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2. Motivation
3. Search Strategy
4. Multilepton Search
5. Search with 2 b-jets and No Leptons
6. Search with All Hadronic $t\bar{t} + E_T$
7. Search with c-jets+ E_T
8. Search with 3b-jets+ E_T
9. Direct Stop Pair Production (1)
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Searches for third generation squarks with the ATLAS detector

Steve Muanza CPPM, CNRS-IN2P3 & AMU

On Behalf of the ATLAS Collaboration

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Introduction

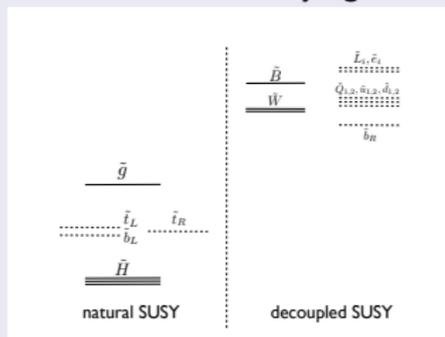
SUSY predicts a partner with $\Delta S = 1/2$ for all SM particles

Spin	Interaction Eigenstates	Mass Eigenstates
0	$\begin{pmatrix} \tilde{e}^- \\ \tilde{\nu}_e \end{pmatrix}_L, \begin{pmatrix} \tilde{\mu}^- \\ \tilde{\nu}_\mu \end{pmatrix}_L, \begin{pmatrix} \tilde{\tau}^- \\ \tilde{\nu}_\tau \end{pmatrix}_L$ $\tilde{e}_n^+, \tilde{\mu}_n^+, \tilde{\tau}_n^+$ <p>Sleptons</p>	$\begin{pmatrix} \tilde{e}^- \\ \tilde{\nu}_e \end{pmatrix}_L, \begin{pmatrix} \tilde{\mu}^- \\ \tilde{\nu}_\mu \end{pmatrix}_L, \tilde{\tau}_1^-, \tilde{\tau}_2^-$ $\tilde{e}_n^+, \tilde{\mu}_n^+, \tilde{\nu}_\tau$ <p>Sleptons</p>
1/2		$\begin{pmatrix} \tilde{e}^- \\ \tilde{\nu}_e \end{pmatrix}_L, \begin{pmatrix} \tilde{\mu}^- \\ \tilde{\nu}_\mu \end{pmatrix}_L, \begin{pmatrix} \tilde{\tau}^- \\ \tilde{\nu}_\tau \end{pmatrix}_L$ e_n^1, μ_n^1, τ_n^1 <p>Leptons</p>
0	$\begin{pmatrix} \tilde{u} \\ \tilde{d} \end{pmatrix}_L, \begin{pmatrix} \tilde{c} \\ \tilde{s} \end{pmatrix}_L, \begin{pmatrix} \tilde{t} \\ \tilde{b} \end{pmatrix}_L$ $\tilde{u}_n^+, \tilde{d}_n^+, \tilde{c}_n^+, \tilde{s}_n^+, \tilde{t}_n^+, \tilde{b}_n^+$ <p>Squarks</p>	$\begin{pmatrix} \tilde{u} \\ \tilde{d} \end{pmatrix}_L, \begin{pmatrix} \tilde{c} \\ \tilde{s} \end{pmatrix}_L, \tilde{t}_1, \tilde{t}_2$ $\tilde{u}_n^+, \tilde{d}_n^+, \tilde{c}_n^+, \tilde{s}_n^+, \tilde{b}_1, \tilde{b}_2$ <p>Squarks</p>
1/2		$\begin{pmatrix} u \\ d \end{pmatrix}_L, \begin{pmatrix} c \\ s \end{pmatrix}_L, \begin{pmatrix} t \\ b \end{pmatrix}_L$ $u_n^1, d_n^1, c_n^1, s_n^1, t_n^1, b_n^1$ <p>Quarks</p>
0	$\Phi_u = \begin{pmatrix} \phi_u^+ \\ \phi_u^0 \end{pmatrix}, \Phi_d = \begin{pmatrix} \phi_d^0 \\ \phi_d^- \end{pmatrix}$ <p>Higgs Doublet Fields</p>	h^0, A^0, H^0, H^\pm <p>Higgs Bosons</p>
1/2	$\Phi_a = \begin{pmatrix} \phi_a^+ \\ \phi_a^0 \\ \phi_a^0 \end{pmatrix}, \Phi_d = \begin{pmatrix} \phi_d^0 \\ \phi_d^- \end{pmatrix}, B^0, W_3^0, W_{1,2}^\pm, \tilde{g}$ <p>Higgsinos Bino Winos Gluinos</p>	$\tilde{\chi}_{1,2,3,4}^0, \tilde{\chi}_{1,2}^\pm, \tilde{g}$ <p>Neutralinos Charginos Gluinos</p>
1	$B^0, W_3^0, W_{1,2}^\pm, g$ <p>U(1)_Y, SU(2)_C Gauge Fields, Gluons</p>	γ, Z^0, W^\pm, g <p>Photon, EW Gauge Bosons, Gluons</p>
3/2		$G_{3/2}$ <p>Gravitino</p>
2		$G_{\mu\nu}$ <p>Graviton</p>

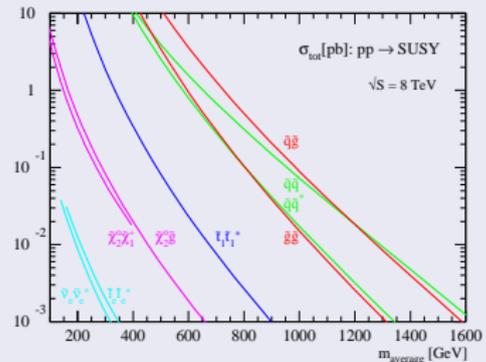
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Natural SUSY

- It requires particles with dominant contributions to M_h radiative corrections to be relatively light



- In this context one expects
 - not too heavy gluinos
 - stop/sbottom as lightest squark

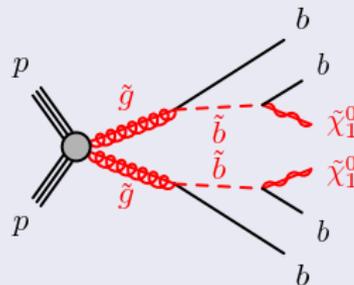
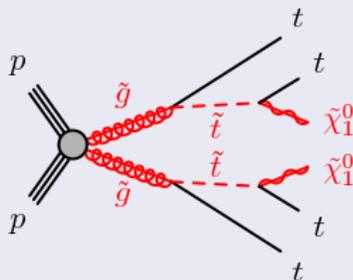


- Present talk reports on recent ATLAS analyses (or updates)
 - Dataset: $\int \mathcal{L} dt = (20.3 \pm 0.6) \text{ fb}^{-1}$ of p+p collisions at $\sqrt{s} = 8 \text{ TeV}$ in 2012
 - All limits at the 95% C.L.

