Searches for SUSY with third-generation signatures in CMS

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We present results of searches for SUSY production at CMS in events containing hadronic jets and missing energy. The tagging of heavy flavor in the jets is used both to distinguish standard-model components, and for sensitivity to those SUSY models that lead to final states rich in heavy-flavored particles.

1 Search for new physics in events with same-sign dileptons, b-tagged jets and missing energy

This is a search for anomalous production with same-sign (SS) dilepton final state with at least 2 b-jets and missing energy. Such topologies resulted from SM processes are rare, thus their anomalous production could be an indication of new physics. Events including 2 to 4 b-quark jets could be signatures of SUSY where bottom and top-quark superpartners are lighter than other $\tilde{q}$. Although is not discussed explicitly here, this study links to other exotic models, like maximal flavour violation (MxFV) and Z'-boson, which would lead to like-sign top pair production. Although here we present results for $4.7fb^{-1}$, more recent result for $4.98fb^{-1}$ have been recently published [1].

1.1 Event selection and Background estimation

Two SS lepton are required to have $p_T \geqslant 20$ GeV $|\eta| < 2.4$ and an invariant mass $m_{\ell\ell} > 8$GeV. Jets and missing transverse energy (E_T^{miss}) were reconstructed with using the particle flow algorithm. At least 2 b-tagged jets were required with $p_T > 40$GeV , $|\ \eta| < 2.5$, while only events with $E_T^{miss} > 30$GeV were considered.The background constitutes from fake leptons, while rare SM processes that can give 2 isolated SS leptons, and misconstructed opposite-sign lepton pair, as SS pairs. The background from fakes is based on events with one or both leptons failing the isolation and identification selection, but still passing a looser selection. The full data-driven techniques for background estimation are analytically discussed here [1]. While the contribution from rare processes like ttW and ttZ represents more than 90% of all, others where considered as well, like WZ, ZZZ which were estimated from Monte Carlo simulation. In general they are strongly suppressed by the b-tagging requirement.

1.2 Models

SUSY models of gluon pair production were considered, with decays to on and off-shell top quarks. Model A1 depicts a 3-body $\tilde{g}$ decay mediated by virtual stop : $\tilde{g} \to t\tilde{t}\chi_1^0$ (Figure 1), with the assumption that the stop is the lightest squark. Other models were also considered, like when stop quarks are light enough to be on-shell, with 2-body $\tilde{g}$ decays to a top-stop pair $\tilde{g} \to \tilde{t}\tilde{t}_1$, $\tilde{t}_1 \to t\chi_1^0$. Those models give final states with as many as 4 isolated high p_T leptons, 4 b-quarks, several light quark jets, and E_T^{miss}. Also, models with multiple tops and W-boson from decays of sbottom quarks were also considered, and for all the above, upper limits on the $m(\chi_1^0$-$\tilde{g}$) plane were obtained at 95 % C.L. Such an example is Figure 2 for model A1.

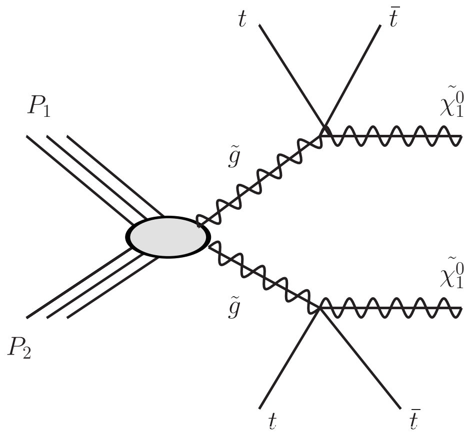

Figure 1: Model A1 with three body decays.

1.3 Results

No significant deviations from the SM expectations was observed, while limits were put at 95% CL on the parameter space for several models of SS top pair production, two models of $\tilde{g}$ decay into virtual or real stop quarks, a model of $\tilde{b}$ pair production, and a model of $\tilde{b}$ production from $\tilde{g}$ decay.

2 Search for supersymmetry in hadronic final states using M_{T2} in 7 TeV pp collisions at the LHC

Hadronic final states are usually imply large E_T^{miss}. In this analysis, the stransverse mass variable, M_{T2} is used purely as a discovery variable, and therefore, is found to be very sensitive to the presence of new physics. Since M_{T2} must depict the produced particle masses which in general are much lighter if they are counted for the SM background processes rather than SUSY ones, evidence of new physics is expected to show up, as an excess in the tail of the M_{T2} distribution.Although we present here results for $1.1 fb^{-1}$ of collected data at sqrt(s) $=$ 7TeV , a recent update of the analysis for $4.73 fb^{-1}$ can be found [2].

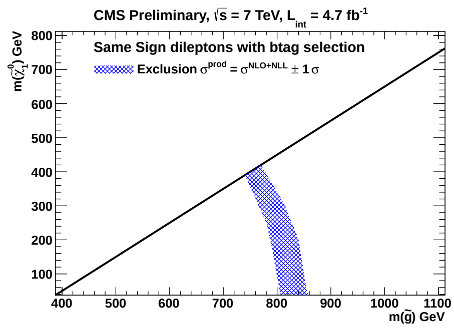

Figure 2: Exclusion limit at 95 % CL on m($\tilde{\chi}_1^0$) - m($\tilde{g}$) plane for model A1

2.1 Event selection and Background estimation

Two different approaches were used, the High M_{T2} analysis aiming on heavy sparticle production decays, which is more sensitive to the case where $\tilde{q}$ are heavy and $\tilde{g}$ are light where $\tilde{g}$-$\tilde{g}$ are dominating, and the $\tilde{g}$, giving rise to 3-body decays with relative small E_T^{miss}. At least 3 Jets were required, where the two leading ones are required to have $p_T \geqslant 100$ GeV and $|\eta| < 2.4$, while the scalar sum of all Jets p_T defined as HT has to be $\geqslant 600$ GeV and a veto on isolated electrons and muons is put as well. Signal region (SR), was defined where M_{T2} >400 GeV, while the Control Region (CR) was defined to be 200 GeV $\leqslant M_{T2} \leqslant$ 400 GeV.

To cover cases where $\tilde{g}$ decay is mediated by virtual $\tilde{q}$ exchange, and the $\tilde{t}$ and $\tilde{b}$ are expected to be lighter than all $\tilde{q}$, the Low M_{T2} analysis was introduced. In this case, at least 4 Jets were selected with at least 1 b-tagged (in order to further suppress the QCD background), while p_T of the leading Jet $\geqslant$ 150 GeV and for the second leading Jet $\geqslant$ 100 GeV, while the SR is defined where $M_{T2} >$ 150 GeV and the CR. The exact selection criteria are discussed analytically [2].

For the background estimation for the High M_{T2} case, a data-driven method was used based on $\Delta\Phi_{min}$ which is the difference in azimuth, between the E_T^{miss} vector and the closest jet, and M_{T2}. For the Low M_{T2} however, the ratio between events before and after b-tagging as a function of M_{T2} was found compatible with a flat distribution. Thus, the QCD contribution in the pre-tagged sample was estimated following the High M_{T2} approach.

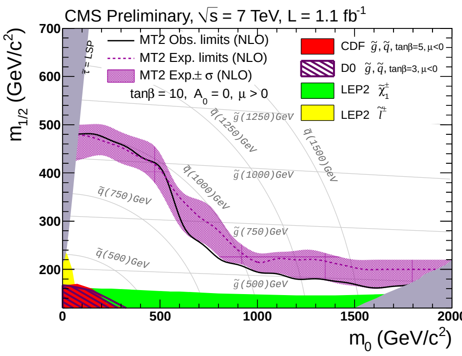

Figure 3: Exclusion limit in the CMSSM $m_0 - m_{1/2}$ plane from the combined High/Low M_{T2} analyses.

2.2 Results

No excess over the SM predictions was observed and data is in good agreement with the Monte Carlo description. Nevertheless, combining both Low and High M_{T2}, upper limits at 95%CL on the mSUGRA / CMSS plane were put after taking into account corrections for efficiencies and systematic uncertainties as in shown in Figure 3.

3 Search for New Physics in Events with b-quark Jets and Missing Transverse Energy in pp Collisions at 7 TeV

Experimental signatures including large E_T^{miss} and multiple Jets with high p_T, are excellent candidates for NP. Also, events including b-jets, usually are accompanied by different background composition which implies also different sensitivity to NP. In this analysis, a search for NP in events with large E_T^{miss} , no identified leptons, at least 3 high p_T Jets, and at least 1 b-jet was performed. Results are based on data equivalent to $1.1 fb^{-1}$. The full analysis can be found here [3].

3.1 Event selection and Background estimation

At least 3 Jets were required with $p_T > 50$GeV , $|\ \eta| < 2.4$, at least 1 b-tagged Jet with $p_T >$ 30 GeV , in events with no identified nor isolated $el(mu)$ candidate with $p_T > 10$ GeV and $|\eta| < 2.5(2.4)$. Two different set of selections were used, namely loose(tight) selection which require $H_T > 350$ (500) GeV and $E_T^{miss} > 200$ (300) GeV.

Main background in the lower p_T region, comes from QCD and is estimated in a data-driven way using $\Delta\Phi_N^{min}$ and E_T^{miss} levels of correlation, while events with a Z+jets where one of more b-jets is present, form an irreducible background when the Z decays to two ν. This is however evaluated by reconstructing $Z \to \ell + \ell-$. However, the dominant background at high E_T^{miss} comes from top quark (either $t\bar{t}$ or single-top), while $W + jets$ constitute a smaller background with similar signatures coming from semi or full hadronic decays. A template method then was introduced, in which the shape of the E_T^{miss} distribution is measured in a single-lepton data control sample and was used to describe the shape of the E_T^{miss} spectrum for Top and W background events. All relevant plots can be found [3].

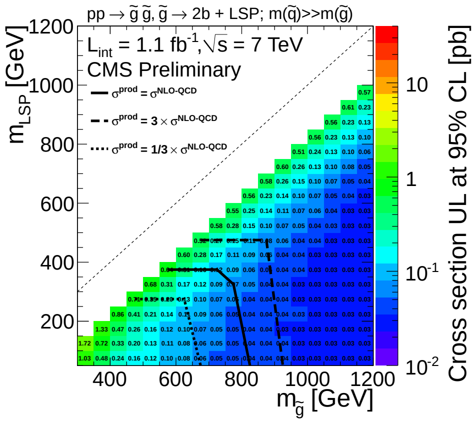

Figure 4: 95% CL cross section upper limits for the T1bbbb Simplified Model

4 Results

In this study, no evidence for an excess of events above the expectation from the standard model was observed. Nevertheless, both in the context of the CMSSM and in the framework of different Simplified Model (like T1bbbb or T1tttt) limits were set. As an example, the 95% CL cross section upper limit for the T1bbbb Simplified Model is shown in Figure 4.

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