



HAL
open science

Search for the lepton flavor violating decay $Z \rightarrow e\mu$ in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector

G. Aad, S. Albrand, J. Brown, J. Collot, S. Crépé-Renaudin, B. Dechenaux, P.A. Delsart, C. Gabaldon, M.H. Genest, J.Y. Hostachy, et al.

► To cite this version:

G. Aad, S. Albrand, J. Brown, J. Collot, S. Crépé-Renaudin, et al.. Search for the lepton flavor violating decay $Z \rightarrow e\mu$ in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector. *Physical Review D*, 2014, 90 (7), pp.072010. 10.1103/PhysRevD.90.072010 . in2p3-01058045

HAL Id: in2p3-01058045

<https://in2p3.hal.science/in2p3-01058045v1>

Submitted on 21 Sep 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



CERN-PH-EP-2014-195

Submitted to: Physical Review D

Search for the lepton flavor violating decay $Z \rightarrow e\mu$ in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector

The ATLAS Collaboration

Abstract

The ATLAS detector at the Large Hadron Collider is used to search for the lepton flavor violating process $Z \rightarrow e\mu$ in pp collisions using 20.3 fb^{-1} of data collected at $\sqrt{s} = 8$ TeV. An enhancement in the $e\mu$ invariant mass spectrum is searched for at the Z boson mass. The number of Z bosons produced in the data sample is estimated using events of similar topology, $Z \rightarrow ee$ and $\mu\mu$, significantly reducing the systematic uncertainty in the measurement. There is no evidence of an enhancement at the Z boson mass, resulting in an upper limit on the branching fraction, $\mathcal{B}(Z \rightarrow e\mu) < 7.5 \times 10^{-7}$ at the 95% confidence level.

Search for the lepton flavor violating decay $Z \rightarrow e\mu$ in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector

The ATLAS Collaboration

The ATLAS detector at the Large Hadron Collider is used to search for the lepton flavor violating process $Z \rightarrow e\mu$ in pp collisions using 20.3 fb^{-1} of data collected at $\sqrt{s} = 8$ TeV. An enhancement in the $e\mu$ invariant mass spectrum is searched for at the Z boson mass. The number of Z bosons produced in the data sample is estimated using events of similar topology, $Z \rightarrow ee$ and $\mu\mu$, significantly reducing the systematic uncertainty in the measurement. There is no evidence of an enhancement at the Z boson mass, resulting in an upper limit on the branching fraction, $\mathcal{B}(Z \rightarrow e\mu) < 7.5 \times 10^{-7}$ at the 95% confidence level.

I. INTRODUCTION

Lepton flavor conservation in the charged lepton sector is a fundamental assumption of the Standard Model (SM) but there is no associated symmetry. Thus, searches for lepton flavor violation (LFV) processes are good candidates for probing new physics. The observation of neutrino oscillations is a clear indication of LFV in the neutral lepton sector; however such an oscillation mechanism cannot induce observable LFV in the charged lepton sector. All searches in the charged lepton sector have produced null results so far [1]. Lepton flavor violation in the charged lepton sector may have a different origin than LFV induced by neutrino oscillations and the search for this effect provides constraints on theories beyond the SM (see for example Refs. [2–4]).

In this paper, a search for the lepton flavor violating decay $Z \rightarrow e\mu$ is presented. There are stringent experimental limits on other charged lepton flavor violating processes, which can be used to derive an upper limit on the branching fraction for $Z \rightarrow e\mu$ with some theoretical assumptions. For example, the upper limit on $\mu \rightarrow 3e$ yields $\mathcal{B}(Z \rightarrow e\mu) < 10^{-12}$ [5] and on $\mu \rightarrow e\gamma$ yields $\mathcal{B}(Z \rightarrow e\mu) < 10^{-10}$ [6]. The experiments at the Large Electron-Positron Collider (LEP) searched directly for the decay $Z \rightarrow e\mu$ [7–10]. The most stringent upper limit is $\mathcal{B}(Z \rightarrow e\mu) < 1.7 \times 10^{-6}$ at the 95% confidence level (CL) using a data sample of 5.0×10^6 Z bosons produced in e^+e^- collisions at $\sqrt{s} = 88\text{--}94$ GeV [7]. The Large Hadron Collider (LHC) has already produced many more Z bosons in pp collisions, but with substantially more background. In this paper, the $20.3 \pm 0.6 \text{ fb}^{-1}$ [11] of data collected at $\sqrt{s} = 8$ TeV by the ATLAS experiment corresponds to 7.8×10^8 Z bosons produced. Despite the larger background at the LHC, a more restrictive direct limit on the $Z \rightarrow e\mu$ decay is reported in this paper.

II. ATLAS DETECTOR

The ATLAS detector [12] consists of an inner detector (ID) surrounded by a solenoid that produces a 2 T magnetic field, electromagnetic and hadronic calorimeters, and a muon spectrometer (MS) immersed in a magnetic field produced by a system of toroids. The ID mea-

sures the trajectories of charged particles over the full azimuthal angle and in a pseudorapidity [13] range of $|\eta| < 2.5$ using silicon pixel, silicon microstrip, and straw-tube transition-radiation tracker (TRT) detectors. Liquid-argon (LAr) electromagnetic (EM) sampling calorimeters cover the range $|\eta| < 3.2$ and a scintillator-tile calorimeter provides hadronic calorimetry for $|\eta| < 1.7$. In the endcaps ($|\eta| > 1.5$), LAr is also used for the hadronic calorimeters, matching the outer $|\eta|$ limit of endcap electromagnetic calorimeters. The LAr forward calorimeters extend the coverage to $|\eta| < 4.9$ and provide both the electromagnetic and hadronic energy measurements. The MS measures the deflection of muons within $|\eta| < 2.7$ using three stations of precision drift tubes (with cathode strip chambers in the innermost station for $|\eta| > 2.0$) and provides separate trigger measurements from dedicated chambers in the region $|\eta| < 2.4$.

A three-level trigger system is used to select interesting events to be recorded for subsequent offline analysis [14]. For this analysis, the candidate events of interest are required to satisfy either a single electron or a single muon trigger that have transverse momentum (p_T) thresholds of 24 GeV.

III. ANALYSIS STRATEGY

The event selection requires two high- p_T isolated, oppositely charged leptons of different flavor: $e^\pm\mu^\mp$. Events are required to contain little jet energy (i.e. small $p_{T\text{max}}^{\text{jet}}$, the maximum transverse momentum of any jet in an event) and small missing transverse momentum (with magnitude E_T^{miss}). The former eliminates background processes such as $t\bar{t} \rightarrow e\mu\nu\bar{\nu}b\bar{b}$ while the latter rejects $WW \rightarrow e\mu\nu\bar{\nu}$. These $p_{T\text{max}}^{\text{jet}}$ and E_T^{miss} requirements are chosen to maximize the Monte Carlo (MC) simulated signal efficiency divided by the square root of the number of candidate background events in the data. Further details of this procedure are given in Sec. VI. After all selection criteria are applied, the dominant background process is $Z \rightarrow \tau\tau \rightarrow e\mu\nu\bar{\nu}\nu\bar{\nu}$, which has an $e\mu$ invariant mass ($m_{e\mu}$) spectrum extending into the Z signal region.

An excess of events above the background expectation is searched for in the $m_{e\mu}$ spectrum at the Z boson mass. The number of $Z \rightarrow e\mu$ candidates is estimated

by fitting the $m_{e\mu}$ spectrum. The expected signal shape is obtained from MC simulation, while the background is parameterized using a Chebychev polynomial. The branching fraction is obtained from the ratio of the number of observed $Z \rightarrow e\mu$ candidates to the number of observed $Z \rightarrow \ell\ell$ events in the data in the mass range $70 < m_{\ell\ell} < 110$ GeV, where $\ell = e, \mu$. These $Z \rightarrow ee$ and $\mu\mu$ samples are selected with the same selection criteria, resulting in the cancellation of the majority of systematic uncertainties due to electron, muon, and jet reconstruction and modeling. The simulated events are used to cross-check the background level in data and to calculate the selection efficiency for $Z \rightarrow e\mu/ee/\mu\mu$. All selection requirements were fixed before analyzing the data in the Z signal region from 85 to 95 GeV.

IV. MONTE CARLO SAMPLES

Monte Carlo simulated samples normalized to the data integrated luminosity are used to determine the major backgrounds pertinent to this analysis as well as to determine the optimal E_T^{miss} and $p_{T\text{max}}^{\text{jet}}$ requirements. All MC samples are produced using the ATLAS detector simulation [15] based on GEANT4 [16]. Signal $Z \rightarrow e\mu$ MC events are produced with POWHEG-BOX r1556 [17] using the CT10 parton distribution function (PDF) [18] and the AU2 set of tunable parameters (tune) [19] along with PYTHIA 8.175 [20] for parton showering, hadronization and underlying event simulation. To ensure proper normalization of the upper limit to the number of $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ events, these events are simulated using the same generator as for the signal simulation. In practice, the $Z \rightarrow e\mu$ sample is created from a $Z \rightarrow ee$ sample by replacing one of the electrons by a muon at the generator level. The $Z \rightarrow \tau\tau$ and W samples are simulated with ALPGEN 2.13 [21] interfaced to HERWIG 6.520.2 and PYTHIA 6.426 [22], respectively, using the CTEQ6L1 PDF [23] with the AUET2 tune [24]. The three diboson backgrounds, $q\bar{q} \rightarrow WW$, $gg \rightarrow WW$, and WZ , are simulated with the CT10 PDF using MC@NLO 4.0 [25] with the AUET2 tune, GG2WW [26] with the AUET2 tune, and POWHEG-BOX interfaced to PYTHIA 8.165 with the AU2 tune, respectively. The top quark backgrounds, $t\bar{t}$ and single top quark production, are simulated with MC@NLO 4.0 and AcerMC 3.8 [27] interfaced to HERWIG 6.520.2 and PYTHIA 6.426, respectively, for parton showering and fragmentation. An average of 20 additional pp collisions per event in the same bunch crossing, known as pileup, are included in each event to match the data.

V. OBJECT SELECTION

Candidate electrons must have $p_T^e > 25$ GeV and, to ensure the shower is well contained in the high-granularity region of the EM calorimeter, $|\eta^e| < 2.47$ [28].

The candidate must not be in the transition region between the barrel and endcap calorimeters, $1.37 < |\eta^e| < 1.52$. The impact parameters of the candidate must also be consistent with originating from the primary vertex, defined as the reconstructed vertex with the largest sum of track p_T^2 , constructed from at least three tracks each with $p_T > 400$ MeV. The longitudinal impact parameter, z_0 , measured with respect to the primary vertex, of the candidate must satisfy $|z_0 \sin \theta| < 0.5$ mm and the transverse impact parameter, d_0 , must satisfy $|d_0| < 6\sigma_{d_0}$, where σ_{d_0} is the uncertainty of the impact parameter. The electron candidate must be isolated from other event activity by requiring the sum of the transverse momentum of tracks with $p_T > 1$ GeV in a cone of size $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2} = 0.2$ around the candidate to satisfy $\Sigma p_T(\Delta R < 0.2)/p_T^e < 0.13$. In the calorimeter, the sum of the transverse energy deposits in the calorimeter clusters in a cone of size $\Delta R = 0.2$ around the candidate must satisfy $\Sigma E_T(\Delta R < 0.2)/p_T^e < 0.14$. Candidates must also satisfy the “tight” identification requirements of Ref. [28], which are based on calorimeter shower shape, ID track quality, and the spatial match between the shower and the track.

Muon candidates must have $p_T^\mu > 25$ GeV and $|\eta^\mu| < 2.5$ to ensure coverage by the ID. Muons are required to have a high-quality TRT track segment if they are within the detector acceptance of the TRT. To ensure the muon originated from the primary vertex, the distances of closest approach to the primary vertex in both z and the transverse plane must satisfy $|z_0 \sin \theta| < 0.5$ mm and $|d_0| < 3\sigma_{d_0}$, respectively. To reject secondary muons from hadronic jets, the ID track used in the muon reconstruction must be isolated by requiring the sum of the p_T of the tracks around the muon candidate to satisfy $\Sigma p_T(\Delta R < 0.2)/p_T^\mu < 0.15$. In the calorimeter, there should be little activity around the muon candidate by requiring the sum of the E_T around the muon candidate to satisfy $\Sigma E_T(\Delta R < 0.2)/p_T^\mu < 0.3$. Candidates must also satisfy the “tight” identification requirements of Ref. [29] and have their MS track matched to the ID track [30].

Hadronic jets [31] are reconstructed using the anti- k_t algorithm with distance parameter $R = 0.4$ [32]. The scalar sum of p_T of tracks associated with the jet which come from the primary vertex, divided by the scalar sum of p_T of all tracks associated with the jet, must be greater than 50% for jets with $|\eta| < 2.4$ and $p_T < 50$ GeV to remove jets originating from pileup in the central region. The rapidity [33] of jets must satisfy $|y| < 4.4$. Finally, only jets with $p_T > 20$ GeV are considered in the event selection.

The E_T^{miss} is defined as the p_T imbalance in the detector. It is formed from the vector sum of the p_T of reconstructed high- p_T objects—electrons, photons, jets, τ leptons, and muons—as well as energy deposits not associated with any reconstructed objects [34].

VI. EVENT SELECTION

A Z candidate is constructed from two opposite sign, different flavor leptons (e or μ). Electron candidates are vetoed if they are within $\Delta R = 0.1$ of a candidate muon. Jets are removed if they are within $\Delta R = 0.3$ of a candidate lepton. Events with more than two candidate leptons are vetoed, as are events with an additional electron or muon that passed the lepton requirements but is not isolated.

As stated above, the selection criteria for E_T^{miss} and $p_{T_{\text{max}}}^{\text{jet}}$ are chosen to maximize the reconstruction efficiency divided by the square root of the estimated number of background events. The efficiency for selecting $e\mu$ candidates is calculated using MC signal events in the Z signal region, $85 < m_{e\mu} < 95$ GeV. The background is determined by fitting the $m_{e\mu}$ spectrum in data in the mass range $70 < m_{e\mu} < 110$ GeV, excluding the Z signal region, and then interpolating the fitted curve into the Z signal region to estimate the number of background events. The fitting range is chosen so that the $m_{e\mu}$ spectrum can be parameterized with a polynomial. In particular, the lower $m_{e\mu}$ limit is chosen to be above the peak in the $Z \rightarrow \tau\tau \rightarrow e\mu$ mass distribution. The optimum selection criteria are found to be $E_T^{\text{miss}} < 17$ GeV and $p_{T_{\text{max}}}^{\text{jet}} < 30$ GeV.

Several background functions with a small number of free parameters in the fit were investigated before analyzing (“unblinding”) the events in the Z mass region. This includes Chebychev polynomials of 2nd to 4th-orders, a Landau function, and an exponential function plus a linear term. The 2nd-order polynomial has an unacceptable χ^2 per degree of freedom, $\chi^2/\text{DOF} = 3.3$. All other functions have $\chi^2/\text{DOF} \sim 1$. The 3rd-order polynomial is chosen as the default background function for simplicity. The systematic error due to the choice of fitting functions is discussed below.

The E_T^{miss} and $p_{T_{\text{max}}}^{\text{jet}}$ distributions in the data are compared with the expectation for a MC simulation of the background and signal in Fig. 1. Each plot has all kinematic cuts applied with the exception of the cut on the kinematic variable being shown—as indicated by the vertical lines and arrows. The signal MC is scaled to the 95% CL upper limit presented in Sec. VII. The multijet background in these distributions refers to events where at least two jets are misidentified as leptons. The shape and normalization of this background can be estimated from like-sign $e\mu$ candidates in the data. The contributions to the same-sign distribution from top quark and W/Z events are estimated using simulation (Sec. IV) and subtracted from the same-sign data.

The E_T^{miss} distribution of $e\mu$ candidate events is shown in Fig. 1(a). The E_T^{miss} requirement removes most of the diboson background while retaining the majority of the simulated signal events. The distribution of the $p_{T_{\text{max}}}^{\text{jet}}$ of the candidate events is shown in Fig. 1(b). The entries in the first bin correspond to events that have no jets passing the jet selection requirements described in Sec. V.

The jet veto eliminates most of the $t\bar{t}$ background while maintaining a high reconstruction efficiency for $Z \rightarrow e\mu$. The remaining major backgrounds in the Z signal region are diboson, multijet, $Z \rightarrow \tau\tau$, and $Z \rightarrow \mu\mu$. For the $Z \rightarrow \mu\mu$ background, one of the muons can interact with the detector material leading to the muon being misidentified as an electron due to its overlap with a bremsstrahlung photon. The E_T^{miss} and the $p_{T_{\text{max}}}^{\text{jet}}$ distributions of the background are well reproduced by the MC simulation. However, in extracting the upper limit on the branching fraction for $Z \rightarrow e\mu$, the background is estimated from the data instead of using MC simulation.

VII. RESULT

The $m_{e\mu}$ distribution with the background expectations superimposed is shown in Fig. 2. The mass spectrum is consistent with the MC background expectation with no evidence of an enhancement at the Z mass. The mass spectrum is fit as a sum of signal and background contributions as shown in Fig. 3. The signal shape is a binned histogram obtained from the signal MC sample and the absolute normalization is a free parameter in the fit. The background is a 3rd-order Chebychev polynomial function. The fit yields a signal of 4 ± 35 events.

The upper limit on $\mathcal{B}(Z \rightarrow e\mu)$ is given by

$$\mathcal{B}(Z \rightarrow e\mu) < \frac{N_{95\%}}{\epsilon_{e\mu} N_Z}, \quad (1)$$

where $N_{95\%}$ is the upper limit on the number of $Z \rightarrow e\mu$ candidate events at 95% CL, $\epsilon_{e\mu}$ is the reconstruction efficiency for a $Z \rightarrow e\mu$ event, and N_Z is an estimate of the total number of Z bosons produced in the data sample. This estimate is obtained from the weighted average of two measurements. One is the number of Z bosons produced as calculated from the number of $Z \rightarrow ee$ events detected in the data, after correcting for the reconstruction efficiency and branching fraction [35]. The other is calculated with the same procedure using the $Z \rightarrow \mu\mu$ channel. The numbers of ee and $\mu\mu$ events are estimated by counting the candidates with dilepton invariant mass in the region $70 < m_{\ell\ell} < 110$ GeV. The reconstruction efficiencies are estimated using MC simulation, calibrated with Z candidates using the tag-and-probe method [28, 30]. The result is summarized in Table I. The weight of each measurement is given by the total uncertainty, the quadratic sum of the statistical and systematic uncertainties. The systematic uncertainties include the uncertainties in the electron and muon reconstruction and trigger efficiencies and the absolute scale and resolution of the electron energy and muon p_T [30, 36]. These systematic uncertainties are uncorrelated between ee and $\mu\mu$ events. Other systematic uncertainties such as those due to imperfect simulation of the E_T^{miss} and $p_{T_{\text{max}}}^{\text{jet}}$ distributions are correlated for the $e\mu$, ee , and $\mu\mu$ channels and cancel in the ratio (Eq. (1)), although they are

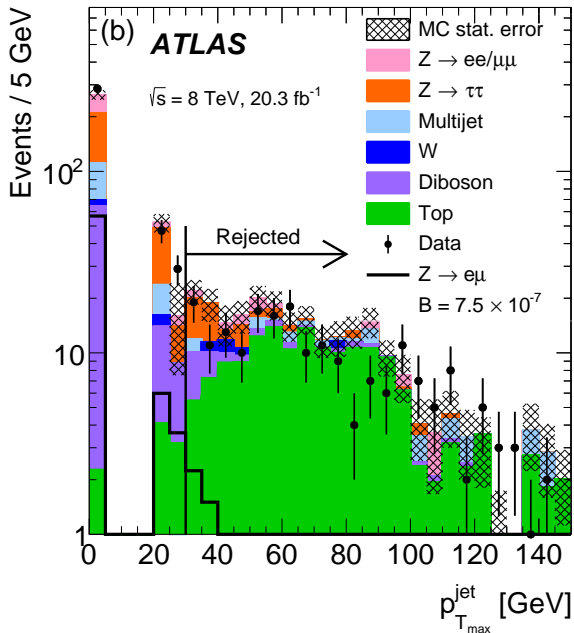
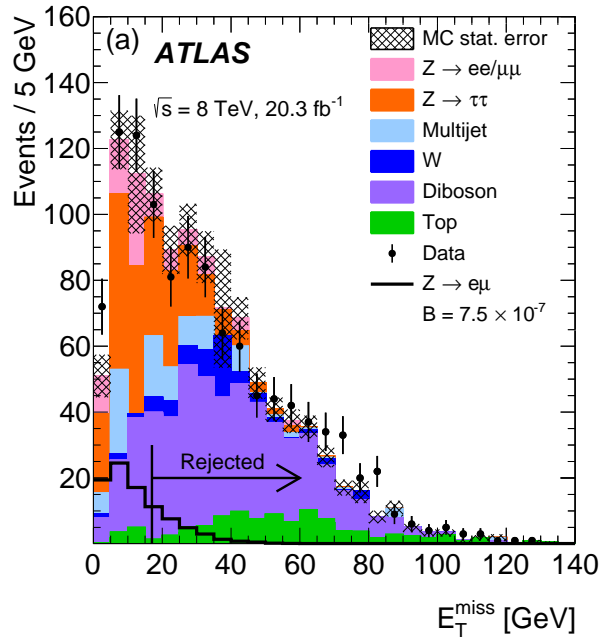


FIG. 1. Distributions of (a) E_T^{miss} and (b) $p_{T_{\text{max}}}^{\text{jet}}$ for $Z \rightarrow e\mu$ candidate events with $85 < m_{e\mu} < 95$ GeV. The expectations for backgrounds from various sources are shown as stacked histograms. Each plot has all cuts applied except for the kinematic variable being shown. The vertical lines and arrows indicate the E_T^{miss} and $p_{T_{\text{max}}}^{\text{jet}}$ requirements. The hatched bands show the total statistical uncertainty of the backgrounds. The expected distribution of $Z \rightarrow e\mu$ signal events, normalized to the upper limit on the branching fraction ($\mathcal{B}(Z \rightarrow e\mu) = 7.5 \times 10^{-7}$), is indicated by a black line. The entries at zero in the $p_{T_{\text{max}}}^{\text{jet}}$ distribution correspond to events with no jets that satisfy the jet selection.

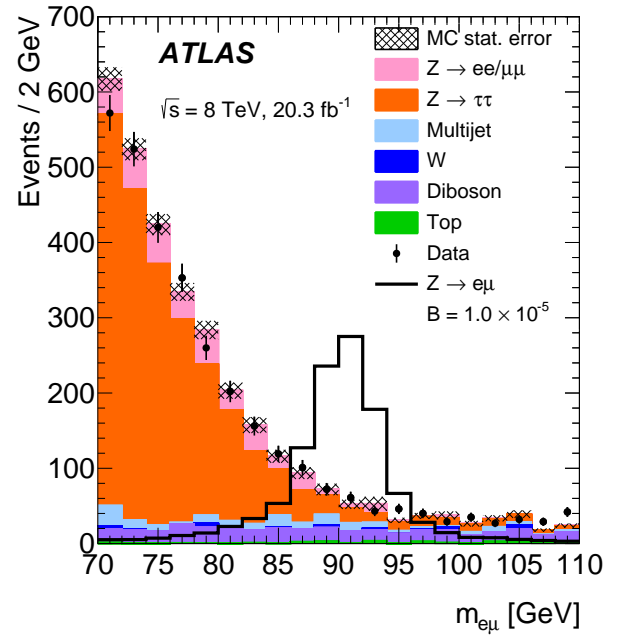


FIG. 2. The $e\mu$ invariant mass distribution in data with the background expectations from various processes after all cuts applied. The hatched bands show the total statistical uncertainty of backgrounds. The expected distribution of $Z \rightarrow e\mu$ signal events, normalized to 13 times the upper limit on the branching fraction ($13 \times \mathcal{B}(Z \rightarrow e\mu) = 1.0 \times 10^{-5}$), is indicated by a black line.

major contributors to the systematic uncertainties shown in Table I before the cancellation. With the cancellation, the systematic uncertainty on $\mathcal{B}(Z \rightarrow e\mu)$ is 1.2%, small compared to the overall fitting systematic uncertainty, and is neglected in the final result.

TABLE I. The reconstruction efficiencies for $Z \rightarrow e\mu$, ee , and $\mu\mu$ events are shown. Also shown are the number of Z bosons produced, N_Z , as estimated from the number of $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ events, after correcting for the corresponding reconstruction efficiencies and branching fractions, as well as the weighted average. The total uncertainties are given.

Z decay	Efficiency (%)	N_Z (10^8)
ee	10.8 ± 0.3	7.85 ± 0.24
$\mu\mu$	17.8 ± 0.4	7.79 ± 0.17
$\langle ee, \mu\mu \rangle$		7.80 ± 0.15
$e\mu$	14.2 ± 0.4	

A one-sided Profile Likelihood [37] is used as a test statistic to calculate an upper limit on the number of signal events using the CL_s procedure [38]. The procedure yields an observed 95% CL upper limit of 72 events. This is consistent with the expected upper limit of 69 events obtained by generating pseudo-experiments from the observed background spectrum. For the pseudo-experiments, the observed data distribution in the sideband is fitted with a 3rd-order Chebychev polynomial and

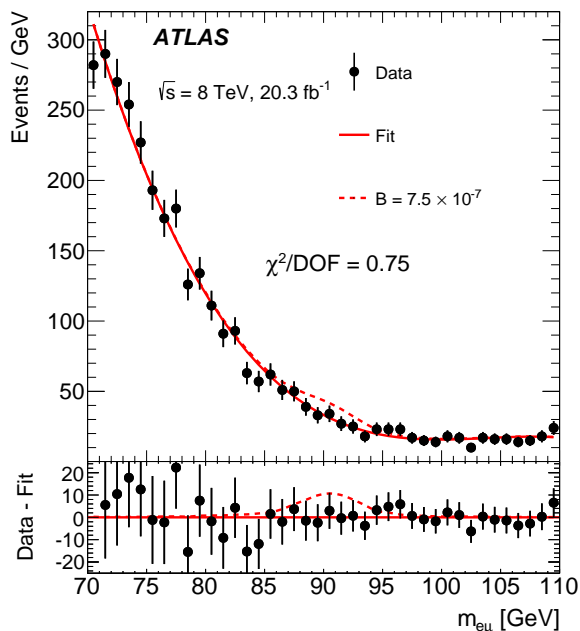


FIG. 3. The $e\mu$ invariant mass distribution fitted with a signal shape obtained from MC simulation and a 3rd-order Chebychev polynomial to describe the background (solid). The observed 95% CL upper limit (dashed) is indicated ($\mathcal{B}(Z \rightarrow e\mu) = 7.5 \times 10^{-7}$). The lower plot shows the data with the background component of the fit subtracted.

the fitted function is then interpolated into the signal region to predict the central value for the number of background events in each bin. The central value of the background events in the background region or interpolated data for the signal region is then fluctuated.

There is a systematic uncertainty due to the choice of fitting function used to estimate the background and the associated fitting region (Sec. VI). The upper and lower limits of the fit region are varied in the ranges 100–120 GeV and 70–80 GeV in 5 GeV increments. The background parameterization that yields the largest upper limit on the number of signal events (83 events) is used to set an upper limit on the branching fraction at the 95% confidence level,

$$\mathcal{B}(Z \rightarrow e\mu) < 7.5 \times 10^{-7}. \quad (2)$$

VIII. CONCLUSIONS

A search for the lepton flavor violating process $Z \rightarrow e\mu$ in pp collisions is performed with the ATLAS detector at the LHC. There is no evidence of an enhancement at the Z boson mass in the $m_{e\mu}$ spectrum for the dataset with an integrated luminosity of 20.3 fb^{-1} at $\sqrt{s} = 8 \text{ TeV}$. Using the CL_s method with a one-sided Profile Likelihood as a test statistic, an upper limit of 83 signal events

at 95% CL is found. This leads to an upper limit on the branching fraction of $\mathcal{B}(Z \rightarrow e\mu) < 7.5 \times 10^{-7}$ at 95% CL, significantly more restrictive than that from the LEP experiments.

ACKNOWLEDGMENTS

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, ERC and NSRF, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT and NSRF, Greece; ISF, MINERVA, GIF, I-CORE and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW and NCN, Poland; GRICES and FCT, Portugal; MNE/IFA, Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTP, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MINECO, 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 (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

-
- [1] S. Mihara, J. Miller, P. Paradisi, and G. Piredda, *Ann. Rev. Nucl. Part. Sci.* **63**, 531 (2013).
- [2] G.-J. Ding and M.-L. Yan, *Phys. Rev. D* **77**, 014005 (2008), arXiv:0709.3435 [hep-ph].
- [3] B. Gripaios, *J. High Energy Phys.* **1002**, 045 (2010), arXiv:0910.1789 [hep-ph].
- [4] M. Hirsch, A. Vicente, J. Meyer, and W. Porod, *Phys. Rev. D* **79**, 055023 (2009), arXiv:0902.0525 [hep-ph].
- [5] D. Dinh, A. Ibarra, E. Molinaro, and S. Petcov, *J. High Energy Phys.* **1208**, 125 (2012), arXiv:1205.4671 [hep-ph].
- [6] S. Davidson, S. Lacroix, and P. Verdier, *J. High Energy Phys.* **1209**, 092 (2012), arXiv:1207.4894 [hep-ph].
- [7] OPAL Collaboration, R. Akers *et al.*, *Z. Phys. C* **67**, 555 (1995).
- [8] DELPHI Collaboration, P. Abreu *et al.*, *Z. Phys. C* **73**, 243 (1997).
- [9] L3 Collaboration, O. Adriani *et al.*, *Phys. Lett. B* **316**, 427 (1993).
- [10] ALEPH Collaboration, D. Decamp *et al.*, *Phys. Rept.* **216**, 253 (1992).
- [11] ATLAS Collaboration, *Eur. Phys. J. C* **73**, 2518 (2013), arXiv:1302.4393 [hep-ex].
- [12] ATLAS Collaboration, *JINST* **3**, S08003 (2008).
- [13] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the center of the detector and the z -axis along the beam pipe. The x -axis points from the IP to the center of the LHC ring, and the y -axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln \tan(\theta/2)$. Transverse momentum and energy are defined relative to the beamline as $p_T = p \sin \theta$ and $E_T = E \sin \theta$.
- [14] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1849 (2012), arXiv:1110.1530 [hep-ex].
- [15] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010), arXiv:1005.4568 [physics.ins-det].
- [16] GEANT4 Collaboration, S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
- [17] T. Melia, P. Nason, R. Rontsch, and G. Zanderighi, *J. High Energy Phys.* **1111**, 078 (2011), arXiv:1107.5051 [hep-ph].
- [18] J. Gao *et al.*, *Phys. Rev. D* **89**, 033009 (2014), arXiv:1302.6246 [hep-ph].
- [19] ATLAS Collaboration, ATL-PHYS-PUB-2012-003, <http://cds.cern.ch/record/1474107>.
- [20] T. Sjostrand, S. Mrenna, and P. Z. Skands, *Comput. Phys. Commun.* **178**, 852 (2008), arXiv:0710.3820 [hep-ph].
- [21] M. L. Mangano, M. Moretti, F. Piccinini, R. Pittau, and A. D. Polosa, *J. High Energy Phys.* **0307**, 001 (2003), arXiv:hep-ph/0206293.
- [22] T. Sjostrand, S. Mrenna, and P. Z. Skands, *J. High Energy Phys.* **0605**, 026 (2006), arXiv:hep-ph/0603175.
- [23] J. Pumplin *et al.*, *J. High Energy Phys.* **0207**, 012 (2002), arXiv:hep-ph/0201195.
- [24] ATLAS Collaboration, ATL-PHYS-PUB-2011-008, <http://cds.cern.ch/record/1345343>.
- [25] S. Frixione and B. R. Webber, *J. High Energy Phys.* **0206**, 029 (2002), arXiv:hep-ph/0204244.
- [26] T. Binoth, M. Ciccolini, N. Kauer, and M. Kramer, *J. High Energy Phys.* **0612**, 046 (2006), arXiv:hep-ph/0611170.
- [27] B. P. Kersevan and E. Richter-Was, *Comput. Phys. Commun.* **184**, 919 (2013), arXiv:hep-ph/0405247.
- [28] ATLAS Collaboration, *Eur. Phys. J. C* **74**, 2941 (2014), arXiv:1404.2240 [hep-ex].
- [29] ATLAS Collaboration, *J. High Energy Phys.* **1012**, 060 (2010), arXiv:1010.2130 [hep-ex].
- [30] ATLAS Collaboration, arXiv:1404.4562 [hep-ex], Submitted to *Eur. Phys. J. C*.
- [31] ATLAS Collaboration, *Eur. Phys. J. C* **73**, 2304 (2013), arXiv:1112.6426 [hep-ex].
- [32] M. Cacciari, G. P. Salam, and G. Soyez, *J. High Energy Phys.* **0804**, 063 (2008), arXiv:0802.1189 [hep-ph].
- [33] The rapidity is defined in terms of the energy, E , and the z -component of the momentum along the beam axis, p_z as $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$.
- [34] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1844 (2012), arXiv:1108.5602 [hep-ex].
- [35] Particle Data Group, J. Beringer *et al.*, *Phys. Rev. D* **86**, 010001 (2012).
- [36] ATLAS Collaboration, arXiv:1407.5063 [hep-ex], Submitted to *Eur. Phys. J. C*.
- [37] L. Moneta *et al.*, PoS **ACAT2010**, 057 (2010), arXiv:1009.1003 [physics.data-an].
- [38] A. L. Read, *J. Phys. G* **28**, 2693 (2002).

The ATLAS Collaboration

G. Aad⁸⁵, B. Abbott¹¹³, J. Abdallah¹⁵³, S. Abdel Khalek¹¹⁷, O. Abdinov¹¹, R. Aben¹⁰⁷, B. Abi¹¹⁴, M. Abolins⁹⁰, O.S. AbouZeid¹⁶⁰, H. Abramowicz¹⁵⁵, H. Abreu¹⁵⁴, R. Abreu³⁰, Y. Abulaiti^{148a,148b}, B.S. Acharya^{166a,166b,a}, L. Adamczyk^{38a}, D.L. Adams²⁵, J. Adelman¹⁷⁸, S. Adomeit¹⁰⁰, T. Adye¹³¹, T. Agatonovic-Jovin^{13a}, J.A. Aguilar-Saavedra^{126a,126f}, M. Agustoni¹⁷, S.P. Ahlen²², F. Ahmadov^{65,b}, G. Aielli^{135a,135b}, H. Akerstedt^{148a,148b}, T.P.A. Åkesson⁸¹, G. Akimoto¹⁵⁷, A.V. Akimov⁹⁶, G.L. Alberghi^{20a,20b}, J. Albert¹⁷¹, S. Albrand⁵⁵, M.J. Alconada Verzini⁷¹, M. Aleksa³⁰, I.N. Aleksandrov⁶⁵, C. Alexa^{26a}, G. Alexander¹⁵⁵, G. Alexandre⁴⁹, T. Alexopoulos¹⁰, M. Alhroob^{166a,166c}, G. Alimonti^{91a}, L. Alio⁸⁵, J. Alison³¹, B.M.M. Allbrooke¹⁸, L.J. Allison⁷², P.P. Allport⁷⁴, A. Aloisio^{104a,104b}, A. Alonso³⁶, F. Alonso⁷¹, C. Alpigiani⁷⁶, A. Altheimer³⁵, B. Alvarez Gonzalez⁹⁰, M.G. Alviggi^{104a,104b}, K. Amako⁶⁶, Y. Amaral Coutinho^{24a}, C. Amelung²³, D. Amidei⁸⁹, S.P. Amor Dos Santos^{126a,126c}, A. Amorim^{126a,126b}, S. Amoroso⁴⁸, N. Amram¹⁵⁵, G. Amundsen²³, C. Anastopoulos¹⁴¹, L.S. Ancu⁴⁹, N. Andari³⁰, T. Andeen³⁵, C.F. Anders^{58b}, G. Anders³⁰, K.J. Anderson³¹, A. Andreazza^{91a,91b}, V. Andrei^{58a}, X.S. Anduaga⁷¹, S. Angelidakis⁹, I. Angelozzi¹⁰⁷, P. Anger⁴⁴, A. Angerami³⁵, F. Anghinolfi³⁰, A.V. Anisenkov^{109,c}, N. Anjos¹², A. Annovi⁴⁷, A. Antonaki⁹, M. Antonelli⁴⁷, A. Antonov⁹⁸, J. Antos^{146b}, F. Anulli^{134a}, M. Aoki⁶⁶, L. Aperio Bella¹⁸, R. Apolle^{120,d}, G. Arabidze⁹⁰, I. Aracena¹⁴⁵, Y. Arai⁶⁶, J.P. Araque^{126a}, A.T.H. Arce⁴⁵, J-F. Arguin⁹⁵, S. Argyropoulos⁴², M. Arik^{19a}, A.J. Armbruster³⁰, O. Arnaez³⁰, V. Arnal⁸², H. Arnold⁴⁸, M. Arratia²⁸, O. Arslan²¹, A. Artamonov⁹⁷, G. Artoni²³, S. Asai¹⁵⁷, N. Asbah⁴², A. Ashkenazi¹⁵⁵, B. Åsman^{148a,148b}, L. Asquith⁶, K. Assamagan²⁵, R. Astalos^{146a}, M. Atkinson¹⁶⁷, N.B. Atlay¹⁴³, B. Auerbach⁶, K. Augsten¹²⁸, M. Auresseau^{147b}, G. Avolio³⁰, G. Azuelos^{95,e}, Y. Azuma¹⁵⁷, M.A. Baak³⁰, A.E. Baas^{58a}, C. Bacci^{136a,136b}, H. Bachacou¹³⁸, K. Bachas¹⁵⁶, M. Backes³⁰, M. Backhaus³⁰, J. Backus Mayes¹⁴⁵, E. Badescu^{26a}, P. Bagiacchi^{134a,134b}, P. Bagnaia^{134a,134b}, Y. Bai^{33a}, T. Bain³⁵, J.T. Baines¹³¹, O.K. Baker¹⁷⁸, P. Balek¹²⁹, F. Balli¹³⁸, E. Banas³⁹, Sw. Banerjee¹⁷⁵, A.A.E. Bannoura¹⁷⁷, V. Bansal¹⁷¹, H.S. Bansil¹⁸, L. Barak¹⁷⁴, S.P. Baranov⁹⁶, E.L. Barberio⁸⁸, D. Barberis^{50a,50b}, M. Barbero⁸⁵, T. Barillari¹⁰¹, M. Barisonzi¹⁷⁷, T. Barklow¹⁴⁵, N. Barlow²⁸, B.M. Barnett¹³¹, R.M. Barnett¹⁵, Z. Barnovska⁵, A. Baroncelli^{136a}, G. Barone⁴⁹, A.J. Barr¹²⁰, F. Barreiro⁸², J. Barreiro Guimarães da Costa⁵⁷, R. Bartoldus¹⁴⁵, A.E. Barton⁷², P. Bartos^{146a}, V. Bartsch¹⁵¹, A. Bassalat¹¹⁷, A. Basye¹⁶⁷, R.L. Bates⁵³, J.R. Batley²⁸, M. Battaglia¹³⁹, M. Battistin³⁰, F. Bauer¹³⁸, H.S. Bawa^{145,f}, M.D. Beattie⁷², T. Beau⁸⁰, P.H. Beauchemin¹⁶³, R. Beccherle^{124a,124b}, P. Bechtel²¹, H.P. Beck¹⁷, K. Becker¹⁷⁷, S. Becker¹⁰⁰, M. Beckingham¹⁷², C. Becot¹¹⁷, A.J. Beddall^{19c}, A. Beddall^{19c}, S. Bedikian¹⁷⁸, V.A. Bednyakov⁶⁵, C.P. Bee¹⁵⁰, L.J. Beemster¹⁰⁷, T.A. Beermann¹⁷⁷, M. Begel²⁵, K. Behr¹²⁰, C. Belanger-Champagne⁸⁷, P.J. Bell⁴⁹, W.H. Bell⁴⁹, G. Bella¹⁵⁵, L. Bellagamba^{20a}, A. Bellerive²⁹, M. Bellomo⁸⁶, K. Belotskiy⁹⁸, O. Beltramello³⁰, O. Benary¹⁵⁵, D. Bencheekroun^{137a}, K. Bendtz^{148a,148b}, N. Benekos¹⁶⁷, Y. Benhammou¹⁵⁵, E. Benhar Nocchioli⁴⁹, J.A. Benitez Garcia^{161b}, D.P. Benjamin⁴⁵, J.R. Bensinger²³, K. Benslama¹³², S. Bentvelsen¹⁰⁷, D. Berge¹⁰⁷, E. Bergeaas Kuutmann¹⁶, N. Berger⁵, F. Berghaus¹⁷¹, J. Beringer¹⁵, C. Bernard²², P. Bernat⁷⁸, C. Bernius⁷⁹, F.U. Bernlochner¹⁷¹, T. Berry⁷⁷, P. Berta¹²⁹, C. Bertella⁸⁵, G. Bertoli^{148a,148b}, F. Bertolucci^{124a,124b}, C. Bertsche¹¹³, D. Bertsche¹¹³, M.I. Besana^{91a}, G.J. Besjes¹⁰⁶, O. Bessidskaia^{148a,148b}, M. Bessner⁴², N. Besson¹³⁸, C. Betancourt⁴⁸, S. Bethke¹⁰¹, W. Bhimji⁴⁶, R.M. Bianchi¹²⁵, L. Bianchini²³, M. Bianco³⁰, O. Biebel¹⁰⁰, S.P. Bieniek⁷⁸, K. Bierwagen⁵⁴, J. Biesiada¹⁵, M. Biglietti^{136a}, J. Bilbao De Mendizabal⁴⁹, H. Bilokon⁴⁷, M. Bindi⁵⁴, S. Binet¹¹⁷, A. Bingul^{19c}, C. Bini^{134a,134b}, C.W. Black¹⁵², J.E. Black¹⁴⁵, K.M. Black²², D. Blackburn¹⁴⁰, R.E. Blair⁶, J.-B. Blanchard¹³⁸, T. Blazek^{146a}, I. Bloch⁴², C. Blocker²³, W. Blum^{83,*}, U. Blumenschein⁵⁴, G.J. Bobbink¹⁰⁷, V.S. Bobrovnikov^{109,c}, S.S. Bocchetta⁸¹, A. Bocci⁴⁵, C. Bock¹⁰⁰, C.R. Boddy¹²⁰, M. Boehler⁴⁸, T.T. Boek¹⁷⁷, J.A. Bogaerts³⁰, A.G. Bogdanchikov¹⁰⁹, A. Bogouch^{92,*}, C. Bohm^{148a}, J. Bohm¹²⁷, V. Boisvert⁷⁷, T. Bold^{38a}, V. Boldea^{26a}, A.S. Boldyrev⁹⁹, M. Bomben⁸⁰, M. Bona⁷⁶, M. Boonekamp¹³⁸, A. Borisov¹³⁰, G. Borissov⁷², M. Borri⁸⁴, S. Borroni⁴², J. Bortfeldt¹⁰⁰, V. Bortolotto^{136a,136b}, K. Bos¹⁰⁷, D. Boscherini^{20a}, M. Bosman¹², H. Boterenbrood¹⁰⁷, J. Boudreau¹²⁵, J. Bouffard², E.V. Bouhova-Thacker⁷², D. Boumediene³⁴, C. Bourdarios¹¹⁷, N. Bousson¹¹⁴, S. Boutouil^{137d}, A. Boveia³¹, J. Boyd³⁰, I.R. Boyko⁶⁵, I. Bozic^{13a}, J. Bracinik¹⁸, A. Brandt⁸, G. Brandt¹⁵, O. Brandt^{58a}, U. Bratzler¹⁵⁸, B. Brau⁸⁶, J.E. Brau¹¹⁶, H.M. Braun^{177,*}, S.F. Brazzale^{166a,166c}, B. Brelier¹⁶⁰, K. Brendlinger¹²², A.J. Brennan⁸⁸, R. Brenner¹⁶⁸, S. Bressler¹⁷⁴, K. Bristow^{147c}, T.M. Bristow⁴⁶, D. Britton⁵³, F.M. Brochu²⁸, I. Brock²¹, R. Brock⁹⁰, C. Bromberg⁹⁰, J. Bronner¹⁰¹, G. Brooijmans³⁵, T. Brooks⁷⁷, W.K. Brooks^{32b}, J. Brosamer¹⁵, E. Brost¹¹⁶, J. Brown⁵⁵, P.A. Bruckman de Renstrom³⁹, D. Bruncko^{146b}, R. Bruneliere⁴⁸, S. Brunet⁶¹, A. Bruni^{20a}, G. Bruni^{20a}, M. Bruschi^{20a}, L. Bryngemark⁸¹, T. Buanes¹⁴, Q. Buat¹⁴⁴, F. Bucci⁴⁹, P. Buchholz¹⁴³, R.M. Buckingham¹²⁰, A.G. Buckley⁵³, S.I. Buda^{26a}, I.A. Budagov⁶⁵, F. Buehrer⁴⁸, L. Bugge¹¹⁹, M.K. Bugge¹¹⁹, O. Bulekov⁹⁸, A.C. Bundock⁷⁴, H. Burckhart³⁰, S. Burdin⁷⁴, B. Burghgrave¹⁰⁸, S. Burke¹³¹, I. Burmeister⁴³, E. Busato³⁴, D. Büscher⁴⁸, V. Büscher⁸³, P. Bussey⁵³, C.P. Buszello¹⁶⁸, B. Butler⁵⁷, J.M. Butler²², A.I. Butt³, C.M. Buttar⁵³, J.M. Butterworth⁷⁸, P. Butti¹⁰⁷, W. Buttinger²⁸, A. Buzatu⁵³, M. Byszewski¹⁰, S. Cabrera Urbán¹⁶⁹, D. Caforio^{20a,20b}, O. Cakir^{4a}, P. Calafiura¹⁵, A. Calandri¹³⁸, G. Calderini⁸⁰, P. Calfayan¹⁰⁰, R. Calkins¹⁰⁸, L.P. Caloba^{24a}, D. Calvet³⁴, S. Calvet³⁴, R. Camacho Toro⁴⁹, S. Camarda⁴², D. Cameron¹¹⁹, L.M. Caminada¹⁵,

R. Caminal Armadans¹², S. Campana³⁰, M. Campanelli⁷⁸, A. Campoverde¹⁵⁰, V. Canale^{104a,104b}, A. Canepa^{161a}, M. Cano Bret⁷⁶, J. Cantero⁸², R. Cantrill^{126a}, T. Cao⁴⁰, M.D.M. Capeans Garrido³⁰, I. Caprini^{26a}, M. Caprini^{26a}, M. Capua^{37a,37b}, R. Caputo⁸³, R. Cardarelli^{135a}, T. Carli³⁰, G. Carlino^{104a}, L. Carminati^{91a,91b}, S. Caron¹⁰⁶, E. Carquin^{32a}, G.D. Carrillo-Montoya^{147c}, J.R. Carter²⁸, J. Carvalho^{126a,126c}, D. Casadei⁷⁸, M.P. Casado¹², M. Casolino¹², E. Castaneda-Miranda^{147b}, A. Castelli¹⁰⁷, V. Castillo Gimenez¹⁶⁹, N.F. Castro^{126a}, P. Catastini⁵⁷, A. Catinaccio³⁰, J.R. Catmore¹¹⁹, A. Cattai³⁰, G. Cattani^{135a,135b}, J. Caudron⁸³, V. Cavaliere¹⁶⁷, D. Cavalli^{91a}, M. Cavalli-Sforza¹², V. Cavasinni^{124a,124b}, F. Ceradini^{136a,136b}, B.C. Cerio⁴⁵, K. Cerny¹²⁹, A.S. Cerqueira^{24b}, A. Cerri¹⁵¹, L. Cerrito⁷⁶, F. Cerutti¹⁵, M. Cerv³⁰, A. Cervelli¹⁷, S.A. Cetin^{19b}, A. Chafaq^{137a}, D. Chakraborty¹⁰⁸, I. Chalupkova¹²⁹, P. Chang¹⁶⁷, B. Chapleau⁸⁷, J.D. Chapman²⁸, D. Charfeddine¹¹⁷, D.G. Charlton¹⁸, C.C. Chau¹⁶⁰, C.A. Chavez Barajas¹⁵¹, S. Cheatham⁸⁷, A. Chegwidden⁹⁰, S. Chekanov⁶, S.V. Chekulaev^{161a}, G.A. Chelkov^{65,g}, M.A. Chelstowska⁸⁹, C. Chen⁶⁴, H. Chen²⁵, K. Chen¹⁵⁰, L. Chen^{33d,h}, S. Chen^{33c}, X. Chen^{33f}, Y. Chen⁶⁷, Y. Chen³⁵, H.C. Cheng⁸⁹, Y. Cheng³¹, A. Cheplakov⁶⁵, R. Cherkaoui El Moursli^{137e}, V. Chernyatin^{25,*}, E. Cheu⁷, L. Chevalier¹³⁸, V. Chiarella⁴⁷, G. Chiefari^{104a,104b}, J.T. Childers⁶, A. Chilingarov⁷², G. Chiodini^{73a}, A.S. Chisholm¹⁸, R.T. Chislett⁷⁸, A. Chitan^{26a}, M.V. Chizhov⁶⁵, S. Chouridou⁹, B.K.B. Chow¹⁰⁰, D. Chromek-Burckhart³⁰, M.L. Chu¹⁵³, J. Chudoba¹²⁷, J.J. Chwastowski³⁹, L. Chytka¹¹⁵, G. Ciapetti^{134a,134b}, A.K. Ciftci^{4a}, R. Ciftci^{4a}, D. Cinca⁵³, V. Cindro⁷⁵, A. Ciocio¹⁵, P. Cirkovic^{13b}, Z.H. Citron¹⁷⁴, M. Citterio^{91a}, M. Ciubancan^{26a}, A. Clark⁴⁹, P.J. Clark⁴⁶, R.N. Clarke¹⁵, W. Cleland¹²⁵, J.C. Clemens⁸⁵, C. Clement^{148a,148b}, Y. Coadou⁸⁵, M. Cobal^{166a,166c}, A. Coccaro¹⁴⁰, J. Cochran⁶⁴, L. Coffey²³, J.G. Cogan¹⁴⁵, J. Coggeshall¹⁶⁷, B. Cole³⁵, S. Cole¹⁰⁸, A.P. Colijn¹⁰⁷, J. Collot⁵⁵, T. Colombo^{58c}, G. Colon⁸⁶, G. Compostella¹⁰¹, P. Conde Muiño^{126a,126b}, E. Coniavitis⁴⁸, M.C. Conidi¹², S.H. Connell^{147b}, I.A. Connelly⁷⁷, S.M. Consonni^{91a,91b}, V. Consorti⁴⁸, S. Constantinescu^{26a}, C. Conta^{121a,121b}, G. Conti⁵⁷, F. Conventi^{104a,i}, M. Cooke¹⁵, B.D. Cooper⁷⁸, A.M. Cooper-Sarkar¹²⁰, N.J. Cooper-Smith⁷⁷, K. Copic¹⁵, T. Cornelissen¹⁷⁷, M. Corradi^{20a}, F. Corriveau^{87,j}, A. Corso-Radu¹⁶⁵, A. Cortes-Gonzalez¹², G. Cortiana¹⁰¹, G. Costa^{91a}, M.J. Costa¹⁶⁹, D. Costanzo¹⁴¹, D. Côté⁸, G. Cottin²⁸, G. Cowan⁷⁷, B.E. Cox⁸⁴, K. Cranmer¹¹⁰, G. Cree²⁹, S. Crépe-Renaudin⁵⁵, F. Crescioli⁸⁰, W.A. Cribbs^{148a,148b}, M. Crispin Ortuzar¹²⁰, M. Cristinziani²¹, V. Croft¹⁰⁶, G. Crosetti^{37a,37b}, C.-M. Cuciuc^{26a}, T. Cuhadar Donszelmann¹⁴¹, J. Cummings¹⁷⁸, M. Curatolo⁴⁷, C. Cuthbert¹⁵², H. Czirr¹⁴³, P. Czodrowski³, Z. Czyczula¹⁷⁸, S. D'Auria⁵³, M. D'Onofrio⁷⁴, M.J. Da Cunha Sargedas De Sousa^{126a,126b}, C. Da Via⁸⁴, W. Dabrowski^{38a}, A. Dafinca¹²⁰, T. Dai⁸⁹, O. Dale¹⁴, F. Dallaire⁹⁵, C. Dallapiccola⁸⁶, M. Dam³⁶, A.C. Daniells¹⁸, M. Dano Hoffmann¹³⁸, V. Dao⁴⁸, G. Darbo^{50a}, S. Darmora⁸, J.A. Dassoulas⁴², A. Dattagupta⁶¹, W. Davey²¹, C. David¹⁷¹, T. Davidek¹²⁹, E. Davies^{120,d}, M. Davies¹⁵⁵, O. Davignon⁸⁰, A.R. Davison⁷⁸, P. Davison⁷⁸, Y. Davygora^{58a}, E. Dawe¹⁴⁴, I. Dawson¹⁴¹, R.K. Daya-Ishmukhametova⁸⁶, K. De⁸, R. de Asmundis^{104a}, S. De Castro^{20a,20b}, S. De Cecco⁸⁰, N. De Groot¹⁰⁶, P. de Jong¹⁰⁷, H. De la Torre⁸², F. De Lorenzi⁶⁴, L. De Nooij¹⁰⁷, D. De Pedis^{134a}, A. De Salvo^{134a}, U. De Sanctis¹⁵¹, A. De Santo¹⁵¹, J.B. De Vivie De Regie¹¹⁷, W.J. Dearnaley⁷², R. Debbe²⁵, C. Debenedetti¹³⁹, B. Dechenaux⁵⁵, D.V. Dedovich⁶⁵, I. Deigaard¹⁰⁷, J. Del Peso⁸², T. Del Prete^{124a,124b}, F. Deliot¹³⁸, C.M. Delitzsch⁴⁹, M. Deliyergiyev⁷⁵, A. Dell'Acqua³⁰, L. Dell'Asta²², M. Dell'Orso^{124a,124b}, M. Della Pietra^{104a,i}, D. della Volpe⁴⁹, M. Delmastro⁵, P.A. Delsart⁵⁵, C. Deluca¹⁰⁷, S. Demers¹⁷⁸, M. Demichev⁶⁵, A. Demilly⁸⁰, S.P. Denisov¹³⁰, D. Derendarz³⁹, J.E. Derkaoui^{137d}, F. Derue⁸⁰, P. Dervan⁷⁴, K. Desch²¹, C. Deterre⁴², P.O. Deviveiros¹⁰⁷, A. Dewhurst¹³¹, S. Dhaliwal¹⁰⁷, A. Di Ciaccio^{135a,135b}, L. Di Ciaccio⁵, A. Di Domenico^{134a,134b}, C. Di Donato^{104a,104b}, A. Di Girolamo³⁰, B. Di Girolamo³⁰, A. Di Mattia¹⁵⁴, B. Di Micco^{136a,136b}, R. Di Nardo⁴⁷, A. Di Simone⁴⁸, R. Di Sipio^{20a,20b}, D. Di Valentino²⁹, F.A. Dias⁴⁶, M.A. Diaz^{32a}, E.B. Diehl⁸⁹, J. Dietrich⁴², T.A. Dietzsch^{58a}, S. Diglio⁸⁵, A. Dimitrievska^{13a}, J. Dingfelder²¹, C. Dionisi^{134a,134b}, P. Dita^{26a}, S. Dita^{26a}, F. Dittus³⁰, F. Djama⁸⁵, T. Djobava^{51b}, M.A.B. do Vale^{24c}, A. Do Valle Wemans^{126a,126g}, D. Dobos³⁰, C. Doglioni⁴⁹, T. Doherty⁵³, T. Dohmae¹⁵⁷, J. Dolejsi¹²⁹, Z. Dolezal¹²⁹, B.A. Dolgoshein^{98,*}, M. Donadelli^{24d}, S. Donati^{124a,124b}, P. Dondero^{121a,121b}, J. Donini³⁴, J. Dopke¹³¹, A. Doria^{104a}, M.T. Dova⁷¹, A.T. Doyle⁵³, M. Dris¹⁰, J. Dubbert⁸⁹, S. Dube¹⁵, E. Dubreuil³⁴, E. Duchovni¹⁷⁴, G. Duckeck¹⁰⁰, O.A. Ducu^{26a}, D. Duda¹⁷⁷, A. Dudarev³⁰, F. Dudziak⁶⁴, L. Duflot¹¹⁷, L. Duguid⁷⁷, M. Dührssen³⁰, M. Dunford^{158a}, H. Duran Yildiz^{4a}, M. Düren⁵², A. Durglishvili^{51b}, M. Dwuznik^{38a}, M. Dyndal^{138a}, J. Ebke¹⁰⁰, W. Edson², N.C. Edwards⁴⁶, W. Ehrenfeld²¹, T. Eifert¹⁴⁵, G. Eigen¹⁴, K. Einsweiler¹⁵, T. Ekelof¹⁶⁸, M. El Kacimi^{137c}, M. Ellert¹⁶⁸, S. Elles⁵, F. Ellinghaus⁸³, N. Ellis³⁰, J. Elmsheuser¹⁰⁰, M. Elsing³⁰, D. Emelianov¹³¹, Y. Enari¹⁵⁷, O.C. Endner⁸³, M. Endo¹¹⁸, R. Engelmann¹⁵⁰, J. Erdmann¹⁷⁸, A. Ereditato¹⁷, D. Eriksson^{148a}, G. Ernis¹⁷⁷, J. Ernst², M. Ernst²⁵, J. Ernwein¹³⁸, D. Errede¹⁶⁷, S. Errede¹⁶⁷, E. Ertel⁸³, M. Escalier¹¹⁷, H. Esch⁴³, C. Escobar¹²⁵, B. Esposito⁴⁷, A.I. Etienvre¹³⁸, E. Etzion¹⁵⁵, H. Evans⁶¹, A. Ezhilov¹²³, L. Fabbri^{20a,20b}, G. Facini³¹, R.M. Fakhruddinov¹³⁰, S. Falciano^{134a}, R.J. Falla⁷⁸, J. Faltova¹²⁹, Y. Fang^{33a}, M. Fanti^{91a,91b}, A. Farbin⁸, A. Farilla^{136a}, T. Farooque¹², S. Farrell¹⁵, S.M. Farrington¹⁷², P. Farthouat³⁰, F. Fassi^{137e}, P. Fassnacht³⁰, D. Fassouliotis⁹, A. Favareto^{50a,50b}, L. Fayard¹¹⁷, P. Federic^{146a}, O.L. Fedin^{123,k}, W. Fedorko¹⁷⁰, M. Fehling-Kaschek⁴⁸, S. Feigl³⁰, L. Feligioni⁸⁵, C. Feng^{33d}, E.J. Feng⁶, H. Feng⁸⁹, A.B. Fenyuk¹³⁰, S. Fernandez Perez³⁰, S. Ferrag⁵³, J. Ferrando⁵³, A. Ferrari¹⁶⁸, P. Ferrari¹⁰⁷, R. Ferrari^{121a}, D.E. Ferreira de Lima⁵³, A. Ferrer¹⁶⁹, D. Ferrere⁴⁹, C. Ferretti⁸⁹, A. Ferretto Parodi^{150a,50b}, M. Fiascaris³¹,

F. Fiedler⁸³, A. Filipčić⁷⁵, M. Filipuzzi⁴², F. Filthaut¹⁰⁶, M. Fincke-Keeler¹⁷¹, K.D. Finelli¹⁵², M.C.N. Fiolhais^{126a,126c}, L. Fiorini¹⁶⁹, A. Firan⁴⁰, A. Fischer², J. Fischer¹⁷⁷, W.C. Fisher⁹⁰, E.A. Fitzgerald²³, M. Flechl⁴⁸, I. Fleck¹⁴³, P. Fleischmann⁸⁹, S. Fleischmann¹⁷⁷, G.T. Fletcher¹⁴¹, G. Fletcher⁷⁶, T. Flick¹⁷⁷, A. Floderus⁸¹, L.R. Flores Castillo^{60a}, A.C. Florez Bustos^{161b}, M.J. Flowerdew¹⁰¹, A. Formica¹³⁸, A. Forti⁸⁴, D. Fortin^{161a}, D. Fournier¹¹⁷, H. Fox⁷², S. Fracchia¹², P. Francavilla⁸⁰, M. Franchini^{20a,20b}, S. Franchino³⁰, D. Francis³⁰, L. Franconi¹¹⁹, M. Franklin⁵⁷, S. Franz⁶², M. Fraternali^{121a,121b}, S.T. French²⁸, C. Friedrich⁴², F. Friedrich⁴⁴, D. Froidevaux³⁰, J.A. Frost²⁸, C. Fukunaga¹⁵⁸, E. Fullana Torregrosa⁸³, B.G. Fulsom¹⁴⁵, J. Fuster¹⁶⁹, C. Gabaldon⁵⁵, O. Gabizon¹⁷⁷, A. Gabrielli^{20a,20b}, A. Gabrielli^{134a,134b}, S. Gadatsch¹⁰⁷, S. Gadomski⁴⁹, G. Gagliardi^{50a,50b}, P. Gagnon⁶¹, C. Galea¹⁰⁶, B. Galhardo^{126a,126c}, E.J. Gallas¹²⁰, V. Gallo¹⁷, B.J. Gallop¹³¹, P. Gallus¹²⁸, G. Galster³⁶, K.K. Gan¹¹¹, J. Gao^{33b,h}, Y.S. Gao^{145,f}, F.M. Garay Walls⁴⁶, F. Garbersson¹⁷⁸, C. García¹⁶⁹, J.E. García Navarro¹⁶⁹, M. Garcia-Sciveres¹⁵, R.W. Gardner³¹, N. Garelli¹⁴⁵, V. Garonne³⁰, C. Gatti⁴⁷, G. Gaudio^{121a}, B. Gaur¹⁴³, L. Gauthier⁹⁵, P. Gauzzi^{134a,134b}, I.L. Gavrilenko⁹⁶, C. Gay¹⁷⁰, G. Gaycken²¹, E.N. Gazis¹⁰, P. Ge^{33d}, Z. Gecse¹⁷⁰, C.N.P. Gee¹³¹, D.A.A. Geerts¹⁰⁷, Ch. Geich-Gimbel²¹, K. Gellerstedt^{148a,148b}, C. Gemme^{50a}, A. Gemmell⁵³, M.H. Genest⁵⁵, S. Gentile^{134a,134b}, M. George⁵⁴, S. George⁷⁷, D. Gerbaudo¹⁶⁵, A. Gershon¹⁵⁵, H. Ghazlane^{137b}, N. Ghodbane³⁴, B. Giacobbe^{20a}, S. Giagu^{134a,134b}, V. Giangiobbe¹², P. Giannetti^{124a,124b}, F. Gianotti³⁰, B. Gibbard²⁵, S.M. Gibson⁷⁷, M. Gilchriese¹⁵, T.P.S. Gillam²⁸, D. Gillberg³⁰, G. Gilles³⁴, D.M. Gingrich^{3,e}, N. Giokaris⁹, M.P. Giordani^{166a,166c}, R. Giordano^{104a,104b}, F.M. Giorgi^{20a}, F.M. Giorgi¹⁶, P.F. Giraud¹³⁸, D. Giugni^{91a}, C. Giuliani⁴⁸, M. Giulini^{58b}, B.K. Gjelsten¹¹⁹, S. Gkaitatzis¹⁵⁶, I. Gkialas^{156,l}, L.K. Gladilin⁹⁹, C. Glasman⁸², J. Glatzer³⁰, P.C.F. Glaysheer⁴⁶, A. Glazov⁴², G.L. Glonti⁶⁵, M. Goblirsch-Kolb¹⁰¹, J.R. Goddard⁷⁶, J. Godlewski³⁰, C. Goeringer⁸³, S. Goldfarb⁸⁹, T. Golling¹⁷⁸, D. Golubkov¹³⁰, A. Gomes^{126a,126b,126d}, L.S. Gomez Fajardo⁴², R. Gonçalo^{126a}, J. Goncalves Pinto Firmino Da Costa¹³⁸, L. Gonella²¹, S. González de la Hoz¹⁶⁹, G. Gonzalez Parra¹², S. Gonzalez-Sevilla⁴⁹, L. Goossens³⁰, P.A. Gorbounov⁹⁷, H.A. Gordon²⁵, I. Gorelov¹⁰⁵, B. Gorini³⁰, E. Gorini^{73a,73b}, A. Gorišek⁷⁵, E. Gornicki³⁹, A.T. Goshaw⁶, C. Gössling⁴³, M.I. Gostkin⁶⁵, M. Gouighri^{137a}, D. Goujdami^{137c}, M.P. Goulette⁴⁹, A.G. Goussiou¹⁴⁰, C. Goy⁵, S. Gozpinar²³, H.M.X. Grabas¹³⁹, L. Graber⁵⁴, I. Grabowska-Bold^{38a}, P. Grafström^{20a,20b}, K.-J. Grahn⁴², J. Gramling⁴⁹, E. Gramstad¹¹⁹, S. Grancagnolo¹⁶, V. Grassi¹⁵⁰, V. Gratchev¹²³, H.M. Gray³⁰, E. Graziani^{136a}, O.G. Grebenyuk¹²³, Z.D. Greenwood^{79,m}, K. Gregersen⁷⁸, I.M. Gregor⁴², P. Grenier¹⁴⁵, J. Griffiths⁸, A.A. Grillo¹³⁹, K. Grimm⁷², S. Grinstein^{12,n}, Ph. Gris³⁴, Y.V. Grishkevich⁹⁹, J.-F. Grivaz¹¹⁷, J.P. Grohs⁴⁴, A. Grohsjean⁴², E. Gross¹⁷⁴, J. Grosse-Knetter⁵⁴, G.C. Grossi^{135a,135b}, J. Groth-Jensen¹⁷⁴, Z.J. Grout¹⁵¹, L. Guan^{33b}, J. Guenther¹²⁸, F. Guescini⁴⁹, D. Guest¹⁷⁸, O. Gueta¹⁵⁵, C. Guicheney³⁴, E. Guido^{50a,50b}, T. Guillemin¹¹⁷, S. Guindon², U. Gul⁵³, C. Gumpert⁴⁴, J. Guo³⁵, S. Gupta¹²⁰, P. Gutierrez¹¹³, N.G. Gutierrez Ortiz⁵³, C. Gutsche⁷⁸, N. Guttman¹⁵⁵, C. Guyot¹³⁸, C. Gwenlan¹²⁰, C.B. Gwilliam⁷⁴, A. Haas¹¹⁰, C. Haber¹⁵, H.K. Hadavand⁸, N. Haddad^{137e}, P. Haefner²¹, S. Hageböck²¹, Z. Hajduk³⁹, H. Hakobyan¹⁷⁹, M. Haleem⁴², D. Hall¹²⁰, G. Halladjian⁹⁰, K. Hamacher¹⁷⁷, P. Hamal¹¹⁵, K. Hamano¹⁷¹, M. Hamer⁵⁴, A. Hamilton^{147a}, S. Hamilton¹⁶³, G.N. Hamity^{147c}, P.G. Hamnett⁴², L. Han^{33b}, K. Hanagaki¹¹⁸, K. Hanawa¹⁵⁷, M. Hance¹⁵, P. Hanke^{58a}, R. Hanna¹³⁸, J.B. Hansen³⁶, J.D. Hansen³⁶, P.H. Hansen³⁶, K. Hara¹⁶², A.S. Hard¹⁷⁵, T. Harenberg¹⁷⁷, F. Hariri¹¹⁷, S. Harkusha⁹², D. Harper⁸⁹, R.D. Harrington⁴⁶, O.M. Harris¹⁴⁰, P.F. Harrison¹⁷², F. Hartjes¹⁰⁷, M. Hasegawa⁶⁷, S. Hasegawa¹⁰³, Y. Hasegawa¹⁴², A. Hasib¹¹³, S. Hassani¹³⁸, S. Haug¹⁷, M. Hauschild³⁰, R. Hauser⁹⁰, M. Havranek¹²⁷, C.M. Hawkes¹⁸, R.J. Hawkings³⁰, A.D. Hawkins⁸¹, T. Hayashi¹⁶², D. Hayden⁹⁰, C.P. Hays¹²⁰, H.S. Hayward⁷⁴, S.J. Haywood¹³¹, S.J. Head¹⁸, T. Heck⁸³, V. Hedberg⁸¹, L. Heelan⁸, S. Heim¹²², T. Heim¹⁷⁷, B. Heinemann¹⁵, L. Heinrich¹¹⁰, J. Hejbal¹²⁷, L. Helary²², C. Heller¹⁰⁰, M. Heller³⁰, S. Hellman^{148a,148b}, D. Hellmich²¹, C. Helsens³⁰, J. Henderson¹²⁰, R.C.W. Henderson⁷², Y. Heng¹⁷⁵, C. Hengler⁴², A. Henrichs¹⁷⁸, A.M. Henriques Correia³⁰, S. Henrot-Versille¹¹⁷, G.H. Herbert¹⁶, Y. Hernández Jiménez¹⁶⁹, R. Herrberg-Schubert¹⁶, G. Herten⁴⁸, R. Hertenberger¹⁰⁰, L. Hervas³⁰, G.G. Hesketh⁷⁸, N.P. Hessey¹⁰⁷, R. Hickling⁷⁶, E. Higón-Rodríguez¹⁶⁹, E. Hill¹⁷¹, J.C. Hill²⁸, K.H. Hiller⁴², S. Hillert²¹, S.J. Hillier¹⁸, I. Hinchliffe¹⁵, E. Hines¹²², M. Hirose¹⁵⁹, D. Hirschbuehl¹⁷⁷, J. Hobbs¹⁵⁰, N. Hod¹⁰⁷, M.C. Hodgkinson¹⁴¹, P. Hodgson¹⁴¹, A. Hoecker³⁰, M.R. Hoferkamp¹⁰⁵, F. Hoenig¹⁰⁰, J. Hoffman⁴⁰, D. Hoffmann⁸⁵, J.I. Hofmann^{58a}, M. Hohlfeld⁸³, T.R. Holmes¹⁵, T.M. Hong¹²², L. Hooft van Huysduynen¹¹⁰, W.H. Hopkins¹¹⁶, Y. Horii¹⁰³, J.-Y. Hostachy⁵⁵, S. Hou¹⁵³, A. Hoummada^{137a}, J. Howard¹²⁰, J. Howarth⁴², M. Hrabovsky¹¹⁵, I. Hristova¹⁶, J. Hrivnac¹¹⁷, T. Hryn'ova⁵, C. Hsu^{147c}, P.J. Hsu⁸³, S.-C. Hsu¹⁴⁰, D. Hu³⁵, X. Hu⁸⁹, Y. Huang⁴², Z. Hubacek³⁰, F. Hubaut⁸⁵, F. Huegging²¹, T.B. Huffman¹²⁰, E.W. Hughes³⁵, G. Hughes⁷², M. Huhtinen³⁰, T.A. Hülsing⁸³, M. Hurwitz¹⁵, N. Huseynov^{65,b}, J. Huston⁹⁰, J. Huth⁵⁷, G. Iacobucci⁴⁹, G. Iakovidis¹⁰, I. Ibragimov¹⁴³, L. Iconomidou-Fayard¹¹⁷, E. Ideal¹⁷⁸, Z. Idrissi^{137e}, P. Iengo^{104a}, O. Igonkina¹⁰⁷, T. Iizawa¹⁷³, Y. Ikegami⁶⁶, K. Ikematsu¹⁴³, M. Ikeno⁶⁶, Y. Ilchenko^{31,o}, D. Iliadis¹⁵⁶, N. Ilic¹⁶⁰, Y. Inamaru⁶⁷, T. Ince¹⁰¹, P. Ioannou⁹, M. Iodice^{136a}, K. Iordanidou⁹, V. Ippolito⁵⁷, A. Irles Quiles¹⁶⁹, C. Isaksson¹⁶⁸, M. Ishino⁶⁸, M. Ishitsuka¹⁵⁹, R. Ishmukhametov¹¹¹, C. Issever¹²⁰, S. Istin^{19a}, J.M. Iturbe Ponce⁸⁴, R. Iuppa^{135a,135b}, J. Ivarsson⁸¹, W. Iwanski³⁹, H. Iwasaki⁶⁶, J.M. Izen⁴¹, V. Izzo^{104a}, B. Jackson¹²², M. Jackson⁷⁴, P. Jackson¹, M.R. Jaekel³⁰, V. Jain², K. Jakobs⁴⁸, S. Jakobsen³⁰, T. Jakoubek¹²⁷, J. Jakubek¹²⁸, D.O. Jamin¹⁵³,

D.K. Jana⁷⁹, E. Jansen⁷⁸, H. Jansen³⁰, J. Janssen²¹, M. Janus¹⁷², G. Jarlskog⁸¹, N. Javadov^{65,b}, T. Javůrek⁴⁸, L. Jeanty¹⁵, J. Jejelava^{51a,p}, G.-Y. Jeng¹⁵², D. Jennens⁸⁸, P. Jenni^{48,q}, J. Jentzsch⁴³, C. Jeske¹⁷², S. Jézéquel¹⁵, H. Ji¹⁷⁵, J. Jia¹⁵⁰, Y. Jiang^{33b}, M. Jimenez Belenguer⁴², S. Jin^{33a}, A. Jinaru^{26a}, O. Jinnouchi¹⁵⁹, M.D. Joergensen³⁶, K.E. Johansson^{148a,148b}, P. Johansson¹⁴¹, K.A. Johns⁷, K. Jon-And^{148a,148b}, G. Jones¹⁷², R.W.L. Jones⁷², T.J. Jones⁷⁴, J. Jongmanns^{58a}, P.M. Jorge^{126a,126b}, K.D. Joshi⁸⁴, J. Jovicevic¹⁴⁹, X. Ju¹⁷⁵, C.A. Jung⁴³, R.M. Jungst³⁰, P. Jussel⁶², A. Juste Rozas^{12,n}, M. Kaci¹⁶⁹, A. Kaczmarek³⁹, M. Kado¹¹⁷, H. Kagan¹¹¹, M. Kagan¹⁴⁵, E. Kajomovitz⁴⁵, C.W. Kalderon¹²⁰, S. Kama⁴⁰, A. Kamenshchikov¹³⁰, N. Kanaya¹⁵⁷, M. Kaneda³⁰, S. Kaneti²⁸, V.A. Kantserov⁹⁸, J. Kanzaki⁶⁶, B. Kaplan¹¹⁰, A. Kapliy³¹, D. Kar⁵³, K. Karakostas¹⁰, N. Karastathis¹⁰, M.J. Kareem⁵⁴, M. Karnevskiy⁸³, S.N. Karpov⁶⁵, Z.M. Karpova⁶⁵, K. Karthik¹¹⁰, V. Kartvelishvili⁷², A.N. Karyukhin¹³⁰, L. Kashif¹⁷⁵, G. Kasieczka^{58b}, R.D. Kass¹¹¹, A. Kastanas¹⁴, Y. Kataoka¹⁵⁷, A. Katre⁴⁹, J. Katzy⁴², V. Kaushik⁷, K. Kawagoe⁷⁰, T. Kawamoto¹⁵⁷, G. Kawamura⁵⁴, S. Kazama¹⁵⁷, V.F. Kazanin¹⁰⁹, M.Y. Kazarinov⁶⁵, R. Keeler¹⁷¹, R. Kehoe⁴⁰, M. Keil⁵⁴, J.S. Keller⁴², J.J. Kempster⁷⁷, H. Keoshkerian⁵, O. Kepka¹²⁷, B.P. Kerševan⁷⁵, S. Kersten¹⁷⁷, K. Kessoku¹⁵⁷, J. Keung¹⁶⁰, F. Khalil-zada¹¹, H. Khandanyan^{148a,148b}, A. Khanov¹¹⁴, A. Khodinov⁹⁸, A. Khomich^{58a}, T.J. Khoo²⁸, G. Khorauli²¹, A. Khoroshilov¹⁷⁷, V. Khovanskiy⁹⁷, E. Khramov⁶⁵, J. Khubua^{51b}, H.Y. Kim⁸, H. Kim^{148a,148b}, S.H. Kim¹⁶², N. Kimura¹⁷³, O. Kind¹⁶, B.T. King⁷⁴, M. King¹⁶⁹, R.S.B. King¹²⁰, S.B. King¹⁷⁰, J. Kirk¹³¹, A.E. Kiryunin¹⁰¹, T. Kishimoto⁶⁷, D. Kisielewska^{38a}, F. Kiss⁴⁸, T. Kittelmann¹²⁵, K. Kiuchi¹⁶², E. Kladiva^{146b}, M. Klein⁷⁴, U. Klein⁷⁴, K. Kleinknecht⁸³, P. Klimek^{148a,148b}, A. Klimentov²⁵, R. Klingenberg⁴³, J.A. Klinger⁸⁴, T. Klioutchnikova³⁰, P.F. Klok¹⁰⁶, E.-E. Kluge^{58a}, P. Kluit¹⁰⁷, S. Kluth¹⁰¹, E. Kneringer⁶², E.B.F.G. Knoops⁸⁵, A. Knue⁵³, D. Kobayashi¹⁵⁹, T. Kobayashi¹⁵⁷, M. Kobel⁴⁴, M. Kocian¹⁴⁵, P. Kodys¹²⁹, P. Koesvarko²¹, T. Koffas²⁹, E. Koffeman¹⁰⁷, L.A. Kogan¹²⁰, S. Kohlmann¹⁷⁷, Z. Kohout¹²⁸, T. Kohriki⁶⁶, T. Koi¹⁴⁵, H. Kolanoski¹⁶, I. Koletsou⁵, J. Koll⁹⁰, A.A. Komar^{96,*}, Y. Komori¹⁵⁷, T. Kondo⁶⁶, N. Kondrashova⁴², K. Köneke⁴⁸, A.C. König¹⁰⁶, S. König⁸³, T. Kono^{66,r}, R. Konoplich^{110,s}, N. Konstantinidis⁷⁸, R. Kopeliainsky¹⁵⁴, S. Koperny^{38a}, L. Köpke⁸³, A.K. Kopp⁴⁸, K. Korcyl³⁹, K. Kordas¹⁵⁶, A. Korn⁷⁸, A.A. Korol^{109,c}, I. Korolkov¹², E.V. Korolkova¹⁴¹, V.A. Korotkov¹³⁰, O. Kortner¹⁰¹, S. Kortner¹⁰¹, V.V. Kostyukhin²¹, V.M. Kotov⁶⁵, A. Kotwal⁴⁵, C. Kourkoumelis⁹, V. Kouskoura¹⁵⁶, A. Koutsman^{161a}, R. Kowalewski¹⁷¹, T.Z. Kowalski^{38a}, W. Kozanecki¹³⁸, A.S. Kozhin¹³⁰, V. Kral¹²⁸, V.A. Kramarenko⁹⁹, G. Kramberger⁷⁵, D. Krasnopevtsev⁹⁸, M.W. Krasny⁸⁰, A. Krasznahorkay³⁰, J.K. Kraus²¹, A. Kravchenko²⁵, S. Kreiss¹¹⁰, M. Kretz^{58c}, J. Kretzschmar⁷⁴, K. Kreutzfeldt⁵², P. Krieger¹⁶⁰, K. Kroeninger⁵⁴, H. Kroha¹⁰¹, J. Kroll¹²², J. Kroseberg²¹, J. Krstic^{13a}, U. Kruchonak⁶⁵, H. Krüger²¹, T. Kruker¹⁷, N. Krumnack⁶⁴, Z.V. Krumshcheyn⁶⁵, A. Kruse¹⁷⁵, M.C. Kruse⁴⁵, M. Kruskal²², T. Kubota⁸⁸, S. Kuday^{4c}, S. Kuehn⁴⁸, A. Kugel^{58c}, A. Kuhl¹³⁹, T. Kuhl⁴², V. Kukhtin⁶⁵, Y. Kulchitsky⁹², S. Kuleshov^{32b}, M. Kuna^{134a,134b}, J. Kunkle¹²², A. Kupco¹²⁷, H. Kurashige⁶⁷, Y.A. Kurochkin⁹², R. Kurumida⁶⁷, V. Kus¹²⁷, E.S. Kuwertz¹⁴⁹, M. Kuze¹⁵⁹, J. Kvita¹¹⁵, A. La Rosa⁴⁹, L. La Rotonda^{37a,37b}, C. Lacasta¹⁶⁹, F. Lacava^{134a,134b}, J. Lacey²⁹, H. Lacker¹⁶, D. Lacour⁸⁰, V.R. Lacuesta¹⁶⁹, E. Ladygin⁶⁵, R. Lafaye⁵, B. Laforge⁸⁰, T. Lagouri¹⁷⁸, S. Lai⁴⁸, H. Laier^{58a}, L. Lambourne⁷⁸, S. Lammers⁶¹, C.L. Lampen⁷, W. Lampl⁷, E. Lançon¹³⁸, U. Landgraf⁴⁸, M.P.J. Landon⁷⁶, V.S. Lang^{58a}, A.J. Lankford¹⁶⁵, F. Lanni²⁵, K. Lantzsck³⁰, S. Laplace⁸⁰, C. Lapoire²¹, J.F. Laporte¹³⁸, T. Lari^{91a}, F. Lasagni Manghi^{20a,20b}, M. Lassnig³⁰, P. Laurelli⁴⁷, W. Lavrijsen¹⁵, A.T. Law¹³⁹, P. Laycock⁷⁴, O. Le Dortz⁸⁰, E. Le Guirriec⁸⁵, E. Le Menedeu¹², T. LeCompte⁶, F. Ledroit-Guillon⁵⁵, C.A. Lee¹⁵³, H. Lee¹⁰⁷, J.S.H. Lee¹¹⁸, S.C. Lee¹⁵³, L. Lee¹, G. Lefebvre⁸⁰, M. Lefebvre¹⁷¹, F. Legger¹⁰⁰, C. Leggett¹⁵, A. Lehan⁷⁴, M. Lehmacher²¹, G. Lehmann Miotto³⁰, X. Lei⁷, W.A. Leight²⁹, A. Leisos¹⁵⁶, A.G. Leister¹⁷⁸, M.A.L. Leite^{24d}, R. Leitner¹²⁹, D. Lellouch¹⁷⁴, B. Lemmer⁵⁴, K.J.C. Leney⁷⁸, T. Lenz²¹, G. Lenzen¹⁷⁷, B. Lenzi³⁰, R. Leone⁷, S. Leone^{124a,124b}, C. Leonidopoulos⁴⁶, S. Leontsinis¹⁰, C. Leroy⁹⁵, C.G. Lester²⁸, C.M. Lester¹²², M. Levchenko¹²³, J. Levêque⁵, D. Levin⁸⁹, L.J. Levinson¹⁷⁴, M. Levy¹⁸, A. Lewis¹²⁰, G.H. Lewis¹¹⁰, A.M. Leyko²¹, M. Leyton⁴¹, B. Li^{33b,t}, B. Li⁸⁵, H. Li¹⁵⁰, H.L. Li³¹, L. Li⁴⁵, L. Li^{33e}, S. Li⁴⁵, Y. Li^{33c,u}, Z. Liang¹³⁹, H. Liao³⁴, B. Liberti^{135a}, P. Lichard³⁰, K. Lie¹⁶⁷, J. Liebal²¹, W. Liebig¹⁴, C. Limbach²¹, A. Limosani⁸⁸, S.C. Lin^{153,v}, T.H. Lin⁸³, F. Linde¹⁰⁷, B.E. Lindquist¹⁵⁰, J.T. Linnemann⁹⁰, E. Lipeles¹²², A. Lipniacka¹⁴, M. Lisovsky⁴², T.M. Liss¹⁶⁷, D. Lissauer²⁵, A. Lister¹⁷⁰, A.M. Litke¹³⁹, B. Liu¹⁵³, D. Liu¹⁵³, J.B. Liu^{33b}, K. Liu^{33b,w}, L. Liu⁸⁹, M. Liu⁴⁵, M. Liu^{33b}, Y. Liu^{33b}, M. Livan^{121a,121b}, S.S.A. Livermore¹²⁰, A. Lleres⁵⁵, J. Llorente Merino⁸², S.L. Lloyd⁷⁶, F. Lo Sterzo¹⁵³, E. Lobodzinska⁴², P. Loch⁷, W.S. Lockman¹³⁹, T. Loddenkoetter²¹, F.K. Loebinger⁸⁴, A.E. Loevschall-Jensen³⁶, A. Loginov¹⁷⁸, T. Lohse¹⁶, K. Lohwasser⁴², M. Lokajicek¹²⁷, V.P. Lombardo⁵, B.A. Long²², J.D. Long⁸⁹, R.E. Long⁷², L. Lopes^{126a}, D. Lopez Mateos⁵⁷, B. Lopez Paredes¹⁴¹, I. Lopez Paz¹², J. Lorenz¹⁰⁰, N. Lorenzo Martinez⁶¹, M. Losada¹⁶⁴, P. Loscutoff¹⁵, X. Lou⁴¹, A. Lounis¹¹⁷, J. Love⁶, P.A. Love⁷², A.J. Lowe^{145,f}, F. Lu^{33a}, N. Lu⁸⁹, H.J. Lubatti¹⁴⁰, C. Luci^{134a,134b}, A. Lucotte⁵⁵, F. Luehring⁶¹, W. Lukas⁶², L. Luminari^{134a}, O. Lundberg^{148a,148b}, B. Lund-Jensen¹⁴⁹, M. Lungwitz⁸³, D. Lynn²⁵, R. Lysak¹²⁷, E. Lytken⁸¹, H. Ma²⁵, L.L. Ma^{33d}, G. Maccarrone⁴⁷, A. Macchiolo¹⁰¹, J. Machado Miguens^{126a,126b}, D. Macina³⁰, D. Madaffari⁸⁵, R. Madar⁴⁸, H.J. Maddocks⁷², W.F. Mader⁴⁴, A. Madsen¹⁶⁸, M. Maeno⁸, T. Maeno²⁵, A. Maevskiy⁹⁹, E. Magradze⁵⁴, K. Mahboubi⁴⁸, J. Mahlstedt¹⁰⁷, S. Mahmoud⁷⁴, C. Maiani¹³⁸, C. Maidantchik^{24a}, A.A. Maier¹⁰¹, A. Maio^{126a,126b,126d}, S. Majewski¹¹⁶, Y. Makida⁶⁶, N. Makovec¹¹⁷, P. Mal^{138,x}, B. Malaescu⁸⁰, Pa. Malecki³⁹,

V.P. Maleev¹²³, F. Malek⁵⁵, U. Mallik⁶³, D. Malon⁶, C. Malone¹⁴⁵, S. Maltezos¹⁰, V.M. Malyshev¹⁰⁹, S. Malyukov³⁰, J. Mamuzic^{13b}, B. Mandelli³⁰, L. Mandelli^{91a}, I. Mandić⁷⁵, R. Mandrysch⁶³, J. Maneira^{126a,126b}, A. Manfredini¹⁰¹, L. Manhaes de Andrade Filho^{24b}, J.A. Manjarres Ramos^{161b}, A. Mann¹⁰⁰, P.M. Manning¹³⁹, A. Manousakis-Katsikakis⁹, B. Mansoulie¹³⁸, R. Mantifel⁸⁷, L. Mapelli³⁰, L. March^{147c}, J.F. Marchand²⁹, G. Marchiori⁸⁰, M. Marcisovsky¹²⁷, C.P. Marino¹⁷¹, M. Marjanovic^{13a}, C.N. Marques^{126a}, F. Marroquim^{24a}, S.P. Marsden⁸⁴, Z. Marshall¹⁵, L.F. Marti¹⁷, S. Marti-Garcia¹⁶⁹, B. Martin³⁰, B. Martin⁹⁰, T.A. Martin¹⁷², V.J. Martin⁴⁶, B. Martin dit Latour¹⁴, H. Martinez¹³⁸, M. Martinez^{12,n}, S. Martin-Haugh¹³¹, A.C. Martyniuk⁷⁸, M. Marx¹⁴⁰, F. Marzano^{134a}, A. Marzin³⁰, L. Masetti⁸³, T. Mashimo¹⁵⁷, R. Mashinistov⁹⁶, J. Masik⁸⁴, A.L. Maslennikov^{109,c}, I. Massa^{20a,20b}, L. Massa^{20a,20b}, N. Massol⁵, P. Mastrandrea¹⁵⁰, A. Mastroberardino^{37a,37b}, T. Masubuchi¹⁵⁷, P. Mättig¹⁷⁷, J. Mattmann⁸³, J. Maurer^{26a}, S.J. Maxfield⁷⁴, D.A. Maximov^{109,c}, R. Mazini¹⁵³, L. Mazzaferro^{135a,135b}, G. Mc Goldrick¹⁶⁰, S.P. Mc Kee⁸⁹, A. McCarn⁸⁹, R.L. McCarthy¹⁵⁰, T.G. McCarthy²⁹, N.A. McCubbin¹³¹, K.W. McFarlane^{56,*}, J.A. Mcfayden⁷⁸, G. Mchedlidze⁵⁴, S.J. McMahon¹³¹, R.A. McPherson^{171,j}, J. Mechnich¹⁰⁷, M. Medinnis⁴², S. Meehan³¹, S. Mehlhase¹⁰⁰, A. Mehta⁷⁴, K. Meier^{58a}, C. Meineck¹⁰⁰, B. Meirose⁸¹, C. Melachrinou³¹, B.R. Mellado Garcia^{147c}, F. Meloni¹⁷, A. Mengarelli^{20a,20b}, S. Menke¹⁰¹, E. Meoni¹⁶³, K.M. Mercurio⁵⁷, S. Mergelmeyer²¹, N. Meric¹³⁸, P. Mermod⁴⁹, L. Merola^{104a,104b}, C. Meroni^{91a}, F.S. Merritt³¹, H. Merritt¹¹¹, A. Messina^{30,y}, J. Metcalfe²⁵, A.S. Mete¹⁶⁵, C. Meyer⁸³, C. Meyer¹²², J-P. Meyer¹³⁸, J. Meyer³⁰, R.P. Middleton¹³¹, S. Migas⁷⁴, L. Mijović²¹, G. Mikenberg¹⁷⁴, M. Mikesikova¹²⁷, M. Mikuž⁷⁵, A. Milic³⁰, D.W. Miller³¹, C. Mills⁴⁶, A. Milov¹⁷⁴, D.A. Milstead^{148a,148b}, D. Milstein¹⁷⁴, A.A. Minaenko¹³⁰, Y. Minami¹⁵⁷, I.A. Minashvili⁶⁵, A.I. Mincer¹¹⁰, B. Mindur^{38a}, M. Mineev⁶⁵, Y. Ming¹⁷⁵, L.M. Mir¹², G. Mirabelli^{134a}, T. Mitani¹⁷³, J. Mitrevski¹⁰⁰, V.A. Mitsou¹⁶⁹, S. Mitsui⁶⁶, A. Miucci⁴⁹, P.S. Miyagawa¹⁴¹, J.U. Mjörnmark⁸¹, T. Moa^{148a,148b}, K. Mochizuki⁸⁵, S. Mohapatra³⁵, W. Mohr⁴⁸, S. Molander^{148a,148b}, R. Moles-Valls¹⁶⁹, K. Mönig⁴², C. Monini⁵⁵, J. Monk³⁶, E. Monnier⁸⁵, J. Montejo Berlingen¹², F. Monticelli⁷¹, S. Monzani^{134a,134b}, R.W. Moore³, N. Morange⁶³, D. Moreno⁸³, M. Moreno Llácer⁵⁴, P. Morettini^{50a}, M. Morgenstern⁴⁴, M. Morii⁵⁷, S. Moritz⁸³, A.K. Morley¹⁴⁹, G. Mornacchi³⁰, J.D. Morris⁷⁶, L. Morvaj¹⁰³, H.G. Moser¹⁰¹, M. Mosidze^{51b}, J. Moss¹¹¹, K. Motohashi¹⁵⁹, R. Mount¹⁴⁵, E. Mountricha²⁵, S.V. Mouraviev^{96,*}, E.J.W. Moyse⁸⁶, S. Muanza⁸⁵, R.D. Mudd¹⁸, F. Mueller^{58a}, J. Mueller¹²⁵, K. Mueller²¹, T. Mueller²⁸, T. Mueller⁸³, D. Muenstermann⁴⁹, Y. Munwes¹⁵⁵, J.A. Murillo Quijada¹⁸, W.J. Murray^{172,131}, H. Musheghyan⁵⁴, E. Musto¹⁵⁴, A.G. Myagkov^{130,z}, M. Myska¹²⁸, O. Nackenhorst⁵⁴, J. Nadal⁵⁴, K. Nagai⁶², R. Nagai¹⁵⁹, Y. Nagai⁸⁵, K. Nagano⁶⁶, A. Nagarkar¹¹¹, Y. Nagasaka⁵⁹, M. Nagel¹⁰¹, A.M. Nairz³⁰, Y. Nakahama³⁰, K. Nakamura⁶⁶, T. Nakamura¹⁵⁷, I. Nakano¹¹², H. Namasivayam⁴¹, G. Nanava²¹, R. Narayan^{58b}, T. Nattermann²¹, T. Naumann⁴², G. Navarro¹⁶⁴, R. Nayyar⁷, H.A. Neal⁸⁹, P.Yu. Nechaeva⁹⁶, T.J. Neep⁸⁴, P.D. Nef¹⁴⁵, A. Negri^{121a,121b}, G. Negri³⁰, M. Negrini^{20a}, S. Nektarijevic⁴⁹, C. Nellist¹¹⁷, A. Nelson¹⁶⁵, T.K. Nelson¹⁴⁵, S. Nemecek¹²⁷, P. Nemethy¹¹⁰, A.A. Nepomuceno^{24a}, M. Nessi^{30,aa}, M.S. Neubauer¹⁶⁷, M. Neumann¹⁷⁷, R.M. Neves¹¹⁰, P. Nevski²⁵, P.R. Newman¹⁸, D.H. Nguyen⁶, R.B. Nickerson¹²⁰, R. Nicolaidou¹³⁸, B. Niquevert³⁰, J. Nielsen¹³⁹, N. Nikiforou³⁵, A. Nikiforov¹⁶, V. Nikolaenko^{130,z}, I. Nikolic-Audit⁸⁰, K. Nikolics⁴⁹, K. Nikolopoulos¹⁸, P. Nilsson⁸, Y. Ninomiya¹⁵⁷, A. Nisati^{134a}, R. Nisius¹⁰¹, T. Nobe¹⁵⁹, L. Nodulman⁶, M. Nomachi¹¹⁸, I. Nomidis²⁹, S. Norberg¹¹³, M. Nordberg³⁰, O. Novgorodova⁴⁴, S. Nowak¹⁰¹, M. Nozaki⁶⁶, L. Nozka¹¹⁵, K. Ntekas¹⁰, G. Nunes Hanninger⁸⁸, T. Nunnemann¹⁰⁰, E. Nurse⁷⁸, F. Nuti⁸⁸, B.J. O'Brien⁴⁶, F. O'grady⁷, D.C. O'Neil¹⁴⁴, V. O'Shea⁵³, F.G. Oakham^{29,e}, H. Oberlack¹⁰¹, T. Obermann²¹, J. Ocariz⁸⁰, A. Ochi⁶⁷, M.I. Ochoa⁷⁸, S. Oda⁷⁰, S. Odaka⁶⁶, H. Ogren⁶¹, A. Oh⁸⁴, S.H. Oh⁴⁵, C.C. Ohm¹⁵, H. Ohman¹⁶⁸, W. Okamura¹¹⁸, H. Okawa²⁵, Y. Okumura³¹, T. Okuyama¹⁵⁷, A. Olariu^{26a}, A.G. Olchevski⁶⁵, S.A. Olivares Pino⁴⁶, D. Oliveira Damazio²⁵, E. Oliver Garcia¹⁶⁹, A. Olszewski³⁹, J. Olszowska³⁹, A. Onofre^{126a,126e}, P.U.E. Onyisi^{31,o}, C.J. Oram^{161a}, M.J. Oreglia³¹, Y. Oren¹⁵⁵, D. Orestano^{136a,136b}, N. Orlando^{73a,73b}, C. Oropeza Barrera⁵³, R.S. Orr¹⁶⁰, B. Osculati^{50a,50b}, R. Ospanov¹²², G. Otero y Garzon²⁷, H. Otono⁷⁰, M. Ouchrif^{137d}, E.A. Ouellette¹⁷¹, F. Ould-Saada¹¹⁹, A. Ouraou¹³⁸, K.P. Oussoren¹⁰⁷, Q. Ouyang^{33a}, A. Ovcharova¹⁵, M. Owen⁸⁴, V.E. Ozcan^{19a}, N. Ozturk⁸, K. Pachal¹²⁰, A. Pacheco Pages¹², C. Padilla Aranda¹², M. Pagáčová⁴⁸, S. Pagan Griso¹⁵, E. Paganis¹⁴¹, C. Pahl¹⁰¹, F. Paige²⁵, P. Pais⁸⁶, K. Pajchel¹¹⁹, G. Palacino^{161b}, S. Palestini³⁰, M. Palka^{38b}, D. Pallin³⁴, A. Palma^{126a,126b}, J.D. Palmer¹⁸, Y.B. Pan¹⁷⁵, E. Panagiotopoulou¹⁰, J.G. Panduro Vazquez⁷⁷, P. Pani¹⁰⁷, N. Panikashvili⁸⁹, S. Panitkin²⁵, D. Pantea^{26a}, L. Paolozzi^{135a,135b}, Th.D. Papadopoulos¹⁰, K. Papageorgiou^{156,l}, A. Paramonov⁶, D. Paredes Hernandez³⁴, M.A. Parker²⁸, F. Parodi^{50a,50b}, J.A. Parsons³⁵, U. Parzefall⁴⁸, E. Pasqualucci^{134a}, S. Passaggio^{50a}, A. Passeri^{136a}, F. Pastore^{136a,136b,*}, Fr. Pastore⁷⁷, G. Pásztor²⁹, S. Pataria¹⁷⁷, N.D. Patel¹⁵², J.R. Pater⁸⁴, S. Patricelli^{104a,104b}, T. Pauly³⁰, J. Pearce¹⁷¹, L.E. Pedersen³⁶, M. Pedersen¹¹⁹, S. Pedraza Lopez¹⁶⁹, R. Pedro^{126a,126b}, S.V. Peleganchuk¹⁰⁹, D. Pelikan¹⁶⁸, H. Peng^{33b}, B. Penning³¹, J. Penwell⁶¹, D.V. Perepelitsa²⁵, E. Perez Codina^{161a}, M.T. Pérez García-Están¹⁶⁹, V. Perez Reale³⁵, L. Perini^{91a,91b}, H. Pernegger³⁰, S. Perrella^{104a,104b}, R. Perrino^{73a}, R. Peschke⁴², V.D. Peshekhonov⁶⁵, K. Peters³⁰, R.F.Y. Peters⁸⁴, B.A. Petersen³⁰, T.C. Petersen³⁶, E. Petit⁴², A. Petridis^{148a,148b}, C. Petridou¹⁵⁶, E. Petrolo^{134a}, F. Petrucci^{136a,136b}, N.E. Pettersson¹⁵⁹, R. Pezoa^{32b}, P.W. Phillips¹³¹, G. Piacquadio¹⁴⁵, E. Pianori¹⁷², A. Picazio⁴⁹, E. Piccaro⁷⁶, M. Piccinini^{20a,20b}, R. Piegaia²⁷, D.T. Pignotti¹¹¹, J.E. Pilcher³¹, A.D. Pilkington⁷⁸,

J. Pina^{126a,126b,126d}, M. Pinamonti^{166a,166c,ab}, A. Pinder¹²⁰, J.L. Pinfeld³, A. Pingel³⁶, B. Pinto^{126a}, S. Pires⁸⁰, M. Pitt¹⁷⁴, C. Pizio^{91a,91b}, L. Plazak^{146a}, M.-A. Pleier²⁵, V. Pleskot¹²⁹, E. Plotnikova⁶⁵, P. Plucinski^{148a,148b}, D. Pluth⁶⁴, S. Poddar^{58a}, F. Podlyski³⁴, R. Poettgen⁸³, L. Poggioli¹¹⁷, D. Pohl²¹, M. Pohl⁴⁹, G. Polesello^{121a}, A. Policicchio^{37a,37b}, R. Polifka¹⁶⁰, A. Polini^{20a}, C.S. Pollard⁴⁵, V. Polychronakos²⁵, K. Pommès³⁰, L. Pontecorvo^{134a}, B.G. Pope⁹⁰, G.A. Popeneciu^{26b}, D.S. Popovic^{13a}, A. Poppleton³⁰, X. Portell Bueso¹², S. Pospisil¹²⁸, K. Potamianos¹⁵, I.N. Potrap⁶⁵, C.J. Potter¹⁵¹, C.T. Potter¹¹⁶, G. Poulard³⁰, J. Poveda⁶¹, V. Pozdnyakov⁶⁵, P. Pralavorio⁸⁵, A. Pranko¹⁵, S. Prasad³⁰, R. Pravahan⁸, S. Prell⁶⁴, D. Price⁸⁴, J. Price⁷⁴, L.E. Price⁶, D. Prieur¹²⁵, M. Primavera^{73a}, M. Proissl⁴⁶, K. Prokofiev⁴⁷, F. Prokoshin^{32b}, E. Protopapadaki¹³⁸, S. Protopopescu²⁵, J. Proudfoot⁶, M. Przybycien^{38a}, H. Przysiezniak⁵, E. Ptacek¹¹⁶, D. Puddu^{136a,136b}, E. Pueschel⁸⁶, D. Puldon¹⁵⁰, M. Purohit^{25,ac}, P. Puzo¹¹⁷, J. Qian⁸⁹, G. Qin⁵³, Y. Qin⁸⁴, A. Quadt⁵⁴, D.R. Quarrie¹⁵, W.B. Quayle^{166a,166b}, M. Queitsch-Maitland⁸⁴, D. Quilty⁵³, A. Qureshi^{161b}, V. Radeka²⁵, V. Radescu⁴², S.K. Radhakrishnan¹⁵⁰, P. Radloff¹¹⁶, P. Rados⁸⁸, F. Ragusa^{91a,91b}, G. Rahal¹⁸⁰, S. Rajagopalan²⁵, M. Rammensee³⁰, A.S. Randle-Conde⁴⁰, C. Rangel-Smith¹⁶⁸, K. Rao¹⁶⁵, F. Rauscher¹⁰⁰, T.C. Rave⁴⁸, T. Ravenscroft⁵³, M. Raymond³⁰, A.L. Read¹¹⁹, N.P. Readoff⁷⁴, D.M. Rebuzzi^{121a,121b}, A. Redelbach¹⁷⁶, G. Redlinger²⁵, R. Reece¹³⁹, K. Reeves⁴¹, L. Rehnisch¹⁶, H. Reisin²⁷, M. Relich¹⁶⁵, C. Rembser³⁰, H. Ren^{33a}, Z.L. Ren¹⁵³, A. Renaud¹¹⁷, M. Rescigno^{134a}, S. Resconi^{91a}, O.L. Rezanova^{109,c}, P. Reznicek¹²⁹, R. Rezvani⁹⁵, R. Richter¹⁰¹, M. Ridel⁸⁰, P. Rieck¹⁶, J. Rieger⁵⁴, M. Rijssenbeek¹⁵⁰, A. Rimoldi^{121a,121b}, L. Rinaldi^{20a}, E. Ritsch⁶², I. Riu¹², F. Rizatdinova¹¹⁴, E. Rizvi⁷⁶, S.H. Robertson^{87,j}, A. Robichaud-Veronneau⁸⁷, D. Robinson²⁸, J.E.M. Robinson⁸⁴, A. Robson⁵³, C. Roda^{124a,124b}, L. Rodrigues³⁰, S. Roe³⁰, O. Røhne¹¹⁹, S. Rolli¹⁶³, A. Romaniouk⁹⁸, M. Romano^{20a,20b}, E. Romero Adam¹⁶⁹, N. Rompotis¹⁴⁰, M. Ronzani⁴⁸, L. Roos⁸⁰, E. Ros¹⁶⁹, S. Rosati^{134a}, K. Rosbach⁴⁹, M. Rose⁷⁷, P. Rose¹³⁹, P.L. Rosendahl¹⁴, O. Rosenthal¹⁴³, V. Rossetti^{148a,148b}, E. Rossi^{104a,104b}, L.P. Rossi^{50a}, R. Rosten¹⁴⁰, M. Rotaru^{26a}, I. Roth¹⁷⁴, J. Rothberg¹⁴⁰, D. Rousseau¹¹⁷, C.R. Royon¹³⁸, A. Rozanov⁸⁵, Y. Rozen¹⁵⁴, X. Ruan^{147c}, F. Rubbo¹², I. Rubinskiy⁴², V.I. Rud⁹⁹, C. Rudolph⁴⁴, M.S. Rudolph¹⁶⁰, F. Rühr⁴⁸, A. Ruiz-Martinez³⁰, Z. Rurikova⁴⁸, N.A. Rusakovich⁶⁵, A. Ruschke¹⁰⁰, J.P. Rutherford⁷, N. Ruthmann⁴⁸, Y.F. Ryabov¹²³, M. Rybar¹²⁹, G. Rybkin¹¹⁷, N.C. Ryder¹²⁰, A.F. Saavedra¹⁵², G. Sabato¹⁰⁷, S. Sacerdoti²⁷, A. Saddique³, I. Sadeh¹⁵⁵, H.F.W. Sadrozinski¹³⁹, R. Sadykov⁶⁵, F. Safai Tehrani^{134a}, H. Sakamoto¹⁵⁷, Y. Sakurai¹⁷³, G. Salamanna^{136a,136b}, A. Salamon^{135a}, M. Saleem¹¹³, D. Salek¹⁰⁷, P.H. Sales De Bruin¹⁴⁰, D. Salihagic¹⁰¹, A. Salmikov¹⁴⁵, J. Salt¹⁶⁹, D. Salvatore^{37a,37b}, F. Salvatore¹⁵¹, A. Salvucci¹⁰⁶, A. Salzburger³⁰, D. Sampsonidis¹⁵⁶, A. Sanchez^{104a,104b}, J. Sánchez¹⁶⁹, V. Sanchez Martinez¹⁶⁹, H. Sandaker¹⁴, R.L. Sandbach⁷⁶, H.G. Sander⁸³, M.P. Sanders¹⁰⁰, M. Sandhoff¹⁷⁷, T. Sandoval²⁸, C. Sandoval¹⁶⁴, R. Sandstroem¹⁰¹, D.P.C. Sankey¹³¹, A. Sansoni⁴⁷, C. Santoni³⁴, R. Santonico^{135a,135b}, H. Santos^{126a}, I. Santoyo Castillo¹⁵¹, K. Sapp¹²⁵, A. Saponov⁶⁵, J.G. Saraiva^{126a,126d}, B. Sarrazin²¹, G. Sartisohn¹⁷⁷, O. Sasaki⁶⁶, Y. Sasaki¹⁵⁷, G. Sauvage^{5,*}, E. Sauvan⁵, P. Savard^{160,e}, D.O. Savu³⁰, C. Sawyer¹²⁰, L. Sawyer^{79,m}, D.H. Saxon⁵³, J. Saxon¹²², C. Sbarra^{20a}, A. Sbrizzi^{20a,20b}, T. Scanlon⁷⁸, D.A. Scannicchio¹⁶⁵, M. Scarcella¹⁵², V. Scarfone^{37a,37b}, J. Schaarschmidt¹⁷⁴, P. Schacht¹⁰¹, D. Schaefer³⁰, R. Schaefer⁴², S. Schaepe²¹, S. Schaezel^{58b}, U. Schäfer⁸³, A.C. Schaffer¹¹⁷, D. Schaile¹⁰⁰, R.D. Schamberger¹⁵⁰, V. Scharf^{58a}, V.A. Schegelsky¹²³, D. Scheirich¹²⁹, M. Schernau¹⁶⁵, M.I. Scherzer³⁵, C. Schiavi^{50a,50b}, J. Schieck¹⁰⁰, C. Schillo⁴⁸, M. Schioppa^{37a,37b}, S. Schlenker³⁰, E. Schmidt⁴⁸, K. Schmieden³⁰, C. Schmitt⁸³, S. Schmitt^{58b}, B. Schneider¹⁷, Y.J. Schnellbach⁷⁴, U. Schnoor⁴⁴, L. Schoeffel¹³⁸, A. Schoening^{58b}, B.D. Schoenrock⁹⁰, A.L.S. Schorlemmer⁵⁴, M. Schott⁸³, D. Schouten^{161a}, J. Schovancova²⁵, S. Schramm¹⁶⁰, M. Schreyer¹⁷⁶, C. Schroeder⁸³, N. Schuh⁸³, M.J. Schultens²¹, H.-C. Schultz-Coulon^{58a}, H. Schulz¹⁶, M. Schumacher⁴⁸, B.A. Schumm¹³⁹, Ph. Schune¹³⁸, C. Schwanenberger⁸⁴, A. Schwartzman¹⁴⁵, T.A. Schwarz⁸⁹, Ph. Schwegler¹⁰¹, Ph. Schwemling¹³⁸, R. Schwienhorst⁹⁰, J. Schwindling¹³⁸, T. Schwindt²¹, M. Schwoerer⁵, F.G. Sciaccia¹⁷, E. Scifo¹¹⁷, G. Sciolla²³, W.G. Scott¹³¹, F. Scuri^{124a,124b}, F. Scutti²¹, J. Searcy⁸⁹, G. Sedov⁴², E. Sedykh¹²³, S.C. Seidel¹⁰⁵, A. Seiden¹³⁹, F. Seifert¹²⁸, J.M. Seixas^{24a}, G. Sekhniaidze^{104a}, S.J. Sekula⁴⁰, K.E. Selbach⁴⁶, D.M. Seliverstov^{123,*}, G. Sellers⁷⁴, N. Semprini-Cesari^{20a,20b}, C. Serfon³⁰, L. Serin¹¹⁷, L. Serkin⁵⁴, T. Serre⁸⁵, R. Seuster^{161a}, H. Severini¹¹³, T. Sfiligoi⁷⁵, F. Sforza¹⁰¹, A. Sfyrla³⁰, E. Shabalina⁵⁴, M. Shamim¹¹⁶, L.Y. Shan^{33a}, R. Shang¹⁶⁷, J.T. Shank²², M. Shapiro¹⁵, P.B. Shatalov⁹⁷, K. Shaw^{166a,166b}, C.Y. Shehu¹⁵¹, P. Sherwood⁷⁸, L. Shi^{153,ad}, S. Shimizu⁶⁷, C.O. Shimmin¹⁶⁵, M. Shimojima¹⁰², M. Shiyakova⁶⁵, A. Shmeleva⁹⁶, M.J. Shochet³¹, D. Short¹²⁰, S. Shrestha⁶⁴, E. Shulga⁹⁸, M.A. Shupe⁷, S. Shushkevich⁴², P. Sicho¹²⁷, O. Sidiropoulou¹⁵⁶, D. Sidorov¹¹⁴, A. Sidoti^{134a}, F. Siegert⁴⁴, Dj. Sijacki^{13a}, J. Silva^{126a,126d}, Y. Silver¹⁵⁵, D. Silverstein¹⁴⁵, S.B. Silverstein^{148a}, V. Simak¹²⁸, O. Simard⁵, Lj. Simic^{13a}, S. Simion¹¹⁷, E. Simioni⁸³, B. Simmons⁷⁸, R. Simioniello^{91a,91b}, M. Simonyan³⁶, P. Sinervo¹⁶⁰, N.B. Sinev¹¹⁶, V. Sipica¹⁴³, G. Siragusa¹⁷⁶, A. Sircar⁷⁹, A.N. Sisakyan^{65,*}, S.Yu. Sivoklokov⁹⁹, J. Sjölin^{148a,148b}, T.B. Sjursen¹⁴, H.P. Skottowe⁵⁷, K.Yu. Skovpen¹⁰⁹, P. Skubic¹¹³, M. Slater¹⁸, T. Slavicek¹²⁸, M. Slawinska¹⁰⁷, K. Sliwa¹⁶³, V. Smakhtin¹⁷⁴, B.H. Smart⁴⁶, L. Smestad¹⁴, S.Yu. Smirnov⁹⁸, Y. Smirnov⁹⁸, L.N. Smirnova^{99,ae}, O. Smirnova⁸¹, K.M. Smith⁵³, M. Smizanska⁷², K. Smolek¹²⁸, A.A. Snesarev⁹⁶, G. Snidero⁷⁶, S. Snyder²⁵, R. Sobie^{171,j}, F. Socher⁴⁴, A. Soffer¹⁵⁵, D.A. Soh^{153,ad}, C.A. Solans³⁰, M. Solar¹²⁸, J. Solc¹²⁸, E.Yu. Soldatov⁹⁸, U. Soldevila¹⁶⁹, A.A. Solodkov¹³⁰, A. Soloshenko⁶⁵, O.V. Solovyanov¹³⁰, V. Solovyev¹²³, P. Sommer⁴⁸, H.Y. Song^{33b}, N. Soni¹, A. Sood¹⁵,

