

Search for the Z Boson Decay to $\tau\tau\mu\mu$ in Proton-Proton Collisions at $\sqrt{s} = 13$ TeVA. Hayrapetyan *et al.*^{*}
(CMS Collaboration)

(Received 28 April 2024; accepted 14 August 2024; published 18 October 2024)

The first search for the Z boson decay to $\tau\tau\mu\mu$ at the CERN LHC is presented, based on data collected by the CMS experiment at the LHC in proton-proton collisions at a center-of-mass energy of 13 TeV and corresponding to an integrated luminosity of 138 fb^{-1} . The data are compatible with the predicted background. For the first time, an upper limit at the 95% confidence level of 6.9 times the standard model expectation is placed on the ratio of the $Z \rightarrow \tau\tau\mu\mu$ to $Z \rightarrow 4\mu$ branching fractions. Limits are also placed on the six flavor-conserving four-lepton effective-field-theory operators involving two muons and two tau leptons, for the first time testing all such operators.

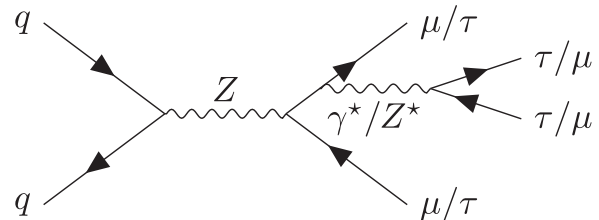
DOI: [10.1103/PhysRevLett.133.161805](https://doi.org/10.1103/PhysRevLett.133.161805)

The large dataset collected by the CMS experiment [1] at the CERN LHC facilitates searches for rare processes within the standard model (SM) of particle physics. The CMS experiment was the first to observe the rare decays $Z \rightarrow J/\psi \ell \ell$ [2] and $Z \rightarrow \ell \ell \ell' \ell'$ [3] in proton-proton (pp) collisions, where ℓ denotes a charged lepton and ℓ' a charged lepton of a possibly different flavor. At leading order (LO), the latter process occurs via a $Z \rightarrow \ell \ell \rightarrow \ell \ell \ell' \ell'$ transition. These transitions are of particular interest because they can receive contributions from hypothetical new particles, such as a Z' boson, that can modify the branching fractions predicted by the SM. Theories predicting such new particles have been reported [4–13] and exclusive couplings to muons and tau leptons are predicted in many models, making $Z \rightarrow \tau\tau\mu\mu$ decays, shown in Fig. 1, important to explore.

To derive constraints on possible beyond-the-SM (BSM) effects, the framework of the SM effective field theory [14,15] (SMEFT) is used in this Letter. Here, the SM Lagrangian density $\mathcal{L}_{\text{SM}}$ is extended by an infinite series of operators of even canonical dimension six and above, $\mathcal{L} = \mathcal{L}_{\text{SM}} + \mathcal{L}_6 + \dots$, where $\mathcal{L}_6 = 1/\Lambda^2 \sum_i \mathcal{C}_i \mathcal{O}_i^6$. In this expression, Λ is the characteristic energy scale of possible BSM interactions, taken to be $\Lambda = 1 \text{ TeV}$, $\mathcal{O}_i^6$ are the dimension-six SMEFT operators, and $\mathcal{C}_i$ are the corresponding dimensionless Wilson coefficients (WCs). We exclusively consider four-lepton operators and include only the lowest-order contributions from the dimension-six operators to the four-lepton decays of the Z boson.

We neglect odd-dimensional operators in this Letter because they would induce lepton- and baryon-number violating processes. Stringent constraints on four-muon operators have been derived from the branching fraction of the $Z \rightarrow 4\mu$ decay [16]. Throughout this Letter, the notation $Z \rightarrow 4\mu$ refers to the prompt decay of the Z boson to four muons that do not originate from decays of tau leptons or hadrons. However, four-lepton operators of dimension six involving two tau leptons and two muons are currently poorly constrained because of a lack of measurements of processes to which they could contribute at LO. Only one of these operators is constrained by measurements of the tau lepton decay to muons and neutrinos via charged-current interactions, whereas all others have never been probed [16,17].

In this Letter, we report the first LHC search for the Z boson decay to two tau leptons and two muons relative to the Z boson decay to four muons. This search benefits from a partial cancellation of experimental systematic uncertainties that affect both decay modes. The two tau leptons are reconstructed via their decays to muons and neutrinos, hence the $Z \rightarrow \tau\tau\mu\mu$ decay is studied in the final state with four muons with a total electric charge of zero. In this analysis, we use pp collision data recorded by the CMS experiment in the years 2016–2018 at a center-of-mass energy of 13 TeV that correspond to an integrated

FIG. 1. Leading-order Feynman diagram of the decay $Z \rightarrow \tau\tau\mu\mu$.^{*}Full author list given at the end of the Letter.

Published by the American Physical Society under the terms of the [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/) license. Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI. Funded by SCOAP³.

luminosity of 138 fb^{-1} [18–20]. Measurements of four-fermion events possibly produced by the Z boson decay studied here have previously been reported at LEP [21–24]. Tabulated results are provided in the HEPData record for this analysis [25].

The CMS apparatus [1] is a multipurpose, nearly hermetic detector, designed to trigger on [26,27] and identify [28–31] electrons, muons, photons, and hadrons. A global particle-flow algorithm [32] aims to reconstruct all individual particles in an event, combining information provided by the all-silicon tracking detector and by the crystal electromagnetic and brass-scintillator hadron calorimeters, operating inside a 3.8 T superconducting solenoid, with data from the gas-ionization muon detectors embedded in the flux-return yoke outside the solenoid. The reconstructed particles are used to identify τ leptons and jets and to measure the missing transverse momentum [33–35].

Events of interest are selected using a two-tiered trigger system. The first level, composed of custom hardware processors, uses information from the calorimeters and muon detectors to select events at a rate of around 100 kHz within a fixed latency of about $4 \mu\text{s}$ [26]. The second level, known as the high-level trigger, consists of a farm of processors running a version of the full event reconstruction software optimized for fast processing and reduces the event rate to around 1 kHz before data storage [27]. In this analysis, a single-muon trigger is used to record events with at least one isolated muon candidate having transverse momentum $p_T > 27(24) \text{ GeV}$ in the 2017 (2016 and 2018) data-taking period(s).

Muons are measured in the pseudorapidity range $|\eta| < 2.4$, with detection planes made using three technologies: drift tubes, cathode strip chambers, and resistive-plate chambers. The efficiency to reconstruct and identify muons is greater than 96% over the full η range. Matching muons to tracks measured in the silicon tracker results in a relative p_T resolution, for muons with p_T up to 100 GeV, of 1% in the barrel and 3% in the end caps [30]. The primary vertex of an event is taken to be the vertex corresponding to the most energetic scattering, evaluated using tracking information alone, as described in Ref. [36].

In this analysis, all reconstructed muons are required to pass a set of loose identification criteria, although the highest- p_T muon must satisfy a tighter condition. Both the loose and the tight criteria are defined in Ref. [30]. All muons are required to be isolated from other activity in the event, quantified by the scalar p_T sum of hadrons and photons with an angular distance from the muon $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.4$, where ϕ is the azimuthal angle. This sum does not include contributions from charged particles identified as originating from pileup vertices and is corrected for the remaining average hadronic activity in an event due to pileup. The ratio of this corrected sum to the muon p_T is required to be smaller than 0.15 for

the muon with the highest p_T and at most 0.25 for all other muons.

Processes leading to a final state with four prompt charged leptons via quark-initiated single or double electroweak gauge boson production are simulated at next-to-LO (NLO) in quantum chromodynamics, including all lepton flavors, using the POWHEG v2 [37–41] Monte Carlo event generator. The invariant mass of any two generated same-flavor leptons with opposite electric charges is required to exceed 4 GeV. Events containing the lepton flavor combinations targeted in this analysis, $\tau\tau\mu\mu$ and 4μ , are isolated from this sample using generator-level information.

Events of triple vector boson (VVV) production and top quark-antiquark ($t\bar{t}$) production in association with a Z boson are generated at NLO with MadGraph5_aMC@NLO v2.6.5 [42]. Higgs boson (H) production and its subsequent decay to four charged leptons is simulated at NLO with POWHEG v2 [43,44] and JHUGEN v.7.0.11 [45–47]. Small background contributions due to combinations of prompt and nonprompt charged leptons come from $t\bar{t}$ and quark-initiated double vector boson (VV) production. The former process, as well as WW and ZZ production with decays to two charged leptons and two neutrinos, are simulated at NLO with POWHEG v2 [40,41,48]. All other VV processes producing two or three charged leptons are generated at NLO using MadGraph5_aMC@NLO v2.6.5. Gluon-induced VV production is negligible compared with the corresponding quark-initiated process and not included in the simulated samples.

All events are generated using the NNPDF3.1 next-to-NLO parton distribution functions [49]. The parton shower and subsequent hadronization are simulated with PYTHIA 8.205 [50] and the underlying event is modeled using the CP5 tune [51]. Additional inelastic pp interactions in the same or adjacent bunch crossings (pileup) are simulated for all processes, and events are reweighted to match the measured number of pileup interactions in the data. The full CMS detector is simulated using Geant4 [52].

The generator-level phase space is defined by a set of criteria imposed on events at the generator level. The presence of exactly four muons that form two pairs with opposite electric charges consistent with the decays $Z \rightarrow 4\mu$ and $Z \rightarrow \tau\tau\mu\mu$, the latter followed by two $\tau \rightarrow \mu\nu\nu$ decays, is required. The invariant mass of the four muons, $m_{4\mu}$, must satisfy $40 < m_{4\mu} < 100 \text{ GeV}$. The pair of oppositely charged muons with the highest invariant mass is required to have $12 < m_{\mu\mu}^{\text{max}} < 75 \text{ GeV}$, whereas for all other such pairs $m_{\mu\mu} > 4 \text{ GeV}$ is imposed.

The same requirements are applied to both data and simulated events at the reconstructed level as well. Additionally, the p_T -leading muon must have $p_T > 29(26) \text{ GeV}$ in the 2017 (2016 and 2018) data-taking period(s), reflecting the single-muon trigger threshold. Minimum transverse momenta of 3.5 GeV are required

for the two muons with the second- and third-highest p_T in the event. The fourth muon must satisfy $p_T > 3.5$ GeV for $|\eta| < 1.2$ and $p_T > 2.5$ GeV for $1.2 < |\eta| < 2.4$ to ensure it reaches the outer muon detectors, considering the CMS magnetic field and the energy loss of the muon traversing the detector. Finally, each muon is required to have an angular distance of $\Delta R > 0.02$ from any other muons, and the four selected muons must form a valid vertex.

The background due to nonprompt muons, most copiously produced in quantum chromodynamics multi-jet events via decays of bottom or charm quarks, is estimated using control samples in the data. Three additional, signal-depleted event categories are defined by inverting the requirement on the isolation of at least one of the three p_T -subleading muon candidates, on their total electric charge, or both. The inverted variables are independent, and the shape of the four-muon invariant mass distribution is consistent between any of these control regions and the search region. The shape and normalization of the background due to nonprompt muons in the latter is obtained by scaling the $m_{4\mu}$ distribution of data in the control region with inverted isolation criterion, from which the residual contribution of prompt muons is subtracted using simulated events. The scale factor is derived from the same extrapolation in the regions with inverted charge requirement. A correction accounting for differences between the regions with and without inverting the total electric charge criterion is derived by repeating the extrapolation between two subsets of events with inverted muon isolation.

A 47% uncertainty in the extrapolation factor used in the estimation of the background from nonprompt muons is due to the statistical uncertainty in the data in the signal-depleted regions; it is the dominant uncertainty in this search. Additional large sources of uncertainty are the number of events in the measurements and the simulation as well as the estimate of the nonprompt muon background in the search region. Minor experimental uncertainties in the efficiencies of different criteria imposed on the muons affect the shape and normalization of all simulated processes. The minor effect ($< 10\%$) of theoretical uncertainties in the renormalization and factorization scales, parton distribution functions, and strong coupling $\alpha_s(m_Z)$ on the $m_{4\mu}$ distribution are also included. For the former, the change in acceptance is estimated from independent variations of each scale by a factor of 0.5 or 2, whereas the uncertainty due to the latter two is estimated following the description in Ref. [53]. The integrated luminosities for the 2016, 2017, and 2018 data-taking years have 1.2%–2.5% individual uncertainties [18–20] that affect only the rate of simulated processes, and the overall luminosity uncertainty for the 2016–2018 period is 1.6%. The uncertainties in the SM cross section of the individual simulated backgrounds amount to 5%–25% depending on the process. The effect of all systematic

uncertainties is also propagated to the background with nonprompt muons estimated from data via the subtraction of simulated events with prompt muons.

The yield of $Z \rightarrow \tau\tau\mu\mu$ events is extracted from a binned maximum likelihood template fit of the expected signal and background to the data in the $m_{4\mu}$ distribution, which is performed with the CMS statistical analysis tool COMBINE [54]. Because of the neutrinos arising from the tau lepton decays, $Z \rightarrow \tau\tau\mu\mu$ events are expected to form a broad distribution in $m_{4\mu}$ in the region below the Z boson mass. Each systematic uncertainty is taken into account as a nuisance parameter in this fit. Uncertainties not affecting the shape of the distribution are modeled with log-normal probability distributions, whereas those affecting both the shape and normalization are instead modeled with Gaussian distributions.

The number of $Z \rightarrow 4\mu$ events is scaled by an unconstrained parameter in the fit. A second unconstrained parameter, r , is used to scale the ratio of the number of $Z \rightarrow \tau\tau\mu\mu$ and $Z \rightarrow 4\mu$ events. Both parameters are defined with respect to the SM expectation, which corresponds to parameter values of 1. In the generator-level phase space defined by the requirements on the dimuon and four-muon invariant mass discussed above, the ratio $\mathcal{R}_{\tau\tau\mu\mu}$ of the $Z \rightarrow \tau\tau\mu\mu$ to $Z \rightarrow 4\mu$ branching fractions is given by

$$\mathcal{R}_{\tau\tau\mu\mu} = \frac{N(Z \rightarrow \tau\tau\mu\mu)}{N(Z \rightarrow 4\mu)} \frac{(A\epsilon)_{Z \rightarrow 4\mu}}{(A\epsilon)_{Z \rightarrow \tau\tau\mu\mu}} \frac{1}{\mathcal{B}^2(\tau \rightarrow \mu\nu\nu)} \frac{f_\tau}{f_\mu}. \quad (1)$$

Here, $N(Z \rightarrow \tau\tau\mu\mu)$ and $N(Z \rightarrow 4\mu)$ are the event yields of the respective processes, where only $\tau \rightarrow \mu\nu\nu$ decays are considered for the former. The acceptance and efficiency of selecting events from the generator-level region are denoted by A and ϵ , respectively. Their products are $(A\epsilon)_{Z \rightarrow 4\mu} = (6.40 \pm 0.01)\%$ and $(A\epsilon)_{Z \rightarrow \tau\tau\mu\mu} = (1.32 \pm 0.02)\%$ for the respective Z boson decay modes and are determined from simulation. The parameters f_τ and f_μ are the fractions of selected events in the simulated signal and reference sample, respectively, that are due to the decay of a single Z boson produced in the s channel. The remaining events are due to VV production leading to the same final state. The parameters, which are computed by `MadGraph5_aMC@NLO`, are $f_\tau = (83.9 \pm 0.1)\%$ and $f_\mu = (85.5 \pm 0.2)\%$, where the uncertainties are statistical. The known branching fraction of the tau lepton decay to a muon and the corresponding neutrinos is $\mathcal{B}(\tau \rightarrow \mu\nu\nu) = (17.39 \pm 0.04)\%$ [55]. The SM expectation in the generator-level phase space, derived using generator-level information of events simulated with `POWHEG v2` at NLO, is $\mathcal{R}_{\tau\tau\mu\mu}^{\text{SM}} = 0.90 \pm 0.02$, where the uncertainty includes statistical uncertainties in the number of generated events of each process and the uncertainties in the other factors of Eq. (1), as stated above.

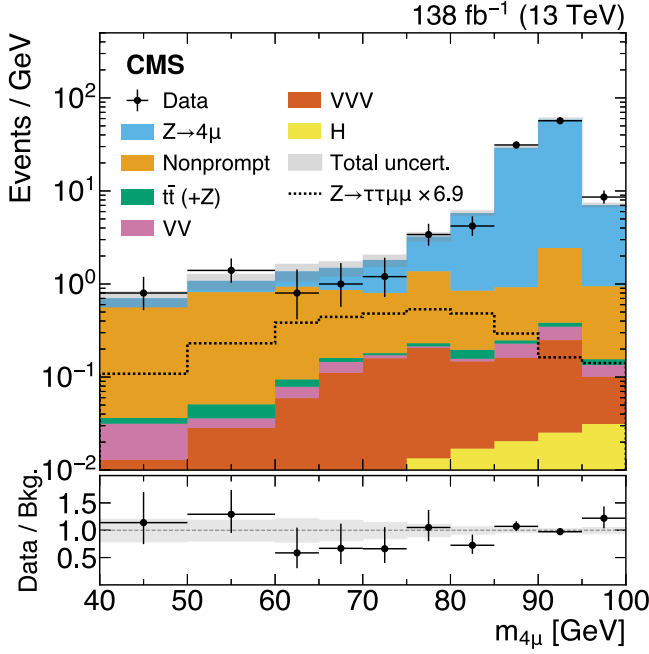


FIG. 2. Distribution of $m_{4\mu}$ after the maximum likelihood fit of the background-only model (stacked histograms) to the data (black points). The nuisance parameters are set to their postfit values and the signal (black dotted line) is overlaid, scaled to the upper limit on its cross section of 6.9 times the SM expectation. The gray shaded areas in both panels correspond to the total uncertainty in the background prediction. The black vertical bars indicate the statistical uncertainty in the data.

In the combined fit of signal and background to the data, the best fit ratio of branching fractions is extracted from the fitted value of r ,

$$\mathcal{R}_{\tau\tau\mu\mu} = r\mathcal{R}_{\tau\tau\mu\mu}^{\text{SM}} = -12.5^{+6.8}_{-8.2}. \quad (2)$$

This agrees with the SM expectation within 2 standard deviations and has a negative value due to the deficit of data in the region $60 < m_{4\mu} < 75$ GeV.

A second maximum likelihood fit of the background-only expectation to the data is performed. The $m_{4\mu}$ distribution after this fit is shown in Fig. 2. The observed data agree with the background prediction within the uncertainties. The postfit number of $Z \rightarrow 4\mu$ events is consistent between the signal-and-background and background-only fits with values of 1.10 ± 0.07 and 1.09 ± 0.07 times the SM expectation, respectively.

