SUSY Searches with ATLAS

16th Lomonosov Conference on Elementary Particle Physics – 27.08.2013

Matthias Hamer
Georg-August-Universität Göttingen

On behalf of the ATLAS Collaboration

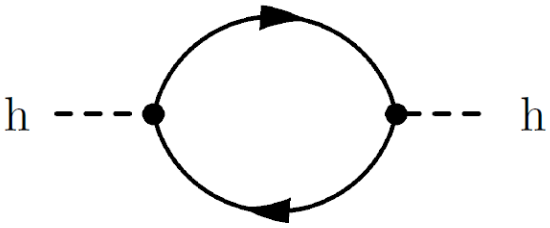
Outline

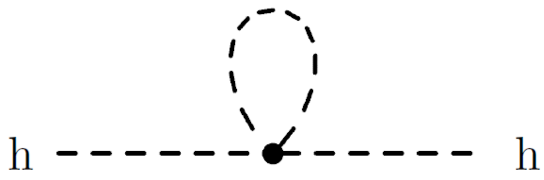
1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary

Outline

1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary

Introduction & Overview



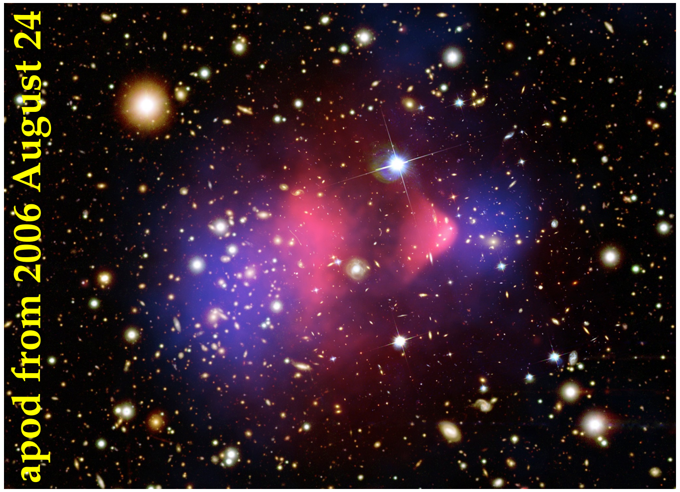


- the Standard Model is not the full story
  → CPV, Dark Matter, Higgs-Mass, GUT, . . .

- SUSY is one concept which extends the SM towards a more complete theory of nature
  → symmetry that connects bosons and fermions

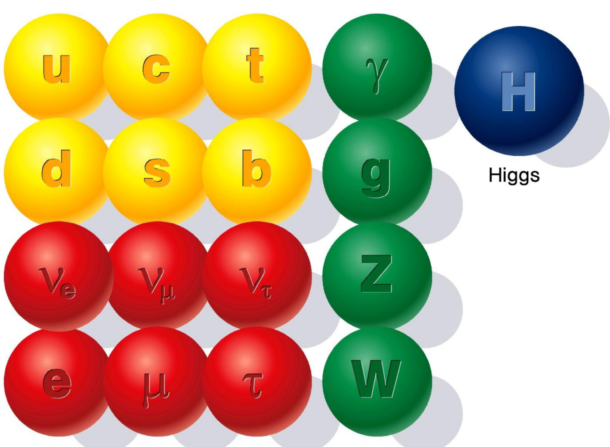
- many possible manifestations of SUSY
  → excellent dark matter candidate
  → 'natural' Higgs mass
  → gauge unification

- no evidence for SUSY so far
  → symmetry broken by unkonwn mechanism
  → modelled by effective Lagrangian at low scale

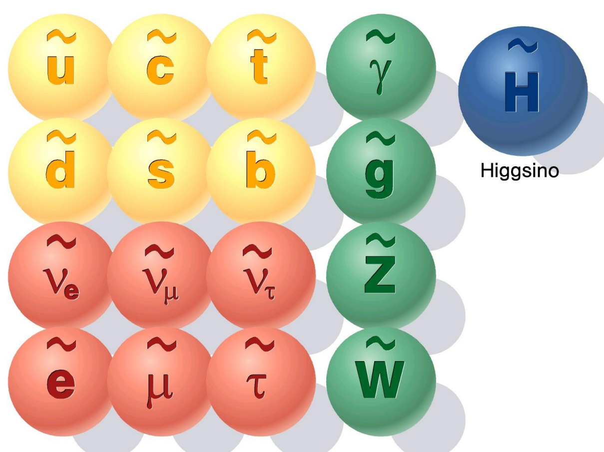


The MSSM

- Minimal Supersymmetric Extension to the Standard Model: MSSM
  → one SUSY operation
  → minimal particle content
  → each deegree of freedom in the SM gets a superpartner with |Δs| = ½
  → effective Lagrangian with 124 parameters
  → derived models with less parameters
  → useful multiplicative quantum number: R-parity



known particles: R = + 1

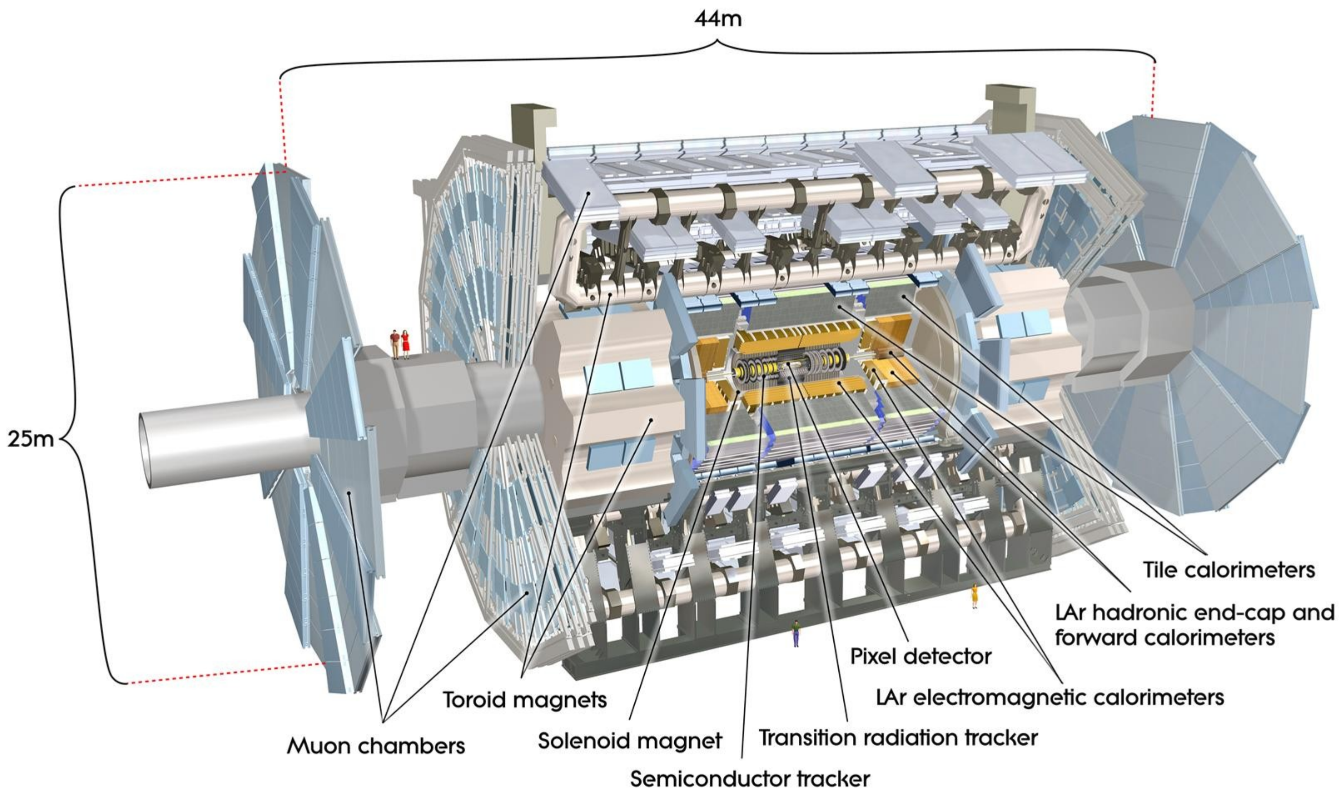


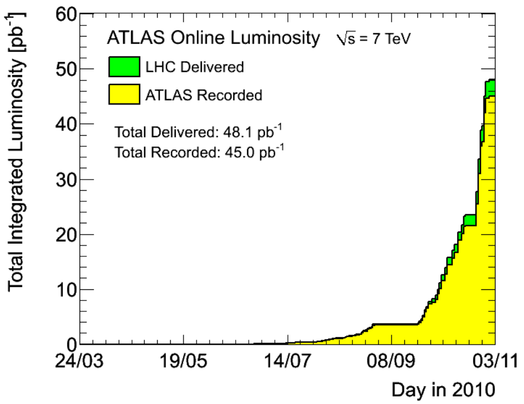
unknown particles: R = - 1

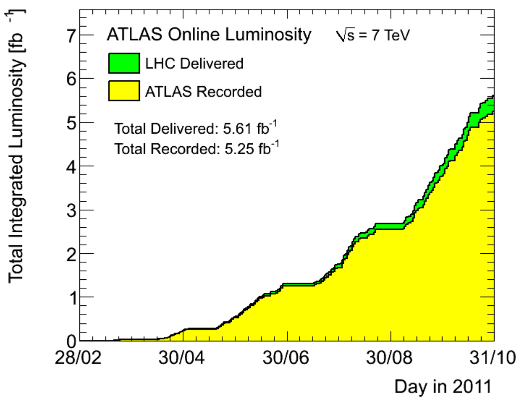
R-parity conserved: stable LSP
→ if WIMP: DM candidate, MET signatures at LHC
→ other signatures possible

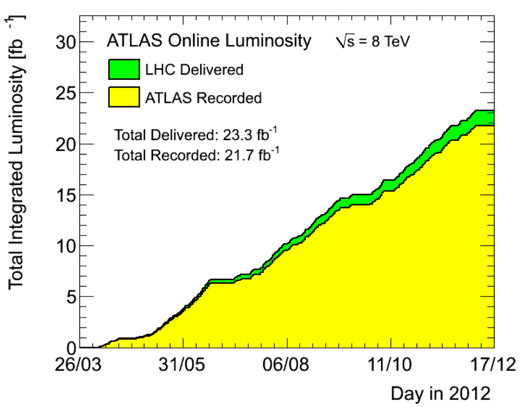
R-parity violated: unstable LSP
→ decays and signature depend on RPV couplings, nature of NLSP, . . .

The ATLAS Detector



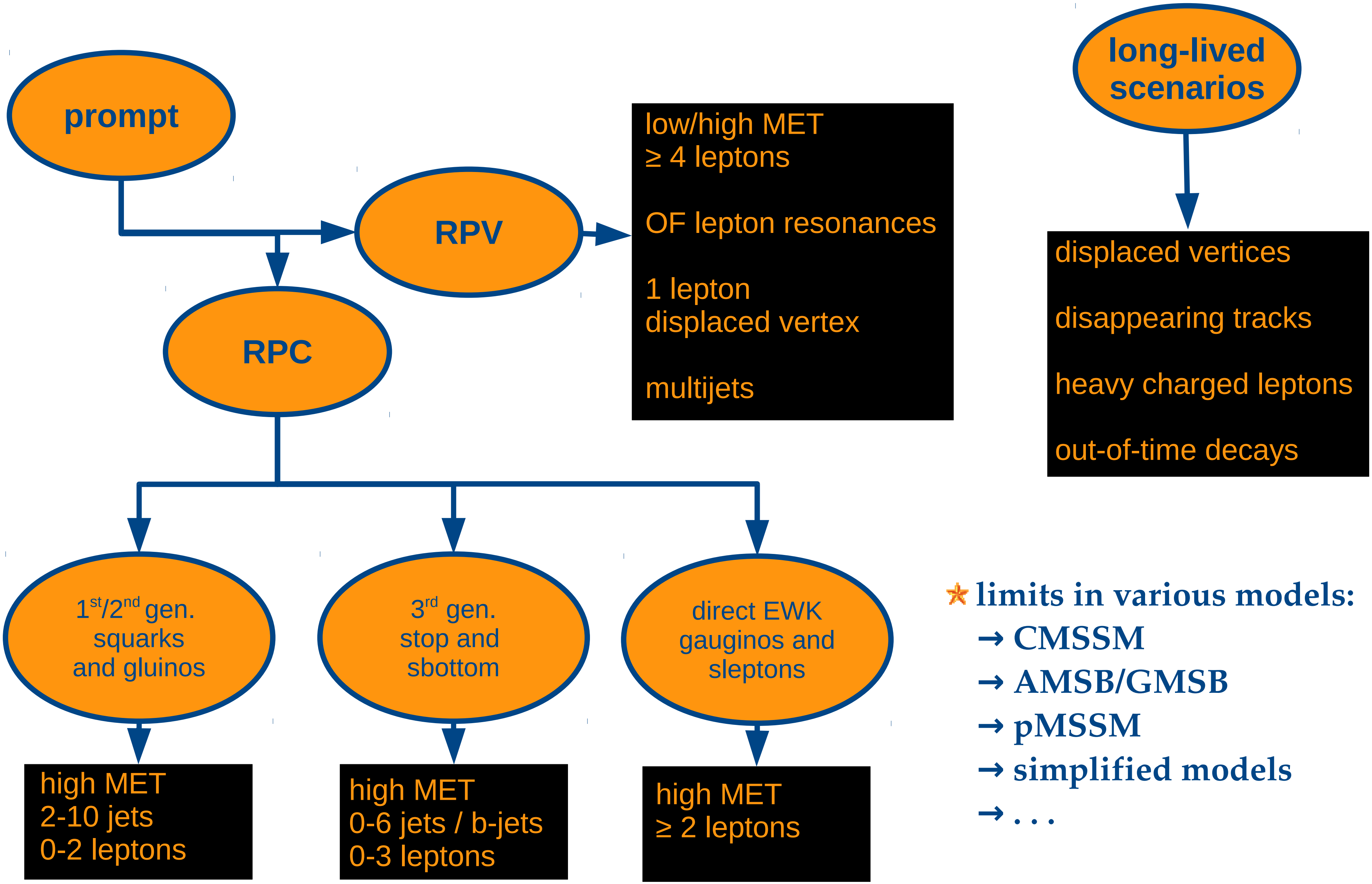






- acquired p-p collision data:
  - → 2010: 45 pb^{-1} at $\sqrt{s}$ = 7 TeV
  - → 2011: 5.25 fb^{-1} at $\sqrt{s}$ = 7 TeV
  - → 2012: 21.7 fb^{-1} at $\sqrt{s}$ = 8 TeV
- most of that data analysed

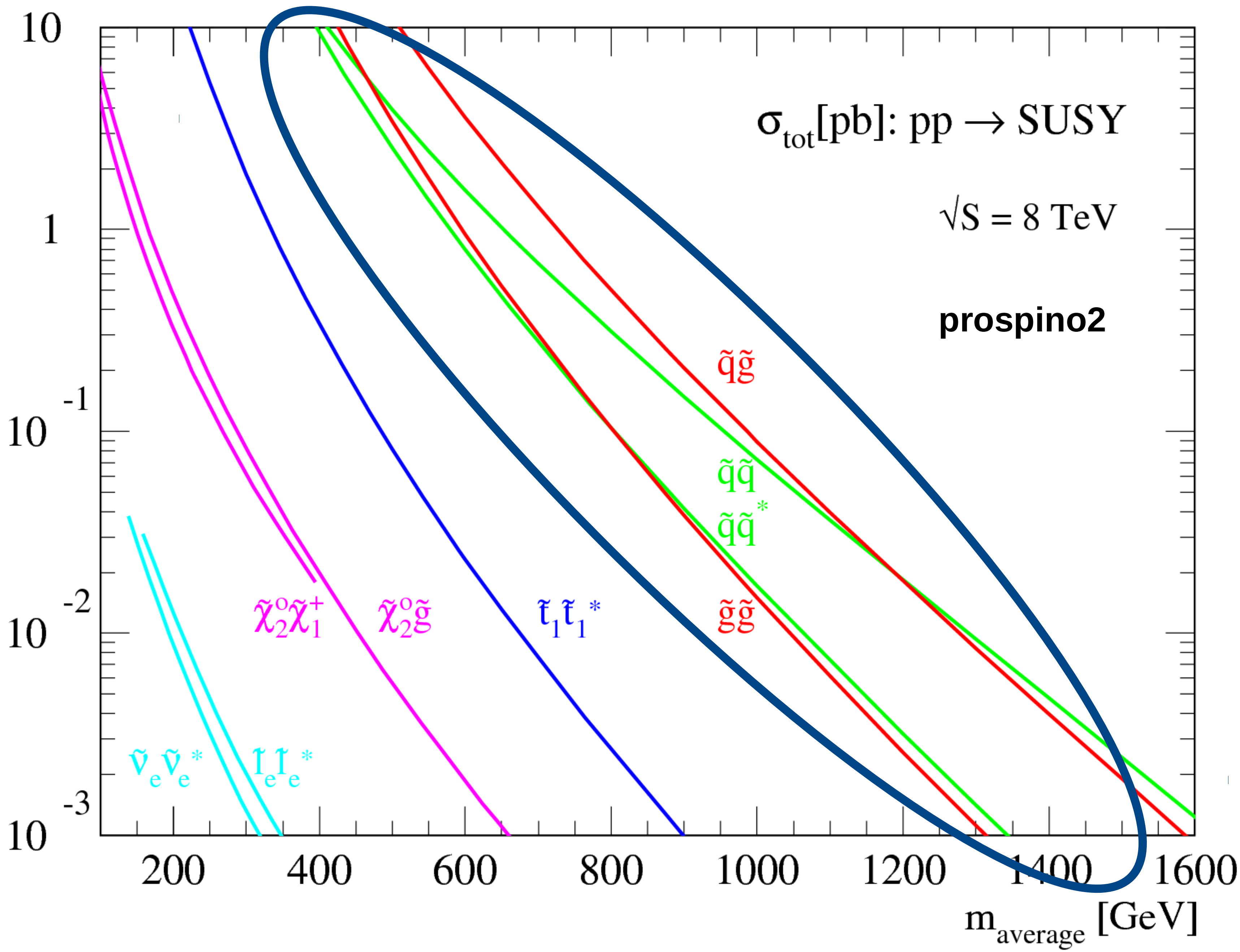
SUSY searches with ATLAS



- **limits in various models:**
  - → CMSSM
  - → AMSB/GMSB
  - → pMSSM
  - → simplified models
  - → . . .

