

Combined Measurement of the Higgs Boson Mass from the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ Decay Channels with the ATLAS Detector Using $\sqrt{s} = 7, 8, \text{ and } 13$ TeV pp Collision Data

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

 (Received 10 August 2023; accepted 6 November 2023; published 21 December 2023)

A measurement of the mass of the Higgs boson combining the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ decay channels is presented. The result is based on 140 fb^{-1} of proton-proton collision data collected by the ATLAS detector during LHC run 2 at a center-of-mass energy of 13 TeV combined with the run 1 ATLAS mass measurement, performed at center-of-mass energies of 7 and 8 TeV, yielding a Higgs boson mass of $125.11 \pm 0.09(\text{stat}) \pm 0.06(\text{syst}) = 125.11 \pm 0.11 \text{ GeV}$. This corresponds to a 0.09% precision achieved on this fundamental parameter of the Standard Model of particle physics.

DOI: [10.1103/PhysRevLett.131.251802](https://doi.org/10.1103/PhysRevLett.131.251802)

The discovery of the Higgs boson in proton-proton (pp) collisions at the CERN LHC by the ATLAS and CMS Collaborations [1,2] with data collected at $\sqrt{s} = 7$ and 8 TeV (run 1) was a major step toward understanding the electroweak symmetry-breaking mechanism. Gauge theories require, in fact, that gauge bosons be massless, in apparent contradiction with observations. In this context, the seminal work of Englert and Brout [3], Higgs [4–6], and Guralnik, Hagen, and Kibble [7,8] has provided a consistent mechanism for the generation of gauge boson masses. The Glashow-Weinberg-Salam theory extended this mechanism proposing a theory of the electroweak interactions [9–11], introducing a doublet of complex scalar fields, which couples also to fermions, providing them with a mass that would otherwise be absent. This forms a major component of the Standard Model (SM) of particle physics. A salient prediction of the SM is the presence of a Higgs boson, whose mass is not predicted by the theory and needs to be estimated experimentally. Since the Higgs boson discovery, thanks to the luminosity accumulated at the LHC between 2015 and 2018 (run 2) and the increased center-of-mass energy at $\sqrt{s} = 13$ TeV, the focus has shifted to the precise measurements of Higgs boson properties [12,13]. The couplings of the Higgs boson to other elementary particles are predicted in the SM once the Higgs boson mass m_H is known. This motivates its precise measurement through decay channels that can be fully reconstructed and with the best mass resolution.

The $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ decays are the most suitable processes to measure m_H at the LHC due to their excellent mass resolution, which produce a clear mass peak above a continuum background [1,2]. The Higgs boson mass m_H was measured by ATLAS and CMS in the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels using the full run 1 dataset, and all measurements by the two experiments were combined resulting in a m_H value of $125.09 \pm 0.24 \text{ GeV}$ [14]. More recently, the CMS Collaboration has measured m_H in the same decay channels using 35.9 fb^{-1} of 13 TeV pp run 2 collision data. The combination of the two CMS run 2 measurements with their run 1 results yielded a m_H value of $125.38 \pm 0.14 \text{ GeV}$ [15]. This Letter presents a measurement of m_H combining the $H \rightarrow \gamma\gamma$ [16] and $H \rightarrow ZZ^* \rightarrow 4\ell$ [17] decay channels. The result is based on 140 fb^{-1} of proton-proton collision data collected by the ATLAS detector [18] during the LHC run 2 at a center-of-mass energy of 13 TeV and updates and supersedes that based on the same final states and a partial run 2 dataset corresponding to an integrated luminosity of 36.1 fb^{-1} [19]. An extensive software suite [20] is used in the reconstruction and analysis of real and simulated data, in detector operations, and in the trigger and data acquisition systems of the experiment. The combined measurements profit from the increased dataset and from significantly improved calibrations of the electron and photon energy [16,21] and of the muon momentum [17,22].

The mass measurement reported in this Letter is performed using the profile likelihood ratio [23,24] defined as $\Lambda(m_H) = \mathcal{L}(m_H, \hat{\theta}(m_H)) / \mathcal{L}(\hat{m}_H, \hat{\theta})$. \hat{m}_H and $\hat{\theta}$ are the values of the parameter of interest and nuisance parameters (NP), respectively, that maximize the likelihood $\mathcal{L}(m_H, \theta)$, while $\hat{\theta}(m_H)$ corresponds to the values of the NP that maximize the likelihood for a given value of m_H . Systematic uncertainties are modeled by constrained NP,

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

Published by the American Physical Society under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/). Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI. Funded by SCOAP³.

while the signal and background normalizations in the various channels entering the fit are treated as free parameters. The confidence intervals are obtained assuming the asymptotic distribution of the $-2 \ln \Lambda(m_H)$ test statistic [24]. The statistical uncertainty on m_H is estimated by fixing all the NP that are associated with systematic uncertainties to their best-fit values and leaving all the remaining parameters unconstrained. The total systematic uncertainty, whose squared value is evaluated as the difference between the squares of the total uncertainty and the statistical uncertainty, can be decomposed into categories representing distinct sources of uncertainty by setting all relevant subsets of NP to their best-fit values.

The full description of the run 2 mass measurement in the $H \rightarrow \gamma\gamma$ channel is given in Ref. [16]. A description of the key aspects of this measurement is summarized here. The $H \rightarrow \gamma\gamma$ decay is reconstructed by requiring two energetic photons fulfilling strict identification and isolation criteria. The invariant mass $m_{\gamma\gamma}$ distribution of the selected photon pairs exhibits a peak near m_H , arising from resonant Higgs boson decays, over a smoothly falling distribution from background processes mainly due to nonresonant diphoton production. The value of m_H is determined from the position of the peak in data through a profile-likelihood fit to the $m_{\gamma\gamma}$ distribution. Simulated signal and background event samples are used to optimize the analysis criteria, to choose the signal and background $m_{\gamma\gamma}$ models used in the fit, and to estimate some of the systematic uncertainties on m_H . To increase the sensitivity of the measurement, the selected events are classified into 14 mutually exclusive categories with different diphoton invariant mass resolutions and signal-to-background ratios, which are analyzed simultaneously. The normalization factor for each category is independent and fitted to the data. The $m_{\gamma\gamma}$ resolution ranges from about 1.1 to 2.0 GeV, depending on the category. The signal model consists of a double-sided Crystal Ball probability density function [25], with the mean and standard deviation of its Gaussian core parametrized as a function of m_H in each category using simulated signal events generated at different m_H hypotheses. Compared with the mass result reported in Ref. [19], the $H \rightarrow \gamma\gamma$ mass measurement used in this combination and reported in Ref. [16] profits from an increased data sample, a new photon reconstruction algorithm with better energy resolution [26], an improved estimation of the photon energy scale with significantly reduced uncertainties [21], and an optimized event classification strategy. Uncertainties for photons converting into electron-positron pairs before reaching the electromagnetic calorimeter, which are experimentally similar to electrons, are only moderately improved by the updated calibrations at energies typically observed in the $H \rightarrow \gamma\gamma$ decay (e.g., $E_T \sim 60$ GeV). For unconverted photons, the energy calibration is improved by typically 30% in the central part of the calorimeter ($|\eta| < 1.37$) and up to a factor 2 in the end

cap region ($1.51 \leq |\eta| < 2.37$). The reduction of the uncertainties on the photon energy scale arises from an improved understanding of the difference in data and simulation of the inputs to the photon energy scale regression and of the introduction of transverse energy (E_T) dependent *in situ* scales derived from $Z \rightarrow e^+e^-$ events, that reduce the calibration extrapolation uncertainties from the Z boson mass to the Higgs mass and from electrons to photons [21]. The measured mass of the Higgs boson in the $H \rightarrow \gamma\gamma$ final state using the full run 2 dataset is $m_H = 125.17 \pm 0.11(\text{stat}) \pm 0.09(\text{syst}) = 125.17 \pm 0.14$ GeV [16]. The dominant sources of systematic uncertainties on the measurement are associated to the $Z \rightarrow e^+e^-$ *in situ* scale (59 MeV), the residual E_T -dependent electron energy scale calibration (44 MeV), and the calibration extrapolation from electrons to photons (30 MeV) [16]. The effect of the interference between the $H \rightarrow \gamma\gamma$ signal and the $\gamma\gamma$ continuous background [27] is evaluated to have an impact on the determination of m_H of approximately 26 MeV. The full effect is accounted as a systematic uncertainty on the quoted result, and no shift of the mass value is applied. A combination with the measurement of m_H using the run 1 dataset [14], $m_H = 126.02 \pm 0.43(\text{stat}) \pm 0.27(\text{syst}) = 126.02 \pm 0.51$ GeV, is performed. In this combination, only the E_T -independent component of the uncertainty associated to the *in situ* scale derived from $Z \rightarrow e^+e^-$ events, the resolution uncertainties, and the theoretical uncertainties related to the various Higgs production modes are considered as correlated between run 1 and run 2. The combined measurement of m_H using run 1 and run 2 datasets in the $H \rightarrow \gamma\gamma$ channels is $m_H = 125.22 \pm 0.11(\text{stat}) \pm 0.09(\text{syst}) = 125.22 \pm 0.14$ GeV.

The full description of the run 2 mass measurement in the $H \rightarrow ZZ^* \rightarrow 4\ell$ channel is given in Ref. [17]. A description of the key aspects of this measurement is summarized here. The $H \rightarrow ZZ^* \rightarrow 4\ell$ decay is reconstructed by requiring two pairs of same-flavor opposite-sign isolated leptons ($\ell = e, \mu$) in the final state. The pair with the invariant mass closer to that of the Z boson mass is defined as the leading dilepton pair, while the remaining one is referred to as the subleading dilepton pair. The selected quadruplets are separated into four subchannels according to the flavor of the leading and subleading dilepton pairs ($4\mu, 2e2\mu, 2\mu2e, 4e$). A neural-network-based classifier is employed to discriminate between the Higgs boson signal and the dominant $ZZ^* \rightarrow 4\ell$ background. The m_H measurement is performed with a simultaneous unbinned maximum likelihood fit of the reconstructed invariant mass of the four-lepton system, $m_{4\ell}$, in the four subchannels. The $m_{4\ell}$ resolution ranges from about 1.5 GeV (4μ and $2e2\mu$ subchannels) to about 2.1 GeV ($2\mu2e$ and $4e$ subchannels). The signal model consists of a double-sided Crystal Ball probability density function, with the mean of its Gaussian core parametrized

as a function of m_H and the standard deviation expressed as a function of the predicted event-level resolution. The signal and background normalization for each of the four subchannels are free parameters in the fit. Compared with the measurement reported in Ref. [19], the $H \rightarrow ZZ^* \rightarrow 4\ell$ used in this combination and reported in Ref. [17] profits from an increased data sample, a new high-precision muon momentum calibration [22], the neural-network-based classifier for the signal versus background discrimination, and the inclusion of the event-by-event invariant mass resolution in the analytical model used to fit the collision data. The measured mass of the Higgs boson in the $H \rightarrow ZZ^* \rightarrow 4\ell$ final state using the full run 2 dataset is $m_H = 124.99 \pm 0.18(\text{stat}) \pm 0.04(\text{syst}) = 124.99 \pm 0.19$ GeV. The dominant sources of systematic uncertainty on the measurement are the uncertainties in the muon momentum scale, resolution and sagitta bias correction (28 MeV), and the electron energy scale [26] (19 MeV). A combination with the measurement of m_H using the run 1 dataset [14], $m_H = 124.51 \pm 0.52(\text{stat}) \pm 0.04(\text{syst}) = 124.51 \pm 0.52$ GeV, has been performed. In this combination, only the uncertainties on the electron calibration were considered correlated, while the muon calibration systematic uncertainty is uncorrelated between the two measurements due to improved and independent techniques in the muon momentum scale calibration. The combined measurement of m_H performed with run 1 and run 2 datasets in the $H \rightarrow ZZ^* \rightarrow 4\ell$ channel is $m_H = 124.94 \pm 0.17(\text{stat}) \pm 0.03(\text{syst}) = 124.94 \pm 0.18$ GeV.

The combined mass measurement in the $H \rightarrow \gamma\gamma$ channel [16] is similarly affected by the statistical uncertainty (110 MeV) and the systematic uncertainty (90 MeV), mainly associated to the photon energy scale calibration.

In contrast, the combined mass measurement in the $H \rightarrow ZZ^* \rightarrow 4\ell$ channel [17] is primarily dominated by the statistical uncertainty (170 MeV), while the systematic uncertainty, mainly related the muon momentum scale calibration, has a minor impact (30 MeV) on the measurement. The differences between the two channels can be traced to the distinct decay branching ratios, final state reconstruction efficiencies, background levels, and the resulting signal-to-background ratios in the two channels. A detailed comparison of the two channels, qualitatively similar to those presented here, is given in Ref. [28].

In the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels combination, the correlations between systematic uncertainties in the two measurements are accounted for in the profile likelihood function by using the same constraint for each of the correlated NP. All potential correlations between measurements and data-taking periods are thoroughly examined. Because of substantial variations in the calibration of electrons, photons, and muons, most correlations are small. If applicable, these correlations are incorporated following the approach that yields the most conservative result. In the combinations of the run 1 and run 2 measurements of the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ individual channels, the correlation of the experimental systematic uncertainties follows what was done in Refs. [16,17], respectively. The correlation scheme between the run 1 $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ measurements is unchanged relative to the published run 1 combination [14]. The choice of correlation model between the run 2 $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ measurements reflects the improvements in the photon calibration adopted by the $H \rightarrow \gamma\gamma$ analysis not being mirrored in the calibration of the electrons used in the $H \rightarrow ZZ^* \rightarrow 4\ell$ analysis;

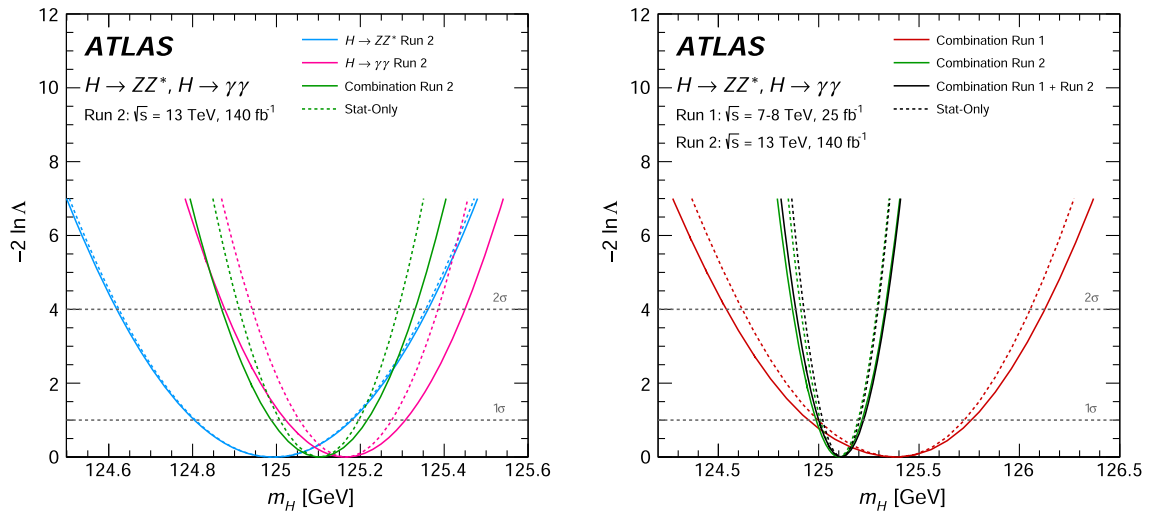


FIG. 1. Value of $-2 \ln \Lambda$ as a function of m_H for (left) $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels and their combination (magenta, cyan, and green, respectively) using run 2 data only and for (right) run 1, run 2, and their combination (red, green, and black, respectively). The dashed lines show the statistical component of the uncertainty. The 1σ (2σ) confidence interval is indicated by the intersections of the horizontal line at 1 (4) with the log-likelihood curves.

TABLE I. Impact of the main sources of systematic uncertainty on the m_H measurement from the combination of the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ final states using run 2 data. The systematic uncertainties associated with the combination of run 1 and run 2 data are nearly identical. The sum in quadrature of the individual contributions is not expected to reproduce the total systematic uncertainty due to the different methodologies employed to derive them.

Source	Systematic uncertainty on m_H (MeV)
e/γ E_T -independent $Z \rightarrow ee$ calibration	44
e/γ E_T -dependent electron energy scale	28
$H \rightarrow \gamma\gamma$ interference bias	17
e/γ photon lateral shower shape	16
e/γ photon conversion reconstruction	15
e/γ energy resolution	11
$H \rightarrow \gamma\gamma$ background modelling	10
Muon momentum scale	8
All other systematic uncertainties	7

only the electron and photon resolution systematic uncertainties and those associated with the E_T -independent component of the electron and photon *in situ* energy scale are considered as correlated. Other sources of systematic uncertainties correlated between the two channels are the theory uncertainties on the prediction of the various Higgs production modes, the modeling of additional (*pileup*) pp collisions, and the uncertainty on the integrated luminosity. The choice of correlation model is also tested by using different approaches (e.g., correlating the muon calibration

systematic uncertainties in run 1 and run 2, correlating all sources of photon and electron calibration systematic uncertainties between the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels) and is shown to have negligible impact on the result. Signal yield normalizations are treated as independent free parameters in the fit to minimize model-dependent assumptions in the measurement of m_H .

