The Compact Muon Solenoid Experiment
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Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

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New physics searches with Dijets and MultiJets in CMS

Suvadeep Bose for the CMS Collaboration

Abstract

Searches for new Physics are performed with inclusive dijet and multijet final states in pp collisions, using data collected by the CMS experiment at the LHC. The measurements of the mass spectra, centrality ratio and angular distribution with dijets are shown. The data exclude new particles predicted by various models such as string resonance, excited quarks and provide a lower limit on the energy scale of quark contact interactions. These results extend previously published limits on these models. The analyses with multijets and inclusive jets also probe possible signature of new physics models such as gluinos and colorons and exclude them for mass ranges, exceeding previous limits.

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New physics searches with dijets and multijets in CMS

Suvadeep Bose for the CMS Collaboration

Department of Physics and Astronomy, University of Nebraska Lincoln, Lincoln, NE 68588

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Keywords: Quark compositeness, Excited quarks, Gravitons

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INTRODUCTION

The CMS experiment [1] at the CERN LHC successfully recorded proton-proton collisions with an integrated luminosity of $L = 5 \text{ fb}^{-1}$ during data taking in 2011. These data have been used to search for signs of new physics beyond the Standard Model using jets in the final state.

SEARCHES WITH DIJETS

Jets are experimental signature of quark and gluons. At large momentum transfer of events with at least two jets (dijets) are used search for new physics.

In theories of physics beyond the standard model, it has been proposed that quarks are composite particles and are bound states of more fundamental entities. A common signature of quark compositeness models is the appearance of new interactions between quark constituents at a characteristic scale Λ that is much larger than the quark masses. At energies well below Λ , these interactions can be approximated by a contact interaction (CI) characterized by a four-fermion coupling. The dijet angular variable, $\chi_{\text{dijet}} = \exp(|y_1 - y_2|)$, is flat for QCD jet production which is dominated by t-channel scattering. Any new physics signature will involve s-channel scattering as well making the scattering angle more isotropic which will be indicated in a peak at low χ_{dijet} . With 2011 data from CMS the normalized dijet angular distributions have been measured [2] for dijet invariant masses from 0.4 TeV to above 3 TeV and compared with a variety of contact interaction models (Fig. 1 (left)), including those which take into account the effects of next-to-leading-order QCD corrections. No evidence of new physics is found.

FIGURE 1. Left: The normalized dijet angular distribution (χ_{dijet}) in the highest dijet mass range $M_{jj} > 3$ TeV compared to various contact interaction models. Right: Dijet mass spectrum compared to various resonance models.

Lower limits are obtained on the contact interaction scale, ranging from 7.5 up to 14.5 TeV at 95% confidence level [2].

A search for narrow resonances with a mass of at least 1 TeV in the dijet mass spectrum is shown in Fig. 1 (right). No resonances are observed [3]. Upper limits at the 95% confidence level are estimated on the product of the resonance cross section, branching fraction into dijets, and acceptance, separately for decays into quark-quark, quark-gluon, and gluon-gluon pairs. The data exclude new particles predicted in the following models at the 95% confidence level: string resonances with mass less than 4.00 TeV, E_6 diquarks with mass less than 3.52 TeV, excited quarks with mass less than 2.49 TeV, axigluons and colorons with mass less than 2.47 TeV, and W' bosons with mass less than 1.51 TeV.

SEARCHES WITH FOUR AND SIX JETS

A search for pair-produced narrow resonances each decaying into a pair of jets, using the paired dijet invariant mass spectrum in four-jet final states has been carried out [4]. The paired dijet mass is defined as the average of the invariant masses of the two dijets with closest invariant mass. Several models predict the existence of pair-produced color-octet scalars (S8) or vectors (C) produced from gluon-gluon (gg) interactions. No resonances are observed in the paired dijet mass spectrum. Upper limits are presented on the product of the resonance cross section, branching fraction into dijets, and acceptance. Pair-produced colorons decaying into $q\bar{q}$ are excluded at the 95% confidence level for mass between 300 and 750 GeV.

Many extensions of the standard model (SM) predict the existence of new, strongly interacting particles that lead to final states with high jet multiplicities. Examples of such particles include gluinos in R -parity-violating (RPV) SUSY models. Results are

FIGURE 2. Left: Exclusion limits on the cross section times branching fraction for gluino pair production followed by RPV decay of each gluino to three light-flavored quark jets. Right: Comparison of lower limits on M_D versus the number of extra dimensions (δ) from various collider experiments.

reported [5] from a search for the production of three-jet resonances. Events with high jet multiplicity and a large scalar sum of jet transverse momenta are analyzed. Limits are set on the cross section for gluino pair production in an R-parity-violating supersymmetry model, for gluino masses greater than 280 GeV. Assuming a branching fraction for gluino decay into three jets of 100%, gluino masses below 460 GeV are excluded at 95% confidence level (Fig. 2 (left)).

SEARCHES WITH MONOJET

Events containing an energetic jet and an imbalance in transverse momentum is a signature common to both dark matter and extra dimensions models. Constraints on the dark matter-nucleon scattering cross sections are determined for both spin-independent and spin-dependent interaction models with mass below the region explored by direct detection experiments [6]. The constraints on the ADD model parameter M_D determined as a function of the number of extra dimensions are set (Fig. 2 (right)) which is an improvement over the previous results.

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