In addition, upper limits at the 95% confidence level (CL) are placed on $\mathcal{R}_{\tau\tau\mu\mu}$ for the first time, derived using the CL_s technique [56,57] and the COMBINE tool [54]. The observed and median expected upper limits on $\mathcal{R}_{\tau\tau\mu\mu}$ are 6.2 and 10.0, respectively, reflecting the deficit of data discussed above. The intervals [7.3, 13.9] ([5.5, 18.8]) include 68 (95%) of the distribution of expected limits under the background-only hypothesis. The observed and

median expected limits correspond to 6.9 and 11.1 times the SM expectation of $\mathcal{R}_{\tau\tau\mu\mu}^{\text{SM}} = 0.90$, respectively.

The 95% CL upper limits are used in the SMEFT framework to derive constraints on potential BSM contributions to $\mathcal{R}_{\tau\tau\mu\mu}$ as suggested in Ref. [16]. In this Letter, the notation $\mathcal{C}_{AB}^{ijkl}$ is used for the WC corresponding to the four-lepton operator $(\bar{\ell}_A^i \gamma_\mu \ell_A^j)(\bar{\ell}_B^k \gamma^\mu \ell_B^l)$ contributing to the process $\ell^l \rightarrow \ell^k \ell^j \ell^i$, where the superscripts denote the lepton generation and A and B indicate the chirality. Constraints on the WCs are derived in terms of $\mathcal{C}/\Lambda^2$ with $\Lambda = 1$ TeV.

In this analysis, all six SMEFT operators in the so-called Warsaw basis [58] that have a canonical dimension of six and involve two muons and two tau leptons are considered. These operators affect only the $Z \rightarrow \tau\tau\mu\mu$ but not the $Z \rightarrow 4\mu$ decay. The effect of each operator on Eq. (1), relative to the SM prediction, is computed using MadGraph5_aMC@NLO v2.7.2 with the SMEFTsim 3.0 package [59,60]. The multiplicative BSM correction to each factor in Eq. (1) is expressed in terms linear or quadratic in the corresponding WC, where the linear terms are due to interference of the BSM process with the SM and the quadratic terms correspond to pure BSM contributions. The total correction to $\mathcal{R}_{\tau\tau\mu\mu}^{\text{SM}}$ is given by the product of the individual corrections to each factor. In what follows, distinctions between linear and quadratic terms refer to the order of the individual correction factors, their product therefore also depends on higher orders of the WCs in both cases.

When we consider one nonzero WC at a time, the intervals allowed at the 95% CL for $\mathcal{C}/\Lambda^2$ are given in Table I. When we consider two nonzero WCs and linear and quadratic terms, the regions allowed and excluded at the 95% CL are shown in Fig. 3 for four representative

TABLE I. Intervals allowed at the 95% CL for $\mathcal{C}/\Lambda^2$ for all 6 dimension-six Wilson coefficients conserving lepton flavor and involving two muons and two tau leptons. The second column shows the allowed intervals considering only terms linear in $\mathcal{C}$, in which case the lower and upper bounds originate from unphysical negative event yields and the limit on $\mathcal{R}_{\tau\tau\mu\mu}$, respectively. For the third column, quadratic terms are considered as well and all bounds are determined by the limit on $\mathcal{R}_{\tau\tau\mu\mu}$.

$\mathcal{C}$	95% CL allowed region for $\mathcal{C}/\Lambda^2$ [$10^3/\text{TeV}^2$]	
	Only linear terms	Linear and quadratic terms
$\mathcal{C}_{LL}^{2233}$	[-2.7, 15.2]	[-3.8, 3.1]
$\mathcal{C}_{LL}^{2332}$	[-2.74, 0.01]	[-21.62, 0.01] $\cup$ [0.05, 20.82]
$\mathcal{C}_{LR}^{2233}$	[-3.0, 18.5]	[-4.3, 3.5]
$\mathcal{C}_{LR}^{3322}$	[-3.0, 17.2]	[-4.2, 3.4]
$\mathcal{C}_{LR}^{2332}$	...	[-17.4, 17.4]
$\mathcal{C}_{RR}^{2233}$	[-3.6, 20.0]	[-4.4, 3.6]

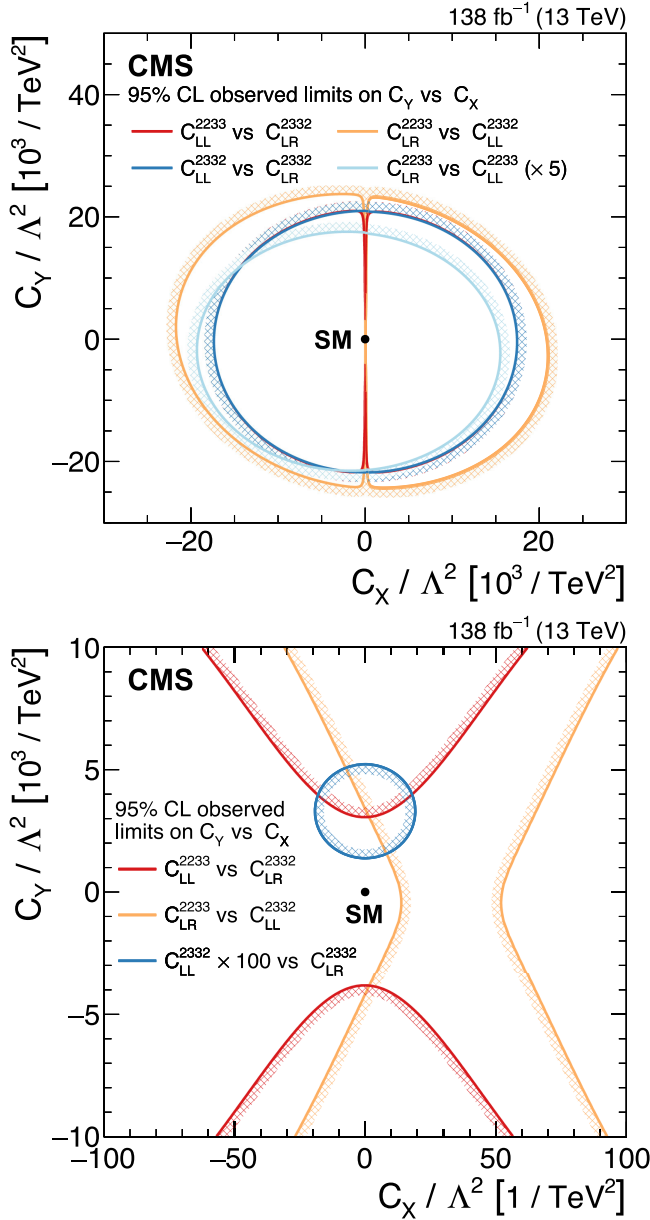


FIG. 3. Observed limits at the 95% CL on different combinations of two Wilson coefficients (colors) showing the full ranges (upper) and an enlarged view of the region around values of 0 (lower). In the upper (lower) figure, the limit on C_{LR}^{2233} vs C_{LL}^{2332} (only C_{LL}^{2332}) is scaled by a factor of 5 (100) for visibility. The SM expectation is indicated by a black dot. The hatches indicate the excluded side of each limit.

combinations of WCs that exhibit characteristic features discussed below. These are the first constraints on all flavor-conserving four-lepton WCs involving two muons and two tau leptons with the exception of C_{LL}^{2233} [16,17], which was limited more stringently by Ref. [17].

The effect of any WC on the event yield is dominant compared to BSM contributions to the signal acceptance and f_τ . It was verified that BSM shape distortions of the

$m_{4\mu}$ distribution after applying the event selection are negligible compared to changes in the overall event yield. The expected value of $\mathcal{B}(\tau \rightarrow \mu\nu\nu)$ in Eq. (1) is only affected by two WCs, C_{LL}^{2233} and C_{LR}^{2233} . For these WCs, however, it has the dominant impact on the determination of the allowed and excluded regions and leads to a larger allowed parameter space when considering quadratic terms as shown in Fig. 3 (upper). The limit on a combination of WCs including neither C_{LL}^{2332} nor C_{LR}^{2332} (light blue) is approximately 5 times more stringent than the limits on combinations that include one or both of these WCs. For combinations that include only C_{LR}^{2332} (red), which enhances $\mathcal{B}(\tau \rightarrow \mu\nu\nu)$, the limit is most stringent for $C_{LR}^{2332} = 0$ and relaxes for nonzero values as shown in Fig. 3 (lower). Including only C_{LL}^{2332} (orange), which causes negative interference with the SM prediction of $\mathcal{B}(\tau \rightarrow \mu\nu\nu)$, leads to an excluded region at small positive values of C_{LL}^{2332} . Considering both C_{LR}^{2332} and C_{LL}^{2332} , their combined effect results in a second excluded region shown in Fig. 3 (lower, dark blue). In this analysis, external constraints on $\mathcal{B}(\tau \rightarrow \mu\nu\nu)$ are neglected, but produce stronger constraints on C_{LL}^{2332} [17] and C_{LR}^{2332} than those presented here due to the small uncertainty in the measured value of $\mathcal{B}(\tau \rightarrow \mu\nu\nu)$ [55].

When we consider only linear terms, each factor in Eq. (1) may take on unphysical values at sufficiently large absolute values of the WCs, such as a negative event yield or $f_\tau \notin [0, 1]$. The allowed regions given in Table I are obtained excluding these and other unphysical scenarios. Considering only linear terms, all lower (upper) limits originate from negative event yields (the limit on $\mathcal{R}_{\tau\tau\mu\mu}$). No linear terms exist for C_{LR}^{2332} because the corresponding operator cannot interfere with the SM process. When considering both linear and quadratic terms, no unphysical regimes are reached within the limits derived from the upper limit on $\mathcal{R}_{\tau\tau\mu\mu}$.

In summary, the first search for the Z boson decay to $\tau\tau\mu\mu$ at the LHC has been presented. The sample of proton-proton collision data analyzed was collected at $\sqrt{s} = 13$ TeV by the CMS experiment and corresponds to an integrated luminosity of 138 fb⁻¹. No excess over the standard model background prediction was observed. For the first time, an upper limit at 95% confidence level of 6.2 was placed on the ratio of the $Z \rightarrow \tau\tau\mu\mu$ to $Z \rightarrow 4\mu$ branching fractions in the phase space considered, equivalent to 6.9 times the standard model expectation of 0.90. Also for the first time, constraints were placed on all flavor-conserving four-lepton Wilson coefficients involving two muons and two tau leptons.

Acknowledgments—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 and other centers 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, the CMS detector, and the supporting computing infrastructure provided by the following funding agencies: SC (Armenia), BMBWF and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, FAPERGS, and FAPESP (Brazil); MES and BNSF (Bulgaria); CERN; CAS, MoST, and NSFC (China); MINCIENCIAS (Colombia); MSES and CSF (Croatia); RIF (Cyprus); SENESCYT (Ecuador); ERC PRG, RVTT3, and MoER TK202 (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); SRNSF (Georgia); BMBF, DFG, and HGF (Germany); GSRI (Greece); NKFIH (Hungary); DAE and DST (India); IPM (Iran); SFI (Ireland); INFN (Italy); MSIP and NRF (Republic of Korea); MES (Latvia); LMTLT (Lithuania); MOE and UM (Malaysia); BUAP, CINVESTAV, CONACYT, LNS, SEP, and UASLP-FAI (Mexico); MOS (Montenegro); MBIE (New Zealand); PAEC (Pakistan); MES and NSC (Poland); FCT (Portugal); MESTD (Serbia); MCIN/AEI and PCTI (Spain); MOSTR (Sri Lanka); Swiss Funding Agencies (Switzerland); MST (Taipei); MHESI and NSTDA (Thailand); TUBITAK and TENMAK (Turkey); NASU (Ukraine); STFC (United Kingdom); DOE and NSF (USA).

- [1] CMS Collaboration, The CMS experiment at the CERN LHC, *J. Instrum.* **3**, S08004 (2008).
- [2] CMS Collaboration, Observation of the $Z \rightarrow \psi \ell^+ \ell^-$ decay in pp collisions at $\sqrt{s} = 13$ TeV, *Phys. Rev. Lett.* **121**, 141801 (2018).
- [3] CMS Collaboration, Observation of Z decays to four leptons with the CMS detector at the LHC, *J. High Energy Phys.* **12** (2012) 034.
- [4] S. Baek, N. G. Deshpande, X.-G. He, and P. Ko, Muon anomalous $g - 2$ and gauged $L_\mu - L_\tau$ models, *Phys. Rev. D* **64**, 055006 (2001).
- [5] K. Harigaya, T. Igari, M. M. Nojiri, M. Takeuchi, and K. Tobe, Muon $g - 2$ and LHC phenomenology in the $L_\mu - L_\tau$ gauge symmetric model, *J. High Energy Phys.* **03** (2014) 105.
- [6] W. Altmannshofer, S. Gori, M. Pospelov, and I. Yavin, Quark flavor transitions in $L_\mu - L_\tau$ models, *Phys. Rev. D* **89**, 095033 (2014).
- [7] N. F. Bell, Y. Cai, R. K. Leane, and A. D. Medina, Leptophilic dark matter with Z' interactions, *Phys. Rev. D* **90**, 035027 (2014).
- [8] A. Crivellin, G. D'Ambrosio, and J. Heeck, Explaining $h \rightarrow \mu^\pm \tau^\mp$, $B \rightarrow K^* \mu^+ \mu^-$ and $B \rightarrow K \mu^+ \mu^- / B \rightarrow K e^+ e^-$ in a two-Higgs-doublet model with gauged $L_\mu - L_\tau$, *Phys. Rev. Lett.* **114**, 151801 (2015).
- [9] F. Elahi and A. Martin, Constraints on $L_\mu - L_\tau$ interactions at the LHC and beyond, *Phys. Rev. D* **93**, 015022 (2016).
- [10] W. Altmannshofer, M. Carena, and A. Crivellin, $L_\mu - L_\tau$ theory of Higgs flavor violation and $(g - 2)_\mu$, *Phys. Rev. D* **94**, 095026 (2016).
- [11] F. Elahi and A. Martin, Using the modified matrix element method to constrain $L_\mu - L_\tau$ interactions, *Phys. Rev. D* **96**, 015021 (2017).
- [12] S. Iguro, K. A. Mohan, and C.-P. Yuan, Detecting a $\mu\tau$ -philic Z' boson via photon initiated processes at the LHC, *Phys. Rev. D* **101**, 075011 (2020).
- [13] A. J. Buras, A. Crivellin, F. Kirk, C. A. Manzari, and M. Montull, Global analysis of leptophilic Z' bosons, *J. High Energy Phys.* **06** (2021) 068.
- [14] I. Brivio and M. Trott, The standard model as an effective field theory, *Phys. Rep.* **793**, 1 (2019).
- [15] G. Isidori, F. Wilsch, and D. Wyler, The standard model effective field theory at work, *Rev. Mod. Phys.* **96**, 015006 (2024).
- [16] R. Boughezal, C.-Y. Chen, F. Petriello, and D. Wiegand, Four-lepton Z boson decay constraints on the Standard Model EFT, *Phys. Rev. D* **103**, 055015 (2021).
- [17] A. Falkowski and K. Mimouni, Model independent constraints on four-lepton operators, *J. High Energy Phys.* **02** (2016) 086.
- [18] CMS Collaboration, Precision luminosity measurement in proton-proton collisions at $\sqrt{s} = 13$ TeV in 2015 and 2016 at CMS, *Eur. Phys. J. C* **81**, 800 (2021).
- [19] CMS Collaboration, CMS luminosity measurement for the 2017 data-taking period at $\sqrt{s} = 13$ TeV, CMS Physics Analysis Summary, Report No. CMS-PAS-LUM-17-004, 2018, <https://cds.cern.ch/record/2676164/>.
- [20] CMS Collaboration, CMS luminosity measurement for the 2018 data-taking period at $\sqrt{s} = 13$ TeV, CMS Physics Analysis Summary, Report No. CMS-PAS-LUM-18-002, 2019, <https://cds.cern.ch/record/2676164/>.
- [21] D. Decamp *et al.* (ALEPH Collaboration), Charged particle pair production associated with a lepton pair in Z decays: Indication of an excess in the tau channel, *Phys. Lett. B* **263**, 112 (1991).
- [22] P. D. Acton *et al.* (OPAL Collaboration), A test of higher order electroweak theory in Z^0 decays to two leptons with an associated pair of charged particles, *Phys. Lett. B* **287**, 389 (1992).
- [23] P. Abreu *et al.* (DELPHI Collaboration), Search for Z^0 decays to two leptons and a charged particle-anti-particle pair, *Nucl. Phys.* **B403**, 3 (1993).
- [24] A. Adam *et al.* (L3 Collaboration), A study of four fermion processes at LEP, *Phys. Lett. B* **321**, 283 (1994).
- [25] HEPData record for this analysis (2024), [10.17182/hepdata.151336](https://hepdata.net/record/151336).
- [26] CMS Collaboration, Performance of the CMS level-1 trigger in proton-proton collisions at $\sqrt{s} = 13$ TeV, *J. Instrum.* **15**, P10017 (2020).
- [27] CMS Collaboration, The CMS trigger system, *J. Instrum.* **12**, P01020 (2017).
- [28] CMS Collaboration, Electron and photon reconstruction and identification with the CMS experiment at the CERN LHC, *J. Instrum.* **16**, P05014 (2021).
- [29] CMS Collaboration, ECAL 2016 refined calibration and Run2 summary plots, CMS Detector Performance

