

# Searches for supersymmetric dark matter candidates and long-lived particles with the ATLAS experiment

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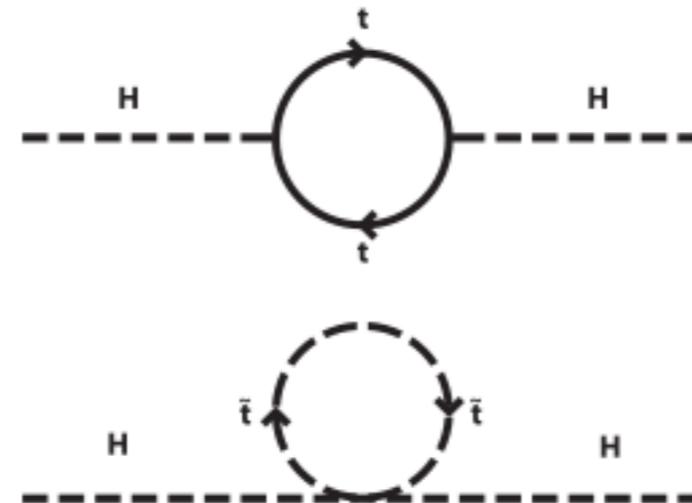
on Behalf of the ATLAS Collaboration

# Supersymmetry as SM extension

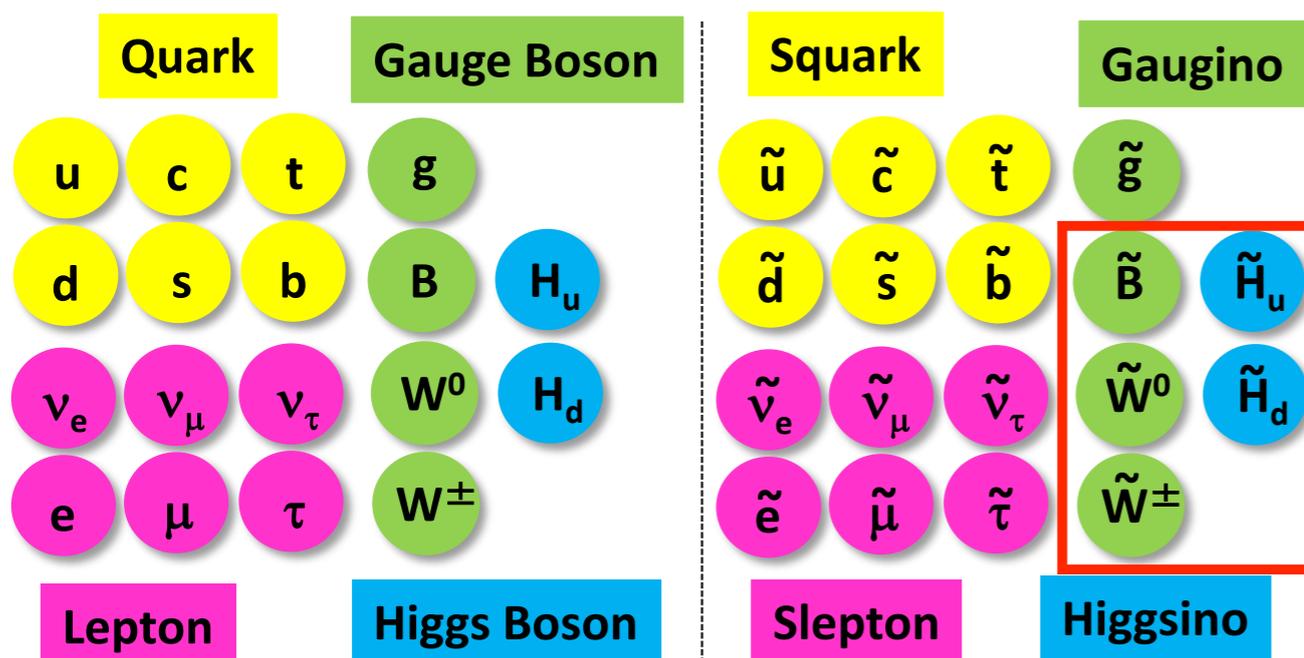
Possible SM extension based on a *broken Symmetry* between bosons and fermions: each SM particle has a supersymmetric partner differing by 1/2 spin

Could provide explanations to:

- Naturalness
- Gauge coupling unification
- Dark matter



Simplified models (reducing the number of free parameters) are studied at LHC

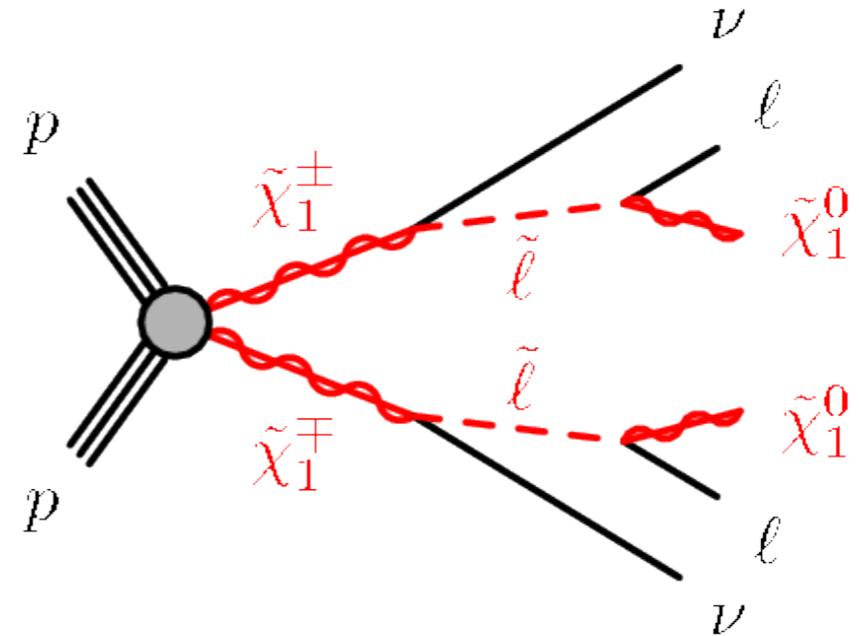


- 2 complex SM Higgs doublets are needed
- R-Parity conserved: sparticles cannot decay only into particles  $\rightarrow$  **LSP**
- Sparticle masses not fully defined by the theory
- Higgsinos and Gauginos define mass eigenstate  $\tilde{\chi}_{1,2}^\pm$  and  $\tilde{\chi}_{1,2,3,4}^0$

# Looking for SUSY at ATLAS

Analyses are optimised for dedicated signal models based on assumptions:

- R-Parity conserved or violated
- Defined mass spectrum
- Restricting free parameters
- Specific final state



## SM Background processes

MC normalized in background process enriched region

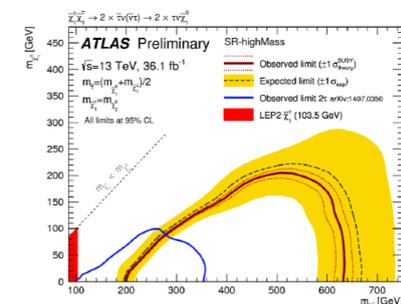
+

Pure MC estimation of non dominant background processes

## Search optimisation

Based on cut and count regions, shape fit..

if nothing found...



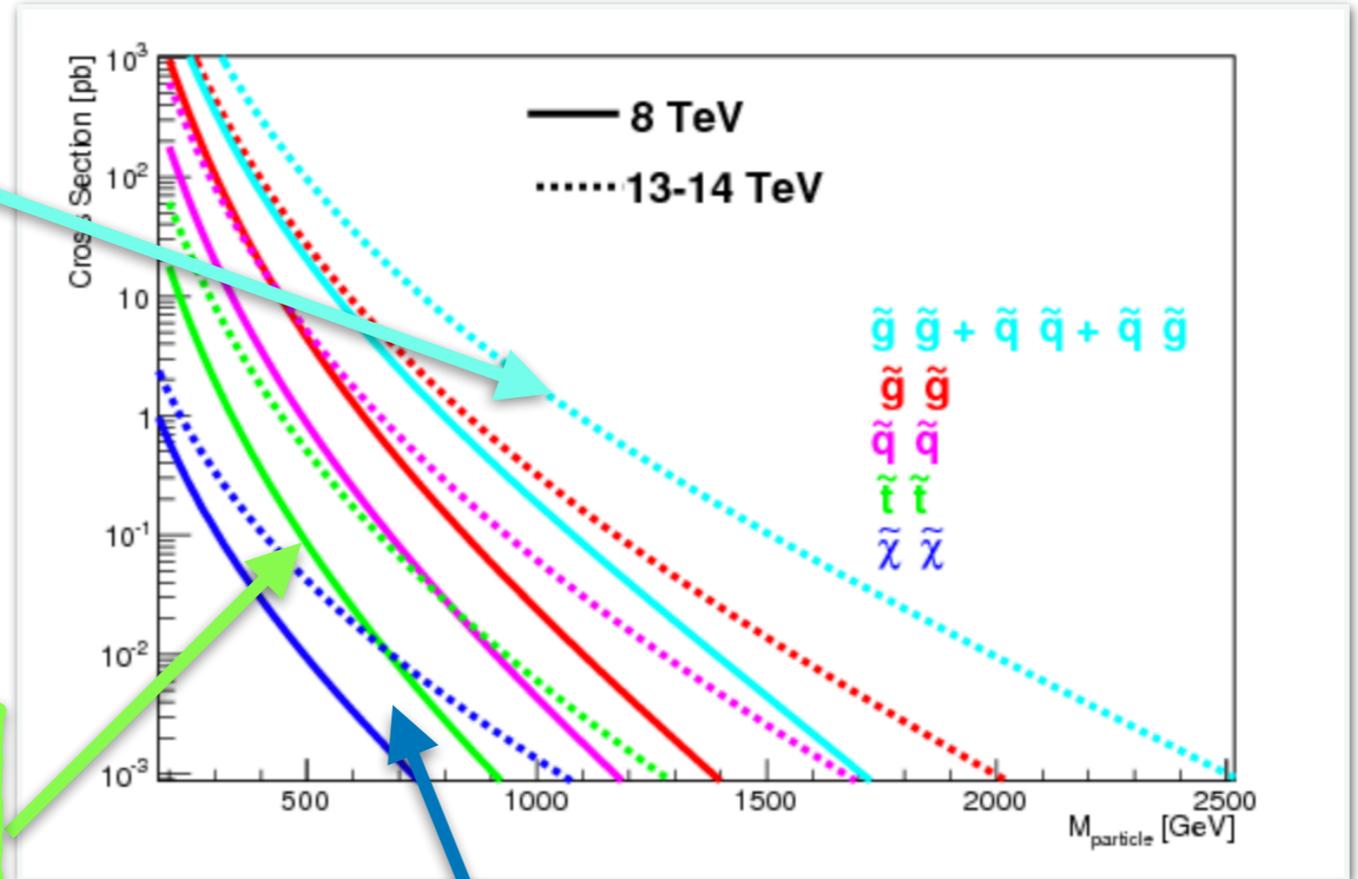
# Looking for SUSY at ATLAS: latest results

