Search for supersymmetric gauginos and third generation squarks with the ATLAS detector

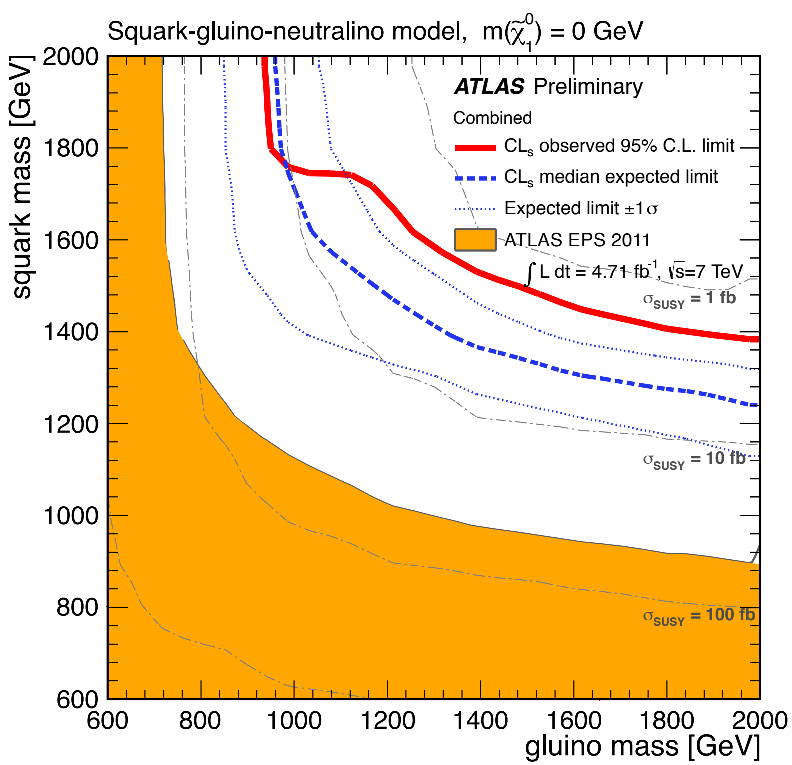
PLHC 2012, Vancouver

Josh McFayden, on behalf of the ATLAS collaboration

Introduction

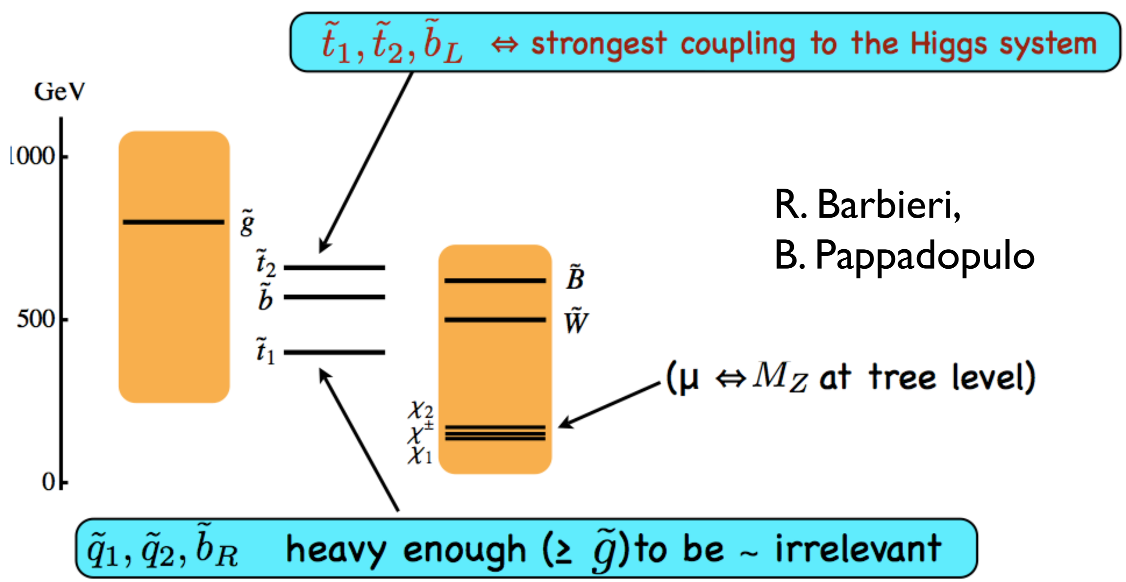
- Searches for **supersymmetric gauginos and 3rd generation squarks** at the LHC are well motivated by **naturalness** arguments.

- The **exclusion of ~TeV scale first and second generation squarks and gluinos** by previous LHC searches makes these searches particularly interesting.



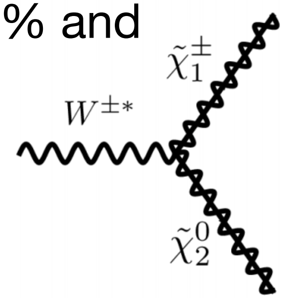
Introduction

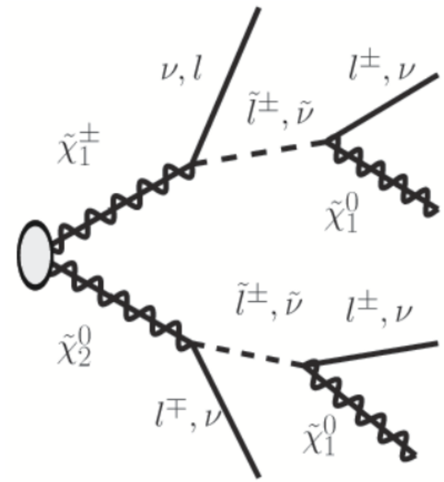
- Searches for **supersymmetric gauginos and 3rd generation squarks** at the LHC are well motivated by **naturalness** arguments.
- The **exclusion of ~TeV scale first and second generation squarks and gluinos** by previous LHC searches makes these searches particularly interesting.
- Several **"natural"** SUSY scenarios rely on **"light"** third generation squarks and gauginos.



Gaugino scenarios

- Weak gaugino search results are interpreted in the following scenarios:
  - **Simplified models** for direct gaugino production:
    - $\tilde{\chi}_1^\pm$, $\tilde{\chi}_2^0$ are assumed to be Wino-like.
    - Assuming BR($\tilde{\chi}_1^\pm \to \tilde{l}\nu, \tilde{\nu}l$)=50%,50% and BR($\tilde{\chi}_2^0 \to \tilde{l}^\pm l^\mp$)=1.
    - s-channel production mode:

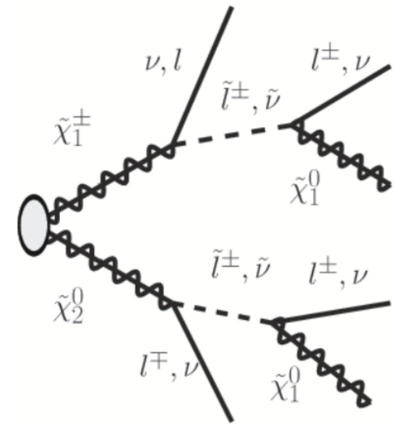




  - **Phenomenological MSSM**:
    - Neutralino/chargino mass eigenstates are mainly dependent on the SU(2), U(1) and higgsino mass parameters.
    - Scenarios with light sleptons increase the number of leptons in final state.
    - Chosen parameters:
      - M_1 = 100 GeV
      - $\tan\beta$ = 6
      - m_A = 500 GeV

3-lepton | Analysis outline & backgrounds

- Search for chargino and neutralino production in the **3-lepton** final state with **2.06 fb^{-1}**.



- Next-to-lightest neutralino can decay
  - **via sleptons and off-shell Zs** (non-resonant final state)
  - **via on-shell Zs**.
- Two signal regions:
  - **3 leptons, E_T^{miss} > 50 GeV, Same flavour opposite sign (SFOS) lepton pair**

Z-enriched signal region:
- SFOS pair in the Z peak (m_{ll} within 10 GeV of the nominal Z mass)

Z-depleted signal region:
- SFOS pair Z-veto (m_{ll} within 10 GeV of the nominal Z mass)
- b-jet veto

- Dominant backgrounds
  - **Irreducible background**, 3 real leptons - WZ/γ^*, ZZ/γ^*, $t\bar{t}$+V - estimated from MC.
  - **Reducible background** from fake leptons - Estimated using DD matrix method.
    - 2 real leptons and 1 fake lepton - tt, single top (Wt), WW, Z/γ^*.
    - 1 real lepton and 2 fake leptons - W, single top (s-channel, t-channel).

arXiv:1204.5638, accepted by PRL

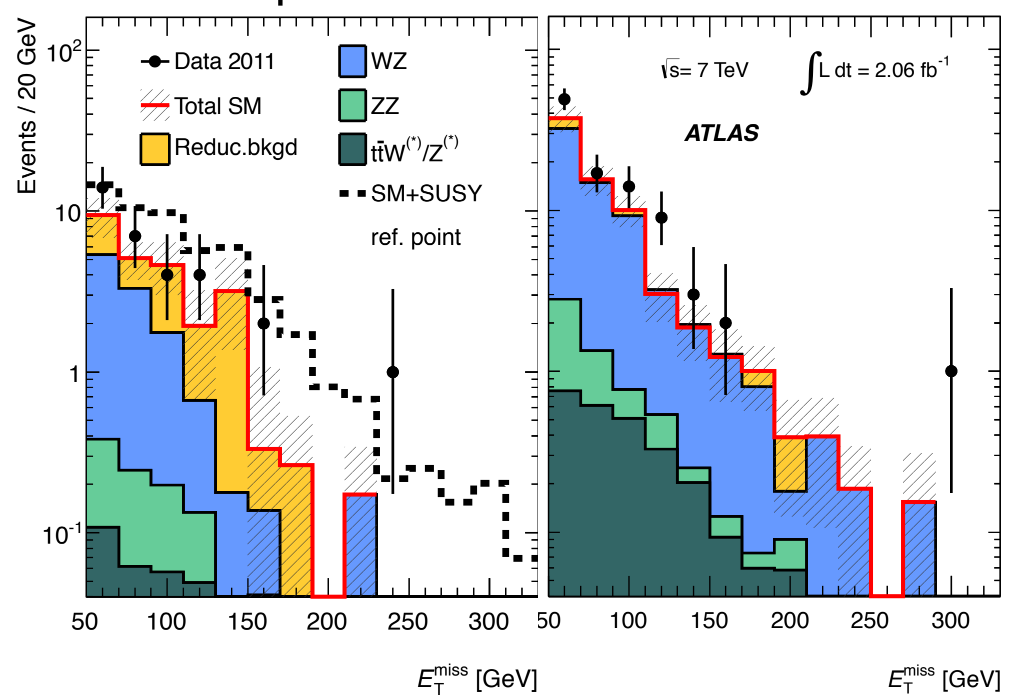
3-lepton | Results

- Generally good agreement is observed between data and SM expectation is observed in both the validation and signal regions.

Selection	VR1	VR2	SR1	SR2
$t\bar{t}W^{(*)}/Z^{(*)}$	1.4±1.1	0.7±0.6	0.4±0.3	2.7±2.1
$ZZ^{(*)}$	6.7±1.5	0.03±0.04	0.7±0.2	3.4±0.8
$WZ^{(*)}$	61±11	0.4±0.2	11±2	58±11
Reducible Bkg.	56±35	14±9	14±4	7.5±3.9
Total Bkg.	125±37	15±9	26±5	72±12
Data	122	12	32	95

- Systematic uncertainties:
  - **Reducible backgrounds**: 29%
    - Largely coming from object misidentification uncertainties
  - **Irreducible backgrounds**: 17%
    - Dominated by uncertainty on acceptance due to PDFs.
  - **Signal**: 10-15%
    - From renormalisation scale, factorisation scale, α_s and PDF variations.

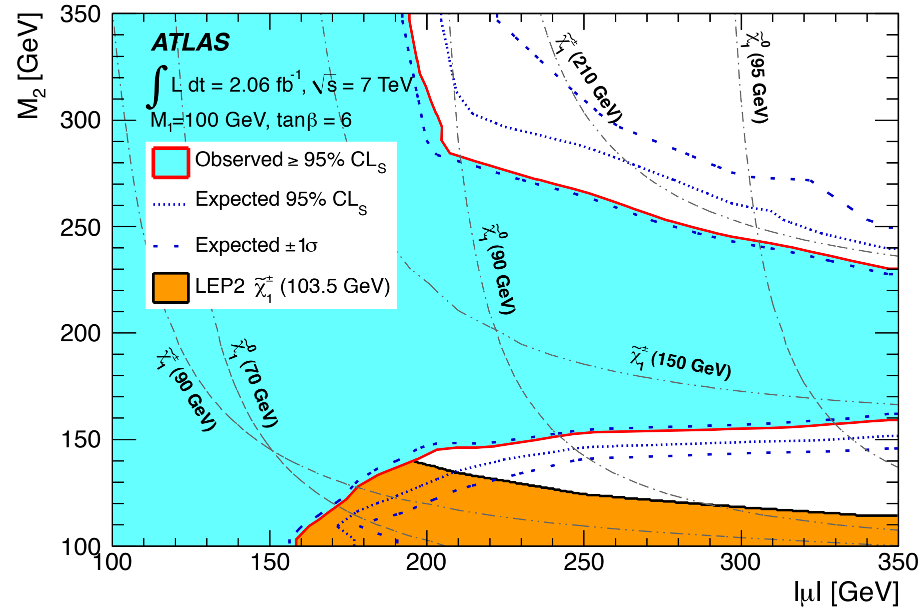
"Z depleted" "Z enriched"

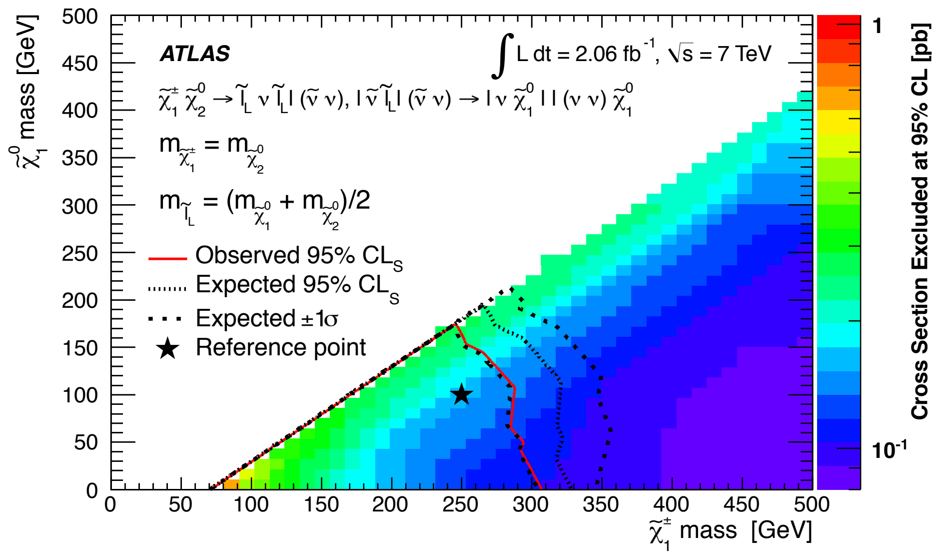


arXiv:1204.5638, accepted by PRL

3-lepton | Interpretation

- Exclusion limits at 95% confidence level are set using the CLs prescription
- Interpretation in MSSM scenario with M_1=100 GeV
  - **M_2 < 200 GeV** excluded for **|μ| < 150 GeV**.
  - **|μ| < 350 GeV** excluded for **150 < M_2 < 230 GeV**.
- Interpretation in simplified models
  - Limits are set in the **$m(\tilde{\chi}^{\pm})$ - $m(\tilde{\chi}^{0})$** plane.
  - **$m(\tilde{\chi}^{0})$ < 170 GeV** excluded for **70 < $m(\tilde{\chi}^{\pm})$ < 300 GeV**.





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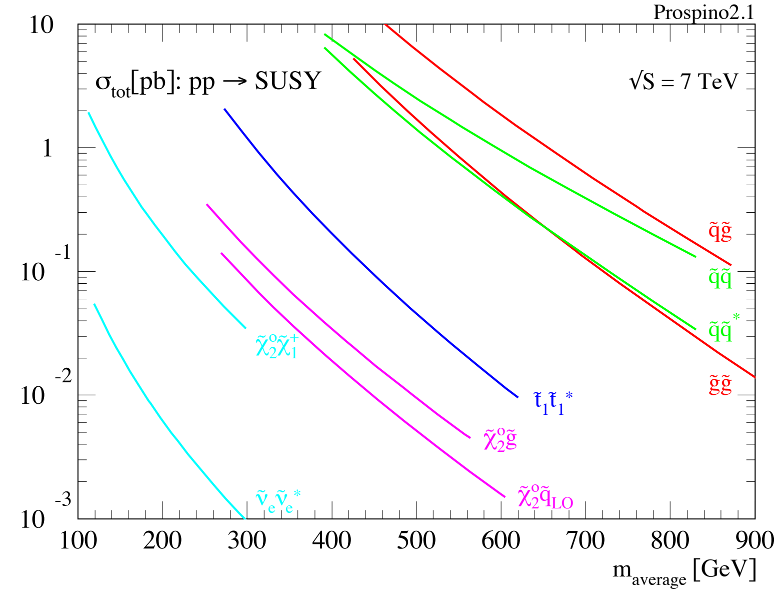
3rd Generation Searches

- Supersymmetry can "naturally" solve the hierarchy problem provided third generation squarks are light.

- **Stop** and **sbottom** production:
  - Gluino mediated
    - Accessible if gluino is light enough.
    - Very rich final states.
  - Direct pair production
    - Significantly lower cross section.
    - More standard model-like final states.



- Searches are presented in the following scenarios:
  - **Direct sbottom pair**
  - **Direct stop pair in GMSB**
  - **Light stop**
  - **Gluino mediated stop/sbottom**

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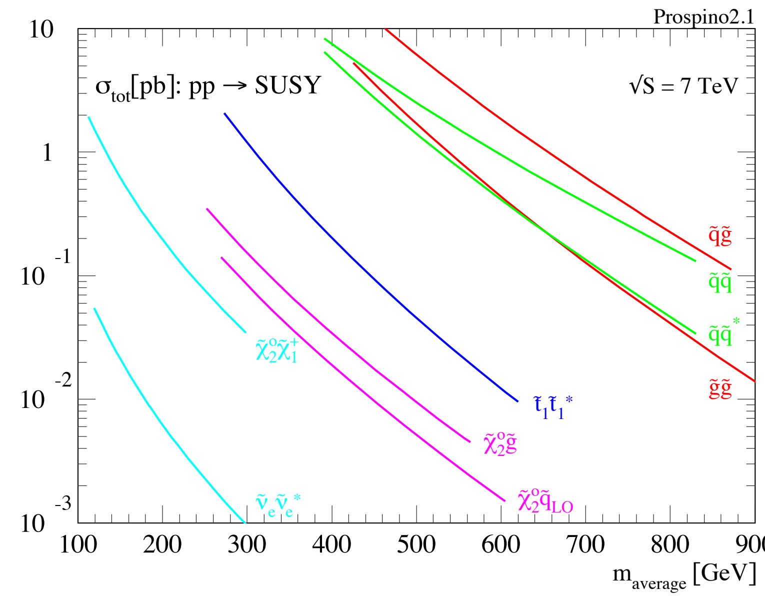

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  - **Direct stop pair in GMSB**
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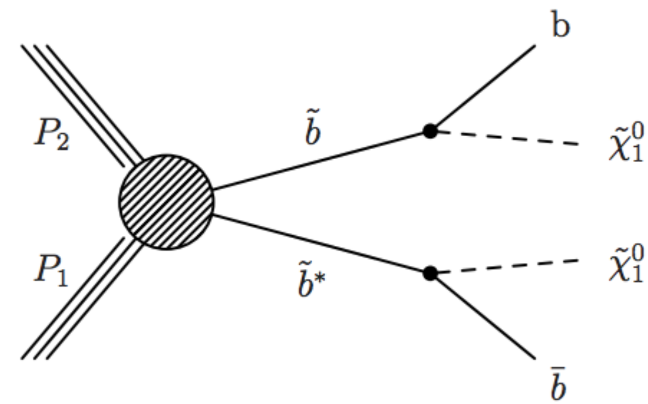
New
5 fb^{-1}

Direct sbottom | Analysis & results

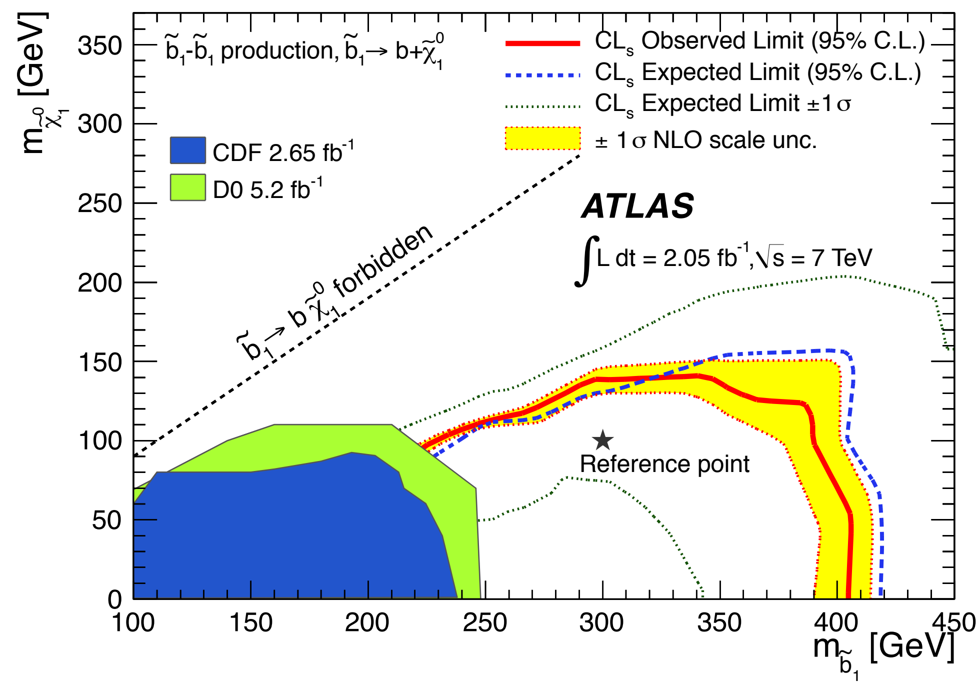
- Search for **direct sbottom** production in the 0-lepton channel with **2.05 fb^{-1}**.



- Events are selected with:
  - **E_T^{miss} > 130 GeV**
  - **Exactly 2 b-jets (p_T >130, 50 GeV)**
  - **Contransverse mass, m_{CT}** cuts of **100**, **150** and **200** GeV define the signal regions.

$$M_{CT}{}^2 = (E_{T_1} + E_{T_2})^2 - (\mathbf{p_{T_1}} - \mathbf{p_{T_2}})^2$$

- Good agreement between data and SM expectation.
- Exclusion limits at 95% confidence level are set in the **m($\tilde{b}$) - m($\tilde{\chi}^0$) plane**:
  - **m($\tilde{b}$) < 390 GeV** excluded for **m($\tilde{\chi}^0$) < 60 GeV**.

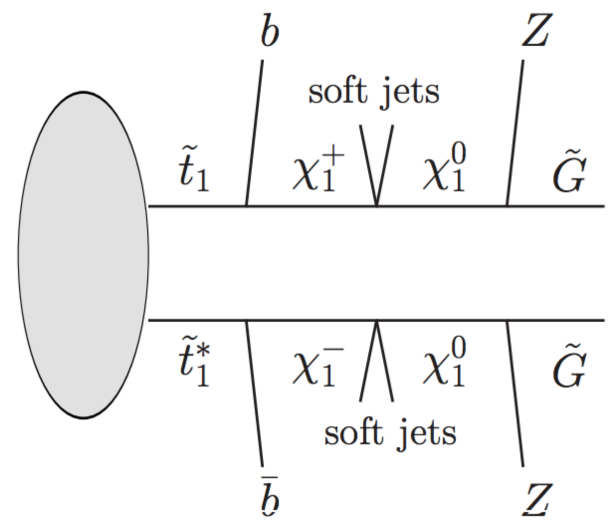


Phys. Rev. Lett. 108, 181802 (2012)

Stop pair - GMSB | Analysis & backgrounds

- Search for **direct stop pair** production in **GMSB scenario** with **2.05 fb^{-1}**.

