Search for Dark Matter Produced in Association with a Dark Higgs Boson Decaying into $W^{\pm}W^{\mp}$ or ZZ in Fully Hadronic Final States from $\sqrt{s}=13$ TeV pp Collisions Recorded with the ATLAS Detector

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

(Received 15 October 2020; accepted 19 January 2021; published 26 March 2021)

Several extensions of the Standard Model predict the production of dark matter particles at the LHC. An uncharted signature of dark matter particles produced in association with $VV = W^{\pm}W^{\mp}$ or ZZ pairs from a decay of a dark Higgs boson s is searched for using 139 fb^{-1} of pp collisions recorded by the ATLAS detector at a center-of-mass energy of 13 TeV. The $s \to V(q\bar{q})V(q\bar{q})$ decays are reconstructed with a novel technique aimed at resolving the dense topology from boosted VV pairs using jets in the calorimeter and tracking information. Dark Higgs scenarios with $m_s > 160$ GeV are excluded.

DOI: 10.1103/PhysRevLett.126.121802

Overwhelming astrophysical evidence [1–4] suggests the existence of dark matter (DM). DM cannot be accounted for within the Standard Model (SM) and its nature is one of the major questions in physics. Several extensions of the SM postulate stable, electrically neutral, weakly interacting massive particles (χ) [4] as DM candidates that can potentially be produced in high-energy collisions at the CERN LHC. Once produced, χ would escape detection, producing an imbalance in the measured transverse momentum [5], resulting in missing transverse momentum $\boldsymbol{p}_T^{\mathrm{miss}}$ (with magnitude $\boldsymbol{E}_T^{\mathrm{miss}}$). A wide class of models probed at the LHC postulate processes where one or more SM particles X are produced recoiling against χ, resulting in an "$X + \boldsymbol{E}_T^{\mathrm{miss}}$" signature. Searches at the LHC have considered X to be a hadronic jet [6,7], top or bottom quarks [8–11], a photon [12,13], a W or Z boson [14–16], or a Higgs boson [17–19].

This Letter presents a pioneering search for DM using the $X + \boldsymbol{E}_T^{\mathrm{miss}}$ signature where X is a hypothetical particle that decays into a vector-boson pair $VV = W^{+}W^{-}$ or ZZ. This signature was not explored for large $\boldsymbol{E}_T^{\mathrm{miss}}$ and resonant VV production with an invariant mass $m_{VV} > 160$ GeV. The signal region (SR) requires large $\boldsymbol{E}_T^{\mathrm{miss}}$ from DM particles and targets the $VV \to q\bar{q}q\bar{q}$ decay, which has the largest branching ratio $\mathcal{B}$. The background is dominated by vector-boson production in association with jets, referred to as $V+$jets. The analysis employs control regions (CRs) requiring either a single muon (μ) or a pair of leptons $\ell^{\pm}\ell^{\mp}$ ($\ell = e, \mu$) in the final state to improve background modeling in the SR.

The discovery of a new boson with SM Higgs properties [20–22] confirmed the mechanism for electroweak symmetry breaking [23–28] and the generation of mass for SM particles. This success motivates a similar mechanism in the dark sector that contains the DM particle, where χ obtains mass via its Yukawa interactions with a dark Higgs boson s [29]. Furthermore, s alleviates the strict constraints from the observed DM relic density [30] by opening up a new annihilation channel into SM particles, when s, rather than χ, is the lightest state in the dark sector.

A two-mediator-based DM model [31] containing a new $U(1)'$ gauge symmetry, which yields an additional massive spin-1 vector Z' boson via the new scalar boson s, is used for the optimization and interpretation of the search presented in this Letter. The relevant model parameters are the Majorana DM particle mass m_χ, the Z' mass $m_{Z'}$, the dark Higgs mass m_s, and the Z' couplings g_q to quarks and g_χ to DM particles. The Born-level Feynman diagrams for the process are shown in Fig. 1. The $s + \chi\chi$ signal is produced through $q\bar{q} \to Z' \to s\chi\chi$, requiring an off-shell

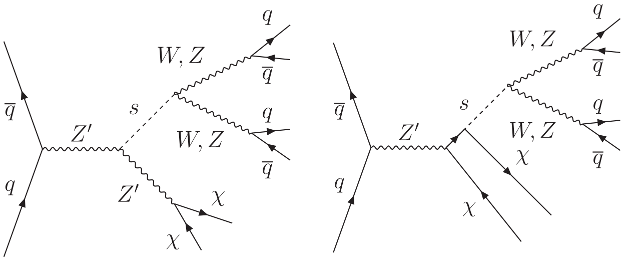


FIG. 1. Born-level Feynman diagrams for the $q\bar{q} \to Z' \to s\chi\chi$, $s \to V(q\bar{q})V(q\bar{q})$ process. The left diagram typically dominates.

---

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

intermediate state such as a Z' or χ. The $s \to W^{\pm}W^{\mp}$ and $s \to ZZ$ processes become relevant for $m_s \gtrsim 160$ GeV and $m_s \gtrsim 180$ GeV, respectively [32]. The proposed framework shares similarities with previously explored spin-1 simplified DM models [33–37], with s being the only addition and χ being a Majorana rather than a Dirac fermion. Within this framework, searches for spin-1 mediators provide complementary sensitivity [38].

The search is performed using 139 fb^{-1} of pp collisions at $\sqrt{s} = 13$ TeV recorded with the ATLAS detector [39,40] in 2015–2018. Events in the SR and the single-muon CR were collected by triggering on $\boldsymbol{E}_T^{\mathrm{miss}}$ reconstructed from calorimeter information [41] above a threshold that varied from 90 to 110 GeV. Events in the dilepton CR were recorded using single-lepton triggers with transverse momentum (p_T) thresholds of 24 GeV and higher, depending on the data-taking period, for electrons and muons.

SM background processes and the $s + \chi\chi$ signal were simulated using Monte Carlo (MC) event generators, except the multijet background, which is found to be negligible using a data-driven method. A detailed simulation of the ATLAS detector [42] based on GEANT4 [43] was used to simulate the detector response for all MC event samples. Contributions from additional pp interactions (pileup) were simulated with PYTHIA 8.186 [44] using the NNPDF23 LO (leading order) parton distribution function (PDF) set [45] and corrected to match data. Parton shower simulations with PYTHIA use the A14 set of tuned parameters [46] with the NNPDF23 LO PDF set.

Signal samples for the $pp \to Z' \to s\chi\chi \to VV\chi\chi \to q\bar{q}q\bar{q}\chi\chi$ process were generated at LO in QCD with up to one additional parton in the event, using MadGraph5_aMC@NLO 2.6.2 [47] interfaced to PYTHIA 8.230, both using the NNPDF23 LO PDF set. Samples were generated in the ($m_{Z'}$, m_s) plane for $m_{Z'} = 0.5, 1, 1.7, 2.5$ TeV and in steps of 25 GeV for $160 < m_s/\mathrm{GeV} < 360$, with $m_\chi = 200$ GeV to avoid $s \to \chi\chi$ decays. Other parameters were chosen as $g_\chi = 1.0$, $g_q = 0.25$ [36,37], and $\sin\theta = 0.01$, where θ is the mixing angle between SM and dark Higgs bosons [29], set to a small value [48].

The $V +$ jets processes were simulated with SHERPA 2.2.1 [49], including mass effects for b- and c-quarks and using NNPDF3.0 PDFs [50]. The perturbative calculations for $V +$ jets were performed at next-to-leading order (NLO) in QCD for up to two partons and at LO for up to four partons [51,52], and matched to the parton shower [53] using the ME + PS@NLO prescription [54]. The $V +$ jets samples are normalized using calculations at next-to-next-to-leading order (NNLO) in QCD [55]. Backgrounds from top quark pair ($t\bar{t}$) production and single top quark production were generated at NLO in QCD with POWHEG-BOX [56–59] v2 using the NNPDF3.0 NLO PDF set, interfaced to PYTHIA 8.230 for parton showering and hadronization. The $t\bar{t}$ samples are normalized using calculations at NNLO in QCD including next-to-next-to-leading logarithmic corrections for soft-gluon radiation [60–66]. The single-top-quark processes are normalized to cross sections at NLO in QCD from Hathor v2.1 [67,68]. Diboson (VV) samples were simulated with SHERPA 2.2.1 at NLO in QCD and normalized using calculations at NNLO in QCD using NNPDF3.0 NNLO PDFs. Backgrounds from associated VH production were generated at NLO in QCD with POWHEG-BOX interfaced to PYTHIA 8.186 using NNPDF3.0 NLO PDFs. The $qq \to VH$ and $gg \to VH$ processes were normalized using calculations at NNLO in QCD and at NLO in QCD combined with next-to-leading-logarithmic order corrections, respectively.

At least one pp collision vertex reconstructed from at least two inner detector (ID) tracks with $p_T^{\mathrm{track}} > 0.5$ GeV is required in the event. The vertex with the highest $\sum(p_T^{\mathrm{track}})^2$ in the event is designated the primary vertex (PV). The ID tracks must have at least seven hits and satisfy $p_T > 0.5$ GeV and $|\eta| < 2.5$ requirements [69,70]. Their transverse and longitudinal impact parameters relative to the PV must satisfy $|\mathrm{d}_0| < 2$ mm and $|z_0 \sin(\theta)| < 3$ mm, respectively.

Muons are reconstructed by matching a track or track segment found in the muon spectrometer to an ID track. Muons must satisfy “medium” or “loose” requirements [71] such that medium (loose) muons must have $|\eta| < 2.5(2.7)$. Electrons are reconstructed by matching a cluster of energy in the calorimeter to an ID track. Electron candidates are identified using a likelihood-based method [72] and must satisfy the loose requirement and have $|\eta| < 2.47$. Electrons and muons must be isolated according to the track proximity criteria in Ref. [73]. Hadronic τ-lepton decays are identified by an algorithm based on a boosted decision tree [74].

Jets are formed from three-dimensional clusters of calorimeter cells with the anti-k_t algorithm [75,76]. Small-R jets use a radius parameter $R = 0.4$ and are referred to as “central” if they satisfy $|\eta| < 2.5$ and $p_T > 20$ GeV and “forward” if they fulfill $2.5 < |\eta| < 4.5$ and $p_T > 30$ GeV. Corrections for pileup [77] and the energy scale and resolution [78] are applied to small-R jets. In addition, central small-R jets with $20 < p_T/\mathrm{GeV} < 60$ and $|\eta| < 2.4$ are identified as originating from the PV using associated tracks [79]. Small-R jets closer than $\Delta R = 0.2$ to an e, μ, or hadronic τ-decay candidate are rejected.

To better reconstruct the challenging multiprong $s \to V(q\bar{q})V(q\bar{q})$ decay, the novel track-assisted reclustering (TAR) algorithm [80] is used. This technique improves the resolution of jet substructure observables by considering both tracking and calorimeter information, combined with the flexibility of jet reclustering. The TAR jets are formed from small-R jets reclustered into larger jets with $R = 0.8$ using trimming parameters optimized for ATLAS [81]. The mass and other substructure observables of TAR jets are reconstructed using ID tracks. For this, ID tracks are first matched to the small-R jets that constitute the $R = 0.8$ jets.

Subsequently, the p_T of tracks matched to a given small-R jet are rescaled such that their sum equals the p_T of that jet, in order to compensate for the neutral jet components missed by the tracker [80]. The TAR algorithm is estimated to improve the sensitivity of the search by a factor of up to 2.5 in expected median discovery significance compared to the conventional large-R jet approach [82], neglecting systematic uncertainties.

In order to suppress contributions from background processes that involve top quarks, which decay almost exclusively to b-quarks, a multivariate algorithm is used to identify jets containing b-hadrons (b-tagging) with an efficiency of 77% [83]. The algorithm is applied to variable-radius track jets with $p_T > 10$ GeV and $|\eta| < 2.5$ formed from ID tracks using the anti-k_t algorithm [84] and a p_T-dependent radius parameter.

The $\boldsymbol{p}_T^{\text{miss}}$ vector is computed as the negative vector sum of the transverse momenta of the e, μ, and small-R jet candidates in the event. The transverse momenta not associated with any e, μ, or jet candidates are accounted for using ID tracks [85]. In addition, an $\boldsymbol{E}_T^{\text{miss}}$ significance $\mathcal{S}$ is computed from the expected resolutions for all the objects used in the $\boldsymbol{E}_T^{\text{miss}}$ calculation [86] and is used to reject multijet background processes.

The signal is characterized by high $\boldsymbol{E}_T^{\text{miss}}$ from DM particles, and substantial hadronic activity from $s \to V(q\bar{q})V(q\bar{q})$ decays that results in an invariant mass consistent with m_s. Thus, the SR requires $\boldsymbol{E}_T^{\text{miss}} > 200$ GeV, no isolated e or μ, no τ lepton decays, and two or more small-R jets. Events in the SR are rejected if a loose electron or muon with $p_T > 7$ GeV is present. In addition, events in the SR and CRs are not considered if they contain hadronic τ-decay candidates with $p_T > 20$ GeV within $|\eta| < 2.5$. The smallest azimuthal angle between the $\boldsymbol{E}_T^{\text{miss}}$ and any of the three highest-p_T (leading) small-R jets is required to be at least $\pi/9$ in order to reduce the multijet background arising from mismeasured jet momenta. This background is further suppressed by requiring $\mathcal{S} > 15$.

The $t\bar{t}$ and diboson processes contribute 1%–7% and 2%–8% of the background in the SR, respectively, while the dominant SM $Z(\nu\nu) + \text{jets}$ and $W(\ell\nu) + \text{jets}$ processes contribute 59%–73% and 15%–32%, respectively, depending on the topology. The modeling of $V + \text{jets}$ is improved using two CRs: the single-muon CR (1μ-CR) enriched in $W + \text{jets}$ and the two-lepton CR (2ℓ-CR) enriched in $Z + \text{jets}$. The 1μ-CR follows the same selection as the SR, except that events must contain exactly one medium muon with $p_T > 27$ GeV and no loose electrons with $p_T > 7$ GeV. Events in the 2ℓ-CR are selected using the same requirements as the SR, except that events must contain exactly two loose electrons or two oppositely charged medium muons and satisfy $\mathcal{S} < 15$. The leading lepton must fulfill $p_T > 27(25)$ GeV for electrons (muons), while for the subleading one $p_T > 7$ GeV is required. The dilepton system is required to be consistent with an energetic Z boson, i.e., $p_T^{\ell\ell} > 200$ GeV and $83 < m_{\ell\ell}/\text{GeV} < 99$.

In order to optimize the sensitivity over a broad VV-pair momentum range, two selection categories, merged and intermediate, are defined. For large s momenta, the dark Higgs boson's decay products become collimated and are reconstructed inside a single TAR jet. These topologies are targeted in the merged category, defined as containing at least one TAR jet with $p_T^{\text{TAR}} > 300$ GeV, and mass m^{TAR} between 100 and 400 GeV. TAR jet substructure variables are employed to discriminate between the four-prong topology of $s \to V(q\bar{q})V(q\bar{q})$ decays and backgrounds with lower multiplicities. This is done using combinations of N-subjettiness [87] variables τ_N by requiring $0 < \tau_4/\tau_2 < 0.3$ and $0 < \tau_4/\tau_3 < 0.6$, which were also experimentally studied in Ref. [88]. The s-candidate mass is identified with m^{TAR}. The merged category dominates the sensitivity, and the product of acceptance and selection efficiency for $\sigma(pp \to s\chi\chi) \times \mathcal{B}(s \to VV)$ lies around 1%.

