

## Search for Pair Production of a New $b'$ Quark that Decays into a Z Boson and a Bottom Quark with the ATLAS Detector

G. Aad *et al.*\*

(ATLAS Collaboration)

(Received 5 April 2012; published 16 August 2012)

A search is reported for the pair production of a new quark  $b'$  with at least one  $b'$  decaying to a Z boson and a bottom quark. The data, corresponding to  $2.0 \text{ fb}^{-1}$  of integrated luminosity, were collected from  $pp$  collisions at  $\sqrt{s} = 7 \text{ TeV}$  with the ATLAS detector at the CERN Large Hadron Collider. Using events with a  $b$ -tagged jet and a Z boson reconstructed from opposite-charge electrons, the mass distribution of large transverse momentum  $b'$  candidates is tested for an enhancement. No evidence for a  $b'$  signal is detected in the observed mass distribution, resulting in the exclusion at a 95% confidence level of  $b'$  quarks with masses  $m_{b'} < 400 \text{ GeV}$  that decay entirely via  $b' \rightarrow Z + b$ . In the case of a vectorlike singlet  $b'$  mixing solely with the third standard model generation, masses  $m_{b'} < 358 \text{ GeV}$  are excluded.

DOI: [10.1103/PhysRevLett.109.071801](https://doi.org/10.1103/PhysRevLett.109.071801)

PACS numbers: 14.65.Jk, 12.60.-i, 13.85.Rm, 14.65.Fy

The matter sector of the standard model (SM) consists of three generations of chiral fermions, with each generation containing a quark doublet and a lepton doublet. A natural question is whether quarks and leptons exist beyond the third generation [1]. In this Letter, we present a search for the pair production of a new quark with electric charge  $-1/3$ , denoted  $b'$ , using data collected by the ATLAS experiment at the Large Hadron Collider. New quarks appear in a variety of models that address shortcomings of the SM [1–5]. In addition to signaling a richer matter content at high energy, their existence would impact lower-scale physics, such as altering Higgs boson ( $H$ ) phenomenology [6], and providing new sources of  $CP$  violation potentially sufficient to generate the baryon asymmetry in the Universe [7].

Several collaborations have previously searched for a chiral  $b'$ . A search by D0 [8] for the decay  $b' \rightarrow \gamma + b$  excludes  $b'$  quarks with masses below  $m_Z + m_b = 96 \text{ GeV}$ . CDF [9] searches for the decay  $b' \rightarrow Z + b$  exclude masses below  $m_W + m_t = 256 \text{ GeV}$ . These limits apply to prompt  $b'$  decays. CDF and D0 have also searched for nonprompt  $b' \rightarrow Z + b$  decays [10], excluding, for example,  $b'$  masses below  $180 \text{ GeV}$  for  $c\tau = 20 \text{ cm}$  [11]. More recently, CDF [12], CMS [13], and ATLAS [14] have searched for the prompt charged-current decay  $b' \rightarrow W + t$ . This decay mode is dominant for a chiral  $b'$  with mass in excess of  $m_W + m_t$ , as the neutral-current modes only occur through loop diagrams [1]. The ATLAS result excludes chiral  $b'$  quarks with masses below  $480 \text{ GeV}$ .

Extensions to the SM often propose new quarks transforming as vectorlike representations of the electroweak gauge groups [2–5]. The decay of a vectorlike  $b'$  to a Z boson and a bottom quark is a tree-level process with a branching ratio comparable to that of the decay  $b' \rightarrow W + t$ . In particular, the branching ratios  $Wt:Zb:Hb$  approach the proportion 2:1:1 in the limit of a large  $b'$  mass as a consequence of the Goldstone boson equivalence theorem [2,5]. Furthermore, if a signal were observed in the  $WtWt$  final state, a search for a resonant  $Z + b$  signal would aid in establishing the charge of the new quark. In light of these observations, this search explores the  $Z + b$  jet final state for the presence of a  $b'$  quark.

The ATLAS detector [15] consists of particle-tracking detectors, electromagnetic and hadronic calorimeters, and a muon spectrometer. At small radii transverse to the beam line, the inner tracking system utilizes fine-granularity pixel and microstrip detectors designed to provide precision track impact parameter and secondary vertex measurements. These silicon-based detectors cover the pseudorapidity [16] range  $|\eta| < 2.5$ . A gas-filled straw tube tracker complements the silicon tracker at larger radii. The tracking detectors are immersed in a 2 T magnetic field produced by a thin superconducting solenoid located in the same cryostat as the barrel electromagnetic (EM) calorimeter. The EM calorimeters employ lead absorbers and utilize liquid argon as the active medium. The barrel EM calorimeter covers  $|\eta| < 1.5$ , and the end-cap EM calorimeters cover  $1.4 < |\eta| < 3.2$ . Hadronic calorimetry in the region  $|\eta| < 1.7$  is achieved using steel absorbers and scintillating tiles as the active medium. Liquid argon calorimetry with copper absorbers is employed in the hadronic end-cap calorimeters, which cover the region  $1.5 < |\eta| < 3.2$ .

The search for the decay  $b' \rightarrow Z + b$  is performed in the final state with the Z boson decaying to an electron-positron pair ( $e^+e^-$ ) using a dataset collected in 2011 corresponding to an integrated luminosity of

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

$1.98 \pm 0.07 \text{ fb}^{-1}$  [17]. The selected events were recorded with a single-electron trigger that is over 95% efficient for reconstructed electrons [18] with momentum transverse to the beam direction,  $p_T$ , exceeding 25 GeV. At least two opposite-charge electron candidates are required, each satisfying  $p_T > 25$  GeV and reconstructed in the pseudorapidity region  $|\eta| < 2.47$ , excluding the barrel to end-cap calorimeter transition region,  $1.37 < |\eta| < 1.52$ . In addition, the electron candidates satisfy *medium* quality requirements [18] on the reconstructed track and properties of the electromagnetic shower. The two opposite-charge electron candidates yielding an invariant mass  $m_{ee}$  that satisfies  $|m_{ee} - m_Z| < 15$  GeV and is closest to the  $Z$  boson mass define the  $Z$  candidate. Approximately 475 000 events pass the  $Z \rightarrow e^+e^-$  selection criteria.

Jets are reconstructed using the anti- $k_t$  clustering algorithm [19] with a distance parameter of 0.4. The inputs to the algorithm are three-dimensional clusters formed from calorimeter energy deposits. Jets are calibrated using  $p_T$ - and  $\eta$ -dependent factors determined from simulation and validated with data [20]. Jets are rejected if they do not satisfy quality criteria to suppress noise and noncollision backgrounds, as are jets whose axis is within  $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.5$  of a reconstructed electron associated with the  $Z$  candidate. A requirement is made to ensure at least 75% of the total  $p_T$  of all tracks associated with the jet be attributed to tracks also associated with the selected  $pp$  collision vertex [21]. Finally, jets in this analysis are restricted to the region covered by the tracking detectors,  $|\eta| < 2.5$ , and satisfy  $p_T > 25$  GeV. Approximately 81 000 events pass the  $Z \rightarrow e^+e^-$  candidate selection and contain at least one selected jet.

The SM production of  $Z$  bosons in association with jets accounts for most events passing the  $Z + \geq 1$  jet selection. Two leading-order Monte Carlo (MC) generators, ALPGEN [22] and SHERPA [23], are used to assess the background arising from this process, with ALPGEN providing the baseline prediction. A description of the generation of these samples, in particular, in regard to differences between ALPGEN and SHERPA in the modeling of  $Z$  boson production in association with  $b$  jets, is detailed in Ref. [24]. The predictions of both are normalized such that the inclusive  $Z$  boson cross section is equal to a next-to-next-to-leading-order (NNLO) calculation [25]. All MC samples fully simulate the ATLAS detector [26] and are reconstructed with the same algorithms as those applied to data. The  $Z + \text{bottom}$  background category comprises simulated  $Z + \text{jet(s)}$  events in which a generated  $p_T > 5$  GeV bottom quark is matched to a selected reconstructed jet. Similarly, events with a jet matched to a charm quark, but not a bottom quark, constitute the  $Z + \text{charm}$  category. In the  $Z + \text{light}$  category, none of the selected jets are matched to a bottom or charm quark.

Additional SM backgrounds modeled with MC events include top quark pair production ( $t\bar{t}$ ), single top

production, heavy vector boson pair (diboson) production,  $Z(\rightarrow \tau\tau) + \text{jet(s)}$  events, and  $W(\rightarrow e\nu) + \text{jet(s)}$  events. Processes with a top quark are simulated with MC@NLO [27,28]. The  $t\bar{t}$  cross section used is the HATHOR [29] approximate NNLO value, while MC@NLO [28] values are used for the single top processes. HERWIG [30] models the contribution of diboson events, with the cross sections set by the MCFM [31] NLO predictions. The remaining  $W/Z + \text{jet(s)}$  backgrounds are simulated with ALPGEN, and normalized using single vector boson production NNLO cross sections [25]. The multijet background is estimated using a data sample with both electron candidates passing *loose* criteria [18] but failing the slightly tighter *medium* criteria. This sample is normalized to the difference in the inclusive  $Z$  sample between the data and all other backgrounds in the region  $50 < m_{ee} < 65$  GeV. The small single top, diboson,  $Z \rightarrow \tau\tau$ ,  $W \rightarrow e\nu$ , and multijet contributions are combined and denoted Other SM.

Figure 1 presents the  $e^+e^-$  invariant mass distribution for events passing the  $Z + \geq 1$  jet selection, before imposing the  $|m_{ee} - m_Z| < 15$  GeV requirement, together with the SM prediction. The observed and predicted number of events are listed in Table I for this and two other stages of the event selection. Most events passing the  $Z + \geq 1$  jet selection arise from the  $Z + \text{light}$  category. The appreciable lifetime of the  $b$  hadron originating from the bottom quark in the decay  $b' \rightarrow Z + b$  provides a means to reduce this background source. A  $b$  jet tagging algorithm referred to as IP3D + SV1 [32] is utilized to select events with at

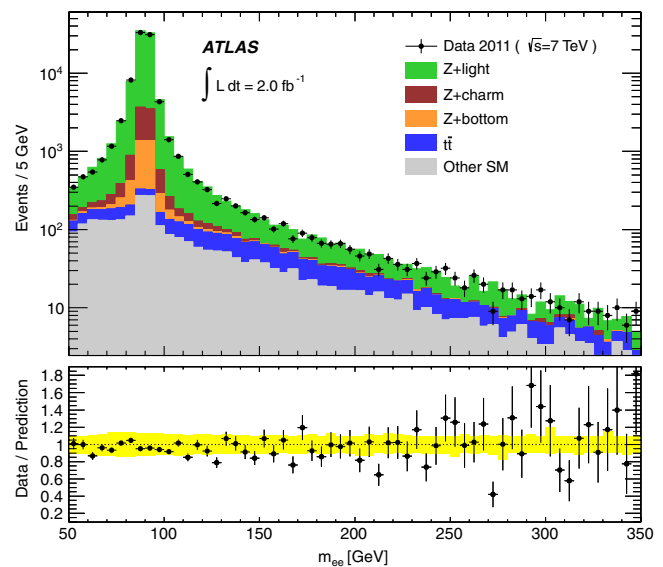


FIG. 1 (color online).  $e^+e^-$  invariant mass distribution for events passing the  $Z + \geq 1$  jet selection, before imposing the  $|m_{ee} - m_Z| < 15$  GeV requirement. The predicted contributions of the SM background sources are shown stacked. The lower panel shows the ratio of the data to the SM prediction, and the solid band denotes the systematic uncertainty on the SM prediction.

TABLE I. Number of predicted and observed events at three stages in the event selection. The contributions from SM backgrounds are shown individually, as well as combined into the total SM prediction. The uncertainties on the predicted number of events combine all sources of uncertainty. The number of expected signal events is also listed for two representative  $b'$  masses in the case where the branching ratio  $\text{BR}(b' \rightarrow Zb) = 1$ .

Source	$Z + \geq 1$ jet	$Z + \geq 1$ $b$ jet	$p_T(Zb) > 150$ GeV
$Z + \text{light}$	$74\,400 \pm 7300$	$590 \pm 140$	$19 \pm 7$
$Z + \text{charm}$	$5340 \pm 520$	$870 \pm 210$	$18 \pm 7$
$Z + \text{bottom}$	$2540 \pm 250$	$1710 \pm 270$	$52 \pm 17$
$t\bar{t}$	$320 \pm 40$	$220 \pm 40$	$20 \pm 4$
Other SM	$1010 \pm 280$	$70 \pm 20$	$1.6 \pm 0.4$
Total SM	$83\,600 \pm 8100$	$3460 \pm 580$	$110 \pm 30$
Data	80519	3466	100
$m_{b'} = 350$ GeV	$110 \pm 12$	$93 \pm 11$	$55 \pm 7$
$m_{b'} = 450$ GeV	$27 \pm 3$	$20 \pm 2$	$14 \pm 2$

least one  $b$  jet from the  $Z + \geq 1$  jet sample. The discriminant combines two likelihood variables based on the tracks associated with a jet. The first employs the longitudinal and transverse track impact parameters, while the second utilizes properties of a reconstructed secondary vertex. In a simulated  $t\bar{t}$  sample, the requirement on the discriminant defining a  $b$  jet is 60% efficient for jets with a  $b$  hadron, and yields a light flavor jet rejection rate of 300 [32].

A total of 3466 events satisfy the  $Z + \geq 1$   $b$  jet selection. Figure 2 presents the  $e^+e^-$  invariant mass distribution in this sample and the SM prediction, before imposing the  $|m_{ee} - m_Z| < 15$  GeV requirement. The accurate modeling of the mass distribution for values beyond the  $Z$  boson mass supports the prediction of  $t\bar{t}$  and Other SM

background events. Within the window around the  $Z$  boson mass, ALPGEN and SHERPA agree to within 1% and 7% in the prediction of the number of  $Z + \text{light}$  and  $Z + \text{charm}$  events, respectively. However, ALPGEN and SHERPA disagree in the prediction of the  $Z + \text{bottom}$  contribution, a fact previously reported in an ATLAS cross section measurement of  $Z$  bosons produced in association with  $b$  jets using a smaller dataset [24]. The ALPGEN and SHERPA  $Z + \text{bottom}$  predictions are scaled to account for the difference between data and all other predicted backgrounds in a subsample of the  $Z + \geq 1$   $b$  jet sample that contains events failing the requirement discussed below on the transverse momentum of the  $b'$  candidate. The scale factors are consistent with those measured in Ref. [24], and the invariant mass distribution of secondary vertex tracks is used to confirm the validity of the resulting prediction for the flavor composition in the  $Z + \geq 1$   $b$  jet sample [24].

Simulated  $b'\bar{b}'$  events are generated for a range of  $b'$  masses using MADGRAPH [33] with the G4LHC extension [6]. PYTHIA [34] performs fragmentation and hadronization of the parton-level events. The signal cross sections are obtained with HATHOR [29], and vary from 80 pb to 30 fb over the range  $m_{b'} = 200\text{--}700$  GeV. In each sample, one  $b'$  decays in the mode  $b' \rightarrow Z + b$ , with the  $Z$  boson decaying via  $Z \rightarrow e^+e^-$ . Two separate samples are produced for each mass value, with the other  $b'$  decaying either via  $b' \rightarrow Z + b$  or  $b' \rightarrow W + t$ , and with all decay modes of the  $Z$  and  $W$  bosons allowed. The factor  $\beta = 2 \times \text{BR}(b' \rightarrow Zb) - \text{BR}(b' \rightarrow Zb)^2$  characterizes the fraction of signal events with at least one  $b' \rightarrow Z + b$  decay as a function of the branching ratio. The case  $\beta = 1$  is equivalent to previous measurements [9] which assumed  $\text{BR}(b' \rightarrow Zb) = 1$ . The case of a vectorlike singlet (VLS) mixing solely with the third SM generation is also considered by computing  $\beta$  as a function of the  $b'$  mass [5]. Over the range  $m_{b'} = 200\text{--}700$  GeV,  $\beta$  varies from 0.9 to 0.5. A SM Higgs of mass 125 GeV is assumed.

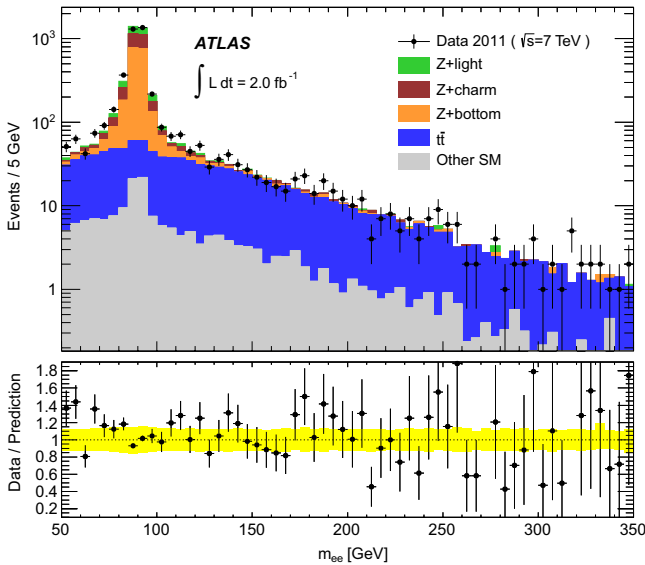


FIG. 2 (color online).  $e^+e^-$  invariant mass distribution for events passing the  $Z + \geq 1$   $b$  jet selection, before imposing the  $|m_{ee} - m_Z| < 15$  GeV requirement.

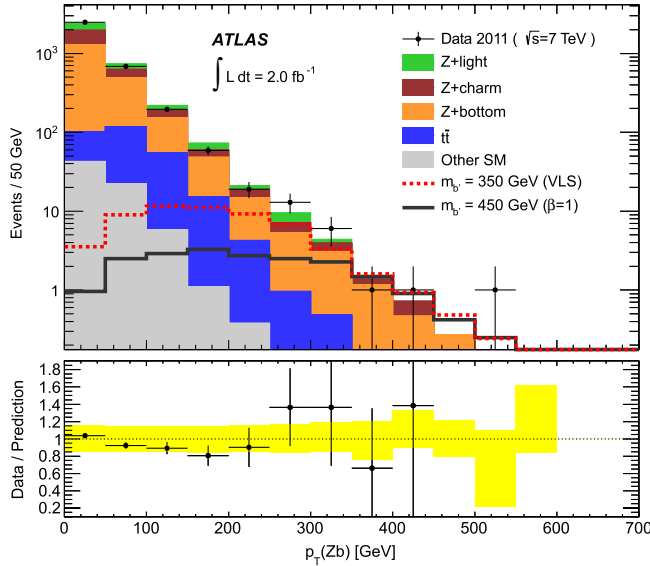


FIG. 3 (color online). Transverse momentum distribution of the  $b'$  candidate in events passing the  $Z + \geq 1$   $b$  jet selection. The predicted contributions of the SM background sources are stacked, while the distributions for the two signal scenarios described in the text are overlaid.

The  $b'$  candidate is formed from the  $e^+e^-$  pair and the highest  $p_T$   $b$  jet. The mass of the  $b'$  candidate,  $m(Zb)$ , is the discriminant distinguishing the background-only and signal-plus-background hypotheses. In  $b'$  pair production, the new quarks are typically produced with large transverse momentum,  $p_T(Zb)$ . Therefore, a  $p_T(Zb) > 150$  GeV requirement is applied to increase the signal sensitivity. Figure 3 presents the  $p_T(Zb)$  distribution for data and the predicted SM backgrounds. Additionally, the signal distribution is overlaid for a  $b'$  mass of 350 GeV, assuming the VLS scenario value  $\beta = 0.63$ , and for a mass of 450 GeV, assuming  $\beta = 1$ .

The fraction of signal events passing all requirements varies from 7% to 43% between  $m_{b'} = 200$ –700 GeV, assuming  $\beta = 1$ , with the efficiency to pass the minimum  $p_T(Zb)$  requirement contributing most to the degree of variation. The requirement  $p_T(Zb) > 150$  GeV was determined by assessing the signal sensitivity for different minimum  $p_T(Zb)$  values, as quantified by the expected cross section exclusion limit. The limit is computed using a binned Poisson likelihood ratio test [35] of the  $m(Zb)$  distribution for different  $m_{b'}$  hypotheses. Pseudoexperiments are generated according to the background-only and signal-plus-background hypotheses, and incorporate the impact of systematic uncertainties. The cross section limit is evaluated using the  $CL_s$  modified frequentist approach [35].

The impact of each systematic uncertainty on the normalization and shape of the  $m(Zb)$  distribution is assessed for each SM background source and the expected  $b'$  signal. The fractional uncertainty on the total number of

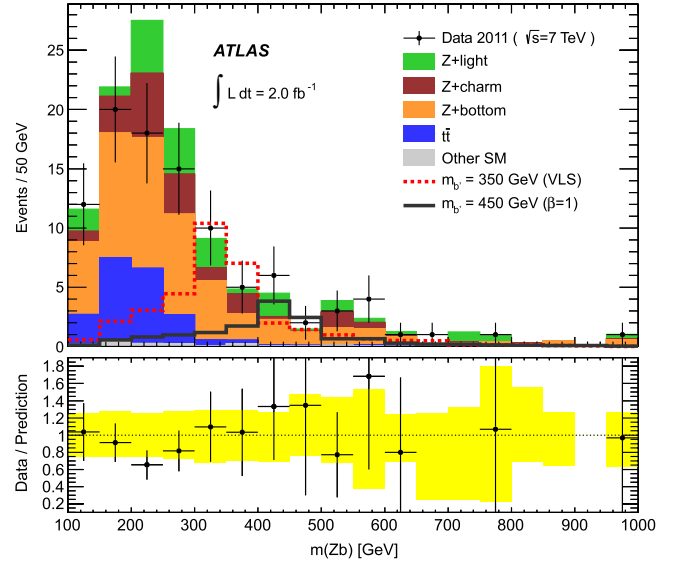


FIG. 4 (color online). Mass distribution of the  $b'$  candidate in events passing the  $Z + \geq 1$   $b$  jet selection and satisfying  $p_T(Zb) > 150$  GeV. The highest mass bin also includes the data and prediction for  $m(Zb) > 1$  TeV.

background events passing the  $p_T(Zb) > 150$  GeV requirement is 27%. Significant contributions arise from uncertainties in the  $p_T(Zb)$  distribution shape in  $Z + \text{jet(s)}$  events. Such sources of uncertainty include the renormalization and factorization scale choice (14%, evaluated using MCFM [36]), shape differences observed between ALPGEN and SHERPA (12%), and variations in the degree of initial and final state QCD radiation (9%). The uncertainty in the efficiency of the  $b$ -tagging requirement contributes an additional 12%. Other sources of uncertainty contributing at the level of 6% or less include the jet energy scale [20], parton distribution functions (PDF), MC sample sizes, electron identification efficiency,  $Z$  boson cross section, luminosity,  $b$  jet mistag rate,  $t\bar{t}$  cross section, jet energy resolution, trigger efficiency, and the Other SM event yield. Most of the above uncertainties, with the notable exception of the  $p_T(Zb)$  modeling uncertainties in  $Z + \text{jet(s)}$  events, contribute to the total uncertainty on the signal normalization, which varies between 11% and 14% depending on the  $b'$  mass.

Figure 4 presents the  $b'$  candidate mass distribution after requiring  $p_T(Zb) > 150$  GeV and the predicted SM background. The distributions for the signal scenarios depicted in Fig. 3 are shown overlaid. The data are in agreement with the SM prediction over the full range of  $m(Zb)$  values. In the absence of evidence of an enhancement, 95% confidence level (C.L.) cross section exclusion limits are derived. Figure 5 presents the expected and observed cross section limits as a function of  $m_{b'}$ , computed under the assumption  $\beta = 1$ . The expected cross section limit was checked to be stable to within 15% over the full mass range considered using the signal samples in which one  $b'$  quark



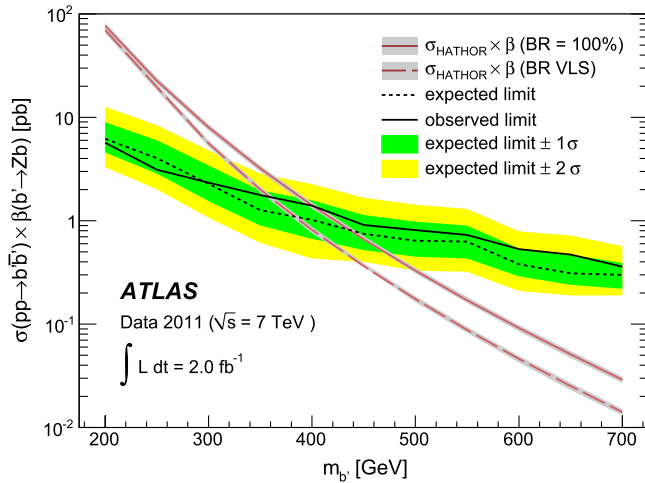


FIG. 5 (color online). The expected and observed 95% C.L. cross section limits as a function of  $b'$  mass. The signal cross section is shown with uncertainties arising from PDFs and renormalization and factorization scale choice. The prediction is also multiplied by the  $\beta$  factors described in the text.

decays via  $b' \rightarrow Z + b$  and the other decays via  $b' \rightarrow W + t$ . The approximate NNLO  $b'\bar{b}'$  cross section prediction is shown multiplied by  $\beta = 1$ , as well as by the VLS  $\beta$  value, with the shaded region representing the total uncertainty arising from PDF uncertainties and the factorization and renormalization scale choice. From the intersection of the observed cross section limit and the theoretical prediction,  $b'$  quarks with masses  $m_{b'} < 400$  GeV decaying entirely via  $b' \rightarrow Z + b$  are excluded at 95% C.L., representing a significant improvement with respect to the previous best limit of 268 GeV [9]. In the case of a vectorlike singlet  $b'$  mixing solely with the third SM generation, masses  $m_{b'} < 358$  GeV are excluded.

In conclusion, a search with  $2.0 \text{ fb}^{-1}$  of ATLAS data is presented for  $b'$  quark pair production, with at least one  $b'$  decaying to a  $Z$  boson and a bottom quark. This decay mode is particularly relevant in the context of vectorlike quarks and is an essential complement to searches in the mode with both  $b'$  decaying to a  $W$  boson and a top quark. No evidence for a  $b'$  is observed in the  $Z + b$  jet final state, and new limits are derived on the mass of a  $b'$  quark decaying via  $b' \rightarrow Z + b$ .

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, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF, DNSRC and Lundbeck Foundation, Denmark; EPLANET and ERC, European Union; IN2P3-CNRS, CEA-DSM/IRFU,

France; GNAS, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTB, Serbia; MSSR, Slovakia; ARRS and MVZT, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, United States of America. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular, from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

- [1] P. H. Frampton, P. Q. Hung, and M. Sher, *Phys. Rep.* **330**, 263 (2000).
- [2] S. P. Martin, *Phys. Rev. D* **81**, 035004 (2010).
- [3] D. Choudhury, T. M. P. Tait, and C. E. M. Wagner, *Phys. Rev. D* **65**, 053002 (2002); K. Kumar, W. Shepherd, T. M. P. Tait, and R. Vega-Morales, *J. High Energy Phys.* **08** (2010) 052.
- [4] S. Sultansoy and G. Unel, *Phys. Lett. B* **669**, 39 (2008).
- [5] J. A. Aguilar-Saavedra, *J. High Energy Phys.* **11** (2009) 030.
- [6] G. D. Kribs, T. Plehn, M. Spannowsky, and T. M. P. Tait, *Phys. Rev. D* **76**, 075016 (2007).
- [7] G. W. S. Hou, *Int. J. Mod. Phys. D* **20**, 1521 (2011).
- [8] D0 Collaboration, *Phys. Rev. Lett.* **78**, 3818 (1997).
- [9] CDF Collaboration, *Phys. Rev. D* **76**, 072006 (2007); CDF Collaboration, *Phys. Rev. Lett.* **84**, 835 (2000).
- [10] P. H. Frampton and P. Q. Hung, *Phys. Rev. D* **58**, 057704 (1998).
- [11] D0 Collaboration, *Phys. Rev. Lett.* **101**, 111802 (2008).
- [12] CDF Collaboration, *Phys. Rev. Lett.* **106**, 141803 (2011); CDF Collaboration, *Phys. Rev. Lett.* **104**, 091801 (2010).
- [13] CMS Collaboration, *Phys. Lett. B* **701**, 204 (2011).
- [14] ATLAS Collaboration, *Phys. Rev. Lett.* **109**, 032001 (2012); G. Aad *et al.* (ATLAS Collaboration), *J. High Energy Phys.* **10** (2011) 107.
- [15] ATLAS Collaboration, *JINST* **3**, S08003 (2008).
- [16] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the center of the detector and the  $z$  axis coinciding with the axis of the beam pipe. The  $x$  axis points from the interaction point to the center of the LHC ring, and the  $y$  axis points upward. Cylindrical coordinates  $(r, \phi)$  parametrize the transverse plane, with  $\phi$  as the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle  $\theta$  as  $\eta = -\ln \tan(\theta/2)$ .

- [17] ATLAS Collaboration, *Eur. Phys. J. C* **71**, 1630 (2011); ATLAS Collaboration, Report No. ATLAS-CONF-2011-116, 2011, <http://cdsweb.cern.ch/record/1376384>.
- [18] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1909 (2012).
- [19] M. Cacciari, G. Salam, and G. Soyez, *J. High Energy Phys.* **04** (2008) 063; M. Cacciari and G. Salam, *Phys. Lett. B* **641**, 57 (2006).
- [20] ATLAS Collaboration, [arXiv:1112.6426](https://arxiv.org/abs/1112.6426) [*Eur. Phys. J. C* (to be published)].
- [21] ATLAS Collaboration, *Phys. Rev. D* **85**, 092002 (2012).
- [22] M. Mangano, F. Piccinini, A. D. Polosa, M. Moretti, and R. Pittau, *J. High Energy Phys.* **07** (2003) 001.
- [23] T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, S. Schumann, F. Siegert and J. Winter, *J. High Energy Phys.* **02** (2009) 007.
- [24] ATLAS Collaboration, *Phys. Lett. B* **706**, 295 (2012).
- [25] C. Anastasiou, L. Dixon, K. Melnikov, and F. Petriello, *Phys. Rev. D* **69**, 094008 (2004).
- [26] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010).
- [27] S. Frixione and B. Webber, *J. High Energy Phys.* **06** (2002) 029.
- [28] S. Frixione, E. Laenen, P. Motylinski, and B. R. Webber, *J. High Energy Phys.* **03** (2006) 092; S. Frixione, E. Laenen, P. Motylinski, C. White, and B. R. Webber, *J. High Energy Phys.* **07** (2008) 029.
- [29] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer, and M. Wiedermann, *Comput. Phys. Commun.* **182**, 1034 (2011).
- [30] G. Corcella, I. G. Knowles, G. Marchesini, S. Moretti, K. Odagiri, P. Richardson, M. H. Seymour, and B. R. Webber, *J. High Energy Phys.* **01** (2001) 010.
- [31] J. M. Campbell and R. K. Ellis, *Phys. Rev. D* **60**, 113006 (1999).
- [32] ATLAS Collaboration, Report No. ATLAS-CONF-2011-102, <https://cdsweb.cern.ch/record/1369219>.
- [33] J. Alwall, P. Demin, S. de Visscher, R. Frederix, M. Herquet, F. Maltoni, T. Plehn, D. L. Rainwater, and T. Stelzer, *J. High Energy Phys.* **09** (2007) 028.
- [34] T. Sjöstrand, S. Mrenna, and P. Skands, *J. High Energy Phys.* **05** (2006) 026.
- [35] T. Junk, *Nucl. Instrum. Methods Phys. Res., Sect. A* **434**, 435 (1999); W. Fisher, Report No. FERMILAB-TM-2386-E, 2006.
- [36] J. M. Campbell, R. K. Ellis, F. Maltoni, and S. Willenbrock, *Phys. Rev. D* **69**, 074021 (2004).

G. Aad,<sup>47</sup> B. Abbott,<sup>110</sup> J. Abdallah,<sup>11</sup> S. Abdel Khalek,<sup>114</sup> A. A. Abdelalim,<sup>48</sup> A. Abdesselam,<sup>117</sup> O. Abidinov,<sup>10</sup> B. Abi,<sup>111</sup> M. Abolins,<sup>87</sup> O. S. AbouZeid,<sup>157</sup> H. Abramowicz,<sup>152</sup> H. Abreu,<sup>135</sup> E. Acerbi,<sup>88a,88b</sup> B. S. Acharya,<sup>163a,163b</sup> L. Adamczyk,<sup>37</sup> D. L. Adams,<sup>24</sup> T. N. Addy,<sup>55</sup> J. Adelman,<sup>174</sup> M. Aderholz,<sup>98</sup> S. Adomeit,<sup>97</sup> P. Adragna,<sup>74</sup> T. Adye,<sup>128</sup> S. Aefsky,<sup>22</sup> J. A. Aguilar-Saavedra,<sup>123b,b</sup> M. Aharrouche,<sup>80</sup> S. P. Ahlen,<sup>21</sup> F. Ahles,<sup>47</sup> A. Ahmad,<sup>147</sup> M. Ahsan,<sup>40</sup> G. Aielli,<sup>132a,132b</sup> T. Akdogan,<sup>18a</sup> T. P. A. Åkesson,<sup>78</sup> G. Akimoto,<sup>154</sup> A. V. Akimov,<sup>93</sup> A. Akiyama,<sup>65</sup> M. S. Alam,<sup>1</sup> M. A. Alam,<sup>75</sup> J. Albert,<sup>168</sup> S. Albrand,<sup>54</sup> M. Aleksa,<sup>29</sup> I. N. Aleksandrov,<sup>63</sup> F. Alessandria,<sup>88a</sup> C. Alexa,<sup>25a</sup> G. Alexander,<sup>152</sup> G. Alexandre,<sup>48</sup> T. Alexopoulos,<sup>9</sup> M. Alhroob,<sup>163a,163c</sup> M. Aliev,<sup>15</sup> G. Alimonti,<sup>88a</sup> J. Alison,<sup>119</sup> M. Aliyev,<sup>10</sup> B. M. M. Allbrooke,<sup>17</sup> P. P. Allport,<sup>72</sup> S. E. Allwood-Spiers,<sup>52</sup> J. Almond,<sup>81</sup> A. Aloisio,<sup>101a,101b</sup> R. Alon,<sup>170</sup> A. Alonso,<sup>78</sup> B. Alvarez Gonzalez,<sup>87</sup> M. G. Alviggi,<sup>101a,101b</sup> K. Amako,<sup>64</sup> P. Amaral,<sup>29</sup> C. Amelung,<sup>22</sup> V. V. Ammosov,<sup>127</sup> A. Amorim,<sup>123a,c</sup> G. Amorós,<sup>166</sup> N. Amram,<sup>152</sup> C. Anastopoulos,<sup>29</sup> L. S. Ancu,<sup>16</sup> N. Andari,<sup>114</sup> T. Andeen,<sup>34</sup> C. F. Anders,<sup>20</sup> G. Anders,<sup>57a</sup> K. J. Anderson,<sup>30</sup> A. Andreazza,<sup>88a,88b</sup> V. Andrei,<sup>57a</sup> M-L. Andrieux,<sup>54</sup> X. S. Anduaga,<sup>69</sup> A. Angerami,<sup>34</sup> F. Anghinolfi,<sup>29</sup> A. Anisenkov,<sup>106</sup> N. Anjos,<sup>123a</sup> A. Annovi,<sup>46</sup> A. Antonaki,<sup>8</sup> M. Antonelli,<sup>46</sup> A. Antonov,<sup>95</sup> J. Antos,<sup>143b</sup> F. Anulli,<sup>131a</sup> S. Aoun,<sup>82</sup> L. Aperio Bella,<sup>4</sup> R. Apolle,<sup>117,d</sup> G. Arabidze,<sup>87</sup> I. Aracena,<sup>142</sup> Y. Arai,<sup>64</sup> A. T. H. Arce,<sup>44</sup> S. Arfaoui,<sup>147</sup> J-F. Arguin,<sup>14</sup> E. Arik,<sup>18a,a</sup> M. Arik,<sup>18a</sup> A. J. Armbruster,<sup>86</sup> O. Arnaez,<sup>80</sup> V. Arnal,<sup>79</sup> C. Arnault,<sup>114</sup> A. Artamonov,<sup>94</sup> G. Artoni,<sup>131a,131b</sup> D. Arutinov,<sup>20</sup> S. Asai,<sup>154</sup> R. Asfandiyarov,<sup>171</sup> S. Ask,<sup>27</sup> B. Åsman,<sup>145a,145b</sup> L. Asquith,<sup>5</sup> K. Assamagan,<sup>24</sup> A. Astbury,<sup>168</sup> B. Aubert,<sup>4</sup> E. Auge,<sup>114</sup> K. Augsten,<sup>126</sup> M. Aourousseau,<sup>144a</sup> G. Avolio,<sup>162</sup> R. Avramidou,<sup>9</sup> D. Axen,<sup>167</sup> C. Ay,<sup>53</sup> G. Azuelos,<sup>92,e</sup> Y. Azuma,<sup>154</sup> M. A. Baak,<sup>29</sup> G. Baccaglioni,<sup>88a</sup> C. Bacci,<sup>133a,133b</sup> A. M. Bach,<sup>14</sup> H. Bachacou,<sup>135</sup> K. Bachas,<sup>29</sup> M. Backes,<sup>48</sup> M. Backhaus,<sup>20</sup> E. Badescu,<sup>25a</sup> P. Bagnaia,<sup>131a,131b</sup> S. Bahinipati,<sup>2</sup> Y. Bai,<sup>32a</sup> D. C. Bailey,<sup>157</sup> T. Bain,<sup>157</sup> J. T. Baines,<sup>128</sup> O. K. Baker,<sup>174</sup> M. D. Baker,<sup>24</sup> S. Baker,<sup>76</sup> E. Banas,<sup>38</sup> P. Banerjee,<sup>92</sup> Sw. Banerjee,<sup>171</sup> D. Banfi,<sup>29</sup> A. Bangert,<sup>149</sup> V. Bansal,<sup>168</sup> H. S. Bansil,<sup>17</sup> L. Barak,<sup>170</sup> S. P. Baranov,<sup>93</sup> A. Barashkou,<sup>63</sup> A. Barbaro Galtieri,<sup>14</sup> T. Barber,<sup>47</sup> E. L. Barberio,<sup>85</sup> D. Barberis,<sup>49a,49b</sup> M. Barbero,<sup>20</sup> D. Y. Bardin,<sup>63</sup> T. Barillari,<sup>98</sup> M. Barisonzi,<sup>173</sup> T. Barklow,<sup>142</sup> N. Barlow,<sup>27</sup> B. M. Barnett,<sup>128</sup> R. M. Barnett,<sup>14</sup> A. Baroncelli,<sup>133a</sup> G. Barone,<sup>48</sup> A. J. Barr,<sup>117</sup> F. Barreiro,<sup>79</sup> J. Barreiro Guimarães da Costa,<sup>56</sup> P. Barrillon,<sup>114</sup> R. Bartoldus,<sup>142</sup> A. E. Barton,<sup>70</sup> V. Bartsch,<sup>148</sup> R. L. Bates,<sup>52</sup> L. Batkova,<sup>143a</sup> J. R. Batley,<sup>27</sup> A. Battaglia,<sup>16</sup> M. Battistin,<sup>29</sup> F. Bauer,<sup>135</sup> H. S. Bawa,<sup>142,f</sup> S. Beale,<sup>97</sup> T. Beau,<sup>77</sup> P. H. Beauchemin,<sup>160</sup> R. Beccherle,<sup>49a</sup> P. Bechtel,<sup>20</sup> H. P. Beck,<sup>16</sup> S. Becker,<sup>97</sup> M. Beckingham,<sup>137</sup> K. H. Becks,<sup>173</sup> A. J. Beddall,<sup>18c</sup> A. Beddall,<sup>18c</sup> S. Bedikian,<sup>174</sup> V. A. Bednyakov,<sup>63</sup> C. P. Bee,<sup>82</sup> M. Begel,<sup>24</sup> S. Behar Harpaz,<sup>151</sup> P. K. Behera,<sup>61</sup> M. Beimforde,<sup>98</sup> C. Belanger-Champagne,<sup>84</sup> P. J. Bell,<sup>48</sup> W. H. Bell,<sup>48</sup> G. Bella,<sup>152</sup> L. Bellagamba,<sup>19a</sup> F. Bellina,<sup>29</sup> M. Bellomo,<sup>29</sup> A. Belloni,<sup>56</sup> O. Beloborodova,<sup>106,g</sup> K. Belotskiy,<sup>95</sup> O. Beltramello,<sup>29</sup> O. Benary,<sup>152</sup> D. Benchechroun,<sup>134a</sup> M. Bendel,<sup>80</sup> K. Bendtz,<sup>145a,145b</sup> N. Benekos,<sup>164</sup>

