



UvA-DARE (Digital Academic Repository)

Search for a Heavy Neutral Particle Decaying to $e, e,$ or in pp Collisions at $s = 8\text{TeV}$ with the ATLAS Detector

Aad, G.; et al., [Unknown]; Aben, R.; Angelozzi, I.; Beemster, L.J.; Bentvelsen, S.C.M.; Berge, D.; Bobbink, G.J.; Bos, K.; Brenner, L.; Butti, P.; Castelli, A.; Colijn, A.P.; de Jong, P.J.; de Nooij, L.; Deigaard, I.; Deluca, C.; Dhaliwal, S.; Ferrari, P.; Gadatsch, S.; Geerts, D.A.A.; Hartjes, F.G.; Hessey, N.P.; Hod, N.; Igonkina, O.; Karastathis, N.; Kluit, P.M.; Koffeman, E.N.; Linde, F.L.; Mahlstedt, J.; Meyer, J.; Oussoren, K.P.; Sabato, G.; Salek, D.; Slawinska, M.; Valencic, N.; van den Wollenberg, W.; van der Deijl, P.C.; van der Geer, R.; van der Graaf, H.; van der Leeuw, R.H.L.; van Vulpen, I.B.; Verkerke, W.; Vermeulen, J.C.; Vreeswijk, M.; Weits, H.; Williams, S.

Published in:
Physical Review Letters

DOI:
[10.1103/PhysRevLett.115.031801](https://doi.org/10.1103/PhysRevLett.115.031801)

[Link to publication](#)

Citation for published version (APA):

Aad, G., et al., . U., Aben, R., Angelozzi, I., Beemster, L. J., Bentvelsen, S., ... Williams, S. (2015). Search for a Heavy Neutral Particle Decaying to $e, e,$ or in pp Collisions at $s = 8\text{TeV}$ with the ATLAS Detector. *Physical Review Letters*, 115(3), [031801]. DOI: 10.1103/PhysRevLett.115.031801

General rights

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

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <http://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (<http://dare.uva.nl>)

Search for a Heavy Neutral Particle Decaying to $e\mu$, $e\tau$, or $\mu\tau$ in pp Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector

G. Aad *et al.**

(ATLAS Collaboration)

(Received 13 March 2015; published 14 July 2015)

This Letter presents a search for a heavy neutral particle decaying into an opposite-sign different-flavor dilepton pair, $e^\pm\mu^\mp$, $e^\pm\tau^\mp$, or $\mu^\pm\tau^\mp$ using 20.3 fb^{-1} of pp collision data at $\sqrt{s} = 8$ TeV collected by the ATLAS detector at the LHC. The numbers of observed candidate events are compatible with the standard model expectations. Limits are set on the cross section of new phenomena in two scenarios: the production of $\tilde{\nu}_\tau$ in R -parity-violating supersymmetric models and the production of a lepton-flavor-violating Z' vector boson.

DOI: 10.1103/PhysRevLett.115.031801

PACS numbers: 13.85.Rm, 12.60.Cn, 12.60.Jv, 14.80.Ly

Lepton-flavor-violation (LFV) in the charged sector, if observed at present sensitivities, would be a clear signature of new physics. Such signatures occur in several new physics scenarios, including R -parity-violating supersymmetry (RPV SUSY) [1,2] and models with an additional heavy neutral gauge boson Z' [3] allowing for LFV couplings.

In RPV SUSY, the Lagrangian terms allowing LFV can be expressed as $\frac{1}{2}\lambda_{ijk}L_iL_j\bar{e}_k + \lambda'_{ijk}L_iQ_j\bar{d}_k$ [1], where L and Q are the $SU(2)$ doublet superfields of leptons and quarks; e and d are the $SU(2)$ singlet superfields of leptons and downlike quarks; λ and λ' are Yukawa couplings; and the indices i , j , and k denote fermion generations. A τ sneutrino ($\tilde{\nu}_\tau$) may be produced in pp collisions by $d\bar{d}$ annihilation and subsequently decay to $e\mu$, $e\tau$, or $\mu\tau$. Although only $\tilde{\nu}_\tau$ is considered here in order to compare with previous searches performed at the Tevatron, the results of our analysis apply to any sneutrino flavor.

The sequential standard model (SSM), where the Z' boson is often assumed to have the same quark and lepton couplings as the standard model (SM) Z boson, can be extended to include LFV couplings for the Z' . The $Z' \rightarrow e\mu$, $e\tau$, or $\mu\tau$ couplings (Q_{12} , Q_{13} , or Q_{23}) [4] are typically expressed as fractions of the SSM $Z' \rightarrow \ell^+\ell^-$ ($\ell = e, \mu, \tau$) coupling.

Strong limits on RPV couplings have been obtained by precision low-energy searches, such as μ to e conversion on nuclei [5], rare μ decays [6], and rare τ decays [7]. These limits often depend on masses of supersymmetric particles that occur in loop diagrams and assume the dominance of certain couplings. The CDF [8,9], D0 [10,11], and ATLAS [12] collaborations have searched for a $\tilde{\nu}_\tau$ in LFV final states and placed limits for various $\tilde{\nu}_\tau$ mass hypotheses.

Both the CDF [13] and ATLAS [14] collaborations have placed limits on Q_{12} as a function of the Z' mass.

This Letter describes a search for a neutral heavy particle ($\tilde{\nu}_\tau$ or Z') decaying into $e^\pm\mu^\mp$ ($e\mu$), $e^\pm\tau^\mp$ ($e\tau$), or $\mu^\pm\tau^\mp$ ($\mu\tau$) using pp collision data collected at $\sqrt{s} = 8$ TeV, where τ_{had} is a τ lepton that decays into hadrons. The ATLAS detector is described in detail elsewhere [15]. Events are selected with a three-level trigger system that requires one or two leptons (e or μ) with high transverse momentum (p_T). The data set has a total integrated luminosity of $20.3 \pm 0.6 \text{ fb}^{-1}$, where the uncertainty is derived following the same methodology as that detailed in Ref. [16].

Electrons are required to have $p_T > 25$ GeV, $|\eta| < 1.37$ or $1.52 < |\eta| < 2.47$ [17], and satisfy the “tight” selection in Ref. [18], which was modified in 2012 to reduce the impact of additional inelastic pp interactions, termed pileup. Muon candidates must have $p_T > 25$ GeV, $|\eta| < 2.4$ and be reconstructed in both the inner tracker detector and the muon spectrometer. The muon momenta measured by the inner detector and muon spectrometer must match within five standard deviations of their combined uncertainty. Good quality reconstruction and p_T resolution at high momentum are ensured by requiring a minimum number of associated hits on the inner detector track [19] and in each of the three muon spectrometer stations.

Candidate events must contain at least one primary interaction vertex reconstructed with more than three associated tracks with $p_T > 400$ MeV. If there is more than one such vertex, the one with the highest sum of p_T^2 of associated tracks is chosen. The longitudinal impact parameter is required to be smaller than 2 mm for candidate electrons and smaller than 1 mm for candidate muons. It is further required that the transverse impact parameter is less than six times its resolution for candidate electrons, and that the transverse impact parameter is smaller than 0.2 mm for candidate muons. A calorimeter isolation criterion $E_T^{\Delta R < 0.2}/E_T < 0.06$ and a tracker isolation criterion

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

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

$p_T^{\Delta R < 0.4}/p_T < 0.06$ are applied for both the electrons and muons, where $E_T^{\Delta R < 0.2}$ is the transverse energy deposited in the calorimeter within a cone of size $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} = 0.2$ around the lepton, and $p_T^{\Delta R < 0.4}$ is the sum of the p_T of tracks with $p_T > 1$ GeV within a cone size of 0.4 around the lepton. E_T and p_T are the lepton transverse energy and momentum, respectively.

Hadronic decays of τ leptons are characterized by one or three charged tracks associated with a narrow energy cluster in the calorimeters [20]. This search uses τ_{had} candidates with only one charged track due to reduced identification and reconstruction efficiency for high- p_T τ decays with three charged tracks. The identification efficiency of one track τ is around 50% and the fake rate is typically 2%–5%. Boosted-decision-tree multivariate discriminators, based on tracking and calorimeter information, are used to reject jets and electrons misidentified as τ_{had} . The τ_{had} candidates must have $|\eta| < 2.47$ and $E_T > 25$ GeV. Candidates with $|\eta| < 0.03$ are removed to exclude a critical region where the incomplete coverage of the inner tracking detectors and calorimeters contribute to substantially increase the misidentification of electrons.

Jets are reconstructed from clusters of energy in the calorimeter using the anti- k_r algorithm [21] with radius parameter $R = 0.4$. Jet energies are calibrated using Monte Carlo (MC) simulation and a combination of several *in situ* calibrations [22]. The calculation of the missing transverse momentum vector \vec{p}_T^{miss} (with magnitude E_T^{miss}) is based on the vector sum of the calibrated p_T of reconstructed jets, electrons, and muons, as well as calorimeter energy clusters not associated with reconstructed objects [23].

Candidate signal events are required to have exactly two leptons, of opposite charge and of different flavor, satisfying the above lepton selection criteria. The two leptons are required to be back-to-back in the azimuthal plane with $|\Delta\phi_{\ell\ell'}| > 2.7$, where $\Delta\phi_{\ell\ell'}$ is the ϕ difference between the two leptons. Because of the presence of the undetected neutrino in the τ decay, the E_T of the τ_{had} candidate is required to be less than the E_T (p_T) of the electron (muon) for the $e\tau_{\text{had}}$ ($\mu\tau_{\text{had}}$) channel. Veto on tagged b -jets, to suppress the contribution of final-state top quarks, is not applied since studies have shown no significant impact on the sensitivity of the search.

A collinear neutrino approximation is used to reconstruct the dilepton invariant mass ($m_{\ell\ell'}$) in the $e\tau_{\text{had}}$ and $\mu\tau_{\text{had}}$ channels. In the hadronic decay of a τ lepton from a heavy resonance, the neutrino and the resultant jet are nearly collinear. The four-vector of the neutrino is reconstructed from the \vec{p}_T^{miss} and η of the τ_{had} jet. Four-vectors of the electron or muon, τ_{had} candidate and neutrino are then used to calculate $m_{\ell\ell'}$. For $e\tau_{\text{had}}$ and $\mu\tau_{\text{had}}$ signal events, the above technique significantly improves the mass resolution and search sensitivity.

Events with $m_{\ell\ell'} < 200$ GeV form a validation region to verify the background modeling, and events with $m_{\ell\ell'} > 200$ GeV are used as the search region.

The SM processes that produce $\ell^\pm\ell'^\mp$ final states can be divided into two categories: processes that produce two prompt leptons such as $Z/\gamma^* \rightarrow \tau\tau$, $t\bar{t}$, single-top Wt channel, diboson production, and processes where one or more photons or jets are misidentified as leptons, predominantly $W/Z + \gamma$, $W/Z + \text{jets}$, and multijet events. The decay of a τ to an electron or a muon is considered as prompt production. For the $e\tau_{\text{had}}$ ($\mu\tau_{\text{had}}$) channel, additional background can originate from the $Z/\gamma^* \rightarrow ee(\mu\mu)$ process if one lepton is misidentified as a τ_{had} candidate. The contributions of these processes are even larger with respect to the $Z/\gamma^* \rightarrow \tau\tau$ background, since the final states e or μ are usually harder than those from leptonic τ decay.

Contributions from processes in the prompt two-lepton category, as well as photon-related and $Z/\gamma^* \rightarrow ee(\mu\mu)$ backgrounds, are estimated using MC simulation [24]. The detector response model is based on the GEANT4 program [25]. Lepton reconstruction and identification efficiencies, energy scales, and resolutions in the MC simulation are corrected to the corresponding values measured in the data. Pileup is included to match distributions observed in the data. Top quark production is generated with MC@NLO v4.06 [26–28] for $t\bar{t}$ and single-top, the Drell–Yan process ($Z/\gamma^* \rightarrow \ell\ell'$) is generated with ALPGEN v2.14 [29], and diboson processes are generated with HERWIG v6.520.2 [30]. Samples of $W\gamma$ and $Z\gamma$ events are generated with SHERPA v1.04 [31–34]. These generated samples are normalized to the most accurate available cross-section calculations, and the uncertainties on the calculations have been included in the overall uncertainty for the SM predictions. For the dominant backgrounds, the Drell–Yan processes are corrected to next-to-next-to-leading order (NNLO) [35], and $t\bar{t}$ is corrected to NNLO, including soft-gluon resummation to next-to-next-to-leading-logarithm order [36,37].

Since it is difficult to model misidentification of jets as leptons, particularly at high p_T , the $W + \text{jets}$ and multijet backgrounds are determined from control regions in the data. The $W + \text{jets}$ background is determined in a control region selected with the same criteria as that used for the signal selection except requiring $E_T^{\text{miss}} > 30$ GeV (to enhance the W contribution) and requiring that the electron or muon p_T be less than 150 GeV (to eliminate potential signal). Simulation studies indicate there is negligible multijet background in this control region. For the $e\tau_{\text{had}}$ and $\mu\tau_{\text{had}}$ channels, the number of events in the control region is corrected for the other SM background sources using MC samples. For the $e\mu$ channel, the number of $W + \text{jets}$ events in the control region is too small to yield a statistically meaningful measurement. Instead, the control region is enlarged by removing the isolation criterion on one lepton, and the $W + \text{jets}$ contribution is estimated using the lepton $E_T^{\Delta R < 0.2}/E_T$ distribution to fit the data with the MC predictions for other SM processes (dominant at low values of the isolation variable) and $W + \text{jets}$ (dominant at large values). For the $W + \text{jets}$ background in all three

TABLE I. Estimated SM backgrounds and observed event yields for the validation ($m_{\ell\ell'} < 200$ GeV) and search ($m_{\ell\ell'} > 200$ GeV) regions. Both the statistical and systematic uncertainties are included. $Z/\gamma^* \rightarrow \mu\mu$ background is larger in the validation region since the probability for muons to be misidentified as taus mainly depends on anomalously large calorimeter deposits that have a larger impact on low p_T muons. Because of correlations, particularly anticorrelations of the $W + \text{jet}$ and multijet contributions, the total uncertainties are not exactly the sum in quadrature of the components.

Process	$m_{\ell\ell'} < 200$ GeV			$m_{\ell\ell'} > 200$ GeV		
	$N_{e\mu}$	$N_{e\tau_{\text{had}}}$	$N_{\mu\tau_{\text{had}}}$	$N_{e\mu}$	$N_{e\tau_{\text{had}}}$	$N_{\mu\tau_{\text{had}}}$
$Z/\gamma^* \rightarrow \tau\tau$	6000 ± 400	11000 ± 900	11200 ± 700	28 ± 12	72 ± 21	99 ± 33
$Z/\gamma^* \rightarrow ee$	—	6100 ± 1100	—	—	430 ± 70	—
$Z/\gamma^* \rightarrow \mu\mu$	—	—	19500 ± 1300	—	—	410 ± 80
$t\bar{t}$	4220 ± 290	690 ± 60	580 ± 50	1640 ± 120	700 ± 60	550 ± 40
Diboson	1440 ± 80	321 ± 29	258 ± 17	474 ± 30	197 ± 17	141 ± 11
Single top quark	470 ± 40	87 ± 11	60 ± 7	202 ± 17	90 ± 10	73 ± 8
$W + \text{jets}$	54 ± 18	17000 ± 4000	14000 ± 4000	8 ± 4	3600 ± 700	2800 ± 600
Multijet	227 ± 32	4800 ± 1000	700 ± 800	58 ± 12	340 ± 210	100 ± 190
Total	12400 ± 600	40400 ± 2900	46000 ± 4000	2400 ± 130	5400 ± 500	4200 ± 400
Data	12954	41304	48304	2474	5336	4184

channels, the extrapolation factor from the control region to the signal region and the shape of the $m_{\ell\ell'}$ distribution are taken from the $W + \text{jets}$ MC sample.

The contribution from multijet production is estimated from a control region with the same selection as the signal region except that the leptons are required to have the same electric charge, under the assumption that the probability of misidentifying a jet as a lepton is independent of the charge. The number of events in this same-sign control region is corrected for contributions from backgrounds with prompt leptons and from $W + \text{jets}$ backgrounds using the procedure described above. The assumption of charge independence of the jet misidentification rates is tested in a multijet-enriched region with two nonisolated leptons. After subtraction of other SM backgrounds, the ratio of opposite-sign to same-sign events is found to be $1.07 \pm 0.06(\text{stat}) \pm 0.02(\text{syst})$.

The background estimates are verified in validation regions defined with the same selection criteria as for the signal regions but with $1.0 < |\Delta\phi_{\ell\ell'}| < 2.7$. In these validation regions, simulation studies show the backgrounds have compositions similar to the signal regions, and the predictions agree with the data within 20% over the entire $m_{\ell\ell'}$ range. An uncertainty of 20% is hence placed on the total background estimate that is used in the final results.

MC signal events are generated with HERWIG v6.520.2 for $\tilde{\nu}_\tau$ and PYTHIA v8.165 [38,39] for Z' . Samples are produced with $\tilde{\nu}_\tau$ and Z' masses ranging from 0.5 to 3 TeV. Signal cross sections are calculated to next-to-leading order for $\tilde{\nu}_\tau$ [40], and NNLO for Z' [35]. The theoretical uncertainties are taken from an envelope of cross-section predictions using different parton distribution function (PDF) sets and factorization and renormalization scales [41,42].

The signal selection efficiency (including τ decay branching ratio if τ is involved) for $m_{\tilde{\nu}_\tau} = 2$ TeV are 42%, 14%, and 10% in the $e\mu$, $e\tau$, and $\mu\tau$ channels,

respectively. The corresponding numbers for a Z' boson with $m_{Z'} = 2$ TeV are 37%, 11%, and 9%. The systematic uncertainties on the signal efficiency vary from 3% to 6% depending on the resonance mass and decay mode. The primary contributions are due to the number of MC events, and the uncertainties related to the muon and τ p_T scales.

The observed and expected event yields in both the validation and search $m_{\ell\ell'}$ regions for all three final states are in good agreement, as summarized in Table I. The $m_{\ell\ell'}$ distributions (Fig. 1) show no significant excess above the SM expectation in any of the three modes. The dominant contributions to the uncertainty bands in Fig. 1 are due to the number of MC events, the MC cross-section uncertainties, the E_T^{miss} scale and resolution, and the uncertainty in the shape of the $m_{\ell\ell'}$ distribution for $W + \text{jets}$.

Upper limits are placed on the production cross section times branching ratio $[\sigma(pp \rightarrow \tilde{\nu}_\tau/Z') \times \text{BR}(\tilde{\nu}_\tau/Z' \rightarrow \ell\ell')]$. For each $\tilde{\nu}_\tau$ or Z' mass, m , the search region is defined to be $m \pm 3\sigma_{\ell\ell'}$, where $\sigma_{\ell\ell'}$ is the standard deviation of the simulated signal $m_{\ell\ell'}$ distribution. The relative width of the signal $m_{\ell\ell'}$ distribution ranges from 3% to 17% for different mass points, channels, and models. To increase the signal efficiency, if the upper side of the search region is greater than 1 TeV, all events above 1 TeV are used. To further reduce the effect of fluctuations in the high-mass region due to low MC event counts, the number of background events in each mass window is estimated using a double exponential fit to the total background $m_{\ell\ell'}$ distribution. The fit uncertainty is taken into account in the limit-setting procedure, including a contribution from varying the fit function range.

A frequentist technique [43] is used to set the expected and observed upper limits as a function of $m_{\tilde{\nu}_\tau}$ and $m_{Z'}$. The likelihood of observing the number of events in data as a function of the expected number of signal and background events is constructed from a Poisson distribution for each

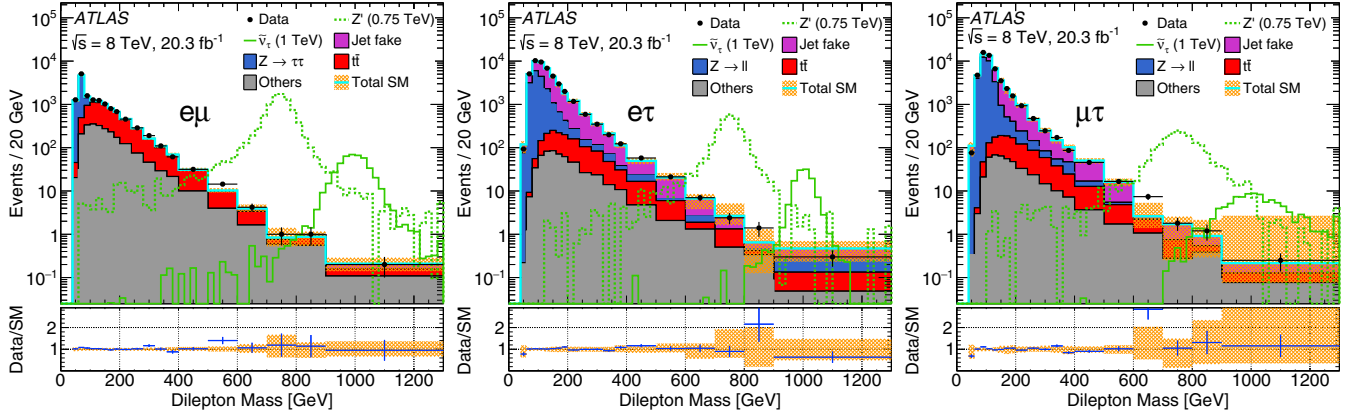


FIG. 1 (color online). Observed and predicted $e\mu$, $e\tau_{\text{had}}$, $\mu\tau_{\text{had}}$ invariant mass distributions. The contributions of the different processes are also shown: “Others” includes diboson and single-top while “Jet fake” refers to $W + \text{jets}$ and multijet. All overflows are included in the rightmost bin. Signal simulations are shown for $m_{\tilde{\nu}_\tau} = 1 \text{ TeV}$ and $m_{Z'} = 0.75 \text{ TeV}$. The couplings $\lambda'_{311} = 0.11$ and $\lambda_{i3k} = 0.07$ ($Q_{\ell\ell'} = 1$) are used for the RPV (Z') model. The uncertainty bands include both the statistical and systematic uncertainties.

$m_{\ell\ell'}$ bin. Systematic uncertainties are taken into account with Gaussian-distributed nuisance parameters. A 95% confidence level (C.L.) limit is then determined. The expected exclusion limits are determined, using simulated pseudoexperiments containing only background processes, as the median of the 95% C.L. limit distributions for each set of pseudoexperiments at each value of $m_{\tilde{\nu}_\tau}$ or $m_{Z'}$, including systematic uncertainties. The ensemble of limits is also used to assess the 1σ and 2σ uncertainty envelopes of the expected limits.

Figure 2 shows the observed and expected cross section times branching ratio limits as a function of $m_{\tilde{\nu}_\tau}$ ($m_{Z'}$), together with the $\pm 1\sigma$ and $\pm 2\sigma$ uncertainty bands. For a

$\tilde{\nu}_\tau$ mass of 1 TeV, the observed limits on the production cross section times branching ratio are 0.5 fb, 2.7 fb, and 9.1 fb for the $e\mu$, $e\tau$, and $\mu\tau$ channels, respectively. The corresponding limits for a Z' boson mass of 1 TeV are 1.0 fb, 4.0 fb, and 9.9 fb for the $e\mu$, $e\tau$, and $\mu\tau$ channels, respectively.

Theoretical predictions of cross section times branching ratio are also shown, assuming $\lambda'_{311} = 0.11$ and $\lambda_{i3k} = 0.07$ for the $\tilde{\nu}_\tau$ and $Q_{ij} = 1$ for the Z' , consistent with benchmark couplings used in previous searches.

For these benchmark couplings, the lower limits on the $\tilde{\nu}_\tau$ mass are 2.0 TeV, 1.7 TeV, and 1.7 TeV for the $e\mu$, $e\tau$, and $\mu\tau$ channels, respectively. The corresponding lower

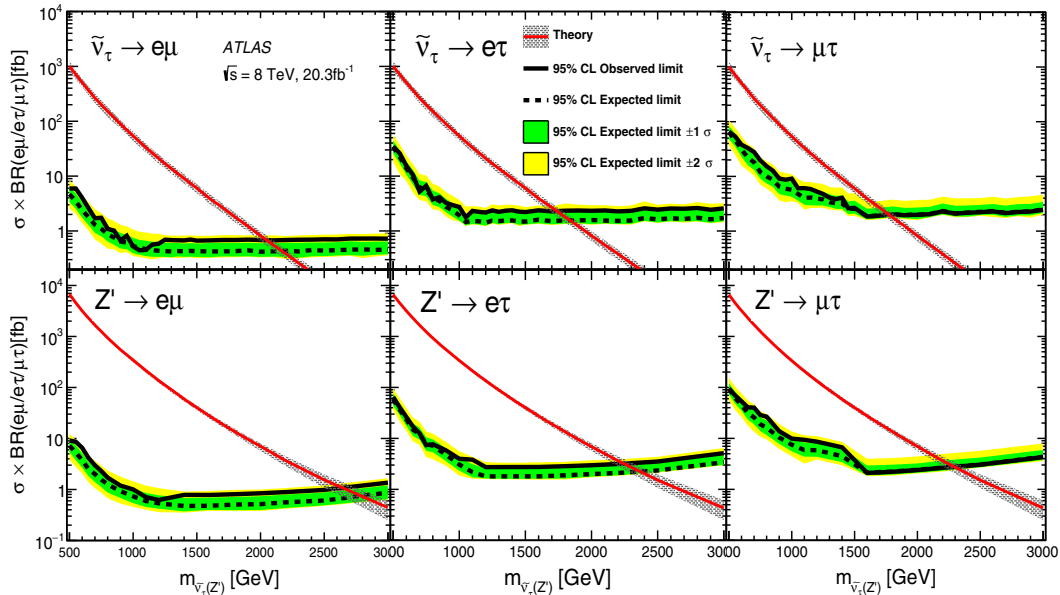


FIG. 2 (color online). The 95% C.L. limits on cross section times branching ratio as a function of $\tilde{\nu}_\tau$ mass (top plots) and Z' mass (bottom plots) for $e\mu$ (left), $e\tau$ (middle), and $\mu\tau$ (right). Theory curves are for the arbitrary choice of couplings $\lambda'_{311} = 0.11$ and $\lambda_{i3k} = 0.07$ for $\tilde{\nu}_\tau$ and $Q_{\ell\ell'} = 1$ for Z' . The gray band around the theory curve represents the theoretical uncertainty from the PDFs and factorization and renormalization scales.

limits on the Z' mass are 2.5 TeV, 2.2 TeV, and 2.2 TeV for the $e\mu$, $e\tau$, and $\mu\tau$ channels, respectively. The observed lower mass limits are a factor of three to four higher than the best limits from the Tevatron [8–11] and 1.5 to 2 times better than the previous limits from ATLAS [12] for the same couplings.

In summary, a search has been performed for a heavy particle decaying to $e\mu$, $e\tau_{\text{had}}$, or $\mu\tau_{\text{had}}$ final states using 20.3 fb^{-1} of pp collision data at $\sqrt{s} = 8 \text{ TeV}$ recorded by the ATLAS detector at the LHC. The data are found to be consistent with SM predictions. Limits are placed on the cross section times branching ratio for an RPV SUSY $\tilde{\nu}_\tau$ and a LFV Z' boson. These results considerably extend previous constraints from the Tevatron and LHC experiments.

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently. We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF, DNSRC and Lundbeck Foundation, Denmark; EPLANET, ERC and NSRF, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT and NSRF, Greece; RGC, Hong Kong SAR, China; ISF, MINERVA, GIF, I-CORE and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW and NCN, Poland; GRICES and FCT, Portugal; MNE/IFA, Romania; MES of Russia and NRC KI, Russian Federation; JINR; MSTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MINECO, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, United States of America. The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

[1] R. Barbier *et al.*, *Phys. Rep.* **420**, 1 (2005).

[2] H. K. Dreiner, M. Kramer, and B. O'Leary, *Phys. Rev. D* **75**, 114016 (2007).

- [3] P. Langacker, *Rev. Mod. Phys.* **81**, 1199 (2009).
- [4] B. Murakami, *Phys. Rev. D* **65**, 055003 (2002).
- [5] SINDRUM II Collaboration, W. H. Bertl *et al.*, *Eur. Phys. J. C* **47**, 337 (2006).
- [6] SINDRUM Collaboration, W. H. Bertl *et al.*, *Nucl. Phys.* **B260**, 1 (1985).
- [7] Belle Collaboration, Y. Miyazaki *et al.*, *Phys. Lett. B* **660**, 154 (2008).
- [8] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **105**, 191801 (2010).
- [9] A. Abulencia *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **96**, 211802 (2006).
- [10] V. M. Abazov *et al.* (D0 Collaboration), *Phys. Rev. Lett.* **105**, 191802 (2010).
- [11] V. M. Abazov *et al.* (D0 Collaboration), *Phys. Rev. Lett.* **100**, 241803 (2008).
- [12] ATLAS Collaboration, *Phys. Lett. B* **723**, 15 (2013).
- [13] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **105**, 191801 (2010).
- [14] ATLAS Collaboration, *Eur. Phys. J. C* **71**, 1809 (2011).
- [15] ATLAS Collaboration, *J. Instrum.* **3**, S08003 (2008).
- [16] ATLAS Collaboration, *Eur. Phys. J. C* **73**, 2518 (2013).
- [17] 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 along the beam direction. The x axis points toward the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam direction. Pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln \tan(\theta/2)$. Transverse projections are defined relative to the beam axis.
- [18] ATLAS Collaboration, *Eur. Phys. J. C* **74**, 2941 (2014).
- [19] ATLAS Collaboration, *Eur. Phys. J. C* **74**, 3130 (2014).
- [20] ATLAS Collaboration, Report No. ATLAS-CONF-2013-064, <https://cds.cern.ch/record/1562839>.
- [21] M. Cacciari, G. P. Salam, and G. Soyez, *J. High Energy Phys.* **04** (2008) 063.
- [22] ATLAS Collaboration, *Eur. Phys. J. C* **73**, 2304 (2013).
- [23] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1844 (2012).
- [24] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010).
- [25] S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
- [26] S. Frixione and B. R. Webber, *J. High Energy Phys.* **06** (2002) 029.
- [27] S. Frixione, E. Laenen, P. Motylinski, and B. R. Webber, *J. High Energy Phys.* **03** (2006) 092.
- [28] S. Frixione, E. Laenen, P. Motylinski, C. White, and B. R. Webber, *J. High Energy Phys.* **07** (2008) 029.
- [29] M. L. Mangano, M. Moretti, F. Piccinini, R. Pittau, and A. Polosa, *J. High Energy Phys.* **07** (2003) 001.
- [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] T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, S. Schumann, F. Siegert, and J. Winter, *J. High Energy Phys.* **02** (2009) 007.
- [32] T. Gleisberg and S. Höche, *J. High Energy Phys.* **12** (2008) 039.
- [33] S. Schumann and F. Krauss, *J. High Energy Phys.* **03** (2008) 038.

- [34] S. Hoeche, F. Krauss, S. Schumann, and F. Siegert, *J. High Energy Phys.* **05** (2009) 053.
 [35] Y. Li and F. Petriello, *Phys. Rev. D* **86**, 094034 (2012).
 [36] M. Czakon and A. Mitov, *Comput. Phys. Commun.* **185**, 2930 (2014).
 [37] M. Czakon, P. Fiedler, and A. Mitov, *Phys. Rev. Lett.* **110**, 252004 (2013).
 [38] T. Sjostrand, S. Mrenna, and P. Skands, *J. High Energy Phys.* **05** (2006) 026.
 [39] T. Sjostrand, S. Mrenna, and P. Skands, *Comput. Phys. Commun.* **178**, 852 (2008).
 [40] S. Wang *et al.*, *Chin. Phys. Lett.* **25**, 58 (2008).
 [41] M. Kramer *et al.*, arXiv:1206.2892.
 [42] ATLAS Collaboration, *Phys. Rev. D* **90**, 052005 (2014).
 [43] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, *Eur. Phys. J. C* **71**, 1554 (2011).

