Direct electroweakino, slepton and stop searches at ATLAS

Rachik Soualah
On behalf of the ATLAS collaboration
INFN and University of Udine

ECFA Linear Collider Workshop (LC2013)
DESY Hamburg, May 27 - 31

SuperSymmetry (SUSY) production at the LHC

- Supersymmetry postulates that for every Standard Model particle there is a corresponding supersymmetric particle (``sparticle'') which has a spin that is different by 1/2 unit.

- SUSY has been proposed to solve the hierarchy problem in the Standard Model.
- SUSY is key element in many Standard Model extensions.

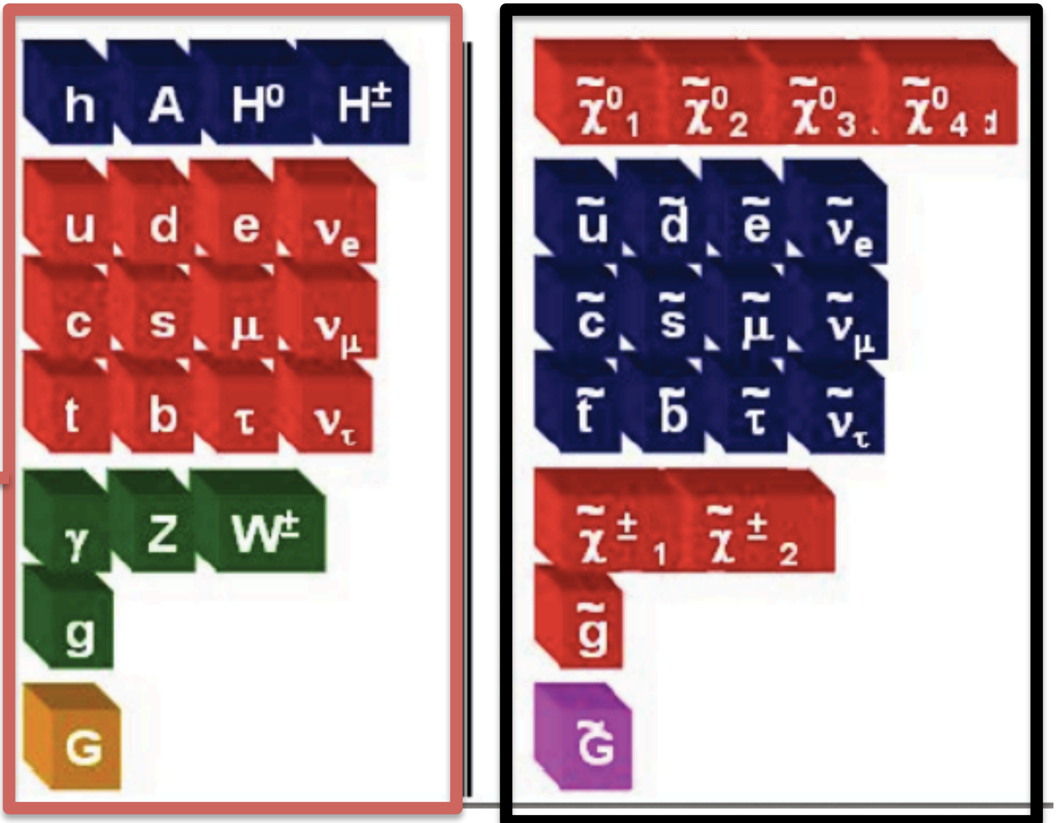
- If the $R_{parity} = (-1)^{3(B-L) + 2s}$ is conserved, Sparticles are produced in pairs and Lightest Supersymmetric Particle (LSP) are stable. Under this assumption LSPs are DM candidates.

- In many Standard Model extensions, SUSY predicts topologies that are large missing ET, High transverse momentum jets, leptons …

SuperSymmetry (SUSY) production at the LHC

- **M**inimal **S**upersymmetric **SM** extension (MSSM):

  - Naturally solves the hierarchy problem in the Standard Model.
  - Enlarged Higgs sector: Two Higgs doublets.
  - For each SM particle there is SUSY partner particle.
  - Solve other problems like the dark matter, gauge unification …

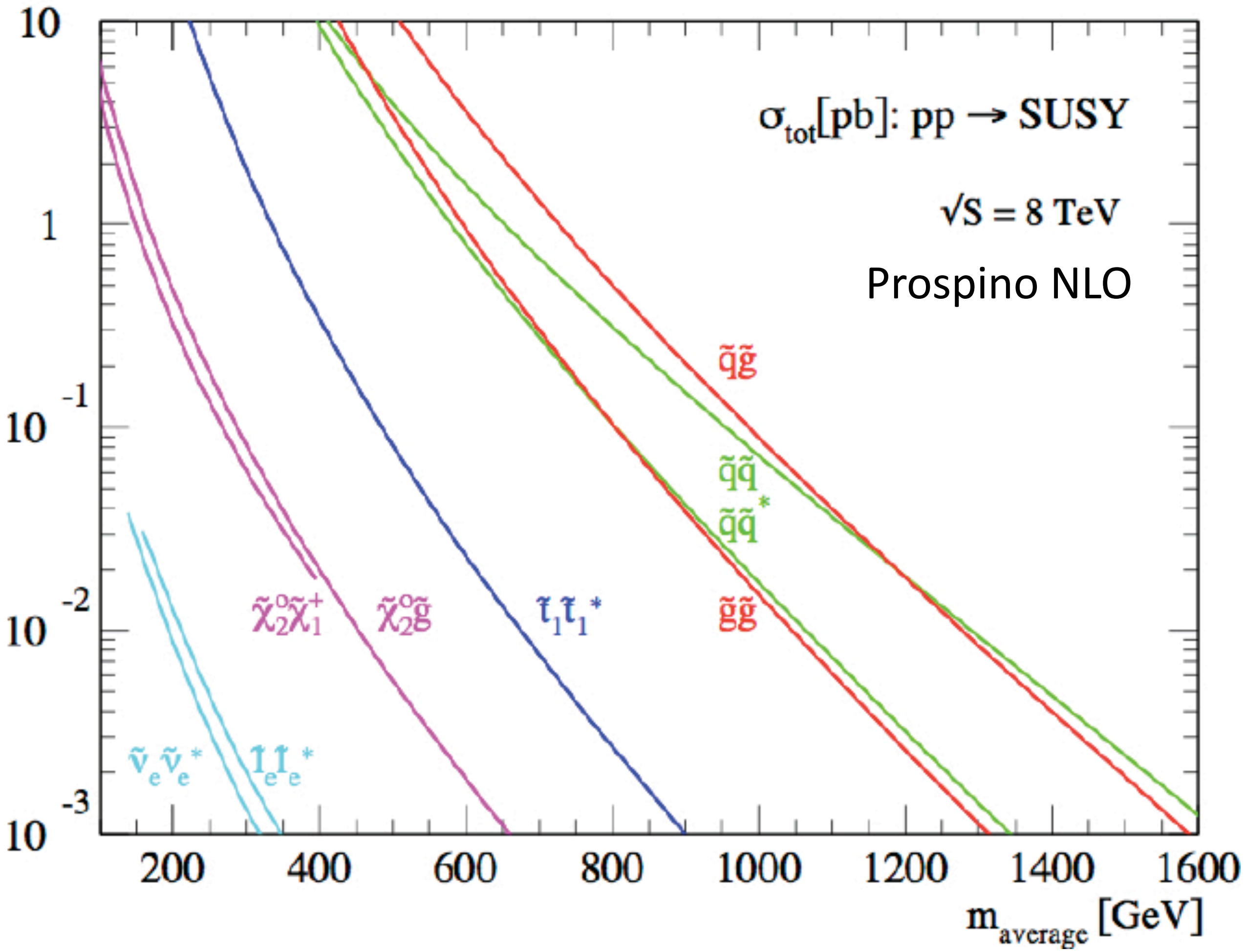


SM and other particles

SUSY particles

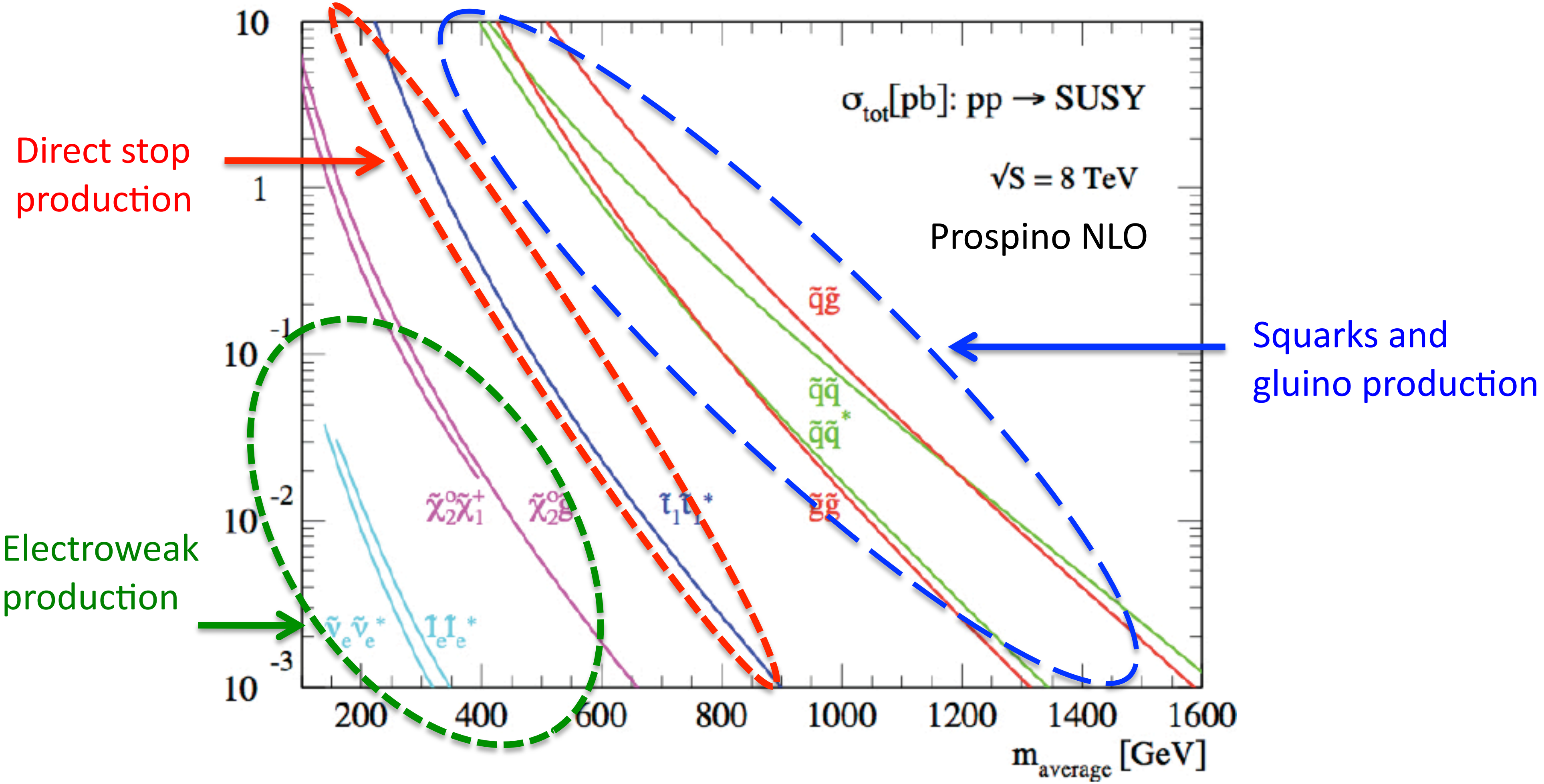
SuperSymmetry (SUSY) production at the LHC

- Assuming the R-Parity conservation the decay leads to lightest SUSY (LSP) stable.