Moderate s-candidate momenta result in less-collimated decay products, which may not be captured by the nominal TAR jet. In such cases, events failing the merged-category requirements are considered in the intermediate category, where the s candidate is reconstructed from a TAR jet with $m^{\text{TAR}} > 60$ GeV that is supplemented by up to two additional small-R jets within $\Delta R = 2.5$ of the TAR jet. If the mass of the TAR jet is compatible with m_W, i.e., $60 < m^{\text{TAR}}/\text{GeV} < 100$, the TAR jet is supplemented with the two small-R jets whose combined invariant mass is closest to m_W. If $m^{\text{TAR}} > 100$ GeV, it is assumed that only one prong of the s decay was not reconstructed within the TAR jet, and thus it is supplemented with exactly one small-R jet. The s-candidate mass is required to lie between 100 and 400 GeV. The product of acceptance and selection efficiency for $\sigma(pp \to s\chi\chi) \times \mathcal{B}(s \to VV)$ ranges between 10% and 20%.

To account for changes in the background composition and benefit from increased signal sensitivity with higher $\boldsymbol{E}_T^{\text{miss}}$, events in the merged category are further classified into ranges in $\boldsymbol{E}_T^{\text{miss}}/\text{GeV}$: [300, 500] and $[500, \infty)$. The range $[200, \infty)$ is used in the intermediate category. The same ranges are defined consistently in the 1μ-CR and the 2ℓ-CR. To ensure kinematic similarity to the $\boldsymbol{p}_T^{\text{miss}}$ arising from the $V + \text{jets}$ in the SR, $\boldsymbol{p}_T^{\text{miss,no}\mu} = \boldsymbol{p}_T^{\text{miss}} + \boldsymbol{p}_T^{\mu}$, which corresponds to the p_T carried by the W boson, is used in the 1μ-CR. Similarly, $\boldsymbol{p}_T^{\ell\ell}$ in the 2ℓ-CR corresponds to $\boldsymbol{p}_T^{\text{miss}}$ in the SR.

The DM signal is extracted via a simultaneous maximum-likelihood fit [89,90] of signal and background simulations to the binned s-candidate mass distributions in the SR and to total yields in the CR categories. The normalizations of $W + \text{jets}$ and $Z + \text{jets}$ processes are free parameters in the fit and are constrained by the total event yields, summed over $\boldsymbol{E}_T^{\text{miss}}$-bin and category, in the 1μ-CR and 2ℓ-CR. Experimental uncertainties related to the

TABLE I. Dominant sources of uncertainty for three dark Higgs scenarios after the fit to Asimov data generated from the expected values of the maximum-likelihood estimators including predicted signals with $m_{Z'} = 1$ TeV and m_s of (a) 160, (b) 235, and (c) 310 GeV. The uncertainty in the fitted signal yield relative to the theory prediction is presented. Total is the quadrature sum of statistical and total systematic uncertainties, which consider correlations.

	Uncertainty [%]		
Source of uncertainty	(a)	(b)	(c)
Signal modeling	11	10	10
$W+$jets modeling	9	21	14
$Z+$jets modeling	7	12	13
MC statistics	11	14	23
Jet energy scale	8	17	24
Jet energy resolution	11	18	15
Lepton reconstruction	8	9	5
Track reconstruction	6	7	5
Systematic uncertainty	30	42	55
Statistical uncertainty	16	25	50
Total uncertainty	34	49	74

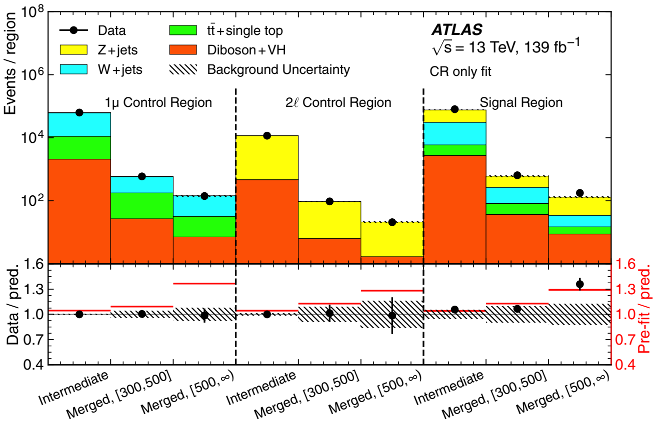
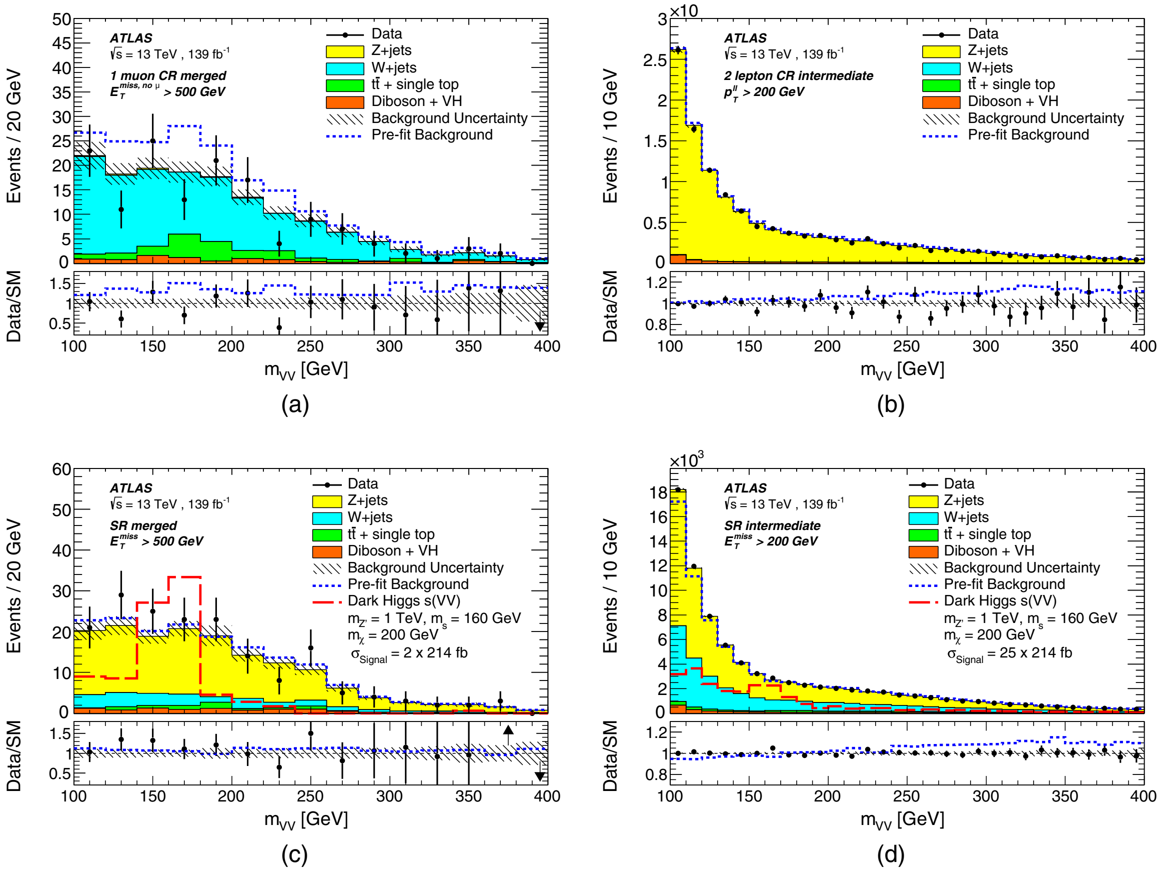


FIG. 2. Data overlaid on SM background postfit yields stacked in each SR and CR category and E_T^{miss} bin with the maximum-likelihood estimators set to the conditional values of the CR-only fit, and propagated to SR and CRs. The ratio of the data to SM expectations after the CR-only fit is shown in the lower panel, along with the red line representing the ratio of the prefit to the postfit background prediction. Prefit uncertainties cover differences between the data and prefit background prediction.

calibration of the scale and resolution of the jet energy [78] as well as to tracking efficiencies [70] affect the reconstruction of m_s using TAR jets. Other leading experimental systematic uncertainties arise from the finite number of MC events and the calibration of the lepton identification efficiencies [71,72]. Dominant theoretical systematic uncertainties originate from the modeling of the signal and the $W+$jets and $Z+$jets background processes. These encompass uncertainties from the choice of PDFs and factorization and normalization scales. In addition, to estimate the uncertainty from the choice of matrix element and parton shower generator for $W+$jets and $Z+$jets, alternative MC samples generated with MadGraph5_aMC@NLO 2.6.2 at LO in QCD with up to four parton emissions using the NNPDF23 LO PDF set and interfaced to PYTHIA 8.230 using a merging scale of $Q_{\text{cut}} =$ 30 GeV are considered. All other systematic uncertainties are estimated similarly to Ref. [17], except for the $t\bar{t}$ normalization, for which theoretical uncertainties [65] are considered. The systematic uncertainties, parametrized as nuisance parameters with Gaussian or log-normal prior probabilities, are profiled and used to constrain the template shapes and the normalizations varied in the fit [91]. Dominant uncertainties after the fit to Asimov data for three representative dark Higgs scenarios are quantified in Table I.

A first fit to the SM backgrounds is performed using only data from the CRs. The observed and fitted yields in the CR categories obtained after this fit are shown in Fig. 2. Also shown are the background yields predicted in the SR when using the observed parameter values from the CR-only fit. The fit reduces the MC-predicted $V+$jets contribution in the merged category. The overall yields in the CRs and the SR are found to be well described by SM simulations. The normalization and the p_T^V dependence of both $W+$jets and $Z+$jets are consistent within uncertainties with SM predictions in the SR and CRs. Figure 3 shows the mass distributions m_{VV} of the s candidate in two representative SR categories and the two corresponding categories in the 1μ-CR, obtained after a simultaneous fit to the SR and the CRs under the hypothesis that only SM predictions are present. The data distributions agree well with MC simulations in the CRs, indicating that $V+$jets background processes reconstructed with the novel TAR algorithm are well modeled. The observed results in the SR indicate that the data are in general well described by SM predictions. A mild excess around $m_{VV} = 160$ GeV is observed, yielding a 2.3σ local significance and 1.3σ global significance when considering nine independent m_s hypotheses. The excess in the intermediate region is narrower than the experimental resolution for m_s.

Upper limits are set on the product of the $pp \to s\chi\chi$ production cross section and $\mathcal{B}(s \to VV)$, using a modified frequentist approach (CL$_s$) [92] with a test statistic based on the profile likelihood in the asymptotic approximation [93]. Exclusion contours in the $(m_{Z'}, m_s)$ plane for the dark Higgs model are presented in Fig. 4 and exclude $m_{Z'}$ up to 1.8 TeV for $m_s = 210$ GeV at 95% confidence level (C.L.). The observed exclusion range in $m_{Z'}$ becomes narrower than expected at low m_s owing to the small excess in data near $m_{VV} = 160$ GeV discussed above. The merged SR provides the maximal sensitivity attained at low m_s and high $m_{Z'}$, while the intermediate SR provides complementary sensitivity.



(a) (b)

(c) (d)

FIG. 3. Distributions of the invariant mass of the dark Higgs boson candidates in the 1μ-CR and 2ℓ-CR (upper row) and in the SR (lower row) in two representative categories, after the fit to data. The upper panels compare the data with the SM expectation before and after the background-only fit. The lower panels display the ratio of data to SM expectations after the fit, with its systematic uncertainty. Also shown is the ratio of SM expectations before and after the fit. The expected signal, with a cross section of 214 fb, from a representative dark Higgs model with $g_q = 0.25$, $g_\chi = 1.0$, and $\sin\theta = 0.01$, is scaled for presentation purposes. No m_{VV} shape information in the CRs is considered in the fit. Prefit uncertainties cover differences between the data and prefit background prediction.

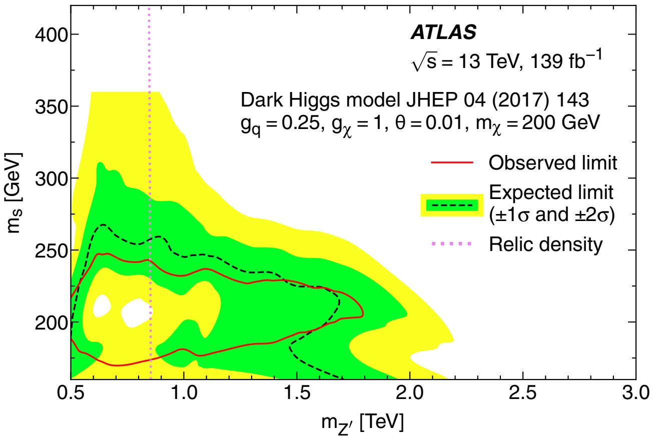


FIG. 4. Observed (expected) exclusion regions at 95% C.L. for the dark Higgs model in the $(m_{Z'}, m_s)$ plane, encircled by the solid (dashed) line. The expected $\pm 1\sigma$ $(\pm 2\sigma)$ uncertainty is shown as the filled green (yellow) band. The observed relic density [30] is obtained for $m_{Z'} = 850$ GeV (dotted line).

In conclusion, this Letter presents a novel search for DM in previously uncovered final states with large $\boldsymbol{E}_T^{\mathrm{miss}}$ and hadronic decays of resonant $VV = W^\pm W^\mp$ or ZZ pairs, with $m_{VV} > 160$ GeV, using the ATLAS detector at the LHC. No significant excess over the predicted background is found in 139 fb^{-1} of 13 TeV pp collision data. This search excludes previously uncharted parameter space of the dark Higgs model for $m_s > 160$ GeV and provides sensitivity complementary to other DM searches using $X + \boldsymbol{E}_T^{\mathrm{miss}}$ signatures.

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently. We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; ANID, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF and DNSRC, Denmark; IN2P3-CNRS and

CEA-DRF/IRFU, France; SRNSFG, Georgia; BMBF, HGF, and MPG, Germany; GSRT, Greece; RGC and Hong Kong SAR, China; ISF and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; NWO, Netherlands; RCN, Norway; MNiSW and NCN, Poland; FCT, Portugal; MNE/IFA, Romania; MES of Russia and NRC KI, Russia Federation; JINR; MESTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SERI, SNSF, and Cantons of Bern and Geneva, Switzerland; MOST, Taiwan; TAEK, Turkey; STFC, United Kingdom; DOE and NSF, United States of America. In addition, individual groups and members received support from BCKDF, CANARIE, Compute Canada and CRC, Canada; ERC, ERDF, Horizon 2020, Marie Skłodowska-Curie Actions and COST, European Union; Investissements d'Avenir Labex, Investissements d'Avenir Idex, and ANR, France; DFG and AvH Foundation, Germany; Herakleitos, Thales, and Aristeia programmes cofinanced by EU-ESF and the Greek NSRF, Greece; BSF-NSF and GIF, Israel; La Caixa Banking Foundation, CERCA Programme Generalitat de Catalunya and PROMETEO and GenT Programmes Generalitat Valenciana, Spain; Göran Gustafssons Stiftelse, Sweden; The Royal Society and Leverhulme Trust, United Kingdom. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN, the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA), the tier-2 facilities worldwide, and large non-WLCG resource providers. Major contributors of computing resources are listed in Ref. [94].

[1] J. Silk *et al.*, *Particle Dark Matter: Observations, Models and Searches*, edited by G. Bertone (Cambridge University Press, Cambridge, United Kingdom, 2010), ISBN 978-1-107-65392-4.

[2] J. L. Feng, Dark matter candidates from particle physics and methods of detection, Annu. Rev. Astron. Astrophys. **48**, 495 (2010).

[3] T. A. Porter, R. P. Johnson, and P. W. Graham, Dark matter searches with astroparticle data, Annu. Rev. Astron. Astrophys. **49**, 155 (2011).

[4] G. Bertone, N. Bozorgnia, J. S. Kim, S. Liem, C. McCabe, S. Otten, and R. R. de Austri, Identifying WIMP dark matter from particle and astroparticle data, J. Cosmol. Astropart. Phys. 03 (2018) 026.

[5] 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 $\eta = -\ln\tan(\theta/2)$. Angular distance is measured in units of $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$.

[6] ATLAS Collaboration, Search for dark matter and other new phenomena in events with an energetic jet and large missing transverse momentum using the ATLAS detector, J. High Energy Phys. 01 (2018) 126.

[7] CMS Collaboration, Search for new physics in final states with an energetic jet or a hadronically decaying W or Z boson and transverse momentum imbalance at $\sqrt{s} = 13$ TeV, Phys. Rev. D **97**, 092005 (2018).

[8] ATLAS Collaboration, Search for dark matter produced in association with bottom or top quarks in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector, Eur. Phys. J. C **78**, 18 (2018).

[9] ATLAS Collaboration, Search for large missing transverse momentum in association with one top-quark in proton–proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 05 (2019) 041.

[10] CMS Collaboration, Search for Dark Matter Particles Produced in Association with a Top Quark Pair at $\sqrt{s} = 13$ TeV, Phys. Rev. Lett. **122**, 011803 (2019).

[11] CMS Collaboration, Search for dark matter produced in association with a single top quark or a top quark pair in proton–proton collisions at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 03 (2019) 141.

[12] ATLAS Collaboration, Search for dark matter at $\sqrt{s} = 13$ TeV in final states containing an energetic photon and large missing transverse momentum with the ATLAS detector, Eur. Phys. J. C **77**, 393 (2017).

[13] CMS Collaboration, Search for new physics in final states with a single photon and missing transverse momentum in proton–proton collisions at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 02 (2019) 074.

[14] ATLAS Collaboration, Search for dark matter in events with a hadronically decaying vector boson and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, J. High Energy Phys. 10 (2018) 180.

[15] ATLAS Collaboration, Search for an invisibly decaying Higgs boson or dark matter candidates produced in association with a Z boson in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **776**, 318 (2018).

[16] CMS Collaboration, Search for dark matter produced with an energetic jet or a hadronically decaying W or Z boson at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 07 (2017) 014.

[17] ATLAS Collaboration, Search for Dark Matter Produced in Association with a Higgs Boson Decaying to $b\bar{b}$ Using 36 fb^{-1} of pp Collisions at $\sqrt{s} = 13$ TeV with the ATLAS Detector, Phys. Rev. Lett. **119**, 181804 (2017).

[18] CMS Collaboration, Search for dark matter produced in association with a Higgs boson decaying to $\gamma\gamma$ or $\tau^+\tau^-$ at $\sqrt{s} = 13$ TeV, J. High Energy Phys. 09 (2018) 046.

[19] CMS Collaboration, Search for dark matter produced in association with a Higgs boson decaying to a pair of bottom quarks in proton–proton collisions at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **79**, 280 (2019).

[20] 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).

[21] 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).

[22] CMS Collaboration, Observation of a new boson with mass near 125 GeV in pp collisions at $\sqrt{s} = 7$ and 8 TeV, J. High Energy Phys. 06 (2013) 081.

[23] F. Englert and R. Brout, Broken Symmetry and the Mass of Gauge Vector Mesons, Phys. Rev. Lett. **13**, 321 (1964).

[24] P. W. Higgs, Broken symmetries, massless particles and gauge fields, Phys. Lett. **12**, 132 (1964).

[25] P. W. Higgs, Broken Symmetries and the Masses of Gauge Bosons, Phys. Rev. Lett. **13**, 508 (1964).

[26] G. Guralnik, C. Hagen, and T. Kibble, Global Conservation Laws and Massless Particles, Phys. Rev. Lett. **13**, 585 (1964).

[27] P. W. Higgs, Spontaneous symmetry breakdown without massless bosons, Phys. Rev. **145**, 1156 (1966).

[28] T. Kibble, Symmetry breaking in non-Abelian gauge theories, Phys. Rev. **155**, 1554 (1967).

[29] M. Duerr, A. Grohsjean, F. Kahlhoefer, B. Penning, K. Schmidt-Hoberg, and C. Schwanenberger, Hunting the dark Higgs, J. High Energy Phys. 04 (2017) 143.

[30] N. Aghanim *et al.*, Planck 2018 results. VI. Cosmological parameters, Astron. Astrophys. **641**, A6 (2020).

[31] M. Duerr, F. Kahlhoefer, K. Schmidt-Hoberg, T. Schwetz, and S. Vogl, How to save the WIMP: Global analysis of a dark matter model with two s-channel mediators, J. High Energy Phys. 09 (2016) 042.

[32] J. R. Andersen *et al.*, Handbook of LHC Higgs Cross Sections: 3. Higgs Properties, edited by S. Heinemeyer, C. Mariotti, G. Passarino, and R. Tanaka (CERN, 2013), https://doi.org/10.5170/CERN-2013-004.

[33] O. Buchmueller, M. J. Dolan, and C. McCabe, Beyond effective field theory for dark matter searches at the LHC, J. High Energy Phys. 01 (2014) 025.

[34] P. Harris, V. V. Khoze, M. Spannowsky, and C. Williams, Constraining dark sectors at colliders: Beyond the effective theory approach, Phys. Rev. D **91**, 055009 (2015).

[35] M. R. Buckley, D. Feld, and D. Goncalves, Scalar simplified models for dark matter, Phys. Rev. D **91**, 015017 (2015).

[36] D. Abercrombie *et al.*, Dark Matter benchmark models for early LHC Run-2 Searches: Report of the ATLAS/CMS Dark Matter Forum, Phys. Dark Universe **27**, 100371 (2020).

[37] J. Abdallah *et al.*, Simplified models for dark matter searches at the LHC, Phys. Dark Universe **9–10**, 8 (2015).

[38] ATLAS Collaboration, Constraints on mediator-based dark matter and scalar dark energy models using $\sqrt{s} = 13$ TeV pp collision data collected by the ATLAS detector, J. High Energy Phys. 05 (2019) 142.

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

[40] ATLAS Collaboration, ATLAS Insertable B-Layer Technical Design Report, Report No. ATLAS-TDR-19; Report No. CERN-LHCC-2010-013, 2010, https://cds.cern.ch/record/1291633.

[41] ATLAS Collaboration, Performance of the ATLAS trigger system in 2015, Eur. Phys. J. C **77**, 317 (2017).

[42] ATLAS Collaboration, The ATLAS Simulation Infrastructure, Eur. Phys. J. C **70**, 823 (2010).

[43] S. Agostinelli *et al.*, GEANT4–a simulation toolkit, Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).

[44] T. Sjöstrand, S. Ask, J. R. Christiansen, R. Corke, N. Desai, P. Ilten, S. Mrenna, S. Prestel, C. O. Rasmussen, and P. Z. Skands, An introduction to PYTHIA 8.2, Comput. Phys. Commun. **191**, 159 (2015).

[45] R. D. Ball, V. Bertone, S. Carrazza, C. S. Deans, L. Del Debbio *et al.*, Parton distributions with LHC data, Nucl. Phys. **B867**, 244 (2013).

[46] ATLAS Collaboration, ATLAS PYTHIA 8 tunes to 7 TeV data, Report No. ATL-PHYS-PUB-2014-021, 2014, https://cds.cern.ch/record/1966419.

[47] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H.-S. Shao, T. Stelzer, P. Torrielli, and M. Zaro, The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, J. High Energy Phys. 07 (2014) 079.

[48] note F. Kahlhöfer (private communication).

[49] T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, S. Schumann, F. Siegert, and J. Winter, Event generation with SHERPA 1.1, J. High Energy Phys. 02 (2009) 007.

[50] R. D. Ball *et al.* (NNPDF Collaboration), Parton distributions for the LHC run II, J. High Energy Phys. 04 (2015) 040.

[51] F. Cascioli, P. Maierhofer, and S. Pozzorini, Scattering Amplitudes with Open Loops, Phys. Rev. Lett. **108**, 111601 (2012).

[52] A. Denner, S. Dittmaier, and L. Hofer, Collier: A fortran-based complex one-loop lIbrary in extended regularizations, Comput. Phys. Commun. **212**, 220 (2017).

[53] S. Schumann and F. Krauss, A parton shower algorithm based on Catani-Seymour dipole factorisation, J. High Energy Phys. 03 (2008) 038.

[54] S. Höche, F. Krauss, M. Schönherr, and F. Siegert, QCD matrix elements + parton showers: The NLO case, J. High Energy Phys. 04 (2013) 027.

[55] 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).

[56] S. Frixione, G. Ridolfi, and P. Nason, A positive-weight next-to-leading-order Monte Carlo for heavy flavour hadroproduction, J. High Energy Phys. 09 (2007) 126.

[57] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, J. High Energy Phys. 11 (2004) 040.

[58] 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.

[59] 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.

[60] M. Beneke, P. Falgari, S. Klein, and C. Schwinn, Hadronic top-quark pair production with NNLL threshold resummation, Nucl. Phys. **B855**, 695 (2012).

[61] M. Cacciari, M. Czakon, M. Mangano, A. Mitov, and P. Nason, Top-pair production at hadron colliders with next-to-next-to-leading logarithmic soft-gluon resummation, Phys. Lett. B **710**, 612 (2012).

[62] P. Bärnreuther, M. Czakon, and A. Mitov, Percent Level Precision Physics at the Tevatron: First Genuine NNLO QCD Corrections to $q\bar{q} \rightarrow t\bar{t} + X$, Phys. Rev. Lett. **109**, 132001 (2012).

[63] M. Czakon and A. Mitov, NNLO corrections to top-pair production at hadron colliders: The all-fermionic scattering channels, J. High Energy Phys. 12 (2012) 054.

[64] M. Czakon and A. Mitov, NNLO corrections to top pair production at hadron colliders: The quark-gluon reaction, J. High Energy Phys. 01 (2013) 080.

[65] M. Czakon, P. Fiedler, and A. Mitov, The Total Top Quark Pair Production Cross Section at Hadron Colliders Through $O(\alpha_S^4)$, Phys. Rev. Lett. **110**, 252004 (2013).

[66] M. Czakon and A. Mitov, Top++: A program for the calculation of the top-pair cross-section at hadron colliders, Comput. Phys. Commun. **185**, 2930 (2014).

[67] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer, and M. Wiedermann, HATHOR: HAdronic Top and Heavy quarks crOss section calculatoR, Comput. Phys. Commun. **182**, 1034 (2011).

[68] P. Kant, O.M. Kind, T. Kintscher, T. Lohse, T. Martini, S. Mölbitz, P. Rieck, and P. Uwer, HatHor for single top-quark production: Updated predictions and uncertainty estimates for single top-quark production in hadronic collisions, Comput. Phys. Commun. **191**, 74 (2015).

[69] ATLAS Collaboration, The Optimization of ATLAS Track Reconstruction in Dense Environments, Report No. ATL-PHYS-PUB-2015-006, 2015, https://cds.cern.ch/record/2002609.

[70] ATLAS Collaboration, Early Inner Detector Tracking Performance in the 2015 data at $\sqrt{s} = 13$ TeV, Report No. ATL-PHYS-PUB-2015-051, 2015, https://cds.cern.ch/record/2110140.

[71] 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).

[72] 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).

[73] ATLAS Collaboration, Search for dark matter in association with a Higgs boson decaying to b-quarks in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector, Phys. Lett. B **765**, 11 (2017).

[74] ATLAS Collaboration, Reconstruction of hadronic decay products of tau leptons with the ATLAS experiment, Eur. Phys. J. C **76**, 295 (2016).

[75] M. Cacciari, G. P. Salam, and G. Soyez, FastJet user manual, Eur. Phys. J. C **72**, 1896 (2012).

[76] M. Cacciari, G. P. Salam, and G. Soyez, The anti-k_t jet clustering algorithm, J. High Energy Phys. 04 (2008) 063.

[77] M. Cacciari, G. P. Salam, and G. Soyez, The catchment area of jets, J. High Energy Phys. 04 (2008) 005.

[78] 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).

[79] ATLAS Collaboration, Tagging and suppression of pileup jets with the ATLAS detector, Report No. ATLAS-CONF-2014-018, 2014, https://cds.cern.ch/record/1700870.

[80] ATLAS Collaboration, Track assisted techniques for jet substructure, Report No. ATL-PHYS-PUB-2018-012, 2018, https://cds.cern.ch/record/2630864.

[81] ATLAS Collaboration, In situ calibration of large-radius jet energy and mass in 13 TeV proton–proton collisions with the ATLAS detector, Eur. Phys. J. C **79**, 135 (2019).

[82] ATLAS Collaboration, Jet mass reconstruction with the ATLAS Detector in early Run 2 data, Report No. ATLAS-CONF-2016-035, 2016, https://cds.cern.ch/record/2200211.

[83] ATLAS Collaboration, ATLAS b-jet identification performance and efficiency measurement with $t\bar{t}$ events in pp collisions at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **79**, 970 (2019).

[84] ATLAS Collaboration, Variable Radius, Exclusive-k_T, and Center-of-Mass Subjet Reconstruction for Higgs($\rightarrow b\bar{b}$) Tagging in ATLAS, Report No. ATL-PHYS-PUB-2017-010, 2017, https://cds.cern.ch/record/2268678.

[85] ATLAS Collaboration, Performance of missing transverse momentum reconstruction with the ATLAS detector using proton–proton collisions at $\sqrt{s} = 13$ TeV, Eur. Phys. J. C **78**, 903 (2018).

[86] ATLAS Collaboration, Object-based missing transverse momentum significance in the ATLAS Detector, Report No. ATLAS-CONF-2018-038, 2018, https://cds.cern.ch/record/2630948.

[87] J. Thaler and K. Van Tilburg, Identifying boosted objects with N-subjettiness, J. High Energy Phys. 03 (2011) 015.

[88] CMS Collaboration, Search for a massive resonance decaying into a Higgs boson and a W or Z boson in hadronic final states in proton-proton collisions at $\sqrt{s} = 8$ TeV, J. High Energy Phys. 02 (2016) 145.

[89] L. Moneta *et al.*, The RooStats project, *Proc. Sci.*, ACAT2010 (2010) 057, arXiv:1009.1003.

[90] W. Verkerke and D. P. Kirkby, The RooFit toolkit for data modeling, arXiv:physics/0306116.

[91] ATLAS Collaboration, Search for the $b\bar{b}$ decay of the Standard Model Higgs boson in associated $(W/Z)H$ production with the ATLAS detector, J. High Energy Phys. 01 (2015) 069.

[92] A. L. Read, Presentation of search results: The CL_S technique, J. Phys. G **28**, 2693 (2002).

[93] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, Eur. Phys. J. C **71** (2011) 1554; Erratum, Eur. Phys. J. C **73**, 2501 (2013).

