



UvA-DARE (Digital Academic Repository)

Search for pair production of a heavy up-type quark decaying to a W boson and a b quark in the lepton + jets channel with the ATLAS detector

Aad, G.; et al., [Unknown]; Bentvelsen, S.; Colijn, A.P.; de Jong, P.; de Nooij, L.; Doxiadis, A.D.; Garitaonandia, H.; Geerts, D.A.A.; Gosselink, M.; Kayl, M.S.; Koffeman, E.; Lee, H.; Linde, F.; Mechnich, J.; Mussche, I.; Ottersbach, J.P.; Rijpstra, M.; Ruckstuhl, N.; Tsiakiris, M.; van der Kraaij, E.; van der Leeuw, R.; van der Poel, E.; van Kesteren, Z.; van Vulpen, I.; Vermeulen, J.C.; Vreeswijk, M.

DOI

[10.1103/PhysRevLett.108.261802](https://doi.org/10.1103/PhysRevLett.108.261802)

Publication date

2012

Document Version

Final published version

Published in

Physical Review Letters

[Link to publication](#)

Citation for published version (APA):

Aad, G., et al., U., Bentvelsen, S., Colijn, A. P., de Jong, P., de Nooij, L., Doxiadis, A. D., Garitaonandia, H., Geerts, D. A. A., Gosselink, M., Kayl, M. S., Koffeman, E., Lee, H., Linde, F., Mechnich, J., Mussche, I., Ottersbach, J. P., Rijpstra, M., Ruckstuhl, N., ... Vreeswijk, M. (2012). Search for pair production of a heavy up-type quark decaying to a W boson and a b quark in the lepton + jets channel with the ATLAS detector. *Physical Review Letters*, 108(26), [261802]. <https://doi.org/10.1103/PhysRevLett.108.261802>

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).

Search for Pair Production of a Heavy Up-Type Quark Decaying to a W Boson and a b Quark in the lepton + jets Channel with the ATLAS Detector

G. Aad *et al.**

(ATLAS Collaboration)

(Received 14 February 2012; published 26 June 2012)

A search is presented for production of a heavy up-type quark (t') together with its antiparticle, assuming subsequent decay to a W boson and a b quark, $t'\bar{t}' \rightarrow W^+ b W^- \bar{b}$. The search is based on 1.04 fb^{-1} of proton-proton collisions at $\sqrt{s} = 7 \text{ TeV}$ collected by the ATLAS detector at the CERN Large Hadron Collider. Data are analyzed in the lepton + jets final state, characterized by a high transverse momentum isolated electron or muon, high missing transverse momentum, and at least three jets. No significant excess of events above the background expectation is observed. A 95% C.L. lower limit of 404 GeV is set for the mass of the t' quark.

DOI: [10.1103/PhysRevLett.108.261802](https://doi.org/10.1103/PhysRevLett.108.261802)

PACS numbers: 14.65.Jk, 12.60.-i, 13.85.Rm, 14.80.-j

The discovery of the top quark [1] completed the third generation of fundamental fermions in the quark sector of the standard model (SM) of particle physics. It is natural to ask whether heavier quarks may exist. These quarks are often present in new physics models aimed at solving the limitations of the SM. For example, models with a fourth generation of heavy chiral fermions could provide new sources of CP violation to explain the matter-antimatter asymmetry in the Universe and allow for a heavier Higgs boson while remaining consistent with precision electro-weak data [2]. The latter is accomplished by keeping a small mass splitting between the heavy up-type quark (t') and the heavy down-type quark (b'). Assuming that $m_{t'} - m_{b'} < m_W$, where m_W is the W boson mass, results in the t' quark predominantly decaying to a W boson and a down-type quark q ($q = d, s, b$). Another possibility is the addition of isospin singlets or doublets of vectorlike quarks, which appear in many extensions of the SM such as little Higgs or extra-dimensional models [3]. In both scenarios, the t' quark can decay into Wb with a large branching ratio, provided there is a significant mixing with the third generation of quarks, consistent with the existing mass and mixing patterns of the known quarks.

The high center-of-mass energy and integrated luminosity in pp collisions available at the Large Hadron Collider (LHC) offer a unique opportunity to probe these scenarios. At the LHC, these new heavy quarks would be predominantly produced in pairs via the strong interaction for masses below $\sim 1 \text{ TeV}$, while for larger masses electro-weak production of single heavy quarks could become the primary production mechanism, depending on the strength

of their interactions with the SM quarks and weak gauge bosons [3].

A search is presented in this Letter for $t'\bar{t}'$ production using pp collision data at $\sqrt{s} = 7 \text{ TeV}$ collected with the ATLAS detector. It is assumed that the t' quark decays exclusively into Wb . The lepton + jets final-state signature is considered, characterized by a high transverse momentum (p_T) isolated electron or muon, high missing transverse momentum (E_T^{miss}), and at least three jets. Similar searches in this channel have been published by the CDF and D0 Collaborations [4,5]; the most stringent limits preclude the existence of a t' quark with a mass below 358 GeV at 95% confidence level (C.L.). A search for $t'\bar{t}'$ in the dilepton final state has been performed by the ATLAS Collaboration [6], excluding a t' quark with a mass below 350 GeV at 95% C.L. The lepton + jets signature has also been recently exploited by the ATLAS Collaboration to search for $b'\bar{b}' \rightarrow W^- t W^+ \bar{t}$ [7].

The ATLAS detector [8] consists of an inner tracking system surrounded by a superconducting solenoid, electromagnetic and hadronic calorimeters, and a muon spectrometer. The inner detector is immersed in a 2 T axial magnetic field and consists of pixel and silicon microstrip detectors inside a transition radiation tracker, providing charged particle tracking in the region $|\eta| < 2.5$ [9]. The electromagnetic calorimeter is based on lead-liquid-argon (LAr). Hadron calorimetry is based on two different detector technologies, with scintillator tiles or LAr as active media and with either steel, copper, or tungsten as the absorber material. The calorimeters provide coverage up to $|\eta| < 4.9$. The muon spectrometer consists of superconducting air-core toroids, a system of trigger chambers covering the range $|\eta| < 2.4$, and high-precision tracking chambers allowing muon momentum measurements within $|\eta| < 2.7$.

The data set used in this analysis was recorded between March and June 2011 by using single electron and muon triggers and includes only events collected under stable

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

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

beam conditions and for which all detector subsystems were fully operational. The corresponding integrated luminosity is 1.04 fb^{-1} . The event selection criteria closely follow those used in recent ATLAS top quark studies, e.g., Ref. [10]. Electron candidates are required to satisfy $p_T > 25 \text{ GeV}$ and $|\eta| < 2.47$, excluding the transition region $1.37 < |\eta| < 1.52$ between the barrel and end cap electromagnetic calorimeters. Muon candidates are required to satisfy $p_T > 20 \text{ GeV}$ and $|\eta| < 2.5$. The p_T threshold requirement ensures that the selected leptons are in the efficiency plateau of the single-lepton triggers. Background from multijet production is suppressed by a requirement of $E_T^{\text{miss}} > 35(20) \text{ GeV}$ [11] in the electron (muon) channel, followed by $E_T^{\text{miss}} + m_T > 60 \text{ GeV}$, where m_T is the transverse mass of the lepton and E_T^{miss} [12]. The E_T^{miss} is constructed from the vector sum of all calorimeter cells contained in topological clusters [13], calibrated at the energy scale of the associated high- p_T object, and including contributions from selected muons. Further requirements are that there be at least three jets with $p_T > 25 \text{ GeV}$ and $|\eta| < 2.5$, with at least one jet satisfying $p_T > 60 \text{ GeV}$. Jets are reconstructed with the anti- k_r algorithm [14] with radius parameter $R = 0.4$, from topological clusters of energy deposits in the calorimeters calibrated at the electromagnetic scale. These jets are then calibrated to the particle level [15] by using a p_T - and η -dependent correction factor derived from simulated events and validated by using data. Finally, to further reduce the backgrounds, at least one jet is required to be identified as originating from the hadronization of a b quark (b tagging). This is achieved via an algorithm [16] using multivariate techniques to combine information from the impact parameters of displaced tracks as well as topological properties of secondary and tertiary decay vertices reconstructed within the jet; a working point is used with $\sim 70\%$ efficiency for b -quark jets and a rejection factor of ~ 100 for jets originating from light quarks (u, d, s) or gluons. Events with exactly one electron or one muon and with exactly three jets or with four or more jets are analyzed separately to take advantage of their different

signal-to-background ratio and background composition, as discussed below.

After event selection, the main background is $t\bar{t}$ production, followed by the production of a W boson in association with jets ($W + \text{jets}$). Smaller contributions arise from multijet events, single top quark, $Z + \text{jets}$, and diboson production. All of the backgrounds which do not involve top quarks are significantly suppressed by the b -tagging requirement. Multijet events contribute to the selected sample via the misidentification of a jet or a photon as an electron or the presence of a nonprompt lepton, e.g., from a semileptonic b - or c -hadron decay. The normalization and shape of the multijet background kinematic distributions are estimated via data-driven methods [11]. For the $W + \text{jets}$ background, the shape is estimated from the simulation, but the normalization is estimated from the asymmetry between $W^+ + \text{jets}$ and $W^- + \text{jets}$ production [17] in the data. All other backgrounds, as well as the signal, are estimated from the simulation and normalized to their theoretical cross sections. A summary of the background estimates in each of the four channels analyzed and a comparison with the observed yields in data are presented in Table I, showing a good agreement within the uncertainties.

Monte Carlo (MC) samples of $t\bar{t}$ and single top quark background are generated by using MC@NLO v3.41 [18], assuming a top quark mass of 172.5 GeV , using the CTEQ6.6 set of parton distribution functions (PDFs) [19], and are normalized to the approximate next-to-next-to-leading-order (NNLO) theoretical cross sections [20,21]. Samples of $W/Z + \text{jets}$ background are generated by using ALPGEN v2.13 [22] and the CTEQ6L1 PDF set [19]. The $Z + \text{jets}$ background is normalized to the NNLO theoretical cross section [23], while the $W + \text{jets}$ background normalization is extracted from the data. Both MC@NLO and ALPGEN are interfaced to HERWIG v6.5 [24] to model the parton shower and fragmentation, while JIMMY [25] is used to simulate the underlying event. The diboson backgrounds are modeled by using HERWIG v6.5 and normalized to their NLO theoretical cross sections [26]. The signal is modeled by using PYTHIA 6.421 [27]. Signal samples are generated for

TABLE I. Number of events observed compared to the background expectation after final event selection in each of the four channels considered. Also shown are the expected signal yields assuming $m_t = 400 \text{ GeV}$. The quoted uncertainties are prior to the fit to data and include both statistical and systematic contributions, taking into account correlations among processes.

	$e + 3 \text{ jets}$	$\mu + 3 \text{ jets}$	$e + \geq 4 \text{ jets}$	$\mu + \geq 4 \text{ jets}$
$t\bar{t}$	2320 ± 460	3000 ± 630	4470 ± 920	5900 ± 1200
$W + \text{jets}$	1440 ± 790	2200 ± 1200	830 ± 580	1160 ± 790
$Z + \text{jets}$	92 ± 53	118 ± 62	86 ± 56	83 ± 46
Single top	382 ± 68	554 ± 94	262 ± 70	325 ± 79
Dibosons	28 ± 7	37 ± 11	12 ± 5	17 ± 5
Multijet	520 ± 520	550 ± 550	320 ± 320	340 ± 340
Total prediction	4800 ± 1000	6500 ± 1500	6000 ± 1100	7800 ± 1400
Data	4533	6421	6145	8149
$t\bar{t}(400 \text{ GeV})$	20.0 ± 3.3	21.0 ± 3.6	102.0 ± 10.5	98.1 ± 11.1

a range of masses $m_{t'}$ from 250 to 500 GeV in steps of 50 GeV and are normalized to the approximate NNLO theoretical cross sections [20] using the CTEQ6.6 PDF. The MC samples generated by using HERWIG or PYTHIA use the MRST2007 LO* PDF set [28]. All MC samples include multiple pp interactions and are processed through a full simulation [29] of the detector geometry and response using GEANT4 [30] and the same reconstruction software as the data. Simulated events are corrected to match the object identification efficiencies and resolutions determined in data control samples. The total signal detection efficiency, considering both lepton flavors and jet multiplicities analyzed, ranges from 5.2% for $m_{t'} = 250$ GeV to 17.3% for $m_{t'} = 500$ GeV.

This analysis uses the reconstructed heavy quark mass (m_{reco}) as the primary discriminating variable. In the case of events with ≥ 4 jets, m_{reco} is estimated by performing a kinematic likelihood fit [17] to the $t'\bar{t}' \rightarrow W^+ b W^- \bar{b} \rightarrow \ell \nu b q \bar{q}' \bar{b}$ hypothesis, imposing the constraints that t' and \bar{t}' have the same mass and that the mass of the lepton-neutrino system, as well as that of a jet pair, equals the nominal W boson mass. The final-state objects considered are the lepton, E_T^{miss} , and the four jets with highest p_T . Among all possible jet-parton permutations, the one yielding the highest likelihood value after maximization over the fit parameters is kept. In the case of events with exactly three jets, m_{reco} is taken to be the invariant mass of the three-jet system. In order to ensure a robust background prediction in the tail of the m_{reco} distribution, a dynamic binning scheme is adopted; starting from the high side and low side of the distributions, bins are merged until the statistical uncertainty in the sum of the background predictions in that bin drops below 5%.

Systematic uncertainties affecting the normalization and shape of the m_{reco} distribution are estimated for both signal and background, taking into account correlations among processes as well as channels. The dominant sources of uncertainty arise from the modeling of the $t\bar{t}$ background. The uncertainties on the $t\bar{t}$ background come from the theoretical uncertainty on the cross section ($^{+7.0}_{-9.6}\%$) as well as the effects on both normalization and shape of the m_{reco} distribution from a number of sources; these are uncertainties on the fragmentation model (based on the comparison of HERWIG and PYTHIA fragmentations), on the NLO event generator (based on the comparison of MC@NLO and POWHEG [31]), and on the top quark mass (taken to be ± 1 GeV).

The uncertainty on the jet energy scale affects the normalization of signal (2%–12%) and backgrounds (5%–30%) modeled through the simulation, as well as the shape of their m_{reco} distributions.

Uncertainties on the modeling of initial- and final-state QCD radiation, evaluated by varying corresponding generator parameters, are considered as correlated between the $t\bar{t}$ background and the $t'\bar{t}'$ signal.

While the normalization is obtained from the asymmetry measurement, the uncertainties on the normalization of the $W + \text{jets}$ background are derived from measurements of $W + 2$ jets dominated data samples and take into account the uncertainty on the heavy-flavor content of the samples as well as the extrapolation to higher jet multiplicities. The total uncertainty on the $W + \text{jets}$ normalization is 50% and 70% for events with exactly 3 jets and ≥ 4 jets, respectively. Uncertainties on the shape of the m_{reco} distribution for the $W + \text{jets}$ background are estimated by varying the choices of the matching scale (from 15 to 10 GeV) and the factorization scale (from $\mu_F^2 = m_W^2 + \sum p_{T,\text{jet}}^2$ to $\mu_F^2 = m_W^2 + p_{T,W}^2$) in ALPGEN.

Uncertainties on the modeling of the b -tagging algorithms affect the identification of b/c jets (6%–8% for signal and backgrounds containing top quarks and 6%–12% for the other backgrounds) as well as the misidentification of light jets ($< 0.5\%$ for signal and backgrounds containing top quarks and up to 5% for the other backgrounds). The $Z + \text{jets}$, single top, and diboson backgrounds are varied within the uncertainty on their theoretical cross sections. The uncertainty on the multijet background event normalizations is conservatively taken as 100%. Uncertainties on the shapes of the multijet background are derived by varying the lepton identification criteria used to extract this background.

The uncertainties on the lepton identification and trigger efficiencies, as well as their energy scales and resolutions, impact the yields by 3% for electrons and 6% for muons.

Uncertainties on the integrated luminosity (3.7%) [32], jet reconstruction efficiency, jet resolution modeling, effect of multiple pp interactions on the modeling of the E_T^{miss} , and treatment of imperfections in the detector description in the MC simulation are also considered and are all found to have a very small effect on the result.

Good agreement between the data and the background prediction is observed in terms of both overall normalization and shape of the m_{reco} distribution. The m_{reco} distribution is analyzed by using a log-likelihood ratio $LLR = -2 \log(L_{s+b}/L_b)$ as a test statistic, where L_{s+b} (L_b) is a Poisson likelihood to observe the data under the signal-plus-background (background-only) hypothesis. The per-bin signal and background predictions are parameterized in terms of 12 nuisance parameters, describing the effect of leading sources of systematic uncertainty such as jet energy scale, initial- and final-state QCD radiation, and $t\bar{t}$, $W + \text{jets}$, and QCD multijet normalizations. The impact of systematic uncertainties on the sensitivity of the search is reduced by maximizing both likelihood functions, L_{s+b} and L_b , with respect to these nuisance parameters, subject to Gaussian constraints of their prior values. The set of fitted nuisance parameters is chosen based on their overall impact on the search sensitivity, the expected constraining power of the data, and their suitability to be treated as continuous parameters. The simultaneous constraint of

several of these systematic uncertainties is possible because of the inclusion of the 3-jet channel in the analysis. The latter has a higher fraction of $W + \text{jets}$ background than the ≥ 4 -jets channel and provides sensitivity to event migration to different jet multiplicities when varying uncertainties such as jet energy scale or initial- and final-state QCD radiation. In addition to the jet multiplicity spectrum, the jet energy scale affects the peak position of the m_{reco} spectrum for $t\bar{t}$ background and can be constrained owing to the small uncertainty on the measured top quark mass [33]. Nuisance parameters associated with smaller systematic

uncertainties (e.g., lepton identification or trigger) are only weakly constrained.

Figure 1 shows a comparison of the postfit m_{reco} distribution between the data and the background prediction for the combined $e/\mu + 3$ jets and $e/\mu + \geq 4$ jets channels. The fitted parameters are typically within 1 standard deviation of their nominal values, and their uncertainties are consistent with expectations based on pseudoexperiments. Several additional studies were performed to check the integrity of the fitting procedure. The likelihood was verified to be parabolic near the minimum for each of the fitted parameters and to yield reasonable fit uncertainties; the lack of sensitivity to the assumed p_T and η correlation of the jet energy scale uncertainty was verified.

In the absence of any significant data excess, either in the $e + \text{jets}$ or $\mu + \text{jets}$ channels individually or in their combination, 95% C.L. upper limits on the $t'\bar{t}'$ production cross section are derived by using the CL_s method [34], which employs the LLR test statistic described above. Pseudoexperiments are generated under both the signal-plus-background ($s + b$) and background-only (b) hypotheses, taking into account per-bin statistical fluctuations of the total predictions according to Poisson statistics, as well as Gaussian fluctuations in the signal and background expectations describing the effect of systematic uncertainties. The fraction of $s + b$ and b pseudoexperiments with LLR larger than the median or observed LLR defines CL_{s+b} and CL_b for the expected or observed limits, respectively. Signal cross sections for which $CL_s = CL_{s+b}/CL_b < 0.05$ are deemed excluded at the 95% C.L.

The resulting observed and expected upper limits on the $t'\bar{t}'$ production cross section are shown in Fig. 2 as a function of the t' mass, compared to the theoretical prediction, assuming a $BR(t' \rightarrow Wb) = 1$. As a result, an

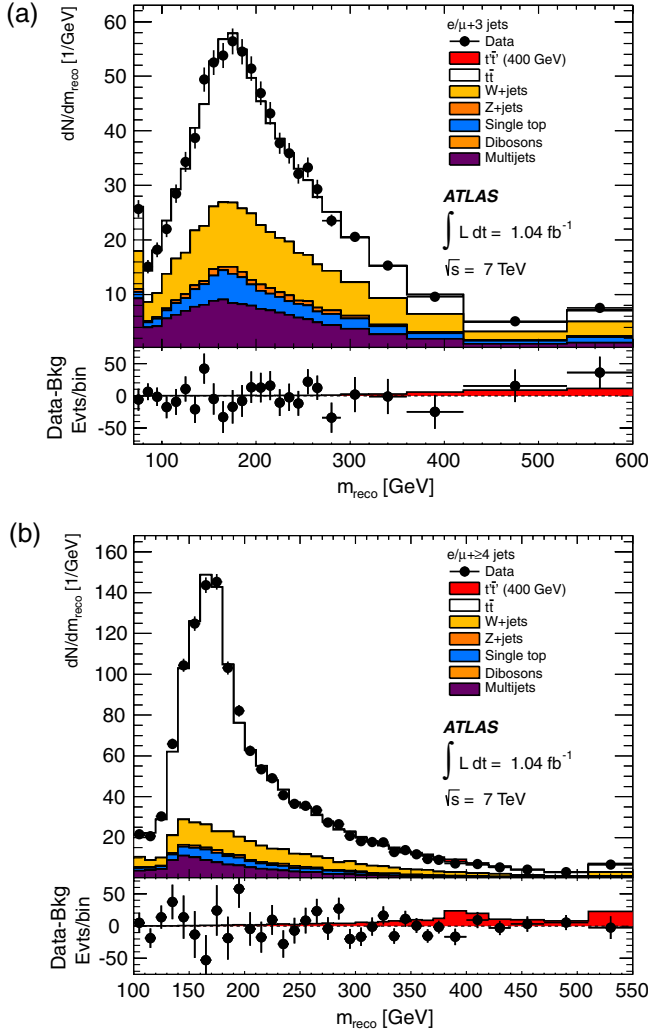


FIG. 1 (color online). m_{reco} distribution in the combined (a) $e/\mu + 3$ jets and (b) $e/\mu + \geq 4$ jets channels. The data (points) are compared to the SM background predictions using the values of the nuisance parameters obtained from the fit to data under the background-only hypothesis (stacked histograms). In the top panels, the bin contents have been divided by bin width. The bottom panels show the background-subtracted data distribution. The underflow and overflow have been folded into the first and last bins, respectively. Also shown is the expected contribution from a signal with mass $m_{t'} = 400$ GeV (histogram).

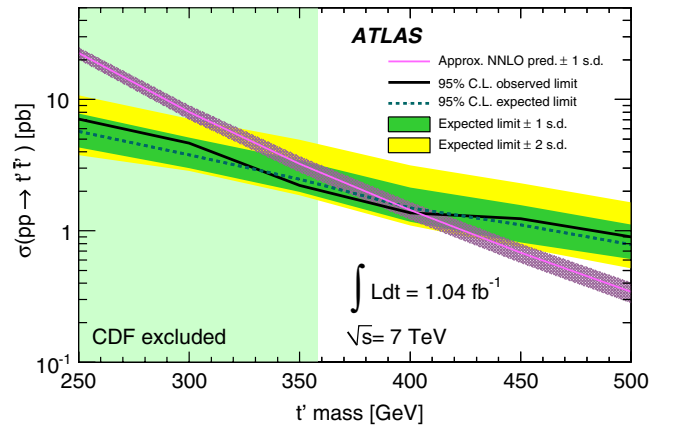


FIG. 2 (color online). Observed (solid line) and expected (dashed line) 95% C.L. upper limits on the $t'\bar{t}'$ cross section as a function of the t' mass. The surrounding shaded bands correspond to the 1 and 2 standard deviations (s.d.) around the expected limit. The thin line shows the theoretical prediction including its 1 s.d. uncertainty band. The shaded area is the mass region previously excluded by the CDF experiment [4].

observed (expected) 95% C.L. lower limit of 404 (394) GeV on the mass of the t' quark is derived.

In summary, a search for $t'\bar{t}'$ production has been performed in the lepton + jets final state under the assumption $BR(t' \rightarrow Wb) = 1$. No significant excess of events in the tail of the m_{reco} distribution was found, resulting in an observed lower limit of $m_{t'} > 404$ GeV at 95% C.L. This represents the most stringent limit to date. This limit is also directly applicable to a down-type vectorlike quark with electric charge of $-4/3$ decaying into a W boson and a b quark [3].

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

[1] F. Abe *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **74**, 2626 (1995); S. Abachi *et al.* (D0 Collaboration), *Phys. Rev. Lett.* **74**, 2632 (1995).
 [2] See, e.g., B. Holdom, W.S. Hou, T. Hurth, M.L. Mangano, S. Sultansoy, and G. Únel, *PMC Phys. A* **3**, 4 (2009), and references therein.
 [3] See, e.g., J.A. Aguilar-Saavedra, *J. High Energy Phys.* **11** (2009) 030, and references therein.
 [4] T. Aaltonen *et al.* (CDF Collaboration), *Phys. Rev. Lett.* **107**, 261801 (2011).

[5] V.M. Abazov *et al.* (D0 Collaboration), *Phys. Rev. Lett.* **107**, 082001 (2011).
 [6] ATLAS Collaboration, [arXiv:1202.3389](https://arxiv.org/abs/1202.3389).
 [7] ATLAS Collaboration, [arXiv:1202.6540](https://arxiv.org/abs/1202.6540) [*Phys. Rev. Lett.* (to be published)].
 [8] ATLAS Collaboration, *JINST* **3**, S08003 (2008).
 [9] Pseudorapidity is defined as $\eta = -\ln[\tan(\theta/2)]$, where θ is the polar angle relative to the beam direction and ϕ is the azimuthal angle in the plane transverse to the beam direction.
 [10] ATLAS Collaboration, [arXiv:1201.1889](https://arxiv.org/abs/1201.1889).
 [11] ATLAS Collaboration, *Eur. Phys. J. C* **71**, 1577 (2011).
 [12] The transverse mass is defined by the formula $m_T = \sqrt{2p_T^\ell E_T^{\text{miss}}(1 - \cos\Delta\phi)}$, where p_T^ℓ is the p_T of the lepton and $\Delta\phi$ is the azimuthal angle separation between the lepton and E_T^{miss} .
 [13] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1844 (2012).
 [14] M. Cacciari, G.P. Salam, and G. Soyez, *J. High Energy Phys.* **04** (2008) 063.
 [15] ATLAS Collaboration, [arXiv:1112.6426](https://arxiv.org/abs/1112.6426) [*Eur. Phys. J. C* (to be published)].
 [16] ATLAS Collaboration, Report No. ATLAS-CONF-2011-102, 2011, <https://cdsweb.cern.ch/record/1369219>.
 [17] ATLAS Collaboration, [arXiv:1203.4211](https://arxiv.org/abs/1203.4211) [*Eur. Phys. J. C* (to be published)].
 [18] S. Frixione and B.R. Webber, *J. High Energy Phys.* **06** (2002) 029; S. Frixione, E. Laenen, P. Motylinski, and B.R. Webber, *J. High Energy Phys.* **03** (2006) 092; S. Frixione, E. Laenen, P. Motylinski, C. White, and B.R. Webber, *J. High Energy Phys.* **07** (2008) 029.
 [19] P.M. Nadolsky, H.-L. Lai, Q.-H. Cao, J. Huston, J. Pumplin, D. Stump, W.-K. Tung, and C.-P. Yuan, *Phys. Rev. D* **78**, 013004 (2008).
 [20] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer, and M. Wiedermann, *Comput. Phys. Commun.* **182**, 1034 (2011).
 [21] N. Kidonakis, *Phys. Rev. D* **83**, 091503 (2011); **81**, 054028 (2010).
 [22] M.L. Mangano, F. Piccinini, A.D. Polosa, M. Moretti, and R. Pittau, *J. High Energy Phys.* **07** (2003) 001.
 [23] K. Melnikov and F. Petriello, *Phys. Rev. D* **74**, 114017 (2006).
 [24] 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.
 [25] J. Butterworth, J. Forshaw, and M. Seymour, *Z. Phys. C* **72**, 637 (1996).
 [26] J. Campbell, R.K. Ellis, and D. Rainwater, *Phys. Rev. D* **68**, 094021 (2003).
 [27] T. Sjostrand, P. Edén, C. Friberg, L. Lönnblad, G. Miu, S. Mrenna, and E. Norrbin, *Comput. Phys. Commun.* **135**, 238 (2001).
 [28] A. Sherstnev and R. Thorne, *Eur. Phys. J. C* **55**, 553 (2008).
 [29] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010).
 [30] S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
 [31] P. Nason, *J. High Energy Phys.* **11** (2004) 040.
 [32] ATLAS Collaboration, *Eur. Phys. J. C* **71**, 1630 (2011); ATLAS-CONF-2011-116, 2011, <https://cdsweb.cern.ch/record/1376384>.

- [33] K. Nakamura *et al.* (Particle Data Group), *J. Phys. G* **37**, 075021 (2010), and 2011 partial update for the 2012 edition.
- [34] T. Junk, *Nucl. Instrum. Methods Phys. Res., Sect. A* **434**, 435 (1999); A.L. Read, *J. Phys. G* **28**, 2693 (2002).
-
- G. Aad,⁴⁷ B. Abbott,¹¹⁰ J. Abdallah,¹¹ A. A. Abdelalim,⁴⁸ A. Abdesselam,¹¹⁷ O. Abdinov,¹⁰ B. Abi,¹¹¹ M. Abolins,⁸⁷ O. S. AbouZeid,¹⁵⁷ H. Abramowicz,¹⁵² H. Abreu,¹¹⁴ E. Acerbi,^{88a,88b} B. S. Acharya,^{163a,163b} L. Adamczyk,³⁷ D. L. Adams,²⁴ T. N. Addy,⁵⁵ J. Adelman,¹⁷⁴ M. Aderholz,⁹⁸ S. Adomeit,⁹⁷ P. Adragna,⁷⁴ T. Adye,¹²⁸ S. Aefsky,²² J. A. Aguilar-Saavedra,^{123b,b} M. Aharrouche,⁸⁰ S. P. Ahlen,²¹ F. Ahles,⁴⁷ A. Ahmad,¹⁴⁷ M. Ahsan,⁴⁰ G. Aielli,^{132a,132b} T. Akdogan,^{18a} T. P. A. Åkesson,⁷⁸ G. Akimoto,¹⁵⁴ A. V. Akimov,⁹³ A. Akiyama,⁶⁶ M. S. Alam,¹ M. A. Alam,⁷⁵ J. Albert,¹⁶⁸ S. Albrand,⁵⁴ M. Aleksa,²⁹ I. N. Aleksandrov,⁶⁴ F. Alessandria,^{88a} C. Alexa,^{25a} G. Alexander,¹⁵² G. Alexandre,⁴⁸ T. Alexopoulos,⁹ M. Alhroob,²⁰ M. Aliev,¹⁵ G. Alimonti,^{88a} J. Alison,¹¹⁹ M. Aliyev,¹⁰ B. M. M. Allbrooke,¹⁷ P. P. Allport,⁷² S. E. Allwood-Spiers,⁵² J. Almond,⁸¹ A. Aloisio,^{101a,101b} R. Alon,¹⁷⁰ A. Alonso,⁷⁸ B. Alvarez Gonzalez,⁸⁷ M. G. Alvigi,^{101a,101b} K. Amako,⁶⁵ P. Amaral,²⁹ C. Amelung,²² V. V. Ammosov,¹²⁷ A. Amorim,^{123a,c} G. Amorós,¹⁶⁶ N. Amram,¹⁵² C. Anastopoulos,²⁹ L. S. Ancu,¹⁶ N. Andari,¹¹⁴ T. Andeen,³⁴ C. F. Anders,²⁰ G. Anders,^{57a} K. J. Anderson,³⁰ A. Andreazza,^{88a,88b} V. Andrei,^{57a} M-L. Andrieux,⁵⁴ X. S. Anduaga,⁶⁹ A. Angerami,³⁴ F. Anghinolfi,²⁹ A. Anisenkov,¹⁰⁶ N. Anjos,^{123a} A. Annovi,⁴⁶ A. Antonaki,⁸ M. Antonelli,⁴⁶ A. Antonov,⁹⁵ J. Antos,^{143b} F. Anulli,^{131a} S. Aoun,⁸² L. Aperio Bella,⁴ R. Apolle,^{117,d} G. Arabidze,⁸⁷ I. Aracena,¹⁴² Y. Arai,⁶⁵ A. T. H. Arce,⁴⁴ S. Arfaoui,¹⁴⁷ J-F. Arguin,¹⁴ E. Erik,^{18a,a} M. Arik,^{18a} A. J. Armbruster,⁸⁶ O. Arnaez,⁸⁰ C. Arnault,¹¹⁴ A. Artamonov,⁹⁴ G. Artoni,^{131a,131b} D. Arutinov,²⁰ S. Asai,¹⁵⁴ R. Asfandiyarov,¹⁷¹ S. Ask,²⁷ B. Åsman,^{145a,145b} L. Asquith,⁵ K. Assamagan,²⁴ A. Astbury,¹⁶⁸ A. Astvatsatourov,⁵¹ B. Aubert,⁴ E. Auge,¹¹⁴ K. Augsten,¹²⁶ M. Aourousseau,^{144a} G. Avolio,¹⁶² R. Avramidou,⁹ D. Axen,¹⁶⁷ C. Ay,⁵³ G. Azuelos,^{92,e} Y. Azuma,¹⁵⁴ M. A. Baak,²⁹ G. Baccaglioni,^{88a} C. Bacci,^{133a,133b} A. M. Bach,¹⁴ H. Bachacou,¹³⁵ K. Bachas,²⁹ M. Backes,⁴⁸ M. Backhaus,²⁰ E. Badescu,^{25a} P. Bagnaia,^{131a,131b} S. Bahinipati,² Y. Bai,^{32a} D. C. Bailey,¹⁵⁷ T. Bain,¹⁵⁷ J. T. Baines,¹²⁸ O. K. Baker,¹⁷⁴ M. D. Baker,²⁴ S. Baker,⁷⁶ E. Banas,³⁸ P. Banerjee,⁹² Sw. Banerjee,¹⁷¹ D. Banfi,²⁹ A. Bangert,¹⁴⁹ V. Bansal,¹⁶⁸ H. S. Bansil,¹⁷ L. Barak,¹⁷⁰ S. P. Baranov,⁹³ A. Barashkou,⁶⁴ A. Barbaro Galtieri,¹⁴ T. Barber,⁴⁷ E. L. Barberio,⁸⁵ D. Barberis,^{49a,49b} M. Barbero,²⁰ D. Y. Bardin,⁶⁴ T. Barillari,⁹⁸ M. Barisonzi,¹⁷³ T. Barklow,¹⁴² N. Barlow,²⁷ B. M. Barnett,¹²⁸ R. M. Barnett,¹⁴ A. Baroncelli,^{133a} G. Barone,⁴⁸ A. J. Barr,¹¹⁷ F. Barreiro,⁷⁹ J. Barreiro Guimarães da Costa,⁵⁶ P. Barrillon,¹¹⁴ R. Bartoldus,¹⁴² A. E. Barton,⁷⁰ V. Bartsch,¹⁴⁸ R. L. Bates,⁵² L. Batkova,^{143a} J. R. Batley,²⁷ A. Battaglia,¹⁶ M. Battistin,²⁹ F. Bauer,¹³⁵ H. S. Bawa,^{142,f} S. Beale,⁹⁷ T. Beau,⁷⁷ P. H. Beauchemin,¹⁶⁰ R. Beccherle,^{49a} P. Bechtel,²⁰ H. P. Beck,¹⁶ S. Becker,⁹⁷ M. Beckingham,¹³⁷ K. H. Becks,¹⁷³ A. J. Beddall,^{18c} A. Beddall,^{18c} S. Bedikian,¹⁷⁴ V. A. Bednyakov,⁶⁴ C. P. Bee,⁸² M. Begel,²⁴ S. Behar Harpaz,¹⁵¹ P. K. Behera,⁶² M. Beimforde,⁹⁸ C. Belanger-Champagne,⁸⁴ P. J. Bell,⁴⁸ W. H. Bell,⁴⁸ G. Bella,¹⁵² L. Bellagamba,^{19a} F. Bellina,²⁹ M. Bellomo,²⁹ A. Belloni,⁵⁶ O. Beloborodova,^{106,g} K. Belotskiy,⁹⁵ O. Beltramello,²⁹ S. Ben Ami,¹⁵¹ O. Benary,¹⁵² D. Benckroun,^{134a} C. Benchouk,⁸² M. Bendel,⁸⁰ N. Benekos,¹⁶⁴ Y. Benhammou,¹⁵² E. Benhar Noccioli,⁴⁸ J. A. Benitez Garcia,^{158b} D. P. Benjamin,⁴⁴ M. Benoit,¹¹⁴ J. R. Bensinger,²² K. Benslama,¹²⁹ S. Bentvelsen,¹⁰⁴ D. Berge,²⁹ E. Bergeaas Kuutmann,⁴¹ N. Berger,⁴ F. Berghaus,¹⁶⁸ E. Berglund,¹⁰⁴ J. Beringer,¹⁴ P. Bernat,⁷⁶ R. Bernhard,⁴⁷ C. Bernius,²⁴ T. Berry,⁷⁵ C. Bertella,⁸² A. Bertin,^{19a,19b} F. Bertinelli,²⁹ F. Bertolucci,^{121a,121b} M. I. Besana,^{88a,88b} N. Besson,¹³⁵ S. Bethke,⁹⁸ W. Bhimji,⁴⁵ R. M. Bianchi,²⁹ M. Bianco,^{71a,71b} O. Biebel,⁹⁷ S. P. Bieniek,⁷⁶ K. Bierwagen,⁵³ J. Biesiada,¹⁴ M. Biglietti,^{133a} H. Bilokon,⁴⁶ M. Bindi,^{19a,19b} S. Binet,¹¹⁴ A. Bingul,^{18c} C. Bini,^{131a,131b} C. Biscarat,¹⁷⁶ U. Bitenc,⁴⁷ K. M. Black,²¹ R. E. Blair,⁵ J.-B. Blanchard,¹³⁵ G. Blanchot,²⁹ T. Blazek,^{143a} C. Blocker,²² J. Blocki,³⁸ A. Blondel,⁴⁸ W. Blum,⁸⁰ U. Blumenschein,⁵³ G. J. Bobbink,¹⁰⁴ V. B. Bobrovnikov,¹⁰⁶ S. S. Bocchetta,⁷⁸ A. Bocci,⁴⁴ C. R. Boddy,¹¹⁷ M. Boehler,⁴¹ J. Boek,¹⁷³ N. Boelaert,³⁵ J. A. Bogaerts,²⁹ A. Bogdanchikov,¹⁰⁶ A. Bogouch,^{89,a} C. Bohm,^{145a} V. Boisvert,⁷⁵ T. Bold,³⁷ V. Boldea,^{25a} N. M. Bolnet,¹³⁵ M. Bona,⁷⁴ V. G. Bondarenko,⁹⁵ M. Bondioli,¹⁶² M. Boonekamp,¹³⁵ C. N. Booth,¹³⁸ S. Bordini,⁷⁷ C. Borer,¹⁶ A. Borisov,¹²⁷ G. Borisso,⁷⁰ I. Borjanovic,^{12a} M. Borri,⁸¹ S. Borroni,⁸⁶ V. Bortolotto,^{133a,133b} K. Bos,¹⁰⁴ D. Boscherini,^{19a} M. Bosman,¹¹ H. Boterenbrood,¹⁰⁴ D. Botterill,¹²⁸ J. Bouchami,⁹² J. Boudreau,¹²² E. V. Bouhova-Thacker,⁷⁰ D. Boumediene,³³ C. Bourdarios,¹¹⁴ N. Bousson,⁸² A. Boveia,³⁰ J. Boyd,²⁹ I. R. Boyko,⁶⁴ N. I. Bozhko,¹²⁷ I. Bozovic-Jelisavcic,^{12b} J. Bracinik,¹⁷ A. Braem,²⁹ P. Branchini,^{133a} G. W. Brandenburg,⁵⁶ A. Brandt,⁷ G. Brandt,¹¹⁷ O. Brandt,⁵³ U. Bratzler,¹⁵⁵ B. Brau,⁸³ J. E. Brau,¹¹³ H. M. Braun,¹⁷³ B. Brelier,¹⁵⁷ J. Bremer,²⁹ R. Brenner,¹⁶⁵ S. Bressler,¹⁷⁰ D. Britton,⁵² F. M. Brochu,²⁷ I. Brock,²⁰ R. Brock,⁸⁷ T. J. Brodbeck,⁷⁰ E. Brodet,¹⁵² F. Broggi,^{88a} C. Bromberg,⁸⁷ J. Bronner,⁹⁸ G. Brooijmans,³⁴ W. K. Brooks,^{31b}

