PROCEEDINGS OF SCIENCE

Search for the pair production of first generation scalar leptoquarks at $\sqrt{s}$ = 13 TeV

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The quark and lepton sectors of the standard model (SM) are strikingly similar in terms of the number of particles and generations. This hints at a fundamental symmetry existing between the two sectors. Indeed, such a symmetry is part of many beyond-the-SM theories such as composite models, technicolor, grand unified SU(5), Pati-Salam SU(4) and E6 superstring-inspired theories. These models give rise to a new class of bosons called leptoquarks that carry both baryon and lepton numbers, a signature of their coupling to quarks and leptons. We perform a dedicated search for scalar leptoquarks using proton-proton collision data taken at a centre-of-mass energy of 13 TeV. The data were recorded by the CMS detector during the 2016 running of the LHC, and correspond to an integrated luminosity of 35.9 fb^{-1}.

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1. Introduction

A general effective model for leptoquarkd (LQs) was proposed in 1987 by Buchmuller, Ruckl and Wyler [1]. The four underlying assumptions of the model are 1) LQs have renormalizable interactions, 2) their interactions are invariant under the SM gauge groups: $SU(3)_C \otimes SU(2)_L \otimes U(1)_Y$, 3) they couple only to SM fermions and gauge bosons and, 4) they conserve lepton and baryon number separately in order to protect against a rapid proton decay. An LQ will decay into a lepton and a quark, giving rise to a final state containing high-momentum leptons and jets.

Thus in this search for first generation LQs, we assume LQs decaying to electrons or electron neutrinos along with jets. The process can give rise to the following three final states:

- Two electrons and two jets(eejj): each LQs decays into an electron and a quark,
- One electron, missing transverse energy, and two jets($e\nu jj$): one LQ decays into an electron and a quark, while the other decays into a neutrino and a quark, and
- No electrons, missing transverse energy, and two jets: each LQ decays into a neutrino and a quark.

The corresponding branching fractions are β^2, $2\times\beta(1-\beta)$, and $(1-\beta)^2$, respectively. We consider two values of β: 1, which corresponds to LQs always decaying to the first final state; and 0.5, where 50% of LQs decay to the second final state, with 25% decaying to the first final states. The first and second final states are denoted as $eejj$ and $e\nu jj$. In this analysis[5], we search for LQ decays in the $eejj$ and $e\nu jj$ final states.

2. Event Selection

2.1 Preselection

At the preselection, we go for a loose set of selection criteria to compare Monte Carlo simulated background predictions with data. For the eejj analysis, we select events with at least two electrons and two jets.When additional objects satisfy these requirements, the two highest p_T leptons and jets are considered. The dilepton invariant mass M_{ee} is required to be greater than 50 GeV. The scalar p_T sum over the leptons and two jets, $S_T = p_T(e_1)+p_T(e_2)+p_T(j_1)+p_T(j_2)$, must be at least 300 GeV. In the eνjj channel, we select events containing exactly one lepton, at least two jets, and $p_T^{miss} > 100$ GeV,the transverse mass of the $e - p_T^{miss}$ system must be greater 50 GeV and $S_T > 300$ GeV, where $S_T = p_T(e)+p_T^{miss}+p_T(j_1)+p_T(j_2)$.

After applying these criteria, the agreement of expected background with the data is examined in a series of plots as shown in Fig. 1.

3. Backgrounds

The major backgrounds from SM processes in the eejj channel are Z+jets and $t\bar{t}$, whereas single top, W+jets, diboson, and γ+jets contribute at a lower level. For the eνjj channel we have $t\bar{t}$ and W+jets as the major backgrounds. There is also an instrumental background from QCD multijet events with jets faking electrons.

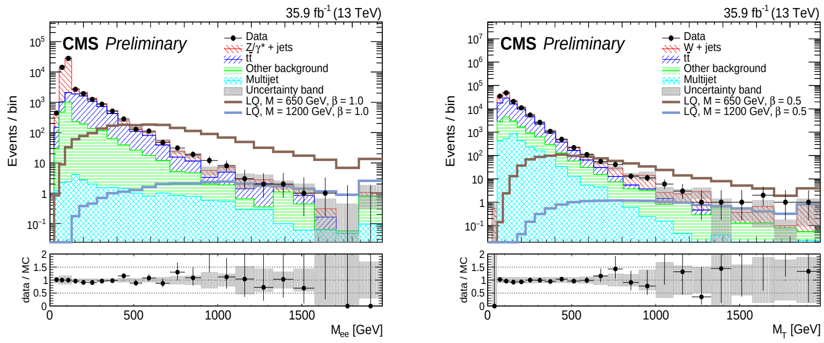

Figure 1: The M_{ee} (left) for the eejj channel and M_T(e,MET (right) for the eνjj channel[2].

4. Results

We do not find any evidence for an LQ signal in the data. Therefore, we proceed to set upper limits on the scalar LQ production cross section using full frequentist CLs method, using the event yields. The upper limits at 95% confidence level on the predicted cross section at NLO are shown in Fig. 2. The intersection of the central value of the theoretical prediction with the upper limit on the cross section yields a limit on the LQ mass. The limits for β = (1,0.5) for the first generation scalar LQs are (1435,1195) GeV, respectively.

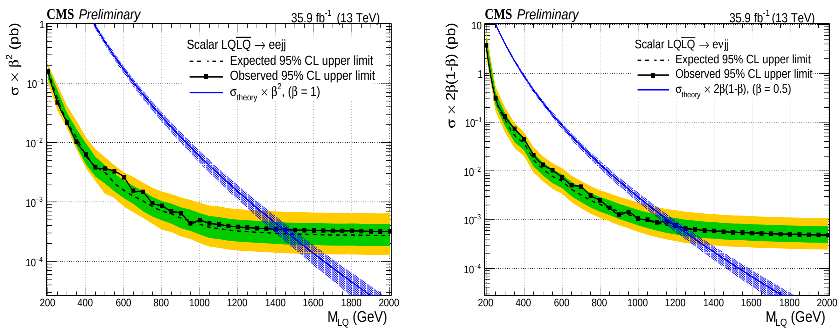

Figure 2: Observed and expected upper limits for first generation scalar LQ pair-production cross section times β^2 for eejj channel (left) and $2\beta(1-\beta)$ for the eνjj channel (right) at the 95% confidence level. The median (dashed line), 1σ (green band), and 2σ (yellow band) expected limits are shown[2].

References

[1] W. Buchmuller and D.Wyler, Phys. Lett. B **177**(1986)377.

[2] CMS Collaboration, CMS PAS EXO-17-009.