

PUBLISHED VERSION

Aad, G.;...; Jackson, Paul Douglas; Jaekel, M.R.;...; Soni, Nitesh; ... et al.; ATLAS Collaboration

[Search for direct top squark pair production in final states with one isolated lepton, jets, and missing transverse momentum in \$\sqrt{s} = 7\$ TeV pp collisions using 4.7 fb⁻¹ of ATLAS data](#)

Physical Review Letters, 2012; 109(21):211803-1-211803-18

© 2012 CERN, for the ATLAS Collaboration

<http://prl.aps.org/abstract/PRL/v109/i21/e211803>

PERMISSIONS

<http://publish.aps.org/authors/transfer-of-copyright-agreement>

“The author(s), and in the case of a Work Made For Hire, as defined in the U.S. Copyright Act, 17 U.S.C.

§101, the employer named [below], shall have the following rights (the “Author Rights”):

[...]

3. The right to use all or part of the Article, including the APS-prepared version without revision or modification, on the author(s)' web home page or employer's website and to make copies of all or part of the Article, including the APS-prepared version without revision or modification, for the author(s)' and/or the employer's use for educational or research purposes.”

1st May 2013

<http://hdl.handle.net/2440/76972>

Search for Direct Top Squark Pair Production in Final States with One Isolated Lepton, Jets, and Missing Transverse Momentum in $\sqrt{s} = 7$ TeV pp Collisions Using 4.7 fb⁻¹ of ATLAS Data

G. Aad *et al.**

(ATLAS Collaboration)

(Received 13 August 2012; published 20 November 2012)

A search is presented for direct top squark pair production in final states with one isolated electron or muon, jets, and missing transverse momentum in proton-proton collisions at $\sqrt{s} = 7$ TeV. The measurement is based on 4.7 fb⁻¹ of data collected with the ATLAS detector at the LHC. Each top squark is assumed to decay to a top quark and the lightest supersymmetric particle (LSP). The data are found to be consistent with standard model expectations. Top squark masses between 230 GeV and 440 GeV are excluded with 95% confidence for massless LSPs, and top squark masses around 400 GeV are excluded for LSP masses up to 125 GeV.

DOI: [10.1103/PhysRevLett.109.211803](https://doi.org/10.1103/PhysRevLett.109.211803)

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

Weak scale supersymmetry (SUSY) [1–9] is an extension to the standard model (SM) that provides a solution to the hierarchy problem by introducing supersymmetric partners of all SM particles. In the framework of a generic R -parity conserving minimal supersymmetric extension of the SM [10–14], SUSY particles are produced in pairs, and the lightest supersymmetric particle (LSP) is stable and can be a dark matter candidate. In a large variety of models, the LSP is the lightest neutralino, $\tilde{\chi}_1^0$, which only interacts weakly and thus escapes detection.

Light top squarks (stop) are suggested by naturalness arguments [15,16]. Searches for direct stop pair production have been previously reported by the CDF and D0 experiments [17,18]. Searches for stops via $\tilde{g}\tilde{g}$ production have been reported by the ATLAS [19–21] and CMS [22,23] Collaborations. In this Letter, one stop mass eigenstate (\tilde{t}_1) is assumed to be significantly lighter than the other squarks. A search is presented for directly pair-produced stops, which are each assumed to decay to a top quark and the LSP. The signature for such a signal is characterized by a top quark pair ($t\bar{t}$) produced in association with possibly large missing transverse momentum, the magnitude of which is referred to as E_T^{miss} , from the undetected LSPs. The analysis targets final states where one top quark decays hadronically and the other semileptonically.

The ATLAS detector [24] has a solenoid, surrounding the inner tracking detector (ID), a calorimeter, as well as a barrel and two end cap toroidal magnets supporting the muon spectrometer. The ID consists of silicon pixel, silicon microstrip, and transition radiation detectors and provides precision tracking of charged particles for pseudorapidity

$|\eta| < 2.5$ [25]. The calorimeter, placed outside the solenoid, covers $|\eta| < 4.9$ and is composed of sampling electromagnetic and hadronic calorimeters with either liquid argon or scintillating tiles as the active media. The muon spectrometer surrounds the calorimeters and consists of a system of precision tracking chambers in $|\eta| < 2.7$, and detectors for triggering in $|\eta| < 2.4$.

The analysis is based on data recorded by the ATLAS detector in 2011 corresponding to 4.7 fb⁻¹ of integrated luminosity with the LHC operating at a pp center-of-mass energy of 7 TeV. The data were collected requiring either a single lepton (electron or muon) or an E_T^{miss} trigger. The combined trigger efficiency is $>98\%$ for the chosen selection criteria on leptons and E_T^{miss} . Requirements that ensure the quality of beam conditions, detector performance, and data are imposed.

Monte Carlo (MC) event samples using the full ATLAS detector simulation [26] based on the GEANT4 program [27] are used to aid in the description of the background and to model the SUSY signal. The effect of multiple pp interactions per bunch crossing is also simulated [28]. Production of top quark pairs is simulated with MC@NLO 4.01 [29,30], alternatively using ALPGEN 2.14 [31] and PowHeg HVQ patch 4 [32–34]. The data modeling is improved for high jet multiplicities by reweighting the MC@NLO sample to match the jet multiplicity distribution in ALPGEN. Uncertainties associated with initial- and final-state radiation (ISR and FSR) [35] are assessed using ACERMC 3.7 [36] samples. A top quark mass of 172.5 GeV is used consistently. W and Z/γ^* production in association with jets are each modeled with ALPGEN. Diboson VV (WW , WZ , and ZZ) production is simulated with ALPGEN and cross-checked with HERWIG 6.520 [37]. Single top production is modeled with MC@NLO, and $t\bar{t}$ events produced in association with Z , W , or WW ($t\bar{t} + V$) are generated with MADGRAPH 5 [38]. Next-to-leading-order (NLO) parton density functions (PDFs) CT10 [39] are used with all NLO MC samples. For all other samples,

*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.

TABLE I. Selection requirements defining the SRA–SRE.

Requirement	SRA	SRB	SRC	SRD	SRE
$E_T^{\text{miss}}[\text{GeV}]>$	150	150	150	225	275
$E_T^{\text{miss}}/\sqrt{H_T} [\text{GeV}^{1/2}]>$	7	9	11	11	11
$m_T[\text{GeV}]>$	120	120	120	130	140

LO PDFs are used: MRSTmc1 [40] with HERWIG, and CTEQ6L1 [41] with ALPGEN and MADGRAPH. Fragmentation and hadronization for the ALPGEN and MC@NLO samples are performed with HERWIG, using JIMMY 4.31 [42] for the underlying event, and for the MADGRAPH samples PYTHIA 6.425 [43] is used. The $t\bar{t}$, single top and $t\bar{t} + V$ production cross sections are normalized to approximate next-to-next-to-leading order (NNLO) [44], next-to-next-to-leading-logarithmic accuracy (NLO + NNLL) [45–47] and NLO [48] calculations, respectively. QCD NNLO FEWZ [49] inclusive W and Z cross sections are used for the normalization of the $W + \text{jets}$ and $Z + \text{jets}$ processes. Expected diboson yields are normalized using NLO QCD predictions obtained with MCFM [50,51].

Stop pair production is modeled using Herwig++ 2.5.2 [52]. The \tilde{t}_1 is chosen to be mostly the partner of the right-handed top quark, and the $\tilde{\chi}_1^0$ to be almost a pure bino. A signal grid is generated with a step size of 50 GeV both for the stop and LSP mass values. Signal cross sections are calculated to NLO in the strong coupling constant, including the resummation of soft gluon emission at next-to-leading-logarithmic accuracy (NLO + NLL) [53–55]. The nominal cross section and the uncertainty are taken from an envelope of cross-section predictions using different PDF sets and factorization and renormalization scales [56]. The $\tilde{t}_1\tilde{t}_1$ cross section for $m_{\tilde{t}_1} = 400$ GeV is (0.21 ± 0.03) pb.

TABLE II. Numbers of observed events in the five signal regions and three background control regions, as well as their estimated values and all (statistical and systematic) uncertainties from a fit to the control regions only, for the electron and muon combined channel. The expected numbers of signal events for $m_{\tilde{t}_1} = 400$ GeV (500 GeV) and $m_{\tilde{\chi}_1^0} = 1$ GeV for benchmark points 1 (2) are listed for comparison. The central values of the fitted sum of backgrounds in the control regions agree with the observations by construction. Furthermore, p_0 -values and 95% CL_s observed (expected) upper limits on beyond-SM events are given, using simultaneous fits including one SR at a time and all CRs.

Regions	SRA	SRB	SRC	SRD	SRE	2-lep TR	1-lep TR	1-lep WR
$t\bar{t}$	36 ± 5	27 ± 4	11 ± 2	4.9 ± 1.3	1.3 ± 0.6	109 ± 10	364 ± 23	59 ± 19
$t\bar{t} + V$, single top	2.9 ± 0.7	2.5 ± 0.6	1.6 ± 0.3	0.9 ± 0.3	0.4 ± 0.1	7.2 ± 1.3	18 ± 3	6.1 ± 1.6
$V + \text{jets}$, VV	2.5 ± 1.3	1.7 ± 0.8	0.4 ± 0.1	0.3 ± 0.1	0.1 ± 0.1	1.6 ± 0.8	38 ± 11	162 ± 23
Multijet	0.4 ± 0.4	0.3 ± 0.3	0.3 ± 0.3	0.3 ± 0.3	$0.0_{-0.0}^{+0.3}$	$0.0_{-0.0}^{+0.6}$	1.7 ± 1.7	0.8 ± 0.8
Total background	42 ± 6	31 ± 4	13 ± 2	6.4 ± 1.4	1.8 ± 0.7	118 ± 10	421 ± 20	228 ± 15
Signal benchmark 1 (2)	25.6(8.8)	23.0(8.1)	17.5(6.9)	13.5(6.2)	7.1(4.5)	1.7(0.6)	2.3(0.6)	0.4(0.1)
Observed events	38	25	15	8	5	118	421	228
p_0 -values	0.50	0.50	0.32	0.24	0.015			
Obs. (exp.) $N_{\text{BSM}} <$	15.1(17.2)	10.1(13.8)	10.8(9.2)	8.4(7.0)	8.2(4.6)			

Events must pass basic quality criteria to reject detector noise and noncollision backgrounds [57,58] and are required to have ≥ 1 reconstructed primary vertex associated with five or more tracks with transverse momentum $p_T > 0.4$ GeV. Events are retained if they contain exactly one muon [59] with $|\eta| < 2.4$ and $p_T > 20$ GeV or one electron passing “tight” [60] selection criteria with $|\eta| < 2.47$ and $p_T > 25$ GeV. Leptons are required to be isolated from other particles. The scalar sum of the transverse momenta of tracks above 1 GeV within a cone of size $\Delta R = 0.2$ around the lepton candidate is required to be $< 10\%$ of the electron p_T , and < 1.8 GeV for the muon. Events are rejected if they contain additional leptons passing looser selection criteria [61]. Jets are reconstructed from three-dimensional calorimeter energy clusters using the anti- k_r jet clustering algorithm [62] with a radius parameter of 0.4. The jet energy is corrected for the effects of calorimeter noncompensation and inhomogeneities using p_T - and η -dependent calibration factors based on MC simulations and validated with extensive test-beam and collision-data studies [63]. To suppress jet background originating from uncorrelated soft collisions, $\geq 75\%$ of the summed p_T of all tracks associated to a jet must come from tracks associated to the selected primary vertex. Events with four or more jets with $|\eta| < 2.5$ and $p_T > 80, 60, 40,$ and 25 GeV are selected. At least one jet needs to be identified as a b -jet, which is a jet containing a b -hadron decay. These are identified using the “MV1” b -tagging algorithm [64] which exploits both impact parameter and secondary vertex information. An operating point is employed corresponding to an average 75% b -tagging efficiency and to a $< 2\%$ misidentification rate for light-quark or gluon jets for jets with $p_T > 20$ GeV and $|\eta| < 2.5$ in $t\bar{t}$ MC events.

Ambiguities between overlapping leptons and jets are resolved by discarding either the jet or lepton candidates [61]

based on their separation ΔR . The measurement of E_T^{miss} is based on the transverse momenta of all electron and muon candidates, all jets after overlap removal, and all calorimeter energy clusters not associated to such objects. The background is reduced by requiring $\Delta\phi_{\text{min}} > 0.8$, where $\Delta\phi_{\text{min}}$ is the minimum azimuthal separation between the two highest p_T jets and the missing transverse momentum direction. A requirement on the three-jet mass m_{jjj} of the hadronically decaying top quark specifically rejects the dileptonic $t\bar{t}$ background, where both W bosons from the top quarks decay leptonically. The jet-jet pair having invariant mass >60 GeV and the smallest ΔR is selected to form the hadronically decaying W boson. The mass m_{jjj} is reconstructed including a third jet closest in ΔR to the hadronic W boson momentum vector and $130 \text{ GeV} < m_{jjj} < 205 \text{ GeV}$ is required.

Five signal regions (SRA–SRE) are defined in order to optimize the sensitivity for different stop and LSP masses. For increasing stop mass and increasing mass difference between stop and LSP, the requirements are tightened on E_T^{miss} , on the ratio $E_T^{\text{miss}}/\sqrt{H_T}$, where H_T is the scalar sum of the momenta of the four selected jets with highest p_T , and on the transverse mass m_T [65], as shown in Table I. The number of observed events in each SR after applying all selection criteria are given in Table II.

The product of the kinematic acceptance, detector, and reconstruction efficiency ($A \cdot \epsilon$) varies between 4% and 0.3% for SRA and between 3% and 0.01% for SRE as the stop-LSP mass difference varies between 550 GeV and 250 GeV.

The dominant background arises from dileptonic $t\bar{t}$ events in which one of the leptons is either not identified, is outside the detector acceptance, or is a hadronically decaying τ lepton. In all these cases, the $t\bar{t}$ decay products include two or more high- p_T neutrinos, resulting in large E_T^{miss} and m_T . Three control regions (CRs) enriched in dileptonic $t\bar{t}$ events (2-lep TR), single-leptonic $t\bar{t}$ events (1-lep TR), and W + jets events (1-lep WR) are designed to normalize the corresponding backgrounds using data. The 2-lep TR differs from the SRs by selecting events with exactly two leptons, applying no requirements on m_T , $E_T^{\text{miss}}/\sqrt{H_T}$ and m_{jjj} , and by requiring $E_T^{\text{miss}} > 125$ GeV. The 1-lep TR and 1-lep WR have selection criteria identical to SRA, except the m_T requirement is changed to $60 < m_T < 90$ GeV and the 1-lep WR has a b -jet veto instead of a b -jet requirement. $t\bar{t}$ production accounts for $>90\%$ of events in the top CRs and W + jets production for $>60\%$ in the W CR. The signal contamination reaches a maximum of 8% in the 2-lep TR for $m_{\tilde{t}_1} = 200$ GeV. The multijet background, which mainly originates from jets misidentified as leptons, is estimated using the matrix method [61]. Other background contributions (VV , $t\bar{t} + V$, and single top) are estimated using MC simulation normalized to the theoretical cross sections. The Z + jets background is found to be negligible.

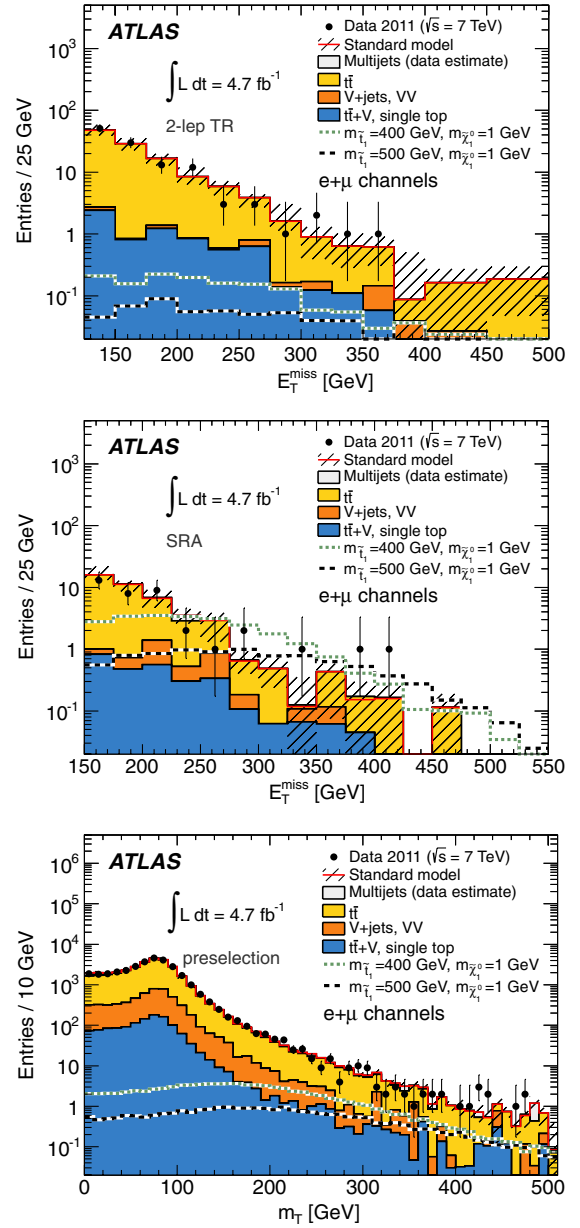


FIG. 1 (color online). Top: E_T^{miss} distributions for the 2-lep TR . Center: E_T^{miss} distributions for SRA. Bottom: m_T distribution for the preselection requirements (see text). All plots show the electron and muon combined channel, before normalization fits. Hatched areas indicate the combined uncertainty due to MC sample size and the jet energy scale.

Good agreement is observed between data and the SM prediction before using the CRs to normalize the $t\bar{t}$ and W + jets backgrounds. As an example, Fig. 1 shows the agreement of the E_T^{miss} distributions in the 2-lep TR , and the E_T^{miss} distribution in SRA. In addition, the m_T distribution for a looser requirements region— $E_T^{\text{miss}} > 40$ GeV and no requirements on $E_T^{\text{miss}}/\sqrt{H_T}$ and m_{jjj} (preselection)—is shown.

Simultaneous fits to the numbers of observed events in the three CRs and one SR at a time are performed to

normalize the $t\bar{t}$ and $W + \text{jets}$ background estimates as well as to search for an excess from a potential signal contribution. The 1-lep and 2-lep TRs have $t\bar{t}$ normalizations that float independently and that are found to be in good agreement with each other. The $t\bar{t}$ estimates in the SRs are based on the 2-lep TR, as this minimizes the extrapolation uncertainties in the fit. Systematic uncertainties are treated as nuisance parameters with Gaussian probability density functions.

