Measurement of Inclusive *W* and *Z* Boson Production Cross Sections
in *pp* Collisions at $\sqrt{s} = 8$ TeV

S. Chatrchyan *et al.*[*]

(CMS Collaboration)

A measurement of total and fiducial inclusive *W* and *Z* boson production cross sections in *pp* collisions at $\sqrt{s} = 8$ TeV is presented. Electron and muon final states are analyzed in a data sample collected with the CMS detector corresponding to an integrated luminosity of 18.2 ± 0.5 pb^{-1}. The measured total inclusive cross sections times branching fractions are $\sigma(pp \to WX) \times \mathcal{B}(W \to \ell\nu) = 12.21 \pm 0.03(\text{stat}) \pm 0.24(\text{syst}) \pm 0.32(\text{lum})$ nb and $\sigma(pp \to ZX) \times \mathcal{B}(Z \to \ell^+\ell^-) = 1.15 \pm 0.01(\text{stat}) \pm 0.02(\text{syst}) \pm 0.03(\text{lum})$ nb for the dilepton mass in the range of 60—120 GeV. The measured values agree with next-to-next-to-leading-order QCD cross section calculations. Ratios of cross sections are reported with a precision of 2%. This is the first measurement of inclusive *W* and *Z* boson production in proton-proton collisions at $\sqrt{s} = 8$ TeV.

The production of *W* and *Z* bosons is one of the most prominent examples of hard scattering processes at hadron colliders [1]. Theoretical predictions are available at next-to-next-to-leading order (NNLO) [2–6] in perturbative quantum chromodynamics (QCD). The calculations are limited by uncertainties in parton distribution functions (PDFs), missing higher-order QCD effects, and electroweak (EW) radiative corrections, which are available at next-to-leading order (NLO) [7–10]. Precise measurements of inclusive cross sections provide tests of perturbative QCD and validate the theoretical predictions of higher-order corrections. Additionally, accurate measurements can be used to constrain PDFs.

Inclusive *W* and *Z* boson production cross sections and their ratios were previously measured by the ATLAS and CMS Collaborations at the Large Hadron Collider (LHC) in proton-proton collisions at $\sqrt{s} = 7$ TeV [11–13]. This Letter describes the inclusive measurement at $\sqrt{s} = 8$ TeV, performed in the electron and muon decay channels, with the CMS detector. A data sample collected in 2012 corresponding to an integrated luminosity of 18.2 ± 0.5 pb^{-1} is used.

The levels of instantaneous luminosity reached by the LHC in 2012 present challenges for the precise measurement of the *W* boson cross section because of the degraded missing transverse momentum resolution resulting from the large number of *pp* interactions per bunch crossing (pileup). A data sample with low pileup was collected in May 2012 by adjusting the beam separation during data taking. An average of 4 interactions per bunch crossing was achieved, compared with the average of 21 during the rest of 2012. The measurements of the *W* and *Z* boson production cross sections are performed using this data sample.

The central feature of the CMS apparatus is a superconducting solenoid, of 6 m internal diameter, providing a field of 3.8 T. Within the field volume are a silicon pixel and strip tracker, a crystal electromagnetic calorimeter (ECAL), and a brass or scintillator hadron calorimeter. Muons are measured in gas-ionization detectors embedded in the steel flux-return yoke of the magnet. CMS uses a right-handed coordinate system, with the origin at the nominal interaction point, the *x* axis pointing to the center of the LHC, the *y* axis pointing upwards, perpendicular to the plane of the LHC ring, and the *z* axis along the counterclockwise-beam direction. The polar angle θ is measured from the positive *z* axis, and the azimuthal angle ϕ is measured in the *x*-*y* plane. The pseudorapidity η is defined by $\eta = -\ln[\tan(\theta/2)]$. Details of the CMS detector and its performance can be found elsewhere [14].

Leptonic *W* boson decays are characterized by a prompt, energetic, and isolated charged lepton and a neutrino giving rise to significant missing transverse energy E_T^{miss}. Events used in the cross section measurement are not required to have a minimum reconstructed E_T^{miss}, but the E_T^{miss} distribution is used as a discriminant against background from multijet events. Z boson decays to leptons are selected by requiring two energetic and isolated leptons of the same flavor and opposite charge. The Z boson candidates are required to have a reconstructed dilepton mass of between 60 and 120 GeV. Samples of Z boson candidates satisfying looser lepton requirements are used to estimate efficiencies.

Because of the high rate of collisions and the limited bandwidth for data processing, the data acquisition system must be selective in deciding which events are sufficiently interesting to be kept for analysis. Triggers make rapid

---

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

decisions by executing simplified muon and electron reconstruction algorithms. For this analysis, the events are collected when triggered by the presence of a muon with large transverse momentum $p_T > 15$ GeV and $|\eta| < 2.1$ or an electron with large transverse energy $E_T > 22$ GeV and $|\eta| < 2.5$, with loose isolation and identification requirements.

Electrons are identified as clusters of energy deposits in the ECAL matched to tracks measured with the silicon tracker [15–19]. The ECAL fiducial region is defined by $|\eta| < 1.44$ (barrel) or $1.57 < |\eta| < 2.5$ (end cap), where η is the pseudorapidity of the energy cluster. The barrel-end cap transition region and the first ring of end cap trigger towers are excluded because they are partially obscured by cables and services exiting between the barrel and end caps. A cluster is considered to be within the acceptance of the ECAL if it is within the ECAL fiducial region and has transverse energy $E_T > 25$ GeV. Electrons are required to be isolated from other reconstructed particles in a cone of $\Delta R = 0.3$, where $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$. Particle candidates are identified using a particle-flow algorithm [20,21] that provides a complete description of the event in terms of electrons, muons, photons, charged hadrons, and neutral hadrons. An electron candidate is selected if the sum of transverse momenta of particles in the cone is less than 15% of the candidate's transverse energy.

Muons are reconstructed from seed tracks in the muon detector combined with silicon strip and pixel information using a global fit [22,23]. In the p_T range of interest, the momentum resolution is driven by the inner tracking system. Muons with $p_T > 25$ GeV and $|\eta| < 2.1$ are selected, which is consistent with the acceptance of the single muon trigger. A relative isolation variable is computed as discussed for electrons, but in a cone of radius $\Delta R = 0.4$ and with an isolation selection requirement of less than 12%.

The acceptance for W or Z boson events is the fraction of generated events for which the leptons satisfy the restrictions on η and p_T. The event selection criteria will select a subset of the accepted events, and the efficiency specifies the fraction of events selected. This accounts, for example, for the region of the ECAL from $1.44 < |\eta| < 1.55$. Other effects, such as crystal boundaries, are accounted for in the efficiency to reconstruct leptons. Using this acceptance definition, we are able to separate experimental from theoretical uncertainties in the measurement. The detector response is simulated using a detailed description of the CMS detector, based on the GEANT4 package [24]. Additional proton-proton interactions are taken into account using an admixture of simulated minimum bias events, and same reconstruction code is applied for data and simulated events. Data to simulation ratios of efficiencies are used as scale factors. No single event generator gives a reliable description of both EW and QCD effects. The acceptance is estimated using Monte Carlo simulation

based on POWHEG [25–28]. The effects of nonperturbative QCD, higher-order QCD, and electroweak corrections on the estimated acceptance are investigated using specific simulation tools, from which uncertainties are derived [7–10,29,30]. The uncertainty related to the PDFs is estimated following closely the prescription of the PDF4LHC working group [31] to combine uncertainties related to the choice of the NLO PDF and the strong coupling constant α_s.

The W boson candidate events are required to have an identified electron or muon. The W boson signal and background yields are obtained from the E_T^{miss} distributions using a binned maximum-likelihood fit. The missing transverse energy is calculated with the particle-flow algorithm by adding the transverse energy vectors of all identified particles. An accurate E_T^{miss} measurement is essential to distinguish the W signal from QCD multijet backgrounds. To account for shortcomings of the simulation in modeling the recoil against the W boson, a correction is derived from a Z boson sample. The recoil in these events is studied, in data as well as in simulation, and the differences are propagated to the W boson simulation as a function of the p_T of the generated W or Z boson. Other background processes from $W \to \tau\nu$, Drell-Yan, diboson, and top-pair production also become significant at high E_T^{miss}, contributing about 6% of the total selected yield. The background contribution from cosmic rays in the $W \to \mu\nu$ channel is negligible. The E_T^{miss} model is fitted to the observed distribution as the sum of three contributions: the W signal, the QCD background, and other backgrounds. The QCD background is modeled by an analytic function, while the signal and EW backgrounds are modeled with simulation-based fitting functions [11]. The EW contributions are normalized to the W signal yield in the fit through the ratios of the theoretical cross sections. Figure 1 shows the E_T^{miss} distributions of the inclusive W boson samples and the results of the fit.

To extract the Z boson yield, the events in the dilepton mass window are counted. The yields contain a contribution of 3% from γ^*-mediated processes, including interference effects, as estimated with MCFM [32]. Background contamination is estimated from simulation to be about 0.4%. Figure 2 shows the dilepton mass distributions of the inclusive Z samples. The signal yields, the acceptances, and the efficiencies are summarized in the Supplemental Material [33].

The systematic uncertainties are summarized in Table I for the electron and muon channels. The methods used to extract the systematic uncertainties for the acceptance, efficiency, and signal extraction follow closely the W and Z boson cross section measurements performed at $\sqrt{s} = 7$ TeV [11]. The leading experimental uncertainty comes from the measurement of the lepton reconstruction and identification efficiency. Other uncertainties come from the integrated luminosity of the data sample and
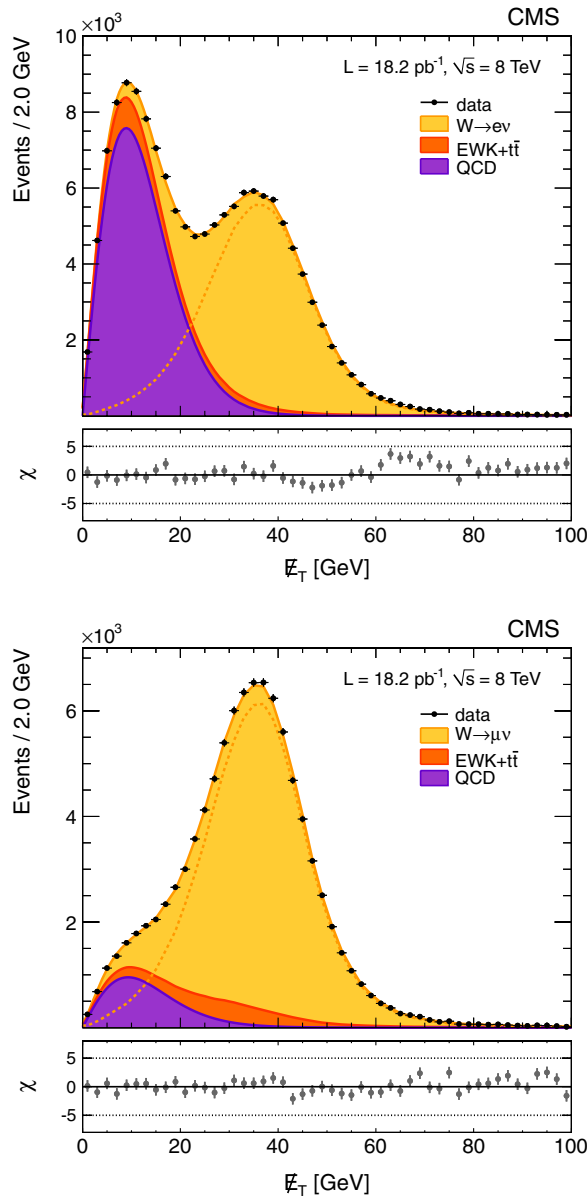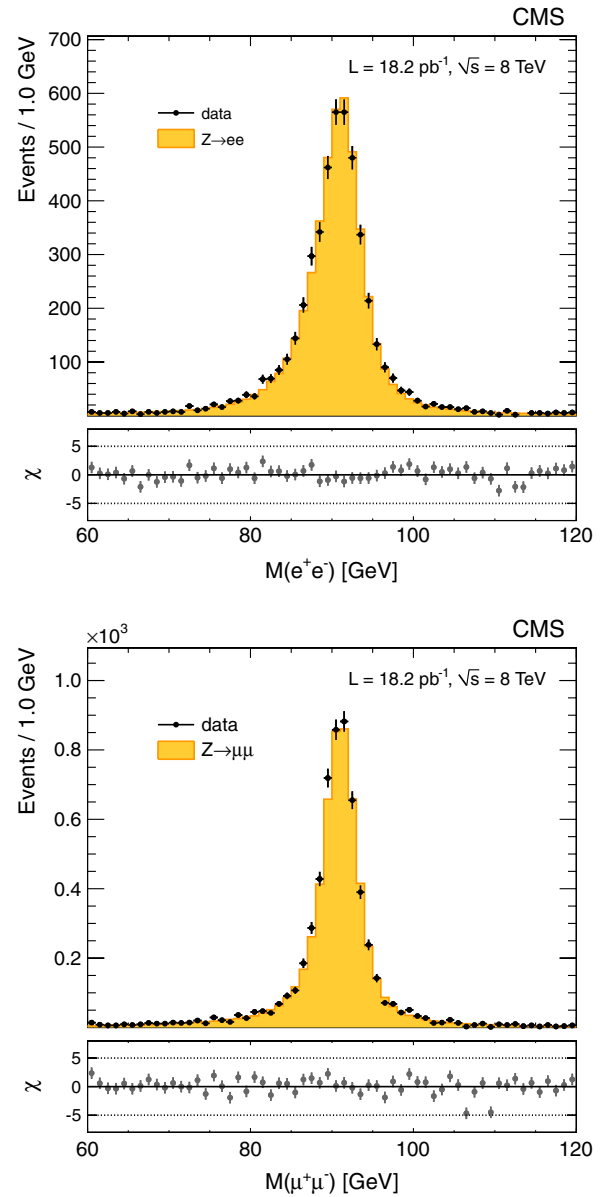
FIG. 1 (color online). The missing transverse energy distributions for W boson candidate events in the electron (top) and muon (bottom) final states. The variable χ shown in the lower plot is defined as $(N_{\mathrm{obs}} - N_{\mathrm{exp}})/\sqrt{N_{\mathrm{obs}}}$, where N_{obs} is the number of observed events and N_{exp} is the total of the fitted signal and background yields.

