Supersymmetry searches with the ATLAS detector

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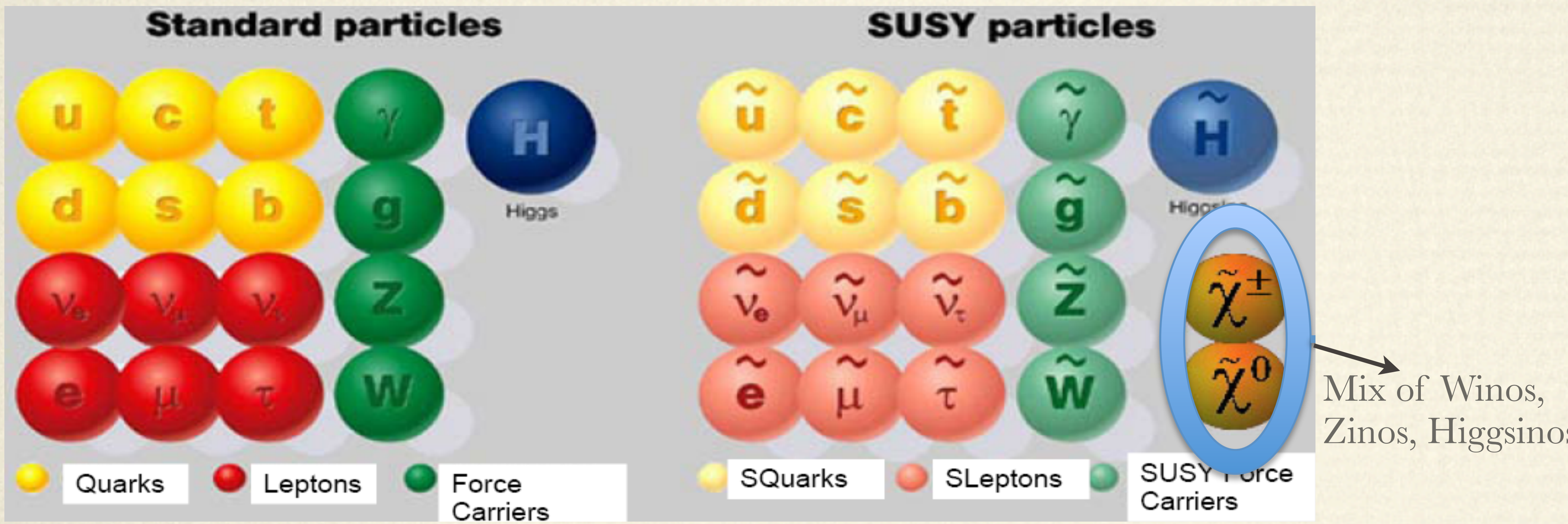
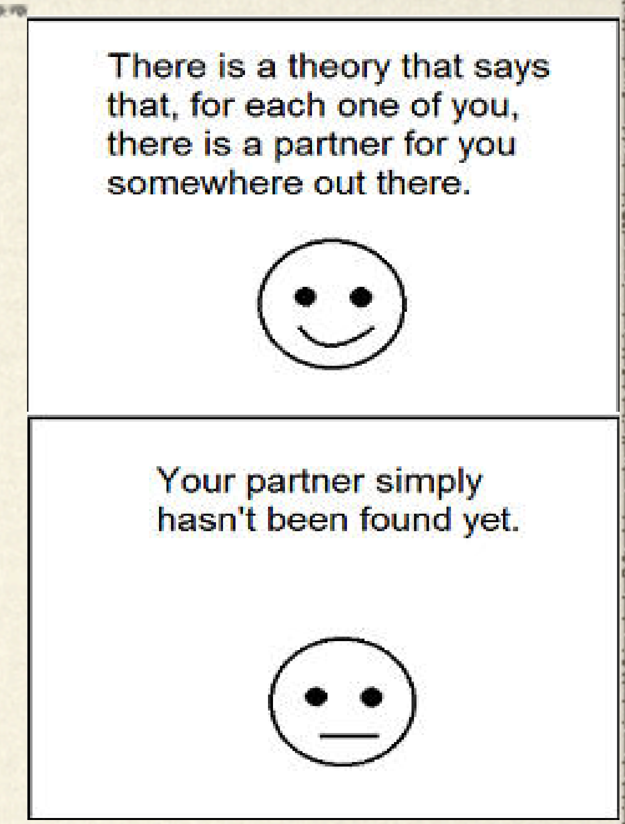
On behalf of the ATLAS collaboration

What we are looking for



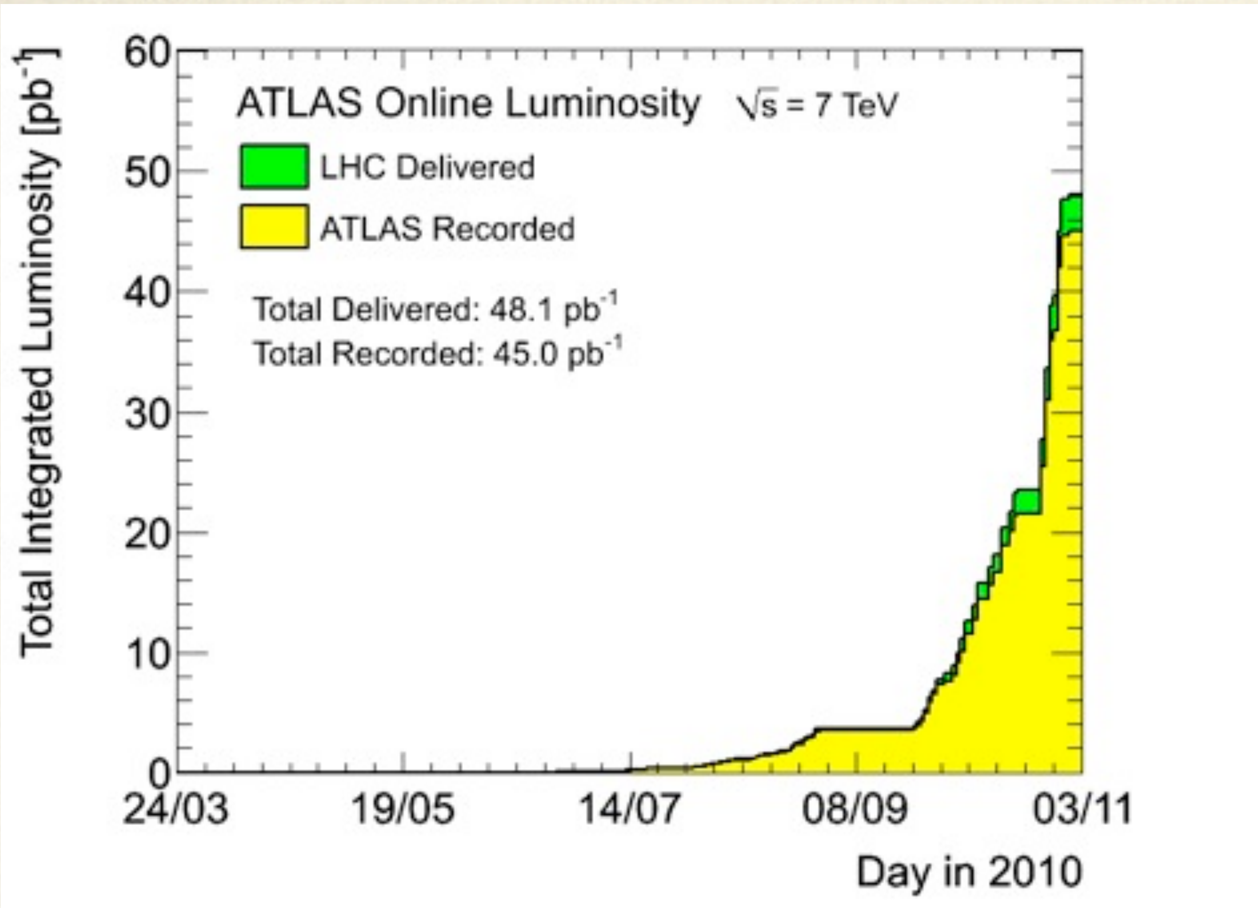


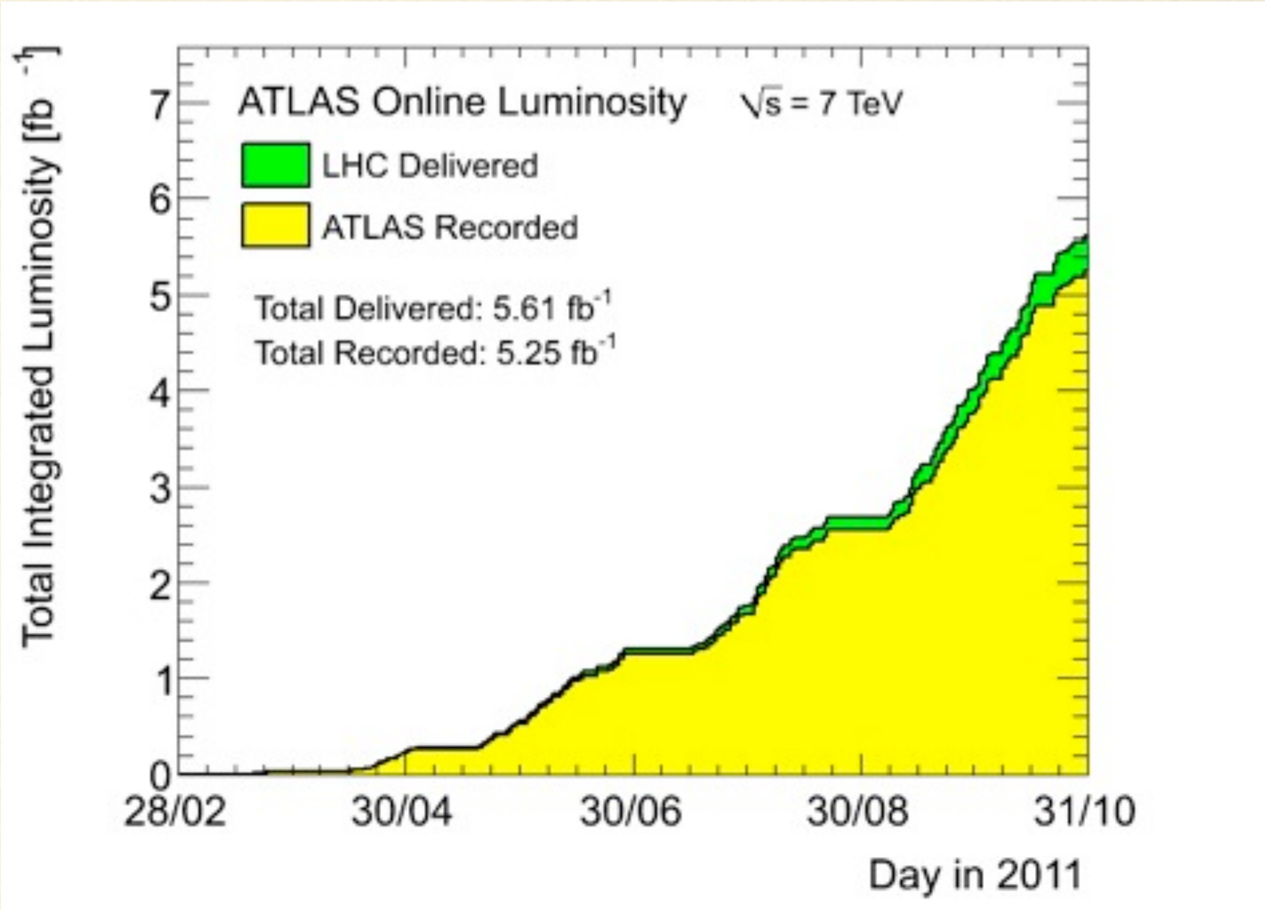
- The theory tells us there is a partner for every SM particle
- We don't know the symmetry breaking mechanism and thus the mass spectrum. Specific models with unproven assumptions on symmetry breaking predict mass spectra with few free parameters
- Naturalness: stop "light" as it must cancel the top loop to Higgs mass. Constraints on first two generations squarks much looser unless flavour universal symmetry breaking
- Dark Matter: lightest particle neutral and weakly interacting
- LEP: slepton, squarks, charginos heavier than about 100 GeV. Tevatron: first generation squarks and gluinos heavier than roughly 400 GeV (unless nearly degenerate with LSP)

What we are looking for

- For ATLAS, **first priority is to discover any signal we are sensitive to**
  - Look into all final states where there might be something.
  - Do not tune cuts on any particular simulated signal, but try to have complementary signal selections which are sensitive to the various possibilities (short or long decay chains, small or large mass splittings, etc.)
  - We are always open to suggestions for promising signatures we are overlooking! (but be patient, it might take a while before we come back with results)
- **In case of negative results, we place exclusion limits** in various forms
  - On cross section times acceptance times selection efficiency ($\sigma A\epsilon$). Model independent but need a detector simulation for comparison with model predictions
  - On constrained models, like mSUGRA
  - On particles masses for toy models with the most relevant particles and decays for that channel, and on production cross section as a function of the particle masses

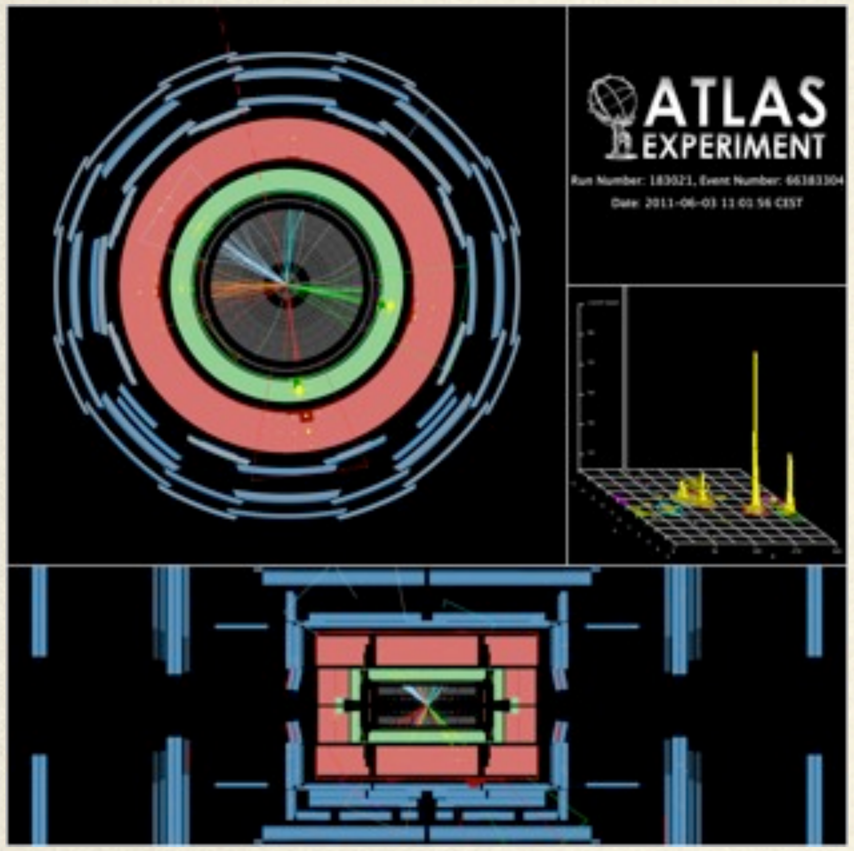
Our data



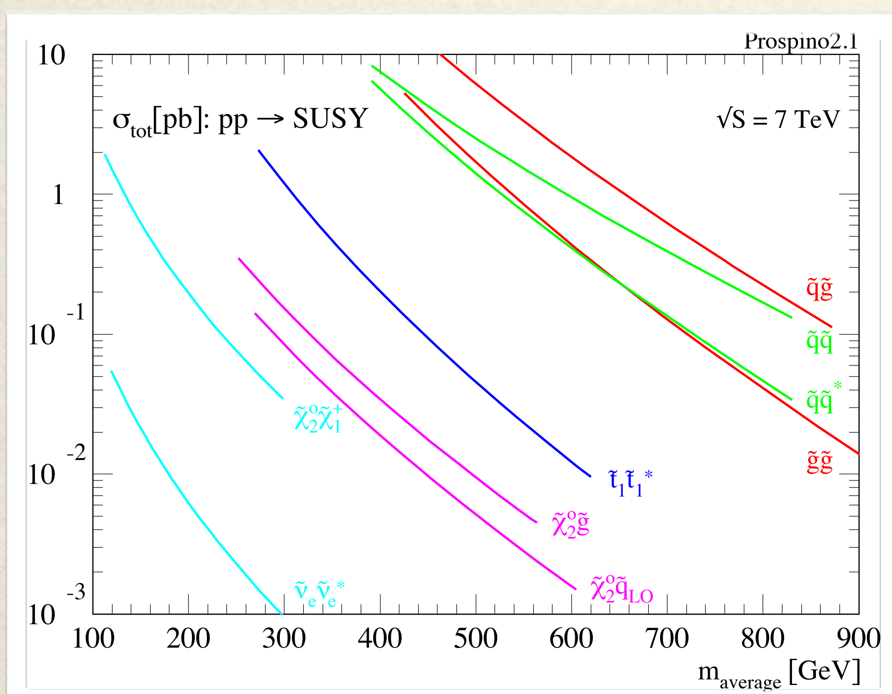


- Results presented here are based on either the full 2010 dataset (35 pb^{-1} after data quality selections) or up to 1.3 fb^{-1} of 2011 data.
- Analysis of the full 2011 dataset (~5 fb^{-1}) in progress - stay tuned!

Jets+E_T^{Miss}+X searches



- The first searches have been focused on the strong production of first generation squarks and gluinos: highest cross section process at LHC, sensitivity well beyond Tevatron limits already with 35 pb^{-1}
- If R-parity conservation, signature is jets+E_T^{Miss}+"X", where X depends on the mass spectrum and available decays
- Each X defines a search channel



Shown here:

EtMiss+jets+0 leptons

EtMiss+jets+1 lepton

EtMiss+jets+2leptons

EtMiss+bjets+0lepton

EtMiss+bjets+1lepton

EtMiss+2 photons

General strategy

- Choose sets of selection cuts (signal regions, SR) optimizing the expected discovery significance for different possible signals

- Choose control regions (CR) to control the main backgrounds, derive a solid prediction of the backround rate in the SRs

Typical background estimate strategy

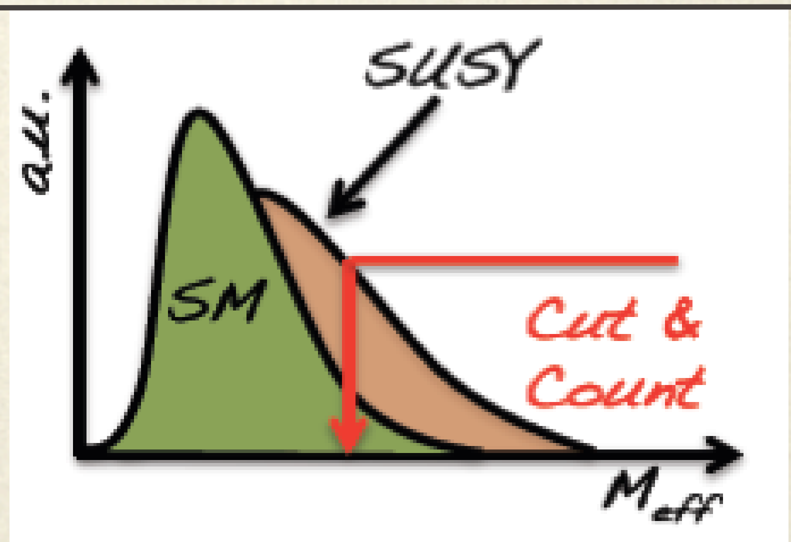
CR → **Transfer factor (TF)** → **SR**

Kinematically close to SR
Good statistics
Good purity of targeted background

TF = N(SR,proc)/N(CR,proc)
- **Uncertainties partially cancel in the ratio**
- **Derived from additional measurements in data (multijets), or from MC**
- **If from MC, theoretical uncertainties (scale, PDF, choice of generator, etc.) taken into account**

- Look in the SRs, compare observed and expected rates

- All the limits I will show are obtained with CLs.



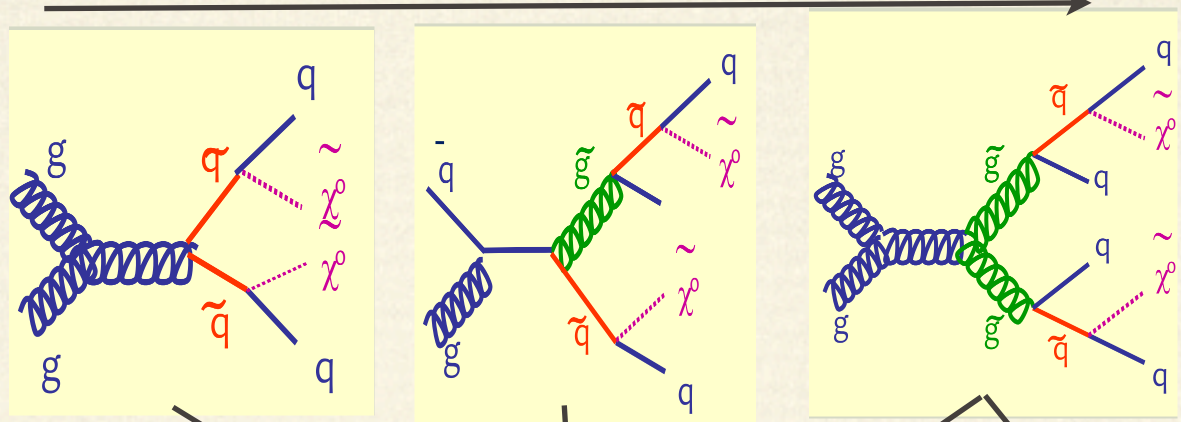
1.04 fb^{-1}

arXiv:1109.6572
submitted to PLB

E_T^{Miss}+ (≥2-4)jets+0 leptons signal selections

Targeting the strong production of squark and/or gluinos decaying into SM particles and a neutralino

Increasing jet multiplicity

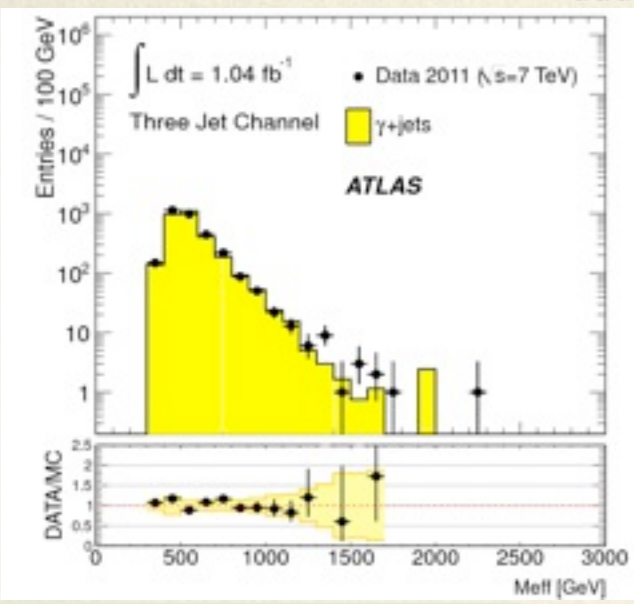


	Signal Region	≥ 2-jet	≥ 3-jet	≥ 4-jet	High mass
Driven by trigger	E_T^{miss}	> 130	> 130	> 130	> 130
	Leading jet p_T	> 130	> 130	> 130	> 130
Defines the channel	Second jet p_T	> 40	> 40	> 40	> 80
	Third jet p_T	–	> 40	> 40	> 80
	Fourth jet p_T	–	–	> 40	> 80
Instrumental background (multi-jet) rejection	$\Delta\phi(\text{jet}, \vec{P}_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
	E_T^{miss}/m_{eff}	> 0.3	> 0.25	> 0.25	> 0.2
S/B enhancement	m_{eff}	> 1000	> 1000	> 500/1000	> 1100

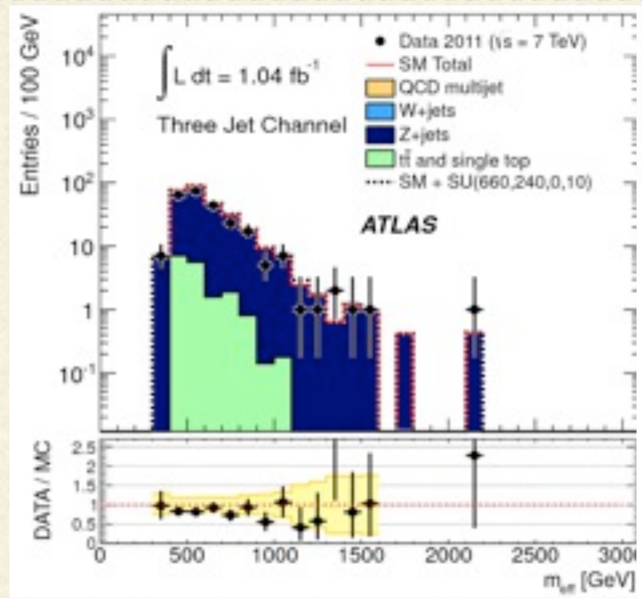
definition

m_{eff} = scalar sum of E_T^{Miss} and the p_T of 2/3/4 highest p_T jets depending on the SR. For the high mass SR, all jets with p_T > 40 GeV and $|\eta|$ < 2.8 are used.