G. Brown,⁸¹ H. Brown,⁷ P. A. Bruckman de Renstrom,³⁸ D. Bruncko,^{143b} R. Bruneliere,⁴⁷ S. Brunet,⁶⁰ A. Bruni,^{19a} G. Bruni,^{19a} M. Bruschi,^{19a} T. Buanes,¹³ Q. Buat,⁵⁴ F. Bucci,⁴⁸ J. Buchanan,¹¹⁷ N. J. Buchanan,² P. Buchholz,¹⁴⁰ R. M. Buckingham,¹¹⁷ A. G. Buckley,⁴⁵ S. I. Buda,^{25a} I. A. Budagov,⁶⁴ B. Budick,¹⁰⁷ V. Büscher,⁸⁰ L. Bugge,¹¹⁶ O. Bulekov,⁹⁵ M. Bunse,⁴² T. Buran,¹¹⁶ H. Burckhart,²⁹ S. Burdin,⁷² T. Burgess,¹³ S. Burke,¹²⁸ E. Busato,³³ P. Bussey,⁵² C. P. Buszello,¹⁶⁵ F. Butin,²⁹ B. Butler,¹⁴² J. M. Butler,²¹ C. M. Buttar,⁵² J. M. Butterworth,⁷⁶ W. Buttinger,²⁷ S. Cabrera Urbán,¹⁶⁶ D. Caforio,^{19a,19b} O. Cakir,^{3a} P. Calafiura,¹⁴ G. Calderini,⁷⁷ P. Calfayan,⁹⁷ R. Calkins,¹⁰⁵ L. P. Caloba,^{23a} R. Caloi,^{131a,131b} D. Calvet,³³ S. Calvet,³³ R. Camacho Toro,³³ P. Camari,^{132a,132b} M. Cambiaghi,^{118a,118b} D. Cameron,¹¹⁶ L. M. Caminada,¹⁴ S. Campana,²⁹ M. Campanelli,⁷⁶ V. Canale,^{101a,101b} F. Canelli,^{30,h} A. Canepa,^{158a} J. Cantero,⁷⁹ L. Capasso,^{101a,101b} M. D. M. Capeans Garrido,²⁹ I. Caprini,^{25a} M. Caprini,^{25a} D. Capriotti,⁹⁸ M. Capua,^{36a,36b} R. Caputo,⁸⁰ C. Caramarcu,²⁴ R. Cardarelli,^{132a} T. Carli,²⁹ G. Carlino,^{101a} L. Carminati,^{88a,88b} B. Caron,⁸⁴ S. Caron,¹⁰³ G. D. Carrillo Montoya,¹⁷¹ A. A. Carter,⁷⁴ J. R. Carter,²⁷ J. Carvalho,^{123a,i} D. Casadei,¹⁰⁷ M. P. Casado,¹¹ M. Cascella,^{121a,121b} C. Caso,^{49a,49b,a} A. M. Castaneda Hernandez,¹⁷¹ E. Castaneda-Miranda,¹⁷¹ V. Castillo Gimenez,¹⁶⁶ N. F. Castro,^{123a} G. Cataldi,^{71a} F. Cataneo,²⁹ A. Catinaccio,²⁹ J. R. Catmore,²⁹ A. Cattai,²⁹ G. Cattani,^{132a,132b} S. Caughron,⁸⁷ D. Cauz,^{163a,163c} P. Cavalleri,⁷⁷ D. Cavalli,^{88a} M. Cavalli-Sforza,¹¹ V. Cavasinni,^{121a,121b} F. Ceradini,^{133a,133b} A. S. Cerqueira,^{23b} A. Cerri,²⁹ L. Cerrito,⁷⁴ F. Cerutti,⁴⁶ S. A. Cetin,^{18b} F. Cevenini,^{101a,101b} A. Chafaq,^{134a} D. Chakraborty,¹⁰⁵ K. Chan,² B. Chapleau,⁸⁴ J. D. Chapman,²⁷ J. W. Chapman,⁸⁶ E. Chareyre,⁷⁷ D. G. Charlton,¹⁷ V. Chavda,⁸¹ C. A. Chavez Barajas,²⁹ S. Cheatham,⁸⁴ S. Chekanov,⁵ S. V. Chekulaev,^{158a} G. A. Chelkov,⁶⁴ M. A. Chelstowska,¹⁰³ C. Chen,⁶³ H. Chen,²⁴ S. Chen,^{32c} T. Chen,^{32c} X. Chen,¹⁷¹ S. Cheng,^{32a} A. Cheplakov,⁶⁴ V. F. Chepurinov,⁶⁴ R. Cherkaoui El Moursli,^{134e} V. Chernyatin,²⁴ E. Cheu,⁶ S. L. Cheung,¹⁵⁷ L. Chevalier,¹³⁵ G. Chiefari,^{101a,101b} L. Chikovani,^{50a} J. T. Childers,²⁹ A. Chilingarov,⁷⁰ G. Chiodini,^{71a} A. S. Chisholm,¹⁷ M. V. Chizhov,⁶⁴ G. Choudalakis,³⁰ S. Chouridou,¹³⁶ I. A. Christidi,⁷⁶ A. Christov,⁴⁷ D. Chromek-Burckhart,²⁹ M. L. Chu,¹⁵⁰ J. Chudoba,¹²⁴ G. Ciapetti,^{131a,131b} K. Ciba,³⁷ A. K. Ciftci,^{3a} R. Ciftci,^{3a} D. Cinca,³³ V. Cindro,⁷³ M. D. Ciobotaru,¹⁶² C. Ciocca,^{19a} A. Ciocio,¹⁴ M. Cirilli,⁸⁶ M. Citterio,^{88a} M. Ciubancan,^{25a} A. Clark,⁴⁸ P. J. Clark,⁴⁵ W. Cleland,¹²² J. C. Clemens,⁸² B. Clement,⁵⁴ C. Clement,^{145a,145b} R. W. Clifft,¹²⁸ Y. Coadou,⁸² M. Cobal,^{163a,163c} A. Cocco,¹⁷¹ J. Cochran,⁶³ P. Coe,¹¹⁷ J. G. Cogan,¹⁴² J. Coggeshall,¹⁶⁴ E. Cogneras,¹⁷⁶ J. Colas,⁴ A. P. Colijn,¹⁰⁴ N. J. Collins,¹⁷ C. Collins-Tooth,⁵² J. Collot,⁵⁴ G. Colon,⁸³ P. Conde Muiño,^{123a} E. Coniavitis,¹¹⁷ M. C. Conidi,¹¹ M. Consonni,¹⁰³ V. Consorti,⁴⁷ S. Constantinescu,^{25a} C. Conta,^{118a,118b} F. Conventi,^{101a,j} J. Cook,²⁹ M. Cooke,¹⁴ B. D. Cooper,⁷⁶ A. M. Cooper-Sarkar,¹¹⁷ K. Copic,¹⁴ T. Cornelissen,¹⁷³ M. Corradi,^{19a} F. Corriveau,^{84,k} A. Cortes-Gonzalez,¹⁶⁴ G. Cortiana,⁹⁸ G. Costa,^{88a} M. J. Costa,¹⁶⁶ D. Costanzo,¹³⁸ T. Costin,³⁰ D. Côté,²⁹ R. Coura Torres,^{23a} L. Courneyea,¹⁶⁸ G. Cowan,⁷⁵ C. Cowden,²⁷ B. E. Cox,⁸¹ K. Cranmer,¹⁰⁷ F. Crescioli,^{121a,121b} M. Cristinziani,²⁰ G. Crosetti,^{36a,36b} R. Crupi,^{71a,71b} S. Crépe-Renaudin,⁵⁴ C.-M. Cuciuc,^{25a} C. Cuenca Almenar,¹⁷⁴ T. Cuhadar Donszelmann,¹³⁸ M. Curatolo,⁴⁶ C. J. Curtis,¹⁷ C. Cuthbert,¹⁴⁹ P. Cwetanski,⁶⁰ H. Czirr,¹⁴⁰ P. Czodrowski,⁴³ Z. Czyczula,¹⁷⁴ S. D'Auria,⁵² M. D'Onofrio,⁷² A. D'Orazio,^{131a,131b} P. V. M. Da Silva,^{23a} C. Da Via,⁸¹ W. Dabrowski,³⁷ T. Dai,⁸⁶ C. Dallapiccola,⁸³ M. Dam,³⁵ M. Dameri,^{49a,49b} D. S. Damiani,¹³⁶ H. O. Danielsson,²⁹ D. Dannheim,⁹⁸ V. Dao,⁴⁸ G. Darbo,^{49a} G. L. Darlea,^{25b} W. Davey,²⁰ T. Davidek,¹²⁵ N. Davidson,⁸⁵ R. Davidson,⁷⁰ E. Davies,^{117,d} M. Davies,⁹² A. R. Davison,⁷⁶ Y. Davygora,^{57a} E. Dawe,¹⁴¹ I. Dawson,¹³⁸ J. W. Dawson,^{5,a} R. K. Daya-Ishmukhametova,²² K. De,⁷ R. de Asmundis,^{101a} S. De Castro,^{19a,19b} P. E. De Castro Faria Salgado,²⁴ S. De Cecco,⁷⁷ J. de Graat,⁹⁷ N. De Groot,¹⁰³ P. de Jong,¹⁰⁴ C. De La Taille,¹¹⁴ H. De la Torre,⁷⁹ B. De Lotto,^{163a,163c} L. de Mora,⁷⁰ L. De Nooij,¹⁰⁴ D. De Pedis,^{131a} A. De Salvo,^{131a} U. De Sanctis,^{163a,163c} A. De Santo,¹⁴⁸ J. B. De Vivie De Regie,¹¹⁴ S. Dean,⁷⁶ W. J. Dearnaley,⁷⁰ R. Debebe,²⁴ C. Debenedetti,⁴⁵ D. V. Dedovich,⁶⁴ J. Degenhardt,¹¹⁹ M. Dehchar,¹¹⁷ C. Del Papa,^{163a,163c} J. Del Peso,⁷⁹ T. Del Prete,^{121a,121b} T. Delemontex,⁵⁴ M. Deliyergiyev,⁷³ A. Dell'Acqua,²⁹ L. Dell'Asta,²¹ M. Della Pietra,^{101a,j} D. della Volpe,^{101a,101b} M. Delmastro,⁴ N. Delruelle,²⁹ P. A. Delsart,⁵⁴ C. Deluca,¹⁴⁷ S. Demers,¹⁷⁴ M. Demichev,⁶⁴ B. Demirköz,¹¹¹ J. Deng,¹⁶² S. P. Denisov,¹²⁷ D. Derendarz,³⁸ J. E. Derkaoui,^{134d} F. Derue,⁷⁷ P. Dervan,⁷² K. Desch,²⁰ E. Devetak,¹⁴⁷ P. O. Deviveiros,¹⁰⁴ A. Dewhurst,¹²⁸ B. DeWilde,¹⁴⁷ S. Dhaliwal,¹⁵⁷ R. Dhullipudi,^{24,m} A. Di Ciaccio,^{132a,132b} L. Di Ciaccio,⁴ A. Di Girolamo,²⁹ B. Di Girolamo,²⁹ S. Di Luise,^{133a,133b} A. Di Mattia,¹⁷¹ B. Di Micco,²⁹ R. Di Nardo,⁴⁶ A. Di Simone,^{132a,132b} R. Di Sipio,^{19a,19b} M. A. Diaz,^{31a} F. Diblen,^{18c} E. B. Diehl,⁸⁶ J. Dietrich,⁴¹ T. A. Dietzsch,^{57a} S. Diglio,⁸⁵ K. Dindar Yagci,³⁹ J. Dingfelder,²⁰ C. Dionisi,^{131a,131b} P. Dita,^{25a} S. Dita,^{25a} F. Dittus,²⁹ F. Djama,⁸² T. Djobava,^{50b} M. A. B. do Vale,^{23c} A. Do Valle Wemans,^{123a} T. K. O. Doan,⁴ M. Dobbs,⁸⁴ R. Dobinson,^{29,a} D. Dobos,²⁹ E. Dobson,^{29,n} J. Dodd,³⁴ C. Doglioni,⁴⁸ T. Doherty,⁵² Y. Doi,^{65,a}

J. Dolejsi,¹²⁵ I. Dolenc,⁷³ Z. Dolezal,¹²⁵ B. A. Dolgoshein,^{95,a} T. Dohmae,¹⁵⁴ M. Donadelli,^{23d} M. Donega,¹¹⁹ J. Donini,³³ J. Dopke,²⁹ A. Doria,^{101a} A. Dos Anjos,¹⁷¹ M. Dosil,¹¹ A. Dotti,^{121a,121b} M. T. Dova,⁶⁹ J. D. Dowell,¹⁷ A. D. Doxiadis,¹⁰⁴ A. T. Doyle,⁵² Z. Drasal,¹²⁵ J. Drees,¹⁷³ N. Dressnandt,¹¹⁹ H. Drevermann,²⁹ C. Driouichi,³⁵ M. Dris,⁹ J. Dubbert,⁹⁸ S. Dube,¹⁴ E. Duchovni,¹⁷⁰ G. Duckeck,⁹⁷ A. Dudarev,²⁹ F. Dudziak,⁶³ M. Dührssen,²⁹ I. P. Duerdoth,⁸¹ L. Duflot,¹¹⁴ M-A. Dufour,⁸⁴ M. Dunford,²⁹ H. Duran Yildiz,^{3a} R. Duxfield,¹³⁸ M. Dwuznik,³⁷ F. Dydak,²⁹ M. Düren,⁵¹ W. L. Ebenstein,⁴⁴ J. Ebke,⁹⁷ S. Eckweiler,⁸⁰ K. Edmonds,⁸⁰ C. A. Edwards,⁷⁵ N. C. Edwards,⁵² W. Ehrenfeld,⁴¹ T. Ehrich,⁹⁸ T. Eifert,¹⁴² G. Eigen,¹³ K. Einsweiler,¹⁴ E. Eisenhandler,⁷⁴ T. Ekelof,¹⁶⁵ M. El Kacimi,^{134c} M. Ellert,¹⁶⁵ S. Elles,⁴ F. Ellinghaus,⁸⁰ K. Ellis,⁷⁴ N. Ellis,²⁹ J. Elmsheuser,⁹⁷ M. Elsing,²⁹ D. Emeliyanov,¹²⁸ R. Engelmann,¹⁴⁷ A. Engl,⁹⁷ B. Epp,⁶¹ A. Eppig,⁸⁶ J. Erdmann,⁵³ A. Ereditato,¹⁶ D. Eriksson,^{145a} J. Ernst,¹ M. Ernst,²⁴ J. Ernwein,¹³⁵ D. Errede,¹⁶⁴ S. Errede,¹⁶⁴ E. Ertel,⁸⁰ M. Escalier,¹¹⁴ C. Escobar,¹²² X. Espinal Curull,¹¹ B. Esposito,⁴⁶ F. Etienne,⁸² A. I. Etienvre,¹³⁵ E. Etzion,¹⁵² D. Evangelakou,⁵³ H. Evans,⁶⁰ L. Fabbri,^{19a,19b} C. Fabre,²⁹ R. M. Fakhruddinov,¹²⁷ S. Falciano,^{131a} Y. Fang,¹⁷¹ M. Fanti,^{88a,88b} A. Farbin,⁷ A. Farilla,^{133a} J. Farley,¹⁴⁷ T. Farooque,¹⁵⁷ S. M. Farrington,¹¹⁷ P. Farthouat,²⁹ P. Fassnacht,²⁹ D. Fassouliotis,⁸ B. Fatholahzadeh,¹⁵⁷ A. Favareto,^{88a,88b} L. Fayard,¹¹⁴ S. Fazio,^{36a,36b} R. Febbraro,³³ P. Federic,^{143a} O. L. Fedin,¹²⁰ W. Fedorko,⁸⁷ M. Fehling-Kaschek,⁴⁷ L. Feligioni,⁸² D. Fellmann,⁵ C. Feng,^{32d} E. J. Feng,³⁰ A. B. Fenyuk,¹²⁷ J. Ferencei,^{143b} J. Ferland,⁹² W. Fernando,¹⁰⁸ S. Ferrag,⁵² J. Ferrando,⁵² V. Ferrara,⁴¹ A. Ferrari,¹⁶⁵ P. Ferrari,¹⁰⁴ R. Ferrari,^{118a} D. E. Ferreira de Lima,⁵² A. Ferrer,¹⁶⁶ M. L. Ferrer,⁴⁶ D. Ferrere,⁴⁸ C. Ferretti,⁸⁶ A. Ferretto Parodi,^{49a,49b} M. Fiascaris,³⁰ F. Fiedler,⁸⁰ A. Filipčič,⁷³ A. Filippas,⁹ F. Filthaut,¹⁰³ M. Fincke-Keeler,¹⁶⁸ M. C. N. Fiolhais,^{123a,i} L. Fiorini,¹⁶⁶ A. Firan,³⁹ G. Fischer,⁴¹ P. Fischer,²⁰ M. J. Fisher,¹⁰⁸ M. Flechl,⁴⁷ I. Fleck,¹⁴⁰ J. Fleckner,⁸⁰ P. Fleischmann,¹⁷² S. Fleischmann,¹⁷³ T. Flick,¹⁷³ A. Floderus,⁷⁸ L. R. Flores Castillo,¹⁷¹ M. J. Flowerdew,⁹⁸ M. Fokitis,⁹ T. Fonseca Martin,¹⁶ D. A. Forbush,¹³⁷ A. Formica,¹³⁵ A. Forti,⁸¹ D. Fortin,^{158a} J. M. Foster,⁸¹ D. Fournier,¹¹⁴ A. Foussat,²⁹ A. J. Fowler,⁴⁴ K. Fowler,¹³⁶ H. Fox,⁷⁰ P. Francavilla,¹¹ S. Franchino,^{118a,118b} D. Francis,²⁹ T. Frank,¹⁷⁰ M. Franklin,⁵⁶ S. Franz,²⁹ M. Fraternali,^{118a,118b} S. Fratina,¹¹⁹ S. T. French,²⁷ F. Friedrich,⁴³ R. Froeschl,²⁹ D. Froidevaux,²⁹ J. A. Frost,²⁷ C. Fukunaga,¹⁵⁵ E. Fullana Torregrosa,²⁹ J. Fuster,¹⁶⁶ C. Gabaldon,²⁹ O. Gabizon,¹⁷⁰ T. Gadfort,²⁴ S. Gadomski,⁴⁸ G. Gagliardi,^{49a,49b} P. Gagnon,⁶⁰ C. Galea,⁹⁷ E. J. Gallas,¹¹⁷ V. Gallo,¹⁶ B. J. Gallop,¹²⁸ P. Gallus,¹²⁴ K. K. Gan,¹⁰⁸ Y. S. Gao,^{142,f} V. A. Gapienko,¹²⁷ A. Gaponenko,¹⁴ F. Garbersson,¹⁷⁴ M. Garcia-Sciveres,¹⁴ C. García,¹⁶⁶ J. E. García Navarro,¹⁶⁶ R. W. Gardner,³⁰ N. Garelli,²⁹ H. Garitaonandia,¹⁰⁴ V. Garonne,²⁹ J. Garvey,¹⁷ C. Gatti,⁴⁶ G. Gaudio,^{118a} B. Gaur,¹⁴⁰ L. Gauthier,¹³⁵ I. L. Gavrilenko,⁹³ C. Gay,¹⁶⁷ G. Gaycken,²⁰ J-C. Gayde,²⁹ E. N. Gazis,⁹ P. Ge,^{32d} C. N. P. Gee,¹²⁸ D. A. A. Geerts,¹⁰⁴ Ch. Geich-Gimbel,²⁰ K. Gellerstedt,^{145a,145b} C. Gemme,^{49a} A. Gemmell,⁵² M. H. Genest,⁵⁴ S. Gentile,^{131a,131b} M. George,⁵³ S. George,⁷⁵ P. Gerlach,¹⁷³ A. Gershon,¹⁵² C. Geweniger,^{57a} H. Ghazlane,^{134b} N. Ghodbane,³³ B. Giacobbe,^{19a} S. Giagu,^{131a,131b} V. Giakoumopoulou,⁸ V. Giangiobbe,¹¹ F. Gianotti,²⁹ B. Gibbard,²⁴ A. Gibson,¹⁵⁷ S. M. Gibson,²⁹ L. M. Gilbert,¹¹⁷ V. Gilevsky,⁹⁰ D. Gillberg,²⁸ A. R. Gillman,¹²⁸ D. M. Gingrich,^{2,e} J. Ginzburg,¹⁵² N. Giokaris,⁸ M. P. Giordani,^{163c} R. Giordano,^{101a,101b} F. M. Giorgi,¹⁵ P. Giovannini,⁹⁸ P. F. Giraud,¹³⁵ D. Giugni,^{88a} M. Giunta,⁹² P. Giusti,^{19a} B. K. Gjelsten,¹¹⁶ L. K. Gladilin,⁹⁶ C. Glasman,⁷⁹ J. Glatzer,⁴⁷ A. Glazov,⁴¹ K. W. Glitza,¹⁷³ G. L. Glonti,⁶⁴ J. R. Goddard,⁷⁴ J. Godfrey,¹⁴¹ J. Godlewski,²⁹ M. Goebel,⁴¹ T. Göpfert,⁴³ C. Goeringer,⁸⁰ C. Gössling,⁴² T. Göttfert,⁹⁸ S. Goldfarb,⁸⁶ T. Golling,¹⁷⁴ A. Gomes,^{123a,c} L. S. Gomez Fajardo,⁴¹ R. Gonçalves,⁷⁵ J. Goncalves Pinto Firmino Da Costa,⁴¹ L. Gonella,²⁰ A. Gonidec,²⁹ S. Gonzalez,¹⁷¹ S. González de la Hoz,¹⁶⁶ G. Gonzalez Parra,¹¹ M. L. Gonzalez Silva,²⁶ S. Gonzalez-Sevilla,⁴⁸ J. J. Goodson,¹⁴⁷ L. Goossens,²⁹ P. A. Gorbounov,⁹⁴ H. A. Gordon,²⁴ I. Gorelov,¹⁰² G. Gorfine,¹⁷³ B. Gorini,²⁹ E. Gorini,^{71a,71b} A. Gorišek,⁷³ E. Gornicki,³⁸ S. A. Gorokhov,¹²⁷ V. N. Goryachev,¹²⁷ B. Gosdzik,⁴¹ M. Gosselink,¹⁰⁴ M. I. Gostkin,⁶⁴ I. Gough Eschrich,¹⁶² M. Gouighri,^{134a} D. Goujdami,^{134c} M. P. Goulette,⁴⁸ A. G. Goussiou,¹³⁷ C. Goy,⁴ S. Gozpinar,²² I. Grabowska-Bold,³⁷ P. Grafström,²⁹ K-J. Grahm,⁴¹ F. Grancagnolo,^{71a} S. Grancagnolo,¹⁵ V. Grassi,¹⁴⁷ V. Gratchev,¹²⁰ N. Grau,³⁴ H. M. Gray,²⁹ J. A. Gray,¹⁴⁷ E. Graziani,^{133a} O. G. Grebenyuk,¹²⁰ T. Greenshaw,⁷² Z. D. Greenwood,^{24,m} K. Gregersen,³⁵ I. M. Gregor,⁴¹ P. Grenier,¹⁴² J. Griffiths,¹³⁷ N. Grigalashvili,⁶⁴ A. A. Grillo,¹³⁶ S. Grinstein,¹¹ Y. V. Grishkevich,⁹⁶ J.-F. Grivaz,¹¹⁴ M. Groh,⁹⁸ E. Gross,¹⁷⁰ J. Grosse-Knetter,⁵³ J. Groth-Jensen,¹⁷⁰ K. Grybel,¹⁴⁰ V. J. Guarino,⁵ D. Guest,¹⁷⁴ C. Guichenev,³³ A. Guida,^{71a,71b} S. Guindon,⁵³ H. Guler,^{84,o} J. Gunther,¹²⁴ B. Guo,¹⁵⁷ J. Guo,³⁴ A. Gupta,³⁰ Y. Gusakov,⁶⁴ V. N. Gushchin,¹²⁷ P. Gutierrez,¹¹⁰ N. Guttman,¹⁵² O. Gutzwiller,¹⁷¹ C. Guyot,¹³⁵ C. Gwenlan,¹¹⁷ C. B. Gwilliam,⁷² A. Haas,¹⁴² S. Haas,²⁹ C. Haber,¹⁴ H. K. Hadavand,³⁹ D. R. Hadley,¹⁷ P. Haefner,⁹⁸ F. Hahn,²⁹ S. Haider,²⁹ Z. Hajduk,³⁸ H. Hakobyan,¹⁷⁵ D. Hall,¹¹⁷ J. Haller,⁵³ K. Hamacher,¹⁷³ P. Hamal,¹¹² M. Hamer,⁵³ A. Hamilton,^{144b,p}

S. Hamilton,¹⁶⁰ H. Han,^{32a} L. Han,^{32b} K. Hanagaki,¹¹⁵ K. Hanawa,¹⁵⁹ M. Hance,¹⁴ C. Handel,⁸⁰ P. Hanke,^{57a}
 J. R. Hansen,³⁵ J. B. Hansen,³⁵ J. D. Hansen,³⁵ P. H. Hansen,³⁵ P. Hansson,¹⁴² K. Hara,¹⁵⁹ G. A. Hare,¹³⁶
 T. Harenberg,¹⁷³ S. Harkusha,⁸⁹ D. Harper,⁸⁶ R. D. Harrington,⁴⁵ O. M. Harris,¹³⁷ K. Harrison,¹⁷ J. Hartert,⁴⁷
 F. Hartjes,¹⁰⁴ T. Haruyama,⁶⁵ A. Harvey,⁵⁵ S. Hasegawa,¹⁰⁰ Y. Hasegawa,¹³⁹ S. Hassani,¹³⁵ M. Hatch,²⁹ D. Hauff,⁹⁸
 S. Haug,¹⁶ M. Hauschild,²⁹ R. Hauser,⁸⁷ M. Havranek,²⁰ B. M. Hawes,¹¹⁷ C. M. Hawkes,¹⁷ R. J. Hawkings,²⁹
 A. D. Hawkins,⁷⁸ D. Hawkins,¹⁶² T. Hayakawa,⁶⁶ T. Hayashi,¹⁵⁹ D. Hayden,⁷⁵ H. S. Hayward,⁷² S. J. Haywood,¹²⁸
 E. Hazen,²¹ M. He,^{32d} S. J. Head,¹⁷ V. Hedberg,⁷⁸ L. Heelan,⁷ S. Heim,⁸⁷ B. Heinemann,¹⁴ S. Heisterkamp,³⁵
 L. Helary,⁴ C. Heller,⁹⁷ M. Heller,²⁹ S. Hellman,^{145a,145b} D. Hellmich,²⁰ C. Helsen,¹¹ R. C. W. Henderson,⁷⁰
 M. Henke,^{57a} A. Henrichs,⁵³ A. M. Henriques Correia,²⁹ S. Henrot-Versille,¹¹⁴ F. Henry-Couannier,⁸² C. Hensel,⁵³
 T. Henß,¹⁷³ C. M. Hernandez,⁷ Y. Hernández Jiménez,¹⁶⁶ R. Herrberg,¹⁵ A. D. Hershenhorn,¹⁵¹ G. Herten,⁴⁷
 R. Hertenberger,⁹⁷ L. Hervas,²⁹ G. G. Hesketh,⁷⁶ N. P. Hessey,¹⁰⁴ E. Higón-Rodríguez,¹⁶⁶ D. Hill,^{5a} J. C. Hill,²⁷
 N. Hill,⁵ K. H. Hiller,⁴¹ S. Hillert,²⁰ S. J. Hillier,¹⁷ I. Hinchliffe,¹⁴ E. Hines,¹¹⁹ M. Hirose,¹¹⁵ F. Hirsch,⁴²
 D. Hirschbuehl,¹⁷³ J. Hobbs,¹⁴⁷ N. Hod,¹⁵² M. C. Hodgkinson,¹³⁸ P. Hodgson,¹³⁸ A. Hoecker,²⁹
 M. R. Hoferkamp,¹⁰² J. Hoffman,³⁹ D. Hoffmann,⁸² M. Hohlfeld,⁸⁰ M. Holder,¹⁴⁰ S. O. Holmgren,^{145a} T. Holy,¹²⁶
 J. L. Holzbauer,⁸⁷ Y. Homma,⁶⁶ T. M. Hong,¹¹⁹ L. Hooft van Huysduynen,¹⁰⁷ T. Horazdovsky,¹²⁶ C. Horn,¹⁴²
 S. Horner,⁴⁷ J.-Y. Hostachy,⁵⁴ S. Hou,¹⁵⁰ M. A. Houlden,⁷² A. Hoummada,^{134a} J. Howarth,⁸¹ D. F. Howell,¹¹⁷
 I. Hristova,¹⁵ J. Hrivnac,¹¹⁴ I. Hruska,¹²⁴ T. Hryn'ova,⁴ P. J. Hsu,⁸⁰ S.-C. Hsu,¹⁴ G. S. Huang,¹¹⁰ Z. Hubacek,¹²⁶
 F. Hubaut,⁸² F. Huegging,²⁰ A. Huettmann,⁴¹ T. B. Huffman,¹¹⁷ E. W. Hughes,³⁴ G. Hughes,⁷⁰ R. E. Hughes-Jones,⁸¹
 M. Huhtinen,²⁹ P. Hurst,⁵⁶ M. Hurwitz,¹⁴ U. Husemann,⁴¹ N. Huseynov,^{64,q} J. Huston,⁸⁷ J. Huth,⁵⁶ G. Iacobucci,⁴⁸
 G. Iakovidis,⁹ M. Ibbotson,⁸¹ I. Ibragimov,¹⁴⁰ R. Ichimiya,⁶⁶ L. Iconomidou-Fayard,¹¹⁴ J. Idarraga,¹¹⁴ P. Iengo,^{101a}
 O. Igonkina,¹⁰⁴ Y. Ikegami,⁶⁵ M. Ikeno,⁶⁵ Y. Ilchenko,³⁹ D. Iliadis,¹⁵³ N. Ilic,¹⁵⁷ M. Imori,¹⁵⁴ T. Ince,²⁰
 J. Inigo-Golfin,²⁹ P. Ioannou,⁸ M. Iodice,^{133a} V. Ippolito,^{131a,131b} A. Irles Quiles,¹⁶⁶ C. Isaksson,¹⁶⁵ A. Ishikawa,⁶⁶
 M. Ishino,⁶⁷ R. Ishmukhametov,³⁹ C. Issever,¹¹⁷ S. Istin,^{18a} A. V. Ivashin,¹²⁷ W. Iwanski,³⁸ H. Iwasaki,⁶⁵ J. M. Izen,⁴⁰
 V. Izzo,^{101a} B. Jackson,¹¹⁹ J. N. Jackson,⁷² P. Jackson,¹⁴² M. R. Jaekel,²⁹ V. Jain,⁶⁰ K. Jakobs,⁴⁷ S. Jakobsen,³⁵
 J. Jakubek,¹²⁶ D. K. Jana,¹¹⁰ E. Jankowski,¹⁵⁷ E. Jansen,⁷⁶ H. Jansen,²⁹ A. Jantsch,⁹⁸ M. Janus,²⁰ G. Jarlskog,⁷⁸
 L. Jeanty,⁵⁶ K. Jelen,³⁷ I. Jen-La Plante,³⁰ P. Jenni,²⁹ A. Jeremie,⁴ P. Jež,³⁵ S. Jézéquel,⁴ M. K. Jha,^{19a} H. Ji,¹⁷¹ W. Ji,⁸⁰
 J. Jia,¹⁴⁷ Y. Jiang,^{32b} M. Jimenez Belenguer,⁴¹ G. Jin,^{32b} S. Jin,^{32a} O. Jinnouchi,¹⁵⁶ M. D. Joergensen,³⁵ D. Joffe,³⁹
 L. G. Johansen,¹³ M. Johansen,^{145a,145b} K. E. Johansson,^{145a} P. Johansson,¹³⁸ S. Johnert,⁴¹ K. A. Johns,⁶
 K. Jon-And,^{145a,145b} G. Jones,¹¹⁷ R. W. L. Jones,⁷⁰ T. W. Jones,⁷⁶ T. J. Jones,⁷² O. Jonsson,²⁹ C. Joram,²⁹
 P. M. Jorge,^{123a} J. Joseph,¹⁴ J. Jovicevic,¹⁴⁶ T. Jovin,^{12b} X. Ju,¹⁷¹ C. A. Jung,⁴² R. M. Jungst,²⁹ V. Juranek,¹²⁴
 P. Jussel,⁶¹ A. Juste Rozas,¹¹ V. V. Kabachenko,¹²⁷ S. Kabana,¹⁶ M. Kaci,¹⁶⁶ A. Kaczmarska,³⁸ P. Kadlecik,³⁵
 M. Kado,¹¹⁴ H. Kagan,¹⁰⁸ M. Kagan,⁵⁶ S. Kaiser,⁹⁸ E. Kajomovitz,¹⁵¹ S. Kalinin,¹⁷³ L. V. Kalinovskaya,⁶⁴
 S. Kama,³⁹ N. Kanaya,¹⁵⁴ M. Kaneda,²⁹ S. Kaneti,²⁷ T. Kanno,¹⁵⁶ V. A. Kantserov,⁹⁵ J. Kanzaki,⁶⁵ B. Kaplan,¹⁷⁴
 A. Kapliy,³⁰ J. Kaplon,²⁹ D. Kar,⁴³ M. Karagounis,²⁰ M. Karagoz,¹¹⁷ M. Karnevskiy,⁴¹ K. Karr,⁵ V. Kartvelishvili,⁷⁰
 A. N. Karyukhin,¹²⁷ L. Kashif,¹⁷¹ G. Kasieczka,^{57b} R. D. Kass,¹⁰⁸ A. Kastanas,¹³ M. Kataoka,⁴ Y. Kataoka,¹⁵⁴
 E. Katsoufis,⁹ J. Katzy,⁴¹ V. Kaushik,⁶ K. Kawagoe,⁶⁶ T. Kawamoto,¹⁵⁴ G. Kawamura,⁸⁰ M. S. Kayl,¹⁰⁴
 V. A. Kazanin,¹⁰⁶ M. Y. Kazarinov,⁶⁴ R. Keeler,¹⁶⁸ R. Kehoe,³⁹ M. Keil,⁵³ G. D. Kekelidze,⁶⁴ J. Kennedy,⁹⁷
 C. J. Kenney,¹⁴² M. Kenyon,⁵² O. Kepka,¹²⁴ N. Kerschen,²⁹ B. P. Kerševan,⁷³ S. Kersten,¹⁷³ K. Kessoku,¹⁵⁴
 J. Keung,¹⁵⁷ F. Khalil-zada,¹⁰ H. Khandanyan,¹⁶⁴ A. Khanov,¹¹¹ D. Kharchenko,⁶⁴ A. Khodinov,⁹⁵
 A. G. Kholodenko,¹²⁷ A. Khomich,^{57a} T. J. Khoo,²⁷ G. Khoriauli,²⁰ A. Khoroshilov,¹⁷³ N. Khovanskiy,⁶⁴
 V. Khovanskiy,⁹⁴ E. Khramov,⁶⁴ J. Khubua,^{50b} H. Kim,^{145a,145b} M. S. Kim,² S. H. Kim,¹⁵⁹ N. Kimura,¹⁶⁹ O. Kind,¹⁵
 B. T. King,⁷² M. King,⁶⁶ R. S. B. King,¹¹⁷ J. Kirk,¹²⁸ L. E. Kirsch,²² A. E. Kiryunin,⁹⁸ T. Kishimoto,⁶⁶
 D. Kisieleska,³⁷ T. Kittelmann,¹²² A. M. Kiver,¹²⁷ E. Kladiva,^{143b} J. Klaiber-Lodewigs,⁴² M. Klein,⁷² U. Klein,⁷²
 K. Kleinknecht,⁸⁰ M. Klemetti,⁸⁴ A. Klier,¹⁷⁰ P. Klimek,^{145a,145b} A. Klimentov,²⁴ R. Klingenberg,⁴² J. A. Klinger,⁸¹
 E. B. Klinkby,³⁵ T. Klioutchnikova,²⁹ P. F. Klok,¹⁰³ S. Klous,¹⁰⁴ E.-E. Kluge,^{57a} T. Kluge,⁷² P. Kluit,¹⁰⁴ S. Kluth,⁹⁸
 N. S. Knecht,¹⁵⁷ E. Kneringer,⁶¹ J. Knobloch,²⁹ E.B.F.G. Knoops,⁸² A. Knue,⁵³ B. R. Ko,⁴⁴ T. Kobayashi,¹⁵⁴
 M. Kobel,⁴³ M. Kocian,¹⁴² P. Kodys,¹²⁵ K. Köneke,²⁹ A. C. König,¹⁰³ S. Koenig,⁸⁰ L. Köpke,⁸⁰ F. Koetsveld,¹⁰³
 P. Koevesarki,²⁰ T. Koffas,²⁸ E. Koffeman,¹⁰⁴ L. A. Kogan,¹¹⁷ F. Kohn,⁵³ Z. Kohout,¹²⁶ T. Kohriki,⁶⁵ T. Koi,¹⁴²
 T. Kokott,²⁰ G. M. Kolachev,¹⁰⁶ H. Kolanoski,¹⁵ V. Kolesnikov,⁶⁴ I. Koletsou,^{88a} J. Koll,⁸⁷ M. Kollfrath,⁴⁷
 S. D. Kolya,⁸¹ A. A. Komar,⁹³ Y. Komori,¹⁵⁴ T. Kondo,⁶⁵ T. Kono,^{41,r} A. I. Kononov,⁴⁷ R. Konoplich,^{107,s}
 N. Konstantinidis,⁷⁶ A. Kootz,¹⁷³ S. Koperny,³⁷ K. Korcyl,³⁸ K. Kordas,¹⁵³ V. Koreshev,¹²⁷ A. Korn,¹¹⁷ A. Korol,¹⁰⁶

I. Korolkov,¹¹ E. V. Korolkova,¹³⁸ V. A. Korotkov,¹²⁷ O. Kortner,⁹⁸ S. Kortner,⁹⁸ V. V. Kostyukhin,²⁰
M. J. Kotamäki,²⁹ S. Kotov,⁹⁸ V. M. Kotov,⁶⁴ A. Kotwal,⁴⁴ C. Kourkoulis,⁸ V. Kouskoura,¹⁵³ A. Koutsman,^{158a}
R. Kowalewski,¹⁶⁸ T. Z. Kowalski,³⁷ W. Kozanecki,¹³⁵ A. S. Kozhin,¹²⁷ V. Kral,¹²⁶ V. A. Kramarenko,⁹⁶
G. Kramberger,⁷³ M. W. Krasny,⁷⁷ A. Krasznahorkay,¹⁰⁷ J. Kraus,⁸⁷ J. K. Kraus,²⁰ A. Kreisel,¹⁵² F. Krejci,¹²⁶
J. Kretzschmar,⁷² N. Krieger,⁵³ P. Krieger,¹⁵⁷ K. Kroeninger,⁵³ H. Kroha,⁹⁸ J. Kroll,¹¹⁹ J. Kroseberg,²⁰ J. Krstic,^{12a}
U. Kruchonak,⁶⁴ H. Krüger,²⁰ T. Kruker,¹⁶ N. Krumnack,⁶³ Z. V. Krumshiteyn,⁶⁴ A. Kruth,²⁰ T. Kubota,⁸⁵ S. Kuday,^{3a}
S. Kuehn,⁴⁷ A. Kugel,^{57c} T. Kuhl,⁴¹ D. Kuhn,⁶¹ V. Kukhtin,⁶⁴ Y. Kulchitsky,⁸⁹ S. Kuleshov,^{31b} C. Kummer,⁹⁷
M. Kuna,⁷⁷ N. Kundu,¹¹⁷ J. Kunkle,¹¹⁹ A. Kupco,¹²⁴ H. Kurashige,⁶⁶ M. Kurata,¹⁵⁹ Y. A. Kurochkin,⁸⁹ V. Kus,¹²⁴
E. S. Kuwertz,¹⁴⁶ M. Kuze,¹⁵⁶ J. Kvita,¹⁴¹ R. Kwee,¹⁵ A. La Rosa,⁴⁸ L. La Rotonda,^{36a,36b} L. Labarga,⁷⁹ J. Labbe,⁴
S. Lablak,^{134a} C. Lacasta,¹⁶⁶ F. Lacava,^{131a,131b} H. Lacker,¹⁵ D. Lacour,⁷⁷ V. R. Lacuesta,¹⁶⁶ E. Ladygin,⁶⁴
R. Lafaye,⁴ B. Laforge,⁷⁷ T. Lagouri,⁷⁹ S. Lai,⁴⁷ E. Laisne,⁵⁴ M. Lamanna,²⁹ C. L. Lampen,⁶ W. Lampl,⁶
E. Lancon,¹³⁵ U. Landgraf,⁴⁷ M. P. J. Landon,⁷⁴ J. L. Lane,⁸¹ C. Lange,⁴¹ A. J. Lankford,¹⁶² F. Lanni,²⁴
K. Lantzsch,¹⁷³ S. Laplace,⁷⁷ C. Lapoire,²⁰ J. F. Laporte,¹³⁵ T. Lari,^{88a} A. V. Larionov,¹²⁷ A. Larnier,¹¹⁷ C. Lasseur,²⁹
M. Lassnig,²⁹ P. Laurelli,⁴⁶ V. Lavorini,^{36a,36b} W. Lavrijsen,¹⁴ P. Laycock,⁷² A. B. Lazarev,⁶⁴ O. Le Dortz,⁷⁷
E. Le Guirrec,⁸² C. Le Maner,¹⁵⁷ E. Le Menedeu,⁹ C. Lebel,⁹² T. LeCompte,⁵ F. Ledroit-Guillon,⁵⁴ H. Lee,¹⁰⁴
J. S. H. Lee,¹¹⁵ S. C. Lee,¹⁵⁰ L. Lee,¹⁷⁴ M. Lefebvre,¹⁶⁸ M. Legendre,¹³⁵ A. Leger,⁴⁸ B. C. LeGeyt,¹¹⁹ F. Legger,⁹⁷
C. Leggett,¹⁴ M. Lehmacher,²⁰ G. Lehmann Miotto,²⁹ X. Lei,⁶ M. A. L. Leite,^{23d} R. Leitner,¹²⁵ D. Lellouch,¹⁷⁰
M. Leltchouk,³⁴ B. Lemmer,⁵³ V. Lendermann,^{57a} K. J. C. Leney,^{144b} T. Lenz,¹⁰⁴ G. Lenzen,¹⁷³ B. Lenzi,²⁹
K. Leonhardt,⁴³ S. Leontsinis,⁹ C. Leroy,⁹² J-R. Lessard,¹⁶⁸ J. Lesser,^{145a} C. G. Lester,²⁷ A. Leung Fook Cheong,¹⁷¹
J. Levêque,⁴ D. Levin,⁸⁶ L. J. Levinson,¹⁷⁰ M. S. Levitski,¹²⁷ A. Lewis,¹¹⁷ G. H. Lewis,¹⁰⁷ A. M. Leyko,²⁰
M. Leyton,¹⁵ B. Li,⁸² H. Li,^{171,t} S. Li,^{32b,u} X. Li,⁸⁶ Z. Liang,^{117,v} H. Liao,³³ B. Liberti,^{132a} P. Lichard,²⁹
M. Lichtnecker,⁹⁷ K. Lie,¹⁶⁴ W. Liebig,¹³ R. Lifshitz,¹⁵¹ C. Limbach,²⁰ A. Limosani,⁸⁵ M. Limper,⁶² S. C. Lin,^{150,w}
F. Linde,¹⁰⁴ J. T. Linnemann,⁸⁷ E. Lipeles,¹¹⁹ L. Lipinsky,¹²⁴ A. Lipniacka,¹³ T. M. Liss,¹⁶⁴ D. Lissauer,²⁴ A. Lister,⁴⁸
A. M. Litke,¹³⁶ C. Liu,²⁸ D. Liu,¹⁵⁰ H. Liu,⁸⁶ J. B. Liu,⁸⁶ M. Liu,^{32b} Y. Liu,^{32b} M. Livan,^{118a,118b}
S. S. A. Livermore,¹¹⁷ A. Lleres,⁵⁴ J. Llorente Merino,⁷⁹ S. L. Lloyd,⁷⁴ E. Lobodzinska,⁴¹ P. Loch,⁶
W. S. Lockman,¹³⁶ T. Loddenkoetter,²⁰ F. K. Loebinger,⁸¹ A. Loginov,¹⁷⁴ C. W. Loh,¹⁶⁷ T. Lohse,¹⁵ K. Lohwasser,⁴⁷
M. Lokajicek,¹²⁴ J. Loken,¹¹⁷ V. P. Lombardo,⁴ R. E. Long,⁷⁰ L. Lopes,^{123a} D. Lopez Mateos,⁵⁶ J. Lorenz,⁹⁷
N. Lorenzo Martinez,¹¹⁴ M. Losada,¹⁶¹ P. Loscutoff,¹⁴ F. Lo Sterzo,^{131a,131b} M. J. Losty,^{158a} X. Lou,⁴⁰ A. Lounis,¹¹⁴
K. F. Loureiro,¹⁶¹ J. Love,²¹ P. A. Love,⁷⁰ A. J. Lowe,^{142,f} F. Lu,^{32a} H. J. Lubatti,¹³⁷ C. Luci,^{131a,131b} A. Lucotte,⁵⁴
A. Ludwig,⁴³ D. Ludwig,⁴¹ I. Ludwig,⁴⁷ J. Ludwig,⁴⁷ F. Luehring,⁶⁰ G. Luijckx,¹⁰⁴ D. Lumb,⁴⁷ L. Luminari,^{131a}
E. Lund,¹¹⁶ B. Lund-Jensen,¹⁴⁶ B. Lundberg,⁷⁸ J. Lundberg,^{145a,145b} J. Lundquist,³⁵ M. Lungwitz,⁸⁰ G. Lutz,⁹⁸
D. Lynn,²⁴ J. Lys,¹⁴ E. Lytken,⁷⁸ H. Ma,²⁴ L. L. Ma,¹⁷¹ J. A. Macana Goia,⁹² G. Maccarrone,⁴⁶ A. Macchiolo,⁹⁸
B. Maček,⁷³ J. Machado Miguens,^{123a} R. Mackeprang,³⁵ R. J. Madaras,¹⁴ W. F. Mader,⁴³ R. Maenner,^{57c} T. Maeno,²⁴
P. Mättig,¹⁷³ S. Mättig,⁴¹ L. Magnoni,²⁹ E. Magradze,⁵³ Y. Mahalalel,¹⁵² K. Mahboubi,⁴⁷ G. Mahout,¹⁷
C. Maiani,^{131a,131b} C. Maidantchik,^{23a} A. Maio,^{123a,c} S. Majewski,²⁴ Y. Makida,⁶⁵ N. Makovec,¹¹⁴ P. Mal,¹³⁵
B. Malaescu,²⁹ Pa. Malecki,³⁸ P. Malecki,³⁸ V. P. Maleev,¹²⁰ F. Malek,⁵⁴ U. Mallik,⁶² D. Malon,⁵ C. Malone,¹⁴²
S. Maltezos,⁹ V. Malyshev,¹⁰⁶ S. Malyukov,²⁹ R. Mameghani,⁹⁷ J. Mamuzic,^{12b} A. Manabe,⁶⁵ L. Mandelli,^{88a}
I. Mandić,⁷³ R. Mandrysch,¹⁵ J. Maneira,^{123a} P. S. Mangeard,⁸⁷ L. Manhaes de Andrade Filho,^{23a} I. D. Manjavidze,⁶⁴
A. Mann,⁵³ P. M. Manning,¹³⁶ A. Manousakis-Katsikakis,⁸ B. Mansoulie,¹³⁵ A. Manz,⁹⁸ A. Mapelli,²⁹ L. Mapelli,²⁹
L. March,⁷⁹ J. F. Marchand,²⁸ F. Marchese,^{132a,132b} G. Marchiori,⁷⁷ M. Marcisovsky,¹²⁴ C. P. Marino,¹⁶⁸
F. Marroquim,^{23a} R. Marshall,⁸¹ Z. Marshall,²⁹ F. K. Martens,¹⁵⁷ S. Marti-Garcia,¹⁶⁶ A. J. Martin,¹⁷⁴ B. Martin,²⁹
B. Martin,⁸⁷ F. F. Martin,¹¹⁹ J. P. Martin,⁹² Ph. Martin,⁵⁴ T. A. Martin,¹⁷ V. J. Martin,⁴⁵ B. Martin dit Latour,⁴⁸
S. Martin-Haugh,¹⁴⁸ M. Martinez,¹¹ V. Martinez Outschoorn,⁵⁶ A. C. Martyniuk,¹⁶⁸ M. Marx,⁸¹ F. Marzano,^{131a}
A. Marzin,¹¹⁰ L. Masetti,⁸⁰ T. Mashimo,¹⁵⁴ R. Mashinistov,⁹³ J. Masik,⁸¹ A. L. Maslennikov,¹⁰⁶ I. Massa,^{19a,19b}
G. Massaro,¹⁰⁴ N. Massol,⁴ P. Mastrandrea,^{131a,131b} A. Mastroberardino,^{36a,36b} T. Masubuchi,¹⁵⁴ P. Matricon,¹¹⁴
H. Matsumoto,¹⁵⁴ H. Matsunaga,¹⁵⁴ T. Matsushita,⁶⁶ C. Mattraversi,^{117,d} J. M. Maugain,²⁹ J. Maurer,⁸²
S. J. Maxfield,⁷² D. A. Maximov,^{106,g} E. N. May,⁵ A. Mayne,¹³⁸ R. Mazini,¹⁵⁰ M. Mazur,²⁰ M. Mazzanti,^{88a}
S. P. Mc Kee,⁸⁶ A. McCarn,¹⁶⁴ R. L. McCarthy,¹⁴⁷ T. G. McCarthy,²⁸ N. A. McCubbin,¹²⁸ K. W. McFarlane,⁵⁵
J. A. McFayden,¹³⁸ H. McGlone,⁵² G. Mchedlidze,^{50b} R. A. McLaren,²⁹ T. McLaughlan,¹⁷ S. J. McMahan,¹²⁸
R. A. McPherson,^{168,k} A. Meade,⁸³ J. Mechnich,¹⁰⁴ M. Mechtel,¹⁷³ M. Medinnis,⁴¹ R. Meera-Lebbai,¹¹⁰
T. Meguro,¹¹⁵ R. Mehdiyev,⁹² S. Mehlhase,³⁵ A. Mehta,⁷² K. Meier,^{57a} B. Meirose,⁷⁸ C. Melachrinou,³⁰

B. R. Mellado Garcia,¹⁷¹ L. Mendoza Navas,¹⁶¹ Z. Meng,^{150,t} A. Mengarelli,^{19a,19b} S. Menke,⁹⁸ C. Menot,²⁹ E. Meoni,¹¹ K. M. Mercurio,⁵⁶ P. Mermod,⁴⁸ L. Merola,^{101a,101b} C. Meroni,^{88a} F. S. Merritt,³⁰ H. Merritt,¹⁰⁸ A. Messina,²⁹ J. Metcalfe,¹⁰² A. S. Mete,⁶³ C. Meyer,⁸⁰ C. Meyer,³⁰ J.-P. Meyer,¹³⁵ J. Meyer,¹⁷² J. Meyer,⁵³ T. C. Meyer,²⁹ W. T. Meyer,⁶³ J. Miao,^{32d} S. Michal,²⁹ L. Micu,^{25a} R. P. Middleton,¹²⁸ S. Migas,⁷² L. Mijović,⁴¹ G. Mikenberg,¹⁷⁰ M. Mikestikova,¹²⁴ M. Mikuž,⁷³ D. W. Miller,³⁰ R. J. Miller,⁸⁷ W. J. Mills,¹⁶⁷ C. Mills,⁵⁶ A. Milov,¹⁷⁰ D. A. Milstead,^{145a,145b} D. Milstein,¹⁷⁰ A. A. Minaenko,¹²⁷ M. Miñano Moya,¹⁶⁶ I. A. Minashvili,⁶⁴ A. I. Mincer,¹⁰⁷ B. Mindur,³⁷ M. Mineev,⁶⁴ Y. Ming,¹⁷¹ L. M. Mir,¹¹ G. Mirabelli,^{131a} L. Miralles Verge,¹¹ A. Misiejuk,⁷⁵ J. Mitrevski,¹³⁶ G. Y. Mitrofanov,¹²⁷ V. A. Mitsou,¹⁶⁶ S. Mitsui,⁶⁵ P. S. Miyagawa,¹³⁸ K. Miyazaki,⁶⁶ J. U. Mjörnmark,⁷⁸ T. Moa,^{145a,145b} P. Mockett,¹³⁷ S. Moed,⁵⁶ V. Moeller,²⁷ K. Mönig,⁴¹ N. Möser,²⁰ S. Mohapatra,¹⁴⁷ W. Mohr,⁴⁷ S. Mohrdieck-Möck,⁹⁸ A. M. Moisseev,^{127,a} R. Moles-Valls,¹⁶⁶ J. Molina-Perez,²⁹ J. Monk,⁷⁶ E. Monnier,⁸² S. Montesano,^{88a,88b} F. Monticelli,⁶⁹ S. Monzani,^{19a,19b} R. W. Moore,² G. F. Moorhead,⁸⁵ C. Mora Herrera,⁴⁸ A. Moraes,⁵² N. Morange,¹³⁵ J. Morel,⁵³ G. Morello,^{36a,36b} D. Moreno,⁸⁰ M. Moreno Llácer,¹⁶⁶ P. Morettini,^{49a} M. Morgenstern,⁴³ M. Morii,⁵⁶ J. Morin,⁷⁴ A. K. Morley,²⁹ G. Mornacchi,²⁹ S. V. Morozov,⁹⁵ J. D. Morris,⁷⁴ L. Morvaj,¹⁰⁰ H. G. Moser,⁹⁸ M. Mosidze,^{50b} J. Moss,¹⁰⁸ R. Mount,¹⁴² E. Mountricha,^{9,x} S. V. Mouraviev,⁹³ E. J. W. Moyses,⁸³ M. Mudrinic,^{12b} F. Mueller,^{57a} J. Mueller,¹²² K. Mueller,²⁰ T. A. Müller,⁹⁷ T. Mueller,⁸⁰ D. Muenstermann,²⁹ A. Muir,¹⁶⁷ Y. Munwes,¹⁵² W. J. Murray,¹²⁸ I. Mussche,¹⁰⁴ E. Musto,^{101a,101b} A. G. Myagkov,¹²⁷ M. Myska,¹²⁴ J. Nadal,¹¹ K. Nagai,¹⁵⁹ K. Nagano,⁶⁵ A. Nagarkar,¹⁰⁸ Y. Nagasaka,⁵⁹ M. Nagel,⁹⁸ A. M. Nairz,²⁹ Y. Nakahama,²⁹ K. Nakamura,¹⁵⁴ T. Nakamura,¹⁵⁴ I. Nakano,¹⁰⁹ G. Nanava,²⁰ A. Napier,¹⁶⁰ R. Narayan,^{57b} M. Nash,^{76,d} N. R. Nation,²¹ T. Nattermann,²⁰ T. Naumann,⁴¹ G. Navarro,¹⁶¹ H. A. Neal,⁸⁶ E. Nebot,⁷⁹ P. Yu. Nechaeva,⁹³ T. J. Neep,⁸¹ A. Negri,^{118a,118b} G. Negri,²⁹ S. Nektarijevic,⁴⁸ A. Nelson,¹⁶² S. Nelson,¹⁴² T. K. Nelson,¹⁴² S. Nemecek,¹²⁴ P. Nemethy,¹⁰⁷ A. A. Nepomuceno,^{23a} M. Nessi,^{29,y} M. S. Neubauer,¹⁶⁴ A. Neusiedl,⁸⁰ R. M. Neves,¹⁰⁷ P. Nevski,²⁴ P. R. Newman,¹⁷ V. Nguyen Thi Hong,¹³⁵ R. B. Nickerson,¹¹⁷ R. Nicolaidou,¹³⁵ L. Nicolas,¹³⁸ B. Nicquevert,²⁹ F. Niedercorn,¹¹⁴ J. Nielsen,¹³⁶ T. Niinikoski,²⁹ N. Nikiforou,³⁴ A. Nikiforov,¹⁵ V. Nikolaenko,¹²⁷ K. Nikolaev,⁶⁴ I. Nikolic-Audit,⁷⁷ K. Nikolics,⁴⁸ K. Nikolopoulos,²⁴ H. Nilsen,⁴⁷ P. Nilsson,⁷ Y. Ninomiya,¹⁵⁴ A. Nisati,^{131a} T. Nishiyama,⁶⁶ R. Nisius,⁹⁸ L. Nodulman,⁵ M. Nomachi,¹¹⁵ I. Nomidis,¹⁵³ M. Nordberg,²⁹ B. Nordkvist,^{145a,145b} P. R. Norton,¹²⁸ J. Novakova,¹²⁵ M. Nozaki,⁶⁵ L. Nozka,¹¹² I. M. Nugent,^{158a} A.-E. Nuncio-Quiroz,²⁰ G. Nunes Hanninger,⁸⁵ T. Nunnemann,⁹⁷ E. Nurse,⁷⁶ B. J. O'Brien,⁴⁵ S. W. O'Neale,^{17,a} D. C. O'Neil,¹⁴¹ V. O'Shea,⁵² L. B. Oakes,⁹⁷ F. G. Oakham,^{28,e} H. Oberlack,⁹⁸ J. Ocariz,⁷⁷ A. Ochi,⁶⁶ S. Oda,¹⁵⁴ S. Odaka,⁶⁵ J. Odier,⁸² H. Ogren,⁶⁰ A. Oh,⁸¹ S. H. Oh,⁴⁴ C. C. Ohm,^{145a,145b} T. Ohshima,¹⁰⁰ H. Ohshita,¹³⁹ T. Ohsugi,⁵⁸ S. Okada,⁶⁶ H. Okawa,¹⁶² Y. Okumura,¹⁰⁰ T. Okuyama,¹⁵⁴ A. Olariu,^{25a} M. Olcese,^{49a} A. G. Olchevski,⁶⁴ S. A. Olivares Pino,^{31a} M. Oliveira,^{123a,i} D. Oliveira Damazio,²⁴ E. Oliver Garcia,¹⁶⁶ D. Olivito,¹¹⁹ A. Olszewski,³⁸ J. Olszowska,³⁸ C. Omachi,⁶⁶ A. Onofre,^{123a,z} P. U. E. Onyisi,³⁰ C. J. Oram,^{158a} M. J. Oreglia,³⁰ Y. Oren,¹⁵² D. Orestano,^{133a,133b} I. Orlov,¹⁰⁶ C. Oropeza Barrera,⁵² R. S. Orr,¹⁵⁷ B. Osculati,^{49a,49b} R. Ospanov,¹¹⁹ C. Osuna,¹¹ G. Otero y Garzon,²⁶ J. P. Ottersbach,¹⁰⁴ M. Ouchrif,^{134d} E. A. Ouellette,¹⁶⁸ F. Ould-Saada,¹¹⁶ A. Ouraou,¹³⁵ Q. Ouyang,^{32a} A. Ovcharova,¹⁴ M. Owen,⁸¹ S. Owen,¹³⁸ V. E. Ozcan,^{18a} N. Ozturk,⁷ A. Pacheco Pages,¹¹ C. Padilla Aranda,¹¹ S. Pagan Griso,¹⁴ E. Paganis,¹³⁸ F. Paige,²⁴ P. Pais,⁸³ K. Pajchel,¹¹⁶ G. Palacino,^{158b} C. P. Paleari,⁶ S. Palestini,²⁹ D. Pallin,³³ A. Palma,^{123a} J. D. Palmer,¹⁷ Y. B. Pan,¹⁷¹ E. Panagiotopoulou,⁹ B. Panes,^{31a} N. Panikashvili,⁸⁶ S. Panitkin,²⁴ D. Pantea,^{25a} M. Panuskova,¹²⁴ V. Paolone,¹²² A. Papadellis,^{145a} Th. D. Papadopoulou,⁹ A. Paramonov,⁵ D. Paredes Hernandez,³³ W. Park,^{24,aa} M. A. Parker,²⁷ F. Parodi,^{49a,49b} J. A. Parsons,³⁴ U. Parzefall,⁴⁷ E. Pasqualucci,^{131a} S. Passaggio,^{49a} A. Passeri,^{133a} F. Pastore,^{133a,133b} Fr. Pastore,⁷⁵ G. Pásztor,^{48,bb} S. Patarraia,¹⁷³ N. Patel,¹⁴⁹ J. R. Pater,⁸¹ S. Patricelli,^{101a,101b} T. Pauly,²⁹ M. Pecsý,^{143a} M. I. Pedraza Morales,¹⁷¹ S. V. Peleganchuk,¹⁰⁶ H. Peng,^{32b} R. Pengo,²⁹ B. Penning,³⁰ A. Penson,³⁴ J. Penwell,⁶⁰ M. Perantoni,^{23a} K. Perez,^{34,cc} T. Perez Cavalcanti,⁴¹ E. Perez Codina,¹¹ M. T. Pérez García-Estañ,¹⁶⁶ V. Perez Reale,³⁴ L. Perini,^{88a,88b} H. Pernegger,²⁹ R. Perrino,^{71a} P. Perrodo,⁴ S. Persema,^{3a} A. Perus,¹¹⁴ V. D. Peshekhonov,⁶⁴ K. Peters,²⁹ B. A. Petersen,²⁹ J. Petersen,²⁹ T. C. Petersen,³⁵ E. Petit,⁴ A. Petridis,¹⁵³ C. Petridou,¹⁵³ E. Petrolo,^{131a} F. Petrucci,^{133a,133b} D. Petschull,⁴¹ M. Petteni,¹⁴¹ R. Pezoa,^{31b} A. Phan,⁸⁵ P. W. Phillips,¹²⁸ G. Piacquadio,²⁹ A. Picazio,⁴⁸ E. Piccaro,⁷⁴ M. Piccinini,^{19a,19b} S. M. Piec,⁴¹ R. Piegai,²⁶ D. T. Pignotti,¹⁰⁸ J. E. Pilcher,³⁰ A. D. Pilkington,⁸¹ J. Pina,^{123a,c} M. Pinamonti,^{163a,163c} A. Pinder,¹¹⁷ J. L. Pinfold,² J. Ping,^{32c} B. Pinto,^{123a} O. Pirotte,²⁹ C. Pizio,^{88a,88b} M. Plamondon,¹⁶⁸ M.-A. Pleier,²⁴ A. V. Pleskach,¹²⁷ A. Poblaguev,²⁴ S. Poddar,^{57a} F. Podlyski,³³ L. Poggioli,¹¹⁴ T. Poghosyan,²⁰ M. Pohl,⁴⁸ F. Polci,⁵⁴ G. Polesello,^{118a} A. Policicchio,^{36a,36b} A. Polini,^{19a} J. Poll,⁷⁴ V. Polychronakos,²⁴ D. M. Pomarede,¹³⁵ D. Pomeroy,²² K. Pommès,²⁹

L. Pontecorvo,^{131a} B. G. Pope,⁸⁷ G. A. Popeneciu,^{25a} D. S. Popovic,^{12a} A. Poppleton,²⁹ X. Portell Bueso,²⁹ C. Posch,²¹ G. E. Pospelov,⁹⁸ S. Pospisil,¹²⁶ I. N. Potrap,⁹⁸ C. J. Potter,¹⁴⁸ C. T. Potter,¹¹³ G. Poulard,²⁹ J. Poveda,¹⁷¹ V. Pozdnyakov,⁶⁴ R. Prabhu,⁷⁶ P. Pralavorio,⁸² A. Pranko,¹⁴ S. Prasad,²⁹ R. Pravahan,⁷ S. Prell,⁶³ K. Pretzl,¹⁶ L. Pribyl,²⁹ D. Price,⁶⁰ J. Price,⁷² L. E. Price,⁵ M. J. Price,²⁹ D. Prieur,¹²² M. Primavera,^{71a} K. Prokofiev,¹⁰⁷ F. Prokoshin,^{31b} S. Protopopescu,²⁴ J. Proudfoot,⁵ X. Prudent,⁴³ M. Przybycien,³⁷ H. Przysieszniak,⁴ S. Psoroulas,²⁰ E. Ptacek,¹¹³ E. Pueschel,⁸³ J. Purdham,⁸⁶ M. Purohit,^{24,aa} P. Puzo,¹¹⁴ Y. Pylypchenko,⁶² J. Qian,⁸⁶ Z. Qian,⁸² Z. Qin,⁴¹ A. Quadt,⁵³ D. R. Quarrie,¹⁴ W. B. Quayle,¹⁷¹ F. Quinonez,^{31a} M. Raas,¹⁰³ V. Radescu,^{57b} B. Radics,²⁰ P. Radloff,¹¹³ T. Rador,^{18a} F. Ragusa,^{88a,88b} G. Rahal,¹⁷⁶ A. M. Rahimi,¹⁰⁸ D. Rahm,²⁴ S. Rajagopalan,²⁴ M. Rammensee,⁴⁷ M. Rammes,¹⁴⁰ A. S. Randle-Conde,³⁹ K. Randrianarivony,²⁸ P. N. Ratoff,⁷⁰ F. Rauscher,⁹⁷ T. C. Rave,⁴⁷ M. Raymond,²⁹ A. L. Read,¹¹⁶ D. M. Rebuffi,^{118a,118b} A. Redelbach,¹⁷² G. Redlinger,²⁴ R. Reece,¹¹⁹ K. Reeves,⁴⁰ A. Reichold,¹⁰⁴ E. Reinherz-Aronis,¹⁵² A. Reinsch,¹¹³ I. Reisinger,⁴² C. Rembser,²⁹ Z. L. Ren,¹⁵⁰ A. Renaud,¹¹⁴ M. Rescigno,^{131a} S. Resconi,^{88a} B. Resende,¹³⁵ P. Reznicek,⁹⁷ R. Rezvani,¹⁵⁷ A. Richards,⁷⁶ R. Richter,⁹⁸ E. Richter-Was,^{4,dd} M. Ridel,⁷⁷ M. Rijpstra,¹⁰⁴ M. Rijssenbeek,¹⁴⁷ A. Rimoldi,^{118a,118b} L. Rinaldi,^{19a} R. R. Rios,³⁹ I. Riu,¹¹ G. Rivoltella,^{88a,88b} F. Rizatdinova,¹¹¹ E. Rizvi,⁷⁴ S. H. Robertson,^{84,k} A. Robichaud-Veronneau,¹¹⁷ D. Robinson,²⁷ J. E. M. Robinson,⁷⁶ A. Robson,⁵² J. G. Rocha de Lima,¹⁰⁵ C. Roda,^{121a,121b} D. Roda Dos Santos,²⁹ D. Rodriguez,¹⁶¹ A. Roe,⁵³ S. Roe,²⁹ O. Røhne,¹¹⁶ V. Rojo,¹ S. Rolli,¹⁶⁰ A. Romaniouk,⁹⁵ M. Romano,^{19a,19b} V. M. Romanov,⁶⁴ G. Romeo,²⁶ E. Romero Adam,¹⁶⁶ L. Roos,⁷⁷ E. Ros,¹⁶⁶ S. Rosati,^{131a} K. Rosbach,⁴⁸ A. Rose,¹⁴⁸ M. Rose,⁷⁵ G. A. Rosenbaum,¹⁵⁷ E. I. Rosenberg,⁶³ P. L. Rosendahl,¹³ O. Rosenthal,¹⁴⁰ L. Rosselet,⁴⁸ V. Rossetti,¹¹ E. Rossi,^{131a,131b} L. P. Rossi,^{49a} M. Rotaru,^{25a} I. Roth,¹⁷⁰ J. Rothberg,¹³⁷ D. Rousseau,¹¹⁴ C. R. Royon,¹³⁵ A. Rozanov,⁸² Y. Rozen,¹⁵¹ X. Ruan,^{32a,cc} I. Rubinskiy,⁴¹ B. Ruckert,⁹⁷ N. Ruckstuhl,¹⁰⁴ V. I. Rud,⁹⁶ C. Rudolph,⁴³ G. Rudolph,⁶¹ F. Rühr,⁶ F. Ruggieri,^{133a,133b} A. Ruiz-Martinez,⁶³ V. Rumiantsev,^{90,a} L. Rumyantsev,⁶⁴ K. Runge,⁴⁷ Z. Rurikova,⁴⁷ N. A. Rusakovich,⁶⁴ J. P. Rutherford,⁶ C. Ruwiedel,¹⁴ P. Ruzicka,¹²⁴ Y. F. Ryabov,¹²⁰ V. Ryadovikov,¹²⁷ P. Ryan,⁸⁷ M. Rybar,¹²⁵ G. Rybkin,¹¹⁴ N. C. Ryder,¹¹⁷ S. Rzaeva,¹⁰ A. F. Saavedra,¹⁴⁹ I. Sadeh,¹⁵² H. F. W. Sadrozinski,¹³⁶ R. Sadykov,⁶⁴ F. Safai Tehrani,^{131a} H. Sakamoto,¹⁵⁴ G. Salamanna,⁷⁴ A. Salamon,^{132a} M. Saleem,¹¹⁰ D. Salihagic,⁹⁸ A. Salnikov,¹⁴² J. Salt,¹⁶⁶ B. M. Salvachua Ferrando,⁵ D. Salvatore,^{36a,36b} F. Salvatore,¹⁴⁸ A. Salvucci,¹⁰³ A. Salzburger,²⁹ D. Sampsonidis,¹⁵³ B. H. Samset,¹¹⁶ A. Sanchez,^{101a,101b} V. Sanchez Martinez,¹⁶⁶ H. Sandaker,¹³ H. G. Sander,⁸⁰ M. P. Sanders,⁹⁷ M. Sandhoff,¹⁷³ T. Sandoval,²⁷ C. Sandoval,¹⁶¹ R. Sandstroem,⁹⁸ S. Sandvoss,¹⁷³ D. P. C. Sankey,¹²⁸ A. Sansoni,⁴⁶ C. Santamarina Rios,⁸⁴ C. Santoni,³³ R. Santonico,^{132a,132b} H. Santos,^{123a} J. G. Saraiva,^{123a} T. Sarangi,¹⁷¹ E. Sarkisyan-Grinbaum,⁷ F. Sarri,^{121a,121b} G. Sartisohn,¹⁷³ O. Sasaki,⁶⁵ N. Sasao,⁶⁷ I. Satsounkevitch,⁸⁹ G. Sauvage,⁴ E. Sauvan,⁴ J. B. Sauvan,¹¹⁴ P. Savard,^{157,e} V. Savinov,¹²² D. O. Savu,²⁹ L. Sawyer,^{24,m} D. H. Saxon,⁵² L. P. Says,³³ C. Sbarra,^{19a} A. Sbrizzi,^{19a,19b} O. Scallon,⁹² D. A. Scannicchio,¹⁶² M. Scarcella,¹⁴⁹ J. Schaarschmidt,¹¹⁴ P. Schacht,⁹⁸ U. Schäfer,⁸⁰ S. Schaepe,²⁰ S. Schaezel,^{57b} A. C. Schaffer,¹¹⁴ D. Schaile,⁹⁷ R. D. Schamberger,¹⁴⁷ A. G. Schamov,¹⁰⁶ V. Scharf,^{57a} V. A. Schegelsky,¹²⁰ D. Scheirich,⁸⁶ M. Schernau,¹⁶² M. I. Scherzer,³⁴ C. Schiavi,^{49a,49b} J. Schieck,⁹⁷ M. Schioppa,^{36a,36b} S. Schlenker,²⁹ J. L. Schlereth,⁵ E. Schmidt,⁴⁷ K. Schmieden,²⁰ C. Schmitt,⁸⁰ S. Schmitt,^{57b} M. Schmitz,²⁰ A. Schöning,^{57b} M. Schott,²⁹ D. Schouten,^{158a} J. Schovancova,¹²⁴ M. Schram,⁸⁴ C. Schroeder,⁸⁰ N. Schroer,^{57c} G. Schuler,²⁹ M. J. Schultens,²⁰ J. Schultes,¹⁷³ H.-C. Schultz-Coulon,^{57a} H. Schulz,¹⁵ J. W. Schumacher,²⁰ M. Schumacher,⁴⁷ B. A. Schumm,¹³⁶ Ph. Schune,¹³⁵ C. Schwanenberger,⁸¹ A. Schwartzman,¹⁴² Ph. Schwemling,⁷⁷ R. Schwienhorst,⁸⁷ R. Schwierz,⁴³ J. Schwindling,¹³⁵ T. Schwindt,²⁰ M. Schwoerer,⁴ W. G. Scott,¹²⁸ J. Searcy,¹¹³ G. Sedov,⁴¹ E. Sedykh,¹²⁰ E. Segura,¹¹ S. C. Seidel,¹⁰² A. Seiden,¹³⁶ F. Seifert,⁴³ J. M. Seixas,^{23a} G. Sekhniaidze,^{101a} K. E. Selbach,⁴⁵ D. M. Seliverstov,¹²⁰ B. Sellden,^{145a} G. Sellers,⁷² M. Seman,^{143b} N. Semprini-Cesari,^{19a,19b} C. Serfon,⁹⁷ L. Serin,¹¹⁴ L. Serkin,⁵³ R. Seuster,⁹⁸ H. Severini,¹¹⁰ M. E. Sevir,⁸⁵ A. Sfyrla,²⁹ E. Shabalina,⁵³ M. Shamim,¹¹³ L. Y. Shan,^{32a} J. T. Shank,²¹ Q. T. Shao,⁸⁵ M. Shapiro,¹⁴ P. B. Shatalov,⁹⁴ L. Shaver,⁶ K. Shaw,^{163a,163c} D. Sherman,¹⁷⁴ P. Sherwood,⁷⁶ A. Shibata,¹⁰⁷ H. Shichi,¹⁰⁰ S. Shimizu,²⁹ M. Shimojima,⁹⁹ T. Shin,⁵⁵ M. Shiyakova,⁶⁴ A. Shmeleva,⁹³ M. J. Shochet,³⁰ D. Short,¹¹⁷ S. Shrestha,⁶³ E. Shulga,⁹⁵ M. A. Shupe,⁶ P. Sicho,¹²⁴ A. Sidoti,^{131a} F. Siegert,⁴⁷ Dj. Sijacki,^{12a} O. Silbert,¹⁷⁰ J. Silva,^{123a} Y. Silver,¹⁵² D. Silverstein,¹⁴² S. B. Silverstein,^{145a} V. Simak,¹²⁶ O. Simard,¹³⁵ Lj. Simic,^{12a} S. Simion,¹¹⁴ B. Simmons,⁷⁶ M. Simonyan,³⁵ P. Sinervo,¹⁵⁷ N. B. Sinev,¹¹³ V. Sipica,¹⁴⁰ G. Siragusa,¹⁷² A. Sircar,²⁴ A. N. Sisakyan,⁶⁴ S. Yu. Sivoklov,⁹⁶ J. Sjölin,^{145a,145b} T. B. Sjursen,¹³ L. A. Skinnari,¹⁴ H. P. Skottowe,⁵⁶ K. Skovpen,¹⁰⁶ P. Skubic,¹¹⁰ N. Skvorodnev,²² M. Slater,¹⁷ T. Slavicek,¹²⁶ K. Sliwa,¹⁶⁰ J. Sloper,²⁹ V. Smakhtin,¹⁷⁰ B. H. Smart,⁴⁵ S. Yu. Smirnov,⁹⁵ Y. Smirnov,⁹⁵ L. N. Smirnova,⁹⁶ O. Smirnova,⁷⁸ B. C. Smith,⁵⁶

D. Smith,¹⁴² K. M. Smith,⁵² M. Smizanska,⁷⁰ K. Smolek,¹²⁶ A. A. Snesarev,⁹³ S. W. Snow,⁸¹ J. Snow,¹¹⁰ J. Snuverink,¹⁰⁴ S. Snyder,²⁴ M. Soares,^{123a} R. Sobie,^{168,k} J. Sodomka,¹²⁶ A. Soffer,¹⁵² C. A. Solans,¹⁶⁶ M. Solar,¹²⁶ J. Solc,¹²⁶ E. Soldatov,⁹⁵ U. Soldevila,¹⁶⁶ E. Solfaroli Camillocci,^{131a,131b} A. A. Solodkov,¹²⁷ O. V. Solovyanov,¹²⁷ N. Soni,² V. Sopko,¹²⁶ B. Sopko,¹²⁶ M. Sosebee,⁷ R. Soualah,^{163a,163c} A. Soukharev,¹⁰⁶ S. Spagnolo,^{71a,71b} F. Spanò,⁷⁵ R. Spighi,^{19a} G. Spigo,²⁹ F. Spila,^{131a,131b} R. Spiwoks,²⁹ M. Spousta,¹²⁵ T. Spreitzer,¹⁵⁷ B. Spurlock,⁷ R. D. St. Denis,⁵² J. Stahlman,¹¹⁹ R. Stamen,^{57a} E. Stanecka,³⁸ R. W. Stanek,⁵ C. Stanescu,^{133a} S. Stapnes,¹¹⁶ E. A. Starchenko,¹²⁷ J. Stark,⁵⁴ P. Staroba,¹²⁴ P. Starovoitov,⁹⁰ A. Staude,⁹⁷ P. Stavina,^{143a} G. Steele,⁵² P. Steinbach,⁴³ P. Steinberg,²⁴ I. Stekl,¹²⁶ B. Stelzer,¹⁴¹ H. J. Stelzer,⁸⁷ O. Stelzer-Chilton,^{158a} H. Stenzel,⁵¹ S. Stern,⁹⁸ K. Stevenson,⁷⁴ G. A. Stewart,²⁹ J. A. Stillings,²⁰ M. C. Stockton,⁸⁴ K. Stoerig,⁴⁷ G. Stoicea,^{25a} S. Stonjek,⁹⁸ P. Strachota,¹²⁵ A. R. Stradling,⁷ A. Straessner,⁴³ J. Strandberg,¹⁴⁶ S. Strandberg,^{145a,145b} A. Strandlie,¹¹⁶ M. Strang,¹⁰⁸ E. Strauss,¹⁴² M. Strauss,¹¹⁰ P. Strizenec,^{143b} R. Ströhmer,¹⁷² D. M. Strom,¹¹³ J. A. Strong,^{75,a} R. Stroynowski,³⁹ J. Strube,¹²⁸ B. Stugu,¹³ I. Stumer,^{24,a} J. Stupak,¹⁴⁷ P. Sturm,¹⁷³ N. A. Styles,⁴¹ D. A. Soh,^{150,v} D. Su,¹⁴² HS. Subramania,² A. Succurro,¹¹ Y. Sugaya,¹¹⁵ T. Sugimoto,¹⁰⁰ C. Suhr,¹⁰⁵ K. Suita,⁶⁶ M. Suk,¹²⁵ V. V. Sulin,⁹³ S. Sultansoy,^{3d} T. Sumida,⁶⁷ X. Sun,⁵⁴ J. E. Sundermann,⁴⁷ K. Suruliz,¹³⁸ S. Sushkov,¹¹ G. Susinno,^{36a,36b} M. R. Sutton,¹⁴⁸ Y. Suzuki,⁶⁵ Y. Suzuki,⁶⁶ M. Svatos,¹²⁴ Yu. M. Sviridov,¹²⁷ S. Swedish,¹⁶⁷ I. Sykora,^{143a} T. Sykora,¹²⁵ B. Szeless,²⁹ J. Sánchez,¹⁶⁶ D. Ta,¹⁰⁴ K. Tackmann,⁴¹ A. Taffard,¹⁶² R. Tafirout,^{158a} N. Taiblum,¹⁵² Y. Takahashi,¹⁰⁰ H. Takai,²⁴ R. Takashima,⁶⁸ H. Takeda,⁶⁶ T. Takeshita,¹³⁹ Y. Takubo,⁶⁵ M. Talby,⁸² A. Talyshev,^{106,g} M. C. Tamssett,²⁴ J. Tanaka,¹⁵⁴ R. Tanaka,¹¹⁴ S. Tanaka,¹³⁰ S. Tanaka,⁶⁵ Y. Tanaka,⁹⁹ A. J. Tanasijczuk,¹⁴¹ K. Tani,⁶⁶ N. Tannoury,⁸² G. P. Tappern,²⁹ S. Tapprogge,⁸⁰ D. Tardif,¹⁵⁷ S. Tarem,¹⁵¹ F. Tarrade,²⁸ G. F. Tartarelli,^{88a} P. Tas,¹²⁵ M. Tasevsky,¹²⁴ E. Tassi,^{36a,36b} M. Tatarkhanov,¹⁴ Y. Tayalati,^{134d} C. Taylor,⁷⁶ F. E. Taylor,⁹¹ G. N. Taylor,⁸⁵ W. Taylor,^{158b} M. Teinturier,¹¹⁴ M. Teixeira Dias Castanheira,⁷⁴ P. Teixeira-Dias,⁷⁵ K. K. Temming,⁴⁷ H. Ten Kate,²⁹ P. K. Teng,¹⁵⁰ S. Terada,⁶⁵ K. Terashi,¹⁵⁴ J. Terron,⁷⁹ M. Testa,⁴⁶ R. J. Teuscher,^{157,k} J. Thadome,¹⁷³ J. Therhaag,²⁰ T. Theveneaux-Pelzer,⁷⁷ M. Thioye,¹⁷⁴ S. Thoma,⁴⁷ J. P. Thomas,¹⁷ E. N. Thompson,³⁴ P. D. Thompson,¹⁷ P. D. Thompson,¹⁵⁷ A. S. Thompson,⁵² L. A. Thomsen,³⁵ E. Thomson,¹¹⁹ M. Thomson,²⁷ R. P. Thun,⁸⁶ F. Tian,³⁴ M. J. Tibbetts,¹⁴ T. Tic,¹²⁴ V. O. Tikhomirov,⁹³ Y. A. Tikhonov,^{106,g} S. Timoshenko,⁹⁵ P. Tipton,¹⁷⁴ F. J. Tique Aires Viegas,²⁹ S. Tisserant,⁸² B. Toczek,³⁷ T. Todorov,⁴ S. Todorova-Nova,¹⁶⁰ B. Toggerson,¹⁶² J. Tojo,⁶⁵ S. Tokár,^{143a} K. Tokunaga,⁶⁶ K. Tokushuku,⁶⁵ K. Tollefson,⁸⁷ M. Tomoto,¹⁰⁰ L. Tompkins,³⁰ K. Toms,¹⁰² G. Tong,^{32a} A. Tonoyan,¹³ C. Topfel,¹⁶ N. D. Topilin,⁶⁴ I. Torchiani,²⁹ E. Torrence,¹¹³ H. Torres,⁷⁷ E. Torró Pastor,¹⁶⁶ J. Toth,^{82,bb} F. Touchard,⁸² D. R. Tovey,¹³⁸ T. Trefzger,¹⁷² L. Tremblet,²⁹ A. Tricoli,²⁹ I. M. Trigger,^{158a} S. Trincaz-Duvoid,⁷⁷ T. N. Trinh,⁷⁷ M. F. Tripania,⁶⁹ W. Trischuk,¹⁵⁷ A. Trivedi,^{24,aa} B. Trocmé,⁵⁴ C. Troncon,^{88a} M. Trotter-McDonald,¹⁴¹ M. Trzebinski,³⁸ A. Trzupek,³⁸ C. Tsarouchas,²⁹ J. C.-L. Tseng,¹¹⁷ M. Tsiakiris,¹⁰⁴ P. V. Tsiarehshka,⁸⁹ D. Tsiou, ^{4,ff} G. Tsiopolitis,⁹ V. Tsiskaridze,⁴⁷ E. G. Tskhadadze,^{50a} I. I. Tsukerman,⁹⁴ V. Tsulaia,¹⁴ J.-W. Tsung,²⁰ S. Tsuno,⁶⁵ D. Tsybychev,¹⁴⁷ A. Tua,¹³⁸ A. Tudorache,^{25a} V. Tudorache,^{25a} J. M. Tuggle,³⁰ M. Turala,³⁸ D. Turecek,¹²⁶ I. Turk Cakir,^{3e} E. Turlay,¹⁰⁴ R. Turra,^{88a,88b} P. M. Tuts,³⁴ A. Tykhonov,⁷³ M. Tylmad,^{145a,145b} M. Tyndel,¹²⁸ G. Tzanakos,⁸ K. Uchida,²⁰ I. Ueda,¹⁵⁴ R. Ueno,²⁸ M. Ugland,¹³ M. Uhlenbrock,²⁰ M. Uhrmacher,⁵³ F. Ukegawa,¹⁵⁹ G. Unal,²⁹ D. G. Underwood,⁵ A. Undrus,²⁴ G. Unel,¹⁶² Y. Unno,⁶⁵ D. Urbaniec,³⁴ G. Usai,⁷ M. Uslenghi,^{118a,118b} L. Vacavant,⁸² V. Vacek,¹²⁶ B. Vachon,⁸⁴ S. Vahsen,¹⁴ J. Valenta,¹²⁴ P. Valente,^{131a} S. Valentinetti,^{19a,19b} S. Valkar,¹²⁵ E. Valladolid Gallego,¹⁶⁶ S. Vallecorsa,¹⁵¹ J. A. Valls Ferrer,¹⁶⁶ H. van der Graaf,¹⁰⁴ E. van der Kraaij,¹⁰⁴ R. Van Der Leeuw,¹⁰⁴ E. van der Poel,¹⁰⁴ D. van der Ster,²⁹ N. van Eldik,⁸³ P. van Gemmeren,⁵ Z. van Kesteren,¹⁰⁴ I. van Vulpen,¹⁰⁴ M. Vanadia,⁹⁸ W. Vandelli,²⁹ G. Vandoni,²⁹ A. Vaniachine,⁵ P. Vankov,⁴¹ F. Vannucci,⁷⁷ F. Varela Rodriguez,²⁹ R. Vari,^{131a} E. W. Varnes,⁶ D. Varouchas,¹⁴ A. Vartapetian,⁷ K. E. Varvell,¹⁴⁹ V. I. Vassilikopoulos,⁵⁵ F. Vazeille,³³ T. Vazquez Schroeder,⁵³ G. Vegni,^{88a,88b} J. J. Veillet,¹¹⁴ C. Vellidis,⁸ F. Veloso,^{123a} R. Veness,²⁹ S. Veneziano,^{131a} A. Ventura,^{71a,71b} D. Ventura,¹³⁷ M. Venturi,⁴⁷ N. Venturi,¹⁵⁷ V. Vercesi,^{118a} M. Verducci,¹³⁷ W. Verkerke,¹⁰⁴ J. C. Vermeulen,¹⁰⁴ A. Vest,⁴³ M. C. Vetterli,^{141,e} I. Vichou,¹⁶⁴ T. Vickey,^{144b,gg} O. E. Vickey Boeriu,^{144b} G. H. A. Viehhauser,¹¹⁷ S. Viel,¹⁶⁷ M. Villa,^{19a,19b} M. Villaplana Perez,¹⁶⁶ E. Vilucchi,⁴⁶ M. G. Vincker,²⁸ E. Vinek,²⁹ V. B. Vinogradov,⁶⁴ M. Virchaux,^{135,a} J. Virzi,¹⁴ O. Vitells,¹⁷⁰ M. Viti,⁴¹ I. Vivarelli,⁴⁷ F. Vives Vaque,² S. Vlachos,⁹ D. Vladoiu,⁹⁷ M. Vlasak,¹²⁶ N. Vlasov,²⁰ A. Vogel,²⁰ P. Vokac,¹²⁶ G. Volpi,⁴⁶ M. Volpi,⁸⁵ G. Volpini,^{88a} H. von der Schmitt,⁹⁸ J. von Loeben,⁹⁸ H. von Radziewski,⁴⁷ E. von Toerne,²⁰ V. Vorobel,¹²⁵ A. P. Vorobiev,¹²⁷ V. Vorwerk,¹¹ M. Vos,¹⁶⁶ R. Voss,²⁹ T. T. Voss,¹⁷³ J. H. Vosseveld,⁷² N. Vranjes,¹³⁵ M. Vranjes Milosavljevic,¹⁰⁴ V. Vrba,¹²⁴ M. Vreeswijk,¹⁰⁴ T. Vu Anh,⁴⁷ R. Vuillermet,²⁹ I. Vukotic,¹¹⁴

W. Wagner,¹⁷³ P. Wagner,¹¹⁹ H. Wahlen,¹⁷³ J. Wakabayashi,¹⁰⁰ J. Walbersloh,⁴² S. Walch,⁸⁶ J. Walder,⁷⁰ R. Walker,⁹⁷
W. Walkowiak,¹⁴⁰ R. Wall,¹⁷⁴ P. Waller,⁷² C. Wang,⁴⁴ H. Wang,¹⁷¹ H. Wang,^{32b,hh} J. Wang,¹⁵⁰ J. Wang,⁵⁴
J. C. Wang,¹³⁷ R. Wang,¹⁰² S. M. Wang,¹⁵⁰ A. Warburton,⁸⁴ C. P. Ward,²⁷ M. Warsinsky,⁴⁷ P. M. Watkins,¹⁷
A. T. Watson,¹⁷ I. J. Watson,¹⁴⁹ M. F. Watson,¹⁷ G. Watts,¹³⁷ S. Watts,⁸¹ A. T. Waugh,¹⁴⁹ B. M. Waugh,⁷⁶
M. Weber,¹²⁸ M. S. Weber,¹⁶ P. Weber,⁵³ A. R. Weidberg,¹¹⁷ P. Weigell,⁹⁸ J. Weingarten,⁵³ C. Weiser,⁴⁷
H. Wellenstein,²² P. S. Wells,²⁹ T. Wenaus,²⁴ D. Wendland,¹⁵ S. Wendler,¹²² Z. Weng,^{150,v} T. Wengler,²⁹ S. Wenig,²⁹
N. Wermes,²⁰ M. Werner,⁴⁷ P. Werner,²⁹ M. Werth,¹⁶² M. Wessels,^{57a} C. Weydert,⁵⁴ K. Whalen,²⁸
S. J. Wheeler-Ellis,¹⁶² S. P. Whitaker,²¹ A. White,⁷ M. J. White,⁸⁵ S. R. Whitehead,¹¹⁷ D. Whiteson,¹⁶²
D. Whittington,⁶⁰ F. Wicek,¹¹⁴ D. Wicke,¹⁷³ F. J. Wickens,¹²⁸ W. Wiedenmann,¹⁷¹ M. Wielers,¹²⁸ P. Wienemann,²⁰
C. Wiglesworth,⁷⁴ L. A. M. Wiik-Fuchs,⁴⁷ P. A. Wijeratne,⁷⁶ A. Wildauer,¹⁶⁶ M. A. Wildt,^{41,r} I. Wilhelm,¹²⁵
H. G. Wilkens,²⁹ J. Z. Will,⁹⁷ E. Williams,³⁴ H. H. Williams,¹¹⁹ W. Willis,³⁴ S. Willocq,⁸³ J. A. Wilson,¹⁷
M. G. Wilson,¹⁴² A. Wilson,⁸⁶ I. Wingerter-Seez,⁴ S. Winkelmann,⁴⁷ F. Winklmeier,²⁹ M. Wittgen,¹⁴²
M. W. Wolter,³⁸ H. Wolters,^{123a,i} W. C. Wong,⁴⁰ G. Wooden,⁸⁶ B. K. Wosiek,³⁸ J. Wotschack,²⁹ M. J. Woudstra,⁸³
K. W. Wozniak,³⁸ K. Wraight,⁵² C. Wright,⁵² M. Wright,⁵² B. Wrona,⁷² S. L. Wu,¹⁷¹ X. Wu,⁴⁸ Y. Wu,^{32b,ii} E. Wulf,³⁴
R. Wunstorf,⁴² B. M. Wynne,⁴⁵ S. Xella,³⁵ M. Xiao,¹³⁵ S. Xie,⁴⁷ Y. Xie,^{32a} C. Xu,^{32b,x} D. Xu,¹³⁸ G. Xu,^{32a}
B. Yabsley,¹⁴⁹ S. Yacoob,^{144b} M. Yamada,⁶⁵ H. Yamaguchi,¹⁵⁴ A. Yamamoto,⁶⁵ K. Yamamoto,⁶³ S. Yamamoto,¹⁵⁴
T. Yamamura,¹⁵⁴ T. Yamanaka,¹⁵⁴ J. Yamaoka,⁴⁴ T. Yamazaki,¹⁵⁴ Y. Yamazaki,⁶⁶ Z. Yan,²¹ H. Yang,⁸⁶ U. K. Yang,⁸¹
Y. Yang,⁶⁰ Y. Yang,^{32a} Z. Yang,^{145a,145b} S. Yanush,⁹⁰ Y. Yao,¹⁴ Y. Yasu,⁶⁵ G. V. Ybeles Smit,¹²⁹ J. Ye,³⁹ S. Ye,²⁴
M. Yilmaz,^{3c} R. Yoosofmiya,¹²² K. Yorita,¹⁶⁹ R. Yoshida,⁵ C. Young,¹⁴² S. Youssef,²¹ D. Yu,²⁴ J. Yu,⁷ J. Yu,¹¹¹
L. Yuan,^{32a,jj} A. Yurkewicz,¹⁰⁵ B. Zabinski,³⁸ V. G. Zaets,¹²⁷ R. Zaidan,⁶² A. M. Zaitsev,¹²⁷ Z. Zajacova,²⁹
L. Zanello,^{131a,131b} A. Zaytsev,¹⁰⁶ C. Zeitnitz,¹⁷³ M. Zeller,¹⁷⁴ M. Zeman,¹²⁴ A. Zemla,³⁸ C. Zender,²⁰ O. Zenin,¹²⁷
T. Ženiš,^{143a} Z. Zinonos,^{121a,121b} S. Zenz,¹⁴ D. Zerwas,¹¹⁴ G. Zevi della Porta,⁵⁶ Z. Zhan,^{32d} D. Zhang,^{32b,hh}
H. Zhang,⁸⁷ J. Zhang,⁵ X. Zhang,^{32d} Z. Zhang,¹¹⁴ L. Zhao,¹⁰⁷ T. Zhao,¹³⁷ Z. Zhao,^{32b} A. Zhemchugov,⁶⁴ S. Zheng,^{32a}
J. Zhong,¹¹⁷ B. Zhou,⁸⁶ N. Zhou,¹⁶² Y. Zhou,¹⁵⁰ C. G. Zhu,^{32d} H. Zhu,⁴¹ J. Zhu,⁸⁶ Y. Zhu,^{32b} X. Zhuang,⁹⁷
V. Zhuravlov,⁹⁸ D. Zieminska,⁶⁰ R. Zimmermann,²⁰ S. Zimmermann,²⁰ S. Zimmermann,⁴⁷ M. Ziolkowski,¹⁴⁰
R. Zitoun,⁴ L. Živković,³⁴ V. V. Zmouchko,^{127,a} G. Zobernig,¹⁷¹ A. Zoccoli,^{19a,19b} Y. Zolnierowski,⁴ A. Zsenei,²⁹
M. zur Nedden,¹⁵ V. Zutshi,¹⁰⁵ and L. Zwalinski²⁹

(ATLAS Collaboration)

¹University at Albany, Albany, New York, USA²Department of Physics, University of Alberta, Edmonton, Alberta, Canada^{3a}Department of Physics, Ankara University, Ankara, Turkey^{3b}Department of Physics, Dumlupinar University, Kutahya, Turkey^{3c}Department of Physics, Gazi University, Ankara, Turkey^{3d}Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey^{3e}Turkish Atomic Energy Authority, Ankara, Turkey⁴LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France⁵High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA⁶Department of Physics, University of Arizona, Tucson, Arizona, USA⁷Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA⁸Physics Department, University of Athens, Athens, Greece⁹Physics Department, National Technical University of Athens, Zografou, Greece¹⁰Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan¹¹Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain^{12a}Institute of Physics, University of Belgrade, Belgrade, Serbia^{12b}Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia¹³Department for Physics and Technology, University of Bergen, Bergen, Norway¹⁴Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA¹⁵Department of Physics, Humboldt University, Berlin, Germany¹⁶Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland¹⁷School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom^{18a}Department of Physics, Bogazici University, Istanbul, Turkey^{18b}Division of Physics, Dogus University, Istanbul, Turkey

- ^{18c}*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
- ^{18d}*Department of Physics, Istanbul Technical University, Istanbul, Turkey*
- ^{19a}*INFN Sezione di Bologna, Italy*
- ^{19b}*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
- ²⁰*Physikalisches Institut, University of Bonn, Bonn, Germany*
- ²¹*Department of Physics, Boston University, Boston, Massachusetts, USA*
- ²²*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
- ^{23a}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
- ^{23b}*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
- ^{23c}*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
- ^{23d}*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*
- ²⁴*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
- ^{25a}*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
- ^{25b}*University Politehnica Bucharest, Bucharest, Romania*
- ^{25c}*West University in Timisoara, Timisoara, Romania*
- ²⁶*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
- ²⁷*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
- ²⁸*Department of Physics, Carleton University, Ottawa, Ontario, Canada*
- ²⁹*CERN, Geneva, Switzerland*
- ³⁰*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
- ^{31a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
- ^{31b}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
- ^{32a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
- ^{32b}*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
- ^{32c}*Department of Physics, Nanjing University, Jiangsu, China*
- ^{32d}*School of Physics, Shandong University, Shandong, China*
- ³³*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France*
- ³⁴*Nevis Laboratory, Columbia University, Irvington, New York, USA*
- ³⁵*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
- ^{36a}*INFN Gruppo Collegato di Cosenza, Italy*
- ^{36b}*Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy*
- ³⁷*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
- ³⁸*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
- ³⁹*Physics Department, Southern Methodist University, Dallas, Texas, USA*
- ⁴⁰*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
- ⁴¹*DESY, Hamburg and Zeuthen, Germany*
- ⁴²*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
- ⁴³*Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany*
- ⁴⁴*Department of Physics, Duke University, Durham, North Carolina, USA*
- ⁴⁵*SUPA—School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁴⁶*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
- ⁴⁷*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg i.Br, Germany*
- ⁴⁸*Section de Physique, Université de Genève, Genève, Switzerland*
- ^{49a}*INFN Sezione di Genova, Italy*
- ^{49b}*Dipartimento di Fisica, Università di Genova, Genova, Italy*
- ^{50a}*E. Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi, Georgia*
- ^{50b}*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
- ⁵¹*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
- ⁵²*SUPA-School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁵³*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
- ⁵⁴*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
- ⁵⁵*Department of Physics, Hampton University, Hampton, Virginia, USA*
- ⁵⁶*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
- ^{57a}*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{57b}*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{57c}*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
- ⁵⁸*Faculty of Science, Hiroshima University, Hiroshima, Japan*
- ⁵⁹*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
- ⁶⁰*Department of Physics, Indiana University, Bloomington, Indiana, USA*

- ⁶¹*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
⁶²*University of Iowa, Iowa City, Iowa, USA*
⁶³*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
⁶⁴*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
⁶⁵*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
⁶⁶*Graduate School of Science, Kobe University, Kobe, Japan*
⁶⁷*Faculty of Science, Kyoto University, Kyoto, Japan*
⁶⁸*Kyoto University of Education, Kyoto, Japan*
⁶⁹*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
⁷⁰*Physics Department, Lancaster University, Lancaster, United Kingdom*
^{71a}*INFN Sezione di Lecce, Italy*
^{71b}*Dipartimento di Fisica, Università del Salento, Lecce, Italy*
⁷²*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
⁷³*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
⁷⁴*School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom*
⁷⁵*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
⁷⁶*Department of Physics and Astronomy, University College London, London, United Kingdom*
⁷⁷*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
⁷⁸*Fysiska institutionen, Lunds universitet, Lund, Sweden*
⁷⁹*Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain*
⁸⁰*Institut für Physik, Universität Mainz, Mainz, Germany*
⁸¹*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
⁸²*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
⁸³*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
⁸⁴*Department of Physics, McGill University, Montreal, Quebec, Canada*
⁸⁵*School of Physics, University of Melbourne, Victoria, Australia*
⁸⁶*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
⁸⁷*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
^{88a}*INFN Sezione di Milano, Italy*
^{88b}*Dipartimento di Fisica, Università di Milano, Milano, Italy*
⁸⁹*B. I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
⁹⁰*National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus*
⁹¹*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
⁹²*Group of Particle Physics, University of Montreal, Montreal, Quebec, Canada*
⁹³*P. N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*
⁹⁴*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
⁹⁵*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
⁹⁶*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
⁹⁷*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
⁹⁸*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
⁹⁹*Nagasaki Institute of Applied Science, Nagasaki, Japan*
¹⁰⁰*Graduate School of Science, Nagoya University, Nagoya, Japan*
^{101a}*INFN Sezione di Napoli, Italy*
^{101b}*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
¹⁰²*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
¹⁰³*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, The Netherlands*
¹⁰⁴*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, The Netherlands*
¹⁰⁵*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
¹⁰⁶*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia*
¹⁰⁷*Department of Physics, New York University, New York, New York, USA*
¹⁰⁸*Ohio State University, Columbus, Ohio, USA*
¹⁰⁹*Faculty of Science, Okayama University, Okayama, Japan*
¹¹⁰*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
¹¹¹*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
¹¹²*Palacký University, RCPTM, Olomouc, Czech Republic*
¹¹³*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
¹¹⁴*LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France*
¹¹⁵*Graduate School of Science, Osaka University, Osaka, Japan*
¹¹⁶*Department of Physics, University of Oslo, Oslo, Norway*
¹¹⁷*Department of Physics, Oxford University, Oxford, United Kingdom*
^{118a}*INFN Sezione di Pavia, Italy*

- ^{118b}*Dipartimento di Fisica, Università di Pavia, Pavia, Italy*
- ¹¹⁹*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
- ¹²⁰*Petersburg Nuclear Physics Institute, Gatchina, Russia*
- ^{121a}*INFN Sezione di Pisa, Italy*
- ^{121b}*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
- ¹²²*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
- ^{123a}*Laboratorio de Instrumentacao e Fisica Experimental de Particulas—LIP, Lisboa, Portugal*
- ^{123b}*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain*
- ¹²⁴*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
- ¹²⁵*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
- ¹²⁶*Czech Technical University in Prague, Praha, Czech Republic*
- ¹²⁷*State Research Center Institute for High Energy Physics, Protvino, Russia*
- ¹²⁸*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ¹²⁹*Physics Department, University of Regina, Regina, Saskatchewan, Canada*
- ¹³⁰*Ritsumeikan University, Kusatsu, Shiga, Japan*
- ^{131a}*INFN Sezione di Roma I, Italy*
- ^{131b}*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
- ^{132a}*INFN Sezione di Roma Tor Vergata, Italy*
- ^{132b}*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
- ^{133a}*INFN Sezione di Roma Tre, Italy*
- ^{133b}*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
- ^{134a}*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies—Université Hassan II, Casablanca, Morocco*
- ^{134b}*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
- ^{134c}*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
- ^{134d}*Faculté des Sciences, Université Mohamed Premier and LTPM, Oujda, Morocco*
- ^{134e}*Faculté des Sciences, Université Mohammed V- Agdal, Rabat, Morocco*
- ¹³⁵*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France*
- ¹³⁶*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
- ¹³⁷*Department of Physics, University of Washington, Seattle, Washington, USA*
- ¹³⁸*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
- ¹³⁹*Department of Physics, Shinshu University, Nagano, Japan*
- ¹⁴⁰*Fachbereich Physik, Universität Siegen, Siegen, Germany*
- ¹⁴¹*Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada*
- ¹⁴²*SLAC National Accelerator Laboratory, Stanford, California, USA*
- ^{143a}*Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovak Republic*
- ^{143b}*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
- ^{144a}*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
- ^{144b}*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
- ^{145a}*Department of Physics, Stockholm University, Sweden*
- ^{145b}*The Oskar Klein Centre, Stockholm, Sweden*
- ¹⁴⁶*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
- ¹⁴⁷*Departments of Physics and Astronomy and Chemistry, Stony Brook University, Stony Brook, New York, USA*
- ¹⁴⁸*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
- ¹⁴⁹*School of Physics, University of Sydney, Sydney, Australia*
- ¹⁵⁰*Institute of Physics, Academia Sinica, Taipei, Taiwan*
- ¹⁵¹*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
- ¹⁵²*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
- ¹⁵³*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
- ¹⁵⁴*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
- ¹⁵⁵*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
- ¹⁵⁶*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
- ¹⁵⁷*Department of Physics, University of Toronto, Toronto, Ontario, Canada*
- ^{158a}*TRIUMF, Vancouver, British Columbia, Canada*
- ^{158b}*Department of Physics and Astronomy, York University, Toronto, Ontario, Canada*
- ¹⁵⁹*Institute of Pure and Applied Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571, Japan*
- ¹⁶⁰*Science and Technology Center, Tufts University, Medford, Massachusetts, USA*
- ¹⁶¹*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
- ¹⁶²*Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA*
- ^{163a}*INFN Gruppo Collegato di Udine, Italy*

^{163b}*ICTP, Trieste, Italy*^{163c}*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*¹⁶⁴*Department of Physics, University of Illinois, Urbana, Illinois, USA*¹⁶⁵*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*¹⁶⁶*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*¹⁶⁷*Department of Physics, University of British Columbia, Vancouver, British Columbia, Canada*¹⁶⁸*Department of Physics and Astronomy, University of Victoria, Victoria, British Columbia, Canada*¹⁶⁹*Waseda University, Tokyo, Japan*¹⁷⁰*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*¹⁷¹*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*¹⁷²*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*¹⁷³*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*¹⁷⁴*Department of Physics, Yale University, New Haven, Connecticut, USA*¹⁷⁵*Yerevan Physics Institute, Yerevan, Armenia*¹⁷⁶*Domaine scientifique de la Doua, Centre de Calcul CNRS/IN2P3, Villeurbanne Cedex, France*^aDeceased.^bAlso at Laboratório de Instrumentação e Física Experimental de Partículas—LIP, Lisboa, Portugal.^cAlso at Faculdade de Ciências and CFNUL, Universidade de Lisboa, Lisboa, Portugal.^dAlso at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.^eAlso at TRIUMF, Vancouver BC, Canada.^fAlso at Department of Physics, California State University, Fresno, CA, USA.^gAlso at Novosibirsk State University, Novosibirsk, Russia.^hAlso at Fermilab, Batavia, IL, USA.ⁱAlso at Department of Physics, University of Coimbra, Coimbra, Portugal.^jAlso at Università di Napoli Parthenope, Napoli, Italy.^kAlso at Institute of Particle Physics (IPP), Canada.^lAlso at Department of Physics, Middle East Technical University, Ankara, Turkey.^mAlso at Louisiana Tech University, Ruston, LA, USA.ⁿAlso at Department of Physics and Astronomy, University College London, London, United Kingdom.^oAlso at Group of Particle Physics, University of Montreal, Montreal, QC, Canada.^pAlso at Department of Physics, University of Cape Town, Cape Town, South Africa.^qAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.^rAlso at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.^sAlso at Manhattan College, New York, NY, USA.^tAlso at School of Physics, Shandong University, Shandong, China.^uAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.^vAlso at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.^wAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.^xAlso at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Énergie Atomique), Gif-sur-Yvette, France.^yAlso at Section de Physique, Université de Genève, Geneva, Switzerland.^zAlso at Departamento de Física, Universidade de Minho, Braga, Portugal.^{aa}Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.^{bb}Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.^{cc}Also at California Institute of Technology, Pasadena, CA, USA.^{dd}Also at Institute of Physics, Jagiellonian University, Krakow, Poland.^{ee}Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.^{ff}Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.^{gg}Also at Department of Physics, Oxford University, Oxford, United Kingdom.^{hh}Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.ⁱⁱAlso at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.^{jj}Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.