PRAMANA — journal of physics | © Indian Academy of Sciences | Vol. xx, No. x
xxxx xxxx
pp. 1–3

Search for new physics in dijet mass and angular distributions in pp collisions at $\sqrt{s} = 7$ TeV measured with the ATLAS detector

THORSTEN DIETZSCH[a, *]
[a]Kirchhoff Institute for Physics, Heidelberg University, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany, on behalf of the ATLAS collaboration

Abstract. We present a search for physics beyond the Standard Model in proton-proton collisions at a centre-of-mass energy of $\sqrt{s} = 7\,\mathrm{TeV}$, performed with the ATLAS Detector at the Large Hadron Collider (LHC). No evidence for new physics is found in dijet mass and angular distributions and stringent limits are set on a variety of models of new physics, including excited quarks, quark contact interactions, axigluons, and quantum black holes.

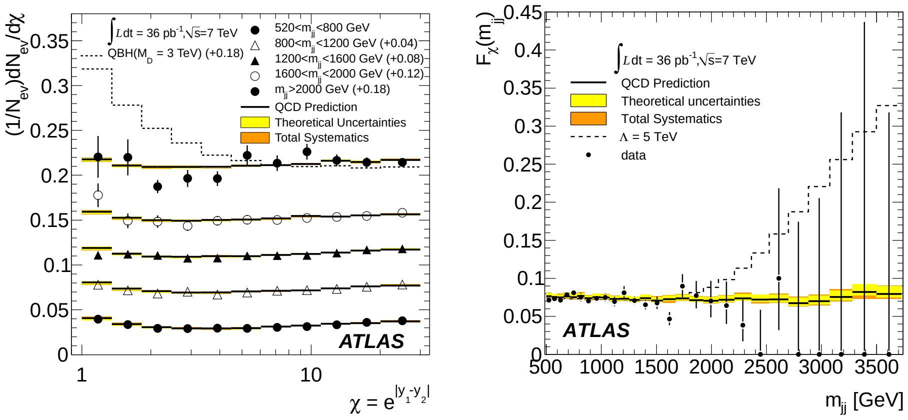
Keywords. ATLAS, dijet distributions

Introduction The production of events with two energetic jets of particles (dijet events) is well understood within the Standard Model. An enhanced production of dijet final states is expected in several scenarios of new physics. By studying the dijet invariant mass, m_{jj}, and the dijet angular distributions, sensitive searches for both resonant and non-resonant deviations from the Standard Model are performed. Quark contact interactions [1], i.e. the hypothesis that quarks are composed of more fundamental particles, and Randall-Meade quantum black holes [2] are considered as benchmark models for non-resonant processes. Both models imply an additional isotropic component in the dijet angular distributions. Example distributions are included in Figure 1. Excited quarks, q^*, could be produced via $qg \to q^*$ [3, 4], predominantly decaying into qg. In the work presented here, the excited quarks are assumed to have spin 1/2, and the compositeness scale, Λ, is set to the q^* mass. Other considered resonant processes are axigluons [5–7] and the color octet scalar (s8) model [8]. For the latter, the model used here leads to a simple event topology with two gluons in the initial and final states, directly yielding high p_T dijets. The analysis presented here has been done using data collected by the ATLAS experiment at the LHC.

Dijet angular analysis In the dijet angular analysis, $36\,\mathrm{pb}^{-1}$ of data collected in 2010 are studied in the two variables $\chi = \exp(|\Delta y|)$ and $F_\chi(m_{jj})$, defined[1] as $F_\chi(m_{jj}) = [N_{events}(|\Delta y| < 1.2)/N_{events}(|\Delta y| < 3.4)](m_{jj})$. The choice of these quantities is motivated by the expected deviations, in various new physics scenarios, from the flat QCD

*dietzsch@cern.ch

[1] Δy denotes the rapidity difference of the two jets with the highest transverse momenta (p_T), while m_{jj} is their invariant mass.



(a) (b)

Figure 1. The observed (filled points) and expected (histograms) distributions for χ (a) and $F_\chi(m_{jj})$ (b). QCD predictions are shown with systematic uncertainties (narrow bands), and data with statistical uncertainties. Taken from Reference [9].

Analysis	**Model**	**Characteristic quantity**	**95% C.L. Limits [TeV]** Expected	Observed
Angular $36\,\mathrm{pb}^{-1}$	Contact Interaction	Compositeness scale Λ	5.7	9.5
	Quantum Black Hole	Quantum gravity scale M_D	3.49	3.78
Resonance $0.81\,\mathrm{fb}^{-1}$	Excited quark q*	Excited quark mass	2.77	2.91
	Axigluon	Axigluon mass	3.02	3.21
	Color octet scalar	Color octet scalar mass	1.71	1.91

Table 1. The 95% C.L. lower limits on the characteristic mass and energy scales of some of the models of new physics, studied in [9, 10].

prediction in the differential χ spectra and in the $F_\chi(m_{jj})$ distribution. The analysis adopts a Monte Carlo-driven background estimation, achieving NLO precision by multiplying LO PYTHIA QCD simulations with bin-by-bin k-factors. Systematic uncertainties are convoluted via MC pseudo-experiments. The resulting distributions are displayed in Figure 1. No evidence for new physics is found. Table 1 shows the limits obtained on models of contact interactions and quantum black holes. The full analysis details, including limits on additional models, are given in Reference [9].

Dijet resonance search In the dijet resonance search, the invariant mass of the two leading jets, m_{jj}, is studied using $0.81\,\mathrm{fb}^{-1}$ of data collected in 2011. The analysis uses an algorithm [11] that looks for an excess of events over a smooth background by means of the function $f(x) = p_1(1-x)^{p_2}x^{p_3+p_4\ln x}$, with $x \equiv m_{jj}/\sqrt{s}$ and the fit parameters p_i. No resonant structure is found (see Figure 2). The resulting limits on models of excited quarks, axigluons and color octet scalars are presented in Table 1. Reference [10] contains further information, including the limits obtained on generic Gaussian resonance models.

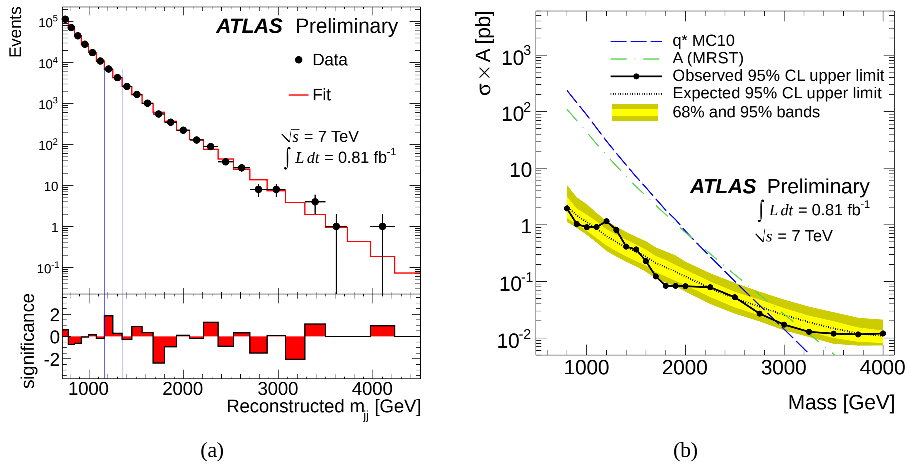


Figure 2. (a) The dijet mass distribution for the data and the background fit. (b) The 95% C.L. upper limit on $\sigma \times A$ (acceptance) as a function of the resonance mass. Predictions for excited quarks (q*) and axigluons (A) are shown, using the MC10 version of the ATLAS MC and MRST PDFs. Taken from Reference [10].

Conclusions We have used the invariant mass and angular distributions of dijet events collected by the ATLAS experiment at the LHC to set limits on various models of new physics. The forthcoming data will allow us to discover new phenomena or significantly improve our limits.

References

[1] E. Eichten, I. Hinchliffe, K. Lane, and C. Quigg, *Supercollider physics*, Rev. Mod. Phys. **56** (1984) 579–707, 688.

[2] P. Meade and L. Randall, *Black holes and quantum gravity at the LHC*, JHEP **05** (2008) 003.

[3] U. Baur, I. Hinchliffe, and D. Zeppenfeld, *Excited quark production at hadron colliders*, International Journal of Modern Physics A **2** (1987) 1285–1297.

[4] U. Baur, M. Spira, and P. M. Zerwas, *Excited-quark and -lepton production at hadron colliders*, Phys. Rev. D **42** (1990) 815–824.

[5] P. Frampton, *Alternative version of chiral color as alternative to the Standard Model*, Phys. Rev. D **81** (2010) 095005.

[6] P. Frampton and S. Glashow, *Unifiable chiral color with natural Glashow-Iliopoulos-Maiani mechanism*, Phys. Rev. Lett. **58** (1987) 2168–2170.

[7] J. Bagger, C. Schmidt, and S. King, *Axigluon production in hadronic collisions*, Phys. Rev. D **37** (1988) 1188–1196.

[8] T. Han, I. Lewis, and Z. Liu, *Colored resonant signals at the LHC: Largest rate and simplest topology*, JHEP **12** (2010) 1–26.

[9] The ATLAS Collaboration, *A search for new physics in dijet mass and angular distributions in pp collisions at $\sqrt{s} = 7$ TeV measured with the ATLAS detector*, New Journal of Physics **13** (2011) 053044.

[10] The ATLAS Collaboration, *Search for new physics in dijet mass distributions in 0.81* fb^{-1} *of pp collisions at $\sqrt{s} = 7$ TeV*, ATLAS-CONF-2011-095 (2011) . `http://cdsweb.cern.ch/record/1369186`.

[11] G. Choudalakis, *On hypothesis testing, trials factor, hypertests and the BumpHunter*, Arxiv preprint:1101.0390 (2011) .