[94] ATLAS Collaboration, ATLAS computing acknowledgements, Report No. ATL-SOFT-PUB-2020-001, https://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,n] B. Achkar,[53]

L. Adam,[100] C. Adam Bourdarios,[5] L. Adamczyk,[84a] L. Adamek,[166] J. Adelman,[121] 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,ab] A. Ahmad,[36] F. Ahmadov,[80] W. S. Ahmed,[104] X. Ai,[18] G. Aielli,[74a,74b] S. Akatsuka,[86]
M. Akbiyik,[100] 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,[36] 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,[18] 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] 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] H. Asada,[117] 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] P. A. Atmasiddha,[106] K. Augsten,[141] V. A. Austrup,[181] G. Avolio,[36] M. K. Ayoub,[15a]
G. Azuelos,[110,ai] D. Babal,[28a] H. Bachacou,[144] K. Bachas,[161] 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] R. Balasubramanian,[120] 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,[19] Sw. Banerjee,[180,i] 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,af]
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]
P. Bauer,[24] H. S. Bawa,[31] A. Bayirli,[12c] 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,p] 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,[29] 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]
A. Berthold,[48] I. A. Bertram,[90] O. Bessidskaia Bylund,[181] N. Besson,[144] S. Bethke,[115] A. Betti,[42] A. J. Bevan,[93] J. Beyer,[115]
S. Bhatta,[154] 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,[141] M. Bindi,[53]
A. Bingul,[12d] C. Bini,[73a,73b] S. Biondi,[23b,23a] C. J. Birch-sykes,[101] M. Birman,[179] T. Bisanz,[36] J. P. Biswal,[3] D. Biswas,[180,i]
A. Bitadze,[101] C. Bittrich,[48] K. Bjørke,[133] T. Blazek,[28a] I. Bloch,[46] C. Blocker,[26] A. Blue,[57] U. Blumenschein,[93]
G. J. Bobbink,[120] V. S. Bobrovnikov,[122b,122a] S. S. Bocchetta,[97] D. Bogavac,[14] A. G. Bogdanchikov,[122b,122a] C. Bohm,[45a]
V. Boisvert,[94] P. Bokan,[171,171,53] T. Bold,[84a] A. E. Bolz,[61b] M. Bomben,[135] M. Bona,[93] J. S. Bonilla,[131] M. Boonekamp,[144]
C. D. Booth,[94] A. G. Borbély,[57] H. M. Borecka-Bielska,[91] L. S. Borgna,[95] A. Borisov,[123] G. Borissov,[90] D. Bortoletto,[134]
D. Boscherini,[23b] M. Bosman,[14] J. D. Bossio Sola,[104] K. Bouaouda,[35a] J. Boudreau,[138] E. V. Bouhova-Thacker,[90]
D. Boumediene,[38] A. Boveia,[127] J. Boyd,[36] D. Boye,[33c] I. R. Boyko,[80] A. J. Bozson,[94] J. Bracinik,[21] N. Brahimi,[60d]
G. Brandt,[181] O. Brandt,[32] F. Braren,[46] B. Brau,[103] J. E. Brau,[131] W. D. Breaden Madden,[57] K. Brendlinger,[46] R. Brener,[159]
L. Brenner,[36] R. Brenner,[171] S. Bressler,[179] B. Brickwedde,[100] D. L. Briglin,[21] D. Britton,[57] D. Britzger,[115] I. Brock,[24]
R. Brock,[107] G. Brooijmans,[39] W. K. Brooks,[146d] E. Brost,[29] P. A. Bruckman de Renstrom,[85] B. Brüers,[46] D. Bruncko,[28b]
A. Bruni,[23b] G. Bruni,[23b] M. Bruschi,[23b] N. Bruscino,[73a,73b] L. Bryngemark,[152] T. Buanes,[17] Q. Buat,[154] P. Buchholz,[150]
A. G. Buckley,[57] I. A. Budagov,[80] M. K. Bugge,[133] O. Bulekov,[112] B. A. Bullard,[59] T. J. Burch,[121] S. Burdin,[91]
C. D. Burgard,[120] A. M. Burger,[129] B. Burghgrave,[8] J. T. P. Burr,[46] C. D. Burton,[11] J. C. Burzynski,[103] V. Büscher,[100]

E. Buschmann,[53] P. J. Bussey,[57] J. M. Butler,[25] C. M. Buttar,[57] J. M. Butterworth,[95] P. Butti,[36] W. Buttinger,[143]
C. J. Buxo Vazquez,[107] A. Buzatu,[157] A. R. Buzykaev,[122b,122a] G. Cabras,[23b,23a] S. Cabrera Urbán,[173] D. Caforio,[56] H. Cai,[138]
V. M. M. Cairo,[152] O. Cakir,[4a] N. Calace,[36] P. Calafiura,[18] G. Calderini,[135] P. Calfayan,[66] G. Callea,[57] L. P. Caloba,[81b]
A. Caltabiano,[74a,74b] S. Calvente Lopez,[99] D. Calvet,[38] S. Calvet,[38] T. P. Calvet,[102] M. Calvetti,[72a,72b] R. Camacho Toro,[135]
S. Camarda,[36] D. Camarero Munoz,[99] P. Camarri,[74a,74b] M. T. Camerlingo,[75a,75b] D. Cameron,[133] C. Camincher,[36]
S. Campana,[36] M. Campanelli,[95] A. Camplani,[40] V. Canale,[70a,70b] A. Canesse,[104] M. Cano Bret,[78] J. Cantero,[129] T. Cao,[160]
Y. Cao,[172] M. Capua,[41b,41a] R. Cardarelli,[74a] F. Cardillo,[173] G. Carducci,[41b,41a] I. Carli,[142] T. Carli,[36] G. Carlino,[70a]
B. T. Carlson,[138] E. M. Carlson,[175,167a] L. Carminati,[69a,69b] R. M. D. Carney,[152] S. Caron,[119] E. Carquin,[146d] S. Carrá,[46]
G. Carratta,[23b,23a] J. W. S. Carter,[166] T. M. Carter,[50] M. P. Casado,[14,f] A. F. Casha,[166] E. G. Castiglia,[182] F. L. Castillo,[173]
L. Castillo Garcia,[14] V. Castillo Gimenez,[173] N. F. Castro,[139a,139e] A. Catinaccio,[36] J. R. Catmore,[133] A. Cattai,[36]
V. Cavaliere,[29] V. Cavasinni,[72a,72b] E. Celebi,[12b] F. Celli,[134] K. Cerny,[130] A. S. Cerqueira,[81a] A. Cerri,[155] L. Cerrito,[74a,74b]
F. Cerutti,[18] A. Cervelli,[23b,23a] S. A. Cetin,[12b] Z. Chadi,[35a] D. Chakraborty,[121] J. Chan,[180] W. S. Chan,[120] W. Y. Chan,[91]
J. D. Chapman,[32] B. Chargeishvili,[158b] D. G. Charlton,[21] T. P. Charman,[93] M. Chatterjee,[20] C. C. Chau,[34] S. Che,[127]
S. Chekanov,[6] S. V. Chekulaev,[167a] G. A. Chelkov,[80,ad] B. Chen,[79] C. Chen,[60a] C. H. Chen,[79] H. Chen,[15c] H. Chen,[29]
J. Chen,[60a] J. Chen,[39] J. Chen,[26] S. Chen,[136] S. J. Chen,[15c] X. Chen,[15b] Y. Chen,[60a] Y-H. Chen,[46] H. C. Cheng,[63a]
H. J. Cheng,[15a] A. Cheplakov,[80] E. Cheremushkina,[123] R. Cherkaoui El Moursli,[35e] E. Cheu,[7] K. Cheung,[64]
T. J. A. Chevalérias,[144] L. Chevalier,[144] V. Chiarella,[51] G. Chiarelli,[72a] G. Chiodini,[68a] A. S. Chisholm,[21] A. Chitan,[27b]
I. Chiu,[162] Y. H. Chiu,[175] M. V. Chizhov,[80] K. Choi,[11] A. R. Chomont,[73a,73b] Y. Chou,[103] Y. S. Chow,[120] L. D. Christopher,[33e]
M. C. Chu,[63a] X. Chu,[15a,15d] J. Chudoba,[140] J. J. Chwastowski,[85] L. Chytka,[130] D. Cieri,[115] K. M. Ciesla,[85] V. Cindro,[92]
I. A. Cioară,[27b] A. Ciocio,[18] F. Cirotto,[70a,70b] Z. H. Citron,[179,j] M. Citterio,[69a] D. A. Ciubotaru,[27b] B. M. Ciungu,[166]
A. Clark,[54] P. J. Clark,[50] S. E. Clawson,[101] C. Clement,[45a,45b] Y. Coadou,[102] M. Cobal,[67a,67c] A. Coccaro,[55b] J. Cochran,[79]
R. Coelho Lopes De Sa,[103] H. Cohen,[160] A. E. C. Coimbra,[36] B. Cole,[39] A. P. Colijn,[120] J. Collot,[58] P. Conde Muiño,[139a,139h]
S. H. Connell,[33c] I. A. Connelly,[57] S. Constantinescu,[27b] F. Conventi,[70a,aj] A. M. Cooper-Sarkar,[134] F. Cormier,[174]
K. J. R. Cormier,[166] L. D. Corpe,[95] M. Corradi,[73a,73b] E. E. Corrigan,[97] F. Corriveau,[104,z] M. J. Costa,[173] F. Costanza,[5]
D. Costanzo,[148] G. Cowan,[94] J. W. Cowley,[32] J. Crane,[101] K. Cranmer,[125] R. A. Creager,[136] S. Crépé-Renaudin,[58]
F. Crescioli,[135] M. Cristinziani,[24] V. Croft,[169] G. Crosetti,[41b,41a] A. Cueto,[5] T. Cuhadar Donszelmann,[170] H. Cui,[15a,15d]
A. R. Cukierman,[152] W. R. Cunningham,[57] S. Czekierda,[85] P. Czodrowski,[36] M. M. Czurylo,[61b]
M. J. Da Cunha Sargedas De Sousa,[60b] J. V. Da Fonseca Pinto,[81b] C. Da Via,[101] W. Dabrowski,[84a] F. Dachs,[36] T. Dado,[47]
S. Dahbi,[33e] T. Dai,[106] C. Dallapiccola,[103] M. Dam,[40] G. D'amen,[29] V. D'Amico,[75a,75b] J. Damp,[100] J. R. Dandoy,[136]
M. F. Daneri,[30] M. Danninger,[151] V. Dao,[36] G. Darbo,[55b] O. Dartsi,[5] A. Dattagupta,[131] T. Daubney,[46] S. D'Auria,[69a,69b]
C. David,[167b] T. Davidek,[142] D. R. Davis,[49] I. Dawson,[148] K. De,[8] R. De Asmundis,[70a] M. De Beurs,[120] S. De Castro,[23b,23a]
N. De Groot,[119] P. de Jong,[120] H. De la Torre,[107] A. De Maria,[15c] D. De Pedis,[73a] A. De Salvo,[73a] U. De Sanctis,[74a,74b]
M. De Santis,[74a,74b] A. De Santo,[155] J. B. De Vivie De Regie,[65] D. V. Dedovich,[80] A. M. Deiana,[42] J. Del Peso,[99]
Y. Delabat Diaz,[46] D. Delgove,[65] F. Deliot,[144] C. M. Delitzsch,[7] M. Della Pietra,[70a,70b] D. Della Volpe,[54] A. Dell'Acqua,[36]
L. Dell'Asta,[74a,74b] M. Delmastro,[5] C. Delporte,[65] P. A. Delsart,[58] S. Demers,[182] M. Demichev,[80] G. Demontigny,[110]
S. P. Denisov,[123] L. D'Eramo,[121] D. Derendarz,[85] J. E. Derkaoui,[35d] F. Derue,[135] P. Dervan,[91] K. Desch,[24] K. Dette,[166]
C. Deutsch,[24] M. R. Devesa,[30] P. O. Deviveiros,[36] F. A. Di Bello,[73a,73b] A. Di Ciaccio,[74a,74b] L. Di Ciaccio,[5]
W. K. Di Clemente,[136] C. Di Donato,[70a,70b] A. Di Girolamo,[36] G. Di Gregorio,[72a,72b] A. Di Luca,[76a,76b] B. Di Micco,[75a,75b]
R. Di Nardo,[75a,75b] K. F. Di Petrillo,[59] R. Di Sipio,[166] C. Diaconu,[102] F. A. Dias,[120] T. Dias Do Vale,[139a] M. A. Diaz,[146a]
F. G. Diaz Capriles,[24] J. Dickinson,[18] M. Didenko,[165] E. B. Diehl,[106] J. Dietrich,[19] S. Díez Cornell,[46] C. Diez Pardos,[150]
A. Dimitrievska,[18] W. Ding,[15b] J. Dingfelder,[24] S. J. Dittmeier,[61b] F. Dittus,[36] F. Djama,[102] T. Djobava,[158b] J. I. Djuvsland,[17]
M. A. B. Do Vale,[81c] M. Dobre,[27b] D. Dodsworth,[26] C. Doglioni,[97] J. Dolejsi,[142] Z. Dolezal,[142] M. Donadelli,[81d] B. Dong,[60c]
J. Donini,[38] A. D'onofrio,[15c] M. D'Onofrio,[91] J. Dopke,[143] A. Doria,[70a] M. T. Dova,[89] A. T. Doyle,[57] E. Drechsler,[151]
E. Dreyer,[151] T. Dreyer,[53] A. S. Drobac,[169] D. Du,[60b] T. A. du Pree,[120] Y. Duan,[60d] F. Dubinin,[111] M. Dubovsky,[28a]
A. Dubreuil,[54] E. Duchovni,[179] G. Duckeck,[114] O. A. Ducu,[36] D. Duda,[115] A. Dudarev,[36] A. C. Dudder,[100] E. M. Duffield,[18]
M. D'uffizi,[101] L. Duflot,[65] M. Dührssen,[36] C. Dülsen,[181] M. Dumancic,[179] A. E. Dumitriu,[27b] M. Dunford,[61a] S. Dungs,[47]
A. Duperrin,[102] H. Duran Yildiz,[4a] M. Düren,[56] A. Durglishvili,[158b] D. Duschinger,[48] B. Dutta,[46] D. Duvnjak,[1]
G. I. Dyckes,[136] M. Dyndal,[36] S. Dysch,[101] B. S. Dziedzic,[85] M. G. Eggleston,[49] T. Eifert,[8] G. Eigen,[17] K. Einsweiler,[18]
T. Ekelof,[171] H. El Jarrari,[35e] V. Ellajosyula,[171] M. Ellert,[171] F. Ellinghaus,[181] A. A. Elliot,[93] N. Ellis,[36] J. Elmsheuser,[29]

