Latest results from SUSY searches with the ATLAS experiment

Lund University, Nov 15, 2016

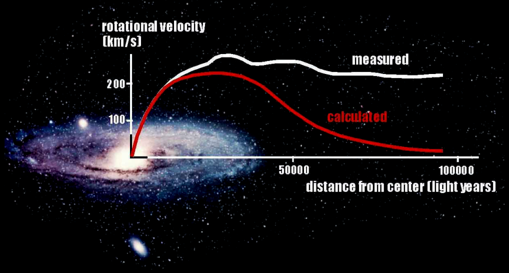
Christian Ohm, on behalf of
the ATLAS Collaboration

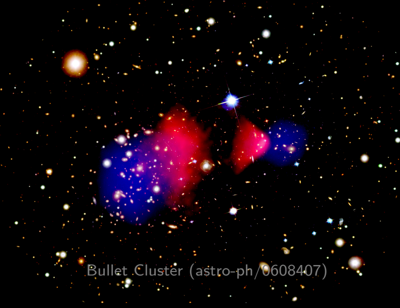
Outline

1. Introduction
    - Supersymmetry
    - Dataset & detector performance
    - Typical analysis strategy

2. Results
    - Inclusive $\tilde{q}/\tilde{g}$ production
    - 3rd generation $\tilde{q}$ production
    - Electroweak production

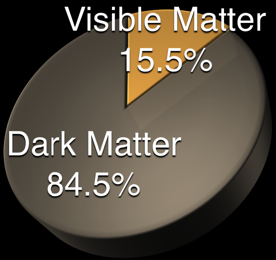
3. Summary & conclusions





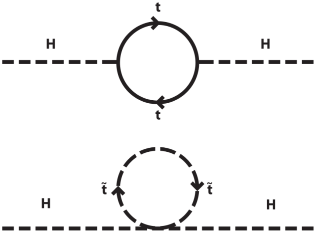
Bullet Cluster (astro-ph/0608407)

- Strong evidence for Dark Matter from astronomy and observational cosmology
- What is it made up of?
  We don't know.
- Can we produce it at the LHC?



(Planck: 1502.01589)

Theory



- "Unnatural" fine-tuning of m_H^2

  $\Rightarrow$ presence of scalar top partner would cancel quadratic radiative corrections and *protect* m_H^2

- No gauge coupling unification in the Standard Model

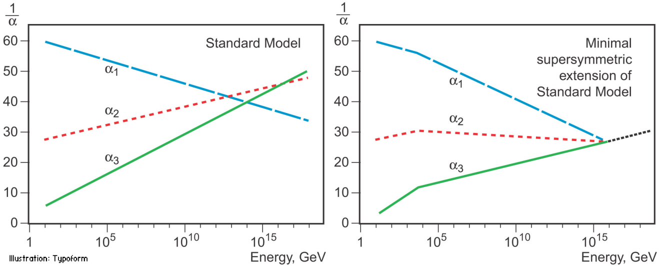


Illustration: Typoform

A brief introduction to Supersymmetry

SUSY can solve these problems

- Could explain Dark Matter
- Alleviates hierarchy problem
- Allows for gauge coupling unification

How?

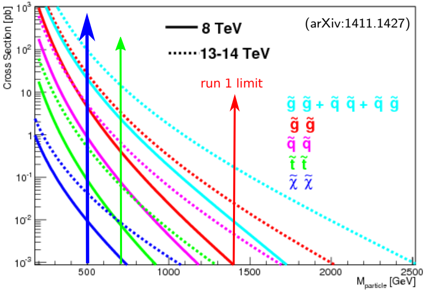
- Generalization of SM: symmetry between force and matter particles
- Introduces sfermions and gauginos $\Rightarrow$ doubles particle content wrt SM

  Sfermions: $q, \ell \longleftrightarrow \tilde{q}, \tilde{\ell}$
  Gauginos: e.g. $g \longleftrightarrow \tilde{g}$

But. . .

- With ∼100 free parameters $\Rightarrow$ wide range of possible exp. signatures

So, SUSY is theoretically appealing, phenomenologically rich, and therefore experimentally challenging



(arXiv:1411.1427)

8 TeV $\rightarrow$ 13 TeV $\Rightarrow \sigma(\mathrm{SUSY})$ grows:

- $\sigma(\tilde{g}\tilde{g}) \times 30$ for $m_{\tilde{g}} = 1.4$ TeV
- $\sigma(\tilde{t}\tilde{t}) \times 8$ for $m_{\tilde{t}} = 700$ GeV
- $\sigma(\tilde{\chi}\tilde{\chi}) \times 4$ for $m_{\tilde{\chi}} = 500$ GeV

In contrast: $\sigma(t\bar{t}) \times 3.3 \Rightarrow S/B$ boost

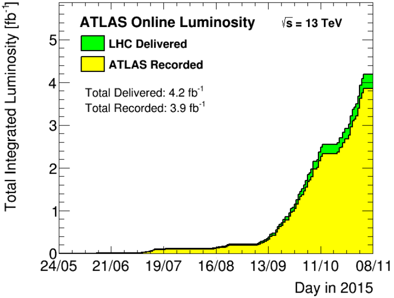
Early Run II priorities:

- Optimize for discovery, keep analyses simple and robust
- Target strong production of $\tilde{g}$ and $\tilde{q}$, then EW prod. with increased $\int \mathcal{L}dt$

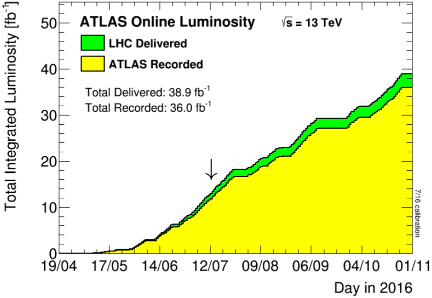
ATLAS Run II 13 TeV dataset

The LHC performed extremely well in 2016 pp run!

2015



2016 (so far)



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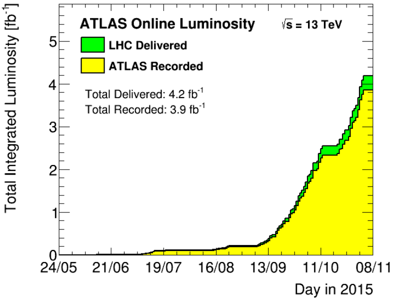
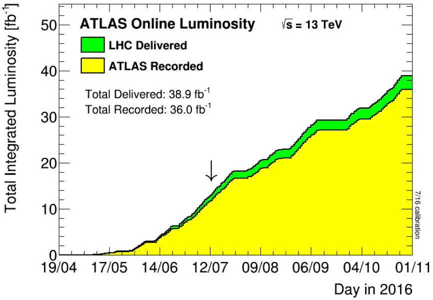


2016 (so far)



- Used for all 18 results shown today:
  $\int \mathcal{L}\, dt \;=\; 13\text{-}18\ \text{fb}^{-1}$ at $\sqrt{s} = 13\ \text{TeV}$

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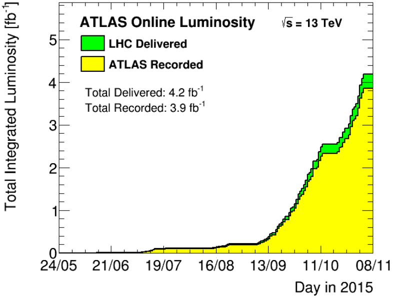

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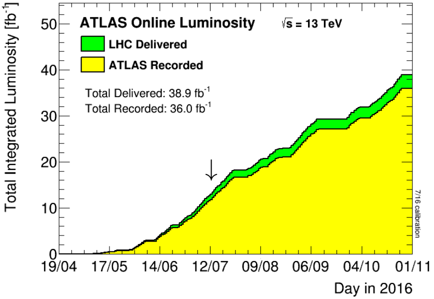
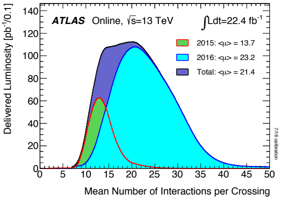
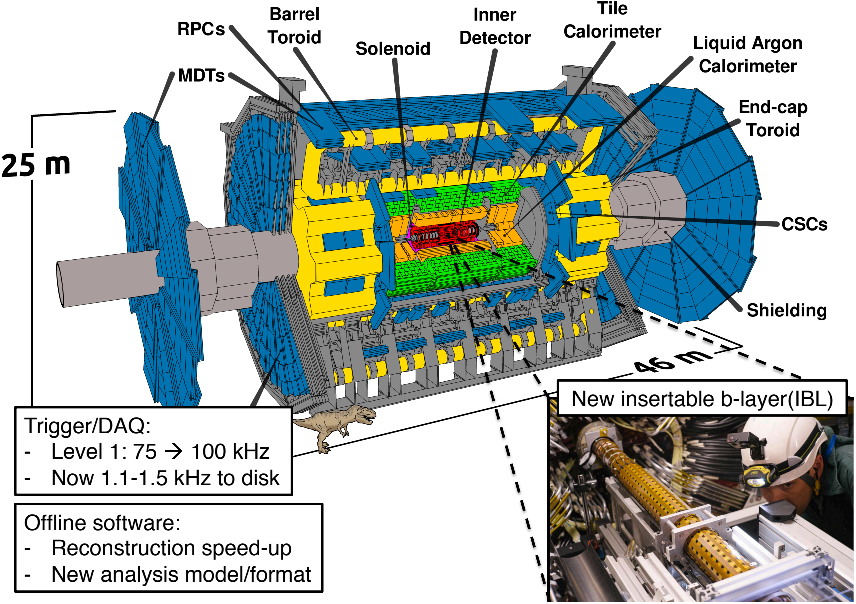




- Used for all 18 results shown today:

  $\int \mathcal{L}\, dt \;=\; 13\text{-}18\ \mathrm{fb}^{-1}$ at $\sqrt{s} = 13$ TeV
- Pileup increased with luminosity

The ATLAS detector in Run II

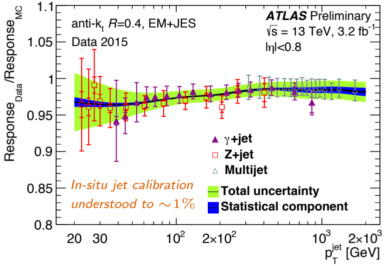


New insertable b-layer(IBL)

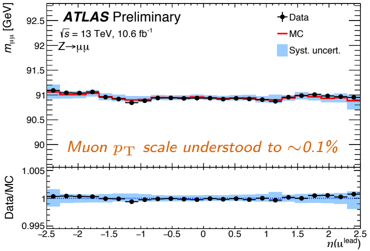
Trigger/DAQ:
- Level 1: 75 → 100 kHz
- Now 1.1-1.5 kHz to disk

Offline software:
- Reconstruction speed-up
- New analysis model/format

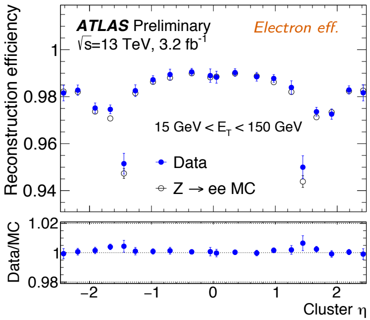
Detector performance with 13 TeV data



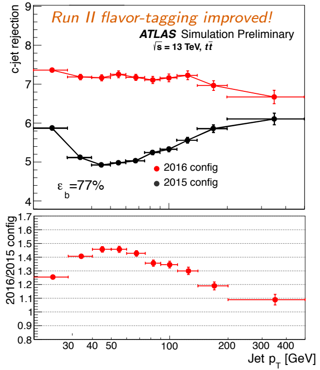
In-situ jet calibration understood to $\sim 1\%$



Muon p_T scale understood to $\sim$0.1%



Electron eff.



