Search for SUSY in Hadronic Final States at CMS

Riccardo Bellan
Department of Physics
University of California, Santa Barbara
Santa Barbara, CA (US).

1 Introduction

We present the results of searches for SUSY production at CMS [1] in events containing hadronic jets and missing energy, with or without isolated photons or heavy flavor particles, using the full data-set collected in 2011 at 7 TeV in the centre of mass. The results are interpreted in the context of the Constrained Minimal Supersymmetric Standard Model (cMSSM), and of a number of "simplified models".

Results from four distinct analyses have been presented. Three of them target a final state with missing transverse momentum and multijets, whereas one searches for SUSY adding also one or two photons in the event topology.

2 Jets + $\not\!\!E_T$ Final States

The analyses that do not have photons in the final states have similar backgrounds that can be listed as follow: from jet energy mismeasurement in multijets events (often called QCD background), from W and $t\bar{t}$ semi-leptonic processes where the charged lepton ($\ell^{\pm}$) is lost due to detector acceptance, kinematic cuts or identification efficiency, and finally the irreducible background from Z boson decay into neutrinos.

The first presented analysis is based on the M_{T2} variable [2], which is a generalisation of the transverse mass for decay chains with two unobserved particles, as typical in SUSY events. M_{T2} assumes values close to zero for back-to-back events, with no genuine missing energy. This feature naturally suppress the background arising from jet energy mismeasurement in multijets events. Together with the $H_T = \sum_i p_{T,i}^{jet}$ variable M_{T2} provides a good discriminating power between Standard Model (SM) processes and SUSY-like events. This analysis has also a cut flow that makes usage of b-tagging requirement aiming to cover complementary SUSY signal topologies.

Another analysis pursued by the CMS collaboration is an inclusive search with jets and missing transverse momentum [6], aimed to fully characterise the background kinematic in the search regions, achieved with a detailed data-driven modelling of the background [4]. We perform the analysis binning the phase space in H_T and

$\not{H}_T = |-\sum_i \overrightarrow{p}_{T,i}^{jet}|$. QCD is estimated via the "rebalance and smearing" technique, where the particle level p_T's are restored from the detector level inclusive multijets data using a kinematic fit subject to the constraint $\not{H}_T$ = soft-particles (i.e., those particles not associated with jets that have a $p_T > 50$ GeV). The obtained set of momenta is subsequently smeared using the jet resolution functions, including non-Gaussian tails. The background from W and $t\bar{t}$ semi-leptonic decay, where the $\ell^{\pm}$ is lost, is estimated from a muon control sample, correcting for the lepton isolation and identification efficiencies (also modelling the case when an electron is lost). The special case where a τ is produced and decays in hadrons is handled using a muon control sample where a template of the detector response to the visible energy of the τ decays is used to smear the muon momentum and thus simulate a $\tau - jet$. Finally, the $Z \to \nu\bar{\nu}$ background is estimated using a γ+jets sample exploiting the commonalities of the processes that lie beneath the production of prompt-isolated photon and Z bosons.

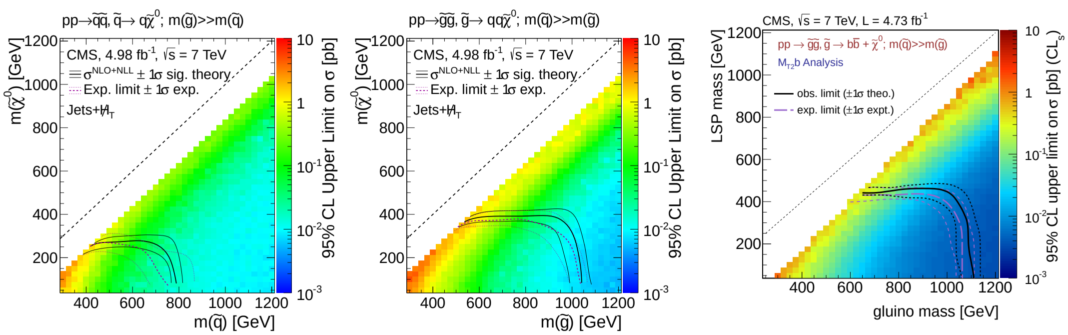

Figure 1: 95% C.L. upper limit on signal cross section in Simplified Models: $pp \to \tilde{q}\tilde{q}, \tilde{q} \to q\tilde{\chi}^0$ (left), $pp \to \tilde{g}\tilde{g}, \tilde{g} \to qq\tilde{\chi}^0$ (centre), derived with the inclusive jet + missing transverse momentum analysis; $pp \to \tilde{g}\tilde{g}, \tilde{g} \to bb\tilde{\chi}^0$ (right), measured with M_{T2} based analysis.

The analysis [5] based on the so called *Razor* variables, R (dimensionless, related to the missing transverse energy $\not{E}_T$) and M_R (an event-by-event indicator of the heavy particle mass scale), aims to fully characterise the data-sets collected by the CMS experiment. The events are divided in 6 exclusive boxes, defined by the number of leptons in the final state (0, 1 or 2) and lepton type (electron or muon). In both simulation and data, the distributions of SM background events are seen to have an exponential dependence R and M_R over a large fraction of the R^2-M_R plane. The analysis uses simulated events to understand the shapes of the SM background distributions and the number – and initial values – of independent parameters needed to describe them. For each of the main SM backgrounds, a control sample is then defined from a subset of the data that is dominated by this particular background in order to obtain a data-driven description of the shapes of the background components. A full SM background representation is thus built using statistically independent data samples; this is used as input for a global fit to the remaining data. The fit is performed in the corner of low M_R and small R^2 (with information shared across different boxes); the model is then extrapolated on an orthogonal region of the R^2-M_R plane defined to be the search region.

All analyses did not measure any statistically significant deviation from the SM prediction. The results therefore were used to excludes the existence of beyond-SM processes in a portion of the cMSSM plane (Fig. 2) and in several Simplified Models [7], a selection of which is shown in Fig. 1.

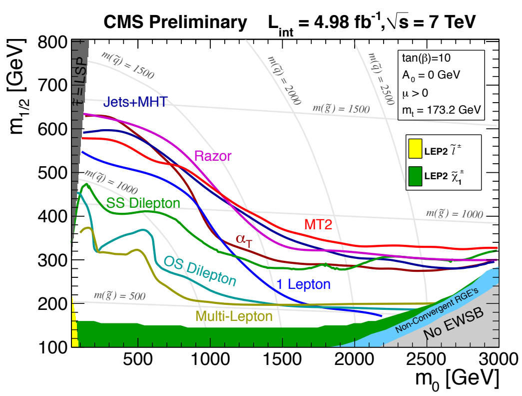

Figure 2: Observed limits from several 2011 CMS SUSY searches plotted in the cMSSM (m_0,$m_{1/2}$) plane.

3 Photon(s) + Jets + $\not\!\!E_T$ Final States

This type of analyses are motivated by the exploration of the General Gauge Mediation (GGM) models, where the gravitino is the lightest stable particle (LSP). The phenomenology of these models is driven by the NLSP (next-to-LSP) particle type. Two different scenarios have been investigated: (I) Bino-like neutralino, where the neutralino is the NLSP; (II) Wino-like neutralino/chargino, where both charginos and neutralinos are NLSP. The charginos mostly decays in a W boson and a gravitino, in contrast to neutralino that decays into a photon and a gravitino, therefore the two sub-analyses looks for at least 1 jet and 2 photons (I) or at least 2 jets and 1 photon (II). The dominant background arises from QCD processes and it is estimated using an orthogonal sample of non-isolated photons. The subdominat background from Electroweak processes is estimated from $e-e$, $e-\gamma$ and single$-e$ samples, reweighting for the probability to misreconstruct an electron as a photon.

Also for this set of analyses we did not find any deviation from the SM background expectation, therefore we set limits for the aforementioned models. Fig 3 shows the exclusion limits at 95 % C.L. for the Bino-like and Wino-like neutralino models.

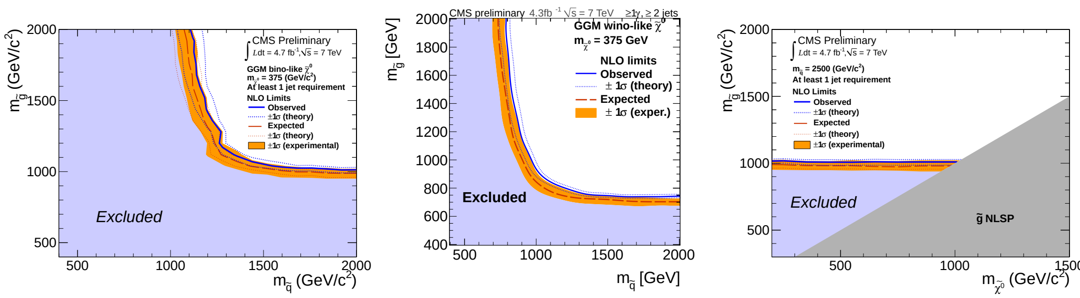

Figure 3: 95% C.L. exclusion contours in gluino-squark mass space for bino-like (left) and wino-like (centre) neutralinos for the di-photon (left) and single photon (centre) analysis. Rightmost plot shows the 95% C.L. exclusion contours in gluino-bino mass space for bino-like neutralinos di-photon analysis.

References

[1] CMS Collaboration, The CMS experiment at the CERN LHC, JINST 03 (2008) S08004.

[2] CMS Collaboration, Search for Supersymmetry in hadronic final states using MT2 with the CMS detector at 7 TeV, CMS PAS SUS-12-002, arXiv:1207.1798, submitted to JHEP.

[3] CMS Collaboration, Search for supersymmetry in events with photons and missing energy, CMS PAS SUS-12-001.

[4] CMS Collaboration, Inclusive search for new physics at CMS with the jets and missing momentum signature, JHEP 1108:155 (2011).

[5] CMS Collaboration, Search for supersymmetry with the razor variables at s = 7 TeV, CMS PAS SUS-12-005

[6] CMS Collaboration, Search for new physics in the multijets + missing transverse energy final state, CMS PAS SUS-12-011, arXiv:1207.1898, submitted to PRL.

[7] CMS Collaboration, Interpretation of Searches for Supersymmetry, CMS PAS SUS-12-016.