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Gluino Mediated Production

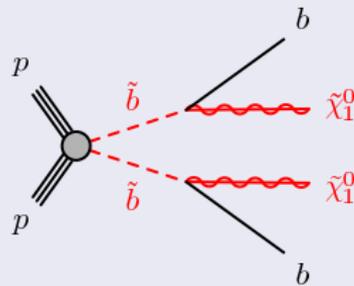
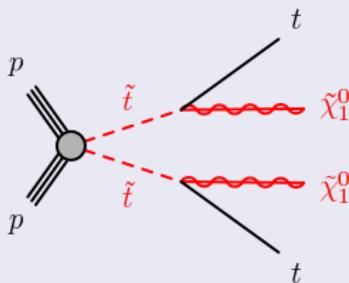
- Start with the highest cross section process
- Hypothesis: gluino lighter than 1st/2nd generation squarks
- Large b-jet multiplicity and large $\cancel{E}_T \Rightarrow$ low SM background



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Direct Production

- Also look for direct production in case gluinos are out of reach
- Lower cross sections, still higher than those of EWK gauginos
- Lower b-jet multiplicity



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Limits & Interpretations: Simplified Models
 Limits & Interpretations: Complete Models

Analysis

"Search for supersymmetry at $\sqrt{s} = 8$ TeV in final states with jets and two same-sign leptons or three leptons with the ATLAS detector"

- Ref: *arXiv:1404.2500 [hep-ex], subm. to JHEP*
- See ATLAS talk by T. Gillam

Inclusive Search Topology

- $\ell^\pm \ell^\pm + [1 - 3]b - jets + \cancel{E}_T$, ($\ell^\pm = e^\pm / \mu^\pm$)
- $\ell^\pm \ell^\pm + [0]b - jets + \cancel{E}_T$
- $3\ell^\pm + [1 - 3]b - jets + \cancel{E}_T$

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Limits & Interpretations

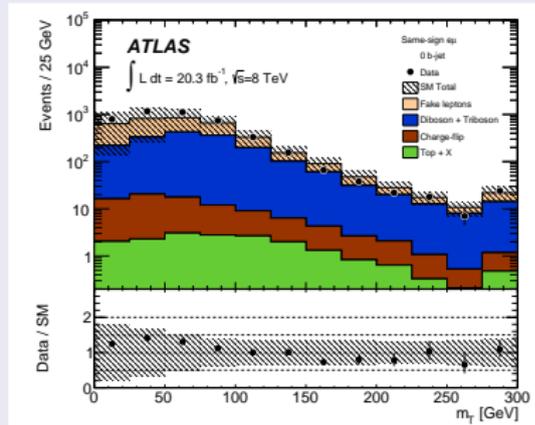
- $M_T = \frac{\sqrt{2p_T(\ell^\pm)\cancel{E}_T[1 - \cos\Delta\phi(\ell^\pm, \cancel{E}_T)]}$
- Distr. in $e^\pm\mu^\pm + [0]b - jet + \cancel{E}_T$
 inclusive topology

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Limits & Interpretations

- $M_{eff} = \cancel{E}_T + \sum_{leptons} p_T + \sum_{jets} p_T$
- Distr. in $e^\pm e^\pm + [1 - 3]b - jet + \cancel{E}_T$
 inclusive topology



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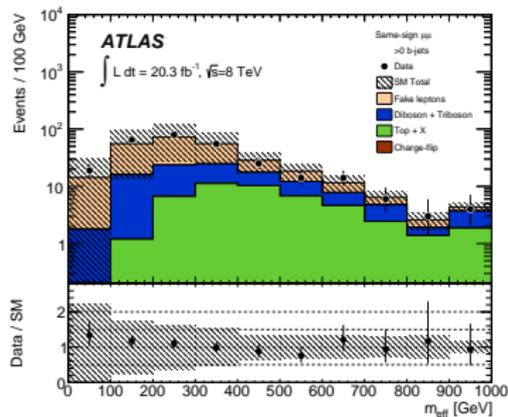
- $M_T = \frac{1}{\sqrt{2p_T(\ell^\pm)\cancel{E}_T[1 - \cos\Delta\phi(\ell^\pm, \cancel{E}_T)]}}$
- Distr. in $e^\pm\mu^\pm + [0]b - jet + \cancel{E}_T$
inclusive topology
- $M_{eff} = \cancel{E}_T + \sum_{leptons} p_T + \sum_{jets} p_T$
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- $M_T = \sqrt{2p_T(\ell^\pm)\cancel{E}_T[1 - \cos\Delta\phi(\ell^\pm, \cancel{E}_T)]}$
- Distr. in $e^\pm\mu^\pm + [0]b\text{-jet} + \cancel{E}_T$ inclusive topology
- $M_{eff} = \cancel{E}_T + \sum_{leptons} p_T + \sum_{jets} p_T$
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Background

- MC estimate of physics background:
 - ttW, ttZ, WW, WZ
- Data-driven estimate of instrumental background:
 - hadron faking isolated ℓ^\pm
 - non-isolated ℓ^\pm from heavy flavor hadron decay faking isolated ℓ^\pm
 - e^\pm from γ -conversion
 - e^\pm with mis-measured charge

Limits Derivation

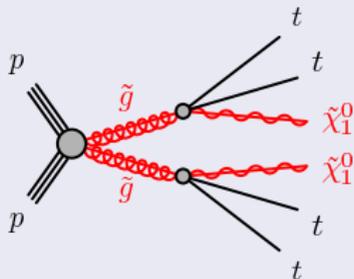
- Signal exclusion fit simultaneously all SRs (maximizes sensitivity to SUSY scenario)
- No excess observed in data wrt SM expectations in any analyses
- Limits are calculated using the CL_S prescription

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Gluino Mediated Production

• $M_{\tilde{g}} \ll M_{\tilde{t}_1}$

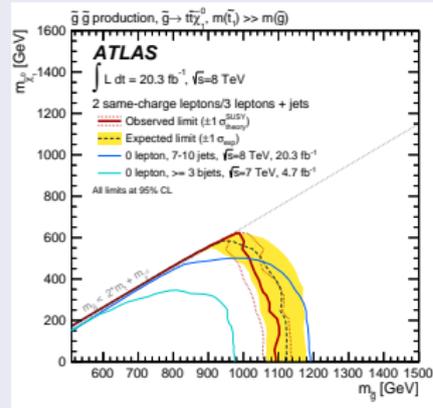


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Gluino Mediated Production

- $M_{\tilde{g}} > M_{\tilde{t}_1}$
 $(M_{\tilde{\chi}_1^\pm}, M_{\tilde{\chi}_1^0}) = (118, 60) \text{ GeV}$



