Squark/gluino in leptonic channels with the ATLAS detector

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on behalf of the ATLAS collaboration

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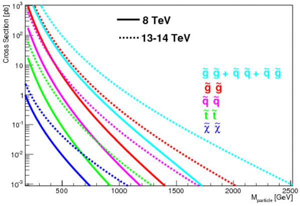
Introduction

- **Supersymmetry** is one of the theories beyond the Standard Model offering a solution to many open issues such as the hierarchy problem and dark matter.
- At the LHC, there are three main **SUSY production** mechanisms:
  - strong production of squarks and gluinos
    dominant
  - third generation production
    light stop and sbottom quarks are theoretically favoured
  - electroweak production
    direct production of gauginos (charginos, neutralinos)



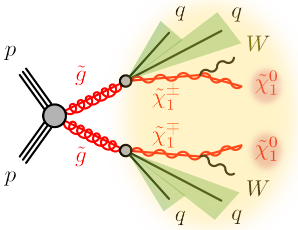
arXiv:1411.1427

- **Early Run 2 data** at $\sqrt{s} = 13\,\mathrm{TeV}$ can have better sensitivity than the full Run 1 dataset even with the integrated luminosity of $3.2\,\mathrm{fb}^{-1}$.

SUSY search strategy

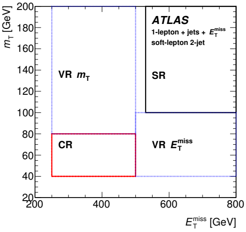
Discriminant variables

- large n_{jet}
  coloured squark/gluino
- large $E_{\text{T}}^{\text{miss}}$
  R-parity conserving models
- high p_{T} objects
  decay of massive squark/gluino
  $m_{\text{eff}} = E_{\text{T}}^{\text{miss}} + \sum p_{\text{T}}^{\text{lep,jet}}$, $H_{\text{T}} = \sum p_{\text{T}}^{\text{lep,jet}}$
- leptons



Background estimation

- irreducible background
  - dominant sources ($t\bar{t}, Z, W$)
  normalized to data in dedicated control regions (CRs)
  - sub-dominant sources ($t\bar{t}V, VV$)
  estimated using MC simulation with theoretical uncertainties
- reducible background
  - data-driven techniques (analysis dependent)
- validation
  - all predictions validated in validation regions (VRs) close to SRs



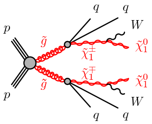
Analyses with leptons

- following **simplified models** (100% BF) and **GMSB model** containing at least one lepton in the final state have been studied by the dedicated analyses

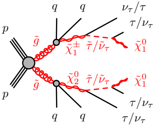
1 LEPTON	2 LEPTONS	2SS/3 LEPTONS

1 lepton

- gluino production
- arXiv:1605.04285

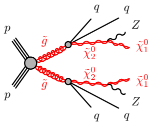


- gluino production
- to be published soon



2 leptons

- gluino production
- ATLAS-CONF-2015-082



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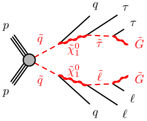
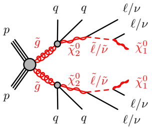
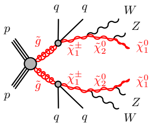
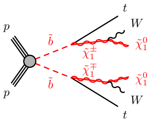


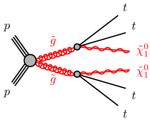
2SS/3 leptons

- gluino/sbottom production
- EPJC(2016)76:259









- see Antonia Strubig's talk for squark/gluino searches in hadronic final states
- see Jan Schaeffer's talk for third generation searches
- see Jordan Tucker's talk for long-lived particles + RPV searches

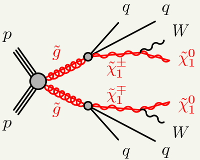
1L + jets + E_T^{miss} arXiv:1605.04285

Main target

- gluino pair production with one-step decay
  $\tilde{g} \to q\bar{q}\,\tilde{\chi}_1^\pm$ with $\tilde{\chi}_1^\pm \to W^\pm\,\tilde{\chi}_1^0$
- two scenarios

a) $x \equiv \frac{m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0}}{m_{\tilde{g}} - m_{\tilde{\chi}_1^0}} = \frac{1}{2}$

b) $m_{\tilde{\chi}_1^0} = 60$ GeV



→ leptonic decay

→ hadronic decay

Signal regions

- targeting different mass hierarchies
- **soft-lepton** $p_T \in [6\text{-}7, 35]$ GeV

2-jet small $\Delta m \Rightarrow$ low-p_T/soft decay products
high-p_T ISR jet

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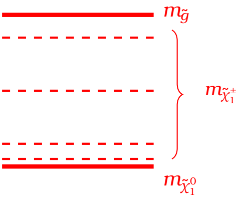
Major backgrounds

- $t\bar{t}$ and W+jets
- normalized in CRs defined at lower values of m_T, E_T^{miss}, E_T^{miss}/m_{eff} and aplanarity



1L + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ arXiv:1605.04285

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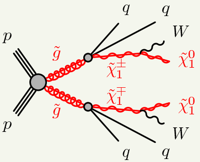

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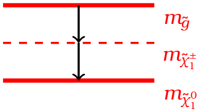

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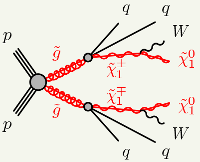

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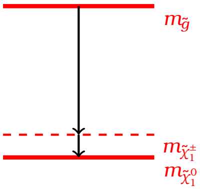

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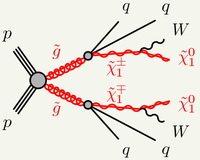

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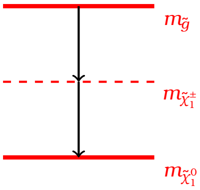

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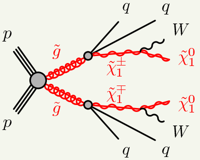

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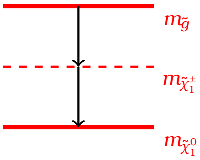

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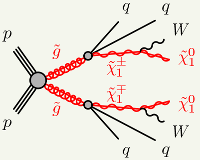

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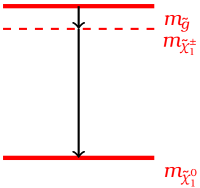

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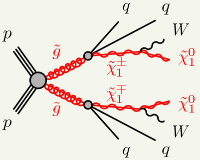

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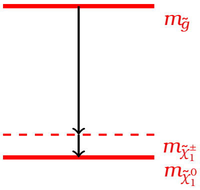
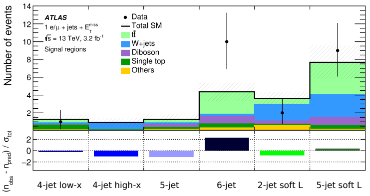


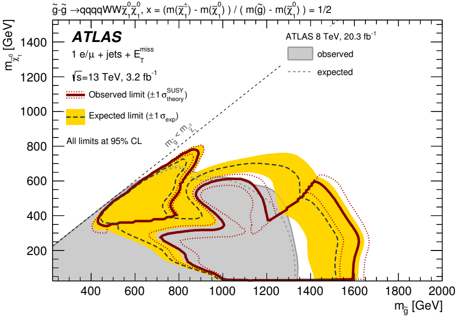
1L + jets + E_T^{miss} arXiv:1605.04285

Results

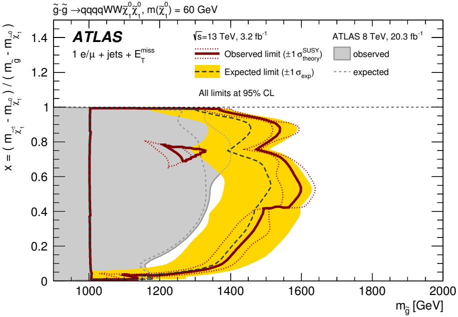
- data/MC agreement within 2σ in all SRs
- no significant excess observed
- high $\Delta m(\tilde{g}, \tilde{\chi}_1^0)$: $m_{\tilde{g}}$ excluded up to 1.6 TeV
- low $\Delta m(\tilde{g}, \tilde{\chi}_1^0)$: $m_{\tilde{g}}$ excluded up to 870 GeV



Scenario A)



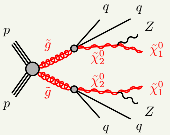
Scenario B)