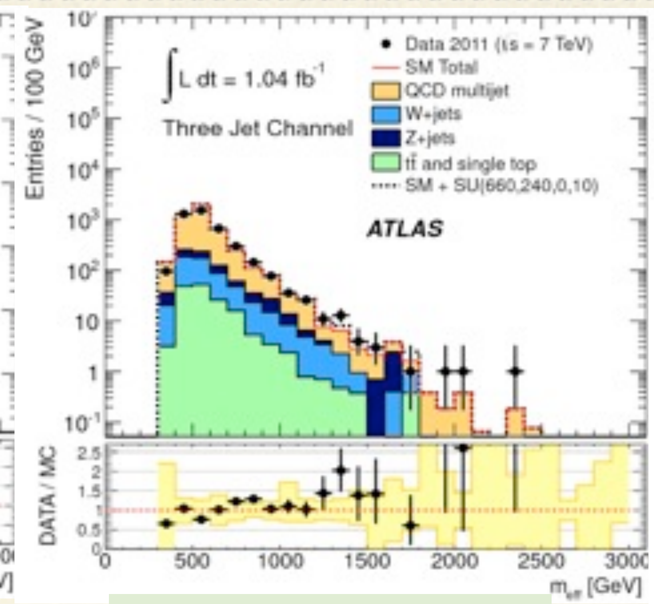
E_T^{Miss}+(≥2-4)jets+0 leptons background estimate



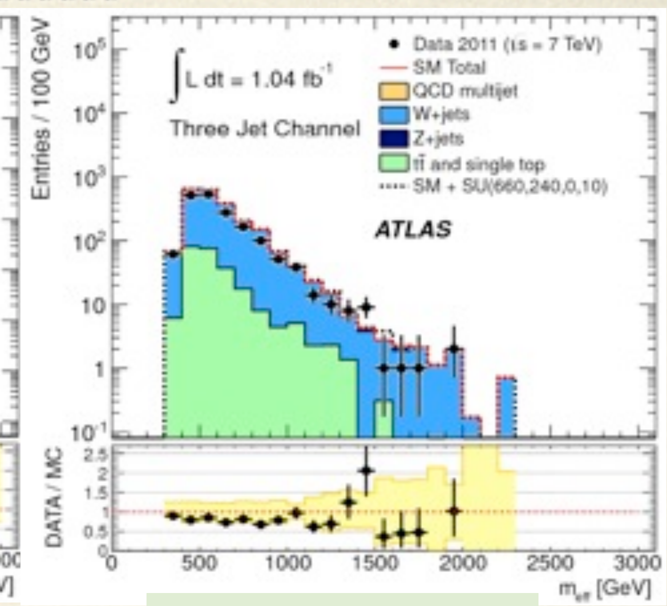
Z(νν)+jets CR1
gamma+jets selection



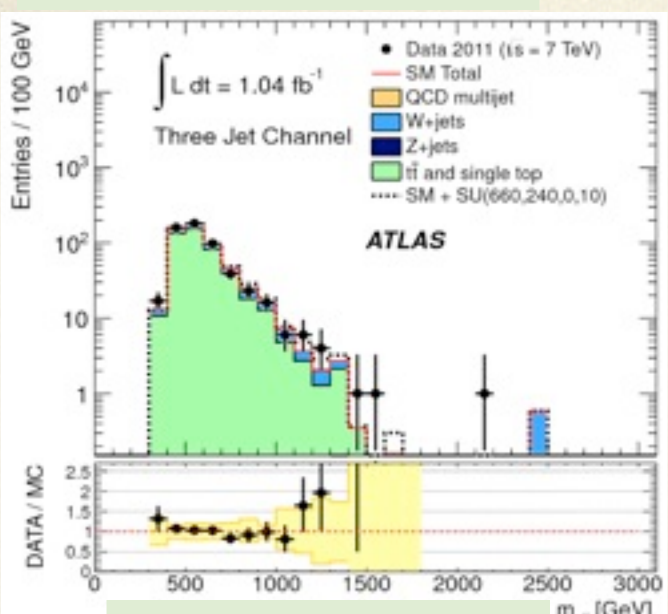
Z(νν)+jets CR2
Z(ll)+jets selection



multi-jet CR
$\Delta\phi$(E_T^{Miss},jets) cut reversed



W+jets CR
1-lepton W+jets candidates

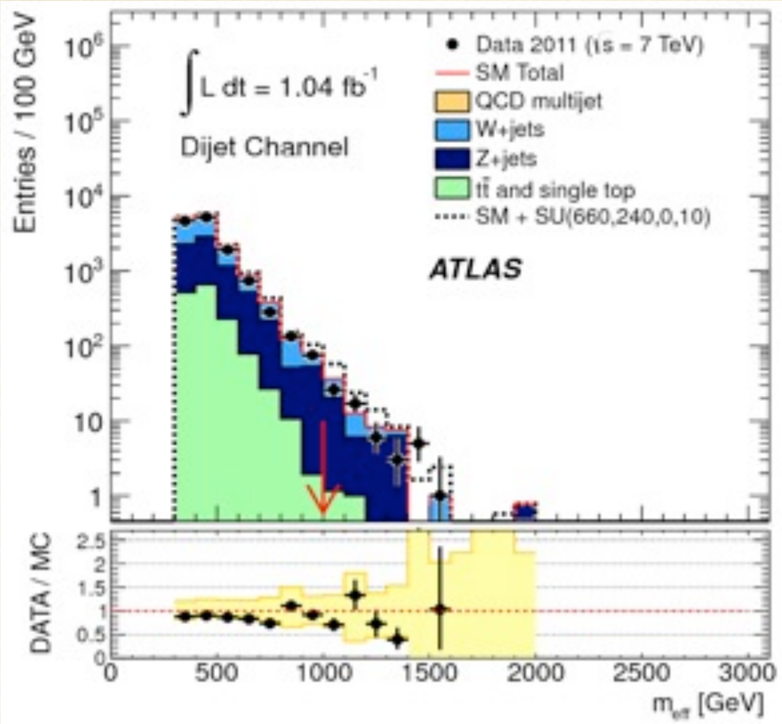


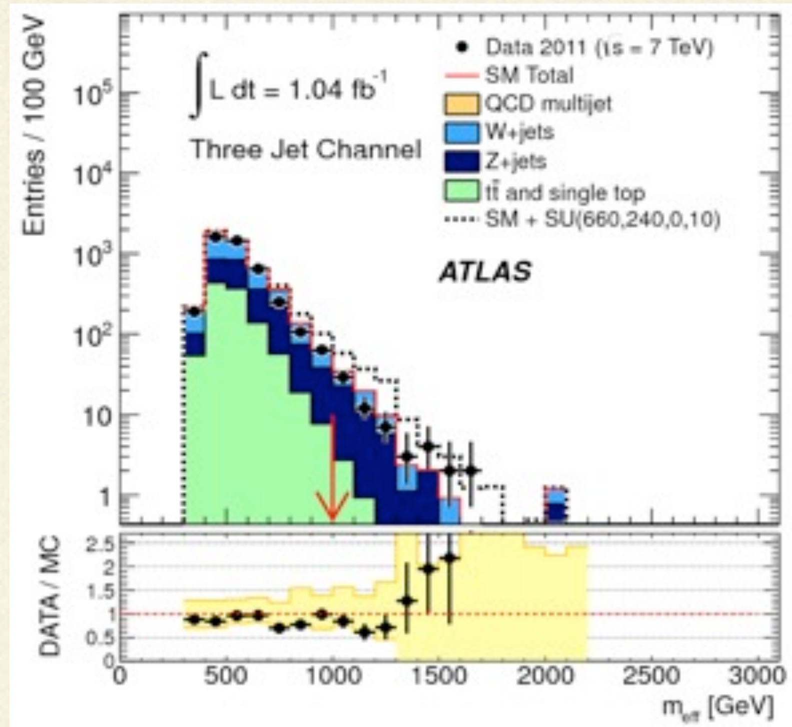
tt CR
semileptonic ttbar candidates

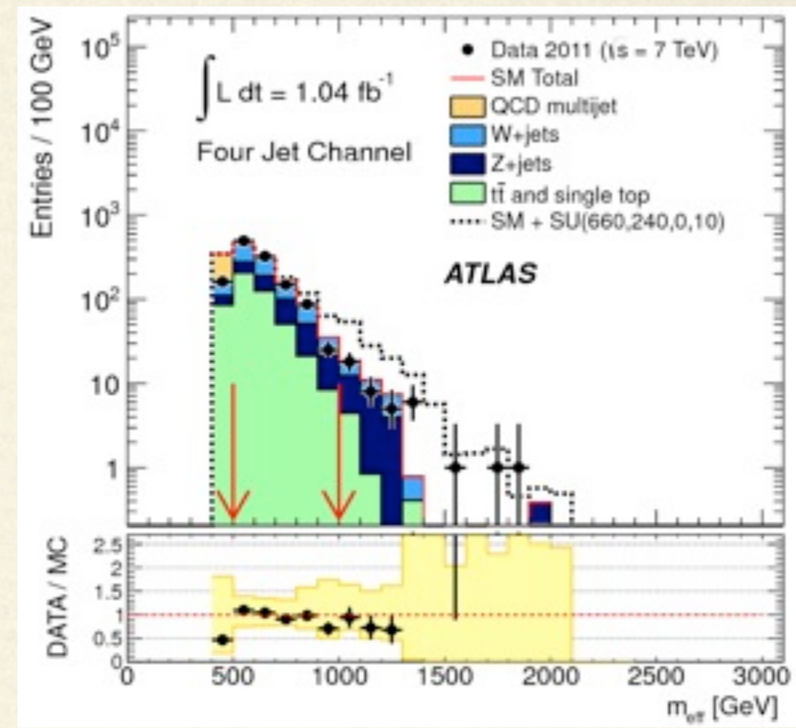
- Five control regions (CR) are defined for each SR, each targeting a specific background source.
- The SR backgrounds are obtained from a likelihood fit to CR data, extrapolating to the SR using MonteCarlo for W+jets, Z+jets, and top pair production.
  - For multijet, the expected ratio between SR and CR is obtained entirely from data, smearing a low ETMiss sample with jet response functions obtained with measurements on multi-jet data.
  - For limits, signal contamination in the CR is taken into account

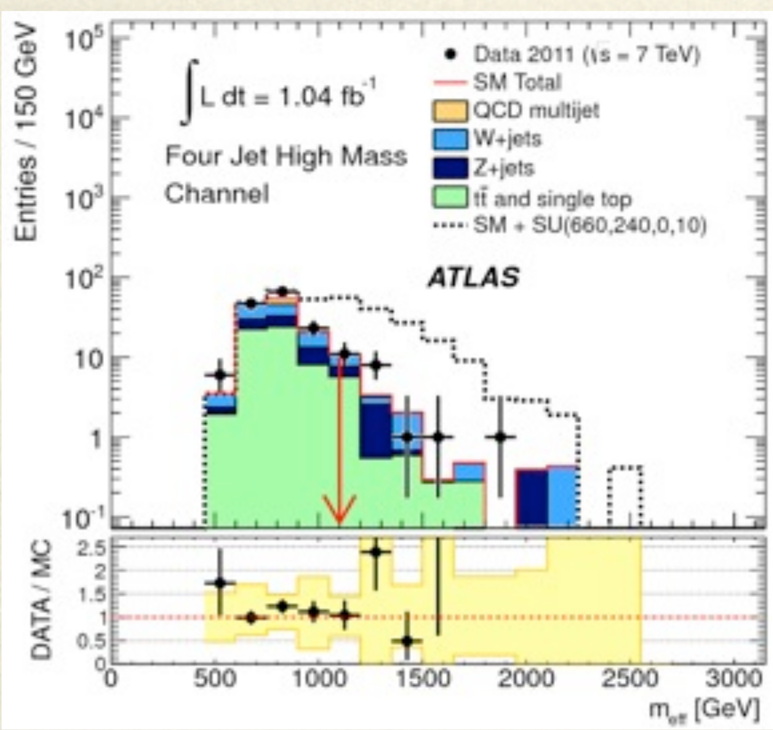
E_T^{Miss}+(≥2-4)jets+0 leptons results

- Effective mass distributions after all other cuts. The arrows indicate the final cuts.







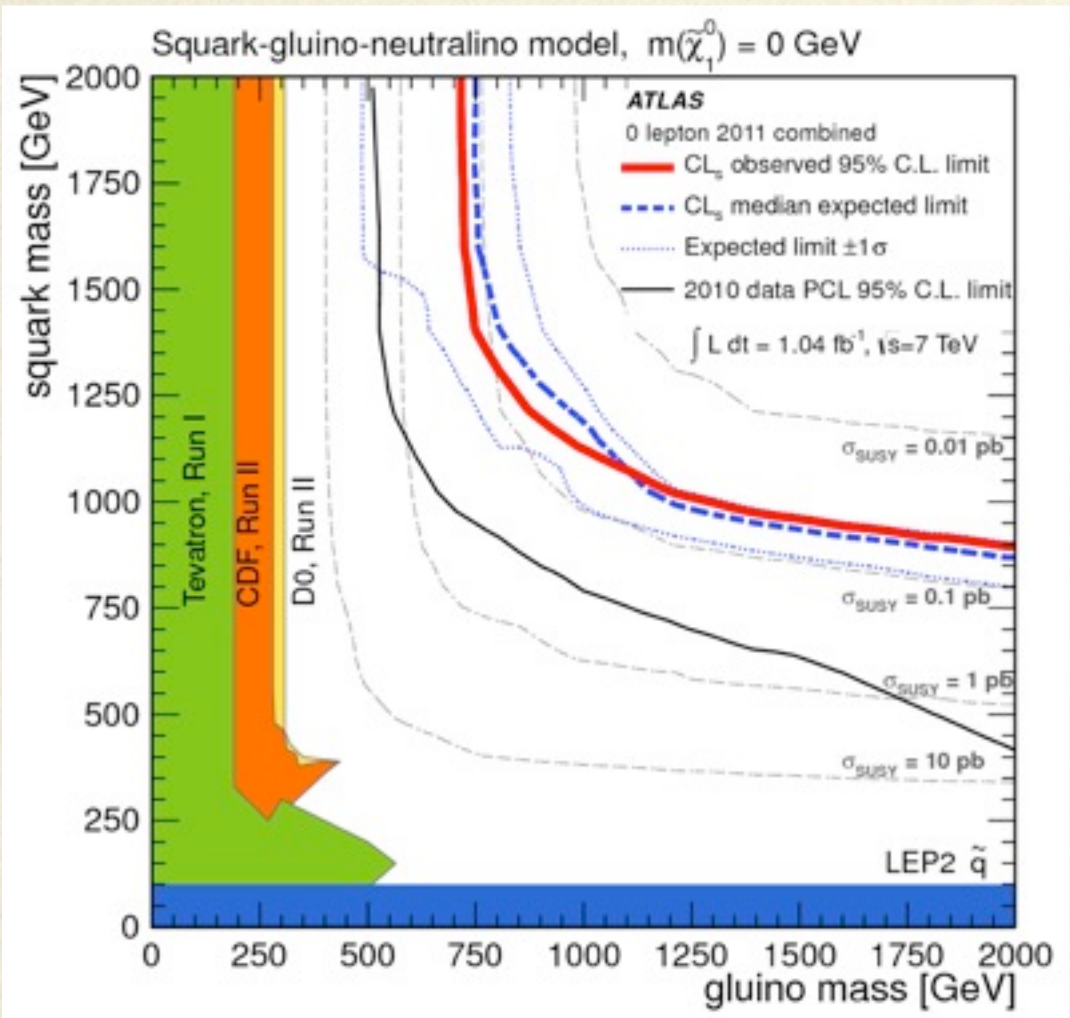


Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, $m_{\rm eff}$ > 500 GeV	≥ 4-jet, $m_{\rm eff}$ > 1000 GeV	High mass
Z/γ+jets	32.3 ± 2.6 ± 6.9	25.5 ± 2.6 ± 4.9	209 ± 9 ± 38	16.2 ± 2.2 ± 3.7	3.3 ± 1.0 ± 1.3
W+jets	26.4 ± 4.0 ± 6.7	22.6 ± 3.5 ± 5.6	349 ± 30 ± 122	13.0 ± 2.2 ± 4.7	2.1 ± 0.8 ± 1.1
$t\bar{t}$+ single top	3.4 ± 1.6 ± 1.6	5.9 ± 2.0 ± 2.2	425 ± 39 ± 84	4.0 ± 1.3 ± 2.0	5.7 ± 1.8 ± 1.9
QCD multi-jet	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.73 ± 0.14 ± 0.50	2.10 ± 0.37 ± 0.82
Total	62.4 ± 4.4 ± 9.3	54.9 ± 3.9 ± 7.1	1015 ± 41 ± 144	33.9 ± 2.9 ± 6.2	13.1 ± 1.9 ± 2.5
Data	58	59	1118	40	18

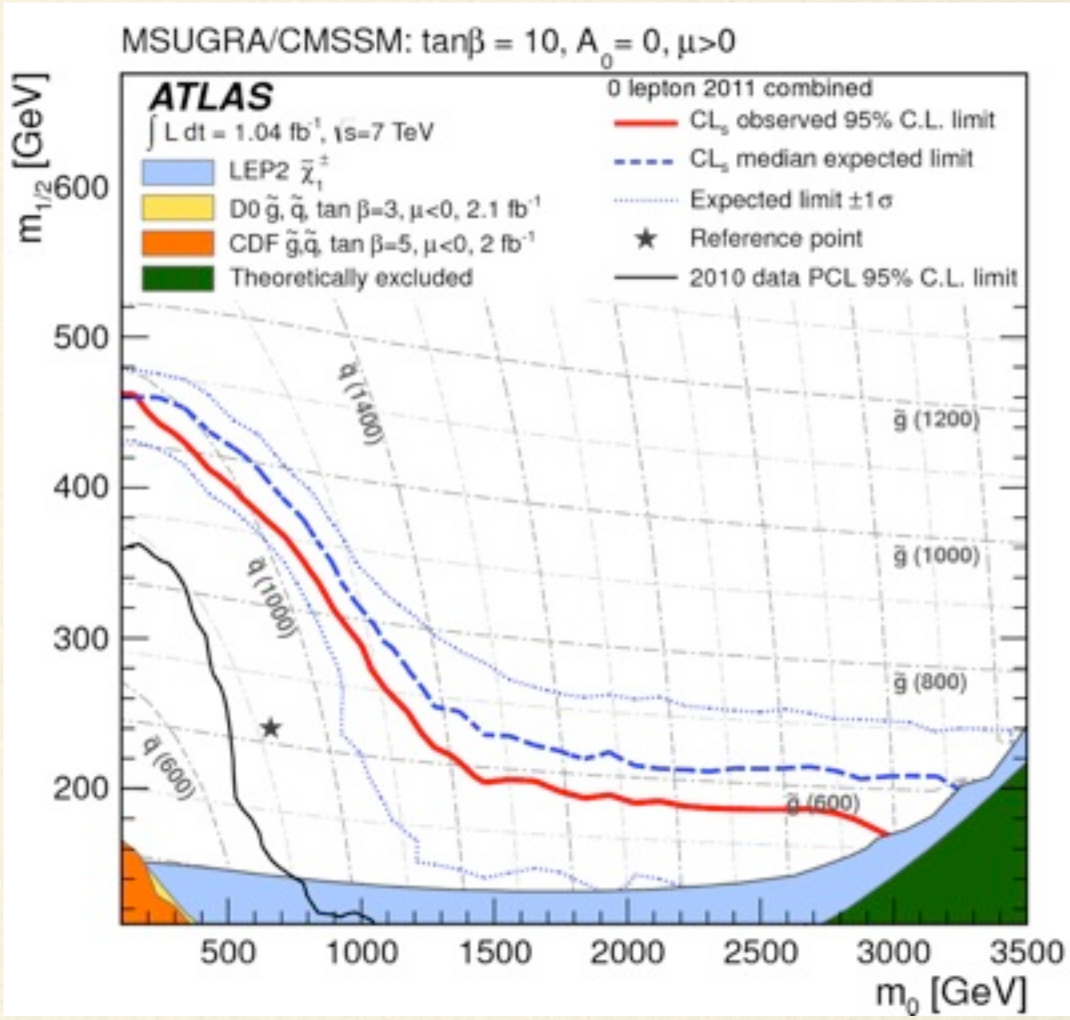
Good agreement between data and SM expectation in all signal regions

E_T^{Miss}+(≥2-4)jets+0 leptons interpretation

For limits, the SR with the best *expected* sensitivity is used for each signal point