G. Aad,⁸⁵ B. Abbott,¹¹³ J. Abdallah,¹⁵² O. Abdinov,¹¹ R. Aben,¹⁰⁷ M. Abolins,⁹⁰ O. S. AbouZeid,¹⁵⁹ H. Abramowicz,¹⁵⁴ H. Abreu,¹⁵³ R. Abreu,³⁰ Y. Abulaiti,^{147a,147b} B. S. Acharya,^{165a,165b,b} L. Adamczyk,^{38a} D. L. Adams,²⁵ J. Adelman,¹⁰⁸ S. Adomeit,¹⁰⁰ T. Adye,¹³¹ A. A. Affolder,⁷⁴ T. Agatonovic-Jovin,¹³ J. A. Aguilar-Saavedra,^{126a,126f} M. Agustoni,¹⁷ S. P. Ahlen,²² F. Ahmadov,^{65,c} G. Aielli,^{134a,134b} H. Akerstedt,^{147a,147b} T. P. A. Åkesson,⁸¹ G. Akimoto,¹⁵⁶ A. V. Akimov,⁹⁶ G. L. Alberghi,^{20a,20b} J. Albert,¹⁷⁰ S. Albrand,⁵⁵ M. J. Alconada Verzini,⁷¹ M. Aleksa,³⁰ I. N. Aleksandrov,⁶⁵ C. Alexa,^{26a} G. Alexander,¹⁵⁴ T. Alexopoulos,¹⁰ M. Alhroob,¹¹³ G. Alimonti,^{91a} L. Alio,⁸⁵ J. Alison,³¹ S. P. Alkire,³⁵ B. M. M. Allbrooke,¹⁸ P. P. Allport,⁷⁴ A. Aloisio,^{104a,104b} A. Alonso,³⁶ F. Alonso,⁷¹ C. Alpigiani,⁷⁶ A. Altheimer,³⁵ B. Alvarez Gonzalez,⁹⁰ M. G. Alviggi,^{104a,104b} K. Amako,⁶⁶ Y. Amaral Coutinho,^{24a} C. Amelung,²³ D. Amidei,⁸⁹ S. P. Amor Dos Santos,^{126a,126c} A. Amorim,^{126a,126b} S. Amoroso,⁴⁸ N. Amram,¹⁵⁴ G. Amundsen,²³ C. Anastopoulos,¹⁴⁰ L. S. Ancu,⁴⁹ N. Andari,³⁰ T. Andeen,³⁵ C. F. Anders,^{58b} G. Anders,³⁰ K. J. Anderson,³¹ A. Andreazza,^{91a,91b} V. Andrei,^{58a} S. Angelidakis,⁹ I. Angelozzi,¹⁰⁷ P. Anger,⁴⁴ A. Angerami,³⁵ F. Anghinolfi,³⁰ A. V. Anisenkov,^{109,d} N. Anjos,¹² A. Annovi,^{124a,124b} M. Antonelli,⁴⁷ A. Antonov,⁹⁸ J. Antos,^{145b} F. Anulli,^{133a} M. Aoki,⁶⁶ L. Aperio Bella,¹⁸ G. Arabidze,⁹⁰ Y. Arai,⁶⁶ J. P. Araque,^{126a} A. T. H. Arce,⁴⁵ F. A. Arduh,⁷¹ J-F. Arguin,⁹⁵ S. Argyropoulos,⁴² M. Arik,^{19a} A. J. Armbruster,³⁰ O. Arnaez,³⁰ V. Arnal,⁸² H. Arnold,⁴⁸ M. Arratia,²⁸ O. Arslan,²¹ A. Artamonov,⁹⁷ G. Artoni,²³ S. Asai,¹⁵⁶ N. Asbah,⁴² A. Ashkenazi,¹⁵⁴ B. Åsman,^{147a,147b} L. Asquith,¹⁵⁰ K. Assamagan,²⁵ R. Astalos,^{145a} M. Atkinson,¹⁶⁶ N. B. Atlay,¹⁴² B. Auerbach,⁶ K. Augsten,¹²⁸ M. Aurousseau,^{146b} G. Avolio,³⁰ B. Axen,¹⁵ M. K. Ayoub,¹¹⁷ G. Azuelos,^{95,e} M. A. Baak,³⁰ A. E. Baas,^{58a} C. Bacci,^{135a,135b} H. Bachacou,¹³⁷ K. Bachas,¹⁵⁵ M. Backes,³⁰ M. Backhaus,³⁰ E. Badescu,^{26a} P. Bagiacchi,^{133a,133b} P. Bagnaia,^{133a,133b} Y. Bai,^{33a} T. Bain,³⁵ J. T. Baines,¹³¹ O. K. Baker,¹⁷⁷ P. Balek,¹²⁹ T. Balestri,¹⁴⁹ F. Balli,⁸⁴ E. Banas,³⁹ Sw. Banerjee,¹⁷⁴ A. A. E. Bannoura,¹⁷⁶ H. S. Bansil,¹⁸ L. Barak,³⁰ S. P. Baranov,⁹⁶ E. L. Barberio,⁸⁸ D. Barberis,^{50a,50b} M. Barbero,⁸⁵ T. Barillari,¹⁰¹ M. Barisonzi,^{165a,165b} T. Barklow,¹⁴⁴ N. Barlow,²⁸ S. L. Barnes,⁸⁴ B. M. Barnett,¹³¹ R. M. Barnett,¹⁵ Z. Barnovska,⁵ A. Baroncelli,^{135a} G. Barone,⁴⁹ A. J. Barr,¹²⁰ F. Barreiro,⁸² J. Barreiro Guimaraes da Costa,⁵⁷ R. Bartoldus,¹⁴⁴ A. E. Barton,⁷² P. Bartos,^{145a} A. Bassalat,¹¹⁷ A. Basye,¹⁶⁶ R. L. Bates,⁵³ S. J. Batista,¹⁵⁹ J. R. Batley,²⁸ M. Battaglia,¹³⁸ M. Bause,^{133a,133b} F. Bauer,¹³⁷ H. S. Bawa,^{144,f} J. B. Beacham,¹¹¹ M. D. Beattie,⁷² T. Beau,⁸⁰ P. H. Beauchemin,¹⁶² R. Beccherle,^{124a,124b} P. Bechtel,²¹ H. P. Beck,^{17,g} K. Becker,¹²⁰ M. Becker,⁸³ S. Becker,¹⁰⁰ M. Beckingham,¹⁷¹ C. Becot,¹¹⁷ A. J. Beddall,^{19c} A. Beddall,^{19c} V. A. Bednyakov,⁶⁵ C. P. Bee,¹⁴⁹ L. J. Beemster,¹⁰⁷ T. A. Beermann,¹⁷⁶ M. Begel,²⁵ J. K. Behr,¹²⁰ C. Belanger-Champagne,⁸⁷ W. H. Bell,⁴⁹ G. Bella,¹⁵⁴ L. Bellagamba,^{20a} A. Bellerive,²⁹ M. Bellomo,⁸⁶ K. Belotskiy,⁹⁸ O. Beltramello,³⁰ O. Benary,¹⁵⁴ D. Benchekroun,^{136a} M. Bender,¹⁰⁰ K. Bendtz,^{147a,147b} N. Benekos,¹⁰ Y. Benhammou,¹⁵⁴ E. Benhar Nocchioli,⁴⁹ J. A. Benitez Garcia,^{160b} D. P. Benjamin,⁴⁵ J. R. Bensinger,²³ S. Bentvelsen,¹⁰⁷ L. Beresford,¹²⁰ M. Beretta,⁴⁷ D. Berge,¹⁰⁷ E. Bergeaas Kuutmann,¹⁶⁷ N. Berger,⁵ F. Berghaus,¹⁷⁰ J. Beringer,¹⁵ C. Bernard,²² N. R. Bernard,⁸⁶ C. Bernius,¹¹⁰ F. U. Bernlochner,²¹ T. Berry,⁷⁷ P. Berta,¹²⁹ C. Bertella,⁸³ G. Bertoli,^{147a,147b} F. Bertolucci,^{124a,124b} C. Bertsche,¹¹³ D. Bertsche,¹¹³ M. I. Besana,^{91a} G. J. Besjes,¹⁰⁶ O. Bessidskaia Bylund,^{147a,147b} M. Bessner,⁴² N. Besson,¹³⁷ C. Betancourt,⁴⁸ S. Bethke,¹⁰¹ A. J. Bevan,⁷⁶ W. Bhimji,⁴⁶ R. M. Bianchi,¹²⁵ L. Bianchini,²³ M. Bianco,³⁰ O. Biebel,¹⁰⁰ S. P. Bieniek,⁷⁸ M. Biglietti,^{135a} J. Bilbao De Mendizabal,⁴⁹ H. Bilokon,⁴⁷ M. Bindi,⁵⁴ S. Binet,¹¹⁷ A. Bingul,^{19c} C. Bini,^{133a,133b} C. W. Black,¹⁵¹ J. E. Black,¹⁴⁴ K. M. Black,²² D. Blackburn,¹³⁹ R. E. Blair,⁶ J.-B. Blanchard,¹³⁷ J. E. Blanco,⁷⁷ T. Blazek,^{145a} I. Bloch,⁴² C. Blocker,²³ W. Blum,^{83,a} U. Blumenschein,⁵⁴ G. J. Bobbink,¹⁰⁷ V. S. Bobrovnikov,^{109,d} S. S. Bocchetta,⁸¹ A. Bocci,⁴⁵ C. Bock,¹⁰⁰ M. Boehler,⁴⁸ J. A. Bogaerts,³⁰ A. G. Bogdanchikov,¹⁰⁹ C. Bohm,^{147a} V. Boisvert,⁷⁷ T. Bold,^{38a} V. Boldea,^{26a} A. S. Boldyrev,⁹⁹ M. Bomben,⁸⁰ M. Bona,⁷⁶ M. Boonekamp,¹³⁷ A. Borisov,¹³⁰ G. Borissov,⁷² S. Borroni,⁴² J. Bortfeldt,¹⁰⁰

V. Bortolotto,^{60a,60b,60c} K. Bos,¹⁰⁷ D. Boscherini,^{20a} M. Bosman,¹² J. Boudreau,¹²⁵ J. Bouffard,² E. V. Bouhova-Thacker,⁷² D. Boumediene,³⁴ C. Bourdarios,¹¹⁷ N. Bousson,¹¹⁴ S. Boutouil,^{136d} A. Boveia,³⁰ J. Boyd,³⁰ I. R. Boyko,⁶⁵ I. Bozic,¹³ J. Bracinik,¹⁸ A. Brandt,⁸ G. Brandt,¹⁵ O. Brandt,^{58a} U. Bratzler,¹⁵⁷ B. Brau,⁸⁶ J. E. Brau,¹¹⁶ H. M. Braun,^{176a} S. F. Brazzale,^{165a,165c} K. Brendlinger,¹²² A. J. Brennan,⁸⁸ L. Brenner,¹⁰⁷ R. Brenner,¹⁶⁷ S. Bressler,¹⁷³ K. Bristow,^{146c} T. M. Bristow,⁴⁶ D. Britton,⁵³ D. Britzger,⁴² F. M. Brochu,²⁸ I. Brock,²¹ R. Brock,⁹⁰ J. Bronner,¹⁰¹ G. Brooijmans,³⁵ T. Brooks,⁷⁷ W. K. Brooks,^{32b} J. Brosamer,¹⁵ E. Brost,¹¹⁶ J. Brown,⁵⁵ P. A. Bruckman de Renstrom,³⁹ D. Bruncko,^{145b} R. Bruneliere,⁴⁸ A. Bruni,^{20a} G. Bruni,^{20a} M. Bruschi,^{20a} L. Bryngemark,⁸¹ T. Buanes,¹⁴ Q. Buat,¹⁴³ P. Buchholz,¹⁴² A. G. Buckley,⁵³ S. I. Buda,^{26a} I. A. Budagov,⁶⁵ F. Buehrer,⁴⁸ L. Bugge,¹¹⁹ M. K. Bugge,¹¹⁹ O. Bulekov,⁹⁸ H. Burckhart,³⁰ S. Burdin,⁷⁴ B. Burghgrave,¹⁰⁸ S. Burke,¹³¹ I. Burmeister,⁴³ E. Busato,³⁴ D. Büscher,⁴⁸ V. Büscher,⁸³ P. Bussey,⁵³ C. P. Buszello,¹⁶⁷ J. M. Butler,²² A. I. Butt,³ C. M. Buttar,⁵³ J. M. Butterworth,⁷⁸ P. Butti,¹⁰⁷ W. Buttinger,²⁵ A. Buzatu,⁵³ R. Buzykaev,^{109,d} S. Cabrera Urbán,¹⁶⁸ D. Caforio,¹²⁸ O. Cakir,^{4a} P. Calafiura,¹⁵ A. Calandri,¹³⁷ G. Calderini,⁸⁰ P. Calfayan,¹⁰⁰ L. P. Caloba,^{24a} D. Calvet,³⁴ S. Calvet,³⁴ R. Camacho Toro,⁴⁹ S. Camarda,⁴² D. Cameron,¹¹⁹ L. M. Caminada,¹⁵ R. Caminal Armadans,¹² S. Campana,³⁰ M. Campanelli,⁷⁸ A. Campoverde,¹⁴⁹ V. Canale,^{104a,104b} A. Canepa,^{160a} M. Cano Bret,⁷⁶ J. Cantero,⁸² R. Cantrill,^{126a} T. Cao,⁴⁰ M. D. M. Capeans Garrido,³⁰ I. Caprini,^{26a} M. Caprini,^{26a} M. Capua,^{37a,37b} R. Caputo,⁸³ R. Cardarelli,^{134a} T. Carli,³⁰ G. Carlino,^{104a} L. Carminati,^{91a,91b} S. Caron,¹⁰⁶ E. Carquin,^{32a} G. D. Carrillo-Montoya,⁸ J. R. Carter,²⁸ J. Carvalho,^{126a,126c} D. Casadei,⁷⁸ M. P. Casado,¹² M. Casolino,¹² E. Castaneda-Miranda,^{146b} A. Castelli,¹⁰⁷ V. Castillo Gimenez,¹⁶⁸ N. F. Castro,^{126a,h} P. Catastini,⁵⁷ A. Catinaccio,³⁰ J. R. Catmore,¹¹⁹ A. Cattai,³⁰ J. Caudron,⁸³ V. Cavaliere,¹⁶⁶ D. Cavalli,^{91a} M. Cavalli-Sforza,¹² V. Cavasinni,^{124a,124b} F. Ceradini,^{135a,135b} B. C. Cerio,⁴⁵ K. Cerny,¹²⁹ A. S. Cerqueira,^{24b} A. Cerri,¹⁵⁰ L. Cerrito,⁷⁶ F. Cerutti,¹⁵ M. Cerv,³⁰ A. Cervelli,¹⁷ S. A. Cetin,^{19b} A. Chafaq,^{136a} D. Chakraborty,¹⁰⁸ I. Chalupkova,¹²⁹ P. Chang,¹⁶⁶ B. Chapleau,⁸⁷ J. D. Chapman,²⁸ D. G. Charlton,¹⁸ C. C. Chau,¹⁵⁹ C. A. Chavez Barajas,¹⁵⁰ S. Cheatham,¹⁵³ A. Chegwiddden,⁹⁰ S. Chekanov,⁶ S. V. Chekulaev,^{160a} G. A. Chelkov,^{65,i} M. A. Chelstowska,⁸⁹ C. Chen,⁶⁴ H. Chen,²⁵ K. Chen,¹⁴⁹ L. Chen,^{33d,j} S. Chen,^{33c} X. Chen,^{33f} Y. Chen,⁶⁷ H. C. Cheng,⁸⁹ Y. Cheng,³¹ A. Cheplakov,⁶⁵ E. Cheremushkina,¹³⁰ R. Cherkaoui El Moursli,^{136e} V. Chernyatin,^{25,a} E. Cheu,⁷ L. Chevalier,¹³⁷ V. Chiarella,⁴⁷ J. T. Childers,⁶ G. Chiodini,^{73a} A. S. Chisholm,¹⁸ R. T. Chislett,⁷⁸ A. Chitan,^{26a} M. V. Chizhov,⁶⁵ K. Choi,⁶¹ S. Chouridou,⁹ B. K. B. Chow,¹⁰⁰ V. Christodoulou,⁷⁸ D. Chromek-Burckhart,³⁰ M. L. Chu,¹⁵² J. Chudoba,¹²⁷ A. J. Chuinard,⁸⁷ J. J. Chwastowski,³⁹ L. Chytka,¹¹⁵ G. Ciapetti,^{133a,133b} A. K. Ciftci,^{4a} D. Cinca,⁵³ V. Cindro,⁷⁵ I. A. Cioara,²¹ A. Ciochio,¹⁵ Z. H. Citron,¹⁷³ M. Ciubancan,^{26a} A. Clark,⁴⁹ B. L. Clark,⁵⁷ P. J. Clark,⁴⁶ R. N. Clarke,¹⁵ W. Cleland,¹²⁵ C. Clement,^{147a,147b} Y. Coadou,⁸⁵ M. Cobal,^{165a,165c} A. Coccaro,¹³⁹ J. Cochran,⁶⁴ L. Coffey,²³ J. G. Cogan,¹⁴⁴ B. Cole,³⁵ S. Cole,¹⁰⁸ A. P. Colijn,¹⁰⁷ J. Collot,⁵⁵ T. Colombo,^{58c} G. Compostella,¹⁰¹ P. Conde Muiño,^{126a,126b} E. Coniavitis,⁴⁸ S. H. Connell,^{146b} I. A. Connelly,⁷⁷ S. M. Consonni,^{91a,91b} V. Consorti,⁴⁸ S. Constantinescu,^{26a} C. Conta,^{121a,121b} G. Conti,³⁰ F. Conventi,^{104a,k} M. Cooke,¹⁵ B. D. Cooper,⁷⁸ A. M. Cooper-Sarkar,¹²⁰ K. Copic,¹⁵ T. Cornelissen,¹⁷⁶ M. Corradi,^{20a} F. Corriveau,^{87,l} A. Corso-Radu,¹⁶⁴ A. Cortes-Gonzalez,¹² G. Cortiana,¹⁰¹ G. Costa,^{91a} M. J. Costa,¹⁶⁸ D. Costanzo,¹⁴⁰ D. Côté,⁸ G. Cottin,²⁸ G. Cowan,⁷⁷ B. E. Cox,⁸⁴ K. Cranmer,¹¹⁰ G. Cree,²⁹ S. Crépe-Renaudin,⁵⁵ F. Crescioli,⁸⁰ W. A. Cribbs,^{147a,147b} M. Crispin Ortuzar,¹²⁰ M. Cristinziani,²¹ V. Croft,¹⁰⁶ G. Crosetti,^{37a,37b} T. Cuhadar Donszelmann,¹⁴⁰ J. Cummings,¹⁷⁷ M. Curatolo,⁴⁷ C. Cuthbert,¹⁵¹ H. Czirr,¹⁴² P. Czodrowski,³ S. D'Auria,⁵³ M. D'Onofrio,⁷⁴ M. J. Da Cunha Sargedas De Sousa,^{126a,126b} C. Da Via,⁸⁴ W. Dabrowski,^{38a} A. Dafinca,¹²⁰ T. Dai,⁸⁹ O. Dale,¹⁴ F. Dallaire,⁹⁵ C. Dallapiccola,⁸⁶ M. Dam,³⁶ J. R. Dandoy,³¹ A. C. Daniells,¹⁸ M. Danninger,¹⁶⁹ M. Dano Hoffmann,¹³⁷ V. Dao,⁴⁸ G. Darbo,^{50a} S. Darmora,⁸ J. Dassoulas,³ A. Dattagupta,⁶¹ W. Davey,²¹ C. David,¹⁷⁰ T. Davidek,¹²⁹ E. Davies,^{120,m} M. Davies,¹⁵⁴ P. Davison,⁷⁸ Y. Davygora,^{58a} E. Dawe,⁸⁸ I. Dawson,¹⁴⁰ R. K. Daya-Ishmukhametova,⁸⁶ K. De,⁸ R. de Asmundis,^{104a} S. De Castro,^{20a,20b} S. De Cecco,⁸⁰ N. De Groot,¹⁰⁶ P. de Jong,¹⁰⁷ H. De la Torre,⁸² F. De Lorenzi,⁶⁴ L. De Nooij,¹⁰⁷ D. De Pedis,^{133a} A. De Salvo,^{133a} U. De Sanctis,¹⁵⁰ A. De Santo,¹⁵⁰ J. B. De Vivie De Regie,¹¹⁷ W. J. Dearnaley,⁷² R. Debe, ²⁵ C. Debenedetti,¹³⁸ D. V. Dedovich,⁶⁵ I. Deigaard,¹⁰⁷ J. Del Peso,⁸² T. Del Prete,^{124a,124b} D. Delgove,¹¹⁷ F. Deliot,¹³⁷ C. M. Delitzsch,⁴⁹ M. Deliyergiyev,⁷⁵ A. Dell'Acqua,³⁰ L. Dell'Asta,²² M. Dell'Orso,^{124a,124b} M. Della Pietra,^{104a,k} D. della Volpe,⁴⁹ M. Delmastro,⁵ P. A. Delsart,⁵⁵ C. Deluca,¹⁰⁷ D. A. DeMarco,¹⁵⁹ S. Demers,¹⁷⁷ M. Demichev,⁶⁵ A. Demilly,⁸⁰ S. P. Denisov,¹³⁰ D. Derendarz,³⁹ J. E. Derkaoui,^{136d} F. Derue,⁸⁰ P. Dervan,⁷⁴ K. Desch,²¹ C. Deterre,⁴² P. O. Deviveiros,³⁰ A. Dewhurst,¹³¹ S. Dhaliwal,¹⁰⁷ A. Di Ciaccio,^{134a,134b} L. Di Ciaccio,⁵ A. Di Domenico,^{133a,133b} C. Di Donato,^{104a,104b} A. Di Girolamo,³⁰ B. Di Girolamo,³⁰ A. Di Mattia,¹⁵³ B. Di Micco,^{135a,135b} R. Di Nardo,⁴⁷ A. Di Simone,⁴⁸ R. Di Sipio,¹⁵⁹ D. Di Valentino,²⁹ C. Diaconu,⁸⁵ M. Diamond,¹⁵⁹ F. A. Dias,⁴⁶ M. A. Diaz,^{32a} E. B. Diehl,⁸⁹ J. Dietrich,¹⁶ S. Diglio,⁸⁵