2L(on-Z) + jets + E_T^{miss} ATLAS-CONF-2015-082

Main target

- gluino pair production with one-step decay
  $\tilde{g} \to q\bar{q}\,\tilde{\chi}_2^0$ with $\tilde{\chi}_2^0 \to Z\,\tilde{\chi}_1^0$
- fixed LSP mass: $m_{\tilde{\chi}_1^0} = 1$ GeV



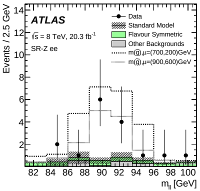
→ leptonic decay

→ hadronic decay

Signal region

- e^+e^- or $\mu^+\mu^-$ pairs
- $m_{\ell\ell} \in [81, 101]$ GeV
- $E_T^{miss} > 225$ GeV
- $H_T > 600$ GeV
- $n_{jets} \geq 2$

same selections as in Run 1

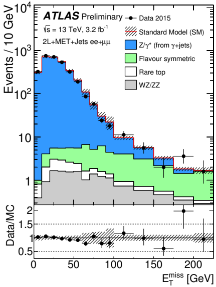


arxiv:1503.03290

3σ in the ee channel

Major backgrounds

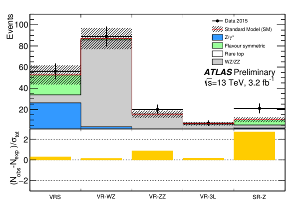
- flavour-symmetric → ∼ 60% from $t\bar{t}$, WW, Wt
  estimated using data-driven method from $e\mu$ CR
- Z/γ^*+jets → fake E_T^{miss} from jet mismeasurements
  estimated using data-driven method from γ+jets events



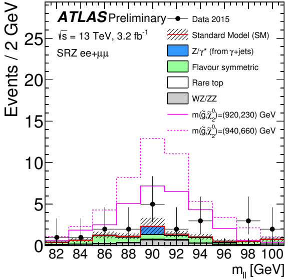
2L(on-Z) + jets + E_T^{miss} ATLAS-CONF-2015-082

Results

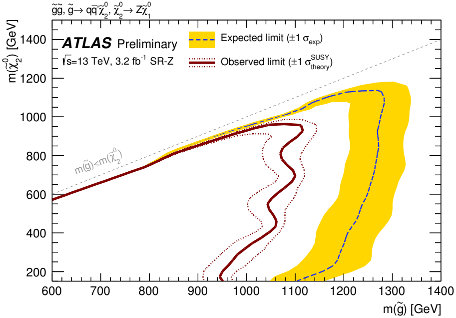
- very good data/exp. bkg agreement in all VRs
- modest 2.2σ deviation in SR
- 10.3 expected and 21 observed events
- for $m_{\tilde{\chi}_2^0} \sim 700$ GeV: $m_{\tilde{g}}$ excluded up to 1.1 TeV
- for $m_{\tilde{\chi}_2^0} \sim 200$ GeV: $m_{\tilde{g}}$ excluded up to 0.95 TeV



$m_{\ell\ell}$ distribution in SR



$\tilde{g} \to q\bar{q}\,\tilde{\chi}_2^0 \to q\bar{q}Z\,\tilde{\chi}_1^0$



2SS/3L + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ EPJC(2016)76:259

Main target

- gluino pair production with two-step decay

a) $\tilde{g} \to q\bar{q}\,\tilde{\chi}_2^0$ with $\tilde{\chi}_2^0 \to \ell\tilde{\ell}$ and $\tilde{\ell} \to \ell\tilde{\chi}_1^0$

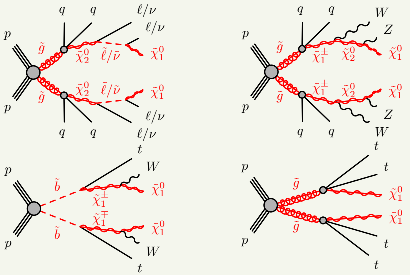
b) $\tilde{g} \to q\bar{q}\,\tilde{\chi}_1^\pm$ with $\tilde{\chi}_1^\pm \to W^\pm\,\tilde{\chi}_2^0$ and $\tilde{\chi}_2^0 \to Z\tilde{\chi}_1^0$

- sbottom pair production with one-step decay

c) $\tilde{b}_1 \to t\,\tilde{\chi}_1^\pm$ with $\tilde{\chi}_1^\pm \to W^\pm\,\tilde{\chi}_1^0$

- gluino pair production with direct decay

d) $\tilde{g} \to tt\,\tilde{\chi}_1^0$



Signal regions

- few SM processes with same-sign leptons

  looser kinematic requirements

  sensitive to many SUSY processes

- classification by $N_{b\text{-jets}}$
- large m_{eff} and $E_{\mathrm{T}}^{\mathrm{miss}}$

Signal region	$N_{\mathrm{lept}}^{\mathrm{signal}}$	$N_{b-\mathrm{jets}}^{20}$	N_{jets}^{50}	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	m_{eff} [GeV]
SR0b3j	≥3	=0	≥3	>200	>550
SR0b5j	≥2	=0	≥5	>125	>650
SR1b	≥2	≥1	≥4	>150	>550
SR3b	≥2	≥3	-	>125	>650

2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

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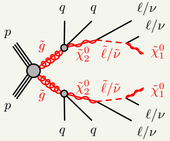

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2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

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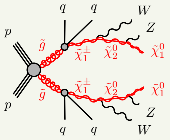

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2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

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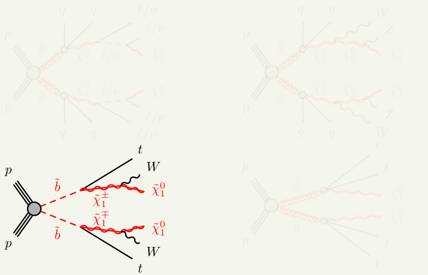

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2SS/3L + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ EPJC(2016)76:259

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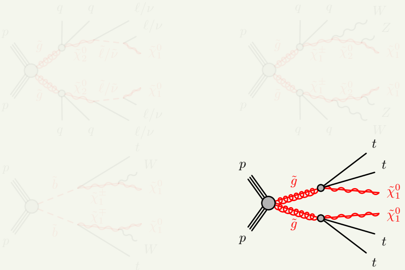

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2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

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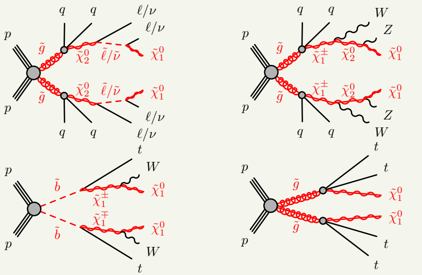
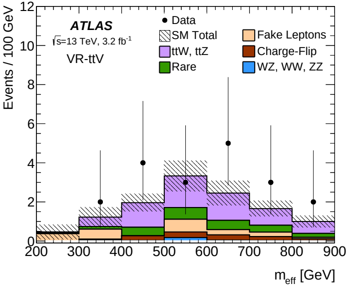




Major backgrounds

- fake and non-prompt → from b-decays in $t\bar{t}$ events estimated using data-driven matrix method
- e charge-flip → from hard bremsstrahlung γ estimated using data-driven method from $Z \rightarrow ee$ events
- prompt → from WZ, $t\bar{t}W$ and $t\bar{t}Z$ estimated from MC and checked in VRs

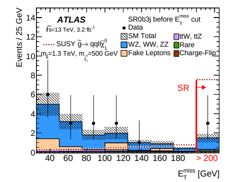
2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

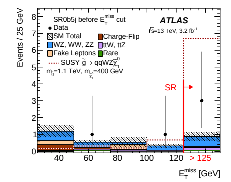
Results

- fair data/MC agreement within 1.5σ in VRs
- no significant excess observed in SRs

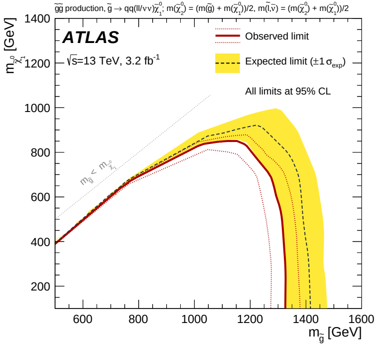
a) $m_{\tilde{g}}$ excluded up to 1.3 TeV for low $m_{\tilde{\chi}_1^0}$

b) $m_{\tilde{g}}$ excluded up to 1.1 TeV for low $m_{\tilde{\chi}_1^0}$

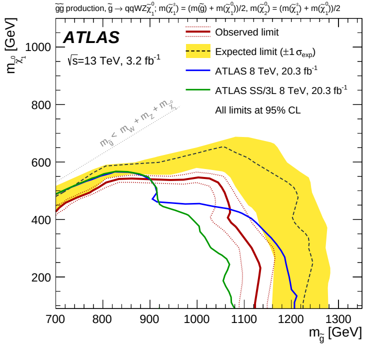




Scenario a)



