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Search for first generation scalar leptoquarks in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector [☆]

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ABSTRACT

We report a search for first generation scalar leptoquarks using 1.03 fb^{-1} of proton–proton collisions data produced by the Large Hadron Collider at $\sqrt{s} = 7$ TeV and recorded by the ATLAS experiment. Leptoquarks are sought via their decay into an electron or neutrino and a quark, producing events with two oppositely charged electrons and at least two jets, or events with an electron, missing transverse momentum and at least two jets. Control data samples are used to validate background predictions from Monte Carlo simulation. In the signal region, the observed event yields are consistent with the background expectations. We exclude at 95% confidence level the production of first generation scalar leptoquark with masses $m_{LQ} < 660$ (607) GeV when assuming the branching fraction of a leptoquark to a charged lepton is equal to 1.0 (0.5).

1. Introduction

Similarities between leptons and quarks in the Standard Model (SM) suggest that they might be a part of some symmetry at energy scales above the electroweak symmetry breaking scale. In this type of symmetry, transitions between leptons and quarks, mediated by a new type of gauge boson, a leptoquark (LQ), may occur. LQs are putative color-triplet bosons with spin 0 or 1, and fractional electric charge [1]. They are predicted in many extensions of the SM, such as Grand Unification models, and possess both quark and lepton quantum numbers. The Yukawa coupling λ_{LQ-l-q} of a leptoquark to a lepton and a quark, and the branching ratio (β) to a charged lepton, are model dependent. In pp collisions, if λ_{LQ-l-q} is of the order of the electroweak coupling strength, leptoquarks are predominantly produced in pairs via the strong interaction. At the LHC, the pair production cross section is dominated by gluon fusion for LQ masses $m_{LQ} \lesssim 1$ TeV, whereas at higher masses it is dominated by quark–antiquark annihilation. Under these assumptions, the production rate for scalar LQs depends only on the known QCD coupling constant and the unknown LQ mass, and has been calculated at up to next-to-leading order. It is usually assumed that leptoquarks only couple to one generation of SM isospin multiplet to accommodate experimental constraints on flavor-changing neutral currents, and lepton and baryon number violation [2]. Consequently, they are classified as first, second, or third generation according to the fermion generation to which they couple [3]. Lower mass limits on the first generation LQs already exist from searches of LQ produced in pairs at the LHC [4,5], Tevatron [6] and LEP [7]. Limits on single LQ production come from HERA [8] and other experiments [9].

In this Letter we present updated results on a search for the pair production of first generation scalar leptoquarks in pp collisions at $\sqrt{s} = 7$ TeV. The search is performed with a dataset corresponding to an integrated luminosity of $1.030 \pm 0.035\ \text{fb}^{-1}$ [10] of data collected by the ATLAS detector at the LHC from March 2011 to July 2011. We search for leptoquarks in two different final states. In the first one both LQs decay into an electron and a quark, while in the second final state one of the LQs decays into an electron and a quark and the other LQ decays into an electron–neutrino and a quark. These result in two different experimental signatures. One such signature is the production of two electrons and two jets and the other one comprises one electron, two jets, and missing transverse momentum (the magnitude of which is denoted as $E_{\mathrm{T}}^{\mathrm{miss}}$). The results from the two final states are combined and presented in the m_{LQ} versus β plane, where β is the branching ratio for a single LQ to decay into a charged lepton and a quark.

2. The ATLAS detector

The ATLAS detector [11] is a general-purpose particle detector with cylindrical geometry,[1] which consists of several subdetectors

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[1] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the center of the detector and z axis coinciding with the axis of the beam pipe. The x axis points from the interaction point to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.

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surrounding the interaction point, and providing nearly 4π coverage in solid angle. The location of the interaction point and momenta of charged particles are determined by the multi-layer silicon pixel and strip detectors covering $|\eta| < 2.5$ in pseudorapidity η, and a transition radiation tracker extending to $|\eta| < 2.0$, which are inside a superconducting solenoid producing a field of 2 T. The tracking system is surrounded by a high-granularity liquid-argon (LAr) sampling electromagnetic calorimeter with coverage up to $|\eta| < 3.2$. An iron-scintillator tile hadronic calorimeter provides coverage in the range $|\eta| < 1.7$. In the end-cap and forward regions LAr calorimeters provide both electromagnetic and hadronic measurements and cover the region $1.5 < |\eta| < 4.9$. The muon spectrometer, consisting of precision tracking detectors and superconducting toroids, is located outside the calorimeters.

We perform the search in the data sample selected by a three-level trigger requiring at least one high transverse energy (E_{T}) electron. The trigger is fully efficient for electrons with $E_{\mathrm{T}} > 30$ GeV, as measured in an inclusive $Z \to ee$ control sample [12].

3. Simulated samples

Samples of Monte Carlo (MC) events are used to devise selection criteria and validate background predictions. Background and signal samples are processed through the full ATLAS detector simulation based on GEANT4 [13], followed by the same reconstruction algorithms as used for collision data. The effects from in-time and out-of-time proton–proton collisions are included in the MC simulation. In the simulated samples, an event weight is applied to the average number of additional proton–proton collisions occurring in the same bunch crossing (event pile-up), to ensure that the number of interactions per bunch crossing, amounting to an average of 6, is well modeled.

The dominant backgrounds to the leptoquark signal include W and Z boson production in association with one or more jets, single and pair production of top quarks, QCD multi-jet (MJ) and diboson processes. The ALPGEN [14] generator is used for the simulation of the W, Z boson production in association with n partons. This program is interfaced to HERWIG [15] and JIMMY [16] to model parton showers and multiple parton interactions, respectively. The MLM [14] jet-parton matching scheme is used to form inclusive $W/Z+$jets MC samples. MC@NLO [17] is used to estimate single and pair production of top quarks. Diboson events are generated using HERWIG, and scaled to next-to-leading (NLO) cross section predictions [17,18].

Signal LQ samples are produced with PYTHIA [19] and normalized with NLO cross sections determined from Ref. [20] using CTEQ6.6 [21] parton distribution functions.

4. Object identification

This search is based on selecting events with a high E_{T} electron, two high p_{T} jets, and an additional electron or large $E_{\mathrm{T}}^{\mathrm{miss}}$. Electron candidates are reconstructed as energy deposits in the electromagnetic calorimeter. Electrons are required to have a shower profile consistent with that expected for this particle, and to have a track pointing to the energy deposit in the calorimeter. The pattern of the energy deposits on the first layer of the EM calorimeter is used to reject hadrons, while contamination from photon conversions is reduced by requiring a hit in the first layer of the pixel detector [22]. In addition to these criteria, we require electrons to have a transverse energy $E_{\mathrm{T}} > 30$ GeV and fall within a well instrumented region of the detector. Further rejection against hadrons is achieved by requiring the electron candidates to be isolated from additional energy deposits in the calorimeter by requiring that $E_{\mathrm{T}}^{0.2}/E_{\mathrm{T}} < 0.1$, where $E_{\mathrm{T}}^{0.2}$ is the transverse energy in a cone of radius $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.2$ centered on the electron track, excluding the electron contribution, and corrected for the energy from event pile-up and the electron energy leakage inside the cone.

Jets are defined as localized energy deposits in the calorimeter and are reconstructed using the anti-k_t algorithm [23] with a distance parameter of 0.4 and by performing a four-vector sum over calorimeter clusters. Reconstructed jets are corrected for the non-compensating calorimeter response, upstream material and other effects by using p_{T}- and η-dependent correction factors derived from MC and validated with test-beam and collision data [24]. We further require that jets satisfy $E_{\mathrm{T}} > 30$ GeV, $|\eta| < 2.8$ and are separated from electrons passing the above selection within $\Delta R > 0.4$. Selected jets must also pass quality requirements to reject jets arising from electronic noise bursts, cosmic rays and beam background, originating mainly from beam-gas events and beam-halo events [25].

The presence of neutrinos is inferred from the missing transverse momentum $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$ (and its magnitude $E_{\mathrm{T}}^{\mathrm{miss}}$) [26]. $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$ is defined as the negative vector sum of the transverse momenta of reconstructed electrons, muons and jets, as well as calorimeter clusters not associated to reconstructed objects.

Corrections are made to the simulated samples to ensure a good description of the energy resolution and the trigger and reconstruction efficiencies. These are determined in control data samples and applied to both simulated background and signal samples. These corrections change the total expected yields by less than 2%.

5. Event selection

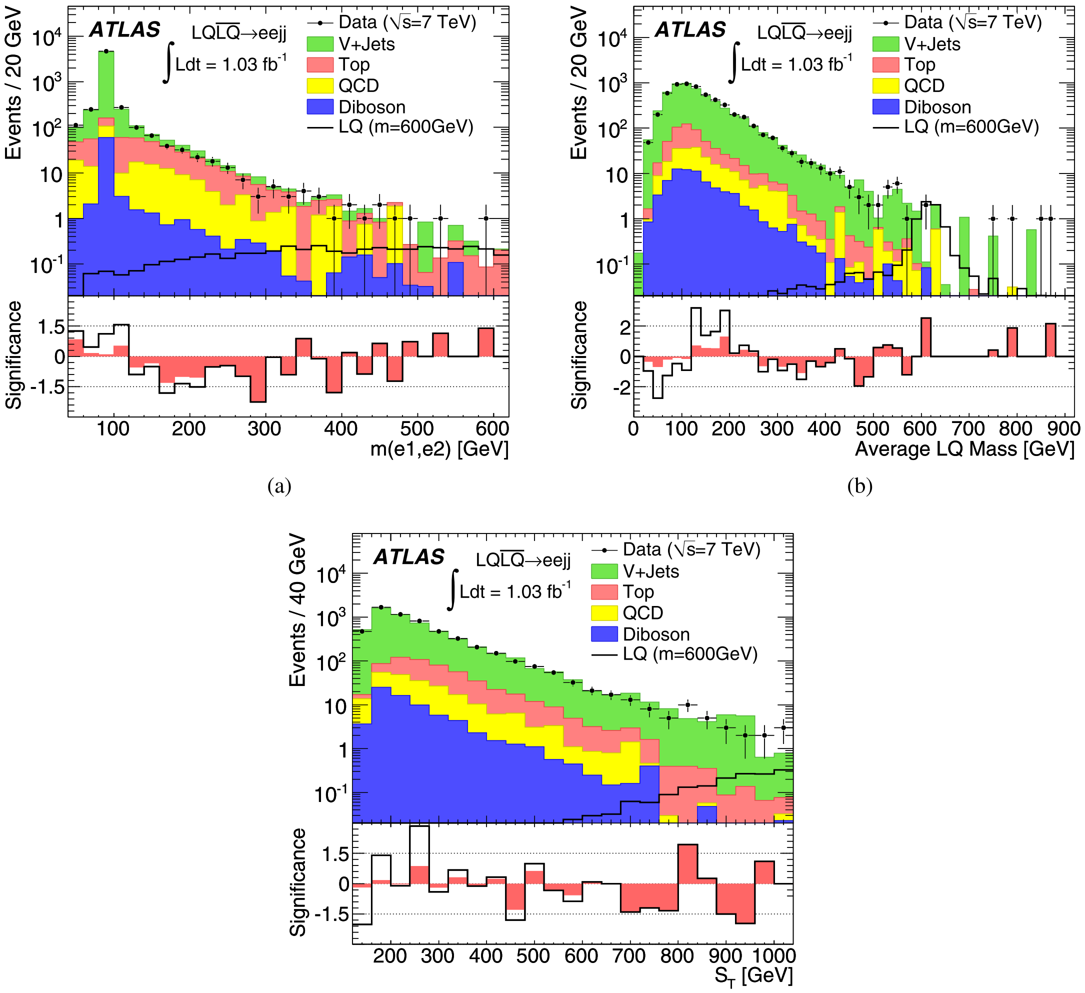
We define event selections to create samples with high signal and background acceptance. Events are selected to be consistent with the $\mathrm{LQ}\overline{\mathrm{LQ}} \to eeq\bar{q}/e\nu q\bar{q}$ decays. In the $eejj$ topology we require two electrons and at least two jets as defined in Section 4 and an invariant mass of the electron pair $m_{ee} > 40$ GeV. In the $e\nu jj$ topology, one electron, at least two jets and $E_{\mathrm{T}}^{\mathrm{miss}} > 30$ GeV are required, together with a requirement on the transverse mass of the electron and the $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$, $m_{\mathrm{T}} = \sqrt{2\vec{p}_{\mathrm{T}}^{e}\vec{p}_{\mathrm{T}}^{\mathrm{miss}}(1-\cos(\Delta\phi))} > 40$ GeV, where $\Delta\phi$ is the angle between the electron p_{T} and $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$. In addition, we require that $\Delta\phi(\mathrm{jet}, \vec{p}_{\mathrm{T}}^{\mathrm{miss}}) > 4.5 \times (1 - E_{\mathrm{T}}^{\mathrm{miss}}/45\ \mathrm{GeV})$ in the $e\nu jj$ channel for events with $E_{\mathrm{T}}^{\mathrm{miss}} < 45$ GeV to reduce residual contamination from MJ events. Events with additional identified electrons as defined in Section 4 or muons with $p_{\mathrm{T}} > 30$ GeV and $|\eta| < 2.4$ are rejected.

After all the selection criteria are applied the signal acceptance is of 70% for a LQ signal of $m_{LQ} = 600$ GeV for both channels, but the sample is still dominated by background events.

6. Background determination

The MJ background estimate is derived directly from data, whereas MC samples are used to predict the other backgrounds. We verify the shape of the $V+$jets ($V = W^{\pm}, Z$) and top quark background prediction using control regions, which are defined to enhance either the $V+$jets or the top quark production contribution, while keeping a negligible LQ signal contamination. These control regions are also used to derive the final normalization of the $V+$jets and top quark backgrounds.

The $V+$jets and top quark control regions are defined by applying additional selection criteria on m_{ee} and m_{T} to the selected sample. The remaining signal contamination is reduced by applying an upper threshold to the summed transverse momentum in the event, S_{T}, defined as the scalar sum of the p_{T} of the two



(a)

(b)

(c)

Fig. 1. Data and SM background comparisons of the input *LLR* variables for the *eejj* channel. (a) Invariant mass of the two electrons in the event; (b) Average LQ mass resulting from the best (electron, jet) combinations in each event, and (c) S_T. The stacked distributions show the various background contributions, and data are indicated by the points with error bars. The 600 GeV LQ signal is also shown for $\beta = 1.0$. The solid line (band) in the lower plots shows the Gaussian statistical (statistical + systematic) significance of the difference between data and the prediction.

leading jets and the transverse energy of the two electrons in the *eejj* channel. In the S_T definition in the $e\nu jj$ channel, the second electron E_T is substituted by the E_T^{miss}.