**Strong production** (Inclusive searches):  
**0L 2-6Jets** ATLAS-CONF-2017-022  
**0L 7-11 Jets** ATLAS-CONF-2017-033  
**multi b-jets** ATLAS-CONF-2017-021  
**SS/3L + jets** arXiv:1706.03731

**3rd Generation**  
**stop 0L** ATLAS-CONF-2017-020  
**stop 1L** with DM+HF ATLAS-CONF-2017-037  
**Stop 2L** ATLAS-CONF-2017-034  
**2b+MET** ATLAS-CONF-2017-038  
**Stop in Z/h** arXiv:1706.03986

**Many R-Parity violating analyses**

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections>



**EWK production**  
**EWK 2/3L** ATLAS-CONF-2017-039  
**EWK di-tau** ATLAS-CONF-2017-035

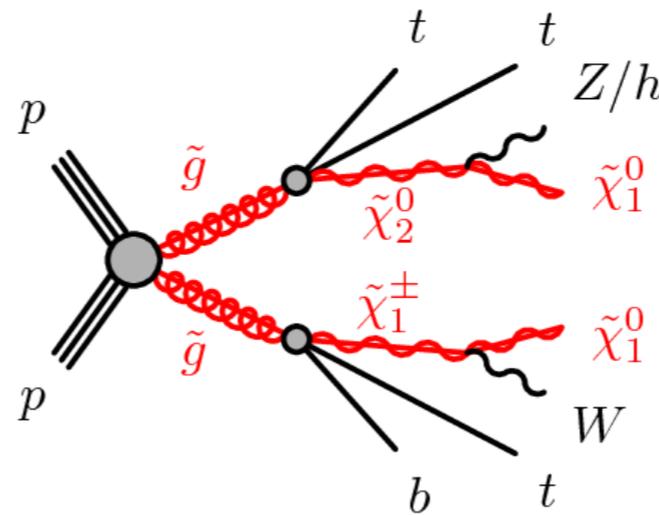
# Inclusive search: multijets analysis

## Target:

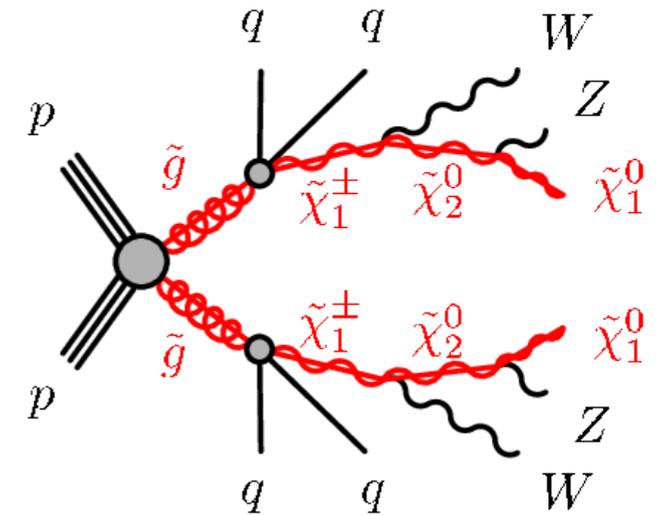
High multiplicity jet events originating from gluinos decay

## Main discriminating variables:

- Missing transverse energy
- Jet and b-tagged jet multiplicity
- Scalar sum of jet momenta
- Mass of "fat" jets