The dominant systematic uncertainties in the fitted $t\bar{t}$ background estimate are theoretical and modeling uncertainties, which affect the event kinematics and thus the extrapolation from the CR to the various SRs. They are determined by using different generators (MC@NLO, PowHeg and ALPGEN), different showering models (HERWIG and PYTHIA), and by varying ISR or FSR parameters, and amount to 10–30%. Electroweak single top production is associated with an 8% theoretical uncertainty [45–47] and the $t\bar{t} + V$ background has a 30% uncertainty [48]. The difference between ALPGEN and HERWIG predictions is used to assess the uncertainty on the diboson background, and the uncertainty on the multijet background is based on the matrix method. Both of these uncertainties are estimated as 100%.

Experimental uncertainties affect the signal and background yields, including those normalized in CRs. They are estimated by aid of MC events and are dominated by uncertainties in the jet energy scale, jet energy resolution, and b -tagging. Uncertainties related to the trigger and lepton reconstruction and identification (momentum and energy scales, resolutions and efficiencies) give smaller contributions. Other small uncertainties are due to modeling of multiple pp interactions, the integrated luminosity, and the limited numbers of MC and data events. The uncertainty on $A \cdot \epsilon$ varies between 9% and 16% as the simulated stop-LSP mass difference varies between 550 GeV (SRE) and 250 GeV (SRA and SRB).

Table II shows the results of the background fit to the CRs, extrapolated to the SRs. The fitted numbers of $t\bar{t}$ and $W + \text{jets}$ events are compatible with the MC predictions, with factors of 1.01 and 0.90 applied, respectively. To assess the agreement between the SM expectation and the observation in the SRs, a second set of simultaneous fits including one SR at a time and all CRs is performed. The p_0 -values (probing the background-only hypothesis) obtained are given in Table II. No significant excess of events is found.

One-sided exclusion limits are derived using the CL_s method [66], based on the same simultaneous fit method but taking the predicted signal contamination in the CRs into account. To obtain the best expected combined exclusion limit, a mapping in the stop-LSP mass plane is constructed by selecting the SR with the lowest expected CL_s value for each grid point. The expected and observed 95% CL_s exclusion limits are displayed in Fig. 2. Stop masses

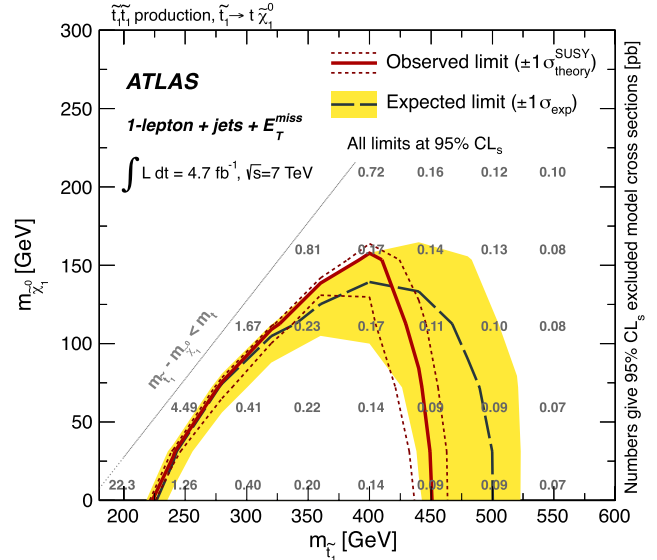


FIG. 2 (color online). Expected (dashed) and observed (solid curve) 95% CL_s excluded region (under the curve) in the plane of $m_{\tilde{\chi}_1^0}$ vs $m_{\tilde{t}_1}$, assuming $BR(\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0) = 100\%$. All uncertainties except the signal cross-section uncertainties are included. The contours of the shaded band around the expected limit are the $\pm 1\sigma$ results. The dotted lines around the observed limit illustrate the change in the observed limit as the nominal signal cross section is scaled up and down by the theoretical uncertainty. The overlaid numbers give the 95% CL_s upper limit on the signal cross section, in pb.

are excluded between 230 GeV and 440 GeV for massless LSPs, and stop masses around 400 GeV are excluded for LSP masses up to 125 GeV. These values are derived from the $-1\sigma_{\text{theory}}^{\text{SUSY}}$ observed limit contour. These stop mass limits significantly extend previous results [17, 18]. Limits on beyond-SM contributions are derived from the same simultaneous fit but without signal model-dependent inputs (i.e., without signal contamination in the CRs, and without signal systematic uncertainties). The resulting limits are shown at the bottom of Table II.

In summary, a search for stop pair production is presented in final states with one isolated lepton, jets, and missing transverse momentum in $\sqrt{s} = 7$ TeV pp collisions corresponding to 4.7 fb^{-1} of ATLAS 2011 data. Each stop is assumed to decay to a top quark and a long-lived undetected neutral particle. No significant excess of events above the rate predicted by the standard model is observed and 95% CL_s upper limits are set on the stop mass in the stop-LSP mass plane, significantly extending previous stop-mass limits.

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; D NRF, DNSRC, and Lundbeck Foundation, Denmark; EPLANET and ERC, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG, and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP, and Benozio Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; 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; and 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, and Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK), and BNL (USA) and in the Tier-2 facilities worldwide.

-
- [1] H. Miyazawa, *Prog. Theor. Phys.* **36**, 1266 (1966).
 [2] R. Ramond, *Phys. Rev. D* **3**, 2415 (1971).
 [3] Y. Golfand and E. Likhtman, *JETP Lett.* **13**, 323 (1971).
 [4] A. Neveu and J. Schwarz, *Nucl. Phys.* **B31**, 86 (1971).
 [5] A. Neveu and J. Schwarz, *Phys. Rev. D* **4**, 1109 (1971).
 [6] J. Gervais and B. Sakita, *Nucl. Phys.* **B34**, 632 (1971).
 [7] D. Volkov and V. Akulov, *Phys. Lett.* **46B**, 109 (1973).
 [8] J. Wess and B. Zumino, *Phys. Lett. B* **49B**, 52 (1974).
 [9] J. Wess and B. Zumino, *Nucl. Phys.* **B70**, 39 (1974).
 [10] P. Fayet, *Phys. Lett.* **64B**, 159 (1976).
 [11] P. Fayet, *Phys. Lett.* **69B**, 489 (1977).
 [12] G.R. Farrar and P. Fayet, *Phys. Lett.* **76B**, 575 (1978).
 [13] P. Fayet, *Phys. Lett.* **84B**, 416 (1979).
 [14] S. Dimopoulos and H. Georgi, *Nucl. Phys.* **B193**, 150 (1981).
 [15] R. Barbieri and G. Giudice, *Nucl. Phys.* **B306**, 63 (1988).
 [16] B. de Carlos and J. Casas, *Phys. Lett. B* **309**, 320 (1993).
 [17] CDF Collaboration, *Phys. Rev. Lett.* **104**, 251801 (2010).
 [18] D0 Collaboration, *Phys. Lett. B* **675**, 289 (2009).
 [19] ATLAS Collaboration, *Phys. Rev. D* **85**, 112006 (2012).
 [20] ATLAS Collaboration, *Phys. Rev. Lett.* **108**, 241802 (2012).
 [21] ATLAS Collaboration, *J. High Energy Phys.* **07** (2012) 167.
 [22] CMS Collaboration, *J. High Energy Phys.* **07** (2011) 113.
 [23] CMS Collaboration, *J. High Energy Phys.* **08** (2012) 110.
 [24] ATLAS Collaboration, *JINST* **3**, S08003 (2008).
 [25] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point in the center of the detector and the z axis along the beam pipe. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity η is defined in terms of the polar angle θ by $\eta = -\text{Intan}(\theta/2)$, and $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$.
 [26] ATLAS Collaboration, *Eur. Phys. J. C* **70**, 823 (2010).
 [27] S. Agostinelli *et al.* (GEANT4 Collaboration), *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
 [28] ATLAS Collaboration, Report No. ATLAS-CONF-2012-064.
 [29] S. Frixione, E. Laenen, P. Motylinski, and B.R. Webber, *J. High Energy Phys.* **03** (2006) 092.
 [30] S. Frixione, E. Laenen, P. Motylinski, B.R. Webber, and C.D. White, *J. High Energy Phys.* **07** (2008) 029.
 [31] M.L. Mangano, M. Moretti, F. Piccinini, R. Pittau, and A.D. Polosa, *J. High Energy Phys.* **07** (2003) 001.
 [32] S. Alioli, P. Nason, C. Oleari, and E. Re, *J. High Energy Phys.* **06** (2010) 043.
 [33] P. Nason, *J. High Energy Phys.* **11** (2004) 040.
 [34] S. Frixione, P. Nason, and C. Oleari, *J. High Energy Phys.* **11** (2007) 070.
 [35] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 2043 (2012).
 [36] B.P. Kersevan and E. Richter-Was, [arXiv:hep-ph/0405247](https://arxiv.org/abs/hep-ph/0405247).
 [37] 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.
 [38] J. Alwall, P. Demin, S. de Visscher, R. Frederix, M. Herquet, F. Maltoni, T. Plehn, D.L. Rainwater, and T. Stelzer, *J. High Energy Phys.* **09** (2007) 028.
 [39] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P. Nadolsky, J. Pumplin, and C.-P. Yuan, *Phys. Rev. D* **82**, 074024 (2010).
 [40] A.D. Martin, W.J. Stirling, R.S. Thorne, and G. Watt, *Eur. Phys. J. C* **63**, 189 (2009).
 [41] J. Pumplin, D.R. Stump, J. Huston, H.-L. Lai, P. Nadolsky, and W.-K. Tung, *J. High Energy Phys.* **07** (2002) 012.
 [42] J.M. Butterworth, J.R. Forshaw, and M.H. Seymour, *Z. Phys. C* **72**, 637 (1996).
 [43] T. Sjostrand, S. Mrenna, and P.Z. Skands, *J. High Energy Phys.* **05** (2006) 026.
 [44] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer, and M. Wiedermann, *Comput. Phys. Commun.* **182**, 1034 (2011).
 [45] N. Kidonakis, *Phys. Rev. D* **83**, 091503 (2011).
 [46] N. Kidonakis, *Phys. Rev. D* **82**, 054018 (2010).
 [47] N. Kidonakis, *Phys. Rev. D* **81**, 054028 (2010).
 [48] J.M. Campbell and R.K. Ellis, [arXiv:1204.5678](https://arxiv.org/abs/1204.5678).
 [49] R. Gavin, Y. Li, F. Petriello, and S. Quackenbush, *Comput. Phys. Commun.* **182**, 2388 (2011).
 [50] J.M. Campbell and R.K. Ellis, *Phys. Rev. D* **60**, 113006 (1999).
 [51] J.M. Campbell, R.K. Ellis, and C. Williams, *J. High Energy Phys.* **07** (2011) 018.

- [52] M. Bahr *et al.*, *Eur. Phys. J. C* **58**, 639 (2008).
 [53] W. Beenakker, M. Kramer, T. Plehn, M. Spira, and P.M. Zerwas, *Nucl. Phys.* **B515**, 3 (1998).
 [54] W. Beenakker, S. Brensing, M. Krämer, A. Kulesza, E. Laenen, and I. Niessen, *J. High Energy Phys.* **08** (2010) 098.
 [55] W. Beenakker, S. Brensing, M. Krämer, A. Kulesza, E. Laenen, L. Motyka, and I. Niessen, *Int. J. Mod. Phys. A* **26**, 2637 (2011).
 [56] M. Kramer *et al.*, [arXiv:1206.2892](https://arxiv.org/abs/1206.2892).
 [57] ATLAS Collaboration, Report No. ATLAS-CONF-2012-020.
 [58] ATLAS Collaboration, *Eur. Phys. J. C* **71**, 1593 (2011).
 [59] ATLAS Collaboration, Report no. ATLAS-CONF-2011-063.
 [60] ATLAS Collaboration, *Eur. Phys. J. C* **72**, 1909 (2012).
 [61] ATLAS Collaboration, *Phys. Rev. D* **85**, 012006 (2012).
 [62] M. Cacciari, G.P. Salam, and G. Soyez, *J. High Energy Phys.* **04** (2008) 063.
 [63] ATLAS Collaboration, [arXiv:1112.6426](https://arxiv.org/abs/1112.6426).
 [64] ATLAS Collaboration, Report No. ATLAS-CONF-2012-043.
 [65] m_T is defined as $m_T^2 = 2p_T^{\text{lep}} E_T^{\text{miss}} (1 - \cos(\Delta\phi))$, where $\Delta\phi$ is the azimuthal angle between the lepton and missing momentum direction.
 [66] A. Read, *J. Phys. G* **28**, 2693 (2002).

G. Aad,⁴⁸ T. Abajyan,²¹ B. Abbott,¹¹¹ J. Abdallah,¹² S. Abdel Khalek,¹¹⁵ A. A. Abdelalim,⁴⁹ O. Abidinov,¹¹ R. Aben,¹⁰⁵ B. Abi,¹¹² M. Abolins,⁸⁸ O. S. AbouZeid,¹⁵⁸ H. Abramowicz,¹⁵³ H. Abreu,¹³⁶ B. S. Acharya,^{164a,164b} L. Adamczyk,³⁸ D. L. Adams,²⁵ T. N. Addy,⁵⁶ J. Adelman,¹⁷⁶ S. Adomeit,⁹⁸ P. Adragna,⁷⁵ T. Adye,¹²⁹ S. Aefsky,²³ J. A. Aguilar-Saavedra,^{124b,b} M. Agustoni,¹⁷ M. Aharrouché,⁸¹ S. P. Ahlen,²² F. Ahles,⁴⁸ A. Ahmad,¹⁴⁸ M. Ahsan,⁴¹ G. Aielli,^{133a,133b} T. Akdogan,^{19a} T. P. A. Åkesson,⁷⁹ G. Akimoto,¹⁵⁵ A. V. Akimov,⁹⁴ M. S. Alam,² M. A. Alam,⁷⁶ J. Albert,¹⁶⁹ S. Albrand,⁵⁵ M. Aleksa,³⁰ I. N. Aleksandrov,⁶⁴ F. Alessandria,^{89a} C. Alexa,^{26a} G. Alexander,¹⁵³ G. Alexandre,⁴⁹ T. Alexopoulos,¹⁰ M. Alhroob,^{164a,164c} M. Aliev,¹⁶ G. Alimonti,^{89a} J. Alison,¹²⁰ B. M. M. Allbrooke,¹⁸ P. P. Allport,⁷³ S. E. Allwood-Spiers,⁵³ J. Almond,⁸² A. Aloisio,^{102a,102b} R. Alon,¹⁷² A. Alonso,⁷⁹ F. Alonso,⁷⁰ A. D. Altheimer,³⁵ B. Alvarez Gonzalez,⁸⁸ M. G. Alvigi,^{102a,102b} K. Amako,⁶⁵ C. Amelung,²³ V. V. Ammosov,^{128,a} A. Amorim,^{124a,c} N. Amram,¹⁵³ C. Anastopoulos,³⁰ L. S. Ancu,¹⁷ N. Andari,¹¹⁵ T. Andeen,³⁵ C. F. Anders,^{58b} G. Anders,^{58a} K. J. Anderson,³¹ A. Andreazza,^{89a,89b} V. Andrei,^{58a} X. S. Anduaga,⁷⁰ P. Anger,⁴⁴ A. Angerami,³⁵ F. Anghinolfi,³⁰ A. Anisenkov,¹⁰⁷ N. Anjos,^{124a} A. Annovi,⁴⁷ A. Antonaki,⁹ M. Antonelli,⁴⁷ A. Antonov,⁹⁶ J. Antos,^{144b} F. Anulli,^{132a} M. Aoki,¹⁰¹ S. Aoun,⁸³ L. Aperio Bella,⁵ R. Apolle,^{118,d} G. Arabidze,⁸⁸ I. Aracena,¹⁴³ Y. Arai,⁶⁵ A. T. H. Arce,⁴⁵ S. Arfaoui,¹⁴⁸ J-F. Arguin,¹⁵ E. Arik,^{19a,a} M. Arik,^{19a} A. J. Armbruster,⁸⁷ O. Arnaez,⁸¹ V. Arnal,⁸⁰ C. Arnault,¹¹⁵ A. Artamonov,⁹⁵ G. Artoni,^{132a,132b} D. Arutinov,²¹ S. Asai,¹⁵⁵ R. Asfandiyarov,¹⁷³ S. Ask,²⁸ B. Åsman,^{146a,146b} L. Asquith,⁶ K. Assamagan,²⁵ A. Astbury,¹⁶⁹ M. Atkinson,¹⁶⁵ B. Aubert,⁵ E. Auge,¹¹⁵ K. Augsten,¹²⁷ M. Aurousseau,^{145a} G. Avolio,¹⁶³ R. Avramidou,¹⁰ D. Axen,¹⁶⁸ G. Azuelos,^{93,e} Y. Azuma,¹⁵⁵ M. A. Baak,³⁰ G. Baccaglioni,^{89a} C. Bacci,^{134a,134b} A. M. Bach,¹⁵ H. Bachacou,¹³⁶ K. Bachas,³⁰ M. Backes,⁴⁹ M. Backhaus,²¹ E. Badescu,^{26a} P. Bagnaia,^{132a,132b} S. Bahinipati,³ Y. Bai,^{33a} D. C. Bailey,¹⁵⁸ T. Bain,¹⁵⁸ J. T. Baines,¹²⁹ O. K. Baker,¹⁷⁶ M. D. Baker,²⁵ S. Baker,⁷⁷ E. Banas,³⁹ P. Banerjee,⁹³ Sw. Banerjee,¹⁷³ D. Banfi,³⁰ A. Bangert,¹⁵⁰ V. Bansal,¹⁶⁹ H. S. Bansil,¹⁸ L. Barak,¹⁷² S. P. Baranov,⁹⁴ A. Barbaro Galtieri,¹⁵ T. Barber,⁴⁸ E. L. Barberio,⁸⁶ D. Barberis,^{50a,50b} M. Barbero,²¹ D. Y. Bardin,⁶⁴ T. Barillari,⁹⁹ M. Barisonzi,¹⁷⁵ T. Barklow,¹⁴³ N. Barlow,²⁸ B. M. Barnett,¹²⁹ R. M. Barnett,¹⁵ A. Baroncelli,^{134a} G. Barone,⁴⁹ A. J. Barr,¹¹⁸ F. Barreiro,⁸⁰ J. Barreiro Guimarães da Costa,⁵⁷ P. Barrillon,¹¹⁵ R. Bartoldus,¹⁴³ A. E. Barton,⁷¹ V. Bartsch,¹⁴⁹ A. Basye,¹⁶⁵ R. L. Bates,⁵³ L. Batkova,^{144a} J. R. Batley,²⁸ A. Battaglia,¹⁷ M. Battistin,³⁰ F. Bauer,¹³⁶ H. S. Bawa,^{143,f} S. Beale,⁹⁸ T. Beau,⁷⁸ P. H. Beauchemin,¹⁶¹ R. Beccherle,^{50a} P. Bechtel,²¹ H. P. Beck,¹⁷ A. K. Becker,¹⁷⁵ S. Becker,⁹⁸ M. Beckingham,¹³⁸ K. H. Becks,¹⁷⁵ A. J. Beddall,^{19c} A. Beddall,^{19c} S. Bedikian,¹⁷⁶ V. A. Bednyakov,⁶⁴ C. P. Bee,⁸³ L. J. Beamster,¹⁰⁵ M. Begel,²⁵ S. Behar Harpaz,¹⁵² M. Beimforde,⁹⁹ C. Belanger-Champagne,⁸⁵ P. J. Bell,⁴⁹ W. H. Bell,⁴⁹ G. Bella,¹⁵³ L. Bellagamba,^{20a} F. Bellina,³⁰ M. Bellomo,³⁰ A. Belloni,⁵⁷ O. Beloborodova,^{107,g} K. Belotskiy,⁹⁶ O. Beltramello,³⁰ O. Benary,¹⁵³ D. Bencheikroun,^{135a} K. Bendtz,^{146a,146b} N. Benekos,¹⁶⁵ Y. Benhammou,¹⁵³ E. Benhar Nocchioli,⁴⁹ J. A. Benitez Garcia,^{159b} D. P. Benjamin,⁴⁵ M. Benoit,¹¹⁵ J. R. Bensinger,²³ K. Benslama,¹³⁰ S. Bentvelsen,¹⁰⁵ D. Berge,³⁰ E. Bergeaas Kuutmann,⁴² N. Berger,⁵ F. Berghaus,¹⁶⁹ E. Berglund,¹⁰⁵ J. Beringer,¹⁵ P. Bernat,⁷⁷ R. Bernhard,⁴⁸ C. Bernius,²⁵ T. Berry,⁷⁶ C. Bertella,⁸³ A. Bertin,^{20a,20b} F. Bertolucci,^{122a,122b} M. I. Besana,^{89a,89b} G. J. Besjes,¹⁰⁴ N. Besson,¹³⁶ S. Bethke,⁹⁹ W. Bhimji,⁴⁶ R. M. Bianchi,³⁰ M. Bianco,^{72a,72b} O. Biebel,⁹⁸ S. P. Bieniek,⁷⁷ K. Bierwagen,⁵⁴ J. Biesiada,¹⁵ M. Biglietti,^{134a} H. Bilokon,⁴⁷ M. Bindi,^{20a,20b} S. Binet,¹¹⁵ A. Bingul,^{19c} C. Bini,^{132a,132b} C. Biscarat,¹⁷⁸ B. Bittner,⁹⁹ K. M. Black,²² R. E. Blair,⁶ J.-B. Blanchard,¹³⁶ G. Blanchot,³⁰ T. Blazek,^{144a} I. Bloch,⁴² C. Blocker,²³ J. Blocki,³⁹ A. Blondel,⁴⁹ W. Blum,⁸¹ U. Blumenschein,⁵⁴ G. J. Bobbink,¹⁰⁵

- V. B. Bobrovnikov,¹⁰⁷ S. S. Bocchetta,⁷⁹ A. Bocci,⁴⁵ C. R. Boddy,¹¹⁸ M. Boehler,⁴⁸ J. Boek,¹⁷⁵ N. Boelaert,³⁶
 J. A. Bogaerts,³⁰ A. Bogdanchikov,¹⁰⁷ A. Bogouch,^{90,a} C. Bohm,^{146a} J. Bohm,¹²⁵ V. Boisvert,⁷⁶ T. Bold,³⁸
 V. Boldea,^{26a} N. M. Bolnet,¹³⁶ M. Bomben,⁷⁸ M. Bona,⁷⁵ M. Boonekamp,¹³⁶ S. Bordoni,⁷⁸ C. Borer,¹⁷ A. Borisov,¹²⁸
 G. Borisso,⁷¹ I. Borjanovic,^{13a} M. Borri,⁸² S. Borroni,⁸⁷ V. Bortolotto,^{134a,134b} K. Bos,¹⁰⁵ D. Boscherini,^{20a}
 M. Bosman,¹² H. Boterenbrood,¹⁰⁵ J. Bouchami,⁹³ J. Boudreau,¹²³ E. V. Bouhova-Thacker,⁷¹ D. Boumediene,³⁴
 C. Bourdarios,¹¹⁵ N. Bousson,⁸³ A. Boveia,³¹ J. Boyd,³⁰ I. R. Boyko,⁶⁴ I. Bozovic-Jelisavcic,^{13b} J. Bracinik,¹⁸
 P. Branchini,^{134a} A. Brandt,⁸ G. Brandt,¹¹⁸ O. Brandt,⁵⁴ U. Bratzler,¹⁵⁶ B. Brau,⁸⁴ J. E. Brau,¹¹⁴ H. M. Braun,^{175,a}
 S. F. Brazzale,^{164a,164c} B. Brelier,¹⁵⁸ J. Bremer,³⁰ K. Brendlinger,¹²⁰ R. Brenner,¹⁶⁶ S. Bressler,¹⁷² D. Britton,⁵³
 F. M. Brochu,²⁸ I. Brock,²¹ R. Brock,⁸⁸ F. Broggi,^{89a} C. Bromberg,⁸⁸ J. Bronner,⁹⁹ G. Brooijmans,³⁵ T. Brooks,⁷⁶
 W. K. Brooks,^{32b} G. Brown,⁸² H. Brown,⁸ P. A. Bruckman de Renstrom,³⁹ D. Bruncko,^{144b} R. Bruneliere,⁴⁸
 S. Brunet,⁶⁰ A. Bruni,^{20a} G. Bruni,^{20a} M. Bruschi,^{20a} T. Buanes,¹⁴ Q. Buat,⁵⁵ F. Bucci,⁴⁹ J. Buchanan,¹¹⁸
 P. Buchholz,¹⁴¹ R. M. Buckingham,¹¹⁸ A. G. Buckley,⁴⁶ S. I. Buda,^{26a} I. A. Budagov,⁶⁴ B. Budick,¹⁰⁸ V. Büscher,⁸¹
 L. Bugge,¹¹⁷ O. Bulekov,⁹⁶ A. C. Bundock,⁷³ M. Bunse,⁴³ T. Buran,¹¹⁷ H. Burckhart,³⁰ S. Burdin,⁷³ T. Burgess,¹⁴
 S. Burke,¹²⁹ E. Busato,³⁴ P. Bussey,⁵³ C. P. Buszello,¹⁶⁶ B. Butler,¹⁴³ J. M. Butler,²² C. M. Buttar,⁵³
 J. M. Butterworth,⁷⁷ W. Buttlinger,²⁸ S. Cabrera Urbán,¹⁶⁷ D. Caforio,^{20a,20b} O. Cakir,^{4a} P. Calafiura,¹⁵ G. Calderini,⁷⁸
 P. Calfayan,⁹⁸ R. Calkins,¹⁰⁶ L. P. Caloba,^{24a} R. Caloi,^{132a,132b} D. Calvet,³⁴ S. Calvet,³⁴ R. Camacho Toro,³⁴
 P. Camarri,^{133a,133b} D. Cameron,¹¹⁷ L. M. Caminada,¹⁵ R. Caminal Armadans,¹² S. Campana,³⁰ M. Campanelli,⁷⁷
 V. Canale,^{102a,102b} F. Canelli,^{31,h} A. Canepa,^{159a} J. Cantero,⁸⁰ R. Cantrill,⁷⁶ L. Capasso,^{102a,102b}
 M. D. M. Capeans Garrido,³⁰ I. Caprini,^{26a} M. Caprini,^{26a} D. Capriotti,⁹⁹ M. Capua,^{37a,37b} R. Caputo,⁸¹
 R. Cardarelli,^{133a} T. Carli,³⁰ G. Carlino,^{102a} L. Carminati,^{89a,89b} B. Caron,⁸⁵ S. Caron,¹⁰⁴ E. Carquin,^{32b}
 G. D. Carrillo Montoya,¹⁷³ A. A. Carter,⁷⁵ J. R. Carter,²⁸ J. Carvalho,^{124a,i} D. Casadei,¹⁰⁸ M. P. Casado,¹²
 M. Cascella,^{122a,122b} C. Caso,^{50a,50b,a} A. M. Castaneda Hernandez,^{173,j} E. Castaneda-Miranda,¹⁷³
 V. Castillo Gimenez,¹⁶⁷ N. F. Castro,^{124a} G. Cataldi,^{72a} P. Catastini,⁵⁷ A. Catinaccio,³⁰ J. R. Catmore,³⁰ A. Cattai,³⁰
 G. Cattani,^{133a,133b} S. Caughron,⁸⁸ V. Cavaliere,¹⁶⁵ P. Cavalleri,⁷⁸ D. Cavalli,^{89a} M. Cavalli-Sforza,¹²
 V. Cavasinni,^{122a,122b} F. Ceradini,^{134a,134b} A. S. Cerqueira,^{24b} A. Cerri,³⁰ L. Cerrito,⁷⁵ F. Cerutti,⁴⁷ S. A. Cetin,^{19b}
 A. Chafaq,^{135a} D. Chakraborty,¹⁰⁶ I. Chalupkova,¹²⁶ K. Chan,³ P. Chang,¹⁶⁵ B. Chapleau,⁸⁵ J. D. Chapman,²⁸
 J. W. Chapman,⁸⁷ E. Chareyre,⁷⁸ D. G. Charlton,¹⁸ V. Chavda,⁸² C. A. Chavez Barajas,³⁰ S. Cheatham,⁸⁵
 S. Chekanov,⁶ S. V. Chekulaev,^{159a} G. A. Chelkov,⁶⁴ M. A. Chelstowska,¹⁰⁴ C. Chen,⁶³ H. Chen,²⁵ S. Chen,^{33c}
 X. Chen,¹⁷³ Y. Chen,³⁵ A. Cheplakov,⁶⁴ R. Cherkaoui El Moursli,^{135e} V. Chernyatin,²⁵ E. Cheu,⁷ S. L. Cheung,¹⁵⁸
 L. Chevalier,¹³⁶ G. Chiefari,^{102a,102b} L. Chikovani,^{51a,j} J. T. Childers,³⁰ A. Chilingarov,⁷¹ G. Chiodini,^{72a}
 A. S. Chisholm,¹⁸ R. T. Chislett,⁷⁷ A. Chitan,^{26a} M. V. Chizhov,⁶⁴ G. Choudalakis,³¹ S. Houridou,¹³⁷
 I. A. Christidi,⁷⁷ A. Christov,⁴⁸ D. Chromek-Burckhart,³⁰ M. L. Chu,¹⁵¹ J. Chudoba,¹²⁵ G. Ciapetti,^{132a,132b}
 A. K. Ciftci,^{4a} R. Ciftci,^{4a} D. Cinca,³⁴ V. Cindro,⁷⁴ C. Ciocca,^{20a,20b} A. Ciocio,¹⁵ M. Cirilli,⁸⁷ P. Cirkovic,^{13b}
 M. Citterio,^{89a} M. Ciubancan,^{26a} A. Clark,⁴⁹ P. J. Clark,⁴⁶ R. N. Clarke,¹⁵ W. Cleland,¹²³ J. C. Clemens,⁸³
 B. Clement,⁵⁵ C. Clement,^{146a,146b} Y. Coadou,⁸³ M. Cobal,^{164a,164c} A. Coccaro,¹³⁸ J. Cochran,⁶³ L. Coffey,²³
 J. G. Cogan,¹⁴³ J. Coggeshall,¹⁶⁵ E. Cogneras,¹⁷⁸ J. Colas,⁵ S. Cole,¹⁰⁶ A. P. Colijn,¹⁰⁵ N. J. Collins,¹⁸
 C. Collins-Tooth,⁵³ J. Collot,⁵⁵ T. Colombo,^{119a,119b} G. Colon,⁸⁴ P. Conde Muño,^{124a} E. Coniavitis,¹¹⁸
 M. C. Conidi,¹² S. M. Consonni,^{89a,89b} V. Consorti,⁴⁸ S. Constantinescu,^{26a} C. Conta,^{119a,119b} G. Conti,⁵⁷
 F. Conventi,^{102a,k} M. Cooke,¹⁵ B. D. Cooper,⁷⁷ A. M. Cooper-Sarkar,¹¹⁸ K. Copic,¹⁵ T. Cornelissen,¹⁷⁵ M. Corradi,^{20a}
 F. Corriveau,^{85,l} A. Cortes-Gonzalez,¹⁶⁵ G. Cortiana,⁹⁹ G. Costa,^{89a} M. J. Costa,¹⁶⁷ D. Costanzo,¹³⁹ D. Côté,³⁰
 L. Courneyea,¹⁶⁹ G. Cowan,⁷⁶ C. Cowden,²⁸ B. E. Cox,⁸² K. Cranmer,¹⁰⁸ F. Crescioli,^{122a,122b} M. Cristinziani,²¹
 G. Crosetti,^{37a,37b} S. Crépé-Renaudin,⁵⁵ C.-M. Cuciuc,^{26a} C. Cuenca Almenar,¹⁷⁶ T. Cuhadar Donszelmann,¹³⁹
 M. Curatolo,⁴⁷ C. J. Curtis,¹⁸ C. Cuthbert,¹⁵⁰ P. Cwetanski,⁶⁰ H. Czirr,¹⁴¹ P. Czodrowski,⁴⁴ Z. Czczyula,¹⁷⁶
 S. D'Auria,⁵³ M. D'Onofrio,⁷³ A. D'Orazio,^{132a,132b} M. J. Da Cunha Sargedas De Sousa,^{124a} C. Da Via,⁸²
 W. Dabrowski,³⁸ A. Dafinca,¹¹⁸ T. Dai,⁸⁷ C. Dallapiccola,⁸⁴ M. Dam,³⁶ M. Dameri,^{50a,50b} D. S. Damiani,¹³⁷
 H. O. Danielsson,³⁰ V. Dao,⁴⁹ G. Darbo,^{50a} G. L. Darlea,^{26b} J. A. Dassoulas,⁴² W. Davey,²¹ T. Davidek,¹²⁶
 N. Davidson,⁸⁶ R. Davidson,⁷¹ E. Davies,^{118,d} M. Davies,⁹³ O. Davignon,⁷⁸ A. R. Davison,⁷⁷ Y. Davygora,^{58a}
 E. Dawe,¹⁴² I. Dawson,¹³⁹ R. K. Daya-Ishmukhametova,²³ K. De,⁸ R. de Asmundis,^{102a} S. De Castro,^{20a,20b}
 S. De Cecco,⁷⁸ J. de Graat,⁹⁸ N. De Groot,¹⁰⁴ P. de Jong,¹⁰⁵ C. De La Taille,¹¹⁵ H. De la Torre,⁸⁰ F. De Lorenzi,⁶³
 L. de Mora,⁷¹ L. De Nooij,¹⁰⁵ D. De Pedis,^{132a} A. De Salvo,^{132a} U. De Sanctis,^{164a,164c} A. De Santo,¹⁴⁹
 J. B. De Vivie De Regie,¹¹⁵ G. De Zorzi,^{132a,132b} W. J. Dearnaley,⁷¹ R. Debbe,²⁵ C. Debenedetti,⁴⁶ B. Dechenaux,⁵⁵

- D. V. Dedovich,⁶⁴ J. Degenhardt,¹²⁰ C. Del Papa,^{164a,164c} J. Del Peso,⁸⁰ T. Del Prete,^{122a,122b} T. Delemontex,⁵⁵ M. Deliyergiyev,⁷⁴ A. Dell'Acqua,³⁰ L. Dell'Asta,²² M. Della Pietra,^{102a,k} D. della Volpe,^{102a,102b} M. Delmastro,⁵ P. A. Delsart,⁵⁵ C. Deluca,¹⁰⁵ S. Demers,¹⁷⁶ M. Demichev,⁶⁴ B. Demirkoz,^{12,m} J. Deng,¹⁶³ S. P. Denisov,¹²⁸ D. Derendarz,³⁹ J. E. Derkaoui,^{135d} F. Derue,⁷⁸ P. Dervan,⁷³ K. Desch,²¹ E. Devetak,¹⁴⁸ P. O. Deviveiros,¹⁰⁵ A. Dewhurst,¹²⁹ B. DeWilde,¹⁴⁸ S. Dhaliwal,¹⁵⁸ R. Dhullipudi,^{25,n} A. Di Ciaccio,^{133a,133b} L. Di Ciaccio,⁵ A. Di Girolamo,³⁰ B. Di Girolamo,³⁰ S. Di Luise,^{134a,134b} A. Di Mattia,¹⁷³ B. Di Micco,³⁰ R. Di Nardo,⁴⁷ A. Di Simone,^{133a,133b} R. Di Sipio,^{20a,20b} M. A. Diaz,^{32a} E. B. Diehl,⁸⁷ J. Dietrich,⁴² T. A. Dietzsch,^{58a} S. Diglio,⁸⁶ K. Dindar Yagci,⁴⁰ J. Dingfelder,²¹ F. Dinut,^{26a} C. Dionisi,^{132a,132b} P. Dita,^{26a} S. Dita,^{26a} F. Dittus,³⁰ F. Djama,⁸³ T. Djobava,^{51b} M. A. B. do Vale,^{24c} A. Do Valle Wemans,^{124a,o} T. K. O. Doan,⁵ M. Dobbs,⁸⁵ R. Dobinson,^{30,a} D. Dobos,³⁰ E. Dobson,^{30,p} J. Dodd,³⁵ C. Doglioni,⁴⁹ T. Doherty,⁵³ Y. Doi,^{65,a} J. Dolejsi,¹²⁶ I. Dolenc,⁷⁴ Z. Dolezal,¹²⁶ B. A. Dolgoshein,^{96,a} T. Dohmae,¹⁵⁵ M. Donadelli,^{24d} J. Donini,³⁴ J. Dopke,³⁰ A. Doria,^{102a} A. Dos Anjos,¹⁷³ A. Dotti,^{122a,122b} M. T. Dova,⁷⁰ A. D. Doxiadis,¹⁰⁵ A. T. Doyle,⁵³ M. Dris,¹⁰ J. Dubbert,⁹⁹ S. Dube,¹⁵ E. Duchovni,¹⁷² G. Duckeck,⁹⁸ D. Duda,¹⁷⁵ A. Dudarev,³⁰ F. Dudziak,⁶³ M. Dührssen,³⁰ I. P. Duerdoth,⁸² L. Duflot,¹¹⁵ M-A. Dufour,⁸⁵ L. Duguid,⁷⁶ M. Dunford,³⁰ H. Duran Yildiz,^{4a} R. Duxfield,¹³⁹ M. Dwuznik,³⁸ F. Dydak,³⁰ M. Düren,⁵² J. Ebke,⁹⁸ S. Eckweiler,⁸¹ K. Edmonds,⁸¹ W. Edson,² C. A. Edwards,⁷⁶ N. C. Edwards,⁵³ W. Ehrenfeld,⁴² T. Eifert,¹⁴³ G. Eigen,¹⁴ K. Einsweiler,¹⁵ E. Eisenhandler,⁷⁵ T. Ekelof,¹⁶⁶ M. El Kacimi,^{135c} M. Ellert,¹⁶⁶ S. Elles,⁵ F. Ellinghaus,⁸¹ K. Ellis,⁷⁵ N. Ellis,³⁰ J. Elmsheuser,⁹⁸ M. Elsing,³⁰ D. Emelianov,¹²⁹ R. Engelmann,¹⁴⁸ A. Engl,⁹⁸ B. Epp,⁶¹ J. Erdmann,⁵⁴ A. Ereditato,¹⁷ D. Eriksson,^{146a} J. Ernst,² M. Ernst,²⁵ J. Ernwein,¹³⁶ D. Errede,¹⁶⁵ S. Errede,¹⁶⁵ E. Ertel,⁸¹ M. Escalier,¹¹⁵ H. Esch,⁴³ C. Escobar,¹²³ X. Espinal Curull,¹² B. Esposito,⁴⁷ F. Etienne,⁸³ A. I. Etiennevire,¹³⁶ E. Etzion,¹⁵³ D. Evangelakou,⁵⁴ H. Evans,⁶⁰ L. Fabbri,^{20a,20b} C. Fabre,³⁰ R. M. Fakhruddinov,¹²⁸ S. Falciano,^{132a} Y. Fang,¹⁷³ M. Fanti,^{89a,89b} A. Farbin,⁸ A. Farilla,^{134a} J. Farley,¹⁴⁸ T. Farooque,¹⁵⁸ S. Farrell,¹⁶³ S. M. Farrington,¹⁷⁰ P. Farthouat,³⁰ F. Fassi,¹⁶⁷ P. Fassnacht,³⁰ D. Fassouliotis,⁹ B. Fatholahzadeh,¹⁵⁸ A. Favareto,^{89a,89b} L. Fayard,¹¹⁵ S. Fazio,^{37a,37b} R. Febbraro,³⁴ P. Federic,^{144a} O. L. Fedin,¹²¹ W. Fedorko,⁸⁸ M. Fehling-Kaschek,⁴⁸ L. Feligioni,⁸³ D. Fellmann,⁶ C. Feng,^{33d} E. J. Feng,⁶ A. B. Fenyuk,¹²⁸ J. Ferencei,^{144b} W. Fernando,⁶ S. Ferrag,⁵³ J. Ferrando,⁵³ V. Ferrara,⁴² A. Ferrari,¹⁶⁶ P. Ferrari,¹⁰⁵ R. Ferrari,^{119a} D. E. Ferreira de Lima,⁵³ A. Ferrer,¹⁶⁷ D. Ferrere,⁴⁹ C. Ferretti,⁸⁷ A. Ferretto Parodi,^{50a,50b} M. Fiascaris,³¹ F. Fiedler,⁸¹ A. Filipčić,⁷⁴ F. Filthaut,¹⁰⁴ M. Fincke-Keeler,¹⁶⁹ M. C. N. Fiolhais,^{124a,i} L. Fiorini,¹⁶⁷ A. Firan,⁴⁰ G. Fischer,⁴² M. J. Fisher,¹⁰⁹ M. Flechl,⁴⁸ I. Fleck,¹⁴¹ J. Fleckner,⁸¹ P. Fleischmann,¹⁷⁴ S. Fleischmann,¹⁷⁵ T. Flick,¹⁷⁵ A. Floderus,⁷⁹ L. R. Flores Castillo,¹⁷³ M. J. Flowerdew,⁹⁹ T. Fonseca Martin,¹⁷ A. Formica,¹³⁶ A. Forti,⁸² D. Fortin,^{159a} D. Fournier,¹¹⁵ H. Fox,⁷¹ P. Francavilla,¹² M. Franchini,^{20a,20b} S. Franchino,^{119a,119b} D. Francis,³⁰ T. Frank,¹⁷² S. Franz,³⁰ M. Fraternali,^{119a,119b} S. Fratina,¹²⁰ S. T. French,²⁸ C. Friedrich,⁴² F. Friedrich,⁴⁴ R. Froeschl,³⁰ D. Froidevaux,³⁰ J. A. Frost,²⁸ C. Fukunaga,¹⁵⁶ E. Fullana Torregrosa,³⁰ B. G. Fulsom,¹⁴³ J. Fuster,¹⁶⁷ C. Gabaldon,³⁰ O. Gabizon,¹⁷² T. Gadfort,²⁵ S. Gadomski,⁴⁹ G. Gagliardi,^{50a,50b} P. Gagnon,⁶⁰ C. Galea,⁹⁸ E. J. Gallas,¹¹⁸ V. Gallo,¹⁷ B. J. Gallop,¹²⁹ P. Gallus,¹²⁵ K. K. Gan,¹⁰⁹ Y. S. Gao,^{143,f} A. Gaponenko,¹⁵ F. Garberon,¹⁷⁶ M. Garcia-Sciveres,¹⁵ C. García,¹⁶⁷ J. E. García Navarro,¹⁶⁷ R. W. Gardner,³¹ N. Garelli,³⁰ H. Garitaonandia,¹⁰⁵ V. Garonne,³⁰ C. Gatti,⁴⁷ G. Gaudio,^{119a} B. Gaur,¹⁴¹ L. Gauthier,¹³⁶ P. Gauzzi,^{132a,132b} I. L. Gavrilenko,⁹⁴ C. Gay,¹⁶⁸ G. Gaycken,²¹ E. N. Gazis,¹⁰ P. Ge,^{33d} Z. Gecse,¹⁶⁸ C. N. P. Gee,¹²⁹ D. A. A. Geerts,¹⁰⁵ Ch. Geich-Gimbel,²¹ K. Gellerstedt,^{146a,146b} C. Gemme,^{50a} A. Gemmell,⁵³ M. H. Genest,⁵⁵ S. Gentile,^{132a,132b} M. George,⁵⁴ S. George,⁷⁶ P. Gerlach,¹⁷⁵ A. Gershon,¹⁵³ C. Geweniger,^{58a} H. Ghazlane,^{135b} N. Ghodbane,³⁴ B. Giacobbe,^{20a} S. Giagu,^{132a,132b} V. Giakoumopoulou,⁹ V. Giangiobbe,¹² F. Gianotti,³⁰ B. Gibbard,²⁵ A. Gibson,¹⁵⁸ S. M. Gibson,³⁰ D. Gillberg,²⁹ A. R. Gillman,¹²⁹ D. M. Gingrich,^{3,e} J. Ginzburg,¹⁵³ N. Giokaris,⁹ M. P. Giordani,^{164c} R. Giordano,^{102a,102b} F. M. Giorgi,¹⁶ P. Giovannini,⁹⁹ P. F. Giraud,¹³⁶ D. Giugni,^{89a} M. Giunta,⁹³ P. Giusti,^{20a} B. K. Gjelsten,¹¹⁷ L. K. Gladilin,⁹⁷ C. Glasman,⁸⁰ J. Glatzer,⁴⁸ A. Glazov,⁴² K. W. Glitza,¹⁷⁵ G. L. Glonti,⁶⁴ J. R. Goddard,⁷⁵ J. Godfrey,¹⁴² J. Godlewski,³⁰ M. Goebel,⁴² T. Göpfert,⁴⁴ C. Goeringer,⁸¹ C. Gössling,⁴³ S. Goldfarb,⁸⁷ T. Golling,¹⁷⁶ A. Gomes,^{124a,c} L. S. Gomez Fajardo,⁴² R. Gonçalves,⁷⁶ J. Goncalves Pinto Firmino Da Costa,⁴² L. Gonella,²¹ S. González de la Hoz,¹⁶⁷ G. Gonzalez Parra,¹² M. L. Gonzalez Silva,²⁷ S. Gonzalez-Sevilla,⁴⁹ J. J. Goodson,¹⁴⁸ L. Goossens,³⁰ P. A. Gorbounov,⁹⁵ H. A. Gordon,²⁵ I. Gorelov,¹⁰³ G. Gorfine,¹⁷⁵ B. Gorini,³⁰ E. Gorini,^{72a,72b} A. Gorišek,⁷⁴ E. Gornicki,³⁹ B. Gosdzik,⁴² A. T. Goshaw,⁶ M. Gosselink,¹⁰⁵ M. I. Gostkin,⁶⁴ I. Gough Eschrich,¹⁶³ M. Gouighri,^{135a} D. Goujdami,^{135c} M. P. Goulette,⁴⁹ A. G. Goussiou,¹³⁸ C. Goy,⁵ S. Gozpinar,²³ I. Grabowska-Bold,³⁸ P. Grafström,^{20a,20b} K-J. Grahn,⁴² F. Grancagnolo,^{72a} S. Grancagnolo,¹⁶ V. Grassi,¹⁴⁸ V. Gratchev,¹²¹ N. Grau,³⁵ H. M. Gray,³⁰ J. A. Gray,¹⁴⁸

E. Graziani,^{134a} O. G. Grebenyuk,¹²¹ T. Greenshaw,⁷³ Z. D. Greenwood,^{25,n} K. Gregersen,³⁶ I. M. Gregor,⁴² P. Grenier,¹⁴³ J. Griffiths,⁸ N. Grigalashvili,⁶⁴ A. A. Grillo,¹³⁷ S. Grinstein,¹² Ph. Gris,³⁴ Y. V. Grishkevich,⁹⁷ J.-F. Grivaz,¹¹⁵ E. Gross,¹⁷² J. Grosse-Knetter,⁵⁴ J. Groth-Jensen,¹⁷² K. Grybel,¹⁴¹ D. Guest,¹⁷⁶ C. Guicheney,³⁴ S. Guindon,⁵⁴ U. Gul,⁵³ H. Guler,^{85,q} J. Gunther,¹²⁵ B. Guo,¹⁵⁸ J. Guo,³⁵ P. Gutierrez,¹¹¹ N. Guttman,¹⁵³ O. Gutzwiller,¹⁷³ C. Guyot,¹³⁶ C. Gwenlan,¹¹⁸ C. B. Gwilliam,⁷³ A. Haas,¹⁴³ S. Haas,³⁰ C. Haber,¹⁵ H. K. Hadavand,⁴⁰ D. R. Hadley,¹⁸ P. Haefner,²¹ F. Hahn,³⁰ S. Haider,³⁰ Z. Hajduk,³⁹ H. Hakobyan,¹⁷⁷ D. Hall,¹¹⁸ J. Haller,⁵⁴ K. Hamacher,¹⁷⁵ P. Hamal,¹¹³ M. Hamer,⁵⁴ A. Hamilton,^{145b,r} S. Hamilton,¹⁶¹ L. Han,^{33b} K. Hanagaki,¹¹⁶ K. Hanawa,¹⁶⁰ M. Hance,¹⁵ C. Handel,⁸¹ P. Hanke,^{58a} J. R. Hansen,³⁶ J. B. Hansen,³⁶ J. D. Hansen,³⁶ P. H. Hansen,³⁶ P. Hansson,¹⁴³ K. Hara,¹⁶⁰ G. A. Hare,¹³⁷ T. Harenberg,¹⁷⁵ S. Harkusha,⁹⁰ D. Harper,⁸⁷ R. D. Harrington,⁴⁶ O. M. Harris,¹³⁸ J. Hartert,⁴⁸ F. Hartjes,¹⁰⁵ T. Haruyama,⁶⁵ A. Harvey,⁵⁶ S. Hasegawa,¹⁰¹ Y. Hasegawa,¹⁴⁰ S. Hassani,¹³⁶ S. Haug,¹⁷ M. Hauschild,³⁰ R. Hauser,⁸⁸ M. Havranek,²¹ C. M. Hawkes,¹⁸ R. J. Hawkings,³⁰ A. D. Hawkins,⁷⁹ T. Hayakawa,⁶⁶ T. Hayashi,¹⁶⁰ D. Hayden,⁷⁶ C. P. Hays,¹¹⁸ H. S. Hayward,⁷³ S. J. Haywood,¹²⁹ S. J. Head,¹⁸ V. Hedberg,⁷⁹ L. Heelan,⁸ S. Heim,⁸⁸ B. Heinemann,¹⁵ S. Heisterkamp,³⁶ L. Helary,²² C. Heller,⁹⁸ M. Heller,³⁰ S. Hellman,^{146a,146b} D. Hellmich,²¹ C. Helsens,¹² R. C. W. Henderson,⁷¹ M. Henke,^{58a} A. Henrichs,⁵⁴ A. M. Henriques Correia,³⁰ S. Henrot-Versille,¹¹⁵ C. Hensel,⁵⁴ T. Henß,¹⁷⁵ C. M. Hernandez,⁸ Y. Hernández Jiménez,¹⁶⁷ R. Herrberg,¹⁶ G. Hertzen,⁴⁸ R. Hertenberger,⁹⁸ L. Hervas,³⁰ G. G. Hesketh,⁷⁷ N. P. Hessey,¹⁰⁵ E. Higón-Rodríguez,¹⁶⁷ J. C. Hill,²⁸ K. H. Hiller,⁴² S. Hillert,²¹ S. J. Hillier,¹⁸ I. Hinchliffe,¹⁵ E. Hines,¹²⁰ M. Hirose,¹¹⁶ F. Hirsch,⁴³ D. Hirschbuehl,¹⁷⁵ J. Hobbs,¹⁴⁸ N. Hod,¹⁵³ M. C. Hodgkinson,¹³⁹ P. Hodgson,¹³⁹ A. Hoecker,³⁰ M. R. Hoferkamp,¹⁰³ J. Hoffman,⁴⁰ D. Hoffmann,⁸³ M. Hohlfeld,⁸¹ M. Holder,¹⁴¹ S. O. Holmgren,^{146a} T. Holy,¹²⁷ J. L. Holzbauer,⁸⁸ T. M. Hong,¹²⁰ L. Hooft van Huysduynen,¹⁰⁸ S. Horner,⁴⁸ J.-Y. Hostachy,⁵⁵ S. Hou,¹⁵¹ A. Hoummada,^{135a} J. Howard,¹¹⁸ J. Howarth,⁸² I. Hristova,¹⁶ J. Hrivnac,¹¹⁵ T. Hryn'ova,⁵ P. J. Hsu,⁸¹ S.-C. Hsu,¹⁵ D. Hu,³⁵ Z. Hubacek,¹²⁷ F. Hubaut,⁸³ F. Huegging,²¹ A. Huettmann,⁴² T. B. Huffman,¹¹⁸ E. W. Hughes,³⁵ G. Hughes,⁷¹ M. Huhtinen,³⁰ M. Hurwitz,¹⁵ U. Husemann,⁴² N. Huseynov,^{64,s} J. Huston,⁸⁸ J. Huth,⁵⁷ G. Iacobucci,⁴⁹ G. Iakovidis,¹⁰ M. Ibbotson,⁸² I. Ibragimov,¹⁴¹ L. Iconomidou-Fayard,¹¹⁵ J. Idarraga,¹¹⁵ P. Iengo,^{102a} O. Igonkina,¹⁰⁵ Y. Ikegami,⁶⁵ M. Ikeno,⁶⁵ D. Iliadis,¹⁵⁴ N. Ilic,¹⁵⁸ T. Ince,²¹ J. Inigo-Golfin,³⁰ P. Ioannou,⁹ M. Iodice,^{134a} K. Iordanidou,⁹ V. Ippolito,^{132a,132b} A. Irls Quiles,¹⁶⁷ C. Isaksson,¹⁶⁶ M. Ishino,⁶⁷ M. Ishitsuka,¹⁵⁷ R. Ishmukhametov,⁴⁰ C. Issever,¹¹⁸ S. Istin,^{19a} A. V. Ivashin,¹²⁸ W. Iwanski,³⁹ H. Iwasaki,⁶⁵ J. M. Izen,⁴¹ V. Izzo,^{102a} B. Jackson,¹²⁰ J. N. Jackson,⁷³ P. Jackson,¹ M. R. Jaekel,³⁰ V. Jain,⁶⁰ K. Jakobs,⁴⁸ S. Jakobsen,³⁶ T. Jakoubek,¹²⁵ J. Jakubek,¹²⁷ D. K. Jana,¹¹¹ E. Jansen,⁷⁷ H. Jansen,³⁰ A. Jantsch,⁹⁹ M. Janus,⁴⁸ G. Jarlskog,⁷⁹ L. Jeanty,⁵⁷ I. Jen-La Plante,³¹ D. Jennens,⁸⁶ P. Jenni,³⁰ A. E. Loevschall-Jensen,³⁶ P. Jež,³⁶ S. Jézéquel,⁵ M. K. Jha,^{20a} H. Ji,¹⁷³ W. Ji,⁸¹ J. Jia,¹⁴⁸ Y. Jiang,^{33b} M. Jimenez Belenguer,⁴² S. Jin,^{33a} O. Jinnouchi,¹⁵⁷ M. D. Joergensen,³⁶ D. Joffe,⁴⁰ M. Johansen,^{146a,146b} K. E. Johansson,^{146a} P. Johansson,¹³⁹ S. Johnert,⁴² K. A. Johns,⁷ K. Jon-And,^{146a,146b} G. Jones,¹⁷⁰ R. W. L. Jones,⁷¹ T. J. Jones,⁷³ C. Joram,³⁰ P. M. Jorge,^{124a} K. D. Joshi,⁸² J. Jovicevic,¹⁴⁷ T. Jovin,^{13b} X. Ju,¹⁷³ C. A. Jung,⁴³ R. M. Jungst,³⁰ V. Juranek,¹²⁵ P. Jussel,⁶¹ A. Juste Rozas,¹² S. Kabana,¹⁷ M. Kaci,¹⁶⁷ A. Kaczmarek,³⁹ P. Kadlecik,³⁶ M. Kado,¹¹⁵ H. Kagan,¹⁰⁹ M. Kagan,⁵⁷ E. Kajomovitz,¹⁵² S. Kalinin,¹⁷⁵ L. V. Kalinovskaya,⁶⁴ S. Kama,⁴⁰ N. Kanaya,¹⁵⁵ M. Kaneda,³⁰ S. Kaneti,²⁸ T. Kanno,¹⁵⁷ V. A. Kantserov,⁹⁶ J. Kanzaki,⁶⁵ B. Kaplan,¹⁰⁸ A. Kapliy,³¹ J. Kaplon,³⁰ D. Kar,⁵³ M. Karagounis,²¹ K. Karakostas,¹⁰ M. Karnevskiy,⁴² V. Kartvelishvili,⁷¹ A. N. Karyukhin,¹²⁸ L. Kashif,¹⁷³ G. Kasieczka,^{58b} R. D. Kass,¹⁰⁹ A. Kastanas,¹⁴ M. Kataoka,⁵ Y. Kataoka,¹⁵⁵ E. Katsoufis,¹⁰ J. Katzy,⁴² V. Kaushik,⁷ K. Kawagoe,⁶⁹ T. Kawamoto,¹⁵⁵ G. Kawamura,⁸¹ M. S. Kayl,¹⁰⁵ S. Kazama,¹⁵⁵ V. A. Kazanin,¹⁰⁷ M. Y. Kazarinov,⁶⁴ R. Keeler,¹⁶⁹ R. Kehoe,⁴⁰ M. Keil,⁵⁴ G. D. Kekelidze,⁶⁴ J. S. Keller,¹³⁸ M. Kenyon,⁵³ O. Kepka,¹²⁵ N. Kerschen,³⁰ B. P. Kerševan,⁷⁴ S. Kersten,¹⁷⁵ K. Kessoku,¹⁵⁵ J. Keung,¹⁵⁸ F. Khalil-zada,¹¹ H. Khandanyan,^{146a,146b} A. Khanov,¹¹² D. Kharchenko,⁶⁴ A. Khodinov,⁹⁶ A. Khomich,^{58a} T. J. Khoo,²⁸ G. Khoriauli,²¹ A. Khoroshilov,¹⁷⁵ V. Khovanskiy,⁹⁵ E. Khranov,⁶⁴ J. Khubua,^{51b} H. Kim,^{146a,146b} S. H. Kim,¹⁶⁰ N. Kimura,¹⁷¹ O. Kind,¹⁶ B. T. King,⁷³ M. King,⁶⁶ R. S. B. King,¹¹⁸ J. Kirk,¹²⁹ A. E. Kiryunin,⁹⁹ T. Kishimoto,⁶⁶ D. Kisielowska,³⁸ T. Kitamura,⁶⁶ T. Kittelmann,¹²³ K. Kiuchi,¹⁶⁰ E. Kladiva,^{144b} M. Klein,⁷³ U. Klein,⁷³ K. Kleinknecht,⁸¹ M. Klemetti,⁸⁵ A. Klier,¹⁷² P. Klimek,^{146a,146b} A. Klimentov,²⁵ R. Klingenberg,⁴³ J. A. Klinger,⁸² E. B. Klinkby,³⁶ T. Klioutchnikova,³⁰ P. F. Klok,¹⁰⁴ S. Klous,¹⁰⁵ E.-E. Kluge,^{58a} T. Kluge,⁷³ P. Kluit,¹⁰⁵ S. Kluth,⁹⁹ N. S. Knecht,¹⁵⁸ E. Kneringer,⁶¹ E. B. F. G. Knoop,⁸³ A. Knue,⁵⁴ B. R. Ko,⁴⁵ T. Kobayashi,¹⁵⁵ M. Kobel,⁴⁴ M. Kocian,¹⁴³ P. Kodys,¹²⁶ K. Köneke,³⁰ A. C. König,¹⁰⁴ S. Koenig,⁸¹ L. Köpke,⁸¹ F. Koetsveld,¹⁰⁴ P. Koevesarki,²¹ T. Koffas,²⁹ E. Koffeman,¹⁰⁵ L. A. Kogan,¹¹⁸ S. Kohlmann,¹⁷⁵ F. Kohn,⁵⁴ Z. Kohout,¹²⁷ T. Kohriki,⁶⁵ T. Koi,¹⁴³ G. M. Kolachev,^{107,a} H. Kolanoski,¹⁶ V. Kolesnikov,⁶⁴

I. Koletsou,^{89a} J. Koll,⁸⁸ A. A. Komar,⁹⁴ Y. Komori,¹⁵⁵ T. Kondo,⁶⁵ T. Kono,^{42,t} A. I. Kononov,⁴⁸ R. Konoplich,^{108,u}
 N. Konstantinidis,⁷⁷ S. Koperny,³⁸ K. Korcyl,³⁹ K. Kordas,¹⁵⁴ A. Korn,¹¹⁸ A. Korol,¹⁰⁷ I. Korolkov,¹²
 E. V. Korolkova,¹³⁹ V. A. Korotkov,¹²⁸ O. Kortner,⁹⁹ S. Kortner,⁹⁹ V. V. Kostyukhin,²¹ S. Kotov,⁹⁹ V. M. Kotov,⁶⁴
 A. Kotwal,⁴⁵ C. Kourkouvelis,⁹ V. Kouskoura,¹⁵⁴ A. Koutsman,^{159a} R. Kowalewski,¹⁶⁹ T. Z. Kowalski,³⁸
 W. Kozanecki,¹³⁶ A. S. Kozhin,¹²⁸ V. Kral,¹²⁷ V. A. Kramarenko,⁹⁷ G. Kramberger,⁷⁴ M. W. Krasny,⁷⁸
 A. Krasznahorkay,¹⁰⁸ J. K. Kraus,²¹ S. Kreiss,¹⁰⁸ F. Krejci,¹²⁷ J. Kretzschmar,⁷³ N. Krieger,⁵⁴ P. Krieger,¹⁵⁸
 K. Kroeninger,⁵⁴ H. Kroha,⁹⁹ J. Kroll,¹²⁰ J. Kroseberg,²¹ J. Krstic,^{13a} U. Kruchonak,⁶⁴ H. Krüger,²¹ T. Kruker,¹⁷
 N. Krumnack,⁶³ Z. V. Krumshteyn,⁶⁴ T. Kubota,⁸⁶ S. Kудay,^{4a} S. Kuehn,⁴⁸ A. Kugel,^{58c} T. Kuhl,⁴² D. Kuhn,⁶¹
 V. Kukhtin,⁶⁴ Y. Kulchitsky,⁹⁰ S. Kuleshov,^{32b} C. Kummer,⁹⁸ M. Kuna,⁷⁸ J. Kunkle,¹²⁰ A. Kupco,¹²⁵ H. Kurashige,⁶⁶
 M. Kurata,¹⁶⁰ Y. A. Kurochkin,⁹⁰ V. Kus,¹²⁵ E. S. Kuwertz,¹⁴⁷ M. Kuze,¹⁵⁷ J. Kvita,¹⁴² R. Kwee,¹⁶ A. La Rosa,⁴⁹
 L. La Rotonda,^{37a,37b} L. Labarga,⁸⁰ J. Labbe,⁵ S. Lablak,^{135a} C. Lacasta,¹⁶⁷ F. Lacava,^{132a,132b} H. Lacker,¹⁶
 D. Lacour,⁷⁸ V. R. Lacuesta,¹⁶⁷ E. Ladygin,⁶⁴ R. Lafaye,⁵ B. Laforge,⁷⁸ T. Lagouri,¹⁷⁶ S. Lai,⁴⁸ E. Laisne,⁵⁵
 M. Lamanna,³⁰ L. Lambourne,⁷⁷ C. L. Lampen,⁷ W. Lampl,⁷ E. Lancon,¹³⁶ U. Landgraf,⁴⁸ M. P. J. Landon,⁷⁵
 J. L. Lane,⁸² V. S. Lang,^{58a} C. Lange,⁴² A. J. Lankford,¹⁶³ F. Lanni,²⁵ K. Lantzsch,¹⁷⁵ S. Laplace,⁷⁸ C. Lapoire,²¹
 J. F. Laporte,¹³⁶ T. Lari,^{89a} A. Lerner,¹¹⁸ M. Lassnig,³⁰ P. Laurelli,⁴⁷ V. Lavorini,^{37a,37b} W. Lavrijsen,¹⁵ P. Laycock,⁷³
 O. Le Dortz,⁷⁸ E. Le Guirriec,⁸³ E. Le Menedeu,¹² T. LeCompte,⁶ F. Ledroit-Guillon,⁵⁵ H. Lee,¹⁰⁵ J. S. H. Lee,¹¹⁶
 S. C. Lee,¹⁵¹ L. Lee,¹⁷⁶ M. Lefebvre,¹⁶⁹ M. Legendre,¹³⁶ F. Legger,⁹⁸ C. Leggett,¹⁵ M. Lehmacher,²¹
 G. Lehmann Miotto,³⁰ X. Lei,⁷ M. A. L. Leite,^{24d} R. Leitner,¹²⁶ D. Lellouch,¹⁷² B. Lemmer,⁵⁴ V. Lendermann,^{58a}
 K. J. C. Leney,^{145b} T. Lenz,¹⁰⁵ G. Lenzen,¹⁷⁵ B. Lenzi,³⁰ K. Leonhardt,⁴⁴ S. Leontsinis,¹⁰ F. Lepold,^{58a} C. Leroy,⁹³
 J-R. Lessard,¹⁶⁹ C. G. Lester,²⁸ C. M. Lester,¹²⁰ J. Levêque,⁵ D. Levin,⁸⁷ L. J. Levinson,¹⁷² A. Lewis,¹¹⁸
 G. H. Lewis,¹⁰⁸ A. M. Leyko,²¹ M. Leyton,¹⁶ B. Li,⁸³ H. Li,^{173,v} S. Li,^{33b,w} X. Li,⁸⁷ Z. Liang,^{118,x} H. Liao,³⁴
 B. Liberti,^{133a} P. Lichard,³⁰ M. Lichtnecker,⁹⁸ K. Lie,¹⁶⁵ W. Liebig,¹⁴ C. Limbach,²¹ A. Limosani,⁸⁶ M. Limper,⁶²
 S. C. Lin,^{151,y} F. Linde,¹⁰⁵ J. T. Linnemann,⁸⁸ E. Lipeles,¹²⁰ A. Lipniacka,¹⁴ T. M. Liss,¹⁶⁵ D. Lissauer,²⁵ A. Lister,⁴⁹
 A. M. Litke,¹³⁷ C. Liu,²⁹ D. Liu,¹⁵¹ H. Liu,⁸⁷ J. B. Liu,⁸⁷ L. Liu,⁸⁷ M. Liu,^{33b} Y. Liu,^{33b} M. Livan,^{119a,119b}
 S. S. A. Livermore,¹¹⁸ A. Lleres,⁵⁵ J. Llorente Merino,⁸⁰ S. L. Lloyd,⁷⁵ E. Lobodzinska,⁴² P. Loch,⁷
 W. S. Lockman,¹³⁷ T. Loddenkoetter,²¹ F. K. Loebinger,⁸² A. Loginov,¹⁷⁶ C. W. Loh,¹⁶⁸ T. Lohse,¹⁶ K. Lohwasser,⁴⁸
 M. Lokajicek,¹²⁵ V. P. Lombardo,⁵ R. E. Long,⁷¹ L. Lopes,^{124a} D. Lopez Mateos,⁵⁷ J. Lorenz,⁹⁸
 N. Lorenzo Martinez,¹¹⁵ M. Losada,¹⁶² P. Loscutoff,¹⁵ F. Lo Sterzo,^{132a,132b} M. J. Losty,^{159a,a} X. Lou,⁴¹ A. Lounis,¹¹⁵
 K. F. Loureiro,¹⁶² J. Love,⁶ P. A. Love,⁷¹ A. J. Lowe,^{143,f} F. Lu,^{33a} H. J. Lubatti,¹³⁸ C. Luci,^{132a,132b} A. Lucotte,⁵⁵
 A. Ludwig,⁴⁴ D. Ludwig,⁴² I. Ludwig,⁴⁸ J. Ludwig,⁴⁸ F. Luehring,⁶⁰ G. Luijckx,¹⁰⁵ W. Lukas,⁶¹ D. Lumb,⁴⁸
 L. Luminari,^{132a} E. Lund,¹¹⁷ B. Lund-Jensen,¹⁴⁷ B. Lundberg,⁷⁹ J. Lundberg,^{146a,146b} O. Lundberg,^{146a,146b}
 J. Lundquist,³⁶ M. Lungwitz,⁸¹ D. Lynn,²⁵ E. Lytken,⁷⁹ H. Ma,²⁵ L. L. Ma,¹⁷³ G. Maccarrone,⁴⁷ A. Macchiolo,⁹⁹
 B. Maček,⁷⁴ J. Machado Miguens,^{124a} R. Mackeprang,³⁶ R. J. Madaras,¹⁵ H. J. Maddocks,⁷¹ W. F. Mader,⁴⁴
 R. Maenner,^{58c} T. Maeno,²⁵ P. Mättig,¹⁷⁵ S. Mättig,⁸¹ L. Magnoni,¹⁶³ E. Magradze,⁵⁴ K. Mahboubi,⁴⁸ S. Mahmoud,⁷³
 G. Mahout,¹⁸ C. Maiani,¹³⁶ C. Maidantchik,^{24a} A. Maio,^{124a,c} S. Majewski,²⁵ Y. Makida,⁶⁵ N. Makovec,¹¹⁵ P. Mal,¹³⁶
 B. Malaescu,³⁰ Pa. Malecki,³⁹ P. Malecki,³⁹ V. P. Maleev,¹²¹ F. Malek,⁵⁵ U. Mallik,⁶² D. Malon,⁶ C. Malone,¹⁴³
 S. Maltezos,¹⁰ V. Malyshev,¹⁰⁷ S. Malyukov,³⁰ R. Mameghani,⁹⁸ J. Mamuzic,^{13b} A. Manabe,⁶⁵ L. Mandelli,^{89a}
 I. Mandić,⁷⁴ R. Mandrysch,¹⁶ J. Maneira,^{124a} A. Manfredini,⁹⁹ P. S. Mangeard,⁸⁸ L. Manhaes de Andrade Filho,^{24b}
 J. A. Manjarres Ramos,¹³⁶ A. Mann,⁵⁴ P. M. Manning,¹³⁷ A. Manousakis-Katsikakis,⁹ B. Mansoulie,¹³⁶ A. Mapelli,³⁰
 L. Mapelli,³⁰ L. March,⁸⁰ J. F. Marchand,²⁹ F. Marchese,^{133a,133b} G. Marchiori,⁷⁸ M. Marcisovsky,¹²⁵ C. P. Marino,¹⁶⁹
 F. Marroquim,^{24a} Z. Marshall,³⁰ F. K. Martens,¹⁵⁸ L. F. Marti,¹⁷ S. Marti-Garcia,¹⁶⁷ B. Martin,³⁰ B. Martin,⁸⁸
 J. P. Martin,⁹³ T. A. Martin,¹⁸ V. J. Martin,⁴⁶ B. Martin dit Latour,⁴⁹ S. Martin-Haugh,¹⁴⁹ M. Martinez,¹²
 V. Martinez Outschoorn,⁵⁷ A. C. Martyniuk,¹⁶⁹ M. Marx,⁸² F. Marzano,^{132a} A. Marzin,¹¹¹ L. Masetti,⁸¹
 T. Mashimo,¹⁵⁵ R. Mashinistov,⁹⁴ J. Masik,⁸² A. L. Maslennikov,¹⁰⁷ I. Massa,^{20a,20b} G. Massaro,¹⁰⁵ N. Massol,⁵
 P. Mastrandrea,¹⁴⁸ A. Mastroberardino,^{37a,37b} T. Masubuchi,¹⁵⁵ P. Matricon,¹¹⁵ H. Matsunaga,¹⁵⁵ T. Matsushita,⁶⁶
 C. Mattraversi,^{118,d} J. Maurer,⁸³ S. J. Maxfield,⁷³ A. Mayne,¹³⁹ R. Mazini,¹⁵¹ M. Mazur,²¹ L. Mazzaferro,^{133a,133b}
 M. Mazzanti,^{89a} J. Mc Donald,⁸⁵ S. P. Mc Kee,⁸⁷ A. McCarn,¹⁶⁵ R. L. McCarthy,¹⁴⁸ T. G. McCarthy,²⁹
 N. A. McCubbin,¹²⁹ K. W. McFarlane,^{56,a} J. A. McFayden,¹³⁹ G. Mchedlidze,^{51b} T. Mclaughlan,¹⁸ S. J. McMahan,¹²⁹
 R. A. McPherson,^{169,l} A. Meade,⁸⁴ J. Mechnich,¹⁰⁵ M. Mechtel,¹⁷⁵ M. Medinnis,⁴² R. Meera-Lebbai,¹¹¹
 T. Meguro,¹¹⁶ R. Mehdiyev,⁹³ S. Mehlhase,³⁶ A. Mehta,⁷³ K. Meier,^{58a} B. Meirose,⁷⁹ C. Melachrinou,³¹
 B. R. Mellado Garcia,¹⁷³ F. Meloni,^{89a,89b} L. Mendoza Navas,¹⁶² Z. Meng,^{151,v} A. Mengarelli,^{20a,20b} S. Menke,⁹⁹

- E. Meoni,¹⁶¹ K. M. Mercurio,⁵⁷ P. Mermod,⁴⁹ L. Merola,^{102a,102b} C. Meroni,^{89a} F. S. Merritt,³¹ H. Merritt,¹⁰⁹
A. Messina,^{30,z} J. Metcalfe,²⁵ A. S. Mete,¹⁶³ C. Meyer,⁸¹ C. Meyer,³¹ J.-P. Meyer,¹³⁶ J. Meyer,¹⁷⁴ J. Meyer,⁵⁴
T. C. Meyer,³⁰ J. Miao,^{33d} S. Michal,³⁰ L. Micu,^{26a} R. P. Middleton,¹²⁹ S. Migas,⁷³ L. Mijović,¹³⁶ G. Mikenberg,¹⁷²
M. Mikestikova,¹²⁵ M. Mikuz,⁷⁴ D. W. Miller,³¹ R. J. Miller,⁸⁸ W. J. Mills,¹⁶⁸ C. Mills,⁵⁷ A. Milov,¹⁷²
D. A. Milstead,^{146a,146b} D. Milstein,¹⁷² A. A. Minaenko,¹²⁸ M. Miñano Moya,¹⁶⁷ I. A. Minashvili,⁶⁴ A. I. Mincer,¹⁰⁸
B. Mindur,³⁸ M. Mineev,⁶⁴ Y. Ming,¹⁷³ L. M. Mir,¹² G. Mirabelli,^{132a} J. Mitrevski,¹³⁷ V. A. Mitsou,¹⁶⁷ S. Mitsui,⁶⁵
P. S. Miyagawa,¹³⁹ J. U. Mjörnmark,⁷⁹ T. Moa,^{146a,146b} V. Moeller,²⁸ K. Mönig,⁴² N. Möser,²¹ S. Mohapatra,¹⁴⁸
W. Mohr,⁴⁸ R. Moles-Valls,¹⁶⁷ J. Monk,⁷⁷ E. Monnier,⁸³ J. Montejo Berlingen,¹² F. Monticelli,⁷⁰ S. Monzani,^{20a,20b}
R. W. Moore,³ G. F. Moorhead,⁸⁶ C. Mora Herrera,⁴⁹ A. Moraes,⁵³ N. Morange,¹³⁶ J. Morel,⁵⁴ G. Morello,^{37a,37b}
D. Moreno,⁸¹ M. Moreno Llácer,¹⁶⁷ P. Morettini,^{50a} M. Morgenstern,⁴⁴ M. Morii,⁵⁷ A. K. Morley,³⁰ G. Mornacchi,³⁰
J. D. Morris,⁷⁵ L. Morvaj,¹⁰¹ H. G. Moser,⁹⁹ M. Mosidze,^{51b} J. Moss,¹⁰⁹ R. Mount,¹⁴³ E. Mountricha,^{10,aa}
S. V. Mouraviev,^{94,a} E. J. W. Moyse,⁸⁴ F. Mueller,^{58a} J. Mueller,¹²³ K. Mueller,²¹ T. A. Müller,⁹⁸ T. Mueller,⁸¹
D. Muenstermann,³⁰ Y. Munwes,¹⁵³ W. J. Murray,¹²⁹ I. Mussche,¹⁰⁵ E. Musto,^{102a,102b} A. G. Myagkov,¹²⁸
M. Myska,¹²⁵ J. Nadal,¹² K. Nagai,¹⁶⁰ R. Nagai,¹⁵⁷ K. Nagano,⁶⁵ A. Nagarkar,¹⁰⁹ Y. Nagasaka,⁵⁹ M. Nagel,⁹⁹
A. M. Nairz,³⁰ Y. Nakahama,³⁰ K. Nakamura,¹⁵⁵ T. Nakamura,¹⁵⁵ I. Nakano,¹¹⁰ G. Nanava,²¹ A. Napier,¹⁶¹
R. Narayan,^{58b} M. Nash,^{77,d} T. Nattermann,²¹ T. Naumann,⁴² G. Navarro,¹⁶² H. A. Neal,⁸⁷ P. Yu. Nechaeva,⁹⁴
T. J. Neep,⁸² A. Negri,^{119a,119b} G. Negri,³⁰ M. Negrini,^{20a} S. Nektarijevic,⁴⁹ A. Nelson,¹⁶³ T. K. Nelson,¹⁴³
S. Nemecek,¹²⁵ P. Nemethy,¹⁰⁸ A. A. Nepomuceno,^{24a} M. Nessi,^{30,bb} M. S. Neubauer,¹⁶⁵ M. Neumann,¹⁷⁵
A. Neusiedl,⁸¹ R. M. Neves,¹⁰⁸ P. Nevski,²⁵ P. R. Newman,¹⁸ V. Nguyen Thi Hong,¹³⁶ R. B. Nickerson,¹¹⁸
R. Nicolaidou,¹³⁶ B. Niquevert,³⁰ F. Niedercorn,¹¹⁵ J. Nielsen,¹³⁷ N. Nikiforou,³⁵ A. Nikiforov,¹⁶ V. Nikolaenko,¹²⁸
I. Nikolic-Audit,⁷⁸ K. Nikolics,⁴⁹ K. Nikolopoulos,¹⁸ H. Nilsen,⁴⁸ P. Nilsson,⁸ Y. Ninomiya,¹⁵⁵ A. Nisati,^{132a}
R. Nisius,⁹⁹ T. Nobe,¹⁵⁷ L. Nodulman,⁶ M. Nomachi,¹¹⁶ I. Nomidis,¹⁵⁴ S. Norberg,¹¹¹ M. Nordberg,³⁰
P. R. Norton,¹²⁹ J. Novakova,¹²⁶ M. Nozaki,⁶⁵ L. Nozka,¹¹³ I. M. Nugent,^{159a} A.-E. Nuncio-Quiroz,²¹
G. Nunes Hanninger,⁸⁶ T. Nunnemann,⁹⁸ E. Nurse,⁷⁷ B. J. O'Brien,⁴⁶ D. C. O'Neil,¹⁴² V. O'Shea,⁵³ L. B. Oakes,⁹⁸
F. G. Oakham,^{29,e} H. Oberlack,⁹⁹ J. Ocariz,⁷⁸ A. Ochi,⁶⁶ S. Oda,⁶⁹ S. Odaka,⁶⁵ J. Odier,⁸³ H. Ogren,⁶⁰ A. Oh,⁸²
S. H. Oh,⁴⁵ C. C. Ohm,³⁰ T. Ohshima,¹⁰¹ H. Okawa,²⁵ Y. Okumura,³¹ T. Okuyama,¹⁵⁵ A. Olariu,^{26a}
A. G. Olchevski,⁶⁴ S. A. Olivares Pino,^{32a} M. Oliveira,^{124a,i} D. Oliveira Damazio,²⁵ E. Oliver Garcia,¹⁶⁷ D. Olivito,¹²⁰
A. Olszewski,³⁹ J. Olszowska,³⁹ A. Onofre,^{124a,cc} P. U. E. Onyisi,³¹ C. J. Oram,^{159a} M. J. Oreglia,³¹ Y. Oren,¹⁵³
D. Orestano,^{134a,134b} N. Orlando,^{72a,72b} I. Orlov,¹⁰⁷ C. Oropeza Barrera,⁵³ R. S. Orr,¹⁵⁸ B. Osculati,^{50a,50b}
R. Ospanov,¹²⁰ C. Osuna,¹² G. Otero y Garzon,²⁷ J. P. Ottersbach,¹⁰⁵ M. Ouchrif,^{135d} E. A. Ouellette,¹⁶⁹
F. Ould-Saada,¹¹⁷ A. Ouraou,¹³⁶ Q. Ouyang,^{33a} A. Ovcharova,¹⁵ M. Owen,⁸² S. Owen,¹³⁹ V. E. Ozcan,^{19a} N. Ozturk,⁸
A. Pacheco Pages,¹² C. Padilla Aranda,¹² S. Pagan Griso,¹⁵ E. Paganis,¹³⁹ C. Pahl,⁹⁹ F. Paige,²⁵ P. Pais,⁸⁴
K. Pajchel,¹¹⁷ G. Palacino,^{159b} C. P. Paleari,⁷ S. Palestini,³⁰ D. Pallin,³⁴ A. Palma,^{124a} J. D. Palmer,¹⁸ Y. B. Pan,¹⁷³
E. Panagiotopoulou,¹⁰ P. Pani,¹⁰⁵ N. Panikashvili,⁸⁷ S. Panitkin,²⁵ D. Pantea,^{26a} A. Papadellis,^{146a}
Th. D. Papadopoulou,¹⁰ A. Paramonov,⁶ D. Paredes Hernandez,³⁴ W. Park,^{25,dd} M. A. Parker,²⁸ F. Parodi,^{50a,50b}
J. A. Parsons,³⁵ U. Parzefall,⁴⁸ S. Pashapour,⁵⁴ E. Pasqualucci,^{132a} S. Passaggio,^{50a} A. Passeri,^{134a}
F. Pastore,^{134a,134b,a} Fr. Pastore,⁷⁶ G. Pásztor,^{49,ee} S. Patariaia,¹⁷⁵ N. Patel,¹⁵⁰ J. R. Pater,⁸² S. Patricelli,^{102a,102b}
T. Pauly,³⁰ M. Pecsý,^{144a} S. Pedraza Lopez,¹⁶⁷ M. I. Pedraza Morales,¹⁷³ S. V. Peleganchuk,¹⁰⁷ D. Pelikan,¹⁶⁶
H. Peng,^{33b} B. Penning,³¹ A. Penson,³⁵ J. Penwell,⁶⁰ M. Perantoni,^{24a} K. Perez,^{35,ff} T. Perez Cavalcanti,⁴²
E. Perez Codina,^{159a} M. T. Pérez García-Estañ,¹⁶⁷ V. Perez Reale,³⁵ L. Perini,^{89a,89b} H. Pernegger,³⁰ R. Perrino,^{72a}
P. Perrodo,⁵ V. D. Peshekhonov,⁶⁴ K. Peters,³⁰ B. A. Petersen,³⁰ J. Petersen,³⁰ T. C. Petersen,³⁶ E. Petit,⁵
A. Petridis,¹⁵⁴ C. Petridou,¹⁵⁴ E. Petrolo,^{132a} F. Petrucci,^{134a,134b} D. Petschull,⁴² M. Petteni,¹⁴² R. Pezoa,^{32b}
A. Phan,⁸⁶ P. W. Phillips,¹²⁹ G. Piacquadio,³⁰ A. Picazio,⁴⁹ E. Piccaro,⁷⁵ M. Piccinini,^{20a,20b} S. M. Piec,⁴²
R. Piegai,²⁷ D. T. Pignotti,¹⁰⁹ J. E. Pilcher,³¹ A. D. Pilkington,⁸² J. Pina,^{124a,c} M. Pinamonti,^{164a,164c} A. Pinder,¹¹⁸
J. L. Pinfold,³ B. Pinto,^{124a} C. Pizio,^{89a,89b} M. Plamondon,¹⁶⁹ M.-A. Pleier,²⁵ E. Plotnikova,⁶⁴ A. Poblaguev,²⁵
S. Poddar,^{58a} F. Podlyski,³⁴ L. Poggioli,¹¹⁵ D. Pohl,²¹ M. Pohl,⁴⁹ G. Polesello,^{119a} A. Policicchio,^{37a,37b} A. Polini,^{20a}
J. Poll,⁷⁵ V. Polychronakos,²⁵ D. Pomeroy,²³ K. Pommès,³⁰ L. Pontecorvo,^{132a} B. G. Pope,⁸⁸ G. A. Popeneciu,^{26a}
D. S. Popovic,^{13a} A. Poppleton,³⁰ X. Portell Bueso,³⁰ G. E. Pospelov,⁹⁹ S. Pospisil,¹²⁷ I. N. Potrap,⁹⁹ C. J. Potter,¹⁴⁹
C. T. Potter,¹¹⁴ G. Poulard,³⁰ J. Poveda,⁶⁰ V. Pozdnyakov,⁶⁴ R. Prabhu,⁷⁷ P. Pralavorio,⁸³ A. Pranko,¹⁵ S. Prasad,³⁰
R. Pravahan,²⁵ S. Prell,⁶³ K. Pretzl,¹⁷ D. Price,⁶⁰ J. Price,⁷³ L. E. Price,⁶ D. Prieur,¹²³ M. Primavera,^{72a}
K. Prokofiev,¹⁰⁸ F. Prokoshin,^{32b} S. Protopopescu,²⁵ J. Proudfoot,⁶ X. Prudent,⁴⁴ M. Przybycien,³⁸ H. Przysieznik,⁵

S. Psoroulas,²¹ E. Ptacek,¹¹⁴ E. Pueschel,⁸⁴ J. Purdham,⁸⁷ M. Purohit,^{25,dd} P. Puzo,¹¹⁵ Y. Pylypchenko,⁶² J. Qian,⁸⁷ A. Quadt,⁵⁴ D. R. Quarrie,¹⁵ W. B. Quayle,¹⁷³ F. Quinonez,^{32a} M. Raas,¹⁰⁴ V. Radescu,⁴² P. Radloff,¹¹⁴ T. Rador,^{19a} F. Ragusa,^{89a,89b} G. Rahal,¹⁷⁸ A. M. Rahimi,¹⁰⁹ D. Rahm,²⁵ S. Rajagopalan,²⁵ M. Rammensee,⁴⁸ M. Rammes,¹⁴¹ A. S. Randle-Conde,⁴⁰ K. Randrianarivony,²⁹ F. Rauscher,⁹⁸ T. C. Rave,⁴⁸ M. Raymond,³⁰ A. L. Read,¹¹⁷ D. M. Rebuzzi,^{119a,119b} A. Redelbach,¹⁷⁴ G. Redlinger,²⁵ R. Reece,¹²⁰ K. Reeves,⁴¹ E. Reinherz-Aronis,¹⁵³ A. Reinsch,¹¹⁴ I. Reisinger,⁴³ C. Rembser,³⁰ Z. L. Ren,¹⁵¹ A. Renaud,¹¹⁵ M. Rescigno,^{132a} S. Resconi,^{89a} B. Resende,¹³⁶ P. Reznicek,⁹⁸ R. Rezvani,¹⁵⁸ R. Richter,⁹⁹ E. Richter-Was,^{5,gg} M. Ridel,⁷⁸ M. Rijpstra,¹⁰⁵ M. Rijssenbeek,¹⁴⁸ A. Rimoldi,^{119a,119b} L. Rinaldi,^{20a} R. R. Rios,⁴⁰ I. Riu,¹² G. Rivoltella,^{89a,89b} F. Rizatdinova,¹¹² E. Rizvi,⁷⁵ S. H. Robertson,^{85,1} A. Robichaud-Veronneau,¹¹⁸ D. Robinson,²⁸ J. E. M. Robinson,⁸² A. Robson,⁵³ J. G. Rocha de Lima,¹⁰⁶ C. Roda,^{122a,122b} D. Roda Dos Santos,³⁰ A. Roe,⁵⁴ S. Roe,³⁰ O. Røhne,¹¹⁷ S. Rolli,¹⁶¹ A. Romaniouk,⁹⁶ M. Romano,^{20a,20b} G. Romeo,²⁷ E. Romero Adam,¹⁶⁷ N. Rompotis,¹³⁸ L. Roos,⁷⁸ E. Ros,¹⁶⁷ S. Rosati,^{132a} K. Rosbach,⁴⁹ A. Rose,¹⁴⁹ M. Rose,⁷⁶ G. A. Rosenbaum,¹⁵⁸ E. I. Rosenberg,⁶³ P. L. Rosendahl,¹⁴ O. Rosenthal,¹⁴¹ L. Rosselet,⁴⁹ V. Rossetti,¹² E. Rossi,^{132a,132b} L. P. Rossi,^{50a} M. Rotaru,^{26a} I. Roth,¹⁷² J. Rothberg,¹³⁸ D. Rousseau,¹¹⁵ C. R. Royon,¹³⁶ A. Rozanov,⁸³ Y. Rozen,¹⁵² X. Ruan,^{33a,hh} F. Rubbo,¹² I. Rubinskiy,⁴² N. Ruckstuhl,¹⁰⁵ V. I. Rud,⁹⁷ C. Rudolph,⁴⁴ G. Rudolph,⁶¹ F. Rühr,⁷ A. Ruiz-Martinez,⁶³ L. Rummyantsev,⁶⁴ Z. Rurikova,⁴⁸ N. A. Rusakovich,⁶⁴ J. P. Rutherford,⁷ C. Ruwiedel,^{15,a} P. Ruzicka,¹²⁵ Y. F. Ryabov,¹²¹ M. Rybar,¹²⁶ G. Rybkin,¹¹⁵ N. C. Ryder,¹¹⁸ A. F. Saavedra,¹⁵⁰ I. Sadeh,¹⁵³ H. F. W. Sadrozinski,¹³⁷ R. Sadykov,⁶⁴ F. Safai Tehrani,^{132a} H. Sakamoto,¹⁵⁵ G. Salamanna,⁷⁵ A. Salamon,^{133a} M. Saleem,¹¹¹ D. Salek,³⁰ D. Salihagic,⁹⁹ A. Salnikov,¹⁴³ J. Salt,¹⁶⁷ B. M. Salvachua Ferrando,⁶ D. Salvatore,^{37a,37b} F. Salvatore,¹⁴⁹ A. Salvucci,¹⁰⁴ A. Salzburger,³⁰ D. Sampsonidis,¹⁵⁴ B. H. Samset,¹¹⁷ A. Sanchez,^{102a,102b} V. Sanchez Martinez,¹⁶⁷ H. Sandaker,¹⁴ H. G. Sander,⁸¹ M. P. Sanders,⁹⁸ M. Sandhoff,¹⁷⁵ T. Sandoval,²⁸ C. Sandoval,¹⁶² R. Sandstroem,⁹⁹ D. P. C. Sankey,¹²⁹ A. Sansoni,⁴⁷ C. Santamarina Rios,⁸⁵ C. Santoni,³⁴ R. Santonic,^{133a,133b} H. Santos,^{124a} J. G. Saraiva,^{124a} T. Sarangi,¹⁷³ E. Sarkisyan-Grinbaum,⁸ F. Sarri,^{122a,122b} G. Sartisohn,¹⁷⁵ O. Sasaki,⁶⁵ Y. Sasaki,¹⁵⁵ N. Sasao,⁶⁷ I. Satsounkevitch,⁹⁰ G. Sauvage,^{5,a} E. Sauvan,⁵ J. B. Sauvan,¹¹⁵ P. Savard,^{158,e} V. Savinov,¹²³ D. O. Savu,³⁰ L. Sawyer,^{25,n} D. H. Saxon,⁵³ J. Saxon,¹²⁰ C. Sbarra,^{20a} A. Sbrizzi,^{20a,20b} D. A. Scannicchio,¹⁶³ M. Scarcella,¹⁵⁰ J. Schaarschmidt,¹¹⁵ P. Schacht,⁹⁹ D. Schaefer,¹²⁰ U. Schäfer,⁸¹ S. Schaepe,²¹ S. Schaezel,^{58b} A. C. Schaffer,¹¹⁵ D. Schaile,⁹⁸ R. D. Schamberger,¹⁴⁸ A. G. Schamov,¹⁰⁷ V. Scharf,^{58a} V. A. Schegelsky,¹²¹ D. Scheirich,⁸⁷ M. Schernau,¹⁶³ M. I. Scherzer,³⁵ C. Schiavi,^{50a,50b} J. Schieck,⁹⁸ M. Schioppa,^{37a,37b} S. Schlenker,³⁰ E. Schmidt,⁴⁸ K. Schmieden,²¹ C. Schmitt,⁸¹ S. Schmitt,^{58b} M. Schmitz,²¹ B. Schneider,¹⁷ U. Schnoor,⁴⁴ A. Schoening,^{58b} A. L. S. Schorlemmer,⁵⁴ M. Schott,³⁰ D. Schouten,^{159a} J. Schovancova,¹²⁵ M. Schram,⁸⁵ C. Schroeder,⁸¹ N. Schroer,^{58c} M. J. Schultens,²¹ J. Schultes,¹⁷⁵ H.-C. Schultz-Coulon,^{58a} H. Schulz,¹⁶ M. Schumacher,⁴⁸ B. A. Schumm,¹³⁷ Ph. Schune,¹³⁶ C. Schwanenberger,⁸² A. Schwartzman,¹⁴³ Ph. Schwegler,⁹⁹ Ph. Schwemling,⁷⁸ R. Schwienhorst,⁸⁸ R. Schwierz,⁴⁴ J. Schwindling,¹³⁶ T. Schwindt,²¹ M. Schwoerer,⁵ G. Sciolla,²³ W. G. Scott,¹²⁹ J. Searcy,¹¹⁴ G. Sedov,⁴² E. Sedykh,¹²¹ S. C. Seidel,¹⁰³ A. Seiden,¹³⁷ F. Seifert,⁴⁴ J. M. Seixas,^{24a} G. Sekhniadze,^{102a} S. J. Sekula,⁴⁰ K. E. Selbach,⁴⁶ D. M. Seliverstov,¹²¹ B. Sellden,^{146a} G. Sellers,⁷³ M. Seman,^{144b} N. Semprini-Cesari,^{20a,20b} C. Serfon,⁹⁸ L. Serin,¹¹⁵ L. Serkin,⁵⁴ R. Seuster,⁹⁹ H. Severini,¹¹¹ A. Sfyrla,³⁰ E. Shabalina,⁵⁴ M. Shamim,¹¹⁴ L. Y. Shan,^{33a} J. T. Shank,²² Q. T. Shao,⁸⁶ M. Shapiro,¹⁵ P. B. Shatalov,⁹⁵ K. Shaw,^{164a,164c} D. Sherman,¹⁷⁶ P. Sherwood,⁷⁷ A. Shibata,¹⁰⁸ S. Shimizu,¹⁰¹ M. Shimojima,¹⁰⁰ T. Shin,⁵⁶ M. Shiyakova,⁶⁴ A. Shmeleva,⁹⁴ M. J. Shochet,³¹ D. Short,¹¹⁸ S. Shrestha,⁶³ E. Shulga,⁹⁶ M. A. Shupe,⁷ P. Sicho,¹²⁵ A. Sidoti,^{132a} F. Siegert,⁴⁸ Dj. Sijacki,^{13a} O. Silbert,¹⁷² J. Silva,^{124a} Y. Silver,¹⁵³ D. Silverstein,¹⁴³ S. B. Silverstein,^{146a} V. Simak,¹²⁷ O. Simard,¹³⁶ Lj. Simic,^{13a} S. Simion,¹¹⁵ E. Simioni,⁸¹ B. Simmons,⁷⁷ R. Simoniello,^{89a,89b} M. Simonyan,³⁶ P. Sinervo,¹⁵⁸ N. B. Sinev,¹¹⁴ V. Sipica,¹⁴¹ G. Siragusa,¹⁷⁴ A. Sircar,²⁵ A. N. Sisakyan,^{64,a} S. Yu. Sivoklokov,⁹⁷ J. Sjölin,^{146a,146b} T. B. Sjurson,¹⁴ L. A. Skinnari,¹⁵ H. P. Skottowe,⁵⁷ K. Skovpen,¹⁰⁷ P. Skubic,¹¹¹ M. Slater,¹⁸ T. Slavicek,¹²⁷ K. Sliwa,¹⁶¹ V. Smakhtin,¹⁷² B. H. Smart,⁴⁶ S. L. Smestad,¹¹⁷ S. Yu. Smirnov,⁹⁶ Y. Smirnov,⁹⁶ L. N. Smirnova,⁹⁷ O. Smirnova,⁷⁹ B. C. Smith,⁵⁷ D. Smith,¹⁴³ K. M. Smith,⁵³ M. Smizanska,⁷¹ K. Smolek,¹²⁷ A. A. Snesarev,⁹⁴ S. W. Snow,⁸² J. Snow,¹¹¹ S. Snyder,²⁵ R. Sobie,^{169,1} J. Sodomka,¹²⁷ A. Soffer,¹⁵³ C. A. Solans,¹⁶⁷ M. Solar,¹²⁷ J. Solc,¹²⁷ E. Yu. Soldatov,⁹⁶ U. Soldevila,¹⁶⁷ E. Solfaroli Camillocci,^{132a,132b} A. A. Solodkov,¹²⁸ O. V. Solovyanov,¹²⁸ V. Solovyev,¹²¹ N. Soni,¹ V. Sopko,¹²⁷ B. Sopko,¹²⁷ M. Sosebee,⁸ R. Soualah,^{164a,164c} A. Soukharev,¹⁰⁷ S. Spagnolo,^{72a,72b} F. Spanò,⁷⁶ R. Spighi,^{20a} G. Spigo,³⁰ R. Spiwoks,³⁰ M. Spousta,^{126,ii} T. Spreitzer,¹⁵⁸ B. Spurlock,⁸ R. D. St. Denis,⁵³ J. Stahlman,¹²⁰ R. Stamen,^{58a} E. Stanecka,³⁹ R. W. Stanek,⁶ C. Stanescu,^{134a} M. Stanescu-Bellu,⁴² M. M. Stanitzki,⁴² S. Stapnes,¹¹⁷

E. A. Starchenko,¹²⁸ J. Stark,⁵⁵ P. Staroba,¹²⁵ P. Starovoitov,⁴² R. Staszewski,³⁹ A. Staude,⁹⁸ P. Stavina,^{144a,a}
 G. Steele,⁵³ P. Steinbach,⁴⁴ P. Steinberg,²⁵ I. Stekl,¹²⁷ B. Stelzer,¹⁴² H. J. Stelzer,⁸⁸ O. Stelzer-Chilton,^{159a}
 H. Stenzel,⁵² S. Stern,⁹⁹ G. A. Stewart,³⁰ J. A. Stillings,²¹ M. C. Stockton,⁸⁵ K. Stoerig,⁴⁸ G. Stoicea,^{26a} S. Stojek,⁹⁹
 P. Strachota,¹²⁶ A. R. Stradling,⁸ A. Straessner,⁴⁴ J. Strandberg,¹⁴⁷ S. Strandberg,^{146a,146b} A. Strandlie,¹¹⁷
 M. Strang,¹⁰⁹ E. Strauss,¹⁴³ M. Strauss,¹¹¹ P. Strizenec,^{144b} R. Ströhmer,¹⁷⁴ D. M. Strom,¹¹⁴ J. A. Strong,^{76,a}
 R. Stroynowski,⁴⁰ J. Strube,¹²⁹ B. Stugu,¹⁴ I. Stumer,^{25,a} J. Stupak,¹⁴⁸ P. Sturm,¹⁷⁵ N. A. Styles,⁴² D. A. Soh,^{151,x}
 D. Su,¹⁴³ H. S. Subramania,³ A. Succurro,¹² Y. Sugaya,¹¹⁶ C. Suhr,¹⁰⁶ M. Suk,¹²⁶ V. V. Sulin,⁹⁴ S. Sultansoy,^{4d}
 T. Sumida,⁶⁷ X. Sun,⁵⁵ J. E. Sundermann,⁴⁸ K. Suruliz,¹³⁹ G. Susinno,^{37a,37b} M. R. Sutton,¹⁴⁹ Y. Suzuki,⁶⁵
 Y. Suzuki,⁶⁶ M. Svatos,¹²⁵ S. Swedish,¹⁶⁸ I. Sykora,^{144a} T. Sykora,¹²⁶ J. Sánchez,¹⁶⁷ D. Ta,¹⁰⁵ K. Tackmann,⁴²
 A. Taffard,¹⁶³ R. Tafirout,^{159a} N. Taiblum,¹⁵³ Y. Takahashi,¹⁰¹ H. Takai,²⁵ R. Takashima,⁶⁸ H. Takeda,⁶⁶
 T. Takeshita,¹⁴⁰ Y. Takubo,⁶⁵ M. Talby,⁸³ A. Talyshev,^{107,g} M. C. Tamssett,²⁵ J. Tanaka,¹⁵⁵ R. Tanaka,¹¹⁵ S. Tanaka,¹³¹
 S. Tanaka,⁶⁵ A. J. Tanasijczuk,¹⁴² K. Tani,⁶⁶ N. Tannoury,⁸³ S. Tapprogge,⁸¹ D. Tardif,¹⁵⁸ S. Tarem,¹⁵² F. Tarrade,²⁹
 G. F. Tartarelli,^{89a} P. Tas,¹²⁶ M. Tasevsky,¹²⁵ E. Tassi,^{37a,37b} M. Tatarikhanov,¹⁵ Y. Tayalati,^{135d} C. Taylor,⁷⁷
 F. E. Taylor,⁹² G. N. Taylor,⁸⁶ W. Taylor,^{159b} M. Teinturier,¹¹⁵ F. A. Teischinger,³⁰ M. Teixeira Dias Castanheira,⁷⁵
 P. Teixeira-Dias,⁷⁶ K. K. Temming,⁴⁸ H. Ten Kate,³⁰ P. K. Teng,¹⁵¹ S. Terada,⁶⁵ K. Terashi,¹⁵⁵ J. Terron,⁸⁰ M. Testa,⁴⁷
 R. J. Teuscher,^{158,1} J. Therhaag,²¹ T. Theveneaux-Pelzer,⁷⁸ S. Thoma,⁴⁸ J. P. Thomas,¹⁸ E. N. Thompson,³⁵
 P. D. Thompson,¹⁸ P. D. Thompson,¹⁵⁸ A. S. Thompson,⁵³ L. A. Thomsen,³⁶ E. Thomson,¹²⁰ M. Thomson,²⁸
 W. M. Thong,⁸⁶ R. P. Thun,⁸⁷ F. Tian,³⁵ M. J. Tibbetts,¹⁵ T. Tic,¹²⁵ V. O. Tikhomirov,⁹⁴ Y. A. Tikhonov,^{107,g}
 S. Timoshenko,⁹⁶ P. Tipton,¹⁷⁶ S. Tisserant,⁸³ T. Todorov,⁵ S. Todorova-Nova,¹⁶¹ B. Toggerson,¹⁶³ J. Tojo,⁶⁹
 S. Tokár,^{144a} K. Tokushuku,⁶⁵ K. Tollefson,⁸⁸ M. Tomoto,¹⁰¹ L. Tompkins,³¹ K. Toms,¹⁰³ A. Tonoyan,¹⁴ C. Topfel,¹⁷
 N. D. Topilin,⁶⁴ I. Torchiani,³⁰ E. Torrence,¹¹⁴ H. Torres,⁷⁸ E. Torró Pastor,¹⁶⁷ J. Toth,^{83,ee} F. Touchard,⁸³
 D. R. Tovey,¹³⁹ T. Trefzger,¹⁷⁴ L. Tremblet,³⁰ A. Tricoli,³⁰ I. M. Trigger,^{159a} S. Trincaz-Duvoid,⁷⁸ M. F. Tripania,⁷⁰
 N. Triplett,²⁵ W. Trischuk,¹⁵⁸ B. Trocmé,⁵⁵ C. Troncon,^{89a} M. Trotter-McDonald,¹⁴² M. Trzebinski,³⁹ A. Trzupek,³⁹
 C. Tsarouchas,³⁰ J. C-L. Tseng,¹¹⁸ M. Tsiakiris,¹⁰⁵ P. V. Tsiarehsha,⁹⁰ D. Tsonou,^{5,jj} G. Tsiopolitis,¹⁰ S. Tsiskaridze,¹²
 V. Tsiskaridze,⁴⁸ E. G. Tskhadadze,^{51a} I. I. Tsukerman,⁹⁵ V. Tsulaia,¹⁵ J.-W. Tsung,²¹ S. Tsuno,⁶⁵ D. Tsybychev,¹⁴⁸
 A. Tua,¹³⁹ A. Tudorache,^{26a} V. Tudorache,^{26a} J. M. Tuggle,³¹ M. Turala,³⁹ D. Turecek,¹²⁷ I. Turk Cakir,^{4e}
 E. Turlay,¹⁰⁵ R. Turra,^{89a,89b} P. M. Tuts,³⁵ A. Tykhonov,⁷⁴ M. Tylmad,^{146a,146b} M. Tyndel,¹²⁹ G. Tzanakos,⁹
 K. Uchida,²¹ I. Ueda,¹⁵⁵ R. Ueno,²⁹ M. Uglan,¹⁴ M. Uhlenbrock,²¹ M. Uhrmacher,⁵⁴ F. Ukegawa,¹⁶⁰ G. Unal,³⁰
 A. Undrus,²⁵ G. Unel,¹⁶³ Y. Unno,⁶⁵ D. Urbaniec,³⁵ P. Urquijo,²¹ G. Usai,⁸ M. Uslenghi,^{119a,119b} L. Vacavant,⁸³
 V. Vacek,¹²⁷ B. Vachon,⁸⁵ S. Vahsen,¹⁵ J. Valenta,¹²⁵ S. Valentinetti,^{20a,20b} A. Valero,¹⁶⁷ S. Valkar,¹²⁶
 E. Valladolid Gallego,¹⁶⁷ S. Vallecorsa,¹⁵² J. A. Valls Ferrer,¹⁶⁷ P. C. Van Der Deijl,¹⁰⁵ R. van der Geer,¹⁰⁵
 H. van der Graaf,¹⁰⁵ R. Van Der Leeuw,¹⁰⁵ E. van der Poel,¹⁰⁵ D. van der Ster,³⁰ N. van Eldik,³⁰ P. van Gemmeren,⁶
 I. van Vulpen,¹⁰⁵ M. Vanadia,⁹⁹ W. Vandelli,³⁰ A. Vaniachine,⁶ P. Vankov,⁴² F. Vannucci,⁷⁸ R. Vari,^{132a} T. Varol,⁸⁴
 D. Varouchas,¹⁵ A. Vartapetian,⁸ K. E. Varvell,¹⁵⁰ V. I. Vassilakopoulos,⁵⁶ F. Vazeille,³⁴ T. Vazquez Schroeder,⁵⁴
 G. Vegni,^{89a,89b} J. J. Veillet,¹¹⁵ F. Veloso,^{124a} R. Veness,³⁰ S. Veneziano,^{132a} A. Ventura,^{72a,72b} D. Ventura,⁸⁴
 M. Venturi,⁴⁸ N. Venturi,¹⁵⁸ V. Vercesi,^{119a} M. Verducci,¹³⁸ W. Verkerke,¹⁰⁵ J. C. Vermeulen,¹⁰⁵ A. Vest,⁴⁴
 M. C. Vetterli,^{142,e} I. Vichou,¹⁶⁵ T. Vickey,^{145b,kk} O. E. Vickey Boeriu,^{145b} G. H. A. Viehhauser,¹¹⁸ S. Viel,¹⁶⁸
 M. Villa,^{20a,20b} M. Villaplana Perez,¹⁶⁷ E. Vilucchi,⁴⁷ M. G. Vincter,²⁹ E. Vinek,³⁰ V. B. Vinogradov,⁶⁴
 M. Virchaux,^{136,a} J. Virzi,¹⁵ O. Vitells,¹⁷² M. Viti,⁴² I. Vivarelli,⁴⁸ F. Vives Vaque,³ S. Vlachos,¹⁰ D. Vladoiu,⁹⁸
 M. Vlasak,¹²⁷ A. Vogel,²¹ P. Vokac,¹²⁷ G. Volpi,⁴⁷ M. Volpi,⁸⁶ G. Volpini,^{89a} H. von der Schmitt,⁹⁹
 H. von Radziewski,⁴⁸ E. von Toerne,²¹ V. Vorobel,¹²⁶ V. Vorwerk,¹² M. Vos,¹⁶⁷ R. Voss,³⁰ T. T. Voss,¹⁷⁵
 J. H. Vossebeld,⁷³ N. Vranjes,¹³⁶ M. Vranjes Milosavljevic,¹⁰⁵ V. Vrba,¹²⁵ M. Vreeswijk,¹⁰⁵ T. Vu Anh,⁴⁸
 R. Vuillermet,³⁰ I. Vukotic,³¹ W. Wagner,¹⁷⁵ P. Wagner,¹²⁰ H. Wahlen,¹⁷⁵ S. Wahrenund,⁴⁴ J. Wakabayashi,¹⁰¹
 S. Walch,⁸⁷ J. Walder,⁷¹ R. Walker,⁹⁸ W. Walkowiak,¹⁴¹ R. Wall,¹⁷⁶ P. Waller,⁷³ B. Walsh,¹⁷⁶ C. Wang,⁴⁵ H. Wang,¹⁷³
 H. Wang,^{33b,ll} J. Wang,¹⁵¹ J. Wang,⁵⁵ R. Wang,¹⁰³ S. M. Wang,¹⁵¹ T. Wang,²¹ A. Warburton,⁸⁵ C. P. Ward,²⁸
 M. Warsinsky,⁴⁸ A. Washbrook,⁴⁶ C. Wasicki,⁴² I. Watanabe,⁶⁶ P. M. Watkins,¹⁸ A. T. Watson,¹⁸ I. J. Watson,¹⁵⁰
 M. F. Watson,¹⁸ G. Watts,¹³⁸ S. Watts,⁸² A. T. Waugh,¹⁵⁰ B. M. Waugh,⁷⁷ M. S. Weber,¹⁷ P. Weber,⁵⁴
 A. R. Weidberg,¹¹⁸ P. Weigell,⁹⁹ J. Weingarten,⁵⁴ C. Weiser,⁴⁸ P. S. Wells,³⁰ T. Wenaus,²⁵ D. Wendland,¹⁶
 Z. Weng,^{151,x} T. Wengler,³⁰ S. Wenig,³⁰ N. Wermes,²¹ M. Werner,⁴⁸ P. Werner,³⁰ M. Werth,¹⁶³ M. Wessels,^{58a}
 J. Wetter,¹⁶¹ C. Weydert,⁵⁵ K. Whalen,²⁹ S. J. Wheeler-Ellis,¹⁶³ A. White,⁸ M. J. White,⁸⁶ S. White,^{122a,122b}
 S. R. Whitehead,¹¹⁸ D. Whiteson,¹⁶³ D. Whittington,⁶⁰ F. Wicke,¹¹⁵ D. Wicke,¹⁷⁵ F. J. Wickens,¹²⁹

W. Wiedenmann,¹⁷³ M. Wielers,¹²⁹ P. Wienemann,²¹ C. Wiglesworth,⁷⁵ L. A. M. Wiik-Fuchs,⁴⁸ P. A. Wijeratne,⁷⁷
 A. Wildauer,⁹⁹ M. A. Wildt,^{42,t} I. Wilhelm,¹²⁶ H. G. Wilkens,³⁰ J. Z. Will,⁹⁸ E. Williams,³⁵ H. H. Williams,¹²⁰
 W. Willis,³⁵ S. Willocq,⁸⁴ J. A. Wilson,¹⁸ M. G. Wilson,¹⁴³ A. Wilson,⁸⁷ I. Wingerter-Seez,⁵ S. Winkelmann,⁴⁸
 F. Winklmeier,³⁰ M. Wittgen,¹⁴³ S. J. Wollstadt,⁸¹ M. W. Wolter,³⁹ H. Wolters,^{124a,i} W. C. Wong,⁴¹ G. Wooden,⁸⁷
 B. K. Wosiek,³⁹ J. Wotschack,³⁰ M. J. Woudstra,⁸² K. W. Wozniak,³⁹ K. Wraight,⁵³ M. Wright,⁵³ B. Wrona,⁷³
 S. L. Wu,¹⁷³ X. Wu,⁴⁹ Y. Wu,^{33b,mm} E. Wulf,³⁵ B. M. Wynne,⁴⁶ S. Xella,³⁶ M. Xiao,¹³⁶ S. Xie,⁴⁸ C. Xu,^{33b,aa} D. Xu,¹³⁹
 B. Yabsley,¹⁵⁰ S. Yacoob,^{145a,nn} M. Yamada,⁶⁵ H. Yamaguchi,¹⁵⁵ A. Yamamoto,⁶⁵ K. Yamamoto,⁶³ S. Yamamoto,¹⁵⁵
 T. Yamamura,¹⁵⁵ T. Yamanaka,¹⁵⁵ J. Yamaoka,⁴⁵ T. Yamazaki,¹⁵⁵ Y. Yamazaki,⁶⁶ Z. Yan,²² H. Yang,⁸⁷ U. K. Yang,⁸²
 Y. Yang,⁶⁰ Z. Yang,^{146a,146b} S. Yanush,⁹¹ L. Yao,^{33a} Y. Yao,¹⁵ Y. Yasu,⁶⁵ G. V. Ybeles Smit,¹³⁰ J. Ye,⁴⁰ S. Ye,²⁵
 M. Yilmaz,^{4c} R. Yoosoofmiya,¹²³ K. Yorita,¹⁷¹ R. Yoshida,⁶ C. Young,¹⁴³ C. J. Young,¹¹⁸ S. Youssef,²² D. Yu,²⁵
 J. Yu,⁸ J. Yu,¹¹² L. Yuan,⁶⁶ A. Yurkewicz,¹⁰⁶ M. Byszewski,³⁰ B. Zabinski,³⁹ R. Zaidan,⁶² A. M. Zaitsev,¹²⁸
 Z. Zajacova,³⁰ L. Zanello,^{132a,132b} D. Zanzi,⁹⁹ A. Zaytsev,²⁵ C. Zeitnitz,¹⁷⁵ M. Zeman,¹²⁵ A. Zemla,³⁹ C. Zender,²¹
 O. Zenin,¹²⁸ T. Ženiš,^{144a} Z. Zinonos,^{122a,122b} S. Zenz,¹⁵ D. Zerwas,¹¹⁵ G. Zevi della Porta,⁵⁷ Z. Zhan,^{33d}
 D. Zhang,^{33b,li} H. Zhang,⁸⁸ J. Zhang,⁶ X. Zhang,^{33d} Z. Zhang,¹¹⁵ L. Zhao,¹⁰⁸ T. Zhao,¹³⁸ Z. Zhao,^{33b}
 A. Zhemchugov,⁶⁴ J. Zhong,¹¹⁸ B. Zhou,⁸⁷ N. Zhou,¹⁶³ Y. Zhou,¹⁵¹ C. G. Zhu,^{33d} H. Zhu,⁴² J. Zhu,⁸⁷ Y. Zhu,^{33b}
 X. Zhuang,⁹⁸ V. Zhuravlov,⁹⁹ D. Zieminska,⁶⁰ N. I. Zimin,⁶⁴ R. Zimmermann,²¹ S. Zimmermann,²¹
 S. Zimmermann,⁴⁸ M. Ziolkowski,¹⁴¹ R. Zitoun,⁵ L. Živković,³⁵ V. V. Zmouchko,^{128,a} G. Zobernig,¹⁷³
 A. Zoccoli,^{20a,20b} M. zur Nedden,¹⁶ V. Zutshi,¹⁰⁶ and L. Zwalinski³⁰

(ATLAS Collaboration)

¹*School of Chemistry and Physics, University of Adelaide, North Terrace Campus, 5000, SA, Australia*²*Physics Department, SUNY Albany, Albany New York, USA*³*Department of Physics, University of Alberta, Edmonton Alberta, Canada*^{4a}*Department of Physics, Ankara University, Ankara, Turkey*^{4b}*Department of Physics, Dumlupinar University, Kutahya, Turkey*^{4c}*Department of Physics, Gazi University, Ankara, Turkey*^{4d}*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*^{4e}*Turkish Atomic Energy Authority, Ankara, Turkey*⁵*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*⁶*High Energy Physics Division, Argonne National Laboratory, Argonne Illinois, USA*⁷*Department of Physics, University of Arizona, Tucson Arizona, USA*⁸*Department of Physics, The University of Texas at Arlington, Arlington Texas, USA*⁹*Physics Department, University of Athens, Athens, Greece*¹⁰*Physics Department, National Technical University of Athens, Zografou, Greece*¹¹*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*¹²*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain*^{13a}*Institute of Physics, University of Belgrade, Belgrade, Serbia*^{13b}*Vinca Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*¹⁴*Department for Physics and Technology, University of Bergen, Bergen, Norway*¹⁵*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley California, USA*¹⁶*Department of Physics, Humboldt University, Berlin, Germany*¹⁷*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*¹⁸*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*^{19a}*Department of Physics, Bogazici University, Istanbul, Turkey*^{19b}*Division of Physics, Dogus University, Istanbul, Turkey*^{19c}*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*^{19d}*Department of Physics, Istanbul Technical University, Istanbul, Turkey*^{20a}*INFN Sezione di Bologna, Italy*^{20b}*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*²¹*Physikalisches Institut, University of Bonn, Bonn, Germany*²²*Department of Physics, Boston University, Boston Massachusetts, USA*²³*Department of Physics, Brandeis University, Waltham Massachusetts, USA*^{24a}*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*^{24b}*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*^{24c}*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*

- ^{24d}*Instituto de Física, Universidade de Sao Paulo, Sao Paulo, Brazil*
- ²⁵*Physics Department, Brookhaven National Laboratory, Upton New York, USA*
- ^{26a}*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
- ^{26b}*University Politehnica Bucharest, Bucharest, Romania*
- ^{26c}*West University in Timisoara, Timisoara, Romania*
- ²⁷*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
- ²⁸*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
- ²⁹*Department of Physics, Carleton University, Ottawa Ontario, Canada*
- ³⁰*CERN, Geneva, Switzerland*
- ³¹*Enrico Fermi Institute, University of Chicago, Chicago Illinois, USA*
- ^{32a}*Departamento de Física, Pontificia Universidad Católica de Chile, Santiago, Chile*
- ^{32b}*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
- ^{33a}*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
- ^{33b}*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
- ^{33c}*Department of Physics, Nanjing University, Jiangsu, China*
- ^{33d}*School of Physics, Shandong University, Shandong, China*
- ³⁴*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France*
- ³⁵*Nevis Laboratory, Columbia University, Irvington New York, USA*
- ³⁶*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
- ^{37a}*INFN Gruppo Collegato di Cosenza, Italy*
- ^{37b}*Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy*
- ³⁸*AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland*
- ³⁹*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
- ⁴⁰*Physics Department, Southern Methodist University, Dallas Texas, USA*
- ⁴¹*Physics Department, University of Texas at Dallas, Richardson Texas, USA*
- ⁴²*DESY, Hamburg and Zeuthen, Germany*
- ⁴³*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
- ⁴⁴*Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany*
- ⁴⁵*Department of Physics, Duke University, Durham North Carolina, USA*
- ⁴⁶*SUPA-School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
- ⁴⁷*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
- ⁴⁸*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany*
- ⁴⁹*Section de Physique, Université de Genève, Geneva, Switzerland*
- ^{50a}*INFN Sezione di Genova, Italy*
- ^{50b}*Dipartimento di Fisica, Università di Genova, Genova, Italy*
- ^{51a}*E. Andronikashvili Institute of Physics, Tbilisi State University, Tbilisi, Georgia*
- ^{51b}*High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia*
- ⁵²*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
- ⁵³*SUPA-School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
- ⁵⁴*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
- ⁵⁵*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
- ⁵⁶*Department of Physics, Hampton University, Hampton Virginia, USA*
- ⁵⁷*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge Massachusetts, USA*
- ^{58a}*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58b}*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
- ^{58c}*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
- ⁵⁹*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
- ⁶⁰*Department of Physics, Indiana University, Bloomington Indiana, USA*
- ⁶¹*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
- ⁶²*University of Iowa, Iowa City Iowa, USA*
- ⁶³*Department of Physics and Astronomy, Iowa State University, Ames Iowa, USA*
- ⁶⁴*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia, USA*
- ⁶⁵*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
- ⁶⁶*Graduate School of Science, Kobe University, Kobe, Japan*
- ⁶⁷*Faculty of Science, Kyoto University, Kyoto, Japan*
- ⁶⁸*Kyoto University of Education, Kyoto, Japan*
- ⁶⁹*Department of Physics, Kyushu University, Fukuoka, Japan*
- ⁷⁰*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
- ⁷¹*Physics Department, Lancaster University, Lancaster, United Kingdom*

- ^{72a}INFN Sezione di Lecce, Italy
- ^{72b}Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
- ⁷³Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
- ⁷⁴Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
- ⁷⁵School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
- ⁷⁶Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
- ⁷⁷Department of Physics and Astronomy, University College London, London, United Kingdom
- ⁷⁸Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
- ⁷⁹Fysiska institutionen, Lunds universitet, Lund, Sweden
- ⁸⁰Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain
- ⁸¹Institut für Physik, Universität Mainz, Mainz, Germany
- ⁸²School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
- ⁸³CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
- ⁸⁴Department of Physics, University of Massachusetts, Amherst Massachusetts, USA
- ⁸⁵Department of Physics, McGill University, Montreal Quebec, Canada
- ⁸⁶School of Physics, University of Melbourne, Victoria, Australia
- ⁸⁷Department of Physics, The University of Michigan, Ann Arbor Michigan, USA
- ⁸⁸Department of Physics and Astronomy, Michigan State University, East Lansing Michigan, USA
- ^{89a}INFN Sezione di Milano, Italy
- ^{89b}Dipartimento di Fisica, Università di Milano, Milano, Italy
- ⁹⁰B. I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
- ⁹¹National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Republic of Belarus
- ⁹²Department of Physics, Massachusetts Institute of Technology, Cambridge Massachusetts, USA
- ⁹³Group of Particle Physics, University of Montreal, Montreal Quebec, Canada
- ⁹⁴P. N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
- ⁹⁵Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
- ⁹⁶Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
- ⁹⁷Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
- ⁹⁸Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
- ⁹⁹Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
- ¹⁰⁰Nagasaki Institute of Applied Science, Nagasaki, Japan
- ¹⁰¹Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan
- ^{102a}INFN Sezione di Napoli, Italy
- ^{102b}Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy
- ¹⁰³Department of Physics and Astronomy, University of New Mexico, Albuquerque New Mexico, USA
- ¹⁰⁴Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
- ¹⁰⁵Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
- ¹⁰⁶Department of Physics, Northern Illinois University, DeKalb Illinois, USA
- ¹⁰⁷Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia
- ¹⁰⁸Department of Physics, New York University, New York New York, USA
- ¹⁰⁹Ohio State University, Columbus Ohio, USA
- ¹¹⁰Faculty of Science, Okayama University, Okayama, Japan
- ¹¹¹Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman Oklahoma, USA
- ¹¹²Department of Physics, Oklahoma State University, Stillwater Oklahoma, USA
- ¹¹³Palacký University, RCPTM, Olomouc, Czech Republic
- ¹¹⁴Center for High Energy Physics, University of Oregon, Eugene Oregon, USA
- ¹¹⁵LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France
- ¹¹⁶Graduate School of Science, Osaka University, Osaka, Japan
- ¹¹⁷Department of Physics, University of Oslo, Oslo, Norway
- ¹¹⁸Department of Physics, Oxford University, Oxford, United Kingdom
- ^{119a}INFN Sezione di Pavia, Italy
- ^{119b}Dipartimento di Fisica, Università di Pavia, Pavia, Italy
- ¹²⁰Department of Physics, University of Pennsylvania, Philadelphia Pennsylvania, USA
- ¹²¹Petersburg Nuclear Physics Institute, Gatchina, Russia
- ^{122a}INFN Sezione di Pisa, Italy
- ^{122b}Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
- ¹²³Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh Pennsylvania, USA
- ^{124a}Laboratorio de Instrumentacao e Fisica Experimental de Particulas-LIP, Lisboa, Portugal
- ^{124b}Departamento de Física Teórica y del Cosmos and CAFPE, Universidad de Granada, Granada, Spain
- ¹²⁵Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
- ¹²⁶Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic

- ¹²⁷*Czech Technical University in Prague, Praha, Czech Republic*
- ¹²⁸*State Research Center Institute for High Energy Physics, Protvino, Russia*
- ¹²⁹*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ¹³⁰*Physics Department, University of Regina, Regina Saskatchewan, Canada*
- ¹³¹*Ritsumeikan University, Kusatsu, Shiga, Japan*
- ^{132a}*INFN Sezione di Roma I, Italy*
- ^{132b}*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
- ^{133a}*INFN Sezione di Roma Tor Vergata, Italy*
- ^{133b}*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
- ^{134a}*INFN Sezione di Roma Tre, Italy*
- ^{134b}*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
- ^{135a}*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies-Université Hassan II, Casablanca, Morocco*
- ^{135b}*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
- ^{135c}*Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech, Morocco*
- ^{135d}*Faculté des Sciences, Université Mohamed Premier and LTPM, Oujda, Morocco*
- ^{135e}*Faculté des sciences, Université Mohammed V-Agdal, Rabat, Morocco*
- ¹³⁶*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France*
- ¹³⁷*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz California, USA*
- ¹³⁸*Department of Physics, University of Washington, Seattle Washington, USA*
- ¹³⁹*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
- ¹⁴⁰*Department of Physics, Shinshu University, Nagano, Japan*
- ¹⁴¹*Fachbereich Physik, Universität Siegen, Siegen, Germany*
- ¹⁴²*Department of Physics, Simon Fraser University, Burnaby British Columbia, Canada*
- ¹⁴³*SLAC National Accelerator Laboratory, Stanford California, USA*
- ^{144a}*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
- ^{144b}*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
- ^{145a}*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
- ^{145b}*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
- ^{146a}*Department of Physics, Stockholm University, Sweden*
- ^{146b}*The Oskar Klein Centre, Stockholm, Sweden*
- ¹⁴⁷*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
- ¹⁴⁸*Departments of Physics and Astronomy and Chemistry, Stony Brook University, Stony Brook New York, USA*
- ¹⁴⁹*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
- ¹⁵⁰*School of Physics, University of Sydney, Sydney, Australia*
- ¹⁵¹*Institute of Physics, Academia Sinica, Taipei, Taiwan*
- ¹⁵²*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
- ¹⁵³*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
- ¹⁵⁴*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
- ¹⁵⁵*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
- ¹⁵⁶*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
- ¹⁵⁷*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
- ¹⁵⁸*Department of Physics, University of Toronto, Toronto Ontario, Canada*
- ^{159a}*TRIUMF, Vancouver British Columbia, Canada*
- ^{159b}*Department of Physics and Astronomy, York University, Toronto Ontario, Canada*
- ¹⁶⁰*Institute of Pure and Applied Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571, Japan*
- ¹⁶¹*Science and Technology Center, Tufts University, Medford Massachusetts, USA*
- ¹⁶²*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
- ¹⁶³*Department of Physics and Astronomy, University of California Irvine, Irvine California, USA*
- ^{164a}*INFN Gruppo Collegato di Udine, Italy*
- ^{164b}*ICTP, Trieste, Italy*
- ^{164c}*Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*
- ¹⁶⁵*Department of Physics, University of Illinois, Urbana Illinois, USA*
- ¹⁶⁶*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
- ¹⁶⁷*Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
- ¹⁶⁸*Department of Physics, University of British Columbia, Vancouver British Columbia, Canada*
- ¹⁶⁹*Department of Physics and Astronomy, University of Victoria, Victoria British Columbia, Canada*
- ¹⁷⁰*Department of Physics, University of Warwick, Coventry, United Kingdom*
- ¹⁷¹*Waseda University, Tokyo, Japan*

¹⁷²*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*¹⁷³*Department of Physics, University of Wisconsin, Madison Wisconsin, USA*¹⁷⁴*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*¹⁷⁵*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*¹⁷⁶*Department of Physics, Yale University, New Haven Connecticut, USA*¹⁷⁷*Yerevan Physics Institute, Yerevan, Armenia*¹⁷⁸*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 Department of Physics, UASLP, San Luis Potosi, Mexico.^kAlso at Università di Napoli Parthenope, Napoli, Italy.^lAlso at Institute of Particle Physics (IPP), Canada.^mAlso at Department of Physics, Middle East Technical University, Ankara, Turkey.ⁿAlso at Louisiana Tech University, Ruston LA, USA.^oAlso at Dep Física and CEFITEC of Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal.^pAlso at Department of Physics and Astronomy, University College London, London, United Kingdom.^qAlso at Group of Particle Physics, University of Montreal, Montreal QC, Canada.^rAlso at Department of Physics, University of Cape Town, Cape Town, South Africa.^sAlso at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.^tAlso at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.^uAlso at Manhattan College, New York NY, USA.^vAlso at School of Physics, Shandong University, Shandong, China.^wAlso at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.^xAlso at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.^yAlso at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.^zAlso at Dipartimento di Fisica, Università La Sapienza, Roma, Italy.^{aa}Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Énergie Atomique), Gif-sur-Yvette, France.^{bb}Also at Section de Physique, Université de Genève, Geneva, Switzerland.^{cc}Also at Departamento de Física, Universidade de Minho, Braga, Portugal.^{dd}Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, USA.^{ee}Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.^{ff}Also at California Institute of Technology, Pasadena CA, USA.^{gg}Also at Institute of Physics, Jagiellonian University, Krakow, Poland.^{hh}Also at LAL, Université Paris-Sud and CNRS/IN2P3, Orsay, France.ⁱⁱAlso at Nevis Laboratory, Columbia University, Irvington NY, USA.^{jj}Also at Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom.^{kk}Also at Department of Physics, Oxford University, Oxford, United Kingdom.^{ll}Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.^{mm}Also at Department of Physics, The University of Michigan, Ann Arbor MI, USAⁿⁿAlso at Discipline of Physics, University of KwaZulu-Natal, Durban, South Africa.