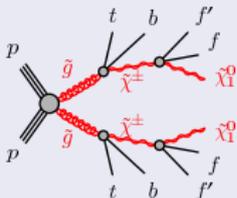
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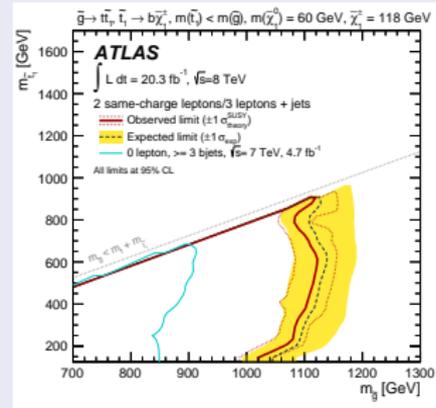
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Glino Mediated Production

- $M_{\tilde{g}} \ll M_{\tilde{t}_1}$

- $\tilde{g} \rightarrow t + c + \tilde{\chi}_1^0$
 $M_{\tilde{t}_1} - M_{\tilde{\chi}_1^0} = 20 \text{ GeV}$



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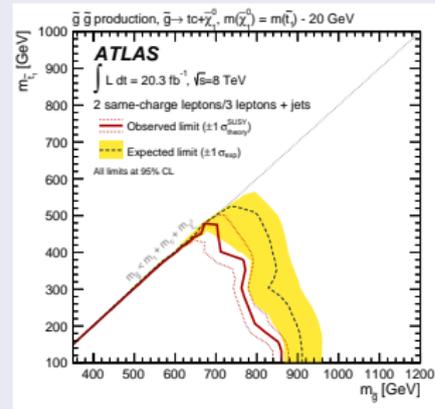
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 $(M_{\tilde{\chi}_1^\pm}, M_{\tilde{\chi}_1^0}) = (118, 60)$ GeV

- $g\bar{g} \rightarrow \tilde{t}_1 + \bar{t}$
 $\tilde{t}_1 \rightarrow b + s$ (R_P)



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 $M_{\tilde{t}_1} - M_{\tilde{\chi}_1^0} = 20 \text{ GeV}$
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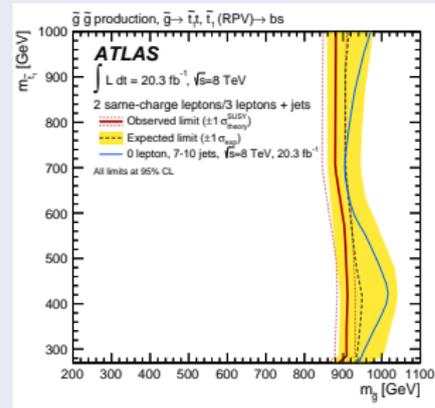
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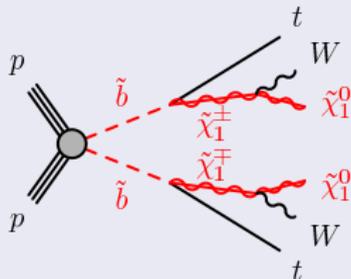


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Direct Sbottom Pair Production

- $\tilde{b}_1 \rightarrow t + \tilde{\chi}_1^\pm$
 $M_{\tilde{\chi}_1^0} = 60 \text{ GeV}$



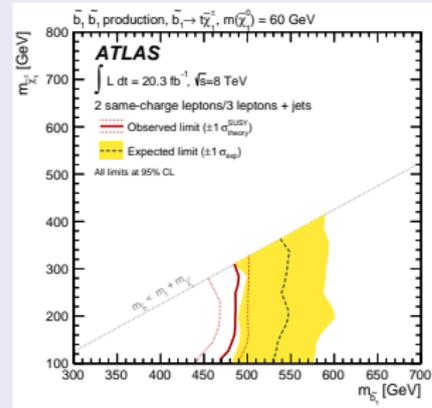
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Direct Sbottom Pair Production

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

$$M_{\tilde{\chi}_1^\pm} = 2M_{\tilde{\chi}_1^0}$$



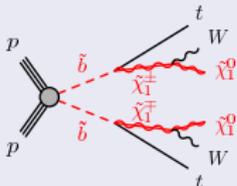
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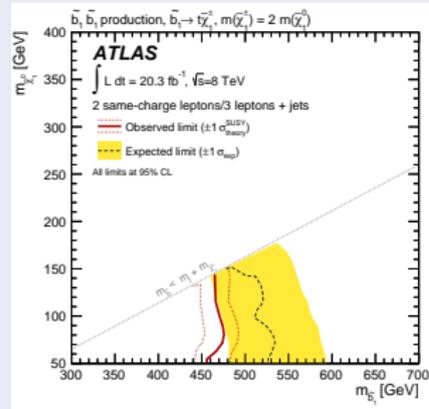


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8. Search with 3b-jets+ E_T
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Minimal Supergravity

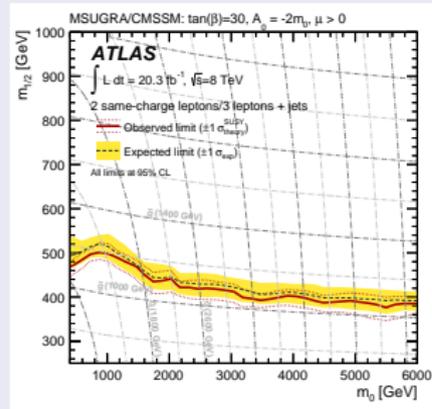
- $\tan\beta = 30, A_0 = -2m_0$
 $\mu > 0$

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- $\tan\beta = 30$, $A_0 = -2m_0$
 $\mu > 0$ (bR_P)



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Minimal Supergravity

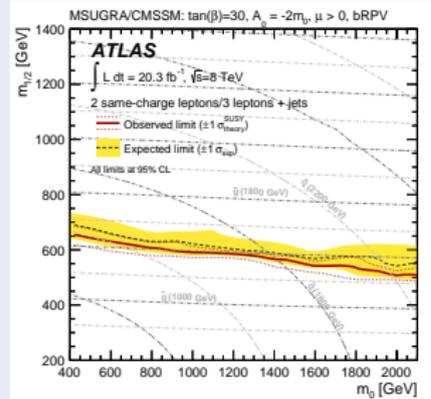
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Minimal Supergravity