FIG. 2 (color online). The dilepton mass distributions for Z boson candidate events in the electron (top) and muon (bottom) final states. The variable χ shown in the lower plot is defined as $(N_{\mathrm{obs}} - N_{\mathrm{exp}})/\sqrt{N_{\mathrm{obs}}}$, where N_{obs} is the number of observed events and N_{exp} is the total of the signal and background yields.

theoretical uncertainties, which are dominated by the PDF uncertainties.

The luminosity of the data sample is measured with an uncertainty of 2.6% by counting the number of clusters per event in the silicon pixel detector. The highly granular detector, consisting of ~60 million channels, guarantees an excellent linearity of the pixel detector response versus pileup. The method is calibrated by means of a procedure pioneered by van der Meer [40], consisting of beam scans along the vertical and horizontal directions. This van der Meer technique determines the luminosity at the percent

level from a measurement of the beam parameters [41]. The dominant contribution to the luminosity uncertainty originates from the assumptions on the functional form of the beam shapes.

The theoretical predictions of cross sections and cross section ratios are computed at NNLO with the program FEWZ [42] and the MSTW2008 [43] set of PDFs. The uncertainties in these predictions, at the 68% confidence level (CL), include contributions from the uncertainty of the strong coupling constant α_s [44,45], the choice of heavy-quark masses (charm and bottom quarks) [46], as well as neglected higher-order corrections beyond NNLO,

TABLE I. Systematic uncertainties in percent for the electron and muon channels; "…" means that the source either does not apply or is negligible.

Sources	W^+ e	W^+ μ	W^- e	W^- μ	W e	W μ	W^+/W^- e	W^+/W^- μ	Z e	Z μ	W/Z e	W/Z μ
Lepton reconstruction and identification	2.8	1.0	2.5	0.9	2.5	1.0	3.8	1.2	2.8	1.1	3.8	1.5
Momentum scale and resolution	0.4	0.3	0.7	0.3	0.5	0.3	0.3	0.1	…	…	0.5	0.3
E_T^{miss} scale and resolution	0.8	0.5	0.7	0.5	0.8	0.5	0.3	0.1	…	…	0.8	0.5
Background subtraction/modeling	0.2	0.2	0.3	0.1	0.3	0.1	0.1	0.2	0.4	0.4	0.5	0.4
Total experimental	3.0	1.2	2.7	1.1	2.7	1.2	3.8	1.2	2.8	1.2	3.9	1.7
Theoretical uncertainty	2.1	2.0	2.6	2.5	2.7	2.2	1.5	1.4	2.6	1.9	2.0	2.5
Luminosity	2.6	2.6	2.6	2.6	2.6	2.6	…	…	2.6	2.6	…	…
Total	4.5	3.5	4.6	3.8	4.6	3.6	4.1	1.8	4.6	3.4	4.4	3.0

which are estimated by allowing the renormalization and factorization scales to vary. The NNLO predictions for the total cross sections times branching fractions are 7.12 ± 0.20 nb for W^+, 5.06 ± 0.13 nb for W^-, and 1.13 ± 0.04 nb for Z boson production. The Z boson cross section requires an invariant mass within the range 60—120 GeV, and it includes the effects of virtual photons.

The results in the electron and muon decay channels are compatible with a p value of 0.42. Assuming universality of lepton couplings to W and Z bosons, the channels are combined by calculating an average cross section value weighted by their statistical and systematic uncertainties, taking into account the correlated uncertainties. The two leptonic decay channels are combined by assuming fully correlated uncertainties for the acceptance and luminosity, but with other uncertainties assumed to be uncorrelated.

In measurements of the ratios of cross sections some systematic uncertainties cancel, most importantly the uncertainty in the luminosity. The uncertainties in the lepton reconstruction and identification are treated as uncorrelated, and the resulting experimental uncertainty in the ratio measurements can, therefore, be larger than that for individual cross section measurements. A summary of the measurements is given in Table II, including the results

obtained within the fiducial regions in p_T and η. See Supplemental Material [33] for the total cross sections times branching fractions and ratios for the electron and muon decay channels.

The upper two plots in Fig. 3 show the measured and predicted W versus Z and W^+ versus W^- cross sections for different PDF sets. The uncertainties in the theoretical predictions correspond to the PDF uncertainties only. This approach eliminates the need to propagate acceptance uncertainties originating from the PDFs and higher-order corrections into the measurement. The final measurement is compared with the predicted cross sections in the acceptance region for three different PDFs with their respective uncertainty bands propagated through the prediction.

In summary, we have performed the first measurements of total and fiducial inclusive W and Z production cross sections times branching fractions in pp collisions at $\sqrt{s} = 8$ TeV using 18.2 ± 0.5 pb^{-1} of low-pileup data recorded with the CMS detector. The W and Z bosons are observed via their decays to electrons and muons. The measured total inclusive production cross sections times branching fractions are $\sigma(pp \to WX) \times \mathcal{B}(W \to \ell\nu) = 12.21 \pm 0.03(\mathrm{stat}) \pm 0.24(\mathrm{syst}) \pm 0.32(\mathrm{lum})$ nb and, for the dilepton mass in the range of 60–120 GeV, $\sigma(pp \to ZX) \times \mathcal{B}(Z \to \ell^+\ell^-) = 1.15 \pm 0.01(\mathrm{stat}) \pm 0.02(\mathrm{syst}) \pm 0.03(\mathrm{lum})$ nb. In addition

TABLE II. Summary of total and fiducial W^+, W^-, W, and Z production cross sections times branching fractions, W to Z and W^+ to W^- ratios, and their theoretical predictions.

Channel	$\sigma \times \mathcal{B}$ [nb] (total)	NNLO [nb]	Quantity	Ratio (total)	NNLO
W^+	$7.11 \pm 0.03(\mathrm{stat}) \pm 0.14(\mathrm{syst}) \pm 0.18(\mathrm{lum})$	7.12 ± 0.20	R_{W^+/W^-}	$1.39 \pm 0.01(\mathrm{stat}) \pm 0.02(\mathrm{syst})$	1.41 ± 0.01
W^-	$5.09 \pm 0.02(\mathrm{stat}) \pm 0.11(\mathrm{syst}) \pm 0.13(\mathrm{lum})$	5.06 ± 0.13	$R_{W/Z}$	$10.63 \pm 0.11(\mathrm{stat}) \pm 0.25(\mathrm{syst})$	10.74 ± 0.04
W	$12.21 \pm 0.03(\mathrm{stat}) \pm 0.24(\mathrm{syst}) \pm 0.32(\mathrm{lum})$	12.18 ± 0.32			
Z	$1.15 \pm 0.01(\mathrm{stat}) \pm 0.02(\mathrm{syst}) \pm 0.03(\mathrm{lum})$	1.13 ± 0.04			

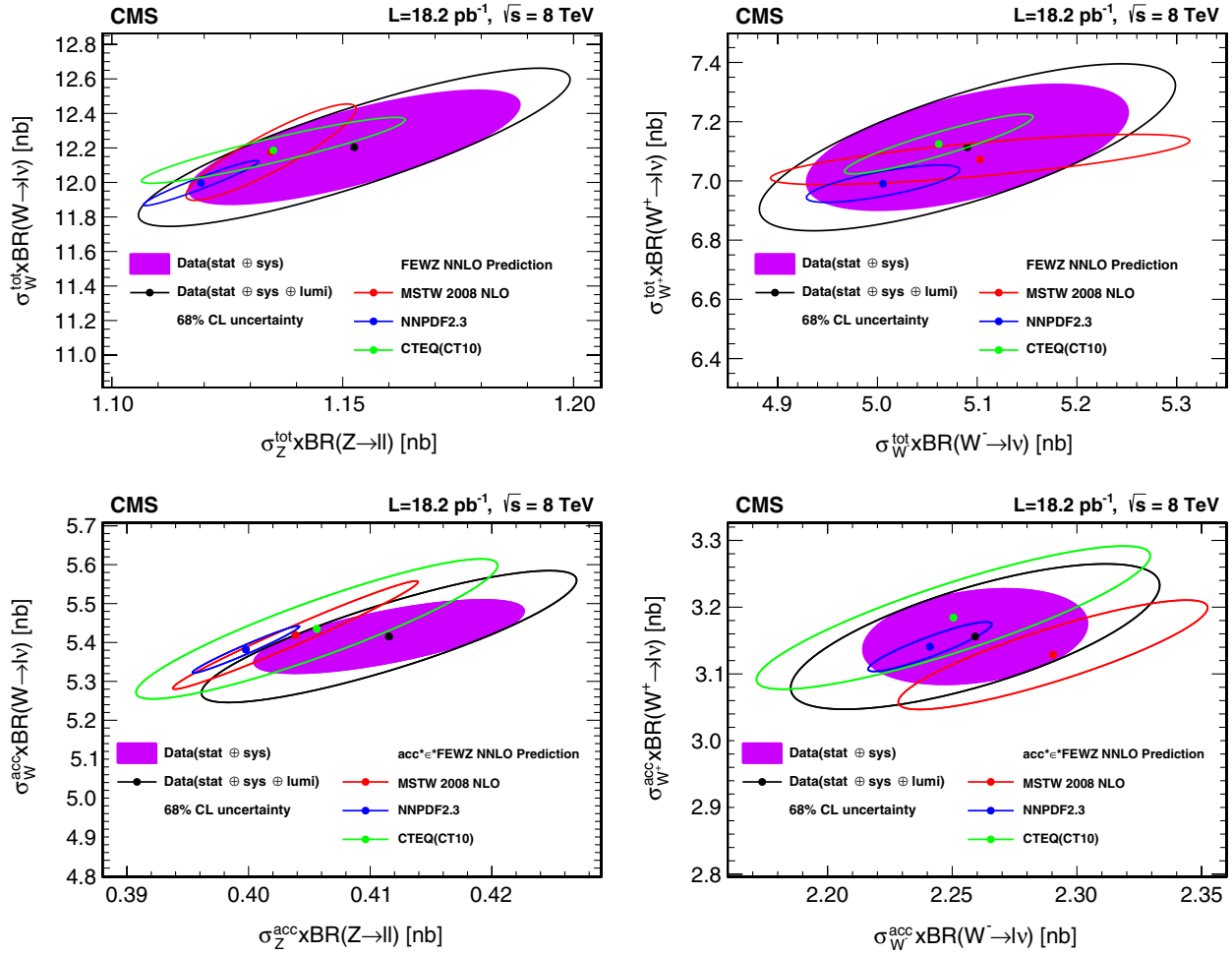| Channel	$\sigma \times \mathcal{B}$ [nb] (fiducial)	NNLO [nb]	Quantity	Ratio (fiducial)	NNLO
W^+	$3.16 \pm 0.01(\mathrm{stat}) \pm 0.04(\mathrm{syst}) \pm 0.08(\mathrm{lum})$	3.18 ± 0.10	R_{W^+/W^-}	$1.40 \pm 0.01(\mathrm{stat}) \pm 0.02(\mathrm{syst})$	1.42 ± 0.02
W^-	$2.26 \pm 0.01(\mathrm{stat}) \pm 0.02(\mathrm{syst}) \pm 0.06(\mathrm{lum})$	2.25 ± 0.07	$R_{W/Z}$	$13.26 \pm 0.15(\mathrm{stat}) \pm 0.21(\mathrm{syst})$	13.49 ± 0.28
W	$5.42 \pm 0.02(\mathrm{stat}) \pm 0.06(\mathrm{syst}) \pm 0.14(\mathrm{lum})$	5.43 ± 0.16			
Z	$0.41 \pm 0.01(\mathrm{stat}) \pm 0.01(\mathrm{syst}) \pm 0.01(\mathrm{lum})$	0.40 ± 0.01			

FIG. 3 (color online). Measured and predicted W versus Z boson (left column) and W^+ versus W^- boson (right column) production cross sections times branching fractions. The ellipses illustrate the 68% CL coverage for total uncertainties (open) and excluding the luminosity uncertainty (filled). The top row shows the inclusive cross sections times branching fractions and the bottom row shows the results within the fiducial regions. The uncertainties in the theoretical predictions correspond to the PDF uncertainty components only and are evaluated for MSTW 2008 NLO [43], NNPDF 2.3 [47], and CT10 [48].

to the inclusive cross sections, we present ratios of cross sections measured with a precision of 2%. The measurements in the electron and muon channels are consistent and in agreement with NNLO calculations. Additional figures summarizing our measurements are available in the Supplemental Material [33].

