Searches for gaugino production with the ATLAS detector

SEARCH 2012 – University of Maryland, USA
Christophe Clement (Stockholm U.)
on behalf of the ATLAS Collaboration
### Gaugino Production Signals In this Talk

<table>
<thead>
<tr>
<th>Signal Region</th>
<th>#lept.</th>
<th>Eg. of possible gaugino signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 photon + $E_T^{\text{miss}}$</td>
<td>N/A</td>
<td>$\tilde{\chi}_d^0 \rightarrow \gamma + \tilde{G}$</td>
</tr>
<tr>
<td>2-lepton OS and SS =2</td>
<td></td>
<td>$\tilde{\chi}_1^+ \tilde{\chi}_1^- \rightarrow (l^\pm \nu \tilde{\chi}_d^0) + (l^\mp \nu \tilde{\chi}_d^0)$ with one non-reconstructed lepton</td>
</tr>
<tr>
<td>3-lepton =3</td>
<td></td>
<td>$\tilde{\chi}_2^0 \tilde{\chi}_1^\pm \rightarrow (l^+ l^- \tilde{\chi}_d^0) + (l^\pm \nu \tilde{\chi}_d^0)$</td>
</tr>
<tr>
<td>4-lepton $\geq$4</td>
<td></td>
<td>$\tilde{\chi}_2^0 \tilde{\chi}_2^0 \rightarrow (l^\pm l^\mp \tilde{\chi}_d^0) + (l^\pm l^\mp \tilde{\chi}_d^0)$</td>
</tr>
</tbody>
</table>

⇒ R-parity conserving scenarios  
⇒ Two, Three and Four lepton analyses.

Gaugino decays can proceed via:  
virtual or on-shell sleptons, Z*, W*

⇒ Signal regions with and w/o Z-veto
GMSB inspired models the **LSP** is gravitino $\tilde{G}$

If the **NLSP** $\tilde{\chi}_1^0$ is Bino-like giving $\tilde{\chi}_1^0 \to \gamma + \tilde{G}$

• **Generalised model of gauge mediated** SUSY (GGM) with gluino production

• **Minimal model of GMSB** (SPS8)
  Squark-gluinos are very heavy

  Direct $\tilde{\chi}_2^0, \tilde{\chi}_4^\pm$ production.

Models with one extra universal extra dimension (UED)
Production of the KK excitations of squarks and gluinos

Cascade decay chains until the Lighest KK Particle is produced: $\gamma^*$
If N additional dimensions accessible only to gravity and (4+N)-D Planck scale $\sim$1TeV

$\Rightarrow$ The LKP is unstable $\gamma^* \to \gamma + G$
Loose photons
Limit on energy in the hadronic layers
Shower width in the 2nd ECAL layer

Tight photons
Detailed shower shape, use fine granularity of 1st ECAL layer.

Loose di-photon trigger with $E_T>20$ GeV
2 tight photons with $E_T>25$ GeV
Isolated clusters ($E_T<5$ GeV)

Signal Region: $E_T^{\text{miss}}>125$ GeV

Backgrounds
$\gamma\gamma$, $\gamma$+jets, multijets

$W+X$ and $t\bar{t}$ backgrounds

$E_T^{\text{miss}}$ template from $\gamma\gamma$ sample with at $\geq1$ non tight $\gamma$
or from Z->ee, normalised in $E_T^{\text{miss}}<20$ GeV.
2 Photon + $E_T^{\text{miss}}$ Backgrounds

W+X and tt backgrounds

$E_T^{\text{miss}}$ template from 1 tight $\gamma + 1$ electron in $E_T^{\text{miss}} > 20$ GeV- scale by Probability for electron to be mis-identified as tight electron. (5-17% in $\eta$ bins)
2 Photon + $E_T^{\text{miss}}$ Results

