Overview of SUSY Physics at Atlas

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Supersymmetry predicts, for every Standard Model particle, an as-yet-undiscovered partner whose spin quantum number differs by half a unit. A review of ATLAS searches for signals of supersymmetry in proton-proton collisions at the Large Hadron Collider are presented. Results are based on collision data collected in 2015 and 2016 at a center-of-mass energy $\sqrt{s}$ = 13 TeV recorded by the ATLAS detector. These searches involve various channels, with final states including jets, missing transverse momentum, leptons as well as long-lived particle signatures. No significant excess over the Standard Model expectations are found. The results are interpreted within several simplified supersymmetric models as well as dark matter production scenarios, and exclusion limits at 95% confidence level on the sparticle masses are derived.

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[1] Speaker

1. Introduction

The Standard Model (SM), the mainstream theory of fundamental particles, is not the last word in our understanding of matter and forces, since it leaves unanswered several questions. The SM does not provide a consistent explanation to several theoretical concerns, like the gravity force, the mass of neutrinos, the existence of valuable candidates for the non baryonic component of the galaxies referred to as Dark Matter (DM), and the observed matter-antimatter asymmetry in the Universe.

Supersymmetry [1] (SUSY) is one of the most studied theory describing physics beyond SM, since it potentially solves several of its shortcomings. SUSY can provide an elegant solution to the naturalness problem of the SM; it leads to a unification of the gauge coupling strengths at a common scale and predicts, when imposing so-called R-parity to restore proton stability, the existence of a massive stable weakly interacting particle, so-called Lightest Supersymmetric Particle (LSP), a valuable dark matter candidate.

The ATLAS experiment [2] at the Large Hadron Collider (LHC) has run extensive physics searches to cover various analysis strategies for SUSY. Strong production is the dominant mode of producing sparticles at the hadron colliders, followed by the production of the third generation squarks, and electroweak production.

These proceedings summarizes, for each production mode, some highlights on recent SUSY measurements among the many searches and signatures. They are based on the LHC proton-proton collision data collected by the Atlas experiment during 2015 and until summer 2016 at a centre-of-mass energy of 13 TeV. The complete and up-to-date list of supersymmetry results from the Atlas experiment can be found here [3].

2. Analysis strategy

Given the large gain in sensitivity in Run 2, due to the increased center-of-mass energy of $\sqrt{s}$ = 13 TeV, all searches are based on simple and robust analysis strategies.

We use specific variables to maximise the amount of signal events and reject background events, mainly QCD multijet production. One example is the effective mass, $m_{eff,}$, defined as the scalar sum of the transverse momentum p_T of the *n* selected jets in the search channel plus the E_T^{miss}:

$$m_{\mathrm{eff}}(n_j) = \sum_{i=1}^{n} \left|\vec{p}_{\mathrm{T}}^{\,(i)}\right| + E_{\mathrm{T}}^{\mathrm{miss}}.$$

The effective mass is a measure of the overall activity of the event. Since strongly produced supersymmetric events feature multiple high p_T jets and a

significant amount of E_T^{miss}, supersymmetric events will on average have a higher m_{eff} than SM events.
Another variable used to control the background from copiously produced QCD multi-jet events is the stransverse mass m_{T2}:

$$m_{T2} = \min_{\vec{q}_T^1 + \vec{q}_T^2 = \vec{p}_T^{miss}} \left(\max \left[m_T(\vec{p}_T^{\ell_1}, \vec{q}_T^1), m_T(\vec{p}_T^{\ell_2}, \vec{q}_T^2) \right] \right),$$

measuring the transverse-momentum imbalance, which strongly suppresses fake contributions due to potential hadronic-jet mismeasurement.
Also the ratio $E_T^{miss}/m_{eff}(n_j)$ is used to reject multijet background events: in multijet events, E_T^{miss} is mainly associated with jet mismeasurement, and the contribution from final state objects is negligible. Clearly, supersymmetric events, would have a higher $E_T^{miss}/m_{eff}(n_j)$, since E_T^{miss} would contribute a larger fraction to the $m_{eff}(n_j)$.
Inclusive searches also make extensive use, as a discriminating variable, of the missing transverse momentum significance, $E_T^{miss}/\sqrt{H_T}$, where H_T is the scalar sum of the transverse energy of jets.

