



The Compact Muon Solenoid Experiment

CMS Note

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Searches for beyond-the-standard model physics in events with a Z boson, jets and missing transverse energy

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Abstract

This note describes a search for beyond-the-standard model (BSM) physics in events with a leptonically-decaying Z boson, jets, and missing transverse energy (E_T^{miss}). This signature is predicted to occur in several BSM scenarios, for example supersymmetric (SUSY) models. Two search strategies are pursued. The first is an inclusive approach which selects events with at least two jets and large E_T^{miss} , produced in association with the $Z \rightarrow \ell\ell$ candidate. The second is a targeted search in which additional requirements are imposed in order to achieve sensitivity to the production of the weakly-coupled SUSY charginos and neutralinos. The main backgrounds of SM $Z + \text{jets}$ and $t\bar{t}$ production are estimated with the data-driven E_T^{miss} templates technique and the opposite-flavor subtraction technique, respectively. Additional backgrounds are estimated from simulation after validation in data control samples. No excesses above the SM expectations are observed. The results are interpreted in the context of simplified model spectra.

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1 Introduction

This note presents two searches for beyond-the-standard model (BSM) physics in events containing a leptonically-decaying Z boson, jets, and missing transverse energy. This is an update of previous searches performed with 2011 data [1, 2]. The search is based on a data sample of pp collisions collected at $\sqrt{s} = 8$ TeV in 2012, corresponding to an integrated luminosity of 5.1 fb^{-1} .

The production of Z bosons is expected in many BSM scenarios, for example supersymmetric (SUSY) models. In SUSY models with neutralino lightest SUSY particle (LSP), Z bosons may be produced in the decays $\tilde{\chi}_2^0 \rightarrow Z\tilde{\chi}_1^0$, where $\tilde{\chi}_2^0$ is the second lightest neutralino and $\tilde{\chi}_1^0$ is the lightest neutralino. In models with gravitino LSP such as gauge-mediated SUSY breaking (GMSB) models, Z bosons may be produced via $\tilde{\chi}_1^0 \rightarrow Z\tilde{G}$, where \tilde{G} is the gravitino. Such decays may occur either in the cascade decays of the strongly-produced squarks and gluinos, or via direct production of the electroweak charginos and neutralino. Examples of such processes (see Fig. 1) are:

- strong production: $pp \rightarrow \tilde{g}\tilde{g} \rightarrow (q\bar{q}\tilde{\chi}_2^0)(q\bar{q}\tilde{\chi}_2^0) \rightarrow (q\bar{q}Z\tilde{\chi}_1^0)(q\bar{q}Z\tilde{\chi}_1^0) \rightarrow ZZ + 4 \text{ jets} + E_T^{\text{miss}}$
- electroweak production: $pp \rightarrow \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \rightarrow (W\tilde{\chi}_1^0)(Z\tilde{\chi}_1^0) \rightarrow WZ + E_T^{\text{miss}}$

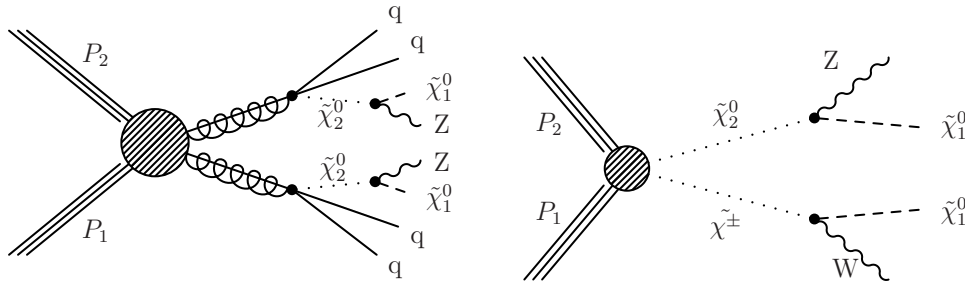


Figure 1: Examples of BSM physics signatures targeted in this search. In the left diagram, Z bosons are produced in the cascade decays of the strongly-interacting gluinos. In the right diagram, a Z boson is produced via direct production of the weakly-coupled charginos and neutralinos.

We thus pursue two strategies. The first is an inclusive strategy which selects events with a $Z \rightarrow \ell\ell$ candidate, at least two jets, and large E_T^{miss} . This strategy is useful for targeting, e.g., the production of Z bosons in the cascade decays of strongly-interacting particles as depicted in Fig. 1 (left). In the second strategy, we impose additional requirements which strongly suppress the backgrounds while retaining high efficiency for events with Z bosons produced via direct production of the weakly-coupled charginos and neutralinos. These two strategies are referred to as the “inclusive search” and the “targeted search,” respectively.

After selecting events with jets and a $Z \rightarrow \ell^+\ell^-$ ($\ell = e, \mu$) candidate, the dominant background consists of SM Z production accompanied by jets from initial-state radiation ($Z + \text{jets}$). The E_T^{miss} in $Z + \text{jets}$ events arises primarily when jet energies are mismeasured. The $Z + \text{jets}$ cross section is several orders of magnitude larger than our signal, and the artificial E_T^{miss} is not necessarily well reproduced in simulation. Therefore, the critical prerequisite to a discovery of BSM physics in the $Z + \text{jets} + E_T^{\text{miss}}$ final state is to establish that a potential excess is not due to SM $Z + \text{jets}$ production accompanied by artificial E_T^{miss} from jet mismeasurements. In this note, the $Z + \text{jets}$ background is estimated with the E_T^{miss} templates technique, in which the artificial E_T^{miss} in $Z + \text{jets}$ events is modeled using a $\gamma + \text{jets}$ control sample. The second background category consists of processes which produce leptons with uncorrelated flavor. These “flavor-symmetric” (FS) backgrounds, which are dominated by $t\bar{t}$ but also contain WW, $DY \rightarrow \tau\tau$ and single top processes, are estimated using a data control sample of $e\mu$ events. Additional backgrounds from WZ and ZZ production are estimated from MC, after validation of the MC modeling of these processes using 3-lepton and 4-lepton data control samples.