5 events observed in signal region

$4.1\pm0.6\,(\text{stat})\pm1.6\,(\text{syst})$ predicted SM events

uncertainties on the signal prediction

<table>
<thead>
<tr>
<th>Source of uncertainty</th>
<th>GGM</th>
<th>SPS8</th>
<th>UED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated luminosity</td>
<td>3.7%</td>
<td>3.7%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Trigger</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Photon identification</td>
<td>3.9%</td>
<td>3.9%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Photon isolation</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Pile-up</td>
<td>1.3%</td>
<td>1.3%</td>
<td>1.6%</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}$</td>
<td>1.7%</td>
<td>5.6%</td>
<td>0.7%</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}$</td>
<td>1.0%</td>
<td>0.7%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Signal MC statistics</td>
<td>2.9%</td>
<td>2.3%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Total signal uncertainty</td>
<td>6.6%</td>
<td>8.3%</td>
<td>6.0%</td>
</tr>
<tr>
<td>PDF and scale</td>
<td>31%</td>
<td>5.5%</td>
<td>10%*</td>
</tr>
<tr>
<td>Total</td>
<td>32%</td>
<td>10%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

SPS8 limits $\sigma < (27-91)\,\text{fb}$ for $\Lambda$ in 220-80 TeV

* calculated with LO PDF (NLO not available for UED)
2 Photon + $E_T^{\text{miss}}$ GGM Results

GGM model limits $\sigma < (22-129) \text{ fb}$

Larger value corresponds to $m_{\tilde{g}}, m_{\tilde{\chi}_1^0} = (400, 50) \text{ GeV}$

Lower value corresponds to heavy neutralino masses

other SUSY sparticles at 1.5 TeV
Potentially OS and SS pairs and same of different flavour

$ee, e\mu, \mu\mu$ pairs EXACTLY 2 leptons

$M_{ll}>20$ GeV

Single electron or muon triggers: **common to all analyses presented in this talk.**

Leading electron $p_T>25$ GeV, leading muon or 2$^\text{nd}$ lepton $p_T>20$ GeV (compatibility with trigger)
2-Lepton Analysis: Event Selections

**In the paper, try to cover as many SUSY models as possible vary**

The number of jets

The $E_T^{\text{miss}}$ Selection

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<table>
<thead>
<tr>
<th>Signal Region</th>
<th>Opposite Sign</th>
<th>Same Sign</th>
<th>Flavour subtraction analysis, for SUSY with $ee$ or $\mu\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_T^{\text{miss}}$ [GeV]</td>
<td>OS-inc 250</td>
<td>OS-3j 220</td>
<td>OS-4j 100</td>
</tr>
<tr>
<td>Leading jet $p_T$ [GeV]</td>
<td>-</td>
<td>80 100</td>
<td>- 50</td>
</tr>
<tr>
<td>Second jet $p_T$ [GeV]</td>
<td>-</td>
<td>40 70</td>
<td>- 50</td>
</tr>
<tr>
<td>Third jet $p_T$ [GeV]</td>
<td>-</td>
<td>40 70</td>
<td>- -</td>
</tr>
<tr>
<td>Fourth jet $p_T$ [GeV]</td>
<td>-</td>
<td>- 70</td>
<td>- -</td>
</tr>
<tr>
<td>Number of jets</td>
<td>-</td>
<td>$\geq 3$</td>
<td>$\geq 4$</td>
</tr>
<tr>
<td>$m_{ll}$ veto [GeV]</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

OS / SS leptons pairs => Chains with leptons from the same/(or not) side of the event

Jets => Strong SUSY production

**No jet selection** => Sensitive to gaugino production.

(PLB 709 (2012) 137 has also a GMSB interpretation, cf. ATLAS-CONF-2011-156)

https://cdsweb.cern.ch/record/139824)
2 lepton backgrounds

Irreducible (=2 real isolated leptons)
- double top: Data driven, leading background in OS sample
- WW, WZ, ZZ: Monte Carlo derivation NLO cross section
- single top: MC NLO cross section
- $Z/\gamma\rightarrow ll +$ jets

Reducible backgrounds
- 1 or 2 fake leptons from heavy flavor, prompt photons, photon conversions
- charge flip in the same sign region,

Opposite Sign No Jet Requirements

Same Sign after Jet Requirements

Region sensitive to gaugino production
Data Driven Top Background

Signal region requires $E_T^{\text{miss}} > 150$ GeV (up to 250 GeV) and up to 4 jets. In practice, a small fraction of top only passes these extreme cuts.

This is a less well known part of top pair production where $t\bar{t} + 1,2,3,\ldots$ partons dominates.

Cannot rely on Monte Carlo until this phase space of top production has been measured.