The general strategy of all SUSY searches is the following: first we define signal regions (SR) where the signal is expected to show up. Then specific backgrounds dominated regions are selected, the control regions (CRs), each of which is enriched in one of the main backgrounds (W production, Z production, $t\tilde{t}$, diboson and QCD). We extract normalization from CRs, while the shape is taken from Monte Carlo simulations. Reducible backgrounds are estimated using data-driven techniques.
The CRs are designed to be close kinematically to SRs but still orthogonal to them. Then combined fits of SRs and corresponding CRs fixes background predictions. The output of the fitting procedure is checked through validation regions (VRs). If no problem is observed, the SRs are unblinded to see if there is any excess over SM prediction in the final discriminating variable distribution. If there is none we can put exclusion limits on various SUSY models. Still, the limit set on the visible cross sections are model independent and can be used to constrain any beyond the Standard Model physics.

3. Strong SUSY production

In the minimal supersymmetric extension of the Standard Model (MSSM) [4,5], TeV-scale squarks and gluinos produced in pp collisions will decay promptly in long decay chains containing mainly quark and gluon jets. If R-parity conservation holds [6], pair-produced gluinos or squarks decay either directly or via intermediate states to the lightest supersymmetric particle (LSP), which is stable and is assumed to be only weakly interacting, making it a candidate for dark matter [7, 8].

SUSY events are therefore characterized by multiple energetic jets as well as E_T^{miss} originating from the undetected LSP energies. Depending on the sparticle present (or not) in between the squarks/gluinos and the LSP, charged lepton(s) and/or photons could also appear in the cascade. This section summarizes the present status of searches for gluinos and first/second generation squarks when the neutralino, χ_0, is the LSP. To improve the sensitivity to these models, searches are usually divided in lepton veto (Sect. 3.1) and leptonic (Sect. 3.2) searches. The former target more inclusive or generic scenarios while the latter are generally more optimal for specific models. In both cases, requiring that some jets are originating from a b-quark can increase the sensitivity.
Considering more complex final states, as e.g. arising from cascade decays of the gluino proceeding via intermediate sparticles, the final state might contain a high jet multiplicity. The multi-jet analysis (Sect. 3.3) targets such scenarios using signal regions requiring between ≥ 8 and ≥ 10 jets.
The main background in inclusive searches for squarks and gluinos are multijet events with real or mismeasured missing energy, top quark pairs and weak gauge bosons produced in association with jets.

3.1 Lepton-veto analysis

This search [9] targets SUSY models with direct decays of gluinos or squarks to the LSP, as well as one-step decays, via an intermediate chargino, as shown in Figure 1.

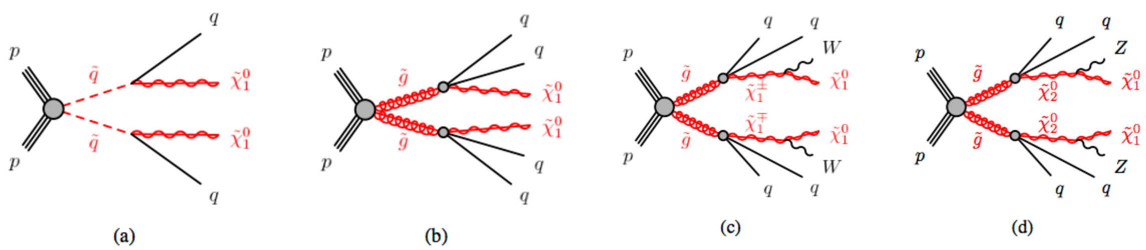


Figure 1: *Examples of (a) squark-pair production with direct decay of squarks and (b, c, d) gluino-pair production with (b) direct or (c, d) one-step decays of gluinos, in the simplified models.*

In this analysis two approaches are considered for the search of these sparticles in final states containing only hadronic jets and large missing transverse momentum. The first is based on the effective mass m_{eff} as a discriminating variable between signal and background. The second is the complementary search using the Recursive Jigsaw Reconstruction (RJR) techniques [10] in the construction of a discriminating variable set. Thirteen inclusive SRs characterized by increasing minimum jet multiplicity from two to six are defined. Five SRs target the high mass gluinos/squarks with a large mass difference with the LSP, while six SRs cover more compressed spectra. None of the searches have observed a significant excess above the SM predictions. Therefore limits on new physics are set.

In Figure 2 limits are shown for two classes of simplified models in which only direct production of light-flavour squark or gluino pairs are considered. They are obtained by using the signal region with the best expected sensitivity at each point. In these simplified model scenarios, the upper limit of the excluded light-flavour squark mass region is 1.35 TeV assuming massless $\tilde{\chi}_1^0$. The corresponding limit on the gluino mass is 1.86 TeV. The best sensitivity in the region of parameter space where the mass difference between the squark (gluino) and the lightest neutralino is small, is obtained from the dedicated RJR-C signal regions. In these regions with very compressed spectra with mass difference < 10 GeV, squark (gluino) masses up to 600 GeV (850 GeV) are excluded.

