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Search for scalar leptoquark pair production decaying into top-quarks and leptons at $\sqrt{s}$ = 13 TeV with ATLAS detector

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This contribution presents a search for pair-produced scalar leptoquarks decaying to leptons and hadronically decaying top quarks at the LHC using 139 fb^{-1} of proton–proton collision data collected with the ATLAS detector at $\sqrt{s}$ = 13 TeV. Leptoquarks are predicted by various extensions of the Standard Model to draw the similarity between the quark and lepton sectors, and they provide a promising explanation for anomalies observed in both the lepton universality tests in B decays and the muon anomalous magnetic moment measurement. Searches for pair-produced scalar leptoquarks decaying into electron–top or muon–top pairs have been performed in final states with exactly two leptons. A parameterized gradient boosted decision tree approach is used to suppress the Standard Model backgrounds. No excess over the Standard Model prediction was observed. Exclusion limits on the leptoquark masses are set at 1480 GeV and 1470 GeV for the electron and muon channel, respectively.

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1. Introduction

Leptoquarks (LQs) are hypothetical colour-triplet bosons that appear in many Grand Unified Theory (GUT) models. They allow tree level transitions from a quark to a lepton or vice versa. Recently observed anomalies in B meson decays suggest lepton flavour universality violation [1], which could be accounted for by TeV-scale LQs. LQs could also explain a long-standing discrepancy in the E821 muon anomalous magnetic moment measurement [2]. A search for pair production of scalar leptoquarks decaying into either an electron or a muon and a top quark in proton–proton (pp) collisions is presented [3]. Data collected with the ATLAS detector [4] during Run 2 (2015–2018) of the LHC [5] are used, which corresponds to an integrated luminosity of 139 fb^{-1}, at a centre-of-mass energy of 13 TeV.

2. Analysis strategy and results

This analysis searches for the production of LQ pairs decaying into top quarks and leptons, with a focus on the fully hadronic top quark decay channel in the boosted regime. Events are required to contain two opposite-sign same-flavour leptons, either electrons or muons, and two large-radius jets as the top quark candidates. To suppress background contributions from Z+jets events, the selected events are also required to have dilepton invariant mass $m_{\ell\ell} > 120$ GeV. In the selected region, a boosted decision tree (BDT) classifier is used to identify the signal process from the dominant backgrounds, $t\bar{t}$ and Z+jets processes. The classifier is parameterized by expanding the input variables to include the hypothetical LQ mass (m_{LQ}), resulting in a single classifier that provides optimized discrimination across a wide range of LQ masses. The BDT output score is then used as the final discriminant in the signal region. Dedicated control regions are constructed to control the normalization of the dominant backgrounds, $t\bar{t}$ and Z+jets processes.

A simultaneous maximum-likelihood fit to the binned BDT score distribution in the signal region and the overall number of events in the control regions is performed. A comparison of the post-fit agreement between data and prediction for the signal and control regions where $m_{\mathrm{LQ}} = 1.5$ TeV is shown in Figure 1. No significant excess is observed over the Standard Model (SM) predictions. Exclusion limits are set on different values of LQ mass as a function of branching ratio ($\mathcal{B}$) into a charged lepton and a top quark at 95% confidence level (CL), as shown in Figure 2. LQ masses are excluded up to 1480 (1470) GeV in the electron (muon) channels, assuming a 100% branching ratio for the decay of LQ$\rightarrow t\ell$.

3. Summary

Recent results by the ATLAS collaboration on searches for LQ pair production in the LQ$\rightarrow te$ and LQ$\rightarrow t\mu$ channels have been presented, using 139 fb^{-1} of pp collision data at $\sqrt{s} = 13$ TeV recorded by the ATLAS detector at the LHC. No significant excess of data over the SM expectation has been observed, and this result has been interpreted as exclusion limits at 95% CL on LQ masses as a function of branching ratio into a charged lepton and a top quark.

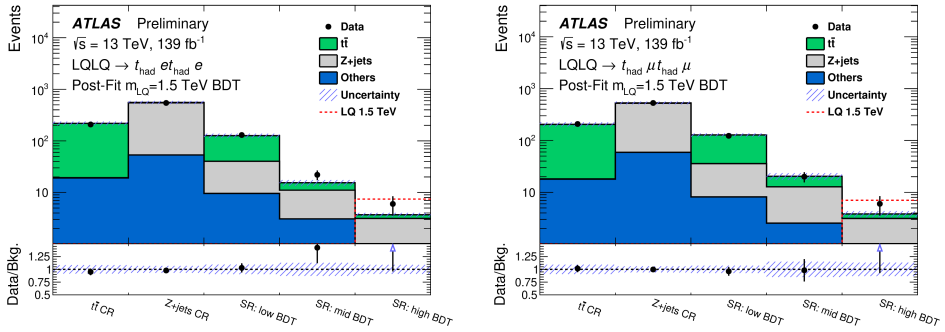

Figure 1: Fit results (background-only) for the binned BDT output score distribution in the signal region of the electron (left) and muon (right) channels, and the overall number of events in the $t\bar{t}$ and Z+jets control regions, where $m_{\mathrm{LQ}} = 1.5$ TeV. The band represents the post-fit systematic uncertainty. [3]

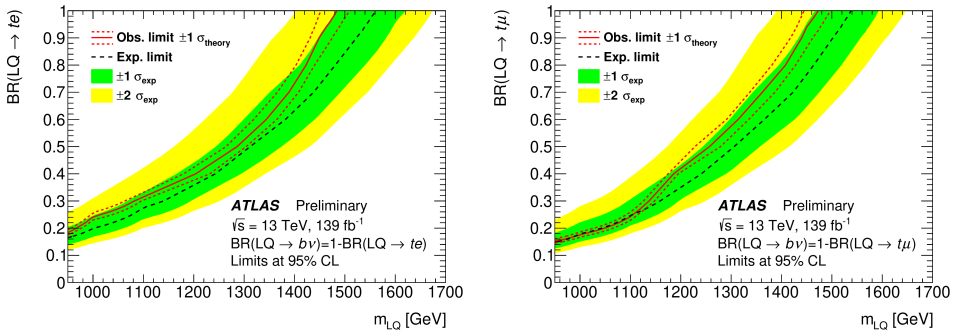

Figure 2: Exclusion limits on the leptoquark mass for scalar leptoquark pair production as a function of the branching ratio into a top quark and an electron (left) or a muon (right). The observed nominal limits are indicated by a black solid curve, with the surrounding red dotted lines obtained by varying the signal cross section by its $\pm 1\ \sigma$ theoretical uncertainty. Expected limits are indicated by a black dashed curve. [3]

References

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