Scenario b)



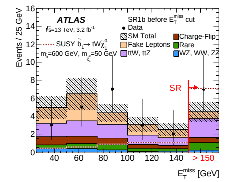
2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

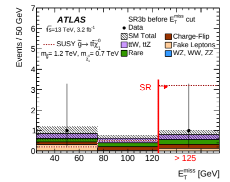
Results

- fair data/MC agreement within 1.5σ in VRs
- no significant excess observed in SRs

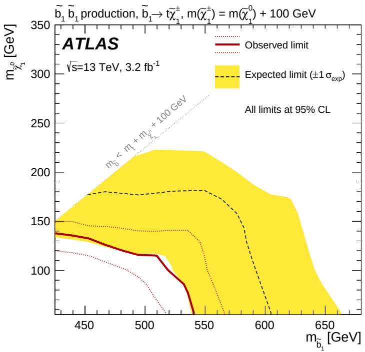
c) $m_{\tilde{b}_1}$ excluded up to 540 GeV for low $m_{\tilde{\chi}_1^0}$

d) $m_{\tilde{g}}$ excluded up to 1.2 TeV for $m_{\tilde{\chi}_1^0} \lesssim 600$ GeV

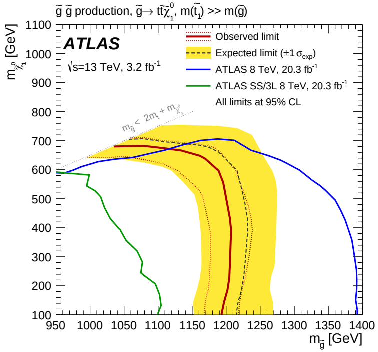




Scenario c)



Scenario d)



τ^{had} + jets + E_T^{miss} NEW!

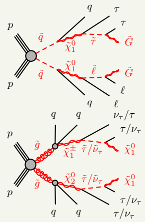
Main target

a) GMSB model

- free parameters: $\Lambda, \tan\beta$
- other parameters set such that $\tilde{\tau}_1$ is NLSP for large $\tan\beta$
- squark pair production dominates for high Λ

b) simplified model

- gluino pair production with two-step decay
- $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0} = (m_{\tilde{g}} + m_{\tilde{\chi}_1^0})/2$
- $m_{\tilde{\tau}} = m_{\tilde{\nu}_\tau} = (m_{\tilde{\chi}_1^\pm} + m_{\tilde{\chi}_1^0})/2$



Signal regions

- 2 exclusive final states considered
  $N_\tau = 1$ and $N_\tau \geq 2$
- SRs for b) target different $\Delta m(\tilde{g}, \tilde{\chi}_1^0)$

1τ low $\Delta m \Rightarrow$ low-p_T τ and high -p_T ISR jet
high $\Delta m \Rightarrow$ high-p_T jets from $\tilde{g}$

2τ one SR defined for GMSB

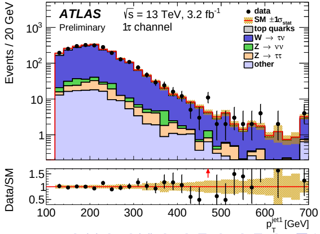
- discriminant variables against $t\bar{t}$ and V+jets
  m_T^τ, $m_T^{\tau_1} + m_T^{\tau_2}$, $m_{T2}^{\tau\tau}$

Major backgrounds

1τ true τ: $t\bar{t}(1\tau)$, $W(\tau\nu)$+jets

1τ fake τ: $t\bar{t}(2l)$, $Z(\nu\nu)$+jets

- normalized in dedicated CRs



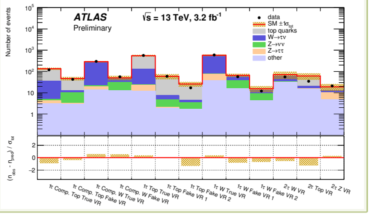
τ^{had} + jets + E_T^{miss} NEW!

Results

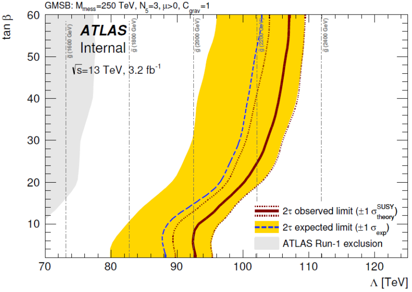
- good data/MC agreement in all VRs
- no excess observed in SRs

a) smaller $\tan\beta$: $\Lambda/m_{\tilde{g}}$ excluded up to 92 TeV/2.0 TeV
   large $\tan\beta$: $\Lambda/m_{\tilde{g}}$ excluded up to 107 TeV/2.3 TeV

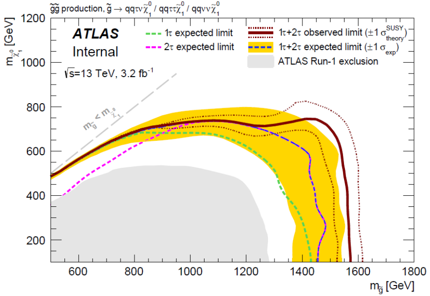
b) for $m_{\tilde{\chi}_1^0} \sim 750$ GeV: $m_{\tilde{g}}$ excluded up to 1.4 TeV
   for $m_{\tilde{\chi}_1^0} \sim 100$ GeV: $m_{\tilde{g}}$ excluded up to 1.57 TeV



GMSB model

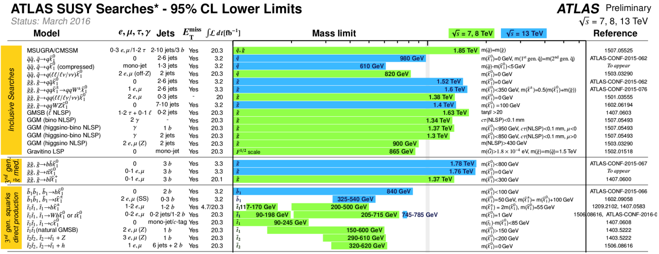


Simplified model



Conclusions

- no statistically significant excess over Standard Model prediction observed
- improved mass limits wrt Run 1 results even with the very first 2015 Run 2 data
- exciting times in front of us with much better statistics!



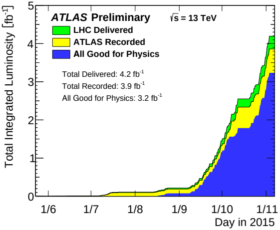
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

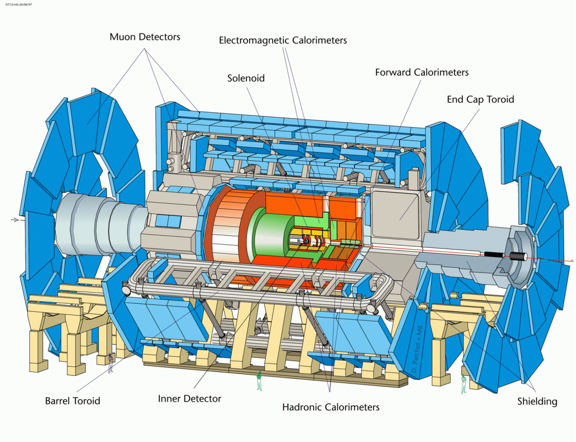
THANK YOU FOR YOUR ATTENTION!

