



UvA-DARE (Digital Academic Repository)

Measurement of Z boson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector

Aad, G.; et al., [Unknown]; Aben, R.; Beemster, L.J.; Bentvelsen, S.; Berglund, E.; Bobbink, G.J.; Bos, K.; Boterenbrood, H.; Colijn, A.P.; de Jong, P.; de Nooij, L.; Deluca, C.; Deviveiros, P.O.; Doxiadis, A.D.; Ferrari, P.; Garitaonandia, H.; Geerts, D.A.A.; Gosselink, M.; Hartjes, F.; Hesse, N.P.; Igonkina, O.; Kayl, M.S.; Klous, S.; Kluit, P.; Koffeman, E.; Lee, H.; Lenz, T.; Linde, F.; Luijckx, G.; Mahlstedt, J.; Massaro, G.; Mechnich, J.; Mussche, I.; Ottersbach, J.P.; Pani, P.; Rijpstra, M.; Ruckstuhl, N.; Ta, D.; Tsiakiris, M.; Turlay, E.; van der Deijl, P.C.; van der Geer, R.; van der Graaf, H.; van der Leeuw, R.; van der Poel, E.; van Vulpen, I.; Verkerke, W.; Vermeulen, J.C.; Vranjes Milosavljevic, M.; Vreeswijk, M.

DOI

[10.1103/PhysRevLett.110.022301](https://doi.org/10.1103/PhysRevLett.110.022301)

Publication date

2013

Document Version

Final published version

Published in

Physical Review Letters

[Link to publication](#)

Citation for published version (APA):

Aad, G., et al., U., Aben, R., Beemster, L. J., Bentvelsen, S., Berglund, E., Bobbink, G. J., Bos, K., Boterenbrood, H., Colijn, A. P., de Jong, P., de Nooij, L., Deluca, C., Deviveiros, P. O., Doxiadis, A. D., Ferrari, P., Garitaonandia, H., Geerts, D. A. A., Gosselink, M., ... Vreeswijk, M. (2013). Measurement of Z boson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector. *Physical Review Letters*, 110(2), 022301. <https://doi.org/10.1103/PhysRevLett.110.022301>

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, P.O. Box 19185, 1000 GD Amsterdam, The Netherlands. You will be contacted as soon as possible.

Download date: 13 Jun 2026

Measurement of Z Boson Production in Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS Detector

G. Aad *et al.**

(ATLAS Collaboration)

(Received 24 October 2012; published 8 January 2013)

The ATLAS experiment has observed 1995 Z boson candidates in data corresponding to 0.15 nb^{-1} of integrated luminosity obtained in the 2011 LHC Pb + Pb run at $\sqrt{s_{NN}} = 2.76$ TeV. The Z bosons are reconstructed via dielectron and dimuon decay channels, with a background contamination of less than 3%. Results from the two channels are consistent and are combined. Within the statistical and systematic uncertainties, the per-event Z boson yield is proportional to the number of binary collisions estimated by the Glauber model. The elliptic anisotropy of the azimuthal distribution of the Z boson with respect to the event plane is found to be consistent with zero.

DOI: [10.1103/PhysRevLett.110.022301](https://doi.org/10.1103/PhysRevLett.110.022301)

PACS numbers: 25.75.Cj, 14.70.Hp, 23.70.+j, 25.75.Dw

Extensive studies of heavy ion (HI) collisions carried out by the experiments at the Relativistic Heavy Ion Collider (RHIC) at BNL, and the Large Hadron Collider (LHC) at CERN, have established that the hot and dense matter produced in HI collisions causes a significant modification of the energetic color-charge carriers propagating through such a medium [1,2]. An understanding of this phenomenon requires measuring the unmodified production rates of the particles before they lose energy. The best candidates to perform such measurements are particles that do not interact via the strong force. The PHENIX experiment at RHIC measured the properties of photons [3]. At the LHC, the CMS experiment reported results on photons and W bosons [4,5]. The number of these bosons was found to scale with the number of incoherent nucleon-nucleon collisions. Both the ATLAS and CMS Collaborations have reported measurements of $Z \rightarrow \mu\mu$ production at $\sqrt{s_{NN}} = 2.76$ TeV [6,7], which show, within a limited statistical precision, the same scaling behavior. This Letter presents a precise measurement of Z boson production in Pb + Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, using the dielectron and dimuon decay channels. The Z boson production rate is measured as a function of centrality, rapidity (y^Z), transverse momentum (p_T^Z), and orientation with respect to the event plane [8].

The ATLAS detector [9] at the LHC covers nearly the entire solid angle around the collision point. It consists of an inner tracking detector surrounded by a thin superconducting solenoid, electromagnetic and hadronic calorimeters, and a muon spectrometer incorporating three superconducting toroid magnet systems.

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

Published by the American Physical Society under the terms of the [Creative Commons Attribution 3.0 License](https://creativecommons.org/licenses/by/3.0/). Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI.

The inner detector system (ID) is immersed in a 2 T axial magnetic field and provides charged particle tracking in the range $|\eta| < 2.5$. The high-granularity silicon pixel detector covers the vertex region and is surrounded by the silicon microstrip tracker and the transition radiation tracker.

The calorimeters cover the range $|\eta| < 4.9$. Within the region $|\eta| < 3.2$, electromagnetic calorimetry is provided by barrel and end-cap high-granularity lead liquid-argon (LAr) calorimeters, with an additional thin LAr presampler covering $|\eta| < 1.8$. The electromagnetic calorimeter is backed by a hadronic calorimeter. Forward calorimeters (FCal) are located in the range $3.1 < |\eta| < 4.9$.

The muon spectrometer (MS) comprises separate trigger and high-precision tracking chambers that measure the deflection of muons in a magnetic field generated by superconducting air-core toroids. The precision chambers cover the region $|\eta| < 2.7$ with three layers of monitored drift tubes (MDT), complemented by cathode strip chambers (CSC) in the innermost layer of the forward region. The muon trigger system covers the range $|\eta| < 2.4$ with resistive plate chambers in the barrel, and thin gap chambers in the end-cap regions.

This analysis uses the 2011 LHC Pb + Pb collision data at $\sqrt{s_{NN}} = 2.76$ TeV, obtained by the ATLAS experiment with integrated luminosity of approximately 0.15 nb^{-1} . The data sample for this study was collected using a three-level trigger system [10], which selected events with electron or muon candidates.

Electron candidates were identified at the first trigger level ($L1$) as a cluster of cells in the electromagnetic calorimeter, formed into $(\Delta\phi \times \Delta\eta) = 0.1 \times 0.1$ trigger towers, within the range $|\eta| < 2.5$, excluding the transition region between calorimeter sections ($1.37 < |\eta| < 1.52$). The cluster transverse energy was required to exceed $E_T = 14$ GeV.

Muon candidates were selected using all three trigger levels. The $L1$ muon trigger searched for patterns of hits in the trigger chambers consistent with muons. If a muon

had p_T exceeding 4 GeV, the event was accepted for further processing by the high-level trigger (HLT). The L1 muon algorithm also identified regions of interest (RoI) within the detector to be investigated by the HLT. In the HLT, the track parameters of each muon were recalculated by including the precision data from the MDT or CSC in the RoI defined by the previous trigger level. Muon candidates were reconstructed either solely from the MS or using combined data from the MS and ID. In addition to the events selected using the RoI-based muon trigger, the reconstruction was performed over the whole MS by the HLT to identify muons with $p_T > 10$ GeV. The full scan searched all events in which a neutral particle signal was detected in each of two zero degree calorimeters (ZDC) ($|\eta| > 8.3$), or which contained an energy deposition in the calorimeters of $E_T > 10$ GeV.

In addition to the single-lepton trigger, each event had to pass the minimum-bias (MB) event selection, which required a timing signal coincidence of better than 3 ns between the MB trigger scintillators ($2.1 < |\eta| < 3.8$), as well as the reconstruction of a collision vertex in the ID. The total number of sampled events is $(1.03 \pm 0.02) \times 10^9$ [11].

Analyzed events are divided into centrality classes. Centrality reflects the overlap volume of the two colliding nuclei. Collisions with a small (large) impact parameter are referred to as central (peripheral). The overlap volume is closely related to the average number of participant nucleons which scatter inelastically in each nuclear collision $\langle N_{\text{part}} \rangle$, and to the average number of binary collisions between the nucleons of the colliding nuclei $\langle N_{\text{coll}} \rangle$. Equivalently, $\langle N_{\text{coll}} \rangle$ may be defined as the average nuclear thickness function $\langle T_{\text{AA}} \rangle$ multiplied by the total inelastic $p + p$ cross section of 64 ± 5 mb [12].

The Pb + Pb collision centrality is measured using the scalar sum of transverse energy ($\sum E_T$) deposited in the FCal, calibrated at the electromagnetic energy scale [13]. The fraction of events with more than one Pb + Pb collision is estimated not to exceed 0.05%, except for the most central 5% of events in which the fraction does not exceed 0.5%. A cut on the FCal energy of $\sum E_T < 3.8$ TeV is applied to prevent contamination by events with multiple Pb + Pb interactions. Glauber model calculations relate centrality to $\langle N_{\text{part}} \rangle$ and $\langle N_{\text{coll}} \rangle$, following the procedure documented in Ref. [14]. In the present sample, $\langle N_{\text{coll}} \rangle$ ($\langle N_{\text{part}} \rangle$) ranges from 1683 ± 130 (382 ± 2) for the most central class, 0%–5%, to 78 ± 7 (46 ± 3) for the most peripheral class, 40%–80%.

The efficiencies of the electron and muon triggers are evaluated from 5.5×10^7 events selected with the MB trigger during the 2011 run. The MB trigger required a transverse energy deposition of $E_T > 50$ GeV in the calorimeters or a coincidence of both ZDC signals and a track in the ID. The average trigger efficiency for muons with $p_T > 10$ GeV decreases from $(98.2 \pm 0.5)\%$ in peripheral events to $(90.9 \pm 0.5)\%$ in central events, where the ID

occupancy is higher. The average trigger efficiency for electrons with $|\eta| < 2.5$ and $E_T > 20$ GeV is $(98.1 \pm 0.1)\%$, independent of centrality. The trigger efficiency for $Z \rightarrow \mu\mu$ decays ranges from $(99.0 \pm 0.6)\%$ in peripheral events to $(95.0 \pm 0.9)\%$ in central events. For $Z \rightarrow ee$ decays the efficiency is $(99.9 \pm 0.1)\%$ independent of centrality.

For the $Z \rightarrow ee$ analysis, electron candidates are formed using the standard ATLAS reconstruction algorithm [15], requiring the matching of a track to an energy cluster in the electromagnetic calorimeter. Electron selection is limited to $|\eta| < 2.5$ and both electrons are required to have $E_T > 20$ GeV. Following the reconstruction requirements, further electron identification cuts are made to reject background. The standard electron identification cuts [15] used in the $p + p$ environment are not suited to the Pb + Pb environment due to the large underlying event (UE) energy deposition in the calorimeter. To address this, a different set of cuts has been developed to accommodate the modification of the calorimeter variables by the presence of the UE. The cuts used are based on the energy balance between the track momentum and cluster energy (E/p), as well as calorimeter shower shape variables. Furthermore, the UE energy is estimated (following Ref. [16]) and subtracted on an electron-by-electron basis to recover the proper electron energy.

The electron combined reconstruction and identification efficiency is evaluated in a Monte Carlo simulation using electrons from 7×10^5 PYTHIA (version 6.425) [17] $p + p \rightarrow Z \rightarrow ee$ events with $66 < m_Z < 116$ GeV and $|y^Z| < 2.5$ embedded into Pb + Pb events generated by the HIJING event generator (version 1.38b) [18]. The response of the ATLAS detector to the generated particles is modeled using GEANT4 [19,20]. The combined reconstruction and identification efficiency for electrons of $E_T > 20$ GeV ranges from 72% to 76% from central to peripheral events, with a common absolute uncertainty of 5.4%.

For the $Z \rightarrow ee$ analysis, all electrons found in triggered events are paired with each other, requiring that at least one electron in the pair matches a trigger object. The opposite-sign charged pairs with an invariant mass satisfying $66 < m_{ee} < 102$ GeV are accepted as signal Z boson candidates. The same-sign pairs in this window are taken as an estimate of the combinatorial background. In total, 772 opposite-sign pairs and 42 same-sign pairs are reconstructed.

In the $Z \rightarrow \mu\mu$ analysis, single muons are reconstructed with several levels of quality [21]. High quality muons are reconstructed in both the MS and ID with consistent angular measurements, as well as with a good match to the event vertex. At least one muon in each pair, matched to the trigger, is required to be of such quality. If the second muon in the pair has hit patterns in the MS and ID satisfying criteria of high reconstruction quality, the minimum p_T threshold is set to 10 GeV for both muons. If the second muon fails this condition, both muons are required to satisfy $p_T > 20$ GeV.

The muon combined reconstruction and identification efficiency is evaluated using muons from 5.3×10^5 PYTHIA $p + p \rightarrow Z \rightarrow \mu\mu$ events with $66 < m_Z < 116$ GeV and $|y^Z| < 2.5$ embedded into HIJING events. For muons with $p_T > 20$ GeV, $|\eta| < 2.5$ and associated to the event vertex, the reconstruction efficiency of the MS varies from $(97 \pm 1)\%$ to $(98 \pm 1)\%$ from central to peripheral events. Requiring a match between the MS and ID reduces the efficiency to $(89 \pm 1)\%$ and $(91 \pm 1)\%$, respectively, due to track loss in the ID, predominantly at $|\eta| > 1.5$.

As in the $Z \rightarrow ee$ analysis, an invariant mass window of $66 < m_{\mu\mu} < 102$ GeV is used to define oppositely charged muon pairs as Z boson candidates and same-sign charged pairs as a background estimate. In total, 1223 opposite-sign candidates and 14 same-sign pairs are reconstructed in the $Z \rightarrow \mu\mu$ channel.

The invariant mass distributions of the selected pairs together with estimated combinatorial backgrounds for all p_T^Z and $y^Z < 2.5$ are shown in Fig. 1, compared with the simulation normalized to the number of pairs in the region $66 < m_{\ell\ell} < 102$ GeV ($\ell = e, \mu$). In order to calculate the yield, the combinatorial background estimated with the same-sign pairs must be subtracted. Backgrounds from electroweak processes and top pair decays [22] are small compared to the combinatorial backgrounds, and their contribution is accounted for in the systematic uncertainty related to the background.

The main sources of systematic uncertainty in both measurement channels are associated with the precision to which the corrections applied to the data can be calculated. In the $p + p$ environment, the muon reconstruction efficiencies in data and simulation agree to 1% (2% for $p_T < 15$ GeV) [23]. The MS maintains low occupancy in the Pb + Pb environment. The difference in the fraction of

muons reconstructed only in the MS, between data and simulation is used to estimate the systematic uncertainty on the reconstruction efficiency. To evaluate the uncertainty on the efficiency of the electron identification cuts stemming from the simulation, the efficiency is computed from the HI data using a tag-and-probe technique [15] and compared to the efficiency computed from simulation. The systematic uncertainty due to momentum resolution is estimated by introducing additional momentum smearing to the simulation. The efficiency (resolution) uncertainties are $\approx 5.5\%$ (2.5%) for $Z \rightarrow \mu\mu$, and 8% (2.5%) in $Z \rightarrow ee$; these estimates vary with p_T^Z and y^Z .

The trigger efficiency uncertainties are estimated by using alternative methods and comparing their results with those obtained from the MB data set. For this comparison the simulation trigger efficiency is used, as well as the conditional trigger efficiency of a second lepton in a triggered pair reconstructed as a Z boson.

For each $Z \rightarrow ll$ analysis, correction factors to account for the efficiency (relative to Z bosons produced with $66 < m_Z < 116$ GeV) and detector resolution within the selected acceptance based on the simulation are calculated differentially in event centrality, p_T^Z , and y^Z . In each decay channel, the correction factor is applied and the background, estimated by the same-sign pairs, is subtracted. The two measurements are averaged with weights set by their respective uncertainties.

The fully corrected y^Z distribution is shown in Fig. 2. No centrality dependence of this shape is observed. The data are compared to a model composed of PYTHIA events normalized to the $Z \rightarrow ll$ cross section in $p + p$ collisions at $\sqrt{s_{NN}} = 2.76$ TeV taken from next-to-next-to-leading-order (NNLO) calculations used in Ref. [24] and scaled by $\langle T_{AA} \rangle$. Using the same computational approach as in

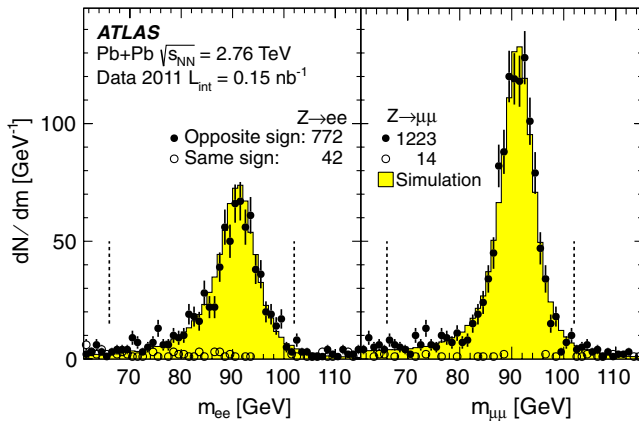


FIG. 1 (color online). The invariant mass distributions of $Z \rightarrow ee$ (left) and $Z \rightarrow \mu\mu$ (right) candidates, integrated over momentum, rapidity, and centrality. Bars represent the statistical uncertainty. The number of pairs with $66 < m_{\ell\ell} < 102$ GeV (marked by the vertical dashed lines) is listed. The simulation is weighted to match the centrality distribution in data and normalized in the region $66 < m_{\ell\ell} < 102$ GeV.