Y. Benhammou,<sup>152</sup> E. Benhar Noccioli,<sup>48</sup> J. A. Benitez Garcia,<sup>158b</sup> D. P. Benjamin,<sup>44</sup> M. Benoit,<sup>114</sup> J. R. Bensinger,<sup>22</sup> K. Benslama,<sup>129</sup> S. Bentvelsen,<sup>104</sup> D. Berge,<sup>29</sup> E. Bergeaas Kuutmann,<sup>41</sup> N. Berger,<sup>4</sup> F. Berghaus,<sup>168</sup> E. Berglund,<sup>104</sup> J. Beringer,<sup>14</sup> P. Bernat,<sup>76</sup> R. Bernhard,<sup>47</sup> C. Bernius,<sup>24</sup> T. Berry,<sup>75</sup> C. Bertella,<sup>82</sup> A. Bertin,<sup>19a,19b</sup> F. Bertinelli,<sup>29</sup> F. Bertolucci,<sup>121a,121b</sup> M. I. Besana,<sup>88a,88b</sup> N. Besson,<sup>135</sup> S. Bethke,<sup>98</sup> W. Bhimji,<sup>45</sup> R. M. Bianchi,<sup>29</sup> M. Bianco,<sup>71a,71b</sup> O. Biebel,<sup>97</sup> S. P. Bieniek,<sup>76</sup> K. Bierwagen,<sup>53</sup> J. Biesiada,<sup>14</sup> M. Biglietti,<sup>133a</sup> H. Bilokon,<sup>46</sup> M. Bindi,<sup>19a,19b</sup> S. Binet,<sup>114</sup> A. Bingul,<sup>18c</sup> C. Bini,<sup>131a,131b</sup> C. Biscarat,<sup>176</sup> U. Bitenc,<sup>47</sup> K. M. Black,<sup>21</sup> R. E. Blair,<sup>5</sup> J.-B. Blanchard,<sup>135</sup> G. Blanchot,<sup>29</sup> T. Blazek,<sup>143a</sup> C. Blocker,<sup>22</sup> J. Blocki,<sup>38</sup> A. Blondel,<sup>48</sup> W. Blum,<sup>80</sup> U. Blumenschein,<sup>53</sup> G. J. Bobbink,<sup>104</sup> V. B. Bobrovnikov,<sup>106</sup> S. S. Bocchetta,<sup>78</sup> A. Bocci,<sup>44</sup> C. R. Boddy,<sup>117</sup> M. Boehler,<sup>41</sup> J. Boek,<sup>173</sup> N. Boelaert,<sup>35</sup> J. A. Bogaerts,<sup>29</sup> A. Bogdanchikov,<sup>106</sup> A. Bogouch,<sup>89,a</sup> C. Bohm,<sup>145a</sup> J. Bohm,<sup>124</sup> V. Boisvert,<sup>75</sup> T. Bold,<sup>37</sup> V. Boldea,<sup>25a</sup> N. M. Bolnet,<sup>135</sup> M. Bomben,<sup>77</sup> M. Bona,<sup>74</sup> V. G. Bondarenko,<sup>95</sup> M. Bondioli,<sup>162</sup> M. Boonekamp,<sup>135</sup> C. N. Booth,<sup>138</sup> S. Bordini,<sup>77</sup> C. Borer,<sup>16</sup> A. Borisov,<sup>127</sup> G. Borissov,<sup>70</sup> I. Borjanovic,<sup>12a</sup> M. Borri,<sup>81</sup> S. Borroni,<sup>86</sup> V. Bortolotto,<sup>133a,133b</sup> K. Bos,<sup>104</sup> D. Boscherini,<sup>19a</sup> M. Bosman,<sup>11</sup> H. Boterenbrood,<sup>104</sup> D. Botterill,<sup>128</sup> J. Bouchami,<sup>92</sup> J. Boudreau,<sup>122</sup> E. V. Bouhova-Thacker,<sup>70</sup> D. Boumediene,<sup>33</sup> C. Bourdarios,<sup>114</sup> N. Bousson,<sup>82</sup> A. Boveia,<sup>30</sup> J. Boyd,<sup>29</sup> I. R. Boyko,<sup>63</sup> N. I. Bozhko,<sup>127</sup> I. Bozovic-Jelisavcic,<sup>12b</sup> J. Bracinik,<sup>17</sup> A. Braem,<sup>29</sup> P. Branchini,<sup>133a</sup> G. W. Brandenburg,<sup>56</sup> A. Brandt,<sup>7</sup> G. Brandt,<sup>117</sup> O. Brandt,<sup>53</sup> U. Bratzler,<sup>155</sup> B. Brau,<sup>83</sup> J. E. Brau,<sup>113</sup> H. M. Braun,<sup>173</sup> B. Brelrier,<sup>157</sup> J. Bremer,<sup>29</sup> K. Brendlinger,<sup>119</sup> R. Brenner,<sup>165</sup> S. Bressler,<sup>170</sup> D. Britton,<sup>52</sup> F. M. Brochu,<sup>27</sup> I. Brock,<sup>20</sup> R. Brock,<sup>87</sup> T. J. Brodbeck,<sup>70</sup> E. Brodet,<sup>152</sup> F. Broggi,<sup>88a</sup> C. Bromberg,<sup>87</sup> J. Bronner,<sup>98</sup> G. Brooijmans,<sup>34</sup> W. K. Brooks,<sup>31b</sup> G. Brown,<sup>81</sup> H. Brown,<sup>7</sup> P. A. Bruckman de Renstrom,<sup>38</sup> D. Bruncko,<sup>143b</sup> R. Bruneliere,<sup>47</sup> S. Brunet,<sup>59</sup> A. Bruni,<sup>19a</sup> G. Bruni,<sup>19a</sup> M. Bruschi,<sup>19a</sup> T. Buanes,<sup>13</sup> Q. Buat,<sup>54</sup> F. Bucci,<sup>48</sup> J. Buchanan,<sup>117</sup> P. Buchholz,<sup>140</sup> R. M. Buckingham,<sup>117</sup> A. G. Buckley,<sup>45</sup> S. I. Buda,<sup>25a</sup> I. A. Budagov,<sup>63</sup> B. Budick,<sup>107</sup> V. Büscher,<sup>80</sup> L. Bugge,<sup>116</sup> O. Bulekov,<sup>95</sup> A. C. Bundock,<sup>72</sup> M. Bunse,<sup>42</sup> T. Buran,<sup>116</sup> H. Burckhart,<sup>29</sup> S. Burdin,<sup>72</sup> T. Burgess,<sup>13</sup> S. Burke,<sup>128</sup> E. Busato,<sup>33</sup> P. Bussey,<sup>52</sup> C. P. Buszello,<sup>165</sup> F. Butin,<sup>29</sup> B. Butler,<sup>142</sup> J. M. Butler,<sup>21</sup> C. M. Buttar,<sup>52</sup> J. M. Butterworth,<sup>76</sup> W. Buttinger,<sup>27</sup> S. Cabrera Urbán,<sup>166</sup> D. Caforio,<sup>19a,19b</sup> O. Cakir,<sup>3a</sup> P. Calafiura,<sup>14</sup> G. Calderini,<sup>77</sup> P. Calfayan,<sup>97</sup> R. Calkins,<sup>105</sup> L. P. Caloba,<sup>23a</sup> R. Caloi,<sup>131a,131b</sup> D. Calvet,<sup>33</sup> S. Calvet,<sup>33</sup> R. Camacho Toro,<sup>33</sup> P. Camarri,<sup>132a,132b</sup> M. Cambiaghi,<sup>118a,118b</sup> D. Cameron,<sup>116</sup> L. M. Caminada,<sup>14</sup> S. Campana,<sup>29</sup> M. Campanelli,<sup>76</sup> V. Canale,<sup>101a,101b</sup> F. Canelli,<sup>30,h</sup> A. Canepa,<sup>158a</sup> J. Cantero,<sup>79</sup> L. Capasso,<sup>101a,101b</sup> M. D. M. Capeans Garrido,<sup>29</sup> I. Caprini,<sup>25a</sup> M. Caprini,<sup>25a</sup> D. Capriotti,<sup>98</sup> M. Capua,<sup>36a,36b</sup> R. Caputo,<sup>80</sup> R. Cardarelli,<sup>132a</sup> T. Carli,<sup>29</sup> G. Carlino,<sup>101a</sup> L. Carminati,<sup>88a,88b</sup> B. Caron,<sup>84</sup> S. Caron,<sup>103</sup> E. Carquin,<sup>31b</sup> G. D. Carrillo Montoya,<sup>171</sup> A. A. Carter,<sup>74</sup> J. R. Carter,<sup>27</sup> J. Carvalho,<sup>123a,i</sup> D. Casadei,<sup>107</sup> M. P. Casado,<sup>11</sup> M. Cascella,<sup>121a,121b</sup> C. Caso,<sup>49a,49b,a</sup> A. M. Castaneda Hernandez,<sup>171</sup> E. Castaneda-Miranda,<sup>171</sup> V. Castillo Gimenez,<sup>166</sup> N. F. Castro,<sup>123a</sup> G. Cataldi,<sup>71a</sup> P. Catastini,<sup>56</sup> A. Catinaccio,<sup>29</sup> J. R. Catmore,<sup>29</sup> A. Cattai,<sup>29</sup> G. Cattani,<sup>132a,132b</sup> S. Caughron,<sup>87</sup> D. Cauz,<sup>163a,163c</sup> P. Cavalleri,<sup>77</sup> D. Cavalli,<sup>88a</sup> M. Cavalli-Sforza,<sup>11</sup> V. Cavasinni,<sup>121a,121b</sup> F. Ceradini,<sup>133a,133b</sup> A. S. Cerqueira,<sup>23b</sup> A. Cerri,<sup>29</sup> L. Cerrito,<sup>74</sup> F. Cerutti,<sup>46</sup> S. A. Cetin,<sup>18b</sup> F. Cevenini,<sup>101a,101b</sup> A. Chafaq,<sup>134a</sup> D. Chakraborty,<sup>105</sup> I. Chalupkova,<sup>125</sup> K. Chan,<sup>2</sup> B. Chapleau,<sup>84</sup> J. D. Chapman,<sup>27</sup> J. W. Chapman,<sup>86</sup> E. Chareyre,<sup>77</sup> D. G. Charlton,<sup>17</sup> V. Chavda,<sup>81</sup> C. A. Chavez Barajas,<sup>29</sup> S. Cheatham,<sup>84</sup> S. Chekanov,<sup>5</sup> S. V. Chekulaev,<sup>158a</sup> G. A. Chelkov,<sup>63</sup> M. A. Chelstowska,<sup>103</sup> C. Chen,<sup>62</sup> H. Chen,<sup>24</sup> S. Chen,<sup>32c</sup> T. Chen,<sup>32c</sup> X. Chen,<sup>171</sup> S. Cheng,<sup>32a</sup> A. Cheplakov,<sup>63</sup> V. F. Chepurinov,<sup>63</sup> R. Cherkaoui El Moursli,<sup>134e</sup> V. Chernyatin,<sup>24</sup> E. Cheu,<sup>6</sup> S. L. Cheung,<sup>157</sup> L. Chevalier,<sup>135</sup> G. Chiefari,<sup>101a,101b</sup> L. Chikovani,<sup>50a</sup> J. T. Childers,<sup>29</sup> A. Chilingarov,<sup>70</sup> G. Chiodini,<sup>71a</sup> A. S. Chisholm,<sup>17</sup> R. T. Chislett,<sup>76</sup> M. V. Chizhov,<sup>63</sup> G. Choudalakis,<sup>30</sup> S. Chouridou,<sup>136</sup> I. A. Christidi,<sup>76</sup> A. Christov,<sup>47</sup> D. Chromek-Burckhart,<sup>29</sup> M. L. Chu,<sup>150</sup> J. Chudoba,<sup>124</sup> G. Ciapetti,<sup>131a,131b</sup> A. K. Ciftci,<sup>3a</sup> R. Ciftci,<sup>3a</sup> D. Cinca,<sup>33</sup> V. Cindro,<sup>73</sup> C. Ciocca,<sup>19a</sup> A. Ciocio,<sup>14</sup> M. Cirilli,<sup>86</sup> M. Citterio,<sup>88a</sup> M. Ciubancan,<sup>25a</sup> A. Clark,<sup>48</sup> P. J. Clark,<sup>45</sup> W. Cleland,<sup>122</sup> J. C. Clemens,<sup>82</sup> B. Clement,<sup>54</sup> C. Clement,<sup>145a,145b</sup> Y. Coadou,<sup>82</sup> M. Cobal,<sup>163a,163c</sup> A. Coccaro,<sup>137</sup> J. Cochran,<sup>62</sup> P. Coe,<sup>117</sup> J. G. Cogan,<sup>142</sup> J. Coggeshall,<sup>164</sup> E. Cogneras,<sup>176</sup> J. Colas,<sup>4</sup> A. P. Colijn,<sup>104</sup> N. J. Collins,<sup>17</sup> C. Collins-Tooth,<sup>52</sup> J. Collot,<sup>54</sup> G. Colon,<sup>83</sup> P. Conde Muiño,<sup>123a</sup> E. Coniavitis,<sup>117</sup> M. C. Conidi,<sup>11</sup> M. Consonni,<sup>103</sup> S. M. Consonni,<sup>88a,88b</sup> V. Consorti,<sup>47</sup> S. Constantinescu,<sup>25a</sup> C. Conta,<sup>118a,118b</sup> G. Conti,<sup>56</sup> F. Conventi,<sup>101a,j</sup> J. Cook,<sup>29</sup> M. Cooke,<sup>14</sup> B. D. Cooper,<sup>76</sup> A. M. Cooper-Sarkar,<sup>117</sup> K. Copic,<sup>14</sup> T. Cornelissen,<sup>173</sup> M. Corradi,<sup>19a</sup> F. Corriveau,<sup>84,k</sup> A. Cortes-Gonzalez,<sup>164</sup> G. Cortiana,<sup>98</sup> G. Costa,<sup>88a</sup> M. J. Costa,<sup>166</sup> D. Costanzo,<sup>138</sup> T. Costin,<sup>30</sup> D. Côté,<sup>29</sup> L. Courneyea,<sup>168</sup> G. Cowan,<sup>75</sup> C. Cowden,<sup>27</sup> B. E. Cox,<sup>81</sup> K. Cranmer,<sup>107</sup> F. Crescioli,<sup>121a,121b</sup> M. Cristinziani,<sup>20</sup> G. Crosetti,<sup>36a,36b</sup> R. Crupi,<sup>71a,71b</sup> S. Crépe-Renaudin,<sup>54</sup> C.-M. Cuciuc,<sup>25a</sup> C. Cuenca Almenar,<sup>174</sup> T. Cuhadar Donszelmann,<sup>138</sup> M. Curatolo,<sup>46</sup> C. J. Curtis,<sup>17</sup> C. Cuthbert,<sup>149</sup> P. Cwetanski,<sup>59</sup> H. Czirr,<sup>140</sup>

- P. Czodrowski,<sup>43</sup> Z. Czyczula,<sup>174</sup> S. D'Auria,<sup>52</sup> M. D'Onofrio,<sup>72</sup> A. D'Orazio,<sup>131a,131b</sup> P. V. M. Da Silva,<sup>23a</sup>  
 C. Da Via,<sup>81</sup> W. Dabrowski,<sup>37</sup> A. Dafinca,<sup>117</sup> T. Dai,<sup>86</sup> C. Dallapiccola,<sup>83</sup> M. Dam,<sup>35</sup> M. Dameri,<sup>49a,49b</sup>  
 D. S. Damiani,<sup>136</sup> H. O. Danielsson,<sup>29</sup> D. Dannheim,<sup>98</sup> V. Dao,<sup>48</sup> G. Darbo,<sup>49a</sup> G. L. Darlea,<sup>25b</sup> W. Davey,<sup>20</sup>  
 T. Davidek,<sup>125</sup> N. Davidson,<sup>85</sup> R. Davidson,<sup>70</sup> E. Davies,<sup>117,d</sup> M. Davies,<sup>92</sup> A. R. Davison,<sup>76</sup> Y. Davygora,<sup>57a</sup>  
 E. Dawe,<sup>141</sup> I. Dawson,<sup>138</sup> J. W. Dawson,<sup>5a</sup> R. K. Daya-Ishmukhametova,<sup>22</sup> K. De,<sup>7</sup> R. de Asmundis,<sup>101a</sup>  
 S. De Castro,<sup>19a,19b</sup> P. E. De Castro Faria Salgado,<sup>24</sup> S. De Cecco,<sup>77</sup> J. de Graat,<sup>97</sup> N. De Groot,<sup>103</sup> P. de Jong,<sup>104</sup>  
 C. De La Taille,<sup>114</sup> H. De la Torre,<sup>79</sup> F. De Lorenzi,<sup>62</sup> B. De Lotto,<sup>163a,163c</sup> L. de Mora,<sup>70</sup> L. De Nooij,<sup>104</sup>  
 D. De Pedis,<sup>131a</sup> A. De Salvo,<sup>131a</sup> U. De Sanctis,<sup>163a,163c</sup> A. De Santo,<sup>148</sup> J. B. De Vivie De Regie,<sup>114</sup>  
 G. De Zorzi,<sup>131a,131b</sup> S. Dean,<sup>76</sup> W. J. Dearnaley,<sup>70</sup> R. Debbe,<sup>24</sup> C. Debenedetti,<sup>45</sup> B. Dechenaux,<sup>54</sup> D. V. Dedovich,<sup>63</sup>  
 J. Degenhardt,<sup>119</sup> C. Del Papa,<sup>163a,163c</sup> J. Del Peso,<sup>79</sup> T. Del Prete,<sup>121a,121b</sup> T. Delemontex,<sup>54</sup> M. Deliyergiyev,<sup>73</sup>  
 A. Dell'Acqua,<sup>29</sup> L. Dell'Asta,<sup>21</sup> M. Della Pietra,<sup>101a,j</sup> D. della Volpe,<sup>101a,101b</sup> M. Delmastro,<sup>4</sup> N. Delruelle,<sup>29</sup>  
 P. A. Delsart,<sup>54</sup> C. Deluca,<sup>147</sup> S. Demers,<sup>174</sup> M. Demichev,<sup>63</sup> B. Demirkoz,<sup>11,l</sup> J. Deng,<sup>162</sup> S. P. Denisov,<sup>127</sup>  
 D. Derendarz,<sup>38</sup> J. E. Derkaoui,<sup>134d</sup> F. Derue,<sup>77</sup> P. Dervan,<sup>72</sup> K. Desch,<sup>20</sup> E. Devetak,<sup>147</sup> P. O. Deviveiros,<sup>104</sup>  
 A. Dewhurst,<sup>128</sup> B. DeWilde,<sup>147</sup> S. Dhaliwal,<sup>157</sup> R. Dhullipudi,<sup>24,m</sup> A. Di Ciaccio,<sup>132a,132b</sup> L. Di Ciaccio,<sup>4</sup>  
 A. Di Girolamo,<sup>29</sup> B. Di Girolamo,<sup>29</sup> S. Di Luise,<sup>133a,133b</sup> A. Di Mattia,<sup>171</sup> B. Di Micco,<sup>29</sup> R. Di Nardo,<sup>46</sup>  
 A. Di Simone,<sup>132a,132b</sup> R. Di Sipio,<sup>19a,19b</sup> M. A. Diaz,<sup>31a</sup> F. Diblen,<sup>18c</sup> E. B. Diehl,<sup>86</sup> J. Dietrich,<sup>41</sup> T. A. Dietzsch,<sup>57a</sup>  
 S. Diglio,<sup>85</sup> K. Dindar Yagci,<sup>39</sup> J. Dingfelder,<sup>20</sup> C. Dionisi,<sup>131a,131b</sup> P. Dita,<sup>25a</sup> S. Dita,<sup>25a</sup> F. Dittus,<sup>29</sup> F. Djama,<sup>82</sup>  
 T. Djobava,<sup>50b</sup> M. A. B. do Vale,<sup>23c</sup> A. Do Valle Wemans,<sup>123a</sup> T. K. O. Doan,<sup>4</sup> M. Dobbs,<sup>84</sup> R. Dobinson,<sup>29,a</sup>  
 D. Dobos,<sup>29</sup> E. Dobson,<sup>29,n</sup> J. Dodd,<sup>34</sup> C. Doglioni,<sup>48</sup> T. Doherty,<sup>52</sup> Y. Doi,<sup>64,a</sup> J. Dolejsi,<sup>125</sup> I. Dolenc,<sup>73</sup>  
 Z. Dolezal,<sup>125</sup> B. A. Dolgoshein,<sup>95,a</sup> T. Dohmae,<sup>154</sup> M. Donadelli,<sup>23d</sup> M. Donega,<sup>119</sup> J. Donini,<sup>33</sup> J. Dopke,<sup>29</sup>  
 A. Doria,<sup>101a</sup> A. Dos Anjos,<sup>171</sup> M. Dosil,<sup>11</sup> A. Dotti,<sup>121a,121b</sup> M. T. Dova,<sup>69</sup> A. D. Doxiadis,<sup>104</sup> A. T. Doyle,<sup>52</sup>  
 Z. Drasal,<sup>125</sup> N. Dressnandt,<sup>119</sup> C. Driouichi,<sup>35</sup> M. Dris,<sup>9</sup> J. Dubbert,<sup>98</sup> S. Dube,<sup>14</sup> E. Duchovni,<sup>170</sup> G. Duckeck,<sup>97</sup>  
 A. Dudarev,<sup>29</sup> F. Dudziak,<sup>62</sup> M. Dührssen,<sup>29</sup> I. P. Duerdoth,<sup>81</sup> L. Dufлот,<sup>114</sup> M-A. Dufour,<sup>84</sup> M. Dunford,<sup>29</sup>  
 H. Duran Yildiz,<sup>3a</sup> R. Duxfield,<sup>138</sup> M. Dwuznik,<sup>37</sup> F. Dydak,<sup>29</sup> M. Düren,<sup>51</sup> W. L. Ebenstein,<sup>44</sup> J. Ebke,<sup>97</sup>  
 S. Eckweiler,<sup>80</sup> K. Edmonds,<sup>80</sup> C. A. Edwards,<sup>75</sup> N. C. Edwards,<sup>52</sup> W. Ehrenfeld,<sup>41</sup> T. Ehrich,<sup>98</sup> T. Eifert,<sup>142</sup>  
 G. Eigen,<sup>13</sup> K. Einsweiler,<sup>14</sup> E. Eisenhandler,<sup>74</sup> T. Ekelof,<sup>165</sup> M. El Kacimi,<sup>134c</sup> M. Ellert,<sup>165</sup> S. Elles,<sup>4</sup>  
 F. Ellinghaus,<sup>80</sup> K. Ellis,<sup>74</sup> N. Ellis,<sup>29</sup> J. Elmsheuser,<sup>97</sup> M. Elsing,<sup>29</sup> D. Emelianov,<sup>128</sup> R. Engelmann,<sup>147</sup> A. Engl,<sup>97</sup>  
 B. Epp,<sup>60</sup> A. Eppig,<sup>86</sup> J. Erdmann,<sup>53</sup> A. Ereditato,<sup>16</sup> D. Eriksson,<sup>145a</sup> J. Ernst,<sup>1</sup> M. Ernst,<sup>24</sup> J. Ernwein,<sup>135</sup>  
 D. Errede,<sup>164</sup> S. Errede,<sup>164</sup> E. Ertel,<sup>80</sup> M. Escalier,<sup>114</sup> C. Escobar,<sup>122</sup> X. Espinal Curull,<sup>11</sup> B. Esposito,<sup>46</sup> F. Etienne,<sup>82</sup>  
 A. I. Etienne,<sup>135</sup> E. Etzion,<sup>152</sup> D. Evangelakou,<sup>53</sup> H. Evans,<sup>59</sup> L. Fabbri,<sup>19a,19b</sup> C. Fabre,<sup>29</sup> R. M. Fakhruddinov,<sup>127</sup>  
 S. Falciano,<sup>131a</sup> Y. Fang,<sup>171</sup> M. Fanti,<sup>88a,88b</sup> A. Farbin,<sup>7</sup> A. Farilla,<sup>133a</sup> J. Farley,<sup>147</sup> T. Farooque,<sup>157</sup> S. Farrell,<sup>162</sup>  
 S. M. Farrington,<sup>117</sup> P. Farthouat,<sup>29</sup> P. Fassnacht,<sup>29</sup> D. Fassouliotis,<sup>8</sup> B. Fatholahzadeh,<sup>157</sup> A. Favareto,<sup>88a,88b</sup>  
 L. Fayard,<sup>114</sup> S. Fazio,<sup>36a,36b</sup> R. Febbraro,<sup>33</sup> P. Federic,<sup>143a</sup> O. L. Fedin,<sup>120</sup> W. Fedorko,<sup>87</sup> M. Fehling-Kaschek,<sup>47</sup>  
 L. Felgioni,<sup>82</sup> D. Fellmann,<sup>5</sup> C. Feng,<sup>32d</sup> E. J. Feng,<sup>30</sup> A. B. Fenyuk,<sup>127</sup> J. Ferencei,<sup>143b</sup> J. Ferland,<sup>92</sup> W. Fernando,<sup>5</sup>  
 S. Ferrag,<sup>52</sup> J. Ferrando,<sup>52</sup> V. Ferrara,<sup>41</sup> A. Ferrari,<sup>165</sup> P. Ferrari,<sup>104</sup> R. Ferrari,<sup>118a</sup> D. E. Ferreira de Lima,<sup>52</sup>  
 A. Ferrer,<sup>166</sup> M. L. Ferrer,<sup>46</sup> D. Ferrere,<sup>48</sup> C. Ferretti,<sup>86</sup> A. Ferretto Parodi,<sup>49a,49b</sup> M. Fiascaris,<sup>30</sup> F. Fiedler,<sup>80</sup>  
 A. Filipčič,<sup>73</sup> A. Filippas,<sup>9</sup> F. Filthaut,<sup>103</sup> M. Fincke-Keeler,<sup>168</sup> M. C. N. Fiolhais,<sup>123a,i</sup> L. Fiorini,<sup>166</sup> A. Firan,<sup>39</sup>  
 G. Fischer,<sup>41</sup> M. J. Fisher,<sup>108</sup> M. Flechl,<sup>47</sup> I. Fleck,<sup>140</sup> J. Fleckner,<sup>80</sup> P. Fleischmann,<sup>172</sup> S. Fleischmann,<sup>173</sup> T. Flick,<sup>173</sup>  
 A. Floderus,<sup>78</sup> L. R. Flores Castillo,<sup>171</sup> M. J. Flowerdew,<sup>98</sup> M. Fokitis,<sup>9</sup> T. Fonseca Martin,<sup>16</sup> D. A. Forbush,<sup>137</sup>  
 A. Formica,<sup>135</sup> A. Forti,<sup>81</sup> D. Fortin,<sup>158a</sup> J. M. Foster,<sup>81</sup> D. Fournier,<sup>114</sup> A. Foussat,<sup>29</sup> A. J. Fowler,<sup>44</sup> K. Fowler,<sup>136</sup>  
 H. Fox,<sup>70</sup> P. Francavilla,<sup>11</sup> S. Franchino,<sup>118a,118b</sup> D. Francis,<sup>29</sup> T. Frank,<sup>170</sup> M. Franklin,<sup>56</sup> S. Franz,<sup>29</sup>  
 M. Fraternali,<sup>118a,118b</sup> S. Fratina,<sup>119</sup> S. T. French,<sup>27</sup> C. Friedrich,<sup>41</sup> F. Friedrich,<sup>43</sup> R. Froeschl,<sup>29</sup> D. Froidevaux,<sup>29</sup>  
 J. A. Frost,<sup>27</sup> C. Fukunaga,<sup>155</sup> E. Fullana Torregrosa,<sup>29</sup> B. G. Fulsom,<sup>142</sup> J. Fuster,<sup>166</sup> C. Gabaldon,<sup>29</sup> O. Gabizon,<sup>170</sup>  
 T. Gadfort,<sup>24</sup> S. Gadomski,<sup>48</sup> G. Gagliardi,<sup>49a,49b</sup> P. Gagnon,<sup>59</sup> C. Galea,<sup>97</sup> E. J. Gallas,<sup>117</sup> V. Gallo,<sup>16</sup> B. J. Gallop,<sup>128</sup>  
 P. Gallus,<sup>124</sup> K. K. Gan,<sup>108</sup> Y. S. Gao,<sup>142,f</sup> V. A. Gapienko,<sup>127</sup> A. Gaponenko,<sup>14</sup> F. Garbersson,<sup>174</sup> M. Garcia-Sciveres,<sup>14</sup>  
 C. García,<sup>166</sup> J. E. García Navarro,<sup>166</sup> R. W. Gardner,<sup>30</sup> N. Garelli,<sup>29</sup> H. Garitaonandia,<sup>104</sup> V. Garonne,<sup>29</sup> J. Garvey,<sup>17</sup>  
 C. Gatti,<sup>46</sup> G. Gaudio,<sup>118a</sup> B. Gaur,<sup>140</sup> L. Gauthier,<sup>135</sup> P. Gauzzi,<sup>131a,131b</sup> I. L. Gavrilenko,<sup>93</sup> C. Gay,<sup>167</sup> G. Gaycken,<sup>20</sup>  
 J-C. Gayde,<sup>29</sup> E. N. Gazis,<sup>9</sup> P. Ge,<sup>32d</sup> Z. Gecse,<sup>167</sup> C. N. P. Gee,<sup>128</sup> D. A. A. Geerts,<sup>104</sup> Ch. Geich-Gimbel,<sup>20</sup>  
 K. Gellerstedt,<sup>145a,145b</sup> C. Gemme,<sup>49a</sup> A. Gemmell,<sup>52</sup> M. H. Genest,<sup>54</sup> S. Gentile,<sup>131a,131b</sup> M. George,<sup>53</sup> S. George,<sup>75</sup>  
 P. Gerlach,<sup>173</sup> A. Gershon,<sup>152</sup> C. Geweniger,<sup>57a</sup> H. Ghazlane,<sup>134b</sup> N. Ghodbane,<sup>33</sup> B. Giacobbe,<sup>19a</sup> S. Giagu,<sup>131a,131b</sup>  
 V. Giakoumopoulou,<sup>8</sup> V. Giangiobbe,<sup>11</sup> F. Gianotti,<sup>29</sup> B. Gibbard,<sup>24</sup> A. Gibson,<sup>157</sup> S. M. Gibson,<sup>29</sup> L. M. Gilbert,<sup>117</sup>



- V. Gilewsky,<sup>90</sup> D. Gillberg,<sup>28</sup> A. R. Gillman,<sup>128</sup> D. M. Gingrich,<sup>2,e</sup> J. Ginzburg,<sup>152</sup> N. Giokaris,<sup>8</sup> M. P. Giordani,<sup>163c</sup> R. Giordano,<sup>101a,101b</sup> F. M. Giorgi,<sup>15</sup> P. Giovannini,<sup>98</sup> P. F. Giraud,<sup>135</sup> D. Giugni,<sup>88a</sup> M. Giunta,<sup>92</sup> P. Giusti,<sup>19a</sup> B. K. Gjelsten,<sup>116</sup> L. K. Gladilin,<sup>96</sup> C. Glasman,<sup>79</sup> J. Glatzer,<sup>47</sup> A. Glazov,<sup>41</sup> K. W. Glitza,<sup>173</sup> G. L. Glonti,<sup>63</sup> J. R. Goddard,<sup>74</sup> J. Godfrey,<sup>141</sup> J. Godlewski,<sup>29</sup> M. Goebel,<sup>41</sup> T. Göpfert,<sup>43</sup> C. Goeringer,<sup>80</sup> C. Gössling,<sup>42</sup> T. Göttfert,<sup>98</sup> S. Goldfarb,<sup>86</sup> T. Golling,<sup>174</sup> A. Gomes,<sup>123a,c</sup> L. S. Gomez Fajardo,<sup>41</sup> R. Gonçalves,<sup>75</sup> J. Goncalves Pinto Firmino Da Costa,<sup>41</sup> L. Gonella,<sup>20</sup> A. Gonidec,<sup>29</sup> S. Gonzalez,<sup>171</sup> S. González de la Hoz,<sup>166</sup> G. Gonzalez Parra,<sup>11</sup> M. L. Gonzalez Silva,<sup>26</sup> S. Gonzalez-Sevilla,<sup>48</sup> J. J. Goodson,<sup>147</sup> L. Goossens,<sup>29</sup> P. A. Gorbounov,<sup>94</sup> H. A. Gordon,<sup>24</sup> I. Gorelov,<sup>102</sup> G. Gorfine,<sup>173</sup> B. Gorini,<sup>29</sup> E. Gorini,<sup>71a,71b</sup> A. Gorišek,<sup>73</sup> E. Gornicki,<sup>38</sup> V. N. Goryachev,<sup>127</sup> B. Gosdzik,<sup>41</sup> A. T. Goshaw,<sup>5</sup> M. Gosselink,<sup>104</sup> M. I. Gostkin,<sup>63</sup> I. Gough Eschrich,<sup>162</sup> M. Gouighri,<sup>134a</sup> D. Goujdami,<sup>134c</sup> M. P. Goulette,<sup>48</sup> A. G. Goussiou,<sup>137</sup> C. Goy,<sup>4</sup> S. Gozpinar,<sup>22</sup> I. Grabowska-Bold,<sup>37</sup> P. Grafström,<sup>29</sup> K.-J. Grahn,<sup>41</sup> F. Grancagnolo,<sup>71a</sup> S. Grancagnolo,<sup>15</sup> V. Grassi,<sup>147</sup> V. Gratchev,<sup>120</sup> N. Grau,<sup>34</sup> H. M. Gray,<sup>29</sup> J. A. Gray,<sup>147</sup> E. Graziani,<sup>133a</sup> O. G. Grebenyuk,<sup>120</sup> T. Greenshaw,<sup>72</sup> Z. D. Greenwood,<sup>24,m</sup> K. Gregersen,<sup>35</sup> I. M. Gregor,<sup>41</sup> P. Grenier,<sup>142</sup> J. Griffiths,<sup>137</sup> N. Grigalashvili,<sup>63</sup> A. A. Grillo,<sup>136</sup> S. Grinstein,<sup>11</sup> Y. V. Grishkevich,<sup>96</sup> J.-F. Grivaz,<sup>114</sup> E. Gross,<sup>170</sup> J. Grosse-Knetter,<sup>53</sup> J. Groth-Jensen,<sup>170</sup> K. Grybel,<sup>140</sup> V. J. Guarino,<sup>5</sup> D. Guest,<sup>174</sup> C. Guicheney,<sup>33</sup> A. Guida,<sup>71a,71b</sup> S. Guindon,<sup>53</sup> H. Guler,<sup>84,o</sup> J. Gunther,<sup>124</sup> B. Guo,<sup>157</sup> J. Guo,<sup>34</sup> A. Gupta,<sup>30</sup> Y. Gusakov,<sup>63</sup> V. N. Gushchin,<sup>127</sup> P. Gutierrez,<sup>110</sup> N. Guttman,<sup>152</sup> O. Gutzwiller,<sup>171</sup> C. Guyot,<sup>135</sup> C. Gwenlan,<sup>117</sup> C. B. Gwilliam,<sup>72</sup> A. Haas,<sup>142</sup> S. Haas,<sup>29</sup> C. Haber,<sup>14</sup> H. K. Hadavand,<sup>39</sup> D. R. Hadley,<sup>17</sup> P. Haefner,<sup>98</sup> F. Hahn,<sup>29</sup> S. Haider,<sup>29</sup> Z. Hajduk,<sup>38</sup> H. Hakobyan,<sup>175</sup> D. Hall,<sup>117</sup> J. Haller,<sup>53</sup> K. Hamacher,<sup>173</sup> P. Hamal,<sup>112</sup> M. Hamer,<sup>53</sup> A. Hamilton,<sup>144b,p</sup> S. Hamilton,<sup>160</sup> H. Han,<sup>32a</sup> L. Han,<sup>32b</sup> K. Hanagaki,<sup>115</sup> K. Hanawa,<sup>159</sup> M. Hance,<sup>14</sup> C. Handel,<sup>80</sup> P. Hanke,<sup>57a</sup> J. R. Hansen,<sup>35</sup> J. B. Hansen,<sup>35</sup> J. D. Hansen,<sup>35</sup> P. H. Hansen,<sup>35</sup> P. Hansson,<sup>142</sup> K. Hara,<sup>159</sup> G. A. Hare,<sup>136</sup> T. Harenberg,<sup>173</sup> S. Harkusha,<sup>89</sup> D. Harper,<sup>86</sup> R. D. Harrington,<sup>45</sup> O. M. Harris,<sup>137</sup> K. Harrison,<sup>17</sup> J. Hartert,<sup>47</sup> F. Hartjes,<sup>104</sup> T. Haruyama,<sup>64</sup> A. Harvey,<sup>55</sup> S. Hasegawa,<sup>100</sup> Y. Hasegawa,<sup>139</sup> S. Hassani,<sup>135</sup> M. Hatch,<sup>29</sup> D. Hauff,<sup>98</sup> S. Haug,<sup>16</sup> M. Hauschild,<sup>29</sup> R. Hauser,<sup>87</sup> M. Havranek,<sup>20</sup> C. M. Hawkes,<sup>17</sup> R. J. Hawkings,<sup>29</sup> A. D. Hawkins,<sup>78</sup> D. Hawkins,<sup>162</sup> T. Hayakawa,<sup>65</sup> T. Hayashi,<sup>159</sup> D. Hayden,<sup>75</sup> H. S. Hayward,<sup>72</sup> S. J. Haywood,<sup>128</sup> E. Hazen,<sup>21</sup> M. He,<sup>32d</sup> S. J. Head,<sup>17</sup> V. Hedberg,<sup>78</sup> L. Heelan,<sup>7</sup> S. Heim,<sup>87</sup> B. Heinemann,<sup>14</sup> S. Heisterkamp,<sup>35</sup> L. Helary,<sup>4</sup> C. Heller,<sup>97</sup> M. Heller,<sup>29</sup> S. Hellman,<sup>145a,145b</sup> D. Hellmich,<sup>20</sup> C. Helsen,<sup>11</sup> R. C. W. Henderson,<sup>70</sup> M. Henke,<sup>57a</sup> A. Henrichs,<sup>53</sup> A. M. Henriques Correia,<sup>29</sup> S. Henrot-Versille,<sup>114</sup> F. Henry-Couannier,<sup>82</sup> C. Hensel,<sup>53</sup> T. Henß,<sup>173</sup> C. M. Hernandez,<sup>7</sup> Y. Hernández Jiménez,<sup>166</sup> R. Herrberg,<sup>15</sup> G. Herten,<sup>47</sup> R. Hertenberger,<sup>97</sup> L. Hervas,<sup>29</sup> G. G. Hesketh,<sup>76</sup> N. P. Hessey,<sup>104</sup> E. Higón-Rodríguez,<sup>166</sup> D. Hill,<sup>5,a</sup> J. C. Hill,<sup>27</sup> N. Hill,<sup>5</sup> K. H. Hiller,<sup>41</sup> S. Hillert,<sup>20</sup> S. J. Hillier,<sup>17</sup> I. Hinchliffe,<sup>14</sup> E. Hines,<sup>119</sup> M. Hirose,<sup>115</sup> F. Hirsch,<sup>42</sup> D. Hirschbuehl,<sup>173</sup> J. Hobbs,<sup>147</sup> N. Hod,<sup>152</sup> M. C. Hodgkinson,<sup>138</sup> P. Hodgson,<sup>138</sup> A. Hoecker,<sup>29</sup> M. R. Hoeferkamp,<sup>102</sup> J. Hoffman,<sup>39</sup> D. Hoffmann,<sup>82</sup> M. Hohlfeld,<sup>80</sup> M. Holder,<sup>140</sup> S. O. Holmgren,<sup>145a</sup> T. Holy,<sup>126</sup> J. L. Holzbauer,<sup>87</sup> Y. Homma,<sup>65</sup> T. M. Hong,<sup>119</sup> L. Hooft van Huysduynen,<sup>107</sup> T. Horazdovsky,<sup>126</sup> C. Horn,<sup>142</sup> S. Horner,<sup>47</sup> J.-Y. Hostachy,<sup>54</sup> S. Hou,<sup>150</sup> M. A. Houlden,<sup>72</sup> A. Hoummada,<sup>134a</sup> J. Howarth,<sup>81</sup> D. F. Howell,<sup>117</sup> I. Hristova,<sup>15</sup> J. Hrivnac,<sup>114</sup> I. Hruska,<sup>124</sup> T. Hryn'ova,<sup>4</sup> P. J. Hsu,<sup>80</sup> S.-C. Hsu,<sup>14</sup> G. S. Huang,<sup>110</sup> Z. Hubacek,<sup>126</sup> F. Hubaut,<sup>82</sup> F. Huegging,<sup>20</sup> A. Huettmann,<sup>41</sup> T. B. Huffman,<sup>117</sup> E. W. Hughes,<sup>34</sup> G. Hughes,<sup>70</sup> R. E. Hughes-Jones,<sup>81</sup> M. Huhtinen,<sup>29</sup> P. Hurst,<sup>56</sup> M. Hurwitz,<sup>14</sup> U. Husemann,<sup>41</sup> N. Huseynov,<sup>63,q</sup> J. Huston,<sup>87</sup> J. Huth,<sup>56</sup> G. Iacobucci,<sup>48</sup> G. Iakovidis,<sup>9</sup> M. Ibbotson,<sup>81</sup> I. Ibragimov,<sup>140</sup> L. Iconomidou-Fayard,<sup>114</sup> J. Idarraga,<sup>114</sup> P. Iengo,<sup>101a</sup> O. Igonkina,<sup>104</sup> Y. Ikegami,<sup>64</sup> M. Ikeno,<sup>64</sup> D. Iliadis,<sup>153</sup> N. Ilic,<sup>157</sup> M. Imori,<sup>154</sup> T. Ince,<sup>20</sup> J. Inigo-Golfín,<sup>29</sup> P. Ioannou,<sup>8</sup> M. Iodice,<sup>133a</sup> K. Iordanidou,<sup>8</sup> V. Ippolito,<sup>131a,131b</sup> A. Irlés Quiles,<sup>166</sup> C. Isaksson,<sup>165</sup> A. Ishikawa,<sup>65</sup> M. Ishino,<sup>66</sup> R. Ishmukhametov,<sup>39</sup> C. Issever,<sup>117</sup> S. Istin,<sup>18a</sup> A. V. Ivashin,<sup>127</sup> W. Iwanski,<sup>38</sup> H. Iwasaki,<sup>64</sup> J. M. Izen,<sup>40</sup> V. Izzo,<sup>101a</sup> B. Jackson,<sup>119</sup> J. N. Jackson,<sup>72</sup> P. Jackson,<sup>142</sup> M. R. Jaekel,<sup>29</sup> V. Jain,<sup>59</sup> K. Jakobs,<sup>47</sup> S. Jakobsen,<sup>35</sup> J. Jakubek,<sup>126</sup> D. K. Jana,<sup>110</sup> E. Jansen,<sup>76</sup> H. Jansen,<sup>29</sup> A. Jantsch,<sup>98</sup> M. Janus,<sup>47</sup> G. Jarlskog,<sup>78</sup> L. Jeanty,<sup>56</sup> K. Jelen,<sup>37</sup> I. Jen-La Plante,<sup>30</sup> P. Jenni,<sup>29</sup> A. Jeremie,<sup>4</sup> P. Jež,<sup>35</sup> S. Jézéquel,<sup>4</sup> M. K. Jha,<sup>19a</sup> H. Ji,<sup>171</sup> W. Ji,<sup>80</sup> J. Jia,<sup>147</sup> Y. Jiang,<sup>32b</sup> M. Jimenez Belenguier,<sup>41</sup> G. Jin,<sup>32b</sup> S. Jin,<sup>32a</sup> O. Jinnouchi,<sup>156</sup> M. D. Joergensen,<sup>35</sup> D. Joffe,<sup>39</sup> L. G. Johansen,<sup>13</sup> M. Johansen,<sup>145a,145b</sup> K. E. Johansson,<sup>145a</sup> P. Johansson,<sup>138</sup> S. Johnert,<sup>41</sup> K. A. Johns,<sup>6</sup> K. Jon-And,<sup>145a,145b</sup> G. Jones,<sup>117</sup> R. W. L. Jones,<sup>70</sup> T. W. Jones,<sup>76</sup> T. J. Jones,<sup>72</sup> O. Jonsson,<sup>29</sup> C. Joram,<sup>29</sup> P. M. Jorge,<sup>123a</sup> J. Joseph,<sup>14</sup> K. D. Joshi,<sup>81</sup> J. Jovicevic,<sup>146</sup> T. Jovin,<sup>12b</sup> X. Ju,<sup>171</sup> C. A. Jung,<sup>42</sup> R. M. Jungst,<sup>29</sup> V. Juranek,<sup>124</sup> P. Jussel,<sup>60</sup> A. Juste Rozas,<sup>11</sup> V. V. Kabachenko,<sup>127</sup> S. Kabana,<sup>16</sup> M. Kaci,<sup>166</sup> A. Kaczmarzka,<sup>38</sup> P. Kadlecik,<sup>35</sup> M. Kado,<sup>114</sup> H. Kagan,<sup>108</sup> M. Kagan,<sup>56</sup> S. Kaiser,<sup>98</sup> E. Kajomovitz,<sup>151</sup> S. Kalinin,<sup>173</sup> L. V. Kalinovskaya,<sup>63</sup> S. Kama,<sup>39</sup> N. Kanaya,<sup>154</sup> M. Kaneda,<sup>29</sup> S. Kaneti,<sup>27</sup>

T. Kanno,<sup>156</sup> V. A. Kantserov,<sup>95</sup> J. Kanzaki,<sup>64</sup> B. Kaplan,<sup>174</sup> A. Kapliy,<sup>30</sup> J. Kaplon,<sup>29</sup> D. Kar,<sup>52</sup> M. Karagounis,<sup>20</sup> M. Karagoz,<sup>117</sup> M. Karnevskiy,<sup>41</sup> V. Kartvelishvili,<sup>70</sup> A. N. Karyukhin,<sup>127</sup> L. Kashif,<sup>171</sup> G. Kasieczka,<sup>57b</sup> R. D. Kass,<sup>108</sup> A. Kastanas,<sup>13</sup> M. Kataoka,<sup>4</sup> Y. Kataoka,<sup>154</sup> E. Katsoufis,<sup>9</sup> J. Katzy,<sup>41</sup> V. Kaushik,<sup>6</sup> K. Kawagoe,<sup>68</sup> T. Kawamoto,<sup>154</sup> G. Kawamura,<sup>80</sup> M. S. Kayl,<sup>104</sup> V. A. Kazanin,<sup>106</sup> M. Y. Kazarinov,<sup>63</sup> R. Keeler,<sup>168</sup> R. Kehoe,<sup>39</sup> M. Keil,<sup>53</sup> G. D. Kekelidze,<sup>63</sup> J. S. Keller,<sup>137</sup> J. Kennedy,<sup>97</sup> M. Kenyon,<sup>52</sup> O. Kepka,<sup>124</sup> N. Kerschen,<sup>29</sup> B. P. Kerševan,<sup>73</sup> S. Kersten,<sup>173</sup> K. Kessoku,<sup>154</sup> J. Keung,<sup>157</sup> F. Khalil-zada,<sup>10</sup> H. Khandanyan,<sup>164</sup> A. Khanov,<sup>111</sup> D. Kharchenko,<sup>63</sup> A. Khodinov,<sup>95</sup> A. G. Kholodenko,<sup>127</sup> A. Khomich,<sup>57a</sup> T. J. Khoo,<sup>27</sup> G. Khorauli,<sup>20</sup> A. Khoroshilov,<sup>173</sup> N. Khovanskiy,<sup>63</sup> V. Khovanskiy,<sup>94</sup> E. Khramov,<sup>63</sup> J. Khubua,<sup>50b</sup> H. Kim,<sup>145a,145b</sup> M. S. Kim,<sup>2</sup> S. H. Kim,<sup>159</sup> N. Kimura,<sup>169</sup> O. Kind,<sup>15</sup> B. T. King,<sup>72</sup> M. King,<sup>65</sup> R. S. B. King,<sup>117</sup> J. Kirk,<sup>128</sup> L. E. Kirsch,<sup>22</sup> A. E. Kiryunin,<sup>98</sup> T. Kishimoto,<sup>65</sup> D. Kisielewska,<sup>37</sup> T. Kittelmann,<sup>122</sup> A. M. Kiver,<sup>127</sup> E. Kladiva,<sup>143b</sup> M. Klein,<sup>72</sup> U. Klein,<sup>72</sup> K. Kleinknecht,<sup>80</sup> M. Klemetti,<sup>84</sup> A. Klier,<sup>170</sup> P. Klimek,<sup>145a,145b</sup> A. Klimentov,<sup>24</sup> R. Klingenberg,<sup>42</sup> J. A. Klinger,<sup>81</sup> E. B. Klinkby,<sup>35</sup> T. Klioutchnikova,<sup>29</sup> P. F. Klok,<sup>103</sup> S. Klous,<sup>104</sup> E.-E. Kluge,<sup>57a</sup> T. Kluge,<sup>72</sup> P. Kluit,<sup>104</sup> S. Kluth,<sup>98</sup> N. S. Knecht,<sup>157</sup> E. Kneringer,<sup>60</sup> J. Knobloch,<sup>29</sup> E. B. F. G. Knoops,<sup>82</sup> A. Knue,<sup>53</sup> B. R. Ko,<sup>44</sup> T. Kobayashi,<sup>154</sup> M. Kobel,<sup>43</sup> M. Kocian,<sup>142</sup> P. Kodys,<sup>125</sup> K. Köneke,<sup>29</sup> A. C. König,<sup>103</sup> S. Koenig,<sup>80</sup> L. Köpke,<sup>80</sup> F. Koetsveld,<sup>103</sup> P. Koesvesarki,<sup>20</sup> T. Koffas,<sup>28</sup> E. Koffeman,<sup>104</sup> L. A. Kogan,<sup>117</sup> S. Kohlmann,<sup>173</sup> F. Kohn,<sup>53</sup> Z. Kohout,<sup>126</sup> T. Kohriki,<sup>64</sup> T. Koi,<sup>142</sup> T. Kokott,<sup>20</sup> G. M. Kolachev,<sup>106</sup> H. Kolanoski,<sup>15</sup> V. Kolesnikov,<sup>63</sup> I. Koletsou,<sup>88a</sup> J. Koll,<sup>87</sup> M. Kollerfrath,<sup>47</sup> S. D. Kolya,<sup>81</sup> A. A. Komar,<sup>93</sup> Y. Komori,<sup>154</sup> T. Kondo,<sup>64</sup> T. Kono,<sup>41,r</sup> A. I. Kononov,<sup>47</sup> R. Konoplich,<sup>107,s</sup> N. Konstantinidis,<sup>76</sup> A. Kootz,<sup>173</sup> S. Koperny,<sup>37</sup> K. Korcyl,<sup>38</sup> K. Kordas,<sup>153</sup> V. Koreshev,<sup>127</sup> A. Korn,<sup>117</sup> A. Korol,<sup>106</sup> I. Korolkov,<sup>11</sup> E. V. Korolkova,<sup>138</sup> V. A. Korotkov,<sup>127</sup> O. Kortner,<sup>98</sup> S. Kortner,<sup>98</sup> V. V. Kostyukhin,<sup>20</sup> M. J. Kotamäki,<sup>29</sup> S. Kotov,<sup>98</sup> V. M. Kotov,<sup>63</sup> A. Kotwal,<sup>44</sup> C. Kourkoumelis,<sup>8</sup> V. Kouskoura,<sup>153</sup> A. Koutsman,<sup>158a</sup> R. Kowalewski,<sup>168</sup> T. Z. Kowalski,<sup>37</sup> W. Kozanecki,<sup>135</sup> A. S. Kozhin,<sup>127</sup> V. Kral,<sup>126</sup> V. A. Kramarenko,<sup>96</sup> G. Kramberger,<sup>73</sup> M. W. Krasny,<sup>77</sup> A. Krasznahorkay,<sup>107</sup> J. Kraus,<sup>87</sup> J. K. Kraus,<sup>20</sup> F. Krejci,<sup>126</sup> J. Kretschmar,<sup>72</sup> N. Krieger,<sup>53</sup> P. Krieger,<sup>157</sup> K. Kroeninger,<sup>53</sup> H. Kroha,<sup>98</sup> J. Kroll,<sup>119</sup> J. Kroseberg,<sup>20</sup> J. Krstic,<sup>12a</sup> U. Kruchonak,<sup>63</sup> H. Krüger,<sup>20</sup> T. Kruker,<sup>16</sup> N. Krumnack,<sup>62</sup> Z. V. Krumshteyn,<sup>63</sup> A. Kruth,<sup>20</sup> T. Kubota,<sup>85</sup> S. Kудay,<sup>3a</sup> S. Kuehn,<sup>47</sup> A. Kugel,<sup>57c</sup> T. Kuhl,<sup>41</sup> D. Kuhn,<sup>60</sup> V. Kukhtin,<sup>63</sup> Y. Kulchitsky,<sup>89</sup> S. Kuleshov,<sup>31b</sup> C. Kummer,<sup>97</sup> M. Kuna,<sup>77</sup> J. Kunkle,<sup>119</sup> A. Kupco,<sup>124</sup> H. Kurashige,<sup>65</sup> M. Kurata,<sup>159</sup> Y. A. Kurochkin,<sup>89</sup> V. Kus,<sup>124</sup> E. S. Kuwertz,<sup>146</sup> M. Kuze,<sup>156</sup> J. Kvita,<sup>141</sup> R. Kwee,<sup>15</sup> A. La Rosa,<sup>48</sup> L. La Rotonda,<sup>36a,36b</sup> L. Labarga,<sup>79</sup> J. Labbe,<sup>4</sup> S. Lablak,<sup>134a</sup> C. Lacasta,<sup>166</sup> F. Lacava,<sup>131a,131b</sup> H. Lacker,<sup>15</sup> D. Lacour,<sup>77</sup> V. R. Lacuesta,<sup>166</sup> E. Ladygin,<sup>63</sup> R. Lafaye,<sup>4</sup> B. Laforge,<sup>77</sup> T. Lagouri,<sup>79</sup> S. Lai,<sup>47</sup> E. Laisne,<sup>54</sup> M. Lamanna,<sup>29</sup> L. Lambourne,<sup>76</sup> C. L. Lampen,<sup>6</sup> W. Lampl,<sup>6</sup> E. Lancon,<sup>135</sup> U. Landgraf,<sup>47</sup> M. P. J. Landon,<sup>74</sup> J. L. Lane,<sup>81</sup> C. Lange,<sup>41</sup> A. J. Lankford,<sup>162</sup> F. Lanni,<sup>24</sup> K. Lantzsch,<sup>173</sup> S. Laplace,<sup>77</sup> C. Lapoire,<sup>20</sup> J. F. Laporte,<sup>135</sup> T. Lari,<sup>88a</sup> A. V. Larionov,<sup>127</sup> A. Larner,<sup>117</sup> C. Lasseur,<sup>29</sup> M. Lassnig,<sup>29</sup> P. Laurelli,<sup>46</sup> V. Lavorini,<sup>36a,36b</sup> W. Lavrijsen,<sup>14</sup> P. Laycock,<sup>72</sup> A. B. Lazarev,<sup>63</sup> O. Le Dortz,<sup>77</sup> E. Le Guirriec,<sup>82</sup> C. Le Maner,<sup>157</sup> E. Le Menedeu,<sup>11</sup> C. Lebel,<sup>92</sup> T. LeCompte,<sup>5</sup> F. Ledroit-Guillon,<sup>54</sup> H. Lee,<sup>104</sup> J. S. H. Lee,<sup>115</sup> S. C. Lee,<sup>150</sup> L. Lee,<sup>174</sup> M. Lefebvre,<sup>168</sup> M. Legendre,<sup>135</sup> A. Leger,<sup>48</sup> B. C. LeGeyt,<sup>119</sup> F. Legger,<sup>97</sup> C. Leggett,<sup>14</sup> M. Lehmacher,<sup>20</sup> G. Lehmann Miotto,<sup>29</sup> X. Lei,<sup>6</sup> M. A. L. Leite,<sup>23d</sup> R. Leitner,<sup>125</sup> D. Lellouch,<sup>170</sup> M. Leltchouk,<sup>34</sup> B. Lemmer,<sup>53</sup> V. Lendermann,<sup>57a</sup> K. J. C. Leney,<sup>144b</sup> T. Lenz,<sup>104</sup> G. Lenzen,<sup>173</sup> B. Lenzi,<sup>29</sup> K. Leonhardt,<sup>43</sup> S. Leontsinis,<sup>9</sup> F. Lepold,<sup>57a</sup> C. Leroy,<sup>92</sup> J.-R. Lessard,<sup>168</sup> C. G. Lester,<sup>27</sup> C. M. Lester,<sup>119</sup> J. Levêque,<sup>4</sup> D. Levin,<sup>86</sup> L. J. Levinson,<sup>170</sup> M. S. Levitski,<sup>127</sup> A. Lewis,<sup>117</sup> G. H. Lewis,<sup>107</sup> A. M. Leyko,<sup>20</sup> M. Leyton,<sup>15</sup> B. Li,<sup>82</sup> H. Li,<sup>171,t</sup> S. Li,<sup>32b,u</sup> X. Li,<sup>86</sup> Z. Liang,<sup>117,v</sup> H. Liao,<sup>33</sup> B. Liberti,<sup>132a</sup> P. Lichard,<sup>29</sup> M. Lichtnecker,<sup>97</sup> K. Lie,<sup>164</sup> W. Liebig,<sup>13</sup> C. Limbach,<sup>20</sup> A. Limosani,<sup>85</sup> M. Limper,<sup>61</sup> S. C. Lin,<sup>150,w</sup> F. Linde,<sup>104</sup> J. T. Linnemann,<sup>87</sup> E. Lipeles,<sup>119</sup> L. Lipinsky,<sup>124</sup> A. Lipniacka,<sup>13</sup> T. M. Liss,<sup>164</sup> D. Lissauer,<sup>24</sup> A. Lister,<sup>48</sup> A. M. Litke,<sup>136</sup> C. Liu,<sup>28</sup> D. Liu,<sup>150</sup> H. Liu,<sup>86</sup> J. B. Liu,<sup>86</sup> M. Liu,<sup>32b</sup> Y. Liu,<sup>32b</sup> M. Livan,<sup>118a,118b</sup> S. S. A. Livermore,<sup>117</sup> A. Lleres,<sup>54</sup> J. Llorente Merino,<sup>79</sup> S. L. Lloyd,<sup>74</sup> E. Lobodzinska,<sup>41</sup> P. Loch,<sup>6</sup> W. S. Lockman,<sup>136</sup> T. Loddenkoetter,<sup>20</sup> F. K. Loebinger,<sup>81</sup> A. Loginov,<sup>174</sup> C. W. Loh,<sup>167</sup> T. Lohse,<sup>15</sup> K. Lohwasser,<sup>47</sup> M. Lokajicek,<sup>124</sup> J. Loken,<sup>117</sup> V. P. Lombardo,<sup>4</sup> R. E. Long,<sup>70</sup> L. Lopes,<sup>123a</sup> D. Lopez Mateos,<sup>56</sup> J. Lorenz,<sup>97</sup> N. Lorenzo Martinez,<sup>114</sup> M. Losada,<sup>161</sup> P. Loscutoff,<sup>14</sup> F. Lo Sterzo,<sup>131a,131b</sup> M. J. Losty,<sup>158a</sup> X. Lou,<sup>40</sup> A. Lounis,<sup>114</sup> K. F. Loureiro,<sup>161</sup> J. Love,<sup>21</sup> P. A. Love,<sup>70</sup> A. J. Lowe,<sup>142,f</sup> F. Lu,<sup>32a</sup> H. J. Lubatti,<sup>137</sup> C. Luci,<sup>131a,131b</sup> A. Lucotte,<sup>54</sup> A. Ludwig,<sup>43</sup> D. Ludwig,<sup>41</sup> I. Ludwig,<sup>47</sup> J. Ludwig,<sup>47</sup> F. Luehring,<sup>59</sup> G. Luijckx,<sup>104</sup> W. Lukas,<sup>60</sup> D. Lumb,<sup>47</sup> L. Luminari,<sup>131a</sup> E. Lund,<sup>116</sup> B. Lund-Jensen,<sup>146</sup> B. Lundberg,<sup>78</sup> J. Lundberg,<sup>145a,145b</sup> J. Lundquist,<sup>35</sup> M. Lungwitz,<sup>80</sup> G. Lutz,<sup>98</sup> D. Lynn,<sup>24</sup> J. Lys,<sup>14</sup> E. Lytken,<sup>78</sup> H. Ma,<sup>24</sup> L. L. Ma,<sup>171</sup> J. A. Macana Goia,<sup>92</sup> G. Maccarrone,<sup>46</sup> A. Macchiolo,<sup>98</sup> B. Maček,<sup>73</sup> J. Machado Miguens,<sup>123a</sup> R. Mackeprang,<sup>35</sup> R. J. Madaras,<sup>14</sup> W. F. Mader,<sup>43</sup> R. Maenner,<sup>57c</sup> T. Maeno,<sup>24</sup> P. Mättig,<sup>173</sup> S. Mättig,<sup>41</sup>

- L. Magnoni,<sup>29</sup> E. Magradze,<sup>53</sup> Y. Mahalalel,<sup>152</sup> K. Mahboubi,<sup>47</sup> S. Mahmoud,<sup>72</sup> G. Mahout,<sup>17</sup> C. Maiani,<sup>131a,131b</sup>  
 C. Maidantchik,<sup>23a</sup> A. Maio,<sup>123a,c</sup> S. Majewski,<sup>24</sup> Y. Makida,<sup>64</sup> N. Makovec,<sup>114</sup> P. Mal,<sup>135</sup> B. Malaescu,<sup>29</sup>  
 Pa. Malecki,<sup>38</sup> P. Malecki,<sup>38</sup> V. P. Maleev,<sup>120</sup> F. Malek,<sup>54</sup> U. Mallik,<sup>61</sup> D. Malon,<sup>5</sup> C. Malone,<sup>142</sup> S. Maltezos,<sup>9</sup>  
 V. Malyshev,<sup>106</sup> S. Malyukov,<sup>29</sup> R. Mameghani,<sup>97</sup> J. Mamuzic,<sup>12b</sup> A. Manabe,<sup>64</sup> L. Mandelli,<sup>88a</sup> I. Mandić,<sup>73</sup>  
 R. Mandrysch,<sup>15</sup> J. Maneira,<sup>123a</sup> P. S. Mangeard,<sup>87</sup> L. Manhaes de Andrade Filho,<sup>23a</sup> I. D. Manjavidze,<sup>63</sup> A. Mann,<sup>53</sup>  
 P. M. Manning,<sup>136</sup> A. Manousakis-Katsikakis,<sup>8</sup> B. Mansoulie,<sup>135</sup> A. Manz,<sup>98</sup> A. Mapelli,<sup>29</sup> L. Mapelli,<sup>29</sup> L. March,<sup>79</sup>  
 J. F. Marchand,<sup>28</sup> F. Marchese,<sup>132a,132b</sup> G. Marchiori,<sup>77</sup> M. Marcisovsky,<sup>124</sup> C. P. Marino,<sup>168</sup> F. Marroquim,<sup>23a</sup>  
 R. Marshall,<sup>81</sup> Z. Marshall,<sup>29</sup> F. K. Martens,<sup>157</sup> S. Marti-Garcia,<sup>166</sup> A. J. Martin,<sup>174</sup> B. Martin,<sup>29</sup> B. Martin,<sup>87</sup>  
 F. F. Martin,<sup>119</sup> J. P. Martin,<sup>92</sup> Ph. Martin,<sup>54</sup> T. A. Martin,<sup>17</sup> V. J. Martin,<sup>45</sup> B. Martin dit Latour,<sup>48</sup> S. Martin-Haugh,<sup>148</sup>  
 M. Martinez,<sup>11</sup> V. Martinez Outschoorn,<sup>56</sup> A. C. Martyniuk,<sup>168</sup> M. Marx,<sup>81</sup> F. Marzano,<sup>131a</sup> A. Marzin,<sup>110</sup>  
 L. Masetti,<sup>80</sup> T. Mashimo,<sup>154</sup> R. Mashinistov,<sup>93</sup> J. Masik,<sup>81</sup> A. L. Maslennikov,<sup>106</sup> I. Massa,<sup>19a,19b</sup> G. Massaro,<sup>104</sup>  
 N. Massol,<sup>4</sup> P. Mastrandrea,<sup>131a,131b</sup> A. Mastroberardino,<sup>36a,36b</sup> T. Masubuchi,<sup>154</sup> P. Matricon,<sup>114</sup> H. Matsunaga,<sup>154</sup>  
 T. Matsushita,<sup>65</sup> C. Mattravers,<sup>117,d</sup> J. M. Maugain,<sup>29</sup> J. Maurer,<sup>82</sup> S. J. Maxfield,<sup>72</sup> E. N. May,<sup>5</sup> A. Mayne,<sup>138</sup>  
 R. Mazini,<sup>150</sup> M. Mazur,<sup>20</sup> L. Mazzaferro,<sup>132a,132b</sup> M. Mazzanti,<sup>88a</sup> S. P. Mc Kee,<sup>86</sup> A. McCarn,<sup>164</sup> R. L. McCarthy,<sup>147</sup>  
 T. G. McCarthy,<sup>28</sup> N. A. McCubbin,<sup>128</sup> K. W. McFarlane,<sup>55</sup> J. A. McFayden,<sup>138</sup> H. McGlone,<sup>52</sup> G. Mchedlidze,<sup>50b</sup>  
 R. A. McLaren,<sup>29</sup> T. McLaughlan,<sup>17</sup> S. J. McMahon,<sup>128</sup> R. A. McPherson,<sup>168,k</sup> A. Meade,<sup>83</sup> J. Mechnich,<sup>104</sup>  
 M. Mechtel,<sup>173</sup> M. Medinnis,<sup>41</sup> R. Meera-Lebbai,<sup>110</sup> T. Meguro,<sup>115</sup> R. Mehdiyev,<sup>92</sup> S. Mehlhase,<sup>35</sup> A. Mehta,<sup>72</sup>  
 K. Meier,<sup>57a</sup> B. Meirose,<sup>78</sup> C. Melachrinou,<sup>30</sup> B. R. Mellado Garcia,<sup>171</sup> F. Meloni,<sup>88a,88b</sup> L. Mendoza Navas,<sup>161</sup>  
 Z. Meng,<sup>150,t</sup> A. Mengarelli,<sup>19a,19b</sup> S. Menke,<sup>98</sup> C. Menot,<sup>29</sup> E. Meoni,<sup>11</sup> K. M. Mercurio,<sup>56</sup> P. Mermod,<sup>48</sup>  
 L. Merola,<sup>101a,101b</sup> C. Meroni,<sup>88a</sup> F. S. Merritt,<sup>30</sup> H. Merritt,<sup>108</sup> A. Messina,<sup>29</sup> J. Metcalfe,<sup>102</sup> A. S. Mete,<sup>62</sup>  
 C. Meyer,<sup>80</sup> C. Meyer,<sup>30</sup> J.-P. Meyer,<sup>135</sup> J. Meyer,<sup>172</sup> J. Meyer,<sup>53</sup> T. C. Meyer,<sup>29</sup> W. T. Meyer,<sup>62</sup> J. Miao,<sup>32d</sup> S. Michal,<sup>29</sup>  
 L. Micu,<sup>25a</sup> R. P. Middleton,<sup>128</sup> S. Migas,<sup>72</sup> L. Mijović,<sup>41</sup> G. Mikenberg,<sup>170</sup> M. Mikesikova,<sup>124</sup> M. Mikuz,<sup>73</sup>  
 D. W. Miller,<sup>30</sup> R. J. Miller,<sup>87</sup> W. J. Mills,<sup>167</sup> C. Mills,<sup>56</sup> A. Milov,<sup>170</sup> D. A. Milstead,<sup>145a,145b</sup> D. Milstein,<sup>170</sup>  
 A. A. Minaenko,<sup>127</sup> M. Miñano Moya,<sup>166</sup> I. A. Minashvili,<sup>63</sup> A. I. Mincer,<sup>107</sup> B. Mindur,<sup>37</sup> M. Mineev,<sup>63</sup> Y. Ming,<sup>171</sup>  
 L. M. Mir,<sup>11</sup> G. Mirabelli,<sup>131a</sup> L. Miralles Verge,<sup>11</sup> A. Misiejuk,<sup>75</sup> J. Mitrevski,<sup>136</sup> G. Y. Mitrofanov,<sup>127</sup>  
 V. A. Mitsou,<sup>166</sup> S. Mitsui,<sup>64</sup> P. S. Miyagawa,<sup>138</sup> K. Miyazaki,<sup>65</sup> J. U. Mjörnmark,<sup>78</sup> T. Moa,<sup>145a,145b</sup> P. Mockett,<sup>137</sup>  
 S. Moed,<sup>56</sup> V. Moeller,<sup>27</sup> K. Mönig,<sup>41</sup> N. Möser,<sup>20</sup> S. Mohapatra,<sup>147</sup> W. Mohr,<sup>47</sup> S. Mohr dieck-Möck,<sup>98</sup>  
 R. Moles-Valls,<sup>166</sup> J. Molina-Perez,<sup>29</sup> J. Monk,<sup>76</sup> E. Monnier,<sup>82</sup> S. Montesano,<sup>88a,88b</sup> F. Monticelli,<sup>69</sup>  
 S. Monzani,<sup>19a,19b</sup> R. W. Moore,<sup>2</sup> G. F. Moorhead,<sup>85</sup> C. Mora Herrera,<sup>48</sup> A. Moraes,<sup>52</sup> N. Morange,<sup>135</sup> J. Morel,<sup>53</sup>  
 G. Morello,<sup>36a,36b</sup> D. Moreno,<sup>80</sup> M. Moreno Llácer,<sup>166</sup> P. Morettini,<sup>49a</sup> M. Morgenstern,<sup>43</sup> M. Morii,<sup>56</sup> J. Morin,<sup>74</sup>  
 A. K. Morley,<sup>29</sup> G. Mornacchi,<sup>29</sup> S. V. Morozov,<sup>95</sup> J. D. Morris,<sup>74</sup> L. Morvaj,<sup>100</sup> H. G. Moser,<sup>98</sup> M. Mosidze,<sup>50b</sup>  
 J. Moss,<sup>108</sup> R. Mount,<sup>142</sup> E. Mountricha,<sup>9,x</sup> S. V. Mouraviev,<sup>93</sup> E. J. W. Moyse,<sup>83</sup> M. Mudrinic,<sup>12b</sup> F. Mueller,<sup>57a</sup>  
 J. Mueller,<sup>122</sup> K. Mueller,<sup>20</sup> T. A. Müller,<sup>97</sup> T. Mueller,<sup>80</sup> D. Muenstermann,<sup>29</sup> Y. Munwes,<sup>152</sup> W. J. Murray,<sup>128</sup>  
 I. Mussche,<sup>104</sup> E. Musto,<sup>101a,101b</sup> A. G. Myagkov,<sup>127</sup> M. Myska,<sup>124</sup> J. Nadal,<sup>11</sup> K. Nagai,<sup>159</sup> K. Nagano,<sup>64</sup>  
 A. Nagarkar,<sup>108</sup> Y. Nagasaka,<sup>58</sup> M. Nagel,<sup>98</sup> A. M. Nairz,<sup>29</sup> Y. Nakahama,<sup>29</sup> K. Nakamura,<sup>154</sup> T. Nakamura,<sup>154</sup>  
 I. Nakano,<sup>109</sup> G. Nanava,<sup>20</sup> A. Napier,<sup>160</sup> R. Narayan,<sup>57b</sup> M. Nash,<sup>76,d</sup> N. R. Nation,<sup>21</sup> T. Nattermann,<sup>20</sup>  
 T. Naumann,<sup>41</sup> G. Navarro,<sup>161</sup> H. A. Neal,<sup>86</sup> E. Nebot,<sup>79</sup> P. Yu. Nechaeva,<sup>93</sup> T. J. Neep,<sup>81</sup> A. Negri,<sup>118a,118b</sup> G. Negri,<sup>29</sup>  
 S. Nektarijevic,<sup>48</sup> A. Nelson,<sup>162</sup> T. K. Nelson,<sup>142</sup> S. Nemecek,<sup>124</sup> P. Nemethy,<sup>107</sup> A. A. Nepomuceno,<sup>23a</sup> M. Nessi,<sup>29,y</sup>  
 M. S. Neubauer,<sup>164</sup> A. Neusiedl,<sup>80</sup> R. M. Neves,<sup>107</sup> P. Nevski,<sup>24</sup> P. R. Newman,<sup>17</sup> V. Nguyen Thi Hong,<sup>135</sup>  
 R. B. Nickerson,<sup>117</sup> R. Nicolaidou,<sup>135</sup> L. Nicolas,<sup>138</sup> B. Nicquevert,<sup>29</sup> F. Niedercorn,<sup>114</sup> J. Nielsen,<sup>136</sup> T. Niinikoski,<sup>29</sup>  
 N. Nikiforou,<sup>34</sup> A. Nikiforov,<sup>15</sup> V. Nikolaenko,<sup>127</sup> K. Nikolaev,<sup>63</sup> I. Nikolic-Audit,<sup>77</sup> K. Nikolics,<sup>48</sup>  
 K. Nikolopoulos,<sup>24</sup> H. Nilsen,<sup>47</sup> P. Nilsson,<sup>7</sup> Y. Ninomiya,<sup>154</sup> A. Nisati,<sup>131a</sup> T. Nishiyama,<sup>65</sup> R. Nisius,<sup>98</sup>  
 L. Nodulman,<sup>5</sup> M. Nomachi,<sup>115</sup> I. Nomidis,<sup>153</sup> M. Nordberg,<sup>29</sup> P. R. Norton,<sup>128</sup> J. Novakova,<sup>125</sup> M. Nozaki,<sup>64</sup>  
 L. Nozka,<sup>112</sup> I. M. Nugent,<sup>158a</sup> A.-E. Nuncio-Quiroz,<sup>20</sup> G. Nunes Hanninger,<sup>85</sup> T. Nunnemann,<sup>97</sup> E. Nurse,<sup>76</sup>  
 B. J. O'Brien,<sup>45</sup> S. W. O'Neale,<sup>17,a</sup> D. C. O'Neil,<sup>141</sup> V. O'Shea,<sup>52</sup> L. B. Oakes,<sup>97</sup> F. G. Oakham,<sup>28,e</sup> H. Oberlack,<sup>98</sup>  
 J. Ocariz,<sup>77</sup> A. Ochi,<sup>65</sup> S. Oda,<sup>154</sup> S. Odaka,<sup>64</sup> J. Odier,<sup>82</sup> H. Ogren,<sup>59</sup> A. Oh,<sup>81</sup> S. H. Oh,<sup>44</sup> C. C. Ohm,<sup>145a,145b</sup>  
 T. Ohshima,<sup>100</sup> H. Ohshita,<sup>139</sup> S. Okada,<sup>65</sup> H. Okawa,<sup>162</sup> Y. Okumura,<sup>100</sup> T. Okuyama,<sup>154</sup> A. Olariu,<sup>25a</sup> M. Olcese,<sup>49a</sup>  
 A. G. Olchevski,<sup>63</sup> S. A. Olivares Pino,<sup>31a</sup> M. Oliveira,<sup>123a,i</sup> D. Oliveira Damazio,<sup>24</sup> E. Oliver Garcia,<sup>166</sup> D. Olivito,<sup>119</sup>  
 A. Olszewski,<sup>38</sup> J. Olszowska,<sup>38</sup> C. Omachi,<sup>65</sup> A. Onofre,<sup>123a,z</sup> P. U. E. Onyisi,<sup>30</sup> C. J. Oram,<sup>158a</sup> M. J. Oreglia,<sup>30</sup>  
 Y. Oren,<sup>152</sup> D. Orestano,<sup>133a,133b</sup> N. Orlando,<sup>71a,71b</sup> I. Orlov,<sup>106</sup> C. Oropeza Barrera,<sup>52</sup> R. S. Orr,<sup>157</sup> B. Osculati,<sup>49a,49b</sup>  
 R. Ospanov,<sup>119</sup> C. Osuna,<sup>11</sup> G. Otero y Garzon,<sup>26</sup> J. P. Ottersbach,<sup>104</sup> M. Ouchrif,<sup>134d</sup> E. A. Ouellette,<sup>168</sup>

- F. Ould-Saada,<sup>116</sup> A. Ouraou,<sup>135</sup> Q. Ouyang,<sup>32a</sup> A. Ovcharova,<sup>14</sup> M. Owen,<sup>81</sup> S. Owen,<sup>138</sup> V. E. Ozcan,<sup>18a</sup> N. Ozturk,<sup>7</sup>  
A. Pacheco Pages,<sup>11</sup> C. Padilla Aranda,<sup>11</sup> S. Pagan Griso,<sup>14</sup> E. Paganis,<sup>138</sup> F. Paige,<sup>24</sup> P. Pais,<sup>83</sup> K. Pajchel,<sup>116</sup>  
G. Palacino,<sup>158b</sup> C. P. Paleari,<sup>6</sup> S. Palestini,<sup>29</sup> D. Pallin,<sup>33</sup> A. Palma,<sup>123a</sup> J. D. Palmer,<sup>17</sup> Y. B. Pan,<sup>171</sup>  
E. Panagiotopoulou,<sup>9</sup> N. Panikashvili,<sup>86</sup> S. Panitkin,<sup>24</sup> D. Pantea,<sup>25a</sup> M. Panuskova,<sup>124</sup> V. Paolone,<sup>122</sup>  
A. Papadelis,<sup>145a</sup> Th. D. Papadopoulou,<sup>9</sup> A. Paramonov,<sup>5</sup> D. Paredes Hernandez,<sup>33</sup> W. Park,<sup>24,aa</sup> M. A. Parker,<sup>27</sup>  
F. Parodi,<sup>49a,49b</sup> J. A. Parsons,<sup>34</sup> U. Parzefall,<sup>47</sup> S. Pashapour,<sup>53</sup> E. Pasqualucci,<sup>131a</sup> S. Passaggio,<sup>49a</sup> A. Passeri,<sup>133a</sup>  
F. Pastore,<sup>133a,133b</sup> Fr. Pastore,<sup>75</sup> G. Pásztor,<sup>48,bb</sup> S. Pataraiia,<sup>173</sup> N. Patel,<sup>149</sup> J. R. Pater,<sup>81</sup> S. Patricelli,<sup>101a,101b</sup>  
T. Pauly,<sup>29</sup> M. Pecsý,<sup>143a</sup> M. I. Pedraza Morales,<sup>171</sup> S. V. Peleganchuk,<sup>106</sup> D. Pelikan,<sup>165</sup> H. Peng,<sup>32b</sup> B. Penning,<sup>30</sup>  
A. Penson,<sup>34</sup> J. Penwell,<sup>59</sup> M. Perantoni,<sup>23a</sup> K. Perez,<sup>34,cc</sup> T. Perez Cavalcanti,<sup>41</sup> E. Perez Codina,<sup>158a</sup>  
M. T. Pérez García-Estañ,<sup>166</sup> V. Perez Reale,<sup>34</sup> L. Perini,<sup>88a,88b</sup> H. Pernegger,<sup>29</sup> R. Perrino,<sup>71a</sup> P. Perrodo,<sup>4</sup>  
S. Persema,<sup>3a</sup> V. D. Peshekhonov,<sup>63</sup> K. Peters,<sup>29</sup> B. A. Petersen,<sup>29</sup> J. Petersen,<sup>29</sup> T. C. Petersen,<sup>35</sup> E. Petit,<sup>4</sup>  
A. Petridis,<sup>153</sup> C. Petridou,<sup>153</sup> E. Petrollo,<sup>131a</sup> F. Petrucci,<sup>133a,133b</sup> D. Petschull,<sup>41</sup> M. Petteni,<sup>141</sup> R. Pezoa,<sup>31b</sup>  
A. Phan,<sup>85</sup> P. W. Phillips,<sup>128</sup> G. Piacquadio,<sup>29</sup> A. Picazio,<sup>48</sup> E. Piccaro,<sup>74</sup> M. Piccinini,<sup>19a,19b</sup> S. M. Piec,<sup>41</sup>  
R. Piegai,<sup>26</sup> D. T. Pignotti,<sup>108</sup> J. E. Pilcher,<sup>30</sup> A. D. Pilkington,<sup>81</sup> J. Pina,<sup>123a,c</sup> M. Pinamonti,<sup>163a,163c</sup> A. Pinder,<sup>117</sup>  
J. L. Pinfold,<sup>2</sup> J. Ping,<sup>32c</sup> B. Pinto,<sup>123a</sup> C. Pizio,<sup>88a,88b</sup> R. Placakyte,<sup>41</sup> M. Plamondon,<sup>168</sup> M.-A. Pleier,<sup>24</sup>  
A. V. Pleskach,<sup>127</sup> E. Plotnikova,<sup>63</sup> A. Poblaguev,<sup>24</sup> S. Poddar,<sup>57a</sup> F. Podlyski,<sup>33</sup> L. Poggioli,<sup>114</sup> T. Poghosyan,<sup>20</sup>  
M. Pohl,<sup>48</sup> F. Polci,<sup>54</sup> G. Polesello,<sup>118a</sup> A. Policicchio,<sup>36a,36b</sup> A. Polini,<sup>19a</sup> J. Poll,<sup>74</sup> V. Polychronakos,<sup>24</sup>  
D. M. Pomarede,<sup>135</sup> D. Pomeroy,<sup>22</sup> K. Pommès,<sup>29</sup> L. Pontecorvo,<sup>131a</sup> B. G. Pope,<sup>87</sup> G. A. Popeneciu,<sup>25a</sup>  
D. S. Popovic,<sup>12a</sup> A. Poppleton,<sup>29</sup> X. Portell Bueso,<sup>29</sup> C. Posch,<sup>21</sup> G. E. Pospelov,<sup>98</sup> S. Pospisil,<sup>126</sup> I. N. Potrap,<sup>98</sup>  
C. J. Potter,<sup>148</sup> C. T. Potter,<sup>113</sup> G. Poulard,<sup>29</sup> J. Poveda,<sup>171</sup> V. Pozdnyakov,<sup>63</sup> R. Prabhu,<sup>76</sup> P. Pralavorio,<sup>82</sup> A. Pranko,<sup>14</sup>  
S. Prasad,<sup>29</sup> R. Pravahan,<sup>24</sup> S. Prell,<sup>62</sup> K. Pretzl,<sup>16</sup> L. Pribyl,<sup>29</sup> D. Price,<sup>59</sup> J. Price,<sup>72</sup> L. E. Price,<sup>5</sup> M. J. Price,<sup>29</sup>  
D. Prieur,<sup>122</sup> M. Primavera,<sup>71a</sup> K. Prokofiev,<sup>107</sup> F. Prokoshin,<sup>31b</sup> S. Protopopescu,<sup>24</sup> J. Proudfoot,<sup>5</sup> X. Prudent,<sup>43</sup>  
M. Przybycien,<sup>37</sup> H. Przysiezniak,<sup>4</sup> S. Psoroulas,<sup>20</sup> E. Ptacek,<sup>113</sup> E. Pueschel,<sup>83</sup> J. Purdham,<sup>86</sup> M. Purohit,<sup>24,aa</sup>  
P. Puzo,<sup>114</sup> Y. Pylypchenko,<sup>61</sup> J. Qian,<sup>86</sup> Z. Qian,<sup>82</sup> Z. Qin,<sup>41</sup> A. Quadt,<sup>53</sup> D. R. Quarrie,<sup>14</sup> W. B. Quayle,<sup>171</sup>  
F. Quinonez,<sup>31a</sup> M. Raas,<sup>103</sup> V. Radescu,<sup>41</sup> B. Radics,<sup>20</sup> P. Radloff,<sup>113</sup> T. Rador,<sup>18a</sup> F. Ragusa,<sup>88a,88b</sup> G. Rahal,<sup>176</sup>  
A. M. Rahimi,<sup>108</sup> D. Rahm,<sup>24</sup> S. Rajagopalan,<sup>24</sup> M. Rammensee,<sup>47</sup> M. Rammes,<sup>140</sup> A. S. Randle-Conde,<sup>39</sup>  
K. Randrianarivony,<sup>28</sup> P. N. Ratoff,<sup>70</sup> F. Rauscher,<sup>97</sup> T. C. Rave,<sup>47</sup> M. Raymond,<sup>29</sup> A. L. Read,<sup>116</sup>  
D. M. Rebuzzi,<sup>118a,118b</sup> A. Redelbach,<sup>172</sup> G. Redlinger,<sup>24</sup> R. Reece,<sup>119</sup> K. Reeves,<sup>40</sup> A. Reichold,<sup>104</sup>  
E. Reinherz-Aronis,<sup>152</sup> A. Reinsch,<sup>113</sup> I. Reisinger,<sup>42</sup> C. Rembser,<sup>29</sup> Z. L. Ren,<sup>150</sup> A. Renaud,<sup>114</sup> M. Rescigno,<sup>131a</sup>  
S. Resconi,<sup>88a</sup> B. Resende,<sup>135</sup> P. Reznicek,<sup>97</sup> R. Rezvani,<sup>157</sup> A. Richards,<sup>76</sup> R. Richter,<sup>98</sup> E. Richter-Was,<sup>4,dd</sup>  
M. Ridel,<sup>77</sup> M. Rijpstra,<sup>104</sup> M. Rijssenbeek,<sup>147</sup> A. Rimoldi,<sup>118a,118b</sup> L. Rinaldi,<sup>19a</sup> R. R. Rios,<sup>39</sup> I. Riu,<sup>11</sup>  
G. Rivoltella,<sup>88a,88b</sup> F. Rizatdinova,<sup>111</sup> E. Rizvi,<sup>74</sup> S. H. Robertson,<sup>84,k</sup> A. Robichaud-Veronneau,<sup>117</sup> D. Robinson,<sup>27</sup>  
J. E. M. Robinson,<sup>76</sup> A. Robson,<sup>52</sup> J. G. Rocha de Lima,<sup>105</sup> C. Roda,<sup>121a,121b</sup> D. Roda Dos Santos,<sup>29</sup> D. Rodriguez,<sup>161</sup>  
A. Roe,<sup>53</sup> S. Roe,<sup>29</sup> O. Røhne,<sup>116</sup> V. Rojo,<sup>1</sup> S. Rolli,<sup>160</sup> A. Romaniouk,<sup>95</sup> M. Romano,<sup>19a,19b</sup> V. M. Romanov,<sup>63</sup>  
G. Romeo,<sup>26</sup> E. Romero Adam,<sup>166</sup> L. Roos,<sup>77</sup> E. Ros,<sup>166</sup> S. Rosati,<sup>131a</sup> K. Rosbach,<sup>48</sup> A. Rose,<sup>148</sup> M. Rose,<sup>75</sup>  
G. A. Rosenbaum,<sup>157</sup> E. I. Rosenberg,<sup>62</sup> P. L. Rosendahl,<sup>13</sup> O. Rosenthal,<sup>140</sup> L. Rossetlet,<sup>48</sup> V. Rossetti,<sup>11</sup>  
E. Rossi,<sup>131a,131b</sup> L. P. Rossi,<sup>49a</sup> M. Rotaru,<sup>25a</sup> I. Roth,<sup>170</sup> J. Rothberg,<sup>137</sup> D. Rousseau,<sup>114</sup> C. R. Royon,<sup>135</sup>  
A. Rozanov,<sup>82</sup> Y. Rozen,<sup>151</sup> X. Ruan,<sup>32a,ee</sup> F. Rubbo,<sup>11</sup> I. Rubinskiy,<sup>41</sup> B. Ruckert,<sup>97</sup> N. Ruckstuhl,<sup>104</sup> V. I. Rud,<sup>96</sup>  
C. Rudolph,<sup>43</sup> G. Rudolph,<sup>60</sup> F. Rühr,<sup>6</sup> F. Ruggieri,<sup>133a,133b</sup> A. Ruiz-Martinez,<sup>62</sup> V. Rumiantsev,<sup>90,a</sup> L. Rummyantsev,<sup>63</sup>  
K. Runge,<sup>47</sup> Z. Rurikova,<sup>47</sup> N. A. Rusakovich,<sup>63</sup> J. P. Rutherford,<sup>6</sup> C. Ruwiedel,<sup>14</sup> P. Ruzicka,<sup>124</sup> Y. F. Ryabov,<sup>120</sup>  
V. Ryadovikov,<sup>127</sup> P. Ryan,<sup>87</sup> M. Rybar,<sup>125</sup> G. Rybkin,<sup>114</sup> N. C. Ryder,<sup>117</sup> S. Rzaeva,<sup>10</sup> A. F. Saavedra,<sup>149</sup> I. Sadeh,<sup>152</sup>  
H. F.-W. Sadrozinski,<sup>136</sup> R. Sadykov,<sup>63</sup> F. Safai Tehrani,<sup>131a</sup> H. Sakamoto,<sup>154</sup> G. Salamanna,<sup>74</sup> A. Salamon,<sup>132a</sup>  
M. Saleem,<sup>110</sup> D. Salek,<sup>29</sup> D. Salihagic,<sup>98</sup> A. Salnikov,<sup>142</sup> J. Salt,<sup>166</sup> B. M. Salvachua Ferrando,<sup>5</sup> D. Salvatore,<sup>36a,36b</sup>  
F. Salvatore,<sup>148</sup> A. Salvucci,<sup>103</sup> A. Salzburger,<sup>29</sup> D. Sampsonidis,<sup>153</sup> B. H. Samset,<sup>116</sup> A. Sanchez,<sup>101a,101b</sup>  
V. Sanchez Martinez,<sup>166</sup> H. Sandaker,<sup>13</sup> H. G. Sander,<sup>80</sup> M. P. Sanders,<sup>97</sup> M. Sandhoff,<sup>173</sup> T. Sandoval,<sup>27</sup>  
C. Sandoval,<sup>161</sup> R. Sandstroem,<sup>98</sup> S. Sandvoss,<sup>173</sup> D. P. C. Sankey,<sup>128</sup> A. Sansoni,<sup>46</sup> C. Santamarina Rios,<sup>84</sup>  
C. Santoni,<sup>33</sup> R. Santonico,<sup>132a,132b</sup> H. Santos,<sup>123a</sup> J. G. Saraiva,<sup>123a</sup> T. Sarangi,<sup>171</sup> E. Sarkisyan-Grinbaum,<sup>7</sup>  
F. Sarri,<sup>121a,121b</sup> G. Sartisohn,<sup>173</sup> O. Sasaki,<sup>64</sup> N. Sasao,<sup>66</sup> I. Satsounkevitch,<sup>89</sup> G. Sauvage,<sup>4</sup> E. Sauvan,<sup>4</sup>  
J. B. Sauvan,<sup>114</sup> P. Savard,<sup>157,e</sup> V. Savinov,<sup>122</sup> D. O. Savu,<sup>29</sup> L. Sawyer,<sup>24,m</sup> D. H. Saxon,<sup>52</sup> J. Saxon,<sup>119</sup> L. P. Says,<sup>33</sup>  
C. Sbarra,<sup>19a</sup> A. Sbrizzi,<sup>19a,19b</sup> O. Scallion,<sup>92</sup> D. A. Scannicchio,<sup>162</sup> M. Scarcella,<sup>149</sup> J. Schaarschmidt,<sup>114</sup> P. Schacht,<sup>98</sup>  
D. Schaefer,<sup>119</sup> U. Schäfer,<sup>80</sup> S. Schaepe,<sup>20</sup> S. Schaezel,<sup>57b</sup> A. C. Schaffer,<sup>114</sup> D. Schaile,<sup>97</sup> R. D. Schamberger,<sup>147</sup>



