Run-2 Supersymmetry searches in ATLAS

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On behalf of the ATLAS Collaboration

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Outline

- Overview of Run-1 and Run-2 SUSY searches
- Common analysis procedures
  - Selection of physics objects (jets, b-jets, leptons)
  - Event-selection variables
  - Background estimation & validation methods
- Results and interpretations for 7 analyses:

1.	2-6 jets	ATLAS-CONF-2015-062
2.	7-10 jets	ATLAS-CONF-2015-077
3.	1 lepton	ATLAS-CONF-2015-076
4.	2 same-sign or 3 leptons	ATLAS-CONF-2015-078
5.	3 or more b-jets	ATLAS-CONF-2015-067
6.	Sbottom pair	ATLAS-CONF-2015-066
7.	$Z \rightarrow \ell\ell$	ATLAS-CONF-2015-082

Run-1 (7-8 TeV) SUSY results

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

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

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[fb^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.8 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	20.3	$\tilde{q}$ 850 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	20.3	$\tilde{q}$ 100-440 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0)<10$ GeV	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$ 780 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	20.3	$\tilde{g}$ 1.33 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1405.7875
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^{\pm}\to qqW^{\pm}\tilde{\chi}_1^0$	0-1 e,μ	2-6 jets	Yes	20	$\tilde{g}$ 1.26 TeV	$m(\tilde{\chi}_1^0)<300$ GeV, $m(\tilde{\chi}^{\pm})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	1507.05525
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20	$\tilde{g}$ 1.32 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1501.03555
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$ 1.6 TeV	$\tan\beta>20$	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$ 1.29 TeV	$c\tau$(NLSP)<0.1 mm	1507.05493
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)<900$ GeV, $c\tau$(NLSP)<0.1 mm, $\mu<0$	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$ 1.25 TeV	$m(\tilde{\chi}_1^0)<850$ GeV, $c\tau$(NLSP)<0.1 mm, $\mu>0$	1507.05493
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde{g}$ 850 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	20.1	$\tilde{g}$ 1.25 TeV	$m(\tilde{\chi}_1^0)<400$ GeV	1407.0600
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)<400$ GeV	1407.0600
	$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 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	20.1	$\tilde{b}_1$ 100-620 GeV	$m(\tilde{\chi}_1^0)<90$ GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^{\pm}$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$ 275-440 GeV	$m(\tilde{\chi}_1^{\pm})=2\,m(\tilde{\chi}_1^0)$	1404.2500
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	1-2 e,μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$ 110-167 GeV, 230-460 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	$\tilde{t}_1$ 90-191 GeV, 210-700 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1506.08616
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-240 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	$\tilde{t}_1$ 150-580 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	$\tilde{t}_2$ 290-600 GeV	$m(\tilde{\chi}_1^0)<200$ GeV	1403.5222
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	$\tilde{\ell}$ 90-325 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	$\tilde{\chi}_1^{\pm}$ 140-465 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	$\tilde{\chi}_1^{\pm}$ 100-350 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	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 700 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	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 420 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	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 250 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	$\tilde{\chi}_{2,3}^0$ 620 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	$\tilde{W}$ 124-361 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	$m(\tilde{\chi}_1^{\pm})-m(\tilde{\chi}_1^0)\sim160$ 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	$\tilde{\chi}_1^{\pm}$ 482 GeV	$m(\tilde{\chi}_1^{\pm})-m(\tilde{\chi}_1^0)\sim160$ MeV, $\tau(\tilde{\chi}_1^{\pm})<15$ ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$ 832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 $\mu s<\tau(\tilde{g})<1000$ s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	19.1	$\tilde{g}$ 1.27 TeV		1411.6795
	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	$\tilde{\chi}_1^0$ 435 GeV	$2<\tau(\tilde{\chi}_1^0)<3$ 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	$\tilde{q}, \tilde{g}$ 1.35 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	$\tilde{\chi}_1^{\pm}$ 750 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
	$\tilde{g}\tilde{g}, \tilde{g}\to q\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 870 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	$\tilde{g}$ 850 GeV		1404.250
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	$\tilde{t}_1$ 100-308 GeV		ATLAS-CONF-2015-026
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$	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	$\tilde{c}$ 490 GeV	$m(\tilde{\chi}_1^0)<200$ GeV	1501.01325

10^{-1} — 1 — Mass scale [TeV]

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

Run 2 (13 TeV) SUSY analyses…

- ATLAS collected 3.87 fb^{-1}, after quality cuts: 3.2 ± 0.2 fb^{-1}
- Much smaller than our 8 TeV Run-1 sample: ~20 fb^{-1}
- But cross sections for strongly produced heavy particles increase significantly in going from 8 TeV to 13 TeV:

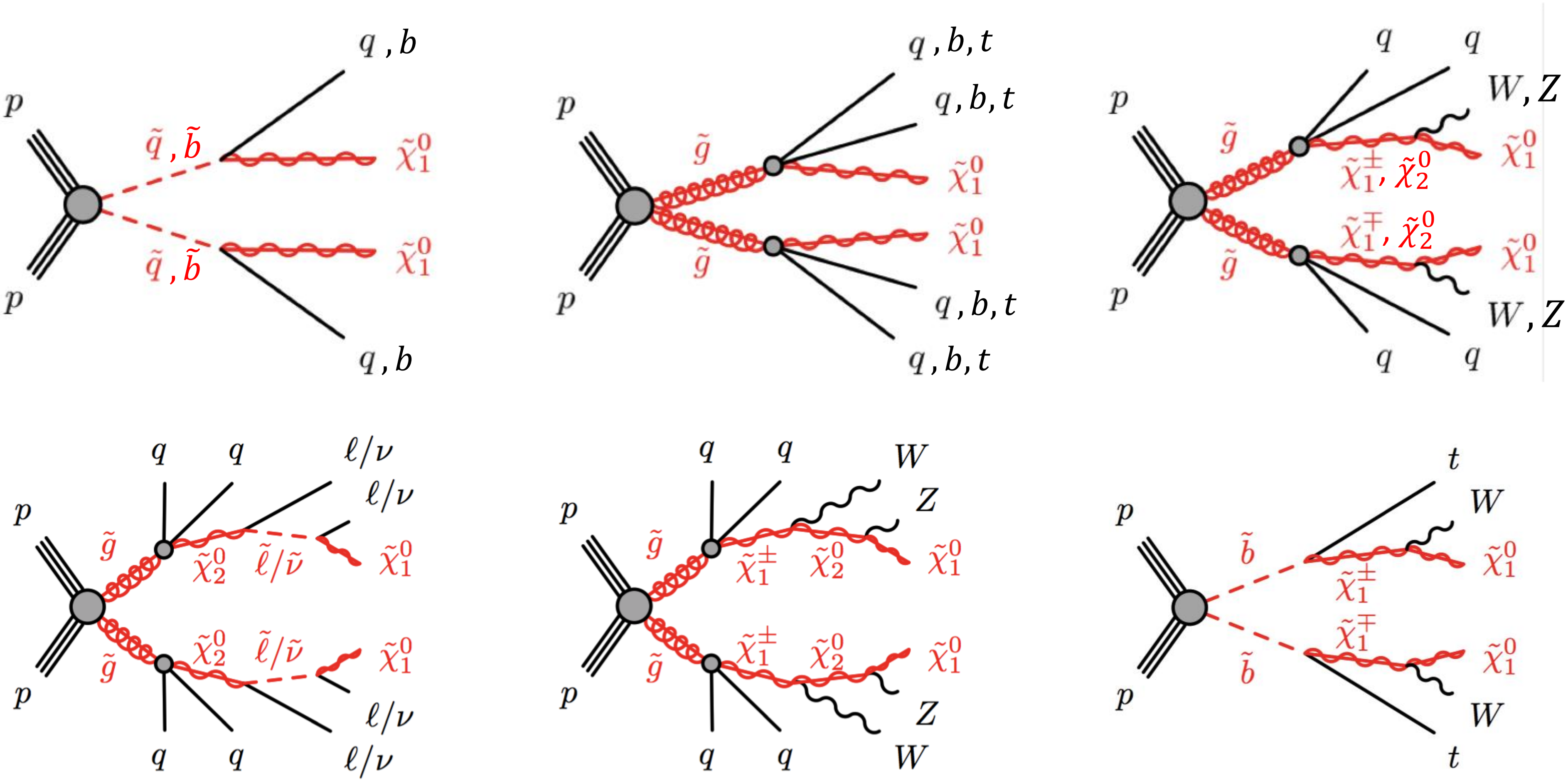
  $\sim\times\, 15$ for $\sigma(\tilde{q}\bar{\tilde{q}})$ with $m_{\tilde{q}} = 1$ TeV

  $\sim\times\, 35$ for $\sigma(\tilde{g}\tilde{g})$ with $m_{\tilde{g}} = 1.5$ TeV

→ Run-2 SUSY searches focus on gluino and squark production

- 7 analyses using a variety of signatures with 44 signal regions:
  - Missing transverse energy (MET, E_T^{miss})
  - Jets
  - Leptons: 0, 1, 2 (Z), 2 same sign or 3
  - b-jets: 0, 1, 2, or 3+

… cover a range of SUSY scenarios



Physics object selection

- Jets:
  - Reconstructed from calorimeter energy clusters using the anti-k_T algorithm with radius parameter $R = 0.4$
  - Jets are reclustered with $R = 1$ to search for boosted top quarks
  - Corrected for avg. energy deposition from pile-up (= multiple *pp* collisions, averaging 14 in 2015)
  - Jet energy scale calibrated with detector response from MC and 8 TeV data
  - Event rejected if contains jet identified as due to noise or non-collision
- b-jets:
  - Tagged by multivariate algorithm using the impact parameters of tracks in the jet, and the presence and flight paths of displaced vertices from b/c hadrons
- Electrons:
  - Matching EM calorimeter clusters to inner-detector tracks & TRT threshold
- Muons:
  - Matching tracks in the muon spectrometer and inner detector

Event selection inputs

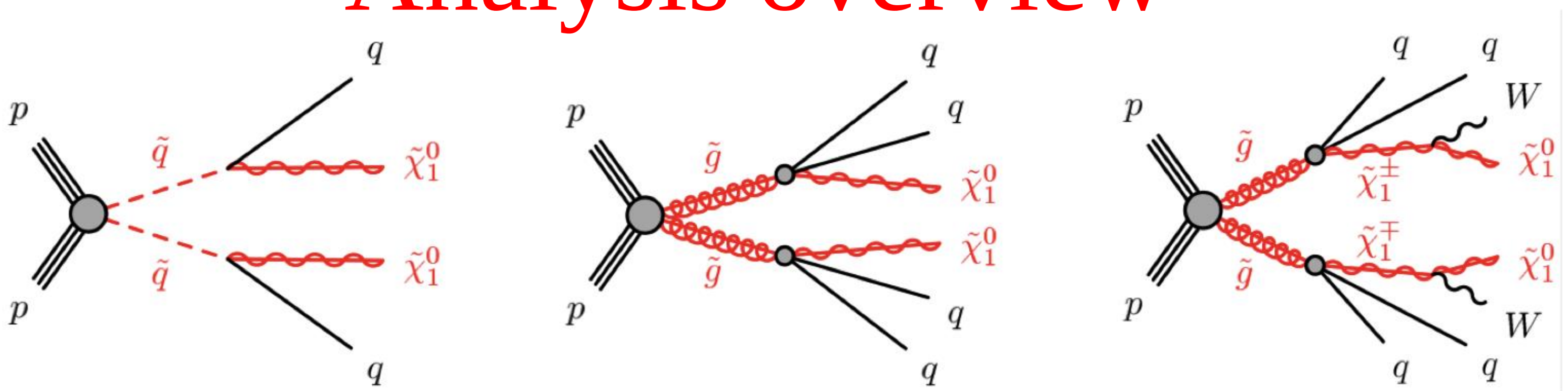
- Physics-object overlap removal:
  - If 2 objects (e, μ, jet, or b-jet) are nearby, indicating mis-identification, one of them is discarded according to an optimized algorithm
- Missing transverse energy:
  - $$\vec{p}_T^{\,miss} = -\left[\sum_{\substack{\text{physics}\\ \text{objects}}} \vec{p}_T + \sum_{\substack{\text{other}\\ \text{PV tracks}}} \vec{p}_T\right]$$
  - $$\text{MET} \equiv E_T^{miss} = \left|\vec{p}_T^{\,miss}\right|$$
- Scalar p_T sum
  - $$H_T = \sum_{\substack{\text{physics}\\ \text{objects}}} p_T$$
- Effective mass:
  - $$m_{\text{eff}} = \sum_{\substack{\text{physics}\\ \text{objects}}} p_T + E_T^{miss}$$

Common analysis procedures

- Define signal regions (SRs)
  - Based on N_{leptons}, N_{jets}, $N_{b-\text{jets}}$ with p_T cuts, H_T, MET, m_{eff}, etc.
  - Targeting different regions in SUSY parameter space
- Estimate background for each SR in control regions (CRs)
  - Usually using Monte Carlo distributions to relate CR yields to SR yields
  - Background estimate from CRs validated using validation regions (VRs)
  - Smaller backgrounds often obtained from MC
- If no excess, set limits using the CLs prescription, accounting for systematic uncertainties:
  - Finite MC statistics
  - Theory, e.g., models used for background shapes
  - Jet energy scale and resolution
  - Lepton / b-jet ID efficiencies and purities

1/7. Search using 2-6 jets no leptons

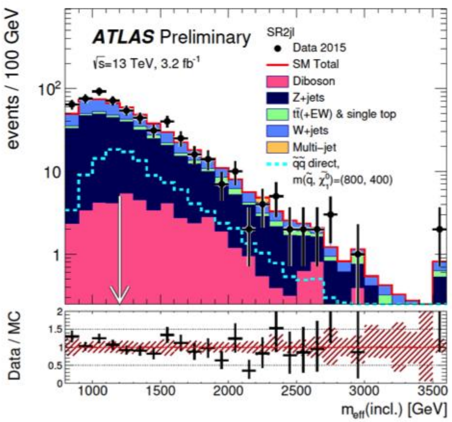
Analysis overview



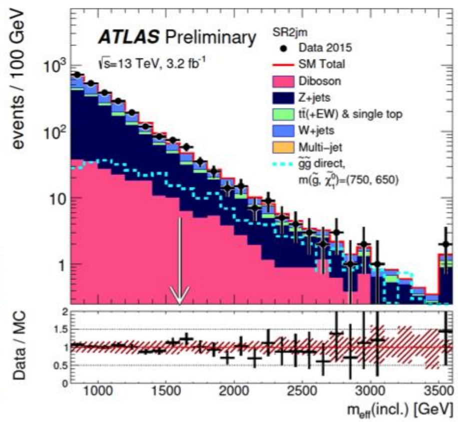
- 7 SRs with 2-6 jets & different cuts
  - Targeting different models
- Veto leptons with $p_T > 10$ GeV
- 4 CRs for each SR, to obtain background from
  - Multi-jet
  - $Z(\rightarrow \nu\bar{\nu})$ + jets
  - $W(\rightarrow \ell\bar{\nu})$ + jets
  - $t\bar{t}$, single-t
- Background from MC
  - Di-boson

Requirement	Signal Region						
	2jl	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
E_T^{miss} [GeV] >	200						
$p_T(j_1)$ [GeV] >	200	300	200				
$p_T(j_2)$ [GeV] >	200	50	200	100			
$p_T(j_3)$ [GeV] >	–			100			
$p_T(j_4)$ [GeV] >	–			100			
$p_T(j_5)$ [GeV] >	–				100		
$p_T(j_6)$ [GeV] >	–					100	
$\Delta\phi(\text{jet}_{1,2,(3)}, \boldsymbol{E}_T^{miss})_{min}$ >	0.8	0.4	0.8	0.4			
$\Delta\phi(\text{jet}_{i>3}, \boldsymbol{E}_T^{miss})_{min}$ >	–			0.2			
$E_T^{miss} / \sqrt{H_T}$ [GeV$^{1/2}$] >	15		20	–			
Aplanarity >	–			0.04			
$E_T^{miss} / m_{eff}(N_j)$ >	–			0.2	0.25		0.2
m_{eff}(incl.) [GeV] >	1200	1600	2200	2200	1600	1600	2000
Leptons:	none with $p_T > 10$ GeV						

m_{eff} in signal regions



(a)



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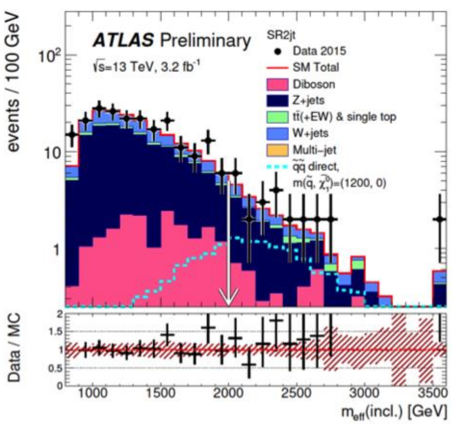

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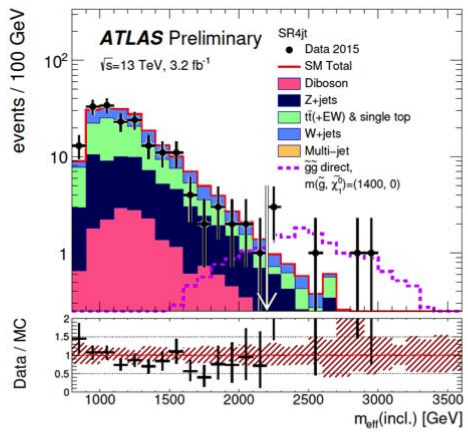

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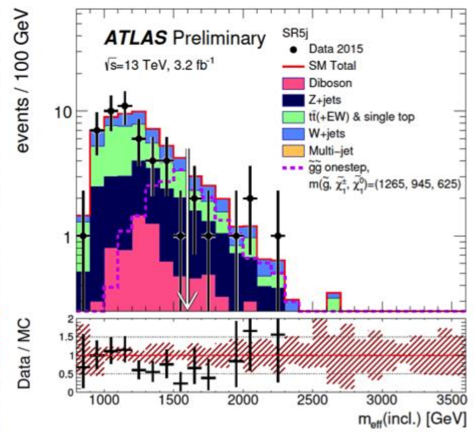

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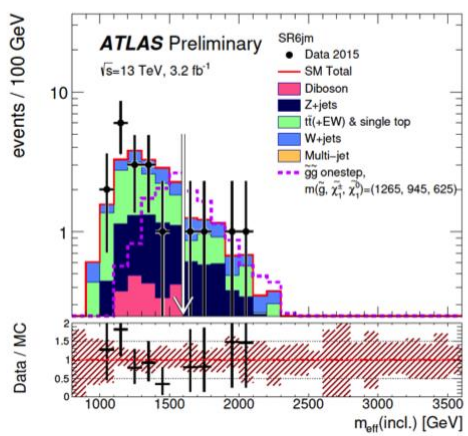

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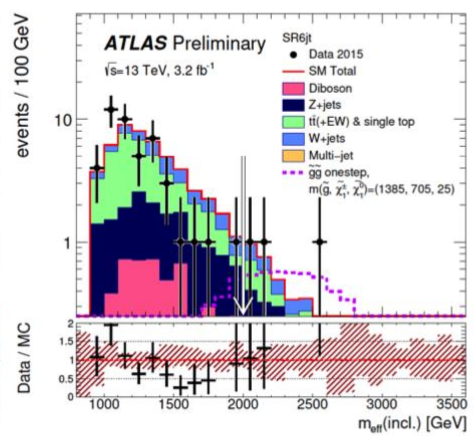
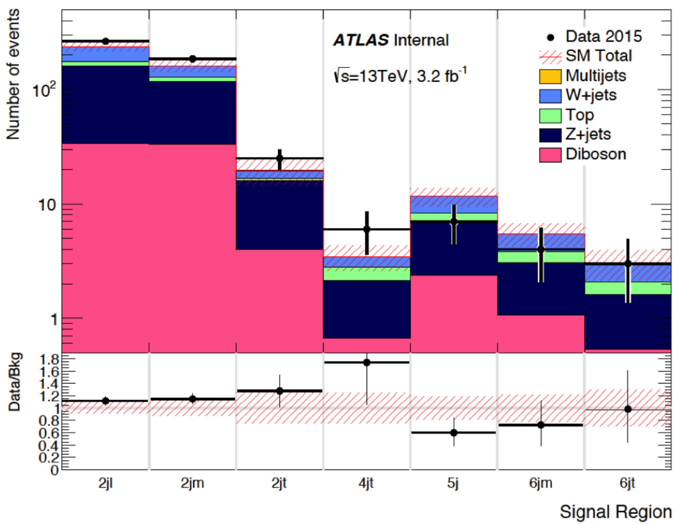
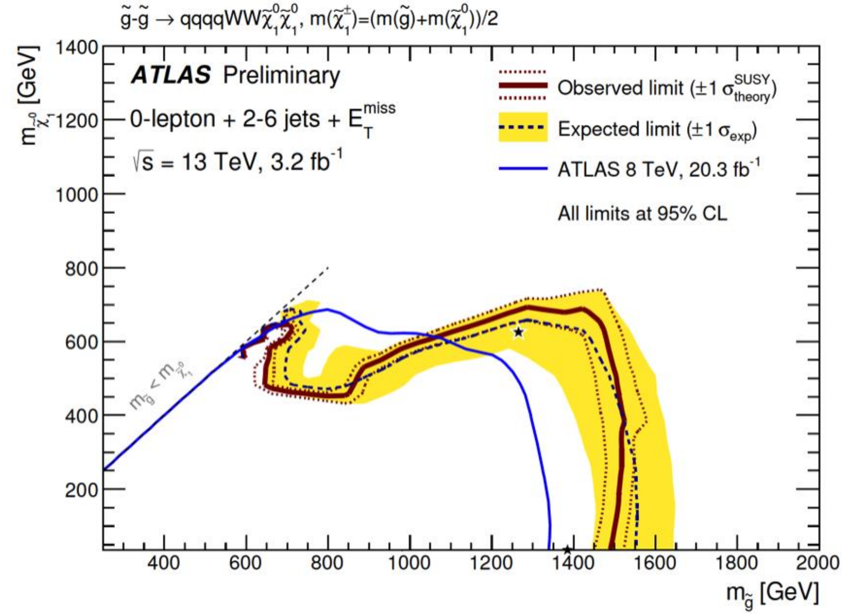


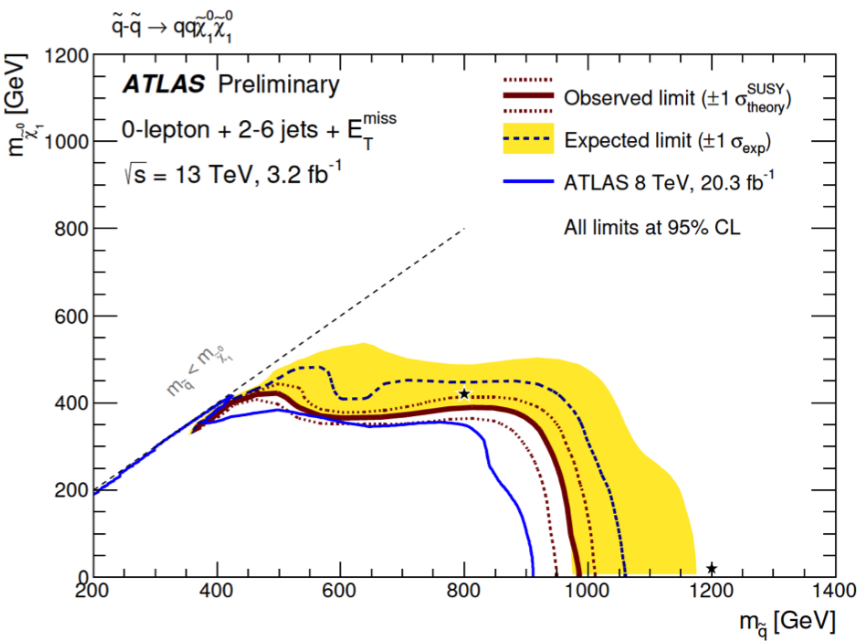
(d)

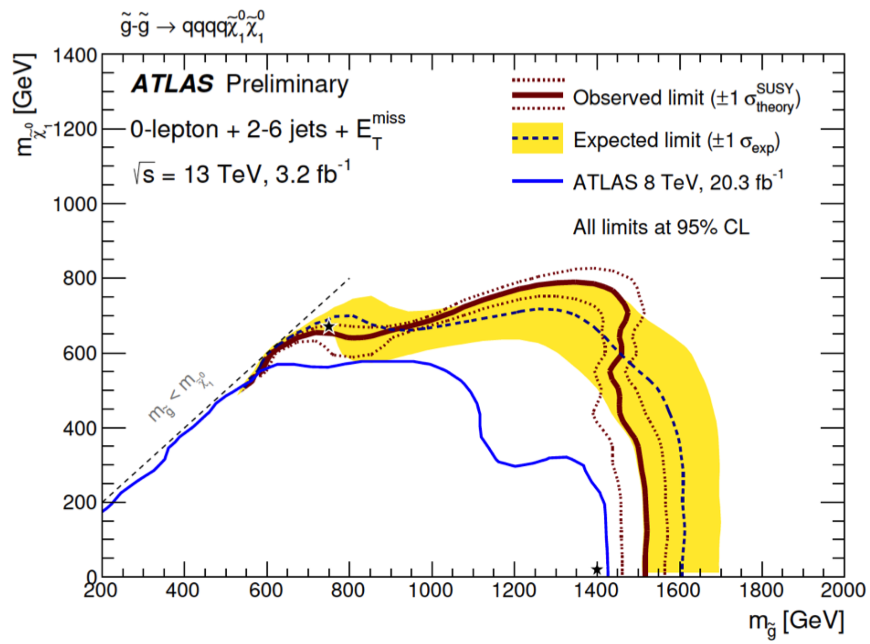
Results

Expected and observed event count in each SR:





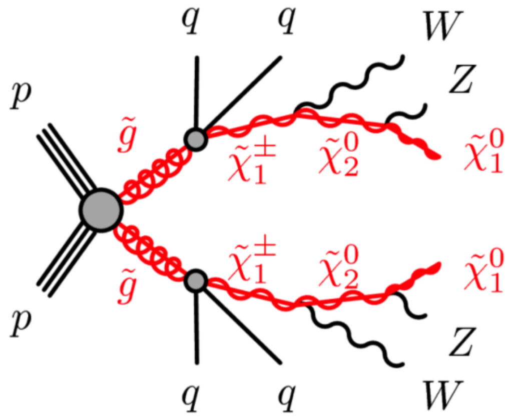




2/7. Search using 7-10 jets no leptons

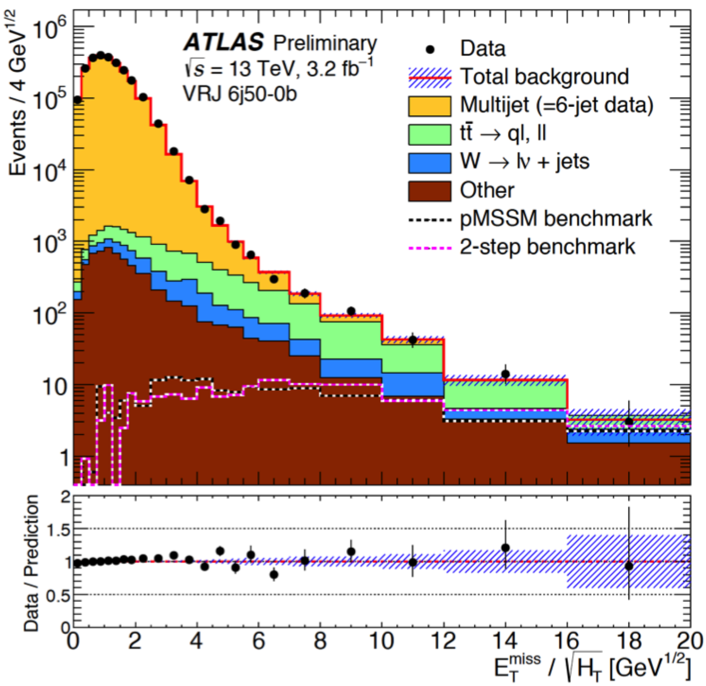
Analysis overview

- 6 SRs with 7-8 $p_T > 80$ GeV jets, incl. 0-2 b-jets
- 9 SRs with 8-10 $p_T > 50$ GeV jets , incl. 0-2 b-jets
- No leptons with $pT > 10$ GeV



- $t\bar{t}$, V+jets background obtained from CRs containing a lepton with $p_T > 20$ GeV

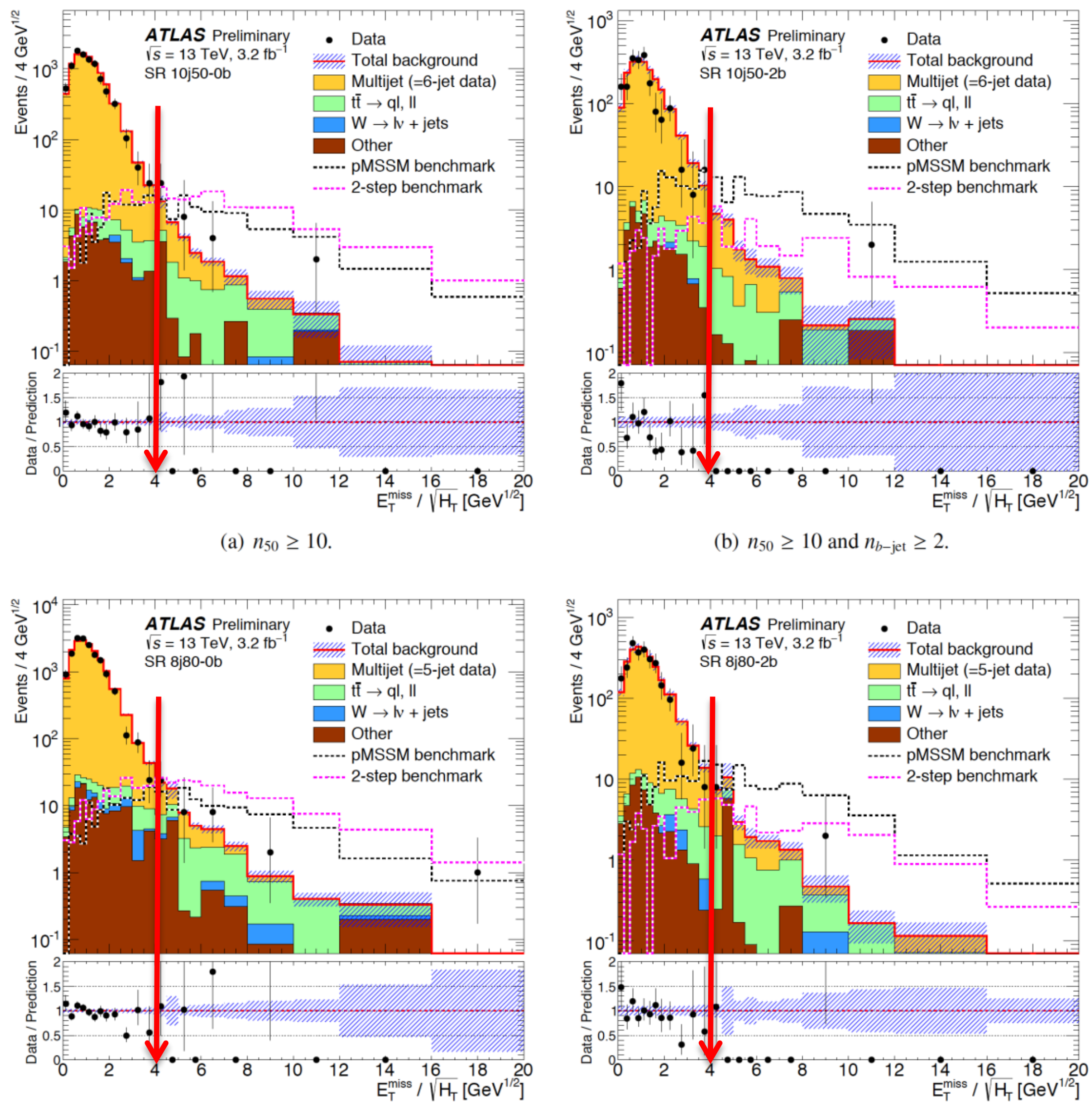
- Multijet background from CRs with 1 jet less.
- Utilize near invariance of $E_T^{miss}/\sqrt{H_T}$ wrt. N_{jets} when MET originates from calorimeter mismeasurement
  - Checked in VRs



(a) $n_{50} = 7$, using a template with $n_{50} = 6$.

$E_T^{miss}/\sqrt{H_T}$ in some SRs

- SR: $\frac{E_T^{miss}}{\sqrt{H_T}} > 4\,\sqrt{\text{GeV}}$
- Distribution normalization: $\frac{E_T^{miss}}{\sqrt{H_T}} < 1.5\,\sqrt{\text{GeV}}$



(a) $n_{50} \geq 10$.