A. Dimitrievska,¹³ J. Dingfelder,²¹ F. Dittus,³⁰ F. Djama,⁸⁵ T. Djobava,^{51b} J. I. Djuvslund,^{58a} M. A. B. do Vale,^{24c} D. Dobos,³⁰ M. Dobre,^{26a} C. Doglioni,⁴⁹ T. Dohmae,¹⁵⁶ J. Dolejsi,¹²⁹ Z. Dolezal,¹²⁹ B. A. Dolgoshein,^{98a} M. Donadelli,^{24d} S. Donati,^{124a,124b} P. Dondero,^{121a,121b} J. Donini,³⁴ J. Dopke,¹³¹ A. Doria,^{104a} M. T. Dova,⁷¹ A. T. Doyle,⁵³ E. Drechsler,⁵⁴ M. Dris,¹⁰ E. Dubreuil,³⁴ E. Duchovni,¹⁷³ G. Duckeck,¹⁰⁰ O. A. Ducu,^{26a,85} D. Duda,¹⁷⁶ A. Dudarev,³⁰ L. Dufлот,¹¹⁷ L. Duguid,⁷⁷ M. Dührssen,³⁰ M. Dunford,^{58a} H. Duran Yildiz,^{4a} M. Düren,⁵² A. Durglishvili,^{51b} D. Duschinger,⁴⁴ M. Dwuznik,^{38a} M. Dyndal,^{38a} C. Eckardt,⁴² K. M. Ecker,¹⁰¹ W. Edson,² N. C. Edwards,⁴⁶ W. Ehrenfeld,²¹ T. Eifert,³⁰ G. Eigen,¹⁴ K. Einsweiler,¹⁵ T. Ekelof,¹⁶⁷ M. El Kacimi,^{136c} M. Ellert,¹⁶⁷ S. Elles,⁵ F. Ellinghaus,⁸³ A. A. Elliot,¹⁷⁰ N. Ellis,³⁰ J. Elmsheuser,¹⁰⁰ M. Elsing,³⁰ D. Emeliyanov,¹³¹ Y. Enari,¹⁵⁶ O. C. Endner,⁸³ M. Endo,¹¹⁸ R. Engelmann,¹⁴⁹ J. Erdmann,⁴³ A. Ereditato,¹⁷ D. Eriksson,^{147a} G. Ernis,¹⁷⁶ J. Ernst,² M. Ernst,²⁵ S. Errede,¹⁶⁶ E. Ertel,⁸³ M. Escalier,¹¹⁷ H. Esch,⁴³ C. Escobar,¹²⁵ B. Esposito,⁴⁷ A. I. Etiennevire,¹³⁷ E. Etzion,¹⁵⁴ H. Evans,⁶¹ A. Ezhilov,¹²³ L. Fabbri,^{20a,20b} G. Facini,³¹ R. M. Fakhrutdinov,¹³⁰ S. Falciano,^{133a} R. J. Falla,⁷⁸ J. Faltova,¹²⁹ Y. Fang,^{33a} M. Fanti,^{91a,91b} A. Farbin,⁸ A. Farilla,^{135a} T. Farrowque,¹² S. Farrell,¹⁵ S. M. Farrington,¹⁷¹ P. Farthouat,³⁰ F. Fassi,^{136c} P. Fassnacht,³⁰ D. Fassouliotis,⁹ A. Favareto,^{50a,50b} L. Fayard,¹¹⁷ P. Federic,^{145a} O. L. Fedin,^{123,n} W. Fedorko,¹⁶⁹ S. Feigl,³⁰ L. Felgioni,⁸⁵ C. Feng,^{33d} E. J. Feng,⁶ H. Feng,⁸⁹ A. B. Fenyuk,¹³⁰ P. Fernandez Martinez,¹⁶⁸ S. Fernandez Perez,³⁰ S. Ferrag,⁵³ J. Ferrando,⁵³ A. Ferrari,¹⁶⁷ P. Ferrari,¹⁰⁷ R. Ferrari,^{121a} D. E. Ferreira de Lima,⁵³ A. Ferrer,¹⁶⁸ D. Ferrere,⁴⁹ C. Ferretti,⁸⁹ A. Ferretto Parodi,^{50a,50b} M. Fiascaris,³¹ F. Fiedler,⁸³ A. Filipčić,⁷⁵ M. Filipuzzi,⁴² F. Filthaut,¹⁰⁶ M. Fincke-Keeler,¹⁷⁰ K. D. Finelli,¹⁵¹ M. C. N. Fiolhais,^{126a,126c} L. Fiorini,¹⁶⁸ A. Firan,⁴⁰ A. Fischer,² C. Fischer,¹² J. Fischer,¹⁷⁶ W. C. Fisher,⁹⁰ E. A. Fitzgerald,²³ M. Flechl,⁴⁸ I. Fleck,¹⁴² P. Fleischmann,⁸⁹ S. Fleischmann,¹⁷⁶ G. T. Fletcher,¹⁴⁰ G. Fletcher,⁷⁶ T. Flick,¹⁷⁶ A. Floderus,⁸¹ L. R. Flores Castillo,^{60a} M. J. Flowerdew,¹⁰¹ A. Formica,¹³⁷ A. Forti,⁸⁴ D. Fournier,¹¹⁷ H. Fox,⁷² S. Fracchia,¹² P. Francavilla,⁸⁰ M. Franchini,^{20a,20b} D. Francis,³⁰ L. Franconi,¹¹⁹ M. Franklin,⁵⁷ M. Fraternali,^{121a,121b} D. Freeborn,⁷⁸ S. T. French,²⁸ F. Friedrich,⁴⁴ D. Froidevaux,³⁰ J. A. Frost,¹²⁰ C. Fukunaga,¹⁵⁷ E. Fullana Torregrosa,⁸³ B. G. Fulsom,¹⁴⁴ J. Fuster,¹⁶⁸ C. Gabaldon,⁵⁵ O. Gabizon,¹⁷⁶ A. Gabrielli,^{20a,20b} A. Gabrielli,^{133a,133b} S. Gadatsch,¹⁰⁷ S. Gadomski,⁴⁹ G. Gagliardi,^{50a,50b} P. Gagnon,⁶¹ C. Galea,¹⁰⁶ B. Galhardo,^{126a,126c} E. J. Gallas,¹²⁰ B. J. Gallop,¹³¹ P. Gallus,¹²⁸ G. Galster,³⁶ K. K. Gan,¹¹¹ J. Gao,^{33b,85} Y. Gao,⁴⁶ Y. S. Gao,^{144,f} F. M. Garay Walls,⁴⁶ F. Garberon,¹⁷⁷ C. García,¹⁶⁸ J. E. García Navarro,¹⁶⁸ M. Garcia-Sciveres,¹⁵ R. W. Gardner,³¹ N. Garelli,¹⁴⁴ V. Garonne,¹¹⁹ C. Gatti,⁴⁷ A. Gaudiello,^{50a,50b} G. Gaudio,^{121a} B. Gaur,¹⁴² L. Gauthier,⁹⁵ P. Gauzzi,^{133a,133b} I. L. Gavrilenko,⁹⁶ C. Gay,¹⁶⁹ G. Gaycken,²¹ E. N. Gazis,¹⁰ P. Ge,^{33d} Z. Gece,¹⁶⁹ C. N. P. Gee,¹³¹ D. A. A. Geerts,¹⁰⁷ Ch. Geich-Gimbel,²¹ M. P. Geisler,^{58a} C. Gemme,^{50a} M. H. Genest,⁵⁵ S. Gentile,^{133a,133b} M. George,⁵⁴ S. George,⁷⁷ D. Gerbaudo,¹⁶⁴ A. Gershon,¹⁵⁴ H. Ghazlane,^{136b} N. Ghodbane,³⁴ B. Giacobbe,^{20a} S. Giagu,^{133a,133b} V. Giangiobbe,¹² P. Giannetti,^{124a,124b} B. Gibbard,²⁵ S. M. Gibson,⁷⁷ M. Gilchriese,¹⁵ T. P. S. Gillam,²⁸ D. Gillberg,³⁰ G. Gilles,³⁴ D. M. Gingrich,^{3,e} N. Giokaris,⁹ M. P. Giordani,^{165a,165c} F. M. Giorgi,^{20a} F. M. Giorgi,¹⁶ P. F. Giraud,¹³⁷ P. Giromini,⁴⁷ D. Giugni,^{91a} C. Giuliani,⁴⁸ M. Giulini,^{58b} B. K. Gjelsten,¹¹⁹ S. Gkaitatzis,¹⁵⁵ I. Gkialas,¹⁵⁵ E. L. Gkoukousis,¹¹⁷ L. K. Gladilin,⁹⁹ C. Glasman,⁸² J. Glatzer,³⁰ P. C. F. Glaysher,⁴⁶ A. Glazov,⁴² M. Goblirsch-Kolb,¹⁰¹ J. R. Goddard,⁷⁶ J. Godlewski,³⁹ S. Goldfarb,⁸⁹ T. Golling,⁴⁹ D. Golubkov,¹³⁰ A. Gomes,^{126a,126b,126d} R. Gonçalves,^{126a} J. Goncalves Pinto Firmino Da Costa,¹³⁷ L. Gonella,²¹ S. González de la Hoz,¹⁶⁸ G. Gonzalez Parra,¹² S. Gonzalez-Sevilla,⁴⁹ L. Goossens,³⁰ P. A. Gorbounov,⁹⁷ H. A. Gordon,²⁵ I. Gorelov,¹⁰⁵ B. Gorini,³⁰ E. Gorini,^{73a,73b} A. Gorišek,⁷⁵ E. Gornicki,³⁹ A. T. Goshaw,⁴⁵ C. Gössling,⁴³ M. I. Gostkin,⁶⁵ D. Goujdami,^{136c} A. G. Goussiou,¹³⁹ N. Govender,^{146b} H. M. X. Grabas,¹³⁸ L. Graber,⁵⁴ I. Grabowska-Bold,^{38a} P. Grafström,^{20a,20b} K.-J. Grahn,⁴² J. Gramling,⁴⁹ E. Gramstad,¹¹⁹ S. Grancagnolo,¹⁶ V. Grassi,¹⁴⁹ V. Gratchev,¹²³ H. M. Gray,³⁰ E. Graziani,^{135a} Z. D. Greenwood,^{79,o} K. Gregersen,⁷⁸ I. M. Gregor,⁴² P. Grenier,¹⁴⁴ J. Griffiths,⁸ A. A. Grillo,¹³⁸ K. Grimm,⁷² S. Grinstein,^{12,p} Ph. Gris,³⁴ J.-F. Grivaz,¹¹⁷ J. P. Grohs,⁴⁴ A. Grohsjean,⁴² E. Gross,¹⁷³ J. Grosse-Knetter,⁵⁴ G. C. Grossi,⁷⁹ Z. J. Grout,¹⁵⁰ L. Guan,^{33b} J. Guenther,¹²⁸ F. Guescini,⁴⁹ D. Guest,¹⁷⁷ O. Gueta,¹⁵⁴ E. Guido,^{50a,50b} T. Guillemin,¹¹⁷ S. Guindon,² U. Gul,⁵³ C. Gumpert,⁴⁴ J. Guo,^{33e} S. Gupta,¹²⁰ P. Gutierrez,¹¹³ N. G. Gutierrez Ortiz,⁵³ C. Gutsche,⁴⁴ C. Guyot,¹³⁷ C. Gwenlan,¹²⁰ C. B. Gwilliam,⁷⁴ A. Haas,¹¹⁰ C. Haber,¹⁵ H. K. Hadavand,⁸ N. Haddad,^{136e} P. Haefner,²¹ S. Hageböck,²¹ Z. Hajduk,³⁹ H. Hakobyan,¹⁷⁸ M. Haleem,⁴² J. Haley,¹¹⁴ D. Hall,¹²⁰ G. Halladjian,⁹⁰ G. D. Hallewell,⁸⁵ K. Hamacher,¹⁷⁶ P. Hamal,¹¹⁵ K. Hamano,¹⁷⁰ M. Hamer,⁵⁴ A. Hamilton,^{146a} S. Hamilton,¹⁶² G. N. Hamity,^{146c} P. G. Hamnett,⁴² L. Han,^{33b} K. Hanagaki,¹¹⁸ K. Hanawa,¹⁵⁶ M. Hance,¹⁵ P. Hanke,^{58a} R. Hanna,¹³⁷ J. B. Hansen,³⁶ J. D. Hansen,³⁶ M. C. Hansen,²¹ P. H. Hansen,³⁶ K. Hara,¹⁶¹ A. S. Hard,¹⁷⁴ T. Harenberg,¹⁷⁶ F. Hariri,¹¹⁷ S. Harkusha,⁹² R. D. Harrington,⁴⁶ P. F. Harrison,¹⁷¹ F. Hartjes,¹⁰⁷ M. Hasegawa,⁶⁷ S. Hasegawa,¹⁰³ Y. Hasegawa,¹⁴¹ A. Hasib,¹¹³ S. Hassani,¹³⁷ S. Haug,¹⁷ R. Hauser,⁹⁰ L. Hauswald,⁴⁴ M. Havranek,¹²⁷ C. M. Hawkes,¹⁸ R. J. Hawking,³⁰ A. D. Hawkins,⁸¹

