PROCEEDINGS OF SCIENCE

SUSY searches for EWK production of Gauginos and Sleptons at the LHC with the CMS detector

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Recent results from CMS on searches for the electroweak production of supersymmetry particles are reviewed. The searches are performed in final states with three or four leptons, two same-sign leptons, two opposite-sign-same-flavor leptons with two jets, and two non-resonant opposite-sign leptons. The results are based on the full 2012 dataset which comprises 19.5 fb^{-1} of proton-proton collisions at $\sqrt{s}$ = 8 TeV. The observed yields agree with the standard model expectations and are used to place limits on the rates of the direct production of charginos, neutralinos and sleptons.

The European Physical Society Conference on High Energy Physics -EPS-HEP2013
18-24 July 2013
Stockholm, Sweden

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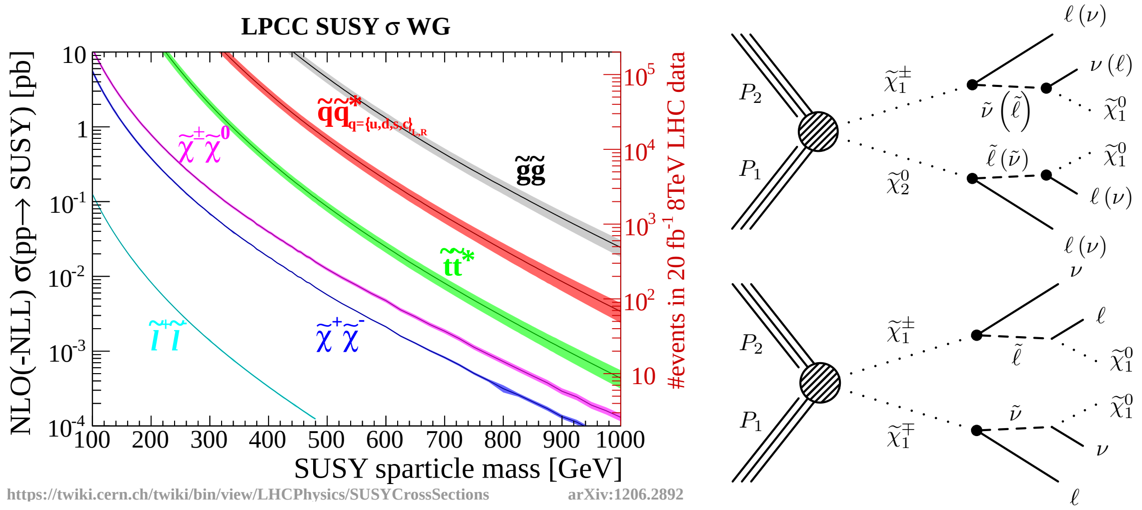
PoS(EPS-HEP 2013)312

1. Introduction

First searches for supersymmetry (SUSY) at LHC have been concentrated on the processes dominated by the strong production cross sections, such as gluino- or squark-pair production, and characterized by high hadronic activity. The accumulation of data allowed to probe models which are expected to have lower production cross sections such as direct production of $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, $\tilde{\chi}_2^0\tilde{\chi}_2^0$, $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ or $\tilde{\ell}\tilde{\ell}$ (Fig. 1). The search for these processes at the Compact Muon Solenoid (CMS) [1] experiment is performed with signatures having two or more leptons and none or low hadronic activity, thus complementing strong SUSY searches. The results in various considered final states are widely consistent with the expected standard model (SM) contribution and therefore are used to place limits in simplified model spectra (SMS) [3].



(a) (b)

Figure 1: (a) Production cross sections of various sparticles at 8 TeV [2]. (b) The examples of the processes and final states targeted by this search.