The combined value measured using run 2 data is $m_H = 125.10 \pm 0.11$ GeV. The uncertainty is compatible with the expected error assuming a SM Higgs boson mass of 125 GeV. The statistical component of the uncertainty is ± 0.09 GeV. The corresponding profile likelihood, for the two channels and for their combination, is shown in Fig. 1 (left) as a function of m_H . If the small interference predicted by the SM between the Higgs boson and the nonresonant diphoton background was considered for the $H \rightarrow \gamma\gamma$ signal parametrization, the m_H value measured by the combination would increase by 15 MeV. This result is in good agreement with the ATLAS + CMS run 1 measurement [19], $m_H = 125.09 \pm 0.24$ GeV. The contributions of the main sources of systematic uncertainty to the combined measurement, using ATLAS run 2 data, are summarized in Table I. The values differ from those reported in Refs. [16,17] because of the relative impact of the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ results in the combination. The E_T -independent component of the electron and photon *in situ* energy scale (“ $e/\gamma E_T$ -independent $Z \rightarrow ee$ calibration” in Table I) is among the few uncertainties correlated between the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ measurements and impacts the former measurement by 59 MeV [16] and the latter by 19 MeV [17]. The combined measurement

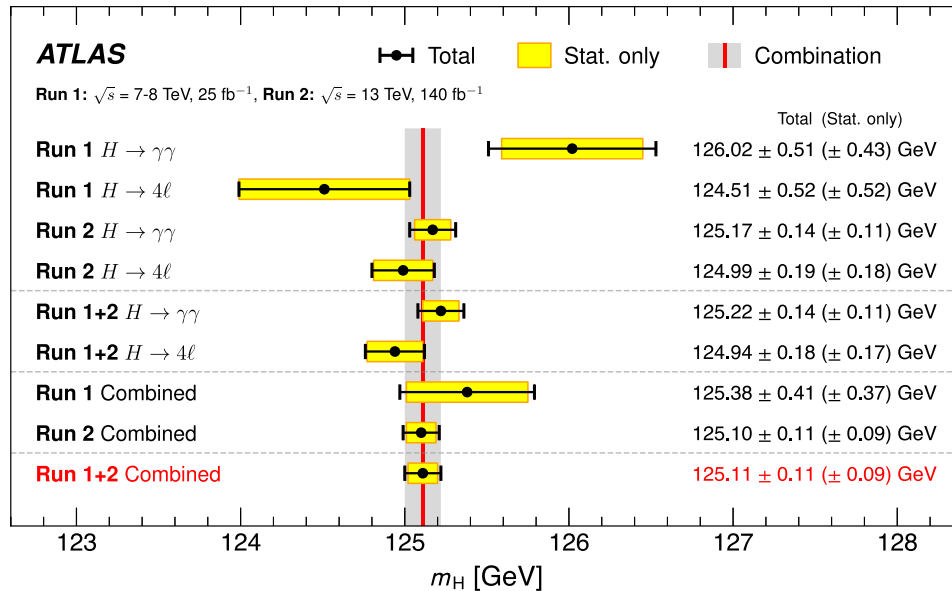


FIG. 2. Summary of m_H measurements from the individual $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels and their combination presented in this Letter. The uncertainty bar on each point corresponds to the total uncertainty; the horizontal shaded bands represent the statistical component of the uncertainties; the vertical red line and gray band represent the combined result presented in this Letter with its total uncertainty.

from the ATLAS run 1 and run 2 results is $m_H = 125.11 \pm 0.11$ GeV. The statistical component of the uncertainty is ± 0.09 GeV. The four combined measurements are compatible with a p value of 18%. Figure 1 (right) shows the corresponding profile likelihoods, separately for the ATLAS run 1 and run 2 datasets, as well as for their combination, as a function of m_H . The contributions of the main sources of systematic uncertainty to the combination of run 1 and run 2 data are nearly identical to those presented in Table I. Figure 2 presents a summary of the m_H measurements from the individual $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels and their combinations discussed in this Letter.

In conclusion, the Higgs boson mass m_H is measured using run 2 collision data at 13 TeV yielding

$$\begin{aligned} m_H &= 125.10 \pm 0.09(\text{stat}) \pm 0.07(\text{syst}) \\ &= 125.10 \pm 0.11 \text{ GeV}, \end{aligned}$$

which is a significant improvement with respect to that reported in Ref. [19]. The systematic uncertainty affecting the $H \rightarrow \gamma\gamma$ measurement is reduced by a factor of about 3 thanks to a novel and improved approach to the photon energy calibration. This is comparable with the factor of about 2 associated with the increase in the data statistics. The systematic uncertainty on the muon momentum calibration decreases by about 50% relative to Ref. [19]. Combining the run 2 result with the m_H measurements performed in run 1 at 7 and 8 TeV, the combined result is

$$\begin{aligned} m_H &= 125.11 \pm 0.09(\text{stat}) \pm 0.06(\text{syst}) \\ &= 125.11 \pm 0.11 \text{ GeV}. \end{aligned}$$

This result currently represents the most precise measurement of the Higgs boson mass, reaching a 0.09% precision on this fundamental quantity.

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; CNPq and FAPESP, Brazil; NSERC, NRC, and CFI, Canada; CERN; ANID, Chile; CAS, MOST, and NSFC, China; Minciencias, Colombia; MEYS CR, Czech Republic; DNRF and DNSRC, Denmark; IN2P3-CNRS and CEA-DRF/IRFU, France; SRNSFG, Georgia; BMBF, HGF, and MPG, Germany; GSRI, Greece; RGC and Hong Kong SAR, China; ISF and Benozziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; NWO, Netherlands; RCN, Norway; MEiN, Poland; FCT, Portugal; MNE/IFA, Romania; MESTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DSI/NRF, South Africa; MICINN, Spain;

SRC and Wallenberg Foundation, Sweden; SERI, SNSF, and Cantons of Bern and Geneva, Switzerland; MOST, Taiwan; TENMAK, Turkey; STFC, United Kingdom; DOE and NSF, United States of America. In addition, individual groups and members have received support from BCKDF, CANARIE, Compute Canada, and CRC, Canada; PRIMUS 21/SCI/017 and UNCE SCI/013, Czech Republic; COST, ERC, ERDF, Horizon 2020, and Marie Skłodowska-Curie Actions, European Union; Investissements d’Avenir Labex, Investissements d’Avenir Idex, and ANR, France; DFG and AvH Foundation, Germany; Herakleitos, Thales, and Aristeia programs cofinanced by EU-ESF and the Greek NSRF, Greece; BSF-NSF and MINERVA, Israel; Norwegian Financial Mechanism 2014-2021, Norway; NCN and NAWA, Poland; 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 (United Kingdom), and BNL (USA), the Tier-2 facilities worldwide, and large non-WLCG resource providers. Major contributors of computing resources are listed in Ref. [29].

-
- [1] 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).
 - [2] 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).
 - [3] F. Englert and R. Brout, Broken symmetry and the mass of gauge vector mesons, *Phys. Rev. Lett.* **13**, 321 (1964).
 - [4] P. W. Higgs, Broken symmetries, massless particles and gauge fields, *Phys. Lett.* **12**, 132 (1964).
 - [5] P. W. Higgs, Broken symmetries and the masses of gauge bosons, *Phys. Rev. Lett.* **13**, 508 (1964).
 - [6] P. W. Higgs, Spontaneous symmetry breakdown without massless bosons, *Phys. Rev.* **145**, 1156 (1966).
 - [7] G. S. Guralnik, C. R. Hagen, and T. W. B. Kibble, Global conservation laws and massless particles, *Phys. Rev. Lett.* **13**, 585 (1964).
 - [8] T. W. B. Kibble, Symmetry breaking in non-Abelian gauge theories, *Phys. Rev.* **155**, 1554 (1967).
 - [9] S. L. Glashow, Partial-symmetries of weak interactions, *Nucl. Phys.* **22**, 579 (1961).
 - [10] A. Salam, Weak and electromagnetic interactions, *Conf. Proc. C* **680519**, 367 (1968).
 - [11] S. Weinberg, A model of leptons, *Phys. Rev. Lett.* **19**, 1264 (1967).

- [12] ATLAS Collaboration, A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery, *Nature (London)* **607**, 52 (2022); **612**, E24 (2022).
- [13] CMS Collaboration, A portrait of the Higgs boson by the CMS experiment ten years after the discovery, *Nature (London)* **607**, 60 (2022).
- [14] ATLAS and CMS Collaborations, Combined measurement of the Higgs boson mass in pp collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS experiments, *Phys. Rev. Lett.* **114**, 191803 (2015).
- [15] CMS Collaboration, A measurement of the Higgs boson mass in the diphoton decay channel, *Phys. Lett. B* **805**, 135425 (2020).
- [16] ATLAS Collaboration, Measurement of the Higgs boson mass with $H \rightarrow \gamma\gamma$ decays in 140 fb^{-1} of $\sqrt{s} = 13 \text{ TeV}$ pp collisions with the ATLAS detector, *Phys. Lett. B* **847**, 138315 (2023).
- [17] ATLAS Collaboration, Measurement of the Higgs boson mass in the $H \rightarrow ZZ^* \rightarrow 4\ell$ decay channel using 139 fb^{-1} of $\sqrt{s} = 13 \text{ TeV}$ pp collisions recorded by the ATLAS detector at the LHC, *Phys. Lett. B* **843**, 137880 (2023).
- [18] ATLAS Collaboration, The ATLAS experiment at the CERN Large Hadron Collider, *J. Instrum.* **3**, S08003 (2008).
- [19] ATLAS Collaboration, Measurement of the Higgs boson mass in the $H \rightarrow ZZ^* \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ channels with $\sqrt{s} = 13 \text{ TeV}$ pp collisions using the ATLAS detector, *Phys. Lett. B* **784**, 345 (2018).
- [20] ATLAS Collaboration, The ATLAS Collaboration software and firmware, Report No. ATL-SOFT-PUB-2021-001, 2021, <https://cds.cern.ch/record/2767187>.
- [21] ATLAS Collaboration, Electron and photon energy calibration with the ATLAS detector using LHC Run 2 data, [arXiv:2309.05471](https://arxiv.org/abs/2309.05471).
- [22] ATLAS Collaboration, Studies of the muon momentum calibration and performance of the ATLAS detector with pp collisions at $\sqrt{s} = 13 \text{ TeV}$, *Eur. Phys. J. C* **83**, 686 (2023).
- [23] ATLAS and CMS Collaborations, and LHC Higgs Combination Group, Procedure for the LHC Higgs boson search combination in Summer 2011, Report No. ATL-PHYS-PUB-2011-011, 2011, <https://cds.cern.ch/record/1375842>.
- [24] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Asymptotic formulae for likelihood-based tests of new physics, *Eur. Phys. J. C* **71**, 1554 (2011); **73**, 2501(E) (2013).
- [25] M. Oreglia, A study of the reactions $\psi' \rightarrow \gamma\gamma\psi$, Appendix D (1980), <https://www-public.slac.stanford.edu/SciDoc/doc/Meta.aspx?slacPubNumber=slac-R-236>.
- [26] 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).
- [27] L. J. Dixon and Y. Li, Bounding the Higgs boson width through interferometry, *Phys. Rev. Lett.* **111**, 111802 (2013).
- [28] ATLAS Collaboration, Measurement of the Higgs boson mass from the $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels in pp collisions at center-of-mass energies of 7 and 8 TeV with the ATLAS detector, *Phys. Rev. D* **90**, 052004 (2014).
- [29] ATLAS Collaboration, ATLAS computing acknowledgements, Report No. ATL-SOFT-PUB-2023-001, 2023, <https://cds.cern.ch/record/2869272>.

G. Aad¹⁰², B. Abbott¹²⁰, K. Abeling⁵⁵, N. J. Abicht⁴⁹, S. H. Abidi²⁹, A. Aboulhorma^{35e}, H. Abramowicz¹⁵¹, H. Abreu¹⁵⁰, Y. Abulaiti¹¹⁷, B. S. Acharya^{69a,69b}, C. Adam Bourdarios⁴, L. Adamczyk^{86a}, S. V. Addepalli²⁶, M. J. Addison¹⁰¹, J. Adelman¹¹⁵, A. Adiguzel^{21c}, T. Adye¹³⁴, A. A. Affolder¹³⁶, Y. Afik³⁶, M. N. Agaras¹³, J. Agarwala^{73a,73b}, A. Aggarwal¹⁰⁰, C. Agheorghiesei^{27c}, A. Ahmad³⁶, F. Ahmadov^{38,c}, W. S. Ahmed¹⁰⁴, S. Ahuja⁹⁵, X. Ai^{62a}, G. Aielli^{76a,76b}, A. Aikot¹⁶³, M. Ait Tamlihat^{35e}, B. Aitbenkikh^{35a}, I. Aizenberg¹⁶⁹, M. Akbiyik¹⁰⁰, T. P. A. Åkesson⁹⁸, A. V. Akimov³⁷, D. Akiyama¹⁶⁸, N. N. Akolkar²⁴, K. Al Khoury⁴¹, G. L. Alberghi^{23b}, J. Albert¹⁶⁵, P. Albicocco⁵³, G. L. Albouy⁶⁰, S. Alderweireldt⁵², M. Aleksa³⁶, I. N. Aleksandrov³⁸, C. Alexa^{27b}, T. Alexopoulos¹⁰, F. Alfonsi^{23b}, M. Algren⁵⁶, M. Alhroob¹²⁰, B. Ali¹³², H. M. J. Ali⁹¹, S. Ali¹⁴⁸, S. W. Alibocus⁹², M. Aliev¹⁴⁵, G. Alimonti^{71a}, W. Alkakh⁵⁵, C. Allaire⁶⁶, B. M. M. Allbrooke¹⁴⁶, J. F. Allen⁵², C. A. Allendes Flores^{137f}, P. P. Allport²⁰, A. Aloisio^{72a,72b}, F. Alonso⁹⁰, C. Alpigiani¹³⁸, M. Alvarez Estevez⁹⁹, A. Alvarez Fernandez¹⁰⁰, M. Alves Cardoso⁵⁶, M. G. Alviggi^{72a,72b}, M. Aly¹⁰¹, Y. Amaral Coutinho^{83b}, A. Ambler¹⁰⁴, C. Amelung³⁶, M. Amerl¹⁰¹, C. G. Ames¹⁰⁹, D. Amidei¹⁰⁶, S. P. Amor Dos Santos^{130a}, K. R. Amos¹⁶³, V. Ananiev¹²⁵, C. Anastopoulos¹³⁹, T. Andeen¹¹, J. K. Anders³⁶, S. Y. Andreev^{47a,47b}, A. Andreatza^{71a,71b}, S. Angelidakis⁹, A. Angerami^{41,d}, A. V. Anisenkov³⁷, A. Annovi^{74a}, C. Antel⁵⁶, M. T. Anthony¹³⁹, E. Antipov¹⁴⁵, M. Antonelli⁵³, F. Anulli^{75a}, M. Aoki⁸⁴, T. Aoki¹⁵³, J. A. Aparisi Pozo¹⁶³, M. A. Aparo¹⁴⁶, L. Aperio Bella⁴⁸, C. Appelt¹⁸, A. Apyan²⁶, N. Aranzabal³⁶, S. J. Arbiol Val⁸⁷, C. Arcangeletti⁵³, A. T. H. Arce⁵¹, E. Arena⁹², J-F. Arguin¹⁰⁸, S. Argyropoulos⁵⁴, J.-H. Arling⁴⁸, O. Arnaez⁴, H. Arnold¹¹⁴, G. Artoni^{75a,75b}, H. Asada¹¹¹, K. Asai¹¹⁸, S. Asai¹⁵³, N. A. Asbah⁶¹, J. Assahsah^{35d}, K. Assamagan²⁹, R. Astalos^{28a}, S. Atashi¹⁶⁰, R. J. Atkin^{33a}, M. Atkinson¹⁶², H. Atmani^{35f}, P. A. Atlasiddha¹⁰⁶, K. Augsten¹³², S. Auricchio^{72a,72b}, A. D. Auriol²⁰, V. A. Austrup¹⁰¹, G. Avolio³⁶

K. Axiotis⁵⁶ G. Azuelos^{108,e} D. Babal^{28b} H. Bachacou¹³⁵ K. Bachas^{152,f} A. Bachiu³⁴ F. Backman^{47a,47b}
 A. Badea⁶¹ T. M. Baer¹⁰⁶ P. Bagnaia^{75a,75b} M. Bahmani¹⁸ A. J. Bailey¹⁶³ V. R. Bailey¹⁶² J. T. Baines¹³⁴
 L. Baines⁹⁴ O. K. Baker¹⁷² E. Bakos¹⁵ D. Bakshi Gupta⁸ V. Balakrishnan¹²⁰ R. Balasubramanian¹¹⁴
 E. M. Baldin³⁷ P. Balek^{86a} E. Ballabene^{23b,23a} F. Balli¹³⁵ L. M. Baltes^{63a} W. K. Balunas³² J. Balz¹⁰⁰
 E. Banas⁸⁷ M. Bandieramonte¹²⁹ A. Bandyopadhyay²⁴ S. Bansal²⁴ L. Barak¹⁵¹ M. Barakat⁴⁸
 E. L. Barberio¹⁰⁵ D. Barberis^{57b,57a} M. Barbero¹⁰² M. Z. Barel¹¹⁴ K. N. Barends^{33a} T. Barillari¹¹⁰
 M-S. Barisits³⁶ T. Barklow¹⁴³ P. Baron¹²² D. A. Baron Moreno¹⁰¹ A. Baroncelli^{62a} G. Barone²⁹ A. J. Barr¹²⁶
 J. D. Barr⁹⁶ L. Barranco Navarro^{47a,47b} F. Barreiro⁹⁹ J. Barreiro Guimarães da Costa^{14a} U. Barron¹⁵¹
 M. G. Barros Teixeira^{130a} S. Barsov³⁷ F. Bartels^{63a} R. Bartoldus¹⁴³ A. E. Barton⁹¹ P. Bartos^{28a} A. Basan^{100,g}
 M. Baselga⁴⁹ A. Bassalat^{66,h} M. J. Basso^{156a} C. R. Basson¹⁰¹ R. L. Bates⁵⁹ S. Batlamous^{35e} J. R. Batley³²
 B. Batool¹⁴¹ M. Battaglia¹³⁶ D. Battulga¹⁸ M. Bauce^{75a,75b} M. Bauer³⁶ P. Bauer²⁴ L. T. Bazzano Hurrell³⁰
 J. B. Beacham⁵¹ T. Beau¹²⁷ J. Y. Beaucamp⁹⁰ P. H. Beauchemin¹⁵⁸ F. Becherer⁵⁴ P. Bechtel²⁴ H. P. Beck^{19,i}
 K. Becker¹⁶⁷ A. J. Beddall⁸² V. A. Bednyakov³⁸ C. P. Bee¹⁴⁵ L. J. Beemster¹⁵ T. A. Beermann³⁶ M. Begalli^{83d}
 M. Begel²⁹ A. Behera¹⁴⁵ J. K. Behr⁴⁸ J. F. Beirer⁵⁵ F. Beisiegel²⁴ M. Belfkir¹⁵⁹ G. Bella¹⁵¹
 L. Bellagamba^{23b} A. Bellerive³⁴ P. Bellos²⁰ K. Beloborodov³⁷ D. Benckekroun^{35a} F. Bendebba^{35a}
 Y. Benhammou¹⁵¹ M. Benoit²⁹ J. R. Bensinger²⁶ S. Bentvelsen¹¹⁴ L. Beresford⁴⁸ M. Beretta⁵³
 E. Bergeas Kuutmann¹⁶¹ N. Berger⁴ B. Bergmann¹³² J. Beringer^{17a} G. Bernardi⁵ C. Bernius¹⁴³
 F. U. Bernlochner²⁴ F. Bernon^{36,102} A. Berrocal Guardia¹³ T. Berry⁹⁵ P. Berta¹³³ A. Berthold⁵⁰
 I. A. Bertram⁹¹ S. Bethke¹¹⁰ A. Betti^{75a,75b} A. J. Bevan⁹⁴ N. K. Bhalla⁵⁴ M. Bhamjee^{33c} S. Bhatta¹⁴⁵
 D. S. Bhattacharya¹⁶⁶ P. Bhattacharai¹⁴³ V. S. Bhopatkar¹²¹ R. Bi^{29,j} R. M. Bianchi¹²⁹ G. Bianco^{23b,23a}
 O. Biebel¹⁰⁹ R. Bielski¹²³ M. Biglietti^{77a} M. Bindi⁵⁵ A. Bingul^{21b} C. Bini^{75a,75b} A. Biondini⁹²
 C. J. Birch-sykes¹⁰¹ G. A. Bird^{20,134} M. Birman¹⁶⁹ M. Biros¹³³ S. Biryukov¹⁴⁶ T. Bisanz⁴⁹ E. Bisceglie^{43b,43a}
 J. P. Biswal¹³⁴ D. Biswas¹⁴¹ A. Bitadze¹⁰¹ K. Bjørke¹²⁵ I. Bloch⁴⁸ C. Blocker²⁶ A. Blue⁵⁹
 U. Blumenschein⁹⁴ J. Blumenthal¹⁰⁰ G. J. Bobbink¹¹⁴ V. S. Bobrovnikov³⁷ M. Boehler⁵⁴ B. Boehm¹⁶⁶
 D. Bogavac³⁶ A. G. Bogdanchikov³⁷ C. Bohm^{47a} V. Boisvert⁹⁵ P. Bokan⁴⁸ T. Bold^{86a} M. Bomben⁵
 M. Bona⁹⁴ M. Boonekamp¹³⁵ C. D. Booth⁹⁵ A. G. Borbély^{59,k} I. S. Bordulev³⁷ H. M. Borecka-Bielska¹⁰⁸
 G. Borissov⁹¹ D. Bortoletto¹²⁶ D. Boscherini^{23b} M. Bosman¹³ J. D. Bossio Sola³⁶ K. Bouaouda^{35a}
 N. Bouchhar¹⁶³ J. Boudreau¹²⁹ E. V. Bouhova-Thacker⁹¹ D. Boumediene⁴⁰ R. Bouquet¹⁶⁵ A. Boveia¹¹⁹
 J. Boyd³⁶ D. Boye²⁹ I. R. Boyko³⁸ J. Bracinik²⁰ N. Brahimí^{62d} G. Brandt¹⁷¹ O. Brandt³² F. Braren⁴⁸
 B. Brau¹⁰³ J. E. Brau¹²³ R. Brener¹⁶⁹ L. Brenner¹¹⁴ R. Brenner¹⁶¹ S. Bressler¹⁶⁹ D. Britton⁵⁹
 D. Britzger¹¹⁰ I. Brock²⁴ G. Brooijmans⁴¹ W. K. Brooks^{137f} E. Brost²⁹ L. M. Brown^{165,l} L. E. Bruce⁶¹
 T. L. Bruckler¹²⁶ P. A. Bruckman de Renstrom⁸⁷ B. Brüers⁴⁸ A. Bruni^{23b} G. Bruni^{23b} M. Bruschi^{23b}
 N. Bruscinò^{75a,75b} T. Buanes¹⁶ Q. Buat¹³⁸ D. Buchin¹¹⁰ A. G. Buckley⁵⁹ O. Bulekov³⁷ B. A. Bullard¹⁴³
 S. Burdin⁹² C. D. Burgard⁴⁹ A. M. Burger⁴⁰ B. Burghgrave⁸ O. Burlayenko⁵⁴ J. T. P. Burr³² C. D. Burton¹¹
 J. C. Burzynski¹⁴² E. L. Busch⁴¹ V. Büscher¹⁰⁰ P. J. Bussey⁵⁹ J. M. Butler²⁵ C. M. Buttar⁵⁹
 J. M. Butterworth⁹⁶ W. Buttinger¹³⁴ C. J. Buxo Vazquez¹⁰⁷ A. R. Buzykaev³⁷ S. Cabrera Urbán¹⁶³
 L. Cadamuro⁶⁶ D. Caforio⁵⁸ H. Cai¹²⁹ Y. Cai^{14a,14e} Y. Cai^{14c} V. M. M. Cairo³⁶ O. Cakir^{3a} N. Calace³⁶
 P. Calafiura^{17a} G. Calderini¹²⁷ P. Calfayan⁶⁸ G. Callea⁵⁹ L. P. Caloba^{83b} D. Calvet⁴⁰ S. Calvet⁴⁰
 T. P. Calvet¹⁰² M. Calvetti^{74a,74b} R. Camacho Toro¹²⁷ S. Camarda³⁶ D. Camarero Muñoz²⁶ P. Camarri^{76a,76b}
 M. T. Camerlingo^{72a,72b} D. Cameron^{36,m} C. Camincher¹⁶⁵ M. Campanelli⁹⁶ A. Camplani⁴² V. Canale^{72a,72b}
 A. Canesse¹⁰⁴ J. Cantero¹⁶³ Y. Cao¹⁶² F. Capocasa²⁶ M. Capua^{43b,43a} A. Carbone^{71a,71b} R. Cardarelli^{76a}
 J. C. J. Cardenas⁸ F. Cardillo¹⁶³ G. Carducci^{43b,43a} T. Carli³⁶ G. Carlino^{72a} J. I. Carlotto¹³ B. T. Carlson^{129,n}
 E. M. Carlson^{165,156a} L. Carminati^{71a,71b} A. Carnelli¹³⁵ M. Carnesale^{75a,75b} S. Caron¹¹³ E. Carquin^{137f}
 S. Carrá^{71a,71b} G. Carratta^{23b,23a} F. Carrio Argos^{33g} J. W. S. Carter¹⁵⁵ T. M. Carter⁵² M. P. Casado^{13,o}
 M. Caspar⁴⁸ F. L. Castillo⁴ L. Castillo Garcia¹³ V. Castillo Gimenez¹⁶³ N. F. Castro^{130a,130e} A. Catinaccio³⁶
 J. R. Catmore¹²⁵ V. Cavaliere²⁹ N. Cavalli^{23b,23a} V. Cavasinni^{74a,74b} Y. C. Cekmecelioglu⁴⁸ E. Celebi^{21a}
 F. Celli¹²⁶ M. S. Centonze^{70a,70b} V. Cepaitis⁵⁶ K. Cerny¹²² A. S. Cerqueira^{83a} A. Cerri¹⁴⁶ L. Cerrito^{76a,76b}
 F. Cerutti^{17a} B. Cervato¹⁴¹ A. Cervelli^{23b} G. Cesarini⁵³ S. A. Cetin⁸² Z. Chadi^{35a} D. Chakraborty¹¹⁵
 J. Chan¹⁷⁰ W. Y. Chan¹⁵³ J. D. Chapman³² E. Chapon¹³⁵ B. Chargeishvili^{149b} D. G. Charlton²⁰

T. P. Charman¹⁹, M. Chatterjee¹⁹, C. Chauhan¹³³, S. Chekanov⁶, S. V. Chekulaev^{156a}, G. A. Chelkov^{38,p},
A. Chen¹⁰⁶, B. Chen¹⁵¹, B. Chen¹⁶⁵, H. Chen^{14c}, H. Chen²⁹, J. Chen^{62c}, J. Chen¹⁴², M. Chen¹²⁶, S. Chen¹⁵³,
S. J. Chen^{14c}, X. Chen^{62c,135}, X. Chen^{14b,q}, Y. Chen^{62a}, C. L. Cheng¹⁷⁰, H. C. Cheng^{64a}, S. Cheong¹⁴³,
A. Cheplakov³⁸, E. Cheremushkina⁴⁸, E. Cherepanova¹¹⁴, R. Cherkaoui El Moursli^{35e}, E. Cheu⁷, K. Cheung⁶⁵,
L. Chevalier¹³⁵, V. Chiarella⁵³, G. Chiarelli^{74a}, N. Chiedde¹⁰², G. Chiodini^{70a}, A. S. Chisholm²⁰, A. Chitan^{27b},
M. Chitishvili¹⁶³, M. V. Chizhov³⁸, K. Choi¹¹, A. R. Chomont^{75a,75b}, Y. Chou¹⁰³, E. Y. S. Chow¹¹³,
T. Chowdhury^{33g}, K. L. Chu¹⁶⁹, M. C. Chu^{64a}, X. Chu^{14a,14e}, J. Chudoba¹³¹, J. J. Chwastowski⁸⁷, D. Cieri¹¹⁰,
K. M. Ciesla^{86a}, V. Cindro⁹³, A. Ciocio^{17a}, F. Ciroto^{72a,72b}, Z. H. Citron^{169,r}, M. Citterio^{71a}, D. A. Ciubotaru^{27b},
B. M. Ciungu¹⁵⁵, A. Clark⁵⁶, P. J. Clark⁵², C. Clarry¹⁵⁵, J. M. Clavijo Columbie⁴⁸, S. E. Clawson⁴⁸,
C. Clement^{47a,47b}, J. Clercx⁴⁸, L. Clissa^{23b,23a}, Y. Coadou¹⁰², M. Cobal^{69a,69c}, A. Coccaro^{57b},
R. F. Coelho Barrue^{130a}, R. Coelho Lopes De Sa¹⁰³, S. Coelli^{71a}, H. Cohen¹⁵¹, A. E. C. Coimbra^{71a,71b}, B. Cole⁴¹,
J. Collot⁶⁰, P. Conde Muiño^{130a,130g}, M. P. Connell^{33c}, S. H. Connell^{33c}, I. A. Connelly⁵⁹, E. I. Conroy¹²⁶,
F. Conventi^{72a,s}, H. G. Cooke²⁰, A. M. Cooper-Sarkar¹²⁶, A. Cordeiro Oudot Choi¹²⁷, L. D. Corpe⁴⁰,
M. Corradi^{75a,75b}, F. Corriveau^{104,t}, A. Cortes-Gonzalez¹⁸, M. J. Costa¹⁶³, F. Costanza⁴, D. Costanzo¹³⁹,
B. M. Cote¹¹⁹, G. Cowan⁹⁵, K. Cranmer¹⁷⁰, D. Cremonini^{23b,23a}, S. Crépe-Renaudin⁶⁰, F. Crescioli¹²⁷,
M. Cristinziani¹⁴¹, M. Cristoforetti^{78a,78b}, V. Croft¹¹⁴, J. E. Crosby¹²¹, G. Crosetti^{43b,43a}, A. Cueto⁹⁹,
T. Cuhadar Donszelmann¹⁶⁰, H. Cui^{14a,14e}, Z. Cui⁷, W. R. Cunningham⁵⁹, F. Curcio^{43b,43a}, P. Czodrowski³⁶,
M. M. Czurylo^{63b}, M. J. Da Cunha Sargedas De Sousa^{57b,57a}, J. V. Da Fonseca Pinto^{83b}, C. Da Via¹⁰¹,
W. Dabrowski^{86a}, T. Dado⁴⁹, S. Dahbi^{33g}, T. Dai¹⁰⁶, D. Dal Santo¹⁹, C. Dallapiccola¹⁰³, M. Dam⁴²,
G. D'amen²⁹, V. D'Amico¹⁰⁹, J. Damp¹⁰⁰, J. R. Dandoy¹²⁸, M. F. Daneri³⁰, M. Danninger¹⁴², V. Dao³⁶,
G. Darbo^{57b}, S. Darmora⁶, S. J. Das^{29,j}, S. D'Auria^{71a,71b}, C. David^{156b}, T. Davidek¹³³, B. Davis-Purcell³⁴,
I. Dawson⁹⁴, H. A. Day-hall¹³², K. De⁸, R. De Asmundis^{72a}, N. De Biase⁴⁸, S. De Castro^{23b,23a}, N. De Groot¹¹³,
P. de Jong¹¹⁴, H. De la Torre¹¹⁵, A. De Maria^{14c}, A. De Salvo^{75a}, U. De Sanctis^{76a,76b}, A. De Santo¹⁴⁶,
J. B. De Vivie De Regie⁶⁰, D. V. Dedovich³⁸, J. Degens¹¹⁴, A. M. Deiana⁴⁴, F. Del Corso^{23b,23a}, J. Del Peso⁹⁹,
F. Del Rio^{63a}, F. Deliot¹³⁵, C. M. Delitzsch⁴⁹, M. Della Pietra^{72a,72b}, D. Della Volpe⁵⁶, A. Dell'Acqua³⁶,
L. Dell'Asta^{71a,71b}, M. Delmastro⁴, P. A. Delsart⁶⁰, S. Demers¹⁷², M. Demichev³⁸, S. P. Denisov³⁷,
L. D'Eramo⁴⁰, D. Derendarz⁸⁷, F. Derue¹²⁷, P. Dervan⁹², K. Desch²⁴, C. Deutsch²⁴, F. A. Di Bello^{57b,57a},
A. Di Ciaccio^{76a,76b}, L. Di Ciaccio⁴, A. Di Domenico^{75a,75b}, C. Di Donato^{72a,72b}, A. Di Girolamo³⁶,
G. Di Gregorio³⁶, A. Di Luca^{78a,78b}, B. Di Micco^{77a,77b}, R. Di Nardo^{77a,77b}, C. Diaconu¹⁰², M. Diamantopoulou³⁴,
F. A. Dias¹¹⁴, T. Dias Do Vale¹⁴², M. A. Diaz^{137a,137b}, F. G. Diaz Capriles²⁴, M. Didenko¹⁶³, E. B. Diehl¹⁰⁶,
L. Diehl⁵⁴, S. Díez Cornell⁴⁸, C. Diez Pardos¹⁴¹, C. Dimitriadi^{161,24,161}, A. Dimitrievska^{17a}, J. Dingfelder²⁴,
I-M. Dinu^{27b}, S. J. Dittmeier^{63b}, F. Dittus³⁶, F. Djama¹⁰², T. Djobava^{149b}, J. I. Djuvslund¹⁶, C. Doglioni^{101,98},
A. Dohnalova^{28a}, J. Dolejsi¹³³, Z. Dolezal¹³³, K. M. Dona³⁹, M. Donadelli^{83c}, B. Dong¹⁰⁷, J. Donini⁴⁰,
A. D'Onofrio^{77a,77b}, M. D'Onofrio⁹², J. Dopke¹³⁴, A. Doria^{72a}, N. Dos Santos Fernandes^{130a}, P. Dougan¹⁰¹,
M. T. Dova⁹⁰, A. T. Doyle⁵⁹, M. A. Draguet¹²⁶, E. Dreyer¹⁶⁹, I. Drivas-koulouris¹⁰, M. Drnevich¹¹⁷,
A. S. Drobac¹⁵⁸, M. Drozdova⁵⁶, D. Du^{62a}, T. A. du Pree¹¹⁴, F. Dubinin³⁷, M. Dubovsky^{28a}, E. Duchovni¹⁶⁹,
G. Duckeck¹⁰⁹, O. A. Ducu^{27b}, D. Duda⁵², A. Dudarev³⁶, E. R. Duden²⁶, M. D'uffizi¹⁰¹, L. Duflost⁶⁶,
M. Dührssen³⁶, C. Dülsen¹⁷¹, A. E. Dumitriu^{27b}, M. Dunford^{63a}, S. Dungs⁴⁹, K. Dunne^{47a,47b}, A. Duperrin¹⁰²,
H. Duran Yildiz^{3a}, M. Düren⁵⁸, A. Durglishvili^{149b}, B. L. Dwyer¹¹⁵, G. I. Dyckes^{17a}, M. Dyndal^{86a},
B. S. Dziedzic⁸⁷, Z. O. Earnshaw¹⁴⁶, G. H. Eberwein¹²⁶, B. Eckerova^{28a}, S. Eggebrecht⁵⁵,
E. Egidio Purcino De Souza¹²⁷, L. F. Ehrke⁵⁶, G. Eigen¹⁶, K. Einsweiler^{17a}, T. Ekelof¹⁶¹, P. A. Ekman⁹⁸,
S. El Farkh^{35b}, Y. El Ghazali^{35b}, H. El Jarrari^{35e,148}, A. El Moussaouy^{108,u}, V. Ellajosyula¹⁶¹, M. Ellert¹⁶¹,
F. Ellinghaus¹⁷¹, N. Ellis³⁶, J. Elmsheuser²⁹, M. Elsing³⁶, D. Emelianov¹³⁴, Y. Enari¹⁵³, I. Ene^{17a}, S. Epari¹³,
J. Erdmann⁴⁹, P. A. Erland⁸⁷, M. Errenst¹⁷¹, M. Escalier⁶⁶, C. Escobar¹⁶³, E. Etzion¹⁵¹, G. Evans^{130a},
H. Evans⁶⁸, L. S. Evans⁹⁵, M. O. Evans¹⁴⁶, A. Ezhilov³⁷, S. Ezzarqtouni^{35a}, F. Fabbri⁵⁹, L. Fabbri^{23b,23a},
G. Facini⁹⁶, V. Fadeyev¹³⁶, R. M. Fakhrutdinov³⁷, S. Falciano^{75a}, L. F. Falda Ulhoa Coelho³⁶, P. J. Falke²⁴,
J. Faltova¹³³, C. Fan¹⁶², Y. Fan^{14a}, Y. Fang^{14a,14e}, M. Fanti^{71a,71b}, M. Faraj^{69a,69b}, Z. Farazpay⁹⁷, A. Farbin⁸,
A. Farilla^{77a}, T. Farooque¹⁰⁷, S. M. Farrington⁵², F. Fassi^{35e}, D. Fassouliotis⁹, M. Fauci Giannelli^{76a,76b},
W. J. Fawcett³², L. Fayard⁶⁶, P. Federic¹³³, P. Federicova¹³¹, O. L. Fedin^{37,p}, G. Fedotov³⁷, M. Feickert¹⁷⁰

L. Feligioni¹⁰² D. E. Fellers¹²³ C. Feng^{62b} M. Feng^{14b} Z. Feng¹¹⁴ M. J. Fenton¹⁶⁰ A. B. Fenyuk³⁷
 L. Ferencz⁴⁸ R. A. M. Ferguson⁹¹ S. I. Fernandez Luengo^{137f} P. Fernandez Martinez¹³ M. J. V. Fernoux¹⁰²
 J. Ferrando⁴⁸ A. Ferrari¹⁶¹ P. Ferrari^{114,113} R. Ferrari^{73a} D. Ferrere⁵⁶ C. Ferretti¹⁰⁶ F. Fiedler¹⁰⁰
 P. Fiedler¹³² A. Filipčić⁹³ E. K. Filmer¹ F. Filthaut¹¹³ M. C. N. Fiolhais^{130a,130c,v} L. Fiorini¹⁶³
 W. C. Fisher¹⁰⁷ T. Fitschen¹⁰¹ P. M. Fitzhugh¹³⁵ I. Fleck¹⁴¹ P. Fleischmann¹⁰⁶ T. Flick¹⁷¹ M. Flores^{33d,w}
 L. R. Flores Castillo^{64a} L. Flores Sanz De Acedo³⁶ F. M. Follega^{78a,78b} N. Fomin¹⁶ J. H. Foo¹⁵⁵ B. C. Forland⁶⁸
 A. Formica¹³⁵ A. C. Forti¹⁰¹ E. Fortin³⁶ A. W. Fortman⁶¹ M. G. Foti^{17a} L. Fountas^{9,x} D. Fournier⁶⁶
 H. Fox⁹¹ P. Francavilla^{74a,74b} S. Francescato⁶¹ S. Franchellucci⁵⁶ M. Franchini^{23b,23a} S. Franchino^{63a}
 D. Francis³⁶ L. Franco¹¹³ V. Franco Lima³⁶ L. Franconi⁴⁸ M. Franklin⁶¹ G. Frattari²⁶ A. C. Freegard⁹⁴
 W. S. Freund^{83b} Y. Y. Frid¹⁵¹ J. Friend⁵⁹ N. Fritzsche⁵⁰ A. Froch⁵⁴ D. Froidevaux³⁶ J. A. Frost¹²⁶ Y. Fu^{62a}
 S. Fuenzalida Garrido^{137f} M. Fujimoto¹⁰² E. Fullana Torregrosa^{163,a} K. Y. Fung^{64a} E. Furtado De Simas Filho^{83b}
 M. Furukawa¹⁵³ J. Fuster¹⁶³ A. Gabrielli^{23b,23a} A. Gabrielli¹⁵⁵ P. Gadow³⁶ G. Gagliardi^{57b,57a}
 L. G. Gagnon^{17a} E. J. Gallas¹²⁶ B. J. Gallop¹³⁴ K. K. Gan¹¹⁹ S. Ganguly¹⁵³ Y. Gao⁵²
 F. M. Garay Walls^{137a,137b} B. Garcia^{29j} C. García¹⁶³ A. Garcia Alonso¹¹⁴ A. G. Garcia Caffaro¹⁷²
 J. E. García Navarro¹⁶³ M. Garcia-Sciveres^{17a} G. L. Gardner¹²⁸ R. W. Gardner³⁹ N. Garelli¹⁵⁸ D. Garg⁸⁰
 R. B. Garg^{143,y} J. M. Gargan⁵² C. A. Garner¹⁵⁵ C. M. Garvey^{33a} P. Gaspar^{83b} V. K. Gassmann¹⁵⁸ G. Gaudio^{73a}
 V. Gautam¹³ P. Gauzzi^{75a,75b} I. L. Gavrilenko³⁷ A. Gavrilyuk³⁷ C. Gay¹⁶⁴ G. Gaycken⁴⁸ E. N. Gaziz¹⁰
 A. A. Geanta^{27b} C. M. Gee¹³⁶ A. Gekow¹¹⁹ C. Gemme^{57b} M. H. Genest⁶⁰ S. Gentile^{75a,75b} A. D. Gentry¹¹²
 S. George⁹⁵ W. F. George²⁰ T. Geralis⁴⁶ P. Gessinger-Befurt³⁶ M. E. Geyik¹⁷¹ M. Ghani¹⁶⁷ M. Ghneimat¹⁴¹
 K. Ghorbanian⁹⁴ A. Ghosal¹⁴¹ A. Ghosh¹⁶⁰ A. Ghosh⁷ B. Giacobbe^{23b} S. Giagu^{75a,75b} T. Giani¹¹⁴
 P. Giannetti^{74a} A. Giannini^{62a} S. M. Gibson⁹⁵ M. Gignac¹³⁶ D. T. Gil^{86b} A. K. Gilbert^{86a} B. J. Gilbert⁴¹
 D. Gillberg³⁴ G. Gilles¹¹⁴ N. E. K. Gillwald⁴⁸ L. Ginabat¹²⁷ D. M. Gingrich^{2,e} M. P. Giordani^{69a,69c}
 P. F. Giraud¹³⁵ G. Giugliarelli^{69a,69c} D. Giugni^{71a} F. Giulia³⁶ I. Gkialas^{9,x} L. K. Gladilin³⁷ C. Glasman⁹⁹
 G. R. Gledhill¹²³ G. Glemža⁴⁸ M. Glisic¹²³ I. Gnesi^{43b,z} Y. Go^{29j} M. Goblirsch-Kolb³⁶ B. Gocke⁴⁹
 D. Godin¹⁰⁸ B. Gokturk^{21a} S. Goldfarb¹⁰⁵ T. Golling⁵⁶ M. G. D. Gololo^{33g} D. Golubkov³⁷ J. P. Gombas¹⁰⁷
 A. Gomes^{130a,130b} G. Gomes Da Silva¹⁴¹ A. J. Gomez Delegido¹⁶³ R. Gonçalo^{130a,130c} G. Gonella¹²³
 L. Gonella²⁰ A. Gongadze^{149c} F. Gonnella²⁰ J. L. Gonski⁴¹ R. Y. González Andana⁵² S. González de la Hoz¹⁶³
 S. Gonzalez Fernandez¹³ R. Gonzalez Lopez⁹² C. Gonzalez Renteria^{17a} M. V. Gonzalez Rodrigues⁴⁸
 R. Gonzalez Suarez¹⁶¹ S. Gonzalez-Sevilla⁵⁶ G. R. Gonzalvo Rodriguez¹⁶³ L. Goossens³⁶ B. Gorini³⁶
 E. Gorini^{70a,70b} A. Gorišek⁹³ T. C. Gosart¹²⁸ A. T. Goshaw⁵¹ M. I. Gostkin³⁸ S. Goswami¹²¹
 C. A. Gottardo³⁶ S. A. Gotz¹⁰⁹ M. Gouighri^{35b} V. Goumarre⁴⁸ A. G. Goussiou¹³⁸ N. Govender^{33c}
 I. Grabowska-Bold^{86a} K. Graham³⁴ E. Gramstad¹²⁵ S. Grancagnolo^{70a,70b} M. Grandi¹⁴⁶ C. M. Grant^{1,135}
 P. M. Gravila^{27f} F. G. Gravili^{70a,70b} H. M. Gray^{17a} M. Greco^{70a,70b} C. Greife²⁴ I. M. Gregor⁴⁸ P. Grenier¹⁴³
 S. G. Grewe¹¹⁰ C. Grieco¹³ A. A. Grillo¹³⁶ K. Grimm³¹ S. Grinstein^{13,aa} J.-F. Grivaz⁶⁶ E. Gross¹⁶⁹
 J. Grosse-Knetter⁵⁵ C. Grud¹⁰⁶ J. C. Grundy¹²⁶ L. Guan¹⁰⁶ W. Guan²⁹ C. Gubbels¹⁶⁴
 J. G. R. Guerrero Rojas¹⁶³ G. Guerrieri^{69a,69c} F. Guescini¹¹⁰ R. Gugel¹⁰⁰ J. A. M. Guhit¹⁰⁶ A. Guida¹⁸
 T. Guillemin⁴ E. Guilloton^{167,134} S. Guindon³⁶ F. Guo^{14a,14e} J. Guo^{62c} L. Guo⁴⁸ Y. Guo¹⁰⁶ R. Gupta⁴⁸
 R. Gupta¹²⁹ S. Gurbuz²⁴ S. S. Gurdasani⁵⁴ G. Gustavino³⁶ M. Guth⁵⁶ P. Gutierrez¹²⁰
 L. F. Gutierrez Zagazeta¹²⁸ M. Gutsche⁵⁰ C. Gutschow⁹⁶ C. Gwenlan¹²⁶ C. B. Gwilliam⁹² E. S. Haaland¹²⁵
 A. Haas¹¹⁷ M. Habedank⁴⁸ C. Haber^{17a} H. K. Hadavand⁸ A. Hadeef¹⁰⁰ S. Hadzic¹¹⁰ A. I. Hagan⁹¹
 J. J. Hahn¹⁴¹ E. H. Haines⁹⁶ M. Haleem¹⁶⁶ J. Haley¹²¹ J. J. Hall¹³⁹ G. D. Hallewell¹⁰² L. Halser¹⁹
 K. Hamano¹⁶⁵ M. Hamer²⁴ G. N. Hamity⁵² E. J. Hampshire⁹⁵ J. Han^{62b} K. Han^{62a} L. Han^{14c} L. Han^{62a}
 S. Han^{17a} Y. F. Han¹⁵⁵ K. Hanagaki⁸⁴ M. Hance¹³⁶ D. A. Hangal^{41,d} H. Hanif¹⁴² M. D. Hank¹²⁸
 R. Hankache¹⁰¹ J. B. Hansen⁴² J. D. Hansen⁴² P. H. Hansen⁴² K. Hara¹⁵⁷ D. Harada⁵⁶ T. Harenberg¹⁷¹
 S. Harkusha³⁷ M. L. Harris¹⁰³ Y. T. Harris¹²⁶ J. Harrison¹³ N. M. Harrison¹¹⁹ P. F. Harrison¹⁶⁷
 N. M. Hartman¹¹⁰ N. M. Hartmann¹⁰⁹ Y. Hasegawa¹⁴⁰ R. Hauser¹⁰⁷ C. M. Hawkes²⁰ R. J. Hawkings³⁶
 Y. Hayashi¹⁵³ S. Hayashida¹¹¹ D. Hayden¹⁰⁷ C. Hayes¹⁰⁶ R. L. Hayes¹¹⁴ C. P. Hays¹²⁶ J. M. Hays⁹⁴
 H. S. Hayward⁹² F. He^{62a} M. He^{14a,14e} Y. He¹⁵⁴ Y. He⁴⁸ N. B. Heatley⁹⁴ V. Hedberg⁹⁸ A. L. Heggelund¹²⁵
 N. D. Hehir⁹⁴ C. Heidegger⁵⁴ K. K. Heidegger⁵⁴ W. D. Heidorn⁸¹ J. Heilman³⁴ S. Heim⁴⁸ T. Heim^{17a}

J. G. Heinlein¹²⁸ J. J. Heinrich¹²³ L. Heinrich^{110,bb} J. Hejbal¹³¹ L. Helary⁴⁸ A. Held¹⁷⁰ S. Hellesund¹⁶ C. M. Helling¹⁶⁴ S. Hellman^{47a,47b} R. C. W. Henderson⁹¹ L. Henkelmann³² A. M. Henriques Correia³⁶ H. Herde⁹⁸ Y. Hernández Jiménez¹⁴⁵ L. M. Herrmann²⁴ T. Herrmann⁵⁰ G. Hertel⁵⁴ R. Hertenberger¹⁰⁹ L. Hervas³⁶ M. E. Hesping¹⁰⁰ N. P. Hessey^{156a} H. Hibi⁸⁵ E. Hill¹⁵⁵ S. J. Hillier²⁰ J. R. Hinds¹⁰⁷ F. Hinterkeuser²⁴ M. Hirose¹²⁴ S. Hirose¹⁵⁷ D. Hirschbuehl¹⁷¹ T. G. Hitchings¹⁰¹ B. Hiti⁹³ J. Hobbs¹⁴⁵ R. Hobincu^{27e} N. Hod¹⁶⁹ M. C. Hodgkinson¹³⁹ B. H. Hodgkinson³² A. Hoecker³⁶ D. D. Hofer¹⁰⁶ J. Hofer⁴⁸ T. Holm²⁴ M. Holzbock¹¹⁰ L. B. A. H. Hommels³² B. P. Honan¹⁰¹ J. Hong^{62c} T. M. Hong¹²⁹ B. H. Hooberman¹⁶² W. H. Hopkins⁶ Y. Horii¹¹¹ S. Hou¹⁴⁸ A. S. Howard⁹³ J. Howarth⁵⁹ J. Hoya⁶ M. Hrabovsky¹²² A. Hrynevich⁴⁸ T. Hryn'ova⁴ P. J. Hsu⁶⁵ S.-C. Hsu¹³⁸ Q. Hu^{62a} Y. F. Hu^{14a,14e} S. Huang^{64b} X. Huang^{14c} X. Huang^{14a,14e} Y. Huang^{139,cc} Y. Huang^{14a} Z. Huang¹⁰¹ Z. Hubacek¹³² M. Huebner²⁴ F. Huegging²⁴ T. B. Huffman¹²⁶ C. A. Hugli⁴⁸ M. Huhtinen³⁶ S. K. Huiberts¹⁶ R. Hulsken¹⁰⁴ N. Huseynov¹² J. Huston¹⁰⁷ J. Huth⁶¹ R. Hyneman¹⁴³ G. Iacobucci⁵⁶ G. Iakovidis²⁹ I. Ibragimov¹⁴¹ L. Iconomidou-Fayard⁶⁶ P. Ingo^{72a,72b} R. Iguchi¹⁵³ T. Iizawa^{126,dd} Y. Ikegami⁸⁴ N. Ilic¹⁵⁵ H. Imam^{35a} M. Ince Lezki⁵⁶ T. Ingebretsen Carlson^{47a,47b} G. Introzzi^{73a,73b} M. Iodice^{77a} V. Ippolito^{75a,75b} R. K. Irwin⁹² M. Ishino¹⁵³ W. Islam¹⁷⁰ C. Issever^{18,48} S. Istin^{21a,ee} H. Ito¹⁶⁸ J. M. Iturbe Ponce^{64a} R. Iuppa^{78a,78b} A. Ivina¹⁶⁹ J. M. Izen⁴⁵ V. Izzo^{72a} P. Jacka^{131,132} P. Jackson¹ R. M. Jacobs⁴⁸ B. P. Jaeger¹⁴² C. S. Jagfeld¹⁰⁹ G. Jain^{156a} P. Jain⁵⁴ K. Jakobs⁵⁴ T. Jakoubek¹⁶⁹ J. Jamieson⁵⁹ K. W. Janas^{86a} M. Javurkova¹⁰³ F. Jeanneau¹³⁵ L. Jeanty¹²³ J. Jejelava^{149a,ff} P. Jenni^{54,gg} C. E. Jessiman³⁴ S. Jézéquel⁴ C. Jia^{62b} J. Jia¹⁴⁵ X. Jia⁶¹ X. Jia^{14a,14c} Z. Jia^{14c} S. Jiggins⁴⁸ J. Jimenez Pena¹³ S. Jin^{14c} A. Jinaru^{27b} O. Jinnouchi¹⁵⁴ P. Johansson¹³⁹ K. A. Johns⁷ J. W. Johnson¹³⁶ D. M. Jones³² E. Jones⁴⁸ P. Jones³² R. W. L. Jones⁹¹ T. J. Jones⁹² H. L. Joos^{55,36} R. Joshi¹¹⁹ J. Jovicevic¹⁵ X. Ju^{17a} J. J. Junggeburth^{103,hh} T. Junkermann^{63a} A. Juste Rozas^{13,aa} M. K. Juzek⁸⁷ S. Kabana^{137e} A. Kaczmarzka⁸⁷ M. Kado¹¹⁰ H. Kagan¹¹⁹ M. Kagan¹⁴³ A. Kahn⁴¹ A. Kahn¹²⁸ C. Kahra¹⁰⁰ T. Kaji¹⁵³ E. Kajomovitz¹⁵⁰ N. Kakati¹⁶⁹ I. Kalaitzidou⁵⁴ C. W. Kalderon²⁹ A. Kamenshchikov¹⁵⁵ N. J. Kang¹³⁶ D. Kar^{33g} K. Karava¹²⁶ M. J. Kareem^{156b} E. Karentzos⁵⁴ I. Karkanias¹⁵² O. Karkout¹¹⁴ S. N. Karpov³⁸ Z. M. Karpova³⁸ V. Kartvelishvili⁹¹ A. N. Karyukhin³⁷ E. Kasimi¹⁵² J. Katzy⁴⁸ S. Kaur³⁴ K. Kawade¹⁴⁰ M. P. Kawale¹²⁰ C. Kawamoto⁸⁸ T. Kawamoto¹³⁵ E. F. Kay³⁶ F. I. Kaya¹⁵⁸ S. Kazakos¹⁰⁷ V. F. Kazanin³⁷ Y. Ke¹⁴⁵ J. M. Keaveney^{33a} R. Keeler¹⁶⁵ G. V. Kehris⁶¹ J. S. Keller³⁴ A. S. Kelly⁹⁶ J. J. Kempster¹⁴⁶ K. E. Kennedy⁴¹ P. D. Kennedy¹⁰⁰ O. Kepka¹³¹ B. P. Kerridge¹⁶⁷ S. Kersten¹⁷¹ B. P. Kerševan⁹³ S. Keshri⁶⁶ L. Keszeghova^{28a} S. Ketabchi Haghghat¹⁵⁵ R. A. Khan¹²⁹ M. Khandoga¹²⁷ A. Khanov¹²¹ A. G. Kharlamov³⁷ T. Kharlamova³⁷ E. E. Khoda¹³⁸ M. Kholodenko³⁷ T. J. Khoo¹⁸ G. Khoraiuli¹⁶⁶ J. Khubua^{149b} Y. A. R. Khwaira⁶⁶ A. Kilgallon¹²³ D. W. Kim^{47a,47b} Y. K. Kim³⁹ N. Kimura⁹⁶ M. K. Kingston⁵⁵ A. Kirchhoff⁵⁵ C. Kirfel²⁴ F. Kirfel²⁴ J. Kirk¹³⁴ A. E. Kiryunin¹¹⁰ C. Kitsaki¹⁰ O. Kivernyk²⁴ M. Klassen^{63a} C. Klein³⁴ L. Klein¹⁶⁶ M. H. Klein¹⁰⁶ M. Klein⁹² S. B. Klein⁵⁶ U. Klein⁹² P. Klimek³⁶ A. Klimentov²⁹ T. Klioutchnikova³⁶ P. Kluit¹¹⁴ S. Kluth¹¹⁰ E. Kneringer⁷⁹ T. M. Knight¹⁵⁵ A. Knue⁴⁹ R. Kobayashi⁸⁸ D. Kobylanski¹⁶⁹ S. F. Koch¹²⁶ M. Kocian¹⁴³ P. Kodyš¹³³ D. M. Koeck¹²³ P. T. Koenig²⁴ T. Koffas³⁴ O. Kolay⁵⁰ M. Kolb¹³⁵ I. Koletsou⁴ T. Komarek¹²² K. Köneke⁵⁴ A. X. Y. Kong¹ T. Kono¹¹⁸ N. Konstantinidis⁹⁶ P. Kontaxakis⁵⁶ B. Konya⁹⁸ R. Kopeliansky⁶⁸ S. Koperny^{86a} K. Korcyl⁸⁷ K. Kordas^{152,ii} G. Koren¹⁵¹ A. Korn⁹⁶ S. Korn⁵⁵ I. Korolkov¹³ N. Korotkova³⁷ B. Kortman¹¹⁴ O. Kortner¹¹⁰ S. Kortner¹¹⁰ W. H. Kostecka¹¹⁵ V. V. Kostyukhin¹⁴¹ A. Kotsokhechagia¹³⁵ A. Kotwal⁵¹ A. Koulouris³⁶ A. Kourkoumeli-Charalampidi^{73a,73b} C. Kourkoumelis⁹ E. Kourlitis^{110,bb} O. Kovanda¹⁴⁶ R. Kowalewski¹⁶⁵ W. Kozanecki¹³⁵ A. S. Kozhin³⁷ V. A. Kramarenko³⁷ G. Kramberger⁹³ P. Kramer¹⁰⁰ M. W. Krasny¹²⁷ A. Krasznahorkay³⁶ J. W. Kraus¹⁷¹ J. A. Kremer⁴⁸ T. Kresse⁵⁰ J. Kretschmar⁹² K. Kreul¹⁸ P. Krieger¹⁵⁵ S. Krishnamurthy¹⁰³ M. Krivos¹³³ K. Krizka²⁰ K. Kroeninger⁴⁹ H. Kroha¹¹⁰ J. Kroll¹³¹ J. Kroll¹²⁸ K. S. Krowpman¹⁰⁷ U. Kruchonak³⁸ H. Krüger²⁴ N. Krumnack⁸¹ M. C. Kruse⁵¹ J. A. Krzysiak⁸⁷ O. Kuchinskaia³⁷ S. Kuday^{3a} S. Kuehn³⁶ R. Kuesters⁵⁴ T. Kuhl⁴⁸ V. Kukhtin³⁸ Y. Kulchitsky^{37,p} S. Kuleshov^{137d,137b} M. Kumar^{33g} N. Kumari⁴⁸ A. Kupco¹³¹ T. Kupfer⁴⁹ A. Kupich³⁷ O. Kuprash⁵⁴ H. Kurashige⁸⁵ L. L. Kurchaninov^{156a} O. Kurdysh⁶⁶ Y. A. Kurochkin³⁷ A. Kurova³⁷ M. Kuze¹⁵⁴ A. K. Kvam¹⁰³ J. Kvita¹²² T. Kwan¹⁰⁴ N. G. Kyriacou¹⁰⁶ L. A. O. Laatu¹⁰² C. Lacasta¹⁶³ F. Lacava^{75a,75b} H. Lacker¹⁸ D. Lacour¹²⁷ N. N. Lad⁹⁶ E. Ladygin³⁸

