The Compact Muon Solenoid Experiment

Conference Report

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Search for non-standard SUSY signatures in CMS

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Abstract

New studies of the CMS collaboration are presented on the sensitivity to searches for non-standard signatures of particular SUSY scenarios. These signatures include non-pointing photons as well as pairs of prompt photons as expected in GMSB SUSY models, as well as heavy stable charged particles produced in split supersymmetry models, long lived staus from GMSB SUSY and long lived stops in other SUSY scenarios. Detailed detector simulation is used for the study, and all relevant Standard Model background and detector effects that can mimic these special signatures are included. It is shown that with luminosities as low as 100 pb^{-1} CMS will probe an interesting and so far unexplored parameter range of these models.

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1 Two photon searches in GMSB

1.1 mGMSB model

The minimal Gauge Mediated Supersymmetry Breaking (mGMSB)[1] model, with supersymmetry (SUSY)[2][3] breaking transmitted via gauge interactions (from hidden sector to visible sector), is an alternative to the minimal supergravity (mSUGRA) scenario. The six parameters to define the model could be summarized as : M_m (messenger mass scale), N_m (number of SU(5) messenger multiplets), C_{grav} (NLSP lifetime), $\tan\beta$ (ratio of the vacuum expectation values of the two Higgs fields), $\text{sign}(\mu)$ (sign of the Higgsino mass term) and Λ (SUSY breaking scale). There are some sets of parameters that give the neutralino as the Next Lightest Supersymmetric Particle (NLSP) and the gravitino as the Lightest Supersymmetric Particle (LSP). In such a case, the branching ratio of the decay of the neutralino into a gravitino and a photon could be higher than 80%. As sparticles are produced in pairs, the final states will contain two photons with high p_T , and large missing transverse energy (MET) from the gravitino which is escaping the detector. The SUSY cascade that produced the initial neutralino will also give some hard p_T jets.

1.2 Selection

The selection follows the signal signature, using photon identification, MET and jets provided by the CMS detector[4]. First of all, the online selection will consist in choosing the trigger bit "single γ " in the high level trigger menu. Then a photon isolation requirement is applied, and also the momentum p_T (γ) should be greater than 80 GeV. The MET is large in this mGMSB signal, and a transverse missing momentum greater than 160 GeV was required. Finally four jets are demanded, each of them should have a transverse momentum greater than 50 GeV. Afterwards, an optimization splits the selection into two streams, depending whether the photon is pointing or non-pointing. Tab.1 summarizes the expected number of events, normalized using an integrated luminosity of 10 fb^{-1} .

These cuts are robust against the different Standard Model (SM) backgrounds, especially the QCD multijets and γ +jets, that could give the same final state due to the fake MET coming from the mismeasured jets. The $t\bar{t}$ and W+jets backgrounds were also considered, as an electron could be misidentified as a photon, and a large MET could come from the neutrinos.

Dataset	Preselection	Non-pointing $\gamma\gamma$	Pointing $\gamma\gamma$
GMSB $\Lambda = 140 \text{ TeV}$	402.3	2.96	289.4
Z+jets	0.65	0.00	0.37
W+jets	2.76	0.00	1.46
QCD	54.9	0.27	2.32
$t\bar{t}$ (incl.)	16.3	0.00	6.13
Σ backgrounds	74.7	0.27	10.27

Table 1: Number of events for GMSB signal and SM backgrounds

1.3 Results in mGMSB

The significance is estimated using a likelihood ratio method and toy experiments. Figure 1 shows the needed integrated luminosity to reach the 5σ discovery criteria, for Λ equals to 140 TeV. These results[5] are given as a function of the $c\tau$ parameter, and the three curves superimposed correspond to the pointing photons channel, the non-pointing photons channel and the combination of both channels. A 4 fb^{-1} integrated luminosity should be enough to cover the whole range of the flight path ($c\tau$) values.

2 HSCP searches

2.1 Different models

Several models predict different Heavy Stable Charged Particle (HSCP). Other sets of parameters in mGMSB model predict quasi-stable sleptons (stau) with masses greater than hundred GeV. Universal Extra Dimension (UED) models predict also such quasi-stable sleptons, as for all SM particles corresponds a so-called Kaluza-Klein (KK) state. The split SUSY (model with high scalar masses) permits also the existence of long lived gluino.

Figure 1: GMSB results in the two photons final state

Finally, the MSSM allows the light stop to be the NLSP, with the only possible decay of the stop into c quark and a chargino, and then a long lived stop. The HSCP could be lepton-like (stau) or hadron-like (gluino or stop). In the last case, gluino and stop will hadronize to form R-hadrons : R-baryons, R-mesons or R-glueball.

2.2 Detection techniques and measurement

The HSCP will appear with a muon-like signature, except that the velocity is lower compared to relativistic muons (for both lepton-like and R-hadrons), and there could be some charge flipping for the R-hadrons (trajectory modified and neutral R-hadrons not visible).

The β measurement will be done using two different techniques. First of all, the dE/dx could be measured in the inner tracker, and then β calculated using the relation $\beta^{-2} = k dE/dx$ with k measured from a proton sample. Another way is to use the muon system [6], calculating the time of flight, as a non relativistic particle will present delayed hits.

Once the β parameter is properly estimated, the HSCP mass can be calculated using the momentum measurement from the muon system.

2.3 Results for HSCP

The selection consists in a p_T muon cut at 30 GeV and an upper limit set at 0.8 for the β parameter measured in the tracker or in the muon system. All SM backgrounds and cosmic muons become negligible compared to the mGMSB stau, the KK stau, the stop and gluino signals.

Figure 2: HSCP results

Figure 2 presents on the left the needed integrated luminosity to get 3 events, while on the right two examples of expected mass distributions are given. The gluino and stop channels should be easily seen after the start-up, while the stau and KK channels need more integrated luminosity.

These results are consistent with the cross-sections of the different process. As shown in Tab.2, the cross-sections of the stop and gluinos could be very high, up to few hundred pb. The stau production is more modest, with only few pb. Finally the KK states have some residual cross-sections, of the order of few fb. More progress on HSCP searches in CMS can be found in Ref.[7].

Process	Cross-section (pb)
KK tau (300 GeV)	0.020
stau (247 GeV)	0.097
stop (200 GeV)	177
stop (500 GeV)	1.27
gluino (300 GeV)	100
gluino (600 GeV)	5.00

Table 2:

3 Conclusion

The two photons GMSB signal can be discovered at the start-up of the LHC. It would require an integrated luminosity of 1fb^{-1} to cover models with Λ lower than 200 TeV, while 100fb^{-1} are needed to go to Λ values of 300 TeV.

In HSCP searches, the high cross-sections give a discovery potential from the start-up of the LHC. Indeed the mGMSB staus or R-hadrons (stop or gluino) with masses up to a few hundred GeV could be seen in the first 100pb^{-1} . The KK states are more challenging but the discovery is still possible with more than 1fb^{-1} .

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