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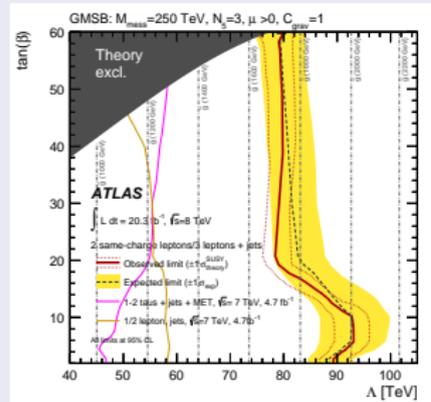
Gauge Mediated SUSY Breaking

- $M_{mess} = 250 \text{ TeV}$, $N_5 = 3$
 $\mu > 0$, $C_{grav} = 1$

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Gauge Mediated SUSY Breaking



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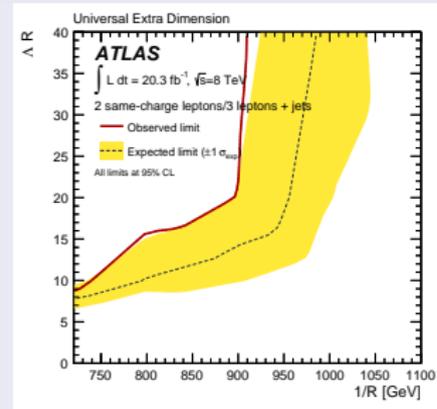
Universal Extra Dimensions

- Non SUSY Model

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Universal Extra Dimensions



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Analysis

"Search for direct third-generation squark pair production in final states with missing transverse momentum and two b-jets in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector"

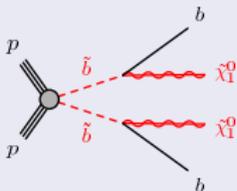
- Ref: [arXiv:1308.2631 \[hep-ex\]](https://arxiv.org/abs/1308.2631), *JHEP* 10 (2013) 189

Inclusive Search Topology

- $2b - jets + 0\ell^\pm + \cancel{E}_T$

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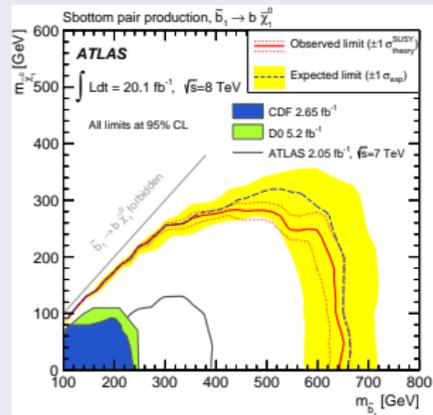
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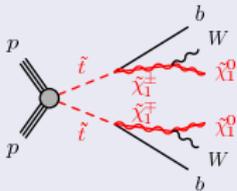
- $\tilde{\chi}_1^\pm \rightarrow \text{SoftTrack}(s) + \cancel{E}_T$
 $M_{\tilde{\chi}_1^\pm} - M_{\tilde{\chi}_1^0} = 5 \text{ GeV}$



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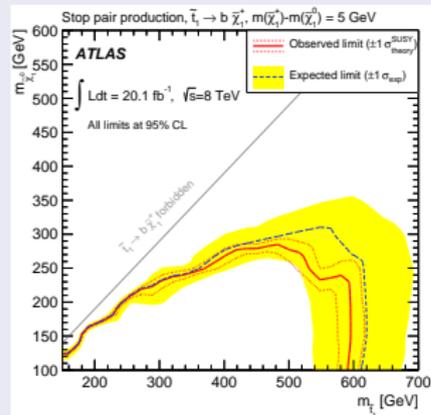
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- $\tilde{\chi}_1^\pm \rightarrow \text{Soft Tracks} + \cancel{E}_T$
 $M_{\tilde{\chi}_1^\pm} - M_{\tilde{\chi}_1^0} = 20 \text{ GeV}$

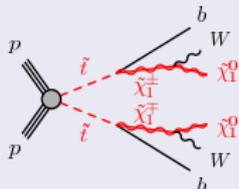


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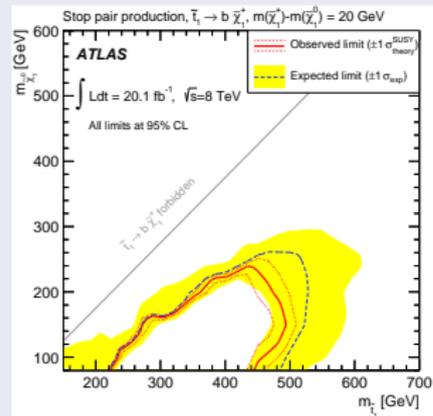
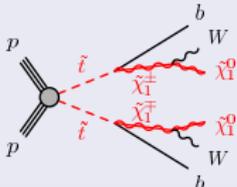


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Analysis

"Search for direct production of the top squark in the all-hadronic $t\bar{t} + \cancel{E}_T$ final state in 21 fb^{-1} of pp collisions at $\sqrt{s} = 8 \text{ TeV}$ with the ATLAS detector"

- Ref: *ATLAS-CONF-2013-024*

Inclusive Search Topology

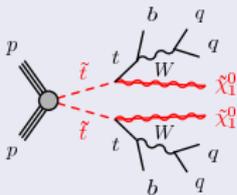
- $t\bar{t} \rightarrow \text{jets} + 0l^{\pm} + \cancel{E}_T$

Event Selection

- Trigger: $\cancel{E}_T > 80 \text{ GeV}$
- Offline:
 - Main Variables: M_T and \cancel{E}_T
 - Tau Veto

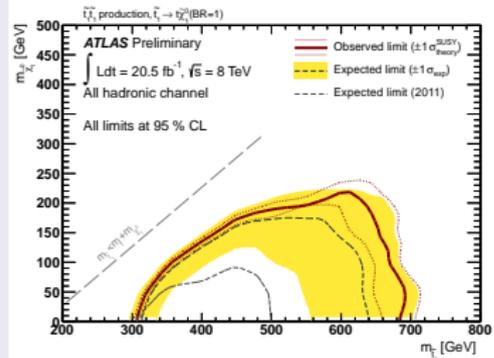
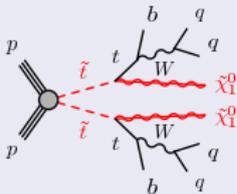
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Analysis

"Search for strong production of supersymmetric particles in final states with missing transverse momentum and at least three b-jets using 20.1 fb⁻¹ of pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector"

