Searches for electroweak production of charginos, neutralinos and sleptons with the ATLAS detector

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on behalf of the ATLAS collaboration

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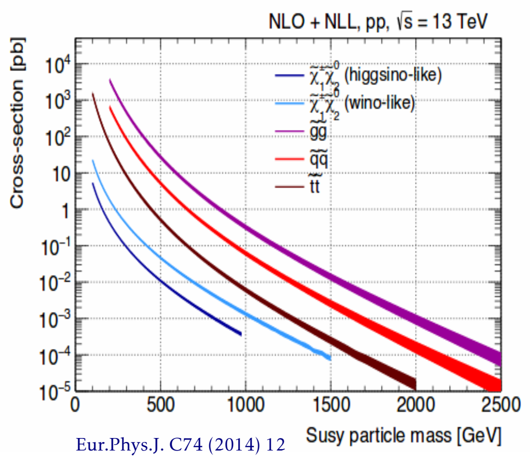
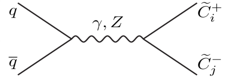
Why EW SUSY searches ?

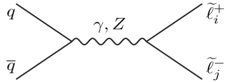
- Search for EW SUSY below the TeV scale is motivated by naturalness arguments
- EW production has a low cross-section compared to strong production of squarks & gluinos
  - very challenging searches
  - but leads to multi-lepton signatures with very low SM background



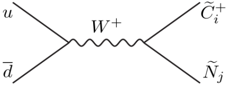
Eur.Phys.J. C74 (2014) 12



chargino pair production



slepton pair production



chargino-neutralino production

EW SUSY mass spectrum

- Gauge eigenstates Bino, Wino and Higgsinos mix to form the mass eigenstates :

4 neutralinos : $\widetilde{\chi}_1^0, \widetilde{\chi}_2^0, \widetilde{\chi}_3^0, \widetilde{\chi}_4^0$

2 charginos : $\widetilde{\chi}_1^\pm, \widetilde{\chi}_2^\pm$

$$\begin{array}{l} \left(\begin{array}{cccc} M_1 & 0 & -g'v_d/\sqrt{2} & g'v_u/\sqrt{2} \\ 0 & M_2 & gv_d/\sqrt{2} & -gv_u/\sqrt{2} \\ -g'v_d/\sqrt{2} & gv_d/\sqrt{2} & 0 & -\mu \\ g'v_u/\sqrt{2} & -gv_u/\sqrt{2} & -\mu & 0 \end{array}\right) \begin{array}{l} \text{Bino} \\ \text{Wino} \\ \text{Higgsino} \\ \text{Higgsino} \end{array} \end{array}$$

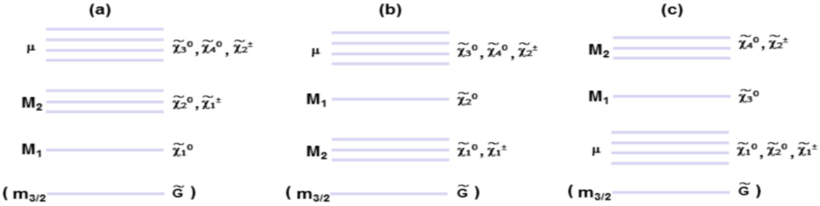
$$\left(\begin{array}{cc} M_2 & \sqrt{2}s_\beta\, m_W \\ \sqrt{2}c_\beta\, m_W & \mu \end{array}\right) \begin{array}{l} \text{Wino} \\ \text{Higgsino} \end{array}$$

- Three typical EW SUSY mass spectrum used in simplified models, depending on the relative values of the M_1, M_2 and μ parameters, each corresponding to a different $\widetilde{\chi}_1^0$ flavor (ArXiv :1404.7191)

bino-like

Wino-like or co-NLSP

Higgsino-like



→ ~ all models shown here

→ ~ long-lived $\widetilde{\chi}_1^\pm$ (disapearing track)

→ not shown here

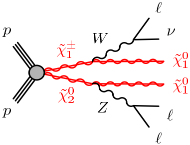
Overview of RPC EW searches

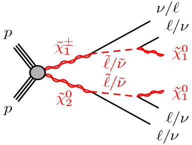
Signature depends on electroweakino mixture and sleptons masses : 2/3/4 leptons + $\not{E}_T$:

Wino-like and mass degenerate $\widetilde{\chi}_2^0$ and $\widetilde{\chi}_1^{\pm}$ → largest cross-section in most of MSSM parameter space

naturally decays through $W/Z/H$:

- 3 leptons (e,μ) + $\not{E}_T$
- 2 leptons (e,μ) SFOS + $\not{E}_T$





if $m(\widetilde{\chi}_1^0) < m(\tilde{\ell},\tilde{\nu}) < m(\widetilde{\chi}_1^{\pm},\widetilde{\chi}_2^0)$:

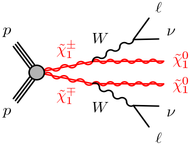
- 3 lepton (e,μ) + $\not{E}_T$
- 2 τ + $\not{E}_T$ for light $\tilde{\tau}_1$

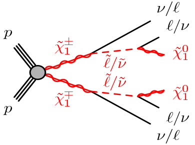
Pair production of charginos, neutralinos or sleptons via coupling to Z/γ

naturally decays through W :

- 2 leptons (e,μ) OS + $\not{E}_T$

8 TeV result only





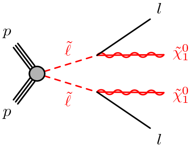
if $m(\widetilde{\chi}_1^0) < m(\tilde{\ell},\tilde{\nu}) < m(\widetilde{\chi}_1^{\pm})$:

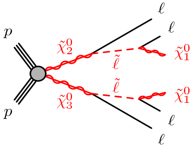
- 2 leptons (e,μ) OS + $\not{E}_T$
- 2 τ + $\not{E}_T$

if light sleptons :

- 2 leptons (e,μ) SF OS + $\not{E}_T$

→ larger cross-section for $\tilde{\ell}_L$





right-sleptons :

- 4 leptons + $\not{E}_T$

8 TeV result only

Discrimination of SUSY signal and SM background

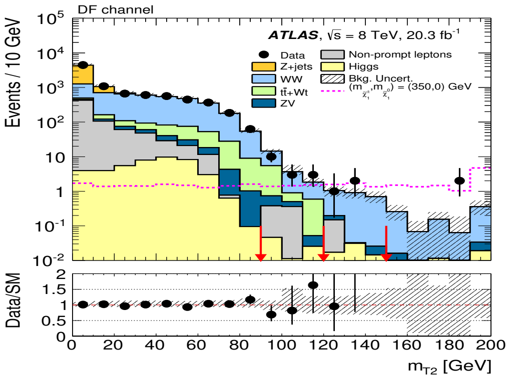
- Many kinematic variables are used to discriminate SUSY vs SM :

$\rightarrow N_{\text{jets}}, N_{\ell}, p_{\mathrm{T}}(jet, \ell), \Delta\phi, \not{E}_T, H_T, m_{\text{eff}}, m_T, m_{T2}, m_{CT}$ etc ...

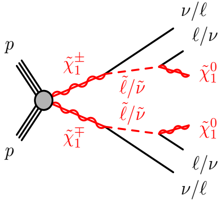
- Some variables initially developed to measure the mass of pair produced particles with semi-invisible decay also useful for SUSY vs SM discrimination

▸ Example : m_{T2} : generalization of transverse mass m_{T} used to measure the W mass at hadron colliders :

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



→ end point for WW and $t\bar{t}$ at m_W



2-lepton analysis : selection

ATLAS-CONF-2017-039

2ℓ Same Flavour Opposite Sign (SFOS) $(e^+e^-, \mu^+\mu^-)$ + jets :

- target W/Z-mediated decay

→ request $m_{\ell\ell} \sim m_Z$, $m_{jj} \sim m_W$

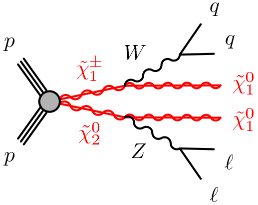
- medium/large $\Delta m(\widetilde{\chi}_2^0/\widetilde{\chi}_1^\pm, \widetilde{\chi}_1^0)$:

  → 2 SR with ⩾ 2 jets and $\not{E}_T > 150$, 250 GeV

- small $\Delta m(\widetilde{\chi}_2^0/\widetilde{\chi}_1^\pm, \widetilde{\chi}_1^0)$:

  → 2 SRs assuming either :

  - W recoil against the $Z + \not{E}_T$ system
  - full $W + Z + \not{E}_T$ system recoil against an ISR jet



2ℓ Opposite Sign (OS) + 0jets :

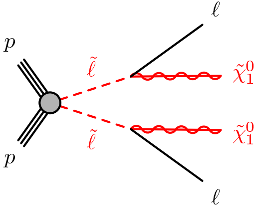
- target models with light enough sleptons
- events are split into 2 categories with different bkg composition :

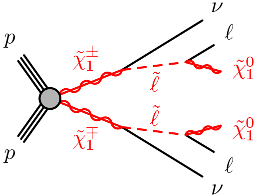
  ○ **Same Flavour $(e^+e^-, \mu^+\mu^-)$:**

  → 13 SRs binned in m_{T2} and $m_{\ell\ell}$

  ○ **Different Flavour $(e^\pm\mu^\mp)$:**

  → 4 SRs binned in m_{T2}

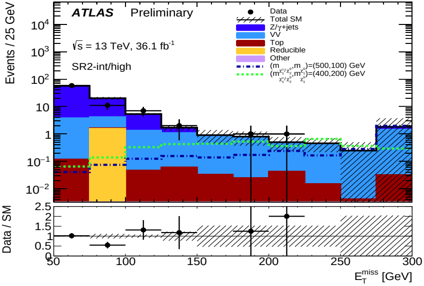




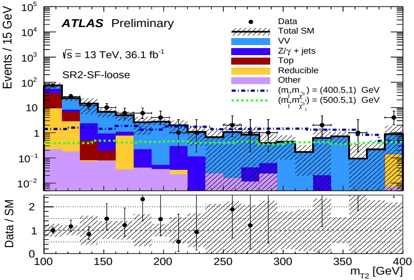
2-lepton analysis : backgrounds+results ATLAS-CONF-2017-039

