Eur. Phys. J. C (2017) 77:578
DOI 10.1140/epjc/s10052-017-5079-z

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Search for physics beyond the standard model in events with two leptons of same sign, missing transverse momentum, and jets in proton–proton collisions at $\sqrt{s} = 13$ TeV

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Received: 24 April 2017 / Accepted: 18 July 2017 / Published online: 1 September 2017

Abstract A data sample of events from proton–proton collisions with two isolated same-sign leptons, missing transverse momentum, and jets is studied in a search for signatures of new physics phenomena by the CMS Collaboration at the LHC. The data correspond to an integrated luminosity of 35.9 fb^{-1}, and a center-of-mass energy of 13 TeV. The properties of the events are consistent with expectations from standard model processes, and no excess yield is observed. Exclusion limits at 95% confidence level are set on cross sections for the pair production of gluinos, squarks, and same-sign top quarks, as well as top-quark associated production of a heavy scalar or pseudoscalar boson decaying to top quarks, and on the standard model production of events with four top quarks. The observed lower mass limits are as high as 1500 GeV for gluinos, 830 GeV for bottom squarks. The excluded mass range for heavy (pseudo)scalar bosons is 350–360 (350–410) GeV. Additionally, model-independent limits in several topological regions are provided, allowing for further interpretations of the results.

1 Introduction

Final states with two leptons of same charge, denoted as same-sign (SS) dileptons, are produced rarely by standard model (SM) processes in proton–proton (pp) collisions. Because the SM rates of SS dileptons are low, studies of these final states provide excellent opportunities to search for manifestations of physics beyond the standard model (BSM). Over the last decades, a large number of new physics mechanisms have been proposed to extend the SM and address its shortcomings. Many of these can give rise to potentially large contributions to the SS dilepton signature, e.g., the production of supersymmetric (SUSY) particles [1,2], SS top quarks [3,4], scalar gluons (sgluons) [5,6], heavy scalar bosons of extended Higgs sectors [7,8], Majorana neutrinos [9], and vector-like quarks [10].

In the SUSY framework [11–20], the SS final state can appear in R-parity conserving models through gluino or squark pair production when the decay of each of the pair-produced particles yields one or more W bosons. For example, a pair of gluinos (which are Majorana particles) can give rise to SS charginos and up to four top quarks, yielding signatures with up to four W bosons, as well as jets, b quark jets, and large missing transverse momentum ($E_{\mathrm{T}}^{\mathrm{miss}}$). Similar signatures can also result from the pair production of bottom squarks, subsequently decaying to charginos and top quarks.

While R-parity conserving SUSY models often lead to signatures with large $E_{\mathrm{T}}^{\mathrm{miss}}$, it is also interesting to study final states without significant $E_{\mathrm{T}}^{\mathrm{miss}}$ beyond what is produced by the neutrinos from leptonic W boson decays. For example, some SM and BSM scenarios can lead to the production of SS or multiple top quark pairs, such as the associated production of a heavy (pseudo)scalar, which subsequently decays to a pair of top quarks. This scenario is realized in Type II two Higgs doublet models (2HDM) where associated production with a single top quark or a $\mathrm{t\bar{t}}$ pair can in some cases provide a promising window to probe these heavy (pseudo)scalar bosons [21–23].

This paper extends the search for new physics presented in Ref. [24]. We consider final states with two leptons (electrons and muons) of same charge, two or more hadronic jets, and moderate $E_{\mathrm{T}}^{\mathrm{miss}}$. Compared to searches with zero or one lepton, this final state provides enhanced sensitivity to low-momentum leptons and SUSY models with compressed mass spectra. The results are based on an integrated luminosity corresponding to 35.9 fb^{-1} of $\sqrt{s} = 13$ TeV proton–proton collisions collected with the CMS detector at the CERN LHC. Previous LHC searches in the SS dilepton channel have been performed by the ATLAS [25–27] and CMS [24,28–32] Collaborations. With respect to Ref. [24], the event categoriza-

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tracts Harmonia 2014/14/M/ST2/00428, Opus 2014/13/B/ST2/02543, 2014/15/B/ST2/03998, and 2015/19/B/ST2/02861, Sonata-bis 2012/07/E/ST2/01406; the National Priorities Research Program by Qatar National Research Fund; the Programa Clarín-COFUND del Principado de Asturias; the Thalis and Aristeia programs cofinanced by EU-ESF and the Greek NSRF; the Rachadapisek Sompot Fund for Postdoctoral Fellowship, Chulalongkorn University and the Chulalongkorn Academic into Its 2nd Century Project Advancement Project (Thailand); and the Welch Foundation, contract C-1845.

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