- Ref: *ATLAS-CONF-2013-068*

Inclusive Search Topology

- $2c - jets + \cancel{E}_T$

Event Selection

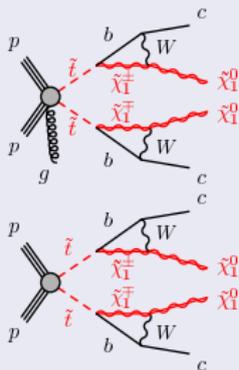
- Trigger: $\cancel{E}_T > 80$ GeV
- Offline:
 - Very Low ΔM : tag an ISR-jet \rightarrow mono-jet selection
 - Low ΔM : tag a c-jet

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c-tagging

- Trigger: $\cancel{E}_T > 80$ GeV
- Offline:
 - MVA: Tracks I.P. and properties of 2^{ndary} vertices
 - Performance: $\epsilon_c = 20\%$, $R_b \approx 5$, $R_{LF} \approx 140$

Limits & Interpretations: Simplified Models

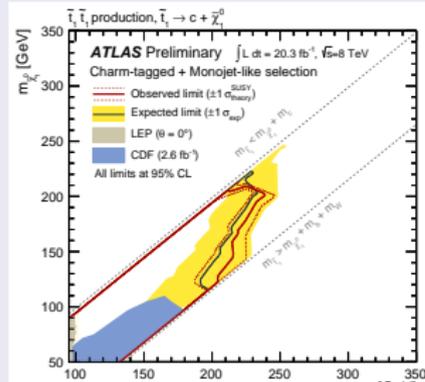
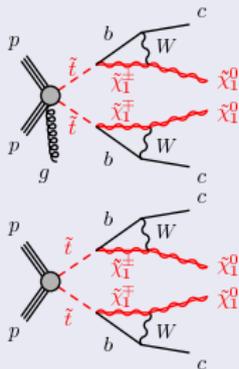


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Analysis

"Search for strong production of supersymmetric particles in final states with missing transverse momentum and at least three b-jets using 20.1 fb⁻¹ of pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector"

- Ref: *ATLAS-CONF-2013-061*

Inclusive Search Topology

- $[0 - 1]\ell^\pm + jets + 3b - jets + \cancel{E}_T$

Event Selection

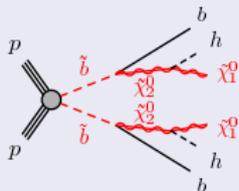
- Main Variables: M_{eff} and $\cancel{E}_T/\sqrt{H_T}$

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Direct Sbottom Pair Production

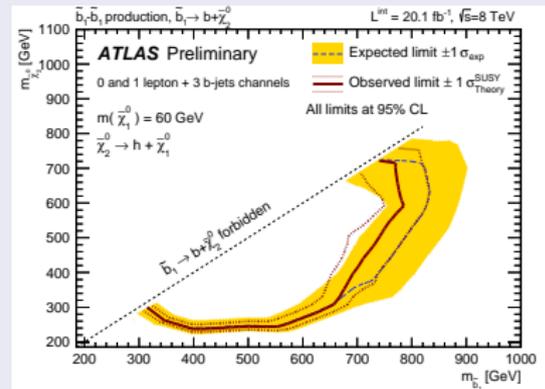
- $BR(\tilde{b}_1 \rightarrow b + \tilde{\chi}_2^0) = 1$
 $BR(\tilde{\chi}_2^0 \rightarrow h + \tilde{\chi}_1^0) = 1$



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Direct Sbottom Pair Production

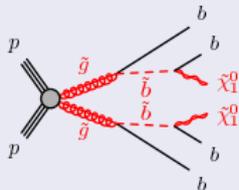


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Gluino Mediated Sbottom Pair Production

- $BR(\tilde{g} \rightarrow \tilde{b}_1 + \bar{b}) = 1$
 on-shell \tilde{b}_1
 $BR(\tilde{b}_1 \rightarrow b + \tilde{\chi}_1^0) = 1$

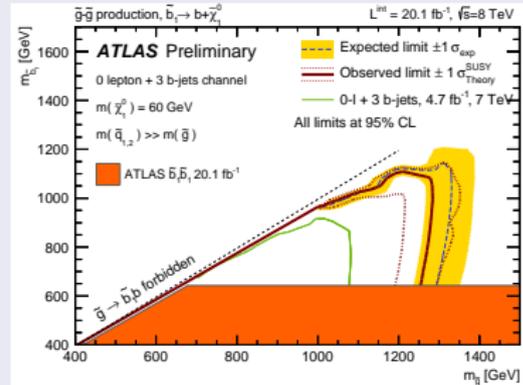


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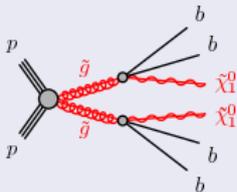
1. Introduction
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 off-shell \tilde{b}_1



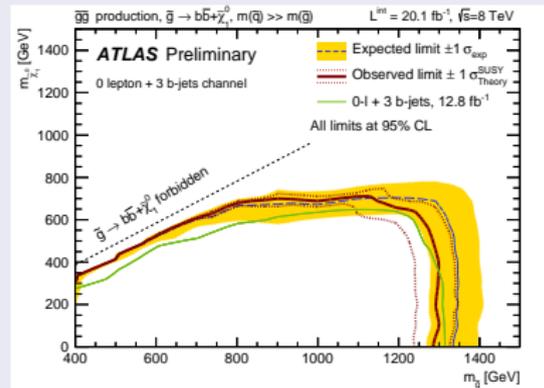
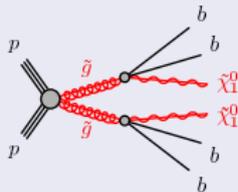
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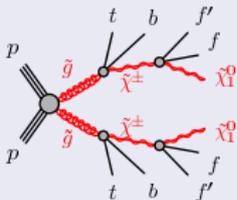


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 Limits & Interpretations: Complete Models

Gluino Mediated Stop Pair Production

- $BR(\tilde{g} \rightarrow t + \tilde{\chi}_1^0) = 1,$
 $BR(\tilde{t}_1 \rightarrow b + \tilde{\chi}_1^\pm) = 1$
 $BR(\tilde{\chi}_1^\pm \rightarrow W^\pm + \tilde{\chi}_1^0) = 1$
 $(M_{\tilde{\chi}_1^\pm}, M_{\tilde{\chi}_1^0}) = (120, 60) \text{ GeV}$

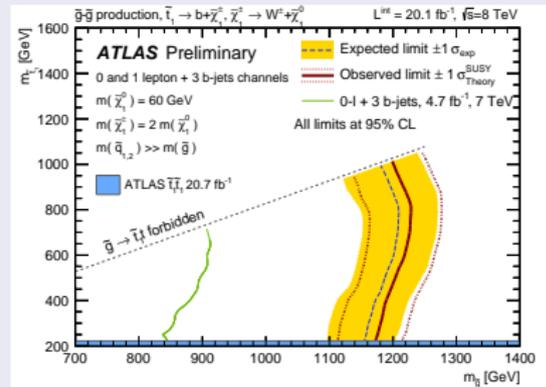


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 Limits & Interpretations: Complete Models