⇒ Build one or several Control Regions to as close as possible to the signal region
⇒ Extrapolate to the signal region.
⇒ Compare consistency between control regions

$$N_{\text{prediction}}^{\text{top}} = N_{\text{CR}}^{\text{top}} \times \left( \frac{N_{\text{SR}}^{\text{top}}}{N_{\text{CR}}^{\text{top}}} \right)_{\text{MC}}$$
Selecting Control Regions with a Top-Tagger

**Top Tagger: \( M_{CT} \) Tagger**

$$m_{CT}^2(v_1, v_2) = \left[ E_T(v_1) + E_T(v_2) \right]^2 - \left[ p_T(v_1) - p_T(v_2) \right]^2$$

where \( v_1, v_2 \) are leptons, jets, and jet-lepton combinations. Possess *kinematic end-points* characteristic of top pairs.

**Top-tag =**

3 \( M_{CT} \) variables + lepton-jet mass are compatible with top.

**Dominating systematics**

from the extrapolation CR->SR.

**Optimize** the control regions to minimise the expected systematic error.

Same regions give same performance, methods are comparable.
Excellent agreement between the data and the Standard Model prediction.

⇒ Set model independent upper limits on the visible SUSY cross section (Acceptance x efficiency x Branching)

⇒ Set model dependent limits in simplified model grids.

**Model Independent Limit $\sigma_{\text{eff}}$ with $L=1\text{fb}^{-1}$**

<table>
<thead>
<tr>
<th>Signal Region</th>
<th>Background</th>
<th>Obs.</th>
<th>95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS-inc</td>
<td>15.5 ± 4.0</td>
<td>13</td>
<td>9.9 fb</td>
</tr>
<tr>
<td>OS-3j</td>
<td>13.0 ± 4.0</td>
<td>17</td>
<td>14.4 fb</td>
</tr>
<tr>
<td>OS-4j</td>
<td>5.7 ± 3.6</td>
<td>2</td>
<td>6.4 fb</td>
</tr>
<tr>
<td>SS-inc</td>
<td>32.6 ± 7.9</td>
<td>25</td>
<td>14.8 fb</td>
</tr>
<tr>
<td>SS-2j</td>
<td>24.9 ± 5.9</td>
<td>28</td>
<td>17.7 fb</td>
</tr>
</tbody>
</table>

**Systematics uncertainties on $tt$ in OS**

<table>
<thead>
<tr>
<th>Source</th>
<th>OS-inc</th>
<th>OS-3j</th>
<th>OS-4j</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC &amp; CR statistics</td>
<td>7%</td>
<td>10%</td>
<td>21%</td>
</tr>
<tr>
<td>JES</td>
<td>11%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>JER</td>
<td>1%</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>Generator</td>
<td>16%</td>
<td>13%</td>
<td>58%</td>
</tr>
<tr>
<td>ISR/FSR</td>
<td>20%</td>
<td>16%</td>
<td>26%</td>
</tr>
<tr>
<td>Total</td>
<td>27%</td>
<td>25%</td>
<td>68%</td>
</tr>
</tbody>
</table>

OS: leading systematics JES, JER
SS: leading systematics is lepton fake rate
Simplified Model Interpretation Pure Wino (L=1 fb⁻¹)

\[ \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow \tilde{l} \tilde{l}, \tilde{l} \tilde{l} \rightarrow \tilde{l} \tilde{\chi}_1^0 \tilde{\chi}_1^0 \]

Same Sign \( E_{\text{miss}}^{\text{miss}}>100 \text{ GeV} \)

\[ m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}, \quad m_{\tilde{l} \tilde{l}} = m_{\text{LSP}} + \frac{1}{2} (m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_2^0}) \]

\[ \int L \, dt = 1.04 \text{ fb}^{-1}, \sqrt{s} = 7 \text{ TeV} \]

- Observed 95% CL
- Expected
- Expected ± 1σ

**ATLAS**

\[ B(\tilde{\chi}_2^0 \rightarrow \tilde{l} \tilde{l} \tilde{\chi}_d^0) = B(\tilde{\chi}_d^+ \rightarrow \tilde{l} \tilde{\chi}_1^0) = 100\% \]

