Search for supersymmetry in events with opposite-sign dileptons and missing transverse energy using an artificial neural network

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In this paper, a search for supersymmetry (SUSY) is presented in events with two opposite-sign isolated leptons in the final state, accompanied by hadronic jets and missing transverse energy. An artificial neural network is employed to discriminate possible SUSY signals from a standard model background. The analysis uses a data sample collected with the CMS detector during the 2011 LHC run, corresponding to an integrated luminosity of 4.98 fb^{-1} of proton-proton collisions at the center-of-mass energy of 7 TeV. Compared to other CMS analyses, this one uses relaxed criteria on missing transverse energy ($\not{E}_T > 40$ GeV) and total hadronic transverse energy ($H_T > 120$ GeV), thus probing different regions of parameter space. Agreement is found between standard model expectation and observations, yielding limits in the context of the constrained minimal supersymmetric standard model and on a set of simplified models.

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I. INTRODUCTION

One of the most natural extensions of the standard model (SM) of particle physics is supersymmetry (SUSY) [1–8]. Supersymmetry allows for gauge coupling unification at the energy of 10^{16} GeV, provides a good dark matter candidate [lightest supersymmetric particle (LSP)] [9], is a necessary component to explain quantum gravity in the framework of string theory, and automatically cancels the quadratic divergences in radiative corrections to the Higgs boson mass. For every particle in the standard model, SUSY introduces a superpartner, the "sparticle," with spin differing by 1/2 unit from the SM particle. There are theoretical arguments that suggest sparticle masses could be less than $\sim$1 TeV [7,8] making the experiments at the Large Hadron Collider (LHC) an ideal place for their discovery.

With the successful 2011 LHC run, an integrated luminosity of 4.98 fb^{-1} in collisions at 7 TeV center-of-mass energy has been collected with the Compact Muon Solenoid (CMS) experiment. This data set is used to search for the presence of SUSY particles in events with two opposite-sign leptons (electrons and muons) in the final state, utilizing an artificial neural network (ANN). Two opposite-sign leptons can be produced in a SUSY cascade through the decay of neutralinos and charginos. Assuming that R parity is conserved [10], a stable, weakly interacting LSP exists, resulting in a missing transverse energy ($\not{E}_T$) signature. The amount of missing transverse energy depends on the mass splittings among the heavier sparticles. So far, typical dilepton SUSY searches in CMS have required several jets with large transverse momentum, which correspond to large values of H_T, the scalar sum over the transverse momenta of all jets satisfying the jet selection, and large missing transverse energy to discriminate a SUSY signal from the very large SM backgrounds. Compared with previous CMS searches [11,12], this analysis uses relaxed criteria on missing transverse energy ($\not{E}_T > 40$ GeV) and H_T ($H_T > 120$ GeV). For SUSY models that yield events with large $\not{E}_T$, the ANN's performance is comparable to the data analyses using large $\not{E}_T$ and H_T. Hence, for such models the additional power of a multivariate technique is not required to discriminate between new physics and the SM backgrounds. However, for SUSY models that yield low-$\not{E}_T$ or low-H_T signatures, the discriminating power of the ANN helps to suppress the large SM backgrounds.

The results are interpreted in the context of the constrained minimal supersymmetric standard model (CMSSM [13,14]), and a class of simplified model scenarios (SMS) [15,16]. For illustration purposes, the benchmark CMSSM point LM6 ($m_0 = 85$ GeV, $m_{1/2} = 400$ GeV, $\tan\beta = 10$, $A_0 = 0$ GeV) is used throughout the paper. In the class of SMS considered, gluinos are pair produced, with one of them decaying as $\tilde{g} \to \tilde{\chi}_2^0 jj \to \tilde{\chi}_1^0 \ell^+ \ell^- jj$ and the other as $\tilde{g} \to \tilde{\chi}_2^0 jj$. Here $\tilde{\chi}_2^0$ is the second-lightest neutralino, $\tilde{\chi}_1^0$ is the lightest neutralino, and the LSP, and $\ell = e$, μ, or τ with equal probability. This SMS thus always leads to a pair of opposite-sign leptons in the final state, in addition to the jets and $\not{E}_T$. The SMS is fully described by the following parameters: the masses of the gluino ($m_{\tilde{g}}$), and the LSP (m_{LSP}), along with the neutralino mass in the gluino decay which is set to $m_{\tilde{\chi}_2^0} = (m_{\tilde{g}} + m_{\mathrm{LSP}})/2$.

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