- **irreducible bkg :**
  - ○ dominated by diboson, then $t\bar{t}$ and Wt
  - → renormalise MC in CR for 2ℓ+0jets
  - → taken from MC for 2ℓ+jets
- **reducible bkg :**
  - ○ Z+jets with fake $E\!\!\!/_T$:
  - → from MC for 2ℓ+0jets
  - → from γ+jets events for 2ℓ+jets
  - ○ non-prompt ℓ :
  - → from data-driven matrix method

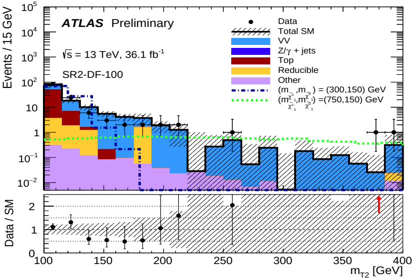
2ℓ + jets



2ℓ SF + 0jets



2ℓ DF + 0jets



2-lepton analysis : Interpretation

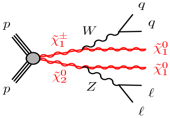
ATLAS-CONF-2017-039

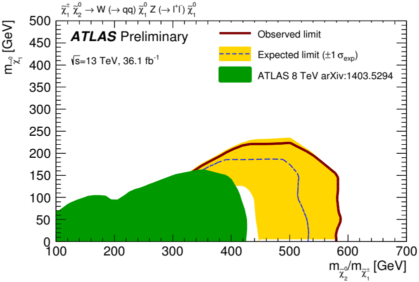
■ Models with light sleptons :

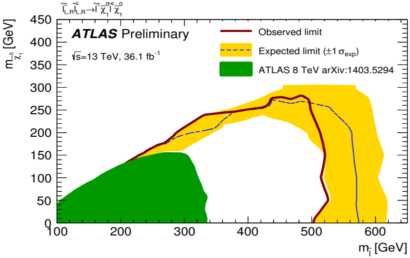
- BR = 1/6 for each $\tilde{\ell}_L$ and $\tilde{\nu}$ flavour
- $m_{\tilde{\nu}} = m_{\tilde{\ell}_L} = (m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_1^\pm})/2$

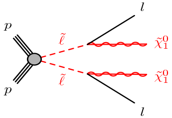
■ Models with heavy sleptons

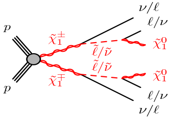
- decay via W, Z

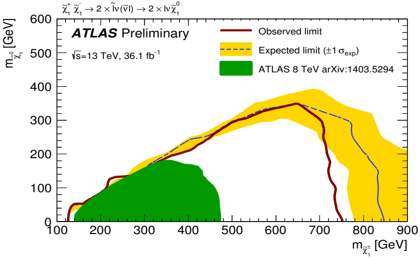












3-lepton analysis : overview ATLAS-CONF-2017-039

Event selection :

- **W/Z-mediated decay**
  - ○ $m_{SFOS} \sim m_Z$
  - ○ 6 SR binned in $\not\!\!E_T$, m_T, = 0 or ⩾ 1 jet
- **$\tilde{\ell}$-mediated decay**
  - ○ $m_{SFOS} \neq m_Z, \not\!\!E_T > 130$ GeV, $m_T > 110$ GeV
  - ○ 5 SR binned in $p_T^{\ell_3}$

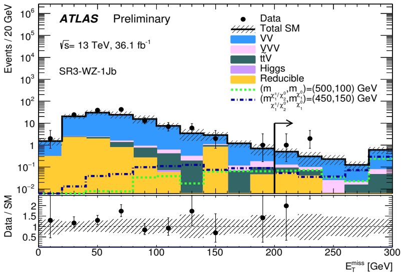
Background estimates :

- **irreducible bkg :**
  - ○ dominated by diboson WZ

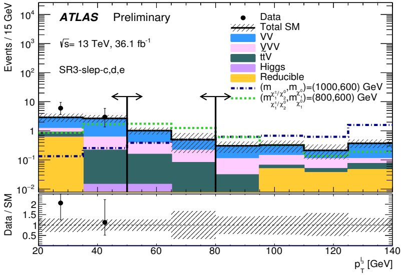
    → renormalise MC in dedicated control regions with reverted m_T cut
- **reducible bkg :**
  - ○ Z+jets, $t\bar{t}$, Wt, WW events with ⩾ 1 non-prompt lepton

  → from data-driven fake factor method

W/Z-mediated decay SR



$\tilde{\ell}$-mediated decay SR



3-lepton analysis : interpretation

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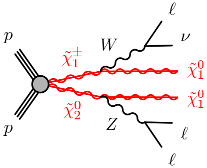
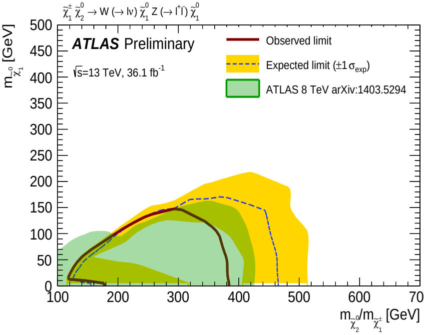
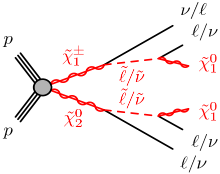
heavy sleptons