Gluino Mediated Stop Pair Production

- $BR(\tilde{t}_1 \rightarrow t + \tilde{\chi}_1^0) = 1$
 $M_{\tilde{\chi}_1^0} = 60 \text{ GeV}$



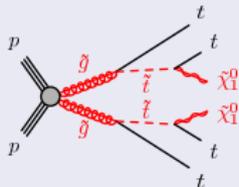
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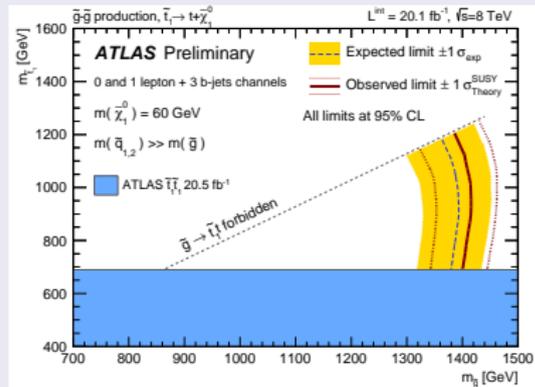
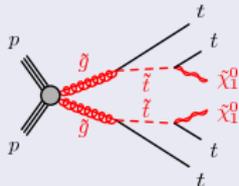
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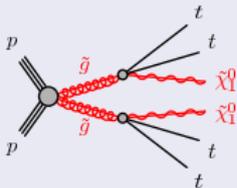


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Gluino Mediated Stop Pair Production (cont'd)

- $BR(\tilde{g} \rightarrow t + \bar{t} + \tilde{\chi}_1^0) = 1$
 off-shell \tilde{t}_1

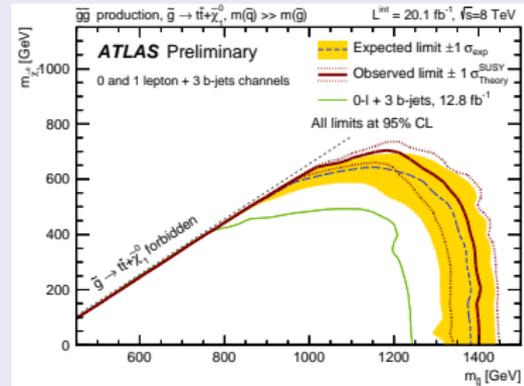


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Gluino Mediated Stop Pair Production (cont'd)

- $BR(\tilde{g} \rightarrow b + \bar{t} + \tilde{\chi}_1^\pm) = 1$
 $M_{\tilde{\chi}_1^\pm} - M_{\tilde{\chi}_1^0} = 2 \text{ GeV}$



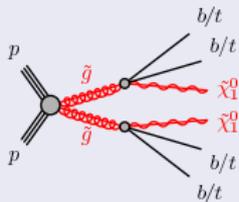
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Glino Mediated Stop Pair Production (cont'd)

- $BR(\tilde{g} \rightarrow t + \bar{t} + \tilde{\chi}_1^0) = 1$
 off-shell \tilde{t}_1

- $BR(\tilde{g} \rightarrow b + \bar{t} + \tilde{\chi}_1^\pm) = 1$
 $M_{\tilde{\chi}_1^\pm} - M_{\tilde{\chi}_1^0} = 2 \text{ GeV}$

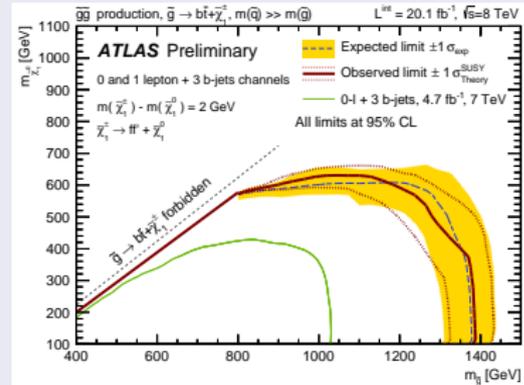


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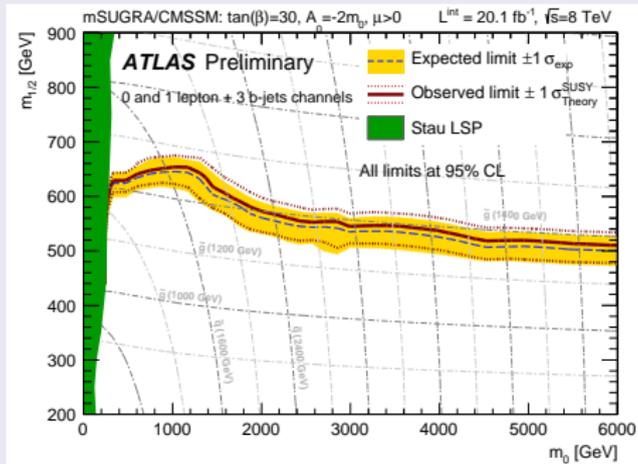
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Minimal Supergravity



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Limits & Interpretations: Simplified Model

Analysis

"Search for the direct pair production of top squarks decaying to a b quark, a tau lepton, and weakly interacting particles, in $\sqrt{s} = 8$ TeV pp collisions using 20 fb⁻¹ of ATLAS data"

- Ref: *ATLAS-CONF-2014-014*

Inclusive Search Topology

- $l^\pm l^\mp + \cancel{E}_T$

Event Selection

- Main variable: M_{T2}
- $$M_{T2}(\mathbf{p}_T^{vis_1}, \mathbf{p}_T^{vis_2}, \cancel{\mathbf{p}}_T) = \min_{\substack{\mathbf{p}_T^{invis_1} \\ \mathbf{p}_T^{invis_2} = \cancel{\mathbf{p}}_T - \mathbf{p}_T^{invis_1}}} \max[M_T(\mathbf{p}_T^{vis_1}, \mathbf{p}_T^{invis_1}), M_T(\mathbf{p}_T^{vis_2}, \mathbf{p}_T^{invis_2})]$$

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- Re-interpretation of the "3 b-jets" analysis
- New selection for small \tilde{t}_1 and $\tilde{\tau}_1^\pm$ masses

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- $\ell^\pm \ell^\mp + \cancel{E}_T$

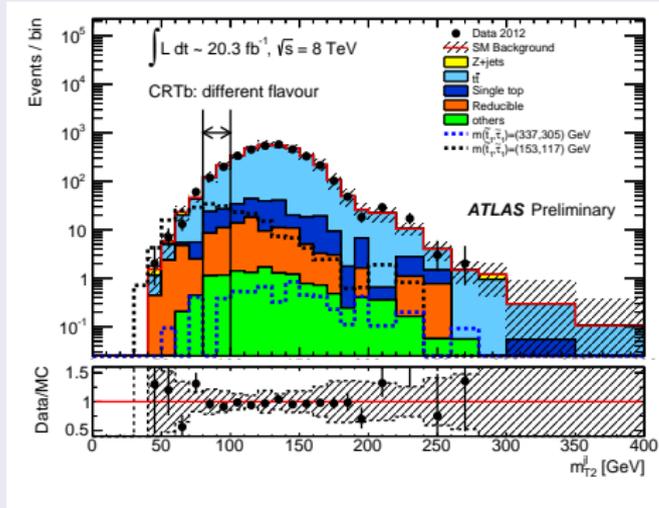
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Event Selection (cont'd)

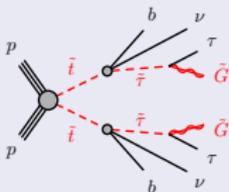


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Limits & Interpretations: Simplified Model

Gauge Mediated SUSY Breaking

- $BR(\tilde{t}_1 \rightarrow b + \nu + \tilde{\tau}_1^\pm) = 1$
 $BR(\tilde{\tau}_1^\pm \rightarrow \tau^\pm + \tilde{G}_{3/2}) = 1$

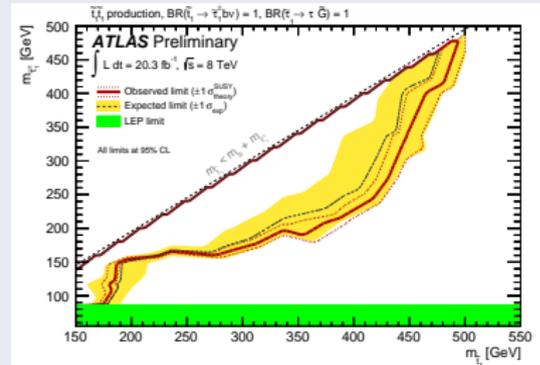
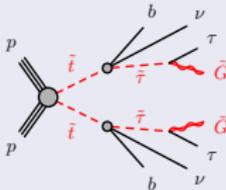


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Limits & Interpretations: Simplified Model
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Analysis

"Search for direct top squark pair production in events with a Z boson, b-jets and missing transverse momentum in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector"

- Ref: [arXiv:1403.5222 \[hep-ex\]](https://arxiv.org/abs/1403.5222), *subm. to EJPC*
- Motivation: In case direct $\tilde{t}_1 \bar{\tilde{t}}_1$ searches have limited sensitivities due to compressed scenarios, consider production of $\tilde{t}_2 \bar{\tilde{t}}_2$

Inclusive Search Topology

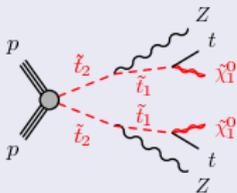
- $Z(\rightarrow \ell^\pm \ell^\mp) + 2b - jets + \cancel{E}_T$

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Gauge Mediated SUSY Breaking

- $BR(\tilde{t}_2 \rightarrow Z + \tilde{t}_1) = 1$

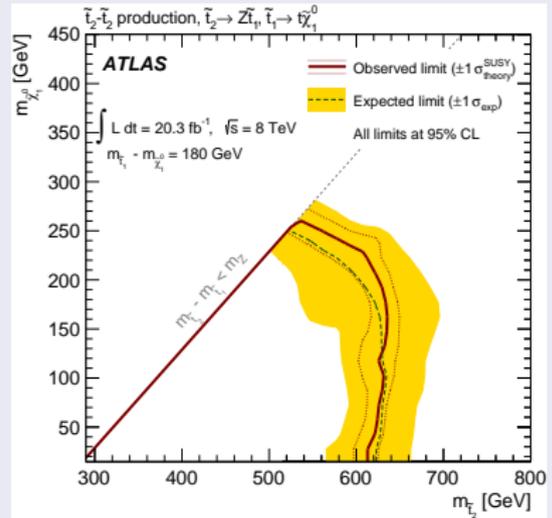
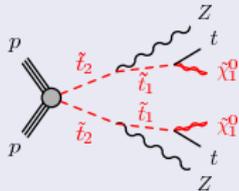


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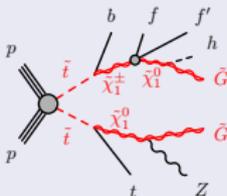


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Natural Gauge Mediated SUSY Breaking

- $\tilde{\chi}_1^0 \rightarrow Z + \tilde{G}_{3/2}$
 or $\tilde{\chi}_1^0 \rightarrow h + \tilde{G}_{3/2}$

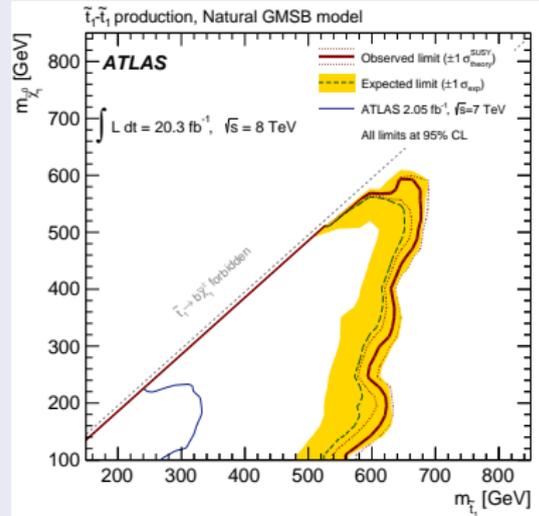
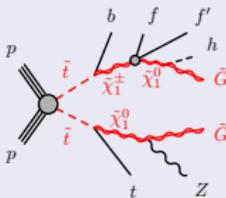


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Conclusion

- Several searches for 3rd generation squarks presented
- No excess observed in data wrt SM expectations

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Conclusion

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- Several interpretations of these results in different SUSY scenarios
- Summary plot