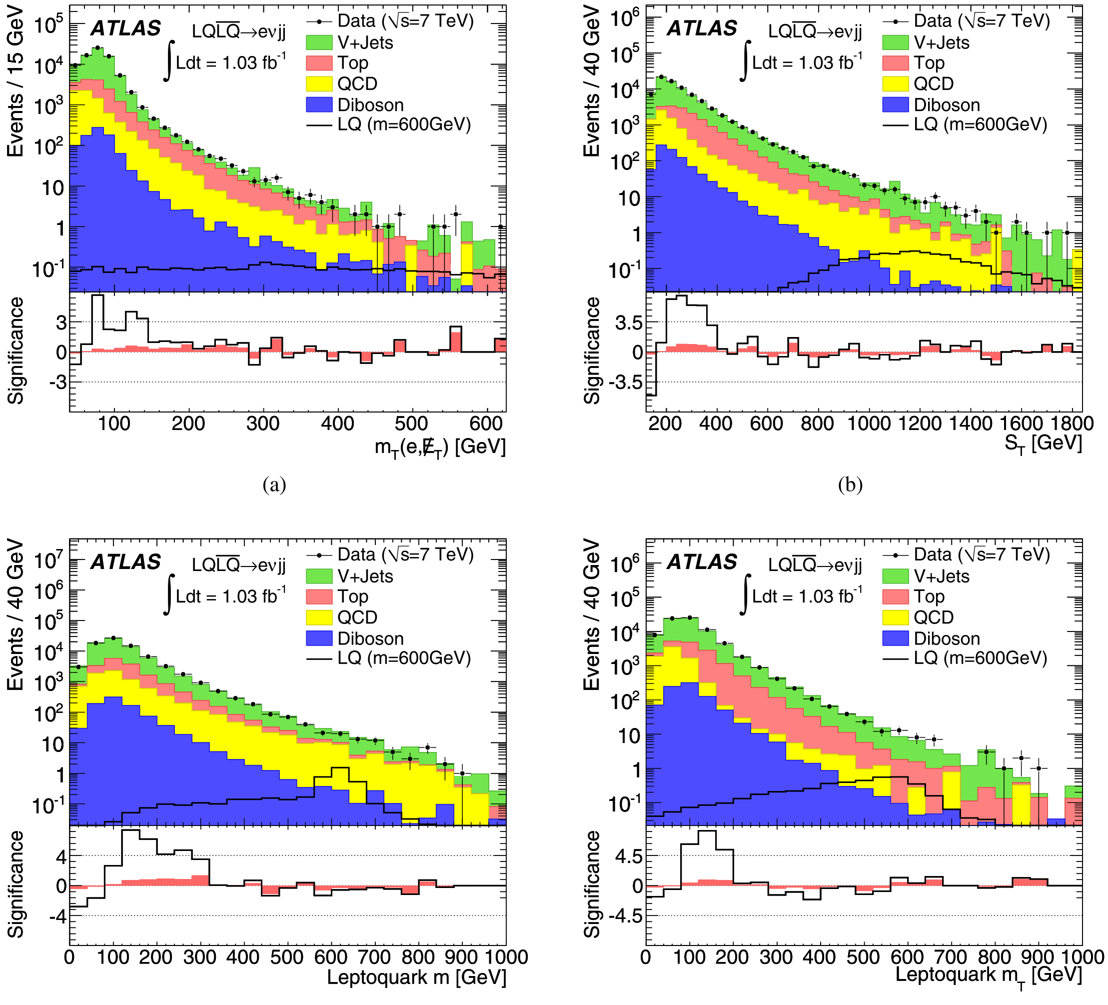
In the *eejj* topology we define two control regions **(i)** $Z+$jets: formed by events with at least two jets and in which the two electrons are required to have an invariant mass within a Z mass window $81 < m_{ee} < 101$ GeV, and **(ii)** $t\bar{t}$: events with at least two jets and exactly one electron and one muon [27], defined as in Section 4. In the $e\nu jj$ topology we define three control regions **(iii)** $W+2$ jets: events with exactly two jets, an electron and E_T^{miss} such that the transverse mass of the electron and the E_T^{miss} is in the region of the W Jacobian peak, $40 < m_T < 120$ GeV, and an $S_T < 225$ GeV requirement to limit the presence of signal events, **(iv)** $W+3$ jets: as in **(iii)** but with three or more jets, and **(v)** $t\bar{t}$: events with at least 4 jets, where the thresholds on the first and second jets are raised to 50 GeV and 40 GeV, respectively.

To estimate the MJ background, we perform fits to the m_{ee} distribution in the *eejj* channel, and to the E_T^{miss} distribution in the $e\nu jj$ channel. In these fits, the relative fraction of the MJ background is a free parameter. Templates for the MJ background distributions are derived from MJ enhanced samples, which are formed using electron candidates passing relaxed selection requirements but failing the nominal electron identification criteria described in Section 4. The MJ enhanced samples are corrected to remove the residual contamination from real electrons. In the *eejj* channel, the fits are applied to the sample selected following the criteria of Section 5, as well as to control regions **(i)** and **(ii)**, and the $W+$jets background is estimated together with the MJ background. In the $e\nu jj$ channel, the fits are applied to the selected sample as well as to control regions **(iii)–(v)**.

We observe 5615 data events in the *eejj* channel and 76 855 data events in the $e\nu jj$ channel, with SM expectations of 5600 ± 1000 and $74\,000 \pm 11\,000$, respectively. For $m_{LQ} = 600$ GeV, we expect 7.5 ± 0.5 signal events in the *eejj* channel and 4.5 ± 0.2 signal events in the $e\nu jj$ channel. The aforementioned uncertainties fully account for (the dominant) systematic and statistical uncertainties.

7. Likelihood analysis

We use a likelihood ratio method to separate signal and SM background. The likelihoods are constructed separately for background (L_B) and signal (L_S) hypotheses from a set of discriminating variables as follows: $L_B \equiv \prod b_i(x_j)$, $L_S \equiv \prod s_i(x_j)$, where b_i, s_i are the probabilities of the i-th input variable from the normalized



(a)

(b)

(c)

(d)

Fig. 2. Data and SM background comparisons of the input *LLR* variables for the $e\nu jj$ channel. (a) Transverse mass of the electron and the $E_{\mathrm{T}}^{\mathrm{miss}}$ in the event, (b) S_{T}, (c) LQ mass, and (d) LQ transverse masses. The stacked distributions show the various background contributions, and data are indicated by the points with error bars. The 600 GeV LQ signal is also shown for $\beta = 0.5$. The solid line (band) in the lower plots shows the Gaussian statistical (statistical + systematic) significance of the difference between data and the prediction.

summed background and signal distributions respectively, and x_j is the value of that variable for the j-th event in a given sample. Separate L_S distributions are created for several signal mass points, allowing mass-dependent optimization. Using the aforementioned quantities, a likelihood ratio is defined as $LLR = \log(L_S/L_B)$ and is used as the final variable to determine whether or not there is a LQ signal present in our data.

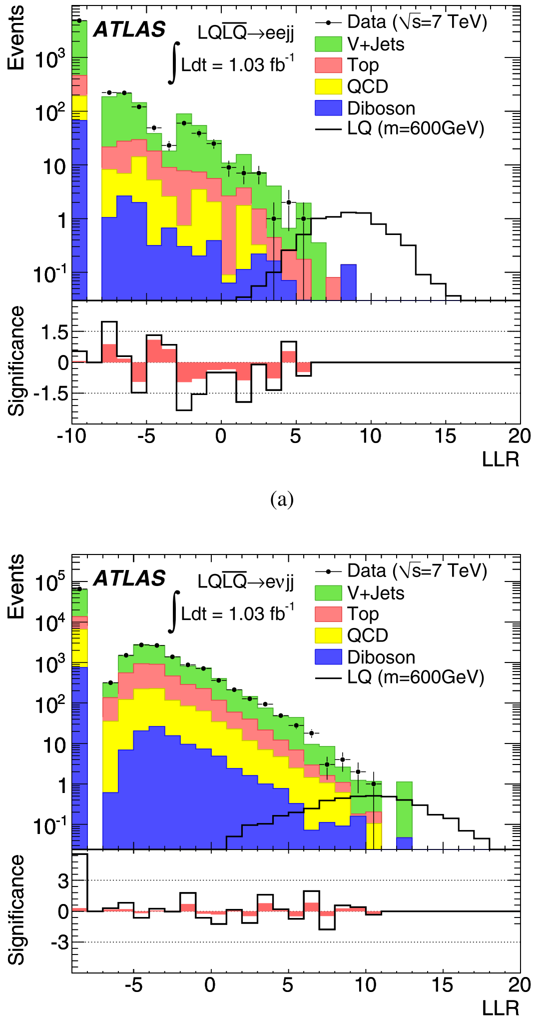
The following discriminating variables, selected to give the best separation between signal and background, are used. For the *eejj* channel, we use m_{ee}, $S_{\mathrm{T}} = E_{\mathrm{T}}^{\mathrm{e1}} + E_{\mathrm{T}}^{\mathrm{e2}} + p_{\mathrm{T}}^{\mathrm{jet1}} + p_{\mathrm{T}}^{\mathrm{jet2}}$ and the average invariant LQ mass $\bar{m}_{LQ}$. For the $e\nu jj$ topology, we use $m_{\mathrm{T}}(e, E_{\mathrm{T}}^{\mathrm{miss}})$, S_{T}, the transverse LQ mass $m_{\mathrm{T}}^{LQ}(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$ and the invariant LQ mass $m_{LQ}(\mathrm{e}, \mathrm{jet})$. To obtain the LQ masses, we calculate the invariant mass of the electron-jet system and the transverse mass of the $E_{\mathrm{T}}^{\mathrm{miss}}$-jet system. Since the LQs are produced in pairs, there are two possible mass combinations for the electron-jet and $E_{\mathrm{T}}^{\mathrm{miss}}$-jet pairs, and the combination giving the smallest mass difference is used. In the *eejj* channel, two possible electron-jet combinations arise from this procedure, and we take their average $\bar{m}_{LQ}$ for the analysis. The discriminating variables are shown in Figs. 1 and 2 for the *eejj* and the $e\nu jj$ channels, respectively.

8. Systematic uncertainties

Systematic uncertainties affect both background normalizations and shapes of the input distributions into the *LLR*. We consider systematic uncertainties from a variety of sources. These are described as follows.

The jet energy scale (JES) and resolution (JER) uncertainties are considered independently, and applied by varying the JES (JER) within its uncertainty of 4% to 6.5% (14%) depending on the jet p_{T} and η [28,29] for all simulated events. These variations are also propagated to the $E_{\mathrm{T}}^{\mathrm{miss}}$ in the $e\nu jj$ channel. The resulting uncertainties for the $m_{LQ} = 600$ GeV signal and background are 5% (8%) and 11% for the *eejj* ($e\nu jj$) final state.

Systematic uncertainties on the electron energy scale (1.6%) and resolution (0.6%), and on the electron trigger, reconstruction and identification efficiencies are derived by varying the selection criteria defining the Drell–Yan control sample used for the various measurements [12]. In addition, a 1% uncertainty is included to account for the efficiency of the isolation requirement. They lead to total signal and background yield uncertainties of 8% and 5% (3.5%), respectively, for the *eejj* ($e\nu jj$) channel and for a signal of mass $m_{LQ} = 600$ GeV.



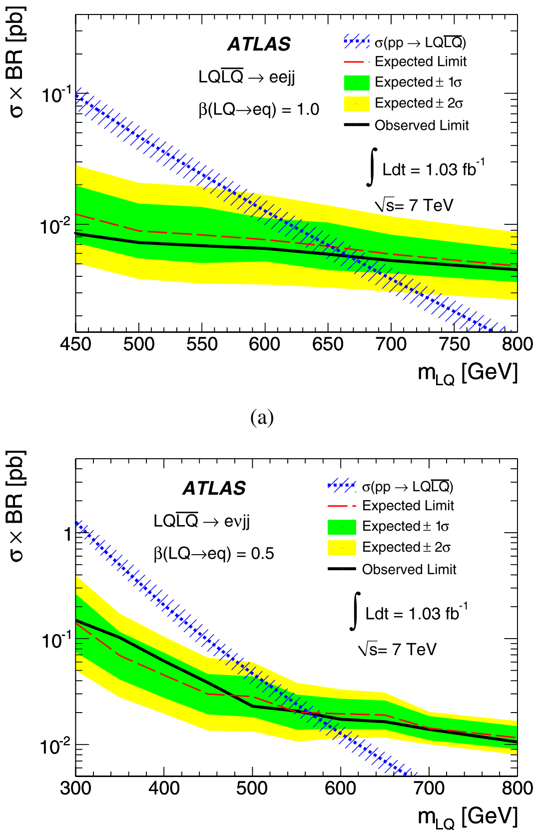
(a)

(b)

Fig. 3. *LLR* distributions for the *eejj* (a) and for the $e\nu jj$ (b) final states. The data are indicated with the points and the filled histograms show the SM background. The MJ background is estimated from data, while the other background contributions are obtained from simulated samples as described in the text. The LQ signal corresponding to a LQ mass of 600 GeV is indicated by a solid line, and is normalized assuming $\beta = 1.0$ (0.5) in the *eejj* ($e\nu jj$) channel. The lowest bin corresponds to background events regions of the phase space for which no signal events are expected. The solid line (band) in the lower plots shows the Gaussian statistical (statistical + systematic) significance of the difference between data and the prediction.

Table 1
The predicted and observed yields in a signal enhanced region defined by requiring $LLR > 0$ for both channels. Background predictions are scaled as described in Section 6. The *eejj* ($e\nu jj$) channel signal yields are computed assuming $\beta = 1.0$ (0.5). Statistical and systematic uncertainties added in quadrature are shown.

Source	*eejj* Channel		$e\nu jj$ Channel	
	400 GeV	600 GeV	400 GeV	600 GeV
W + jets	–	–	1500 ± 670	670 ± 210
Z + jets	98 ± 53	26 ± 14	45 ± 41	18 ± 19
$t\bar{t}$	15 ± 9	4.6 ± 2.2	430 ± 180	150 ± 38
Single t	1.4 ± 0.9	0.7 ± 0.4	53 ± 19	23 ± 4
Dibosons	1.5 ± 0.8	0.7 ± 0.3	25 ± 11	11 ± 2
MJ	9.2 ± 4.5	2.3 ± 1.5	170 ± 35	75 ± 15
Total	120 ± 55	34 ± 14	2200 ± 690	950 ± 220
Data	82	22	2207	900
LQ	120 ± 8	7.5 ± 0.5	69 ± 4	4.5 ± 0.2



(a)

(b)

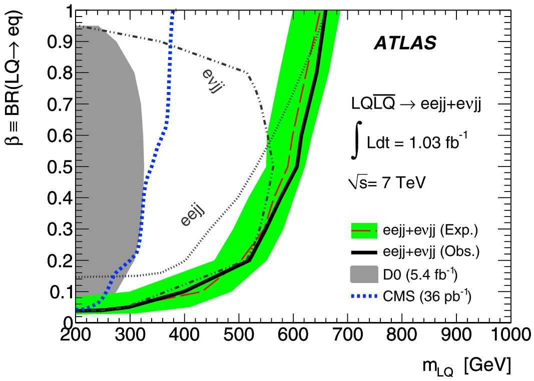
Fig. 4. 95% CL upper limit on the pair production cross section times branching ratio of the first generation leptoquarks for the *eejj* channel at $\beta = 1.0$ (a) and for the $e\nu jj$ channel at $\beta = 0.5$ (b). The solid lines indicate the individual observed limits, while the expected limits are indicated by the dashed lines. The theory prediction is indicated by the dotted line, which includes the systematic uncertainties due to the choice of the PDF and due to the renormalization and factorization scales. The dark green (light yellow) solid band contains 68% (95%) of possible outcomes from pseudo-experiments in which the yield is Poisson-fluctuated around the background-only expectation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this Letter.)

