PROCEEDINGS OF SCIENCE

Search for electroweak production of supersymmetric particles at LHC Run 2 with the ATLAS detector

Sonia Carrà *
INFN, Sezione di Milano and Università degli Studi di Milano, Dipartimento di Fisica
E-mail: sonia.carra@cern.ch

A search for electroweak production of supersymmetric particles decaying to final states with two or three leptons and missing transverse momentum is presented. The analysis is based on 36.1 fb^{-1} of $\sqrt{s}$ = 13 TeV proton-proton collisions recorded by the ATLAS detector at the Large Hadron Collider. No significant deviations from the Standard Model expectation are observed and stringent exclusion limits at 95% confidence level are placed on the masses of the supersymmetric particles considered.

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*on behalf of the ATLAS Collaboration

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1. Introduction

Supersymmetry (SUSY) [1] is one of the most motivated Standard Model (SM) extensions. Despite the meticulous search during the LHC Run 1, there is no evidence supporting this theory. Starting from 2015, LHC is performing a second data taking run with a higher center of mass energy (13 TeV), providing a great occasion for the search of beyond the Standard Model physics. New results obtained with the 2015-2016 ATLAS detector data [2], with an integrated luminosity of 36.1 fb^{-1}, are presented [3]. The direct production of electroweak particles, with two or three leptons in the final state and missing transverse momentum, is considered.

2. Motivation

Supersymmetry introduces a partner to each SM particle with the same quantum numbers except spin and mass, and can potentially provide an explanation for Dark Matter and the stability of the Higgs mass against radiative corrections.

The production of supersymmetric particles depends on the type of interaction involved and on the masses of the particles themselves. Squarks and gluinos would be produced in strong interactions with significantly larger production cross-sections than non-colored SUSY particles of equal masses, such as sleptons and charginos. The direct electroweak production can dominate SUSY production at the LHC if the masses of the gluinos and the squarks are significantly larger. With searches performed by the ATLAS and CMS experiments during LHC Run 2, the exclusion limits on squark and gluinos masses extend to up to approximately 2 TeV, making electroweak production an increasingly promising probe for SUSY signals at the LHC.

3. Signal model

In the presented search, the Minimal Supersymmetryc Standard Model with R-parity conservation, is considered. Five SUSY production diagrams are treated (Figure 1): (a) sleptons pair production ($\tilde{\ell}^{\pm}\tilde{\ell}^{\mp}$), decaying to neutralinos ($\tilde{\chi}_1^0$), with 2 leptons and no jets final state (2ℓ+0jets); (b) charginos pair production ($\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$), decaying through $\tilde{\ell}$, with 2 leptons and no jets final state; (c) $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ production, decaying through W/Z, with W hadronic decay, with 2 leptons and jets final state (2ℓ+jets); (d) $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ production, decaying through W/Z, with W leptonic decay, with 3 leptons final state (3ℓ); (e) $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ production, decaying through $\tilde{\ell}$, with 3 leptons final state.

Neutrinos and $\tilde{\chi}_1^0$ are weakly interacting particles and are measured through momenta imbalance, the missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$). A dedicated search strategy is developed for each signature.

4. Analysis strategy

Many Standard Model processes have the same final state of the supersymmetric signals illustrated in the previous section. The presence of a new particle is expected to be an excess of events over the SM background. The main contributions come from the diboson events (*ZZ*, *WW* and *ZW*, indicated as *VV*) and *Z*+jets events. The search is performed selecting a kinematic region optimized to have a good signal/background ratio, the signal region (SR).

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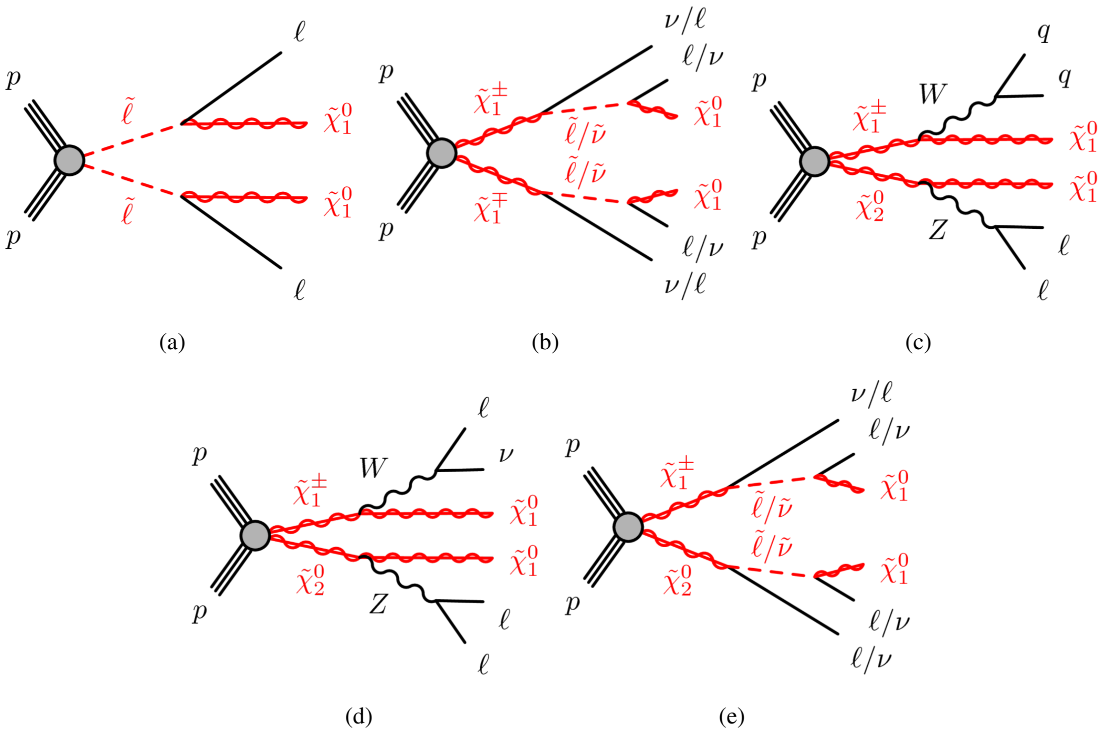

Figure 1: Diagrams for the considered physics scenarios.

Channel	2ℓ+0jets	2ℓ+jets	3ℓ
Fake leptons	Matrix method		Fake factor
$t\bar{t}+Wt$	Control region	Monte Carlo	Fake factor
VV	Control region	Monte Carlo	Control region
Z/γ+jets	Monte Carlo	γ+jets template	Fake factor
Higgs/VVV/top+V		Monte Carlo	

Table 1: Summary of the background estimation methods used in each search channel. In the 2ℓ+0jets case, top and diboson background are estimated using control regions (CR); matrix method is used in the fake leptons evaluation and minor processes are taken from Monte Carlo simulation. The γ+jets template provides the Z/γ+jets estimation in the 2ℓ+jets search channel; matrix method provides the fake leptons evaluation and minor processes are taken from Monte Carlo simulation. For 3ℓ channel, fake leptons, top and Z/γ+jets are estimated with the fake factor method; diboson are evaluated with a CR and minor processes from Monte Carlo simulation.

Considering the 2ℓ+0jets search channel, the signal region is selected requiring large *stransverse mass* (m_{T2}) [4] and large invariant mass. In the 2ℓ+jets case, large m_{T2}, $E_{\mathrm{T}}^{\mathrm{miss}}$ and jet multiplicity are required in order to have a good sensitivity. Leptons and jets invariant masses close to the W/Z bosons are also required. The 3ℓ search channel SR is defined with large $E_{\mathrm{T}}^{\mathrm{miss}}$ and large minimum trasverse mass ($m_{\mathrm{T}}^{\mathrm{min}}$), computed for each possible leptons pair.

The signal is expected to have a small cross section compared to the SM processes, so a precise background estimation is required. Dedicated control regions and data driven methods have been developed for each search channel. The various techniques are summirazied in Table 1.

5. Results

Comparing the observed events in the SRs to the SM prediction, no significant excess was observed in any of the channels. Limits on the SUSY particles masses were set. For $\tilde{\ell}$ pair production, $\tilde{\ell}$ masses are excluded up to 500 GeV (Figure 2(a)); for $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ decaying through $\tilde{\ell}$, $\tilde{\chi}_1^{\pm}$ masses are excluded up to 750 GeV(Figure 2(b)). Considering $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ decaying through W/Z with 2ℓ+jets final state, masses are excluded up to 580 GeV (Figure 2(c)). For $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ decaying through W/Z with 3ℓ final state, masses are excluded up to 380 GeV (Figure 2(d)); considering the $\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0$ decaying through $\tilde{\ell}$, masses are excluded up to 1130 GeV (Figure 2(e)).

6. Conclusion

An analysis targeting the observation of supersymmetric particles electroweak production was presented. No significant excess above the SM expectation was observed in any of the search channel considered. Stringent exclusion limits, improving the Run 1 results, were set on the SUSY particles masses.

References

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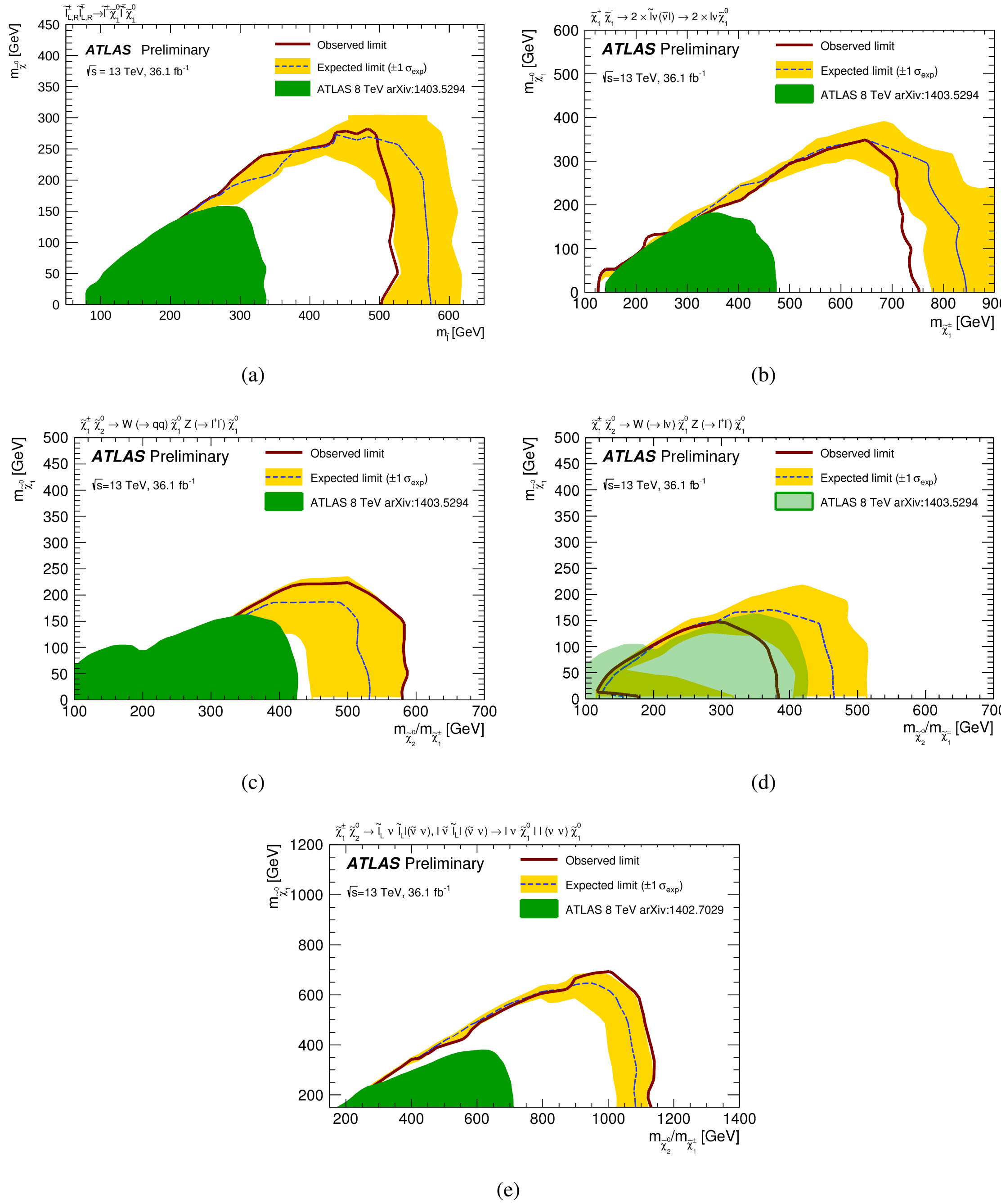

Figure 2: Exclusion plots for the considered physics scenarios: (a) direct $\tilde{\ell}$, (b) $\tilde{\chi}_1^{\pm}$ through $\tilde{\ell}$, (c) $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ decaying through WZ, (d) $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ through WZ, (e) $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ through $\tilde{\ell}$. All limits are computed at 95% CL. The observed limits obtained from ATLAS in Run 1 are also shown.