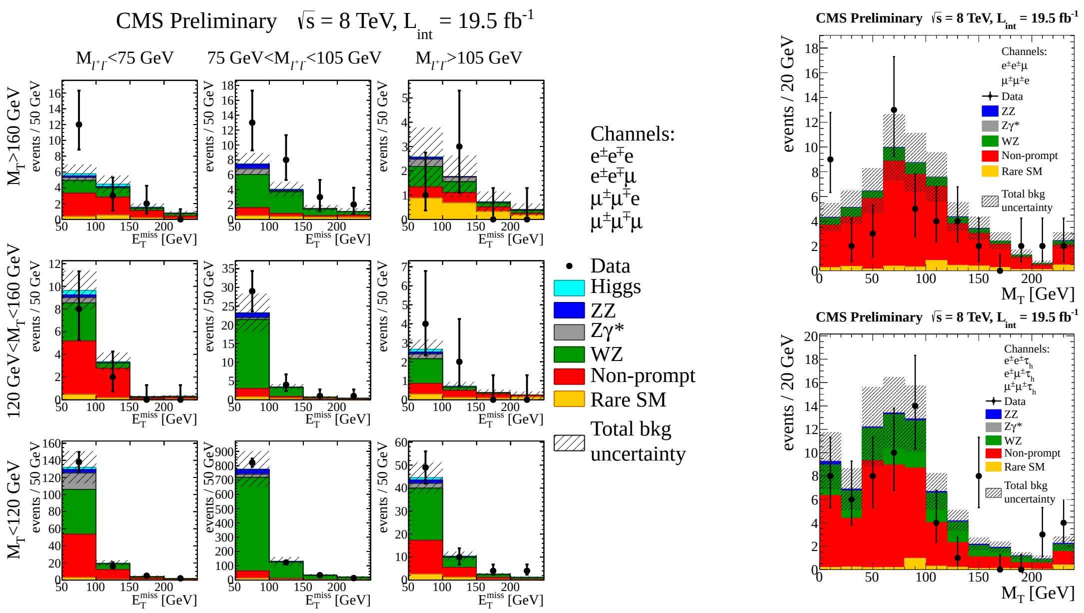
2. Experimental results

While the search is performed with several distinct signatures which require an individual approach for the analysis and background estimation, the components of the search share a common tactic exploiting the electroweak nature of the sought processes. Signal events are not expected to have a substantial hadronic activity which could arise only from the initial state radiation or from Z and W bosons decays if these are present in a gaugino decay chain. All analyses employ a b-tagged jet veto to suppress $t\bar{t}$ background. Also they start from a various number of isolated leptons and require moderate missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$).

Trileptons For this signature, three leptons (e, μ, and up to one hadronically decaying τ_{h}) are required. Events are categorized based on the presence or absence of an opposite-sign-same-flavor (OSSF) lepton pair, and a τ_{h}, and are classified further depending on consistency with originating from a WZ event. The search regions are defined in bins of $E_{\mathrm{T}}^{\mathrm{miss}}$ (starting with

50 GeV), invariant mass $M_{\ell\ell}$ of the most Z-like dileptons, and transverse mass M_{T} of the remaining lepton.

Main backgrounds are SM WZ production which is assessed from simulation with data-based corrections, and processes with non-prompt leptons which could originate from heavy quarks decays or from misidentified light jets. These are estimated with extrapolating from dedicated control regions in data. The contribution of processes yielding three prompt leptons is estimated from simulation. These include ZZ, WWW, processes with a Higgs boson, etc. Small contribution from asymmetric photon conversions is assessed from data. The results are consistent with expected yields in 45 exclusive search regions (Fig. 2).



(a) OSSF channel (b) no OSSF and SSτ channels

Figure 2: Expected and observed distributions in various search regions of the trileptons analysis.

Quadleptons Four leptons with up to one hadronically decaying taus are selected for this analysis. The events are binned in $E_{\mathrm{T}}^{\mathrm{miss}}$, number of OSSF lepton pairs and number of τ_{h} (Fig. 3a). The background estimation methods are the same as for the trilepton analysis.

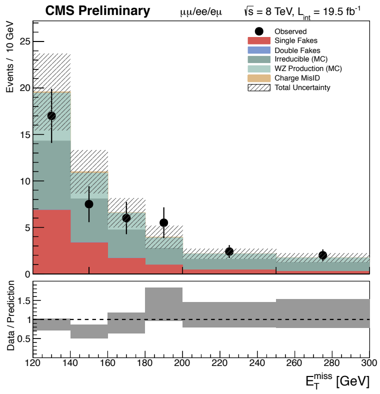
Same-sign dileptons Two light leptons of same charge are selected, and further veto on a third lepton (e, μ or τ_{h}) is imposed. The search is performed in two regions: with $E_{\mathrm{T}}^{\mathrm{miss}} > 200$ GeV, and with $120 < E_{\mathrm{T}}^{\mathrm{miss}} < 200$ GeV, $N_{\mathrm{jets}} < 3$ (Fig. 3b).

Z with dijets Two OSSF light leptons consistent with a Z boson, and two jets with invariant mass between 70 and 100 GeV are required. To be complementary with other searches, a 3[rd] lepton (e, μ or τ_{h}) is vetoed. Search regions start with a requirement of $E_{\mathrm{T}}^{\mathrm{miss}} > 80$ GeV and have gradually increasing $E_{\mathrm{T}}^{\mathrm{miss}}$ threshold.

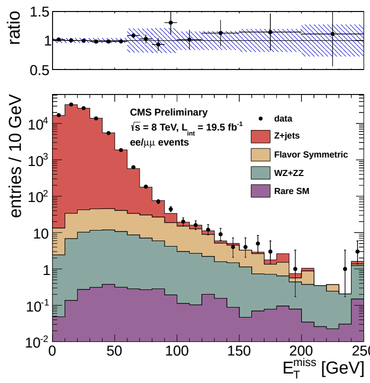
Z with jets background is estimated by utilizing a γ with jets process, flavor-symmetric background is assessed with eμ events, and diboson production as well as rare SM processes are taken from simulation (Fig. 3c).

E_T^{miss} (GeV)	Observed	Total Bkg
1 OSSF, 0 τ		
0–30	1	2.3 ± 0.6
30–50	3	1.2 ± 0.3
50–100	2	1.5 ± 0.4
> 100	2	0.8 ± 0.3
1 OSSF, 1 τ		
0–30	33	25 ± 12
30–50	11	11 ± 3.1
50–100	9	9.3 ± 1.9
> 100	2	2.9 ± 0.6
2 OSSF, 0 τ		
0–30	142	149 ± 46
30–50	25	28 ± 11
50–100	4	4.5 ± 2.7
> 100	1	0.8 ± 0.3

(a) 4ℓ



(b) Same-sign dileptons



(c) Z with dijets

Figure 3: Results in three searches are consistent with the SM expectations.

Non-resonant opposite-sign dileptons The events with two oppositely-charged light leptons either of different flavor or inconsistent with a Z mass, and with $E_T^{miss} > 60$ GeV are selected. The analysis is performed by utilizing an $M_{CT\perp}$ variable [4] which has an endpoint for a processes involving two W bosons (i.e. WW or $t\bar{t}$), and which is not a subject for such constraint in case of undetectable particles from SUSY processes. The $M_{CT\perp}$ templatets for SM processes are obtained from either data (for top production, or processes with non-prompt leptons) or simulation (diboson or rare SM processes). The data are fitted with derived templates in low $M_{CT\perp}$ region (between 10 and 120 GeV), and the search is performed in $M_{CT\perp} > 120$ GeV region.

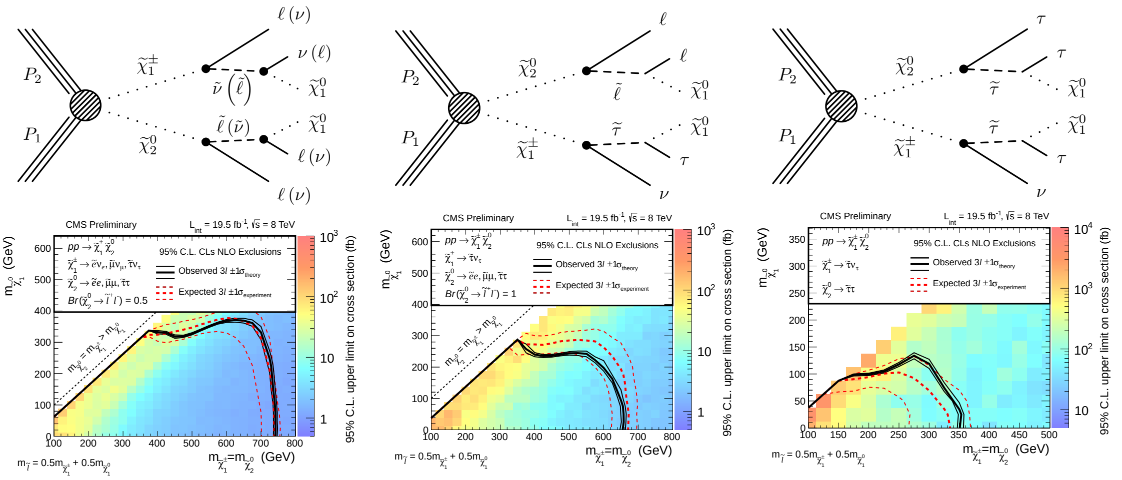
3. Interpretations

Decays which follow chargino-netralino pair production greatly depend on the mass hierarchy of the other sparticles and the composition of gauginos. Several possible scenarios are considered. In case sleptons and sneutrinos are lighter than gauginos, decays happen via $\tilde{\ell}$ and $\tilde{\nu}$ with branching fractions which depend on whether sleptons are partners to the left-handed or right-handed leptons. In "flavor-democratic" scenario, $\tilde{\ell}_R$ do not contribute, while $\tilde{\ell}_L$ and $\tilde{\nu}_L$ do. Charginos and neutralinos decay with equal probability to all lepton and neutrino flavors (Fig. 4a). In "tau-enriched" model, $\tilde{\ell}_R$ are present, and since chargino couples to them via its higgsino component, it decays preferably to $\tilde{\tau}\nu_\tau$, while neutralino decays to three (s)lepton flavors (Fig. 4b). In "tau-dominated" case, both chargino and neutralino decay to tau lepton and its partners (Fig. 4c). In all these interpretations it is assumed that $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$, and $m_{\tilde{\ell}} = m_{\tilde{\nu}} = m_{\tilde{\chi}_1^0} + x_{\tilde{\ell}}\left(m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0}\right)$, where $x_{\tilde{\ell}} = 0.5$. Trilepton results are used to place the limits in these scenarios. Special cases of compressed spectra with $x_{\tilde{\ell}} = 0.05$ or 0.95 are also considered. There is a high probability of losing one of the three leptons, and therefore the same-sign dileptons analysis helps to recover the sensitivity (Fig. 5a).

In case sleptons are heavy and decoupled, charginos and neutralinos decay to LSP through W and Z. Trilepton and Z+dijets analyses are used to place limits in this model (Fig. 5b).

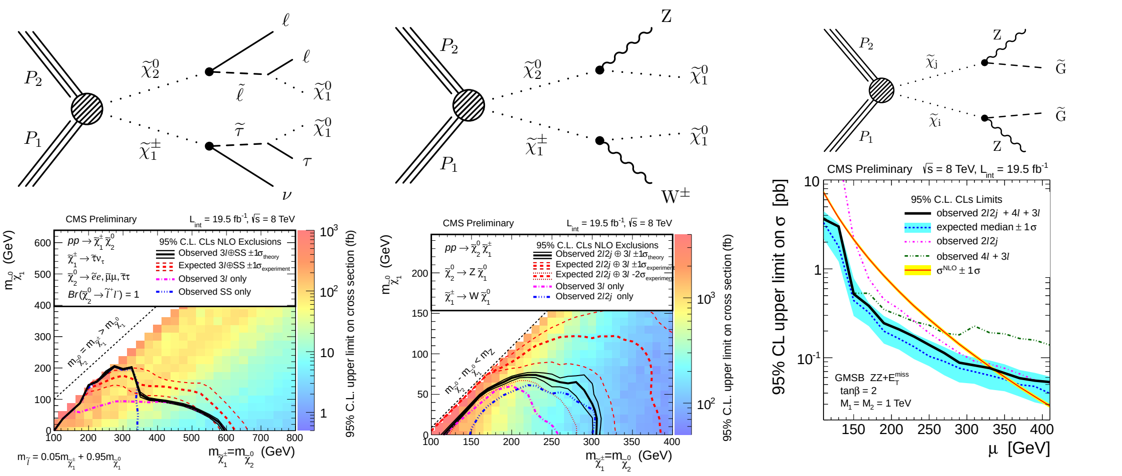
Trilepton, quadlepton and Z+dijets analyses are combined together to probe the reach in the gravity-mediated symmetry breaking scenario (GMSB) which has a large branching fraction to the ZZ+$E_{\mathrm{T}}^{\mathrm{miss}}$ final state. Mass parameters are set to $M_1 = M_2 = 1$ TeV, and $\tan\beta = 2$. This model is excluded at 95% CL for $\mu < 330$ GeV (Fig. 5c) where $\mu \approx m_{\tilde{\chi}_1^0} \approx m_{\tilde{\chi}_2^0} \approx m_{\tilde{\chi}_1^\pm}$ to within few GeV.

For chargino- and slepton-pair production, the limits are set with the non-resonant opposite-sign dileptons analysis results (Fig. 6).



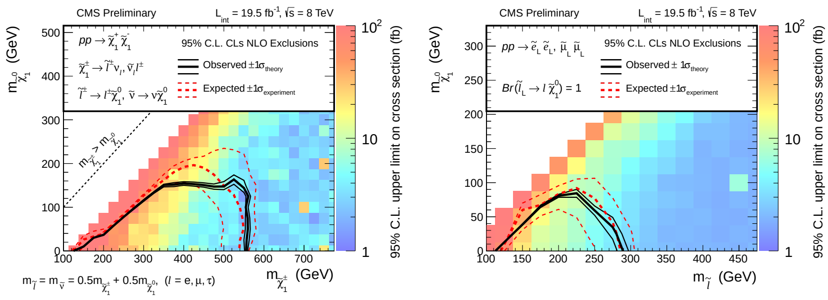
(a) “Flavor-democratic” (b) “Tau-enriched” (c) “Tau-dominated”

Figure 4: Upper limits on the production cross section of chargino-neutralino pair for three scenarios as described in the text ($x_{\tilde{\ell}} = 0.5$). Curves show expected (red) and observed (black) limits on the sparticle masses assuming the NLO cross sections.



(a) “Tau-enriched”, $x_{\tilde{\ell}} = 0.05$ (b) $\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \rightarrow \mathrm{WZ}\tilde{\chi}_1^0\tilde{\chi}_1^0$ (c) GMSB scenario

Figure 5: (a) and (b) Upper limits on $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ production cross section in two possible decay modes. (c) Upper limit on production cross section in GMSB model.



(a) Chargino-pair production (b) Slepton-pair production

Figure 6: Limits set with non-resonant opposite-sign dileptons search.

4. Conclusions

An extensive search for the electroweak supersymmetry production has been performed at the CMS with various signatures. The data are consistent with expectations in the wide range of search regions. The results have been used to place limits on the SUSY production cross sections in several scenarios. The accessible masses change from 740 GeV in the most favorable scenario to as low as 560 GeV and 300 GeV in less accessible cases.

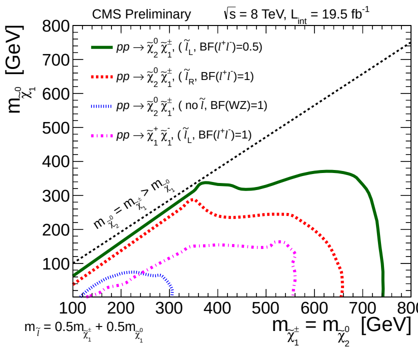


Figure 7: The summary of exclusions for chargino-neutralino (and chargino-chargino) pair production in various scenarios of gaugino composition and sparticle mass hierarchy.

References

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