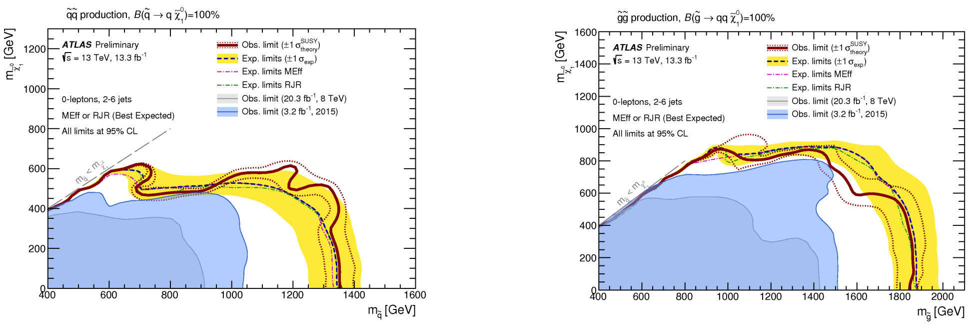


Figure 2: *Exclusion limits for direct production of (a) light-flavour squark pairs with decoupled gluinos and (b) gluino pairs with decoupled quarks. Gluinos (light-flavour squarks) are required to decay to two quarks (one quark) and a neutralino LSP. Exclusion limits are obtained by using the signal region with the best expected sensitivity at each point. The blue dashed lines show the expected limit at 95% CL, with the light yellow bands indicating the 1σ excursions due to the experimental and background-only theoretical uncertainties. Observed limits are indicated by medium dark curves where the solid contour represents the nominal limit, and the dotted lines are obtained by varying the signal cross-section by the renormalization and factorization scale and PDF uncertainties.*

3.2 One lepton analysis

If a W boson appears as product in the cascade decay originating from chargino, top or slepton, analyses requiring the presence of leptons in the final state might be particularly sensitive, as they suppress the QCD multi-jet background effectively. The one lepton analysis [11] is optimized to probe other regions of parameter space, and expecially more compressed mass spectra. Experimental challenges drastically change: lepton triggers can be exploited and

requirements on jet kinematics can be reduced. Lowering cuts on E_T^{miss} and H_T is possible since the multi-jet QCD background is naturally suppressed by the presence of an isolated lepton. Finally, other variables exist like the transverse mass m_T, which efficiently reduces $t\tilde{t}$ and W+jets backgrounds by requiring $m_T > m_W$. This allows to compensate the loss due to the leptonic branching ratio(s) when comparing with lepton-veto analyses.
This analysis is optimized to SUSY simplified models in which pair-produced gluinos or squarks decay via the lightest chargino to the LSP, which is assumed to be the lightest neutralino. Two decay topologies are considered: in the squark-production model, the squark decays to the LSP via a chargino, by emitting an on- or off-shell W boson, depending on the available phase space; in the gluino-production model, the gluino decays to the lightest chargino and two SM quarks, followed by the same chargino decay.
The search is performed in ten signal regions to provide sensitivity to a broad range of mass spectra in both models. One of those signal regions requires a low-p_T lepton (7/6 < p_T(e/μ) < 35 GeV), in order to target the gluino production scenarios with compressed mass spectra, while the others require hard lepton signals to target different mass hierarchy scenarios for the gluino and squark signal models. Further requirements on the jet multiplicity, E_T^{miss}, m_{eff} and on the transverse mass m_T, defined as:

$$m_\mathrm{T} = \sqrt{2p_\mathrm{T}^l E_\mathrm{T}^\mathrm{miss}(1 - \cos\Delta\phi(\vec{p}_\mathrm{T}^l, \vec{p}_\mathrm{T}^\mathrm{miss}))}$$

help to suppress the dominant $t\bar{t}$ and W+jets backgrounds. The observed data agree with the SM background prediction in the signal regions and limits on the visible cross-section are derived in models of new physics within the kinematic requirements of this search. In addition, exclusion limits are placed on models with squark or gluino pair production and subsequent decays via an intermediate chargino to the lightest neutralino. Limits of previous searches conducted in LHC Run 1 are significantly extended. Gluino (squark) masses up to 1.8 TeV (1.1 TeV) are excluded for low neutralino masses (≤ 400 GeV or ≤ 300 GeV) and chargino masses of ~ 930 GeV (470 GeV or 650 GeV).