2 step decay

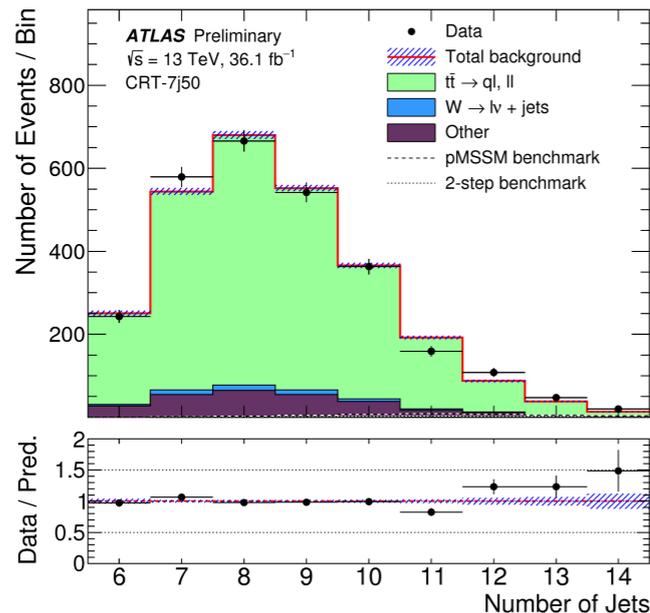


pMSSM

## Background estimates

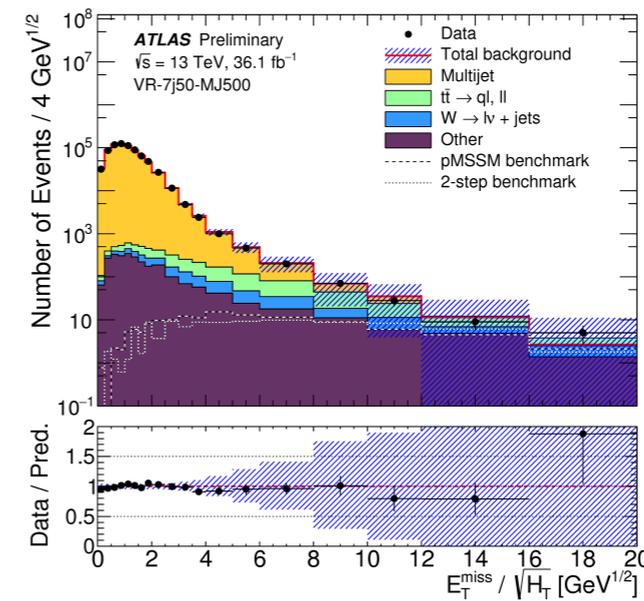
### W+jets/ttbar enriched 1 lepton CR

1 lepton, same SR selection lower jet multiplicity



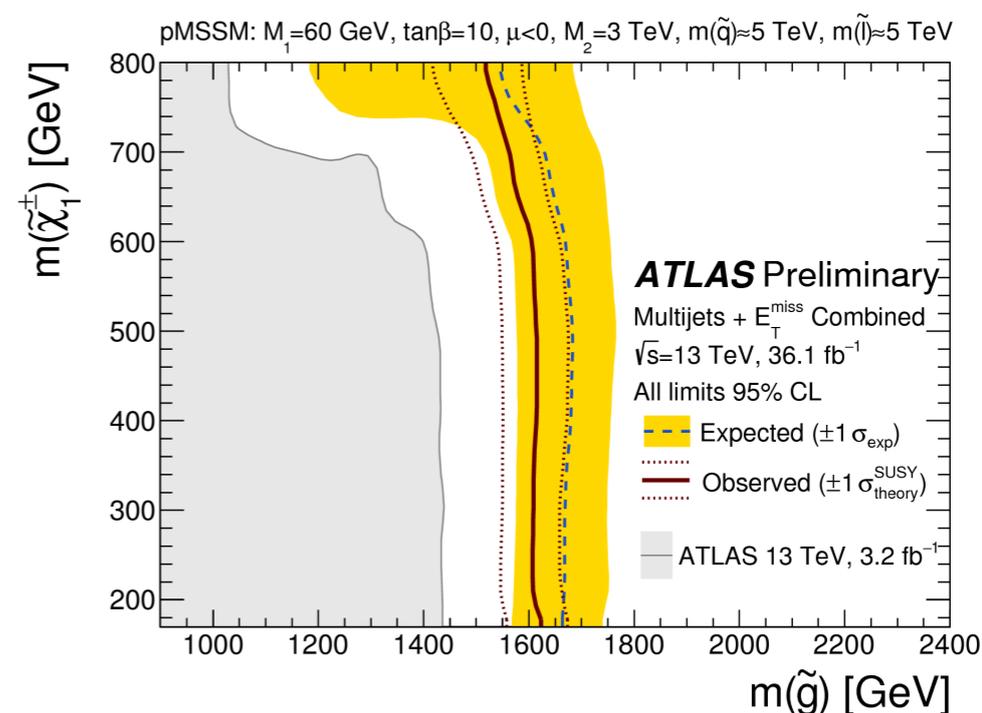
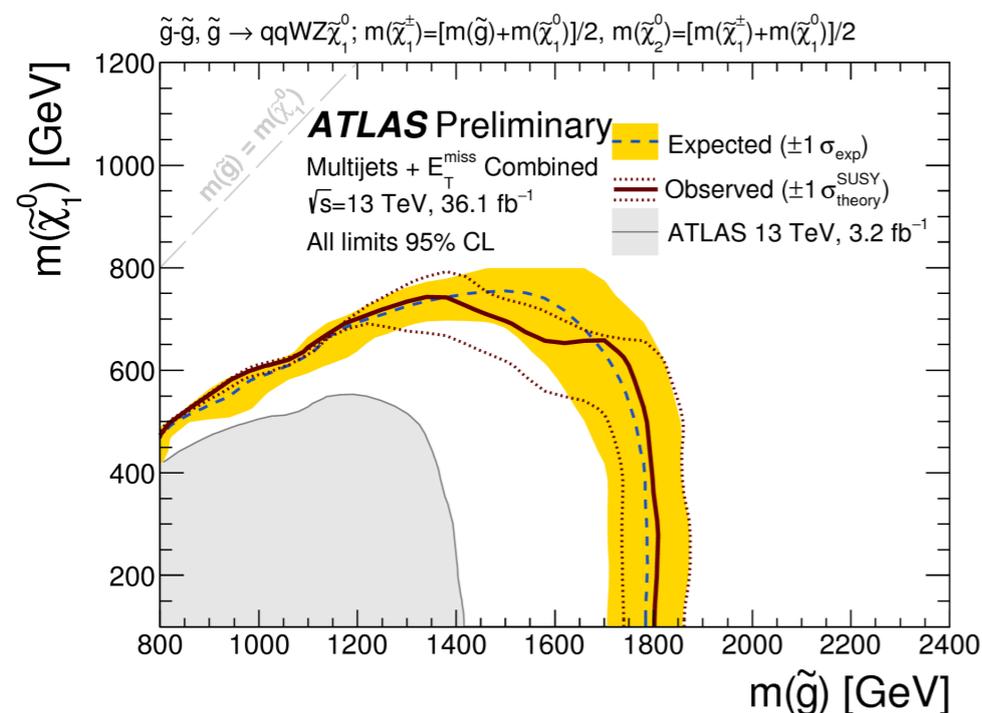
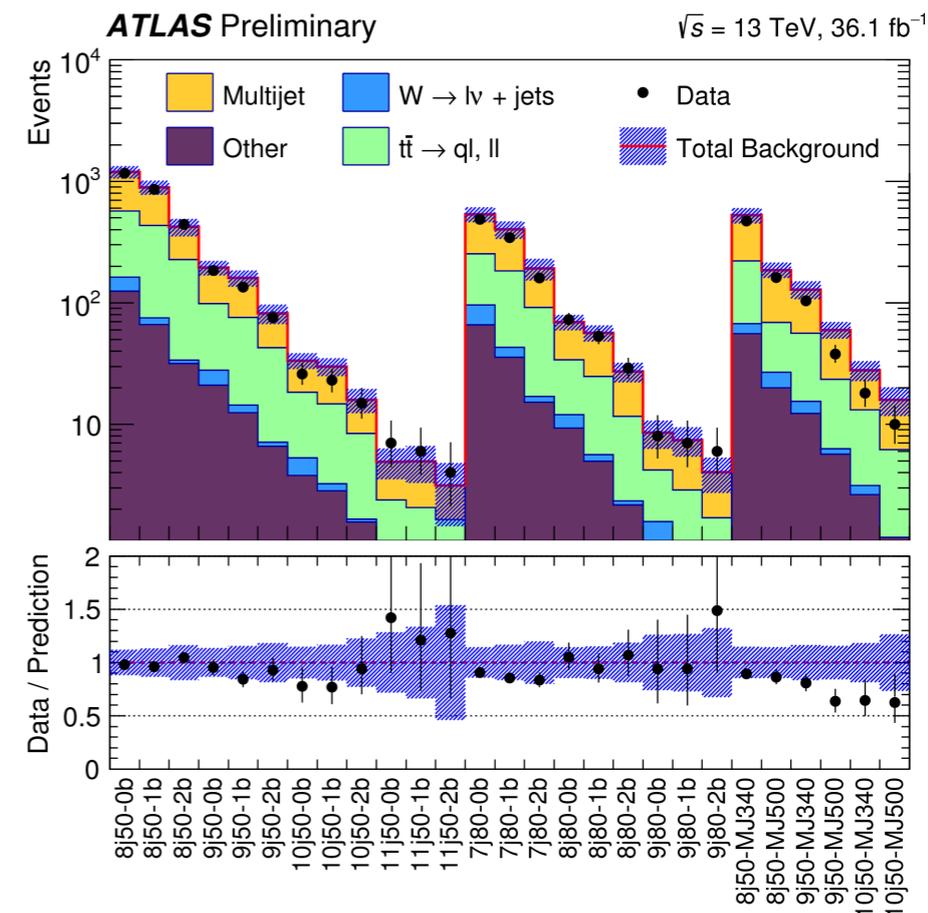
### QCD Multijet background

Template based on MET/√H<sub>T</sub> at lower jet multiplicity



# Inclusive search: multijets analysis

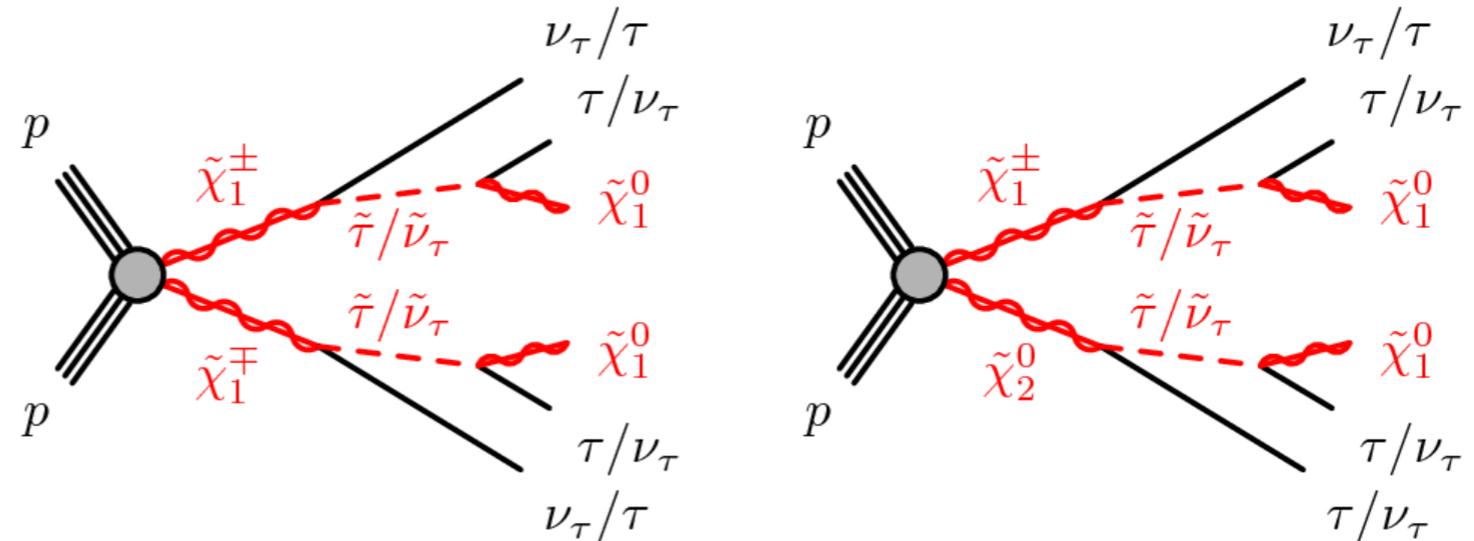
- 27 SRs based on jet/b-jet multiplicity and sum of reclustered jet masses
- No significant excess found
- Limits on gluino masses obtained:
  - In two steps decay gluino is excluded up to 1.8 TeV for light LSP
  - In pMSSM for chargino mass below 600 GeV gluino excluded up to 1.6 TeV



# Electroweak production: 2 $\tau$ final state

**Target:**

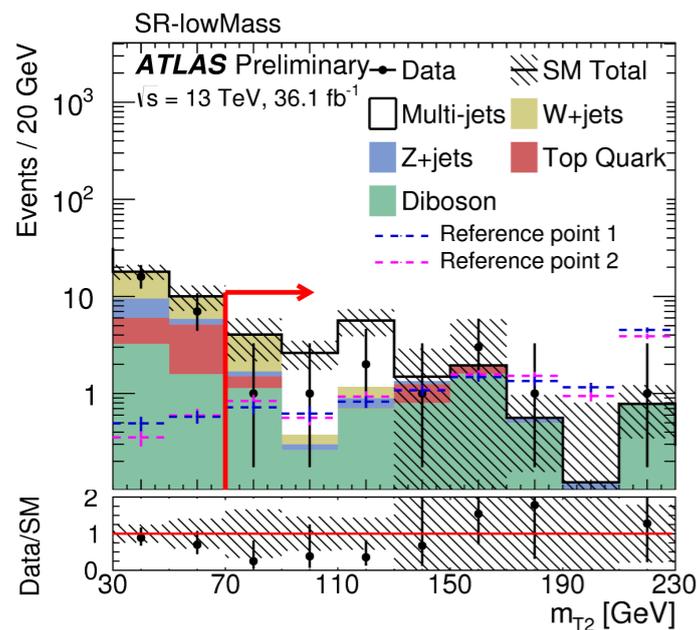
Neutralino/Chargino production having tau leptons in final state



