Search for New Physics with leptons and/or jets at ATLAS

Antonio Policicchio[1] on behalf of the ATLAS Collaboration

[1]INFN Cosenza, c/o Dipartimento di Fisica, Universitá della Calabria, I-87036 Rende (Cs), Italy

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Data taken in 2011 with the ATLAS detector at the Large Hadron Collider (LHC) have been used to search for physics beyond the Standard Model. Results are presented based on between 1 and 5 fb^{-1} of $\sqrt(s)$ = 7 TeV proton-proton collisions mainly focussing on final states with jets and/or leptons. No evidence of new physics is found.

1 Introduction

The CERN LHC delivered more than 5 fb^{-1} of proton-proton collisions at $\sqrt{s} = 7$ TeV to the ATLAS [1] detector in 2011. Selected results on Beyond Standard Model (BSM) searches are summarized in this paper. The emphasis here is on *exotic* physics mainly focussing on final states with leptons and/or jets: new gauge bosons, composite objets, extra dimensions and other exotica. Results are presented by final state, showing how each search can be used to constrain different models. Some cross-section limit plots are also shown.

2 Results

Di-jets resonances are signatures for many BSM models and include string balls, GUT diquarks, excited quarks, W' and Z'. Searches are based on 5 fb^{-1} of data [2]. Additional sensitivity to new physics is obtained by studying the dijet angular distribution: high mass BSM objects are expected to be produced nearly at rest and therefore to produce a central angular distribution [2]. ATLAS sets the following limits at 95% CL (bayesian approach) $m_{q^*} > 3.35$ TeV for a generic Gaussian resonance such as for an excited quark, $m_{s_8} > 1.94$ TeV for color octet scalars, $m_{BH} > 3.96$ TeV for mini quantum black holes assuming six extra space-time dimensions for quantum gravity, and excludes quark contact interactions below a compositeness scale of 7.8 TeV. Fig. 1 (left) shows the obtained limit on the cross section times acceptance for a narrow dijet resonance, as a function of its mass. Also shown is the theoretical curve for a model of excited quark.

ATLAS searches for resonances in the dilepton (electrons and muons) invariant mass spectrum. BSM physics signals used as benchmarks include different models of Z' and graviton resonance. The search [3] is based on 5 fb^{-1} and sets mass limits $m_{Z'} > 2.11$ TeV on SSM Z' production and $m_{G^*} > 2.16$ TeV on Randall-Sandrum RS1 graviton production for coupling strength $k/\bar{M}_{Pl} = 0.1$. Fig. 1 (right) shows the cross section limits for Z' as a function of

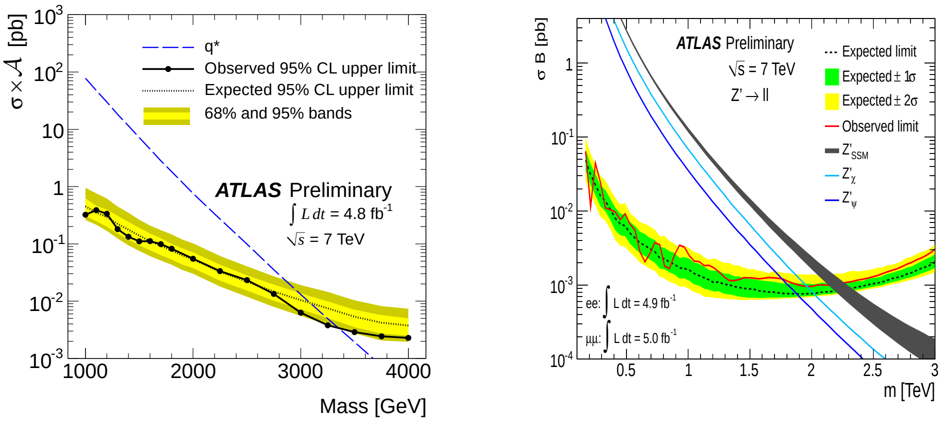

Figure 1: Left: dijet resonance limit on a generic Gaussian signal [2]; right: expected and observed cross section limits on dilepton resonances as a function of invariant dilepton mass [3].

dilepton resonance mass. The shape of the high mass tail is also sensitive to BSM physics. Limits, with 1.2 fb^{-1} of integrated luminosiy, are set on quark-lepton compositeness scales Λ^- > 10.1 TeV (8.0 TeV) and $\Lambda^+ > 9.4$ TeV (7.0 TeV) in the electron (muon) channel assuming destructive and constructive interference with Drell-Yan distribution, respectively [4].

ATLAS has carried out same-sign dileptons and multilepton searches looking for a variety of new physics signatures: doubly-charged Higgs, excited neutrinos, extra dimensions. The search for same-sign dimuons is based on 1.6 fb^{-1} and sets limits on doubly-charged Higgs production at $m_{H^{\pm\pm}} > 355$ GeV, assuming pair production via the exchange of a virtual Z/γ^* and 100% branching ratio to muons, and on like-sign top quark production cross section of 3.7 pb [5]. A search for two like-sign muons in events with high track multiplicity in 1.3 fb^{-1} sets a model independent limit on the new physics contribution to the signal region at 0.018 pb [6].

Inclusive searches in events with three or more leptons are based on 1 fb^{-1}. Data are consistent with Standard Model (SM) expectation. Fiducial limits are extracted on models predicting excesses of multi-lepton events using pair production of doubly-charged Higgs bosons as a benchmark model. The observed fiducial cross-section limit is 38 fb. Cross-section upper limits are also set at $\sigma < 41$, 34 fb for 200, 300 GeV mass, assuming decay to either a neutrino and a Z boson or an electron and a W boson [7].

ATLAS has searched for pair-produced leptoquarks decaying to either $lqlq$ or $lq\nu q$. Searches are restricted to one generation, i.e. e, μ or τ. A first generation search [8] in the $eejj$ and $e\nu jj$ channels using 1.1 fb^{-1} sets mass limits $m_{LQ} > 660$ GeV for $\beta = 1$ and $m_{LQ} > 607$ GeV for $\beta = 0.5$, where β is the branching ratio of a leptoquark to the channel with a charged lepton. The limits in the $\beta - m_{LQ}$ plane are shown in Fig. 2 (left), where β is the branching ratio of a leptoquark to the channel with a charged lepton. A search for a second generation using the $\mu\mu jj$ and $\mu\nu jj$ channels has been performed in 1 fb^{-1}: the mass limits are $m_{LQ} > 685$ GeV for $\beta = 1$ and $m_{LQ} > 594$ GeV for $\beta = 0.5$ [9]. The limits in the $\beta - m_{LQ}$ plane are shown in Fig. 2 (right).

A search has been performed for singly produced excited leptons by contact interaction and decaying to $e\gamma$ or $\mu\gamma$ resonance in events with $ee\gamma$ or $\mu\mu\gamma$, based on 5 fb^{-1} of data [10]. Fig. 3

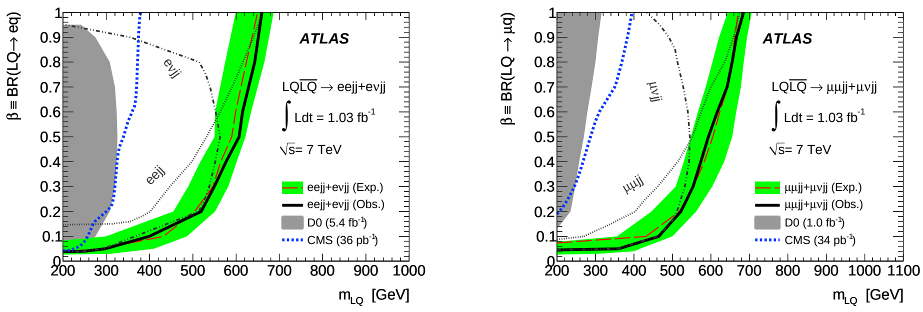

Figure 2: Expected and observed limit on leptoquark production. Left is for first generation limit in the $\beta - m_{LQ}$ plane [8] and right is for second generation [9].

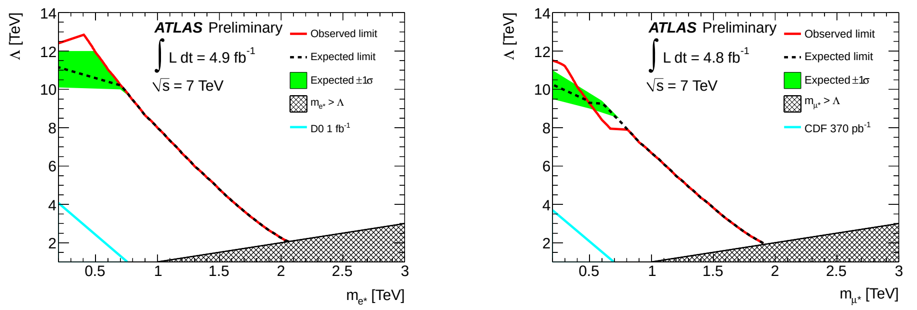

Figure 3: Expected and observed limits on excited electron (left) and muon (right) production [10].

shows the two-dimensional limits on compositeness scale Λ and excited lepton mass m_{l^*}. At $\Lambda = m_{l^*}$, the mass limits are $m_{e^*} > 2.0$ TeV and $m_{\mu^*} > 1.9$ TeV.

A search for diboson resonances has been performed in the channel $ZZ \rightarrow llll$ and $ZZ \rightarrow lljj$ in 1 fb^{-1} and a limit has been set at $m_{G^*} > 845$ GeV on the spin-2 RS1 graviton with coupling strength $k/\bar{M}_{Pl} = 0.1$ [11].

A heavy neutrinos N coupling to a right-handed boson W_R via the decay chain $qq \rightarrow W_R \rightarrow Nl \rightarrow W_R^* ll \rightarrow lljj$ lead to a mass resonance in both ljj and $lljj$. A search in 2.1 fb^{-1} assumes similar masses for heavy electron and muon neutrinos, and sets a mass limit $m_{W_R} > 1.8$ TeV for $m_{W_R} - m_N > 300$ GeV [12]. Separate limits have been set for Dirac and Majorana neutrinos and results are very similar.

Decays far from the interaction point are signatures of long-lived neutral particles. ATLAS has performed a search based on 1.9 fb^{-1} for pairs of back-to-back particles decaying in the muon system [13]. A dedicated trigger algorithm and a vertex finding routine in the muon system have been developed. Such decays are signatures, for example, of Higgs decays to pairs of long-lived neutral particles $h \rightarrow \pi_v \pi_v$, where π_v is a pseudoscalar from an Hidden Sector weakly coupled to the SM sector. Limits have been set as a function of the proper decay length of the π_v excluding the range 0.5-23 m depending on the Higgs mass (120-140 GeV) and on the π_v mass (20-40 GeV). Exclusion limits are shown in Fig. 4.

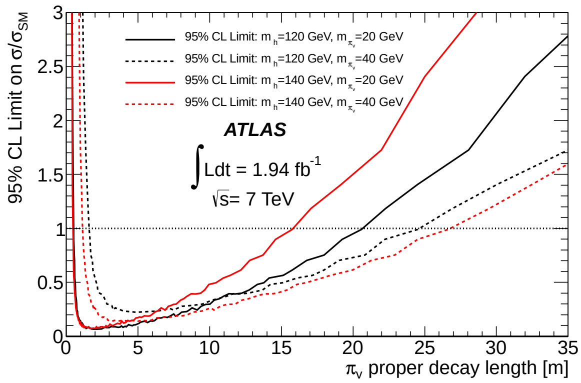

Figure 4: Observed 95% upper limits on the process $h \to \pi_v \pi_v$ as a function of the π_v proper decay length, expressed as a multiple of the SM cross section for Higgs production. Exclusion limits assume 100% branching ratio for the Higgs decaying to π_v's [13].

3 Conclusions

ATLAS has searched in a wide range of final states for signal of new physics BSM. No evidence for new physics has (yet) been found. Important constraints have been set on a variety of BSM models.

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