Search for the Second Generation Leptoquarks at the ATLAS Experiment

Matthias Schott - On behalf of the ATLAS Collaboration
CERN PH-Department
Geneva, SWITZERLAND

ATL-PHYS-PROC-2011-182
22 October 2011

1 Introduction

This paper summarizes the search for scalar leptoquarks of the second generation in proton-proton collisions at a center-of-mass energy of $\sqrt{s} = 7$ TeV. The analysis is based on $35\,\mathrm{pb}^{-1}$ of data recorded by the ATLAS detector during the 2010 LHC run. Leptoquarks (LQ) are hypothetical particles that carry both lepton and baryon quantum numbers. There existence would give an explanation for the striking symmetry between quarks (q) and leptons (l) in the Standard Model (SM) of particle physics.

Scalar leptoquarks with a mass M_{LQ} can be produced in proton-proton collisions in leptoquark-antileptoquark pairs via QCD processes, when the available center of mass energy of the interacting partons exceeds $2 \cdot M_{LQ}$. The only relevant parameters of the scalar production of LQ are their mass and the branching fraction for a single leptoquark to decay into a charged lepton and a quark, labelled as β. The expected 2nd generation LQ-pair signature in the detector is two highly energetic jets (jj) and two opposite sign, highly energetic leptons ($\mu\mu$, $\mu\nu$).

2 Analyses Strategy

The analysis is performed via a cut-based approach separately in the $\mu\mu jj$ and the $\mu\nu jj$ final state, where only the first one is discussed in detail in the following. Analyses for both final states begin by selecting event samples that have high acceptance for signal production. The samples are dominated by the major backgrounds, $Z+jets$ and $t\bar{t}$ for the $\mu\mu jj$ case, and $W+jets$ and $t\bar{t}$ for the $\mu\nu jj$ case. The major difference between signal and background events is the presence of jet-lepton (also jet-neutrino in the case of $l\nu jj$) pairs coming from the decay of the parent LQ, giving a peak in the reconstructed jet-lepton mass spectrum for the signal.

In the following, the $\mu\mu jj$ final state is discussed in more detail: The main observables which are used to discriminate signal and background events in this case are the invariant mass of the two muons ($m_{\mu\mu}$), the average leptoquark candidate mass ($\overline{m}_{LQ}$) and the transverse momentum sum of all the selected decay products, i.e.

$S_T = p_T^{\mu_1} + p_T^{\mu_2} + p_T^{jet_1} + p_T^{jet_2}$. The signal region is defined using a random grid search optimization method, leading to the requirements $m_{\mu\mu} > 120$ GeV, $\overline{m}_{LQ} > 150$ GeV and $S_T > 450$ GeV.

The Z+jets background is estimated via a data-driven method, while the number of produced and selected top-quark pairs is estimated via Monte Carlo (MC) simulations. Several control regions are used to validate the background determination based on MC. A good agreement between MC and data was observed in all control regions.

3 Results

The data in the defined signal region are in good agreement with the Standard Model expectations for both decay channels. The 95% CL upper bounds on the production cross section are determined. These are translated into lower bounds for second generation LQ masses of $M_{LQ} > 422$ GeV and $M_{LQ} > 362$ GeV for $\beta = 1.0$ and $\beta = 0.5$, respectively (Figure 1). These are the most stringent bounds to date from direct searches for 2nd generation LQ in much of the phase space.

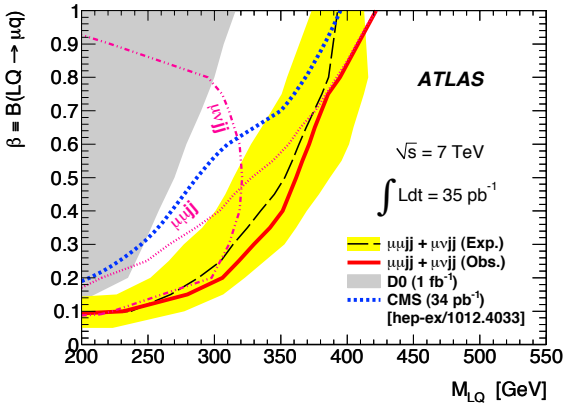

Figure 1: 95% CL exclusion region for the muon decay channels [1].

References

[1] The ATLAS Collaboration, Search for pair production of first or second generation leptoquarks in proton-proton collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector at the LHC. Apr 2011, Phys. Rev. D 83, 112006 (2011), arXiv:1104.4481 [hep -ex]