IL NUOVO CIMENTO **42 C** (2019) 199
DOI 10.1393/ncc/i2019-19199-1

Colloquia: IFAE 2018

Search for direct top squark pair production in final states with two leptons in $\sqrt{s} = 13\,\text{TeV}$ pp collision with the ATLAS detector

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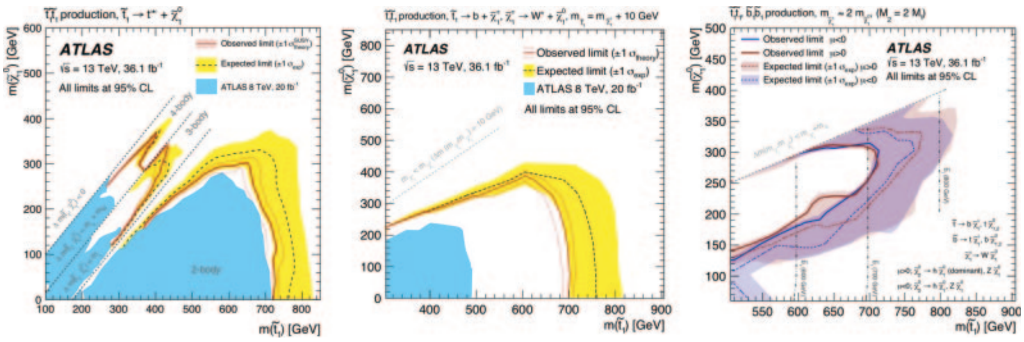
received 31 January 2019

Summary. — The results of a search for direct pair production of top squarks in events with two opposite-charge leptons (electron or muons) are reported, using 36.1 fb^{-1} of integrated luminosity from pp collision at $\sqrt{s} = 13\,\text{TeV}$ collected by the ATLAS experiment at the LHC. No significant excess of events is observed above the Standard Model background, and limits at 95% confidence level on top squarks are set.

The Standard Model (SM) of particle physics, despite being extremely successful in describing the nature and interaction of elementary particles, is believed to be a low-energy approximation of a more general theory. It fails to explain several observations, such as the nature of dark matter and the stabilisation of the Higgs boson mass against radiative corrections from the Planck scale. Extending the SM with the inclusion of Supersymmetry [1] by introducing new particles that are supersymmetric partners of the SM particles provides a solution to these problems. Supersymmetric particles directly produced through the strong interaction are the ones with higher production cross-section in a hadronic collider such as LHC, making the search for colored particles, in particular for the supersymmetric partner of the top quark $\tilde{t}_1$ (called top squark) which is supposed to be the lightest of the colored supersymmetric quarks, a promising one for SUSY signals at LHC.

The top squark is assumed to decay into lighter, non-colored, SUSY particles whose mass eigenstates are mixing of supersymmetric partners of electroweak vector bosons and the Higgs boson. These are called charginos $\tilde{\chi}^{\pm}_{i=1,2}$ and neutralinos $\tilde{\chi}^{0}_{j=1,2,3,4}$ where the subscripts are ordered according to the particles masses. Depending on the mass difference between the top squark and the lighter SUSY particles, different decay modes are considered in the analysis presented [2]. The decays $\tilde{t} \to t\tilde{\chi}^0_1$ and $\tilde{t} \to b\tilde{\chi}^{\pm}_1$ with $\tilde{\chi}^{\pm}_1 \to W\tilde{\chi}^0_1$ (two-body decay) dominate when they are kinematically accessible. For intermediate mass differences, $m_{\tilde{\chi}^0_1} + m_W + m_b < m_{\tilde{t}} < m_{\tilde{\chi}^0_1} + m_t$, the decay $\tilde{t} \to bW\tilde{\chi}^0_1$



(a) Exclusion contour for a simplified model assuming $\tilde{t} \to t^{(*)}\tilde{\chi}_1^0$ with 100% BR.

(b) Exclusion contour for a simplified model assuming $\tilde{t} \to b\tilde{\chi}_1^{\pm}$ with 100% BR.

(c) Exclusion contour for the pMSSM model.

Fig. 1. – Limits on the masses of the SUSY particles at 95% CL set by the analysis reported [2].

(three-body decay) is considered. For smaller mass differences, the decay $\tilde{t} \to bff'\tilde{\chi}_1^0$ (four-body decay) is assumed to occur.

The analysis uses $36.1\,\text{fb}^{-1}$ of integrated luminosity from pp collision at $\sqrt{s} = 13\,\text{TeV}$ collected by the ATLAS experiment [3] in 2015 and 2016 at the LHC. The final states are requested to have exactly two opposite charged, isolated leptons (electrons or muons) and missing transverse momentum E_T^{miss}. For the two-body and three-body selections, the leading lepton is required to have $p_T > 25\,\text{GeV}$, while the subleading lepton is required to have $p_T > 20\,\text{GeV}$. For the four-body selection the events are required to have $E_T^{\text{miss}} > 200\,\text{GeV}$, while the leptons p_T threshold is reduced to 7 GeV. The two leptons are required to have invariant mass $m_{\ell\ell} > 20\,\text{GeV}$ (10 GeV for the four-body selection) and events with same-flavour lepton pairs and $m_{\ell\ell} \in [71.2, 111.2]\,\text{GeV}$ are rejected in order to reduce the backgrounds produced by Z-bosons. Moreover, the SUSY candidate events for the two-body selection are required to have $m_{T2}^{\ell\ell}$ [4] greater than 110, 140 or 180 GeV according to the region of the mass-space probed. For the three-body selection these events are selected according to super-razor [5] techniques. Finally, for the four-body selection the leading jet, assumed to be an ISR jet boosting the system, is required to have $p_T > 150\,\text{GeV}$, while a third jet (if present) must satisfy $p_T(j_3)/E_T^{\text{miss}} < 0.14$.

The main backgrounds are events where the leptons come from the decays of dibosons, $t\bar{t}$, $t\bar{t} + Z$ and Z+jets. For these backgrounds the prediction coming from Monte Carlo simulations is normalized in Control Regions using a semi-data-driven procedure [6]. Contributions coming from fake and non-prompt leptons are derived from data using the Matrix Method. In all the regions analyzed no significant excess is observed with respect to the background-only hypothesis, therefore new limits on the SUSY particles masses have been set. These are reported in fig. 1(a) and (b) considering the simplified SUSY model analyzed and interpreted as limit on the Minimal Supersymmetric Standard Model (pMSSM) [7] in fig. 1(c).

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