Outline

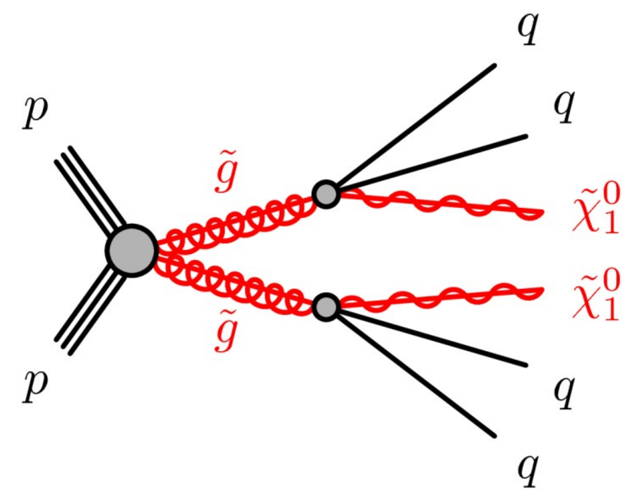
1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary

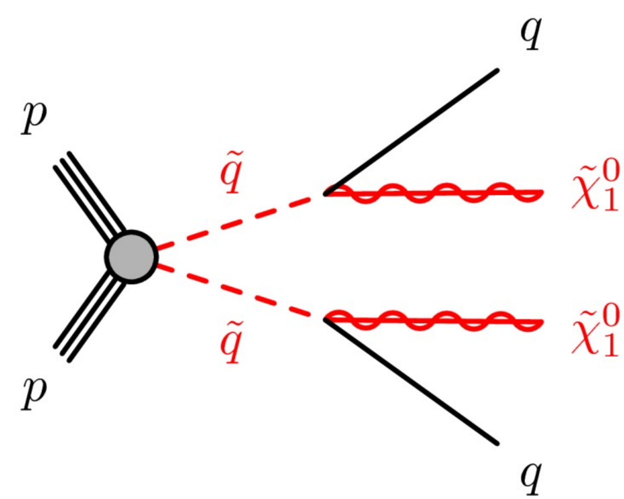


σ_{tot}[pb]: pp → SUSY
√S = 8 TeV
prospino2
$\tilde{q}\tilde{g}$
$\tilde{q}\tilde{q}$
$\tilde{q}\tilde{q}^*$
$\tilde{g}\tilde{g}$
$\tilde{\chi}^o_2\tilde{\chi}^+_1$
$\tilde{\chi}^o_2\tilde{g}$
$\tilde{t}_1\tilde{t}_1^*$
$\tilde{\nu}_e\tilde{\nu}_e^*$
$\tilde{l}_e\tilde{l}_e^*$
10
1
10^{-1}
10^{-2}
10^{-3}
200
400
600
800
1000
1200
1400
1600
$m_{average}$ [GeV]

Inclusive Searches for Squarks and Gluinos

- targets scenarios with
  → direct squark/gluino production (jets)
  → R-parity conservation (MET signature)
  → full hadronic decays preferred (lepton veto)





Requirement	Channel: A (2-jets) L	A (2-jets) M	B (3-jets) M	B (3-jets) T	C (4-jets) M	C (4-jets) T	D (5-jets) –	E (6-jets) L	E (6-jets) M	E (6-jets) T
E_T^{miss}[GeV] >	160									
$p_T(j_1)$ [GeV] >	130									
$p_T(j_2)$ [GeV] >	60									
$p_T(j_3)$ [GeV] >	–		60		60		60	60		
$p_T(j_4)$ [GeV] >	–		–		60		60	60		
$p_T(j_5)$ [GeV] >	–		–		–		60	60		
$p_T(j_6)$ [GeV] >	–		–		–		–	60		
$\Delta\phi(\text{jet}_i, \mathbf{E}_T^{miss})_{min}$ >	0.4 (i = {1, 2, (3 if $p_T(j_3)$ > 40 GeV)})				0.4 (i = {1, 2, 3}), 0.2 (p_T > 40 GeV jets)					
$E_T^{miss}/m_{eff}(Nj)$ >	0.2	–[a]	0.3	0.4	0.25	0.25	0.2	0.15	0.2	0.25
m_{eff}(incl.) [GeV] >	1000	1600	1800	2200	1200	2200	1600	1000	1200	1500

(a) For SR A-medium the cut on $E_T^{miss}/m_{eff}(Nj)$ is replaced by a requirement $E_T^{miss}/\sqrt{H_T}$ > 15 GeV$^{1/2}$.

20.3 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

transfer factors (DD, MC) to estimate SM background in the SR

CR	SR background	CR process	CR selection
CRY	$Z(\rightarrow \nu\nu)$+jets	γ+jets	Isolated photon
CRQ	multi-jets	multi-jets	Reversed $\Delta\phi(\text{jet}, \mathbf{E}_T^{miss})_{min}$ and $E_T^{miss}/m_{eff}(Nj)$ requirements[a]
CRW	$W(\rightarrow \ell\nu)$+jets	$W(\rightarrow \ell\nu)$+jets	30 GeV < $m_T(\ell, E_T^{miss})$ < 100 GeV, b-veto
CRT	$t\bar{t}$ and single-t	$t\bar{t} \rightarrow bbqq'\ell\nu$	30 GeV < $m_T(\ell, E_T^{miss})$ < 100 GeV, b-tag

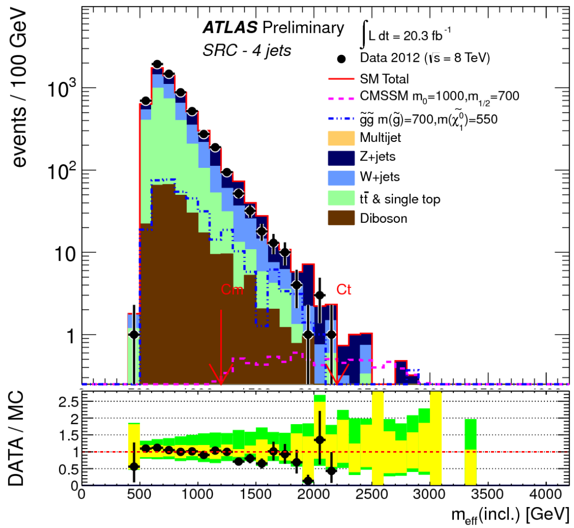
(a) For SR A-medium the selection requirement placed on $E_T^{miss}/\sqrt{H_T}$ is reversed.

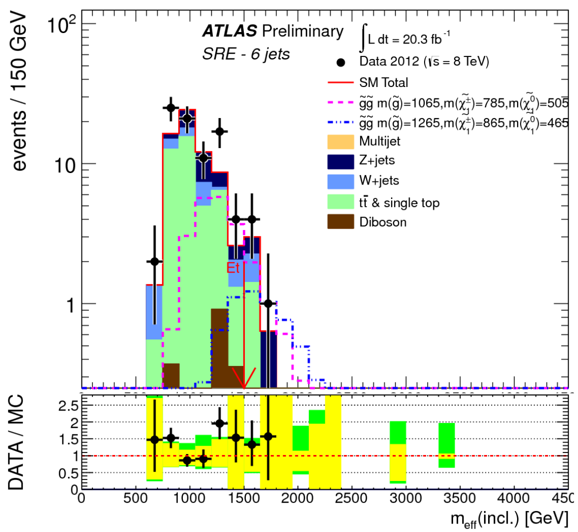
ATLAS-CONF-2013-047

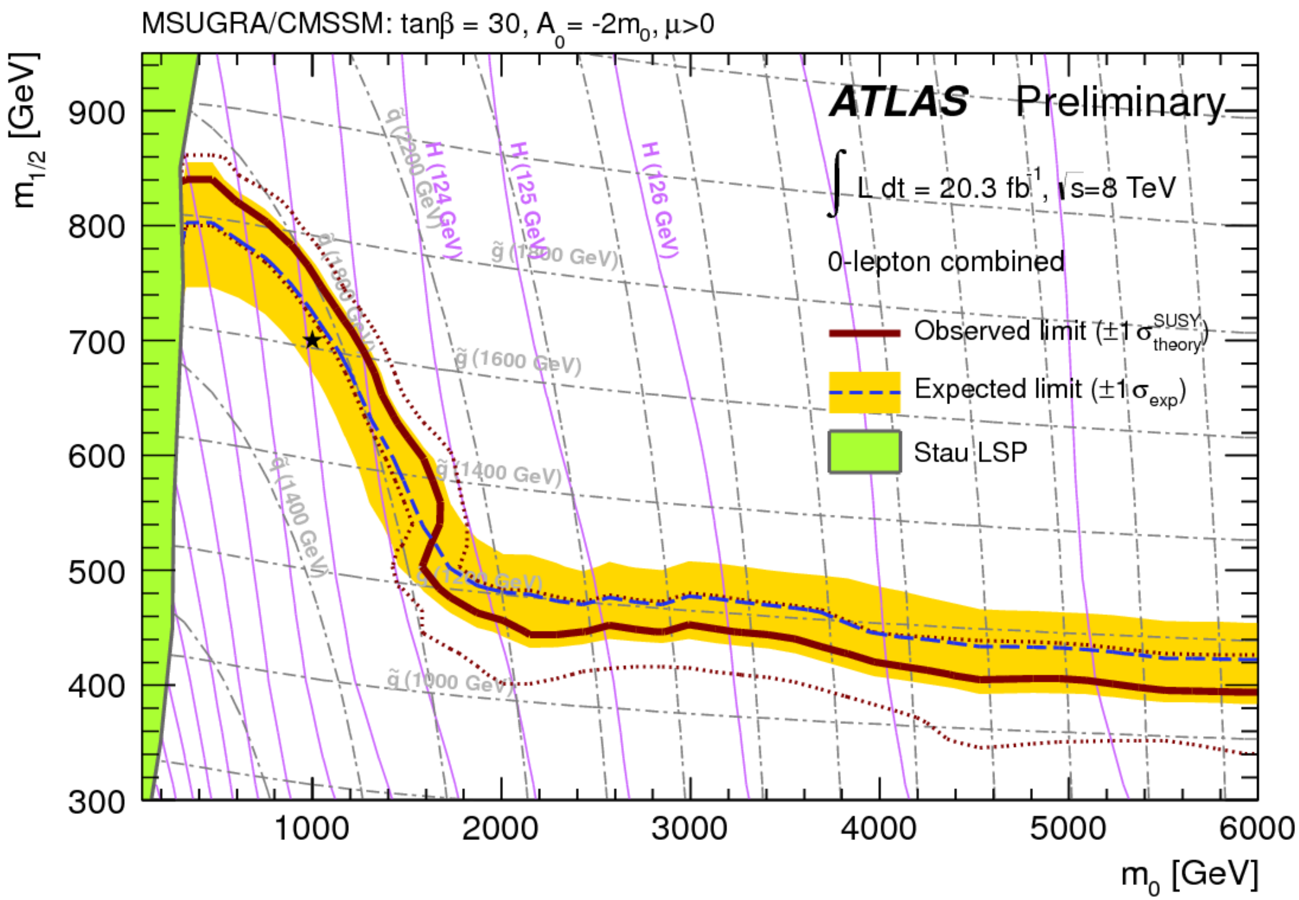
Inclusive Searches for Squarks and Gluinos

ATLAS-CONF-2013-047

- good agreement between SM prediction and data



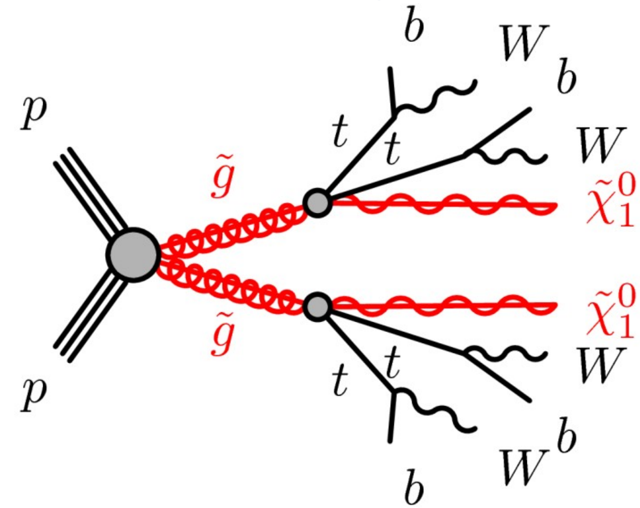


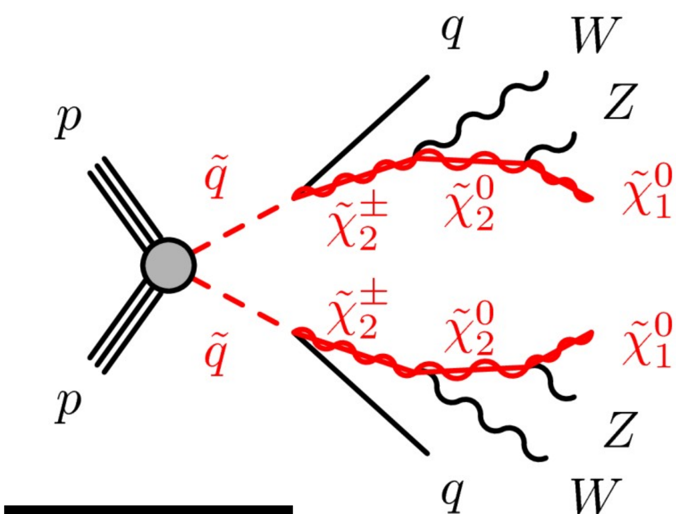


Inclusive Searches for Squarks and Gluinos

- scenarios with higher jet multiplicity
  - → gluino decays via stops
  - → squark decays involving charginos and the heavier neutralinos

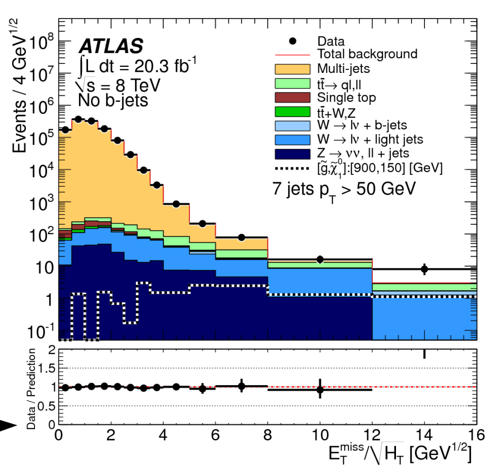
	Multi-jet + flavour stream					Multi-jet + M_J^Σ stream		
Identifier	8j50	9j50	$\geq$ 10j50	7j80	$\geq$ 8j80	$\geq$ 8j50	$\geq$ 9j50	$\geq$ 10j50
Jet $\lvert\eta\rvert$	< 2.0			< 2.0		< 2.8		
Jet p_T	> 50 GeV			> 80 GeV		> 50 GeV		
Jet count	$= 8$	$= 9$	≥ 10	$= 7$	≥ 8	≥ 8	≥ 9	≥ 10
b-jets ($p_T > 40$ GeV, $\lvert\eta\rvert < 2.5$)	0 | 1 | ≥ 2	0 | 1 | ≥ 2	—	0 | 1 | ≥ 2	0 | 1 | ≥ 2	—		
M_J^Σ [GeV]	—			—		> 340 and > 420 for each case		
$E_T^{miss}/\sqrt{H_T}$	> 4 GeV$^{1/2}$			> 4 GeV$^{1/2}$		> 4 GeV$^{1/2}$		

