Search for Dilepton Resonances in pp Collisions at $\sqrt{s} = 7$ TeV with the ATLAS Detector

G. Aad *et al.**
(ATLAS Collaboration)

(Received 7 August 2011; published 29 December 2011)

This Letter reports on a search for narrow high-mass resonances decaying into dilepton final states. The data were recorded by the ATLAS experiment in pp collisions at $\sqrt{s} = 7$ TeV at the Large Hadron Collider and correspond to a total integrated luminosity of 1.08 (1.21) fb^{-1} in the e^+e^- ($\mu^+\mu^-$) channel. No statistically significant excess above the standard model expectation is observed and upper limits are set at the 95% C.L. on the cross section times branching fraction of Z' resonances and Randall-Sundrum gravitons decaying into dileptons as a function of the resonance mass. A lower mass limit of 1.83 TeV on the sequential standard model Z' boson is set. A Randall-Sundrum graviton with coupling $k/\bar{M}_{\mathrm{Pl}} = 0.1$ is excluded at 95% C.L. for masses below 1.63 TeV.

DOI: 10.1103/PhysRevLett.107.272002 PACS numbers: 13.85.Rm, 12.60.Cn, 14.70.Pw

This Letter describes a search for narrow high-mass resonances decaying into e^+e^- or $\mu^+\mu^-$ pairs using 7 TeV pp collision data recorded with the ATLAS detector [1]. Such resonances, which are predicted by several extensions of the standard model (SM), include new heavy spin-1 neutral gauge bosons such as Z' [2–4] and Z^* [5], technimesons [6–8], as well as spin-2 Randall-Sundrum (RS) gravitons G^* [9].

The benchmark models considered for the Z' are the sequential standard model (SSM) [2], with the same couplings to fermions as the Z boson, and the E_6 grand unified symmetry group [4], broken into $SU(5)$ and two additional $U(1)$ groups, leading to new neutral gauge fields ψ and χ. The particles associated with the additional fields can mix in a linear combination to form the Z' candidate: $Z'(\theta_{E_6}) = Z'_\psi \cos\theta_{E_6} + Z'_\chi \sin\theta_{E_6}$, where θ_{E_6} is the mixing angle between the two gauge bosons. The pattern of spontaneous symmetry breaking and the value of θ_{E_6} determine the Z' couplings to fermions; six well-motivated choices of θ_{E_6} [2,4] lead to the specific Z' states named Z'_ψ, Z'_N, Z'_η, Z'_I, Z'_S, and Z'_χ.

Other models predict additional spatial dimensions as a possible explanation for the gap between the electroweak symmetry breaking scale and the gravitational energy scale. The RS model [9] predicts excited Kaluza-Klein modes of the graviton, which appear as spin-2 resonances. These modes have a narrow intrinsic width when $k/\bar{M}_{\mathrm{Pl}} < 0.1$, where k is the spacetime curvature in the extra dimension and $\bar{M}_{\mathrm{Pl}} = M_{\mathrm{Pl}}/\sqrt{8\pi}$ is the reduced Planck scale.

Previous searches have set direct and indirect constraints on the mass of the G^* and Z' resonances [10,11]. The Tevatron [12,13] experiments exclude a Z'_{SSM} with a mass lower than 1.071 TeV [13]. Recent measurements from the LHC experiments, based on ≈ 40 pb^{-1} of data recorded in 2010, exclude a Z'_{SSM} with a mass lower than 1.042 TeV (ATLAS) [14] and 1.140 TeV (CMS) [15]. Indirect constraints from LEP [16–19] extend these limits to 1.787 TeV [11]. Constraints on the mass of the RS graviton have been set by the CMS [15], CDF [20], and D0 [21] Collaborations, excluding RS gravitons with mass below 1.079 TeV for $k/\bar{M}_{\mathrm{Pl}} = 0.1$ [15].

The ATLAS detector consists of inner tracking devices surrounded by a 2 T superconducting solenoid, electromagnetic and hadronic calorimeters, and a muon spectrometer with a toroidal magnetic field. Charged particles in the pseudorapidity range $|\eta| < 2.5$ [22] are reconstructed with the inner detector, which consists of silicon pixel, silicon strip, and transition radiation detectors. The superconducting solenoid is surrounded by a hermetic calorimeter that covers $|\eta| < 4.9$. For $|\eta| < 2.5$, the electromagnetic calorimeter is finely segmented and plays an important role in electron identification. Outside the calorimeter, air-core toroids provide the magnetic field for the muon spectrometer. Three sets of precision drift tubes and cathode strip chambers provide an accurate measurement of the muon track curvature in the region $|\eta| < 2.7$. Resistive-plate and thin-gap chambers provide muon triggering capability up to $|\eta| < 2.4$.

The data sample used in this analysis, recorded during the first half of 2011, corresponds to a total integrated luminosity of 1.08 (1.21) fb^{-1} in the e^+e^- ($\mu^+\mu^-$) channel. Events are required to pass single electron (muon) triggers with a transverse energy E_T (transverse momentum p_T) threshold above 20 (22) GeV. Collision candidates are selected by requiring a primary vertex with at least three associated charged particle tracks with $p_T > 0.4$ GeV.

In the e^+e^- channel, two electron candidates are required with transverse energy $E_T > 25$ GeV and $|\eta| < 2.47$; the transition region $1.37 \leq |\eta| \leq 1.52$

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

between the barrel and the end cap calorimeters is excluded. Electron candidates are formed from clusters of cells reconstructed in the electromagnetic calorimeter associated with a charged particle track in the inner detector. Criteria on the transverse shower shape, the longitudinal leakage into the hadronic calorimeter, and the association with an inner detector track are applied to the cluster to define a so-called *medium* electron [23,24]. The electron energy is obtained from the calorimeter measurement and its direction from the associated track. A hit in the first active pixel layer is required to suppress background from photon conversions. To further suppress background from QCD jet production, the higher E_T electron is required to be isolated by demanding that $\Sigma E_T(\Delta R < 0.2) < 7$ GeV, where $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ and $\Sigma E_T(\Delta R < 0.2)$ is the sum of the transverse energies around the electron direction. The core of the electron energy deposition is excluded and the sum is corrected for transverse shower leakage and pileup from additional pp collisions. The two electron candidates are not required to have opposite charge to minimize the impact of possible charge misidentification. For these selection criteria, the total signal acceptance for a $Z' \rightarrow e^+e^-$ ($G^* \rightarrow e^+e^-$) of mass 1.5 TeV is 65% (69%), and is approximately independent of mass above 600 GeV. These numbers include the acceptance of all selection cuts and efficiencies and reflect the lepton angular distributions due to spin.

In the $\mu^+\mu^-$ channel, two muon candidates of opposite charge are required, each satisfying $p_T > 25$ GeV. Muon tracks are reconstructed independently in both the inner detector and muon spectrometer, and their momenta are determined from a combined fit to these two measurements. To optimize the momentum resolution, each muon candidate is required to pass quality cuts in the inner detector and to have at least three hits in each of the inner, middle, and outer layers of the muon system. Muons with hits in both the barrel and the end cap regions are discarded because of residual misalignment between these two parts of the muon spectrometer. The effects of misalignments and intrinsic position resolution are included in the simulation. The p_T resolution at 1 TeV ranges from 15% (central) to 44% (for $|\eta| > 2$).

To suppress background from cosmic rays, the muon tracks are required to have a transverse impact parameter $|d_0| < 0.2$ mm, a distance along the beam line to the primary vertex below 1 mm, and the z position of the primary vertex $|z(\mathrm{PV})| < 200$ mm. To reduce background from QCD jets, each muon is required to be isolated such that $\Sigma p_T(\Delta R < 0.3)/p_T(\mu) < 0.05$, where only tracks with $p_T > 1$ GeV enter the sum. The total signal acceptance is 40% (44%) for a $Z' \rightarrow \mu^+\mu^-$ ($G^* \rightarrow \mu^+\mu^-$) of mass 1.5 TeV. The lower acceptance compared to the electron channel is due to the stringent requirements on the muon selection criteria to improve p_T resolution.

For both channels, the dominant and irreducible background is due to the Z/γ^* (Drell-Yan) process, characterized by the same final state as the signal. Small contributions from $t\bar{t}$ and diboson (WW, WZ, and ZZ) production are also present in both channels. Semileptonic decays of b and c quarks in the $\mu^+\mu^-$ sample and a mixture of photon conversions, semileptonic heavy quark decays, and hadrons faking electrons in the e^+e^- sample are backgrounds that are referred to below as QCD background. Jets accompanying W bosons (W + jets) may similarly produce lepton candidates.

The expected signal and backgrounds, with the exception of the QCD component, are evaluated with simulated samples and rescaled using the most precise available cross section predictions. The Z', G^* signal, and Z/γ^* processes are generated with PYTHIA 6.421 [25] using MRST2007 LO* [26] parton distribution functions (PDFs). Interference between the Z/γ^* processes and the heavy resonances is small and therefore neglected. The diboson processes are generated with HERWIG 6.510 [27] using MRST2007 LO* PDFs. The W + jets background is generated with ALPGEN [28] using CTEQ6L1 [29] PDFs and the $t\bar{t}$ background with MC@NLO 3.41 [30] using CTEQ66 [31]

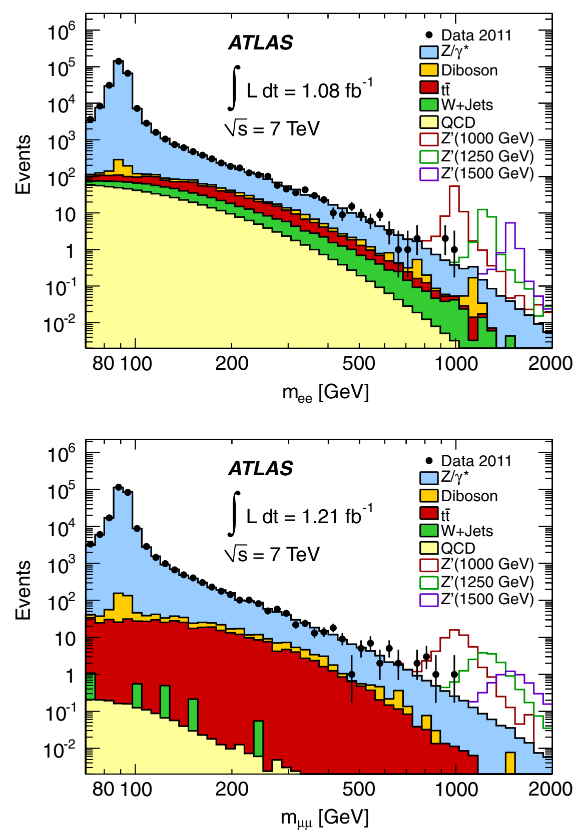

FIG. 1 (color online). Dielectron (top) and dimuon (bottom) invariant mass ($m_{\ell\ell}$) distribution after final selection, compared to the stacked sum of all expected backgrounds, with three example Z'_{SSM} signals overlaid. The bin width is constant in $\log m_{\ell\ell}$.

TABLE I. Expected and observed number of events in the dielectron (top) and dimuon (bottom) channels. The first bin is used to normalize the total background to the data. The errors quoted include both statistical and systematic uncertainties, except the error on the total background in the normalization region which is given by the square root of the number of observed events. The systematic uncertainties are correlated across bins and are discussed in the text.

$m_{e^+e^-}$ [GeV]	70–110	110–200	200–400	400–800	800–3000
Drell-Yan	258 482 ± 410	5449 ± 180	613 ± 26	53.8 ± 3.1	2.8 ± 0.1
$t\bar{t}$	218 ± 36	253 ± 10	82 ± 3	5.4 ± 0.3	0.1 ± 0.0
Diboson	368 ± 19	85 ± 5	29 ± 2	3.1 ± 0.5	0.3 ± 0.1
W + jets	150 ± 100	150 ± 26	43 ± 10	4.6 ± 1.8	0.2 ± 0.4
QCD	332 ± 59	191 ± 75	36 ± 29	1.8 ± 1.4	<0.05
Total	259 550 ± 510	6128 ± 200	803 ± 40	68.8 ± 3.9	3.4 ± 0.4
Data	259 550	6117	808	65	3
$m_{\mu^+\mu^-}$ [GeV]	70–110	110–200	200–400	400–800	800–3000
Drell-Yan	236 319 ± 320	5171 ± 150	483 ± 22	40.3 ± 2.5	2.0 ± 0.3
$t\bar{t}$	193 ± 21	193 ± 20	63 ± 6	4.2 ± 0.4	0.1 ± 0.0
Diboson	307 ± 16	69 ± 5	25 ± 2	1.7 ± 0.5	<0.05
W + jets	1 ± 1	1 ± 1	<0.5	<0.05	<0.05
QCD	1 ± 1	<0.5	<0.5	<0.05	<0.05
Total	236821 ± 487	5434 ± 150	571 ± 23	46.1 ± 2.6	2.1 ± 0.3
Data	236 821	5406	557	51	5

PDFs. For both, JIMMY 4.31 [32] is used to describe multiple parton interactions and HERWIG to describe the remaining underlying event and parton showers. Final-state photon radiation is handled with PHOTOS [33]. The samples are processed through a full ATLAS detector simulation [34] based on GEANT4 [35].

The Z/γ^* cross section is calculated at next-to-next-to-leading order (NNLO) using PHOZPR [36] with MSTW2008 PDFs [37]. The ratio of this cross section to the leading-order cross section is used to determine a mass-dependent QCD K factor which is applied to the results of the leading-order simulations. The same QCD K factor is applied to the Z' signal. No QCD K factor is available for G^* production at 7 TeV [38,39]. Higher-order weak corrections (beyond the photon radiation included in the simulation) are calculated using HORACE [40,41], yielding a weak K factor due to virtual heavy gauge boson loops. The weak K factor is only applied to the Drell-Yan background. The diboson cross sections are calculated to next-to-leading order (NLO) using MCFM [42] with an uncertainty of 5%. The W + jets cross section is rescaled to the inclusive NNLO calculation of FEWZ [43], resulting in 30% uncertainty when at least one parton with $E_T > 20$ GeV accompanies the W boson. The $t\bar{t}$ cross section is predicted at approximate NNLO, with 10% uncertainty [44,45].

The QCD background in the e^+e^- sample is estimated with data using "reversed electron identification" and "isolation fit" techniques [14], and a third method that uses fake rates measured from inclusive jet samples. In the reversed electron identification technique, data with both electron candidates failing some identification criteria (chosen not to affect kinematic distributions) are used to determine the QCD background distribution versus m_{ee}. This method is used for the central estimate and the others which bracket it, to assign a systematic uncertainty. The QCD background in the $\mu^+\mu^-$ sample is evaluated from data using the muon isolation variable $\Sigma p_T(\Delta R < 0.3)/p_T$ [14]. The QCD and W + jets backgrounds are small (negligible) for the electron (muon) channel. Backgrounds from cosmic rays are negligible.

The observed invariant mass distributions are compared to the SM expectation. For this purpose, the Drell-Yan, $t\bar{t}$,

TABLE II. Summary of the dominant systematic uncertainties on the expected signal and background yields at $m_{\ell^+\ell^-} = 1.5$ TeV for the Z' (G^*) analysis.

Source	Dielectrons		Dimuons	
	Signal	Background	Signal	Background
Normalization	5%	Not applicable	5%	Not applicable
PDFs/α_S	Not applicable	10%	Not applicable	10%
QCD K factor	Not applicable	3%	Not applicable	3%
Weak K factor	Not applicable	4.5%	Not applicable	4.5%
Trigger/reconstruction	Negligible	Negligible	4.5%	4.5%
Total	5%	11%	7%	12%

diboson and W + jets backgrounds from Monte Carlo simulation are scaled according to their respective cross sections and added to the QCD background. The simulated backgrounds are then rescaled so that the sum matches the observed number of data events in the 70–110 GeV mass interval. The scaling factor is within 1% of unity. The advantage of this approach is that the uncertainty on the luminosity, and any mass independent uncertainties on efficiencies, cancel between the Z' (G^*) and the Z boson.