We congratulate our colleagues in the CERN accelerator departments for the excellent performance of the LHC and thank the technical and administrative staffs at CERN and at other CMS institutes for their contributions to the success of the CMS effort. In addition, we gratefully acknowledge the computing centers and personnel of the Worldwide LHC Computing Grid for delivering so effectively the computing infrastructure essential to our analyses. Finally, we acknowledge the enduring support for the construction and operation of the LHC and the CMS detector provided by the following funding agencies: BMWF and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES,

[1] S. D. Drell and T.-M. Yan, Phys. Rev. Lett. **25**, 316 (1970).
[2] P. J. Rijken and W. L. van Neerven, Phys. Rev. D **51**, 44 (1995).
[3] R. Hamberg, W. L. van Neerven, and T. Matsuura, Nucl. Phys. **B359**, 343 (1991).
[4] W. L. van Neerven and E. B. Zijlstra, Nucl. Phys. **B382**, 11 (1992).
[5] R. V. Harlander and W. B. Kilgore, Phys. Rev. Lett. **88**, 201801 (2002).
[6] C. Anastasiou, L. Dixon, K. Melnikov, and F. Petriello, Phys. Rev. D **69**, 094008 (2004).
[7] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and A. Vicini, J. High Energy Phys. 10 (2007) 109.
[8] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and A. Vicini, J. High Energy Phys. 12 (2006) 016.
[9] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and M. Treccani, J. High Energy Phys. 05 (2005) 019.
[10] C. M. Carloni Calame, G. Montagna, O. Nicrosini, and M. Treccani, Phys. Rev. D **69**, 037301 (2004).
[11] CMS Collaboration, J. High Energy Phys. 10 (2011) 132.
[12] CMS Collaboration, J. High Energy Phys. 08 (2011) 117.
[13] G. Aad et al. (ATLAS Collaboration), Phys. Rev. D **85**, 072004 (2012).
[14] CMS Collaboration, JINST **3**, S08004 (2008).
[15] W. Adam, R. Frühwirth, A. Strandlie, and T. Todor, Technical Report CMS-NOTE-2005-001 (2005).
[16] CMS Collaboration, Eur. Phys. J. C **70**, 1165 (2010).
[17] CMS Collaboration, JINST **8**, P09009 (2013).
[18] CMS Collaboration, Phys. Rev. Lett. **106**, 082001 (2011).
[19] S. Baffioni, C. Charlot, F. Ferri, D. Futyan, P. Meridiani, I. Puljak, C. Rovelli, R. Salerno, and Y. Sirois, Eur. Phys. J. C **49**, 1099 (2007).
[20] CMS Collaboration, CMS Physics Analysis Summary Report No. CMS-PAS-PFT-10-001 (2010); http://cdsweb.cern.ch/record/1247373.
[21] CMS Collaboration, CMS Physics Analysis Summary Report No. CMS-PAS-PFT-10-003 (2010); http://cdsweb.cern.ch/record/1279347.
[22] CMS Collaboration, CMS Physics Analysis Summary Report No. CMS-PAS-MUO-10-002 (2010); http://cdsweb.cern.ch/record/1279140.
[23] CMS Collaboration, JINST **5**, T03022 (2010).
[24] S. Agostinelli et al. (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[25] S. Alioli, P. Nason, C. Oleari, and E. Re, J. High Energy Phys. 07 (2008) 060.
[26] P. Nason, J. High Energy Phys. 11 (2004) 040.

[27] S. Frixione, P. Nason, and C. Oleari, J. High Energy Phys. 11 (2007) 070.
[28] S. Alioli, P. Nason, C. Oleari, and E. Re, J. High Energy Phys. 06 (2010) 043.
[29] C. Balázs and C.-P. Yuan, Phys. Rev. D **56**, 5558 (1997).
[30] E. Barberio, B. van Eijk, and Z. Wąs, Comput. Phys. Commun. **66**, 115 (1991).
[31] M. Botje, J. Butterworth, A. Cooper-Sarkar, A. de Roeck, J. Feltesse, S. Forte, A. Glazov, J. Huston, R. McNulty, T. Sjöstrand, and R. Thorne, arXiv:1101.0538.
[32] J. M. Campbell and R. K. Ellis, Nucl. Phys. B, Proc. Suppl. **205–206**, 10 (2010).
[33] See Supplemental Material at http://link.aps.org/supplemental/10.1103/PhysRevLett.112.191802 for additional information on signal yields, acceptances, and efficiencies; cross sections times branching fractions and ratios for the electron and muon channels; and figures summarizing the results, which includes Refs. [34–39].
[34] C. Albajar et al. (UA1 Collaboration), Phys. Lett. B **198**, 271 (1987).
[35] C. Albajar et al. (UA2 Collaboration), Phys. Lett. B **276**, 365 (1992).
[36] F. Abe et al. (CDF Collaboration), Phys. Rev. Lett. **76**, 3070 (1996).
[37] F. Abe et al. (CDF Collaboration), Phys. Rev. D **59**, 052002 (1999).
[38] A. Abulencia et al. (CDF Collaboration), J. Phys. G **34**, 2457 (2007).
[39] B. Abbott et al. (D0 Collaboration), Phys. Rev. D **61**, 072001 (2000).
[40] S. van der Meer, Technical Report CERN-ISR-PO-68-31, ISR-PO-68-31 (1968); http://cdsweb.cern.ch/record/1482193.
[41] CMS Collaboration, CMS Physics Analysis Summary Report No. CMS-PAS-LUM-12-001 (2012).
[42] K. Melnikov and F. Petriello, Phys. Rev. Lett. **96**, 231803 (2006).
[43] A. D. Martin, W. J. Stirling, R. S. Thorne, and G. Watt, Eur. Phys. J. C **63**, 189 (2009).
[44] A. Martin, W. Stirling, R. Thorne, and G. Watt, Eur. Phys. J. C **64**, 653 (2009).
[45] G. Watt, J. High Energy Phys. 09 (2011) 069.
[46] A. Martin, W. Stirling, R. Thorne, and G. Watt, Eur. Phys. J. C **70**, 51 (2010).
[47] R. D. Ball, V. Bertone, S. Carrazza, C. S. Deans, L. Del Debbio, S. Forte, A. Guffanti, N. P. Hartland, J. I. Latorre, J. Rojo, and M. Ubiali, Nucl. Phys. **B867**, 244 (2013).
[48] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P. M. Nadolsky, J. Pumplin, and C.-P. Yuan, Phys. Rev. D **82**, 074024 (2010).

S. Chatrchyan,[1] V. Khachatryan,[1] A. M. Sirunyan,[1] A. Tumasyan,[1] W. Adam,[2] T. Bergauer,[2] M. Dragicevic,[2] J. Erö,[2]
C. Fabjan,[2,b] M. Friedl,[2] R. Frühwirth,[2,b] V. M. Ghete,[2] N. Hörmann,[2] J. Hrubec,[2] M. Jeitler,[2,b] W. Kiesenhofer,[2] V. Knünz,[2]
M. Krammer,[2,b] I. Krätschmer,[2] D. Liko,[2] I. Mikulec,[2] D. Rabady,[2,c] B. Rahbaran,[2] C. Rohringer,[2] H. Rohringer,[2]
R. Schöfbeck,[2] J. Strauss,[2] A. Taurok,[2] W. Treberer-Treberspurg,[2] W. Waltenberger,[2] C.-E. Wulz,[2,b] V. Mossolov,[3]
N. Shumeiko,[3] J. Suarez Gonzalez,[3] S. Alderweireldt,[4] M. Bansal,[4] S. Bansal,[4] T. Cornelis,[4] E. A. De Wolf,[4] X. Janssen,[4]

A. Knutsson,[4] S. Luyckx,[4] L. Mucibello,[4] S. Ochesanu,[4] B. Roland,[4] R. Rougny,[4] H. Van Haevermaet,[4] P. Van Mechelen,[4] N. Van Remortel,[4] A. Van Spilbeeck,[4] F. Blekman,[5] S. Blyweert,[5] J. D'Hondt,[5] A. Kalogeropoulos,[5] J. Keaveney,[5] M. Maes,[5] A. Olbrechts,[5] S. Tavernier,[5] W. Van Doninck,[5] P. Van Mulders,[5] G. P. Van Onsem,[5] I. Villella,[5] B. Clerbaux,[6] G. De Lentdecker,[6] L. Favart,[6] A. P. R. Gay,[6] T. Hreus,[6] A. Léonard,[6] P. E. Marage,[6] A. Mohammadi,[6] L. Perniè,[6] T. Reis,[6] T. Seva,[6] L. Thomas,[6] C. Vander Velde,[6] P. Vanlaer,[6] J. Wang,[6] V. Adler,[7] K. Beernaert,[7] L. Benucci,[7] A. Cimmino,[7] S. Costantini,[7] S. Dildick,[7] G. Garcia,[7] B. Klein,[7] J. Lellouch,[7] A. Marinov,[7] J. Mccartin,[7] A. A. Ocampo Rios,[7] D. Ryckbosch,[7] M. Sigamani,[7] N. Strobbe,[7] F. Thyssen,[7] M. Tytgat,[7] S. Walsh,[7] E. Yazgan,[7] N. Zaganidis,[7] S. Basegmez,[8] C. Beluffi,[8,d] G. Bruno,[8] R. Castello,[8] A. Caudron,[8] L. Ceard,[8] C. Delaere,[8] T. du Pree,[8] D. Favart,[8] L. Forthomme,[8] A. Giammanco,[8,e] J. Hollar,[8] V. Lemaitre,[8] J. Liao,[8] O. Militaru,[8] C. Nuttens,[8] D. Pagano,[8] A. Pin,[8] K. Piotrzkowski,[8] A. Popov,[8,f] M. Selvaggi,[8] J. M. Vizan Garcia,[8] N. Beliy,[9] T. Caebergs,[9] E. Daubie,[9] G. H. Hammad,[9] G. A. Alves,[10] M. Correa Martins Junior,[10] T. Martins,[10] M. E. Pol,[10] M. H. G. Souza,[10] W. L. Aldá Júnior,[11] W. Carvalho,[11] J. Chinellato,[11,g] A. Custódio,[11] E. M. Da Costa,[11] D. De Jesus Damiao,[11] C. De Oliveira Martins,[11] S. Fonseca De Souza,[11] H. Malbouisson,[11] M. Malek,[11] D. Matos Figueiredo,[11] L. Mundim,[11] H. Nogima,[11] W. L. Prado Da Silva,[11] A. Santoro,[11] L. Soares Jorge,[11] A. Sznajder,[11] E. J. Tonelli Manganote,[11,g] A. Vilela Pereira,[11] T. S. Anjos,[12b] C. A. Bernardes,[12b] F. A. Dias,[12a,h] T. R. Fernandez Perez Tomei,[12a] E. M. Gregores,[12b] C. Lagana,[12a] F. Marinho,[12a] P. G. Mercadante,[12b] S. F. Novaes,[12a] Sandra S. Padula,[12a] V. Genchev,[13,c] P. Iaydjiev,[13,c] S. Piperov,[13] M. Rodozov,[13] G. Sultanov,[13] M. Vutova,[13] A. Dimitrov,[14] R. Hadjiiska,[14] V. Kozhuharov,[14] L. Litov,[14] B. Pavlov,[14] P. Petkov,[14] J. G. Bian,[15] G. M. Chen,[15] H. S. Chen,[15] C. H. Jiang,[15] D. Liang,[15] S. Liang,[15] X. Meng,[15] J. Tao,[15] J. Wang,[15] X. Wang,[15] Z. Wang,[15] H. Xiao,[15] M. Xu,[15] C. Asawatangtrakuldee,[16] Y. Ban,[16] Y. Guo,[16] Q. Li,[16] W. Li,[16] S. Liu,[16] Y. Mao,[16] S. J. Qian,[16] D. Wang,[16] L. Zhang,[16] W. Zou,[16] C. Avila,[17] C. A. Carrillo Montoya,[17] J. P. Gomez,[17] B. Gomez Moreno,[17] J. C. Sanabria,[17] N. Godinovic,[18] D. Lelas,[18] R. Plestina,[18,i] D. Polic,[18] I. Puljak,[18] Z. Antunovic,[19] M. Kovac,[19] V. Brigljevic,[20] S. Duric,[20] K. Kadija,[20] J. Luetic,[20] D. Mekterovic,[20] S. Morovic,[20] L. Tikvica,[20] A. Attikis,[21] G. Mavromanolakis,[21] J. Mousa,[21] C. Nicolaou,[21] F. Ptochos,[21] P. A. Razis,[21] M. Finger,[22] M. Finger Jr.,[22] A. A. Abdelalim,[23,j] Y. Assran,[23,k] A. Ellithi Kamel,[23,l] M. A. Mahmoud,[23,m] A. Radi,[23,n,o] M. Kadastik,[24] M. Müntel,[24] M. Murumaa,[24] M. Raidal,[24] L. Rebane,[24] A. Tiko,[24] P. Eerola,[25] G. Fedi,[25] M. Voutilainen,[25] J. Härkönen,[26] V. Karimäki,[26] R. Kinnunen,[26] M. J. Kortelainen,[26] T. Lampén,[26] K. Lassila-Perini,[26] S. Lehti,[26] T. Lindén,[26] P. Luukka,[26] T. Mäenpää,[26] T. Peltola,[26] E. Tuominen,[26] J. Tuominiemi,[26] E. Tuovinen,[26] L. Wendland,[26] A. Korpela,[27] T. Tuuva,[27] M. Besancon,[28] S. Choudhury,[28] F. Couderc,[28] M. Dejardin,[28] D. Denegri,[28] B. Fabbro,[28] J. L. Faure,[28] F. Ferri,[28] S. Ganjour,[28] A. Givernaud,[28] P. Gras,[28] G. Hamel de Monchenault,[28] P. Jarry,[28] E. Locci,[28] J. Malcles,[28] L. Millischer,[28] A. Nayak,[28] J. Rander,[28] A. Rosowsky,[28] M. Titov,[28] S. Baffioni,[29] F. Beaudette,[29] L. Benhabib,[29] L. Bianchini,[29] M. Bluj,[29,p] P. Busson,[29] C. Charlot,[29] N. Daci,[29] T. Dahms,[29] M. Dalchenko,[29] L. Dobrzynski,[29] A. Florent,[29] R. Granier de Cassagnac,[29] M. Haguenauer,[29] P. Miné,[29] C. Mironov,[29] I. N. Naranjo,[29] M. Nguyen,[29] C. Ochando,[29] P. Paganini,[29] D. Sabes,[29] R. Salerno,[29] Y. Sirois,[29] C. Veelken,[29] A. Zabi,[29] J.-L. Agram,[30,q] J. Andrea,[30] D. Bloch,[30] D. Bodin,[30] J.-M. Brom,[30] E. C. Chabert,[30] C. Collard,[30] E. Conte,[30,q] F. Drouhin,[30,q] J.-C. Fontaine,[30,q] D. Gelé,[30] U. Goerlach,[30] C. Goetzmann,[30] P. Juillot,[30] A.-C. Le Bihan,[30] P. Van Hove,[30] S. Gadrat,[31] S. Beauceron,[32] N. Beaupere,[32] G. Boudoul,[32] S. Brochet,[32] J. Chasserat,[32] R. Chierici,[32] D. Contardo,[32] P. Depasse,[32] H. El Mamouni,[32] J. Fay,[32] S. Gascon,[32] M. Gouzevitch,[32] B. Ille,[32] T. Kurca,[32] M. Lethuillier,[32] L. Mirabito,[32] S. Perries,[32] L. Sgandurra,[32] V. Sordini,[32] Y. Tschudi,[32] M. Vander Donckt,[32] P. Verdier,[32] S. Viret,[32] Z. Tsamalaidze,[33,r] C. Autermann,[34] S. Beranek,[34] B. Calpas,[34] M. Edelhoff,[34] L. Feld,[34] N. Heracleous,[34] O. Hindrichs,[34] K. Klein,[34] J. Merz,[34] A. Ostapchuk,[34] A. Perieanu,[34] F. Raupach,[34] J. Sammet,[34] S. Schael,[34] D. Sprenger,[34] H. Weber,[34] B. Wittmer,[34] V. Zhukov,[34,f] M. Ata,[35] J. Caudron,[35] E. Dietz-Laursonn,[35] D. Duchardt,[35] M. Erdmann,[35] R. Fischer,[35] A. Güth,[35] T. Hebbeker,[35] C. Heidemann,[35] K. Hoepfner,[35] D. Klingebiel,[35] P. Kreuzer,[35] M. Merschmeyer,[35] A. Meyer,[35] M. Olschewski,[35] K. Padeken,[35] P. Papacz,[35] H. Pieta,[35] H. Reithler,[35] S. A. Schmitz,[35] L. Sonnenschein,[35] J. Steggemann,[35] D. Teyssier,[35] S. Thüer,[35] M. Weber,[35] V. Cherepanov,[36] Y. Erdogan,[36] G. Flügge,[36] H. Geenen,[36] M. Geisler,[36] W. Haj Ahmad,[36] F. Hoehle,[36] B. Kargoll,[36] T. Kress,[36] Y. Kuessel,[36] J. Lingemann,[36,c] A. Nowack,[36] I. M. Nugent,[36] L. Perchalla,[36] O. Pooth,[36] A. Stahl,[36] M. Aldaya Martin,[37] I. Asin,[37] N. Bartosik,[37] J. Behr,[37] W. Behrenhoff,[37] U. Behrens,[37] M. Bergholz,[37,s] A. Bethani,[37] K. Borras,[37] A. Burgmeier,[37] A. Cakir,[37] L. Calligaris,[37] A. Campbell,[37] F. Costanza,[37] C. Diez Pardos,[37] T. Dorland,[37] G. Eckerlin,[37] D. Eckstein,[37] G. Flucke,[37] A. Geiser,[37] I. Glushkov,[37] P. Gunnellini,[37] S. Habib,[37] J. Hauk,[37] G. Hellwig,[37] H. Jung,[37] M. Kasemann,[37] P. Katsas,[37] C. Kleinwort,[37] H. Kluge,[37] M. Krämer,[37] D. Krücker,[37] E. Kuznetsova,[37] W. Lange,[37] J. Leonard,[37] K. Lipka,[37] W. Lohmann,[37,s] B. Lutz,[37] R. Mankel,[37]

PHYSICAL REVIEW LETTERS

I. Marfin,[37] I.-A. Melzer-Pellmann,[37] A. B. Meyer,[37] J. Mnich,[37] A. Mussgiller,[37] S. Naumann-Emme,[37] O. Novgorodova,[37] F. Nowak,[37] J. Olzem,[37] H. Perrey,[37] A. Petrukhin,[37] D. Pitzl,[37] R. Placakyte,[37] A. Raspereza,[37] P. M. Ribeiro Cipriano,[37] C. Riedl,[37] E. Ron,[37] M. Ö. Sahin,[37] J. Salfeld-Nebgen,[37] R. Schmidt,[37,s] T. Schoerner-Sadenius,[37] N. Sen,[37] M. Stein,[37] R. Walsh,[37] C. Wissing,[37] V. Blobel,[38] H. Enderle,[38] J. Erfle,[38] U. Gebbert,[38] M. Görner,[38] M. Gosselink,[38] J. Haller,[38] K. Heine,[38] R. S. Höing,[38] G. Kaussen,[38] H. Kirschenmann,[38] R. Klanner,[38] R. Kogler,[38] J. Lange,[38] T. Peiffer,[38] N. Pietsch,[38] D. Rathjens,[38] C. Sander,[38] H. Schettler,[38] P. Schleper,[38] E. Schlieckau,[38] A. Schmidt,[38] M. Schröder,[38] T. Schum,[38] M. Seidel,[38] J. Sibille,[38,t] V. Sola,[38] H. Stadie,[38] G. Steinbrück,[38] J. Thomsen,[38] D. Troendle,[38] L. Vanelderen,[38] C. Barth,[39] C. Baus,[39] J. Berger,[39] C. Böser,[39] T. Chwalek,[39] W. De Boer,[39] A. Descroix,[39] A. Dierlamm,[39] M. Feindt,[39] M. Guthoff,[39,c] C. Hackstein,[39] F. Hartmann,[39,c] T. Hauth,[39,c] M. Heinrich,[39] H. Held,[39] K. H. Hoffmann,[39] U. Husemann,[39] I. Katkov,[39,f] J. R. Komaragiri,[39] A. Kornmayer,[39,c] P. Lobelle Pardo,[39] D. Martschei,[39] S. Mueller,[39] Th. Müller,[39] M. Niegel,[39] A. Nürnberg,[39] O. Oberst,[39] J. Ott,[39] G. Quast,[39] K. Rabbertz,[39] F. Ratnikov,[39] S. Röcker,[39] F.-P. Schilling,[39] G. Schott,[39] H. J. Simonis,[39] F. M. Stober,[39] R. Ulrich,[39] J. Wagner-Kuhr,[39] S. Wayand,[39] T. Weiler,[39] M. Zeise,[39] G. Anagnostou,[40] G. Daskalakis,[40] T. Geralis,[40] S. Kesisoglou,[40] A. Kyriakis,[40] D. Loukas,[40] A. Markou,[40] C. Markou,[40] E. Ntomari,[40] L. Gouskos,[41] T. J. Mertzimekis,[41] A. Panagiotou,[41] N. Saoulidou,[41] E. Stiliaris,[41] X. Aslanoglou,[42] I. Evangelou,[42] G. Flouris,[42] C. Foudas,[42] P. Kokkas,[42] N. Manthos,[42] I. Papadopoulos,[42] E. Paradas,[42] G. Bencze,[43] C. Hajdu,[43] P. Hidas,[43] D. Horvath,[43,u] B. Radics,[43] F. Sikler,[43] V. Veszpremi,[43] G. Vesztergombi,[43,v] A. J. Zsigmond,[43] N. Beni,[44] S. Czellar,[44] J. Molnar,[44] J. Palinkas,[44] Z. Szillasi,[44] J. Karancsi,[45] P. Raics,[45] Z. L. Trocsanyi,[45] B. Ujvari,[45] S. K. Swain,[46,w] S. B. Beri,[47] V. Bhatnagar,[47] N. Dhingra,[47] R. Gupta,[47] M. Kaur,[47] M. Z. Mehta,[47] M. Mittal,[47] N. Nishu,[47] L. K. Saini,[47] A. Sharma,[47] J. B. Singh,[47] Ashok Kumar,[48] Arun Kumar,[48] S. Ahuja,[48] A. Bhardwaj,[48] B. C. Choudhary,[48] S. Malhotra,[48] M. Naimuddin,[48] K. Ranjan,[48] P. Saxena,[48] V. Sharma,[48] R. K. Shivpuri,[48] S. Banerjee,[49] S. Bhattacharya,[49] K. Chatterjee,[49] S. Dutta,[49] B. Gomber,[49] Sa. Jain,[49] Sh. Jain,[49] R. Khurana,[49] A. Modak,[49] S. Mukherjee,[49] D. Roy,[49] S. Sarkar,[49] M. Sharan,[49] A. P. Singh,[49] A. Abdulsalam,[50] D. Dutta,[50] S. Kailas,[50] V. Kumar,[50] A. K. Mohanty,[50,c] L. M. Pant,[50] P. Shukla,[50] A. Topkar,[50] T. Aziz,[51] R. M. Chatterjee,[51] S. Ganguly,[51] S. Ghosh,[51] M. Guchait,[51,x] A. Gurtu,[51,y] G. Kole,[51] S. Kumar,[51] M. Maity,[51,z] G. Majumder,[51] K. Mazumdar,[51] G. B. Mohanty,[51] B. Parida,[51] K. Sudhakar,[51] N. Wickramage,[51,aa] S. Banerjee,[52] S. Dugad,[52] H. Arfaei,[53,bb] H. Bakhshiansohi,[53] S. M. Etesami,[53,cc] A. Fahim,[53,bb] H. Hesari,[53] A. Jafari,[53] M. Khakzad,[53] M. Mohammadi Najafabadi,[53] S. Paktinat Mehdiabadi,[53] B. Safarzadeh,[53,dd] M. Zeinali,[53] M. Grunewald,[54] M. Abbrescia,[55a,55b] L. Barbone,[55a,55b] C. Calabria,[55a,55b] S. S. Chhibra,[55a,55b] A. Colaleo,[55a] D. Creanza,[55a,55c] N. De Filippis,[55a,55c,c] M. De Palma,[55a,55b] L. Fiore,[55a] G. Iaselli,[55a,55c] G. Maggi,[55a,55c] M. Maggi,[55a] B. Marangelli,[55a,55b] S. My,[55a,55c] S. Nuzzo,[55a,55b] N. Pacifico,[55a] A. Pompili,[55a,55b] G. Pugliese,[55a,55c] G. Selvaggi,[55a,55b] L. Silvestris,[55a] G. Singh,[55a,55b] R. Venditti,[55a,55b] P. Verwilligen,[55a] G. Zito,[55a] G. Abbiendi,[56a] A. C. Benvenuti,[56a] D. Bonacorsi,[56a,56b] S. Braibant-Giacomelli,[56a,56b] L. Brigliadori,[56a,56b] R. Campanini,[56a,56b] P. Capiluppi,[56a,56b] A. Castro,[56a,56b] F. R. Cavallo,[56a] M. Cuffiani,[56a,56b] G. M. Dallavalle,[56a] F. Fabbri,[56a] A. Fanfani,[56a,56b] D. Fasanella,[56a,56b] P. Giacomelli,[56a] C. Grandi,[56a] L. Guiducci,[56a,56b] S. Marcellini,[56a] G. Masetti,[56a,c] M. Meneghelli,[56a,56b] A. Montanari,[56a] F. L. Navarria,[56a,56b] F. Odorici,[56a] A. Perrotta,[56a] F. Primavera,[56a,56b] A. M. Rossi,[56a,56b] T. Rovelli,[56a,56b] G. P. Siroli,[56a,56b] N. Tosi,[56a,56b] R. Travaglini,[56a,56b] S. Albergo,[57a,57b] M. Chiorboli,[57a,57b] S. Costa,[57a,57b] F. Giordano,[57a,57c,c] R. Potenza,[57a,57b] A. Tricomi,[57a,57b] C. Tuve,[57a,57b] G. Barbagli,[58a] V. Ciulli,[58a,58b] C. Civinini,[58a] R. D'Alessandro,[58a,58b] E. Focardi,[58a,58b] S. Frosali,[58a,58b] E. Gallo,[58a] S. Gonzi,[58a,58b] V. Gori,[58a,58b] P. Lenzi,[58a,58b] M. Meschini,[58a] S. Paoletti,[58a] G. Sguazzoni,[58a] A. Tropiano,[58a,58b] L. Benussi,[59] S. Bianco,[59] F. Fabbri,[59] D. Piccolo,[59] P. Fabbricatore,[60a] R. Musenich,[60a] S. Tosi,[60a,60b] A. Benaglia,[61a] F. De Guio,[61a,61b] L. Di Matteo,[61a,61b] S. Fiorendi,[61a,61b] S. Gennai,[61a] A. Ghezzi,[61a,61b] P. Govoni,[61a,61b] M. T. Lucchini,[61a,61b,c] S. Malvezzi,[61a] R. A. Manzoni,[61a,61b,c] A. Martelli,[61a,61b,c] A. Massironi,[61a,61b] D. Menasce,[61a] L. Moroni,[61a] M. Paganoni,[61a,61b] D. Pedrini,[61a] S. Ragazzi,[61a,61b] N. Redaelli,[61a] T. Tabarelli de Fatis,[61a,61b] S. Buontempo,[62a] N. Cavallo,[62a,62c] A. De Cosa,[62a,62b] F. Fabozzi,[62a,62c] A. O. M. Iorio,[62a,62b] L. Lista,[62a] S. Meola,[62a,62d,c] M. Merola,[62a] P. Paolucci,[62a,c] P. Azzi,[63a] N. Bacchetta,[63a] M. Bellato,[63a] D. Bisello,[63a,63b] A. Branca,[63a,63b] R. Carlin,[63a,63b] P. Checchia,[63a] T. Dorigo,[63a] U. Dosselli,[63a] M. Galanti,[63a,63b,c] F. Gasparini,[63a,63b] U. Gasparini,[63a,63b] P. Giubilato,[63a,63b] A. Gozzelino,[63a] K. Kanishchev,[63a,63c] S. Lacaprara,[63a] I. Lazzizzera,[63a,63c] M. Margoni,[63a,63b] A. T. Meneguzzo,[63a,63b] M. Nespolo,[63a] J. Pazzini,[63a,63b] N. Pozzobon,[63a,63b] P. Ronchese,[63a,63b] M. Sgaravatto,[63a] F. Simonetto,[63a,63b] E. Torassa,[63a] M. Tosi,[63a,63b] P. Zotto,[63a,63b] A. Zucchetta,[63a,63b] G. Zumerle,[63a,63b] M. Gabusi,[64a,64b] S. P. Ratti,[64a,64b] C. Riccardi,[64a,64b] P. Vitulo,[64a,64b] M. Biasini,[65a,65b] G. M. Bilei,[65a] L. Fanò,[65a,65b] P. Lariccia,[65a,65b] G. Mantovani,[65a,65b] M. Menichelli,[65a] A. Nappi,[65a,65b,a] F. Romeo,[65a,65b] A. Saha,[65a] A. Santocchia,[65a,65b] A. Spiezia,[65a,65b] K. Androsov,[66a,ee] P. Azzurri,[66a] G. Bagliesi,[66a]