The systematic uncertainty for the production model of V + jets is taken to be the largest difference between the nominal data-driven prediction using ALPGEN and that obtained by using SHERPA [30], giving an uncertainty of 1.5% and 3% for the *eejj* and the $e\nu jj$ channels, respectively.

The systematic uncertainty for the $t\bar{t}$ production model is evaluated by comparing the yields between events generated with MC@NLO and those generated with various alternate samples. These include samples generated with POWHEG [31], a different top mass (170 GeV and 175 GeV instead of the nominal value equal to 172.5 GeV), and a different amount of initial and final state-radiation (ISR/FSR). The result is an uncertainty in the $t\bar{t}$ yield of 10% and 15% for the single electron and dielectron analyses, respectively.

Systematic uncertainties are determined for the MJ backgrounds by comparing results from alternative normalizations to those from the methods described earlier. The largest variation is taken, resulting in an uncertainty of 20% and 28% in the MJ normalization for the $e\nu jj$ and the *eejj* channels, respectively. An uncertainty of 3.7% [10] on the integrated luminosity is applied to both diboson and single top background yields, as well as to expected signal yields.

Finally, further uncertainties on the simulated background contributions originate from finite statistics in the MC samples used.



(a)

Fig. 5. 95% CL exclusion region resulting from the combination of the two channels shown in the β versus leptoquark mass plane. The shaded area indicates the D0 exclusion limit [6], while the thick dotted line indicates the CMS exclusion [4]. The dotted and dotted-dashed lines indicate the individual limits for the $eejj$ and the $e\nu jj$, respectively. The combined observed limit is indicated by the solid black line. The combined expected limit is indicated by the dashed line, together with the solid band containing 68% of possible outcomes from pseudo-experiments in which the yield is Poisson-fluctuated around the background-only expectation.

These range from 2%–9%, depending on the LQ mass under consideration. Additional signal uncertainties considered arise from the choice of the PDF, which results in an uncertainty on the signal acceptance of 1%–8% for LQ masses between 300 GeV and 700 GeV, and from ISR/FSR effects, resulting in an uncertainty of 2% for both channels.

9. Results

The *LLR* distributions for data, backgrounds and a LQ signal assuming $m_{LQ} = 600$ GeV are shown in Fig. 3 for both channels. The observed and predicted event yields requiring $LLR > 0$ for the major background sources, as well as the expected signal, are shown in Table 1. We do not observe any excess of events at high *LLR* values where signal is expected, indicating no evidence of scalar LQ pair production. Given the absence of signal we determine 95% CL upper limits on the LQ pair production cross sections using a modified frequentist CL_s method based on a Poisson log-likelihood ratio statistical test [32,33]. Systematic and statistical uncertainties are treated as nuisance parameters with a Gaussian probability density function, and the full *LLR* distribution is considered. The effect of the various systematic uncertainties on the shape of the *LLR* distribution are included on the calculation by integrating over a Gaussian distribution with standard deviation equal to the fractional change in the yield between the systematically adjusted distribution and the nominal case for each individual uncertainty in each bin. The 95% CL upper bounds on the cross section for LQ pair production as a function of mass are shown in Fig. 4 for both the $eejj$ and the $e\nu jj$ channels for $\beta = 1.0$ and $\beta = 0.5$, respectively. The obtained cross section limits are combined, and reinterpreted as limits in the β vs. m_{LQ} plane as shown in Fig. 5.

10. Conclusions

We report on a search for pair production of first generation scalar leptoquarks at ATLAS using a data sample corresponding to an integrated luminosity of 1.03 fb^{-1}. No excess over SM background expectations is observed in the data in the signal enhanced region, and 95% CL upper bounds on the production cross section are thus determined. These are translated into lower observed (expected) limits on leptoquark masses of $m > 660$ (650) GeV and $m > 607$ (587) GeV when assuming its branching fraction to a charged lepton to be equal to 1.0 and 0.5, respectively. These are the most stringent limits to date arising from direct searches for leptoquarks.

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References

[1] B. Schrempp, F. Schrempp, Phys. Lett. B 153 (1985) 101;
H. Georgi, S. Glashow, Phys. Rev. Lett. 32 (1974) 438;
J. Pati, A. Salam, Phys. Rev. D 10 (1974) 275;
G. Senjanovic, A. Sokorac, Z. Phys. C 20 (1983) 255;
P. Frampton, B.-H. Lee, Phys. Rev. Lett. 64 (1990) 619;
P. Frampton, T. Kephart, Phys. Rev. D 42 (1990) 3892;
E. Witten, Nucl. Phys. B 258 (1985) 75;
K. Lane, Nucl. Phys. (1993). Lectures given at Theoretical Advanced Study Institute (TAS193) in: Elem. Part. Physics, 1233; arXiv:hep-ph/9401324.
[2] S. Kovalenko, I. Schmidt, Phys. Lett. B 562 (2003) 104.
[3] W. Buchmüller, R. Rückl, D. Wyler, Phys. Lett. B 191 (1987) 442;
W. Buchmüller, R. Rückl, D. Wyler, Phys. Lett. B 448 (1999) 320, Erratum.
[4] CMS Collaboration, Phys. Lett. B 703 (2011) 246.
[5] ATLAS Collaboration, Phys. Rev. D 83 (2011) 112006.
[6] D0 Collaboration, Phys. Rev. D 84 RC (2011) 071104.
[7] OPAL Collaboration, Eur. Phys. J. C 31 (2003) 281.
[8] H1 Collaboration, Phys. Lett. B 704 (2011) 388, doi:10.1016/j.physletb.2011.09.017.
[9] K. Nakamura, et al., Particle Data Group, J. Phys. G 37 (2010) 075021.
[10] ATLAS Collaboration, ATLAS-CONF-2011-116, http://cdsweb.cern.ch/record/1376384;
ATLAS Collaboration, Eur. Phys. J. C 71 (2011) 1630.
[11] ATLAS Collaboration, JINST 3 (2008) S08003.

[12] ATLAS Collaboration, arXiv:1110.3174, Eur. Phys. J. C, submitted for publication.

[13] S. Agostinelli, et al., Nucl. Instrum. Meth. A 506 (2003) 250;
G. Aad, Eur. Phys. J. C 70 (2010) 823.

[14] M. Mangano, et al., JHEP 0307 (2003) 001.

[15] G. Corcella, et al., JHEP 0101 (2001) 010, arXiv:hep-ph/0011363.

[16] J. Butterworth, J. Forshaw, M. Seymour, Z. Phys. C 72 (1996) 637.

[17] S. Frixione, B.R. Webber, JHEP 0206 (2002) 029;
S. Frixione, P. Nason, B.R. Webber, JHEP 0308 (2003) 007.

[18] J.M. Campbell, R.K. Ellis, Phys. Rev. D 60 (1999) 113006.

[19] T. Sjöstrand, S. Mrenna, P. Skands, JHEP 0605 (2006) 026.

[20] M. Kramer, T. Plehn, M. Spira, P.M. Zerwas, Phys. Rev. D 71 (2005) 057503.

[21] D. Stump, et al., JHEP 0310 (2003) 046.

[22] ATLAS Collaboration, arXiv:1110.3174.

[23] M. Cacciari, G.P. Salam, G. Soyez, JHEP 0804 (2008) 063;
M. Cacciari, G.P. Salam, Phys. Lett. B 641 (2006) 57.

[24] ATLAS Collaboration, CERN-PH-EP-2011-191, http://cdsweb.cern.ch/record/1399505.

[25] ATLAS Collaboration, ATLAS-CONF-2010-038, http://cdsweb.cern.ch/record/1277678;
ATLAS Collaboration, arXiv:1112.6426, Eur. Phys. J. C, submitted for publication.

[26] ATLAS Collaboration, Eur. Phys. J. C 72 (2012) 1844, doi:10.1140/epjc/s10052-011-1844-6.

[27] ATLAS Collaboration, ATLAS-CONF-2011-063, http://cdsweb.cern.ch/record/1345743.

[28] ATLAS Collaboration, ATLAS-CONF-2011-032, http://cdsweb.cern.ch/record/1337782.

[29] ATLAS Collaboration, ATLAS-CONF-2010-054, http://cdsweb.cern.ch/record/1281311.

[30] T. Gleisberg, et al., JHEP 0902 (2009) 007;
S. Schumann, F. Krauss, JHEP 0803 (2008) 038;
S. Hoeche, F. Krauss, S. Schumann, F. Siegert, JHEP 0905 (2009) 053.

[31] S. Frixione, P. Nason, C. Oleari, JHEP 0711 (2007) 070.

[32] W. Fisher, FERMILAB-TM-2386-E.

[33] T. Junk, Nucl. Instrum. Meth. A 434 (1999) 435.

ATLAS Collaboration

G. Aad[48], B. Abbott[111], J. Abdallah[11], A.A. Abdelalim[49], A. Abdesselam[118], O. Abdinov[10], B. Abi[112], M. Abolins[88], O.S. AbouZeid[158], H. Abramowicz[153], H. Abreu[115], E. Acerbi[89a,89b], B.S. Acharya[164a,164b], L. Adamczyk[37], D.L. Adams[24], T.N. Addy[56], J. Adelman[175], M. Aderholz[99], S. Adomeit[98], P. Adragna[75], T. Adye[129], S. Aefsky[22], J.A. Aguilar-Saavedra[124b,a], M. Aharrouche[81], S.P. Ahlen[21], F. Ahles[48], A. Ahmad[148], M. Ahsan[40], G. Aielli[133a,133b], T. Akdogan[18a], T.P.A. Åkesson[79], G. Akimoto[155], A.V. Akimov[94], A. Akiyama[67], M.S. Alam[1], M.A. Alam[76], J. Albert[169], S. Albrand[55], M. Aleksa[29], I.N. Aleksandrov[65], F. Alessandria[89a], C. Alexa[25a], G. Alexander[153], G. Alexandre[49], T. Alexopoulos[9], M. Alhroob[20], M. Aliev[15], G. Alimonti[89a], J. Alison[120], M. Aliyev[10], P.P. Allport[73], S.E. Allwood-Spiers[53], J. Almond[82], A. Aloisio[102a,102b], R. Alon[171], A. Alonso[79], B. Alvarez Gonzalez[88], M.G. Alviggi[102a,102b], K. Amako[66], P. Amaral[29], C. Amelung[22], V.V. Ammosov[128], A. Amorim[124a,b], G. Amorós[167], N. Amram[153], C. Anastopoulos[29], L.S. Ancu[16], N. Andari[115], T. Andeen[34], C.F. Anders[20], G. Anders[58a], K.J. Anderson[30], A. Andreazza[89a,89b], V. Andrei[58a], M.-L. Andrieux[55], X.S. Anduaga[70], A. Angerami[34], F. Anghinolfi[29], A. Anisenkov[107], N. Anjos[124a], A. Annovi[47], A. Antonaki[8], M. Antonelli[47], A. Antonov[96], J. Antos[144b], F. Anulli[132a], S. Aoun[83], L. Aperio Bella[4], R. Apolle[118,c], G. Arabidze[88], I. Aracena[143], Y. Arai[66], A.T.H. Arce[44], J.P. Archambault[28], J.-F. Arguin[14], E. Arik[18a,*], M. Arik[18a], A.J. Armbruster[87], O. Arnaez[81], A. Artamonov[95], G. Artoni[132a,132b], D. Arutinov[20], S. Asai[155], R. Asfandiyarov[172], S. Ask[27], B. Åsman[146a,146b], L. Asquith[5], K. Assamagan[24], A. Astbury[169], A. Astvatsatourov[52], B. Aubert[4], E. Auge[115], K. Augsten[127], M. Aurousseau[145a], G. Avolio[163], R. Avramidou[9], D. Axen[168], C. Ay[54], G. Azuelos[93,d], Y. Azuma[155], M.A. Baak[29], G. Baccaglioni[89a], C. Bacci[134a,134b], A.M. Bach[14], H. Bachacou[136], K. Bachas[29], G. Bachy[29], M. Backes[49], M. Backhaus[20], E. Badescu[25a], P. Bagnaia[132a,132b], S. Bahinipati[2], Y. Bai[32a], D.C. Bailey[158], T. Bain[158], J.T. Baines[129], O.K. Baker[175], M.D. Baker[24], S. Baker[77], E. Banas[38], P. Banerjee[93], Sw. Banerjee[172], D. Banfi[29], A. Bangert[150], V. Bansal[169], H.S. Bansil[17], L. Barak[171], S.P. Baranov[94], A. Barashkou[65], A. Barbaro Galtieri[14], T. Barber[48], E.L. Barberio[86], D. Barberis[50a,50b], M. Barbero[20], D.Y. Bardin[65], T. Barillari[99], M. Barisonzi[174], T. Barklow[143], N. Barlow[27], B.M. Barnett[129], R.M. Barnett[14], A. Baroncelli[134a], G. Barone[49], A.J. Barr[118], F. Barreiro[80], J. Barreiro Guimarães da Costa[57], R. Bartoldus[143], A.E. Barton[71], V. Bartsch[149], R.L. Bates[53], L. Batkova[144a], J.R. Batley[27], A. Battaglia[16], M. Battistin[29], F. Bauer[136], H.S. Bawa[143,e], S. Beale[98], B. Beare[158], T. Beau[78], P.H. Beauchemin[161], R. Beccherle[50a], P. Bechtle[20], H.P. Beck[16], S. Becker[98], M. Beckingham[138], K.H. Becks[174], A.J. Beddall[18c], A. Beddall[18c], S. Bedikian[175], V.A. Bednyakov[65], C.P. Bee[83], M. Begel[24], S. Behar Harpaz[152], P.K. Behera[63], M. Beimforde[99], C. Belanger-Champagne[85], P.J. Bell[49], W.H. Bell[49], G. Bella[153], L. Bellagamba[19a], F. Bellina[29], M. Bellomo[29], A. Belloni[57], O. Beloborodova[107], K. Belotskiy[96], O. Beltramello[29], S. Ben Ami[152], O. Benary[153], D. Benchekroun[135a], C. Benchouk[83], M. Bendel[81], N. Benekos[165], Y. Benhammou[153], E. Benhar Noccioli[49], J.A. Benitez Garcia[159b], D.P. Benjamin[44], M. Benoit[115], J.R. Bensinger[22], K. Benslama[130], S. Bentvelsen[105], D. Berge[29], E. Bergeaas Kuutmann[41], N. Berger[4], F. Berghaus[169], E. Berglund[105], J. Beringer[14], P. Bernat[77], R. Bernhard[48], C. Bernius[24], T. Berry[76], C. Bertella[83], A. Bertin[19a,19b], F. Bertinelli[29], F. Bertolucci[122a,122b], M.I. Besana[89a,89b], N. Besson[136], S. Bethke[99], W. Bhimji[45], R.M. Bianchi[29], M. Bianco[72a,72b], O. Biebel[98], S.P. Bieniek[77], K. Bierwagen[54], J. Biesiada[14], M. Biglietti[134a,134b], H. Bilokon[47], M. Bindi[19a,19b], S. Binet[115], A. Bingul[18c], C. Bini[132a,132b],

C. Biscarat[177], U. Bitenc[48], K.M. Black[21], R.E. Blair[5], J.-B. Blanchard[115], G. Blanchot[29], T. Blazek[144a],
C. Blocker[22], J. Blocki[38], A. Blondel[49], W. Blum[81], U. Blumenschein[54], G.J. Bobbink[105],
V.B. Bobrovnikov[107], S.S. Bocchetta[79], A. Bocci[44], C.R. Boddy[118], M. Boehler[41], J. Boek[174], N. Boelaert[35],
S. Böser[77], J.A. Bogaerts[29], A. Bogdanchikov[107], A. Bogouch[90,∗], C. Bohm[146a], V. Boisvert[76], T. Bold[37],
V. Boldea[25a], N.M. Bolnet[136], M. Bona[75], V.G. Bondarenko[96], M. Bondioli[163], M. Boonekamp[136],
G. Boorman[76], C.N. Booth[139], S. Bordoni[78], C. Borer[16], A. Borisov[128], G. Borissov[71], I. Borjanovic[12a],
S. Borroni[87], K. Bos[105], D. Boscherini[19a], M. Bosman[11], H. Boterenbrood[105], D. Botterill[129],
J. Bouchami[93], J. Boudreau[123], E.V. Bouhova-Thacker[71], D. Boumediene[33], C. Bourdarios[115],
N. Bousson[83], A. Boveia[30], J. Boyd[29], I.R. Boyko[65], N.I. Bozhko[128], I. Bozovic-Jelisavcic[12b], J. Bracinik[17],
A. Braem[29], P. Branchini[134a], G.W. Brandenburg[57], A. Brandt[7], G. Brandt[118], O. Brandt[54], U. Bratzler[156],
B. Brau[84], J.E. Brau[114], H.M. Braun[174], B. Brelier[158], J. Bremer[29], R. Brenner[166], S. Bressler[171],
D. Breton[115], D. Britton[53], F.M. Brochu[27], I. Brock[20], R. Brock[88], T.J. Brodbeck[71], E. Brodet[153],
F. Broggi[89a], C. Bromberg[88], J. Bronner[99], G. Brooijmans[34], W.K. Brooks[31b], G. Brown[82], H. Brown[7],
P.A. Bruckman de Renstrom[38], D. Bruncko[144b], R. Bruneliere[48], S. Brunet[61], A. Bruni[19a], G. Bruni[19a],
M. Bruschi[19a], T. Buanes[13], Q. Buat[55], F. Bucci[49], J. Buchanan[118], N.J. Buchanan[2], P. Buchholz[141],
R.M. Buckingham[118], A.G. Buckley[45], S.I. Buda[25a], I.A. Budagov[65], B. Budick[108], V. Büscher[81],
L. Bugge[117], O. Bulekov[96], M. Bunse[42], T. Buran[117], H. Burckhart[29], S. Burdin[73], T. Burgess[13],
S. Burke[129], E. Busato[33], P. Bussey[53], C.P. Buszello[166], F. Butin[29], B. Butler[143], J.M. Butler[21],
C.M. Buttar[53], J.M. Butterworth[77], W. Buttinger[27], S. Cabrera Urbán[167], D. Caforio[19a,19b], O. Cakir[3a],
P. Calafiura[14], G. Calderini[78], P. Calfayan[98], R. Calkins[106], L.P. Caloba[23a], R. Caloi[132a,132b], D. Calvet[33],
S. Calvet[33], R. Camacho Toro[33], P. Camarri[133a,133b], M. Cambiaghi[119a,119b], D. Cameron[117],
L.M. Caminada[14], S. Campana[29], M. Campanelli[77], V. Canale[102a,102b], F. Canelli[30,f], A. Canepa[159a],
J. Cantero[80], L. Capasso[102a,102b], M.D.M. Capeans Garrido[29], I. Caprini[25a], M. Caprini[25a], D. Capriotti[99],
M. Capua[36a,36b], R. Caputo[81], R. Cardarelli[133a], T. Carli[29], G. Carlino[102a], L. Carminati[89a,89b],
S. Caron[104], G.D. Carrillo Montoya[172], A.A. Carter[75], J.R. Carter[27], J. Carvalho[124a,g], D. Casadei[108],
M.P. Casado[11], M. Cascella[122a,122b], C. Caso[50a,50b,∗], A.M. Castaneda Hernandez[172],
E. Castaneda-Miranda[172], V. Castillo Gimenez[167], N.F. Castro[124a], G. Cataldi[72a], F. Cataneo[29],
A. Catinaccio[29], J.R. Catmore[71], A. Cattai[29], G. Cattani[133a,133b], S. Caughron[88], D. Cauz[164a,164c],
P. Cavalleri[78], D. Cavalli[89a], M. Cavalli-Sforza[11], V. Cavasinni[122a,122b], F. Ceradini[134a,134b],
A.S. Cerqueira[23b], A. Cerri[29], L. Cerrito[75], F. Cerutti[47], S.A. Cetin[18b], F. Cevenini[102a,102b], A. Chafaq[135a],
D. Chakraborty[106], K. Chan[2], B. Chapleau[85], J.D. Chapman[27], J.W. Chapman[87], E. Chareyre[78],
D.G. Charlton[17], V. Chavda[82], C.A. Chavez Barajas[29], S. Cheatham[85], S. Chekanov[5], S.V. Chekulaev[159a],
G.A. Chelkov[65], M.A. Chelstowska[104], C. Chen[64], H. Chen[24], K. Chen[148], S. Chen[32c], T. Chen[32c],
X. Chen[172], S. Cheng[32a], A. Cheplakov[65], V.F. Chepurnov[65], R. Cherkaoui El Moursli[135e],
V. Chernyatin[24], E. Cheu[6], S.L. Cheung[158], L. Chevalier[136], G. Chiefari[102a,102b], L. Chikovani[51a],
J.T. Childers[58a], A. Chilingarov[71], G. Chiodini[72a], M.V. Chizhov[65], G. Choudalakis[30], S. Chouridou[137],
I.A. Christidi[77], A. Christov[48], D. Chromek-Burckhart[29], M.L. Chu[151], J. Chudoba[125], G. Ciapetti[132a,132b],
K. Ciba[37], A.K. Ciftci[3a], R. Ciftci[3a], D. Cinca[33], V. Cindro[74], M.D. Ciobotaru[163], C. Ciocca[19a], A. Ciocio[14],
M. Cirilli[87], M. Ciubancan[25a], A. Clark[49], P.J. Clark[45], W. Cleland[123], J.C. Clemens[83], B. Clement[55],
C. Clement[146a,146b], R.W. Clifft[129], Y. Coadou[83], M. Cobal[164a,164c], A. Coccaro[172], J. Cochran[64], P. Coe[118],
J.G. Cogan[143], J. Coggeshall[165], E. Cogneras[177], J. Colas[4], A.P. Colijn[105], C. Collard[115], N.J. Collins[17],
C. Collins-Tooth[53], J. Collot[55], G. Colon[84], P. Conde Muiño[124a], E. Coniavitis[118], M.C. Conidi[11],
M. Consonni[104], V. Consorti[48], S. Constantinescu[25a], C. Conta[119a,119b], F. Conventi[102a,h], J. Cook[29],
M. Cooke[14], B.D. Cooper[77], A.M. Cooper-Sarkar[118], K. Copic[14], T. Cornelissen[174], M. Corradi[19a],
F. Corriveau[85,i], A. Cortes-Gonzalez[165], G. Cortiana[99], G. Costa[89a], M.J. Costa[167], D. Costanzo[139],
T. Costin[30], D. Côté[29], L. Courneyea[169], G. Cowan[76], C. Cowden[27], B.E. Cox[82], K. Cranmer[108],
F. Crescioli[122a,122b], M. Cristinziani[20], G. Crosetti[36a,36b], R. Crupi[72a,72b], S. Crépé-Renaudin[55],
C.-M. Cuciuc[25a], C. Cuenca Almenar[175], T. Cuhadar Donszelmann[139], M. Curatolo[47], C.J. Curtis[17],
C. Cuthbert[150], P. Cwetanski[61], H. Czirr[141], P. Czodrowski[43], Z. Czyczula[175], S. D'Auria[53],
M. D'Onofrio[73], A. D'Orazio[132a,132b], P.V.M. Da Silva[23a], C. Da Via[82], W. Dabrowski[37], T. Dai[87],
C. Dallapiccola[84], M. Dam[35], M. Dameri[50a,50b], D.S. Damiani[137], H.O. Danielsson[29], D. Dannheim[99],
V. Dao[49], G. Darbo[50a], G.L. Darlea[25b], C. Daum[105], W. Davey[20], T. Davidek[126], N. Davidson[86],

R. Davidson[71], E. Davies[118,c], M. Davies[93], A.R. Davison[77], Y. Davygora[58a], E. Dawe[142], I. Dawson[139], J.W. Dawson[5,*], R.K. Daya[22], K. De[7], R. de Asmundis[102a], S. De Castro[19a,19b], P.E. De Castro Faria Salgado[24], S. De Cecco[78], J. de Graat[98], N. De Groot[104], P. de Jong[105], C. De La Taille[115], H. De la Torre[80], B. De Lotto[164a,164c], L. de Mora[71], L. De Nooij[105], D. De Pedis[132a], A. De Salvo[132a], U. De Sanctis[164a,164c], A. De Santo[149], J.B. De Vivie De Regie[115], S. Dean[77], W.J. Dearnaley[71], R. Debbe[24], C. Debenedetti[45], D.V. Dedovich[65], J. Degenhardt[120], M. Dehchar[118], C. Del Papa[164a,164c], J. Del Peso[80], T. Del Prete[122a,122b], T. Delemontex[55], M. Deliyergiyev[74], A. Dell'Acqua[29], L. Dell'Asta[21], M. Della Pietra[102a,h], D. della Volpe[102a,102b], M. Delmastro[4], N. Delruelle[29], P.A. Delsart[55], C. Deluca[148], S. Demers[175], M. Demichev[65], B. Demirkoz[11,j], J. Deng[163], S.P. Denisov[128], D. Derendarz[38], J.E. Derkaoui[135d], F. Derue[78], P. Dervan[73], K. Desch[20], E. Devetak[148], P.O. Deviveiros[105], A. Dewhurst[129], B. DeWilde[148], S. Dhaliwal[158], R. Dhullipudi[24,k], A. Di Ciaccio[133a,133b], L. Di Ciaccio[4], A. Di Girolamo[29], B. Di Girolamo[29], S. Di Luise[134a,134b], A. Di Mattia[172], B. Di Micco[29], R. Di Nardo[47], A. Di Simone[133a,133b], R. Di Sipio[19a,19b], M.A. Diaz[31a], F. Diblen[18c], E.B. Diehl[87], J. Dietrich[41], T.A. Dietzsch[58a], S. Diglio[86], K. Dindar Yagci[39], J. Dingfelder[20], C. Dionisi[132a,132b], P. Dita[25a], S. Dita[25a], F. Dittus[29], F. Djama[83], T. Djobava[51b], M.A.B. do Vale[23c], A. Do Valle Wemans[124a], T.K.O. Doan[4], M. Dobbs[85], R. Dobinson[29,*], D. Dobos[29], E. Dobson[29,l], M. Dobson[163], J. Dodd[34], C. Doglioni[49], T. Doherty[53], Y. Doi[66,*], J. Dolejsi[126], I. Dolenc[74], Z. Dolezal[126], B.A. Dolgoshein[96,*], T. Dohmae[155], M. Donadelli[23d], M. Donega[120], J. Donini[33], J. Dopke[29], A. Doria[102a], A. Dos Anjos[172], M. Dosil[11], A. Dotti[122a,122b], M.T. Dova[70], J.D. Dowell[17], A.D. Doxiadis[105], A.T. Doyle[53], Z. Drasal[126], J. Drees[174], N. Dressnandt[120], H. Drevermann[29], C. Driouichi[35], M. Dris[9], J. Dubbert[99], S. Dube[14], E. Duchovni[171], G. Duckeck[98], A. Dudarev[29], F. Dudziak[64], M. Dührssen[29], I.P. Duerdoth[82], L. Duflot[115], M.-A. Dufour[85], M. Dunford[29], H. Duran Yildiz[3b], R. Duxfield[139], M. Dwuznik[37], F. Dydak[29], M. Düren[52], W.L. Ebenstein[44], J. Ebke[98], S. Eckweiler[81], K. Edmonds[81], C.A. Edwards[76], N.C. Edwards[53], W. Ehrenfeld[41], T. Ehrich[99], T. Eifert[143], G. Eigen[13], K. Einsweiler[14], E. Eisenhandler[75], T. Ekelof[166], M. El Kacimi[135c], M. Ellert[166], S. Elles[4], F. Ellinghaus[81], K. Ellis[75], N. Ellis[29], J. Elmsheuser[98], M. Elsing[29], D. Emeliyanov[129], R. Engelmann[148], A. Engl[98], B. Epp[62], A. Eppig[87], J. Erdmann[54], A. Ereditato[16], D. Eriksson[146a], J. Ernst[1], M. Ernst[24], J. Ernwein[136], D. Errede[165], S. Errede[165], E. Ertel[81], M. Escalier[115], C. Escobar[123], X. Espinal Curull[11], B. Esposito[47], F. Etienne[83], A.I. Etienvre[136], E. Etzion[153], D. Evangelakou[54], H. Evans[61], L. Fabbri[19a,19b], C. Fabre[29], R.M. Fakhrutdinov[128], S. Falciano[132a], Y. Fang[172], M. Fanti[89a,89b], A. Farbin[7], A. Farilla[134a], J. Farley[148], T. Farooque[158], S.M. Farrington[118], P. Farthouat[29], P. Fassnacht[29], D. Fassouliotis[8], B. Fatholahzadeh[158], A. Favareto[89a,89b], L. Fayard[115], S. Fazio[36a,36b], R. Febbraro[33], P. Federic[144a], O.L. Fedin[121], W. Fedorko[88], M. Fehling-Kaschek[48], L. Feligioni[83], C. Feng[32d], E.J. Feng[30], A.B. Fenyuk[128], J. Ferencei[144b], J. Ferland[93], W. Fernando[109], S. Ferrag[53], J. Ferrando[53], V. Ferrara[41], A. Ferrari[166], P. Ferrari[105], R. Ferrari[119a], A. Ferrer[167], M.L. Ferrer[47], D. Ferrere[49], C. Ferretti[87], A. Ferretto Parodi[50a,50b], M. Fiascaris[30], F. 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