- Summary, Report No. CMS-DP-2020-021, 2020, <https://cds.cern.ch/record/2717925>.
- [30] CMS Collaboration, Performance of the CMS muon detector and muon reconstruction with proton-proton collisions at $\sqrt{s} = 13$ TeV, *J. Instrum.* **13**, P06015 (2018).
 - [31] CMS Collaboration, Description and performance of track and primary-vertex reconstruction with the CMS tracker, *J. Instrum.* **9**, P10009 (2014).
 - [32] CMS Collaboration, Particle-flow reconstruction and global event description with the CMS detector, *J. Instrum.* **12**, P10003 (2017).
 - [33] CMS Collaboration, Performance of reconstruction and identification of τ leptons decaying to hadrons and ν_τ in pp collisions at $\sqrt{s} = 13$ TeV, *J. Instrum.* **13**, P10005 (2018).
 - [34] CMS Collaboration, Jet energy scale and resolution in the CMS experiment in pp collisions at 8 TeV, *J. Instrum.* **12**, P02014 (2017).
 - [35] CMS Collaboration, Performance of missing transverse momentum reconstruction in proton-proton collisions at $\sqrt{s} = 13$ TeV using the CMS detector, *J. Instrum.* **14**, P07004 (2019).
 - [36] CMS Collaboration, Technical proposal for the Phase-II upgrade of the Compact Muon Solenoid, CMS Technical Proposal, Reports No. CERN-LHCC-2015-010, No. CMS-TDR-15-02, 2015, <http://cds.cern.ch/record/2020886>.
 - [37] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, *J. High Energy Phys.* **11** (2004) 040.
 - [38] S. Frixione, P. Nason, and C. Oleari, Matching NLO QCD computations with parton shower simulations: The POWHEG method, *J. High Energy Phys.* **11** (2007) 070.
 - [39] S. Alioli, P. Nason, C. Oleari, and E. Re, A general framework for implementing NLO calculations in shower Monte Carlo programs: The POWHEG BOX, *J. High Energy Phys.* **06** (2010) 043.
 - [40] T. Melia, P. Nason, R. Röntsch, and G. Zanderighi, W^+W^- , WZ and ZZ production in the POWHEG BOX, *J. High Energy Phys.* **11** (2011) 078.
 - [41] P. Nason and G. Zanderighi, W^+W^- , WZ and ZZ production in the POWHEG-BOX-V2, *Eur. Phys. J. C* **74**, 2702 (2014).
 - [42] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H. S. Shao, T. Stelzer, P. Torrielli, and M. Zaro, The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations, *J. High Energy Phys.* **07** (2014) 079.
 - [43] P. Nason and C. Oleari, NLO Higgs boson production via vector-boson fusion matched with shower in POWHEG, *J. High Energy Phys.* **02** (2010) 037.
 - [44] E. Bagnaschi, G. Degraffi, P. Slavich, and A. Vicini, Higgs production via gluon fusion in the POWHEG approach in the SM and in the MSSM, *J. High Energy Phys.* **02** (2012) 088.
 - [45] Y. Gao, A. V. Gritsan, Z. Guo, K. Melnikov, M. Schulze, and N. V. Tran, Spin determination of single-produced resonances at hadron colliders, *Phys. Rev. D* **81**, 075022 (2010).
 - [46] S. Bolognesi, Y. Gao, A. V. Gritsan, K. Melnikov, M. Schulze, N. V. Tran, and A. Whitbeck, Spin and parity of a single-produced resonance at the LHC, *Phys. Rev. D* **86**, 095031 (2012).
 - [47] I. Anderson, S. Bolognesi, F. Caola, Y. Gao, A. V. Gritsan, C. B. Martin, K. Melnikov, M. Schulze, N. V. Tran, A. Whitbeck, and Y. Zhou, Constraining anomalous HVV interactions at proton and lepton colliders, *Phys. Rev. D* **89**, 035007 (2014).
 - [48] S. Frixione, P. Nason, and G. Ridolfi, A positive-weight next-to-leading-order Monte Carlo for heavy flavour hadroproduction, *J. High Energy Phys.* **09** (2007) 126.
 - [49] R. D. Ball *et al.* (NNPDF Collaboration), Parton distributions from high-precision collider data, *Eur. Phys. J. C* **77**, 663 (2017).
 - [50] T. Sjöstrand, S. Ask, J. R. Christiansen, R. Corke, N. Desai, P. Ilten, S. Mrenna, S. Prestel, C. O. Rasmussen, and P. Z. Skands, An introduction to PYTHIA 8.2, *Comput. Phys. Commun.* **191**, 159 (2015).
 - [51] CMS Collaboration, Extraction and validation of a new set of CMS PYTHIA8 tunes from underlying-event measurements, *Eur. Phys. J. C* **80**, 4 (2020).
 - [52] S. Agostinelli *et al.* (GEANT4 Collaboration), Geant4—a simulation toolkit, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
 - [53] J. Butterworth *et al.*, PDF4LHC recommendations for LHC Run II, *J. Phys. G* **43**, 023001 (2016).
 - [54] CMS Collaboration, The CMS statistical analysis and combination tool: COMBINE, [arXiv:2404.06614](https://arxiv.org/abs/2404.06614) [Comput. Software Big Sci. (to be published)].
 - [55] Particle Data Group, Review of particle physics, *Prog. Theor. Exp. Phys.* **2022**, 083C01 (2022).
 - [56] T. Junk, Confidence level computation for combining searches with small statistics, *Nucl. Instrum. Methods Phys. Res., Sect. A* **434**, 435 (1999).
 - [57] A. L. Read, Presentation of search results: The CL_s technique, *J. Phys. G* **28**, 2693 (2002).
 - [58] B. Grzadkowski, M. Iskrzyński, M. Misiak, and J. Rosiek, Dimension-six terms in the standard model Lagrangian, *J. High Energy Phys.* **10** (2010) 085.
 - [59] I. Brivio, Y. Jiang, and M. Trott, The SMEFTsim package, theory and tools, *J. High Energy Phys.* **12** (2017) 070.
 - [60] I. Brivio, SMEFTsim 3.0—a practical guide, *J. High Energy Phys.* **04** (2021) 073.

A. Hayrapetyan,¹ A. Tumasyan^{1,b}, W. Adam², J. W. Andrejkovic,² T. Bergauer², S. Chatterjee², K. Damanakis², M. Dragicevic², P. S. Hussain², M. Jeitler^{2,c}, N. Krammer², A. Li², D. Liko², I. Mikulec², J. Schieck^{2,c}, R. Schöfbeck², D. Schwarz², M. Sonawane², S. Templ², W. Waltenberger², C.-E. Wulz^{2,c}, M. R. Darwish^{3,d}

T. Janssen³, P. Van Mechelen³, N. Breugelmans⁴, J. D'Hondt⁴, S. Dansana⁴, A. De Moor⁴, M. Delcourt⁴,
 F. Heyen⁴, S. Lowette⁴, I. Makarenko⁴, D. Müller⁴, S. Tavernier⁴, M. Tytgat^{4,e}, G. P. Van Onsem⁴,
 S. Van Putte⁴, D. Vannerom⁴, B. Clerbaux⁵, A. K. Das⁵, G. De Lentdecker⁵, H. Evard⁵, L. Favart⁵,
 P. Giannios⁵, D. Hohov⁵, J. Jaramillo⁵, A. Khalilzadeh⁵, F. A. Khan⁵, K. Lee⁵, M. Mahdavihorrani⁵,
 A. Malara⁵, S. Paredes⁵, L. Thomas⁵, M. Vanden Bemden⁵, C. Vander Velde⁵, P. Vanlaere⁵, M. De Coen⁶,
 D. Dobur⁶, G. Gokbulut⁶, Y. Hong⁶, J. Knolle⁶, L. Lambrecht⁶, D. Marckx⁶, G. Mestdach⁶, K. Mota Amarilo⁶,
 C. Rendón⁶, A. Samalan⁶, K. Skovpen⁶, N. Van Den Bossche⁶, J. van der Linden⁶, L. Wezenbeek⁶, A. Benecke⁷,
 A. Bethani⁷, G. Bruno⁷, C. Caputo⁷, J. De Favereau De Jeneret⁷, C. Delaere⁷, I. S. Donertas⁷, A. Giammanco⁷,
 A. O. Guzel⁷, Sa. Jain⁷, V. Lemaitre⁷, J. Lidrych⁷, P. Mastrapasqua⁷, T. T. Tran⁷, S. Wertz⁷, G. A. Alves⁸,
 E. Coelho⁸, C. Hensel⁸, T. Menezes De Oliveira⁸, A. Moraes⁸, P. Rebello Teles⁸, M. Socio⁸, A. Vilela Pereira^{8,f},
 W. L. Aldá Júnior⁹, M. Alves Gallo Pereira⁹, M. Barroso Ferreira Filho⁹, H. Brandao Malbouisson⁹, W. Carvalho⁹,
 J. Chinellato^{9,g}, E. M. Da Costa⁹, G. G. Da Silveira^{9,h}, D. De Jesus Damiao⁹, S. Fonseca De Souza⁹,
 R. Gomes De Souza⁹, M. Macedo⁹, J. Martins^{9,i}, C. Mora Herrera⁹, L. Mundim⁹, H. Nogima⁹, J. P. Pinheiro⁹,
 A. Santoro⁹, A. Sznajder⁹, M. Thiel⁹, C. A. Bernardes^{10,h}, L. Calligaris¹⁰, T. R. Fernandez Perez Tomei¹⁰,
 E. M. Gregores¹⁰, I. Maietto Silverio¹⁰, P. G. Mercadante¹⁰, S. F. Novaes¹⁰, B. Orzari¹⁰, Sandra S. Padula¹⁰,
 A. Aleksandrov¹¹, G. Antchev¹¹, R. Hadjiiska¹¹, P. Iaydjiev¹¹, M. Misheva¹¹, M. Shopova¹¹, G. Sultanov¹¹,
 A. Dimitrov¹², L. Litov¹², B. Pavlov¹², P. Petkov¹², A. Petrov¹², E. Shumka¹², S. Keshri¹³, S. Thakur¹³,
 T. Cheng¹⁴, T. Javaid¹⁴, L. Yuan¹⁴, Z. Hu¹⁵, Z. Liang¹⁵, J. Liu¹⁵, K. Yi^{15,j,k}, G. M. Chen^{16,l}, H. S. Chen^{16,l},
 M. Chen^{16,l}, F. Iemmi¹⁶, C. H. Jiang¹⁶, A. Kapoor^{16,m}, H. Liao¹⁶, Z.-A. Liu^{16,n}, M. A. Shahzad^{16,l}, R. Sharma^{16,o},
 J. N. Song^{16,n}, J. Tao¹⁶, C. Wang^{16,l}, J. Wang¹⁶, Z. Wang^{16,l}, H. Zhang¹⁶, J. Zhao¹⁶, A. Agapitos¹⁷, Y. Ban¹⁷,
 S. Deng¹⁷, B. Guo¹⁷, C. Jiang¹⁷, A. Levin¹⁷, C. Li¹⁷, Q. Li¹⁷, Y. Mao¹⁷, S. Qian¹⁷, S. J. Qian¹⁷, X. Qin¹⁷,
 X. Sun¹⁷, D. Wang¹⁷, H. Yang¹⁷, L. Zhang¹⁷, Y. Zhao¹⁷, C. Zhou¹⁷, S. Yang¹⁸, Z. You¹⁹, K. Jaffel²⁰, N. Lu²⁰,
 G. Bauer^{21,p}, B. Li²¹, J. Zhang²¹, X. Gao^{22,q}, Z. Lin²³, C. Lu²³, M. Xiao²³, C. Avila²⁴, D. A. Barbosa Trujillo²⁴,
 A. Cabrera²⁴, C. Florez²⁴, J. Fraga²⁴, J. A. Reyes Vega²⁴, F. Ramirez²⁵, M. Rodriguez²⁵, A. A. Ruales Barbosa²⁵,
 J. D. Ruiz Alvarez²⁵, D. Giljanovic²⁶, N. Godinovic²⁶, D. Lelas²⁶, A. Sculac²⁶, M. Kovac²⁶, A. Petkovic²⁷,
 T. Sculac²⁷, P. Bargassa²⁸, V. Brigljevic²⁸, B. K. Chitroda²⁸, D. Ferencek²⁸, K. Jakovcic²⁸, S. Mishra²⁸,
 A. Starodumov^{28,r}, T. Susa²⁸, A. Attikis²⁹, K. Christoforou²⁹, A. Hadjiagapiou²⁹, C. Leonidou²⁹, J. Mousa²⁹,
 C. Nicolaou²⁹, L. Paizanos²⁹, F. Ptochos²⁹, P. A. Razis²⁹, H. Rykaczewski²⁹, H. Saka²⁹, A. Stepennov²⁹,
 M. Finger³⁰, M. Finger Jr.³⁰, A. Kveton³⁰, E. Carrera Jarrin³¹, Y. Assran^{32,s,t}, B. El-mahdy³², S. Elgammal^{32,t},
 M. A. Mahmoud³³, Y. Mohammed³³, K. Ehataht³⁴, M. Kadastik³⁴, T. Lange³⁴, S. Nandan³⁴, C. Nielsen³⁴,
 J. Pata³⁴, M. Raidal³⁴, L. Tani³⁴, C. Veelken³⁴, H. Kirschenmann³⁵, K. Osterberg³⁵, M. Voutilainen³⁵,
 S. Bharthuar³⁶, N. Bin Norjoharuddeen³⁶, E. Brücken³⁶, F. Garcia³⁶, P. Inkaew³⁶, K. T. S. Kallonen³⁶,
 R. Kinnunen³⁶, T. Lampén³⁶, K. Lassila-Perini³⁶, S. Lehti³⁶, T. Lindén³⁶, L. Martikainen³⁶, M. Myllymäki³⁶,
 M. m. Rantanen³⁶, H. Siikonen³⁶, J. Tuominiemi³⁶, P. Luukka³⁷, H. Petrow³⁷, M. Besancon³⁸, F. Couderc³⁸,
 M. Dejardin³⁸, D. Denegri³⁸, J. L. Faure³⁸, F. Ferri³⁸, S. Ganjour³⁸, P. Gras³⁸, G. Hamel de Monchenault³⁸,
 V. Lohezic³⁸, J. Malcles³⁸, F. Orlandi³⁸, L. Portales³⁸, J. Rander³⁸, A. Rosowsky³⁸, M. Ö. Sahin³⁸,
 A. Savoy-Navarro^{38,u}, P. Simkina³⁸, M. Titov³⁸, M. Tornago³⁸, F. Beaudette³⁹, P. Busson³⁹, A. Cappati³⁹,
 C. Charlot³⁹, M. Chiusi³⁹, F. Damas³⁹, O. Davignon³⁹, A. De Wit³⁹, I. T. Ehle³⁹, B. A. Fontana Santos Alves³⁹,
 S. Ghosh³⁹, A. Gilbert³⁹, R. Granier de Cassagnac³⁹, A. Hakimi³⁹, B. Harikrishnan³⁹, L. Kalipoliti³⁹, G. Liu³⁹,
 M. Nguyen³⁹, C. Ochando³⁹, R. Salerno³⁹, J. B. Sauvan³⁹, Y. Sirois³⁹, L. Urda Gómez³⁹, E. Vernazza³⁹,
 A. Zabi³⁹, A. Zghiche³⁹, J.-L. Agram^{40,v}, J. Andrea⁴⁰, D. Apparú⁴⁰, D. Bloch⁴⁰, J.-M. Brom⁴⁰,
 E. C. Chabert⁴⁰, C. Collard⁴⁰, S. Falke⁴⁰, U. Goerlach⁴⁰, R. Haeberle⁴⁰, A.-C. Le Bihan⁴⁰, M. Meena⁴⁰,
 O. Poncet⁴⁰, G. Saha⁴⁰, M. A. Sessini⁴⁰, P. Van Hove⁴⁰, P. Vaucelle⁴⁰, A. Di Florio⁴¹, D. Amram⁴²,
 S. Beauceron⁴², B. Blancon⁴², G. Boudoul⁴², N. Chanon⁴², D. Contardo⁴², P. Depasse⁴², C. Dozen^{42,w},
 H. El Mamouni⁴², J. Fay⁴², S. Gascon⁴², M. Gouzevitch⁴², C. Greenberg⁴², G. Grenier⁴², B. Ille⁴², E. Jourdain⁴²,
 I. B. Laktineh⁴², M. Lethuillier⁴², L. Mirabito⁴², S. Perries⁴², A. Purohit⁴², M. Vander Donckt⁴², P. Verdier⁴²,
 J. Xiao⁴², I. Bagaturia^{43,x}, I. Lomidze⁴³, Z. Tsamalaidze^{43,r}, V. Botta⁴⁴, L. Feld⁴⁴, K. Klein⁴⁴, M. Lipinski⁴⁴,
 D. Meuser⁴⁴, A. Pauls⁴⁴, D. Pérez Adán⁴⁴, N. Röwert⁴⁴, M. Teroerde⁴⁴, S. Diekmann⁴⁵, A. Dodonova⁴⁵,
 N. Eich⁴⁵, D. Eliseev⁴⁵, F. Engelke⁴⁵, J. Erdmann⁴⁵, M. Erdmann⁴⁵, P. Fackeldey⁴⁵, B. Fischer⁴⁵

- T. Hebbeker⁴⁵, K. Hoepfner⁴⁵, F. Ivone⁴⁵, A. Jung⁴⁵, M. y. Lee⁴⁵, F. Mausolf⁴⁵, M. Merschmeyer⁴⁵,
 A. Meyer⁴⁵, S. Mukherjee⁴⁵, D. Noll⁴⁵, F. Nowotny⁴⁵, A. Pozdnyakov⁴⁵, Y. Rath⁴⁵, W. Redjeb⁴⁵, F. Rehm⁴⁵,
 H. Reithler⁴⁵, V. Sarkisovi⁴⁵, A. Schmidt⁴⁵, A. Sharma⁴⁵, J. L. Spah⁴⁵, A. Stein⁴⁵,
 F. Torres Da Silva De Araujo^{45,y}, S. Wiedenbeck⁴⁵, S. Zaleski⁴⁵, C. Dziwok⁴⁶, G. Flüge⁴⁶, T. Kress⁴⁶,
 A. Nowack⁴⁶, O. Pooth⁴⁶, A. Stahl⁴⁶, T. Ziemons⁴⁶, A. Zotz⁴⁶, H. Aarup Petersen⁴⁷, M. Aldaya Martin⁴⁷,
 J. Alimena⁴⁷, S. Amoroso⁴⁷, Y. An⁴⁷, J. Bach⁴⁷, S. Baxter⁴⁷, M. Bayatmakou⁴⁷, H. Becerril Gonzalez⁴⁷,
 O. Behnke⁴⁷, A. Belvedere⁴⁷, S. Bhattacharya⁴⁷, F. Blekman^{47,z}, K. Borrás^{47,aa}, A. Campbell⁴⁷, A. Cardini⁴⁷,
 C. Cheng⁴⁷, F. Colombina⁴⁷, S. Consuegra Rodríguez⁴⁷, G. Correia Silva⁴⁷, M. De Silva⁴⁷, G. Eckerlin⁴⁷,
 D. Eckstein⁴⁷, L. I. Estevez Banos⁴⁷, O. Filatov⁴⁷, E. Gallo^{47,z}, A. Geiser⁴⁷, V. Guglielmi⁴⁷, M. Guthoff⁴⁷,
 A. Hinzmann⁴⁷, L. Jeppe⁴⁷, B. Kaech⁴⁷, M. Kasemann⁴⁷, C. Kleinwort⁴⁷, R. Kogler⁴⁷, M. Komm⁴⁷,
 D. Krücker⁴⁷, W. Lange⁴⁷, D. Leyva Pernia⁴⁷, K. Lipka^{47,bb}, W. Lohmann^{47,cc}, F. Lorkowski⁴⁷, R. Mankel⁴⁷,
 I.-A. Melzer-Pellmann⁴⁷, M. Mendizabal Morentin⁴⁷, A. B. Meyer⁴⁷, G. Milella⁴⁷, K. Moral Figueroa⁴⁷,
 A. Mussgiller⁴⁷, L. P. Nair⁴⁷, J. Niedziela⁴⁷, A. Nürnberg⁴⁷, Y. Otari⁴⁷, J. Park⁴⁷, E. Ranken⁴⁷, A. Raspereza⁴⁷,
 D. Rastorguev⁴⁷, J. Rübenach⁴⁷, L. Rygaard⁴⁷, A. Saggio⁴⁷, M. Scham^{47,dd,aa}, S. Schnake^{47,aa}, P. Schütze⁴⁷,
 C. Schwanenberger^{47,z}, D. Selivanova⁴⁷, K. Sharko⁴⁷, M. Shchedrolosiev⁴⁷, D. Stafford⁴⁷, F. Vazzoler⁴⁷,
 A. Ventura Barroso⁴⁷, R. Walsh⁴⁷, D. Wang⁴⁷, Q. Wang⁴⁷, Y. Wen⁴⁷, K. Wichmann⁴⁷, L. Wiens^{47,aa},
 C. Wissing⁴⁷, Y. Yang⁴⁷, A. Zimmermann Castro Santos⁴⁷, A. Albrecht⁴⁸, S. Albrecht⁴⁸, M. Antonello⁴⁸,
 S. Bein⁴⁸, L. Benato⁴⁸, S. Bollweg⁴⁸, M. Bonanomi⁴⁸, P. Connor⁴⁸, K. El Morabit⁴⁸, Y. Fischer⁴⁸, E. Garutti⁴⁸,
 A. Grohsjean⁴⁸, J. Haller⁴⁸, H. R. Jabusch⁴⁸, G. Kasieczka⁴⁸, P. Keicher⁴⁸, R. Klanner⁴⁸, W. Korcari⁴⁸,
 T. Kramer⁴⁸, C. c. Kuo⁴⁸, V. Kutzner⁴⁸, F. Labe⁴⁸, J. Lange⁴⁸, A. Lobanov⁴⁸, C. Matthies⁴⁸, L. Moureaux⁴⁸,
 M. Mrowietz⁴⁸, A. Nigamova⁴⁸, Y. Nissan⁴⁸, A. Paasch⁴⁸, K. J. Pena Rodriguez⁴⁸, T. Quadfasel⁴⁸, B. Raciti⁴⁸,
 M. Rieger⁴⁸, D. Savoie⁴⁸, J. Schindler⁴⁸, P. Schleper⁴⁸, M. Schröder⁴⁸, J. Schwandt⁴⁸, M. Sommerhalder⁴⁸,
 H. Stadie⁴⁸, G. Steinbrück⁴⁸, A. Tews⁴⁸, M. Wolf⁴⁸, S. Brommer⁴⁹, M. Burkart⁴⁹, E. Butz⁴⁹, T. Chwalek⁴⁹,
 A. Dierlamm⁴⁹, A. Droll⁴⁹, N. Faltermann⁴⁹, M. Giffels⁴⁹, A. Gottmann⁴⁹, F. Hartmann^{49,ee}, R. Hofsaess⁴⁹,
 M. Horzela⁴⁹, U. Husemann⁴⁹, J. Kieseler⁴⁹, M. Klute⁴⁹, R. Koppenhöfer⁴⁹, J. M. Lawhorn⁴⁹, M. Link⁴⁹,
 A. Lintuluoto⁴⁹, B. Maier⁴⁹, S. Maier⁴⁹, S. Mitra⁴⁹, M. Mormile⁴⁹, Th. Müller⁴⁹, M. Neukum⁴⁹, M. Oh⁴⁹,
 E. Pfeffer⁴⁹, M. Presilla⁴⁹, G. Quast⁴⁹, K. Rabbertz⁴⁹, B. Regnery⁴⁹, N. Shadskiy⁴⁹, I. Shvetsov⁴⁹,
 H. J. Simonis⁴⁹, L. Sowa⁴⁹, L. Stockmeier⁴⁹, K. Tauqeer⁴⁹, M. Toms⁴⁹, N. Trevisani⁴⁹, R. F. Von Cube⁴⁹,
 M. Wassmer⁴⁹, S. Wieland⁴⁹, F. Wittig⁴⁹, R. Wolf⁴⁹, X. Zuo⁴⁹, G. Anagnostou⁵⁰, G. Daskalakis⁵⁰, A. Kyriakis⁵⁰,
 A. Papadopoulos^{50,ee}, A. Stakia⁵⁰, P. Kontaxakis⁵¹, G. Melachroinos⁵¹, Z. Painesis⁵¹, A. Panagiotou⁵¹,
 I. Papavergou⁵¹, I. Paraskevas⁵¹, N. Saoulidou⁵¹, K. Theofilatos⁵¹, E. Tziaferi⁵¹, K. Vellidis⁵¹, I. Zisopoulos⁵¹,
 G. Bakas⁵², T. Chatzistavrou⁵², G. Karapostoli⁵², K. Kousouris⁵², I. Papakrivopoulos⁵², E. Siamarkou⁵²,
 G. Tsiopolitis⁵², A. Zacharopoulou⁵², K. Adamidis⁵³, I. Bestintzanos⁵³, I. Evangelou⁵³, C. Foudas⁵³, C. Kamtsikis⁵³,
 P. Katsoulis⁵³, P. Kokkas⁵³, P. G. Kosmoglou Kioseoglou⁵³, N. Manthos⁵³, I. Papadopoulos⁵³, J. Strogas⁵³,
 C. Hajdu⁵⁴, D. Horvath^{54,ff,gg}, K. Márton⁵⁴, A. J. Rádli^{54,hh}, F. Sikler⁵⁴, V. Veszpremi⁵⁴, M. Csanád⁵⁵,
 K. Farkas⁵⁵, A. Fehérkúti^{55,ii}, M. M. A. Gadallah^{55,jj}, Á. Kadlecik⁵⁵, P. Major⁵⁵, G. Pásztor⁵⁵, G. I. Veres⁵⁵,
 P. Raics⁵⁶, B. Ujvari⁵⁶, G. Zilizi⁵⁶, G. Bencze⁵⁷, S. Czellar⁵⁷, J. Molnar⁵⁷, Z. Szillasi⁵⁷, T. Csorgo^{58,ii}, T. Novak⁵⁸,
 J. Babbar⁵⁹, S. Bansal⁵⁹, S. B. Beri⁵⁹, V. Bhatnagar⁵⁹, G. Chaudhary⁵⁹, S. Chauhan⁵⁹, N. Dhingra^{59,kk},
 A. Kaur⁵⁹, A. Kaur⁵⁹, H. Kaur⁵⁹, M. Kaur⁵⁹, S. Kumar⁵⁹, K. Sandeep⁵⁹, T. Sheokand⁵⁹, J. B. Singh⁵⁹,
 A. Singla⁵⁹, A. Ahmed⁶⁰, A. Bhardwaj⁶⁰, A. Chhetri⁶⁰, B. C. Choudhary⁶⁰, A. Kumar⁶⁰, A. Kumar⁶⁰,
 M. Naimuddin⁶⁰, K. Ranjan⁶⁰, M. K. Saini⁶⁰, S. Saumya⁶⁰, S. Baradia⁶¹, S. Barman^{61,ll}, S. Bhattacharya⁶¹,
 S. Das Gupta⁶¹, S. Dutta⁶¹, S. Dutta⁶¹, S. Sarkar⁶¹, M. M. Ameen⁶², P. K. Behera⁶², S. C. Behera⁶², S. Chatterjee⁶²,
 G. Dash⁶², P. Jana⁶², P. Kalbhor⁶², S. Kamble⁶², J. R. Komaragiri^{62,mm}, D. Kumar^{62,mm}, P. R. Pujahari⁶²,
 N. R. Saha⁶², A. Sharma⁶², A. K. Sikdar⁶², R. K. Singh⁶², P. Verma⁶², S. Verma⁶², A. Vijay⁶², S. Dugad⁶³,
 M. Kumar⁶³, G. B. Mohanty⁶³, B. Parida⁶³, M. Shelake⁶³, P. Suryadevara⁶³, A. Bala⁶⁴, S. Banerjee⁶⁴,
 R. M. Chatterjee⁶⁴, M. Guchait⁶⁴, Sh. Jain⁶⁴, A. Jaiswal⁶⁴, S. Kumar⁶⁴, G. Majumder⁶⁴, K. Mazumdar⁶⁴,
 S. Parolia⁶⁴, A. Thachayath⁶⁴, S. Bahinipati^{65,nn}, C. Kar⁶⁵, D. Maity^{65,oo}, P. Mal⁶⁵, T. Mishra⁶⁵,
 V. K. Muraleedharan Nair Bindhu^{65,oo}, K. Naskar^{65,oo}, A. Nayak^{65,oo}, S. Nayak⁶⁵, K. Pal⁶⁵, P. Sadangi⁶⁵,
 S. K. Swain⁶⁵, S. Varghese^{65,oo}, D. Vats^{65,oo}, S. Acharya^{66,pp}, A. Alpna⁶⁶, S. Dube⁶⁶, B. Gomber^{66,pp}

- P. Hazarika⁶⁶, B. Kansal⁶⁶, A. Laha⁶⁶, B. Sahu^{66,pp}, S. Sharma⁶⁶, K. Y. Vaish⁶⁶, H. Bakhshiansohi^{67,qq},
 A. Jafari^{67,rr}, M. Zeinali^{67,ss}, S. Bashiri⁶⁸, S. Chenarani^{68,tt}, S. M. Etesami⁶⁸, Y. Hosseini⁶⁸, M. Khakzad⁶⁸,
 E. Khazaie^{68,uu}, M. Mohammadi Najafabadi⁶⁸, S. Tizchang^{68,vv}, M. Felcini⁶⁹, M. Grunewald⁶⁹,
 M. Abbrescia^{70a,70b}, A. Colaleo^{70a,70b}, D. Creanza^{70a,70c}, B. D'Anzi^{70a,70b}, N. De Filippis^{70a,70c}, M. De Palma^{70a,70b},
 L. Fiore^{70a}, G. Iaselli^{70a,70c}, M. Louka^{70a,70b}, G. Maggi^{70a,70c}, M. Maggi^{70a}, I. Margjeka^{70a}, V. Mastrapasqua^{70a,70b},
 S. My^{70a,70b}, S. Nuzzo^{70a,70b}, A. Pellicchia^{70a,70b}, A. Pompili^{70a,70b}, G. Pugliese^{70a,70c}, R. Radogna^{70a,70b},
 D. Ramos^{70a}, A. Ranieri^{70a}, L. Silvestris^{70a}, F. M. Simone^{70a,70c}, Ü. Sözbilir^{70a}, A. Stamerra^{70a,70b},
 D. Troiano^{70a,70b}, R. Venditti^{70a,70b}, P. Verwilligen^{70a}, A. Zaza^{70a,70b}, G. Abbiendi^{71a}, C. Battilana^{71a,71b},
 D. Bonacorsi^{71a,71b}, L. Borgonovi^{71a}, I. Brivio^{71a,71b}, P. Capiluppi^{71a,71b}, A. Castro^{71a,71b,a}, F. R. Cavallo^{71a},
 M. Cuffiani^{71a,71b}, G. M. Dallavalle^{71a}, T. Diotallevi^{71a,71b}, F. Fabbri^{71a}, A. Fanfani^{71a,71b}, D. Fasanella^{71a},
 P. Giacomelli^{71a}, L. Giommi^{71a,71b}, C. Grandi^{71a}, L. Guiducci^{71a,71b}, S. Lo Meo^{71a,ww}, M. Lorusso^{71a,71b},
 L. Lunerti^{71a}, S. Marcellini^{71a}, G. Masetti^{71a}, F. L. Navarria^{71a,71b}, G. Paggi^{71a,71b}, A. Perrotta^{71a},
 F. Primavera^{71a,71b}, A. M. Rossi^{71a,71b}, S. Rossi Tisbeni^{71a,71b}, T. Rovelli^{71a,71b}, G. P. Siroli^{71a,71b}, S. Costa^{72a,72b,xx},
 A. Di Mattia^{72a}, A. Lapertosa^{72a}, R. Potenza^{72a,72b}, A. Tricomi^{72a,72b,xx}, C. Tuve^{72a,72b}, P. Assiouras^{73a},
 G. Barbagli^{73a}, G. Bardelli^{73a,73b}, B. Camaiani^{73a,73b}, A. Cassese^{73a}, R. Ceccarelli^{73a}, V. Ciulli^{73a,73b},
 C. Civinini^{73a}, R. D'Alessandro^{73a,73b}, E. Focardi^{73a,73b}, T. Kello^{73a}, G. Latino^{73a,73b}, P. Lenzi^{73a,73b}, M. Lizzo^{73a},
 M. Meschini^{73a}, S. Paoletti^{73a}, A. Papanastassiou^{73a,73b}, G. Sguazzoni^{73a}, L. Viliani^{73a}, L. Benussi⁷⁴, S. Bianco⁷⁴,
 S. Meola^{74,yy}, D. Piccolo⁷⁴, P. Chatagnon^{75a}, F. Ferro^{75a}, E. Robutti^{75a}, S. Tosi^{75a,75b}, A. Benaglia^{76a},
 G. Boldrini^{76a,76b}, F. Brivio^{76a,76b}, F. Cetorelli^{76a,76b}, F. De Guio^{76a,76b}, M. E. Dinardo^{76a,76b}, P. Dini^{76a},
 S. Gennai^{76a}, R. Gerosa^{76a,76b}, A. Ghezzi^{76a,76b}, P. Govoni^{76a,76b}, L. Guzzi^{76a}, M. T. Lucchini^{76a,76b},
 M. Malberti^{76a}, S. Malvezzi^{76a}, A. Massironi^{76a}, D. Menasce^{76a}, L. Moroni^{76a}, M. Paganoni^{76a,76b},
 S. Palluotto^{76a,76b}, D. Pedrini^{76a}, A. Perego^{76a,76b}, B. S. Pinolini^{76a}, G. Pizzati^{76a,76b}, S. Ragazzi^{76a,76b},
 T. Tabarelli de Fatis^{76a,76b}, S. Buontempo^{77a}, A. Cagnotta^{77a,77b}, F. Carnevali^{77a,77b}, N. Cavallo^{77a,77c},
 F. Fabozzi^{77a,77c}, A. O. M. Iorio^{77a,77b}, L. Lista^{77a,77b,zz}, P. Paolucci^{77a,ee}, B. Rossi^{77a}, C. Sciacca^{77a,77b},
 R. Ardino^{78a}, P. Azzi^{78a}, N. Bacchetta^{78a,aaa}, M. Biasotto^{78a,bbb}, D. Bisello^{78a,78b}, P. Bortignon^{78a},
 G. Bortolato^{78a,78b}, A. Bragagnolo^{78a,78b}, A. C. M. Bulla^{78a}, R. Carlin^{78a,78b}, P. Checchia^{78a}, T. Dorigo^{78a},
 F. Gasparini^{78a,78b}, E. Lusiani^{78a}, M. Margoni^{78a,78b}, A. T. Meneguzzo^{78a,78b}, M. Migliorini^{78a,78b}, J. Pazzini^{78a,78b},
 P. Ronchese^{78a,78b}, R. Rossin^{78a,78b}, F. Simonetto^{78a,78b}, G. Strong^{78a}, M. Tosi^{78a,78b}, A. Triossi^{78a,78b},
 S. Ventura^{78a}, M. Zanetti^{78a,78b}, P. Zotto^{78a,78b}, A. Zucchetta^{78a,78b}, G. Zumerle^{78a,78b}, C. Aimè^{79a},
 A. Braghieri^{79a}, S. Calzaferri^{79a}, D. Fiorina^{79a}, P. Montagna^{79a,79b}, V. Re^{79a}, C. Riccardi^{79a,79b}, P. Salvini^{79a},
 I. Vai^{79a,79b}, P. Vitulo^{79a,79b}, S. Ajmal^{80a,80b}, M. E. Ascoti^{80a,80b}, G. M. Bilei^{80a}, C. Carrivale^{80a,80b},
 D. Ciangottini^{80a,80b}, L. Fanò^{80a,80b}, M. Magherini^{80a,80b}, V. Mariani^{80a,80b}, M. Menichelli^{80a}, F. Moscatelli^{80a,ccc},
 A. Rossi^{80a,80b}, A. Santocchia^{80a,80b}, D. Spiga^{80a}, T. Tedeschi^{80a,80b}, C. A. Alexe^{81a,81c}, P. Asenov^{81a,81b},
 P. Azzurri^{81a}, G. Bagliesi^{81a}, R. Bhattacharya^{81a}, L. Bianchini^{81a,81b}, T. Boccali^{81a}, E. Bossini^{81a},
 D. Bruschini^{81a,81c}, R. Castaldi^{81a}, M. A. Ciocci^{81a,81b}, M. Cipriani^{81a,81b}, V. D'Amante^{81a,81d}, R. Dell'Orso^{81a},
 S. Donato^{81a}, A. Giassi^{81a}, F. Ligabue^{81a,81c}, D. Matos Figueiredo^{81a}, A. Messineo^{81a,81b}, M. Musich^{81a,81b},
 F. Palla^{81a}, A. Rizzi^{81a,81b}, G. Rolandi^{81a,81c}, S. Roy Chowdhury^{81a}, T. Sarkar^{81a}, A. Scribano^{81a}, P. Spagnolo^{81a},
 R. Tenchini^{81a}, G. Tonelli^{81a,81b}, N. Turini^{81a,81d}, F. Vaselli^{81a,81c}, A. Venturi^{81a}, P. G. Verdini^{81a},
 C. Baldenegro Barrera^{82a,82b}, P. Barria^{82a}, C. Basile^{82a,82b}, M. Campana^{82a,82b}, F. Cavallari^{82a},
 L. Cunqueiro Mendez^{82a,82b}, D. Del Re^{82a,82b}, E. Di Marco^{82a}, M. Diemoz^{82a}, F. Errico^{82a,82b}, E. Longo^{82a,82b},
 J. Mijuskovic^{82a,82b}, G. Organtini^{82a,82b}, F. Pandolfi^{82a}, R. Paramatti^{82a,82b}, C. Quaranta^{82a,82b}, S. Rahatlou^{82a,82b},
 C. Rovelli^{82a}, F. Santanastasio^{82a,82b}, L. Soffi^{82a}, N. Amapane^{83a,83b}, R. Arcidiacono^{83a,83c}, S. Argiro^{83a,83b},
 M. Arneodo^{83a,83c}, N. Bartosik^{83a}, R. Bellan^{83a,83b}, A. Bellora^{83a,83b}, C. Biino^{83a}, C. Borca^{83a,83b}, N. Cartiglia^{83a},
 M. Costa^{83a,83b}, R. Covarelli^{83a,83b}, N. Demaria^{83a}, L. Finco^{83a}, M. Grippo^{83a,83b}, B. Kiani^{83a,83b}, F. Legger^{83a},
 F. Luongo^{83a,83b}, C. Mariotti^{83a}, L. Markovic^{83a,83b}, S. Maselli^{83a}, A. Mecca^{83a,83b}, L. Menzio^{83a,83b},
 P. Meridiani^{83a}, E. Migliore^{83a,83b}, M. Monteno^{83a}, R. Mulargia^{83a}, M. M. Obertino^{83a,83b}, G. Ortona^{83a},
 L. Pacher^{83a,83b}, N. Pastrone^{83a}, M. Pelliccioni^{83a}, M. Ruspa^{83a,83c}, F. Siviero^{83a,83b}, V. Sola^{83a,83b},
 A. Solano^{83a,83b}, A. Staiano^{83a}, C. Tarricone^{83a,83b}, D. Trocino^{83a}, G. Umoret^{83a,83b}, E. Vlasov^{83a,83b},
 R. White^{83a,83b}, S. Belforte^{84a}, V. Candelise^{84a,84b}, M. Casarsa^{84a}, F. Cossutti^{84a}, K. De Leo^{84a}