**Models with stau can lead to dark matter relic density compatible with observation**

**Main discriminating variables:**

- Missing transverse energy
- Stranverse mass ( $m_{T2}$ )



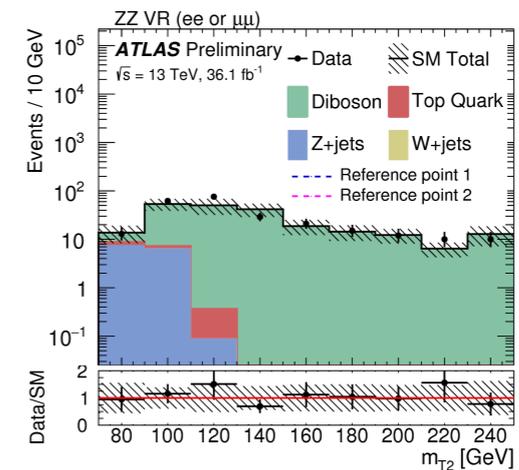
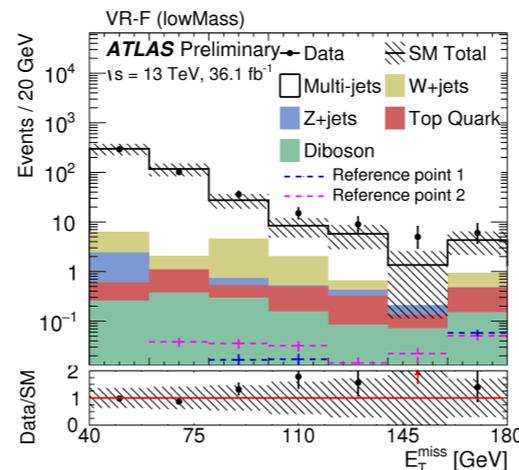
**Background estimates**

**Multijets (mis. taus):** Estimated from data

**W+jets (mis. taus):** Estimated from MC and data

**Irreducible background (ttbar, single top, WW, ZZ):** Estimated from MC

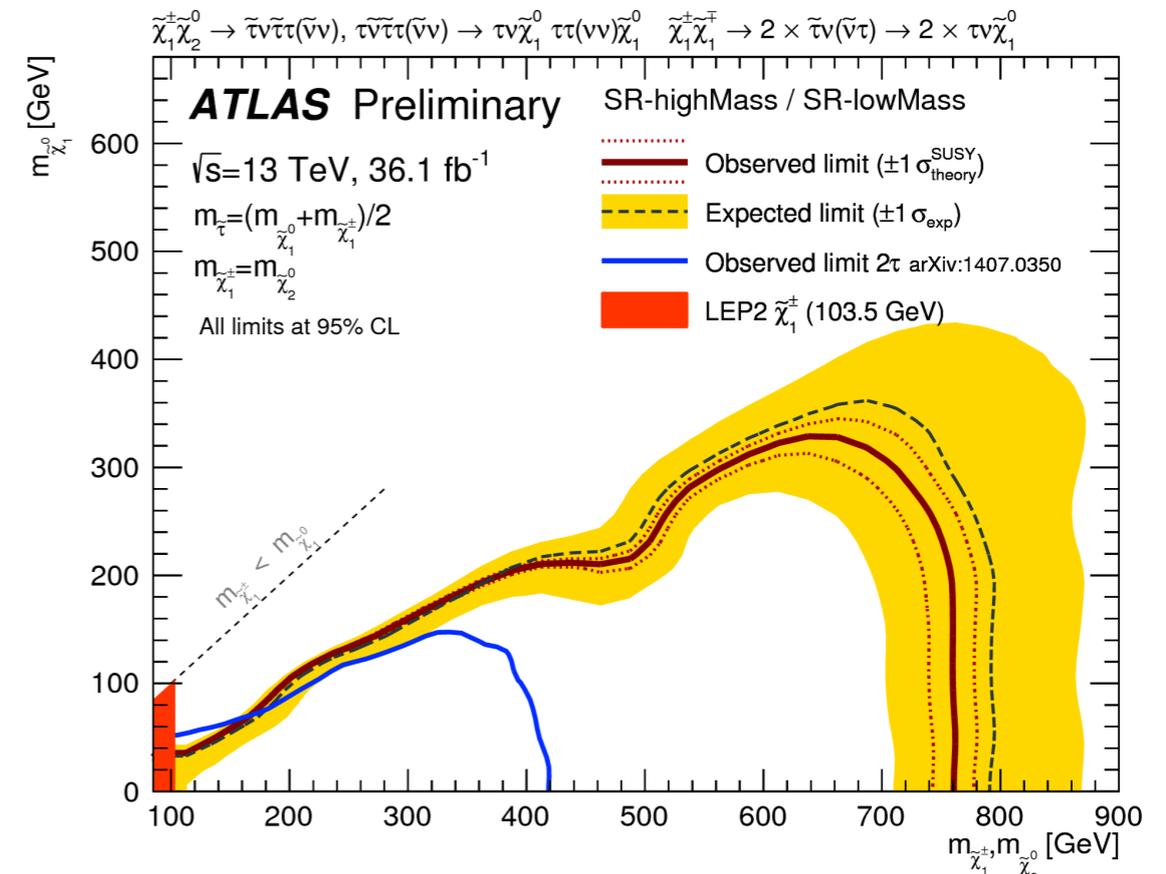
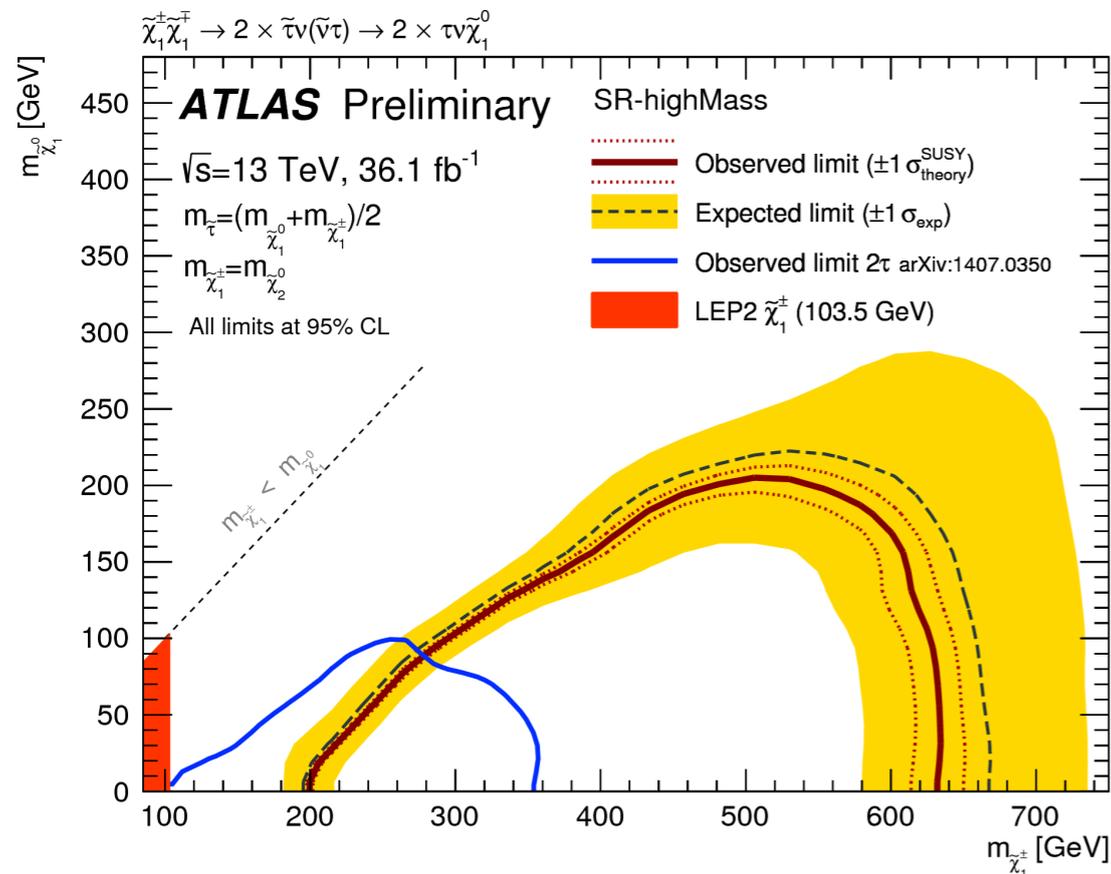
**VRs are defined to validate each background estimation:**