3.3 High-jets multiplicity analysis

Considering more complex event topologies, as e.g. arising from cascade decays of the gluino proceeding via intermediate sparticles, the final state might contain a high jet multiplicity. This analysis [12] targets such scenarios using signal regions requiring between ≥ 8 and ≥ 10 jets, in association with E_T^{miss}, where those jets are consistent with coming from the decays of heavy objects, and can be clustered into a smaller number of high-mass jets. Such signatures are exhibited, for example, by squark or gluino pair production followed by cascade decay chains, and/or decays to heavy SM particles, such as top quarks or W, Z or Higgs bosons, each of which can produce multiple jets in their decays.

In contrast to many other searches for the production of strongly interacting SUSY particles in the hadronic channel at ATLAS, the requirement made here of large jet multiplicity means that the threshold on E_T^{miss} can be modest.
The dominant standard model backgrounds to this search comprise QCD multijet production and top quark pair-production, in which the tops decay fully hadronically, or via a tau lepton. By selecting events in which the sum of the masses of the large-radius jets is large, these backgrounds are greatly reduced, increasing sensitivity to decays of heavy objects.
Six signal regions are defined from the jet multiplicity in events with no leptons.
The final discriminating variable between SUSY and background used to search for an excess of events in various channels is $E_T^{miss}/\sqrt{H_T}$: a cut at 4 $\mathrm{GeV}^{1/2}$ ensures a good balance between signal acceptance and background rejection in all signal regions and removes a large portion of the multijet background. This analysis does not see any significant excess either, as shown in Figure 3.
The results are interpreted in the context of a simplified supersymmetric model, and a slice (two-dimensional subspace) of the pMSSM [13], each of which predict cascade decays of supersymmetric particles and hence large jet multiplicities. The resulting exclusion regions are shown in Figure 4. For each signal model point, the signal region with the best expected limit is used.
The data exclude gluino masses up to 1600 GeV at the 95% CL, significantly extending previous bounds. Model-independent limits are presented which allow reinterpretation of the results to cases of other models which also predict decays into multijet final states in association with invisible particles.

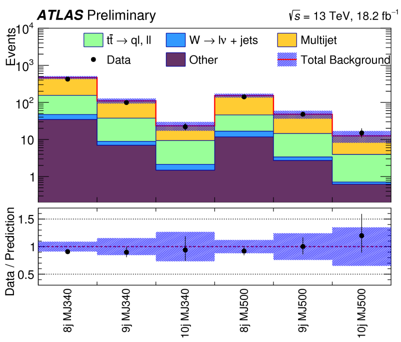


Figure 3: *Summary plot showing the data and SM predictions for the six signal regions. The sub-plot shows the ratio of the yields to the SM predictions.*

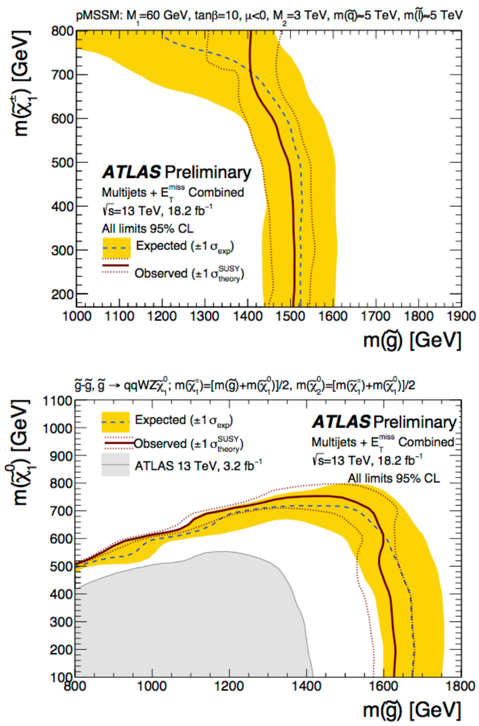


Figure 4: *The 95% CL exclusion curves for the two supersymmetric models described in the text. The solid red and dashed blue curves show the 95% CL observed and expected limits, respectively, including all uncertainties except the theoretical signal cross-section uncertainty. The dotted red lines are the result of the signal cross-section variation by ±1σ (as defined by the PDF and scale uncertainties). The shaded yellow band around the expected limit shows the ±1σ variation of the expected limit.*

4. Third generation SUSY production

Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Therefore, even if the production cross-section is smaller than for gluinos and first/second generation of squarks, they may well be directly produced at the LHC with generally less complex final states. General characteristics of these searches are the presence of leptons (electrons or muons), multiple jets, some of which may be *b*-tagged, and missing transverse energy.

The ATLAS experiment has an extensive search program for third generation SUSY particles. These proceedings present new results that are interpreted in two simplified SUSY scenarios stemming from assumptions made regarding the mass spectrum: gluino-mediated and direct production of stops and sbottoms. In addition, signal models [14, 15] of the associated production of top pairs with a pair of dark matter (DM) particles produced through a scalar (pseudoscalar) mediator φ (*a*) are also taken into consideration, since they target the same final state. Figure 5 (e) illustrates a Feynman diagram where the DM particles (represented by χ) are pair-produced via a spin-0 mediator (either scalar or pseudoscalar).

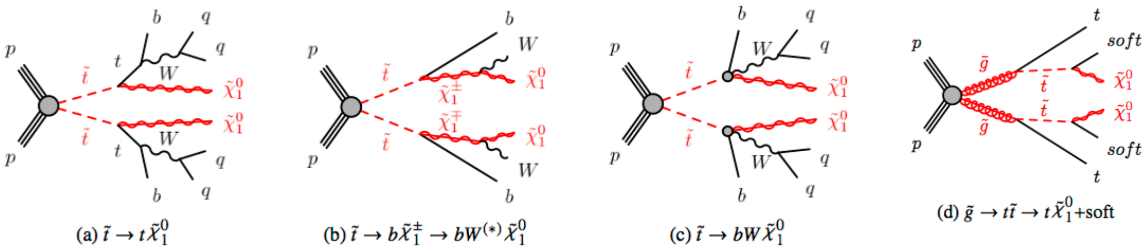
In order to fulfill precision constraints from flavor measurements, the model assumes Yukawa-like couplings between the dark sector mediator and the SM fermions. This motivates the choice of studying these models in heavy flavor quark final states. The model has five free parameters corresponding to the mass of the mediator and the DM particle, the coupling of the mediator with the DM and SM particles, and the width of the mediator. The mediator width is assumed to be the minimal width that can be calculated from all parameters of the model. The coupling of the mediator to the dark matter particle (g_χ) is set to be equal to its coupling to the quarks (g_q) and cross sections corresponding to a range of couplings are considered. The minimum mediator coupling considered is 0.1 and the maximum is 3.5, at the perturbative limit, and has the same strength for SM and DM particles.

4.1 Zero lepton analysis

The search for stop quark pair production in the all-hadronic channel [16] considers three different decay modes for direct pair production of top squarks, as illustrated in Figure 5 (a)-(c), respectively, and one indirect production channel of top squarks through gluino decays, as shown in Figure 5 (d) . A simplified model of top quark pairs produced in association with a pair of dark matter (DM) particles is also considered (Figure 5 (e)).

The main experimental signature for all signal topologies is the presence of multiple jets (two of which originate from b quarks), no reconstructed electron or muon and a significant E_T^{miss} from the LSP. Major background are represented

by $t\bar{t}$ and W+jets events. 19 sets of signal regions are defined to target each topology and kinematic regime.
Substantial SM $t\bar{t}$ background rejection is provided by requirements on E_T^{miss} and on the transverse mass calculated from the E_T^{miss} and b-tagged jet closest in phi to the E_T^{miss} direction. Additional discrimination is provided by applying an upper cut on the missing transverse momentum significance, $E_T^{miss}/\sqrt{H_T}$.



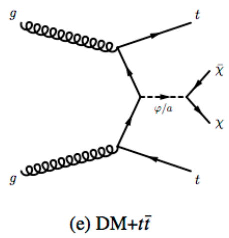


Figure 5: *The decay topologies of the signal models considered with experimental signatures of four or more jets plus missing transverse momentum.*

The agreement between the data and the SM prediction is good in all the SRs, and the interpretation is done in the simplified model assuming production of stop pair that decay to top and $\tilde{\chi}_1^0$.
Exclusion limits are reported in terms of the top squark and neutralino masses. Assuming branching fractions of 100% to $t\ \tilde{\chi}_1^0$, top squark masses in the range 310–820 GeV are excluded for $\tilde{\chi}_1^0$ masses below 160 GeV. In the case where $m_{\tilde{t}} \sim m_t + m\tilde{\chi}_1^0$ top squark masses between 23–380 GeV are excluded. Limits are also reported in terms of simplified models describing the associated production of dark matter (χ) with top quark pairs through a (pseudo)scalar mediator; models with a global coupling of 3.5, mediator masses up to 300 GeV, and χ masses below 40 GeV are excluded. The limits in various interpretations significantly extend previous results.

