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A search for new charged heavy gauge W' bosons with the ATLAS detector at the LHC.

Geoffrey GILLES[*†]
Université Blaise Pascal - LPC - IN2P3 - CNRS
E-mail: geoffrey.gilles@cern.ch

This document presents a search for a W' boson, decaying to a top quark and a b quark in an effective coupling approach, using a multivariate method based on boosted decision trees. It reports preliminary exclusion limits on the $W' \to tb$ cross-section times branching ratio as a function of the W'-boson mass and effective couplings. The search covers W'-boson masses between 0.5 and 3.0 TeV, for right-handed or left-handed W'-boson chiralities, with 14.3 fb^{-1} of proton-proton collision data produced by the LHC in 2012, at a center-of-mass energy of 8 TeV and collected by the ATLAS detector.

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[*]Speaker.
[†]On behalf of the ATLAS collaboration.

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1. Introduction

Many theoretical approaches beyond the Standard Model involve enhanced symmetries that introduce new charged vector currents carried by new heavy gauge bosons, usually called W'. The W' bosons can appear as Kaluza-Klein excitations of the W boson in extra-spacetime dimension models [1], as massive right-handed counterpart of the W boson in Left-Right Symmetric models [2] in order to restore the parity symmetry at high energy, or in Little Higgs models [3] which provide mechanisms to cancel the quadratic divergences that appear in the Higgs-boson mass calculation. In many of these theories, the W' boson is expected to couple more strongly to the 3$^{\text{rd}}$ generation of quarks than to the two first ones. Opening channels potentially inaccessible to leptonic searches, a specific search for $W' \to tb$[1] signal against the Standard Model background events in an effective coupling approach [4] is performed. After defining the event selection criteria, a multivariate technique based on Boosted Decision Trees (BDT) classifiers [5], is used to search for a right-handed or left handed W' boson in the mass range of 0.5 – 3.0 TeV. This search [6] is performed with 14.3 fb^{-1} of proton-proton collisions data produced by the LHC in 2012 and collected by the ATLAS detector [7], at a center-of-mass energy of 8 TeV.

2. Summary of the search

This search is performed in the semi-leptonic final state $W' \to tb \to b\bar{b}l\nu$, requiring the presence of a prompt lepton (electron or muon) for a cleaner experimental signature and two b-jets in order to reduce the background. In this context, top-quark pairs ($t\bar{t}$) and W+jets events are the main backgrounds. Other smaller background processes consist of single top-quark production, diboson and Z+jets events. An additional instrumental background stems from multijet production with a jet misidentified as a lepton. The multijet and W+jets backgrounds are determined with data-driven methods and all of the remaining background processes are modelled using simulation and scaled to their theoretical predictions. In addition a specific set of selection criteria is used in order to further reduce the backgrounds. The W' boson is searched for in events with two or three jets, two of which are identified as b-jets (2-tag). The signal region used for the search is defined by selecting events where the reconstructed invariant-mass of the tb system "$m(tb)$" is higher than 270 GeV. After the event selection, a BDT algorithm is used to separate a potential W'-boson signal from the background. Two BDTs are trained in the 2-jet 2-tag and 3-jet 2-tag channels using right-handed W' bosons of mass 1.75 TeV as signal and all of the background processes weighted to their relative abundance as background. A set of a dozen of discriminating kinematical variables is used to build the BDTs for each channel where $m(tb)$ and $p_T(t)$ are the two most discriminating ones. Only variables which are well modelled in control regions are selected.

3. Results

No excess of data is observed over the full BDT range. Therefore, the BDT disctributions for 2- and 3-jet channels are combined in a statistical analysis based on the hybrid Bayesian-frequentist CL$_s$ procedure [8], employed to calculate exclusion limits at 95% Confidence Level (C.L.) in the

[1] In this document we use the notation "tb" to describe both $W'^{+} \to t\bar{b}$ and $W'^{-} \to \bar{t}b$ processes

production cross-section times branching ratio of the signal as a function of its mass. Masses below 1.84 (1.74) TeV are excluded for right-handed (left-handed) W' boson, while the expected limit is 1.72 (1.56) TeV (Fig.1). Limits on the g'/g effective couplings as a function of the W'-boson mass are also derived from the limits on the W'-boson cross-section.

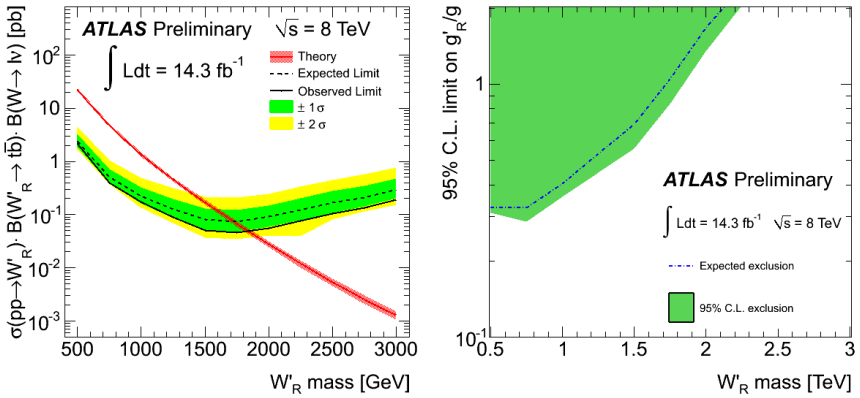

Figure 1: Observed and expected 95% C.L. limits on the right-handed W'-boson cross-section times branching ratio (left) and g'_R/g effective couplings (right) as a function of the W'-boson mass [6].

4. Conclusions

This search for W' bosons, performed with 14.3 fb^{-1} of proton-proton collision data produced by the LHC in 2012, at a center-of-mass energy of 8 TeV and collected by the ATLAS detector, shows consistency of the data with the Standard Model expectation. No presence of W'-boson signal events is observed. Exclusion limits at 95% C.L. are set on the W'-boson mass and on its effective couplings. Masses below 1.84 (1.74) TeV are excluded for right-handed (left-handed) W' boson.

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