b-tags)	$(\geq 4, \geq 1)$	$(\geq 4, \geq 1)$	$(\geq 4, \geq 1)$
Jet p_{T} [GeV]	$> (60, 60, 40, 25)$	$> (120, 85, 65, 25)$	$> (125, 75, 65, 25)$
b-tagged jet p_{T} [GeV]	–	> 60	–
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 300	> 320	> 380
m_{T} [GeV]	> 120	> 170	> 225
$H_{\mathrm{T,sig}}^{\mathrm{miss}}$	> 14	> 14	–
am_{T2} [GeV]	> 140	> 160	> 190
$m_{\mathrm{top}}^{\mathrm{reclustered}}$ [GeV]	–	> 130	> 130
$\Delta\phi(\vec{p}_{\mathrm{T}}^{\mathrm{miss}}, \ell)$	> 0.8	> 1.2	> 1.2
$\lvert\Delta\phi(\mathrm{jet}_i, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$	> 1.4	> 1.0	> 1.0
$\lvert\Delta\phi(j_{1,2}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}})\rvert$		> 0.4	
m_{T2}^{τ} based τ-veto [GeV]		> 80	
exclusion technique	cut-and-count	cut-and-count	cut-and-count

ATLAS-CONF-2017-037

Backup

Top squark: Fully hadronic final state systematics [%] (1)

	SRA-TT	SRA-TW	SRA-T0	SRB-TT	SRB-TW	SRB-T0
Total syst. unc.	24	23	15	19	14	15
$t\bar{t}$ theory	10	6	3	10	11	12
$t\bar{t}$+V theory	2	<1	<1	1	<1	<1
Z theory	1	3	2	<1	1	<1
Single top theory	6	3	5	3	4	5
Diboson theory	<1	2	<1	<1	<1	<1
$\mu_{t\bar{t}}$	<1	<1	<1	2	2	1
$\mu_{t\bar{t}+Z}$	6	3	2	4	3	2
μ_Z	6	10	7	5	6	4
μ_W	1	1	1	2	1	2
$\mu_{\text{single top}}$	5	3	5	4	4	5
JER	10	12	4	3	4	3
JES	4	7	1	7	4	<1
b-tagging	1	3	2	5	4	4
E_T^{miss} soft term	2	2	<1	1	<1	<1
Multijet estimate	1	<1	<1	2	2	<1
Pileup	10	5	5	8	1	3

`arXiv:1709.04183`

Backup

Top squark: Fully hadronic final state systematics [%] (2)

	SRC1	SRC2	SRC3	SRC4	SRC5	SRD-low	SRD-high	SRE
Total syst. unc.	31	18	18	16	80	25	18	22
$t\bar{t}$ theory	27	11	14	11	71	12	10	11
$t\bar{t}$+V theory	<1	<1	<1	<1	<1	<1	<1	1
Z theory	<1	<1	<1	<1	<1	<1	<1	2
W theory	<1	<1	1	3	2	<1	<1	1
Single top theory	3	2	2	3	<1	5	6	12
$\mu_{t\bar{t}}$	4	6	6	5	5	1	1	<1
$\mu_{t\bar{t}+Z}$	<1	<1	<1	<1	<1	2	2	4
μ_Z	<1	<1	<1	<1	<1	4	5	5
μ_W	<1	<1	1	3	3	3	1	2
$\mu_{\text{single top}}$	3	2	2	3	<1	5	6	6
JER	4	10	6	5	10	3	6	4
JES	4	5	2	2	17	8	4	5
b-tagging	2	2	<1	2	4	9	7	<1
$E_{\mathrm{T}}^{\mathrm{miss}}$ soft term	1	3	2	3	15	4	3	2
Multijet estimate	12	3	<1	<1	<1	2	2	<1
Pileup	<1	1	<1	2	14	9	<1	2

arXiv:1709.04183

Backup

DM+$t\bar{t}$: 0-/2-lepton final states systematics [%]

	SRb1 [%]	SRb2 [%]	SRt1 [%]	SRt2 [%]	SRt3 [%]
Total systematic uncertainty	18	15–18	29	14	28
Z theoretical uncertainties	5.7	7.9–12	5.0	2.1	<1
$t\bar{t}$+Z theoretical uncertainties	<1	<1	3.3	5.3	8.4
$t\bar{t}$ theoretical uncertainties	<1	2.7–9.8	17	5.7	11
MC statistical uncertainties	6.4	4.8–6.4	15	5.9	18
Z fitted normalisation	13	12–19	2.3	3.4	-
$t\bar{t}$+Z fitted normalisation	-	-	2.2	3.5	7.1
$t\bar{t}$ fitted normalisation	-	1.9–4.2	3.9	1.4	2.0
Fake or non-prompt leptons	-	-	-	-	7.9
Pile-up	3.8	<1–1.4	6.8	5.5	<1
Jet energy resolution	1.5	1.3–6.9	7.0	<1	<1
Jet energy scale	7.7	5.0–10	5.0	2.8	8.2
E_T^{miss} soft term	<1	4.3–6.3	2.0	<1	12
b-tagging	<1	2.4–6.9	8.6	3.1	<1

arXiv:1710.11412