4.2 One lepton analysis

This search [17] targets two different scenarios. Scenario 1 focuses on the direct pair production of the lighter stop ($\tilde{t}_1$), which can decay into a variety of final states, depending amongst other things on the SUSY particle mass spectrum, in particular on the masses of the stop, chargino and lightest neutralino. In scenario 2, dark matter particles are pair-produced via a spin-0 mediator (either scalar or pseudoscalar). The mediator couples to the SM particles by mixing with the Higgs sector.

The event selection requires one lepton, where the W boson from one of the top quarks decays to an electron or muon, and one b-tagged jet from the hadronic decay of the other top quark. The main backgrounds are top pair production and top pair production in association with a Z-boson that decays to two neutrinos. Additionally, variables such as the transverse mass and the invariant mass of the three jets in the event most compatible with the hadronic decay products of a top quark, where the three jets are selected by a χ^2-minimization including the jet momenta and energy resolutions, are used to enhance the sensitivity.

Mild excesses corresponding to 2.2σ and 2.6σ are observed in two signal regions, leading to the unusual form of the exclusion limit. No significant excess over the SM is observed and exclusion limits are set, in the context of both scenarios. These are shown in Figure 6.

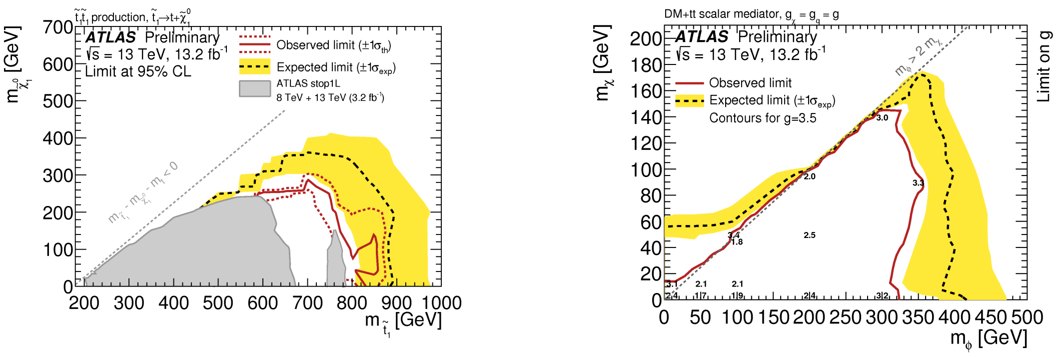


Figure 6: *Exclusion limits for the one-lepton stop analysis. Left: Exclusion limit for direct stop pair production assuming top plus neutralino t decay with a branching ratio of 100%. Right: Exclusion limit for dark matter associated production with top quarks for a pseudoscalar mediator. The observed and expected lines correspond to the limit for the coupling g = 3.5.*

4.3 Two lepton analysis

This analysis [18] targets three main signals, targeted as “hadronic m_{T2}”, “three-body” and “dark matter”, respectively. The first focuses on the pair production of top squarks, each of them decaying through the three-body mode into $bW\tilde{\chi}_1^0$. The second set of selections targets the decay mode to the lightest chargino and a *b* quark, followed by the chargino decay into the lightest neutralino, a lepton and a neutrino. The third set of selections targets the production of DM in association with a leptonically decaying $t\bar{t}$ pair. The event selection requires two opposite sign leptons, which do not originate from a Z boson. In addition the stransverse mass m_{T2} and the kinematic variable R1 = E_T^{miss} / m_{eff} are used to suppress the backgrounds. The highest sensitivity is reached for compressed spectra, where the b-jets have low p_T, thus no tagging requirement is applied. Since no significant excess over the SM is observed, exclusion limits are set. These are shown in Figure 7. For a mass difference of 90 GeV between the stop and the neutralino and the three body decay mode, a stop mass below 365 GeV is excluded. The chargino decay mode is excluded for a stop mass between 400 and 495 GeV, a chargino mass of 100 GeV and a neutralino mass of 50 GeV. Finally, a pseudoscalar or scalar mediator lighter than 330 GeV is excluded for a coupling strength of 3.5 and a dark matter particle mass below 20 GeV.