Limit on \( \sigma_{\text{eff}} / A \times \varepsilon \)

Color gives limit for the given masses
=3 Lepton Analysis L=2 fb$^{-1}$

Two signal regions

- **$Z$ depleted “SR1”** (sensitive to virtual sleptons, off-shell Z)
- **$Z$ enriched “SR2”** (sensitive to on-shell Z)

**SR1**: $\geq 1$ SFOS pair ($M_{ll} > 20$ GeV) + $E_T^{miss} > 50$ GeV + $|M_{ll} - M_Z| > 10$ GeV + b-jet veto

**SR2**: $\geq 1$ SFOS pair ($M_{ll} > 20$ GeV) + $E_T^{miss} > 50$ GeV + $|M_{ll} - M_Z| < 10$ GeV

Leptons are $e$ ($p_T > 25$ GeV) or $\mu$ ($p_T > 20$ GeV) and are required to be isolated from other activity
Dominated by backgrounds:
• 3 real leptons WW, ZZ, tt+V
• Non negligible component of reducible backgrounds
3 lepton backgrounds

Irreducible ($\geq 3$ real isolated leptons)
- WZ, ZZ, $tt + W$, $tt + Z$

Derived from simulation with cross sections at NLO

Reducerable backgrounds (leptons from heavy flavor and isolated photons)
- $tt$ (dominant, heavy flavor)
- single top, WW
- $V +$ jets ($<1\%$ of the backgrounds)

In 99\% of the reducible background the leading lepton is real and isolated
$\Rightarrow$ Multijet QCD is negligible

Determined by using the data itself (matrix method)

Reducerable backgrounds ($\ell \rightarrow \ell \gamma^{*} \rightarrow \ell \mu$)
- A virtual photon converts into an asymmetric $\mu\mu$ pair, only one $\mu$ is found.

Derived from data

Background Validation Regions 1,2
- Z dominated: 3 leptons with $30 < E_{T}^{\text{miss}} < 50$ GeV $\quad$ VR1
- tt dominated: 3 leptons with SFOS veto, $E_{T}^{\text{miss}} > 50$ GeV $\quad$ VR2
Fake Lepton Estimates: Matrix Method

**Loose lepton:**
loose lepton ID criteria
⇒ more fakes

**Tight lepton:**
signal lepton definition
⇒ less fakes

\[ \begin{pmatrix}
N_{LL} \\
N_{LT} \\
N_{TL} \\
N_{TT}
\end{pmatrix} =
\begin{pmatrix}
\epsilon_1 \epsilon_2 & \epsilon_1 f_2 & f_1 \epsilon_2 & f_1 f_2 \\
\epsilon_1 (1 - \epsilon_2) & \epsilon_1 (1 - f_2) & f_1 (1 - \epsilon_2) & f_1 (1 - f_2) \\
(1 - \epsilon_1) \epsilon_2 & (1 - \epsilon_1) f_2 & (1 - f_1) \epsilon_2 & (1 - f_1) f_2 \\
(1 - \epsilon_1) (1 - \epsilon_2) & (1 - \epsilon_1) (1 - f_2) & (1 - f_1) (1 - \epsilon_2) & (1 - f_1) (1 - f_2)
\end{pmatrix} \cdot
\begin{pmatrix}
N_{RR} \\
N_{RF} \\
N_{FR} \\
N_{FF}
\end{pmatrix} \]

\(N_{LL}, N_{LT}, N_{TL}, N_{TT}\) are event counts in the data

\(f\) and \(\epsilon\) are probabilities \(P(\text{lepton is tight} \mid \text{lepton is loose})\) for the fake and the real leptons

- Derive \(f\) and \(\epsilon\) from data
- Computed for different types of fakes: heavy flavor, conversions

Christophe Clement
Search 2012 – March 18\(^{th}\) 2012
Contribution from $\ell\ell \rightarrow \ell\ell\mu$

Reducible backgrounds ($\ell \rightarrow \ell \gamma^* \rightarrow \ell\mu$)

A virtual photon converts into an asymmetric $\mu\mu$ pair, only one $\mu$ is found. Probability for this process derived from data and normalised with data.