B. Laforge¹²⁷ T. Lagouri^{137e} F. Z. Lahbabi^{35a} S. Lai⁵⁵ I. K. Lakomic^{86a} N. Lalloue⁶⁰ J. E. Lambert^{165,1}
 S. Lammers⁶⁸ W. Lampl⁷ C. Lampoudis^{152,ii} A. N. Lancaster¹¹⁵ E. Lançon²⁹ U. Landgraf⁵⁴
 M. P. J. Landon⁹⁴ V. S. Lang⁵⁴ R. J. Langenberg¹⁰³ O. K. B. Langrekken¹²⁵ A. J. Lankford¹⁶⁰ F. Lanni³⁶
 K. Lantzsch²⁴ A. Lanza^{73a} A. Lapertosa^{57b,57a} J. F. Laporte¹³⁵ T. Lari^{71a} F. Lasagni Manghi^{23b} M. Lassnig³⁶
 V. Latonova¹³¹ A. Laudrain¹⁰⁰ A. Laurier¹⁵⁰ S. D. Lawlor¹³⁹ Z. Lawrence¹⁰¹ R. Lazaridou¹⁶⁷
 M. Lazzaroni^{71a,71b} B. Le¹⁰¹ E. M. Le Boulicaut⁵¹ B. Leban⁹³ A. Lebedev⁸¹ M. LeBlanc^{101,1j}
 F. Ledroit-Guillon⁶⁰ A. C. A. Lee⁹⁶ S. C. Lee¹⁴⁸ S. Lee^{47a,47b} T. F. Lee⁹² L. L. Leeuw^{33c} H. P. Lefebvre⁹⁵
 M. Lefebvre¹⁶⁵ C. Leggett^{17a} G. Lehmann Miotto³⁶ M. Leigh⁵⁶ W. A. Leight¹⁰³ W. Leinonen¹¹³
 A. Leisos^{152,kk} M. A. L. Leite^{83c} C. E. Leitgeb⁴⁸ R. Leitner¹³³ K. J. C. Leney⁴⁴ T. Lenz²⁴ S. Leone^{74a}
 C. Leonidopoulos⁵² A. Leopold¹⁴⁴ C. Leroy¹⁰⁸ R. Les¹⁰⁷ C. G. Lester³² M. Levchenko³⁷ J. Levêque⁴
 D. Levin¹⁰⁶ L. J. Levinson¹⁶⁹ M. P. Lewicki⁸⁷ D. J. Lewis⁴ A. Li⁵ B. Li^{62b} C. Li^{62a} C-Q. Li^{62c} H. Li^{62a}
 H. Li^{62b} H. Li^{14c} H. Li^{14b} H. Li^{62b} J. Li^{62c} K. Li¹³⁸ L. Li^{62c} M. Li^{14a,14e} Q. Y. Li^{62a} S. Li^{14a,14e}
 S. Li^{62d,62c,1l} T. Li^{5,mm} X. Li¹⁰⁴ Z. Li¹²⁶ Z. Li¹⁰⁴ Z. Li⁹² Z. Li^{14a,14e} S. Liang^{14a,14e} Z. Liang^{14a}
 M. Liberatore^{135,nn} B. Liberti^{76a} K. Lie^{64c} J. Lieber Marin^{83b} H. Lien⁶⁸ K. Lin¹⁰⁷ R. E. Lindley⁷
 J. H. Lindon² E. Lipeles¹²⁸ A. Lipniacka¹⁶ A. Lister¹⁶⁴ J. D. Little⁴ B. Liu^{14a} B. X. Liu¹⁴² D. Liu^{62d,62c}
 J. B. Liu^{62a} J. K. K. Liu³² K. Liu^{62d,62c} M. Liu^{62a} M. Y. Liu^{62a} P. Liu^{14a} Q. Liu^{62d,138,62c} X. Liu^{62a}
 Y. Liu^{14d,14e} Y. L. Liu^{62b} Y. W. Liu^{62a} J. Llorente Merino¹⁴² S. L. Lloyd⁹⁴ E. M. Lobodzinska⁴⁸ P. Loch⁷
 T. Lohse¹⁸ K. Lohwasser¹³⁹ E. Loiacono⁴⁸ M. Lokajicek^{131,a} J. D. Lomas²⁰ J. D. Long¹⁶² I. Longarini¹⁶⁰
 L. Longo^{70a,70b} R. Longo¹⁶² I. Lopez Paz⁶⁷ A. Lopez Solis⁴⁸ J. Lorenz¹⁰⁹ N. Lorenzo Martinez⁴
 A. M. Lory¹⁰⁹ O. Loseva³⁷ X. Lou^{47a,47b} X. Lou^{14a,14e} A. Lounis⁶⁶ J. Love⁶ P. A. Love⁹¹ G. Lu^{14a,14e}
 M. Lu⁸⁰ S. Lu¹²⁸ Y. J. Lu⁶⁵ H. J. Lubatti¹³⁸ C. Luci^{75a,75b} F. L. Lucio Alves^{14c} A. Lucotte⁶⁰ F. Luehring⁶⁸
 I. Luise¹⁴⁵ O. Lukianchuk⁶⁶ O. Lundberg¹⁴⁴ B. Lund-Jensen¹⁴⁴ N. A. Luongo¹²³ M. S. Lutz¹⁵¹ A. B. Lux²⁵
 D. Lynn²⁹ H. Lyons⁹² R. Lysak¹³¹ E. Lytken⁹⁸ V. Lyubushkin³⁸ T. Lyubushkina³⁸ M. M. Lyukova¹⁴⁵
 H. Ma²⁹ K. Ma^{62a} L. L. Ma^{62b} W. Ma^{62a} Y. Ma¹²¹ D. M. Mac Donell¹⁶⁵ G. Maccarrone⁵³
 J. C. MacDonald¹⁰⁰ P. C. Machado De Abreu Farias^{83b} R. Madar⁴⁰ W. F. Mader⁵⁰ T. Madula⁹⁶ J. Maeda⁸⁵
 T. Maeno²⁹ H. Maguire¹³⁹ V. Maiboroda¹³⁵ A. Maio^{130a,130b,130d} K. Maj^{86a} O. Majersky⁴⁸ S. Majewski¹²³
 N. Makovec⁶⁶ V. Maksimovic¹⁵ B. Malaescu¹²⁷ Pa. Malecki⁸⁷ V. P. Maleev³⁷ F. Malek⁶⁰ M. Mali⁹³
 D. Malito^{95,oo} U. Mallik⁸⁰ S. Maltezos¹⁰ S. Malyukov³⁸ J. Mamuzic¹³ G. Mancini⁵³ G. Manco^{73a,73b}
 J. P. Mandalia⁹⁴ I. Mandić⁹³ L. Manhaes de Andrade Filho^{83a} I. M. Maniatis¹⁶⁹ J. Manjarres Ramos^{102,pp}
 D. C. Mankad¹⁶⁹ A. Mann¹⁰⁹ B. Mansoulie¹³⁵ S. Manzoni³⁶ L. Mao^{62c} X. Mapekula^{33c} A. Marantis^{152,kk}
 G. Marchiori⁵ M. Marcisovsky¹³¹ C. Marcon^{71a,71b} M. Marinescu²⁰ M. Marjanovic¹²⁰ E. J. Marshall⁹¹
 Z. Marshall^{17a} S. Marti-Garcia¹⁶³ T. A. Martin¹⁶⁷ V. J. Martin⁵² B. Martin dit Latour¹⁶ L. Martinelli^{75a,75b}
 M. Martinez^{13,aa} P. Martinez Agullo¹⁶³ V. I. Martinez Outschoorn¹⁰³ P. Martinez Suarez¹³ S. Martin-Haugh¹³⁴
 V. S. Martoiu^{27b} A. C. Martyniuk⁹⁶ A. Marzin³⁶ D. Mascione^{78a,78b} L. Masetti¹⁰⁰ T. Mashimo¹⁵³ J. Masik¹⁰¹
 A. L. Maslennikov³⁷ L. Massa^{23b} P. Massarotti^{72a,72b} P. Mastrandrea^{74a,74b} A. Mastroberardino^{43b,43a}
 T. Masubuchi¹⁵³ T. Mathisen¹⁶¹ J. Matousek¹³³ N. Matsuzawa¹⁵³ J. Maurer^{27b} B. Maček⁹³ D. A. Maximov³⁷
 R. Mazini¹⁴⁸ I. Maznas¹⁵² M. Mazza¹⁰⁷ S. M. Mazza¹³⁶ E. Mazzeo^{71a,71b} C. Mc Ginn²⁹ J. P. Mc Gowan¹⁰⁴
 S. P. Mc Kee¹⁰⁶ E. F. McDonald¹⁰⁵ A. E. McDougall¹¹⁴ J. A. Mcfayden¹⁴⁶ R. P. McGovern¹²⁸
 G. Mchedlidze^{149b} R. P. Mckenzie^{33g} T. C. Mclachlan⁴⁸ D. J. Mclaughlin⁹⁶ S. J. McMahon¹³⁴
 C. M. Mcpartland⁹² R. A. McPherson^{165,t} S. Mehlhase¹⁰⁹ A. Mehta⁹² D. Melini¹⁵⁰ B. R. Mellado Garcia^{33g}
 A. H. Melo⁵⁵ F. Meloni⁴⁸ A. M. Mendes Jacques Da Costa¹⁰¹ H. Y. Meng¹⁵⁵ L. Meng⁹¹ S. Menke¹¹⁰
 M. Mentink³⁶ E. Meoni^{43b,43a} G. Mercado¹¹⁵ C. Merlassino¹²⁶ L. Merola^{72a,72b} C. Meroni^{71a,71b} G. Merz¹⁰⁶
 O. Meshkov³⁷ J. Metcalfe⁶ A. S. Mete⁶ C. Meyer⁶⁸ J-P. Meyer¹³⁵ R. P. Middleton¹³⁴ L. Mijović⁵²
 G. Mikenberg¹⁶⁹ M. Mikestikova¹³¹ M. Mikuž⁹³ H. Mildner¹⁰⁰ A. Milic³⁶ C. D. Milke⁴⁴ D. W. Miller³⁹
 L. S. Miller³⁴ A. Milov¹⁶⁹ D. A. Milstead^{47a,47b} T. Min^{14c} A. A. Minaenko³⁷ I. A. Minashvili^{149b} L. Mince⁵⁹
 A. I. Mincer¹¹⁷ B. Mindur^{86a} M. Mineev³⁸ Y. Mino⁸⁸ L. M. Mir¹³ M. Miralles Lopez¹⁶³ M. Mironova^{17a}
 A. Mishima¹⁵³ M. C. Missio¹¹³ A. Mitra¹⁶⁷ V. A. Mitsou¹⁶³ Y. Mitsumori¹¹¹ O. Miu¹⁵⁵ P. S. Miyagawa⁹⁴
 T. Mkrtchyan^{63a} M. Mlinarevic⁹⁶ T. Mlinarevic⁹⁶ M. Mlynarikova³⁶ S. Mobius¹⁹ P. Moder⁴⁸ P. Mogg¹⁰⁹
 A. F. Mohammed^{14a,14e} S. Mohapatra⁴¹ G. Mokgatitwane^{33g} L. Moleri¹⁶⁹ B. Mondal¹⁴¹ S. Mondal¹³²

G. Monig¹⁴⁶ K. Mönig⁴⁸ E. Monnier¹⁰² L. Monsonis Romero¹⁶³ J. Montejo Berlingen¹³ M. Montella¹¹⁹
 F. Montekali^{77a,77b} F. Monticelli⁹⁰ S. Monzani^{69a,69c} N. Morange⁶⁶ A. L. Moreira De Carvalho^{130a}
 M. Moreno Llácer¹⁶³ C. Moreno Martinez⁵⁶ P. Morettini^{57b} S. Morgenstern³⁶ M. Morii⁶¹ M. Morinaga¹⁵³
 A. K. Morley³⁶ F. Morodei^{75a,75b} L. Morvaj³⁶ P. Moschovakos³⁶ B. Moser³⁶ M. Mosidze^{149b} T. Moskalets⁵⁴
 P. Moskvitina¹¹³ J. Moss^{31,qq} E. J. W. Moyse¹⁰³ O. Mtintsilana^{33g} S. Muanza¹⁰² J. Mueller¹²⁹
 D. Muenstermann⁹¹ R. Müller¹⁹ G. A. Mullier¹⁶¹ A. J. Mullin³² J. J. Mullin¹²⁸ D. P. Mungo¹⁵⁵
 D. Munoz Perez¹⁶³ F. J. Munoz Sanchez¹⁰¹ M. Murin¹⁰¹ W. J. Murray^{167,134} A. Murrone^{71a,71b} M. Muškinja^{17a}
 C. Mwewa²⁹ A. G. Myagkov^{37,p} A. J. Myers⁸ G. Myers⁶⁸ M. Myska¹³² B. P. Nachman^{17a} O. Nackenhorst⁴⁹
 A. Nag⁵⁰ K. Nagai¹²⁶ K. Nagano⁸⁴ J. L. Nagle^{29,j} E. Nagy¹⁰² A. M. Nairz³⁶ Y. Nakahama⁸⁴
 K. Nakamura⁸⁴ K. Nakkalil⁵ H. Nanjo¹²⁴ R. Narayan⁴⁴ E. A. Narayanan¹¹² I. Naryshkin³⁷ M. Naseri³⁴
 S. Nasri¹⁵⁹ C. Nass²⁴ G. Navarro^{22a} J. Navarro-Gonzalez¹⁶³ R. Nayak¹⁵¹ A. Nayaz¹⁸ P. Y. Nechaeva³⁷
 F. Nechansky⁴⁸ L. Nedic¹²⁶ T. J. Neep²⁰ A. Negri^{73a,73b} M. Negrini^{23b} C. Nellist¹¹⁴ C. Nelson¹⁰⁴
 K. Nelson¹⁰⁶ S. Nemecek¹³¹ M. Nessi^{36,rr} M. S. Neubauer¹⁶² F. Neuhaus¹⁰⁰ J. Neundorff⁴⁸ R. Newhouse¹⁶⁴
 P. R. Newman²⁰ C. W. Ng¹²⁹ Y. W. Y. Ng⁴⁸ B. Ngair^{35e} H. D. N. Nguyen¹⁰⁸ R. B. Nickerson¹²⁶
 R. Nicolaidou¹³⁵ J. Nielsen¹³⁶ M. Niemeier⁵⁵ J. Niermann^{55,36} N. Nikiforou³⁶ V. Nikolaenko^{37,p}
 I. Nikolic-Audit¹²⁷ K. Nikolopoulos²⁰ P. Nilsson²⁹ I. Ninca⁴⁸ H. R. Nindhito⁵⁶ G. Ninio¹⁵¹ A. Nisati^{75a}
 N. Nishu² R. Nisius¹¹⁰ J.-E. Nitschke⁵⁰ E. K. Nkadimeng^{33g} T. Nobe¹⁵³ D. L. Noel³² T. Nommensen¹⁴⁷
 M. B. Norfolk¹³⁹ R. R. B. Norisam⁹⁶ B. J. Norman³⁴ J. Novak⁹³ T. Novak⁴⁸ L. Novotny¹³² R. Novotny¹¹²
 L. Nozka¹²² K. Ntekas¹⁶⁰ N. M. J. Nunes De Moura Junior^{83b} E. Nurse⁹⁶ J. Ocariz¹²⁷ A. Ochi⁸⁵ I. Ochoa^{130a}
 S. Oerdek^{48,ss} J. T. Offermann³⁹ A. Ogrodnik¹³³ A. Oh¹⁰¹ C. C. Ohm¹⁴⁴ H. Oide⁸⁴ R. Oishi¹⁵³
 M. L. Ojeda⁴⁸ M. W. O'Keefe⁹² Y. Okumura¹⁵³ L. F. Oleiro Seabra^{130a} S. A. Olivares Pino^{137d}
 D. Oliveira Damazio²⁹ D. Oliveira Goncalves^{83a} J. L. Oliver¹⁶⁰ Ö. O. Öncel⁵⁴ A. P. O'Neill¹⁹
 A. Onofre^{130a,130e} P. U. E. Onyisi¹¹ M. J. Oreglia³⁹ G. E. Orellana⁹⁰ D. Orestano^{77a,77b} N. Orlando¹³
 R. S. Orr¹⁵⁵ V. O'Shea⁵⁹ L. M. Osojnak¹²⁸ R. Ospanov^{62a} G. Otero y Garzon³⁰ H. Otono⁸⁹ P. S. Ott^{63a}
 G. J. Ottino^{17a} M. Ouchrif^{35d} J. Ouellette²⁹ F. Ould-Saada¹²⁵ M. Owen⁵⁹ R. E. Owen¹³⁴ K. Y. Oyulmaz^{21a}
 V. E. Ozcan^{21a} F. Ozturk⁸⁷ N. Ozturk⁸ S. Ozturk⁸² H. A. Pacey¹²⁶ A. Pacheco Pages¹³ C. Padilla Aranda¹³
 G. Padovano^{75a,75b} S. Pagan Griso^{17a} G. Palacino⁶⁸ A. Palazzo^{70a,70b} S. Palestini³⁶ J. Pan¹⁷² T. Pan^{64a}
 D. K. Panchal¹¹ C. E. Pandini¹¹⁴ J. G. Panduro Vazquez⁹⁵ H. D. Pandya¹ H. Pang^{14b} P. Pani⁴⁸
 G. Panizzo^{69a,69c} L. Paolozzi⁵⁶ C. Papadatos¹⁰⁸ S. Parajuli⁴⁴ A. Paramonov⁶ C. Paraskevopoulos¹⁰
 D. Paredes Hernandez^{64b} K. R. Park⁴¹ T. H. Park¹⁵⁵ M. A. Parker³² F. Parodi^{57b,57a} E. W. Parrish¹¹⁵
 V. A. Parrish⁵² J. A. Parsons⁴¹ U. Parzefall⁵⁴ B. Pascual Dias¹⁰⁸ L. Pascual Dominguez¹⁵¹ E. Pasqualucci^{75a}
 S. Passaggio^{57b} F. Pastore⁹⁵ P. Pasuwan^{47a,47b} P. Patel⁸⁷ U. M. Patel⁵¹ J. R. Pater¹⁰¹ T. Pauly³⁶
 J. Parkes¹⁴³ M. Pedersen¹²⁵ R. Pedro^{130a} S. V. Peleganchuk³⁷ O. Penc³⁶ E. A. Pender⁵² K. E. Pensi¹⁰⁹
 M. Penzin³⁷ B. S. Peralva^{83d} A. P. Pereira Peixoto⁶⁰ L. Pereira Sanchez^{47a,47b} D. V. Perepelitsa^{29,j}
 E. Perez Codina^{156a} M. Perganti¹⁰ L. Perini^{71a,71b,a} H. Pernegger³⁶ O. Perrin⁴⁰ K. Peters⁴⁸ R. F. Y. Peters¹⁰¹
 B. A. Petersen³⁶ T. C. Petersen⁴² E. Petit¹⁰² V. Petousis¹³² C. Petridou^{152,ii} A. Petrukhin¹⁴¹ M. Pettee^{17a}
 N. E. Pettersson³⁶ A. Petukhov³⁷ K. Petukhova¹³³ R. Pezoa^{137f} L. Pezzotti³⁶ G. Pezzullo¹⁷² T. M. Pham¹⁷⁰
 T. Pham¹⁰⁵ P. W. Phillips¹³⁴ G. Piacquadio¹⁴⁵ E. Pianori^{17a} F. Piazza¹²³ R. Piegaia³⁰ D. Pietreanu^{27b}
 A. D. Pilkington¹⁰¹ M. Pinamonti^{69a,69c} J. L. Pinfold² B. C. Pinheiro Pereira^{130a} A. E. Pinto Pinoargote^{100,135}
 L. Pintucci^{69a,69c} K. M. Piper¹⁴⁶ A. Pirttikoski⁵⁶ D. A. Pizzi³⁴ L. Pizzimento^{64b} A. Pizzini¹¹⁴ M.-A. Pleier²⁹
 V. Plesanovs⁵⁴ V. Pleskot¹³³ E. Plotnikova³⁸ G. Poddar⁴ R. Poettgen⁹⁸ L. Poggioli¹²⁷ I. Pokharel⁵⁵
 S. Polacek¹³³ G. Polesello^{73a} A. Poley^{142,156a} R. Polifka¹³² A. Polini^{23b} C. S. Pollard¹⁶⁷ Z. B. Pollock¹¹⁹
 V. Polychronakos²⁹ E. Pompa Pacchi^{75a,75b} D. Ponomarenko¹¹³ L. Pontecorvo³⁶ S. Popa^{27a}
 G. A. Popeneciu^{27d} A. Poreba³⁶ D. M. Portillo Quintero^{156a} S. Pospisil¹³² M. A. Postill¹³⁹ P. Postolache^{27c}
 K. Potamianos¹⁶⁷ P. A. Potepa^{86a} I. N. Potrap³⁸ C. J. Potter³² H. Potti¹ T. Poulsen⁴⁸ J. Poveda¹⁶³
 M. E. Pozo Astigarraga³⁶ A. Prades Ibanez¹⁶³ J. Pretel⁵⁴ D. Price¹⁰¹ M. Primavera^{70a} M. A. Principe Martin⁹⁹
 R. Privara¹²² T. Procter⁵⁹ M. L. Proffitt¹³⁸ N. Proklova¹²⁸ K. Prokofiev^{64c} G. Proto¹¹⁰ S. Protopopescu²⁹
 J. Proudfoot⁶ M. Przybycien^{86a} W. W. Przygoda^{86b} J. E. Puddefoot¹³⁹ D. Pudzha³⁷ D. Pyatiizbyantseva³⁷
 J. Qian¹⁰⁶ D. Qichen¹⁰¹ Y. Qin¹⁰¹ T. Qiu⁵² A. Quadt⁵⁵ M. Queitsch-Maitland¹⁰¹ G. Quetant⁵⁶

R. P. Quinn¹⁶⁴ G. Rabanal Bolanos⁶¹ D. Rafanoharana⁵⁴ F. Ragusa^{71a,71b} J. L. Rainbolt³⁹ J. A. Raine⁵⁶
 S. Rajagopalan²⁹ E. Ramakoti³⁷ I. A. Ramirez-Berend³⁴ K. Ran^{48,14e} N. P. Rapheeha^{33g} H. Rasheed^{27b}
 V. Raskina¹²⁷ D. F. Rassloff^{63a} S. Rave¹⁰⁰ B. Ravina⁵⁵ I. Ravinovich¹⁶⁹ M. Raymond³⁶ A. L. Read¹²⁵
 N. P. Readioff¹³⁹ D. M. Rebuzzi^{73a,73b} G. Redlinger²⁹ A. S. Reed¹¹⁰ K. Reeves²⁶ J. A. Reidelsturz^{171,tt}
 D. Reikher¹⁵¹ A. Rej^{49,uu} C. Rembser³⁶ A. Renardi⁴⁸ M. Renda^{27b} M. B. Rendel¹¹⁰ F. Renner⁴⁸
 A. G. Rennie¹⁶⁰ A. L. Rescia⁴⁸ S. Resconi^{71a} M. Ressegotti^{57b,57a} S. Rettie³⁶ J. G. Reyes Rivera¹⁰⁷
 E. Reynolds^{17a} O. L. Rezanova³⁷ P. Reznicek¹³³ N. Ribaric⁹¹ E. Ricci^{78a,78b} R. Richter¹¹⁰ S. Richter^{47a,47b}
 E. Richter-Was^{86b} M. Ridel¹²⁷ S. Ridouani^{35d} P. Rieck¹¹⁷ P. Riedler³⁶ E. M. Riefel^{47a,47b} J. O. Rieger¹¹⁴
 M. Rijssenbeek¹⁴⁵ A. Rimoldi^{73a,73b} M. Rimoldi³⁶ L. Rinaldi^{23b,23a} T. T. Rinn²⁹ M. P. Rinnagel¹⁰⁹
 G. Ripellino¹⁶¹ I. Riu¹³ P. Rivadeneira⁴⁸ J. C. Rivera Vergara¹⁶⁵ F. Rizatdinova¹²¹ E. Rizvi⁹⁴
 B. A. Roberts¹⁶⁷ B. R. Roberts^{17a} S. H. Robertson^{104,t} D. Robinson³² C. M. Robles Gajardo^{137f}
 M. Robles Manzano¹⁰⁰ A. Robson⁵⁹ A. Rocchi^{76a,76b} C. Roda^{74a,74b} S. Rodriguez Bosca^{63a}
 Y. Rodriguez Garcia^{22a} A. Rodriguez Rodriguez⁵⁴ A. M. Rodríguez Vera^{156b} S. Roe³⁶ J. T. Roemer¹⁶⁰
 A. R. Roepe-Gier¹³⁶ J. Roggel¹⁷¹ O. Røhne¹²⁵ R. A. Rojas¹⁰³ C. P. A. Roland¹²⁷ J. Roloff²⁹
 A. Romaniouk³⁷ E. Romano^{73a,73b} M. Romano^{23b} A. C. Romero Hernandez¹⁶² N. Rompotis⁹² L. Roos¹²⁷
 S. Rosati^{75a} B. J. Rosser³⁹ E. Rossi¹²⁶ E. Rossi^{72a,72b} L. P. Rossi^{57b} L. Rossini⁵⁴ R. Rosten¹¹⁹
 M. Rotaru^{27b} B. Rottler⁵⁴ C. Rougier^{102,pp} D. Rousseau⁶⁶ D. Rouso³² A. Roy¹⁶² S. Roy-Garand¹⁵⁵
 A. Rozanov¹⁰² Z. M. A. Rozario⁵⁹ Y. Rozen¹⁵⁰ X. Ruan^{33g} A. Rubio Jimenez¹⁶³ A. J. Ruby⁹²
 V. H. Ruelas Rivera¹⁸ T. A. Ruggeri¹ A. Ruggiero¹²⁶ A. Ruiz-Martinez¹⁶³ A. Rummler³⁶ Z. Rurikova⁵⁴
 N. A. Rusakovich³⁸ H. L. Russell¹⁶⁵ G. Russo^{75a,75b} J. P. Rutherford⁷ S. Rutherford Colmenares³²
 K. Rybacki⁹¹ M. Rybar¹³³ E. B. Rye¹²⁵ A. Ryzhov⁴⁴ J. A. Sabater Iglesias⁵⁶ P. Sabatini¹⁶³ L. Sabetta^{75a,75b}
 H. F.-W. Sadrozinski¹³⁶ F. Safai Tehrani^{75a} B. Safarzadeh Samani¹³⁴ M. Safdari¹⁴³ S. Saha¹⁶⁵ M. Sahinsoy¹¹⁰
 M. Saimpert¹³⁵ M. Saito¹⁵³ T. Saito¹⁵³ D. Salamani³⁶ A. Salnikov¹⁴³ J. Salt¹⁶³ A. Salvador Salas¹⁵¹
 D. Salvatore^{43b,43a} F. Salvatore¹⁴⁶ A. Salzburger³⁶ D. Sammel⁵⁴ D. Sampsonidis^{152,ii} D. Sampsonidou¹²³
 J. Sánchez¹⁶³ A. Sanchez Pineda⁴ V. Sanchez Sebastian¹⁶³ H. Sandaker¹²⁵ C. O. Sander⁴⁸ J. A. Sandesara¹⁰³
 M. Sandhoff¹⁷¹ C. Sandoval^{22b} D. P. C. Sankey¹³⁴ T. Sano⁸⁸ A. Sansoni⁵³ L. Santi^{75a,75b} C. Santoni⁴⁰
 H. Santos^{130a,130b} S. N. Santpur^{17a} A. Santra¹⁶⁹ K. A. Saoucha^{116b} J. G. Saraiva^{130a,130d} J. Sardain⁷
 O. Sasaki⁸⁴ K. Sato¹⁵⁷ C. Sauer^{63b} F. Sauerburger⁵⁴ E. Sauvan⁴ P. Savard^{155,e} R. Sawada¹⁵³ C. Sawyer¹³⁴
 L. Sawyer⁹⁷ I. Sayago Galvan¹⁶³ C. Sbarra^{23b} A. Sbrizzi^{23b,23a} T. Scanlon⁹⁶ J. Schaarschmidt¹³⁸ P. Schacht¹¹⁰
 U. Schäfer¹⁰⁰ A. C. Schaffer^{66,44} D. Schaile¹⁰⁹ R. D. Schamberger¹⁴⁵ C. Scharf¹⁸ M. M. Schefer¹⁹
 V. A. Schegelsky³⁷ D. Scheirich¹³³ F. Schenck¹⁸ M. Schernau¹⁶⁰ C. Scheulen⁵⁵ C. Schiavi^{57b,57a}
 E. J. Schioppa^{70a,70b} M. Schioppa^{43b,43a} B. Schlag^{143,y} K. E. Schleicher⁵⁴ S. Schlenker³⁶ J. Schmeing¹⁷¹
 M. A. Schmidt¹⁷¹ K. Schmieden¹⁰⁰ C. Schmitt¹⁰⁰ N. Schmitt¹⁰⁰ S. Schmitt⁴⁸ L. Schoeffel¹³⁵
 A. Schoening^{63b} P. G. Scholer⁵⁴ E. Schopf¹²⁶ M. Schott¹⁰⁰ J. Schovancova³⁶ S. Schramm⁵⁶ F. Schroeder¹⁷¹
 T. Schroer⁵⁶ H.-C. Schultz-Coulon^{63a} M. Schumacher⁵⁴ B. A. Schumm¹³⁶ Ph. Schune¹³⁵ A. J. Schuy¹³⁸
 H. R. Schwartz¹³⁶ A. Schwartzman¹⁴³ T. A. Schwarz¹⁰⁶ Ph. Schwemling¹³⁵ R. Schwienhorst¹⁰⁷
 A. Sciandra¹³⁶ G. Sciolla²⁶ F. Scuri^{74a} C. D. Sebastiani⁹² K. Sedlaczek¹¹⁵ P. Seema¹⁸ S. C. Seidel¹¹²
 A. Seiden¹³⁶ B. D. Seidlitz⁴¹ C. Seitz⁴⁸ J. M. Seixas^{83b} G. Sekhniaidze^{72a} S. J. Sekula⁴⁴ L. Selem⁶⁰
 N. Semprini-Cesari^{23b,23a} D. Sengupta⁵⁶ V. Senthilkumar¹⁶³ L. Serin⁶⁶ L. Serkin^{69a,69b} M. Sessa^{76a,76b}
 H. Severini¹²⁰ F. Sforza^{57b,57a} A. Sfyrta⁵⁶ E. Shabalina⁵⁵ R. Shaheen¹⁴⁴ J. D. Shahinian¹²⁸
 D. Shaked Renous¹⁶⁹ L. Y. Shan^{14a} M. Shapiro^{17a} A. Sharma³⁶ A. S. Sharma¹⁶⁴ P. Sharma⁸⁰ S. Sharma⁴⁸
 P. B. Shatalov³⁷ K. Shaw¹⁴⁶ S. M. Shaw¹⁰¹ A. Shcherbakova³⁷ Q. Shen^{62c,5} P. Sherwood⁹⁶ L. Shi⁹⁶
 X. Shi^{14a} C. O. Shimmin¹⁷² J. D. Shinner⁹⁵ I. P. J. Shipsey¹²⁶ S. Shirabe^{56,rr} M. Shiyakova^{38,vv} J. Shlomi¹⁶⁹
 M. J. Shochet³⁹ J. Shojaii¹⁰⁵ D. R. Shope¹²⁵ B. Shrestha¹²⁰ S. Shrestha^{119,ww} E. M. Shrif^{33g} M. J. Shroff¹⁶⁵
 P. Sicho¹³¹ A. M. Sickles¹⁶² E. Sideras Haddad^{33g} A. Sidoti^{23b} F. Siegert⁵⁰ Dj. Sijacki¹⁵ R. Sikora^{86a}
 F. Sili⁹⁰ J. M. Silva²⁰ M. V. Silva Oliveira²⁹ S. B. Silverstein^{47a} S. Simion⁶⁶ R. Simoniello³⁶ E. L. Simpson⁵⁹
 H. Simpson¹⁴⁶ L. R. Simpson¹⁰⁶ N. D. Simpson⁹⁸ S. Simsek⁸² S. Sindhu⁵⁵ P. Sinervo¹⁵⁵ S. Singh¹⁵⁵
 S. Sinha⁴⁸ S. Sinha¹⁰¹ M. Sioli^{23b,23a} I. Siral³⁶ E. Sitnikova⁴⁸ S. Yu. Sivoklov^{37,a} J. Sjölin^{47a,47b}
 A. Skaf⁵⁵ E. Skorda^{20,xx} P. Skubic¹²⁰ M. Slawinska⁸⁷ V. Smakhtin¹⁶⁹ B. H. Smart¹³⁴ J. Smiesko³⁶

S. Yu. Smirnov³⁷, Y. Smirnov³⁷, L. N. Smirnova^{37,p}, O. Smirnova⁹⁸, A. C. Smith⁴¹, E. A. Smith³⁹,
H. A. Smith¹²⁶, J. L. Smith⁹², R. Smith¹⁴³, M. Smizanska⁹¹, K. Smolek¹³², A. A. Snesarev³⁷, S. R. Snider¹⁵⁵,
H. L. Snoek¹¹⁴, S. Snyder²⁹, R. Sobie^{165,t}, A. Soffer¹⁵¹, C. A. Solans Sanchez³⁶, E. Yu. Soldatov³⁷,
U. Soldevila¹⁶³, A. A. Solodkov³⁷, S. Solomon²⁶, A. Soloshenko³⁸, K. Solovieva⁵⁴, O. V. Solovyanov⁴⁰,
V. Solovyevev³⁷, P. Sommer³⁶, A. Sonay¹³, W. Y. Song^{156b}, J. M. Sonneveld¹¹⁴, A. Sopczak¹³², A. L. Sapiro⁹⁶,
F. Sopkova^{28b}, I. R. Sotarriva Alvarez¹⁵⁴, V. Sothilingam^{63a}, O. J. Soto Sandoval^{137c,137b}, S. Sottocornola⁶⁸,
R. Soualah^{116b}, Z. Soumami^{35e}, D. South⁴⁸, N. Soybelman¹⁶⁹, S. Spagnolo^{70a,70b}, M. Spalla¹¹⁰, D. Sperlich⁵⁴,
G. Spigo³⁶, S. Spinali⁹¹, D. P. Spiteri⁵⁹, M. Spousta¹³³, E. J. Staats³⁴, A. Stabile^{71a,71b}, R. Stamen^{63a},
A. Stampekis²⁰, M. Standke²⁴, E. Stanecka⁸⁷, M. V. Stange⁵⁰, B. Stanislaus^{17a}, M. M. Stanitzki⁴⁸, B. Stapf⁴⁸,
E. A. Starchenko³⁷, G. H. Stark¹³⁶, J. Stark^{102,pp}, D. M. Starke^{156b}, P. Staroba¹³¹, P. Starovoitov^{63a}, S. Starz¹⁰⁴,
R. Staszewski⁸⁷, G. Stavropoulos⁴⁶, J. Steentoft¹⁶¹, P. Steinberg²⁹, B. Stelzer^{142,156a}, H. J. Stelzer¹²⁹,
O. Stelzer-Chilton^{156a}, H. Stenzel⁵⁸, T. J. Stevenson¹⁴⁶, G. A. Stewart³⁶, J. R. Stewart¹²¹, M. C. Stockton³⁶,
G. Stoicea^{27b}, M. Stolarski^{130a}, S. Stonjek¹¹⁰, A. Straessner⁵⁰, J. Strandberg¹⁴⁴, S. Strandberg^{47a,47b},
M. Stratmann¹⁷¹, M. Strauss¹²⁰, T. Streblner¹⁰², P. Strizenc^{28b}, R. Strohmer¹⁶⁶, D. M. Strom¹²³, L. R. Strom⁴⁸,
R. Stroynowski⁴⁴, A. Strubig^{47a,47b}, S. A. Stucci²⁹, B. Stugu¹⁶, J. Stupak¹²⁰, N. A. Styles⁴⁸, D. Su¹⁴³, S. Su^{62a},
W. Su^{62d}, X. Su^{62a,66}, K. Sugizaki¹⁵³, V. V. Sulim³⁷, M. J. Sullivan⁹², D. M. S. Sultan^{78a,78b}, L. Sultanaliev³⁷,
S. Sultansoy^{3b}, T. Sumida⁸⁸, S. Sun¹⁰⁶, S. Sun¹⁷⁰, O. Sunneborn Gudnadottir¹⁶¹, N. Sur¹⁰², M. R. Sutton¹⁴⁶,
H. Suzuki¹⁵⁷, M. Svatos¹³¹, M. Swiatlowski^{156a}, T. Swirski¹⁶⁶, I. Sykora^{28a}, M. Sykora¹³³, T. Sykora¹³³,
D. Ta¹⁰⁰, K. Tackmann^{48,yy}, A. Taffard¹⁶⁰, R. Tafirout^{156a}, J. S. Tafoya Vargas⁶⁶, E. P. Takeva⁵², Y. Takubo⁸⁴,
M. Talby¹⁰², A. A. Talyshv³⁷, K. C. Tam^{64b}, N. M. Tamir¹⁵¹, A. Tanaka¹⁵³, J. Tanaka¹⁵³, R. Tanaka⁶⁶,
M. Tanasini^{57b,57a}, Z. Tao¹⁶⁴, S. Tapia Araya^{137f}, S. Tapprogge¹⁰⁰, A. Tarek Abouelfadl Mohamed¹⁰⁷, S. Tarem¹⁵⁰,
K. Tariq^{14a}, G. Tarna^{102,27b}, G. F. Tartarelli^{71a}, P. Tas¹³³, M. Tasevsky¹³¹, E. Tassi^{43b,43a}, A. C. Tate¹⁶²,
G. Tateno¹⁵³, Y. Tayalati^{35e,zz}, G. N. Taylor¹⁰⁵, W. Taylor^{156b}, A. S. Tee¹⁷⁰, R. Teixeira De Lima¹⁴³,
P. Teixeira-Dias⁹⁵, J. J. Teoh¹⁵⁵, K. Terashi¹⁵³, J. Terron⁹⁹, S. Terzo¹³, M. Testa⁵³, R. J. Teuscher^{155,t},
A. Thaler⁷⁹, O. Theiner⁵⁶, N. Themistokleous⁵², T. Theveneaux-Pelzer¹⁰², O. Thielmann¹⁷¹, D. W. Thomas⁹⁵,
J. P. Thomas²⁰, E. A. Thompson^{17a}, P. D. Thompson²⁰, E. Thomson¹²⁸, Y. Tian⁵⁵, V. Tikhomirov^{37,p},
Yu. A. Tikhonov³⁷, S. Timoshenko³⁷, D. Timoshyn¹³³, E. X. L. Ting¹, P. Tipton¹⁷², S. H. Tlou^{33g}, A. Thourji⁴⁰,
K. Todome¹⁵⁴, S. Todorova-Nova¹³³, S. Todt⁵⁰, M. Togawa⁸⁴, J. Tojo⁸⁹, S. Tokar^{28a}, K. Tokushuku⁸⁴,
O. Toldaiev⁶⁸, R. Tombs³², M. Tomoto^{84,111}, L. Tompkins^{143,y}, K. W. Topolnicki^{86b}, E. Torrence¹²³,
H. Torres^{102,pp}, E. Torro Pastor¹⁶³, M. Toscani³⁰, C. Tosciri³⁹, M. Tost¹¹, D. R. Tovey¹³⁹, A. Traet¹⁶,
I. S. Trandafir^{27b}, T. Trefzger¹⁶⁶, A. Tricoli²⁹, I. M. Trigger^{156a}, S. Trincaz-Duvoid¹²⁷, D. A. Trischuk²⁶,
B. Trocme⁶⁰, C. Troncon^{71a}, L. Truong^{33c}, M. Trzebinski⁸⁷, A. Trzupek⁸⁷, F. Tsai¹⁴⁵, M. Tsai¹⁰⁶,
A. Tsiamis^{152,ii}, P. V. Tsiarshka³⁷, S. Tsigaridas^{156a}, A. Tsirigotis^{152,kk}, V. Tiskaridze¹⁵⁵, E. G. Tskhadadze^{149a},
M. Tsooulou^{152,ii}, Y. Tsujikawa⁸⁸, I. I. Tsukerman³⁷, V. Tsulaia^{17a}, S. Tsuno⁸⁴, O. Tsur¹⁵⁰, K. Tsurii¹¹⁸,
D. Tsybychev¹⁴⁵, Y. Tu^{64b}, A. Tudorache^{27b}, V. Tudorache^{27b}, A. N. Tuna³⁶, S. Turchikhin^{57b,57a},
I. Turk Cakir^{3a}, R. Turra^{71a}, T. Turtuvshin^{38,aaa}, P. M. Tuts⁴¹, S. Tzamarias^{152,ii}, P. Tzani¹⁰, E. Tzovara¹⁰⁰,
F. Ukegawa¹⁵⁷, P. A. Ulloa Poblete^{137c,137b}, E. N. Umaka²⁹, G. Unal³⁶, M. Unal¹¹, A. Undrus²⁹, G. Unel¹⁶⁰,
J. Urban^{28b}, P. Urquijo¹⁰⁵, P. Urrejola^{137a}, G. Usai⁸, R. Ushioda¹⁵⁴, M. Usman¹⁰⁸, Z. Uysal^{21b}, V. Vacek¹³²,
B. Vachon¹⁰⁴, K. O. H. Vadla¹²⁵, T. Vafeiadis³⁶, A. Vaitkus⁹⁶, C. Valderanis¹⁰⁹, E. Valdes Santurio^{47a,47b},
M. Valente^{156a}, S. Valentinetti^{23b,23a}, A. Valero¹⁶³, E. Valiente Moreno¹⁶³, A. Vallier^{102,pp}, J. A. Valls Ferrer¹⁶³,
D. R. Van Arneman¹¹⁴, T. R. Van Daalen¹³⁸, A. Van Der Graaf⁴⁹, P. Van Gemmeren⁶, M. Van Rijnbach^{125,36},
S. Van Stroud⁹⁶, I. Van Vulpen¹¹⁴, M. Vanadia^{76a,76b}, W. Vandelli³⁶, M. Vandenbroucke¹³⁵, E. R. Vandewall¹²¹,
D. Vannicola¹⁵¹, L. Vannoli^{57b,57a}, R. Vari^{75a}, E. W. Varnes⁷, C. Varni^{17b}, T. Varol¹⁴⁸, D. Varouchas⁶⁶,
L. Varriale¹⁶³, K. E. Varvell¹⁴⁷, M. E. Vasile^{27b}, L. Vaslin⁸⁴, G. A. Vasquez¹⁶⁵, A. Vasyukov³⁸, F. Vazeille⁴⁰,
T. Vazquez Schroeder³⁶, J. Veatch³¹, V. Vecchio¹⁰¹, M. J. Veen¹⁰³, I. Veliscek¹²⁶, L. M. Veloce¹⁵⁵,
F. Veloso^{130a,130c}, S. Veneziano^{75a}, A. Ventura^{70a,70b}, S. Ventura Gonzalez¹³⁵, A. Verbytskyi¹¹⁰, M. Verducci^{74a,74b},
C. Vergis²⁴, M. Verissimo De Araujo^{83b}, W. Verkerke¹¹⁴, J. C. Vermeulen¹¹⁴, C. Vernieri¹⁴³, M. Vessella¹⁰³,
M. C. Vetterli^{142,e}, A. Vgenopoulos^{152,ii}, N. Viaux Maira^{137f}, T. Vickey¹³⁹, O. E. Vickey Boeriu¹³⁹,
G. H. A. Viehhauser¹²⁶, L. Vigani^{63b}, M. Villa^{23b,23a}, M. Villaplana Perez¹⁶³, E. M. Villhauer⁵², E. Vilucchi⁵³

M. G. Vincker³⁴ G. S. Virdee²⁰ A. Vishwakarma⁵² A. Visibile¹¹⁴ C. Vittori³⁶ I. Vivarelli¹⁴⁶ E. Voevodina¹¹⁰ F. Vogel¹⁰⁹ J. C. Voigt⁵⁰ P. Vokac¹³² Yu. Volkotrub^{86a} J. Von Ahnen⁴⁸ E. Von Toerne²⁴ B. Vormwald³⁶ V. Vorobel¹³³ K. Vorobev³⁷ M. Vos¹⁶³ K. Voss¹⁴¹ J. H. Vosseveld⁹² M. Vozak¹¹⁴ L. Vozdecky⁹⁴ N. Vranjes¹⁵ M. Vranjes Milosavljevic¹⁵ M. Vreeswijk¹¹⁴ N. K. Vu, R. Vuillermet³⁶ O. Vujanovic¹⁰⁰ I. Vukotic³⁹ S. Wada¹⁵⁷ C. Wagner¹⁰³ J. M. Wagner^{17a} W. Wagner¹⁷¹ S. Wahdan¹⁷¹ H. Wahlberg⁹⁰ M. Wakida¹¹¹ J. Walder¹³⁴ R. Walker¹⁰⁹ W. Walkowiak¹⁴¹ A. Wall¹²⁸ T. Wamorkar⁶ A. Z. Wang¹³⁶ C. Wang¹⁰⁰ C. Wang^{62c} H. Wang^{17a} J. Wang^{64a} R.-J. Wang¹⁰⁰ R. Wang⁶¹ R. Wang⁶ S. M. Wang¹⁴⁸ S. Wang^{62b} T. Wang^{62a} W. T. Wang⁸⁰ W. Wang^{14a} X. Wang^{14c} X. Wang¹⁶² X. Wang^{62c} Y. Wang^{62d} Y. Wang^{14c} Z. Wang¹⁰⁶ Z. Wang^{62d,51,62c} Z. Wang¹⁰⁶ A. Warburton¹⁰⁴ R. J. Ward²⁰ N. Warrack⁵⁹ A. T. Watson²⁰ H. Watson⁵⁹ M. F. Watson²⁰ E. Watton^{59,134} G. Watts¹³⁸ B. M. Waugh⁹⁶ C. Weber²⁹ H. A. Weber¹⁸ M. S. Weber¹⁹ S. M. Weber^{63a} C. Wei^{62a} Y. Wei¹²⁶ A. R. Weidberg¹²⁶ E. J. Weik¹¹⁷ J. Weingarten⁴⁹ M. Weirich¹⁰⁰ C. Weiser⁵⁴ C. J. Wells⁴⁸ T. Wenaus²⁹ B. Wendland⁴⁹ T. Wengler³⁶ N. S. Wenke¹¹⁰ N. Wermes²⁴ M. Wessels^{63a} A. M. Wharton⁹¹ A. S. White⁶¹ A. White⁸ M. J. White¹ D. Whiteson¹⁶⁰ L. Wickremasinghe¹²⁴ W. Wiedenmann¹⁷⁰ C. Wiel⁵⁰ M. Wielers¹³⁴ C. Wiglesworth⁴² D. J. Wilbern¹²⁰ H. G. Wilkens³⁶ D. M. Williams⁴¹ H. H. Williams¹²⁸ S. Williams³² S. Willocq¹⁰³ B. J. Wilson¹⁰¹ P. J. Windischhofer³⁹ F. I. Winkel³⁰ F. Winklmeier¹²³ B. T. Winter⁵⁴ J. K. Winter¹⁰¹ M. Wittgen¹⁴³ M. Wobisch⁹⁷ Z. Wolfs¹¹⁴ J. Wollrath¹⁶⁰ M. W. Wolter⁸⁷ H. Wolters^{130a,130c} A. F. Wongel⁴⁸ E. L. Woodward⁴¹ S. D. Worm⁴⁸ B. K. Wosiek⁸⁷ K. W. Woźniak⁸⁷ S. Wozniowski⁵⁵ K. Wraight⁵⁹ C. Wu²⁰ J. Wu^{14a,14c} M. Wu^{64a} M. Wu¹¹³ S. L. Wu¹⁷⁰ X. Wu⁵⁶ Y. Wu^{62a} Z. Wu¹³⁵ J. Wuerzinger^{110,bb} T. R. Wyatt¹⁰¹ B. M. Wynne⁵² S. Xella⁴² L. Xia^{14c} M. Xia^{14b} J. Xiang^{64c} M. Xie^{62a} X. Xie^{62a} S. Xin^{14a,14e} A. Xiong¹²³ J. Xiong^{17a} D. Xu^{14a} H. Xu^{62a} L. Xu^{62a} R. Xu¹²⁸ T. Xu¹⁰⁶ Y. Xu^{14b} Z. Xu^{14c,52} B. Yabsley¹⁴⁷ S. Yacoub^{33a} Y. Yamaguchi¹⁵⁴ E. Yamashita¹⁵³ H. Yamauchi¹⁵⁷ T. Yamazaki^{17a} Y. Yamazaki⁸⁵ J. Yan^{62c} S. Yan¹²⁶ Z. Yan²⁵ H. J. Yang^{62c,62d} H. T. Yang^{62a} S. Yang^{62a} T. Yang^{64c} X. Yang³⁶ X. Yang^{14a} Y. Yang⁴⁴ Y. Yang^{62a} Z. Yang^{62a} W.-M. Yao^{17a} Y. C. Yap⁴⁸ H. Ye^{14c} H. Ye⁵⁵ J. Ye^{14a} S. Ye²⁹ X. Ye^{62a} Y. Yeh⁹⁶ I. Yeletsikh³⁸ B. K. Yeo^{17b} M. R. Yexley⁹⁶ P. Yin⁴¹ K. Yorita¹⁶⁸ S. Younas^{27b} C. J. S. Young³⁶ C. Young¹⁴³ C. Yu^{14a,14e,bbb} Y. Yu^{62a} M. Yuan¹⁰⁶ R. Yuan^{62b} L. Yue⁹⁶ M. Zaazoua^{62a} B. Zabinski⁸⁷ E. Zaid⁵² T. Zakareishvili^{149b} N. Zakharchuk³⁴ S. Zambito⁵⁶ J. A. Zamora Saa^{137d,137b} J. Zang¹⁵³ D. Zanzi⁵⁴ O. Zaplatilek¹³² C. Zeitnitz¹⁷¹ H. Zeng^{14a} J. C. Zeng¹⁶² D. T. Zenger Jr.²⁶ O. Zenin³⁷ T. Ženiš^{28a} S. Zenz⁹⁴ S. Zerradi^{35a} D. Zerwas⁶⁶ M. Zhai^{14a,14e} B. Zhang^{14c} D. F. Zhang¹³⁹ J. Zhang^{62b} J. Zhang⁶ K. Zhang^{14a,14e} L. Zhang^{14c} P. Zhang^{14a,14e} R. Zhang¹⁷⁰ S. Zhang¹⁰⁶ S. Zhang⁴⁴ T. Zhang¹⁵³ X. Zhang^{62c} X. Zhang^{62b} Y. Zhang^{62c,5} Y. Zhang⁹⁶ Y. Zhang^{14c} Z. Zhang^{17a} Z. Zhang⁶⁶ H. Zhao¹³⁸ P. Zhao⁵¹ T. Zhao^{62b} Y. Zhao¹³⁶ Z. Zhao^{62a} A. Zhemchugov³⁸ J. Zheng^{14c} K. Zheng¹⁶² X. Zheng^{62a} Z. Zheng¹⁴³ D. Zhong¹⁶² B. Zhou¹⁰⁶ H. Zhou⁷ N. Zhou^{62c} Y. Zhou⁷ C. G. Zhu^{62b} J. Zhu¹⁰⁶ Y. Zhu^{62c} Y. Zhu^{62a} X. Zhuang^{14a} K. Zhukov³⁷ V. Zhulanov³⁷ N. I. Zimine³⁸ J. Zinsser^{63b} M. Ziolkowski¹⁴¹ L. Živković¹⁵ A. Zoccoli^{23b,23a} K. Zoch⁶¹ T. G. Zorbos¹³⁹ O. Zormpa⁴⁶ W. Zou⁴¹ and L. Zwalinski³⁶

(ATLAS Collaboration)

¹Department of Physics, University of Adelaide, Adelaide, Australia
²Department of Physics, University of Alberta, Edmonton, Alberta, Canada
^{3a}Department of Physics, Ankara University, Ankara, Türkiye
^{3b}Division of Physics, TOBB University of Economics and Technology, Ankara, Türkiye
⁴LAPP, Université Savoie Mont Blanc, CNRS/IN2P3, Annecy, France
⁵APC, Université Paris Cité, CNRS/IN2P3, Paris, France
⁶High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA
⁷Department of Physics, University of Arizona, Tucson, Arizona, USA
⁸Department of Physics, University of Texas at Arlington, Arlington Texas, USA
⁹Physics Department, National and Kapodistrian University of Athens, Athens, Greece
¹⁰Physics Department, National Technical University of Athens, Zografou, Greece

- ¹¹*Department of Physics, University of Texas at Austin, Austin, Texas, USA*
- ¹²*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
- ¹³*Institut de Física d'Altes Energies (IFAE), Barcelona Institute of Science and Technology, Barcelona, Spain*
- ^{14a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
- ^{14b}*Physics Department, Tsinghua University, Beijing, China*
- ^{14c}*Department of Physics, Nanjing University, Nanjing, China*
- ^{14d}*School of Science, Shenzhen Campus of Sun Yat-sen University, China*
- ^{14e}*University of Chinese Academy of Science (UCAS), Beijing, China*
- ¹⁵*Institute of Physics, University of Belgrade, Belgrade, Serbia*
- ¹⁶*Department for Physics and Technology, University of Bergen, Bergen, Norway*
- ^{17a}*Physics Division, Lawrence Berkeley National Laboratory, Berkeley, California, USA*
- ^{17b}*University of California, Berkeley, California, USA*
- ¹⁸*Institut für Physik, Humboldt Universität zu Berlin, Berlin, Germany*
- ¹⁹*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
- ²⁰*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
- ^{21a}*Department of Physics, Bogazici University, Istanbul, Türkiye*
- ^{21b}*Department of Physics Engineering, Gaziantep University, Gaziantep, Türkiye*
- ^{21c}*Department of Physics, Istanbul University, Istanbul, Türkiye*
- ^{22a}*Facultad de Ciencias y Centro de Investigaciones, Universidad Antonio Nariño, Bogotá, Colombia*
- ^{22b}*Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia*
- ^{23a}*Dipartimento di Fisica e Astronomia A. Righi, Università di Bologna, Bologna, Italy*
- ^{23b}*INFN Sezione di Bologna, Italy*
- ²⁴*Physikalisches Institut, Universität Bonn, Bonn, Germany*
- ²⁵*Department of Physics, Boston University, Boston, Massachusetts, USA*
- ²⁶*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
- ^{27a}*Transilvania University of Brasov, Brasov, Romania*
- ^{27b}*Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
- ^{27c}*Department of Physics, Alexandru Ioan Cuza University of Iasi, Iasi, Romania*
- ^{27d}*National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj-Napoca, Romania*
- ^{27e}*University Politehnica Bucharest, Bucharest, Romania*
- ^{27f}*West University in Timisoara, Timisoara, Romania*
- ^{27g}*Faculty of Physics, University of Bucharest, Bucharest, 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*Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Física, y CONICET, Instituto de Física de Buenos Aires (IFIBA), 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}*Themba Labs, Western Cape, South Africa*
- ^{33c}*Department of Mechanical Engineering Science, University of Johannesburg, Johannesburg, South Africa*
- ^{33d}*National Institute of Physics, University of the Philippines Diliman (Philippines), Philippines*
- ^{33e}*University of South Africa, Department of Physics, Pretoria, South Africa*
- ^{33f}*University of Zululand, KwaDlangezwa, South Africa*
- ^{33g}*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, Morocco*
- ^{35b}*Faculté des Sciences, Université Ibn-Tofail, Kénitra, Morocco*
- ^{35c}*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
- ^{35d}*LPMR, Faculté des Sciences, Université Mohamed Premier, Oujda, Morocco*
- ^{35e}*Faculté des sciences, Université Mohammed V, Rabat, Morocco*
- ^{35f}*Institute of Applied Physics, Mohammed VI Polytechnic University, Ben Guerir, Morocco*
- ³⁶*CERN, Geneva, Switzerland*
- ³⁷*Affiliated with an institute covered by a cooperation agreement with CERN*
- ³⁸*Affiliated with an international laboratory covered by a cooperation agreement with CERN*

- ³⁹*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
- ⁴⁰*LPC, Université Clermont Auvergne, CNRS/IN2P3, Clermont-Ferrand, France*
- ⁴¹*Nevis Laboratory, Columbia University, Irvington New York, USA*
- ⁴²*Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark*
- ^{43a}*Dipartimento di Fisica, Università della Calabria, Rende, Italy*
- ^{43b}*INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati, Italy*
- ⁴⁴*Physics Department, Southern Methodist University, Dallas, Texas, USA*
- ⁴⁵*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
- ⁴⁶*National Centre for Scientific Research “Demokritos”, Agia Paraskevi, Greece*
- ^{47a}*Department of Physics, Stockholm University, Sweden*
- ^{47b}*Oskar Klein Centre, Stockholm, Sweden*
- ⁴⁸*Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany*
- ⁴⁹*Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany*
- ⁵⁰*Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany*
- ⁵¹*Department of Physics, Duke University, Durham, North Carolina, USA*
- ⁵²*SUPA—School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁵³*INFN e Laboratori Nazionali di Frascati, Frascati, Italy*
- ⁵⁴*Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany*
- ⁵⁵*II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany*
- ⁵⁶*Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève, Switzerland*
- ^{57a}*Dipartimento di Fisica, Università di Genova, Genova, Italy*
- ^{57b}*INFN Sezione di Genova, Italy*
- ⁵⁸*II. Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
- ⁵⁹*SUPA—School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁶⁰*LPSC, Université Grenoble Alpes, CNRS/IN2P3, Grenoble INP, Grenoble, France*
- ⁶¹*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
- ^{62a}*Department of Modern Physics and State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei, China*
- ^{62b}*Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao, China*
- ^{62c}*School of Physics and Astronomy, Shanghai Jiao Tong University, Key Laboratory for Particle Astrophysics and Cosmology (MOE), SKLPPC, Shanghai, China*
- ^{62d}*Tsung-Dao Lee Institute, Shanghai, China*
- ^{63a}*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{63b}*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{64a}*Department of Physics, Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China*
- ^{64b}*Department of Physics, University of Hong Kong, Hong Kong, China*
- ^{64c}*Department of Physics and Institute for Advanced Study, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China*
- ⁶⁵*Department of Physics, National Tsing Hua University, Hsinchu, Taiwan*
- ⁶⁶*IJCLab, Université Paris-Saclay, CNRS/IN2P3, 91405, Orsay, France*
- ⁶⁷*Centro Nacional de Microelectrónica (IMB-CNM-CSIC), Barcelona, Spain*
- ⁶⁸*Department of Physics, Indiana University, Bloomington, Indiana, USA*
- ^{69a}*INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine, Italy*
- ^{69b}*ICTP, Trieste, Italy*
- ^{69c}*Dipartimento Politecnico di Ingegneria e Architettura, Università di Udine, Udine, Italy*
- ^{70a}*INFN Sezione di Lecce, Italy*
- ^{70b}*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
- ^{71a}*INFN Sezione di Milano, Italy*
- ^{71b}*Dipartimento di Fisica, Università di Milano, Milano, Italy*
- ^{72a}*INFN Sezione di Napoli, Italy*
- ^{72b}*Dipartimento di Fisica, Università di Napoli, Napoli, Italy*
- ^{73a}*INFN Sezione di Pavia, Italy*
- ^{73b}*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
- ^{74a}*INFN Sezione di Pisa, Italy*
- ^{74b}*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
- ^{75a}*INFN Sezione di Roma, Italy*
- ^{75b}*Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*

- ^{76a}*INFN Sezione di Roma Tor Vergata, Italy*
^{76b}*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
^{77a}*INFN Sezione di Roma Tre, Italy*
^{77b}*Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
^{78a}*INFN-TIFPA, Italy*
^{78b}*Università degli Studi di Trento, Trento, Italy*
⁷⁹*Universität Innsbruck, Department of Astro and Particle Physics, Innsbruck, Austria*
⁸⁰*University of Iowa, Iowa City, Iowa, USA*
⁸¹*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
⁸²*Istinye University, Sariyer, Istanbul, Türkiye*
^{83a}*Departamento de Engenharia Elétrica, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, Brazil*
^{83b}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
^{83c}*Instituto de Física, Universidade de São Paulo, São Paulo, Brazil*
^{83d}*Rio de Janeiro State University, Rio de Janeiro, Brazil*
⁸⁴*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
⁸⁵*Graduate School of Science, Kobe University, Kobe, Japan*
^{86a}*AGH University of Krakow, Faculty of Physics and Applied Computer Science, Krakow, Poland*
^{86b}*Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland*
⁸⁷*Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland*
⁸⁸*Faculty of Science, Kyoto University, Kyoto, Japan*
⁸⁹*Research Center for Advanced Particle Physics and Department of Physics, Kyushu University, Fukuoka, Japan*
⁹⁰*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
⁹¹*Physics Department, Lancaster University, Lancaster, United Kingdom*
⁹²*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
⁹³*Department of Experimental Particle Physics, Jožef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana, Slovenia*
⁹⁴*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
⁹⁵*Department of Physics, Royal Holloway University of London, Egham, United Kingdom*
⁹⁶*Department of Physics and Astronomy, University College London, London, United Kingdom*
⁹⁷*Louisiana Tech University, Ruston, Louisiana, USA*
⁹⁸*Fysiska institutionen, Lunds universitet, Lund, Sweden*
⁹⁹*Departamento de Física Teórica 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, Quebec, 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*Group of Particle Physics, University of Montreal, Montreal, Quebec, Canada*
¹⁰⁹*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
¹¹⁰*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
¹¹¹*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
¹¹²*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
¹¹³*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University/Nikhef, Nijmegen, Netherlands*
¹¹⁴*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
¹¹⁵*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
^{116a}*New York University Abu Dhabi, Abu Dhabi, United Arab Emirates*
^{116b}*University of Sharjah, Sharjah, United Arab Emirates*
¹¹⁷*Department of Physics, New York University, New York, New York, USA*
¹¹⁸*Ochanomizu University, Otsuka, Bunkyo-ku, Tokyo, Japan*
¹¹⁹*Ohio State University, Columbus, Ohio, USA*
¹²⁰*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
¹²¹*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
¹²²*Palacký University, Joint Laboratory of Optics, Olomouc, Czech Republic*
¹²³*Institute for Fundamental Science, University of Oregon, Eugene, Oregon, USA*
¹²⁴*Graduate School of Science, Osaka University, Osaka, Japan*

- ¹²⁵*Department of Physics, University of Oslo, Oslo, Norway*
- ¹²⁶*Department of Physics, Oxford University, Oxford, United Kingdom*
- ¹²⁷*LPNHE, Sorbonne Université, Université Paris Cité, CNRS/IN2P3, Paris, France*
- ¹²⁸*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
- ¹²⁹*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
- ^{130a}*Laboratório de Instrumentação e Física Experimental de Partículas—LIP, Lisboa, Portugal*
- ^{130b}*Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal*
- ^{130c}*Departamento de Física, Universidade de Coimbra, Coimbra, Portugal*
- ^{130d}*Centro de Física Nuclear da Universidade de Lisboa, Lisboa, Portugal*
- ^{130e}*Departamento de Física, Universidade do Minho, Braga, Portugal*
- ^{130f}*Departamento de Física Teórica y del Cosmos, Universidad de Granada, Granada (Spain), Spain*
- ^{130g}*Departamento de Física, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*
- ¹³¹*Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic*
- ¹³²*Czech Technical University in Prague, Prague, Czech Republic*
- ¹³³*Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic*
- ¹³⁴*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ¹³⁵*IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France*
- ¹³⁶*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
- ^{137a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
- ^{137b}*Millennium Institute for Subatomic physics at high energy frontier (SAPHIR), Santiago, Chile*
- ^{137c}*Instituto de Investigación Multidisciplinario en Ciencia y Tecnología, y Departamento de Física, Universidad de La Serena, Chile*
- ^{137d}*Universidad Andres Bello, Department of Physics, Santiago, Chile*
- ^{137e}*Instituto de Alta Investigación, Universidad de Tarapacá, Arica, Chile*
- ^{137f}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
- ¹³⁸*Department of Physics, University of Washington, Seattle, Washington, USA*
- ¹³⁹*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
- ¹⁴⁰*Department of Physics, Shinshu University, Nagano, Japan*
- ¹⁴¹*Department Physik, Universität Siegen, Siegen, Germany*
- ¹⁴²*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*
- ¹⁴³*SLAC National Accelerator Laboratory, Stanford, California, USA*
- ¹⁴⁴*Department of Physics, Royal Institute of Technology, Stockholm, Sweden*
- ¹⁴⁵*Departments of Physics and Astronomy, Stony Brook University, Stony Brook, New York, USA*
- ¹⁴⁶*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
- ¹⁴⁷*School of Physics, University of Sydney, Sydney, Australia*
- ¹⁴⁸*Institute of Physics, Academia Sinica, Taipei, Taiwan*
- ^{149a}*E. Andronikashvili Institute of Physics, Iv. Javakishvili Tbilisi State University, Tbilisi, Georgia*
- ^{149b}*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
- ^{149c}*University of Georgia, Tbilisi, Georgia*
- ¹⁵⁰*Department of Physics, Technion, Israel Institute of Technology, Haifa, Israel*
- ¹⁵¹*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
- ¹⁵²*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
- ¹⁵³*International Center for Elementary Particle Physics and Department of Physics, University of Tokyo, Tokyo, Japan*
- ¹⁵⁴*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
- ¹⁵⁵*Department of Physics, University of Toronto, Toronto, Ontario, Canada*
- ^{156a}*TRIUMF, Vancouver, British Columbia, Canada*
- ^{156b}*Department of Physics and Astronomy, York University, Toronto, Ontario, Canada*
- ¹⁵⁷*Division of Physics and Tomonaga Center for the History of the Universe, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan*
- ¹⁵⁸*Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA*
- ¹⁵⁹*United Arab Emirates University, Al Ain, United Arab Emirates*
- ¹⁶⁰*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
- ¹⁶¹*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
- ¹⁶²*Department of Physics, University of Illinois, Urbana, Illinois, USA*
- ¹⁶³*Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia—CSIC, Valencia, Spain*
- ¹⁶⁴*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada*
- ¹⁶⁵*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada*
- ¹⁶⁶*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg, Germany*

¹⁶⁷*Department of Physics, University of Warwick, Coventry, United Kingdom*

¹⁶⁸*Waseda University, Tokyo, Japan*

¹⁶⁹*Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot, Israel*

¹⁷⁰*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*

¹⁷¹*Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik,
Bergische Universität Wuppertal, Wuppertal, Germany*

¹⁷²*Department of Physics, Yale University, New Haven, Connecticut, USA*

^aDeceased.

^bAlso at Department of Physics, King's College London, London, United Kingdom.

^cAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.

^dAlso at Lawrence Livermore National Laboratory, Livermore, USA.

^eAlso at TRIUMF, Vancouver, British Columbia, Canada.

^fAlso at Department of Physics, University of Thessaly, Greece.

^gAlso at Institut für Physik, Universität Mainz, Mainz, Germany.

^hAlso at An-Najah National University, Nablus, Palestine.

ⁱAlso at Department of Physics, University of Fribourg, Fribourg, Switzerland.

^jAlso at University of Colorado Boulder, Department of Physics, Colorado, USA.

^kAlso at SUPA—School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom.

^lAlso at Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada.

^mAlso at CERN Tier-0, Switzerland.

ⁿAlso at Department of Physics, Westmont College, Santa Barbara, USA.

^oAlso at Departament de Física de la Universitat Autònoma de Barcelona, Barcelona, Spain.

^pAlso at Affiliated with an institute covered by a cooperation agreement with CERN.

^qAlso at The Collaborative Innovation Center of Quantum Matter (CICQM), Beijing, China.

^rAlso at Department of Physics, Ben Gurion University of the Negev, Beer Sheva, Israel.

^sAlso at Università di Napoli Parthenope, Napoli, Italy.

^tAlso at Institute of Particle Physics (IPP), Canada.

^uAlso at Group of Particle Physics, University of Montreal, Montreal, Quebec, Canada.

^vAlso at Borough of Manhattan Community College, City University of New York, New York, New York, USA.

^wAlso at National Institute of Physics, University of the Philippines Diliman (Philippines), Philippines.

^xAlso at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece.

^yAlso at Department of Physics, Stanford University, Stanford, California, USA.

^zAlso at Centro Studi e Ricerche Enrico Fermi, Italy.

^{aa}Also at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.

^{bb}Also at Technical University of Munich, Munich, Germany.

^{cc}Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.

^{dd}Also at Department of Physics, Oxford University, Oxford, United Kingdom.

^{ee}Also at Yeditepe University, Physics Department, Istanbul, Türkiye.

^{ff}Also at Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia.

^{gg}Also at CERN, Geneva, Switzerland.

^{hh}Also at Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA.

ⁱⁱAlso at Center for Interdisciplinary Research and Innovation (CIRI-AUTH), Thessaloniki, Greece.

^{jj}Also at School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom.

^{kk}Also at Hellenic Open University, Patras, Greece.

^{ll}Also at Center for High Energy Physics, Peking University, China.

^{mmm}Also at APC, Université Paris Cité, CNRS/IN2P3, Paris, France.

ⁿⁿAlso at IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France.

^{oo}Also at Department of Physics, Royal Holloway University of London, Egham, United Kingdom.

^{pp}Also at L2IT, Université de Toulouse, CNRS/IN2P3, UPS, Toulouse, France.

^{qq}Also at Department of Physics, California State University, Sacramento, USA.

^{rr}Also at Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève, Switzerland.

^{ss}Also at Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen, Germany.

^{tt}Also at Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal, Germany.

^{uu}Also at Fakultät Physik, Technische Universität Dortmund, Dortmund, Germany.

^{vv}Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.

^{ww}Also at Washington College, Chestertown, Maryland, USA.

^{xx}Also at School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom.

^{yy}Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.

^{zz}Also at Institute of Applied Physics, Mohammed VI Polytechnic University, Ben Guerir, Morocco.

^{aaa}Also at Institute of Physics and Technology, Ulaanbaatar, Mongolia.

^{bbb}Also at University of Chinese Academy of Sciences (UCAS), Beijing, China.