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Search for electroweak supersymmetric particle production in final states with two leptons and missing transverse momentum with the ATLAS detector

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Searches for the production of electroweak supersymmetric particles decaying into final states with exactly two isolated, oppositely-charged leptons (electrons, muons), no reconstructed jets and missing transverse momentum are performed using 20.3 fb^{-1} of 2012 proton-proton collision data at $\sqrt{s} = 8$ TeV recorded with the general purpose detector ATLAS at the Large Hardon Collider. In the absence of any significant excess with respect to the prediction from Standard Model processes, the results are interpreted in the framework of simplified Supersymmetry models [1].

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1. Introduction

Weak scale Supersymmetry (SUSY) is one of the best motivated extensions of the Standard Model (SM), providing a possible solution to the hierarchy problem and a viable dark matter candidate in the form of the lightest supersymmetric particle (LSP). The dominant SUSY production channels at the LHC depend on the masses of the sparticles. In scenarios where the masses of the first and second generation sfermions and gluinos are larger than few TeVs, direct production of weak gauginos (charginos, $\tilde{\chi}^{\pm}$ and neutralinos, $\tilde{\chi}^{0}$) as well as sleptons ($\tilde{\ell}$ and $\tilde{\nu}$) may be the dominant SUSY process. The searches presented here target final states with two leptons and missing energy. They can be produced by $\tilde{\ell}\tilde{\ell}$ production followed by $\tilde{\ell}^{\pm} \to \ell^{\pm}\tilde{\chi}_1^0$ decay, or by $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ production followed by $\tilde{\chi}_1^{\pm} \to (\tilde{\ell}^{\pm}\nu$ or $\ell^{\pm}\tilde{\nu}) \to \ell^{\pm}\nu\tilde{\chi}_1^0$ decay with two additional neutrinos contributing to the missing transverse momentum. If the lightest chargino is heavier than the LSP, the chargino decays as $\tilde{\chi}_1^{\pm} \to W^{\pm}\tilde{\chi}_1^0$, producing an on- or off-shell W boson.

2. Event selection

Based on the target signal model, five signal regions (SRs) are designed (see Table 1) selecting final states with two isolated opposite-sign leptons (electrons or muons), missing transverse momentum and no jets (including b-tagged jets). SR-m_{T2} signal regions are optimised to provide sensitivity to sleptons either through direct production or in chargino decays, while the SR-WW signal regions are targeting chargino- and neutralino-pair production followed by on-shell W decays.

Table 1: Event selection criteria for the five signal regions with variables as defined in [1]

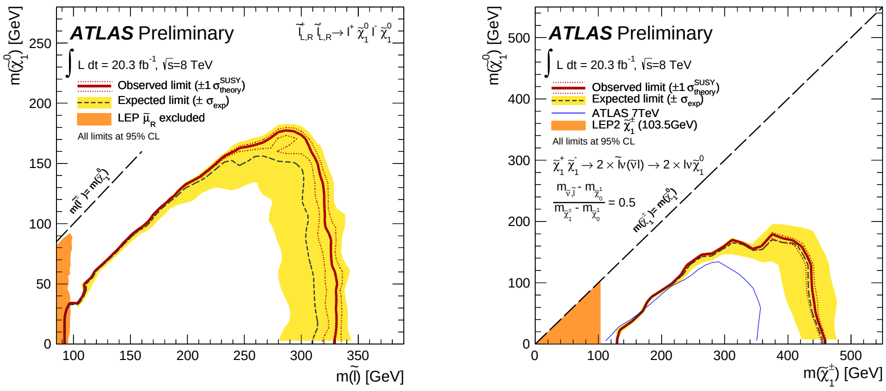
	SR-$m_{\mathrm{T2},90}$	SR-$m_{\mathrm{T2},120}$	SR-WWa	SR-WWb	SR-WWc
lepton flavour	e^+e^-, $\mu^+\mu^-$, $e^{\pm}\mu^{\mp}$		$e^{\pm}\mu^{\mp}$		
$p_{\mathrm{T}}^{\ell 1}$	—		> 35 GeV		
$p_{\mathrm{T}}^{\ell 2}$	—		> 20 GeV		
$m_{\ell\ell}$	$\lvert m_{\ell\ell} - m_Z \rvert > 10$ GeV		< 80 GeV	< 130 GeV	—
$p_{\mathrm{T},\ell\ell}$	—		> 70 GeV	< 170 GeV	< 190 GeV
$\Delta\phi_{\ell\ell}$	—		< 1.8 rad		
$E_{\mathrm{T}}^{\mathrm{miss,rel}}$	> 40 GeV		> 70 GeV	—	
m_{T2}	> 90 GeV	> 110 GeV	—	> 90 GeV	> 100 GeV

3. Background estimation

The main SM background comes from WW diboson and top-pair production where two leptonically decaying W bosons result in the same final state as the SUSY signal. Another significant source of background in the same-flavour channel is WZ and ZZ production. These events are estimated by defining dedicated control regions for each background and extracting a normalization factor to be applied to the simulations in the signal regions. Leptons originating from heavy-flavour decays or photon conversion or mistakenly reconstructed hadronic jets can be mis-identified as signal leptons. This "fake" background is obtained in a fully data-driven way (matrix method). Other minor backgrounds such as $Z+$jets are estimated using the MC predictions.

4. Results

No significant excesses over the Standard Model predictions are observed. In scenarios with direct sleptons decays, a common value for left- and right-handed slepton masses between 90 GeV and 320 GeV is excluded at 95% confidence level for a massless neutralino (Figure 1 a). In the scenario of chargino-pair production, with wino-like charginos decaying into the lightest neutralino via an intermediate slepton, chargino masses between 130 GeV and 450 GeV are excluded at 95% confidence level for a 20 GeV neutralino (Figure 1 b). In the scenario of chargino-pair production with W boson decays, the excluded cross-section is above the model cross-section by a factor 1.9–2.8 in the $\tilde{\chi}_1^{\pm}$ mass range 100–190 GeV and then increases gradually to 4.7 when reaching a $\tilde{\chi}_1^{\pm}$ mass of 250 GeV. The best sensitivity is obtained for the $(m_{\tilde{\chi}_1^{\pm}}, m_{\tilde{\chi}_1^0}) = (100, 0)$ GeV mass point where $\sigma/\sigma_{\mathrm{SUSY}} = 1.8$.



(a) (b)

Figure 1: 95% CL exclusion limits for both right- and left-handed (mass degenerate) selectron and smuon production in the $m_{\tilde{\chi}_1^0}$–$m_{\tilde{\ell}}$ plane (a) and 95% CL exclusion limits for $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ pair production in the simplified model with sleptons and sneutrinos with $m_{\tilde{\ell}} = m_{\tilde{\nu}} = (m_{\tilde{\chi}_1^{\pm}} + m_{\tilde{\chi}_1^0})/2$ (b)[1]. The dashed and solid lines show the 95% CL$_S$ expected and observed limits, respectively, including all uncertainties except for the theoretical signal cross-section uncertainty (PDF and scale). The solid band around the expected limit shows the $\pm 1\sigma$ result where all uncertainties, except those on the signal cross-sections, are considered. The $\pm 1\sigma$ lines around the observed limit represent the results obtained when moving the nominal signal cross-section up or down by the $\pm 1\sigma$ theoretical uncertainty. Illustrated also are the LEP limits [2] on the mass of the right-handed smuon $\tilde{\mu}_R$ in (a) and on the mass of the chargino in (b). The blue line indicates the limit from the previous analysis with the 7 TeV data [3].

References

[1] ATLAS Collaboration, ATLAS-CONF-2013-049, http://cdsweb.cern.ch/record/1557779

[2] LEPSUSYWG, ALEPH, DELPHI, L3 and OPAL experiments, note LEPSUSYWG/01-03.1, 04-01.1, http://lepsusy.web.cern.ch/lepsusy/Welcome.html

[3] ATLAS Collaboration, *Phys. Lett.* **B718** (2013) 879-901 [hep-ex/1208.2884]