A. Sopczak¹²⁸, B. Sopko¹²⁸, V. Sopko¹²⁸, V. Sorin¹², M. Sosebee⁸, R. Soualah^{166a,166c}, P. Soueid⁹⁵,
 A.M. Soukharev^{109,c}, D. South⁴², S. Spagnolo^{73a,73b}, F. Spanò⁷⁷, W.R. Spearman⁵⁷, F. Spettel¹⁰¹, R. Spighi^{20a},
 G. Spigo³⁰, L.A. Spiller⁸⁸, M. Spousta¹²⁹, T. Spreitzer¹⁶⁰, B. Spurlock⁸, R.D. St. Denis^{53,*}, S. Staerz⁴⁴,
 J. Stahlman¹²², R. Stamen^{58a}, S. Stamm¹⁶, E. Stanecka³⁹, R.W. Stanek⁶, C. Stanescu^{136a}, M. Stanescu-Bellu⁴²,
 M.M. Stanitzki⁴², S. Stapnes¹¹⁹, E.A. Starchenko¹³⁰, J. Stark⁵⁵, P. Staroba¹²⁷, P. Starovoitov⁴², R. Staszewski³⁹,
 P. Stavina^{146a,*}, P. Steinberg²⁵, B. Stelzer¹⁴⁴, H.J. Stelzer³⁰, O. Stelzer-Chilton^{161a}, H. Stenzel⁵², S. Stern¹⁰¹,
 G.A. Stewart⁵³, J.A. Stillings²¹, M.C. Stockton⁸⁷, M. Stoebe⁸⁷, G. Stoicea^{26a}, P. Stolte⁵⁴, S. Stonjek¹⁰¹,
 A.R. Stradling⁸, A. Straessner⁴⁴, M.E. Stramaglia¹⁷, J. Strandberg¹⁴⁹, S. Strandberg^{148a,148b}, A. Strandlie¹¹⁹,
 E. Strauss¹⁴⁵, M. Strauss¹¹³, P. Strizenc^{146b}, R. Ströhmer¹⁷⁶, D.M. Strom¹¹⁶, R. Stroynowski⁴⁰, A. Strubig¹⁰⁶,
 S.A. Stucci¹⁷, B. Stugu¹⁴, N.A. Styles⁴², D. Su¹⁴⁵, J. Su¹²⁵, R. Subramaniam⁷⁹, A. Succurro¹², Y. Sugaya¹¹⁸,
 C. Suhr¹⁰⁸, M. Suk¹²⁸, V.V. Sulin⁹⁶, S. Sultansoy^{4d}, T. Sumida⁶⁸, S. Sun⁵⁷, X. Sun^{33a}, J.E. Sundermann⁴⁸,
 K. Suruliz¹⁴¹, G. Susinno^{37a,37b}, M.R. Sutton¹⁵¹, Y. Suzuki⁶⁶, M. Svatos¹²⁷, S. Swedish¹⁷⁰, M. Swiatlowski¹⁴⁵,
 I. Sykora^{146a}, T. Sykora¹²⁹, D. Ta⁹⁰, C. Taccini^{136a,136b}, K. Tackmann⁴², J. Taenzer¹⁶⁰, A. Taffard¹⁶⁵,
 R. Tafirout^{161a}, N. Taiblum¹⁵⁵, H. Takai²⁵, R. Takashima⁶⁹, H. Takeda⁶⁷, T. Takeshita¹⁴², Y. Takubo⁶⁶,
 M. Talby⁸⁵, A.A. Talyshev^{109,c}, J.Y.C. Tam¹⁷⁶, K.G. Tan⁸⁸, J. Tanaka¹⁵⁷, R. Tanaka¹¹⁷, S. Tanaka¹³³, S. Tanaka⁶⁶,
 A.J. Tanasijczuk¹⁴⁴, B.B. Tannenwald¹¹¹, N. Tannoury²¹, S. Tapprogge⁸³, S. Tarem¹⁵⁴, F. Tarrade²⁹,
 G.F. Tartarelli^{91a}, P. Tas¹²⁹, M. Tasevsky¹²⁷, T. Tashiro⁶⁸, E. Tassi^{37a,37b}, A. Tavares Delgado^{126a,126b},
 Y. Tayalati^{137d}, F.E. Taylor⁹⁴, G.N. Taylor⁸⁸, W. Taylor^{161b}, F.A. Teischinger³⁰, M. Teixeira Dias Castanheira⁷⁶,
 P. Teixeira-Dias⁷⁷, K.K. Temming⁴⁸, H. Ten Kate³⁰, P.K. Teng¹⁵³, J.J. Teoh¹¹⁸, S. Terada⁶⁶, K. Terashi¹⁵⁷,
 J. Terron⁸², S. Terzo¹⁰¹, M. Testa⁴⁷, R.J. Teuscher^{160,j}, J. Therhaag²¹, T. Theveneaux-Pelzer³⁴, J.P. Thomas¹⁸,
 J. Thomas-Wilsker⁷⁷, E.N. Thompson³⁵, P.D. Thompson¹⁸, P.D. Thompson¹⁶⁰, R.J. Thompson⁸⁴,
 A.S. Thompson⁵³, L.A. Thomsen³⁶, E. Thomson¹²², M. Thomson²⁸, W.M. Thong⁸⁸, R.P. Thun^{89,*}, F. Tian³⁵,
 M.J. Tibbetts¹⁵, V.O. Tikhomirov^{96,af}, Yu.A. Tikhonov^{109,c}, S. Timoshenko⁹⁸, E. Tiouchichine⁸⁵, P. Tipton¹⁷⁸,
 S. Tisserant⁸⁵, T. Todorov⁵, S. Todorova-Nova¹²⁹, B. Toggerson⁷, J. Tojo⁷⁰, S. Tokár^{146a}, K. Tokushuku⁶⁶,
 K. Tollefson⁹⁰, E. Tolley⁵⁷, L. Tomlinson⁸⁴, M. Tomoto¹⁰³, L. Tompkins³¹, K. Toms¹⁰⁵, N.D. Topilin⁶⁵,
 E. Torrence¹¹⁶, H. Torres¹⁴⁴, E. Torró Pastor¹⁶⁹, J. Toth^{85,ag}, F. Touchard⁸⁵, D.R. Tovey¹⁴¹, H.L. Tran¹¹⁷,
 T. Trefzger¹⁷⁶, L. Tremblet³⁰, A. Tricoli³⁰, I.M. Trigger^{161a}, S. Trincaz-Duvoid⁸⁰, M.F. Tripiana¹², W. Trischuk¹⁶⁰,
 B. Trocme⁵⁵, C. Troncon^{91a}, M. Trottier-McDonald¹⁵, M. Trovatelli^{136a,136b}, P. True⁹⁰, M. Trzebinski³⁹,
 A. Trzupiek³⁹, C. Tsarouchas³⁰, J.C.-L. Tseng¹²⁰, P.V. Tsiareshka⁹², D. Tsionou¹³⁸, G. Tsiopolitis¹⁰, N. Tsirintanis⁹,
 S. Tsiskaridze¹², V. Tsiskaridze⁴⁸, E.G. Tskhadadze^{51a}, I.I. Tsukerman⁹⁷, V. Tsulaia¹⁵, S. Tsuno⁶⁶,
 D. Tsybychev¹⁵⁰, A. Tudorache^{26a}, V. Tudorache^{26a}, A.N. Tuna¹²², S.A. Tupputi^{20a,20b}, S. Turchikhin^{99,ae},
 D. Turecek¹²⁸, I. Turk Cakir^{4c}, R. Turra^{91a,91b}, A.J. Turvey⁴⁰, P.M. Tuts³⁵, A. Tykhonov⁴⁹, M. Tylmad^{148a,148b},
 M. Tyndel¹³¹, K. Uchida²¹, I. Ueda¹⁵⁷, R. Ueno²⁹, M. Ughetto⁸⁵, M. Ugland¹⁴, M. Uhlenbrock²¹, F. Ukegawa¹⁶²,
 G. Unal³⁰, A. Undrus²⁵, G. Unel¹⁶⁵, F.C. Ungaro⁴⁸, Y. Unno⁶⁶, C. Unverdorben¹⁰⁰, D. Urbaniec³⁵, P. Urquijo⁸⁸,
 G. Usai⁸, A. Usanova⁶², L. Vacavant⁸⁵, V. Vacek¹²⁸, B. Vachon⁸⁷, N. Valencic¹⁰⁷, S. Valentinetti^{20a,20b},
 A. Valero¹⁶⁹, L. Valery³⁴, S. Valkar¹²⁹, E. Valladolid Gallego¹⁶⁹, S. Vallecorsa⁴⁹, J.A. Valls Ferrer¹⁶⁹,
 W. Van Den Wollenberg¹⁰⁷, P.C. Van Der Deijl¹⁰⁷, R. van der Geer¹⁰⁷, H. van der Graaf¹⁰⁷, R. Van Der Leeuw¹⁰⁷,
 D. van der Ster³⁰, N. van Eldik³⁰, P. van Gemmeren⁶, J. Van Nieuwkoop¹⁴⁴, I. van Vulpen¹⁰⁷, M.C. van Woerden³⁰,
 M. Vanadia^{134a,134b}, W. Vandelli³⁰, R. Vanguri¹²², A. Vaniachine⁶, P. Vankov⁴², F. Vannucci⁸⁰, G. Vardanyan¹⁷⁹,
 R. Vari^{134a}, E.W. Varnes⁷, T. Varol⁸⁶, D. Varouchas⁸⁰, A. Vartapetian⁸, K.E. Varvell¹⁵², F. Vazeille³⁴,
 T. Vazquez Schroeder⁵⁴, J. Veatch⁷, F. Veloso^{126a,126c}, S. Veneziano^{134a}, A. Ventura^{73a,73b}, D. Ventura⁸⁶,
 M. Venturi¹⁷¹, N. Venturi¹⁶⁰, A. Venturini²³, V. Vercesi^{121a}, M. Verducci^{134a,134b}, W. Verkerke¹⁰⁷,
 J.C. Vermeulen¹⁰⁷, A. Vest⁴⁴, M.C. Vetterli^{144,e}, O. Viazlo⁸¹, I. Vichou¹⁶⁷, T. Vickey^{147c,ah}, O.E. Vickey Boeriu^{147c},
 G.H.A. Viehhauser¹²⁰, S. Viel¹⁷⁰, R. Vigne³⁰, M. Villa^{20a,20b}, M. Villaplana Perez^{91a,91b}, E. Vilucchi⁴⁷,
 M.G. Vincker²⁹, V.B. Vinogradov⁶⁵, J. Virzi¹⁵, I. Vivarelli¹⁵¹, F. Vives Vaque³, S. Vlachos¹⁰, D. Vladoiu¹⁰⁰,
 M. Vlasak¹²⁸, A. Vogel²¹, M. Vogel^{32a}, P. Vokac¹²⁸, G. Volpi^{124a,124b}, M. Volpi⁸⁸, H. von der Schmitt¹⁰¹,
 H. von Radziewski⁴⁸, E. von Toerne²¹, V. Vorobel¹²⁹, K. Vorobev⁹⁸, M. Vos¹⁶⁹, R. Voss³⁰, J.H. Vosseveld⁷⁴,
 N. Vranjes¹³⁸, M. Vranjes Milosavljevic^{13a}, V. Vrba¹²⁷, M. Vreeswijk¹⁰⁷, T. Vu Anh⁴⁸, R. Vuillermet³⁰, I. Vukotic³¹,
 Z. Vykydal¹²⁸, P. Wagner²¹, W. Wagner¹⁷⁷, H. Wahlberg⁷¹, S. Wahrenmund⁴⁴, J. Wakabayashi¹⁰³, J. Walder⁷²,
 R. Walker¹⁰⁰, W. Walkowiak¹⁴³, R. Wall¹⁷⁸, P. Waller⁷⁴, B. Walsh¹⁷⁸, C. Wang^{153,ai}, C. Wang⁴⁵, F. Wang¹⁷⁵,
 H. Wang¹⁵, H. Wang⁴⁰, J. Wang⁴², J. Wang^{33a}, K. Wang⁸⁷, R. Wang¹⁰⁵, S.M. Wang¹⁵³, T. Wang²¹, X. Wang¹⁷⁸,
 C. Wanotayaroj¹¹⁶, A. Warburton⁸⁷, C.P. Ward²⁸, D.R. Wardrope⁷⁸, M. Warsinsky⁴⁸, A. Washbrook⁴⁶,
 C. Wasicki⁴², P.M. Watkins¹⁸, A.T. Watson¹⁸, I.J. Watson¹⁵², M.F. Watson¹⁸, G. Watts¹⁴⁰, S. Watts⁸⁴,
 B.M. Waugh⁷⁸, S. Webb⁸⁴, M.S. Weber¹⁷, S.W. Weber¹⁷⁶, J.S. Webster³¹, A.R. Weidberg¹²⁰, P. Weigell¹⁰¹,
 B. Weinert⁶¹, J. Weingarten⁵⁴, C. Weiser⁴⁸, H. Weits¹⁰⁷, P.S. Wells³⁰, T. Wenaus²⁵, D. Wendland¹⁶, Z. Weng^{153,ad},
 T. Wengler³⁰, S. Wenig³⁰, N. Wermes²¹, M. Werner⁴⁸, P. Werner³⁰, M. Wessels^{58a}, J. Wetter¹⁶³, K. Whalen²⁹,
 A. White⁸, M.J. White¹, R. White^{32b}, S. White^{124a,124b}, D. Whiteson¹⁶⁵, D. Wicke¹⁷⁷, F.J. Wickens¹³¹,
 W. Wiedenmann¹⁷⁵, M. Wielers¹³¹, P. Wienemann²¹, C. Wiglesworth³⁶, L.A.M. Wiik-Fuchs²¹, P.A. Wijeratne⁷⁸,

