Search for New Phenomena in the Dijet Mass Distribution updated using 13.0 fb⁻¹ of pp Collisions at $\sqrt{s}$ = 8 TeV collected by the ATLAS Detector

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Abstract. The invariant mass distributions of dijet events produced in pp collisions at a center of mass energy of 8 TeV by the LHC has been studied using the ATLAS detector. A total integrated luminosity of 13.0 fb⁻¹ collected in 2012 has been employed. The observed dijet masses extend up to 4.69 TeV. No local excesses have been observed. A 95% C.L. limit on the production of a benchmark model of excited quarks, q*, has been set at 3.84 TeV. The previous ATLAS 95% C.L. limit on q* mass using 5.8 fb⁻¹ of 2012 data was set at 3.66 TeV. Limits on cross section times acceptance, $\sigma \times A$, have also been updated using simplified gaussian models in order to allow limit setting on new theories.

1 Introduction

The invariant mass distribution of dijet events, m_{jj}, produced in proton-proton collisions at the LHC [1] at a center of mass energy of 8 TeV and measured by the ATLAS experiment [2] has been searched for localized excesses that could arise from resonant phenomena of new physics. Previous results from the ATLAS Collaboration in this analysis, obtained with 5.8 fb⁻¹ of 8 TeV data collected in 2012, are presented in reference [3]. In that occasion a 95% C.L. exclusion limit on the mass of a benchmark model of excited quarks, q*, was set at 3.66 TeV. The analysis has now been updated using 13.0 fb⁻¹ of 8 TeV data collected in 2012 and is reported in reference [4].

2 Event selection

Events are selected using the logical OR of two central, single-jet triggers requiring at least one large energy deposit in the calorimeter. This combination of triggers avoids inefficiencies due to splitting and merging of jets.

Jets used in the analysis are reconstructed using the anti-k_T clustering algorithm with a radius R = 0.6. Jets are calibrated to remove pile-up effects and their energy is restored to the hadronic scale. Events are selected by requiring the two leading jets to be central, $|\eta| < 2.8$, and with rapidity in the center of mass frame, $y^* = \frac{1}{2}(y_1 - y_2)$, $|y^*| < 0.6$. The dijet invariant mass value of the two leading jets is required to be $m_{jj} > 1000$ GeV. The adopted kinematic selection criteria restrict the jets in the analysis to a minimum p_T of 150 GeV. The highest jet entering the analysis has $p_T = 2.43$ TeV while the event with the highest dijet mass observed has $m_{jj} = 4.69$ TeV.

The dominant source of uncertainty is that associated to the jet energy scale, JES, which is 4% in the central region of the detector. All other sources of uncertainty coming from the corrections entering the analysis are much smaller than the JES uncertainty. The jet energy resolution uncertainty is found to be negligible.

3 Background extraction

The background distribution is extracted from data by fitting the m_{jj} distribution with a smooth function:

$$f(x) = p_1(1 - x)^{p_2} x^{p_3 + p_4 \ln x} \quad x \equiv m_{jj}/\sqrt{s}$$

The shape of the function is empirically chosen to smoothly fit the m_{jj} distribution while avoiding to fit possible local excesses and was already employed in previous analyses. This method reduces the effects of the uncertainties deriving from jet energy scale and luminosity.

4 Search phase

Figure 1 shows the reconstructed dijet invariant mass distribution together with the fitted function. In order to have more stability in the bins with lower statistics, a maximum likelihood fit is performed using the smooth four-parameter function described in section 3. The fit gives χ^2/ndf = 15.5/18 with a p-value for the null hypothesis, obtained from pseudoexperiments, of 0.61, confirming the overall agreement between data and fit. The lower panel in figure 1 shows the significance, in terms of standard deviations, of the disagreement between data and fit in each bin of m_{jj} based on Poisson statistics. The BumpHunter algorithm has been used to look in the m_{jj} spectrum for localized excesses with respect to the smooth background fitting function assuming a Poisson distribution and taking
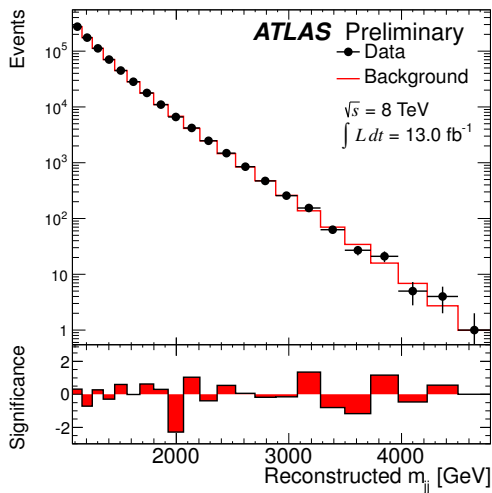
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Figure 1. The dijet invariant mass distribution fitted with a smooth function. The significance of the data-to-fit difference is reported for each bin [4].

Figure 2. The observed 95% C.L. limits on $\sigma \times A$ as a function of m_{jj} (black line). The black dotted line shows the expected limits with 68% (green) and 95% (yellow) confidence regions. The blue dashed line represents the q* $\sigma \times A$ prediction [4].

into account the look-elsewhere effect. In order to prevent any bias in the background extraction, the region corresponding to the most significant local excess is excluded from the background fit if the p-value of the fit is smaller than 0.01. No significant excess has been observed.

5 Excited quarks limit setting

The bayesian method has been used to set 95% C.L. limits on $\sigma \times A$ for a benchmark model of excited quarks [5, 6]. For this purpose a set of MC samples for different q* mass values has been produced using PYTHIA 8 with CT10 PDFs. Figure 2 shows the observed 95% C.L. limits on $\sigma \times A$ as a function of m_{jj}. The observed upper limit on q* is 3.84 TeV, in agreement with the expected value of 3.70 TeV obtained from pseudoexperiments.

6 Gaussian limits

95% C.L. limits on $\sigma \times A$ have been set on simplified gaussian models to allow comparison with other new physics models producing dijet resonances. This can be done as long as the signal given by the models after kinematic selection is gaussian. Limits are obtained in the same way as the excited quark benchmark but using gaussian-shaped resonances instead of the excited quark templates [7]. Results are presented in figure 4 for three different resonance signal widths.

7 Conclusions

An update to the search for new phenomena in the dijet mass distribution using 13.0 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV collected by the ATLAS detector is presented. No resonance-like signal has been found. The 95% C.L. limit on a benchmark model of excited quarks has been extended to 3.84 TeV. Limits on simplified gaussian models have also been updated.
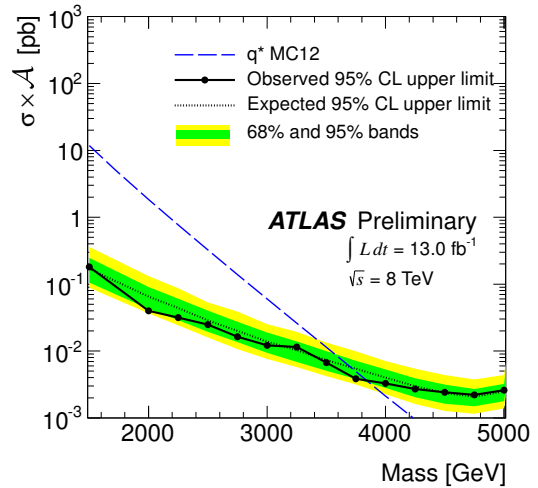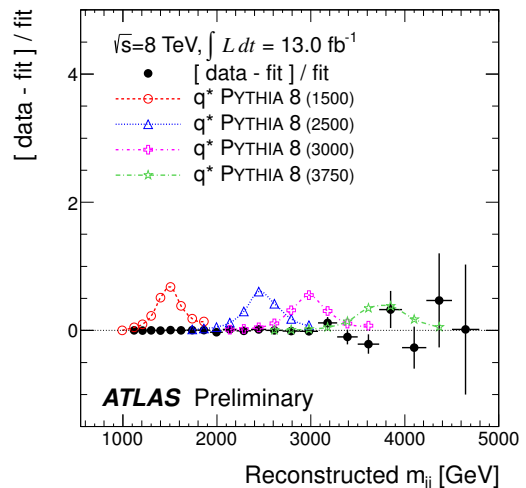

Figure 3. Four q* templates normalized to the background fit and compared to data [4].

