SUSY sensitivity and discovery potential using dileptons at $\sqrt{s} = 7$ TeV

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Abstract

SUSY sensitivity and discovery discovery potential using dileptons at $\sqrt{s} = 7$ TeV is presented in this note. The mass reach as well as CMS sensitivity to several regions in parameter space is evaluated within the framework of minimal supergravity and assuming R-parity conservation. These studies are performed for inclusive searches involving same and opposite sign dileptons. The new physics is characterized by large $\not\!\!E_T$ and significant hadronic activity. The study shows significant sensitivity in several regions in the parameters space with 100 pb^{-1} and 1 fb^{-1} of integrated luminosity.

1 Introduction

In this note, we present the results of CMS sensitivity to SUSY as well as mass reach in the mSUGRA framework with R-parity conservation. This model is characterized by five free parameters described as follows:

- m_0: the common scalar mass at the GUT scale;
- $m_{1/2}$: the common gaugino mass at the GUT scale;
- A_0: the common soft trilinear SUSY breaking parameter at the GUT scale;
- tanβ: the ratio of the Higgs vacuum expectation values at the electroweak scale;
- sign μ: the sign of the Higgsino mass term.

We set $A_0 = 0$, sign$\mu > 0$ and tan$\beta = 3$ in order to be able to directly compare with the recent Tevatron results [xx]. The gluino-squark mass plane is then scanned via variations of m_0 and $m_{1/2}$ parameters. In this framework, all supersymmetric particles except the neutralino are unstable and thus will decay into their SM counterparts right after being produced. This cascade decay will result in dilepton final states associated with several jets, plus missing transverse energy ($\not\!\!E_T$) from the LSP.

The note is organized as follows. In Section 2 we list the Monte Carlo data samples, as well as the software tags used in this analysis. In Section 3 we describe the same (SS) and opposite (OS) sign dilepton event selection used in this study. The statistical procedure used for exclusion as well as the discovery potential is summarized in Section 4. In Section 5 we discuss the exclusion limits and mass reach using SS dileptons followed by similar study involving OS dileptons in Section 6. Finally, in Section 7 we summarize the results.

2 Data Samples

This study is based on the 3_1_X reco full simulation SM background samples listed in Table 1. The Standard Model (SM) data sets have been normalized to the cross-sections [1]; for the SUSY parameter scan studies, we have used 3_3_6 reco fast simulation data set [3]. In this data set several benchmark point are produced using fixed $A_0 = 0$, tan$\beta = 3$, sign $\mu > 0$ but with varying $m_0(0 - 2000)$ and $m_{1/2}(100 - 600)$ on a grid of 50 and 20 GeV steps, respectively.

/WW/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/WZ/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/ZZ/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Wenu/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Wmunu/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Wtaunu/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Zee/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Zmumu/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/Ztautau/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/TTbar/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/SingleTop_sChannel-madgraph/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/SingleTop_tChannel-madgraph/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/SingleTop_tWChannel-madgraph/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO
/TANB3_CMSW336FASTv0JetID/spadhi-TANB3_CMSW336FASTv0JetID-*/USER

Table 1: The data sets used in this study.

The Monte Carlo events were analyzed with CMSSW_3_3_6 with the additional tags listed in Table 2.

3 Event Selection

The event selection used is not optimized for any specific SUSY scenario. It is based on small modifications to the dilepton event selections that we used in recently approved WW [4] and $t\bar{t}$ [5] cross-section analyses. A quick summary of the event selection is:

V00-03-04 RecoEgamma/EgammaTools
V03-00-12-13 RecoMET/METProducers
V00-02-07-15 RecoMET/METAlgorithms
V00-06-10-02 RecoMET/Configuration
V03-01-01-04 DataFormats/METReco
V00-05-38 RecoEcal/EgammaCoreTools
V01-08-23-05 JetMETCorrections/Configuration
V01-08-08-09 CondFormats/JetMETObjects
V02-06-03 HLTrigger/HLTcore

Table 2: Additional software tags used in this study.