Backup slides

ATLAS experiment

- general purpose detector at the LHC
- $3.9\,\text{fb}^{-1}$ recorded at $\sqrt{s} = 13$ TeV during 2015 pp data-taking
- large luminosity results in large pileup$\rightarrow$ pileup suppression strategies developed





Mass reach of ATLAS SUSY searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: March 2016

ATLAS Preliminary

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

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

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$	Mass limit		Condition	Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q}, \tilde{g}$	1.85 TeV	$m(\tilde{q})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	3.2	$\tilde{q}$	980 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	ATLAS-CONF-2015-062
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$	610 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0)$<5 GeV	*To appear*
	$\tilde{q}\tilde{q}, \tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$	820 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1503.03290
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	3.2	$\tilde{g}$	1.52 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2015-062
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e,μ	2-6 jets	Yes	3.3	$\tilde{g}$	1.6 TeV	$m(\tilde{\chi}_1^0)$<350 GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2015-076
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20	$\tilde{g}$	1.38 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1501.03555
	$\tilde{g}\tilde{g}, \tilde{g}\to qqWZ\tilde{\chi}_1^0$	0	7-10 jets	Yes	3.2	$\tilde{g}$	1.4 TeV	$m(\tilde{\chi}_1^0)$ =100 GeV	1602.06194
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$	1.63 TeV	$\tan\beta$ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$	1.34 TeV	$c\tau$(NLSP)<0.1 mm	1507.05493
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$	1.37 TeV	$m(\tilde{\chi}_1^0)$<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<850 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	1507.05493
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde{g}$	900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale	865 GeV	$m(\tilde{G})>1.8\times10^{-4}$ eV, $m(\tilde{g})=m(\tilde{q})$=1.5 TeV	1502.01518
3rd gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	3.3	$\tilde{g}$	1.78 TeV	$m(\tilde{\chi}_1^0)$<800 GeV	ATLAS-CONF-2015-067
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	3.3	$\tilde{g}$	1.76 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	*To appear*
	$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.37 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	3.2	$\tilde{b}_1$	840 GeV	$m(\tilde{\chi}_1^0)$<100 GeV	ATLAS-CONF-2015-066
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	3.2	$\tilde{b}_1$	325-540 GeV	$m(\tilde{\chi}_1^0)$=50 GeV, $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0)$+100 GeV	1602.09058
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$	117-170 GeV; 200-500 GeV	$m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$, $m(\tilde{\chi}_1^0)$=55 GeV	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3	$\tilde{t}_1$	90-198 GeV; 205-715 GeV; 745-785 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1506.08616, ATLAS-CONF-2016-007
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-245 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	150-600 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$	290-610 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+h$	1 e,μ	6 jets + 2 b	Yes	20.3	$\tilde{t}_2$	320-620 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1506.08616
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	90-335 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-475 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	355 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1407.0350
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	715 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	425 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	270 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1501.07110
	$\tilde{\chi}_2^0\tilde{\chi}_3^0, \tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$	635 GeV	$m(\tilde{\chi}_2^0)=m(\tilde{\chi}_3^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$	1405.5086
	GGM (wino NLSP) weak prod.	1 $e,\mu+\gamma$	-	Yes	20.3	$\tilde{W}$	115-370 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns	1310.3675
	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	495 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^\pm)$<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	850 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	1310.6584
	Metastable $\tilde{g}$ R-hadron	dE/dx trk	-	-	3.2	$\tilde{g}$	1.54 TeV	$m(\tilde{\chi}_1^0)$=100 GeV, τ>10 ns	*To appear*
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	537 GeV	10<$\tan\beta$<50	1411.6795
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	440 GeV	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	$\tilde{\chi}_1^0$	1.0 TeV	7 <$c\tau(\tilde{\chi}_1^0)$< 740 mm, $m(\tilde{g})$=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}, \tilde{\chi}_1^0\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$	1.0 TeV	6 <$c\tau(\tilde{\chi}_1^0)$< 480 mm, $m(\tilde{g})$=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$	1.7 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1503.04430
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q}, \tilde{g}$	1.45 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^\pm)$, $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^\pm)$, $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}, \tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	917 GeV	BR(t)=BR(b)=BR(c)=0%	1502.05686
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	980 GeV	$m(\tilde{\chi}_1^0)$=600 GeV	1502.05686
	$\tilde{g}\tilde{g}, \tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$	880 GeV		1404.2500
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	$\tilde{t}_1$	320 GeV		1601.07453
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$	2 e,μ	2 b	-	20.3	$\tilde{t}_1$	0.4-1.0 TeV	BR($\tilde{t}_1\to be/\mu$)>20%	ATLAS-CONF-2015-015
Other	Scalar charm, $\tilde{c}\to c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	$\tilde{c}$	510 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1501.01325

Mass scale [TeV] (10^{-1} – 1)

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

Definitions of transverse masses

TRANSVERSE MASS m_{T}

$$m_{\mathrm{T}}^2(\mathbf{p}_{\mathrm{T}}^1, \mathbf{p}_{\mathrm{T}}^2) = [E_{\mathrm{T}}^1 + E_{\mathrm{T}}^2]^2 - [\mathbf{p}_{\mathrm{T}}^1 + \mathbf{p}_{\mathrm{T}}^2]^2$$

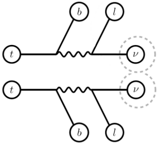
- $m_{\mathrm{T}} \equiv m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}}) = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}}[1 - \cos\Delta\phi(\mathbf{p}_{\mathrm{T}}^{\ell}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}})]}$ bounded by m_W: reduce $WW, Wt, t\bar{t}$

STRANSVERSE MASS m_{T2}

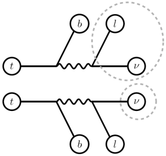
- generalization of m_{T} to pair decay with final state consisting of 2 visible objects and $E_{\mathrm{T}}^{\mathrm{miss}}$

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

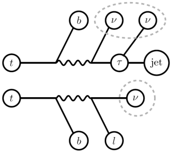
- $m_{\mathrm{T2}} \equiv m_{\mathrm{T2}}(\mathbf{p}_{\mathrm{T}}^{l_1}, \mathbf{p}_{\mathrm{T}}^{l_2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}})$ bounded by m_W: reduce $WW, Wt, t\bar{t} \to 2\ell$
- am_{T2} bounded by m_t: reduce $t\bar{t} \to 2\ell$ with a lost lepton
- m_{T2}^{τ} bounded by m_W: reduce $t\bar{t} \to \ell\tau^{\mathrm{had}}$



m_{T2}



am_{T2}



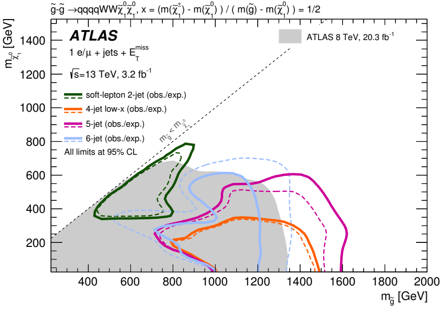
m_{T2}^{τ}

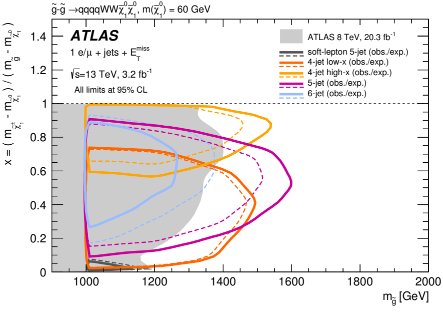
1L + jets + E_T^{miss} arXiv:1605.04285

	2-jet soft-lepton SR	5-jet soft-lepton SR
$N_{lep}(p_T^{\ell=e(\mu)} > 7(6)\text{GeV})$	$=1$	$=1$
$p_T^{\ell=e(\mu)}$ (GeV)	7(6)–35	7(6)–35
N_{jet}	≥ 2	≥ 5
p_T^{jet} (GeV)	$> 180, 30$	$> 200, 200, 200, 30, 30$
E_T^{miss} (GeV)	> 530	> 375
m_T (GeV)	> 100	-
E_T^{miss}/m_{eff}^{inc}	> 0.38	-
H_T (GeV)	-	> 1100
Jet aplanarity	-	> 0.02

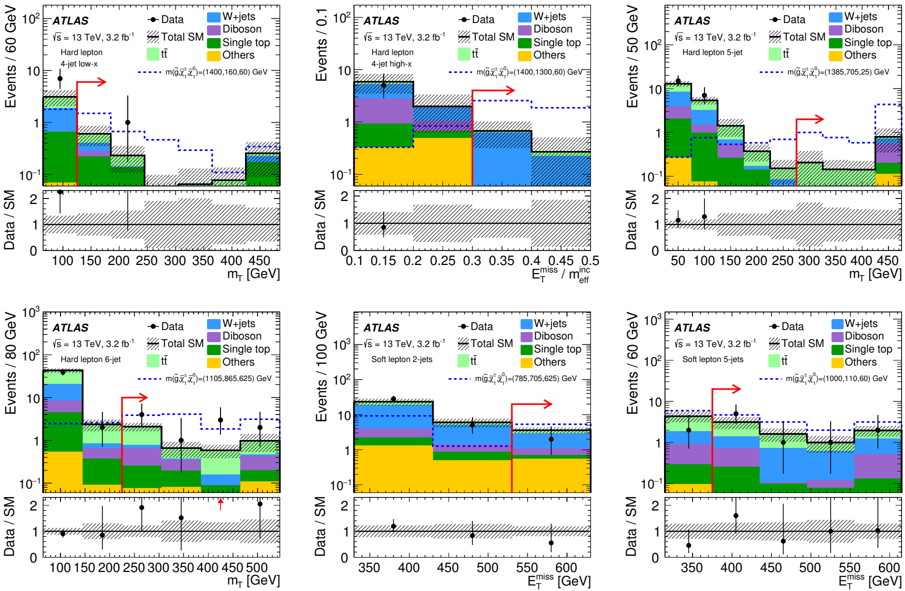
	4-jet high-x SR	4-jet low-x SR	5-jet SR	6-jet SR
$N_{lep}(p_T^{\ell=e(\mu)} > 10\text{GeV})$	$=1$	$=1$	$=1$	$=1$
$p_T^{\ell=e(\mu)}$ (GeV)	> 35	> 35	> 35	> 35
N_{jet}	≥ 4	≥ 4	≥ 5	≥ 6
p_T^{jet} (GeV)	$> 325, 30, ..., 30$	$> 325, 150, ..., 150$	$> 225, 50, ..., 50$	$> 125, 30, ..., 30$
E_T^{miss} (GeV)	> 200	> 200	> 250	> 250
m_T (GeV)	> 425	> 125	> 275	> 225
E_T^{miss}/m_{eff}^{inc}	> 0.3	-	> 0.1	> 0.2
m_{eff}^{inc} (GeV)	> 1800	> 2000	> 1800	> 1000
Jet aplanarity	-	> 0.04	> 0.04	> 0.04

1L + jets + E_T^{miss} arXiv:1605.04285





1L + jets + E_T^{miss} arXiv:1605.04285



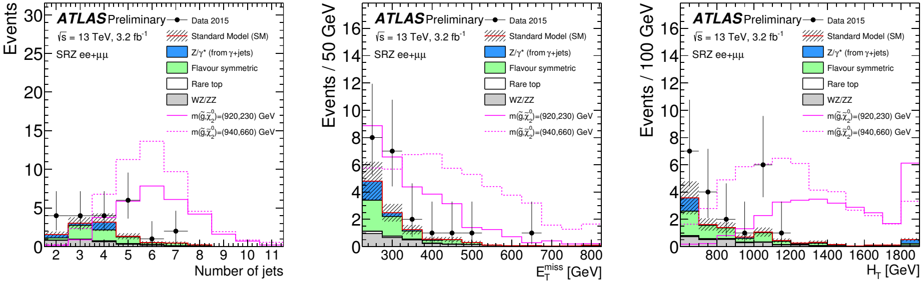
1L + jets + E_T^{miss} arXiv:1605.04285

	Hard-lepton				Soft-lepton	
	4-jet low x	4-jet high x	5-jet	6-jet	2-jet	5-jet
Observed events	1	0	0	10	2	9
Fitted background events	1.3 ± 0.5	0.9 ± 0.5	1.3 ± 0.6	4.4 ± 1.0	3.6 ± 0.7	7.7 ± 1.9
$t\bar{t}$	0.40 ± 0.31	0.08 ± 0.07	0.40 ± 0.24	2.5 ± 0.9	0.64 ± 0.33	3.6 ± 1.2
W+jets	0.19 ± 0.12	0.8 ± 0.5	0.16 ± 0.12	0.23 ± 0.16	1.9 ± 0.5	2.5 ± 1.3
Z+jets	0.045 ± 0.023	0.028 ± 0.027	0.073 ± 0.035	0.08 ± 0.08	0.47 ± 0.12	0.09 ± 0.04
Single-top	0.5 ± 0.5	$0.04^{+0.10}_{-0.04}$	$0.21^{+0.22}_{-0.21}$	0.4 ± 0.4	0.16 ± 0.14	0.42 ± 0.33
Diboson	$0.06^{+0.20}_{-0.06}$	$0.002^{+0.014}_{-0.002}$	0.37 ± 0.23	0.9 ± 0.5	0.38 ± 0.16	0.9 ± 0.6
$t\bar{t}$+V	0.048 ± 0.021	0.024 ± 0.012	0.059 ± 0.029	0.23 ± 0.08	0.085 ± 0.028	0.065 ± 0.024

2L(on-Z) + jets + E_T^{miss} ATLAS-CONF-2015-082

Region	E_T^{miss} [GeV]	H_T [GeV]	n_{jets}	$m_{\ell\ell}$ [GeV]	**SF/DF**	$\Delta\phi(\text{jet}_{12}, p_T^{miss})$	$m_T(\ell_3, E_T^{miss})$ [GeV]	$n_{b\text{-jets}}$
Signal regions								
SRZ	> 225	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
Control regions								
Z normalisation	< 60	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
CR-FS	> 225	> 600	≥ 2	$61 < m_{\ell\ell} < 121$	DF	> 0.4	-	-
CRT	> 225	> 600	≥ 2	$m_{\ell\ell} \notin [81, 101]$	SF	> 0.4	-	-
Validation regions								
VRZ	< 225	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
VRT	100–200	> 600	≥ 2	$m_{\ell\ell} \notin [81, 101]$	SF	> 0.4	-	-
VRS	100–200	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4	-	-
VR-FS	100–200	> 600	≥ 2	$61 < m_{\ell\ell} < 121$	DF	> 0.4	-	-
VR-WZ	100–200	-	-	-	3ℓ	-	< 100	0
VR-ZZ	< 100	-	-	-	4ℓ	-	-	0
VR-3L	60–100	> 200	≥ 2	$81 < m_{\ell\ell} < 101$	3ℓ	> 0.4	-	-

2L(on-Z) + jets + E_T^{miss} ATLAS-CONF-2015-082



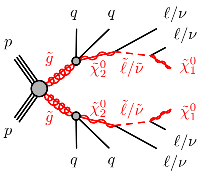
2L(on-Z) + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ ATLAS-CONF-2015-082

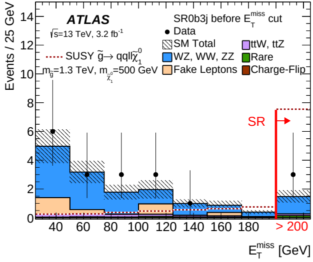
	VRS	VR-WZ	VR-ZZ	VR-3L
Observed events	56	89	20	7
Total expected background events	52.6 ± 9.1	87 ± 10	15.5 ± 3.4	6.5 ± 1.6
Flavour symmetric ($t\bar{t}$, Wt, WW and $Z \to \tau\tau$) events	18.9 ± 4.8	1.3 ± 0.4	0	0.3 ± 0.2
WZ/ZZ events	7.5 ± 1.7	82 ± 10	15.5 ± 3.4	4.9 ± 1.6
Z/γ^{*} + jets events	24.8 ± 7.6	2.7 ± 2.8	0	0.2 ± 0.2
Rare top events	1.4 ± 0.2	0.9 ± 0.4	0.04 ± 0.02	1.0 ± 0.1

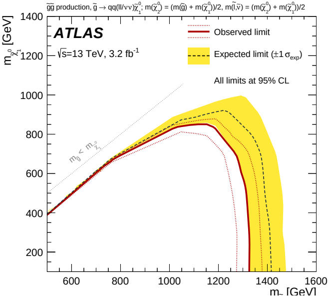
2L(on-Z) + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ ATLAS-CONF-2015-082

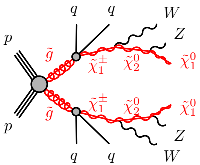
Source	Relative systematic uncertainty [%]
	SRZ
Total systematic uncertainty	22
Flavour symmetry (statistical)	14
Flavour symmetry (systematic)	12
$Z/\gamma^* +$ jets (systematic)	7.8
WZ generator uncertainty	7.6
$Z/\gamma^* +$ jets (statistical)	2.2