M. Elsing,[36] D. Emeliyanov,[143] A. Emerman,[39] Y. Enari,[162] M. B. Epland,[49] J. Erdmann,[47] A. Ereditato,[20] P. A. Erland,[85] M. Errenst,[181] M. Escalier,[65] C. Escobar,[173] O. Estrada Pastor,[173] E. Etzion,[160] G. E. Evans,[139a] H. Evans,[66] M. O. Evans,[155] A. Ezhilov,[137] F. Fabbri,[57] L. Fabbri,[23b,23a] V. Fabiani,[119] G. Facini,[177] R. M. Fakhrutdinov,[123] S. Falciano,[73a] P. J. Falke,[24] S. Falke,[36] J. Faltova,[142] Y. Fang,[15a] Y. Fang,[15a] G. Fanourakis,[44] M. Fanti,[69a,69b] M. Faraj,[67a,67c] A. Farbin,[8] A. Farilla,[75a] E. M. Farina,[71a,71b] T. Farooque,[107] S. M. Farrington,[50] P. Farthouat,[36] F. Fassi,[35e] P. Fassnacht,[36] D. Fassouliotis,[9] M. Faucci Giannelli,[50] W. J. Fawcett,[32] L. Fayard,[65] O. L. Fedin,[137,o] W. Fedorko,[174] A. Fehr,[20] M. Feickert,[172] L. Feligioni,[102] A. Fell,[148] C. Feng,[60b] M. Feng,[49] M. J. Fenton,[170] A. B. Fenyuk,[123] S. W. Ferguson,[43] J. Ferrando,[46] A. Ferrari,[171] P. Ferrari,[120] R. Ferrari,[71a] D. E. Ferreira de Lima,[61b] A. Ferrer,[173] D. Ferrere,[54] C. Ferretti,[106] F. Fiedler,[100] A. Filipčič,[92] F. Filthaut,[119] K. D. Finelli,[25] M. C. N. Fiolhais,[139a,139c,a] L. Fiorini,[173] F. Fischer,[114] J. Fischer,[100] W. C. Fisher,[107] T. Fitschen,[21] I. Fleck,[150] P. Fleischmann,[106] T. Flick,[181] B. M. Flierl,[114] L. Flores,[136] L. R. Flores Castillo,[63a] F. M. Follega,[76a,76b] N. Fomin,[17] J. H. Foo,[166] G. T. Forcolin,[76a,76b] B. C. Forland,[66] A. Formica,[144] F. A. Förster,[14] A. C. Forti,[101] E. Fortin,[102] M. G. Foti,[134] D. Fournier,[65] H. Fox,[90] P. Francavilla,[72a,72b] S. Francescato,[73a,73b] M. Franchini,[23b,23a] S. Franchino,[61a] D. Francis,[36] L. Franco,[5] L. Franconi,[20] M. Franklin,[59] G. Frattari,[73a,73b] A. N. Fray,[93] P. M. Freeman,[21] B. Freund,[110] W. S. Freund,[81b] E. M. Freundlich,[47] D. C. Frizzell,[128] D. Froidevaux,[36] J. A. Frost,[134] M. Fujimoto,[126] C. Fukunaga,[163] E. Fullana Torregrosa,[173] T. Fusayasu,[116] J. Fuster,[173] A. Gabrielli,[23b,23a] A. Gabrielli,[36] S. Gadatsch,[54] P. Gadow,[115] G. Gagliardi,[55b,55a] L. G. Gagnon,[110] G. E. Gallardo,[134] E. J. Gallas,[134] B. J. Gallop,[143] R. Gamboa Goni,[93] K. K. Gan,[127] S. Ganguly,[179] J. Gao,[60a] Y. Gao,[50] Y. S. Gao,[31,l] F. M. Garay Walls,[146a] C. García,[173] J. E. García Navarro,[173] J. A. García Pascual,[15a] C. Garcia-Argos,[52] M. Garcia-Sciveres,[18] R. W. Gardner,[37] N. Garelli,[152] S. Gargiulo,[52] C. A. Garner,[166] V. Garonne,[133] S. J. Gasiorowski,[147] P. Gaspar,[81b] A. Gaudiello,[55b,55a] G. Gaudio,[71a] P. Gauzzi,[73a,73b] I. L. Gavrilenko,[111] A. Gavrilyuk,[124] C. Gay,[174] G. Gaycken,[46] E. N. Gazis,[10] A. A. Geanta,[27b] C. M. Gee,[145] C. N. P. Gee,[143] J. Geisen,[97] M. Geisen,[100] C. Gemme,[55b] M. H. Genest,[58] C. Geng,[106] S. Gentile,[73a,73b] S. George,[94] T. Geralis,[44] L. O. Gerlach,[53] P. Gessinger-Befurt,[100] G. Gessner,[47] M. Ghasemi Bostanabad,[175] M. Ghneimat,[150] A. Ghosh,[65] A. Ghosh,[78] B. Giacobbe,[23b] S. Giagu,[73a,73b] N. Giangiacomi,[166] P. Giannetti,[72a] A. Giannini,[70a,70b] G. Giannini,[14] S. M. Gibson,[94] M. Gignac,[145] D. T. Gil,[84b] B. J. Gilbert,[39] D. Gillberg,[34] G. Gilles,[181] N. E. K. Gillwald,[46] D. M. Gingrich,[3,ai] M. P. Giordani,[67a,67c] P. F. Giraud,[144] G. Giugliarelli,[67a,67c] D. Giugni,[69a] F. Giuli,[74a,74b] S. Gkaitatzis,[161] I. Gkialas,[9,g] E. L. Gkougkousis,[14] P. Gkountoumis,[10] L. K. Gladilin,[113] C. Glasman,[99] J. Glatzer,[14] P. C. F. Glaysher,[46] A. Glazov,[46] G. R. Gledhill,[131] I. Gnesi,[41b,b] M. Goblirsch-Kolb,[26] D. Godin,[110] S. Goldfarb,[105] T. Golling,[54] D. Golubkov,[123] A. Gomes,[139a,139b] R. Goncalves Gama,[53] R. Gonçalo,[139a,139c] G. Gonella,[131] L. Gonella,[21] A. Gongadze,[80] F. Gonnella,[21] J. L. Gonski,[39] S. González de la Hoz,[173] S. Gonzalez Fernandez,[14] R. Gonzalez Lopez,[91] C. Gonzalez Renteria,[18] R. Gonzalez Suarez,[171] S. Gonzalez-Sevilla,[54] G. R. Gonzalvo Rodriguez,[173] L. Goossens,[36] N. A. Gorasia,[21] P. A. Gorbounov,[124] H. A. Gordon,[29] B. Gorini,[36] E. Gorini,[68a,68b] A. Gorišek,[92] A. T. Goshaw,[49] M. I. Gostkin,[80] C. A. Gottardo,[119] M. Gouighri,[35b] A. G. Goussiou,[147] N. Govender,[33c] C. Goy,[5] I. Grabowska-Bold,[84a] E. C. Graham,[91] J. Gramling,[170] E. Gramstad,[133] S. Grancagnolo,[19] M. Grandi,[155] V. Gratchev,[137] P. M. Gravila,[27f] F. G. Gravili,[68a,68b] C. Gray,[57] H. M. Gray,[18] C. Grefe,[24] K. Gregersen,[97] I. M. Gregor,[46] P. Grenier,[152] K. Grevtsov,[46] C. Grieco,[14] N. A. Grieser,[128] A. A. Grillo,[145] K. Grimm,[31,k] S. Grinstein,[14,v] J.-F. Grivaz,[65] S. Groh,[100] E. Gross,[179] J. Grosse-Knetter,[53] Z. J. Grout,[95] C. Grud,[106] A. Grummer,[118] J. C. Grundy,[134] L. Guan,[106] W. Guan,[180] C. Gubbels,[174] J. Guenther,[77] A. Guerguichon,[65] J. G. R. Guerrero Rojas,[173] F. Guescini,[115] D. Guest,[77] R. Gugel,[100] A. Guida,[46] T. Guillemin,[5] S. Guindon,[36] J. Guo,[60c] W. Guo,[106] Y. Guo,[60a] Z. Guo,[102] R. Gupta,[46] S. Gurbuz,[12c] G. Gustavino,[128] M. Guth,[52] P. Gutierrez,[128] C. Gutschow,[95] C. Guyot,[144] C. Gwenlan,[134] C. B. Gwilliam,[91] E. S. Haaland,[133] A. Haas,[125] C. Haber,[18] H. K. Hadavand,[8] A. Hadef,[100] M. Haleem,[176] J. Haley,[129] J. J. Hall,[148] G. Halladjian,[107] G. D. Hallewell,[102] K. Hamano,[175] H. Hamdaoui,[35e] M. Hamer,[24] G. N. Hamity,[50] K. Han,[60a] L. Han,[15c] L. Han,[60a] S. Han,[18] Y. F. Han,[166] K. Hanagaki,[82,t] M. Hance,[145] D. M. Handl,[114] M. D. Hank,[37] R. Hankache,[135] E. Hansen,[97] J. B. Hansen,[40] J. D. Hansen,[40] M. C. Hansen,[24] P. H. Hansen,[40] E. C. Hanson,[101] K. Hara,[168] T. Harenberg,[181] S. Harkusha,[108] P. F. Harrison,[177] N. M. Hartman,[152] N. M. Hartmann,[114] Y. Hasegawa,[149] A. Hasib,[50] S. Hassani,[144] S. Haug,[20] R. Hauser,[107] M. Havranek,[141] C. M. Hawkes,[21] R. J. Hawkings,[36] S. Hayashida,[117] D. Hayden,[107] C. Hayes,[106] R. L. Hayes,[174] C. P. Hays,[134] J. M. Hays,[93] H. S. Hayward,[91] S. J. Haywood,[143] F. He,[60a] Y. He,[164] M. P. Heath,[50] V. Hedberg,[97] A. L. Heggelund,[133] N. D. Hehir,[93] C. Heidegger,[52] K. K. Heidegger,[52] W. D. Heidorn,[79] J. Heilman,[34] S. Heim,[46] T. Heim,[18] B. Heinemann,[46,ag] J. G. Heinlein,[136] J. J. Heinrich,[131] L. Heinrich,[36] J. Hejbal,[140] L. Helary,[46] A. Held,[125] S. Hellesund,[133] C. M. Helling,[145] S. Hellman,[45a,45b] C. Helsens,[36] R. C. W. Henderson,[90] L. Henkelmann,[32] A. M. Henriques Correia,[36] H. Herde,[26]

Y. Hernández Jiménez,[33e] H. Herr,[100] M. G. Herrmann,[114] T. Herrmann,[48] G. Herten,[52] R. Hertenberger,[114] L. Hervas,[36]
G. G. Hesketh,[95] N. P. Hessey,[167a] H. Hibi,[83] S. Higashino,[82] E. Higón-Rodriguez,[173] K. Hildebrand,[37] J. C. Hill,[32]
K. K. Hill,[29] K. H. Hiller,[46] S. J. Hillier,[21] M. Hils,[48] I. Hinchliffe,[18] F. Hinterkeuser,[24] M. Hirose,[132] S. Hirose,[168]
D. Hirschbuehl,[181] B. Hiti,[92] O. Hladik,[140] J. Hobbs,[154] R. Hobincu,[27e] N. Hod,[179] M. C. Hodgkinson,[148] A. Hoecker,[36]
D. Hohn,[52] D. Hohov,[65] T. Holm,[24] T. R. Holmes,[37] M. Holzbock,[115] L. B. A. H. Hommels,[32] T. M. Hong,[138] J. C. Honig,[52]
A. Hönle,[115] B. H. Hooberman,[172] W. H. Hopkins,[6] Y. Horii,[117] P. Horn,[48] L. A. Horyn,[37] S. Hou,[157] A. Hoummada,[35a]
J. Howarth,[57] J. Hoya,[89] M. Hrabovsky,[130] J. Hrivnac,[65] A. Hrynevich,[109] T. Hryn'ova,[5] P. J. Hsu,[64] S.-C. Hsu,[147] Q. Hu,[39]
S. Hu,[60c] Y. F. Hu,[15a,15d,ak] D. P. Huang,[95] X. Huang,[15c] Y. Huang,[60a] Y. Huang,[15a] Z. Hubacek,[141] F. Hubaut,[102]
M. Huebner,[24] F. Huegging,[24] T. B. Huffman,[134] M. Huhtinen,[36] R. Hulsken,[58] R. F. H. Hunter,[34] N. Huseynov,[80,aa]
J. Huston,[107] J. Huth,[59] R. Hyneman,[152] S. Hyrych,[28a] G. Iacobucci,[54] G. Iakovidis,[29] I. Ibragimov,[150]
L. Iconomidou-Fayard,[65] P. Iengo,[36] R. Ignazzi,[40] R. Iguchi,[162] T. Iizawa,[54] Y. Ikegami,[82] M. Ikeno,[82] N. Ilic,[119,166,z]
F. Iltzsche,[48] H. Imam,[35a] G. Introzzi,[71a,71b] M. Iodice,[75a] K. Iordanidou,[167a] V. Ippolito,[73a,73b] M. F. Isacson,[171] M. Ishino,[162]
W. Islam,[129] C. Issever,[19,46] S. Istin,[159] J. M. Iturbe Ponce,[63a] R. Iuppa,[76a,76b] A. Ivina,[179] J. M. Izen,[43] V. Izzo,[70a] P. Jacka,[140]
P. Jackson,[1] R. M. Jacobs,[46] B. P. Jaeger,[151] V. Jain,[2] G. Jäkel,[181] K. B. Jakobi,[100] K. Jakobs,[52] T. Jakoubek,[179] J. Jamieson,[57]
K. W. Janas,[84a] R. Jansky,[54] M. Janus,[53] P. A. Janus,[84a] G. Jarlskog,[97] A. E. Jaspan,[91] N. Javadov,[80,aa] T. Javůrek,[36]
M. Javurkova,[103] F. Jeanneau,[144] L. Jeanty,[131] J. Jejelava,[158a] P. Jenni,[52,c] N. Jeong,[46] S. Jézéquel,[5] J. Jia,[154] Z. Jia,[15c]
H. Jiang,[79] Y. Jiang,[60a] Z. Jiang,[152] S. Jiggins,[52] F. A. Jimenez Morales,[38] J. Jimenez Pena,[115] S. Jin,[15c] A. Jinaru,[27b]
O. Jinnouchi,[164] H. Jivan,[33e] P. Johansson,[148] K. A. Johns,[7] C. A. Johnson,[66] E. Jones,[177] R. W. L. Jones,[90] S. D. Jones,[155]
T. J. Jones,[91] J. Jovicevic,[36] X. Ju,[18] J. J. Junggeburth,[115] A. Juste Rozas,[14,v] A. Kaczmarska,[85] M. Kado,[73a,73b] H. Kagan,[127]
M. Kagan,[152] A. Kahn,[39] C. Kahra,[100] T. Kaji,[178] E. Kajomovitz,[159] C. W. Kalderon,[29] A. Kaluza,[100] A. Kamenshchikov,[123]
M. Kaneda,[162] N. J. Kang,[145] S. Kang,[79] Y. Kano,[117] J. Kanzaki,[82] L. S. Kaplan,[180] D. Kar,[33e] K. Karava,[134] M. J. Kareem,[167b]
I. Karkanias,[161] S. N. Karpov,[80] Z. M. Karpova,[80] V. Kartvelishvili,[90] A. N. Karyukhin,[123] E. Kasimi,[161] A. Kastanas,[45a,45b]
C. Kato,[60d] J. Katzy,[46] K. Kawade,[149] K. Kawagoe,[88] T. Kawaguchi,[117] T. Kawamoto,[144] G. Kawamura,[53] E. F. Kay,[175]
F. I. Kaya,[169] S. Kazakos,[14] V. F. Kazanin,[122b,122a] J. M. Keaveney,[33a] R. Keeler,[175] J. S. Keller,[34] E. Kellermann,[97]
D. Kelsey,[155] J. J. Kempster,[21] J. Kendrick,[21] K. E. Kennedy,[39] O. Kepka,[140] S. Kersten,[181] B. P. Kerševan,[92]
S. Ketabchi Haghighat,[166] F. Khalil-Zada,[13] M. Khandoga,[144] A. Khanov,[129] A. G. Kharlamov,[122b,122a]
T. Kharlamova,[122b,122a] E. E. Khoda,[174] T. J. Khoo,[77] G. Khoriauli,[176] E. Khramov,[80] J. Khubua,[158b] S. Kido,[83] M. Kiehn,[36]
E. Kim,[164] Y. K. Kim,[37] N. Kimura,[95] A. Kirchhoff,[53] D. Kirchmeier,[48] J. Kirk,[143] A. E. Kiryunin,[115] T. Kishimoto,[162]
D. P. Kisliuk,[166] V. Kitali,[46] C. Kitsaki,[10] O. Kivernyk,[24] T. Klapdor-Kleingrothaus,[52] M. Klassen,[61a] C. Klein,[34]
M. H. Klein,[106] M. Klein,[91] U. Klein,[91] K. Kleinknecht,[100] P. Klimek,[36] A. Klimentov,[29] F. Klimpel,[36] T. Klingl,[24]
T. Klioutchnikova,[36] F. F. Klitzner,[114] P. Kluit,[120] S. Kluth,[115] E. Kneringer,[77] E. B. F. G. Knoops,[102] A. Knue,[52]
D. Kobayashi,[88] M. Kobel,[48] M. Kocian,[152] T. Kodama,[162] P. Kodys,[142] D. M. Koeck,[155] P. T. Koenig,[24] T. Koffas,[34]
N. M. Köhler,[36] M. Kolb,[144] I. Koletsou,[5] T. Komarek,[130] T. Kondo,[82] K. Köneke,[52] A. X. Y. Kong,[1] A. C. König,[119]
T. Kono,[126] V. Konstantinides,[95] N. Konstantinidis,[95] B. Konya,[97] R. Kopeliansky,[66] S. Koperny,[84a] K. Korcyl,[85]
K. Kordas,[161] G. Koren,[160] A. Korn,[95] I. Korolkov,[14] E. V. Korolkova,[148] N. Korotkova,[113] O. Kortner,[115] S. Kortner,[115]
V. V. Kostyukhin,[148,165] A. Kotsokechagia,[65] A. Kotwal,[49] A. Koulouris,[10] A. Kourkoumeli-Charalampidi,[71a,71b]
C. Kourkoumelis,[9] E. Kourlitis,[6] V. Kouskoura,[29] R. Kowalewski,[175] W. Kozanecki,[101] A. S. Kozhin,[123]
V. A. Kramarenko,[113] G. Kramberger,[92] D. Krasnopevtsev,[60a] M. W. Krasny,[135] A. Krasznahorkay,[36] D. Krauss,[115]
J. A. Kremer,[100] J. Kretzschmar,[91] K. Kreul,[19] P. Krieger,[166] F. Krieter,[114] S. Krishnamurthy,[103] A. Krishnan,[61b] M. Krivos,[142]
K. Krizka,[18] K. Kroeninger,[47] H. Kroha,[115] J. Kroll,[140] J. Kroll,[136] K. S. Krowpman,[107] U. Kruchonak,[80] H. Krüger,[24]
N. Krumnack,[79] M. C. Kruse,[49] J. A. Krzysiak,[85] A. Kubota,[164] O. Kuchinskaia,[165] S. Kuday,[4b] D. Kuechler,[46]
J. T. Kuechler,[46] S. Kuehn,[36] T. Kuhl,[46] V. Kukhtin,[80] Y. Kulchitsky,[108,ac] S. Kuleshov,[146b] Y. P. Kulinich,[172] M. Kuna,[58]
A. Kupco,[140] T. Kupfer,[47] O. Kuprash,[52] H. Kurashige,[83] L. L. Kurchaninov,[167a] Y. A. Kurochkin,[108] A. Kurova,[112]
M. G. Kurth,[15a,15d] E. S. Kuwertz,[36] M. Kuze,[164] A. K. Kvam,[147] J. Kvita,[130] T. Kwan,[104] C. Lacasta,[173] F. Lacava,[73a,73b]
D. P. J. Lack,[101] H. Lacker,[19] D. Lacour,[135] E. Ladygin,[80] R. Lafaye,[5] B. Laforge,[135] T. Lagouri,[146c] S. Lai,[53]
I. K. Lakomiec,[84a] J. E. Lambert,[128] S. Lammers,[66] W. Lampl,[7] C. Lampoudis,[161] E. Lançon,[29] U. Landgraf,[52]
M. P. J. Landon,[93] V. S. Lang,[52] J. C. Lange,[53] R. J. Langenberg,[103] A. J. Lankford,[170] F. Lanni,[29] K. Lantzsch,[24] A. Lanza,[71a]
A. Lapertosa,[55b,55a] J. F. Laporte,[144] T. Lari,[69a] F. Lasagni Manghi,[23b,23a] M. Lassnig,[36] V. Latonova,[140] T. S. Lau,[63a]
A. Laudrain,[100] A. Laurier,[34] M. Lavorgna,[70a,70b] S. D. Lawlor,[94] M. Lazzaroni,[69a,69b] B. Le,[101] E. Le Guirriec,[102]