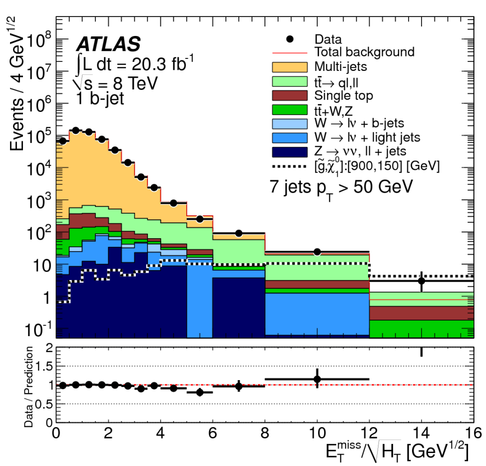




background estimation: DD and MC

BG model validated in CR



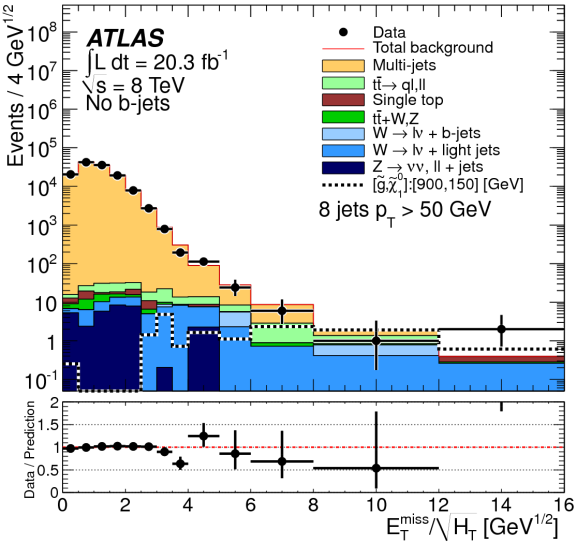


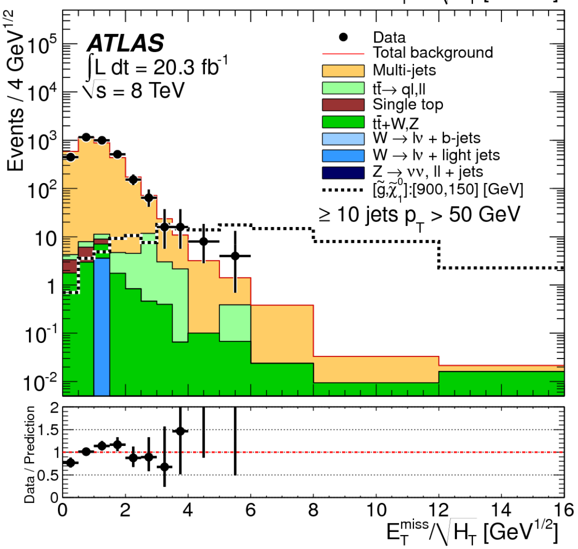
20.3 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

CERN-PH-EP-2013-110

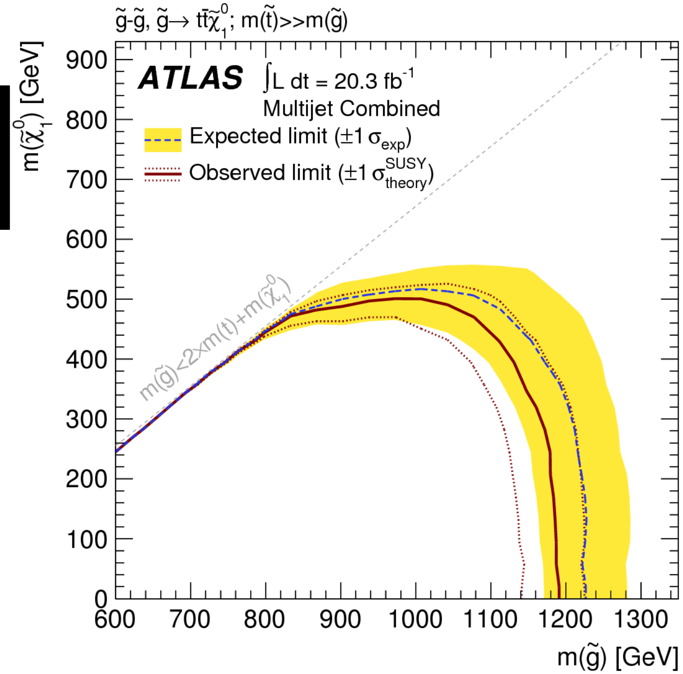
Inclusive Searches for Squarks and Gluinos

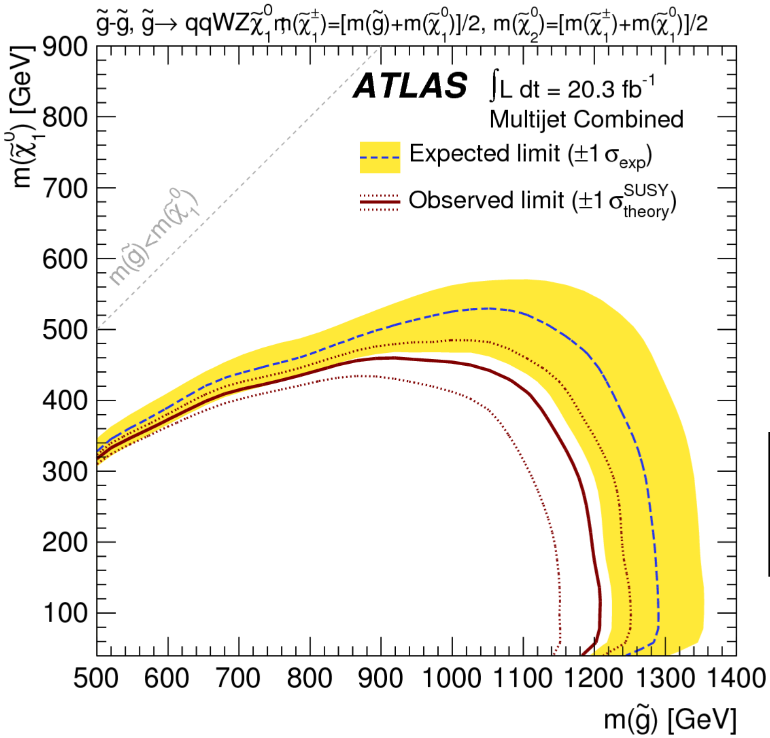
- good agreement between SM expectation and data





gluino – stop (off-shell)



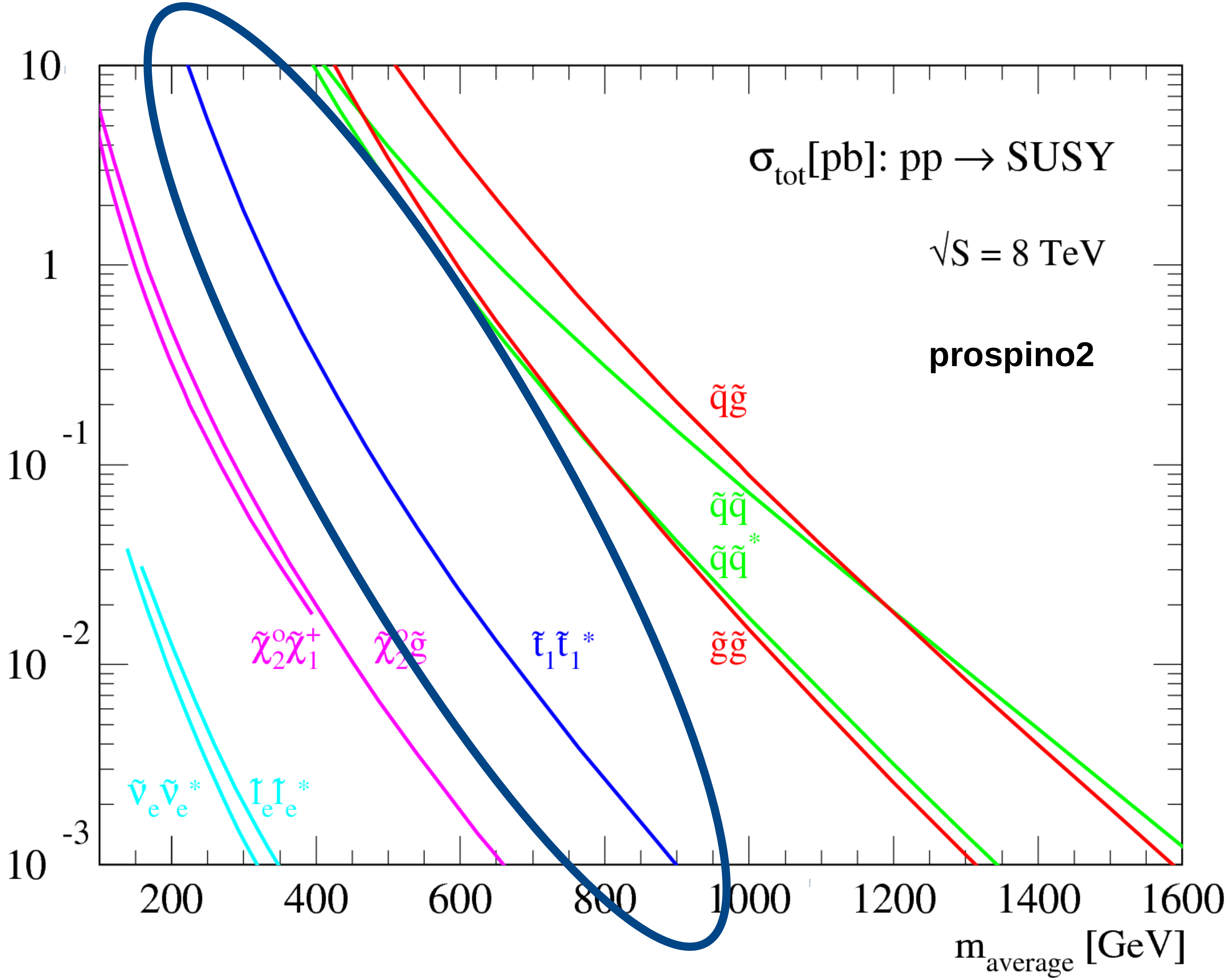


gluino – squark via gauginos

CERN-PH-EP-2013-110

Outline

1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary



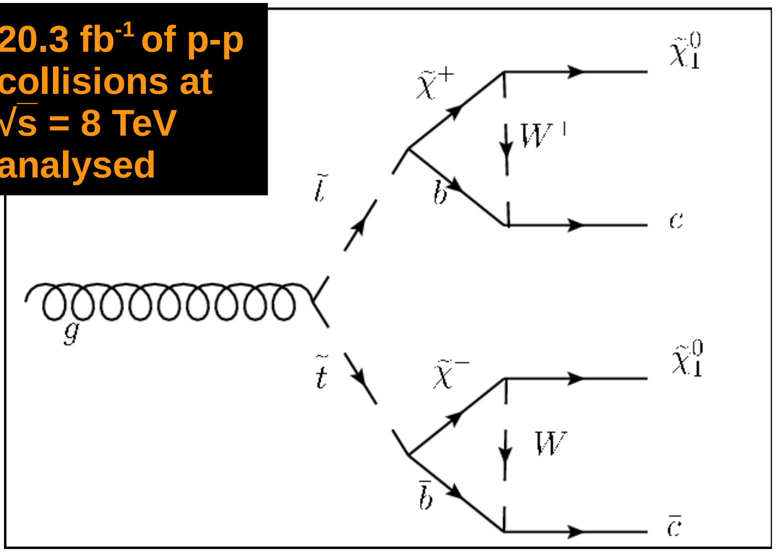
σ_{tot}[pb]: pp → SUSY
√S = 8 TeV
prospino2
$\tilde{q}\tilde{g}$
$\tilde{q}\tilde{q}$
$\tilde{q}\tilde{q}^*$
$\tilde{g}\tilde{g}$
$\tilde{t}_1\tilde{t}_1^*$
$\tilde{\chi}_2^o\tilde{\chi}_1^+$
$\tilde{\chi}_2^o\tilde{g}$
$\tilde{\nu}_e\tilde{\nu}_e^*$
$\tilde{l}_e\tilde{l}_e^*$
10
1
10^{-1}
10^{-2}
10^{-3}
200
400
600
800
1000
1200
1400
1600
$m_{average}$ [GeV]

Search for 3rd Generation Squarks

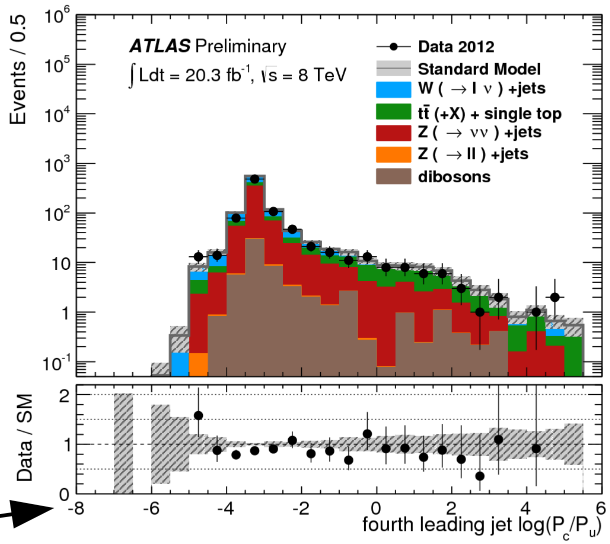
- targets scenarios with
  - → direct production of stops and sbottoms
  - → heavy gluinos and 1st/2nd generation squarks
  - → various decays of stop/sbottom/W
- here: stop search for an exclusive decay

$$\tilde{t} \rightarrow c\ \tilde{\chi}^0_1$$

20.3 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed



Primary vertex	
$E_T^{miss} > 120$ GeV	
Jet quality requirements	
At least one jet with $p_T > 120$ GeV and $\lvert\eta\rvert < 2.8$	
Lepton vetoes: no isolated electrons (muons) with $p_T > 20$ GeV ($p_T > 10$ GeV)	
Monojet-like selection M1	**Charm-tagged selection C1**
At most three jets with $p_T > 30$ GeV and $\lvert\eta\rvert < 2.8$ $\Delta\phi(\text{jet}, \mathbf{p}_T^{miss}) > 0.4$	At least three jets with $p_T > 30$ GeVand $\lvert\eta\rvert < 2.5$ (in addition to the leading jet) b-veto for second and third jet *medium* c-tag for fourth jet $\Delta\phi(\text{jet}, \mathbf{p}_T^{miss}) > 0.4$
minimum leading jet p_T (GeV) 280	270
minimum E_T^{miss} (GeV) 220	410



background estimation: DD and MC

ATLAS-CONF-2013-068

medium c-tag:

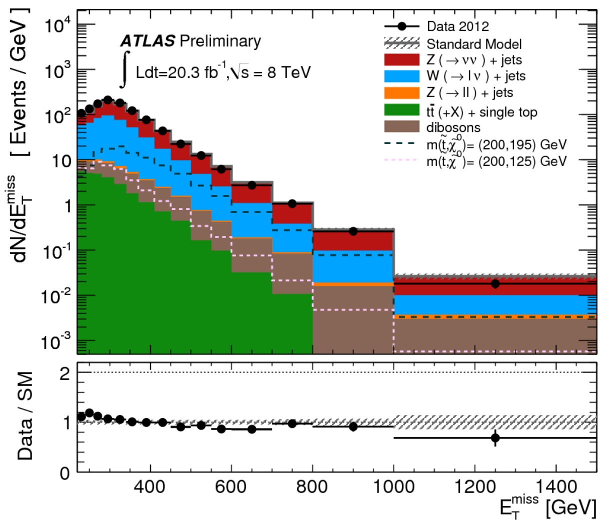
efficiency: 20%

rejection factor: 5/140/10 (b-jets/LF/τ)

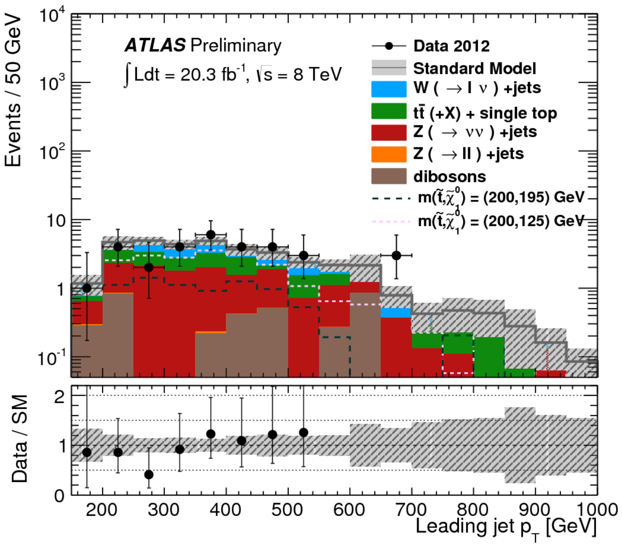
Search for 3rd Generation Squarks

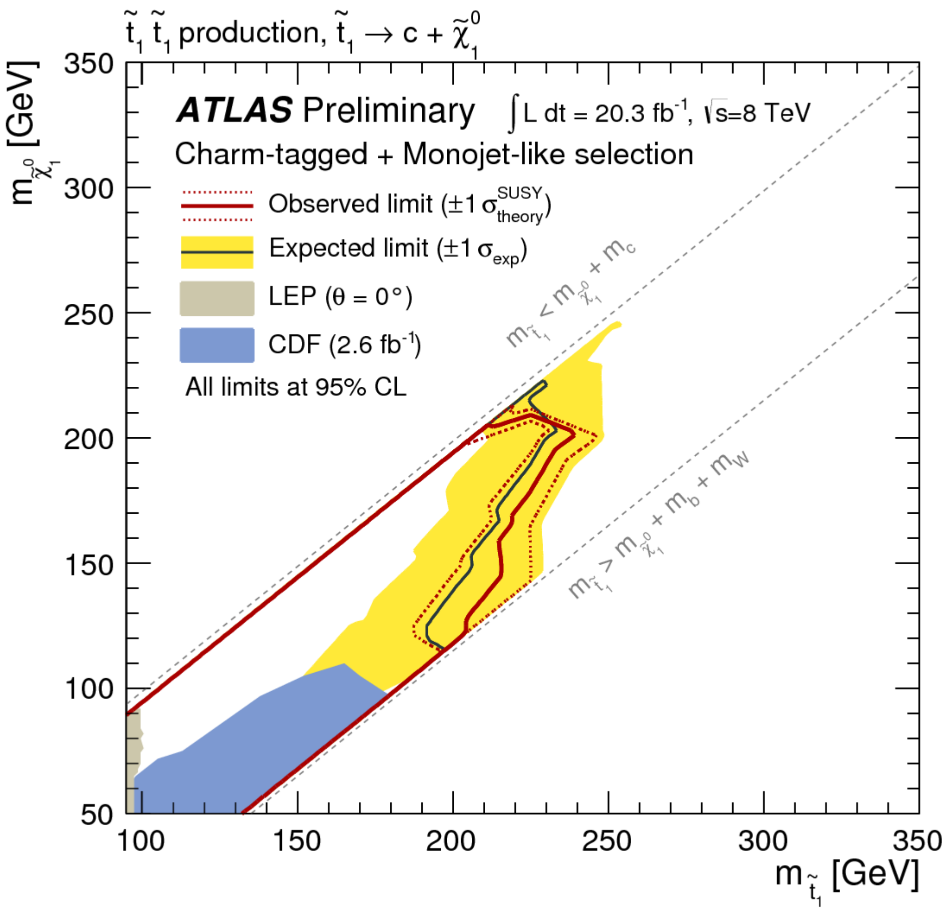
- good agreement between SM prediction and data

ATLAS-CONF-2013-068

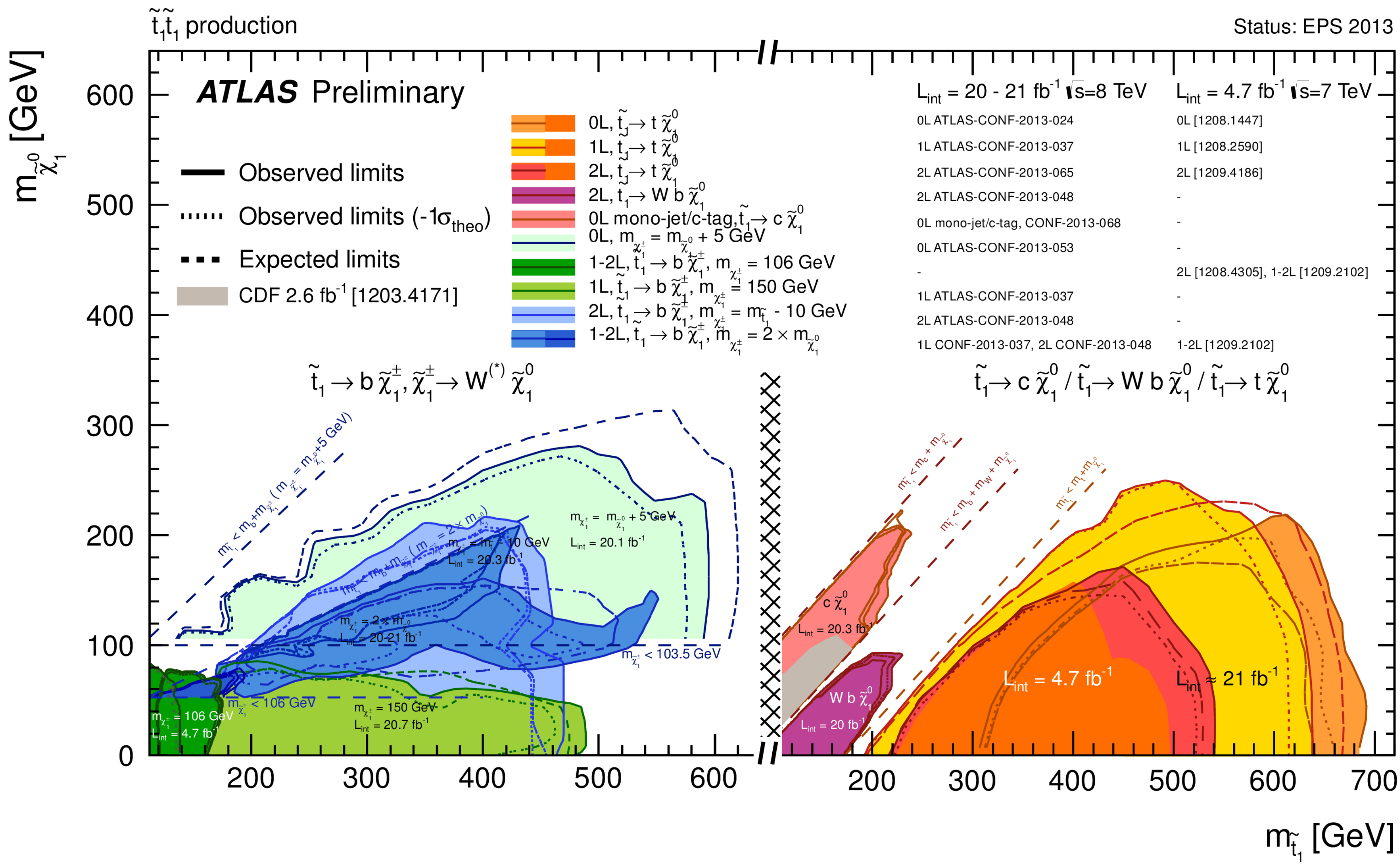


Signal Region	M1	C1
Observed events (20.3 fb^{-1})	30793	25
SM prediction	29800 ± 900	29 ± 7



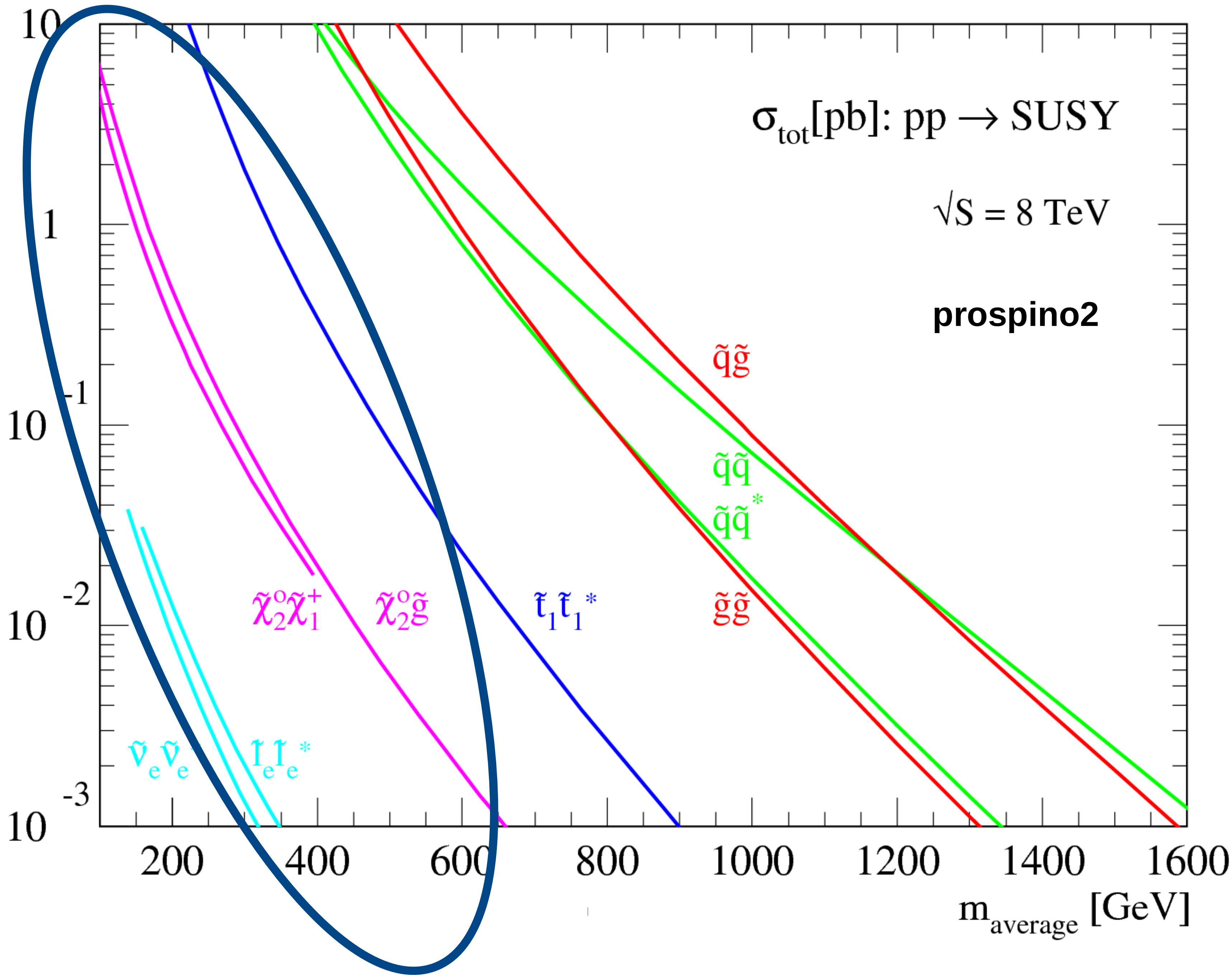


Search for 3rd Generation Squarks



Outline

1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary



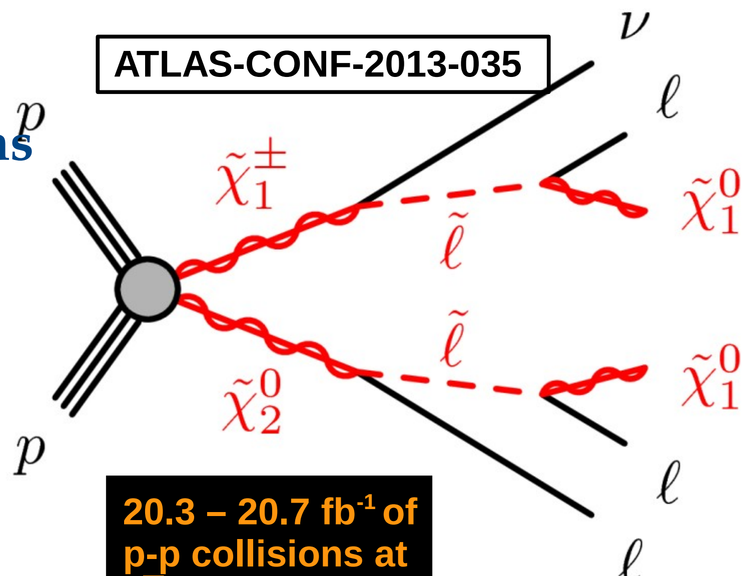
σ_{tot}[pb]: pp → SUSY
$\sqrt{S}$ = 8 TeV
prospino2
$\tilde{q}\tilde{g}$
$\tilde{q}\tilde{q}$
$\tilde{q}\tilde{q}^*$
$\tilde{g}\tilde{g}$
$\tilde{t}_1\tilde{t}_1^*$
$\tilde{\chi}_2^o\tilde{\chi}_1^+$
$\tilde{\chi}_2^o\tilde{g}$
$\tilde{\nu}_e\tilde{\nu}_e$
$\tilde{l}_e\tilde{l}_e^*$
10
1
10^{-1}
10^{-2}
10^{-3}
200
400
600
800
1000
1200
1400
1600
$m_{average}$ [GeV]

Search for Electroweak SUSY production

- targets scenarios with
  - → direct production of EW gauginos and sleptons
  - → heavy coloured superpartners
  - → different production and decay mechanisms
  - → typically leptons in the final state

  - → searching in final states with 2, 3 and ≥4 leptons

ATLAS-CONF-2013-035

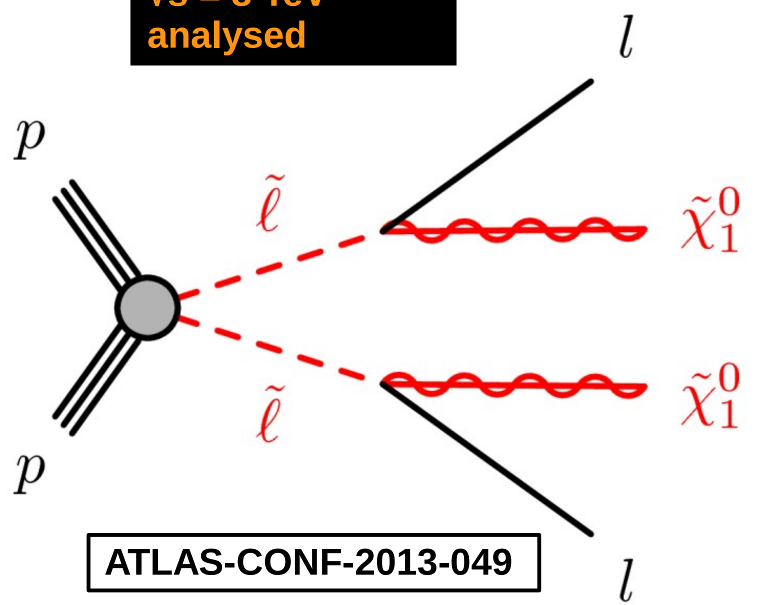


background estimation: DD and MC

20.3 – 20.7 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

2 Leptons

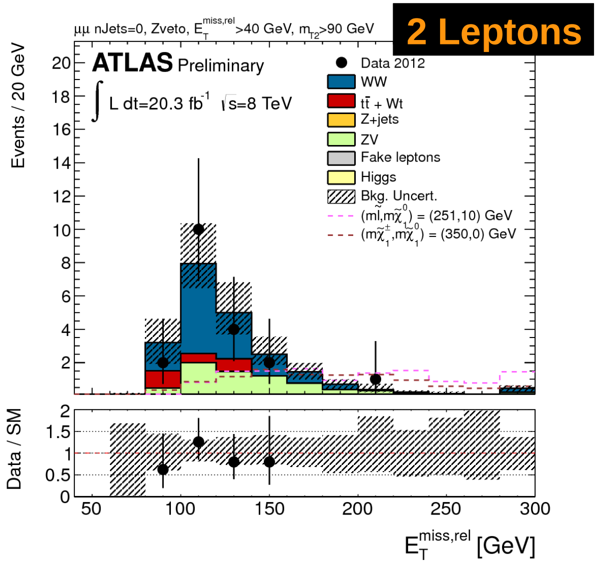
SR-$m_{T2,90}$	e^+e^-	$e^\pm\mu^\mp$	$\mu^+\mu^-$	all
Observed	15	19	19	53
Background total	16.6 ± 2.3	20.7 ± 3.2	22.4 ± 3.3	59.7 ± 7.3
WW	9.3 ± 1.6	14.1 ± 2.2	12.6 ± 2.0	36.1 ± 5.1
ZV (V = W or Z)	6.3 ± 1.5	0.8 ± 0.3	7.3 ± 1.7	14.4 ± 3.2
Top	$0.9^{+1.1}_{-0.9}$	5.6 ± 2.1	2.5 ± 1.8	8.9 ± 3.9
Higgs	0.11 ± 0.04	0.19 ± 0.05	0.08 ± 0.04	0.38 ± 0.08
Fake	$0.00^{+0.18}_{-0.00}$	$0.00^{+0.14}_{-0.00}$	$0.00^{+0.15}_{-0.00}$	$0.00^{+0.28}_{-0.00}$
Signal expectation				
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0})$ = (191, 90) GeV	21.6	0	21.6	43.2
$(m_{\tilde{\ell}}, m_{\tilde{\chi}_1^0})$ = (251, 10) GeV	12.2	0	12.5	24.7
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0})$ = (350, 0) GeV	11.7	16.6	10.5	38.8
$(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0})$ = (425, 75) GeV	4.3	6.7	4.4	15.4

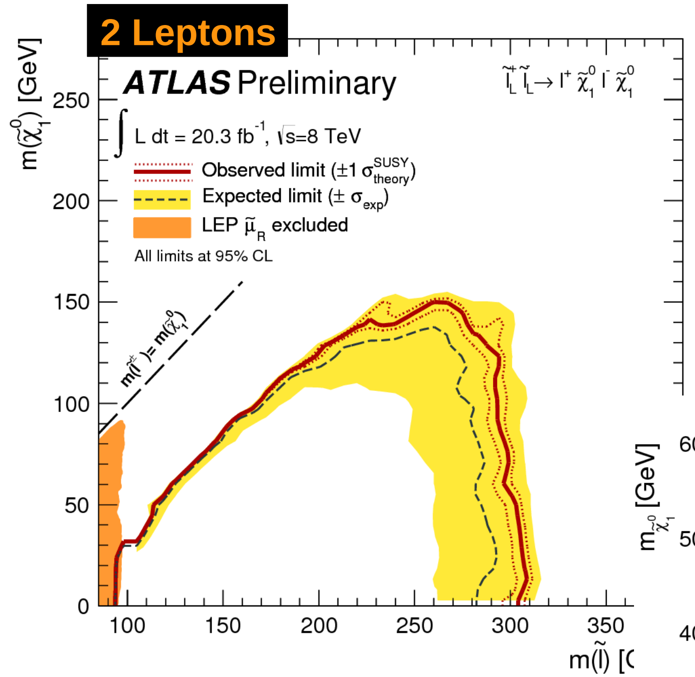


ATLAS-CONF-2013-049

Search for Electroweak SUSY production

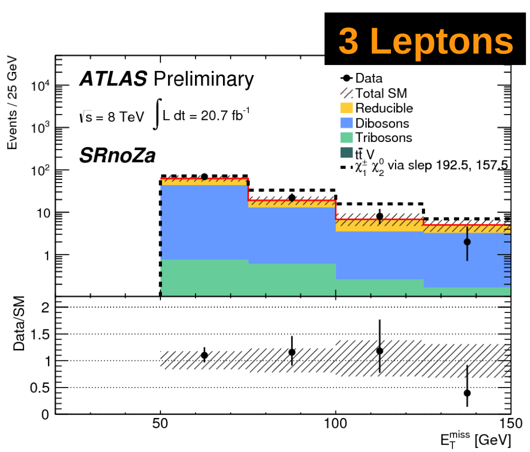
- good agreement between SM prediction and data



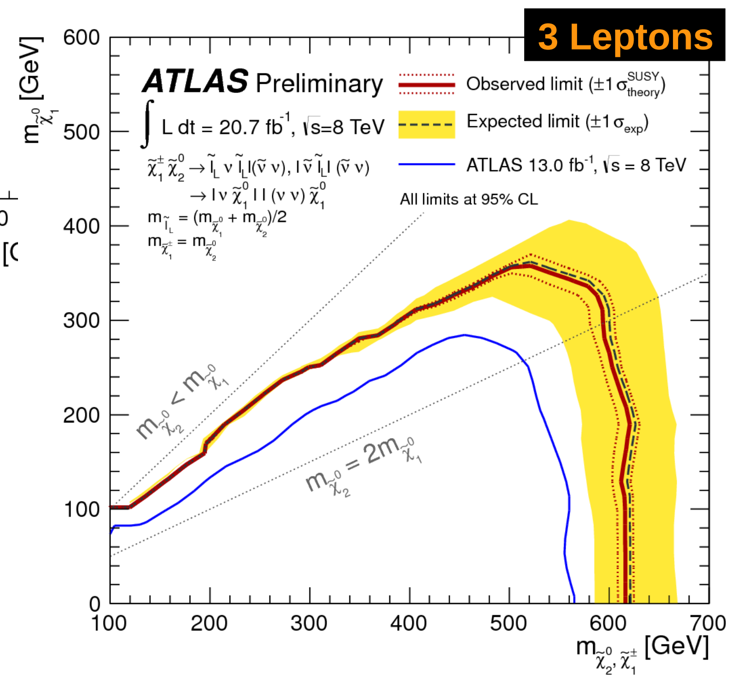


ATLAS-CONF-2013-035

ATLAS-CONF-2013-049



limits in simplified models with well defined mass hierarchy, gaugino mixing and branching fractions



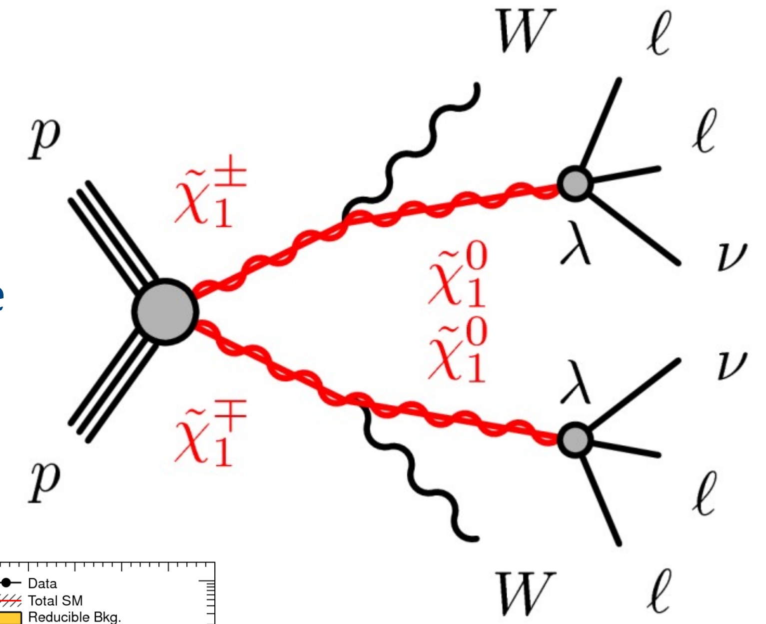
Outline

1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary

Searches for RPV and long-lived SUSY

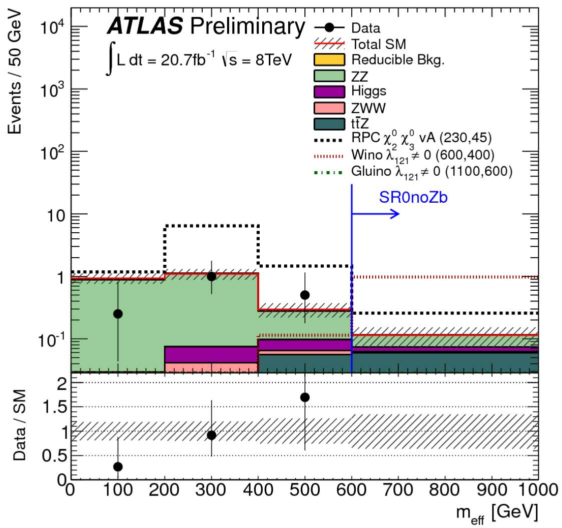
$$\lambda_{ijk} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k + \kappa_i L_i H_2$$

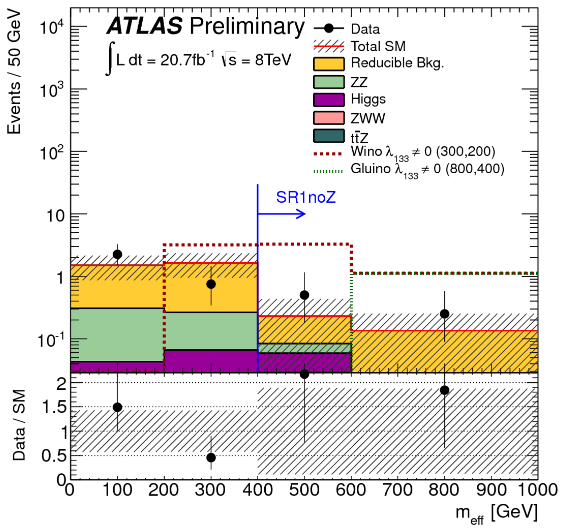
- RPV scenarios
  - → LSP is unstable
  - → may decay into multilepton final states
  - → direct LSP production typically negligible
  - → consider NLSP production only
  - → chargino and gluino NLSP considered here



SR	N($\ell = e, \mu$)	N(τ)	Z Candidate	E_T^{miss}[GeV]		m_{eff}[GeV]
SR0noZb	≥4	≥0	extended veto	>75	or	>600
SR1noZ	=3	≥1	extended veto	>100	or	>400

background estimation DD and MC





20.7 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

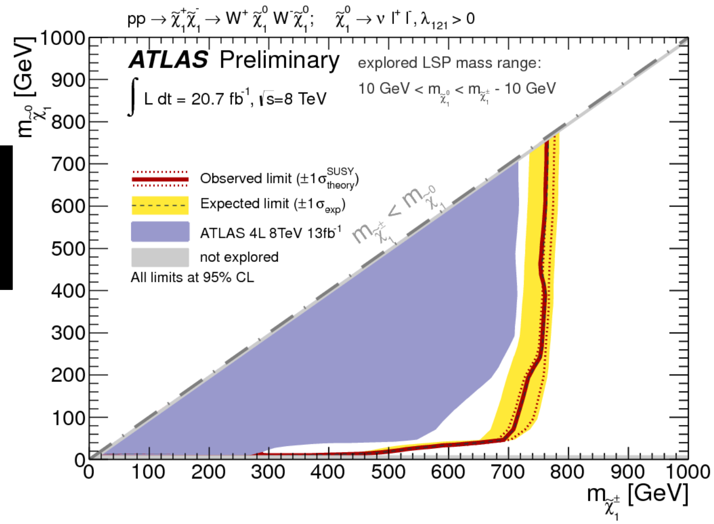
ATLAS-CONF-2013-036

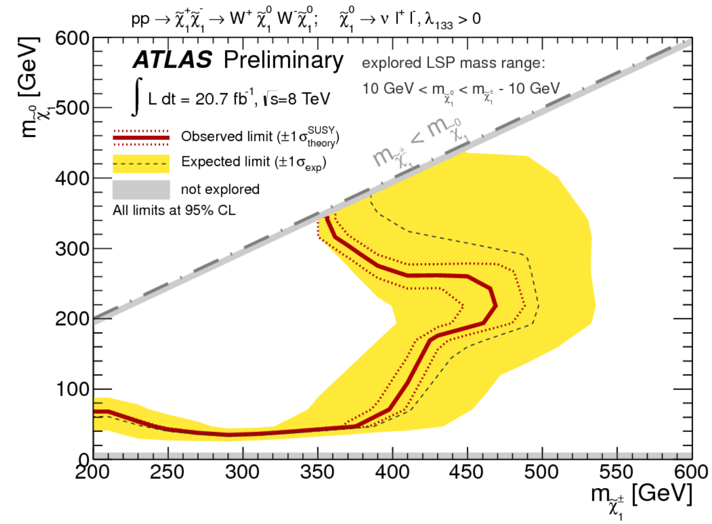
Searches for RPV and long-lived SUSY

- good agreement between SM expectation and data
  → limits set in various models

ATLAS-CONF-2013-036

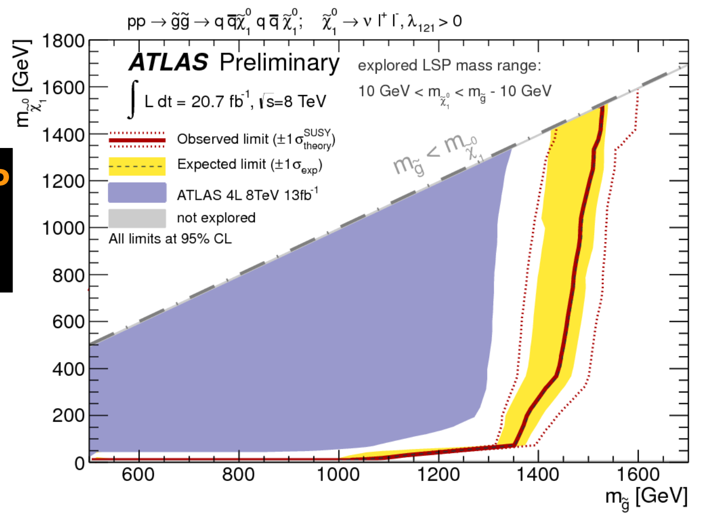
wino NLSP
$\lambda_{121} \neq 0$

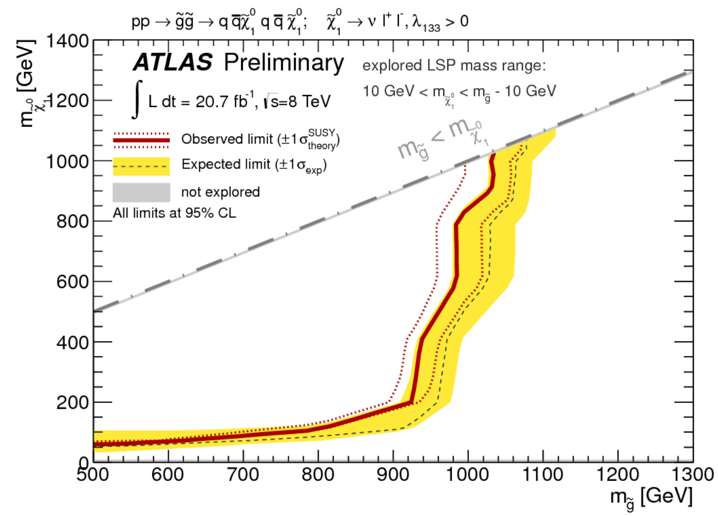




wino NLSP
$\lambda_{133} \neq 0$

gluino NLSP
$\lambda_{121} \neq 0$

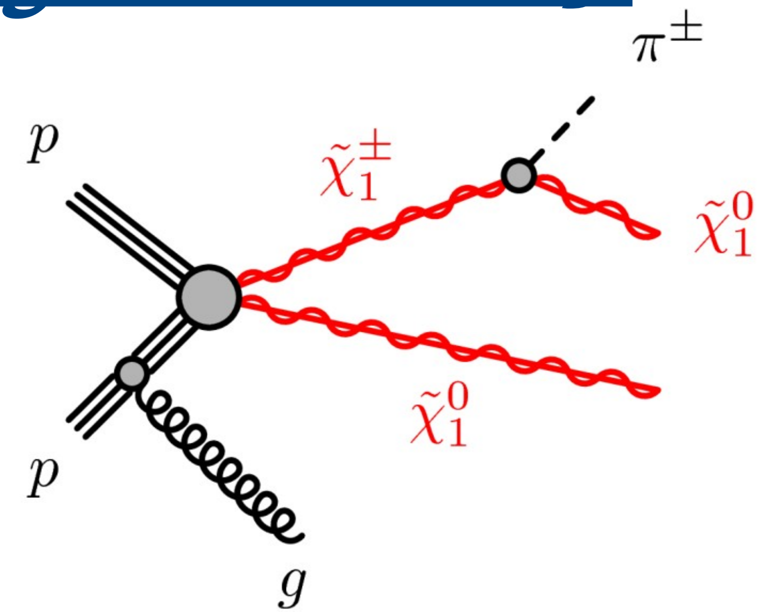




gluino NLSP
$\lambda_{133} \neq 0$

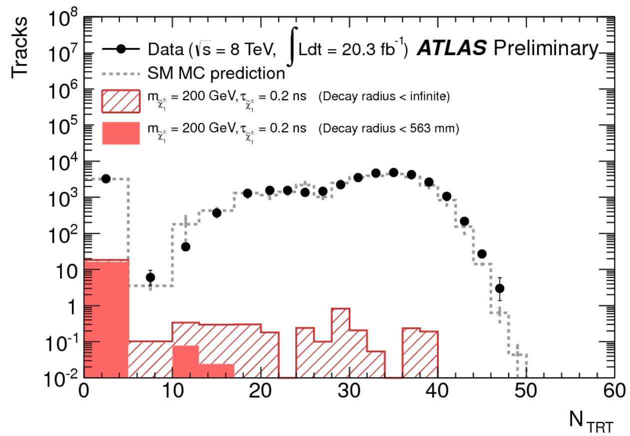
Searches for RPV and long-lived SUSY

- AMSB scenarios
  - → lightest chargino and neutralino nearly mass degenerate
  - → chargino has significant lifetime
  - → look for disappearing tracks

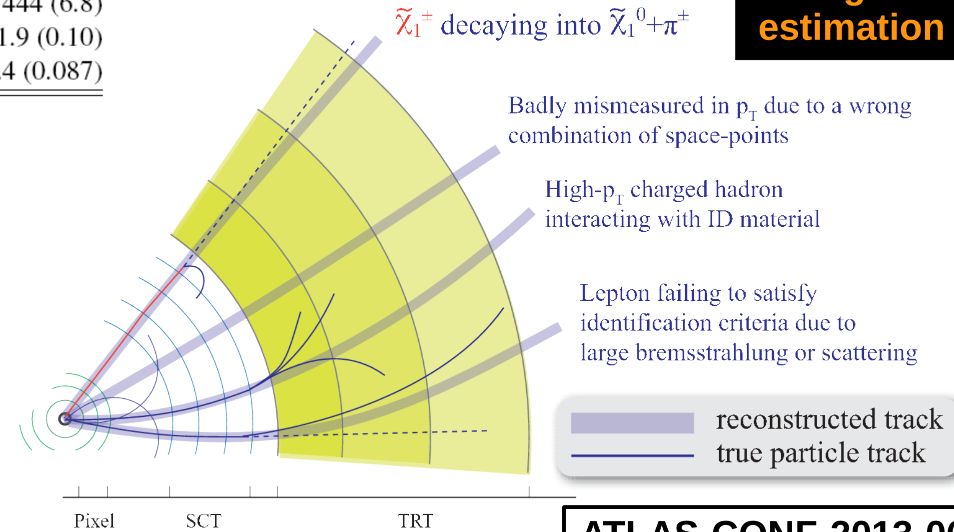


Selection requirement	Observed events	Expected signal events (efficiency [%])
Quality requirements and trigger	20479553	1873 (8.8)
Jet cleaning	18627508	1867 (8.8)
Lepton veto	12485944	1827 (8.6)
Leading jet $p_T > 90$ GeV	10308840	1571 (7.4)
$E_T^{miss} > 90$ GeV	6113773	1484 (7.0)
$\Delta\phi_{min}^{jet-E_T^{miss}} > 1.5$	5604087	1444 (6.8)
High-p_T isolated track selection	34379	21.9 (0.10)
Disappearing-track selection	3256	18.4 (0.087)

DD background estimation



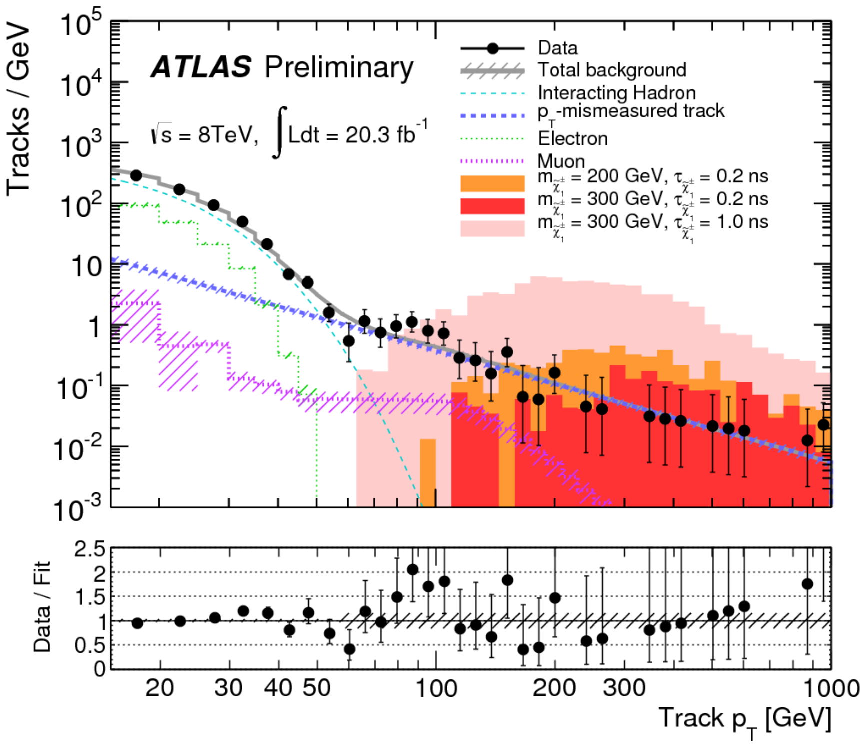
20.3 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

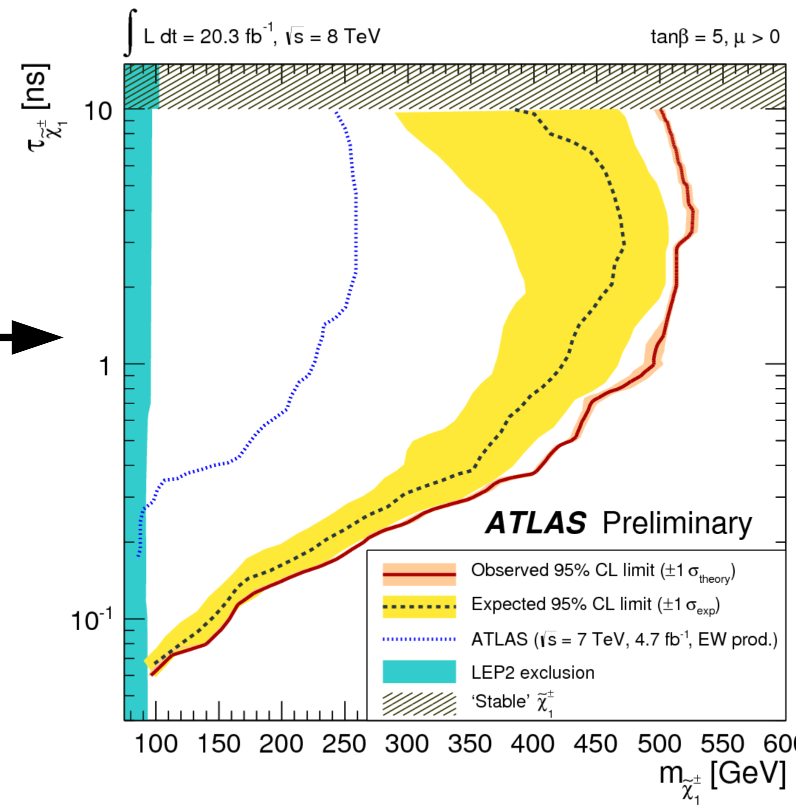


ATLAS-CONF-2013-069

Searches for RPV and long-lived SUSY

- good agreement between the background expectation and data





ATLAS-CONF-2013-069

Outline

1) Introduction & Overview
2) Inclusive Searches for Squarks and Gluinos
3) Searches for 3rd Generation Squarks
4) Searches for Electroweak SUSY Production
5) Searches for RPV and long-lived SUSY
6) Summary

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [fb^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	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
	$\tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}_1^{\pm} \to qqW^{\pm}\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^{\pm})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g} \to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$	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 ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ 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 $e, \mu + \gamma$	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
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g} \to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.14 TeV	$m(\tilde{\chi}_1^0)$ <200 GeV	ATLAS-CONF-2013-054
	$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g} \to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
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	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), $\tilde{t}_1 \to t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	$\tilde{t}_1$	225-525 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(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, $m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=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
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(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	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell} \to \ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+ \to \tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}$	125-450 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to \tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to W^*\tilde{\chi}_1^0Z^*\tilde{\chi}_1^0$	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 $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$	270 GeV	$m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^{\pm})$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	857 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \to \tilde{\tau}(\tilde{e}, \tilde{\mu})+\tau(e, \mu)$	1-2 μ	0	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	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 μ	0	Yes	4.4	$\tilde{q}$	700 GeV	1 mm<$c\tau$<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	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp \to \tilde{\nu}_\tau + X, \tilde{\nu}_\tau \to e(\mu) + \tau$	1 $e, \mu + \tau$	0	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{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, λ_{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 $e, \mu + \tau$	0	Yes	20.7	$\tilde{\chi}_1^{\pm}$	350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{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	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

Mass scale [TeV]: 10^{-1}, 1

$\sqrt{s}$ = 7 TeV full data — $\sqrt{s}$ = 8 TeV partial data — $\sqrt{s}$ = 8 TeV full data

*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.

Summary

- p-p collision data taken during three years of LHC operation has been/is being analysed
- no evidence for the existence of superpartners has been found
- superpartners with masses of $\mathcal{O}(1)$ TeV ruled out in many models
- standard scenarios have been strongly constrained by the results
  → difficult to sustain these scenarios ('naturalness')
- wide variety of simplified models derived from more complicated models are being studied
- more results to come

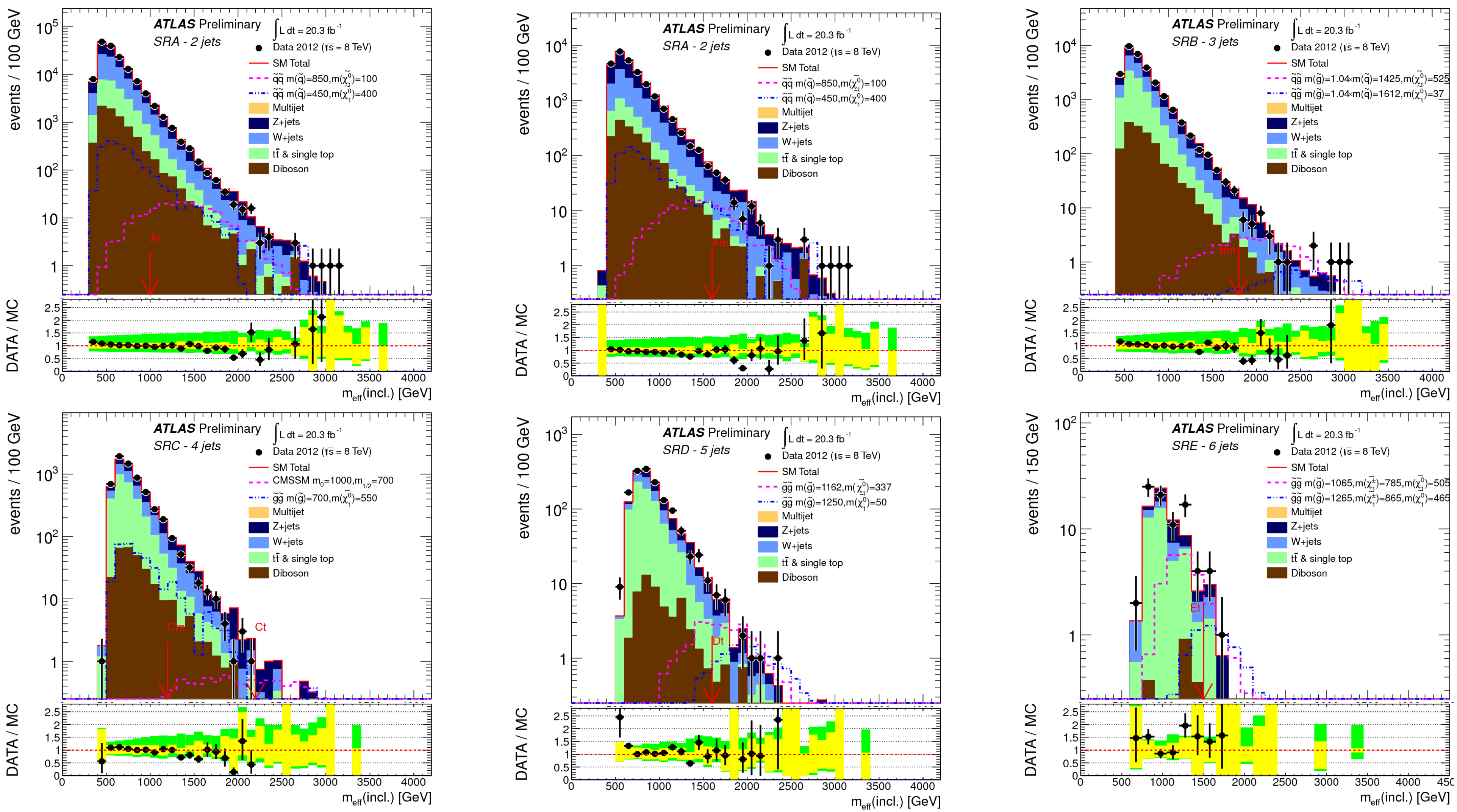
Thank you!

Extra Material

Inclusive Searches for Squarks and Gluinos

- good agreement between SM prediction and data

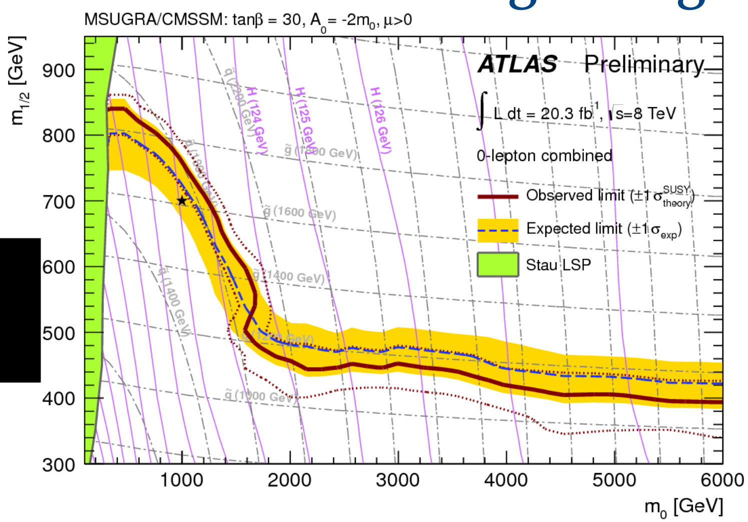
ATLAS-CONF-2013-047

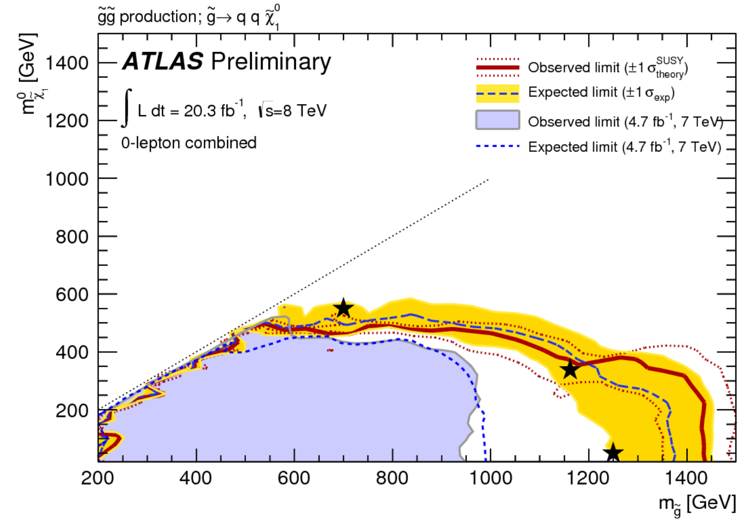


Inclusive Searches for Squarks and Gluinos

- observe no excess in signal regions → constrain models

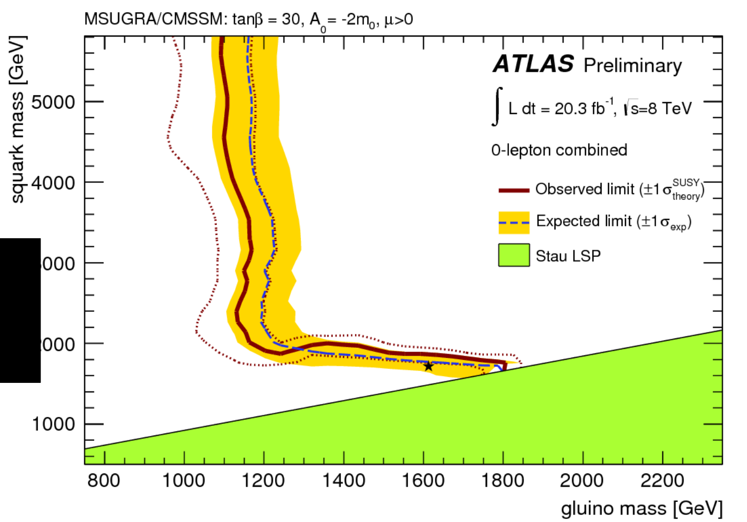
CMSSM m_{12} - m_0

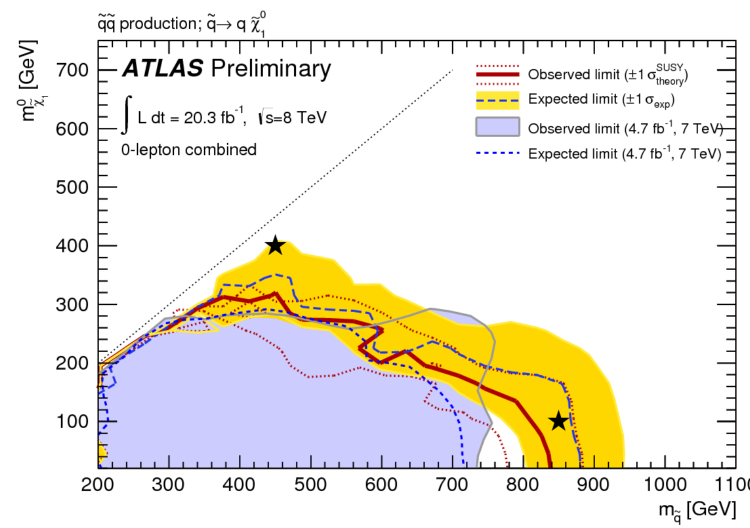




simplified model: gluino NLSP

CMSSM $m_{\tilde{q}}$ - $m_{\tilde{g}}$

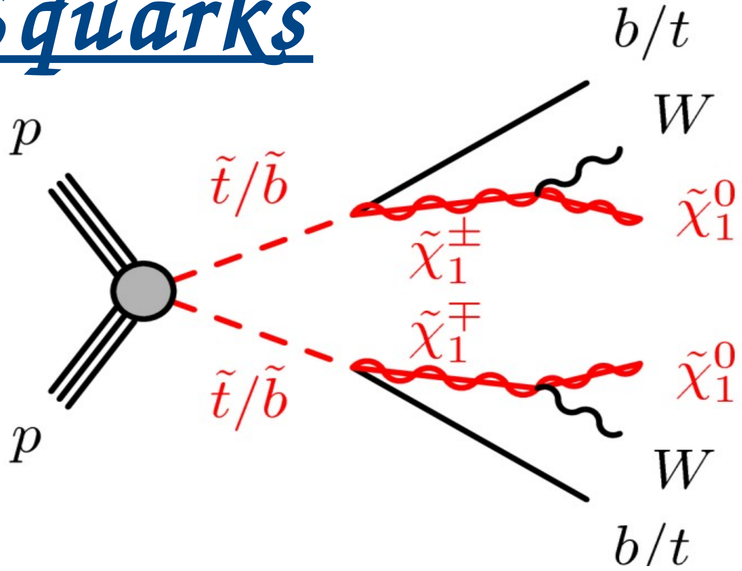




simplified model: squark NLSP

ATLAS-CONF-2013-047

Search for 3rd Generation Squarks



- targets scenarios with
  - → direct production of stops and sbottoms
  - → heavy gluinos and $1^{st}/2^{nd}$ generation squarks
  - → various decays of stop/sbottom/W
- here: stop search for 2 exclusive decays
  1) $\tilde{t} \rightarrow b\,\tilde{\chi}_1^+$
     SR: 2 OS leptons (pT < 60 GeV)
     2 b-jets
     m_{T2} < 90 GeV
     $m_{T2}^{b\text{-jet}}$ > 160 GeV
  2) $\tilde{t} \rightarrow t\,\tilde{\chi}_1^0$
     SR: 2 OS leptons
     ≥ 2 jets (leading jet: pT > 50 GeV)
     m_{eff} > 300 GeV
     BDT to define 11 SR

background estimation: DD and MC

20.3 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed

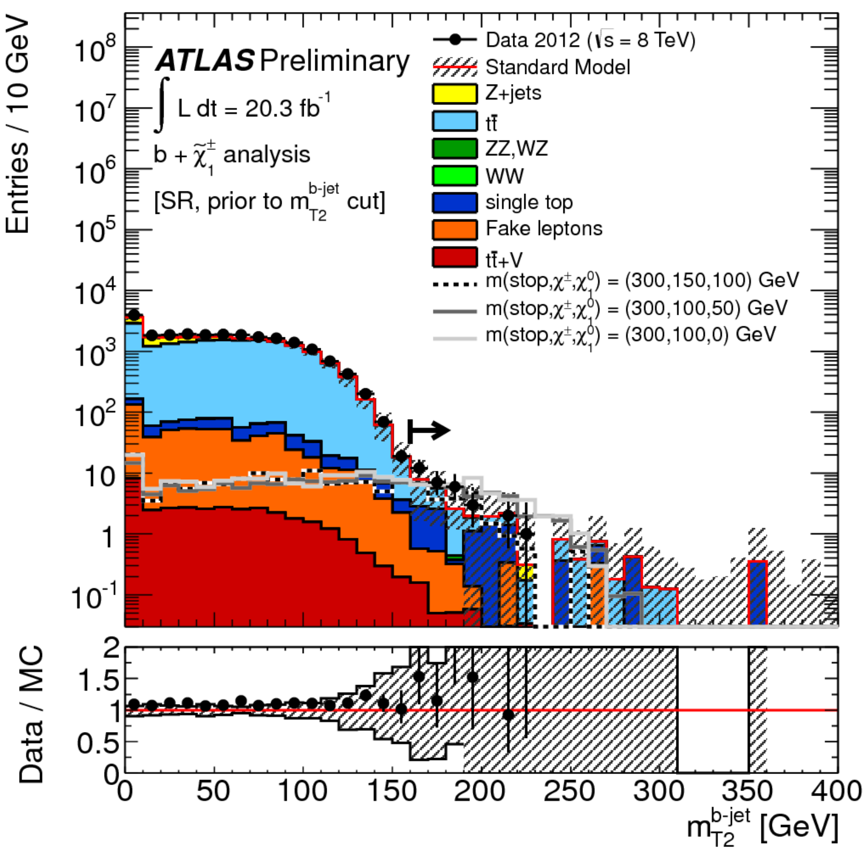
$$m_{T2}(\mathbf{p}_T^1, \mathbf{p}_T^2, \mathbf{q}_T) = \min_{\mathbf{q}_T^1+\mathbf{q}_T^2=\mathbf{q}_T} \left\{ \max[\, m_T(\mathbf{p}_T^1, \mathbf{q}_T^1), m_T(\mathbf{p}_T^2, \mathbf{q}_T^2)\,] \right\}$$

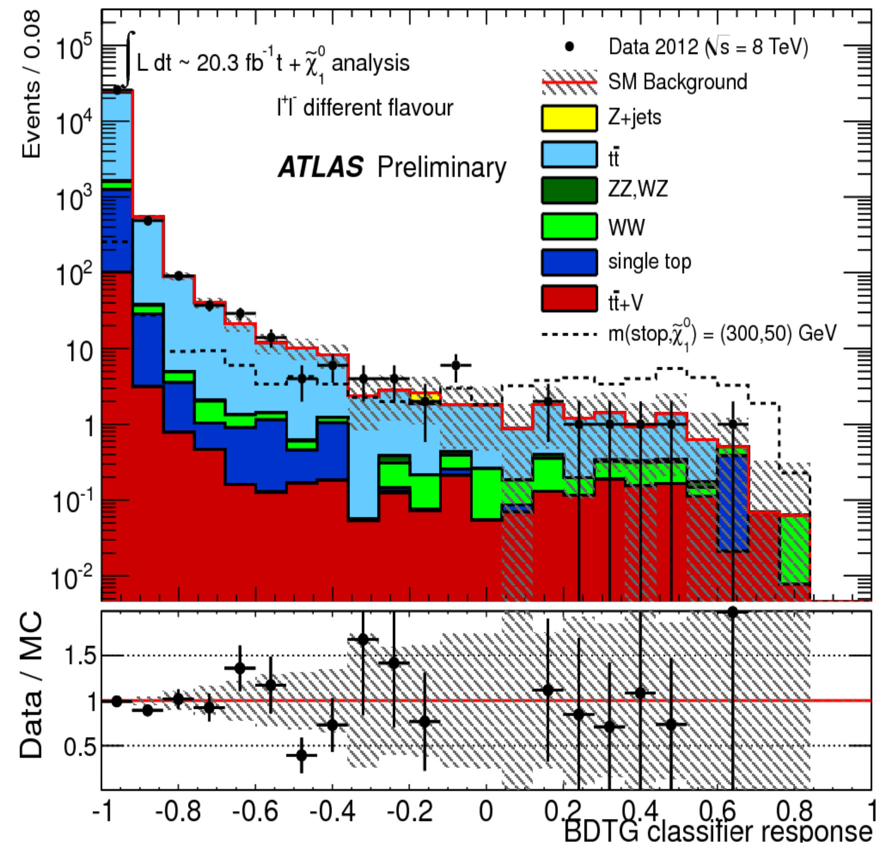
	Training Sample ($m(\tilde{t}_1), m(\tilde{\chi}_1^0)$) [GeV]
SR_1^{DF}	(225,0)
SR_2^{DF}	(225,25)
SR_3^{DF}	(250,25)
SR_4^{DF}	(300,50)
SR_5^{DF}	(350,170)
SR_6^{DF}	(500,250)
SR_7^{DF}	(550,0)
SR_1^{SF}	(225,25)
SR_2^{SF}	(300,50)
SR_3^{SF}	(300,100)
SR_4^{SF}	(500,250)

ATLAS-CONF-2013-065

Search for 3rd Generation Squarks

- good agreement between SM prediction and data

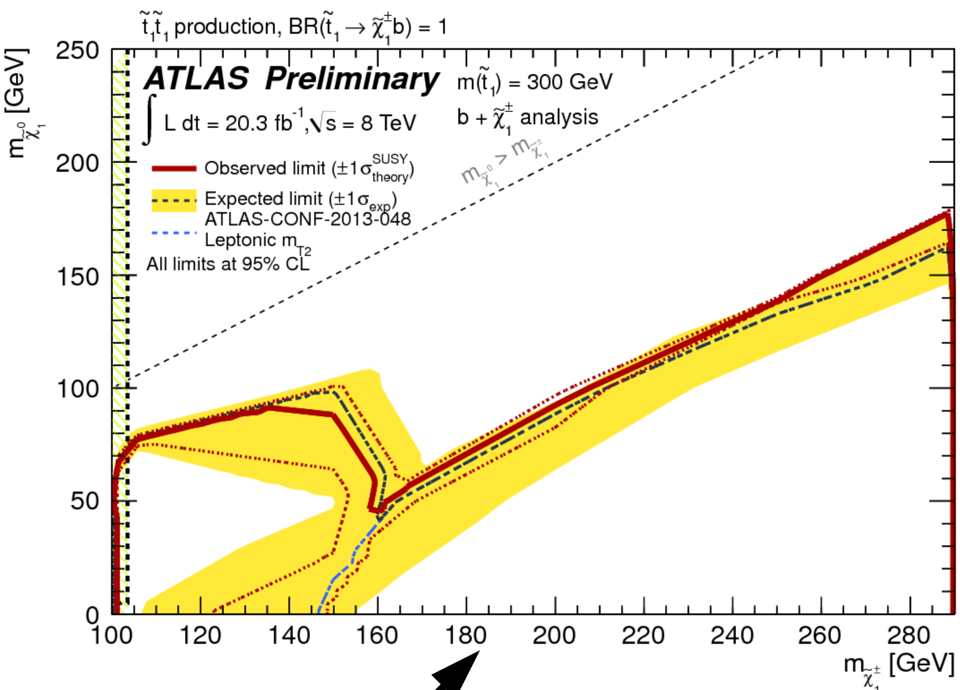


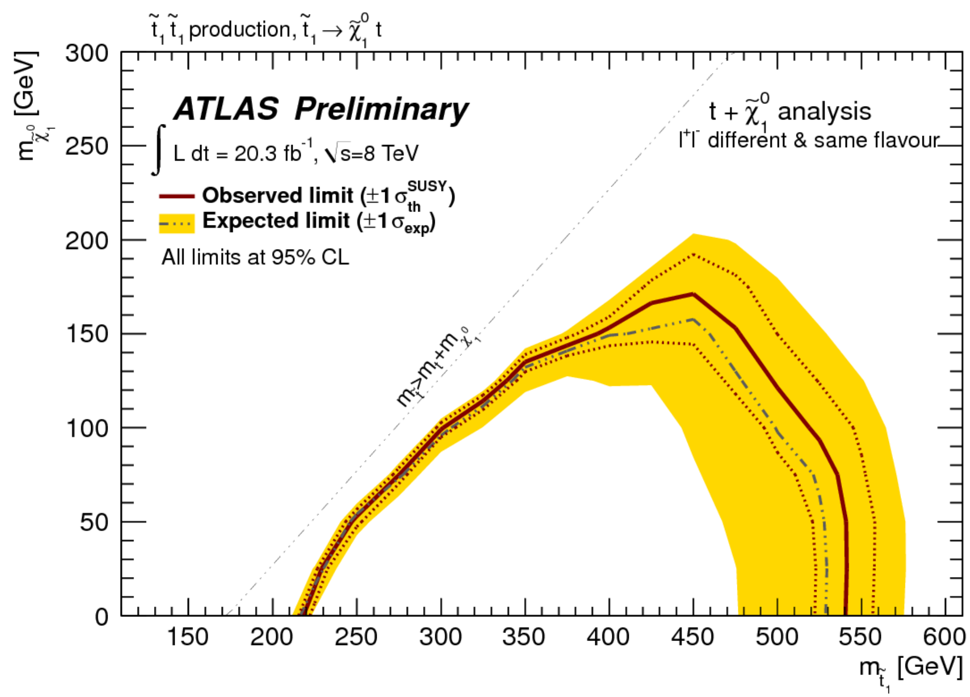


ATLAS-CONF-2013-065

Search for 3rd Generation Squarks

- limits are set in simplified models

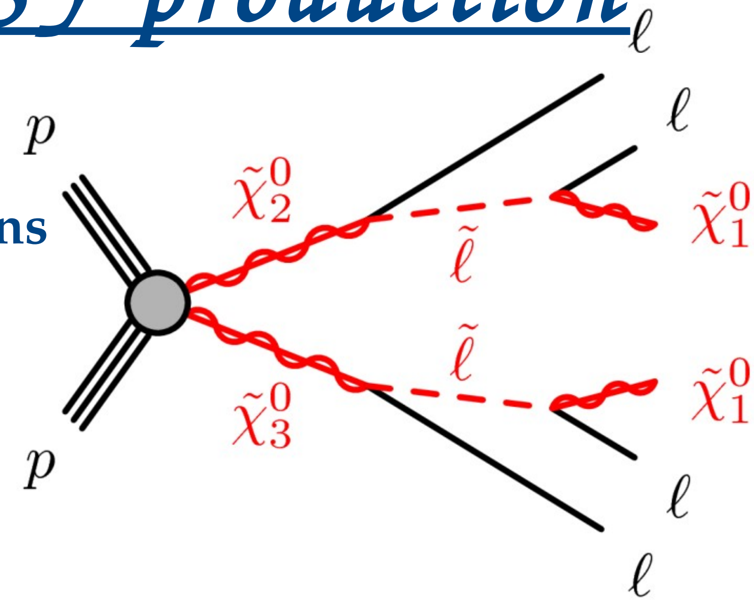




combination with an analysis requiring $m_{T2} > 90$ GeV

ATLAS-CONF-2013-065

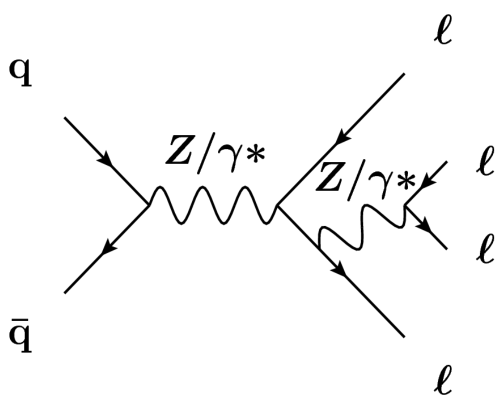
Search for Electroweak SUSY production



- targets scenarios with
  → direct production of EW gauginos and sleptons
  → heavy coloured superpartners
  → different production and decay mechanisms
  → typically leptons in the final state

- here: search for production of neutralino pairs
  SR: ≥ 4 leptons
  MET > 50 GeV
  veto Z → 2,3,4 l candidates

20.7 fb^{-1} of p-p collisions at $\sqrt{s}$ = 8 TeV analysed



background estimation: DD and MC

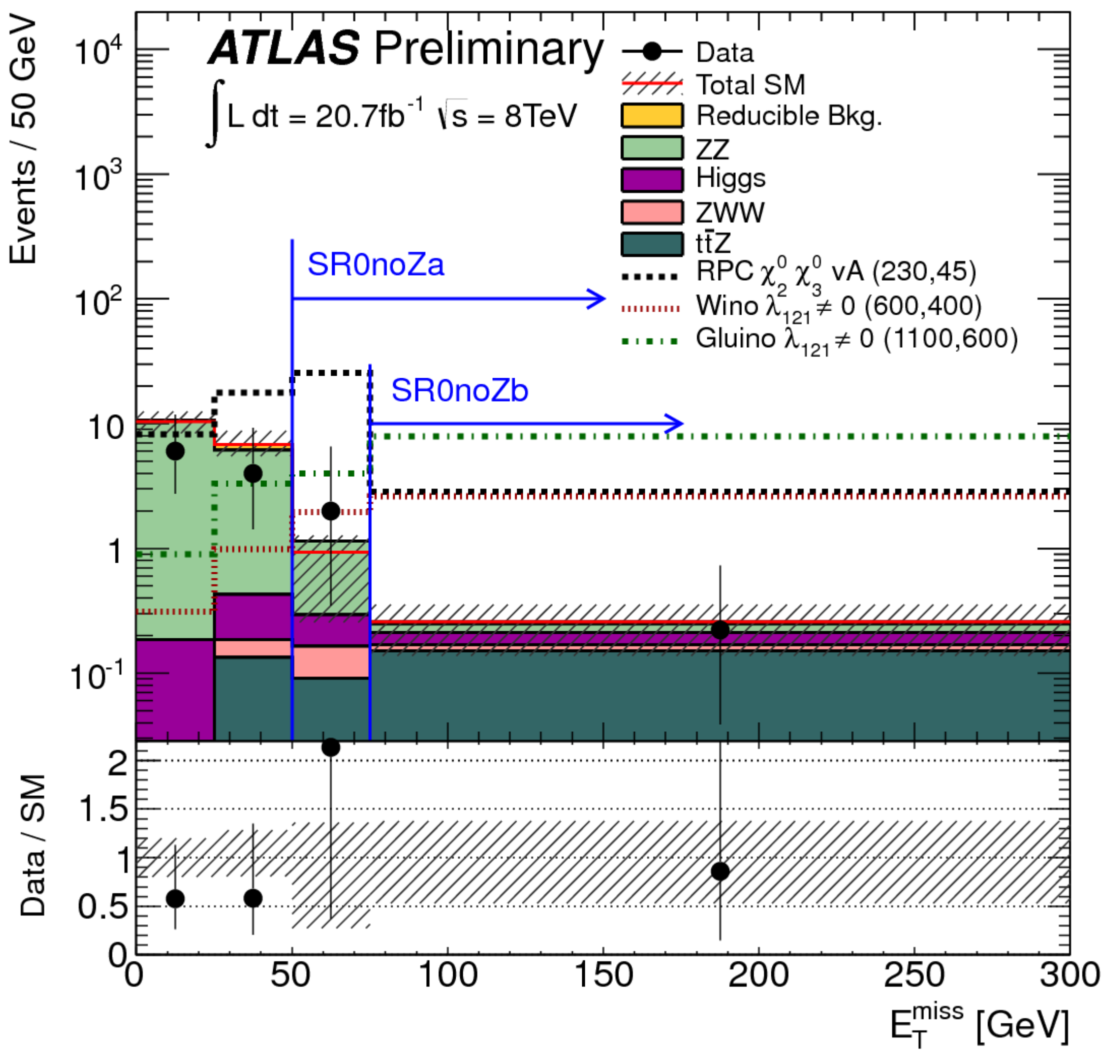
validated using control regions

Sample	VR0noZ	VR0Z
ZZ	7.2 ± 3.6	167 ± 38
ZWW	0.031 ± 0.031	0.35 ± 0.35
$t\bar{t}Z$	$0^{+0.05}_{-0}$	1.5 ± 0.7
Higgs	0.17 ± 0.05	4.5 ± 0.9
Irreducible Bkg.	7.4 ± 3.6	173 ± 39
Reducible Bkg.	$0.3^{+0.7}_{-0.3}$	$2.0^{+2.6}_{-2.0}$
Total Bkg.	7.7 ± 3.4	175 ± 37
Data	3	201
CL_b	0.10	0.51

ATLAS-CONF-2013-036

Search for Electroweak SUSY production

- good agreement between SM prediction and data

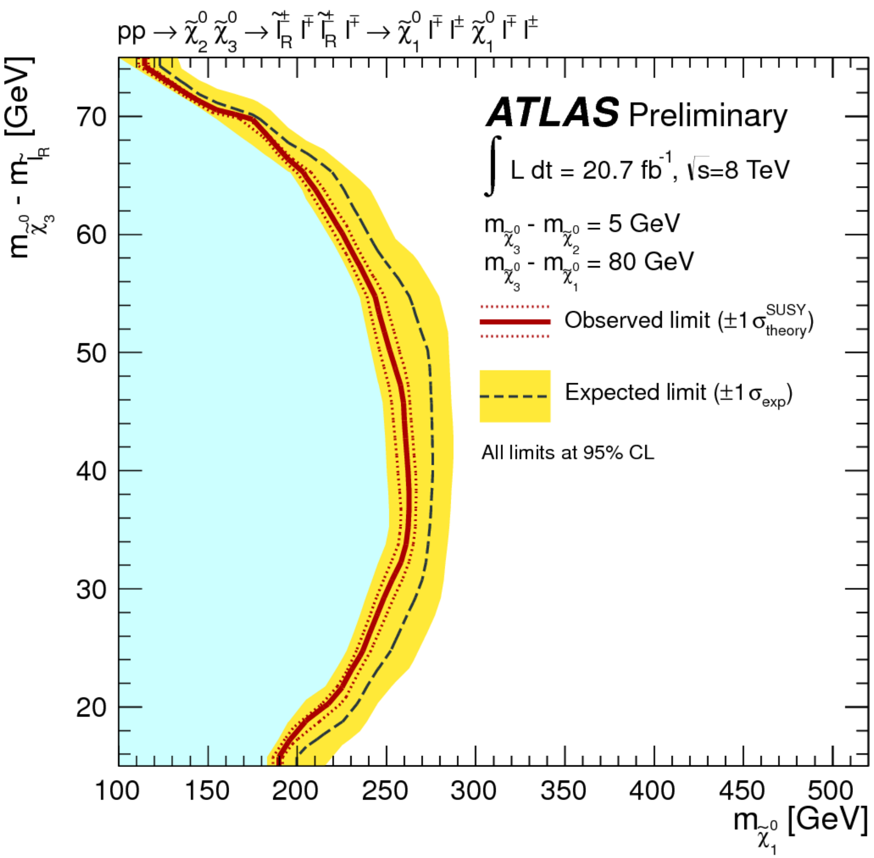


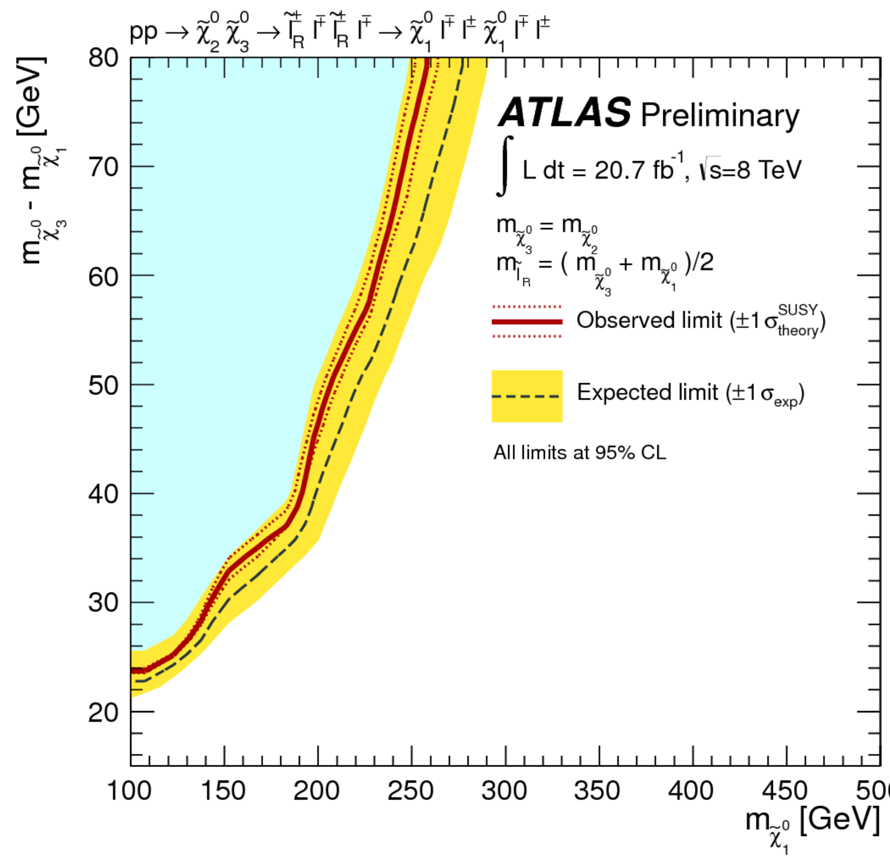
Sample	SR0noZa
ZZ	0.6 ± 0.5
ZWW	0.12 ± 0.12
$t\bar{t}Z$	0.73 ± 0.34
Higgs	0.26 ± 0.07
Irreducible Bkg.	1.7 ± 0.8
Reducible Bkg.	$0^{+0.16}_{-0}$
Total Bkg.	1.7 ± 0.8
Data	2
p_0-value	0.29
N_{signal} Excluded (exp)	3.9
N_{signal} Excluded (obs)	4.7
$\sigma_{visible}$ Excluded (exp) [fb]	0.19
$\sigma_{visible}$ Excluded (obs) [fb]	0.23

ATLAS-CONF-2013-036

Search for Electroweak SUSY production

- limits are set in simplified models

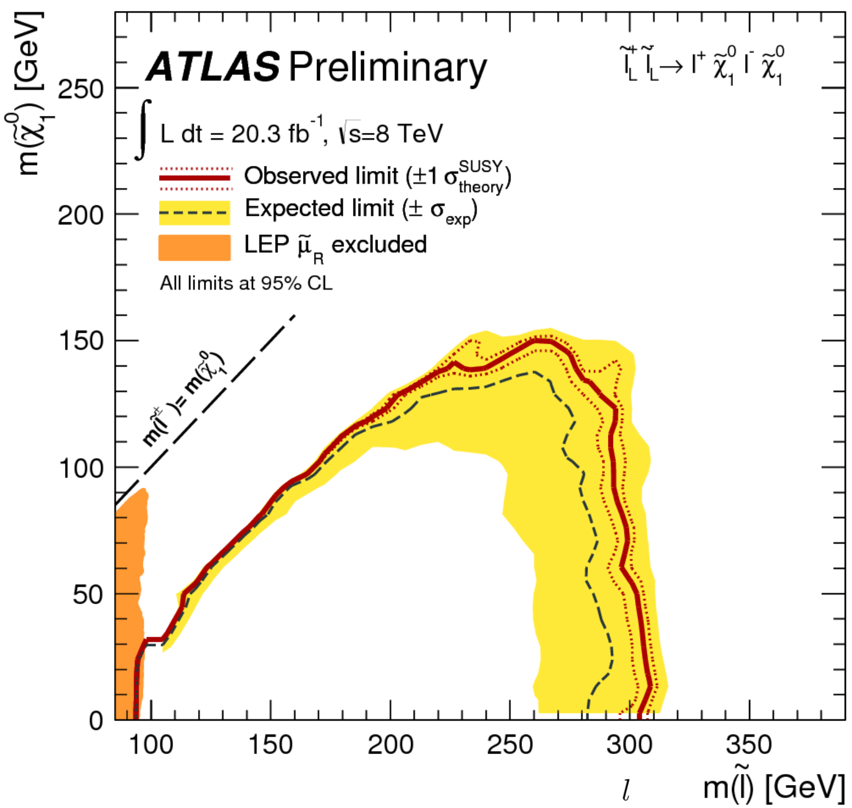


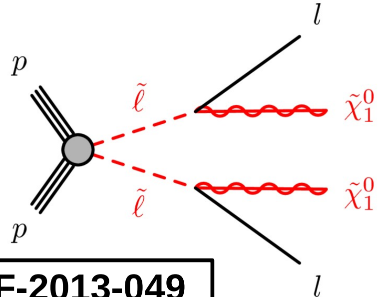


ATLAS-CONF-2013-036

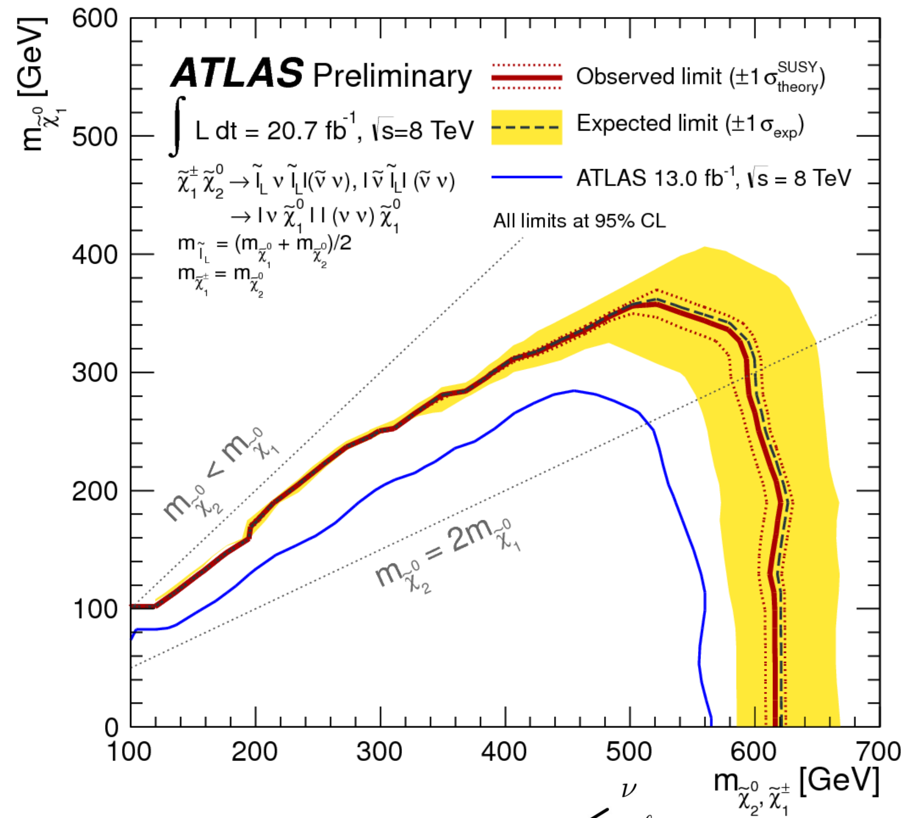
Search for Electroweak SUSY production

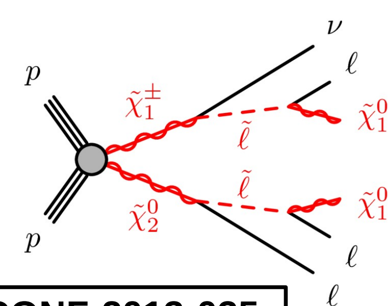
- final states with two and three leptons





ATLAS-CONF-2013-049





ATLAS-CONF-2013-035