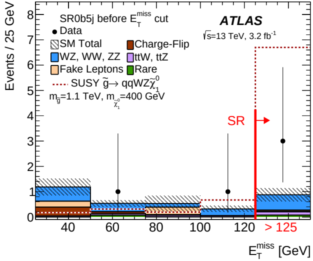
2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

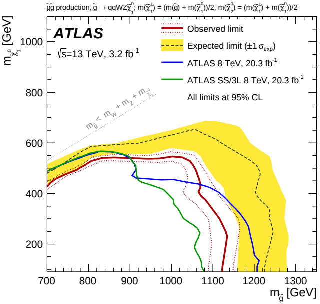




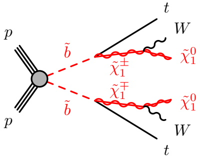


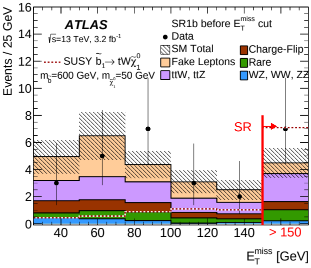


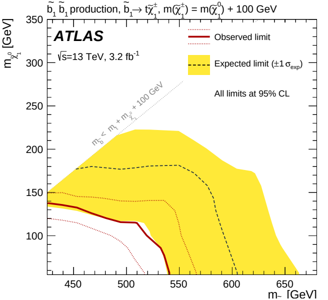


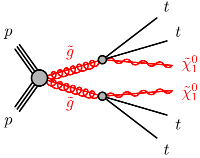


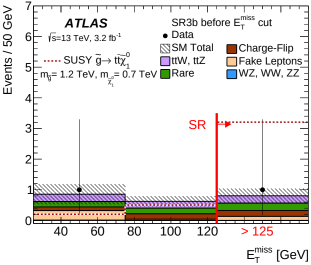
2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

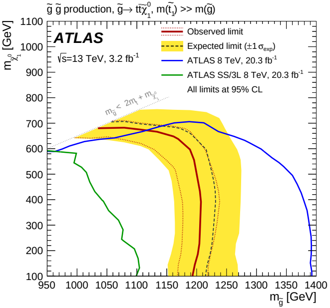




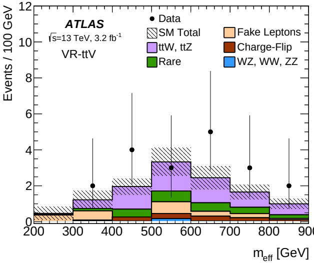


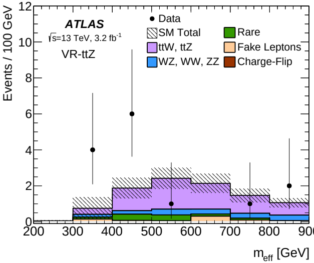






2SS/3L + jets + E_T^{miss} EPJC (2016) 76:259





	$N_{\rm lept}^{\rm signal}$ ($N_{\rm lept}^{\rm cand}$)	$N_{b-\rm jets}^{20}$	$N_{\rm jets}^{25}$	$E_{\rm T}^{\rm miss}$ [GeV]	$m_{\rm eff}$ [GeV]	Other
VR-WW	=2 (=2) =1 SS pair	=0	≥2	35–200	300–900	$m(j_1 j_2) > 500$ GeV $p_{\rm T}(j_2) > 40$ GeV $p_{\rm T}(\ell_2) > 30$ GeV veto $80 < m_{ee} < 100$ GeV
VR-WZ	=3 (=3)	=0	1–3	30–200	<900	$p_{\rm T}(\ell_3) > 30$ GeV
VR-ttV	≥2 (-) ≥1 SS pair	≥2	≥5 ($e^\pm e^\pm$,$e^\pm\mu^\pm$) ≥3 ($\mu^\pm\mu^\pm$)	20–200	200–900	$p_{\rm T}(\ell_2) > 25$ GeV veto $\{E_{\rm T}^{\rm miss} > 125$ and $m_{\rm eff} > 650\,{\rm GeV}\}$
VR-ttZ	≥3 (-) ≥1 SFOS pair	≥1	≥4 (=1 b-jet) ≥3 (≥2 b-jets)	20–150	100–900	$p_{\rm T}(\ell_2) > 25$ GeV $p_{\rm T}(\ell_3) > 20$ GeV (if e) $80 < m_{\rm SFOS} < 100$ GeV
All VRs	Veto events belonging to any SR, or if ℓ_1 or ℓ_2 is an electron with $\|\eta\| > 1.37$ (except in VR-WZ)					

2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

	VR-WW	VR-WZ	VR-ttV	VR-ttZ
Observed events	4	82	19	14
Total background events	3.4 ± 0.8	98 ± 15	12.1 ± 2.7	9.7 ± 2.5
Fake/non-prompt leptons	0.6 ± 0.5	8 ± 6	2.1 ± 1.4	0.6 ± 1.0
Charge-flip	0.26 ± 0.05	–	1.14 ± 0.15	–
$t\bar{t}W$	0.05 ± 0.03	0.25 ± 0.09	2.4 ± 0.8	0.10 ± 0.03
$t\bar{t}Z$	0.02 ± 0.01	0.72 ± 0.26	3.9 ± 1.3	6.3 ± 2.1
WZ	1.0 ± 0.4	78 ± 13	0.19 ± 0.10	1.2 ± 0.4
$W^{\pm}W^{\pm}jj$	1.3 ± 0.5	–	0.02 ± 0.03	–
ZZ	0.02 ± 0.01	8.2 ± 2.8	0.12 ± 0.15	0.30 ± 0.19
Rare	0.10 ± 0.05	2.8 ± 1.4	2.3 ± 1.2	1.1 ± 0.6

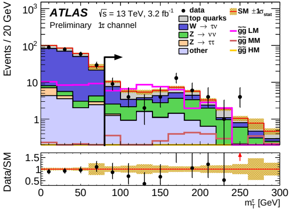
	SR0b3j	SR0b5j	SR1b	SR3b
Observed events	3	3	7	1
Total background events	1.5 ± 0.4	0.88 ± 0.29	4.5 ± 1.0	0.80 ± 0.25
$p(s = 0)$	0.13	0.04	0.15	0.36
Fake/non-prompt leptons	< 0.2	0.05 ± 0.18	0.8 ± 0.8	0.13 ± 0.17
Charge-flip	–	0.02 ± 0.01	0.60 ± 0.12	0.19 ± 0.06
$t\bar{t}W$	0.02 ± 0.01	0.08 ± 0.04	1.1 ± 0.4	0.10 ± 0.05
$t\bar{t}Z$	0.10 ± 0.04	0.05 ± 0.03	0.92 ± 0.31	0.14 ± 0.06
WZ	1.2 ± 0.4	0.48 ± 0.20	0.18 ± 0.11	< 0.02
$W^{\pm}W^{\pm}jj$	–	0.12 ± 0.07	0.03 ± 0.02	< 0.01
ZZ	< 0.03	< 0.04	< 0.03	< 0.03
Rare	0.14 ± 0.08	0.07 ± 0.05	0.8 ± 0.4	0.24 ± 0.14

2SS/3L + jets + E_T^{miss} EPJC(2016)76:259

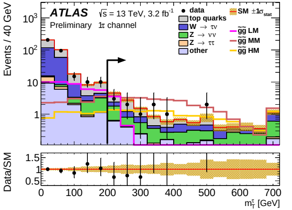
	SR0b3j	SR0b5j	SR1b	SR3b
Diboson theoretical uncertainties	23%	16%	1%	<1%
$t\bar{t}V$ theoretical uncertainties	3%	4%	13%	9%
Other theoretical uncertainties	5%	3%	9%	15%
MC statistical uncertainties	11%	14%	3%	6%
Jet energy scale	12%	11%	6%	5%
Jet energy resolution	3%	9%	2%	3%
b-tagging	4%	6%	3%	10%
PDF	6%	6%	6%	8%
Fake/non-prompt leptons	18%	20%	18%	21%
Charge flip	–	1%	3%	8%
Total background uncertainties	30%	34%	22%	31%
Total background events	1.5	0.88	4.5	0.80

τ^{had} + jets + E_T^{miss} NEW!

