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Search for R-Parity conserving SUSY in the all-hadronic channel at CMS

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Abstract

The present status of searches for SUSY in multi-jet events with missing transverse energy at CMS will be reviewed with particular focus on robust analysis techniques that are suited for early physics data. The importance of topological variables for controlling the overwhelming background from QCD events and data-driven methods for the estimation of the remaining backgrounds will be laid out. Estimates of the search reach for the early data taking period will be presented.

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Search For R-Parity Conserving SUSY In The All-Hadronic Channel At CMS

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INTRODUCTION

This paper focuses on developments in recent times (2008-2009) and only briefly reviews the previous SUSY search proposal in the all-hadronic channel with the CMS detector. First a summary of the search proposal that was developed before 2007 is given, followed by a more detailed description of a search for SUSY in the dijet channel and a novel estimation of the irreducible background from events with invisible Z-boson decays.

MISSING TRANSVERSE ENERGY BASED SEARCH FOR SUSY

A search for SUSY in the all-hadronic channel with more than three jets is described in [1]. The dominant discriminator between R-Parity conserving SUSY and Standard Model (SM) physics is the transverse “missing” energy (E_T^{miss}) carried away by the lightest stable particle of the SUSY model, which escapes the detector undetected. The main SM backgrounds from proton-proton collisions stem from either mismeasured events with no true missing transverse energy (mostly QCD) or from SM events, which have neutrinos in the final state, especially Z+jets, where the Z decays to neutrinos, but also W+jets and $t\bar{t}$ lead to backgrounds to the SUSY signal. Further background is expected from beamhalo muons and muons from cosmic rays. The phase-space of the search is defined by the following requirements:

- Transverse energy (E_T^1) of leading jet greater than 180 GeV and the absolute value of the pseudo-rapidity (η^1) smaller than 1.7
- $E_T^2 > 110$ GeV
- At least three jets with $E_T > 30$ GeV.
- $E_T^2 + E_T^3 + E_T^4 + E_T^{miss} > 500$ GeV
- $E_T^{miss} > 200$ GeV

FIGURE 2. Left: Kinematic variable α (Eq. 1) for mSUGRA parameter point LM1 [1] and SM background for 14 TeV collision energy. Right: Same datasets, but kinematic variable α_T (Eq. 1).

QCD events has a α_T value of 0.5, since the two jets balance each other in the transverse plane. Mismeasurements of the energy lead to smaller values of α_T , given that the lower jet E_T is always the in the numerator. Only relatively large deviation in the azimuthal angle between the two jets from π (back-to-back) will decrease the transverse mass such that the α_T value exceeds 0.5. In order to account for resolution effects a cut value of 0.55 is proposed.

For the background estimation the facts that the ratio $R(\alpha_T)$ of events which pass the α_T cut is not dependent on the pseudo-rapidity η of the leading jet and that SM backgrounds are much more forward (higher $|\eta^1|$) than the SUSY signal can be used. Therefore the forward region ($3 > |\eta^1| > 2.5$) can be used to measure the $R(\alpha_T)$ and with this $R(\alpha_T)$ the number of events in the central region can be estimated. Figure 3 shows the number of predicted and the number of measured events for a scenario with and without SUSY signal. While in the case of only SM background the predicted background is consistent with the measured events, there is a clear excess visible in case of signal. Figure 4 shows the $R(\alpha_T)$ as a function of $|\eta^1|$ for different threshold of H_T ($=E_T^1 + E_T^2$) in the case that SUSY a signal is present. For low H_T values the $R(\alpha_T)$ distribution is flat, because the nominator and the denominator are dominated by SM background events. For larger H_T , the number which pass the α_T threshold is dominated by signal, which more central then the background. Hence $R(\alpha_T)$ increases in the central region with increasing H_T . This test will be used to show in data in the low H_T region that $R(\alpha_T)$ is indeed independent of $|\eta^1|$ for the background.

The concept of kinematic variables was generalized to n-jet systems. Figure 4 shows the generalized α_T (see [5]) for jet multiplicities of three to six combined for an integrated luminosity of 100 pb^{-1} at 10 TeV. Also for higher jet multiplicities the kinematic variable showed very robust behavior [5] with respect to mismeasurements much larger then predicted by simulation.

VECTOR BOSON BACKGROUND ESTIMATION

There was a dedicated presentation on how to utilize γ +jets to estimate the vector boson background and there is a summary in these proceedings. A detailed description of the

FIGURE 3. Predicted and measured numbers of events in simulation as a function of $|\eta^1|$. Left: SM background only. Right SM background and mSUGRA parameter point LM1.

FIGURE 4. Left: $R(\alpha_T)$ for different HT thresholds. Right: α_T for jet multiplicities of three to six for mSUGRA parameter points LM1 and LM0 and SM background for 10 TeV collision energy.

method can be found in [6].

SUMMARY

The traditional search based on missing energy measurements is estimated to have a discovery potential even for 100 pb^{-1} at 10 TeV, which exceeds previous experiments. Robust search strategies based on kinematic variables have been added allowing SUSY searches to be extended to include dijet events. Also for multijets kinematic variables show especially robust behavior with respect to mismeasurements.

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