Searches for squark and gluino production in hadronic final states with the ATLAS experiment

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On behalf of the ATLAS collaboration

XXIV International Workshop on Deep-Inelastic Scattering and Related Subjects
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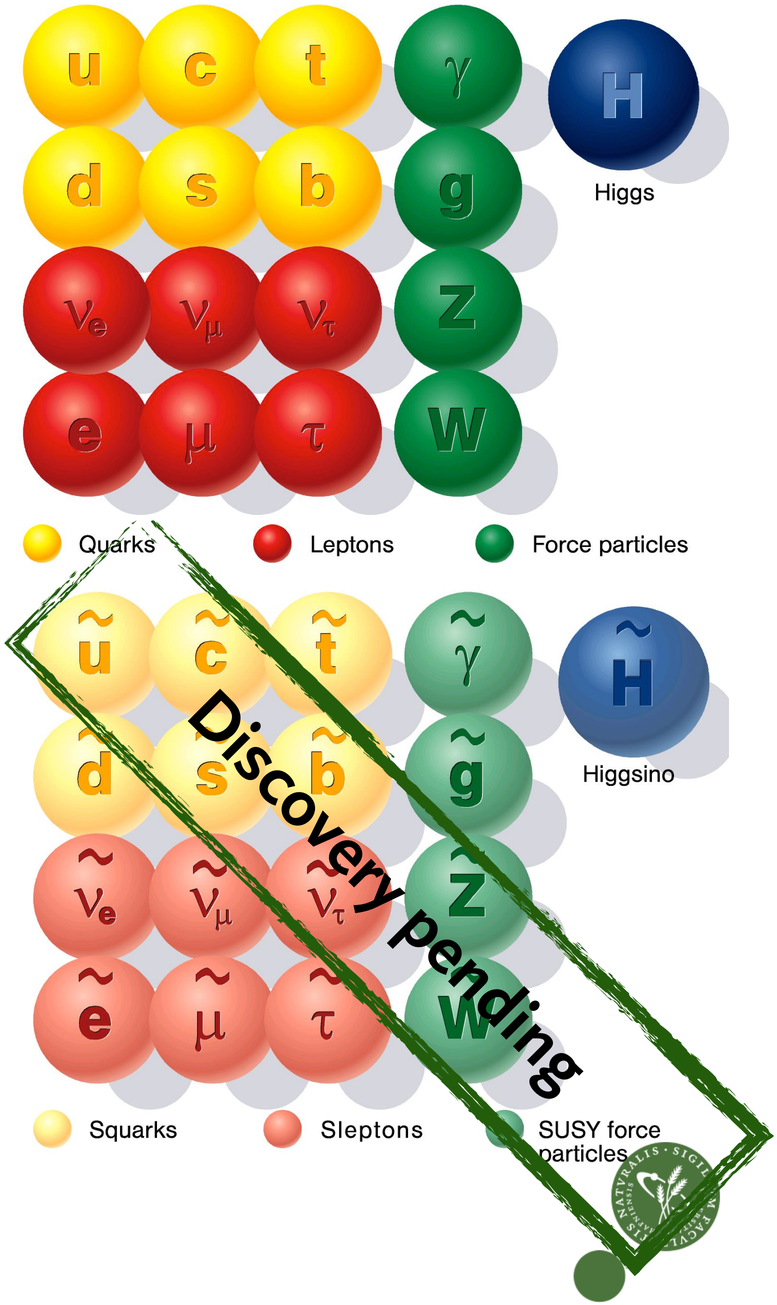
Overview

- Why supersymmetry?
- Supersymmetry production at the LHC
- The ATLAS detector
- Targeted SUSY models
- Analysis strategy
- Discriminating variables
- Background estimation
- Results
- Conclusion and outlook

Why do we (still) like supersymmetry?

- **SUSY is a matter-force symmetry**
- Introduces bosonic superpartners for SM fermions, fermionic partners for SM bosons
- Allows **unification** of fundamental interactions
- Provides solution to the **hierarchy problem and fine-tuning of the Higgs mass**
- Offers candidate for **dark matter** particles

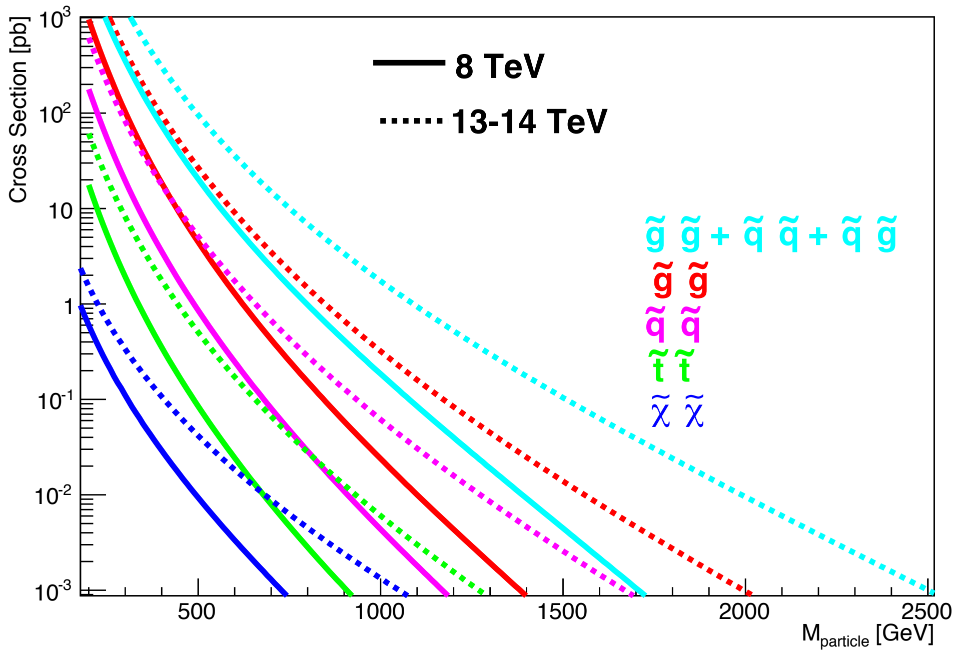


- **No SUSY detected yet: broken symmetry**
- **A priori >100 free parameters** in the full model
- Mass hierarchy and mixing matrices dictate possible decays and determine the lifetimes
- **Many possible scenarios** in your detector!

Supersymmetry at the LHC

- In the **Minimal Supersymmetric Standard Model** (MSSM), baryon number and lepton not preserved: introduce **quantum number R = $(-1)^{3(B-L)+2s}$**
- **SM and SUSY get opposite parities**; assuming R-parity conserved: **pair production; stable lightest SUSY particle** (LSP).
  (For RPV SUSY, see Bradley Axen's talk)

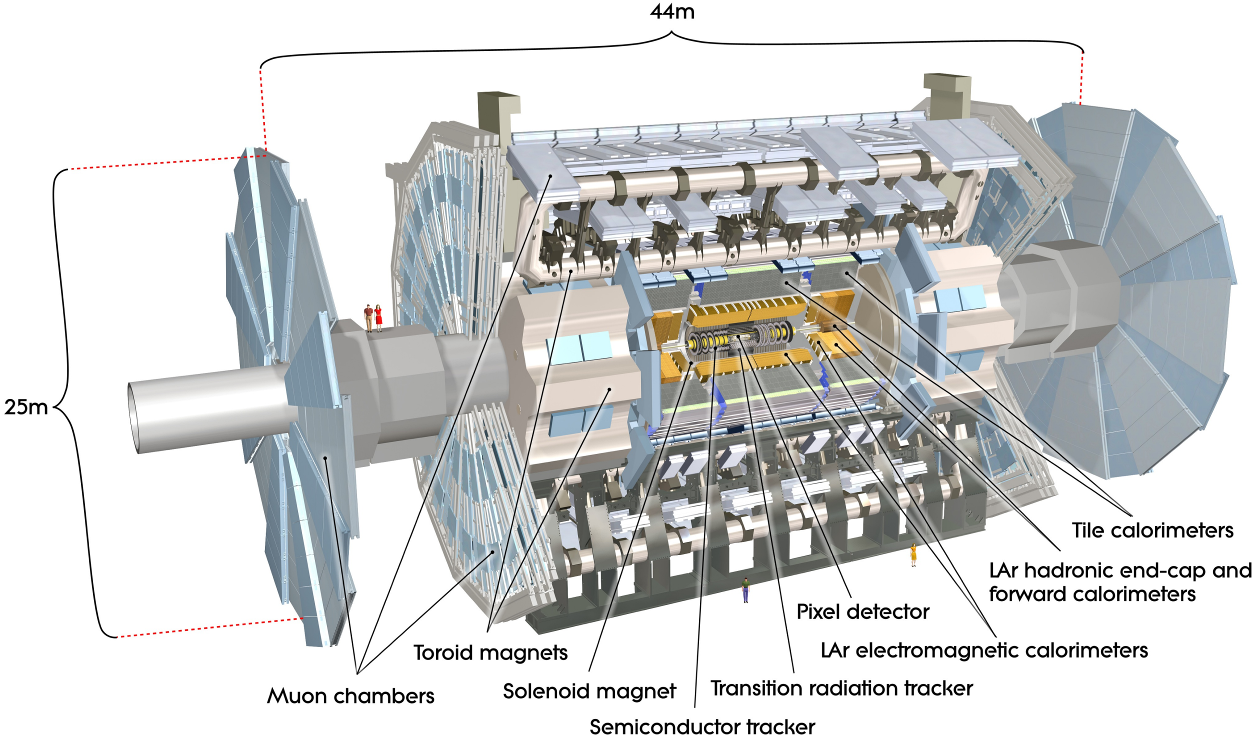
- At the LHC, 3 main prod. mechanisms:
  - **Strong production of squarks and gluinos**: dominant, search using missing energy and jets
  - **3rd generation production (stop and sbottom quark)**: light 3rd gen. squarks preferred by naturalness arguments; analyses exploit states with b-jets
  - **Electroweak production**: direct production of gauginos (charginos, neutralinos) *see also Yusufu Shehu's talk*

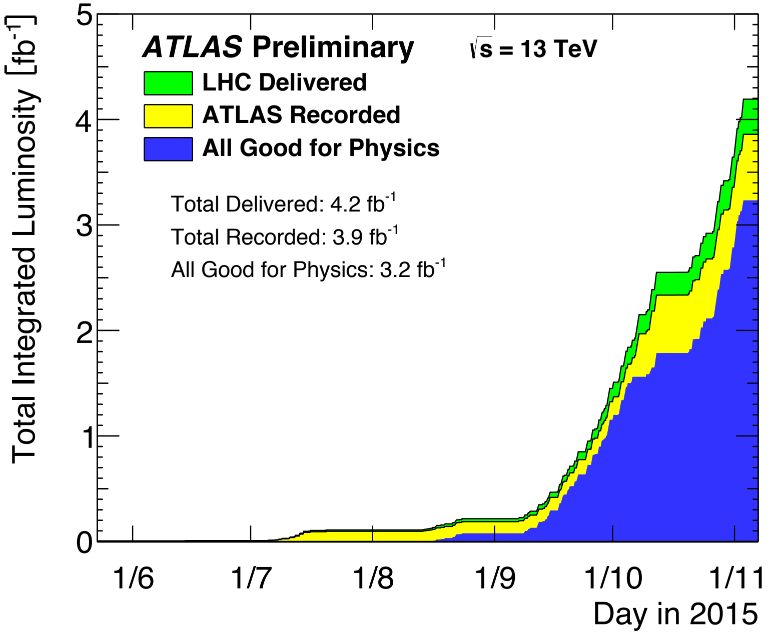


arXiv:1411.1427

Cross-section for EWK at 14 TeV, for coloured particles at 13 TeV

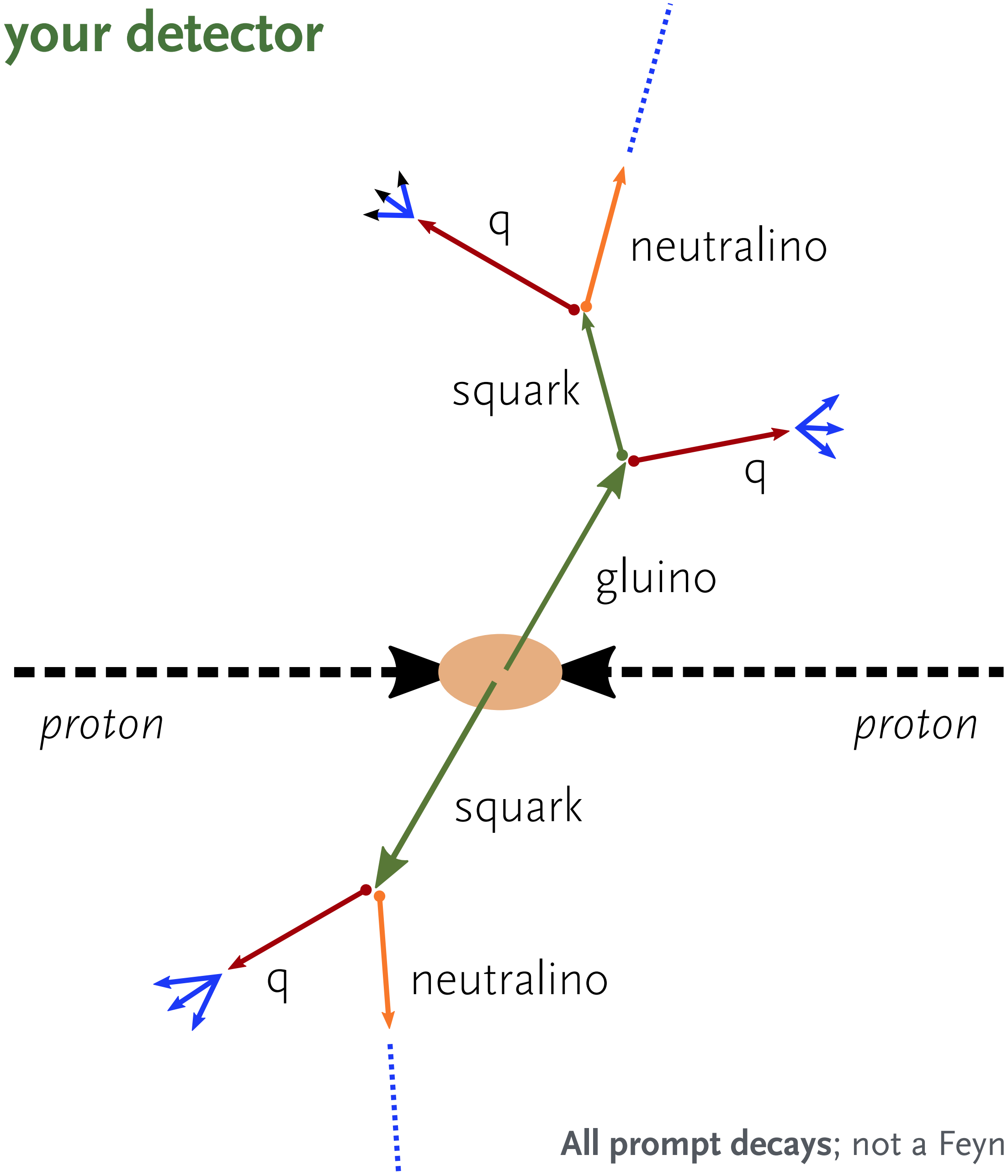
The ATLAS detector





- **High-precision tracking system** (silicon pixels/strips and a transition radiation tracker), with **new *insertable b-layer (IBL)***
- **Two calorimeters** (EM: liquid Ar; hadronic: scintillating tiles)
- **Muon spectrometer**: muon identification (comb. with tracker)
- **Two large magnet systems** (toroidal and solenoidal)
- Good jet resolution especially important for SUSY searches

SUSY in your detector



All prompt decays; not a Feynman diagram

(RPV and long-lived SUSY in Bradley Axen's talk)

Analyses covered

- **Inclusive searches:**
  - 0 leptons + 2-6 jets: ATLAS-CONF-2015-062
  - 0 leptons + 7-10 jets: arXiv:1602.06194 (SUSY-2015-07)

- **Third generation searches:**
  - 0 leptons + 2 b-jets: ATLAS-CONF-2015-066
  - 0 or 1 lepton + 3+ b-jets: ATLAS-CONF-2015-067

- See Sébastien Kahn's talk for leptonic final states!

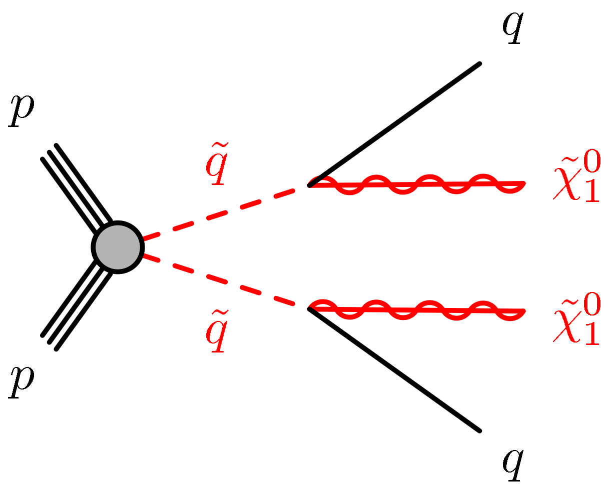
- Some limits presented at the CERN seminar on 15 December 2015 and at the winter conferences
- One result superseded by paper

- Documentation for all these in backup slides

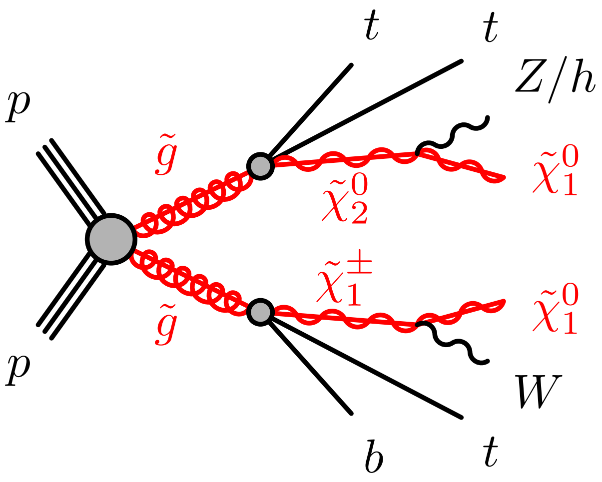
ATLAS-CONF-2015-062

arXiv:1602.06194

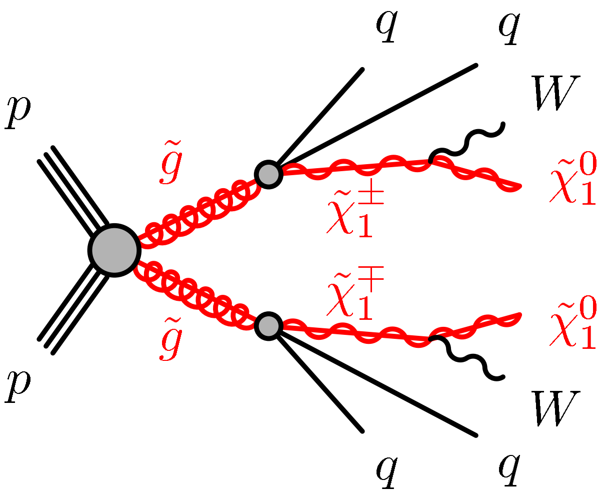
Targeted models - inclusive squarks and gluinos



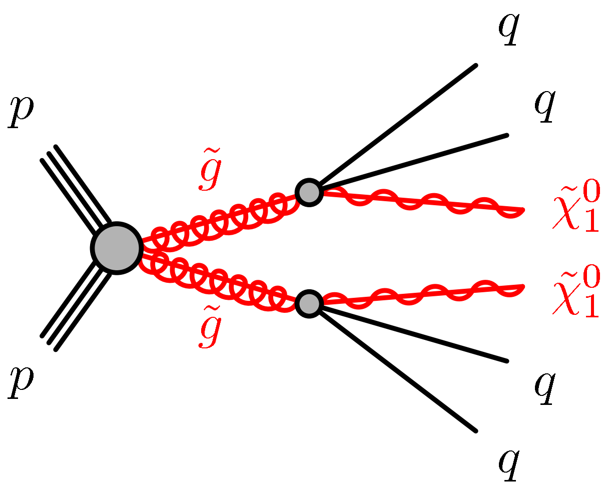
Direct squark production



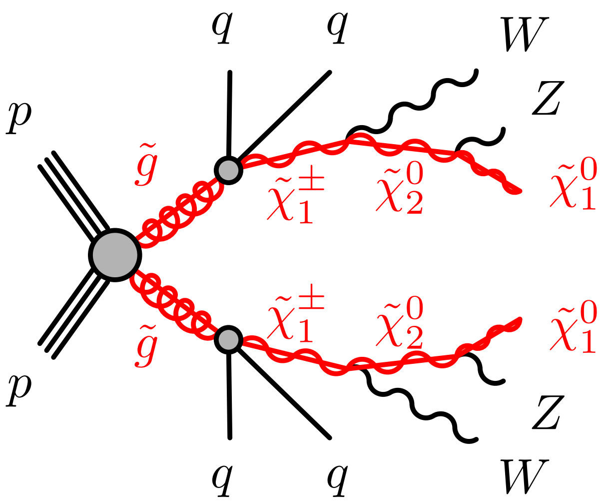
One-step gluino decays



One-step gluino decays



Direct gluino production



Two-step gluino decays

~*q* denotes a squark of
the first two generations

Variables used to discriminate signal and background

- The **2-6 jets search** is based around the ***effective mass***:

$$m_{\mathrm{eff}} = E_{\mathrm{T}}^{\mathrm{miss}} + \sum_{i \in \mathrm{jets}} |p_{\mathrm{T}}^{(i)}|$$

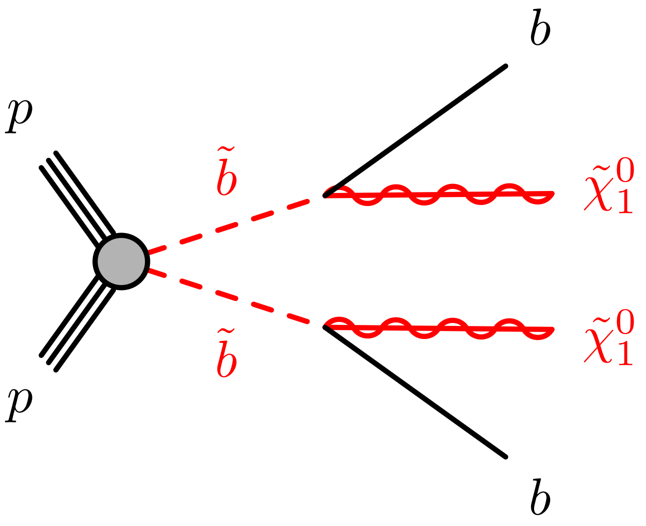
- Correlates ~80% with SUSY particle mass in case of massless neutralino
- Additional cuts on $\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ and $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$ to reduce the multijet background

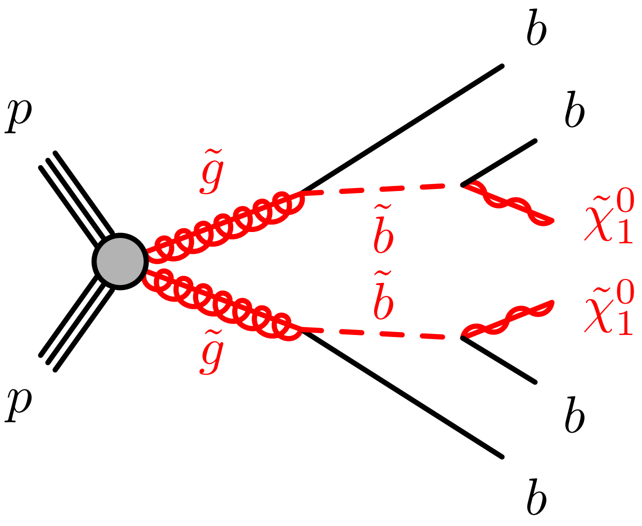
- The **7-10 jets search** additionally uses bins in the number of b-jets and uses the MET significance $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$, where H_{T} is the sum of jet pT's

ATLAS-CONF-2015-066

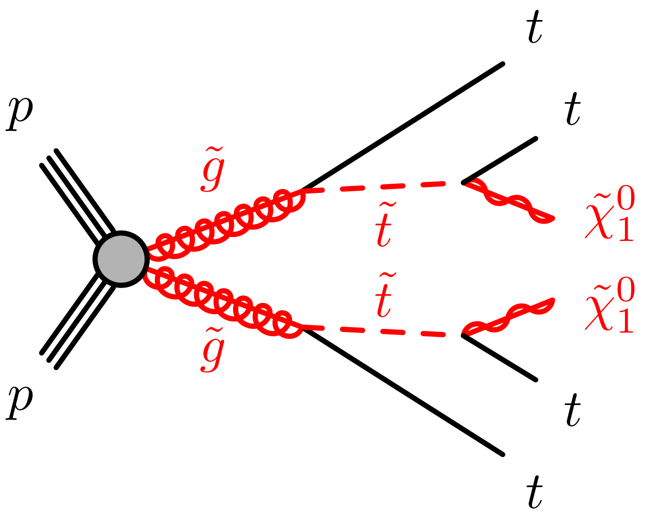
ATLAS-CONF-2015-067

Targeted models - third generation squarks





“Gbb”



“Gtt”

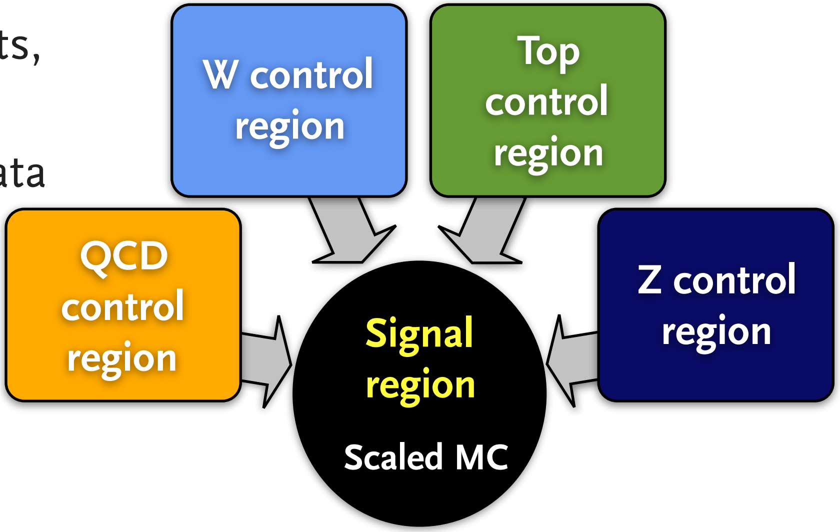
- **2 b-jet analysis** uses ***contransverse mass***:
  $$m^2_{\mathrm{CT}} = [E_{\mathrm{T}}(v_1) + E_{\mathrm{T}}(v_2)]^2 - [\mathbf{p}_{\mathrm{T}}(v_1) - \mathbf{p}_{\mathrm{T}}(v_2)]^2$$
  with v_1 and v_2 the two visible particles, which has an endpoint for ttbar at 135 GeV and for sbottom at $m_{\mathrm{CT}}^{\mathrm{max}} = (m^2_{\tilde{b}_1} - m^2_{\tilde{\chi}_1^0})/m_{\tilde{b}_1}$

- **3+ b-jet analyses** uses the effective mass and $m_{\mathrm{T}}^{\mathrm{min}}$(b-jets, $E_{\mathrm{T}}^{\mathrm{miss}}$) which has an endpoint for semileptonic ttbar events
- In addition, it uses cuts on the number of high-mass large-radius jets for direct gluino decays via stop quarks (gluino→ttbar + $\tilde{\chi}_1^0$)

General analysis strategy

- All analyses performed on **trigger plateau** and with **good data quality**
- MC samples used to optimise event selection
- **Data kept blinded** in the signal regions until analysis almost completed
- SUSY signals **acceptance and efficiency simulated** with MC

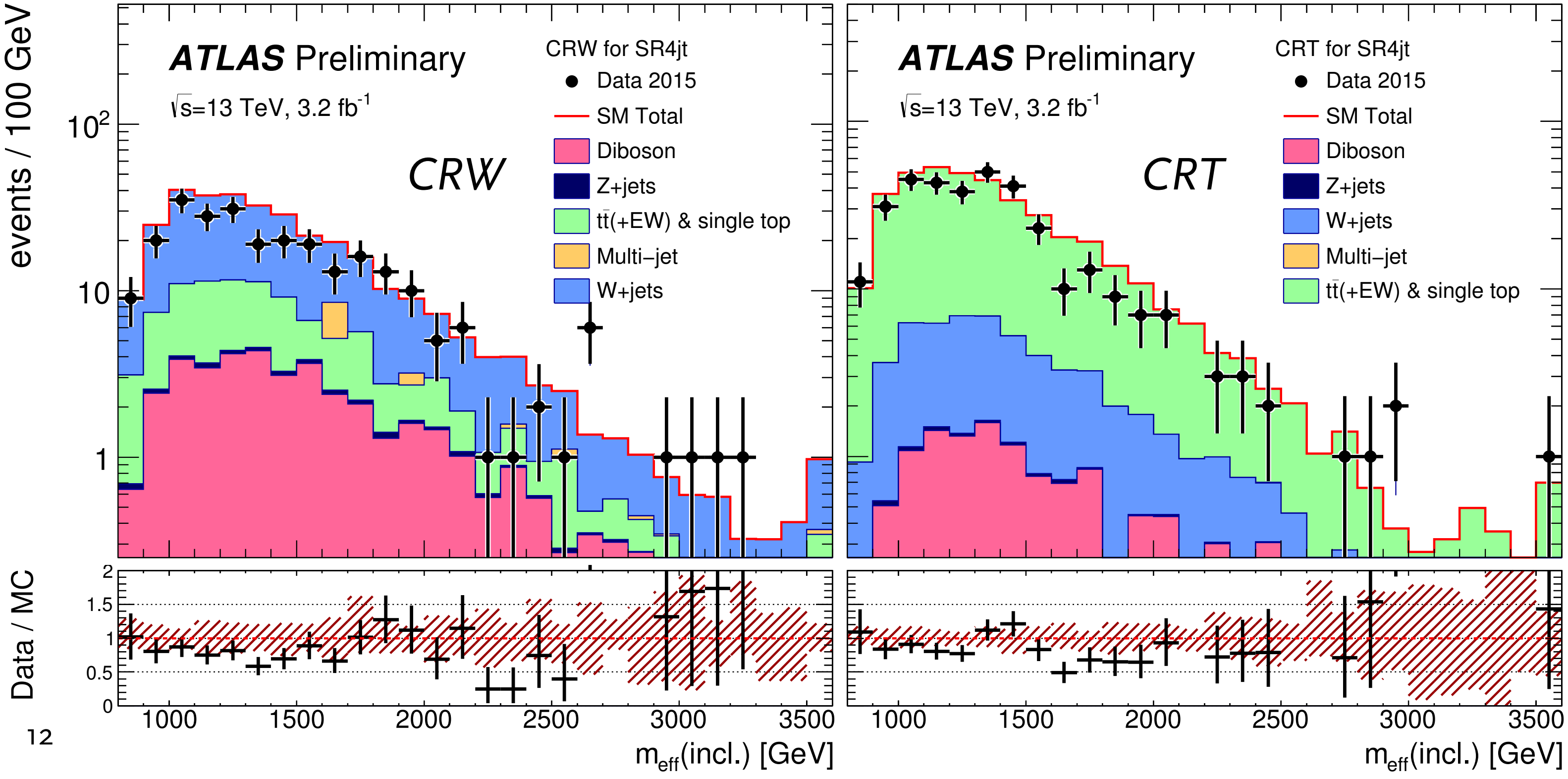
- **Background** estimation:
  - **Reducible**: due to fake or misidentified objects, typically fully data-driven approaches used
  - **Irreducible**: taken from MC, normalised to data using simultaneous fit in control region(s); checked in validation region(s)
  - Allows cancellation of uncertainties
  - Note: *no* shape fits used
  - **Minor irreducible backgrounds:** pure MC



- **Unblind signal regions**, and:
  - celebrate in case of excess
  - if not, interpret results using different models

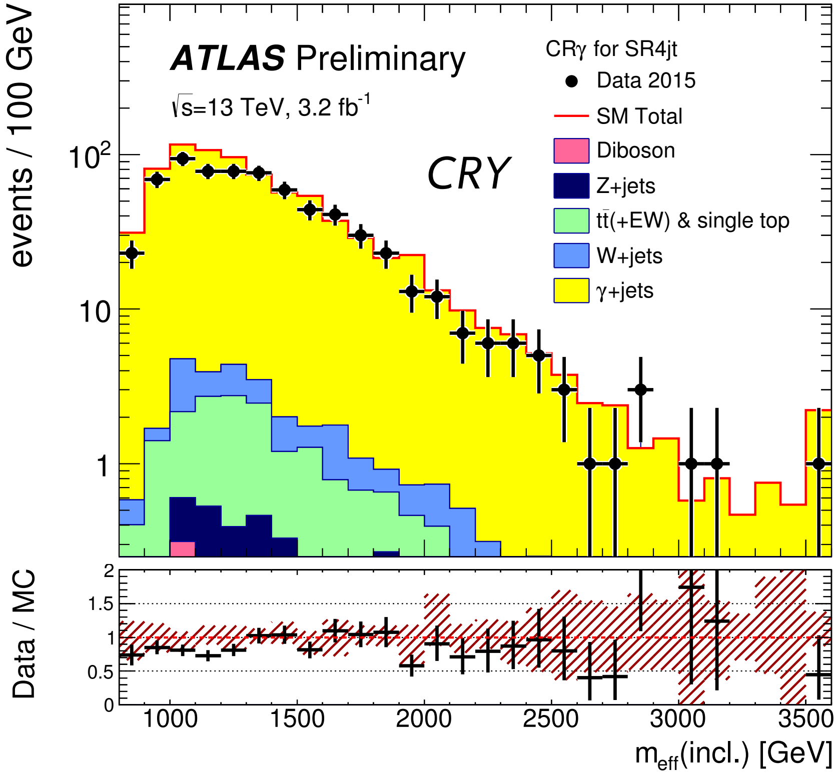
W+jets and ttbar background estimation

- Events from W+jets and ttbar enter signal regions in case of missing leptons (out of acceptance or misidentification), or through hadronic tau decays
- Control regions with exactly 1 isolated electron or muon used
- W+jets and ttbar separated by requiring or vetoing a b-jet, respectively
- Kinematic cuts slightly relaxed w.r.t. signal region
- Final prediction obtained in simultaneous control region fit



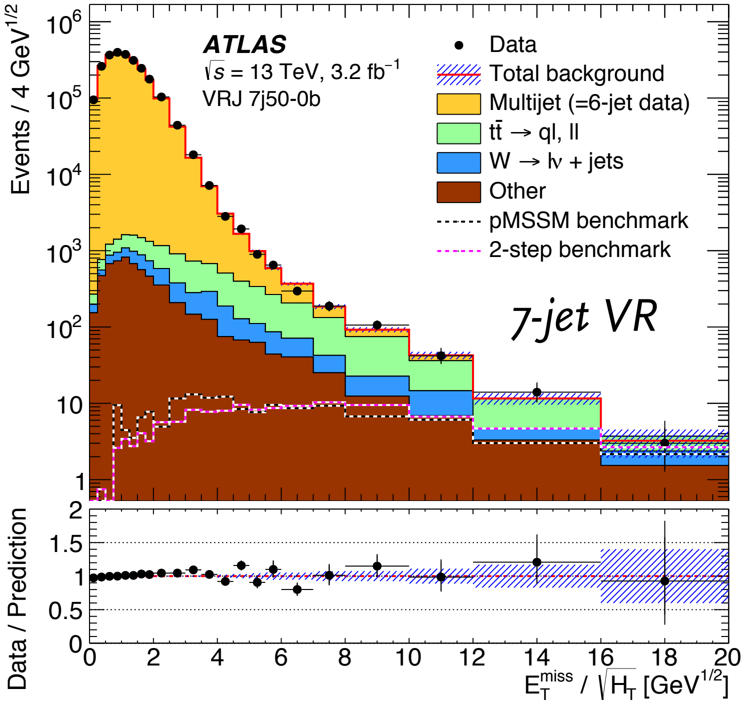
Z→νν background estimation

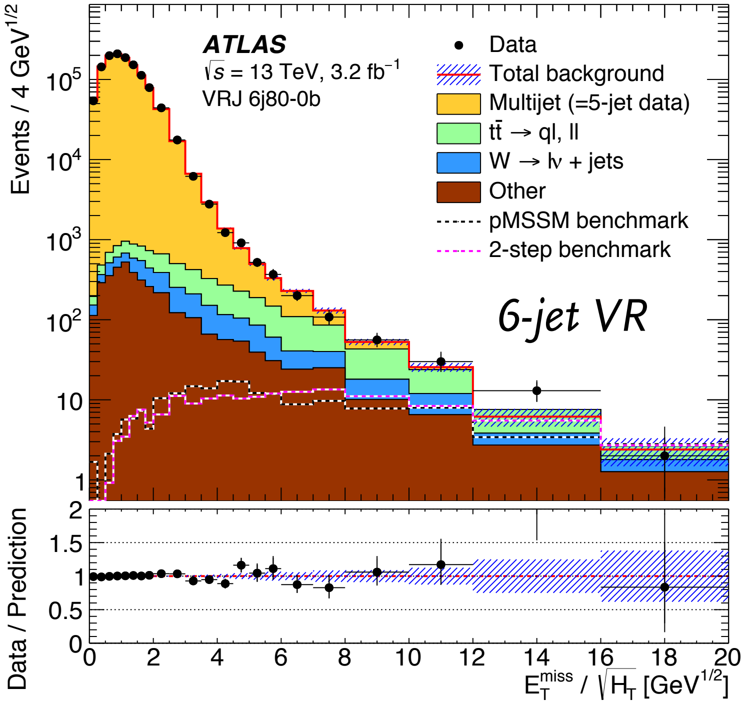
- Not enough Z→ℓℓ data to use as control region
- γ+jets events used instead: similar kinematic properties to the signal region used, but with a high-pT photon instead of E_T^{miss}
- Instrumental effects assumed to be identical for both processes
- Z/γ correction factor derived from data and MC in loose control region
- Obtained normalisation validated against measured Z→ℓℓ events



QCD background estimation

- The 2-6 jet and 3+ b-jet analyses: the background is negligible (< 0.5%) due to hard selections on E_T^{miss} and $\Delta\phi$(jet, E_T^{miss})
- 7-10 jet analysis has soft cut on $E_T^{miss}/\sqrt{H_T}$: QCD remains a major background
- Remaining background estimated from a template at low jet multiplicity data of the $E_T^{miss}/\sqrt{H_T}$ distribution
- Assumed that distribution is invariant to higher jet multiplicities
- (Validated in regions with lower jet multiplicities than SR)

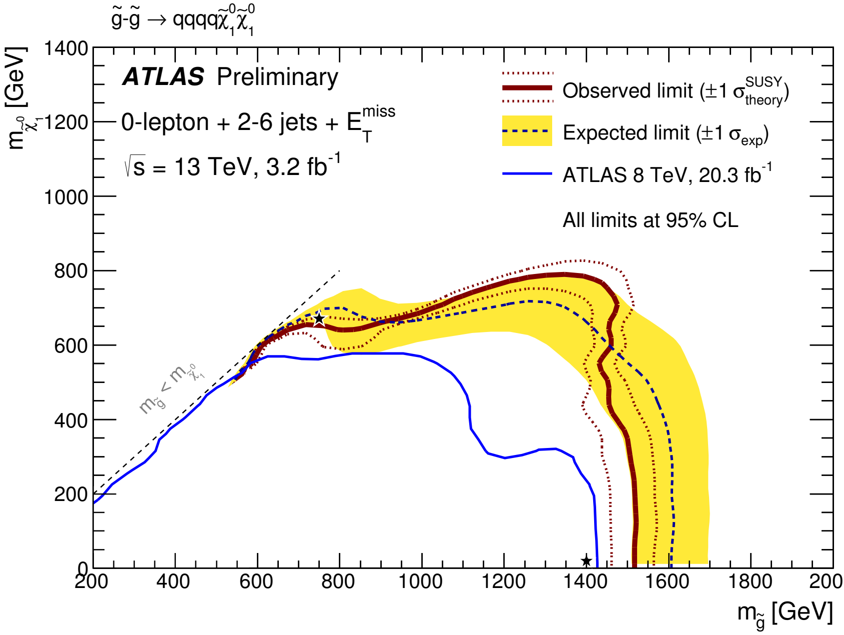




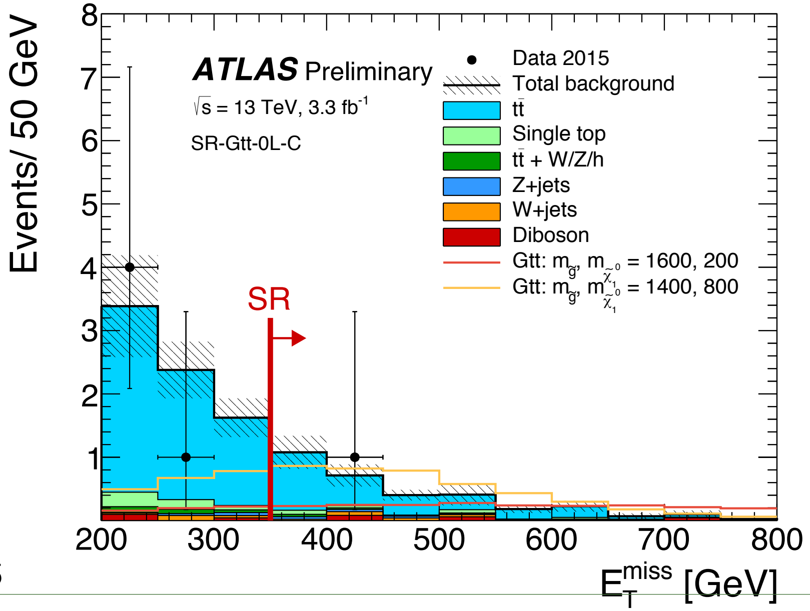
ATLAS-CONF-2015-062
ATLAS-CONF-2015-067

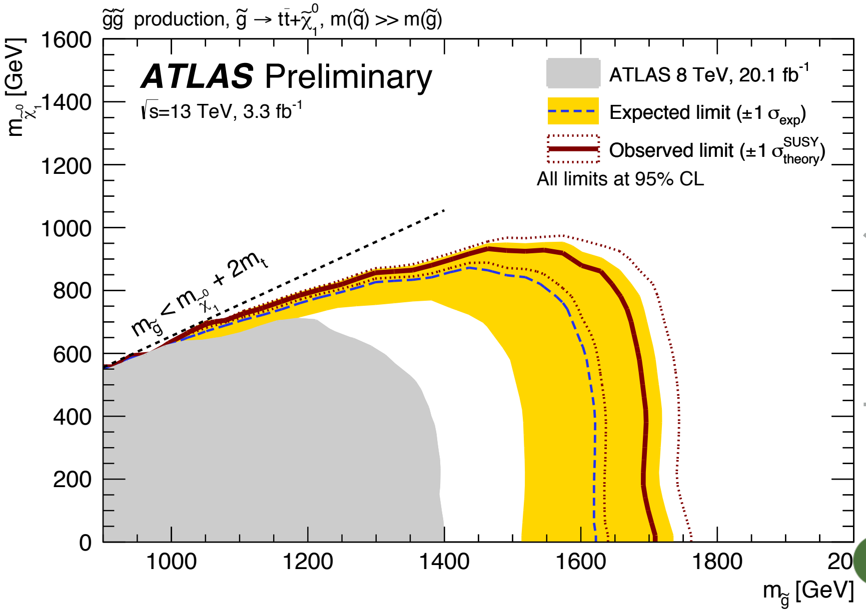
Results: gluino decays via squark, sbottom and stop

- Results from **2-6 jet search**:
  7 overlapping SRs with 2-6 jets using cuts on m_{eff} and E_T^{miss}/m_{eff}; best SR picked for each point
- Results from **3+ b-jet search**: uses 3 SRs
  - 0 lep, 4+ OR 8+ jets, with cuts on E_T^{miss} and m_{eff}, to target sbottom
  - 1 lep + 6+ jets to target stop
  - **NEW**: statistical combination of 0+1 lepton regions



Decays to squark





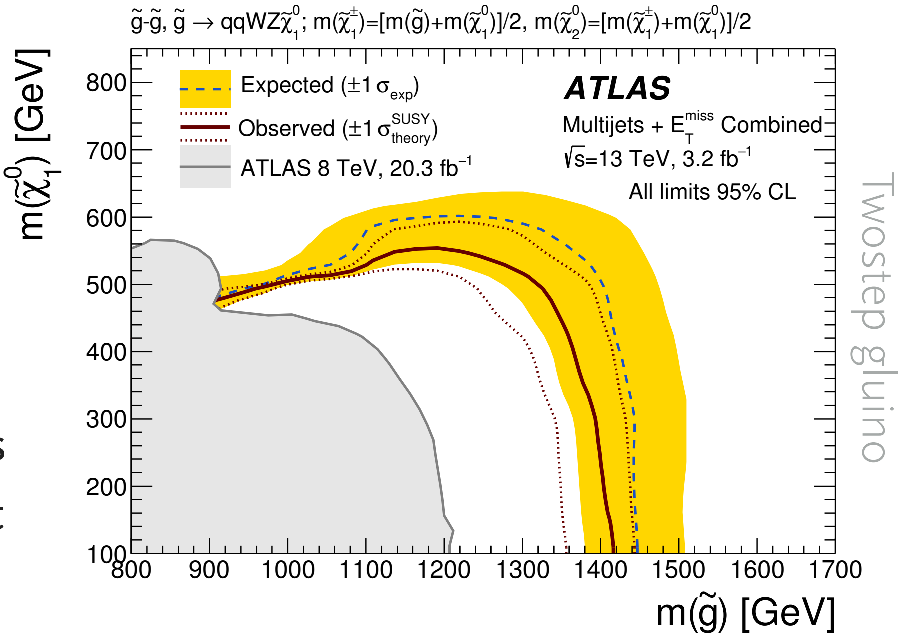
Decays to stop

ATLAS-CONF-2015-062

arXiv:1602.06194

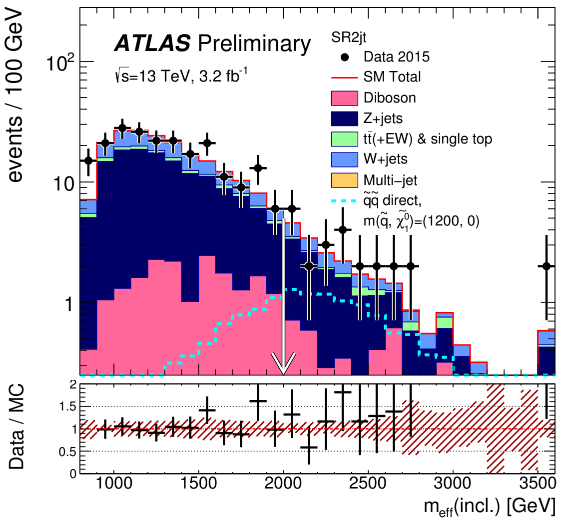
Results: direct squark decays, gluino one- and twostep

- Results from **2-6 jet search**: see previous slide
- Results for **7-10 jet search**: two sets of regions using 50 GeV jets or 80 GeV jets
    - 50 GeV: 8+, 9+ or 10+ jets with 0, 1 or 2+ b-jets. $E_T^{miss}/\sqrt{H_T}$ cut
    - 80 GeV: idem only with 7+ or 8+ jets
    - Best SR picked for each model point

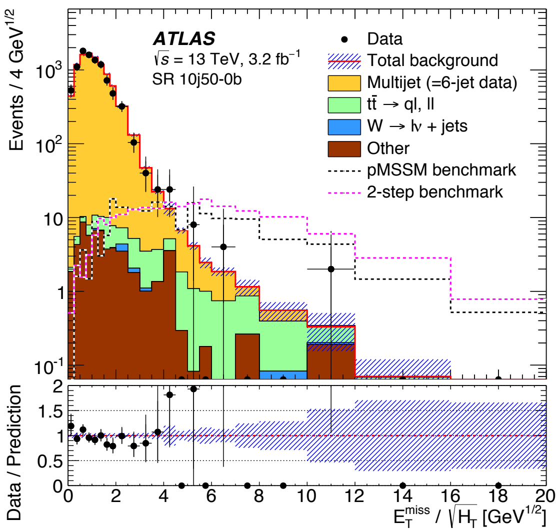


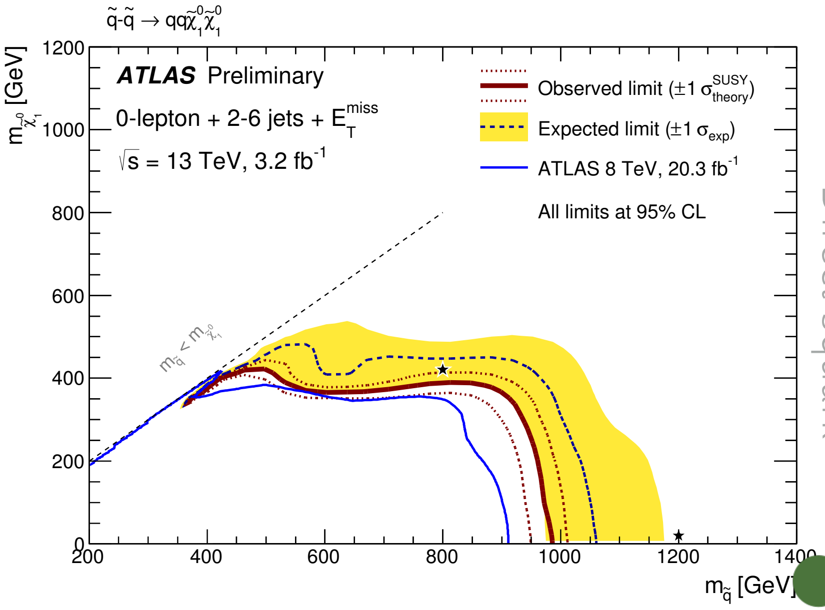
Twostep gluino

2-6 jets search



7-10 jets search



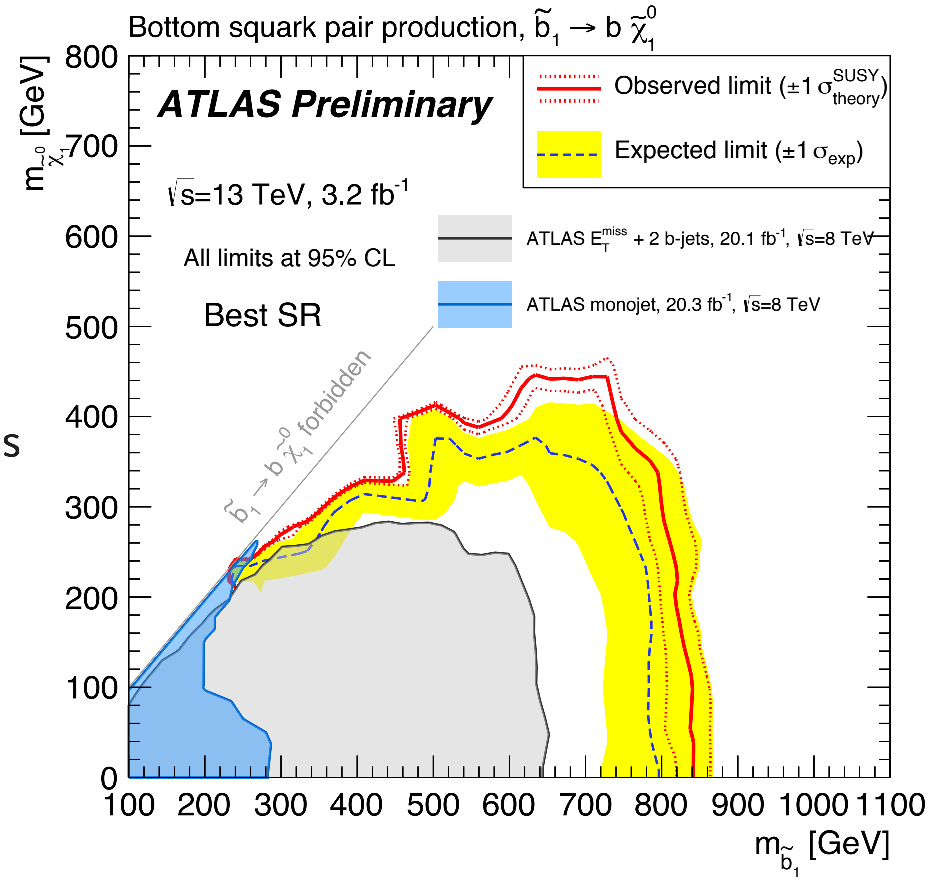


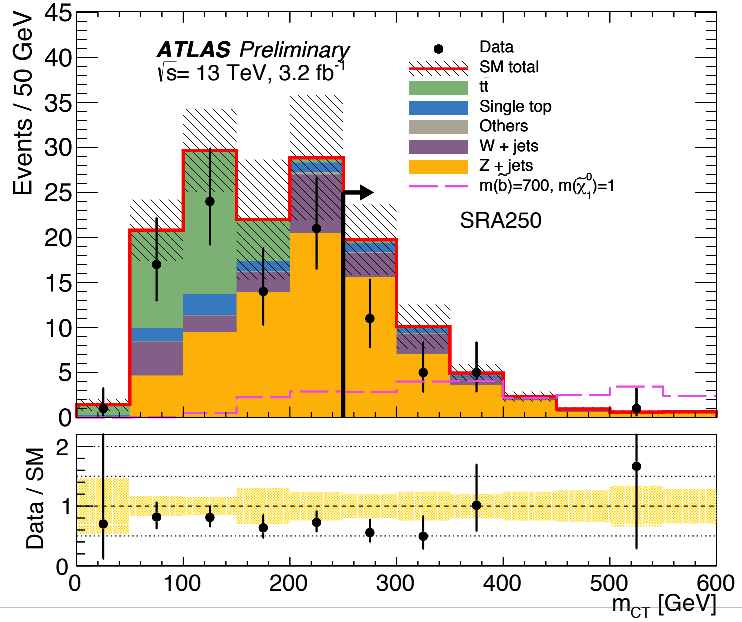
Direct squark

ATLAS-CONF-2015-066

Results: bottom-squark pair-production

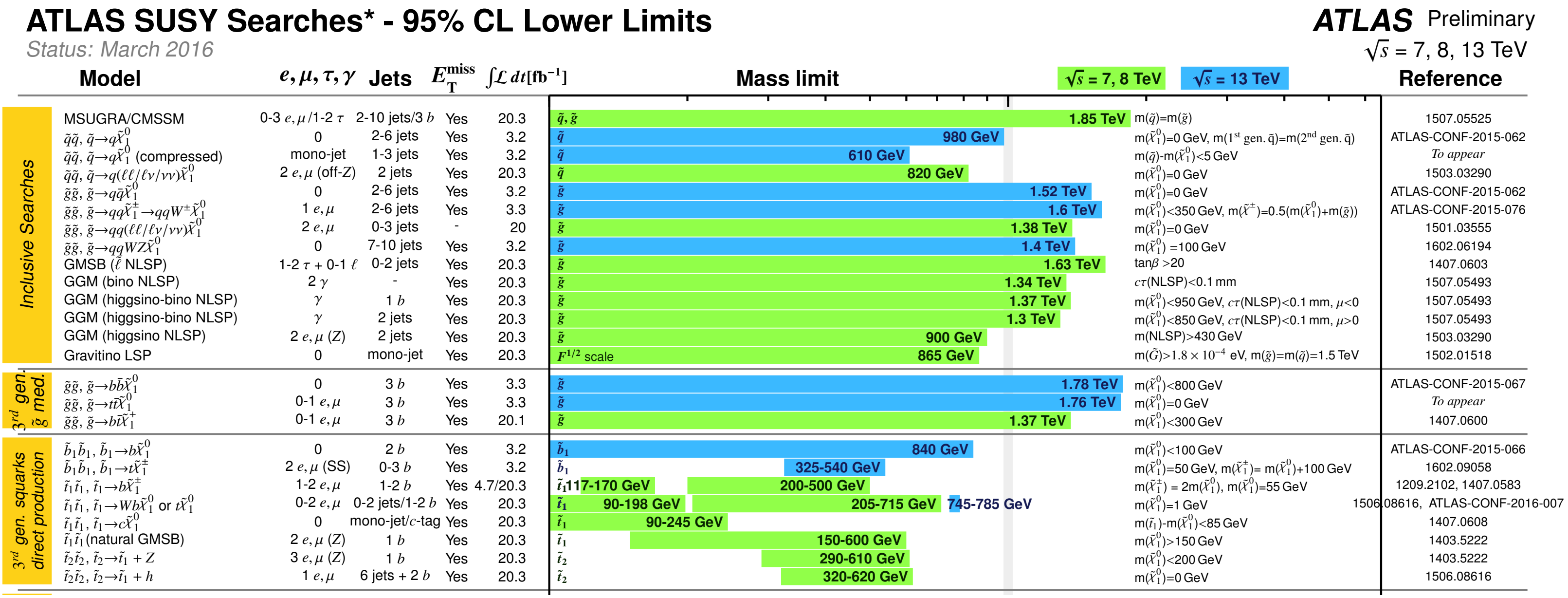
- **2 b-jet search with two sets of SRs**: one for large and one for small mass differences between sbottom and LSP
- **Improvement due to IBL**: 2x rejection of light jets at same b-tagging efficiency
- For large mass differences cut on contransverse mass; for small mass differences use recoil against ISR jet
- Backgrounds: W+jets, Z+jets and top events from control regions with 1 or 2 leptons





Conclusion and outlook

- **First run-2 data has made 2015 a productive year** for SUSY searches for squarks and gluinos
- Most searches focused on a simple strategy analogous to run-1 and primarily on gluino production, due to cross-section increase
- Many benefitted from additional discovery potential
- **No significant excesses** over Standard Model observed
- **2016 will be a very interesting year for SUSY searches as the LHC ventures into territory (far) beyond the currently obtained limits!**



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}	$\int\mathcal{L}\,dt[fb^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q},\tilde{g}$	🟩 1.85 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(1^{st} gen. $\tilde{q}$)=m(2^{nd} 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	tanβ >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($\tilde{G}$)>1.8×10^{-4} eV, m($\tilde{g}$)=m($\tilde{q}$)=1.5 TeV	1502.01518
3^{rd} 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
3^{rd} 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

All ATLAS SUSY public results always available online

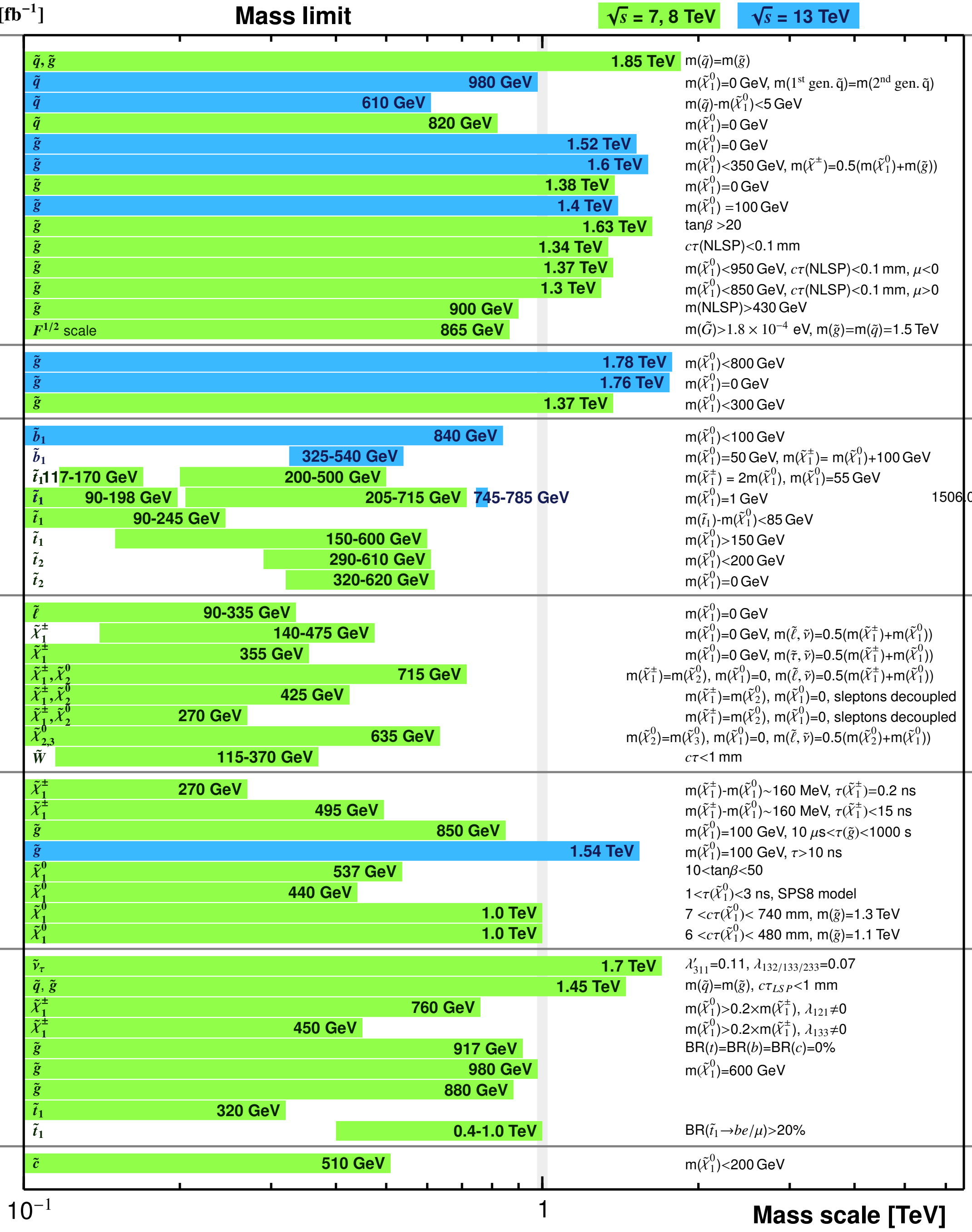
Backup material

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: March 2016

ATLAS Preliminary

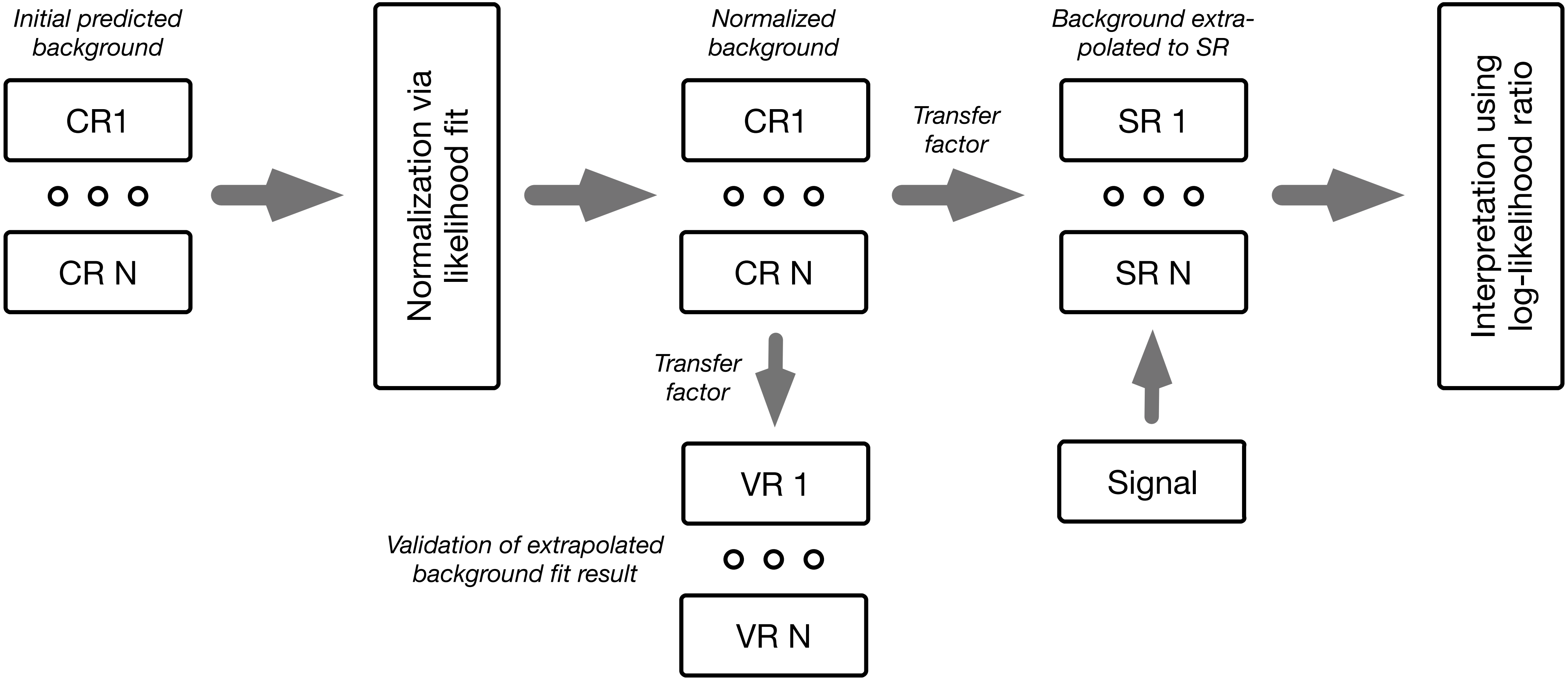
$\sqrt{s}$ = 7, 8, 13 TeV



	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	$\tilde{q},\tilde{g}$	🟩 1.85 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(1^{st} gen. $\tilde{q}$)=m(2^{nd} 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	tanβ >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($\tilde{G}$)>1.8×10^{-4} eV, m($\tilde{g}$)=m($\tilde{q}$)=1.5 TeV	1502.01518
3^{rd} 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
3^{rd} 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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0h\tilde{\chi}_1^0$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	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, τ($\tilde{\chi}_1^{\pm}$)=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, τ($\tilde{\chi}_1^{\pm}$)<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<τ($\tilde{g}$)<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<tanβ<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<τ($\tilde{\chi}_1^0$)<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×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×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
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	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

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

Background estimation using control regions



arXiv:1410.1280 / Eur. Phys. J. C 75 (2015) 153

0 leptons, 2-6 jets, E_T^{miss}

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0-lepton: signal and control region definitions

Requirement	Signal Region						
	2jl	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] $>$	200						
$p_{\mathrm{T}}(j_1)$ [GeV] $>$	200	300	200				
$p_{\mathrm{T}}(j_2)$ [GeV] $>$	200	50	200	100			
$p_{\mathrm{T}}(j_3)$ [GeV] $>$	–			100			
$p_{\mathrm{T}}(j_4)$ [GeV] $>$	–			100			
$p_{\mathrm{T}}(j_5)$ [GeV] $>$	–				100		
$p_{\mathrm{T}}(j_6)$ [GeV] $>$	–					100	
$\Delta\phi(\mathrm{jet}_{1,2,(3)}, \boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}} >$	0.8	0.4	0.8	0.4			
$\Delta\phi(\mathrm{jet}_{i>3}, \boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}} >$	–			0.2			
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ [GeV$^{1/2}$] $>$	15		20	–			
Aplanarity $>$	–			0.04			
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(N_{\mathrm{j}}) >$	–			0.2	0.25		0.2
m_{eff}(incl.) [GeV] $>$	1200	1600	2000	2200	1600	1600	2000

CR	SR background	CR process	CR selection
CRγ	$Z(\rightarrow \nu\bar{\nu})$+jets	γ+jets	Isolated photon
CRQ	Multi-jet	Multi-jet	SR with reversed requirements on (i) (jet, $\boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ and (ii) $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(N_{\mathrm{j}})$ or $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$
CRW	$W(\rightarrow \ell\nu)$+jets	$W(\rightarrow \ell\nu)$+jets	30 GeV $< m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}}) <$ 100 GeV, b-veto
CRT	$t\bar{t}$(+EW) and single top	$t\bar{t} \rightarrow b\bar{b}qq'\ell\nu$	30 GeV $< m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}}) <$ 100 GeV, b-tag

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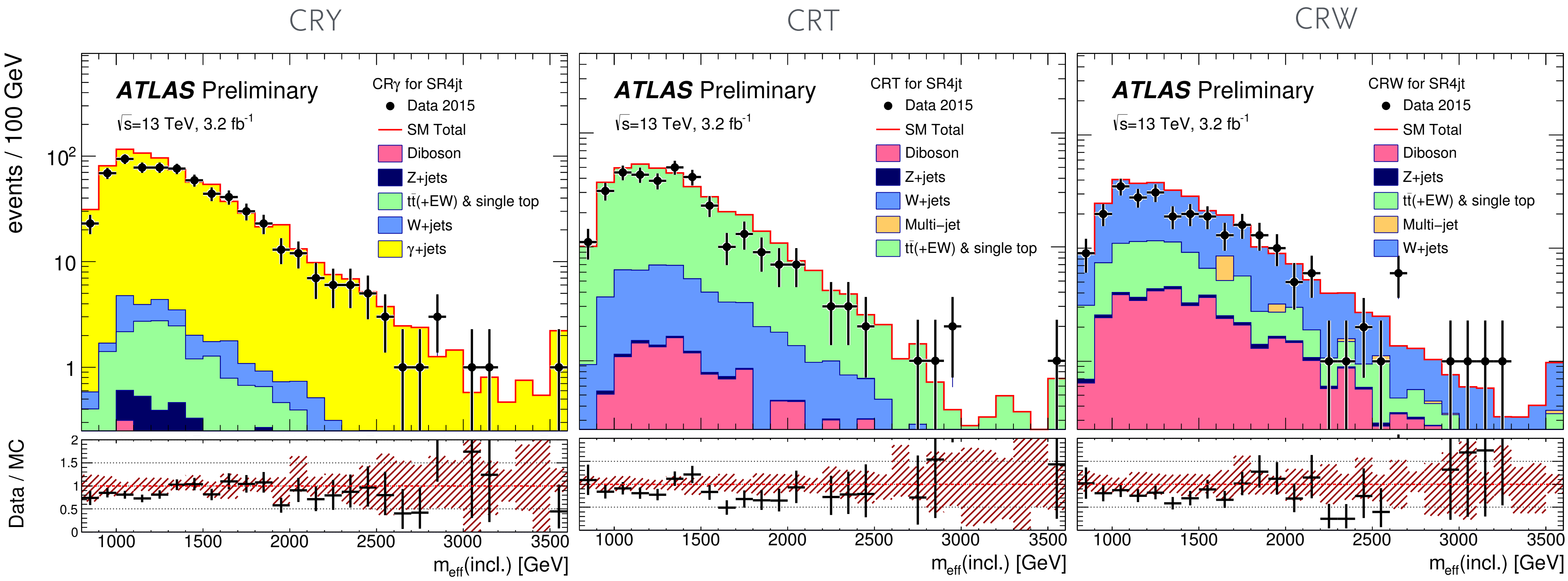
0-lepton: control region results



CRY

CRT

CRW

Control regions shown for SR4jt

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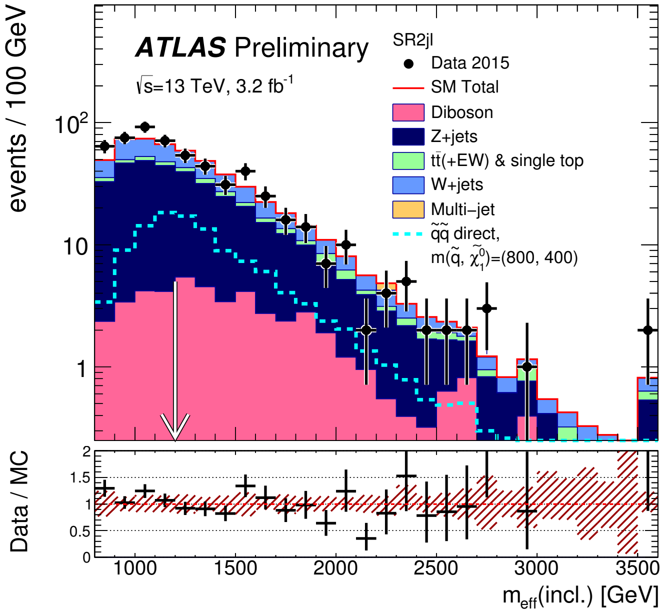
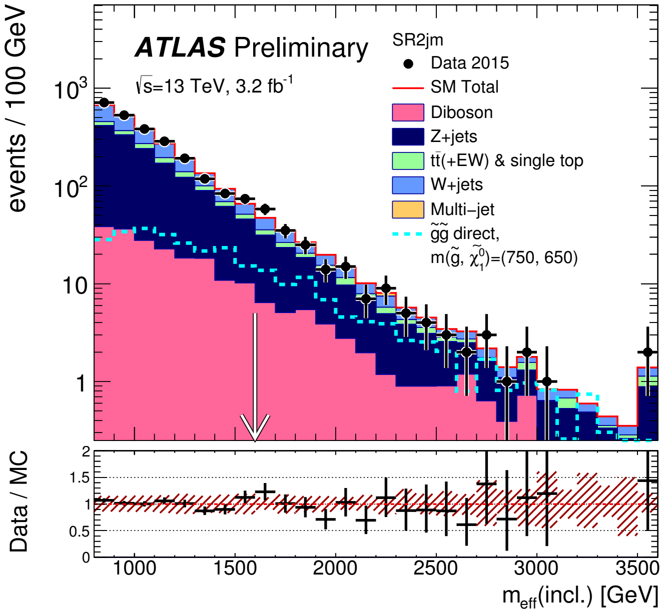
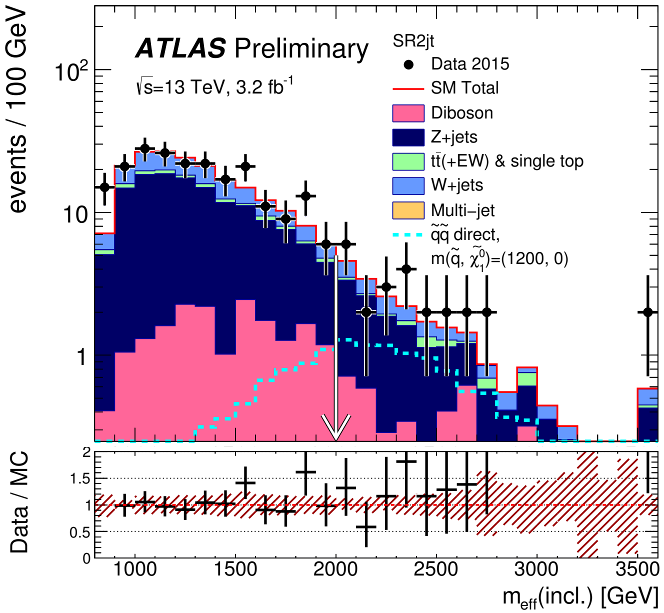
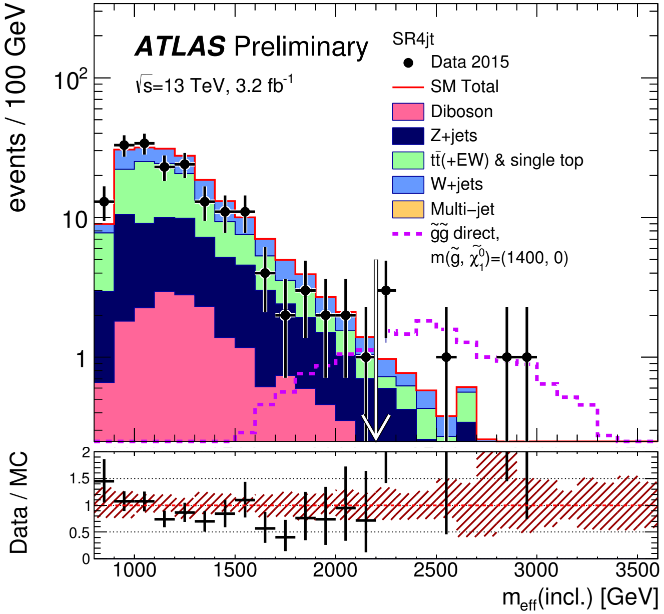
0-lepton: signal region results - 1/2









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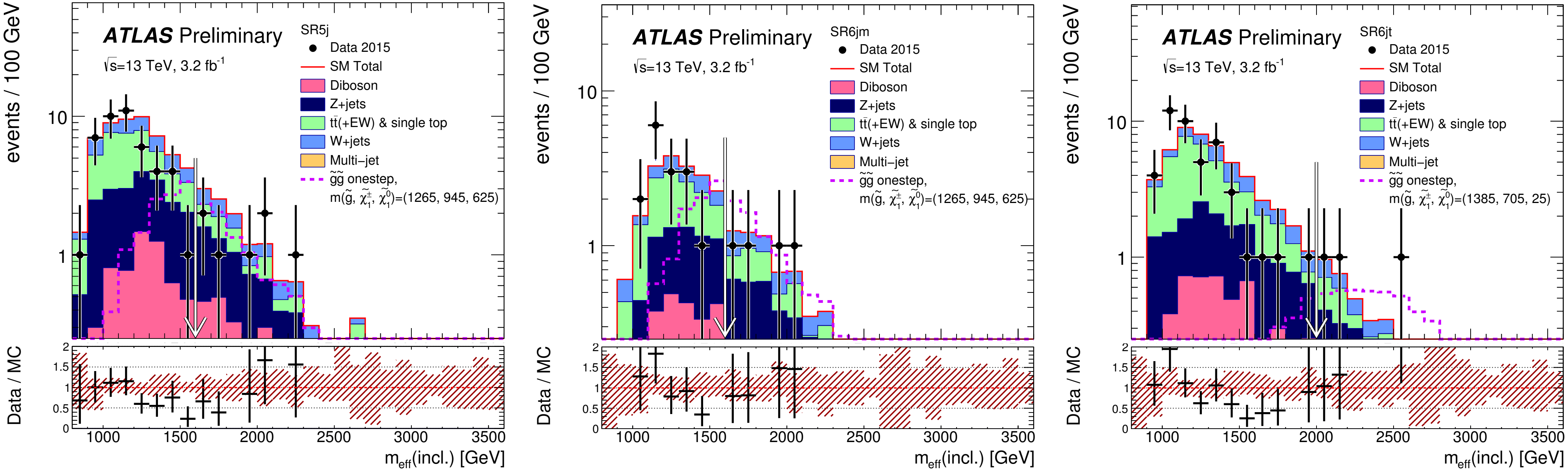
0-lepton: signal region results - 2/2



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0-lepton: results table

Signal Region	**2jl**	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
MC expected events							
Diboson	33	33	4.0	0.7	2.4	1.1	0.5
Z/γ^*+jets	151	94	12	1.8	4.9	2.5	1.3
W+jets	72	42	4.5	0.9	3.0	1.6	0.9
$t\bar{t}$(+EW) + single top	18	17	1.2	0.9	2.7	1.6	1.1
Multi-jet	0.6	0.8	0.03	–	–	–	–
Total MC	275	188	22	4.3	13	6.7	3.8
Fitted background events							
Diboson	33 ± 17	33 ± 17	4.0 ± 2.0	0.67 ± 0.35	2.4 ± 1.3	1.1 ± 0.6	0.5 ± 0.4
Z/γ^*+jets	127 ± 12	85 ± 8	12 ± 4	1.5 ± 0.6	4.5 ± 1.3	2.0 ± 0.7	1.1 ± 0.6
W+jets	61 ± 4	32 ± 5	2.9 ± 0.8	0.7 ± 0.4	3.3 ± 1.0	1.7 ± 0.7	1.0 ± 0.6
$t\bar{t}$(+EW) + single top	14.6 ± 2.9	10.5 ± 2.6	0.7 ± 0.5	0.6 ± 0.4	1.4 ± 0.5	0.8 ± 0.4	0.46 ± 0.33
Multi-jet	0.51 ± 0.06	0.6 ± 0.5	–	–	–	–	–
Total bkg	237 ± 22	163 ± 20	20 ± 5	3.5 ± 0.8	11.7 ± 2.2	5.5 ± 1.2	3.1 ± 0.9
Observed	264	186	25	6	7	4	3
$\langle\epsilon\sigma\rangle^{95}_{\mathrm{obs}}$ [fb]	24	21	5.9	2.5	2.0	1.6	1.6
S^{95}_{obs}	76	67	19	8.2	6.3	5.3	5.0
S^{95}_{exp}	52^{+22}_{-15}	46^{+19}_{-12}	$14.1^{+5.1}_{-3.1}$	$5.7^{+2.2}_{-1.6}$	$8.5^{+3.3}_{-2.1}$	$6.5^{+2.5}_{-1.6}$	$5.0^{+2.3}_{-1.4}$
p_0 (Z)	0.11 (1.20)	0.12 (1.15)	0.18 (0.93)	0.14 (1.08)	0.5 (0.0)	0.5 (0.0)	0.5 (0.0)

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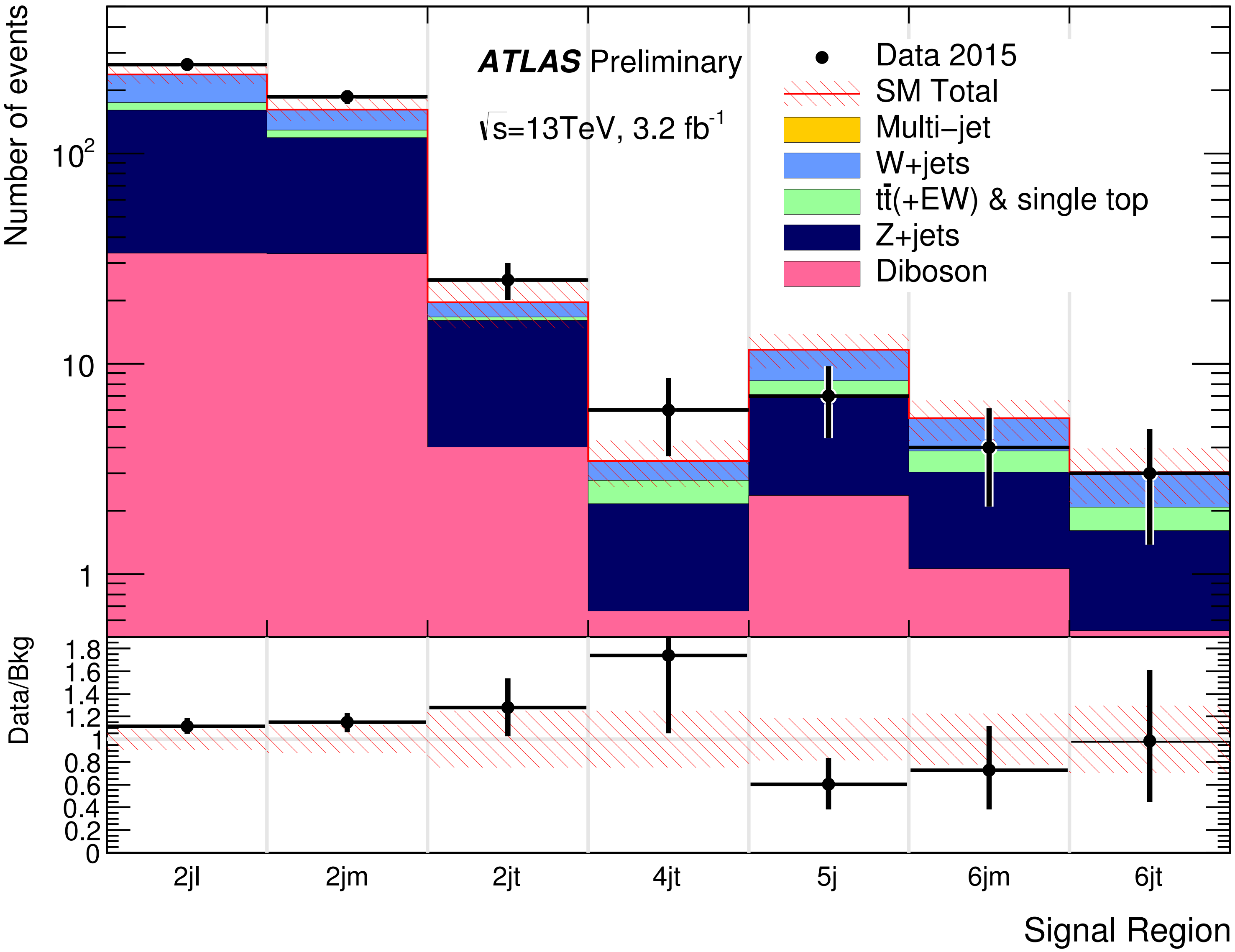
0-lepton: results overview



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0-lepton: systematic uncertainties

Channel	**2jl**	**2jm**	**2jt**	**4jt**	**5j**	**6jm**	**6jt**
Total bkg	237	163	20	3.5	11.7	5.5	3.1
Total bkg unc.	±22 [9%]	±20 [12%]	±5 [25%]	±0.8 [23%]	±2.2 [19%]	±1.2 [22%]	±0.9 [29%]
MC statistics	–	±1.8 [1%]	±0.5 [3%]	±0.26 [7%]	±0.5 [4%]	±0.35 [6%]	±0.27 [9%]
$\Delta\mu_{Z+\text{jets}}$	±6 [3%]	±5 [3%]	±2.0 [10%]	±0.5 [14%]	±0.8 [7%]	±0.6 [11%]	±0.4 [13%]
$\Delta\mu_{W+\text{jets}}$	±4 [2%]	±4 [2%]	±0.7 [3%]	±0.32 [9%]	±0.7 [6%]	±0.5 [9%]	±0.4 [13%]
$\Delta\mu_{\text{Top}}$	±1.2 [1%]	±1.6 [1%]	±0.21 [1%]	±0.26 [7%]	±0.32 [3%]	±0.21 [4%]	±0.24 [8%]
$\Delta\mu_{\text{Multi-jet}}$	±0.05 [0%]	±0.09 [0%]	–	–	–	–	–
CRγ corr. factor	±8 [3%]	±6 [4%]	±0.8 [4%]	±0.1 [3%]	±0.29 [2%]	±0.13 [2%]	±0.07 [2%]
Theory W	±1.4 [1%]	±2.3 [1%]	±0.4 [2%]	±0.22 [6%]	±0.7 [6%]	±0.4 [7%]	±0.34 [11%]
Theory Z	±6 [3%]	±3.2 [2%]	±4 [20%]	±0.32 [9%]	±0.9 [8%]	±0.32 [6%]	±0.3 [10%]
Theory Top	±2.7 [1%]	±2.1 [1%]	±0.5 [3%]	±0.24 [7%]	±0.2 [2%]	±0.27 [5%]	±0.2 [6%]
Theory Diboson	±16 [7%]	±16 [10%]	±2.0 [10%]	–	±1.0 [9%]	–	–
Jet/$E_{\text{T}}^{\text{miss}}$	±1.5 [1%]	±2.1 [1%]	±0.29 [1%]	±0.14 [4%]	±0.8 [7%]	±0.4 [7%]	±0.27 [9%]

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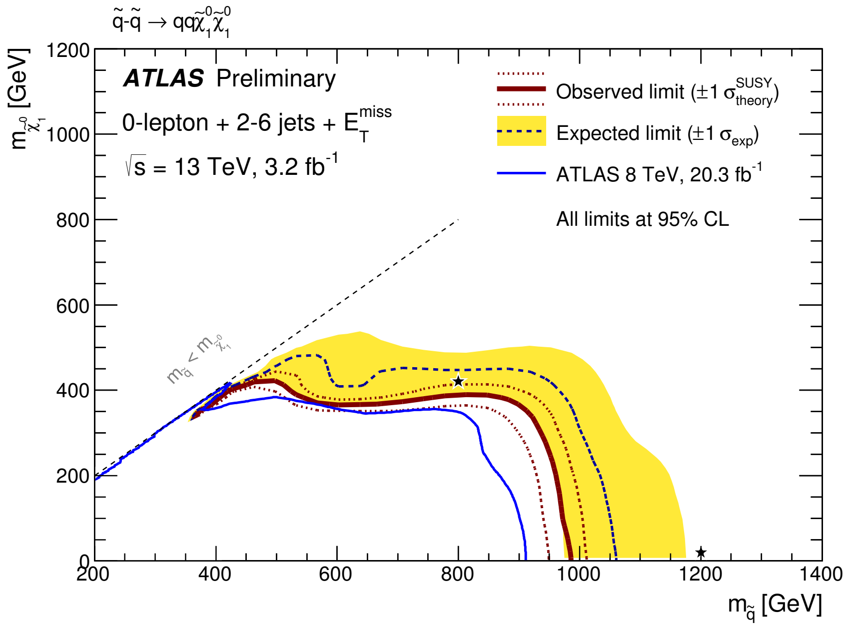
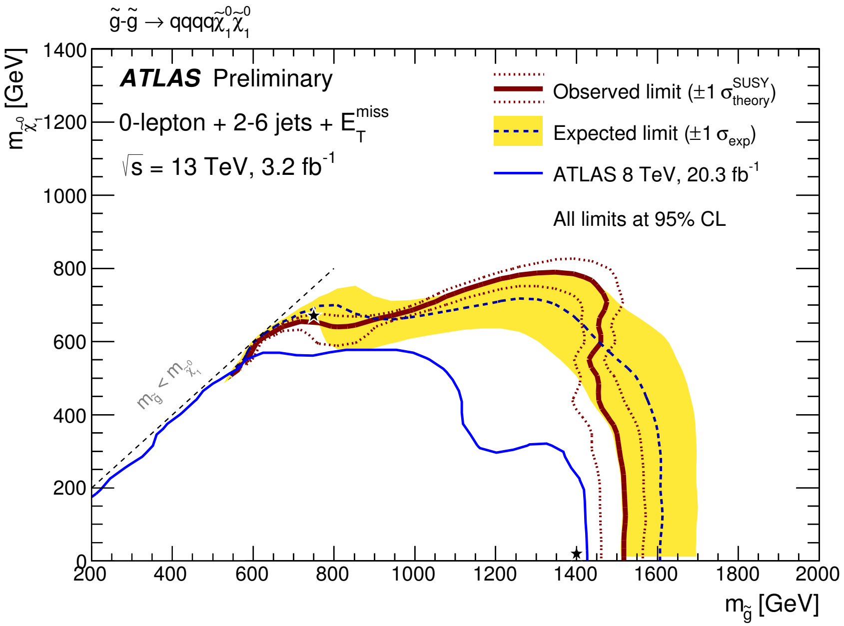
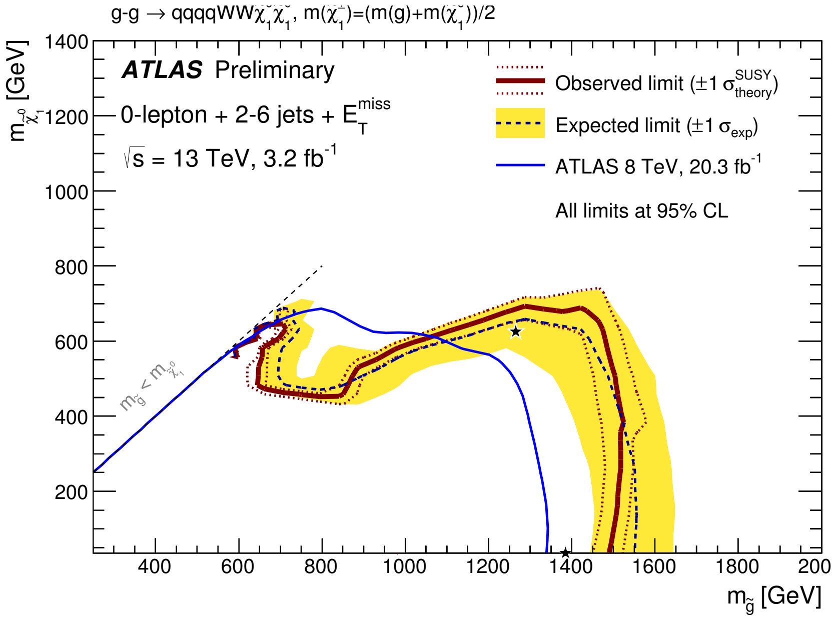
0-lepton: limit plots







0 leptons, 7+ jets, E_T^{miss}

arXiv:1602.06194 (SUSY-2015-07)

arXiv:1602.06194
(SUSY-2015-07)

Multijets: signal and control region definitions

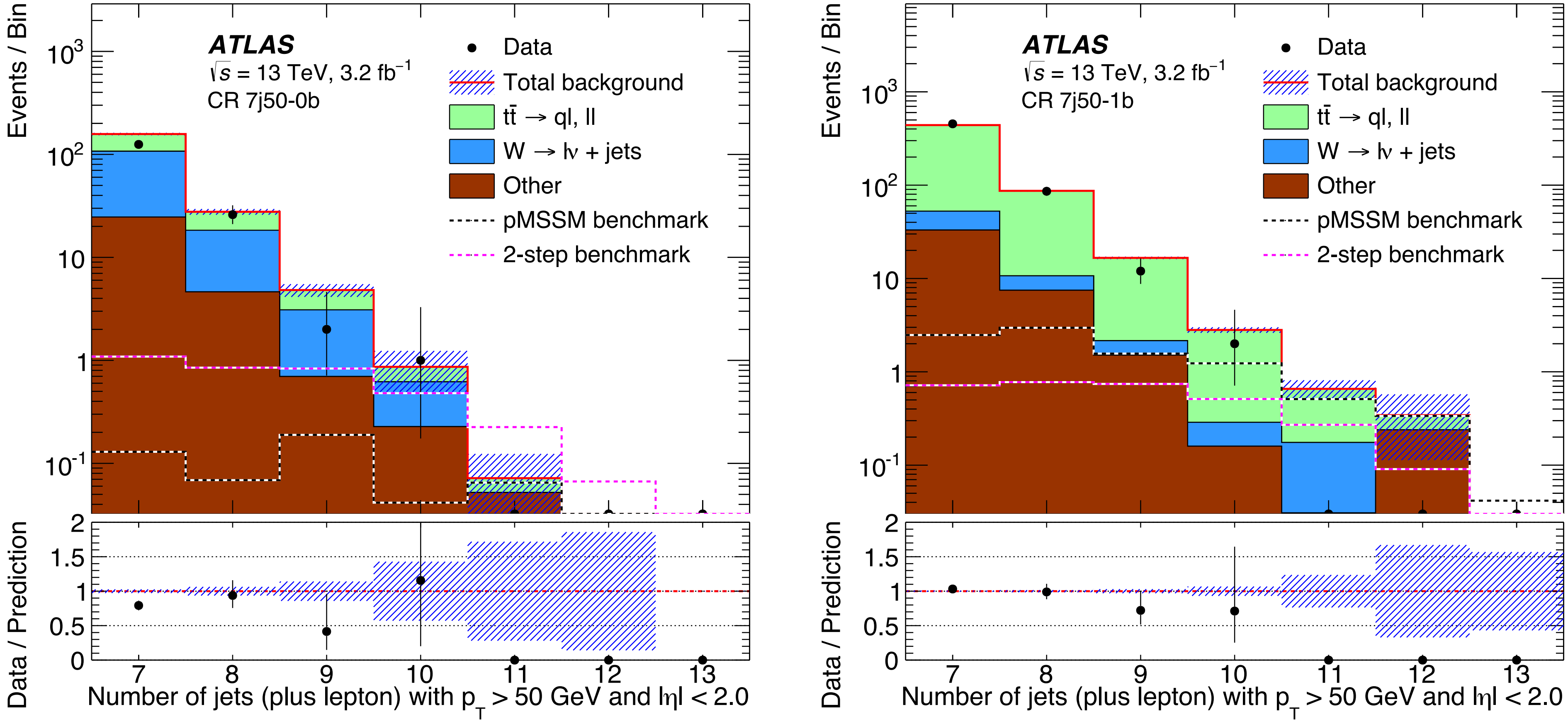
	`8j50`	`8j50-1b`	`8j50-2b`	`9j50`	`9j50-1b`	`9j50-2b`	`10j50`	`10j50-1b`	`10j50-2b`
n_{50}	≥ 8			≥ 9			≥ 10		
$n_{b-\text{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_{\mathrm{T}}^{\text{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 4\,\mathrm{GeV}^{1/2}$								

	`7j80`	`7j80-1b`	`7j80-2b`	`8j80`	`8j80-1b`	`8j80-2b`
n_{80}	≥ 7			≥ 8		
$n_{b-\text{jet}}$	—	≥ 1	≥ 2	—	≥ 1	≥ 2
$E_{\mathrm{T}}^{\text{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 4\,\mathrm{GeV}^{1/2}$					

SR name	n`j50` or n`j50-1b` or n`j50-2b`		n`j80` or n`j80-1b` or n`j80-2b`	
CR name	`CR`$(n-1)$`j50-0b`	`CR`$(n-1)$`j50-1b`	`CR`$(n-1)$`j80-0b`	`CR`$(n-1)$`j80-1b`
p_{T}^{ℓ} $(\ell \in \{e\,\mu\})$	> 20 GeV			
m_{T}	< 120 GeV			
$E_{\mathrm{T}}^{\text{miss}}/\sqrt{H_{\mathrm{T}}}$	$> 3\,\mathrm{GeV}^{1/2}$			
n_{50}^{CR}	$\geq n_{50}-1$		—	
n_{80}^{CR}	—		$\geq n_{80}-1$	
$n_{b-\text{jet}}$	0	≥ 1	0	≥ 1

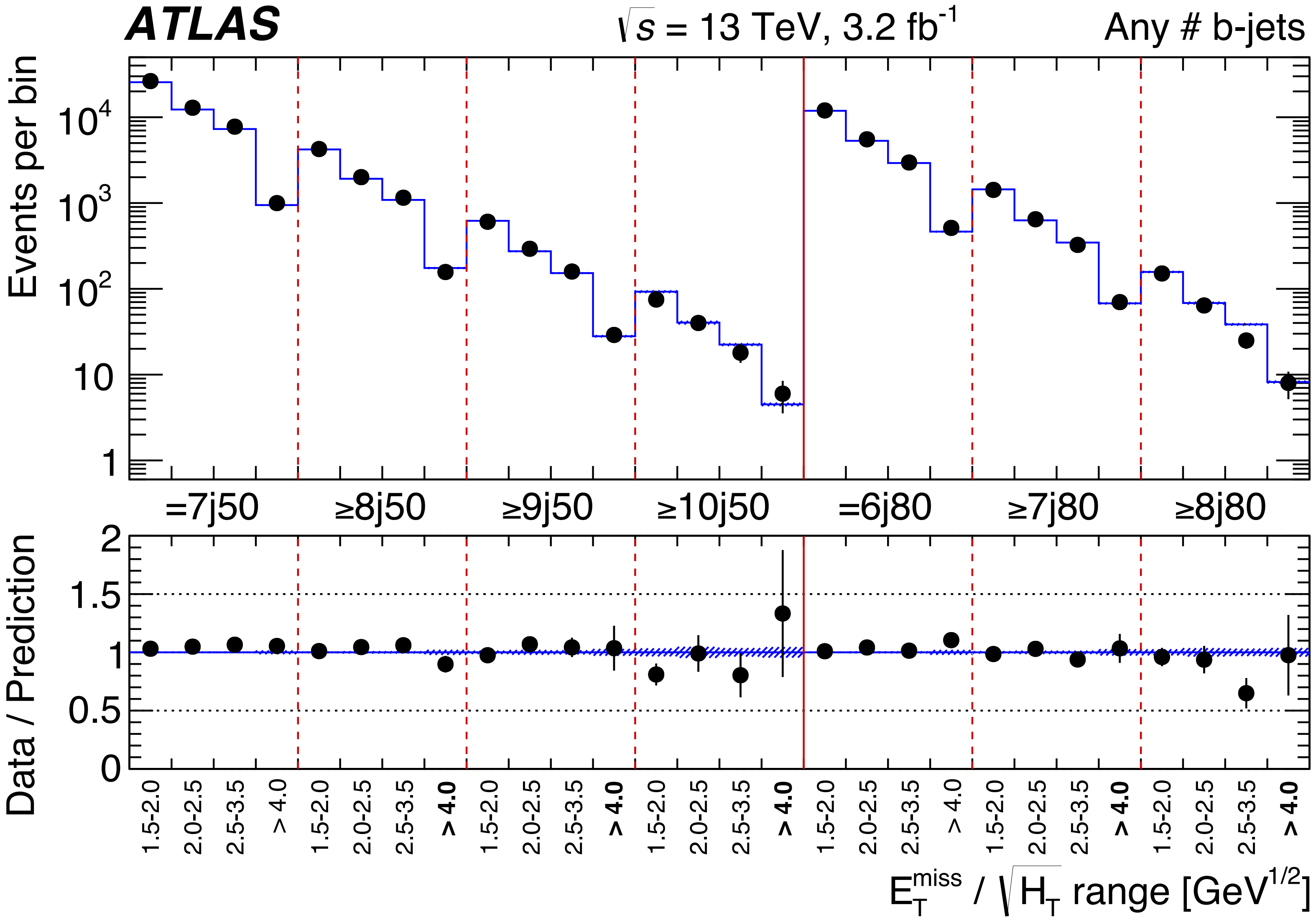
arXiv:1602.06194
(SUSY-2015-07)

Multijets: control region results (7-jet example)



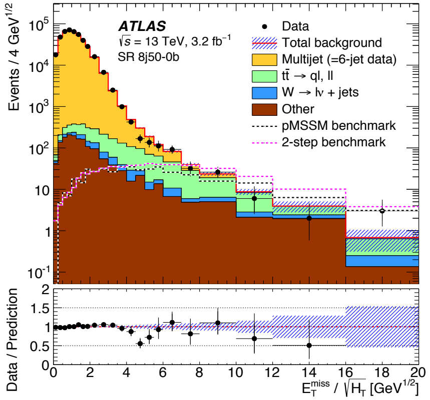
arXiv:1602.06194
(SUSY-2015-07)

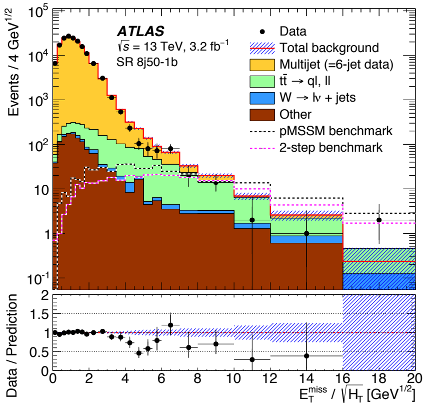
Multijets: closure test for multijets background

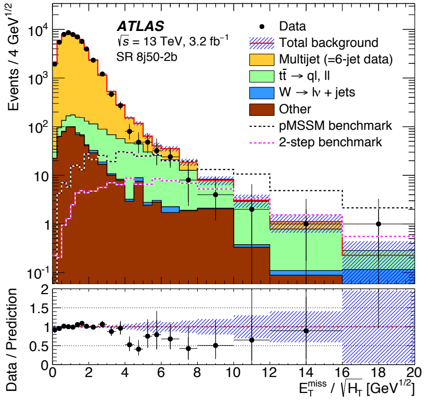


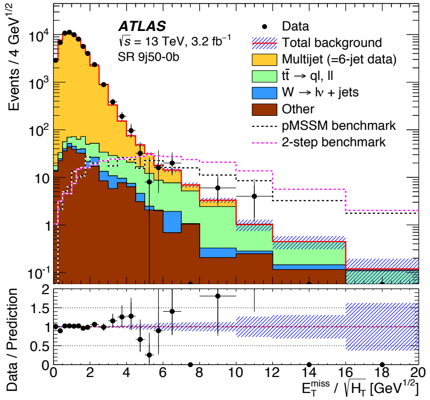
arXiv:1602.06194
(SUSY-2015-07)

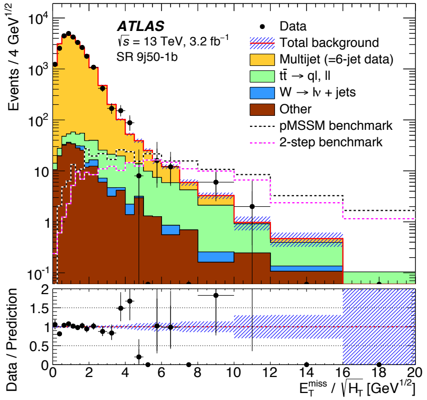
Multijets: signal region results (50 GeV jet regions)

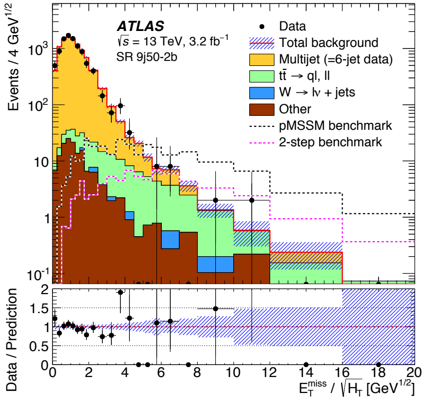


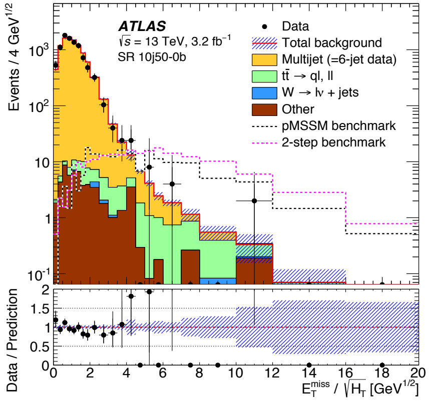


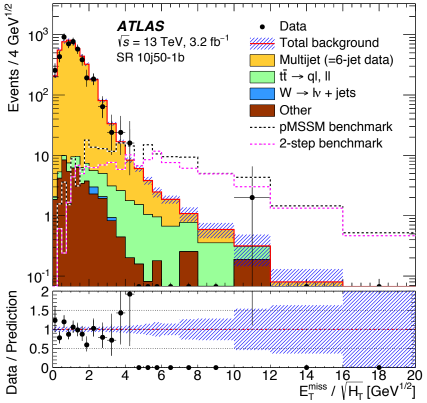


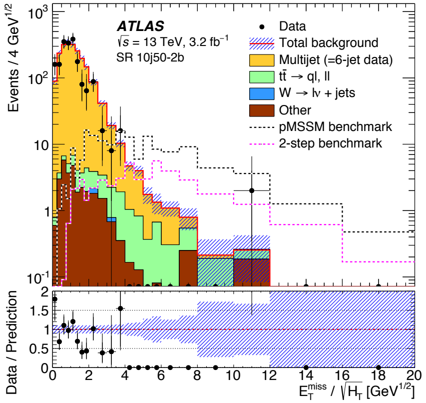






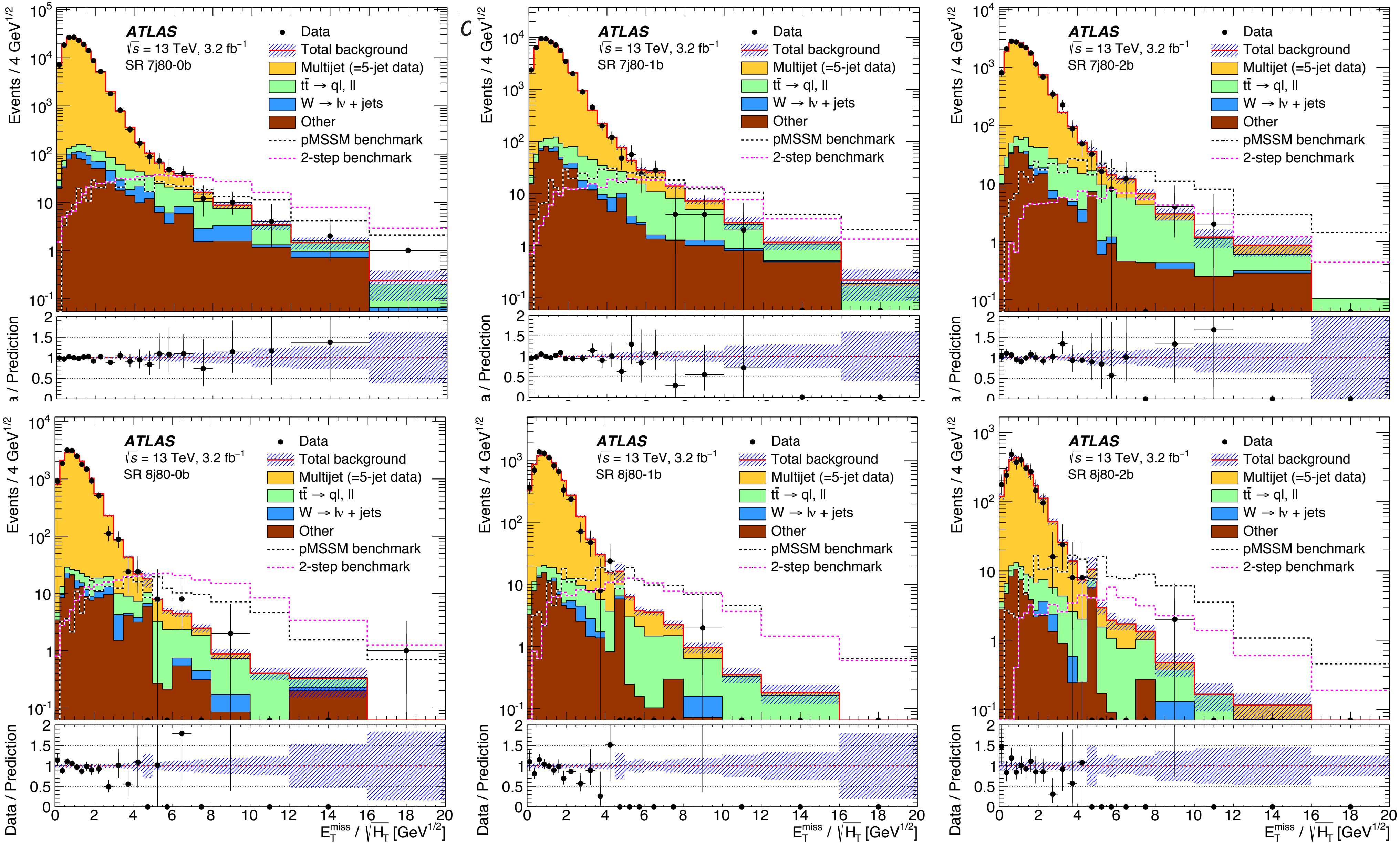






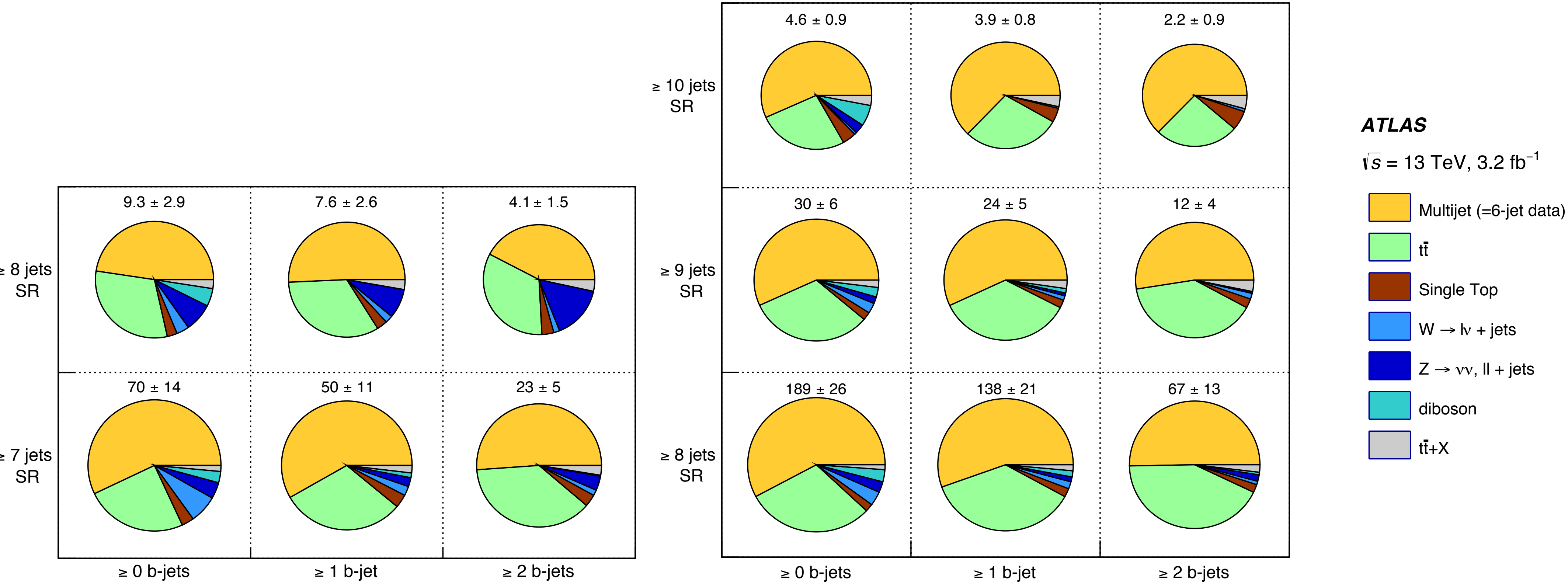
arXiv:1602.06194
(SUSY-2015-07)

Multijets: signal region results (80 GeV jet regions)



arXiv:1602.06194
(SUSY-2015-07)

Multijets: signal region background composition



Jet $p_T > 80$ GeV

Jet $p_T > 50$ GeV

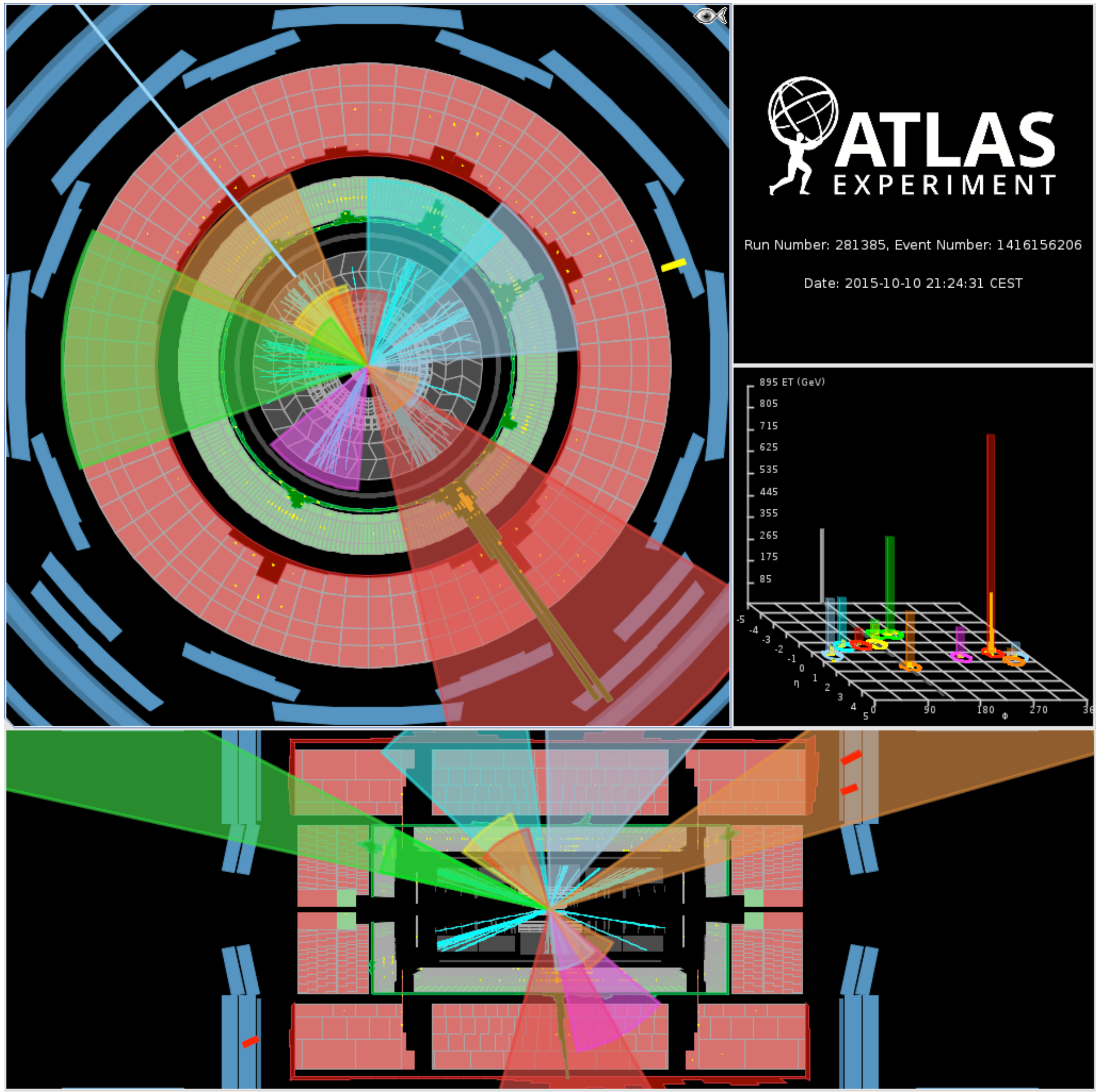
arXiv:1602.06194
(SUSY-2015-07)

Multijets: results table

Signal region	Fitted background			Obs events
	Multijet	Leptonic	Total	
8j50	109.3 ± 6.9	80 ± 25	189 ± 26	157
8j50-1b	76.7 ± 2.7	62 ± 21	138 ± 21	97
8j50-2b	33.8 ± 2.1	33 ± 13	67 ± 13	39
9j50	16.8 ± 1.3	12.8 ± 5.4	29.6 ± 5.6	29
9j50-1b	13.5 ± 2.0	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 ± 0.61	1.99 ± 0.62	4.60 ± 0.87	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 ± 5.3	30 ± 13	70 ± 14	70
7j80-1b	29.1 ± 3.4	20.8 ± 10	50 ± 11	42
7j80-2b	11.5 ± 1.6	11.0 ± 5.0	22.5 ± 5.2	19
8j80	4.5 ± 1.9	4.9 ± 2.2	9.3 ± 2.9	8
8j80-1b	3.9 ± 1.5	3.8 ± 2.1	7.6 ± 2.6	4
8j80-2b	1.72 ± 0.93	2.3 ± 1.1	4.1 ± 1.5	2

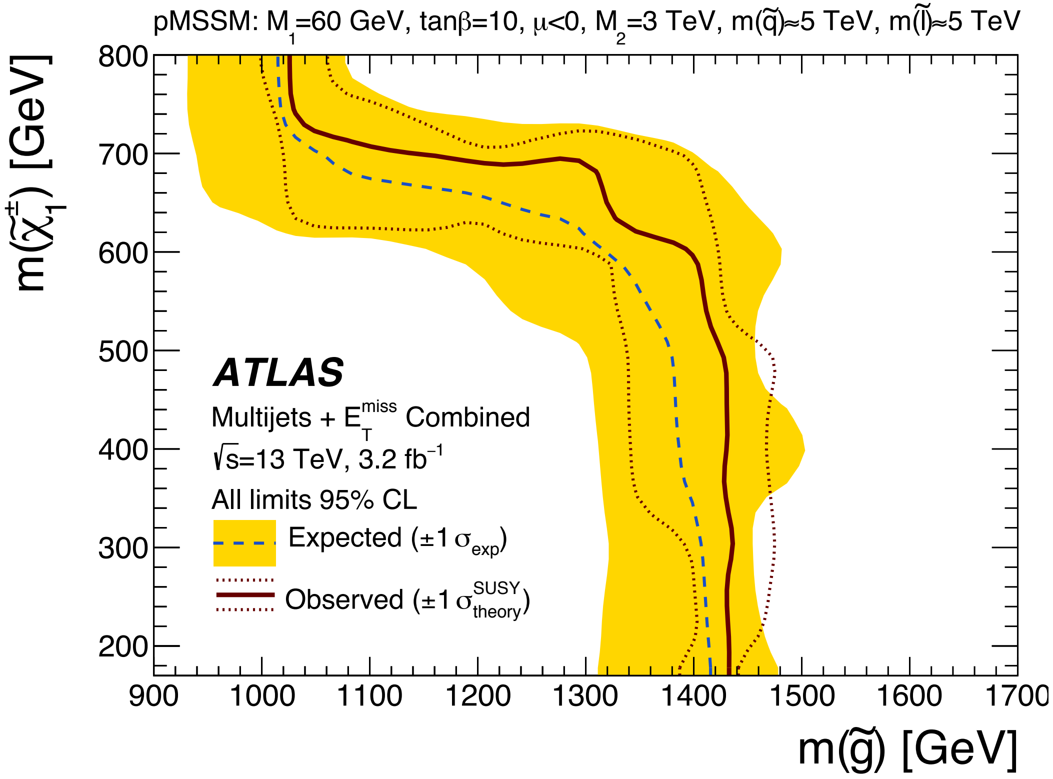
arXiv:1602.06194
(SUSY-2015-07)

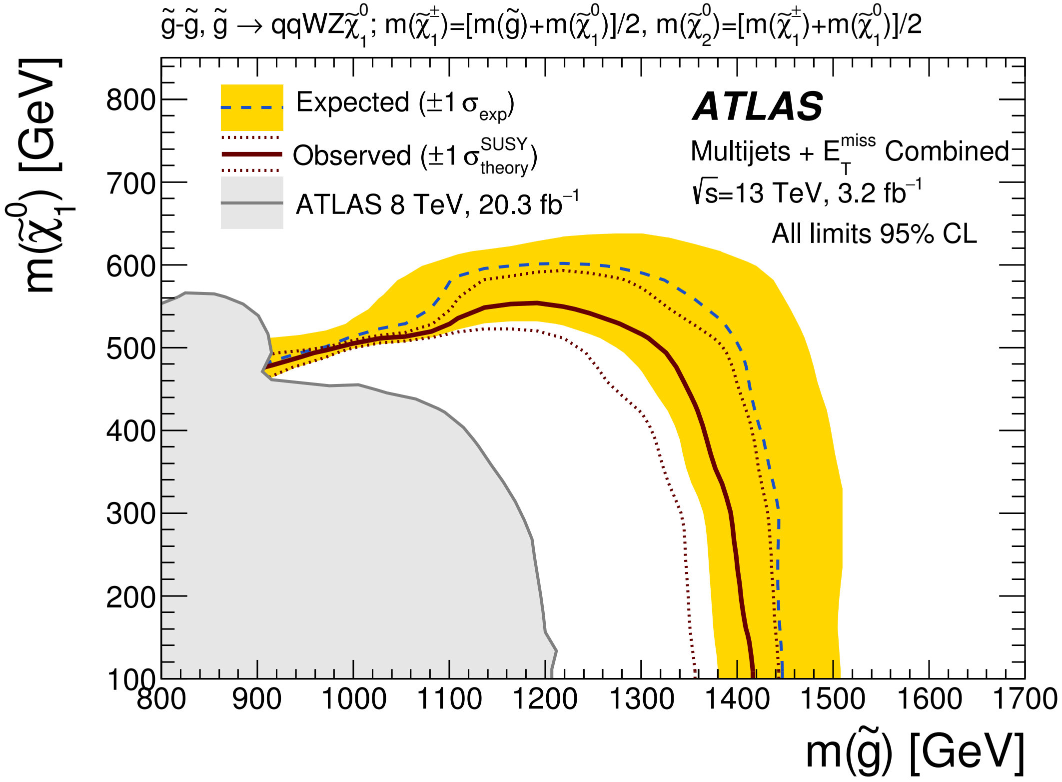
Multijets: 8-jet candidate event in 8j80



arXiv:1602.06194
(SUSY-2015-07)

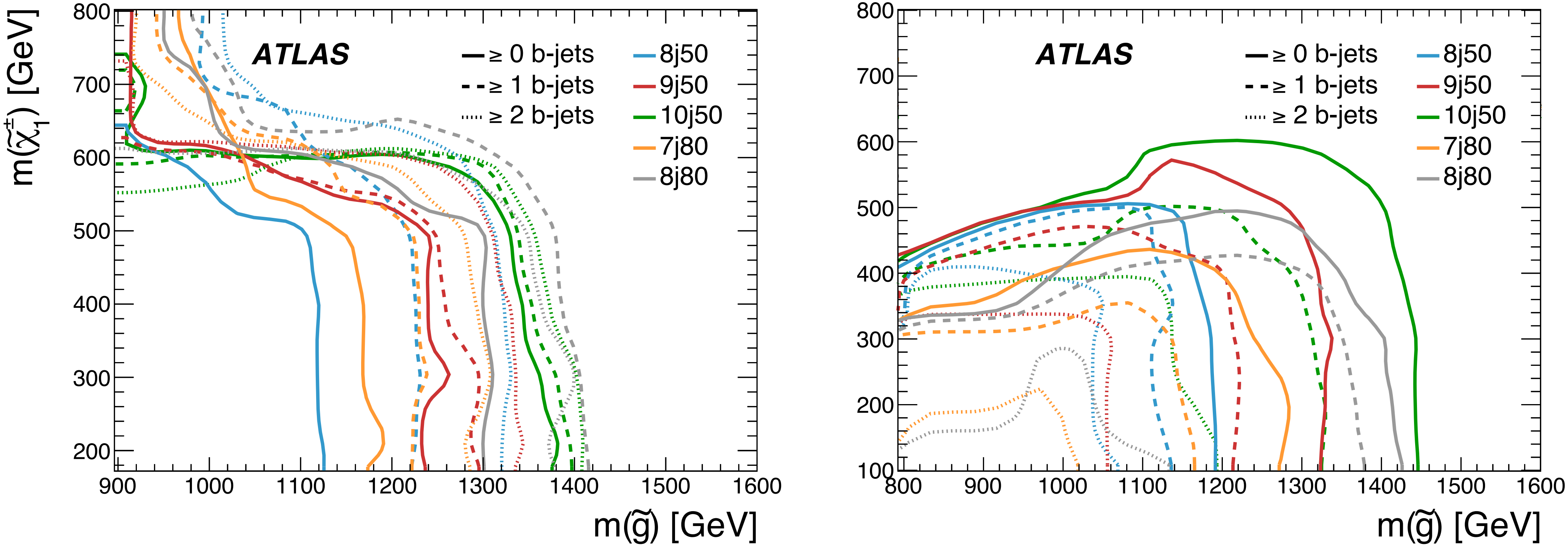
Multijets: limit plots





arXiv:1602.06194
(SUSY-2015-07)

Multijets: limit plots per signal region



0 leptons + 2 b-jets

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2 b-jets: signal region definitions

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

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2 b-jets: control region definitions

Variable	CRzA	CRttA	CRstA	CRwA	CRzB	CRttB
Number of lep.	2 SFOS	1	1	1	2 SFOS	1
Lead. lep. p_{T} [GeV]	> 26	> 26	> 26	> 26	> 26	> 26
2nd lep. p_{T} [GeV]	> 20	-	-	-	> 20	-
$m_{\ell\ell}$ [GeV]	$[76 - 106]$	-	-	-	$[76 - 106]$	-
m_{T} [GeV]	-	-	-	> 30	-	-
Lead. jet $p_{\mathrm{T}}(j_1)$ [GeV]	-	> 130	-	> 130	50	130
4th jet $p_{\mathrm{T}}(j_4)$	vetoed if > 50 GeV					
b-tagged jets	j_1 and j_2	j_1 and j_2	j_1 and j_2	j_1	j_2 and (j_3 or j_4)	j_2 and (j_3 or j_4)
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	< 100	> 100	> 100	> 100	< 70	> 200
$E_{\mathrm{T}}^{\mathrm{miss,cor}}$ [GeV]	> 100	-	-	-	> 100	-
m_{bb} [GeV]	-	< 200	> 200	$(m_{bj}) > 200$	-	-
m_{CT} [GeV]	> 150	> 150	> 150	> 150	-	-
$m_{b\ell}^{\mathrm{min}}$ [GeV]	-	-	> 170	-	-	-
$\Delta\phi(j_1,\ E_{\mathrm{T}}^{\mathrm{miss}})$	-	-	-	-	> 2.0	> 2.5

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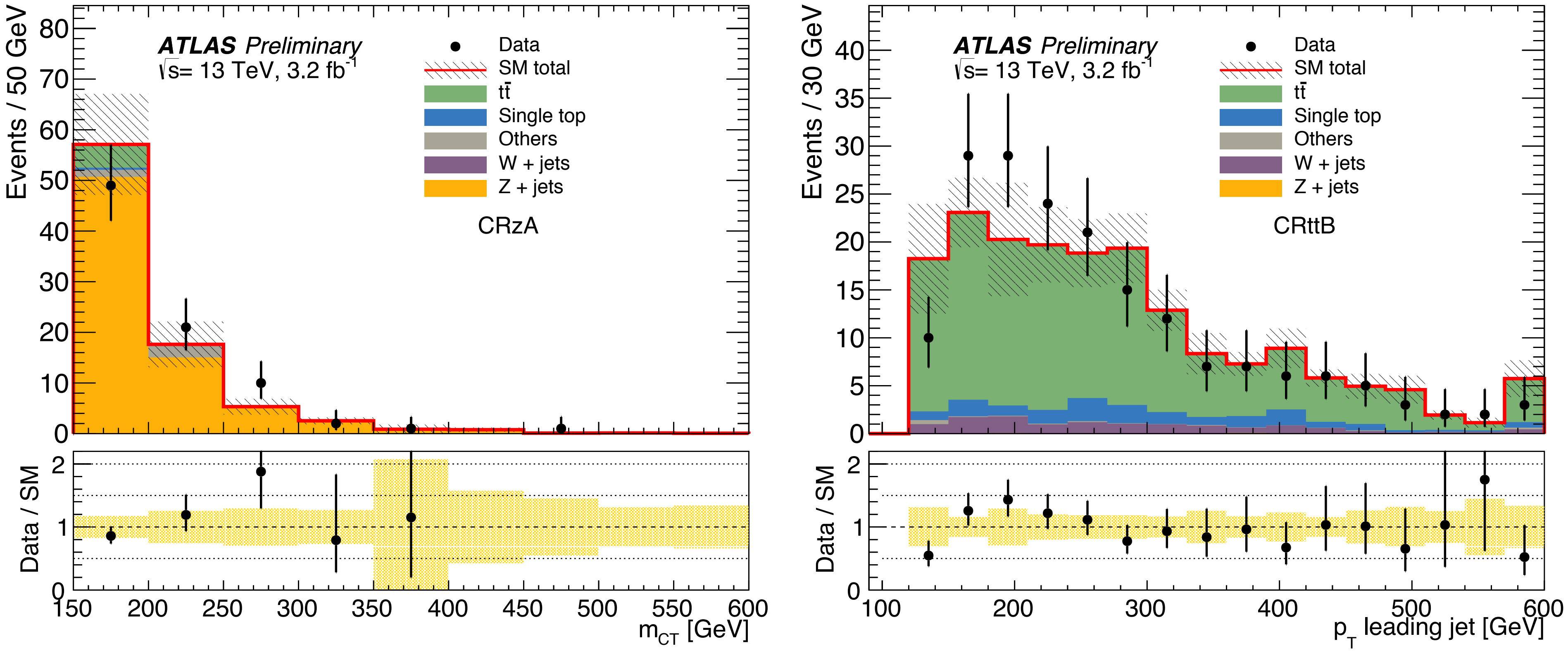
2 b-jets: control region results



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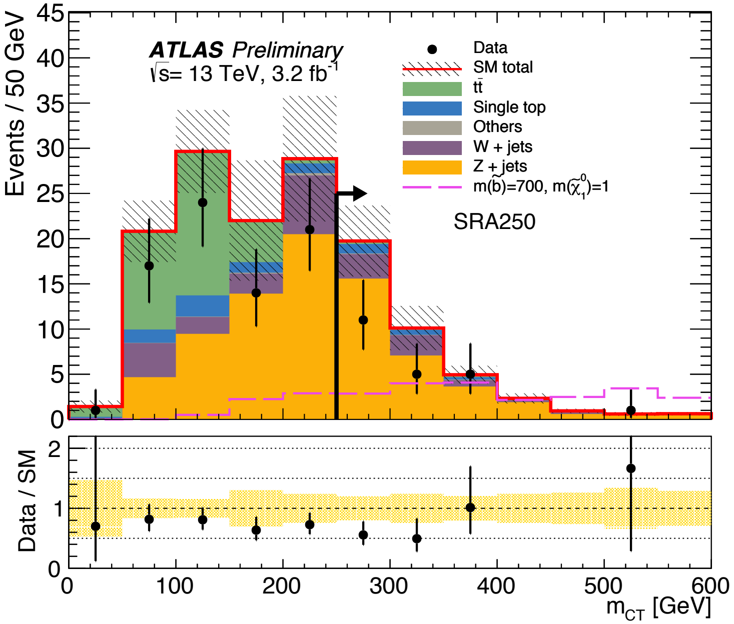
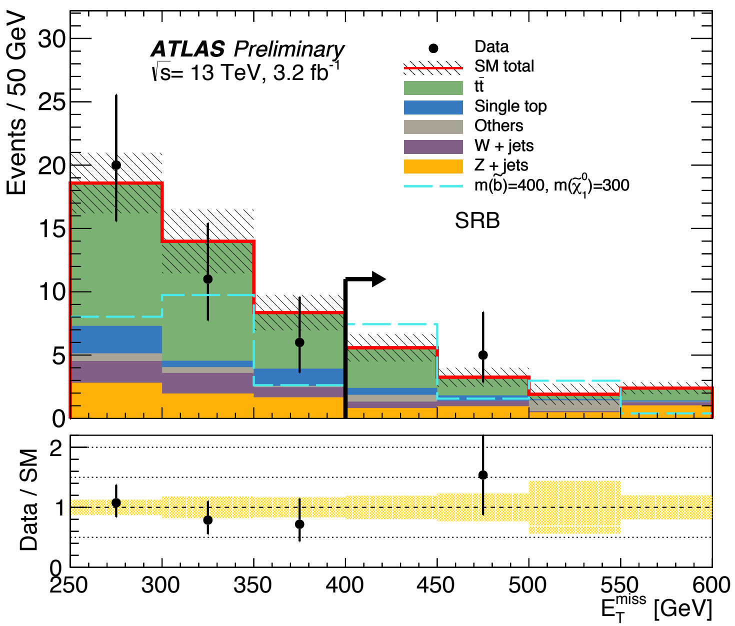
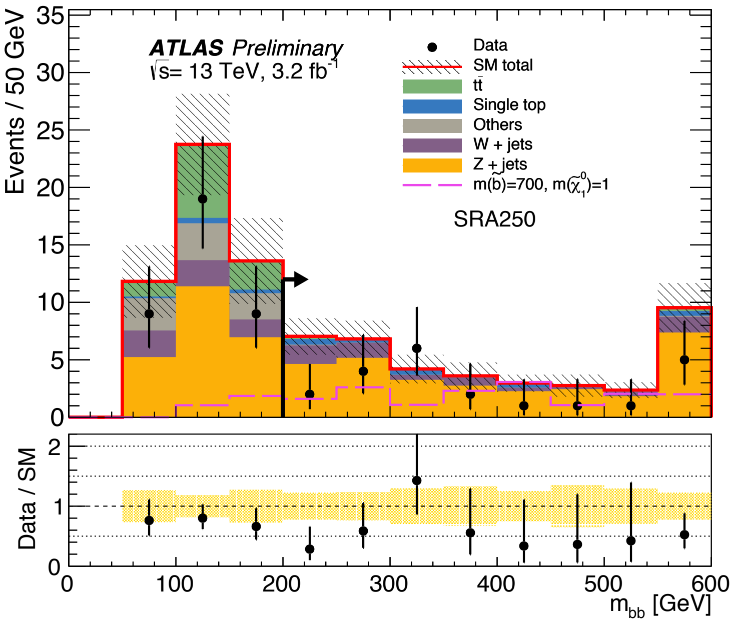
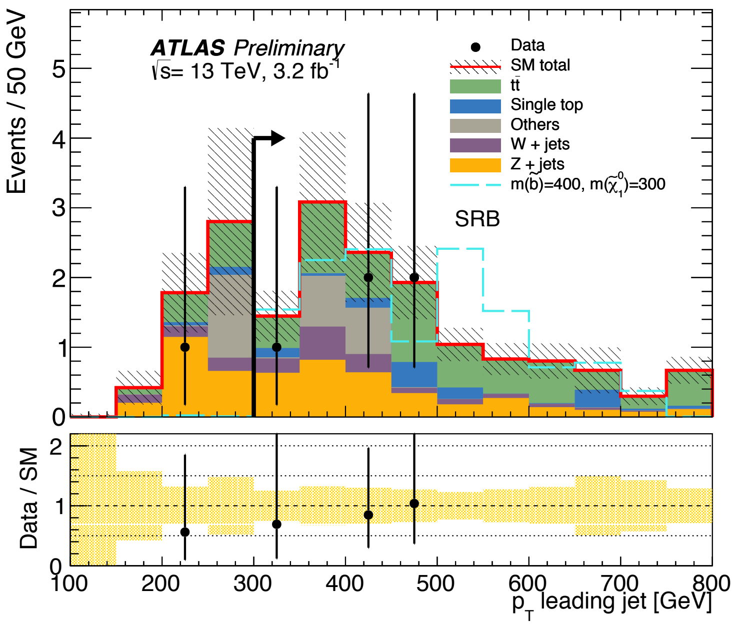
2 b-jets: signal region results









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2 b-jets: results table (control regions)

CR	CRzA	CRwA	CRttA	CRstA	CRzB	CRttB
Observed events	84	540	255	54	55	181
Fitted bkg events	84 ± 9	540 ± 23	255 ± 16	54 ± 7	55 ± 7	181 ± 13
Fitted $t\bar{t}$ events	4.7 ± 1.4	123 ± 29	169 ± 25	8.3 ± 3.8	14 ± 4	150 ± 15
Fitted single top events	0.4 ± 0.4	49 ± 25	27 ± 13	22 ± 8	0.4 ± 0.2	16.8 ± 2.9
Fitted W+jets events	-	350 ± 47	52 ± 17	23 ± 6	-	12.6 ± 4.9
Fitted Z+jets events	75 ± 9	5.0 ± 1.6	2.3 ± 0.5	-	41 ± 8	0.3 ± 0.1
Fitted “Other” events	3.6 ± 1.3	11.7 ± 2.1	4.4 ± 0.9	0.8 ± 0.4	-	1.3 ± 0.6
MC exp. SM events	54	491	283	56	49	196
MC exp. $t\bar{t}$ events	5.7	148	204	10	15	166
MC exp. single top events	0.5	62	34	28	0.4	17
MC exp. W+jets events	-	266	40	17	-	12.6
MC exp. Z+jets events	45	3.0	1.4	-	33	0.2
MC exp. “Other” events	3.6	11.7	4.4	0.8	-	1.3

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2 b-jets: results table (signal regions)

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
MC exp. SM events	27	6.5	1.5	13
MC exp. $t\bar{t}$ events	1.1	0.45	0.07	6.6
MC exp. single top events	2.7	0.7	0.20	1.2
MC exp. W+jets events	4.7	1.0	0.31	1.2
MC exp. Z+jets events	18	4.2	0.9	2.7
MC exp. "Other" events	0.7	0.1	0.02	1.4

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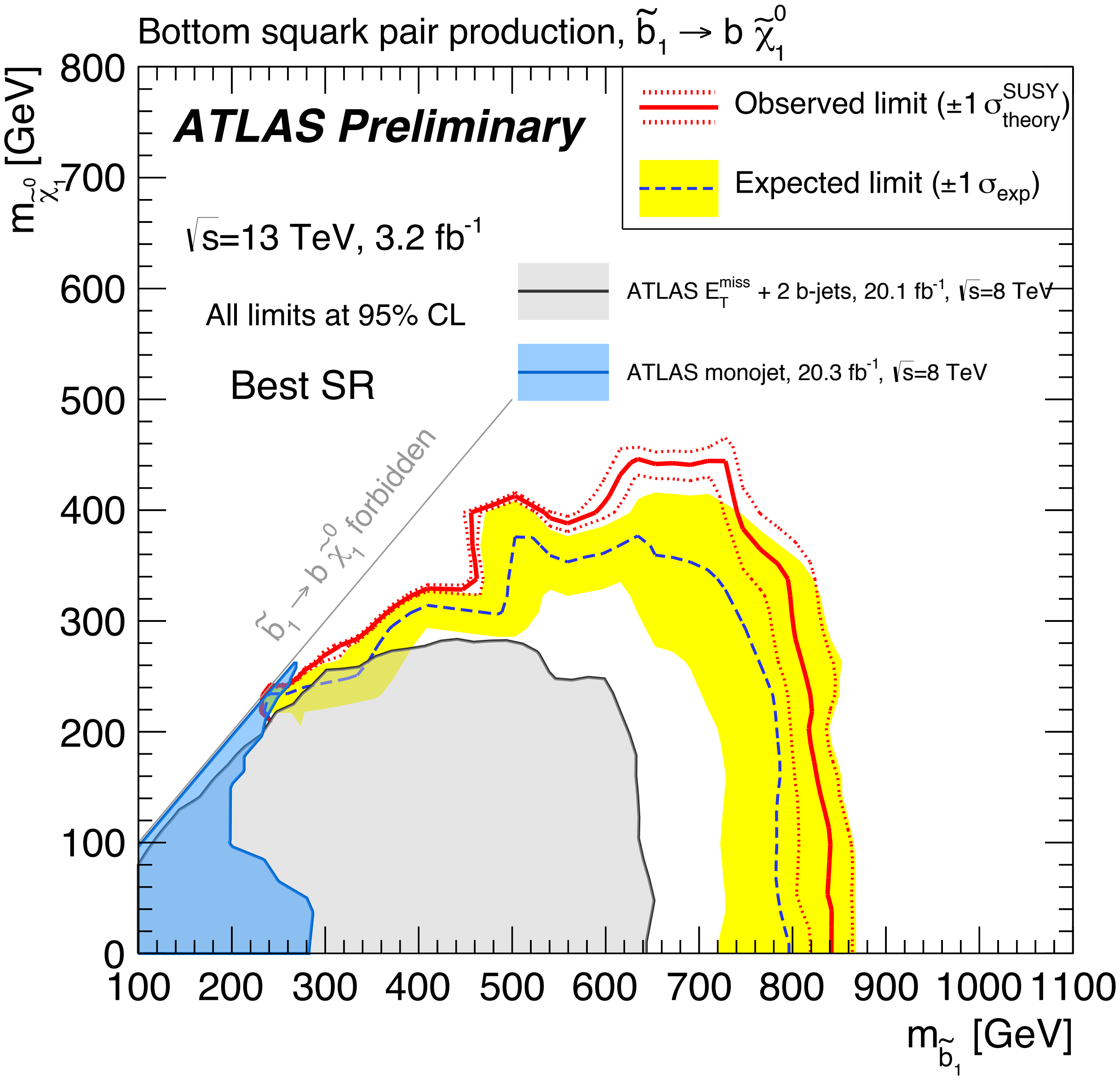
2 b-jets: limit plots



0 or 1 leptons + 3+ b-jets

ATLAS-CONF-2015-067

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0/1 lepton, 3+ b-jets: signal and control regions (Gbb)

Criteria common to all Gbb regions: ≥ 4 signal jets, ≥ 3 b-jets

	Variable	Signal region	Control region	Validation region
Criteria common to all regions of the same type	Lepton	Candidate veto	$= 1$ signal	Candidate veto
	$\Delta\phi^{4\mathrm{j}}_{\mathrm{min}}$	> 0.4	–	> 0.4
	$\mathrm{m}^{b-\mathrm{jets}}_{\mathrm{T,min}}$	–	–	< 160
	m_{T}	–	< 150	–
Region A (Large mass splitting)	${p_{\mathrm{T}}}^{\mathrm{jet}}$	> 90	> 90	> 90
	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 350	> 250	> 250
	$\mathrm{m}^{4\mathrm{j}}_{\mathrm{eff}}$	> 1600	> 1200	< 1400
Region B (Moderate mass splitting)	${p_{\mathrm{T}}}^{\mathrm{jet}}$	> 90	> 90	> 90
	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 450	> 300	> 300
	$\mathrm{m}^{4\mathrm{j}}_{\mathrm{eff}}$	> 1400	> 1000	< 1400
Region C (Small mass splitting)	${p_{\mathrm{T}}}^{\mathrm{jet}}$	> 30	> 30	> 30
	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 500	> 400	> 400
	$\mathrm{m}^{4\mathrm{j}}_{\mathrm{eff}}$	> 1400	> 1200	< 1400

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0/1 lepton, 3+ b-jets: signal and control regions (Gtt 0-lep)

Criteria common to all Gtt 0-lepton regions: ${p_{\mathrm{T}}}^{\mathrm{jet}} > 30$ GeV

	Variable	Signal region	Control region	VR1L	VR0L
Criteria common to all regions of the same type	Lepton	0 signal	= 1 signal	= 1 signal	0 signal
	$\Delta\phi^{4j}_{\mathrm{min}}$	> 0.4	–	–	> 0.4
	$\mathrm{N}^{\mathrm{jet}}$	≥ 8	≥ 7	≥ 7	≥ 8
	$\mathrm{m}^{b-\mathrm{jets}}_{\mathrm{T,min}}$	> 80	–	> 80	< 80
	m_{T}	–	< 150	< 150	–
Region A (Large mass splitting)	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 400	> 250	> 250	> 200
	$\mathrm{m}^{\mathrm{incl}}_{\mathrm{eff}}$	> 1700	> 1350	> 1350	> 1400
	$\mathrm{N}^{b-\mathrm{jet}}$	≥ 3	≥ 3	≥ 3	≥ 2
	$\mathrm{N}^{\mathrm{top}}$	≥ 1	≥ 1	≥ 1	≥ 1
Region B (Moderate mass splitting)	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 350	> 200	> 200	> 200
	$\mathrm{m}^{\mathrm{incl}}_{\mathrm{eff}}$	> 1250	> 1000	> 1000	> 1100
	$\mathrm{N}^{b-\mathrm{jet}}$	≥ 4	≥ 4	≥ 4	≥ 3
	$\mathrm{N}^{\mathrm{top}}$	≥ 1	≥ 1	≥ 1	≥ 1
Region C (Small mass splitting)	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 350	> 200	> 200	> 200
	$\mathrm{m}^{\mathrm{incl}}_{\mathrm{eff}}$	> 1250	> 1000	> 1000	> 1250
	$\mathrm{N}^{b-\mathrm{jet}}$	≥ 4	≥ 4	≥ 4	≥ 3

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0/1 lepton, 3+ b-jets: signal and control regions (Gtt 1-lep)

Criteria common to all Gtt 1-lepton regions: ≥ 1 signal lepton, ${p_{\mathrm{T}}}^{\mathrm{jet}} > 30$ GeV

	Variable	Signal region	Control region	VR-m_{T}	VR-$\mathrm{m}_{\mathrm{T,min}}^{b-\mathrm{jets}}$
Criteria common to all regions of the same type	m_{T}	> 150	< 150	> 150	< 150
	$\mathrm{N}^{\mathrm{jet}}$	≥ 6	≥ 6	≥ 5	≥ 6
	$\mathrm{N}^{b-\mathrm{jet}}$	≥ 3	≥ 3	$= 3$	$= 3$
Region A (Large mass splitting)	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 200	> 200	> 200	> 200
	$\mathrm{m}_{\mathrm{eff}}^{\mathrm{incl}}$	> 1100	> 1100	> 600	> 600
	$\mathrm{m}_{\mathrm{T,min}}^{b-\mathrm{jets}}$	> 160	–	< 160	> 140
	$\mathrm{N}^{\mathrm{top}}$	≥ 1	≥ 1	≥ 1	≥ 1
Region B (Moderate to small mass splitting)	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 300	> 300	> 200	> 200
	$\mathrm{m}_{\mathrm{eff}}^{\mathrm{incl}}$	> 900	> 900	> 600	> 600
	$\mathrm{m}_{\mathrm{T,min}}^{b-\mathrm{jets}}$	> 160	–	< 160	> 160

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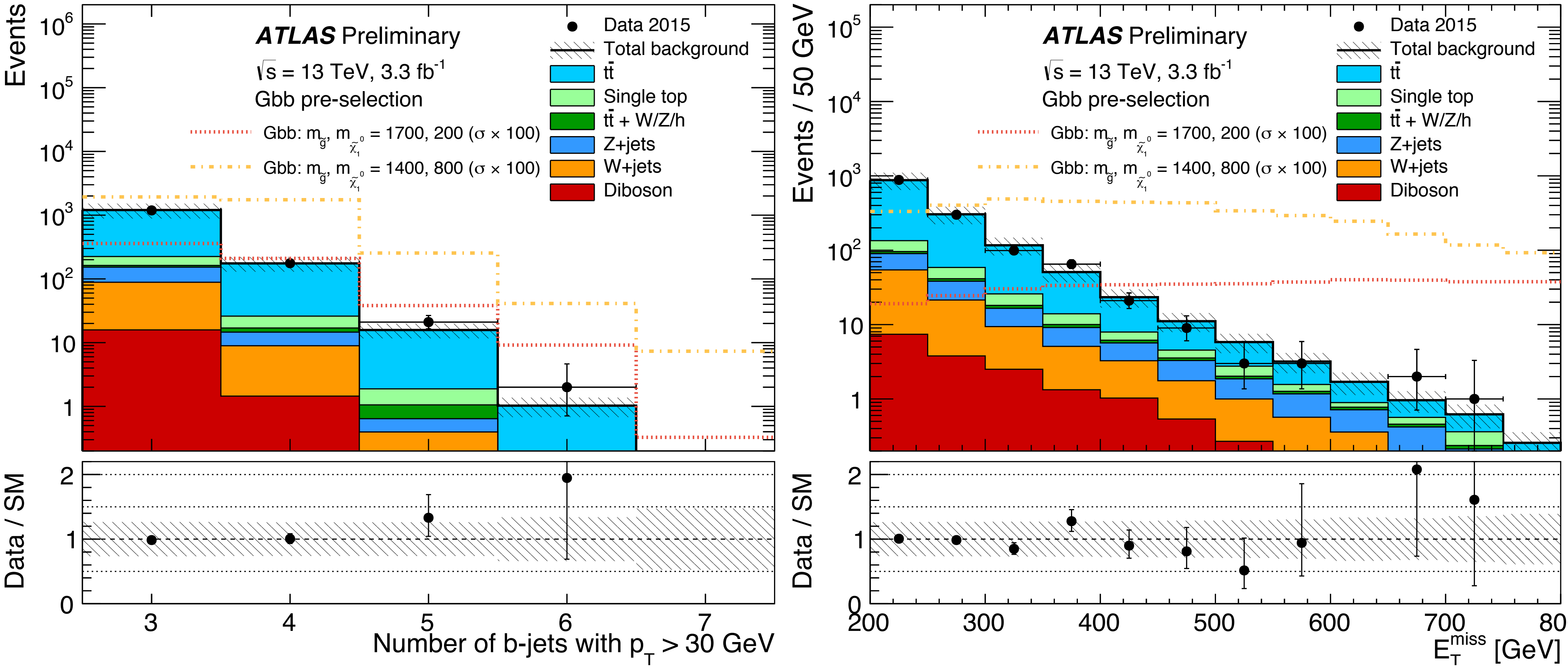
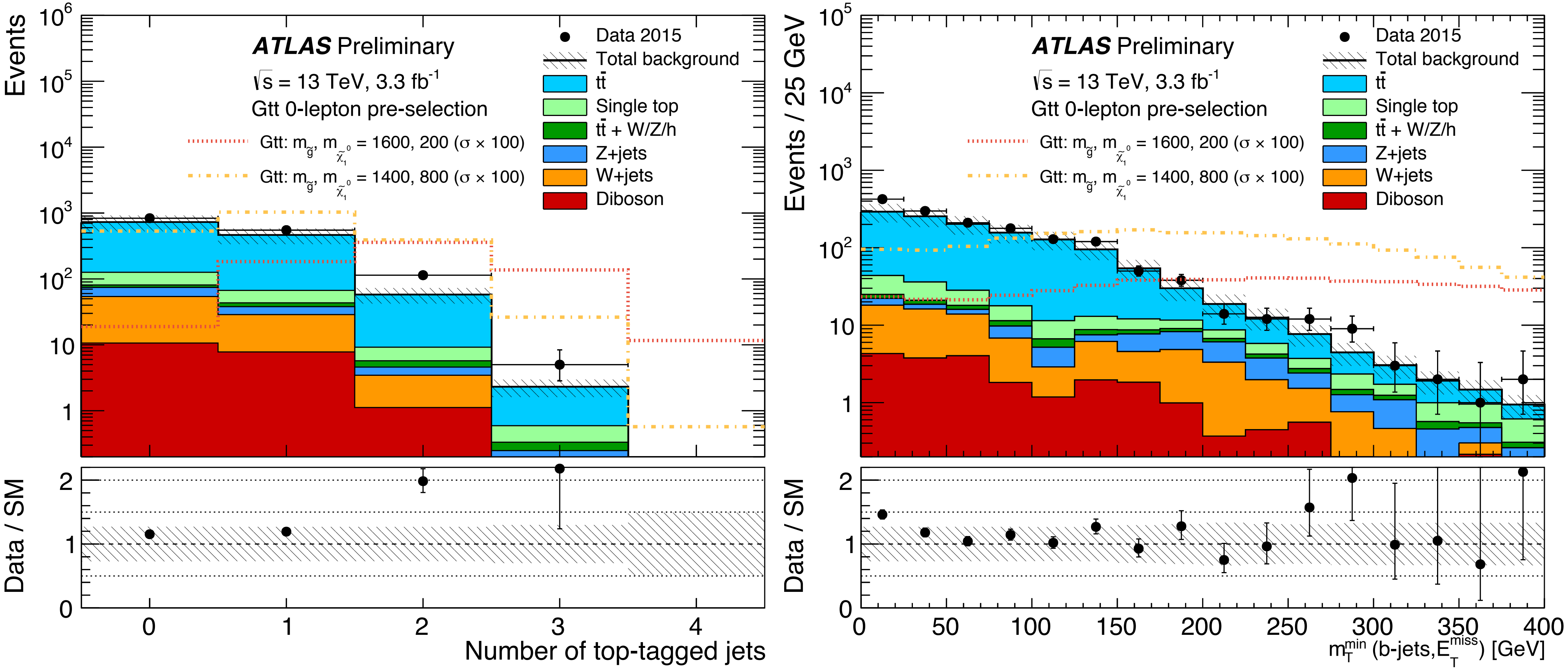
0/1 lepton, 3+ b-jets: preselection results (Gbb)



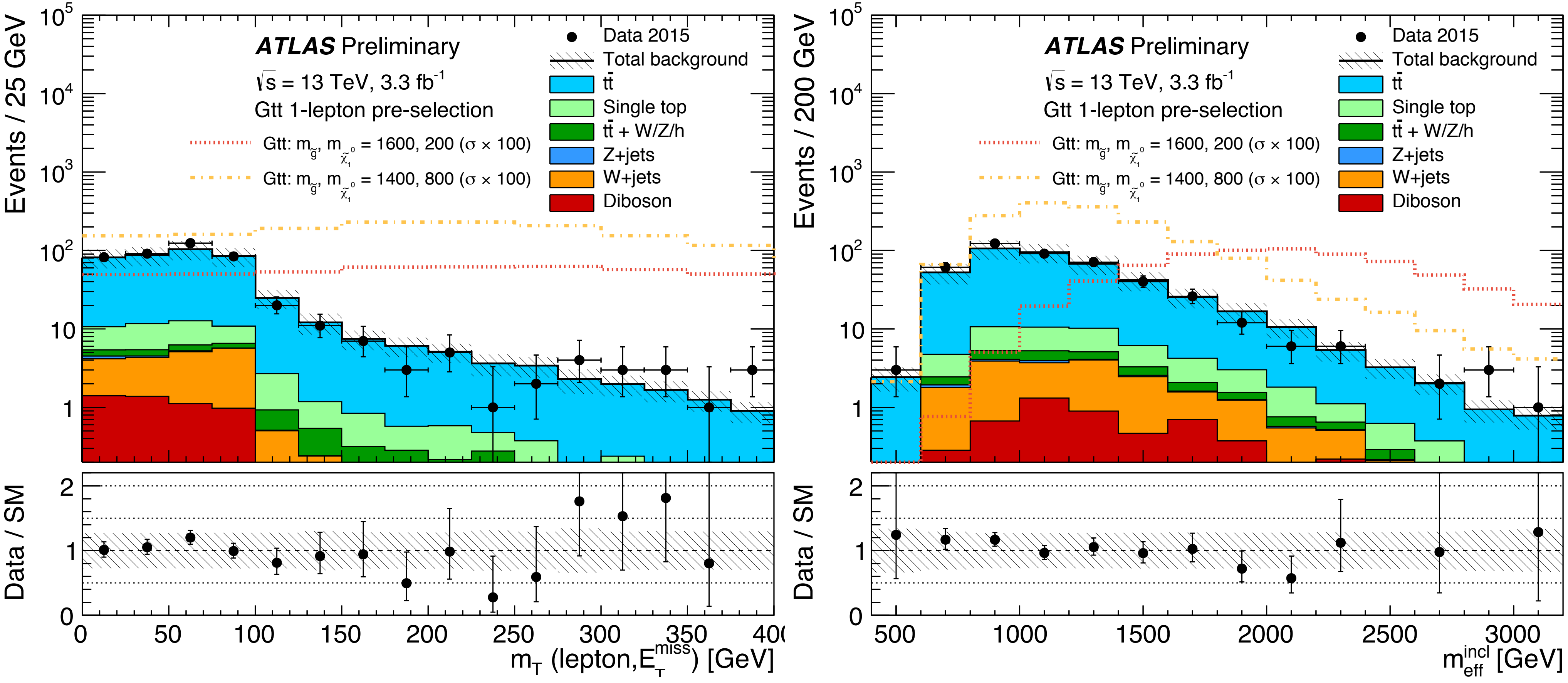
ATLAS-CONF-2015-067

0/1 lepton, 3+ b-jets: preselection results (Gtt 0-lep)



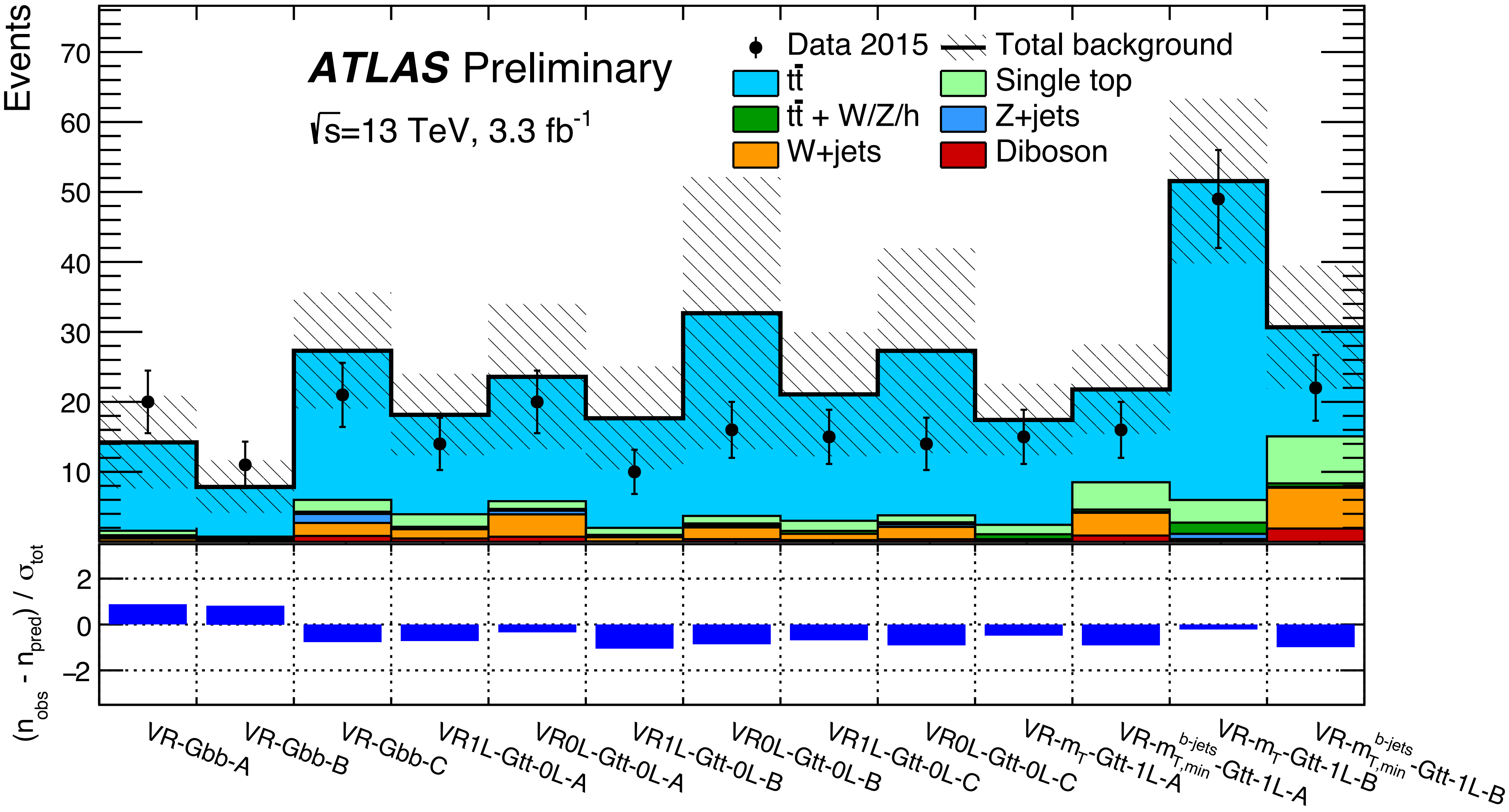
ATLAS-CONF-2015-067

0/1 lepton, 3+ b-jets: preselection results (Gtt 1-lep)



ATLAS-CONF-2015-067

0/1 lepton, 3+ b-jets: validation region results



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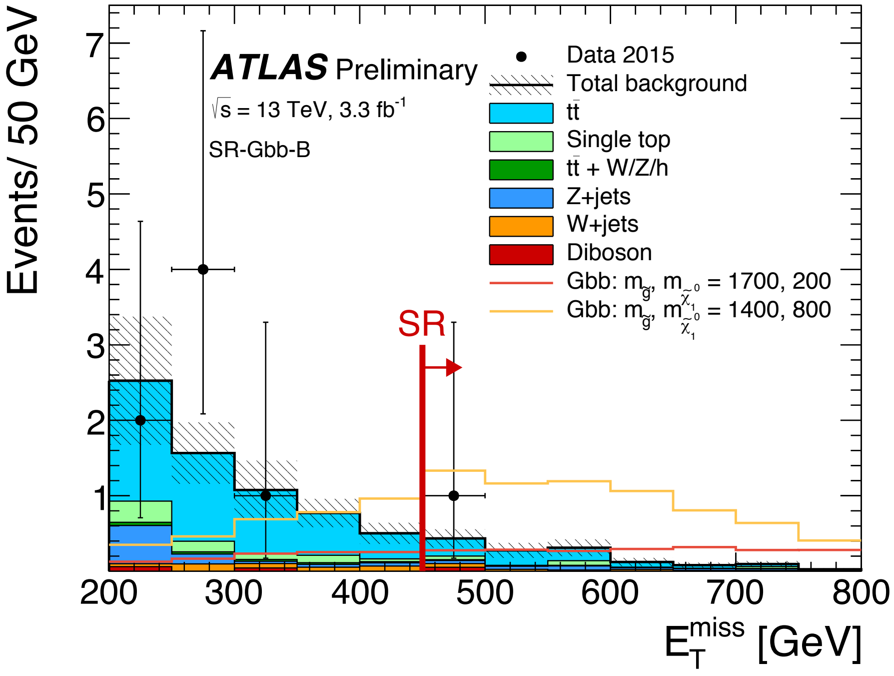
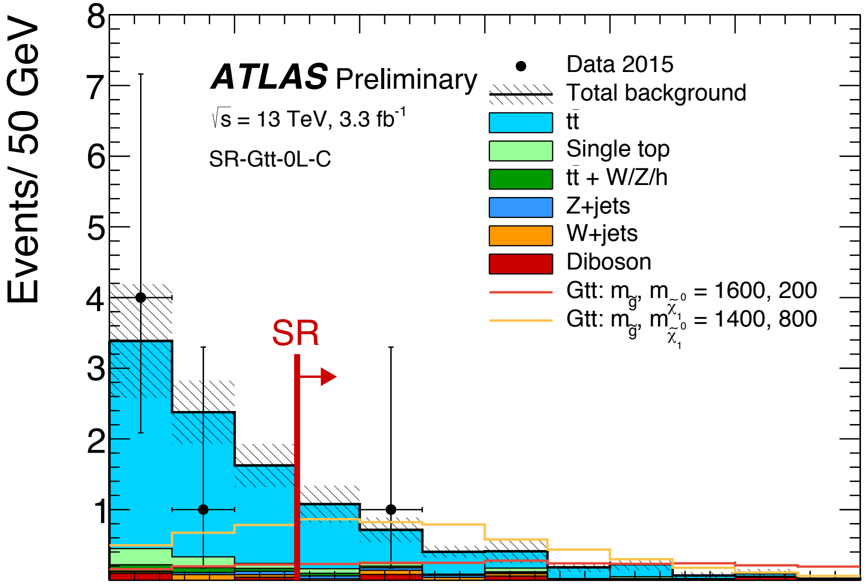
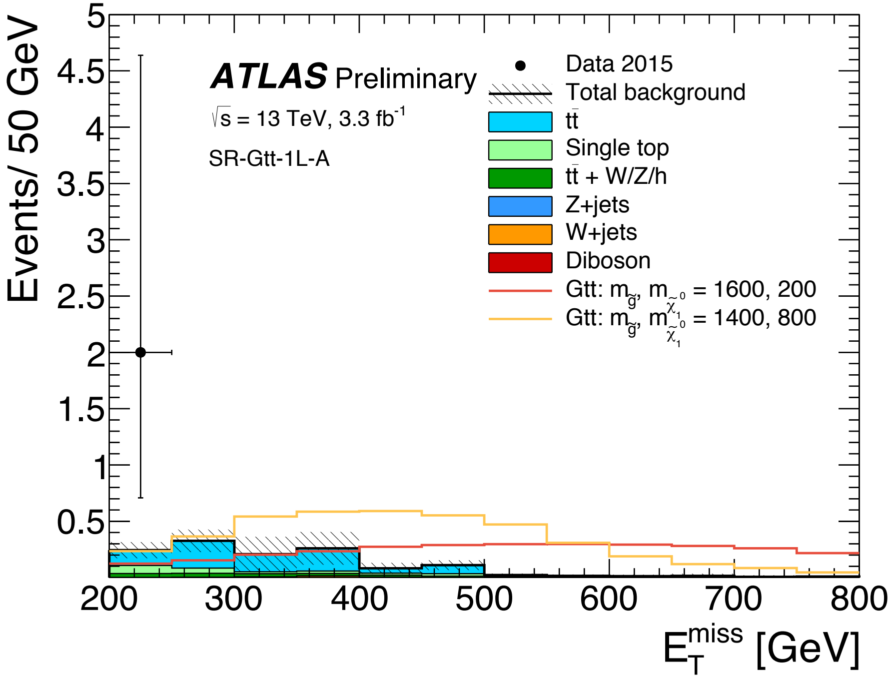
0/1 lepton, 3+ b-jets: signal region results







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0/1 lepton, 3+ b-jets: signal region results (Gbb)

	SR-Gbb-A	SR-Gbb-B	SR-Gbb-C
Observed events	0	1	5
Fitted background events	1.4 ± 0.7	1.5 ± 0.5	7.5 ± 1.4
$t\bar{t}$	0.7 ± 0.5	0.83 ± 0.32	3.9 ± 1.0
Z+jets	0.25 ± 0.26	0.25 ± 0.22	1.4 ± 0.6
W+jets	0.19 ± 0.10	0.15 ± 0.06	0.95 ± 0.34
Single-top	0.22 ± 0.10	0.16 ± 0.15	0.67 ± 0.33
$t\bar{t}W$, $t\bar{t}Z$, $t\bar{t}H$, $t\bar{t}t\bar{t}$	< 0.1	< 0.1	0.18 ± 0.10
Diboson	–	< 0.1	0.43 ± 0.25
MC-only prediction	1.7	1.6	7.1
$\mu_{t\bar{t}}$	0.7 ± 0.3	0.9 ± 0.4	1.1 ± 0.4

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0/1 lepton, 3+ b-jets: signal region results (Gtt)

	SR-Gtt-0l-A	SR-Gtt-0L-B	SR-Gtt-0L-C
Observed events	1	1	1
Fitted background events	2.0 ± 0.7	2.8 ± 1.7	3.2 ± 1.7
$t\bar{t}$	1.3 ± 0.6	2.2 ± 1.6	2.4 ± 1.7
Z+jets	0.24 ± 0.17	0.13 ± 0.13	0.16 ± 0.09
W+jets	0.21 ± 0.14	0.15 ± 0.16	0.20 ± 0.21
Single-top	0.14 ± 0.16	0.15 ± 0.13	0.18 ± 0.16
$t\bar{t}W$, $t\bar{t}Z$, $t\bar{t}h$, $t\bar{t}t\bar{t}$	< 0.1	0.10 ± 0.06	0.11 ± 0.06
Diboson	< 0.1	< 0.1	0.18 ± 0.18
MC-only prediction	1.8	1.9	2.6
$\mu_{t\bar{t}}$	1.2 ± 0.4	1.7 ± 0.7	1.4 ± 0.6

	SR-Gtt-1L-A	SR-Gtt-1L-B
Observed events	2	0
Fitted background events	1.3 ± 0.4	1.1 ± 0.6
$t\bar{t}$	0.91 ± 0.33	0.8 ± 0.5
Z+jets	–	–
W+jets	< 0.1	< 0.1
Single-top	0.19 ± 0.15	0.15 ± 0.13
$t\bar{t}W$, $t\bar{t}Z$, $t\bar{t}h$, $t\bar{t}t\bar{t}$	0.18 ± 0.10	0.18 ± 0.10
Diboson	–	–
MC-only prediction	1.3	1.2
$\mu_{t\bar{t}}$	1.0 ± 0.3	0.9 ± 0.3

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0/1 lepton, 3+ b-jets: limit plots