Proyecto Trabajo de Fin de Máster 2017 – 2018

Search for ZZ / ZW diboson resonances in the semileptonic X → ZV → l+l- qqbar final state at √s = 13 TeV with CMS

The Large Hadron Collider (LHC), currently operating at CERN, is the world's largest and most powerful particle physics accelerator. Since 2010 the Compact Muon Solenoid (CMS) experiment is exploring the physics of hadron collisions in the energy region of several TeV and very large luminosities of the LHC. At the end of the LHC Run 1 (2010 – 2012), CMS accumulated 21 fb^{-1} of proton – proton collisions at an energy in the center-of-mass of 8 TeV, LHC instantaneous luminosities up to 7.6 x 10^{33} cm^{2} s^{-1} and pileup levels up to 34 collisions/crossing. A most important result was the discovery of the Higgs boson in 2012. In 2015 a new LHC data-taking period started (Run 2) with an energy in the center-of-mass of 13 TeV. Currently, we are operating CMS with instantaneous luminosities up to 1.7 x 10^{34} cm^{-2} s^{-1} and pile-up levels up to 50 collisions/crossing. We expect to reach luminosities of 2 x 10^{34} cm^{-2} s^{-1} at the end of 2017 or in 2018. The total integrated luminosities accumulated by CMS in 2015 and 2016 are 3 fb^{-1} and 36 fb^{-1}, respectively.

The search for new physics beyond the Standard Model (BSM) is possibly the most important goal of CMS at Run 2. With the huge number of LHC collisions, a number of experimental channels are available for the first time with high statistics. One example is the production of top – antitop quark pairs at invariant masses up to several TeV. A second very important example is the production of vector boson pairs (Z and W) with very large invariant masses. These channels are particularly sensitive to the existence of BSM physics signals as (among others) new heavy partners of the Higgs boson, heavy versions of the electroweak bosons, or Kaluza-Klein particle excitations in models with Randall-Sundrum warped extra dimensions.

The CIEMAT-UAM group at CMS has been leading several of this kind of analyses at CMS since 2011 (see references below). In particular we are experts in searching for diboson (ZZ and ZW) resonances in the semileptonic decay channel X to ZV to l+ l- qqbar (with V a generic name for a Z or a W). The analysis takes advantage of two isolated high transverse momentum leptons (electrons or muons) for high-purity triggering and definition of the data sample, q and qbar jet reconstruction for high efficiency, and b-tagging for heavy quark detection. The jet reconstruction analysis uses two techniques: standard narrow jets for X invariant masses up to about 500 GeV, and boosted merged jets up to X invariant masses of several TeV. The boosted merged jet reconstruction is a cutting-edge technique developed in the last years at the LHC experiments, that allow to reconstruct highly-boosted V bosons and top

quarks as a wide jet, with substructure characteristics very different of “normal” QCD background jets.

The work proposed here consist in analyzing the first CMS data at sqrt(s) = 13 TeV, searching for heavy ZZ and ZW resonances in the semileptonic decay channel X to ZV to l+l- qqbar, following the procedures described above. The data will be compared to the prediction of a background model based on SM processes, and the level of agreement data – background model will allow us to reach conclusions about either the presence, or the exclusion of BSM signals in the data. The statistical significance of the observation will be carefully evaluated.

References:

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