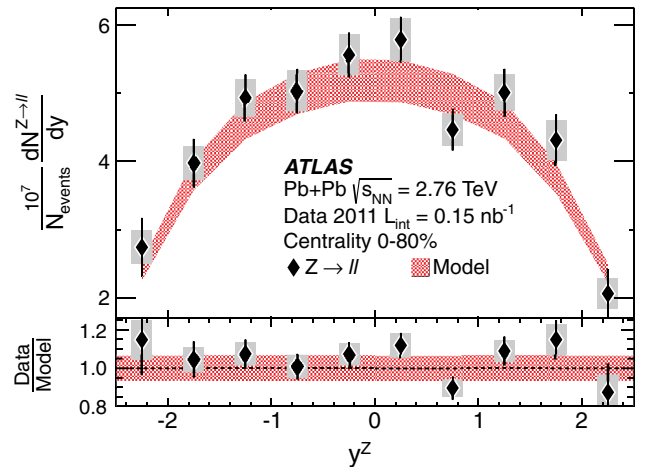


FIG. 2 (color online). The corrected per-event rapidity distribution of measured Z bosons. Bars and boxes represent statistical and systematic uncertainties, respectively. The data are compared to the model distribution shown as a band whose width is the normalization uncertainty.

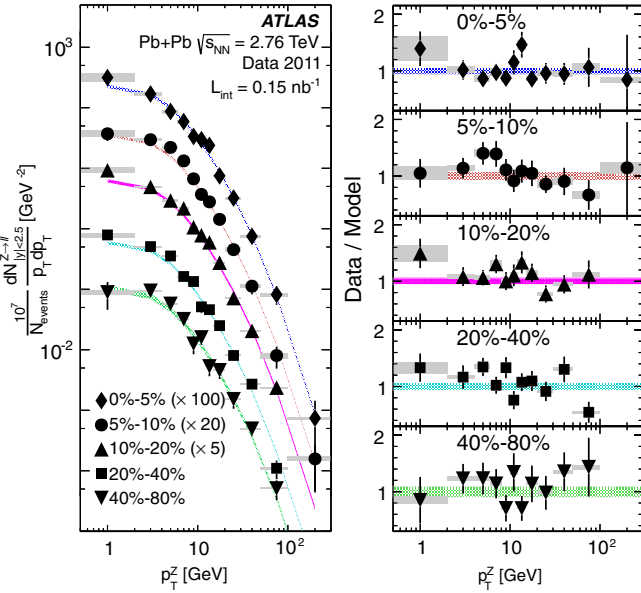


FIG. 3 (color online). Left: corrected per-event p_T^Z spectra of measured Z bosons in five centrality classes. The data are compared to a PYTHIA simulation normalized to the NNLO $p + p$ cross section and scaled by $\langle T_{AA} \rangle$, shown as bands. Right: ratios of the data to the model in each centrality class. Bars represent statistical uncertainties, boxes represent systematic uncertainties, and bands represent the normalization uncertainty.

Ref. [24] but incorporating $p + n$ and $n + n$ collisions would increase the cross section by 3%. The shape is well reproduced by PYTHIA, and the integrated yield is in good agreement with the $\langle T_{AA} \rangle$ -scaled NNLO cross section.

The fully corrected p_T distributions in five centrality classes are shown in the left panel of Fig. 3 along with the model prediction. The shape as a function of p_T^Z is well reproduced by PYTHIA. The right panel of Fig. 3 shows the ratios of the data to the PYTHIA prediction scaled by $\langle T_{AA} \rangle$. The ratios are constant within uncertainties for all centrality classes over the range of measured p_T^Z .

To further examine the binary collision scaling of the data, the Z boson per-event yields, divided by $\langle N_{coll} \rangle$, are shown in Fig. 4 as a function of $\langle N_{part} \rangle$, in several p_T^Z bins. The figure demonstrates that the $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ results are consistent within their uncertainties for all p_T^Z and centrality regions. Within the statistical significance of the data sample, the Z boson per-event yield obeys binary collision scaling.

The elliptic anisotropy v_2 of the Z boson is defined as $v_2 = \langle \cos 2(\phi - \Psi_2) \rangle / \sigma_2$, where ϕ is the azimuthal angle of the Z boson momentum vector and Ψ_2 is the azimuthal angle of the event plane, the plane containing the momentum vectors of both lead nuclei and measured with resolution σ_2 [25]. The v_2 values measured in the two decay channels are consistent and are combined. The main uncertainty on the v_2 measurement arises from the event plane (EP) resolution, which is measured from the difference of Ψ_2 determined using the two sides of the FCal at

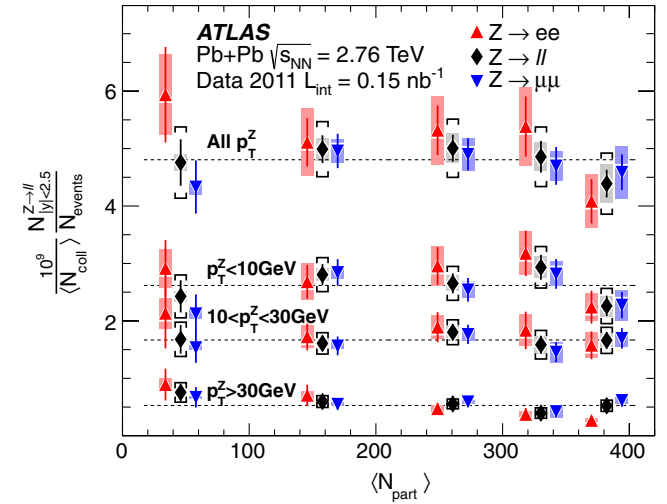


FIG. 4 (color online). Centrality dependence of Z boson yields divided by $\langle N_{coll} \rangle$. Results for ee (upward pointing triangles) and $\mu\mu$ (downward pointing triangles) channels are shifted left and right, respectively, from their weighted average (diamonds). Bars and boxes represent statistical and systematic uncertainties, respectively. For the combined results, the brackets show the combined uncertainty including the uncertainty on $\langle N_{coll} \rangle$, and the dashed lines show the results of fits, using a constant.

positive and negative rapidities [25]. To ensure that the jets associated with Z boson production do not affect the determination of Ψ_2 , the EP resolution is also measured comparing the FCal signal on the side which may be affected by a recoiling jet to the one of the unaffected side. A systematic uncertainty of 12 mrad is assigned for possible EP distortion.

The v_2 of the Z boson is shown in Fig. 5 as a function of $|y^Z|$, p_T^Z , and $\langle N_{part} \rangle$. The averaged v_2 of the Z boson has been measured to be $v_2 = -0.015 \pm 0.018(\text{stat}) \pm 0.014(\text{sys})$, which indicates an isotropic distribution. This observation is an independent measurement consistent with $Z \rightarrow ll$ yields being unaffected by the medium in HI collisions.

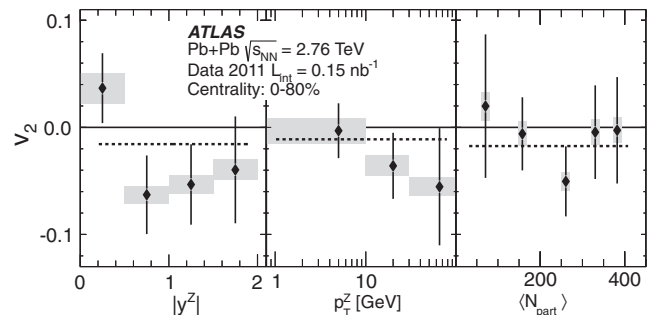


FIG. 5. v_2 as a function of $|y^Z|$ (left), p_T^Z (center), and $\langle N_{part} \rangle$ (right). Bars and boxes represent statistical and systematic uncertainties, respectively. The dashed lines show the results of constant fits to the v_2 values, considering only statistical uncertainties.

Using the ATLAS detector, Z boson production has been measured in Pb + Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV using 0.15 nb^{-1} of integrated luminosity collected in the 2011 LHC physics run. Within $|y^Z| < 2.5$, and $66 < m_{\ell\ell} < 102$ GeV, a total of 772 and 1223 Z boson candidates are reconstructed in the $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ channels, respectively. The combinatorial background is at the level of 5% in the dielectron channel and 1% for the dimuon channel. The Z boson production yield integrated over $|y^Z| < 2.5$ is consistent between the two channels in all measured p_T and centrality regions. The momentum and rapidity distributions of the Z bosons are consistent with PYTHIA simulations of Z boson production in $p + p$ collisions scaled to the NNLO cross section and multiplied by $\langle T_{AA} \rangle$. Within the uncertainties the Z boson yield is found to be proportional to $\langle N_{\text{coll}} \rangle$. The elliptic anisotropy of the Z boson measured as a function of rapidity, p_T^Z and $\langle N_{\text{part}} \rangle$ is consistent with zero within the uncertainties of the measurements.

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; BMWF and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR, and VSC CR, Czech Republic; DNRF, DNSRC, and Lundbeck Foundation, Denmark; EPLANET and ERC, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG, and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP, and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTP, Serbia; MSSR, Slovakia; ARRS and MVZT, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF, and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, United States of America. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular, from CERN and 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 (U.K.) and BNL (U.S.) and in the Tier-2 facilities worldwide.

-
- [1] M. J. Tannenbaum, *Rep. Prog. Phys.* **69**, 2005 (2006).
 - [2] B. Muller, J. Schukraft, and B. Wyslouch, *Annu. Rev. Nucl. Part. Sci.* **62**, 361 (2012).
 - [3] S. Afanasiev *et al.* (PHENIX Collaboration), *Phys. Rev. Lett.* **109**, 152302 (2012).
 - [4] CMS Collaboration, *Phys. Lett. B* **710**, 256 (2012).
 - [5] CMS Collaboration, *Phys. Lett. B* **715**, 66 (2012).
 - [6] ATLAS Collaboration, *Phys. Lett. B* **697**, 294 (2011).
 - [7] CMS Collaboration, *Phys. Rev. Lett.* **106**, 212301 (2011).
 - [8] The ATLAS reference system is a Cartesian right-handed coordinate system, with the nominal collision point at the origin. The anticlockwise beam direction defines the positive z axis, while the positive x axis is defined as pointing from the collision point to the center of the LHC ring and the positive y axis points upwards. Transverse quantities, such as p_T and E_T , are defined in the (x, y) plane. The azimuthal angle ϕ is measured around the beam axis, and the polar angle θ is measured with respect to the z -axis. The rapidity is given by $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$ and pseudorapidity is defined as $\eta = -\ln[\tan(\theta/2)]$.
 - [9] ATLAS Collaboration, *JINST* **3**, S08003 (2008).
 - [10] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1849 (2012).
 - [11] ATLAS Collaboration, Report No. ATLAS-CONF-2012-122, 2012, <http://cdsweb.cern.ch/record/1473425>.
 - [12] K. Nakamura *et al.* (Particle Data Group Collaboration), *J. Phys. G* **37**, 075021 (2010).
 - [13] ATLAS Collaboration, *Phys. Lett. B* **707**, 330 (2012).
 - [14] ATLAS Collaboration, *Phys. Lett. B* **710**, 363 (2012).
 - [15] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1909 (2012).
 - [16] ATLAS Collaboration, [arXiv:1208.1967](https://arxiv.org/abs/1208.1967).
 - [17] T. Sjöstrand, S. Mrenna, and P. Skands, *J. High Energy Phys.* **05** (2006) 026.
 - [18] X. N. Wang and M. Gyulassy, *Phys. Rev. D* **44**, 3501 (1991).
 - [19] S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
 - [20] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010).
 - [21] ATLAS Collaboration, Report No. ATLAS-CONF-2010-036, 2010, <https://cdsweb.cern.ch/record/1277675>.
 - [22] ATLAS Collaboration, *Phys. Rev. D* **85**, 072004 (2012).
 - [23] ATLAS Collaboration, Report No. ATLAS-CONF-2011-063, 2011, <https://cdsweb.cern.ch/record/1345743>.
 - [24] ATLAS Collaboration, *J. High Energy Phys.* **12** (2010) 060.
 - [25] ATLAS Collaboration, *Phys. Rev. C* **86**, 014907 (2012).

G. Aad,⁴⁸ T. Abajyan,²¹ B. Abbott,¹¹¹ J. Abdallah,¹² S. Abdel Khalek,¹¹⁵ A. A. Abdelalim,⁴⁹ O. Abidinov,¹¹ R. Aben,¹⁰⁵ B. Abi,¹¹² M. Abolins,⁸⁸ O. S. AbouZeid,¹⁵⁸ H. Abramowicz,¹⁵³ H. Abreu,¹³⁶ B. S. Acharya,^{164a,164b} L. Adamczyk,³⁸ D. L. Adams,²⁵ T. N. Addy,⁵⁶ J. Adelman,¹⁷⁶ S. Adomeit,⁹⁸ P. Adragna,⁷⁵ T. Adye,¹²⁹ S. Aefsky,²³ J. A. Aguilar-Saavedra,^{124b,b} M. Agustoni,¹⁷ M. Aharrouche,⁸¹ S. P. Ahlen,²² F. Ahles,⁴⁸ A. Ahmad,¹⁴⁸ M. Ahsan,⁴¹ G. Aielli,^{133a,133b} T. Akdogan,^{19a} T. P. A. Åkesson,⁷⁹ G. Akimoto,¹⁵⁵ A. V. Akimov,⁹⁴ M. S. Alam,² M. A. Alam,⁷⁶

