Inclusive searches for supersymmetric signatures with the ATLAS detector

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on behalf of the ATLAS collaboration

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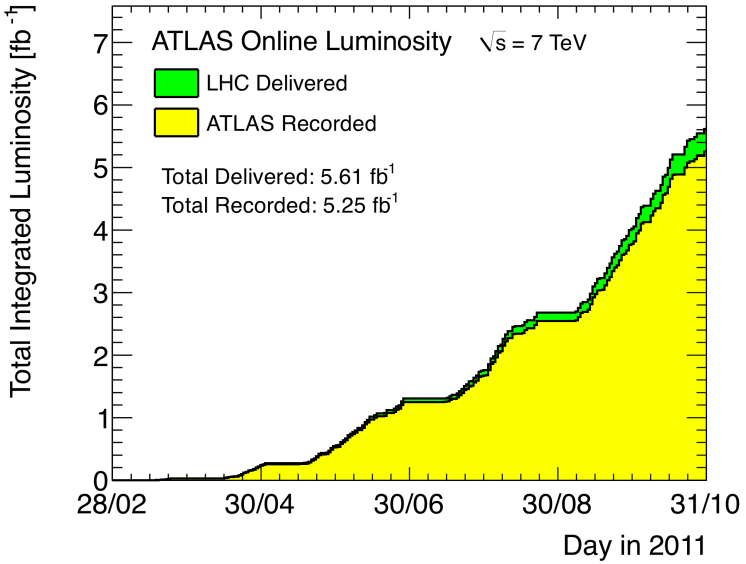
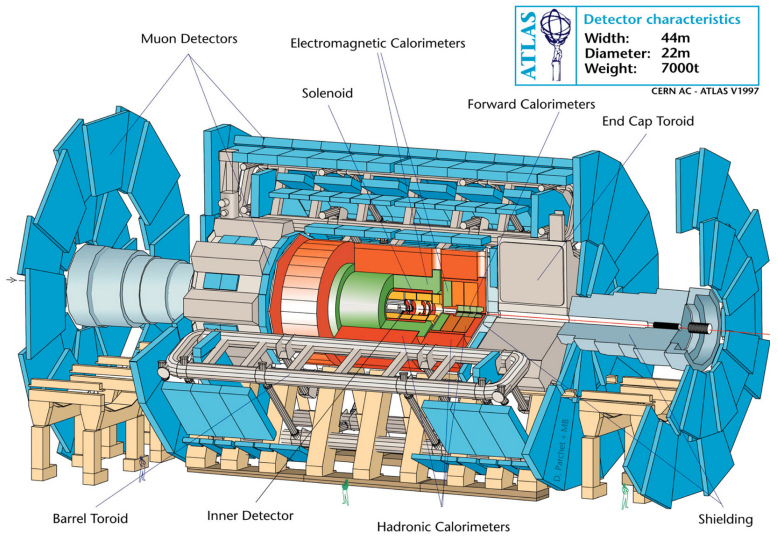
ATLAS and the LHC

LHC
-Very successful run on 2011
-pp collisions at $\sqrt{s}$=7TeV,
-Delivered 5.6fb^{-1}
-Atlas recorded 5.25fb^{-1}



ATLAS
-General propose experiment
-2T Solenoid magnet surrounds ID
-Toroid magnet supporting the MS
-Tracking $|\eta| < 2.5$
-Muon Reconstruction $|\eta| < 2.7$
-Calorimetry $|\eta| < 4.9$
-Three Level Trigger system

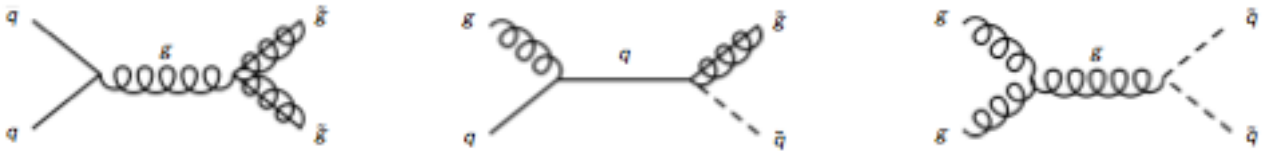


Supersymmetry (SUSY)

- Well motivated extension to the Standard Model
  - Solves the hierarchy problem by postulating a symmetry between fermions and bosons:
    - Every Fermion (Boson) has a Bosonic (Fermionic) twin
    - Quadratic divergences cancel
  - If exists must be broken $m_{susy} > m_{SM}$
    - Hierarchy problem solvable and GUT for $m_{BSM} \sim O(1TeV)$
  - R-Parity: LSP is stable and WIMP
    - $\not{E}_T$ in event, no mass peaks → search for SUSY in tails of distributions
    - SUSY particles created in pairs
  - Most General Broken SUSY ~ O(100) parameters
    - SUSY models - reduce the number of free parameters

Outlook

- Searches with integrated luminosity up to 4.7fb^{-1}
- jets + $\not{E}_T$ + X based searches



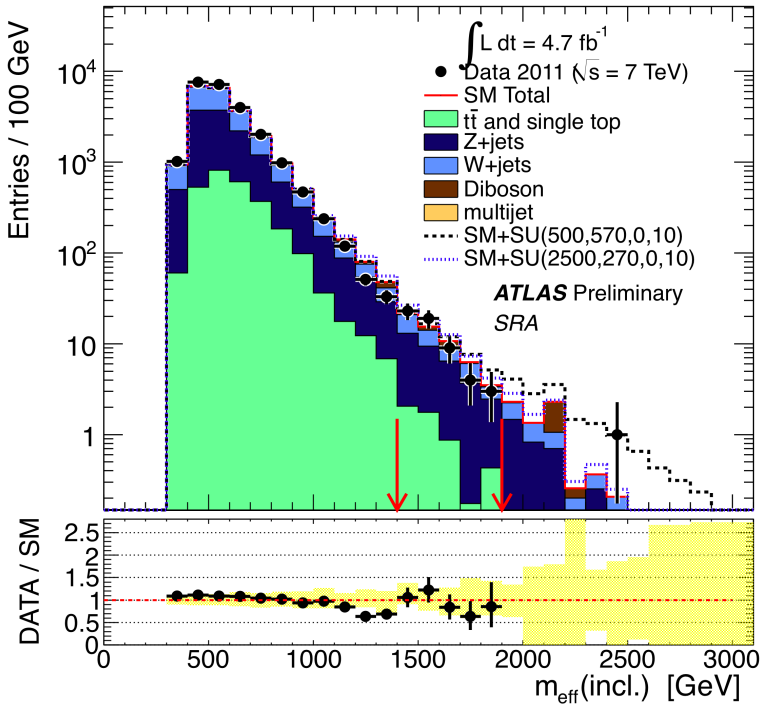
  - Strong production of SUSY decaying through long chains → Jets
  - Decay chains particles end in neutral LSP → $\not{E}_T$
- SM Decay Products of SUSY particles (GMSB)
  - In some models the LSP is the gravitino
  - Phenomenology is dominated by the NLSP
  - NLSP decays to its SM partner
- Search for the SUSY particle itself (AMSB)
  - In some models (mass degeneracy or small coupling) SUSY particles live long and decay outside the interaction region.

Search with ≥ 2-6 jets + $\not{E}_T$

performed with 4.7fb^{-1}

ATLAS-CONF-2012-033

- Production of $\tilde{g}\tilde{g}$,$\tilde{q}\tilde{q}$, $\tilde{q}\tilde{g}$
  - $\tilde{g}\rightarrow qq\tilde{X}_0$ and $\tilde{q}\rightarrow q\tilde{X}_0$
- Selection
  - Lepton veto (avoid overlap with 1L analysis)
  - 2-6 jets
  - $\not{E}_T$ > 160 GeV
  - $\Delta\Phi(E_T, \text{jet})_{min}$ reject multi jet bkg.
- 5- Signal Regions , 11- Channels
  - SRs based on N_{jet}
  - Channels based on SR + m_{eff} (incl.)
- Background
  - Fake $\not{E}_T$ and Z(νν) from data
  - CR extrapolated to SR using MC



Backgrounds and Control Regions

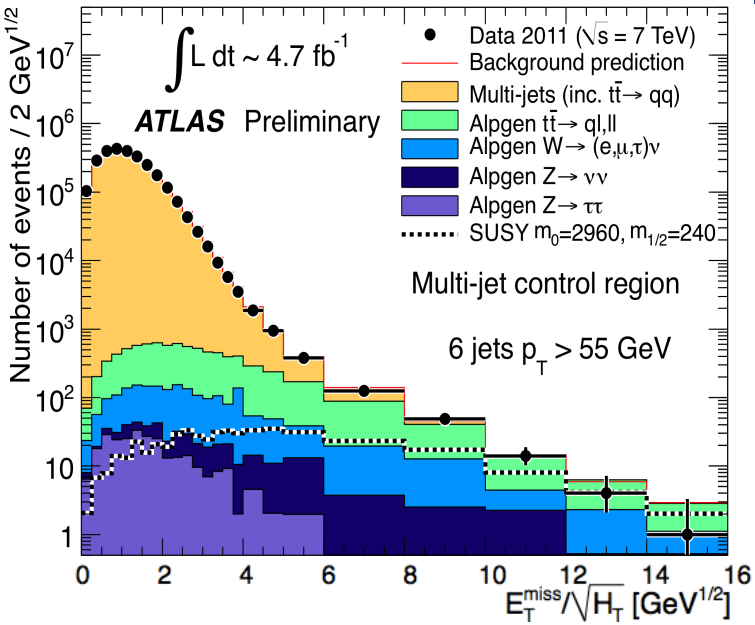
SR Background	CR process	CR selection
$Z(\rightarrow \nu\nu)$+jets	γ+jets	Isolated photon
$Z(\rightarrow \nu\nu)$+jets	$Z(\rightarrow \ell\ell)$+jets	$\lvert m(\ell,\ell) - m(Z)\rvert < 25$ GeV
Multi-jets	Multi-jets	Reversed $\Delta\phi(j_i, E_T^{miss})$ cut
$W(\rightarrow \ell\nu)$+jets	$W(\rightarrow \ell\nu)$+jets	30 GeV $< m_T(\ell, E_T^{miss}) <$ 100 GeV, b-veto
$t\bar{t}$ and single-t	$t\bar{t} \rightarrow bbqq'\ell\nu$	30 GeV $< m_T(\ell, E_T^{miss}) <$ 100 GeV, b-tag

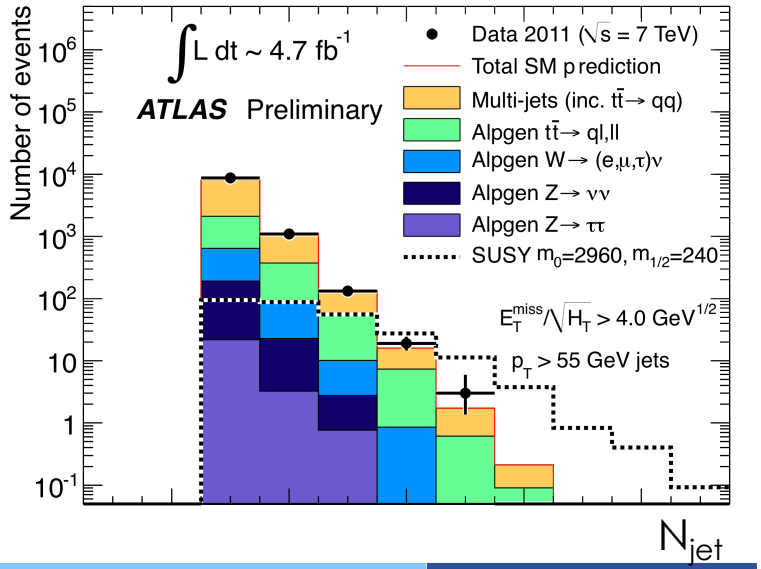
Search with ≥ 6-9 jets + $\not{E}_T$

performed with 4.7fb^{-1}

ATLAS-CONF-2012-037

- $\tilde{g}$ decay can produce many jets e.g. $\tilde{g} \rightarrow t\bar{t}X_0$, long decay chains (mSUGRA)
- Trigger: Multi-jet based instead of $\not{E}_T$
  - small overlap with 2-6j analysis
- Selection
  - 6-9 jets , Lepton Veto
  - $\not{E}_T$ significance: $\not{E}_T / \sqrt{H_T} > 4$ GeV$^{1/2}$
- Multi Jet Background
  - Shape of $\not{E}_T / \sqrt{H_T}$ independent on N_{jet}
  - Extract shape from $N_{Jet}(CR) < N_{jet}(SR)$
  - Normalisation $N_{jet}(SR)$ - $\not{E}_T / \sqrt{H_T} < 1.5$ GeV$^{1/2}$
- Leptonic Background (W+jets, Z+jets, tt)
  - Sub-dominant, from MC, normalised according to CR and then validated in VR



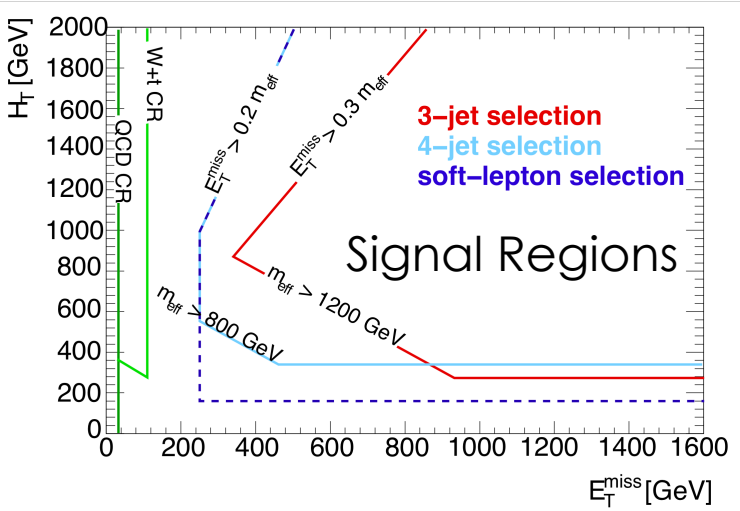


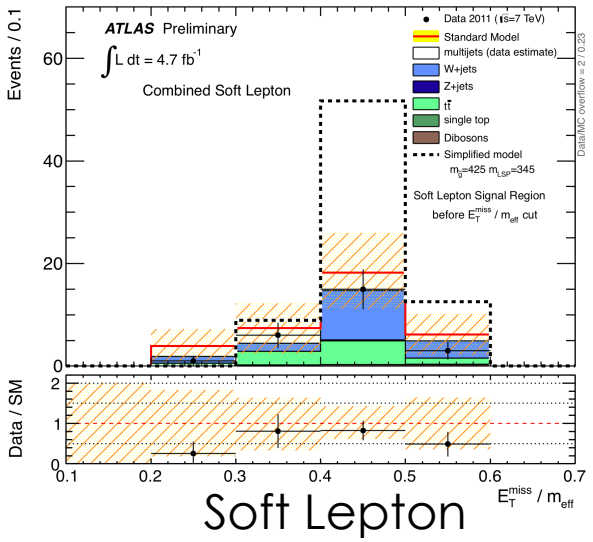
Search with 1L + jets + $\not{E}_T$

performed with 4.7fb^{-1}

ATLAS-CONF-2012-041

- Isolated Lepton from SUSY chain-decay
  - Clean Signature
  - Soft Lepton analysis more sensitive where neutralino and gluino are close in mass (20-30 times)
- Selection
  - Isolated Lepton (e,μ)
  - Signal Regions
    - N_{jet}, $\not{E}_T$, m_{eff}, $\not{E}_T$ / m_{eff}
- Backgrounds
  - tt, W+jets, Z+jets, single t, di-boson
  - Simultaneous Profile Likelihood with nuisance parameters
    - Determines parts of theoretical uncertainties from data in the TFs





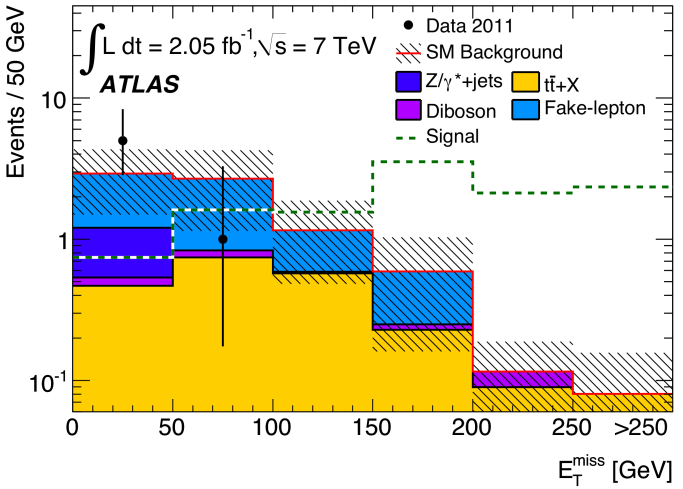
Search with 2L (s.s.)+ jets + $\not{E}_T$

performed with 2.05fb^{-1}

arXiv: *hep-ex-1203.5764*

- gluino is majorana fermion
  - Equal probability to produce SS and OS leptons
  - SS clean signature
  - Enhances sensitivity in the region