J. Bernardini,[66a] T. Boccali,[66a] G. Broccolo,[66a,66c] R. Castaldi,[66a] R. T. D'Agnolo,[66a,66c,c] R. Dell'Orso,[66a] F. Fiori,[66a,66c] L. Foà,[66a,66c] A. Giassi,[66a] A. Kraan,[66a] F. Ligabue,[66a,66c] T. Lomtadze,[66a] L. Martini,[66a,ee] A. Messineo,[66a,66b] F. Palla,[66a] A. Rizzi,[66a,66b] A. T. Serban,[66a] P. Spagnolo,[66a] P. Squillacioti,[66a] R. Tenchini,[66a] G. Tonelli,[66a,66b] A. Venturi,[66a] P. G. Verdini,[66a] C. Vernieri,[66a,66c] L. Barone,[67a,67b] F. Cavallari,[67a] D. Del Re,[67a,67b] M. Diemoz,[67a] C. Fanelli,[67a,67b] M. Grassi,[67a,67b,c] E. Longo,[67a,67b] F. Margaroli,[67a,67b] P. Meridiani,[67a] F. Micheli,[67a,67b] S. Nourbakhsh,[67a,67b] G. Organtini,[67a,67b] R. Paramatti,[67a] S. Rahatlou,[67a,67b] L. Soffi,[67a,67b] N. Amapane,[68a,68b] R. Arcidiacono,[68a,68c] S. Argiro,[68a,68b] M. Arneodo,[68a,68c] C. Biino,[68a] N. Cartiglia,[68a] S. Casasso,[68a,68b] M. Costa,[68a,68b] N. Demaria,[68a] C. Mariotti,[68a] S. Maselli,[68a] G. Mazza,[68a] E. Migliore,[68a,68b] V. Monaco,[68a,68b] M. Musich,[68a] M. M. Obertino,[68a,68c] N. Pastrone,[68a] M. Pelliccioni,[68a,c] A. Potenza,[68a,68b] A. Romero,[68a,68b] M. Ruspa,[68a,68c] R. Sacchi,[68a,68b] A. Solano,[68a,68b] A. Staiano,[68a] U. Tamponi,[68a] S. Belforte,[69a] V. Candelise,[69a,69b] M. Casarsa,[69a] F. Cossutti,[69a,c] G. Della Ricca,[69a,69b] B. Gobbo,[69a] C. La Licata,[69a,69b] M. Marone,[69a,69b] D. Montanino,[69a,69b] A. Penzo,[69a] A. Schizzi,[69a,69b] A. Zanetti,[69a] T. Y. Kim,[70] S. K. Nam,[70] S. Chang,[71] D. H. Kim,[71] G. N. Kim,[71] J. E. Kim,[71] D. J. Kong,[71] Y. D. Oh,[71] H. Park,[71] D. C. Son,[71] J. Y. Kim,[72] Zero J. Kim,[72] S. Song,[72] S. Choi,[73] D. Gyun,[73] B. Hong,[73] M. Jo,[73] H. Kim,[73] T. J. Kim,[73] K. S. Lee,[73] S. K. Park,[73] Y. Roh,[73] M. Choi,[74] J. H. Kim,[74] C. Park,[74] I. C. Park,[74] S. Park,[74] G. Ryu,[74] Y. Choi,[75] Y. K. Choi,[75] J. Goh,[75] M. S. Kim,[75] E. Kwon,[75] B. Lee,[75] J. Lee,[75] S. Lee,[75] H. Seo,[75] I. Yu,[75] I. Grigelionis,[76] A. Juodagalvis,[76] H. Castilla-Valdez,[77] E. De La Cruz-Burelo,[77] I. Heredia-de La Cruz,[77,ff] R. Lopez-Fernandez,[77] J. Martínez-Ortega,[77] A. Sanchez-Hernandez,[77] L. M. Villasenor-Cendejas,[77] S. Carrillo Moreno,[78] F. Vazquez Valencia,[78] H. A. Salazar Ibarguen,[79] E. Casimiro Linares,[80] A. Morelos Pineda,[80] M. A. Reyes-Santos,[80] D. Krofcheck,[81] A. J. Bell,[82] P. H. Butler,[82] R. Doesburg,[82] S. Reucroft,[82] H. Silverwood,[82] M. Ahmad,[83] M. I. Asghar,[83] J. Butt,[83] H. R. Hoorani,[83] W. A. Khan,[83] T. Khurshid,[83] S. Qazi,[83] M. A. Shah,[83] M. Shoaib,[83] H. Bialkowska,[84] B. Boimska,[84] T. Frueboes,[84] M. Górski,[84] M. Kazana,[84] K. Nawrocki,[84] K. Romanowska-Rybinska,[84] M. Szleper,[84] G. Wrochna,[84] P. Zalewski,[84] G. Brona,[85] K. Bunkowski,[85] M. Cwiok,[85] W. Dominik,[85] K. Doroba,[85] A. Kalinowski,[85] M. Konecki,[85] J. Krolikowski,[85] M. Misiura,[85] W. Wolszczak,[85] N. Almeida,[86] P. Bargassa,[86] A. David,[86] P. Faccioli,[86] P. G. Ferreira Parracho,[86] M. Gallinaro,[86] J. Rodrigues Antunes,[86] J. Seixas,[86,c] J. Varela,[86] P. Vischia,[86] M. Gavrilenko,[87] I. Golutvin,[87] V. Karjavin,[87] V. Konoplyanikov,[87] V. Korenkov,[87] G. Kozlov,[87] A. Lanev,[87] A. Malakhov,[87] V. Matveev,[87] P. Moisenz,[87] V. Palichik,[87] V. Perelygin,[87] S. Shmatov,[87] S. Shulha,[87] N. Skatchkov,[87] V. Smirnov,[87] E. Tikhonenko,[87] A. Zarubin,[87] S. Evstyukhin,[88] V. Golovtsov,[88] Y. Ivanov,[88] V. Kim,[88,gg] P. Levchenko,[88] V. Murzin,[88] V. Oreshkin,[88] I. Smirnov,[88] V. Sulimov,[88] L. Uvarov,[88] S. Vavilov,[88] A. Vorobyev,[88] An. Vorobyev,[88] Yu. Andreev,[89] A. Dermenev,[89] S. Gninenko,[89] N. Golubev,[89] M. Kirsanov,[89] N. Krasnikov,[89] A. Pashenkov,[89] D. Tlisov,[89] A. Toropin,[89] V. Epshteyn,[90] M. Erofeeva,[90] V. Gavrilov,[90] N. Lychkovskaya,[90] V. Popov,[90] G. Safronov,[90] S. Semenov,[90] A. Spiridonov,[90] V. Stolin,[90] E. Vlasov,[90] A. Zhokin,[90] V. Andreev,[91] M. Azarkin,[91] I. Dremin,[91] M. Kirakosyan,[91] A. Leonidov,[91] G. Mesyats,[91] S. V. Rusakov,[91] A. Vinogradov,[91] A. Belyaev,[92] E. Boos,[92] M. Dubinin,[92,h] L. Dudko,[92] A. Ershov,[92] A. Gribushin,[92] V. Klyukhin,[92] O. Kodolova,[92] I. Lokhtin,[92] A. Markina,[92] S. Obraztsov,[92] S. Petrushanko,[92] V. Savrin,[92] A. Snigirev,[92] I. Azhgirey,[93] I. Bayshev,[93] S. Bitioukov,[93] V. Kachanov,[93] A. Kalinin,[93] D. Konstantinov,[93] V. Krychkine,[93] V. Petrov,[93] R. Ryutin,[93] A. Sobol,[93] L. Tourtchanovitch,[93] S. Troshin,[93] N. Tyurin,[93] A. Uzunian,[93] A. Volkov,[93] P. Adzic,[94,hh] M. Djordjevic,[94] M. Ekmedzic,[94] D. Krpic,[94,hh] J. Milosevic,[94] M. Aguilar-Benitez,[95] J. Alcaraz Maestre,[95] C. Battilana,[95] E. Calvo,[95] M. Cerrada,[95] M. Chamizo Llatas,[95,c] N. Colino,[95] B. De La Cruz,[95] A. Delgado Peris,[95] D. Domínguez Vázquez,[95] C. Fernandez Bedoya,[95] J. P. Fernández Ramos,[95] A. Ferrando,[95] J. Flix,[95] M. C. Fouz,[95] P. Garcia-Abia,[95] O. Gonzalez Lopez,[95] S. Goy Lopez,[95] J. M. Hernandez,[95] M. I. Josa,[95] G. Merino,[95] E. Navarro De Martino,[95] J. Puerta Pelayo,[95] A. Quintario Olmeda,[95] I. Redondo,[95] L. Romero,[95] J. Santaolalla,[95] M. S. Soares,[95] C. Willmott,[95] C. Albajar,[96] J. F. de Trocóniz,[96] H. Brun,[97] J. Cuevas,[97] J. Fernandez Menendez,[97] S. Folgueras,[97] I. Gonzalez Caballero,[97] L. Lloret Iglesias,[97] J. Piedra Gomez,[97] J. A. Brochero Cifuentes,[98] I. J. Cabrillo,[98] A. Calderon,[98] S. H. Chuang,[98] J. Duarte Campderros,[98] M. Fernandez,[98] G. Gomez,[98] J. Gonzalez Sanchez,[98] A. Graziano,[98] C. Jorda,[98] A. Lopez Virto,[98] J. Marco,[98] R. Marco,[98] C. Martinez Rivero,[98] F. Matorras,[98] F. J. Munoz Sanchez,[98] T. Rodrigo,[98] A. Y. Rodríguez-Marrero,[98] A. Ruiz-Jimeno,[98] L. Scodellaro,[98] I. Vila,[98] R. Vilar Cortabitarte,[98] D. Abbaneo,[99] E. Auffray,[99] G. Auzinger,[99] M. Bachtis,[99] P. Baillon,[99] A. H. Ball,[99] D. Barney,[99] J. Bendavid,[99] J. F. Benitez,[99] C. Bernet,[99,i] G. Bianchi,[99] P. Bloch,[99] A. Bocci,[99] A. Bonato,[99] O. Bondu,[99] C. Botta,[99] H. Breuker,[99] T. Camporesi,[99] G. Cerminara,[99] T. Christiansen,[99] J. A. Coarasa Perez,[99] S. Colafranceschi,[99,ii] D. d'Enterria,[99] A. Dabrowski,[99] A. De Roeck,[99] S. De Visscher,[99] S. Di Guida,[99] M. Dobson,[99] N. Dupont-Sagorin,[99] A. Elliott-Peisert,[99] J. Eugster,[99] W. Funk,[99]

G. Georgiou,[99] M. Giffels,[99] D. Gigi,[99] K. Gill,[99] D. Giordano,[99] M. Girone,[99] M. Giunta,[99] F. Glege,[99]
R. Gomez-Reino Garrido,[99] S. Gowdy,[99] R. Guida,[99] J. Hammer,[99] M. Hansen,[99] P. Harris,[99] C. Hartl,[99] B. Hegner,[99]
A. Hinzmann,[99] V. Innocente,[99] P. Janot,[99] E. Karavakis,[99] K. Kousouris,[99] K. Krajczar,[99] P. Lecoq,[99] Y.-J. Lee,[99]
C. Lourenço,[99] N. Magini,[99] M. Malberti,[99] L. Malgeri,[99] M. Mannelli,[99] L. Masetti,[99] F. Meijers,[99] S. Mersi,[99] E. Meschi,[99]
R. Moser,[99] M. Mulders,[99] P. Musella,[99] E. Nesvold,[99] L. Orsini,[99] E. Palencia Cortezon,[99] E. Perez,[99] L. Perrozzi,[99]
A. Petrilli,[99] A. Pfeiffer,[99] M. Pierini,[99] M. Pimiä,[99] D. Piparo,[99] G. Polese,[99] L. Quertenmont,[99] A. Racz,[99] W. Reece,[99]
G. Rolandi,[99,jj] C. Rovelli,[99,kk] M. Rovere,[99] H. Sakulin,[99] F. Santanastasio,[99] C. Schäfer,[99] C. Schwick,[99] I. Segoni,[99]
S. Sekmen,[99] A. Sharma,[99] P. Siegrist,[99] P. Silva,[99] M. Simon,[99] P. Sphicas,[99,ll] D. Spiga,[99] M. Stoye,[99] A. Tsirou,[99]
G. I. Veres,[99,v] J. R. Vlimant,[99] H. K. Wöhri,[99] S. D. Worm,[99,mm] W. D. Zeuner,[99] W. Bertl,[100] K. Deiters,[100] W. Erdmann,[100]
K. Gabathuler,[100] R. Horisberger,[100] Q. Ingram,[100] H. C. Kaestli,[100] S. König,[100] D. Kotlinski,[100] U. Langenegger,[100]
D. Renker,[100] T. Rohe,[100] F. Bachmair,[101] L. Bäni,[101] P. Bortignon,[101] M. A. Buchmann,[101] B. Casal,[101] N. Chanon,[101]
A. Deisher,[101] G. Dissertori,[101] M. Dittmar,[101] M. Donegà,[101] M. Dünser,[101] P. Eller,[101] K. Freudenreich,[101] C. Grab,[101]
D. Hits,[101] P. Lecomte,[101] W. Lustermann,[101] A. C. Marini,[101] P. Martinez Ruiz del Arbol,[101] N. Mohr,[101] F. Moortgat,[101]
C. Nägeli,[101,nn] P. Nef,[101] F. Nessi-Tedaldi,[101] F. Pandolfi,[101] L. Pape,[101] F. Pauss,[101] M. Peruzzi,[101] F. J. Ronga,[101]
M. Rossini,[101] L. Sala,[101] A. K. Sanchez,[101] A. Starodumov,[101,oo] B. Stieger,[101] M. Takahashi,[101] L. Tauscher,[101,a] A. Thea,[101]
K. Theofilatos,[101] D. Treille,[101] C. Urscheler,[101] R. Wallny,[101] H. A. Weber,[101] C. Amsler,[102,pp] V. Chiochia,[102] C. Favaro,[102]
M. Ivova Rikova,[102] B. Kilminster,[102] B. Millan Mejias,[102] P. Otiougova,[102] P. Robmann,[102] H. Snoek,[102] S. Taroni,[102]
S. Tupputi,[102] M. Verzetti,[102] M. Cardaci,[103] K. H. Chen,[103] C. Ferro,[103] C. M. Kuo,[103] S. W. Li,[103] W. Lin,[103] Y. J. Lu,[103]
R. Volpe,[103] S. S. Yu,[103] P. Bartalini,[104] P. Chang,[104] Y. H. Chang,[104] Y. W. Chang,[104] Y. Chao,[104] K. F. Chen,[104] C. Dietz,[104]
U. Grundler,[104] W.-S. Hou,[104] Y. Hsiung,[104] K. Y. Kao,[104] Y. J. Lei,[104] R.-S. Lu,[104] D. Majumder,[104] E. Petrakou,[104]
X. Shi,[104] J. G. Shiu,[104] Y. M. Tzeng,[104] M. Wang,[104] B. Asavapibhop,[105] N. Suwonjandee,[105] A. Adiguzel,[106]
M. N. Bakirci,[106,qq] S. Cerci,[106,rr] C. Dozen,[106] I. Dumanoglu,[106] E. Eskut,[106] S. Girgis,[106] G. Gokbulut,[106] E. Gurpinar,[106]
I. Hos,[106] E. E. Kangal,[106] A. Kayis Topaksu,[106] G. Onengut,[106,ss] K. Ozdemir,[106] S. Ozturk,[106,qq] A. Polatoz,[106]
K. Sogut,[106,tt] D. Sunar Cerci,[106,rr] B. Tali,[106,rr] H. Topakli,[106,qq] M. Vergili,[106] I. V. Akin,[107] T. Aliev,[107] B. Bilin,[107]
S. Bilmis,[107] M. Deniz,[107] H. Gamsizkan,[107] A. M. Guler,[107] G. Karapinar,[107,uu] K. Ocalan,[107] A. Ozpineci,[107] M. Serin,[107]
R. Sever,[107] U. E. Surat,[107] M. Yalvac,[107] M. Zeyrek,[107] E. Gülmez,[108] B. Isildak,[108,vv] M. Kaya,[108,ww] O. Kaya,[108,ww]
S. Ozkorucuklu,[108,xx] N. Sonmez,[108,yy] H. Bahtiyar,[109,zz] E. Barlas,[109] K. Cankocak,[109] Y. O. Günaydin,[109,aaa] F. I. Vardarlı,[109]
M. Yücel,[109] L. Levchuk,[110] P. Sorokin,[110] J. J. Brooke,[111] E. Clement,[111] D. Cussans,[111] H. Flacher,[111] R. Frazier,[111]
J. Goldstein,[111] M. Grimes,[111] G. P. Heath,[111] H. F. Heath,[111] L. Kreczko,[111] S. Metson,[111] D. M. Newbold,[111,mm]
K. Nirunpong,[111] A. Poll,[111] S. Senkin,[111] V. J. Smith,[111] T. Williams,[111] L. Basso,[112,bbb] K. W. Bell,[112] A. Belyaev,[112,bbb]
C. Brew,[112] R. M. Brown,[112] D. J. A. Cockerill,[112] J. A. Coughlan,[112] K. Harder,[112] S. Harper,[112] J. Jackson,[112] E. Olaiya,[112]
D. Petyt,[112] B. C. Radburn-Smith,[112] C. H. Shepherd-Themistocleous,[112] I. R. Tomalin,[112] W. J. Womersley,[112]
R. Bainbridge,[113] O. Buchmuller,[113] D. Burton,[113] D. Colling,[113] N. Cripps,[113] M. Cutajar,[113] P. Dauncey,[113] G. Davies,[113]
M. Della Negra,[113] W. Ferguson,[113] J. Fulcher,[113] D. Futyan,[113] A. Gilbert,[113] A. Guneratne Bryer,[113] G. Hall,[113]
Z. Hatherell,[113] J. Hays,[113] G. Iles,[113] M. Jarvis,[113] G. Karapostoli,[113] M. Kenzie,[113] R. Lane,[113] R. Lucas,[113,mm] L. Lyons,[113]
A.-M. Magnan,[113] J. Marrouche,[113] B. Mathias,[113] R. Nandi,[113] J. Nash,[113] A. Nikitenko,[113,oo] J. Pela,[113] M. Pesaresi,[113]
K. Petridis,[113] M. Pioppi,[113,ccc] D. M. Raymond,[113] S. Rogerson,[113] A. Rose,[113] C. Seez,[113] P. Sharp,[113,a] A. Sparrow,[113]
A. Tapper,[113] M. Vazquez Acosta,[113] T. Virdee,[113] S. Wakefield,[113] N. Wardle,[113] T. Whyntie,[113] M. Chadwick,[114]
J. E. Cole,[114] P. R. Hobson,[114] A. Khan,[114] P. Kyberd,[114] D. Leggat,[114] D. Leslie,[114] W. Martin,[114] I. D. Reid,[114]
P. Symonds,[114] L. Teodorescu,[114] M. Turner,[114] J. Dittmann,[115] K. Hatakeyama,[115] A. Kasmi,[115] H. Liu,[115]
T. Scarborough,[115] O. Charaf,[116] S. I. Cooper,[116] C. Henderson,[116] P. Rumerio,[116] A. Avetisyan,[117] T. Bose,[117] C. Fantasia,[117]
A. Heister,[117] P. Lawson,[117] D. Lazic,[117] J. Rohlf,[117] D. Sperka,[117] J. St. John,[117] L. Sulak,[117] J. Alimena,[118]
S. Bhattacharya,[118] G. Christopher,[118] D. Cutts,[118] Z. Demiragli,[118] A. Ferapontov,[118] A. Garabedian,[118] U. Heintz,[118]
S. Jabeen,[118] G. Kukartsev,[118] E. Laird,[118] G. Landsberg,[118] M. Luk,[118] M. Narain,[118] M. Segala,[118] T. Sinthuprasith,[118]
T. Speer,[118] R. Breedon,[119] G. Breto,[119] M. Calderon De La Barca Sanchez,[119] S. Chauhan,[119] M. Chertok,[119] J. Conway,[119]
R. Conway,[119] P. T. Cox,[119] R. Erbacher,[119] M. Gardner,[119] R. Houtz,[119] W. Ko,[119] A. Kopecky,[119] R. Lander,[119] O. Mall,[119]
T. Miceli,[119] R. Nelson,[119] D. Pellett,[119] F. Ricci-Tam,[119] B. Rutherford,[119] M. Searle,[119] S. Shalhout,[119] J. Smith,[119]
M. Squires,[119] M. Tripathi,[119] S. Wilbur,[119] R. Yohay,[119] V. Andreev,[120] D. Cline,[120] R. Cousins,[120] S. Erhan,[120]
P. Everaerts,[120] C. Farrell,[120] M. Felcini,[120] J. Hauser,[120] M. Ignatenko,[120] C. Jarvis,[120] G. Rakness,[120] P. Schlein,[120,a]

E. Takasugi,[120] P. Traczyk,[120] V. Valuev,[120] M. Weber,[120] J. Babb,[121] R. Clare,[121] M. E. Dinardo,[121] J. Ellison,[121]
J. W. Gary,[121] G. Hanson,[121] H. Liu,[121] O. R. Long,[121] A. Luthra,[121] H. Nguyen,[121] S. Paramesvaran,[121] J. Sturdy,[121]
S. Sumowidagdo,[121] R. Wilken,[121] S. Wimpenny,[121] W. Andrews,[122] J. G. Branson,[122] G. B. Cerati,[122] S. Cittolin,[122]
D. Evans,[122] A. Holzner,[122] R. Kelley,[122] M. Lebourgeois,[122] J. Letts,[122] I. Macneill,[122] B. Mangano,[122] S. Padhi,[122]
C. Palmer,[122] G. Petrucciani,[122] M. Pieri,[122] M. Sani,[122] V. Sharma,[122] S. Simon,[122] E. Sudano,[122] M. Tadel,[122] Y. Tu,[122]
A. Vartak,[122] S. Wasserbaech,[122,ddd] F. Würthwein,[122] A. Yagil,[122] J. Yoo,[122] D. Barge,[123] R. Bellan,[123] C. Campagnari,[123]
M. D'Alfonso,[123] T. Danielson,[123] K. Flowers,[123] P. Geffert,[123] C. George,[123] F. Golf,[123] J. Incandela,[123] C. Justus,[123]
P. Kalavase,[123] D. Kovalskyi,[123] V. Krutelyov,[123] S. Lowette,[123] R. Magaña Villalba,[123] N. Mccoll,[123] V. Pavlunin,[123]
J. Ribnik,[123] J. Richman,[123] R. Rossin,[123] D. Stuart,[123] W. To,[123] C. West,[123] A. Apresyan,[124] A. Bornheim,[124] J. Bunn,[124]
Y. Chen,[124] E. Di Marco,[124] J. Duarte,[124] D. Kcira,[124] Y. Ma,[124] A. Mott,[124] H. B. Newman,[124] C. Rogan,[124] M. Spiropulu,[124]
V. Timciuc,[124] J. Veverka,[124] R. Wilkinson,[124] S. Xie,[124] Y. Yang,[124] R. Y. Zhu,[124] V. Azzolini,[125] A. Calamba,[125]
R. Carroll,[125] T. Ferguson,[125] Y. Iiyama,[125] D. W. Jang,[125] Y. F. Liu,[125] M. Paulini,[125] J. Russ,[125] H. Vogel,[125] I. Vorobiev,[125]
J. P. Cumalat,[126] B. R. Drell,[126] W. T. Ford,[126] A. Gaz,[126] E. Luiggi Lopez,[126] U. Nauenberg,[126] J. G. Smith,[126] K. Stenson,[126]
K. A. Ulmer,[126] S. R. Wagner,[126] J. Alexander,[127] A. Chatterjee,[127] N. Eggert,[127] L. K. Gibbons,[127] W. Hopkins,[127]
A. Khukhunaishvili,[127] B. Kreis,[127] N. Mirman,[127] G. Nicolas Kaufman,[127] J. R. Patterson,[127] A. Ryd,[127] E. Salvati,[127]
W. Sun,[127] W. D. Teo,[127] J. Thom,[127] J. Thompson,[127] J. Tucker,[127] Y. Weng,[127] L. Winstrom,[127] P. Wittich,[127] D. Winn,[128]
S. Abdullin,[129] M. Albrow,[129] J. Anderson,[129] G. Apollinari,[129] L. A. T. Bauerdick,[129] A. Beretvas,[129] J. Berryhill,[129]
P. C. Bhat,[129] K. Burkett,[129] J. N. Butler,[129] V. Chetluru,[129] H. W. K. Cheung,[129] F. Chlebana,[129] S. Cihangir,[129]
V. D. Elvira,[129] I. Fisk,[129] J. Freeman,[129] Y. Gao,[129] E. Gottschalk,[129] L. Gray,[129] D. Green,[129] O. Gutsche,[129] D. Hare,[129]
R. M. Harris,[129] J. Hirschauer,[129] B. Hooberman,[129] S. Jindariani,[129] M. Johnson,[129] U. Joshi,[129] B. Klima,[129] S. Kunori,[129]
S. Kwan,[129] J. Linacre,[129] D. Lincoln,[129] R. Lipton,[129] J. Lykken,[129] K. Maeshima,[129] J. M. Marraffino,[129]
V. I. Martinez Outschoorn,[129] S. Maruyama,[129] D. Mason,[129] P. McBride,[129] K. Mishra,[129] S. Mrenna,[129] Y. Musienko,[129,eee]
C. Newman-Holmes,[129] V. O'Dell,[129] O. Prokofyev,[129] N. Ratnikova,[129] E. Sexton-Kennedy,[129] S. Sharma,[129]
W. J. Spalding,[129] L. Spiegel,[129] L. Taylor,[129] S. Tkaczyk,[129] N. V. Tran,[129] L. Uplegger,[129] E. W. Vaandering,[129] R. Vidal,[129]
J. Whitmore,[129] W. Wu,[129] F. Yang,[129] J. C. Yun,[129] D. Acosta,[130] P. Avery,[130] D. Bourilkov,[130] M. Chen,[130] T. Cheng,[130]
S. Das,[130] M. De Gruttola,[130] G. P. Di Giovanni,[130] D. Dobur,[130] A. Drozdetskiy,[130] R. D. Field,[130] M. Fisher,[130] Y. Fu,[130]
I. K. Furic,[130] J. Hugon,[130] B. Kim,[130] J. Konigsberg,[130] A. Korytov,[130] A. Kropivnitskaya,[130] T. Kypreos,[130] J. F. Low,[130]
K. Matchev,[130] P. Milenovic,[130,fff] G. Mitselmakher,[130] L. Muniz,[130] R. Remington,[130] A. Rinkevicius,[130] N. Skhirtladze,[130]
M. Snowball,[130] J. Yelton,[130] M. Zakaria,[130] V. Gaultney,[131] S. Hewamanage,[131] L. M. Lebolo,[131] S. Linn,[131]
P. Markowitz,[131] G. Martinez,[131] J. L. Rodriguez,[131] T. Adams,[132] A. Askew,[132] J. Bochenek,[132] J. Chen,[132] B. Diamond,[132]
S. V. Gleyzer,[132] J. Haas,[132] S. Hagopian,[132] V. Hagopian,[132] K. F. Johnson,[132] H. Prosper,[132] V. Veeraraghavan,[132]
M. Weinberg,[132] M. M. Baarmand,[133] B. Dorney,[133] M. Hohlmann,[133] H. Kalakhety,[133] F. Yumiceva,[133] M. R. Adams,[134]
L. Apanasevich,[134] V. E. Bazterra,[134] R. R. Betts,[134] I. Bucinskaite,[134] J. Callner,[134] R. Cavanaugh,[134] O. Evdokimov,[134]
L. Gauthier,[134] C. E. Gerber,[134] D. J. Hofman,[134] S. Khalatyan,[134] P. Kurt,[134] F. Lacroix,[134] D. H. Moon,[134] C. O'Brien,[134]
C. Silkworth,[134] D. Strom,[134] P. Turner,[134] N. Varelas,[134] U. Akgun,[135] E. A. Albayrak,[135] B. Bilki,[135,ggg] W. Clarida,[135]
K. Dilsiz,[135] F. Duru,[135] S. Griffiths,[135] J.-P. Merlo,[135] H. Mermerkaya,[135,hhh] A. Mestvirishvili,[135] A. Moeller,[135]
J. Nachtman,[135] C. R. Newsom,[135] H. Ogul,[135] Y. Onel,[135] F. Ozok,[135,zz] S. Sen,[135] P. Tan,[135] E. Tiras,[135] J. Wetzel,[135]
T. Yetkin,[135,iii] K. Yi,[135] B. A. Barnett,[136] B. Blumenfeld,[136] S. Bolognesi,[136] D. Fehling,[136] G. Giurgiu,[136] A. V. Gritsan,[136]
G. Hu,[136] P. Maksimovic,[136] M. Swartz,[136] A. Whitbeck,[136] P. Baringer,[137] A. Bean,[137] G. Benelli,[137] R. P. Kenny III,[137]
M. Murray,[137] D. Noonan,[137] S. Sanders,[137] R. Stringer,[137] J. S. Wood,[137] A. F. Barfuss,[138] I. Chakaberia,[138] A. Ivanov,[138]
S. Khalil,[138] M. Makouski,[138] Y. Maravin,[138] S. Shrestha,[138] I. Svintradze,[138] J. Gronberg,[139] D. Lange,[139] F. Rebassoo,[139]
D. Wright,[139] A. Baden,[140] B. Calvert,[140] S. C. Eno,[140] J. A. Gomez,[140] N. J. Hadley,[140] R. G. Kellogg,[140] T. Kolberg,[140]
Y. Lu,[140] M. Marionneau,[140] A. C. Mignerey,[140] K. Pedro,[140] A. Peterman,[140] A. Skuja,[140] J. Temple,[140] M. B. Tonjes,[140]
S. C. Tonwar,[140] A. Apyan,[141] G. Bauer,[141] W. Busza,[141] E. Butz,[141] I. A. Cali,[141] M. Chan,[141] V. Dutta,[141]
G. Gomez Ceballos,[141] M. Goncharov,[141] Y. Kim,[141] M. Klute,[141] Y. S. Lai,[141] A. Levin,[141] P. D. Luckey,[141] T. Ma,[141]
S. Nahn,[141] C. Paus,[141] D. Ralph,[141] C. Roland,[141] G. Roland,[141] G. S. F. Stephans,[141] F. Stöckli,[141] K. Sumorok,[141]
K. Sung,[141] D. Velicanu,[141] R. Wolf,[141] B. Wyslouch,[141] M. Yang,[141] Y. Yilmaz,[141] A. S. Yoon,[141] M. Zanetti,[141]
V. Zhukova,[141] B. Dahmes,[142] A. De Benedetti,[142] G. Franzoni,[142] A. Gude,[142] J. Haupt,[142] S. C. Kao,[142] K. Klapoetke,[142]
Y. Kubota,[142] J. Mans,[142] N. Pastika,[142] R. Rusack,[142] M. Sasseville,[142] A. Singovsky,[142] N. Tambe,[142] J. Turkewitz,[142]

L. M. Cremaldi,[143] R. Kroeger,[143] L. Perera,[143] R. Rahmat,[143] D. A. Sanders,[143] D. Summers,[143] E. Avdeeva,[144] K. Bloom,[144] S. Bose,[144] D. R. Claes,[144] A. Dominguez,[144] M. Eads,[144] R. Gonzalez Suarez,[144] J. Keller,[144] I. Kravchenko,[144] J. Lazo-Flores,[144] S. Malik,[144] F. Meier,[144] G. R. Snow,[144] J. Dolen,[145] A. Godshalk,[145] I. Iashvili,[145] S. Jain,[145] A. Kharchilava,[145] A. Kumar,[145] S. Rappoccio,[145] Z. Wan,[145] G. Alverson,[146] E. Barberis,[146] D. Baumgartel,[146] M. Chasco,[146] J. Haley,[146] D. Nash,[146] T. Orimoto,[146] D. Trocino,[146] D. Wood,[146] J. Zhang,[146] A. Anastassov,[147] K. A. Hahn,[147] A. Kubik,[147] L. Lusito,[147] N. Mucia,[147] N. Odell,[147] B. Pollack,[147] A. Pozdnyakov,[147] M. Schmitt,[147] S. Stoynev,[147] M. Velasco,[147] S. Won,[147] D. Berry,[148] A. Brinkerhoff,[148] K. M. Chan,[148] M. Hildreth,[148] C. Jessop,[148] D. J. Karmgard,[148] J. Kolb,[148] K. Lannon,[148] W. Luo,[148] S. Lynch,[148] N. Marinelli,[148] D. M. Morse,[148] T. Pearson,[148] M. Planer,[148] R. Ruchti,[148] J. Slaunwhite,[148] N. Valls,[148] M. Wayne,[148] M. Wolf,[148] L. Antonelli,[149] B. Bylsma,[149] L. S. Durkin,[149] C. Hill,[149] R. Hughes,[149] K. Kotov,[149] T. Y. Ling,[149] D. Puigh,[149] M. Rodenburg,[149] G. Smith,[149] C. Vuosalo,[149] G. Williams,[149] B. L. Winer,[149] H. Wolfe,[149] E. Berry,[150] P. Elmer,[150] V. Halyo,[150] P. Hebda,[150] J. Hegeman,[150] A. Hunt,[150] P. Jindal,[150] S. A. Koay,[150] D. Lopes Pegna,[150] P. Lujan,[150] D. Marlow,[150] T. Medvedeva,[150] M. Mooney,[150] J. Olsen,[150] P. Piroué,[150] X. Quan,[150] A. Raval,[150] H. Saka,[150] D. Stickland,[150] C. Tully,[150] J. S. Werner,[150] S. C. Zenz,[150] A. Zuranski,[150] E. Brownson,[151] A. Lopez,[151] H. Mendez,[151] J. E. Ramirez Vargas,[151] E. Alagoz,[152] D. Benedetti,[152] G. Bolla,[152] D. Bortoletto,[152] M. De Mattia,[152] A. Everett,[152] Z. Hu,[152] M. Jones,[152] K. Jung,[152] O. Koybasi,[152] M. Kress,[152] N. Leonardo,[152] V. Maroussov,[152] P. Merkel,[152] D. H. Miller,[152] N. Neumeister,[152] I. Shipsey,[152] D. Silvers,[152] A. Svyatkovskiy,[152] M. Vidal Marono,[152] F. Wang,[152] L. Xu,[152] H. D. Yoo,[152] J. Zablocki,[152] Y. Zheng,[152] S. Guragain,[153] N. Parashar,[153] A. Adair,[154] B. Akgun,[154] K. M. Ecklund,[154] F. J. M. Geurts,[154] W. Li,[154] B. P. Padley,[154] R. Redjimi,[154] J. Roberts,[154] J. Zabel,[154] B. Betchart,[155] A. Bodek,[155] R. Covarelli,[155] P. de Barbaro,[155] R. Demina,[155] Y. Eshaq,[155] T. Ferbel,[155] A. Garcia-Bellido,[155] P. Goldenzweig,[155] J. Han,[155] A. Harel,[155] D. C. Miner,[155] G. Petrillo,[155] D. Vishnevskiy,[155] M. Zielinski,[155] A. Bhatti,[156] R. Ciesielski,[156] L. Demortier,[156] K. Goulianos,[156] G. Lungu,[156] S. Malik,[156] C. Mesropian,[156] S. Arora,[157] A. Barker,[157] J. P. Chou,[157] C. Contreras-Campana,[157] E. Contreras-Campana,[157] D. Duggan,[157] D. Ferencek,[157] Y. Gershtein,[157] R. Gray,[157] E. Halkiadakis,[157] D. Hidas,[157] A. Lath,[157] S. Panwalkar,[157] M. Park,[157] R. Patel,[157] V. Rekovic,[157] J. Robles,[157] K. Rose,[157] S. Salur,[157] S. Schnetzer,[157] C. Seitz,[157] S. Somalwar,[157] R. Stone,[157] S. Thomas,[157] M. Walker,[157] G. Cerizza,[158] M. Hollingsworth,[158] S. Spanier,[158] Z. C. Yang,[158] A. York,[158] O. Bouhali,[159,jjj] R. Eusebi,[159] W. Flanagan,[159] J. Gilmore,[159] T. Kamon,[159,kkk] V. Khotilovich,[159] R. Montalvo,[159] I. Osipenkov,[159] Y. Pakhotin,[159] A. Perloff,[159] J. Roe,[159] A. Safonov,[159] T. Sakuma,[159] I. Suarez,[159] A. Tatarinov,[159] D. Toback,[159] N. Akchurin,[160] J. Damgov,[160] C. Dragoiu,[160] P. R. Dudero,[160] C. Jeong,[160] K. Kovitanggoon,[160] S. W. Lee,[160] T. Libeiro,[160] I. Volobouev,[160] E. Appelt,[161] A. G. Delannoy,[161] S. Greene,[161] A. Gurrola,[161] W. Johns,[161] C. Maguire,[161] Y. Mao,[161] A. Melo,[161] M. Sharma,[161] P. Sheldon,[161] B. Snook,[161] S. Tuo,[161] J. Velkovska,[161] M. W. Arenton,[162] S. Boutle,[162] B. Cox,[162] B. Francis,[162] J. Goodell,[162] R. Hirosky,[162] A. Ledovskoy,[162] C. Lin,[162] C. Neu,[162] J. Wood,[162] S. Gollapinni,[163] R. Harr,[163] P. E. Karchin,[163] C. Kottachchi Kankanamge Don,[163] P. Lamichhane,[163] A. Sakharov,[163] M. Anderson,[164] D. A. Belknap,[164] L. Borrello,[164] D. Carlsmith,[164] M. Cepeda,[164] S. Dasu,[164] E. Friis,[164] K. S. Grogg,[164] M. Grothe,[164] R. Hall-Wilton,[164] M. Herndon,[164] A. Hervé,[164] K. Kaadze,[164] P. Klabbers,[164] J. Klukas,[164] A. Lanaro,[164] C. Lazaridis,[164] R. Loveless,[164] A. Mohapatra,[164] M. U. Mozer,[164] I. Ojalvo,[164] G. A. Pierro,[164] I. Ross,[164] A. Savin,[164] W. H. Smith[164] and J. Swanson[164]

(CMS Collaboration)

[1]*Yerevan Physics Institute, Yerevan, Armenia*
[2]*Institut für Hochenergiephysik der OeAW, Wien, Austria*
[3]*National Centre for Particle and High Energy Physics, Minsk, Belarus*
[4]*Universiteit Antwerpen, Antwerpen, Belgium*
[5]*Vrije Universiteit Brussel, Brussel, Belgium*
[6]*Université Libre de Bruxelles, Bruxelles, Belgium*
[7]*Ghent University, Ghent, Belgium*
[8]*Université Catholique de Louvain, Louvain-la-Neuve, Belgium*
[9]*Université de Mons, Mons, Belgium*
[10]*Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil*
[11]*Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil*
[12a]*Universidade Estadual Paulista, São Paulo, Brazil*
[12b]*Universidade Federal do ABC, São Paulo, Brazil*