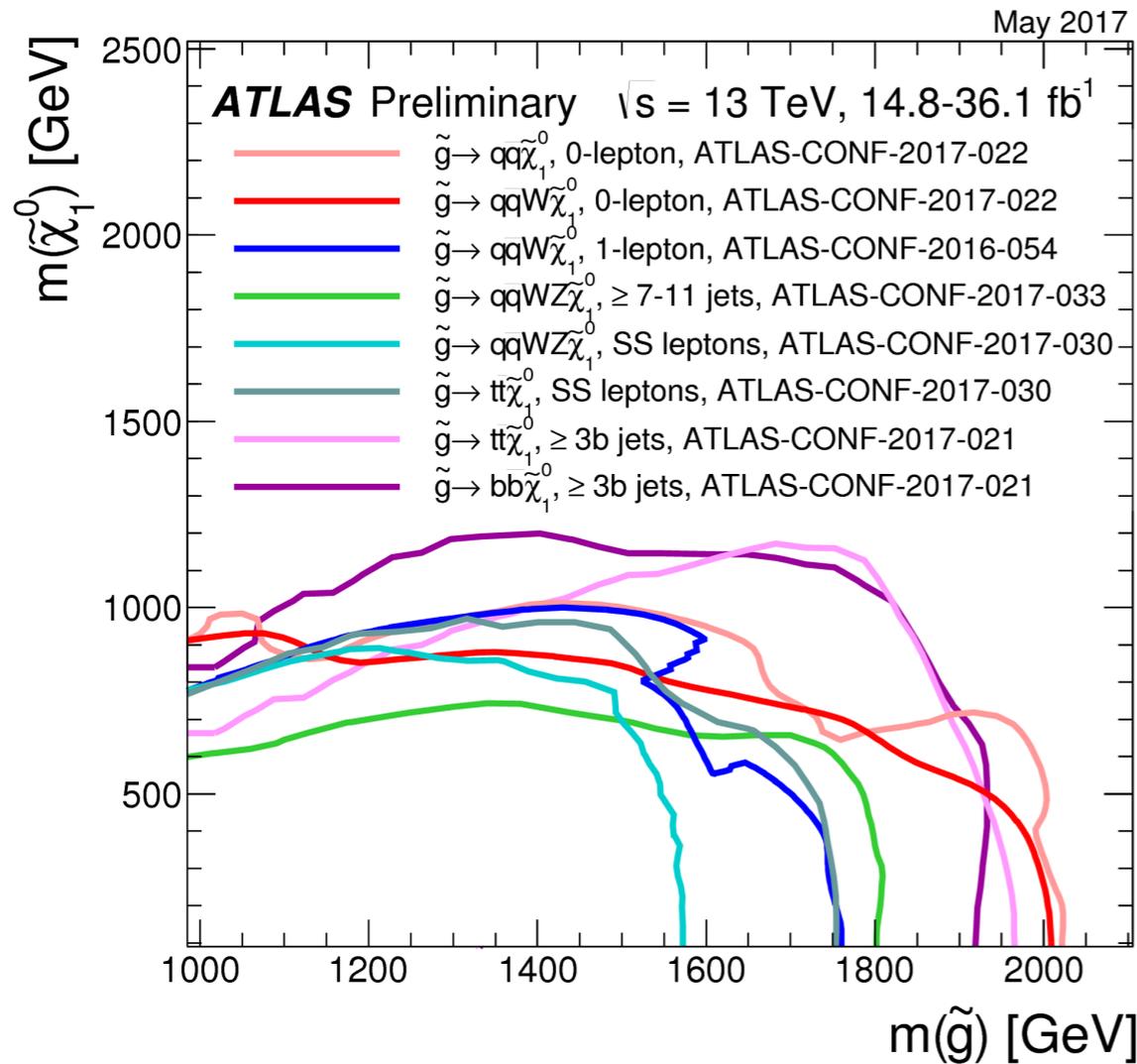
# Electroweak production: 2 $\tau$ final state

- **2 Signal regions defined** targeting signal model with mass difference between chargino and neutralino smaller or larger than 200 GeV
- No significant excess found
- Chargino/next-to-lightest Neutralino masses up to 630 GeV and 760 are excluded for massless neutralino in the two scenarios

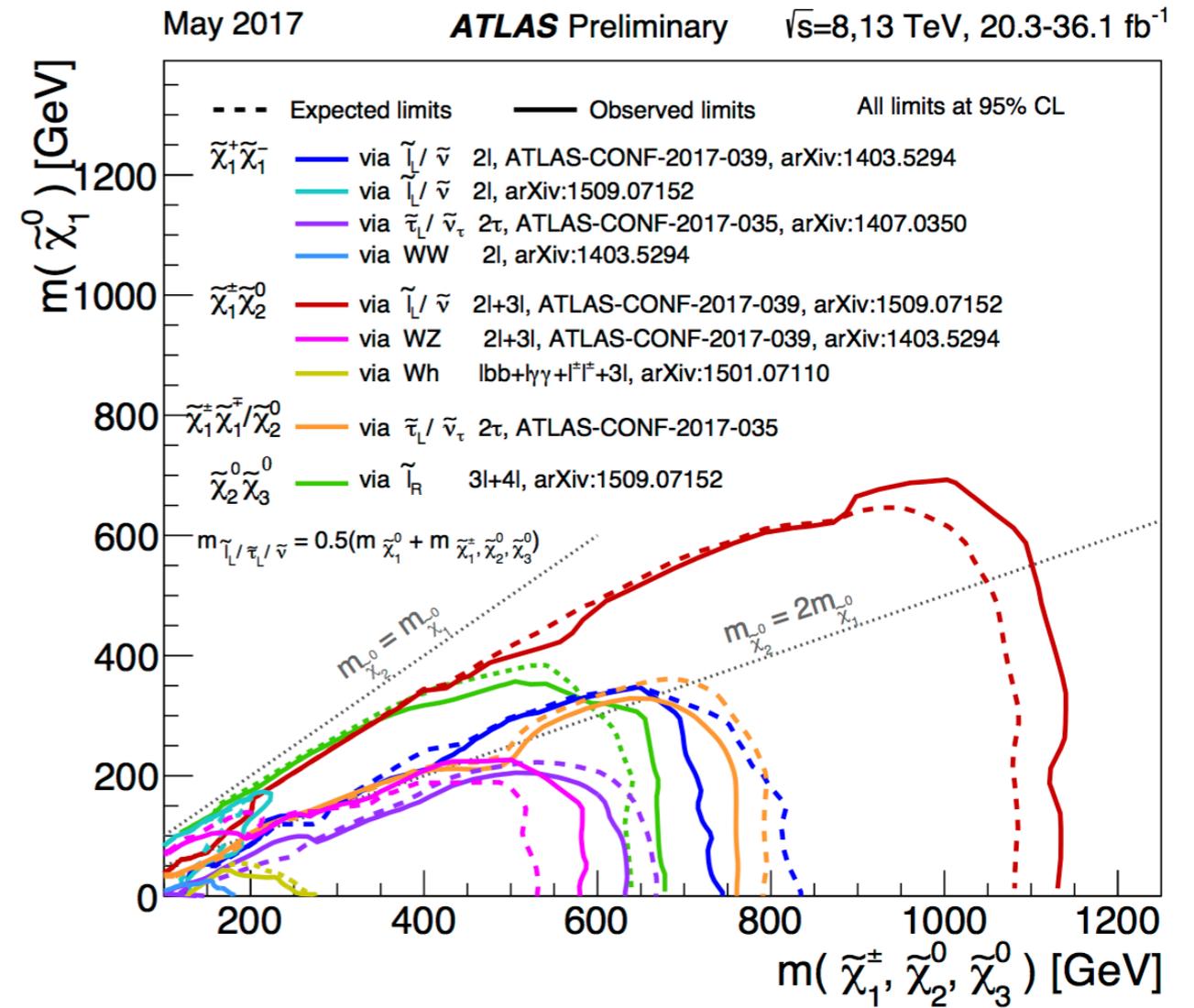
SM process	SR-lowMass	SR-highMass
diboson	$5.9 \pm 2.2$	$1.0 \pm 0.8$
$W$ +jets	$1.8 \pm 1.1$	$0.7 \pm 0.5$
Top quark	$1.2 \pm 1.0$	$0.03^{+0.26}_{-0.03}$
$Z$ +jets	$0.6^{+0.7}_{-0.6}$	$0.6 \pm 0.5$
multi-jet	$4.3 \pm 4.0$	$1.3 \pm 1.1$
SM total	$14 \pm 6$	$3.7 \pm 1.4$
Observed	10	5
Reference point 1	$11.6 \pm 2.6$	$11.8 \pm 2.8$
Reference point 2	$10.0 \pm 2.1$	$11.4 \pm 2.6$
$p_0$	0.5	0.3
Expected $\sigma_{\text{vis}}^{95}$ [fb]	$0.31^{+0.12}_{-0.08}$	$0.17^{+0.08}_{-0.05}$
Observed $\sigma_{\text{vis}}^{95}$ [fb]	0.26	0.20



# Summary of strong and electroweak production



**Strong**



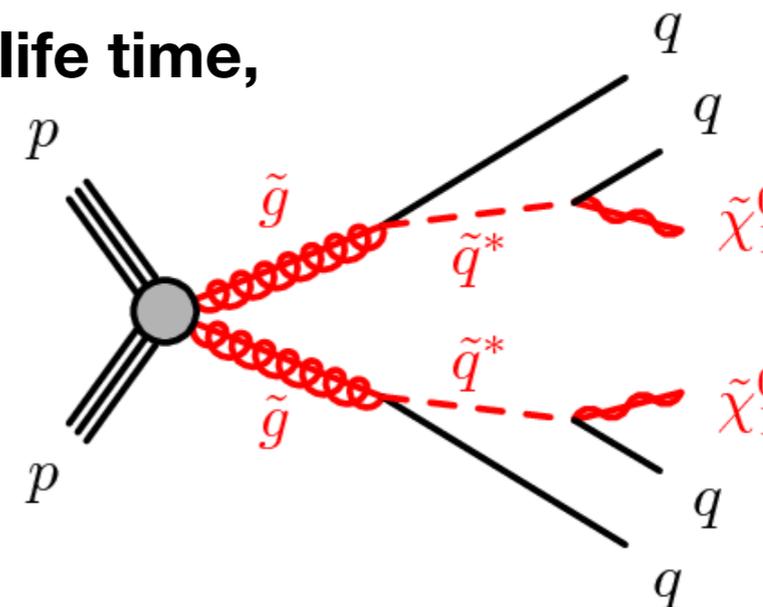
**Electroweak**

# Search for long lived particles: displaced vertices

Several SUSY models foresee sparticles having long life time, leading to **displaced vertices**

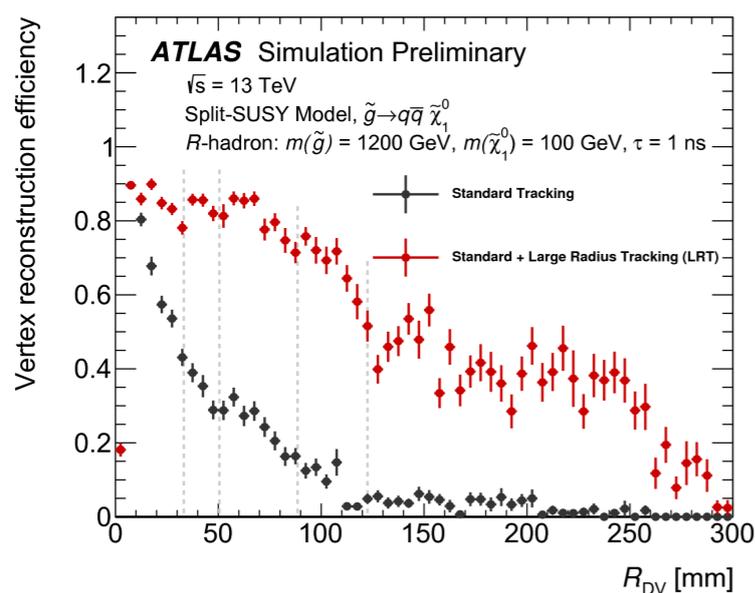
## Target:

Glauino production decaying into virtual heavy squark (suppressed decay)



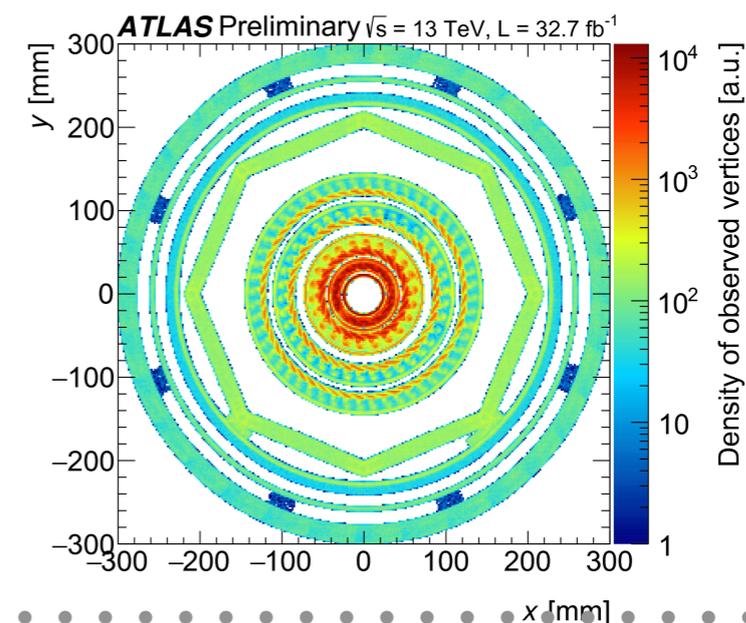
## Analysis strategy:

- Reconstruction of displaced vertices, accepting tracks up to  $|d_0| < 300$  mm and  $|z_0| < 1500$  mm.
- Minimum invariant mass of selected vertices and missing transverse energy are also required.



## Background:

- Hadronic interactions in the material
- Merged vertices
- Accidental tracks crossing vertices

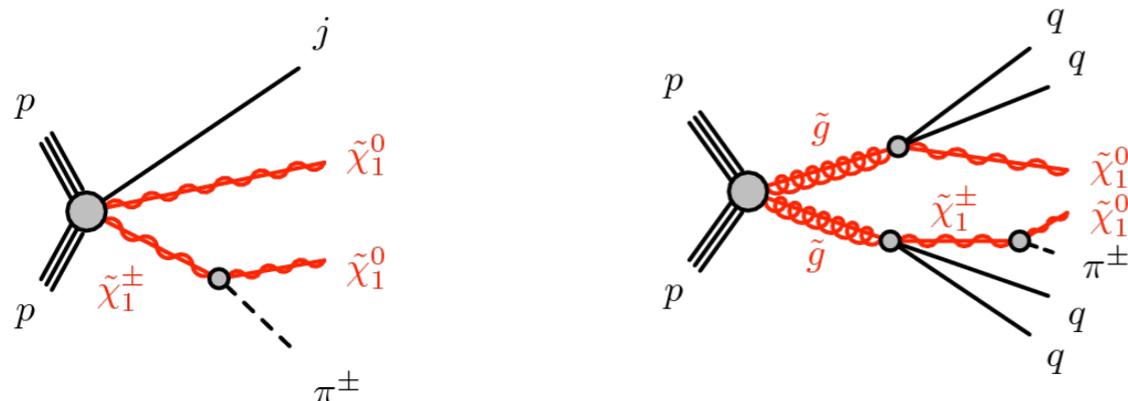




# Search for long lived particles: disappearing tracks

## Target:

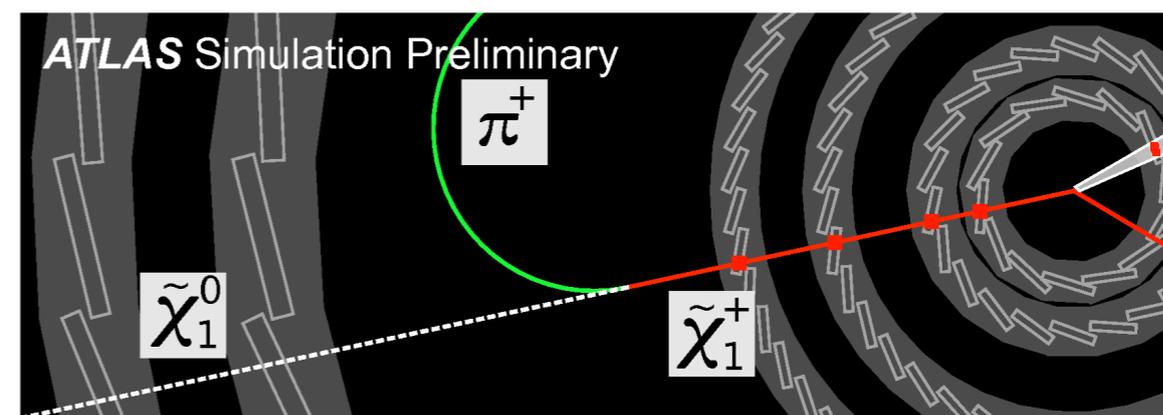
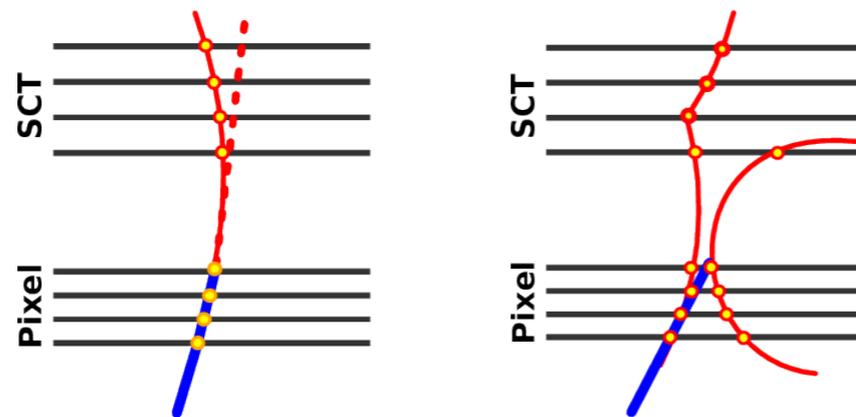
Long living chargino decaying into pion (not reconstructed) and neutralino



## Background:

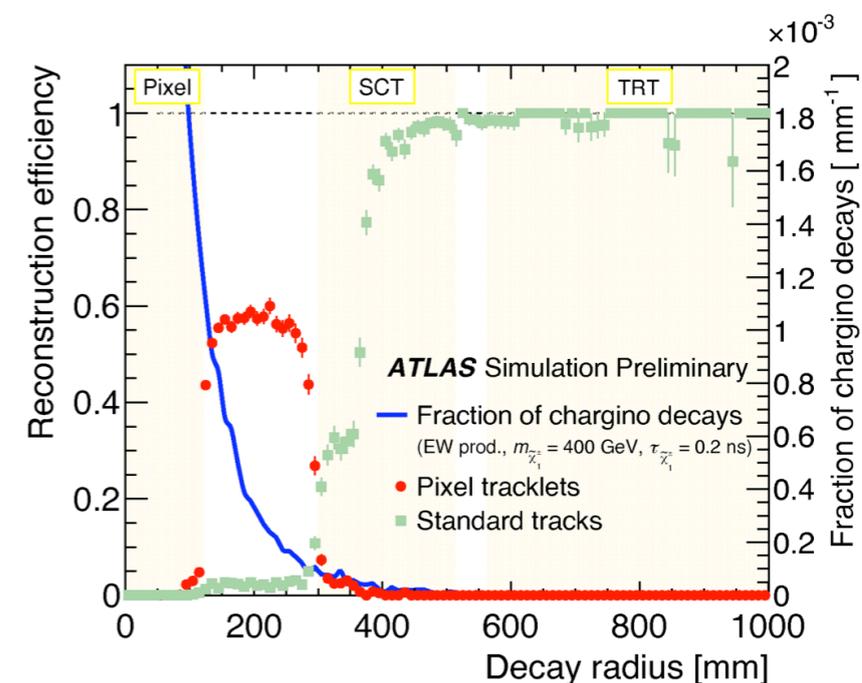
Interaction in the detector material

- Lepton emitting hard photon radiation
- Random combination of hits

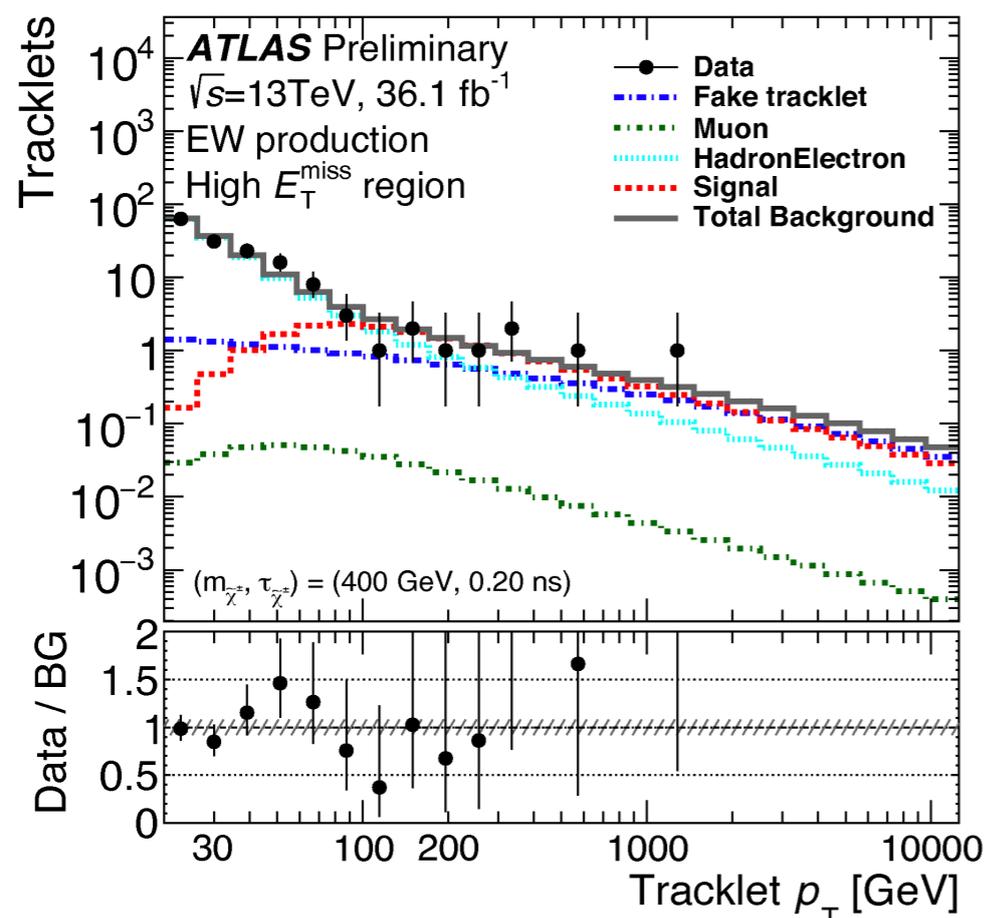


## Analysis strategy:

Reconstruction of tracklets based on pixel hits only. To reject background, jet activity and missing transverse energy also required

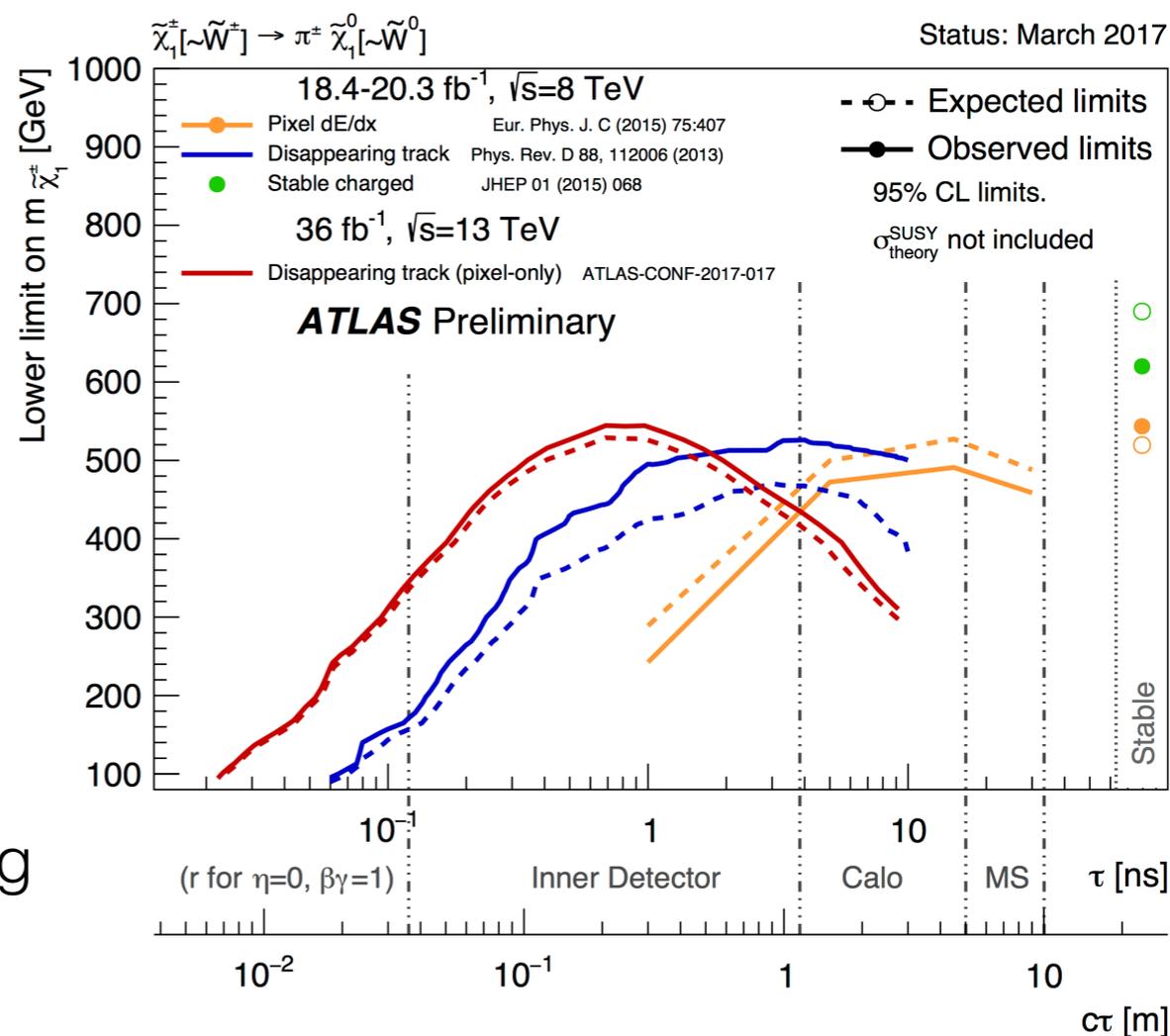


# Search for long lived particles: disappearing tracks



**No excess observed,  
 exclusion limits are derived**

Chargino masses up to 430 GeV are excluded for lifetime of 0.2 ns, corresponding to a mass splitting of 160 MeV



# Summary and conclusions

- **Many SUSY searches foresee LSP dark matter candidates as final state**
- **Only few analyses have been discussed, much wider panorama (see next slide)**
- **No significant excess found so far, but:**
  - **Full Run 2 dataset will provide more insight in many unexplored SUSY scenarios**
  - **More complex tools and analysis strategies are being implemented**