References

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[3] ATLAS Collaboration, *Search for New Phenomena in the Dijet mass Distribution using 5.8 fb^{-1} of pp Collisions at $\sqrt{s}$ = 8 TeV collected by the ATLAS Detector*, ATLAS-CONF-2012-088, https://cds.cern.ch/record/1460400, 2012.

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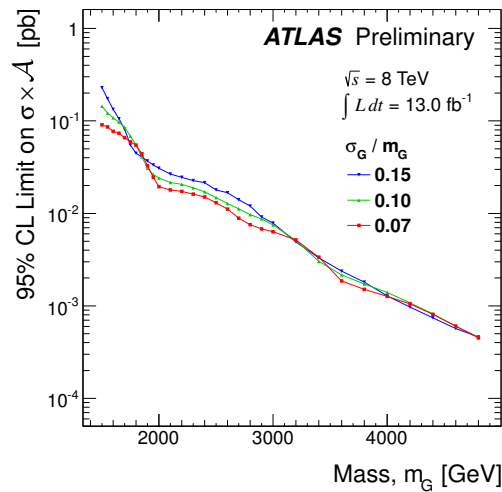
Figure 4. 95% C.L. limits on $\sigma \times A$ for simplified gaussian dijet resonance models. Limits are reported for three different signal widths [4].

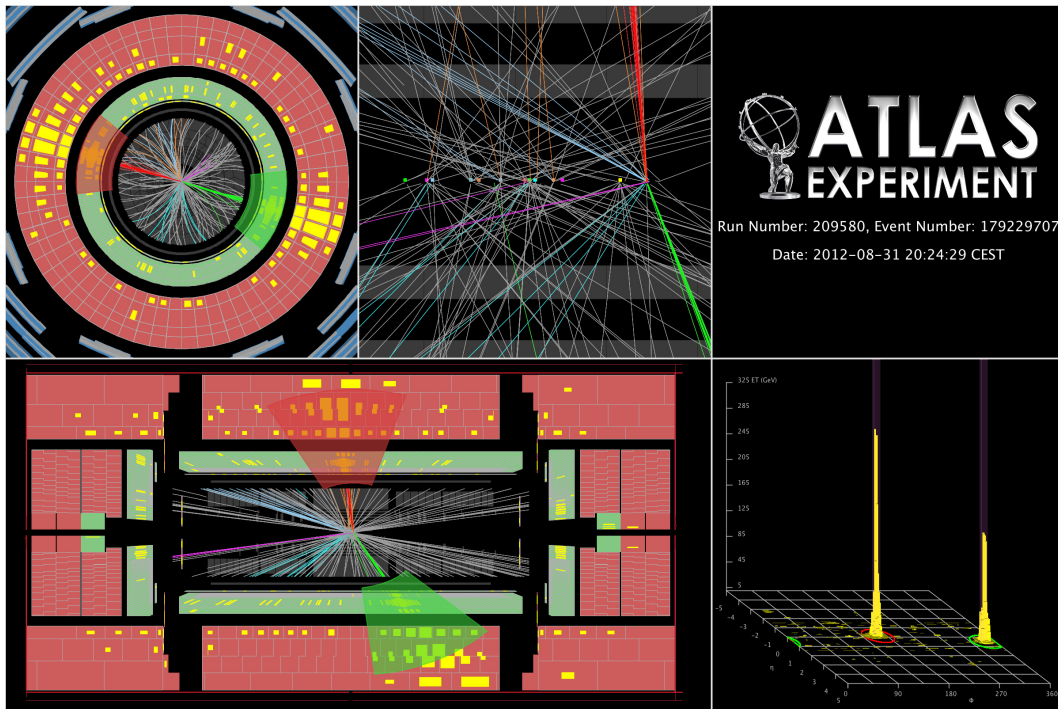**Figure 5.** Event display of the highest m_{jj} event observed. The two leading jets have an invariant mass of 4.69 TeV. The leading jet has a p_T of 2.29 TeV while the subleading has a p_T of 2.19 TeV [4].

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