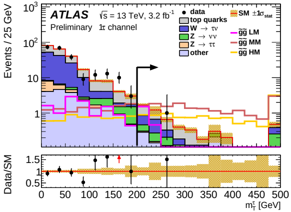
▸ 1τ channel



Compressed SR

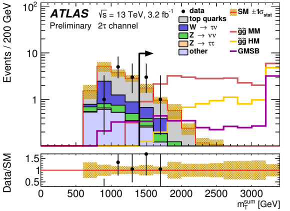


Medium-Mass SR

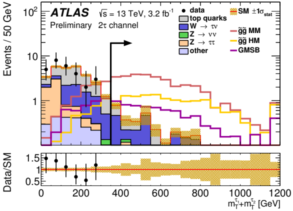


High-Mass SR

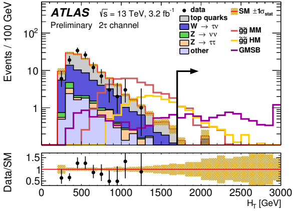
▸ 2τ channel



Compressed SR



High-Mass SR



GMSB SR

1L stop + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ ATLAS-CONF-2016-007

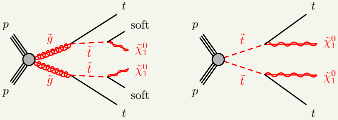
Main target

- gluino-mediated stop pair production with one-step decay

a) $\tilde{g} \to t\,\tilde{t}$ with $\tilde{t} \to \tilde{\chi}_1^0 + \mathrm{soft}$ where $\Delta m(\tilde{t}, \tilde{\chi}_1^0) = 5\ \mathrm{GeV}$

- stop pair production with direct decay

b) $\tilde{t} \to t\,\tilde{\chi}_1^0$



Signal regions

- signal signature: $t\bar{t} + E_{\mathrm{T}}^{\mathrm{miss}}$

  difficult to separate from $t\bar{t}$

- discriminant variables against bkg

$t\bar{t} \to 1\ell$	$m_{\mathrm{T}} > m_W$
$t\bar{t} \to 2\ell$	$am_{\mathrm{T2}} > m_t$
$t\bar{t} \to \ell\tau^{\mathrm{had}}$	$m_{\mathrm{T2}}^{\tau} > m_W$
W+jets	$N_{b\text{-jets}} \geq 1$

- 3 SRs with exactly one lepton

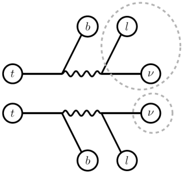
SR1 $E_{\mathrm{T}}^{\mathrm{miss}} > 260\ \mathrm{GeV}$

SR2 $E_{\mathrm{T}}^{\mathrm{miss}} > 350\ \mathrm{GeV}$, large-$R$ jet (boosted t)

SR3 $E_{\mathrm{T}}^{\mathrm{miss}} > 480\ \mathrm{GeV}$, large-$R$ jet (boosted t)

Major backgrounds

- $t\bar{t}$, W+jets, single top Wt and $t\bar{t}$+W/Z
- estimated using CRs defined with reverted values of m_{T} and am_{T2} and different $N_{b\text{-jets}}$



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

1L stop + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ ATLAS-CONF-2016-007

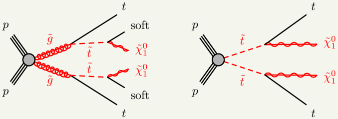
Main target

- gluino-mediated stop pair production with one-step decay

a) $\tilde{g} \to t\,\tilde{t}$ with $\tilde{t} \to \tilde{\chi}_1^0 + \mathrm{soft}$ where $\Delta m(\tilde{t}, \tilde{\chi}_1^0) = 5$ GeV

- stop pair production with direct decay

b) $\tilde{t} \to t\,\tilde{\chi}_1^0$



Signal regions

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  difficult to separate from $t\bar{t}$

- discriminant variables against bkg

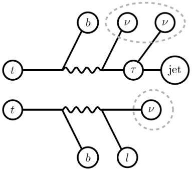
$t\bar{t} \to 1\ell$	$m_{\mathrm{T}} > m_W$
$t\bar{t} \to 2\ell$	$am_{\mathrm{T2}} > m_t$
$t\bar{t} \to \ell\tau^{\mathrm{had}}$	$m_{\mathrm{T2}}^{\tau} > m_W$
W+jets	$N_{b\text{-jets}} \geq 1$

- 3 SRs with exactly one lepton

SR1 $E_{\mathrm{T}}^{\mathrm{miss}} > 260$ GeV
SR2 $E_{\mathrm{T}}^{\mathrm{miss}} > 350$ GeV, large-R jet (boosted t)
SR3 $E_{\mathrm{T}}^{\mathrm{miss}} > 480$ GeV, large-R jet (boosted t)

Major backgrounds

- $t\bar{t}$, W+jets, single top Wt and $t\bar{t}$+W/Z
- estimated using CRs defined with reverted values of m_{T} and am_{T2} and different $N_{b\text{-jets}}$



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

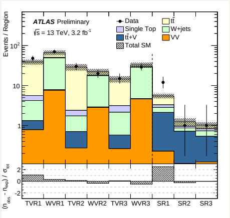
1L stop + jets + E_T^{miss} ATLAS-CONF-2016-007

Results

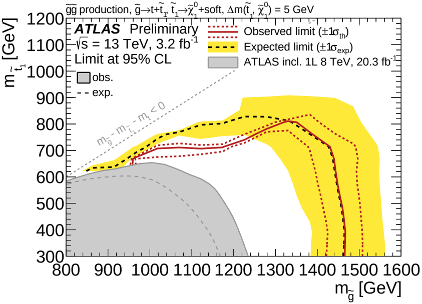
- very good data/MC agreement in all VRs
- modest 2.3σ deviation in SR1
- 5.5 expected and 12 observed events

a) $m_{\tilde{g}}$ excluded up to 1.5 TeV

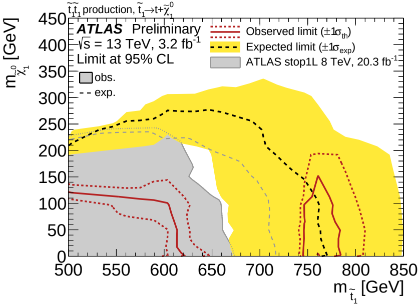
b) $m_{\tilde{t}_1}$ excluded only from 745 GeV to 780 GeV



Scenario a)



Scenario b)



1L stop + jets + E_T^{miss} ATLAS−CONF−2016−007

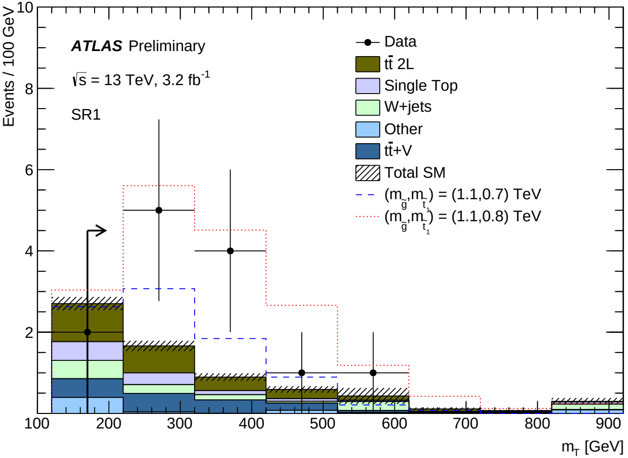
Common event selection	
Trigger	E_T^{miss} trigger
Lepton	exactly one signal lepton (e, μ), no additional baseline leptons.
Jets	at least four signal jets, and $\lvert\Delta\phi(\text{jet}_i, \vec{p}_T^{miss})\rvert > 0.4$ for $i \in \{1, 2\}$.
hadronic τ	veto events with a hadronic τ and $m_{T2}^{\tau} < 80$ GeV.