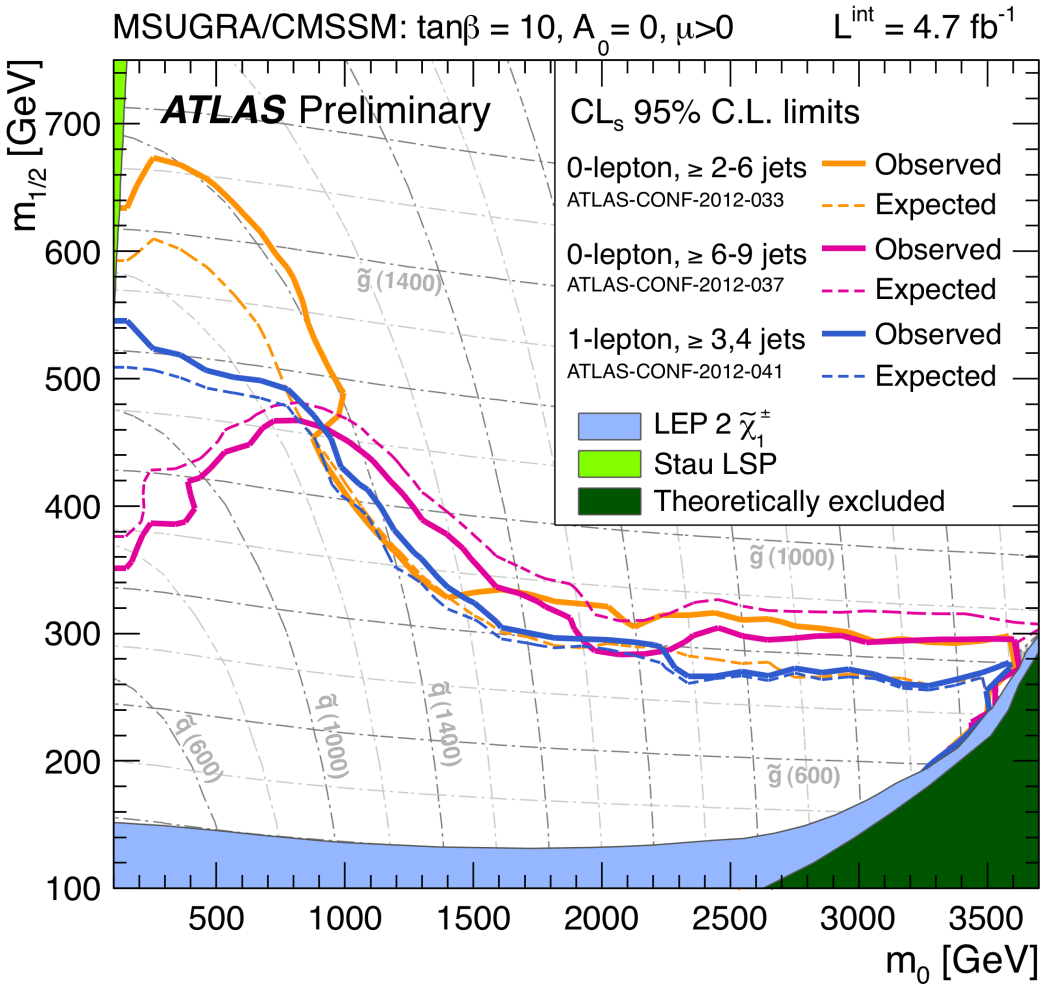
    $m_{\tilde{g}} \sim m_t + m_t + m_{X0}$
- Selection
  - Two highest p_T leptons with SS
  - $N_{jet} \geq 4$
  - $\not{E}_T > 150$ GeV
  - and m_T (SR2)
- tt+X, diboson Backgrounds
- "Fake Lepton" Backgrounds
  - misidentified jet
  - lepton from b or c
- Charge Misidentification Backgrounds
  - electrons



	SR1	SR2
$t\bar{t}$ +X	0.37 ± 0.26	0.21 ± 0.16
Diboson	0.05 ± 0.02	0.02 ± 0.01
Fake-lepton	0.34 ± 0.20	< 0.17
Charge mis-ID	0.08 ± 0.01	0.039 ± 0.007
Total SM	0.84 ± 0.33	0.27 ± 0.24
Observed	0	0

mSUGRA limits with jets + $\not{E}_T$

performed with 4.7fb^{-1}



mSUGRA limits with jets + $\not{E}_T$

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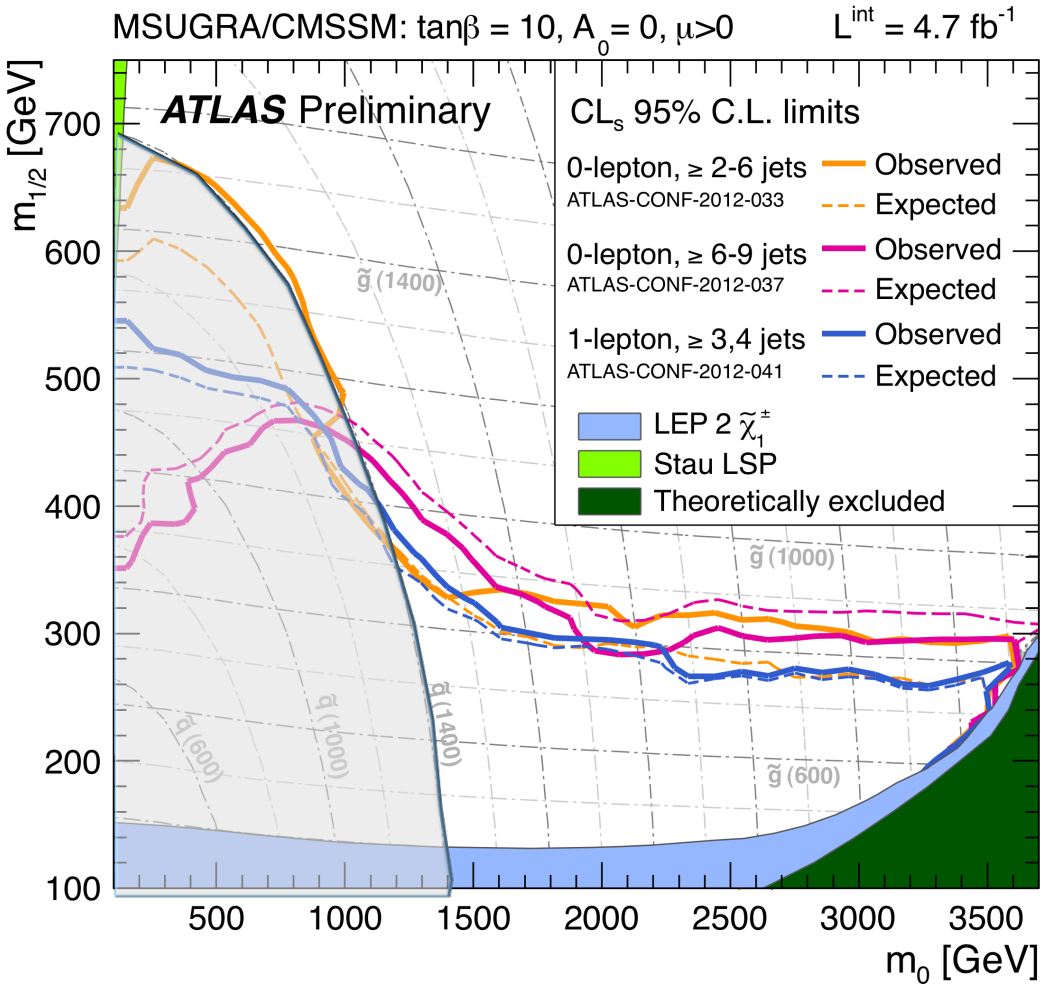
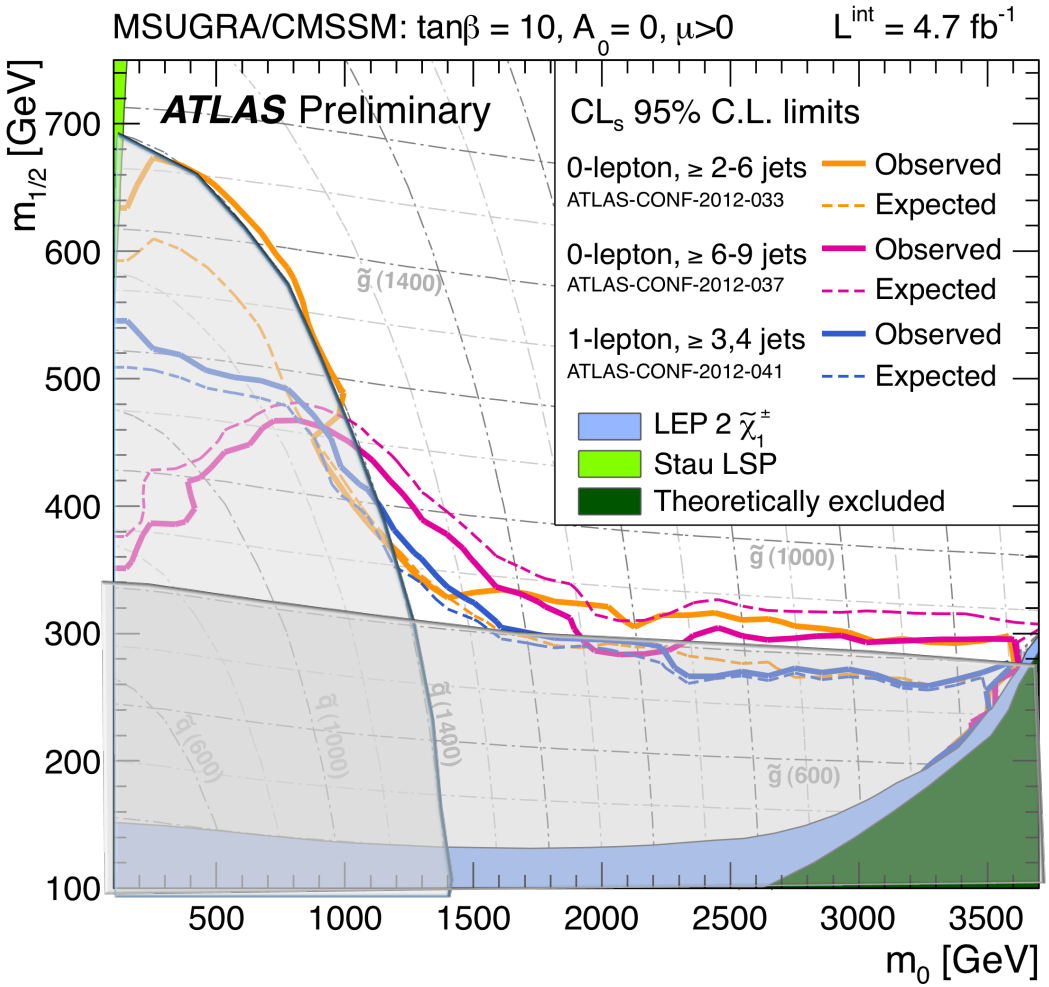