A. G. Schamov,<sup>106</sup> V. Scharf,<sup>57a</sup> V. A. Schegelsky,<sup>120</sup> D. Scheirich,<sup>86</sup> M. Schernau,<sup>162</sup> M. I. Scherzer,<sup>34</sup>  
 C. Schiavi,<sup>49a,49b</sup> J. Schieck,<sup>97</sup> M. Schioppa,<sup>36a,36b</sup> S. Schlenker,<sup>29</sup> J. L. Schlereth,<sup>5</sup> E. Schmidt,<sup>47</sup> K. Schmieden,<sup>20</sup>  
 C. Schmitt,<sup>80</sup> S. Schmitt,<sup>57b</sup> M. Schmitz,<sup>20</sup> A. Schöning,<sup>57b</sup> M. Schott,<sup>29</sup> D. Schouten,<sup>158a</sup> J. Schovancova,<sup>124</sup>  
 M. Schram,<sup>84</sup> C. Schroeder,<sup>80</sup> N. Schroer,<sup>57c</sup> G. Schuler,<sup>29</sup> M. J. Schultens,<sup>20</sup> J. Schultes,<sup>173</sup> H.-C. Schultz-Coulon,<sup>57a</sup>  
 H. Schulz,<sup>15</sup> J. W. Schumacher,<sup>20</sup> M. Schumacher,<sup>47</sup> B. A. Schumm,<sup>136</sup> Ph. Schune,<sup>135</sup> C. Schwanenberger,<sup>81</sup>  
 A. Schwartzman,<sup>142</sup> Ph. Schwemling,<sup>77</sup> R. Schwienhorst,<sup>87</sup> R. Schwierz,<sup>43</sup> J. Schwindling,<sup>135</sup> T. Schwindt,<sup>20</sup>  
 M. Schwoerer,<sup>4</sup> G. Sciolla,<sup>22</sup> W. G. Scott,<sup>128</sup> J. Searcy,<sup>113</sup> G. Sedov,<sup>41</sup> E. Sedykh,<sup>120</sup> E. Segura,<sup>11</sup> S. C. Seidel,<sup>102</sup>  
 A. Seiden,<sup>136</sup> F. Seifert,<sup>43</sup> J. M. Seixas,<sup>23a</sup> G. Sekhniaidze,<sup>101a</sup> S. J. Sekula,<sup>39</sup> K. E. Selbach,<sup>45</sup> D. M. Seliverstov,<sup>120</sup>  
 B. Sellden,<sup>145a</sup> G. Sellers,<sup>72</sup> M. Seman,<sup>143b</sup> N. Semprini-Cesari,<sup>19a,19b</sup> C. Serfon,<sup>97</sup> L. Serin,<sup>114</sup> L. Serkin,<sup>53</sup>  
 R. Seuster,<sup>98</sup> H. Severini,<sup>110</sup> M. E. Sevir,<sup>85</sup> A. Sfyrla,<sup>29</sup> E. Shabalina,<sup>53</sup> M. Shamim,<sup>113</sup> L. Y. Shan,<sup>32a</sup> J. T. Shank,<sup>21</sup>  
 Q. T. Shao,<sup>85</sup> M. Shapiro,<sup>14</sup> P. B. Shatalov,<sup>94</sup> L. Shaver,<sup>6</sup> K. Shaw,<sup>163a,163c</sup> D. Sherman,<sup>174</sup> P. Sherwood,<sup>76</sup>  
 A. Shibata,<sup>107</sup> H. Shichi,<sup>100</sup> S. Shimizu,<sup>29</sup> M. Shimojima,<sup>99</sup> T. Shin,<sup>55</sup> M. Shiyakova,<sup>63</sup> A. Shmeleva,<sup>93</sup>  
 M. J. Shochet,<sup>30</sup> D. Short,<sup>117</sup> S. Shrestha,<sup>62</sup> E. Shulga,<sup>95</sup> M. A. Shupe,<sup>6</sup> P. Sicho,<sup>124</sup> A. Sidoti,<sup>131a</sup> F. Siegert,<sup>47</sup>  
 Dj. Sijacki,<sup>12a</sup> O. Silbert,<sup>170</sup> J. Silva,<sup>123a</sup> Y. Silver,<sup>152</sup> D. Silverstein,<sup>142</sup> S. B. Silverstein,<sup>145a</sup> V. Simak,<sup>126</sup>  
 O. Simard,<sup>135</sup> Lj. Simic,<sup>12a</sup> S. Simion,<sup>114</sup> B. Simmons,<sup>76</sup> R. Simoniello,<sup>88a,88b</sup> M. Simonyan,<sup>35</sup> P. Sinervo,<sup>157</sup>  
 N. B. Sinev,<sup>113</sup> V. Sipica,<sup>140</sup> G. Siragusa,<sup>172</sup> A. Sircar,<sup>24</sup> A. N. Sisakyan,<sup>63</sup> S. Yu. Sivoklokov,<sup>96</sup> J. Sjölin,<sup>145a,145b</sup>  
 T. B. Sjursen,<sup>13</sup> L. A. Skinnari,<sup>14</sup> H. P. Skottowe,<sup>56</sup> K. Skovpen,<sup>106</sup> P. Skubic,<sup>110</sup> N. Skvorodnev,<sup>22</sup> M. Slater,<sup>17</sup>  
 T. Slavicek,<sup>126</sup> K. Sliwa,<sup>160</sup> J. Sloper,<sup>29</sup> V. Smakhtin,<sup>170</sup> B. H. Smart,<sup>45</sup> S. Yu. Smirnov,<sup>95</sup> Y. Smirnov,<sup>95</sup>  
 L. N. Smirnova,<sup>96</sup> O. Smirnova,<sup>78</sup> B. C. Smith,<sup>56</sup> D. Smith,<sup>142</sup> K. M. Smith,<sup>52</sup> M. Smizanska,<sup>70</sup> K. Smolek,<sup>126</sup>  
 A. A. Snesarev,<sup>93</sup> S. W. Snow,<sup>81</sup> J. Snow,<sup>110</sup> S. Snyder,<sup>24</sup> R. Sobie,<sup>168,k</sup> J. Sodomka,<sup>126</sup> A. Soffer,<sup>152</sup> C. A. Solans,<sup>166</sup>  
 M. Solar,<sup>126</sup> J. Solc,<sup>126</sup> E. Soldatov,<sup>95</sup> U. Soldevila,<sup>166</sup> E. Solfaroli Camillocci,<sup>131a,131b</sup> A. A. Solodkov,<sup>127</sup>  
 O. V. Solovyanov,<sup>127</sup> N. Soni,<sup>2</sup> V. Sopko,<sup>126</sup> B. Sopko,<sup>126</sup> M. Sosebee,<sup>7</sup> R. Soualah,<sup>163a,163c</sup> A. Soukharev,<sup>106</sup>  
 S. Spagnolo,<sup>71a,71b</sup> F. Spanò,<sup>75</sup> R. Spighi,<sup>19a</sup> G. Spigo,<sup>29</sup> F. Spila,<sup>131a,131b</sup> R. Spiwoks,<sup>29</sup> M. Spousta,<sup>125</sup>  
 T. Spreitzer,<sup>157</sup> B. Spurlock,<sup>7</sup> R. D. St. Denis,<sup>52</sup> J. Stahlman,<sup>119</sup> R. Stamen,<sup>57a</sup> E. Stanecka,<sup>38</sup> R. W. Stanek,<sup>5</sup>  
 C. Stanescu,<sup>133a</sup> M. Stanescu-Bellu,<sup>41</sup> S. Stapnes,<sup>116</sup> E. A. Starchenko,<sup>127</sup> J. Stark,<sup>54</sup> P. Staroba,<sup>124</sup> P. Starovoitov,<sup>41</sup>  
 A. Staude,<sup>97</sup> P. Stavina,<sup>143a</sup> G. Steele,<sup>52</sup> P. Steinbach,<sup>43</sup> P. Steinberg,<sup>24</sup> I. Stekl,<sup>126</sup> B. Stelzer,<sup>141</sup> H. J. Stelzer,<sup>87</sup>  
 O. Stelzer-Chilton,<sup>158a</sup> H. Stenzel,<sup>51</sup> S. Stern,<sup>98</sup> K. Stevenson,<sup>74</sup> G. A. Stewart,<sup>29</sup> J. A. Stillings,<sup>20</sup> M. C. Stockton,<sup>84</sup>  
 K. Stoerig,<sup>47</sup> G. Stoicea,<sup>25a</sup> S. Stonjek,<sup>98</sup> P. Strachota,<sup>125</sup> A. R. Stradling,<sup>7</sup> A. Straessner,<sup>43</sup> J. Strandberg,<sup>146</sup>  
 S. Strandberg,<sup>145a,145b</sup> A. Strandlie,<sup>116</sup> M. Strang,<sup>108</sup> E. Strauss,<sup>142</sup> M. Strauss,<sup>110</sup> P. Strizenec,<sup>143b</sup> R. Ströhmer,<sup>172</sup>  
 D. M. Strom,<sup>113</sup> J. A. Strong,<sup>75,a</sup> R. Stroynowski,<sup>39</sup> J. Strube,<sup>128</sup> B. Stugu,<sup>13</sup> I. Stumer,<sup>24,a</sup> J. Stupak,<sup>147</sup> P. Sturm,<sup>173</sup>  
 N. A. Styles,<sup>41</sup> D. A. Soh,<sup>150,v</sup> D. Su,<sup>142</sup> H. S. Subramania,<sup>2</sup> A. Succurro,<sup>11</sup> Y. Sugaya,<sup>115</sup> T. Sugimoto,<sup>100</sup> C. Suhr,<sup>105</sup>  
 K. Suita,<sup>65</sup> M. Suk,<sup>125</sup> V. V. Sulin,<sup>93</sup> S. Sultansoy,<sup>3d</sup> T. Sumida,<sup>66</sup> X. Sun,<sup>54</sup> J. E. Sundermann,<sup>47</sup> K. Suruliz,<sup>138</sup>  
 S. Sushkov,<sup>11</sup> G. Susinno,<sup>36a,36b</sup> M. R. Sutton,<sup>148</sup> Y. Suzuki,<sup>64</sup> Y. Suzuki,<sup>65</sup> M. Svatos,<sup>124</sup> Yu. M. Sviridov,<sup>127</sup>  
 S. Swedish,<sup>167</sup> I. Sykora,<sup>143a</sup> T. Sykora,<sup>125</sup> B. Szeless,<sup>29</sup> J. Sánchez,<sup>166</sup> D. Ta,<sup>104</sup> K. Tackmann,<sup>41</sup> A. Taffard,<sup>162</sup>  
 R. Tafirout,<sup>158a</sup> N. Taiblum,<sup>152</sup> Y. Takahashi,<sup>100</sup> H. Takai,<sup>24</sup> R. Takashima,<sup>67</sup> H. Takeda,<sup>65</sup> T. Takeshita,<sup>139</sup>  
 Y. Takubo,<sup>64</sup> M. Talby,<sup>82</sup> A. Talyshev,<sup>106,g</sup> M. C. Tamsett,<sup>24</sup> J. Tanaka,<sup>154</sup> R. Tanaka,<sup>114</sup> S. Tanaka,<sup>130</sup> S. Tanaka,<sup>64</sup>  
 Y. Tanaka,<sup>99</sup> A. J. Tanasijczuk,<sup>141</sup> K. Tani,<sup>65</sup> N. Tannoury,<sup>82</sup> G. P. Tappern,<sup>29</sup> S. Tapprogge,<sup>80</sup> D. Tardif,<sup>157</sup>  
 S. Tarem,<sup>151</sup> F. Tarrade,<sup>28</sup> G. F. Tartarelli,<sup>88a</sup> P. Tas,<sup>125</sup> M. Tasevsky,<sup>124</sup> E. Tassi,<sup>36a,36b</sup> M. Tatarkhanov,<sup>14</sup>  
 Y. Tayalati,<sup>134d</sup> C. Taylor,<sup>76</sup> F. E. Taylor,<sup>91</sup> G. N. Taylor,<sup>85</sup> W. Taylor,<sup>158b</sup> M. Teinturier,<sup>114</sup>  
 M. Teixeira Dias Castanheira,<sup>74</sup> P. Teixeira-Dias,<sup>75</sup> K. K. Temming,<sup>47</sup> H. Ten Kate,<sup>29</sup> P. K. Teng,<sup>150</sup> S. Terada,<sup>64</sup>  
 K. Terashi,<sup>154</sup> J. Terron,<sup>79</sup> M. Testa,<sup>46</sup> R. J. Teuscher,<sup>157,k</sup> J. Thadome,<sup>173</sup> J. Therhaag,<sup>20</sup> T. Theveneaux-Pelzer,<sup>77</sup>  
 M. Thioye,<sup>174</sup> S. Thoma,<sup>47</sup> J. P. Thomas,<sup>17</sup> E. N. Thompson,<sup>34</sup> P. D. Thompson,<sup>17</sup> P. D. Thompson,<sup>157</sup>  
 A. S. Thompson,<sup>52</sup> L. A. Thomsen,<sup>35</sup> E. Thomson,<sup>119</sup> M. Thomson,<sup>27</sup> R. P. Thun,<sup>86</sup> F. Tian,<sup>34</sup> M. J. Tibbetts,<sup>14</sup>  
 T. Tic,<sup>124</sup> V. O. Tikhomirov,<sup>93</sup> Y. A. Tikhonov,<sup>106,g</sup> S. Timoshenko,<sup>95</sup> P. Tipton,<sup>174</sup> F. J. Tique Aires Viegas,<sup>29</sup>  
 S. Tisserant,<sup>82</sup> B. Toczek,<sup>37</sup> T. Todorov,<sup>4</sup> S. Todorova-Nova,<sup>160</sup> B. Toggerson,<sup>162</sup> J. Tojo,<sup>68</sup> S. Tokár,<sup>143a</sup>  
 K. Tokunaga,<sup>65</sup> K. Tokushuku,<sup>64</sup> K. Tollefson,<sup>87</sup> M. Tomoto,<sup>100</sup> L. Tompkins,<sup>30</sup> K. Toms,<sup>102</sup> G. Tong,<sup>32a</sup>  
 A. Tonoyan,<sup>13</sup> C. Topfel,<sup>16</sup> N. D. Topilin,<sup>63</sup> I. Torchiani,<sup>29</sup> E. Torrence,<sup>113</sup> H. Torres,<sup>77</sup> E. Torró Pastor,<sup>166</sup> J. Toth,<sup>82,bb</sup>  
 F. Touchard,<sup>82</sup> D. R. Tovey,<sup>138</sup> T. Trefzger,<sup>172</sup> L. Tremblet,<sup>29</sup> A. Tricoli,<sup>29</sup> I. M. Trigger,<sup>158a</sup> S. Trincaz-Duvold,<sup>77</sup>  
 M. F. Tripania,<sup>69</sup> W. Trischuk,<sup>157</sup> A. Trivedi,<sup>24,aa</sup> B. Trocmé,<sup>54</sup> C. Troncon,<sup>88a</sup> M. Trottier-McDonald,<sup>141</sup>  
 M. Trzebinski,<sup>38</sup> A. Trzupek,<sup>38</sup> C. Tsarouchas,<sup>29</sup> J. C.-L. Tseng,<sup>117</sup> M. Tsiakiris,<sup>104</sup> P. V. Tsiarehsha,<sup>89</sup> D. Tsonou,<sup>4,ff</sup>  
 G. Tsipolitis,<sup>9</sup> V. Tsiskaridze,<sup>47</sup> E. G. Tskhadadze,<sup>50a</sup> I. I. Tsukerman,<sup>94</sup> V. Tsulaia,<sup>14</sup> J.-W. Tsung,<sup>20</sup> S. Tsuno,<sup>64</sup>

D. Tsybychev,<sup>147</sup> A. Tua,<sup>138</sup> A. Tudorache,<sup>25a</sup> V. Tudorache,<sup>25a</sup> J. M. Tuggle,<sup>30</sup> M. Turala,<sup>38</sup> D. Turecek,<sup>126</sup>  
 I. Turk Cakir,<sup>3e</sup> E. Turlay,<sup>104</sup> R. Turra,<sup>88a,88b</sup> P. M. Tuts,<sup>34</sup> A. Tykhonov,<sup>73</sup> M. Tylmad,<sup>145a,145b</sup> M. Tyndel,<sup>128</sup>  
 G. Tzanakos,<sup>8</sup> K. Uchida,<sup>20</sup> I. Ueda,<sup>154</sup> R. Ueno,<sup>28</sup> M. Ugland,<sup>13</sup> M. Uhlenbrock,<sup>20</sup> M. Uhrmacher,<sup>53</sup> F. Ukegawa,<sup>159</sup>  
 G. Unal,<sup>29</sup> D. G. Underwood,<sup>5</sup> A. Undrus,<sup>24</sup> G. Unel,<sup>162</sup> Y. Unno,<sup>64</sup> D. Urbaniec,<sup>34</sup> G. Usai,<sup>7</sup> M. Uslenghi,<sup>118a,118b</sup>  
 L. Vacavant,<sup>82</sup> V. Vacek,<sup>126</sup> B. Vachon,<sup>84</sup> S. Vahsen,<sup>14</sup> J. Valenta,<sup>124</sup> P. Valente,<sup>131a</sup> S. Valentineti,<sup>19a,19b</sup> S. Valkar,<sup>125</sup>  
 E. Valladolid Gallego,<sup>166</sup> S. Vallecorsa,<sup>151</sup> J. A. Valls Ferrer,<sup>166</sup> H. van der Graaf,<sup>104</sup> E. van der Kraaij,<sup>104</sup>  
 R. Van Der Leeuw,<sup>104</sup> E. van der Poel,<sup>104</sup> D. van der Ster,<sup>29</sup> N. van Eldik,<sup>83</sup> P. van Gemmeren,<sup>5</sup> Z. van Kesteren,<sup>104</sup>  
 I. van Vulpen,<sup>104</sup> M. Vanadia,<sup>98</sup> W. Vandelli,<sup>29</sup> G. Vandoni,<sup>29</sup> A. Vaniachine,<sup>5</sup> P. Vankov,<sup>41</sup> F. Vannucci,<sup>77</sup>  
 F. Varela Rodriguez,<sup>29</sup> R. Vari,<sup>131a</sup> T. Varol,<sup>83</sup> D. Varouchas,<sup>14</sup> A. Vartapetian,<sup>7</sup> K. E. Varvell,<sup>149</sup>  
 V. I. Vassilikopoulos,<sup>55</sup> F. Vazeille,<sup>33</sup> T. Vazquez Schroeder,<sup>53</sup> G. Vegni,<sup>88a,88b</sup> J. J. Veillet,<sup>114</sup> C. Vellidis,<sup>8</sup>  
 F. Veloso,<sup>123a</sup> R. Veness,<sup>29</sup> S. Veneziano,<sup>131a</sup> A. Ventura,<sup>71a,71b</sup> D. Ventura,<sup>137</sup> M. Venturi,<sup>47</sup> N. Venturi,<sup>157</sup>  
 V. Vercesi,<sup>118a</sup> M. Verducci,<sup>137</sup> W. Verkerke,<sup>104</sup> J. C. Vermeulen,<sup>104</sup> A. Vest,<sup>43</sup> M. C. Vetterli,<sup>141,e</sup> I. Vichou,<sup>164</sup>  
 T. Vickey,<sup>144b,gg</sup> O. E. Vickey Boeriu,<sup>144b</sup> G. H. A. Viehhauser,<sup>117</sup> S. Viel,<sup>167</sup> M. Villa,<sup>19a,19b</sup> M. Villaplana Perez,<sup>166</sup>  
 E. Vilucchi,<sup>46</sup> M. G. Vincker,<sup>28</sup> E. Vinek,<sup>29</sup> V. B. Vinogradov,<sup>63</sup> M. Virchaux,<sup>135,a</sup> J. Virzi,<sup>14</sup> O. Vitells,<sup>170</sup> M. Viti,<sup>41</sup>  
 I. Vivarelli,<sup>47</sup> F. Vives Vaque,<sup>2</sup> S. Vlachos,<sup>9</sup> D. Vladoiu,<sup>97</sup> M. Vlasak,<sup>126</sup> N. Vlasov,<sup>20</sup> A. Vogel,<sup>20</sup> P. Vokac,<sup>126</sup>  
 G. Volpi,<sup>46</sup> M. Volpi,<sup>85</sup> G. Volpini,<sup>88a</sup> H. von der Schmitt,<sup>98</sup> J. von Loeben,<sup>98</sup> H. von Radziewski,<sup>47</sup> E. von Toerne,<sup>20</sup>  
 V. Vorobel,<sup>125</sup> A. P. Vorobiev,<sup>127</sup> V. Vorwerk,<sup>11</sup> M. Vos,<sup>166</sup> R. Voss,<sup>29</sup> T. T. Voss,<sup>173</sup> J. H. Vosseveld,<sup>72</sup> N. Vranjes,<sup>135</sup>  
 M. Vranjes Milosavljevic,<sup>104</sup> V. Vrba,<sup>124</sup> M. Vreeswijk,<sup>104</sup> T. Vu Anh,<sup>47</sup> R. Vuillemet,<sup>29</sup> I. Vukotic,<sup>114</sup>  
 W. Wagner,<sup>173</sup> P. Wagner,<sup>119</sup> H. Wahlen,<sup>173</sup> J. Wakabayashi,<sup>100</sup> S. Walch,<sup>86</sup> J. Walder,<sup>70</sup> R. Walker,<sup>97</sup>  
 W. Walkowiak,<sup>140</sup> R. Wall,<sup>174</sup> P. Waller,<sup>72</sup> C. Wang,<sup>44</sup> H. Wang,<sup>171</sup> H. Wang,<sup>32b,hh</sup> J. Wang,<sup>150</sup> J. Wang,<sup>54</sup>  
 J. C. Wang,<sup>137</sup> R. Wang,<sup>102</sup> S. M. Wang,<sup>150</sup> T. Wang,<sup>20</sup> A. Warburton,<sup>84</sup> C. P. Ward,<sup>27</sup> M. Warsinsky,<sup>47</sup>  
 A. Washbrook,<sup>45</sup> C. Wasicki,<sup>41</sup> P. M. Watkins,<sup>17</sup> A. T. Watson,<sup>17</sup> I. J. Watson,<sup>149</sup> M. F. Watson,<sup>17</sup> G. Watts,<sup>137</sup>  
 S. Watts,<sup>81</sup> A. T. Waugh,<sup>149</sup> B. M. Waugh,<sup>76</sup> M. Weber,<sup>128</sup> M. S. Weber,<sup>16</sup> P. Weber,<sup>53</sup> A. R. Weidberg,<sup>117</sup> P. Weigell,<sup>98</sup>  
 J. Weingarten,<sup>53</sup> C. Weiser,<sup>47</sup> H. Wellenstein,<sup>22</sup> P. S. Wells,<sup>29</sup> T. Wenaus,<sup>24</sup> D. Wendland,<sup>15</sup> S. Wendler,<sup>122</sup>  
 Z. Weng,<sup>150,v</sup> T. Wengler,<sup>29</sup> S. Wenig,<sup>29</sup> N. Wermes,<sup>20</sup> M. Werner,<sup>47</sup> P. Werner,<sup>29</sup> M. Werth,<sup>162</sup> M. Wessels,<sup>57a</sup>  
 J. Wetter,<sup>160</sup> C. Weydert,<sup>54</sup> K. Whalen,<sup>28</sup> S. J. Wheeler-Ellis,<sup>162</sup> S. P. Whitaker,<sup>21</sup> A. White,<sup>7</sup> M. J. White,<sup>85</sup>  
 S. White,<sup>121a,121b</sup> S. R. Whitehead,<sup>117</sup> D. Whiteson,<sup>162</sup> D. Whittington,<sup>59</sup> F. Wicek,<sup>114</sup> D. Wicke,<sup>173</sup> F. J. Wickens,<sup>128</sup>  
 W. Wiedenmann,<sup>171</sup> M. Wielers,<sup>128</sup> P. Wienemann,<sup>20</sup> C. Wiglesworth,<sup>74</sup> L. A. M. Wiik-Fuchs,<sup>47</sup> P. A. Wijeratne,<sup>76</sup>  
 A. Wildauer,<sup>166</sup> M. A. Wildt,<sup>41,r</sup> I. Wilhelm,<sup>125</sup> H. G. Wilkens,<sup>29</sup> J. Z. Will,<sup>97</sup> E. Williams,<sup>34</sup> H. H. Williams,<sup>119</sup>  
 W. Willis,<sup>34</sup> S. Willocq,<sup>83</sup> J. A. Wilson,<sup>17</sup> M. G. Wilson,<sup>142</sup> A. Wilson,<sup>86</sup> I. Wingerter-Seez,<sup>4</sup> S. Winkelmann,<sup>47</sup>  
 F. Winklmeier,<sup>29</sup> M. Wittgen,<sup>142</sup> M. W. Wolter,<sup>38</sup> H. Wolters,<sup>123a,i</sup> W. C. Wong,<sup>40</sup> G. Wooden,<sup>86</sup> B. K. Wosiek,<sup>38</sup>  
 J. Wotschack,<sup>29</sup> M. J. Woudstra,<sup>83</sup> K. W. Wozniak,<sup>38</sup> K. Wraight,<sup>52</sup> C. Wright,<sup>52</sup> M. Wright,<sup>52</sup> B. Wrona,<sup>72</sup>  
 S. L. Wu,<sup>171</sup> X. Wu,<sup>48</sup> Y. Wu,<sup>32b,ii</sup> E. Wulf,<sup>34</sup> R. Wunstorf,<sup>42</sup> B. M. Wynne,<sup>45</sup> S. Xella,<sup>35</sup> M. Xiao,<sup>135</sup> S. Xie,<sup>47</sup>  
 Y. Xie,<sup>32a</sup> C. Xu,<sup>32b,x</sup> D. Xu,<sup>138</sup> G. Xu,<sup>32a</sup> B. Yabsley,<sup>149</sup> S. Yacoob,<sup>144b</sup> M. Yamada,<sup>64</sup> H. Yamaguchi,<sup>154</sup>  
 A. Yamamoto,<sup>64</sup> K. Yamamoto,<sup>62</sup> S. Yamamoto,<sup>154</sup> T. Yamamura,<sup>154</sup> T. Yamanaka,<sup>154</sup> J. Yamaoka,<sup>44</sup> T. Yamazaki,<sup>154</sup>  
 Y. Yamazaki,<sup>65</sup> Z. Yan,<sup>21</sup> H. Yang,<sup>86</sup> U. K. Yang,<sup>81</sup> Y. Yang,<sup>59</sup> Y. Yang,<sup>32a</sup> Z. Yang,<sup>145a,145b</sup> S. Yanush,<sup>90</sup> Y. Yao,<sup>14</sup>  
 Y. Yasu,<sup>64</sup> G. V. Ybeles Smit,<sup>129</sup> J. Ye,<sup>39</sup> S. Ye,<sup>24</sup> M. Yilmaz,<sup>3c</sup> R. Yoosofmiya,<sup>122</sup> K. Yorita,<sup>169</sup> R. Yoshida,<sup>5</sup>  
 C. Young,<sup>142</sup> C. J. Young,<sup>117</sup> S. Youssef,<sup>21</sup> D. Yu,<sup>24</sup> J. Yu,<sup>7</sup> J. Yu,<sup>111</sup> L. Yuan,<sup>65</sup> A. Yurkewicz,<sup>105</sup> B. Zabinski,<sup>38</sup>  
 V. G. Zaets,<sup>127</sup> R. Zaidan,<sup>61</sup> A. M. Zaitsev,<sup>127</sup> Z. Zajacova,<sup>29</sup> L. Zanello,<sup>131a,131b</sup> A. Zaytsev,<sup>106</sup> C. Zeitnitz,<sup>173</sup>  
 M. Zeller,<sup>174</sup> M. Zeman,<sup>124</sup> A. Zemla,<sup>38</sup> C. Zender,<sup>20</sup> O. Zenin,<sup>127</sup> T. Ženiš,<sup>143a</sup> Z. Zinonos,<sup>121a,121b</sup> S. Zenz,<sup>14</sup>  
 D. Zerwas,<sup>114</sup> G. Zevi della Porta,<sup>56</sup> Z. Zhan,<sup>32d</sup> D. Zhang,<sup>32b,hh</sup> H. Zhang,<sup>87</sup> J. Zhang,<sup>5</sup> X. Zhang,<sup>32d</sup> Z. Zhang,<sup>114</sup>  
 L. Zhao,<sup>107</sup> T. Zhao,<sup>137</sup> Z. Zhao,<sup>32b</sup> A. Zhemchugov,<sup>63</sup> S. Zheng,<sup>32a</sup> J. Zhong,<sup>117</sup> B. Zhou,<sup>86</sup> N. Zhou,<sup>162</sup> Y. Zhou,<sup>150</sup>  
 C. G. Zhu,<sup>32d</sup> H. Zhu,<sup>41</sup> J. Zhu,<sup>86</sup> Y. Zhu,<sup>32b</sup> X. Zhuang,<sup>97</sup> V. Zhuravlov,<sup>98</sup> D. Zieminska,<sup>59</sup> R. Zimmermann,<sup>20</sup>  
 S. Zimmermann,<sup>20</sup> S. Zimmermann,<sup>47</sup> M. Ziolkowski,<sup>140</sup> R. Zitoun,<sup>4</sup> L. Živković,<sup>34</sup> V. V. Zmouchko,<sup>127,a</sup>  
 G. Zobernig,<sup>171</sup> A. Zoccoli,<sup>19a,19b</sup> M. zur Nedden,<sup>15</sup> V. Zutshi,<sup>105</sup> and L. Zwalinski<sup>29</sup>

(ATLAS Collaboration)

<sup>1</sup>University at Albany, Albany New York, USA<sup>2</sup>Department of Physics, University of Alberta, Edmonton Alberta, Canada<sup>3a</sup>Department of Physics, Ankara University, Ankara, Turkey<sup>3b</sup>Department of Physics, Dumlupinar University, Kutahya, Turkey

- <sup>3c</sup>Department of Physics, Gazi University, Ankara, Turkey
- <sup>3d</sup>Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey
- <sup>3e</sup>Turkish Atomic Energy Authority, Ankara, Turkey
- <sup>4</sup>LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France
- <sup>5</sup>High Energy Physics Division, Argonne National Laboratory, Argonne Illinois, USA
- <sup>6</sup>Department of Physics, University of Arizona, Tucson Arizona, USA
- <sup>7</sup>Department of Physics, The University of Texas at Arlington, Arlington Texas, USA
- <sup>8</sup>Physics Department, University of Athens, Athens, Greece
- <sup>9</sup>Physics Department, National Technical University of Athens, Zografou, Greece
- <sup>10</sup>Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan
- <sup>11</sup>Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain
- <sup>12a</sup>Institute of Physics, University of Belgrade, Belgrade, Serbia
- <sup>12b</sup>Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia
- <sup>13</sup>Department for Physics and Technology, University of Bergen, Bergen, Norway
- <sup>14</sup>Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley California, USA
- <sup>15</sup>Department of Physics, Humboldt University, Berlin, Germany
- <sup>16</sup>Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland
- <sup>17</sup>School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom
- <sup>18a</sup>Department of Physics, Bogazici University, Istanbul, Turkey
- <sup>18b</sup>Division of Physics, Dogus University, Istanbul, Turkey
- <sup>18c</sup>Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey
- <sup>18d</sup>Department of Physics, Istanbul Technical University, Istanbul, Turkey
- <sup>19a</sup>INFN Sezione di Bologna, Italy
- <sup>19b</sup>Dipartimento di Fisica, Università di Bologna, Bologna, Italy
- <sup>20</sup>Physikalisches Institut, University of Bonn, Bonn, Germany
- <sup>21</sup>Department of Physics, Boston University, Boston Massachusetts, USA
- <sup>22</sup>Department of Physics, Brandeis University, Waltham Massachusetts, USA
- <sup>23a</sup>Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil
- <sup>23b</sup>Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil
- <sup>23c</sup>Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil
- <sup>23d</sup>Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil
- <sup>24</sup>Physics Department, Brookhaven National Laboratory, Upton New York, USA
- <sup>25a</sup>National Institute of Physics and Nuclear Engineering, Bucharest, Romania
- <sup>25b</sup>University Politehnica Bucharest, Bucharest, Romania
- <sup>25c</sup>West University in Timisoara, Timisoara, Romania
- <sup>26</sup>Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
- <sup>27</sup>Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
- <sup>28</sup>Department of Physics, Carleton University, Ottawa Ontario, Canada
- <sup>29</sup>CERN, Geneva, Switzerland
- <sup>30</sup>Enrico Fermi Institute, University of Chicago, Chicago Illinois, USA
- <sup>31a</sup>Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile
- <sup>31b</sup>Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
- <sup>32a</sup>Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
- <sup>32b</sup>Department of Modern Physics, University of Science and Technology of China, Anhui, China
- <sup>32c</sup>Department of Physics, Nanjing University, Jiangsu, China
- <sup>32d</sup>School of Physics, Shandong University, Shandong, China
- <sup>33</sup>Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France
- <sup>34</sup>Nevis Laboratory, Columbia University, Irvington New York, USA
- <sup>35</sup>Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
- <sup>36a</sup>INFN Gruppo Collegato di Cosenza, Italy
- <sup>36b</sup>Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy
- <sup>37</sup>AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland
- <sup>38</sup>The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
- <sup>39</sup>Physics Department, Southern Methodist University, Dallas Texas, USA
- <sup>40</sup>Physics Department, University of Texas at Dallas, Richardson Texas, USA
- <sup>41</sup>DESY, Hamburg and Zeuthen, Germany
- <sup>42</sup>Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
- <sup>43</sup>Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany
- <sup>44</sup>Department of Physics, Duke University, Durham North Carolina, USA

- <sup>45</sup>SUPA—School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
- <sup>46</sup>INFN Laboratori Nazionali di Frascati, Frascati, Italy
- <sup>47</sup>Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg i.Br., Germany
- <sup>48</sup>Section de Physique, Université de Genève, Geneva, Switzerland
- <sup>49a</sup>INFN Sezione di Genova, Italy
- <sup>49b</sup>Dipartimento di Fisica, Università di Genova, Genova, Italy
- <sup>50a</sup>E.Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi, Georgia
- <sup>50b</sup>High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
- <sup>51</sup>II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
- <sup>52</sup>SUPA—School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
- <sup>53</sup>II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
- <sup>54</sup>Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France
- <sup>55</sup>Department of Physics, Hampton University, Hampton Virginia, USA
- <sup>56</sup>Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge Massachusetts, USA
- <sup>57a</sup>Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
- <sup>57b</sup>Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
- <sup>57c</sup>ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
- <sup>58</sup>Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
- <sup>59</sup>Department of Physics, Indiana University, Bloomington Indiana, USA
- <sup>60</sup>Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
- <sup>61</sup>University of Iowa, Iowa City Iowa, USA
- <sup>62</sup>Department of Physics and Astronomy, Iowa State University, Ames Iowa, USA
- <sup>63</sup>Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
- <sup>64</sup>KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
- <sup>65</sup>Graduate School of Science, Kobe University, Kobe, Japan
- <sup>66</sup>Faculty of Science, Kyoto University, Kyoto, Japan
- <sup>67</sup>Kyoto University of Education, Kyoto, Japan
- <sup>68</sup>Department of Physics, Kyushu University, Fukuoka, Japan
- <sup>69</sup>Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
- <sup>70</sup>Physics Department, Lancaster University, Lancaster, United Kingdom
- <sup>71a</sup>INFN Sezione di Lecce, Italy
- <sup>71b</sup>Dipartimento di Fisica, Università del Salento, Lecce, Italy
- <sup>72</sup>Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
- <sup>73</sup>Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
- <sup>74</sup>School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
- <sup>75</sup>Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- <sup>76</sup>Department of Physics and Astronomy, University College London, London, United Kingdom
- <sup>77</sup>Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- <sup>78</sup>Fysiska institutionen, Lunds universitet, Lund, Sweden
- <sup>79</sup>Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
- <sup>80</sup>Institut für Physik, Universität Mainz, Mainz, Germany
- <sup>81</sup>School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- <sup>82</sup>CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- <sup>83</sup>Department of Physics, University of Massachusetts, Amherst Massachusetts, USA
- <sup>84</sup>Department of Physics, McGill University, Montreal Quebec, Canada
- <sup>85</sup>School of Physics, University of Melbourne, Victoria, Australia
- <sup>86</sup>Department of Physics, The University of Michigan, Ann Arbor Michigan, USA
- <sup>87</sup>Department of Physics and Astronomy, Michigan State University, East Lansing Michigan, USA
- <sup>88a</sup>INFN Sezione di Milano, Italy
- <sup>88b</sup>Dipartimento di Fisica, Università di Milano, Milano, Italy
- <sup>89</sup>B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
- <sup>90</sup>National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus
- <sup>91</sup>Department of Physics, Massachusetts Institute of Technology, Cambridge Massachusetts, USA
- <sup>92</sup>Group of Particle Physics, University of Montreal, Montreal Quebec, Canada
- <sup>93</sup>P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
- <sup>94</sup>Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- <sup>95</sup>Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
- <sup>96</sup>Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
- <sup>97</sup>Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- <sup>98</sup>Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany



- <sup>99</sup>*Nagasaki Institute of Applied Science, Nagasaki, Japan*
- <sup>100</sup>*Graduate School of Science, Nagoya University, Nagoya, Japan*
- <sup>101a</sup>*INFN Sezione di Napoli, Italy*
- <sup>101b</sup>*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
- <sup>102</sup>*Department of Physics and Astronomy, University of New Mexico, Albuquerque New Mexico, USA*
- <sup>103</sup>*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
- <sup>104</sup>*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
- <sup>105</sup>*Department of Physics, Northern Illinois University, DeKalb Illinois, USA*
- <sup>106</sup>*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
- <sup>107</sup>*Department of Physics, New York University, New York New York, USA*
- <sup>108</sup>*The Ohio State University, Columbus Ohio, USA*
- <sup>109</sup>*Faculty of Science, Okayama University, Okayama, Japan*
- <sup>110</sup>*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman Oklahoma, USA*
- <sup>111</sup>*Department of Physics, Oklahoma State University, Stillwater Oklahoma, USA*
- <sup>112</sup>*Palacký University, RCPTM, Olomouc, Czech Republic*
- <sup>113</sup>*Center for High Energy Physics, University of Oregon, Eugene Oregon, USA*
- <sup>114</sup>*LAL, Univ. Paris-Sud and CNRS/IN2P3, Orsay, France*
- <sup>115</sup>*Graduate School of Science, Osaka University, Osaka, Japan*
- <sup>116</sup>*Department of Physics, University of Oslo, Oslo, Norway*
- <sup>117</sup>*Department of Physics, Oxford University, Oxford, United Kingdom*
- <sup>118a</sup>*INFN Sezione di Pavia, Italy*
- <sup>118b</sup>*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
- <sup>119</sup>*Department of Physics, University of Pennsylvania, Philadelphia Pennsylvania, USA*
- <sup>120</sup>*Petersburg Nuclear Physics Institute, Gatchina, Russia*
- <sup>121a</sup>*INFN Sezione di Pisa, Italy*
- <sup>121b</sup>*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
- <sup>122</sup>*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh Pennsylvania, USA*
- <sup>123a</sup>*Laboratorio de Instrumentacao e Fisica Experimental de Particulas—LIP, Lisboa, Portugal*
- <sup>123b</sup>*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
- <sup>124</sup>*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
- <sup>125</sup>*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
- <sup>126</sup>*Czech Technical University in Prague, Praha, Czech Republic*
- <sup>127</sup>*State Research Center Institute for High Energy Physics, Protvino, Russia*
- <sup>128</sup>*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
- <sup>129</sup>*Physics Department, University of Regina, Regina Saskatchewan, Canada*
- <sup>130</sup>*Ritsumeikan University, Kusatsu, Shiga, Japan*
- <sup>131a</sup>*INFN Sezione di Roma I, Italy*
- <sup>131b</sup>*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
- <sup>132a</sup>*INFN Sezione di Roma Tor Vergata, Italy*
- <sup>132b</sup>*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
- <sup>133a</sup>*INFN Sezione di Roma Tre, Italy*
- <sup>133b</sup>*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
- <sup>134a</sup>*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies—Université Hassan II, Casablanca, Morocco*
- <sup>134b</sup>*Centre National de l’Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
- <sup>134c</sup>*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
- <sup>134d</sup>*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
- <sup>134e</sup>*Faculté des Sciences, Université Mohammed V- Agdal, Rabat, Morocco*
- <sup>135</sup>*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l’Univers), CEA Saclay (Commissariat a l’Energie Atomique), Gif-sur-Yvette, France*
- <sup>136</sup>*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz California, USA*
- <sup>137</sup>*Department of Physics, University of Washington, Seattle Washington, USA*
- <sup>138</sup>*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
- <sup>139</sup>*Department of Physics, Shinshu University, Nagano, Japan*
- <sup>140</sup>*Fachbereich Physik, Universität Siegen, Siegen, Germany*
- <sup>141</sup>*Department of Physics, Simon Fraser University, Burnaby British Columbia, Canada*
- <sup>142</sup>*SLAC National Accelerator Laboratory, Stanford California, USA*
- <sup>143a</sup>*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
- <sup>143b</sup>*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
- <sup>144a</sup>*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
- <sup>144b</sup>*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*

- <sup>145a</sup>*Department of Physics, Stockholm University, Sweden*  
<sup>145b</sup>*The Oskar Klein Centre, Stockholm, Sweden*  
<sup>146</sup>*Physics Department, Royal Institute of Technology, Stockholm, Sweden*  
<sup>147</sup>*Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook New York, USA*  
<sup>148</sup>*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*  
<sup>149</sup>*School of Physics, University of Sydney, Sydney, Australia*  
<sup>150</sup>*Institute of Physics, Academia Sinica, Taipei, Taiwan*  
<sup>151</sup>*Department of Physics, Technion: Israel Inst. of Technology, Haifa, Israel*  
<sup>152</sup>*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*  
<sup>153</sup>*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*  
<sup>154</sup>*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*  
<sup>155</sup>*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*  
<sup>156</sup>*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*  
<sup>157</sup>*Department of Physics, University of Toronto, Toronto Ontario, Canada*  
<sup>158a</sup>*TRIUMF, Vancouver British Columbia, Canada*  
<sup>158b</sup>*Department of Physics and Astronomy, York University, Toronto Ontario, Canada*  
<sup>159</sup>*Institute of Pure and Applied Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571, Japan*  
<sup>160</sup>*Science and Technology Center, Tufts University, Medford Massachusetts, USA*  
<sup>161</sup>*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*  
<sup>162</sup>*Department of Physics and Astronomy, University of California Irvine, Irvine California, USA*  
<sup>163a</sup>*INFN Gruppo Collegato di Udine, Italy*  
<sup>163b</sup>*ICTP, Trieste, Italy*  
<sup>163c</sup>*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*  
<sup>164</sup>*Department of Physics, University of Illinois, Urbana Illinois, USA*  
<sup>165</sup>*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*  
<sup>166</sup>*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*  
<sup>167</sup>*Department of Physics, University of British Columbia, Vancouver British Columbia, Canada*  
<sup>168</sup>*Department of Physics and Astronomy, University of Victoria, Victoria British Columbia, Canada*  
<sup>169</sup>*Waseda University, Tokyo, Japan*  
<sup>170</sup>*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*  
<sup>171</sup>*Department of Physics, University of Wisconsin, Madison Wisconsin, USA*  
<sup>172</sup>*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*  
<sup>173</sup>*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*  
<sup>174</sup>*Department of Physics, Yale University, New Haven Connecticut, USA*  
<sup>175</sup>*Yerevan Physics Institute, Yerevan, Armenia*  
<sup>176</sup>*Domaine scientifique de la Doua, Centre de Calcul CNRS/IN2P3, Villeurbanne Cedex, France*

<sup>a</sup>Deceased.

<sup>b</sup>Also at Laboratorio de Instrumentacao e Fisica Experimental de Particulas—LIP, Lisboa, Portugal.

<sup>c</sup>Also at Faculdade de Ciencias and CFNUL, Universidade de Lisboa, Lisboa, Portugal.

<sup>d</sup>Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.

<sup>e</sup>Also at TRIUMF, Vancouver BC, Canada.

<sup>f</sup>Also at Department of Physics, California State University, Fresno CA, USA.

<sup>g</sup>Also at Novosibirsk State University, Novosibirsk, Russia.

<sup>h</sup>Also at Fermilab, Batavia IL., USA.

<sup>i</sup>Also at Department of Physics, University of Coimbra, Coimbra, Portugal.

<sup>j</sup>Also at Università di Napoli Parthenope, Napoli, Italy.

<sup>k</sup>Also at Institute of Particle Physics (IPP), Canada.

<sup>l</sup>Also at Department of Physics, Middle East Technical University, Ankara, Turkey.

<sup>m</sup>Also at Louisiana Tech University, Ruston LA, USA.

<sup>n</sup>Also at Department of Physics and Astronomy, University College London, London, United Kingdom.

<sup>o</sup>Also at Group of Particle Physics, University of Montreal, Montreal QC, Canada.

<sup>p</sup>Also at Department of Physics, University of Cape Town, Cape Town, South Africa.

<sup>q</sup>Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.

<sup>r</sup>Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.

<sup>s</sup>Also at Manhattan College, New York NY, USA.

<sup>t</sup>Also at School of Physics, Shandong University, Shandong, China.

<sup>u</sup>Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.

<sup>v</sup>Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.

<sup>w</sup>Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.

<sup>x</sup>Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France.

<sup>y</sup>Also at Section de Physique, Université de Genève, Geneva, Switzerland.

<sup>z</sup>Also at Departamento de Fisica, Universidade de Minho, Braga, Portugal.

<sup>aa</sup>Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, USA.

<sup>bb</sup>Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.

<sup>cc</sup>Also at California Institute of Technology, Pasadena CA, USA.

<sup>dd</sup>Also at Institute of Physics, Jagiellonian University, Krakow, Poland.

<sup>ee</sup>Also at LAL, Univ. Paris-Sud and CNRS/IN2P3, Orsay, France.

<sup>ff</sup>Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.

<sup>gg</sup>Also at Department of Physics, Oxford University, Oxford, United Kingdom.

<sup>hh</sup>Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.

<sup>ii</sup>Also at Department of Physics, The University of Michigan, Ann Arbor MI, USA.