PROCEEDINGS OF SCIENCE

SUSY searches in events with two opposite-sign same-flavor leptons, jets and MET with the CMS detector

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Searches for Supersymmetry (SUSY) in events with two opposite-sign same-flavour leptons offer sensitivity to the production of sleptons or Z bosons in the cascade decays of initially produced heavy SUSY particles. In the considered models, this signature is accompanied by the presence of several jets and high missing transverse energy. Analysing their respective datasets recorded at $\sqrt{s} = 8$ TeV, the ATLAS and CMS collaborations previously reported deviations from the predicted Standard Model backgrounds in this final state, with significances between 2.6 and 3.0 σ. However, these excesses had been observed in different regions of the dilepton invariant mass. The dataset recorded with the CMS detector at $\sqrt{s} = 13$ TeV in 2015, corresponding to 2.3 fb^{-1}, offers the opportunity to substantiate or refute these interesting hints for new phenomena. Unfortunately, no significant deviation from the background estimates are observed in either of the two selections which had shown excesses in the $\sqrt{s} = 8$ TeV datasets.

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1. Introduction

A summary of a search for physics beyond the standard model in events with opposite-sign (OS), same-flavor (SF) pairs of light leptons (e,μ), missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$), and jets is presented. Such events offer sensitivity to decay chains involving charged sleptons or the production of Z bosons, resulting in kinematic edges or an excess at the Z boson mass in the dilepton invariant mass $m_{\ell\ell}$ distribution. In their searches at $\sqrt{s} = 8$ TeV, CMS and ATLAS reported slight excesses of 2.6 σ [1] and 3.0 σ [2] local significance. However, the CMS excess was observed for values of the dilepton invariant mass ($m_{\ell\ell}$) below the Z boson mass, while the ATLAS excess was observed for values of $m_{\ell\ell}$ consistent with the Z boson mass. Figure 1 shows the $m_{\ell\ell}$ distributions exhibiting these excesses for both searches. To resolve this situation, these final states have been studied again at $\sqrt{s} = 13$ TeV using the data collected by CMS in 2015.

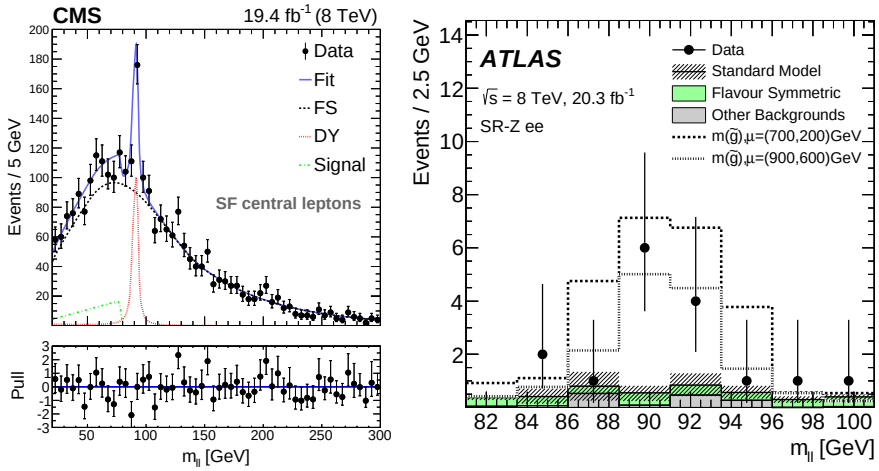

Figure 1: Left: Result of a fit to the $m_{\ell\ell}$ distribution in search for a kinematic edge in the CMS dataset recorded at $\sqrt{s} = 8$ TeV [1]. Right: Result of the search for an excess in the Z boson mass window for dielectron events in the ATLAS dataset recorded at $\sqrt{s} = 8$ TeV [2].

2. Event selection

Leptons are selected with $p_{\mathrm{T}}^{\ell} > 20$ GeV and $|\eta^{\ell}| < 2.4$. The barrel-endcap overlap region in the CMS ECAL $1.4 < |\eta^{\ell}| < 1.6$ is rejected. In the off-Z search, the event sample is additionally split in central (both $|\eta^{\ell}| < 1.4$) and forward (at least one $|\eta^{\ell}| > 1.6$) categories and five bins in $m_{\ell\ell}$. The on-Z search focuses on 81 GeV $< m_{\ell\ell} <$101 GeV. The signal region in the off-Z search is defined by $E_{\mathrm{T}}^{\mathrm{miss}} > 100$ GeV & $N_{\mathrm{jets}} \geq 3$ or $E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV & $N_{\mathrm{jets}} \geq 2$, where N_{jets} is the number of selected hadronic jets. Additionally, subregions with a b-tag veto and b-tag requirement are defined. In the on-Z search, several signal regions are defined by binning in $E_{\mathrm{T}}^{\mathrm{miss}}$ and N_{jets}. Additionally, an ATLAS-like signal region is defined by requesting $E_{\mathrm{T}}^{\mathrm{miss}} > 225$ GeV, $\sum_{\mathrm{jets}} p_{\mathrm{T}} + p_{\mathrm{T}}^{\ell_1,\ell_2} > 600$ GeV, and the azimuthal angle between $E_{\mathrm{T}}^{\mathrm{miss}}$ and the two leading jets larger than 0.4.

3. Background estimates

The dominant standard model backgrounds to these selections are flavor-symmetric processes, which produce the same number of SF as $e\mu$ events. Therefore, they are estimated from an $e\mu$ control sample. A correction for deviations from flavor-symmetry caused by detector effects is applied. It is measured on data with 4-6% precision and is close to unity for both central and forward leptons. Backgrounds from $Z \to \ell\ell$ events are estimated from $\gamma+$jets control samples, as they share the signature of a well-measured boson recoiling against jets. Rare standard model processes such as $t\bar{t}$V or WZ are estimated from simulation, which has been validated in data control regions.

4. Results

The results of the off-Z search are shown in Figure 2. On the left side, the $m_{\ell\ell}$ distribution for central leptons is shown, which exhibited the excess at low $m_{\ell\ell}$ at $\sqrt{s} = 8$ TeV. Good agreement between data and the background estimate is observed. This is also the case for all other signal regions, as exhibited in the summary plot on the right side of the figure. The results of the on-

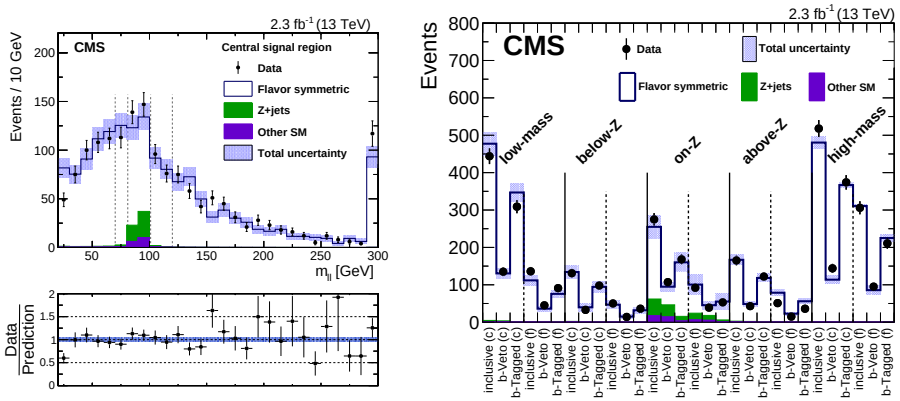

Figure 2: Left: $m_{\ell\ell}$ distribution for events with central leptons and without b-tag requirement, corresponding to the 8 TeV selection [3]. Right: Summary of event yields in all signal regions of the off-Z search [3].

Z search are shown in Figure 3. The left side shows the $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution in the ATLAS-like selection, where the last bin corresponds to the ATLAS signal region at $\sqrt{s} = 8$ TeV. No significant deviation from the background expectation is observed. Good agreement is also observed in all other search regions of the on-Z search, as shown on the right side of the figure. The results of the search are interpreted in two simplified models. The model used for the interpretation of the off-Z search features bottom squark pair production. The squarks decay according to $\tilde{b} \to b\tilde{\chi}_2^0$, followed by the decay $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\ell\ell$, either via an intermediate slepton $\tilde{\ell}$ or a Z boson. Both possibilities occur with 50% probability. The mass of the $\tilde{\chi}_1^0$ is fixed to 100 GeV and the slepton mass is chosen to be halfway between the mass of the two neutralinos. Limits are then set in the $m_{\tilde{b}} - m_{\tilde{\chi}_2^0}$ plane, shown in Figure 4 (left), reaching $m_{\tilde{b}}$ of 620 GeV for low values of $m_{\tilde{\chi}_2^0}$. The off-Z search is interpreted in a GMBS-inspired model of gluino pair production, where the gluinos decay according to $\tilde{g} \to q\bar{q}\tilde{\chi}_1^0$. In this model, a gravitino $\tilde{G}$ with $m_{\tilde{G}}$ is the lightest supersymmetric particle and the neutralino

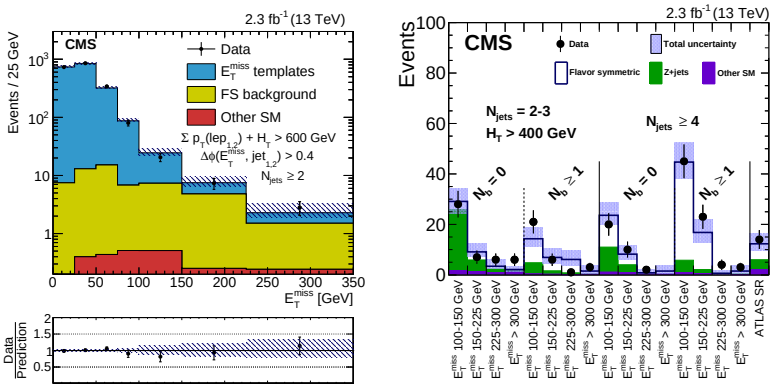

Figure 3: Left: $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution for the ATLAS-like signal region in the on-Z search [3]. Right: Summary of results for all signal regions in the on-Z search [3].

decays according to $\tilde{\chi}_1^0 \to Z\tilde{G}$. Limits are set in the $m_{\tilde{g}} - m_{\tilde{\chi}_1^0}$ plane, shown in Figure 4 (right), reaching as high as $m_{\tilde{g}} = 1.28$ TeV.

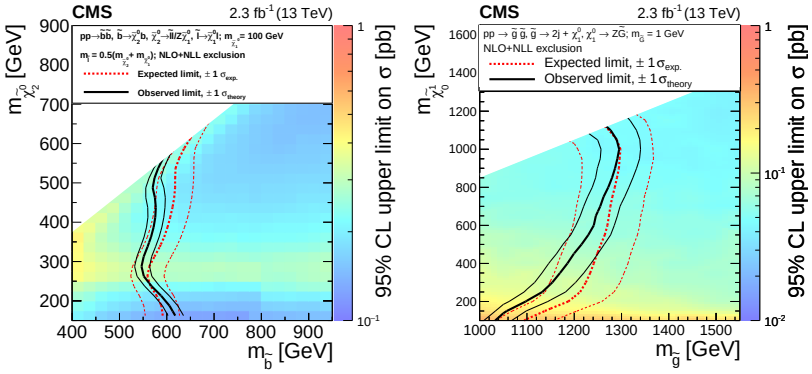

Figure 4: Left: Exlusion limit in the $m_{\tilde{b}} - m_{\tilde{\chi}_2^0}$ plane [3]. Right: Exlusion limit in the $m_{\tilde{g}} - m_{\tilde{\chi}_1^0}$ plane [3].

5. Summary

After the CMS and ATLAS collaborations observed small excesses in different selections in their opposite-sign, same-flavor dilepton searches for supersymmetry at $\sqrt{s} = 8$ TeV, the dataset collected by CMS at $\sqrt{s} = 13$ TeV in 2015 is used to study these signatures again. Neither of the excesses observed by CMS or ATLAS at $\sqrt{s} = 8$ TeV could be confirmed, and limits on models of bottom squark and gluino pair production are set.

References

[1] CMS Collaboration, "Search for physics beyond the standard model in events with two leptons, jets, and missing transverse momentum in pp collisions at $\sqrt{s} = 8$ TeV", *JHEP* **1504** (2015) 124, doi:10.1007/JHEP04(2015)124, arXiv:1502.06031.

[2] ATLAS Collaboration, "Search for supersymmetry in events containing a same-flavour opposite-sign dilepton pair, jets, and large missing transverse momentum in $\sqrt{s}$= 8 TeV pp collisions with the ATLAS detector", *Eur. Phys. J* **C75** (2015) 318, doi:10.1140/epjc/s10052-015-3661-9, arXiv:1503.03290.

[3] CMS Collaboration, "Search for new physics in final states with two opposite-sign, same-flavor leptons, jets, and missing transverse momentum in pp collisions at $\sqrt{s}$ = 13 TeV", arXiv:1607.00915, Submitted to JHEP.