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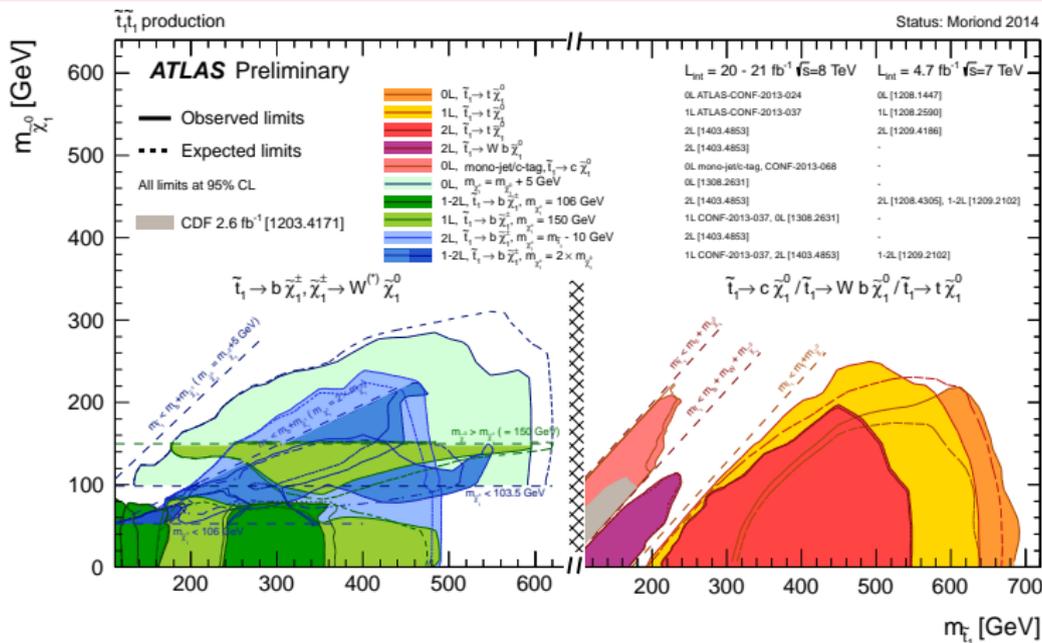
Conclusion

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- Summary plot

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ATLAS SUSY Limits

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: Midroad 2014

$$\int \mathcal{L} dt = (4.6 - 22.9) \text{ fb}^{-1} \quad \sqrt{s} = 7, 8 \text{ TeV}$$

Model	$\epsilon, \mu, \tau, \gamma$	Jets	E_T^{min}	$[\mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	Reference
MSI GRC MSSM	0	3-6 jets	YES	20.3	1.2 TeV	#10-mj
MSI GRC MSSM	1, ϵ, μ	3-6 jets	YES	20.3	1.2 TeV	#10-mj
MSI GRC MSSM	0	3-6 jets	YES	20.3	1.1 TeV	#10-mj
$\tilde{t}_1 \rightarrow c\tilde{t}$	0	3-6 jets	YES	20.3	740 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t}^*$	0	3-6 jets	YES	20.3	1.3 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	3-6 jets	YES	20.3	1.1 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	3-6 jets	YES	20.3	1.1 TeV	#11-bj
CMSS (1 NLSP)	2, ϵ, μ	2-4 jets	YES	4.7	1.2 TeV	#10-bj
CMSS (1 NLSP)	1, ϵ, μ	2-4 jets	YES	4.7	1.2 TeV	#10-bj
OGM (1 NLSP)	2, ϵ, μ	2 jets	YES	20.1	1.2 TeV	#11-bj
OGM (1 NLSP)	1, ϵ, μ	2 jets	YES	20.1	1.2 TeV	#11-bj
OGM (Higgs 1 NLSP)	2, ϵ, μ	2 jets	YES	4.8	910 GeV	#11-bj
OGM (Higgs 1 NLSP)	1, ϵ, μ	2 jets	YES	4.8	910 GeV	#11-bj
OGM (Higgs 1 NLSP)	2, ϵ, μ	0-3 jets	YES	5.8	890 GeV	#11-bj
OGM (Higgs 1 NLSP)	1, ϵ, μ	0-3 jets	YES	5.8	890 GeV	#11-bj
CMSS (1 SP)	mono-jet	YES	10.5	648 GeV	#11-bj	
$\tilde{t}_1 \rightarrow b\tilde{t}$	0	3 jets	YES	20.1	1.2 TeV	#11-bj
$\tilde{t}_1 \rightarrow b\tilde{t}^*$	0	0-10 jets	YES	20.3	1.1 TeV	#11-bj
$\tilde{t}_1 \rightarrow b\tilde{t} + \tilde{t}_1 \rightarrow b\tilde{t}^*$	0-1, ϵ, μ	3 jets	YES	20.1	1.34 TeV	#11-bj
$\tilde{t}_1 \rightarrow b\tilde{t} + \tilde{t}_1 \rightarrow b\tilde{t}^*$	0-1, ϵ, μ	3 jets	YES	20.1	1.3 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t}$	0	2 jets	YES	20.1	100-520 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	20.1	275-420 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	0-3 jets	YES	20.1	110-387 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	1-2 jets	YES	4.7	130-210 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	20.3	150-210 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	2-6 jets	YES	20.3	215-330 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	20.1	195-300 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	1 jet	YES	20.1	200-510 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	20.1	320-500 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	0-3 jets	YES	20.1	90-290 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	1 jet	YES	20.3	195-300 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	3, ϵ, μ	1 jet	YES	20.3	200-500 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	0	YES	20.3	90-320 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	0	YES	20.3	140-250 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	20.1	180-330 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	3, ϵ, μ	0	YES	20.3	700 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	0	YES	20.3	420 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	2 jets	YES	20.3	380 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	0-10 jets	YES	20.3	270 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	1-5 jets	YES	22.9	832 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	1-5 jets	YES	22.9	476 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	1 jet	YES	4.7	230 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	1 jet	YES	20.3	1.0 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	2 jets	YES	4.6	1.61 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	1 jet	YES	4.6	1.1 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	1, ϵ, μ	7-8 jets	YES	4.7	1.2 TeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	4, ϵ, μ	0	YES	20.1	700 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	2 jets	YES	20.1	350 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	0	6-7 jets	YES	20.3	910 GeV	#11-bj
$\tilde{t}_1 \rightarrow c\tilde{t} + \tilde{t}_1 \rightarrow c\tilde{t}^*$	2, ϵ, μ	0-3 jets	YES	20.1	890 GeV	#11-bj
Scale Δa_μ or g_μ (1 NLSP)	0	4 jets	YES	4.6	100-267 GeV	#11-bj
Scale Δa_μ or g_μ (1 NLSP)	2, ϵ, μ	2 jets	YES	14.3	390-500 GeV	#11-bj
Scale Δa_μ or g_μ (1 NLSP)	0	mono-jet	YES	10.5	390-500 GeV	#11-bj

$\sqrt{s} = 7 \text{ TeV}$ full data

$\sqrt{s} = 8 \text{ TeV}$ pre-8 TeV full data

$\sqrt{s} = 8 \text{ TeV}$ full data

Mass scale [TeV]