A. Lebedev,[79] M. LeBlanc,[7] T. LeCompte,[6] F. Ledroit-Guillon,[58] A. C. A. Lee,[95] C. A. Lee,[29] G. R. Lee,[17] L. Lee,[59]
S. C. Lee,[157] S. Lee,[79] B. Lefebvre,[167a] H. P. Lefebvre,[94] M. Lefebvre,[175] C. Leggett,[18] K. Lehmann,[151] N. Lehmann,[20]
G. Lehmann Miotto,[36] W. A. Leight,[46] A. Leisos,[161,u] M. A. L. Leite,[81d] C. E. Leitgeb,[114] R. Leitner,[142] K. J. C. Leney,[42]
T. Lenz,[24] S. Leone,[72a] C. Leonidopoulos,[50] A. Leopold,[135] C. Leroy,[110] R. Les,[107] C. G. Lester,[32] M. Levchenko,[137]
J. Levêque,[5] D. Levin,[106] L. J. Levinson,[179] D. J. Lewis,[21] B. Li,[15b] B. Li,[106] C-Q. Li,[60c,60d] F. Li,[60c] H. Li,[60a] H. Li,[60b] J. Li,[60c]
K. Li,[147] L. Li,[60c] M. Li,[15a,15d] Q. Y. Li,[60a] S. Li,[60d,60c] X. Li,[46] Y. Li,[46] Z. Li,[60b] Z. Li,[134] Z. Li,[104] Z. Li,[91] Z. Liang,[15a]
M. Liberatore,[46] B. Liberti,[74a] K. Lie,[63c] S. Lim,[29] C. Y. Lin,[32] K. Lin,[107] R. A. Linck,[66] R. E. Lindley,[7] J. H. Lindon,[21]
A. Linss,[46] A. L. Lionti,[54] E. Lipeles,[136] A. Lipniacka,[17] T. M. Liss,[172,ah] A. Lister,[174] J. D. Little,[8] B. Liu,[79] B. L. Liu,[151]
H. B. Liu,[29] J. B. Liu,[60a] J. K. K. Liu,[37] K. Liu,[60d] M. Liu,[60a] M. Y. Liu,[60a] P. Liu,[15a] X. Liu,[60a] Y. Liu,[46] Y. Liu,[15a,15d]
Y. L. Liu,[106] Y. W. Liu,[60a] M. Livan,[71a,71b] A. Lleres,[58] J. Llorente Merino,[151] S. L. Lloyd,[93] C. Y. Lo,[63b]
E. M. Lobodzinska,[46] P. Loch,[7] S. Loffredo,[74a,74b] T. Lohse,[19] K. Lohwasser,[148] M. Lokajicek,[140] J. D. Long,[172] R. E. Long,[90]
I. Longarini,[73a,73b] L. Longo,[36] I. Lopez Paz,[101] A. Lopez Solis,[148] J. Lorenz,[114] N. Lorenzo Martinez,[5] A. M. Lory,[114]
A. Lösle,[52] X. Lou,[45a,45b] X. Lou,[15a] A. Lounis,[65] J. Love,[6] P. A. Love,[90] J. J. Lozano Bahilo,[173] M. Lu,[60a] Y. J. Lu,[64]
H. J. Lubatti,[147] C. Luci,[73a,73b] F. L. Lucio Alves,[15c] A. Lucotte,[58] F. Luehring,[66] I. Luise,[154] L. Luminari,[73a]
B. Lund-Jensen,[153] N. A. Luongo,[131] M. S. Lutz,[160] D. Lynn,[29] H. Lyons,[91] R. Lysak,[140] E. Lytken,[97] F. Lyu,[15a]
V. Lyubushkin,[80] T. Lyubushkina,[80] H. Ma,[29] L. L. Ma,[60b] Y. Ma,[95] D. M. Mac Donell,[175] G. Maccarrone,[51]
C. M. Macdonald,[148] J. C. MacDonald,[148] J. Machado Miguens,[136] R. Madar,[38] W. F. Mader,[48]
M. Madugoda Ralalage Don,[129] N. Madysa,[48] J. Maeda,[83] T. Maeno,[29] M. Maerker,[48] V. Magerl,[52] N. Magini,[79]
J. Magro,[67a,67c,q] D. J. Mahon,[39] C. Maidantchik,[81b] A. Maio,[139a,139b,139d] K. Maj,[84a] O. Majersky,[28a] S. Majewski,[131]
Y. Makida,[82] N. Makovec,[65] B. Malaescu,[135] Pa. Malecki,[85] V. P. Maleev,[137] F. Malek,[58] D. Malito,[41b,41a] U. Mallik,[78]
C. Malone,[32] S. Maltezos,[10] S. Malyukov,[80] J. Mamuzic,[173] G. Mancini,[51] J. P. Mandalia,[93] I. Mandić,[92]
L. Manhaes de Andrade Filho,[81a] I. M. Maniatis,[161] J. Manjarres Ramos,[48] K. H. Mankinen,[97] A. Mann,[114] A. Manousos,[77]
B. Mansoulie,[144] I. Manthos,[161] S. Manzoni,[120] A. Marantis,[161] G. Marceca,[30] L. Marchese,[134] G. Marchiori,[135]
M. Marcisovsky,[140] L. Marcoccia,[74a,74b] C. Marcon,[97] M. Marjanovic,[128] Z. Marshall,[18] M. U. F. Martensson,[171]
S. Marti-Garcia,[173] C. B. Martin,[127] T. A. Martin,[177] V. J. Martin,[50] B. Martin dit Latour,[17] L. Martinelli,[75a,75b]
M. Martinez,[14,v] P. Martinez Agullo,[173] V. I. Martinez Outschoorn,[103] S. Martin-Haugh,[143] V. S. Martoiu,[27b]
A. C. Martyniuk,[95] A. Marzin,[36] S. R. Maschek,[115] L. Masetti,[100] T. Mashimo,[162] R. Mashinistov,[111] J. Masik,[101]
A. L. Maslennikov,[122b,122a] L. Massa,[23b,23a] P. Massarotti,[70a,70b] P. Mastrandrea,[72a,72b] A. Mastroberardino,[41b,41a]
T. Masubuchi,[162] D. Matakias,[29] A. Matic,[114] N. Matsuzawa,[162] P. Mättig,[24] J. Maurer,[27b] B. Maček,[92]
D. A. Maximov,[122b,122a] R. Mazini,[157] I. Maznas,[161] S. M. Mazza,[145] J. P. Mc Gowan,[104] S. P. Mc Kee,[106] T. G. McCarthy,[115]
W. P. McCormack,[18] E. F. McDonald,[105] A. E. McDougall,[120] J. A. Mcfayden,[18] G. Mchedlidze,[158b] M. A. McKay,[42]
K. D. McLean,[175] S. J. McMahon,[143] P. C. McNamara,[105] C. J. McNicol,[177] R. A. McPherson,[175,z] J. E. Mdhluli,[33e]
Z. A. Meadows,[103] S. Meehan,[36] T. Megy,[38] S. Mehlhase,[114] A. Mehta,[91] B. Meirose,[43] D. Melini,[159]
B. R. Mellado Garcia,[33e] J. D. Mellenthin,[53] M. Melo,[28a] F. Meloni,[46] A. Melzer,[24] E. D. Mendes Gouveia,[139a,139e]
A. M. Mendes Jacques Da Costa,[21] H. Y. Meng,[166] L. Meng,[36] X. T. Meng,[106] S. Menke,[115] E. Meoni,[41b,41a]
S. Mergelmeyer,[19] S. A. M. Merkt,[138] C. Merlassino,[134] P. Mermod,[54] L. Merola,[70a,70b] C. Meroni,[69a] G. Merz,[106]
O. Meshkov,[113,111] J. K. R. Meshreki,[150] J. Metcalfe,[6] A. S. Mete,[6] C. Meyer,[66] J-P. Meyer,[144] M. Michetti,[19]
R. P. Middleton,[143] L. Mijović,[50] G. Mikenberg,[179] M. Mikestikova,[140] M. Mikuž,[92] H. Mildner,[148] A. Milic,[166]
C. D. Milke,[42] D. W. Miller,[37] L. S. Miller,[34] A. Milov,[179] D. A. Milstead,[45a,45b] A. A. Minaenko,[123] I. A. Minashvili,[158b]
L. Mince,[57] A. I. Mincer,[125] B. Mindur,[84a] M. Mineev,[80] Y. Minegishi,[162] Y. Mino,[86] L. M. Mir,[14] M. Mironova,[134]
T. Mitani,[178] J. Mitrevski,[114] V. A. Mitsou,[173] M. Mittal,[60c] O. Miu,[166] A. Miucci,[20] P. S. Miyagawa,[93] A. Mizukami,[82]
J. U. Mjörnmark,[97] T. Mkrtchyan,[61a] M. Mlynarikova,[121] T. Moa,[45a,45b] S. Mobius,[53] K. Mochizuki,[110] P. Moder,[46]
P. Mogg,[114] S. Mohapatra,[39] R. Moles-Valls,[24] K. Mönig,[46] E. Monnier,[102] A. Montalbano,[151] J. Montejo Berlingen,[36]
M. Montella,[95] F. Monticelli,[89] S. Monzani,[69a] N. Morange,[65] A. L. Moreira De Carvalho,[139a] D. Moreno,[22a]
M. Moreno Llácer,[173] C. Moreno Martinez,[14] P. Morettini,[55b] M. Morgenstern,[159] S. Morgenstern,[48] D. Mori,[151] M. Morii,[59]
M. Morinaga,[178] V. Morisbak,[133] A. K. Morley,[36] G. Mornacchi,[36] A. P. Morris,[95] L. Morvaj,[36] P. Moschovakos,[36]
B. Moser,[120] M. Mosidze,[158b] T. Moskalets,[144] P. Moskvitina,[119] J. Moss,[31,m] E. J. W. Moyse,[103] S. Muanza,[102] J. Mueller,[138]
R. S. P. Mueller,[114] D. Muenstermann,[90] G. A. Mullier,[97] D. P. Mungo,[69a,69b] J. L. Munoz Martinez,[14]
F. J. Munoz Sanchez,[101] P. Murin,[28b] W. J. Murray,[177,143] A. Murrone,[69a,69b] J. M. Muse,[128] M. Muškinja,[18] C. Mwewa,[33a]

