



Searches for supersymmetry at CMS in final states with photons

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Abstract

Four searches for supersymmetry at CMS in final states with photons are discussed in this article. The data analyzed corresponds to up to 19.7fb^{-1} and was recorded at centre-of-mass energies of 7 and 8 TeV by the CMS experiment. Searches in final states with photons are sensitive to various scenarios for physics beyond the standard model, especially gauge mediated supersymmetry breaking. To increase the sensitivity for various classes of models, four analyses with different selections and background estimation methods are performed. Wino-like neutralino mixing scenarios are probed in final states with at least one photon and jets, while final states with at least two photons are most sensitive to bino-like neutralino mixing scenarios. A higgsino-like neutralino scenario is studied by selecting two photons with an invariant mass close to the Higgs mass. While all of these analyses explore events with high missing transverse energy, a fourth analysis covers also final states with two photons and low missing transverse energy. No excess of data over the standard model expectation is observed, and upper limits on various signal cross sections are calculated.

Keywords:

search, supersymmetry, photon, CMS, GMSB, higgsino, stealth SUSY

1. Introduction

Searches for supersymmetry (SUSY) in final states with photons are especially sensitive to gauge mediated supersymmetry breaking (GMSB). As the lightest neutralino decays into a gravitino (\tilde{G}) and a standard model (SM) boson, the mixing of the lightest neutralino is important for the resulting final states. Three of the analyses presented here are optimized for the discovery of wino-, bino-, and higgsino-like neutralino scenarios, while the fourth analysis abandons the missing transverse energy (\cancel{E}_T) requirement and is sensitive to various other scenarios for physics beyond the SM. The data is recorded by the CMS experiment [1].

2. Final states with one or two photons and \cancel{E}_T

Events are selected with either a high energetic photon, hadronic activity, jets and \cancel{E}_T , or with two photons

and \cancel{E}_T [2]. The background of jets misidentified as photons and photon-jet production is estimated from a control sample with a photon-like jet instead of the photon. The ratio of selected events with photons to the control sample is propagated from events with low \cancel{E}_T to the signal region with high \cancel{E}_T . Kinematic dependencies of this ratio on photon p_T or the recoil against the photons are considered.

To estimate the background from electrons misidentified as photons, events with electrons instead of photons are selected and scaled by the probability of an electron faking a photon. This probability is measured using the $Z \rightarrow ee$ resonance. For the single-photon analysis, initial and final state radiation is estimated using simulation. Figure 1 shows the event yields, background prediction and two signal scenarios for both signal selections.

No evidence for physics beyond the SM is found, and multiple statistically independent bins in \cancel{E}_T are used to calculate limits at 95% confidence level using data

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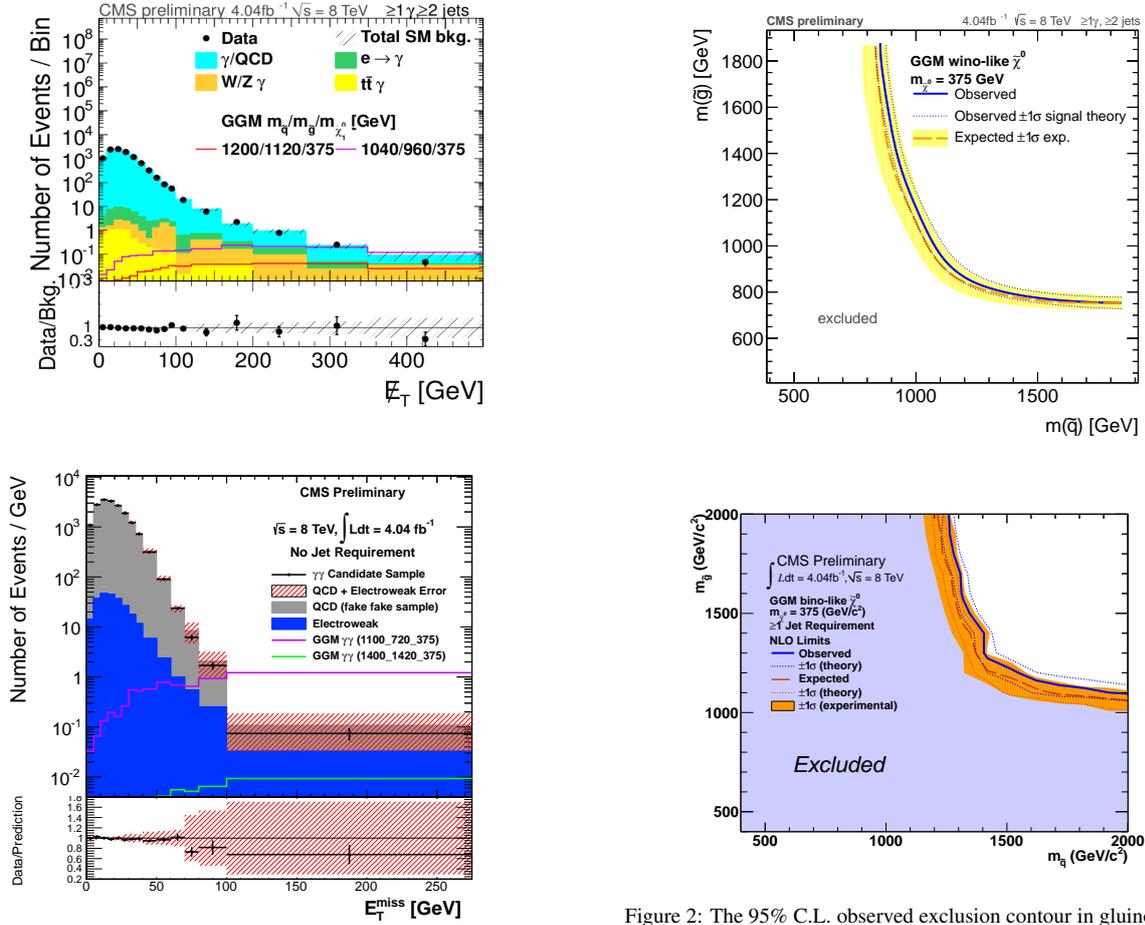


Figure 1: Total standard model background prediction compared to the number of single-photon events (top) and di-photon events (bottom), including signal benchmark points where the masses ($m_{\tilde{q}}/m_{\tilde{g}}/m_{\tilde{\chi}_1^0}$) are given in GeV in the plots.

corresponding to 4.04 fb^{-1} . The event yields are interpreted for bino- and wino-like neutralino scenarios in the gluino-squark mass space in the general gauge mediation framework. The exclusion contours are shown in Fig. 2.

3. Final states with a Higgs boson and E_T

Events containing two photons with an invariant mass close to the Higgs mass and two b-jets are selected [3]. To increase the sensitivity, these events are categorized with respect to having an additional b-jet, or the invariant mass of two b-jets being close to the Higgs mass. The background is estimated by a fit in the sidebands of

Figure 2: The 95% C.L. observed exclusion contour in gluino-squark mass space for wino-like neutralino for the single photon analysis (top) and for bino-like neutralino for the di-photon analysis (bottom).

the invariant mass spectrum of the di-photon system, as shown in Fig. 3.

The 95% confidence limits are calculated in bins of E_T and combined for all event categories for higgsino-like neutralinos in the stop-higgsino mass plane. The cross section limit and the exclusion contour is shown in Fig. 4 for data corresponding to 19.7 fb^{-1} . Stop masses of 370 GeV and below are excluded.

4. Final states with two photons

A search without E_T requirement can be sensitive to extra dimensions, heavy-flavor compositeness, little Higgs, R-parity violation, GMSB and stealth SUSY [4]. Events with two photons, at least four jets and the scalar sum S_T of the transverse momenta of all jets, photons and E_T larger than 700 GeV are selected. The signal region is separated into events with exactly four jets and five or more jets.

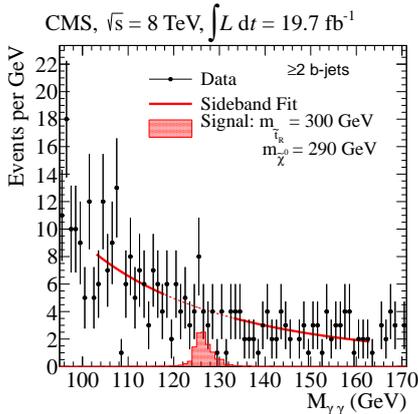


Figure 3: Invariant mass of two photons. Events with an invariant mass smaller than 118 GeV or larger than 133 GeV are used to estimate the background using a fit. A hypothetical signal is drawn in addition.

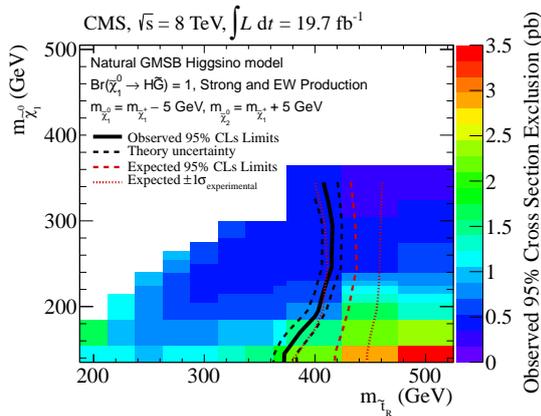


Figure 4: Limits on SUSY production cross sections for different top squark and higgsino masses. The regions to the left of the contours are expected (thick dashed red) and observed (solid black curves) to be excluded at the 95% confidence level.

To estimate the background, two control regions are defined: A “jet multiplicity sideband” (JMSB) composed of events with two or three jets and $S_T > 600$ GeV, and a “ S_T sideband” with four or more jets and $600 < S_T < 700$ GeV. Since the shape of the S_T -spectrum was found to be independent of the jet multiplicity, the S_T shape is taken from the JMSB and the normalization is taken from the S_T sideband. The S_T distribution, the background estimation, and a signal are shown in Fig. 5.

In Fig. 6, limits on stealth SUSY [5] cross sections as function of the squark mass are compared to the predicted stealth SUSY cross section for data corresponding to 4.96 fb^{-1} at a centre-of-mass energy of 7 TeV.

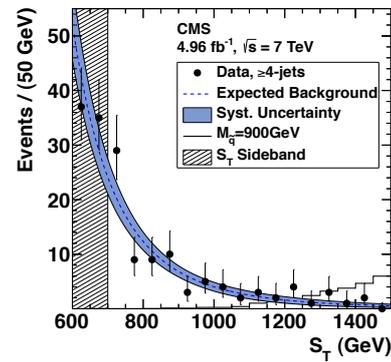


Figure 5: Observed S_T spectrum, background expectation with systematic uncertainty, and predicted signal for a squark mass of 900 GeV in events with four or more jets.

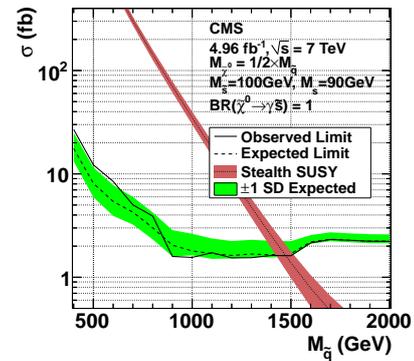


Figure 6: Stealth SUSY cross-section limit at the 95% CL as a function of $M_{\tilde{q}}$. The observed limit, median expected limit, and the prediction for a stealth SUSY model is shown.

Squark masses below 1400 GeV are excluded in this scenario.

References

- [1] S. Chatrchyan, et al., The CMS experiment at the CERN LHC, JINST 3 (2008) S08004. doi:10.1088/1748-0221/3/08/S08004.
- [2] CMS Collaboration, Search for supersymmetry in events with photons and missing energy, CMS-PAS-SUS-12-018 (2012).
- [3] S. Chatrchyan, et al., Search for top squark and higgsino production using diphoton Higgs boson decays, Phys.Rev.Lett. 112 (2014) 161802. arXiv:1312.3310, doi:10.1103/PhysRevLett.112.161802.
- [4] S. Chatrchyan, et al., Search for supersymmetry in events with photons and low missing transverse energy in pp collisions at $\sqrt{s} = 7$ TeV, Phys.Lett. B719 (2013) 42–61. arXiv:1210.2052, doi:10.1016/j.physletb.2012.12.055.
- [5] J. Fan, M. Reece, J. T. Ruderman, Stealth Supersymmetry, JHEP 1111 (2011) 012. arXiv:1105.5135, doi:10.1007/JHEP11(2011)012.