G. Della Ricca^{84a,84b} S. Dogra⁸⁵ J. Hong⁸⁵ C. Huh⁸⁵ B. Kim⁸⁵ J. Kim⁸⁵ D. Lee⁸⁵ H. Lee⁸⁵ S. W. Lee⁸⁵
 C. S. Moon⁸⁵ Y. D. Oh⁸⁵ M. S. Ryu⁸⁵ S. Sekmen⁸⁵ B. Tae⁸⁵ Y. C. Yang⁸⁵ M. S. Kim⁸⁶ G. Bak⁸⁷
 P. Gwak⁸⁷ H. Kim⁸⁷ D. H. Moon⁸⁷ E. Asilar⁸⁸ J. Choi⁸⁸ D. Kim⁸⁸ T. J. Kim⁸⁸ J. A. Merlin⁸⁸ Y. Ryou⁸⁸
 S. Choi⁸⁹ S. Han⁸⁹ B. Hong⁸⁹ K. Lee⁸⁹ K. S. Lee⁸⁹ S. Lee⁸⁹ S. K. Park⁸⁹ J. Yoo⁸⁹ J. Goh⁹⁰ S. Yang⁹⁰
 H. S. Kim⁹¹ Y. Kim⁹¹ S. Lee⁹¹ J. Almond⁹² J. H. Bhyun⁹² J. Choi⁹² J. Choi⁹² W. Jun⁹² J. Kim⁹² S. Ko⁹²
 H. Kwon⁹² H. Lee⁹² J. Lee⁹² J. Lee⁹² B. H. Oh⁹² S. B. Oh⁹² H. Seo⁹² U. K. Yang⁹² I. Yoon⁹² W. Jang⁹³
 D. Y. Kang⁹³ Y. Kang⁹³ S. Kim⁹³ B. Ko⁹³ J. S. H. Lee⁹³ Y. Lee⁹³ I. C. Park⁹³ Y. Roh⁹³ I. J. Watson⁹³
 S. Ha⁹⁴ H. D. Yoo⁹⁴ M. Choi⁹⁵ M. R. Kim⁹⁵ H. Lee⁹⁵ Y. Lee⁹⁵ I. Yu⁹⁵ T. Beyrouthy⁹⁶ Y. Gharbia⁹⁶
 K. Dreimanis⁹⁷ A. Gaile⁹⁷ G. Pikurs⁹⁷ A. Potrebko⁹⁷ M. Seidel⁹⁷ D. Sidiropoulos Kontos⁹⁷ N. R. Strautnieks⁹⁸
 M. Ambrozis⁹⁹ A. Juodagalvis⁹⁹ A. Rinkevicius⁹⁹ G. Tamulaitis⁹⁹ I. Yusuff^{100,ddd} Z. Zolkapli¹⁰⁰
 J. F. Benitez¹⁰¹ A. Castaneda Hernandez¹⁰¹ H. A. Encinas Acosta¹⁰¹ L. G. Gallegos Maríñez¹⁰¹ M. León Coello¹⁰¹
 J. A. Murillo Quijada¹⁰¹ A. Sehrawat¹⁰¹ L. Valencia Palomo¹⁰¹ G. Ayala¹⁰² H. Castilla-Valdez¹⁰²
 H. Crotte Ledesma¹⁰² E. De La Cruz-Burelo¹⁰² I. Heredia-De La Cruz^{102,eee} R. Lopez-Fernandez¹⁰²
 J. Mejia Guisao¹⁰² C. A. Mondragon Herrera¹⁰² A. Sánchez Hernández¹⁰² C. Oropeza Barrera¹⁰³
 D. L. Ramirez Guadarrama¹⁰³ M. Ramírez García¹⁰³ I. Bautista¹⁰⁴ I. Pedraza¹⁰⁴ H. A. Salazar Ibarguen¹⁰⁴
 C. Uribe Estrada¹⁰⁴ I. Bujanja¹⁰⁵ N. Raicevic¹⁰⁵ P. H. Butler¹⁰⁶ A. Ahmad¹⁰⁷ M. I. Asghar¹⁰⁷ A. Awais¹⁰⁷
 M. I. M. Awan¹⁰⁷ H. R. Hoorani¹⁰⁷ W. A. Khan¹⁰⁷ V. Avati¹⁰⁸ L. Grzanka¹⁰⁸ M. Malawski¹⁰⁸ H. Bialkowska¹⁰⁹
 M. Bluj¹⁰⁹ M. Górski¹⁰⁹ M. Kazana¹⁰⁹ M. Szleper¹⁰⁹ P. Zalewski¹⁰⁹ K. Bunkowski¹¹⁰ K. Doroba¹¹⁰
 A. Kalinowski¹¹⁰ M. Konecki¹¹⁰ J. Krolikowski¹¹⁰ A. Muhammad¹¹⁰ K. Pozniak¹¹¹ W. Zabolotny¹¹¹
 M. Araujo¹¹² D. Bastos¹¹² C. Beirão Da Cruz E Silva¹¹² A. Boletti¹¹² M. Bozzo¹¹² T. Camporesi¹¹²
 G. Da Molin¹¹² P. Faccioli¹¹² M. Gallinaro¹¹² J. Hollar¹¹² N. Leonardo¹¹² G. B. Marozzo¹¹² T. Niknejad¹¹²
 A. Petrilli¹¹² M. Pisano¹¹² J. Seixas¹¹² J. Varela¹¹² J. W. Wulff¹¹² P. Adzic¹¹³ P. Milenovic¹¹³
 M. Dordevic¹¹⁴ J. Milosevic¹¹⁴ L. Nadder¹¹⁴ V. Rekovic¹¹⁴ J. Alcaraz Maestre¹¹⁵ Cristina F. Bedoya¹¹⁵
 Oliver M. Carretero¹¹⁵ M. Cepeda¹¹⁵ M. Cerrada¹¹⁵ N. Colino¹¹⁵ B. De La Cruz¹¹⁵ A. Delgado Peris¹¹⁵
 A. Escalante Del Valle¹¹⁵ D. Fernández Del Val¹¹⁵ J. P. Fernández Ramos¹¹⁵ J. Flix¹¹⁵ M. C. Fouz¹¹⁵
 O. Gonzalez Lopez¹¹⁵ S. Goy Lopez¹¹⁵ J. M. Hernandez¹¹⁵ M. I. Josa¹¹⁵ E. Martin Viscasillas¹¹⁵ D. Moran¹¹⁵
 C. M. Morcillo Perez¹¹⁵ Á. Navarro Tobar¹¹⁵ C. Perez Dengra¹¹⁵ A. Pérez-Calero Yzquierdo¹¹⁵
 J. Puerta Pelayo¹¹⁵ I. Redondo¹¹⁵ S. Sánchez Navas¹¹⁵ J. Sastre¹¹⁵ J. Vazquez Escobar¹¹⁵ J. F. de Trocóniz¹¹⁶
 B. Alvarez Gonzalez¹¹⁷ J. Cuevas¹¹⁷ J. Fernandez Menendez¹¹⁷ S. Folgueras¹¹⁷ I. Gonzalez Caballero¹¹⁷
 J. R. González Fernández¹¹⁷ P. Leguina¹¹⁷ E. Palencia Cortezon¹¹⁷ C. Ramón Álvarez¹¹⁷ V. Rodríguez Bouza¹¹⁷
 A. Soto Rodríguez¹¹⁷ A. Trapote¹¹⁷ C. Vico Villalba¹¹⁷ P. Vischia¹¹⁷ S. Bhowmik¹¹⁸ S. Blanco Fernández¹¹⁸
 J. A. Brochero Cifuentes¹¹⁸ I. J. Cabrillo¹¹⁸ A. Calderon¹¹⁸ J. Duarte Campderros¹¹⁸ M. Fernandez¹¹⁸
 G. Gomez¹¹⁸ C. Lasasa García¹¹⁸ R. Lopez Ruiz¹¹⁸ C. Martinez Rivero¹¹⁸ P. Martinez Ruiz del Arbol¹¹⁸
 F. Matorras¹¹⁸ P. Matorras Cuevas¹¹⁸ E. Navarrete Ramos¹¹⁸ J. Piedra Gomez¹¹⁸ L. Scodellaro¹¹⁸ I. Vila¹¹⁸
 J. M. Vizan Garcia¹¹⁸ B. Kailasapathy^{119,fff} D. D. C. Wickramaratna¹¹⁹ W. G. D. Dharmaratna^{120,ggg}
 K. Liyanage¹²⁰ N. Perera¹²⁰ D. Abbaneo¹²¹ C. Amendola¹²¹ E. Auffray¹²¹ G. Auzinger¹²¹ J. Baechler¹²¹
 D. Barney¹²¹ A. Bermúdez Martínez¹²¹ M. Bianco¹²¹ B. Bilin¹²¹ A. A. Bin Anuar¹²¹ A. Bocci¹²¹
 C. Botta¹²¹ E. Brondolin¹²¹ C. Caillol¹²¹ G. Cerminara¹²¹ N. Chernyavskaya¹²¹ D. d'Enterria¹²¹
 A. Dabrowski¹²¹ A. David¹²¹ A. De Roeck¹²¹ M. M. Defranchis¹²¹ M. Deile¹²¹ M. Dobson¹²¹
 G. Franzoni¹²¹ W. Funk¹²¹ S. Giani¹²¹ D. Gigi¹²¹ K. Gill¹²¹ F. Glege¹²¹ L. Gouskos¹²¹ J. Hegeman¹²¹
 J. K. Heikkilä¹²¹ B. Huber¹²¹ V. Innocente¹²¹ T. James¹²¹ P. Janot¹²¹ O. Kaluzinska¹²¹ S. Laurila¹²¹
 P. Lecoq¹²¹ E. Leutgeb¹²¹ C. Lourenço¹²¹ L. Malgeri¹²¹ M. Mannelli¹²¹ A. C. Marini¹²¹ M. Matthewman¹²¹
 A. Mehta¹²¹ F. Meijers¹²¹ S. Mersi¹²¹ E. Meschi¹²¹ V. Milosevic¹²¹ F. Monti¹²¹ F. Moortgat¹²¹
 M. Mulders¹²¹ I. Neutelings¹²¹ S. Orfanelli¹²¹ F. Pantaleo¹²¹ G. Petrucciani¹²¹ A. Pfeiffer¹²¹ M. Pierini¹²¹
 H. Qu¹²¹ D. Rabady¹²¹ B. Ribeiro Lopes¹²¹ M. Rovere¹²¹ H. Sakulin¹²¹ S. Sanchez Cruz¹²¹ S. Scarfi¹²¹
 C. Schwick¹²¹ M. Selvaggi¹²¹ A. Sharma¹²¹ K. Shchelina¹²¹ P. Silva¹²¹ P. Sphicas^{121,hhh} A. G. Stahl Leiton¹²¹
 A. Steen¹²¹ S. Summers¹²¹ D. Treille¹²¹ P. Tropea¹²¹ D. Walter¹²¹ J. Wanczyk^{121,iii} J. Wang¹²¹
 S. Wuchterl¹²¹ P. Zehetner¹²¹ P. Zejdl¹²¹ W. D. Zeuner¹²¹ T. Bevilacqua^{122,jjj} L. Caminada^{122,jjj}
 A. Ebrahimi¹²² W. Erdmann¹²² R. Horisberger¹²² Q. Ingram¹²² H. C. Kaestli¹²² D. Kotlinski¹²² C. Lange¹²²

M. Missiroli^{122,jjj} L. Noehte^{122,jjj} T. Rohe¹²² T. K. Aarrestad¹²³ K. Androsov^{123,iii} M. Backhaus¹²³
 G. Bonomelli¹²³ A. Calandri¹²³ C. Cazzaniga¹²³ K. Datta¹²³ P. De Bryas Dexmiers D'archiac^{123,iii}
 A. De Cosa¹²³ G. Dissertori¹²³ M. Dittmar¹²³ M. Donegà¹²³ F. Eble¹²³ M. Galli¹²³ K. Gedia¹²³
 F. Glessgen¹²³ C. Grab¹²³ N. Härringer¹²³ T. G. Harte¹²³ D. Hits¹²³ W. Lustermann¹²³ A.-M. Lyon¹²³
 R. A. Manzoni¹²³ M. Marchegiani¹²³ L. Marchese¹²³ C. Martin Perez¹²³ A. Mascellani^{123,iii}
 F. Nessi-Tedaldi¹²³ F. Pauss¹²³ V. Perovic¹²³ S. Pigazzini¹²³ C. Reissel¹²³ T. Reitenspiess¹²³ B. Ristic¹²³
 F. Riti¹²³ R. Seidita¹²³ J. Steggemann^{123,iii} A. Tarabini¹²³ D. Valsecchi¹²³ R. Wallny¹²³ C. Amsler^{124,kkk}
 P. Bärtshi¹²⁴ M. F. Canelli¹²⁴ K. Cormier¹²⁴ M. Huwiler¹²⁴ W. Jin¹²⁴ A. Jofrehei¹²⁴ B. Kilminster¹²⁴
 S. Leontsinis¹²⁴ S. P. Liechti¹²⁴ A. Macchiolo¹²⁴ P. Meiring¹²⁴ F. Meng¹²⁴ U. Molinatti¹²⁴ J. Motta¹²⁴
 A. Reimers¹²⁴ P. Robmann¹²⁴ M. Senger¹²⁴ E. Shokr¹²⁴ F. Stäger¹²⁴ R. Tramontano¹²⁴ C. Adloff^{125,III}
 D. Bhowmik¹²⁵ C. M. Kuo¹²⁵ W. Lin¹²⁵ P. K. Rout¹²⁵ P. C. Tiwari^{125,nmm} S. S. Yu¹²⁵ L. Ceard¹²⁶ K. F. Chen¹²⁶
 P. s. Chen¹²⁶ Z. g. Chen¹²⁶ A. De Iorio¹²⁶ W.-S. Hou¹²⁶ T. h. Hsu¹²⁶ Y. w. Kao¹²⁶ S. Karmakar¹²⁶ G. Kole¹²⁶
 Y. y. Li¹²⁶ R.-S. Lu¹²⁶ E. Paganis¹²⁶ X. f. Su¹²⁶ J. Thomas-Wilsker¹²⁶ L. s. Tsai¹²⁶ H. y. Wu¹²⁶ E. Yazgan¹²⁶
 C. Asawatangtrakuldee¹²⁷ N. Srimanobhas¹²⁷ V. Wachirapusanand¹²⁷ D. Agyel¹²⁸ F. Boran¹²⁸ F. Dolek¹²⁸
 I. Dumanoglu^{128,mmm} E. Eskut¹²⁸ Y. Guler^{128,nnn} E. Gurpinar Guler^{128,nnn} C. Isik¹²⁸ O. Kara¹²⁸
 A. Kayis Topaksu¹²⁸ U. Kiminsu¹²⁸ G. Onengut¹²⁸ K. Ozdemir^{128,ooo} A. Polatoz¹²⁸ B. Tali^{128,ppp}
 U. G. Tok¹²⁸ S. Turkcpar¹²⁸ E. Uslan¹²⁸ I. S. Zorbakir¹²⁸ G. Sokmen¹²⁹ M. Yalvac^{129,qqq} B. Akgun¹³⁰
 I. O. Atakisi¹³⁰ E. Gülmez¹³⁰ M. Kaya^{130,rrr} O. Kaya^{130,sss} S. Tekten^{130,ttt} A. Cakir¹³¹
 K. Cankocak^{131,mmm,uuu} G. G. Dincer^{131,mmm} Y. Komurcu¹³¹ S. Sen^{131,vvv} O. Aydilek^{132,www} V. Epshteyn¹³²
 B. Haciasahinoglu¹³² I. Hos^{132,xxx} B. Kaynak¹³² S. Ozkorucuklu¹³² O. Potok¹³² H. Sert¹³² C. Simsek¹³²
 C. Zorbilmez¹³² S. Cerci^{133,ppp} B. Isildak^{133,yyy} D. Sunar Cerci¹³³ T. Yetkin¹³³ A. Boyaryntsev¹³⁴
 B. Grynyov¹³⁴ L. Levchuk¹³⁵ D. Anthony¹³⁶ J. J. Brooke¹³⁶ A. Bundock¹³⁶ F. Bury¹³⁶ E. Clement¹³⁶
 D. Cussans¹³⁶ H. Flacher¹³⁶ M. Glowacki¹³⁶ J. Goldstein¹³⁶ H. F. Heath¹³⁶ M.-L. Holmberg¹³⁶ L. Kreczko¹³⁶
 S. Paramesvaran¹³⁶ L. Robertshaw¹³⁶ S. Seif El Nasr-Storey¹³⁶ V. J. Smith¹³⁶ N. Stylianou^{136,zzz}
 K. Walkingshaw Pass¹³⁶ A. H. Ball¹³⁷ K. W. Bell¹³⁷ A. Belyaev^{137,aaaa} C. Brew¹³⁷ R. M. Brown¹³⁷
 D. J. A. Cockerill¹³⁷ C. Cooke¹³⁷ A. Elliot¹³⁷ K. V. Ellis¹³⁷ K. Harder¹³⁷ S. Harper¹³⁷ J. Linacre¹³⁷
 K. Manolopoulos¹³⁷ D. M. Newbold¹³⁷ E. Olaiya¹³⁷ D. Petyt¹³⁷ T. Reis¹³⁷ A. R. Sahasransu¹³⁷ G. Salvi¹³⁷
 T. Schuh¹³⁷ C. H. Shepherd-Themistocleous¹³⁷ I. R. Tomalin¹³⁷ K. C. Whalen¹³⁷ T. Williams¹³⁷ I. Andreou¹³⁸
 R. Bainbridge¹³⁸ P. Bloch¹³⁸ C. E. Brown¹³⁸ O. Buchmuller¹³⁸ V. Cacchio¹³⁸ C. A. Carrillo Montoya¹³⁸
 G. S. Chahal^{138,bbbb} D. Colling¹³⁸ J. S. Dancu¹³⁸ I. Das¹³⁸ P. Dauncey¹³⁸ G. Davies¹³⁸ J. Davies¹³⁸
 M. Della Negra¹³⁸ S. Fayer¹³⁸ G. Fedi¹³⁸ G. Hall¹³⁸ M. H. Hassanshahi¹³⁸ A. Howard¹³⁸ G. Iles¹³⁸
 M. Knight¹³⁸ J. Langford¹³⁸ J. León Holgado¹³⁸ L. Lyons¹³⁸ A.-M. Magnan¹³⁸ S. Mallios¹³⁸
 M. Mieskolainen¹³⁸ J. Nash^{138,cccc} M. Pesaresi¹³⁸ P. B. Pradeep¹³⁸ B. C. Radburn-Smith¹³⁸ A. Richards¹³⁸
 A. Rose¹³⁸ K. Savva¹³⁸ C. Seez¹³⁸ R. Shukla¹³⁸ A. Tapper¹³⁸ K. Uchida¹³⁸ G. P. Uttley¹³⁸ L. H. Vage¹³⁸
 T. Virdee^{138,ee} M. Vojinovic¹³⁸ N. Wardle¹³⁸ D. Winterbottom¹³⁸ K. Coldham¹³⁹ J. E. Cole¹³⁹ A. Khan¹³⁹
 P. Kyberd¹³⁹ I. D. Reid¹³⁹ S. Abdullin¹⁴⁰ A. Brinkerhoff¹⁴⁰ B. Caraway¹⁴⁰ E. Collins¹⁴⁰ J. Dittmann¹⁴⁰
 K. Hatakeyama¹⁴⁰ J. Hiltbrand¹⁴⁰ B. McMaster¹⁴⁰ J. Samudio¹⁴⁰ S. Sawant¹⁴⁰ C. Sutantawibul¹⁴⁰
 J. Wilson¹⁴⁰ R. Bartek¹⁴¹ A. Dominguez¹⁴¹ C. Huerta Escamilla¹⁴¹ A. E. Simsek¹⁴¹ R. Uniyal¹⁴¹
 A. M. Vargas Hernandez¹⁴¹ B. Bam¹⁴² A. Buchot Perraguin¹⁴² R. Chudasama¹⁴² S. I. Cooper¹⁴²
 C. Crovella¹⁴² S. V. Gleyzer¹⁴² E. Pearson¹⁴² C. U. Perez¹⁴² P. Rumerio^{142,dddd} E. Usai¹⁴² R. Yi¹⁴²
 A. Akpinar¹⁴³ C. Cosby¹⁴³ G. De Castro¹⁴³ Z. Demiragli¹⁴³ C. Erice¹⁴³ C. Fangmeier¹⁴³
 C. Fernandez Madrazo¹⁴³ E. Fontanesi¹⁴³ D. Gastler¹⁴³ F. Golf¹⁴³ S. Jeon¹⁴³ J. O'cain¹⁴³ I. Reed¹⁴³
 J. Rohlf¹⁴³ K. Salyer¹⁴³ D. Sperka¹⁴³ D. Spitzbart¹⁴³ I. Suarez¹⁴³ A. Tsatsos¹⁴³ A. G. Zecchinelli¹⁴³
 G. Benelli¹⁴⁴ X. Coubez^{144,aa} D. Cutts¹⁴⁴ M. Hadley¹⁴⁴ U. Heintz¹⁴⁴ J. M. Hogan^{144,eeee} T. Kwon¹⁴⁴
 G. Landsberg¹⁴⁴ K. T. Lau¹⁴⁴ D. Li¹⁴⁴ J. Luo¹⁴⁴ S. Mondal¹⁴⁴ M. Narain^{144,a} N. Pervan¹⁴⁴ S. Sagir^{144,fff}
 F. Simpson¹⁴⁴ M. Stamenkovic¹⁴⁴ N. Venkatasubramanian¹⁴⁴ X. Yan¹⁴⁴ W. Zhang¹⁴⁴ S. Abbott¹⁴⁵ J. Bonilla¹⁴⁵
 C. Brainerd¹⁴⁵ R. Breedon¹⁴⁵ H. Cai¹⁴⁵ M. Calderon De La Barca Sanchez¹⁴⁵ M. Chertok¹⁴⁵ M. Citron¹⁴⁵
 J. Conway¹⁴⁵ P. T. Cox¹⁴⁵ R. Erbacher¹⁴⁵ F. Jensen¹⁴⁵ O. Kukral¹⁴⁵ G. Mocellin¹⁴⁵ M. Mulhearn¹⁴⁵
 S. Ostrom¹⁴⁵ W. Wei¹⁴⁵ Y. Yao¹⁴⁵ S. Yoo¹⁴⁵ F. Zhang¹⁴⁵ M. Bachtis¹⁴⁶ R. Cousins¹⁴⁶ A. Datta¹⁴⁶

- G. Flores Avila¹⁴⁶, J. Hauser¹⁴⁶, M. Ignatenko¹⁴⁶, M. A. Iqbal¹⁴⁶, T. Lam¹⁴⁶, E. Manca¹⁴⁶, A. Nunez Del Prado¹⁴⁶,
 D. Saltzberg¹⁴⁶, V. Valuev¹⁴⁶, R. Clare¹⁴⁷, J. W. Gary¹⁴⁷, M. Gordon¹⁴⁷, G. Hanson¹⁴⁷, W. Si¹⁴⁷,
 S. Wimpenny^{147,a}, A. Aportela¹⁴⁸, A. Arora¹⁴⁸, J. G. Branson¹⁴⁸, S. Cittolin¹⁴⁸, S. Cooperstein¹⁴⁸, D. Diaz¹⁴⁸,
 J. Duarte¹⁴⁸, L. Giannini¹⁴⁸, Y. Gu¹⁴⁸, J. Guiang¹⁴⁸, R. Kansal¹⁴⁸, V. Krutelyov¹⁴⁸, R. Lee¹⁴⁸, J. Letts¹⁴⁸,
 M. Masciovecchio¹⁴⁸, F. Mokhtar¹⁴⁸, S. Mukherjee¹⁴⁸, M. Pieri¹⁴⁸, M. Quinnan¹⁴⁸, B. V. Sathia Narayanan¹⁴⁸,
 V. Sharma¹⁴⁸, M. Tadel¹⁴⁸, E. Vourliotis¹⁴⁸, F. Würthwein¹⁴⁸, Y. Xiang¹⁴⁸, A. Yagil¹⁴⁸, A. Barzdukas¹⁴⁹,
 L. Brennan¹⁴⁹, C. Campagnari¹⁴⁹, K. Downham¹⁴⁹, C. Grieco¹⁴⁹, J. Incandela¹⁴⁹, J. Kim¹⁴⁹, A. J. Li¹⁴⁹,
 P. Masterson¹⁴⁹, H. Mei¹⁴⁹, J. Richman¹⁴⁹, S. N. Santpur¹⁴⁹, U. Sarica¹⁴⁹, R. Schmitz¹⁴⁹, F. Setti¹⁴⁹,
 J. Sheplock¹⁴⁹, D. Stuart¹⁴⁹, T. Á. Vami¹⁴⁹, S. Wang¹⁴⁹, D. Zhang¹⁴⁹, A. Bornheim¹⁵⁰, O. Cerri¹⁵⁰, A. Latorre¹⁵⁰,
 J. Mao¹⁵⁰, H. B. Newman¹⁵⁰, G. Reales Gutiérrez¹⁵⁰, M. Spiropulu¹⁵⁰, J. R. Vlimant¹⁵⁰, C. Wang¹⁵⁰, S. Xie¹⁵⁰,
 R. Y. Zhu¹⁵⁰, J. Alison¹⁵¹, S. An¹⁵¹, M. B. Andrews¹⁵¹, P. Bryant¹⁵¹, M. Cremonesi¹⁵¹, V. Dutta¹⁵¹,
 T. Ferguson¹⁵¹, T. A. Gómez Espinosa¹⁵¹, A. Harilal¹⁵¹, A. Kallil Tharayil¹⁵¹, C. Liu¹⁵¹, T. Mudholkar¹⁵¹,
 S. Murthy¹⁵¹, P. Palit¹⁵¹, K. Park¹⁵¹, M. Paulini¹⁵¹, A. Roberts¹⁵¹, A. Sanchez¹⁵¹, W. Terrill¹⁵¹, J. P. Cumalat¹⁵²,
 W. T. Ford¹⁵², A. Hart¹⁵², A. Hassani¹⁵², G. Karathanasis¹⁵², N. Manganelli¹⁵², A. Perloff¹⁵², C. Savard¹⁵²,
 N. Schonbeck¹⁵², K. Stenson¹⁵², K. A. Ulmer¹⁵², S. R. Wagner¹⁵², N. Zipper¹⁵², D. Zuolo¹⁵², J. Alexander¹⁵³,
 S. Bright-Thonney¹⁵³, X. Chen¹⁵³, D. J. Cranshaw¹⁵³, J. Fan¹⁵³, X. Fan¹⁵³, S. Hogan¹⁵³, P. Kotamnives¹⁵³,
 J. Monroy¹⁵³, M. Oshiro¹⁵³, J. R. Patterson¹⁵³, M. Reid¹⁵³, A. Ryd¹⁵³, J. Thom¹⁵³, P. Wittich¹⁵³, R. Zou¹⁵³,
 M. Albrow¹⁵⁴, M. Alyari¹⁵⁴, O. Amram¹⁵⁴, G. Apollinari¹⁵⁴, A. Apresyan¹⁵⁴, L. A. T. Bauerdick¹⁵⁴, D. Berry¹⁵⁴,
 J. Berryhill¹⁵⁴, P. C. Bhat¹⁵⁴, K. Burkett¹⁵⁴, J. N. Butler¹⁵⁴, A. Canepa¹⁵⁴, G. B. Cerati¹⁵⁴, H. W. K. Cheung¹⁵⁴,
 F. Chlebana¹⁵⁴, G. Cummings¹⁵⁴, J. Dickinson¹⁵⁴, I. Dutta¹⁵⁴, V. D. Elvira¹⁵⁴, Y. Feng¹⁵⁴, J. Freeman¹⁵⁴,
 A. Gandrakota¹⁵⁴, Z. Gece¹⁵⁴, L. Gray¹⁵⁴, D. Green¹⁵⁴, A. Grummer¹⁵⁴, S. Grünendahl¹⁵⁴, D. Guerrero¹⁵⁴,
 O. Gutsche¹⁵⁴, R. M. Harris¹⁵⁴, R. Heller¹⁵⁴, T. C. Herwig¹⁵⁴, J. Hirschauer¹⁵⁴, B. Jayatilaka¹⁵⁴, S. Jindariani¹⁵⁴,
 M. Johnson¹⁵⁴, U. Joshi¹⁵⁴, T. Klijnsma¹⁵⁴, B. Klima¹⁵⁴, K. H. M. Kwok¹⁵⁴, S. Lammel¹⁵⁴, D. Lincoln¹⁵⁴,
 R. Lipton¹⁵⁴, T. Liu¹⁵⁴, C. Madrid¹⁵⁴, K. Maeshima¹⁵⁴, C. Mantilla¹⁵⁴, D. Mason¹⁵⁴, P. McBride¹⁵⁴,
 P. Merkel¹⁵⁴, S. Mrenna¹⁵⁴, S. Nahn¹⁵⁴, J. Ngadiuba¹⁵⁴, D. Noonan¹⁵⁴, S. Norberg¹⁵⁴, V. Papadimitriou¹⁵⁴,
 N. Pastika¹⁵⁴, K. Pedro¹⁵⁴, C. Pena^{154,gggg}, F. Ravera¹⁵⁴, A. Reinsvold Hall^{154,hhhh}, L. Ristori¹⁵⁴, M. Safdari¹⁵⁴,
 E. Sexton-Kennedy¹⁵⁴, N. Smith¹⁵⁴, A. Soha¹⁵⁴, L. Spiegel¹⁵⁴, S. Stoynev¹⁵⁴, J. Strait¹⁵⁴, L. Taylor¹⁵⁴,
 S. Tkaczyk¹⁵⁴, N. V. Tran¹⁵⁴, L. Uplegger¹⁵⁴, E. W. Vaandering¹⁵⁴, I. Zoi¹⁵⁴, C. Aruta¹⁵⁵, P. Avery¹⁵⁵,
 D. Bourilkov¹⁵⁵, P. Chang¹⁵⁵, V. Cherepanov¹⁵⁵, R. D. Field¹⁵⁵, E. Koenig¹⁵⁵, M. Kolosova¹⁵⁵, J. Konigsberg¹⁵⁵,
 A. Korytov¹⁵⁵, K. Matchev¹⁵⁵, N. Menendez¹⁵⁵, G. Mitselmakher¹⁵⁵, K. Mohrman¹⁵⁵,
 A. Muthirakalayil Madhu¹⁵⁵, N. Rawal¹⁵⁵, S. Rosenzweig¹⁵⁵, Y. Takahashi¹⁵⁵, J. Wang¹⁵⁵, T. Adams¹⁵⁶,
 A. Al Kadhimi¹⁵⁶, A. Askew¹⁵⁶, S. Bower¹⁵⁶, R. Habibullah¹⁵⁶, V. Hagopian¹⁵⁶, R. Hashmi¹⁵⁶, R. S. Kim¹⁵⁶,
 S. Kim¹⁵⁶, T. Kolberg¹⁵⁶, G. Martinez¹⁵⁶, H. Prosper¹⁵⁶, P. R. Prova¹⁵⁶, M. Wulansatiti¹⁵⁶, R. Yohay¹⁵⁶, J. Zhang¹⁵⁶,
 B. Alsufyani¹⁵⁷, M. M. Baarmand¹⁵⁷, S. Butalla¹⁵⁷, S. Das¹⁵⁷, T. Elkafrawy^{157,iiii}, M. Hohlmann¹⁵⁷, M. Rahmani¹⁵⁷,
 E. Yanes¹⁵⁷, M. R. Adams¹⁵⁸, A. Baty¹⁵⁸, C. Bennett¹⁵⁸, R. Cavanaugh¹⁵⁸, R. Escobar Franco¹⁵⁸, O. Evdokimov¹⁵⁸,
 C. E. Gerber¹⁵⁸, M. Hawksworth¹⁵⁸, A. Hingrajiya¹⁵⁸, D. J. Hofman¹⁵⁸, J. h. Lee¹⁵⁸, D. S. Lemos¹⁵⁸,
 A. H. Merrit¹⁵⁸, C. Mills¹⁵⁸, S. Nanda¹⁵⁸, G. Oh¹⁵⁸, B. Ozek¹⁵⁸, D. Pilipovic¹⁵⁸, R. Pradhan¹⁵⁸, E. Prifti¹⁵⁸,
 T. Roy¹⁵⁸, S. Rudrabhatla¹⁵⁸, M. B. Tonjes¹⁵⁸, N. Varelas¹⁵⁸, M. A. Wadud¹⁵⁸, Z. Ye¹⁵⁸, J. Yoo¹⁵⁸,
 M. Alhusseini¹⁵⁹, D. Blend¹⁵⁹, K. Dilsiz^{159,jjjj}, L. Emediato¹⁵⁹, G. Karaman¹⁵⁹, O. K. Köseyan¹⁵⁹, J.-P. Merlo¹⁵⁹,
 A. Mestvirishvili^{159,kkkk}, O. Neogi¹⁵⁹, H. Ogul^{159,llll}, Y. Onel¹⁵⁹, A. Penzo¹⁵⁹, C. Snyder¹⁵⁹, E. Tiras^{159,mmmm},
 B. Blumenfeld¹⁶⁰, L. Corcodilos¹⁶⁰, J. Davis¹⁶⁰, A. V. Gritsan¹⁶⁰, L. Kang¹⁶⁰, S. Kyriacou¹⁶⁰, P. Maksimovic¹⁶⁰,
 M. Roguljic¹⁶⁰, J. Roskes¹⁶⁰, S. Sekhar¹⁶⁰, M. Swartz¹⁶⁰, A. Abreu¹⁶¹, L. F. Alcerro Alcerro¹⁶¹, J. Anguiano¹⁶¹,
 S. Arteaga Escatel¹⁶¹, P. Baringer¹⁶¹, A. Bean¹⁶¹, Z. Flowers¹⁶¹, D. Grove¹⁶¹, J. King¹⁶¹, G. Krintiras¹⁶¹,
 M. Lazarovits¹⁶¹, C. Le Mahieu¹⁶¹, J. Marquez¹⁶¹, N. Minafra¹⁶¹, M. Murray¹⁶¹, M. Nickel¹⁶¹, M. Pitt¹⁶¹,
 S. Popescu^{161,nnnn}, C. Rogan¹⁶¹, C. Royon¹⁶¹, R. Salvatico¹⁶¹, S. Sanders¹⁶¹, C. Smith¹⁶¹, G. Wilson¹⁶¹,
 B. Allmond¹⁶², R. Gujju Gurunadha¹⁶², A. Ivanov¹⁶², K. Kaadze¹⁶², Y. Maravin¹⁶², J. Natoli¹⁶², D. Roy¹⁶²,
 G. Sorrentino¹⁶², A. Baden¹⁶³, A. Belloni¹⁶³, J. Bistany-riebman¹⁶³, Y. M. Chen¹⁶³, S. C. Eno¹⁶³, N. J. Hadley¹⁶³,
 S. Jabeen¹⁶³, R. G. Kellogg¹⁶³, T. Koeth¹⁶³, B. Kronheim¹⁶³, Y. Lai¹⁶³, S. Lascio¹⁶³, A. C. Mignerey¹⁶³,
 S. Nabili¹⁶³, C. Palmer¹⁶³, C. Papageorgakis¹⁶³, M. M. Paranjpe¹⁶³, L. Wang¹⁶³, J. Bendavid¹⁶⁴, I. A. Cali¹⁶⁴

P. c. Chou¹⁶⁴, M. D'Alfonso¹⁶⁴, J. Eysermans¹⁶⁴, C. Freer¹⁶⁴, G. Gomez-Ceballos¹⁶⁴, M. Goncharov¹⁶⁴,
 G. Grosso¹⁶⁴, P. Harris¹⁶⁴, D. Hoang¹⁶⁴, D. Kovalskyi¹⁶⁴, J. Krupa¹⁶⁴, L. Lavezzo¹⁶⁴, Y.-J. Lee¹⁶⁴, K. Long¹⁶⁴,
 C. McGinn¹⁶⁴, A. Novak¹⁶⁴, C. Paus¹⁶⁴, D. Rankin¹⁶⁴, C. Roland¹⁶⁴, G. Roland¹⁶⁴, S. Rothman¹⁶⁴,
 G. S. F. Stephans¹⁶⁴, Z. Wang¹⁶⁴, B. Wyslouch¹⁶⁴, T. J. Yang¹⁶⁴, B. Crossman¹⁶⁵, B. M. Joshi¹⁶⁵, C. Kapsiak¹⁶⁵,
 M. Krohn¹⁶⁵, D. Mahon¹⁶⁵, J. Mans¹⁶⁵, B. Marzocchi¹⁶⁵, M. Revering¹⁶⁵, R. Rusack¹⁶⁵, R. Saradhy¹⁶⁵,
 N. Strobbe¹⁶⁵, L. M. Cremaldi¹⁶⁶, K. Bloom¹⁶⁷, D. R. Claes¹⁶⁷, G. Haza¹⁶⁷, J. Hossain¹⁶⁷, C. Joo¹⁶⁷,
 I. Kravchenko¹⁶⁷, J. E. Siado¹⁶⁷, W. Tabb¹⁶⁷, A. Vagnerini¹⁶⁷, A. Wightman¹⁶⁷, F. Yan¹⁶⁷, D. Yu¹⁶⁷,
 H. Bandyopadhyay¹⁶⁸, L. Hay¹⁶⁸, H. w. Hsia¹⁶⁸, I. Iashvili¹⁶⁸, A. Kalogeropoulos¹⁶⁸, A. Kharchilava¹⁶⁸,
 M. Morris¹⁶⁸, D. Nguyen¹⁶⁸, S. Rappoccio¹⁶⁸, H. Rejeb Sfar¹⁶⁸, A. Williams¹⁶⁸, P. Young¹⁶⁸, G. Alverson¹⁶⁹,
 E. Barberis¹⁶⁹, J. Dervan¹⁶⁹, Y. Haddad¹⁶⁹, Y. Han¹⁶⁹, A. Krishna¹⁶⁹, J. Li¹⁶⁹, M. Lu¹⁶⁹, G. Madigan¹⁶⁹,
 R. McCarthy¹⁶⁹, D. M. Morse¹⁶⁹, V. Nguyen¹⁶⁹, T. Orimoto¹⁶⁹, A. Parker¹⁶⁹, L. Skinnari¹⁶⁹, D. Wood¹⁶⁹,
 J. Bueghly¹⁷⁰, S. Dittmer¹⁷⁰, K. A. Hahn¹⁷⁰, Y. Liu¹⁷⁰, Y. Miao¹⁷⁰, D. G. Monk¹⁷⁰, M. H. Schmitt¹⁷⁰,
 A. Talierno¹⁷⁰, M. Velasco¹⁷⁰, G. Agarwal¹⁷¹, R. Band¹⁷¹, R. Bucci¹⁷¹, S. Castells¹⁷¹, A. Das¹⁷¹,
 R. Goldouzian¹⁷¹, M. Hildreth¹⁷¹, K. W. Ho¹⁷¹, K. Hurtado Anampa¹⁷¹, T. Ivanov¹⁷¹, C. Jessop¹⁷¹,
 K. Lannon¹⁷¹, J. Lawrence¹⁷¹, N. Loukas¹⁷¹, L. Lutton¹⁷¹, J. Mariano¹⁷¹, N. Marinelli¹⁷¹, I. Mcalister¹⁷¹,
 T. McCauley¹⁷¹, C. Mcgrady¹⁷¹, C. Moore¹⁷¹, Y. Musienko^{171,r}, H. Nelson¹⁷¹, M. Osherson¹⁷¹, A. Piccinelli¹⁷¹,
 R. Ruchti¹⁷¹, A. Townsend¹⁷¹, Y. Wan¹⁷¹, M. Wayne¹⁷¹, H. Yockey¹⁷¹, M. Zarucki¹⁷¹, L. Zygala¹⁷¹, A. Basnet¹⁷²,
 B. Bylsma¹⁷², M. Carrigan¹⁷², L. S. Durkin¹⁷², C. Hill¹⁷², M. Joyce¹⁷², M. Nunez Ornelas¹⁷², K. Wei¹⁷²,
 B. L. Winer¹⁷², B. R. Yates¹⁷², H. Bouchamaoui¹⁷³, P. Das¹⁷³, G. Dezoort¹⁷³, P. Elmer¹⁷³, A. Frankenthal¹⁷³,
 B. Greenberg¹⁷³, N. Haubrich¹⁷³, K. Kennedy¹⁷³, G. Kopp¹⁷³, S. Kwan¹⁷³, D. Lange¹⁷³, A. Loeliger¹⁷³,
 D. Marlow¹⁷³, I. Ojalvo¹⁷³, J. Olsen¹⁷³, A. Shevelev¹⁷³, D. Stickland¹⁷³, C. Tully¹⁷³, S. Malik¹⁷⁴,
 A. S. Bakshi¹⁷⁵, V. E. Barnes¹⁷⁵, S. Chandra¹⁷⁵, R. Chawla¹⁷⁵, A. Gu¹⁷⁵, L. Gutay¹⁷⁵, M. Jones¹⁷⁵,
 A. W. Jung¹⁷⁵, A. M. Koshy¹⁷⁵, M. Liu¹⁷⁵, G. Negro¹⁷⁵, N. Neumeister¹⁷⁵, G. Paspalaki¹⁷⁵, S. Piperov¹⁷⁵,
 V. Scheurer¹⁷⁵, J. F. Schulte¹⁷⁵, M. Stojanovic¹⁷⁵, J. Thieman¹⁷⁵, A. K. Virdi¹⁷⁵, F. Wang¹⁷⁵, W. Xie¹⁷⁵,
 J. Dolen¹⁷⁶, N. Parashar¹⁷⁶, A. Pathak¹⁷⁶, D. Acosta¹⁷⁷, T. Carnahan¹⁷⁷, K. M. Ecklund¹⁷⁷,
 P. J. Fernández Manteca¹⁷⁷, S. Freed¹⁷⁷, P. Gardner¹⁷⁷, F. J. M. Geurts¹⁷⁷, W. Li¹⁷⁷, J. Lin¹⁷⁷, O. Miguel Colin¹⁷⁷,
 B. P. Padley¹⁷⁷, R. Redjimi¹⁷⁷, J. Rotter¹⁷⁷, E. Yigitbasi¹⁷⁷, Y. Zhang¹⁷⁷, A. Bodek¹⁷⁸, P. de Barbaro¹⁷⁸,
 R. Demina¹⁷⁸, J. L. Dulemba¹⁷⁸, A. Garcia-Bellido¹⁷⁸, O. Hindrichs¹⁷⁸, A. Khukhunaishvili¹⁷⁸, N. Parmar¹⁷⁸,
 P. Parygin^{178,r}, E. Popova^{178,r}, R. Taus¹⁷⁸, K. Goulianos¹⁷⁹, B. Chiarito¹⁸⁰, J. P. Chou¹⁸⁰, S. V. Clark¹⁸⁰,
 D. Gadkari¹⁸⁰, Y. Gershtein¹⁸⁰, E. Halkiadakis¹⁸⁰, M. Heindl¹⁸⁰, C. Houghton¹⁸⁰, D. Jaroslawski¹⁸⁰,
 O. Karacheban^{180,cc}, S. Konstantinou¹⁸⁰, I. Laflotte¹⁸⁰, A. Lath¹⁸⁰, R. Montalvo¹⁸⁰, K. Nash¹⁸⁰, J. Reichert¹⁸⁰,
 H. Routray¹⁸⁰, P. Saha¹⁸⁰, S. Salur¹⁸⁰, S. Schnetzer¹⁸⁰, S. Somalwar¹⁸⁰, R. Stone¹⁸⁰, S. A. Thayil¹⁸⁰, S. Thomas¹⁸⁰,
 J. Vora¹⁸⁰, H. Wang¹⁸⁰, H. Acharya¹⁸¹, D. Ally¹⁸¹, A. G. Delannoy¹⁸¹, S. Fiorendi¹⁸¹, S. Higginbotham¹⁸¹,
 T. Holmes¹⁸¹, A. R. Kanuganti¹⁸¹, N. Karunaratna¹⁸¹, L. Lee¹⁸¹, E. Nibigira¹⁸¹, S. Spanier¹⁸¹, D. Aebi¹⁸²,
 M. Ahmad¹⁸², T. Akhter¹⁸², O. Bouhali^{182,oooo}, R. Eusebi¹⁸², J. Gilmore¹⁸², T. Huang¹⁸², T. Kamon^{182,pppp},
 H. Kim¹⁸², S. Luo¹⁸², R. Mueller¹⁸², D. Overton¹⁸², D. Rathjens¹⁸², A. Safonov¹⁸², N. Akchurin¹⁸³,
 J. Damgov¹⁸³, N. Gogate¹⁸³, V. Hegde¹⁸³, A. Hussain¹⁸³, Y. Kazhykarim¹⁸³, K. Lamichhane¹⁸³, S. W. Lee¹⁸³,
 A. Mankel¹⁸³, T. Peltola¹⁸³, I. Volobouev¹⁸³, E. Appelt¹⁸⁴, Y. Chen¹⁸⁴, S. Greene¹⁸⁴, A. Gurrola¹⁸⁴, W. Johns¹⁸⁴,
 R. Kunnawalkam Elayavalli¹⁸⁴, A. Melo¹⁸⁴, F. Romeo¹⁸⁴, P. Sheldon¹⁸⁴, S. Tuo¹⁸⁴, J. Velkovska¹⁸⁴,
 J. Viinikainen¹⁸⁴, B. Cardwell¹⁸⁵, B. Cox¹⁸⁵, J. Hakala¹⁸⁵, R. Hirosky¹⁸⁵, A. Ledovskoy¹⁸⁵, C. Neu¹⁸⁵,
 S. Bhattacharya¹⁸⁶, P. E. Karchin¹⁸⁶, A. Aravind¹⁸⁷, S. Banerjee¹⁸⁷, K. Black¹⁸⁷, T. Bose¹⁸⁷, S. Dasu¹⁸⁷,
 I. De Bruyn¹⁸⁷, P. Everaerts¹⁸⁷, C. Galloni¹⁸⁷, H. He¹⁸⁷, M. Herndon¹⁸⁷, A. Herve¹⁸⁷, C. K. Koraka¹⁸⁷,
 A. Lanaro¹⁸⁷, R. Loveless¹⁸⁷, J. Madhusudan Sreekala¹⁸⁷, A. Mallampalli¹⁸⁷, A. Mohammadi¹⁸⁷, S. Mondal¹⁸⁷,
 G. Parida¹⁸⁷, L. Pétré¹⁸⁷, D. Pinna¹⁸⁷, A. Savin¹⁸⁷, V. Shang¹⁸⁷, V. Sharma¹⁸⁷, W. H. Smith¹⁸⁷, D. Teague¹⁸⁷,
 H. F. Tsoi¹⁸⁷, W. Vetens¹⁸⁷, A. Warden¹⁸⁷, S. Afanasiev¹⁸⁸, V. Alexakhin¹⁸⁸, V. Andreev¹⁸⁸, Yu. Andreev¹⁸⁸,
 T. Aushev¹⁸⁸, M. Azarkin¹⁸⁸, A. Babaev¹⁸⁸, V. Blinov^{188,r}, E. Boos¹⁸⁸, V. Borshch¹⁸⁸, D. Budkouski¹⁸⁸,
 V. Bunichev¹⁸⁸, M. Chadeeva^{188,r}, V. Chekhovskiy¹⁸⁸, R. Chistov^{188,r}, A. Dermenev¹⁸⁸, T. Dimova^{188,r},
 D. Druzhkin^{188,qqqq}, M. Dubinin^{188,gggg}, L. Dudko¹⁸⁸, G. Gavrilo¹⁸⁸, V. Gavrilo¹⁸⁸, S. Gninenko¹⁸⁸,
 V. Golovtsov¹⁸⁸, N. Golubev¹⁸⁸, I. Golutvin¹⁸⁸, I. Gorbunov¹⁸⁸, Y. Ivanov¹⁸⁸, V. Kachanov¹⁸⁸, V. Karjavine¹⁸⁸

A. Karneyeu¹⁸⁸, V. Kim^{188,r}, M. Kirakosyan¹⁸⁸, D. Kirpichnikov¹⁸⁸, M. Kirsanov¹⁸⁸, V. Klyukhin¹⁸⁸,
 O. Kodolova^{188,rrrr}, D. Konstantinov¹⁸⁸, V. Korenkov¹⁸⁸, A. Kozyrev^{188,r}, N. Krasnikov¹⁸⁸, A. Lanev¹⁸⁸,
 P. Levchenko^{188,ssss}, O. Lukina¹⁸⁸, N. Lychkovskaya¹⁸⁸, V. Makarenko¹⁸⁸, A. Malakhov¹⁸⁸, V. Matveev^{188,r},
 V. Murzin¹⁸⁸, A. Nikitenko^{188,ttt,rrrr}, S. Obraztsov¹⁸⁸, V. Oreshkin¹⁸⁸, V. Palichik¹⁸⁸, V. Perelygin¹⁸⁸,
 M. Perfilov¹⁸⁸, S. Polikarpov^{188,r}, V. Popov¹⁸⁸, O. Radchenko^{188,r}, M. Savina¹⁸⁸, V. Savrin¹⁸⁸, V. Shalaev¹⁸⁸,
 S. Shmatov¹⁸⁸, S. Shulha¹⁸⁸, Y. Skovpen^{188,r}, S. Slabospitskii¹⁸⁸, V. Smirnov¹⁸⁸, A. Snigirev¹⁸⁸, D. Sosnov¹⁸⁸,
 V. Sulimov¹⁸⁸, E. Tcherniaev¹⁸⁸, A. Terkulov¹⁸⁸, O. Teryaev¹⁸⁸, I. Tlisova¹⁸⁸, A. Toropin¹⁸⁸, L. Uvarov¹⁸⁸,
 A. Uzunian¹⁸⁸, A. Vorobyev^{188,a}, G. Vorotnikov¹⁸⁸, N. Voytishin¹⁸⁸, B. S. Yuldashev^{188,uuuu}, A. Zarubin¹⁸⁸,
 I. Zhizhin¹⁸⁸, and A. Zhokin¹⁸⁸

(CMS Collaboration)

¹*Yerevan Physics Institute, Yerevan, Armenia*

²*Institut für Hochenergiephysik, Vienna, Austria*

³*Universiteit Antwerpen, Antwerpen, Belgium*

⁴*Vrije Universiteit Brussel, Brussel, Belgium*

⁵*Université Libre de Bruxelles, Bruxelles, Belgium*

⁶*Ghent University, Ghent, Belgium*

⁷*Université Catholique de Louvain, Louvain-la-Neuve, Belgium*

⁸*Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil*

⁹*Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil*

¹⁰*Universidade Estadual Paulista, Universidade Federal do ABC, São Paulo, Brazil*

¹¹*Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, Sofia, Bulgaria*

¹²*University of Sofia, Sofia, Bulgaria*

¹³*Instituto De Alta Investigación, Universidad de Tarapacá, Casilla 7 D, Arica, Chile*

¹⁴*Beihang University, Beijing, China*

¹⁵*Department of Physics, Tsinghua University, Beijing, China*

¹⁶*Institute of High Energy Physics, Beijing, China*

¹⁷*State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China*

¹⁸*Guangdong Provincial Key Laboratory of Nuclear Science and Guangdong-Hong Kong Joint Laboratory of Quantum Matter, South China Normal University, Guangzhou, China*

¹⁹*Sun Yat-Sen University, Guangzhou, China*

²⁰*University of Science and Technology of China, Hefei, China*

²¹*Nanjing Normal University, Nanjing, China*

²²*Institute of Modern Physics and Key Laboratory of Nuclear Physics and Ion-beam Application (MOE) - Fudan University, Shanghai, China*

²³*Zhejiang University, Hangzhou, Zhejiang, China*

²⁴*Universidad de Los Andes, Bogota, Colombia*

²⁵*Universidad de Antioquia, Medellin, Colombia*

²⁶*University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split, Croatia*

²⁷*University of Split, Faculty of Science, Split, Croatia*

²⁸*Institute Rudjer Boskovic, Zagreb, Croatia*

²⁹*University of Cyprus, Nicosia, Cyprus*

³⁰*Charles University, Prague, Czech Republic*

³¹*Universidad San Francisco de Quito, Quito, Ecuador*

³²*Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt*

³³*Center for High Energy Physics (CHEP-FU), Fayoum University, El-Fayoum, Egypt*

³⁴*National Institute of Chemical Physics and Biophysics, Tallinn, Estonia*

³⁵*Department of Physics, University of Helsinki, Helsinki, Finland*

³⁶*Helsinki Institute of Physics, Helsinki, Finland*

³⁷*Lappeenranta-Lahti University of Technology, Lappeenranta, Finland*

³⁸*IRFU, CEA, Université Paris-Saclay, Gif-sur-Yvette, France*

³⁹*Laboratoire Leprince-Ringuet, CNRS/IN2P3, Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau, France*

⁴⁰*Université de Strasbourg, CNRS, IPHC UMR 7178, Strasbourg, France*

- ⁴¹*Centre de Calcul de l'Institut National de Physique Nucleaire et de Physique des Particules, CNRS/IN2P3, Villeurbanne, France*
- ⁴²*Institut de Physique des 2 Infinis de Lyon (IP2I), Villeurbanne, France*
- ⁴³*Georgian Technical University, Tbilisi, Georgia*
- ⁴⁴*RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany*
- ⁴⁵*RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany*
- ⁴⁶*RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany*
- ⁴⁷*Deutsches Elektronen-Synchrotron, Hamburg, Germany*
- ⁴⁸*University of Hamburg, Hamburg, Germany*
- ⁴⁹*Karlsruher Institut fuer Technologie, Karlsruhe, Germany*
- ⁵⁰*Institute of Nuclear and Particle Physics (INPP), NCSR Demokritos, Aghia Paraskevi, Greece*
- ⁵¹*National and Kapodistrian University of Athens, Athens, Greece*
- ⁵²*National Technical University of Athens, Athens, Greece*
- ⁵³*University of Ioánnina, Ioánnina, Greece*
- ⁵⁴*HUN-REN Wigner Research Centre for Physics, Budapest, Hungary*
- ⁵⁵*MTA-ELTE Lendület CMS Particle and Nuclear Physics Group, Eötvös Loránd University, Budapest, Hungary*
- ⁵⁶*Faculty of Informatics, University of Debrecen, Debrecen, Hungary*
- ⁵⁷*Institute of Nuclear Research ATOMKI, Debrecen, Hungary*
- ⁵⁸*Karoly Robert Campus, MATE Institute of Technology, Gyongyos, Hungary*
- ⁵⁹*Panjab University, Chandigarh, India*
- ⁶⁰*University of Delhi, Delhi, India*
- ⁶¹*Saha Institute of Nuclear Physics, HBNI, Kolkata, India*
- ⁶²*Indian Institute of Technology Madras, Madras, India*
- ⁶³*Tata Institute of Fundamental Research-A, Mumbai, India*
- ⁶⁴*Tata Institute of Fundamental Research-B, Mumbai, India*
- ⁶⁵*National Institute of Science Education and Research, An OCC of Homi Bhabha National Institute, Bhubaneswar, Odisha, India*
- ⁶⁶*Indian Institute of Science Education and Research (IISER), Pune, India*
- ⁶⁷*Isfahan University of Technology, Isfahan, Iran*
- ⁶⁸*Institute for Research in Fundamental Sciences (IPM), Tehran, Iran*
- ⁶⁹*University College Dublin, Dublin, Ireland*
- ^{70a}*INFN Sezione di Bari, Bari, Italy*
- ^{70b}*Università di Bari, Bari, Italy*
- ^{70c}*Politecnico di Bari, Bari, Italy*
- ^{71a}*INFN Sezione di Bologna, Bologna, Italy*
- ^{71b}*Università di Bologna, Bologna, Italy*
- ^{72a}*INFN Sezione di Catania, Catania, Italy*
- ^{72b}*Università di Catania, Catania, Italy*
- ^{73a}*INFN Sezione di Firenze, Firenze, Italy*
- ^{73b}*Università di Firenze, Firenze, Italy*
- ⁷⁴*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
- ^{75a}*INFN Sezione di Genova, Genova, Italy*
- ^{75b}*Università di Genova, Genova, Italy*
- ^{76a}*INFN Sezione di Milano-Bicocca, Milano, Italy*
- ^{76b}*Università di Milano-Bicocca, Milano, Italy*
- ^{77a}*INFN Sezione di Napoli, Napoli, Italy*
- ^{77b}*Università di Napoli 'Federico II', Napoli, Italy*
- ^{77c}*Università della Basilicata, Potenza, Italy*
- ^{77d}*Scuola Superiore Meridionale (SSM), Napoli, Italy*
- ^{78a}*INFN Sezione di Padova, Padova, Italy*
- ^{78b}*Università di Padova, Padova, Italy*
- ^{78c}*Università di Trento, Trento, Italy*
- ^{79a}*INFN Sezione di Pavia, Pavia, Italy*
- ^{79b}*Università di Pavia, Pavia, Italy*
- ^{80a}*INFN Sezione di Perugia, Perugia, Italy*
- ^{80b}*Università di Perugia, Perugia, Italy*
- ^{81a}*INFN Sezione di Pisa, Pisa, Italy*
- ^{81b}*Università di Pisa, Pisa, Italy*
- ^{81c}*Scuola Normale Superiore di Pisa, Pisa, Italy*
- ^{81d}*Università di Siena, Siena, Italy*

- ^{82a}*INFN Sezione di Roma, Roma, Italy*
- ^{82b}*Sapienza Università di Roma, Roma, Italy*
- ^{83a}*INFN Sezione di Torino, Torino, Italy*
- ^{83b}*Università di Torino, Torino, Italy*
- ^{83c}*Università del Piemonte Orientale, Novara, Italy*
- ^{84a}*INFN Sezione di Trieste, Trieste, Italy*
- ^{84b}*Università di Trieste, Trieste, Italy*
- ⁸⁵*Kyungpook National University, Daegu, Korea*
- ⁸⁶*Department of Mathematics and Physics - GWNu, Gangneung, Korea*
- ⁸⁷*Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea*
- ⁸⁸*Hanyang University, Seoul, Korea*
- ⁸⁹*Korea University, Seoul, Korea*
- ⁹⁰*Kyung Hee University, Department of Physics, Seoul, Korea*
- ⁹¹*Sejong University, Seoul, Korea*
- ⁹²*Seoul National University, Seoul, Korea*
- ⁹³*University of Seoul, Seoul, Korea*
- ⁹⁴*Yonsei University, Department of Physics, Seoul, Korea*
- ⁹⁵*Sungkyunkwan University, Suwon, Korea*
- ⁹⁶*College of Engineering and Technology, American University of the Middle East (AUM), Dasman, Kuwait*
- ⁹⁷*Riga Technical University, Riga, Latvia*
- ⁹⁸*University of Latvia (LU), Riga, Latvia*
- ⁹⁹*Vilnius University, Vilnius, Lithuania*
- ¹⁰⁰*National Centre for Particle Physics, Universiti Malaya, Kuala Lumpur, Malaysia*
- ¹⁰¹*Universidad de Sonora (UNISON), Hermosillo, Mexico*
- ¹⁰²*Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico*
- ¹⁰³*Universidad Iberoamericana, Mexico City, Mexico*
- ¹⁰⁴*Benemerita Universidad Autonoma de Puebla, Puebla, Mexico*
- ¹⁰⁵*University of Montenegro, Podgorica, Montenegro*
- ¹⁰⁶*University of Canterbury, Christchurch, New Zealand*
- ¹⁰⁷*National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan*
- ¹⁰⁸*AGH University of Krakow, Faculty of Computer Science, Electronics and Telecommunications, Krakow, Poland*
- ¹⁰⁹*National Centre for Nuclear Research, Swierk, Poland*
- ¹¹⁰*Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland*
- ¹¹¹*Warsaw University of Technology, Warsaw, Poland*
- ¹¹²*Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal*
- ¹¹³*Faculty of Physics, University of Belgrade, Belgrade, Serbia*
- ¹¹⁴*VINCA Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*
- ¹¹⁵*Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain*
- ¹¹⁶*Universidad Autónoma de Madrid, Madrid, Spain*
- ¹¹⁷*Universidad de Oviedo, Instituto Universitario de Ciencias y Tecnologías Espaciales de Asturias (ICTEA), Oviedo, Spain*
- ¹¹⁸*Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain*
- ¹¹⁹*University of Colombo, Colombo, Sri Lanka*
- ¹²⁰*University of Ruhuna, Department of Physics, Matara, Sri Lanka*
- ¹²¹*CERN, European Organization for Nuclear Research, Geneva, Switzerland*
- ¹²²*Paul Scherrer Institut, Villigen, Switzerland*
- ¹²³*ETH Zurich - Institute for Particle Physics and Astrophysics (IPA), Zurich, Switzerland*
- ¹²⁴*Universität Zürich, Zurich, Switzerland*
- ¹²⁵*National Central University, Chung-Li, Taiwan*
- ¹²⁶*National Taiwan University (NTU), Taipei, Taiwan*
- ¹²⁷*High Energy Physics Research Unit, Department of Physics, Faculty of Science, Chulalongkorn University, Bangkok, Thailand*
- ¹²⁸*Çukurova University, Physics Department, Science and Art Faculty, Adana, Turkey*
- ¹²⁹*Middle East Technical University, Physics Department, Ankara, Turkey*
- ¹³⁰*Bogazici University, Istanbul, Turkey*
- ¹³¹*Istanbul Technical University, Istanbul, Turkey*
- ¹³²*Istanbul University, Istanbul, Turkey*
- ¹³³*Yildiz Technical University, Istanbul, Turkey*
- ¹³⁴*Institute for Scintillation Materials of National Academy of Science of Ukraine, Kharkiv, Ukraine*
- ¹³⁵*National Science Centre, Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine*
- ¹³⁶*University of Bristol, Bristol, United Kingdom*

- ¹³⁷*Rutherford Appleton Laboratory, Didcot, United Kingdom*
- ¹³⁸*Imperial College, London, United Kingdom*
- ¹³⁹*Brunel University, Uxbridge, United Kingdom*
- ¹⁴⁰*Baylor University, Waco, Texas, USA*
- ¹⁴¹*Catholic University of America, Washington, DC, USA*
- ¹⁴²*The University of Alabama, Tuscaloosa, Alabama, USA*
- ¹⁴³*Boston University, Boston, Massachusetts, USA*
- ¹⁴⁴*Brown University, Providence, Rhode Island, USA*
- ¹⁴⁵*University of California, Davis, Davis, California, USA*
- ¹⁴⁶*University of California, Los Angeles, California, USA*
- ¹⁴⁷*University of California, Riverside, Riverside, California, USA*
- ¹⁴⁸*University of California, San Diego, La Jolla, California, USA*
- ¹⁴⁹*University of California, Santa Barbara - Department of Physics, Santa Barbara, California, USA*
- ¹⁵⁰*California Institute of Technology, Pasadena, California, USA*
- ¹⁵¹*Carnegie Mellon University, Pittsburgh, Pennsylvania, USA*
- ¹⁵²*University of Colorado Boulder, Boulder, Colorado, USA*
- ¹⁵³*Cornell University, Ithaca, New York, USA*
- ¹⁵⁴*Fermi National Accelerator Laboratory, Batavia, Illinois, USA*
- ¹⁵⁵*University of Florida, Gainesville, Florida, USA*
- ¹⁵⁶*Florida State University, Tallahassee, Florida, USA*
- ¹⁵⁷*Florida Institute of Technology, Melbourne, Florida, USA*
- ¹⁵⁸*University of Illinois Chicago, Chicago, Illinois, USA*
- ¹⁵⁹*The University of Iowa, Iowa City, Iowa, USA*
- ¹⁶⁰*Johns Hopkins University, Baltimore, Maryland, USA*
- ¹⁶¹*The University of Kansas, Lawrence, Kansas, USA*
- ¹⁶²*Kansas State University, Manhattan, Kansas, USA*
- ¹⁶³*University of Maryland, College Park, Maryland, USA*
- ¹⁶⁴*Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
- ¹⁶⁵*University of Minnesota, Minneapolis, Minnesota, USA*
- ¹⁶⁶*University of Mississippi, Oxford, Mississippi, USA*
- ¹⁶⁷*University of Nebraska-Lincoln, Lincoln, Nebraska, USA*
- ¹⁶⁸*State University of New York at Buffalo, Buffalo, New York, USA*
- ¹⁶⁹*Northeastern University, Boston, Massachusetts, USA*
- ¹⁷⁰*Northwestern University, Evanston, Illinois, USA*
- ¹⁷¹*University of Notre Dame, Notre Dame, Indiana, USA*
- ¹⁷²*The Ohio State University, Columbus, Ohio, USA*
- ¹⁷³*Princeton University, Princeton, New Jersey, USA*
- ¹⁷⁴*University of Puerto Rico, Mayaguez, Puerto Rico, USA*
- ¹⁷⁵*Purdue University, West Lafayette, Indiana, USA*
- ¹⁷⁶*Purdue University Northwest, Hammond, Indiana, USA*
- ¹⁷⁷*Rice University, Houston, Texas, USA*
- ¹⁷⁸*University of Rochester, Rochester, New York, USA*
- ¹⁷⁹*The Rockefeller University, New York, New York, USA*
- ¹⁸⁰*Rutgers, The State University of New Jersey, Piscataway, New Jersey, USA*
- ¹⁸¹*University of Tennessee, Knoxville, Tennessee, USA*
- ¹⁸²*Texas A&M University, College Station, Texas, USA*
- ¹⁸³*Texas Tech University, Lubbock, Texas, USA*
- ¹⁸⁴*Vanderbilt University, Nashville, Tennessee, USA*
- ¹⁸⁵*University of Virginia, Charlottesville, Virginia, USA*
- ¹⁸⁶*Wayne State University, Detroit, Michigan, USA*
- ¹⁸⁷*University of Wisconsin - Madison, Madison, Wisconsin, USA*
- ¹⁸⁸*An institute or international laboratory covered by a cooperation agreement with [CERN](#)*

^aDeceased.

^bAlso at Yerevan State University, Yerevan, Armenia.

^cAlso at TU Wien, Vienna, Austria.

^dAlso at Institute of Basic and Applied Sciences, Faculty of Engineering, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt.

^eAlso at Ghent University, Ghent, Belgium.

^fAlso at Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil.

- ^gAlso at Universidade Estadual de Campinas, Campinas, Brazil.
- ^hAlso at Federal University of Rio Grande do Sul, Porto Alegre, Brazil.
- ⁱAlso at UFMS, Nova Andradina, Brazil.
- ^jAlso at Nanjing Normal University, Nanjing, China.
- ^kAlso at The University of Iowa, Iowa City, Iowa, USA.
- ^lAlso at University of Chinese Academy of Sciences, Beijing, China.
- ^mAlso at China Center of Advanced Science and Technology, Beijing, China.
- ⁿAlso at University of Chinese Academy of Sciences, Beijing, China.
- ^oAlso at China Spallation Neutron Source, Guangdong, China.
- ^pAlso at Henan Normal University, Xinxiang, China.
- ^qAlso at Université Libre de Bruxelles, Bruxelles, Belgium.
- ^rAlso at Another institute or international laboratory covered by a cooperation agreement with CERN.
- ^sAlso at Suez University, Suez, Egypt.
- ^tAlso at British University in Egypt, Cairo, Egypt.
- ^uAlso at Purdue University, West Lafayette, Indiana, USA.
- ^vAlso at Université de Haute Alsace, Mulhouse, France.
- ^wAlso at Istinye University, Istanbul, Turkey.
- ^xAlso at Ilia State University, Tbilisi, Georgia.
- ^yAlso at The University of the State of Amazonas, Manaus, Brazil.
- ^zAlso at University of Hamburg, Hamburg, Germany.
- ^{aa}Also at RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany.
- ^{bb}Also at Bergische University Wuppertal (BUW), Wuppertal, Germany.
- ^{cc}Also at Brandenburg University of Technology, Cottbus, Germany.
- ^{dd}Also at Forschungszentrum Jülich, Juelich, Germany.
- ^{ee}Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland.
- ^{ff}Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary.
- ^{gg}Also at Universitatea Babes-Bolyai—Facultatea de Fizica, Cluj-Napoca, Romania.
- ^{hh}Also at MTA-ELTE Lendület CMS Particle and Nuclear Physics Group, Eötvös Loránd University, Budapest, Hungary.
- ⁱⁱAlso at HUN-REN Wigner Research Centre for Physics, Budapest, Hungary.
- ^{jj}Also at Physics Department, Faculty of Science, Assiut University, Assiut, Egypt.
- ^{kk}Also at Punjab Agricultural University, Ludhiana, India.
- ^{ll}Also at University of Visva-Bharati, Santiniketan, India.
- ^{mm}Also at Indian Institute of Science (IISc), Bangalore, India.
- ⁿⁿAlso at IIT Bhubaneswar, Bhubaneswar, India.
- ^{oo}Also at Institute of Physics, Bhubaneswar, India.
- ^{pp}Also at University of Hyderabad, Hyderabad, India.
- ^{qq}Also at Deutsches Elektronen-Synchrotron, Hamburg, Germany.
- ^{rr}Also at Isfahan University of Technology, Isfahan, Iran.
- ^{ss}Also at Sharif University of Technology, Tehran, Iran.
- ^{tt}Also at Department of Physics, University of Science and Technology of Mazandaran, Behshahr, Iran.
- ^{uu}Also at Department of Physics, Isfahan University of Technology, Isfahan, Iran.
- ^{vv}Also at Department of Physics, Faculty of Science, Arak University, ARAK, Iran.
- ^{ww}Also at Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Bologna, Italy.
- ^{xx}Also at Centro Siciliano di Fisica Nucleare e di Struttura Della Materia, Catania, Italy.
- ^{yy}Also at Università degli Studi Guglielmo Marconi, Roma, Italy.
- ^{zz}Also at Scuola Superiore Meridionale, Università di Napoli 'Federico II', Napoli, Italy.
- ^{aaa}Also at Fermi National Accelerator Laboratory, Batavia, Illinois, USA.
- ^{bbb}Also at Laboratori Nazionali di Legnaro dell'INFN, Legnaro, Italy.
- ^{ccc}Also at Consiglio Nazionale delle Ricerche—Istituto Officina dei Materiali, Perugia, Italy.
- ^{ddd}Also at Department of Applied Physics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Malaysia.
- ^{eee}Also at Consejo Nacional de Ciencia y Tecnología, Mexico City, Mexico.
- ^{fff}Also at Trincomalee Campus, Eastern University, Sri Lanka, Nilaveli, Sri Lanka.
- ^{ggg}Also at Saegis Campus, Nugegoda, Sri Lanka.
- ^{hhh}Also at National and Kapodistrian University of Athens, Athens, Greece.
- ⁱⁱⁱAlso at Ecole Polytechnique Fédérale Lausanne, Lausanne, Switzerland.
- ^{jjj}Also at Universität Zürich, Zurich, Switzerland.
- ^{kkk}Also at Stefan Meyer Institute for Subatomic Physics, Vienna, Austria.
- ^{lll}Also at Laboratoire d'Annecy-le-Vieux de Physique des Particules, IN2P3-CNRS, Annecy-le-Vieux, France.
- ^{mmm}Also at Near East University, Research Center of Experimental Health Science, Mersin, Turkey.
- ⁿⁿⁿAlso at Konya Technical University, Konya, Turkey.

- ^{ooo} Also at Izmir Bakircay University, Izmir, Turkey.
- ^{ppp} Also at Adiyaman University, Adiyaman, Turkey.
- ^{qqq} Also at Bozok Universitetesi Rektörlüğü, Yozgat, Turkey.
- ^{rrr} Also at Marmara University, Istanbul, Turkey.
- ^{sss} Also at Milli Savunma University, Istanbul, Turkey.
- ^{ttt} Also at Kafkas University, Kars, Turkey.
- ^{uuu} Also at Istanbul Okan University, Istanbul, Turkey.
- ^{vvv} Also at Hacettepe University, Ankara, Turkey.
- ^{www} Also at Erzincan Binali Yildirim University, Erzincan, Turkey.
- ^{xxx} Also at Istanbul University—Cerrahpasa, Faculty of Engineering, Istanbul, Turkey.
- ^{yyy} Also at Yildiz Technical University, Istanbul, Turkey.
- ^{zzz} Also at Vrije Universiteit Brussel, Brussel, Belgium.
- ^{aaa} Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.
- ^{bbb} Also at IPPP Durham University, Durham, United Kingdom.
- ^{ccc} Also at Monash University, Faculty of Science, Clayton, Australia.
- ^{ddd} Also at Università di Torino, Torino, Italy.
- ^{eee} Also at Bethel University, St. Paul, Minnesota, USA.
- ^{fff} Also at Karamanoğlu Mehmetbey University, Karaman, Turkey.
- ^{ggg} Also at California Institute of Technology, Pasadena, California, USA.
- ^{hhh} Also at United States Naval Academy, Annapolis, Maryland, USA.
- ⁱⁱⁱ Also at Ain Shams University, Cairo, Egypt.
- ^{jjj} Also at Bingol University, Bingol, Turkey.
- ^{kkk} Also at Georgian Technical University, Tbilisi, Georgia.
- ^{lll} Also at Sinop University, Sinop, Turkey.
- ^{mmm} Also at Erciyes University, Kayseri, Turkey.
- ⁿⁿⁿ Also at Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH), Bucharest, Romania.
- ^{ooo} Also at Texas A&M University at Qatar, Doha, Qatar.
- ^{ppp} Also at Kyungpook National University, Daegu, Korea.
- ^{qqq} Also at Universiteit Antwerpen, Antwerpen, Belgium.
- ^{rrr} Also at Yerevan Physics Institute, Yerevan, Armenia.
- ^{sss} Also at Northeastern University, Boston, Massachusetts, USA.
- ^{ttt} Also at Imperial College, London, United Kingdom.
- ^{uuu} Also at Institute of Nuclear Physics of the Uzbekistan Academy of Sciences, Tashkent, Uzbekistan.