(b) $n_{50} \geq 10$ and $n_{b\text{-jet}} \geq 2$.

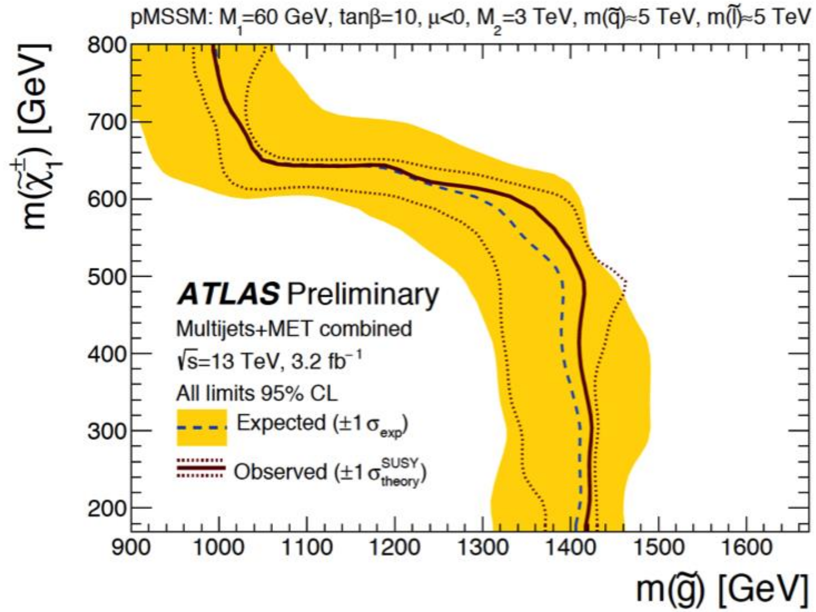
(c) $n_{80} \geq 8$.

(d) $n_{50} \geq 8$ and $n_{b\text{-jet}} \geq 2$.

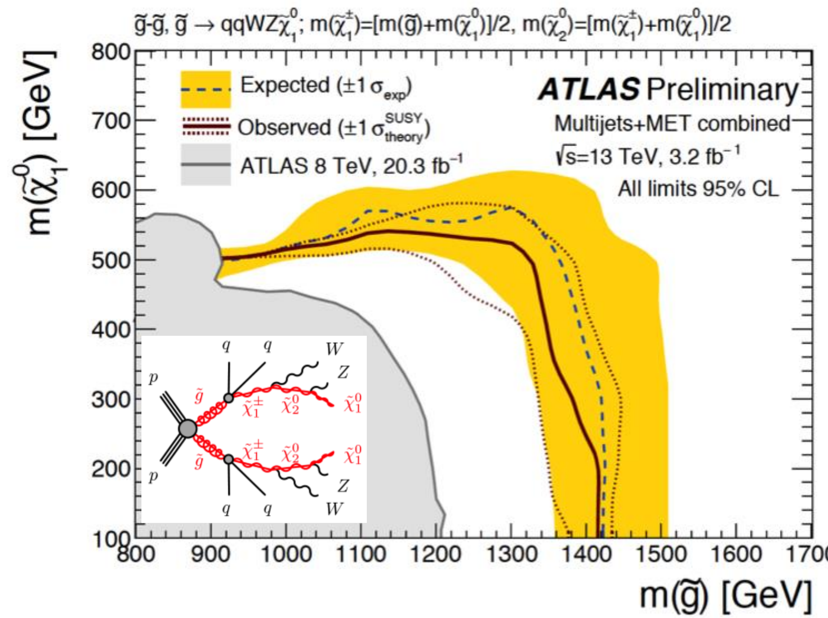
Results

Expected and observed event count in each SR:

Signal region	Fitted background			Obs events
	Multijet	Leptonic	Total	
8j50	109.3 ± 6.8	79 ± 25	189 ± 26	157
8j50-1b	76.7 ± 2.6	61 ± 21	138 ± 21	97
8j50-2b	33.8 ± 2.1	33 ± 13	67 ± 13	39
9j50	16.8 ± 1.2	12.8 ± 5.4	29.6 ± 5.6	29
9j50-1b	13.5 ± 1.9	10.2 ± 4.9	23.8 ± 5.3	21
9j50-2b	6.4 ± 1.6	5.8 ± 3.3	12.1 ± 3.6	9
10j50	2.61 ± 0.60	1.99 ± 0.62	4.60 ± 0.86	6
10j50-1b	2.42 ± 0.62	1.44 ± 0.49	3.86 ± 0.79	3
10j50-2b	1.40 ± 0.87	0.83 ± 0.37	2.23 ± 0.94	1
7j80	40.0 ± 5.1	30 ± 12	70 ± 13	70
7j80-1b	29.1 ± 3.2	20.8 ± 10	50 ± 10	42
7j80-2b	11.5 ± 1.6	11.0 ± 4.9	22.5 ± 5.2	19
8j80	4.5 ± 1.9	4.9 ± 2.1	9.3 ± 2.8	8
8j80-1b	3.9 ± 1.5	3.8 ± 2.1	7.6 ± 2.6	4
8j80-2b	1.72 ± 0.92	2.3 ± 1.1	4.1 ± 1.4	2



(a) pMSSM slice



(b) Simplified cascade decay model

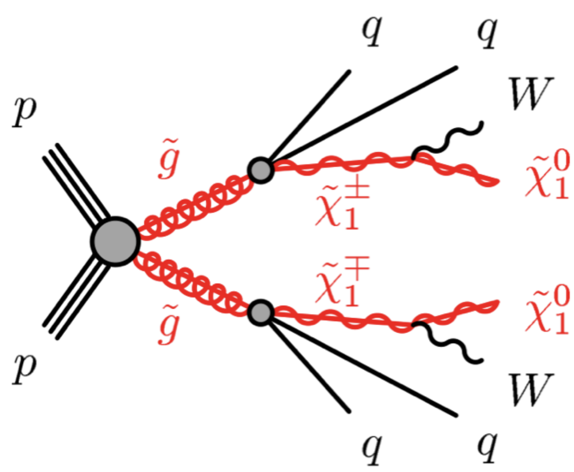
3/7. Search using 1-lepton

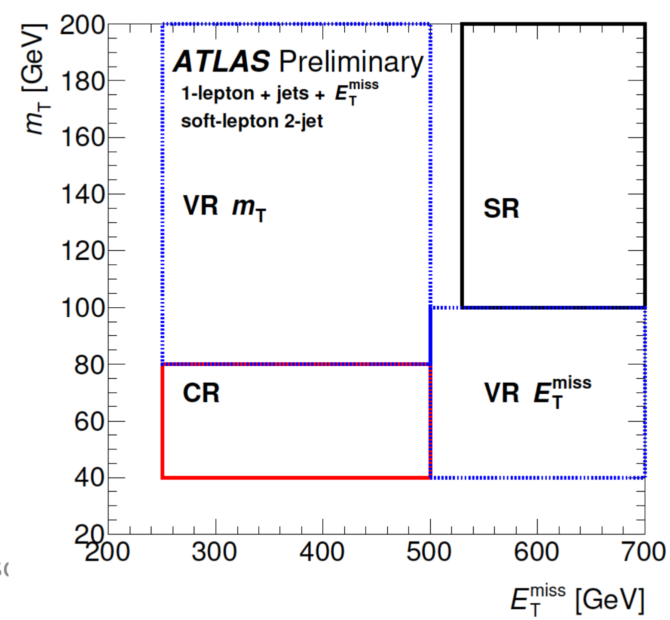
Analysis overview

- 4 hard-ℓ SRs:
  - $p_T > 35$ GeV lepton
  - No additional leptons with $p_T > 10$ GeV
  - 4-6 jets
- 2 soft-ℓ SRs:
  - $p_T > 7(6)$ GeV for $e(\mu)$ and $p_T < 35$ GeV
  - No additional $e(\mu)$ with $p_T > 7(6)$ GeV
  - 2 or 5 jets
- Dominant background: W + jets and $t\bar{t}$.
  - Suppressed with cuts on transverse mass

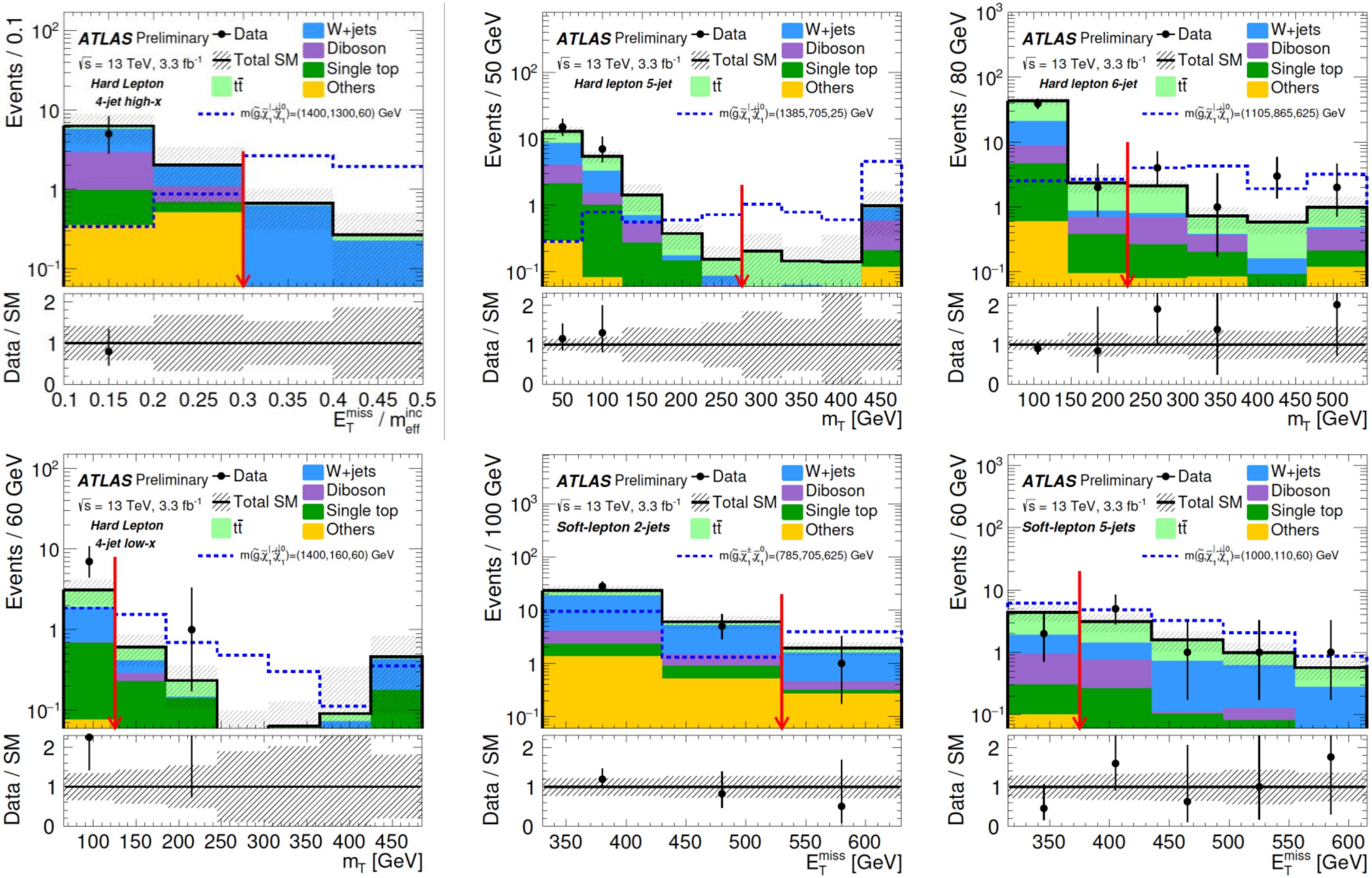
$$m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos[\Delta\phi(\vec{\ell}, \boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}})])}$$

