Supersymmetry (SUSY) is considered one of the best motivated extensions of the Standard Model. The second period of data taking at the Large Hadron Collider (LHC) at 13 TeV of center of mass energy, Run-2, started in 2015 and provides an important testbed for the search of beyond the Standard Model physics. In particular, the direct production of supersymmetric electroweak particles, such as sleptons, neutralinos and charginos, could be a promising probe for SUSY signals at the LHC, since the most recent searches for strongly-produced superparticles have excluded gluinos and squarks of all generations up to the TeV scale. This proceeding summarizes some of the most recent ATLAS results obtained from the searches for gauginos and sleptons.
Weak scale SUSY is a theoretical extension to the Standard Model (SM) which, if realised in nature, would solve the hierarchy problem through the addition of a new fermion (boson) supersymmetric partner to each boson (fermion) in the SM. In SUSY models which conserve R-parity, SUSY particles (sparticles) must be produced in pairs and the lightest supersymmetric particle (LSP) is stable and can be weakly interacting, thus often constituting a viable candidate for dark matter. Due to its stability, any LSP produced at the LHC would escape detection and give rise to missing transverse momentum ($E_T^{\text{miss}}$) in the final state, which can be used to discriminate SUSY signals from the SM background.

LHC sparticle production cross-sections are highly dependent on the sparticle masses. The coloured sparticles (squarks and gluinos, superpartners of the SM quarks and gluons respectively) are strongly produced and have significantly larger production cross-sections than non-coloured sparticles of equal masses, such as the sleptons (superpartners of the SM leptons) and the electroweakinos. The superpartners of the SM Higgs and the electroweak gauge bosons, known as higgsinos, winos and bino are collectively known as electroweakinos. They mix to form chargino ($\tilde{\chi}^{\pm}_i$, $i = 1, 2$) and neutralino ($\tilde{\chi}^0_j$, $j = 1, 2, 3, 4$) mass eigenstates (states are ordered by increasing values of their mass). If gluino and squark masses were much heavier than low-mass electroweakinos or sleptons, then SUSY production at the LHC would be dominated by direct electroweak production. The latest ATLAS [1] limits (based on simplified models) for squark and gluino production extend beyond the TeV scale, thus making electroweak production of sparticles a promising and important probe to search for SUSY at the LHC.

1. Exotic decays of the Higgs boson

The first analysis presented in this report is a search for exotic decays of the Higgs boson Standard Model to at least one photon and missing transverse momentum using 79.8 fb$^{-1}$ of proton-proton collisions. This analysis was performed in the context of Gauge Mediated Supersymmetry Breaking (and Next-to-Minimal Supersymmetric Standard Models) models, in which the Higgs boson can decay to an $\tilde{\chi}^0_1$ ($\tilde{\chi}^0_2$) and $\tilde{G}$ ($\tilde{\chi}^0_1$) or two $\tilde{\chi}^0_1$ ($\tilde{\chi}^0_2$) depending on $m_{\tilde{\chi}^0_1}$ ($m_{\tilde{\chi}^0_2}$) value. In these cases, the photon can arise from a $\tilde{\chi}^0_1$ ($\tilde{\chi}^0_2$) decay into a $\tilde{G}$ ($\tilde{\chi}^0_1$) and a photon. Higgs bosons produced in association with a Z boson are considered in order to reduce the number of background events. No excess with respect to the Standard Model prediction is observed. Assuming a Standard Model $Zh$ production cross-section, the branching fraction of a Higgs boson to neutralinos or neutralino/gravitino is constrained to be less than 5–18% at the 95% confidence level depending on the the next-to-lightest supersymmetric particle (NLSP) and the LSP masses. The limits on the cross-section times branching fraction are shown on Figure 1.

2. Direct chargino pair production

The results of a search for the direct pair production of charginos decaying via $W$-bosons are also presented. The search was performed using 80.5 fb$^{-1}$ of integrated luminosity from LHC collected in the 2015, 2016 and 2017 data taking campaigns. Charginos are searched for in final states with two isolated leptons (electron or muon), missing transverse momentum and at most one light jet in the final state. No excess above Standard Model expectations is observed. Exclusion
Figure 1: 95% CL observed and expected limits of \((\sigma / \sigma_{SM}) \times BF\) for various NLSP and LSP masses. The inner and outer bands show the ±1σ and ±2σ excursions of the expected limits respectively. Top: Limits are for the case \(0 < m_{NLSP} < m_h/2\) and the Higgs boson is assumed to decay to a \(\gamma \gamma + E_T^{miss}\) final state \([2]\). Bottom: Limits are for the case \(m_h/2 < m_{NLSP} < m_h\) and the Higgs boson is assumed to decay to a \(\gamma + E_T^{miss}\) final state \([2]\).

limits are derived on the chargino mass assuming a simplified model in which it decays with a 100% branching ratio to an on-shell \(W\)-boson and the lightest neutralino: \(\tilde{\chi}_1^\pm \rightarrow W^{\pm} \tilde{\chi}_0^0\). For a massless neutralino, chargino masses up to 410 GeV are excluded at 95% confidence level. Results in the defined signal regions and cross-section limits as a function of the mass are shown on Figure 2.

3. Sleptons searches

The last two results presented in this report correspond to searches for electroweak production of sleptons using 36.1 fb\(^{-1}\) of integrated luminosity from LHC proton-proton collision data
recorded by the ATLAS detector in 2015-2016. The first analysis searches for sleptons production performed in a general scenario (bulk scenario) and the second one in scenarios with compressed mass spectra (compressed scenarios).

3.1 Bulk scenarios

This search was performed for production of sleptons decaying into final states involving two electrons or muons. Slepton pair production scenarios based on simplified models are considered, where each slepton decays directly into the lightest neutralino and a lepton. No significant deviations from the Standard Model expectation are observed and stringent limits at 95% confidence level are placed on the masses of relevant supersymmetric particles in each of these scenarios. For the case where the lightest neutralino is massless, slepton-pair production masses up to 500 GeV are excluded assuming three generations of mass-degenerate sleptons. The obtained limits are shown on the top of Figure 3.

3.2 Compressed scenarios

A search for electroweak production of sleptons in scenarios with compressed mass spectra in final states with two low-momentum leptons and missing transverse momentum is presented. Events with same-flavor pairs of electrons or muons with opposite electric charge are selected. The data are found to be consistent with the Standard Model prediction. Results are interpreted using simplified models of R-parity-conserving supersymmetry in which there is a small mass difference between the masses of the produced sleptons particles and the lightest neutralino. Exclusion limits at 95% confidence level are set on slepton masses of up to 190 GeV for pair production of sleptons. In the compressed mass regime, the exclusion limits extend down to mass splittings of 1 GeV. Limits are shown on the bottom of Figure 3.
Figure 3: Observed and expected exclusion limits on SUSY simplified models for slepton-pair production in a bulk scenario (Top)\cite{4} and in a compressed scenario (Bottom)\cite{5}. The observed (solid thick red line) and expected (thin dashed blue line) exclusion contours are indicated. The shaded band corresponds to the $\pm 1\sigma$ variations in the expected limit, including all uncertainties except theoretical uncertainties in the signal cross-section. The dotted lines around the observed limit illustrate the change in the observed limit as the nominal signal cross-section is scaled up and down by the theoretical uncertainty. All limits are computed at 95% confidence level.
References


