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ATLAS Collaboration; Aad, G.

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Search for Higgs Boson Decays into a *Z* Boson and a Light Hadronically Decaying Resonance Using 13 TeV *pp* Collision Data from the ATLAS Detector

G. Aad *et al.*[*]
(ATLAS Collaboration)

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A search for Higgs boson decays into a Z boson and a light resonance in two-lepton plus jet events is performed, using a pp collision dataset with an integrated luminosity of 139 fb^{-1} collected at $\sqrt{s} = 13$ TeV by the ATLAS experiment at the CERN LHC. The resonance considered is a light boson with a mass below 4 GeV from a possible extended scalar sector or a charmonium state. Multivariate discriminants are used for the event selection and for evaluating the mass of the light resonance. No excess of events above the expected background is found. Observed (expected) 95% confidence-level upper limits are set on the Higgs boson production cross section times branching fraction to a Z boson and the signal resonance, with values in the range 17–340 pb (16^{+6}_{-5}–320^{+130}_{-90} pb) for the different light spin-0 boson mass and branching fraction hypotheses, and with values of 110 and 100 pb (100^{+40}_{-30} and 100^{+40}_{-30} pb) for the η_c and J/ψ hypotheses, respectively.

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The structure of the standard model (SM) scalar sector is the subject of intense scrutiny by the ATLAS [1] and CMS [2] Collaborations at the CERN Large Hadron Collider (LHC) [3]. At the current level of precision, all of the measured properties of the Higgs boson (H) [4,5] are found to be consistent with their SM predictions [6–10], and no additional Higgs boson has been observed to date. However, given the small natural decay width of the Higgs boson, even small additional contributions from physics beyond the SM can lead to final states with substantial, and thus possibly detectable, branching fractions ($\mathcal{B}$) [11]. This Letter presents a search for Higgs boson decays into a Z boson and a hadronically decaying light resonance in events with a same-flavor lepton pair (electrons or muons) and a jet in the ATLAS detector. Hadronic decays of an η_c or of a J/ψ charmonium resonance (Q), or of a light spin-0 boson from an extended Higgs sector with a mass up to 4 GeV, are considered and are reconstructed as a single jet.

The Yukawa sector of the SM [12] does not provide an explanation for the observed fermion mass hierarchy. As a result, a wide range of new physics scenarios have been proposed, including the Froggatt-Nielsen mechanism [13] and the Higgs-dependent Yukawa couplings model [14]; for a recent overview, see Ref. [15]. The couplings of the Higgs boson to the third-generation fermions [16–21] have been observed, and a program to probe its couplings to the first- and second-generation charged leptons has been established [22–25]. For its couplings to first- and second-generation quarks, several approaches are being explored. Focusing on the Higgs boson's coupling to the charm quark, direct searches have been performed for Higgs boson decays into charm quarks [26,27] and for exclusive decays into a J/ψ and a photon [28,29], with no excess observed. Constraints from differential cross section measurements of Higgs boson production versus transverse momentum (p_T) have also been derived [30,31]. Higgs boson decays into a gauge boson and a charmonium state, including an η_c or a J/ψ, have been proposed as another way to access the coupling of the Higgs boson to the charm quark [32–34] and to probe the nature of the Higgs boson [35]. This search follows the last approach and maximizes the signal acceptance by focusing on inclusive hadronic final states of the mesons in $H \to Z\eta_c$ and $H \to ZJ/\psi$ decays, which have SM branching fractions of 1.4×10^{-5} and 2.2×10^{-6} [35], respectively.

While the SM posits a single complex Higgs doublet field [36,37], extended Higgs sectors are motivated [38] and provide a rich phenomenology of additional scalars. Two such models discussed here are the two-Higgs-doublet model (2HDM) [11,39] and the 2HDM with an additional scalar singlet (2HDM + S) [11,40]. These represent two of the simplest extensions of the scalar sector, and with their type-II fermion couplings they are necessary to generate the masses in the minimal supersymmetric SM and the next-to-minimal supersymmetric SM, respectively [41]. Both of these models can include additional light pseudoscalars (a) with significant $\mathcal{B}(H \to Za)$ or $\mathcal{B}(H \to aa)$ [11]. In the

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[*] Full author list given at the end of the article.

2HDM(+S), these two $\mathcal{B}$ values can be adjusted independently, therefore searches for $H \to aa$ do not constrain $\mathcal{B}(H \to Za)$, so that searches for the latter decay are required [11,34]. Despite the Yukawa nature of the a to fermion couplings, there are large regions of parameter space depending on the mass of a and the ratio of the vacuum expectation values of the two Higgs-doublet fields ($\tan\beta$) [11], where these pseudoscalars decay mainly to gluons and light up-type quarks, as the decays into down-type fermions are suppressed. These experimental signatures are also relevant in axion models [42–44], models of electroweak baryogenesis [45], neutrino mass models [46], dark-matter models [46,47], and models of grand unification [48]. Previous searches for Higgs boson decays into light scalars have been performed at the Tevatron [49] and the LHC [50–59]. However, these were mostly focused on searches for $H \to aa$, in final states including leptons, photons, or bottom quarks. By targeting the $H \to Za$, $a \to$ hadrons decay channel, this search accesses new, previously unexplored regions of the parameter space.

Searches for hadronic decays of light resonances are challenging at the LHC due to the large multijet background. However, substantial progress has been made in the use of jet substructure techniques in boosted final states [60], typically in searches or measurements involving heavy resonances [61,62]. In this Letter, jet substructure variables enable the reconstruction of a light, boosted, hadronic final state. Information from the individual substructure variables is combined using machine learning techniques. Specifically, for event selection, a multilayer perceptron (MLP) [63] classifier is employed. Given the range of masses considered, the classifier is provided with resonance-mass-related information from a separate MLP-based mass estimator, which results in improved classification performance over the full mass range.

This search is performed using the complete run 2 pp collision dataset, produced between 2015 and 2018 at a center-of-mass energy $\sqrt{s} = 13$ TeV by the LHC. The data were collected by the ATLAS detector [1] and correspond to an integrated luminosity of 139 fb^{-1}.

Monte Carlo (MC) samples of simulated events are used to model the signal selection efficiency. The signal samples were generated via the gluon-gluon fusion process using POWHEG-BOX v2 [64–66], with the CT10 next-to-leading order (NLO) parton distribution function (PDF) set [67]. Particle decays, hadronization, parton showers, and the underlying event were modeled using PYTHIA v8.212 [68] and Evt Gen v1.6.0 [69], interfaced to the AZNLO [70] set of tuned parameters and the CTEQ6 L1 PDF set [71]. Next-to-next-to-leading order (NNLO) corrections are applied to the p_T distribution of the Higgs boson. The a branching fractions were determined using PYTHIA 8 [68] with a 2HDM $\tan\beta$ value of 1, which predicts $a \to gg$ to be the dominant decay mode until $a \to c\bar{c}$ becomes kinematically accessible. The signal MC samples used in this analysis have a masses of 0.5, 0.75, 1, 1.5, 2, 2.5, 3, 3.5, and 4 GeV. The Z boson is required to decay into pairs of electrons, muons, or τ leptons.

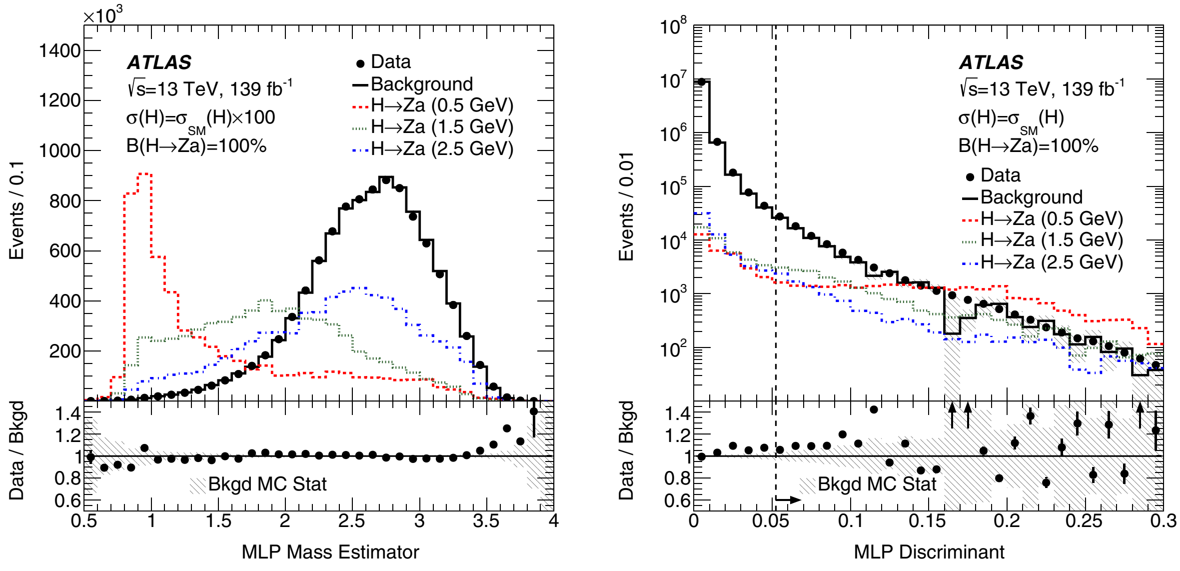
The background is dominated by $Z +$ jets events, modeled using SHERPA 2.2.1 [72] interfaced to the NNPDF 3.0 (NNLO) PDF set [73]. The inclusive production cross sections are known to NNLO in QCD [74]. The ZZ, ZW, and $t\bar{t}$ processes contribute $< 1\%$ of the total background in this search. The diboson backgrounds were modeled using SHERPA 2.2.1 interfaced to the NNPDF 3.0 (NNLO) PDF set, except for gluon-induced ZZ production, which was modeled using SHERPA 2.2.2 [72]. All of the SHERPA samples used a set of tuned parameters developed by the SHERPA authors. The $t\bar{t}$ process was modeled using POWHEG-BOX v2, while the subsequent decay, hadronization, parton shower, and underlying event were modeled using PYTHIA v8.230 and EvtGen v1.6.0. The NNPDF 2.3 (LO) PDF set [75] and the A14 set of tuned parameters [76] were used.