- To enhance the signal sensitivity the selection is as follows:
  - 2 jets (1 b-tagged)
  - Large E_T^{miss}
  - OSSF lepton pair - in Z window $m_Z \pm 5$ GeV

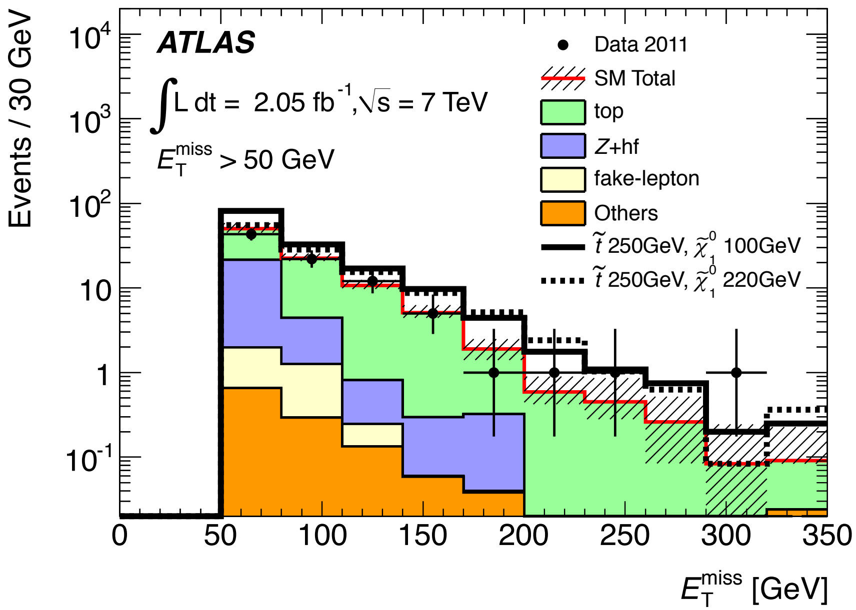


- Signal regions
  - **E_T^{miss} > 50 GeV** - large mass splittings
  - **E_T^{miss} > 80 GeV** - small mass splittings

- Background estimation
  - Semi-data driven estimation using Top and Z/γ*+jets control regions.
  - Data-driven matrix method estimation of **W+jets** and **multijets** events with fake leptons.

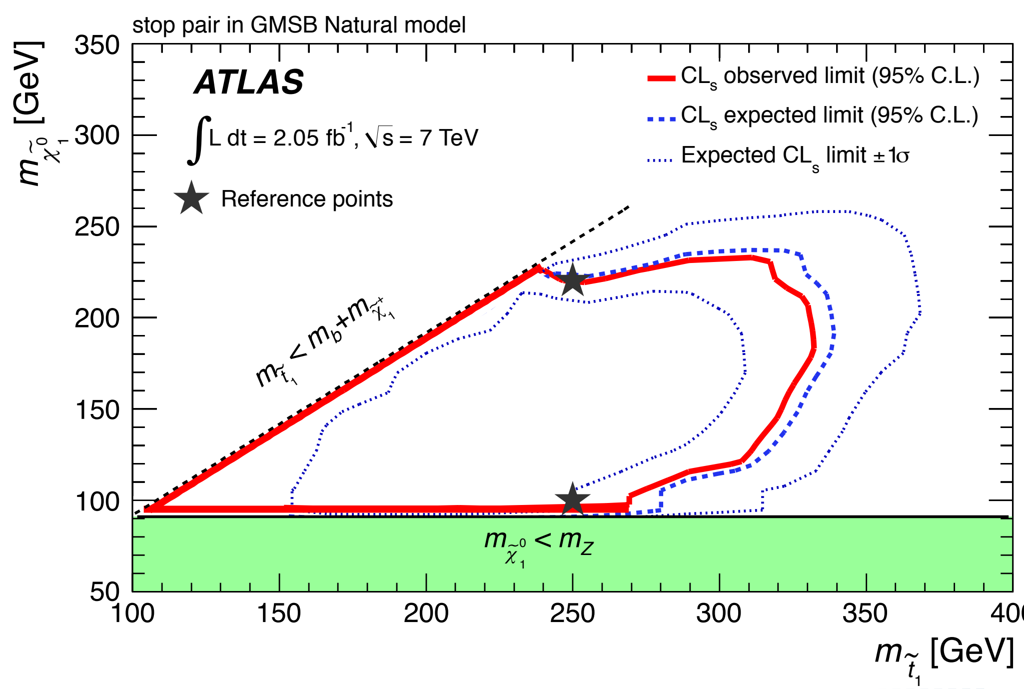
ATLAS-CONF-2012-036, submitted to PLB

Stop pair - GMSB | Results & interpretation



	$ee+\mu\mu$	
Data	86	43
SM	92±19	40.7 ± 6.0
top	64.3±7.7	34.8 ± 5.0
Z+hf	24±16	4.2±3.2
fake lepton	2.4 ± 0.9	1.1 ± 0.6
Others	1.2 ± 1.2	0.6 ± 0.6

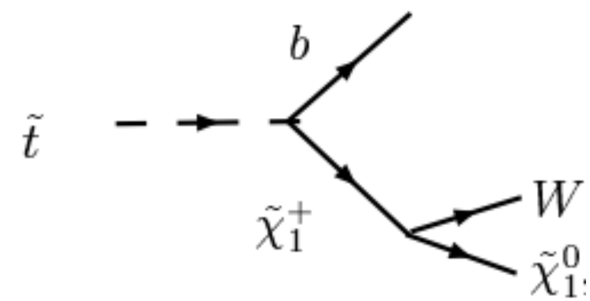
- Interpreted in GMSB Natural model:
  - **m(t̃) < 310 GeV** excluded for **115 < m($\tilde{\chi}^0$) < 230 GeV**
  - **m(t̃) < 330 GeV** excluded for **m($\tilde{\chi}^0$) = 190 GeV**



 ATLAS-CONF-2012-036, submitted to PLB

Light stop | Analysis outline

- Search for light scalar tops with **2 leptons (e,μ)** with **4.7 fb^{-1}**
- Large mixing can lead to one squark mass eigenstate being significantly lighter than others - **can be lighter than the top**.
- Expect signature of **leptons**, **E_T^{miss}** and **at least one jet** in the final state.
- Selection:
  - **Electron (muon) p_T > 17 (12) GeV**
  - **Highest lepton p_T < 30 GeV**
  - **≥ 1 jet p_T > 25 GeV**
  - **E_T^{miss} > 20 GeV**
  - **E_T^{miss} significance > 7.5 √GeV**



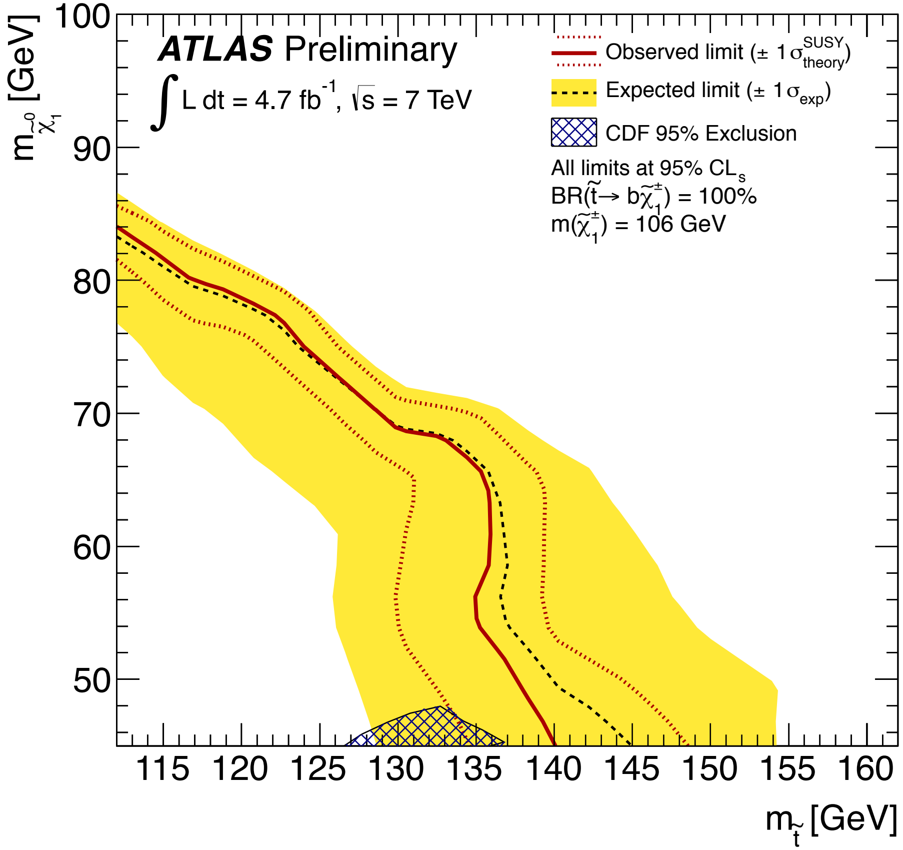
$$m(t) > m(\tilde{t}_1) > m(\tilde{\chi}_1^{\pm})$$

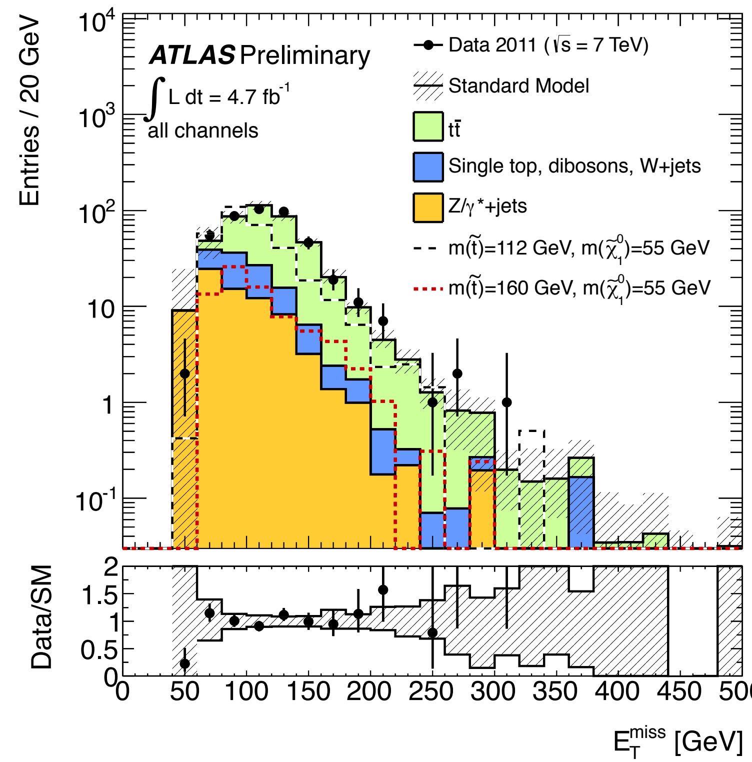
- Background estimation
  - Semi-data driven estimation using **Top** and **Z/γ*+jets** control regions.

Light stop | Results & interpretation

- Exclusion limits at 95% confidence level are set in the pMSSM **m(stop)-m(neutralino)** plane.
- **$m(\tilde{t}) < 130$ GeV** excluded for **$m(\tilde{\chi}^0) < 65$ GeV**

	all
$t\bar{t}$	293 ± 12 ± 34
Z/γ^*+jets	76 ± 16 ± 27
Single top	28 ± 2 ± 5
W+jets	13 ± 3 ± 3
Diboson	22 ± 1 ± 3
multijet	8.0 ± 3.7 ± 2.3
Total	440 ± 21 ± 43
Data	431





ATLAS-CONF-2012-059

Light stop | Results & interpretation

- Exclusion limits at 95% confidence level are set in the pMSSM **m(stop)-m(neutralino)** plane.
- **$m(\tilde{t})$ < 130 GeV** excluded for **$m(\tilde{\chi}^0)$ < 65 GeV**

	all
$t\bar{t}$	293 ± 12 ± 34
Z/γ^*+jets	76 ± 16 ± 27
Single top	28 ± 2 ± 5
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Diboson	22 ± 1 ± 3
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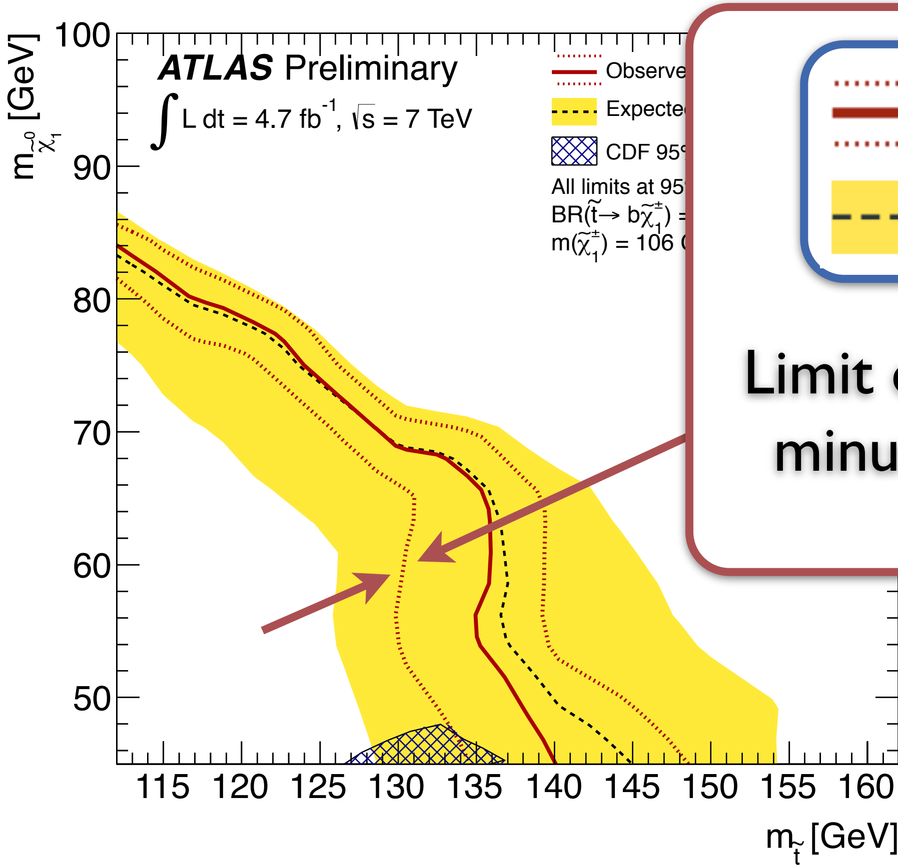
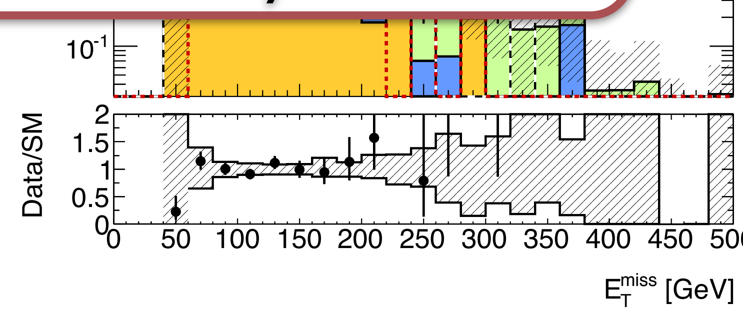
Total	[illegible] 21 ± 43



Observed limit ($\pm 1\ \sigma^{SUSY}_{theory}$)

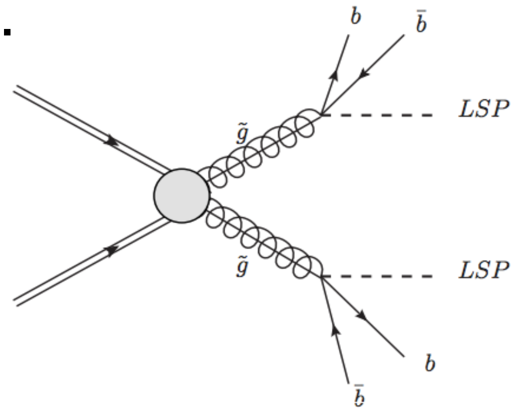
Expected limit ($\pm 1\ \sigma_{exp}$)

Limit quoted is the observed limit minus the 1σ signal theoretical uncertainty



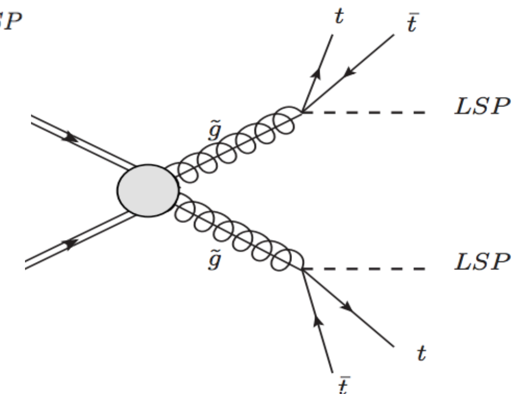
ATLAS-CONF-2012-059

- Search for **gluino-mediated sbottom** and **stop** production in the **3 b-jet** final states with **4.7 fb^{-1}**.



Basic selection:

- Leading jet p_T > 130 GeV
- E_T^{miss} > 160 GeV
- veto events with leptons
- ≥ 3 b-jets p_T > 30 GeV



Common criteria: lepton veto, $p_T^{j_1} > 130$ GeV, ≥ 3 b-jets, $E_T^{miss}/m_{eff} > 0.2$, $\Delta\phi_{min} > 0.4$

SR	N_J	E_T^{miss}	m_{eff}	b-tag OP
SR4-L	≥ 4j	>160 GeV	>500 GeV	60%
SR4-M	≥ 4j	>160 GeV	>700 GeV	60%
SR4-T	≥ 4j	>160 GeV	>900 GeV	70%
SR6-L	≥ 6j	>160 GeV	>700 GeV	70%
SR6-T	≥ 6j	>200 GeV	>900 GeV	75%

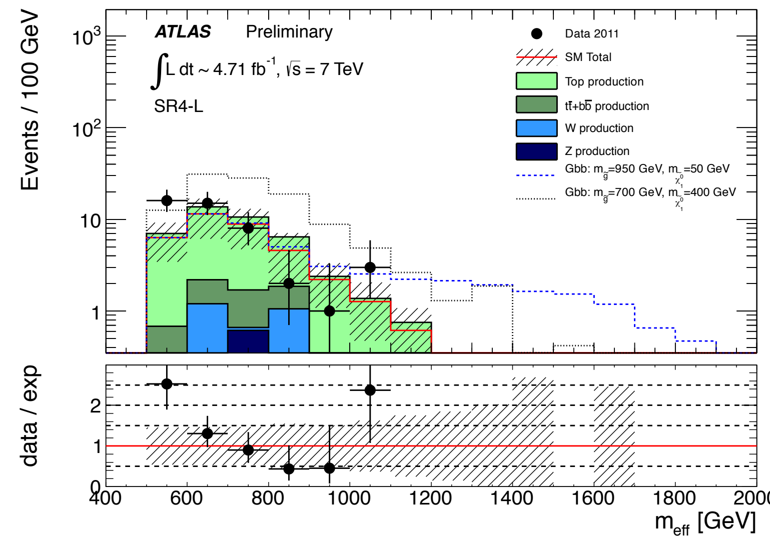
Optimised for:

- SR4-L, SR4-M, SR4-T: gluino mediated **sbottom**
- SR6-L, SR6-T: gluino mediated **stop**

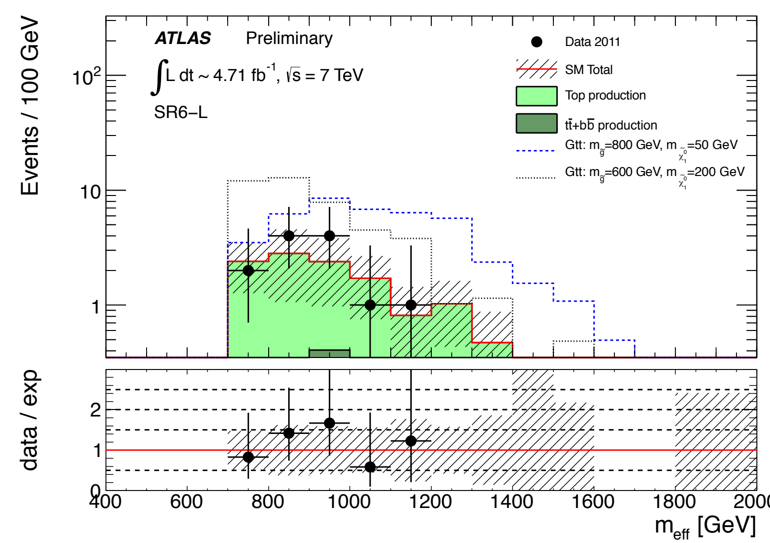
ATLAS-CONF-2012-058

Gluino-mediated stop and sbottom | Results

SR	$t\bar{t}$+jets (MC)	others	SM	data
SR4-L	33.3 ± 7.9 (32.6 ± 15.4)	11.1 ± 4.9	44.4 ± 10.0	45
SR4-M	16.4 ± 4.1 (16.1 ± 8.4)	6.6 ± 2.9	23.0 ± 5.4	14
SR4-T	9.7 ± 2.1 (11.4 ± 5.4)	3.8 ± 1.6	13.3 ± 2.6	10
SR6-L	10.3 ± 3.3 (10.0 ± 6.2)	2.4 ± 1.4	12.7 ± 3.6	12
SR6-T	8.3 ± 2.4 (7.9 ± 5.3)	1.6 ± 1.1	9.9 ± 2.6	8

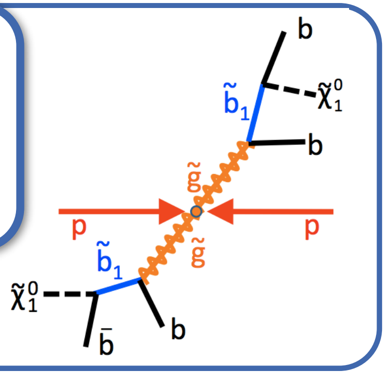


- Background estimation
  - **Top** background
    - Extrapolate from **2 b-tag control region** to **3 b-tag signal region**.
  - **QCD multijet** background
    - Estimated using a data driven approach.
- Systematic errors
  - Dominated by **b-tagging uncertainties** ~18-23%



- Exclusion limits at 95% C.L. are set in the **gluino-sbottom** and **gluino-stop** mass planes in **pMSSM** scenarios.

$$\tilde{g} \to \tilde{b}_1 b$$
$$\tilde{b}_1 \to b + \tilde{\chi}_1^0$$
$$m_{\tilde{\chi}_1^0} = 60 \text{ GeV}$$



$$\tilde{g} \to \tilde{t}_1 t$$
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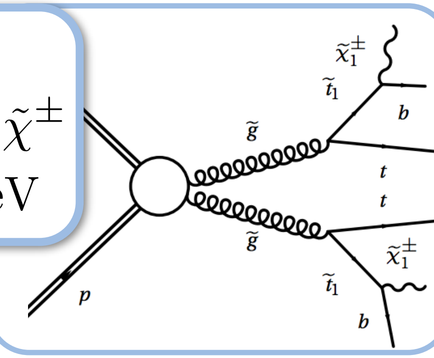
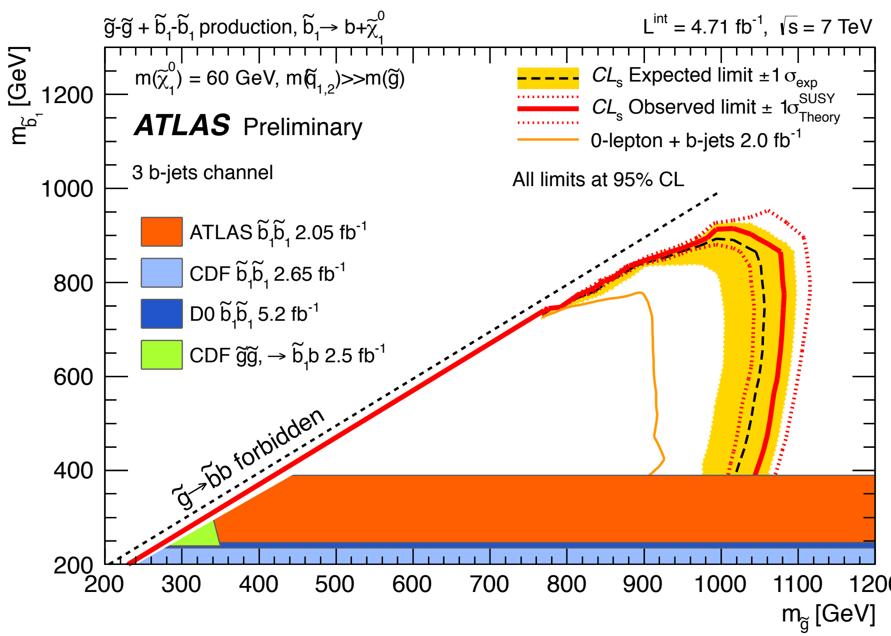
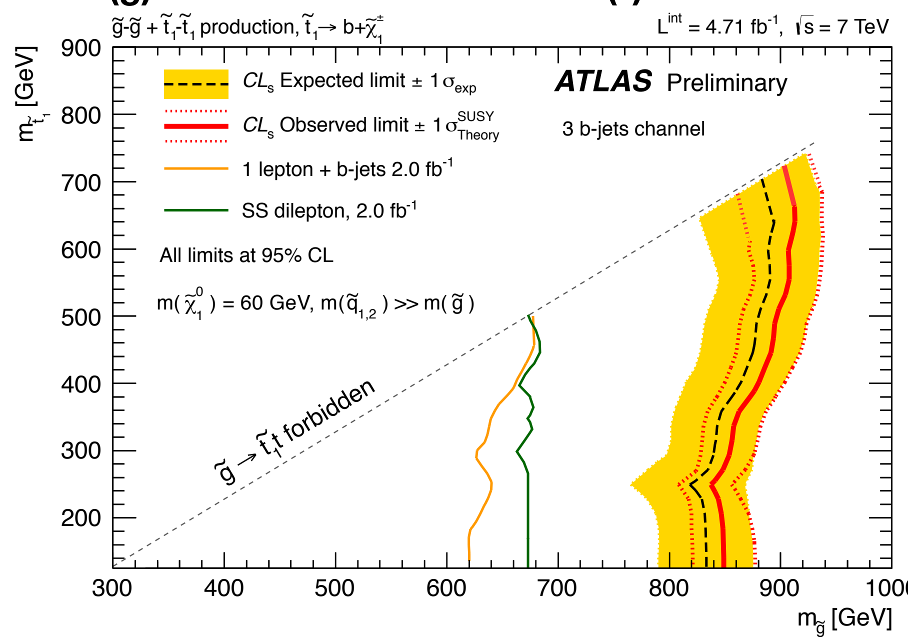


- **m($\tilde{g}$) < 1000 GeV** excluded for **m($\tilde{b}$) < 870 GeV**

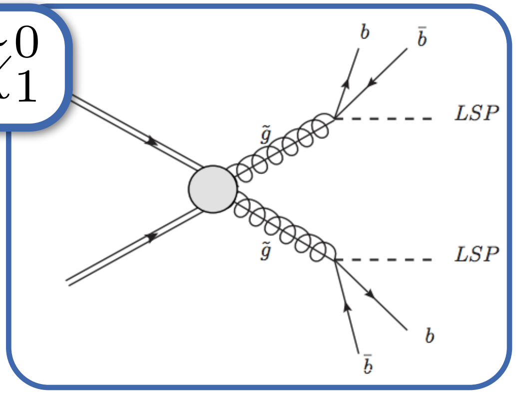


m($\tilde{g}$) < 820 GeV excluded for **m($\tilde{t}$) < 640 GeV**

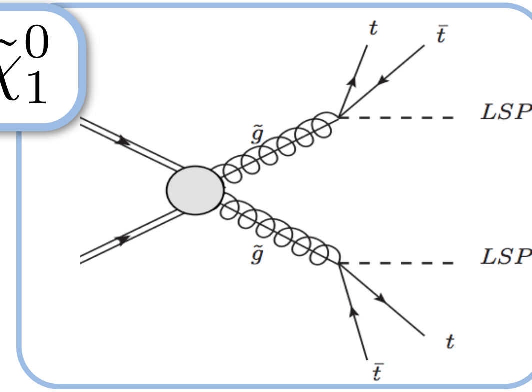


- Exclusion limits at 95% C.L. are set in the **gluino-neutralino** mass plane for **Gbb** and **Gtt simplified model scenarios.**

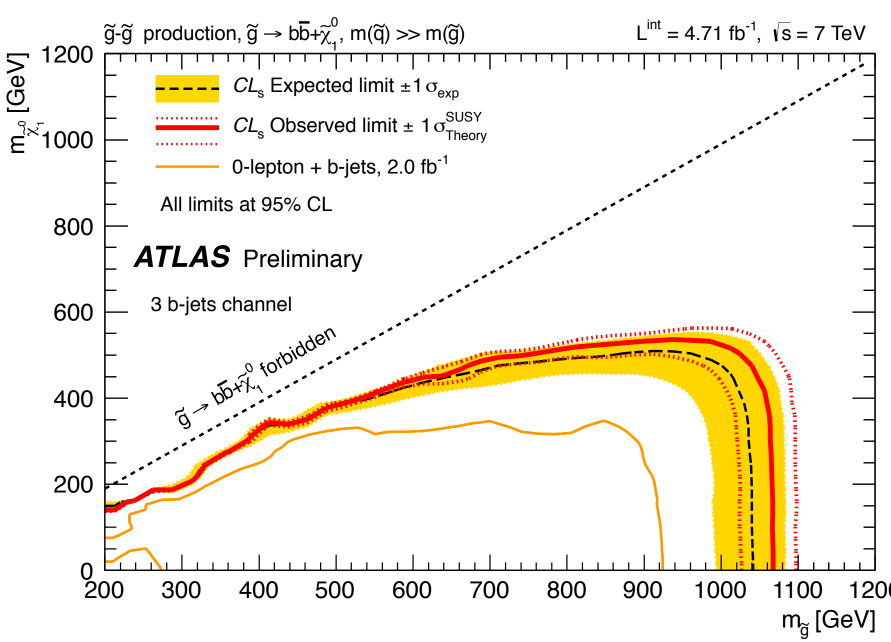
$\tilde{g} \rightarrow b\bar{b}\tilde{\chi}_1^0$



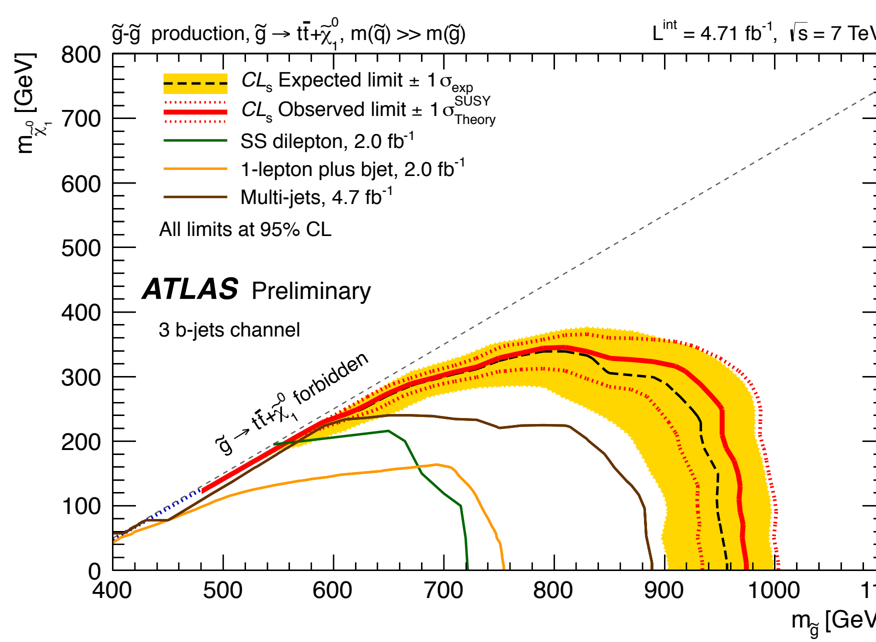
$\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$



- **m($\tilde{g}$) < 1020 GeV** excluded for **m($\tilde{\chi}^0$) < 400 GeV**



m($\tilde{g}$) < 940 GeV excluded for **m($\tilde{\chi}^0$) < 50 GeV**



Summary

- Results have been presented here in searches for supersymmetric **gauginos** and **3rd generation squarks** with 2-5 fb^{-1} of 2011 ATLAS data.
- Previous exclusion limits have been extended in a number of scenarios - no sign of SUSY yet!
- A number ATLAS of searches are expected to be released with new or updated 5 fb^{-1} analyses soon!
  - Gaugino searches
  - Direct stop searches
- Looking forward to 8 TeV 2012 data with considerably higher integrated luminosity.

Back-ups

Di-lepton | Analysis outline

- Search for supersymmetric weak gauginos with a final state of the **2-leptons (e,μ)** and **E_T^{miss}** with 1 fb^{-1} of ATLAS data.
  - **Inclusive:**
    - **Opposite sign (OS)**
    - **Same sign (SS)**
  - **Flavour subtraction (FS)**
    - Subtract different flavour (DF) from same flavour (SF)

$$\tilde{\chi}_i^0 \rightarrow l^{\pm} l^{\mp} \tilde{\chi}_j^0$$
$$\tilde{\chi}_i^{\pm} \rightarrow l^{\pm} l^{\mp} \tilde{\chi}_j^{\pm}$$

Opposite sign same flavour

$$\tilde{\chi}_i^0 \rightarrow l^{\pm} \nu \tilde{\chi}_j^{\pm}$$
$$\tilde{\chi}_i^{\pm} \rightarrow l^{\pm} \nu \tilde{\chi}_j^0$$

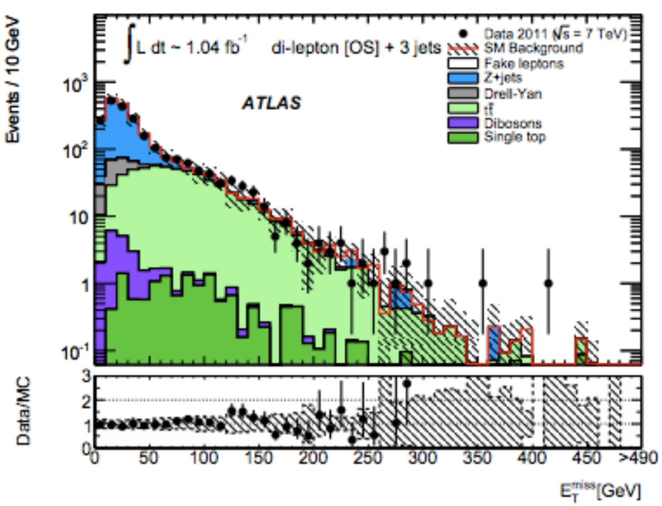
Same sign any flavour

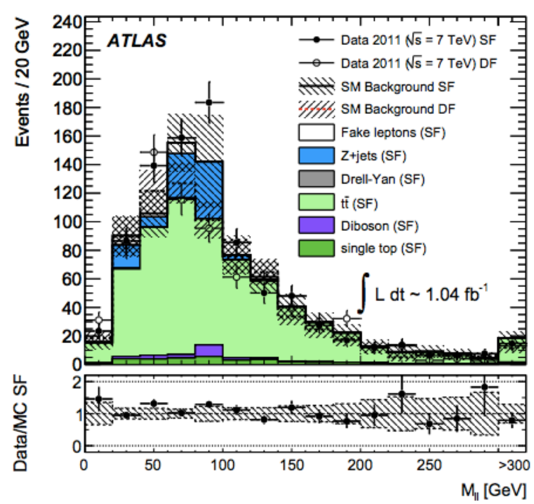
Signal Region	OS-SR1	OS-SR2	OS-SR3	SS-SR1	SS-SR2	FS-SR1	FS-SR2	FS-SR3
E_T^{miss} [GeV]	250	220	100	100	80	80	80	250
Leading jet p_T [GeV]	-	80	100	-	50	-	-	-
Second jet p_T [GeV]	-	40	70	-	50	-	-	-
Third jet p_T [GeV]	-	40	70	-	-	-	-	-
Fourth jet p_T [GeV]	-	-	70	-	-	-	-	-
Number of jets	-	-	-	-	-	-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

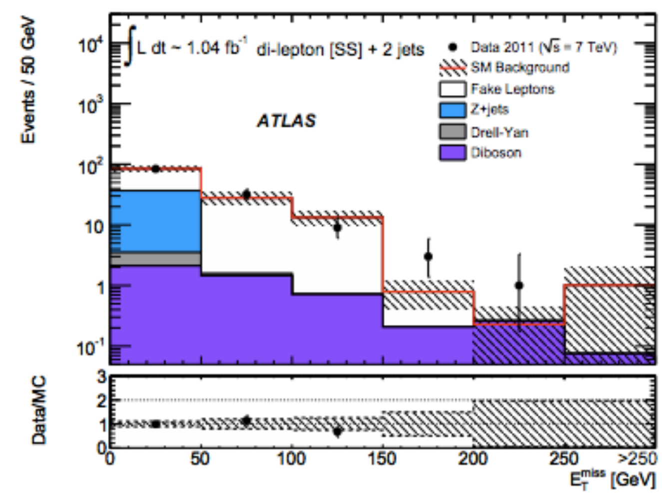
Di-lepton | Backgrounds & results

- Background estimation
  - **tt̄ and Z/γ*+jets backgrounds** - estimated using MC normalised in control regions.
  - **Fakes** - data driven estimation.
  - **Charge misidentification** - probability taken from $Z \rightarrow e^+e^-$ events in MC.
- Generally good agreement is found between data and the SM expectation.
- Dominant systematic uncertainties
  - **Background** - Jet energy scale, jet energy resolution, generator and ISR/FSR.
  - **Signal** - cross section and jet energy scale.

	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



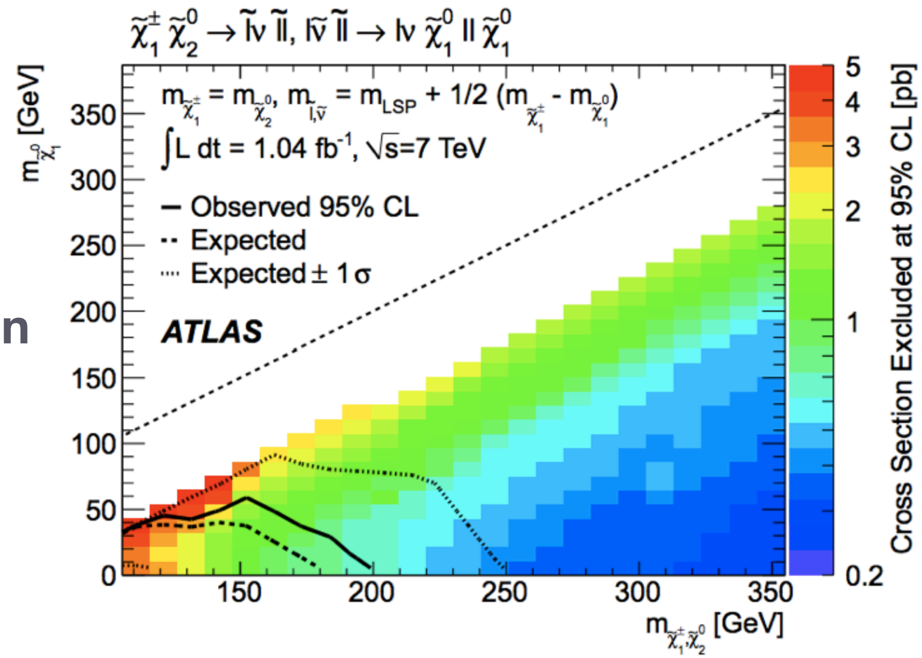




Di-lepton | Interpretation

- Exclusion limits at 95% confidence level (CL) are set.

- **Inclusive SS and OS**
  - Interpretation in $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ **direct production gaugino simplified models**.
  - Visible cross section is corrected for acceptance and efficiency.
    - Acceptances of ~5-15% for low mass region and efficiencies of ~20%.



- **Flavour subtraction**
  - Limits are set on $\mathcal{S}$, a measure of the excess in the number of opposite-sign same-flavour events.
  - This can be interpreted by setting a limit on $\bar{\mathcal{S}}_s$, the mean contribution to number of events to $\mathcal{S}$ from new phenomena.

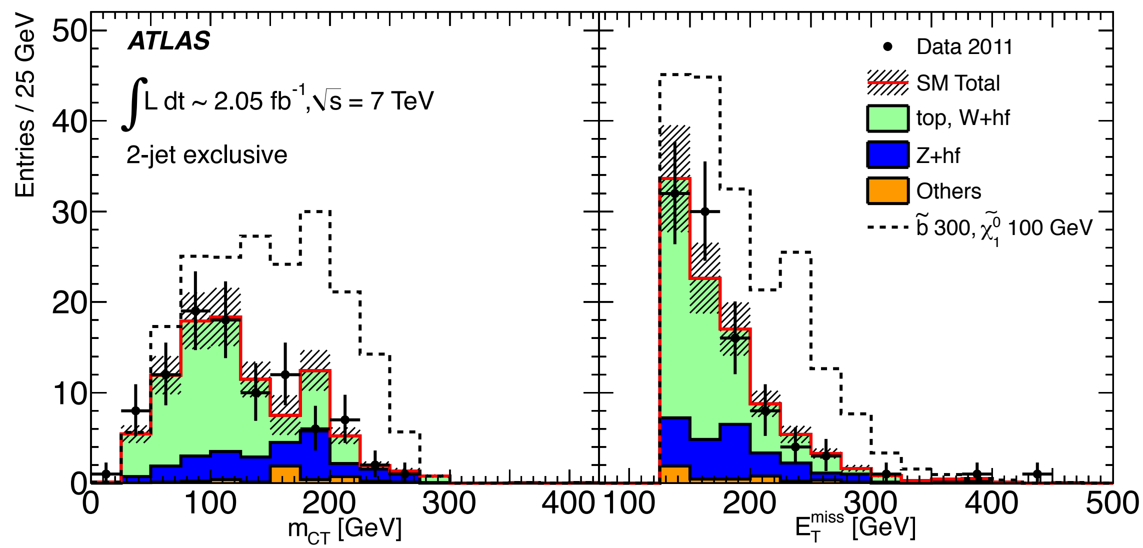
$$\mathcal{S} = \frac{N(e^{\pm}e^{\mp})}{\beta(1-(1-\tau_e)^2)} + \frac{\beta N(\mu^{\pm}\mu^{\mp})}{(1-(1-\tau_\mu)^2)} - \frac{N(e^{\pm}\mu^{\mp})}{1-(1-\tau_e)(1-\tau_\mu)}$$

	$\mathcal{S} > \mathcal{S}_{obs}$ (%)	Limit $\bar{\mathcal{S}}_s$ (95% CL)
FS-no Z	39	94
FS-2j	6	158
FS-inc	79	4.5

Direct sbottom | Results & interpretation

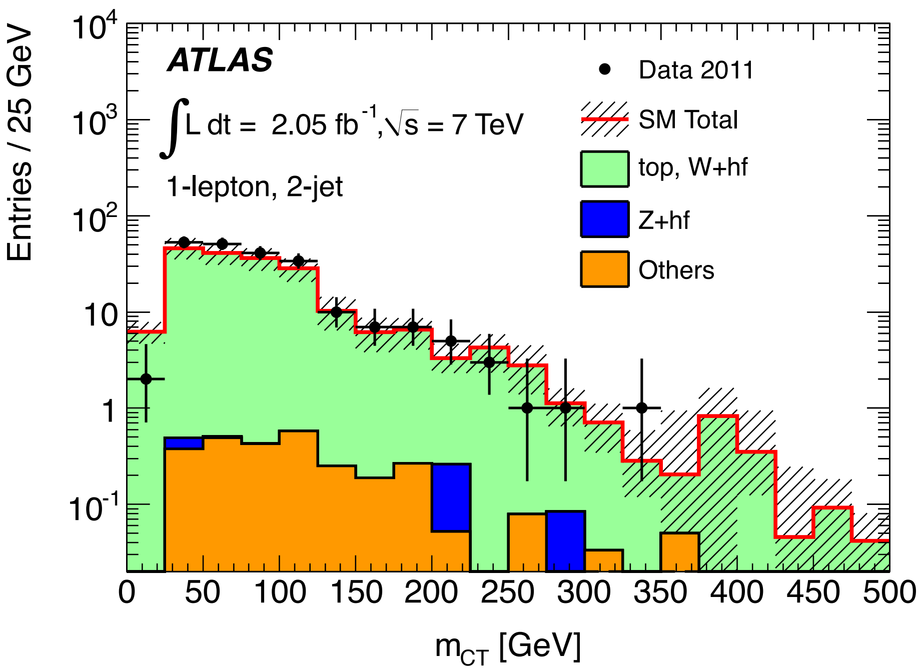
m_{CT}	Top, W + hf TF (MC)	Z + hf TF (MC)	Others MC + JS	Total SM	Data
0	67 ± 10	23 ± 8	3.6 ± 1.5	94 ± 16	96
	(60 ± 25)	(16 ± 9)		(80 ± 35)	
100	36 ± 10	23 ± 9	3.1 ± 1.6	62 ± 13	56
	(34 ± 16)	(12 ± 7)		(49 ± 25)	
150	12 ± 5	12 ± 6	2.7 ± 0.9	27 ± 8	28
	(13 ± 8)	(8.3 ± 4.7)		(24 ± 13)	
200	3.2 ± 1.6	3.9 ± 3.2	1.0 ± 0.9	8.1 ± 3.5	10
	(4.1 ± 3.4)	(2.8 ± 1.5)		(8.0 ± 4.9)	

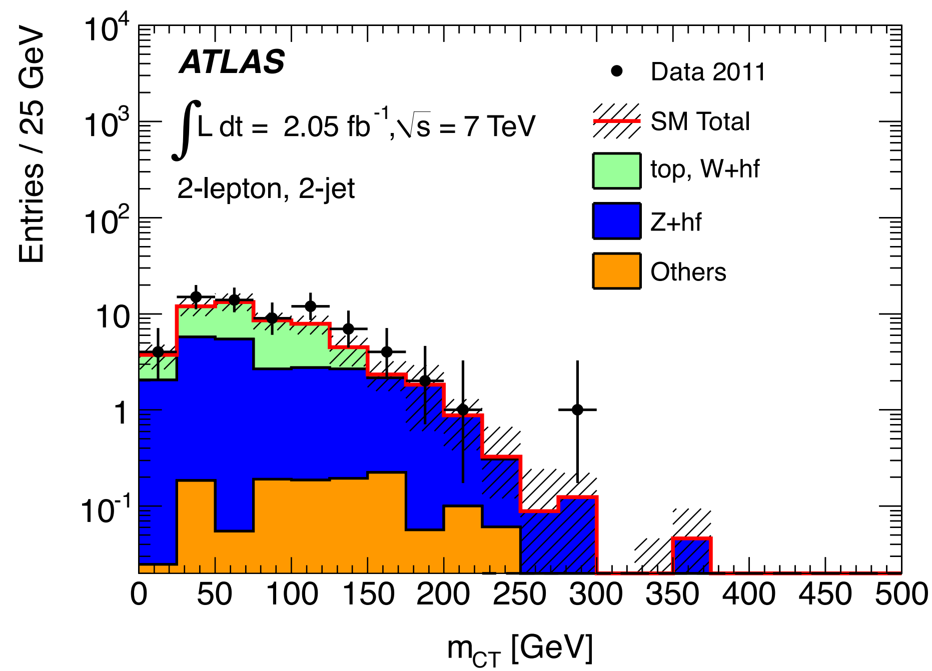
- Systematic uncertainties
  - Background: 21-44%
    - Dominant uncertainties coming from finite statistics in CR and theoretical modelling of $t\bar{t}$.
  - Signal:
    - Detector effects 35-45%: jet energy scale and b-tagging efficiency uncertainties.



2 b-jet m_{CT} | Background estimation

- **Semi-leptonic $t\bar{t}$** - 1-lepton control region, transfer factor from CR to SR.
- **Z + heavy flavour** - 2-lepton control region, leptons added to E_T^{miss}.





Direct stop - GMSB | Model

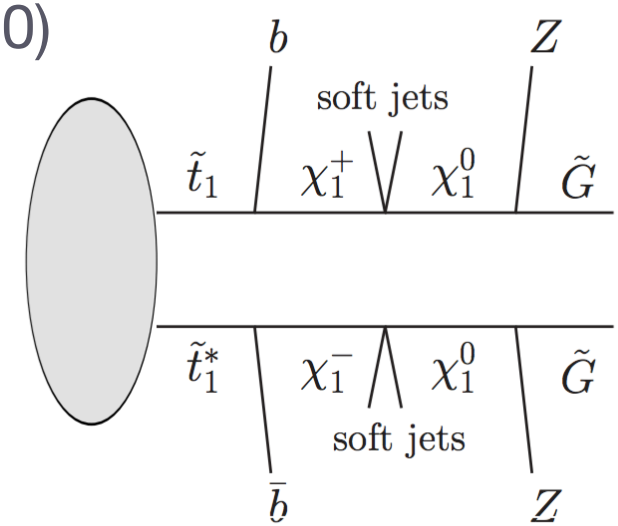
- GMSB Natural model -
  - See M. Asano et al., JHEP 12, 019 (2010)
  - χ^0_1 is pure higgsino-like and lighter than the stop
  - The following parameters are assumed:

$$m_{\tilde{q}_3} = m_{\tilde{u}_3} = -A_t/2; \quad \tan\beta = 10$$

  - First and second generation and gluinos are set to 2 TeV
  - Stop decay:
    - $\tilde{t}_1 \to b\tilde{\chi}^+$ or $\tilde{t}_1 \to t\tilde{\chi}^0_{1(2)}$

$$\tilde{\chi}^\pm_1 \to \tilde{\chi}^0_1 f f'$$

$$\tilde{\chi}^0_1 \to Z\tilde{G}$$

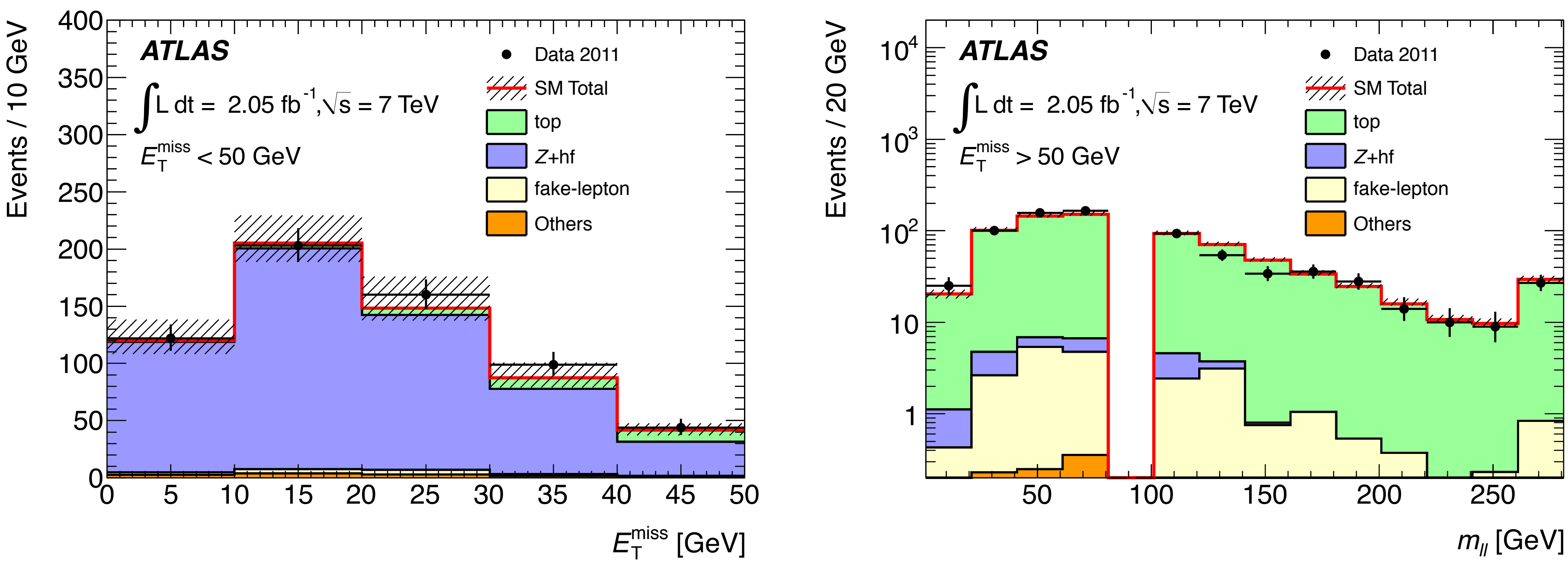


Experimental signature is largely determined by the nature of the next-to-lightest SUSY particle ($\tilde{\chi}^0_1$)

$$\mathcal{B}\left(\tilde{\chi}^0_1 \to Z\tilde{G}\right) = 1 - 0.65\,[m_{\tilde{\chi}^0_1} : 100 - 350\,\mathrm{GeV}]$$

Stop pair in GMSB | Background estimation

- **Top** - Identical to signal region but with reversed mll Z window.
  - Transfer factor from CR to SR is derived from Monte Carlo.
- **Z + Heavy Flavour (HF)** - Low ETmiss (<50 GeV)
  - Taken from Monte Carlo, validated in control region.
- **Fake lepton** - from W+jets and multijets estimated with data-driven matrix method.



Light stop | Selection & results

Requirement	ee channel	$e\mu$ channel	$\mu\mu$ channel
Signal Region			
lepton p_T	> 17 GeV	> 17(12) GeV for $e(\mu)$	> 12 GeV
highest lepton p_T	< 30 GeV	< 30 GeV	< 30 GeV
m_{ll}	> 20 GeV and Z veto	> 20 GeV	> 20 GeV and Z veto
jet p_T	≥ 1 jet, p_T > 25 GeV	≥ 1 jet, p_T > 25 GeV	≥ 1 jet, p_T > 25 GeV
E_T^{miss}	> 20 GeV	> 20 GeV	> 20 GeV
$E_T^{miss,sig}$	> 7.5 GeV$^{1/2}$	> 7.5 GeV$^{1/2}$	> 7.5 GeV$^{1/2}$
Top Control Region			
lepton p_T	> 17 GeV	> 17(12) GeV for $e(\mu)$	> 12 GeV
highest lepton p_T	> 30 GeV	> 30 GeV	> 30 GeV
m_{ll}	> 20 GeV and Z veto	> 20 GeV	> 20 GeV and Z veto
jet p_T	≥ 2 (b)jets, p_T > 25 GeV	≥ 2 (b)jets, p_T > 25 GeV	≥ 2 (b)jets, p_T > 25 GeV
b jet p_T	≥ 1 b jet, p_T > 25 GeV	≥ 1 b jet, p_T > 25 GeV	≥ 1 b jet, p_T > 25 GeV
E_T^{miss}	> 20 GeV	> 20 GeV	> 20 GeV
$E_T^{miss,sig}$	> 7.5 GeV$^{1/2}$	> 7.5 GeV$^{1/2}$	> 7.5 GeV$^{1/2}$
Z Control Region			
lepton p_T	> 17 GeV	n/a	> 12 GeV
highest lepton p_T	< 30 GeV	n/a	< 30 GeV
m_{ll}	> 81 GeV and < 101 GeV	n/a	> 81 GeV and < 101 GeV
jet p_T	≥ 1 jet, p_T > 25 GeV	n/a	≥ 1 jet, p_T > 25 GeV
E_T^{miss}	> 20 GeV	n/a	> 20 GeV
$E_T^{miss,sig}$	> 4.0 GeV$^{1/2}$	n/a	> 4.0 GeV$^{1/2}$

	ee	$e\mu$	$\mu\mu$	all
$t\bar{t}$	44 ± 4 ± 5	139 ± 7 ± 22	111 ± 8 ± 10	293 ± 12 ± 34
Z/γ^*+jets	5 ± 1 ± 2	23 ± 2 ± 8	48 ± 16 ± 27	76 ± 16 ± 27
Single top	3 ± 0.5 ± 1	12 ± 1 ± 2	12 ± 1 ± 2	28 ± 2 ± 5
W+jets	3 ± 3 ± 3	5 ± 2 ± 1	6 ± 2 ± 1	13 ± 3 ± 3
Diboson	4 ± 0.4 ± 0.5	9 ± 0.7 ± 2	10 ± 0.7 ± 1	22 ± 1 ± 3
multijet	$2.9\,^{+3.2}_{-2.9} \pm 2.2$	2.0 ± 1.4 ± 0.3	3.0 ± 2.8 ± 0.3	8.0 ± 3.7 ± 2.3
Total	61 ± 6 ± 6	189 ± 8 ± 21	190 ± 19 ± 31	440 ± 21 ± 43
Data	48	188	195	431
σ_{vis} (exp. limit) [fb]	4.9	11.1	16.2	22.0
σ_{vis} (obs. limit) [fb]	3.3	10.9	16.9	21.0
$m(\tilde{t},\tilde{\chi}_1^0)$ = (112, 55) GeV	44.1 ± 4.8	137 ± 8	140 ± 8	322 ± 13
$m(\tilde{t},\tilde{\chi}_1^0)$ = (160, 55) GeV	8.8 ± 1.5	31.4 ± 2.7	36.5 ± 2.9	76.6 ± 4.3

Light stop | Background estimation

- Dominant background is expected to be:
  - **di-leptonic $t\bar{t}$**
  - **Z/γ*+jets.**

- Estimated by extrapolating from a suitable control region (CR) to the signal region (SR).

$$(N_{t\bar{t}})_{\mathrm{SR}} = ((N_{\mathrm{data}})_{\mathrm{CR}} - (N_{\mathrm{non}\text{-}t\bar{t},\mathrm{MC}})_{\mathrm{CR}}) \frac{(N_{t\bar{t},\mathrm{MC}})_{\mathrm{SR}}}{(N_{t\bar{t},\mathrm{MC}})_{\mathrm{CR}}}$$

  - **Top CR** - requirement of a b-jet and one extra jet.
  - **Z/γ*+jets CR** - reverse Z veto.

3 b-jet | Background estimation

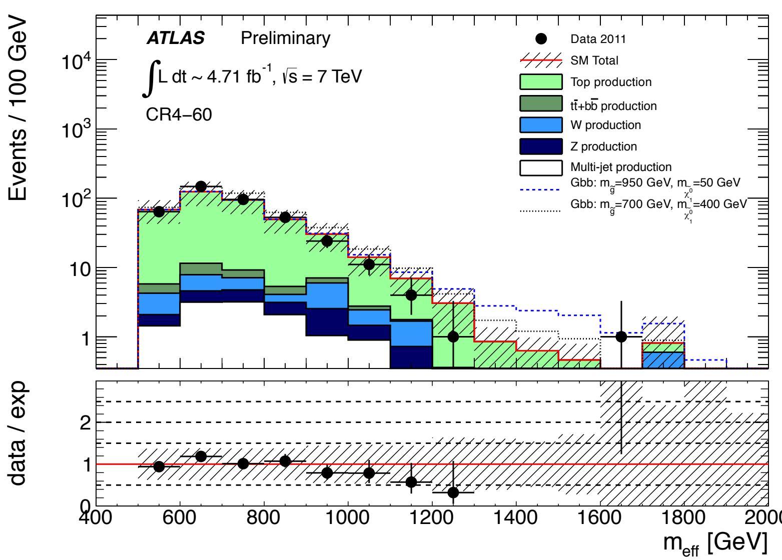
- Top background
  - Semi-leptonic top with a W decaying to c and τ that are mis-tagged as b-jets.
  - Extrapolate from **2 b-tag control region** to **3 b-tag signal region**:

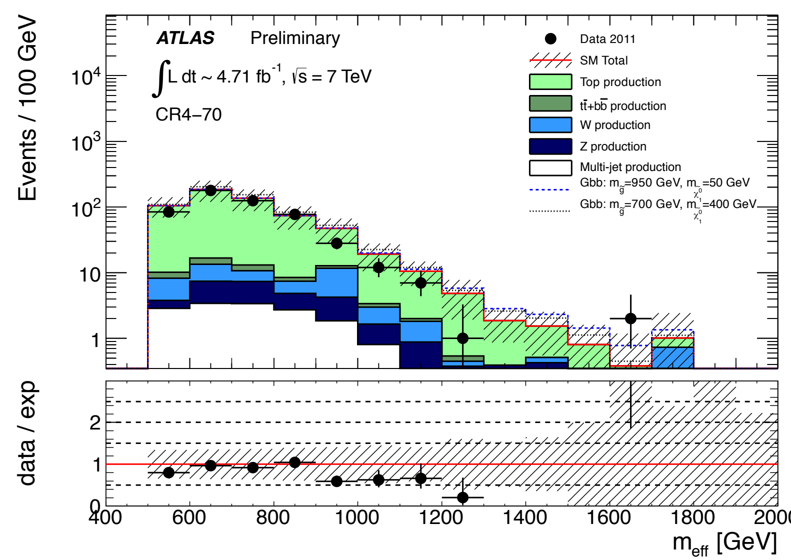
$$N_{3b}^{Pred,top} = (N_{2b}^{data} - N_{2b}^{MC,notop}) \times \frac{N_{3b}^{MC,top}}{N_{2b}^{MC,top}} = (N_{2b}^{data} - N_{2b}^{MC,notop}) \times T_f(2b \rightarrow 3b)$$

  - Validated in a **1-lepton validation** region and by a **fake b-tag matrix method**.

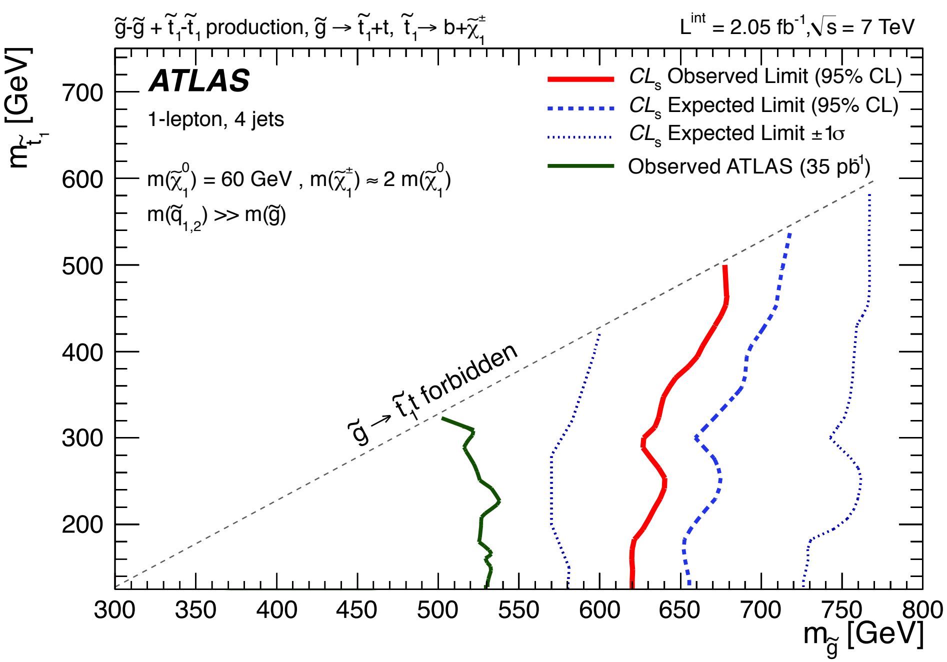
CR	$t\bar{t}$+jets	others	SM	data
CR4-60	329 ± 92	66 ± 26	395 ± 115	402
CR4-70	489 ± 125	102 ± 37	590 ± 160	515
CR6-70	38 ± 11	7 ± 3	45 ± 13	46
CR6-75	40 ± 12	10 ± 4	50 ± 15	52

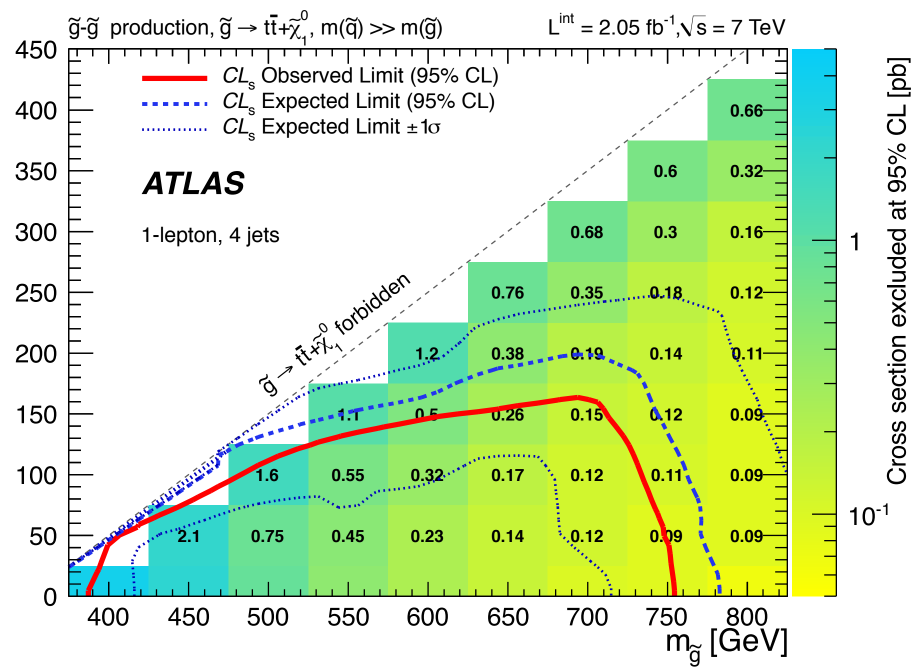
- QCD multijet background
  - Estimated using a data driven approach.





- Previous **2.05 fb^{-1} 1-lepton** gluino mediated stop search.
- Interpretation in pMSSM and simplified model scenarios.





Quick review of m_{CT}

- **Contransverse mass, m_{CT}**, is a kinematic variable that can be used to measure the masses of particles in events with pairs of semi-invisible decays.

D.R.Tovey
JHEP 0804:034,2008

D.R.Tovey, G.Polesello
JHEP 1003:030,2010

- Definition: $${M_{CT}}^2 = (E_{T_1} + E_{T_2})^2 - (\mathbf{p_{T_1}} - \mathbf{p_{T_2}})^2$$

- Offline analysis variable is **boost corrected** m_{CT}.
  - Frame is re-boosted in transverse plane to account for any ISR which can smear out the m_{CT} endpoint.

- m_{CT} is low for back-to-back QCD dijets as the small $\cos(\Phi_{12})$ dominates.
- m_{CT} is high for jets boosted in transverse plane.

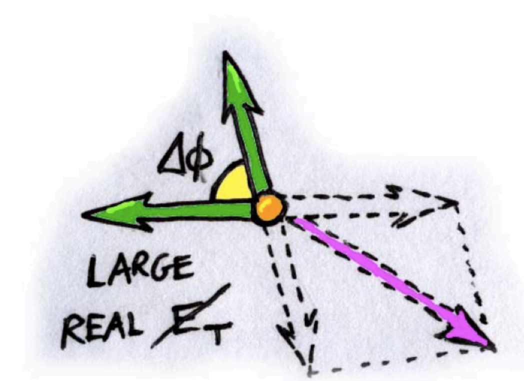
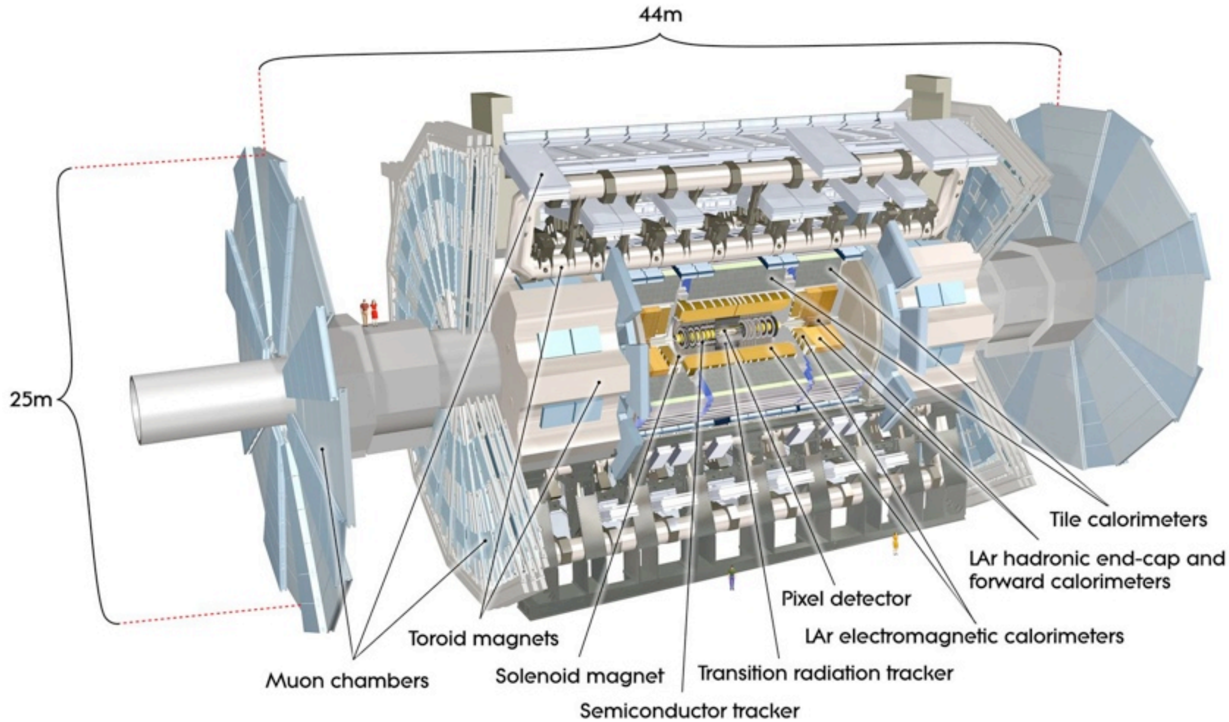


Image: Tom Whyntie (CMS/ICL) 2010

ATLAS Detector



- ATLAS has forward-backward symmetric cylindrical geometry.
  - **Inner tracker:** 2 T magnetic field providing precision tracking of charged particles.
  - **Calorimeter systems:** Liquid argon or scintillating tiles provide energy measurements.
  - **Muon spectrometer:** Surrounded by air-core superconducting magnets providing a magnetic field strength varying from 1 to 8 T·m the muon spectrometer provides trigger and high precision tracking capabilities.