Simplified model with a gluino, first two generation squarks, and massless neutralino
m($\tilde{g}$) > 700 GeV   m($\tilde{q}$) > 875 GeV
m($\tilde{g}$) = m($\tilde{q}$) > 1075 GeV



mSUGRA/CMSSM with tanβ =0,A=0,m>0
m($\tilde{g}$) = m($\tilde{q}$) > 950 GeV

1.3 fb^{-1}

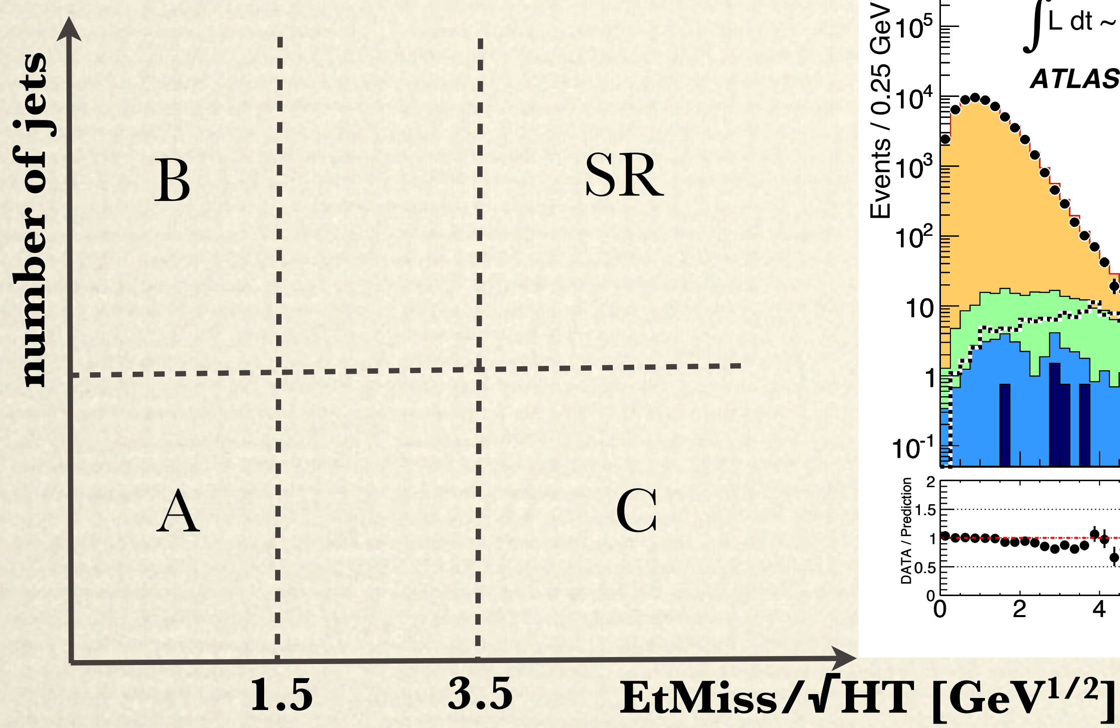
arXiv:1110.2299
accepted by JHEP

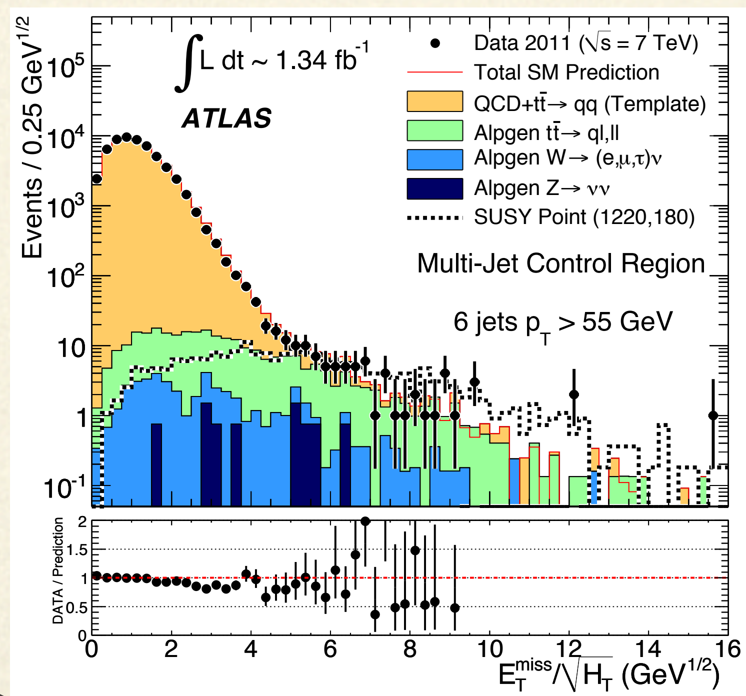
E_T^{Miss}+(≥6-8)jets+0 leptons selections and backgrounds

	Signal region	7j55	8j55	6j80	7j80
Trigger-driven	Jet p_T	> 55 GeV		> 80 GeV	
Trigger-driven	Jet $\|\eta\|$	< 2.8			
Trigger-driven	ΔR_{jj}	> 0.6 for any pair of jets			
	Number of jets	≥ 7	≥ 8	≥ 6	≥ 7
S/B discrimination	$E_T^{miss}/\sqrt{H_T}$	> 3.5 GeV$^{1/2}$			

definition
H_T = scalar sum of p_T of jets with p_T > 40 GeV and $|\eta|$< 2.8

- Targeting gluino pair production and long decay chains
- Based on multi-jet triggers
- Multi-jet and fully hadronic ttbar: $E_T^{Miss}/\sqrt{HT}$ shape invariant with jet multiplicity, measured with 5-6 jets
- W, semileptonic top: CR with one lepton, 40 <m_T(lep,E_T^{Miss}) < 100 GeV, b veto or tag. Extrapolation to SR from MC.

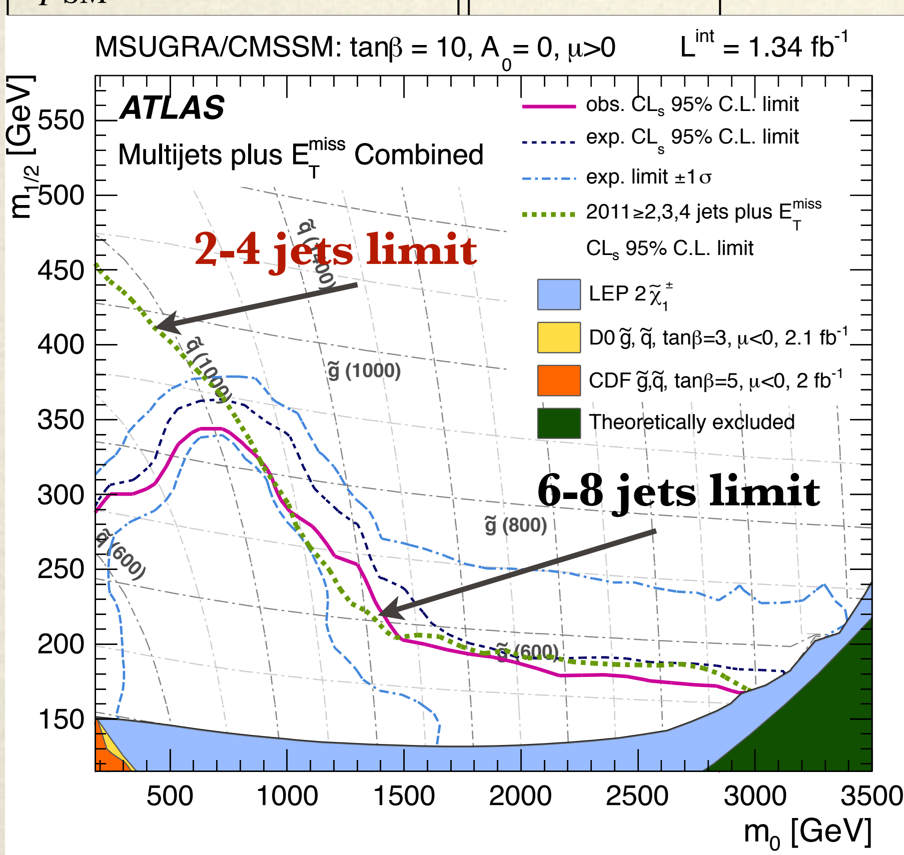




multi-jet background estimate
SR background = BxC/A

E_T^{Miss}+(≥6-8)jets+0 leptons results

Signal region	**7j55**	**8j55**	**6j80**	**7j80**	
Multi-jets	26 ± 5.2	2.3 ± 0.7	19 ± 4	1.3 ± 0.4	
$t\bar{t} \rightarrow q\ell, \ell\ell$	10.8 ± 6.7	$0^{+4.3}$	6.0 ± 4.6	$0^{+0.13}$	
W + jets	0.95 ± 0.45	$0^{+0.13}$	0.34 ± 0.24	$0^{+0.13}$	
Z + jets	$1.5^{+1.8}_{-1.5}$	$0^{+0.75}$	$0^{+0.75}$	$0^{+0.75}$	
Total Standard Model	39 ± 9	$2.3^{+4.4}_{-0.7}$	26 ± 6	$1.3^{+0.9}_{-0.4}$	
Data	45	4	26	3	
$N^{95\%}_{\mathrm{BSM,max}}$	26.0	11.2	16.3	6.0	**Limit on signal event rate in SRs**
$\sigma^{95\%}_{\mathrm{BSM,max}} \times \epsilon/\mathrm{fb}$	19.4	8.4	12.2	4.5	**Limit on signal cross section times efficiency in SRs**
p_{SM}	0.30	0.36	0.49	0.16	**SM hypothesis p-value**



In mSUGRA gluino dominated regions, results competitive with those of 2-4 jet search. m($\tilde{g}$) > 520 GeV at 95% C.L.

1.04 fb^{-1}

arXiv:1109.6606
submitted to PRD

E_T^{Miss}+jets+1 lepton signal selection and backgrounds

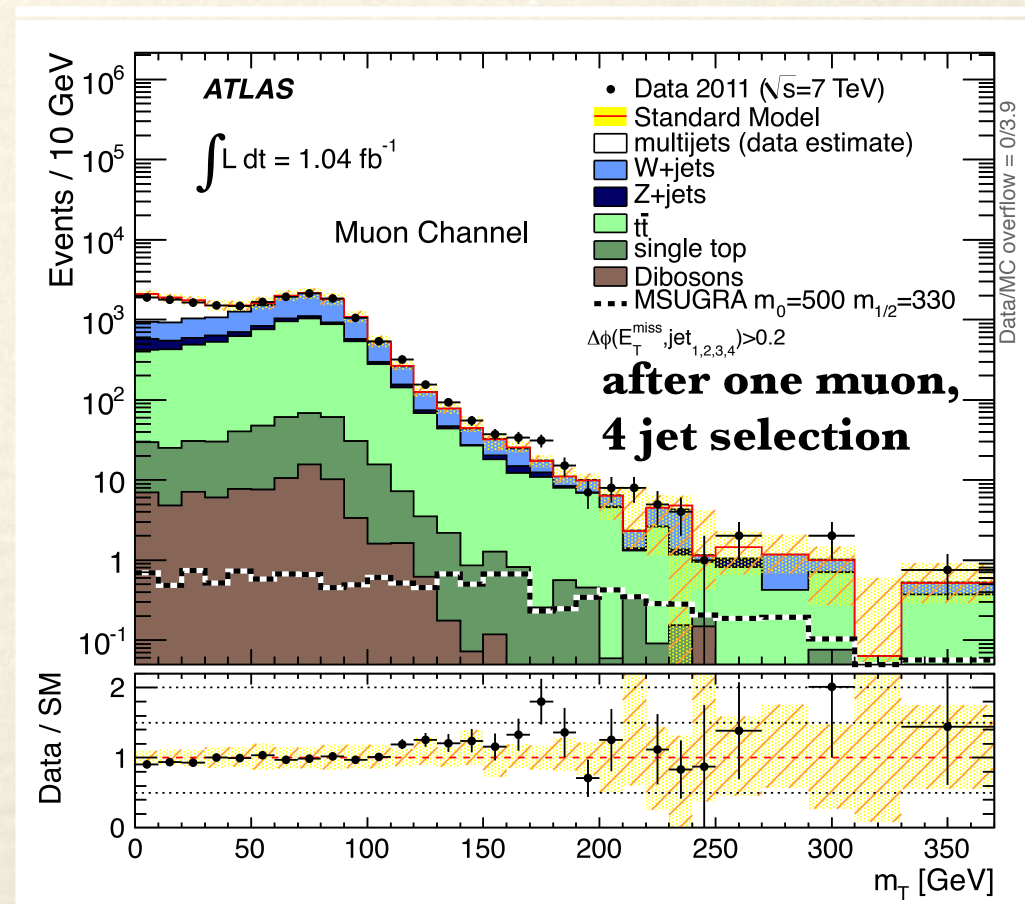
- **Looking for** gluino and squark decays to LSP, but with one lepton in decay chains.
  - example: $\tilde{g} \to q\bar{q}\tilde{\chi}^{\pm} \to q\bar{q}W^{(*)}\tilde{\chi}^{0}$
- **Signal selection:**
  - Single electron or muon trigger, 1 electron (muon), with $p_T > 25$ (20) GeV, $M_T > 100$ GeV
  - E_T^{Miss} cut between 125 and 240 GeV depending on the signal region.
  - Four signal regions (3 jet loose, 3 jet tight, 4 jet loose, 4 jet tight). 3/4-jet cuts more sensitive to squark/gluinos. Tight/loose cuts more sensitive to light LSP/compressed mass spectrum scenarios.

definitions

$$m_{\text{eff}} = p_T^{\ell} + \sum_{i=1}^{3(4)} p_T^{\text{jet}_i} + E_T^{\text{miss}},$$

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

- **Background estimate:**
  - multi-jet from data, using a control sample with looser lepton selection.
  - W(*ttbar*) control region: $40 < M_T < 80$ GeV, $30 < E_T^{Miss} < 80$ GeV, b-tag veto (*one b-tag jet*), all other cuts same as SR. CR ⇒SR extrapolation with MC.

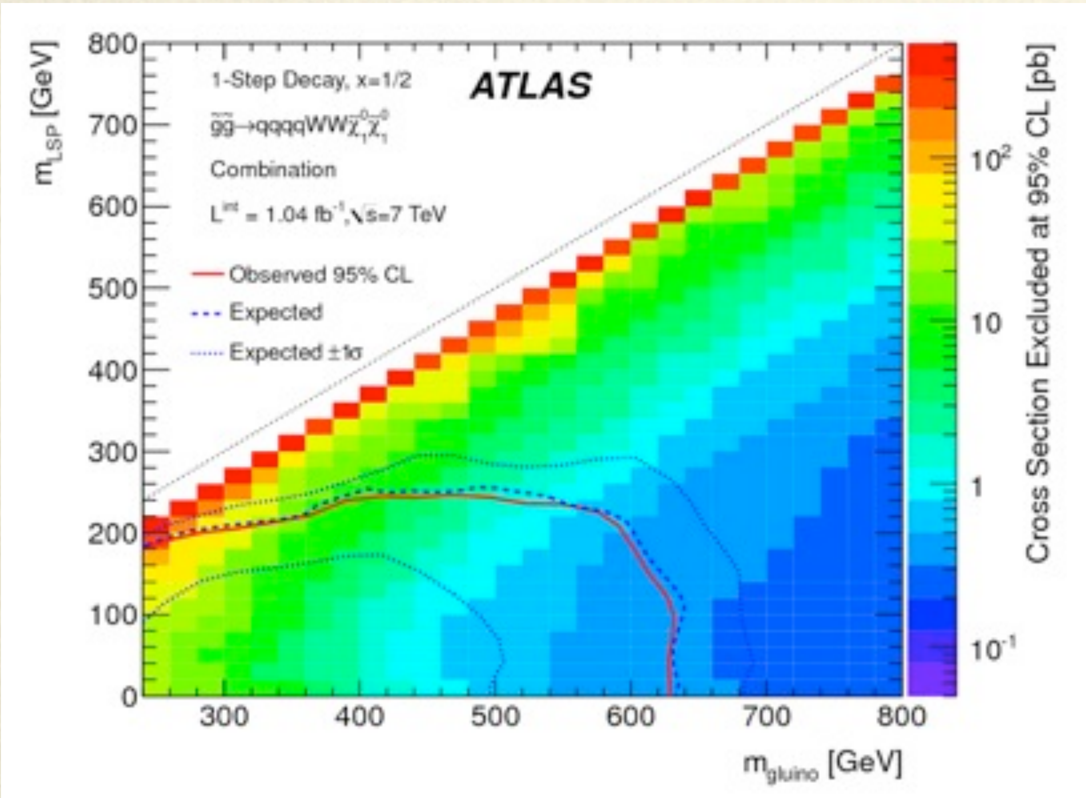


E_T^{Miss}+jets+1 lepton results

Electron channel	3JL Signal region	3JT Signal region	4JL Signal region	4JT Signal region
Observed events	71	14	41	9
Fitted top events	56 ± 20 (51)	7.6 ± 3.0 (6.8)	38 ± 15 (34)	4.5 ± 2.6 (4.1)
Fitted W/Z events	35 ± 20 (34)	10.5 ± 6.5 (10.1)	9.5 ± 7.5 (9.2)	3.5 ± 2.2 (3.4)
Fitted multijet events	$6.0^{+2.3}_{-1.4}$	$0.46^{+0.37}_{-0.22}$	$0.90^{+0.54}_{-0.37}$	$0.00^{+0.02}_{-0.00}$
Fitted sum of background events	97 ± 30	18.5 ± 7.4	48 ± 18	8.0 ± 3.7

Muon channel	3JL Signal region	3JT Signal region	4JL Signal region	4JT Signal region
Observed events	58	11	50	7
Fitted top events	47 ± 16 (38)	8.9 ± 3.2 (7.3)	39 ± 13 (36)	4.7 ± 2.2 (4.3)
Fitted W/Z events	16.6 ± 9.4 (20.1)	5.0 ± 3.2 (6.1)	14.1 ± 8.5 (14.2)	1.4 ± 1.1 (1.4)
Fitted multijet events	$0.0^{+0.0}_{-0.0}$	$0.0^{+0.6}_{-0.0}$	$0.0^{+0.0}_{-0.0}$	$0.0^{+0.6}_{-0.0}$
Fitted sum of background events	64 ± 19	13.9 ± 4.3	53 ± 16	6.0 ± 2.7

Data consistent with SM expectation for all selections



Cross section limits as a function of gluino and LSP mass, for the decay mode:

$$\tilde{g} \rightarrow q\bar{q}\tilde{\chi}^{\pm} \rightarrow q\bar{q}W^{(*)}\tilde{\chi}^{0}$$

$$x = (m_{\tilde{\chi}^{\pm}} - m_{\tilde{\chi}^{0}})/(m_{\tilde{g}} - m_{\tilde{\chi}^{0}}) = 1/2$$

Full line is the limit assuming the MSSM NLO cross section and 100% branching ratio for the decay above

1.04 fb^{-1}

arXiv:1110.6189
submitted to PLB

E_T^{Miss}+jets+2 lepton selections and backgrounds

(a) $\tilde{\chi}_i^0 \to l^\pm \nu \tilde{\chi}_j^\mp$, (b) $\tilde{\chi}_i^\pm \to l^\pm \nu \tilde{\chi}_j^0$ (c) $\tilde{\chi}_i^0 \to l^\pm l^\mp \tilde{\chi}_j^0$ (d) $\tilde{\chi}_i^\pm \to l^\pm l^\mp \tilde{\chi}_j^\pm$

- Supersymmetric events can have two leptons if (c) or (d) happen in one decay chain (leptons have same flavour and opposite sign) or if (a) or (b) occur in both chain (leptons might have different flavour and/or same sign).

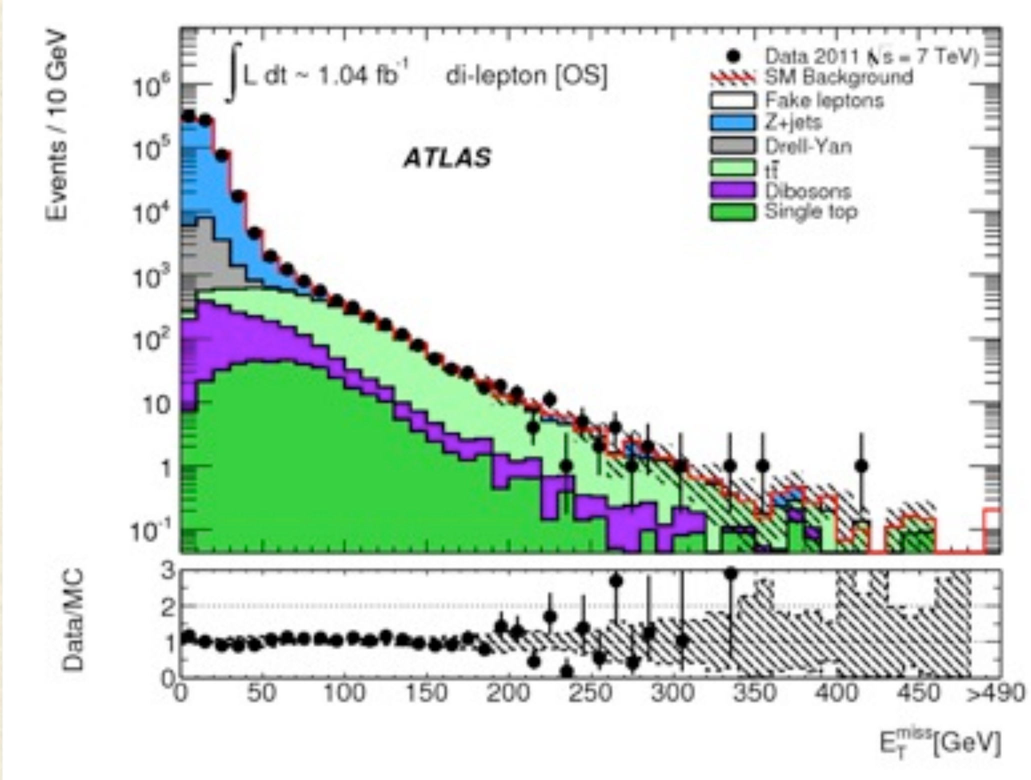
- **Analysis 1: Opposite sign inclusive search**
  - Three signal selections (see table)
  - Main background is dileptonic top pairs.

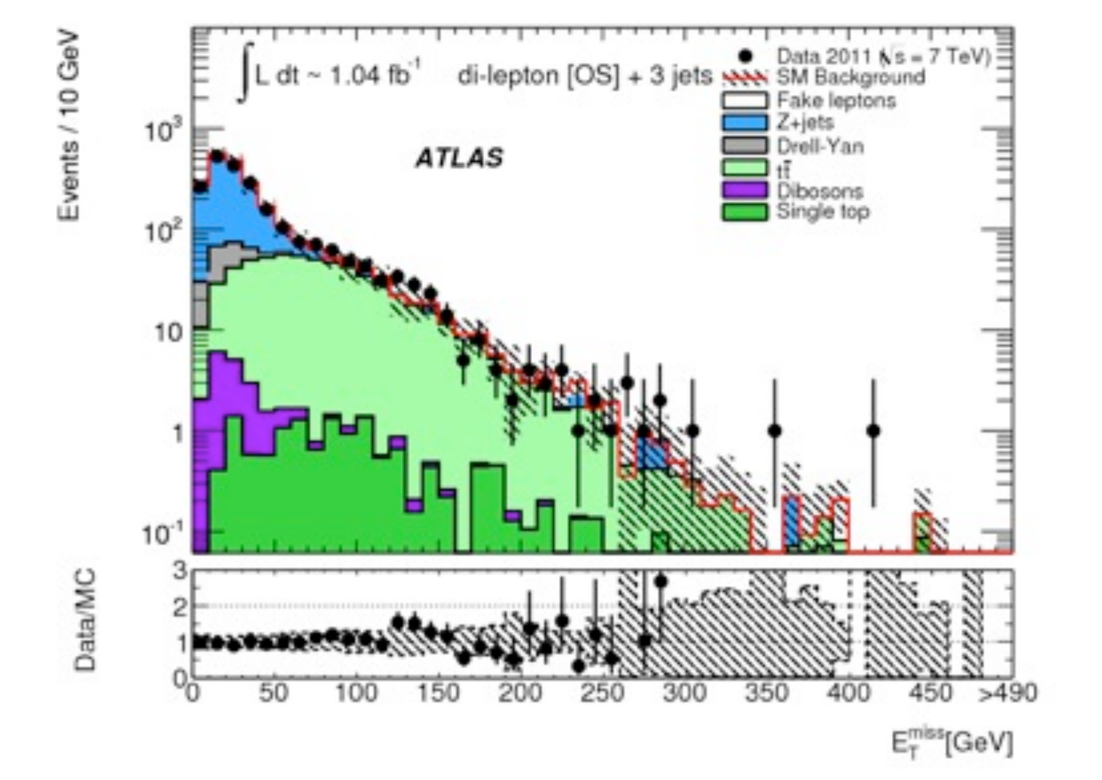
Signal Region	OS-SR1	OS-SR2	OS-SR3	SS-SR1	SS-SR2
E_T^{miss} [GeV]	250	220	100	100	80
Leading jet p_T [GeV]	-	80	100	-	50
Second jet p_T [GeV]	-	40	70	-	50
Third jet p_T [GeV]	-	40	70	-	-
Fourth jet p_T [GeV]	-	-	70	-	-
Number of jets	-	≥ 3	≥ 4	-	≥ 2

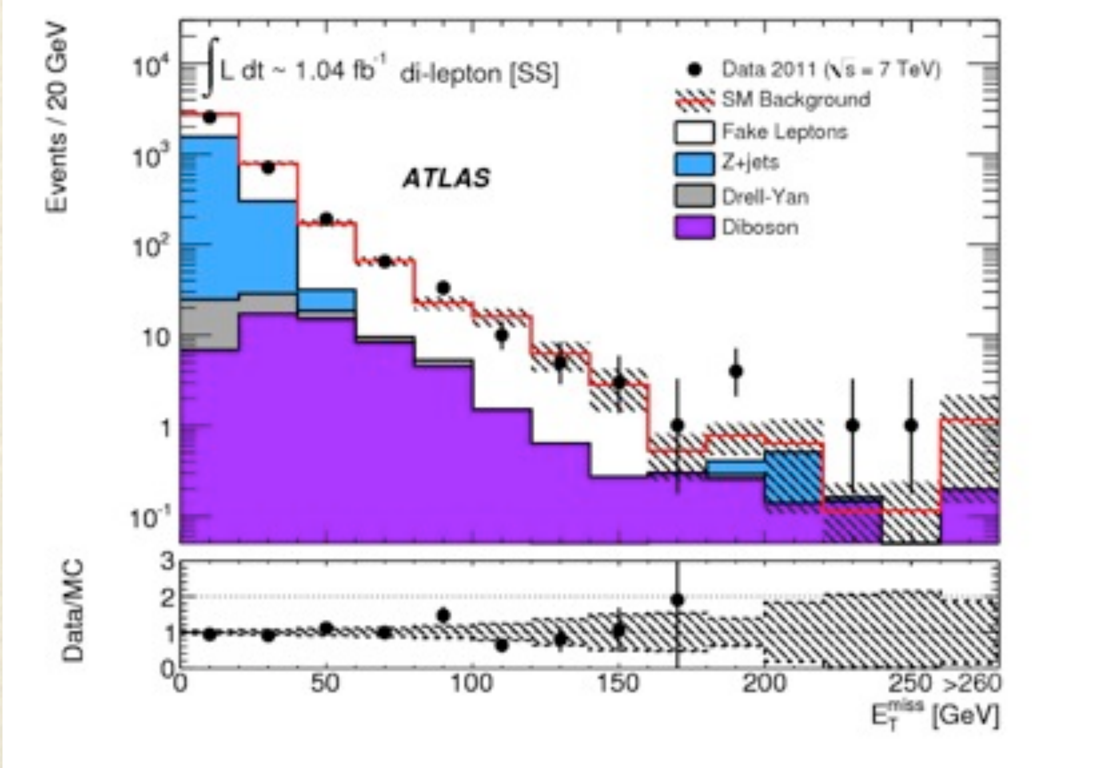
- **Analysis 2: Same sign inclusive search**
  - Two signal selection (see table)
  - SM rate very small, from dibosons or opposite sign events with mismeasured charge

- **Analysis 3: Flavour subtraction search**
  - Look for an excess of $e^\pm e^\mp + \mu^\pm \mu^\mp$ over $e^\pm \mu^\mp$. Sensitive to (c) or (d). Main background (top) cancels in the subtraction on average.

E_T^{Miss}+jets+2 lepton results





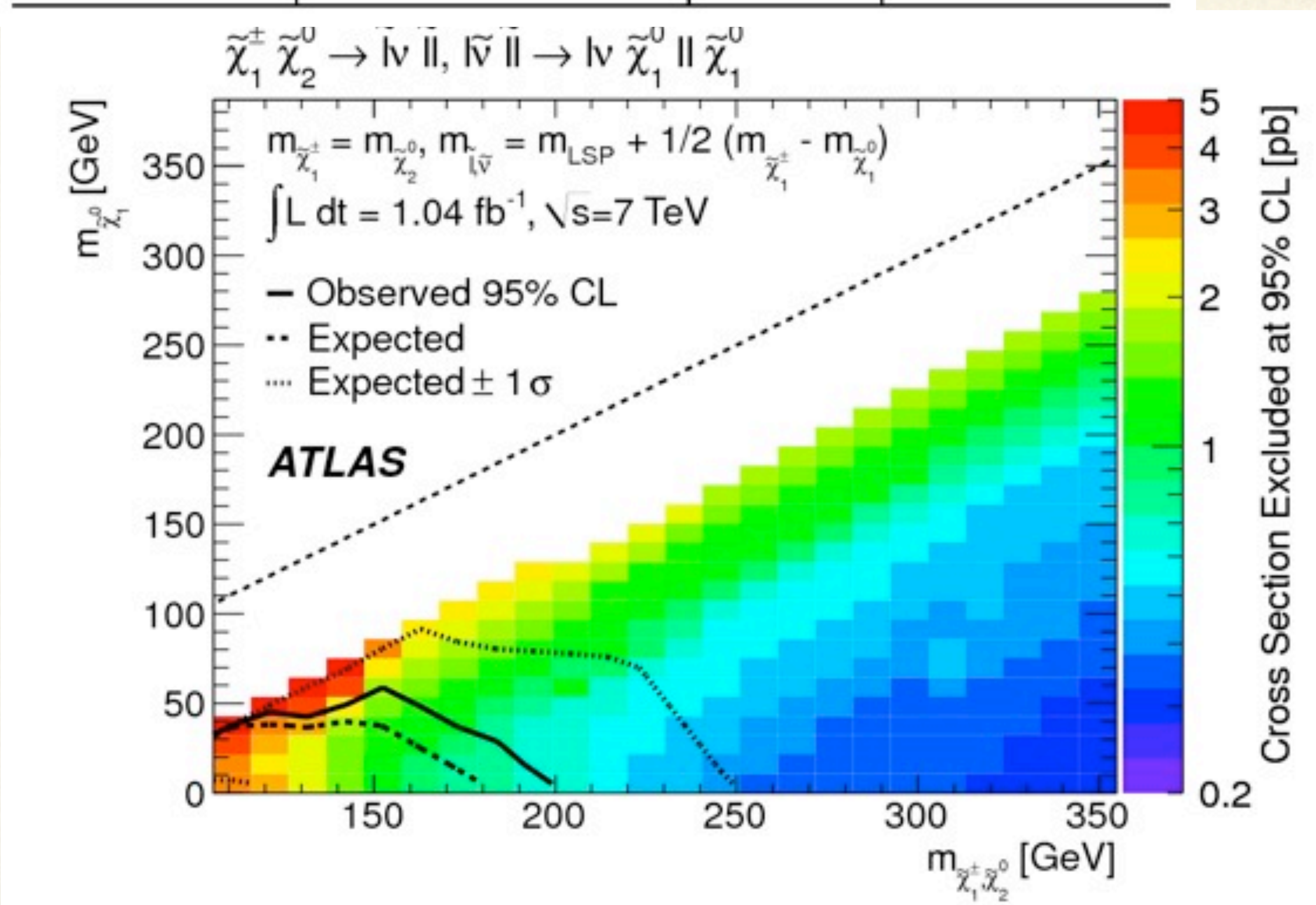


- Data are in good agreement with SM expectation for all signal regions

E_T^{Miss}+jets+2 lepton results

	Background	Obs.	95% CL
OS-SR1	15.5 ± 4.0	13	9.9 fb
OS-SR2	13.0 ± 4.0	17	14.4 fb
OS-SR3	5.7 ± 3.6	2	6.4 fb
SS-SR1	32.6 ± 7.9	25	14.8 fb
SS-SR2	24.9 ± 5.9	28	17.7 fb

- Model independent limits on $\sigma A \epsilon$,



The SS selection without jets is also sensitive to **electroweak production** of $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, if they decay to slepton:

$$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to (\nu\tilde{l}^{\pm})(l^{\pm}\tilde{l}^{\mp}) \to (\nu l^{\pm}\tilde{\chi}_1^0)(l^{\pm}l^{\mp}\tilde{\chi}_1^0)$$
$$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to (\tilde{l}^{\pm}\tilde{\nu})(l^{\pm}\tilde{l}^{\mp}) \to (l^{\pm}\nu\tilde{\chi}_1^0)(l^{\pm}l^{\mp}\tilde{\chi}_1^0)$$

(with one lepton undetected or out of acceptance)

Plot: cross section limit as a function of the mass of $\tilde{\chi}_1^0$ and $m(\tilde{\chi}_1^{\pm}) = m(\tilde{\chi}_2^0)$

Limits assuming 100% BR in sleptons are also shown.

E_T^{Miss}+*b*-jets+0 lepton selections and backgrounds

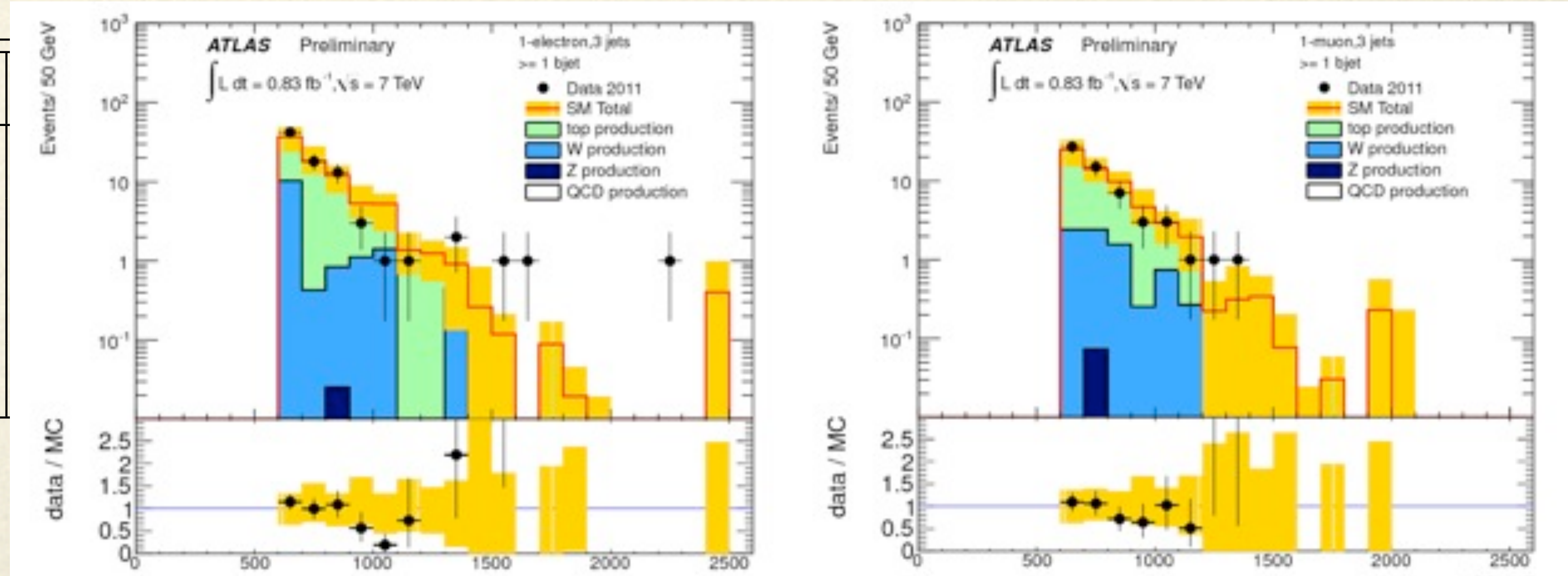
0.83 fb^{-1}

ATL-CONF-2011-098

- Targeting gluino pair production followed by either $\tilde{g} \to \tilde{b}b \to bb\tilde{\chi}_1^0$ or $\tilde{g} \to bb\tilde{\chi}_1^0$
  - In many models, the third squark generation is the lightest and these decay modes might have branching ratios close to 100%
- Cuts: E_T^{Miss} > 130 GeV, leading jet p_T > 130 GeV, >= 3 jets with p_T > 50 GeV, no lepton, $\Delta\phi(E_T^{Miss}, jets) > 0.4$, $E_T^{Miss}/M_{eff} > 0.25$
- Number of b-jets and m_{eff} cut define 4 signal regions
- Dominant background is ttbar for all SR; normalized with data in a CR with one lepton and 40 < $M_T(lep, E_T^{Miss})$ < 80 GeV; TF from MC

Sig. Reg.
3JA (1 btag m_{eff} >500 GeV)
3JB (1 btag m_{eff} >700 GeV)
3JC (2 btag m_{eff} >500 GeV)
3JD (2 btag m_{eff} >700 GeV)

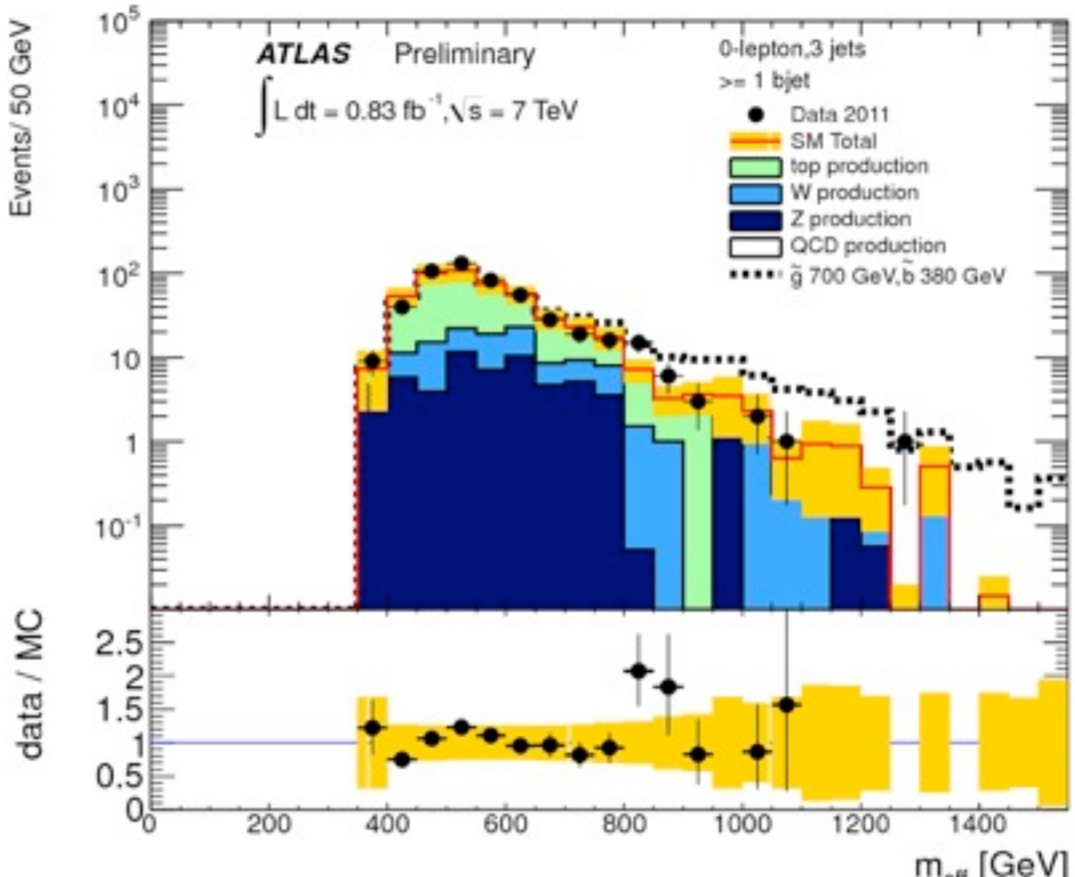
Signal region definition



Effective mass distributions in top control region

E_T^{Miss}+*b*-jets+0 lepton results

Sig. Reg.	Data (0.83 fb^{-1})	Top	W/Z	QCD	Total
3JA (1 btag m_{eff} >500 GeV)	361	221^{+82}_{-68}	121 ± 61	15 ± 7	356^{+103}_{-92}
3JB (1 btag m_{eff} >700 GeV)	63	37^{+15}_{-12}	31 ± 19	1.9 ± 0.9	70^{+24}_{-22}
3JC (2 btag m_{eff} >500 GeV)	76	55^{+25}_{-22}	20 ± 12	3.6 ± 1.8	79^{+28}_{-25}
3JD (2 btag m_{eff} >700 GeV)	12	$7.8^{+3.5}_{-2.9}$	5 ± 4	0.5 ± 0.3	$13.0^{+5.6}_{-5.2}$

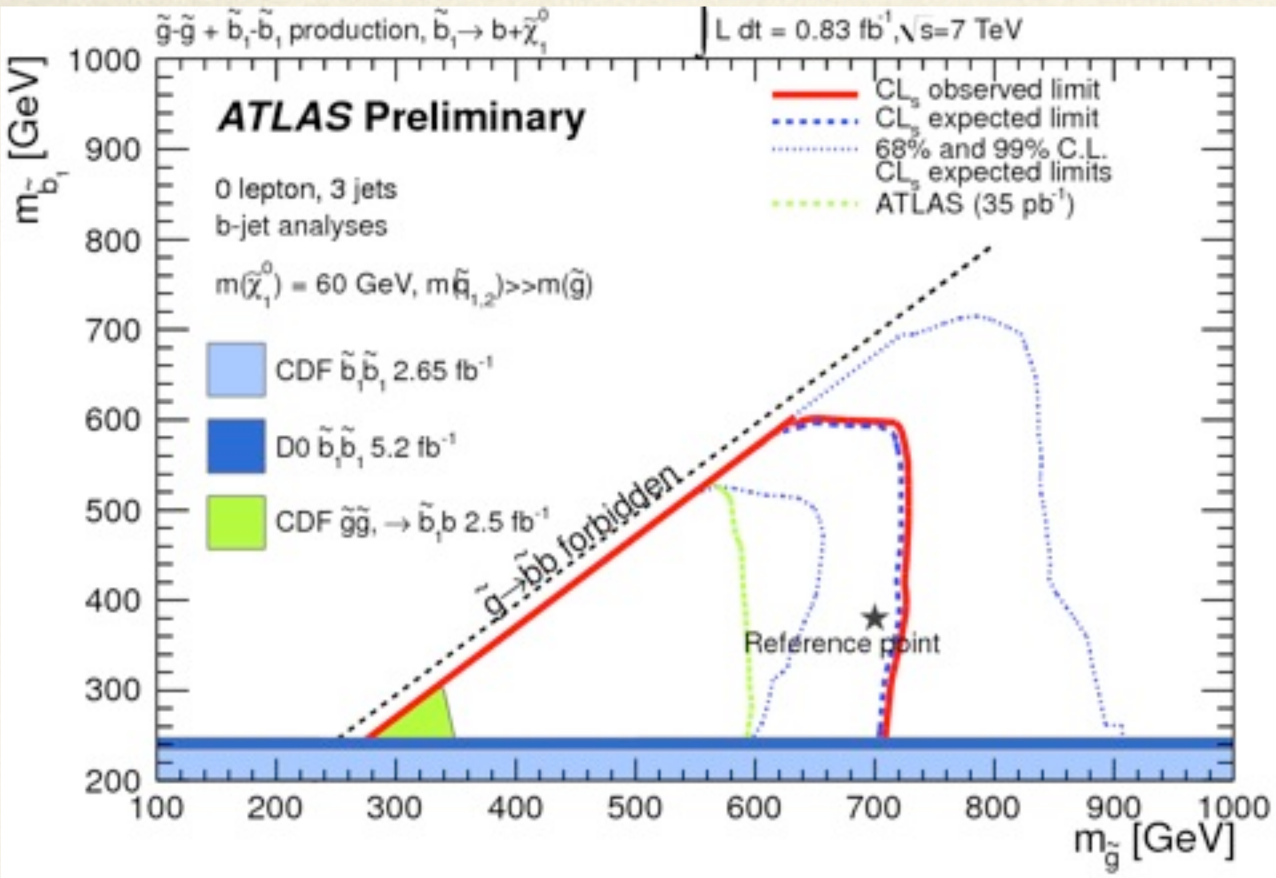


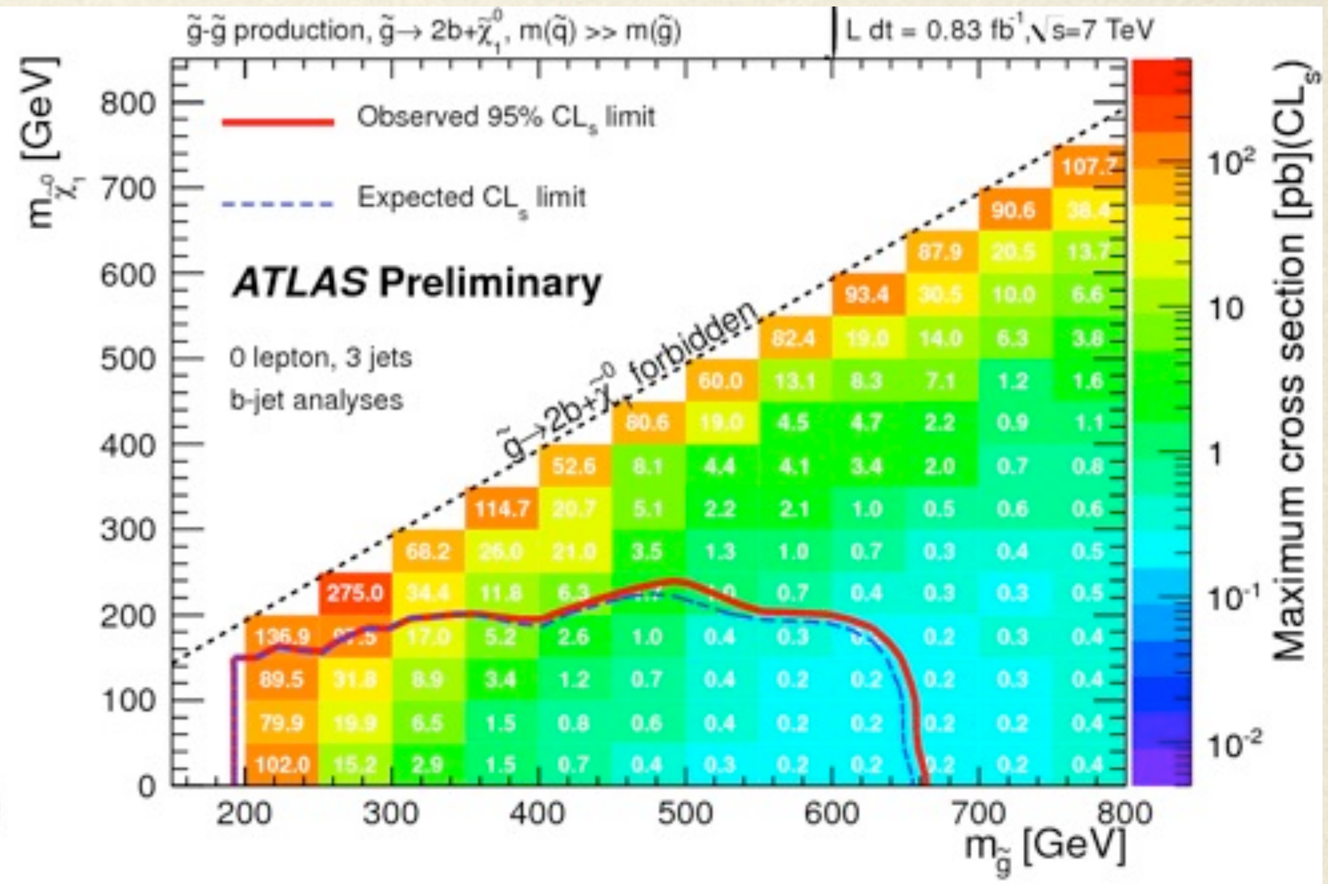
Effective mass, 1 bjet selection

Sig. Reg.	95% C.L. N events CL_s (PCL)	95% C.L. σ_{eff}(pb) CL_s (PCL)
3JA (1 btag m_{eff} >500 GeV)	240 (206)	0.288 (0.247)
3JB (1 btag m_{eff} >700 GeV)	51 (40)	0.061 (0.048)
3JC (2 btag m_{eff} >500 GeV)	65 (53)	0.078 (0.064)
3JD (2 btag m_{eff} >700 GeV)	14 (11)	0.017 (0.014)

Limits on new physics rate and $\sigma A \epsilon$,

E_T^{Miss}+*b*-jets+0 lepton interpretation





- Limits on gluino and sbottom masses, assuming $m(\tilde{\chi}_1^0)$ = 60 GeV and BR($\tilde{g} \to \tilde{b}$ b) = BR($\tilde{b} \to b\tilde{\chi}_1^0$) = 100%
- **m($\tilde{g}$) > 720 GeV for m($\tilde{b}$) < 600 GeV**

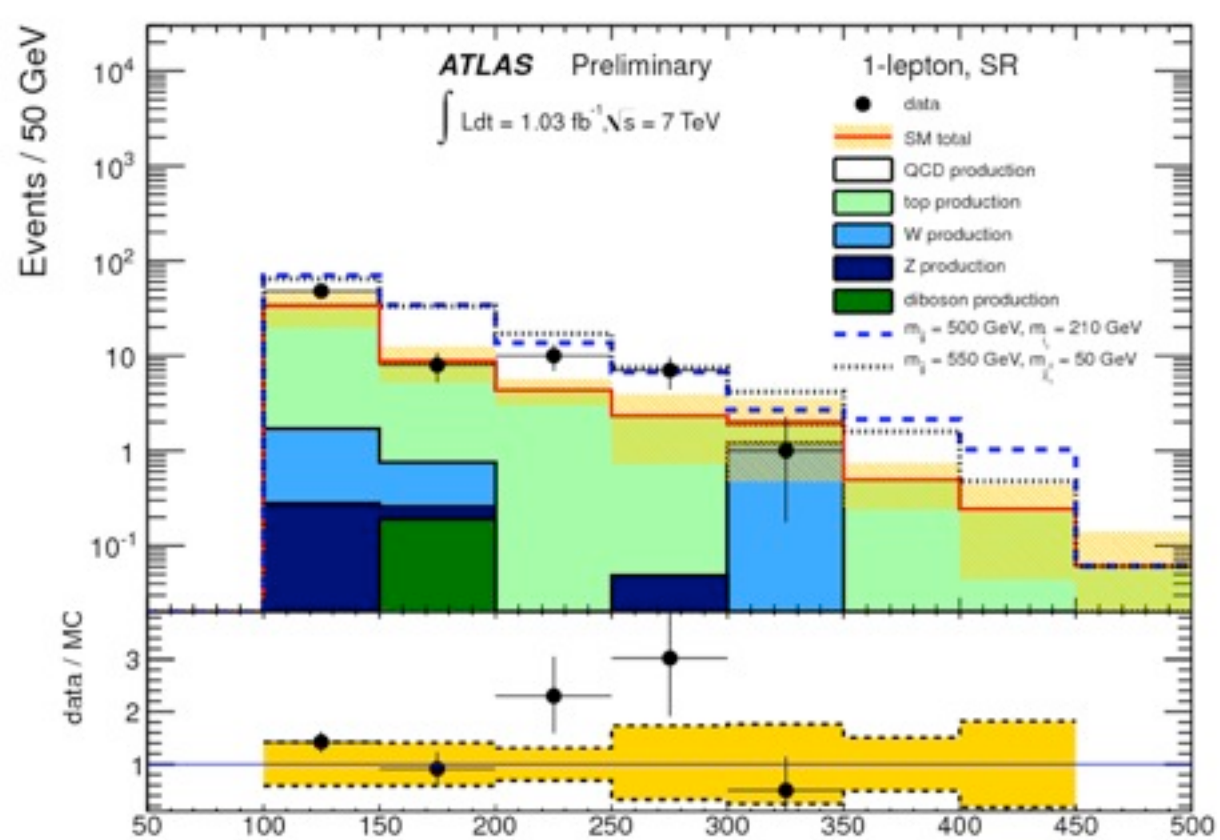
- Limits as a function of gluino and neutralino masses, for three body $\tilde{g} \to \tilde{b}\, b\tilde{\chi}_1^0$
- **m($\tilde{g}$) > 660 GeV for m($\tilde{\chi}_1^0$) < 200 GeV**

E_T^{Miss}+*b*-jets+1 lepton

1.03 fb^{-1}

ATL-CONF-2011-130

- Targeting gluino pair production followed by either $\tilde{g} \rightarrow \tilde{t}t \rightarrow t\,b\tilde{\chi}^{\pm}$ or $\tilde{g} \rightarrow tt\tilde{\chi}_1^0$
  - If allowed, $g \rightarrow tt \rightarrow tt\tilde{\chi}_1^0$ has larger acceptance = limits will be conservative.
- Cuts: One electron or muon with p_T > 25/20 GeV, E_T^{Miss} > 80 GeV, >= 4 jets with p_T > 50 GeV, m_{eff} > 600 GeV
- CR for dominant top pair background: same as CR but 40 < M_T(lep,E_T^{Miss}) < 100 GeV.



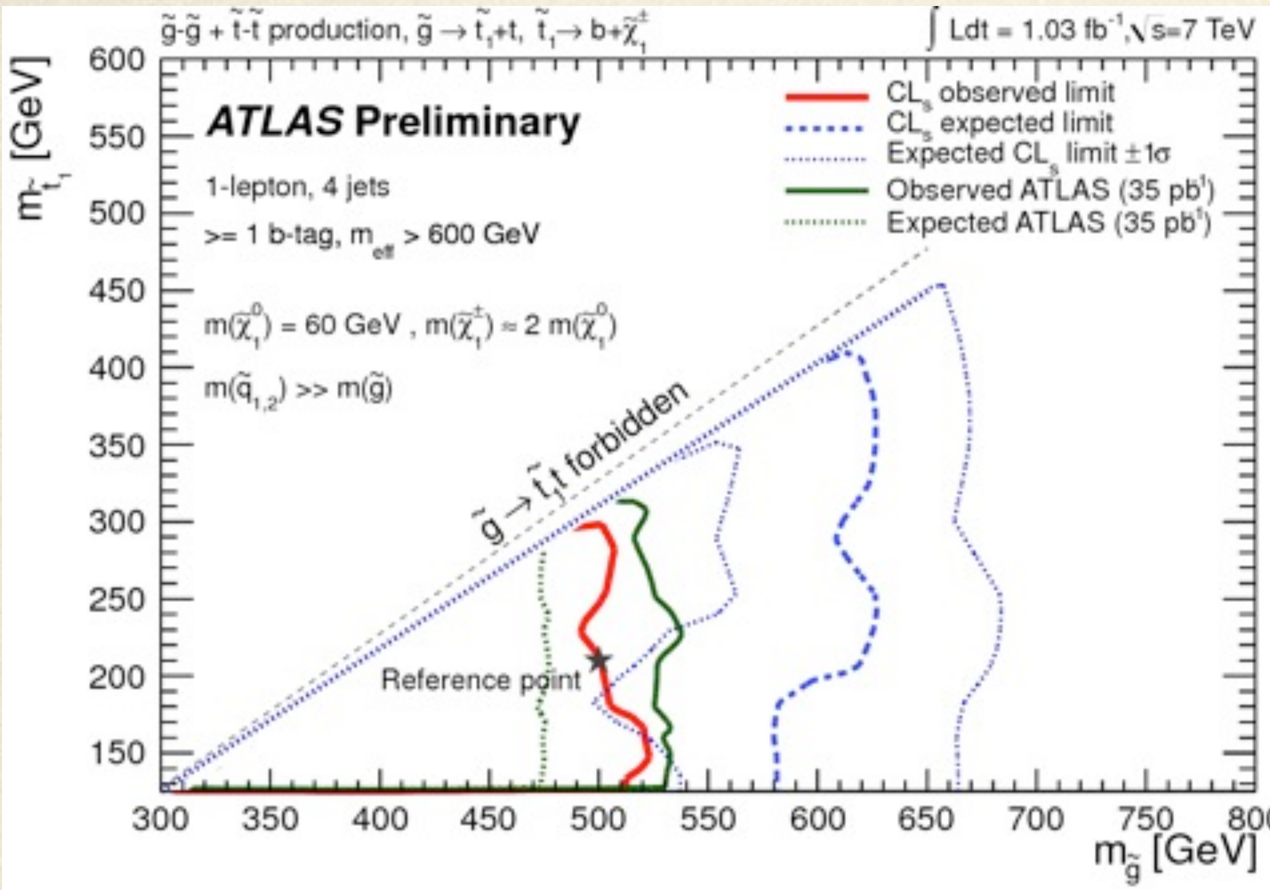
transverse mass for the signal region events

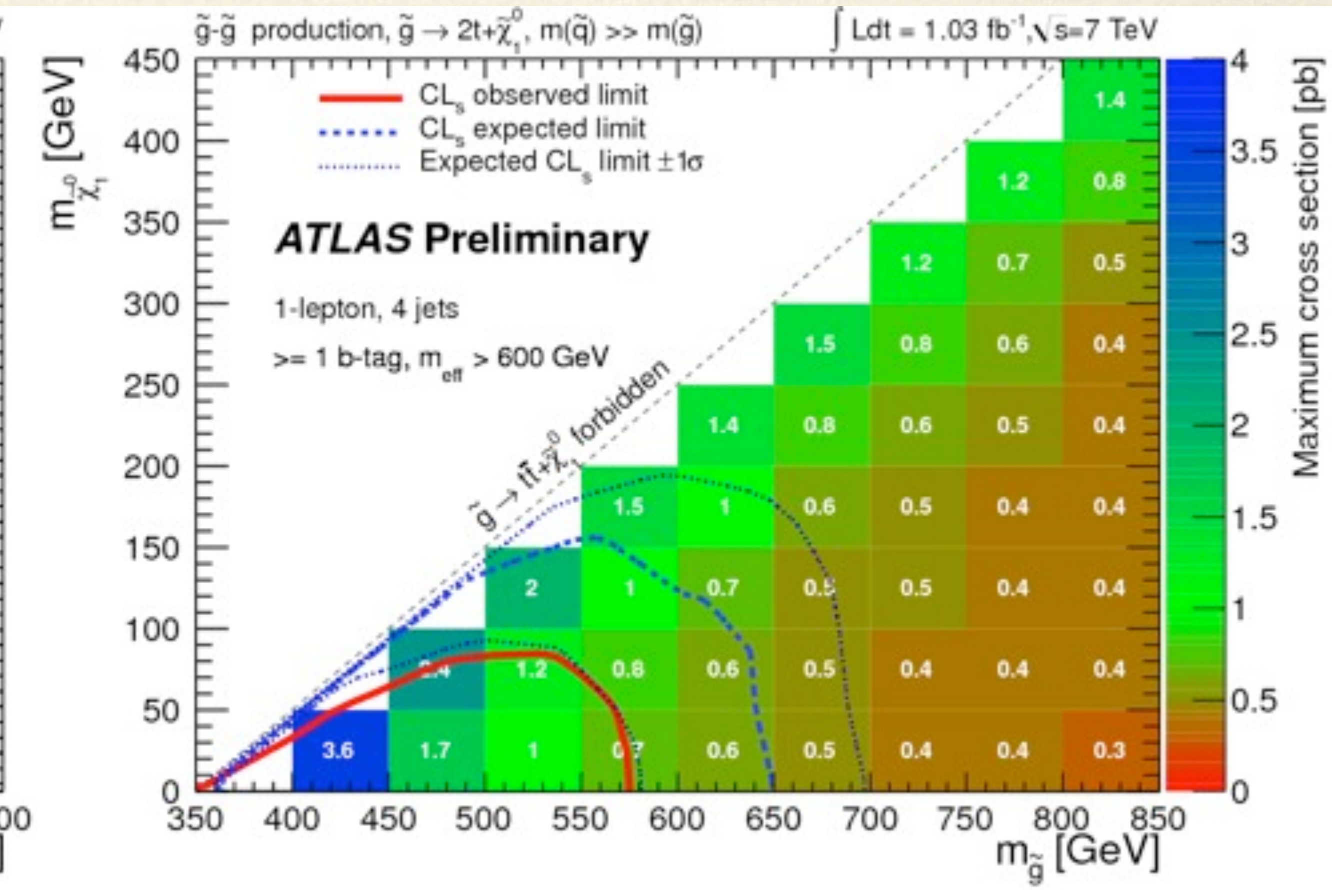
Results:

54.9 ± 13.6 events expected in signal region

74 events observed

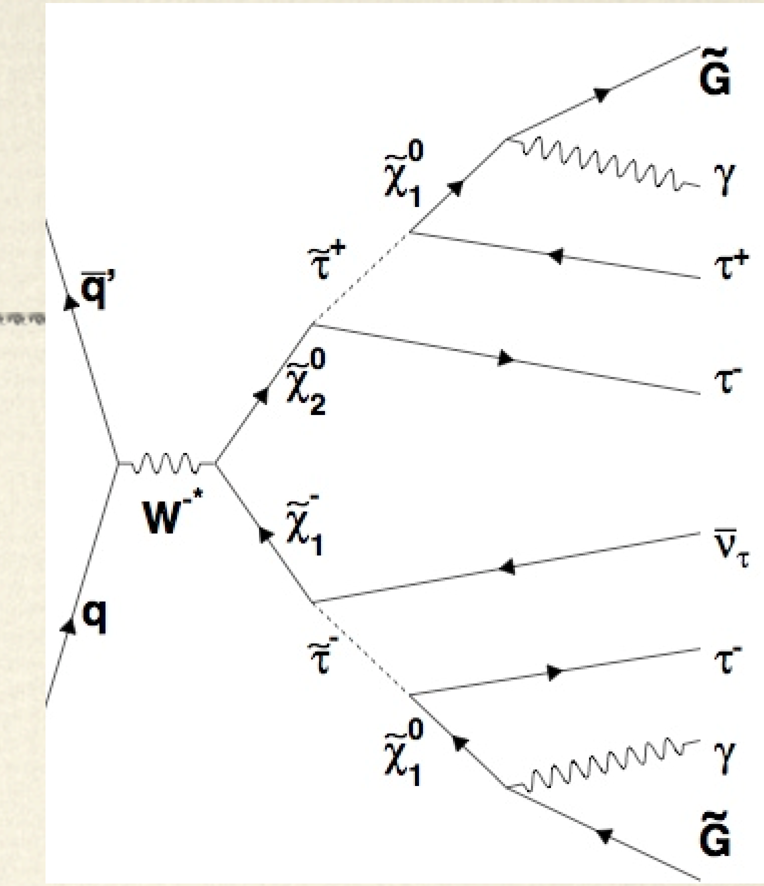
E_T^{Miss}+*b*-jets+1 lepton interpretation



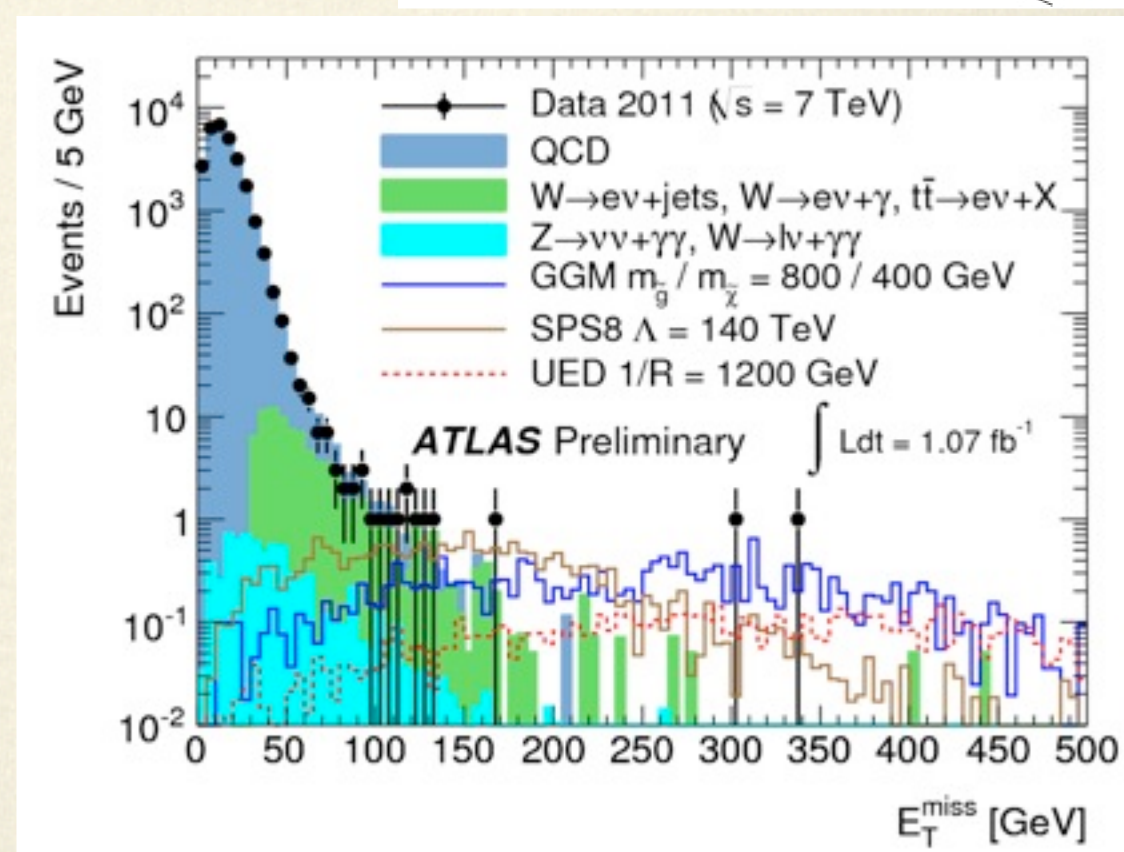


- Limits on gluino and stop masses, assuming $m(\tilde{\chi}_1^0)$ = 60 GeV, $m(\tilde{\chi}^{\pm}$ = $2m(\tilde{\chi}_1^0)$, BR($g \to \tilde{t}$ t) = BR($\tilde{t} \to$ b $\tilde{\chi}^{\pm}$) = 100%, and BR($\tilde{\chi}^{\pm} \to \tilde{\chi}_1^0$ l nu) = 11%
- Limits on gluino and neutralino masses, three body decay $\tilde{g} \to t\, t\, \tilde{\chi}_1^0$

E_T^{Miss}+2 photons

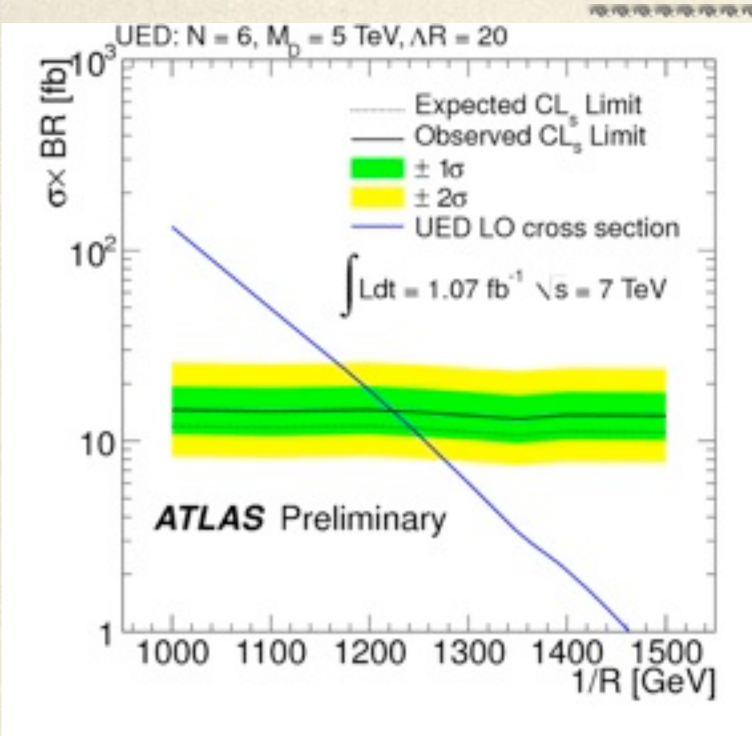


- Targeting the direct or gluino mediated production of a pair of bino-like NLSP decaying into gravitino and photon
- Selection: two photons of p_T > 25 GeV, E_T^{Miss} > 125 GeV.
- Three categories of backgrounds:
  - **QCD** (di-jet, jet-gamma, gamma gamma) with fake E_T^{Miss}. Estimated with a loose photon selection, normalized to gamma gamma data with E_T^{Miss} < 20 GeV
  - **e gamma** (W or semileptonic top pairs) with real E_T^{Miss}, with the electron misidentified as photon. Estimated from an egamma sample, to which the electron -> gamma misidentification probability (measured from a Z ee sample) is applied.
  - **Irreducible**: Zgg, Wgg. From MonteCarlo.

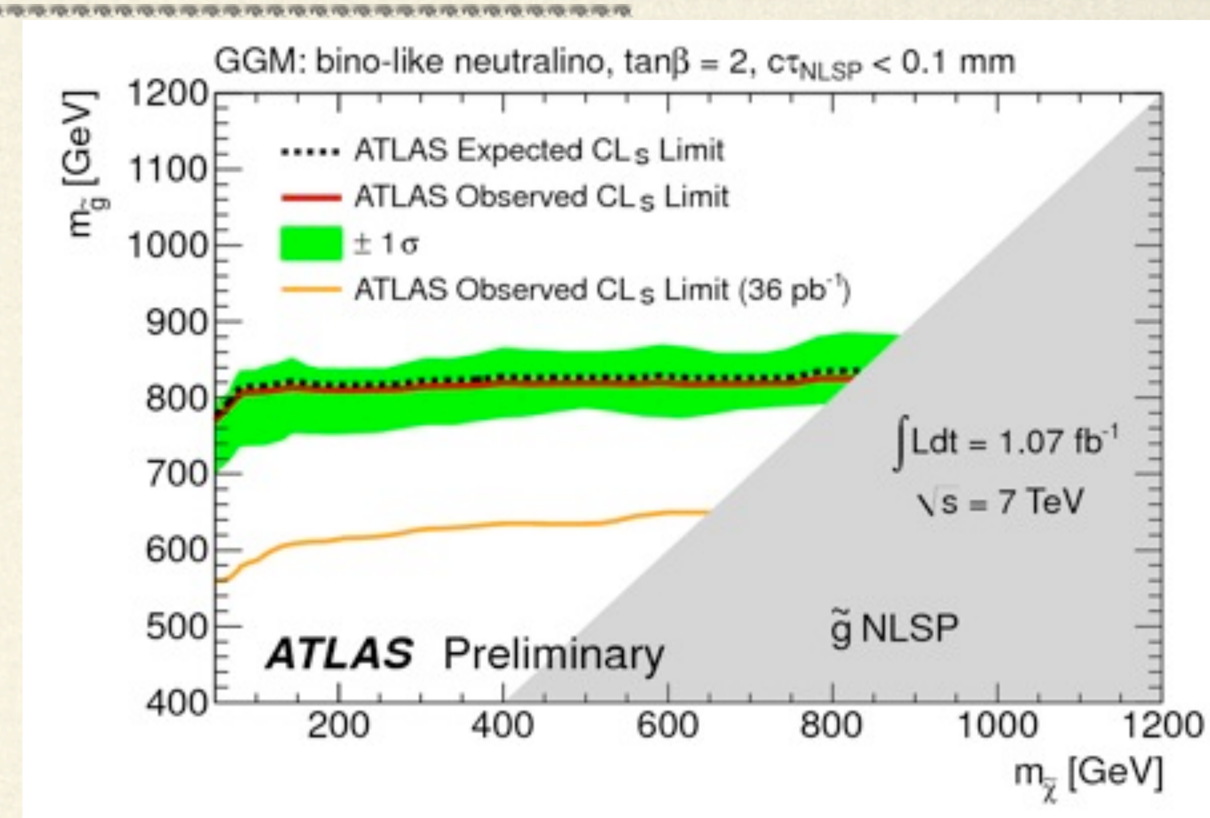


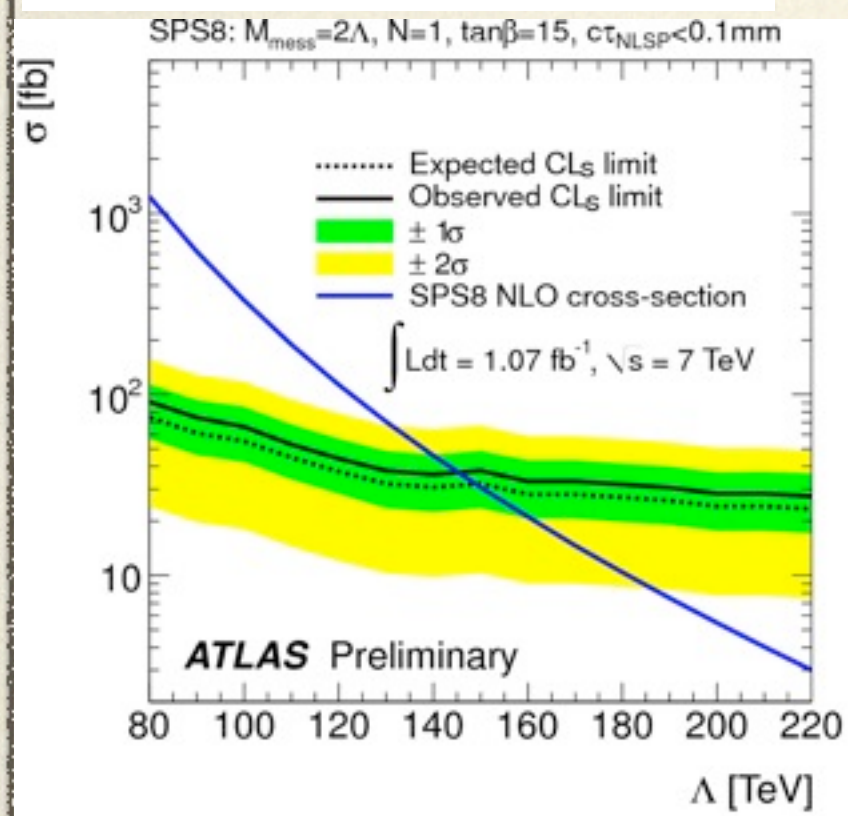
5 events observed in signal region
expected = 4.1 ±0.6 (stat.) ±1.6 (syst.)

E_T^{Miss}+2 photons limits



Universal extra dimensions
1/R > 1226 GeV for ∧R = 20





SPS8
Minimal GMSB model (*) with heavy squark and gluinos, so that gaugino EW production dominant.

General Gauge Mediation
m(g) > 806 GeV for bino masses larger than 50 GeV

First limit from LHC:
∧ > 145 TeV

* Eur. Phys. J. C25 (2002) 113

Long lived particles and R-parity violation searches

- Long lived particles are predicted in many scenarios: weak R-partity violating (RPV) couplings, long-lived NLSP due to small NLSP-LSP mass splitting or weak coupling to gravitino LSP, split susy with heavy scalars, ...
- If coloured, they would hadronize with quarks (R-hadrons).
- I will present four searches for long lived particles
  - For particles decaying in the Inner Detector: a search for secondary decay vertices and one for disappearing tracks
  - Two searches for non relativistic heavy particles (R-hadrons or sleptons)
- Also I will show the search for an eμ resonance, which is relevant for some RPV scenarios

33 pb^{-1}

arXiv:1109.2242
submitted to PLB

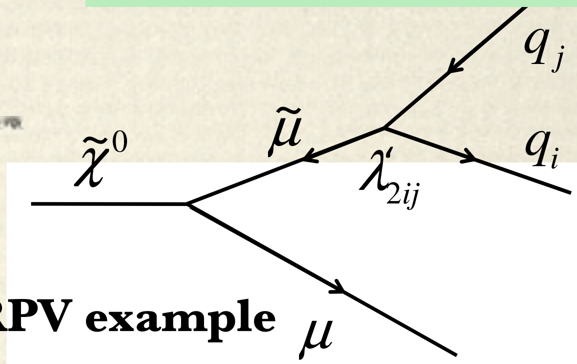
Displaced vertices search

- **Target:** heavy particle decaying in charged particles with ct between ~1 mm to tens of cm, and produced with (or decaying into) an high-p_T muon

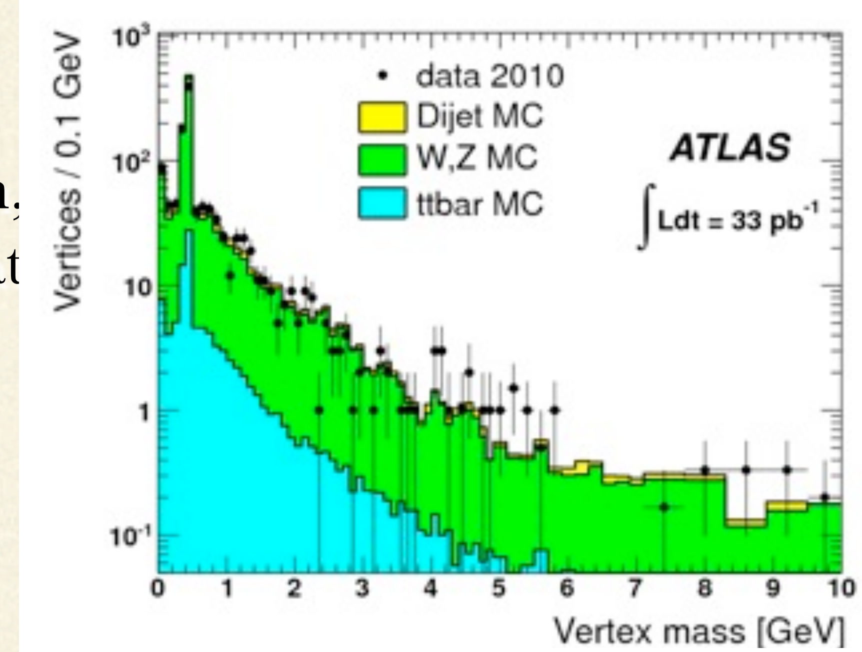
- Ask **one muon** with p_T > 45 GeV and at least **one 4-track vertex** with fit chi square < 5, radius between 40 and 180 mm, z coordinate less than 300 mm, distance from primary vertex at least 4 mm, veto position matching high density detector material (to reject conversions and hadronic interactions), vertex mass larger than 10 GeV.

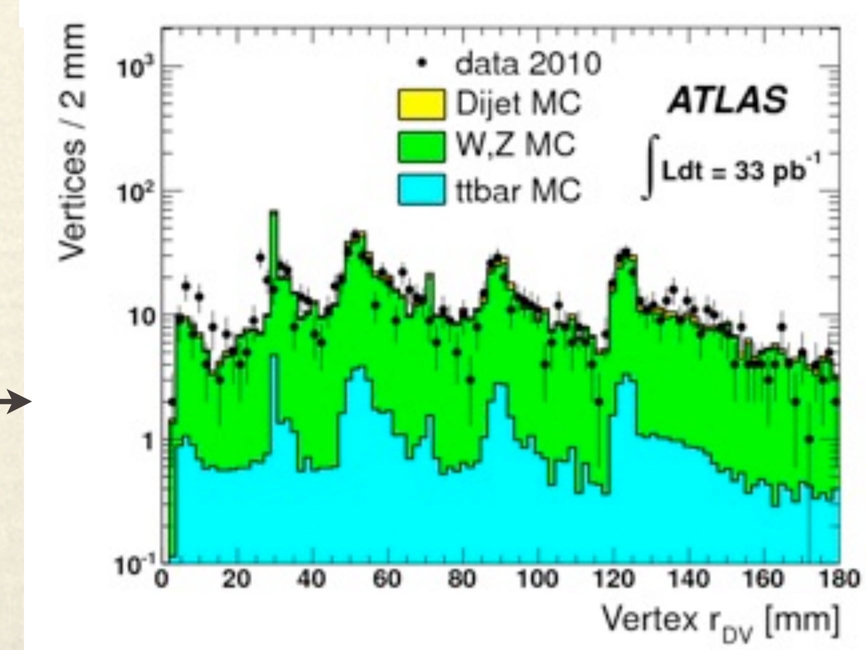
- Estimate background as the product of the probability of having an high p_T muon and one such vertex, from MC. Tracking and vertex description in MC validated on data.

Control plots done with all requirements except material veto, and number of tracks, and with vertex mass cut reversed.

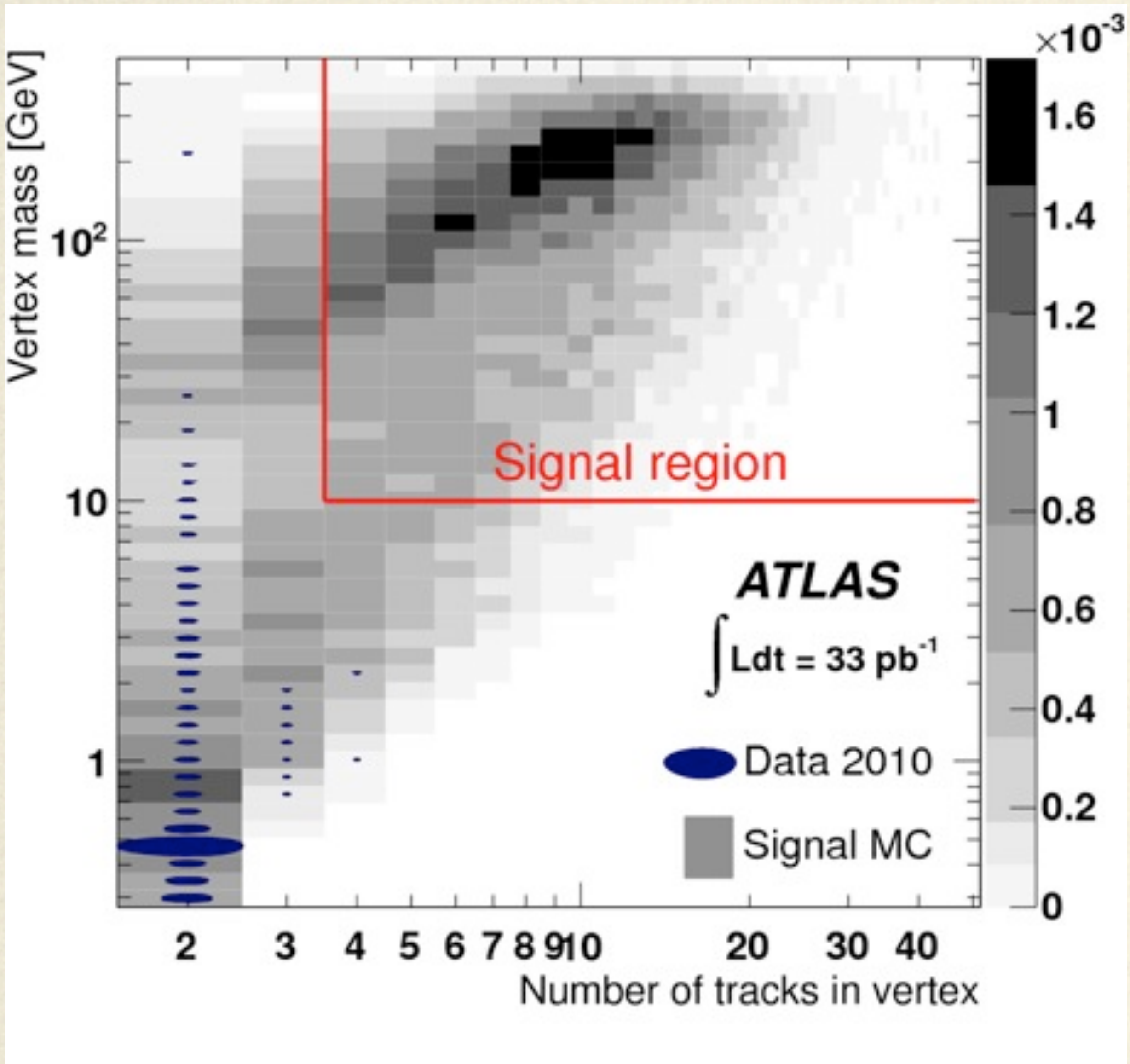


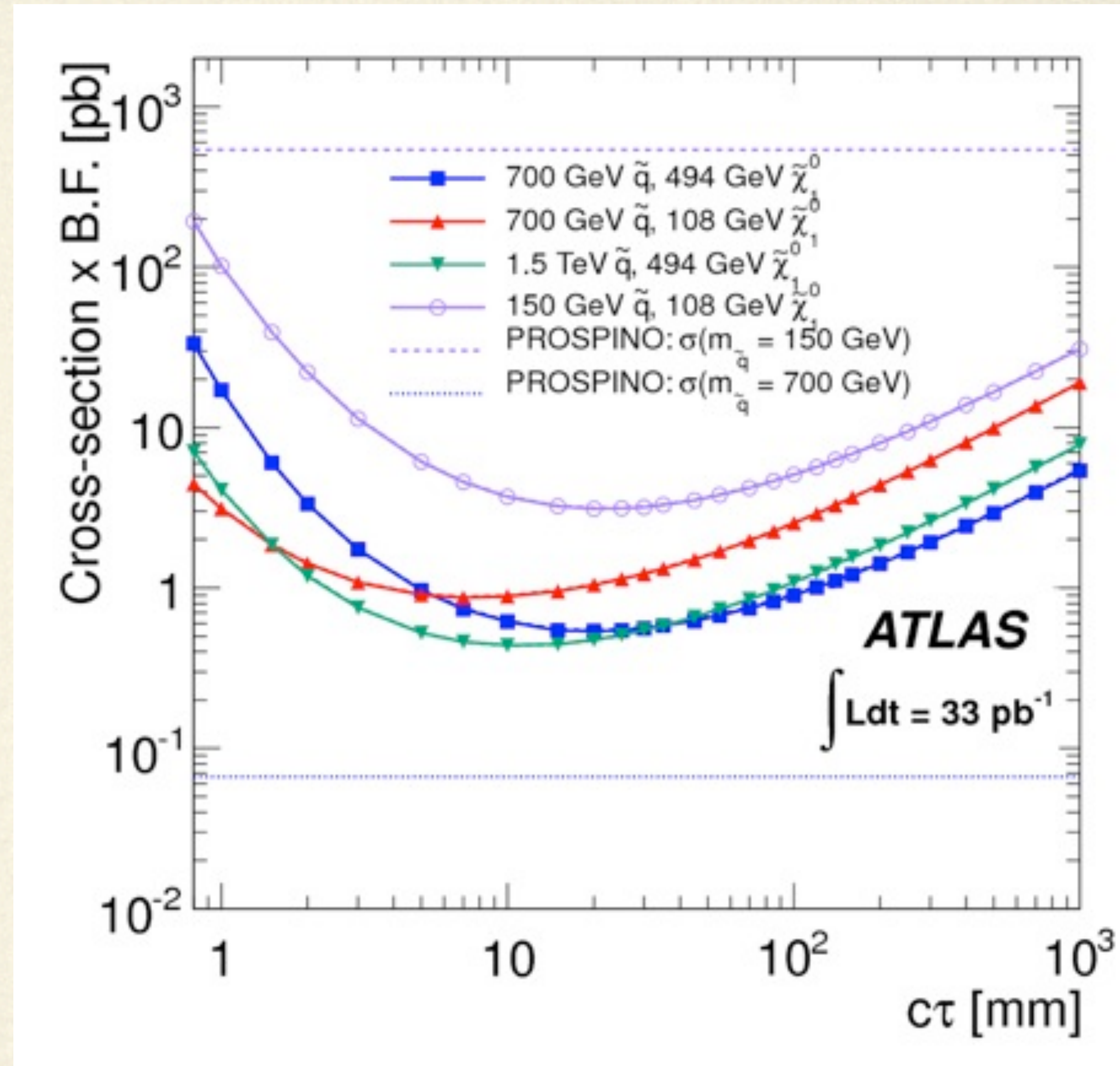
An RPV example





Displaced vertices analysis results



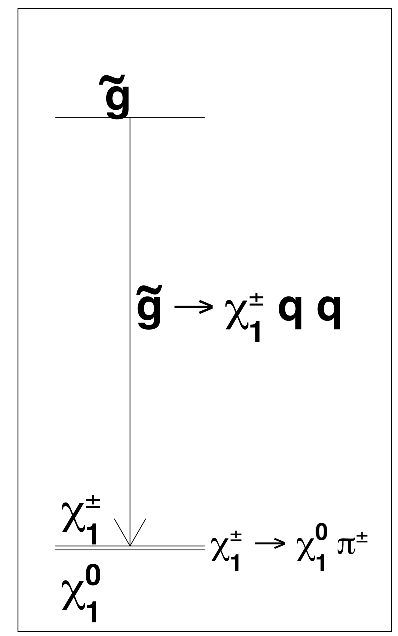


- No events are observed in the signal region, with an expected background of less than 0.03
- Limits derived for various squark and neutralino masses.

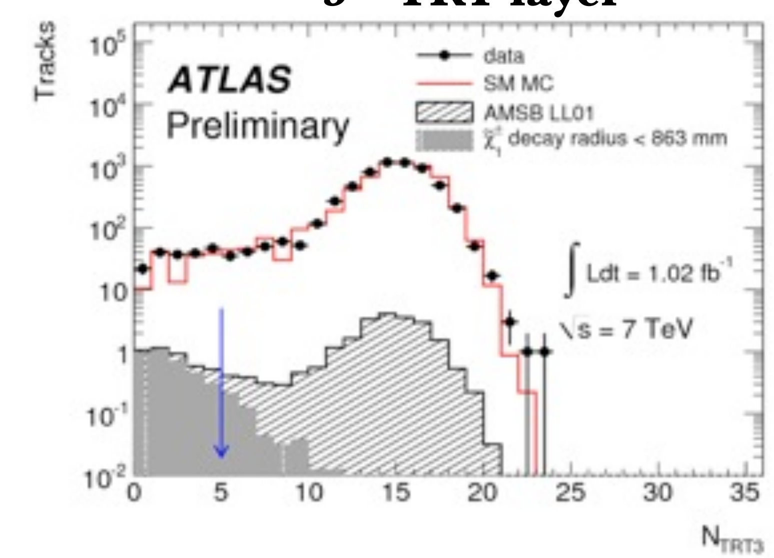
1.02 fb^{-1}

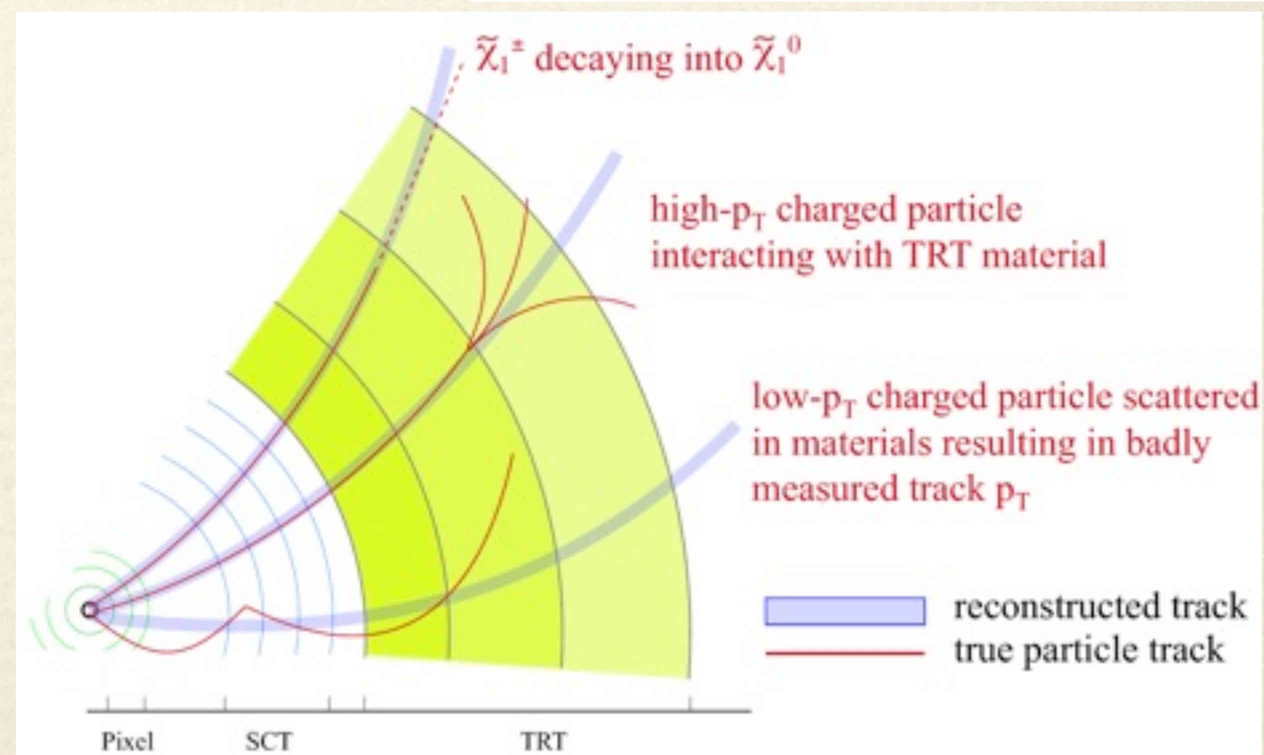
Disappearing track search

- In **anomaly mediated models** the lightest chargino decays into a soft pion and the neutralino, with a lifetime of order of ns.
- Selection:
  - $E_T^{Miss} > 130$ GeV, ≥ 1 jet with $p_T > 130$ GeV, ≥ 2 other jets with $p_T > 60$ GeV (*from gluino decay*), no electron or muon with $p_T > 10$ GeV
  - The highest p_T track is isolated, well reconstructed in Pixel and SCT, points to barrel TRT fiducial volume, has no hit in outer TRT ring (*chargino track*)
- Background p_T spectrum obtained from data:
  - Hadrons interacting in the TRT: control sample of non-interacting hadrons
  - Badly reconstructed tracks: low ETMiss, no Pixel hit tracks

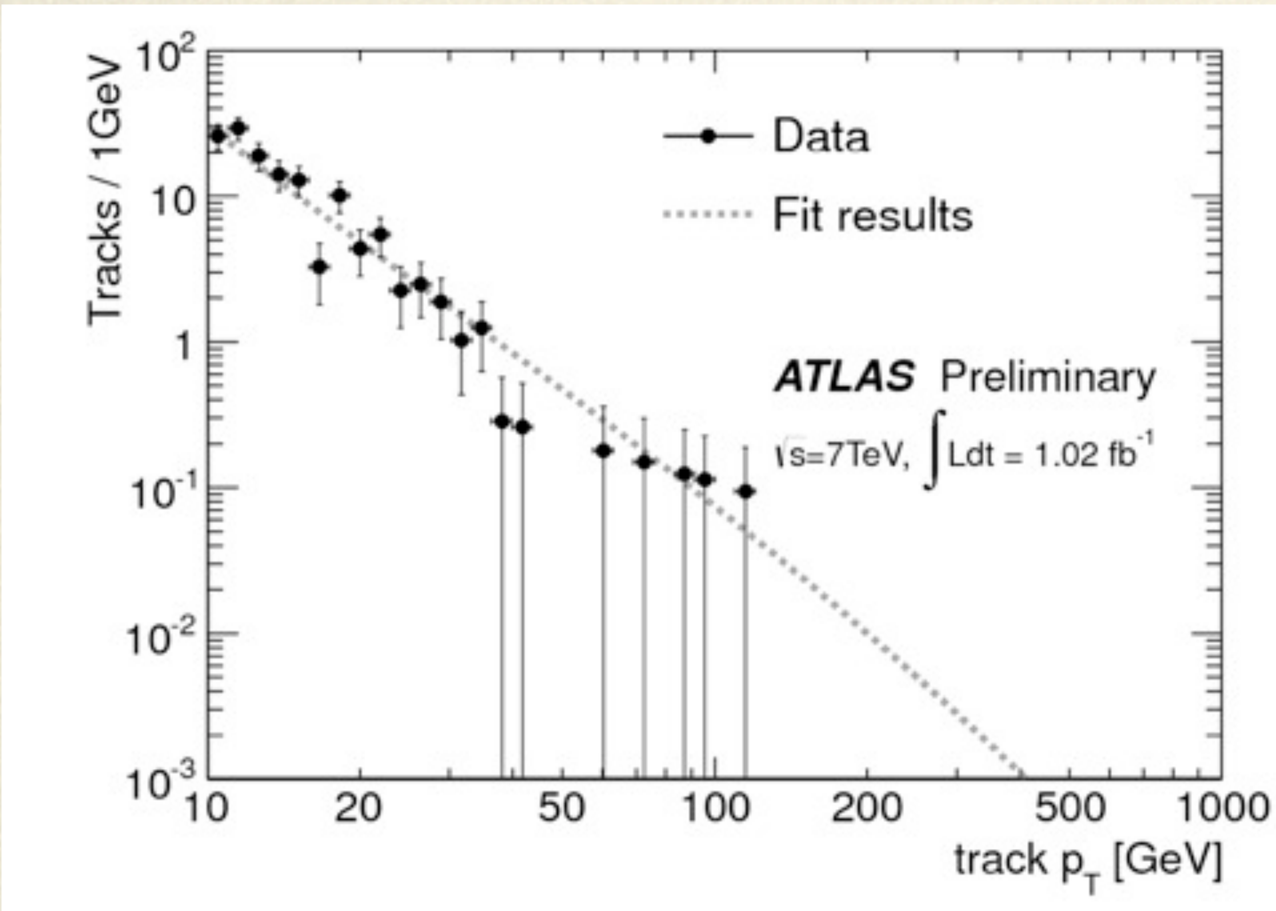


Number of hits in 3rd TRT layer

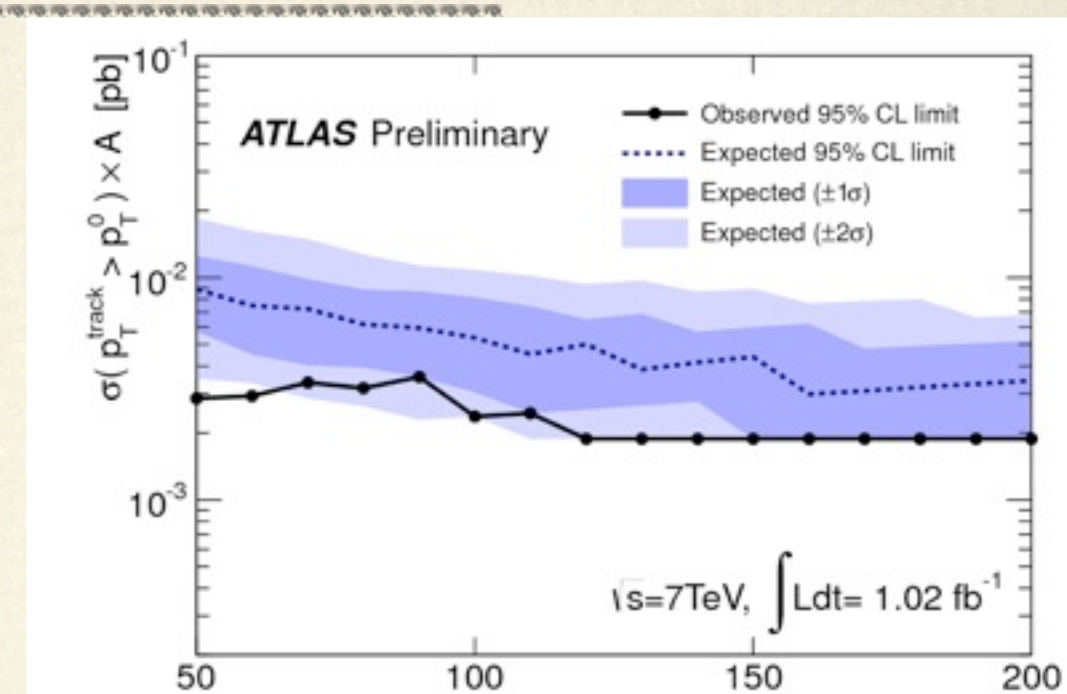




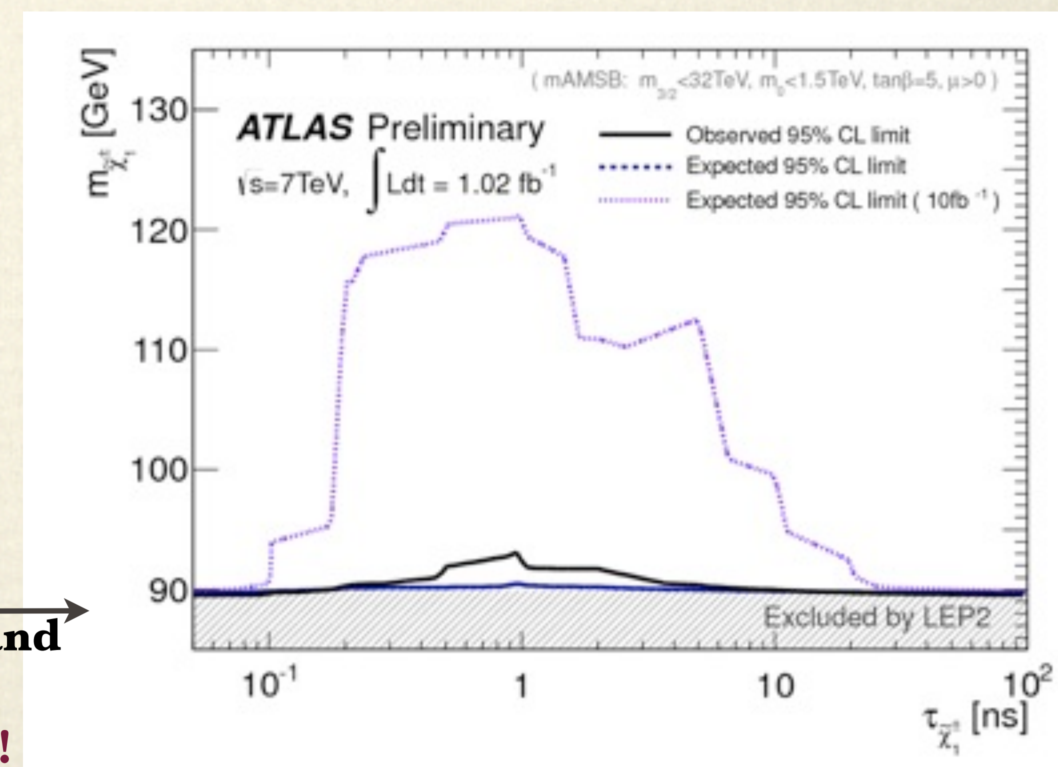
Disappearing track search results



The pT spectrum of selected track candidates (above) is fitted with the background template from control samples plus the signal template from MC.
Fit is consistent with no signal.



Effective cross section limit as a function of the track p_T cut



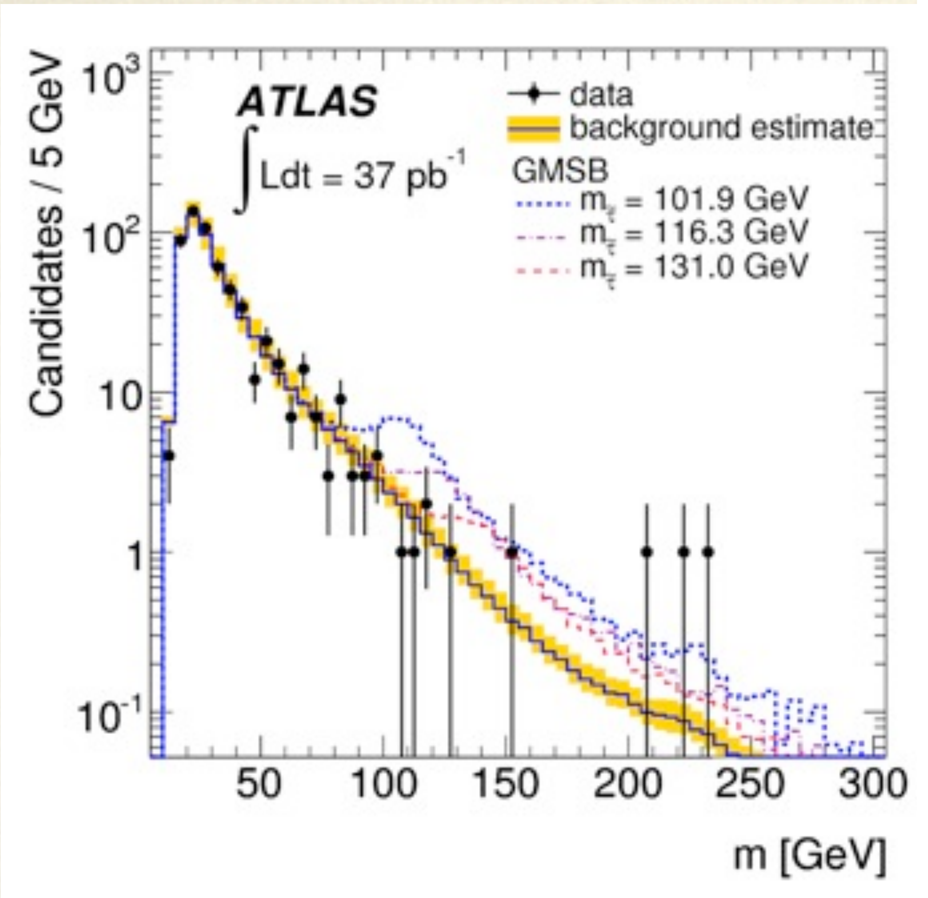
Limits in chargino mass and lifetime plane.
First limits beyond LEP!

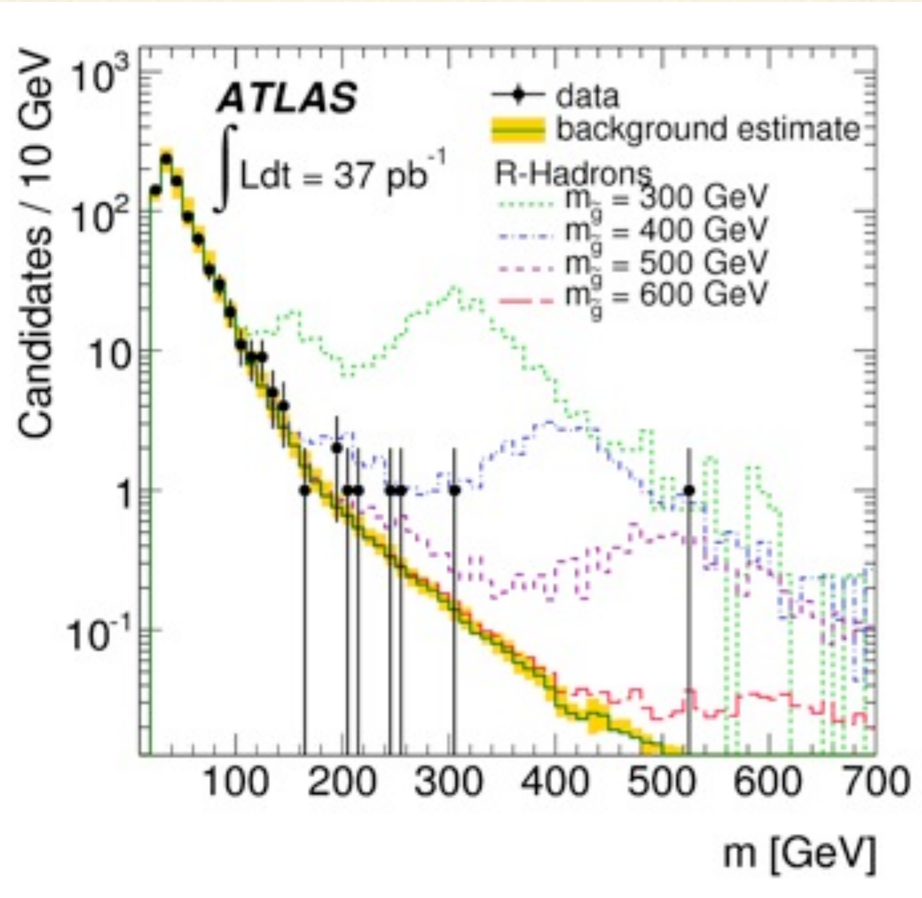
Muon spectrometer based search for slow particles

37 pb^{-1}

PLB 703,428

- Signature is speed v/c < 1. Mass reconstructed from momentum and velocity.
- Muon-triggered events, time of flight is measured from muon and hadron calorimeters. Search for long lived scalar leptons and R-hadrons (the latter are allowed to be neutral before interacting the calorimeters, i.e. an Inner Detector track is not required)
- Background estimate based on measured velocity resolution function





Limits:

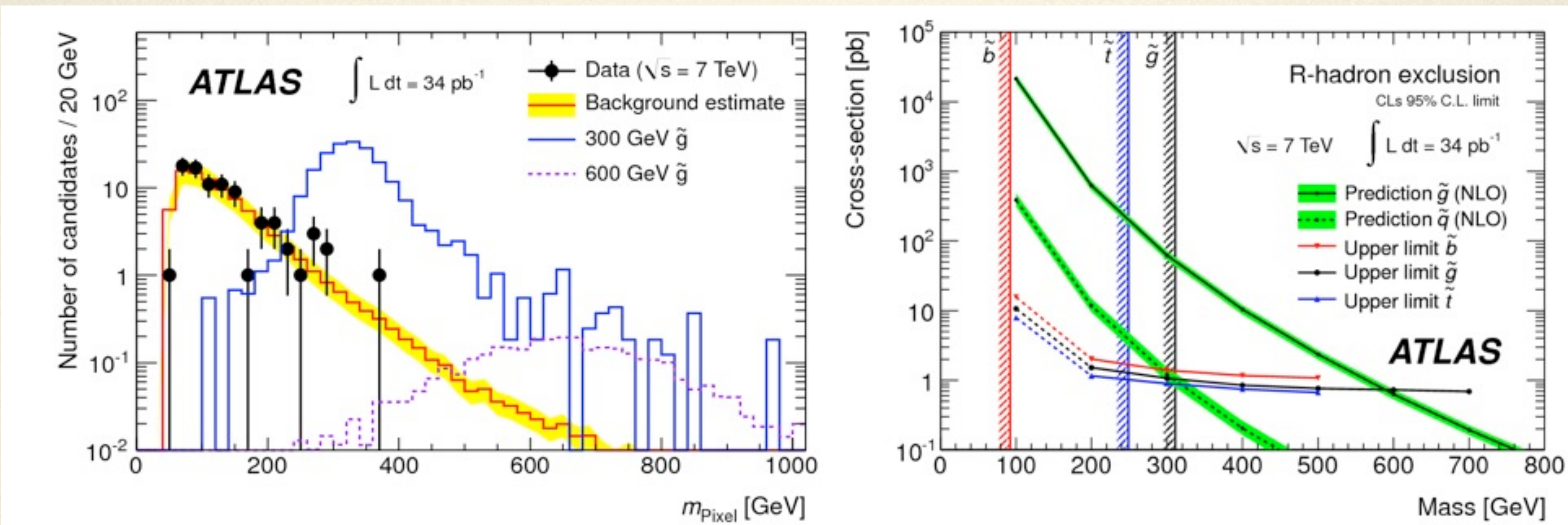
- slepton, GMSB: 136 GeV
- slepton, electroweak production: 110 GeV
- R-hadron gluino: 530-544 GeV

Muon agnostic search for slow particles

34 pb^{-1}

PLB 701,1

- Using the pixel dE/dx and the tile time of flight to measure particle velocity
- Background is from instrumental resolution tails in these variables. Since they are uncorrelated, resolution function can be measured from data.



Limits derived on the mass of long-lived scalar bottom (294 GeV), top (309 GeV) and gluino (562-584 GeV).