J. Albert,¹⁶⁹ S. Albrand,⁵⁵ M. Aleksa,³⁰ I. N. Aleksandrov,⁶⁴ F. Alessandria,^{89a} C. Alexa,^{26a} G. Alexander,¹⁵³
 G. Alexandre,⁴⁹ T. Alexopoulos,¹⁰ M. Alhroob,^{164a,164c} M. Aliev,¹⁶ G. Alimonti,^{89a} J. Alison,¹²⁰
 B. M. M. Allbrooke,¹⁸ P. P. Allport,⁷³ S. E. Allwood-Spiers,⁵³ J. Almond,⁸² A. Aloisio,^{102a,102b} R. Alon,¹⁷²
 A. Alonso,⁷⁹ F. Alonso,⁷⁰ A. Altheimer,³⁵ B. Alvarez Gonzalez,⁸⁸ M. G. Alviggi,^{102a,102b} K. Amako,⁶⁵
 C. Amelung,²³ V. V. Ammosov,^{128,a} S. P. Amor Dos Santos,^{124a} A. Amorim,^{124a,c} N. Amram,¹⁵³ C. Anastopoulos,³⁰
 L. S. Ancu,¹⁷ N. Andari,¹¹⁵ T. Andeen,³⁵ C. F. Anders,^{58b} G. Anders,^{58a} K. J. Anderson,³¹ A. Andreazza,^{89a,89b}
 V. Andrei,^{58a} M.-L. Andrieux,⁵⁵ X. S. Anduaga,⁷⁰ P. Anger,⁴⁴ A. Angerami,³⁵ F. Anghinolfi,³⁰ A. Anisenkov,¹⁰⁷
 N. Anjos,^{124a} A. Annovi,⁴⁷ A. Antonaki,⁹ M. Antonelli,⁴⁷ A. Antonov,⁹⁶ J. Antos,^{144b} F. Anulli,^{132a} M. Aoki,¹⁰¹
 S. Aoun,⁸³ L. Aperio Bella,⁵ R. Apolle,^{118,d} G. Arabidze,⁸⁸ I. Aracena,¹⁴³ Y. Arai,⁶⁵ A. T. H. Arce,⁴⁵ S. Arfaoui,¹⁴⁸
 J.-F. Arguin,⁹³ E. Arik,^{19a,a} M. Arik,^{19a} A. J. Armbruster,⁸⁷ O. Arnaez,⁸¹ V. Arnal,⁸⁰ C. Arnault,¹¹⁵ A. Artamonov,⁹⁵
 G. Artoni,^{132a,132b} D. Arutinov,²¹ S. Asai,¹⁵⁵ S. Ask,²⁸ B. Åsman,^{146a,146b} L. Asquith,⁶ K. Assamagan,²⁵
 A. Astbury,¹⁶⁹ M. Atkinson,¹⁶⁵ B. Aubert,⁵ E. Auge,¹¹⁵ K. Augsten,¹²⁷ M. Aurusseau,^{145a} G. Avolio,¹⁶³
 R. Avramidou,¹⁰ D. Axen,¹⁶⁸ G. Azuelos,^{93,e} Y. Azuma,¹⁵⁵ M. A. Baak,³⁰ G. Baccaglioni,^{89a} C. Bacci,^{134a,134b}
 A. M. Bach,¹⁵ H. Bachacou,¹³⁶ K. Bachas,³⁰ M. Backes,⁴⁹ M. Backhaus,²¹ J. Backus Mayes,¹⁴³ E. Badescu,^{26a}
 P. Bagnaia,^{132a,132b} S. Bahinipati,³ Y. Bai,^{33a} D. C. Bailey,¹⁵⁸ T. Bain,¹⁵⁸ J. T. Baines,¹²⁹ O. K. Baker,¹⁷⁶
 M. D. Baker,²⁵ S. Baker,⁷⁷ P. Balek,¹²⁶ E. Banas,³⁹ P. Banerjee,⁹³ Sw. Banerjee,¹⁷³ D. Banfi,³⁰ A. Bangert,¹⁵⁰
 V. Bansal,¹⁶⁹ H. S. Bansil,¹⁸ L. Barak,¹⁷² S. P. Baranov,⁹⁴ A. Barbaro Galtieri,¹⁵ T. Barber,⁴⁸ E. L. Barberio,⁸⁶
 D. Barberis,^{50a,50b} M. Barbero,²¹ D. Y. Bardin,⁶⁴ T. Barillari,⁹⁹ M. Barisonzi,¹⁷⁵ T. Barklow,¹⁴³ N. Barlow,²⁸
 B. M. Barnett,¹²⁹ R. M. Barnett,¹⁵ A. Baroncelli,^{134a} G. Barone,⁴⁹ A. J. Barr,¹¹⁸ F. Barreiro,⁸⁰
 J. Barreiro Guimarães da Costa,⁵⁷ P. Barrillon,¹¹⁵ R. Bartoldus,¹⁴³ A. E. Barton,⁷¹ V. Bartsch,¹⁴⁹ A. Basye,¹⁶⁵
 R. L. Bates,⁵³ L. Batkova,^{144a} J. R. Batley,²⁸ A. Battaglia,¹⁷ M. Battistin,³⁰ F. Bauer,¹³⁶ H. S. Bawa,^{143,f} S. Beale,⁹⁸
 T. Beau,⁷⁸ P. H. Beauchemin,¹⁶¹ R. Beccherle,^{50a} P. Bechtel,²¹ H. P. Beck,¹⁷ A. K. Becker,¹⁷⁵ S. Becker,⁹⁸
 M. Beckingham,¹³⁸ K. H. Becks,¹⁷⁵ A. J. Beddall,^{19c} A. Beddall,^{19c} S. Bedikian,¹⁷⁶ V. A. Bednyakov,⁶⁴ C. P. Bee,⁸³
 L. J. Beamster,¹⁰⁵ M. Begel,²⁵ S. Behar Harpaz,¹⁵² P. K. Behera,⁶² M. Beimforde,⁹⁹ C. Belanger-Champagne,⁸⁵
 P. J. Bell,⁴⁹ W. H. Bell,⁴⁹ G. Bella,¹⁵³ L. Bellagamba,^{20a} M. Bellomo,³⁰ A. Belloni,⁵⁷ O. Beloborodova,^{107,g}
 K. Belotskiy,⁹⁶ O. Beltramello,³⁰ O. Benary,¹⁵³ D. Bencheekroun,^{135a} K. Bendtz,^{146a,146b} N. Benekos,¹⁶⁵
 Y. Benhammou,¹⁵³ E. Benhar Noccioli,⁴⁹ J. A. Benitez Garcia,^{159b} D. P. Benjamin,⁴⁵ M. Benoit,¹¹⁵ J. R. Bensinger,²³
 K. Benslama,¹³⁰ S. Bentvelsen,¹⁰⁵ D. Berge,³⁰ E. Bergeaas Kuutmann,⁴² N. Berger,⁵ F. Berghaus,¹⁶⁹ E. Berglund,¹⁰⁵
 J. Beringer,¹⁵ P. Bernat,⁷⁷ R. Bernhard,⁴⁸ C. Bernius,²⁵ T. Berry,⁷⁶ C. Bertella,⁸³ A. Bertin,^{20a,20b}
 F. Bertolucci,^{122a,122b} M. I. Besana,^{89a,89b} G. J. Besjes,¹⁰⁴ N. Besson,¹³⁶ S. Bethke,⁹⁹ W. Bhimji,⁴⁶ R. M. Bianchi,³⁰
 M. Bianco,^{72a,72b} O. Biebel,⁹⁸ S. P. Bieniek,⁷⁷ K. Bierwagen,⁵⁴ J. Biesiada,¹⁵ M. Biglietti,^{134a} H. Bilokon,⁴⁷
 M. Bindi,^{20a,20b} S. Binet,¹¹⁵ A. Bingul,^{19c} C. Bini,^{132a,132b} C. Biscarat,¹⁷⁸ B. Bittner,⁹⁹ K. M. Black,²² R. E. Blair,⁶
 J.-B. Blanchard,¹³⁶ G. Blanchot,³⁰ T. Blazek,^{144a} I. Bloch,⁴² C. Blocker,²³ J. Blocki,³⁹ A. Blondel,⁴⁹ W. Blum,⁸¹
 U. Blumenschein,⁵⁴ G. J. Bobbink,¹⁰⁵ V. B. Bobrovnikov,¹⁰⁷ S. S. Bocchetta,⁷⁹ A. Bocci,⁴⁵ C. R. Boddy,¹¹⁸
 M. Boehler,⁴⁸ J. Boek,¹⁷⁵ N. Boelaert,³⁶ J. A. Bogaerts,³⁰ A. Bogdanchikov,¹⁰⁷ A. Bogouch,^{90,a} C. Bohm,^{146a}
 J. Bohm,¹²⁵ V. Boisvert,⁷⁶ T. Bold,³⁸ V. Boldea,^{26a} N. M. Bolnet,¹³⁶ M. Bomben,⁷⁸ M. Bona,⁷⁵ M. Boonekamp,¹³⁶
 S. Bordononi,⁷⁸ C. Borer,¹⁷ A. Borisov,¹²⁸ G. Borissov,⁷¹ I. Borjanovic,^{13a} M. Borri,⁸² S. Borroni,⁸⁷
 V. Bortolotto,^{134a,134b} K. Bos,¹⁰⁵ D. Boscherini,^{20a} M. Bosman,¹² H. Boterenbrood,¹⁰⁵ J. Bouchami,⁹³
 J. Boudreau,¹²³ E. V. Bouhova-Thacker,⁷¹ D. Boumediene,³⁴ C. Bourdarios,¹¹⁵ N. Bousson,⁸³ A. Boveia,³¹
 J. Boyd,³⁰ I. R. Boyko,⁶⁴ I. Bozovic-Jelisavcic,^{13b} J. Bracinik,¹⁸ P. Branchini,^{134a} G. W. Brandenburg,⁵⁷ A. Brandt,⁸
 G. Brandt,¹¹⁸ O. Brandt,⁵⁴ U. Bratzler,¹⁵⁶ B. Brau,⁸⁴ J. E. Brau,¹¹⁴ H. M. Braun,^{175,a} S. F. Brazzale,^{164a,164c}
 B. Brelief,¹⁵⁸ J. Bremer,³⁰ K. Brendlinger,¹²⁰ R. Brenner,¹⁶⁶ S. Bressler,¹⁷² D. Britton,⁵³ F. M. Brochu,²⁸ I. Brock,²¹
 R. Brock,⁸⁸ F. Broggi,^{89a} C. Bromberg,⁸⁸ J. Bronner,⁹⁹ G. Brooijmans,³⁵ T. Brooks,⁷⁶ W. K. Brooks,^{32b} G. Brown,⁸²
 H. Brown,⁸ P. A. Bruckman de Renstrom,³⁹ D. Bruncko,^{144b} R. Bruneliere,⁴⁸ S. Brunet,⁶⁰ A. Bruni,^{20a} G. Bruni,^{20a}
 M. Bruschi,^{20a} T. Buanes,¹⁴ Q. Buat,⁵⁵ F. Bucci,⁴⁹ J. Buchanan,¹¹⁸ P. Buchholz,¹⁴¹ R. M. Buckingham,¹¹⁸
 A. G. Buckley,⁴⁶ S. I. Buda,^{26a} I. A. Budagov,⁶⁴ B. Budick,¹⁰⁸ V. Büscher,⁸¹ L. Bugge,¹¹⁷ O. Bulekov,⁹⁶
 A. C. Bundock,⁷³ M. Bunse,⁴³ T. Buran,¹¹⁷ H. Burckhart,³⁰ S. Burdin,⁷³ T. Burgess,¹⁴ S. Burke,¹²⁹ E. Busato,³⁴
 P. Bussey,⁵³ C. P. Buszello,¹⁶⁶ B. Butler,¹⁴³ J. M. Butler,²² C. M. Buttar,⁵³ J. M. Butterworth,⁷⁷ W. Buttinger,²⁸
 M. Byszewski,³⁰ S. Cabrera Urbán,¹⁶⁷ D. Caforio,^{20a,20b} O. Cakir,^{4a} P. Calafiura,¹⁵ G. Calderini,⁷⁸ P. Calfayan,⁹⁸
 R. Calkins,¹⁰⁶ L. P. Caloba,^{24a} R. Caloi,^{132a,132b} D. Calvet,³⁴ S. Calvet,³⁴ R. Camacho Toro,³⁴ P. Camarri,^{133a,133b}
 D. Cameron,¹¹⁷ L. M. Caminada,¹⁵ R. Caminal Armadans,¹² S. Campana,³⁰ M. Campanelli,⁷⁷ V. Canale,^{102a,102b}

F. Canelli,^{31,h} A. Canepa,^{159a} J. Cantero,⁸⁰ R. Cantrill,⁷⁶ L. Capasso,^{102a,102b} M. D. M. Capeans Garrido,³⁰ I. Caprini,^{26a} M. Caprini,^{26a} D. Capriotti,⁹⁹ M. Capua,^{37a,37b} R. Caputo,⁸¹ R. Cardarelli,^{133a} T. Carli,³⁰ G. Carlino,^{102a} L. Carminati,^{89a,89b} B. Caron,⁸⁵ S. Caron,¹⁰⁴ E. Carquin,^{32b} G. D. Carrillo Montoya,¹⁷³ A. A. Carter,⁷⁵ J. R. Carter,²⁸ J. Carvalho,^{124a,i} D. Casadei,¹⁰⁸ M. P. Casado,¹² M. Cascella,^{122a,122b} C. Caso,^{50a,50b,a} A. M. Castaneda Hernandez,^{173,j} E. Castaneda-Miranda,¹⁷³ V. Castillo Gimenez,¹⁶⁷ N. F. Castro,^{124a} G. Cataldi,^{72a} P. Catastini,⁵⁷ A. Catinaccio,³⁰ J. R. Catmore,³⁰ A. Cattai,³⁰ G. Cattani,^{133a,133b} S. Caughron,⁸⁸ V. Cavaliere,¹⁶⁵ P. Cavalleri,⁷⁸ D. Cavalli,^{89a} M. Cavalli-Sforza,¹² V. Cavasinni,^{122a,122b} F. Ceradini,^{134a,134b} A. S. Cerqueira,^{24b} A. Cerri,³⁰ L. Cerrito,⁷⁵ F. Cerutti,⁴⁷ S. A. Cetin,^{19b} A. Chafaq,^{135a} D. Chakraborty,¹⁰⁶ I. Chalupkova,¹²⁶ K. Chan,³ P. Chang,¹⁶⁵ B. Chapleau,⁸⁵ J. D. Chapman,²⁸ J. W. Chapman,⁸⁷ E. Chareyre,⁷⁸ D. G. Charlton,¹⁸ V. Chavda,⁸² C. A. Chavez Barajas,³⁰ S. Cheatham,⁸⁵ S. Chekanov,⁶ S. V. Chekulaev,^{159a} G. A. Chelkov,⁶⁴ M. A. Chelstowska,¹⁰⁴ C. Chen,⁶³ H. Chen,²⁵ S. Chen,^{33c} X. Chen,¹⁷³ Y. Chen,³⁵ Y. Cheng,³¹ A. Cheplakov,⁶⁴ R. Cherkaoui El Moursli,^{135e} V. Chernyatin,²⁵ E. Cheu,⁷ S. L. Cheung,¹⁵⁸ L. Chevalier,¹³⁶ G. Chiefari,^{102a,102b} L. Chikovani,^{51a,a} J. T. Childers,³⁰ A. Chilingarov,⁷¹ G. Chiodini,^{72a} A. S. Chisholm,¹⁸ R. T. Chislett,⁷⁷ A. Chitan,^{26a} M. V. Chizhov,⁶⁴ G. Choudalakis,³¹ S. Chouridou,¹³⁷ I. A. Christidi,⁷⁷ A. Christov,⁴⁸ D. Chromek-Burckhart,³⁰ M. L. Chu,¹⁵¹ J. Chudoba,¹²⁵ G. Ciapetti,^{132a,132b} A. K. Ciftci,^{4a} R. Ciftci,^{4a} D. Cinca,³⁴ V. Cindro,⁷⁴ C. Ciocca,^{20a,20b} A. Ciocio,¹⁵ M. Cirilli,⁸⁷ P. Cirkovic,^{13b} Z. H. Citron,¹⁷² M. Citterio,^{89a} M. Ciubancan,^{26a} A. Clark,⁴⁹ P. J. Clark,⁴⁶ R. N. Clarke,¹⁵ W. Cleland,¹²³ J. C. Clemens,⁸³ B. Clement,⁵⁵ C. Clement,^{146a,146b} Y. Coadou,⁸³ M. Cobal,^{164a,164c} A. Cocco,¹³⁸ J. Cochran,⁶³ L. Coffey,²³ J. G. Cogan,¹⁴³ J. Coggeshall,¹⁶⁵ E. Cogneras,¹⁷⁸ J. Colas,⁵ S. Cole,¹⁰⁶ A. P. Colijn,¹⁰⁵ N. J. Collins,¹⁸ C. Collins-Tooth,⁵³ J. Collot,⁵⁵ T. Colombo,^{119a,119b} G. Colon,⁸⁴ G. Compostella,⁹⁹ P. Conde Muiño,^{124a} E. Coniavitis,¹⁶⁶ M. C. Conidi,¹² S. M. Consonni,^{89a,89b} V. Consorti,⁴⁸ S. Constantinescu,^{26a} C. Conta,^{119a,119b} G. Conti,⁵⁷ F. Conventi,^{102a,k} M. Cooke,¹⁵ B. D. Cooper,⁷⁷ A. M. Cooper-Sarkar,¹¹⁸ K. Copic,¹⁵ T. Cornelissen,¹⁷⁵ M. Corradi,^{20a} F. Corriveau,^{85,l} A. Cortes-Gonzalez,¹⁶⁵ G. Cortiana,⁹⁹ G. Costa,^{89a} M. J. Costa,¹⁶⁷ D. Costanzo,¹³⁹ D. Côté,³⁰ L. Courneyea,¹⁶⁹ G. Cowan,⁷⁶ C. Cowden,²⁸ B. E. Cox,⁸² K. Cranmer,¹⁰⁸ F. Crescioli,^{122a,122b} M. Cristinziani,²¹ G. Crosetti,^{37a,37b} S. Crépe-Renaudin,⁵⁵ C.-M. Cuciuc,^{26a} C. Cuenca Almenar,¹⁷⁶ T. Cuhadar Donszelmann,¹³⁹ M. Curatolo,⁴⁷ C. J. Curtis,¹⁸ C. Cuthbert,¹⁵⁰ P. Cwetanski,⁶⁰ H. Czirr,¹⁴¹ P. Czodrowski,⁴⁴ Z. Czyzula,¹⁷⁶ S. D'Auria,⁵³ M. D'Onofrio,⁷³ A. D'Orazio,^{132a,132b} M. J. Da Cunha Sargedas De Sousa,^{124a} C. Da Via,⁸² W. Dabrowski,³⁸ A. Dafinca,¹¹⁸ T. Dai,⁸⁷ C. Dallapiccola,⁸⁴ M. Dam,³⁶ M. Dameri,^{50a,50b} D. S. Damiani,¹³⁷ H. O. Danielsson,³⁰ V. Dao,⁴⁹ G. Darbo,^{50a} G. L. Darlea,^{26b} J. A. Dassoulas,⁴² W. Davey,²¹ T. Davidek,¹²⁶ N. Davidson,⁸⁶ R. Davidson,⁷¹ E. Davies,^{118,d} M. Davies,⁹³ O. Davignon,⁷⁸ A. R. Davison,⁷⁷ Y. Davygora,^{58a} E. Dawe,¹⁴² I. Dawson,¹³⁹ R. K. Daya-Ishmukhametova,²³ K. De,⁸ R. de Asmundis,^{102a} S. De Castro,^{20a,20b} S. De Cecco,⁷⁸ J. de Graat,⁹⁸ N. De Groot,¹⁰⁴ P. de Jong,¹⁰⁵ C. De La Taille,¹¹⁵ H. De la Torre,⁸⁰ F. De Lorenzi,⁶³ L. de Mora,⁷¹ L. De Nooij,¹⁰⁵ D. De Pedis,^{132a} A. De Salvo,^{132a} U. De Sanctis,^{164a,164c} A. De Santo,¹⁴⁹ J. B. De Vivie De Regie,¹¹⁵ G. De Zorzi,^{132a,132b} W. J. Dearnaley,⁷¹ R. Debbe,²⁵ C. Debenedetti,⁴⁶ B. Dechenaux,⁵⁵ D. V. Dedovich,⁶⁴ J. Degenhardt,¹²⁰ C. Del Papa,^{164a,164c} J. Del Peso,⁸⁰ T. Del Prete,^{122a,122b} T. Delemontex,⁵⁵ M. Deliyergiyev,⁷⁴ A. Dell'Acqua,³⁰ L. Dell'Asta,²² M. Della Pietra,^{102a,k} D. della Volpe,^{102a,102b} M. Delmastro,⁵ P. A. Delsart,⁵⁵ C. Deluca,¹⁰⁵ S. Demers,¹⁷⁶ M. Demichev,⁶⁴ B. Demirkoz,^{12,m} J. Deng,¹⁶³ S. P. Denisov,¹²⁸ D. Derendarz,³⁹ J. E. Derkaoui,^{135d} F. Derue,⁷⁸ P. Dervan,⁷³ K. Desch,²¹ E. Devetak,¹⁴⁸ P. O. Deviveiros,¹⁰⁵ A. Dewhurst,¹²⁹ B. DeWilde,¹⁴⁸ S. Dhaliwal,¹⁵⁸ R. Dhullipudi,^{25,n} A. Di Ciaccio,^{133a,133b} L. Di Ciaccio,⁵ A. Di Girolamo,³⁰ B. Di Girolamo,³⁰ S. Di Luise,^{134a,134b} A. Di Mattia,¹⁷³ B. Di Micco,³⁰ R. Di Nardo,⁴⁷ A. Di Simone,^{133a,133b} R. Di Sipio,^{20a,20b} M. A. Diaz,^{32a} E. B. Diehl,⁸⁷ J. Dietrich,⁴² T. A. Dietzsch,^{58a} S. Diglio,⁸⁶ K. Dindar Yagci,⁴⁰ J. Dingfelder,²¹ F. Dinut,^{26a} C. Dionisi,^{132a,132b} P. Dita,^{26a} S. Dita,^{26a} F. Dittus,³⁰ F. Djama,⁸³ T. Djobava,^{51b} M. A. B. do Vale,^{24c} A. Do Valle Wemans,^{124a,o} T. K. O. Doan,⁵ M. Dobbs,⁸⁵ R. Dobinson,^{30,a} D. Dobos,³⁰ E. Dobson,^{30,p} J. Dodd,³⁵ C. Doglioni,⁴⁹ T. Doherty,⁵³ Y. Doi,^{65,a} J. Dolejsi,¹²⁶ I. Dolenc,⁷⁴ Z. Dolezal,¹²⁶ B. A. Dolgoshein,^{96,a} T. Dohmae,¹⁵⁵ M. Donadelli,^{24d} J. Donini,³⁴ J. Dopke,³⁰ A. Doria,^{102a} A. Dos Anjos,¹⁷³ A. Dotti,^{122a,122b} M. T. Dova,⁷⁰ A. D. Doxiadis,¹⁰⁵ A. T. Doyle,⁵³ N. Dressnandt,¹²⁰ M. Dris,¹⁰ J. Dubbert,⁹⁹ S. Dube,¹⁵ E. Duchovni,¹⁷² G. Duckeck,⁹⁸ D. Duda,¹⁷⁵ A. Dudarev,³⁰ F. Dudziak,⁶³ M. Dührssen,³⁰ I. P. Duerdoth,⁸² L. Duflot,¹¹⁵ M-A. Dufour,⁸⁵ L. Duguid,⁷⁶ M. Dunford,^{58a} H. Duran Yildiz,^{4a} R. Duxfield,¹³⁹ M. Dwuznik,³⁸ F. Dydak,³⁰ M. Düren,⁵² W. L. Ebenstein,⁴⁵ J. Ebke,⁹⁸ S. Eckweiler,⁸¹ K. Edmonds,⁸¹ W. Edson,² C. A. Edwards,⁷⁶ N. C. Edwards,⁵³ W. Ehrenfeld,⁴² T. Eifert,¹⁴³ G. Eigen,¹⁴ K. Einsweiler,¹⁵ E. Eisenhandler,⁷⁵ T. Ekelof,¹⁶⁶ M. El Kacimi,^{135c} M. Ellert,¹⁶⁶ S. Elles,⁵ F. Ellinghaus,⁸¹ K. Ellis,⁷⁵ N. Ellis,³⁰ J. Elmsheuser,⁹⁸ M. Elsing,³⁰

- D. Emelianov,¹²⁹ R. Engelmann,¹⁴⁸ A. Engl,⁹⁸ B. Epp,⁶¹ J. Erdmann,⁵⁴ A. Ereditato,¹⁷ D. Eriksson,^{146a} J. Ernst,² M. Ernst,²⁵ J. Ernwein,¹³⁶ D. Errede,¹⁶⁵ S. Errede,¹⁶⁵ E. Ertel,⁸¹ M. Escalier,¹¹⁵ H. Esch,⁴³ C. Escobar,¹²³ X. Espinal Curull,¹² B. Esposito,⁴⁷ F. Etienne,⁸³ A. I. Etievre,¹³⁶ E. Etzion,¹⁵³ D. Evangelakou,⁵⁴ H. Evans,⁶⁰ L. Fabbri,^{20a,20b} C. Fabre,³⁰ R. M. Fakhrutdinov,¹²⁸ S. Falciano,^{132a} Y. Fang,¹⁷³ M. Fanti,^{89a,89b} A. Farbin,⁸ A. Farilla,^{134a} J. Farley,¹⁴⁸ T. Farooque,¹⁵⁸ S. Farrell,¹⁶³ S. M. Farrington,¹⁷⁰ P. Farthouat,³⁰ F. Fassi,¹⁶⁷ P. Fassnacht,³⁰ D. Fassouliotis,⁹ B. Fatholahzadeh,¹⁵⁸ A. Favareto,^{89a,89b} L. Fayard,¹¹⁵ S. Fazio,^{37a,37b} R. Febbraro,³⁴ P. Federic,^{144a} O. L. Fedin,¹²¹ W. Fedorko,⁸⁸ M. Fehling-Kaschek,⁴⁸ L. Feligioni,⁸³ D. Fellmann,⁶ C. Feng,^{33d} E. J. Feng,⁶ A. B. Fenyuk,¹²⁸ J. Ferencei,^{144b} W. Fernando,⁶ S. Ferrag,⁵³ J. Ferrando,⁵³ V. Ferrara,⁴² A. Ferrari,¹⁶⁶ P. Ferrari,¹⁰⁵ R. Ferrari,^{119a} D. E. Ferreira de Lima,⁵³ A. Ferrer,¹⁶⁷ D. Ferrere,⁴⁹ C. Ferretti,⁸⁷ A. Ferretto Parodi,^{50a,50b} M. Fiascaris,³¹ F. Fiedler,⁸¹ A. Filipič,⁷⁴ F. Filthaut,¹⁰⁴ M. Fincke-Keeler,¹⁶⁹ M. C. N. Fiolhais,^{124a,i} L. Fiorini,¹⁶⁷ A. Firan,⁴⁰ G. Fischer,⁴² M. J. Fisher,¹⁰⁹ M. Flechl,⁴⁸ I. Fleck,¹⁴¹ J. Fleckner,⁸¹ P. Fleischmann,¹⁷⁴ S. Fleischmann,¹⁷⁵ T. Flick,¹⁷⁵ A. Floderus,⁷⁹ L. R. Flores Castillo,¹⁷³ M. J. Flowerdew,⁹⁹ T. Fonseca Martin,¹⁷ A. Formica,¹³⁶ A. Forti,⁸² D. Fortin,^{159a} D. Fournier,¹¹⁵ A. J. Fowler,⁴⁵ H. Fox,⁷¹ P. Francavilla,¹² M. Franchini,^{20a,20b} S. Franchino,^{119a,119b} D. Francis,³⁰ T. Frank,¹⁷² M. Franklin,⁵⁷ S. Franz,³⁰ M. Fraternali,^{119a,119b} S. Fratina,¹²⁰ S. T. French,²⁸ C. Friedrich,⁴² F. Friedrich,⁴⁴ R. Froeschl,³⁰ D. Froidevaux,³⁰ J. A. Frost,²⁸ C. Fukunaga,¹⁵⁶ E. Fullana Torregrosa,³⁰ B. G. Fulsom,¹⁴³ J. Fuster,¹⁶⁷ C. Gabaldon,³⁰ O. Gabizon,¹⁷² T. Gadfort,²⁵ S. Gadomski,⁴⁹ G. Gagliardi,^{50a,50b} P. Gagnon,⁶⁰ C. Galea,⁹⁸ B. Galhardo,^{124a} E. J. Gallas,¹¹⁸ V. Gallo,¹⁷ B. J. Gallop,¹²⁹ P. Gallus,¹²⁵ K. K. Gan,¹⁰⁹ Y. S. Gao,^{143,f} A. Gaponenko,¹⁵ F. Garberson,¹⁷⁶ M. Garcia-Sciveres,¹⁵ C. García,¹⁶⁷ J. E. García Navarro,¹⁶⁷ R. W. Gardner,³¹ N. Garelli,³⁰ H. Garitaonandia,¹⁰⁵ V. Garonne,³⁰ C. Gatti,⁴⁷ G. Gaudio,^{119a} B. Gaur,¹⁴¹ L. Gauthier,¹³⁶ P. Gauzzi,^{132a,132b} I. L. Gavrilenko,⁹⁴ C. Gay,¹⁶⁸ G. Gaycken,²¹ E. N. Gazis,¹⁰ P. Ge,^{33d} Z. Gecse,¹⁶⁸ C. N. P. Gee,¹²⁹ D. A. A. Geerts,¹⁰⁵ Ch. Geich-Gimbel,²¹ K. Gellerstedt,^{146a,146b} C. Gemme,^{50a} A. Gemmell,⁵³ M. H. Genest,⁵⁵ S. Gentile,^{132a,132b} M. George,⁵⁴ S. George,⁷⁶ P. Gerlach,¹⁷⁵ A. Gershon,¹⁵³ C. Geweniger,^{58a} H. Ghazlane,^{135b} N. Ghodbane,³⁴ B. Giacobbe,^{20a} S. Giagu,^{132a,132b} V. Giakoumopoulou,⁹ V. Giangiobbe,¹² F. Gianotti,³⁰ B. Gibbard,²⁵ A. Gibson,¹⁵⁸ S. M. Gibson,³⁰ D. Gillberg,²⁹ A. R. Gillman,¹²⁹ D. M. Gingrich,^{3,e} J. Ginzburg,¹⁵³ N. Giokaris,⁹ M. P. Giordani,^{164c} R. Giordano,^{102a,102b} F. M. Giorgi,¹⁶ P. Giovannini,⁹⁹ P. F. Giraud,¹³⁶ D. Giugni,^{89a} M. Giunta,⁹³ P. Giusti,^{20a} B. K. Gjelsten,¹¹⁷ L. K. Gladilin,⁹⁷ C. Glasman,⁸⁰ J. Glatzer,²¹ A. Glazov,⁴² K. W. Glitza,¹⁷⁵ G. L. Glonti,⁶⁴ J. R. Goddard,⁷⁵ J. Godfrey,¹⁴² J. Godlewski,³⁰ M. Goebel,⁴² T. Göpfert,⁴⁴ C. Goeringer,⁸¹ C. Gössling,⁴³ S. Goldfarb,⁸⁷ T. Golling,¹⁷⁶ A. Gomes,^{124a,c} L. S. Gomez Fajardo,⁴² R. Gonçalves,⁷⁶ J. Goncalves Pinto Firmino Da Costa,⁴² L. Gonella,²¹ S. González de la Hoz,¹⁶⁷ G. Gonzalez Parra,¹² M. L. Gonzalez Silva,²⁷ S. Gonzalez-Sevilla,⁴⁹ J. J. Goodson,¹⁴⁸ L. Goossens,³⁰ P. A. Gorbounov,⁹⁵ H. A. Gordon,²⁵ I. Gorelov,¹⁰³ G. Gorfine,¹⁷⁵ B. Gorini,³⁰ E. Gorini,^{72a,72b} A. Gorišek,⁷⁴ E. Gornicki,³⁹ B. Gosdzik,⁴² A. T. Goshaw,⁶ M. Gosselink,¹⁰⁵ M. I. Gostkin,⁶⁴ I. Gough Eschrich,¹⁶³ M. Gouighri,^{135a} D. Goujdami,^{135c} M. P. Goulette,⁴⁹ A. G. Goussiou,¹³⁸ C. Goy,⁵ S. Gozpinar,²³ I. Grabowska-Bold,³⁸ P. Grafström,^{20a,20b} K.-J. Grahn,⁴² E. Gramstad,¹¹⁷ F. Grancagnolo,^{72a} S. Grancagnolo,¹⁶ V. Grassi,¹⁴⁸ V. Gratchev,¹²¹ N. Grau,³⁵ H. M. Gray,³⁰ J. A. Gray,¹⁴⁸ E. Graziani,^{134a} O. G. Grebenyuk,¹²¹ T. Greenshaw,⁷³ Z. D. Greenwood,^{25,n} K. Gregersen,³⁶ I. M. Gregor,⁴² P. Grenier,¹⁴³ J. Griffiths,⁸ N. Grigalashvili,⁶⁴ A. A. Grillo,¹³⁷ S. Grinstein,¹² Ph. Gris,³⁴ Y. V. Grishkevich,⁹⁷ J.-F. Grivaz,¹¹⁵ E. Gross,¹⁷² J. Grosse-Knetter,⁵⁴ J. Groth-Jensen,¹⁷² K. Grybel,¹⁴¹ D. Guest,¹⁷⁶ C. Guicheney,³⁴ S. Guindon,⁵⁴ U. Gul,⁵³ J. Gunther,¹²⁵ B. Guo,¹⁵⁸ J. Guo,³⁵ P. Gutierrez,¹¹¹ N. Guttman,¹⁵³ O. Gutzwiller,¹⁷³ C. Guyot,¹³⁶ C. Gwenlan,¹¹⁸ C. B. Gwilliam,⁷³ A. Haas,¹⁴³ S. Haas,³⁰ C. Haber,¹⁵ H. K. Hadavand,⁴⁰ D. R. Hadley,¹⁸ P. Haefner,²¹ F. Hahn,³⁰ S. Haider,³⁰ Z. Hajduk,³⁹ H. Hakobyan,¹⁷⁷ D. Hall,¹¹⁸ K. Hamacher,¹⁷⁵ P. Hamal,¹¹³ M. Hamer,⁵⁴ A. Hamilton,^{145b,q} S. Hamilton,¹⁶¹ L. Han,^{33b} K. Hanagaki,¹¹⁶ K. Hanawa,¹⁶⁰ M. Hance,¹⁵ C. Handel,⁸¹ P. Hanke,^{58a} J. R. Hansen,³⁶ J. B. Hansen,³⁶ J. D. Hansen,³⁶ P. H. Hansen,³⁶ P. Hansson,¹⁴³ K. Hara,¹⁶⁰ G. A. Hare,¹³⁷ T. Harenberg,¹⁷⁵ S. Harkusha,⁹⁰ D. Harper,⁸⁷ R. D. Harrington,⁴⁶ O. M. Harris,¹³⁸ J. Hartert,⁴⁸ F. Hartjes,¹⁰⁵ T. Haruyama,⁶⁵ A. Harvey,⁵⁶ S. Hasegawa,¹⁰¹ Y. Hasegawa,¹⁴⁰ S. Hassani,¹³⁶ S. Haug,¹⁷ M. Hauschild,³⁰ R. Hauser,⁸⁸ M. Havranek,²¹ C. M. Hawkes,¹⁸ R. J. Hawkins,³⁰ A. D. Hawkins,⁷⁹ T. Hayakawa,⁶⁶ T. Hayashi,¹⁶⁰ D. Hayden,⁷⁶ C. P. Hays,¹¹⁸ H. S. Hayward,⁷³ S. J. Hayward,¹²⁹ S. J. Head,¹⁸ V. Hedberg,⁷⁹ L. Heelan,⁸ S. Heim,⁸⁸ B. Heinemann,¹⁵ S. Heisterkamp,³⁶ L. Helary,²² C. Heller,⁹⁸ M. Heller,³⁰ S. Hellman,^{146a,146b} D. Hellmich,²¹ C. Hensens,¹² R. C. W. Henderson,⁷¹ M. Henke,^{58a} A. Henrichs,⁵⁴ A. M. Henriques Correia,³⁰ S. Henrot-Versille,¹¹⁵ C. Hensel,⁵⁴ T. Henß,¹⁷⁵ C. M. Hernandez,⁸ Y. Hernández Jiménez,¹⁶⁷ R. Herrberg,¹⁶ G. Herten,⁴⁸ R. Hertenberger,⁹⁸ L. Hervas,³⁰ G. G. Hesketh,⁷⁷ N. P. Hessey,¹⁰⁵ E. Higón-Rodríguez,¹⁶⁷ J. C. Hill,²⁸ K. H. Hiller,⁴² S. Hillert,²¹

S. J. Hillier,¹⁸ I. Hinchliffe,¹⁵ E. Hines,¹²⁰ M. Hirose,¹¹⁶ F. Hirsch,⁴³ D. Hirschbuehl,¹⁷⁵ J. Hobbs,¹⁴⁸ N. Hod,¹⁵³ M. C. Hodgkinson,¹³⁹ P. Hodgson,¹³⁹ A. Hoecker,³⁰ M. R. Hoferkamp,¹⁰³ J. Hoffman,⁴⁰ D. Hoffmann,⁸³ M. Hohlfield,⁸¹ M. Holder,¹⁴¹ S. O. Holmgren,^{146a} T. Holy,¹²⁷ J. L. Holzbauer,⁸⁸ T. M. Hong,¹²⁰ L. Hooft van Huysduynen,¹⁰⁸ S. Horner,⁴⁸ J.-Y. Hostachy,⁵⁵ S. Hou,¹⁵¹ A. Hoummada,^{135a} J. Howard,¹¹⁸ J. Howarth,⁸² I. Hristova,¹⁶ J. Hrivnac,¹¹⁵ T. Hryn'ova,⁵ P. J. Hsu,⁸¹ S.-C. Hsu,¹⁵ D. Hu,³⁵ Z. Hubacek,¹²⁷ F. Hubaut,⁸³ F. Huegging,²¹ A. Huettmann,⁴² T. B. Huffman,¹¹⁸ E. W. Hughes,³⁵ G. Hughes,⁷¹ M. Huhtinen,³⁰ M. Hurwitz,¹⁵ N. Huseynov,^{64,r} J. Huston,⁸⁸ J. Huth,⁵⁷ G. Iacobucci,⁴⁹ G. Iakovidis,¹⁰ M. Ibbotson,⁸² I. Ibragimov,¹⁴¹ L. Iconomidou-Fayard,¹¹⁵ J. Idarraga,¹¹⁵ P. Inengo,^{102a} O. Igonkina,¹⁰⁵ Y. Ikegami,⁶⁵ M. Ikeno,⁶⁵ D. Iliadis,¹⁵⁴ N. Ilic,¹⁵⁸ T. Ince,⁹⁹ J. Inigo-Golfin,³⁰ P. Ioannou,⁹ M. Iodice,^{134a} K. Iordanidou,⁹ V. Ippolito,^{132a,132b} A. Irlles Quiles,¹⁶⁷ C. Isaksson,¹⁶⁶ M. Ishino,⁶⁷ M. Ishitsuka,¹⁵⁷ R. Ishmukhametov,¹⁰⁹ C. Issever,¹¹⁸ S. Istin,^{19a} A. V. Ivashin,¹²⁸ W. Iwanski,³⁹ H. Iwasaki,⁶⁵ J. M. Izen,⁴¹ V. Izzo,^{102a} B. Jackson,¹²⁰ J. N. Jackson,⁷³ P. Jackson,¹ M. R. Jaekel,³⁰ V. Jain,⁶⁰ K. Jakobs,⁴⁸ S. Jakobsen,³⁶ T. Jakoubek,¹²⁵ J. Jakubek,¹²⁷ D. O. Jamin,¹⁵¹ D. K. Jana,¹¹¹ E. Jansen,⁷⁷ H. Jansen,³⁰ A. Jantsch,⁹⁹ M. Janus,⁴⁸ G. Jarlskog,⁷⁹ L. Jeanty,⁵⁷ I. Jen-La Plante,³¹ D. Jennens,⁸⁶ P. Jenni,³⁰ A. E. Loevschall-Jensen,³⁶ P. Jež,³⁶ S. Jézéquel,⁵ M. K. Jha,^{20a} H. Ji,¹⁷³ W. Ji,⁸¹ J. Jia,¹⁴⁸ Y. Jiang,^{33b} M. Jimenez Belenguer,⁴² S. Jin,^{33a} O. Jinnouchi,¹⁵⁷ M. D. Joergensen,³⁶ D. Joffe,⁴⁰ M. Johansen,^{146a,146b} K. E. Johansson,^{146a} P. Johansson,¹³⁹ S. Johnert,⁴² K. A. Johns,⁷ K. Jon-And,^{146a,146b} G. Jones,¹⁷⁰ R. W. L. Jones,⁷¹ T. J. Jones,⁷³ C. Joram,³⁰ P. M. Jorge,^{124a} K. D. Joshi,⁸² J. Jovicevic,¹⁴⁷ T. Jovin,^{13b} X. Ju,¹⁷³ C. A. Jung,⁴³ R. M. Jungst,³⁰ V. Juraneck,¹²⁵ P. Jussel,⁶¹ A. Juste Rozas,¹² S. Kabana,¹⁷ M. Kaci,¹⁶⁷ A. Kaczmarska,³⁹ P. Kadlecik,³⁶ M. Kado,¹¹⁵ H. Kagan,¹⁰⁹ M. Kagan,⁵⁷ E. Kajomovitz,¹⁵² S. Kalinin,¹⁷⁵ L. V. Kalinovskaya,⁶⁴ S. Kama,⁴⁰ N. Kanaya,¹⁵⁵ M. Kaneda,³⁰ S. Kaneti,²⁸ T. Kanno,¹⁵⁷ V. A. Kantserov,⁹⁶ J. Kanzaki,⁶⁵ B. Kaplan,¹⁰⁸ A. Kapliy,³¹ J. Kaplon,³⁰ D. Kar,⁵³ M. Karagounis,²¹ K. Karakostas,¹⁰ M. Karnevskiy,⁴² V. Kartvelishvili,⁷¹ A. N. Karyukhin,¹²⁸ L. Kashif,¹⁷³ G. Kasieczka,^{58b} R. D. Kass,¹⁰⁹ A. Kastanas,¹⁴ M. Kataoka,⁵ Y. Kataoka,¹⁵⁵ E. Katsoufis,¹⁰ J. Katzy,⁴² V. Kaushik,⁷ K. Kawagoe,⁶⁹ T. Kawamoto,¹⁵⁵ G. Kawamura,⁸¹ M. S. Kayl,¹⁰⁵ S. Kazama,¹⁵⁵ V. A. Kazanin,¹⁰⁷ M. Y. Kazarinov,⁶⁴ R. Keeler,¹⁶⁹ P. T. Keener,¹²⁰ R. Kehoe,⁴⁰ M. Keil,⁵⁴ G. D. Kekelidze,⁶⁴ J. S. Keller,¹³⁸ M. Kenyon,⁵³ O. Kepka,¹²⁵ N. Kerschen,³⁰ B. P. Kerševan,⁷⁴ S. Kersten,¹⁷⁵ K. Kessoku,¹⁵⁵ J. Keung,¹⁵⁸ F. Khalil-zada,¹¹ H. Khandanyan,^{146a,146b} A. Khanov,¹¹² D. Kharchenko,⁶⁴ A. Khodinov,⁹⁶ A. Khomich,^{58a} T. J. Khoo,²⁸ G. Khoriauli,²¹ A. Khoroshilov,¹⁷⁵ V. Khovanskiy,⁹⁵ E. Khramov,⁶⁴ J. Khubua,^{51b} H. Kim,^{146a,146b} S. H. Kim,¹⁶⁰ N. Kimura,¹⁷¹ O. Kind,¹⁶ B. T. King,⁷³ M. King,⁶⁶ R. S. B. King,¹¹⁸ J. Kirk,¹²⁹ A. E. Kiryunin,⁹⁹ T. Kishimoto,⁶⁶ D. Kisielewska,³⁸ T. Kitamura,⁶⁶ T. Kittelmann,¹²³ K. Kiuchi,¹⁶⁰ E. Kladiva,^{144b} M. Klein,⁷³ U. Klein,⁷³ K. Kleinknecht,⁸¹ M. Klemetti,⁸⁵ A. Klier,¹⁷² P. Klimek,^{146a,146b} A. Klimentov,²⁵ R. Klingenberg,⁴³ J. A. Klinger,⁸² E. B. Klinkby,³⁶ T. Klioutchnikova,³⁰ P. F. Klok,¹⁰⁴ S. Klous,¹⁰⁵ E.-E. Kluge,^{58a} T. Kluge,⁷³ P. Kluit,¹⁰⁵ S. Kluth,⁹⁹ E. Kneringer,⁶¹ E. B. F. G. Knoops,⁸³ A. Knue,⁵⁴ B. R. Ko,⁴⁵ T. Kobayashi,¹⁵⁵ M. Kobel,⁴⁴ M. Kocian,¹⁴³ P. Kodys,¹²⁶ K. Köneke,³⁰ A. C. König,¹⁰⁴ S. Koenig,⁸¹ L. Köpke,⁸¹ F. Koetsveld,¹⁰⁴ P. Koevesarki,²¹ T. Koffas,²⁹ E. Koffeman,¹⁰⁵ L. A. Kogan,¹¹⁸ S. Kohlmann,¹⁷⁵ F. Kohn,⁵⁴ Z. Kohout,¹²⁷ T. Kohriki,⁶⁵ T. Koi,¹⁴³ G. M. Kolachev,^{107,a} H. Kolanoski,¹⁶ V. Kolesnikov,⁶⁴ I. Koletsou,^{89a} J. Koll,⁸⁸ A. A. Komar,⁹⁴ Y. Komori,¹⁵⁵ T. Kondo,⁶⁵ T. Kono,^{42,s} A. I. Kononov,⁴⁸ R. Konoplich,^{108,t} N. Konstantinidis,⁷⁷ R. Kopeliansky,¹⁵² S. Koperny,³⁸ K. Korcyl,³⁹ K. Kordas,¹⁵⁴ A. Korn,¹¹⁸ A. Korol,¹⁰⁷ I. Korolkov,¹² E. V. Korolkova,¹³⁹ V. A. Korotkov,¹²⁸ O. Kortner,⁹⁹ S. Kortner,⁹⁹ V. V. Kostyukhin,²¹ S. Kotov,⁹⁹ V. M. Kotov,⁶⁴ A. Kotwal,⁴⁵ C. Kourkouvelis,⁹ V. Kouskoura,¹⁵⁴ A. Koutsman,^{159a} R. Kowalewski,¹⁶⁹ T. Z. Kowalski,³⁸ W. Kozanecki,¹³⁶ A. S. Kozhin,¹²⁸ V. Kral,¹²⁷ V. A. Kramarenko,⁹⁷ G. Kramberger,⁷⁴ M. W. Krasny,⁷⁸ A. Krasznahorkay,¹⁰⁸ J. K. Kraus,²¹ S. Kreiss,¹⁰⁸ F. Krejci,¹²⁷ J. Kretschmar,⁷³ N. Krieger,⁵⁴ P. Krieger,¹⁵⁸ K. Kroeninger,⁵⁴ H. Kroha,⁹⁹ J. Kroll,¹²⁰ J. Kroseberg,²¹ J. Krstic,^{13a} U. Kruchonak,⁶⁴ H. Krüger,²¹ T. Kruker,¹⁷ N. Krumnack,⁶³ Z. V. Krumshteyn,⁶⁴ T. Kubota,⁸⁶ S. Kuday,^{4a} S. Kuehn,⁴⁸ A. Kugel,^{58c} T. Kuhl,⁴² D. Kuhn,⁶¹ V. Kukhtin,⁶⁴ Y. Kulchitsky,⁹⁰ S. Kuleshov,^{32b} C. Kummer,⁹⁸ M. Kuna,⁷⁸ J. Kunkle,¹²⁰ A. Kupco,¹²⁵ H. Kurashige,⁶⁶ M. Kurata,¹⁶⁰ Y. A. Kurochkin,⁹⁰ V. Kus,¹²⁵ E. S. Kuwertz,¹⁴⁷ M. Kuze,¹⁵⁷ J. Kvita,¹⁴² R. Kwee,¹⁶ A. La Rosa,⁴⁹ L. La Rotonda,^{37a,37b} L. Labarga,⁸⁰ J. Labbe,⁵ S. Lablak,^{135a} C. Lacasta,¹⁶⁷ F. Lacava,^{132a,132b} J. Lacey,²⁹ H. Lacker,¹⁶ D. Lacour,⁷⁸ V. R. Lacuesta,¹⁶⁷ E. Ladygin,⁶⁴ R. Lafaye,⁵ B. Laforge,⁷⁸ T. Lagouri,¹⁷⁶ S. Lai,⁴⁸ E. Laisne,⁵⁵ M. Lamanna,³⁰ L. Lambourne,⁷⁷ C. L. Lampen,⁷ W. Lampl,⁷ E. Lancon,¹³⁶ U. Landgraf,⁴⁸ M. P. J. Landon,⁷⁵ V. S. Lang,^{58a} C. Lange,⁴² A. J. Lankford,¹⁶³ F. Lanni,²⁵ K. Lantzsck,¹⁷⁵ S. Laplace,⁷⁸ C. Lapoire,²¹ J. F. Laporte,¹³⁶ T. Lari,^{89a} A. Larner,¹¹⁸ M. Lassnig,³⁰ P. Laurelli,⁴⁷ V. Lavorini,^{37a,37b} W. Lavrijsen,¹⁵ P. Laycock,⁷³ O. Le Dortz,⁷⁸ E. Le Guirriec,⁸³ E. Le Menedeu,¹² T. LeCompte,⁶ F. Ledroit-Guillon,⁵⁵ H. Lee,¹⁰⁵

J. S. H. Lee,¹¹⁶ S. C. Lee,¹⁵¹ L. Lee,¹⁷⁶ M. Lefebvre,¹⁶⁹ M. Legendre,¹³⁶ F. Legger,⁹⁸ C. Leggett,¹⁵ M. Lehmacher,²¹
 G. Lehmann Miotto,³⁰ M. A. L. Leite,^{24d} R. Leitner,¹²⁶ D. Lellouch,¹⁷² B. Lemmer,⁵⁴ V. Lendermann,^{58a}
 K. J. C. Leney,^{145b} T. Lenz,¹⁰⁵ G. Lenzen,¹⁷⁵ B. Lenzi,³⁰ K. Leonhardt,⁴⁴ S. Leontsinis,¹⁰ F. Lepold,^{58a} C. Leroy,⁹³
 J.-R. Lessard,¹⁶⁹ C. G. Lester,²⁸ C. M. Lester,¹²⁰ J. Levêque,⁵ D. Levin,⁸⁷ L. J. Levinson,¹⁷² A. Lewis,¹¹⁸
 G. H. Lewis,¹⁰⁸ A. M. Leyko,²¹ M. Leyton,¹⁶ B. Li,⁸³ H. Li,¹⁴⁸ H. L. Li,³¹ S. Li,^{33b,u} X. Li,⁸⁷ Z. Liang,^{118,v} H. Liao,³⁴
 B. Liberti,^{133a} P. Lichard,³⁰ M. Lichtnecker,⁹⁸ K. Lie,¹⁶⁵ W. Liebig,¹⁴ C. Limbach,²¹ A. Limosani,⁸⁶ M. Limper,⁶²
 S. C. Lin,^{151,w} F. Linde,¹⁰⁵ J. T. Linnemann,⁸⁸ E. Lipeles,¹²⁰ A. Lipniacka,¹⁴ T. M. Liss,¹⁶⁵ D. Lissauer,²⁵ A. Lister,⁴⁹
 A. M. Litke,¹³⁷ C. Liu,²⁹ D. Liu,¹⁵¹ H. Liu,⁸⁷ J. B. Liu,⁸⁷ L. Liu,⁸⁷ M. Liu,^{33b} Y. Liu,^{33b} M. Livan,^{119a,119b}
 S. S. A. Livermore,¹¹⁸ A. Lleres,⁵⁵ J. Llorente Merino,⁸⁰ S. L. Lloyd,⁷⁵ E. Lobodzinska,⁴² P. Loch,⁷
 W. S. Lockman,¹³⁷ T. Loddenkoetter,²¹ F. K. Loebinger,⁸² A. Loginov,¹⁷⁶ C. W. Loh,¹⁶⁸ T. Lohse,¹⁶ K. Lohwasser,⁴⁸
 M. Lokajicek,¹²⁵ V. P. Lombardo,⁵ R. E. Long,⁷¹ L. Lopes,^{124a} D. Lopez Mateos,⁵⁷ J. Lorenz,⁹⁸
 N. Lorenzo Martinez,¹¹⁵ M. Losada,¹⁶² P. Loscutoff,¹⁵ F. Lo Sterzo,^{132a,132b} M. J. Losty,^{159a,a} X. Lou,⁴¹ A. Lounis,¹¹⁵
 K. F. Loureiro,¹⁶² J. Love,⁶ P. A. Love,⁷¹ A. J. Lowe,^{143,f} F. Lu,^{33a} H. J. Lubatti,¹³⁸ C. Luci,^{132a,132b} A. Lucotte,⁵⁵
 A. Ludwig,⁴⁴ D. Ludwig,⁴² I. Ludwig,⁴⁸ J. Ludwig,⁴⁸ F. Luehring,⁶⁰ G. Luijckx,¹⁰⁵ W. Lukas,⁶¹ L. Luminari,^{132a}
 E. Lund,¹¹⁷ B. Lund-Jensen,¹⁴⁷ B. Lundberg,⁷⁹ J. Lundberg,^{146a,146b} O. Lundberg,^{146a,146b} J. Lundquist,³⁶
 M. Lungwitz,⁸¹ D. Lynn,²⁵ E. Lytken,⁷⁹ H. Ma,²⁵ L. L. Ma,¹⁷³ G. Maccarrone,⁴⁷ A. Macchiolo,⁹⁹ B. Maček,⁷⁴
 J. Machado Miguens,^{124a} R. Mackeprang,³⁶ R. J. Madaras,¹⁵ H. J. Maddocks,⁷¹ W. F. Mader,⁴⁴ R. Maenner,^{58c}
 T. Maeno,²⁵ P. Mättig,¹⁷⁵ S. Mättig,⁸¹ L. Magnoni,¹⁶³ E. Magradze,⁵⁴ K. Mahboubi,⁴⁸ J. Mahlstedt,¹⁰⁵
 S. Mahmoud,⁷³ G. Mahout,¹⁸ C. Maiani,¹³⁶ C. Maidantchik,^{24a} A. Maio,^{124a,c} S. Majewski,²⁵ Y. Makida,⁶⁵
 N. Makovec,¹¹⁵ P. Mal,¹³⁶ B. Malaescu,³⁰ Pa. Malecki,³⁹ P. Malecki,³⁹ V. P. Maleev,¹²¹ F. Malek,⁵⁵ U. Mallik,⁶²
 D. Malon,⁶ C. Malone,¹⁴³ S. Maltezos,¹⁰ V. Malyshev,¹⁰⁷ S. Malyukov,³⁰ R. Mameghani,⁹⁸ J. Mamuzic,^{13b}
 A. Manabe,⁶⁵ L. Mandelli,^{89a} I. Mandić,⁷⁴ R. Mandrysch,¹⁶ J. Maneira,^{124a} A. Manfredini,⁹⁹ P. S. Mangeard,⁸⁸
 L. Manhaes de Andrade Filho,^{24b} J. A. Manjarres Ramos,¹³⁶ A. Mann,⁵⁴ P. M. Manning,¹³⁷
 A. Manousakis-Katsikakis,⁹ B. Mansoulie,¹³⁶ A. Mapelli,³⁰ L. Mapelli,³⁰ L. March,¹⁶⁷ J. F. Marchand,²⁹
 F. Marchese,^{133a,133b} G. Marchiori,⁷⁸ M. Marcisovsky,¹²⁵ C. P. Marino,¹⁶⁹ F. Marroquim,^{24a} Z. Marshall,³⁰
 F. K. Martens,¹⁵⁸ L. F. Marti,¹⁷ S. Marti-Garcia,¹⁶⁷ B. Martin,³⁰ B. Martin,⁸⁸ J. P. Martin,⁹³ T. A. Martin,¹⁸
 V. J. Martin,⁴⁶ B. Martin dit Latour,⁴⁹ S. Martin-Haugh,¹⁴⁹ M. Martinez,¹² V. Martinez Outschoorn,⁵⁷
 A. C. Martyniuk,¹⁶⁹ M. Marx,⁸² F. Marzano,^{132a} A. Marzin,¹¹¹ L. Masetti,⁸¹ T. Mashimo,¹⁵⁵ R. Mashinistov,⁹⁴
 J. Masik,⁸² A. L. Maslennikov,¹⁰⁷ I. Massa,^{20a,20b} G. Massaro,¹⁰⁵ N. Massol,⁵ P. Mastrandrea,¹⁴⁸
 A. Mastroberardino,^{37a,37b} T. Masubuchi,¹⁵⁵ P. Matricon,¹¹⁵ H. Matsunaga,¹⁵⁵ T. Matsushita,⁶⁶ C. Mattravers,^{118,d}
 J. Maurer,⁸³ S. J. Maxfield,⁷³ A. Mayne,¹³⁹ R. Mazini,¹⁵¹ M. Mazur,²¹ L. Mazzaferro,^{133a,133b} M. Mazzanti,^{89a}
 J. Mc Donald,⁸⁵ S. P. Mc Kee,⁸⁷ A. McCarn,¹⁶⁵ R. L. McCarthy,¹⁴⁸ T. G. McCarthy,²⁹ N. A. McCubbin,¹²⁹
 K. W. McFarlane,^{56,a} J. A. Mcfayden,¹³⁹ G. Mchedlidze,^{51b} T. McLaughlan,¹⁸ S. J. McMahon,¹²⁹
 R. A. McPherson,^{169,l} A. Meade,⁸⁴ J. Mechnich,¹⁰⁵ M. Mechtel,¹⁷⁵ M. Medinnis,⁴² R. Meera-Lebbai,¹¹¹
 T. Meguro,¹¹⁶ R. Mehdiyev,⁹³ S. Mehlhase,³⁶ A. Mehta,⁷³ K. Meier,^{58a} B. Meirose,⁷⁹ C. Melachrinou,³¹
 B. R. Mellado Garcia,¹⁷³ F. Meloni,^{89a,89b} L. Mendoza Navas,¹⁶² Z. Meng,^{151,x} A. Mengarelli,^{20a,20b} S. Menke,⁹⁹
 E. Meoni,¹⁶¹ K. M. Mercurio,⁵⁷ P. Mermod,⁴⁹ L. Merola,^{102a,102b} C. Meroni,^{89a} F. S. Merritt,³¹ H. Merritt,¹⁰⁹
 A. Messina,^{30,y} J. Metcalfe,²⁵ A. S. Mete,¹⁶³ C. Meyer,⁸¹ C. Meyer,³¹ J.-P. Meyer,¹³⁶ J. Meyer,¹⁷⁴ J. Meyer,⁵⁴
 T. C. Meyer,³⁰ S. Michal,³⁰ L. Micu,^{26a} R. P. Middleton,¹²⁹ S. Migas,⁷³ L. Mijović,¹³⁶ G. Mikenberg,¹⁷²
 M. Mkestikova,¹²⁵ M. Mikuž,⁷⁴ D. W. Miller,³¹ R. J. Miller,⁸⁸ W. J. Mills,¹⁶⁸ C. Mills,⁵⁷ A. Milov,¹⁷²
 D. A. Milstead,^{146a,146b} D. Milstein,¹⁷² A. A. Minaenko,¹²⁸ M. Miñano Moya,¹⁶⁷ I. A. Minashvili,⁶⁴ A. I. Mincer,¹⁰⁸
 B. Mindur,³⁸ M. Mineev,⁶⁴ Y. Ming,¹⁷³ L. M. Mir,¹² G. Mirabelli,^{132a} J. Mitrevski,¹³⁷ V. A. Mitsou,¹⁶⁷ S. Mitsui,⁶⁵
 P. S. Miyagawa,¹³⁹ J. U. Mjörnmark,⁷⁹ T. Moa,^{146a,146b} V. Moeller,²⁸ K. Mönig,⁴² N. Möser,²¹ S. Mohapatra,¹⁴⁸
 W. Mohr,⁴⁸ R. Moles-Valls,¹⁶⁷ A. Molfetas,³⁰ J. Monk,⁷⁷ E. Monnier,⁸³ J. Montejo Berlingen,¹² F. Monticelli,⁷⁰
 S. Monzani,^{20a,20b} R. W. Moore,³ G. F. Moorhead,⁸⁶ C. Mora Herrera,⁴⁹ A. Moraes,⁵³ N. Morange,¹³⁶ J. Morel,⁵⁴
 G. Morello,^{37a,37b} D. Moreno,⁸¹ M. Moreno Llácer,¹⁶⁷ P. Morettini,^{50a} M. Morgenstern,⁴⁴ M. Morii,⁵⁷
 A. K. Morley,³⁰ G. Mornacchi,³⁰ J. D. Morris,⁷⁵ L. Morvaj,¹⁰¹ H. G. Moser,⁹⁹ M. Mosidze,^{51b} J. Moss,¹⁰⁹
 R. Mount,¹⁴³ E. Mountricha,^{10,z} S. V. Mouraviev,^{94,a} E. J. W. Moyses,⁸⁴ F. Mueller,^{58a} J. Mueller,¹²³ K. Mueller,²¹
 T. A. Müller,⁹⁸ T. Mueller,⁸¹ D. Muenstermann,³⁰ Y. Munwes,¹⁵³ W. J. Murray,¹²⁹ I. Mussche,¹⁰⁵ E. Musto,^{102a,102b}
 A. G. Myagkov,¹²⁸ M. Myska,¹²⁵ O. Nackenhurst,⁵⁴ J. Nadal,¹² K. Nagai,¹⁶⁰ R. Nagai,¹⁵⁷ K. Nagano,⁶⁵
 A. Nagarkar,¹⁰⁹ Y. Nagasaka,⁵⁹ M. Nagel,⁹⁹ A. M. Nairz,³⁰ Y. Nakahama,³⁰ K. Nakamura,¹⁵⁵ T. Nakamura,¹⁵⁵

- I. Nakano,¹¹⁰ G. Nanava,²¹ A. Napier,¹⁶¹ R. Narayan,^{58b} M. Nash,^{77,d} T. Nattermann,²¹ T. Naumann,⁴²
 G. Navarro,¹⁶² H. A. Neal,⁸⁷ P. Yu. Nechaeva,⁹⁴ T. J. Neep,⁸² A. Negri,^{119a,119b} G. Negri,³⁰ M. Negrini,^{20a}
 S. Nektarijevic,⁴⁹ A. Nelson,¹⁶³ T. K. Nelson,¹⁴³ S. Nemecek,¹²⁵ P. Nemethy,¹⁰⁸ A. A. Nepomuceno,^{24a}
 M. Nessi,^{30,aa} M. S. Neubauer,¹⁶⁵ M. Neumann,¹⁷⁵ A. Neusiedl,⁸¹ R. M. Neves,¹⁰⁸ P. Nevski,²⁵ F. M. Newcomer,¹²⁰
 P. R. Newman,¹⁸ V. Nguyen Thi Hong,¹³⁶ R. B. Nickerson,¹¹⁸ R. Nicolaidou,¹³⁶ B. Nicquevert,³⁰ F. Niedercorn,¹¹⁵
 J. Nielsen,¹³⁷ N. Nikiforou,³⁵ A. Nikiforov,¹⁶ V. Nikolaenko,¹²⁸ I. Nikolic-Audit,⁷⁸ K. Nikolics,⁴⁹
 K. Nikolopoulos,¹⁸ H. Nilsen,⁴⁸ P. Nilsson,⁸ Y. Ninomiya,¹⁵⁵ A. Nisati,^{132a} R. Nisius,⁹⁹ T. Nobe,¹⁵⁷ L. Nodulman,⁶
 M. Nomachi,¹¹⁶ I. Nomidis,¹⁵⁴ S. Norberg,¹¹¹ M. Nordberg,³⁰ P. R. Norton,¹²⁹ J. Novakova,¹²⁶ M. Nozaki,⁶⁵
 L. Nozka,¹¹³ I. M. Nugent,^{159a} A.-E. Nuncio-Quiroz,²¹ G. Nunes Hanninger,⁸⁶ T. Nunnemann,⁹⁸ E. Nurse,⁷⁷
 B. J. O'Brien,⁴⁶ D. C. O'Neil,¹⁴² V. O'Shea,⁵³ L. B. Oakes,⁹⁸ F. G. Oakham,^{29,e} H. Oberlack,⁹⁹ J. Ocariz,⁷⁸ A. Ochi,⁶⁶
 S. Oda,⁶⁹ S. Odaka,⁶⁵ J. Odier,⁸³ H. Ogren,⁶⁰ A. Oh,⁸² S. H. Oh,⁴⁵ C. C. Ohm,³⁰ T. Ohshima,¹⁰¹ W. Okamura,¹¹⁶
 H. Okawa,²⁵ Y. Okumura,³¹ T. Okuyama,¹⁵⁵ A. Olariu,^{26a} A. G. Olchevski,⁶⁴ S. A. Olivares Pino,^{32a} M. Oliveira,^{124a,i}
 D. Oliveira Damazio,²⁵ E. Oliver Garcia,¹⁶⁷ D. Olivito,¹²⁰ A. Olszewski,³⁹ J. Olszowska,³⁹ J. Onderwaater,¹⁷²
 A. Onofre,^{124a,bb} P. U. E. Onyisi,³¹ C. J. Oram,^{159a} M. J. Oreglia,³¹ Y. Oren,¹⁵³ D. Orestano,^{134a,134b}
 N. Orlando,^{72a,72b} I. Orlov,¹⁰⁷ C. Oropeza Barrera,⁵³ R. S. Orr,¹⁵⁸ B. Osculati,^{50a,50b} R. Ospanov,¹²⁰ C. Osuna,¹²
 G. Otero y Garzon,²⁷ J. P. Ottersbach,¹⁰⁵ M. Ouchrif,^{135d} E. A. Ouellette,¹⁶⁹ F. Ould-Saada,¹¹⁷ A. Ouraou,¹³⁶
 Q. Ouyang,^{33a} A. Ovcharova,¹⁵ M. Owen,⁸² S. Owen,¹³⁹ V. E. Ozcan,^{19a} N. Ozturk,⁸ A. Pacheco Pages,¹²
 C. Padilla Aranda,¹² S. Pagan Griso,¹⁵ E. Paganis,¹³⁹ C. Pahl,⁹⁹ F. Paige,²⁵ P. Pais,⁸⁴ K. Pajchel,¹¹⁷ G. Palacino,^{159b}
 C. P. Paleari,⁷ S. Palestini,³⁰ D. Pallin,³⁴ A. Palma,^{124a} J. D. Palmer,¹⁸ Y. B. Pan,¹⁷³ E. Panagiotopoulou,¹⁰
 J. G. Panduro Vazquez,⁷⁶ P. Pani,¹⁰⁵ N. Panikashvili,⁸⁷ S. Panitkin,²⁵ D. Pantea,^{26a} A. Papadelis,^{146a}
 Th. D. Papadopoulou,¹⁰ A. Paramonov,⁶ D. Paredes Hernandez,³⁴ W. Park,^{25,cc} M. A. Parker,²⁸ F. Parodi,^{50a,50b}
 J. A. Parsons,³⁵ U. Parzefall,⁴⁸ S. Pashapour,⁵⁴ E. Pasqualucci,^{132a} S. Passaggio,^{50a} A. Passeri,^{134a}
 F. Pastore,^{134a,134b,a} Fr. Pastore,⁷⁶ G. Pásztor,^{49,dd} S. Patariaia,¹⁷⁵ N. Patel,¹⁵⁰ J. R. Pater,⁸² S. Patricelli,^{102a,102b}
 T. Pauly,³⁰ M. Pecsny,^{144a} S. Pedraza Lopez,¹⁶⁷ M. I. Pedraza Morales,¹⁷³ S. V. Peleganchuk,¹⁰⁷ D. Pelikan,¹⁶⁶
 H. Peng,^{33b} B. Penning,³¹ A. Penson,³⁵ J. Penwell,⁶⁰ M. Perantoni,^{24a} K. Perez,^{35,ee} T. Perez Cavalcanti,⁴²
 E. Perez Codina,^{159a} M. T. Pérez García-Estañ,¹⁶⁷ V. Perez Reale,³⁵ L. Perini,^{89a,89b} H. Pernegger,³⁰ R. Perrino,^{72a}
 P. Perrodo,⁵ V. D. Peshekhonov,⁶⁴ K. Peters,³⁰ B. A. Petersen,³⁰ J. Petersen,³⁰ T. C. Petersen,³⁶ E. Petit,⁵
 A. Petridis,¹⁵⁴ C. Petridou,¹⁵⁴ E. Petrolo,^{132a} F. Petrucci,^{134a,134b} D. Petschull,⁴² M. Petteni,¹⁴² R. Pezoa,^{32b}
 A. Phan,⁸⁶ P. W. Phillips,¹²⁹ G. Piacquadio,³⁰ A. Picazio,⁴⁹ E. Piccaro,⁷⁵ M. Piccinini,^{20a,20b} S. M. Piec,⁴²
 R. Piegaiia,²⁷ D. T. Pignotti,¹⁰⁹ J. E. Pilcher,³¹ A. D. Pilkington,⁸² J. Pina,^{124a,c} M. Pinamonti,^{164a,164c} A. Pinder,¹¹⁸
 J. L. Pinfold,³ B. Pinto,^{124a} C. Pizio,^{89a,89b} M. Plamondon,¹⁶⁹ M.-A. Pleier,²⁵ E. Plotnikova,⁶⁴ A. Poblaguev,²⁵
 S. Poddar,^{58a} F. Podlyski,³⁴ L. Poggioli,¹¹⁵ D. Pohl,²¹ M. Pohl,⁴⁹ G. Polesello,^{119a} A. Policicchio,^{37a,37b} A. Polini,^{20a}
 J. Poll,⁷⁵ V. Polychronakos,²⁵ D. Pomeroy,²³ K. Pommès,³⁰ L. Pontecorvo,^{132a} B. G. Pope,⁸⁸ G. A. Popeneci,^{26a}
 D. S. Popovic,^{13a} A. Poppleton,³⁰ X. Portell Bueso,³⁰ G. E. Pospelov,⁹⁹ S. Pospisil,¹²⁷ I. N. Potrap,⁹⁹ C. J. Potter,¹⁴⁹
 C. T. Potter,¹¹⁴ G. Poulard,³⁰ J. Poveda,⁶⁰ V. Pozdnyakov,⁶⁴ R. Prabhu,⁷⁷ P. Pralavorio,⁸³ A. Pranko,¹⁵ S. Prasad,³⁰
 R. Pravahan,²⁵ S. Prell,⁶³ K. Pretzl,¹⁷ D. Price,⁶⁰ J. Price,⁷³ L. E. Price,⁶ D. Prieur,¹²³ M. Primavera,^{72a}
 K. Prokofiev,¹⁰⁸ F. Prokoshin,^{32b} S. Protopopescu,²⁵ J. Proudfoot,⁶ X. Prudent,⁴⁴ M. Przybycien,³⁸ H. Przysiezniak,⁵
 S. Psoroulas,²¹ E. Ptacek,¹¹⁴ E. Pueschel,⁸⁴ J. Purdham,⁸⁷ M. Purohit,^{25,cc} P. Puzo,¹¹⁵ Y. Pylypchenko,⁶² J. Qian,⁸⁷
 A. Quadt,⁵⁴ D. R. Quarrie,¹⁵ W. B. Quayle,¹⁷³ F. Quinonez,^{32a} M. Raas,¹⁰⁴ V. Radeka,²⁵ V. Radescu,⁴² P. Radloff,¹¹⁴
 T. Rador,^{19a} F. Ragusa,^{89a,89b} G. Rahal,¹⁷⁸ A. M. Rahimi,¹⁰⁹ D. Rahm,²⁵ S. Rajagopalan,²⁵ M. Rammensee,⁴⁸
 M. Rammes,¹⁴¹ A. S. Randle-Conde,⁴⁰ K. Randrianarivony,²⁹ F. Rauscher,⁹⁸ T. C. Rave,⁴⁸ M. Raymond,³⁰
 A. L. Read,¹¹⁷ D. M. Rebuffi,^{119a,119b} A. Redelbach,¹⁷⁴ G. Redlinger,²⁵ R. Reece,¹²⁰ K. Reeves,⁴¹
 E. Reinherz-Aronis,¹⁵³ A. Reinsch,¹¹⁴ I. Reisinger,⁴³ C. Rembser,³⁰ Z. L. Ren,¹⁵¹ A. Renaud,¹¹⁵ M. Rescigno,^{132a}
 S. Resconi,^{89a} B. Resende,¹³⁶ P. Reznicek,⁹⁸ R. Rezvani,¹⁵⁸ R. Richter,⁹⁹ E. Richter-Was,^{5,ff} M. Ridel,⁷⁸
 M. Rijpstra,¹⁰⁵ M. Rijssenbeek,¹⁴⁸ A. Rimoldi,^{119a,119b} L. Rinaldi,^{20a} R. R. Rios,⁴⁰ I. Riu,¹² G. Rivoltella,^{89a,89b}
 F. Rizatdinova,¹¹² E. Rizvi,⁷⁵ S. H. Robertson,^{85,1} A. Robichaud-Veronneau,¹¹⁸ D. Robinson,²⁸ J. E. M. Robinson,⁸²
 A. Robson,⁵³ J. G. Rocha de Lima,¹⁰⁶ C. Roda,^{122a,122b} D. Roda Dos Santos,³⁰ A. Roe,⁵⁴ S. Roe,³⁰ O. Røhne,¹¹⁷
 S. Rolli,¹⁶¹ A. Romaniouk,⁹⁶ M. Romano,^{20a,20b} G. Romeo,²⁷ E. Romero Adam,¹⁶⁷ N. Rompotis,¹³⁸ L. Roos,⁷⁸
 E. Ros,¹⁶⁷ S. Rosati,^{132a} K. Rosbach,⁴⁹ A. Rose,¹⁴⁹ M. Rose,⁷⁶ G. A. Rosenbaum,¹⁵⁸ E. I. Rosenberg,⁶³
 P. L. Rosendahl,¹⁴ O. Rosenthal,¹⁴¹ L. Rossetet,⁴⁹ V. Rossetti,¹² E. Rossi,^{132a,132b} L. P. Rossi,^{50a} M. Rotaru,^{26a}
 I. Roth,¹⁷² J. Rothberg,¹³⁸ D. Rousseau,¹¹⁵ C. R. Royon,¹³⁶ A. Rozanov,⁸³ Y. Rozen,¹⁵² X. Ruan,^{33a,gg} F. Rubbo,¹²