A. Wildauer¹⁰¹, M.A. Wildt^{42,aj}, H.G. Wilkens³⁰, J.Z. Will¹⁰⁰, H.H. Williams¹²², S. Williams²⁸, C. Willis⁹⁰, S. Willocq⁸⁶, A. Wilson⁸⁹, J.A. Wilson¹⁸, I. Wingerter-Seez⁵, F. Winklmeier¹¹⁶, B.T. Winter²¹, M. Wittgen¹⁴⁵, T. Wittig⁴³, J. Wittkowski¹⁰⁰, S.J. Wollstadt⁸³, M.W. Wolter³⁹, H. Wolters^{126a,126c}, B.K. Wosiek³⁹, J. Wotschack³⁰, M.J. Woudstra⁸⁴, K.W. Wozniak³⁹, M. Wright⁵³, M. Wu⁵⁵, S.L. Wu¹⁷⁵, X. Wu⁴⁹, Y. Wu⁸⁹, E. Wulf⁶³⁵, T.R. Wyatt⁸⁴, B.M. Wynne⁴⁶, S. Xella³⁶, M. Xiao¹³⁸, D. Xu^{33a}, L. Xu^{33b,ak}, B. Yabsley¹⁵², S. Yacoub^{147b,al}, R. Yakabe⁶⁷, M. Yamada⁶⁶, H. Yamaguchi¹⁵⁷, Y. Yamaguchi¹¹⁸, A. Yamamoto⁶⁶, K. Yamamoto⁶⁴, S. Yamamoto¹⁵⁷, T. Yamamura¹⁵⁷, T. Yamanaka¹⁵⁷, K. Yamauchi¹⁰³, Y. Yamazaki⁶⁷, Z. Yan²², H. Yang^{33e}, H. Yang¹⁷⁵, U.K. Yang⁸⁴, Y. Yang¹¹¹, S. Yanush⁹³, L. Yao^{33a}, W.-M. Yao¹⁵, Y. Yasu⁶⁶, E. Yatsenko⁴², K.H. Yau Wong²¹, J. Ye⁴⁰, S. Ye²⁵, I. Yeletsikh⁶⁵, A.L. Yen⁵⁷, E. Yildirim⁴², M. Yilmaz^{4b}, R. Yoosofmiya¹²⁵, K. Yorita¹⁷³, R. Yoshida⁶, K. Yoshihara¹⁵⁷, C. Young¹⁴⁵, C.J.S. Young³⁰, S. Youssef²², D.R. Yu¹⁵, J. Yu⁸, J.M. Yu⁸⁹, J. Yu¹¹⁴, L. Yuan⁶⁷, A. Yurkewicz¹⁰⁸, I. Yusuff^{28,am}, B. Zabinski³⁹, R. Zaidan⁶³, A.M. Zaitsev^{130,z}, A. Zaman¹⁵⁰, S. Zambito²³, L. Zanello^{134a,134b}, D. Zanzi⁸⁸, C. Zeitnitz¹⁷⁷, M. Zeman¹²⁸, A. Zemla^{38a}, K. Zengel²³, O. Zenin¹³⁰, T. Ženiš^{146a}, D. Zerwas¹¹⁷, G. Zevi della Porta⁵⁷, D. Zhang⁸⁹, F. Zhang¹⁷⁵, H. Zhang⁹⁰, J. Zhang⁶, L. Zhang¹⁵³, X. Zhang^{33d}, Z. Zhang¹¹⁷, Z. Zhao^{33b}, A. Zhemchugov⁶⁵, J. Zhong¹²⁰, B. Zhou⁸⁹, L. Zhou³⁵, N. Zhou¹⁶⁵, C.G. Zhu^{33d}, H. Zhu^{33a}, J. Zhu⁸⁹, Y. Zhu^{33b}, X. Zhuang^{33a}, K. Zhukov⁹⁶, A. Zibell¹⁷⁶, D. Zieminska⁶¹, N.I. Zimine⁶⁵, C. Zimmermann⁸³, R. Zimmermann²¹, S. Zimmermann²¹, S. Zimmermann⁴⁸, Z. Zinonos⁵⁴, M. Ziolkowski¹⁴³, G. Zoernig¹⁷⁵, A. Zoccoli^{20a,20b}, M. zur Nedden¹⁶, G. Zurzolo^{104a,104b}, V. Zutshi¹⁰⁸, L. Zwalinski³⁰.

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

² Physics Department, SUNY Albany, Albany NY, United States of America

³ Department of Physics, University of Alberta, Edmonton AB, Canada

⁴ (a) Department of Physics, Ankara University, Ankara; (b) Department of Physics, Gazi University, Ankara; (c) Istanbul Aydin University, Istanbul; (d) Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey

⁵ LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France

⁶ High Energy Physics Division, Argonne National Laboratory, Argonne IL, United States of America

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

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

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, Barcelona, Spain

¹³ (a) Institute of Physics, University of Belgrade, Belgrade; (b) 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 CA, United States of America

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

¹⁹ (a) Department of Physics, Bogazici University, Istanbul; (b) Department of Physics, Dogus University, Istanbul;

(c) Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey

²⁰ (a) INFN Sezione di Bologna; (b) Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy

²¹ Physikalisches Institut, University of Bonn, Bonn, Germany

²² Department of Physics, Boston University, Boston MA, United States of America

²³ Department of Physics, Brandeis University, Waltham MA, United States of America

²⁴ (a) Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; (b) Federal University of Juiz de Fora (UFJF), Juiz de Fora; (c) Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei; (d) Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil

²⁵ Physics Department, Brookhaven National Laboratory, Upton NY, United States of America

²⁶ (a) National Institute of Physics and Nuclear Engineering, Bucharest; (b) National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj Napoca; (c) University Politehnica Bucharest, Bucharest; (d) 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 ON, Canada

- ³⁰ CERN, Geneva, Switzerland
- ³¹ Enrico Fermi Institute, University of Chicago, Chicago IL, United States of America
- ³² ^(a) Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; ^(b) Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
- ³³ ^(a) Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; ^(b) Department of Modern Physics, University of Science and Technology of China, Anhui; ^(c) Department of Physics, Nanjing University, Jiangsu; ^(d) School of Physics, Shandong University, Shandong; ^(e) Physics Department, Shanghai Jiao Tong University, Shanghai; ^(f) Physics Department, Tsinghua University, Beijing 100084, China
- ³⁴ Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France
- ³⁵ Nevis Laboratory, Columbia University, Irvington NY, United States of America
- ³⁶ Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
- ³⁷ ^(a) INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati; ^(b) Dipartimento di Fisica, Università della Calabria, Rende, Italy
- ³⁸ ^(a) AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow; ^(b) Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland
- ³⁹ The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
- ⁴⁰ Physics Department, Southern Methodist University, Dallas TX, United States of America
- ⁴¹ Physics Department, University of Texas at Dallas, Richardson TX, United States of America
- ⁴² DESY, Hamburg and Zeuthen, Germany
- ⁴³ Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
- ⁴⁴ Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany
- ⁴⁵ Department of Physics, Duke University, Durham NC, United States of America
- 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
- ⁵⁰ ^(a) INFN Sezione di Genova; ^(b) Dipartimento di Fisica, Università di Genova, Genova, Italy
- ⁵¹ ^(a) E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi; ^(b) 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 Grenoble-Alpes, CNRS/IN2P3, Grenoble, France
- ⁵⁶ Department of Physics, Hampton University, Hampton VA, United States of America
- ⁵⁷ Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge MA, United States of America
- ⁵⁸ ^(a) Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; ^(b) Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; ^(c) ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
- ⁵⁹ Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
- ⁶⁰ ^(a) Department of Physics, Shatin, N.T., Hong Kong; ^(b) Department of Physics, Hong Kong; ^(c) Department of Physics, Clear Water Bay, Kowloon, Hong Kong, China
- ⁶¹ Department of Physics, Indiana University, Bloomington IN, United States of America
- ⁶² Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- ⁶³ University of Iowa, Iowa City IA, United States of America
- ⁶⁴ Department of Physics and Astronomy, Iowa State University, Ames IA, United States of America
- ⁶⁵ Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
- ⁶⁶ KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
- ⁶⁷ Graduate School of Science, Kobe University, Kobe, Japan
- ⁶⁸ Faculty of Science, Kyoto University, Kyoto, Japan
- ⁶⁹ Kyoto University of Education, Kyoto, Japan
- ⁷⁰ Department of Physics, Kyushu University, Fukuoka, Japan
- ⁷¹ Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
- ⁷² Physics Department, Lancaster University, Lancaster, United Kingdom
- ⁷³ ^(a) INFN Sezione di Lecce; ^(b) Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
- ⁷⁴ Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
- ⁷⁵ Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia

- 76 School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
- 77 Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- 78 Department of Physics and Astronomy, University College London, London, United Kingdom
- 79 Louisiana Tech University, Ruston LA, United States of America
- 80 Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- 81 Fysiska institutionen, Lunds universitet, Lund, Sweden
- 82 Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
- 83 Institut für Physik, Universität Mainz, Mainz, Germany
- 84 School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- 85 CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- 86 Department of Physics, University of Massachusetts, Amherst MA, United States of America
- 87 Department of Physics, McGill University, Montreal QC, Canada
- 88 School of Physics, University of Melbourne, Victoria, Australia
- 89 Department of Physics, The University of Michigan, Ann Arbor MI, United States of America
- 90 Department of Physics and Astronomy, Michigan State University, East Lansing MI, United States of America
- 91 ^(a) INFN Sezione di Milano; ^(b) Dipartimento di Fisica, Università di Milano, Milano, Italy
- 92 B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
- 93 National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus
- 94 Department of Physics, Massachusetts Institute of Technology, Cambridge MA, United States of America
- 95 Group of Particle Physics, University of Montreal, Montreal QC, Canada
- 96 P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
- 97 Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- 98 Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
- 99 D.V.Skobeltzyn Institute of Nuclear Physics, M.V.Lomonosov Moscow State University, Moscow, Russia
- 100 Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- 101 Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
- 102 Nagasaki Institute of Applied Science, Nagasaki, Japan
- 103 Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan
- 104 ^(a) INFN Sezione di Napoli; ^(b) Dipartimento di Fisica, Università di Napoli, Napoli, Italy
- 105 Department of Physics and Astronomy, University of New Mexico, Albuquerque NM, United States of America
- 106 Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
- 107 Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
- 108 Department of Physics, Northern Illinois University, DeKalb IL, United States of America
- 109 Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia
- 110 Department of Physics, New York University, New York NY, United States of America
- 111 Ohio State University, Columbus OH, United States of America
- 112 Faculty of Science, Okayama University, Okayama, Japan
- 113 Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman OK, United States of America
- 114 Department of Physics, Oklahoma State University, Stillwater OK, United States of America
- 115 Palacký University, RCPTM, Olomouc, Czech Republic
- 116 Center for High Energy Physics, University of Oregon, Eugene OR, United States of America
- 117 LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France
- 118 Graduate School of Science, Osaka University, Osaka, Japan
- 119 Department of Physics, University of Oslo, Oslo, Norway
- 120 Department of Physics, Oxford University, Oxford, United Kingdom
- 121 ^(a) INFN Sezione di Pavia; ^(b) Dipartimento di Fisica, Università di Pavia, Pavia, Italy
- 122 Department of Physics, University of Pennsylvania, Philadelphia PA, United States of America
- 123 Petersburg Nuclear Physics Institute, Gatchina, Russia
- 124 ^(a) INFN Sezione di Pisa; ^(b) Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
- 125 Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh PA, United States of America
- 126 ^(a) Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa; ^(b) Faculdade de Ciências, Universidade de Lisboa, Lisboa; ^(c) Department of Physics, University of Coimbra, Coimbra; ^(d) Centro de Física Nuclear da Universidade de Lisboa, Lisboa; ^(e) Departamento de Física, Universidade do Minho, Braga; ^(f) Departamento de Física Teórica y del Cosmos and CAFPE, Universidad de Granada, Granada (Spain); ^(g) Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal

- 127 Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
 128 Czech Technical University in Prague, Praha, Czech Republic
 129 Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic
 130 State Research Center Institute for High Energy Physics, Protvino, Russia
 131 Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
 132 Physics Department, University of Regina, Regina SK, Canada
 133 Ritsumeikan University, Kusatsu, Shiga, Japan
 134 (a) INFN Sezione di Roma; (b) Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy
 135 (a) INFN Sezione di Roma Tor Vergata; (b) Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy
 136 (a) INFN Sezione di Roma Tre; (b) Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy
 137 (a) Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca; (b) Centre National de l'Énergie des Sciences Techniques Nucleaires, Rabat; (c) Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech; (d) Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda; (e) Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco
 138 DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Énergie Atomique et aux Énergies Alternatives), Gif-sur-Yvette, France
 139 Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz CA, United States of America
 140 Department of Physics, University of Washington, Seattle WA, United States of America
 141 Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
 142 Department of Physics, Shinshu University, Nagano, Japan
 143 Fachbereich Physik, Universität Siegen, Siegen, Germany
 144 Department of Physics, Simon Fraser University, Burnaby BC, Canada
 145 SLAC National Accelerator Laboratory, Stanford CA, United States of America
 146 (a) Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava; (b) Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
 147 (a) Department of Physics, University of Cape Town, Cape Town; (b) Department of Physics, University of Johannesburg, Johannesburg; (c) School of Physics, University of the Witwatersrand, Johannesburg, South Africa
 148 (a) Department of Physics, Stockholm University; (b) The Oskar Klein Centre, Stockholm, Sweden
 149 Physics Department, Royal Institute of Technology, Stockholm, Sweden
 150 Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook NY, United States of America
 151 Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
 152 School of Physics, University of Sydney, Sydney, Australia
 153 Institute of Physics, Academia Sinica, Taipei, Taiwan
 154 Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel
 155 Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
 156 Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
 157 International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
 158 Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
 159 Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
 160 Department of Physics, University of Toronto, Toronto ON, Canada
 161 (a) TRIUMF, Vancouver BC; (b) Department of Physics and Astronomy, York University, Toronto ON, Canada
 162 Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Japan
 163 Department of Physics and Astronomy, Tufts University, Medford MA, United States of America
 164 Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
 165 Department of Physics and Astronomy, University of California Irvine, Irvine CA, United States of America
 166 (a) INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine; (b) ICTP, Trieste; (c) Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy
 167 Department of Physics, University of Illinois, Urbana IL, United States of America
 168 Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
 169 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
 170 Department of Physics, University of British Columbia, Vancouver BC, Canada
 171 Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada
 172 Department of Physics, University of Warwick, Coventry, United Kingdom

¹⁷³ Waseda University, Tokyo, Japan

¹⁷⁴ Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel

¹⁷⁵ Department of Physics, University of Wisconsin, Madison WI, United States of America

¹⁷⁶ Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany

¹⁷⁷ Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany

¹⁷⁸ Department of Physics, Yale University, New Haven CT, United States of America

¹⁷⁹ Yerevan Physics Institute, Yerevan, Armenia

¹⁸⁰ Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France

^a Also at Department of Physics, King's College London, London, United Kingdom

^b Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan

^c Also at Novosibirsk State University, Novosibirsk, Russia

^d Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom

^e Also at TRIUMF, Vancouver BC, Canada

^f Also at Department of Physics, California State University, Fresno CA, United States of America

^g Also at Tomsk State University, Tomsk, Russia

^h Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France

ⁱ Also at Università di Napoli Parthenope, Napoli, Italy

^j Also at Institute of Particle Physics (IPP), Canada

^k Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia

^l Also at Department of Financial and Management Engineering, University of the Aegean, Chios, Greece

^m Also at Louisiana Tech University, Ruston LA, United States of America

ⁿ Also at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain

^o Also at Department of Physics, The University of Texas at Austin, Austin TX, United States of America

^p Also at Institute of Theoretical Physics, Iliia State University, Tbilisi, Georgia

^q Also at CERN, Geneva, Switzerland

^r Also at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan

^s Also at Manhattan College, New York NY, United States of America

^t Also at Institute of Physics, Academia Sinica, Taipei, Taiwan

^u Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France

^v Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan

^w Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France

^x Also at School of Physical Sciences, National Institute of Science Education and Research, Bhubaneswar, India

^y Also at Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy

^z Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia

^{aa} Also at Section de Physique, Université de Genève, Geneva, Switzerland

^{ab} Also at International School for Advanced Studies (SISSA), Trieste, Italy

^{ac} Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, United States of America

^{ad} Also at School of Physics and Engineering, Sun Yat-sen University, Guangzhou, China

^{ae} Also at Faculty of Physics, M.V.Lomonosov Moscow State University, Moscow, Russia

^{af} Also at Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia

^{ag} Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary

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

^{ai} Also at Department of Physics, Nanjing University, Jiangsu, China

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

^{ak} Also at Department of Physics, The University of Michigan, Ann Arbor MI, United States of America

^{al} Also at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa

^{am} Also at University of Malaya, Department of Physics, Kuala Lumpur, Malaysia

* Deceased