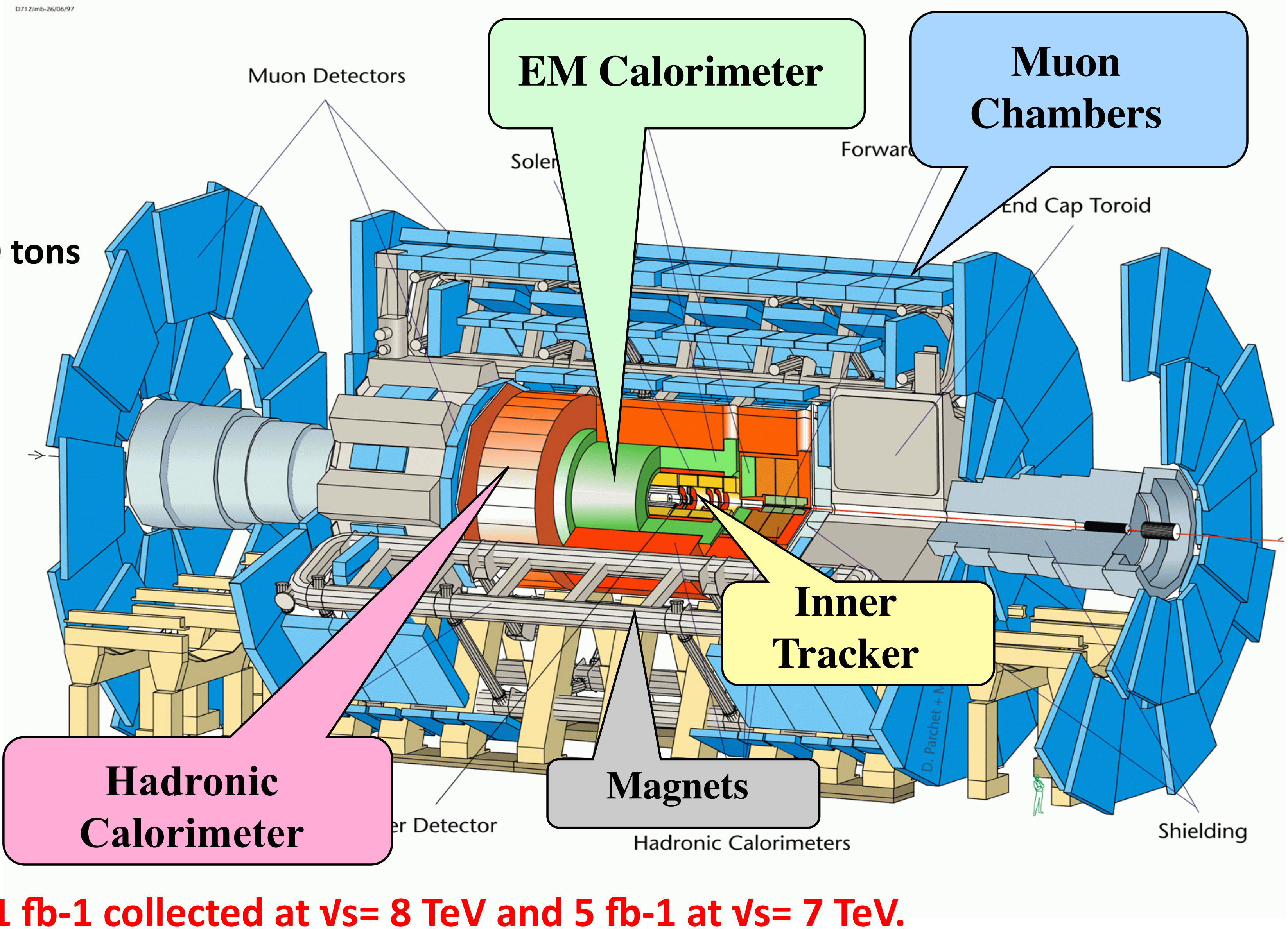
SuperSymmetry (SUSY) production at the LHC

- At the LHC we look for light sleptons, squarks and gluinos which are heavy.



The ATLAS Detector

Length: ~ 45 m
Radius: ~ 12 m
Weight: ~ 7000 tons



→ **About 21 fb-1 collected at √s= 8 TeV and 5 fb-1 at √s= 7 TeV.**

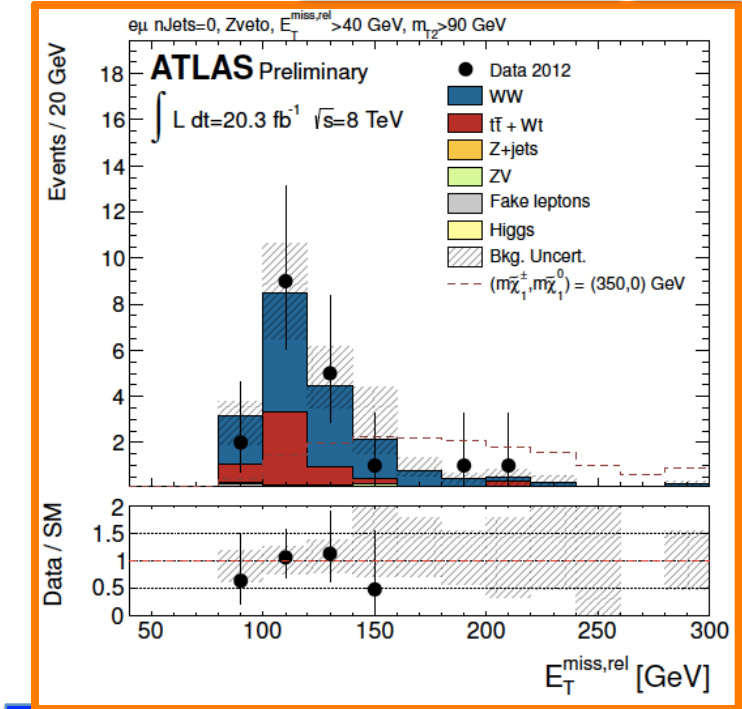
EW Channels → 2 leptons (e/mu)

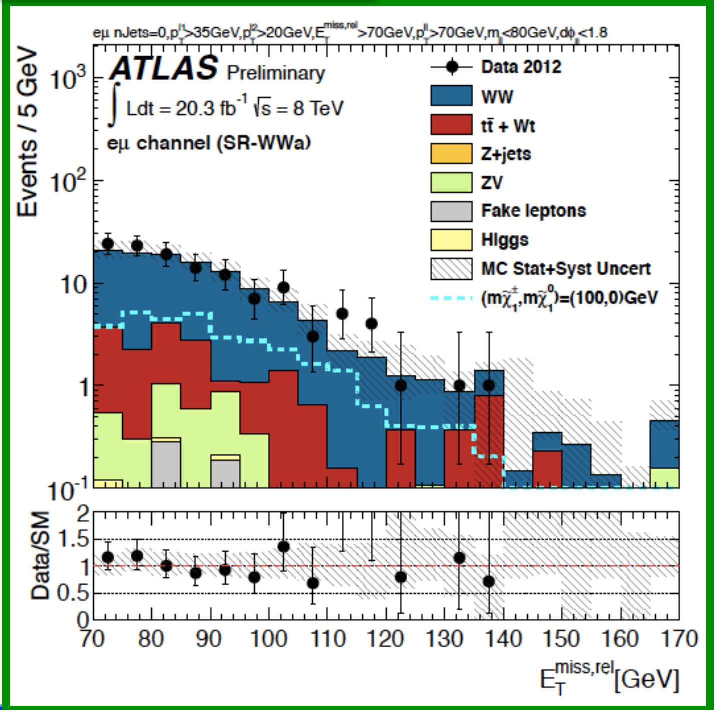
ATLAS-CONF-2013-049

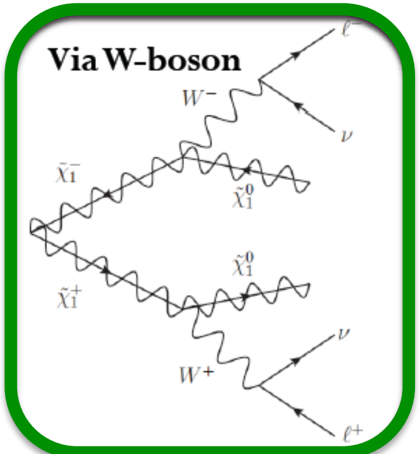
- Direct slepton-pair and chargino-pair production in final states with two opposite-sign leptons, missing transverse momentum and no jets

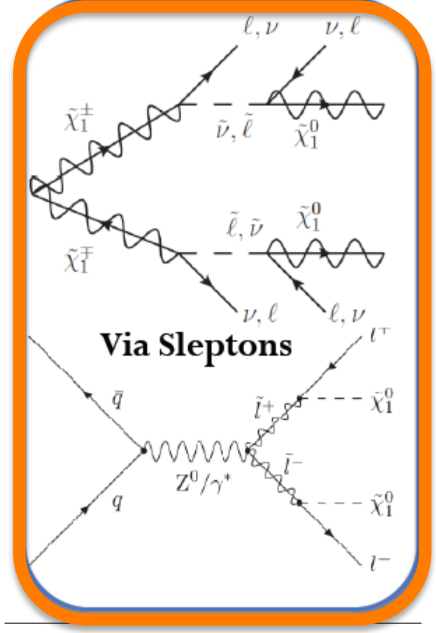
-- > In this analysis, the considered signal regions are :

	SR-$m_{T2,90}$	SR-$m_{T2,110}$	SR-WWa	SR-WWb	SR-WWc
lepton flavour	$e^+e^-, \mu^+\mu^-, e^\pm\mu^\mp$		$e^\pm\mu^\mp$		
$p_T^{\ell 1}$	—		> 35 GeV		
$p_T^{\ell 2}$	—		> 20 GeV		
$m_{\ell\ell}$	Z veto		< 80 GeV	< 130 GeV	—
$p_{T,\ell\ell}$	—		> 70 GeV	< 170 GeV	< 190 GeV
$\Delta\phi_{\ell\ell}$	—		< 1.8 rad		
$E_T^{\mathrm{miss,rel}}$	> 40 GeV		> 70 GeV	—	
m_{T2}	> 90 GeV	> 110 GeV	—	> 90 GeV	> 100 GeV

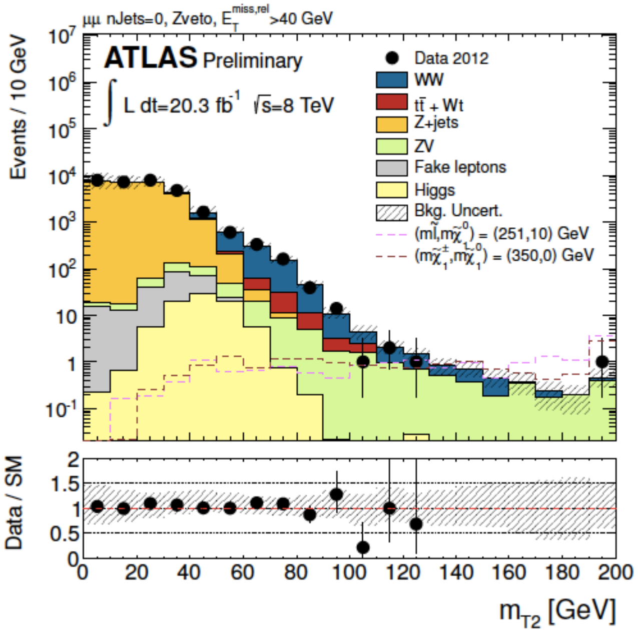








EW Channels → 2 leptons (e/mu)

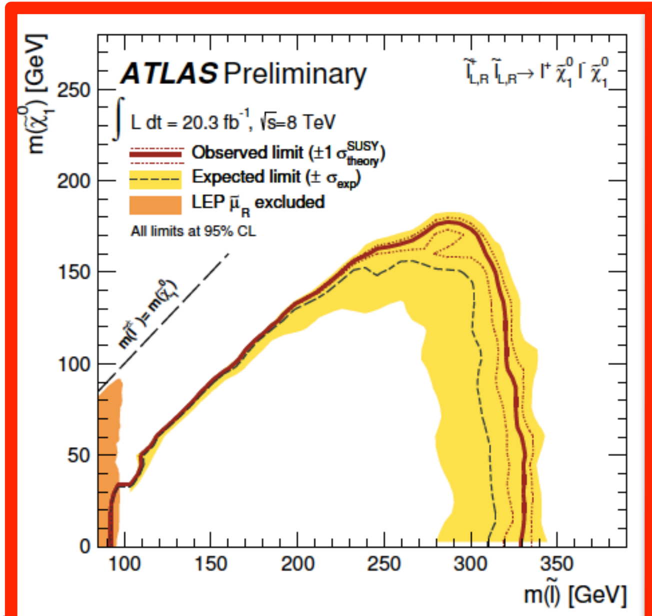


ATLAS-CONF-2013-049

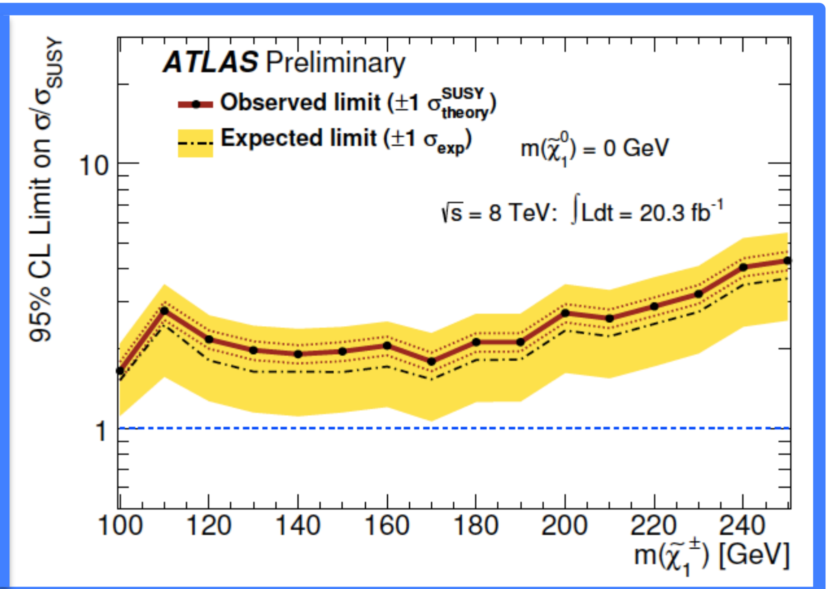
SR-$m_{T2,90}$	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Observed	15	19	19	53
Background total	16.6 ± 2.3	20.7 ± 3.2	22.4 ± 3.3	59.7 ± 7.3
SR-$m_{T2,110}$	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Observed	4	5	4	13
Background total	6.1 ± 2.2	4.4 ± 2.0	6.3 ± 2.4	16.9 ± 6.0

	SR-WWa	SR-WWb	SR-WWc
Observed	123	16	9
Background total	117.9 ± 14.6	13.6 ± 2.3	7.4 ± 1.5

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



Exclusion limits of Selectron and smuon production from slepton- neutralino mass plane



Exclusion limit from SR-WW for massless neutralinos.
→ First WW+MET at LHC.