$m_{squark} > 1.4$ TeV

mSUGRA limits with jets + $\not{E}_T$

performed with 4.7fb^{-1}

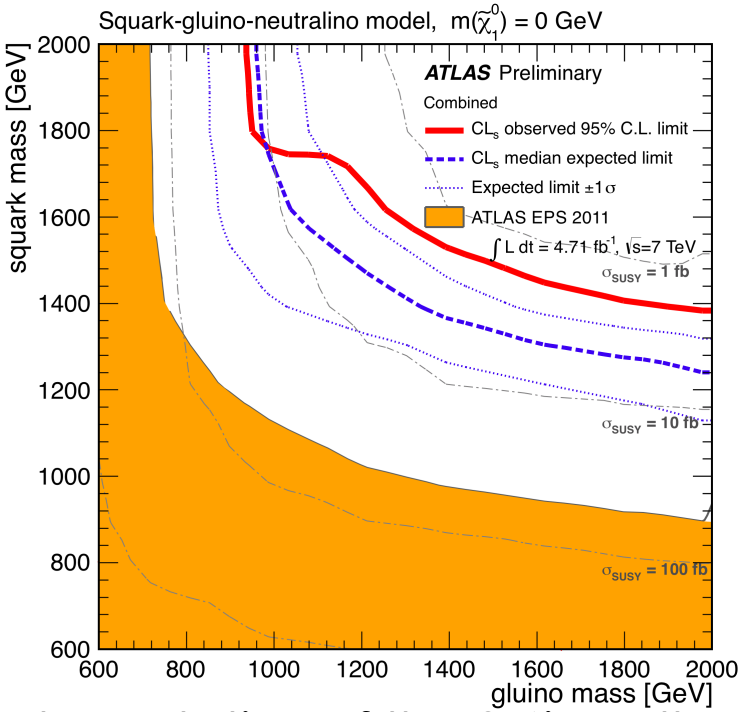


$m_{squark} > 1.4$ TeV and $m_{gluino} > 800$ GeV

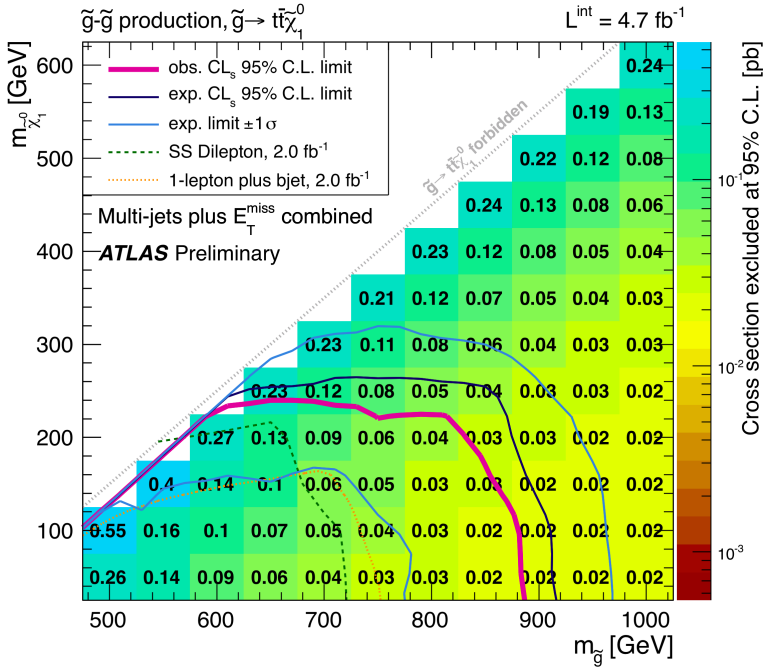
Simplified models - limits 0L + jets + $\not{E}_T$

performed with 4.7fb^{-1}

Models with ad-hoc particle content – new interpretation of results



Interpretation of the 2-6j result



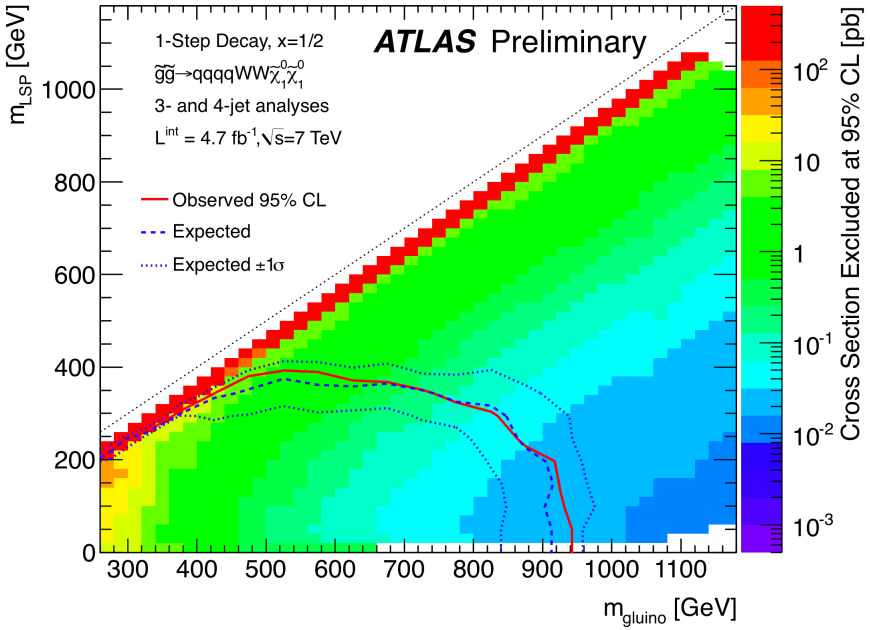
Interpretation of the 6-9j result

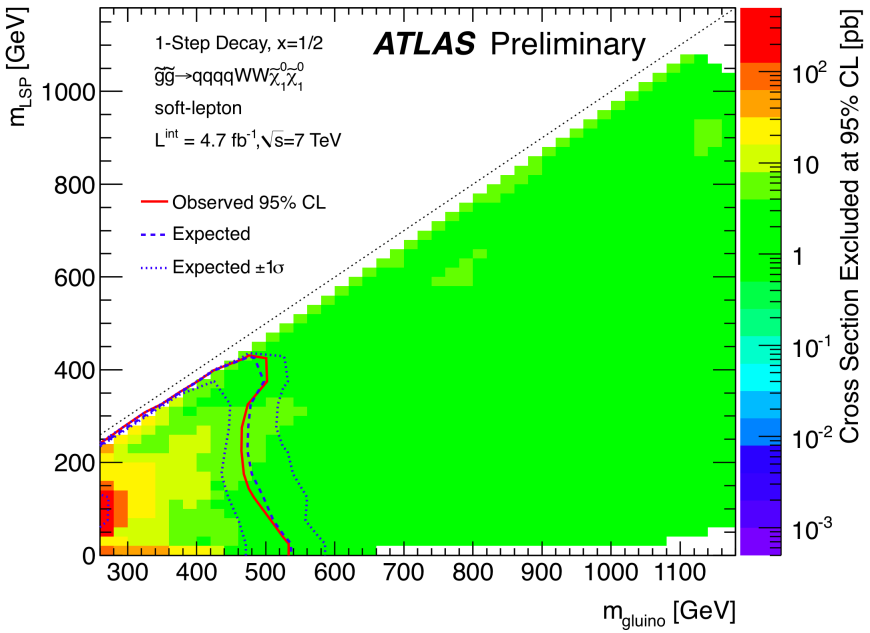
$m(\tilde{X}_0) = 0$
2nd generation squarks as $m_{\tilde{q}}$
3rd generation squarks at 5TeV
Direct decays to jets+neutralinos

$\tilde{g}\tilde{g}$ pair production
$\tilde{g}\to t\bar{t}\tilde{X}_0$ with probability 1

Simplified models limits – 1L + jets + $\not{E}_T$

performed with 4.7fb^{-1}





Simplified model:
$\tilde{g}\tilde{g}$ production
$\tilde{g}\to qq\tilde{X}^{+}\to qqW^{+}\tilde{X}_0$

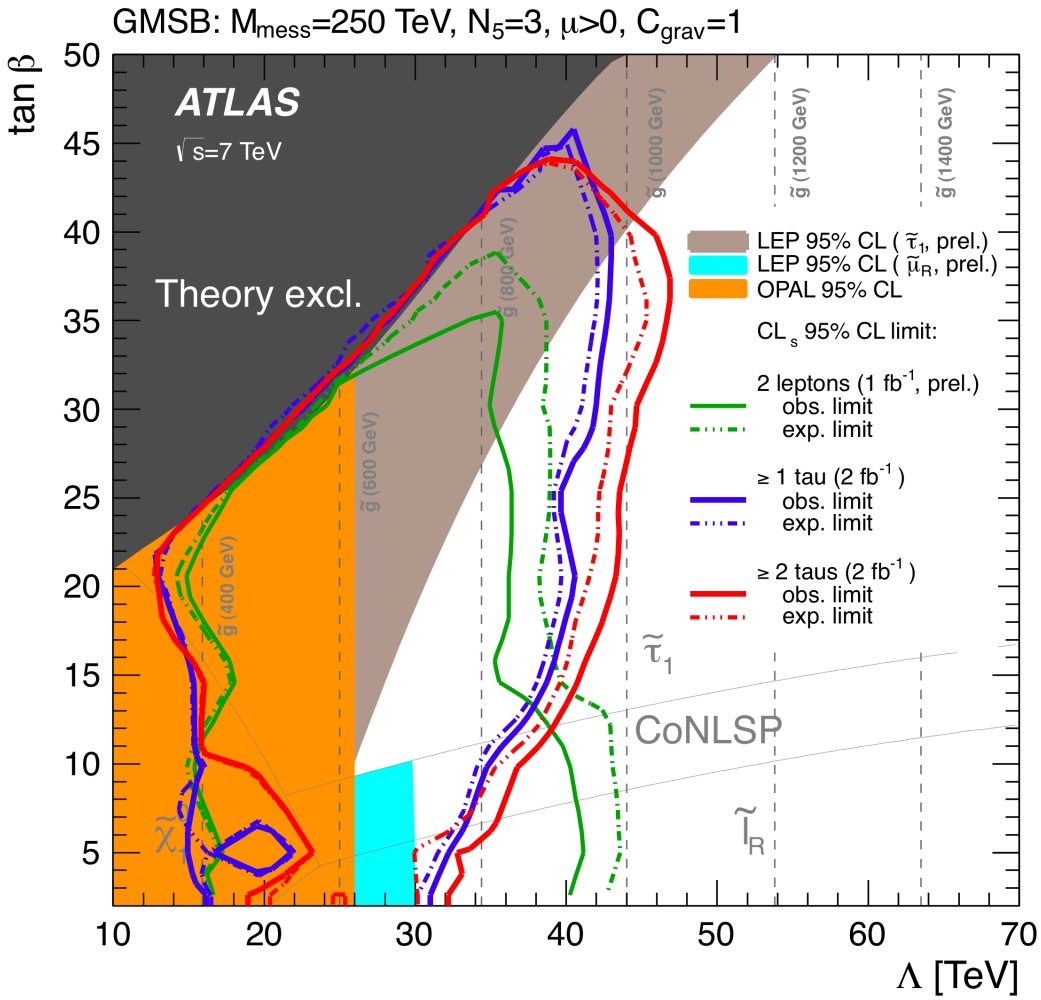
Soft Lepton –20-30 times more sensitive in the m_{LSP}~m_{gluino} region

m_{gluino}> 900 GeV for m_{LSP}< 200 GeV and $m_{chargino}$= ½ (m_{gluino}- m_{LSP})

Search with ≥ 1,2 τ + jets + $\not{E}_T$ (GMSB)

performed with 2.05fb^{-1}

- GMSB
  - LSP is the gravitino ($\tilde{G}$)
  - NLSP can be $\tilde{X}_0$, $\tilde{g}$, $\tilde{l}$, $\tilde{\tau}$
  - $\tilde{\tau} \rightarrow G\tau$
- Selection
  - Hadronic τ based on BDT
  - SR $\not{E}_T$, m_{eff}, $m_T(\not{E}_T, \tau)$
- Backgrounds
  - W+jet, Z+jets and tt
- 1 ≥ τ: arXiv:1204.3852
- 2 ≥ τ: arXiv:1203.6580

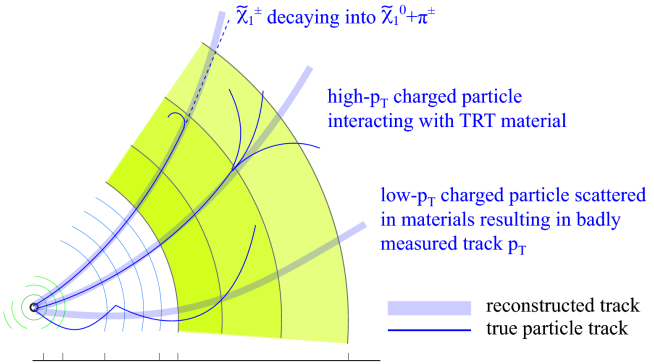


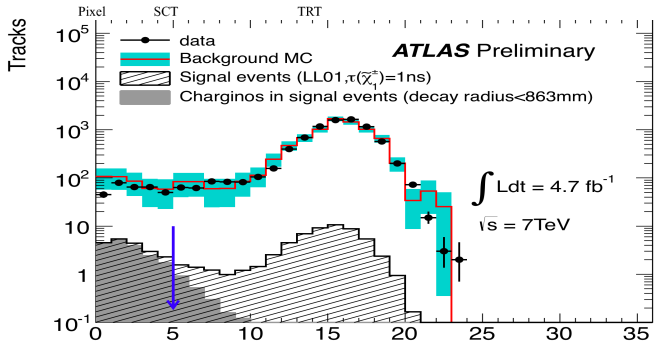
Long Lived Chargino (AMSB)

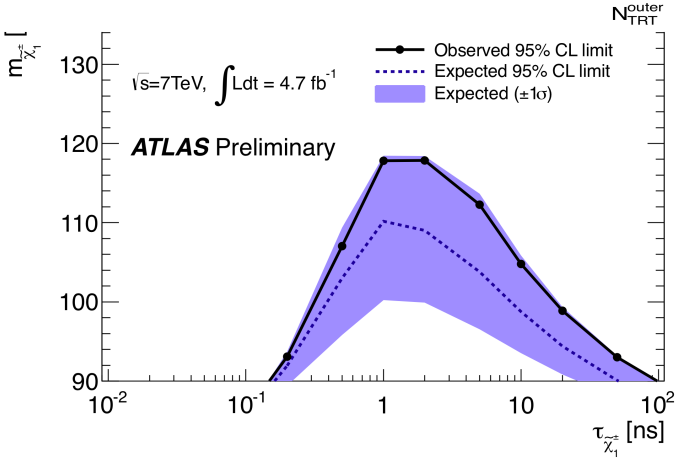
performed with 4.7fb^{-1}

ATLAS-CONF-2012-034

- In AMSB models
  - Chargino can live long enough to be detected directly
- Direct search for a chargino that decays in the inner detector
- Selection
  - Event Selection: $\not{E}_T$, N_{jet}, Lepton Veto
  - Candidate Selection:
    - Good quality track in the before the TRT
    - N_{hits}< 5 for outer TRT module
- Backgrounds
  - High p_T interacting track
  - Bad Track

