

ATLAS SUSY Searches Moriond 2012 Results

LHC Physics Discussion

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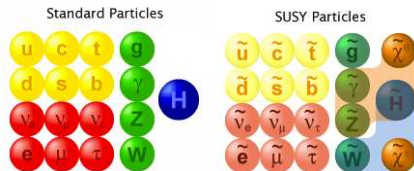
Supersymmetry

- ▷ **Standard Model Predictions very successful BUT incomplete: e.g.**

- ▷ Hierarchy problem
- ▷ Dark matter

- ▷ **Idea: Symmetry between fermions and bosons.**

- ▷ SUSY solves these issues



- ▷ Consider R-parity conserved
- ▷ Lightest SUSY particle (LSP): stable
- ▷ Next-to-LSP → phenomenology

Models and parameters:

- ▷ **mSUGRA/CMSSM:**
 - ▷ $m_{1/2}$: common gaugino mass
 - ▷ m_0 : common scalar mass
- ▷ **GMSB:**
 - ▷ Λ : SUSY breaking scale
 - ▷ $\tan \beta$: Ratio of Higgs VEV
- ▷ **Simplified models:**
 - ▷ **Reduced particle spectrum:** masses

Search Strategy for SUSY

▷ Production at LHC:

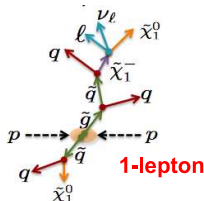
- ▷ Mainly strong production of squarks and gluinos
- ▷ Consider R-parity conserved : Pairs of sparticles

▷ Decay:

- ▷ Decay via cascades
- ▷ Into stable LSP ($\tilde{\chi}_1^0$, $\tilde{G}$)

▷ Signature:

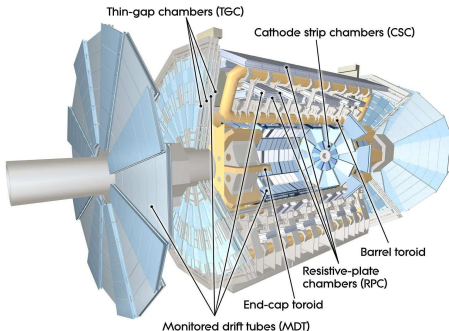
- ▷ Multiple, high energetic jets
- ▷ Missing transverse momentum E_T^{miss} from LSP
- ▷ Distinguish final states by additional particles:
0, 1, 2 leptons, taus, 2 photons, b-jets



▷ Analysis ("Cut and Count"):

- ▷ Define signal regions
- ▷ Discriminate btw. signal and background
- ▷ **Background:**
 - $t\bar{t}$, W/Z + X, QCD
 - Prefer data-driven (to MC)
- ▷ Excess of signal over background?
- ▷ Interpretation (in a specific model)

ATLAS Detector and Data Taking

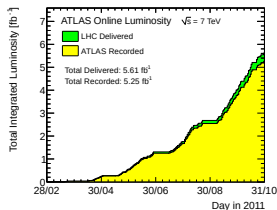


▷ ATLAS:

- ▷ General purpose detector at the LHC

▷ Data Taking 2011 at $\sqrt{s} = 7$ TeV:

- ▷ $3.5 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ peak luminosity
- ▷ $L = 5.6 \text{ fb}^{-1}$ delivered by LHC
- ▷ $L \leq 4.7 \text{ fb}^{-1}$ available for analysis



▷ **≥ 1 τ and ≥ 2 τ search:**

- $L = 2 \text{ fb}^{-1}$ ATLAS-CONF-2012-005
- $L = 2 \text{ fb}^{-1}$ ATLAS-CONF-2012-002

▷ **Gluino mediated sbottom search:**

- $L = 2 \text{ fb}^{-1}$ ATLAS-CONF-2012-003

▷ **Stop search:**

- $L = 2 \text{ fb}^{-1}$ ATLAS-CONF-2012-003

▷ **Squark and gluino search with no leptons:**

- $L = 4.7 \text{ fb}^{-1}$ ATLAS-CONF-2012-033

▷ **The presented analysis and others can be found here:**

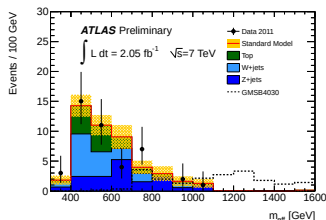
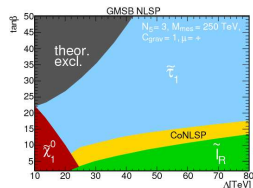
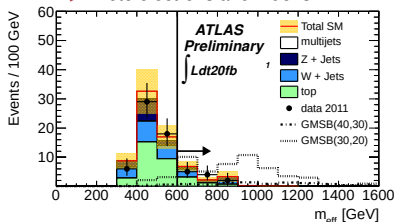
<https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults>

Phenomenology in GMSB:

- τ produced via:
 $\tilde{\tau} \rightarrow \tau \tilde{G}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau} \tau, \tilde{l}_R \rightarrow \tilde{\tau} \tau /$
- Signature: multiple τ , jets and E_T^{miss}

Selection:

- Trigger: Jet($p_T > 75$ GeV) + E_T^{miss} (> 45 GeV)
- ≥ 2 jets with $p_T > 30$ GeV
- Veto electrons and muons



$\geq 1\tau$ analysis

- ≥ 1 tight τ , $p_T^\tau > 20$ GeV
- $m_T(\tau_1) > 110$ GeV
- $m_{\text{eff}} > 600$ GeV

$\geq 2\tau$ analysis:

- ≥ 2 loose τ , $p_T^\tau > 20$ GeV
- $m_T(\tau_1) + m_T(\tau_2) > 80$ GeV
- $m_{\text{eff}} > 700$ GeV

Stau: Interpretation

Result:

- ▷ No excess observed

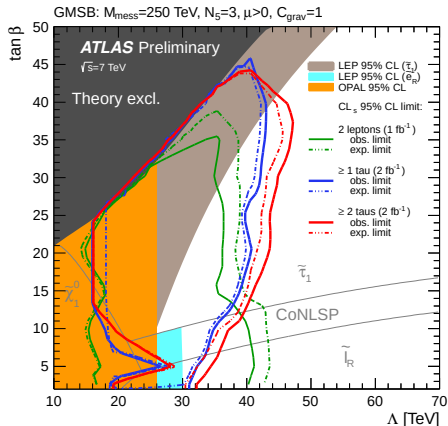
Analysis	SM background	Observed
$\geq 1\tau$	13.2 ± 4.3	11
$\geq 2\tau$	5.3 ± 2.6	3

GMSB Parameter:

- ▷ Λ : SUSY breaking scale
- ▷ $\tan \beta$: Ratio of Higgs VEV
- ▷ $M_{mess} = 250$ TeV, $N_5 = 3$, $\mu > 0$, $C_{grav} = 1$

Limits:

- ▷ independent of $\tan \beta$:
 - $\geq 1\tau$: $\Lambda < 31$ GeV
 - $\geq 2\tau$: $\Lambda < 32$ GeV
- ▷ best exclusion:
 - $\geq 1\tau$: $\Lambda < 40$ GeV at $\tan \beta = 44$
 - $\geq 2\tau$: $\Lambda < 47$ GeV at $\tan \beta = 37$



Gluino Mediated Sbottom Production

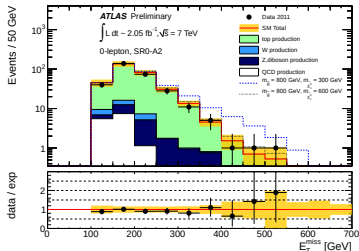
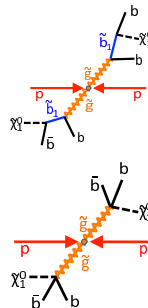
▷ Production:

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

▷ Signature: several b-jets and E_T^{miss}

▷ Selection:

- ▷ Trigger: $\text{Jet}(p_T > 130 \text{ GeV}) + E_T^{\text{miss}} (> 130 \text{ GeV})$
- ▷ ≥ 3 jets with $p_T 50 \text{ GeV}$, ≥ 1 b-tag jet
- ▷ Veto electrons and muons



▷ 6 signal regions:

- ▷ $\geq 1, \geq 2$ b-tagged jets
- ▷ $m_{\text{eff}} > 500, 700, 900 \text{ GeV}$

Gluino Mediated Sbottom Production: Interpretation

Interpreted in simplified MSSM scenario:

$\tilde{g} \tilde{g}$ or $\tilde{b} \tilde{b}$ production

Mass spectrum:

- $m_{\tilde{g}} > m_{\tilde{b}_1} > m_{\tilde{\chi}_1^0}$
- Other squarks much heavier
- $m_{\tilde{\chi}_1^0} = 60 \text{ GeV}$

Decays:

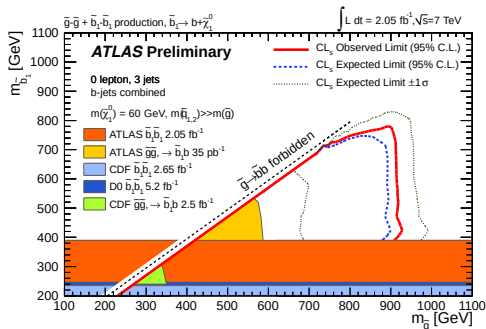
- $\text{BR}(\tilde{g} \rightarrow \tilde{b} b) = 1$
- $\text{BR}(\tilde{b} \rightarrow \tilde{\chi}_1^0 b) = 1$

Limits:

$m_{\tilde{g}} < 920 \text{ GeV}$ for $m_{\tilde{b}} < 800 \text{ GeV}$

Limit from *direct* sbottom production:

$m_{\tilde{b}} < 400 \text{ GeV}$ for all $\tilde{g}$ masses



Stop Production

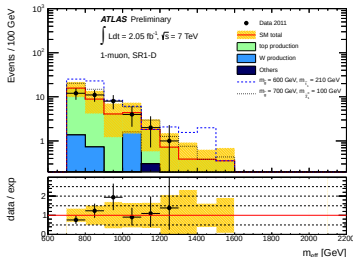
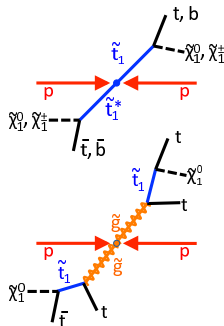
Production:

$$\bar{g} \rightarrow \bar{t}t \rightarrow \bar{t}\bar{\chi}_1^0 \text{ or } \bar{t} \rightarrow t\bar{\chi}_1^0 / b\bar{\chi}^\pm$$

Signature: several top/bottom quarks and E_T^{miss}

Selection:

- ▷ Trigger: 1 electron ($p_T > 25$ GeV) or 1 muon ($p_T > 20$ GeV)
- ▷ ≥ 4 jets with $p_T > 50$ GeV
- ▷ ≥ 1 b-tagged jet
- ▷ = 1 lepton
- ▷ $m_T > 100$ GeV



2 signal regions:

- ▷ $m_{\text{eff}} > 700$ GeV, $E_T^{\text{miss}} > 80$ GeV
- ▷ $m_{\text{eff}} > 700$ GeV, $E_T^{\text{miss}} > 200$ GeV

Stop Production: Interpretation

▷ Interpreted in simplified MSSM scenario:

▷ $\tilde{g}\tilde{g}$ or $t\bar{t}$ production

▷ Mass spectrum:

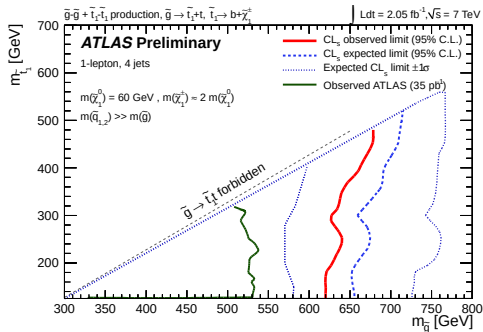
- ▷ All quarks heavier than $\tilde{g}$ except $\tilde{t}_1$
- ▷ $m_{\tilde{g}} > m_{\tilde{t}_1} + m_t$
- ▷ $m_{\tilde{\chi}_1^0} = 60 \text{ GeV}$
- ▷ $m_{\tilde{\chi}_1^\pm} \simeq 2m_{\tilde{\chi}_1^0}$

▷ Decays:

- ▷ $\text{BR}(\tilde{g} \rightarrow \tilde{t}_1 t) = 1$
- ▷ $\text{BR}(\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm) = 1$
- ▷ $\text{BR}(\tilde{\chi}_1^\pm \rightarrow \tilde{\chi}_1^0 l^\pm \nu) = 11\%$

▷ Limits:

▷ $m_{\tilde{g}} < 620 \text{ GeV}$ for $m_{\tilde{t}_1} < 440 \text{ GeV}$



Squark and Gluino Production

Phenomenology:

$$\tilde{q} \rightarrow q\tilde{\chi}_1^0 \text{ or } \tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0$$

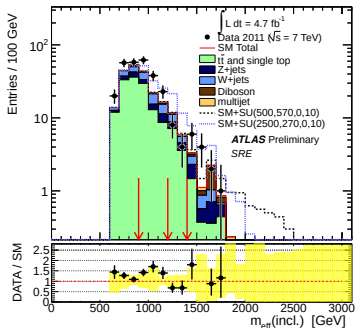
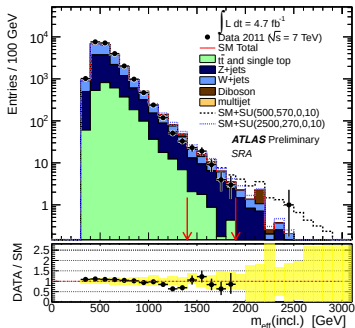
Signature: multiple jets and E_T^{miss}

Selection:

- ▷ Trigger: Jet($p_T > 75$ GeV) + $E_T^{\text{miss}} (> 55$ GeV)
- ▷ ≥ 2 jets with $p_T > 60$ GeV
- ▷ $E_T^{\text{miss}} > 160$ GeV
- ▷ Lepton veto

11 signal regions:

- ▷ $\geq 2 - 6$ jets
- ▷ $m_{\text{eff}} > 900 - 1900$ GeV



Squark and Gluino Production: Interpretation

▷ Interpreted in mSUGRA/CMSSM scenario:

▷ $\tilde{g}\tilde{g}$, $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{g}$ production

▷ Parameter:

▷ $\tan \beta = 10$

▷ $A_0 = 0$

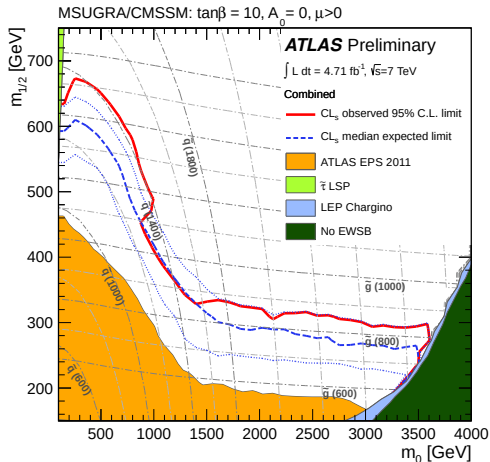
▷ $\mu > 0$

▷ Limits:

▷ $m_{1/2} < 300$ GeV for all m_0

▷ $m_0 < 680$ GeV for all $m_{1/2}$

▷ $\tilde{q}$ and $\tilde{g}$ of equal mass excluded below 1400 GeV



Summary

- ▷ SUSY is a good candidates for BSM physics
- ▷ Reported SUSY search results from Moriond conference
 $L = 2 - 4.7 \text{ fb}^{-1}$ of analyzed data
- ▷ Focus on 3rd generation SUSY and hadronic final states
- ▷ No SUSY hints
- ▷ Exclusion limits in different scenarios:

production	scenario	limit on parameter	comment
Stau	GMSB	$\Lambda < 31 \text{ TeV}$	indep. of $\tan \beta$
Sbottom	simplified MSSM	$m_{\tilde{g}} < 920 \text{ GeV}$	for $m_{\tilde{b}} < 800 \text{ GeV}$
Stop	simplified MSSM	$m_{\tilde{b}} < 400 \text{ GeV}$	indep. of $m_{\tilde{g}}$
Squark and Gluino	mSUGRA/CMSSM	$m_{\tilde{g}} < 620 \text{ GeV}$	for $m_{\tilde{t}} < 440 \text{ GeV}$
		$m_{\tilde{g}, \tilde{q}} < 1400 \text{ GeV}$	for $m_{\tilde{g}} \simeq m_{\tilde{q}}$

- ▷ New results with full 2011 data set will be released soon