T. Hayashi,¹⁶¹ D. Hayden,⁹⁰ C. P. Hays,¹²⁰ J. M. Hays,⁷⁶ H. S. Hayward,⁷⁴ S. J. Haywood,¹³¹ S. J. Head,¹⁸ T. Heck,⁸³
V. Hedberg,⁸¹ L. Heelan,⁸ S. Heim,¹²² T. Heim,¹⁷⁶ B. Heinemann,¹⁵ L. Heinrich,¹¹⁰ J. Hejbal,¹²⁷ L. Helary,²²
S. Hellman,^{147a,147b} D. Hellmich,²¹ C. Hensens,³⁰ J. Henderson,¹²⁰ R. C. W. Henderson,⁷² Y. Heng,¹⁷⁴ C. Hengler,⁴²
A. Henrichs,¹⁷⁷ A. M. Henriques Correia,³⁰ S. Henrot-Versille,¹¹⁷ G. H. Herbert,¹⁶ Y. Hernández Jiménez,¹⁶⁸
R. Herrberg-Schubert,¹⁶ G. Hertzen,⁴⁸ R. Hertzenberger,¹⁰⁰ L. Hervas,³⁰ G. G. Hesketh,⁷⁸ N. P. Hessey,¹⁰⁷ J. W. Hetherly,⁴⁰
R. Hickling,⁷⁶ E. Higón-Rodríguez,¹⁶⁸ E. Hill,¹⁷⁰ J. C. Hill,²⁸ K. H. Hiller,⁴² S. J. Hillier,¹⁸ I. Hinchliffe,¹⁵ E. Hines,¹²²
R. R. Hinman,¹⁵ M. Hirose,¹⁵⁸ D. Hirschbuehl,¹⁷⁶ J. Hobbs,¹⁴⁹ N. Hod,¹⁰⁷ M. C. Hodgkinson,¹⁴⁰ P. Hodgson,¹⁴⁰
A. Hoecker,³⁰ M. R. Hoferkamp,¹⁰⁵ F. Hoenig,¹⁰⁰ M. Hohlfield,⁸³ D. Hohn,²¹ T. R. Holmes,¹⁵ T. M. Hong,¹²²
L. Hooft van Huysduynen,¹¹⁰ W. H. Hopkins,¹¹⁶ Y. Horii,¹⁰³ A. J. Horton,¹⁴³ J.-Y. Hostachy,⁵⁵ S. Hou,¹⁵² A. Hoummada,^{136a}
J. Howard,¹²⁰ J. Howarth,⁴² M. Hrabovsky,¹¹⁵ I. Hristova,¹⁶ J. Hrivnac,¹¹⁷ T. Hryn'ova,⁵ A. Hrynevich,⁹³ C. Hsu,^{146c}
P. J. Hsu,^{152,q} S.-C. Hsu,¹³⁹ D. Hu,³⁵ Q. Hu,^{33b} X. Hu,⁸⁹ Y. Huang,⁴² Z. Hubacek,³⁰ F. Hubaut,⁸⁵ F. Huegging,²¹
T. B. Huffman,¹²⁰ E. W. Hughes,³⁵ G. Hughes,⁷² M. Huhtinen,³⁰ T. A. Hülsing,⁸³ N. Huseynov,^{65,c} J. Huston,⁹⁰ J. Huth,⁵⁷
G. Iacobucci,⁴⁹ G. Iakovidis,²⁵ I. Ibragimov,¹⁴² L. Iconomidou-Fayard,¹¹⁷ E. Ideal,¹⁷⁷ Z. Idrissi,^{136e} P. Iengo,³⁰
O. Igonkina,¹⁰⁷ T. Iizawa,¹⁷² Y. Ikegami,⁶⁶ K. Ikematsu,¹⁴² M. Ikeno,⁶⁶ Y. Ilchenko,^{31,r} D. Iliadis,¹⁵⁵ N. Ilic,¹⁵⁹ Y. Inamaru,⁶⁷
T. Ince,¹⁰¹ P. Ioannou,⁹ M. Iodice,^{135a} K. Iordanidou,⁹ V. Ippolito,⁵⁷ A. Irlles Quiles,¹⁶⁸ C. Isaksson,¹⁶⁷ M. Ishino,⁶⁸
M. Ishitsuka,¹⁵⁸ R. Ishmukhametov,¹¹¹ C. Issever,¹²⁰ S. Istin,^{19a} J. M. Iturbe Ponce,⁸⁴ R. Iuppa,^{134a,134b} J. Ivarsson,⁸¹
W. Iwanski,³⁹ H. Iwasaki,⁶⁶ J. M. Izen,⁴¹ V. Izzo,^{104a} S. Jabbar,³ B. Jackson,¹²² M. Jackson,⁷⁴ P. Jackson,¹ M. R. Jaekel,³⁰
V. Jain,² K. Jakobs,⁴⁸ S. Jakobsen,³⁰ T. Jakoubek,¹²⁷ J. Jakubek,¹²⁸ D. O. Jamin,¹⁵² D. K. Jana,⁷⁹ E. Jansen,⁷⁸ R. W. Jansky,⁶²
J. Janssen,²¹ M. Janus,¹⁷¹ G. Jarlskog,⁸¹ N. Javadov,^{65,c} T. Javůrek,⁴⁸ L. Jeanty,¹⁵ J. Jejelava,^{51a,s} G.-Y. Jeng,¹⁵¹ D. Jennens,⁸⁸
P. Jenni,^{48,t} J. Jentzsch,⁴³ C. Jeske,¹⁷¹ S. Jézéquel,⁵ H. Ji,¹⁷⁴ J. Jia,¹⁴⁹ Y. Jiang,^{33b} S. Jiggins,⁷⁸ J. Jimenez Pena,¹⁶⁸ S. Jin,^{33a}
A. Jinaru,^{26a} O. Jinnouchi,¹⁵⁸ M. D. Joergensen,³⁶ P. Johansson,¹⁴⁰ K. A. Johns,⁷ K. Jon-And,^{147a,147b} G. Jones,¹⁷¹
R. W. L. Jones,⁷² T. J. Jones,⁷⁴ J. Jongmanns,^{58a} P. M. Jorge,^{126a,126b} K. D. Joshi,⁸⁴ J. Jovicevic,^{160a} X. Ju,¹⁷⁴ C. A. Jung,⁴³
P. Jussel,⁶² A. Juste Rozas,^{12,p} M. Kaci,¹⁶⁸ A. Kaczmarska,³⁹ M. Kado,¹¹⁷ H. Kagan,¹¹¹ M. Kagan,¹⁴⁴ S. J. Kahn,⁸⁵
E. Kajomovitz,⁴⁵ C. W. Kalderon,¹²⁰ S. Kama,⁴⁰ A. Kamenshchikov,¹³⁰ N. Kanaya,¹⁵⁶ M. Kaneda,³⁰ S. Kaneti,²⁸
V. A. Kantserov,⁹⁸ J. Kanzaki,⁶⁶ B. Kaplan,¹¹⁰ A. Kapliy,³¹ D. Kar,⁵³ K. Karakostas,¹⁰ A. Karamaoun,³ N. Karastathis,^{10,107}
M. J. Kareem,⁵⁴ M. Karnevskiy,⁸³ S. N. Karpov,⁶⁵ Z. M. Karpova,⁶⁵ K. Karthik,¹¹⁰ V. Kartvelishvili,⁷² A. N. Karyukhin,¹³⁰
L. Kashif,¹⁷⁴ R. D. Kass,¹¹¹ A. Kastanas,¹⁴ Y. Kataoka,¹⁵⁶ A. Katre,⁴⁹ J. Katzy,⁴² K. Kawagoe,⁷⁰ T. Kawamoto,¹⁵⁶
G. Kawamura,⁵⁴ S. Kazama,¹⁵⁶ V. F. Kazanin,^{109,d} M. Y. Kazarinov,⁶⁵ R. Keeler,¹⁷⁰ R. Kehoe,⁴⁰ J. S. Keller,⁴²
J. J. Kempster,⁷⁷ H. Keoshkerian,⁸⁴ O. Kepka,¹²⁷ B. P. Kerševan,⁷⁵ S. Kersten,¹⁷⁶ R. A. Keyes,⁸⁷ F. Khalil-zada,¹¹
H. Khandanyan,^{147a,147b} A. Khanov,¹¹⁴ A. G. Kharlamov,^{109,d} T. J. Khoo,²⁸ V. Khovanskiy,⁹⁷ E. Khramov,⁶⁵ J. Khubua,^{51b,u}
H. Y. Kim,⁸ H. Kim,^{147a,147b} S. H. Kim,¹⁶¹ Y. Kim,³¹ N. Kimura,¹⁵⁵ O. M. Kind,¹⁶ B. T. King,⁷⁴ M. King,¹⁶⁸ R. S. B. King,¹²⁰
S. B. King,¹⁶⁹ J. Kirk,¹³¹ A. E. Kiryunin,¹⁰¹ T. Kishimoto,⁶⁷ D. Kisielewska,^{38a} F. Kiss,⁴⁸ K. Kiuchi,¹⁶¹ O. Kivernyk,¹³⁷
E. Kladiva,^{145b} M. H. Klein,³⁵ M. Klein,⁷⁴ U. Klein,⁷⁴ K. Kleinknecht,⁸³ P. Klimek,^{147a,147b} A. Klimentov,²⁵
R. Klingenberg,⁴³ J. A. Klinger,⁸⁴ T. Klioutchnikova,³⁰ P. F. Klok,¹⁰⁶ E.-E. Kluge,^{58a} P. Kluit,¹⁰⁷ S. Kluth,¹⁰¹ E. Kneringer,⁶²
E. B. F. G. Knoops,⁸⁵ A. Knue,⁵³ D. Kobayashi,¹⁵⁸ T. Kobayashi,¹⁵⁶ M. Kobel,⁴⁴ M. Kocian,¹⁴⁴ P. Kodys,¹²⁹ T. Koffas,²⁹
E. Koffeman,¹⁰⁷ L. A. Kogan,¹²⁰ S. Kohlmann,¹⁷⁶ Z. Kohout,¹²⁸ T. Kohriki,⁶⁶ T. Koi,¹⁴⁴ H. Kolanoski,¹⁶ I. Koletsou,⁵
A. A. Komar,^{96,a} Y. Komori,¹⁵⁶ T. Kondo,⁶⁶ N. Kondrashova,⁴² K. Köneke,⁴⁸ A. C. König,¹⁰⁶ S. König,⁸³ T. Kono,^{66,v}
R. Konoplich,^{110,w} N. Konstantinidis,⁷⁸ R. Kopeliansky,¹⁵³ S. Koperny,^{38a} L. Köpke,⁸³ A. K. Kopp,⁴⁸ K. Korcyl,³⁹
K. Kordas,¹⁵⁵ A. Korn,⁷⁸ A. A. Korol,^{109,d} I. Korolkov,¹² E. V. Korolkova,¹⁴⁰ O. Kortner,¹⁰¹ S. Kortner,¹⁰¹ T. Kosek,¹²⁹
V. V. Kostyukhin,²¹ V. M. Kotov,⁶⁵ A. Kotwal,⁴⁵ A. Kourkoumeli-Charalampidi,¹⁵⁵ C. Kourkoumelis,⁹ V. Kouskoura,²⁵
A. Koutsman,^{160a} R. Kowalewski,¹⁷⁰ T. Z. Kowalski,^{38a} W. Kozanecki,¹³⁷ A. S. Kozhin,¹³⁰ V. A. Kramarenko,⁹⁹
G. Kramberger,⁷⁵ D. Krasnopevtsev,⁹⁸ M. W. Krasny,⁸⁰ A. Krasznahorkay,³⁰ J. K. Kraus,²¹ A. Kravchenko,²⁵ S. Kreiss,¹¹⁰
M. Kretz,^{58c} J. Kretzschmar,⁷⁴ K. Kreutzfeldt,⁵² P. Krieger,¹⁵⁹ K. Krizka,³¹ K. Kroeninger,⁴³ H. Kroha,¹⁰¹ J. Kroll,¹²²
J. Kroseberg,²¹ J. Krstic,¹³ U. Kruchonak,⁶⁵ H. Krüger,²¹ N. Krumnack,⁶⁴ Z. V. Krumshcheyn,⁶⁵ A. Kruse,¹⁷⁴ M. C. Kruse,⁴⁵
M. Kruskal,²² T. Kubota,⁸⁸ H. Kucuk,⁷⁸ S. Kудay,^{4b} S. Kuehn,⁴⁸ A. Kugel,^{58c} F. Kuger,¹⁷⁵ A. Kuhl,¹³⁸ T. Kuhl,⁴²
V. Kukhtin,⁶⁵ Y. Kulchitsky,⁹² S. Kuleshov,^{32b} M. Kuna,^{133a,133b} T. Kunigo,⁶⁸ A. Kupco,¹²⁷ H. Kurashige,⁶⁷
Y. A. Kurochkin,⁹² R. Kurumida,⁶⁷ V. Kus,¹²⁷ E. S. Kuwertz,¹⁴⁸ M. Kuze,¹⁵⁸ J. Kvita,¹¹⁵ T. Kwan,¹⁷⁰ D. Kyriazopoulos,¹⁴⁰
A. La Rosa,⁴⁹ J. L. La Rosa Navarro,^{24d} L. La Rotonda,^{37a,37b} C. Lacasta,¹⁶⁸ F. Lacava,^{133a,133b} J. Lacey,²⁹ H. Lacker,¹⁶
D. Lacour,⁸⁰ V. R. Lacuesta,¹⁶⁸ E. Ladygin,⁶⁵ R. Lafaye,⁵ B. Laforge,⁸⁰ T. Lagouri,¹⁷⁷ S. Lai,⁴⁸ L. Lambourne,⁷⁸

S. Lammers,⁶¹ C. L. Lampen,⁷ W. Lampl,⁷ E. Lançon,¹³⁷ U. Landgraf,⁴⁸ M. P. J. Landon,⁷⁶ V. S. Lang,^{58a} A. J. Lankford,¹⁶⁴ F. Lanni,²⁵ K. Lantzsch,³⁰ S. Laplace,⁸⁰ C. Lapoire,³⁰ J. F. Laporte,¹³⁷ T. Lari,^{91a} F. Lasagni Manghi,^{20a,20b} M. Lassnig,³⁰ P. Laurelli,⁴⁷ W. Lavrijsen,¹⁵ A. T. Law,¹³⁸ P. Laycock,⁷⁴ O. Le Dortz,⁸⁰ E. Le Guirriec,⁸⁵ E. Le Menedeu,¹² M. LeBlanc,¹⁷⁰ T. LeCompte,⁶ F. Ledroit-Guillon,⁵⁵ C. A. Lee,^{146b} S. C. Lee,¹⁵² L. Lee,¹ G. Lefebvre,⁸⁰ M. Lefebvre,¹⁷⁰ F. Legger,¹⁰⁰ C. Leggett,¹⁵ A. Lehan,⁷⁴ G. Lehmann Miotto,³⁰ X. Lei,⁷ W. A. Leight,²⁹ A. Leisos,¹⁵⁵ A. G. Leister,¹⁷⁷ M. A. L. Leite,^{24d} R. Leitner,¹²⁹ D. Lellouch,¹⁷³ B. Lemmer,⁵⁴ K. J. C. Leney,⁷⁸ T. Lenz,²¹ B. Lenzi,³⁰ R. Leone,⁷ S. Leone,^{124a,124b} C. Leonidopoulos,⁴⁶ S. Leontsinis,¹⁰ C. Leroy,⁹⁵ C. G. Lester,²⁸ M. Levchenko,¹²³ J. Levêque,⁵ D. Levin,⁸⁹ L. J. Levinson,¹⁷³ M. Levy,¹⁸ A. Lewis,¹²⁰ A. M. Leyko,²¹ M. Leyton,⁴¹ B. Li,^{33b,x} H. Li,¹⁴⁹ H. L. Li,³¹ L. Li,⁴⁵ L. Li,^{33e} S. Li,⁴⁵ Y. Li,^{33c,y} Z. Liang,¹³⁸ H. Liao,³⁴ B. Liberti,^{134a} A. Liblong,¹⁵⁹ P. Lichard,³⁰ K. Lie,¹⁶⁶ J. Liebal,²¹ W. Liebig,¹⁴ C. Limbach,²¹ A. Limosani,¹⁵¹ S. C. Lin,^{152,z} T. H. Lin,⁸³ F. Linde,¹⁰⁷ B. E. Lindquist,¹⁴⁹ J. T. Linnemann,⁹⁰ E. Lipeles,¹²² A. Lipniacka,¹⁴ M. Lisovsky,⁴² T. M. Liss,¹⁶⁶ D. Lissauer,²⁵ A. Lister,¹⁶⁹ A. M. Litke,¹³⁸ B. Liu,^{152,aa} D. Liu,¹⁵² J. Liu,⁸⁵ J. B. Liu,^{33b} K. Liu,⁸⁵ L. Liu,¹⁶⁶ M. Liu,⁴⁵ M. Liu,^{33b} Y. Liu,^{33b} M. Livan,^{121a,121b} A. Lleres,⁵⁵ J. Llorente Merino,⁸² S. L. Lloyd,⁷⁶ F. Lo Sterzo,¹⁵² E. Lobodzinska,⁴² P. Loch,⁷ W. S. Lockman,¹³⁸ F. K. Loebinger,⁸⁴ A. E. Loeschall-Jensen,³⁶ A. Loginov,¹⁷⁷ T. Lohse,¹⁶ K. Lohwasser,⁴² M. Lokajicek,¹²⁷ B. A. Long,²² J. D. Long,⁸⁹ R. E. Long,⁷² K. A. Looper,¹¹¹ L. Lopes,^{126a} D. Lopez Mateos,⁵⁷ B. Lopez Paredes,¹⁴⁰ I. Lopez Paz,¹² J. Lorenz,¹⁰⁰ N. Lorenzo Martinez,⁶¹ M. Losada,¹⁶³ P. Loscutoff,¹⁵ P. J. Lösel,¹⁰⁰ X. Lou,^{33a} A. Lounis,¹¹⁷ J. Love,⁶ P. A. Love,⁷² N. Lu,⁸⁹ H. J. Lubatti,¹³⁹ C. Luci,^{133a,133b} A. Lucotte,⁵⁵ F. Luehring,⁶¹ W. Lukas,⁶² L. Luminari,^{133a} O. Lundberg,^{147a,147b} B. Lund-Jensen,¹⁴⁸ M. Lungwitz,⁸³ D. Lynn,²⁵ R. Lysak,¹²⁷ E. Lytken,⁸¹ H. Ma,²⁵ L. L. Ma,^{33d} G. Maccarrone,⁴⁷ A. Macchiolo,¹⁰¹ C. M. Macdonald,¹⁴⁰ J. Machado Miguens,^{122,126b} D. Macina,³⁰ D. Madaffari,⁸⁵ R. Madar,³⁴ H. J. Maddocks,⁷² W. F. Mader,⁴⁴ A. Madsen,¹⁶⁷ S. Maeland,¹⁴ T. Maeno,²⁵ A. Maevskiy,⁹⁹ E. Magradze,⁵⁴ K. Mahboubi,⁴⁸ J. Mahlstedt,¹⁰⁷ C. Maiani,¹³⁷ C. Maidantchik,^{24a} A. A. Maier,¹⁰¹ T. Maier,¹⁰⁰ A. Maio,^{126a,126b,126d} S. Majewski,¹¹⁶ Y. Makida,⁶⁶ N. Makovec,¹¹⁷ B. Malaescu,⁸⁰ Pa. Malecki,³⁹ V. P. Maleev,¹²³ F. Malek,⁵⁵ U. Mallik,⁶³ D. Malon,⁶ C. Malone,¹⁴⁴ S. Maltezos,¹⁰ V. M. Malyshev,¹⁰⁹ S. Malyukov,³⁰ J. Mamuzic,⁴² G. Mancini,⁴⁷ B. Mandelli,³⁰ L. Mandelli,^{91a} I. Mandić,⁷⁵ R. Mandrysch,⁶³ J. Maneira,^{126a,126b} A. Manfredini,¹⁰¹ L. Manhaes de Andrade Filho,^{24b} J. Manjarres Ramos,^{160b} A. Mann,¹⁰⁰ P. M. Manning,¹³⁸ A. Manousakis-Katsikakis,⁹ B. Mansoulie,¹³⁷ R. Mantifel,⁸⁷ M. Mantoani,⁵⁴ L. Mapelli,³⁰ L. March,^{146c} G. Marchiori,⁸⁰ M. Marcisovsky,¹²⁷ C. P. Marino,¹⁷⁰ M. Marjanovic,¹³ F. Marroquim,^{24a} S. P. Marsden,⁸⁴ Z. Marshall,¹⁵ L. F. Marti,¹⁷ S. Marti-Garcia,¹⁶⁸ B. Martin,⁹⁰ T. A. Martin,¹⁷¹ V. J. Martin,⁴⁶ B. Martin dit Latour,¹⁴ M. Martinez,^{12,p} S. Martin-Haugh,¹³¹ V. S. Martoiu,^{26a} A. C. Martyniuk,⁷⁸ M. Marx,¹³⁹ F. Marzano,^{133a} A. Marzin,³⁰ L. Masetti,⁸³ T. Mashimo,¹⁵⁶ R. Mashinistov,⁹⁶ J. Masik,⁸⁴ A. L. Maslennikov,^{109,d} I. Massa,^{20a,20b} L. Massa,^{20a,20b} N. Massol,⁵ P. Mastrandrea,¹⁴⁹ A. Mastroberardino,^{37a,37b} T. Masubuchi,¹⁵⁶ P. Mättig,¹⁷⁶ J. Mattmann,⁸³ J. Maurer,^{26a} S. J. Maxfield,⁷⁴ D. A. Maximov,^{109,d} R. Mazini,¹⁵² S. M. Mazza,^{91a,91b} L. Mazzaferro,^{134a,134b} G. Mc Goldrick,¹⁵⁹ S. P. Mc Kee,⁸⁹ A. McCann,⁸⁹ R. L. McCarthy,¹⁴⁹ T. G. McCarthy,²⁹ N. A. McCubbin,¹³¹ K. W. McFarlane,^{56,a} J. A. McFayden,⁷⁸ G. Mchedlidze,⁵⁴ S. J. McMahon,¹³¹ R. A. McPherson,^{170,1} M. Medinnis,⁴² S. Meehan,^{146a} S. Mehlhase,¹⁰⁰ A. Mehta,⁷⁴ K. Meier,^{58a} C. Meineck,¹⁰⁰ B. Meirose,⁴¹ B. R. Mellado Garcia,^{146c} F. Meloni,¹⁷ A. Mengarelli,^{20a,20b} S. Menke,¹⁰¹ E. Meoni,¹⁶² K. M. Mercurio,⁵⁷ S. Mergelmeyer,²¹ P. Mermod,⁴⁹ L. Merola,^{104a,104b} C. Meroni,^{91a} F. S. Merritt,³¹ A. Messina,^{133a,133b} J. Metcalfe,²⁵ A. S. Mete,¹⁶⁴ C. Meyer,⁸³ C. Meyer,¹²² J.-P. Meyer,¹³⁷ J. Meyer,¹⁰⁷ R. P. Middleton,¹³¹ S. Miglioranza,^{165a,165c} L. Mijović,²¹ G. Mikenberg,¹⁷³ M. Mikestikova,¹²⁷ M. Mikuž,⁷⁵ M. Milesi,⁸⁸ A. Milic,³⁰ D. W. Miller,³¹ C. Mills,⁴⁶ A. Milov,¹⁷³ D. A. Milstead,^{147a,147b} A. A. Minaenko,¹³⁰ Y. Minami,¹⁵⁶ I. A. Minashvili,⁶⁵ A. I. Mincer,¹¹⁰ B. Mindur,^{38a} M. Mineev,⁶⁵ Y. Ming,¹⁷⁴ L. M. Mir,¹² T. Mitani,¹⁷² J. Mitrevski,¹⁰⁰ V. A. Mitsou,¹⁶⁸ A. Miucci,⁴⁹ P. S. Miyagawa,¹⁴⁰ J. U. Mjörnmark,⁸¹ T. Moa,^{147a,147b} K. Mochizuki,⁸⁵ S. Mohapatra,³⁵ W. Mohr,⁴⁸ S. Molander,^{147a,147b} R. Moles-Valls,¹⁶⁸ K. Mönig,⁴² C. Monini,⁵⁵ J. Monk,³⁶ E. Monnier,⁸⁵ J. Montejo Berlingen,¹² F. Monticelli,⁷¹ S. Monzani,^{133a,133b} R. W. Moore,³ N. Morange,¹¹⁷ D. Moreno,¹⁶³ M. Moreno Llácer,⁵⁴ P. Moretini,^{50a} M. Morgenstern,⁴⁴ M. Morii,⁵⁷ V. Morisbak,¹¹⁹ S. Moritz,⁸³ A. K. Morley,¹⁴⁸ G. Mornacchi,³⁰ J. D. Morris,⁷⁶ S. S. Mortensen,³⁶ A. Morton,⁵³ L. Morvaj,¹⁰³ M. Mosidze,^{51b} J. Moss,¹¹¹ K. Motohashi,¹⁵⁸ R. Mount,¹⁴⁴ E. Mountricha,²⁵ S. V. Mouraviev,^{96,a} E. J. W. Moyse,⁸⁶ S. Muanza,⁸⁵ R. D. Mudd,¹⁸ F. Mueller,¹⁰¹ J. Mueller,¹²⁵ K. Mueller,²¹ R. S. P. Mueller,¹⁰⁰ T. Mueller,²⁸ D. Muenstermann,⁴⁹ P. Mullen,⁵³ Y. Munwes,¹⁵⁴ J. A. Murillo Quijada,¹⁸ W. J. Murray,^{171,131} H. Musheghyan,⁵⁴ E. Musto,¹⁵³ A. G. Myagkov,^{130,bb} M. Myska,¹²⁸ O. Nackenhorst,⁵⁴ J. Nadal,⁵⁴ K. Nagai,¹²⁰ R. Nagai,¹⁵⁸ Y. Nagai,⁸⁵ K. Nagano,⁶⁶ A. Nagarkar,¹¹¹ Y. Nagasaka,⁵⁹ K. Nagata,¹⁶¹ M. Nagel,¹⁰¹ E. Nagy,⁸⁵ A. M. Nairz,³⁰ Y. Nakahama,³⁰ K. Nakamura,⁶⁶ T. Nakamura,¹⁵⁶ I. Nakano,¹¹² H. Namasivayam,⁴¹ R. F. Naranjo Garcia,⁴² R. Narayan,^{58b} T. Naumann,⁴² G. Navarro,¹⁶³

R. Nayyar,⁷ H. A. Neal,⁸⁹ P. Yu. Nechaeva,⁹⁶ T. J. Neep,⁸⁴ P. D. Nef,¹⁴⁴ A. Negri,^{121a,121b} M. Negrini,^{20a} S. Nektarijevic,¹⁰⁶ C. Nellist,¹¹⁷ A. Nelson,¹⁶⁴ S. Nemecek,¹²⁷ P. Nemethy,¹¹⁰ A. A. Nepomuceno,^{24a} M. Nessi,^{30,cc} M. S. Neubauer,¹⁶⁶ M. Neumann,¹⁷⁶ R. M. Neves,¹¹⁰ P. Nevski,²⁵ P. R. Newman,¹⁸ D. H. Nguyen,⁶ R. B. Nickerson,¹²⁰ R. Nicolaidou,¹³⁷ B. Nicquevert,³⁰ J. Nielsen,¹³⁸ N. Nikiforou,³⁵ A. Nikiforov,¹⁶ V. Nikolaenko,^{130,bb} I. Nikolic-Audit,⁸⁰ K. Nikolopoulos,¹⁸ J. K. Nilsen,¹¹⁹ P. Nilsson,²⁵ Y. Ninomiya,¹⁵⁶ A. Nisati,^{133a} R. Nisius,¹⁰¹ T. Nobe,¹⁵⁸ M. Nomachi,¹¹⁸ I. Nomidis,²⁹ T. Nooney,⁷⁶ S. Norberg,¹¹³ M. Nordberg,³⁰ O. Novgorodova,⁴⁴ S. Nowak,¹⁰¹ M. Nozaki,⁶⁶ L. Nozka,¹¹⁵ K. Ntekas,¹⁰ G. Nunes Hanninger,⁸⁸ T. Nunnemann,¹⁰⁰ E. Nurse,⁷⁸ F. Nuti,⁸⁸ B. J. O'Brien,⁴⁶ F. O'grady,⁷ D. C. O'Neil,¹⁴³ V. O'Shea,⁵³ F. G. Oakham,^{29,e} H. Oberlack,¹⁰¹ T. Obermann,²¹ J. Ocariz,⁸⁰ A. Ochi,⁶⁷ I. Ochoa,⁷⁸ J. P. Ochoa-Ricoux,^{32a} S. Oda,⁷⁰ S. Odaka,⁶⁶ H. Ogren,⁶¹ A. Oh,⁸⁴ S. H. Oh,⁴⁵ C. C. Ohm,¹⁵ H. Ohman,¹⁶⁷ H. Oide,³⁰ W. Okamura,¹¹⁸ H. Okawa,¹⁶¹ Y. Okumura,³¹ T. Okuyama,¹⁵⁶ A. Olariu,^{26a} S. A. Olivares Pino,⁴⁶ D. Oliveira Damazio,²⁵ E. Oliver Garcia,¹⁶⁸ A. Olszewski,³⁹ J. Olszowska,³⁹ A. Onofre,^{126a,126e} P. U. E. Onyisi,^{31,r} C. J. Oram,^{160a} M. J. Oreglia,³¹ Y. Oren,¹⁵⁴ D. Orestano,^{135a,135b} N. Orlando,¹⁵⁵ C. Oropeza Barrera,⁵³ R. S. Orr,¹⁵⁹ B. Osculati,^{50a,50b} R. Ospanov,⁸⁴ G. Otero y Garzon,²⁷ H. Otono,⁷⁰ M. Ouchrif,^{136d} E. A. Ouellette,¹⁷⁰ F. Ould-Saada,¹¹⁹ A. Ouraou,¹³⁷ K. P. Oussoren,¹⁰⁷ Q. Ouyang,^{33a} A. Ovcharova,¹⁵ M. Owen,⁵³ R. E. Owen,¹⁸ V. E. Ozcan,^{19a} N. Ozturk,⁸ K. Pachal,¹²⁰ A. Pacheco Pages,¹² C. Padilla Aranda,¹² M. Pagáčová,⁴⁸ S. Pagan Griso,¹⁵ E. Paganis,¹⁴⁰ C. Pahl,¹⁰¹ F. Paige,²⁵ P. Pais,⁸⁶ K. Pajchel,¹¹⁹ G. Palacino,^{160b} S. Palestini,³⁰ M. Palka,^{38b} D. Pallin,³⁴ A. Palma,^{126a,126b} Y. B. Pan,¹⁷⁴ E. Panagiotopoulou,¹⁰ C. E. Pandini,⁸⁰ J. G. Panduro Vazquez,⁷⁷ P. Pani,^{147a,147b} S. Panitkin,²⁵ L. Paolozzi,^{134a,134b} Th. D. Papadopoulos,¹⁰ K. Papageorgiou,¹⁵⁵ A. Paramonov,⁶ D. Paredes Hernandez,¹⁵⁵ M. A. Parker,²⁸ K. A. Parker,¹⁴⁰ F. Parodi,^{50a,50b} J. A. Parsons,³⁵ U. Parzefall,⁴⁸ E. Pasqualucci,^{133a} S. Passaggio,^{50a} F. Pastore,^{135a,135b,a} Fr. Pastore,⁷⁷ G. Pásztor,²⁹ S. Pataraiia,¹⁷⁶ N. D. Patel,¹⁵¹ J. R. Pater,⁸⁴ T. Pauly,³⁰ J. Pearce,¹⁷⁰ B. Pearson,¹¹³ L. E. Pedersen,³⁶ M. Pedersen,¹¹⁹ S. Pedraza Lopez,¹⁶⁸ R. Pedro,^{126a,126b} S. V. Peleganchuk,¹⁰⁹ D. Pelikan,¹⁶⁷ H. Peng,^{33b} B. Penning,³¹ J. Penwell,⁶¹ D. V. Perepelitsa,²⁵ E. Perez Codina,^{160a} M. T. Pérez García-Estañ,¹⁶⁸ L. Perini,^{91a,91b} H. Pernegger,³⁰ S. Perrella,^{104a,104b} R. Peschke,⁴² V. D. Peshekhonov,⁶⁵ K. Peters,³⁰ R. F. Y. Peters,⁸⁴ B. A. Petersen,³⁰ T. C. Petersen,³⁶ E. Petit,⁴² A. Petridis,^{147a,147b} C. Petridou,¹⁵⁵ E. Petrolo,^{133a} F. Petrucci,^{135a,135b} N. E. Pettersson,¹⁵⁸ R. Pezoa,^{32b} P. W. Phillips,¹³¹ G. Piacquadio,¹⁴⁴ E. Pianori,¹⁷¹ A. Picazio,⁴⁹ E. Piccaro,⁷⁶ M. Piccini,^{20a,20b} M. A. Pickering,¹²⁰ R. Piegaia,²⁷ D. T. Pignotti,¹¹¹ J. E. Pilcher,³¹ A. D. Pilkington,⁸⁴ J. Pina,^{126a,126b,126d} M. Pinamonti,^{165a,165c,dd} J. L. Pinfeld,³ A. Pingel,³⁶ B. Pinto,^{126a} S. Pires,⁸⁰ M. Pitt,¹⁷³ C. Pizio,^{91a,91b} L. Plazak,^{145a} M.-A. Pleier,²⁵ V. Pleskot,¹²⁹ E. Plotnikova,⁶⁵ P. Plucinski,^{147a,147b} D. Pluth,⁶⁴ R. Poettgen,⁸³ L. Poggioli,¹¹⁷ D. Pohl,²¹ G. Polesello,^{121a} A. Policicchio,^{37a,37b} R. Polifka,¹⁵⁹ A. Polini,^{20a} C. S. Pollard,⁵³ V. Polychronakos,²⁵ K. Pommès,³⁰ L. Pontecorvo,^{133a} B. G. Pope,⁹⁰ G. A. Popeneciu,^{26b} D. S. Popovic,¹³ A. Poppleton,³⁰ S. Pospisil,¹²⁸ K. Potamianos,¹⁵ I. N. Potrap,⁶⁵ C. J. Potter,¹⁵⁰ C. T. Potter,¹¹⁶ G. Poulard,³⁰ J. Poveda,³⁰ V. Pozdnyakov,⁶⁵ P. Pralavorio,⁸⁵ A. Pranko,¹⁵ S. Prasad,³⁰ S. Prell,⁶⁴ D. Price,⁸⁴ J. Price,⁷⁴ L. E. Price,⁶ M. Primavera,^{73a} S. Prince,⁸⁷ M. Proissl,⁴⁶ K. Prokofiev,^{60c} F. Prokoshin,^{32b} E. Protopapadaki,¹³⁷ S. Protopopescu,²⁵ J. Proudfoot,⁶ M. Przybycien,^{38a} E. Ptacek,¹¹⁶ D. Puudu,^{135a,135b} E. Pueschel,⁸⁶ D. Puldon,¹⁴⁹ M. Purohit,^{25,ee} P. Puzo,¹¹⁷ J. Qian,⁸⁹ G. Qin,⁵³ Y. Qin,⁸⁴ A. Quadt,⁵⁴ D. R. Quarrie,¹⁵ W. B. Quayle,^{165a,165b} M. Queitsch-Maitland,⁸⁴ D. Quilty,⁵³ S. Raddum,¹¹⁹ V. Radeka,²⁵ V. Radescu,⁴² S. K. Radhakrishnan,¹⁴⁹ P. Radloff,¹¹⁶ P. Rados,⁸⁸ F. Ragusa,^{91a,91b} G. Rahal,¹⁷⁹ S. Rajagopalan,²⁵ M. Rammensee,³⁰ C. Rangel-Smith,¹⁶⁷ F. Rauscher,¹⁰⁰ S. Rave,⁸³ T. Ravenscroft,⁵³ M. Raymond,³⁰ A. L. Read,¹¹⁹ N. P. Readioff,⁷⁴ D. M. Rebuffi,^{121a,121b} A. Redelbach,¹⁷⁵ G. Redlinger,²⁵ R. Reece,¹³⁸ K. Reeves,⁴¹ L. Rehnisch,¹⁶ H. Reisin,²⁷ M. Relich,¹⁶⁴ C. Rembser,³⁰ H. Ren,^{33a} A. Renaud,¹¹⁷ M. Rescigno,^{133a} S. Resconi,^{91a} O. L. Rezanova,^{109,d} P. Reznicek,¹²⁹ R. Rezvani,⁹⁵ R. Richter,¹⁰¹ S. Richter,⁷⁸ E. Richter-Was,^{38b} O. Ricken,²¹ M. Ridel,⁸⁰ P. Rieck,¹⁶ C. J. Riegel,¹⁷⁶ J. Rieger,⁵⁴ M. Rijssenbeek,¹⁴⁹ A. Rimoldi,^{121a,121b} L. Rinaldi,^{20a} B. Ristić,⁴⁹ E. Ritsch,⁶² I. Riu,¹² F. Rizatdinova,¹¹⁴ E. Rizvi,⁷⁶ S. H. Robertson,^{87,1} A. Robichaud-Veronneau,⁸⁷ D. Robinson,²⁸ J. E. M. Robinson,⁸⁴ A. Robson,⁵³ C. Roda,^{124a,124b} S. Roe,³⁰ O. Røhne,¹¹⁹ S. Rolli,¹⁶² A. Romaniouk,⁹⁸ M. Romano,^{20a,20b} S. M. Romano Saez,³⁴ E. Romero Adam,¹⁶⁸ N. Rompotis,¹³⁹ M. Ronzani,⁴⁸ L. Roos,⁸⁰ E. Ros,¹⁶⁸ S. Rosati,^{133a} K. Rosbach,⁴⁸ P. Rose,¹³⁸ P. L. Rosendahl,¹⁴ O. Rosenthal,¹⁴² V. Rossetti,^{147a,147b} E. Rossi,^{104a,104b} L. P. Rossi,^{50a} R. Rosten,¹³⁹ M. Rotaru,^{26a} I. Roth,¹⁷³ J. Rothberg,¹³⁹ D. Rousseau,¹¹⁷ C. R. Royon,¹³⁷ A. Rozanov,⁸⁵ Y. Rozen,¹⁵³ X. Ruan,^{146c} F. Rubbo,¹⁴⁴ I. Rubinskiy,⁴² V. I. Rud,⁹⁹ C. Rudolph,⁴⁴ M. S. Rudolph,¹⁵⁹ F. Rühr,⁴⁸ A. Ruiz-Martinez,³⁰ Z. Rurikova,⁴⁸ N. A. Rusakovich,⁶⁵ A. Ruschke,¹⁰⁰ H. L. Russell,¹³⁹ J. P. Rutherford,⁷ N. Ruthmann,⁴⁸ Y. F. Ryabov,¹²³ M. Rybar,¹²⁹ G. Rybkin,¹¹⁷ N. C. Ryder,¹²⁰ A. F. Saavedra,¹⁵¹ G. Sabato,¹⁰⁷ S. Sacerdoti,²⁷ A. Saddique,³ H. F.-W. Sadrozinski,¹³⁸ R. Sadykov,⁶⁵ F. Safai Tehrani,^{133a} M. Saimpert,¹³⁷ H. Sakamoto,¹⁵⁶ Y. Sakurai,¹⁷² G. Salamanna,^{135a,135b} A. Salamon,^{134a} M. Saleem,¹¹³