EW Channels → 2 leptons (taus)

ATLAS-CONF-2013-028

Direct $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}(\tilde{\chi}_1^{\pm} \to \tilde{\tau}_L\nu, \tau\tilde{\nu})$ and $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}(\tilde{\chi}_2^{0} \to \tilde{\tau}_L\tau)$ production investigated via 2 tau final states (same Stop MT2 strategy).

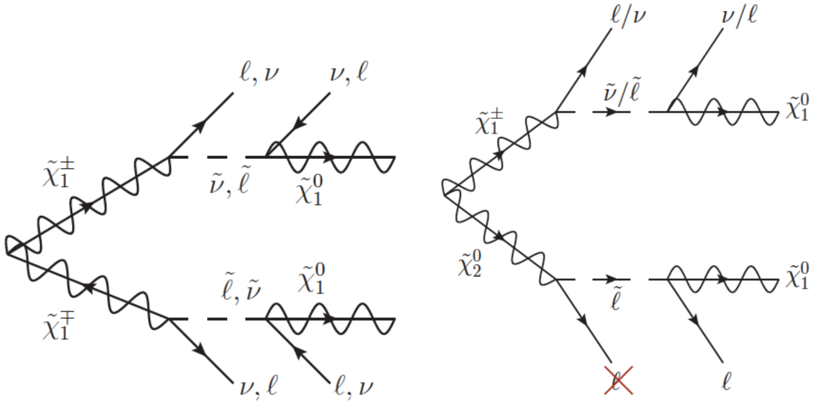
Main Background:

- Tau's from Di-bosons, top or Z production.

→Estimated from MC.

- Fake tau's from Mis-identified jets.

→ Estimated from Data.



chargino-neutralino, chargino-chargino productions and direct tau slepton production

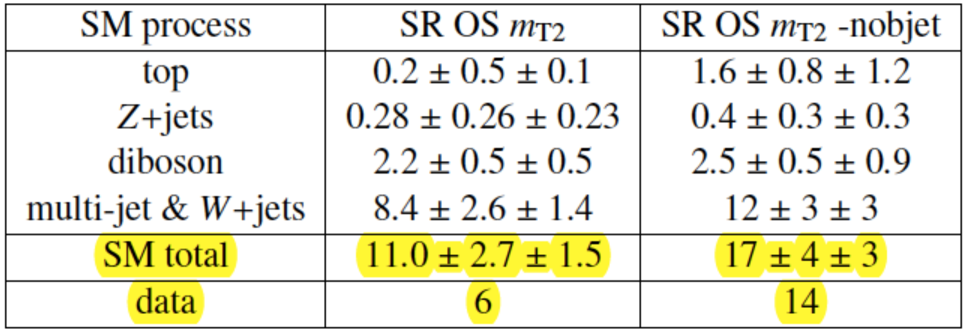
We consider 2 SR regions:

Signal region	requirements
OS m_{T2}	at least 1 OS tau pair jet veto Z-veto E_T^{miss}> 40 GeV m_{T2}> 90 GeV
OS m_{T2}-nobjet	at least 1 OS tau pair b-jet veto Z-veto E_T^{miss}> 40 GeV m_{T2}> 100 GeV

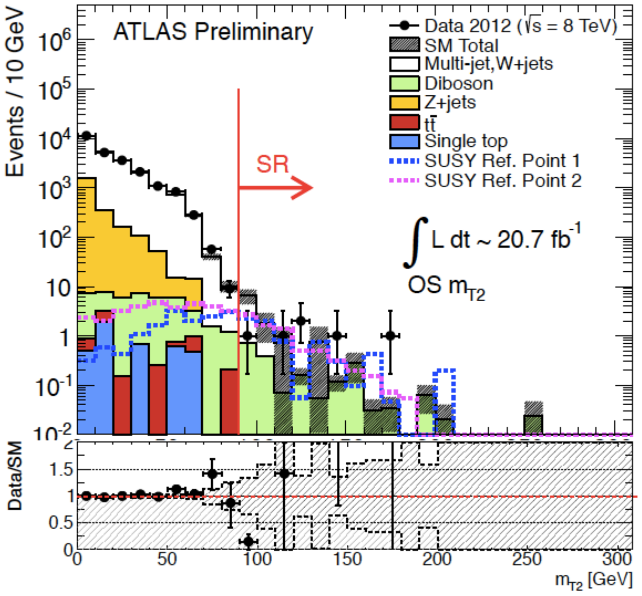
EW Channels → 2 leptons (taus)

ATLAS-CONF-2013-028

Direct $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}(\tilde{\chi}_1^{\pm} \rightarrow \tilde{\tau}_L\nu, \tau\tilde{\nu})$ and $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0(\tilde{\chi}_2^0 \rightarrow \tilde{\tau}_L\tau)$ production investigated via 2 tau final states (same Stop MT2 strategy).

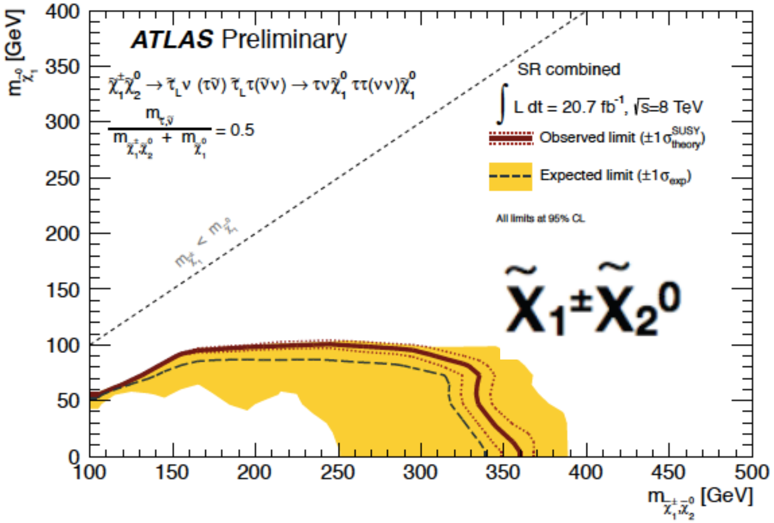


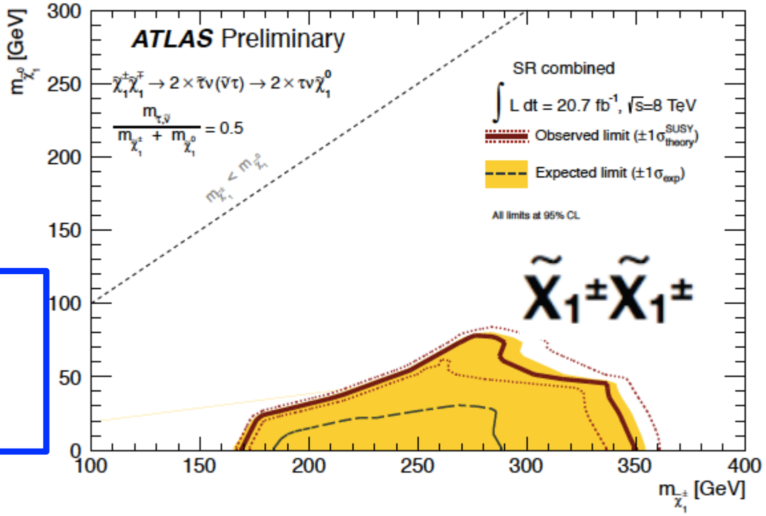
SM process	SR OS m_{T2}	SR OS m_{T2} -nobjet
top	0.2 ± 0.5 ± 0.1	1.6 ± 0.8 ± 1.2
Z+jets	0.28 ± 0.26 ± 0.23	0.4 ± 0.3 ± 0.3
diboson	2.2 ± 0.5 ± 0.5	2.5 ± 0.5 ± 0.9
multi-jet & W+jets	8.4 ± 2.6 ± 1.4	12 ± 3 ± 3
SM total	11.0 ± 2.7 ± 1.5	17 ± 4 ± 3
data	6	14



Since no significant excess above the SM background is observed we set exclusion limits using simplified models

First chargino pair production limit in light Stau scenarios at LHC !





EW chargino and neutralino production: 3Leptons (e/mu)

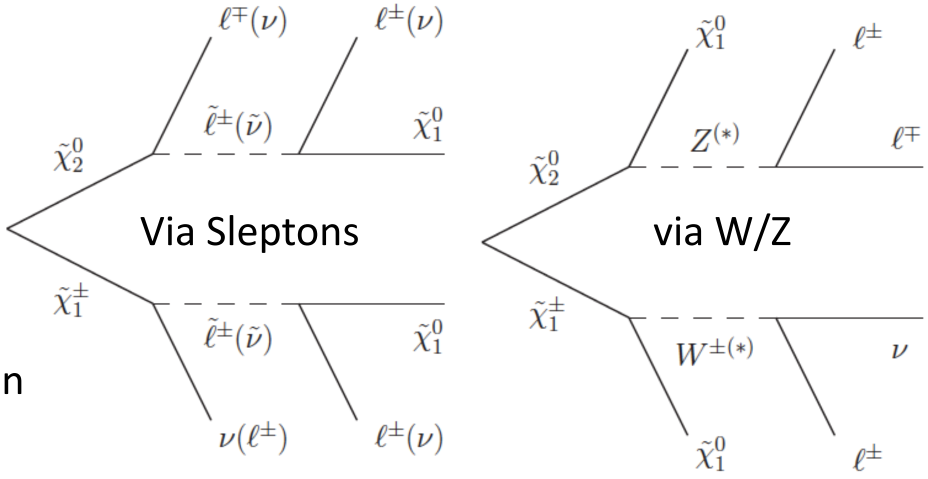
$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$

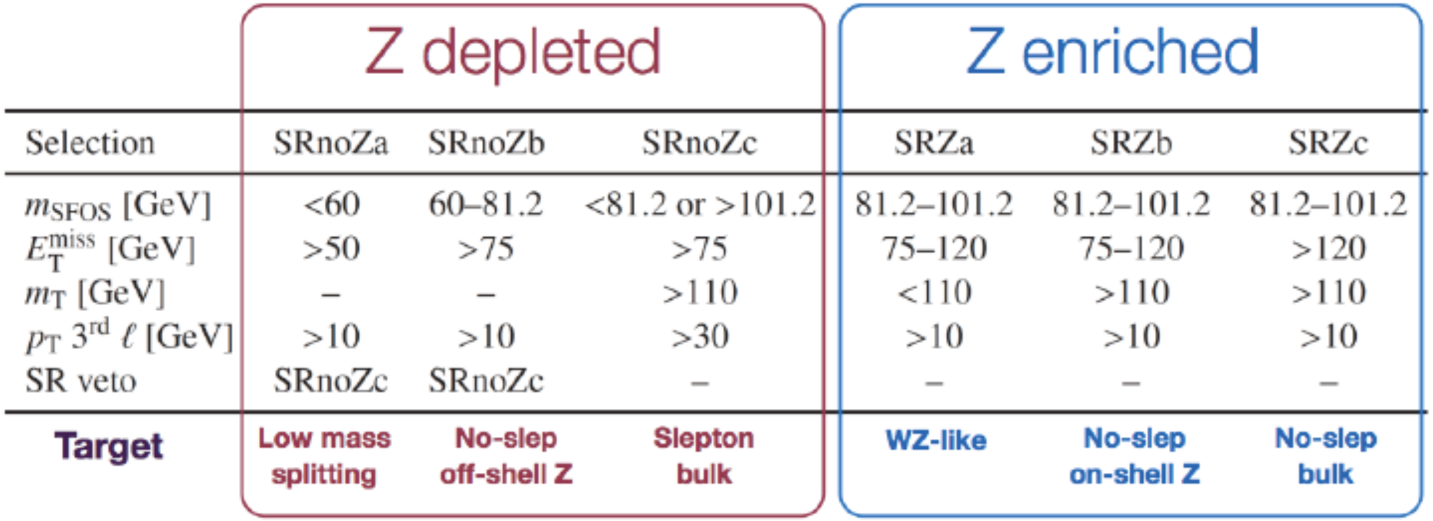
ATLAS-CONF-2013-035

- Search for direct production of charginos and neutralinos production where final state contains exactly 3 leptons (e,mu) and Etmiss.

In this analysis, we define 2 SR:

- Z-depleted regions target neutralino decays via intermediate sleptons or via off-shell Z-bosons.
- Z-enriched regions target decays via an on-shell Z-boson



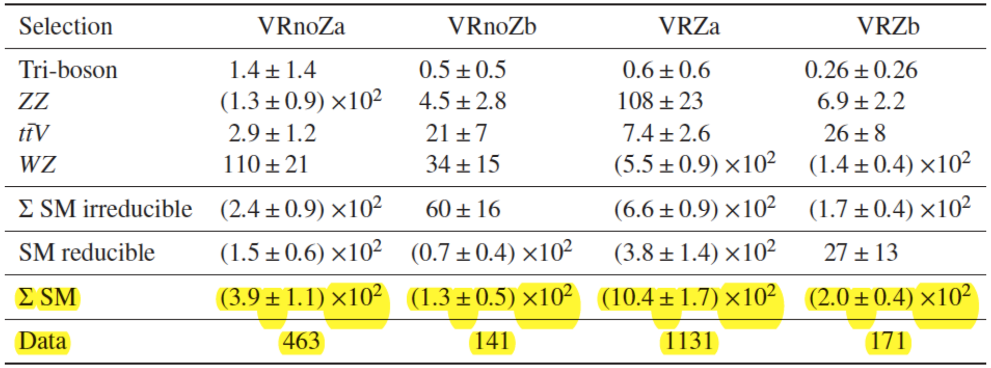


	Z depleted			Z enriched		
Selection	SRnoZa	SRnoZb	SRnoZc	SRZa	SRZb	SRZc
m_{SFOS} [GeV]	<60	60–81.2	<81.2 or >101.2	81.2–101.2	81.2–101.2	81.2–101.2
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	>50	>75	>75	75–120	75–120	>120
m_{T} [GeV]	–	–	>110	<110	>110	>110
p_{T} 3rd ℓ [GeV]	>10	>10	>30	>10	>10	>10
SR veto	SRnoZc	SRnoZc	–	–	–	–
Target	**Low mass splitting**	**No-slep off-shell Z**	**Slepton bulk**	**WZ-like**	**No-slep on-shell Z**	**No-slep bulk**

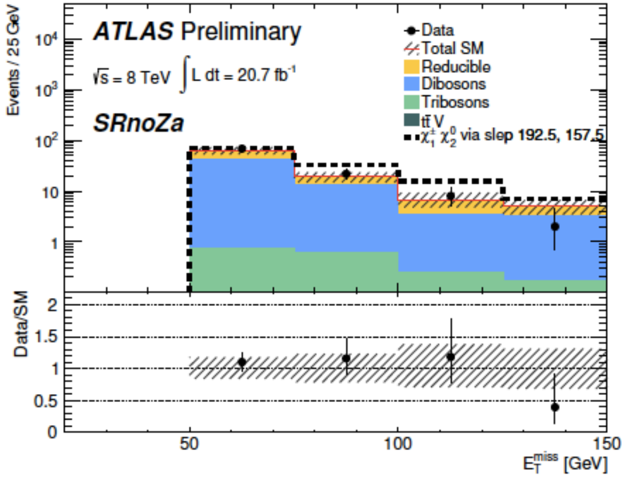
EW chargino and neutralino production: 3Leptons (e/mu)

- **Irreducible background:** Di-bosons (MC).
- **Reducible background:** Fakes leptons (Matrix Method).

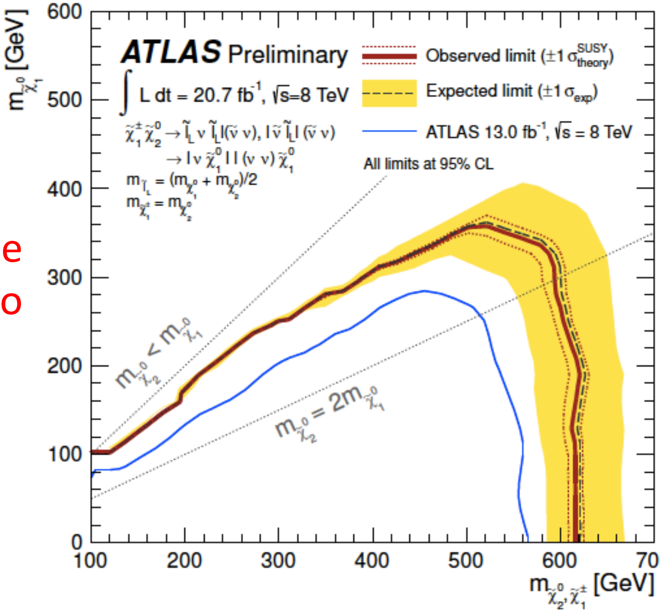
ATLAS-CONF-2013-035



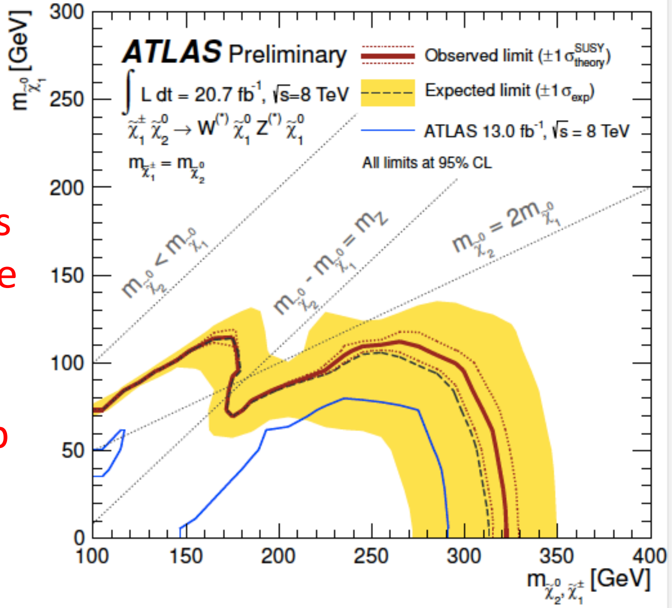
Selection	VRnoZa	VRnoZb	VRZa	VRZb
Tri-boson	1.4 ± 1.4	0.5 ± 0.5	0.6 ± 0.6	0.26 ± 0.26
ZZ	$(1.3 \pm 0.9) \times 10^2$	4.5 ± 2.8	108 ± 23	6.9 ± 2.2
$t\bar{t}V$	2.9 ± 1.2	21 ± 7	7.4 ± 2.6	26 ± 8
WZ	110 ± 21	34 ± 15	$(5.5 \pm 0.9) \times 10^2$	$(1.4 \pm 0.4) \times 10^2$
Σ SM irreducible	$(2.4 \pm 0.9) \times 10^2$	60 ± 16	$(6.6 \pm 0.9) \times 10^2$	$(1.7 \pm 0.4) \times 10^2$
SM reducible	$(1.5 \pm 0.6) \times 10^2$	$(0.7 \pm 0.4) \times 10^2$	$(3.8 \pm 1.4) \times 10^2$	27 ± 13
Σ SM	$(3.9 \pm 1.1) \times 10^2$	$(1.3 \pm 0.5) \times 10^2$	$(10.4 \pm 1.7) \times 10^2$	$(2.0 \pm 0.4) \times 10^2$
Data	463	141	1131	171



Decay via sleptons exclude degenerate chargino neutralino up to 600 GeV



Decay via gauge bosons (W/Z) exclude degenerate chargino neutralino up to 315 GeV



EW Channels → 4 Leptons (e/mu/tau)

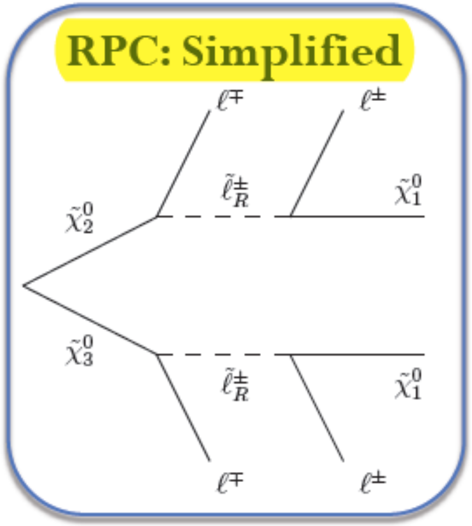
ATLAS-CONF-2013-036

- This analysis is sensitive to R-parity conserving (RPC) and R-parity violating (RPV) scenarios.

1- RPC Signal in the context of simplified models:

- $\tilde{\chi}_2^0 \tilde{\chi}_3^0$ production and decay mode to Sleptons.
- Assuming BR 100 % for both electron and muon channels.

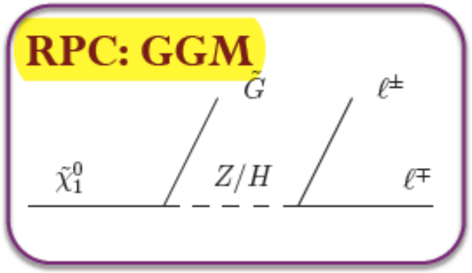
→ 4 charged leptons + Etmis (from Neutralino)



2- RPC General Gauge Mediated (GGM) via gauge mediation:

- In the GGM scenario, the $\tilde{G}$ is the nearly-massless gravitino (LSP).
- The Higgsino-like neutralino (NLSP) can decay into $Z\tilde{G}$ or $h\tilde{G}$.

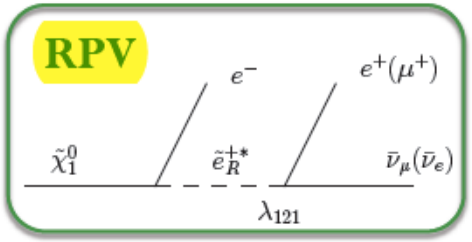
→ 4 charged leptons + Etmis (from Gravitino)



3-RPV Signal:

- Lepton number violation for decays with light leptons (λ_{121}) and taus (λ_{133}).
- LSP can decay via Sleptons leading to a final state with high lepton multiplicities.

→ 4-6 charged leptons + Etmis (from Neutrinos)



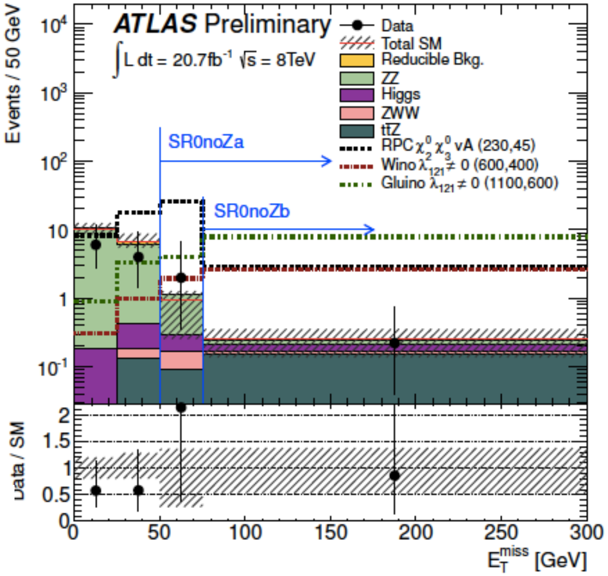
EW Channels → 4 Leptons (e/mu/tau)

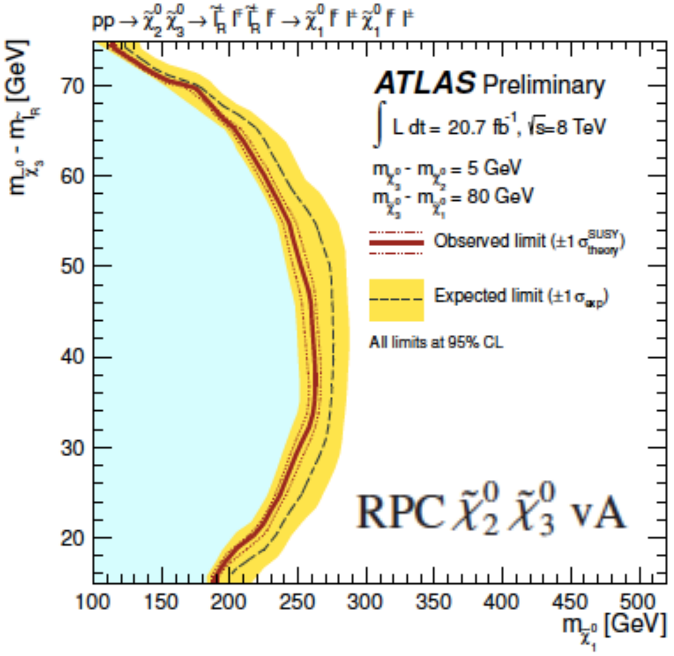
ATLAS-CONF-2013-036

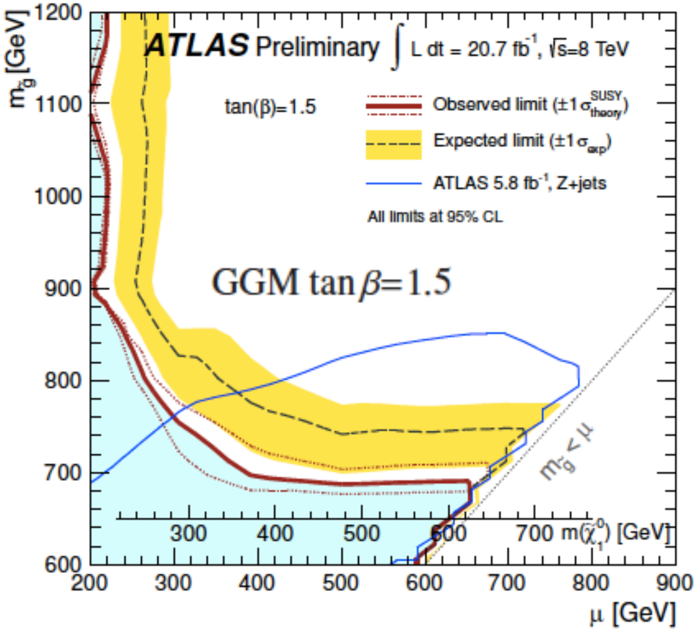
- The selection requirements for the signal regions:

SR	$N(\ell = e,\mu)$	$N(\tau)$	Z Candidate	E_T^{miss}[GeV]		m_{eff}[GeV]	Scenario
SR0noZa	≥ 4	≥ 0	extended veto	>50			RPC
SR0noZb	≥ 4	≥ 0	extended veto	>75	or	>600	RPV
SR1noZ	$=3$	≥ 1	extended veto	>100	or	>400	RPV
SR0Z	≥ 4	≥ 0	request	>75			GGM
SR1Z	$=3$	≥ 1	request	>100			GGM

Sample	SR0noZa	SR0noZb	SR1noZ	SR0Z	SR1Z
Total Bkg.	1.7 ± 0.8	1.6 ± 0.6	2.0 ± 1.3	4.8 ± 1.8	$1.3^{+1.0}_{-0.5}$
Data	2	1	4	8	3







Since no significant excess above the SM background is observed, exclusion limits are set.

Direct stop and sbottom searches

- Expect mass stop/sbottom < 1 TeV for naturalness reasons.
- Several possible signatures:
  - stop->top+neutralino: 0, 1 and 2 leptons.
  - stop->b+chargino: 2, 1 and 0 leptons (2b+MET).
  - Final states with Z boson.
  - Sbottom->b+neutralino: 0-lepton (2b + MET)
  - Sbottom->t+chargino: SS leptons, 3 lepton.

ATLAS-CONF-2013-024

ATLAS-CONF-2013-037

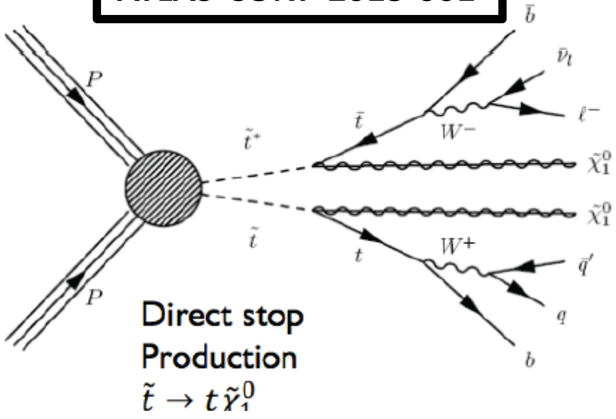
ATLAS-CONF-2012-167

ATLAS-CONF-2013-025

ATLAS-CONF-2013-001

- **Stop → top +neutralino (0 lepton):**

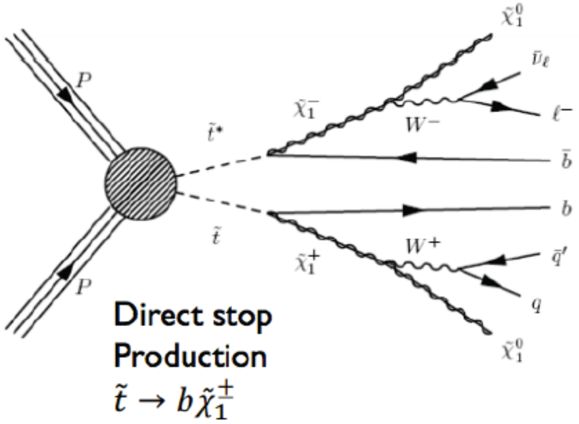
  - assume exclusive decays into top quarks.
  - hadronic top decay reconstruction and study MET shape.
  - Main background is semi-leptonic ttbar where the lepton is a hadronic tau



Direct stop Production
$\tilde{t} \to t\tilde{\chi}_1^0$

- **Stop->top+neutralino (1-lepton)**

  - Multiple signal regions and high MET.
  - Based mainly on MET and mT
  - Tag 1 b-jet, reconstruct one hadronic top mass
  - Dominant BG: di-leptonic ttbar decays (one lepton is either lost or a tau). W+ Heavy Flavor.



Direct stop Production
$\tilde{t} \to b\tilde{\chi}_1^\pm$

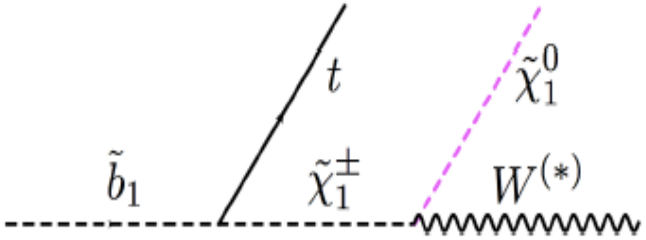
Direct stop and sbottom searches

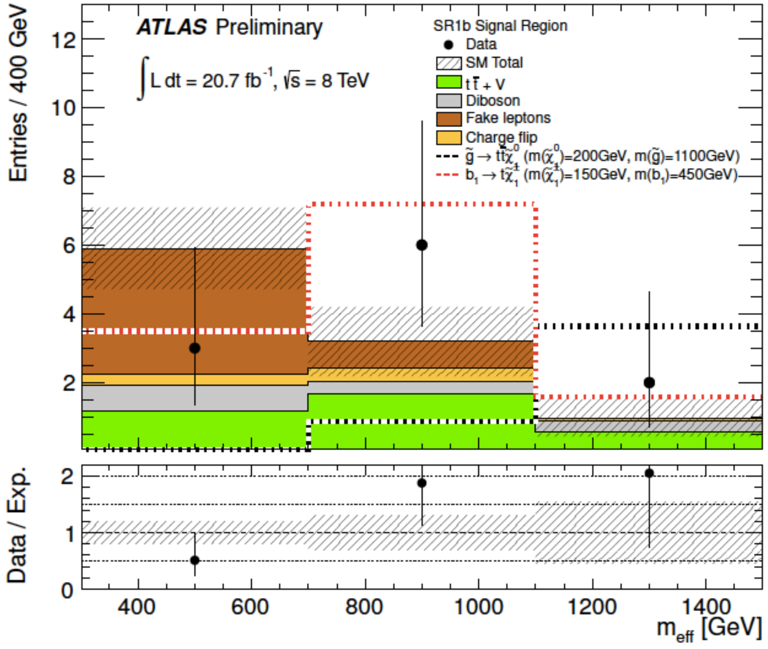
ATLAS-CONF-2013-007

- Search for strongly produced supersymmetric particles in final states with two same-sign leptons and jets.

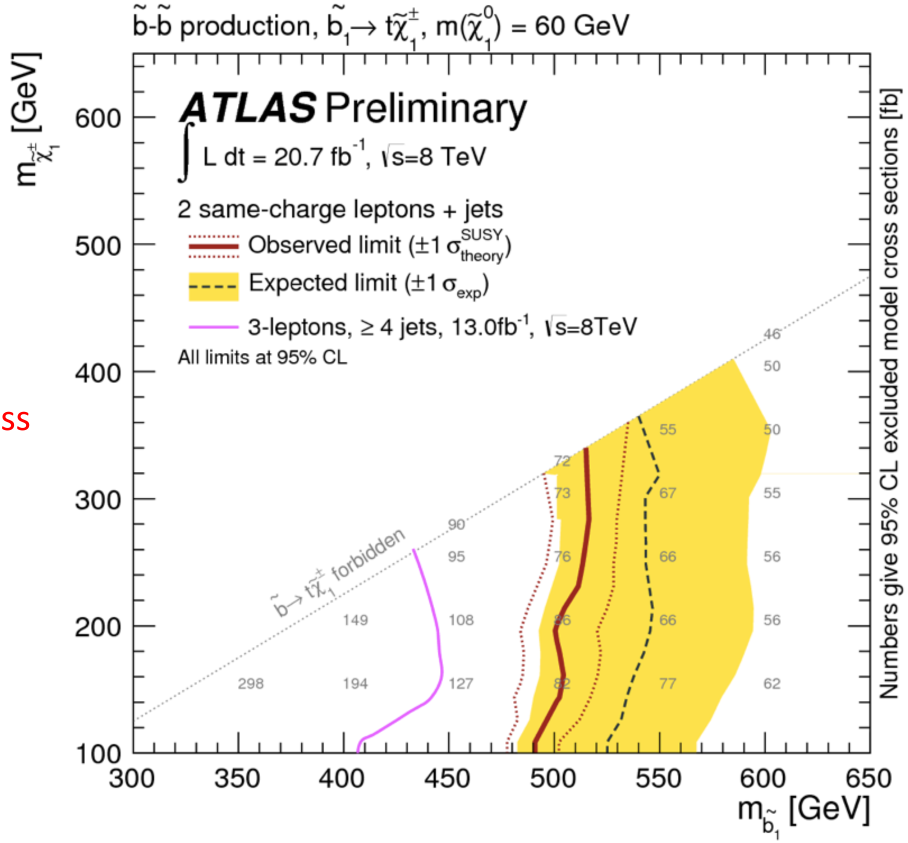
- ETmiss , jets, 2 SS leptons (ee, em, mm).
- The main background: ttbar+ V, di-bosons, fake leptons.
- As discriminating variables $m_{\mathrm{T}}(\ell_1, E_{\mathrm{T}}^{\mathrm{miss}})$ and

$$m_{\mathrm{eff}} = \Sigma_{i\leq n}(p_{\mathrm{T}}^{jet})_i + \Sigma_{j\leq m}(p_{\mathrm{T}}^{\ell})_j + E_{\mathrm{T}}^{\mathrm{miss}}$$





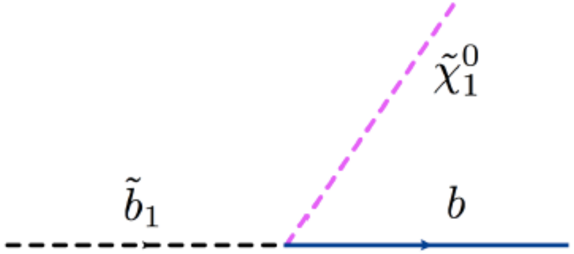
Since no significant excess above the SM background is observed, exclusion limits are set.



