1. INTRODUCTION

- **Supersymmetry (SUSY):** Theoretical extension to the Standard Model (SM), postulates existence of a supersymmetric partner for each SM particle with $\frac{1}{2}$ difference in spin.

- **Charginos $\tilde{\chi}^\pm_{1,2}$ and neutralinos $\tilde{\chi}^0_{1,2,3,4}$:**
  - Linear superpositions of SUSY partners of Higgs and of electroweak gauge bosons.
  - Dominant production at LHC if strongly interacting SUSY particles are heavier than a few TeV.
  - Possible explanation for discrepancy in muon anomalous magnetic moment $g-2$ measurement with respect to SM prediction.

- **Search for production of $\tilde{\chi}_1^\pm\tilde{\chi}_1^0$ using full ATLAS Run-2 data ($L = 139$ fb$^{-1}$) in the context of R-parity conserving supersymmetric simplified model:**
  - $\tilde{\chi}_1^0$ is the lightest supersymmetric particle (LSP), stable, weakly interacting → escapes detector.
  - $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ are mass-degenerated.
  - $\tilde{\chi}_1^\pm \rightarrow W \tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \rightarrow h \tilde{\chi}_1^0$ with branching ratios of 100%.
  - $W \rightarrow l \nu$ and $h \rightarrow b \bar{b}$ with SM branching ratios.

Final state: $1l + 2b$-jets + $E_T^{miss}$

- Previous search for the same final state with 36.1 fb$^{-1}$ of $\sqrt{s}=13$ TeV pp collision data recorded by the ATLAS detector. (PhysRevD.100.012006)

2. DISCRIMINATING VARIABLES

- **Transverse mass $m_T$:** Endpoint at W mass for W+jets and semileptonic ttbar backgrounds.
  \[ m_T = \sqrt{2p_T^\ell E_T^{miss}(1 - \cos[\Delta\phi(p_T^\ell, p_T^{miss})])} \]

- **Contransverse mass $m_{CT}$:** Endpoint at $\sim 150$ GeV for ttbar background.
  \[ m_{CT} = \sqrt{2p_T^{b_1} p_T^{b_2} (1 + \cos \Delta \phi_{bb})} \]

- **Invariant mass of 2 leading b-jets $m_{bb}$:** Peak at Higgs mass of 125 GeV for signals.
  \[ m_{bb} = \sqrt{2p_T^{b_1} p_T^{b_2} (\cosh \Delta \eta_{bb} - \cos \Delta \phi_{bb})} \]

- **Missing transverse momentum $E_T^{miss}$:**
  - Originates from neutrino and LSPs → signature tends to have large $E_T^{miss}$.
  - Negative vectorial sum of transverse momentum of reconstructed objects in final state.
3. EVENT SELECTION

- **MET trigger** applied with offline cut of $E_T^{miss} > 240$ GeV.
- Events required to have exactly 1 lepton; 2 or 3 jets and 2 of which are b-tagged; $100 < m_{bb} < 140$ GeV.
- $m_T$ used to define 3 separate classes of signal regions (SR):
  - **SRLM**: $100 < m_T < 160$ GeV → low $\Delta m(\tilde{\chi}_1^0/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$
  - **SRMM**: $160 < m_T < 240$ GeV → medium $\Delta m(\tilde{\chi}_1^0/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$
  - **SRHM**: $m_T > 240$ GeV and $m(l, b) > 120$ GeV → high $\Delta m(\tilde{\chi}_1^0/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$
- Set of orthogonal control regions (CR) defined for each of dominant backgrounds (ttbar, single-top and W+jets) by harmonizing cuts on $m_T$, $m_{CT}$ and $m_{bb}$.
- 2 sets of orthogonal validation regions (VR) defined for each SR: off-peak ($m_{bb} < 100$ or $m_{bb} > 140$ GeV) and on-peak $m_{bb}$ regions.

4. FIT STRATEGY

- **Background-only fit**: only CRs participate to the fit, determine expected backgrounds in SRs.
- **Model-dependent fit**: each SR binned in 3 $m_{CT}$ [GeV] regions: [180, 230]; [230, 280] and >280 → simultaneous 2-dimensional fit in $m_{CT}$ and $m_T$.
- **Model-independent limits and null-hypothesis test**: merge $m_{CT}$ bins, remove upper bounds on $m_T$ for SRLM and SRMM.

5. SYSTEMATIC UNCERTAINITIES

- Evaluated for all simulated signal and background samples.
- 10% from ttbar parton shower in SRLM.
- Single-top generator accounts for 10% in SRMM and 21% in SRHM.
- 6% and 20% systematic uncertainties in inclusive cross-section assigned for diboson and triboson samples, respectively.
- Overall theory uncertainties of signals range from 10% to 25%.
- Major experimental uncertainties from jet energy scale, jet energy resolution, $E_T^{miss}$ modelling and pileup, contribute 5–10% in SRs, less significant impact than theoretical ones.
- MC statistical uncertainties are 5–18% in SRs.
6. RESULTS

The results show a compatibility of the observed and expected event yields in all the analysis regions. **No significant excess over the SM prediction is observed in data.**

$m_{\tilde{\chi}_1^0/\tilde{\chi}_2^0}$ up to 740 GeV excluded at 95% CL for a massless $\tilde{\chi}_1^0$.

improves on previous limit by ~200 GeV in $m_{\tilde{\chi}_1^0/\tilde{\chi}_2^0}$ for a massless $\tilde{\chi}_1^0$ due to increase of integrated luminosity and improved 2-dimensional fit.

the strongest limit at low $\Delta m(\tilde{\chi}_1^+/\tilde{\chi}_2^0,\tilde{\chi}_1^0)$ among all searches for production of $\tilde{\chi}_1^0\rightarrow Wh$.

### Table

<table>
<thead>
<tr>
<th>Signal Region</th>
<th>$&lt;\sigma/&gt;_{\text{elo}}$ [fb]</th>
<th>$S_{\text{obs}}$</th>
<th>$S_{\text{exp}}$</th>
<th>CL$_{95}$</th>
<th>$p_0$</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR-LM(disc.)</td>
<td>0.26</td>
<td>36.8</td>
<td>20.6$^{+5.0}_{-3.4}$</td>
<td>0.97</td>
<td>0.03</td>
<td>1.88</td>
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<tr>
<td>SR-MM(disc.)</td>
<td>0.18</td>
<td>24.8</td>
<td>15.3$^{+4.6}_{-3.2}$</td>
<td>0.94</td>
<td>0.06</td>
<td>1.54</td>
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<tr>
<td>SR-HM(disc.)</td>
<td>0.11</td>
<td>14.7</td>
<td>9.7$^{+2.7}_{-2.2}$</td>
<td>0.89</td>
<td>0.10</td>
<td>1.30</td>
</tr>
</tbody>
</table>

**ATLAS**

- $\sqrt{s}=13$ TeV, 139 fb$^{-1}$, All limits at 95% CL
- Expected Limit ($11\sigma_{\text{exp}}$)
- Observed Limit ($11\sigma_{\text{obs}}$)