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Search for new physics in events with opposite-sign leptons, jets, and missing transverse energy in pp collisions at $\sqrt{s} = 7$ TeV

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ABSTRACT

A search is presented for physics beyond the standard model (BSM) in final states with a pair of opposite-sign isolated leptons accompanied by jets and missing transverse energy. The search uses LHC data recorded at a center-of-mass energy $\sqrt{s} = 7$ TeV with the CMS detector, corresponding to an integrated luminosity of approximately 5 fb^{-1}. Two complementary search strategies are employed. The first probes models with a specific dilepton production mechanism that leads to a characteristic kinematic edge in the dilepton mass distribution. The second strategy probes models of dilepton production with heavy, colored objects that decay to final states including invisible particles, leading to very large hadronic activity and missing transverse energy. No evidence for an event yield in excess of the standard model expectations is found. Upper limits on the BSM contributions to the signal regions are deduced from the results, which are used to exclude a region of the parameter space of the constrained minimal supersymmetric extension of the standard model. Additional information related to detector efficiencies and response is provided to allow testing specific models of BSM physics not considered in this Letter.

1. Introduction

In this Letter we describe a search for physics beyond the standard model (BSM) in events containing a pair of opposite-sign leptons, jets, and missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$), in a sample of proton–proton collisions at a center-of-mass energy of 7 TeV. The data sample was collected with the Compact Muon Solenoid (CMS) detector [1] at the Large Hadron Collider (LHC) in 2011 and corresponds to an integrated luminosity of 4.98 fb^{-1}. This is an update and extension of a previous analysis performed with a data sample of 34 pb^{-1} collected in 2010 [2].

The BSM signature in this search is motivated by three general considerations. First, new particles predicted by BSM physics scenarios are expected to be heavy in most cases, since they have so far eluded detection. Second, BSM physics signals may be produced with large cross section via the strong interaction, resulting in significant hadronic activity. Third, astrophysical evidence for dark matter suggests [3–6] that the mass of weakly-interacting massive particles is of the order of the electroweak symmetry breaking scale. Such particles, if produced in proton–proton collisions, could escape detection and give rise to an apparent imbalance in the event transverse energy. The analysis therefore focuses on the region of high $E_{\mathrm{T}}^{\mathrm{miss}}$. An example of a specific BSM scenario is provided by R-parity conserving supersymmetric (SUSY) models, in which the colored squarks and gluinos are pair-produced and subsequently undergo cascade decays, producing jets and leptons [7,8]. These cascade decays may terminate in the production of the lightest SUSY particle (LSP), often the lightest neutralino, which escapes detection and results in large $E_{\mathrm{T}}^{\mathrm{miss}}$. This LSP is a candidate for a dark matter weakly-interacting massive particle. Another BSM scenario which may lead to similar signatures is the model of universal extra dimensions (UED) [9].

The results reported in this Letter are part of a broad program of BSM searches in events with jets and $E_{\mathrm{T}}^{\mathrm{miss}}$, classified by the number and type of leptons in the final state. Here we describe a search for events containing an opposite-sign isolated lepton pair in addition to jets and $E_{\mathrm{T}}^{\mathrm{miss}}$. We reconstruct electrons and muons, which provide a clean signature with low background. In addition, we reconstruct τ leptons in their hadronic decay modes to improve the sensitivity to models with enhanced coupling to third generation particles. Complementary CMS searches with different final states have already been reported, for example in Refs. [10,11]. Results from the ATLAS Collaboration in this final state using approximately 1–2 fb^{-1} have been reported in Refs. [12,13].

The analysis strategy is as follows. In order to select dilepton events, we use a preselection based on that of the CMS top quark pair ($\mathrm{t\bar{t}}$) cross section measurement in the dilepton channel [14]; the details of this preselection are presented in Section 3. Reasonable agreement is found between the observed yields in data and the predictions from standard model (SM) Monte Carlo

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