1.07 fb^{-1}

arXiv:1109.3089
submitted to EPJCL

eμ resonance search

- Possible signals: Z' with lepton flavour violations, RPV SUSY with scalar tau decay

  $d\bar{d} \rightarrow \tilde{\nu}_\tau \rightarrow e\mu$ Production and decay

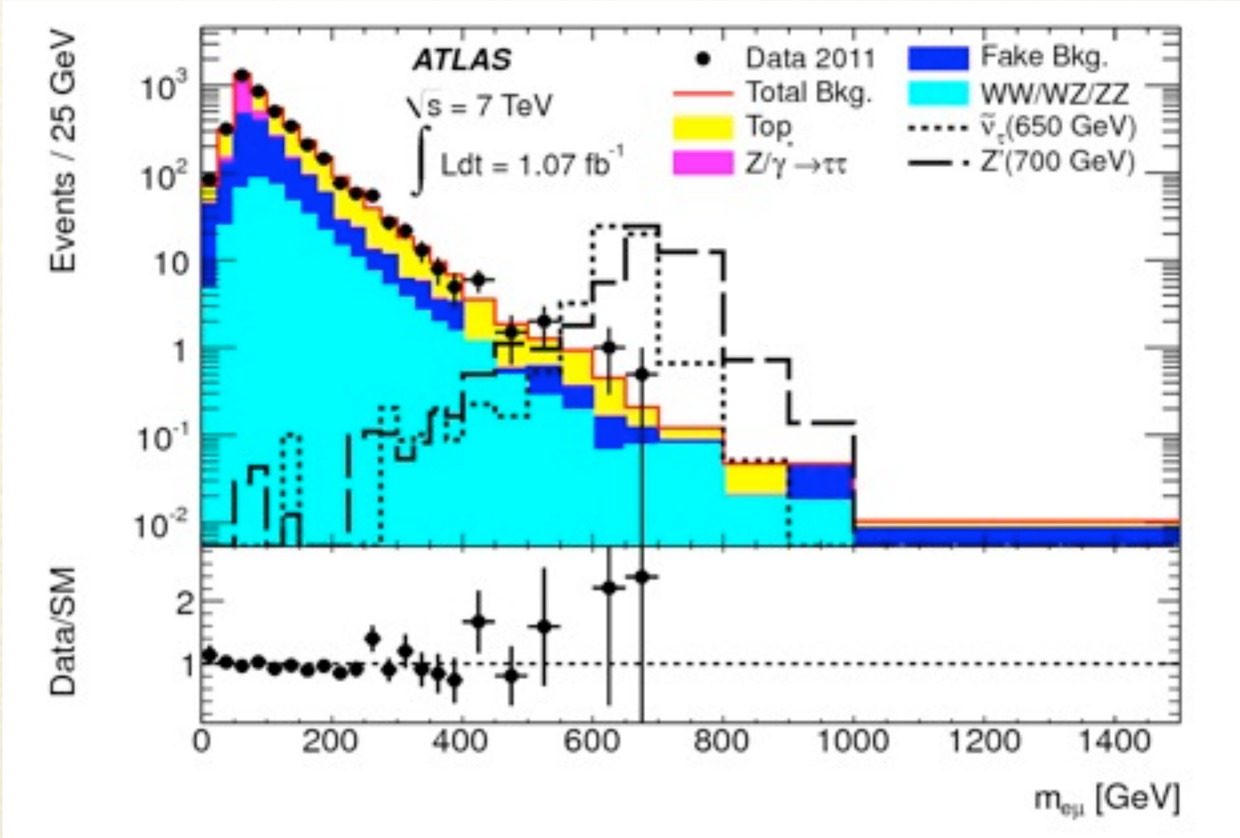
  $\frac{1}{2}\lambda_{ijk}\hat{L}_i\hat{L}_j\hat{E}_k + \lambda'_{ijk}\hat{L}_i\hat{Q}_j\hat{D}_k$ Relevant RPV Lagrangian

- Two relevant RPV couplings: λ'_{311} for production, λ_{312} for decay

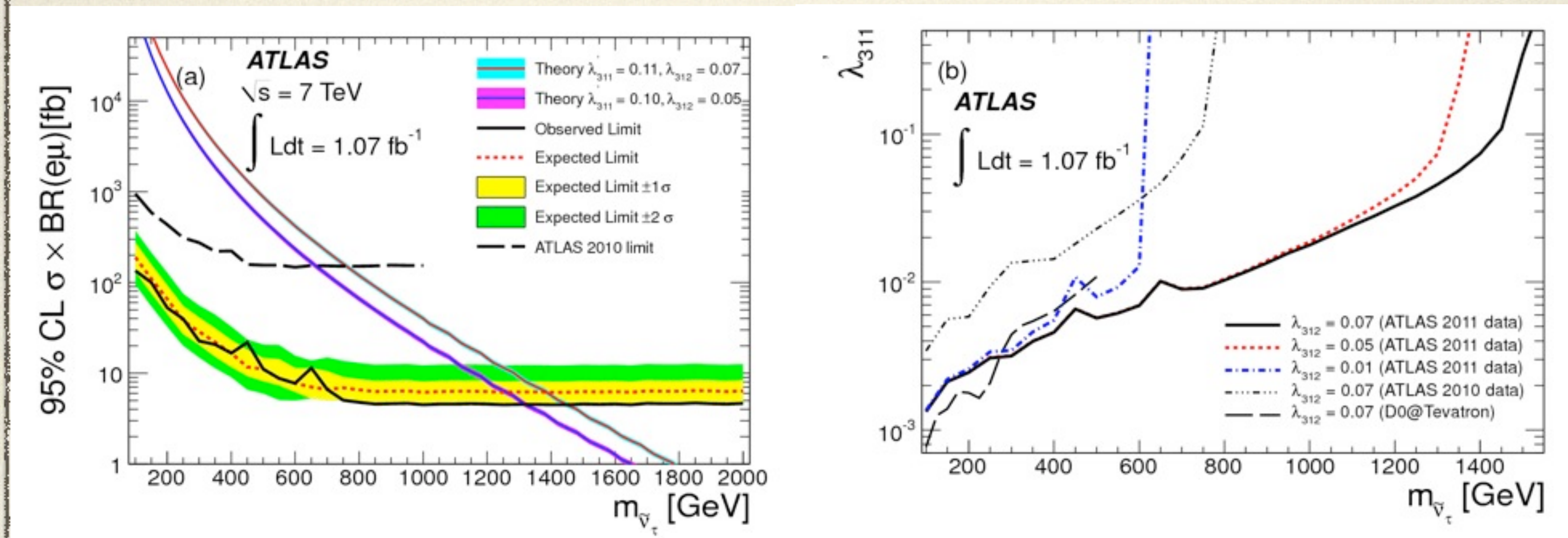
- Selection is exactly one electron and one muon with p_T > 25 GeV

- Data-driven multi-jet estimate from loose lepton control samples; other processes from MonteCarlo.

Process	Number of events
$t\bar{t}$	1580 ± 170
Jet fake	1180 ± 120
$Z/\gamma^* \rightarrow \tau\tau$	750 ± 60
WW	380 ± 31
Single top	154 ± 16
$W/Z+\gamma$	82 ± 13
WZ	22.4 ± 2.3
ZZ	2.48 ± 0.26
Total background	4150 ± 250
Data	4053

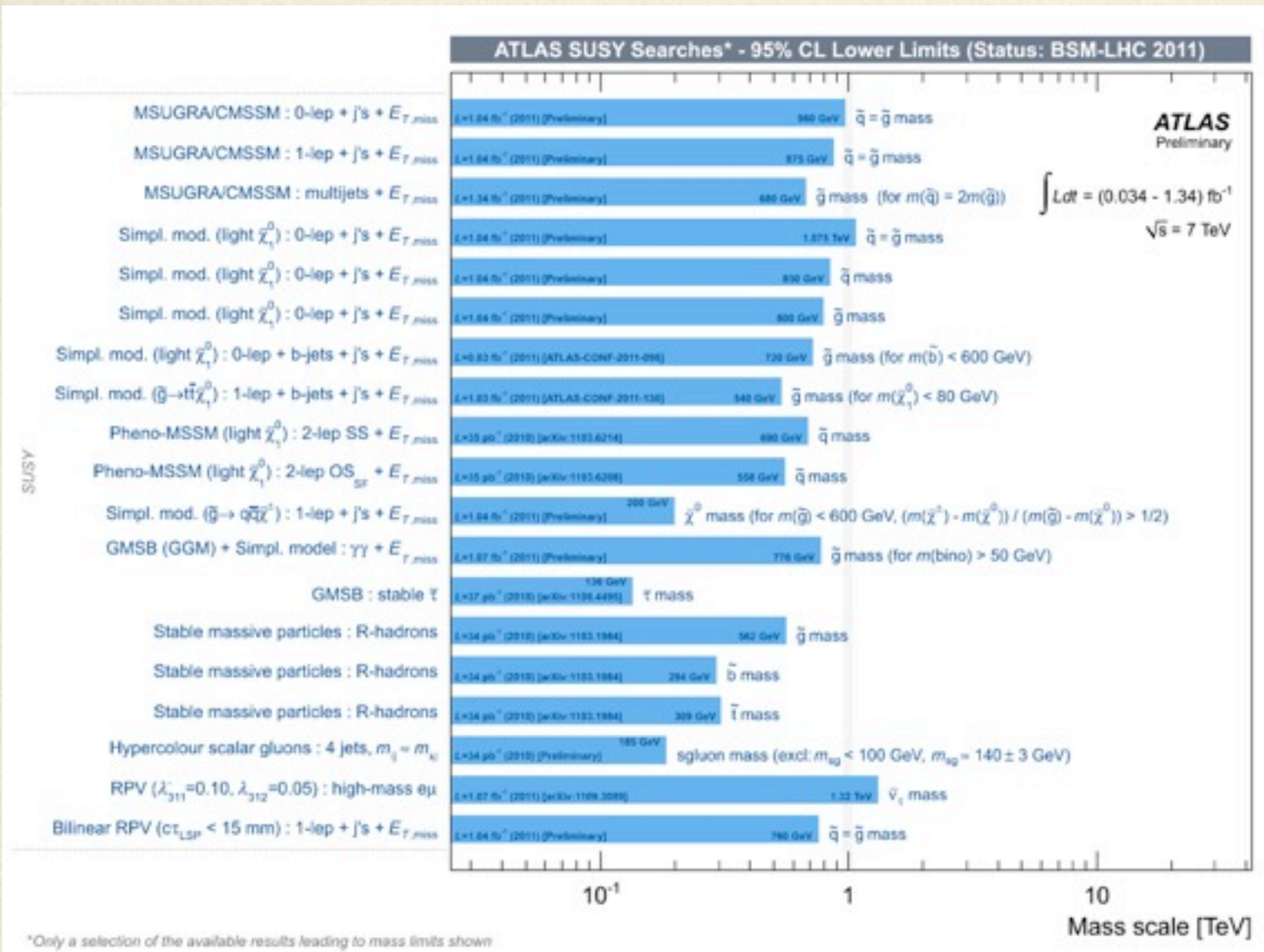


eμ resonance search interpretation

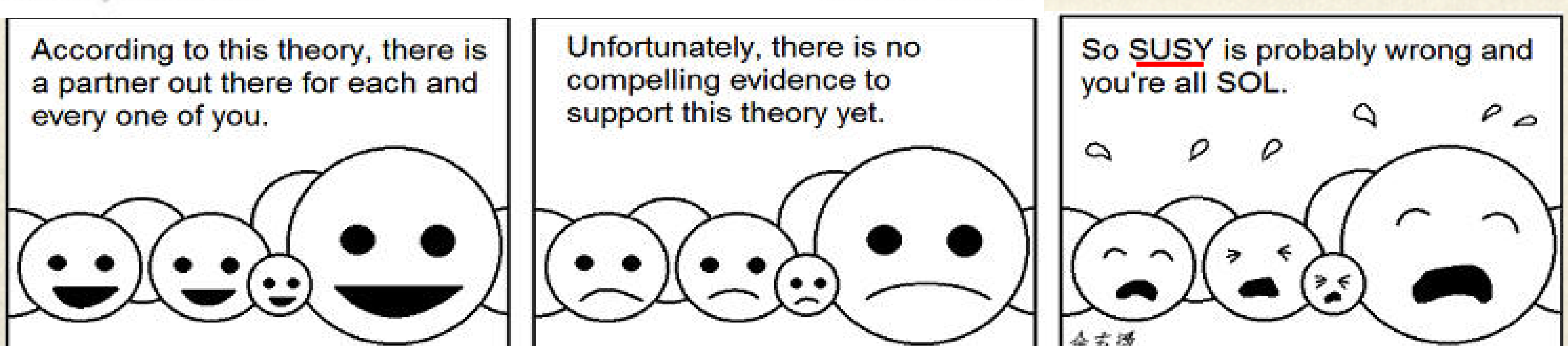


- Most stringent limits on the couplings for sneutrino masses > 270 GeV
- For $\lambda'_{311} = 0.10, \lambda_{312} = 0.05$, limit is 1.32 TeV

Conclusions ?



- No evidence of non-SM contributions has been found in 1 fb^{-1} of collision data and a large variety of final states
- SUSY limits on squarks and gluinos are now approaching the TeV scale



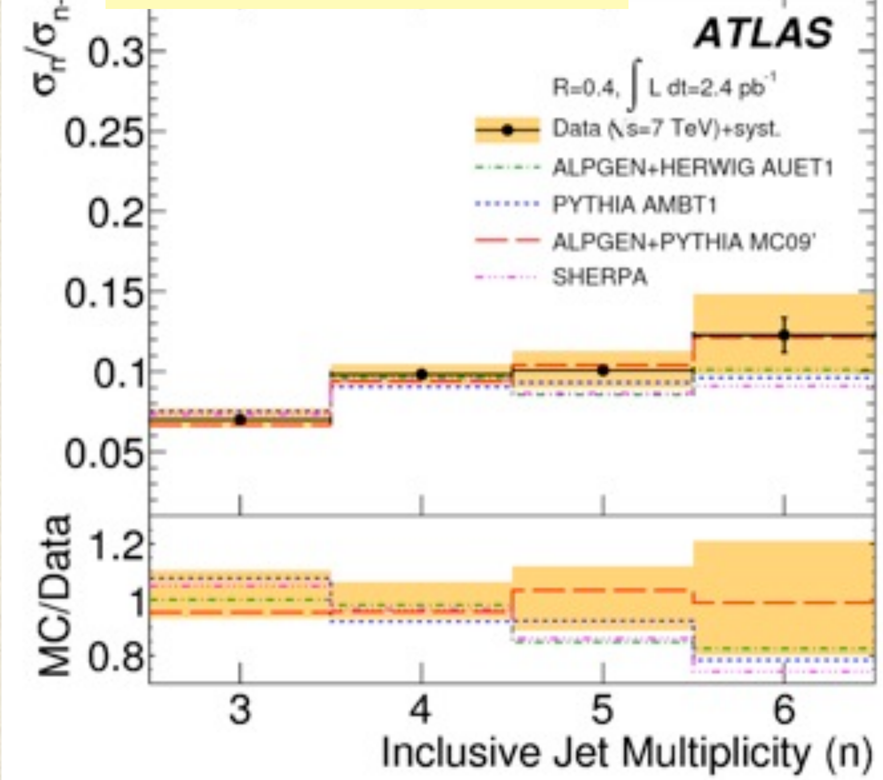
Outlook

- These results rule out the easy scenario of sub-TeV squark (first generations) or gluino with a light LSP.
- With 5 fb^{-1} now on disk, we are looking at many other possibilities:
  - Direct production of scalar bottom, top, slepton, and gaugino
  - Compressed mass spectrum
  - Refining consolidate searches, like moving from cut-and-count in one bin to shape analysis, work on systematics etc., to further push up sensitivity
- We haven't given up, and we are still optimizing our searches for discovery, not exclusion... stay tuned for more results with full 2011 data set!

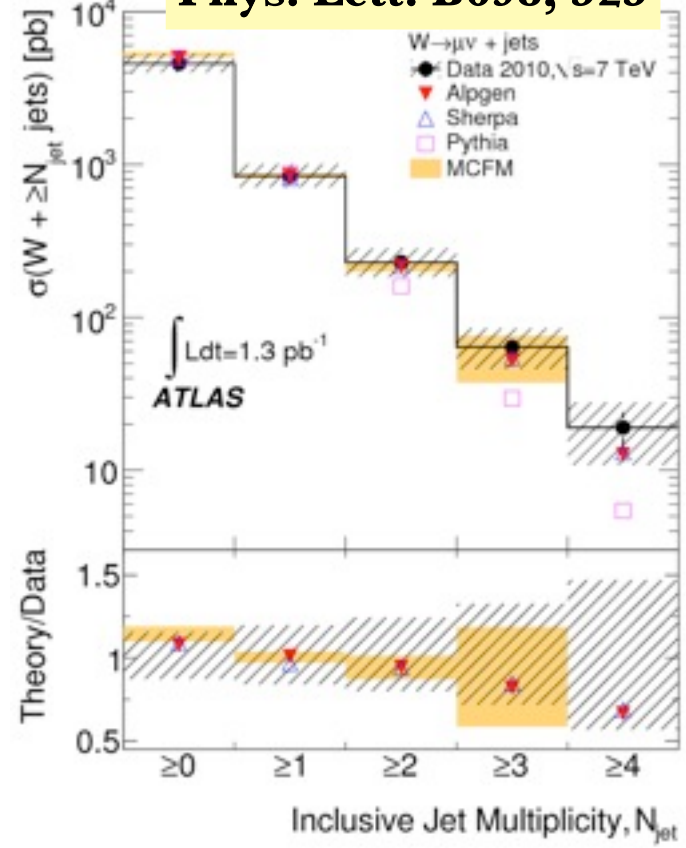
Backup slides

Performance and Standard Model measurements

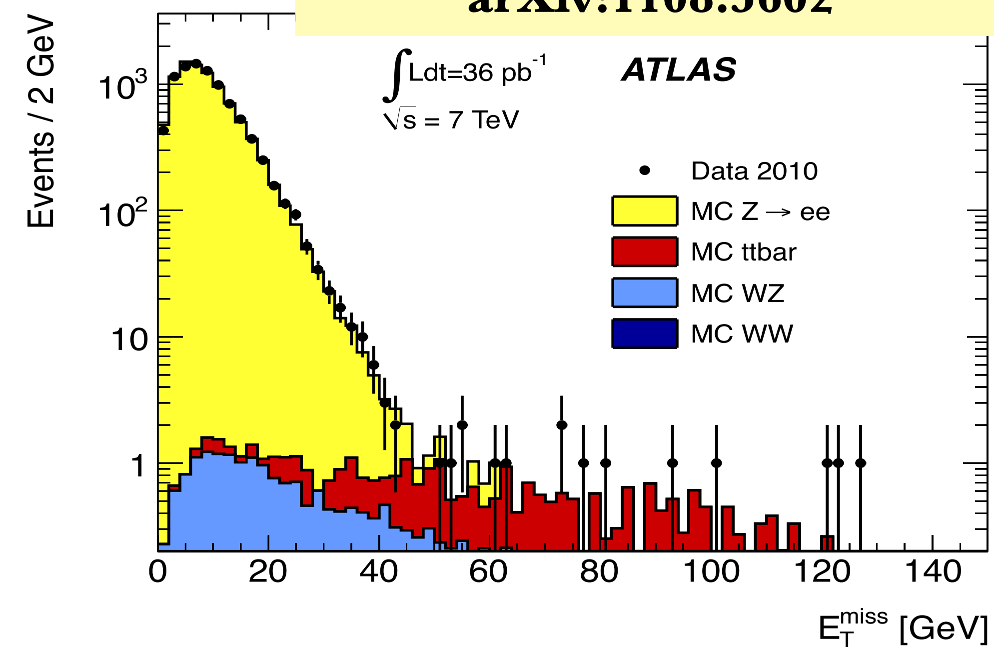
Multi jet cross section
arXiv:1107.2092



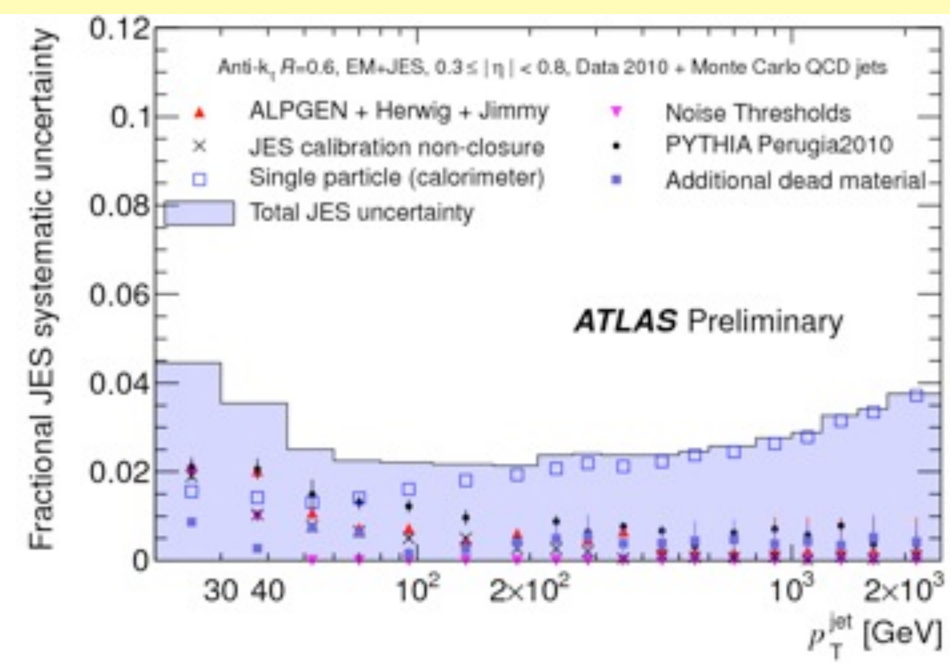
W+jet cross section
Phys. Lett. B698, 325



Missing Et in Z(ee) candidates
arXiv:1108.5602

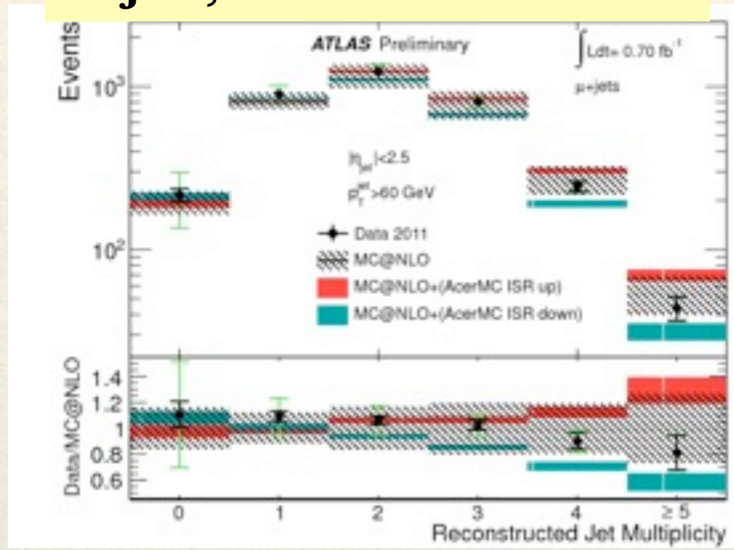


Jet energy scale uncertainty for central jets
ATL-CONF-2011-032



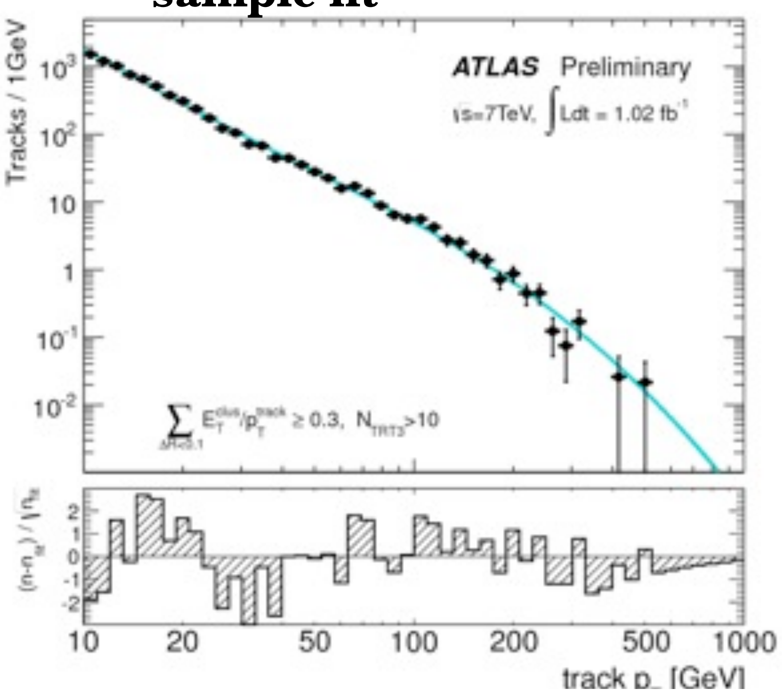
- The new pysics searches presented here are possible because of the excellent performance of our detector and the understanding we achieved of Standard Model processes.

tt+jets, ATL-CONF-2011-142



AMSB search backup plots

Hadron track control sample fit



Bad track control sample fit