# Summary and conclusion

ATLAS SUSY Searches\* - 95% CL Lower Limits  
May 2017

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

Model	$e, \mu, \tau, \gamma$	Jets	$E_T^{\text{miss}}$	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7, 8$ TeV	$\sqrt{s} = 13$ TeV	Reference	
Inclusive Searches	MSUGRA/CMSSM	0-3 $e, \mu$ /1-2 $\tau$	2-10 jets/3 $b$	Yes	20.3	$\tilde{q}, \tilde{g}$	1.85 TeV	$m(\tilde{g})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{q}$	1.57 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$	ATLAS-CONF-2017-022
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$	608 GeV	$m(\tilde{g})-m(\tilde{\chi}_1^0) < 5$ GeV	1604.07773
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	36.1	$\tilde{g}$	2.02 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2017-022
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\chi}_1^0 \rightarrow q\tilde{q}W^\pm\tilde{\chi}_1^0$	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
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell/\nu\nu)\tilde{\chi}_1^0$	3 $e, \mu$	4 jets	-	36.1	$\tilde{g}$	1.825 TeV	$m(\tilde{\chi}_1^0) < 400$ GeV	ATLAS-CONF-2017-030
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}WZ\tilde{\chi}_1^0$	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 $\tau$ + 0-1 $\ell$	0-2 jets	Yes	3.2	$\tilde{g}$	2.0 TeV	$c\tau(\text{NLSP}) < 0.1$ mm	1607.05979
	GGM (bino NLSP)	2 $\gamma$	-	Yes	3.2	$\tilde{g}$	1.65 TeV	$c\tau(\text{NLSP}) < 0.1$ mm, $\mu < 0$	1606.09150
	GGM (higgsino-bino NLSP)	$\gamma$	1 $b$	Yes	20.3	$\tilde{g}$	1.37 TeV	$m(\tilde{\chi}_1^0) < 950$ GeV, $c\tau(\text{NLSP}) < 0.1$ mm, $\mu < 0$	1507.05493
	GGM (higgsino-bino NLSP)	$\gamma$	2 jets	Yes	13.3	$\tilde{g}$	1.8 TeV	$m(\tilde{\chi}_1^0) > 680$ GeV, $c\tau(\text{NLSP}) < 0.1$ mm, $\mu > 0$	ATLAS-CONF-2016-066
GGM (higgsino NLSP)	2 $e, \mu$ ( $Z$ )	2 jets	Yes	20.3	$\tilde{g}$	900 GeV	$m(\text{NLSP}) > 430$ GeV	1503.03290	
Gravitino LSP	0	mono-jet	Yes	20.3	$P^{1/2}$ scale	865 GeV	$m(\tilde{G}) > 1.8 \times 10^{-4}$ eV, $m(\tilde{g})=m(\tilde{g})=1.5$ TeV	1502.01518	
3 <sup>rd</sup> gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\chi}_1^0$	0	3 $b$	Yes	36.1	$\tilde{g}$	1.92 TeV	$m(\tilde{\chi}_1^0) < 600$ GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0$	0-1 $e, \mu$	3 $b$	Yes	36.1	$\tilde{g}$	1.97 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2017-021
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{t}\tilde{\chi}_1^0$	0-1 $e, \mu$	3 $b$	Yes	20.1	$\tilde{g}$	1.37 TeV	$m(\tilde{\chi}_1^0) < 300$ GeV	1407.0600
3 <sup>rd</sup> gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$	0	2 $b$	Yes	36.1	$\tilde{b}_1$	950 GeV	$m(\tilde{\chi}_1^0) < 420$ GeV	ATLAS-CONF-2017-038
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{\chi}_1^\pm$	2 $e, \mu$ (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
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm$	0-2 $e, \mu$	1-2 $b$	Yes	4.7/13.3	$\tilde{t}_1$	117-170 GeV	$m(\tilde{\chi}_1^\pm) = 2m(\tilde{\chi}_1^0), m(\tilde{\chi}_1^0)=55$ GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{\chi}_1^0$ or $\tilde{t}\tilde{t}^0$	0-2 $e, \mu$	0-2 jets/1-2 $b$	Yes	20.3/36.1	$\tilde{t}_1$	90-198 GeV	$m(\tilde{\chi}_1^0)=1$ GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$	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 $e, \mu$ ( $Z$ )	1 $b$	Yes	20.3	$\tilde{t}_1$	150-600 GeV	$m(\tilde{\chi}_1^0) > 150$ GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + Z$	3 $e, \mu$ ( $Z$ )	1 $b$	Yes	36.1	$\tilde{t}_2$	290-790 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2017-019
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow \tilde{t}_1 + h$	1-2 $e, \mu$	4 $b$	Yes	36.1	$\tilde{t}_2$	320-880 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2017-019
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell} \rightarrow \ell\tilde{\chi}_1^0$	2 $e, \mu$	0	Yes	36.1	$\tilde{\ell}$	90-440 GeV	$m(\tilde{\chi}_1^0)=0$	ATLAS-CONF-2017-039
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow \ell\nu(\ell\nu)$	2 $e, \mu$	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
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm/\tilde{\chi}_2^0, \tilde{\chi}_1^\pm \rightarrow \tilde{\tau}\nu(\tilde{\tau}\nu), \tilde{\chi}_2^0 \rightarrow \tilde{\tau}\tau(\tilde{\nu}\tilde{\nu})$	2 $\tau$	-	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
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow \tilde{\ell}_L\nu\tilde{\ell}_L, \ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L, \ell(\tilde{\nu}\nu)$	3 $e, \mu$	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
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 $e, \mu$	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
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow W\tilde{\chi}_1^0h\tilde{\chi}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	$e, \mu, \gamma$	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
	$\tilde{\chi}_2^0\tilde{\chi}_3^0, \tilde{\chi}_2^0 \rightarrow \tilde{\ell}_R\tilde{\ell}$	4 $e, \mu$	0	Yes	20.3	$\tilde{\chi}_2^0, \tilde{\chi}_3^0$	635 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$	1405.5086
	GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	1 $e, \mu + \gamma$	-	Yes	20.3	$\tilde{W}$	115-370 GeV	$c\tau < 1$ mm	1507.05493
GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	2 $\gamma$	-	Yes	20.3	$\tilde{W}$	590 GeV	$c\tau < 1$ mm	1507.05493	
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^\pm$	430 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0) \sim 160$ MeV, $\tau(\tilde{\chi}_1^\pm)=0.2$ ns	ATLAS-CONF-2017-017
	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$	495 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0) \sim 160$ MeV, $\tau(\tilde{\chi}_1^\pm) < 15$ ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$	850 GeV	$m(\tilde{\chi}_1^0)=100$ GeV, $10 \mu\text{s} < \tau(\tilde{g}) < 1000$ 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, $\tau > 10$ ns	1604.04520
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{\ell}, \tilde{\mu}) + \tau(e, \mu)$	1-2 $\mu$	-	-	19.1	$\tilde{\chi}_1^0$	537 GeV	$10 < \tan\beta < 50$	1411.6795
	GMSB, $\tilde{\lambda}_1^0 \rightarrow \gamma\tilde{G}$ , long-lived $\tilde{\lambda}_1^0$	2 $\gamma$	-	Yes	20.3	$\tilde{\lambda}_1^0$	440 GeV	$1 < \tau(\tilde{\lambda}_1^0) < 3$ ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}, \tilde{\lambda}_1^0 \rightarrow ee\nu/\mu\nu/\mu\nu$	displ. $ee/\mu\mu/\mu\mu$	-	-	20.3	$\tilde{\lambda}_1^0$	1.0 TeV	$7 < c\tau(\tilde{\lambda}_1^0) < 740$ mm, $m(\tilde{g})=1.3$ TeV	1504.05162
GGM $\tilde{g}\tilde{g}, \tilde{\lambda}_1^0 \rightarrow Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\lambda}_1^0$	1.0 TeV	$6 < c\tau(\tilde{\lambda}_1^0) < 480$ mm, $m(\tilde{g})=1.1$ TeV	1504.05162	
RPV	LFV $pp \rightarrow \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \rightarrow e\mu/\epsilon\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	3.2	$\tilde{\nu}_\tau$	1.9 TeV	$\lambda'_{311}=0.11, \lambda_{132/133/233}=0.07$	1607.08079
	Bilinear RPV CMSSM	2 $e, \mu$ (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
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow ee\nu, \mu\nu, \mu\mu\nu$	4 $e, \mu$	-	Yes	13.3	$\tilde{\chi}_1^\pm$	1.14 TeV	$m(\tilde{\chi}_1^\pm) > 400$ GeV, $\lambda_{12k} \neq 0$ ( $k=1, 2$ )	ATLAS-CONF-2016-075
	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\pm, \tilde{\chi}_1^\pm \rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow \tau\tau\nu_e, e\tau\nu_\tau$	3 $e, \mu + \tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$	450 GeV	$m(\tilde{\chi}_1^\pm) > 0.2 \times m(\tilde{\chi}_1^\pm), \lambda_{133} \neq 0$	1405.5086
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{q}$	0	4-5 large- $R$ jets	-	14.8	$\tilde{g}$	1.08 TeV	$BR(b)=BR(c)=BR(s)=0\%$	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow qq\tilde{q}, \tilde{\chi}_1^0 \rightarrow qq\tilde{q}$	0	4-5 large- $R$ jets	-	14.8	$\tilde{g}$	1.55 TeV	$m(\tilde{\chi}_1^0)=800$ GeV	ATLAS-CONF-2016-057
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_1^0, \tilde{\chi}_1^0 \rightarrow qq\tilde{q}$	1 $e, \mu$	8-10 jets/0-4 $b$	-	36.1	$\tilde{g}$	2.1 TeV	$m(\tilde{\chi}_1^0)=1$ TeV, $\lambda_{112} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow \tilde{t}_1 t, \tilde{t}_1 \rightarrow bs$	1 $e, \mu$	8-10 jets/0-4 $b$	-	36.1	$\tilde{g}$	1.65 TeV	$m(\tilde{t}_1)=1$ TeV, $\lambda_{323} \neq 0$	ATLAS-CONF-2017-013
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow bs$	0	2 jets + 2 $b$	-	15.4	$\tilde{t}_1$	410 GeV	-	ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\ell}$	2 $e, \mu$	2 $b$	-	36.1	$\tilde{t}_1$	0.4-1.45 TeV	$BR(\tilde{t}_1 \rightarrow b\ell/\mu) > 20\%$	ATLAS-CONF-2017-036
Other	Scalar charm, $\tilde{c} \rightarrow c\tilde{\chi}_1^0$	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.

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Mass scale [TeV]