Searches for effects of TeV-scale gravity in the 2010 ATLAS data

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Models of extra dimensions propose a solution to the hierarchy problem in the Standard Model by introducing the fundamental Planck scale (M_{D}) in $(n + 4)$-dimensions, where n is the number of extra dimensions, which is much smaller than the Planck scale (M_{Pl}) in four space-time dimensions. Mini black holes, quantum black holes, and ADD graviton productions are new phenomena which arise in models [1]. Four kinds of searches for such new phenomena, using data collected in 2010 with the ATLAS detector at the LHC, are presented. In these searches, the ADD model, which introduces large flat extra dimensions, is considered.

Mini black holes are produced with a continuous mass distribution ranging from certain threshold (M_{th}) which should be larger than M_{D}. Such black holes are expected to decay into many high energy particles. One of the searches uses the multi-jet final state [2]. The signal region selects events with at least five jets with $p_{\mathrm{T}} > 50$ GeV and scalar p_{T} sum of jets, $\sum p_{\mathrm{T}}$, > 2 TeV. The $\sum p_{\mathrm{T}}$ distribution of the Standard Model background is not expected to have a significant dependence on the number of jets (N_{J}). Therefore, the number of events in signal region is estimated by using the $\sum p_{\mathrm{T}}$ distribution of events with $N_{\mathrm{J}} < 5$. Figure 1 shows the $\sum p_{\mathrm{T}}$ distributions for the data, corresponding to an integrated luminosity of 35 pb^{-1}. The points and histogram show the events with $N_{\mathrm{J}} \geq 5$ and $N_{\mathrm{J}} < 5$, respectively. The histogram is normalized to the points in the range $1.1 < \sum p_{\mathrm{T}} < 1.2$ TeV. The two distributions agree within the uncertainties and no evidence of a signal is observed. Figure 2 shows the 95% confidence level upper limits as a function of M_{D} and M_{th} for each n. The region below and to the left of the lines is excluded.

A separate search for black holes is motivated by the expected high rate of lepton production in gravitational processes. Same sign dimuon events with at least ten charged tracks are selected. Standard Model backgrounds have low rates after these event selections. The search uses data corresponding to an integrated luminosity of 31 pb^{-1} and the number of observed events in the signal region is consistent with expectation.

Randall-Meade quantum black holes are expected to decay into two particles, and can be detected as resonances in the dijet final state [4]. The search uses data corresponding to an integrated luminosity of 36 pb^{-1}, and measures up to dijet masses of ~ 3.5 TeV. Good agreement is found with the Standard Model prediction. The result excludes M_{D} between 0.75 and 3.67 TeV for six extra dimensions.

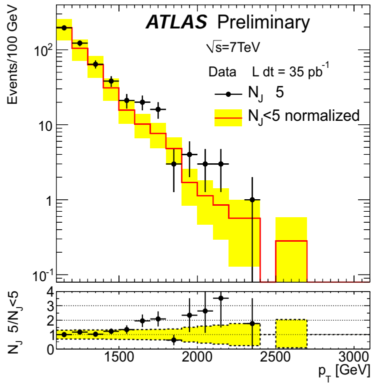

Figure 1: The $\sum p_{\mathrm{T}}$ distribution of the data. The points and histogram show the events with $N_{\mathrm{J}} \geq 5$ and $N_{\mathrm{J}} < 5$, respectively [2].

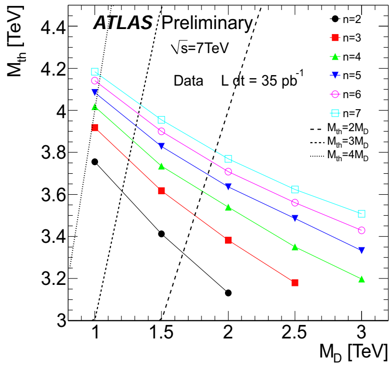

Figure 2: Contour plots of observed limits on Planck scale (M_{D}) versus threshold mass (M_{th}) [2].

ADD graviton production in association with a parton will lead to a monojet final state [5]. The monojet search, using data corresponding to an integrated luminosity of 33 pb^{-1}, shows no evidence of such a signal, and sets a lower limit of 1.8 TeV on M_{D} for four extra dimensions.

References

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[4] ATLAS Collaboration, New J. Phys. **13**, 053044 (2011).

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