Figure 1 presents the invariant mass ($m_{\ell\ell}$) distribution for the dielectron (top) and dimuon (bottom) final states after final selection, while Table I shows the number of data events and the estimated backgrounds in bins of reconstructed $m_{\ell\ell}$. The dilepton invariant mass distributions are well described by the prediction from SM processes. Figure 1 also displays the expected $Z'_{\rm SSM}$ signal for three mass hypotheses.

The invariant mass distribution of the data is compared to the backgrounds and signal templates with pole masses in the 0.13–2.0 TeV range [14,46]. A likelihood function is defined as the product of the Poisson probabilities over all mass bins in the search region. The Poisson probability in each bin is evaluated for the observed number of data events given the background and signal template expectation. The total signal acceptance as a function of mass is propagated into the expectation.

The significance of a signal is summarized by a p value, the probability of observing an excess at least as signal-like as the one observed in data, in the absence of signal. The outcome of the search is ranked using a likelihood ratio, which is scanned as a function of Z' cross section and $m_{Z'}$ over the full considered mass range. The data are consistent with the SM hypothesis, with p values of 54% and 24% for the e^+e^- and $\mu^+\mu^-$ channels, respectively.

Given the absence of a signal, an upper limit on the signal cross section is determined at the 95% C.L. using a Bayesian approach [47] with a flat, positive prior on the signal cross section.

Mass-dependent systematic uncertainties are incorporated as nuisance parameters which are integrated out [47]. They include normalization to the Z peak, PDF, QCD, and weak K factors, as well as trigger, reconstruction, and identification efficiencies. These uncertainties are correlated across all bins in the search region and they are correlated between signal and background.

Since the total background is normalized to the data in the region of the $Z \rightarrow \ell^+\ell^-$ mass peak, the residual systematic uncertainties are small at the Z pole and grow at higher mass. The dominant uncertainties are theoretical. The overall uncertainty due to PDF and α_S variations is estimated to be 10% at 1.5 TeV using the MSTW 2008 eigenvector PDF sets and other PDF sets corresponding to variations of α_S. The difference with respect to CTEQ is included as an additional 3% uncertainty. The uncertainty on the QCD K factor is 3%, evaluated from variations of the renormalization and factorization scales by factors of two around the nominal values. A systematic uncertainty of 4.5% is attributed to electroweak corrections [14]. The uncertainty on the Z/γ^* cross section is 5%, which is applied as a systematic uncertainty on the normalization.

Experimental systematic effects due to resolution and inefficiencies at high mass were studied. In the electron channel, the calorimeter energy resolution is dominated at large E_T by a constant term which is 1.2% in the barrel and 1.8% in the end caps, with negligible uncertainty. The uncertainty on the resolution in the muon channel is due to residual misalignments and intrinsic position uncertainties in the muon spectrometer that propagate to a change in

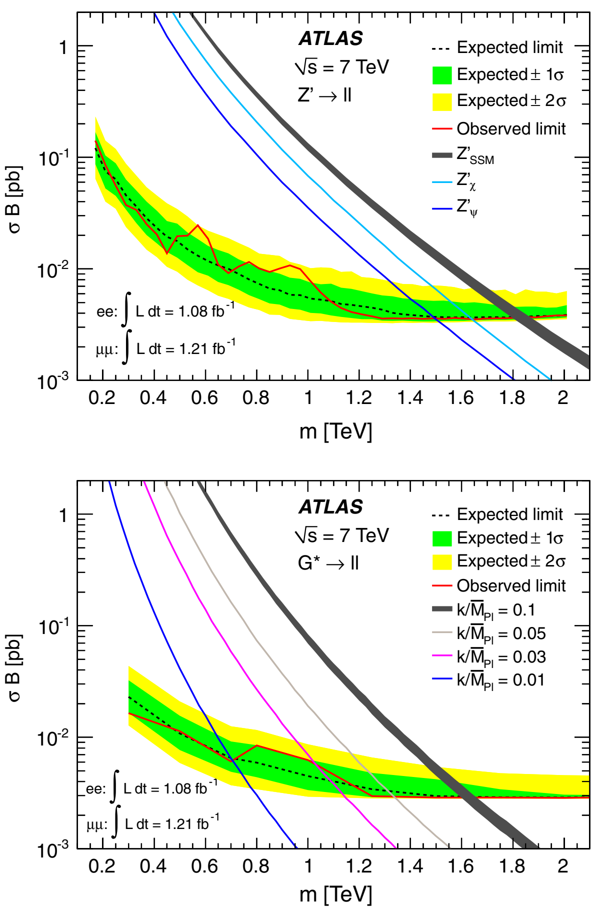

FIG. 2 (color online). Expected and observed 95% C.L. upper limits on σB as a function of mass for Z' (top) and G^* (bottom) models. Both results show the combination of the electron and muon channels. The thickness of the $Z'_{\rm SSM}$ (top) and the G^* for $k/\bar{M}_{\rm Pl} = 0.1$ (bottom) theory curves illustrate the theoretical uncertainties.

TABLE III. Observed (expected) 95% C.L. mass lower limits in TeV on $Z'_{\rm SSM}$ resonance and G^* graviton (with $k/\bar{M}_{\rm Pl} = 0.1$).

Model	e^+e^-	$\mu^+\mu^-$	$\ell^+\ell^-$
$Z'_{\rm SSM}$	1.70 (1.70)	1.61 (1.61)	1.83 (1.83)
G^*	1.51 (1.50)	1.45 (1.44)	1.63 (1.63)

TABLE IV. 95% C.L. lower limits on the masses of E_6-motivated Z' bosons and RS gravitons G^* for various values of the coupling $k/\bar{M}_{\rm Pl}$. Both lepton channels are combined.

	E_6 Z' models						RS graviton			
Model/coupling	Z'_ψ	Z'_N	Z'_η	Z'_I	Z'_S	Z'_χ	0.01	0.03	0.05	0.1
Mass limit [TeV]	1.49	1.52	1.54	1.56	1.60	1.64	0.71	1.03	1.33	1.63

the observed width of the Z' (G^*) line shape. The simulation was adjusted to reproduce the data at high muon momentum. The residual uncertainty translates into an event yield uncertainty of less than 1.5%. The combined uncertainty on the muon trigger and reconstruction efficiency is estimated to be 4.5% at 1.5 TeV. This uncertainty is dominated by a conservative estimate of the impact of large energy loss from muon bremsstrahlung in the calorimeter on the muon reconstruction performance in the muon spectrometer. In the electron channel, a systematic uncertainty of 1.5% at 1.5 TeV is estimated for a possible identification inefficiency caused by the isolation requirement.

The dominant systematic uncertainties are summarized in Table II. Uncertainties below 3% are neglected, and no theory uncertainties are applied to the Z' or G^* signal in the limit setting procedure described below.

The limit on the number of produced Z' (G^*) events is converted into a limit on cross section times branching fraction σB by scaling with the observed number of Z boson events and the theoretical value of $\sigma B(Z \to ll)$. The expected exclusion limits are determined using simulated pseudoexperiments containing only standard model processes, by evaluating the 95% C.L. upper limits for each pseudoexperiment for each fixed value of $m_{Z'}$ (m_{G^*}). The median of the distribution of limits represents the expected limit. The ensemble of limits is used to find the 68% and 95% envelopes of the expected limits as a function of $m_{Z'}$ (m_{G^*}). Figure 2 (top) shows the combined dielectron and dimuon 95% C.L. observed and expected exclusion limits on $\sigma B(Z' \to ll)$. It also shows the theoretical cross section times branching fraction for the $Z'_{\rm SSM}$ and for E_6-motivated Z' models with the lowest and highest σB. Figure 2 (bottom) shows the corresponding limits on the RS graviton. Mass limits obtained for the $Z'_{\rm SSM}$ and G^* (with $k/\bar{M}_{\rm Pl} = 0.1$) are displayed in Table III. The combined mass limits on the E_6-motivated models and the G^* with various couplings are given in Table IV.

In conclusion, the ATLAS detector has been used to search for narrow, heavy resonances in the dilepton invariant mass spectrum above the Z boson pole. Proton-proton collision data with 1.08 (1.21) fb^{-1} in the e^+e^- ($\mu^+\mu^-$) channel have been used. The observed invariant mass spectra are consistent with the SM expectations. Limits are set on the cross section times branching fraction σB. The resulting mass limits are 1.83 TeV for the sequential standard model Z' boson, 1.49–1.64 TeV for various E_6-motivated Z' bosons, and 0.71–1.63 TeV for a Randall-Sundrum graviton with couplings ($k/\bar{M}_{\rm Pl}$) in the range 0.01–0.1. The Z' boson limits are the most stringent to date, including indirect limits set by LEP2.

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

[1] G. Aad *et al.* (ATLAS Collaboration), JINST **3**, S08003 (2008).
[2] P. Langacker, Rev. Mod. Phys. **81**, 1199 (2009).
[3] J. Erler, P. Langacker, S. Munir, and E. R. Pena, J. High Energy Phys. 08 (2009) 017.
[4] D. London and J. L. Rosner, Phys. Rev. D **34**, 1530 (1986).
[5] M. Chizhov, V. Bednyakov, and J. Budagov, Phys. At. Nucl. **71**, 2096 (2008).
[6] K. D. Lane and E. Eichten, Phys. Lett. B **222**, 274 (1989).
[7] K. D. Lane and S. Mrenna, Phys. Rev. D **67**, 115011 (2003).

[8] A. Belyaev *et al.*, Phys. Rev. D **79**, 035006 (2009).
[9] L. Randall and R. Sundrum, Phys. Rev. Lett. **83**, 3370 (1999).
[10] C. Hays, A. V. Kotwal, and O. Stelzer-Chilton, Mod. Phys. Lett. A **24**, 2387 (2009), and references therein.
[11] P. Langacker, arXiv:0911.4294.
[12] V. M. Abazov *et al.* (D0 Collaboration), Phys. Lett. B **695**, 88 (2011).
[13] T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. Lett. **106**, 121801 (2011).
[14] G. Aad *et al.* (ATLAS Collaboration), Phys. Lett. B **700**, 163 (2011).
[15] S. Chatrchyan *et al.* (CMS Collaboration), J. High Energy Phys. 05 (2011) 093.
[16] G. Abbiendi *et al.* (OPAL Collaboration), Eur. Phys. J. C **33**, 173 (2004).
[17] J. Abdallah *et al.* (DELPHI Collaboration), Eur. Phys. J. C **45**, 589 (2006).
[18] P. Achard *et al.* (L3 Collaboration), Eur. Phys. J. C **47**, 1 (2006).
[19] S. Schael *et al.* (ALEPH Collaboration), Eur. Phys. J. C **49**, 411 (2006).
[20] T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. Lett. **107**, 051801 (2011).
[21] V. M. Abazov *et al.* (D0 Collaboration), Phys. Rev. Lett. **104**, 241802 (2010).
[22] ATLAS uses a right-handed coordinate system with the z axis along the beam pipe. The x axis points to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.
[23] ATLAS Collaboration, Report No. ATLAS-CONF-2010-005, 2010 [https://cdsweb.cern.ch/record/1273197].
[24] G. Aad *et al.* (ATLAS Collaboration), J. High Energy Phys. 12 (2010) 060.
[25] T. Sjöstrand, S. Mrenna, and P. Z. Skands, J. High Energy Phys. 05 (2006) 026.
[26] A. Sherstnev and R. S. Thorne, Eur. Phys. J. C **55**, 553 (2008).
[27] G. Corcella *et al.*, J. High Energy Phys. 01 (2001) 010.
[28] M. L. Mangano *et al.*, J. High Energy Phys. 07 (2003) 001.
[29] J. Pumplin *et al.*, J. High Energy Phys. 07 (2002) 012.
[30] S. Frixione and B. Webber, J. High Energy Phys. 06 (2002) 029.
[31] P. M. Nadolsky *et al.*, Phys. Rev. D **78**, 013004 (2008).
[32] J. M. Butterworth, J. R. Forshaw, and M. H. Seymour, Z. Phys. C **72**, 637 (1996).
[33] P. Golonka and Z. Wąs, Eur. Phys. J. C **45**, 97 (2006).
[34] G. Aad *et al.* (ATLAS Collaboration), Eur. Phys. J. C **70**, 823 (2010).
[35] S. Agostinelli *et al.* (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[36] R. Hamberg, W. L. van Neerven, and T. Matsuura, Nucl. Phys. **B359**, 343 (1991); **B644**, 403 (2002).
[37] A. Martin, W. Stirling, R. Thorne, and G. Watt, Eur. Phys. J. C **63**, 189 (2009).
[38] M. C. Kumar, P. Mathews, V. Ravindran, and A. Tripathi, Nucl. Phys. **B818**, 28 (2009).
[39] M. C. Kumar, P. Mathews, and V. Ravindran, Eur. Phys. J. C **49**, 599 (2006).
[40] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and A. Vicini, J. High Energy Phys. 12 (2006) 016.
[41] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and A. Vicini, J. High Energy Phys. 10 (2007) 109.
[42] J. M. Campbell and R. K. Ellis, Phys. Rev. D **60**, 113006 (1999).
[43] K. Melnikov and F. Petriello, Phys. Rev. D **74**, 114017 (2006).
[44] S. Moch and P. Uwer, Phys. Rev. D **78**, 034003 (2008).
[45] U. Langenfeld, S. Moch, and P. Uwer, arXiv:0907.2527.
[46] T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. Lett. **102**, 091805 (2009).
[47] A. Caldwell, D. Kollar, and K. Kröninger, Comput. Phys. Commun. **180**, 2197 (2009).

G. Aad,[47] B. Abbott,[110] J. Abdallah,[11] A. A. Abdelalim,[48] A. Abdesselam,[117] O. Abdinov,[10] B. Abi,[111] M. Abolins,[87] H. Abramowicz,[152] H. Abreu,[114] E. Acerbi,[88a,88b] B. S. Acharya,[163a,163b] D. L. Adams,[24] T. N. Addy,[55] J. Adelman,[174] M. Aderholz,[98] S. Adomeit,[97] P. Adragna,[74] T. Adye,[128] S. Aefsky,[22] J. A. Aguilar-Saavedra,[123b,a] M. Aharrouche,[80] S. P. Ahlen,[21] F. Ahles,[47] A. Ahmad,[147] M. Ahsan,[40] G. Aielli,[132a,132b] T. Akdogan,[18a] T. P. A. Åkesson,[78] G. Akimoto,[154] A. V. Akimov,[93] A. Akiyama,[66] M. S. Alam,[1] M. A. Alam,[75] J. Albert,[168] S. Albrand,[54] M. Aleksa,[29] I. N. Aleksandrov,[64] F. Alessandria,[88a] C. Alexa,[25a] G. Alexander,[152] G. Alexandre,[48] T. Alexopoulos,[9] M. Alhroob,[20] M. Aliev,[15] G. Alimonti,[88a] J. Alison,[119] M. Aliyev,[10] P. P. Allport,[72] S. E. Allwood-Spiers,[52] J. Almond,[81] A. Aloisio,[101a,101b] R. Alon,[170] A. Alonso,[78] M. G. Alviggi,[101a,101b] K. Amako,[65] P. Amaral,[29] C. Amelung,[22] V. V. Ammosov,[127] A. Amorim,[123a,b] G. Amorós,[166] N. Amram,[152] C. Anastopoulos,[29] L. S. Ancu,[16] N. Andari,[114] T. Andeen,[34] C. F. Anders,[20] G. Anders,[57a] K. J. Anderson,[30] A. Andreazza,[88a,88b] V. Andrei,[57a] M-L. Andrieux,[54] X. S. Anduaga,[69] A. Angerami,[34] F. Anghinolfi,[29] N. Anjos,[123a] A. Annovi,[46] A. Antonaki,[8] M. Antonelli,[46] A. Antonov,[95] J. Antos,[143b] F. Anulli,[131a] S. Aoun,[82] L. Aperio Bella,[4] R. Apolle,[117,c] G. Arabidze,[87] I. Aracena,[142] Y. Arai,[65] A. T. H. Arce,[44] J. P. Archambault,[28] S. Arfaoui,[29,d] J-F. Arguin,[14] E. Arik,[18a,gg] M. Arik,[18a] A. J. Armbruster,[86] O. Arnaez,[80] C. Arnault,[114] A. Artamonov,[94] G. Artoni,[131a,131b] D. Arutinov,[20] S. Asai,[154] R. Asfandiyarov,[171] S. Ask,[27] B. Åsman,[145a,145b] L. Asquith,[5] K. Assamagan,[24] A. Astbury,[168] A. Astvatsatourov,[51] G. Atoian,[174] B. Aubert,[4] E. Auge,[114] K. Augsten,[126] M. Aurousseau,[144a] N. Austin,[72] G. Avolio,[162] R. Avramidou,[9] D. Axen,[167] C. Ay,[53] G. Azuelos,[92,e] Y. Azuma,[154]

M. A. Baak,[29] G. Baccaglioni,[88a] C. Bacci,[133a,133b] A. M. Bach,[14] H. Bachacou,[135] K. Bachas,[29] G. Bachy,[29] M. Backes,[48] M. Backhaus,[20] E. Badescu,[25a] P. Bagnaia,[131a,131b] S. Bahinipati,[2] Y. Bai,[32a] D. C. Bailey,[157] T. Bain,[157] J. T. Baines,[128] O. K. Baker,[174] M. D. Baker,[24] S. Baker,[76] E. Banas,[38] P. Banerjee,[92] Sw. Banerjee,[171] D. Banfi,[29] A. Bangert,[136] V. Bansal,[168] H. S. Bansil,[17] L. Barak,[170] S. P. Baranov,[93] A. Barashkou,[64] A. Barbaro Galtieri,[14] T. Barber,[27] E. L. Barberio,[85] D. Barberis,[49a,49b] M. Barbero,[20] D. Y. Bardin,[64] T. Barillari,[98] M. Barisonzi,[173] T. Barklow,[142] N. Barlow,[27] B. M. Barnett,[128] R. M. Barnett,[14] A. Baroncelli,[133a] G. Barone,[48] A. J. Barr,[117] F. Barreiro,[79] J. Barreiro Guimarães da Costa,[56] P. Barrillon,[114] R. Bartoldus,[142] A. E. Barton,[70] D. Bartsch,[20] V. Bartsch,[148] R. L. Bates,[52] L. Batkova,[143a] J. R. Batley,[27] A. Battaglia,[16] M. Battistin,[29] G. Battistoni,[88a] F. Bauer,[135] H. S. Bawa,[142,f] B. Beare,[157] T. Beau,[77] P. H. Beauchemin,[117] R. Beccherle,[49a] P. Bechtle,[41] H. P. Beck,[16] M. Beckingham,[47] K. H. Becks,[173] A. J. Beddall,[18c] A. Beddall,[18c] S. Bedikian,[174] V. A. Bednyakov,[64] C. P. Bee,[82] M. Begel,[24] S. Behar Harpaz,[151] P. K. Behera,[62] M. Beimforde,[98] C. Belanger-Champagne,[84] P. J. Bell,[48] W. H. Bell,[48] G. Bella,[152] L. Bellagamba,[19a] F. Bellina,[29] M. Bellomo,[29] A. Belloni,[56] O. Beloborodova,[106] K. Belotskiy,[95] O. Beltramello,[29] S. Ben Ami,[151] O. Benary,[152] D. Benchekroun,[134a] C. Benchouk,[82] M. Bendel,[80] N. Benekos,[164] Y. Benhammou,[152] D. P. Benjamin,[44] M. Benoit,[114] J. R. Bensinger,[22] K. Benslama,[129] S. Bentvelsen,[104] D. Berge,[29] E. Bergeaas Kuutmann,[41] N. Berger,[4] F. Berghaus,[168] E. Berglund,[48] J. Beringer,[14] K. Bernardet,[82] P. Bernat,[76] R. Bernhard,[47] C. Bernius,[24] T. Berry,[75] A. Bertin,[19a,19b] F. Bertinelli,[29] F. Bertolucci,[121a,121b] M. I. Besana,[88a,88b] N. Besson,[135] S. Bethke,[98] W. Bhimji,[45] R. M. Bianchi,[29] M. Bianco,[71a,71b] O. Biebel,[97] S. P. Bieniek,[76] K. Bierwagen,[53] J. Biesiada,[14] M. Biglietti,[133a,133b] H. Bilokon,[46] M. Bindi,[19a,19b] S. Binet,[114] A. Bingul,[18c] C. Bini,[131a,131b] C. Biscarat,[176] U. Bitenc,[47] K. M. Black,[21] R. E. Blair,[5] J.-B. Blanchard,[114] G. Blanchot,[29] T. Blazek,[143a] C. Blocker,[22] J. Blocki,[38] A. Blondel,[48] W. Blum,[80] U. Blumenschein,[53] G. J. Bobbink,[104] V. B. Bobrovnikov,[106] S. S. Bocchetta,[78] A. Bocci,[44] C. R. Boddy,[117] M. Boehler,[41] J. Boek,[173] N. Boelaert,[35] S. Böser,[76] J. A. Bogaerts,[29] A. Bogdanchikov,[106] A. Bogouch,[89,gg] C. Bohm,[145a] V. Boisvert,[75] T. Bold,[162,g] V. Boldea,[25a] N. M. Bolnet,[135] M. Bona,[74] V. G. Bondarenko,[95] M. Bondioli,[162] M. Boonekamp,[135] G. Boorman,[75] C. N. Booth,[138] S. Bordoni,[77] C. Borer,[16] A. Borisov,[127] G. Borissov,[70] I. Borjanovic,[12a] S. Borroni,[86] K. Bos,[104] D. Boscherini,[19a] M. Bosman,[11] H. Boterenbrood,[104] D. Botterill,[128] J. Bouchami,[92] J. Boudreau,[122] E. V. Bouhova-Thacker,[70] C. Bourdarios,[114] N. Bousson,[82] A. Boveia,[30] J. Boyd,[29] I. R. Boyko,[64] N. I. Bozhko,[127] I. Bozovic-Jelisavcic,[12b] J. Bracinik,[17] A. Braem,[29] P. Branchini,[133a] G. W. Brandenburg,[56] A. Brandt,[7] G. Brandt,[15] O. Brandt,[53] U. Bratzler,[155] B. Brau,[83] J. E. Brau,[113] H. M. Braun,[173] B. Brelier,[157] J. Bremer,[29] R. Brenner,[165] S. Bressler,[151] D. Breton,[114] D. Britton,[52] F. M. Brochu,[27] I. Brock,[20] R. Brock,[87] T. J. Brodbeck,[70] E. Brodet,[152] F. Broggi,[88a] C. Bromberg,[87] G. Brooijmans,[34] W. K. Brooks,[31b] G. Brown,[81] H. Brown,[7] P. A. Bruckman de Renstrom,[38] D. Bruncko,[143b] R. Bruneliere,[47] S. Brunet,[60] A. Bruni,[19a] G. Bruni,[19a] M. Bruschi,[19a] T. Buanes,[13] F. Bucci,[48] J. Buchanan,[117] N. J. Buchanan,[2] P. Buchholz,[140] R. M. Buckingham,[117] A. G. Buckley,[45] S. I. Buda,[25a] I. A. Budagov,[64] B. Budick,[107] V. Büscher,[80] L. Bugge,[116] D. Buira-Clark,[117] O. Bulekov,[95] M. Bunse,[42] T. Buran,[116] H. Burckhart,[29] S. Burdin,[72] T. Burgess,[13] S. Burke,[128] E. Busato,[33] P. Bussey,[52] C. P. Buszello,[165] F. Butin,[29] B. Butler,[142] J. M. Butler,[21] C. M. Buttar,[52] J. M. Butterworth,[76] W. Buttinger,[27] T. Byatt,[76] S. Cabrera Urbán,[166] D. Caforio,[19a,19b] O. Cakir,[3a] P. Calafiura,[14] G. Calderini,[77] P. Calfayan,[97] R. Calkins,[105] L. P. Caloba,[23a] R. Caloi,[131a,131b] D. Calvet,[33] S. Calvet,[33] R. Camacho Toro,[33] P. Camarri,[132a,132b] M. Cambiaghi,[118a,118b] D. Cameron,[116] S. Campana,[29] M. Campanelli,[76] V. Canale,[101a,101b] F. Canelli,[30,h] A. Canepa,[158a] J. Cantero,[79] L. Capasso,[101a,101b] M. D. M. Capeans Garrido,[29] I. Caprini,[25a] M. Caprini,[25a] D. Capriotti,[98] M. Capua,[36a,36b] R. Caputo,[147] R. Cardarelli,[132a] T. Carli,[29] G. Carlino,[101a] L. Carminati,[88a,88b] B. Caron,[158a] S. Caron,[47] G. D. Carrillo Montoya,[171] A. A. Carter,[74] J. R. Carter,[27] J. Carvalho,[123a,i] D. Casadei,[107] M. P. Casado,[11] M. Cascella,[121a,121b] C. Caso,[49a,49b,gg] A. M. Castaneda Hernandez,[171] E. Castaneda-Miranda,[171] V. Castillo Gimenez,[166] N. F. Castro,[123a] G. Cataldi,[71a] F. Cataneo,[29] A. Catinaccio,[29] J. R. Catmore,[70] A. Cattai,[29] G. Cattani,[132a,132b] S. Caughron,[87] D. Cauz,[163a,163c] P. Cavalleri,[77] D. Cavalli,[88a] M. Cavalli-Sforza,[11] V. Cavasinni,[121a,121b] F. Ceradini,[133a,133b] A. S. Cerqueira,[23a] A. Cerri,[29] L. Cerrito,[74] F. Cerutti,[46] S. A. Cetin,[18b] F. Cevenini,[101a,101b] A. Chafaq,[134a] D. Chakraborty,[105] K. Chan,[2] B. Chapleau,[84] J. D. Chapman,[27] J. W. Chapman,[86] E. Chareyre,[77] D. G. Charlton,[17] V. Chavda,[81] C. A. Chavez Barajas,[29] S. Cheatham,[84] S. Chekanov,[5] S. V. Chekulaev,[158a] G. A. Chelkov,[64] M. A. Chelstowska,[103] C. Chen,[63] H. Chen,[24] S. Chen,[32c] T. Chen,[32c] X. Chen,[171] S. Cheng,[32a] A. Cheplakov,[64] V. F. Chepurnov,[64] R. Cherkaoui El Moursli,[134e] V. Chernyatin,[24] E. Cheu,[6] S. L. Cheung,[157] L. Chevalier,[135] G. Chiefari,[101a,101b] L. Chikovani,[50] J. T. Childers,[57a] A. Chilingarov,[70] G. Chiodini,[71a] M. V. Chizhov,[64] G. Choudalakis,[30]

S. Chouridou,[136] I. A. Christidi,[76] A. Christov,[47] D. Chromek-Burckhart,[29] M. L. Chu,[150] J. Chudoba,[124] G. Ciapetti,[131a,131b] K. Ciba,[37] A. K. Ciftci,[3a] R. Ciftci,[3a] D. Cinca,[33] V. Cindro,[73] M. D. Ciobotaru,[162] C. Ciocca,[19a,19b] A. Ciocio,[14] M. Cirilli,[86] M. Ciubancan,[25a] A. Clark,[48] P. J. Clark,[45] W. Cleland,[122] J. C. Clemens,[82] B. Clement,[54] C. Clement,[145a,145b] R. W. Clifft,[128] Y. Coadou,[82] M. Cobal,[163a,163c] A. Coccaro,[49a,49b] J. Cochran,[63] P. Coe,[117] J. G. Cogan,[142] J. Coggeshall,[164] E. Cogneras,[176] C. D. Cojocaru,[28] J. Colas,[4] A. P. Colijn,[104] C. Collard,[114] N. J. Collins,[17] C. Collins-Tooth,[52] J. Collot,[54] G. Colon,[83] P. Conde Muiño,[123a] E. Coniavitis,[117] M. C. Conidi,[11] M. Consonni,[103] V. Consorti,[47] S. Constantinescu,[25a] C. Conta,[118a,118b] F. Conventi,[101a,j] J. Cook,[29] M. Cooke,[14] B. D. Cooper,[76] A. M. Cooper-Sarkar,[117] N. J. Cooper-Smith,[75] K. Copic,[34] T. Cornelissen,[49a,49b] M. Corradi,[19a] F. Corriveau,[84,k] A. Cortes-Gonzalez,[164] G. Cortiana,[98] G. Costa,[88a] M. J. Costa,[166] D. Costanzo,[138] T. Costin,[30] D. Côté,[29] L. Courneyea,[168] G. Cowan,[75] C. Cowden,[27] B. E. Cox,[81] K. Cranmer,[107] F. Crescioli,[121a,121b] M. Cristinziani,[20] G. Crosetti,[36a,36b] R. Crupi,[71a,71b] S. Crépé-Renaudin,[54] C.-M. Cuciuc,[25a] C. Cuenca Almenar,[174] T. Cuhadar Donszelmann,[138] M. Curatolo,[46] C. J. Curtis,[17] P. Cwetanski,[60] H. Czirr,[140] Z. Czyczula,[116] S. D'Auria,[52] M. D'Onofrio,[72] A. D'Orazio,[131a,131b] P. V. M. Da Silva,[23a] C. Da Via,[81] W. Dabrowski,[37] T. Dai,[86] C. Dallapiccola,[83] M. Dam,[35] M. Dameri,[49a,49b] D. S. Damiani,[136] H. O. Danielsson,[29] D. Dannheim,[98] V. Dao,[48] G. Darbo,[49a] G. L. Darlea,[25b] C. Daum,[104] J. P. Dauvergne,[29] W. Davey,[85] T. Davidek,[125] N. Davidson,[85] R. Davidson,[70] E. Davies,[117,c] M. Davies,[92] A. R. Davison,[76] Y. Davygora,[57a] E. Dawe,[141] I. Dawson,[138] J. W. Dawson,[5,gg] R. K. Daya,[39] K. De,[7] R. de Asmundis,[101a] S. De Castro,[19a,19b] P. E. De Castro Faria Salgado,[24] S. De Cecco,[77] J. de Graat,[97] N. De Groot,[103] P. de Jong,[104] C. De La Taille,[114] H. De la Torre,[79] B. De Lotto,[163a,163c] L. De Mora,[70] L. De Nooij,[104] D. De Pedis,[131a] A. De Salvo,[131a] U. De Sanctis,[163a,163c] A. De Santo,[148] J. B. De Vivie De Regie,[114] S. Dean,[76] R. Debbe,[24] D. V. Dedovich,[64] J. Degenhardt,[119] M. Dehchar,[117] C. Del Papa,[163a,163c] J. Del Peso,[79] T. Del Prete,[121a,121b] M. Deliyergiyev,[73] A. Dell'Acqua,[29] L. Dell'Asta,[88a,88b] M. Della Pietra,[101a,j] D. della Volpe,[101a,101b] M. Delmastro,[29] P. Delpierre,[82] N. Delruelle,[29] P. A. Delsart,[54] C. Deluca,[147] S. Demers,[174] M. Demichev,[64] B. Demirkoz,[11,l] J. Deng,[162] S. P. Denisov,[127] D. Derendarz,[38] J. E. Derkaoui,[134d] F. Derue,[77] P. Dervan,[72] K. Desch,[20] E. Devetak,[147] P. O. Deviveiros,[157] A. Dewhurst,[128] B. DeWilde,[147] S. Dhaliwal,[157] R. Dhullipudi,[24,m] A. Di Ciaccio,[132a,132b] L. Di Ciaccio,[4] A. Di Girolamo,[29] B. Di Girolamo,[29] S. Di Luise,[133a,133b] A. Di Mattia,[87] B. Di Micco,[29] R. Di Nardo,[132a,132b] A. Di Simone,[132a,132b] R. Di Sipio,[19a,19b] M. A. Diaz,[31a] F. Diblen,[18c] E. B. Diehl,[86] J. Dietrich,[41] T. A. Dietzsch,[57a] S. Diglio,[114] K. Dindar Yagci,[39] J. Dingfelder,[20] C. Dionisi,[131a,131b] P. Dita,[25a] S. Dita,[25a] F. Dittus,[29] F. Djama,[82] T. Djobava,[50] M. A. B. do Vale,[23a] A. Do Valle Wemans,[123a] T. K. O. Doan,[4] M. Dobbs,[84] R. Dobinson,[29,gg] D. Dobos,[29] E. Dobson,[29] M. Dobson,[162] J. Dodd,[34] C. Doglioni,[117] T. Doherty,[52] Y. Doi,[65,gg] J. Dolejsi,[125] I. Dolenc,[73] Z. Dolezal,[125] B. A. Dolgoshein,[95,gg] T. Dohmae,[154] M. Donadelli,[23d] M. Donega,[119] J. Donini,[54] J. Dopke,[29] A. Doria,[101a] A. Dos Anjos,[171] M. Dosil,[11] A. Dotti,[121a,121b] M. T. Dova,[69] J. D. Dowell,[17] A. D. Doxiadis,[104] A. T. Doyle,[52] Z. Drasal,[125] J. Drees,[173] N. Dressnandt,[119] H. Drevermann,[29] C. Driouichi,[35] M. Dris,[9] J. Dubbert,[98] T. Dubbs,[136] S. Dube,[14] E. Duchovni,[170] G. Duckeck,[97] A. Dudarev,[29] F. Dudziak,[63] M. Dührssen,[29] I. P. Duerdoth,[81] L. Duflot,[114] M-A. Dufour,[84] M. Dunford,[29] H. Duran Yildiz,[3b] R. Duxfield,[138] M. Dwuznik,[37] F. Dydak,[29] M. Düren,[51] W. L. Ebenstein,[44] J. Ebke,[97] S. Eckert,[47] S. Eckweiler,[80] K. Edmonds,[80] C. A. Edwards,[75] N. C. Edwards,[52] W. Ehrenfeld,[41] T. Ehrich,[98] T. Eifert,[29] G. Eigen,[13] K. Einsweiler,[14] E. Eisenhandler,[74] T. Ekelof,[165] M. El Kacimi,[134c] M. Ellert,[165] S. Elles,[4] F. Ellinghaus,[80] K. Ellis,[74] N. Ellis,[29] J. Elmsheuser,[97] M. Elsing,[29] D. Emeliyanov,[128] R. Engelmann,[147] A. Engl,[97] B. Epp,[61] A. Eppig,[86] J. Erdmann,[53] A. Ereditato,[16] D. Eriksson,[145a] J. Ernst,[1] M. Ernst,[24] J. Ernwein,[135] D. Errede,[164] S. Errede,[164] E. Ertel,[80] M. Escalier,[114] C. Escobar,[122] X. Espinal Curull,[11] B. Esposito,[46] F. Etienne,[82] A. I. Etienvre,[135] E. Etzion,[152] D. Evangelakou,[53] H. Evans,[60] L. Fabbri,[19a,19b] C. Fabre,[29] R. M. Fakhrutdinov,[127] S. Falciano,[131a] Y. Fang,[171] M. Fanti,[88a,88b] A. Farbin,[7] A. Farilla,[133a] J. Farley,[147] T. Farooque,[157] S. M. Farrington,[117] P. Farthouat,[29] P. Fassnacht,[29] D. Fassouliotis,[8] B. Fatholahzadeh,[157] A. Favareto,[88a,88b] L. Fayard,[114] S. Fazio,[36a,36b] R. Febbraro,[33] P. Federic,[143a] O. L. Fedin,[120] W. Fedorko,[87] M. Fehling-Kaschek,[47] L. Feligioni,[82] D. Fellmann,[5] C. U. Felzmann,[85] C. Feng,[32d] E. J. Feng,[30] A. B. Fenyuk,[127] J. Ferencei,[143b] J. Ferland,[92] W. Fernando,[108] S. Ferrag,[52] J. Ferrando,[52] V. Ferrara,[41] A. Ferrari,[165] P. Ferrari,[104] R. Ferrari,[118a] A. Ferrer,[166] M. L. Ferrer,[46] D. Ferrere,[48] C. Ferretti,[86] A. Ferretto Parodi,[49a,49b] M. Fiascaris,[30] F. Fiedler,[80] A. Filipčič,[73] A. Filippas,[9] F. Filthaut,[103] M. Fincke-Keeler,[168] M. C. N. Fiolhais,[123a,i] L. Fiorini,[166] A. Firan,[39] G. Fischer,[41] P. Fischer,[20] M. J. Fisher,[108] S. M. Fisher,[128] M. Flechl,[47] I. Fleck,[140] J. Fleckner,[80] P. Fleischmann,[172] S. Fleischmann,[173] T. Flick,[173] L. R. Flores Castillo,[171] M. J. Flowerdew,[98] M. Fokitis,[9] T. Fonseca Martin,[16] D. A. Forbush,[137] A. Formica,[135] A. Forti,[81] D. Fortin,[158a] J. M. Foster,[81] D. Fournier,[114] A. Foussat,[29] A. J. Fowler,[44]

K. Fowler,[136] H. Fox,[70] P. Francavilla,[121a,121b] S. Franchino,[118a,118b] D. Francis,[29] T. Frank,[170] M. Franklin,[56] S. Franz,[29] M. Fraternali,[118a,118b] S. Fratina,[119] S. T. French,[27] F. Friedrich,[43] R. Froeschl,[29] D. Froidevaux,[29] J. A. Frost,[27] C. Fukunaga,[155] E. Fullana Torregrosa,[29] J. Fuster,[166] C. Gabaldon,[29] O. Gabizon,[170] T. Gadfort,[24] S. Gadomski,[48] G. Gagliardi,[49a,49b] P. Gagnon,[60] C. Galea,[97] E. J. Gallas,[117] M. V. Gallas,[29] V. Gallo,[16] B. J. Gallop,[128] P. Gallus,[124] E. Galyaev,[40] K. K. Gan,[108] Y. S. Gao,[142,f] V. A. Gapienko,[127] A. Gaponenko,[14] F. Garberson,[174] M. Garcia-Sciveres,[14] C. García,[166] J. E. García Navarro,[48] R. W. Gardner,[30] N. Garelli,[29] H. Garitaonandia,[104] V. Garonne,[29] J. Garvey,[17] C. Gatti,[46] G. Gaudio,[118a] O. Gaumer,[48] B. Gaur,[140] L. Gauthier,[135] I. L. Gavrilenko,[93] C. Gay,[167] G. Gaycken,[20] J-C. Gayde,[29] E. N. Gazis,[9] P. Ge,[32d] C. N. P. Gee,[128] D. A. A. Geerts,[104] Ch. Geich-Gimbel,[20] K. Gellerstedt,[145a,145b] C. Gemme,[49a] A. Gemmell,[52] M. H. Genest,[97] S. Gentile,[131a,131b] M. George,[53] S. George,[75] P. Gerlach,[173] A. Gershon,[152] C. Geweniger,[57a] H. Ghazlane,[134b] P. Ghez,[4] N. Ghodbane,[33] B. Giacobbe,[19a] S. Giagu,[131a,131b] V. Giakoumopoulou,[8] V. Giangiobbe,[121a,121b] F. Gianotti,[29] B. Gibbard,[24] A. Gibson,[157] S. M. Gibson,[29] L. M. Gilbert,[117] M. Gilchriese,[14] V. Gilewsky,[90] D. Gillberg,[28] A. R. Gillman,[128] D. M. Gingrich,[2,e] J. Ginzburg,[152] N. Giokaris,[8] M. P. Giordani,[163c] R. Giordano,[101a,101b] F. M. Giorgi,[15] P. Giovannini,[98] P. F. Giraud,[135] D. Giugni,[88a] M. Giunta,[92] P. Giusti,[19a] B. K. Gjelsten,[116] L. K. Gladilin,[96] C. Glasman,[79] J. Glatzer,[47] A. Glazov,[41] K. W. Glitza,[173] G. L. Glonti,[64] J. Godfrey,[141] J. Godlewski,[29] M. Goebel,[41] T. Göpfert,[43] C. Goeringer,[80] C. Gössling,[42] T. Göttfert,[98] S. Goldfarb,[86] T. Golling,[174] S. N. Golovnia,[127] A. Gomes,[123a,b] L. S. Gomez Fajardo,[41] R. Gonçalo,[75] J. Goncalves Pinto Firmino Da Costa,[41] L. Gonella,[20] A. Gonidec,[29] S. Gonzalez,[171] S. González de la Hoz,[166] M. L. Gonzalez Silva,[26] S. Gonzalez-Sevilla,[48] J. J. Goodson,[147] L. Goossens,[29] P. A. Gorbounov,[94] H. A. Gordon,[24] I. Gorelov,[102] G. Gorfine,[173] B. Gorini,[29] E. Gorini,[71a,71b] A. Gorišek,[73] E. Gornicki,[38] S. A. Gorokhov,[127] V. N. Goryachev,[127] B. Gosdzik,[41] M. Gosselink,[104] M. I. Gostkin,[64] I. Gough Eschrich,[162] M. Gouighri,[134a] D. Goujdami,[134c] M. P. Goulette,[48] A. G. Goussiou,[137] C. Goy,[4] I. Grabowska-Bold,[162,g] V. Grabski,[175] P. Grafström,[29] C. Grah,[173] K-J. Grahn,[41] F. Grancagnolo,[71a] S. Grancagnolo,[15] V. Grassi,[147] V. Gratchev,[120] N. Grau,[34] H. M. Gray,[29] J. A. Gray,[147] E. Graziani,[133a] O. G. Grebenyuk,[120] D. Greenfield,[128] T. Greenshaw,[72] Z. D. Greenwood,[24,m] K. Gregersen,[35] I. M. Gregor,[41] P. Grenier,[142] J. Griffiths,[137] N. Grigalashvili,[64] A. A. Grillo,[136] S. Grinstein,[11] Y. V. Grishkevich,[96] J.-F. Grivaz,[114] J. Grognuz,[29] M. Groh,[98] E. Gross,[170] J. Grosse-Knetter,[53] J. Groth-Jensen,[170] K. Grybel,[140] V. J. Guarino,[5] D. Guest,[174] C. Guicheney,[33] A. Guida,[71a,71b] T. Guillemin,[4] S. Guindon,[53] H. Guler,[84,n] J. Gunther,[124] B. Guo,[157] J. Guo,[34] A. Gupta,[30] Y. Gusakov,[64] V. N. Gushchin,[127] A. Gutierrez,[92] P. Gutierrez,[110] N. Guttman,[152] O. Gutzwiller,[171] C. Guyot,[135] C. Gwenlan,[117] C. B. Gwilliam,[72] A. Haas,[142] S. Haas,[29] C. Haber,[14] R. Hackenburg,[24] H. K. Hadavand,[39] D. R. Hadley,[17] P. Haefner,[98] F. Hahn,[29] S. Haider,[29] Z. Hajduk,[38] H. Hakobyan,[175] J. Haller,[53] K. Hamacher,[173] P. Hamal,[112] A. Hamilton,[48] S. Hamilton,[160] H. Han,[32a] L. Han,[32b] K. Hanagaki,[115] M. Hance,[119] C. Handel,[80] P. Hanke,[57a] J. R. Hansen,[35] J. B. Hansen,[35] J. D. Hansen,[35] P. H. Hansen,[35] P. Hansson,[142] K. Hara,[159] G. A. Hare,[136] T. Harenberg,[173] S. Harkusha,[89] D. Harper,[86] R. D. Harrington,[21] O. M. Harris,[137] K. Harrison,[17] J. Hartert,[47] F. Hartjes,[104] T. Haruyama,[65] A. Harvey,[55] S. Hasegawa,[100] Y. Hasegawa,[139] S. Hassani,[135] M. Hatch,[29] D. Hauff,[98] S. Haug,[16] M. Hauschild,[29] R. Hauser,[87] M. Havranek,[20] B. M. Hawes,[117] C. M. Hawkes,[17] R. J. Hawkings,[29] D. Hawkins,[162] T. Hayakawa,[66] D Hayden,[75] H. S. Hayward,[72] S. J. Haywood,[128] E. Hazen,[21] M. He,[32d] S. J. Head,[17] V. Hedberg,[78] L. Heelan,[7] S. Heim,[87] B. Heinemann,[14] S. Heisterkamp,[35] L. Helary,[4] M. Heller,[114] S. Hellman,[145a,145b] D. Hellmich,[20] C. Helsens,[11] R. C. W. Henderson,[70] M. Henke,[57a] A. Henrichs,[53] A. M. Henriques Correia,[29] S. Henrot-Versille,[114] F. Henry-Couannier,[82] C. Hensel,[53] T. Henß,[173] C. M. Hernandez,[7] Y. Hernández Jiménez,[166] R. Herrberg,[15] A. D. Hershenhorn,[151] G. Herten,[47] R. Hertenberger,[97] L. Hervas,[29] N. P. Hessey,[104] A. Hidvegi,[145a] E. Higón-Rodriguez,[166] D. Hill,[5,gg] J. C. Hill,[27] N. Hill,[5] K. H. Hiller,[41] S. Hillert,[20] S. J. Hillier,[17] I. Hinchliffe,[14] E. Hines,[119] M. Hirose,[115] F. Hirsch,[42] D. Hirschbuehl,[173] J. Hobbs,[147] N. Hod,[152] M. C. Hodgkinson,[138] P. Hodgson,[138] A. Hoecker,[29] M. R. Hoeferkamp,[102] J. Hoffman,[39] D. Hoffmann,[82] M. Hohlfeld,[80] M. Holder,[140] S. O. Holmgren,[145a] T. Holy,[126] J. L. Holzbauer,[87] Y. Homma,[66] T. M. Hong,[119] L. Hooft van Huysduynen,[107] T. Horazdovsky,[126] C. Horn,[142] S. Horner,[47] K. Horton,[117] J-Y. Hostachy,[54] S. Hou,[150] M. A. Houlden,[72] A. Hoummada,[134a] J. Howarth,[81] D. F. Howell,[117] I. Hristova,[15] J. Hrivnac,[114] I. Hruska,[124] T. Hryn'ova,[4] P. J. Hsu,[174] S.-C. Hsu,[14] G. S. Huang,[110] Z. Hubacek,[126] F. Hubaut,[82] F. Huegging,[20] T. B. Huffman,[117] E. W. Hughes,[34] G. Hughes,[70] R. E. Hughes-Jones,[81] M. Huhtinen,[29] P. Hurst,[56] M. Hurwitz,[14] U. Husemann,[41] N. Huseynov,[64,o] J. Huston,[87] J. Huth,[56] G. Iacobucci,[48] G. Iakovidis,[9] M. Ibbotson,[81] I. Ibragimov,[140] R. Ichimiya,[66] L. Iconomidou-Fayard,[114] J. Idarraga,[114] M. Idzik,[37] P. Iengo,[101a,101b] O. Igonkina,[104] Y. Ikegami,[65] M. Ikeno,[65] Y. Ilchenko,[39] D. Iliadis,[153] D. Imbault,[77] M. Imhaeuser,[173] M. Imori,[154] T. Ince,[20] J. Inigo-Golfin,[29] P. Ioannou,[8]

M. Iodice,[133a] G. Ionescu,[4] A. Irles Quiles,[166] K. Ishii,[65] A. Ishikawa,[66] M. Ishino,[67] R. Ishmukhametov,[39] C. Issever,[117] S. Istin,[18a] A. V. Ivashin,[127] W. Iwanski,[38] H. Iwasaki,[65] J. M. Izen,[40] V. Izzo,[101a] B. Jackson,[119] J. N. Jackson,[72] P. Jackson,[142] M. R. Jaekel,[29] V. Jain,[60] K. Jakobs,[47] S. Jakobsen,[35] J. Jakubek,[126] D. K. Jana,[110] E. Jankowski,[157] E. Jansen,[76] A. Jantsch,[98] M. Janus,[20] G. Jarlskog,[78] L. Jeanty,[56] K. Jelen,[37] I. Jen-La Plante,[30] P. Jenni,[29] A. Jeremie,[4] P. Jež,[35] S. Jézéquel,[4] M. K. Jha,[19a] H. Ji,[171] W. Ji,[80] J. Jia,[147] Y. Jiang,[32b] M. Jimenez Belenguer,[41] G. Jin,[32b] S. Jin,[32a] O. Jinnouchi,[156] M. D. Joergensen,[35] D. Joffe,[39] L. G. Johansen,[13] M. Johansen,[145a,145b] K. E. Johansson,[145a] P. Johansson,[138] S. Johnert,[41] K. A. Johns,[6] K. Jon-And,[145a,145b] G. Jones,[81] R. W. L. Jones,[70] T. W. Jones,[76] T. J. Jones,[72] O. Jonsson,[29] C. Joram,[29] P. M. Jorge,[123a,b] J. Joseph,[14] T. Jovin,[12b] X. Ju,[129] V. Juranek,[124] P. Jussel,[61] A. Juste Rozas,[11] V. V. Kabachenko,[127] S. Kabana,[16] M. Kaci,[166] A. Kaczmarska,[38] P. Kadlecik,[35] M. Kado,[114] H. Kagan,[108] M. Kagan,[56] S. Kaiser,[98] E. Kajomovitz,[151] S. Kalinin,[173] L. V. Kalinovskaya,[64] S. Kama,[39] N. Kanaya,[154] M. Kaneda,[29] T. Kanno,[156] V. A. Kantserov,[95] J. Kanzaki,[65] B. Kaplan,[174] A. Kapliy,[30] J. Kaplon,[29] D. Kar,[43] M. Karagoz,[117] M. Karnevskiy,[41] K. Karr,[5] V. Kartvelishvili,[70] A. N. Karyukhin,[127] L. Kashif,[171] A. Kasmi,[39] R. D. Kass,[108] A. Kastanas,[13] M. Kataoka,[4] Y. Kataoka,[154] E. Katsoufis,[9] J. Katzy,[41] V. Kaushik,[6] K. Kawagoe,[66] T. Kawamoto,[154] G. Kawamura,[80] M. S. Kayl,[104] V. A. Kazanin,[106] M. Y. Kazarinov,[64] J. R. Keates,[81] R. Keeler,[168] R. Kehoe,[39] M. Keil,[53] G. D. Kekelidze,[64] M. Kelly,[81] J. Kennedy,[97] C. J. Kenney,[142] M. Kenyon,[52] O. Kepka,[124] N. Kerschen,[29] B. P. Kerševan,[73] S. Kersten,[173] K. Kessoku,[154] C. Ketterer,[47] J. Keung,[157] M. Khakzad,[28] F. Khalil-zada,[10] H. Khandanyan,[164] A. Khanov,[111] D. Kharchenko,[64] A. Khodinov,[95] A. G. Kholodenko,[127] A. Khomich,[57a] T. J. Khoo,[27] G. Khoriauli,[20] A. Khoroshilov,[173] N. Khovanskiy,[64] V. Khovanskiy,[94] E. Khramov,[64] J. Khubua,[50] H. Kim,[7] M. S. Kim,[2] P. C. Kim,[142] S. H. Kim,[159] N. Kimura,[169] O. Kind,[15] B. T. King,[72] M. King,[66] R. S. B. King,[117] J. Kirk,[128] L. E. Kirsch,[22] A. E. Kiryunin,[98] T. Kishimoto,[66] D. Kisielewska,[37] T. Kittelmann,[122] A. M. Kiver,[127] E. Kladiva,[143b] J. Klaiber-Lodewigs,[42] M. Klein,[72] U. Klein,[72] K. Kleinknecht,[80] M. Klemetti,[84] A. Klier,[170] A. Klimentov,[24] R. Klingenberg,[42] E. B. Klinkby,[35] T. Klioutchnikova,[29] P. F. Klok,[103] S. Klous,[104] E.-E. Kluge,[57a] T. Kluge,[72] P. Kluit,[104] S. Kluth,[98] N. S. Knecht,[157] E. Kneringer,[61] J. Knobloch,[29] E. B. F. G. Knoops,[82] A. Knue,[53] B. R. Ko,[44] T. Kobayashi,[154] M. Kobel,[43] M. Kocian,[142] A. Kocnar,[112] P. Kodys,[125] K. Köneke,[29] A. C. König,[103] S. Koenig,[80] L. Köpke,[80] F. Koetsveld,[103] P. Koevesarki,[20] T. Koffas,[28] E. Koffeman,[104] F. Kohn,[53] Z. Kohout,[126] T. Kohriki,[65] T. Koi,[142] T. Kokott,[20] G. M. Kolachev,[106] H. Kolanoski,[15] V. Kolesnikov,[64] I. Koletsou,[88a] J. Koll,[87] D. Kollar,[29] M. Kollefrath,[47] S. D. Kolya,[81] A. A. Komar,[93] Y. Komori,[154] T. Kondo,[65] T. Kono,[41,p] A. I. Kononov,[47] R. Konoplich,[107,q] N. Konstantinidis,[76] A. Kootz,[173] S. Koperny,[37] S. V. Kopikov,[127] K. Korcyl,[38] K. Kordas,[153] V. Koreshev,[127] A. Korn,[117] A. Korol,[106] I. Korolkov,[11] E. V. Korolkova,[138] V. A. Korotkov,[127] O. Kortner,[98] S. Kortner,[98] V. V. Kostyukhin,[20] M. J. Kotamäki,[29] S. Kotov,[98] V. M. Kotov,[64] A. Kotwal,[44] C. Kourkoumelis,[8] V. Kouskoura,[153] A. Koutsman,[104] R. Kowalewski,[168] T. Z. Kowalski,[37] W. Kozanecki,[135] A. S. Kozhin,[127] V. Kral,[126] V. A. Kramarenko,[96] G. Kramberger,[73] M. W. Krasny,[77] A. Krasznahorkay,[107] J. Kraus,[87] A. Kreisel,[152] F. Krejci,[126] J. Kretzschmar,[72] N. Krieger,[53] P. Krieger,[157] K. Kroeninger,[53] H. Kroha,[98] J. Kroll,[119] J. Kroseberg,[20] J. Krstic,[12a] U. Kruchonak,[64] H. Krüger,[20] T. Kruker,[16] Z. V. Krumshteyn,[64] A. Kruth,[20] T. Kubota,[85] S. Kuehn,[47] A. Kugel,[57c] T. Kuhl,[41] D. Kuhn,[61] V. Kukhtin,[64] Y. Kulchitsky,[89] S. Kuleshov,[31b] C. Kummer,[97] M. Kuna,[77] N. Kundu,[117] J. Kunkle,[119] A. Kupco,[124] H. Kurashige,[66] M. Kurata,[159] Y. A. Kurochkin,[89] V. Kus,[124] W. Kuykendall,[137] M. Kuze,[156] P. Kuzhir,[90] J. Kvita,[29] R. Kwee,[15] A. La Rosa,[171] L. La Rotonda,[36a,36b] L. Labarga,[79] J. Labbe,[4] S. Lablak,[134a] C. Lacasta,[166] F. Lacava,[131a,131b] H. Lacker,[15] D. Lacour,[77] V. R. Lacuesta,[166] E. Ladygin,[64] R. Lafaye,[4] B. Laforge,[77] T. Lagouri,[79] S. Lai,[47] E. Laisne,[54] M. Lamanna,[29] C. L. Lampen,[6] W. Lampl,[6] E. Lancon,[135] U. Landgraf,[47] M. P. J. Landon,[74] H. Landsman,[151] J. L. Lane,[81] C. Lange,[41] A. J. Lankford,[162] F. Lanni,[24] K. Lantzsch,[29] S. Laplace,[77] C. Lapoire,[20] J. F. Laporte,[135] T. Lari,[88a] A. V. Larionov,[127] A. Larner,[117] C. Lasseur,[29] M. Lassnig,[29] P. Laurelli,[46] A. Lavorato,[117] W. Lavrijsen,[14] P. Laycock,[72] A. B. Lazarev,[64] O. Le Dortz,[77] E. Le Guirriec,[82] C. Le Maner,[157] E. Le Menedeu,[135] C. Lebel,[92] T. LeCompte,[5] F. Ledroit-Guillon,[54] H. Lee,[104] J. S. H. Lee,[149] S. C. Lee,[150] L. Lee,[174] M. Lefebvre,[168] M. Legendre,[135] A. Leger,[48] B. C. LeGeyt,[119] F. Legger,[97] C. Leggett,[14] M. Lehmacher,[20] G. Lehmann Miotto,[29] X. Lei,[6] M. A. L. Leite,[23d] R. Leitner,[125] D. Lellouch,[170] M. Leltchouk,[34] B. Lemmer,[53] V. Lendermann,[57a] K. J. C. Leney,[144b] T. Lenz,[104] G. Lenzen,[173] B. Lenzi,[29] K. Leonhardt,[43] S. Leontsinis,[9] C. Leroy,[92] J-R. Lessard,[168] J. Lesser,[145a] C. G. Lester,[27] A. Leung Fook Cheong,[171] J. Levêque,[4] D. Levin,[86] L. J. Levinson,[170] M. S. Levitski,[127] M. Lewandowska,[21] A. Lewis,[117] G. H. Lewis,[107] A. M. Leyko,[20] M. Leyton,[15] B. Li,[82] H. Li,[171] S. Li,[32b,d] X. Li,[86] Z. Liang,[39] Z. Liang,[117,r] H. Liao,[33] B. Liberti,[132a] P. Lichard,[29] M. Lichtnecker,[97] K. Lie,[164] W. Liebig,[13] R. Lifshitz,[151]

J. N. Lilley,[17] C. Limbach,[20] A. Limosani,[85] M. Limper,[62] S. C. Lin,[150,s] F. Linde,[104] J. T. Linnemann,[87] E. Lipeles,[119] L. Lipinsky,[124] A. Lipniacka,[13] T. M. Liss,[164] D. Lissauer,[24] A. Lister,[48] A. M. Litke,[136] C. Liu,[28] D. Liu,[150,t] H. Liu,[86] J. B. Liu,[86] M. Liu,[32b] S. Liu,[2] Y. Liu,[32b] M. Livan,[118a,118b] S. S. A. Livermore,[117] A. Lleres,[54] J. Llorente Merino,[79] S. L. Lloyd,[74] E. Lobodzinska,[41] P. Loch,[6] W. S. Lockman,[136] T. Loddenkoetter,[20] F. K. Loebinger,[81] A. Loginov,[174] C. W. Loh,[167] T. Lohse,[15] K. Lohwasser,[47] M. Lokajicek,[124] J. Loken,[117] V. P. Lombardo,[4] R. E. Long,[70] L. Lopes,[123a,b] D. Lopez Mateos,[56] M. Losada,[161] P. Loscutoff,[14] F. Lo Sterzo,[131a,131b] M. J. Losty,[158a] X. Lou,[40] A. Lounis,[114] K. F. Loureiro,[161] J. Love,[21] P. A. Love,[70] A. J. Lowe,[142,f] F. Lu,[32a] H. J. Lubatti,[137] C. Luci,[131a,131b] A. Lucotte,[54] A. Ludwig,[43] D. Ludwig,[41] I. Ludwig,[47] J. Ludwig,[47] F. Luehring,[60] G. Luijckx,[104] D. Lumb,[47] L. Luminari,[131a] E. Lund,[116] B. Lund-Jensen,[146] B. Lundberg,[78] J. Lundberg,[145a,145b] J. Lundquist,[35] M. Lungwitz,[80] A. Lupi,[121a,121b] G. Lutz,[98] D. Lynn,[24] J. Lys,[14] E. Lytken,[78] H. Ma,[24] L. L. Ma,[171] J. A. Macana Goia,[92] G. Maccarrone,[46] A. Macchiolo,[98] B. Maček,[73] J. Machado Miguens,[123a] R. Mackeprang,[35] R. J. Madaras,[14] W. F. Mader,[43] R. Maenner,[57c] T. Maeno,[24] P. Mättig,[173] S. Mättig,[41] L. Magnoni,[29] E. Magradze,[53] Y. Mahalalel,[152] K. Mahboubi,[47] G. Mahout,[17] C. Maiani,[131a,131b] C. Maidantchik,[23a] A. Maio,[123a,b] S. Majewski,[24] Y. Makida,[65] N. Makovec,[114] P. Mal,[6] Pa. Malecki,[38] P. Malecki,[38] V. P. Maleev,[120] F. Malek,[54] U. Mallik,[62] D. Malon,[5] C. Malone,[142] S. Maltezos,[9] V. Malyshev,[106] S. Malyukov,[29] R. Mameghani,[97] J. Mamuzic,[12b] A. Manabe,[65] L. Mandelli,[88a] I. Mandić,[73] R. Mandrysch,[15] J. Maneira,[123a] P. S. Mangeard,[87] I. D. Manjavidze,[64] A. Mann,[53] P. M. Manning,[136] A. Manousakis-Katsikakis,[8] B. Mansoulie,[135] A. Manz,[98] A. Mapelli,[29] L. Mapelli,[29] L. March,[79] J. F. Marchand,[29] F. Marchese,[132a,132b] G. Marchiori,[77] M. Marcisovsky,[124] A. Marin,[21,gg] C. P. Marino,[60] F. Marroquim,[23a] R. Marshall,[81] Z. Marshall,[29] F. K. Martens,[157] S. Marti-Garcia,[166] A. J. Martin,[174] B. Martin,[29] B. Martin,[87] F. F. Martin,[119] J. P. Martin,[92] Ph. Martin,[54] T. A. Martin,[17] V. J. Martin,[45] B. Martin dit Latour,[48] S. Martin–Haugh,[148] M. Martinez,[11] V. Martinez Outschoorn,[56] A. C. Martyniuk,[81] M. Marx,[81] F. Marzano,[131a] A. Marzin,[110] L. Masetti,[80] T. Mashimo,[154] R. Mashinistov,[93] J. Masik,[81] A. L. Maslennikov,[106] I. Massa,[19a,19b] G. Massaro,[104] N. Massol,[4] P. Mastrandrea,[131a,131b] A. Mastroberardino,[36a,36b] T. Masubuchi,[154] M. Mathes,[20] P. Matricon,[114] H. Matsumoto,[154] H. Matsunaga,[154] T. Matsushita,[66] C. Mattravers,[117,c] J. M. Maugain,[29] S. J. Maxfield,[72] D. A. Maximov,[106] E. N. May,[5] A. Mayne,[138] R. Mazini,[150] M. Mazur,[20] M. Mazzanti,[88a] E. Mazzoni,[121a,121b] S. P. Mc Kee,[86] A. McCarn,[164] R. L. McCarthy,[147] T. G. McCarthy,[28] N. A. McCubbin,[128] K. W. McFarlane,[55] J. A. Mcfayden,[138] H. McGlone,[52] G. Mchedlidze,[50] R. A. McLaren,[29] T. Mclaughlan,[17] S. J. McMahon,[128] R. A. McPherson,[168,k] A. Meade,[83] J. Mechnich,[104] M. Mechtel,[173] M. Medinnis,[41] R. Meera-Lebbai,[110] T. Meguro,[115] R. Mehdiyev,[92] S. Mehlhase,[35] A. Mehta,[72] K. Meier,[57a] J. Meinhardt,[47] B. Meirose,[78] C. Melachrinos,[30] B. R. Mellado Garcia,[171] L. Mendoza Navas,[161] Z. Meng,[150,t] A. Mengarelli,[19a,19b] S. Menke,[98] C. Menot,[29] E. Meoni,[11] K. M. Mercurio,[56] P. Mermod,[117] L. Merola,[101a,101b] C. Meroni,[88a] F. S. Merritt,[30] A. Messina,[29] J. Metcalfe,[102] A. S. Mete,[63] S. Meuser,[20] C. Meyer,[80] J-P. Meyer,[135] J. Meyer,[172] J. Meyer,[53] T. C. Meyer,[29] W. T. Meyer,[63] J. Miao,[32d] S. Michal,[29] L. Micu,[25a] R. P. Middleton,[128] P. Miele,[29] S. Migas,[72] L. Mijović,[41] G. Mikenberg,[170] M. Mikestikova,[124] M. Mikuž,[73] D. W. Miller,[30] R. J. Miller,[87] W. J. Mills,[167] C. Mills,[56] A. Milov,[170] D. A. Milstead,[145a,145b] D. Milstein,[170] A. A. Minaenko,[127] M. Miñano,[166] I. A. Minashvili,[64] A. I. Mincer,[107] B. Mindur,[37] M. Mineev,[64] Y. Ming,[129] L. M. Mir,[11] G. Mirabelli,[131a] L. Miralles Verge,[11] A. Misiejuk,[75] J. Mitrevski,[136] G. Y. Mitrofanov,[127] V. A. Mitsou,[166] S. Mitsui,[65] P. S. Miyagawa,[138] K. Miyazaki,[66] J. U. Mjörnmark,[78] T. Moa,[145a,145b] P. Mockett,[137] S. Moed,[56] V. Moeller,[27] K. Mönig,[41] N. Möser,[20] S. Mohapatra,[147] W. Mohr,[47] S. Mohrdieck-Möck,[98] A. M. Moisseev,[127,gg] R. Moles-Valls,[166] J. Molina-Perez,[29] J. Monk,[76] E. Monnier,[82] S. Montesano,[88a,88b] F. Monticelli,[69] S. Monzani,[19a,19b] R. W. Moore,[2] G. F. Moorhead,[85] C. Mora Herrera,[48] A. Moraes,[52] N. Morange,[135] J. Morel,[53] G. Morello,[36a,36b] D. Moreno,[80] M. Moreno Llácer,[166] P. Morettini,[49a] M. Morii,[56] J. Morin,[74] Y. Morita,[65] A. K. Morley,[29] G. Mornacchi,[29] S. V. Morozov,[95] J. D. Morris,[74] L. Morvaj,[100] H. G. Moser,[98] M. Mosidze,[50] J. Moss,[108] R. Mount,[142] E. Mountricha,[135] S. V. Mouraviev,[93] E. J. W. Moyse,[83] M. Mudrinic,[12b] F. Mueller,[57a] J. Mueller,[122] K. Mueller,[20] T. A. Müller,[97] D. Muenstermann,[29] A. Muir,[167] Y. Munwes,[152] W. J. Murray,[128] I. Mussche,[104] E. Musto,[101a,101b] A. G. Myagkov,[127] M. Myska,[124] J. Nadal,[11] K. Nagai,[159] K. Nagano,[65] Y. Nagasaka,[59] A. M. Nairz,[29] Y. Nakahama,[29] K. Nakamura,[154] I. Nakano,[109] G. Nanava,[20] A. Napier,[160] M. Nash,[76,c] N. R. Nation,[21] T. Nattermann,[20] T. Naumann,[41] G. Navarro,[161] H. A. Neal,[86] E. Nebot,[79] P. Yu. Nechaeva,[93] A. Negri,[118a,118b] G. Negri,[29] S. Nektarijevic,[48] A. Nelson,[63] S. Nelson,[142] T. K. Nelson,[142] S. Nemecek,[124] P. Nemethy,[107] A. A. Nepomuceno,[23a] M. Nessi,[29,u] S. Y. Nesterov,[120] M. S. Neubauer,[164] A. Neusiedl,[80] R. M. Neves,[107] P. Nevski,[24] P. R. Newman,[17] V. Nguyen Thi Hong,[135] R. B. Nickerson,[117]

R. Nicolaidou,[135] L. Nicolas,[138] B. Nicquevert,[29] F. Niedercorn,[114] J. Nielsen,[136] T. Niinikoski,[29] N. Nikiforou,[34] A. Nikiforov,[15] V. Nikolaenko,[127] K. Nikolaev,[64] I. Nikolic-Audit,[77] K. Nikolics,[48] K. Nikolopoulos,[24] H. Nilsen,[47] P. Nilsson,[7] Y. Ninomiya,[154] A. Nisati,[131a] T. Nishiyama,[66] R. Nisius,[98] L. Nodulman,[5] M. Nomachi,[115] I. Nomidis,[153] M. Nordberg,[29] B. Nordkvist,[145a,145b] P. R. Norton,[128] J. Novakova,[125] M. Nozaki,[65] M. Nožička,[41] L. Nozka,[112] I. M. Nugent,[158a] A.-E. Nuncio-Quiroz,[20] G. Nunes Hanninger,[85] T. Nunnemann,[97] E. Nurse,[76] T. Nyman,[29] B. J. O'Brien,[45] S. W. O'Neale,[17,gg] D. C. O'Neil,[141] V. O'Shea,[52] F. G. Oakham,[28,e] H. Oberlack,[98] J. Ocariz,[77] A. Ochi,[66] S. Oda,[154] S. Odaka,[65] J. Odier,[82] H. Ogren,[60] A. Oh,[81] S. H. Oh,[44] C. C. Ohm,[145a,145b] T. Ohshima,[100] H. Ohshita,[139] T. K. Ohska,[65] T. Ohsugi,[58] S. Okada,[66] H. Okawa,[162] Y. Okumura,[100] T. Okuyama,[154] M. Olcese,[49a] A. G. Olchevski,[64] M. Oliveira,[123a,i] D. Oliveira Damazio,[24] E. Oliver Garcia,[166] D. Olivito,[119] A. Olszewski,[38] J. Olszowska,[38] C. Omachi,[66] A. Onofre,[123a,v] P. U. E. Onyisi,[30] C. J. Oram,[158a] M. J. Oreglia,[30] Y. Oren,[152] D. Orestano,[133a,133b] I. Orlov,[106] C. Oropeza Barrera,[52] R. S. Orr,[157] B. Osculati,[49a,49b] R. Ospanov,[119] C. Osuna,[11] G. Otero y Garzon,[26] J. P. Ottersbach,[104] M. Ouchrif,[134d] F. Ould-Saada,[116] A. Ouraou,[135] Q. Ouyang,[32a] M. Owen,[81] S. Owen,[138] V. E. Ozcan,[18a] N. Ozturk,[7] A. Pacheco Pages,[11] C. Padilla Aranda,[11] S. Pagan Griso,[14] E. Paganis,[138] F. Paige,[24] K. Pajchel,[116] G. Palacino,[158b] C. P. Paleari,[6] S. Palestini,[29] D. Pallin,[33] A. Palma,[123a,b] J. D. Palmer,[17] Y. B. Pan,[171] E. Panagiotopoulou,[9] B. Panes,[31a] N. Panikashvili,[86] S. Panitkin,[24] D. Pantea,[25a] M. Panuskova,[124] V. Paolone,[122] A. Papadelis,[145a] Th. D. Papadopoulou,[9] A. Paramonov,[5] W. Park,[24,w] M. A. Parker,[27] F. Parodi,[49a,49b] J. A. Parsons,[34] U. Parzefall,[47] E. Pasqualucci,[131a] A. Passeri,[133a] F. Pastore,[133a,133b] Fr. Pastore,[75] G. Pásztor,[48,x] S. Pataraia,[171] N. Patel,[149] J. R. Pater,[81] S. Patricelli,[101a,101b] T. Pauly,[29] M. Pecsy,[143a] M. I. Pedraza Morales,[171] S. V. Peleganchuk,[106] H. Peng,[32b] R. Pengo,[29] A. Penson,[34] J. Penwell,[60] M. Perantoni,[23a] K. Perez,[34,y] T. Perez Cavalcanti,[41] E. Perez Codina,[11] M. T. Pérez García-Estañ,[166] V. Perez Reale,[34] L. Perini,[88a,88b] H. Pernegger,[29] R. Perrino,[71a] P. Perrodo,[4] S. Persembe,[3a] V. D. Peshekhonov,[64] B. A. Petersen,[29] J. Petersen,[29] T. C. Petersen,[35] E. Petit,[82] A. Petridis,[153] C. Petridou,[153] E. Petrolo,[131a] F. Petrucci,[133a,133b] D. Petschull,[41] M. Petteni,[141] R. Pezoa,[31b] A. Phan,[85] A. W. Phillips,[27] P. W. Phillips,[128] G. Piacquadio,[29] E. Piccaro,[74] M. Piccinini,[19a,19b] A. Pickford,[52] S. M. Piec,[41] R. Piegaia,[26] J. E. Pilcher,[30] A. D. Pilkington,[81] J. Pina,[123a,b] M. Pinamonti,[163a,163c] A. Pinder,[117] J. L. Pinfold,[2] J. Ping,[32c] B. Pinto,[123a,b] O. Pirotte,[29] C. Pizio,[88a,88b] R. Placakyte,[41] M. Plamondon,[168] W. G. Plano,[81] M.-A. Pleier,[24] A. V. Pleskach,[127] A. Poblaguev,[24] S. Poddar,[57a] F. Podlyski,[33] L. Poggioli,[114] T. Poghosyan,[20] M. Pohl,[48] F. Polci,[54] G. Polesello,[118a] A. Policicchio,[137] A. Polini,[19a] J. Poll,[74] V. Polychronakos,[24] D. M. Pomarede,[135] D. Pomeroy,[22] K. Pommès,[29] L. Pontecorvo,[131a] B. G. Pope,[87] G. A. Popeneciu,[25a] D. S. Popovic,[12a] A. Poppleton,[29] X. Portell Bueso,[29] R. Porter,[162] C. Posch,[21] G. E. Pospelov,[98] S. Pospisil,[126] I. N. Potrap,[98] C. J. Potter,[148] C. T. Potter,[113] G. Poulard,[29] J. Poveda,[171] R. Prabhu,[76] P. Pralavorio,[82] S. Prasad,[56] R. Pravahan,[7] S. Prell,[63] K. Pretzl,[16] L. Pribyl,[29] D. Price,[60] L. E. Price,[5] M. J. Price,[29] P. M. Prichard,[72] D. Prieur,[122] M. Primavera,[71a] K. Prokofiev,[107] F. Prokoshin,[31b] S. Protopopescu,[24] J. Proudfoot,[5] X. Prudent,[43] H. Przysiezniak,[4] S. Psoroulas,[20] E. Ptacek,[113] E. Pueschel,[83] J. Purdham,[86] M. Purohit,[24,w] P. Puzo,[114] Y. Pylypchenko,[116] J. Qian,[86] Z. Qian,[82] Z. Qin,[41] A. Quadt,[53] D. R. Quarrie,[14] W. B. Quayle,[171] F. Quinonez,[31a] M. Raas,[103] V. Radescu,[57b] B. Radics,[20] T. Rador,[18a] F. Ragusa,[88a,88b] G. Rahal,[176] A. M. Rahimi,[108] D. Rahm,[24] S. Rajagopalan,[24] M. Rammensee,[47] M. Rammes,[140] M. Ramstedt,[145a,145b] A. S. Randle-Conde,[39] K. Randrianarivony,[28] P. N. Ratoff,[70] F. Rauscher,[97] E. Rauter,[98] M. Raymond,[29] A. L. Read,[116] D. M. Rebuzzi,[118a,118b] A. Redelbach,[172] G. Redlinger,[24] R. Reece,[119] K. Reeves,[40] A. Reichold,[104] E. Reinherz-Aronis,[152] A. Reinsch,[113] I. Reisinger,[42] D. Reljic,[12a] C. Rembser,[29] Z. L. Ren,[150] A. Renaud,[114] P. Renkel,[39] M. Rescigno,[131a] S. Resconi,[88a] B. Resende,[135] P. Reznicek,[97] R. Rezvani,[157] A. Richards,[76] R. Richter,[98] E. Richter-Was,[4,z] M. Ridel,[77] S. Rieke,[80] M. Rijpstra,[104] M. Rijssenbeek,[147] A. Rimoldi,[118a,118b] L. Rinaldi,[19a] R. R. Rios,[39] I. Riu,[11] G. Rivoltella,[88a,88b] F. Rizatdinova,[111] E. Rizvi,[74] S. H. Robertson,[84,k] A. Robichaud-Veronneau,[48] D. Robinson,[27] J. E. M. Robinson,[76] M. Robinson,[113] A. Robson,[52] J. G. Rocha de Lima,[105] C. Roda,[121a,121b] D. Roda Dos Santos,[29] S. Rodier,[79] D. Rodriguez,[161] A. Roe,[53] S. Roe,[29] O. Røhne,[116] V. Rojo,[1] S. Rolli,[160] A. Romaniouk,[95] V. M. Romanov,[64] G. Romeo,[26] L. Roos,[77] E. Ros,[166] S. Rosati,[131a,131b] K. Rosbach,[48] A. Rose,[148] M. Rose,[75] G. A. Rosenbaum,[157] E. I. Rosenberg,[63] P. L. Rosendahl,[13] O. Rosenthal,[140] L. Rosselet,[48] V. Rossetti,[11] E. Rossi,[131a,131b] L. P. Rossi,[49a] L. Rossi,[88a,88b] M. Rotaru,[25a] I. Roth,[170] J. Rothberg,[137] D. Rousseau,[114] C. R. Royon,[135] A. Rozanov,[82] Y. Rozen,[151] X. Ruan,[114] I. Rubinskiy,[41] B. Ruckert,[97] N. Ruckstuhl,[104] V. I. Rud,[96] C. Rudolph,[43] G. Rudolph,[61] F. Rühr,[6] F. Ruggieri,[133a,133b] A. Ruiz-Martinez,[63] E. Rulikowska-Zarebska,[37] V. Rumiantsev,[90,gg] L. Rumyantsev,[64] K. Runge,[47] O. Runolfsson,[20] Z. Rurikova,[47] N. A. Rusakovich,[64] D. R. Rust,[60] J. P. Rutherfoord,[6] C. Ruwiedel,[14] P. Ruzicka,[124] Y. F. Ryabov,[120]

V. Ryadovikov,[127] P. Ryan,[87] M. Rybar,[125] G. Rybkin,[114] N. C. Ryder,[117] S. Rzaeva,[10] A. F. Saavedra,[149] I. Sadeh,[152] H. F-W. Sadrozinski,[136] R. Sadykov,[64] F. Safai Tehrani,[131a,131b] H. Sakamoto,[154] G. Salamanna,[74] A. Salamon,[132a] M. Saleem,[110] D. Salihagic,[98] A. Salnikov,[142] J. Salt,[166] B. M. Salvachua Ferrando,[5] D. Salvatore,[36a,36b] F. Salvatore,[148] A. Salvucci,[103] A. Salzburger,[29] D. Sampsonidis,[153] B. H. Samset,[116] A. Sanchez,[101a,101b] H. Sandaker,[13] H. G. Sander,[80] M. P. Sanders,[97] M. Sandhoff,[173] T. Sandoval,[27] C. Sandoval,[161] R. Sandstroem,[98] S. Sandvoss,[173] D. P. C. Sankey,[128] A. Sansoni,[46] C. Santamarina Rios,[84] C. Santoni,[33] R. Santonico,[132a,132b] H. Santos,[123a] J. G. Saraiva,[123a,b] T. Sarangi,[171] E. Sarkisyan-Grinbaum,[7] F. Sarri,[121a,121b] G. Sartisohn,[173] O. Sasaki,[65] T. Sasaki,[65] N. Sasao,[67] I. Satsounkevitch,[89] G. Sauvage,[4] E. Sauvan,[4] J. B. Sauvan,[114] P. Savard,[157,e] V. Savinov,[122] D. O. Savu,[29] P. Savva,[9] L. Sawyer,[24,m] D. H. Saxon,[52] L. P. Says,[33] C. Sbarra,[19a,19b] A. Sbrizzi,[19a,19b] O. Scallon,[92] D. A. Scannicchio,[162] J. Schaarschmidt,[114] P. Schacht,[98] U. Schäfer,[80] S. Schaepe,[20] S. Schaetzel,[57b] A. C. Schaffer,[114] D. Schaile,[97] R. D. Schamberger,[147] A. G. Schamov,[106] V. Scharf,[57a] V. A. Schegelsky,[120] D. Scheirich,[86] M. Schernau,[162] M. I. Scherzer,[14] C. Schiavi,[49a,49b] J. Schieck,[97] M. Schioppa,[36a,36b] S. Schlenker,[29] J. L. Schlereth,[5] E. Schmidt,[47] K. Schmieden,[20] C. Schmitt,[80] S. Schmitt,[57b] M. Schmitz,[20] A. Schöning,[57b] M. Schott,[29] D. Schouten,[141] J. Schovancova,[124] M. Schram,[84] C. Schroeder,[80] N. Schroer,[57c] S. Schuh,[29] G. Schuler,[29] J. Schultes,[173] H.-C. Schultz-Coulon,[57a] H. Schulz,[15] J. W. Schumacher,[20] M. Schumacher,[47] B. A. Schumm,[136] Ph. Schune,[135] C. Schwanenberger,[81] A. Schwartzman,[142] Ph. Schwemling,[77] R. Schwienhorst,[87] R. Schwierz,[43] J. Schwindling,[135] T. Schwindt,[20] G. Sciolla,[22] W. G. Scott,[128] J. Searcy,[113] E. Sedykh,[120] E. Segura,[11] S. C. Seidel,[102] A. Seiden,[136] F. Seifert,[43] J. M. Seixas,[23a] G. Sekhniaidze,[101a] D. M. Seliverstov,[120] B. Sellden,[145a] G. Sellers,[72] M. Seman,[143b] N. Semprini-Cesari,[19a,19b] C. Serfon,[97] L. Serin,[114] R. Seuster,[98] H. Severini,[110] M. E. Sevior,[85] A. Sfyrla,[29] E. Shabalina,[53] M. Shamim,[113] L. Y. Shan,[32a] J. T. Shank,[21] Q. T. Shao,[85] M. Shapiro,[14] P. B. Shatalov,[94] L. Shaver,[6] K. Shaw,[163a,163c] D. Sherman,[174] P. Sherwood,[76] A. Shibata,[107] H. Shichi,[100] S. Shimizu,[29] M. Shimojima,[99] T. Shin,[55] A. Shmeleva,[93] M. J. Shochet,[30] D. Short,[117] M. A. Shupe,[6] P. Sicho,[124] A. Sidoti,[131a,131b] A. Siebel,[173] F. Siegert,[47] J. Siegrist,[14] Dj. Sijacki,[12a] O. Silbert,[170] J. Silva,[123a,b] Y. Silver,[152] D. Silverstein,[142] S. B. Silverstein,[145a] V. Simak,[126] O. Simard,[135] Lj. Simic,[12a] S. Simion,[114] B. Simmons,[76] M. Simonyan,[35] P. Sinervo,[157] N. B. Sinev,[113] V. Sipica,[140] G. Siragusa,[172] A. Sircar,[24] A. N. Sisakyan,[64] S. Yu. Sivoklokov,[96] J. Sjölin,[145a,145b] T. B. Sjursen,[13] L. A. Skinnari,[14] K. Skovpen,[106] P. Skubic,[110] N. Skvorodnev,[22] M. Slater,[17] T. Slavicek,[126] K. Sliwa,[160] T. J. Sloan,[70] J. Sloper,[29] V. Smakhtin,[170] S. Yu. Smirnov,[95] L. N. Smirnova,[96] O. Smirnova,[78] B. C. Smith,[56] D. Smith,[142] K. M. Smith,[52] M. Smizanska,[70] K. Smolek,[126] A. A. Snesarev,[93] S. W. Snow,[81] J. Snow,[110] J. Snuverink,[104] S. Snyder,[24] M. Soares,[123a] R. Sobie,[168,k] J. Sodomka,[126] A. Soffer,[152] C. A. Solans,[166] M. Solar,[126] J. Solc,[126] E. Soldatov,[95] U. Soldevila,[166] E. Solfaroli Camillocci,[131a,131b] A. A. Solodkov,[127] O. V. Solovyanov,[127] J. Sondericker,[24] N. Soni,[2] V. Sopko,[126] B. Sopko,[126] M. Sorbi,[88a,88b] M. Sosebee,[7] A. Soukharev,[106] S. Spagnolo,[71a,71b] F. Spanò,[75] R. Spighi,[19a] G. Spigo,[29] F. Spila,[131a,131b] E. Spiriti,[133a] R. Spiwoks,[29] M. Spousta,[125] T. Spreitzer,[157] B. Spurlock,[7] R. D. St. Denis,[52] T. Stahl,[140] J. Stahlman,[119] R. Stamen,[57a] E. Stanecka,[29] R. W. Stanek,[5] C. Stanescu,[133a] S. Stapnes,[116] E. A. Starchenko,[127] J. Stark,[54] P. Staroba,[124] P. Starovoitov,[90] A. Staude,[97] P. Stavina,[143a] G. Stavropoulos,[14] G. Steele,[52] P. Steinbach,[43] P. Steinberg,[24] I. Stekl,[126] B. Stelzer,[141] H. J. Stelzer,[87] O. Stelzer-Chilton,[158a] H. Stenzel,[51] K. Stevenson,[74] G. A. Stewart,[29] J. A. Stillings,[20] T. Stockmanns,[20] M. C. Stockton,[29] K. Stoerig,[47] G. Stoicea,[25a] S. Stonjek,[98] P. Strachota,[125] A. R. Stradling,[7] A. Straessner,[43] J. Strandberg,[146] S. Strandberg,[145a,145b] A. Strandlie,[116] M. Strang,[108] E. Strauss,[142] M. Strauss,[110] P. Strizenec,[143b] R. Ströhmer,[172] D. M. Strom,[113] J. A. Strong,[75,gg] R. Stroynowski,[39] J. Strube,[128] B. Stugu,[13] I. Stumer,[24,gg] J. Stupak,[147] P. Sturm,[173] D. A. Soh,[150,r] D. Su,[142] HS. Subramania,[2] A. Succurro,[11] Y. Sugaya,[115] T. Sugimoto,[100] C. Suhr,[105] K. Suita,[66] M. Suk,[125] V. V. Sulin,[93] S. Sultansoy,[3d] T. Sumida,[29] X. Sun,[54] J. E. Sundermann,[47] K. Suruliz,[138] S. Sushkov,[11] G. Susinno,[36a,36b] M. R. Sutton,[148] Y. Suzuki,[65] Y. Suzuki,[66] M. Svatos,[124] Yu. M. Sviridov,[127] S. Swedish,[167] I. Sykora,[143a] T. Sykora,[125] B. Szeless,[29] J. Sánchez,[166] D. Ta,[104] K. Tackmann,[41] A. Taffard,[162] R. Tafirout,[158a] N. Taiblum,[152] Y. Takahashi,[100] H. Takai,[24] R. Takashima,[68] H. Takeda,[66] T. Takeshita,[139] M. Talby,[82] A. Talyshev,[106] M. C. Tamsett,[24] J. Tanaka,[154] R. Tanaka,[114] S. Tanaka,[130] S. Tanaka,[65] Y. Tanaka,[99] K. Tani,[66] N. Tannoury,[82] G. P. Tappern,[29] S. Tapprogge,[80] D. Tardif,[157] S. Tarem,[151] F. Tarrade,[28] G. F. Tartarelli,[88a] P. Tas,[125] M. Tasevsky,[124] E. Tassi,[36a,36b] M. Tatarkhanov,[14] Y. Tayalati,[134d] C. Taylor,[76] F. E. Taylor,[91] G. N. Taylor,[85] W. Taylor,[158b] M. Teinturier,[114] M. Teixeira Dias Castanheira,[74] P. Teixeira-Dias,[75] K. K. Temming,[47] H. Ten Kate,[29] P. K. Teng,[150] S. Terada,[65] K. Terashi,[154] J. Terron,[79] M. Terwort,[41,p] M. Testa,[46] R. J. Teuscher,[157,k] J. Thadome,[173] J. Therhaag,[20] T. Theveneaux-Pelzer,[77] M. Thioye,[174] S. Thoma,[47] J. P. Thomas,[17] E. N. Thompson,[83] P. D. Thompson,[17]

P. D. Thompson,[157] A. S. Thompson,[52] E. Thomson,[119] M. Thomson,[27] R. P. Thun,[86] F. Tian,[34] T. Tic,[124] V. O. Tikhomirov,[93] Y. A. Tikhonov,[106] C. J. W. P. Timmermans,[103] P. Tipton,[174] F. J. Tique Aires Viegas,[29] S. Tisserant,[82] J. Tobias,[47] B. Toczek,[37] T. Todorov,[4] S. Todorova-Nova,[160] B. Toggerson,[162] J. Tojo,[65] S. Tokár,[143a] K. Tokunaga,[66] K. Tokushuku,[65] K. Tollefson,[87] M. Tomoto,[100] L. Tompkins,[14] K. Toms,[102] G. Tong,[32a] A. Tonoyan,[13] C. Topfel,[16] N. D. Topilin,[64] I. Torchiani,[29] E. Torrence,[113] H. Torres,[77] E. Torró Pastor,[166] J. Toth,[82,x] F. Touchard,[82] D. R. Tovey,[138] D. Traynor,[74] T. Trefzger,[172] L. Tremblet,[29] A. Tricoli,[29] I. M. Trigger,[158a] S. Trincaz-Duvoid,[77] T. N. Trinh,[77] M. F. Tripiana,[69] W. Trischuk,[157] A. Trivedi,[24,w] B. Trocmé,[54] C. Troncon,[88a] M. Trottier-McDonald,[141] A. Trzupek,[38] C. Tsarouchas,[29] J. C-L. Tseng,[117] M. Tsiakiris,[104] P. V. Tsiareshka,[89] D. Tsionou,[4] G. Tsipolitis,[9] V. Tsiskaridze,[47] E. G. Tskhadadze,[50] I. I. Tsukerman,[94] V. Tsulaia,[14] J.-W. Tsung,[20] S. Tsuno,[65] D. Tsybychev,[147] A. Tua,[138] J. M. Tuggle,[30] M. Turala,[38] D. Turecek,[126] I. Turk Cakir,[3e] E. Turlay,[104] R. Turra,[88a,88b] P. M. Tuts,[34] A. Tykhonov,[73] M. Tylmad,[145a,145b] M. Tyndel,[128] H. Tyrvainen,[29] G. Tzanakos,[8] K. Uchida,[20] I. Ueda,[154] R. Ueno,[28] M. Ugland,[13] M. Uhlenbrock,[20] M. Uhrmacher,[53] F. Ukegawa,[159] G. Unal,[29] D. G. Underwood,[5] A. Undrus,[24] G. Unel,[162] Y. Unno,[65] D. Urbaniec,[34] E. Urkovsky,[152] P. Urrejola,[31a] G. Usai,[7] M. Uslenghi,[118a,118b] L. Vacavant,[82] V. Vacek,[126] B. Vachon,[84] S. Vahsen,[14] J. Valenta,[124] P. Valente,[131a] S. Valentinetti,[19a,19b] S. Valkar,[125] E. Valladolid Gallego,[166] S. Vallecorsa,[151] J. A. Valls Ferrer,[166] H. van der Graaf,[104] E. van der Kraaij,[104] R. Van Der Leeuw,[104] E. van der Poel,[104] D. van der Ster,[29] B. Van Eijk,[104] N. van Eldik,[83] P. van Gemmeren,[5] Z. van Kesteren,[104] I. van Vulpen,[104] W. Vandelli,[29] G. Vandoni,[29] A. Vaniachine,[5] P. Vankov,[41] F. Vannucci,[77] F. Varela Rodriguez,[29] R. Vari,[131a] D. Varouchas,[14] A. Vartapetian,[7] K. E. Varvell,[149] V. I. Vassilakopoulos,[55] F. Vazeille,[33] G. Vegni,[88a,88b] J. J. Veillet,[114] C. Vellidis,[8] F. Veloso,[123a] R. Veness,[29] S. Veneziano,[131a] A. Ventura,[71a,71b] D. Ventura,[137] M. Venturi,[47] N. Venturi,[16] V. Vercesi,[118a] M. Verducci,[137] W. Verkerke,[104] J. C. Vermeulen,[104] A. Vest,[43] M. C. Vetterli,[141,e] I. Vichou,[164] T. Vickey,[144b,aa] O. E. Vickey Boeriu,[144b] G. H. A. Viehhauser,[117] S. Viel,[167] M. Villa,[19a,19b] M. Villaplana Perez,[166] E. Vilucchi,[46] M. G. Vincter,[28] E. Vinek,[29] V. B. Vinogradov,[64] M. Virchaux,[135,gg] J. Virzi,[14] O. Vitells,[170] M. Viti,[41] I. Vivarelli,[47] F. Vives Vaque,[2] S. Vlachos,[9] M. Vlasak,[126] N. Vlasov,[20] A. Vogel,[20] P. Vokac,[126] G. Volpi,[46] M. Volpi,[85] G. Volpini,[88a] H. von der Schmitt,[98] J. von Loeben,[98] H. von Radziewski,[47] E. von Toerne,[20] V. Vorobel,[125] A. P. Vorobiev,[127] V. Vorwerk,[11] M. Vos,[166] R. Voss,[29] T. T. Voss,[173] J. H. Vossebeld,[72] N. Vranjes,[12a] M. Vranjes Milosavljevic,[104] V. Vrba,[124] M. Vreeswijk,[104] T. Vu Anh,[80] R. Vuillermet,[29] I. Vukotic,[114] W. Wagner,[173] P. Wagner,[119] H. Wahlen,[173] J. Wakabayashi,[100] J. Walbersloh,[42] S. Walch,[86] J. Walder,[70] R. Walker,[97] W. Walkowiak,[140] R. Wall,[174] P. Waller,[72] C. Wang,[44] H. Wang,[171] H. Wang,[32b,bb] J. Wang,[150] J. Wang,[32d] J. C. Wang,[137] R. Wang,[102] S. M. Wang,[150] A. Warburton,[84] C. P. Ward,[27] M. Warsinsky,[47] P. M. Watkins,[17] A. T. Watson,[17] M. F. Watson,[17] G. Watts,[137] S. Watts,[81] A. T. Waugh,[149] B. M. Waugh,[76] J. Weber,[42] M. Weber,[128] M. S. Weber,[16] P. Weber,[53] A. R. Weidberg,[117] P. Weigell,[98] J. Weingarten,[53] C. Weiser,[47] H. Wellenstein,[22] P. S. Wells,[29] M. Wen,[46] T. Wenaus,[24] S. Wendler,[122] Z. Weng,[150,r] T. Wengler,[29] S. Wenig,[29] N. Wermes,[20] M. Werner,[47] P. Werner,[29] M. Werth,[162] M. Wessels,[57a] C. Weydert,[54] K. Whalen,[28] S. J. Wheeler-Ellis,[162] S. P. Whitaker,[21] A. White,[7] M. J. White,[85] S. R. Whitehead,[117] D. Whiteson,[162] D. Whittington,[60] F. Wicek,[114] D. Wicke,[173] F. J. Wickens,[128] W. Wiedenmann,[171] M. Wielers,[128] P. Wienemann,[20] C. Wiglesworth,[74] L. A. M. Wiik,[47] P. A. Wijeratne,[76] A. Wildauer,[166] M. A. Wildt,[41,p] I. Wilhelm,[125] H. G. Wilkens,[29] J. Z. Will,[97] E. Williams,[34] H. H. Williams,[119] W. Willis,[34] S. Willocq,[83] J. A. Wilson,[17] M. G. Wilson,[142] A. Wilson,[86] I. Wingerter-Seez,[4] S. Winkelmann,[47] F. Winklmeier,[29] M. Wittgen,[142] M. W. Wolter,[38] H. Wolters,[123a,i] W. C. Wong,[40] G. Wooden,[117] B. K. Wosiek,[38] J. Wotschack,[29] M. J. Woudstra,[83] K. Wraight,[52] C. Wright,[52] B. Wrona,[72] S. L. Wu,[171] X. Wu,[48] Y. Wu,[32b,cc] E. Wulf,[34] R. Wunstorf,[42] B. M. Wynne,[45] L. Xaplanteris,[9] S. Xella,[35] S. Xie,[47] Y. Xie,[32a] C. Xu,[32b,dd] D. Xu,[138] G. Xu,[32a] B. Yabsley,[149] S. Yacoob,[144b] M. Yamada,[65] H. Yamaguchi,[154] A. Yamamoto,[65] K. Yamamoto,[63] S. Yamamoto,[154] T. Yamamura,[154] T. Yamanaka,[154] J. Yamaoka,[44] T. Yamazaki,[154] Y. Yamazaki,[66] Z. Yan,[21] H. Yang,[86] U. K. Yang,[81] Y. Yang,[60] Y. Yang,[32a] Z. Yang,[145a,145b] S. Yanush,[90] Y. Yao,[14] Y. Yasu,[65] G. V. Ybeles Smit,[129] J. Ye,[39] S. Ye,[24] M. Yilmaz,[3c] R. Yoosoofmiya,[122] K. Yorita,[169] R. Yoshida,[5] C. Young,[142] S. Youssef,[21] D. Yu,[24] J. Yu,[7] J. Yu,[32c,dd] L. Yuan,[32a,ee] A. Yurkewicz,[147] V. G. Zaets,[127] R. Zaidan,[62] A. M. Zaitsev,[127] Z. Zajacova,[29] Yo. K. Zalite,[120] L. Zanello,[131a,131b] P. Zarzhitsky,[39] A. Zaytsev,[106] C. Zeitnitz,[173] M. Zeller,[174] M. Zeman,[124] A. Zemla,[38] C. Zendler,[20] O. Zenin,[127] T. Ženiš,[143a] Z. Zenonos,[121a,121b] S. Zenz,[14] D. Zerwas,[114] G. Zevi della Porta,[56] Z. Zhan,[32d] D. Zhang,[32b,bb] H. Zhang,[87] J. Zhang,[5] X. Zhang,[32d] Z. Zhang,[114] L. Zhao,[107] T. Zhao,[137] Z. Zhao,[32b] A. Zhemchugov,[64] S. Zheng,[32a] J. Zhong,[150,ff] B. Zhou,[86] N. Zhou,[162] Y. Zhou,[150] C. G. Zhu,[32d] H. Zhu,[41] J. Zhu,[86] Y. Zhu,[171] X. Zhuang,[97] V. Zhuravlov,[98] D. Zieminska,[60] R. Zimmermann,[20]