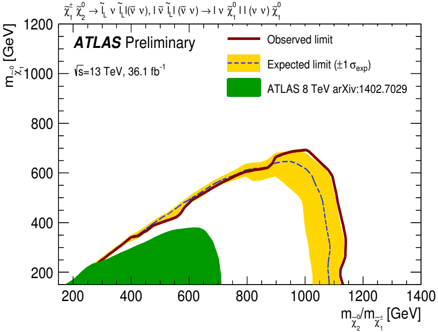




light sleptons



- BR = 1/6 for each $\tilde\ell_L$ and $\tilde\nu$ flavour
- $m_{\tilde\nu} = m_{\tilde\ell_L} = (m_{\tilde\chi_1^0} + m_{\tilde\chi_1^\pm})/2$



2-tau analysis : overview

arXiv:1708.07875

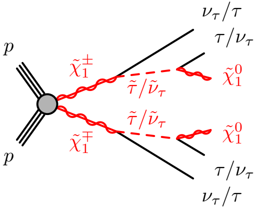
- final states with τ experimentally more challenging than with e/μ, but well motivated :
  - The lightest slepton is likely to be τ_1, with many models predicting $m(\tilde{\tau}) \sim \mathcal{O}(100)$ GeV
  - light $\tilde{\tau}$ can lead to a dark matter relic density consistent with cosmological observations

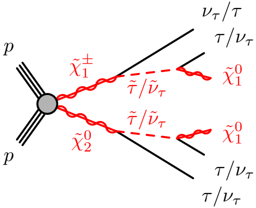
▶ consider simplified models similar to the 2-3 ℓ analysis with $\tilde{\tau}_L, \tilde{\nu}_\tau$ mediated decay

Event selection :

- di-τ asymmetric in p_{T}, or $2\tau + E\!\!\!/_T$ trigger
- $\geqslant 2$ hadronic τ OS
- $m_{\tau\tau} \neq m_Z$ → reject Z+jets
- b-jets veto → reject events with t-quark
- 2 inclusive SRs which target low/high mass splitting
  - low : $\Delta m(\widetilde{\chi}^{\pm}_1, \widetilde{\chi}^0_1) < 200$ GeV
  - high : $\Delta m(\widetilde{\chi}^{\pm}_1, \widetilde{\chi}^0_1) > 200$ GeV

→ apply ≠ cuts on $E\!\!\!/_T$, m_{T2}, $m_{\tau\tau}$, $p_T^{\tau_1}$, $p_T^{\tau_2}$

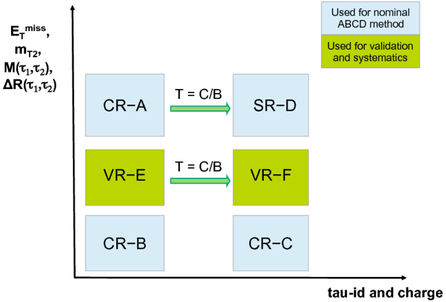




2-tau analysis : backgrounds

arXiv:1708.07875

- **irreducible bkg :**
  - ○ dominated by diboson WW and $ZZ \to \tau\tau\nu\nu$
  - ○ contributions from $t\bar{t}$, Wt, Z+jets
  - → from MC, checked in validation regions
- **reducible bkg :**
  - ○ W+jets with 1 jet mis-identified as τ
  - → renormalise MC to data in control regions
  - ○ multi-jets with 2 jets mis-identified as τ
  - → from data-driven ABCD method : C/B = D/A



