Search for Large Extra Dimensions in Dimuon Events at CMS

Stefan Antonius Schmitz
III. Physikalisches Institut A
RWTH Aachen University
D-52056 Aachen, GERMANY

1 Introduction

In the ADD model of extra dimensions the Planck mass can be reduced to the TeV scale [1]. Accordingly, experimental signatures of extra dimensions might be accessible at LHC collision energies. It is assumed that the phenomenology at sufficiently low energies can be described by an effective field theory [2, 3, 4]. One possible signature are events with two muons in the final state which are created via virtual graviton exchange. Due to the high density of Kaluza-Klein modes one expects a continuous non-resonant enhancement of event rates at high dimuon masses. CMS [5] has presented results from a search for large extra dimensions in dimuon events with $\sqrt{s} = 7\,\text{TeV}$ proton proton collisions using an integrated luminosity of $40\,\text{pb}^{-1}$ [6]. The dimuon high mass tail is found to be well described by the standard model expectation which allows to derive limits on the model parameters of the ADD scenario.

2 Analysis and Results

The analysis is based on events passing a single muon trigger. Each muon needs to be identified both in the central tracker and in the muon system. Muon candidates are required to be reconstructed with pseudorapidity $|\eta| < 2.1$ and transverse momentum $p_T^{\mu} > 30$ GeV. Additional selection criteria including a tracker based isolation requirement are applied to increase the sample purity.

Expected signal contributions are evaluated with the PYTHIA 8 event generator [7]. The dominant standard model Drell-Yan (DY) background is simulated with PYTHIA 6 [8]. Simulated events of both signal and background are passed through a detailed detector simulation. Higher order corrections to the DY process are studied with MC@NLO [9], HORACE [10] and FEWZ [11].

In the absence of a significant excess, limits on a high mass signal contribution are derived from a counting experiment above dimuon masses of 600 GeV. The mass

threshold has been optimized with respect to the expected limits on the ADD parameters. Cross section limits are calculated with a Bayesian approach and then translated into limits on the model parameters. The most relevant systematic uncertainties are the influences of higher order corrections and parton distribution functions on the expected standard model DY cross section. Additional uncertainties are related to the luminosity and the muon reconstruction.

Figure 1 (Left) shows the dimuon mass spectrum, including the standard model expectation and the expected contribution from a simulated signal with $\Lambda_T = 1.6$ TeV. No events are observed above masses of 600 GeV. With an expected background of 0.48 events the observed cross section limits depending on the signal efficiency are found to be between 0.088 and 0.098 pb. Figure 1 (Right) shows the limits on the model parameters M_s and n for different cutoff values $M_{\max}$ on the validity of the effective theory.

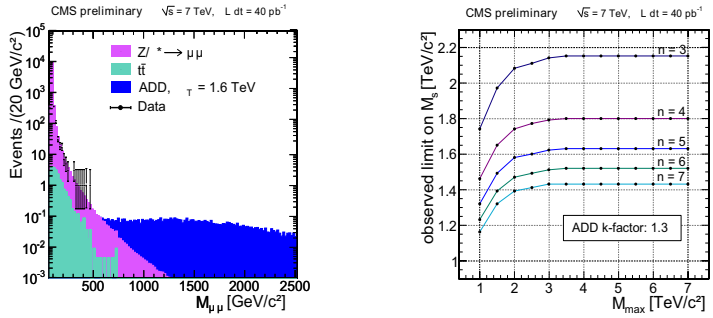

Figure 1: (Left) Dimuon invariant mass spectrum compared with the standard model prediction and a simulated ADD signal with $\Lambda_T = 1.6$ TeV [6]. (Right) Observed 95% upper limits on M_s for different numbers of extra dimensions n as a function of $M_{\max}$ [6].

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