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Search for Physics Beyond the Standard Model with the ATLAS detector

Simone Zimmermann*
On behalf of the ATLAS Collaboration
University of Bonn, Nussalle 12, 53115 Bonn, Germany
E-mail: Simone.Zimmermann@cern.ch

We study events with single photons, with photons and jets, and with two jets to test several new physics hypotheses: Large Extra Dimensions, Weakly Interacting Massive Particles, and excited quarks. The results are the most recent ones obtained from the data recorded in 2011 at $\sqrt{s} = 7$ TeV centre-of-mass energy and in 2012 at $\sqrt{s} = 8$ TeV by the ATLAS experiment at the LHC. A lower mass limit on excited quarks is set at 3.66 TeV and the fundamental Planck scale, M_D, in $4+n$ dimensions, can be excluded below 1.93 TeV ($n = 2$), 1.83 TeV ($n = 3,4$), 1.86 TeV ($n = 5$), and 1.89 TeV ($n = 6$) at 95% CL.

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*Speaker.

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1. Introduction

We search for physics beyond the Standard Model (SM) in events with single photons, with photons and jets, and with two jets with the ATLAS detector at the LHC [1]. No evidence for signal is found, and new limits are set on the fundamental Planck scale of the ADD[1] model of Large Extra Dimensions, on Weakly Interacting Massive Particles (WIMPs) as Dark Matter candidates, and on excited quarks. References to the theoretical models considered can be found in Refs. [2, 3, 4].

2. Single Photon and Missing Transverse Energy Signature

The massive graviton modes of the ADD model and WIMPs escape detection and could be produced in association with energetic photons. Events are selected from a dataset of $4.6\,\text{fb}^{-1}$ recorded at $\sqrt{s} = 7\,\text{TeV}$ in 2011 with a missing transverse momentum trigger and an offline selection of $E_{\text{T}}^{\text{miss}} > 150\,\text{GeV}$. Further requirements include the presence of a photon with $p_{\text{T}} > 150\,\text{GeV}$ and $|\eta| < 2.37$, with at most one jet and no lepton. The photon must be isolated and must not point in the same direction as $E_{\text{T}}^{\text{miss}}$. The main backgrounds, from W/Z+γ and W/Z+jets, are estimated using control samples and fake-rate measurements. The 116 events observed in data are in agreement with the SM background prediction of $137 \pm 18^{\text{stat}} \pm 9^{\text{sys}}$, where the largest contribution, from $Z \to \nu\nu + \gamma$, is irreducible. The fundamental Planck scale M_D, in $4+n$ dimensions, can be excluded below 1.93 TeV ($n = 2$), 1.83 TeV ($n = 3,4$), 1.86 TeV ($n = 5$), and 1.89 TeV ($n = 6$) at 95% CL. Figure 1a shows the 90% CL upper limits on the nucleon-WIMP cross sections of spin-dependent (left) and spin-independent (right) interactions set by ATLAS alongside previous limits from direct WIMP detection and collider experiments. Here, WIMPs are assumed to be Dirac fermions, and the Lorentz structure of their production vertex is specified in terms of the operators D1, D5, D8 and D9 [2].

3. Single Photon and Single Jet Signature

The photon + jet invariant mass ($m_{\gamma j}$) distribution from the mixture of processes predicted in the SM is smooth and rapidly falling. In $2.11\,\text{fb}^{-1}$ of pp collisions recorded by ATLAS in 2011 at $\sqrt{s} = 7\,\text{TeV}$, evidence for narrow s-channel resonances in the photon plus jet production is searched for. Candidate events should pass a single photon trigger with a p_{T} threshold of 80 GeV. There must be at least one isolated photon with $p_{\text{T}} > 85\,\text{GeV}$ and $|\eta| < 1.37$ and at least one jet with $p_{\text{T}} > 30\,\text{GeV}$ and $|\eta| < 2.8$ present in the event. The smooth empirical function

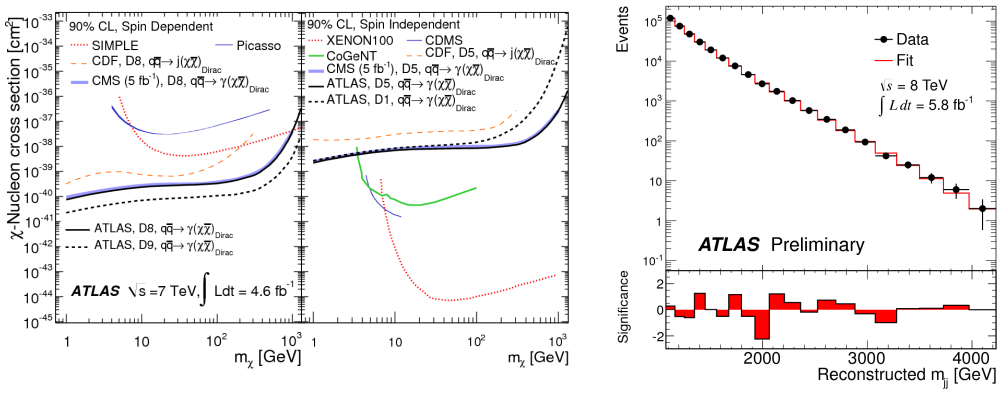
$$f(x \equiv m_{\gamma j}/\sqrt{s}) = p_1(1-x)^{p2}x^{-p3-p4\ln x} \tag{3.1}$$

is fitted to the measured $m_{\gamma j}$ distribution of the highest p_{T} photon and jet in bins corresponding to the mass resolution of the detector (4% at 600 GeV, 3% at 2 TeV). No evidence for the production of resonances above the smooth fitted background is found, and 95% CL limit on generic Gaussian signals (with widths of $\sigma_G/m_G = 5$, 7 and 10%) and on excited-quarks are set. The excited-quark benchmark model can be excluded up to a mass of 2.46 TeV [3].

[1] Arkani-Hamed, Dimopoulos and Dvali

4. Dijet Signature

The Dijet analysis looks for resonances in the invariant mass of the dijet system m_{jj} using $5.8\,\text{fb}^{-1}$ of $\sqrt{s} = 8\,\text{TeV}$ pp collisions collected in 2012. Events are selected by single jet triggers. There must be at least two jets with $p_\text{T} > 150\,\text{GeV}$ and rapidity $|y| < 2.8$. The two highest p_T jets are used to calculate m_{jj}, which is required to exceed 1 TeV. Their rapidities must fulfill $|y_1 - y_2| < 1.2$ to enhance s-channel production. The smooth functional form of Eq. 3.1 is fitted to the measured distribution of m_{jj}, shown in Fig. 1b. No evidence for the production of resonances above the smooth fitted background is found; 95% CL limits on Gaussian shaped signals (with widths of $\sigma_G/m_G = 7$, 10 and 15%) are set, and excited quarks are excluded up to a mass of 3.66 TeV [4].



(a) (b)

Figure 1: (a) 90% CL upper limits on the nucleon-WIMP cross section as a function of the WIMP mass m_χ for spin-dependent (left) and spin-independent (right) interactions. The results are compared with previous limits from CDF, CMS and direct WIMP detection experiments [2]. (b) The reconstructed dijet mass distribution with statistical uncertainties (filled points with error bars) fitted with a smooth functional form (solid line). The bin-by-bin significance of the data-fit difference is shown in the lower panel, using positive values for excesses and negative values for deficits [4].

References

[1] ATLAS Collaboration, *JINST* **3** (2008) S08003

[2] ATLAS Collaboration, *CERN-PH-EP-2012-209* (arXiv:1209.4625 [hep-ex]), submitted to Phys.Rev.Lett.

[3] ATLAS Collaboration, *Phys.Rev.Lett.* **108** (2012) 211802

[4] ATLAS Collaboration, *ATLAS-CONF-2012-088* (http://cdsweb.cern.ch/record/1460400)