

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)



Submitted to: Phys. Rev. Lett.



CERN-EP-2023-156

August 10, 2023

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 $\sqrt{s} = 7, 8$ and 13 TeV pp collision data

The ATLAS Collaboration

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 centre-of-mass energy of 13 TeV combined with the Run 1 ATLAS mass measurement, 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.

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 $\sqrt{s} = 7$ TeV and 8 TeV (Run 1) was a major step towards 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 Brout, Englert [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 ± 0.24 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 ± 0.14 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 centre-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) 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 modelled by constrained NP, 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 non-resonant 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 GeV 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 parameterized 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 endcap 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 $m_H = 125.17 \pm 0.11$ (stat.) ± 0.09 (syst.) = 125.17 ± 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], $m_H = 126.02 \pm 0.43$ (stat.) ± 0.27 (syst.) = 126.02 ± 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 $m_H = 125.22 \pm 0.11$ (stat.) ± 0.09 (syst.) = 125.22 ± 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 sub-channels according to the flavor of the leading and subleading dilepton pairs (4μ , $2e2\mu$, $2\mu2e$, $4e$). 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 leptons system, $m_{4\ell}$, in

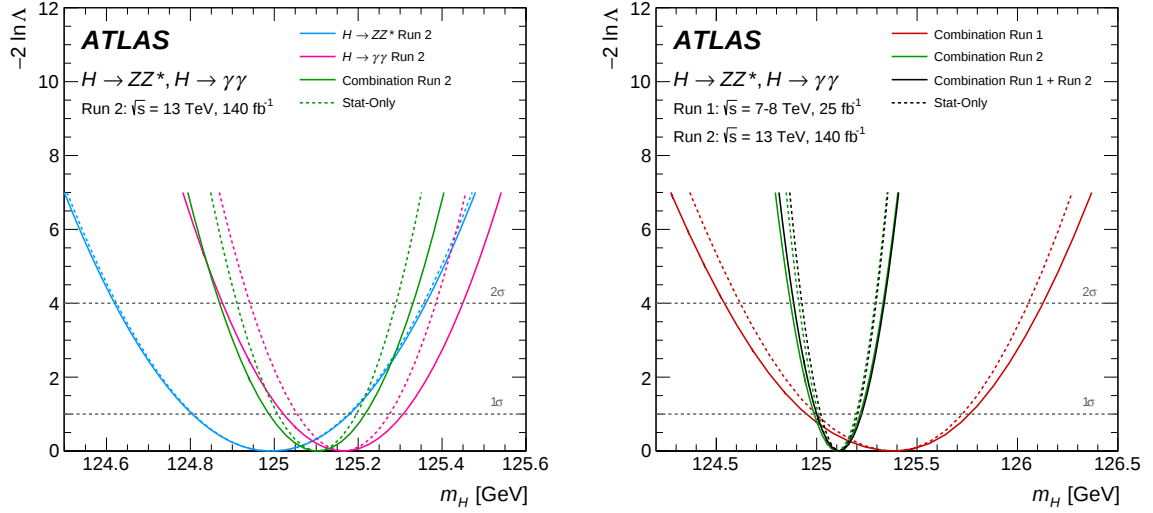


Figure 1: Value of $-2 \ln \Lambda$ as a function of m_H for (left) $H \rightarrow \gamma\gamma$, $H \rightarrow ZZ^* \rightarrow 4\ell$ channels and their combination (magenta, cyan and green, respectively) using Run 2 data only and for (right) Run 1, Run 2 and their combination (red, green and black, respectively). The dashed lines show the statistical component of the uncertainty.

the four sub-channels. The $m_{4\ell}$ resolution ranges from about 1.5 GeV (4μ and $2e2\mu$ sub-channels) to about 2.1 GeV ($2\mu2e$ and $4e$ sub-channels). The signal model consists of a double-sided Crystal Ball probability density function, with the mean of its Gaussian core parameterized 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 sub-channels 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 $m_H = 124.99 \pm 0.18$ (stat.) ± 0.04 (syst.) = 124.99 ± 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], $m_H = 124.51 \pm 0.52$ (stat.) ± 0.04 (syst.) = 124.51 ± 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 measurement 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 $m_H = 124.94 \pm 0.17$ (stat.) ± 0.03 (syst.) = 124.94 ± 0.18 GeV.

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. Due to 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

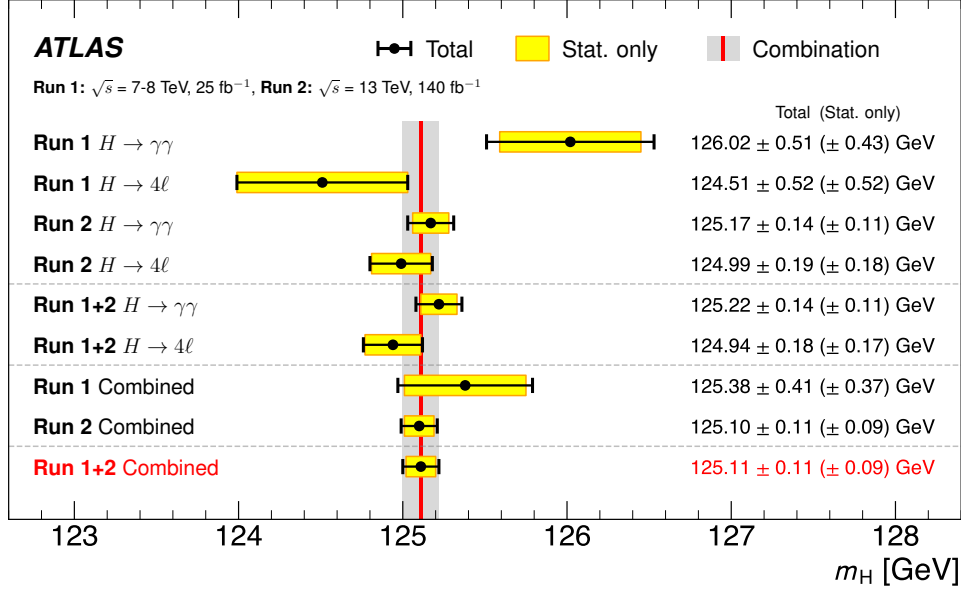


Figure 2: Summary of m_H measurements from the individual $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ^* \rightarrow 4\ell$ channels and their combination presented in this letter. The uncertainty bar on each point corresponds to the total uncertainty; the horizontal shaded bands represent the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

uncertainties follows what was done in Refs. [16] and [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; 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 modelling of additional (*pile-up*) 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 Figure 1 (left) as a function of m_H . If the small interference predicted by the SM between the Higgs boson and the non-resonant di-photon background was considered for the $H \rightarrow \gamma\gamma$ signal parameterization, 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

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

Table 1: 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.

ATLAS Run 2 data, are summarized in Table 1. The values differ from those reported in Refs. [16] and [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/γ E_T -independent $Z \rightarrow ee$ calibration” in Table 1) 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 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 1. 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:

$$m_H = 125.10 \pm 0.09 \text{ (stat.)} \pm 0.07 \text{ (syst.)} = 125.10 \pm 0.11 \text{ GeV},$$

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 three thanks to a novel and improved approach to the photon energy calibration. This is comparable with the factor of about two 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:

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

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 Benoziyo 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, Türkiye; 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 programmes co-financed 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 (UK) and BNL (USA), the Tier-2 facilities worldwide and large non-WLCG resource providers. Major contributors of computing resources are listed in Ref. [28].

References

- [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** \(2012\) 1](#), arXiv: [1207.7214 \[hep-ex\]](#).
- [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** \(2012\) 30](#), arXiv: [1207.7235 \[hep-ex\]](#).
- [3] F. Englert and R. Brout, *Broken Symmetry and the Mass of Gauge Vector Mesons*, [Phys. Rev. Lett. **13** \(1964\) 321](#).
- [4] P. W. Higgs, *Broken symmetries, massless particles and gauge fields*, [Phys. Lett. **12** \(1964\) 132](#).
- [5] P. W. Higgs, *Broken Symmetries and the Masses of Gauge Bosons*, [Phys. Rev. Lett. **13** \(1964\) 508](#).
- [6] P. W. Higgs, *Spontaneous Symmetry Breakdown without Massless Bosons*, [Phys. Rev. **145** \(1966\) 1156](#).
- [7] G. S. Guralnik, C. R. Hagen, and T. W. B. Kibble, *Global Conservation Laws and Massless Particles*, [Phys. Rev. Lett. **13** \(1964\) 585](#).
- [8] T. W. B. Kibble, *Symmetry breaking in nonAbelian gauge theories*, [Phys. Rev. **155** \(1967\) 1554](#).
- [9] S. L. Glashow, *Partial Symmetries of Weak Interactions*, [Nucl. Phys. **22** \(1961\) 579](#).
- [10] A. Salam, *Weak and Electromagnetic Interactions*, [Conf. Proc. C **680519** \(1968\) 367](#).
- [11] S. Weinberg, *A Model of Leptons*, [Phys. Rev. Lett. **19** \(1967\) 1264](#).

- [12] ATLAS Collaboration,
A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery,
Nature **607** (2022) 52, [Erratum: *Nature* 612, E24 (2022)], arXiv: [2207.00092 \[hep-ex\]](#).
- [13] CMS Collaboration,
A portrait of the Higgs boson by the CMS experiment ten years after the discovery,
Nature **607** (2022) 60, arXiv: [2207.00043 \[hep-ex\]](#).
- [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** (2015) 191803, arXiv: [1503.07589 \[hep-ex\]](#).
- [15] CMS Collaboration, *A measurement of the Higgs boson mass in the diphoton decay channel*,
Phys. Lett. B **805** (2020) 135425, arXiv: [2002.06398 \[hep-ex\]](#).
- [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*, (2023),
URL: <https://cds.cern.ch/record/2865479/>.
- [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*, (2022), arXiv: [2207.00320 \[hep-ex\]](#).
- [18] ATLAS Collaboration, *The ATLAS Experiment at the CERN Large Hadron Collider*,
JINST **3** (2008) S08003.
- [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** (2018) 345,
arXiv: [1806.00242 \[hep-ex\]](#).
- [20] ATLAS Collaboration, *The ATLAS Collaboration Software and Firmware*,
ATL-SOFT-PUB-2021-001, 2021, URL: <https://cds.cern.ch/record/2767187>.
- [21] ATLAS Collaboration,
Electron and photon energy calibration with the ATLAS detector using LHC Run 2 data,
CERN-EP-2023-128 (2023).
- [22] ATLAS Collaboration, *Studies of the muon momentum calibration and performance of the ATLAS detector with pp collisions at $\sqrt{s}=13\text{ TeV}$* , (2022), arXiv: [2212.07338 \[hep-ex\]](#).
- [23] T. C. C. The ATLAS Collaboration and T. L. H. C. Group,
Procedure for the LHC Higgs boson search combination in summer 2011,
ATL-PHYS-PUB-2011-011, 2011, URL: <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** (2011) 1554,
arXiv: [1007.1727 \[physics.data-an\]](#), Erratum: *Eur. Phys. J. C* **73** (2013) 2501.
- [25] M. Oreglia, *A Study of the Reactions $\psi' \rightarrow \gamma\gamma\psi$* , Appendix D, (1980), URL: <http://www-public.slac.stanford.edu/sciDoc/docMeta.aspx?slacPubNumber=slac-r-236.html>.
- [26] ATLAS Collaboration, *Electron and photon performance measurements with the ATLAS detector using the 2015–2017 LHC proton–proton collision data*, *JINST* **14** (2019) P12006,
arXiv: [1908.00005 \[hep-ex\]](#).

- [27] L. J. Dixon and Y. Li, *Bounding the Higgs Boson Width Through Interferometry*, *Phys. Rev. Lett.* **111** (2013) 111802, arXiv: [1305.3854 \[hep-ph\]](#).
- [28] ATLAS Collaboration, *ATLAS Computing Acknowledgements*, ATL-SOFT-PUB-2021-003, 2021, URL: <https://cds.cern.ch/record/2776662>.

The ATLAS Collaboration

G. Aad ¹⁰², B. Abbott ¹²⁰, K. Abeling ⁵⁵, N.J. Abicht ⁴⁹, S.H. Abidi ²⁹, A. Aboulhorma ^{35e}, H. Abramowicz ¹⁵¹, H. Abreu ¹⁵⁰, Y. Abulaiti ¹¹⁷, B.S. Acharya ^{69a,69b,q}, C. Adam Bourdarios ⁴, L. Adamczyk ^{86a}, S.V. Addepalli ²⁶, M.J. Addison ¹⁰¹, J. Adelman ¹¹⁵, A. Adiguzel ^{21c}, T. Adye ¹³⁴, A.A. Affolder ¹³⁶, Y. Afik ³⁶, M.N. Agaras ¹³, J. Agarwala ^{73a,73b}, A. Aggarwal ¹⁰⁰, C. Agheorghiesei ^{27c}, A. Ahmad ³⁶, F. Ahmadov ^{38,ak}, W.S. Ahmed ¹⁰⁴, S. Ahuja ⁹⁵, X. Ai ^{62a}, G. Aielli ^{76a,76b}, A. Aikot ¹⁶³, M. Ait Tamlihat ^{35e}, B. Aitbenchikh ^{35a}, I. Aizenberg ¹⁶⁹, M. Akbiyik ¹⁰⁰, T.P.A. Åkesson ⁹⁸, A.V. Akimov ³⁷, D. Akiyama ¹⁶⁸, N.N. Akolkar ²⁴, K. Al Khoury ⁴¹, G.L. Alberghi ^{23b}, J. Albert ¹⁶⁵, P. Albicocco ⁵³, G.L. Albouy ⁶⁰, S. Alderweireldt ⁵², M. Aleksa ³⁶, I.N. Aleksandrov ³⁸, C. Alexa ^{27b}, T. Alexopoulos ¹⁰, F. Alfonsi ^{23b}, M. Algren ⁵⁶, M. Alhroob ¹²⁰, B. Ali ¹³², H.M.J. Ali ⁹¹, S. Ali ¹⁴⁸, S.W. Alibocus ⁹², M. Aliev ¹⁴⁵, G. Alimonti ^{71a}, W. Alkakh ⁵⁵, C. Allaire ⁶⁶, B.M.M. Allbrooke ¹⁴⁶, J.F. Allen ⁵², C.A. Allendes Flores ^{137f}, P.P. Allport ²⁰, A. Aloisio ^{72a,72b}, F. Alonso ⁹⁰, C. Alpigiani ¹³⁸, M. Alvarez Estevez ⁹⁹, A. Alvarez Fernandez ¹⁰⁰, M. Alves Cardoso ⁵⁶, M.G. Alviggi ^{72a,72b}, M. Aly ¹⁰¹, Y. Amaral Coutinho ^{83b}, A. Ambler ¹⁰⁴, C. Amelung ³⁶, M. Ameri ¹⁰¹, C.G. Ames ¹⁰⁹, D. Amidei ¹⁰⁶, S.P. Amor Dos Santos ^{130a}, K.R. Amos ¹⁶³, V. Ananiev ¹²⁵, C. Anastopoulos ¹³⁹, T. Andeen ¹¹, J.K. Anders ³⁶, S.Y. Andrean ^{47a,47b}, A. Andreazza ^{71a,71b}, S. Angelidakis ⁹, A. Angerami ^{41,ao}, A.V. Anisenkov ³⁷, A. Annovi ^{74a}, C. Antel ⁵⁶, M.T. Anthony ¹³⁹, E. Antipov ¹⁴⁵, M. Antonelli ⁵³, F. Anulli ^{75a}, M. Aoki ⁸⁴, T. Aoki ¹⁵³, J.A. Aparisi Pozo ¹⁶³, M.A. Aparo ¹⁴⁶, L. Aperio Bella ⁴⁸, C. Appelt ¹⁸, A. Apyan ²⁶, N. Aranzabal ³⁶, S.J. Arbol Val ⁸⁷, C. Arcangeletti ⁵³, A.T.H. Arce ⁵¹, E. Arena ⁹², J-F. Arguin ¹⁰⁸, S. Argyropoulos ⁵⁴, J.-H. Arling ⁴⁸, O. Arnaez ⁴, H. Arnold ¹¹⁴, G. Artoni ^{75a,75b}, H. Asada ¹¹¹, K. Asai ¹¹⁸, S. Asai ¹⁵³, N.A. Asbah ⁶¹, J. Assahsah ^{35d}, K. Assamagan ²⁹, R. Astalos ^{28a}, S. Atashi ¹⁶⁰, R.J. Atkin ^{33a}, M. Atkinson ¹⁶², H. Atmani ^{35f}, P.A. Atmasiddha ¹⁰⁶, K. Augsten ¹³², S. Auricchio ^{72a,72b}, A.D. Auriol ²⁰, V.A. Austrup ¹⁰¹, G. Avolio ³⁶, K. Axiotis ⁵⁶, G. Azuelos ^{108,av}, D. Babal ^{28b}, H. Bachacou ¹³⁵, K. Bachas ^{152,w}, A. Bachi ³⁴, F. Backman ^{47a,47b}, A. Badea ⁶¹, P. Bagnaia ^{75a,75b}, M. Bahmani ¹⁸, A.J. Bailey ¹⁶³, V.R. Bailey ¹⁶², J.T. Baines ¹³⁴, L. Baines ⁹⁴, O.K. Baker ¹⁷², E. Bakos ¹⁵, D. Bakshi Gupta ⁸, V. Balakrishnan ¹²⁰, R. Balasubramanian ¹¹⁴, E.M. Baldin ³⁷, P. Balek ^{86a}, E. Ballabene ^{23b,23a}, F. Balli ¹³⁵, L.M. Baltes ^{63a}, W.K. Balunas ³², J. Balz ¹⁰⁰, E. Banas ⁸⁷, M. Bandieramonte ¹²⁹, A. Bandyopadhyay ²⁴, S. Bansal ²⁴, L. Barak ¹⁵¹, M. Barakat ⁴⁸, E.L. Barberio ¹⁰⁵, D. Barberis ^{57b,57a}, M. Barbero ¹⁰², M.Z. Barel ¹¹⁴, K.N. Barends ^{33a}, T. Barillari ¹¹⁰, M-S. Barisits ³⁶, T. Barklow ¹⁴³, P. Baron ¹²², D.A. Baron Moreno ¹⁰¹, A. Baroncelli ^{62a}, G. Barone ²⁹, A.J. Barr ¹²⁶, J.D. Barr ⁹⁶, L. Barranco Navarro ^{47a,47b}, F. Barreiro ⁹⁹, J. Barreiro Guimarães da Costa ^{14a}, U. Barron ¹⁵¹, M.G. Barros Teixeira ^{130a}, S. Barsov ³⁷, F. Bartels ^{63a}, R. Bartoldus ¹⁴³, A.E. Barton ⁹¹, P. Bartos ^{28a}, A. Basan ^{100,af}, M. Baselga ⁴⁹, A. Bassalat ^{66,b}, M.J. Basso ^{156a}, C.R. Basson ¹⁰¹, R.L. Bates ⁵⁹, S. Batlamous ^{35e}, J.R. Batley ³², B. Batool ¹⁴¹, M. Battaglia ¹³⁶, D. Battulga ¹⁸, M. Bause ^{75a,75b}, M. Bauer ³⁶, P. Bauer ²⁴, L.T. Bazzano Hurrell ³⁰, J.B. Beacham ⁵¹, T. Beau ¹²⁷, J.Y. Beaucamp ⁹⁰, P.H. Beauchemin ¹⁵⁸, F. Becherer ⁵⁴, P. Bechtel ²⁴, H.P. Beck ^{19,u}, K. Becker ¹⁶⁷, A.J. Beddall ⁸², V.A. Bednyakov ³⁸, C.P. Bee ¹⁴⁵, L.J. Beemster ¹⁵, T.A. Beermann ³⁶, M. Begalli ^{83d}, M. Begel ²⁹, A. Behera ¹⁴⁵, J.K. Behr ⁴⁸, J.F. Beirer ⁵⁵, F. Beisiegel ²⁴, M. Belfkir ¹⁵⁹, G. Bella ¹⁵¹, L. Bellagamba ^{23b}, A. Bellerive ³⁴, P. Bellos ²⁰, K. Beloborodov ³⁷, D. Benchebroun ^{35a}, F. Bendebba ^{35a}, Y. Benhammou ¹⁵¹, M. Benoit ²⁹, J.R. Bensinger ²⁶, S. Bentvelsen ¹¹⁴, L. Beresford ⁴⁸,

M. Beretta ⁵³, E. Bergeaas Kuutmann ¹⁶¹, N. Berger ⁴, B. Bergmann ¹³², J. Beringer ^{17a},
G. Bernardi ⁵, C. Bernius ¹⁴³, F.U. Bernlochner ²⁴, F. Bernon ^{36,102}, A. Berrocal Guardia ¹³,
T. Berry ⁹⁵, P. Berta ¹³³, A. Berthold ⁵⁰, I.A. Bertram ⁹¹, S. Bethke ¹¹⁰, A. Betti ^{75a,75b},
A.J. Bevan ⁹⁴, N.K. Bhalla ⁵⁴, M. Bhamjee ^{33c}, S. Bhatta ¹⁴⁵, D.S. Bhattacharya ¹⁶⁶,
P. Bhattarai ¹⁴³, V.S. Bhopatkar ¹²¹, R. Bi ^{29,ay}, R.M. Bianchi ¹²⁹, G. Bianco ^{23b,23a}, O. Biebel ¹⁰⁹,
R. Bielski ¹²³, M. Biglietti ^{77a}, M. Bindi ⁵⁵, A. Bingul ^{21b}, C. Bini ^{75a,75b}, A. Biondini ⁹²,
C.J. Birch-sykes ¹⁰¹, G.A. Bird ^{20,134}, M. Birman ¹⁶⁹, M. Biros ¹³³, S. Biryukov ¹⁴⁶,
T. Bisanz ⁴⁹, E. Bisceglie ^{43b,43a}, J.P. Biswal ¹³⁴, D. Biswas ¹⁴¹, A. Bitadze ¹⁰¹, K. Bjørke ¹²⁵,
I. Bloch ⁴⁸, C. Blocker ²⁶, A. Blue ⁵⁹, U. Blumenschein ⁹⁴, J. Blumenthal ¹⁰⁰, G.J. Bobbink ¹¹⁴,
V.S. Bobrovnikov ³⁷, M. Boehler ⁵⁴, B. Boehm ¹⁶⁶, D. Bogavac ³⁶, A.G. Bogdanchikov ³⁷,
C. Bohm ^{47a}, V. Boisvert ⁹⁵, P. Bokan ⁴⁸, T. Bold ^{86a}, M. Bomben ⁵, M. Bona ⁹⁴,
M. Boonekamp ¹³⁵, C.D. Booth ⁹⁵, A.G. Borbély ^{59,as}, I.S. Bordulev ³⁷,
H.M. Borecka-Bielska ¹⁰⁸, G. Borissov ⁹¹, D. Bortoletto ¹²⁶, D. Boscherini ^{23b}, M. Bosman ¹³,
J.D. Bossio Sola ³⁶, K. Bouaouda ^{35a}, N. Bouchhar ¹⁶³, J. Boudreau ¹²⁹,
E.V. Bouhova-Thacker ⁹¹, D. Boumediene ⁴⁰, R. Bouquet ¹⁶⁵, A. Boveia ¹¹⁹, J. Boyd ³⁶,
D. Boye ²⁹, I.R. Boyko ³⁸, J. Bracinik ²⁰, N. Brahimi ^{62d}, G. Brandt ¹⁷¹, O. Brandt ³²,
F. Braren ⁴⁸, B. Brau ¹⁰³, J.E. Brau ¹²³, R. Brenner ¹⁶⁹, L. Brenner ¹¹⁴, R. Brenner ¹⁶¹,
S. Bressler ¹⁶⁹, D. Britton ⁵⁹, D. Britzger ¹¹⁰, I. Brock ²⁴, G. Brooijmans ⁴¹, W.K. Brooks ^{137f},
E. Brost ²⁹, L.M. Brown ^{165,n}, L.E. Bruce ⁶¹, T.L. Bruckler ¹²⁶, P.A. Bruckman de Renstrom ⁸⁷,
B. Brüers ⁴⁸, A. Bruni ^{23b}, G. Bruni ^{23b}, M. Bruschi ^{23b}, N. Bruscino ^{75a,75b}, T. Buanes ¹⁶,
Q. Buat ¹³⁸, D. Buchin ¹¹⁰, A.G. Buckley ⁵⁹, O. Bulekov ³⁷, B.A. Bullard ¹⁴³, S. Burdin ⁹²,
C.D. Burgard ⁴⁹, A.M. Burger ⁴⁰, B. Burghgrave ⁸, O. Burlayenko ⁵⁴, J.T.P. Burr ³²,
C.D. Burton ¹¹, J.C. Burzynski ¹⁴², E.L. Busch ⁴¹, V. Büscher ¹⁰⁰, P.J. Bussey ⁵⁹,
J.M. Butler ²⁵, C.M. Buttar ⁵⁹, J.M. Butterworth ⁹⁶, W. Buttinger ¹³⁴, C.J. Buxo Vazquez ¹⁰⁷,
A.R. Buzykaev ³⁷, S. Cabrera Urbán ¹⁶³, L. Cadamuro ⁶⁶, D. Caforio ⁵⁸, H. Cai ¹²⁹,
Y. Cai ^{14a,14e}, Y. Cai ^{14c}, V.M.M. Cairo ³⁶, O. Cakir ^{3a}, N. Calace ³⁶, P. Calafiura ^{17a},
G. Calderini ¹²⁷, P. Calfayan ⁶⁸, G. Callea ⁵⁹, L.P. Caloba ^{83b}, D. Calvet ⁴⁰, S. Calvet ⁴⁰,
T.P. Calvet ¹⁰², M. Calvetti ^{74a,74b}, R. Camacho Toro ¹²⁷, S. Camarda ³⁶, D. Camarero Munoz ²⁶,
P. Camarri ^{76a,76b}, M.T. Camerlingo ^{72a,72b}, D. Cameron ^{36,h}, C. Camincher ¹⁶⁵,
M. Campanelli ⁹⁶, A. Camplani ⁴², V. Canale ^{72a,72b}, A. Canesse ¹⁰⁴, J. Cantero ¹⁶³, Y. Cao ¹⁶²,
F. Capocasa ²⁶, M. Capua ^{43b,43a}, A. Carbone ^{71a,71b}, R. Cardarelli ^{76a}, J.C.J. Cardenas ⁸,
F. Cardillo ¹⁶³, G. Carducci ^{43b,43a}, T. Carli ³⁶, G. Carlino ^{72a}, J.I. Carlotto ¹³, B.T. Carlson ^{129,x},
E.M. Carlson ^{165,156a}, L. Carminati ^{71a,71b}, A. Carnelli ¹³⁵, M. Carnesale ^{75a,75b}, S. Caron ¹¹³,
E. Carquin ^{137f}, S. Carrá ^{71a,71b}, G. Carratta ^{23b,23a}, F. Carrio Argos ^{33g}, J.W.S. Carter ¹⁵⁵,
T.M. Carter ⁵², M.P. Casado ^{13,k}, M. Caspar ⁴⁸, F.L. Castillo ⁴, L. Castillo Garcia ¹³,
V. Castillo Gimenez ¹⁶³, N.F. Castro ^{130a,130e}, A. Catinaccio ³⁶, J.R. Catmore ¹²⁵, V. Cavaliere ²⁹,
N. Cavalli ^{23b,23a}, V. Cavasinni ^{74a,74b}, Y.C. Cekmecelioglu ⁴⁸, E. Celebi ^{21a}, F. Celli ¹²⁶,
M.S. Centonze ^{70a,70b}, V. Cepaitis ⁵⁶, K. Cerny ¹²², A.S. Cerqueira ^{83a}, A. Cerri ¹⁴⁶,
L. Cerrito ^{76a,76b}, F. Cerutti ^{17a}, B. Cervato ¹⁴¹, A. Cervelli ^{23b}, G. Cesarini ⁵³, S.A. Cetin ⁸²,
Z. Chadi ^{35a}, D. Chakraborty ¹¹⁵, J. Chan ¹⁷⁰, W.Y. Chan ¹⁵³, J.D. Chapman ³², E. Chapon ¹³⁵,
B. Chargeishvili ^{149b}, D.G. Charlton ²⁰, T.P. Charman ⁹⁴, M. Chatterjee ¹⁹, C. Chauhan ¹³³,
S. Chekanov ⁶, S.V. Chekulaev ^{156a}, G.A. Chelkov ^{38,a}, A. Chen ¹⁰⁶, B. Chen ¹⁵¹, B. Chen ¹⁶⁵,
H. Chen ^{14c}, H. Chen ²⁹, J. Chen ^{62c}, J. Chen ¹⁴², M. Chen ¹²⁶, S. Chen ¹⁵³, S.J. Chen ^{14c},
X. Chen ^{62c,135}, X. Chen ^{14b,au}, Y. Chen ^{62a}, C.L. Cheng ¹⁷⁰, H.C. Cheng ^{64a}, S. Cheong ¹⁴³,
A. Cheplakov ³⁸, E. Cheremushkina ⁴⁸, E. Cherepanova ¹¹⁴, R. Cherkaoui El Moursli ^{35e},
E. Cheu ⁷, K. Cheung ⁶⁵, L. Chevalier ¹³⁵, V. Chiarella ⁵³, G. Chiarelli ^{74a}, N. Chiedde ¹⁰²,
G. Chiodini ^{70a}, A.S. Chisholm ²⁰, A. Chitan ^{27b}, M. Chitishvili ¹⁶³, M.V. Chizhov ³⁸,

K. Choi ¹¹, A.R. Chomont ^{75a,75b}, Y. Chou ¹⁰³, E.Y.S. Chow ¹¹³, T. Chowdhury ^{33g}, K.L. Chu ¹⁶⁹, M.C. Chu ^{64a}, X. Chu ^{14a,14e}, J. Chudoba ¹³¹, J.J. Chwastowski ⁸⁷, D. Cieri ¹¹⁰, K.M. Ciesla ^{86a}, V. Cindro ⁹³, A. Ciocio ^{17a}, F. Cirotto ^{72a,72b}, Z.H. Citron ^{169,o}, M. Citterio ^{71a}, D.A. Ciubotaru ^{27b}, B.M. Ciungu ¹⁵⁵, A. Clark ⁵⁶, P.J. Clark ⁵², C. Clarry ¹⁵⁵, J.M. Clavijo Columbie ⁴⁸, S.E. Clawson ⁴⁸, C. Clement ^{47a,47b}, J. Clercx ⁴⁸, L. Clissa ^{23b,23a}, Y. Coadou ¹⁰², M. Cobal ^{69a,69c}, A. Coccaro ^{57b}, R.F. Coelho Barrue ^{130a}, R. Coelho Lopes De Sa ¹⁰³, S. Coelli ^{71a}, H. Cohen ¹⁵¹, A.E.C. Coimbra ^{71a,71b}, B. Cole ⁴¹, J. Collot ⁶⁰, P. Conde Muño ^{130a,130g}, M.P. Connell ^{33c}, S.H. Connell ^{33c}, I.A. Connelly ⁵⁹, E.I. Conroy ¹²⁶, F. Conventi ^{72a,aw}, H.G. Cooke ²⁰, A.M. Cooper-Sarkar ¹²⁶, A. Cordeiro Oudot Choi ¹²⁷, L.D. Corpe ⁴⁰, M. Corradi ^{75a,75b}, F. Corriveau ^{104,ai}, A. Cortes-Gonzalez ¹⁸, M.J. Costa ¹⁶³, F. Costanza ⁴, D. Costanzo ¹³⁹, B.M. Cote ¹¹⁹, G. Cowan ⁹⁵, K. Cranmer ¹⁷⁰, D. Cremonini ^{23b,23a}, S. Crépé-Renaudin ⁶⁰, F. Crescioli ¹²⁷, M. Cristinziani ¹⁴¹, M. Cristoforetti ^{78a,78b}, V. Croft ¹¹⁴, J.E. Crosby ¹²¹, G. Crosetti ^{43b,43a}, A. Cueto ⁹⁹, T. Cuhadar Donszelmann ¹⁶⁰, H. Cui ^{14a,14e}, Z. Cui ⁷, W.R. Cunningham ⁵⁹, F. Curcio ^{43b,43a}, P. Czodrowski ³⁶, M.M. Czurylo ^{63b}, M.J. Da Cunha Sargedas De Sousa ^{57b,57a}, J.V. Da Fonseca Pinto ^{83b}, C. Da Via ¹⁰¹, W. Dabrowski ^{86a}, T. Dado ⁴⁹, S. Dahbi ^{33g}, T. Dai ¹⁰⁶, D. Dal Santo ¹⁹, C. Dallapiccola ¹⁰³, M. Dam ⁴², G. D'amen ²⁹, V. D'Amico ¹⁰⁹, J. Damp ¹⁰⁰, J.R. Dandoy ¹²⁸, M.F. Daneri ³⁰, M. Danninger ¹⁴², V. Dao ³⁶, G. Darbo ^{57b}, S. Darmora ⁶, S.J. Das ^{29,ay}, S. D'Auria ^{71a,71b}, C. David ^{156b}, T. Davidek ¹³³, B. Davis-Purcell ³⁴, I. Dawson ⁹⁴, H.A. Day-hall ¹³², K. De ⁸, R. De Asmundis ^{72a}, N. De Biase ⁴⁸, S. De Castro ^{23b,23a}, N. De Groot ¹¹³, P. de Jong ¹¹⁴, H. De la Torre ¹¹⁵, A. De Maria ^{14c}, A. De Salvo ^{75a}, U. De Sanctis ^{76a,76b}, A. De Santo ¹⁴⁶, J.B. De Vivie De Regie ⁶⁰, D.V. Dedovich ³⁸, J. Degens ¹¹⁴, A.M. Deiana ⁴⁴, F. Del Corso ^{23b,23a}, J. Del Peso ⁹⁹, F. Del Rio ^{63a}, F. Deliot ¹³⁵, C.M. Delitzsch ⁴⁹, M. Della Pietra ^{72a,72b}, D. Della Volpe ⁵⁶, A. Dell'Acqua ³⁶, L. Dell'Asta ^{71a,71b}, M. Delmastro ⁴, P.A. Delsart ⁶⁰, S. Demers ¹⁷², M. Demichev ³⁸, S.P. Denisov ³⁷, L. D'Eramo ⁴⁰, D. Derendarz ⁸⁷, F. Derue ¹²⁷, P. Dervan ⁹², K. Desch ²⁴, C. Deutsch ²⁴, F.A. Di Bello ^{57b,57a}, A. Di Ciaccio ^{76a,76b}, L. Di Ciaccio ⁴, A. Di Domenico ^{75a,75b}, C. Di Donato ^{72a,72b}, A. Di Girolamo ³⁶, G. Di Gregorio ³⁶, A. Di Luca ^{78a,78b}, B. Di Micco ^{77a,77b}, R. Di Nardo ^{77a,77b}, C. Diaconu ¹⁰², M. Diamantopoulou ³⁴, F.A. Dias ¹¹⁴, T. Dias Do Vale ¹⁴², M.A. Diaz ^{137a,137b}, F.G. Diaz Capriles ²⁴, M. Didenko ¹⁶³, E.B. Diehl ¹⁰⁶, L. Diehl ⁵⁴, S. Díez Cornell ⁴⁸, C. Diez Pardos ¹⁴¹, C. Dimitriadi ^{161,24,161}, A. Dimitrievska ^{17a}, J. Dingfelder ²⁴, I-M. Dinu ^{27b}, S.J. Dittmeier ^{63b}, F. Dittus ³⁶, F. Djama ¹⁰², T. Djobava ^{149b}, J.I. Djuvsland ¹⁶, C. Doglioni ^{101,98}, A. Dohnalova ^{28a}, J. Dolejsi ¹³³, Z. Dolezal ¹³³, K.M. Dona ³⁹, M. Donadelli ^{83c}, B. Dong ¹⁰⁷, J. Donini ⁴⁰, A. D'Onofrio ^{77a,77b}, M. D'Onofrio ⁹², J. Dopke ¹³⁴, A. Doria ^{72a}, N. Dos Santos Fernandes ^{130a}, P. Dougan ¹⁰¹, M.T. Dova ⁹⁰, A.T. Doyle ⁵⁹, M.A. Draguet ¹²⁶, E. Dreyer ¹⁶⁹, I. Drivas-koulouris ¹⁰, M. Drnevich ¹¹⁷, A.S. Drobac ¹⁵⁸, M. Drozdova ⁵⁶, D. Du ^{62a}, T.A. du Pree ¹¹⁴, F. Dubinin ³⁷, M. Dubovsky ^{28a}, E. Duchovni ¹⁶⁹, G. Duckeck ¹⁰⁹, O.A. Ducu ^{27b}, D. Duda ⁵², A. Dudarev ³⁶, E.R. Duden ²⁶, M. D'uffizi ¹⁰¹, L. Duflot ⁶⁶, M. Dührssen ³⁶, C. Dülse ¹⁷¹, A.E. Dumitriu ^{27b}, M. Dunford ^{63a}, S. Dungs ⁴⁹, K. Dunne ^{47a,47b}, A. Duperrin ¹⁰², H. Duran Yildiz ^{3a}, M. Düren ⁵⁸, A. Durglishvili ^{149b}, B.L. Dwyer ¹¹⁵, G.I. Dyckes ^{17a}, M. Dyndal ^{86a}, B.S. Dziedzic ⁸⁷, Z.O. Earnshaw ¹⁴⁶, G.H. Eberwein ¹²⁶, B. Eckerova ^{28a}, S. Eggebrecht ⁵⁵, E. Egidio Purcino De Souza ¹²⁷, L.F. Ehrke ⁵⁶, G. Eigen ¹⁶, K. Einsweiler ^{17a}, T. Ekelof ¹⁶¹, P.A. Ekman ⁹⁸, S. El Farkh ^{35b}, Y. El Ghazali ^{35b}, H. El Jarrari ^{35e,148}, A. El Moussaouy ^{108,ab}, V. Ellajosyula ¹⁶¹, M. Ellert ¹⁶¹, F. Ellinghaus ¹⁷¹, N. Ellis ³⁶, J. Elmsheuser ²⁹, M. Elsing ³⁶, D. Emelianov ¹³⁴, Y. Enari ¹⁵³, I. Ene ^{17a}, S. Epari ¹³, J. Erdmann ⁴⁹, P.A. Erland ⁸⁷,

M. Errenst ¹⁷¹, M. Escalier ⁶⁶, C. Escobar ¹⁶³, E. Etzion ¹⁵¹, G. Evans ^{130a}, H. Evans ⁶⁸,
L.S. Evans ⁹⁵, M.O. Evans ¹⁴⁶, A. Ezhilov ³⁷, S. Ezzarqtouni ^{35a}, F. Fabbri ⁵⁹, L. Fabbri ^{23b,23a},
G. Facini ⁹⁶, V. Fadeyev ¹³⁶, R.M. Fakhrutdinov ³⁷, S. Falciano ^{75a}, L.F. Falda Ulhoa Coelho ³⁶,
P.J. Falke ²⁴, J. Faltova ¹³³, C. Fan ¹⁶², Y. Fan ^{14a}, Y. Fang ^{14a,14e}, M. Fanti ^{71a,71b},
M. Faraj ^{69a,69b}, Z. Farazpay ⁹⁷, A. Farbin ⁸, A. Farilla ^{77a}, T. Farooque ¹⁰⁷, S.M. Farrington ⁵²,
F. Fassi ^{35e}, D. Fassouliotis ⁹, M. Faucci Giannelli ^{76a,76b}, W.J. Fawcett ³², L. Fayard ⁶⁶,
P. Federic ¹³³, P. Federicova ¹³¹, O.L. Fedin ^{37,a}, G. Fedotov ³⁷, M. Feickert ¹⁷⁰,
L. Feligioni ¹⁰², D.E. Fellers ¹²³, C. Feng ^{62b}, M. Feng ^{14b}, Z. Feng ¹¹⁴, M.J. Fenton ¹⁶⁰,
A.B. Fenyuk ³⁷, L. Ferencz ⁴⁸, R.A.M. Ferguson ⁹¹, S.I. Fernandez Luengo ^{137f},
P. Fernandez Martinez ¹³, M.J.V. Fernoux ¹⁰², J. Ferrando ⁴⁸, A. Ferrari ¹⁶¹, P. Ferrari ^{114,113},
R. Ferrari ^{73a}, D. Ferrere ⁵⁶, C. Ferretti ¹⁰⁶, F. Fiedler ¹⁰⁰, P. Fiedler ¹³², A. Filipčič ⁹³,
E.K. Filmer ¹, F. Filthaut ¹¹³, M.C.N. Fiolhais ^{130a,130c,d}, L. Fiorini ¹⁶³, W.C. Fisher ¹⁰⁷,
T. Fitschen ¹⁰¹, P.M. Fitzhugh ¹³⁵, I. Fleck ¹⁴¹, P. Fleischmann ¹⁰⁶, T. Flick ¹⁷¹, M. Flores ^{33d,ap},
L.R. Flores Castillo ^{64a}, L. Flores Sanz De Acedo ³⁶, F.M. Follega ^{78a,78b}, N. Fomin ¹⁶,
J.H. Foo ¹⁵⁵, B.C. Forland ⁶⁸, A. Formica ¹³⁵, A.C. Forti ¹⁰¹, E. Fortin ³⁶, A.W. Fortman ⁶¹,
M.G. Foti ^{17a}, L. Fountas ^{9,1}, D. Fournier ⁶⁶, H. Fox ⁹¹, P. Francavilla ^{74a,74b}, S. Francescato ⁶¹,
S. Franchellucci ⁵⁶, M. Franchini ^{23b,23a}, S. Franchino ^{63a}, D. Francis ³⁶, L. Franco ¹¹³,
V. Franco Lima ³⁶, L. Franconi ⁴⁸, M. Franklin ⁶¹, G. Frattari ²⁶, A.C. Freegard ⁹⁴,
W.S. Freund ^{83b}, Y.Y. Frid ¹⁵¹, J. Friend ⁵⁹, N. Fritzsche ⁵⁰, A. Froch ⁵⁴, D. Froidevaux ³⁶,
J.A. Frost ¹²⁶, Y. Fu ^{62a}, S. Fuenzalida Garrido ^{137f}, M. Fujimoto ¹⁰², E. Fullana Torregrosa ^{163,*},
K.Y. Fung ^{64a}, E. Furtado De Simas Filho ^{83b}, M. Furukawa ¹⁵³, J. Fuster ¹⁶³, A. Gabrielli ^{23b,23a},
A. Gabrielli ¹⁵⁵, P. Gadow ³⁶, G. Gagliardi ^{57b,57a}, L.G. Gagnon ^{17a}, E.J. Gallas ¹²⁶,
B.J. Gallop ¹³⁴, K.K. Gan ¹¹⁹, S. Ganguly ¹⁵³, Y. Gao ⁵², F.M. Garay Walls ^{137a,137b},
B. Garcia ^{29,ay}, C. García ¹⁶³, A. Garcia Alonso ¹¹⁴, A.G. Garcia Caffaro ¹⁷²,
J.E. García Navarro ¹⁶³, M. Garcia-Sciveres ^{17a}, G.L. Gardner ¹²⁸, R.W. Gardner ³⁹,
N. Garelli ¹⁵⁸, D. Garg ⁸⁰, R.B. Garg ^{143,t}, J.M. Gargan ⁵², C.A. Garner ¹⁵⁵, C.M. Garvey ^{33a},
P. Gaspar ^{83b}, V.K. Gassmann ¹⁵⁸, G. Gaudio ^{73a}, V. Gautam ¹³, P. Gauzzi ^{75a,75b}, I.L. Gavrilenko ³⁷,
A. Gavriluk ³⁷, C. Gay ¹⁶⁴, G. Gaycken ⁴⁸, E.N. Gazis ¹⁰, A.A. Geanta ^{27b}, C.M. Gee ¹³⁶,
A. Gekow ¹¹⁹, C. Gemme ^{57b}, M.H. Genest ⁶⁰, S. Gentile ^{75a,75b}, A.D. Gentry ¹¹², S. George ⁹⁵,
W.F. George ²⁰, T. Geralis ⁴⁶, P. Gessinger-Befurt ³⁶, M.E. Geyik ¹⁷¹, M. Ghani ¹⁶⁷,
M. Ghneimat ¹⁴¹, K. Ghorbanian ⁹⁴, A. Ghosal ¹⁴¹, A. Ghosh ¹⁶⁰, A. Ghosh ⁷, B. Giacobbe ^{23b},
S. Giagu ^{75a,75b}, T. Giani ¹¹⁴, P. Giannetti ^{74a}, A. Giannini ^{62a}, S.M. Gibson ⁹⁵, M. Gignac ¹³⁶,
D.T. Gil ^{86b}, A.K. Gilbert ^{86a}, B.J. Gilbert ⁴¹, D. Gillberg ³⁴, G. Gilles ¹¹⁴, N.E.K. Gillwald ⁴⁸,
L. Ginabat ¹²⁷, D.M. Gingrich ^{2,av}, M.P. Giordani ^{69a,69c}, P.F. Giraud ¹³⁵, G. Giugliarelli ^{69a,69c},
D. Giugni ^{71a}, F. Giuli ³⁶, I. Gkialas ^{9,1}, L.K. Gladilin ³⁷, C. Glasman ⁹⁹, G.R. Gledhill ¹²³,
G. Glemža ⁴⁸, M. Glisic ¹²³, I. Gnesi ^{43b,g}, Y. Go ^{29,ay}, M. Goblirsch-Kolb ³⁶, B. Gocke ⁴⁹,
D. Godin ¹⁰⁸, B. Gokturk ^{21a}, S. Goldfarb ¹⁰⁵, T. Golling ⁵⁶, M.G.D. Gololo ^{33g}, D. Golubkov ³⁷,
J.P. Gombas ¹⁰⁷, A. Gomes ^{130a,130b}, G. Gomes Da Silva ¹⁴¹, A.J. Gomez Delegido ¹⁶³,
R. Gonçalves ^{130a,130c}, G. Gonella ¹²³, L. Gonella ²⁰, A. Gongadze ^{149c}, F. Gonnella ²⁰,
J.L. Gonski ⁴¹, R.Y. González Andana ⁵², S. González de la Hoz ¹⁶³, S. Gonzalez Fernandez ¹³,
R. Gonzalez Lopez ⁹², C. Gonzalez Renteria ^{17a}, M.V. Gonzalez Rodrigues ⁴⁸,
R. Gonzalez Suarez ¹⁶¹, S. Gonzalez-Sevilla ⁵⁶, G.R. Gonzalvo Rodriguez ¹⁶³, L. Goossens ³⁶,
B. Gorini ³⁶, E. Gorini ^{70a,70b}, A. Gorišek ⁹³, T.C. Gosart ¹²⁸, A.T. Goshaw ⁵¹, M.I. Gostkin ³⁸,
S. Goswami ¹²¹, C.A. Gottardo ³⁶, S.A. Gotz ¹⁰⁹, M. Goughri ^{35b}, V. Goumarre ⁴⁸,
A.G. Goussiou ¹³⁸, N. Govender ^{33c}, I. Grabowska-Bold ^{86a}, K. Graham ³⁴, E. Gramstad ¹²⁵,
S. Grancagnolo ^{70a,70b}, M. Grandi ¹⁴⁶, C.M. Grant ^{1,135}, P.M. Gravila ^{27f}, F.G. Gravili ^{70a,70b},
H.M. Gray ^{17a}, M. Greco ^{70a,70b}, C. Greife ²⁴, I.M. Gregor ⁴⁸, P. Grenier ¹⁴³, S.G. Grewe ¹¹⁰,

C. Grieco ¹³, A.A. Grillo ¹³⁶, K. Grimm ³¹, S. Grinstein ^{13,ad}, J.-F. Grivaz ⁶⁶, E. Gross ¹⁶⁹, J. Grosse-Knetter ⁵⁵, C. Grud ¹⁰⁶, J.C. Grundy ¹²⁶, L. Guan ¹⁰⁶, W. Guan ¹⁷⁰, C. Gubbels ¹⁶⁴, J.G.R. Guerrero Rojas ¹⁶³, G. Guerrieri ^{69a,69c}, F. Guescini ¹¹⁰, R. Gugel ¹⁰⁰, J.A.M. Guhit ¹⁰⁶, A. Guida ¹⁸, T. Guillemin ⁴, E. Guilloton ^{167,134}, S. Guindon ³⁶, F. Guo ^{14a,14e}, J. Guo ^{62c}, L. Guo ⁴⁸, Y. Guo ¹⁰⁶, R. Gupta ⁴⁸, R. Gupta ¹²⁹, S. Gurbuz ²⁴, S.S. Gurdasani ⁵⁴, G. Gustavino ³⁶, M. Guth ⁵⁶, P. Gutierrez ¹²⁰, L.F. Gutierrez Zagazeta ¹²⁸, M. Gutsche ⁵⁰, C. Gutschow ⁹⁶, C. Gwenlan ¹²⁶, C.B. Gwilliam ⁹², E.S. Haaland ¹²⁵, A. Haas ¹¹⁷, M. Habedank ⁴⁸, C. Haber ^{17a}, H.K. Hadavand ⁸, A. Hadeef ¹⁰⁰, S. Hadzic ¹¹⁰, A.I. Hagan ⁹¹, J.J. Hahn ¹⁴¹, E.H. Haines ⁹⁶, M. Haleem ¹⁶⁶, J. Haley ¹²¹, J.J. Hall ¹³⁹, G.D. Hallowell ¹⁰², L. Halser ¹⁹, K. Hamano ¹⁶⁵, M. Hamer ²⁴, G.N. Hamity ⁵², E.J. Hampshire ⁹⁵, J. Han ^{62b}, K. Han ^{62a}, L. Han ^{14c}, L. Han ^{62a}, S. Han ^{17a}, Y.F. Han ¹⁵⁵, K. Hanagaki ⁸⁴, M. Hance ¹³⁶, D.A. Hangal ^{41,ao}, H. Hanif ¹⁴², M.D. Hank ¹²⁸, R. Hankache ¹⁰¹, J.B. Hansen ⁴², J.D. Hansen ⁴², P.H. Hansen ⁴², K. Hara ¹⁵⁷, D. Harada ⁵⁶, T. Harenberg ¹⁷¹, S. Harkusha ³⁷, M.L. Harris ¹⁰³, Y.T. Harris ¹²⁶, J. Harrison ¹³, N.M. Harrison ¹¹⁹, P.F. Harrison ¹⁶⁷, N.M. Hartman ¹⁴³, N.M. Hartmann ¹⁰⁹, Y. Hasegawa ¹⁴⁰, R. Hauser ¹⁰⁷, C.M. Hawkes ²⁰, R.J. Hawkings ³⁶, Y. Hayashi ¹⁵³, S. Hayashida ¹¹¹, D. Hayden ¹⁰⁷, C. Hayes ¹⁰⁶, R.L. Hayes ¹¹⁴, C.P. Hays ¹²⁶, J.M. Hays ⁹⁴, H.S. Hayward ⁹², F. He ^{62a}, M. He ^{14a,14e}, Y. He ¹⁵⁴, Y. He ⁴⁸, N.B. Heatley ⁹⁴, V. Hedberg ⁹⁸, A.L. Heggelund ¹²⁵, N.D. Hehir ⁹⁴, C. Heidegger ⁵⁴, K.K. Heidegger ⁵⁴, W.D. Heidorn ⁸¹, J. Heilman ³⁴, S. Heim ⁴⁸, T. Heim ^{17a}, J.G. Heinlein ¹²⁸, J.J. Heinrich ¹²³, L. Heinrich ^{110,at}, J. Hejbal ¹³¹, L. Helary ⁴⁸, A. Held ¹⁷⁰, S. Hellesund ¹⁶, C.M. Helling ¹⁶⁴, S. Hellman ^{47a,47b}, R.C.W. Henderson ⁹¹, L. Henkelmann ³², A.M. Henriques Correia ³⁶, H. Herde ⁹⁸, Y. Hernández Jiménez ¹⁴⁵, L.M. Herrmann ²⁴, T. Herrmann ⁵⁰, G. Herten ⁵⁴, R. Hertenberger ¹⁰⁹, L. Hervas ³⁶, M.E. Hespington ¹⁰⁰, N.P. Hessey ^{156a}, H. Hibi ⁸⁵, E. Hill ¹⁵⁵, S.J. Hillier ²⁰, J.R. Hinds ¹⁰⁷, F. Hinterkeuser ²⁴, M. Hirose ¹²⁴, S. Hirose ¹⁵⁷, D. Hirschbuehl ¹⁷¹, T.G. Hitchings ¹⁰¹, B. Hiti ⁹³, J. Hobbs ¹⁴⁵, R. Hobincu ^{27e}, N. Hod ¹⁶⁹, M.C. Hodgkinson ¹³⁹, B.H. Hodgkinson ³², A. Hoecker ³⁶, J. Hofer ⁴⁸, T. Holm ²⁴, M. Holzbock ¹¹⁰, L.B.A.H. Hommels ³², B.P. Honan ¹⁰¹, J. Hong ^{62c}, T.M. Hong ¹²⁹, B.H. Hooberman ¹⁶², W.H. Hopkins ⁶, Y. Horii ¹¹¹, S. Hou ¹⁴⁸, A.S. Howard ⁹³, J. Howarth ⁵⁹, J. Hoya ⁶, M. Hrabovsky ¹²², A. Hrynevich ⁴⁸, T. Hryn'ova ⁴, P.J. Hsu ⁶⁵, S.-C. Hsu ¹³⁸, Q. Hu ^{62a}, Y.F. Hu ^{14a,14e}, S. Huang ^{64b}, X. Huang ^{14c}, X. Huang ^{14a,14e}, Y. Huang ^{139,m}, Y. Huang ^{14a}, Z. Huang ¹⁰¹, Z. Hubacek ¹³², M. Huebner ²⁴, F. Huegging ²⁴, T.B. Huffman ¹²⁶, C.A. Hugli ⁴⁸, M. Huhtinen ³⁶, S.K. Huiberts ¹⁶, R. Hulsken ¹⁰⁴, N. Huseynov ¹², J. Huston ¹⁰⁷, J. Huth ⁶¹, R. Hyneman ¹⁴³, G. Iacobucci ⁵⁶, G. Iakovidis ²⁹, I. Ibragimov ¹⁴¹, L. Iconomidou-Fayard ⁶⁶, P. Iengo ^{72a,72b}, R. Iguchi ¹⁵³, T. Iizawa ^{126,r}, Y. Ikegami ⁸⁴, N. Ilic ¹⁵⁵, H. Imam ^{35a}, M. Ince Lezki ⁵⁶, T. Ingebretsen Carlson ^{47a,47b}, G. Introzzi ^{73a,73b}, M. Iodice ^{77a}, V. Ippolito ^{75a,75b}, R.K. Irwin ⁹², M. Ishino ¹⁵³, W. Islam ¹⁷⁰, C. Issever ^{18,48}, S. Istin ^{21a,ba}, H. Ito ¹⁶⁸, J.M. Iturbe Ponce ^{64a}, R. Iuppa ^{78a,78b}, A. Ivina ¹⁶⁹, J.M. Izen ⁴⁵, V. Izzo ^{72a}, P. Jacka ^{131,132}, P. Jackson ¹, R.M. Jacobs ⁴⁸, B.P. Jaeger ¹⁴², C.S. Jagfeld ¹⁰⁹, G. Jain ^{156a}, P. Jain ⁵⁴, K. Jakobs ⁵⁴, T. Jakoubek ¹⁶⁹, J. Jamieson ⁵⁹, K.W. Janas ^{86a}, M. Javurkova ¹⁰³, F. Jeanneau ¹³⁵, L. Jeanty ¹²³, J. Jejelava ^{149a,al}, P. Jenni ^{54,i}, C.E. Jessiman ³⁴, S. Jézéquel ⁴, C. Jia ^{62b}, J. Jia ¹⁴⁵, X. Jia ⁶¹, X. Jia ^{14a,14e}, Z. Jia ^{14c}, S. Jiggins ⁴⁸, J. Jimenez Pena ¹³, S. Jin ^{14c}, A. Jinaru ^{27b}, O. Jinnouchi ¹⁵⁴, P. Johansson ¹³⁹, K.A. Johns ⁷, J.W. Johnson ¹³⁶, D.M. Jones ³², E. Jones ⁴⁸, P. Jones ³², R.W.L. Jones ⁹¹, T.J. Jones ⁹², H.L. Joos ^{55,36}, R. Joshi ¹¹⁹, J. Jovicevic ¹⁵, X. Ju ^{17a}, J.J. Junggeburth ^{103,v}, T. Junkermann ^{63a}, A. Juste Rozas ^{13,ad}, M.K. Juzek ⁸⁷, S. Kabana ^{137e}, A. Kaczmarek ⁸⁷, M. Kado ¹¹⁰, H. Kagan ¹¹⁹, M. Kagan ¹⁴³, A. Kahn ⁴¹, A. Kahn ¹²⁸, C. Kahra ¹⁰⁰, T. Kaji ¹⁵³, E. Kajomovitz ¹⁵⁰, N. Kakati ¹⁶⁹, I. Kalaitzidou ⁵⁴, C.W. Kalderon ²⁹, A. Kamenshchikov ¹⁵⁵,

N.J. Kang ¹³⁶, D. Kar ^{33g}, K. Karava ¹²⁶, M.J. Kareem ^{156b}, E. Karentzos ⁵⁴, I. Karkanias ¹⁵²,
 O. Karkout ¹¹⁴, S.N. Karpov ³⁸, Z.M. Karpova ³⁸, V. Kartvelishvili ⁹¹, A.N. Karyukhin ³⁷,
 E. Kasimi ¹⁵², J. Katzy ⁴⁸, S. Kaur ³⁴, K. Kawade ¹⁴⁰, M.P. Kawale ¹²⁰, C. Kawamoto ⁸⁸,
 T. Kawamoto ¹³⁵, E.F. Kay ³⁶, F.I. Kaya ¹⁵⁸, S. Kazakos ¹⁰⁷, V.F. Kazanin ³⁷, Y. Ke ¹⁴⁵,
 J.M. Keaveney ^{33a}, R. Keeler ¹⁶⁵, G.V. Kehris ⁶¹, J.S. Keller ³⁴, A.S. Kelly ⁹⁶, J.J. Kempster ¹⁴⁶,
 K.E. Kennedy ⁴¹, P.D. Kennedy ¹⁰⁰, O. Kepka ¹³¹, B.P. Kerridge ¹⁶⁷, S. Kersten ¹⁷¹,
 B.P. Kerševan ⁹³, S. Keshri ⁶⁶, L. Keszeghova ^{28a}, S. Ketabchi Haghighat ¹⁵⁵, M. Khandoga ¹²⁷,
 A. Khanov ¹²¹, A.G. Kharlamov ³⁷, T. Kharlamova ³⁷, E.E. Khoda ¹³⁸, M. Kholodenko ³⁷,
 T.J. Khoo ¹⁸, G. Khoraiuli ¹⁶⁶, J. Khubua ^{149b}, Y.A.R. Khwaira ⁶⁶, A. Kilgallon ¹²³,
 D.W. Kim ^{47a,47b}, Y.K. Kim ³⁹, N. Kimura ⁹⁶, M.K. Kingston ⁵⁵, A. Kirchhoff ⁵⁵, C. Kirfel ²⁴,
 F. Kirfel ²⁴, J. Kirk ¹³⁴, A.E. Kiryunin ¹¹⁰, C. Kitsaki ¹⁰, O. Kivernyk ²⁴, M. Klassen ^{63a},
 C. Klein ³⁴, L. Klein ¹⁶⁶, M.H. Klein ¹⁰⁶, M. Klein ⁹², S.B. Klein ⁵⁶, U. Klein ⁹²,
 P. Klimek ³⁶, A. Klimentov ²⁹, T. Klioutchnikova ³⁶, P. Kluit ¹¹⁴, S. Kluth ¹¹⁰, E. Kneringer ⁷⁹,
 T.M. Knight ¹⁵⁵, A. Knue ⁴⁹, R. Kobayashi ⁸⁸, D. Kobylanski ¹⁶⁹, S.F. Koch ¹²⁶,
 M. Kocian ¹⁴³, P. Kodyš ¹³³, D.M. Koeck ¹²³, P.T. Koenig ²⁴, T. Koffas ³⁴, O. Kolay ⁵⁰,
 M. Kolb ¹³⁵, I. Koletsou ⁴, T. Komarek ¹²², K. Köneke ⁵⁴, A.X.Y. Kong ¹, T. Kono ¹¹⁸,
 N. Konstantinidis ⁹⁶, P. Kontaxakis ⁵⁶, B. Konya ⁹⁸, R. Kopeliansky ⁶⁸, S. Koperny ^{86a},
 K. Korcyl ⁸⁷, K. Kordas ^{152,f}, G. Koren ¹⁵¹, A. Korn ⁹⁶, S. Korn ⁵⁵, I. Korolkov ¹³,
 N. Korotkova ³⁷, B. Kortman ¹¹⁴, O. Kortner ¹¹⁰, S. Kortner ¹¹⁰, W.H. Kostecka ¹¹⁵,
 V.V. Kostyukhin ¹⁴¹, A. Kotsokechagia ¹³⁵, A. Kotwal ⁵¹, A. Koulouris ³⁶,
 A. Kourkoumeli-Charalampidi ^{73a,73b}, C. Kourkoumelis ⁹, E. Kourlitis ^{110,at}, O. Kovanda ¹⁴⁶,
 R. Kowalewski ¹⁶⁵, W. Kozanecki ¹³⁵, A.S. Kozhin ³⁷, V.A. Kramarenko ³⁷, G. Kramberger ⁹³,
 P. Kramer ¹⁰⁰, M.W. Krasny ¹²⁷, A. Krasznahorkay ³⁶, J.W. Kraus ¹⁷¹, J.A. Kremer ⁴⁸,
 T. Kresse ⁵⁰, J. Kretschmar ⁹², K. Kreul ¹⁸, P. Krieger ¹⁵⁵, S. Krishnamurthy ¹⁰³,
 M. Krivos ¹³³, K. Krizka ²⁰, K. Kroeninger ⁴⁹, H. Kroha ¹¹⁰, J. Kroll ¹³¹, J. Kroll ¹²⁸,
 K.S. Krowpman ¹⁰⁷, U. Kruchonak ³⁸, H. Krüger ²⁴, N. Krumnack ⁸¹, M.C. Kruse ⁵¹,
 J.A. Krzysiak ⁸⁷, O. Kuchinskaia ³⁷, S. Kuday ^{3a}, S. Kuehn ³⁶, R. Kuesters ⁵⁴, T. Kuhl ⁴⁸,
 V. Kukhtin ³⁸, Y. Kulchitsky ^{37,a}, S. Kuleshov ^{137d,137b}, M. Kumar ^{33g}, N. Kumari ⁴⁸,
 A. Kupco ¹³¹, T. Kupfer ⁴⁹, A. Kupich ³⁷, O. Kuprash ⁵⁴, H. Kurashige ⁸⁵, L.L. Kurchaninov ^{156a},
 O. Kurdysh ⁶⁶, Y.A. Kurochkin ³⁷, A. Kurova ³⁷, M. Kuze ¹⁵⁴, A.K. Kvam ¹⁰³, J. Kvita ¹²²,
 T. Kwan ¹⁰⁴, N.G. Kyriacou ¹⁰⁶, L.A.O. Laatu ¹⁰², C. Lacasta ¹⁶³, F. Lacava ^{75a,75b},
 H. Lacker ¹⁸, D. Lacour ¹²⁷, N.N. Lad ⁹⁶, E. Ladygin ³⁸, B. Laforge ¹²⁷, T. Lagouri ^{137e},
 F.Z. Lahbabi ^{35a}, S. Lai ⁵⁵, I.K. Lakomic ^{86a}, N. Lalloue ⁶⁰, J.E. Lambert ^{165,n}, S. Lammers ⁶⁸,
 W. Lampl ⁷, C. Lampoudis ^{152,f}, A.N. Lancaster ¹¹⁵, E. Lançon ²⁹, U. Landgraf ⁵⁴,
 M.P.J. Landon ⁹⁴, V.S. Lang ⁵⁴, R.J. Langenberg ¹⁰³, O.K.B. Langrekken ¹²⁵, A.J. Lankford ¹⁶⁰,
 F. Lanni ³⁶, K. Lantzsch ²⁴, A. Lanza ^{73a}, A. Lapertosa ^{57b,57a}, J.F. Laporte ¹³⁵, T. Lari ^{71a},
 F. Lasagni Manghi ^{23b}, M. Lassnig ³⁶, V. Latonova ¹³¹, A. Laudrain ¹⁰⁰, A. Laurier ¹⁵⁰,
 S.D. Lawlor ¹³⁹, Z. Lawrence ¹⁰¹, R. Lazaridou ¹⁶⁷, M. Lazzaroni ^{71a,71b}, B. Le ¹⁰¹,
 E.M. Le Boulicaut ⁵¹, B. Leban ⁹³, A. Lebedev ⁸¹, M. LeBlanc ^{101,ar}, F. Ledroit-Guillon ⁶⁰,
 A.C.A. Lee ⁹⁶, S.C. Lee ¹⁴⁸, S. Lee ^{47a,47b}, T.F. Lee ⁹², L.L. Leeuw ^{33c}, H.P. Lefebvre ⁹⁵,
 M. Lefebvre ¹⁶⁵, C. Leggett ^{17a}, G. Lehmann Miotto ³⁶, M. Leigh ⁵⁶, W.A. Leight ¹⁰³,
 W. Leinonen ¹¹³, A. Leisos ^{152,ac}, M.A.L. Leite ^{83c}, C.E. Leitgeb ⁴⁸, R. Leitner ¹³³,
 K.J.C. Leney ⁴⁴, T. Lenz ²⁴, S. Leone ^{74a}, C. Leonidopoulos ⁵², A. Leopold ¹⁴⁴, C. Leroy ¹⁰⁸,
 R. Les ¹⁰⁷, C.G. Lester ³², M. Levchenko ³⁷, J. Levêque ⁴, D. Levin ¹⁰⁶, L.J. Levinson ¹⁶⁹,
 M.P. Lewicki ⁸⁷, D.J. Lewis ⁴, A. Li ⁵, 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. Li ¹³⁸, L. Li ^{62c}, M. Li ^{14a,14e}, Q.Y. Li ^{62a},
 S. Li ^{14a,14e}, S. Li ^{62d,62c,e}, T. Li ^{5,c}, X. Li ¹⁰⁴, Z. Li ¹²⁶, Z. Li ¹⁰⁴, Z. Li ⁹², Z. Li ^{14a,14e},

S. Liang^{14a,14e}, Z. Liang^{14a}, M. Liberatore^{135,am}, 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,*}, 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,s}, 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,an}, D.C. Mankad¹⁶⁹, A. Mann¹⁰⁹, B. Mansoulie¹³⁵, S. Manzoni³⁶, L. Mao^{62c}, X. Mapekula^{33c}, A. Marantis^{152,ac}, 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,ad}, 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,ai}, 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}, 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. Mokgatitswane^{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. Monticelli ⁹⁰, S. Monzani ^{69a,69c}, N. Morange ⁶⁶, A.L. Moreira De Carvalho ^{130a}, M. Moreno Llácer ¹⁶³, C. Moreno Martinez ⁵⁶, P. Morettini ^{57b}, S. Morgenstern ³⁶, M. Morii ⁶¹, M. Morinaga ¹⁵³, A.K. Morley ³⁶, F. Morodei ^{75a,75b}, L. Morvaj ³⁶, P. Moschovakos ³⁶, B. Moser ³⁶, M. Mosidze ^{149b}, T. Moskalets ⁵⁴, P. Moskvitina ¹¹³, J. Moss ^{31,p}, E.J.W. Moyse ¹⁰³, O. Mtintsilana ^{33g}, S. Muanza ¹⁰², J. Mueller ¹²⁹, D. Muenstermann ⁹¹, R. Müller ¹⁹, G.A. Mullier ¹⁶¹, A.J. Mullin ³², J.J. Mullin ¹²⁸, D.P. Mungo ¹⁵⁵, D. Munoz Perez ¹⁶³, F.J. Munoz Sanchez ¹⁰¹, M. Murin ¹⁰¹, W.J. Murray ^{167,134}, A. Murrone ^{71a,71b}, M. Muškinja ^{17a}, C. Mwewa ²⁹, A.G. Myagkov ^{37,a}, A.J. Myers ⁸, G. Myers ⁶⁸, M. Myska ¹³², B.P. Nachman ^{17a}, O. Nackenhorst ⁴⁹, A. Nag ⁵⁰, K. Nagai ¹²⁶, K. Nagano ⁸⁴, J.L. Nagle ^{29,ay}, E. Nagy ¹⁰², A.M. Nairz ³⁶, Y. Nakahama ⁸⁴, K. Nakamura ⁸⁴, K. Nakkalil ⁵, H. Nanjo ¹²⁴, R. Narayan ⁴⁴, E.A. Narayanan ¹¹², I. Naryshkin ³⁷, M. Naseri ³⁴, S. Nasri ¹⁵⁹, C. Nass ²⁴, G. Navarro ^{22a}, J. Navarro-Gonzalez ¹⁶³, R. Nayak ¹⁵¹, A. Nayaz ¹⁸, P.Y. Nechaeva ³⁷, F. Nechansky ⁴⁸, L. Nedic ¹²⁶, T.J. Neep ²⁰, A. Negri ^{73a,73b}, M. Negrini ^{23b}, C. Nellist ¹¹⁴, C. Nelson ¹⁰⁴, K. Nelson ¹⁰⁶, S. Nemecek ¹³¹, M. Nessi ^{36,j}, M.S. Neubauer ¹⁶², F. Neuhaus ¹⁰⁰, J. Neundorff ⁴⁸, R. Newhouse ¹⁶⁴, P.R. Newman ²⁰, C.W. Ng ¹²⁹, Y.W.Y. Ng ⁴⁸, B. Ngair ^{35e}, H.D.N. Nguyen ¹⁰⁸, R.B. Nickerson ¹²⁶, R. Nicolaidou ¹³⁵, J. Nielsen ¹³⁶, M. Niemeyer ⁵⁵, J. Niermann ^{55,36}, N. Nikiforou ³⁶, V. Nikolaenko ^{37,a}, I. Nikolic-Audit ¹²⁷, K. Nikolopoulos ²⁰, P. Nilsson ²⁹, I. Ninca ⁴⁸, H.R. Nindhito ⁵⁶, G. Ninio ¹⁵¹, A. Nisati ^{75a}, N. Nishu ², R. Nisius ¹¹⁰, J-E. Nitschke ⁵⁰, E.K. Nkadimeng ^{33g}, T. Nobe ¹⁵³, D.L. Noel ³², T. Nommensen ¹⁴⁷, M.B. Norfolk ¹³⁹, R.R.B. Norisam ⁹⁶, B.J. Norman ³⁴, J. Novak ⁹³, T. Novak ⁴⁸, L. Novotny ¹³², R. Novotny ¹¹², L. Nozka ¹²², K. Ntekas ¹⁶⁰, N.M.J. Nunes De Moura Junior ^{83b}, E. Nurse ⁹⁶, J. Ocariz ¹²⁷, A. Ochi ⁸⁵, I. Ochoa ^{130a}, S. Oerdek ^{48,y}, J.T. Offermann ³⁹, A. Ogrodnik ¹³³, A. Oh ¹⁰¹, C.C. Ohm ¹⁴⁴, H. Oide ⁸⁴, R. Oishi ¹⁵³, M.L. Ojeda ⁴⁸, M.W. O'Keefe ⁹², Y. Okumura ¹⁵³, L.F. Oleiro Seabra ^{130a}, S.A. Olivares Pino ^{137d}, D. Oliveira Damazio ²⁹, D. Oliveira Goncalves ^{83a}, J.L. Oliver ¹⁶⁰, Ö.O. Öncel ⁵⁴, A.P. O'Neill ¹⁹, A. Onofre ^{130a,130e}, P.U.E. Onyisi ¹¹, M.J. Oreglia ³⁹, G.E. Orellana ⁹⁰, D. Orestano ^{77a,77b}, N. Orlando ¹³, R.S. Orr ¹⁵⁵, V. O'Shea ⁵⁹, L.M. Osojnak ¹²⁸, R. Ospanov ^{62a}, G. Otero y Garzon ³⁰, H. Otono ⁸⁹, P.S. Ott ^{63a}, G.J. Ottino ^{17a}, M. Ouchrif ^{35d}, J. Ouellette ²⁹, F. Ould-Saada ¹²⁵, M. Owen ⁵⁹, R.E. Owen ¹³⁴, K.Y. Oyulmaz ^{21a}, V.E. Ozcan ^{21a}, F. Ozturk ⁸⁷, N. Ozturk ⁸, S. Ozturk ⁸², H.A. Pacey ¹²⁶, A. Pacheco Pages ¹³, C. Padilla Aranda ¹³, G. Padovano ^{75a,75b}, S. Pagan Griso ^{17a}, G. Palacino ⁶⁸, A. Palazzo ^{70a,70b}, S. Palestini ³⁶, J. Pan ¹⁷², T. Pan ^{64a}, D.K. Panchal ¹¹, C.E. Pandini ¹¹⁴, J.G. Panduro Vazquez ⁹⁵, H.D. Pandya ¹, H. Pang ^{14b}, P. Pani ⁴⁸, G. Panizzo ^{69a,69c}, L. Paolozzi ⁵⁶, C. Papadatos ¹⁰⁸, S. Parajuli ⁴⁴, A. Paramonov ⁶, C. Paraskevopoulos ¹⁰, D. Paredes Hernandez ^{64b}, K.R. Park ⁴¹, T.H. Park ¹⁵⁵, M.A. Parker ³², F. Parodi ^{57b,57a}, E.W. Parrish ¹¹⁵, V.A. Parrish ⁵², J.A. Parsons ⁴¹, U. Parzefall ⁵⁴, B. Pascual Dias ¹⁰⁸, L. Pascual Dominguez ¹⁵¹, E. Pasqualucci ^{75a}, S. Passaggio ^{57b}, F. Pastore ⁹⁵, P. Pasuwan ^{47a,47b}, P. Patel ⁸⁷, U.M. Patel ⁵¹, J.R. Pater ¹⁰¹, T. Pauly ³⁶, J. Pearkes ¹⁴³, M. Pedersen ¹²⁵, R. Pedro ^{130a}, S.V. Peleganchuk ³⁷, O. Penc ³⁶, E.A. Pender ⁵², K.E. Penski ¹⁰⁹, M. Penzin ³⁷, B.S. Peralva ^{83d}, A.P. Pereira Peixoto ⁶⁰, L. Pereira Sanchez ^{47a,47b}, D.V. Perepelitsa ^{29,ay}, E. Perez Codina ^{156a}, M. Perganti ¹⁰, L. Perini ^{71a,71b,*}, H. Pernegger ³⁶, O. Perrin ⁴⁰, K. Peters ⁴⁸, R.F.Y. Peters ¹⁰¹, B.A. Petersen ³⁶, T.C. Petersen ⁴², E. Petit ¹⁰², V. Petousis ¹³², C. Petridou ^{152,f}, A. Petrukhin ¹⁴¹, M. Pettee ^{17a}, N.E. Pettersson ³⁶, A. Petukhov ³⁷, K. Petukhova ¹³³, R. Pezoa ^{137f}, L. Pezzotti ³⁶, G. Pezzullo ¹⁷², T.M. Pham ¹⁷⁰, T. Pham ¹⁰⁵, P.W. Phillips ¹³⁴, G. Piacquadio ¹⁴⁵, E. Pianori ^{17a}, F. Piazza ¹²³, R. Piegai ³⁰, D. Pietreanu ^{27b}, A.D. Pilkington ¹⁰¹, M. Pinamonti ^{69a,69c}, J.L. Pinfold ², B.C. Pinheiro Pereira ^{130a}, A.E. Pinto Pinoargote ^{100,135}, L. Pintucci ^{69a,69c}, K.M. Piper ¹⁴⁶,

A. Pirttikoski ⁵⁶, D.A. Pizzi ³⁴, L. Pizzimento ^{64b}, A. Pizzini ¹¹⁴, M.-A. Pleier ²⁹, V. Plesanovs ⁵⁴,
 V. Pleskot ¹³³, E. Plotnikova ³⁸, G. Poddar ⁴, R. Poettgen ⁹⁸, L. Poggioli ¹²⁷, I. Pokharel ⁵⁵,
 S. Polacek ¹³³, G. Polesello ^{73a}, A. Poley ^{142,156a}, R. Polifka ¹³², A. Polini ^{23b}, C.S. Pollard ¹⁶⁷,
 Z.B. Pollock ¹¹⁹, V. Polychronakos ²⁹, E. Pompa Pacchi ^{75a,75b}, D. Ponomarenko ¹¹³,
 L. Pontecorvo ³⁶, S. Popa ^{27a}, G.A. Popeneciu ^{27d}, A. Poreba ³⁶, D.M. Portillo Quintero ^{156a},
 S. Pospisil ¹³², M.A. Postill ¹³⁹, P. Postolache ^{27c}, K. Potamianos ¹⁶⁷, P.A. Potepa ^{86a},
 I.N. Potrap ³⁸, C.J. Potter ³², H. Potti ¹, T. Poulsen ⁴⁸, J. Poveda ¹⁶³, M.E. Pozo Astigarraga ³⁶,
 A. Prades Ibanez ¹⁶³, J. Pretel ⁵⁴, D. Price ¹⁰¹, M. Primavera ^{70a}, M.A. Principe Martin ⁹⁹,
 R. Privara ¹²², T. Procter ⁵⁹, M.L. Proffitt ¹³⁸, N. Proklova ¹²⁸, K. Prokofiev ^{64c}, G. Proto ¹¹⁰,
 S. Protopopescu ²⁹, J. Proudfoot ⁶, M. Przybycien ^{86a}, W.W. Przygoda ^{86b}, J.E. Puddefoot ¹³⁹,
 D. Pudzha ³⁷, D. Pyatiizbyantseva ³⁷, J. Qian ¹⁰⁶, D. Qichen ¹⁰¹, Y. Qin ¹⁰¹, T. Qiu ⁵²,
 A. Quadt ⁵⁵, M. Queitsch-Maitland ¹⁰¹, G. Quetant ⁵⁶, R.P. Quinn ¹⁶⁴, G. Rabanal Bolanos ⁶¹,
 D. Rafanoharana ⁵⁴, F. Ragusa ^{71a,71b}, J.L. Rainbolt ³⁹, J.A. Raine ⁵⁶, S. Rajagopalan ²⁹,
 E. Ramakoti ³⁷, I.A. Ramirez-Berend ³⁴, K. Ran ^{48,14e}, N.P. Rapheeha ^{33g}, H. Rasheed ^{27b},
 V. Raskina ¹²⁷, D.F. Rassloff ^{63a}, S. Rave ¹⁰⁰, B. Ravina ⁵⁵, I. Ravinovich ¹⁶⁹, M. Raymond ³⁶,
 A.L. Read ¹²⁵, N.P. Readioff ¹³⁹, D.M. Rebuzzi ^{73a,73b}, G. Redlinger ²⁹, A.S. Reed ¹¹⁰,
 K. Reeves ²⁶, J.A. Reidelsturz ^{171,aa}, D. Reikher ¹⁵¹, A. Rej ^{49,z}, C. Rembser ³⁶, A. Renardi ⁴⁸,
 M. Renda ^{27b}, M.B. Rendel ¹¹⁰, F. Renner ⁴⁸, A.G. Rennie ¹⁶⁰, A.L. Rescia ⁴⁸, S. Resconi ^{71a},
 M. Ressegotti ^{57b,57a}, S. Rettie ³⁶, J.G. Reyes Rivera ¹⁰⁷, E. Reynolds ^{17a}, O.L. Rezanova ³⁷,
 P. Reznicek ¹³³, N. Ribaric ⁹¹, E. Ricci ^{78a,78b}, R. Richter ¹¹⁰, S. Richter ^{47a,47b},
 E. Richter-Was ^{86b}, M. Ridel ¹²⁷, S. Ridouani ^{35d}, P. Rieck ¹¹⁷, P. Riedler ³⁶, E.M. Riefel ^{47a,47b},
 J.O. Rieger ¹¹⁴, M. Rijssenbeek ¹⁴⁵, A. Rimoldi ^{73a,73b}, M. Rimoldi ³⁶, L. Rinaldi ^{23b,23a},
 T.T. Rinn ²⁹, M.P. Rinnagel ¹⁰⁹, G. Ripellino ¹⁶¹, I. Riu ¹³, P. Rivadeneira ⁴⁸,
 J.C. Rivera Vergara ¹⁶⁵, F. Rizatdinova ¹²¹, E. Rizvi ⁹⁴, B.A. Roberts ¹⁶⁷, B.R. Roberts ^{17a},
 S.H. Robertson ^{104,ai}, D. Robinson ³², C.M. Robles Gajardo ^{137f}, M. Robles Manzano ¹⁰⁰,
 A. Robson ⁵⁹, A. Rocchi ^{76a,76b}, C. Roda ^{74a,74b}, S. Rodriguez Bosca ^{63a}, Y. Rodriguez Garcia ^{22a},
 A. Rodriguez Rodriguez ⁵⁴, A.M. Rodríguez Vera ^{156b}, S. Roe ³⁶, J.T. Roemer ¹⁶⁰,
 A.R. Roepe-Gier ¹³⁶, J. Roggel ¹⁷¹, O. Røhne ¹²⁵, R.A. Rojas ¹⁰³, C.P.A. Roland ⁶⁸, J. Roloff ²⁹,
 A. Romaniouk ³⁷, E. Romano ^{73a,73b}, M. Romano ^{23b}, A.C. Romero Hernandez ¹⁶²,
 N. Rompotis ⁹², L. Roos ¹²⁷, S. Rosati ^{75a}, B.J. Rosser ³⁹, E. Rossi ¹²⁶, E. Rossi ^{72a,72b},
 L.P. Rossi ^{57b}, L. Rossini ⁵⁴, R. Rosten ¹¹⁹, M. Rotaru ^{27b}, B. Rottler ⁵⁴, C. Rougier ^{102,an},
 D. Rousseau ⁶⁶, D. Rousso ³², A. Roy ¹⁶², S. Roy-Garand ¹⁵⁵, A. Rozanov ¹⁰²,
 Z.M.A. Rozario ⁵⁹, Y. Rozen ¹⁵⁰, X. Ruan ^{33g}, A. Rubio Jimenez ¹⁶³, A.J. Ruby ⁹²,
 V.H. Ruelas Rivera ¹⁸, T.A. Ruggeri ¹, A. Ruggiero ¹²⁶, A. Ruiz-Martinez ¹⁶³, A. Rummler ³⁶,
 Z. Rurikova ⁵⁴, N.A. Rusakovich ³⁸, H.L. Russell ¹⁶⁵, G. Russo ^{75a,75b}, J.P. Rutherford ⁷,
 S. Rutherford Colmenares ³², K. Rybacki ⁹¹, M. Rybar ¹³³, E.B. Rye ¹²⁵, A. Ryzhov ⁴⁴,
 J.A. Sabater Iglesias ⁵⁶, P. Sabatini ¹⁶³, L. Sabetta ^{75a,75b}, H.F-W. Sadrozinski ¹³⁶,
 F. Safai Tehrani ^{75a}, B. Safarzadeh Samani ¹³⁴, M. Safdari ¹⁴³, S. Saha ¹⁶⁵, M. Sahinsoy ¹¹⁰,
 M. Saimpert ¹³⁵, M. Saito ¹⁵³, T. Saito ¹⁵³, D. Salamani ³⁶, A. Salnikov ¹⁴³, J. Salt ¹⁶³,
 A. Salvador Salas ¹⁵¹, D. Salvatore ^{43b,43a}, F. Salvatore ¹⁴⁶, A. Salzburger ³⁶, D. Sammel ⁵⁴,
 D. Sampsonidis ^{152,f}, D. Sampsonidou ¹²³, J. Sánchez ¹⁶³, A. Sanchez Pineda ⁴,
 V. Sanchez Sebastian ¹⁶³, H. Sandaker ¹²⁵, C.O. Sander ⁴⁸, J.A. Sandesara ¹⁰³, M. Sandhoff ¹⁷¹,
 C. Sandoval ^{22b}, D.P.C. Sankey ¹³⁴, T. Sano ⁸⁸, A. Sansoni ⁵³, L. Santi ^{75a,75b}, C. Santoni ⁴⁰,
 H. Santos ^{130a,130b}, S.N. Santpur ^{17a}, A. Santra ¹⁶⁹, K.A. Saoucha ^{116b}, J.G. Saraiva ^{130a,130d},
 J. Sardain ⁷, O. Sasaki ⁸⁴, K. Sato ¹⁵⁷, C. Sauer ^{63b}, F. Sauerburger ⁵⁴, E. Sauvan ⁴,
 P. Savard ^{155,av}, R. Sawada ¹⁵³, C. Sawyer ¹³⁴, L. Sawyer ⁹⁷, I. Sayago Galvan ¹⁶³, C. Sbarra ^{23b},
 A. Sbrizzi ^{23b,23a}, T. Scanlon ⁹⁶, J. Schaarschmidt ¹³⁸, P. Schacht ¹¹⁰, U. Schäfer ¹⁰⁰,

A.C. Schaffer ^{66,44}, D. Schaile ¹⁰⁹, R.D. Schamberger ¹⁴⁵, C. Scharf ¹⁸, M.M. Schefer ¹⁹,
 V.A. Schegelsky ³⁷, D. Scheirich ¹³³, F. Schenck ¹⁸, M. Schernau ¹⁶⁰, C. Scheulen ⁵⁵,
 C. Schiavi ^{57b,57a}, E.J. Schioppa ^{70a,70b}, M. Schioppa ^{43b,43a}, B. Schlag ^{143,t}, K.E. Schleicher ⁵⁴,
 S. Schlenker ³⁶, J. Schmeing ¹⁷¹, M.A. Schmidt ¹⁷¹, K. Schmieden ¹⁰⁰, C. Schmitt ¹⁰⁰,
 N. Schmitt ¹⁰⁰, S. Schmitt ⁴⁸, L. Schoeffel ¹³⁵, A. Schoening ^{63b}, P.G. Scholer ⁵⁴, E. Schopf ¹²⁶,
 M. Schott ¹⁰⁰, J. Schovancova ³⁶, S. Schramm ⁵⁶, F. Schroeder ¹⁷¹, T. Schroer ⁵⁶,
 H-C. Schultz-Coulon ^{63a}, M. Schumacher ⁵⁴, B.A. Schumm ¹³⁶, Ph. Schune ¹³⁵, A.J. Schuy ¹³⁸,
 H.R. Schwartz ¹³⁶, A. Schwartzman ¹⁴³, T.A. Schwarz ¹⁰⁶, Ph. Schwemling ¹³⁵,
 R. Schwienhorst ¹⁰⁷, A. Sciandra ¹³⁶, G. Sciolla ²⁶, F. Scuri ^{74a}, C.D. Sebastiani ⁹²,
 K. Sedlaczek ¹¹⁵, P. Seema ¹⁸, S.C. Seidel ¹¹², A. Seiden ¹³⁶, B.D. Seidlitz ⁴¹, C. Seitz ⁴⁸,
 J.M. Seixas ^{83b}, G. Sekhniaidze ^{72a}, S.J. Sekula ⁴⁴, L. Selem ⁶⁰, N. Semprini-Cesari ^{23b,23a},
 D. Sengupta ⁵⁶, V. Senthilkumar ¹⁶³, L. Serin ⁶⁶, L. Serkin ^{69a,69b}, M. Sessa ^{76a,76b},
 H. Severini ¹²⁰, F. Sforza ^{57b,57a}, A. Sfyrta ⁵⁶, E. Shabalina ⁵⁵, R. Shaheen ¹⁴⁴,
 J.D. Shahinian ¹²⁸, D. Shaked Renous ¹⁶⁹, L.Y. Shan ^{14a}, M. Shapiro ^{17a}, A. Sharma ³⁶,
 A.S. Sharma ¹⁶⁴, P. Sharma ⁸⁰, S. Sharma ⁴⁸, P.B. Shatalov ³⁷, K. Shaw ¹⁴⁶, S.M. Shaw ¹⁰¹,
 A. Shcherbakova ³⁷, Q. Shen ^{62c,5}, P. Sherwood ⁹⁶, L. Shi ⁹⁶, X. Shi ^{14a}, C.O. Shimmin ¹⁷²,
 J.D. Shinner ⁹⁵, I.P.J. Shipsey ¹²⁶, S. Shirabe ^{56,j}, M. Shiyakova ^{38,ag}, J. Shlomi ¹⁶⁹,
 M.J. Shochet ³⁹, J. Shojaii ¹⁰⁵, D.R. Shope ¹²⁵, B. Shrestha ¹²⁰, S. Shrestha ^{119,az},
 E.M. Shrif ^{33g}, M.J. Shroff ¹⁶⁵, P. Sicho ¹³¹, A.M. Sickles ¹⁶², E. Sideras Haddad ^{33g},
 A. Sidoti ^{23b}, F. Siegert ⁵⁰, Dj. Sijacki ¹⁵, R. Sikora ^{86a}, F. Sili ⁹⁰, J.M. Silva ²⁰,
 M.V. Silva Oliveira ²⁹, S.B. Silverstein ^{47a}, S. Simion ⁶⁶, R. Simoniello ³⁶, E.L. Simpson ⁵⁹,
 H. Simpson ¹⁴⁶, L.R. Simpson ¹⁰⁶, N.D. Simpson ⁹⁸, S. Simsek ⁸², S. Sindhu ⁵⁵, P. Sinervo ¹⁵⁵,
 S. Singh ¹⁵⁵, S. Sinha ⁴⁸, S. Sinha ¹⁰¹, M. Sioli ^{23b,23a}, I. Siral ³⁶, E. Sitnikova ⁴⁸,
 S.Yu. Sivoklov ^{37,*}, J. Sjölin ^{47a,47b}, A. Skaf ⁵⁵, E. Skorda ^{20,aq}, P. Skubic ¹²⁰,
 M. Slawinska ⁸⁷, V. Smakhtin ¹⁶⁹, B.H. Smart ¹³⁴, J. Smiesko ³⁶, S.Yu. Smirnov ³⁷,
 Y. Smirnov ³⁷, L.N. Smirnova ^{37,a}, O. Smirnova ⁹⁸, A.C. Smith ⁴¹, E.A. Smith ³⁹,
 H.A. Smith ¹²⁶, J.L. Smith ⁹², R. Smith ¹⁴³, M. Smizanska ⁹¹, K. Smolek ¹³², A.A. Snesarev ³⁷,
 S.R. Snider ¹⁵⁵, H.L. Snoek ¹¹⁴, S. Snyder ²⁹, R. Sobie ^{165,ai}, A. Soffer ¹⁵¹,
 C.A. Solans Sanchez ³⁶, E.Yu. Soldatov ³⁷, U. Soldevila ¹⁶³, A.A. Solodkov ³⁷, S. Solomon ²⁶,
 A. Soloshenko ³⁸, K. Solovieva ⁵⁴, O.V. Solovyanov ⁴⁰, V. Solovyev ³⁷, P. Sommer ³⁶,
 A. Sonay ¹³, W.Y. Song ^{156b}, J.M. Sonneveld ¹¹⁴, A. Sopczak ¹³², A.L. Sopio ⁹⁶,
 F. Sopkova ^{28b}, I.R. Sotarriva Alvarez ¹⁵⁴, V. Sothilingam ^{63a}, S. Sottocornola ⁶⁸, R. Soualah ^{116b},
 Z. Soumami ^{35e}, D. South ⁴⁸, N. Soybelman ¹⁶⁹, S. Spagnolo ^{70a,70b}, M. Spalla ¹¹⁰,
 D. Sperlich ⁵⁴, G. Spigo ³⁶, S. Spinali ⁹¹, D.P. Spiteri ⁵⁹, M. Spousta ¹³³, E.J. Staats ³⁴,
 A. Stabile ^{71a,71b}, R. Stamen ^{63a}, A. Stampekis ²⁰, M. Standke ²⁴, E. Stanecka ⁸⁷,
 M.V. Stange ⁵⁰, B. Stanislaus ^{17a}, M.M. Stanitzki ⁴⁸, B. Stapf ⁴⁸, E.A. Starchenko ³⁷,
 G.H. Stark ¹³⁶, J. Stark ^{102,an}, D.M. Starko ^{156b}, P. Staroba ¹³¹, P. Starovoitov ^{63a}, S. Stärz ¹⁰⁴,
 R. Staszewski ⁸⁷, G. Stavropoulos ⁴⁶, J. Steentoft ¹⁶¹, P. Steinberg ²⁹, B. Stelzer ^{142,156a},
 H.J. Stelzer ¹²⁹, O. Stelzer-Chilton ^{156a}, H. Stenzel ⁵⁸, T.J. Stevenson ¹⁴⁶, G.A. Stewart ³⁶,
 J.R. Stewart ¹²¹, M.C. Stockton ³⁶, G. Stoicea ^{27b}, M. Stolarski ^{130a}, S. Stonjek ¹¹⁰,
 A. Straessner ⁵⁰, J. Strandberg ¹⁴⁴, S. Strandberg ^{47a,47b}, M. Stratmann ¹⁷¹, M. Strauss ¹²⁰,
 T. Strebler ¹⁰², P. Strizenec ^{28b}, R. Ströhmer ¹⁶⁶, D.M. Strom ¹²³, L.R. Strom ⁴⁸,
 R. Stroynowski ⁴⁴, A. Strubig ^{47a,47b}, S.A. Stucci ²⁹, B. Stugu ¹⁶, J. Stupak ¹²⁰, N.A. Styles ⁴⁸,
 D. Su ¹⁴³, S. Su ^{62a}, W. Su ^{62d}, X. Su ^{62a,66}, K. Sugizaki ¹⁵³, V.V. Sulin ³⁷, M.J. Sullivan ⁹²,
 D.M.S. Sultan ^{78a,78b}, L. Sultanaliev ³⁷, S. Sultansoy ^{3b}, T. Sumida ⁸⁸, S. Sun ¹⁰⁶, S. Sun ¹⁷⁰,
 O. Sunneborn Gudnadottir ¹⁶¹, N. Sur ¹⁰², M.R. Sutton ¹⁴⁶, H. Suzuki ¹⁵⁷, M. Svatos ¹³¹,
 M. Swiatlowski ^{156a}, T. Swirski ¹⁶⁶, I. Sykora ^{28a}, M. Sykora ¹³³, T. Sykora ¹³³, D. Ta ¹⁰⁰,

K. Tackmann ^{48,ae}, A. Taffard ¹⁶⁰, R. Tafirout ^{156a}, J.S. Tafoya Vargas ⁶⁶, E.P. Takeva ⁵²,
 Y. Takubo ⁸⁴, M. Talby ¹⁰², A.A. Talyshev ³⁷, K.C. Tam ^{64b}, N.M. Tamir ¹⁵¹, A. Tanaka ¹⁵³,
 J. Tanaka ¹⁵³, R. Tanaka ⁶⁶, M. Tanasini ^{57b,57a}, Z. Tao ¹⁶⁴, S. Tapia Araya ^{137f},
 S. Tapprogge ¹⁰⁰, A. Tarek Abouelfadl Mohamed ¹⁰⁷, S. Tarem ¹⁵⁰, K. Tariq ^{14a}, G. Tarna ^{102,27b},
 G.F. Tartarelli ^{71a}, P. Tas ¹³³, M. Tasevsky ¹³¹, E. Tassi ^{43b,43a}, A.C. Tate ¹⁶², G. Tateno ¹⁵³,
 Y. Tayalati ^{35e,ah}, G.N. Taylor ¹⁰⁵, W. Taylor ^{156b}, A.S. Tee ¹⁷⁰, R. Teixeira De Lima ¹⁴³,
 P. Teixeira-Dias ⁹⁵, J.J. Teoh ¹⁵⁵, K. Terashi ¹⁵³, J. Terron ⁹⁹, S. Terzo ¹³, M. Testa ⁵³,
 R.J. Teuscher ^{155,ai}, A. Thaler ⁷⁹, O. Theiner ⁵⁶, N. Themistokleous ⁵², T. Theveneaux-Pelzer ¹⁰²,
 O. Thielmann ¹⁷¹, D.W. Thomas ⁹⁵, J.P. Thomas ²⁰, E.A. Thompson ^{17a}, P.D. Thompson ²⁰,
 E. Thomson ¹²⁸, Y. Tian ⁵⁵, V. Tikhomirov ^{37,a}, Yu.A. Tikhonov ³⁷, S. Timoshenko ³⁷,
 D. Timoshyn ¹³³, E.X.L. Ting ¹, P. Tipton ¹⁷², S.H. Tlou ^{33g}, A. Tnourji ⁴⁰, K. Todome ¹⁵⁴,
 S. Todorova-Nova ¹³³, S. Todt ⁵⁰, M. Togawa ⁸⁴, J. Tojo ⁸⁹, S. Tokár ^{28a}, K. Tokushuku ⁸⁴,
 O. Toldaiev ⁶⁸, R. Tombs ³², M. Tomoto ^{84,111}, L. Tompkins ^{143,t}, K.W. Topolnicki ^{86b},
 E. Torrence ¹²³, H. Torres ^{102,an}, E. Torró Pastor ¹⁶³, M. Toscani ³⁰, C. Tosciri ³⁹, M. Tost ¹¹,
 D.R. Tovey ¹³⁹, A. Traeet ¹⁶, I.S. Trandafir ^{27b}, T. Trefzger ¹⁶⁶, A. Tricoli ²⁹, I.M. Trigger ^{156a},
 S. Trincaz-Duvoid ¹²⁷, D.A. Trischuk ²⁶, B. Trocmé ⁶⁰, C. Troncon ^{71a}, L. Truong ^{33c},
 M. Trzebinski ⁸⁷, A. Trzupek ⁸⁷, F. Tsai ¹⁴⁵, M. Tsai ¹⁰⁶, A. Tsiamis ^{152,f}, P.V. Tsiareshka ³⁷,
 S. Tsigaridas ^{156a}, A. Tsirigotis ^{152,ac}, V. Tsiskaridze ¹⁵⁵, E.G. Tskhadadze ^{149a}, M. Tsopoulou ^{152,f},
 Y. Tsujikawa ⁸⁸, I.I. Tsukerman ³⁷, V. Tsulaia ^{17a}, S. Tsuno ⁸⁴, O. Tsur ¹⁵⁰, K. Tsur ¹¹⁸,
 D. Tsybychev ¹⁴⁵, Y. Tu ^{64b}, A. Tudorache ^{27b}, V. Tudorache ^{27b}, A.N. Tuna ³⁶,
 S. Turchikhin ^{57b,57a}, I. Turk Cakir ^{3a}, R. Turra ^{71a}, T. Turtuvshin ^{38,aj}, P.M. Tuts ⁴¹,
 S. Tzamarias ^{152,f}, P. Tzanis ¹⁰, E. Tzovara ¹⁰⁰, F. Ukegawa ¹⁵⁷, P.A. Ulloa Poblete ^{137c,137b},
 E.N. Umaka ²⁹, G. Unal ³⁶, M. Unal ¹¹, A. Undrus ²⁹, G. Unel ¹⁶⁰, J. Urban ^{28b},
 P. Urquijo ¹⁰⁵, P. Urrejola ^{137a}, G. Usai ⁸, R. Ushioda ¹⁵⁴, M. Usman ¹⁰⁸, Z. Uysal ^{21b},
 V. Vacek ¹³², B. Vachon ¹⁰⁴, K.O.H. Vadla ¹²⁵, T. Vafeiadis ³⁶, A. Vaitkus ⁹⁶, C. Valderanis ¹⁰⁹,
 E. Valdes Santurio ^{47a,47b}, M. Valente ^{156a}, S. Valentinetti ^{23b,23a}, A. Valero ¹⁶³,
 E. Valiente Moreno ¹⁶³, A. Vallier ^{102,an}, J.A. Valls Ferrer ¹⁶³, D.R. Van Arneman ¹¹⁴,
 T.R. Van Daalen ¹³⁸, A. Van Der Graaf ⁴⁹, P. Van Gemmeren ⁶, M. Van Rijnbach ^{125,36},
 S. Van Stroud ⁹⁶, I. Van Vulpen ¹¹⁴, M. Vanadia ^{76a,76b}, W. Vandelli ³⁶, M. Vandenbroucke ¹³⁵,
 E.R. Vandewall ¹²¹, D. Vannicola ¹⁵¹, L. Vannoli ^{57b,57a}, R. Vari ^{75a}, E.W. Varnes ⁷,
 C. Varni ^{17b}, T. Varol ¹⁴⁸, D. Varouchas ⁶⁶, L. Varriale ¹⁶³, K.E. Varvell ¹⁴⁷, M.E. Vasile ^{27b},
 L. Vaslin ⁸⁴, G.A. Vasquez ¹⁶⁵, A. Vasyukov ³⁸, F. Vazeille ⁴⁰, T. Vazquez Schroeder ³⁶,
 J. Veatch ³¹, V. Vecchio ¹⁰¹, M.J. Veen ¹⁰³, I. Veliscek ¹²⁶, L.M. Veloce ¹⁵⁵, F. Veloso ^{130a,130c},
 S. Veneziano ^{75a}, A. Ventura ^{70a,70b}, S. Ventura Gonzalez ¹³⁵, A. Verbytskyi ¹¹⁰,
 M. Verducci ^{74a,74b}, C. Vergis ²⁴, M. Verissimo De Araujo ^{83b}, W. Verkerke ¹¹⁴,
 J.C. Vermeulen ¹¹⁴, C. Vernieri ¹⁴³, M. Vessella ¹⁰³, M.C. Vetterli ^{142,av}, A. Vgenopoulos ^{152,f},
 N. Viaux Maira ^{137f}, T. Vickey ¹³⁹, O.E. Vickey Boeriu ¹³⁹, G.H.A. Viehhauser ¹²⁶, L. Vigani ^{63b},
 M. Villa ^{23b,23a}, M. Villaplana Perez ¹⁶³, E.M. Villhauer ⁵², E. Vilucchi ⁵³, M.G. Vinciter ³⁴,
 G.S. Virdee ²⁰, A. Vishwakarma ⁵², A. Visibile ¹¹⁴, C. Vittori ³⁶, I. Vivarelli ¹⁴⁶,
 E. Voevodina ¹¹⁰, F. Vogel ¹⁰⁹, J.C. Voigt ⁵⁰, P. Vokac ¹³², Yu. Volkotrub ^{86a}, J. Von Ahnen ⁴⁸,
 E. Von Toerne ²⁴, B. Vormwald ³⁶, V. Vorobel ¹³³, K. Vorobev ³⁷, M. Vos ¹⁶³, K. Voss ¹⁴¹,
 J.H. Vossebeld ⁹², M. Vozak ¹¹⁴, L. Vozdecky ⁹⁴, N. Vranjes ¹⁵, M. Vranjes Milosavljevic ¹⁵,
 M. Vreeswijk ¹¹⁴, N.K. Vu ^{62d,62c}, R. Vuillermet ³⁶, O. Vujinovic ¹⁰⁰, I. Vukotic ³⁹,
 S. Wada ¹⁵⁷, C. Wagner ¹⁰³, J.M. Wagner ^{17a}, W. Wagner ¹⁷¹, S. Wahdan ¹⁷¹, H. Wahlberg ⁹⁰,
 M. Wakida ¹¹¹, J. Walder ¹³⁴, R. Walker ¹⁰⁹, W. Walkowiak ¹⁴¹, A. Wall ¹²⁸, T. Wamorkar ⁶,
 A.Z. Wang ¹³⁶, C. Wang ¹⁰⁰, C. Wang ^{62c}, H. Wang ^{17a}, J. Wang ^{64a}, R.-J. Wang ¹⁰⁰,
 R. Wang ⁶¹, R. Wang ⁶, S.M. Wang ¹⁴⁸, S. Wang ^{62b}, T. Wang ^{62a}, W.T. Wang ⁸⁰,

W. Wang ^{14a}, X. Wang ^{14c}, X. Wang ¹⁶², X. Wang ^{62c}, Y. Wang ^{62d}, Y. Wang ^{14c}, Z. Wang ¹⁰⁶, Z. Wang ^{62d,51,62c}, Z. Wang ¹⁰⁶, A. Warburton ¹⁰⁴, R.J. Ward ²⁰, N. Warrack ⁵⁹, A.T. Watson ²⁰, H. Watson ⁵⁹, M.F. Watson ²⁰, E. Watton ^{59,134}, G. Watts ¹³⁸, B.M. Waugh ⁹⁶, C. Weber ²⁹, H.A. Weber ¹⁸, M.S. Weber ¹⁹, S.M. Weber ^{63a}, C. Wei ^{62a}, Y. Wei ¹²⁶, A.R. Weidberg ¹²⁶, E.J. Weik ¹¹⁷, J. Weingarten ⁴⁹, M. Weirich ¹⁰⁰, C. Weiser ⁵⁴, C.J. Wells ⁴⁸, T. Wenaus ²⁹, B. Wendland ⁴⁹, T. Wengler ³⁶, N.S. Wenke ¹¹⁰, N. Vermes ²⁴, M. Wessels ^{63a}, A.M. Wharton ⁹¹, A.S. White ⁶¹, A. White ⁸, M.J. White ¹, D. Whiteson ¹⁶⁰, L. Wickremasinghe ¹²⁴, W. Wiedenmann ¹⁷⁰, C. Wiel ⁵⁰, M. Wielers ¹³⁴, C. Wiglesworth ⁴², D.J. Wilbern ¹²⁰, H.G. Wilkens ³⁶, D.M. Williams ⁴¹, H.H. Williams ¹²⁸, S. Williams ³², S. Willocq ¹⁰³, B.J. Wilson ¹⁰¹, P.J. Windischhofer ³⁹, F.I. Winkel ³⁰, F. Winklmeier ¹²³, B.T. Winter ⁵⁴, J.K. Winter ¹⁰¹, M. Wittgen ¹⁴³, M. Wobisch ⁹⁷, Z. Wolffs ¹¹⁴, J. Wollrath ¹⁶⁰, M.W. Wolter ⁸⁷, H. Wolters ^{130a,130c}, A.F. Wongel ⁴⁸, E.L. Woodward ⁴¹, S.D. Worm ⁴⁸, B.K. Wosiek ⁸⁷, K.W. Woźniak ⁸⁷, S. Wozniowski ⁵⁵, K. Wraight ⁵⁹, C. Wu ²⁰, J. Wu ^{14a,14e}, M. Wu ^{64a}, M. Wu ¹¹³, S.L. Wu ¹⁷⁰, X. Wu ⁵⁶, Y. Wu ^{62a}, Z. Wu ¹³⁵, J. Wuerzinger ^{110,at}, T.R. Wyatt ¹⁰¹, B.M. Wynne ⁵², S. Xella ⁴², L. Xia ^{14c}, M. Xia ^{14b}, J. Xiang ^{64c}, M. Xie ^{62a}, X. Xie ^{62a}, S. Xin ^{14a,14e}, A. Xiong ¹²³, J. Xiong ^{17a}, D. Xu ^{14a}, H. Xu ^{62a}, L. Xu ^{62a}, R. Xu ¹²⁸, T. Xu ¹⁰⁶, Y. Xu ^{14b}, Z. Xu ⁵², B. Yabsley ¹⁴⁷, S. Yacoub ^{33a}, Y. Yamaguchi ¹⁵⁴, E. Yamashita ¹⁵³, H. Yamauchi ¹⁵⁷, T. Yamazaki ^{17a}, Y. Yamazaki ⁸⁵, J. Yan ^{62c}, S. Yan ¹²⁶, Z. Yan ²⁵, H.J. Yang ^{62c,62d}, H.T. Yang ^{62a}, S. Yang ^{62a}, T. Yang ^{64c}, X. Yang ³⁶, X. Yang ^{14a}, Y. Yang ⁴⁴, Y. Yang ^{62a}, Z. Yang ^{62a}, W-M. Yao ^{17a}, Y.C. Yap ⁴⁸, H. Ye ^{14c}, H. Ye ⁵⁵, J. Ye ^{14a}, S. Ye ²⁹, X. Ye ^{62a}, Y. Yeh ⁹⁶, I. Yeletsikh ³⁸, B.K. Yeo ^{17b}, M.R. Yexley ⁹⁶, P. Yin ⁴¹, K. Yorita ¹⁶⁸, S. Younas ^{27b}, C.J.S. Young ³⁶, C. Young ¹⁴³, C. Yu ^{14a,14e,ax}, Y. Yu ^{62a}, M. Yuan ¹⁰⁶, R. Yuan ^{62b}, L. Yue ⁹⁶, M. Zaazoua ^{62a}, B. Zabinski ⁸⁷, E. Zaid ⁵², T. Zakareishvili ^{149b}, N. Zakharchuk ³⁴, S. Zambito ⁵⁶, J.A. Zamora Saa ^{137d,137b}, J. Zang ¹⁵³, D. Zanzi ⁵⁴, O. Zaplatilek ¹³², C. Zeitnitz ¹⁷¹, H. Zeng ^{14a}, J.C. Zeng ¹⁶², D.T. Zenger Jr ²⁶, O. Zenin ³⁷, T. Ženiš ^{28a}, S. Zenz ⁹⁴, S. Zerradi ^{35a}, D. Zerwas ⁶⁶, M. Zhai ^{14a,14e}, B. Zhang ^{14c}, D.F. Zhang ¹³⁹, J. Zhang ^{62b}, J. Zhang ⁶, K. Zhang ^{14a,14e}, L. Zhang ^{14c}, P. Zhang ^{14a,14e}, R. Zhang ¹⁷⁰, S. Zhang ¹⁰⁶, S. Zhang ⁴⁴, T. Zhang ¹⁵³, X. Zhang ^{62c}, X. Zhang ^{62b}, Y. Zhang ^{62c,5}, Y. Zhang ⁹⁶, Y. Zhang ^{14c}, Z. Zhang ^{17a}, Z. Zhang ⁶⁶, H. Zhao ¹³⁸, P. Zhao ⁵¹, T. Zhao ^{62b}, Y. Zhao ¹³⁶, Z. Zhao ^{62a}, A. Zhemchugov ³⁸, J. Zheng ^{14c}, K. Zheng ¹⁶², X. Zheng ^{62a}, Z. Zheng ¹⁴³, D. Zhong ¹⁶², B. Zhou ¹⁰⁶, H. Zhou ⁷, N. Zhou ^{62c}, Y. Zhou ⁷, C.G. Zhu ^{62b}, J. Zhu ¹⁰⁶, Y. Zhu ^{62c}, Y. Zhu ^{62a}, X. Zhuang ^{14a}, K. Zhukov ³⁷, V. Zhulanov ³⁷, N.I. Zimine ³⁸, J. Zinsser ^{63b}, M. Ziolkowski ¹⁴¹, L. Živković ¹⁵, A. Zoccoli ^{23b,23a}, K. Zoch ⁶¹, T.G. Zorbas ¹³⁹, O. Zormpa ⁴⁶, W. Zou ⁴¹, L. Zwalinski ³⁶.

¹Department of Physics, University of Adelaide, Adelaide; Australia.

²Department of Physics, University of Alberta, Edmonton AB; Canada.

^{3(a)}Department of Physics, Ankara University, Ankara; ^(b)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 IL; United States of America.

⁷Department of Physics, University of Arizona, Tucson AZ; United States of America.

⁸Department of Physics, University of Texas at Arlington, Arlington TX; United States of America.

⁹Physics Department, National and Kapodistrian University of Athens, Athens; Greece.

¹⁰Physics Department, National Technical University of Athens, Zografou; Greece.

¹¹Department of Physics, University of Texas at Austin, Austin TX; United States of America.

- ¹²Institute of Physics, Azerbaijan Academy of Sciences, Baku; Azerbaijan.
- ¹³Institut de Física d'Altes Energies (IFAE), Barcelona Institute of Science and Technology, Barcelona; Spain.
- ¹⁴(^a)Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; (^b)Physics Department, Tsinghua University, Beijing; (^c)Department of Physics, Nanjing University, Nanjing; (^d)School of Science, Shenzhen Campus of Sun Yat-sen University; (^e)University of Chinese Academy of Science (UCAS), Beijing; China.
- ¹⁵Institute of Physics, University of Belgrade, Belgrade; Serbia.
- ¹⁶Department for Physics and Technology, University of Bergen, Bergen; Norway.
- ¹⁷(^a)Physics Division, Lawrence Berkeley National Laboratory, Berkeley CA; (^b)University of California, Berkeley CA; United States of America.
- ¹⁸Institut für Physik, Humboldt Universität zu Berlin, Berlin; Germany.
- ¹⁹Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern; Switzerland.
- ²⁰School of Physics and Astronomy, University of Birmingham, Birmingham; United Kingdom.
- ²¹(^a)Department of Physics, Bogazici University, Istanbul; (^b)Department of Physics Engineering, Gaziantep University, Gaziantep; (^c)Department of Physics, Istanbul University, Istanbul; Türkiye.
- ²²(^a)Facultad de Ciencias y Centro de Investigaciones, Universidad Antonio Nariño, Bogotá; (^b)Departamento de Física, Universidad Nacional de Colombia, Bogotá; (^c)Pontificia Universidad Javeriana, Bogota; Colombia.
- ²³(^a)Dipartimento di Fisica e Astronomia A. Righi, Università di Bologna, Bologna; (^b)INFN Sezione di Bologna; Italy.
- ²⁴Physikalisches Institut, Universität Bonn, Bonn; Germany.
- ²⁵Department of Physics, Boston University, Boston MA; United States of America.
- ²⁶Department of Physics, Brandeis University, Waltham MA; United States of America.
- ²⁷(^a)Transilvania University of Brasov, Brasov; (^b)Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest; (^c)Department of Physics, Alexandru Ioan Cuza University of Iasi, Iasi; (^d)National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj-Napoca; (^e)University Politehnica Bucharest, Bucharest; (^f)West University in Timisoara, Timisoara; (^g)Faculty of Physics, University of Bucharest, Bucharest; Romania.
- ²⁸(^a)Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava; (^b)Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice; Slovak Republic.
- ²⁹Physics Department, Brookhaven National Laboratory, Upton NY; United States of America.
- ³⁰Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Física, y CONICET, Instituto de Física de Buenos Aires (IFIBA), Buenos Aires; Argentina.
- ³¹California State University, CA; United States of America.
- ³²Cavendish Laboratory, University of Cambridge, Cambridge; United Kingdom.
- ³³(^a)Department of Physics, University of Cape Town, Cape Town; (^b)iThemba Labs, Western Cape; (^c)Department of Mechanical Engineering Science, University of Johannesburg, Johannesburg; (^d)National Institute of Physics, University of the Philippines Diliman (Philippines); (^e)University of South Africa, Department of Physics, Pretoria; (^f)University of Zululand, KwaDlangezwa; (^g)School of Physics, University of the Witwatersrand, Johannesburg; South Africa.
- ³⁴Department of Physics, Carleton University, Ottawa ON; Canada.
- ³⁵(^a)Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca; (^b)Faculté des Sciences, Université Ibn-Tofail, Kénitra; (^c)Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech; (^d)LPMR, Faculté des Sciences, Université

Mohamed Premier, Oujda;^(e) Faculté des sciences, Université Mohammed V, Rabat;^(f) Institute of Applied Physics, Mohammed VI Polytechnic University, Ben Guerir; Morocco.

³⁶CERN, Geneva; Switzerland.

³⁷Affiliated with an institute covered by a cooperation agreement with CERN.

³⁸Affiliated with an international laboratory covered by a cooperation agreement with CERN.

³⁹Enrico Fermi Institute, University of Chicago, Chicago IL; United States of America.

⁴⁰LPC, Université Clermont Auvergne, CNRS/IN2P3, Clermont-Ferrand; France.

⁴¹Nevis Laboratory, Columbia University, Irvington NY; United States of America.

⁴²Niels Bohr Institute, University of Copenhagen, Copenhagen; Denmark.

⁴³(^a) Dipartimento di Fisica, Università della Calabria, Rende; (^b) INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati; Italy.

⁴⁴Physics Department, Southern Methodist University, Dallas TX; United States of America.

⁴⁵Physics Department, University of Texas at Dallas, Richardson TX; United States of America.

⁴⁶National Centre for Scientific Research "Demokritos", Agia Paraskevi; Greece.

⁴⁷(^a) Department of Physics, Stockholm University; (^b) Oskar Klein Centre, Stockholm; Sweden.

⁴⁸Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen; Germany.

⁴⁹Fakultät Physik, Technische Universität Dortmund, Dortmund; Germany.

⁵⁰Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden; Germany.

⁵¹Department of Physics, Duke University, Durham NC; United States of America.

⁵²SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh; United Kingdom.

⁵³INFN e Laboratori Nazionali di Frascati, Frascati; Italy.

⁵⁴Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg; Germany.

⁵⁵II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen; Germany.

⁵⁶Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève; Switzerland.

⁵⁷(^a) Dipartimento di Fisica, Università di Genova, Genova; (^b) INFN Sezione di Genova; Italy.

⁵⁸II. Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen; Germany.

⁵⁹SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow; United Kingdom.

⁶⁰LPSC, Université Grenoble Alpes, CNRS/IN2P3, Grenoble INP, Grenoble; France.

⁶¹Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge MA; United States of America.

⁶²(^a) Department of Modern Physics and State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei; (^b) Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao; (^c) School of Physics and Astronomy, Shanghai Jiao Tong University, Key Laboratory for Particle Astrophysics and Cosmology (MOE), SKLPPC, Shanghai; (^d) Tsung-Dao Lee Institute, Shanghai; China.

⁶³(^a) Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; (^b) Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; Germany.

⁶⁴(^a) Department of Physics, Chinese University of Hong Kong, Shatin, N.T., Hong Kong; (^b) Department of Physics, University of Hong Kong, Hong Kong; (^c) Department of Physics and Institute for Advanced Study, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong; China.

⁶⁵Department of Physics, National Tsing Hua University, Hsinchu; Taiwan.

⁶⁶IJCLab, Université Paris-Saclay, CNRS/IN2P3, 91405, Orsay; France.

⁶⁷Centro Nacional de Microelectrónica (IMB-CNM-CSIC), Barcelona; Spain.

⁶⁸Department of Physics, Indiana University, Bloomington IN; United States of America.

⁶⁹(^a) INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine; (^b) ICTP, Trieste; (^c) Dipartimento Politecnico di Ingegneria e Architettura, Università di Udine, Udine; Italy.

⁷⁰(^a) INFN Sezione di Lecce; (^b) Dipartimento di Matematica e Fisica, Università del Salento, Lecce; Italy.

- ^{71(a)}INFN Sezione di Milano;^(b)Dipartimento di Fisica, Università di Milano, Milano; Italy.
- ^{72(a)}INFN Sezione di Napoli;^(b)Dipartimento di Fisica, Università di Napoli, Napoli; Italy.
- ^{73(a)}INFN Sezione di Pavia;^(b)Dipartimento di Fisica, Università di Pavia, Pavia; Italy.
- ^{74(a)}INFN Sezione di Pisa;^(b)Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa; Italy.
- ^{75(a)}INFN Sezione di Roma;^(b)Dipartimento di Fisica, Sapienza Università di Roma, Roma; Italy.
- ^{76(a)}INFN Sezione di Roma Tor Vergata;^(b)Dipartimento di Fisica, Università di Roma Tor Vergata, Roma; Italy.
- ^{77(a)}INFN Sezione di Roma Tre;^(b)Dipartimento di Matematica e Fisica, Università Roma Tre, Roma; Italy.
- ^{78(a)}INFN-TIFPA;^(b)Università degli Studi di Trento, Trento; Italy.
- ⁷⁹Universität Innsbruck, Department of Astro and Particle Physics, Innsbruck; Austria.
- ⁸⁰University of Iowa, Iowa City IA; United States of America.
- ⁸¹Department of Physics and Astronomy, Iowa State University, Ames IA; United States of America.
- ⁸²Istinye University, Sariyer, Istanbul; Türkiye.
- ^{83(a)}Departamento de Engenharia Elétrica, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora;^(b)Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro;^(c)Instituto de Física, Universidade de São Paulo, São Paulo;^(d)Rio de Janeiro State University, Rio de Janeiro; Brazil.
- ⁸⁴KEK, High Energy Accelerator Research Organization, Tsukuba; Japan.
- ⁸⁵Graduate School of Science, Kobe University, Kobe; Japan.
- ^{86(a)}AGH University of Krakow, Faculty of Physics and Applied Computer Science, Krakow;^(b)Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow; Poland.
- ⁸⁷Institute of Nuclear Physics Polish Academy of Sciences, Krakow; Poland.
- ⁸⁸Faculty of Science, Kyoto University, Kyoto; Japan.
- ⁸⁹Research Center for Advanced Particle Physics and Department of Physics, Kyushu University, Fukuoka ; Japan.
- ⁹⁰Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata; Argentina.
- ⁹¹Physics Department, Lancaster University, Lancaster; United Kingdom.
- ⁹²Oliver Lodge Laboratory, University of Liverpool, Liverpool; United Kingdom.
- ⁹³Department of Experimental Particle Physics, Jožef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana; Slovenia.
- ⁹⁴School of Physics and Astronomy, Queen Mary University of London, London; United Kingdom.
- ⁹⁵Department of Physics, Royal Holloway University of London, Egham; United Kingdom.
- ⁹⁶Department of Physics and Astronomy, University College London, London; United Kingdom.
- ⁹⁷Louisiana Tech University, Ruston LA; United States of America.
- ⁹⁸Fysiska institutionen, Lunds universitet, Lund; Sweden.
- ⁹⁹Departamento de Física Teórica C-15 and CIAFF, Universidad Autónoma de Madrid, Madrid; Spain.
- ¹⁰⁰Institut für Physik, Universität Mainz, Mainz; Germany.
- ¹⁰¹School of Physics and Astronomy, University of Manchester, Manchester; United Kingdom.
- ¹⁰²CPPM, Aix-Marseille Université, CNRS/IN2P3, Marseille; France.
- ¹⁰³Department of Physics, University of Massachusetts, Amherst MA; United States of America.
- ¹⁰⁴Department of Physics, McGill University, Montreal QC; Canada.
- ¹⁰⁵School of Physics, University of Melbourne, Victoria; Australia.
- ¹⁰⁶Department of Physics, University of Michigan, Ann Arbor MI; United States of America.
- ¹⁰⁷Department of Physics and Astronomy, Michigan State University, East Lansing MI; United States of America.
- ¹⁰⁸Group of Particle Physics, University of Montreal, Montreal QC; Canada.
- ¹⁰⁹Fakultät für Physik, Ludwig-Maximilians-Universität München, München; Germany.

- ¹¹⁰Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München; Germany.
- ¹¹¹Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya; Japan.
- ¹¹²Department of Physics and Astronomy, University of New Mexico, Albuquerque NM; United States of America.
- ¹¹³Institute for Mathematics, Astrophysics and Particle Physics, Radboud University/Nikhef, Nijmegen; Netherlands.
- ¹¹⁴Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam; Netherlands.
- ¹¹⁵Department of Physics, Northern Illinois University, DeKalb IL; United States of America.
- ¹¹⁶(^a) New York University Abu Dhabi, Abu Dhabi; (^b) University of Sharjah, Sharjah; United Arab Emirates.
- ¹¹⁷Department of Physics, New York University, New York NY; United States of America.
- ¹¹⁸Ochanomizu University, Otsuka, Bunkyo-ku, Tokyo; Japan.
- ¹¹⁹Ohio State University, Columbus OH; United States of America.
- ¹²⁰Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman OK; United States of America.
- ¹²¹Department of Physics, Oklahoma State University, Stillwater OK; United States of America.
- ¹²²Palacký University, Joint Laboratory of Optics, Olomouc; Czech Republic.
- ¹²³Institute for Fundamental Science, University of Oregon, Eugene, OR; United States of America.
- ¹²⁴Graduate School of Science, Osaka University, Osaka; Japan.
- ¹²⁵Department of Physics, University of Oslo, Oslo; Norway.
- ¹²⁶Department of Physics, Oxford University, Oxford; United Kingdom.
- ¹²⁷LPNHE, Sorbonne Université, Université Paris Cité, CNRS/IN2P3, Paris; France.
- ¹²⁸Department of Physics, University of Pennsylvania, Philadelphia PA; United States of America.
- ¹²⁹Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh PA; United States of America.
- ¹³⁰(^a) Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa; (^b) Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, Lisboa; (^c) Departamento de Física, Universidade de Coimbra, Coimbra; (^d) Centro de Física Nuclear da Universidade de Lisboa, Lisboa; (^e) Departamento de Física, Universidade do Minho, Braga; (^f) Departamento de Física Teórica y del Cosmos, Universidad de Granada, Granada (Spain); (^g) Departamento de Física, Instituto Superior Técnico, Universidade de Lisboa, Lisboa; Portugal.
- ¹³¹Institute of Physics of the Czech Academy of Sciences, Prague; Czech Republic.
- ¹³²Czech Technical University in Prague, Prague; Czech Republic.
- ¹³³Charles University, Faculty of Mathematics and Physics, Prague; Czech Republic.
- ¹³⁴Particle Physics Department, Rutherford Appleton Laboratory, Didcot; United Kingdom.
- ¹³⁵IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette; France.
- ¹³⁶Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz CA; United States of America.
- ¹³⁷(^a) Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; (^b) Millennium Institute for Subatomic physics at high energy frontier (SAPHIR), Santiago; (^c) Instituto de Investigación Multidisciplinario en Ciencia y Tecnología, y Departamento de Física, Universidad de La Serena; (^d) Universidad Andres Bello, Department of Physics, Santiago; (^e) Instituto de Alta Investigación, Universidad de Tarapacá, Arica; (^f) Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso; Chile.
- ¹³⁸Department of Physics, University of Washington, Seattle WA; United States of America.
- ¹³⁹Department of Physics and Astronomy, University of Sheffield, Sheffield; United Kingdom.

- ¹⁴⁰Department of Physics, Shinshu University, Nagano; Japan.
- ¹⁴¹Department Physik, Universität Siegen, Siegen; Germany.
- ¹⁴²Department of Physics, Simon Fraser University, Burnaby BC; Canada.
- ¹⁴³SLAC National Accelerator Laboratory, Stanford CA; United States of America.
- ¹⁴⁴Department of Physics, Royal Institute of Technology, Stockholm; Sweden.
- ¹⁴⁵Departments of Physics and Astronomy, Stony Brook University, Stony Brook NY; United States of America.
- ¹⁴⁶Department of Physics and Astronomy, University of Sussex, Brighton; United Kingdom.
- ¹⁴⁷School of Physics, University of Sydney, Sydney; Australia.
- ¹⁴⁸Institute of Physics, Academia Sinica, Taipei; Taiwan.
- ¹⁴⁹^(a)E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi; ^(b)High Energy Physics Institute, Tbilisi State University, Tbilisi; ^(c)University of Georgia, Tbilisi; Georgia.
- ¹⁵⁰Department of Physics, Technion, Israel Institute of Technology, Haifa; Israel.
- ¹⁵¹Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv; Israel.
- ¹⁵²Department of Physics, Aristotle University of Thessaloniki, Thessaloniki; Greece.
- ¹⁵³International Center for Elementary Particle Physics and Department of Physics, University of Tokyo, Tokyo; Japan.
- ¹⁵⁴Department of Physics, Tokyo Institute of Technology, Tokyo; Japan.
- ¹⁵⁵Department of Physics, University of Toronto, Toronto ON; Canada.
- ¹⁵⁶^(a)TRIUMF, Vancouver BC; ^(b)Department of Physics and Astronomy, York University, Toronto ON; Canada.
- ¹⁵⁷Division of Physics and Tomonaga Center for the History of the Universe, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba; Japan.
- ¹⁵⁸Department of Physics and Astronomy, Tufts University, Medford MA; United States of America.
- ¹⁵⁹United Arab Emirates University, Al Ain; United Arab Emirates.
- ¹⁶⁰Department of Physics and Astronomy, University of California Irvine, Irvine CA; United States of America.
- ¹⁶¹Department of Physics and Astronomy, University of Uppsala, Uppsala; Sweden.
- ¹⁶²Department of Physics, University of Illinois, Urbana IL; United States of America.
- ¹⁶³Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia - CSIC, Valencia; Spain.
- ¹⁶⁴Department of Physics, University of British Columbia, Vancouver BC; Canada.
- ¹⁶⁵Department of Physics and Astronomy, University of Victoria, Victoria BC; Canada.
- ¹⁶⁶Fakultät für Physik und Astronomie, Julius-Maximilians-Universität Würzburg, Würzburg; Germany.
- ¹⁶⁷Department of Physics, University of Warwick, Coventry; United Kingdom.
- ¹⁶⁸Waseda University, Tokyo; Japan.
- ¹⁶⁹Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Rehovot; Israel.
- ¹⁷⁰Department of Physics, University of Wisconsin, Madison WI; United States of America.
- ¹⁷¹Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal; Germany.
- ¹⁷²Department of Physics, Yale University, New Haven CT; United States of America.
- ^a Also Affiliated with an institute covered by a cooperation agreement with CERN.
- ^b Also at An-Najah National University, Nablus; Palestine.
- ^c Also at APC, Université Paris Cité, CNRS/IN2P3, Paris; France.
- ^d Also at Borough of Manhattan Community College, City University of New York, New York NY; United States of America.
- ^e Also at Center for High Energy Physics, Peking University; China.
- ^f Also at Center for Interdisciplinary Research and Innovation (CIRI-AUTH), Thessaloniki ; Greece.

- ^g Also at Centro Studi e Ricerche Enrico Fermi; Italy.
- ^h Also at CERN Tier-0; Switzerland.
- ⁱ Also at CERN, Geneva; Switzerland.
- ^j Also at Département de Physique Nucléaire et Corpusculaire, Université de Genève, Genève; Switzerland.
- ^k Also at Departament de Física de la Universitat Autònoma de Barcelona, Barcelona; Spain.
- ^l Also at Department of Financial and Management Engineering, University of the Aegean, Chios; Greece.
- ^m Also at Department of Physics and Astronomy, University of Sheffield, Sheffield; United Kingdom.
- ⁿ Also at Department of Physics and Astronomy, University of Victoria, Victoria BC; Canada.
- ^o Also at Department of Physics, Ben Gurion University of the Negev, Beer Sheva; Israel.
- ^p Also at Department of Physics, California State University, Sacramento; United States of America.
- ^q Also at Department of Physics, King's College London, London; United Kingdom.
- ^r Also at Department of Physics, Oxford University, Oxford; United Kingdom.
- ^s Also at Department of Physics, Royal Holloway University of London, Egham; United Kingdom.
- ^t Also at Department of Physics, Stanford University, Stanford CA; United States of America.
- ^u Also at Department of Physics, University of Fribourg, Fribourg; Switzerland.
- ^v Also at Department of Physics, University of Massachusetts, Amherst MA; United States of America.
- ^w Also at Department of Physics, University of Thessaly; Greece.
- ^x Also at Department of Physics, Westmont College, Santa Barbara; United States of America.
- ^y Also at Deutsches Elektronen-Synchrotron DESY, Hamburg and Zeuthen; Germany.
- ^z Also at Fakultät Physik, Technische Universität Dortmund, Dortmund; Germany.
- ^{aa} Also at Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal; Germany.
- ^{ab} Also at Group of Particle Physics, University of Montreal, Montreal QC; Canada.
- ^{ac} Also at Hellenic Open University, Patras; Greece.
- ^{ad} Also at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona; Spain.
- ^{ae} Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg; Germany.
- ^{af} Also at Institut für Physik, Universität Mainz, Mainz; Germany.
- ^{ag} Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia; Bulgaria.
- ^{ah} Also at Institute of Applied Physics, Mohammed VI Polytechnic University, Ben Guerir; Morocco.
- ^{ai} Also at Institute of Particle Physics (IPP); Canada.
- ^{aj} Also at Institute of Physics and Technology, Ulaanbaatar; Mongolia.
- ^{ak} Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku; Azerbaijan.
- ^{al} Also at Institute of Theoretical Physics, Ilia State University, Tbilisi; Georgia.
- ^{am} Also at IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette; France.
- ^{an} Also at L2IT, Université de Toulouse, CNRS/IN2P3, UPS, Toulouse; France.
- ^{ao} Also at Lawrence Livermore National Laboratory, Livermore; United States of America.
- ^{ap} Also at National Institute of Physics, University of the Philippines Diliman (Philippines); Philippines.
- ^{aq} Also at School of Physics and Astronomy, University of Birmingham, Birmingham; United Kingdom.
- ^{ar} Also at School of Physics and Astronomy, University of Manchester, Manchester; United Kingdom.
- ^{as} Also at SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow; United Kingdom.
- ^{at} Also at Technical University of Munich, Munich; Germany.
- ^{au} Also at The Collaborative Innovation Center of Quantum Matter (CICQM), Beijing; China.
- ^{av} Also at TRIUMF, Vancouver BC; Canada.
- ^{aw} Also at Università di Napoli Parthenope, Napoli; Italy.
- ^{ax} Also at University of Chinese Academy of Sciences (UCAS), Beijing; China.

^{ay} Also at University of Colorado Boulder, Department of Physics, Colorado; United States of America.

^{az} Also at Washington College, Chestertown, MD; United States of America.

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

* Deceased