- The event is required to pass the single e or μ triggers.
- Two isolated, same or opposite sign leptons (ee, $e\mu$, and $\mu\mu$).
- Leptons must have $P_T > 10$ GeV, $|\eta| < 2.4$ and at least one of them must have $P_T > 20$ GeV.
- For SS analyses, we veto the candidate lepton, if an extra lepton in the event, pairs with the candidate lepton to form a Z within the mass range between $76 < m_{\ell\ell}$ (GeV) < 106. This requirement is designed to reject WZ events.
- At least three L2L3 corrected caloJets with $P_T > 30$ GeV and $|\eta| < 2.4$.
- The scalar sum of the P_T of all jets passing the requirements above should be > 200 GeV.
- We require $\not\!\!E_T > 80$ GeV.
- ——— NEED TO OUTLINE THE OS SELECTION AS WELL HERE IN SOME DETAILS ———-

The details of the lepton and trigger selections are given below.

3.1 Electron Selection

- The electron ID is the "e-gamma category based looseID".
- No muon candidate within $\Delta R < 0.1$.
- $|d_0| < 200$ μm (corrected for beamspot).
- Iso < 0.1, where Iso=Sum/Max(20 GeV, P_T), and Sum = tkIso + hcalIso + Max(0 GeV, ecalIso - 2GeV). All isolation sums are the standard sums used in release 3_1_X from the egamma group (cone of 0.4 for ecal, jurassic, rec-hit based; cone of 0.3 for tracker, and cone of 0.4 for hcal).
- Conversion rejection [**?**] using tracks within cone of 0.3 of the candidate electron for SS studies:
  - $|\Delta \cot\theta| < 0.02$; the difference between cotangent polar angles of tracks parallel to each other.
  - $|d_{2d}| < 0.02$ cm; the two dimensional distance between points within nearest tracks.
  - The charge of the associated GSF and CTF tracks must be consistent. If the CTF track is not reconstructed, the electron is kept.

3.2 Muon Selection

- Must be a global muon **and** a tracker muon [6].
- GlobalMuonPromptTight (global χ^2/ndof$<$10) [7].
- At least 11 valid hits for the silicon track [7].
- $|d_0| < 200$ μm (from silicon track, corrected for beamspot).
- Global fits must have hits in the muon chambers.

- Minimum ionizing: EcalVetoEnergy < 4 GeV and HcalVetoEnergy < 6 GeV [**?**].
- Iso < 0.1, where Iso=Sum/Max(20 GeV, P_T), and Sum = tkIso + hcalIso + ecalIso. All isolation sums are the standard sums stored in the muon object in release 3_1_X, and are calculated in a cone of 0.3.

3.3 Trigger Selection

We use inclusive lepton triggers with no isolation, $i.e.$, the logical OR of `HLT_Ele15_SW_L1R` and `HLT_Mu9`. The combined trigger efficiency is $\sim$ 99% for dilepton events that pass the event selection. These triggers are expected to be present in the data taking trigger table.

4 Statistical Methods

5 Same Sign Dileptons

6 Opposite Sign Dileptons

7 Conclusion

References

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[4] "Prospects for measuring the WW production cross section in pp collisions at $\sqrt{s}$ =10 TeV", CMS AN-2009/042 and PAS EWK-09-002.

[5] "Expectations for observation of top quark pair production in the dilepton final state with the early CMS data", CMS AN-2009/050 and PAS TOP-09-002.

[6] https://hypernews.cern.ch/HyperNews/CMS/get/muon/258.html.

[7] "Muon Identification in CMS", CMS AN-2008/098.

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[9] "Data driven background study for new physics searches with same sign dileptons at $\sqrt{s} = 10$ TeV", CMS AN-2009/138.

[10] "Data driven background estimate for a new physics search with opposite sign dileptons", CMS AN-2009/130.