- I. Rubinskiy,⁴² N. Ruckstuhl,¹⁰⁵ V. I. Rud,⁹⁷ C. Rudolph,⁴⁴ G. Rudolph,⁶¹ F. Rühr,⁷ A. Ruiz-Martinez,⁶³ L. Romyantsev,⁶⁴ Z. Rurikova,⁴⁸ N. A. Rusakovich,⁶⁴ J. P. Rutherford,⁷ P. Ruzicka,¹²⁵ Y. F. Ryabov,¹²¹ M. Rybar,¹²⁶ G. Rybkin,¹¹⁵ N. C. Ryder,¹¹⁸ A. F. Saavedra,¹⁵⁰ I. Sadeh,¹⁵³ H.F.-W. Sadrozinski,¹³⁷ R. Sadykov,⁶⁴ F. Safai Tehrani,^{132a} H. Sakamoto,¹⁵⁵ G. Salamanna,⁷⁵ A. Salamon,^{133a} M. Saleem,¹¹¹ D. Salek,³⁰ D. Salihagic,⁹⁹ A. Salnikov,¹⁴³ J. Salt,¹⁶⁷ B. M. Salvachua Ferrando,⁶ D. Salvatore,^{37a,37b} F. Salvatore,¹⁴⁹ A. Salvucci,¹⁰⁴ A. Salzburger,³⁰ D. Sampsonidis,¹⁵⁴ B. H. Samset,¹¹⁷ A. Sanchez,^{102a,102b} V. Sanchez Martinez,¹⁶⁷ H. Sandaker,¹⁴ H. G. Sander,⁸¹ M. P. Sanders,⁹⁸ M. Sandhoff,¹⁷⁵ T. Sandoval,²⁸ C. Sandoval,¹⁶² R. Sandstroem,⁹⁹ D. P. C. Sankey,¹²⁹ A. Sansoni,⁴⁷ C. Santamarina Rios,⁸⁵ C. Santoni,³⁴ R. Santonico,^{133a,133b} H. Santos,^{124a} J. G. Saraiva,^{124a} T. Sarangi,¹⁷³ E. Sarkisyan-Grinbaum,⁸ F. Sarri,^{122a,122b} G. Sartiso,¹⁷⁵ O. Sasaki,⁶⁵ Y. Sasaki,¹⁵⁵ N. Sasao,⁶⁷ I. Satsounkevitch,⁹⁰ G. Sauvage,^{5a} E. Sauvan,⁵ J. B. Sauvan,¹¹⁵ P. Savard,^{158,e} V. Savinov,¹²³ D. O. Savu,³⁰ L. Sawyer,^{25,n} D. H. Saxon,⁵³ J. Saxon,¹²⁰ C. Sbarra,^{20a} A. Sbrizzi,^{20a,20b} D. A. Scannicchio,¹⁶³ M. Scarcella,¹⁵⁰ J. Schaarschmidt,¹¹⁵ P. Schacht,⁹⁹ D. Schaefer,¹²⁰ U. Schäfer,⁸¹ A. Schaelicke,⁴⁶ S. Schaepe,²¹ S. Schaezel,^{58b} A. C. Schaffer,¹¹⁵ D. Schaile,⁹⁸ R. D. Schamberger,¹⁴⁸ A. G. Schamov,¹⁰⁷ V. Scharf,^{58a} V. A. Schegelsky,¹²¹ D. Scheirich,⁸⁷ M. Schernau,¹⁶³ M. I. Scherzer,³⁵ C. Schiavi,^{50a,50b} J. Schieck,⁹⁸ M. Schioppa,^{37a,37b} S. Schlenker,³⁰ E. Schmidt,⁴⁸ K. Schmieden,²¹ C. Schmitt,⁸¹ S. Schmitt,^{58b} M. Schmitz,²¹ B. Schneider,¹⁷ U. Schnoor,⁴⁴ L. Schoeffel,¹³⁶ A. Schoening,^{58b} A. L. S. Schorlemmer,⁵⁴ M. Schott,³⁰ D. Schouten,^{159a} J. Schovancova,¹²⁵ M. Schram,⁸⁵ C. Schroeder,⁸¹ N. Schroer,^{58c} M. J. Schultens,²¹ J. Schultes,¹⁷⁵ H.-C. Schultz-Coulon,^{58a} H. Schulz,¹⁶ M. Schumacher,⁴⁸ B. A. Schumm,¹³⁷ Ph. Schune,¹³⁶ C. Schwanenberger,⁸² A. Schwartzman,¹⁴³ Ph. Schwegler,⁹⁹ Ph. Schwemling,⁷⁸ R. Schwienhorst,⁸⁸ R. Schwierz,⁴⁴ J. Schwindling,¹³⁶ T. Schwindt,²¹ M. Schwoerer,⁵ G. Sciolla,²³ W. G. Scott,¹²⁹ J. Searcy,¹¹⁴ G. Sedov,⁴² E. Sedykh,¹²¹ S. C. Seidel,¹⁰³ A. Seiden,¹³⁷ F. Seifert,⁴⁴ J. M. Seixas,^{24a} G. Sekhniaidze,^{102a} S. J. Sekula,⁴⁰ K. E. Selbach,⁴⁶ D. M. Seliverstov,¹²¹ B. Sellden,^{146a} G. Sellers,⁷³ M. Seman,^{144b} N. Semprini-Cesari,^{20a,20b} C. Serfon,⁹⁸ L. Serin,¹¹⁵ L. Serkin,⁵⁴ R. Seuster,^{159a} H. Severini,¹¹¹ A. Sfyrla,³⁰ E. Shabalina,⁵⁴ M. Shamim,¹¹⁴ L. Y. Shan,^{33a} J. T. Shank,²² Q. T. Shao,⁸⁶ M. Shapiro,¹⁵ P. B. Shatalov,⁹⁵ K. Shaw,^{164a,164c} D. Sherman,¹⁷⁶ P. Sherwood,⁷⁷ S. Shimizu,¹⁰¹ M. Shimojima,¹⁰⁰ T. Shin,⁵⁶ M. Shiyakova,⁶⁴ A. Shmeleva,⁹⁴ M. J. Shochet,³¹ D. Short,¹¹⁸ S. Shrestha,⁶³ E. Shulga,⁹⁶ M. A. Shupe,⁷ P. Sicho,¹²⁵ A. Sidoti,^{132a} F. Siegert,⁴⁸ Dj. Sijacki,^{13a} O. Silbert,¹⁷² J. Silva,^{124a} Y. Silver,¹⁵³ D. Silverstein,¹⁴³ S. B. Silverstein,^{146a} V. Simak,¹²⁷ O. Simard,¹³⁶ Lj. Simic,^{13a} S. Simion,¹¹⁵ E. Simioni,⁸¹ B. Simmons,⁷⁷ R. Simoniello,^{89a,89b} M. Simonyan,³⁶ P. Sinervo,¹⁵⁸ N. B. Sinev,¹¹⁴ V. Sipica,¹⁴¹ G. Siragusa,¹⁷⁴ A. Sircar,²⁵ A. N. Sisakyan,^{64,a} S. Yu. Sivoklov,⁹⁷ J. Sjölin,^{146a,146b} T. B. Sjursen,¹⁴ L. A. Skinnari,¹⁵ H. P. Skottowe,⁵⁷ K. Skovpen,¹⁰⁷ P. Skubic,¹¹¹ M. Slater,¹⁸ T. Slavicek,¹²⁷ K. Sliwa,¹⁶¹ V. Smakhtin,¹⁷² B. H. Smart,⁴⁶ L. Smestad,¹¹⁷ S. Yu. Smirnov,⁹⁶ Y. Smirnov,⁹⁶ L. N. Smirnova,⁹⁷ O. Smirnova,⁷⁹ B. C. Smith,⁵⁷ D. Smith,¹⁴³ K. M. Smith,⁵³ M. Smizanska,⁷¹ K. Smolek,¹²⁷ A. A. Snesarev,⁹⁴ S. W. Snow,⁸² J. Snow,¹¹¹ S. Snyder,²⁵ R. Sobie,^{169,1} J. Sodomka,¹²⁷ A. Soffer,¹⁵³ C. A. Solans,¹⁶⁷ M. Solar,¹²⁷ J. Solc,¹²⁷ E. Yu. Soldatov,⁹⁶ U. Soldevila,¹⁶⁷ E. Solfaroli Camillocci,^{132a,132b} A. A. Solodkov,¹²⁸ O. V. Solovyanov,¹²⁸ V. Solovyev,¹²¹ N. Soni,¹ V. Sopko,¹²⁷ B. Sopko,¹²⁷ M. Sosebee,⁸ R. Soualah,^{164a,164c} A. Soukharev,¹⁰⁷ S. Spagnolo,^{72a,72b} F. Spanò,⁷⁶ R. Spighi,^{20a} G. Spigo,³⁰ R. Spiwoks,³⁰ M. Spousta,^{126,hh} T. Spreitzer,¹⁵⁸ B. Spurlock,⁸ R. D. St. Denis,⁵³ J. Stahlman,¹²⁰ R. Stamen,^{58a} E. Stanecka,³⁹ R. W. Stanek,⁶ C. Stancu,^{134a} M. Stancu-Bellu,⁴² M. M. Stanitzki,⁴² S. Stapnes,¹¹⁷ E. A. Starchenko,¹²⁸ J. Stark,⁵⁵ P. Staroba,¹²⁵ P. Starovoitov,⁴² R. Staszewski,³⁹ A. Staude,⁹⁸ P. Stavina,^{144a,a} G. Steele,⁵³ P. Steinbach,⁴⁴ P. Steinberg,²⁵ I. Stekl,¹²⁷ B. Stelzer,¹⁴² H. J. Stelzer,⁸⁸ O. Stelzer-Chilton,^{159a} H. Stenzel,⁵² S. Stern,⁹⁹ G. A. Stewart,³⁰ J. A. Stillings,²¹ M. C. Stockton,⁸⁵ K. Stoerig,⁴⁸ G. Stoicea,^{26a} S. Stonjek,⁹⁹ P. Strachota,¹²⁶ A. R. Stradling,⁸ A. Straessner,⁴⁴ J. Strandberg,¹⁴⁷ S. Strandberg,^{146a,146b} A. Strandlie,¹¹⁷ M. Strang,¹⁰⁹ E. Strauss,¹⁴³ M. Strauss,¹¹¹ P. Strizeneč,^{144b} R. Ströhmer,¹⁷⁴ D. M. Strom,¹¹⁴ J. A. Strong,^{76,a} R. Stroynowski,⁴⁰ B. Stugu,¹⁴ I. Stumer,^{25,a} J. Stupak,¹⁴⁸ P. Sturm,¹⁷⁵ N. A. Styles,⁴² D. A. Soh,^{151,v} D. Su,¹⁴³ H. S. Subramania,³ R. Subramaniam,²⁵ A. Succurro,¹² Y. Sugaya,¹¹⁶ C. Suhr,¹⁰⁶ M. Suk,¹²⁶ V. V. Sulin,⁹⁴ S. Sultansoy,^{4d} T. Sumida,⁶⁷ X. Sun,⁵⁵ J. E. Sundermann,⁴⁸ K. Suruliz,¹³⁹ G. Susinno,^{37a,37b} M. R. Sutton,¹⁴⁹ Y. Suzuki,⁶⁵ Y. Suzuki,⁶⁶ M. Svatos,¹²⁵ S. Swedish,¹⁶⁸ I. Sykora,^{144a} T. Sykora,¹²⁶ J. Sánchez,¹⁶⁷ D. Ta,¹⁰⁵ K. Tackmann,⁴² A. Taffard,¹⁶³ R. Tafirout,^{159a} N. Taiblum,¹⁵³ Y. Takahashi,¹⁰¹ H. Takai,²⁵ R. Takashima,⁶⁸ H. Takeda,⁶⁶ T. Takeshita,¹⁴⁰ Y. Takubo,⁶⁵ M. Talby,⁸³ A. Talyshev,^{107,g} M. C. Tamsett,²⁵ J. Tanaka,¹⁵⁵ R. Tanaka,¹¹⁵ S. Tanaka,¹³¹ S. Tanaka,⁶⁵ A. J. Tanasijczuk,¹⁴² K. Tani,⁶⁶ N. Tannoury,⁸³ S. Tapprogge,⁸¹ D. Tardif,¹⁵⁸ S. Tarem,¹⁵² F. Tarrade,²⁹ G. F. Tartarelli,^{89a} P. Tas,¹²⁶ M. Tasevsky,¹²⁵ E. Tassi,^{37a,37b} M. Tatarikhanov,¹⁵ Y. Tayalati,^{135d} C. Taylor,⁷⁷ F. E. Taylor,⁹² G. N. Taylor,⁸⁶ W. Taylor,^{159b} M. Teinturier,¹¹⁵ F. A. Teischinger,³⁰ M. Teixeira Dias Castanheira,⁷⁵ P. Teixeira-Dias,⁷⁶ K. K. Temming,⁴⁸

H. Ten Kate,³⁰ P. K. Teng,¹⁵¹ S. Terada,⁶⁵ K. Terashi,¹⁵⁵ J. Terron,⁸⁰ M. Testa,⁴⁷ R. J. Teuscher,^{158,l} J. Therhaag,²¹ T. Theveneaux-Pelzer,⁷⁸ S. Thoma,⁴⁸ J. P. Thomas,¹⁸ E. N. Thompson,³⁵ P. D. Thompson,¹⁸ P. D. Thompson,¹⁵⁸ A. S. Thompson,⁵³ L. A. Thomsen,³⁶ E. Thomson,¹²⁰ M. Thomson,²⁸ W. M. Thong,⁸⁶ R. P. Thun,⁸⁷ F. Tian,³⁵ M. J. Tibbetts,¹⁵ T. Tic,¹²⁵ V. O. Tikhomirov,⁹⁴ Y. A. Tikhonov,^{107,g} S. Timoshenko,⁹⁶ E. Tiouchichine,⁸³ P. Tipton,¹⁷⁶ S. Tisserant,⁸³ T. Todorov,⁵ S. Todorova-Nova,¹⁶¹ B. Toggerson,¹⁶³ J. Tojo,⁶⁹ S. Tokár,^{144a} K. Tokushuku,⁶⁵ K. Tollefson,⁸⁸ M. Tomoto,¹⁰¹ L. Tompkins,³¹ K. Toms,¹⁰³ A. Tonoyan,¹⁴ C. Topfel,¹⁷ N. D. Topilin,⁶⁴ I. Torchiani,³⁰ E. Torrence,¹¹⁴ H. Torres,⁷⁸ E. Torró Pastor,¹⁶⁷ J. Toth,^{83,dd} F. Touchard,⁸³ D. R. Tovey,¹³⁹ T. Trefzger,¹⁷⁴ L. Tremblet,³⁰ A. Tricoli,³⁰ I. M. Trigger,^{159a} S. Trincaz-Duvoid,⁷⁸ M. F. Tripiana,⁷⁰ N. Triplett,²⁵ W. Trischuk,¹⁵⁸ B. Trocmé,⁵⁵ C. Troncon,^{89a} M. Trotter-McDonald,¹⁴² M. Trzebinski,³⁹ A. Trzuppek,³⁹ C. Tsarouchas,³⁰ J.C.-L. Tseng,¹¹⁸ M. Tsiakiris,¹⁰⁵ P. V. Tsiarehshka,⁹⁰ D. Tsionou,^{5,ii} G. Tsiopolitis,¹⁰ S. Tsiskaridze,¹² V. Tsiskaridze,⁴⁸ E. G. Tskhadadze,^{51a} I. I. Tsukerman,⁹⁵ V. Tsulaia,¹⁵ J.-W. Tsung,²¹ S. Tsuno,⁶⁵ D. Tsybychev,¹⁴⁸ A. Tua,¹³⁹ A. Tudorache,^{26a} V. Tudorache,^{26a} J. M. Tuggle,³¹ M. Turala,³⁹ D. Turecek,¹²⁷ I. Turk Cakir,^{4e} E. Turlay,¹⁰⁵ R. Turra,^{89a,89b} P. M. Tuts,³⁵ A. Tykhonov,⁷⁴ M. Tylmad,^{146a,146b} M. Tyndel,¹²⁹ G. Tzanakos,⁹ K. Uchida,²¹ I. Ueda,¹⁵⁵ R. Ueno,²⁹ M. Ugland,¹⁴ M. Uhlenbrock,²¹ M. Uhrmacher,⁵⁴ F. Ukegawa,¹⁶⁰ G. Unal,³⁰ A. Undrus,²⁵ G. Unel,¹⁶³ Y. Unno,⁶⁵ D. Urbaniec,³⁵ P. Urquijo,²¹ G. Usai,⁸ M. Uslenghi,^{119a,119b} L. Vacavant,⁸³ V. Vacek,¹²⁷ B. Vachon,⁸⁵ S. Vahsen,¹⁵ J. Valenta,¹²⁵ S. Valentinetti,^{20a,20b} A. Valero,¹⁶⁷ S. Valkar,¹²⁶ E. Valladolid Gallego,¹⁶⁷ S. Vallecorsa,¹⁵² J. A. Valls Ferrer,¹⁶⁷ R. Van Berg,¹²⁰ P. C. Van Der Deijl,¹⁰⁵ R. van der Geer,¹⁰⁵ H. van der Graaf,¹⁰⁵ R. Van Der Leeuw,¹⁰⁵ E. van der Poel,¹⁰⁵ D. van der Ster,³⁰ N. van Eldik,³⁰ P. van Gemmeren,⁶ I. van Vulpen,¹⁰⁵ M. Vanadia,⁹⁹ W. Vandelli,³⁰ A. Vaniachine,⁶ P. Vankov,⁴² F. Vannucci,⁷⁸ R. Vari,^{132a} T. Varol,⁸⁴ D. Varouchas,¹⁵ A. Vartapetian,⁸ K. E. Varvell,¹⁵⁰ V. I. Vassilakopoulos,⁵⁶ F. Vazeille,³⁴ T. Vazquez Schroeder,⁵⁴ G. Vegni,^{89a,89b} J. J. Veillet,¹¹⁵ F. Veloso,^{124a} R. Veness,³⁰ S. Veneziano,^{132a} A. Ventura,^{72a,72b} D. Ventura,⁸⁴ M. Venturi,⁴⁸ N. Venturi,¹⁵⁸ V. Vercesi,^{119a} M. Verducci,¹³⁸ W. Verkerke,¹⁰⁵ J. C. Vermeulen,¹⁰⁵ A. Vest,⁴⁴ M. C. Vetterli,^{142,e} I. Vichou,¹⁶⁵ T. Vickey,^{145b,ij} O. E. Vickey Boeriu,^{145b} G. H. A. Viehhauser,¹¹⁸ S. Viel,¹⁶⁸ M. Villa,^{20a,20b} M. Villaplana Perez,¹⁶⁷ E. Vilucchi,⁴⁷ M. G. Vincter,²⁹ E. Vinek,³⁰ V. B. Vinogradov,⁶⁴ M. Virchaux,^{136,a} J. Virzi,¹⁵ O. Vitells,¹⁷² M. Viti,⁴² I. Vivarelli,⁴⁸ F. Vives Vaque,³ S. Vlachos,¹⁰ D. Vladoiu,⁹⁸ M. Vlasak,¹²⁷ A. Vogel,²¹ P. Vokac,¹²⁷ G. Volpi,⁴⁷ M. Volpi,⁸⁶ G. Volpini,^{89a} H. von der Schmitt,⁹⁹ H. von Radziewski,⁴⁸ E. von Toerne,²¹ V. Vorobel,¹²⁶ V. Vorwerk,¹² M. Vos,¹⁶⁷ R. Voss,³⁰ T. T. Voss,¹⁷⁵ J. H. Vosseveld,⁷³ N. Vranjes,¹³⁶ M. Vranjes Milosavljevic,¹⁰⁵ V. Vrba,¹²⁵ M. Vreeswijk,¹⁰⁵ T. Vu Anh,⁴⁸ R. Vuillemet,³⁰ I. Vukotic,³¹ W. Wagner,¹⁷⁵ P. Wagner,¹²⁰ H. Wahlen,¹⁷⁵ S. Wahrenmund,⁴⁴ J. Wakabayashi,¹⁰¹ S. Walch,⁸⁷ J. Walder,⁷¹ R. Walker,⁹⁸ W. Walkowiak,¹⁴¹ R. Wall,¹⁷⁶ P. Waller,⁷³ B. Walsh,¹⁷⁶ C. Wang,⁴⁵ H. Wang,¹⁷³ H. Wang,^{33b,kk} J. Wang,¹⁵¹ J. Wang,⁵⁵ R. Wang,¹⁰³ S. M. Wang,¹⁵¹ T. Wang,²¹ A. Warburton,⁸⁵ C. P. Ward,²⁸ M. Warsinsky,⁴⁸ A. Washbrook,⁴⁶ C. Wasicki,⁴² I. Watanabe,⁶⁶ P. M. Watkins,¹⁸ A. T. Watson,¹⁸ I. J. Watson,¹⁵⁰ M. F. Watson,¹⁸ G. Watts,¹³⁸ S. Watts,⁸² A. T. Waugh,¹⁵⁰ B. M. Waugh,⁷⁷ M. S. Weber,¹⁷ P. Weber,⁵⁴ J. S. Webster,³¹ A. R. Weidberg,¹¹⁸ P. Weigell,⁹⁹ J. Weingarten,⁵⁴ C. Weiser,⁴⁸ P. S. Wells,³⁰ T. Wenaus,²⁵ D. Wendland,¹⁶ Z. Weng,^{151,v} T. Wengler,³⁰ S. Wenig,³⁰ N. Wermes,²¹ M. Werner,⁴⁸ P. Werner,³⁰ M. Werth,¹⁶³ M. Wessels,^{58a} J. Wetter,¹⁶¹ C. Weydert,⁵⁵ K. Whalen,²⁹ S. J. Wheeler-Ellis,¹⁶³ A. White,⁸ M. J. White,⁸⁶ S. White,^{122a,122b} S. R. Whitehead,¹¹⁸ D. Whiteson,¹⁶³ D. Whittington,⁶⁰ F. Wicek,¹¹⁵ D. Wicke,¹⁷⁵ F. J. Wickens,¹²⁹ W. Wiedenmann,¹⁷³ M. Wielers,¹²⁹ P. Wienemann,²¹ C. Wiglesworth,⁷⁵ L. A. M. Wiik-Fuchs,⁴⁸ P. A. Wijeratne,⁷⁷ A. Wildauer,⁹⁹ M. A. Wildt,^{42,s} I. Wilhelm,¹²⁶ H. G. Wilkens,³⁰ J. Z. Will,⁹⁸ E. Williams,³⁵ H. H. Williams,¹²⁰ W. Willis,³⁵ S. Willocq,⁸⁴ J. A. Wilson,¹⁸ M. G. Wilson,¹⁴³ A. Wilson,⁸⁷ I. Wingerter-Seez,⁵ S. Winkelmann,⁴⁸ F. Winklmeier,³⁰ M. Wittgen,¹⁴³ S. J. Wollstadt,⁸¹ M. W. Wolter,³⁹ H. Wolters,^{124a,i} W. C. Wong,⁴¹ G. Wooden,⁸⁷ B. K. Wosiek,³⁹ J. Wotschack,³⁰ M. J. Woudstra,⁸² K. W. Wozniak,³⁹ K. Wraight,⁵³ M. Wright,⁵³ B. Wrona,⁷³ S. L. Wu,¹⁷³ X. Wu,⁴⁹ Y. Wu,^{33b,ll} E. Wulf,³⁵ B. M. Wynne,⁴⁶ S. Xella,³⁶ M. Xiao,¹³⁶ S. Xie,⁴⁸ C. Xu,^{33b,z} D. Xu,¹³⁹ B. Yabsley,¹⁵⁰ S. Yacoob,^{145a,mm} M. Yamada,⁶⁵ H. Yamaguchi,¹⁵⁵ A. Yamamoto,⁶⁵ K. Yamamoto,⁶³ S. Yamamoto,¹⁵⁵ T. Yamamura,¹⁵⁵ T. Yamanaka,¹⁵⁵ T. Yamazaki,¹⁵⁵ Y. Yamazaki,⁶⁶ Z. Yan,²² H. Yang,⁸⁷ U. K. Yang,⁸² Y. Yang,¹⁰⁹ Z. Yang,^{146a,146b} S. Yanush,⁹¹ L. Yao,^{33a} Y. Yao,¹⁵ Y. Yasu,⁶⁵ G. V. Ybeles Smit,¹³⁰ J. Ye,⁴⁰ S. Ye,²⁵ M. Yilmaz,^{4c} R. Yoosoofmiya,¹²³ K. Yorita,¹⁷¹ R. Yoshida,⁶ K. Yoshihara,¹⁵⁵ C. Young,¹⁴³ C. J. Young,¹¹⁸ S. Youssef,²² D. Yu,²⁵ J. Yu,⁸ J. Yu,¹¹² L. Yuan,⁶⁶ A. Yurkewicz,¹⁰⁶ B. Zabinski,³⁹ R. Zaidan,⁶² A. M. Zaitsev,¹²⁸ Z. Zajacova,³⁰ L. Zanello,^{132a,132b} D. Zanzi,⁹⁹ A. Zaytsev,²⁵ C. Zeitnitz,¹⁷⁵ M. Zeman,¹²⁵ A. Zemla,³⁹ C. Zender,²¹ O. Zenin,¹²⁸ T. Ženiš,^{144a} Z. Zinonos,^{122a,122b} S. Zenz,¹⁵ D. Zerwas,¹¹⁵ G. Zevi della Porta,⁵⁷ D. Zhang,^{33b,kk} H. Zhang,⁸⁸ J. Zhang,⁶ X. Zhang,^{33d} Z. Zhang,¹¹⁵ L. Zhao,¹⁰⁸ Z. Zhao,^{33b} A. Zhemchugov,⁶⁴ J. Zhong,¹¹⁸ B. Zhou,⁸⁷

N. Zhou,¹⁶³ Y. Zhou,¹⁵¹ C. G. Zhu,^{33d} H. Zhu,⁴² J. Zhu,⁸⁷ Y. Zhu,^{33b} X. Zhuang,⁹⁸ V. Zhuravlov,⁹⁹ D. Zieminska,⁶⁰
 N. I. Zimin,⁶⁴ R. Zimmermann,²¹ S. Zimmermann,²¹ S. Zimmermann,⁴⁸ M. Ziolkowski,¹⁴¹ R. Zitoun,⁵
 L. Živković,³⁵ V. V. Zmouchko,^{128,a} G. Zobernig,¹⁷³ A. Zoccoli,^{20a,20b} M. zur Nedden,¹⁶
 V. Zutshi,¹⁰⁶ and L. Zwalinski³⁰

(ATLAS Collaboration)

- ¹*School of Chemistry and Physics, University of Adelaide, Adelaide, Australia*
²*Physics Department, SUNY Albany, Albany, New York, USA*
³*Department of Physics, University of Alberta, Edmonton, Alberta, Canada*
^{4a}*Department of Physics, Ankara University, Ankara, Turkey*
^{4b}*Department of Physics, Dumlupinar University, Kutahya, Turkey*
^{4c}*Department of Physics, Gazi University, Ankara, Turkey*
^{4d}*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
^{4e}*Turkish Atomic Energy Authority, Ankara, Turkey*
⁵*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
⁶*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
⁷*Department of Physics, University of Arizona, Tucson, Arizona, USA*
⁸*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
⁹*Physics Department, University of Athens, Athens, Greece*
¹⁰*Physics Department, National Technical University of Athens, Zografou, Greece*
¹¹*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
¹²*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain*
^{13a}*Institute of Physics, University of Belgrade, Belgrade, Serbia*
^{13b}*Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*
¹⁴*Department for Physics and Technology, University of Bergen, Bergen, Norway*
¹⁵*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
¹⁶*Department of Physics, Humboldt University, Berlin, Germany*
¹⁷*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
¹⁸*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
^{19a}*Department of Physics, Bogazici University, Istanbul, Turkey*
^{19b}*Division of Physics, Dogus University, Istanbul, Turkey*
^{19c}*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
^{19d}*Department of Physics, Istanbul Technical University, Istanbul, Turkey*
^{20a}*INFN Sezione di Bologna, Bologna, Italy*
^{20b}*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
²¹*Physikalisches Institut, University of Bonn, Bonn, Germany*
²²*Department of Physics, Boston University, Boston, Massachusetts, USA*
²³*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
^{24a}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
^{24b}*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
^{24c}*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
^{24d}*Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil*
²⁵*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
^{26a}*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
^{26b}*University Politehnica Bucharest, Bucharest, Romania*
^{26c}*West University in Timisoara, Timisoara, Romania*
²⁷*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
²⁸*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
²⁹*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
³⁰*CERN, Geneva, Switzerland*
³¹*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
^{32a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
^{32b}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
^{33a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
^{33b}*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
^{33c}*Department of Physics, Nanjing University, Jiangsu, China*

- ^{33d}*School of Physics, Shandong University, Shandong, China*
- ³⁴*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France*
- ³⁵*Nevis Laboratory, Columbia University, Irvington, New York, USA*
- ³⁶*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
- ^{37a}*INFN Gruppo Collegato di Cosenza, Cosenza, Italy*
- ^{37b}*Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy*
- ³⁸*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
- ³⁹*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
- ⁴⁰*Physics Department, Southern Methodist University, Dallas, Texas, USA*
- ⁴¹*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
- ⁴²*DESY, Hamburg and Zeuthen, Germany*
- ⁴³*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
- ⁴⁴*Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany*
- ⁴⁵*Department of Physics, Duke University, Durham, North Carolina, USA*
- ⁴⁶*SUPA-School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁴⁷*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
- ⁴⁸*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany*
- ⁴⁹*Section de Physique, Université de Genève, Geneva, Switzerland*
- ^{50a}*INFN Sezione di Genova, Genova, Italy*
- ^{50b}*Dipartimento di Fisica, Università di Genova, Genova, Italy*
- ^{51a}*E. Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi, Georgia*
- ^{51b}*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
- ⁵²*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
- ⁵³*SUPA-School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁵⁴*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
- ⁵⁵*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
- ⁵⁶*Department of Physics, Hampton University, Hampton, Virginia, USA*
- ⁵⁷*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
- ^{58a}*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58b}*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58c}*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
- ⁵⁹*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
- ⁶⁰*Department of Physics, Indiana University, Bloomington, Indiana, USA*
- ⁶¹*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
- ⁶²*University of Iowa, Iowa City, Iowa, USA*
- ⁶³*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
- ⁶⁴*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
- ⁶⁵*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
- ⁶⁶*Graduate School of Science, Kobe University, Kobe, Japan*
- ⁶⁷*Faculty of Science, Kyoto University, Kyoto, Japan*
- ⁶⁸*Kyoto University of Education, Kyoto, Japan*
- ⁶⁹*Department of Physics, Kyushu University, Fukuoka, Japan*
- ⁷⁰*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
- ⁷¹*Physics Department, Lancaster University, Lancaster, United Kingdom*
- ^{72a}*INFN Sezione di Lecce, Lecce, Italy*
- ^{72b}*Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy*
- ⁷³*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
- ⁷⁴*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
- ⁷⁵*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
- ⁷⁶*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
- ⁷⁷*Department of Physics and Astronomy, University College London, London, United Kingdom*
- ⁷⁸*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
- ⁷⁹*Fysiska institutionen, Lunds universitet, Lund, Sweden*
- ⁸⁰*Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain*
- ⁸¹*Institut für Physik, Universität Mainz, Mainz, Germany*
- ⁸²*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
- ⁸³*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
- ⁸⁴*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*

- ⁸⁵*Department of Physics, McGill University, Montreal, Quebec, Canada*
- ⁸⁶*School of Physics, University of Melbourne, Victoria, Australia*
- ⁸⁷*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
- ⁸⁸*Department of Physics and Astronomy, Michigan State University, East Lansing Michigan, USA*
- ^{89a}*INFN Sezione di Milano, Italy*
- ^{89b}*Dipartimento di Fisica, Università di Milano, Milano, Italy*
- ⁹⁰*B. I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
- ⁹¹*National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus*
- ⁹²*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
- ⁹³*Group of Particle Physics, University of Montreal, Montreal, Quebec, Canada*
- ⁹⁴*P. N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*
- ⁹⁵*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
- ⁹⁶*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
- ⁹⁷*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
- ⁹⁸*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
- ⁹⁹*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
- ¹⁰⁰*Nagasaki Institute of Applied Science, Nagasaki, Japan*
- ¹⁰¹*Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan*
- ^{102a}*INFN Sezione di Napoli, Napoli, Italy*
- ^{102b}*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
- ¹⁰³*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
- ¹⁰⁴*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
- ¹⁰⁵*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
- ¹⁰⁶*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
- ¹⁰⁷*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
- ¹⁰⁸*Department of Physics, New York University, New York, New York, USA*
- ¹⁰⁹*The Ohio State University, Columbus, Ohio, USA*
- ¹¹⁰*Faculty of Science, Okayama University, Okayama, Japan*
- ¹¹¹*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
- ¹¹²*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
- ¹¹³*Palacký University, RCPTM, Olomouc, Czech Republic*
- ¹¹⁴*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
- ¹¹⁵*LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France*
- ¹¹⁶*Graduate School of Science, Osaka University, Osaka, Japan*
- ¹¹⁷*Department of Physics, University of Oslo, Oslo, Norway*
- ¹¹⁸*Department of Physics, Oxford University, Oxford, United Kingdom*
- ^{119a}*INFN Sezione di Pavia, Pavia, Italy*
- ^{119b}*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
- ¹²⁰*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
- ¹²¹*Petersburg Nuclear Physics Institute, Gatchina, Russia*
- ^{122a}*INFN Sezione di Pisa, Pisa, Italy*
- ^{122b}*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
- ¹²³*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
- ^{124a}*Laboratorio de Instrumentacao e Fisica Experimental de Particulas-LIP, Lisboa, Portugal*
- ^{124b}*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
- ¹²⁵*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
- ¹²⁶*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
- ¹²⁷*Czech Technical University in Prague, Praha, Czech Republic*
- ¹²⁸*State Research Center Institute for High Energy Physics, Protvino, Russia*
- ¹²⁹*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ¹³⁰*Physics Department, University of Regina, Regina, Saskatchewan, Canada*
- ¹³¹*Ritsumeikan University, Kusatsu, Shiga, Japan*
- ^{132a}*INFN Sezione di Roma I, Roma, Italy*
- ^{132b}*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
- ^{133a}*INFN Sezione di Roma Tor Vergata, Roma, Italy*
- ^{133b}*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
- ^{134a}*INFN Sezione di Roma Tre, Roma, Italy*
- ^{134b}*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
- ^{135a}*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies-Université Hassan II, Casablanca, Morocco*
- ^{135b}*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*

- ^{135c}*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
- ^{135d}*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
- ^{135e}*Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco*
- ¹³⁶*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France*
- ¹³⁷*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
- ¹³⁸*Department of Physics, University of Washington, Seattle, Washington, USA*
- ¹³⁹*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
- ¹⁴⁰*Department of Physics, Shinshu University, Nagano, Japan*
- ¹⁴¹*Fachbereich Physik, Universität Siegen, Siegen, Germany*
- ¹⁴²*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*
- ¹⁴³*SLAC National Accelerator Laboratory, Stanford, California, USA*
- ^{144a}*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
- ^{144b}*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
- ^{145a}*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
- ^{145b}*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
- ^{146a}*Department of Physics, Stockholm University, Sweden*
- ^{146b}*The Oskar Klein Centre, Stockholm, Sweden*
- ¹⁴⁷*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
- ¹⁴⁸*Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA*
- ¹⁴⁹*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
- ¹⁵⁰*School of Physics, University of Sydney, Sydney, Australia*
- ¹⁵¹*Institute of Physics, Academia Sinica, Taipei, Taiwan*
- ¹⁵²*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
- ¹⁵³*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
- ¹⁵⁴*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
- ¹⁵⁵*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
- ¹⁵⁶*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
- ¹⁵⁷*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
- ¹⁵⁸*Department of Physics, University of Toronto, Toronto, Ontario, Canada*
- ^{159a}*TRIUMF, Vancouver, British Columbia, Canada*
- ^{159b}*Department of Physics and Astronomy, York University, Toronto, Ontario, Canada*
- ¹⁶⁰*Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan*
- ¹⁶¹*Department of Physics and Astronomy, Tufts University, Medford, Massachusetts, USA*
- ¹⁶²*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
- ¹⁶³*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
- ^{164a}*INFN Gruppo Collegato di Udine, Udine, Italy*
- ^{164b}*ICTP, Trieste, Italy*
- ^{164c}*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*
- ¹⁶⁵*Department of Physics, University of Illinois, Urbana, Illinois, USA*
- ¹⁶⁶*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
- ¹⁶⁷*Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
- ¹⁶⁸*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada*
- ¹⁶⁹*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada*
- ¹⁷⁰*Department of Physics, University of Warwick, Coventry, United Kingdom*
- ¹⁷¹*Waseda University, Tokyo, Japan*
- ¹⁷²*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*
- ¹⁷³*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*
- ¹⁷⁴*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
- ¹⁷⁵*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
- ¹⁷⁶*Department of Physics, Yale University, New Haven, Connecticut, USA*
- ¹⁷⁷*Yerevan Physics Institute, Yerevan, Armenia*
- ¹⁷⁸*Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France*

^aDeceased.

^bAlso at Laboratorio de Instrumentacao e Fisica Experimental de Particulas-LIP, Lisboa, Portugal.

^cAlso at Faculdade de Ciencias and CFNUL, Universidade de Lisboa, Lisboa, Portugal.

^dAlso at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.

- ^eAlso at TRIUMF, Vancouver, British Columbia, Canada.
- ^fAlso at Department of Physics, California State University, Fresno, CA, USA.
- ^gAlso at Novosibirsk State University, Novosibirsk, Russia.
- ^hAlso at Fermilab, Batavia, IL, USA.
- ⁱAlso at Department of Physics, University of Coimbra, Coimbra, Portugal.
- ^jAlso at Department of Physics, UASLP, San Luis Potosi, Mexico.
- ^kAlso at Università di Napoli Parthenope, Napoli, Italy.
- ^lAlso at Institute of Particle Physics (IPP), Canada.
- ^mAlso at Department of Physics, Middle East Technical University, Ankara, Turkey.
- ⁿAlso at Louisiana Tech University, Ruston LA, USA.
- ^oAlso at Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal.
- ^pAlso at Department of Physics and Astronomy, University College London, London, United Kingdom.
- ^qAlso at Department of Physics, University of Cape Town, Cape Town, South Africa.
- ^rAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
- ^sAlso at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
- ^tAlso at Manhattan College, New York, NY, USA.
- ^uAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
- ^vAlso at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.
- ^wAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
- ^xAlso at School of Physics, Shandong University, Shandong, China.
- ^yAlso at Dipartimento di Fisica, Università La Sapienza, Roma, Italy.
- ^zAlso at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique), Gif-sur-Yvette, France.
- ^{aa}Also at Section de Physique, Université de Genève, Geneva, Switzerland.
- ^{bb}Also at Departamento de Física, Universidade de Minho, Braga, Portugal.
- ^{cc}Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.
- ^{dd}Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
- ^{ee}Also at California Institute of Technology, Pasadena, CA, USA.
- ^{ff}Also at Institute of Physics, Jagiellonian University, Krakow, Poland.
- ^{gg}Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.
- ^{hh}Also at Nevis Laboratory, Columbia University, Irvington, NY, USA.
- ⁱⁱAlso at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.
- ^{jj}Also at Department of Physics, Oxford University, Oxford, United Kingdom.
- ^{kk}Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
- ^{ll}Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.
- ^{mm}Also at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa.