Search for top squarks and dark matter particles in opposite-charge dilepton final states at $\sqrt{s} = 13$ TeV

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A search for new physics is presented in final states with two oppositely charged leptons (electrons or muons), jets identified as originating from b quarks, and missing transverse momentum ($p_{\mathrm{T}}^{\mathrm{miss}}$). The search uses proton-proton collision data at $\sqrt{s} = 13$ TeV amounting to 35.9 fb^{-1} of integrated luminosity collected using the CMS detector in 2016. Hypothetical signal events are efficiently separated from the dominant $t\bar{t}$ background with requirements on $p_{\mathrm{T}}^{\mathrm{miss}}$ and transverse-mass variables. No significant deviation is observed from the expected background. Exclusion limits are set in the context of simplified supersymmetric models with pair-produced top squarks. For top squarks, decaying exclusively to a top quark and a neutralino, exclusion limits are placed at 95% confidence level on the mass of the lightest top squark up to 800 GeV and on the lightest neutralino up to 360 GeV. These results, combined with searches in the single-lepton and all-jet final states, raise the exclusion limits up to 1050 GeV for the lightest top squark and up to 500 GeV for the lightest neutralino. For top squarks undergoing a cascade decay through charginos and sleptons, the mass limits reach up to 1300 GeV for top squarks and up to 800 GeV for the lightest neutralino. The results are also interpreted in a simplified model with a dark matter (DM) particle coupled to the top quark through a scalar or pseudoscalar mediator. For light DM, mediator masses up to 100 (50) GeV are excluded for scalar (pseudoscalar) mediators. The result for the scalar mediator achieves some of the most stringent limits to date in this model.

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I. INTRODUCTION

The top quark couples to the Higgs boson more strongly than other fermions because of its large mass. As a result, it plays a prominent role in the so-called hierarchy problem [1,2] of the standard model (SM) of particle physics, since its dominant contribution in the loop corrections to the Higgs boson mass exposes the theory to higher energy scales present in nature. Supersymmetry (SUSY) [3–10] is a well-motivated theory beyond the SM that provides a solution to the hierarchy problem. In addition, in R-parity conserving SUSY [11], the lightest SUSY particle (LSP) is stable and can be a viable dark matter (DM) candidate, assuming it is neutral and weakly interacting. Presently, the lighter SUSY particles may have masses in the TeV range and therefore could be produced in proton-proton (pp) collisions at the CERN LHC. The scalar partners of the right- and left-handed top quarks, the top squarks $\tilde{t}_R$ and $\tilde{t}_L$, can be among these particles. These two states mix into the mass eigenstates $\tilde{t}_1$ and $\tilde{t}_2$. The lighter one, $\tilde{t}_1$, could be within the LHC energy reach to provide a natural solution to the hierarchy problem [12], which strongly motivates searches for top squark production.

In this paper, we present a search for top squark pair production in a final state with two leptons (electrons or muons), hadronic jets identified as originating from b quarks, and significant transverse momentum imbalance. The search is performed using data from pp collisions collected with the CMS detector at the LHC during 2016 at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 35.9 fb^{-1}. We employ an efficient background reduction strategy that suppresses the large background from SM $t\bar{t}$ events by several orders of magnitude through use of dedicated transverse-mass variables [13,14]. The predicted SM backgrounds in the various search regions are validated in data control samples orthogonal in selection to the signal regions in data.

The search is interpreted in simplified models [15–17] describing the strong production of pairs of top squarks. We consider different decay modes, following the naming convention in Ref. [18]. In the T2tt model (Fig. 1, upper left), each top squark decays into a top quark and the lightest neutralino $\tilde{\chi}_1^0$, which is the LSP. Alternatively, we consider the T2bW model (Fig. 1, upper right), where both top squarks decay into a b quark and an intermediate

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