EXOTICA SEARCHES AT THE CMS EXPERIMENT

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This paper presents the results of searches for various new physics phenomena in proton-proton collisions at $\sqrt{s} = 7$ TeV delivered by the LHC and collected with the CMS detector in 2010. While the sensitivity of these early searches varies, in many cases they set the most stringent limits on these new physics phenomena. These results demonstrate good understanding of the detector and backgrounds in a variety of channels, which is a fundamental component of successful searches in view of the much larger data sample expected to be delivered by LHC in 2011 and beyond.

1 Introduction

The standard model (SM) of particle physics has been extremely successful in describing all phenomena at the highest attainable energies thus far. Yet, it is widely believed to be only an effective description of a more complete theory, which supersedes it at higher energy scales. Many theoretical extensions of the SM have been proposed in the past decades, which usually predict the existence of new particles. Examples of such conjectured particles are the Z` and W` bosons, fourth-generation fermions, supersymmetric particles, leptoquarks, excited quarks, gravitons, and many others. Past experiments at the Fermilab Tevatron collider, and previously at the CERN SPS, HERA, and LEP colliders, have performed estensive searches for signs of such new physics. In absence of a positive signal, lower limits on the masses of such new particles have been set. With its higher centre-of-mass energy of 7 TeV, the proton-proton Large Hadron Collider (LHC) at CERN can produce particles with masses larger than the current limits, thus extending the search for new physics in an unexplored territory.

This paper presents the results of searches for various new physics phenomena [a] in proton-proton collisions at $\sqrt{s} = 7$ TeV delivered by the LHC and collected with the Compact Muon Solenoid (CMS) [1] detector in 2010. For the majority of these searches the full dataset has been used, corresponding to an integrated luminosity of almost 40 pb^{-1}. The results are presented in different sections, depending on the phenomenology of the new physics scenario: search for new heavy resonances are presented in Section 2; compositeness models are discussed in Section 3; searches for signs of the existence of extra dimensions are described in Section 4; finally, search for long-lived particles and for other exotic final states are presented in Section 5, followed by a brief summary in Section 6.

[a] Searches for Supersymmetry at CMS are not discussed in this paper. These results can be found in other proceedings of this conference.

2 New Heavy Resonances

2.1 Dilepton and Diphoton Resonances

Many models of new physics and extensions of the SM predict the existence of narrow resonances, possibly at the TeV mass scale, that decay to a pair of charged leptons (such as Z` bosons) or to lepton and neutrino (such as W` bosons). Also the Randall-Sundrum (RS) model of extra dimensions foresees the existence of Kaluza–Klein graviton excitations (G_{KK}) decaying to a pair of charged leptons or pair of photons. The CMS Collaboration has searched for such narrow resonances in the invariant mass spectrum of dimuon/dielectron [2] and diphoton [3] final states, as well as in the transverse mass spectrum of electron+neutrino [4] and muon+neutrino [5] final states. The spectra are consistent with standard model expectations in both the bulk and the tails of the aforementioned distributions. Figure 1 shows the 95% confidence level (CL) upper limits on the cross section of Z` /$G_{KK}$ (W`) production, obtained combining the dielectron (electron+neutrino) and dimuon (muon+neutrino) channels. A Z`(W`) with SM-like coupling can be excluded below 1.14 (1.58) TeV. Model-independent lower limits on the Z` mass have also been reported in Ref. [2] as a function of the couplings of the Z` to fermions in the annihilation of charge 2/3 and charge -1/3 quarks. In the diphoton channel, limits are derived on the cross section for the production of RS gravitons, and hence on the parameters of the warped extra dimension model. For values of the coupling parameter ranging from 0.01 to 0.1, graviton masses below 371 to 945 GeV are excluded at the 95% CL.

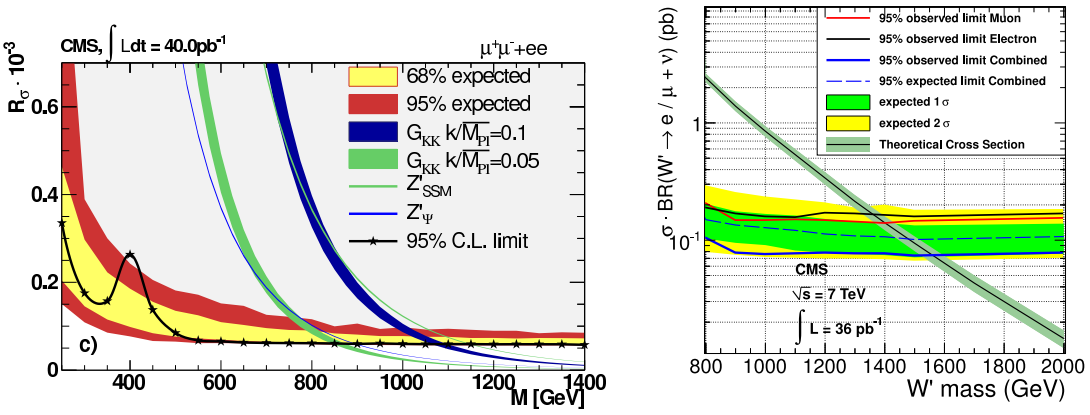

Figure 1: (Left) Upper limits as a function of resonance mass, on the Z` cross section relative to standard model Z boson production, obtained combining dielectron and dimuon final states. (Right) Upper limits as a function of the resonance mass, on the W` cross section for the individual electron+neutrino and muon+neutrino channels, and their combination.

2.2 Leptoquarks

The standard model has an intriguing but ad hoc symmetry between quarks and leptons. In some theories beyond the SM, such as SU(5) gran unification, Pati–Salam SU(4), and others, the existence of a new symmetry relates the quarks and leptons in a fundamental way. These models predict the existence of new bosons, called leptoquarks. The leptoquark (LQ) is coloured, has fractional electric charge, and decays to a charged lepton and a quark with unknown branching fraction β, or a neutrino and a quark with branching fraction $(1-\beta)$. Constraints from experiments sensitive to flavour-changing neutral currents, lepton-family-number violation, and other rare processes favour LQs that couple to quarks and leptons within the same SM generation, for LQ masses accessible to current colliders. Searches for pair-production of first and second

generation scalar LQs has been performed in the eejj[6], eνjj[8], and $\mu\mu$jj[7] channels. The dominant backgrounds for this searches arise from the SM production of Z/γ+jets, W+jets and $\mathrm{t\bar{t}}$ events. The reconstructed variable S_{T}, defined below[b] has a large signal-to-background discrimination power, and it is used to select LQ candidate events.

3 Compositeness Models

4 Extra Dimensions

5 Long-Lived Particles and Other Exotic Signatures

6 Summary

Table 1: CAPTION

Acknowledgments

References

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[b] In the eejj and $\mu\mu$jj channels, S_{T} is defined as the scalar sum of the transverse momenta of the two leading (in p_{T}) charged leptons and jets. In the eνjj channel, S_{T} is defined as the scalar sum of the transverse momentum of the electron, the missing transverse energy ($\not\!\!E_{\mathrm{T}}$), and the two leading jets.