E_T^{miss}, m_{T2}, $M(\tau_1,\tau_2)$, $\Delta R(\tau_1,\tau_2)$

Used for nominal ABCD method

Used for validation and systematics

CR−A

T = C/B

SR−D

VR−E

T = C/B

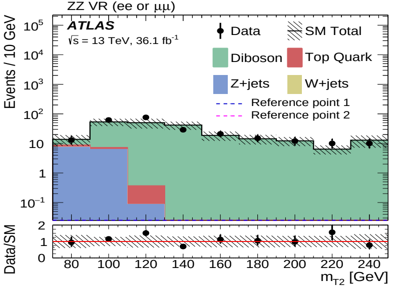
VR−F

CR−B

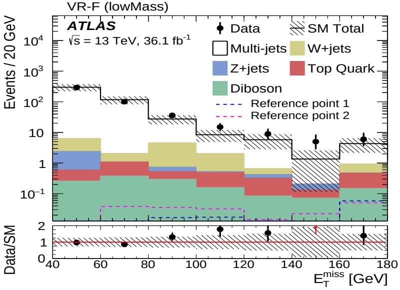
CR−C

tau-id and charge

ZZ validation region

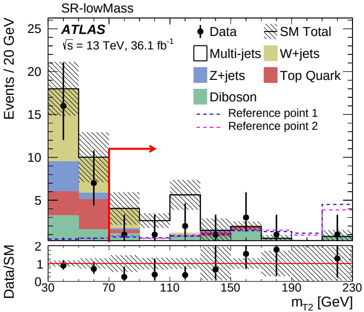


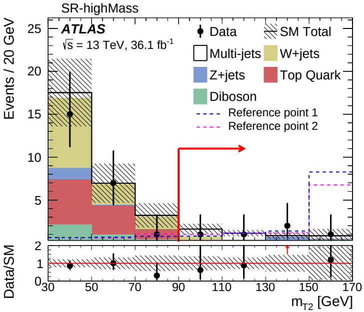
multijets validation region

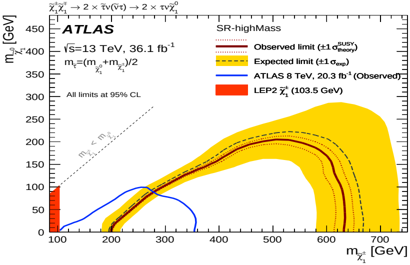


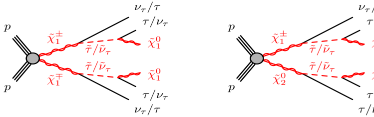
2-tau analysis : results

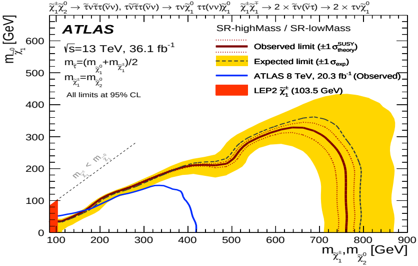
arXiv:1708.07875









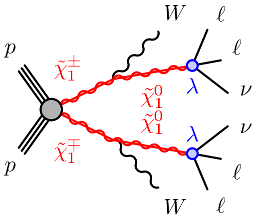


4-lepton analysis : Overview

ATLAS-CONF-2016-075

■ Search for SUSY with R-parity violation :

- In RPV models, the LSP is unstable and decays to SM particles
- assume wino-like $\widetilde{\chi}_1^+$ NLSP, bino-like $\widetilde{\chi}_1^0$ LSP
- assume L violation with $\lambda_{121}, \lambda_{122} \neq 0$ such that $\widetilde{\chi}_1^0$ decays to $e^+e^-\nu$, $\mu^+\mu^-\nu$ or $e^\pm\mu^\mp\nu$ with $BR = 1/3$



■ Event selection :

- ∘ $\geqslant 4\ \ell\ (e, \mu)$ with Z veto
- ∘ 2 SR with $m_{\text{eff}} > 600, 900$ GeV

■ Background estimates :

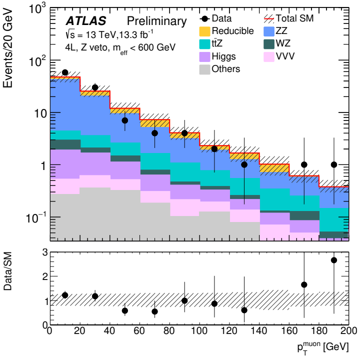
- **irreducible bkg :**
  - ∘ dominated by ZZ, $t\bar{t}+Z$ and VVZ
  - ∘ contributions from H, tWZ, $t\bar{t}WW$, $t\bar{t}t\bar{t}$ and $t\bar{t}t$
- **reducible bkg :**
  - ∘ 1 fake lepton : WZ, WWW, $t\bar{t}W$

  → all taken from MC, and tested in validation regions with low m_{eff}

  - ∘ 2 fake leptons : $t\bar{t}$, Z+jets

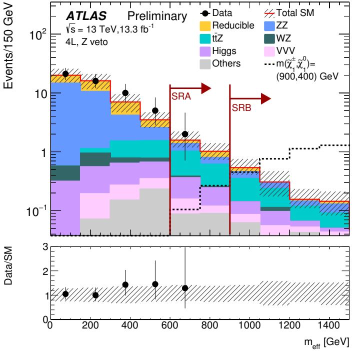
  → from data-driven fake-factor method applied in control region with *loose* leptons

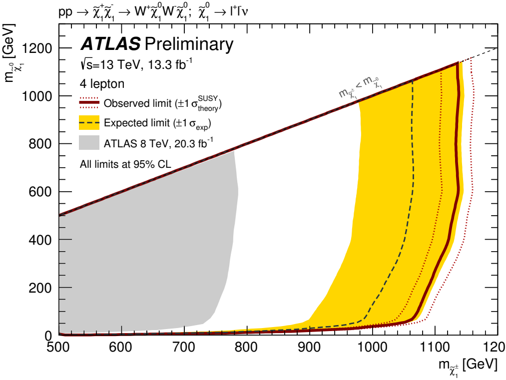
p_T^μ in VR with $m_{\text{eff}} < 600$ GeV



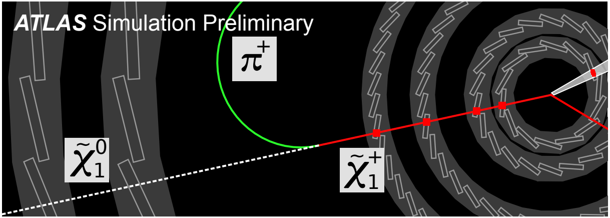
4-lepton analysis : results

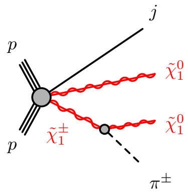
- No excess above SM prediction observed
- SR with best expected sensitivity used to set limits for each signal point
- weaker limits for $m(\text{LSP}) \ll m(\text{NLSP})$ because the decay product of the LSP tend to be collimated





Search for long-lived chargino : Overview





- In the pMSSM, ~ 70% of models with wino-like LSP predicts nearly mass degeneracy between $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_1^0$, with $\tau(\tilde{\chi}_1^\pm) \sim 0.15 - 0.25$ ns and with soft $\pi^\pm$ not reconstructed in the detector

$\Longrightarrow$ **experimental signature is a disapearing track**

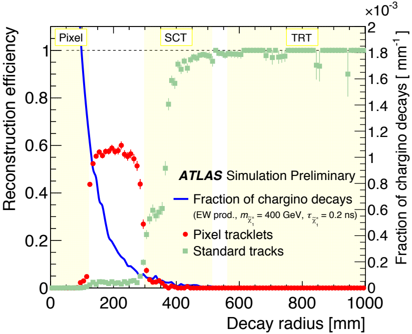
- Analysis improved wrt 8 TeV analysis thanks to the new innermost tracking layer installed for run 2

$\Longrightarrow$ can now use shorter tracks

- **Event selection :**
  - ISR recoil : back-to-back jet+$E\!\!\!/_T$, lepton veto
  - 1 isolated **pixel tracklet** with
    - $\geqslant 1$ hit in each of the 4 pixel layers
    - no SCT hit $\Longrightarrow$ disappearing condition

- Track reco efficiency of 5-10% for $\tau(\tilde{\chi}_1^\pm) = 0.2$ ns

$\Longrightarrow$ 10 × better than standard tracks

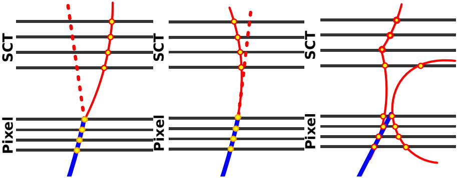


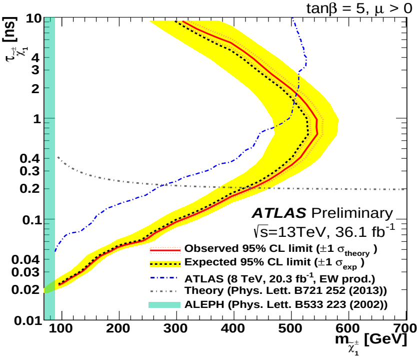
Search for long-lived chargino : results ATLAS-CONF-2017-017

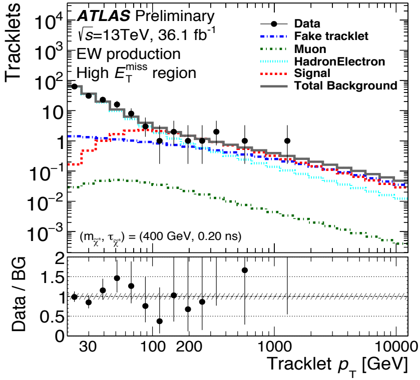
■ Backgrounds :

- $t\bar{t}$ and W+jets events with a fake tracklet from :
  - ○ multiple-scattering, hadronic interactions
  - ○ leptons bremsstrahlung
- fake tracklet from a random combination of hits

⟹ extract bkg track pT templates from data and normalize them in a simultaneous fit of the pT spectrum







Conclusion

- **ATLAS has an extensive search program to cover all signatures of EW SUSY**
  - ▸ no excess above SM expectations so far

▸ Set limits on various models :

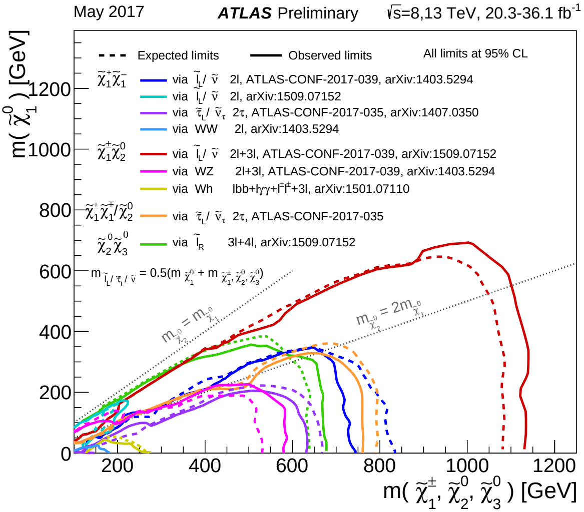
∘ **light sleptons**

→ Exclude $m(\tilde{\chi}_1^\pm) < 1150$ GeV

→ Exclude $m(\tilde{\ell}) < 500$ GeV

∘ **heavy sleptons**

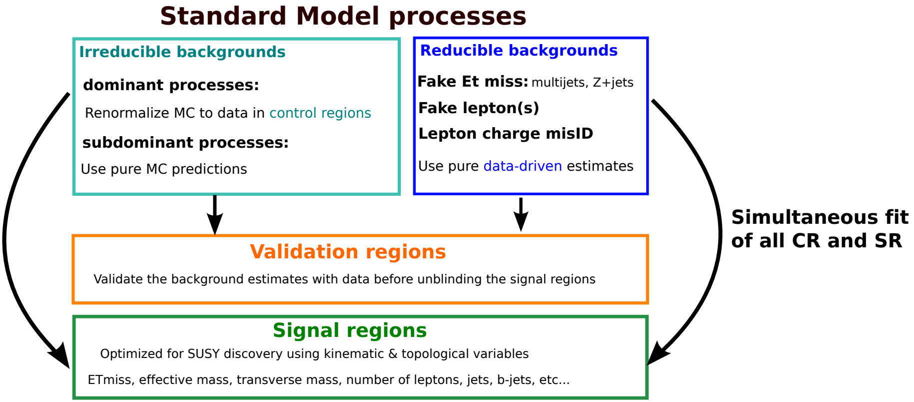
→ Exclude $m(\tilde{\chi}_1^\pm) < 580$ GeV



⟹ **More results to come soon**

BACK-UP

General strategy for SUSY searches



Standard Model processes

Irreducible backgrounds

dominant processes:

Renormalize MC to data in control regions

subdominant processes:

Use pure MC predictions

Reducible backgrounds

Fake Et miss: multijets, Z+jets

Fake lepton(s)

Lepton charge misID

Use pure data-driven estimates

Validation regions

Validate the background estimates with data before unblinding the signal regions

Signal regions

Optimized for SUSY discovery using kinematic & topological variables

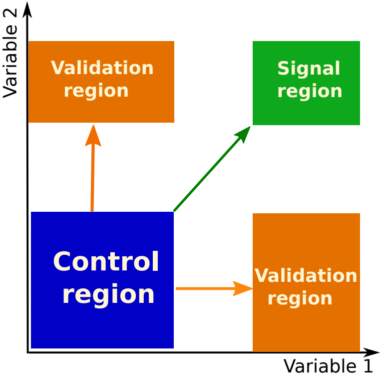
ETmiss, effective mass, transverse mass, number of leptons, jets, b-jets, etc...

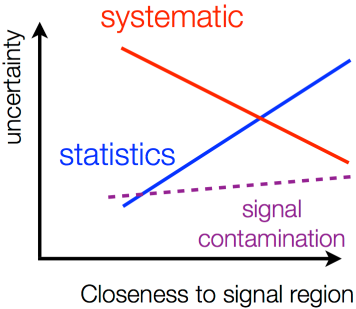
Simultaneous fit of all CR and SR

- strategy for early run 2 analyses with 2015 data :
  - optimise the signal regions for discovery
  - keep the analyses simple and robust : cut & count analyses
  - define overlapping signal regions, and select the one with the best expected sensitivity to set exclusion limits on SUSY models

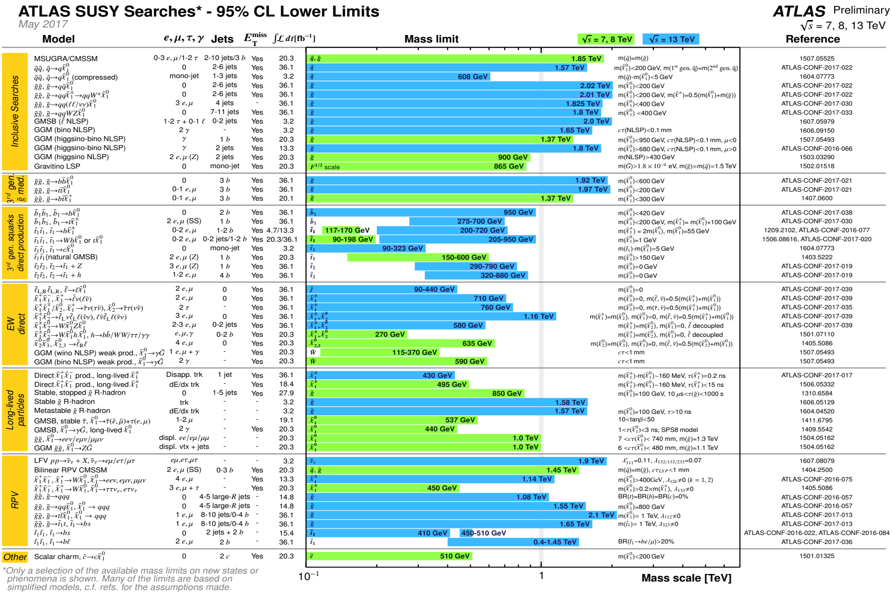
Irreducible backgrounds : semi data-driven technique

- Principle : renormalize MC in **control regions** kinematically close to the **signal region**
- Define CRs by reverting cuts on 1 or 2 variables we believe are more reliably modelled by MC
  - more robust against potential MC mis-modelling of critical variables
  - systematic uncertainties correlated between CR and SR largely cancel out
- compromise between low systematics and statistical uncertainties
- The extrapolation from the CR is validated in intermediate **validation regions**





