SUSY Searches at ATLAS

The Author's Preferred Selection

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University of Sussex

Birmingham, 31 October 2012

+ Outline

Introduction

>> Supersymmetry and all that

The LHC and ATLAS

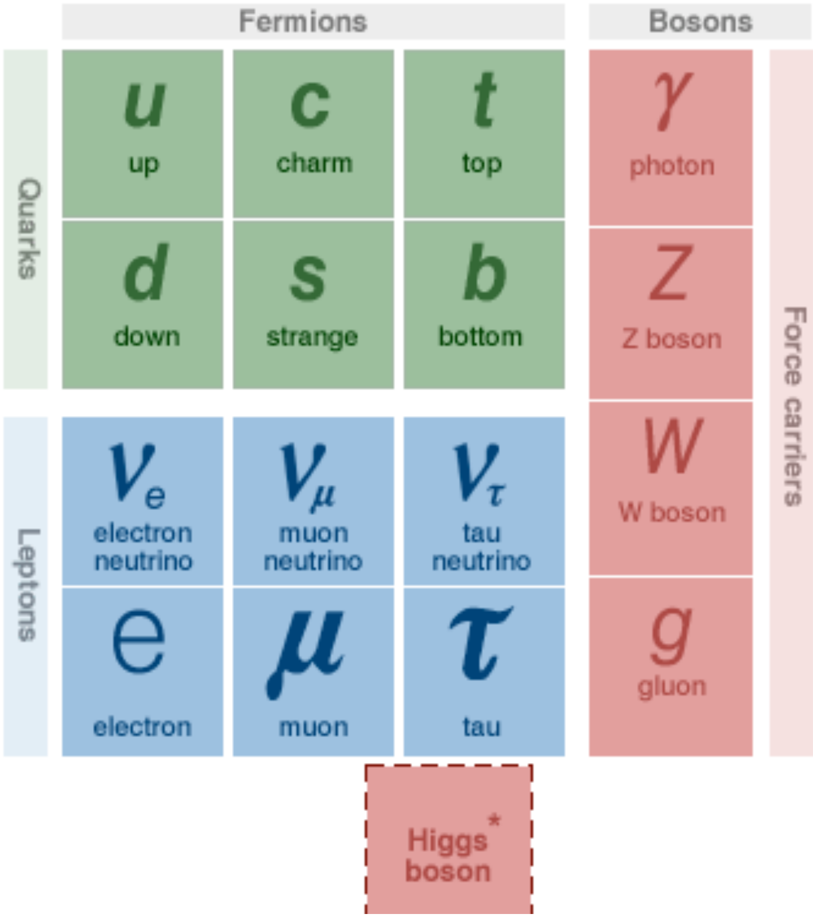
>> Status

SUSY searches at ATLAS

>> The author’s preferred selection

Conclusions

The (Very Resilient) Standard Model



Matter (Fermions)

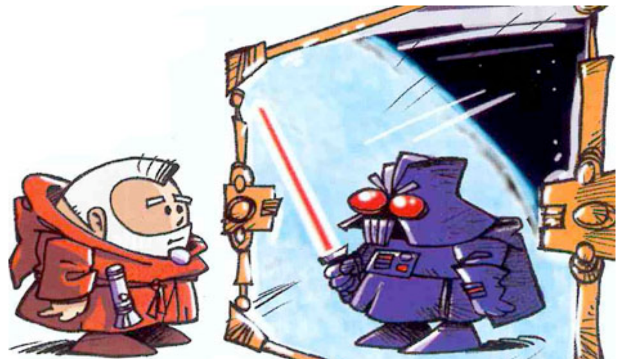
3 quark generations
3 lepton generations

Forces (Bosons)

EWK – γ, Z, $W^{\pm}$
Strong – gluons

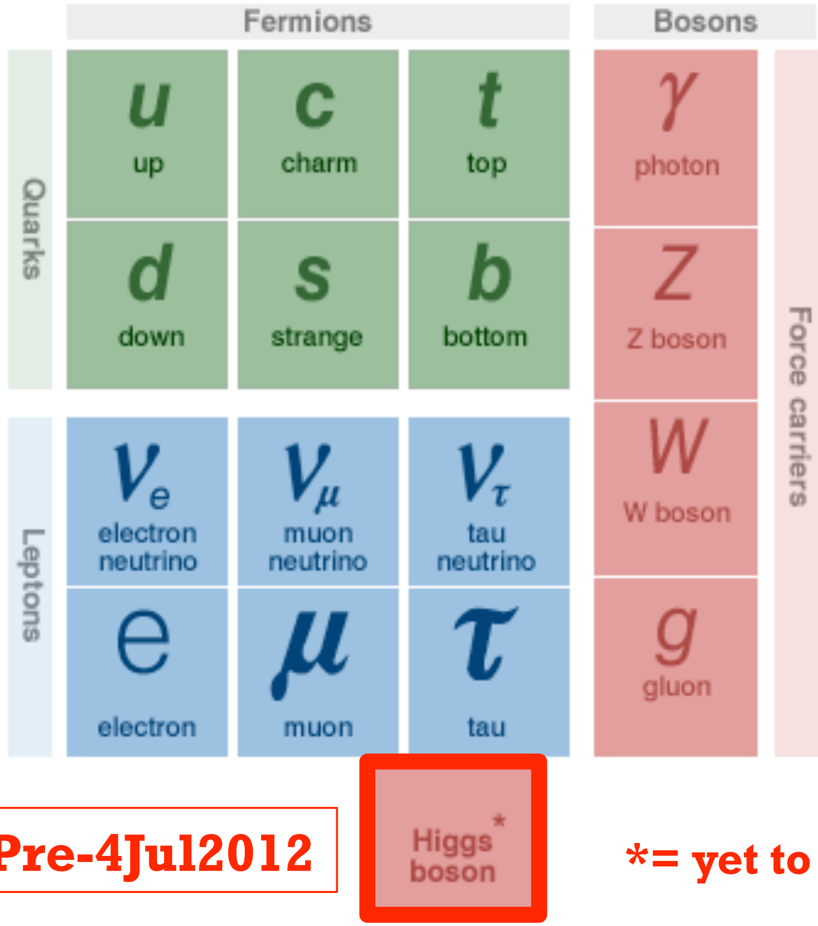
Mass

Higgs boson



And Antimatter Too…

The (Very Resilient) Standard Model



Pre-4Jul2012

Matter (Fermions)

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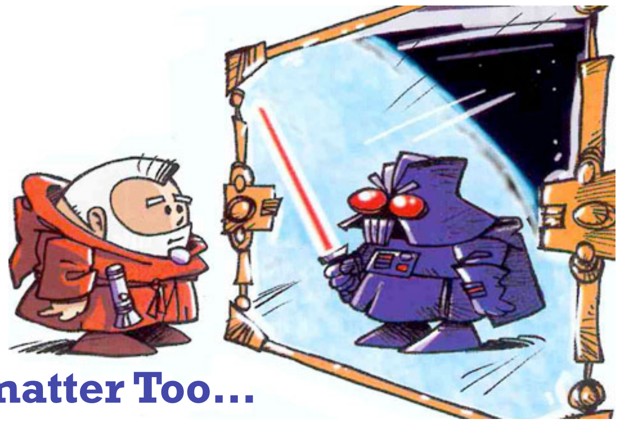
Higgs boson

***= yet to be discovered**



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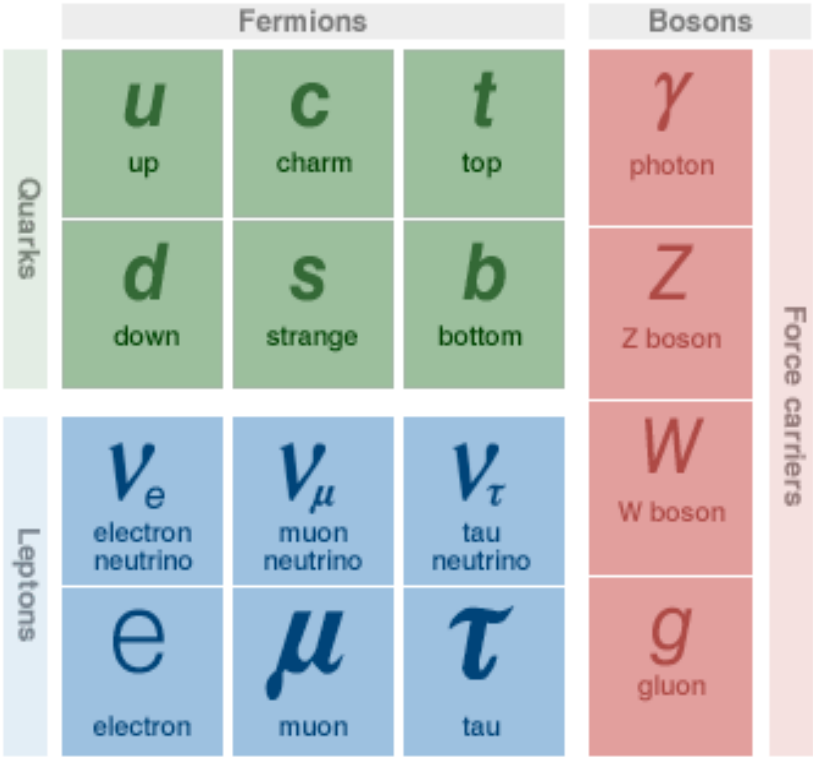

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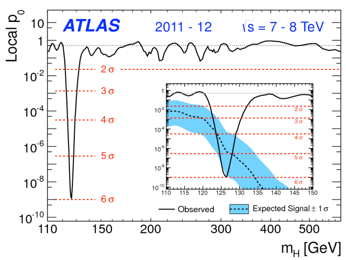
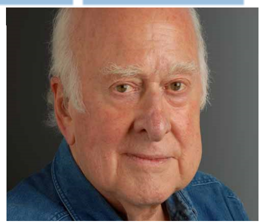
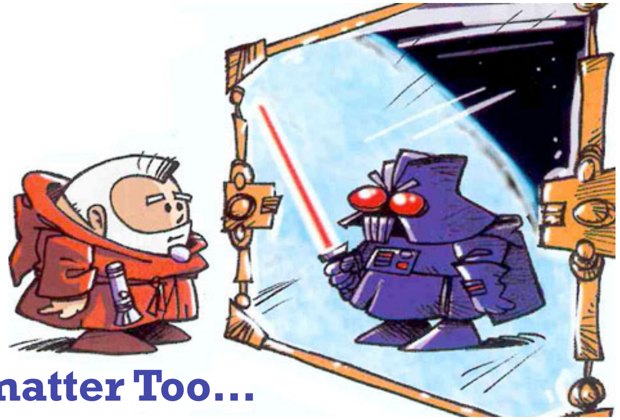


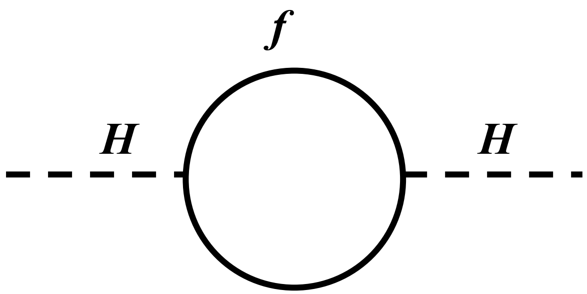


(-like)



And Antimatter Too…

+ Some Outstanding Issues



Hierarchy problem

In absence of protective symmetries, Higgs mass can acquire radiative corrections from fermionic loops

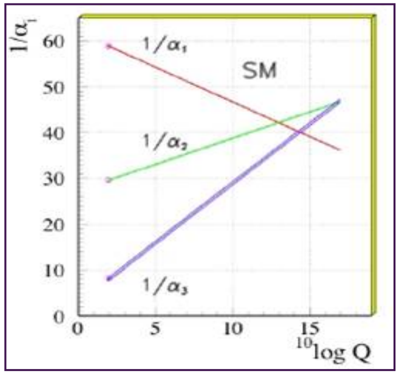
$$\delta m_H^2 \propto \Lambda_{cutoff}^2$$

If no new physics before Planck scale, need fine-tuning to keep Higgs mass relatively small

Weak Scale

The Desert ??

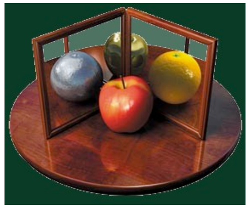
Planck scale



(Non-)Unification of forces

Dark Matter

+ Supersymmetry (SUSY)



New symmetry between bosons and fermions

Every SM particle has a supersymmetric partner with Δ(spin)=1/2

Extended Higgs sector: h, H, A, $H^{\pm}$

Natural solution to hierarchy problem
Exact cancellation of loop contributions

Gauge unification
Possible in SUSY theories

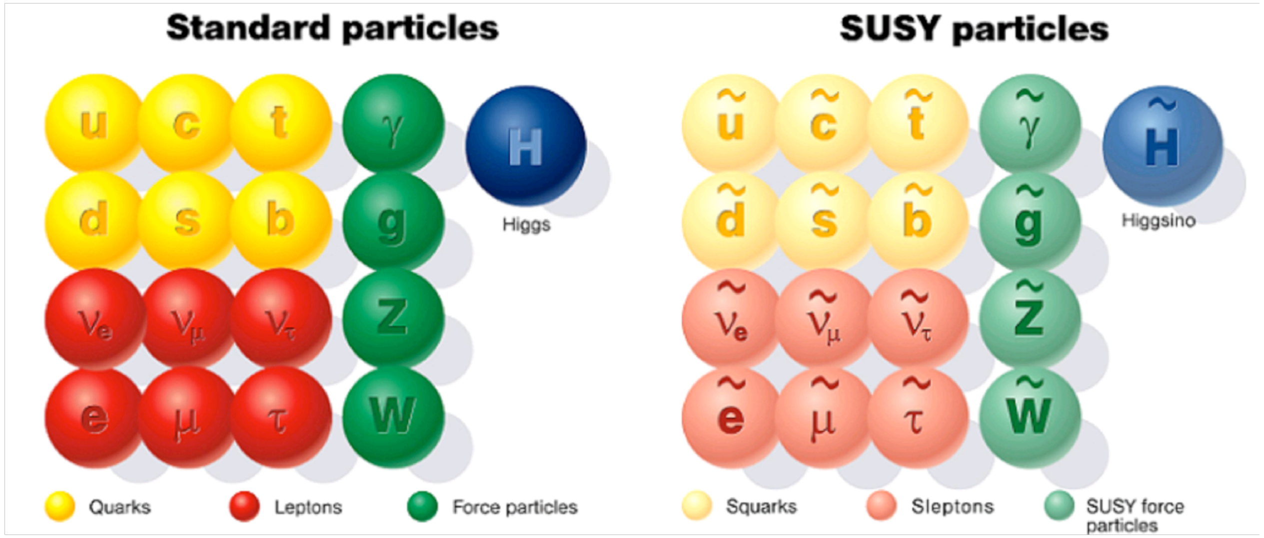
Dark Matter candidate
If R-parity is conserved, stable LSP
(More on R-parity later)

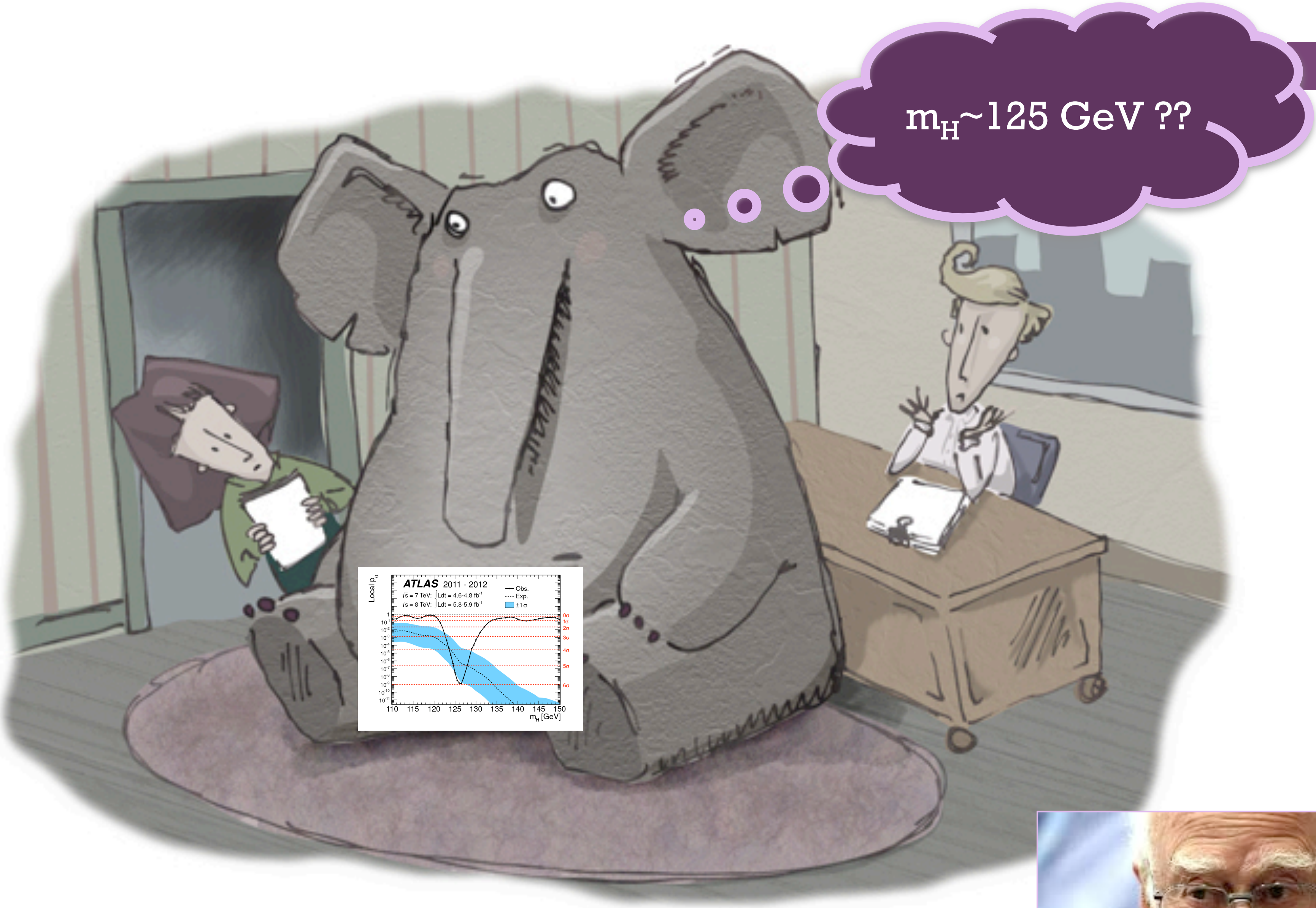
SUSY is a broken symmetry
No superpartners observed with same mass but different spin

$$R = (-1)^{3(B-L)+2S}$$

$$R(SM) = +1$$
$$R(SUSY) = -1$$

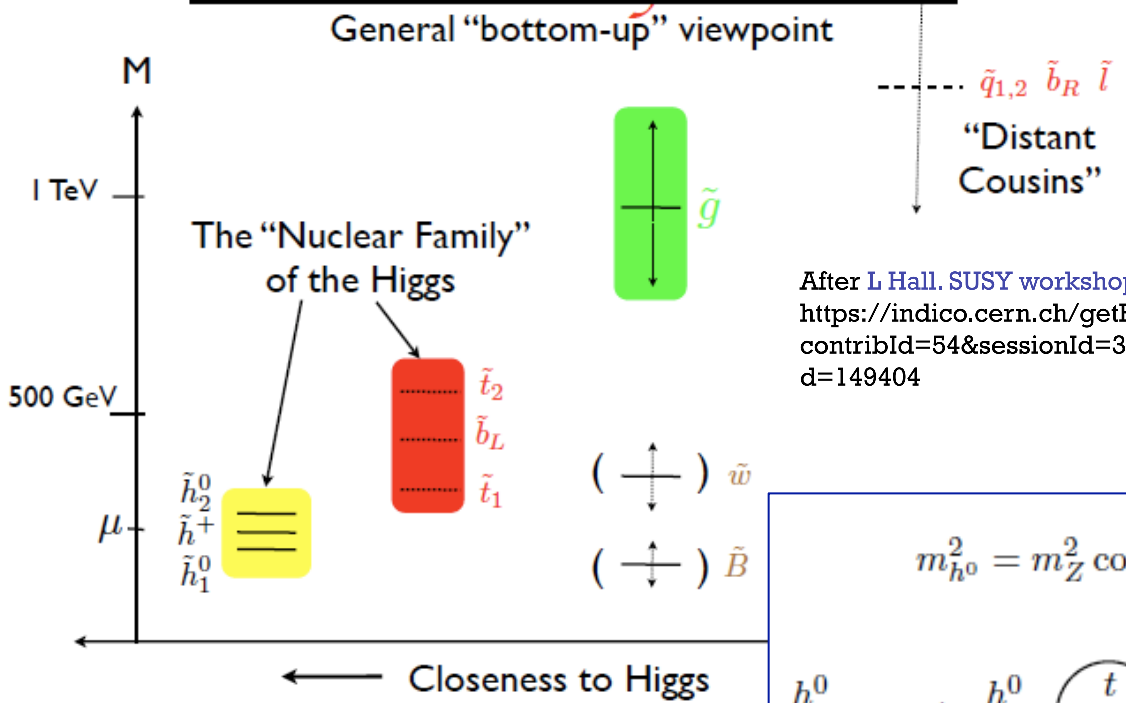
Mechanism for SUSY-breaking unknown





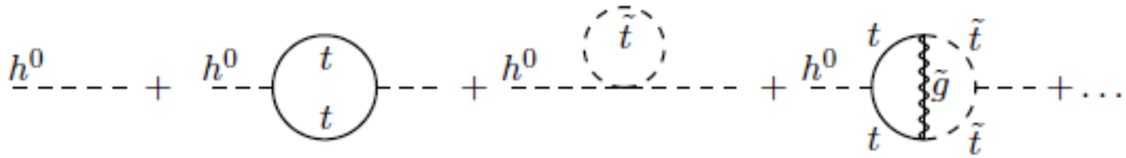
The Elephant in the Room

A Natural Spectrum



After L Hall. SUSY workshop, LBNL, Oct 2011
https://indico.cern.ch/getFile.py/access?contribId=54&sessionId=3&resId=0&materialId=slides&confId=149404

$$m_{h^0}^2 = m_Z^2 \cos^2(2\beta) + \frac{3}{4\pi^2} y_t^2 m_t^2 \ln\left(\frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2}\right) + \ldots$$



m_H regularized by scalar top mass, still possible to have natural SUSY with a relatively light stop / sbottom

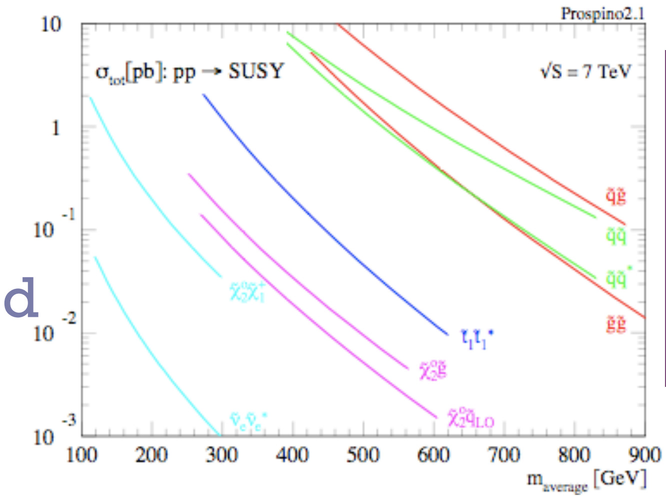
Naturalness achievable even if 1st/2nd-generation squark masses are O(TeV)

Relatively light gluino

Electroweak sector also light

+ Search Strategy

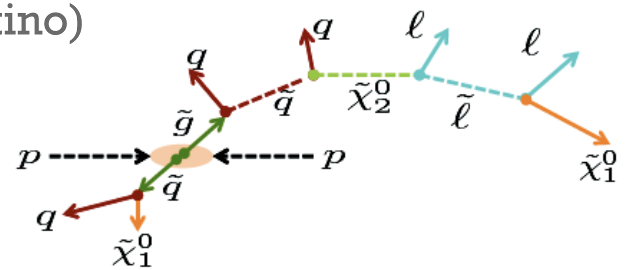
At the LHC, SUSY cross-sections are dominated by the production of coloured sparticles (squarks and gluinos)



R-parity Conserving (RPC) Models

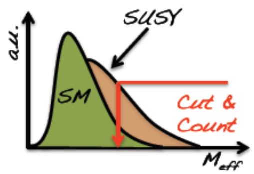
Sparticles produced in pairs

Decay chains (→ **jets**, **leptons**, **…**) terminating with a stable and neutral LSP (neutralino or gravitino)



LSP leaves the detector unseen
→ **Missing transverse energy** (E_T^{miss})

No mass peaks, signal in tails

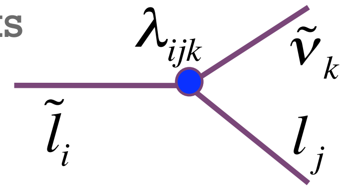


R-parity Violating (RPV) Models

LSP need not be stable or neutral

Can have mass peaks

Not-so-large E_T^{miss}



Other Scenarios

Displaced vertices

Slow highly hadronising particles

…

SUSY Models and Interpretation

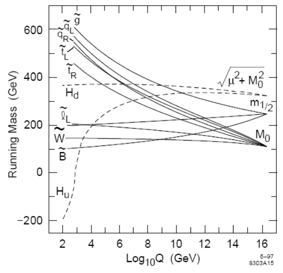
The minimal SUSY extension of the SM (MSSM) has got 105+19 free parameters

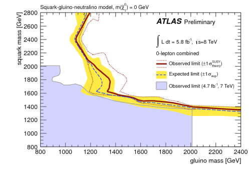
Unmanageable!

Top-down approach

Models of SUSY breaking – cMSSM/mSUGRA, GMSB, etc

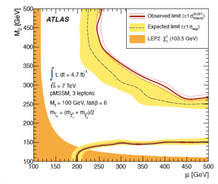
Fix a limited number of parameters at some higher energy scale, then extrapolate back to to the EWK scale & predict phenomenology





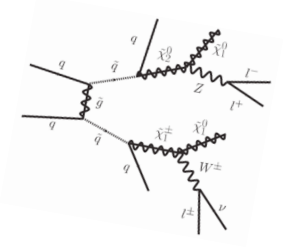
Search for a wide range of signatures – if null result, set limits in parameter space

Bottom-up approach



Phenomenological Models – Assume some sparticle mass hierarchy

Simplified Models – Consider individual decays as separate building blocks



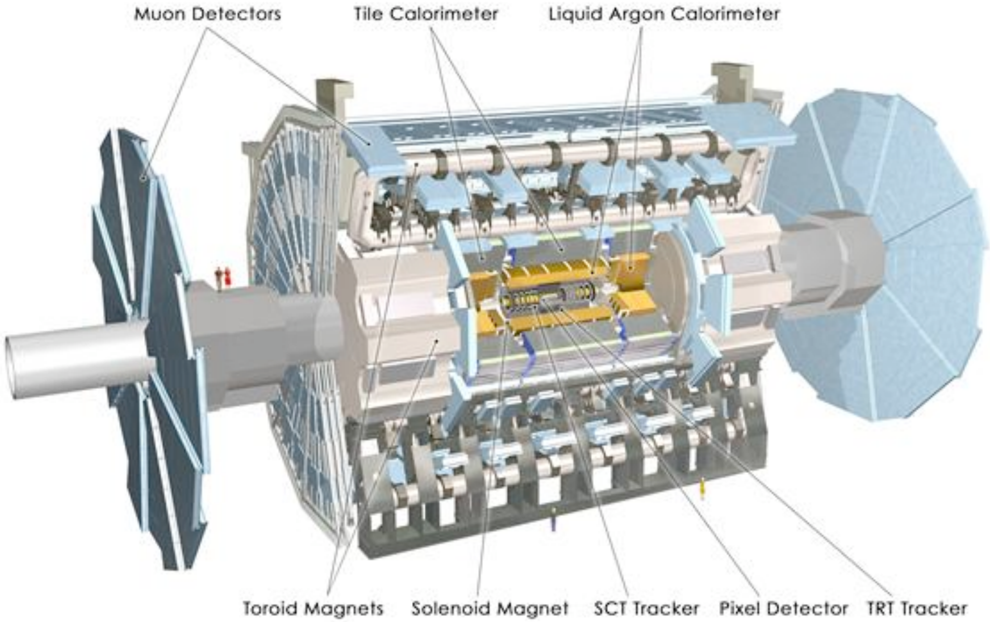
Model-independent limits on "effective cross-section"

$$\sigma \times \varepsilon \times A$$

(A=acceptance, ε=efficiency)

(ie a limit on the number of events in the signal region – for a given luminosity)

+ ATLAS Detector



Multi-purpose detector

Large acceptance (~4π coverage) and hermeticity

Excellent particle identification and reconstruction

Excellent E_T^{miss} and jet reconstruction

Excellent vertex reconstruction

Inner Detector (|η|<2.5,B=2T)
Si pixels and strips, TRT straws
Tracking and vertexing, e/π separation

$$\sigma_{p_T}/p_T \sim 3.8\times10^{-4}\, p_T(GeV) \oplus 0.015$$

EM Calorimeter (|η|<4.9)
Pb-Lar Accordion
e/γ trigger, id and measurement

$$\sigma_E/E \sim 10\%/\sqrt{E(GeV)}$$

Hadron Calorimeter (|η|<4.9)
Fe-scintillator tiles (barrel)

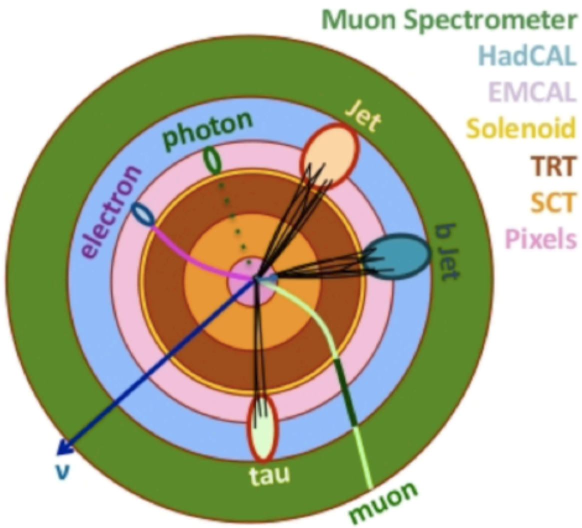
$$\sigma_E/E \sim 50\%/\sqrt{E(GeV)} \oplus 0.03$$

Cu/W-Lar (endcap)

$$\sigma_E/E \sim 90\%/\sqrt{E(GeV)} \oplus 0.07$$

Trigger and measurement of jets and E_T^{miss}

Muon Spectrometer (|η|<2.7)
Air-core toroids with gas-based muon chambers
Muon trigger and measurement
p_T resolution <10% up to ~1TeV



A Collaborative Effort

+ ATLAS Datasets

Instantaneous Luminosity

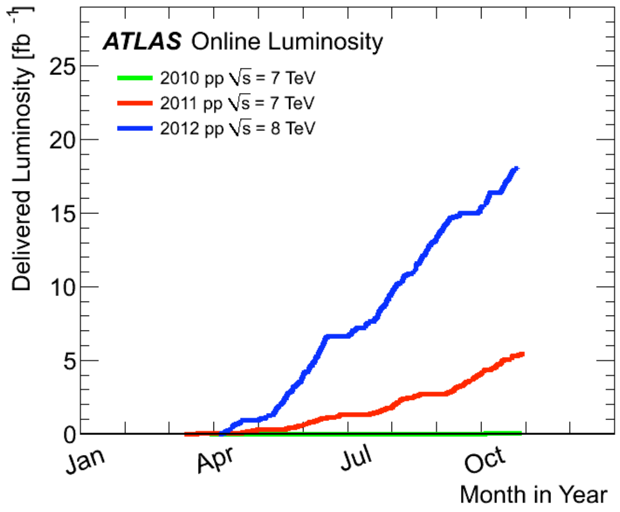
Peak luminosity – 3.65×10^{33} cm^{-2} s^{-1}

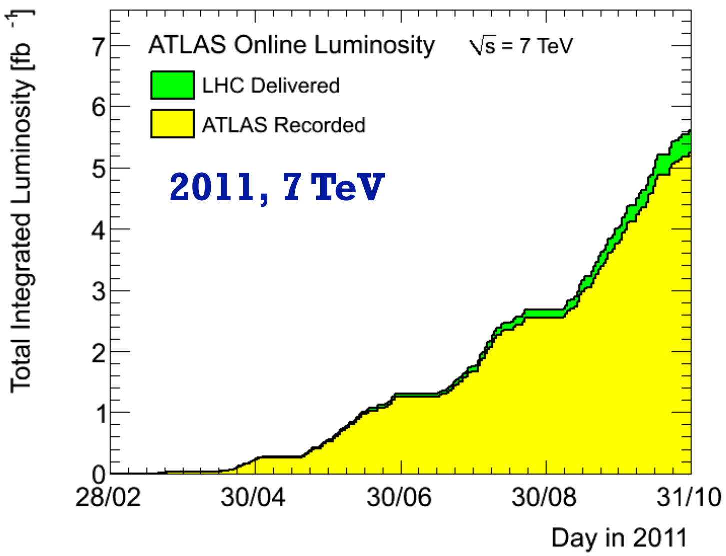
Datasets for SUSY analyses

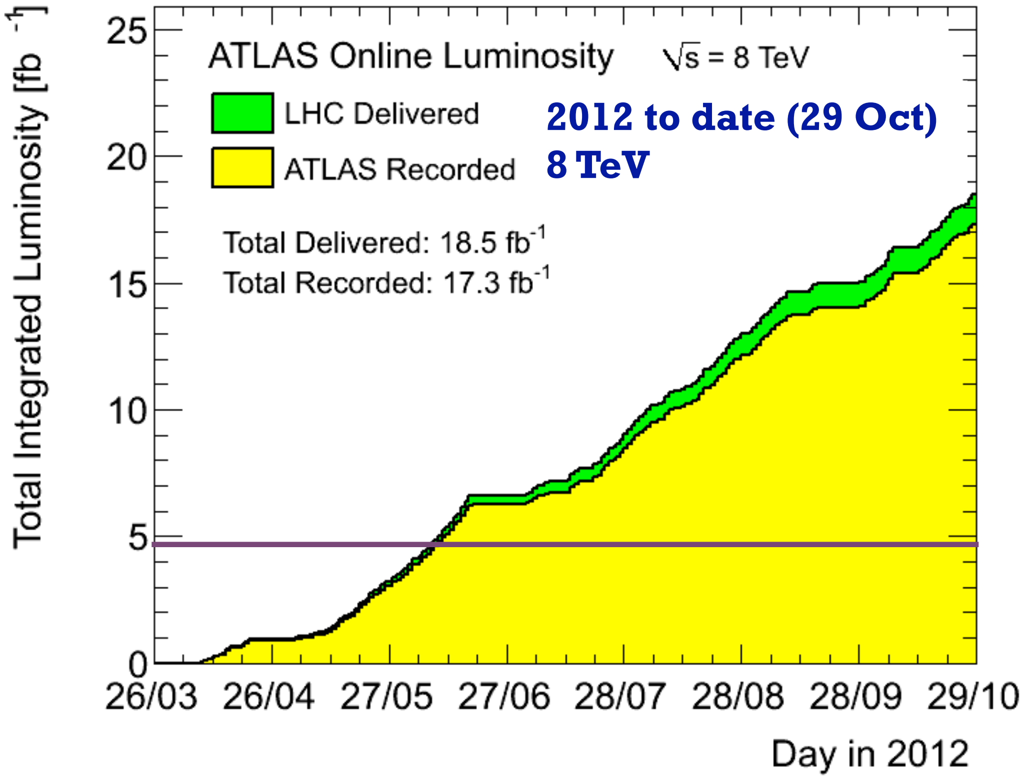
2010 : ~35 pb^{-1}

2011 : 4.7 fb^{-1} (7 TeV)

2012 : 5.8 fb-1 analysed (8 TeV)







Lots of SUSY Results…

2011 Data (7 TeV)

Short Title of the Paper	Date	√s (TeV)	L (fb^{-1})	Document	Plots+Aux. Material	Journal
Disappearing track + jets + Etmiss [Direct long-lived charginos - AMSB] NEW	10/2012	7	4.7	1210.2852	Link	Submitted to JHEP
1-2 taus + 0-1 leptons + jets + Etmiss [GMSB] NEW	10/2012	7	4.7	1210.1314	Link	Submitted to EPJC
Monophoton [ADD, WIMP] NEW	09/2012	7	4.7	1209.4625	Link	Submitted to PRL
2 leptons + jets + Etmiss [Medium stop] NEW	09/2012	7	4.7	1209.4186	Link	Accepted by JHEP
1-2 b-jets + 1-2 leptons + jets + Etmiss [Light Stop] NEW	09/2012	7	4.7	1209.2102	Link	Submitted to PLB
2 photons + Etmiss [GGM] NEW	09/2012	7	4.7	1209.0753	Link	Submitted to PLB
1-2 leptons + >=2-4 jets + Etmiss	08/2012	7	4.7	1208.4688	Link	Accepted by PRD
2 leptons + >=1 jet + Etmiss [Very light stop]	08/2012	7	4.7	1208.4305	Link (inc. HEPData)	Submitted to EPJC
3 leptons + Etmiss [Direct gauginos]	08/2012	7	4.7	1208.3144	Link (inc. HEPData)	Submitted to PLB
2 leptons + Etmiss [Direct gauginos/sleptons]	08/2012	7	4.7	1208.2884	Link	Submitted to PLB
1 lepton + >=4 jets (>=1 b-jet) + Etmiss [Heavy stop]	08/2012	7	4.7	1208.2590	Link	Accepted by PRL
0 lepton + 1-2 b-jet + 5-4 jets + Etmiss [Heavy stop]	08/2012	7	4.7	1208.1447	Link	Accepted by PRL
0 lepton + >=2-6 jets + Etmiss	08/2012	7	4.7	1208.0949	Link	Submitted to PRD
0 lepton + >=3 b-jets + >=(1-3) jets + Etmiss [Gluino med. stop/sb.]	07/2012	7	4.7	1207.4686	Link	Accepted by EPJC
0 lepton + >=(6-9) jets + Etmiss	06/2012	7	4.7	1206.1760	Link (inc. HEPData)	JHEP 1207 (2012) 167
Electron-muon continuum [RPV]	05/2012	7	2.05	1205.0725	Link (inc. HEPData)	EPJC 72 (2012) 2040
Z->ll + b-jet + jets + Etmiss [Direct stop in natural GMSB]	04/2012	7	2.05	1204.6736	Link (inc. HEPData)	PLB 715 (2012) 44
=3 leptons + Etmiss [Direct gauginos]	04/2012	7	2.05	1204.5638	Link (inc. HEPData)	PRL 108 (2012) 261804
>=1 tau + jets + Etmiss [GMSB]	04/2012	7	2.05	1204.3852	Link (inc. HEPData)	PLB 714 (2012) 197
>=2 taus + jets + Etmiss [GMSB]	03/2012	7	2.05	1203.6580	Link (inc. HEPData)	PLB 714 (2012) 180
b-jet(s) + 0-1 lepton + jets + Etmiss [Gluino med. stop/sb.]	03/2012	7	2.05	1203.6193	Link	PRD 85 (2012) 112006
2 same-sign leptons + jets + Etmiss	03/2012	7	2.05	1203.5763	Link (inc. HEPData)	PRL 108 (2012) 241802
2 b-jets + Etmiss [Direct sbottom]	12/2011	7	2.05	1112.3832	Link (inc. HEPData)	PRL 108 (2012) 181802
Disappearing track + jets + Etmiss [AMSB Strong Prod.]	02/2012	7	1.02	1202.4847	Link (inc. HEPData)	EPJC 72 (2012) 1993
2 photons + Etmiss [GGM]	11/2011	7	1.07	1111.4116	Link	PLB 710 (2012) 519
2 leptons + jets + Etmiss	10/2011	7	1.04	1110.6189	Link (inc. HEPData)	PLB 709 (2012) 137
0 lepton + >=(6-8) jets + Etmiss	10/2011	7	1.34	1110.2299	Link (inc. HEPData)	JHEP 11 (2011) 99
1 lepton + jets + Etmiss	09/2011	7	1.04	1109.6606	Link (inc. HEPData)	PRD 85 (2012) 012006
0 lepton + >=(2-4) jets + Etmiss	09/2011	7	1.04	1109.6572	Link (inc. HEPData)	PLB 710 (2012) 67
Electron-muon resonance [RPV]	09/2011	7	1.07	1109.3089	Link (inc. HEPData)	EPJC 71 (2011) 1809

2012 Data (8 TeV)

Short Title of the CONF note	*Date*	*√s (TeV)*	*L (fb^{-1})*	*Document*
0 leptons + >=2-6 jets + Etmiss	08/2012	8	5.8	*ATLAS-CONF-2012-109*
0 leptons + >=6-9 jets + Etmiss	08/2012	8	5.8	*ATLAS-CONF-2012-103*
1 lepton + >=4 jets + Etmiss	08/2012	8	5.8	*ATLAS-CONF-2012-104*
2 same-sign leptons + >=4 jets + Etmiss	08/2012	8	5.8	*ATLAS-CONF-2012-105*

Short Title of the Conf. note	*Date*	*√s (TeV)*	*L (fb^{-1})*	*Document*	*Plots*
1 lepton + >=7 jets + Etmiss	10/2012	7	4.7	*ATLAS-CONF-2012-140*	*Link*
3 leptons + jets + Etmiss	08/2012	7	4.7	*ATLAS-CONF-2012-108*	*Link*
2 b-jets + Etmiss [Direct sbottom]	08/2012	7	4.7	*ATLAS-CONF-2012-106*	*Link*
muon + displaced vertex [RPV]	08/2012	7	4.7	*ATLAS-CONF-2012-113*	*Link*
2 jet-pair resonances [N=1/2 scalar gluons]	08/2012	7	4.7	*ATLAS-CONF-2012-110*	*Link*
General new phenomena search	08/2012	7	4.7	*ATLAS-CONF-2012-107*	*Link*
Monojet [ADD, WIMP]	07/2012	7	4.7	*ATLAS-CONF-2012-084*	*Link*
Long-Lived Particles [R-hadron, slepton]	07/2012	7	4.7	*ATLAS-CONF-2012-075*	*Link*
Disappearing track + jets + Etmiss [AMSB Strong Prod.]	03/2012	7	4.7	*ATLAS-CONF-2012-034*	*Link*
Add. >=4 leptons + Etmiss Interpretation [RPV]	03/2012	7	2.05	*ATLAS-CONF-2012-035*	*Link (inc. HEPData)*
Long lived Particle (Pixel-like)	03/2012	7	2.05	*ATLAS-CONF-2012-022*	*Link*
>=4 leptons + Etmiss	01/2012	7	2.05	*ATLAS-CONF-2012-001*	*Link (inc. HEPData)*
Z->ll + jets + Etmiss [GGM]	04/2012	7	1.04	*ATLAS-CONF-2012-046*	*Link*
Add. 2 leptons + jets + Etmiss interpretation [GMSB]	11/2011	7	1.04	*ATLAS-CONF-2011-156*	*Link*
Add. 0 lepton + jets + Etmiss interpretation	11/2011	7	1.04	*ATLAS-CONF-2011-155*	*Link (inc. HEPData)*
b-jets + 1 lepton + jets + Etmiss	08/2011	7	1.03	*ATLAS-CONF-2011-130*	*Link*
b-jets + 0 lepton + jets + Etmiss	07/2011	7	0.83	*ATLAS-CONF-2011-098*	*Link*
1 lepton + jets + Etmiss	06/2011	7	0.16	*ATLAS-CONF-2011-090*	*Link*
0 lepton + jets + Etmiss	06/2011	7	0.16	*ATLAS-CONF-2011-086*	*Link*

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/**SupersymmetryPublicResults**

+ Lots of SUSY Results…

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1 lepton + >=7 jets + Etmiss	10/2012	7	4.7	ATLAS-CONF-2012-140	Link
3 leptons + jets + Etmiss	08/2012	7	4.7	ATLAS-CONF-2012-108	Link
2 b-jets + Etmiss [Direct sbottom]	08/2012	7	4.7	ATLAS-CONF-2012-106	Link
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Disappearing track + jets + Etmiss [AMSB Strong Prod.]	03/2012	7	4.7	ATLAS-CONF-2012-034	Link
Add. >=4 leptons + Etmiss Interpretation [RPV]	03/2012	7	2.05	ATLAS-CONF-2012-035	Link (inc. HEPData)
Long lived Particle (Pixel-like)	03/2012	7	2.05	ATLAS-CONF-2012-022	Link
>=4 leptons + Etmiss	01/2012	7	2.05	ATLAS-CONF-2012-001	Link (inc. HEPData)
Z->ll + jets + Etmiss [GGM]	04/2012	7	1.04	ATLAS-CONF-2012-046	Link
Add. 2 leptons + jets + Etmiss interpretation [GMSB]	11/2011	7	1.04	ATLAS-CONF-2011-156	Link
Add. 0 lepton + jets + Etmiss interpretation	11/2011	7	1.04	ATLAS-CONF-2011-155	Link (inc. HEPData)
b-jets + 1 lepton + jets + Etmiss	08/2011	7	1.03	ATLAS-CONF-2011-130	Link
b-jets + 0 lepton + jets + Etmiss	07/2011	7	0.83	ATLAS-CONF-2011-098	Link
1 lepton + jets + Etmiss	06/2011	7	0.16	ATLAS-CONF-2011-090	Link
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1 lepton + >=4 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-104
2 same-sign leptons + >=4 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-105

2011 Data (7 TeV)

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2 leptons + jets + Etmiss [Medium stop] NEW	09/2012	7	4.7	1209.4186	Link	Accepted by JHEP
1-2 b-jets + 1-2 leptons + jets + Etmiss [Light Stop] NEW	09/2012	7	4.7	1209.2102	Link	Submitted to PLB
2 photons + Etmiss [GGM] NEW	09/2012	7	4.7	1209.0753	Link	Submitted to PLB
1-2 leptons + >=2-4 jets + Etmiss	08/2012	7	4.7	1208.4688	Link	Accepted by PRD
2 leptons + >=1 jet + Etmiss [Very light stop]	08/2012	7	4.7	1208.4305	Link (inc. HEPData)	Submitted to EPJC
3 leptons + Etmiss [Direct gauginos]	08/2012	7	4.7	1208.3144	Link (inc. HEPData)	Submitted to PLB
2 leptons + Etmiss [Direct gauginos/sleptons]	08/2012	7	4.7	1208.2884	Link	Submitted to PLB
1 lepton + >=4 jets (>=1 b-jet) + Etmiss [Heavy stop]	08/2012	7	4.7	1208.2590	Link	Accepted by PRL
0 lepton + 1-2 b-jet + 5-4 jets + Etmiss [Heavy stop]	08/2012	7	4.7	1208.1447	Link	Accepted by PRL
0 lepton + >=2-6 jets + Etmiss	08/2012	7	4.7	1208.0949	Link	Submitted to PRD
0 lepton + >=3 b-jets + >=(1-3) jets + Etmiss [Gluino med. stop/sb.]	07/2012	7	4.7	1207.4686	Link	Accepted by EPJC
0 lepton + >=(6-9) jets + Etmiss	06/2012	7	4.7	1206.1760	Link (inc. HEPData)	JHEP 1207 (2012) 167
Electron-muon continuum [RPV]	05/2012	7	2.05	1205.0725	Link (inc. HEPData)	EPJC 72 (2012) 2040
Z->ll + b-jet + jets + Etmiss [Direct stop in natural GMSB]	04/2012	7	2.05	1204.6736	Link (inc. HEPData)	PLB 715 (2012) 44
=3 leptons + Etmiss [Direct gauginos]	04/2012	7	2.05	1204.5638	Link (inc. HEPData)	PRL 108 (2012) 261804
>=1 tau + jets + Etmiss [GMSB]	04/2012	7	2.05	1204.3852	Link (inc. HEPData)	PLB 714 (2012) 197
>=2 taus + jets + Etmiss [GMSB]	03/2012	7	2.05	1203.6580	Link (inc. HEPData)	PLB 714 (2012) 180
b-jet(s) + 0-1 lepton + jets + Etmiss [Gluino med. stop/sb.]	03/2012	7	2.05	1203.6193	Link	PRD 85 (2012) 112006
2 same-sign leptons + jets + Etmiss	03/2012	7	2.05	1203.5763	Link (inc. HEPData)	PRL 108 (2012) 241802
2 b-jets + Etmiss [Direct sbottom]	12/2011	7	2.05	1112.3832	Link (inc. HEPData)	PRL 108 (2012) 181802
Disappearing track + jets + Etmiss [AMSB Strong Prod.]	02/2012	7	1.02	1202.4847	Link (inc. HEPData)	EPJC 72 (2012) 1993
2 photons + Etmiss [GGM]	11/2011	7	1.07	1111.4116	Link	PLB 710 (2012) 519
2 leptons + jets + Etmiss	10/2011	7	1.04	1110.6189	Link (inc. HEPData)	PLB 709 (2012) 137
0 lepton + >=(6-8) jets + Etmiss	10/2011	7	1.34	1110.2299	Link (inc. HEPData)	JHEP 11 (2011) 99
1 lepton + jets + Etmiss	09/2011	7	1.04	1109.6606	Link (inc. HEPData)	PRD 85 (2012) 012006
0 lepton + >=(2-4) jets + Etmiss	09/2011	7	1.04	1109.6572	Link (inc. HEPData)	PLB 710 (2012) 67
Electron-muon resonance [RPV]	09/2011	7	1.07	1109.3089	Link (inc. HEPData)	EPJC 71 (2011) 1809

Lots of SUSY Results…

Short Title of the Conf. note	Date	√s (TeV)	L (fb^{-1})	Document	Plots
1 lepton + >=7 jets + Etmiss	10/2012	7	4.7	ATLAS-CONF-2012-140	Link
3 leptons + jets + Etmiss	08/2012	7	4.7	ATLAS-CONF-2012-108	Link
2 b-jets + Etmiss [Direct sbottom]	08/2012	7	4.7	ATLAS-CONF-2012-106	Link
muon + displaced vertex [RPV]	08/2012	7	4.7	ATLAS-CONF-2012-113	Link
2 jet-pair resonances [N=1/2 scalar gluons]	08/2012	7	4.7	ATLAS-CONF-2012-110	Link
General new phenomena search	08/2012	7	4.7	ATLAS-CONF-2012-107	Link
Monojet [ADD, WIMP]	07/2012	7	4.7	ATLAS-CONF-2012-084	Link
Long-Lived Particles [R-hadron, slepton]	07/2012	7	4.7	ATLAS-CONF-2012-075	Link
Disappearing track + jets + Etmiss [AMSB Strong Prod.]	03/2012	7	4.7	ATLAS-CONF-2012-034	Link
Add. >=4 leptons + Etmiss Interpretation [RPV]	03/2012	7	2.05	ATLAS-CONF-2012-035	Link (inc. HEPData)
Long lived Particle (Pixel-like)	03/2012	7	2.05	ATLAS-CONF-2012-022	Link
>=4 leptons + Etmiss	01/2012	7	2.05	ATLAS-CONF-2012-001	Link (inc. HEPData)
Z->ll + jets + Etmiss [GGM]	04/2012	7	1.04	ATLAS-CONF-2012-046	Link
Add. 2 leptons + jets + Etmiss interpretation [GMSB]	11/2011	7	1.04	ATLAS-CONF-2011-156	Link
Add. 0 lepton + jets + Etmiss interpretation	11/2011	7	1.04	ATLAS-CONF-2011-155	Link (inc. HEPData)
b-jets + 1 lepton + jets + Etmiss	08/2011	7	1.03	ATLAS-CONF-2011-130	Link
b-jets + 0 lepton + jets + Etmiss	07/2011	7	0.83	ATLAS-CONF-2011-098	Link
1 lepton + jets + Etmiss	06/2011	7	0.16	ATLAS-CONF-2011-090	Link
0 lepton + jets + Etmiss	06/2011	7	0.16	ATLAS-CONF-2011-086	Link

2012 Data (8 TeV)

Short Title of the CONF note	Date	√s (TeV)	L (fb^{-1})	Document
0 leptons + >=2-6 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-109
0 leptons + >=6-9 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-103
1 lepton + >=4 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-104
2 same-sign leptons + >=4 jets + Etmiss	08/2012	8	5.8	ATLAS-CONF-2012-105

2011 Data (7 TeV)

Short Title of the Paper	Date	√s (TeV)	L (fb^{-1})	Document	Plots+Aux. Material	Journal
Disappearing track + jets + Etmiss [Direct long-lived charginos - AMSB] NEW	10/2012	7	4.7	1210.2852	Link	Submitted to JHEP
1-2 taus + 0-1 leptons + jets + Etmiss [GMSB] NEW	10/2012	7	4.7	1210.1314	Link	Submitted to EPJC
Monophoton [ADD, WIMP] NEW	09/2012	7	4.7	1209.4625	Link	Submitted to PRL
2 leptons + jets + Etmiss [Medium stop] NEW	09/2012	7	4.7	1209.4186	Link	Accepted by JHEP
1-2 b-jets + 1-2 leptons + jets + Etmiss [Light Stop] NEW	09/2012	7	4.7	1209.2102	Link	Submitted to PLB
2 photons + Etmiss [GGM] NEW	09/2012	7	4.7	1209.0753	Link	Submitted to PLB
1-2 leptons + >=2-4 jets + Etmiss	08/2012	7	4.7	1208.4688	Link	Accepted by PRD
2 leptons + >=1 jet + Etmiss [Very light stop]	08/2012	7	4.7	1208.4305	Link (inc. HEPData)	Submitted to EPJC
3 leptons + Etmiss [Direct gauginos]	08/2012	7	4.7	1208.3144	Link (inc. HEPData)	Submitted to PLB
2 leptons + Etmiss [Direct gauginos/sleptons]	08/2012	7	4.7	1208.2884	Link	Submitted to PLB
1 lepton + >=4 jets (>=1 b-jet) + Etmiss [Heavy stop]	08/2012	7	4.7	1208.2590	Link	Accepted by PRL
0 lepton + 1-2 b-jet + 5-4 jets + Etmiss [Heavy stop]	08/2012	7	4.7	1208.1447	Link	Accepted by PRL
0 lepton + >=2-6 jets + Etmiss	08/2012	7	4.7	1208.0949	Link	Submitted to PRD
0 lepton + >=3 b-jets + >=(1-3) jets + Etmiss [Gluino med. stop/sb.]	07/2012	7	4.7	1207.4686	Link	Accepted by EPJC
0 lepton + >=(6-9) jets + Etmiss	06/2012	7	4.7	1206.1760	Link (inc. HEPData)	JHEP 1207 (2012) 167
Electron-muon continuum [RPV]	05/2012	7	2.05	1205.0725	Link (inc. HEPData)	EPJC 72 (2012) 2040
Z->ll + b-jet + jets + Etmiss [Direct stop in natural GMSB]	04/2012	7	2.05	1204.6736	Link (inc. HEPData)	PLB 715 (2012) 44
=3 leptons + Etmiss [Direct gauginos]	04/2012	7	2.05	1204.5638	Link (inc. HEPData)	PRL 108 (2012) 261804
>=1 tau + jets + Etmiss [GMSB]	04/2012	7	2.05	1204.3852	Link (inc. HEPData)	PLB 714 (2012) 197
>=2 taus + jets + Etmiss [GMSB]	03/2012	7	2.05	1203.6580	Link (inc. HEPData)	PLB 714 (2012) 180
b-jet(s) + 0-1 lepton + jets + Etmiss [Gluino med. stop/sb.]	03/2012	7	2.05	1203.6193	Link	PRD 85 (2012) 112006
2 same-sign leptons + jets + Etmiss	03/2012	7	2.05	1203.5763	Link (inc. HEPData)	PRL 108 (2012) 241802
2 b-jets + Etmiss [Direct sbottom]	12/2011	7	2.05	1112.3832	Link (inc. HEPData)	PRL 108 (2012) 181802
Disappearing track + jets + Etmiss [AMSB Strong Prod.]	02/2012	7	1.02	1202.4847	Link (inc. HEPData)	EPJC 72 (2012) 1993
2 photons + Etmiss [GGM]	11/2011	7	1.07	1111.4116	Link	PLB 710 (2012) 519
2 leptons + jets + Etmiss	10/2011	7	1.04	1110.6189	Link (inc. HEPData)	PLB 709 (2012) 137
0 lepton + >=(6-8) jets + Etmiss	10/2011	7	1.34	1110.2299	Link (inc. HEPData)	JHEP 11 (2011) 99
1 lepton + jets + Etmiss	09/2011	7	1.04	1109.6606	Link (inc. HEPData)	PRD 85 (2012) 012006
0 lepton + >=(2-4) jets + Etmiss	09/2011	7	1.04	1109.6572	Link (inc. HEPData)	PLB 710 (2012) 67
Electron-muon resonance [RPV]	09/2011	7	1.07	1109.3089	Link (inc. HEPData)	EPJC 71 (2011) 1809

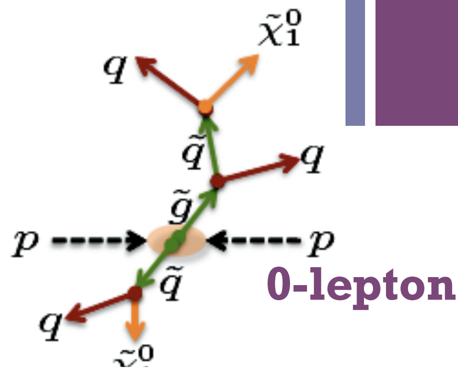
R-parity Conserving SUSY

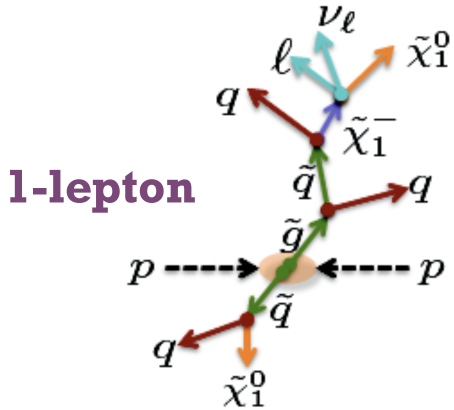
Strong production and RPC SUSY

Broad searches

To cover as many signatures as possible from a broad range of scenarios

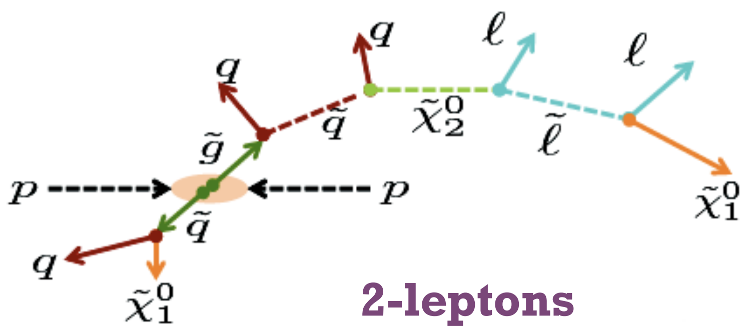
- short / long cascades
- high-pT jets (including b-jets)
- possibly one or more leptons (different flavours)
- possibly photons
- moderate-to-large E_T^{miss}



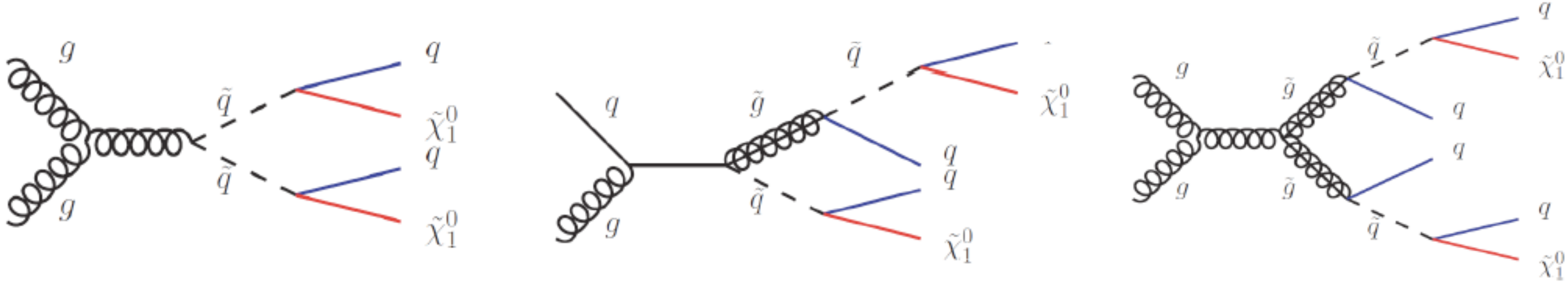


Understanding of SM backgrounds crucial

- QCD, W/Z+jets, ttbar, …
- From (or verified in) control regions



0-lepton + E_T^{miss} (aka "classic" 0-lep)



Jets from gluino and/or squark decays

Large missing trnsverse energy (E_t^{miss}) from escaping neutralinos

Veto events with isolated electrons or muons

$$m_{eff}(Nj) = \sum_{i=1}^{Nj} p_T^{jet,i} + E_t^{miss}$$

Nj= all signal jets

m_{eff}(incl.) : all jets with p_T>40 GeV)

12 signal regions

Requirement	Channel				
	A 2-jets	B 3-jets	C 4-jets	D 5-jets	E 6-jets
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
$\Delta\phi(\text{jet}, E_T^{miss})_{min}$ [rad] >	0.4 ($i = \{1, 2, (3)\}$)		0.4 ($i = \{1, 2, 3\}$), 0.2 (p_T > 40 GeV jets)		
$E_T^{miss}/m_{eff}(Nj)$ >	0.3/0.4/0.4 (2j)	0.25/0.3/– (3j)	0.25/0.3/0.3 (4j)	0.15 (5j)	0.15/0.25/0.3 (6j)
m_{eff}(incl.) [GeV] >	1900/1300/1000	1900/1300/–	1900/1300/1000	1700/–/–	1400/1300/1000

8 TeV, 5.8 fb^{-1}

0-lepton + E_t^{miss} – Background Estimation

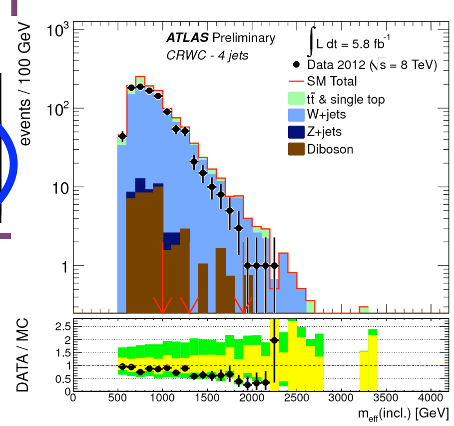
Four **control regions** (CR) for each of the twelve signal regions (SR)

CR	SR background	CR process	CR selection
CRY	$Z(\rightarrow \nu\nu)$+jets	γ+jets	Isolated photon
CRQ	QCD jets	QCD jets	Reversed $\Delta\phi(\text{jet}, E_T^{miss})_{min}$ and $E_T^{miss}/m_{eff}(Nj)$ cuts
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

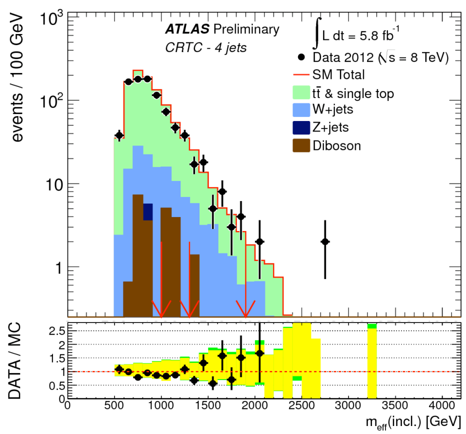
Background from combined likelihood fit to all CRs – accounting for all correlations

$$N_{proc}(SR, scaled) = N_{proc}(CR, obs) * \left[\frac{N_{proc}(SR, raw, proc)}{N_{proc}(CR, raw, proc)} \right]$$

Transfer factors link CR measurement to SR background estimate



Top CR



W+jetsCR

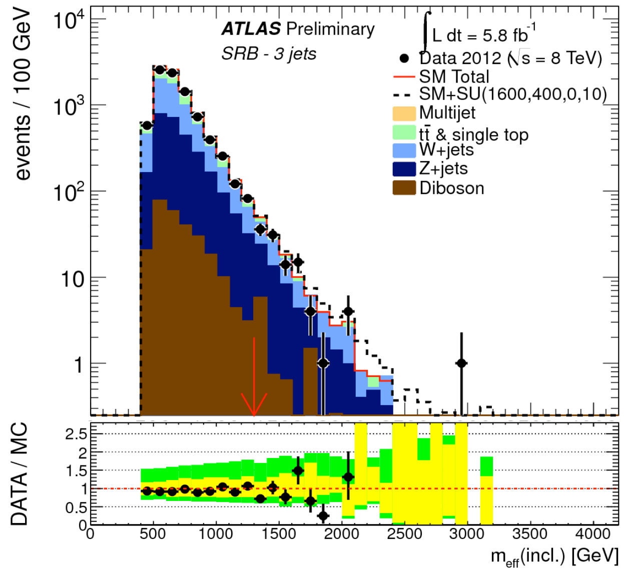
+ 0-lep + E_t^{miss} – Results & Interpretation

8 TeV, 5.8 fb^{-1}

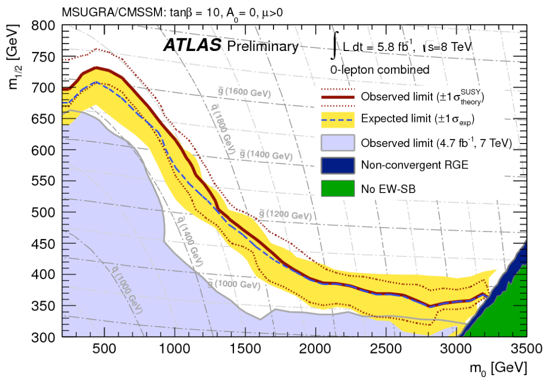
Good agreement between observations and SM expectations

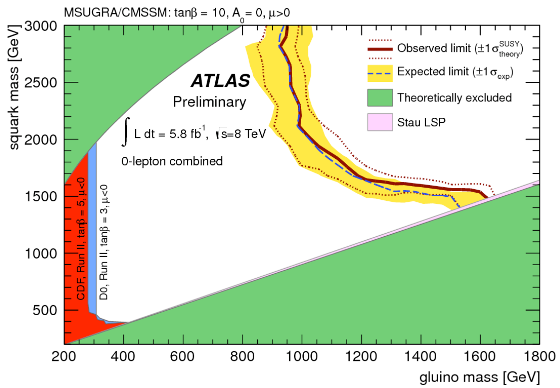
Data from all the channels are used to set limits on SUSY models
Profile log-likelihood ratio test and CLs prescription to derive 95% CL exclusion regions

Exclusion limits obtained by using the SR with the best expected sensitivity at each point



tanβ =10, A_0= 0, μ >0 (MSUGRA/CMSSM models)

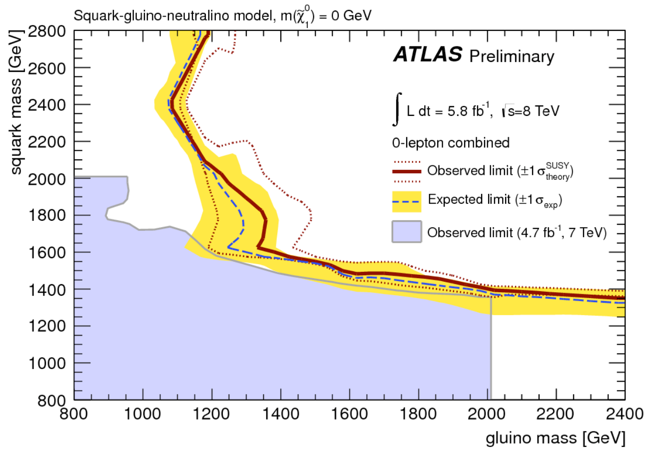




Limit on $m_{1/2}$ ~340 (710) GeV at high (low) m_0 values

Equal mass light-flavor squarks and gluinos excluded below 1500 GeV

Simplified models with m_{LSP}=0 (1st/2nd generation squarks only)



Strong production of gluinos and 1st/2nd-generation squarks, with direct decays to jets and neutralino
(all other sparticles, including 3rd-generation squarks, are decoupled)

+ Compressed Scenarios

Models with compressed MSUGRA scenarios

See PRD84 (2011) 015004

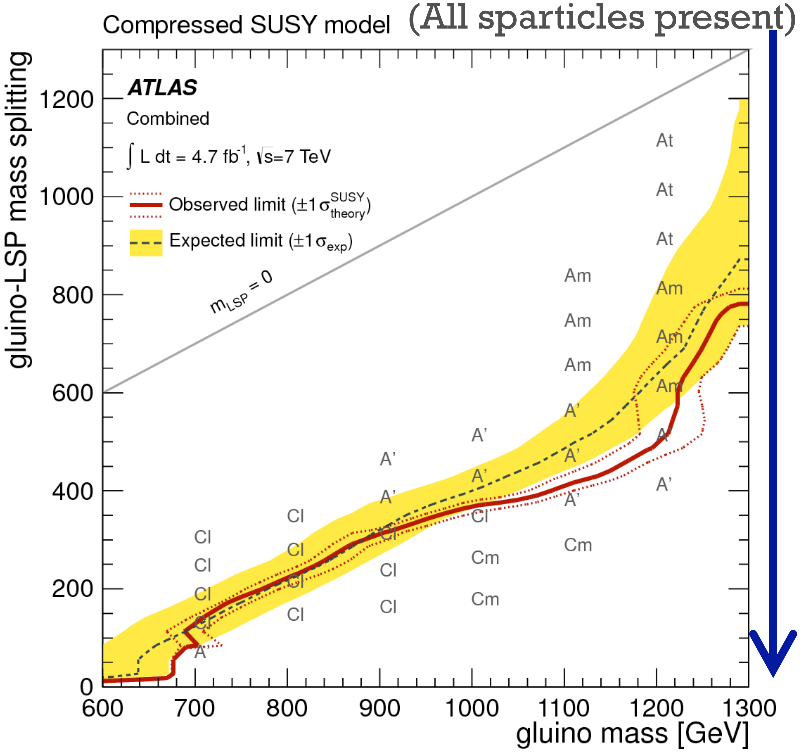
$\Delta M/MSUSY$ from 0.85 to 0.15

Basic sparticle content and spectrum similar to CMSSM, but sizes of all mass splittings controlled by a compression factor.

Signal regions with softer cuts allow to go to lower $\Delta M/M_{SUSY}$

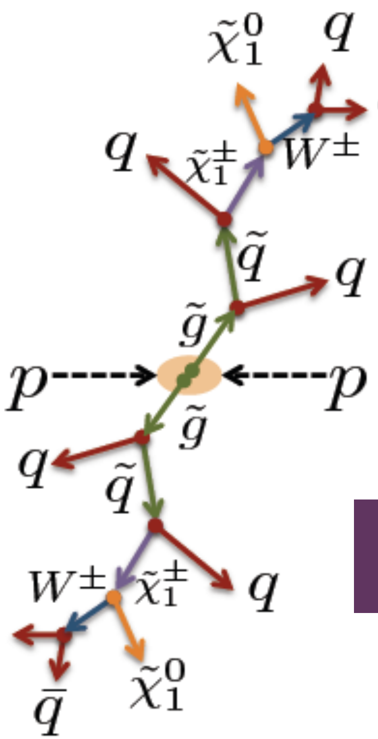
Gain in sensitivity for gluino masses below ~1.2 TeV

(All sparticles present)



More compressed scenarios

+ 0-lepton + Multi-jets + E_t^{miss} – Strategy



Signal region	7j55	8j55	9j55	6j80	7j80	8j80
Number of isolated leptons (e, μ)	= 0					
Jet p_T	> 55 GeV			> 80 GeV		
Jet $\|\eta\|$	< 2.8					
Number of jets	≥ 7	≥ 8	≥ 9	≥ 6	≥ 7	≥ 8
$E_T^{miss} / \sqrt{H_T}$	> 4 $GeV^{1/2}$					

8 TeV, 5.8 fb^{-1}

Extension of "classic" 0-lepton analysis

Provides increased sensitivity to models with many-body decays or sequential cascade decays to coloured particles

$$\tilde{g} + \tilde{g} \rightarrow \left(t + \bar{t} + \tilde{\chi}_1^0\right) + \left(t + \bar{t} + \tilde{\chi}_1^0\right)$$

Direct stop, see also later…

E_T^{miss} resolution dominated by stochastic fluctuations of jets

$$\sigma^2\left(E_T^{miss}\right) \sim H_T \equiv \sum_{jets} p_T$$

(sum over jets with: p_T>40 GeV, $|\eta|$<2.8)

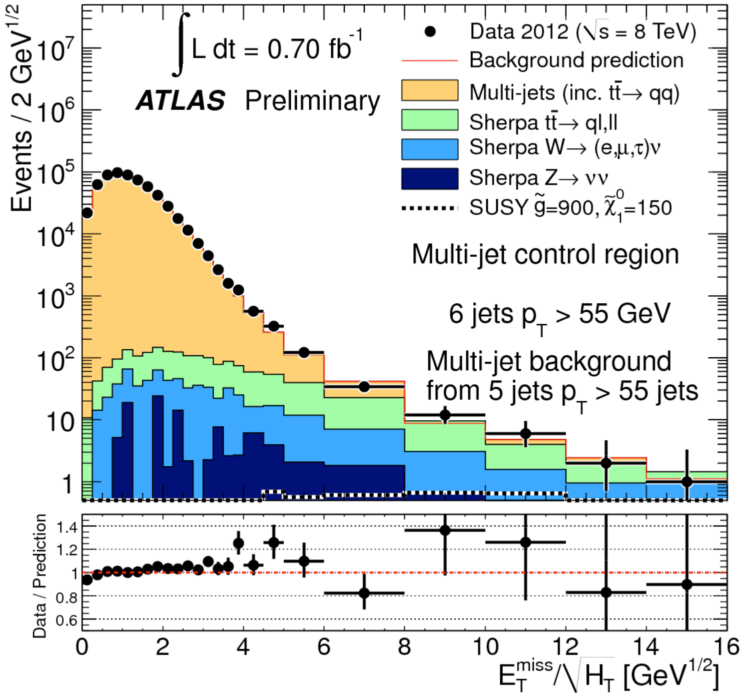
Signal regions with many high-p_T jets, plus E_T^{miss} and lepton veto

Data-driven approach

$E_T^{miss}/\sqrt{H_T}$ variable nearly independent of jet multiplicity and pileup

Use transfer factors from lower to higher jet multiplicities)

+ 0-lepton + Multi-jets + E_t^{miss} – Results



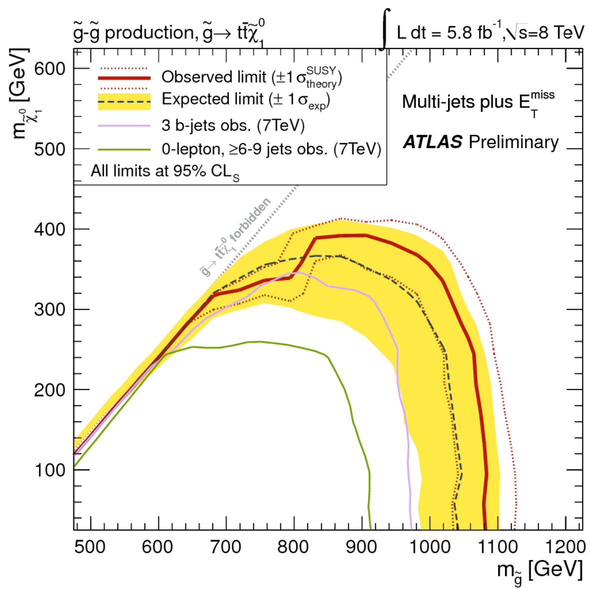
Background Sources	
Multi-jet QCD + Fully hadronic ttbar	Dominant
Semi- and fully leptonic ttbar	Significant
W/Z+jets	Small

8 TeV, 5.8 fb^{-1}

Simplified gluino-neutralino model

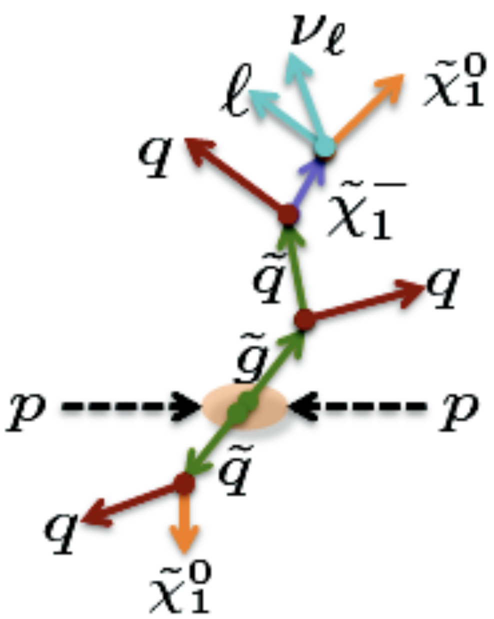
$$\tilde{g} + \tilde{g} \rightarrow \left(t + \bar{t} + \tilde{\chi}_1^0\right) + \left(t + \bar{t} + \tilde{\chi}_1^0\right)$$

Signal region	7j55	8j55	9j55	6j80	7j80	8j80
Multi-jets	219 ± 39	23 ± 7	2.8 ± 0.9	134 ± 32	12 ± 4	1.1 ± 0.4
$t\bar{t} \rightarrow q\ell, \ell\ell$ and $W(\rightarrow \ell\nu)$ + jets	121^{+23}_{-25}	18 ± 8	$2.0^{+2.2}_{-1.3}$	97 ± 24	14^{+10}_{-12}	$1.8^{+1.7}_{-1.4}$
$Z(\rightarrow \nu\nu)$ + jets	13 ± 13	1 ± 1	$0^{+0.4}$	12 ± 12	2 ± 2	$0^{+0.4}$
Total Standard Model	353 ± 48	42 ± 10	$4.8^{+2.4}_{-1.6}$	243 ± 42	28^{+11}_{-12}	$2.9^{+1.8}_{-1.5}$
Data	381	48	3	248	26	1
$N^{95\%}_{\mathrm{BSM,max}}$ (exp)	101	24	7.3	88	26	5.5
$N^{95\%}_{\mathrm{BSM,max}}$ (obs)	122	29	5.4	91	25	4
$\sigma^{95\%}_{\mathrm{BSM,max}} \cdot A \cdot \epsilon$ (exp) [fb]	17.5	4.1	1.3	15.2	4.5	0.9
$\sigma^{95\%}_{\mathrm{BSM,max}} \cdot A \cdot \epsilon$ (obs) [fb]	21	5	0.9	15.7	4.3	0.7



Small overlap with standard 0-lep+jets+Etmiss searches

+ 1-lepton + jets + E_t^{miss} – Strategy



Presence of lepton provides extra advantages compared to purely hadronic searches

- **Triggering**
  efficient single lepton triggers
- **Background suppression**
  QCD background greatly reduced by lepton requirement
- **Background modelling**
  using data-driven techniques

Additional variables used in the event selection:

$$m_T = \sqrt{2 \cdot p_T^\ell \cdot E_T^{miss}\left(1-\cos\left(\Delta\phi(\vec{\ell},\vec{E}_T^{miss})\right)\right)}$$

Transverse mass between selected lepton and E_T^{miss} vector

$$m_{eff} = p_T^\ell + \sum_{i=1}^{Njet} p_T^{jet(i)} + E_T^{miss}$$

H_T (the sum over jets)

Effective mass (all jets >40 GeV)

1-lepton + jets + E_t^{miss} – Event Selection and Backgrounds

One Signal Region

	signal region
N_{lep}	1
p_T^{ℓ} (GeV)	> 25
$p_T^{\ell_2}$ (GeV)	< 10
N_{jet}	≥ 4
p_T^{jet} (GeV)	> 80, 80, 80, 80
E_T^{miss} (GeV)	> 250
m_T (GeV)	> 100
E_T^{miss}/m_{eff}	> 0.2
m_{eff}^{inc} (GeV)	> 800

8 TeV, 5.8 fb^{-1}

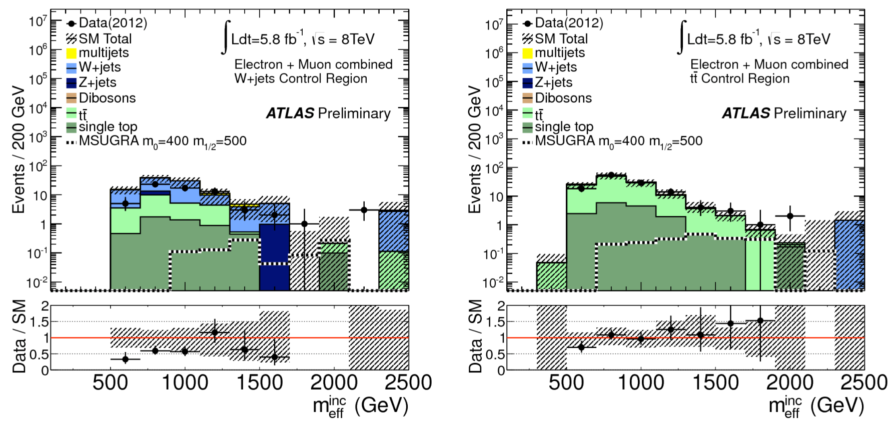
QCD background using "loose-tight" Matrix Method

use data with "loose" lepton to estimate data with "tight" lepton

Non-QCD background dominated by top and W+jets

Use binned fit in CRs to adjust background normalisations

All other backgrounds from simulation



1-lepton + jets + E_t^{miss} – Results

	Signal region	
	Electron	Muon
Observed events	10	4
Fitted background events	9.0 ± 2.8	7.7 ± 3.2
Fitted $t\bar{t}$ events	6.0 ± 2.2	2.6 ± 1.9
Fitted W/Z+jets events	1.5 ± 0.7	4.2 ± 2.3
Fitted other background events	1.0 ± 0.7	0.9 ± 0.3
Fitted multijet events	0.4 ± 0.6	0.0 ± 0.0
MC expected SM events	9.5	11.5
MC expected $t\bar{t}$ events	5.7	4.6
MC expected W/Z+jets events	2.4	6.0
MC expected other background events	1.0	0.8
Data-driven multijet events	0.4	0.0

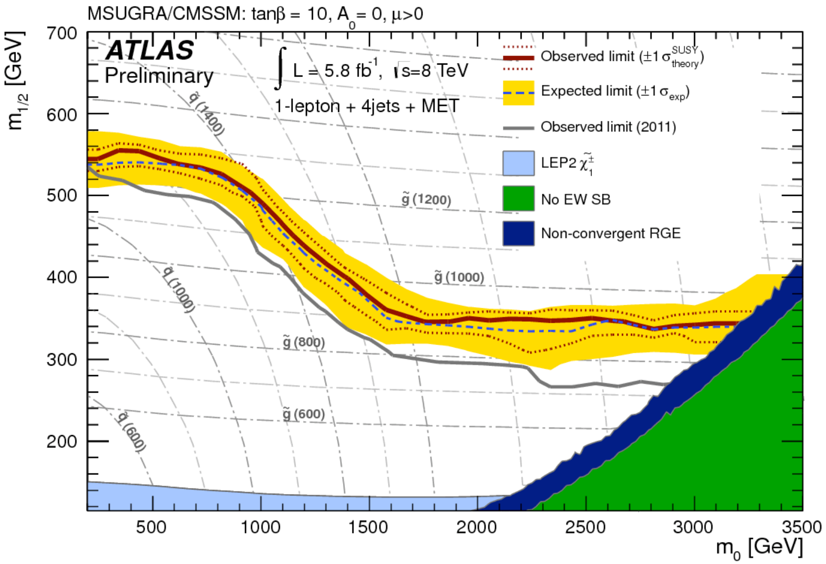
Observed number of events in data consistent with SM

	$\langle\epsilon\sigma\rangle^{95}_{\rm obs}$[fb]	$S^{95}_{\rm obs}$	$S^{95}_{\rm exp}$
Electron	1.69	9.9	$9.3^{+3.3}_{-2.6}$
Muon	1.09	6.4	$8.3^{+3.4}_{-2.3}$

95% CL limits on visible cross-section

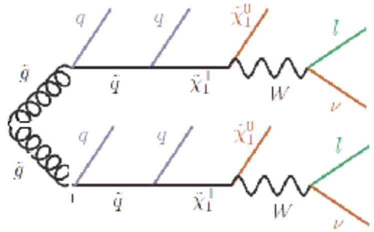
MSUGRA/CMSSM limits from combination of statistically independent e & mu channels

8 TeV, 5.8 fb^{-1}



1-lep competitive with 0-lep at high m_0, where gluino production is dominant

+ 2-SS-lep + jets + E_t^{miss}



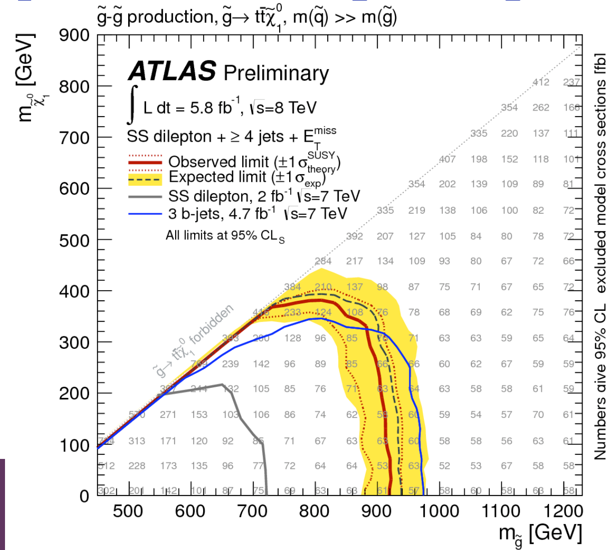
In MSSM, gluino is Majorana
Same-sign lepton pairs will be produced in half of the dilepton events originating from a SUSY cascade

Gluinos decay with equal probability to quark/anti-squark or anti-quark/squark pairs

SS dilepton pairs can originate from

$$\tilde{g}\tilde{g} \rightarrow t\bar{t}\ \tilde{t}_1\tilde{t}_1^*, tt\ \tilde{t}_1^*\tilde{t}_1^*, \bar{t}\bar{t}\ \tilde{t}_1\tilde{t}_1$$

Followed by $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^{\pm}$ or $\tilde{t}_1 \rightarrow t\,\tilde{\chi}_1^0$



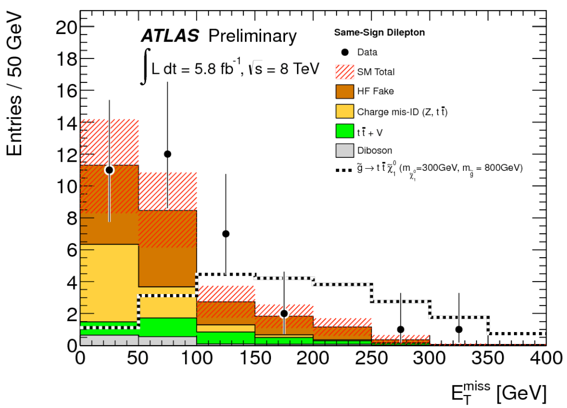
Simplified models

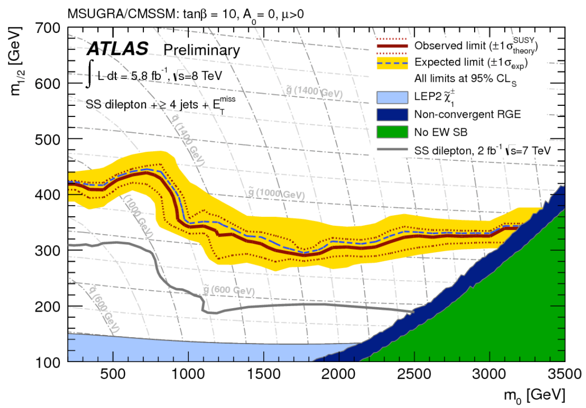
Event selection

2 SS leptons (e, mu) with pT>20 GeV
>=4 high-pT jets (>50 GeV)
Etmiss > 150 GeV

8 TeV, 5.8 fb^{-1}

No significant excess observed





Competitive with 0-lep at high $m_{0,}$ where gluino production is dominant

MSUGRA/CMSSM

+ GMSB 2-lepton Searches (including taus)

In Gauge-Mediated SUSY-Breaking (GMSB) models, the LSP is the gravitino, the next-to-lightest SUSY particle (NLSP) determines the phenomenology

NLSP = stau → enhanced taus

NLSP = selectron/smuon → enhanced e/μ

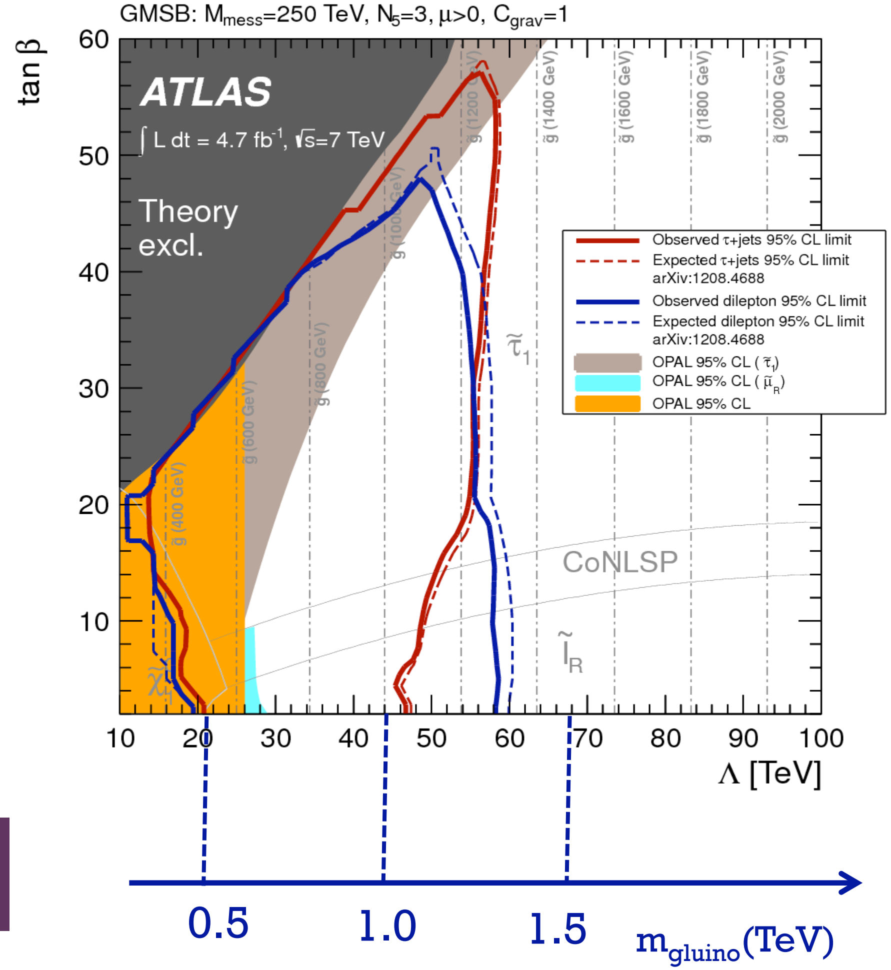
Six exclusive channels:

(e-e, e-μ, μ-μ)+jets+E_T^{miss}

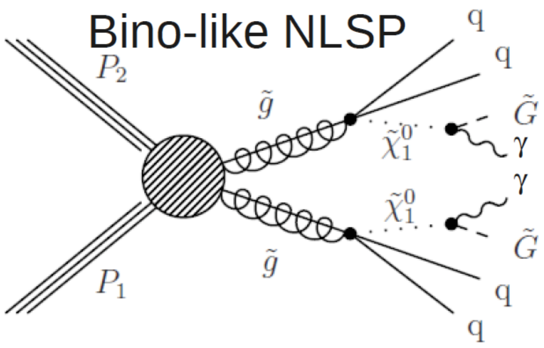
($=1\tau_{had}$, $>=2\tau_{had}$, e/μ+$1\tau_{had}$) +jets+E_T^{miss}

Gluino masses excluded up to 1.3 TeV

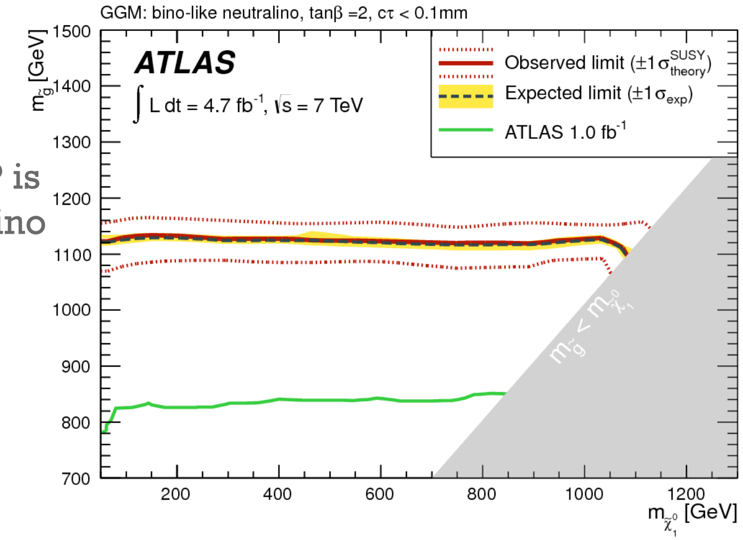
7 TeV, 4.7 fb^{-1}



+ Photon Signals from GGM SUSY



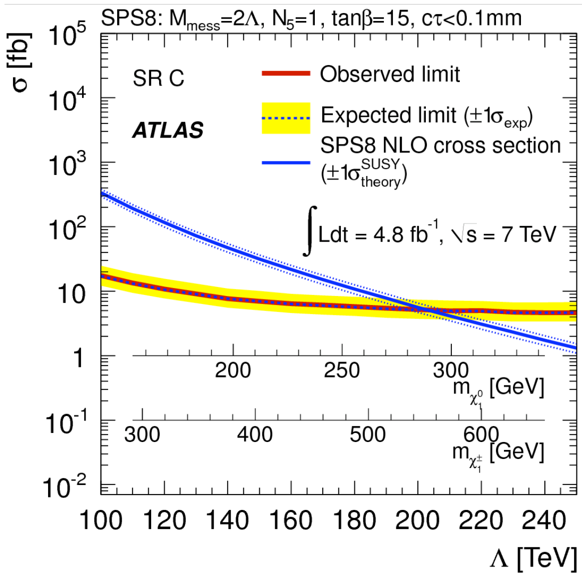
In the "gluino–bino" model ("squark-bino" model), the NLSP is bino-like and, except for the gluino (squark), all other sparticles are "decoupled" (too heavy to be measured)



$$2\times\{\ \tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}\ \} = 2\gamma + E_T^{miss}$$

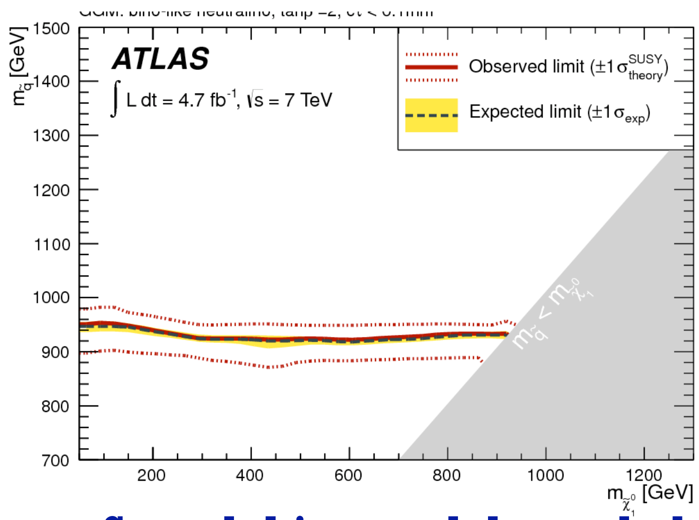
Gluino-bino models: exclude gluino masses up 1.07 TeV

7 TeV, 4.8 fb^{-1}

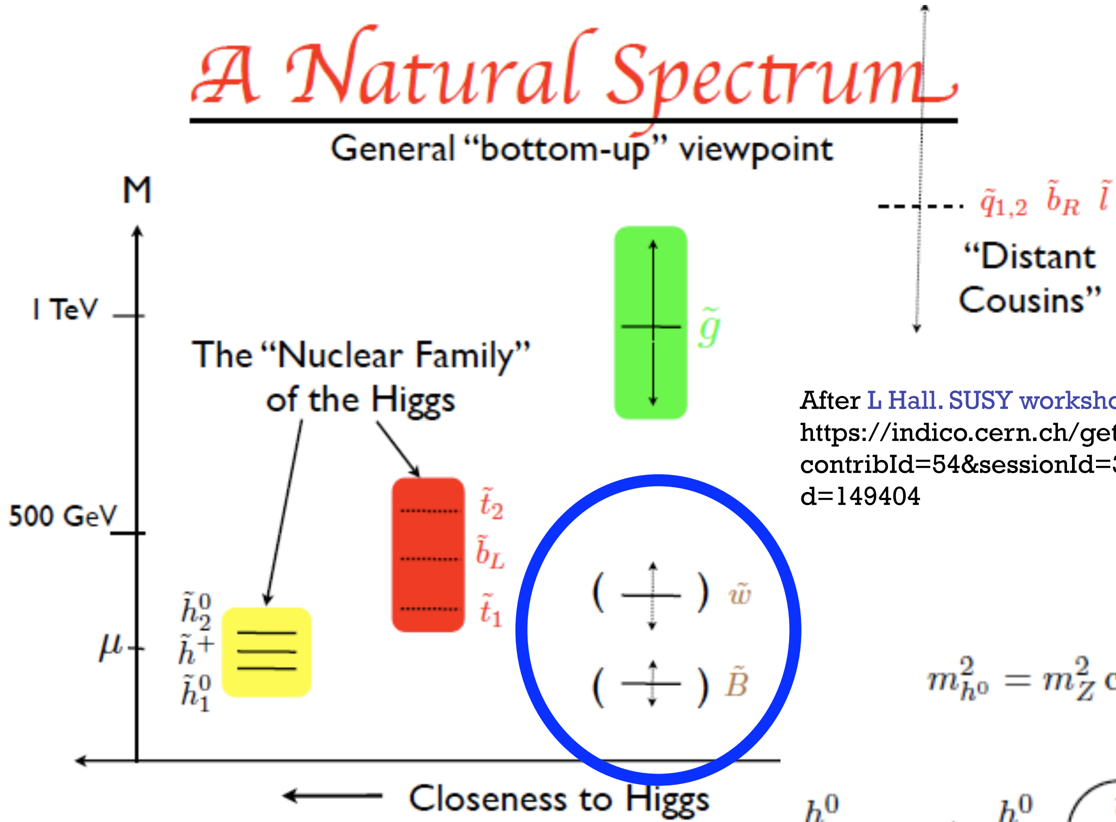


In the minimal GMSB model (SPS8) the only free parameter is SUSY-breaking scale Λ

Lower limit on Λ is 196 TeV (→ 1.4 TeV limit on UED compactification scale 1/R)

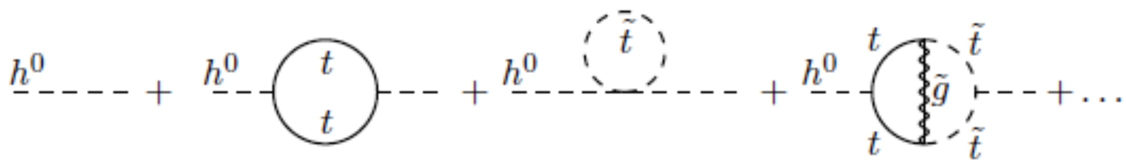


Squark-bino models: exclude gluino masses up 870 GeV



After L Hall. SUSY workshop, LBNL, Oct 2011 https://indico.cern.ch/getFile.py/access?contribId=54&sessionId=3&resId=0&materialId=slides&confId=149404

$$m_{h^0}^2 = m_Z^2 \cos^2(2\beta) + \frac{3}{4\pi^2} y_t^2 m_t^2 \ln\left(\frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2}\right) + \ldots$$



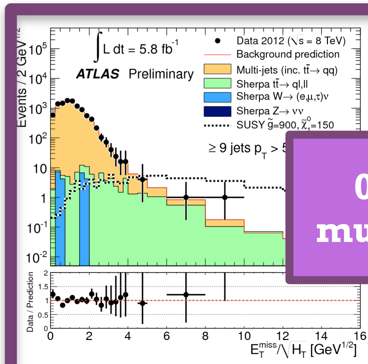
m_H regularized by scalar top mass, still possible to have natural SUSY with a relatively light stop / sbottom

Naturalness achievable even if 1st/2nd-generation squark masses are O(TeV)

Relatively light gluino

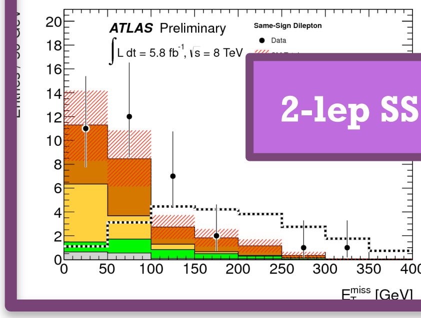
Electroweak sector also light

Gluino-Mediated 3rd Generation

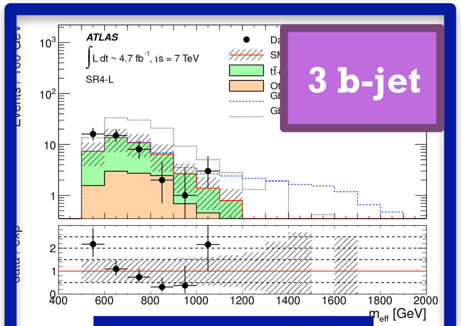


0-lep multijets

8 TeV, 4.7 fb^{-1}

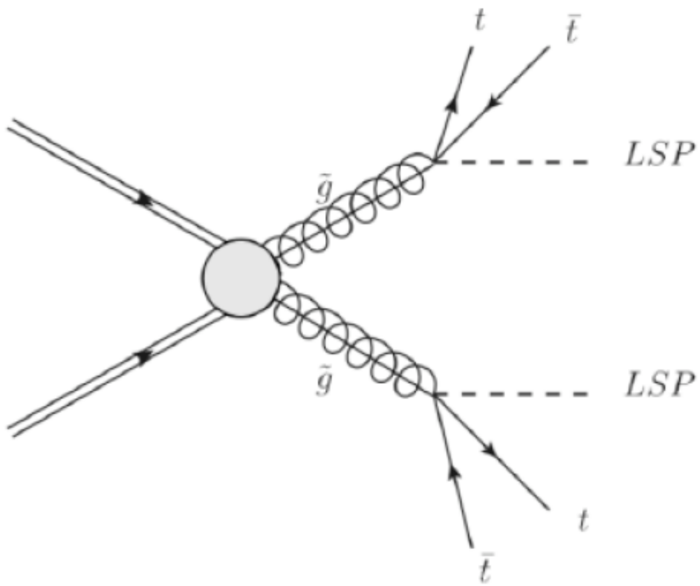


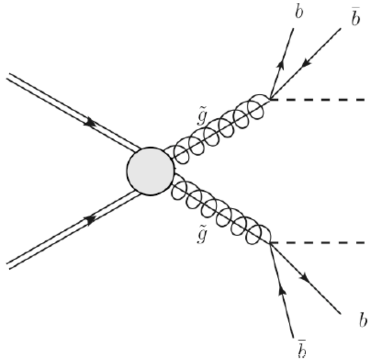
2-lep SS



3 b-jet

7 TeV, 4.7 fb^{-1}





Greatest sensitivity from channels that are good at suppressing top-rich backgrounds

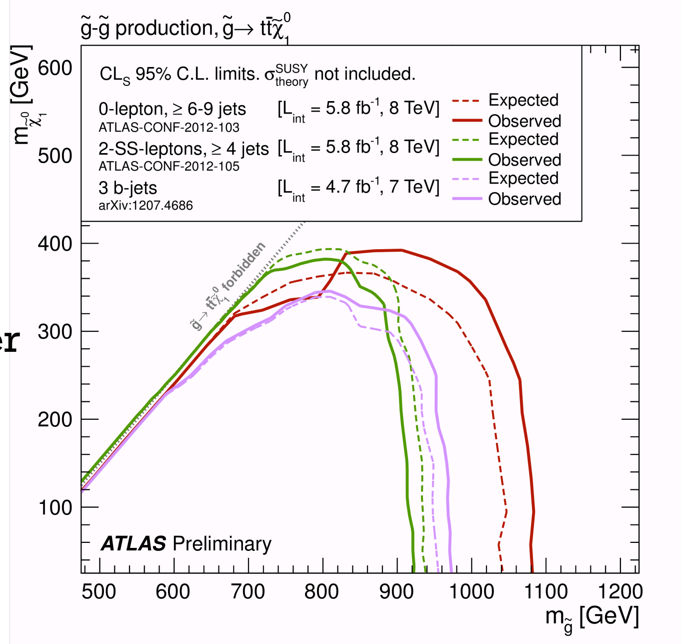
0-lep+multijets+E_T^{miss}

SS 2-lep + jets + E_T^{miss}

See earlier

3 b-jets + E_t^{miss}

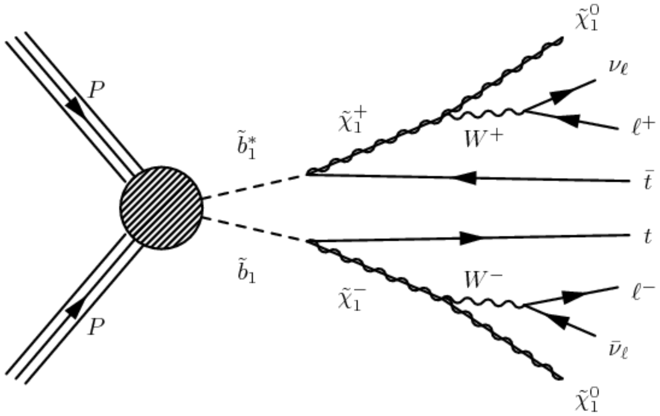
Also 3lep+jets+E_t^{miss}, slightly more sensitive nearer diagonal

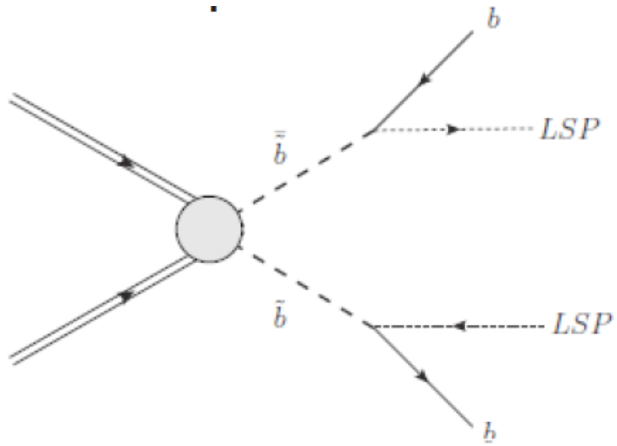


Gluino masses excluded up to ~1080 GeV

+ Direct Sbottom Searches

7 TeV, 4.7 fb^{-1}



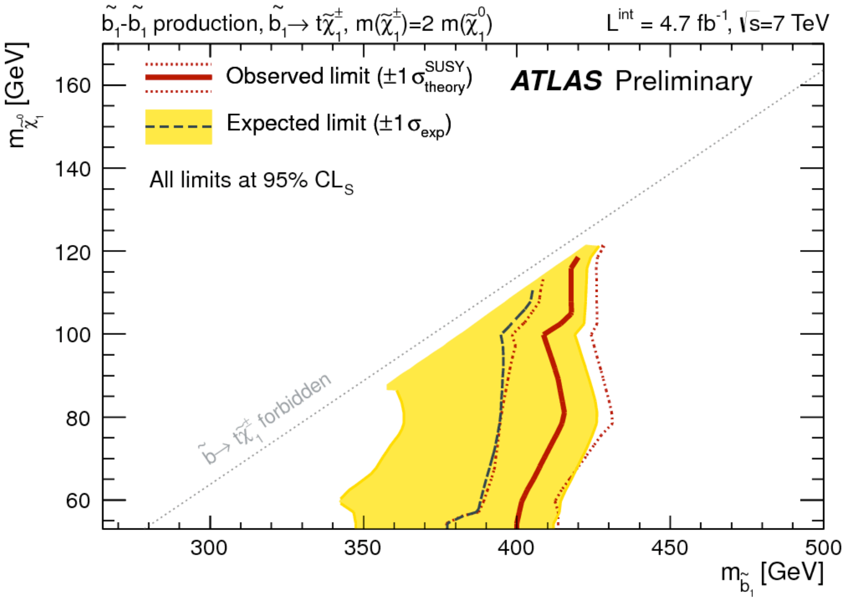


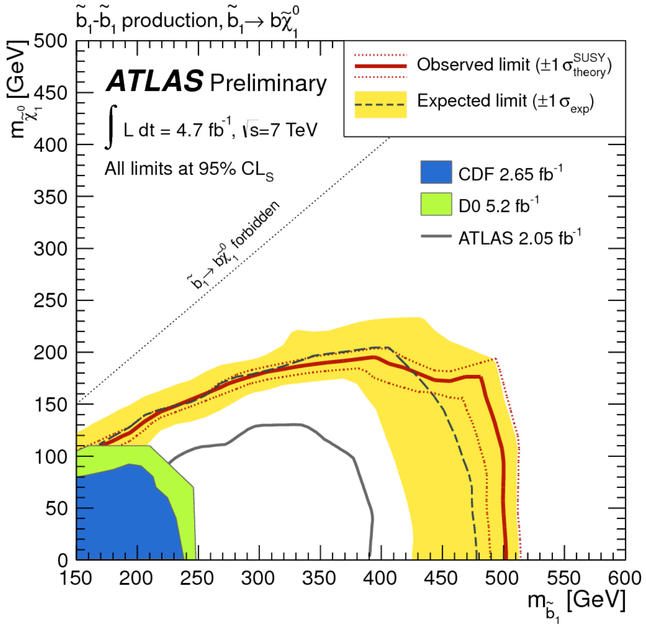
3-lep + jets + E_t^{miss}

2 b-jets + E_t^{miss}

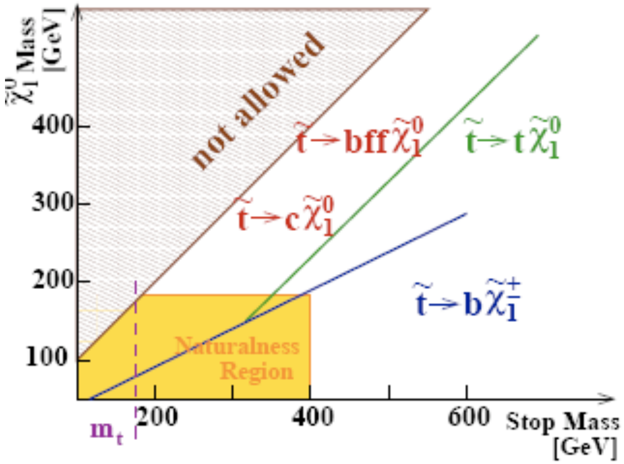
Exploits 2-body decay kinematics

SR dependent on m(sbottom)-m(LSP)





+ Scalar Top (stop) Searches – Strategy



Rich phenomenology, dependent on m(stop)-m(LSP) and on nature of intermediate particles (chargino, heavy neutralino, slepton,…)

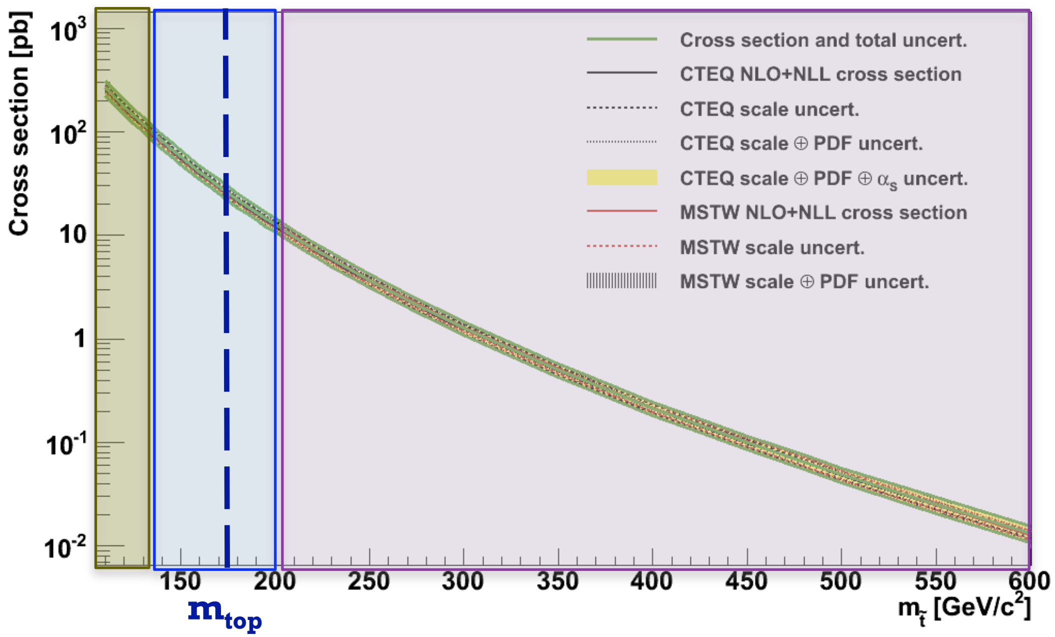
* top+LSP if kinematically allowed, and no gauginos
* chargino+b, if chargino present
* virtual W, if no chargino
* charm+LSP (via loop) – last option

Variety of signatures requires range of strategies to cover all available possibilities (and challenges)

Very light stop – soft objects, large SM backgrounds

Light stop – very similar to ttbar

Heavy stop – low cross-sections

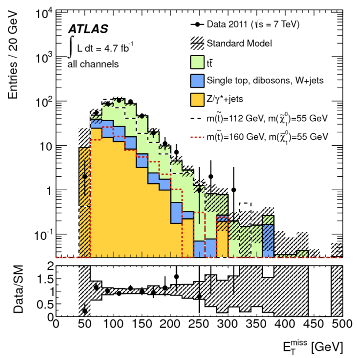


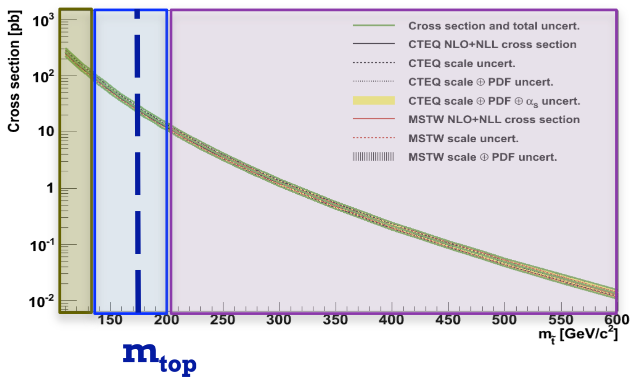
Searching for the Stop at 7 TeV

Searches tailored to stop mass range

Very Light stop – 2 soft leptons

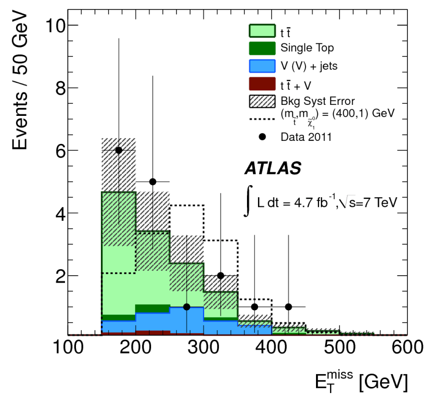
$$\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^{\pm}$$



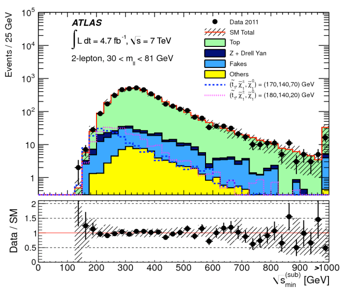


Heavy stop – 0-lep+b-jets

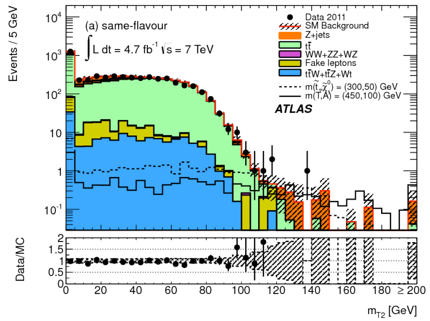
$$\tilde{t}_1 \rightarrow t + \tilde{\chi}_1^{\pm}$$



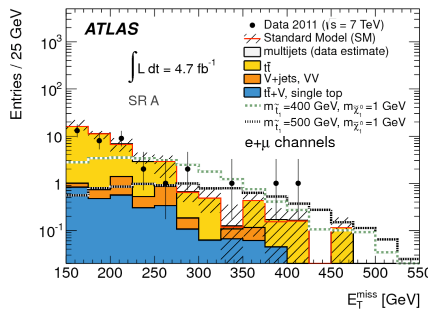
Light stop – 1-2 bjets + 1-2 lep



Medium stop – 2 lep+mT2



Heavy stop – 1-lep+b-jets



+ Summary of Stop Searches (7 TeV)

The absence of any significant excess above SM background expectations is translated into 95% CL exclusion limits for all the considered channels

m(stop) < 200 GeV

7 TeV, 4.7 fb^{-1}

Look at

$$\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^{\pm},$$

$$\tilde{\chi}_1^{\pm} \rightarrow W^{(*)} + \tilde{\chi}_1^{0}$$

with

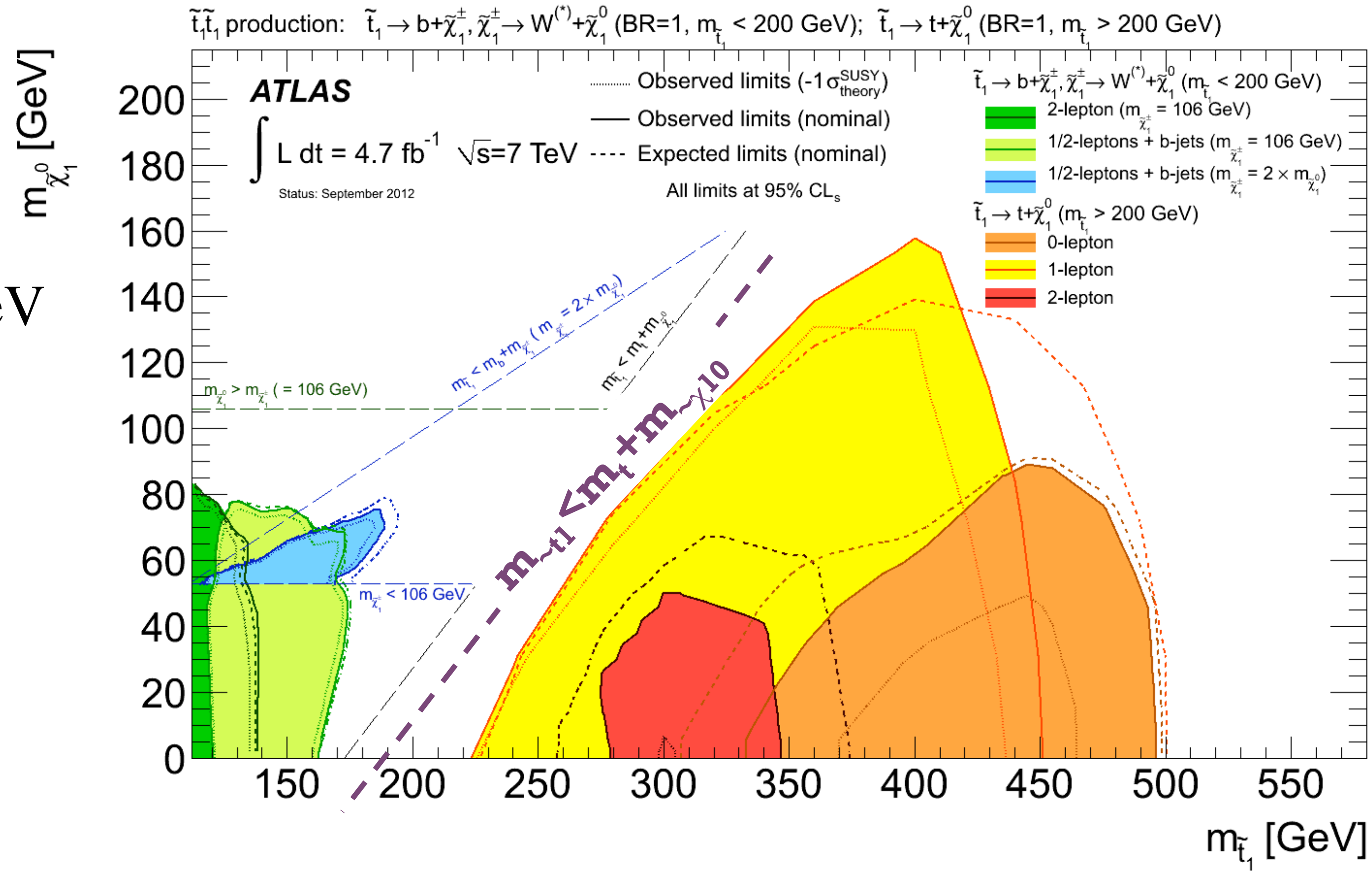
either $m_{\tilde{\chi}_1^{\pm}} = 106$ GeV

or $m_{\tilde{\chi}_1^{\pm}} = 2 \times m_{\tilde{\chi}_1^{0}}$

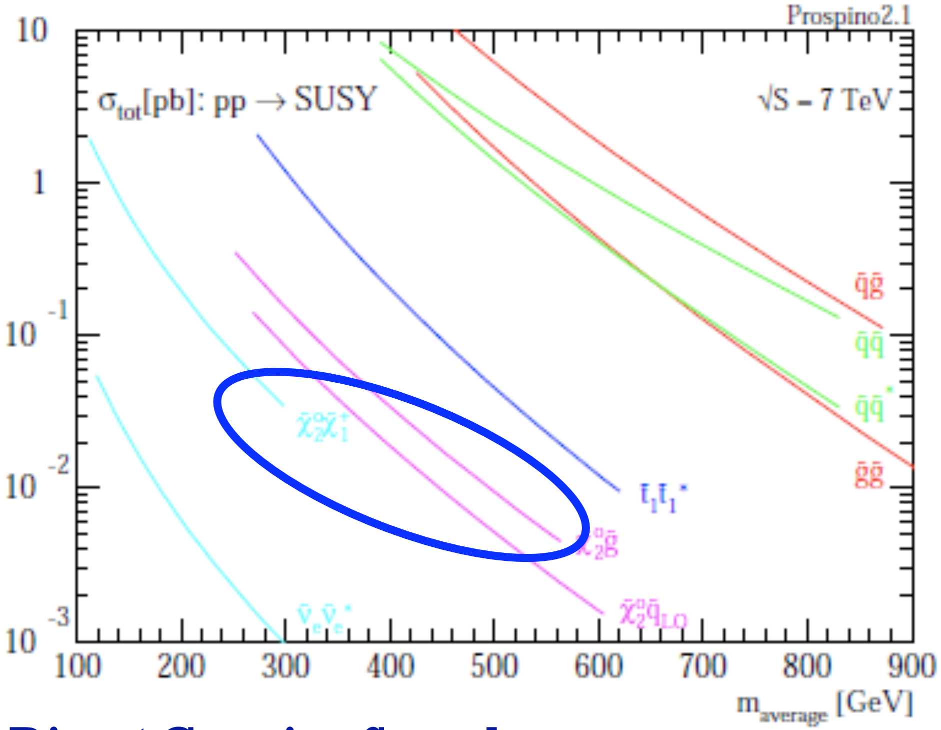
m(stop) > 200 GeV

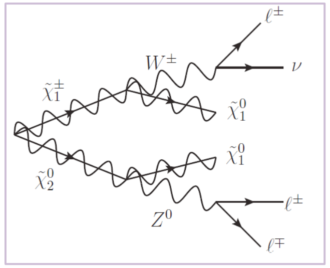
$$\tilde{t}_1 \rightarrow t + \tilde{\chi}_1^{0}$$

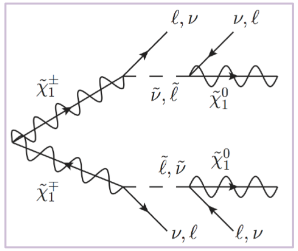
assumed to dominate

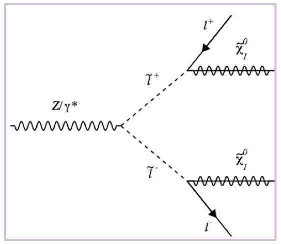


EW SUSY – Charginos, Neutralinos, Sleptons









Direct Gaugino Searches

chargino-chargino: **2-lep**

chargino-neutralino: **3-lep + 2-lep** (when one lepton not seen)

Direct Slepton Searches

slepton-slepton: **2-lep**

+ Weak SUSY – Charginos and Sleptons

Consider purely leptonic decays of chargino pairs

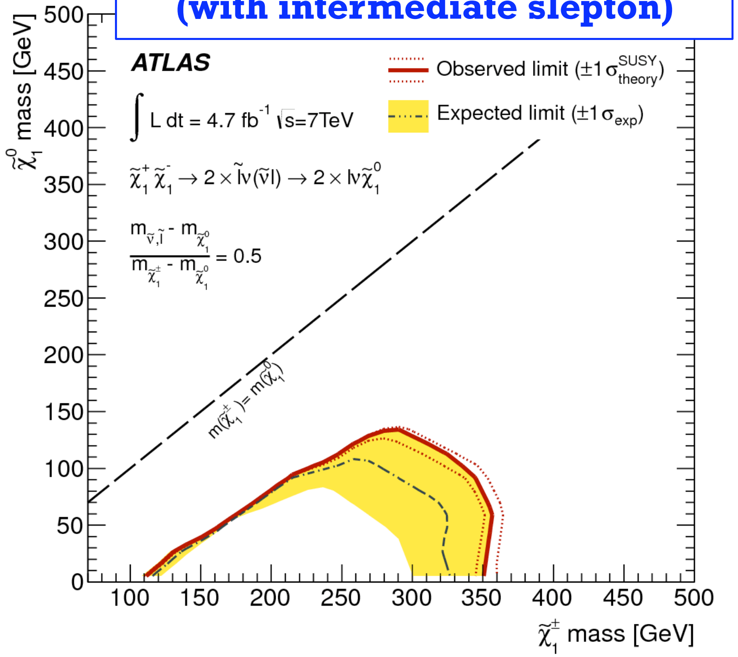
Simplified models with intermediate slepton

Signature: **2-lep + E_t^{miss}**

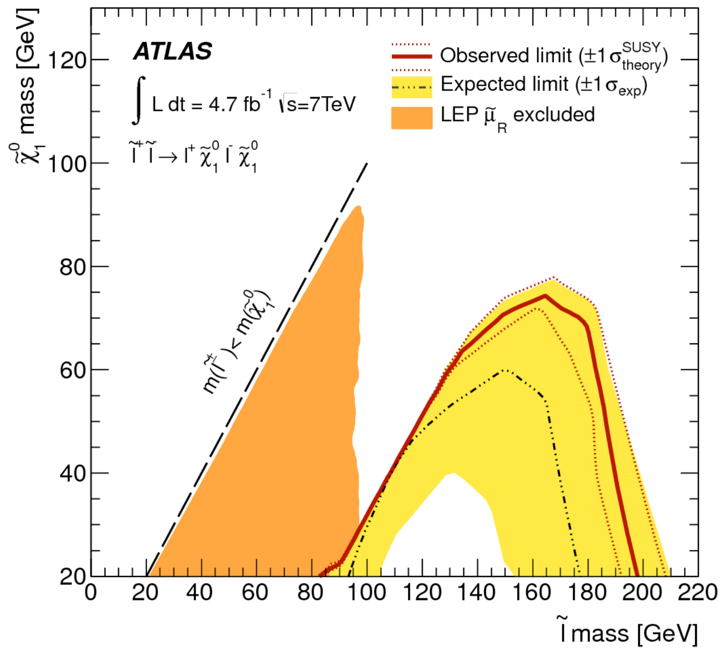
7 TeV, 4.7 fb^{-1}

Search also sensitive to direct slepton production (beyond LEP)

Chargino pairs → 2lep + E_T^{miss} (with intermediate slepton)



Slepton pairs → 2lep + E_T^{miss}



Lepton = electron, muon

Weak SUSY – Charginos and Neutralinos

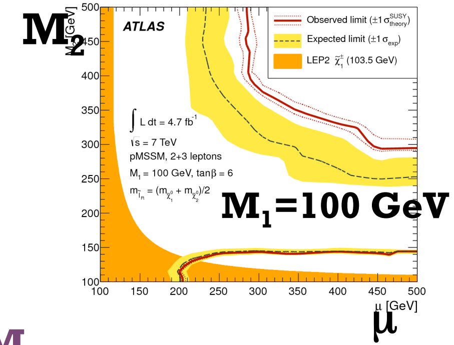
Leptonic decays of chargino-neutralino pairs

Simplified models with/without intermediate slepton

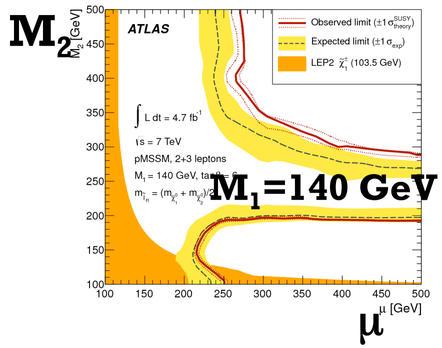
Signature: **3-lep + E_t^{miss} + (Z-request/veto and/or $m_T(\nu,lep)$>90 GeV)**

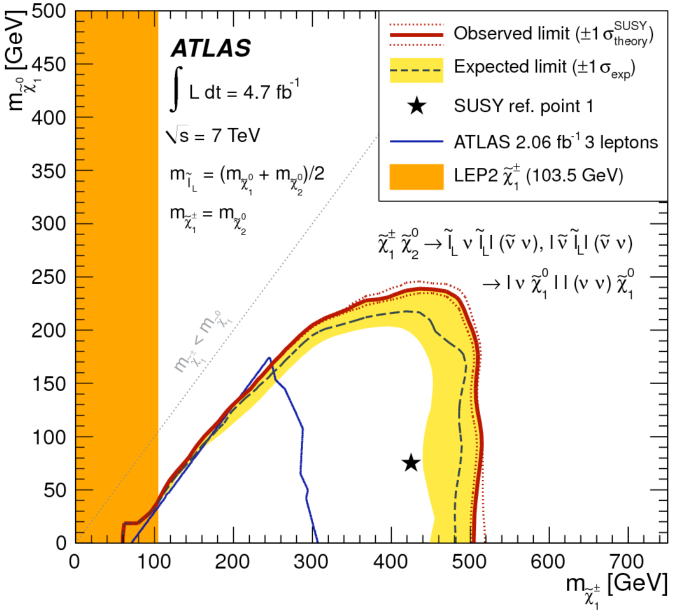
Gain from combining also with 2-lep signature (if one lepton is unseen)

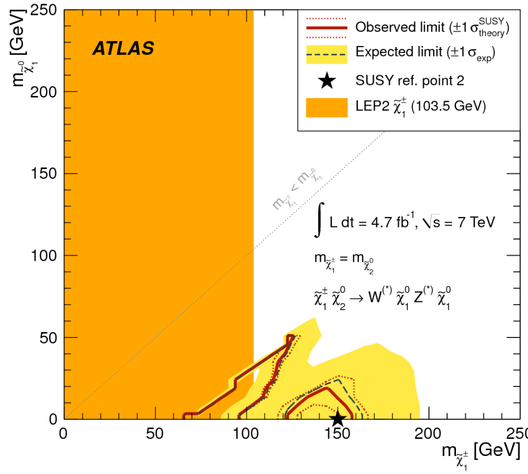
Also consider more complex models with intermediate slepton– **pMSSM**

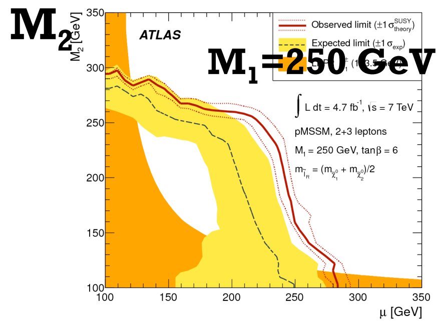


7 TeV, 4.7 fb^{-1}









Lepton = electron, muon

$M_{1,2}$ = gaugino mass
μ = higgs mass parameter

RPV SUSY and All That

+ R-parity Violation (RPV)

$$R = (-1)^{3(B-L)+2S}$$

R-parity conservation is hinted by proton stability, but not strictly required

Proton decay can be prevented by other symmetries that require lepton or baryon number conservation but violate R-parity

(can also accommodate non-zero neutrino masses and neutrino mixing)

General R-parity violating term

$$W_{RPV} = \underbrace{\lambda_{ijk}\hat{L}_i\hat{L}_j\hat{E}_k^C + \lambda'_{ijk}\hat{L}_i\hat{Q}_j\hat{D}_k^C}_{\text{Lepton Nr. violating terms}} + \underbrace{\varepsilon_i\hat{L}_i\hat{H}_u}_{\text{Bilinear Term}} + \underbrace{\lambda''_{ijk}\hat{U}_i^C\hat{D}_j^C\hat{D}_k^C}_{\text{Baryon Nr. violating term}}$$

If R-parity is violated

Sparticles can be produced in odd numbers

LSP can be coloured and/or electrically charged

LSP can be unstable

* LSP mass peaks (from SM final-state particles)
* potentially, long-lived LSP
* missing transverse energy may be small

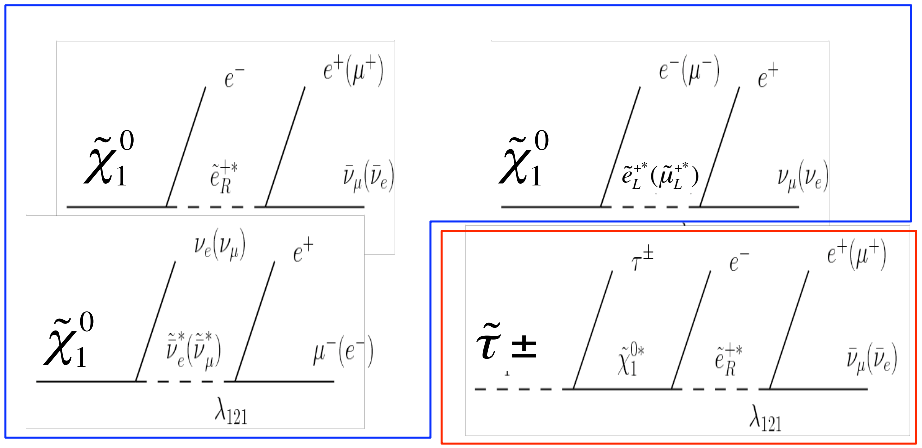
+ RPV 4-leptons

Trilinear lepton-number-violating RPV: $W_{RPV} = \lambda_{ijk} L_i L_j \bar{E}_k$

Can have both charged leptons and neutrinos in the LSP decay

→ high lepton multiplicity and moderate values of E_t^{miss}

Assume single coupling dominance, with λ_{121} as the only non-zero coupling chosen as a representative model with multiple e / μ in final state



Scenario #1

Lightest chargino and neutralino only sparticles below the TeV scale

RPV 3-body decay of LSP to eeν or eμν states (BR = 50 % each)

Scenario #2

($m_{1/2}$, tanβ) slice of MSUGRA/CMSSM (containing BC1 benchmark point [Allanach et al.])

$m_0=A_0=0$, $\mu>0$, $\lambda_{121} = 0.032$

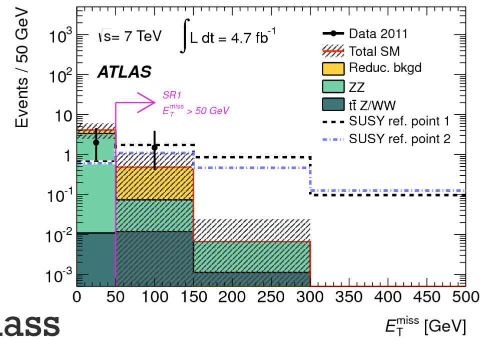
Both strong and weak production

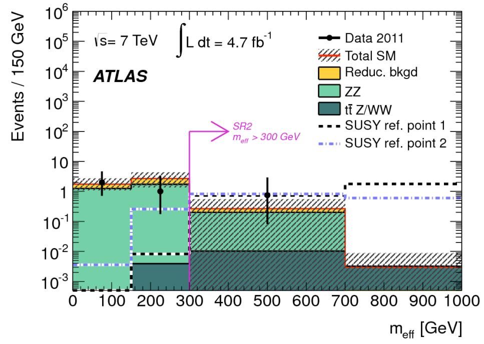
Light stau is LSP in most of parameter space

$$\tilde{\tau}_1 \rightarrow \tau e \mu \nu_e \text{ or } \tilde{\tau}_1 \rightarrow \tau e e \nu_\mu$$

+ RPV 4-leptons

>= 4 leptons (e, m)
No SFOS pairs with mass below 20 GeV
No SFOS pairs within +/- 10 GeV of Z mass

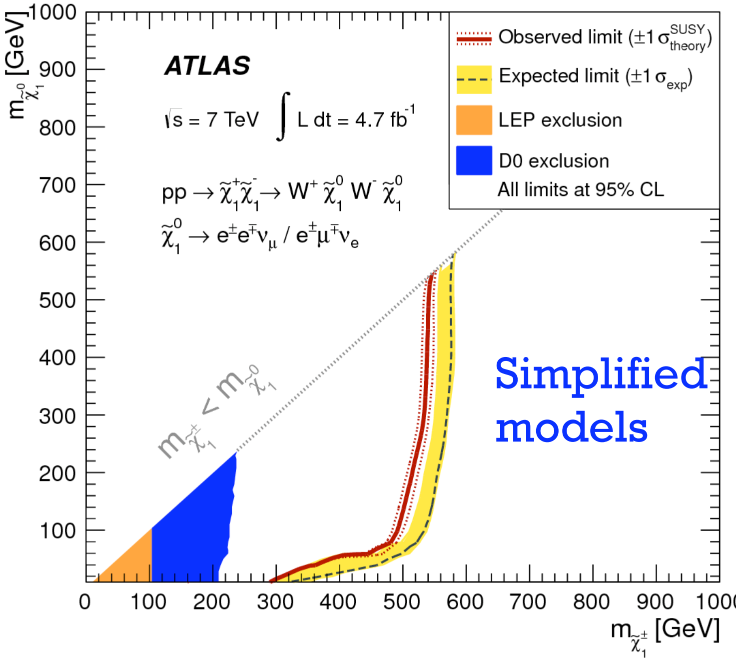


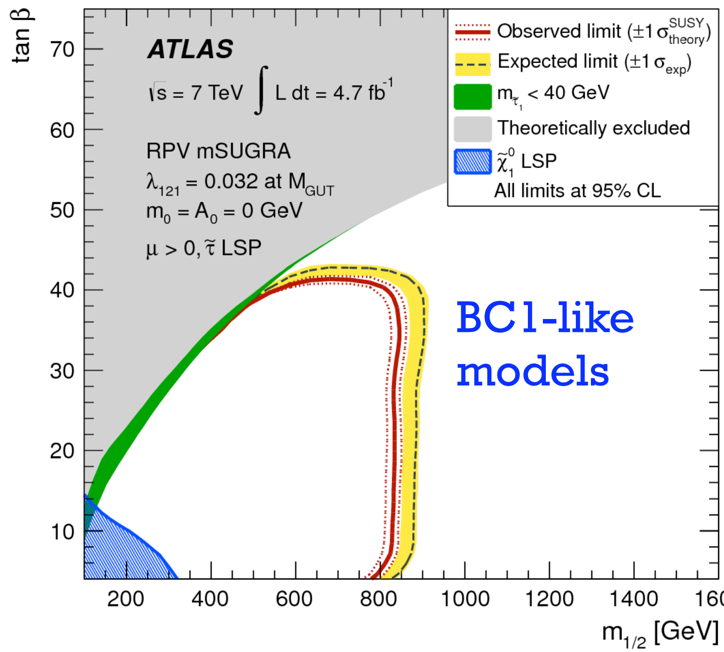


SR1: E_T^{miss} > 50 GeV (missing momentum from neutrinos)

SR2 : m_{eff} > 300 GeV (large multiplicity of high-p_T objects)

$$m_{\rm eff} = E_{\rm T}^{\rm miss} + \sum_{\mu} p_{\rm T}^{\mu} + \sum_{e} E_{\rm T}^{e} + \sum_{j} E_{\rm T}^{j}$$

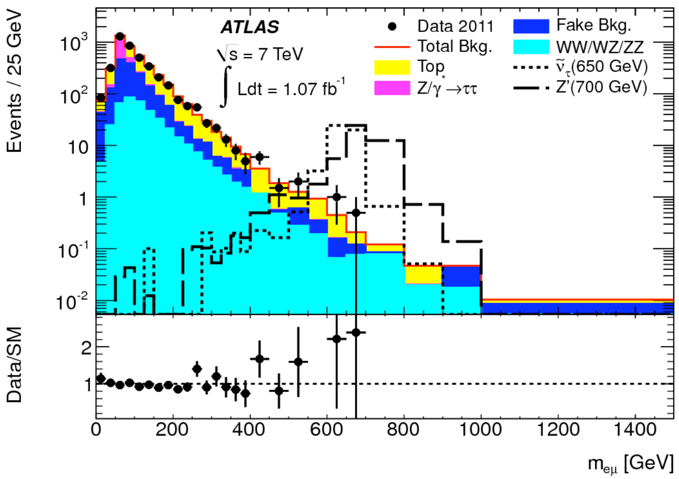




Chargino masses up to 540 GeV excluded for LSP masses above 300GeV

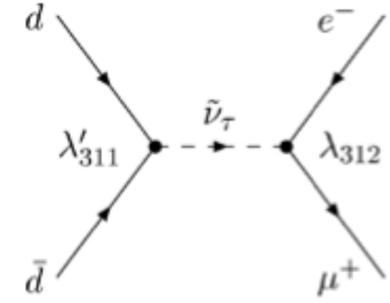
Values of $m_{1/2}$ below 820GeV are excluded when 10 < tan β < 40

+ RPV Scalar Tau Neutrino (eμ resonance)



Search for an excess at high values of the opposite-charge eμ invariant mass spectrum

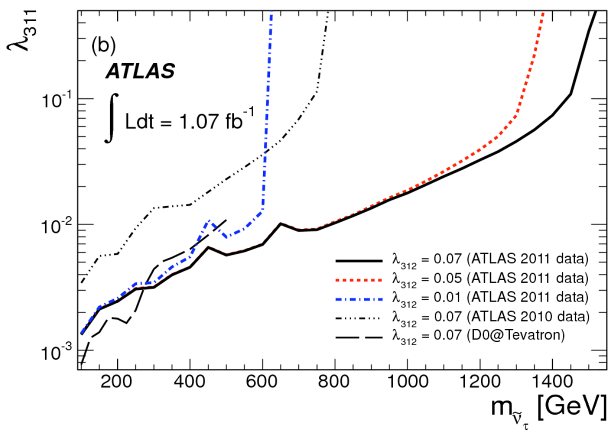
Signal possibly originating from resonant decays of neutral sparticles in RPV SUSY

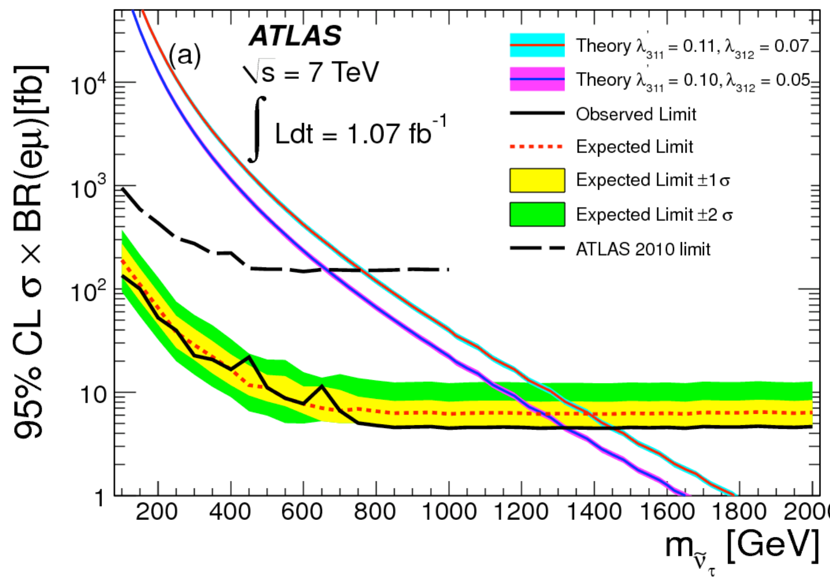


Tau sneutrino = LSP

1.07 fb^{-1}, 7 TeV

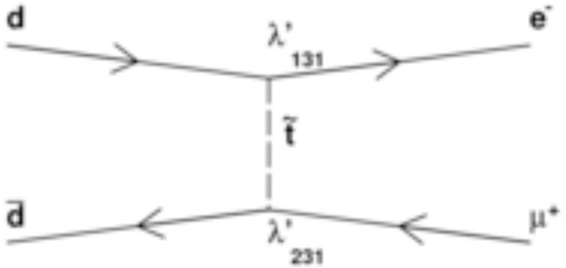
Update in preparation





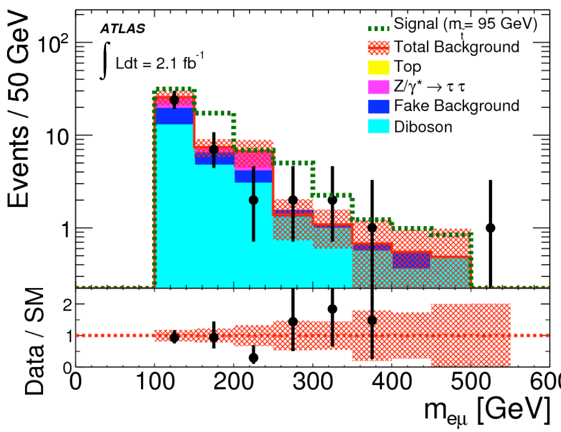
Null result translates into limit on $\sigma \times$ BR and on the coupling constants as a function of the mass of the scalar neutrino

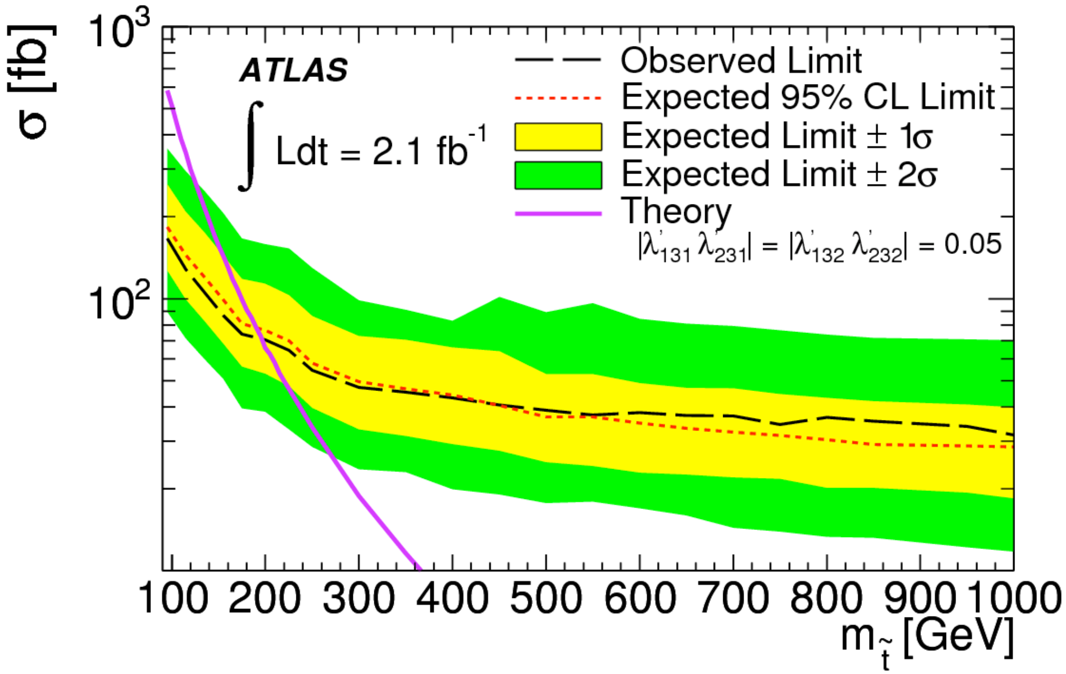
RPV Scalar Top (eμ continuum)



RPV SUSY models also allow for LFV interactions through the t-channel exchange of a scalar quark.

$$d\hat{\sigma}/d\hat{t} = |\lambda'_{131}\lambda'_{231}|^2 \hat{t}^2 / [64 N_c \pi \hat{s}^2 \left(\hat{t} - m^2_{\tilde{t}}\right)^2]$$





A Lot More Results…

…

RPV and Long-Lived Particles

Various possibilities

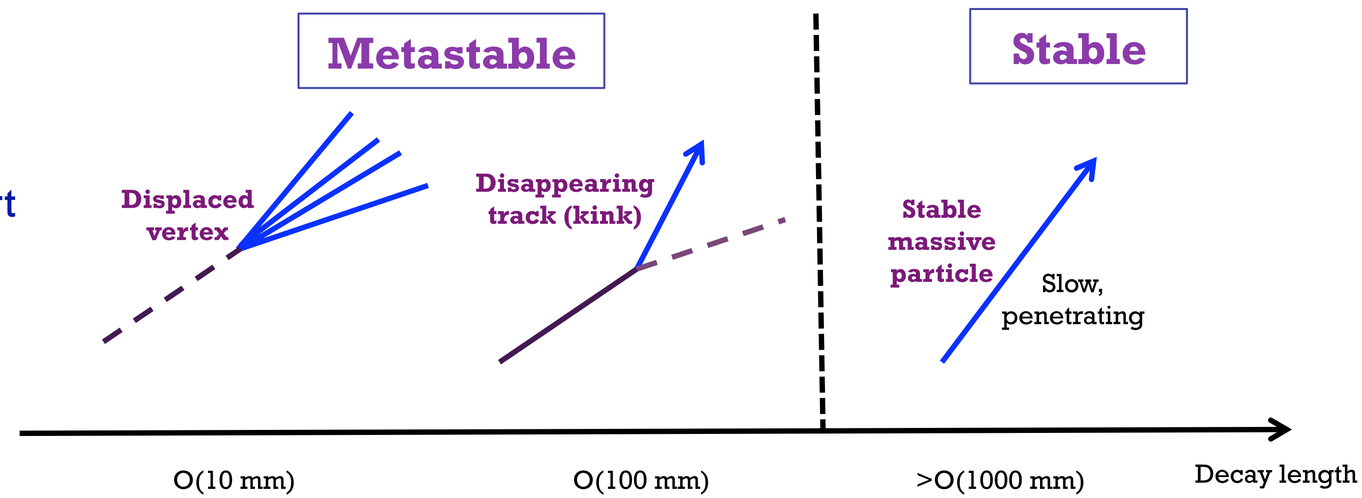
RPV scenarios with $\lambda, \lambda', \lambda'' < 10^{-7}$ → displaced vertex

Low chargino-neutralino mass splitting (~100 MeV) → "kink" from low-p_T π

Long-lived gluino from heavy-squark-mediated decay → R-hadrons

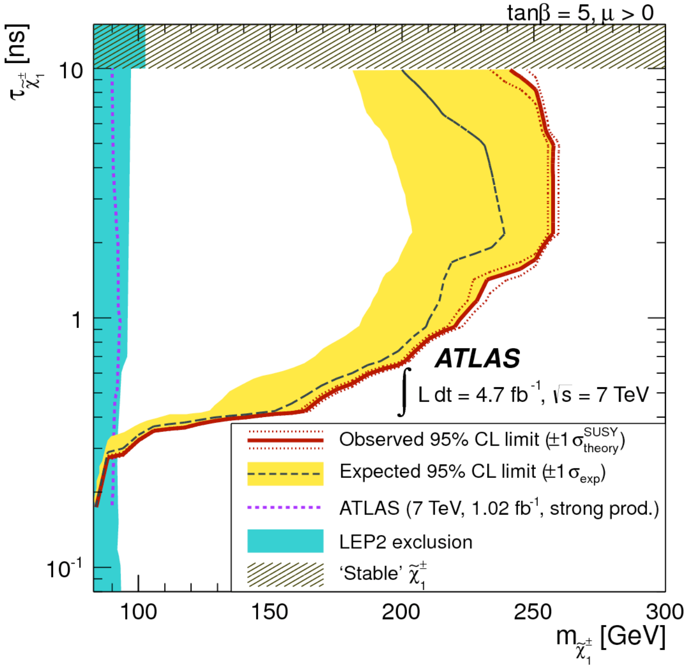
Weak cupling of NLSP to gravitino in GMSB models → stable sleptons

Challenging analyses
Require dedicated effort
(on tracking etc)

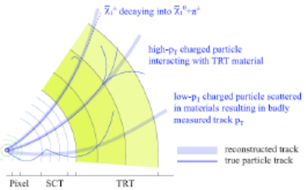


Some results from LL particle searches

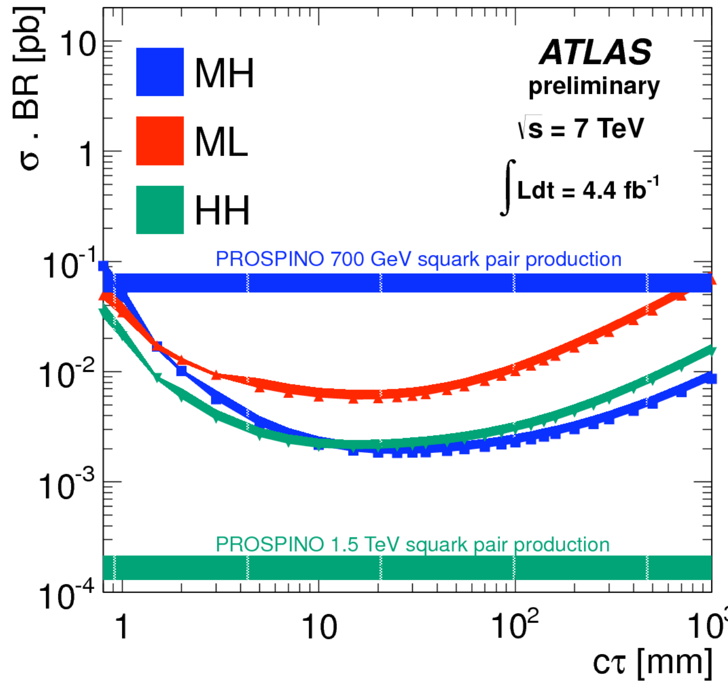
LL AMSB chargino → neutralino + pion



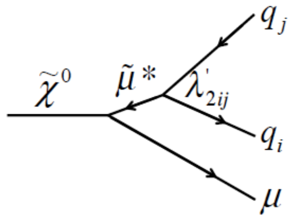
Metastable Chargino

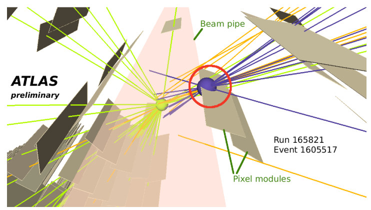


Diplaced mlutitrack vtx with high-p$_T$ muon



Displaced Vertex





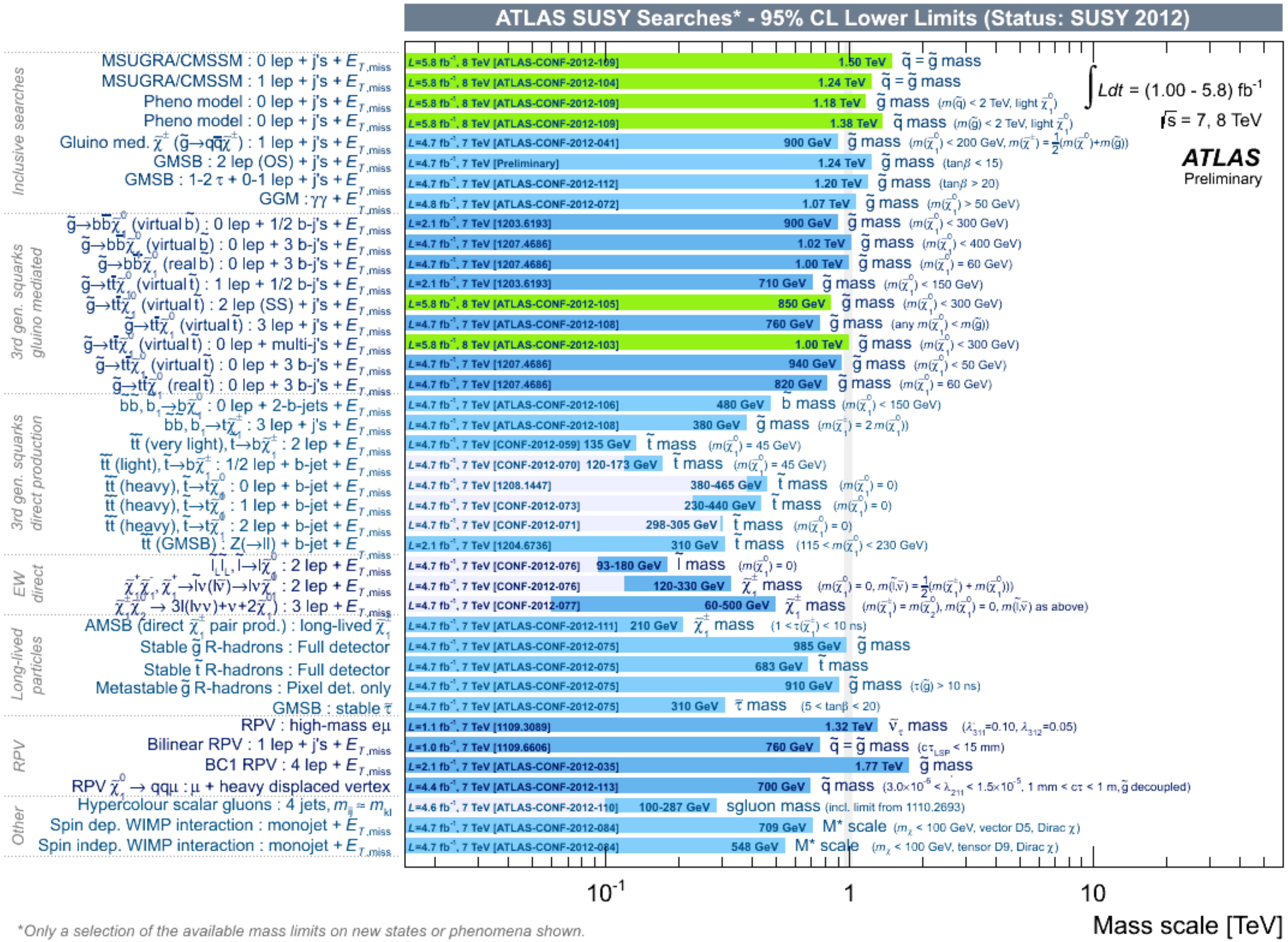
A Lot More Results…

… but…

+

Summary and Conclusions

+ SUSY Searches at ATLAS – Status



*Only a selection of the available mass limits on new states or phenomena shown.
All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

Desperately Searching SUSY (in Every Corner…)

Conclusions

ATLAS has produced an impressive range of results from SUSY searches in 2011 and 2012 collision data

Sadly, no SUSY just yet ☹

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It was not around the corner!!

+ Conclusions

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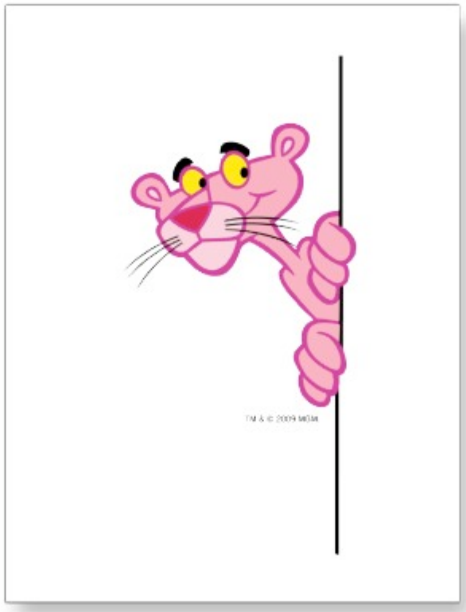
Sadly, no SUSY just yet ☹

It was not around the corner

Plenty of corners still to explore…



Conclusions

ATLAS has produced an impressive range of results from SUSY searches in 2010 and 2011 collision data

Sadly, no SUSY just yet ☹

Plenty of corners still to explore…

… and plenty of data too!

Can't We See the Wood for the Trees ??