The simulation of the ATLAS detector [77] in GEANT4 [78] was used to model the interaction of particles with the detector in all the MC samples. Data-driven corrections are applied to the event-level trigger efficiencies, the jet vertex tagging efficiency [79], the electron [80] reconstruction, identification, and isolation efficiencies, and the muon [81] reconstruction, isolation, and track-to-vertex association efficiencies.

Events are selected by a combination of single electron or muon triggers for each data-taking period [82–85], and the online lepton reconstructed by the trigger is required to be within $\Delta R = 0.1$ [86] of an off-line reconstructed lepton. Events are required to have at least one reconstructed primary interaction vertex [87]. Electron candidates are reconstructed by matching tracks in the inner detector to topological energy clusters in the electromagnetic calorimeter [80] and must pass a likelihood-based selection, which requires the shower profile to be compatible with that of an electromagnetic shower. Muons are reconstructed using tracks in the muon spectrometer, matched to tracks in the inner detector where available [88]. Electrons and muons are each required to have $p_T > 18$ GeV, and at least one must have $p_T > 27$ GeV. Electrons (muons) are required to be reconstructed within $|\eta| < 2.47$ ($|\eta| < 2.7$), but electrons within $1.37 < |\eta| < 1.52$ are excluded. The transverse energy sum in a cone of size $\Delta R = 0.2$ around the electron [muon] in the calorimeter must be less than 20% (30%) of the lepton's p_T, and the summed p_T of tracks within a cone of variable size $\Delta R = \min(0.2, 10\ \mathrm{GeV}/p_T)$ $[\Delta R = \min(0.15, 10\ \mathrm{GeV}/p_T)]$ around the electron [muon] must be less than 15% of its p_T. Contributions from nearby electrons and muons are removed from these cones. If an inner detector track is present, muons must also have a longitudinal impact parameter $|z_0 \sin\theta| < 0.5$ mm and a transverse impact parameter $|d_0| < 1$ mm relative to the primary interaction vertex. At least two same-flavor opposite-sign electrons or muons are required to pass this selection and have an invariant mass compatible with the mass of the Z boson: $81 < m_{\ell\ell} < 101$ GeV. If multiple same-flavor opposite-sign lepton pairs fulfill this requirement, the pairing with an invariant mass closest to that of the Z boson is chosen. $Z \to \tau\tau$ decays are reconstructed through the leptonic decays of the τ leptons.

The hadronically decaying resonance is reconstructed as a single jet using the anti-k_t jet algorithm [89,90] with a radius parameter of 0.4, formed from topological calorimeter energy clusters [91,92] and calibrated to the electromagnetic energy scale. Jet energies are corrected for contributions from simultaneous inelastic pp interactions (pileup) using a jet-area-based technique [93,94] and calibrated [95,96] using p_T- and η-dependent correction factors determined from simulation, with residual corrections from *in situ* measurements applied to data and internal jet properties. Jets are required to have $p_T > 20$ GeV and $|\eta| < 2.5$ and satisfy a jet cleaning requirement [97]. To reject jets from pileup interactions, jets with $p_T < 60$ GeV and $|\eta| < 2.4$ are required to pass a "jet vertex tagger" [79] requirement. An overlap removal procedure resolves cases in which multiple electrons, muons, or jets are reconstructed from the same detector signature. Higgs boson candidates are reconstructed from the lepton pair and jet system, which is required to have an invariant mass passing a loose preselection requirement: $m_{\ell\ell j} < 250$ GeV. If multiple jets satisfy these requirements, the jet with the highest p_T is selected. The acceptance for this preselection, evaluated using generator-level MC samples, varies between 28% and 29% for the different Q/a signal hypotheses.

MLPs [63] are used to select signal events passing this preselection. The MLP input variables are built using tracks matched to the calorimeter jet by ghost association [93], in which the tracks are included in the jet clustering process as with negligible energy and their angles from the jet axis. This allows the MLP to benefit from the high resolution of the tracking detector. These tracks must have $p_T >$ 500 MeV and $|\eta| < 2.5$ and pass loose quality and track-to-vertex association requirements [98] to reject fake tracks from the reconstruction and tracks from pileup, respectively. Six dimensionless variables are constructed using these tracks: the ratio of the p_T of the highest p_T track to the p_T of the ghost-associated track system; the angular separation ΔR between the highest-p_T track and the calorimeter jet axis; NSubJettiness 2 [99], using exclusive-k_t subjet axes with radius parameters of 0.2, and a jet axis radius parameter of 0.4; angularity(2) [100]; and $U_1(0.7)$ and $M_2(0.3)$, which are modified energy correlation functions [101] designed for quark-gluon discrimination and to target two-pronged substructure, respectively. These variables primarily capitalize on the presence of a narrow resonance or two-pronged substructure in the track system. Initially, a *regression* MLP [63], using four hidden layers of 12 nodes, is trained using the above input variables and the a signal samples to estimate the mass of a, as shown in Fig. 1(a). This estimated mass is then



(a) (b)

FIG. 1. Output of (a) the regression and (b) the classification MLPs, for data, background, and three signal hypotheses. Events are required to pass the complete event selection, including the $120 < m_{\ell\ell j} < 135$ GeV requirement, but not the requirement on the classification MLP output variable. The background normalization is set equal to that of the data, and the signal normalizations assume the SM Higgs boson inclusive production cross section and $\mathcal{B}(H \to Za) = 100\%$, and in (a) the signal normalization is scaled up by a factor of 100. The error bars (hatched regions) represent the data (MC) sample statistical uncertainty, in both the histograms and the ratio plots. In (b) the region to the right of the dashed line is the signal region.

provided alongside the six input variables to a *classification* MLP [63], to inform the classifier about the part of the hadronic resonance mass spectrum where the specific event lies. This classification MLP has two hidden layers of six and five nodes and is trained using the a signal samples and the background samples. The 0.75 GeV a signal sample is excluded from the training of the classification MLP to ensure an even spacing between the a mass hypotheses, so the training is not biased toward lower masses. Both MLPs use sigmoidal response functions with summed inputs and are trained using backpropagation with a mean-square estimator [63], as these resulted in optimal discrimination without overtraining. The addition of the regression MLP was found to result in about a 13% improvement in the $S/\sqrt{B}$ of the classification MLP, where S and B are the expected numbers of signal and background events passing the MLP requirement, respectively. The classification MLP output variable (M) is shown in Fig. 1(b).

The signal region (SR) for this search is defined by the requirements $120 < m_{\ell\ell j} < 135$ GeV and $M > 0.0524$, chosen to maximize the expected $S/\sqrt{B}$, averaged over the various a mass hypotheses. The efficiency of this MLP requirement for events passing the preselection is $(0.761 \pm 0.020)\%$ for the background, $(5.89 \pm 0.24)\%$ and $(6.66 \pm 0.26)\%$ for $H \to Z\eta_c$ and $H \to ZJ/\psi$, respectively, and between $(1.88 \pm 0.15)\%$ and $(45.9 \pm 0.8)\%$ for $H \to Za$. The efficiencies for the complete selection are estimated using MC samples and are $(0.545 \pm 0.022)\%$ and $(0.560 \pm 0.022)\%$ for $H \to Z\eta_c$ and $H \to ZJ/\psi$, respectively, and range between $(0.140 \pm 0.011)\%$ and $(3.27 \pm 0.06)\%$ for $H \to Za$. The efficiencies are highest for the lowest a mass hypotheses, due to higher probabilities to pass the MLP requirement. The efficiency for $H \to Z\eta_c$ events to pass the MLP requirement is lower than that of $H \to ZJ/\psi$ events, as J/ψ decays tend to have a lower charged hadron multiplicity. Using the predicted cross section for inclusive SM Higgs boson production of $55.7^{+3.0}_{-3.9}$ pb [102], and $\mathcal{B}[H \to Z(Q/a)] = 100\%$, gives expected signal yields of 4260 and 4370 for $H \to Z\eta_c$ and $H \to ZJ/\psi$, respectively, and between 1090 and 25600 for $H \to Za$.

A "modified *ABCD* estimate" of the total background in the SR is derived using four regions: A, defined by $0.0341 < M < 0.0524$, expected to contain about 10% of the total background, and $155 < m_{\ell\ell j} < 175$ GeV; B, defined by the $m_{\ell\ell j}$ requirement of the SR and the M requirement of region A; C, defined by the M requirement of the SR and the $m_{\ell\ell j}$ requirement of A; and D, which is the SR. An initial data-driven background estimate in the SR is calculated as $D = BC/A$, then MC samples, reweighted to match data, are used to correct this estimate for the 13% correlation between the $m_{\ell\ell j}$ and M variables. This reweighting is performed in the p_T of the calorimeter jet, the number of ghost-associated tracks and $U_1(0.7)$. This background estimate is 82400 ± 2900 events in the SR, where the uncertainty is due to the limited data and MC sample statistics. The background estimation method is found to be consistent with data within 1.7 times the total statistical and systematic uncertainty in 14 validation regions, defined in regions of the $m_{\ell\ell j}$ and M variables.

A measure of $\sigma(pp \to H)\mathcal{B}[H \to Z(Q/a)]$ is extracted for a given signal hypothesis using a maximum-likelihood fit [103] to the number of events observed in the SR. The systematic uncertainties are included in the likelihood fit as nuisance parameters, which modify the signal efficiencies or the simulation-based correction used to calculate the expected background yield. These systematic uncertainties include uncertainties in the signal and background modeling and experimental uncertainties. The sources of modeling uncertainty include the limited MC sample statistics, renormalization scale and choice of MC generator for the signal and background, and a signal uncertainty to account for the extrapolation from gluon-gluon fusion signal samples to the inclusive Higgs boson production cross section. The effects of factorization scale and PDF uncertainties are found to be negligible. The experimental uncertainties considered are due to the luminosity [104], pileup [105], triggers, lepton [81,106,107], and jet [96] reconstruction. The total uncertainty on the extracted signal yield is dominated by the background modeling uncertainties, the largest being due to limited MC sample statistics. The total uncertainty on the background in the SR is 3700 events, where the uncertainty due to the limited data and MC sample statistics is 2900 and the modeling uncertainty is 2300. The data statistical uncertainty corresponds to approximately 8% of the total uncertainty on the extracted signal yield.

The SR contains 82 908 data events. This result is compatible with the SM background-only expectation, and the three-body mass distribution is shown in Fig. 2. Upper limits at 95% confidence level (CL) are set on $\sigma(pp \to H)\mathcal{B}[H \to Z(Q/a)]$ for the various signal hypotheses, using the profile-likelihood test statistic [103] and the CLs technique [108]. The observed (expected) upper limits for the $H \to Z\eta_c$ and $H \to ZJ/\psi$ hypotheses are 110 and 100 pb (100^{+40}_{-30} and 100^{+40}_{-30} pb), respectively, while the upper limits for the $H \to Za$ signal hypotheses are given in Table I. In the absence of systematic uncertainties, these limits would range between 1.9 and 55 pb for the different signal hypotheses. To simplify the interpretation, the upper limits are quoted for $\mathcal{B}(a \to gg) = 100\%$ and $\mathcal{B}(a \to s\bar{s}) = 100\%$. Because of the Yukawa ordering of the decays of Higgs bosons, only decays into gluon and strange quark pairs are considered. The tighter limits for the $a \to s\bar{s}$ decays are due to a higher MLP selection efficiency. The systematic uncertainties for $a \to gg$ and $a \to s\bar{s}$ decay hypotheses are estimated using the inclusive decays as modeled in PYTHIA 8, which is a good approximation due to the dominance of the background modeling

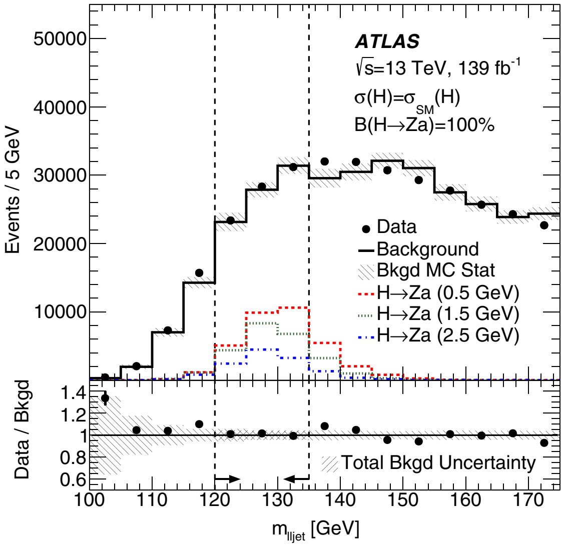


FIG. 2. Invariant mass of the lepton pair plus jet system, for data, background, and three signal hypotheses. Events are required to pass the complete event selection, including the MLP output variable requirement, but not the $120 < m_{\ell\ell j} < 135$ GeV requirement. The background normalization is defined by the background estimate in the signal region, and the signal normalizations assume the SM Higgs boson inclusive production cross section and $\mathcal{B}(H \to Za) = 100\%$. The error bars (hatched regions) represent the data (MC) sample statistical uncertainty, in both the histograms and the ratio plots. The region between the vertical dashed lines is the signal region. The total background uncertainty in the signal region is also indicated.

uncertainties. This assumption allows a limit to be set on the decay of a into gg or $s\bar{s}$ final states, in any ratio, by using a weighted sum of the two limits. Higgs boson decays to a Z boson and a quarkonium state other than the considered signal process are not included in the statistical interpretation.

TABLE I. Expected (Exp) and observed (Obs) 95% CL upper limits on $\sigma(pp \to H)\mathcal{B}(H \to Za)/\text{pb}$. These results are quoted for $\mathcal{B}(a \to gg) = 100\%$ and $\mathcal{B}(a \to s\bar{s}) = 100\%$ for each signal sample.

a mass (GeV)	$a \to gg$		$a \to s\bar{s}$	
	Exp	Obs	Exp	Obs
0.5	16^{+6}_{-5}	17		
0.75	19^{+7}_{-5}	20		
1.0	17^{+7}_{-5}	18		
1.5	20^{+8}_{-6}	22	19^{+7}_{-5}	20
2.0	26^{+10}_{-7}	27	23^{+9}_{-6}	24
2.5	38^{+15}_{-11}	40	32^{+12}_{-9}	33
3.0	75^{+29}_{-21}	78	65^{+25}_{-18}	68
3.5	110^{+40}_{-30}	120		
4.0	320^{+130}_{-90}	340		

In conclusion, a search has been performed for Higgs boson decays into a Z boson and either a η_c or J/ψ charmonium state, or a light spin-0 boson. No excess is found, and 95% CL upper limits are set on $\sigma(pp \to H)\mathcal{B}[H \to Z(Q/a)]$, with values of 110 and 100 pb for the $H \to Z\eta_c$ and $H \to ZJ/\psi$ hypotheses, respectively, and with values in the range 17–340 pb for the $H \to Za$ signal hypotheses. Assuming the SM prediction for inclusive Higgs boson production, the limits on charmonium decay modes correspond to branching fraction limits in excess of 100%. This is the first direct limit on decays of the observed Higgs boson to light scalars, decaying to light quarks or gluons. Because of the large value of $\mathcal{B}(a \to \text{hadrons})$ over the entire 2HDM(+S) parameter space, these limits represent tight, direct constraints for low (high) $\tan\beta$ in the type-II and type-III (type-VI) 2HDM + S [109].

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[1] ATLAS Collaboration, The ATLAS experiment at the CERN Large Hadron Collider, J. Instrum. **3**, S08003 (2008).

[2] CMS Collaboration, The CMS experiment at the CERN LHC, J. Instrum. **3**, S08004 (2008).

[3] L. Evans and P. Bryant, LHC machine, J. Instrum. **3**, S08001 (2008).