A. G. Myagkov,[123,ad] A. A. Myers,[138] G. Myers,[66] J. Myers,[131] M. Myska,[141] B. P. Nachman,[18] O. Nackenhorst,[47] A. Nag Nag,[48] K. Nagai,[134] K. Nagano,[82] Y. Nagasaka,[62] J. L. Nagle,[29] E. Nagy,[102] A. M. Nairz,[36] Y. Nakahama,[117] K. Nakamura,[82] T. Nakamura,[162] H. Nanjo,[132] F. Napolitano,[61a] R. F. Naranjo Garcia,[46] R. Narayan,[42] I. Naryshkin,[137] M. Naseri,[34] T. Naumann,[46] G. Navarro,[22a] P. Y. Nechaeva,[111] F. Nechansky,[46] T. J. Neep,[21] A. Negri,[71a,71b] M. Negrini,[23b] C. Nellist,[119] C. Nelson,[104] M. E. Nelson,[45a,45b] S. Nemecek,[140] M. Nessi,[36,e] M. S. Neubauer,[172] F. Neuhaus,[100] M. Neumann,[181] R. Newhouse,[174] P. R. Newman,[21] C. W. Ng,[138] Y. S. Ng,[19] Y. W. Y. Ng,[170] B. Ngair,[35e] H. D. N. Nguyen,[102] T. Nguyen Manh,[110] E. Nibigira,[38] R. B. Nickerson,[134] R. Nicolaidou,[144] D. S. Nielsen,[40] J. Nielsen,[145] M. Niemeyer,[53] N. Nikiforou,[11] V. Nikolaenko,[123,ad] I. Nikolic-Audit,[135] K. Nikolopoulos,[21] P. Nilsson,[29] H. R. Nindhito,[54] A. Nisati,[73a] N. Nishu,[60c] R. Nisius,[115] I. Nitsche,[47] T. Nitta,[178] T. Nobe,[162] D. L. Noel,[32] Y. Noguchi,[86] I. Nomidis,[135] M. A. Nomura,[29] M. Nordberg,[36] J. Novak,[92] T. Novak,[92] O. Novgorodova,[48] R. Novotny,[118] L. Nozka,[130] K. Ntekas,[170] E. Nurse,[95] F. G. Oakham,[34,ai] J. Ocariz,[135] A. Ochi,[83] I. Ochoa,[139a] J. P. Ochoa-Ricoux,[146a] K. O'Connor,[26] S. Oda,[88] S. Odaka,[82] S. Oerdek,[53] A. Ogrodnik,[84a] A. Oh,[101] C. C. Ohm,[153] H. Oide,[164] R. Oishi,[162] M. L. Ojeda,[166] H. Okawa,[168] Y. Okazaki,[86] M. W. O'Keefe,[91] Y. Okumura,[162] A. Olariu,[27b] L. F. Oleiro Seabra,[139a] S. A. Olivares Pino,[146a] D. Oliveira Damazio,[29] J. L. Oliver,[1] M. J. R. Olsson,[170] A. Olszewski,[85] J. Olszowska,[85] Ö. O. Öncel,[24] D. C. O'Neil,[151] A. P. O'neill,[134] A. Onofre,[139a,139e] P. U. E. Onyisi,[11] H. Oppen,[133] R. G. Oreamuno Madriz,[121] M. J. Oreglia,[37] G. E. Orellana,[89] D. Orestano,[75a,75b] N. Orlando,[14] R. S. Orr,[166] V. O'Shea,[57] R. Ospanov,[60a] G. Otero y Garzon,[30] H. Otono,[88] P. S. Ott,[61a] G. J. Ottino,[18] M. Ouchrif,[35d] J. Ouellette,[29] F. Ould-Saada,[133] A. Ouraou,[144,†] Q. Ouyang,[15a] M. Owen,[57] R. E. Owen,[143] V. E. Ozcan,[12c] N. Ozturk,[8] J. Pacalt,[130] H. A. Pacey,[32] K. Pachal,[49] A. Pacheco Pages,[14] C. Padilla Aranda,[14] S. Pagan Griso,[18] G. Palacino,[66] S. Palazzo,[50] S. Palestini,[36] M. Palka,[84b] P. Palni,[84a] C. E. Pandini,[54] J. G. Panduro Vazquez,[94] P. Pani,[46] G. Panizzo,[67a,67c] L. Paolozzi,[54] C. Papadatos,[110] K. Papageorgiou,[9,g] S. Parajuli,[42] A. Paramonov,[6] C. Paraskevopoulos,[10] D. Paredes Hernandez,[63b] S. R. Paredes Saenz,[134] B. Parida,[179] T. H. Park,[166] A. J. Parker,[31] M. A. Parker,[32] F. Parodi,[55b,55a] E. W. Parrish,[121] J. A. Parsons,[39] U. Parzefall,[52] L. Pascual Dominguez,[135] V. R. Pascuzzi,[18] J. M. P. Pasner,[145] F. Pasquali,[120] E. Pasqualucci,[73a] S. Passaggio,[55b] F. Pastore,[94] P. Pasuwan,[45a,45b] S. Pataraia,[100] J. R. Pater,[101] A. Pathak,[180,i] J. Patton,[91] T. Pauly,[36] J. Pearkes,[152] M. Pedersen,[133] L. Pedraza Diaz,[119] R. Pedro,[139a] T. Peiffer,[53] S. V. Peleganchuk,[122b,122a] O. Penc,[140] C. Peng,[63b] H. Peng,[60a] B. S. Peralva,[81a] M. M. Perego,[65] A. P. Pereira Peixoto,[139a] L. Pereira Sanchez,[45a,45b] D. V. Perepelitsa,[29] E. Perez Codina,[167a] L. Perini,[69a,69b] H. Pernegger,[36] S. Perrella,[36] A. Perrevoort,[120] K. Peters,[46] R. F. Y. Peters,[101] B. A. Petersen,[36] T. C. Petersen,[40] E. Petit,[102] V. Petousis,[141] C. Petridou,[161] F. Petrucci,[75a,75b] M. Pettee,[182] N. E. Pettersson,[103] K. Petukhova,[142] A. Peyaud,[144] R. Pezoa,[146d] L. Pezzotti,[71a,71b] T. Pham,[105] P. W. Phillips,[143] M. W. Phipps,[172] G. Piacquadio,[154] E. Pianori,[18] A. Picazio,[103] R. H. Pickles,[101] R. Piegaia,[30] D. Pietreanu,[27b] J. E. Pilcher,[37] A. D. Pilkington,[101] M. Pinamonti,[67a,67c] J. L. Pinfold,[3] C. Pitman Donaldson,[95] M. Pitt,[160] L. Pizzimento,[74a,74b] A. Pizzini,[120] M.-A. Pleier,[29] V. Plesanovs,[52] V. Pleskot,[142] E. Plotnikova,[80] P. Podberezko,[122b,122a] R. Poettgen,[97] R. Poggi,[54] L. Poggioli,[135] I. Pogrebnyak,[107] D. Pohl,[24] I. Pokharel,[53] G. Polesello,[71a] A. Poley,[151,167a] A. Policicchio,[73a,73b] R. Polifka,[142] A. Polini,[23b] C. S. Pollard,[46] V. Polychronakos,[29] D. Ponomarenko,[112] L. Pontecorvo,[36] S. Popa,[27a] G. A. Popeneciu,[27d] L. Portales,[5] D. M. Portillo Quintero,[58] S. Pospisil,[141] K. Potamianos,[46] I. N. Potrap,[80] C. J. Potter,[32] H. Potti,[11] T. Poulsen,[97] J. Poveda,[173] T. D. Powell,[148] G. Pownall,[46] M. E. Pozo Astigarraga,[36] A. Prades Ibanez,[173] P. Pralavorio,[102] M. M. Prapa,[44] S. Prell,[79] D. Price,[101] M. Primavera,[68a] M. L. Proffitt,[147] N. Proklova,[112] K. Prokofiev,[63c] F. Prokoshin,[80] S. Protopopescu,[29] J. Proudfoot,[6] M. Przybycien,[84a] D. Pudzha,[137] A. Puri,[172] P. Puzo,[65] D. Pyatiizbyantseva,[112] J. Qian,[106] Y. Qin,[101] A. Quadt,[53] M. Queitsch-Maitland,[36] G. Rabanal Bolanos,[59] M. Racko,[28a] F. Ragusa,[69a,69b] G. Rahal,[98] J. A. Raine,[54] S. Rajagopalan,[29] A. Ramirez Morales,[93] K. Ran,[15a,15d] D. F. Rassloff,[61a] D. M. Rauch,[46] F. Rauscher,[114] S. Rave,[100] B. Ravina,[57] I. Ravinovich,[179] J. H. Rawling,[101] M. Raymond,[36] A. L. Read,[133] N. P. Readioff,[148] M. Reale,[68a,68b] D. M. Rebuzzi,[71a,71b] G. Redlinger,[29] K. Reeves,[43] D. Reikher,[160] A. Reiss,[100] A. Rej,[150] C. Rembser,[36] A. Renardi,[46] M. Renda,[27b] M. B. Rendel,[115] A. G. Rennie,[57] S. Resconi,[69a] E. D. Resseguie,[18] S. Rettie,[95] B. Reynolds,[127] E. Reynolds,[21] O. L. Rezanova,[122b,122a] P. Reznicek,[142] E. Ricci,[76a,76b] R. Richter,[115] S. Richter,[46] E. Richter-Was,[84b] M. Ridel,[135] P. Rieck,[115] O. Rifki,[46] M. Rijssenbeek,[154] A. Rimoldi,[71a,71b] M. Rimoldi,[46] L. Rinaldi,[23b] T. T. Rinn,[172] G. Ripellino,[153] I. Riu,[14] P. Rivadeneira,[46] J. C. Rivera Vergara,[175] F. Rizatdinova,[129] E. Rizvi,[93] C. Rizzi,[36] S. H. Robertson,[104,z] M. Robin,[46] D. Robinson,[32] C. M. Robles Gajardo,[146d] M. Robles Manzano,[100] A. Robson,[57] A. Rocchi,[74a,74b] C. Roda,[72a,72b] S. Rodriguez Bosca,[173] A. Rodriguez Rodriguez,[52] A. M. Rodríguez Vera,[167b] S. Roe,[36] J. Roggel,[181] O. Røhne,[133] R. Röhrig,[115] R. A. Rojas,[146d] B. Roland,[52] C. P. A. Roland,[66] J. Roloff,[29] A. Romaniouk,[112] M. Romano,[23b,23a] N. Rompotis,[91] M. Ronzani,[125] L. Roos,[135]

S. Rosati,[73a] G. Rosin,[103] B. J. Rosser,[136] E. Rossi,[46] E. Rossi,[75a,75b] E. Rossi,[70a,70b] L. P. Rossi,[55b] L. Rossini,[46] R. Rosten,[14] M. Rotaru,[27b] B. Rottler,[52] D. Rousseau,[65] G. Rovelli,[71a,71b] A. Roy,[11] D. Roy,[33e] A. Rozanov,[102] Y. Rozen,[159] X. Ruan,[33e] T. A. Ruggeri,[1] F. Rühr,[52] A. Ruiz-Martinez,[173] A. Rummler,[36] Z. Rurikova,[52] N. A. Rusakovich,[80] H. L. Russell,[104] L. Rustige,[38,47] J. P. Rutherfoord,[7] E. M. Rüttinger,[148] M. Rybar,[142] G. Rybkin,[65] E. B. Rye,[133] A. Ryzhov,[123] J. A. Sabater Iglesias,[46] P. Sabatini,[173] L. Sabetta,[73a,73b] S. Sacerdoti,[65] H. F-W. Sadrozinski,[145] R. Sadykov,[80] F. Safai Tehrani,[73a] B. Safarzadeh Samani,[155] M. Safdari,[152] P. Saha,[121] S. Saha,[104] M. Sahinsoy,[115] A. Sahu,[181] M. Saimpert,[36] M. Saito,[162] T. Saito,[162] H. Sakamoto,[162] D. Salamani,[54] G. Salamanna,[75a,75b] A. Salnikov,[152] J. Salt,[173] A. Salvador Salas,[14] D. Salvatore,[41b,41a] F. Salvatore,[155] A. Salvucci,[63a] A. Salzburger,[36] J. Samarati,[36] D. Sammel,[52] D. Sampsonidis,[161] D. Sampsonidou,[60d,60c] J. Sánchez,[173] A. Sanchez Pineda,[67a,36,67c] H. Sandaker,[133] C. O. Sander,[46] I. G. Sanderswood,[90] M. Sandhoff,[181] C. Sandoval,[22b] D. P. C. Sankey,[143] M. Sannino,[55b,55a] Y. Sano,[117] A. Sansoni,[51] C. Santoni,[38] H. Santos,[139a,139b] S. N. Santpur,[18] A. Santra,[173] K. A. Saoucha,[148] A. Sapronov,[80] J. G. Saraiva,[139a,139d] O. Sasaki,[82] K. Sato,[168] F. Sauerburger,[52] E. Sauvan,[5] P. Savard,[166,ai] R. Sawada,[162] C. Sawyer,[143] L. Sawyer,[96] I. Sayago Galvan,[173] C. Sbarra,[23b] A. Sbrizzi,[67a,67c] T. Scanlon,[95] J. Schaarschmidt,[147] P. Schacht,[115] D. Schaefer,[37] L. Schaefer,[136] U. Schäfer,[100] A. C. Schaffer,[65] D. Schaile,[114] R. D. Schamberger,[154] E. Schanet,[114] C. Scharf,[19] N. Scharmberg,[101] V. A. Schegelsky,[137] D. Scheirich,[142] F. Schenck,[19] M. Schernau,[170] C. Schiavi,[55b,55a] L. K. Schildgen,[24] Z. M. Schillaci,[26] E. J. Schioppa,[68a,68b] M. Schioppa,[41b,41a] K. E. Schleicher,[52] S. Schlenker,[36] K. R. Schmidt-Sommerfeld,[115] K. Schmieden,[100] C. Schmitt,[100] S. Schmitt,[46] L. Schoeffel,[144] A. Schoening,[61b] P. G. Scholer,[52] E. Schopf,[134] M. Schott,[100] J. F. P. Schouwenberg,[119] J. Schovancova,[36] S. Schramm,[54] F. Schroeder,[181] A. Schulte,[100] H-C. Schultz-Coulon,[61a] M. Schumacher,[52] B. A. Schumm,[145] Ph. Schune,[144] A. Schwartzman,[152] T. A. Schwarz,[106] Ph. Schwemling,[144] R. Schwienhorst,[107] A. Sciandra,[145] G. Sciolla,[26] F. Scuri,[72a] F. Scutti,[105] L. M. Scyboz,[115] C. D. Sebastiani,[91] K. Sedlaczek,[47] P. Seema,[19] S. C. Seidel,[118] A. Seiden,[145] B. D. Seidlitz,[29] T. Seiss,[37] C. Seitz,[46] J. M. Seixas,[81b] G. Sekhniaidze,[70a] S. J. Sekula,[42] N. Semprini-Cesari,[23b,23a] S. Sen,[49] C. Serfon,[29] L. Serin,[65] L. Serkin,[67a,67b] M. Sessa,[60a] H. Severini,[128] S. Sevova,[152] F. Sforza,[55b,55a] A. Sfyrla,[54] E. Shabalina,[53] J. D. Shahinian,[136] N. W. Shaikh,[45a,45b] D. Shaked Renous,[179] L. Y. Shan,[15a] M. Shapiro,[18] A. Sharma,[36] A. S. Sharma,[1] P. B. Shatalov,[124] K. Shaw,[155] S. M. Shaw,[101] M. Shehade,[179] Y. Shen,[128] A. D. Sherman,[25] P. Sherwood,[95] L. Shi,[95] C. O. Shimmin,[182] Y. Shimogama,[178] M. Shimojima,[116] J. D. Shinner,[94] I. P. J. Shipsey,[134] S. Shirabe,[164] M. Shiyakova,[80,x] J. Shlomi,[179] A. Shmeleva,[111] M. J. Shochet,[37] J. Shojaii,[105] D. R. Shope,[153] S. Shrestha,[127] E. M. Shrif,[33e] M. J. Shroff,[175] E. Shulga,[179] P. Sicho,[140] A. M. Sickles,[172] E. Sideras Haddad,[33e] O. Sidiropoulou,[36] A. Sidoti,[23b,23a] F. Siegert,[48] Dj. Sijacki,[16] M. Silva Jr.,[180] M. V. Silva Oliveira,[36] S. B. Silverstein,[45a] S. Simion,[65] R. Simoniello,[100] C. J. Simpson-allsop,[21] S. Simsek,[12b] P. Sinervo,[166] V. Sinetckii,[113] S. Singh,[151] S. Sinha,[33e] M. Sioli,[23b,23a] I. Siral,[131] S. Yu. Sivoklokov,[113] J. Sjölin,[45a,45b] A. Skaf,[53] E. Skorda,[97] P. Skubic,[128] M. Slawinska,[85] K. Sliwa,[169] V. Smakhtin,[179] B. H. Smart,[143] J. Smiesko,[28b] N. Smirnov,[112] S. Yu. Smirnov,[112] Y. Smirnov,[112] L. N. Smirnova,[113,r] O. Smirnova,[97] E. A. Smith,[37] H. A. Smith,[134] M. Smizanska,[90] K. Smolek,[141] A. Smykiewicz,[85] A. A. Snesarev,[111] H. L. Snoek,[120] I. M. Snyder,[131] S. Snyder,[29] R. Sobie,[175,z] A. Soffer,[160] A. Søgaard,[50] F. Sohns,[53] C. A. Solans Sanchez,[36] E. Yu. Soldatov,[112] U. Soldevila,[173] A. A. Solodkov,[123] A. Soloshenko,[80] O. V. Solovyanov,[123] V. Solovyev,[137] P. Sommer,[148] H. Son,[169] A. Sonay,[14] W. Song,[143] W. Y. Song,[167b] A. Sopczak,[141] A. L. Sopio,[95] F. Sopkova,[28b] S. Sottocornola,[71a,71b] R. Soualah,[67a,67c] A. M. Soukharev,[122b,122a] D. South,[46] S. Spagnolo,[68a,68b] M. Spalla,[115] M. Spangenberg,[177] F. Spanò,[94] D. Sperlich,[52] T. M. Spieker,[61a] G. Spigo,[36] M. Spina,[155] D. P. Spiteri,[57] M. Spousta,[142] A. Stabile,[69a,69b] B. L. Stamas,[121] R. Stamen,[61a] M. Stamenkovic,[120] A. Stampekis,[21] E. Stanecka,[85] B. Stanislaus,[134] M. M. Stanitzki,[46] M. Stankaityte,[134] B. Stapf,[120] E. A. Starchenko,[123] G. H. Stark,[145] J. Stark,[58] P. Staroba,[140] P. Starovoitov,[61a] S. Stärz,[104] R. Staszewski,[85] G. Stavropoulos,[44] M. Stegler,[46] P. Steinberg,[29] A. L. Steinhebel,[131] B. Stelzer,[151,167a] H. J. Stelzer,[138] O. Stelzer-Chilton,[167a] H. Stenzel,[56] T. J. Stevenson,[155] G. A. Stewart,[36] M. C. Stockton,[36] G. Stoicea,[27b] M. Stolarski,[139a] S. Stonjek,[115] A. Straessner,[48] J. Strandberg,[153] S. Strandberg,[45a,45b] M. Strauss,[128] T. Strebler,[102] P. Strizenec,[28b] R. Ströhmer,[176] D. M. Strom,[131] R. Stroynowski,[42] A. Strubig,[45a,45b] S. A. Stucci,[29] B. Stugu,[17] J. Stupak,[128] N. A. Styles,[46] D. Su,[152] W. Su,[60d,147,60c] X. Su,[60a] N. B. Suarez,[138] V. V. Sulin,[111] M. J. Sullivan,[91] D. M. S. Sultan,[54] S. Sultansoy,[4c] T. Sumida,[86] S. Sun,[106] X. Sun,[101] C. J. E. Suster,[156] M. R. Sutton,[155] S. Suzuki,[82] M. Svatos,[140] M. Swiatlowski,[167a] S. P. Swift,[2] T. Swirski,[176] A. Sydorenko,[100] I. Sykora,[28a] M. Sykora,[142] T. Sykora,[142] D. Ta,[100] K. Tackmann,[46,w] J. Taenzer,[160] A. Taffard,[170] R. Tafirout,[167a] E. Tagiev,[123] R. H. M. Taibah,[135] R. Takashima,[87] K. Takeda,[83] T. Takeshita,[149] E. P. Takeva,[50] Y. Takubo,[82] M. Talby,[102] A. A. Talyshev,[122b,122a] K. C. Tam,[63b] N. M. Tamir,[160] J. Tanaka,[162] R. Tanaka,[65] S. Tapia Araya,[172] S. Tapprogge,[100]

A. Tarek Abouelfadl Mohamed,[107] S. Tarem,[159] K. Tariq,[60b] G. Tarna,[27b,d] G. F. Tartarelli,[69a] P. Tas,[142] M. Tasevsky,[140]
E. Tassi,[41b,41a] G. Tateno,[162] A. Tavares Delgado,[139a] Y. Tayalati,[35e] A. J. Taylor,[50] G. N. Taylor,[105] W. Taylor,[167b] H. Teagle,[91]
A. S. Tee,[90] R. Teixeira De Lima,[152] P. Teixeira-Dias,[94] H. Ten Kate,[36] J. J. Teoh,[120] K. Terashi,[162] J. Terron,[99] S. Terzo,[14]
M. Testa,[51] R. J. Teuscher,[166,z] N. Themistokleous,[50] T. Theveneaux-Pelzer,[19] D. W. Thomas,[94] J. P. Thomas,[21]
E. A. Thompson,[46] P. D. Thompson,[21] E. Thomson,[136] E. J. Thorpe,[93] V. O. Tikhomirov,[111,ae] Yu. A. Tikhonov,[122b,122a]
S. Timoshenko,[112] P. Tipton,[182] S. Tisserant,[102] K. Todome,[23b,23a] S. Todorova-Nova,[142] S. Todt,[48] J. Tojo,[88] S. Tokár,[28a]
K. Tokushuku,[82] E. Tolley,[127] R. Tombs,[32] K. G. Tomiwa,[33e] M. Tomoto,[82,117] L. Tompkins,[152] P. Tornambe,[103]
E. Torrence,[131] H. Torres,[48] E. Torró Pastor,[173] M. Toscani,[30] C. Tosciri,[134] J. Toth,[102,y] D. R. Tovey,[148] A. Traeet,[17]
C. J. Treado,[125] T. Trefzger,[176] F. Tresoldi,[155] A. Tricoli,[29] I. M. Trigger,[167a] S. Trincaz-Duvoid,[135] D. A. Trischuk,[174]
W. Trischuk,[166] B. Trocmé,[58] A. Trofymov,[65] C. Troncon,[69a] F. Trovato,[155] L. Truong,[33c] M. Trzebinski,[85] A. Trzupek,[85]
F. Tsai,[46] P. V. Tsiareshka,[108,ac] A. Tsirigotis,[161,u] V. Tsiskaridze,[154] E. G. Tskhadadze,[158a] M. Tsopoulou,[161]
I. I. Tsukerman,[124] V. Tsulaia,[18] S. Tsuno,[82] D. Tsybychev,[154] Y. Tu,[63b] A. Tudorache,[27b] V. Tudorache,[27b] A. N. Tuna,[36]
S. Turchikhin,[80] D. Turgeman,[179] I. Turk Cakir,[4b,s] R. J. Turner,[21] R. Turra,[69a] P. M. Tuts,[39] S. Tzamarias,[161] E. Tzovara,[100]
K. Uchida,[162] F. Ukegawa,[168] G. Unal,[36] M. Unal,[11] A. Undrus,[29] G. Unel,[170] F. C. Ungaro,[105] Y. Unno,[82] K. Uno,[162]
J. Urban,[28b] P. Urquijo,[105] G. Usai,[8] Z. Uysal,[12d] V. Vacek,[141] B. Vachon,[104] K. O. H. Vadla,[133] T. Vafeiadis,[36] A. Vaidya,[95]
C. Valderanis,[114] E. Valdes Santurio,[45a,45b] M. Valente,[167a] S. Valentinetti,[23b,23a] A. Valero,[173] L. Valéry,[46] R. A. Vallance,[21]
A. Vallier,[36] J. A. Valls Ferrer,[173] T. R. Van Daalen,[14] P. Van Gemmeren,[6] S. Van Stroud,[95] I. Van Vulpen,[120]
M. Vanadia,[74a,74b] W. Vandelli,[36] M. Vandenbroucke,[144] E. R. Vandewall,[129] D. Vannicola,[73a,73b] R. Vari,[73a] E. W. Varnes,[7]
C. Varni,[55b,55a] T. Varol,[157] D. Varouchas,[65] K. E. Varvell,[156] M. E. Vasile,[27b] G. A. Vasquez,[175] F. Vazeille,[38]
D. Vazquez Furelos,[14] T. Vazquez Schroeder,[36] J. Veatch,[53] V. Vecchio,[101] M. J. Veen,[120] L. M. Veloce,[166] F. Veloso,[139a,139c]
S. Veneziano,[73a] A. Ventura,[68a,68b] A. Verbytskyi,[115] V. Vercesi,[71a] M. Verducci,[72a,72b] C. M. Vergel Infante,[79] C. Vergis,[24]
W. Verkerke,[120] A. T. Vermeulen,[120] J. C. Vermeulen,[120] C. Vernieri,[152] P. J. Verschuuren,[94] M. C. Vetterli,[151,ai]
N. Viaux Maira,[146d] T. Vickey,[148] O. E. Vickey Boeriu,[148] G. H. A. Viehhauser,[134] L. Vigani,[61b] M. Villa,[23b,23a]
M. Villaplana Perez,[173] E. M. Villhauer,[50] E. Vilucchi,[51] M. G. Vincter,[34] G. S. Virdee,[21] A. Vishwakarma,[50] C. Vittori,[23b,23a]
I. Vivarelli,[155] M. Vogel,[181] P. Vokac,[141] J. Von Ahnen,[46] S. E. von Buddenbrock,[33e] E. Von Toerne,[24] V. Vorobel,[142]
K. Vorobev,[112] M. Vos,[173] J. H. Vossebeld,[91] M. Vozak,[101] N. Vranjes,[16] M. Vranjes Milosavljevic,[16] V. Vrba,[141]
M. Vreeswijk,[120] N. K. Vu,[102] R. Vuillermet,[36] I. Vukotic,[37] S. Wada,[168] P. Wagner,[24] W. Wagner,[181] J. Wagner-Kuhr,[114]
S. Wahdan,[181] H. Wahlberg,[89] R. Wakasa,[168] V. M. Walbrecht,[115] J. Walder,[143] R. Walker,[114] S. D. Walker,[94]
W. Walkowiak,[150] V. Wallangen,[45a,45b] A. M. Wang,[59] A. Z. Wang,[180] C. Wang,[60a] C. Wang,[60c] H. Wang,[18] H. Wang,[3]
J. Wang,[63a] P. Wang,[42] Q. Wang,[128] R.-J. Wang,[100] R. Wang,[60a] R. Wang,[6] S. M. Wang,[157] W. T. Wang,[60a] W. Wang,[15c]
W. X. Wang,[60a] Y. Wang,[60a] Z. Wang,[106] C. Wanotayaroj,[46] A. Warburton,[104] C. P. Ward,[32] R. J. Ward,[21] N. Warrack,[57]
A. T. Watson,[21] M. F. Watson,[21] G. Watts,[147] B. M. Waugh,[95] A. F. Webb,[11] C. Weber,[29] M. S. Weber,[20] S. A. Weber,[34]
S. M. Weber,[61a] Y. Wei,[134] A. R. Weidberg,[134] J. Weingarten,[47] M. Weirich,[100] C. Weiser,[52] P. S. Wells,[36] T. Wenaus,[29]
B. Wendland,[47] T. Wengler,[36] S. Wenig,[36] N. Wermes,[24] M. Wessels,[61a] T. D. Weston,[20] K. Whalen,[131] A. M. Wharton,[90]
A. S. White,[106] A. White,[8] M. J. White,[1] D. Whiteson,[170] B. W. Whitmore,[90] W. Wiedenmann,[180] C. Wiel,[48] M. Wielers,[143]
N. Wieseotte,[100] C. Wiglesworth,[40] L. A. M. Wiik-Fuchs,[52] H. G. Wilkens,[36] L. J. Wilkins,[94] D. M. Williams,[39]
H. H. Williams,[136] S. Williams,[32] S. Willocq,[103] P. J. Windischhofer,[134] I. Wingerter-Seez,[5] E. Winkels,[155] F. Winklmeier,[131]
B. T. Winter,[52] M. Wittgen,[152] M. Wobisch,[96] A. Wolf,[100] R. Wölker,[134] J. Wollrath,[52] M. W. Wolter,[85] H. Wolters,[139a,139c]
V. W. S. Wong,[174] A. F. Wongel,[46] N. L. Woods,[145] S. D. Worm,[46] B. K. Wosiek,[85] K. W. Woźniak,[85] K. Wraight,[57]
S. L. Wu,[180] X. Wu,[54] Y. Wu,[60a] J. Wuerzinger,[134] T. R. Wyatt,[101] B. M. Wynne,[50] S. Xella,[40] L. Xia,[177] J. Xiang,[63c]
X. Xiao,[106] X. Xie,[60a] I. Xiotidis,[155] D. Xu,[15a] H. Xu,[60a] H. Xu,[60a] L. Xu,[29] R. Xu,[136] T. Xu,[144] W. Xu,[106] Y. Xu,[15b] Z. Xu,[60b]
Z. Xu,[152] B. Yabsley,[156] S. Yacoob,[33a] D. P. Yallup,[95] N. Yamaguchi,[88] Y. Yamaguchi,[164] A. Yamamoto,[82] M. Yamatani,[162]
T. Yamazaki,[162] Y. Yamazaki,[83] J. Yan,[60c] Z. Yan,[25] H. J. Yang,[60c,60d] H. T. Yang,[18] S. Yang,[60a] T. Yang,[63c] X. Yang,[60a]
X. Yang,[60b,58] Y. Yang,[162] Z. Yang,[60a] W-M. Yao,[18] Y. C. Yap,[46] H. Ye,[15c] J. Ye,[42] S. Ye,[29] I. Yeletskikh,[80] M. R. Yexley,[90]
E. Yigitbasi,[25] P. Yin,[39] K. Yorita,[178] K. Yoshihara,[79] C. J. S. Young,[36] C. Young,[152] J. Yu,[79] R. Yuan,[60b,h] X. Yue,[61a]
M. Zaazoua,[35e] B. Zabinski,[85] G. Zacharis,[10] E. Zaffaroni,[54] J. Zahreddine,[135] A. M. Zaitsev,[123,ad] T. Zakareishvili,[158b]
N. Zakharchuk,[34] S. Zambito,[36] D. Zanzi,[36] S. V. Zeißner,[47] C. Zeitnitz,[181] G. Zemaityte,[134] J. C. Zeng,[172] O. Zenin,[123]
T. Ženiš,[28a] D. Zerwas,[65] M. Zgubič,[134] B. Zhang,[15c] D. F. Zhang,[15b] G. Zhang,[15b] J. Zhang,[6] K. Zhang,[15a] 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] Y. Zhao,[145] Z. Zhao,[60a] A. Zhemchugov,[80] Z. Zheng,[106] D. Zhong,[172] B. Zhou,[106] C. Zhou,[180] H. Zhou,[7] 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, Alberta, 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;*
[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*
[23a] *INFN Bologna and Universita' di Bologna, Dipartimento di Fisica;*
[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;*
[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, California, 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, Ontario, Canada*
[35a]*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies—Université Hassan II, Casablanca;*
[35b]*Faculté des Sciences, Université Ibn-Tofail, Kénitra;*
[35c]*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech;*
[35d]*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda;*
[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;*
[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;*
[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;*
[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;*
[60b]*Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao;*
[60c]*School of Physics and Astronomy, Shanghai Jiao Tong University, KLPPAC-MoE, SKLPPC, Shanghai;*
[60d]*Tsung-Dao Lee Institute, Shanghai, China*
[61a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg;*
[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;*
[63b]*Department of Physics, University of Hong Kong, Hong Kong;*
[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;*
[67b]*ICTP, Trieste;*
[67c]*Dipartimento Politecnico di Ingegneria e Architettura, Università di Udine, Udine, Italy*
[68a]*INFN Sezione di Lecce;*
[68b]*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
[69a]*INFN Sezione di Milano;*
[69b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[70a]*INFN Sezione di Napoli;*

[70b]*Dipartimento di Fisica, Università di Napoli, Napoli, Italy*
[71a]*INFN Sezione di Pavia;*
[71b]*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
[72a]*INFN Sezione di Pisa;*
[72b]*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
[73a]*INFN Sezione di Roma;*
[73b]*Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
[74a]*INFN Sezione di Roma Tor Vergata;*
[74b]*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[75a]*INFN Sezione di Roma Tre;*
[75b]*Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
[76a]*INFN-TIFPA;*
[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;*
[81b]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro;*
[81c]*Universidade Federal de São João del Rei (UFSJ), São João del Rei;*
[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;*
[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, Québec, 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, Québec, 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;*
[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]*The 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;*
[139b]*Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Lisboa;*
[139c]*Departamento de Física, Universidade de Coimbra, Coimbra;*
[139d]*Centro de Física Nuclear da Universidade de Lisboa, Lisboa;*
[139e]*Departamento de Física, Universidade do Minho, Braga;*
[139f]*Departamento de Física Teórica y del Cosmos, Universidad de Granada, Granada (Spain);*
[139g]*Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica;*
[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;*
[146b]*Universidad Andres Bello, Department of Physics, Santiago;*
[146c]*Instituto de Alta Investigación, Universidad de Tarapacá;*
[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, British Columbia, 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;*
[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, Ontario, Canada*
[167a]*TRIUMF, Vancouver BC;*
[167b]*Department of Physics and Astronomy, York University, Toronto, Ontario, 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, Masachusetts, 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, British Columbia, Canada*
[175]*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, 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*

[†] Deceased.

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

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

[c] Also at CERN, Geneva, Switzerland.

[d] Also at CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille, France.

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

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

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

[h] Also at Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA.

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

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

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

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

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

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

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

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

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

[r] Also at Faculty of Physics, M.V. Lomonosov Moscow State University, Moscow, Russia.

[s] Also at Giresun University, Faculty of Engineering, Giresun, Turkey.

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

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

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

[w] Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.

[x] Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.

[y] Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.

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

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

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

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

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

[ae] Also at National Research Nuclear University MEPhI, Moscow, Russia.

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

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

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

[ai] Also at TRIUMF, Vancouver, British Columbia, Canada.

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

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