Run II flavor-tagging improved!

Detector performance with 13 TeV data

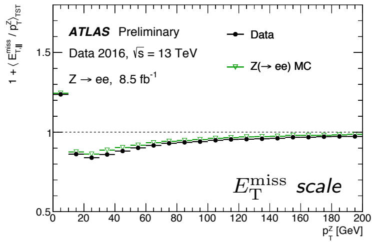
Missing transverse momentum:

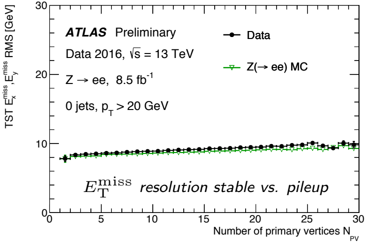
$$E_{\mathrm{T}}^{\mathrm{miss}} = \sqrt{(E_x^{\mathrm{miss}})^2 + (E_y^{\mathrm{miss}})^2}$$

where $E_{x(y)}^{\mathrm{miss}} = -\sum E_{x(y)}$ summed over all calibrated e, γ, μ, τ and jets plus a track-based "soft" term (TST)

$E_{\mathrm{T}}^{\mathrm{miss}}$ is crucial, strong discrimination power for R-parity conserving SUSY with stable lightest SUSY particle (LSP) escaping detection (DM cand.)

Most searches I show today use a $E_{\mathrm{T}}^{\mathrm{miss}}$-based trigger (plateau: $200\ \mathrm{GeV}$)

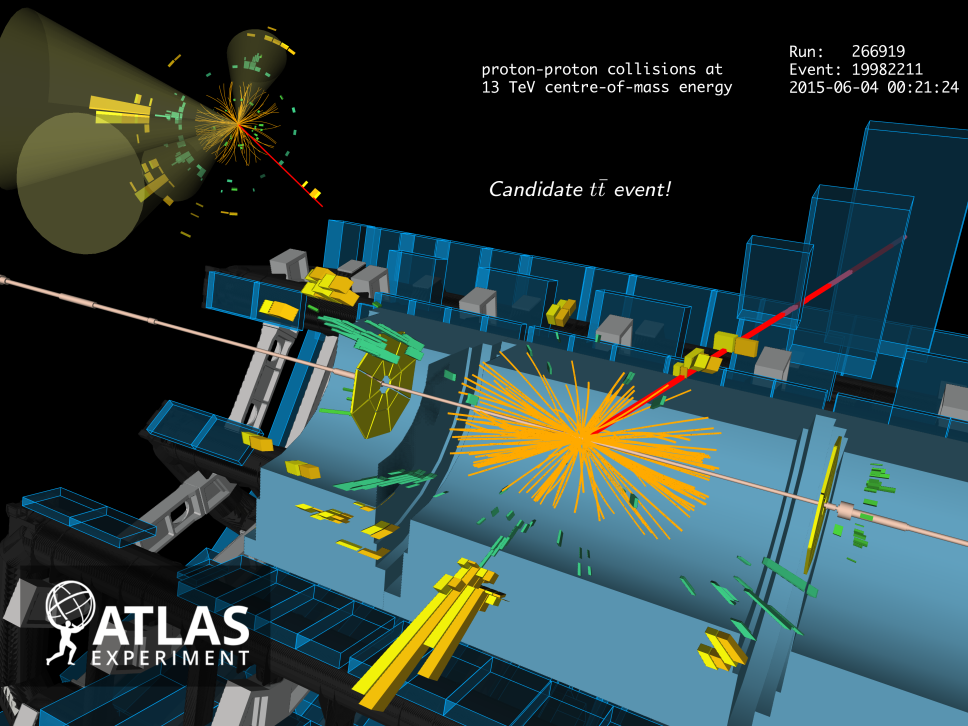




Variables describing event-level kinematics and topology:

$$H_{\mathrm{T}} = \textstyle\sum_{\mathrm{jets},\ell} p_{\mathrm{T}} \qquad m_{\mathrm{eff}}^{(\mathrm{incl})} = \textstyle\sum_{\mathrm{jets},\ell} p_{\mathrm{T}} + E_{\mathrm{T}}^{\mathrm{miss}} \qquad m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos[\Delta\phi(\vec{\ell}, E_{\mathrm{T}}^{\mathrm{miss}})])}$$

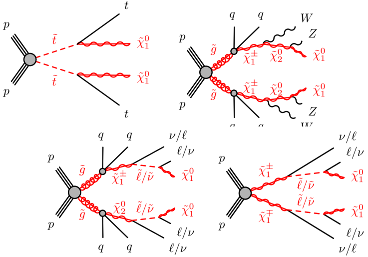
$$M_{\mathrm{J}}^{\Sigma} = \sum m_j^{R=1.0} \qquad m_{\mathrm{T2}} == \min_{\mathbf{q}_{\mathrm{T}}} \left[\max\left(m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 1}, \mathbf{q}_{\mathrm{T}}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}}) \right) \right]$$



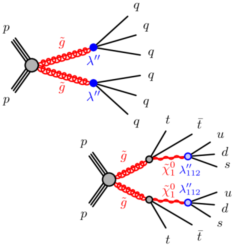
Candidate $t\bar{t}$ event!

Turning every stone

R-parity conserving



R-parity violating



(Not today: long-lived SUSY particles...)

Background modeling:

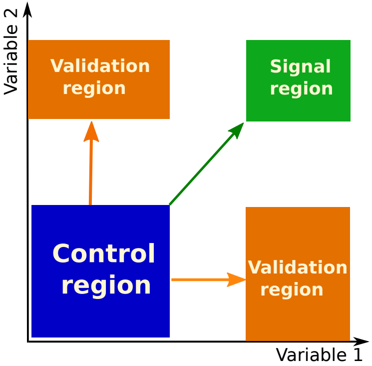
- **Sherpa:** $V/\gamma + \text{jets}$ VV $W\gamma$
- **Powheg:** tt Wt VV
- **Pythia8:** Multijet
- **MadGraph:** $t\bar{t}V$ $t\bar{t}\gamma$ $V + \text{jets}$

SUSY signals:

- Simplified models
- **MG5_aMC@NLO+Py8**

General strategy for Run II: typical workflow

- Define selections for targeted signals
- Optimize for $S/\sqrt{B}$ using variables describing topology & kinematics
- Can't rely on perfect modeling in MC out to tails in distributions $\Rightarrow$ extract normalization from data *in signal-free* region



For main irreducible BGs ($t\bar{t}, V$+jets):

1. High-purity control regions (CRs)
   $\Rightarrow$ simultaneous fit of MC to data
   $\Rightarrow$ normalization factors
2. Test extrapolation using validation regions (VRs)
3. Predict yields in blinded signal regions (SRs)

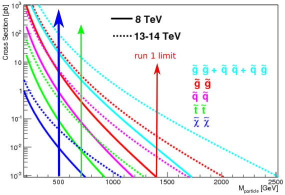
Considerations:

- Extrapolate along reliably modeled variables
- Uncertainties: trade-off between stat and syst.

Reducible backgrounds measured in data, for example:

- "Fake" $E_{\mathrm{T}}^{\mathrm{miss}}$, ℓ
- Charge mis-identification for ℓ

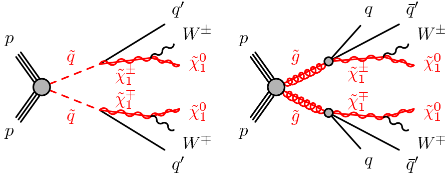
New results: inclusive $\tilde{q}/\tilde{g}$ production

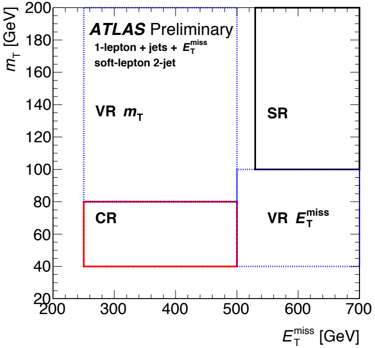


1ℓ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ search

ATLAS-CONF-2016-054

Target: final states with jets, exactly one isolated e/μ, and significant $E_{\mathrm{T}}^{\mathrm{miss}}$





Design of SRs:

- Defined using $n_{\mathrm{jets}}, E_{\mathrm{T}}^{\mathrm{miss}}, m_{\mathrm{T}}, m_{\mathrm{eff}}^{\mathrm{incl}}$
- 6 for $\tilde{g}\tilde{g}$, 4 for $\tilde{q}\tilde{q}$ prod.
- Most for large $\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0)$, 2-jet "soft-$\ell$" SR for compressed spectra