  - Estimated from CRs, e.g., for soft-ℓ 2-jets:



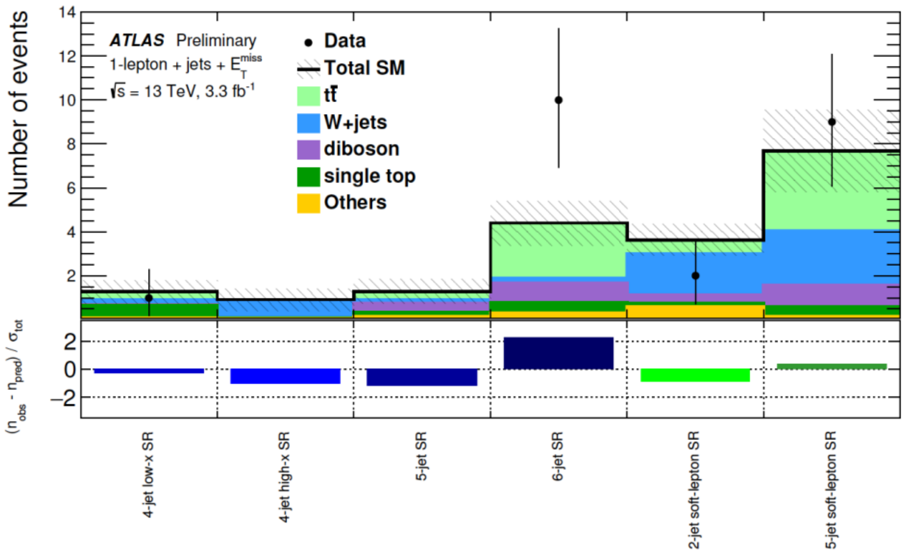


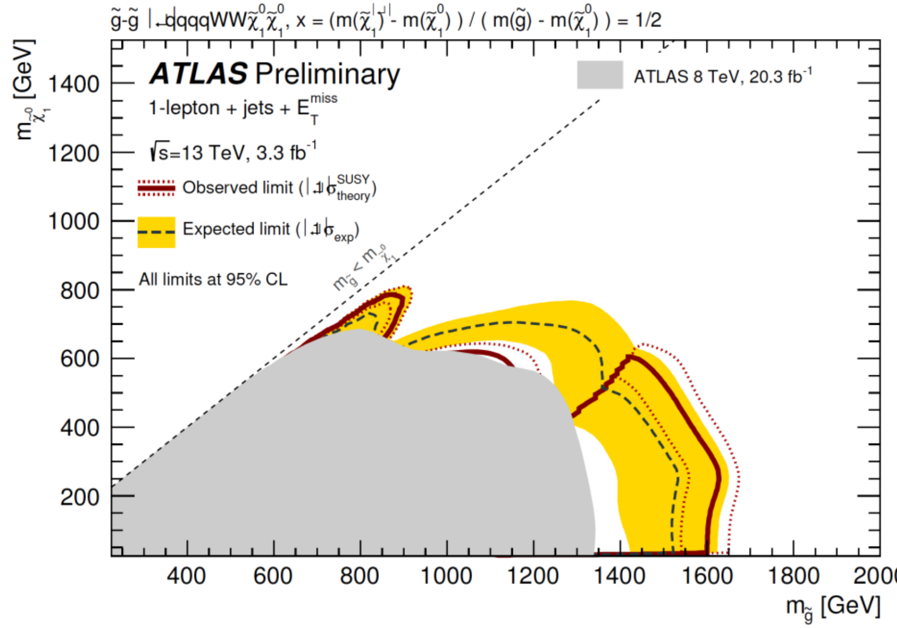
Some SR distributions

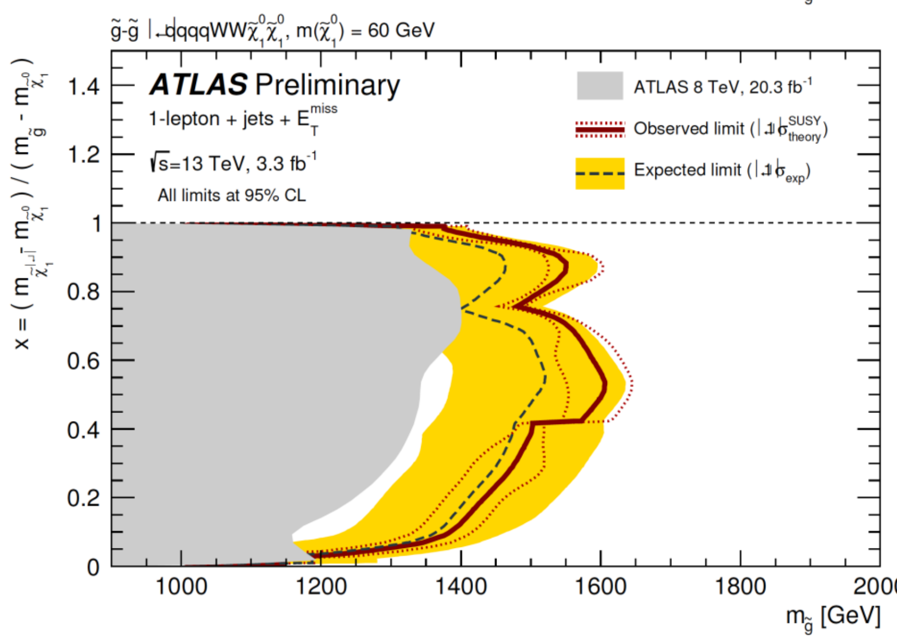


Results

Expected and observed event count in each SR:

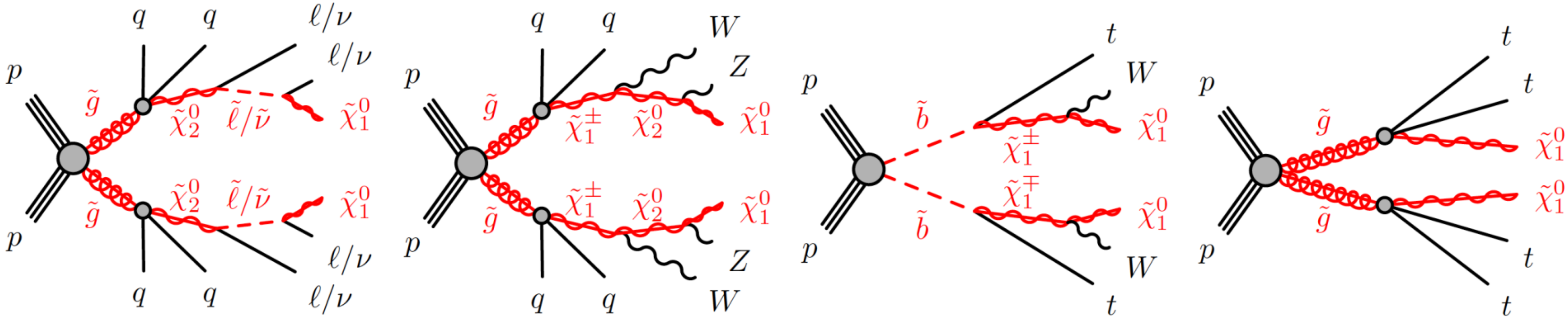






4/7. Search with same-sign dileptons or 3 leptons

Analysis overview

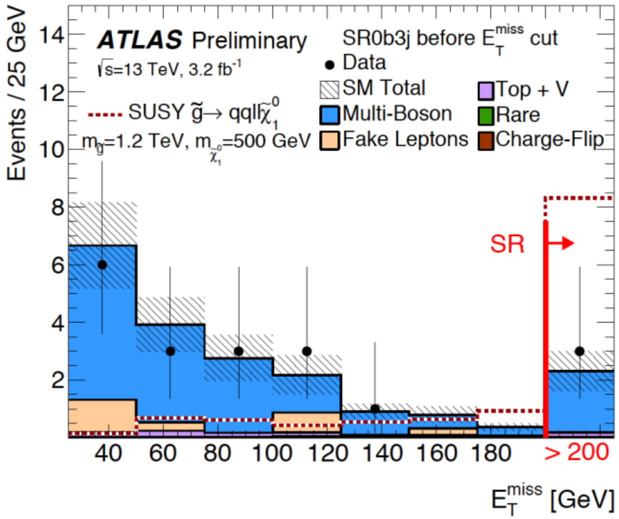


Signal region	$N_{\mathrm{lept}}^{\mathrm{signal}}$	$N_{b\mathrm{jets}}^{20}$	N_{jets}^{50}	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	m_{eff} [GeV]
SR0b3j	≥3	=0	≥3	>200	>550
SR0b5j	≥2 SS	=0	≥5	>125	>650
SR1b	≥2 SS	≥1	≥4	>150	>550
SR3b	≥2 SS	≥3	-	>125	>650

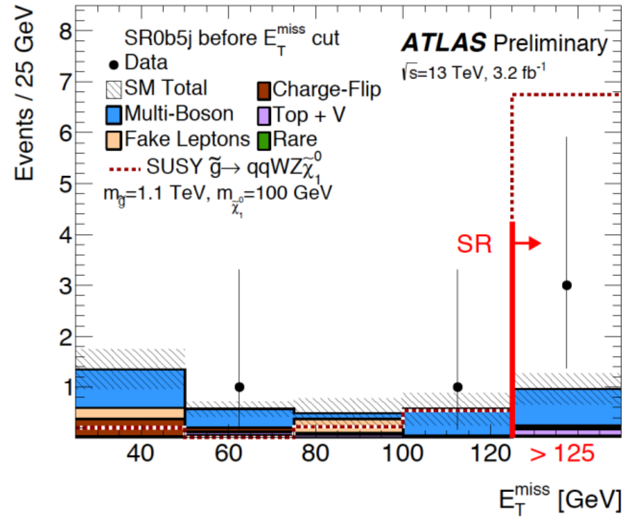
Background estimation:

- Wrong lepton charge:
  - $Z/\gamma^* \to e^+e^-$ sample
- Fake leptons or leptons from heavy-flavor-decay:
  - "Matrix method" with loose lepton selection criteria
- $t\bar{t}V, t\bar{t}h$:
  - From MC with VRs

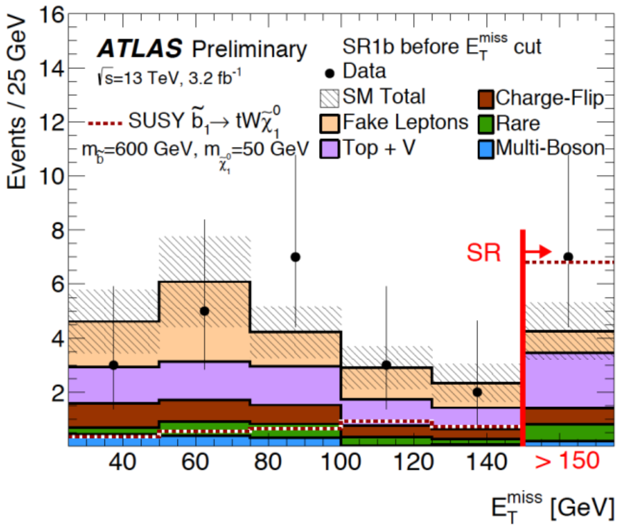
MET distributions in SRs



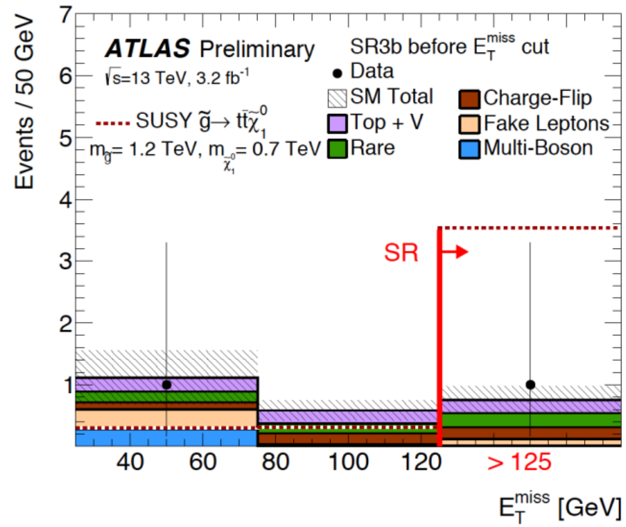
(a)



(b)



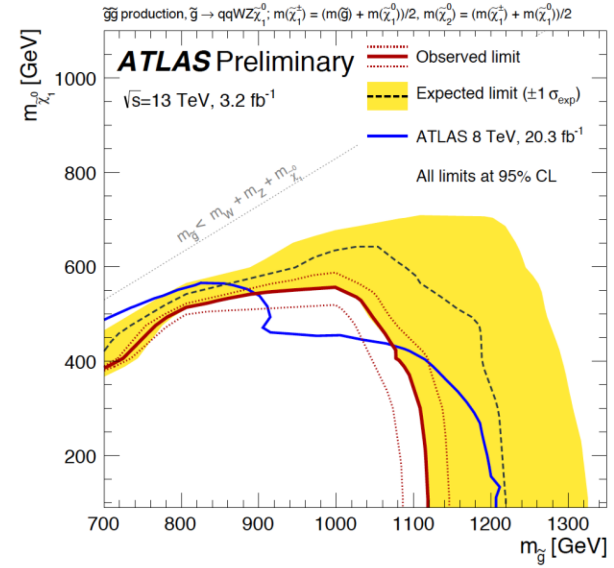
(c)



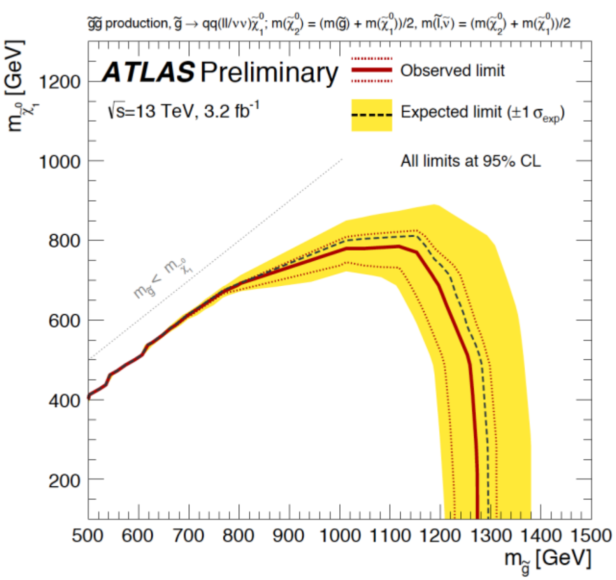
(d)

Results

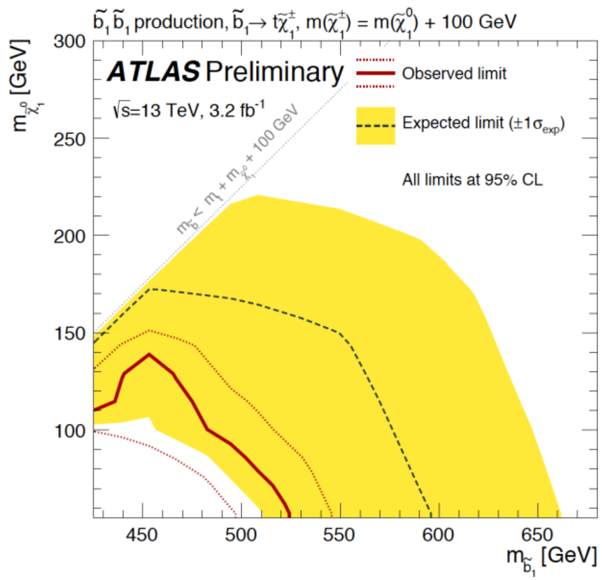
	SR0b3j	SR0b5j	SR1b	SR3b
Observed events	3	3	7	1
Total bkg events	2.4 ± 0.7	0.98 ± 0.32	4.3 ± 1.0	0.78 ± 0.24
$p(s = 0)$	0.33	0.06	0.12	0.36
Fake/non-prompt leptons	< 0.2	$0.04^{+0.17}_{-0.04}$	0.8 ± 0.8	0.12 ± 0.16
Charge flip	–	0.02 ± 0.01	0.60 ± 0.12	0.19 ± 0.06
$t\bar{t}W, t\bar{t}Z$	0.13 ± 0.06	0.11 ± 0.06	2.0 ± 0.7	0.21 ± 0.09
WZ	1.5 ± 0.5	0.61 ± 0.25	0.17 ± 0.09	< 0.02
$W^{\pm}W^{\pm}jj$	–	0.11 ± 0.05	0.03 ± 0.01	< 0.01
ZZ	0.6 ± 0.4	< 0.14	< 0.03	< 0.03
Triboson	0.09 ± 0.05	0.02 ± 0.01	0.02 ± 0.01	< 0.01
Rare	0.05 ± 0.04	0.05 ± 0.04	0.7 ± 0.4	0.26 ± 0.14



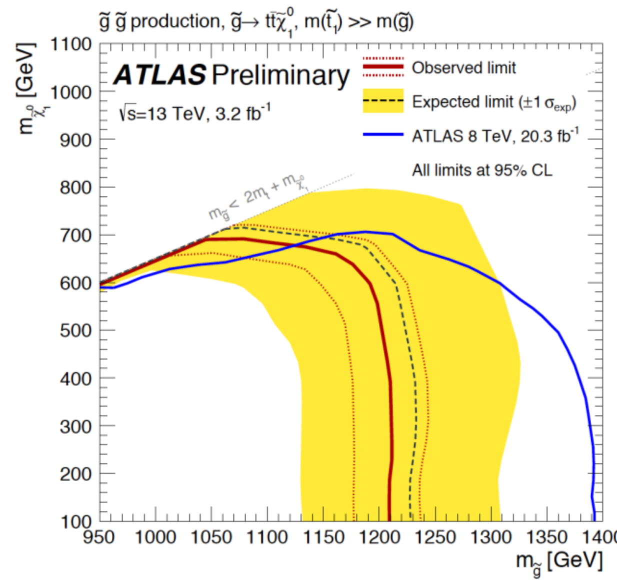
(b) $\tilde{g} \to q\bar{q}'WZ\tilde{\chi}_1^0$ scenario, SR0b5j



(a) $\tilde{g} \to q\bar{q}\ell\ell\tilde{\chi}_1^0$ scenario, SR0b3j



(c) $\tilde{b}_1 \to t\tilde{\chi}_1^-$ scenario, SR1b

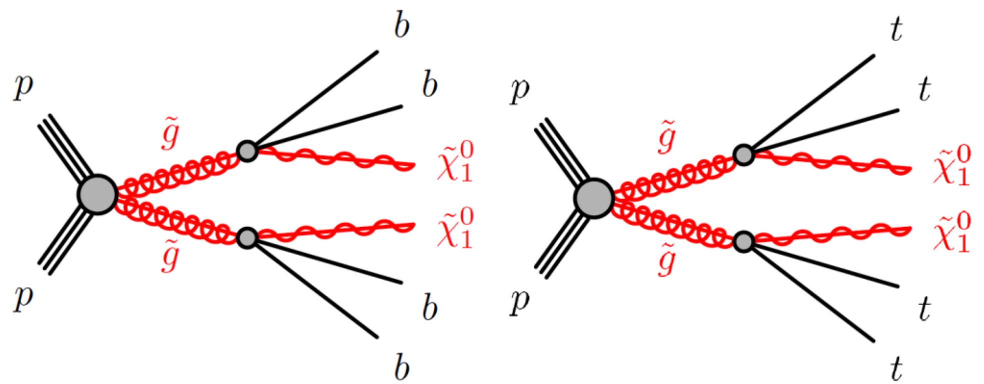


(d) $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ scenario, SR3b

5/7. Search with at least 3 *b*-jets

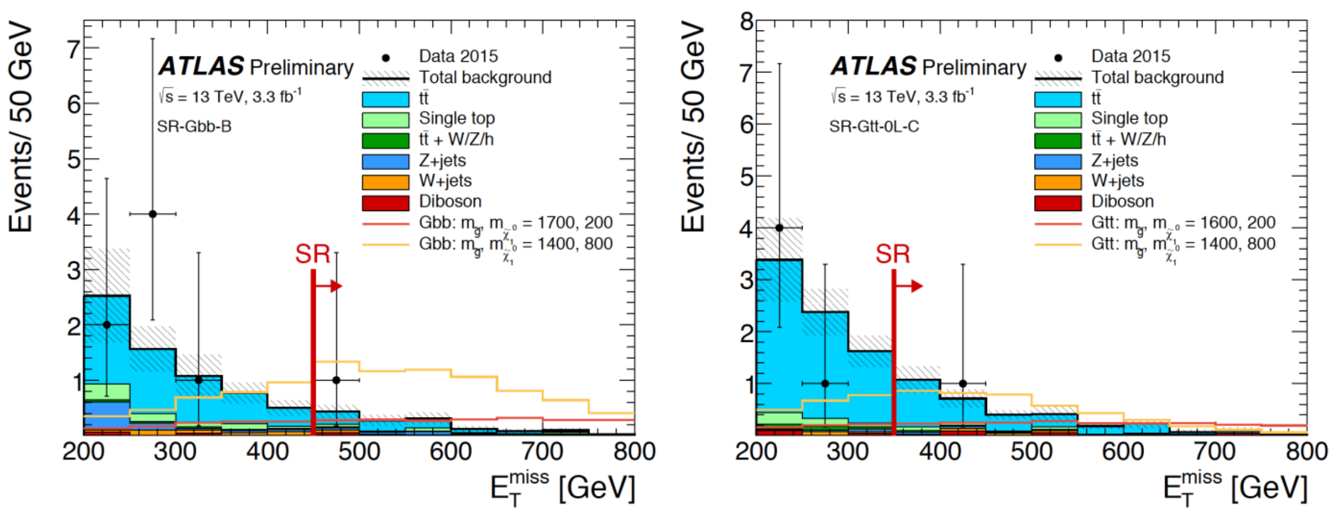
Analysis overview

8 SRs:
- ≥ 3 b-jets
- 0 or 1 lepton
- 0 or ≥ 1 top ($R = 1$ jet)



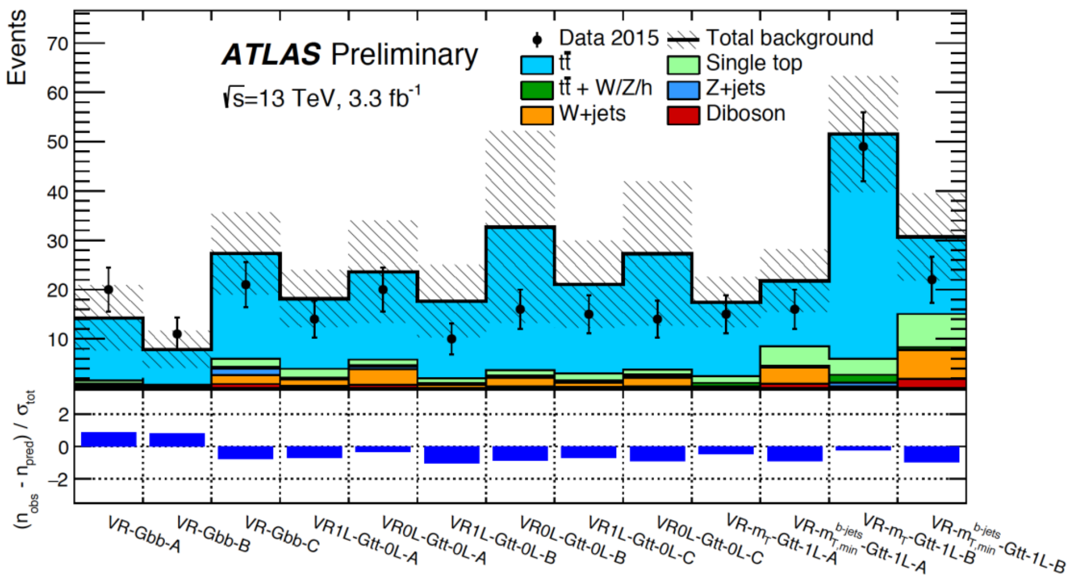
Background Estimation:
- $t\bar{t}$
  - From CR for each SR
- $t\bar{t}V$, $t\bar{t}h$, single-t, $4t$, V+jets
  - From MC

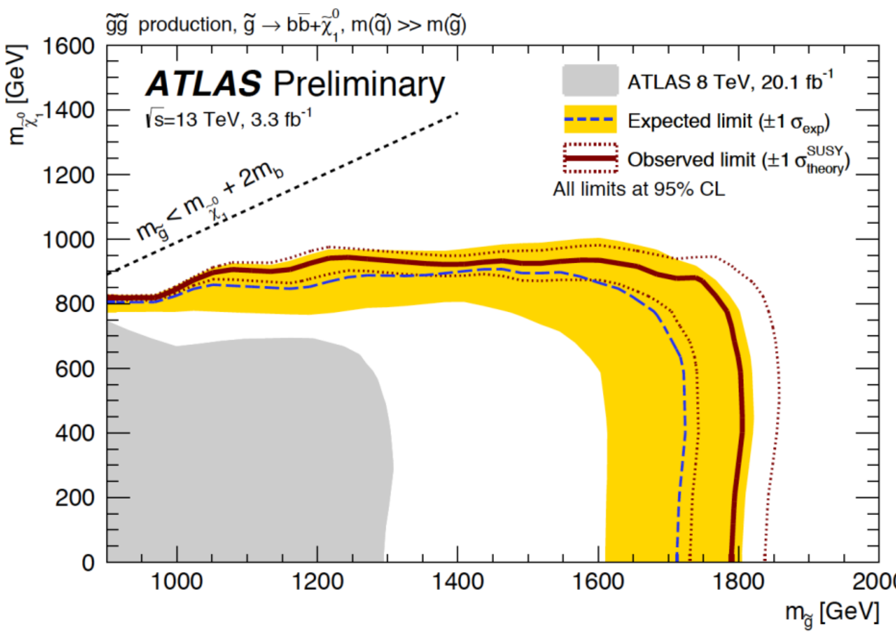
- MET distributions in some SRs:

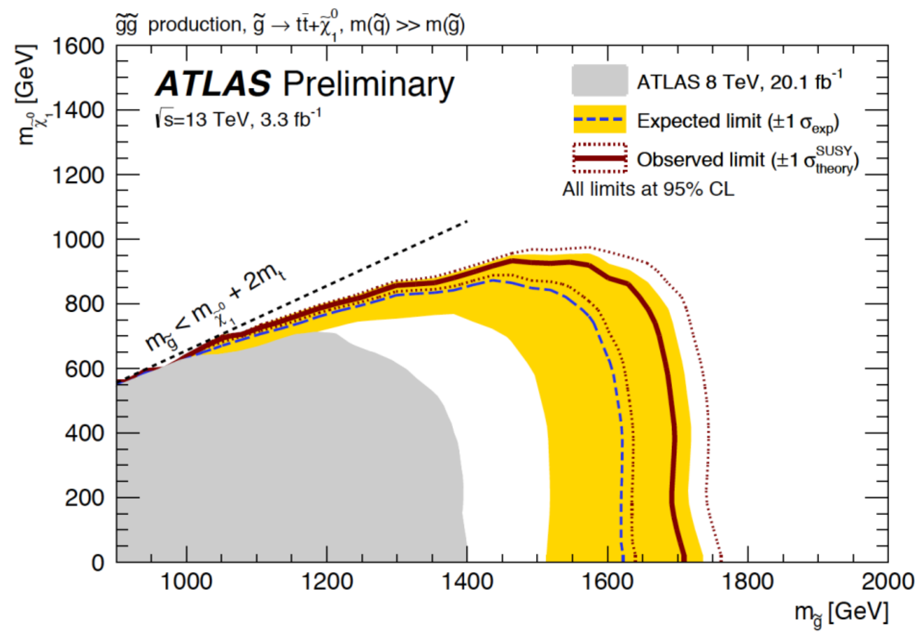


Results

Results of background-only fit in VRs

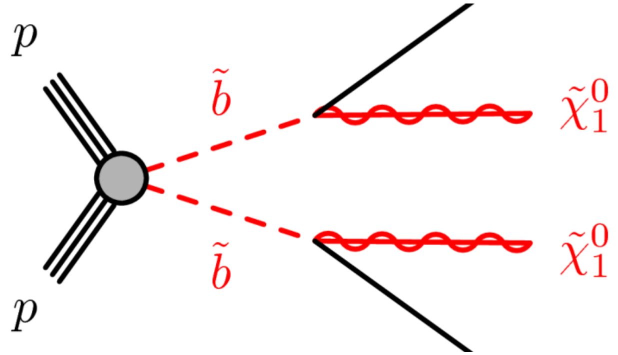






6/7. Search for sbottom pair

Analysis overview



4 SRs:

- 3 "SRA" target pair production
- SRB target pair production with ISR jet

Variable	SRA	SRB
Event cleaning	Common to all SR	
Lepton veto	No e/μ with $p_T > 10$ GeV after overlap removal	
E_T^{miss}	> 250 GeV	> 400 GeV
Leading jet $p_T(j_1)$	> 130 GeV	> 300 GeV
2nd jet $p_T(j_2)$	> 50 GeV	> 50 GeV
Fourth jet $p_T(j_4)$	vetoed if > 50 GeV	
$\Delta\phi^j_{min}$	> 0.4	> 0.4
$\Delta\phi(j_1, E_T^{miss})$	-	> 2.5
b-tagging	j_1 and j_2	j_2 and (j_3 or j_4)
E_T^{miss}/m_{eff}	> 0.25	> 0.25
m_{CT}	$> 250, 350, 450$ GeV	-
m_{bb}	> 200 GeV	-

Main discriminator: contraverse mass,

$$m^2_{CT}(v_1, v_2) = [E_T(v_1) + E_T(v_2)]^2 - [\boldsymbol{p}_T(v_1) - \boldsymbol{p}_T(v_2)]^2$$

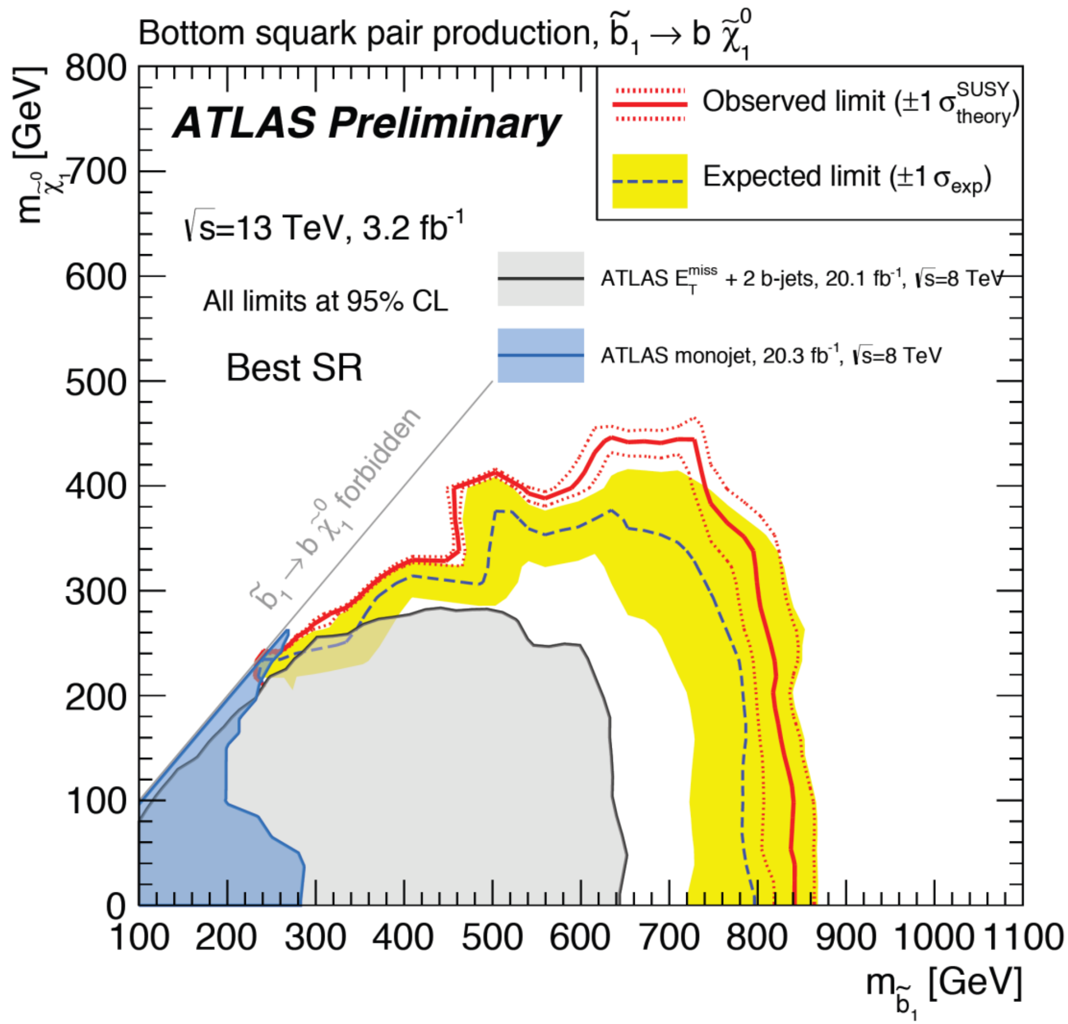
Can be used to measure $m_{\tilde{b}}$

Background:

- $t\bar{t}$ and V + heavy flavor
  - Studied with CRs containing leptons

Results

Signal region channels	SRA250	SRA350	SRA450	SRB
Observed events	22	6	1	5
Fitted bkg events	40 ± 8	9.5 ± 2.6	2.2 ± 0.6	13.1 ± 3.2
Fitted $t\bar{t}$ events	0.9 ± 0.4	0.37 ± 0.16	0.06 ± 0.03	5.9 ± 2.4
Fitted single top events	2.1 ± 1.3	0.54 ± 0.37	0.15 ± 0.10	1.2 ± 0.8
Fitted W+jets events	6.3 ± 2.4	1.3 ± 0.6	0.41 ± 0.23	1.2 ± 0.6
Fitted Z+jets events	30 ± 7	7.1 ± 2.4	1.5 ± 0.5	3.3 ± 1.4
(Alt. method Z+jets events)	*(33 ± 7)*	*(7.2 ± 1.9)*	*(2.7 ± 0.9)*	
Fitted "Other" events	0.7 ± 0.6	0.1 ± 0.1	0.02 ± 0.02	1.4 ± 0.4

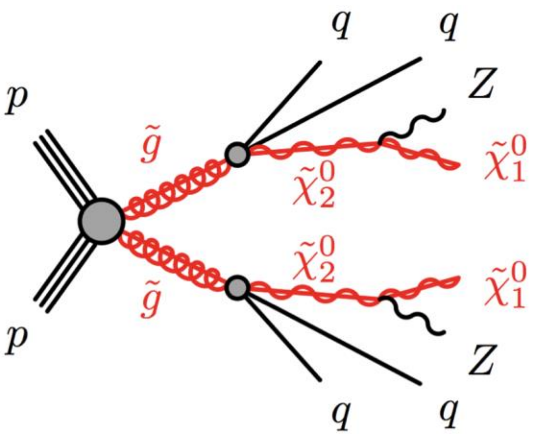


7/7. Search with $Z \to \ell^+\ell^-$

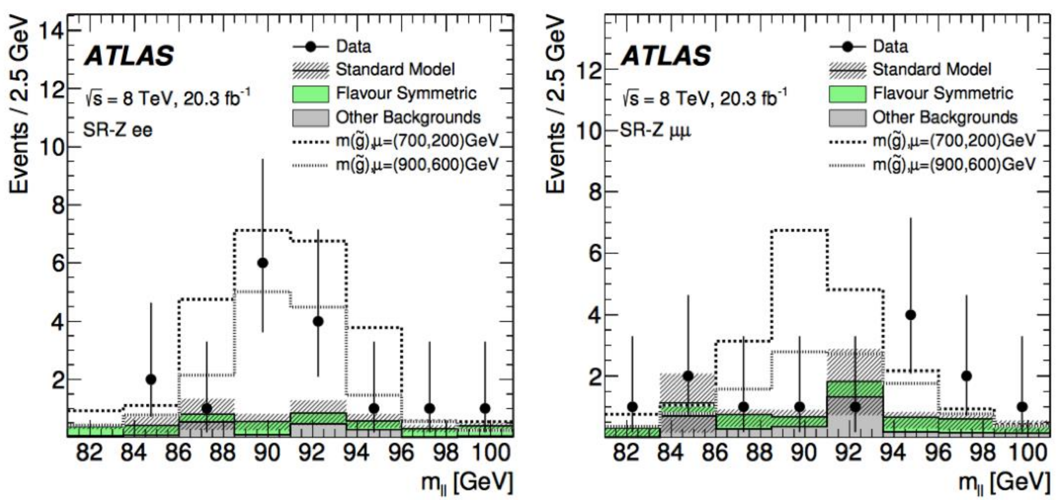
Analysis overview

Target Z production

E_T^{miss} [GeV]	H_T [GeV]	n_{jets}	$m_{\ell\ell}$ [GeV]	SF/DF	$\Delta\phi(\mathrm{jet}_{12}, p_T^{miss})$
> 225	> 600	≥ 2	$81 < m_{\ell\ell} < 101$	SF	> 0.4



Run-1 3σ excess:

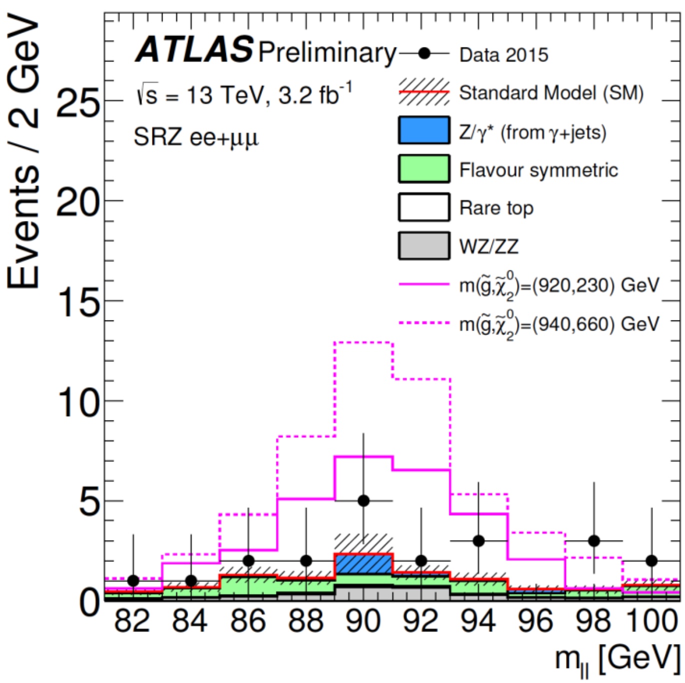


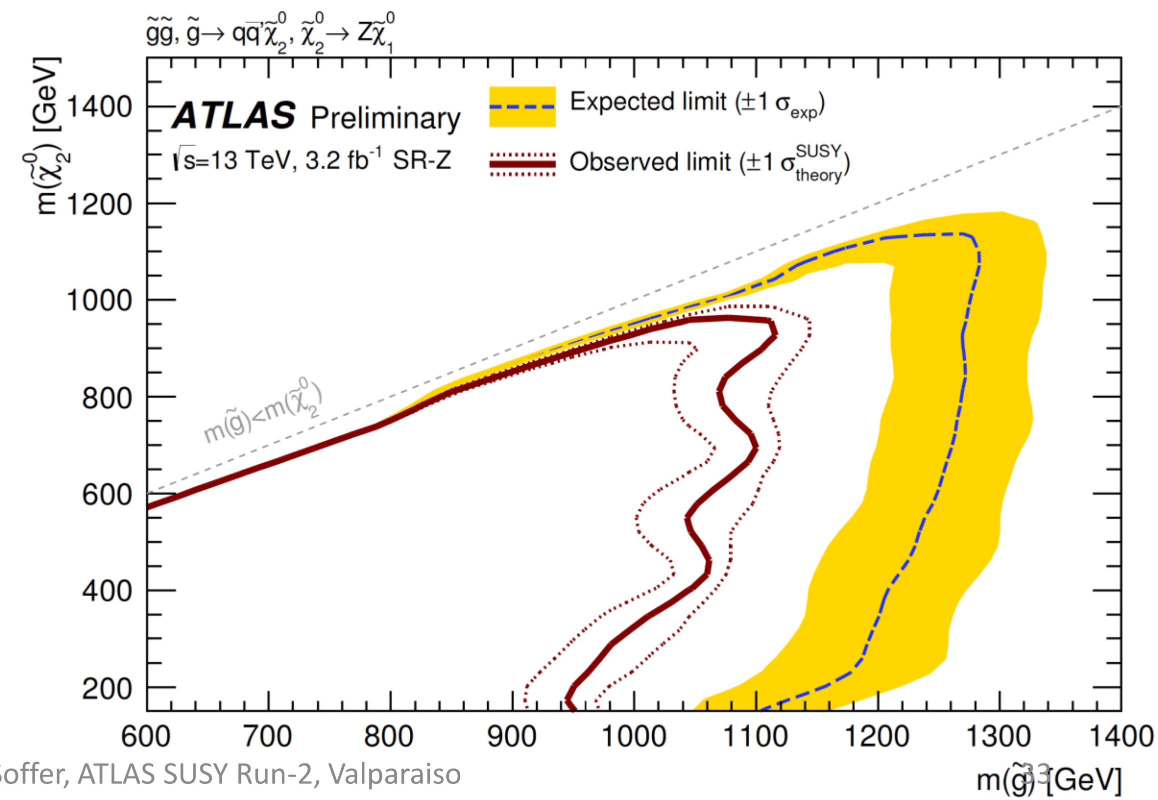
Dominant backgrounds:

- $t\bar{t}, WW, Wt$:
  - Using CR with different-flavor leptons ($e\mu$)
- $Z/\gamma^* +$ jets:
  - Using CR with $\gamma +$ jets

Results

	SRZ
Observed events	21
Total expected background events	10.3 ± 2.3
Flavour symmetric ($t\bar{t}$, Wt, WW and $Z \to \tau\tau$) events	5.1 ± 2.0
WZ/ZZ events	2.9 ± 0.8
Z/γ^* + jets events	1.9 ± 0.8
Rare top events	0.4 ± 0.1
p-value	0.013
Significance	2.2
Observed (Expected) S^{95}	20.0 ($10.2^{+4.4}_{-3.0}$)





Conclusions

- ATLAS doing very well in Run-2 ($3.2 \pm 0.2\ fb^{-1}$)
- Completed 7 analyses to search for SUSY signatures
  - Focusing on strong production – improvement wrt. Run-1
  - No excess signal found
  - Mass limits almost always tighter than those of Run-1
- Working hard on many more SUSY searches with Run-2 data