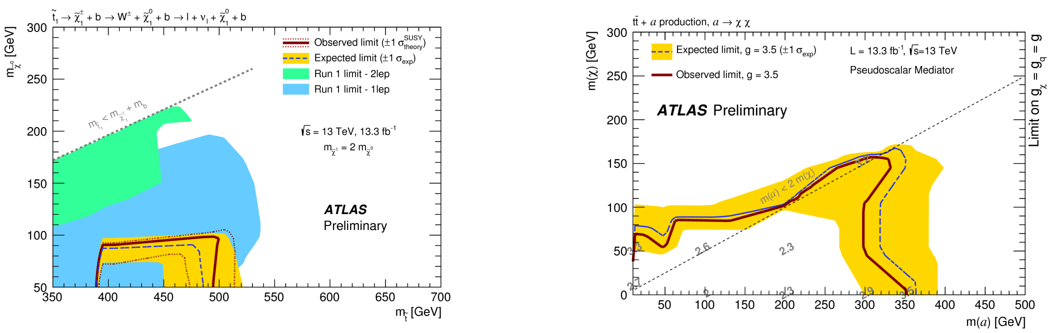


Figure 7: *Exclusion limits for the two lepton stop analysis. Left: Exclusion limit for the scenario where* $m(\tilde{\chi}_1^{\pm}) = 2m(\tilde{\chi}_1^0)$*. Right: Exclusion limit for the dark matter search model wirh a pseudoscalar mediator.*

5. Electroweak SUSY production

In SUSY models, the electroweak sector contains charginos ($\tilde{\chi}_i^{\pm}$, i = 1,2), neutralinos ($\tilde{\chi}_j^0$, j = 1,2,3,4 in order of increasing masses), and sleptons. Charginos and neutralinos are the mass eigenstates formed from the linear superpositions of the SUSY partners of the charged and neutral Higgs bosons and electroweak gauge bosons. The sleptons are the superpartners of the leptons.

If all squarks and gluinos are above the TeV scale, the direct production of the electroweak gauginos and sleptons dominates the total SUSY cross section and final states with two or more leptons provide the best sensitivity.

Three lepton final states are yielded naturally by most of these models, however, under certain conditions, two lepton signatures could be more sensitive, i.e. when the mass splitting is small. On top of the multilepton selection, a Z-veto is generally applied to suppress background from diboson production, and a (b)jet-veto is applied to suppress $t\tilde{t}$ background.

5.1 $2\tau + E_T^{miss}$ analysis

There is a possibility that intermediate staus are the preferred option in supersymmetry. In such cases, there is still the option of having three light leptons, but due to the branching fractions of the tau decay, it is more likely to have one or more hadronic taus in the event. Therefore ATLAS searched for a new signal [19] focusing on two opposite-sign hadronic taus. The electroweak production of chargino pairs and associated production of chargino and next-to-lightest neutralinos are studied in final states with at least two hadronically decaying tau leptons and missing transverse momentum. Simplified models characterised by $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^0$ and $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$ production are considered in this analysis. In both simplified models the lightest neutralino is the LSP. The τ and the $\tilde{\nu}_\tau$ are assumed to be lighter than the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$. Charginos and neutralinos decay into the lightest neutralino via an intermediate on-shell stau or tau sneutrino (see Figure 8).

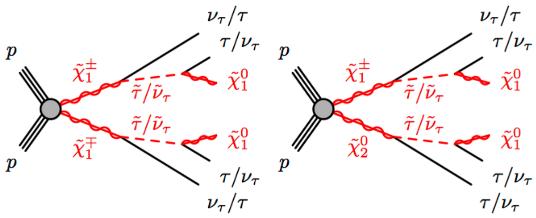


Figure 8: *Representative diagrams for the electroweak production processes of supersymmetric particles considered in this work: (left) $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$ and (right) $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^0$ production.*

To suppress the major backgrounds, a Z-veto and a hard cut on the hadronic activity (a b-tagged jet veto) are applied. Then the stransverse mass, m_{T2}, is used for the final discrimination. The stransverse mass variable is designed for events with two undetected particles and represents a lower bound on the parent particle's mass.

The observed number of events in each signal region are compatible with the expected contributions from SM processes and both are used to place model-dependent exclusion limits at 95 % CL (Figure 9). Chargino masses up to 580 GeV are excluded for a massless lightest neutralino in the scenario of direct production of chargino pairs. In the case of associated production of chargino pairs and mass-degenerate charginos and next-to-lightest neutralinos, chargino masses up to 700 GeV are excluded for a massless lightest neutralino.