Overview of the ATLAS SUSY results



ATLAS SUSY Searches* - 95% CL Lower Limits

May 2017

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
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{q}$ 🟦 1.57 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m(1^{st} gen. $\tilde{q}$)=m(2^{nd} gen. $\tilde{q}$)	ATLAS-CONF-2017-022
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$ 🟦 608 GeV	m($\tilde{q}$)-m($\tilde{\chi}_1^0$)<5 GeV	1604.07773
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$ 🟦 2.02 TeV	m($\tilde{\chi}_1^0$)<200 GeV	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$ 🟦 2.01 TeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}_1^0$)+m($\tilde{g}$))	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	3 e,μ	4 jets	-	36.1	$\tilde{g}$ 🟦 1.825 TeV	m($\tilde{\chi}_1^0$)<400 GeV	ATLAS-CONF-2017-030
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqWZ\tilde{\chi}_1^0$	0	7-11 jets	Yes	36.1	$\tilde{g}$ 🟦 1.8 TeV	m($\tilde{\chi}_1^0$) <400 GeV	ATLAS-CONF-2017-033
	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($\tilde{\chi}_1^0$)<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($\tilde{\chi}_1^0$)>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.	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	36.1	$\tilde{g}$ 🟦 1.92 TeV	m($\tilde{\chi}_1^0$)<600 GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	36.1	$\tilde{g}$ 🟦 1.97 TeV	m($\tilde{\chi}_1^0$)<200 GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	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	36.1	$\tilde{b}_1$ 🟦 950 GeV	m($\tilde{\chi}_1^0$)<420 GeV	ATLAS-CONF-2017-038
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	1 b	Yes	36.1	$\tilde{b}_1$ 🟦 275-700 GeV	m($\tilde{\chi}_1^0$)<200 GeV, m($\tilde{\chi}_1^\pm$)= m($\tilde{\chi}_1^0$)+100 GeV	ATLAS-CONF-2017-030
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde{t}_1$ 🟩 117-170 GeV 🟦 200-720 GeV	m($\tilde{\chi}_1^\pm$) = 2m($\tilde{\chi}_1^0$), m($\tilde{\chi}_1^0$)=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3/36.1	$\tilde{t}_1$ 🟩 90-198 GeV 🟦 205-950 GeV	m($\tilde{\chi}_1^0$)=1 GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet	Yes	3.2	$\tilde{t}_1$ 🟦 90-323 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}_1^0$)=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($\tilde{\chi}_1^0$)>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	36.1	$\tilde{t}_2$ 🟦 290-790 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2017-019
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+h$	1-2 e,μ	4 b	Yes	36.1	$\tilde{t}_2$ 🟦 320-880 GeV	m($\tilde{\chi}_1^0$)=0 GeV	ATLAS-CONF-2017-019
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	36.1	$\tilde{\ell}$ 🟦 90-440 GeV	m($\tilde{\chi}_1^0$)=0	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	36.1	$\tilde{\chi}_1^\pm$ 🟦 710 GeV	m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell},\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp/\tilde{\chi}_2^0$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$, $\tilde{\chi}_2^0\to\tilde{\tau}\tau(\nu\tilde{\nu})$	2 τ	-	Yes	36.1	$\tilde{\chi}_1^\pm$ 🟦 760 GeV	m($\tilde{\chi}_1^0$)=0, m($\tilde{\tau},\tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	ATLAS-CONF-2017-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	36.1	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$ 🟦 1.16 TeV	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($\tilde{\chi}_1^0$))	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 e,μ	0-2 jets	Yes	36.1	$\tilde{\chi}_1^\pm,\tilde{\chi}_2^0$ 🟦 580 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, $\tilde{\ell}$ decoupled	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0h\tilde{\chi}_1^0$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	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, $\tilde{\ell}$ 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., $\tilde{\chi}_1^0\to\gamma\tilde{G}$	1 e,μ + γ	-	Yes	20.3	$\tilde{W}$ 🟩 115-370 GeV	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0\to\gamma\tilde{G}$	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 $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$ 🟦 430 GeV	m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)~160 MeV, τ($\tilde{\chi}_1^\pm$)=0.2 ns	ATLAS-CONF-2017-017
	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
	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($\tilde{\chi}_1^0$)=100 GeV, τ>10 ns	1604.04520
	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
	$\tilde{g}\tilde{g}$, $\tilde{\chi}_1^0\to eev/e\mu\nu/\mu\mu\nu$	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 $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu$,$e\tau$,$\mu\tau$	-	-	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
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde{\chi}_1^\pm$ 🟦 1.14 TeV	m($\tilde{\chi}_1^0$)>400GeV, $\lambda_{12k}\neq0$ (k = 1, 2)	ATLAS-CONF-2016-075
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\nu_e, e\tau\nu_\tau$	3 e,μ + τ	-	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	4-5 large-R jets	-	14.8	$\tilde{g}$ 🟦 1.08 TeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde{g}$ 🟦 1.55 TeV	m($\tilde{\chi}_1^0$)=800 GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to qqq$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$ 🟦 2.1 TeV	m($\tilde{\chi}_1^0$)= 1 TeV, $\lambda_{112}\neq0$	ATLAS-CONF-2017-013
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde{g}$ 🟦 1.65 TeV	m($\tilde{t}_1$)= 1 TeV, $\lambda_{323}\neq0$	ATLAS-CONF-2017-013
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to bs$	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	-	36.1	$\tilde{t}_1$ 🟦 0.4-1.45 TeV	BR($\tilde{t}_1\to be/\mu$)>20%	ATLAS-CONF-2017-036
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. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.