Variable	SR1	TCR1 / WCR1	STCR1
≥4 jets with $p_T >$ [GeV]	(80 50 40 40)	(80 50 40 40)	(80 50 40 40)
E_T^{miss} [GeV]	> 260	> 200	> 200
$H_{T,sig}^{miss}$	> 14	> 5	> 5
m_T [GeV]	> 170	[30,90]	[30,120]
am_{T2} [GeV]	> 175	$[100, 200]$ / > 100	> 200
topness	> 6.5	> 6.5	> 6.5
m_{top}^{χ} [GeV]	< 270	< 270	< 270
$\Delta R(b, \ell)$	< 3.0	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
number of b-tags	≥ 1	≥ 1 / $= 0$	≥ 2

	SR2	TCR2 / WCR2	STCR2
≥4 jets with $p_T >$ [GeV]	(120 80 50 25)	(120 80 50 25)	(120 80 50 25)
E_T^{miss} [GeV]	> 350	> 250	> 200
$H_{T,sig}^{miss}$	> 20	> 15	> 5
m_T [GeV]	> 200	[30,90]	[30,120]
am_{T2} [GeV]	> 175	$[100, 200]$ / > 100	> 200
$\Delta R(b, \ell)$	< 2.5	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
number of b-tags	≥ 1	≥ 1 / $= 0$	≥ 2
leading large-R jet p_T [GeV]	> 200	> 200	> 200
leading large-R jet mass [GeV]	> 140	> 140	> 0
$\Delta\phi(\vec{p}_T^{miss}, 2^{nd}\text{large-R jet})$	> 1.0	> 1.0	> 1.0

	SR3	TCR3 / WCR3	STCR3
≥4 jets with $p_T >$ [GeV]	(120 80 50 25)	(120 80 50 25)	(120 80 50 25)
E_T^{miss} [GeV]	> 480	> 280	> 200
$H_{T,sig}^{miss}$	> 14	> 8	> 5
m_T [GeV]	> 190	[30,90]	[30,120]
am_{T2} [GeV]	> 175	$[100, 200]$ / > 100	> 200
topness [GeV]	> 9.5	> 0	> 9.5
$\Delta R(b, \ell)$	< 2.8	–	–
$\Delta R(b_1, b_2)$	–	–	> 1.2
number of b-tags	≥ 1	≥ 1 / $= 0$	≥ 2
leading large-R jet p_T [GeV]	> 280	> 200	> 200
leading large-R jet mass [GeV]	> 70	> 70	> 70

1L stop + jets + E_T^{miss} ATLAS−CONF−2016−007



1L stop + jets + E_T^{miss} ATLAS-CONF-2016-007

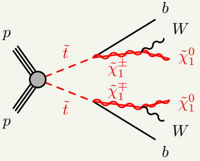
Signal region	SR1	SR2	SR3
Observed	12	1	1
Total bkg	5.50 ± 0.72	1.25 ± 0.26	1.03 ± 0.18
$t\bar{t}$	2.21 ± 0.60	0.29 ± 0.10	0.20 ± 0.07
Single top	0.46 ± 0.39	0.09 ± 0.08	0.10 ± 0.09
W+jets	0.71 ± 0.43	$0.15^{+0.19}_{-0.15}$	0.20 ± 0.09
$t\bar{t} + W/Z$	1.90 ± 0.42	0.61 ± 0.14	0.41 ± 0.10
Diboson	0.23 ± 0.15	0.11 ± 0.07	0.12 ± 0.07
$t\bar{t}$ NF	1.10 ± 0.14	1.06 ± 0.14	0.80 ± 0.13
Single top NF	0.62 ± 0.46	0.65 ± 0.49	0.71 ± 0.42
W+jets NF	0.75 ± 0.12	0.78 ± 0.15	0.93 ± 0.12
$t\bar{t} + W/Z$ NF	1.42 ± 0.24	1.45 ± 0.24	1.46 ± 0.24
p_0	$0.01 (2.3\,\sigma)$	$0.50\ (0.0\,\sigma)$	$0.50\ (0.0\,\sigma)$
N^{limit}_{non-SM} exp. (95% CL)	$6.4^{+3.2}_{-2.0}$	$3.6^{+2.3}_{-1.3}$	$3.5^{+2.2}_{-1.2}$
N^{limit}_{non-SM} obs. (95% CL)	13.3	3.4	3.4

2L stop + jets + E_T^{miss} ATLAS-CONF-2016-009

Main target

- gluino pair production with one-step decay
  $\tilde{t} \to b\,\tilde{\chi}_1^{\pm}$ with $\tilde{\chi}_1^{\pm} \to W^{\pm}\,\tilde{\chi}_1^0$
- two scenarios

a) $\Delta m(\tilde{t}, \tilde{\chi}_1^{\pm}) = 10$ GeV
b) $m_{\tilde{\chi}_1^{\pm}} = 2 \cdot m_{\tilde{\chi}_1^0}$



→ leptonic decay
→ leptonic decay

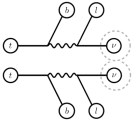
Signal regions

- 2 SRs defined for different-flavour and same-flavour opposite-sign lepton pairs
- soft b-jets: no requirement on $N_{b\text{-jets}}$
- discriminant variables against bkg

$t\bar{t}$, WW	$m_{T2} > 245$ GeV
Z/γ^*+jets	$R1 = \frac{E_T^{miss}}{m_{eff}} > 0.3$
Z contribution	Z-mass veto in SF

Major backgrounds

- $VV \to \ell\ell\nu\nu$
  normalized in SF CR defined within Z-mass window
- $t\bar{t}$
  normalized in DF CR defined at lower m_{T2} and $R1$
- fake and non-prompt lepton
  estimated using data-driven matrix method



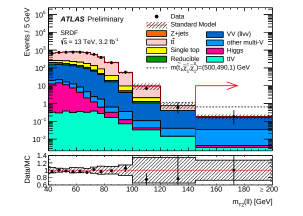
2L stop + jets + E_T^{miss} ATLAS-CONF-2016-009

Results

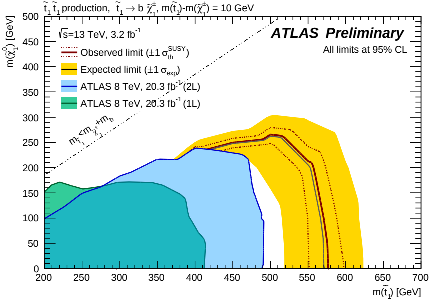
- good data/MC agreement in SRs

a) $m_{\tilde{t}}$ excluded up to 577 GeV

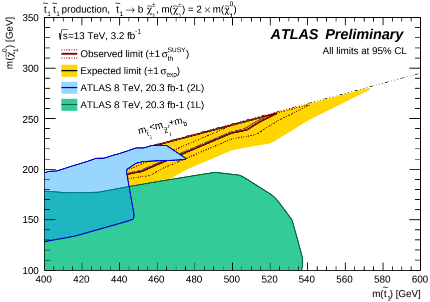
b) $m_{\tilde{t}}$ excluded up to 520 GeV for $m_{\tilde{\chi}_1^0} \sim 200$ GeV



Scenario a)



Scenario b)



2L stop + jets + E_T^{miss} ATLAS-CONF-2016-009

Signal Region	DF	SF
leading lepton p_T [GeV]	> 25	
sub-leading lepton p_T [GeV]	> 15	
additional lepton (veto) p_T [GeV]	> 10	
$m_{\ell\ell}$ [GeV]	>20	(>20 and < 71) or > 111
m_{T2} [GeV]	> 145	
R1	> 0.3	

2L stop + jets + E_T^{miss} ATLAS-CONF-2016-009

Signal Region	DF	SF
Total background expectation	2.01	6.5
Total background systematic	31%	27%
Jet energy scale	3%	4%
Jet energy resolution	15%	2%
E_T^{miss} modelling	1%	1%
Pile up reweighting	2%	6%
MC statistical uncertainties	12%	13%
Diboson theoretical uncertainites	22%	9%
$t\bar{t}$ theoretical uncertainites	1%	1%
Z/γ^*+jets theoretical uncertainites	–	5%
Fake and non-prompt lepton composition	2%	–
Luminosity	5%	2%

2L stop + jets + E_T^{miss} ATLAS-CONF-2016-009

Signal Region	DF	SF
Observed events	2	6
Total (constrained) SM events	2.01 ± 0.62	6.5 ± 1.7
Fit output, $t\bar{t}$ events	0.04 ± 0.04	0.06 ± 0.06
Fit output, $\ell\ell\nu\nu$ events	1.52 ± 0.54	3.82 ± 1.5
Total expected SM events	2.01 ± 0.62	6.3 ± 1.2
Fit input, expected $t\bar{t}$ events	0.04 ± 0.04	0.06 ± 0.06
Fit input, expected $\ell\ell\nu\nu$ events	1.52 ± 0.54	3.59 ± 0.69
Expected other multi-V events	0.34 ± 0.12	1.31 ± 0.47
Expected Higgs events	$0.01^{+0.19}_{-0.01}$	0.26 ± 0.21
Expected Z/γ^*+jets events	–	0.91 ± 0.73
Expected $t\bar{t}$ + V events	0.04 ± 0.03	0.12 ± 0.07
Expected events with fake and non-prompt leptons	0.06 ± 0.03	–