**Step 1)** In $E_T^{\text{miss}} < 50$ GeV derive:

$$P(l \rightarrow l\mu) = \frac{N(\mu\mu\mu \mid m_{\mu\mu\mu} \sim m_Z)}{N(\mu\mu \mid m_{\mu\mu} \sim m_Z)}$$

**Step 2)** Apply probability in $E_T^{\text{miss}} > 50$ GeV:

$$N_{\ell \rightarrow \ell\mu}^{SR} = P(l \rightarrow l\mu) \times N(\mu\mu; E_T^{miss} > 50 \text{GeV})$$

Number of muons

- $N(\mu) = 2$
- $N(\mu) = 3$

$P(l \rightarrow l\mu)$ from data
**Signal Region 1**

Good agreement in validation regions

<table>
<thead>
<tr>
<th>Selection</th>
<th>VR1</th>
<th>VR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t\bar{t} V$</td>
<td>1.4±0.6</td>
<td>0.7±0.6</td>
</tr>
<tr>
<td>ZZ</td>
<td>6.7±1.8</td>
<td>0.03±0.04</td>
</tr>
<tr>
<td>WZ</td>
<td>61±15</td>
<td>0.4±0.2</td>
</tr>
<tr>
<td>Reducible Bkg.</td>
<td>56±35</td>
<td>14±9</td>
</tr>
<tr>
<td>Total Bkg.</td>
<td>125±38</td>
<td>15±9</td>
</tr>
<tr>
<td>Data</td>
<td>122</td>
<td>12</td>
</tr>
</tbody>
</table>

$L=2\text{fb}^{-1}$
**ATLAS** Preliminary

**Signal Region 1**

**Signal Region 2**

**Good agreement in validation regions**

No discrepancy between the prediction and the **signal regions**

⇒ Set upper limits on the SUSY production

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**Upper limits on the visible SUSY cross section**

10.0 fb (expected 7.3 fb) in signal region 1  p-value 0.19

26.1 fb (expected 16.7 fb) in signal region 2  p-value 0.10
3 Lepton Results with pMSSM

Based on SR1 (Z-veto)

Limits in pMSSM
tan (β)=6
heavy gluinos, squarks and heavy left handed sleptons
right handed sleptons half way between $\tilde{\chi}_2^0$, $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_4^0$
3 Lepton Results with Simplified Models

Based on SR1 (Z-veto)

Limits in simplified models

\[ B(\tilde{\chi}_2^0 \rightarrow \tilde{l} l \rightarrow l l \tilde{\chi}_4^0) = B(\tilde{\chi}_2^0 \rightarrow \tilde{\nu} \nu \rightarrow \nu \nu \tilde{\chi}_4^0) = 50\% \]

Wino like \( \tilde{\chi}_2^0, \tilde{\chi}_4^\pm \) and Bino like \( \tilde{\chi}_4^0 \)

Limit on \( \sigma_{\text{eff}} / A \times \epsilon \)

Color gives limit for the given masses

Christophe Clement

Search 2012 – March 18\textsuperscript{th} 2012
With 4 leptons, acceptance and signal efficiency becomes an issue
⇒ Lower $p_T$ thresholds compared to the 2 and 3 lepton analyses

4 isolated $e$ or $\mu$ with $p_T>$10 GeV (15 GeV for crack region electrons)

**Signal Region 1** = $E_T^{\text{miss}}>$50 GeV

**Signal Region 2** = $E_T^{\text{miss}}>$50 GeV + veto on SFOS pairs with $|M_{ll} - M_Z|<$10 GeV

SR2 is sensitive to a range of signals, either sleptons or off-shell $Z$ in the Neutralino 2 or completely different signals eg. RPV SUSY which will not contain $Z$ bosons-
4 lepton backgrounds

Backgrounds with less than 2 real isolated leptons are negligible

Irreducible backgrounds

\[ ZZ \rightarrow l \bar{l} l \bar{l} \]

\[ ttZ \rightarrow \ell \nu b \ell \nu b \ell \]

Internal conversions

\[ Z \rightarrow l \bar{l} \gamma^* \rightarrow l \bar{l} l \bar{l} \]

Photon conversion probability measured in data

Contribution with the largest uncertainty in SR’s

Validation regions

- **tt-rich region**: \[ l \bar{l} l \bar{l} \] with one OS e\(\mu\) pair + b-tag + one non-iso lepton + \(E_T^{\text{miss}}>50\) GeV
- **ZZ-rich region**: \[ l \bar{l} l \bar{l} \] and \(E_T^{\text{miss}}<50\) GeV

<table>
<thead>
<tr>
<th>Validation Region</th>
<th>Prediction</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt-rich</td>
<td>8.4±0.8</td>
<td>8</td>
</tr>
<tr>
<td>ZZ-rich</td>
<td>23±5</td>
<td>20</td>
</tr>
</tbody>
</table>
Contribution from Internal Conversions

Extract the following ratio from data with $E_T^{\text{miss}} < 50 \text{ GeV}$

$$P_{\text{conv}} = \frac{N(\ell\ell\ell\ell \mid m_{\ell\ell\ell\ell} \sim m_Z)}{N(\ell\ell\gamma \mid m_{\ell\ell\gamma} \sim m_Z)}$$

Internal conversions in the signal region

$$N_{\text{int-conv}}^{SR} = P_{\text{conv}} \times N(\ell\ell\gamma \mid E_T^{\text{miss}} > 50 \text{GeV})$$

Good agreement in control plots
Low $p_T$ region for 3rd and 4th leptons

Direct gaugino production with intermediate slepton
4 Lepton Sample Before $E_T^{\text{miss}}$ cut

Good agreement b/w data and Monte Carlo in a range of variables.
4 Lepton Yields Before $E_T^{\text{miss}}$ cut

<table>
<thead>
<tr>
<th>4$\ell$ events</th>
<th>All</th>
<th>$eeee$</th>
<th>$e\bar{e}m$</th>
<th>$e\bar{e}\mu$</th>
<th>$e\mu\mu$</th>
<th>$\mu\mu\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t\bar{t}$</td>
<td>0.22±0.15</td>
<td>0.012±0.042</td>
<td>0.06±0.06</td>
<td>0.10±0.07</td>
<td>0.05±0.07</td>
<td>0±0.018</td>
</tr>
<tr>
<td>Single $t$</td>
<td>0±0.04</td>
<td>0±0.04</td>
<td>0±0.04</td>
<td>0±0.04</td>
<td>0±0.04</td>
<td>0±0.04</td>
</tr>
<tr>
<td>$t\bar{t}V$</td>
<td>0.59±0.26</td>
<td>0.086±0.043</td>
<td>0.14±0.07</td>
<td>0.17±0.08</td>
<td>0.13±0.06</td>
<td>0.07±0.04</td>
</tr>
<tr>
<td>ZZ</td>
<td>19±5</td>
<td>3.8±1.0</td>
<td>0.16±0.08</td>
<td>10.0±2.5</td>
<td>0.17±0.07</td>
<td>4.9±1.2</td>
</tr>
<tr>
<td>WZ</td>
<td>0.54±0.17</td>
<td>0.06±0.03</td>
<td>0.07±0.04</td>
<td>0.17±0.07</td>
<td>0.24±0.09</td>
<td>0±0.011</td>
</tr>
<tr>
<td>WW</td>
<td>0±0.015</td>
<td>0±0.015</td>
<td>0±0.015</td>
<td>0±0.015</td>
<td>0±0.015</td>
<td>0±0.015</td>
</tr>
<tr>
<td>$Z\gamma$</td>
<td>0±0.5</td>
<td>0±0.5</td>
<td>0±0.5</td>
<td>0±0.5</td>
<td>0±0.5</td>
<td>0±0.5</td>
</tr>
<tr>
<td>$Z+(u, d, s \text{ jets})$</td>
<td>3.8±1.6</td>
<td>1.8±0.9</td>
<td>0±0.29</td>
<td>1.5±1.1</td>
<td>0.6±0.6</td>
<td>0±0.29</td>
</tr>
<tr>
<td>$Z+(c, b \text{ jets})$</td>
<td>0.26±0.28</td>
<td>0.022±0.037</td>
<td>0.06±0.07</td>
<td>0.13±0.14</td>
<td>0.05±0.06</td>
<td>0.0021±0.0034</td>
</tr>
<tr>
<td>Drell-Yan</td>
<td>0±0.29</td>
<td>0±0.14</td>
<td>0±0.018</td>
<td>0±0.14</td>
<td>0±0.06</td>
<td>0±0.014</td>
</tr>
</tbody>
</table>

$\Sigma \text{SM}$ | 25±5 | 5.8±1.4 | 0.5±0.6 | 12.0±2.8 | 1.2±0.7 | 5.0±1.4 |

Data | 24 | 8 | 2 | 8 | 0 | 6 |

Good agreement b/w data and Monte Carlo yields
### Final Yields In 4 Lepton Signal Regions

<table>
<thead>
<tr>
<th>Signal Region 1</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t\bar{t}$</td>
<td>$0.17 \pm 0.14$</td>
</tr>
<tr>
<td>Single $t$</td>
<td>$0 \pm 0.04$</td>
</tr>
<tr>
<td>$t\bar{t}V$</td>
<td>$0.48 \pm 0.21$</td>
</tr>
<tr>
<td>$ZZ$</td>
<td>$0.44 \pm 0.19$</td>
</tr>
<tr>
<td>$WZ$</td>
<td>$0.25 \pm 0.10$</td>
</tr>
<tr>
<td>$WW$</td>
<td>$0 \pm 0.015$</td>
</tr>
<tr>
<td>$Z\gamma$</td>
<td>$0 \pm 0.5$</td>
</tr>
<tr>
<td>$Z+(u, d, s \text{ jets})$</td>
<td>$0.33 \pm 0.67$</td>
</tr>
<tr>
<td>$Z+(c, b \text{ jets})$</td>
<td>$0.024 \pm 0.035$</td>
</tr>
<tr>
<td>Drell-Yan</td>
<td>$0 \pm 0.05$</td>
</tr>
<tr>
<td>$\Sigma SM$</td>
<td>$1.7 \pm 0.9$</td>
</tr>
<tr>
<td>Data</td>
<td>$4$</td>
</tr>
</tbody>
</table>

### Signal Region 2

<table>
<thead>
<tr>
<th>Signal Region 2</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t\bar{t}$</td>
<td>$0.13 \pm 0.11$</td>
</tr>
<tr>
<td>Single $t$</td>
<td>$0 \pm 0.04$</td>
</tr>
<tr>
<td>$t\bar{t}V$</td>
<td>$0.07 \pm 0.04$</td>
</tr>
<tr>
<td>$ZZ$</td>
<td>$0.019 \pm 0.020$</td>
</tr>
<tr>
<td>$WZ$</td>
<td>$0.09 \pm 0.05$</td>
</tr>
<tr>
<td>$WW$</td>
<td>$0 \pm 0.015$</td>
</tr>
<tr>
<td>$Z\gamma$</td>
<td>$0 \pm 0.5$</td>
</tr>
<tr>
<td>$Z+(u, d, s \text{ jets})$</td>
<td>$0.33 \pm 0.67$</td>
</tr>
<tr>
<td>$Z+(c, b \text{ jets})$</td>
<td>$0.024 \pm 0.035$</td>
</tr>
<tr>
<td>Drell-Yan</td>
<td>$0 \pm 0.05$</td>
</tr>
<tr>
<td>$\Sigma SM$</td>
<td>$0.7 \pm 0.8$</td>
</tr>
<tr>
<td>Data</td>
<td>$0$</td>
</tr>
</tbody>
</table>

**L=2fb⁻¹**

- Expectation : $1.7 \pm 0.9$
- Observation : 4 events
- p-value     : 0.1

- Expectation : $0.7 \pm 0.8$
- Observation : 0 events
- p-value     : $>0.5$

19 $ZZ$ events before $E_T^{miss}$ cut
Conclusions

• ATLAS has searched for gaugino production in 1-2 fb\(^{-1}\)

• Examined final states with 2photons and =2, =3 and ≥4 leptons, sensitive to gaugino production and decays via on- and off-shell Z or sleptons

• No deviation from the Standard Model prediction

• A lot more can be done: tau decays, higgsino scenarios, additional gaugino decays.

• Additional results with the full 2011 data sets should appear soon.

• Search for electroweak SUSY production is an important element in the systematic search for SUSY at the electroweak scale.

• Due to the low cross section for these processes, gaugino search will benefit tremendously from the expected large integrated luminosity in 2012.

• Stay tuned!