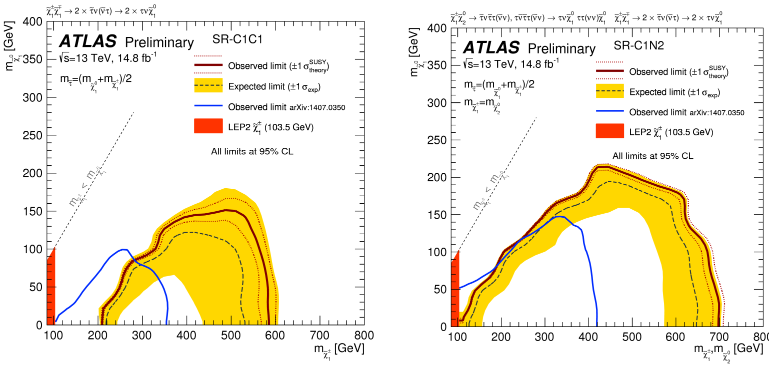


Figure 9: *95% CL exclusion limits for simplified models with $\tilde{\chi}_1^{+}\tilde{\chi}_1^{-}$ production (left) and associated production of $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$and $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{0}$ (right). The LEP limit on the chargino mass is also shown. Results are compared with the observed limits obtained by previous ATLAS searches as blue contours.*

5.2 2/3 leptons + E_T^{miss} analysis

This analysis [20] targets new searches for direct production of a neutralino in association with a chargino in final states with two or three light leptons and large missing transverse momentum. Two scenarios are considered: the first scenario is direct $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$ production decaying with intermediate $\tilde{l}$ leading to a signature of a pair of opposite-sign leptons and $\mathrm{E}_\mathrm{T}^{\mathrm{miss}}$, $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-} \rightarrow \tilde{l}\ \nu_l\ (l\tilde{\nu})\ \tilde{l}'\ \nu_{l'}\ (l'\tilde{\nu}) \rightarrow l\ l' + \mathrm{E}_\mathrm{T}^{\mathrm{miss}}$. The second scenario is direct $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^{0}$ production decaying with intermediate $\tilde{l}$ into three leptons and $\mathrm{E}_\mathrm{T}^{\mathrm{miss}}$, $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^{0} \rightarrow \tilde{l}\ \nu\ (l\tilde{\nu})\ \tilde{l}\ l\ (\tilde{\nu}\ \nu) \rightarrow 3l + \mathrm{E}_\mathrm{T}^{\mathrm{miss}}$. With no significant excess over the Standard Model expectation observed, results are interpreted in the framework of simplified models featuring chargino and neutralino production. The limits (Figure 10) set by this search extend the previous ones set during the LHC Run I by 140 GeV for the $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$ production and by 300 GeV for the case of $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^{0}$ production.

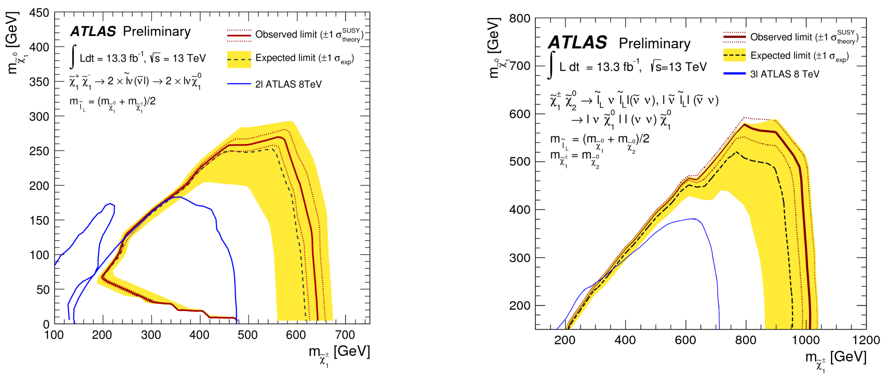


Figure 10: Observed and expected exclusion limits on the $\tilde{\chi}_2^{0}\ \tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_1^{0}$ masses in the context of SUSY scenarios with simplified mass spectra for direct $\tilde{\chi}_1^{+}\ \tilde{\chi}_1^{-}$pair production using the two-lepton signal regions (a) and direct $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^{0}$production using the three-lepton signal regions (b).

6. Conclusions

ATLAS is conducting a comprehensive set of searches within a challenging supersymmetry analysis program. In particular, attention is increasing towards rare electroweak SUSY production, enhanced by the increase in luminosity, complementing the existing strong production searches, and third generation SUSY, which could show up at low masses, favoured by arguments of naturelness.

As shown in these proceedings, there is so far no sign of physics beyond the SM. However, much of the parameter space remains to be probed, and the search for SUSY at the LHC will continue to be vigorously pursued.

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