Search for a heavy resonance decaying into ZZ/WZ final state in proton-proton collisions at 13 TeV using the CMS detector

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Introduction
- July 4, 2012: Discovery of Higgs boson.
- Standard model (SM) got its complete form but fails to answer the following:
  - hierarchy on mass, gravity and why gravity is so weak; dark matter confirmed from the astronomical observations: gravitational lensing, rotational curve of galaxy etc.
  - These persuade the new physics beyond the SM (BSM) is very likely.

BSM Physics
- Extra-Dimension (ED): proposes a heavy resonance decaying to a pair of SM bosons.
- Randall-Sundrum (RS) model: the most attractive setup of warped ED at the TeV scale, as it provides an alternative solution to the aforementioned problems [1-3]:
  - Proposes one additional dimension i.e. 5th dimension which extends between the plank scale and the TeV (weak scale).
  - $e^2$ is the warp factor; re-scales the physical mass.
  - Particles carry momentum to ED. So, from $E^2 = p^2 + m^2$, what they look like to us are heavy particles of O(D GeV).
  - This motivates the search for a heavy resonance.

Heavty object $\rightarrow$ boosted topology $\rightarrow$ jet substructure technique

Experimental Techniques
Jet: collimated spray of particles (quarks, gluons, & their combinations hadrons). Reconstructed in a cone of radius $R$ in descending order of $p_T$ with an algorithm (anti-$k_t$, AKR) i.e. AKR.
Commonly used jets are AK4 or AK8 (fat jet for boosted scenario).

Signal Extraction
- Dataset: 2016 MET 35.9 fb$^{-1}$, SM background samples, and Graviton/W' signal sample.
- Mass of Z boson [65,105] GeV.
- Jet Substructure: jet grooming and N-subjectiveness: remove soft wide angle radiation, pile up effect

Background Estimation
$(MC)_{SB} = (Data)_{SB} \rightarrow (Data)_{SB} = (Data)_{SB} \times \frac{(MC)_{SR}}{(MC)_{SB}}$

Result
We search for these signal shapes over our background. Since, we didn’t see the excess, we calculate the exclusion limit.
The result shown is only for graviton gluon fusion (ggF) production process for graviton.

95% CL on the production cross section as the function of various graviton mass is shown. Red & blue line shows the theory limit for $E= k/M_{Grav} = 1.0 & 0.5$ respectively [4]. This doesn’t exclude the possibility of resonance for any mass. Hence, we need more data to either see or set up the more strict limit on the production of graviton mass.

Conclusion
- We presented the work on search for a heavy resonance on Z($\nu\nu$/V(had)) channel.
- We plan to add the results for Vector boson fusion (VBF) production process for graviton. No any public results yet exist for this case.
- We utilized the jet substructure technique as it is a powerful tool to get better S/B and will be even more inevitable as we march towards high luminosity LHC.
- Experimental data agrees well with the SM background prediction. We didn’t observe any excess in signal.
- If we see the signal, then we don’t only see the ED, we will see the first quantum gravity particle also.

References: