Search for New Physics with Same-Sign Isolated Dilepton Events with Jets and Missing Transverse Energy

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A search for new physics is performed in events with two same-sign isolated leptons, hadronic jets, and missing transverse energy in the final state. The analysis is based on a data sample corresponding to an integrated luminosity of 4.98 fb^{-1} produced in pp collisions at a center-of-mass energy of 7 TeV collected by the CMS experiment at the LHC. This constitutes a factor of 140 increase in integrated luminosity over previously published results. The observed yields agree with the standard model predictions and thus no evidence for new physics is found. The observations are used to set upper limits on possible new physics contributions and to constrain supersymmetric models. To facilitate the interpretation of the data in a broader range of new physics scenarios, information on the event selection, detector response, and efficiencies is provided.

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The standard model (SM) is a very successful theory of elementary particles and their interactions. It is generally believed that new physics (NP) could manifest itself at the TeV scale. Supersymmetry (SUSY) is one of these attractive possibilities. It leads to gauge coupling unification at very high energy, provides a mechanism to mitigate large radiative corrections to the Higgs mass and, in its R-parity-conserving [1] realization, can provide a dark matter candidate. A comprehensive program of searches for the production of supersymmetric particles has been underway since 2010 at the Large Hadron Collider (LHC). Since SUSY models vary widely, these searches target a broad range of possible final states, including purely hadronic states [2,3], leptonic states with one lepton [4,5], two leptons of the opposite sign [6,7], two leptons of the same sign [6,8], and three or more leptons [9], as well as photonic final states [10,11].

In this Letter we report on a search for NP based on isolated same-sign (SS) dileptons, missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$), and hadronic jets. In SUSY SS dileptons can arise, for example, from pair production of colored superpartners (gluinos and/or squarks), with a lepton in the decay chain of each primary SUSY particle [12–14]; more generally, this signature is sensitive to final states with same-sign W bosons and/or top quarks [15–20]. The rarity of SS dileptons in the SM makes a NP search in this final state particularly attractive.

All types of charged leptons, e, μ, and hadronically decaying τs, are included in our search. These final states are indicators of the possible presence of SUSY particles as well as other possible NP scenarios. The results are based on a data sample corresponding to $4.98 \pm 0.11\ \mathrm{fb}^{-1}$ of pp collisions at a center-of-mass energy of 7 TeV collected in 2011 by the Compact Muon Solenoid (CMS) [21] experiment at the LHC. This study results in a major improvement in sensitivity with respect to the search performed with data collected in 2010 [8] because of the 140-fold increase in the integrated luminosity of the data sample. These results are interpreted using the constrained minimal supersymmetric extension of the standard model (CMSSM) [22]. In addition, this analysis provides information on the event selection and detector response in order to facilitate the application of our results to a broader range of NP scenarios.

A detailed description of the CMS detector is found elsewhere [21]. Its central feature is a superconducting solenoid providing an axial magnetic field of 3.8 T. Muons are measured in gas detectors embedded in the steel return yoke of the magnet, while all other particle detection systems are located inside the bore of the solenoid. Charged particle trajectories are measured by a silicon pixel and strip tracker system, covering $|\eta| < 2.5$, where the pseudorapidity is defined as $\eta = -\ln[\tan\theta/2]$, and θ is the polar angle with respect to the counterclockwise beam direction. A crystal electromagnetic calorimeter (ECAL) and a brass-scintillator hadronic calorimeter surround the tracker volume. In addition, the CMS detector has an extensive forward calorimeter and nearly hermetic 4π coverage. The CMS trigger consists of a two-stage system. The first level of the CMS trigger system, composed of custom hardware processors, uses information from the calorimeters and muon detectors to select a subset of the events. The high level trigger processor farm further decreases the event rate from around 100 kHz to around 300 Hz, before data storage.

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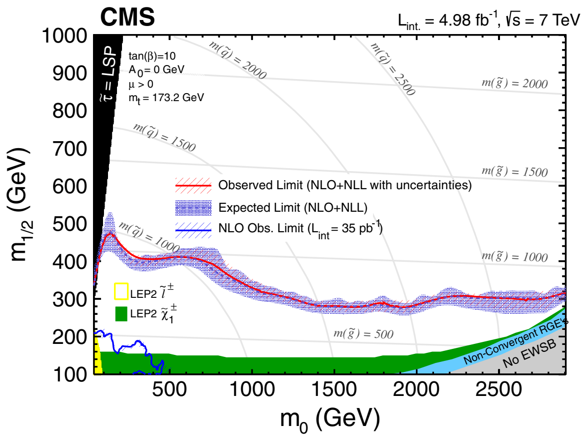

FIG. 3 (color online). Exclusion region, below the red curve, in the CMSSM corresponds to the observed upper limits on the number of events from NP. The central observed curve, which includes experimental uncertainties, is obtained using high p_T leptons with $H_T > 450$ GeV and $E_T^{miss} > 120$ GeV. The hatched region corresponds to the theoretical uncertainties on the cross section, whereas the shaded region shows the experimental errors with $\pm 1\sigma$ variation. We also show the result of the previous analysis [8] to illustrate the improvement.

123 GeV, 37 GeV), respectively. We tested the parameterized efficiency model in the CMSSM, and the results obtained agree at the 15% level with the full simulation results.

In summary, we conducted a search for physics beyond the standard model based on same-sign dileptons in the ee, $\mu\mu$, $e\mu$, $e\tau$, $\mu\tau$, and $\tau\tau$ final states, and find no evidence for an excess over the expected standard model background. We set 95% CL upper limits on contributions from new physics processes based on an integrated luminosity of 4.98 fb^{-1} in the range of 6.2 to 16.9 events, depending on the signal search region. These are the most restrictive limits in this particular final state to date. We have also shown the excluded region in the CMSSM parameter space.

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