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Search for SUSY in jets+MET final state

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The results of inclusive searches for supersymmetry with all-hadronic events produced in proton-proton collisions at 13 TeV are summarized. The data sample corresponds to an integrated luminosity of 2.3 fb^{-1} collected in 2015 with CMS experiment. The searches are based on jet multiplicity, bottom-quark jet multiplicity, and variables characterizing total event energy and missing transverse momentum. The results are interpreted in models of gluino pair production. No significant excess of events beyond the standard models expectation are observed in any channel.

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1. Introduction

The standard model (SM) of particle physics successfully describes a wide range of phenomena. In the SM, the Higgs boson mass is unstable to higher-order corrections, suggesting that the framework is not complete. A number of models have been proposed to overcome various drawbacks of the SM. Supersymmetry (SUSY) [1] is a one such model that relates two basic classes of elementary particles: bosons, which have an integer-valued spin, and fermions, which have a half-integer spin. As examples, squarks and gluinos are the SUSY partners of quarks and gluons, respectively, while neutralinos (charginos) arise from a mixture of the SUSY partners of neutral (charged) Higgs and electroweak gauge bosons. Radiative corrections involving SUSY particles can cancel the divergent contributions from SM particles and thereby stabilize the Higgs boson mass. For this cancellation typically to be natural [2], the top squark, bottom squark, and gluino must have masses on the order of a few TeV or less, possibly allowing them to be produced at the CERN LHC.
Amongst SUSY processes, gluino pair production has the largest potential cross section, making it an apt channel for early SUSY searches in the recently started LHC Run2. In these R-pariy [3] conserving models considered here, final states will have stable LSP(lightest supersymmetric particle) and jets. In this case LSPs will be weakly interacting and show up in detector as missing transverse energy. So we search for SUSY signals in jets+MET(missing transverse energy) final state.
This paper discusses the recent all hadronic SUSY results based on 2.3 fb^{-1} data collected by CMS experiment during 2015. The data corresponds to proton-proton collisions at centre-of-mass energy of 13 TeV. Results are interpreted in the context of three different simplified SUSY models [4]. The event diagrams for the new physics scenarios are shown in the Figure 1.

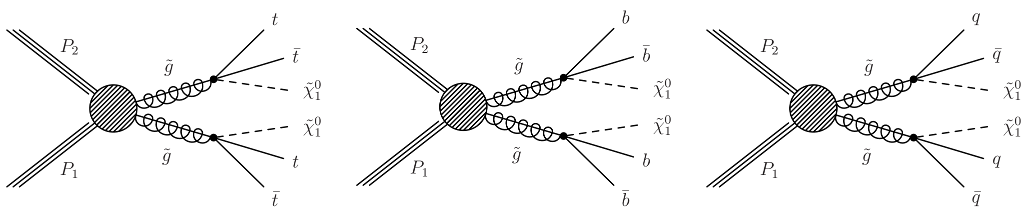

Figure 1: Event diagrams for the new-physics scenarios considered in this study: the (left) T1tttt, (middel) T1bbbb, (right) T1qqqq

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2. CMS Detector

The data is collected using CMS detector [5]. CMS detector has four main sub components. These are tracker,electromagnetic calorimeter, hadron calorimeter and muon chamber. Tracker comprises of pixel and silicon strip detectors that helps to track the path of the charged particles and hence plays a key role in reducing the pile up contaminations in the event. Photons and electrons mostly deposit their energy in electromagnetic calorimeter while hadrons in the hadron calorimeter. As Muons have very less ionozation energy loss they pass through the detector. After reconstruction of all the particles, they are fed to the jet reclusering algorithm. Here in this study anti-kt jets with cone radius 0.4 are used. Missing transverse energy is calculated using the information from all the visible particles in the detector. More informations on the detector can be found in Ref [5].

3. Search Variables

This paper summarizes the results from four different analysises [6–9]. Each analysis uses a different combination of several variables. Other than some common variables(H_T,N_{jet} and N_{b-jet} to be defined later) each of them uses a **specially designed** search variable that aims to reduce the SM backgrounds in a specific way. For illustration purpose, in the following we name the analysis after the corresponding variable.

$\mathbf{H_T^{miss}}$ [6] : H_T^{miss} analysis uses four variables for probing all hadronic SUSY. These are H_T^{miss},the magnitude of vector sum of all the jets in the event; H_T,the scalar sum of p_T of all the jets in the event; N_{jet}, the number of jets in the event; N_{b-jet}, the number of b-tagged jets in the event. H_T^{miss} is nothing but the missing transverse energy(MET) as for final state of jets and MET. But H_T^{miss} is calculated using jets that have a comparatively higher p_T threshold. This helps to reduce the pileup contamination in the event.

$\mathbf{M_{T2}}$ [7] : Along with H_T,N_{jet} and N_{b-jet}, M_{T2} analysis uses a **specially designed** variable called M_{T2}. This kinematic mass variable was introduced to measure the mass of pair produced particles(say 1 and 2) in a situation where both particles ultimately decay to a final state containing an undetected particle X of mass m_X. A generalization of the transverse mass, the M_{T2} variable, is defined as $M_{T2} = \min_{p_T^{X(1)}+p_T^{X(2)}=p_T^{miss}}[\max(M_T^1, M_T^2)]$, where the unknown mass m_X is a free parameter. The minimization is performed on trial momenta of the undetected particles fulfilling the p_T^{miss} expression. And the M_T^1, M_T^2 s are transverse masses of particle 1 and 2. They are defined in Ref [7].

$\boldsymbol{\alpha_T}$: [8] The α_T variable is used to efficiently reject multijet events without significant MET with transverse energy mismeasurements, while retaining a large sensitivity to new physics with final-state signatures containing significant MET. For dijet events, the α_T is defined as
$\alpha_T = \frac{E_T^{j2}}{M_T}$, where E_T^{j2} is the transverse energy of the less energetic jet and M_T is the transverse mass of the dijet system, defined as
$M_T = \sqrt{(\sum_{i=1}^2 E_T^{j_i})^2 - (\sum_{i=1}^2 p_x^{j_i})^2 - (\sum_{i=1}^2 p_y^{j_i})^2}$, where $E_T^{j_i}$, $p_x^{j_i}$, $p_x^{j_i}$ are, respectively, the transverse energy and x or y components of the transverse momentum of jet j_i. For events with three or more jets, a pseudo-dijet system is formed by combining the jets in the event into two pseudo-jets. More information about this analysis will be found in Ref [8]

Razor [9] : Razor variables M_R and R^2 are defined as follows. Given a dijet event with two jet momenta p_{j_1} and p_{j_2}, $M_R = \sqrt{(p_{j_1}+p_{j_2})^2-(p^z_{j_1}+p^z_{j_2})^2}$ and $R = \frac{M_T^R}{M_R}$ with $M_T^R = \sqrt{\frac{MET(p_T^{j1}+p_T^{j2}) - \vec{MET}.(\vec{p_T^{j1}}+\vec{p_T^{j2}})}{2}}$.
Events with more than two jets are forced into a dijet topology using the megajets algorithm [10]. For a typical SUSY decay of a superpartner $\tilde{q}$ decaying into an invisible neutralino($\tilde{\chi}$) and the standard model partner q, the mass variable M_R peaks at a characteristic scale $(M_{\tilde{q}}^2 - M_{\tilde{\chi}}^2)/M_{\tilde{q}}$ [9].

For standard model background processes, the distribution of M_R has a characteristic exponentially decaying shape. The variable R^2 is closely related with the missing transverse energy and is used to suppress QCD background [9].

4. Standard Model Backgrounds

The main backgrouds for SUSY search in jets plus missing transverse energy final state are $t\bar{t}$, W+jets, singletop, $Z(\nu\nu)$+jets and QCD processes. There could be small contributions from processes like WW, ZZ, WZ and $t\bar{t}Z$ depending on the phase space in the search variables. The background estimation methods in general are not similar for all of the analysis discussed here. To estimate these backgrounds data-driven techniques are mostly used with minimal dependance on Monte Carlo is based for estimatin. The details on the estimation methods will be found in Ref [6–9].

5. Results

All of the background events estimated are added together to be compared against the number of data events observed in the signal region. No overall significant excess of events are found in any of the analysises described above. As an example ,the plot of the data vs SM background in 72 search bins for H_T^{miss} [6] analysis is shown in Fig 2. Similar plots for other analysises can be found [6–9]. The upper limits on the production cross sections for the simplified models of supersymmetry are shown in Figs 3, 4 and 5. Gluino masses approximately up to 1.6 TeV are excluded for these SUSY scenarios. For more details, the readers are refered to the web-page of CMS SUSY analysis group [11].

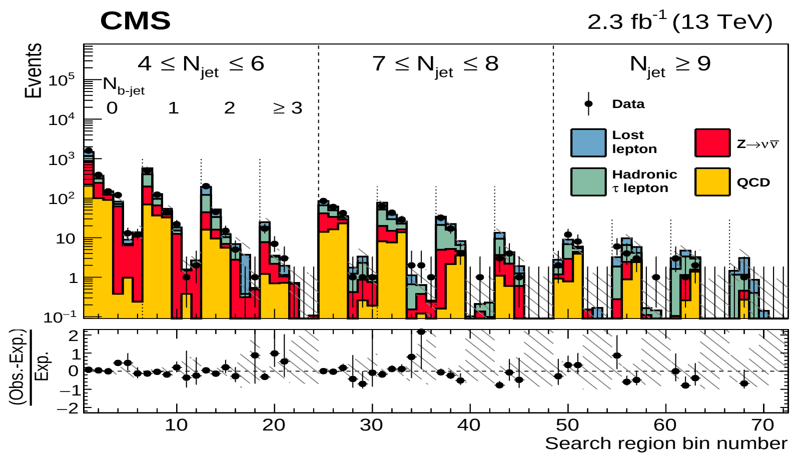

Figure 2: Data verses the SM backgrounds in the 72 search bins considered in [6] analysis

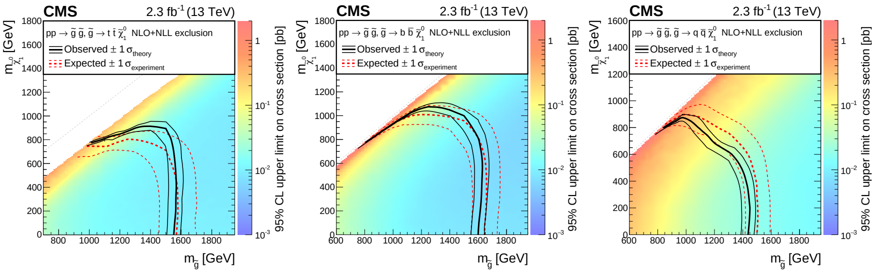

Figure 3: Limit plots for MHT analysis : the (left) T1tttt, (middel) T1bbbb, (right) T1qqqq

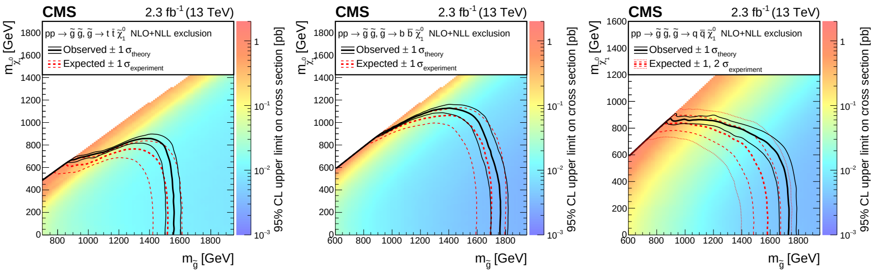

Figure 4: Limit plots for MT2 analysis : the (left) T1tttt, (middel) T1bbbb, (right) T1qqqq

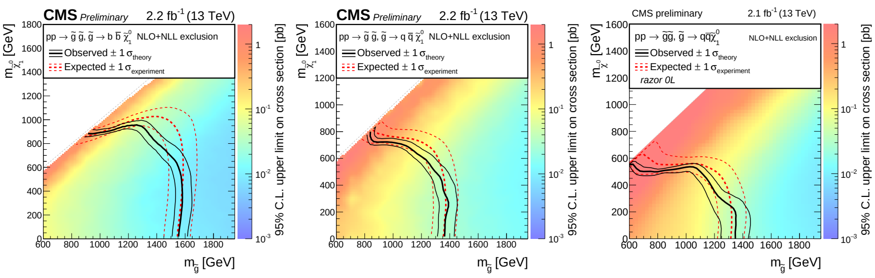

Figure 5: Limit plots for α_T and razor analysis : the (left) T1bbbb(α_T), (middel) T1qqqq(α_T), (right) T1qqqq(razor)

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[11] *http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/SUS/index.html* .