Direct stop and sbottom searches

ATLAS-CONF-2013-053

- Direct third generation squark pair.
- Lepton Veto, ETmiss , 2 b-jets.
- Main background Z → νν+b-jets, W+b-jets, ttbar.
- Two Signal regions (A and B):

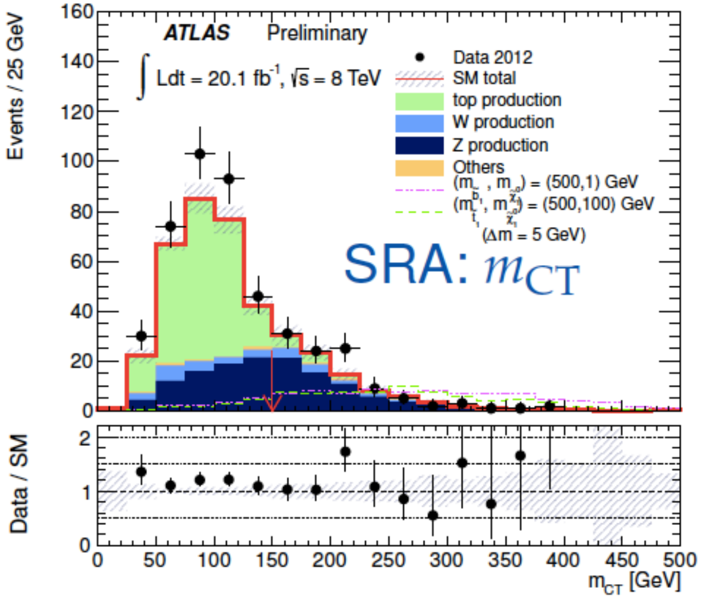


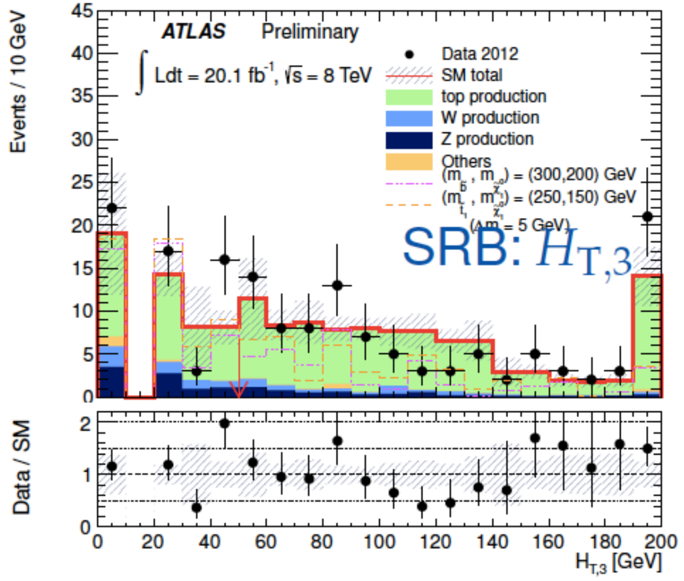
- SRA: large $\Delta m(\tilde{b}_1, \tilde{\chi}_1^0)$ discriminating variable m_{CT},
  5 inclusive cuts with rising cuts on m_{CT} .
- SRB: small $\Delta m(\tilde{b}_1, \tilde{\chi}_1^0)$ - ISR signature, variables $H_{T,3}$, Etmiss where:

$$H_{\mathrm{T},3} = \Sigma_{i=4}^{n-jets} (p_{\mathrm{T}}^{\mathrm{jet}})_i$$

and

$$m_{\mathrm{CT}}^2(v_1,v_2) = [E_{\mathrm{T}}(v_1)+E_{\mathrm{T}}(v_2)]^2 - [\mathbf{p}_{\mathrm{T}}(v_1)-\mathbf{p}_{\mathrm{T}}(v_2)]^2$$



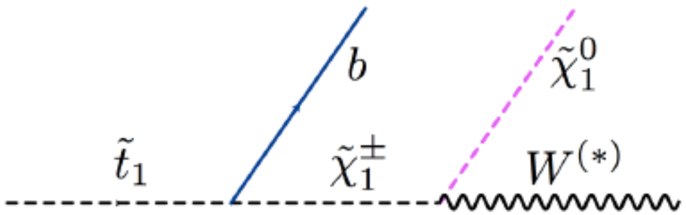


Direct stop and sbottom searches

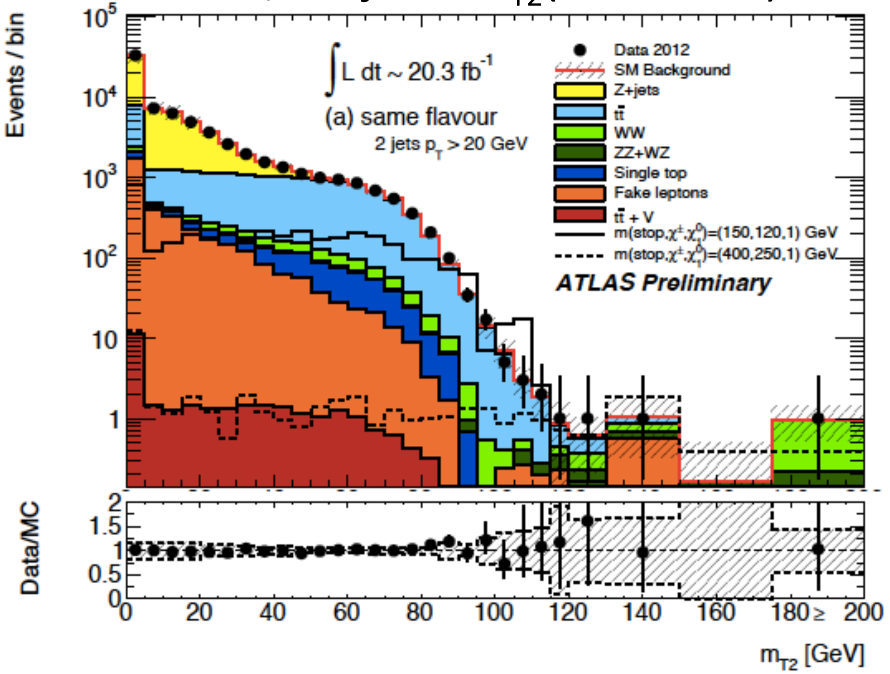
ATLAS-CONF-2013-048

- Etmiss, jets and 2 leptons.
- Main background: WW, WZ, ZZ and ttbar.
- Discriminating variable:

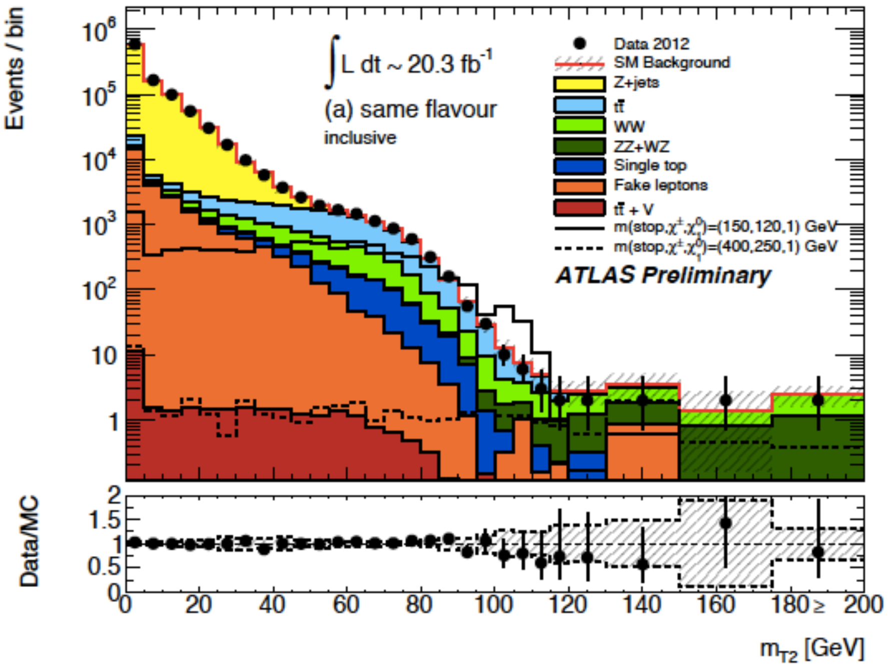
$$m_{\mathrm{T2}}(\mathbf{p}_{\mathrm{T}}^{\ell_1},\mathbf{p}_{\mathrm{T}}^{\ell_2},\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}) = \min_{\mathbf{q}_{\mathrm{T}}+\mathbf{r}_{\mathrm{T}}=\mathbf{p}_{\mathrm{T}}^{\mathrm{miss}}} \left\{\max[\, m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell_1},\mathbf{q}_{\mathrm{T}}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell_2},\mathbf{r}_{\mathrm{T}})\,]\right\},$$



SR SF, ≥ 2 jets: m $_{T2}$(> 120 GeV)



SR Same Flavor: m $_{T2}$(> 90 GeV)



Direct stop and sbottom searches

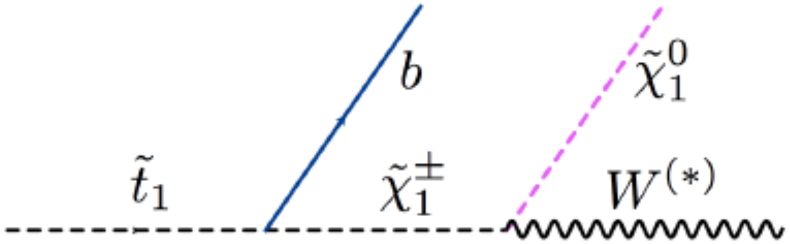
ATLAS-CONF-2013-037

- Etmiss, 4 jets, 1-2 b-jets, 1 isolated lepton
- Main background: dileptonic ttbar, W+jets.
- Discriminating variable: $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$, am_{T2}, m_{eff}

where:

$$m_{\mathrm{T2}} \equiv \min_{\vec{p}_{Ta}^{\,C}+\vec{p}_{Tb}^{\,C}=\vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}} \{\max(m_{Ta}, m_{Tb})\}$$

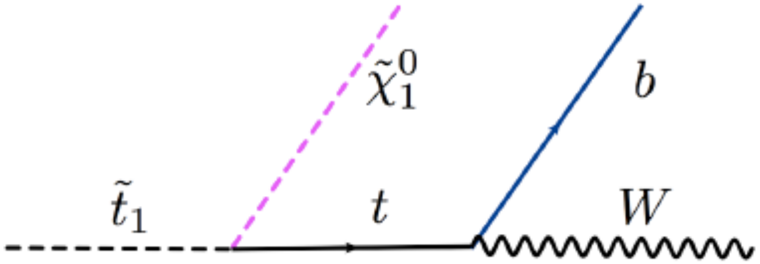
am_{T2}: missing particles W, ν; dilep. $t\bar{t}$ endpoint at m_t



- Etmiss, 4 jets, 1-2 b-jets, 1 lepton
- Discriminating variable:

$$m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}}),\ E_{\mathrm{T}}^{\mathrm{miss}},\ m_{\mathrm{T2}}^{\tau},\ m_{jjj}$$

where m_{T2}^{τ}:hadronic τ $t\bar{t}$ endpoint at m_W



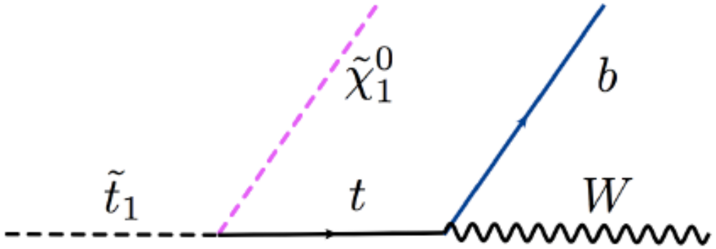
Direct stop and sbottom searches

ATLAS-CONF-2013-024

- **Direct production of the top squark in the all- hadronic ttbar + etmiss final state:**

- Etmiss, 6 jets, 2 b-jets
- Main background: Semilep. ttbar, Z → vv, ttbar+V
- Discriminating variable:

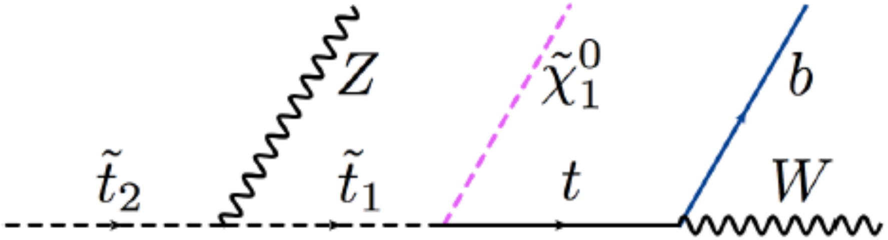
$$m_{\mathrm{T}}(E_{\mathrm{T}}^{\mathrm{miss}}, b_{near}),\ m_t^{had1,2},\ E_{\mathrm{T}}^{\mathrm{miss}}$$



ATLAS-CONF-2013-025

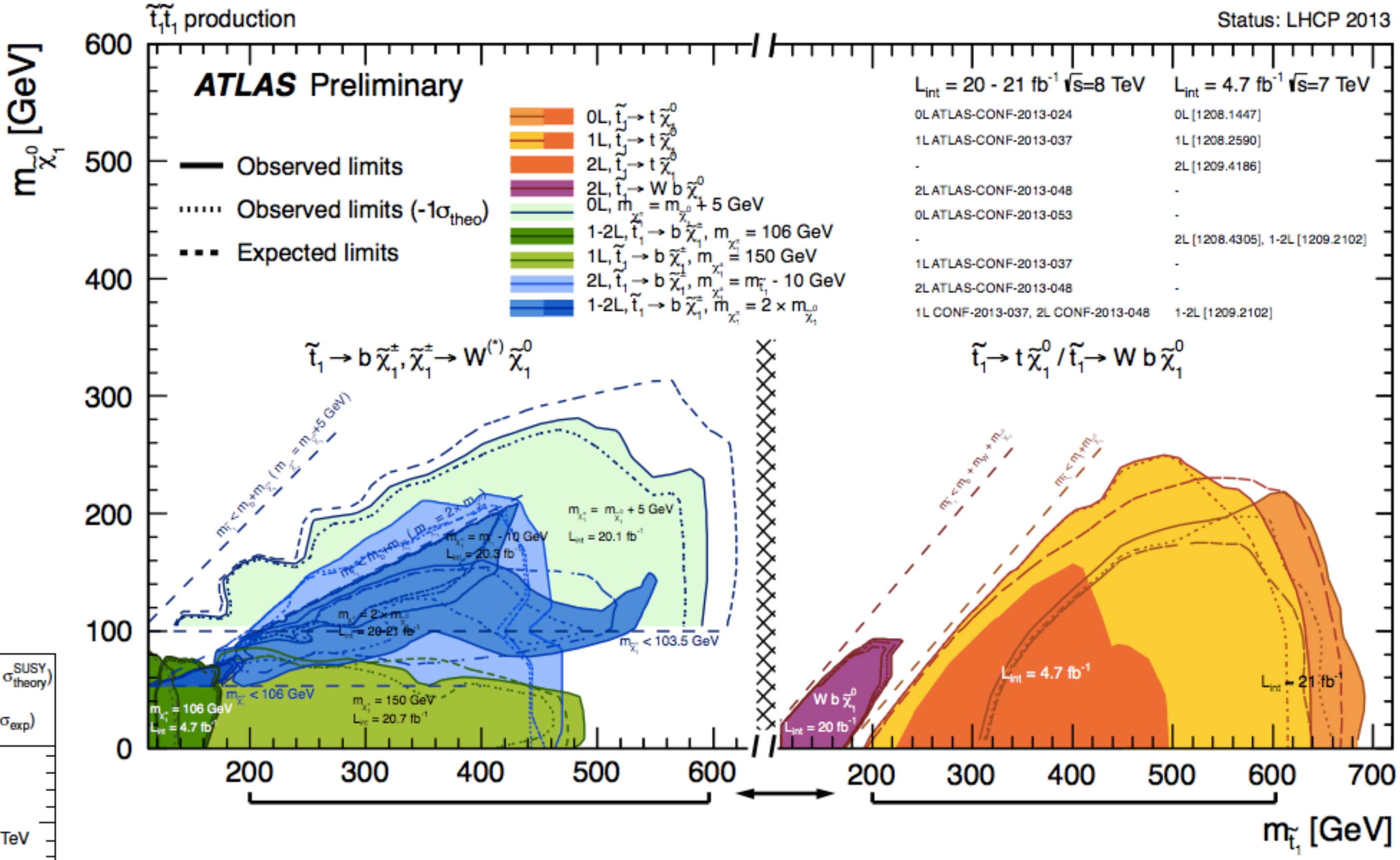
- **Direct production of the top squark in events with a Z boson, b-jets and MET state:**

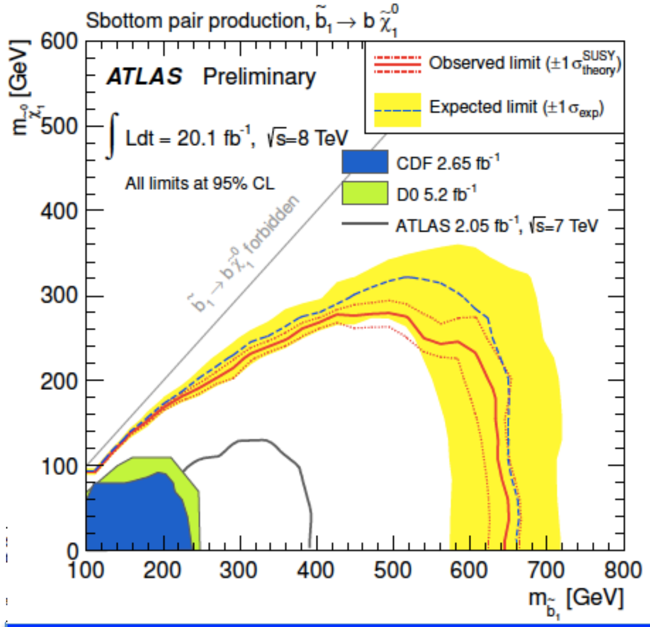
- Etmiss, jets, 1 b-jets, 2-3 leptons
- Main background: Semilep. ttbar, Z → vv, ttbar+V



ATLAS Summary on Stop/Sbottom searches

- Direct stop production: bringing the various decay modes together.
- Better coverage of stop and sbottom masses
- More complex scenarios have been investigated.





- ATLAS recently improved sensitivity at both high and low m(stop).
- So far no stop nor sbottom have been found.

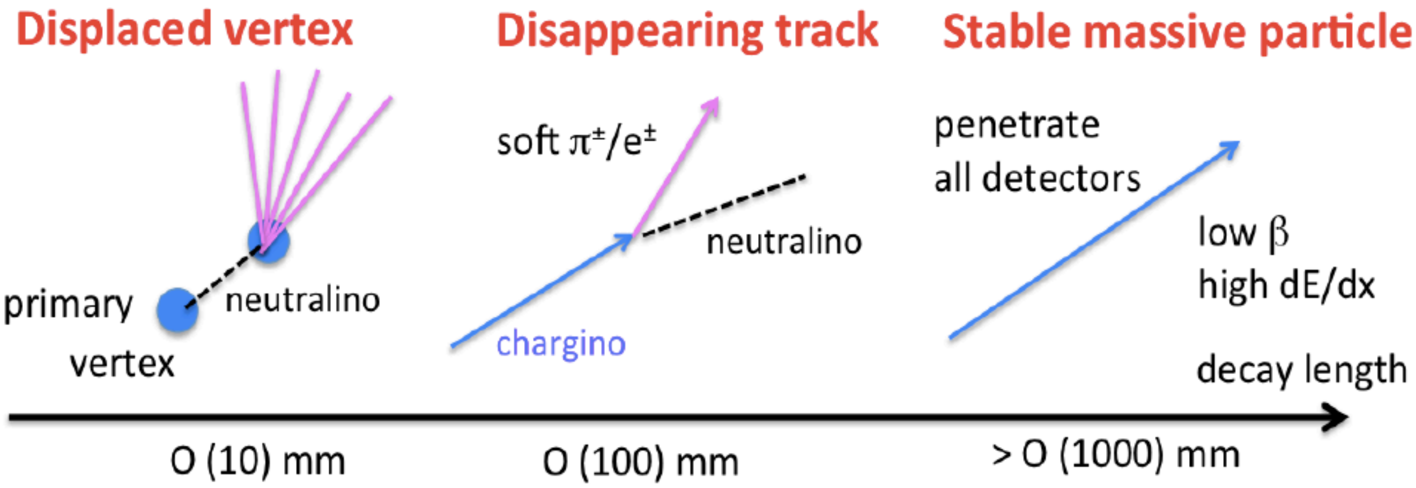
Long lived Particles

- Decays throughout the detectors depending on the different lifetimes

– Typical signatures which could give rise to new physics :

- Displaced vertexes and jets (R Parity Violation (RPV) LSP decay).
- Disappearing tracks (Long lived charginos in AMSB model)
- Non- pointing photons
- Stable massive particle

– **short:** displaced vertices at short distances	*0.1 … 1ns*
– **medium:** disappearing tracks at medium dist.	*1 … 10 ns*
– **long:** dE/dx or time of flight for long distances	*Several ns lifetime*



Long lived Particles: Disappearing tracks (AMSB)

- The main idea of this analysis is to look for charginos decaying in the inner TRT detector volume, leaving a small number of hits in the outer TRT modules.

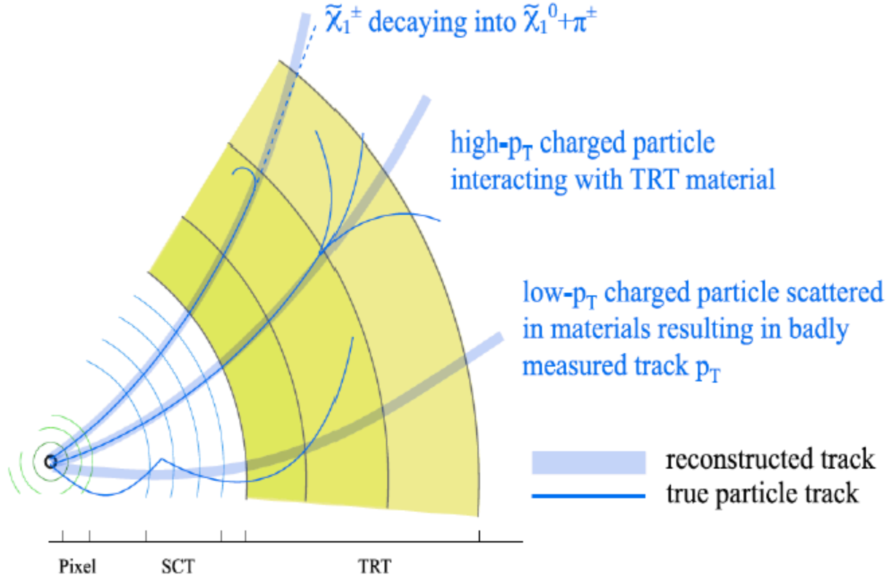
- We search for:

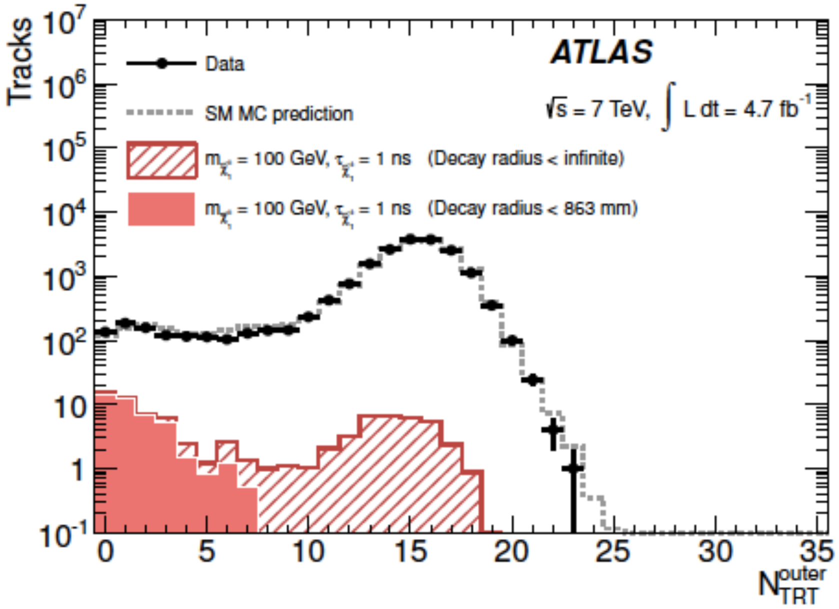
$$\boxed{\begin{array}{l} pp \to \tilde{\chi}_1^{\pm}\tilde{\chi}_1^{0} + jet \\ pp \to \tilde{\chi}_1^{-}\tilde{\chi}_1^{+} + jet \end{array}}$$

- Main background: High Pt charged hadrons and Low pT tracks with large bremsstrahlung radiation.

- Life time of chargino ~ O(0.1 ns)

http://link.springer.com/article/10.1007/JHEP01(2013)131





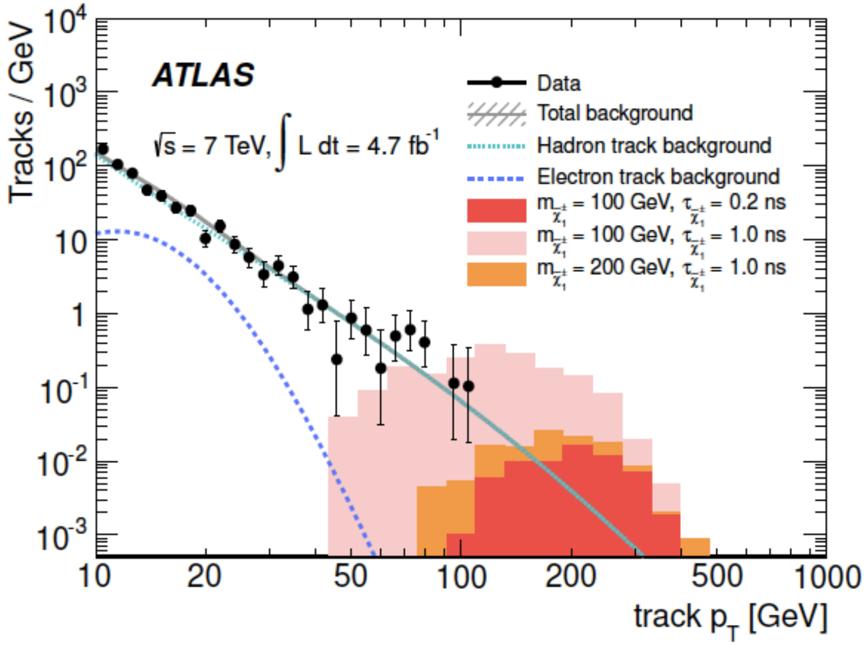
Long lived Particles: Disappearing tracks (AMSB)

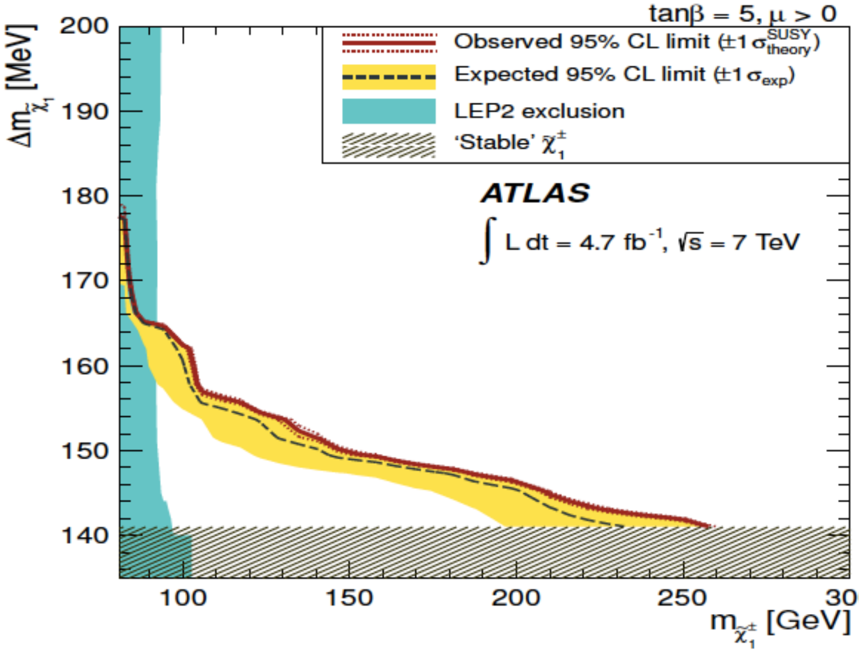
$$pp \to \tilde{\chi}_1^{\pm}\tilde{\chi}_1^{0} + jet$$
$$pp \to \tilde{\chi}_1^{-}\tilde{\chi}_1^{+} + jet$$

- The signal extraction is done in two steps:
  1- Derive the background track **pT** shapes from control regions.
  2- Perform a signal + background template to candidate tracks.

- Chargino mass is excluded up to 103(85) GeV for Δm ~ 160(170) MeV
  → Most probably direct chargino production in anomaly-mediated supersymmetry breaking (AMSB) model.

→ No excess over the SM background is observed





Conclusions

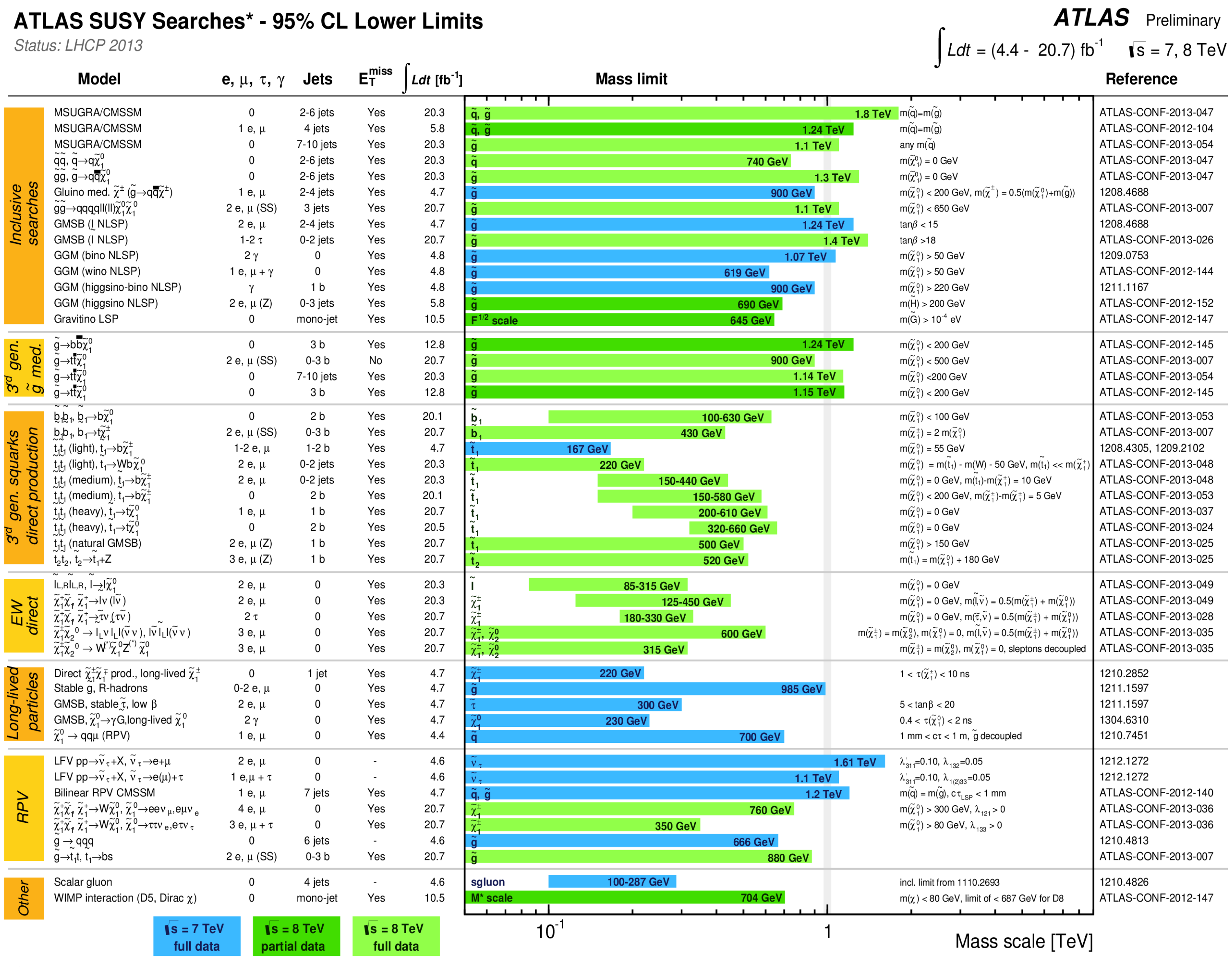
- In this talk we have presented a selection of SUSY searches at ATLAS.
- Most of the SUSY searches presented in this talk are really challenging!
- Most of the analysis are being updated for the full 2012 dataset.
- For several models, ATLAS has a comprehensive SUSY search plan and has set competitive limits of exclusion.
- No evidence of SUSY has been observed so far.
- For complete ATLAS SUSY results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Conclusions

- In this talk we have presented a selection of SUSY searches at ATLAS.
- Most of the SUSY searches presented in this talk are really challenging!
- Most of the analysis are being updated for the full 2012 dataset.
- For several models, ATLAS has a comprehensive SUSY search plan and has set competitive limits of exclusion.
- No evidence of SUSY has been observed so far.
- For complete ATLAS SUSY results:
  https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Thank you for your attention

ATLAS SUSY Summary



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: LHCP 2013

ATLAS Preliminary

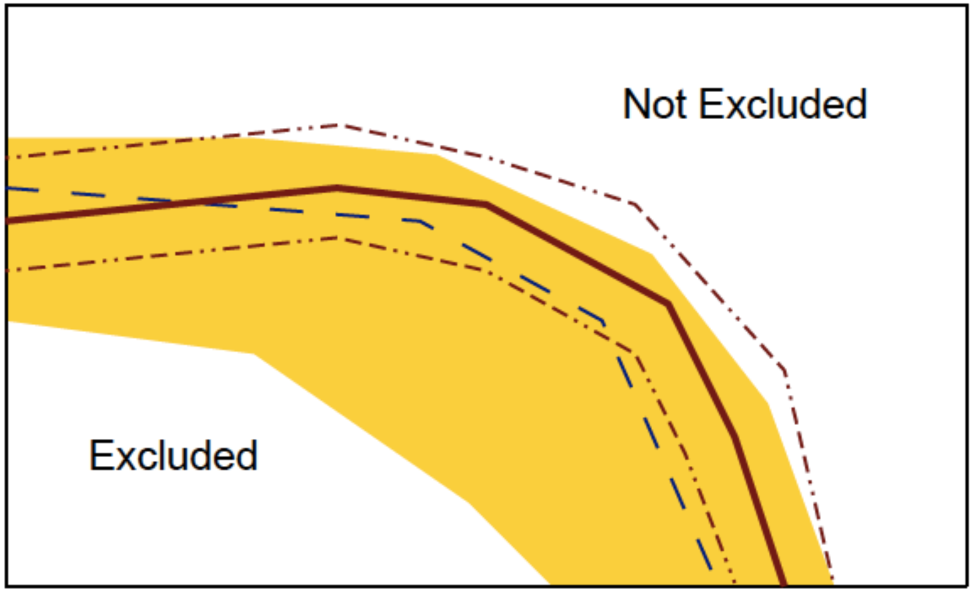
$\int L dt = (4.4 - 20.7)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7, 8$ TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int L dt$ [fb^{-1}]	Mass limit			Reference
Inclusive searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.8 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	4 jets	Yes	5.8	$\tilde{q}, \tilde{g}$	1.24 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2012-104
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2013-047
	Gluino med. $\tilde{\chi}^\pm$ ($\tilde{g}\to q\bar{q}\tilde{\chi}^\pm$)	1 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(\tilde{\chi}^\pm) = 0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	1208.4688
	$\tilde{g}\tilde{g}\to qqqqll(ll)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ (SS)	3 jets	Yes	20.7	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0) < 650$ GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{l}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta < 15$	1208.4688
	GMSB ($\tilde{l}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta > 18$	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$	1.07 TeV	$m(\tilde{\chi}_1^0) > 50$ GeV	1209.0753
	GGM (wino NLSP)	1 e, μ + γ	0	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0) > 50$ GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0) > 220$ GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H}) > 200$ GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{G}) > 10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	12.8	$\tilde{g}$	1.24 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2012-145
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	2 e, μ (SS)	0-3 b	No	20.7	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0) < 500$ GeV	ATLAS-CONF-2013-007
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.14 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	3 b	Yes	12.8	$\tilde{g}$	1.15 TeV	$m(\tilde{\chi}_1^0) < 200$ GeV	ATLAS-CONF-2012-145
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-630 GeV	$m(\tilde{\chi}_1^0) < 100$ GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	430 GeV	$m(\tilde{\chi}_1^\pm) = 2\, m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$	167 GeV	$m(\tilde{\chi}_1^0) = 55$ GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$ (light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	220 GeV	$m(\tilde{\chi}_1^0) = m(\tilde{t}_1) - m(W) - 50$ GeV, $m(\tilde{t}_1) << m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	150-440 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV, $m(\tilde{t}_1)-m(\tilde{\chi}_1^\pm) = 10$ GeV	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$ (medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0) < 200$ GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^\pm) = 5$ GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$ (heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$	500 GeV	$m(\tilde{\chi}_1^0) > 150$ GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$	520 GeV	$m(\tilde{t}_1) = m(\tilde{\chi}_1^0) + 180$ GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{l}_{L,R}\tilde{l}_{L,R}, \tilde{l}\to l\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{l}$	85-315 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{l}\nu(l\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	125-450 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV, $m(\tilde{l},\tilde{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	180-330 GeV	$m(\tilde{\chi}_1^0) = 0$ GeV, $m(\tilde{\tau},\tilde{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to \tilde{l}_L\nu\tilde{l}_L l(\tilde{\nu}\nu), l\tilde{\nu}\tilde{l}_L l(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0) = 0, m(\tilde{l},\tilde{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to W^{(*)}\tilde{\chi}_1^0 Z^{(*)}\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	315 GeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0) = 0$, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ prod., long-lived $\tilde{\chi}_1^\pm$	0	1 jet	Yes	4.7	$\tilde{\chi}_1^\pm$	220 GeV	$1 < \tau(\tilde{\chi}_1^\pm) < 10$ ns	1210.2852
	Stable $\tilde{g}$, R-hadrons	0-2 e, μ	0	Yes	4.7	$\tilde{g}$	985 GeV		1211.1597
	GMSB, stable $\tilde{\tau}$, low β	2 e, μ	0	Yes	4.7	$\tilde{\tau}$	300 GeV	$5 < \tan\beta < 20$	1211.1597
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	$0.4 < \tau(\tilde{\chi}_1^0) < 2$ ns	1304.6310
	$\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 e, μ	0	Yes	4.4	$\tilde{q}$	700 GeV	1 mm < cτ < 1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e, μ	0	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	$\lambda'_{311}=0.10, \lambda_{132}=0.05$	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 e,μ + τ	0	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	$\lambda'_{311}=0.10, \lambda_{1(2)33}=0.05$	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q}) = m(\tilde{g}), c\tau_{LSP} < 1$ mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0) > 300$ GeV, $\lambda_{121} > 0$	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 e, μ + τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$	350 GeV	$m(\tilde{\chi}_1^0) > 80$ GeV, $\lambda_{133} > 0$	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$	666 GeV		1210.4813
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	m(χ) < 80 GeV, limit of < 687 GeV for D8	ATLAS-CONF-2012-147

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.

Backup

SUSY Limit plots legend



- Yellow band: +/- 1 sigma bands (experimental uncertainties only)
- Dark red line —— : Observed limit
- Red dashed lines: - · - · - · - +/- 1 sigma signal theory uncertainty bands on observed limit, -1 sigma band is the limit quoted by ATLAS papers
- Blue line: —— Expected result