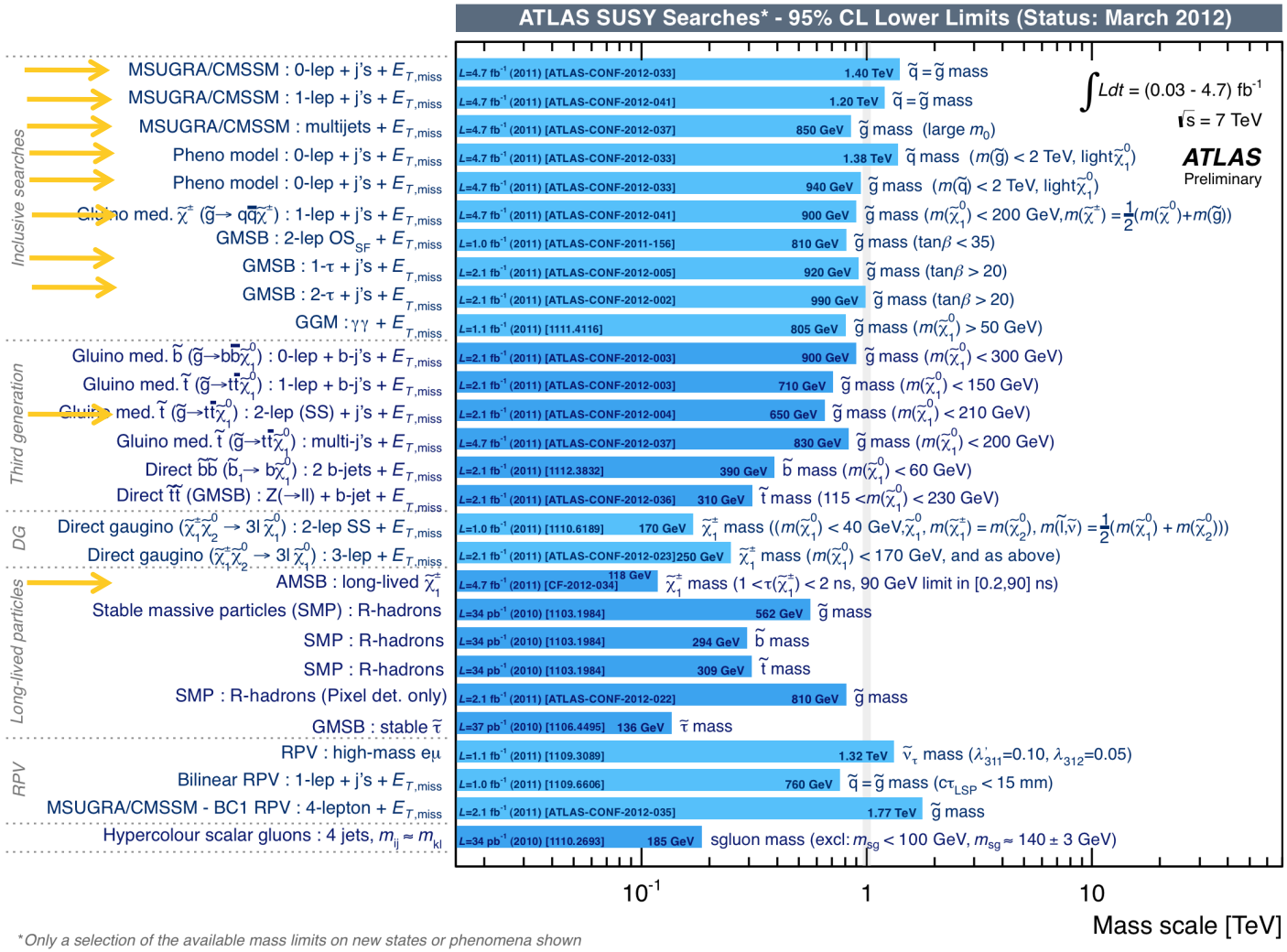






ATLAS SUSY searches

~1TeV No hint of new physics :-(



*Only a selection of the available mass limits on new states or phenomena shown

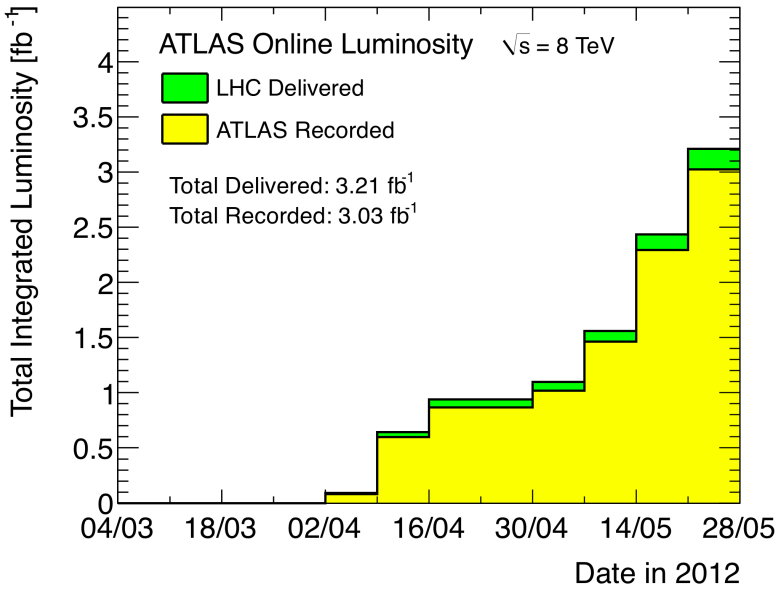
Summary

-No evidence of SUSY has been found :-(

-m_{SUSY} > 1TeV for strongly interacting paticles

-Thriving SUSY community in ATLAS

-Many new results soon



-Exciting times!

-Already recorded more than half the integrated luminosity in 2011 but with √s=8TeV

-Excited for the possibility to find some BSM physics