S. Zimmermann,[20] S. Zimmermann,[47] M. Ziolkowski,[140] R. Zitoun,[4] L. Živković,[34] V. V. Zmouchko,[127,gg] G. Zobernig,[171] A. Zoccoli,[19a,19b] Y. Zolnierowski,[4] A. Zsenei,[29] M. zur Nedden,[15] V. Zutshi,[105] and L. Zwalinski[29]

(ATLAS Collaboration)

[1]*University at Albany, Albany, New York, USA*
[2]*Department of Physics, University of Alberta, Edmonton AB, Canada*
[3a]*Department of Physics, Ankara University, Ankara, Turkey*
[3b]*Department of Physics, Dumlupinar University, Kutahya, Turkey*
[3c]*Department of Physics, Gazi University, Ankara, Turkey*
[3d]*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[3e]*Turkish Atomic Energy Authority, Ankara, Turkey*
[4]*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
[5]*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
[6]*Department of Physics, University of Arizona, Tucson, Arizona, USA*
[7]*Department of Physics, The University of Texas at Arlington, Arlington, Texas, USA*
[8]*Physics Department, University of Athens, Athens, Greece*
[9]*Physics Department, National Technical University of Athens, Zografou, Greece*
[10]*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[11]*Institut de Física d'Altes Energies and Departament de Física de la Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain*
[12a]*Institute of Physics, University of Belgrade, Belgrade, Serbia*
[12b]*Vinca Institute of Nuclear Sciences, Belgrade, Serbia*
[13]*Department for Physics and Technology, University of Bergen, Bergen, Norway*
[14]*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, California, USA*
[15]*Department of Physics, Humboldt University, Berlin, Germany*
[16]*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
[17]*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
[18a]*Department of Physics, Bogazici University, Istanbul, Turkey*
[18b]*Division of Physics, Dogus University, Istanbul, Turkey*
[18c]*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
[18d]*Department of Physics, Istanbul Technical University, Istanbul, Turkey*
[19a]*INFN Sezione di Bologna, Bologna, Italy*
[19b]*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
[20]*Physikalisches Institut, University of Bonn, Bonn, Germany*
[21]*Department of Physics, Boston University, Boston, Massachusetts, USA*
[22]*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
[23a]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
[23b]*Federal University of Juiz de Fora (UFJF), Juiz de Fora, Brazil*
[23c]*Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei, Brazil*
[23d]*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*
[24]*Physics Department, Brookhaven National Laboratory, Upton, New York, USA*
[25a]*National Institute of Physics and Nuclear Engineering, Bucharest, Romania*
[25b]*University Politehnica Bucharest, Bucharest, Romania*
[25c]*West University in Timisoara, Timisoara, Romania*
[26]*Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina*
[27]*Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom*
[28]*Department of Physics, Carleton University, Ottawa ON, Canada*
[29]*CERN, Geneva, Switzerland*
[30]*Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA*
[31a]*Departamento de Fisica, Pontificia Universidad Católica de Chile, Santiago, Chile*
[31b]*Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile*
[32a]*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China*
[32b]*Department of Modern Physics, University of Science and Technology of China, Anhui, China*
[32c]*Department of Physics, Nanjing University, Jiangsu, China*
[32d]*High Energy Physics Group, Shandong University, Shandong, China*
[33]*Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France*
[34]*Nevis Laboratory, Columbia University, Irvington, New York, USA*

[35]*Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark*
[36a]*INFN Gruppo Collegato di Cosenza, Arcavata di Rende, Italy*
[36b]*Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy*
[37]*Faculty of Physics and Applied Computer Science, AGH–University of Science and Technology, Krakow, Poland*
[38]*The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
[39]*Physics Department, Southern Methodist University, Dallas, Texas, USA*
[40]*Physics Department, University of Texas at Dallas, Richardson, Texas, USA*
[41]*DESY, Hamburg and Zeuthen, Germany*
[42]*Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany*
[43]*Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany*
[44]*Department of Physics, Duke University, Durham, North Carolina, USA*
[45]*SUPA—School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom*
[46]*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
[47]*Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg i.Br., Germany*
[48]*Section de Physique, Université de Genève, Geneva, Switzerland*
[49a]*INFN Sezione di Genova, Genova, Italy*
[49b]*Dipartimento di Fisica, Università di Genova, Genova, Italy*
[50]*Institute of Physics and HEP Institute, Georgian Academy of Sciences and Tbilisi State University, Tbilisi, Georgia*
[51]*II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany*
[52]*SUPA—School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom*
[53]*II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany*
[54]*Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France*
[55]*Department of Physics, Hampton University, Hampton, Virginia, USA*
[56]*Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA*
[57a]*Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[57b]*Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany*
[57c]*ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany*
[58]*Faculty of Science, Hiroshima University, Hiroshima, Japan*
[59]*Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan*
[60]*Department of Physics, Indiana University, Bloomington, Indiana, USA*
[61]*Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria*
[62]*University of Iowa, Iowa City, Iowa, USA*
[63]*Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA*
[64]*Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia*
[65]*KEK, High Energy Accelerator Research Organization, Tsukuba, Japan*
[66]*Graduate School of Science, Kobe University, Kobe, Japan*
[67]*Faculty of Science, Kyoto University, Kyoto, Japan*
[68]*Kyoto University of Education, Kyoto, Japan*
[69]*Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina*
[70]*Physics Department, Lancaster University, Lancaster, United Kingdom*
[71a]*INFN Sezione di Lecce, Lecce, Italy*
[71b]*Dipartimento di Fisica, Università del Salento, Lecce, Italy*
[72]*Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom*
[73]*Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia*
[74]*Department of Physics, Queen Mary University of London, London, United Kingdom*
[75]*Department of Physics, Royal Holloway University of London, Surrey, United Kingdom*
[76]*Department of Physics and Astronomy, University College London, London, United Kingdom*
[77]*Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France*
[78]*Fysiska institutionen, Lunds universitet, Lund, Sweden*
[79]*Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain*
[80]*Institut für Physik, Universität Mainz, Mainz, Germany*
[81]*School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom*
[82]*CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France*
[83]*Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA*
[84]*Department of Physics, McGill University, Montreal QC, Canada*
[85]*School of Physics, University of Melbourne, Victoria, Australia*
[86]*Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA*
[87]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA*
[88a]*INFN Sezione di Milano, Milano, Italy*

[88b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[89]*B. I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus*
[90]*National Scientific and Educational center for Particle and High Energy Physics, Minsk, Republic of Belarus*
[91]*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
[92]*Group of Particle Physics, University of Montreal, Montreal QC, Canada*
[93]*P. N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia*
[94]*Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia*
[95]*Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia*
[96]*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
[97]*Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany*
[98]*Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany*
[99]*Nagasaki Institute of Applied Science, Nagasaki, Japan*
[100]*Graduate School of Science, Nagoya University, Nagoya, Japan*
[101a]*INFN Sezione di Napoli, Napoli, Italy*
[101b]*Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy*
[102]*Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA*
[103]*Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands*
[104]*Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands*
[105]*Department of Physics, Northern Illinois University, DeKalb, Illinois, USA*
[106]*Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia*
[107]*Department of Physics, New York University, New York, New York, USA*
[108]*Ohio State University, Columbus, Ohio, USA*
[109]*Faculty of Science, Okayama University, Okayama, Japan*
[110]*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA*
[111]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA*
[112]*Palacký University, RCPTM, Olomouc, Czech Republic*
[113]*Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA*
[114]*LAL, Univ. Paris-Sud and CNRS/IN2P3, Orsay, France*
[115]*Graduate School of Science, Osaka University, Osaka, Japan*
[116]*Department of Physics, University of Oslo, Oslo, Norway*
[117]*Department of Physics, Oxford University, Oxford, United Kingdom*
[118a]*INFN Sezione di Pavia, Pavia, Italy*
[118b]*Dipartimento di Fisica Nucleare e Teorica, Università di Pavia, Pavia, Italy*
[119]*Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA*
[120]*Petersburg Nuclear Physics Institute, Gatchina, Russia*
[121a]*INFN Sezione di Pisa, Pisa, Italy*
[121b]*Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy*
[122]*Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA*
[123a]*Laboratorio de Instrumentacao e Fisica Experimental de Particulas—LIP, Lisboa, Portugal*
[123b]*Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Portugal*
[124]*Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic*
[125]*Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic*
[126]*Czech Technical University in Prague, Praha, Czech Republic*
[127]*State Research Center Institute for High Energy Physics, Protvino, Russia*
[128]*Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[129]*Physics Department, University of Regina, Regina SK, Canada*
[130]*Ritsumeikan University, Kusatsu, Shiga, Japan*
[131a]*INFN Sezione di Roma I, Roma, Italy*
[131b]*Dipartimento di Fisica, Università La Sapienza, Roma, Italy*
[132a]*INFN Sezione di Roma Tor Vergata, Roma, Italy*
[132b]*Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[133a]*INFN Sezione di Roma Tre, Roma, Italy*
[133b]*Dipartimento di Fisica, Università Roma Tre, Roma, Italy*
[134a]*Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies–Université Hassan II, Casablanca, Morocco*
[134b]*Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco*
[134c]*Université Cadi Ayyad, Faculté des sciences Semlalia Département de Physique, B.P. 2390 Marrakech 40000, Morocco*
[134d]*Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco*
[134e]*Faculté des Sciences, Université Mohammed V, Rabat, Morocco*
[135]*DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France*

[136]*Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA*
[137]*Department of Physics, University of Washington, Seattle, Washington, USA*
[138]*Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
[139]*Department of Physics, Shinshu University, Nagano, Japan*
[140]*Fachbereich Physik, Universität Siegen, Siegen, Germany*
[141]*Department of Physics, Simon Fraser University, Burnaby BC, Canada*
[142]*SLAC National Accelerator Laboratory, Stanford, California, USA*
[143a]*Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic*
[143b]*Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
[144a]*Department of Physics, University of Johannesburg, Johannesburg, South Africa*
[144b]*School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
[145a]*Department of Physics, Stockholm University, Stockholm, Sweden*
[145b]*The Oskar Klein Centre, Stockholm, Sweden*
[146]*Physics Department, Royal Institute of Technology, Stockholm, Sweden*
[147]*Department of Physics and Astronomy, Stony Brook University, Stony Brook, New York, USA*
[148]*Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
[149]*School of Physics, University of Sydney, Sydney, Australia*
[150]*Institute of Physics, Academia Sinica, Taipei, Taiwan*
[151]*Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
[152]*Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[153]*Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[154]*International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
[155]*Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
[156]*Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
[157]*Department of Physics, University of Toronto, Toronto ON, Canada*
[158a]*TRIUMF, Vancouver BC, Canada*
[158b]*Department of Physics and Astronomy, York University, Toronto ON, Canada*
[159]*Institute of Pure and Applied Sciences, University of Tsukuba, Ibaraki, Japan*
[160]*Science and Technology Center, Tufts University, Medford, Massachusetts, USA*
[161]*Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia*
[162]*Department of Physics and Astronomy, University of California Irvine, Irvine California, USA*
[163a]*INFN Gruppo Collegato di Udine, Udine, Italy*
[163b]*ICTP, Trieste, Italy*
[163c]*Dipartimento di Fisica, Università di Udine, Udine, Italy*
[164]*Department of Physics, University of Illinois, Urbana, Illinois, USA*
[165]*Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
[166]*Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingenierá Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
[167]*Department of Physics, University of British Columbia, Vancouver BC, Canada*
[168]*Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada*
[169]*Waseda University, Tokyo, Japan*
[170]*Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*
[171]*Department of Physics, University of Wisconsin, Madison, Wisconsin, USA*
[172]*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
[173]*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[174]*Department of Physics, Yale University, New Haven, Connecticut, USA*
[175]*Yerevan Physics Institute, Yerevan, Armenia*
[176]*Domaine scientifique de la Doua, Centre de Calcul CNRS/IN2P3, Villeurbanne Cedex, France*

[a]Also at Laboratorio de Instrumentacao e Fisica Experimental de Particulas–LIP, Lisboa, Portugal.
[b]Also at Faculdade de Ciencias and CFNUL, Universidade de Lisboa, Lisboa, Portugal.
[c]Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.
[d]Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
[e]Also at TRIUMF, Vancouver BC, Canada.
[f]Also at Department of Physics, California State University, Fresno, CA, USA.
[g]Also at Faculty of Physics and Applied Computer Science, AGH-University of Science and Technology, Krakow, Poland.
[h]Also at Fermilab, Batavia, IL, USA.
[i]Also at Department of Physics, University of Coimbra, Coimbra, Portugal.
[j]Also at Università di Napoli Parthenope, Napoli, Italy.

[k]Also at Institute of Particle Physics (IPP), Canada.
[l]Also at Department of Physics, Middle East Technical University, Ankara, Turkey.
[m]Also at Louisiana Tech University, Ruston, LA, USA.
[n]Also at Group of Particle Physics, University of Montreal, Montreal QC, Canada.
[o]Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
[p]Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
[q]Also at Manhattan College, New York, NY, USA.
[r]Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.
[s]Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
[t]Also at High Energy Physics Group, Shandong University, Shandong, China.
[u]Also at Section de Physique, Université de Genève, Geneva, Switzerland.
[v]Also at Departamento de Fisica, Universidade de Minho, Braga, Portugal.
[w]Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.
[x]Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary.
[y]Also at California Institute of Technology, Pasadena, CA, USA.
[z]Also at Institute of Physics, Jagiellonian University, Krakow, Poland.
[aa]Also at Department of Physics, Oxford University, Oxford, United Kingdom.
[bb]Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
[cc]Also at Department of Physics, The University of Michigan, Ann Arbor, MI, USA.
[dd]Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France.
[ee]Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.
[ff]Also at Department of Physics, Nanjing University, Jiangsu, China.
[gg]Deceased.