D. Salek,¹⁰⁷ P. H. Sales De Bruin,¹³⁹ D. Salihagic,¹⁰¹ A. Salnikov,¹⁴⁴ J. Salt,¹⁶⁸ D. Salvatore,^{37a,37b} F. Salvatore,¹⁵⁰
A. Salvucci,¹⁰⁶ A. Salzburger,³⁰ D. Sampsonidis,¹⁵⁵ A. Sanchez,^{104a,104b} J. Sánchez,¹⁶⁸ V. Sanchez Martinez,¹⁶⁸
H. Sandaker,¹⁴ R. L. Sandbach,⁷⁶ H. G. Sander,⁸³ M. P. Sanders,¹⁰⁰ M. Sandhoff,¹⁷⁶ C. Sandoval,¹⁶³ R. Sandstroem,¹⁰¹
D. P. C. Sankey,¹³¹ M. Sannino,^{50a,50b} A. Sansoni,⁴⁷ C. Santoni,³⁴ R. Santonico,^{134a,134b} H. Santos,^{126a} I. Santoyo Castillo,¹⁵⁰
K. Sapp,¹²⁵ A. Saprnov,⁶⁵ J. G. Saraiva,^{126a,126d} B. Sarrazin,²¹ O. Sasaki,⁶⁶ Y. Sasaki,¹⁵⁶ K. Sato,¹⁶¹ G. Sauvage,^{5a}
E. Sauvan,⁵ G. Savage,⁷⁷ P. Savard,^{159,e} C. Sawyer,¹²⁰ L. Sawyer,^{79,o} J. Saxon,³¹ C. Sbarra,^{20a} A. Sbrizzi,^{20a,20b} T. Scanlon,⁷⁸
D. A. Scannicchio,¹⁶⁴ M. Scarcella,¹⁵¹ V. Scarfone,^{37a,37b} J. Schaarschmidt,¹⁷³ P. Schacht,¹⁰¹ D. Schaefer,³⁰ R. Schaefer,⁴²
J. Schaeffer,⁸³ S. Schaepe,²¹ S. Schaezel,^{58b} U. Schäfer,⁸³ A. C. Schaffer,¹¹⁷ D. Schaile,¹⁰⁰ R. D. Schamberger,¹⁴⁹
V. Scharf,^{58a} V. A. Schegelsky,¹²³ D. Scheirich,¹²⁹ M. Schernau,¹⁶⁴ C. Schiavi,^{50a,50b} C. Schillo,⁴⁸ M. Schioppa,^{37a,37b}
S. Schlenker,³⁰ E. Schmidt,⁴⁸ K. Schmieden,³⁰ C. Schmitt,⁸³ S. Schmitt,^{58b} S. Schmitt,⁴² B. Schneider,^{160a}
Y. J. Schnellbach,⁷⁴ U. Schnoor,⁴⁴ L. Schoeffel,¹³⁷ A. Schoening,^{58b} B. D. Schoenrock,⁹⁰ E. Schopf,²¹
A. L. S. Schorlemmer,⁵⁴ M. Schott,⁸³ D. Schouten,^{160a} J. Schovancova,⁸ S. Schramm,¹⁵⁹ M. Schreyer,¹⁷⁵ C. Schroeder,⁸³
N. Schuh,⁸³ M. J. Schultens,²¹ H.-C. Schultz-Coulon,^{58a} H. Schulz,¹⁶ M. Schumacher,⁴⁸ B. A. Schumm,¹³⁸ Ph. Schune,¹³⁷
C. Schwanenberger,⁸⁴ A. Schwartzman,¹⁴⁴ T. A. Schwarz,⁸⁹ Ph. Schwegler,¹⁰¹ Ph. Schwemling,¹³⁷ R. Schwienhorst,⁹⁰
J. Schwindling,¹³⁷ T. Schwindt,²¹ M. Schwoerer,⁵ F. G. Sciacca,¹⁷ E. Scifo,¹¹⁷ G. Sciolla,²³ F. Scuri,^{124a,124b} F. Scutti,²¹
J. Searcy,⁸⁹ G. Sedov,⁴² E. Sedykh,¹²³ P. Seema,²¹ S. C. Seidel,¹⁰⁵ A. Seiden,¹³⁸ F. Seifert,¹²⁸ J. M. Seixas,^{24a}
G. Sekhniaidze,^{104a} S. J. Sekula,⁴⁰ K. E. Selbach,⁴⁶ D. M. Seliverstov,^{123,a} N. Semprini-Cesari,^{20a,20b} C. Serfon,³⁰ L. Serin,¹¹⁷
L. Serkin,^{165a,165b} T. Serre,⁸⁵ R. Seuster,^{160a} H. Severini,¹¹³ T. Sfiligoj,⁷⁵ F. Sforza,¹⁰¹ A. Sfyrla,³⁰ E. Shabalina,⁵⁴
M. Shamim,¹¹⁶ L. Y. Shan,^{33a} R. Shang,¹⁶⁶ J. T. Shank,²² M. Shapiro,¹⁵ P. B. Shatalov,⁹⁷ K. Shaw,^{165a,165b}
A. Shcherbakova,^{147a,147b} C. Y. Shehu,¹⁵⁰ P. Sherwood,⁷⁸ L. Shi,^{152,ff} S. Shimizu,⁶⁷ C. O. Shimmin,¹⁶⁴ M. Shimojima,¹⁰²
M. Shiyakova,⁶⁵ A. Shmeleva,⁹⁶ D. Shoaleh Saadi,⁹⁵ M. J. Shochet,³¹ S. Shojaii,^{91a,91b} S. Shrestha,¹¹¹ E. Shulga,⁹⁸
M. A. Shupe,⁷ S. Shushkevich,⁴² P. Sicho,¹²⁷ O. Sidiropoulou,¹⁷⁵ D. Sidorov,¹¹⁴ A. Sidoti,^{20a,20b} F. Siegert,⁴⁴ Dj. Sijacki,¹³
J. Silva,^{126a,126d} Y. Silver,¹⁵⁴ S. B. Silverstein,^{147a} V. Simak,¹²⁸ O. Simard,⁵ Lj. Simic,¹³ S. Simion,¹¹⁷ E. Simioni,⁸³
B. Simmons,⁷⁸ D. Simon,³⁴ R. Simoniello,^{91a,91b} P. Sinervo,¹⁵⁹ N. B. Sinev,¹¹⁶ G. Siragusa,¹⁷⁵ A. N. Sisakyan,^{65,a}
S. Yu. Sivoklov,⁹⁹ J. Sjölin,^{147a,147b} T. B. Sjørnsen,¹⁴ M. B. Skinner,⁷² H. P. Skottowe,⁵⁷ P. Skubic,¹¹³ M. Slater,¹⁸
T. Slavicek,¹²⁸ M. Slawinska,¹⁰⁷ K. Sliwa,¹⁶² V. Smakhtin,¹⁷³ B. H. Smart,⁴⁶ L. Smestad,¹⁴ S. Yu. Smirnov,⁹⁸ Y. Smirnov,⁹⁸
L. N. Smirnova,^{99,gg} O. Smirnova,⁸¹ M. N. K. Smith,³⁵ M. Smizanska,⁷² K. Smolek,¹²⁸ A. A. Snesev,⁹⁶ G. Snidero,⁷⁶
S. Snyder,²⁵ R. Sobie,^{170,l} F. Socher,⁴⁴ A. Soffer,¹⁵⁴ D. A. Soh,^{152,ff} C. A. Solans,³⁰ M. Solar,¹²⁸ J. Solc,¹²⁸ E. Yu. Soldatov,⁹⁸
U. Soldevila,¹⁶⁸ A. A. Solodkov,¹³⁰ A. Soloshenko,⁶⁵ O. V. Solovyanov,¹³⁰ V. Solovyev,¹²³ P. Sommer,⁴⁸ H. Y. Song,^{33b}
N. Soni,¹ A. Sood,¹⁵ A. Sopczak,¹²⁸ B. Sopko,¹²⁸ V. Sopko,¹²⁸ V. Sorin,¹² D. Sosa,^{58b} M. Sosebee,⁸ C. L. Sotiropoulou,¹⁵⁵
R. Soualah,^{165a,165c} P. Soueid,⁹⁵ A. M. Soukharev,^{109,d} D. South,⁴² S. Spagnolo,^{73a,73b} M. Spalla,^{124a,124b} F. Spanò,⁷⁷
W. R. Spearman,⁵⁷ F. Spettel,¹⁰¹ R. Spighi,^{20a} G. Spigo,³⁰ L. A. Spiller,⁸⁸ M. Spousta,¹²⁹ T. Spreitzer,¹⁵⁹ R. D. St. Denis,^{53,a}
S. Staerz,⁴⁴ J. Stahlman,¹²² R. Stamen,^{58a} S. Stamm,¹⁶ E. Stanecka,³⁹ C. Stanescu,^{135a} M. Stanescu-Bellu,⁴²
M. M. Stanitzki,⁴² S. Stapnes,¹¹⁹ E. A. Starchenko,¹³⁰ J. Stark,⁵⁵ P. Staroba,¹²⁷ P. Starovoitov,⁴² R. Staszewski,³⁹
P. Stavina,^{145a,a} P. Steinberg,²⁵ B. Stelzer,¹⁴³ H. J. Stelzer,³⁰ O. Stelzer-Chilton,^{160a} H. Stenzel,⁵² S. Stern,¹⁰¹ G. A. Stewart,⁵³
J. A. Stillings,²¹ M. C. Stockton,⁸⁷ M. Stoebe,⁸⁷ G. Stoicea,^{26a} P. Stolte,⁵⁴ S. Stonjek,¹⁰¹ A. R. Stradling,⁸ A. Straessner,⁴⁴
M. E. Stramaglia,¹⁷ J. Strandberg,¹⁴⁸ S. Strandberg,^{147a,147b} A. Strandlie,¹¹⁹ E. Strauss,¹⁴⁴ M. Strauss,¹¹³ P. Strizenc,^{145b}
R. Ströhmer,¹⁷⁵ D. M. Strom,¹¹⁶ R. Stroynowski,⁴⁰ A. Strubig,¹⁰⁶ S. A. Stucci,¹⁷ B. Stugu,¹⁴ N. A. Styles,⁴² D. Su,¹⁴⁴ J. Su,¹²⁵
R. Subramaniam,⁷⁹ A. Succurro,¹² Y. Sugaya,¹¹⁸ C. Suhr,¹⁰⁸ M. Suk,¹²⁸ V. V. Sulin,⁹⁶ S. Sultansoy,^{4c} T. Sumida,⁶⁸ S. Sun,⁵⁷
X. Sun,^{33a} J. E. Sundermann,⁴⁸ K. Suruliz,¹⁵⁰ G. Susinno,^{37a,37b} M. R. Sutton,¹⁵⁰ S. Suzuki,⁶⁶ Y. Suzuki,⁶⁶ M. Svatos,¹²⁷
S. Swedish,¹⁶⁹ M. Swiatlowski,¹⁴⁴ I. Sykora,^{145a} T. Sykora,¹²⁹ D. Ta,⁹⁰ C. Taccini,^{135a,135b} K. Tackmann,⁴² J. Taenzer,¹⁵⁹
A. Taffard,¹⁶⁴ R. Tafirout,^{160a} N. Taiblum,¹⁵⁴ H. Takai,²⁵ R. Takashima,⁶⁹ H. Takeda,⁶⁷ T. Takeshita,¹⁴¹ Y. Takubo,⁶⁶
M. Talby,⁸⁵ A. A. Talyshev,^{109,d} J. Y. C. Tam,¹⁷⁵ K. G. Tan,⁸⁸ J. Tanaka,¹⁵⁶ R. Tanaka,¹¹⁷ S. Tanaka,¹³² S. Tanaka,⁶⁶
B. B. Tannenwald,¹¹¹ N. Tannoury,²¹ S. Tapprogge,⁸³ S. Tarem,¹⁵³ F. Tarrade,²⁹ G. F. Tartarelli,^{91a} P. Tas,¹²⁹ M. Tasevsky,¹²⁷
T. Tashiro,⁶⁸ E. Tassi,^{37a,37b} A. Tavares Delgado,^{126a,126b} Y. Tayalati,^{136d} F. E. Taylor,⁹⁴ G. N. Taylor,⁸⁸ W. Taylor,^{160b}
F. A. Teischinger,³⁰ M. Teixeira Dias Castanheira,⁷⁶ P. Teixeira-Dias,⁷⁷ K. K. Temming,⁴⁸ H. Ten Kate,³⁰ P. K. Teng,¹⁵²
J. J. Teoh,¹¹⁸ F. Tepel,¹⁷⁶ S. Terada,⁶⁶ K. Terashi,¹⁵⁶ J. Terron,⁸² S. Terzo,¹⁰¹ M. Testa,⁴⁷ R. J. Teuscher,^{159,1} J. Therhaag,²¹
T. Thevenaux-Pelzer,³⁴ J. P. Thomas,¹⁸ J. Thomas-Wilsker,⁷⁷ E. N. Thompson,³⁵ P. D. Thompson,¹⁸ R. J. Thompson,⁸⁴
A. S. Thompson,⁵³ L. A. Thomsen,³⁶ E. Thomson,¹²² M. Thomson,²⁸ R. P. Thun,^{89,a} M. J. Tibbetts,¹⁵ R. E. Tisce Torres,⁸⁵

V. O. Tikhomirov,^{96,hh} Yu. A. Tikhonov,^{109,d} S. Timoshenko,⁹⁸ E. Tiouchichine,⁸⁵ P. Tipton,¹⁷⁷ S. Tisserant,⁸⁵ T. Todorov,^{5,a} S. Todorova-Nova,¹²⁹ J. Tojo,⁷⁰ S. Tokár,^{145a} K. Tokushuku,⁶⁶ K. Tollefson,⁹⁰ E. Tolley,⁵⁷ L. Tomlinson,⁸⁴ M. Tomoto,¹⁰³ L. Tompkins,^{144,ii} K. Toms,¹⁰⁵ E. Torrence,¹¹⁶ H. Torres,¹⁴³ E. Torró Pastor,¹⁶⁸ J. Toth,^{85,jj} F. Touchard,⁸⁵ D. R. Tovey,¹⁴⁰ T. Trefzger,¹⁷⁵ L. Tremblet,³⁰ A. Tricoli,³⁰ I. M. Trigger,^{160a} S. Trincaz-Duvoid,⁸⁰ M. F. Tripana,¹² W. Trischuk,¹⁵⁹ B. Trocmé,⁵⁵ C. Troncon,^{91a} M. Trotter-McDonald,¹⁵ M. Trovatelli,^{135a,135b} P. True,⁹⁰ M. Trzebinski,³⁹ A. Trzupek,³⁹ C. Tsarouchas,³⁰ J. C.-L. Tseng,¹²⁰ P. V. Tsiarehka,⁹² D. Tsionou,¹⁵⁵ G. Tsiopolitis,¹⁰ N. Tsirintanis,⁹ S. Tsiskaridze,¹² V. Tsiskaridze,⁴⁸ E. G. Tskhadadze,^{51a} I. I. Tsukerman,⁹⁷ V. Tsulaia,¹⁵ S. Tsuno,⁶⁶ D. Tsybychev,¹⁴⁹ A. Tudorache,^{26a} V. Tudorache,^{26a} A. N. Tuna,¹²² S. A. Tupputi,^{20a,20b} S. Turchikhin,^{99,gg} D. Turecek,¹²⁸ R. Turra,^{91a,91b} A. J. Turvey,⁴⁰ P. M. Tuts,³⁵ A. Tykhonov,⁴⁹ M. Tylmad,^{147a,147b} M. Tyndel,¹³¹ I. Ueda,¹⁵⁶ R. Ueno,²⁹ M. Ughetto,^{147a,147b} M. Ugland,¹⁴ M. Uhlenbrock,²¹ F. Ukegawa,¹⁶¹ G. Unal,³⁰ A. Undrus,²⁵ G. Unel,¹⁶⁴ F. C. Ungaro,⁴⁸ Y. Unno,⁶⁶ C. Unverdorben,¹⁰⁰ J. Urban,^{145b} P. Urquijo,⁸⁸ P. Urrejola,⁸³ G. Usai,⁸ A. Usanova,⁶² L. Vacavant,⁸⁵ V. Vacek,¹²⁸ B. Vachon,⁸⁷ C. Valderanis,⁸³ N. Valencic,¹⁰⁷ S. Valentinetti,^{20a,20b} A. Valero,¹⁶⁸ L. Valery,¹² S. Valkar,¹²⁹ E. Valladolid Gallego,¹⁶⁸ S. Vallecorsa,⁴⁹ J. A. Valls Ferrer,¹⁶⁸ W. Van Den Wollenberg,¹⁰⁷ P. C. Van Der Deijl,¹⁰⁷ R. van der Geer,¹⁰⁷ H. van der Graaf,¹⁰⁷ R. Van Der Leeuw,¹⁰⁷ N. van Eldik,¹⁵³ P. van Gemmeren,⁶ J. Van Nieuwkoop,¹⁴³ I. van Vulpen,¹⁰⁷ M. C. van Woerden,³⁰ M. Vanadia,^{133a,133b} W. Vandelli,³⁰ R. Vanguri,¹²² A. Vaniachine,⁶ F. Vannucci,⁸⁰ G. Vardanyan,¹⁷⁸ R. Vari,^{133a} E. W. Varnes,⁷ T. Varol,⁴⁰ D. Varouchas,⁸⁰ A. Vartapetian,⁸ K. E. Varvell,¹⁵¹ F. Vazeille,³⁴ T. Vazquez Schroeder,⁸⁷ J. Veatch,⁷ F. Veloso,^{126a,126c} T. Velz,²¹ S. Veneziano,^{133a} A. Ventura,^{73a,73b} D. Ventura,⁸⁶ M. Venturi,¹⁷⁰ N. Venturi,¹⁵⁹ A. Venturini,²³ V. Vercesi,^{121a} M. Verducci,^{133a,133b} W. Verkerke,¹⁰⁷ J. C. Vermeulen,¹⁰⁷ A. Vest,⁴⁴ M. C. Vetterli,^{143,e} O. Viazlo,⁸¹ I. Vichou,¹⁶⁶ T. Vickey,¹⁴⁰ O. E. Vickey Boeriu,¹⁴⁰ G. H. A. Viehhauser,¹²⁰ S. Viel,¹⁵ R. Vigne,³⁰ M. Villa,^{20a,20b} M. Villaplana Perez,^{91a,91b} E. Vilucchi,⁴⁷ M. G. Vinciter,²⁹ V. B. Vinogradov,⁶⁵ I. Vivarelli,¹⁵⁰ F. Vives Vaque,³ S. Vlachos,¹⁰ D. Vladoiu,¹⁰⁰ M. Vlasak,¹²⁸ M. Vogel,^{32a} P. Vokac,¹²⁸ G. Volpi,^{124a,124b} M. Volpi,⁸⁸ H. von der Schmitt,¹⁰¹ H. von Radziewski,⁴⁸ E. von Toerne,²¹ V. Vorobel,¹²⁹ K. Vorobev,⁹⁸ M. Vos,¹⁶⁸ R. Voss,³⁰ J. H. Vosseveld,⁷⁴ N. Vranjes,¹³ M. Vranjes Milosavljevic,¹³ V. Vrba,¹²⁷ M. Vreeswijk,¹⁰⁷ R. Vuillemer,³⁰ I. Vukotic,³¹ Z. Vykydal,¹²⁸ P. Wagner,²¹ W. Wagner,¹⁷⁶ H. Wahlberg,⁷¹ S. Wahrmund,⁴⁴ J. Wakabayashi,¹⁰³ J. Walder,⁷² R. Walker,¹⁰⁰ W. Walkowiak,¹⁴² C. Wang,^{33c} F. Wang,¹⁷⁴ H. Wang,¹⁵ H. Wang,⁴⁰ J. Wang,⁴² J. Wang,^{33a} K. Wang,⁸⁷ R. Wang,⁶ S. M. Wang,¹⁵² T. Wang,²¹ X. Wang,¹⁷⁷ C. Wanotayaroj,¹¹⁶ A. Warburton,⁸⁷ C. P. Ward,²⁸ D. R. Wardrope,⁷⁸ M. Warsinsky,⁴⁸ A. Washbrook,⁴⁶ C. Wasicki,⁴² P. M. Watkins,¹⁸ A. T. Watson,¹⁸ I. J. Watson,¹⁵¹ M. F. Watson,¹⁸ G. Watts,¹³⁹ S. Watts,⁸⁴ B. M. Waugh,⁷⁸ S. Webb,⁸⁴ M. S. Weber,¹⁷ S. W. Weber,¹⁷⁵ J. S. Webster,³¹ A. R. Weidberg,¹²⁰ B. Weinert,⁶¹ J. Weingarten,⁵⁴ C. Weiser,⁴⁸ H. Weits,¹⁰⁷ P. S. Wells,³⁰ T. Wenaus,²⁵ T. Wengler,³⁰ S. Wenig,³⁰ N. Wermes,²¹ M. Werner,⁴⁸ P. Werner,³⁰ M. Wessels,^{58a} J. Wetter,¹⁶² K. Whalen,²⁹ A. M. Wharton,⁷² A. White,⁸ M. J. White,¹ R. White,^{32b} S. White,^{124a,124b} D. Whiteson,¹⁶⁴ F. J. Wickens,¹³¹ W. Wiedenmann,¹⁷⁴ M. Wielers,¹³¹ P. Wienemann,²¹ C. Wiglesworth,³⁶ L. A. M. Wiik-Fuchs,²¹ A. Wildauer,¹⁰¹ H. G. Wilkens,³⁰ H. H. Williams,¹²² S. Williams,¹⁰⁷ C. Willis,⁹⁰ S. Willocq,⁸⁶ A. Wilson,⁸⁹ J. A. Wilson,¹⁸ I. Wingerter-Seez,⁵ F. Winklmeier,¹¹⁶ B. T. Winter,²¹ M. Wittgen,¹⁴⁴ J. Wittkowski,¹⁰⁰ S. J. Wollstadt,⁸³ M. W. Wolter,³⁹ H. Wolters,^{126a,126c} B. K. Wosiek,³⁹ J. Wotschack,³⁰ M. J. Woudstra,⁸⁴ K. W. Wozniak,³⁹ M. Wu,⁵⁵ M. Wu,³¹ S. L. Wu,¹⁷⁴ X. Wu,⁴⁹ Y. Wu,⁸⁹ T. R. Wyatt,⁸⁴ B. M. Wynne,⁴⁶ S. Xella,³⁶ D. Xu,^{33a} L. Xu,^{33b,kk} B. Yabsley,¹⁵¹ S. Yacoob,^{146b,ll} R. Yakabe,⁶⁷ M. Yamada,⁶⁶ Y. Yamaguchi,¹¹⁸ A. Yamamoto,⁶⁶ S. Yamamoto,¹⁵⁶ T. Yamanaka,¹⁵⁶ K. Yamauchi,¹⁰³ Y. Yamazaki,⁶⁷ Z. Yan,²² H. Yang,^{33e} H. Yang,¹⁷⁴ Y. Yang,¹⁵² L. Yao,^{33a} W.-M. Yao,¹⁵ Y. Yasu,⁶⁶ E. Yatsenko,⁴² K. H. Yau Wong,²¹ J. Ye,⁴⁰ S. Ye,²⁵ I. Yeletsikh,⁶⁵ A. L. Yen,⁵⁷ E. Yildirim,⁴² K. Yorita,¹⁷² R. Yoshida,⁶ K. Yoshihara,¹²² C. Young,¹⁴⁴ C. J. S. Young,³⁰ S. Youssef,²² D. R. Yu,¹⁵ J. Yu,⁸ J. M. Yu,⁸⁹ J. Yu,¹¹⁴ L. Yuan,⁶⁷ A. Yurkewicz,¹⁰⁸ I. Yusuff,^{28,mm} B. Zabinski,³⁹ R. Zaidan,⁶³ A. M. Zaitsev,^{130,bb} J. Zalieckas,¹⁴ A. Zaman,¹⁴⁹ S. Zambito,²³ L. Zanello,^{133a,133b} D. Zanzi,⁸⁸ C. Zeitnitz,¹⁷⁶ M. Zeman,¹²⁸ A. Zemla,^{38a} K. Zengel,²³ O. Zenin,¹³⁰ T. Ženiš,^{145a} D. Zerwas,¹¹⁷ D. Zhang,⁸⁹ F. Zhang,¹⁷⁴ J. Zhang,⁶ L. Zhang,⁴⁸ R. Zhang,^{33b} X. Zhang,^{33d} Z. Zhang,¹¹⁷ X. Zhao,⁴⁰ Y. Zhao,^{33d,117} Z. Zhao,^{33b} A. Zhemchugov,⁶⁵ J. Zhong,¹²⁰ B. Zhou,⁸⁹ C. Zhou,⁴⁵ L. Zhou,³⁵ L. Zhou,⁴⁰ N. Zhou,¹⁶⁴ C. G. Zhu,^{33d} H. Zhu,^{33a} J. Zhu,⁸⁹ Y. Zhu,^{33b} X. Zhuang,^{33a} K. Zhukov,⁹⁶ A. Zibell,¹⁷⁵ D. Zieminska,⁶¹ N. I. Zimine,⁶⁵ C. Zimmermann,⁸³ R. Zimmermann,²¹ S. Zimmermann,⁴⁸ Z. Zinonos,⁵⁴ M. Zinser,⁸³ M. Ziolkowski,¹⁴² L. Živković,¹³ G. Zobernig,¹⁷⁴ A. Zoccoli,^{20a,20b} M. zur Nedden,¹⁶ G. Zurzolo,^{104a,104b} and L. Zwalinski³⁰

(ATLAS Collaboration)

- ¹*Department of Physics, University of Adelaide, Adelaide, Australia*
- ²*Physics Department, SUNY Albany, Albany, New York, USA*
- ³*Department of Physics, University of Alberta, Edmonton, Alberta, Canada*
- ^{4a}*Department of Physics, Ankara University, Ankara, Turkey*
- ^{4b}*Istanbul Aydin University, Istanbul, Turkey*
- ^{4c}*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
- ⁵*LAPP, CNRS/IN2P3 and Université Savoie Mont Blanc, Annecy-le-Vieux, France*
- ⁶*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
- ⁷*Department of Physics, University of Arizona, Tucson, Arizona, USA*
- ⁸*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
- ⁹*Physics Department, University of Athens, Athens, Greece*
- ¹⁰*Physics Department, National Technical University of Athens, Zografou, Greece*
- ¹¹*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
- ¹²*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona, Barcelona, Spain*
- ¹³*Institute of Physics, University of Belgrade, Belgrade, Serbia*
- ¹⁴*Department for Physics and Technology, University of Bergen, Bergen, Norway*
- ¹⁵*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
- ¹⁶*Department of Physics, Humboldt University, Berlin, Germany*
- ¹⁷*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
- ¹⁸*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
- ^{19a}*Department of Physics, Bogazici University, Istanbul, Turkey*
- ^{19b}*Department of Physics, Dogus University, Istanbul, Turkey*
- ^{19c}*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
- ^{20a}*INFN Sezione di Bologna, Italy*
- ^{20b}*Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy*
- ²¹*Physikalisches Institut, University of Bonn, Bonn, Germany*
- ²²*Department of Physics, Boston University, Boston, Massachusetts, USA*
- ²³*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
- ^{24a}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
- ^{24b}*Electrical Circuits Department, Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
- ^{24c}*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
- ^{24d}*Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil*
- ²⁵*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
- ^{26a}*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
- ^{26b}*National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj Napoca, Romania*
- ^{26c}*University Politehnica Bucharest, Bucharest, Romania*
- ^{26d}*West University in Timisoara, Timisoara, Romania*
- ²⁷*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
- ²⁸*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
- ²⁹*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
- ³⁰*CERN, Geneva, Switzerland*
- ³¹*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
- ^{32a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
- ^{32b}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
- ^{33a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
- ^{33b}*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
- ^{33c}*Department of Physics, Nanjing University, Jiangsu, China*
- ^{33d}*School of Physics, Shandong University, Shandong, China*
- ^{33e}*Department of Physics and Astronomy, Shanghai Key Laboratory for Particle Physics and Cosmology, Shanghai Jiao Tong University, Shanghai, China*
- ^{33f}*Physics Department, Tsinghua University, Beijing 100084, China*
- ³⁴*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France*
- ³⁵*Nevis Laboratory, Columbia University, Irvington, New York, USA*
- ³⁶*Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark*
- ^{37a}*INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati, Italy*
- ^{37b}*Dipartimento di Fisica, Università della Calabria, Rende, Italy*
- ^{38a}*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*

- ^{38b}Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland
³⁹Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland
⁴⁰Physics Department, Southern Methodist University, Dallas, Texas, USA
⁴¹Physics Department, University of Texas at Dallas, Richardson, Texas, USA
⁴²DESY, Hamburg and Zeuthen, Germany
⁴³Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
⁴⁴Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany
⁴⁵Department of Physics, Duke University, Durham, North Carolina, USA
⁴⁶SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
⁴⁷INFN Laboratori Nazionali di Frascati, Frascati, Italy
⁴⁸Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany
⁴⁹Section de Physique, Université de Genève, Geneva, Switzerland
^{50a}INFN Sezione di Genova, Italy
^{50b}Dipartimento di Fisica, Università di Genova, Genova, Italy
^{51a}E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi, Georgia
^{51b}High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
⁵²II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
⁵³SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
⁵⁴II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
⁵⁵Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble, France
⁵⁶Department of Physics, Hampton University, Hampton, Virginia, USA
⁵⁷Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA
^{58a}Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
^{58b}Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
^{58c}ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
⁵⁹Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
^{60a}Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China
^{60b}Department of Physics, The University of Hong Kong, Hong Kong, China
^{60c}Department of Physics, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China
⁶¹Department of Physics, Indiana University, Bloomington, Indiana, USA
⁶²Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
⁶³University of Iowa, Iowa City, Iowa, USA
⁶⁴Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA
⁶⁵Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
⁶⁶KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
⁶⁷Graduate School of Science, Kobe University, Kobe, Japan
⁶⁸Faculty of Science, Kyoto University, Kyoto, Japan
⁶⁹Kyoto University of Education, Kyoto, Japan
⁷⁰Department of Physics, Kyushu University, Fukuoka, Japan
⁷¹Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
⁷²Physics Department, Lancaster University, Lancaster, United Kingdom
^{73a}INFN Sezione di Lecce, Italy
^{73b}Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
⁷⁴Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
⁷⁵Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
⁷⁶School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
⁷⁷Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
⁷⁸Department of Physics and Astronomy, University College London, London, United Kingdom
⁷⁹Louisiana Tech University, Ruston, Louisiana, USA
⁸⁰Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
⁸¹Fysiska institutionen, Lunds universitet, Lund, Sweden
⁸²Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
⁸³Institut für Physik, Universität Mainz, Mainz, Germany
⁸⁴School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
⁸⁵CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
⁸⁶Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA
⁸⁷Department of Physics, McGill University, Montreal, Quebec, Canada
⁸⁸School of Physics, University of Melbourne, Victoria, Australia

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

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

¹⁷⁹*Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3),
Villeurbanne, France*

^aDeceased.

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

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

^dAlso at Novosibirsk State University, Novosibirsk, Russia.

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

^fAlso at Department of Physics, California State University, Fresno, CA, USA.

^gAlso at Department of Physics, University of Fribourg, Fribourg, Switzerland.

^hAlso at Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Portugal.

ⁱAlso at Tomsk State University, Tomsk, Russia.

^jAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.

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

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

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

ⁿAlso at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.

^oAlso at Louisiana Tech University, Ruston, LA, USA.

^pAlso at Institutio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.

^qAlso at Department of Physics, National Tsing Hua University, Taiwan.

^rAlso at Department of Physics, The University of Texas at Austin, Austin, TX, USA.

^sAlso at Institute of Theoretical Physics, Ilia State University, Tbilisi, Georgia.

^tAlso at CERN, Geneva, Switzerland.

^uAlso at Georgian Technical University (GTU), Tbilisi, Georgia.

^vAlso at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan.

^wAlso at Manhattan College, New York, NY, USA.

^xAlso at Institute of Physics, Academia Sinica, Taipei, Taiwan.

^yAlso at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.

^zAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.

^{aa}Also at School of Physics, Shandong University, Shandong, China.

^{bb}Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.

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

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

^{ee}Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.

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

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

^{hh}Also at National Research Nuclear University MEPhI, Moscow, Russia.

ⁱⁱAlso at Department of Physics, Stanford University, Stanford, CA, USA.

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

^{kk}Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.

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

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