[4] ATLAS Collaboration, Observation of a new particle in the search for the standard model Higgs boson with the ATLAS detector at the LHC, Phys. Lett. B **716**, 1 (2012).

[5] CMS Collaboration, Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, Phys. Lett. B **716**, 30 (2012).

[6] ATLAS and CMS Collaborations, Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments, Phys. Rev. Lett. **114**, 191803 (2015).

[7] ATLAS Collaboration, Study of the spin and parity of the Higgs boson in diboson decays with the ATLAS detector, Eur. Phys. J. C **75**, 476 (2015); Erratum, Eur. Phys. J. C **76**, 152 (2016).

[8] CMS Collaboration, Search for Higgs boson off-shell production in proton-proton collisions at 7 and 8 TeV and derivation of constraints on its total decay width, J. High Energy Phys. 09 (2016) 051.

[9] ATLAS Collaboration, Constraints on off-shell Higgs boson production and the Higgs boson total width in $ZZ \to 4\ell$ and $ZZ \to 2\ell 2\nu$ final states with the ATLAS detector, Phys. Lett. B **786**, 223 (2018).

[10] ATLAS and CMS Collaborations, Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at $\sqrt{s} = 7$ and 8 TeV, J. High Energy Phys. 08 (2016) 045.

[11] D. Curtin *et al.*, Exotic decays of the 125 GeV Higgs boson, Phys. Rev. D **90**, 075004 (2014).

[12] S. Weinberg, A Model of Leptons, Phys. Rev. Lett. **19**, 1264 (1967).

[13] https://www.sciencedirect.com/science/article/abs/pii/055032137990316X?via%3Dihub.

[14] G. F. Giudice and O. Lebedev, Higgs-dependent Yukawa couplings, Phys. Lett. B **665**, 79 (2008).

[15] LHC Higgs Cross SectionWorking Group, Handbook of LHC Higgs cross sections: 4. Deciphering the nature of the Higgs sector, Report No. CERN-2017-002-M, 2016.

[16] ATLAS Collaboration, Observation of $H \to b\bar{b}$ decays and VH production with the ATLAS detector, Phys. Lett. B **786**, 59 (2018).

[17] CMS Collaboration, Observation of Higgs Boson Decay to Bottom Quarks, Phys. Rev. Lett. **121**, 121801 (2018).

[18] ATLAS Collaboration, Observation of Higgs boson production in association with a top quark pair at the LHC with the ATLAS detector, Phys. Lett. B **784**, 173 (2018).

[19] CMS Collaboration, Observation of $t\bar{t}H$ Production, Phys. Rev. Lett. **120**, 231801 (2018).

[20] ATLAS Collaboration, Cross-section measurements of the Higgs boson decaying into a pair of τ-leptons in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Rev. D **99**, 072001 (2019).

[21] CMS Collaboration, Observation of the Higgs boson decay to a pair of τ leptons, Phys. Lett. B **779**, 283 (2018).

[22] ATLAS Collaboration, A search for the dimuon decay of the standard model Higgs boson in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, ATLAS-CONF-2019-028, 2019.

[23] ATLAS Collaboration, Search for the Higgs boson decays $H \to ee$ and $H \to e\mu$ in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **801**, 135148 (2020).

[24] CMS Collaboration, Search for the Higgs Boson Decaying to Two Muons in Proton-Proton Collisions at $\sqrt{s} = 13$ TeV, Phys. Rev. Lett. **122**, 021801 (2019).

[25] CMS Collaboration, Search for a standard model-like Higgs boson in the $\mu^+\mu^-$ and e^+e^- decay channels at the LHC, Phys. Lett. B **744**, 184 (2015).

[26] ATLAS Collaboration, Search for the Decay of the Higgs Boson to Charm Quarks with the ATLAS Experiment, Phys. Rev. Lett. **120**, 211802 (2018).

[27] CMS Collaboration, A search for the standard model Higgs boson decaying to charm quarks, J. High Energy Phys. 03 (2020) 131.

[28] ATLAS Collaboration, Searches for exclusive Higgs and Z boson decays into $J/\psi\gamma$, $\psi(2S)\gamma$, and $\Upsilon(nS)\gamma$ at $\sqrt{s} =$ 13 TeV with the ATLAS detector, Phys. Lett. B **786**, 134 (2018).

[29] CMS Collaboration, Search for a Higgs boson decaying into $\gamma^*\gamma \to \ell\ell\gamma$ with low dilepton mass in pp collisions at $\sqrt{s} = 8$ TeV, Phys. Lett. B **753**, 341 (2016).

[30] ATLAS Collaboration, Measurements and interpretations of Higgs-boson fiducial cross sections in the diphoton decay channel using 139 fb^{-1} of pp collision data at $\sqrt{s} =$ 13 TeV with the ATLAS detector, ATLAS-CONF-2019-029, 2019.

[31] CMS Collaboration, Measurement and interpretation of differential cross sections for Higgs boson production at $\sqrt{s} = 13$ TeV, Phys. Lett. B **792**, 369 (2019).

[32] G. T. Bodwin, F. Petriello, S. Stoynev, and M. Velasco, Higgs boson decays to quarkonia and the $H\bar{c}c$ coupling, Phys. Rev. D **88**, 053003 (2013).

[33] A. L. Kagan, G. Perez, F. Petriello, Y. Soreq, S. Stoynev, and J. Zupan, Exclusive Window onto Higgs Yukawa Couplings, Phys. Rev. Lett. **114**, 101802 (2015).

[34] A. S. Chisholm, S. Kuttimalai, K. Nikolopoulos, and M. Spannowsky, Measuring rare and exclusive Higgs boson decays into light resonances, Eur. Phys. J. C **76**, 501 (2016).

[35] G. Isidori, A. V. Manohar, and M. Trott, Probing the nature of the Higgs-like Boson via $h \to V\mathcal{F}$ decays, Phys. Lett. B **728**, 131 (2014).
[36] P. W. Higgs, Broken Symmetries and the Masses of Gauge Bosons, Phys. Rev. Lett. **13**, 508 (1964).
[37] F. Englert and R. Brout, Broken Symmetry and the Mass of Gauge Vector Mesons, Phys. Rev. Lett. **13**, 321 (1964).
[38] S. Dawson, C. Englert, and T. Plehn, Higgs physics: It ain't over till it's over, Phys. Rep. **816**, 1 (2019).
[39] C. Delaunay, T. Golling, G. Perez, and Y. Soreq, Enhanced Higgs boson coupling to charm pairs, Phys. Rev. D **89**, 033014 (2014).
[40] A. Belyaev, J. Pivarski, A. Safonov, S. Senkin, and A. Tatarinov, LHC discovery potential of the lightest NMSSM Higgs in the $h_1 \to a_1 a_1 \to 4\mu$ channel, Phys. Rev. D **81**, 075021 (2010).
[41] J. F. Gunion and H. E. Haber, The *CP* conserving two Higgs doublet model: The Approach to the decoupling limit, Phys. Rev. D **67**, 075019 (2003).
[42] M. Bauer, M. Neubert, and A. Thamm, Collider probes of axion-like particles, J. High Energy Phys. 12 (2017) 044.
[43] J. E. Kim, Light pseudoscalars, particle physics and cosmology, Phys. Rep. **150**, 1 (1987).
[44] R. D. Peccei and H. R. Quinn, *CP* Conservation in the Presence of Instantons, Phys. Rev. Lett. **38**, 1440 (1977).
[45] M. Trodden, Electroweak baryogenesis: A Brief review, 471 (1998), arXiv:hep-ph/9805252.
[46] D. A. Camargo, M. D. Campos, T. B. de Melo, and F. S. Queiroz, A two Higgs doublet model for dark matter and neutrino masses, Phys. Lett. B **795**, 319 (2019).
[47] G. Arcadi, 2HDM portal for singlet-doublet dark matter, Eur. Phys. J. C **78**, 864 (2018).
[48] J. F. Gunion, S. Dawson, H. E. Haber, and G. L. Kane, *The Higgs Hunter's Guide* (Brookhaven National Laboratory, New York, 1989), Vol. 80.
[49] D0 Collaboration, Search for Next-to-Minimal Supersymmetric Higgs Bosons in the $h \to aa \to \mu\mu\mu\mu, \mu\mu\tau\tau$ Channels Using $p\bar{p}$ Collisions at $\sqrt{s} = 1.96$ TeV, Phys. Rev. Lett. **103**, 061801 (2009).
[50] CMS Collaboration, Search for an exotic decay of the Higgs boson to a pair of light pseudoscalars in the final state of two muons and two τ leptons in proton-proton collisions at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 11 (2018) 018.
[51] CMS Collaboration, Search for light bosons in decays of the 125 GeV Higgs boson in proton-proton collisions at $\sqrt{s} = 8$ TeV, J. High Energy Phys. 10 (2017) 076.
[52] CMS Collaboration, Search for a very light NMSSM Higgs boson produced in decays of the 125 GeV scalar boson and decaying into τ leptons in pp collisions at $\sqrt{s} = 8$ TeV, J. High Energy Phys. 01 (2016) 079.
[53] CMS Collaboration, A search for pair production of new light bosons decaying into muons, Phys. Lett. B **752**, 146 (2016).
[54] ATLAS Collaboration, Search for Higgs bosons decaying to aa in the $\mu\mu\tau\tau$ final state in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS experiment, Phys. Rev. D **92**, 052002 (2015).
[55] ATLAS Collaboration, Search for the Higgs boson produced in association with a W boson and decaying to four b-quarks via two spin-zero particles in pp collisions at 13 TeV with the ATLAS detector, Eur. Phys. J. C **76**, 605 (2016).
[56] ATLAS Collaboration, Search for Higgs boson decays to beyond-the-standard-model light bosons in four-lepton events with the ATLAS detector at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 06 (2018) 166.
[57] ATLAS Collaboration, Search for Higgs boson decays into a pair of light bosons in the $bb\mu\mu$ final state in pp collision at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **790**, 1 (2019).
[58] ATLAS Collaboration, Search for Higgs boson decays into pairs of light (pseudo)scalar particles in the $\gamma\gamma jj$ final state in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **782**, 750 (2018).
[59] ATLAS Collaboration, Search for new phenomena in events with at least three photons collected in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, Eur. Phys. J. C **76**, 210 (2016).
[60] R. Kogler, B. Nachman, A. Schmidt, L. Asquith, E. Winkels *et al.*, Jet substructure at the Large Hadron Collider: Experimental review, Rev. Mod. Phys. **91**, 045003 (2019).
[61] ATLAS Collaboration, Identification of boosted Higgs bosons decaying into b-quark pairs with the ATLAS detector at 13 TeV, Eur. Phys. J. C **79**, 836 (2019).
[62] ATLAS Collaboration, Measurement of the jet mass in high transverse momentum $Z(\to b\bar{b})\gamma$ production at $\sqrt{s} =$ 13 TeV using the ATLAS detector, arXiv:1907.07093.
[63] A. Hoecker *et al.*, TMVA-toolkit for multivariate data analysis, arXiv:physics/0703039.
[64] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, J. High Energy Phys. 11 (2004) 040.
[65] S. Frixione, P. Nason, and C. Oleari, Matching NLO QCD computations with parton shower simulations: The POWHEG method, J. High Energy Phys. 11 (2007) 070.
[66] S. Alioli, P. Nason, C. Oleari, and E. Re, A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX, J. High Energy Phys. 06 (2010) 043.
[67] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P. M. Nadolsky, J. Pumplin, and C.-P. Yuan, New parton distributions for collider physics, Phys. Rev. D **82**, 074024 (2010).
[68] T. Sjöstrand, S. Mrenna, and P. Z. Skands, A brief introduction to PYTHIA 8.1, Comput. Phys. Commun. **178**, 852 (2008).
[69] D. J. Lange, The EvtGen particle decay simulation package, Nucl. Instrum. Methods Phys. Res., Sect. A **462**, 152 (2001).
[70] ATLAS Collaboration, Measurement of the Z/γ^* boson transverse momentum distribution in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, J. High Energy Phys. 09 (2014) 145.
[71] J. Pumplin, D. R. Stump, J. Huston, H.-L. Lai, P. Nadolsky, and W.-K. Tung, New generation of parton distributions with uncertainties from global QCD analysis, J. High Energy Phys. 07 (2002) 012.
[72] E. Bothmann *et al.*, Event generation with SHERPA 2.2, SciPost Phys. **7**, 034 (2019).
[73] R. D. Ball *et al.*, Parton distributions for the LHC run II, J. High Energy Phys. 04 (2015) 040.
[74] C. Anastasiou, L. J. Dixon, K. Melnikov, and F. Petriello, High precision QCD at hadron colliders: Electroweak

gauge boson rapidity distributions at NNLO, Phys. Rev. D **69**, 094008 (2004).
[75] R. D. Ball *et al.*, Parton distributions with LHC data, Nucl. Phys. **B867**, 244 (2013).
[76] ATLAS Collaboration, ATLAS PYTHIA 8 tunes to 7 TeV data, ATL-PHYS-PUB-2014-021, 2014.
[77] ATLAS Collaboration, The ATLAS simulation infrastructure, Eur. Phys. J. C **70**, 823 (2010).
[78] S. Agostinelli *et al.*, GEANT4—A simulation toolkit, Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[79] ATLAS Collaboration, Tagging and suppression of pileup jets with the ATLAS detector, ATLAS-CONF-2014-018, 2014.
[80] ATLAS Collaboration, Electron and photon performance measurements with the ATLAS detector using the 2015-2017 LHC proton-proton collision data, J. Instrum. **14**, P12006 (2019).
[81] ATLAS Collaboration, Muon reconstruction performance of the ATLAS detector in proton-proton collision data at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **76**, 292 (2016).
[82] ATLAS Collaboration, Performance of the ATLAS trigger system in 2015, Eur. Phys. J. C **77**, 317 (2017).
[83] ATLAS Collaboration, Trigger menu in 2016, ATL-DAQ-PUB-2017-001, 2017.
[84] ATLAS Collaboration, Trigger menu in 2017, ATL-DAQ-PUB-2018-002, 2018.
[85] ATLAS Collaboration, Performance of electron and photon triggers in ATLAS during LHC run 2, Eur. Phys. J. C **80**, 47 (2020).
[86] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the center of the detector and the z axis along the beam pipe. The x axis points from the IP 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 z axis. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.
[87] ATLAS Collaboration, Vertex reconstruction performance of the ATLAS detector at $\sqrt{s} = 13$ TeV, ATL-PHYS-PUB-2015-026, 2015.
[88] ATLAS Collaboration, Measurement of the muon reconstruction performance of the ATLAS detector using 2011 and 2012 LHC proton-proton collision data, Eur. Phys. J. C **74**, 3130 (2014).
[89] M. Cacciari, G. P. Salam, and G. Soyez, The anti-k_t jet clustering algorithm, J. High Energy Phys. 04 (2008) 063.
[90] M. Cacciari, G. P. Salam, and G. Soyez, FastJet user manual, Eur. Phys. J. C **72**, 1896 (2012).
[91] ATLAS Collaboration, Topological cell clustering in the ATLAS calorimeters and its performance in LHC run 1, Eur. Phys. J. C **77**, 490 (2017).
[92] ATLAS Collaboration, Properties of jets and inputs to jet reconstruction and calibration with the ATLAS detector using proton-proton collisions at $\sqrt{s} = 13$ TeV, ATL-PHYS-PUB-2015-036, 2015.
[93] M. Cacciari and G. P. Salam, Pileup subtraction using jet areas, Phys. Lett. B **659**, 119 (2008).
[94] ATLAS Collaboration, Performance of pile-up mitigation techniques for jets in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector, Eur. Phys. J. C **76**, 581 (2016).
[95] ATLAS Collaboration, Jet energy measurement with the ATLAS detector in proton-proton collisions at $\sqrt{s} = 7$ TeV, Eur. Phys. J. C **73**, 2304 (2013).
[96] ATLAS Collaboration, Jet energy scale measurements and their systematic uncertainties in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Rev. D **96**, 072002 (2017).
[97] ATLAS Collaboration, Selection of jets produced in 13 TeV proton-proton collisions with the ATLAS detector, ATLAS-CONF-2015-029, 2015.
[98] ATLAS Collaboration, Performance of the ATLAS track reconstruction algorithms in dense environments in LHC run 2, Eur. Phys. J. C **77**, 673 (2017).
[99] J. Thaler and K. Van Tilburg, Identifying boosted objects with N-subjettiness, J. High Energy Phys. 03 (2011) 015.
[100] L. G. Almeida, S. J. Lee, G. Perez, G. Sterman, I. Sung, and J. Virzi, Substructure of high-p_T jets at the LHC, Phys. Rev. D **79**, 074017 (2009).
[101] I. Moult, L. Necib, and J. Thaler, New angles on energy correlation functions, J. High Energy Phys. 12 (2016) 153.
[102] *Handbook of LHC Higgs Cross Sections: 1. Inclusive Observables*, edited by LHC Higgs Cross Section Working Group, S. Dittmaier, C. Mariotti, G. Passarino, and R. Tanaka, CERN-2011-002 (2011).
[103] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, Eur. Phys. J. C **71**, 1554 (2011); Erratum, Eur. Phys. J. C **73**, 2501 (2013).
[104] ATLAS Collaboration, Luminosity determination in pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector at the LHC, ATLAS-CONF-2019-021, 2019.
[105] ATLAS Collaboration, Measurement of isolated-photon plus two-jet production in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 03 (2020) 179.
[106] ATLAS Collaboration, Electron and photon energy calibration with the ATLAS detector using 2015–2016 LHC proton-proton collision data, J. Instrum. **14**, P03017 (2019).
[107] ATLAS Collaboration, Electron reconstruction and identification in the ATLAS experiment using the 2015 and 2016 LHC proton-proton collision data at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **79**, 639 (2019).
[108] A. L. Read, Presentation of search results: The CL_S technique, J. Phys. G **28**, 2693 (2002).
[109] ATLAS Collaboration, HBSM Working Group 2HDM + S summary plots, ATL-PHYS-PUB-2018-045, 2018.
[110] ATLAS Collaboration, ATLAS Computing Acknowledgements, ATL-SOFT-PUB-2020-001, 2020, http://cds.cern.ch/record/2717821.

G. Aad,[102] B. Abbott,[128] D. C. Abbott,[103] A. Abed Abud,[36] K. Abeling,[53] D. K. Abhayasinghe,[94] S. H. Abidi,[166] O. S. AbouZeid,[40] N. L. Abraham,[155] H. Abramowicz,[160] H. Abreu,[159] Y. Abulaiti,[6] B. S. Acharya,[67a,67b,b] B. Achkar,[53] L. Adam,[100] C. Adam Bourdarios,[5] L. Adamczyk,[84a] L. Adamek,[166] J. Adelman,[121] M. Adersberger,[114] A. Adiguzel,[12c] S. Adorni,[54] T. Adye,[143] A. A. Affolder,[145] Y. Afik,[159] C. Agapopoulou,[65] M. N. Agaras,[38] A. Aggarwal,[119] C. Agheorghiesei,[27c] J. A. Aguilar-Saavedra,[139f,139a,c] A. Ahmad,[36] F. Ahmadov,[80] W. S. Ahmed,[104] X. Ai,[18] G. Aielli,[74a,74b] S. Akatsuka,[86] T. P. A. Åkesson,[97] E. Akilli,[54] A. V. Akimov,[111] K. Al Khoury,[65] G. L. Alberghi,[23b,23a] J. Albert,[175] M. J. Alconada Verzini,[160] S. Alderweireldt,[36] M. Aleksa,[36] I. N. Aleksandrov,[80] C. Alexa,[27b] T. Alexopoulos,[10] A. Alfonsi,[120] F. Alfonsi,[23b,23a] M. Alhroob,[128] B. Ali,[141] S. Ali,[157] M. Aliev,[165] G. Alimonti,[69a] C. Allaire,[36] B. M. M. Allbrooke,[155] B. W. Allen,[131] P. P. Allport,[21] A. Aloisio,[70a,70b] F. Alonso,[89] C. Alpigiani,[147] E. Alunno Camelia,[74a,74b] M. Alvarez Estevez,[99] M. G. Alviggi,[70a,70b] Y. Amaral Coutinho,[81b] A. Ambler,[104] L. Ambroz,[134] C. Amelung,[26] D. Amidei,[106] S. P. Amor Dos Santos,[139a] S. Amoroso,[46] C. S. Amrouche,[54] F. An,[79] C. Anastopoulos,[148] N. Andari,[144] T. Andeen,[11] J. K. Anders,[20] S. Y. Andrean,[45a,45b] A. Andreazza,[69a,69b] V. Andrei,[61a] C. R. Anelli,[175] S. Angelidakis,[9] A. Angerami,[39] A. V. Anisenkov,[122b,122a] A. Annovi,[72a] C. Antel,[54] M. T. Anthony,[148] E. Antipov,[129] M. Antonelli,[51] D. J. A. Antrim,[170] F. Anulli,[73a] M. Aoki,[82] J. A. Aparisi Pozo,[173] M. A. Aparo,[155] L. Aperio Bella,[46] N. Aranzabal,[36] V. Araujo Ferraz,[81a] R. Araujo Pereira,[81b] C. Arcangeletti,[51] A. T. H. Arce,[49] F. A. Arduh,[89] J-F. Arguin,[110] S. Argyropoulos,[52] J.-H. Arling,[46] A. J. Armbruster,[36] A. Armstrong,[170] O. Arnaez,[166] H. Arnold,[120] Z. P. Arrubarrena Tame,[114] G. Artoni,[134] K. Asai,[126] S. Asai,[162] T. Asawatavonvanich,[164] N. Asbah,[59] E. M. Asimakopoulou,[171] L. Asquith,[155] J. Assahsah,[35d] K. Assamagan,[29] R. Astalos,[28a] R. J. Atkin,[33a] M. Atkinson,[172] N. B. Atlay,[19] H. Atmani,[65] K. Augsten,[141] V. A. Austrup,[181] G. Avolio,[36] M. K. Ayoub,[15a] G. Azuelos,[110,d] H. Bachacou,[144] K. Bachas,[161] M. Backes,[134] F. Backman,[45a,45b] P. Bagnaia,[73a,73b] M. Bahmani,[85] H. Bahrasemani,[151] A. J. Bailey,[173] V. R. Bailey,[172] J. T. Baines,[143] C. Bakalis,[10] O. K. Baker,[182] P. J. Bakker,[120] E. Bakos,[16] D. Bakshi Gupta,[8] S. Balaji,[156] E. M. Baldin,[122b,122a] P. Balek,[179] F. Balli,[144] W. K. Balunas,[134] J. Balz,[100] E. Banas,[85] M. Bandieramonte,[138] A. Bandyopadhyay,[24] Sw. Banerjee,[180,e] L. Barak,[160] W. M. Barbe,[38] E. L. Barberio,[105] D. Barberis,[55b,55a] M. Barbero,[102] G. Barbour,[95] T. Barillari,[115] M-S. Barisits,[36] J. Barkeloo,[131] T. Barklow,[152] R. Barnea,[159] B. M. Barnett,[143] R. M. Barnett,[18] Z. Barnovska-Blenessy,[60a] A. Baroncelli,[60a] G. Barone,[29] A. J. Barr,[134] L. Barranco Navarro,[45a,45b] F. Barreiro,[99] J. Barreiro Guimarães da Costa,[15a] U. Barron,[160] S. Barsov,[137] F. Bartels,[61a] R. Bartoldus,[152] G. Bartolini,[102] A. E. Barton,[90] P. Bartos,[28a] A. Basalaev,[46] A. Basan,[100] A. Bassalat,[65,f] M. J. Basso,[166] R. L. Bates,[57] S. Batlamous,[35e] J. R. Batley,[32] B. Batool,[150] M. Battaglia,[145] M. Bauce,[73a,73b] F. Bauer,[144] K. T. Bauer,[170] H. S. Bawa,[31] J. B. Beacham,[49] T. Beau,[135] P. H. Beauchemin,[169] F. Becherer,[52] P. Bechtle,[24] H. C. Beck,[53] H. P. Beck,[20,g] K. Becker,[177] C. Becot,[46] A. Beddall,[12d] A. J. Beddall,[12a] V. A. Bednyakov,[80] M. Bedognetti,[120] C. P. Bee,[154] T. A. Beermann,[181] M. Begalli,[81b] M. Begel,[29] A. Behera,[154] J. K. Behr,[46] F. Beisiegel,[24] M. Belfkir,[5] A. S. Bell,[95] G. Bella,[160] L. Bellagamba,[23b] A. Bellerive,[34] P. Bellos,[9] K. Beloborodov,[122b,122a] K. Belotskiy,[112] N. L. Belyaev,[112] D. Benchekroun,[35a] N. Benekos,[10] Y. Benhammou,[160] D. P. Benjamin,[6] M. Benoit,[54] J. R. Bensinger,[26] S. Bentvelsen,[120] L. Beresford,[134] M. Beretta,[51] D. Berge,[19] E. Bergeaas Kuutmann,[171] N. Berger,[5] B. Bergmann,[141] L. J. Bergsten,[26] J. Beringer,[18] S. Berlendis,[7] G. Bernardi,[135] C. Bernius,[152] F. U. Bernlochner,[24] T. Berry,[94] P. Berta,[100] C. Bertella,[15a] A. Berthold,[48] I. A. Bertram,[90] O. Bessidskaia Bylund,[181] N. Besson,[144] A. Bethani,[101] S. Bethke,[115] A. Betti,[42] A. J. Bevan,[93] J. Beyer,[115] D. S. Bhattacharya,[176] P. Bhattarai,[26] V. S. Bhopatkar,[6] R. Bi,[138] R. M. Bianchi,[138] O. Biebel,[114] D. Biedermann,[19] R. Bielski,[36] K. Bierwagen,[100] N. V. Biesuz,[72a,72b] M. Biglietti,[75a] T. R. V. Billoud,[110] M. Bindi,[53] A. Bingul,[12d] C. 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L. Zhang,[15c] L. Zhang,[60a] M. Zhang,[172] R. Zhang,[180] S. Zhang,[106] X. Zhang,[60c] X. Zhang,[60b] Y. Zhang,[15a,15d] Z. Zhang,[63a]
Z. Zhang,[65] P. Zhao,[49] Z. Zhao,[60a] A. Zhemchugov,[80] Z. Zheng,[106] D. Zhong,[172] B. Zhou,[106] C. Zhou,[180] H. Zhou,[7]
M. S. Zhou,[15a,15d] M. Zhou,[154] N. Zhou,[60c] Y. Zhou,[7] C. G. Zhu,[60b] C. Zhu,[15a,15d] H. L. Zhu,[60a] H. Zhu,[15a] J. Zhu,[106]
Y. Zhu,[60a] X. Zhuang,[15a] K. Zhukov,[111] V. Zhulanov,[122b,122a] D. Zieminska,[66] N. I. Zimine,[80] S. Zimmermann,[52]
Z. Zinonos,[115] M. Ziolkowski,[150] L. Živković,[16] G. Zobernig,[180] A. Zoccoli,[23b,23a] K. Zoch,[53] T. G. Zorbas,[148]
R. Zou,[37] and L. Zwalinski[36]

(ATLAS Collaboration)

[1] *Department of Physics, University of Adelaide, Adelaide, Australia*
[2] *Physics Department, SUNY Albany, Albany, New York, USA*
[3] *Department of Physics, University of Alberta, Edmonton AB, Canada*
[4a] *Department of Physics, Ankara University, Ankara, Turkey*
[4b] *Istanbul Aydin University, Application and Research Center for Advanced Studies, Istanbul, Turkey*
[4c] *Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[5] *LAPP, Université Grenoble Alpes, Université Savoie Mont Blanc, CNRS/IN2P3, Annecy, France*
[6] *High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
[7] *Department of Physics, University of Arizona, Tucson, Arizona, USA*
[8] *Department of Physics, University of Texas at Arlington, Arlington, Texas, USA*
[9] *Physics Department, National and Kapodistrian University of Athens, Athens, Greece*
[10] *Physics Department, National Technical University of Athens, Zografou, Greece*
[11] *Department of Physics, University of Texas at Austin, Austin, Texas, USA*
[12a] *Bahcesehir University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey*
[12b] *Istanbul Bilgi University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey*
[12c] *Department of Physics, Bogazici University, Istanbul, Turkey*
[12d] *Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
[13] *Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[14] *Institut de Física d'Altes Energies (IFAE), Barcelona Institute of Science and Technology, Barcelona, Spain*
[15a] *Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
[15b] *Physics Department, Tsinghua University, Beijing, China*
[15c] *Department of Physics, Nanjing University, Nanjing, China*
[15d] *University of Chinese Academy of Science (UCAS), Beijing, China*
[16] *Institute of Physics, University of Belgrade, Belgrade, Serbia*
[17] *Department for Physics and Technology, University of Bergen, Bergen, Norway*
[18] *Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
[19] *Institut für Physik, Humboldt Universität zu Berlin, Berlin, Germany*
[20] *Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
[21] *School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
[22a] *Facultad de Ciencias y Centro de Investigaciónes, Universidad Antonio Nariño, Bogotá, Colombia*
[22b] *Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia, Colombia*
[23a] *INFN Bologna and Universita' di Bologna, Dipartimento di Fisica, Italy*
[23b] *INFN Sezione di Bologna, Italy*
[24] *Physikalisches Institut, Universität Bonn, Bonn, Germany*
[25] *Department of Physics, Boston University, Boston, Massachusetts, USA*
[26] *Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
[27a] *Transilvania University of Brasov, Brasov, Romania*
[27b] *Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
[27c] *Department of Physics, Alexandru Ioan Cuza University of Iasi, Iasi, Romania*
[27d] *National Institute for Research and Development of Isotopic and Molecular Technologies,*
Physics Department, Cluj-Napoca, Romania
[27e] *University Politehnica Bucharest, Bucharest, Romania*
[27f] *West University in Timisoara, Timisoara, Romania*
[28a] *Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovak Republic*
[28b] *Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
[29] *Physics Department, Brookhaven National Laboratory, Upton, New York, USA*

[30]*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
[31]*California State University, Fresno, USA*
[32]*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
[33a]*Department of Physics, University of Cape Town, Cape Town, South Africa*
[33b]*iThemba Labs, Western Cape, South Africa*
[33c]*Department of Mechanical Engineering Science, University of Johannesburg, Johannesburg, South Africa*
[33d]*University of South Africa, Department of Physics, Pretoria, South Africa*
[33e]*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
[34]*Department of Physics, Carleton University, Ottawa ON, Canada*
[35a]*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies—Université Hassan II, Casablanca, Morocco*
[35b]*Faculté des Sciences, Université Ibn-Tofail, Kénitra, Morocco*
[35c]*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
[35d]*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
[35e]*Faculté des sciences, Université Mohammed V, Rabat, Morocco*
[36]*CERN, Geneva, Switzerland*
[37]*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
[38]*LPC, Université Clermont Auvergne, CNRS/IN2P3, Clermont-Ferrand, France*
[39]*Nevis Laboratory, Columbia University, Irvington, New York, USA*
[40]*Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark*
[41a]*Dipartimento di Fisica, Università della Calabria, Rende, Italy*
[41b]*INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati, Italy*
[42]*Physics Department, Southern Methodist University, Dallas, Texas, USA*
[43]*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
[44]*National Centre for Scientific Research "Demokritos", Agia Paraskevi, Greece*
[45a]*Department of Physics, Stockholm University, Sweden*
[45b]*Oskar Klein Centre, Stockholm, Sweden*
[46]*Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany*
[47]*Lehrstuhl für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
[48]*Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany*
[49]*Department of Physics, Duke University, Durham, North Carolina, USA*
[50]*SUPA—School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
[51]*INFN e Laboratori Nazionali di Frascati, Frascati, Italy*
[52]*Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany*
[53]*II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany*
[54]*Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève, Switzerland*
[55a]*Dipartimento di Fisica, Università di Genova, Genova, Italy*
[55b]*INFN Sezione di Genova, Italy*
[56]*II. Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
[57]*SUPA—School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
[58]*LPSC, Université Grenoble Alpes, CNRS/IN2P3, Grenoble INP, Grenoble, France*
[59]*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
[60a]*Department of Modern Physics and State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei, China*
[60b]*Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao, China*
[60c]*School of Physics and Astronomy, Shanghai Jiao Tong University, KLPPAC-MoE, SKLPPC, Shanghai, China*
[60d]*Tsung-Dao Lee Institute, Shanghai, China*
[61a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[61b]*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[62]*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
[63a]*Department of Physics, Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China*
[63b]*Department of Physics, University of Hong Kong, Hong Kong, China*
[63c]*Department of Physics and Institute for Advanced Study, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China*
[64]*Department of Physics, National Tsing Hua University, Hsinchu, Taiwan*
[65]*IJCLab, Université Paris-Saclay, CNRS/IN2P3, 91405, Orsay, France*
[66]*Department of Physics, Indiana University, Bloomington, Indiana, USA*
[67a]*INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine, Italy*
[67b]*ICTP, Trieste, Italy*

[67c]*Dipartimento Politecnico di Ingegneria e Architettura, Università di Udine, Udine, Italy*
[68a]*INFN Sezione di Lecce, Italy*
[68b]*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[69a]*INFN Sezione di Milano, Italy*
[69b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[70a]*INFN Sezione di Napoli, Italy*
[70b]*Dipartimento di Fisica, Università di Napoli, Napoli, Italy*
[71a]*INFN Sezione di Pavia, Italy*
[71b]*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
[72a]*INFN Sezione di Pisa, Italy*
[72b]*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
[73a]*INFN Sezione di Roma, Italy*
[73b]*Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
[74a]*INFN Sezione di Roma Tor Vergata, Italy*
[74b]*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[75a]*INFN Sezione di Roma Tre, Italy*
[75b]*Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
[76a]*INFN-TIFPA, Italy*
[76b]*Università degli Studi di Trento, Trento, Italy*
[77]*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
[78]*University of Iowa, Iowa City, Iowa, USA*
[79]*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
[80]*Joint Institute for Nuclear Research, Dubna, Russia*
[81a]*Departamento de Engenharia Elétrica, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, Brazil*
[81b]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
[81c]*Universidade Federal de São João del Rei (UFSJ), São João del Rei, Brazil*
[81d]*Instituto de Física, Universidade de São Paulo, São Paulo, Brazil*
[82]*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
[83]*Graduate School of Science, Kobe University, Kobe, Japan*
[84a]*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
[84b]*Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland*
[85]*Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland*
[86]*Faculty of Science, Kyoto University, Kyoto, Japan*
[87]*Kyoto University of Education, Kyoto, Japan*
[88]*Research Center for Advanced Particle Physics and Department of Physics, Kyushu University, Fukuoka, Japan*
[89]*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
[90]*Physics Department, Lancaster University, Lancaster, United Kingdom*
[91]*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
[92]*Department of Experimental Particle Physics, Jožef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana, Slovenia*
[93]*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
[94]*Department of Physics, Royal Holloway University of London, Egham, United Kingdom*
[95]*Department of Physics and Astronomy, University College London, London, United Kingdom*
[96]*Louisiana Tech University, Ruston, Louisiana, USA*
[97]*Fysiska institutionen, Lunds universitet, Lund, Sweden*
[98]*Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France*
[99]*Departamento de Física Teorica C-15 and CIAFF, Universidad Autónoma de Madrid, Madrid, Spain*
[100]*Institut für Physik, Universität Mainz, Mainz, Germany*
[101]*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
[102]*CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille, France*
[103]*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
[104]*Department of Physics, McGill University, Montreal QC, Canada*
[105]*School of Physics, University of Melbourne, Victoria, Australia*
[106]*Department of Physics, University of Michigan, Ann Arbor, Michigan, USA*
[107]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
[108]*B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Belarus*
[109]*Research Institute for Nuclear Problems of Byelorussian State University, Minsk, Belarus*
[110]*Group of Particle Physics, University of Montreal, Montreal QC, Canada*
[111]*P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia*

[112]*National Research Nuclear University MEPhI, Moscow, Russia*
[113]*D.V. Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia*
[114]*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
[115]*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
[116]*Nagasaki Institute of Applied Science, Nagasaki, Japan*
[117]*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
[118]*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
[119]*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
[120]*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
[121]*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
[122a]*Budker Institute of Nuclear Physics and NSU, SB RAS, Novosibirsk, Russia*
[122b]*Novosibirsk State University Novosibirsk, Russia*
[123]*Institute for High Energy Physics of the National Research Centre Kurchatov Institute, Protvino, Russia*
[124]*Institute for Theoretical and Experimental Physics named by A.I. Alikhanov of National Research Centre "Kurchatov Institute", Moscow, Russia*
[125]*Department of Physics, New York University, New York, New York, USA*
[126]*Ochanomizu University, Otsuka, Bunkyo-ku, Tokyo, Japan*
[127]*Ohio State University, Columbus, Ohio, USA*
[128]*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
[129]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
[130]*Palacký University, RCPTM, Joint Laboratory of Optics, Olomouc, Czech Republic*
[131]*Institute for Fundamental Science, University of Oregon, Eugene, Oregon, USA*
[132]*Graduate School of Science, Osaka University, Osaka, Japan*
[133]*Department of Physics, University of Oslo, Oslo, Norway*
[134]*Department of Physics, Oxford University, Oxford, United Kingdom*
[135]*LPNHE, Sorbonne Université, Université de Paris, CNRS/IN2P3, Paris, France*
[136]*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
[137]*Konstantinov Nuclear Physics Institute of National Research Centre "Kurchatov Institute", PNPI, St. Petersburg, Russia*
[138]*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
[139a]*Laboratório de Instrumentação e Física Experimental de Partículas—LIP, Lisboa, Portugal*
[139b]*Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal*
[139c]*Departamento de Física, Universidade de Coimbra, Coimbra, Portugal*
[139d]*Centro de Física Nuclear da Universidade de Lisboa, Lisboa, Portugal*
[139e]*Departamento de Física, Universidade do Minho, Braga, Portugal*
[139f]*Departamento de Física Teórica y del Cosmos, Universidad de Granada, Granada (Spain), Spain*
[139g]*Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal*
[139h]*Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*
[140]*Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic*
[141]*Czech Technical University in Prague, Prague, Czech Republic*
[142]*Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic*
[143]*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[144]*IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France*
[145]*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
[146a]*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
[146b]*Universidad Andres Bello, Department of Physics, Santiago, Chile*
[146c]*Instituto de Alta Investigación, Universidad de Tarapacá, Chile*
[146d]*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
[147]*Department of Physics, University of Washington, Seattle, Washington, USA*
[148]*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
[149]*Department of Physics, Shinshu University, Nagano, Japan*
[150]*Department Physik, Universität Siegen, Siegen, Germany*
[151]*Department of Physics, Simon Fraser University, Burnaby BC, Canada*
[152]*SLAC National Accelerator Laboratory, Stanford, California, USA*
[153]*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
[154]*Departments of Physics and Astronomy, Stony Brook University, Stony Brook, New York, USA*
[155]*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
[156]*School of Physics, University of Sydney, Sydney, Australia*
[157]*Institute of Physics, Academia Sinica, Taipei, Taiwan*
[158a]*E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[158b]*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*

[159]*Department of Physics, Technion, Israel Institute of Technology, Haifa, Israel*
[160]*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[161]*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[162]*International Center for Elementary Particle Physics and Department of Physics, University of Tokyo, Tokyo, Japan*
[163]*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
[164]*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
[165]*Tomsk State University, Tomsk, Russia*
[166]*Department of Physics, University of Toronto, Toronto ON, Canada*
[167a]*TRIUMF, Vancouver BC, Canada*
[167b]*Department of Physics and Astronomy, York University, Toronto ON, Canada*
[168]*Division of Physics and Tomonaga Center for the History of the Universe, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan*
[169]*Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA*
[170]*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
[171]*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
[172]*Department of Physics, University of Illinois, Urbana, Illinois, USA*
[173]*Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia—CSIC, Valencia, Spain*
[174]*Department of Physics, University of British Columbia, Vancouver BC, Canada*
[175]*Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada*
[176]*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg, Germany*
[177]*Department of Physics, University of Warwick, Coventry, United Kingdom*
[178]*Waseda University, Tokyo, Japan*
[179]*Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot, Israel*
[180]*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*
[181]*Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[182]*Department of Physics, Yale University, New Haven, Connecticut, USA*

[a] Deceased.

[b] Also at Department of Physics, King's College London, London, United Kingdom.

[c] Also at Instituto de Fisica Teorica, IFT-UAM/CSIC, Madrid, Spain.

[d] Also at TRIUMF, Vancouver BC, Canada.

[e] Also at Department of Physics and Astronomy, University of Louisville, Louisville, Kentucky, USA.

[f] Also at Physics Department, An-Najah National University, Nablus, Palestine.

[g] Also at Department of Physics, University of Fribourg, Fribourg, Switzerland.

[h] Also at Departament de Fisica de la Universitat Autonoma de Barcelona, Barcelona, Spain.

[i] Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.

[j] Also at Department of Physics, Ben Gurion University of the Negev, Beer Sheva, Israel.

[k] Also at Universita di Napoli Parthenope, Napoli, Italy.

[l] Also at Institute of Particle Physics (IPP), Canada.

[m] Also at Dipartimento di Matematica, Informatica e Fisica, Università di Udine, Udine, Italy.

[n] Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.

[o] Also at Borough of Manhattan Community College, City University of New York, New York, New York, USA.

[p] Also at Department of Physics, California State University, Fresno, USA.

[q] Also at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece.

[r] Also at Centro Studi e Ricerche Enrico Fermi, Italy.

[s] Also at Department of Physics, California State University, East Bay, USA.

[t] Also at Institucio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.

[u] Also at IJCLab, Université Paris-Saclay, CNRS/IN2P3, 91405, Orsay, France.

[v] Also at Graduate School of Science, Osaka University, Osaka, Japan.

[w] Also at Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany.

[x] Also at University of Chinese Academy of Sciences (UCAS), Beijing, China.

[y] Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.

[z] Also at Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands.

[aa] Also at CERN, Geneva, Switzerland.

[bb] Also at Joint Institute for Nuclear Research, Dubna, Russia.

[cc] Also at Hellenic Open University, Patras, Greece.

[dd] Also at The City College of New York, New York, New York, USA.

[ee] Also at Department of Physics, California State University, Sacramento, USA.

[ff] Also at Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève, Switzerland.

[gg] Also at Louisiana Tech University, Ruston, Louisiana, USA.
[hh] Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.
[ii] Also at Faculty of Physics, M.V. Lomonosov Moscow State University, Moscow, Russia.
[jj] Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
[kk] Also at CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille, France.
[ll] Also at National Research Nuclear University MEPhI, Moscow, Russia.
[mm] Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
[nn] Also at Giresun University, Faculty of Engineering, Giresun, Turkey.
[oo] Also at Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA.