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ATLAS Supersymmetry searches

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Summary. — Supersymmetry with large mixing angle predicts that the lightest superpartners of the Standard Model fermions belong to the third generation. Furthermore, naturalness arguments favor masses not too far from the top quark mass. This document presents the status of the searches for supersymmetric particles with the ATLAS detector at LHC, in proton-proton collisions at $\sqrt{s} = 7\,\text{TeV}$. It has been possible to put stringent limits on many supersymmetric particle masses and extend the search for scalar partners of the third generation, both in direct and gluino mediated production.

PACS 12.60.Jv – Supersymmetric models.

1. – Introduction

Supersymmetry (SUSY) provides an extension of the Standard Model (SM) by introducing supersymmetric partners of the known bosons and fermions. In the framework of an R-parity conserving minimal supersymmetric extension of the SM (MSSM), SUSY particles are produced in pairs and the lightest supersymmetric particle (LSP), in many models the lightest neutralino χ_1^0, is stable and a possible candidate for dark matter. An important motivation for SUSY third generation searches is the fact that SUSY can naturally resolve the hierarchy problem, by preventing a large fine-tuning in the Higgs sector, provided that the superpartners of the top quark have relatively low masses.

Furthermore, in the MSSM the scalar partners of right-handed and left-handed fermions, can mix to form two mass eigenstates. This mixing is proportional to the corresponding SM fermion masses and is therefore more important for the third generation. Large mixing can yield sbottom and stop mass eigenstates which are significantly lighter than other sparticles. Consequently, they could be produced with large cross sections at the LHC. Depending on the SUSY particle mass spectrum, the cascade decays of gluino-mediated and pair-produced sbottoms $\tilde{b}$ or stops $\tilde{t}$ result in complex final states consisting of missing transverse momentum (E_{T}^{miss}), several jets, among which b-quark jets are expected, and possibly leptons.

This document reports several ATLAS searches for third generation supersymmetry, carried out using LHC proton-proton collision data at $\sqrt{s} = 7\,\text{TeV}$.

2. – Experimental results

Two analyses targeting gluino ($\tilde{g}$) mediated stop pair production have been performed selecting events with two isolated leptons (e, μ) or events with large jet multiplicity. The two leptons analysis [1] (using 2.05 fb^{-1} of data) assumes that $\tilde{t} \to t\tilde{\chi}_1^0$ or $\tilde{t} \to b\tilde{\chi}_1^{\pm}$, where $\tilde{\chi}_1^{\pm}$ is the chargino. Two leptons with the same charge (the gluino being a Majorana particle), at least four jets with $p_{\mathrm{T}} > 50\,\mathrm{GeV}$ and $E_{\mathrm{T}}^{miss} > 150\,\mathrm{GeV}$ are required. Two signal regions are defined by either applying or not a cut on the transverse mass $m_{\mathrm{T}} > 100\,\mathrm{GeV}$. Exclusion limits are derived at 95% CL: $m_{\tilde{g}} < 660\,\mathrm{GeV}$ is excluded for $m_{\tilde{t}} < 460\,\mathrm{GeV}$. Off-shell stop production has been studied [2] on 4.7 fb^{-1} of data, looking at events with large jet multiplicities (6–9 jets) and E_{T}^{miss}. In particular, to suppress the multi-jets background, the events are required to have $E_{\mathrm{T}}^{miss}/\sqrt{H_{\mathrm{T}}} > 4\,\mathrm{GeV}^{1/2}$, where H_{T} is the scalar sum of the transverse momenta of all jets. No excess is found and depending on the model, $m_{\tilde{g}}$ up to 880 GeV can be excluded.

A search for direct stop pair production has been carried out [3] on 2.05 fb^{-1} of data, assuming a GMSB model where the $\tilde{\chi}_1^0$ decays either via $h\tilde{G}$ or $Z\tilde{G}$, where $\tilde{G}$ is the gravitino (LSP). Events with two same flavour opposite-sign leptons (e, μ) with invariant mass consistent with the Z boson mass, large E_{T}^{miss} and at least two jets with $p_{\mathrm{T}} > 60(50)\,\mathrm{GeV}$ in the final state are selected. At least one of the jets is required to be originating from a b-quark. The results are interpreted in the framework of R-parity conserving, gauge-mediated Supersymmetry breaking scenarios where the $\tilde{\chi}_1^0$ is the next-to-lightest supersymmetric particle. Scalar top masses up to 310 GeV are excluded for $115\,\mathrm{GeV} < m_{\tilde{\chi}_1^0} < 230\,\mathrm{GeV}$ at 95% CL, reaching $m_{\tilde{t}} < 330\,\mathrm{GeV}$ for $m_{\tilde{\chi}_1^0} = 190\,\mathrm{GeV}$.

A search for direct sbottom pair production has been performed [4] assuming sbottom decay into a bottom quark plus a neutralino (LSP) with a branching ratio of 100% using 2.05 fb^{-1} of data. Selected events are required to have exactly two b-tagged jets with $p_{\mathrm{T}} > 130, 50\,\mathrm{GeV}$ and $E_{\mathrm{T}}^{miss} > 130\,\mathrm{GeV}$. Electrons (muons) with $p_{\mathrm{T}} > 20\,\mathrm{GeV}$ (10 GeV) are vetoed, and events are rejected if a third jet with $p_{\mathrm{T}} > 50\,\mathrm{GeV}$ is found. The cuts on the leading jet and the E_{T}^{miss} are driven by the trigger thresholds. The kinematic variable used to further discriminate the signal from the background is the boosted-corrected contransverse mass m_{CT}. Three signal regions are defined with $m_{\mathrm{CT}} > 100, 150$ and 200 GeV to maximize the sensitivity for different mass splitting between the sbottom and the neutralino. In the most conservative hypothesis, sbottom masses up to 390 GeV are excluded for neutralino masses below 60 GeV.

3. – Conclusions

ATLAS has carried out several searches for superpartners of third generation fermions. No excess in data with respect to the SM expectation has been observed so far. However, large regions of the parameter space for natural SUSY are still not excluded and new data with increased centre-of-mass energies together with the study of new channels will bring new opportunities for the discovery of a potential excess.

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