Backgrounds: $t\bar{t}$ and W+jets dominate
$\Rightarrow$ normalize MC in CRs

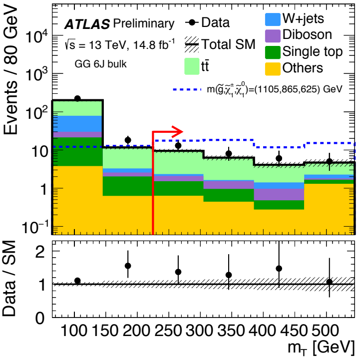
Ex: soft-lepton 2-jet

- Regions split by requirements on $E_{\mathrm{T}}^{\mathrm{miss}}$ and m_{T}
- $t\bar{t}$ CR: ≥ 1 b-jet
- W+jets CR: no b-jets

Simultaneous fit for $t\bar{t}$ & W CRs
$\Rightarrow$ normalization factors

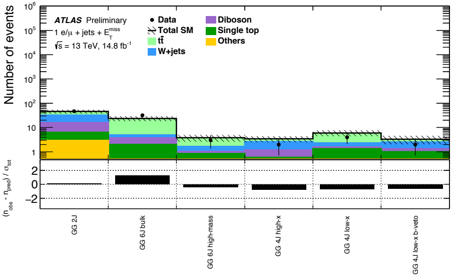
$1\ell + \text{jets} + E_{\mathrm{T}}^{\mathrm{miss}}$: results

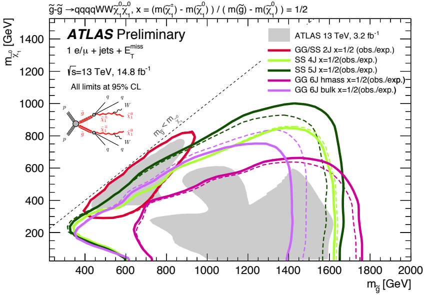
ATLAS-CONF-2016-054



- $\leftarrow m_{\mathrm{T}}$ in 6-jet $\tilde{g}\tilde{g}$ SR
- No significant excess seen in any SR
- Exclusion curves in $m_{\tilde{g}}$-$m_{\tilde{\chi}_1^0}$ plane ↓

Throughout: only showing example interpretations - many more available!



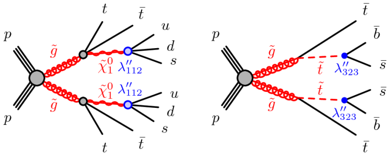


1ℓ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$: results

ATLAS-CONF-2016-054

Brand new search for $\tilde{g}$ RPV decays in 1ℓ + jets

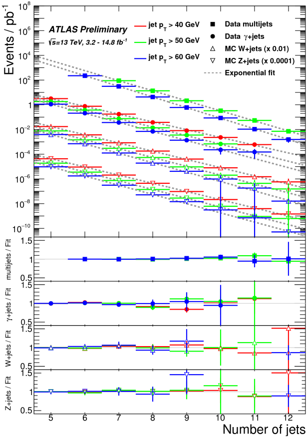
NEW! ATLAS-CONF-2016-094



- R-parity violated ⇒ no sign. $E_{\mathrm{T}}^{\mathrm{miss}}$
- $\geq$1 e/μ, $\geq$(8-10) jets, (0-4) b-jets
- First look for SUSY in this final state!

Background estimation

- Don't trust MC for high n_{jets}
  ⇒ measure in data
- Assumes $P(\text{additional jet})$ constant
  ⇒ extrapolate from n to $n+1$ jets
- Global likelihood fits separately for W, Z, $t\bar{t}$ (templates incl. b-jet mult.)



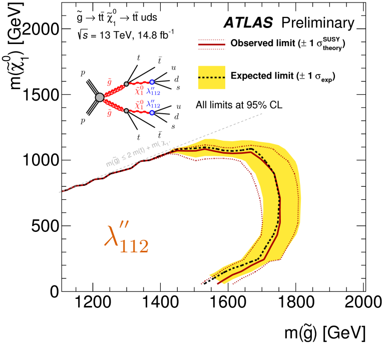
Validation of V+jets fits in γ+jets and multijet events

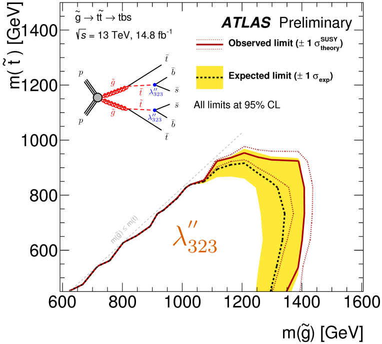
1ℓ + jets + E_T^{miss}: results

ATLAS-CONF-2016-054

Brand new search for $\tilde{g}$ RPV decays in 1ℓ + jets

NEW! ATLAS-CONF-2016-094



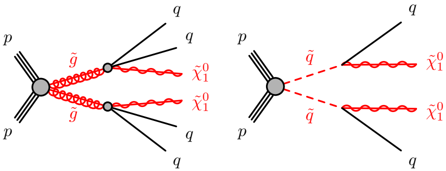


Also model-independent N_{events} limits for each of the SRs!

0ℓ + 4-6 jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ search

ATLAS-CONF-2016-078

Target: Fully hadronic $\tilde{g}$ and $\tilde{q}$

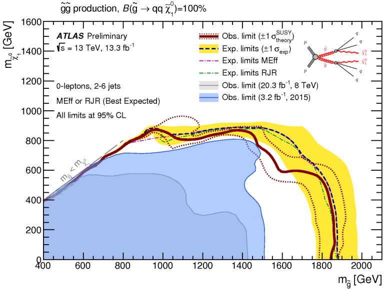


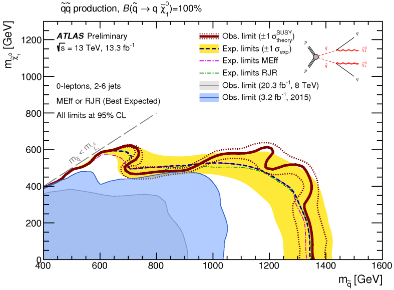
Two categories of SRs:

- 2–6 jets (no ℓ!), subdivided in m_{eff}
- New: *Recursive Jigsaw Reco* (RJR): creates full-kinematics hypothesis for each event using assumption on decay topologies incl. invisible particles (1607.08307)

Backgrounds:

- W+jets, $t\bar{t}$ from CRs
- $Z(\nu\nu)$+jets from γ+jets, VV in MC

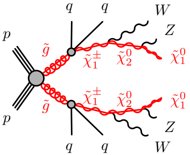




Similar results for m_{eff} and new RJR

0ℓ + 8-10 jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ search

NEW! ATLAS-CONF-2016-095



Uses multijet trigger
$\Rightarrow$ looser $E_{\mathrm{T}}^{\mathrm{miss}}$ req.

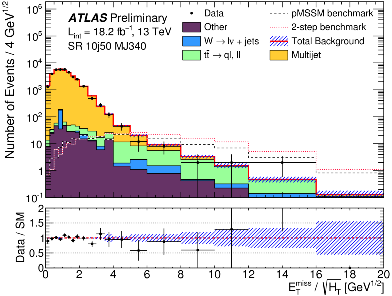
SRs for $\tilde{g}\tilde{g}$ with two-step decays:

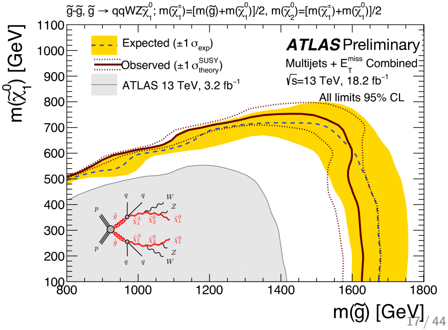
- $\geq$ 8–10 jets ($p_{\mathrm{T}} > 50$ GeV)
- $M_{\mathrm{J}}^{\Sigma} >$ 340 or 500 GeV
- $E_{\mathrm{T}}^{\mathrm{miss}}$ significance: $\frac{E_{\mathrm{T}}^{\mathrm{miss}}}{\sqrt{H_{\mathrm{T}}}} > 4\ \mathrm{GeV}^{1/2}$

Multijet bg estimation:

- $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ ~indep. of n_{jets}
- Extracted templates in 6j CR
  $\Rightarrow$ validate in 7j region
  $\Rightarrow$ predict in 8–10j SRs
- Top and W from 1ℓ CRs with $(N_{\mathrm{jets}}^{\mathrm{SR}} - 1)$ jets to improve stats

No significant excess $\Rightarrow$
$m_{\tilde{g}} \lesssim 1.6$ TeV excluded



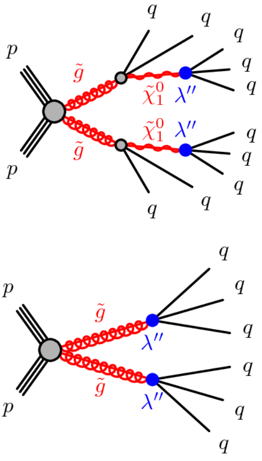


0ℓ + 8-10 jets + E_T^{miss} search

NEW! ATLAS-CONF-2016-095

New RPV multijet result:

- R-parity violated ⇒ no E_T^{miss}



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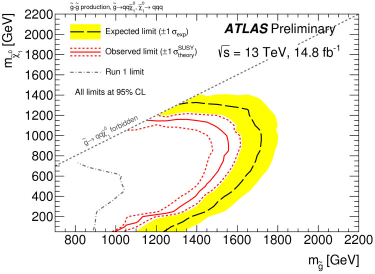
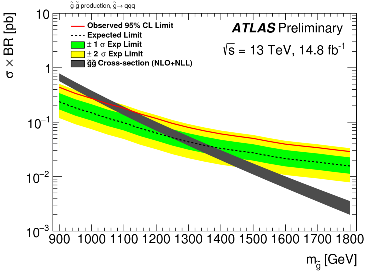
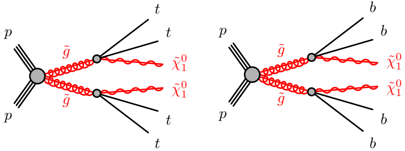


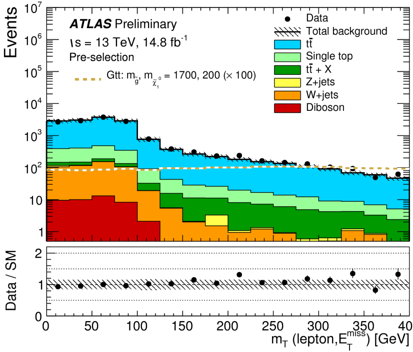


3-4 b-jets + 0-1 ℓ + $E_{\mathrm{T}}^{\mathrm{miss}}$ search

ATLAS-CONF-2016-052

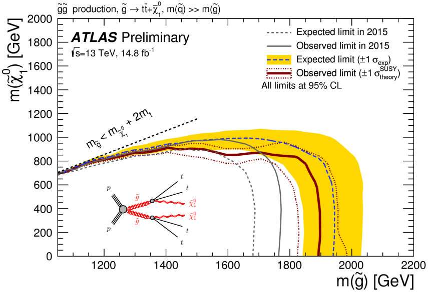
Target: Gtt & Gbb scenarios: $\tilde{g} \to t\bar{t}\tilde{\chi}$



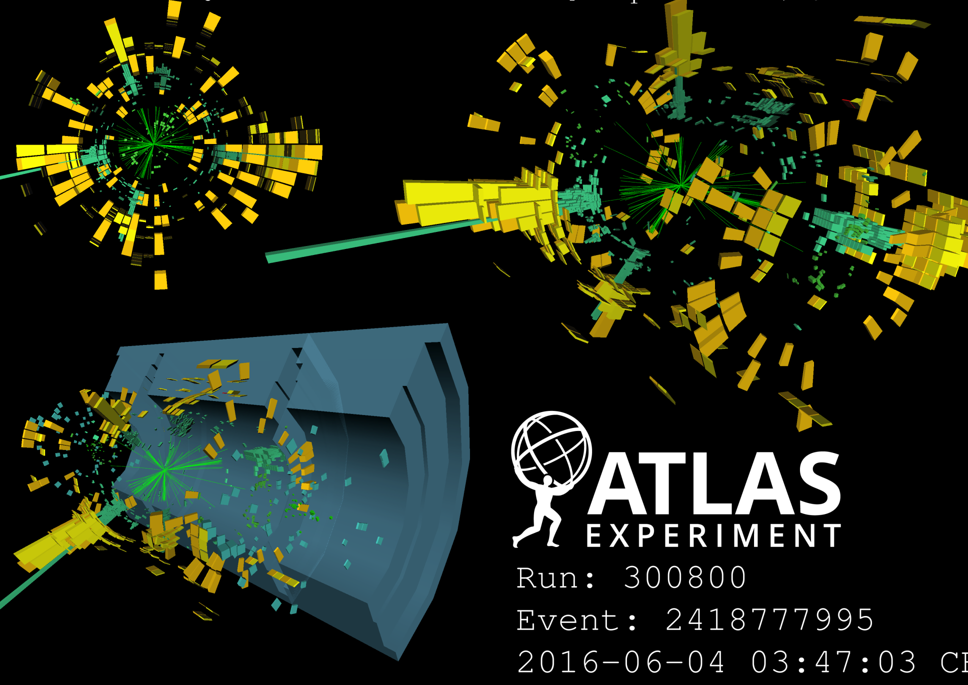


- SR design:
  - 0ℓ $(\tilde{b}, \tilde{t})$ and 1ℓ $(\tilde{t})$
  - Subdivided in $E_{\mathrm{T}}^{\mathrm{miss}}$, m_{eff}, Gtt SRs use $\sum m_j^{R=1.0}$
- Backgrounds
  - All SRs dominated by $t\bar{t}$+jets, measured in low-m_{T} CRs
  - Other BGs from MC

No significant excess ⇒
Limits up to $m_{\tilde{g}} \sim 1.9$ TeV



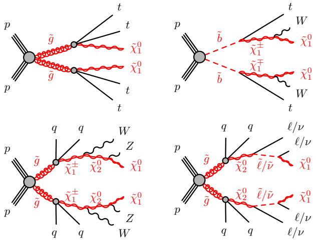
Candidate $3b$ event: jets with 774, 436, 312, and 180 GeV p_{T}, $E_{\mathrm{T}}^{\mathrm{miss}} = 508\ \mathrm{GeV}, m_{\mathrm{eff}} = 2.2\ \mathrm{TeV}$



2ℓ same-sign$/3\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ search

ATLAS-CONF-2016-037

$\tilde{g}/\tilde{q}$ with leptonic $\tilde{\ell}/\tilde{\chi}/W$ decays



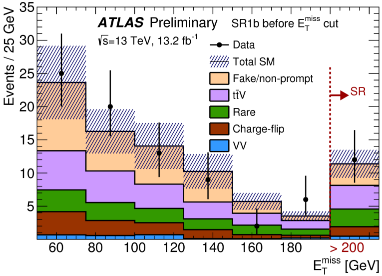
Sensitive to many types of mass spectra!

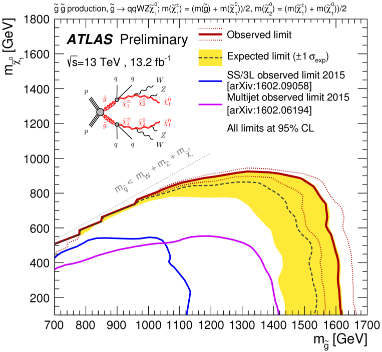
9 SRs (3 optimized for RPV):

- Object multiplicity: ℓ, b-jets, jets
- Event: $E_{\mathrm{T}}^{\mathrm{miss}}$, m_{eff}, ℓ charge config.

Backgrounds

- Real: SS$/3\ell$ from $t\bar{t}V$, VV
- Fake backgrounds:
  - Fake leptons relevant, measured in data
  - Charge mis-id ⇒ measured in $Z \to \ell\ell$

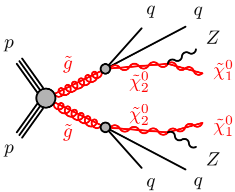




$Z(\ell\ell)$ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ search

ATLAS-CONF-2015-082

Target: $\tilde{g}\tilde{g}$ or $\tilde{q}\tilde{q}$ with $Z \to \ell\ell$ in decay



Background estimation:

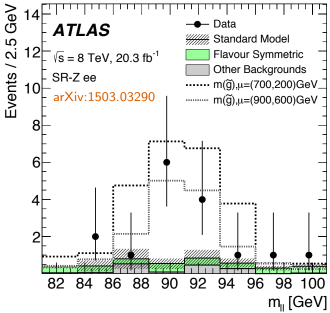
- $t\bar{t}$, WW, Wt: flavor-symmetric (1:1:2 ratio for ee:$\mu\mu$:$e\mu$), estimated from $e\mu$ data:

$$N_{ee/\mu\mu}^{\text{bg est.}} = \frac{1}{2} N_{e\mu}^{\text{CR}} \times k_{ee/\mu\mu}$$

- WZ, ZZ, $t\bar{t}V$ from MC, checked in VR
- Z+jets: estimated from γ+jets events in data

Excess in 8 TeV Run I search:

- ee: 3σ, $\mu\mu$: 1.7σ



Reproduce Run I SR:

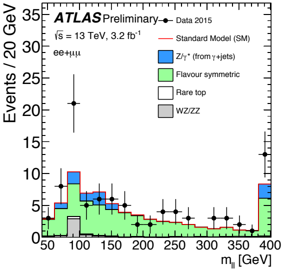
- SFOS $ee/\mu\mu$ with $81\ \mathrm{GeV} < m_{\ell\ell} < 101\ \mathrm{GeV}$
- 2 jets with $\Delta\phi_{\min}(E_{\mathrm{T}}^{\mathrm{miss}}, j) > 0.4$
- $E_{\mathrm{T}}^{\mathrm{miss}} > 225\ \mathrm{GeV}$, $H_{\mathrm{T}} > 600\ \mathrm{GeV}$

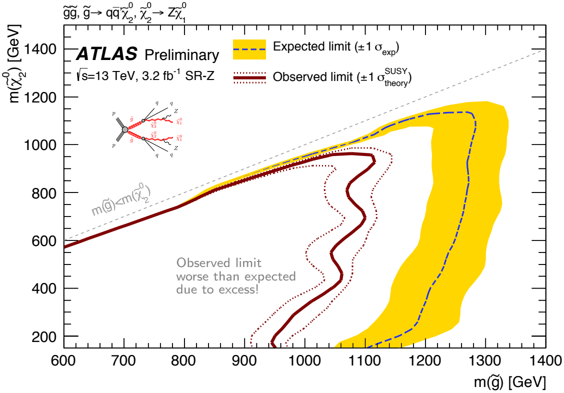
$Z(\ell\ell)$ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$: results from 2015

ATLAS-CONF-2015-082

Final event yield for 2015 data:

- Expected: 10.3 ± 2.3 events
- Observed: 21 (10 ee, 11 $\mu\mu$) events
  $\Rightarrow$ 2.2σ excess





Observed limit
worse than expected
due to excess!

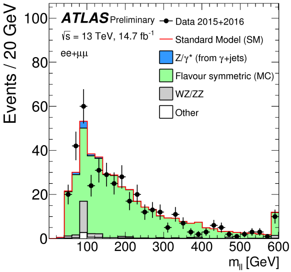
CMS observes 12 with $12^{+4.0}_{-2.8}$ expected (CMS-PAS-SUS-15-011)

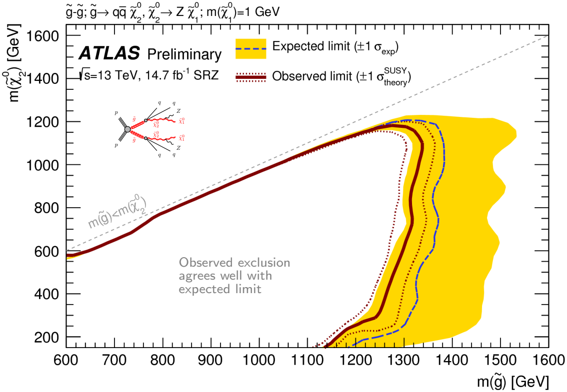
$Z(\ell\ell)$ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$: results from 2016

NEW! ATLAS-CONF-2016-098

Final result for 2015+2016 data:

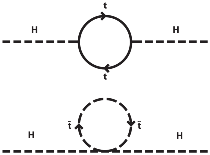
- 2016: 43.5 expected, 43 observed events
- Reprocessing of 2015 data: 21 ⇒ 16 observed
  ⇒ No excess!





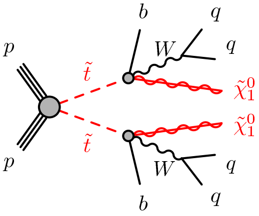
Observed exclusion agrees well with expected limit

New results: direct $\tilde{t}/\tilde{b}$ production

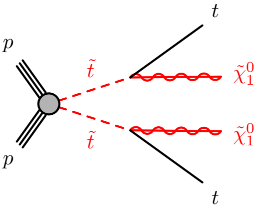


Direct $\tilde{t}\tilde{t}$ production in 0ℓ, 1ℓ and 2ℓ final states

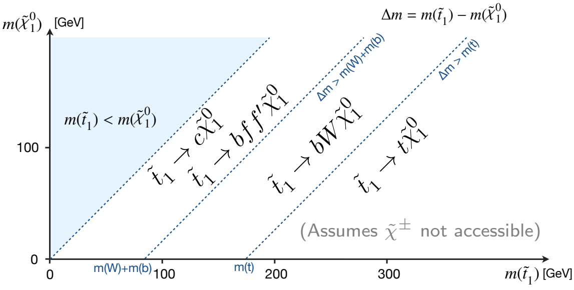
Covers several decay chains for different $\Delta m(\tilde{t}, \tilde{\chi}^0)$



3-body $\tilde{t} \to bW\tilde{\chi}^0$

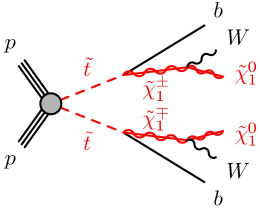


$\tilde{t} \to t\tilde{\chi}^0$

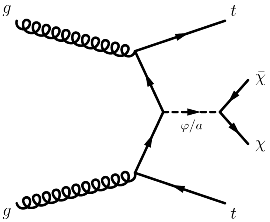


(Assumes $\tilde{\chi}^\pm$ not accessible)

If $\tilde{\chi}^\pm$ accessible:



$\tilde{t} \to b\tilde{\chi}^\pm$



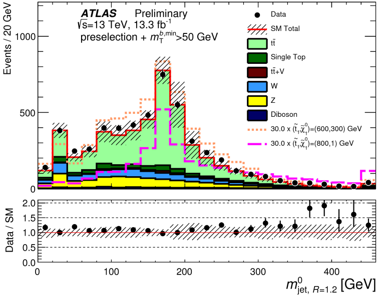
0ℓ, 1ℓ and 2ℓ also sensitive to associated DM+$t\bar{t}$ prod.

Direct $\tilde{t}\tilde{t}$ production in jets + $E_{\rm T}^{\rm miss}$ channel

ATLAS-CONF-2016-077

Flexible search for all fully hadronic decays

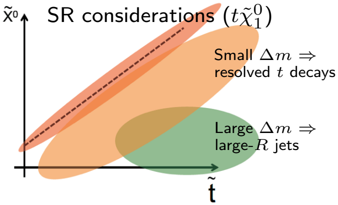
- **Boosted $\tilde{t} \to t\tilde{\chi}^0$**: classify events using mass of two large-R jets:

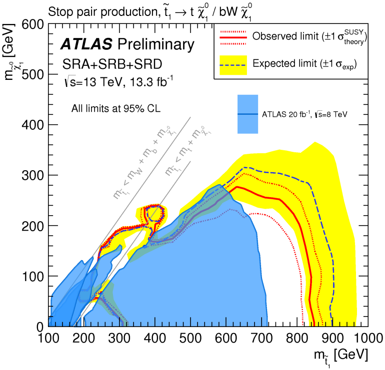


- Exploit ISR for sensitivity to near-diagonal $t\tilde{\chi}^0$:

$$R_{\rm ISR} = \frac{E_{\rm T}^{\rm miss}}{p_{\rm T}^{\rm ISR}} \sim \frac{m_{\tilde{\chi}^0}}{m_{\tilde{t}}}$$

- Main backgrounds: Z+jets, $t\bar{t} + V$

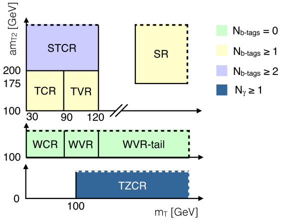

SR considerations $(t\tilde{\chi}_1^0)$

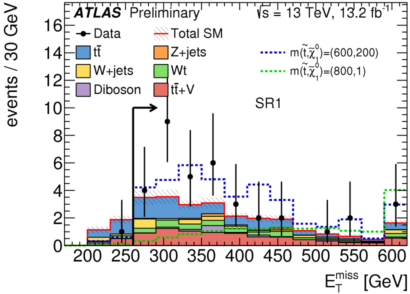


Direct $\tilde{t}\tilde{t}$ production in jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ + 1ℓ channel

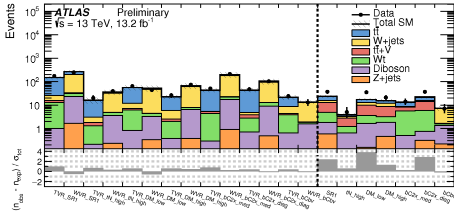
ATLAS-CONF-2016-050

$t\bar{t}$, $t\bar{t}Z$, single-top, W+jets from CRs:

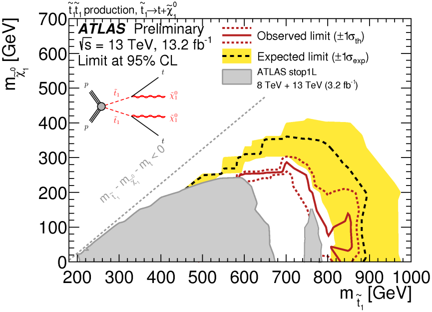




7 SRs for $t\tilde{\chi}^0$, $b\tilde{\chi}^\pm$ and DM+$t\bar{t}$



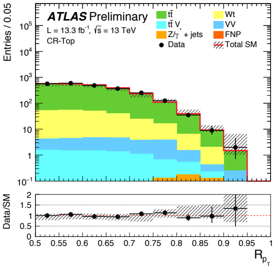
Modest excesses in a few SRs



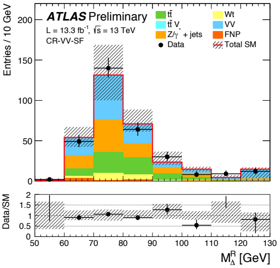
Direct $\tilde{t}\tilde{t}$ production in jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ + 2ℓ channel

ATLAS-CONF-2016-076

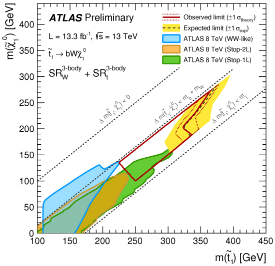
- 3-body decay highlighted here, also $b\tilde{\chi}^{\pm}$ with had. m_{T2}, dedicated DM SRs
- Selection: 2ℓ + 2 b-jets + $E_{\mathrm{T}}^{\mathrm{miss}}$
- Backgrounds: $t\bar{t}$ and Wt, normalization extracted from CRs
- Super-razor variables (1310.4827) used to identify events with two heavy particles decaying into a set of leptons and invisible particles (shown in CRs)



$$R_{p_{\mathrm{T}}} = \frac{|\vec{J}_{\mathrm{T}}|}{|\vec{J}_{\mathrm{T}}| + \sqrt{\hat{s}_R}/4}$$

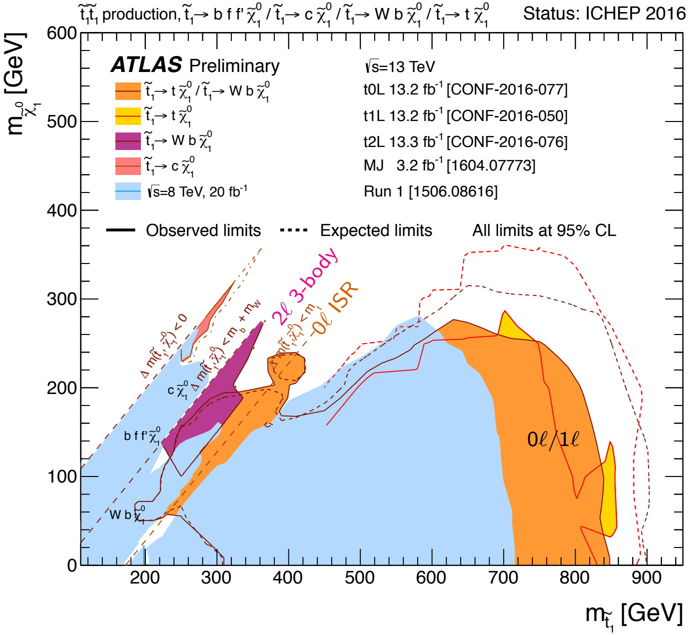


$$M_{\Delta}^{R} = \frac{\sqrt{\hat{s}_R}}{\gamma_{R+1}}$$



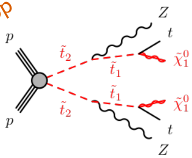
3-body decay mode excluded for $m_{\tilde{t}} \lesssim 350$ GeV

Summary of $\tilde{t} \to t\tilde{\chi}^0$ exclusions

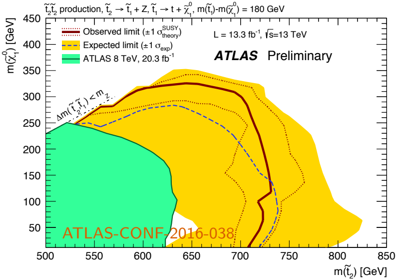


Targeting specific topologies for direct $\tilde{t}\tilde{t}$ production

“Stealth stop”

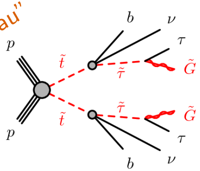


- If $\Delta m(\tilde{t}_1, \tilde{\chi}_0) \sim m_t$, consider direct $\tilde{t}_2\tilde{t}_2$ prod, $\tilde{t}_2 \to Z\tilde{t}_1$
- 3ℓ, on-shell $Z \to \ell\ell$: alternative approach for challenging diagonal

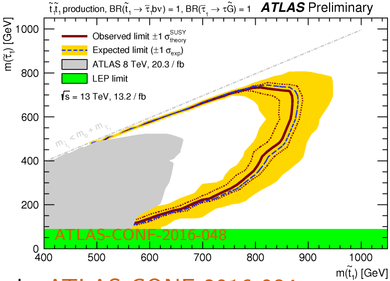


ATLAS-CONF-2016-038

“Stop to stau”



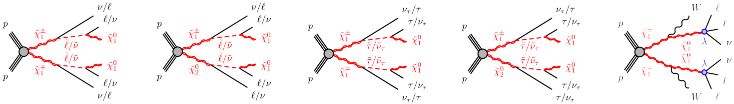
- Important natural GMSB scenarios with $\tilde{\tau}$ NLSP
- Large $E_{\text{T}}^{\text{miss}}$, high m_{T2}, b-jets



ATLAS-CONF-2016-048

More RPV in 2x2 jet resonance search: ATLAS-CONF-2016-084

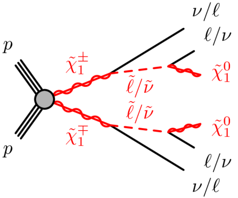
New results: electroweak production of $\tilde{\chi}^{\pm}$ and/or $\tilde{\chi}^{0}$



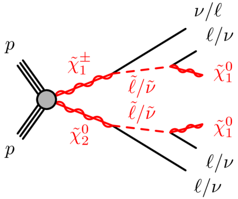
Direct EW production in 2ℓ OS and 3ℓ channels

ATLAS-CONF-2016-096

2ℓ OS



3ℓ



SR2ℓ

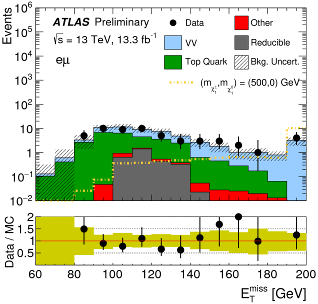
- No jets!
- $Z \to \ell\ell$ veto
- m_{T2} over $90,\ 120,\ 150\ \mathrm{GeV}$
- SF and DF

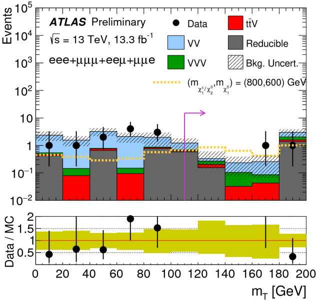
SR3ℓ-H(I)

- No b-jets!
- $Z \to \ell\ell$ veto
- $m_{\mathrm{T}} > 110\ \mathrm{GeV}$
- $E_{\mathrm{T}}^{\mathrm{miss}} > 60(120)\ \mathrm{GeV}$
- $p_{\mathrm{T}}(\ell_3) > 80(30)\ \mathrm{GeV}$

Best ATLAS sensitivity to EW production

with $\tilde{\ell}$-mediated decays!

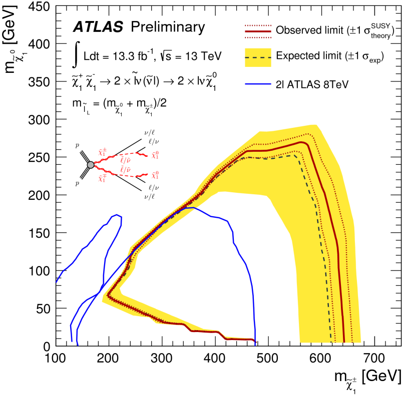




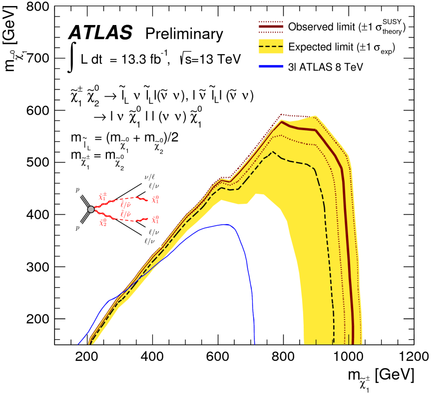
Direct EW production in 2ℓ OS and 3ℓ channels

Observed yields consistent with predicted background levels ⇒ exclusion limits

$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ (2ℓ OS)



$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$ (3ℓ)

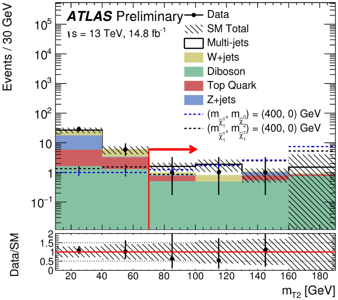


Direct EW production in di-tau channel

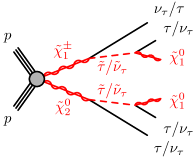
ATLAS-CONF-2016-093

Signal region definition:

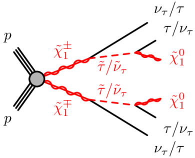
- $\geq 2\tau_{\mathrm{had}}$ (OS), $E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV
- Z veto, b-jet veto
- $m_{\mathrm{T2}} > 70$ GeV

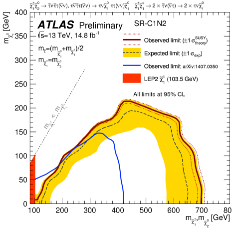


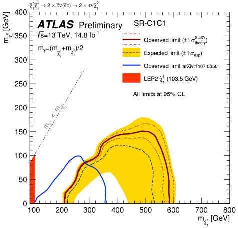
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$



$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$







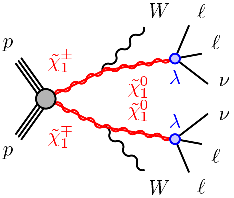
If only $\tilde{\tau}$ accessible in $\tilde{\chi}^0/\tilde{\chi}^{\pm}$ decay, hadronic τ final states gain sensitivity!

Background estimation:

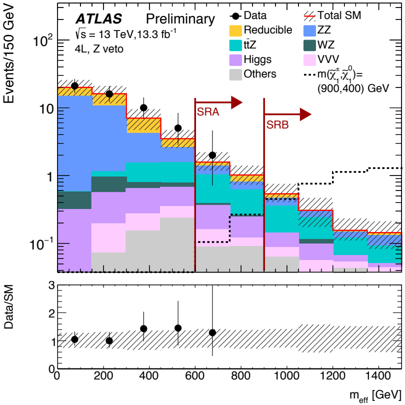
- Fake τ: multijet from data (ABCD), W+jets from MC norm. to CR
- Real τ: $VV \to \tau\tau\nu\nu$, Z+jets, top ($t\bar{t}+\mathrm{jets}/V$, Wt) from MC

EW production in 4ℓ channel

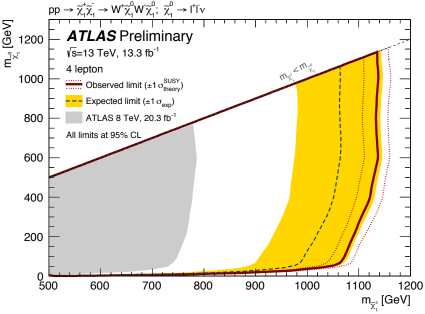
ATLAS-CONF-2016-075



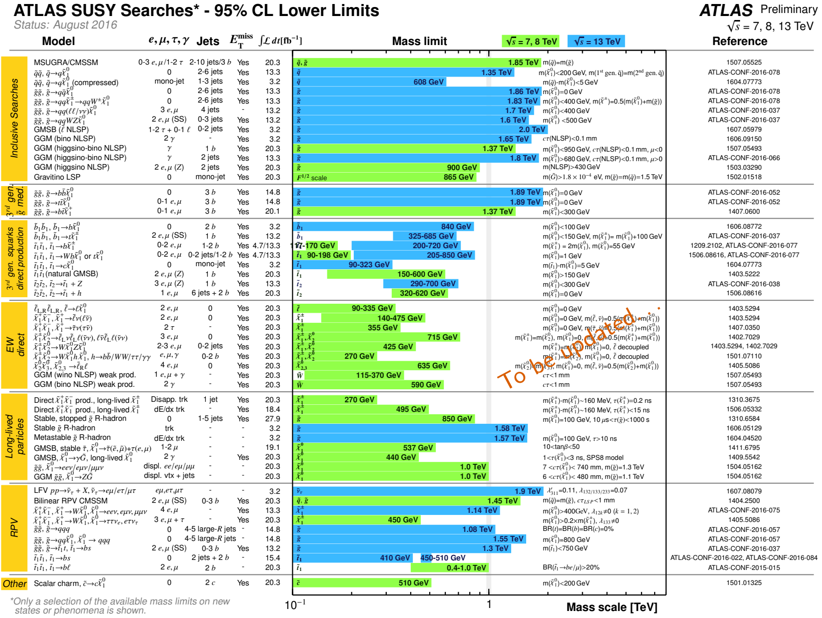
- SRs defined by Z veto, m_{eff} cuts
- Reducible backgrounds:
  - WZ, WWW, $t\bar{t}W$ + 1 fake ℓ (MC)
  - $t\bar{t}$, Z+jets + 2 fake ℓ ⇒ from data using fake-factor method
- Irreducible backgrounds:
  - ZZ, $t\bar{t}Z$, ...



Data consistent with bg ⇒
Limits up to $m_{\tilde{\chi}^{\pm}} \sim 1.1$ TeV



Global summary of excluded mass ranges



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: August 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		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
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{q}$ 1.35 TeV 🟦	m($\tilde{\chi}^0_1$)<200 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	ATLAS-CONF-2016-078
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}^0_1$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$ 608 GeV 🟦	m($\tilde{q}$)-m($\tilde{\chi}^0_1$)<5 GeV	1604.07773
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{g}$ 1.86 TeV 🟦	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-078
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^{\pm}_1\to qqW^{\pm}\tilde{\chi}^0_1$	0	2-6 jets	Yes	13.3	$\tilde{g}$ 1.83 TeV 🟦	m($\tilde{\chi}^0_1$)<400 GeV, m($\tilde{\chi}^{\pm}$)=0.5(m($\tilde{\chi}^0_1$)+m($\tilde{g}$))	ATLAS-CONF-2016-078
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\nu\nu)\tilde{\chi}^0_1$	3 e,μ	4 jets	-	13.2	$\tilde{g}$ 1.7 TeV 🟦	m($\tilde{\chi}^0_1$)<400 GeV	ATLAS-CONF-2016-037
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqWZ\tilde{\chi}^0_1$	2 e,μ (SS)	0-3 jets	Yes	13.2	$\tilde{g}$ 1.6 TeV 🟦	m($\tilde{\chi}^0_1$) <500 GeV	ATLAS-CONF-2016-037
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	3.2	$\tilde{g}$ 2.0 TeV 🟦		1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	$\tilde{g}$ 1.65 TeV 🟦	$c\tau$(NLSP)<0.1 mm	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$ 1.37 TeV 🟩	m($\tilde{\chi}^0_1$)<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	$\tilde{g}$ 1.8 TeV 🟦	m($\tilde{\chi}^0_1$)>680 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	ATLAS-CONF-2016-066
	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.	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{b}\tilde{\chi}^0_1$	0	3 b	Yes	14.8	$\tilde{g}$ 1.89 TeV 🟦	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-052
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	Yes	14.8	$\tilde{g}$ 1.89 TeV 🟦	m($\tilde{\chi}^0_1$)=0 GeV	ATLAS-CONF-2016-052
	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{t}\tilde{\chi}^+_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.37 TeV 🟩	m($\tilde{\chi}^0_1$)<300 GeV	1407.0600
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}^0_1$	0	2 b	Yes	3.2	$\tilde{b}_1$ 840 GeV 🟦	m($\tilde{\chi}^0_1$)<100 GeV	1606.08772
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}^{\pm}_1$	2 e,μ (SS)	1 b	Yes	13.2	$\tilde{b}_1$ 325-685 GeV 🟦	m($\tilde{\chi}^0_1$)<150 GeV, m($\tilde{\chi}^{\pm}_1$)= m($\tilde{\chi}^0_1$)+100 GeV	ATLAS-CONF-2016-037
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}^{\pm}_1$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde{t}_1$ 117-170 GeV 🟩 200-720 GeV 🟦	m($\tilde{\chi}^{\pm}_1$) = 2m($\tilde{\chi}^0_1$), m($\tilde{\chi}^0_1$)=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}^0_1$ or $t\tilde{\chi}^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	4.7/13.3	$\tilde{t}_1$ 90-198 GeV 🟩 205-850 GeV 🟦	m($\tilde{\chi}^0_1$)=1 GeV	1506.08616, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}^0_1$	0	mono-jet	Yes	3.2	$\tilde{t}_1$ 90-323 GeV 🟦	m($\tilde{t}_1$)-m($\tilde{\chi}^0_1$)=5 GeV	1604.07773
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$ 150-600 GeV 🟩	m($\tilde{\chi}^0_1$)>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	13.3	$\tilde{t}_2$ 290-700 GeV 🟦	m($\tilde{\chi}^0_1$)<300 GeV	ATLAS-CONF-2016-038
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+h$	1 e,μ	6 jets + 2 b	Yes	20.3	$\tilde{t}_2$ 320-620 GeV 🟩	m($\tilde{\chi}^0_1$)=0 GeV	1506.08616
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$ 90-335 GeV 🟩	m($\tilde{\chi}^0_1$)=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	$\tilde{\chi}^{\pm}_1$ 140-475 GeV 🟩	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}^{\pm}_1$ 355 GeV 🟩	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	1407.0350
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu),\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 715 GeV 🟩	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^{\pm}_1$)+m($\tilde{\chi}^0_1$))	1402.7029
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1Z\tilde{\chi}^0_1$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 425 GeV 🟩	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, $\tilde{\ell}$ decoupled	1403.5294, 1402.7029
	$\tilde{\chi}^{\pm}_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1h\tilde{\chi}^0_1$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}^{\pm}_1,\tilde{\chi}^0_2$ 270 GeV 🟩	m($\tilde{\chi}^{\pm}_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, $\tilde{\ell}$ decoupled	1501.07110
	$\tilde{\chi}^0_2\tilde{\chi}^0_3$, $\tilde{\chi}^0_{2,3}\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}^0_{2,3}$ 635 GeV 🟩	m($\tilde{\chi}^0_2$)=m($\tilde{\chi}^0_3$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^0_2$)+m($\tilde{\chi}^0_1$))	1405.5086
	GGM (wino NLSP) weak prod.	1 e,μ + γ	-	Yes	20.3	$\tilde{W}$ 115-370 GeV 🟩	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod.	2 γ	-	Yes	20.3	$\tilde{W}$ 590 GeV 🟩	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}^{\pm}_1$ 270 GeV 🟩	m($\tilde{\chi}^{\pm}_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^{\pm}_1$)=0.2 ns	1310.3675
	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}^{\pm}_1$ 495 GeV 🟩	m($\tilde{\chi}^{\pm}_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^{\pm}_1$)<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$ 850 GeV 🟩	m($\tilde{\chi}^0_1$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	3.2	$\tilde{g}$ 1.58 TeV 🟦		1606.05129
	Metastable $\tilde{g}$ R-hadron	dE/dx trk	-	-	3.2	$\tilde{g}$ 1.57 TeV 🟦	m($\tilde{\chi}^0_1$)=100 GeV, τ>10 ns	1604.04520
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}^0_1\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}^0_1$ 537 GeV 🟩	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}^0_1\to\gamma\tilde{G}$, long-lived $\tilde{\chi}^0_1$	2 γ	-	Yes	20.3	$\tilde{\chi}^0_1$ 440 GeV 🟩	1<τ($\tilde{\chi}^0_1$)<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}^0_1$ 1.0 TeV 🟩	7 <$c\tau$($\tilde{\chi}^0_1$)< 740 mm, m($\tilde{g}$)=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}$, $\tilde{\chi}^0_1\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}^0_1$ 1.0 TeV 🟩	6 <$c\tau$($\tilde{\chi}^0_1$)< 480 mm, m($\tilde{g}$)=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau+X,\tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu$,$e\tau$,$\mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$ 1.9 TeV 🟦	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1607.08079
	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
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde{\chi}^{\pm}_1$ 1.14 TeV 🟦	m($\tilde{\chi}^0_1$)>400GeV, $\lambda_{12k}\neq0$ ($k=1,2$)	ATLAS-CONF-2016-075
	$\tilde{\chi}^+_1\tilde{\chi}^-_1$, $\tilde{\chi}^+_1\to W\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to\tau\tau\nu_e, e\tau\nu_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde{\chi}^{\pm}_1$ 450 GeV 🟩	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^{\pm}_1$), $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$ 1.08 TeV 🟦	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$ 1.55 TeV 🟦	m($\tilde{\chi}^0_1$)=800 GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	13.2	$\tilde{g}$ 1.3 TeV 🟦	m($\tilde{t}_1$)<750 GeV	ATLAS-CONF-2016-037
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to bs$	0	2 jets + 2 b	-	15.4	$\tilde{t}_1$ 410 GeV 🟦 450-510 GeV 🟦		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\ell$	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, $\tilde{c}\to c\tilde{\chi}^0_1$	0	2 c	Yes	20.3	$\tilde{c}$ 510 GeV 🟩	m($\tilde{\chi}^0_1$)<200 GeV	1501.01325

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

To be updated . . .

Summary & conclusions

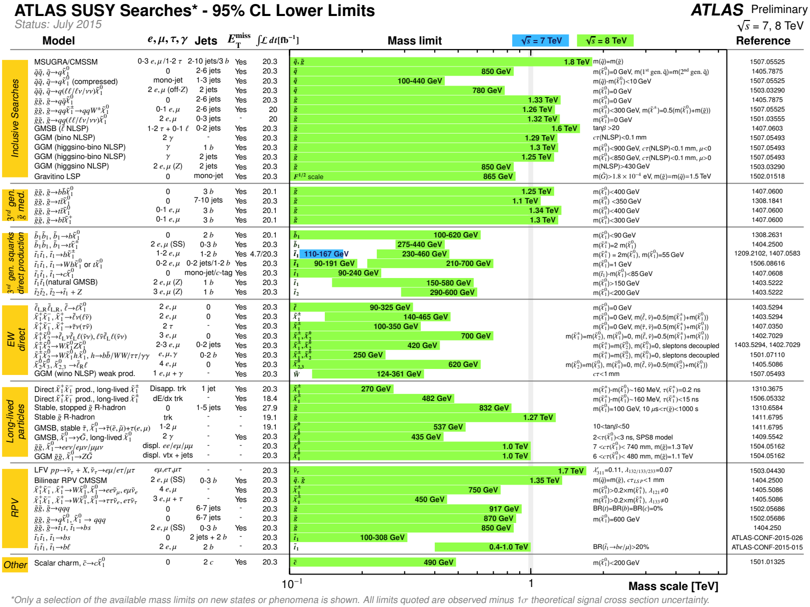
- In the past months, 18 new results from searches for SUSY have been made public by ATLAS, using 13-18 fb^{-1} of $\sqrt{13}$ TeV data from 2015+2016
- Eight analyses are new in Run II, and many improvements have been made for the nine that were also released in March
- In general the data agree well with the background expectations
  ⇒ significant increase in excluded SUSY particle mass ranges
- The $1\ell\ \tilde{t}$ search observes a modest excess
  ⇒ the rest of 2016 data will show if this persists or goes away.
- Increased integrated lumi ⇒ several analyses becoming affected by systematic uncertainties (e.g. MC modeling of $t\bar{t}$, Wt, $t\bar{t}V$ vs $t\bar{t}\gamma$)
  ⇒ work ahead for results with full 2015+2016 dataset
- Technically challenging signatures (e.g. long-lived particles) now higher priority!

Enormous thanks to the LHC for a very successful 2016!

The 2016 pp data-taking is now over - many more fb^{-1} to analyze for the winter conferences!

Back-up material

Run I SUSY results



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

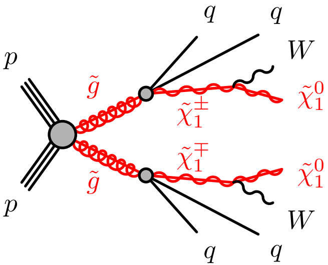
ATLAS Preliminary

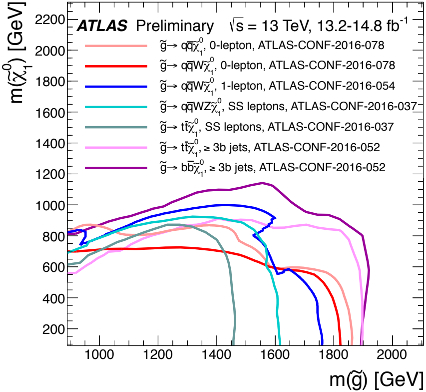
$\sqrt{s}$ = 7, 8 TeV

	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
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}^0_1$	0	2-6 jets	Yes	20.3	$\tilde{q}$	850 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}^0_1$ (compressed)	mono-jet	1-3 jets	Yes	20.3	$\tilde{q}$	100-440 GeV	m($\tilde{q}$)-m($\tilde{\chi}^0_1$)<10 GeV	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}^0_1$	2 e,μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$	780 GeV	m($\tilde{\chi}^0_1$)=0 GeV	1503.03290
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.33 TeV	m($\tilde{\chi}^0_1$)=0 GeV	1405.7875
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}^\pm_1\to qqW^\pm\tilde{\chi}^0_1$	0-1 e,μ	2-6 jets	Yes	20	$\tilde{g}$	1.26 TeV	m($\tilde{\chi}^0_1$)<300 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}^0_1$)+m($\tilde{g}$))	1507.05525
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}^0_1$	2 e,μ	0-3 jets	-	20	$\tilde{g}$	1.32 TeV	m($\tilde{\chi}^0_1$)=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	tanβ >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($\tilde{\chi}^0_1$)<900 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$	1.25 TeV	m($\tilde{\chi}^0_1$)<850 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	1507.05493
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde{g}$	850 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale	865 GeV	m($\tilde{G}$)>1.8×10^{-4} eV, m($\tilde{g}$)=m($\tilde{q}$)=1.5 TeV	1502.01518
3rd gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{b}\tilde{\chi}^0_1$	0	3 b	Yes	20.1	$\tilde{g}$	1.25 TeV	m($\tilde{\chi}^0_1$)<400 GeV	1407.0600
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	m($\tilde{\chi}^0_1$) <350 GeV	1308.1841
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	m($\tilde{\chi}^0_1$)<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($\tilde{\chi}^0_1$)<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}^0_1$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	m($\tilde{\chi}^0_1$)<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}^\pm_1$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$	275-440 GeV	m($\tilde{\chi}^\pm_1$)=2 m($\tilde{\chi}^0_1$)	1404.2500
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}^\pm_1$	1-2 e,μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$	110-167 GeV 230-460 GeV	m($\tilde{\chi}^\pm_1$) = 2m($\tilde{\chi}^0_1$), m($\tilde{\chi}^0_1$)=55 GeV	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}^0_1$ or $t\tilde{\chi}^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3	$\tilde{t}_1$	90-191 GeV 210-700 GeV	m($\tilde{\chi}^0_1$)=1 GeV	1506.08616
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}^0_1$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-240 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}^0_1$)<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($\tilde{\chi}^0_1$)>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($\tilde{\chi}^0_1$)<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	m($\tilde{\chi}^0_1$)=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	$\tilde{\chi}^\pm_1$	140-465 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1403.5294
	$\tilde{\chi}^+_1\tilde{\chi}^-_1, \tilde{\chi}^+_1\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	100-350 GeV	m($\tilde{\chi}^0_1$)=0 GeV, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1407.0350
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	700 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1402.7029
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1Z\tilde{\chi}^0_1$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	420 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2\to W\tilde{\chi}^0_1h\tilde{\chi}^0_1, h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}^\pm_1,\tilde{\chi}^0_2$	250 GeV	m($\tilde{\chi}^\pm_1$)=m($\tilde{\chi}^0_2$), m($\tilde{\chi}^0_1$)=0, sleptons decoupled	1501.07110
	$\tilde{\chi}^0_2\tilde{\chi}^0_3, \tilde{\chi}^0_{2,3}\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}^0_{2,3}$	620 GeV	m($\tilde{\chi}^0_2$)=m($\tilde{\chi}^0_3$), m($\tilde{\chi}^0_1$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}^0_2$)+m($\tilde{\chi}^0_1$))	1405.5086
	GGM (wino NLSP) weak prod.	1 e,μ + γ	-	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 $\tilde{\chi}^\pm_1$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}^\pm_1$	270 GeV	m($\tilde{\chi}^\pm_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^\pm_1$)=0.2 ns	1310.3675
	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^\pm_1$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}^\pm_1$	482 GeV	m($\tilde{\chi}^\pm_1$)-m($\tilde{\chi}^0_1$)~160 MeV, τ($\tilde{\chi}^\pm_1$)<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	832 GeV	m($\tilde{\chi}^0_1$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	19.1	$\tilde{g}$	1.27 TeV		1411.6795
	GMSB, stable $\tilde{\tau}, \tilde{\chi}^0_1\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}^0_1$	537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}^0_1\to\gamma\tilde{G}$, long-lived $\tilde{\chi}^0_1$	2 γ	-	Yes	20.3	$\tilde{\chi}^0_1$	435 GeV	2<τ($\tilde{\chi}^0_1$)<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}, \tilde{\chi}^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}^0_1$	1.0 TeV	7 <$c\tau$($\tilde{\chi}^0_1$)< 740 mm, m($\tilde{g}$)=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}, \tilde{\chi}^0_1\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}^0_1$	1.0 TeV	6 <$c\tau$($\tilde{\chi}^0_1$)< 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
	$\tilde{\chi}^+_1\tilde{\chi}^-_1, \tilde{\chi}^+_1\to W\tilde{\chi}^0_1, \tilde{\chi}^0_1\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	750 GeV	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^\pm_1$), $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}^+_1\tilde{\chi}^-_1, \tilde{\chi}^+_1\to W\tilde{\chi}^0_1, \tilde{\chi}^0_1\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde{\chi}^\pm_1$	450 GeV	m($\tilde{\chi}^0_1$)>0.2×m($\tilde{\chi}^\pm_1$), $\lambda_{133}\neq0$	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
	$\tilde{g}\tilde{g}, \tilde{g}\to q\tilde{\chi}^0_1, \tilde{\chi}^0_1\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	870 GeV	m($\tilde{\chi}^0_1$)=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	$\tilde{g}$	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, $\tilde{c}\to c\tilde{\chi}^0_1$	0	2 c	Yes	20.3	$\tilde{c}$	490 GeV	m($\tilde{\chi}^0_1$)<200 GeV	1501.01325

**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.*

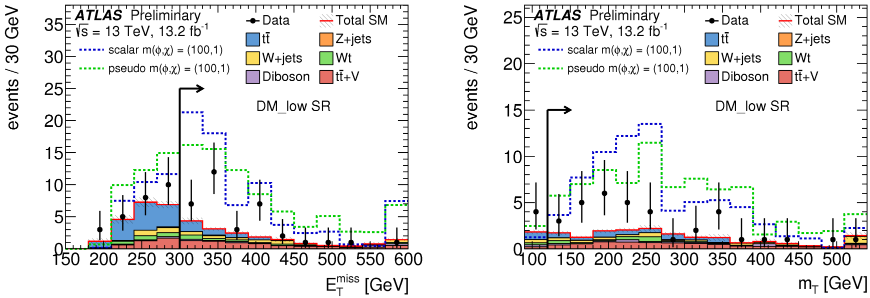
Sensitivity of inclusive strong production searches to $\tilde{g}\tilde{g}$, $\tilde{g} \to qqW\tilde{\chi}^0$





Stop 1ℓ details

3.3σ excess seen in `SR_DMlow` (35 events observed, 17±2 expected):



Many checks done on background estimates, no obvious problems found.

More data already collected, will tell us whether this is a background fluctuation

Stop 1ℓ details

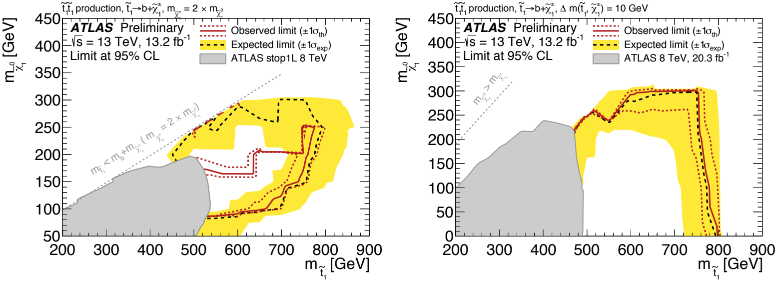


Figure 12: Expected (black dashed) and observed (red solid) 95% excluded regions in the plane of $m_{\tilde{t}_1}$ versus $m_{\tilde{\chi}_1^0}$ for direct stop pair production assuming $b\tilde{\chi}_1^\pm$ decay with a branching ratio of 100%. The chargino mass is assumed to be twice the neutralino mass (left) or close to the stop mass, $m_{\tilde{\chi}_1^\pm} = m_{\tilde{t}_1} - 10\,\text{GeV}$(right). The excluded regions (gray shaded area) from previous publications, stop search in the one-lepton channel at 8TeV (left) [24] and ATLAS stop search at 8TeV (right) [25], are obtained under the hypothesis of mostly-left-handed stops, while new results are obtained with an unpolarized signal assumption.

Summary of $t\bar{t}$+DM exclusion limits

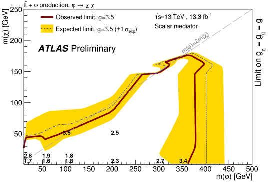
Similar limits for DM+$t\bar{t}$ for 0ℓ, 1ℓ and 2ℓ stop searches:

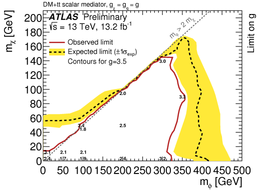
- Scalar mediator up to ~ 350 GeV
- . . . and for a pseudo-scalar mediator up to ~ 350 GeV

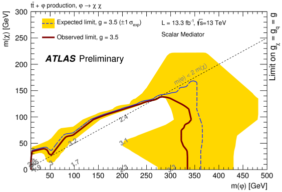
0ℓ:

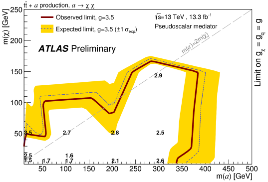
1ℓ:

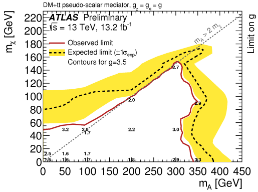
2ℓ:

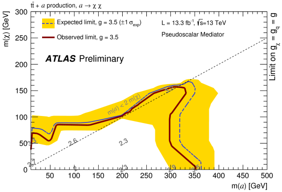












Direct $\tilde{t}$ coverage for the five new results