Searches for Jets + missing Et without leptons at CMS

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DOI: `http://dx.doi.org/10.3204/DESY-PROC-2012-02/224`

We present results of searches for SUSY production at CMS in events containing hadronic jets and missing energy. Various discriminants based on the event kinematics are employed to suppress standard-model backgrounds. The results are interpreted in the context of the Constrained Minimal Supersymmetric Standard Model, and of a number of *simplified models*.

1 Introduction

The CMS [1] experiment at the Large Hadron Collider (LHC) has a reach program to search for the Supersymmetry (SUSY). The evolving list of the analyses and their results can be found at [2]. In this note, the searches with the fully hadronic final states are reviewed. This channel has the largest branching ratio but at the same time faces a huge background from Standard Model (SM) processes with the same signature, such as $Z \to \nu\bar{\nu}$+jets events as well as $t\bar{t}$+jets and W+jets events, where the W either decays into light leptons which are not identified or into hadronically decaying τ leptons. In these processes, genuine missing transverse energy (MET) is caused by neutrinos. A different major background arises from QCD multijet events where one or more jets are severely mismeasured. To estimate the backgrounds, the main focus of the analyses is on the data driven methods. Apart from the classical signature of *Jets + MET*, some new variables are defined which make the separation of the signal and background much more easier. Most of the analyses have used the full collision data from 2011 which is close to 5 fb^{-1} of pp collisions in 7 TeV center of mass energy.

2 Jets + MET

If the colored sparticles are not too heavy, a lot of them can be produced in the LHC. Their decay chain can be ended up to a multijet event plus two stable sparticles which escape from the detection and appear as the missing transverse momentum. So a highly unbalanced event with a large jet multiplicity is known as a classical signature of SUSY. The main backgrounds of this search are the QCD multijet events with highly mismeasured jets [3]. To estimate this background, a multijet control sample, where the jets are rebalanced by maximizing a likelihood using the measured jet resolution is used. The MET is forced to be vanished in all events.

This rebalanced sample can be compared to generated QCD multijet events. Because of the rebalancing and the huge QCD cross-section the method is safe against signal contamination. In a second step, the jets of the rebalanced sample are smeared according to the jet resolution including non-Gaussian tails measured in γ-jet and di-jet data events. To estimate the $Z \to \nu\bar{\nu}$ background, the high P_T γ+jets events when the photon is ignored are used. The background from $t\bar{t}$ and W+jets with a hadronically decaying tau is modeled using a data control sample with one isolated muon. The simulation is used to replace the muon by a hadronic tau. The similar isolated muon or electron data sample can be used to evaluate the $t\bar{t}$ and W+jets events which have a lost lepton. The sample is reweighted according to the muon or electron reconstruction and isolation efficiencies as measured on the Z-peak in data. Figure 1 shows the

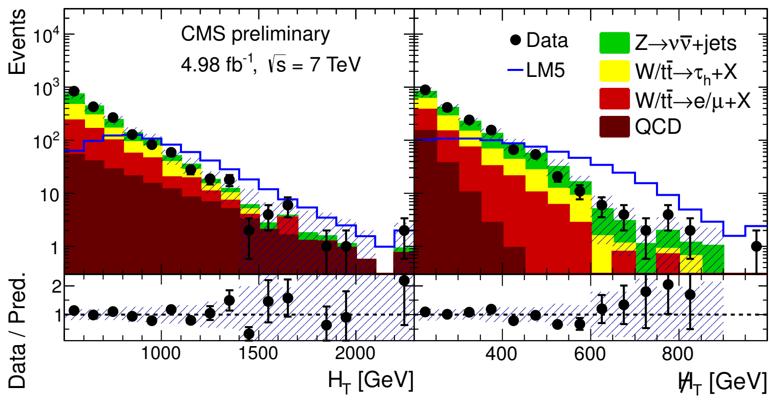

Figure 1: H_T and $\not{H}_T$. The ratio of the data to sum of the backgrounds is shown at the bottom.

scalar (H_T) and vectorial ($\not{H}_T$) sum of the P_T of the jets in the events that survive the cuts. The SM backgrounds predict the data in a good precision and no excess is seen in the data.

3 α_T analysis

The α_T analysis [4] tries to use a search variable which is QCD safe by definition. In a dijet event, α_T is defined as the ratio of the E_T of the next to leading jet and the transverse mass (M_T) of the system of two jets. For the multijet events, the jets are assigned to two mega-jets by minimizing the H_T difference. Figure 2 (left) shows the α_T distribution after applying all cuts for 1.1 fb^{-1} of data. It can be seen that QCD events can not go beyond $\alpha_T = 0.55$. Above this value the distribution is dominated by the SM events with a genuine MET. The residual QCD contribution and the other SM backgrounds in the search region ($\alpha_T > 0.55$) are predicted by scaling the yields for $\alpha_T < 0.55$ in different control samples by R_{α_T}, the ratio of the number of events with $\alpha_T > 0.55$ and $\alpha_T < 0.55$. The control sample for $t\bar{t}$ and W+jets backgrounds is a muon+jets sample and a γ+jets sample is used to model the contribution from Z+jet. In case of QCD multijet events, R_{α_T} is expected to fall with increasing H_T because the jet P_T resolution improves with H_T . Figure 2 (right) shows the dependence of R_{α_T} on H_T. The distribution is flat as expected for events with real MET, demonstrating the QCD depletion in the search region. The distributions for two examples of SUSY contributions are also shown. The data points are consistent with the SM only distribution within the uncertainties.

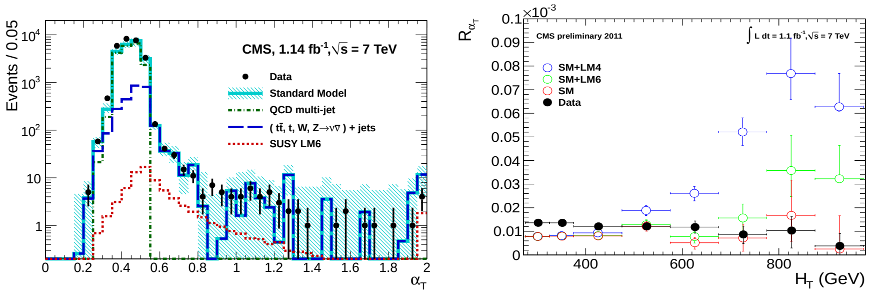

Figure 2: α_T (left), R_{α_T} versus H_T (right), data shows only the expected SM background.

4 Razor analysis

Another QCD safe analysis in CMS which is known as Razor analysis [5] relies on the mass scale and average transverse mass of the events. The search variables are defined as follow:

$$M_R \equiv \sqrt{(E_{j_1} + E_{j_2})^2 - (p_z^{j_1} + p_z^{j_2})^2}\ , M_T^R \equiv \sqrt{\frac{\not{E}_T(p_T^{j1} + p_T^{j2}) - \vec{\not{E}}_T \cdot (\vec{p}_T^{\,j1} + \vec{p}_T^{\,j2})}{2}}\ .$$

given a scale estimator M_R and a transverse estimator M_T^R, the razor dimensionless ratio is defined as $R \equiv \frac{M_T^R}{M_R}$. To make two mega-jets in a multijet event, the combination minimizing the sum of the squared invariant masses is selected. Different SM backgrounds are predicted by a 2 dimensional template in the (M_R, R^2) plane. Figure 3 (left) shows the R^2 distribution for different backgrounds and their sum. No evidence of any new physics is seen.

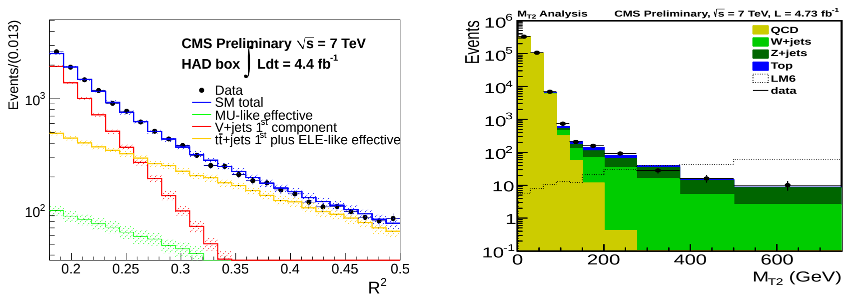

Figure 3: R^2 and M_{T2} distributions for data and different components of the backgrounds.

5 M_{T2} analysis

In the M_{T2} analysis [6] an extension of the well known transverse mass is used to look for the production of the pair produced heavy particles that their decay end up to heavy stable particles. To estimate the QCD contribution a special data driven method is used. Contribution of the $t\bar{t}$ and W+jets is estimated by using a muon+jets control sample. γ+jets is used to predict the

Z+jets background. Figure 3 (right) compares the M_{T2} distribution for different backgrounds, their sum and the real data. There is a good agreement between the data and backgrounds.

6 Interpretation

Looking for new physics with different search variables does not show any evidence for an excess over the predicted SM backgrounds. Statistical methods are used to interpret this lack of evidence numerically and restrict the allowed phase space for SUSY. Exclusion limits at 95% C.L. have been determined in the mSUGRA/CMSSM (m_0, $m_{1/2}$) plane. The results are shown in Figure 4 (left) for $A_0 = 0$, $\mu > 0$ and tan$\beta = 10$. Besides the exclusion in the

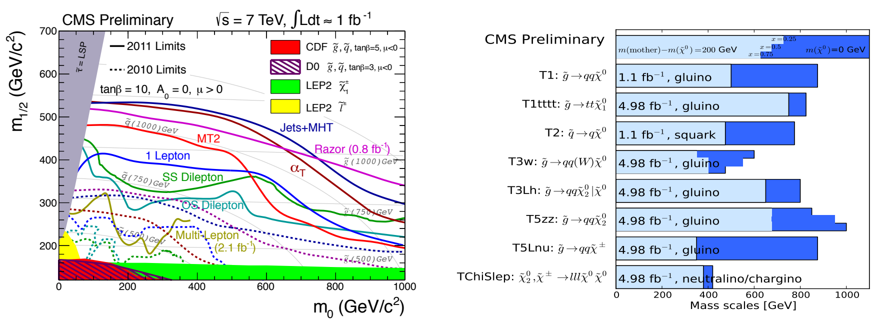

Figure 4: Exclusion limits in mSUGRA/CMSSM plane (left) and the simplified models (right).

mSUGRA/CMSSM plane the results are interpreted in so-called Simplified Models topologies. These are simple signal models each one has exactly one decay mode which is only constrained by the kinematics and the masses of the participating particles. In Figure 4 (right) the excluded masses in different models are shown for m(χ^0) = 0 GeV (dark blue) and m(mother)-m(χ^0) = 200 GeV (light blue).

7 Acknowledgments

The author would like to thank the management and staff of the school of particles and accelerators of IPM, especially Prof. Arfaei for their support. Thanks to all of the members of the CMS collaboration for their outstanding results discussed partly here and thanks to the organizing committee in the University of Bonn for their warm hospitality. Credit: Copyright CERN for the benefit of the CMS Collaboration.

References

[1] S. Chatrchyan *et al.* [CMS Collaboration], JINST **3**, S08004 (2008).

[2] https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS.

[3] S. Chatrchyan *et al.* [CMS Collaboration], (2012) CMS-PAS-SUS-12-011.

[4] S. Chatrchyan *et al.* [CMS Collaboration], Phys. Rev. Lett. **107**, 221804 (2011) [arXiv:1109.2352 [hep-ex]].

[5] S. Chatrchyan *et al.* [CMS Collaboration], (2012) CMS-PAS-SUS-12-005.

[6] S. Chatrchyan *et al.* [CMS Collaboration], (2012) CMS-PAS-SUS-12-002.