[13]Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria
[14]University of Sofia, Sofia, Bulgaria
[15]Institute of High Energy Physics, Beijing, China
[16]State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China
[17]Universidad de Los Andes, Bogota, Colombia
[18]Technical University of Split, Split, Croatia
[19]University of Split, Split, Croatia
[20]Institute Rudjer Boskovic, Zagreb, Croatia
[21]University of Cyprus, Nicosia, Cyprus
[22]Charles University, Prague, Czech Republic
[23]Academy of Scientific Research and Technology of the Arab Republic of Egypt,
Egyptian Network of High Energy Physics, Cairo, Egypt
[24]National Institute of Chemical Physics and Biophysics, Tallinn, Estonia
[25]Department of Physics, University of Helsinki, Helsinki, Finland
[26]Helsinki Institute of Physics, Helsinki, Finland
[27]Lappeenranta University of Technology, Lappeenranta, Finland
[28]DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France
[29]Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France
[30]Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg,
Université de Haute Alsace Mulhouse,
CNRS/IN2P3, Strasbourg, France
[31]Centre de Calcul de l'Institut National de Physique Nucleaire et de Physique des Particules,
CNRS/IN2P3, Villeurbanne, France
[32]Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon,
Villeurbanne, France
[33]Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, Georgia
[34]RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany
[35]RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany
[36]RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany
[37]Deutsches Elektronen-Synchrotron, Hamburg, Germany
[38]University of Hamburg, Hamburg, Germany
[39]Institut für Experimentelle Kernphysik, Karlsruhe, Germany
[40]Institute of Nuclear and Particle Physics (INPP), NCSR Demokritos, Aghia Paraskevi, Greece
[41]University of Athens, Athens, Greece
[42]University of Ioánnina, Ioánnina, Greece
[43]Wigner Research Centre for Physics, Budapest, Hungary
[44]Institute of Nuclear Research ATOMKI, Debrecen, Hungary
[45]University of Debrecen, Debrecen, Hungary
[46]National Institute of Science Education and Research, Bhubaneswar, India
[47]Panjab University, Chandigarh, India
[48]University of Delhi, Delhi, India
[49]Saha Institute of Nuclear Physics, Kolkata, India
[50]Bhabha Atomic Research Centre, Mumbai, India
[51]Tata Institute of Fundamental Research - EHEP, Mumbai, India
[52]Tata Institute of Fundamental Research - HECR, Mumbai, India
[53]Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
[54]University College Dublin, Dublin, Ireland
[55a]INFN Sezione di Bari, Bari, Italy
[55b]Università di Bari, Bari, Italy
[55c]Politecnico di Bari, Bari, Italy
[56a]INFN Sezione di Bologna, Bologna, Italy
[56b]Università di Bologna, Bologna, Italy
[57a]INFN Sezione di Catania, Catania, Italy
[57b]Università di Catania, Catania, Italy
[57c]CSFNSM, Catania, Italy
[58a]INFN Sezione di Firenze, Firenze, Italy
[58b]Università di Firenze, Firenze, Italy
[59]INFN Laboratori Nazionali di Frascati, Frascati, Italy
[60a]INFN Sezione di Genova, Genova, Italy
[60b]Università di Genova, Genova, Italy

[61a]INFN Sezione di Milano-Bicocca, Milano, Italy
[61b]Università di Milano-Bicocca, Milano, Italy
[62a]INFN Sezione di Napoli, Napoli, Italy
[62b]Università di Napoli 'Federico II', Napoli, Italy
[62c]Università della Basilicata (Potenza), Napoli, Italy
[62d]Università G. Marconi (Roma), Napoli, Italy
[63a]INFN Sezione di Padova, Padova, Italy
[63b]Università di Padova, Padova, Italy
[63c]Università di Trento (Trento), Padova, Italy
[64a]INFN Sezione di Pavia, Pavia, Italy
[64b]Università di Pavia, Pavia, Italy
[65a]INFN Sezione di Perugia, Perugia, Italy
[65b]Università di Perugia, Perugia, Italy
[66a]INFN Sezione di Pisa, Pisa, Italy
[66b]Università di Pisa, Pisa, Italy
[66c]Scuola Normale Superiore di Pisa, Pisa, Italy
[67a]INFN Sezione di Roma, Roma, Italy
[67b]Università di Roma, Roma, Italy
[68a]INFN Sezione di Torino, Torino, Italy
[68b]Università di Torino, Torino, Italy
[68c]Università del Piemonte Orientale (Novara), Torino, Italy
[69a]INFN Sezione di Trieste, Trieste, Italy
[69b]Università di Trieste, Trieste, Italy
[70]Kangwon National University, Chunchon, Korea
[71]Kyungpook National University, Daegu, Korea
[72]Chonnam National University, Institute for Universe and Elementary Particles,
Kwangju, Korea
[73]Korea University, Seoul, Korea
[74]University of Seoul, Seoul, Korea
[75]Sungkyunkwan University, Suwon, Korea
[76]Vilnius University, Vilnius, Lithuania
[77]Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico
[78]Universidad Iberoamericana, Mexico City, Mexico
[79]Benemerita Universidad Autonoma de Puebla, Puebla, Mexico
[80]Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico
[81]University of Auckland, Auckland, New Zealand
[82]University of Canterbury, Christchurch, New Zealand
[83]National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan
[84]National Centre for Nuclear Research, Swierk, Poland
[85]Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland
[86]Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal
[87]Joint Institute for Nuclear Research, Dubna, Russia
[88]Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia
[89]Institute for Nuclear Research, Moscow, Russia
[90]Institute for Theoretical and Experimental Physics, Moscow, Russia
[91]P.N. Lebedev Physical Institute, Moscow, Russia
[92]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
[93]State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia
[94]University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia
[95]Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain
[96]Universidad Autónoma de Madrid, Madrid, Spain
[97]Universidad de Oviedo, Oviedo, Spain
[98]Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain
[99]CERN, European Organization for Nuclear Research, Geneva, Switzerland
[100]Paul Scherrer Institut, Villigen, Switzerland
[101]Institute for Particle Physics, ETH Zurich, Zurich, Switzerland
[102]Universität Zürich, Zurich, Switzerland
[103]National Central University, Chung-Li, Taiwan
[104]National Taiwan University (NTU), Taipei, Taiwan
[105]Chulalongkorn University, Bangkok, Thailand

[106]Cukurova University, Adana, Turkey

[107]Middle East Technical University, Physics Department, Ankara, Turkey

[108]Bogazici University, Istanbul, Turkey

[109]Istanbul Technical University, Istanbul, Turkey

[110]National Scientific Center, Kharkov Institute of Physics and Technology,
Kharkov, Ukraine

[111]University of Bristol, Bristol, United Kingdom

[112]Rutherford Appleton Laboratory, Didcot, United Kingdom

[113]Imperial College, London, United Kingdom

[114]Brunel University, Uxbridge, United Kingdom

[115]Baylor University, Waco, USA

[116]The University of Alabama, Tuscaloosa, USA

[117]Boston University, Boston, USA

[118]Brown University, Providence, USA

[119]University of California, Davis, Davis, USA

[120]University of California, Los Angeles, USA

[121]University of California, Riverside, Riverside, USA

[122]University of California, San Diego, La Jolla, USA

[123]University of California, Santa Barbara, Santa Barbara, USA

[124]California Institute of Technology, Pasadena, USA

[125]Carnegie Mellon University, Pittsburgh, USA

[126]University of Colorado at Boulder, Boulder, USA

[127]Cornell University, Ithaca, USA

[128]Fairfield University, Fairfield, USA

[129]Fermi National Accelerator Laboratory, Batavia, USA

[130]University of Florida, Gainesville, USA

[131]Florida International University, Miami, USA

[132]Florida State University, Tallahassee, USA

[133]Florida Institute of Technology, Melbourne, USA

[134]University of Illinois at Chicago (UIC), Chicago, USA

[135]The University of Iowa, Iowa City, USA

[136]Johns Hopkins University, Baltimore, USA

[137]The University of Kansas, Lawrence, USA

[138]Kansas State University, Manhattan, USA

[139]Lawrence Livermore National Laboratory, Livermore, USA

[140]University of Maryland, College Park, USA

[141]Massachusetts Institute of Technology, Cambridge, USA

[142]University of Minnesota, Minneapolis, USA

[143]University of Mississippi, Oxford, USA

[144]University of Nebraska-Lincoln, Lincoln, USA

[145]State University of New York at Buffalo, Buffalo, USA

[146]Northeastern University, Boston, USA

[147]Northwestern University, Evanston, USA

[148]University of Notre Dame, Notre Dame, USA

[149]The Ohio State University, Columbus, USA

[150]Princeton University, Princeton, USA

[151]University of Puerto Rico, Mayaguez, USA

[152]Purdue University, West Lafayette, USA

[153]Purdue University Calumet, Hammond, USA

[154]Rice University, Houston, USA

[155]University of Rochester, Rochester, USA

[156]The Rockefeller University, New York, USA

[157]Rutgers, The State University of New Jersey, Piscataway, USA

[158]University of Tennessee, Knoxville, USA

[159]Texas A&M University, College Station, USA

[160]Texas Tech University, Lubbock, USA

[161]Vanderbilt University, Nashville, USA

[162]University of Virginia, Charlottesville, USA

[163]Wayne State University, Detroit, USA

[164]University of Wisconsin, Madison, USA

[a]Deceased.

[b]Also at Vienna University of Technology, Vienna, Austria.

[c]Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland.

[d]Also at Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France.

[e]Also at National Institute of Chemical Physics and Biophysics, Tallinn, Estonia.

[f]Also at Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia.

[g]Also at Universidade Estadual de Campinas, Campinas, Brazil.

[h]Also at California Institute of Technology, Pasadena, USA.

[i]Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France.

[j]Also at Zewail City of Science and Technology, Zewail, Egypt.

[k]Also at Suez Canal University, Suez, Egypt.

[l]Also at Cairo University, Cairo, Egypt.

[m]Also at Fayoum University, El-Fayoum, Egypt.

[n]Also at British University in Egypt, Cairo, Egypt.

[o]Present address: Ain Shams University, Cairo, Egypt.

[p]Also at National Centre for Nuclear Research, Swierk, Poland.

[q]Also at Université de Haute Alsace, Mulhouse, France.

[r]Also at Joint Institute for Nuclear Research, Dubna, Russia.

[s]Also at Brandenburg University of Technology, Cottbus, Germany.

[t]Also at The University of Kansas, Lawrence, USA.

[u]Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary.

[v]Also at Eötvös Loránd University, Budapest, Hungary.

[w]Also at Tata Institute of Fundamental Research—EHEP, Mumbai, India.

[x]Also at Tata Institute of Fundamental Research—HECR, Mumbai, India.

[y]Present address: King Abdulaziz University, Jeddah, Saudi Arabia.

[z]Also at University of Visva-Bharati, Santiniketan, India.

[aa]Also at University of Ruhuna, Matara, Sri Lanka.

[bb]Also at Sharif University of Technology, Tehran, Iran.

[cc]Also at Isfahan University of Technology, Isfahan, Iran.

[dd]Also at Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, Tehran, Iran.

[ee]Also at Università degli Studi di Siena, Siena, Italy.

[ff]Also at Universidad Michoacana de San Nicolas de Hidalgo, Morelia, Mexico.

[gg]Also at St. Petersburg State Polytechnical University, St. Petersburg, Russia.

[hh]Also at Faculty of Physics, University of Belgrade, Belgrade, Serbia.

[ii]Also at Facoltà Ingegneria, Università di Roma, Roma, Italy.

[jj]Also at Scuola Normale e Sezione dell'INFN, Pisa, Italy.

[kk]Also at INFN Sezione di Roma, Roma, Italy.

[ll]Also at University of Athens, Athens, Greece.

[mm]Also at Rutherford Appleton Laboratory, Didcot, United Kingdom.

[nn]Also at Paul Scherrer Institut, Villigen, Switzerland.

[oo]Also at Institute for Theoretical and Experimental Physics, Moscow, Russia.

[pp]Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland.

[qq]Also at Gaziosmanpasa University, Tokat, Turkey.

[rr]Also at Adiyaman University, Adiyaman, Turkey.

[ss]Also at Cag University, Mersin, Turkey.

[tt]Also at Mersin University, Mersin, Turkey.

[uu]Also at Izmir Institute of Technology, Izmir, Turkey.

[vv]Also at Ozyegin University, Istanbul, Turkey.

[ww]Also at Kafkas University, Kars, Turkey.

[xx]Also at Suleyman Demirel University, Isparta, Turkey.

[yy]Also at Ege University, Izmir, Turkey.

[zz]Also at Mimar Sinan University, Istanbul, Istanbul, Turkey.

[aaa]Also at Kahramanmaras Sütcü Imam University, Kahramanmaras, Turkey.

[bbb]Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.

[ccc]Also at INFN Sezione di Perugia, Università di Perugia, Perugia, Italy.

[ddd]Also at Utah Valley University, Orem, USA.

[eee]Also at Institute for Nuclear Research, Moscow, Russia.

[fff]Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia.

[ggg]Also at Argonne National Laboratory, Argonne, USA.
[hhh]Also at Erzincan University, Erzincan, Turkey.
[iii]Also at Yildiz Technical University, Istanbul, Turkey.
[jjj]Also at Texas A&M University at Qatar, Doha, Qatar.
[kkk]Also at Kyungpook National University, Daegu, Korea.