Search for Heavy Neutrinos and W_R Bosons with Right-Handed Couplings in a Left-Right Symmetric Model in pp Collisions at $\sqrt{s} = 7$ TeV

S. Chatrchyan *et al.*[*]
(CMS Collaboration)

(Received 8 October 2012; published 27 December 2012)

Results are presented from a search for heavy, right-handed muon neutrinos, N_μ, and right-handed W_R bosons, which arise in the left-right symmetric extensions of the standard model. The analysis is based on a 5.0 fb^{-1} sample of proton-proton collisions at a center-of-mass energy of 7 TeV, collected by the CMS detector at the Large Hadron Collider. No evidence is observed for an excess of events over the standard model expectation. For models with exact left-right symmetry, heavy right-handed neutrinos are excluded at 95% confidence level for a range of neutrino masses below the W_R mass, dependent on the value of M_{W_R}. The excluded region in the two-dimensional (M_{W_R}, M_{N_μ}) mass plane extends to $M_{W_R} = 2.5$ TeV.

DOI: 10.1103/PhysRevLett.109.261802 PACS numbers: 13.85.Rm, 12.60.Cn, 14.60.St

The maximal violation of parity conservation is a prominent feature of neutrino interactions that is included in the standard model (SM) in terms of purely left-handed couplings to the W boson. In addition, the observation of neutrino oscillations (see e.g. [1]), together with direct limits on neutrino masses [2], has demonstrated that neutrinos have tiny but nonvanishing masses, suggesting a distinct origin from the masses of the quarks and leptons.

The left-right (LR) symmetric extension of the standard model [3–6] provides a possible explanation for neutrino mass through the seesaw mechanism [7]. The LR symmetry is spontaneously broken at a multi-TeV mass scale, leading to parity violation in weak interactions as described by the SM. By introducing a right-handed SU(2) symmetry group, the LR model incorporates heavy right-handed Majorana neutrinos (N_ℓ, $\ell = e, \mu, \tau$) as well as additional charged ($W_R^\pm$) and neutral (Z_R) gauge bosons.

We search for the production of W_R bosons from proton-proton collisions at the Large Hadron Collider (LHC). The W_R boson is assumed to decay to a muon and to a right-handed neutrino N_μ, which subsequently decays to produce a second muon together with a virtual W_R^*. If the N_μ is a Majorana particle as predicted in the LR model, the two final state muons may have the same sign. The virtual W_R^* decays to a pair of quarks which hadronize into jets (j), resulting in a final state with two muons and two jets,

$$W_R \to \mu_1 N_\mu \to \mu_1 \mu_2 W_R^* \to \mu_1 \mu_2 q q' \to \mu_1 \mu_2 j_1 j_2.$$

The search presented in this Letter is characterized by the W_R and N_μ masses, M_{W_R} and M_{N_μ}, which are allowed to vary independently. Although $M_{N_\mu} > M_{W_R}$ is allowed, it is not considered in this analysis. The branching fraction for $W_R \to \mu N_\mu$ depends on the number of heavy neutrino flavors that are accessible at LHC energies. To simplify the interpretation of the results, N_μ is assumed to be the only heavy neutrino flavor light enough to contribute significantly to the W_R decay width. CMS recently performed a search for heavy Majorana neutrinos in the final state containing two jets and two same-sign electrons or muons and set limits on the coupling between such a neutrino and the left-handed W of the SM as a function of M_{N_μ} [8], while this analysis considers on-shell production of a right-handed W_R boson. No charge requirements are imposed on the final state muons in this analysis.

For given W_R and N_μ masses, the signal cross section can be predicted from the assumed value of the coupling constant g_R, which denotes the strength of the gauge interactions of $W_R^\pm$ bosons. Strict left-right symmetry implies that g_R is equal to the (left-handed) weak interaction coupling strength g_L at M_{W_R}, which will be assumed throughout this Letter. Consequently, the W_R production cross section can be calculated by the FEWZ program [9] using the left-handed W' model [10,11]. As an additional simplification, the left-right boson and lepton mixing angles are assumed to be small.

Estimates based on K_L-K_S mixing results imply a theoretical lower limit of $M_{W_R} \gtrsim 2.5$ TeV [12,13]. Searches for $W_R \to tb$ decays at the Tevatron [14–16] and at the LHC [17,18] exclude W_R masses below 1.85 TeV. An ATLAS search for $W_R \to \ell N_\ell$ using similar model assumptions as those in this Letter, but allowing W_R decays to both N_e and N_μ, excluded a region in the two-dimensional parameter (M_{W_R}, M_{N_ℓ}) space extending to nearly $M_{W_R} = 2.5$ TeV [19].

The analysis is based on a 5.0 fb^{-1} sample of proton-proton collision data at a center-of-mass energy of 7 TeV, collected by the Compact Muon Solenoid (CMS) detector [20] at the LHC. The central feature of the CMS apparatus is a superconducting solenoid, of 6 m internal diameter, providing a field of 3.8 T. Within the field volume are the

---

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

silicon pixel and strip trackers, the lead-tungstate crystal electromagnetic calorimeter, and the brass and scintillator hadron calorimeter. Muons are measured in gas-ionization detectors embedded in the steel return yoke, with detection planes made of three technologies: drift tubes, cathode strip chambers, and resistive plate chambers. The CMS trigger system, composed of custom hardware processors at the first level followed by a processor farm at the next level, selects $\mathcal{O}(100\text{ Hz})$ of the most interesting events. The events used in this analysis were collected with single-muon triggers whose p_T thresholds ranged from 24 GeV to 40 GeV, depending on the instantaneous luminosity.

The $W_R \to \mu N_\mu$ signal samples are generated using PYTHIA 6.4.24 [21], which includes the LR symmetric model with the standard assumptions mentioned previously, with CTEQ6L1 parton distribution functions [22]. We also study SM background processes using simulated samples: $t\bar{t}$ and single-top (both generated using POWHEG [23]), W and Drell-Yan production in association with jets (SHERPA [24]), and diboson production (PYTHIA). Generated events pass through the full CMS detector simulation based on GEANT [25].

The muon identification strategy is based on both the muon detectors and the inner tracker, described in Ref. [26]. At least one of the two muons used to define the W_R candidate is required to be matched to a muon candidate found by the trigger, and both muons are required to satisfy the tight identification criteria discussed in Ref. [27]. The muon identification requirements ensure good consistency between the measurements of the muon detector and the inner tracker, and suppress muons from decay-in-flight of hadrons as well as from shower punch-through. Nonisolated muon backgrounds are controlled by computing the sum of the transverse momentum of tracks within a cone about the muon direction of $\Delta R < 0.3$, with $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$, given the azimuthal angle ϕ and $\eta = -\ln[\tan(\theta/2)]$, where θ is the polar angle with respect to the beam direction. The final p_T sum must be less than 10% of the muon transverse momentum.

Jets are reconstructed by forming clusters of charged and neutral hadrons, photons, and leptons that are first reconstructed based on the CMS particle-flow technique [28], using the anti-k_T clustering algorithm [29] with a radius parameter $R = 0.5$. Energy deposits in the calorimeter with characteristics that match those of noise or beam halo tracks are identified, and events are rejected if either of the two highest-p_T jet candidates was produced by such energy deposits. To suppress backgrounds from heavy-flavor-quark decays, any muon is rejected if found near a jet, with $\Delta R(\mu, j) < 0.5$.

In approximately 95% of simulated signal event samples, the W_R final state decay products are the highest p_T muons and jets in the event. $W_R \to \mu N_\mu$ candidates are thus formed from the two highest-p_T muons and the two highest-p_T jets in the event. As the initial two-body decay $W_R \to \mu N_\mu$ tends to produce a high-momentum muon, events are selected in which the leading muon has $p_T > 60$ GeV and the subleading muon has $p_T > 30$ GeV. A minimum transverse momentum requirement of 40 GeV is imposed on the jet candidates after correcting for the effects of the extra pp collisions in the event and the jet energy response of the detector. Backgrounds are suppressed by requiring the invariant mass of the dimuon system $M_{\mu\mu} > 200$ GeV and the four-object mass $M_{\mu\mu jj} > 600$ GeV.

The signal acceptance is found to be typically near 80% at $M_{N_\mu} \sim M_{W_R}/2$ and decreases rapidly for $M_{N_\mu} \lesssim 0.10 M_{W_R}$. At low neutrino mass, the $N_\mu \to \mu jj$ decay products tend to overlap due to the boost from W_R decay, and the two jets may not be distinguishable or the muon from N_μ decay may be too close to a jet. For W_R signal events which meet the kinematic acceptance requirements, the efficiency to reconstruct the four high-p_T objects using the CMS detector ranges between 75% and 80% as a function of W_R and N_μ mass.

After the muon requirements are applied, the SM backgrounds for $W_R \to \mu N_\mu$ consist primarily of events from processes with two isolated high-p_T muons, namely $t\bar{t} \to bW + \bar{b}W^-$ and Z + jets processes. The impact of the selection criteria on background processes is shown in Table I.

The $t\bar{t}$ background contribution is estimated using a control sample of $e\mu jj$ events reconstructed in data and simulation. This sample is dominated by $t\bar{t}$ events, with small contributions from other SM processes estimated using simulation. The simulated $t\bar{t}$ background

TABLE I. The total number of events reconstructed in data, and the expected contributions from signal and background (bkgd) samples, after different stages of the selection requirements are applied. The first selection given below requires two muons with $p_T > 30$ GeV and two jets with $p_T > 40$ GeV meeting all requirements described in the text. The "Signal" column indicates the expected contribution for $M_{W_R} = 1800$ GeV, with $M_{N_\mu} = 1000$ GeV. The uncertainties for the background expectation are derived for the final stage of selection and more details are given in the text. The yields from earlier stages of the selection have greater relative uncertainty than that for the full selection.

Selection stage	Data	Signal	Total bkgd	$t\bar{t}$	Z + jets	Other
Two muons, two jets	21 769	50	21 061	1603	19 136	322
$\mu_1 p_T > 60$ GeV	13 328	50	12 862	1106	11 531	225
$M_{\mu\mu} > 200$ GeV	365	48	341	211	116	14
$M_{\mu\mu jj} > 600$ GeV	164	48 ± 13	152 ± 22	81 ± 18	65 ± 9	6 ± 3

contribution is scaled to data using events satisfying $M_{e\mu} > 200$ GeV, which is equivalent to the third selection stage in Table I. The scale factor for the simulated $t\bar{t}$ sample, relative to the $t\bar{t}$ cross section measured by CMS [30], is 0.97 ± 0.06. The uncertainty on this scale factor reflects the number of events in data with $M_{e\mu} > 200$ GeV. Applying this scale factor to the $t\bar{t}$ simulation, the $M_{e\mu jj}$ distributions in data and simulation are found to be in agreement. This scale factor is applied to the simulated $t\bar{t}$ event sample at all stages of selection in order to estimate the expected number of $pp \to t\bar{t} + \mathrm{X}$ events that survive successive selection criteria.

The $Z +$ jets background contribution is estimated from $Z \to \mu\mu$ decays reconstructed in simulation and data. The simulated $Z +$ jets background contribution is normalized to data using events in the dimuon mass region 60 GeV $< M_{\mu\mu} <$ 120 GeV after requiring μ_1 $p_{\mathrm{T}} > 60$ GeV as indicated in Table I. Accounting for other SM background processes, the simulated $Z +$ jets scale factor is 1.43 ± 0.01 relative to inclusive next-to-next-to-leading order calculations. The uncertainty on this value reflects the number of events from data with 60 GeV $< M_{\mu\mu} <$ 120 GeV. After rescaling the $Z +$ jets simulation, the shape of the $M_{\mu\mu}$ distribution for data is in agreement with simulation for $M_{\mu\mu} > 60$ GeV.

After all selection criteria are applied, the $t\bar{t}$ and $Z +$ jets processes dominate the total SM background contribution. Other SM processes, mostly diboson and single top, comprise less than 5% of the total background and their contributions are estimated from simulation. Background from $W +$ jets processes, also estimated from simulation, is negligible. The background contribution from multijet processes is estimated using control samples from data and is roughly 0.1% of the total SM background after all selection requirements are applied.

The observed and expected number of events surviving the selections are summarized in Table I. The yields reflect the number of background events surviving each selection stage, with normalization factors obtained from control sample studies ($t\bar{t}$, $Z +$ jets, and multijet processes) or taken directly from simulation. The data are found to be in agreement with SM expectations.

The reconstructed four-object mass in data and simulation is used to estimate limits on W_R production. The $M_{\mu\mu jj}$ distribution for $W_R \to \mu\mu jj$ signal events, for each W_R mass assumption, is included together with the SM background distributions to search for evidence of W_R production.

The dominant uncertainty related to $W_R \to \mu N_\mu$ production arises from the variation in the predicted signal production cross section as a result of the uncertainties in the parton distribution functions (PDFs) of the proton. This uncertainty varies between 4% and 22%, depending on the W_R mass hypothesis, following the PDF4LHC prescriptions [31] for the CT10 [32] and MSTW2008 [33] PDF sets.

The uncertainties associated with muon reconstruction and identification are determined from $Z \to \mu^+\mu^-$ events reconstructed in both data and simulation. The size of this uncertainty is about 15% for signal and 5% for background processes.

The shape of each SM background $M_{\mu\mu jj}$ distribution is modeled by an exponential ($e^{a+bM_{\mu\mu jj}}$) line shape, and the background contributions as a function of mass are determined from the result of fits applied to each background type: $t\bar{t}$, $Z +$ jets, and other SM backgrounds. The background uncertainty is dominated by the uncertainty in the background modeling and is computed as a function of $\mu\mu jj$ mass.

The uncertainty in the exponential fit is taken as the uncertainty due to background modeling. Each background distribution is also fit with an alternative suite of exponential functions to allow for deviations from the assumed shape at high mass. For a given $M_{\mu\mu jj}$ range, we take the maximum of the deviation, relative to the nominal exponential fit, from any alternative fit result as the uncertainty due to background modeling if this deviation exceeds the nominal fit uncertainty.

Uncertainties in the jet energy scale and resolution impact the shape of the signal and background $M_{\mu\mu jj}$ distributions, contributing less than 10% to the signal and background uncertainties. The normalization of the various background samples contributes 5% to the total uncertainty. Muon resolution and trigger efficiency uncertainties, and additional factorization and scale theoretical uncertainties, contribute to the total uncertainty to a lesser extent. The uncertainties in the total number of background events are derived taking into account the relative contribution of all background events after the full event selection, and the correlation of each effect between all background processes.

The total uncertainty for signal and background is summarized in Table I. The $M_{\mu\mu jj}$ distribution for events with $M_{\mu\mu} > 200$ GeV is presented in Fig. 1, which also summarizes the background uncertainty as a function of $M_{\mu\mu jj}$ and demonstrates the dominant background model uncertainty relative to the total background uncertainty.

As no evidence for $W_R \to \mu N_\mu$ decay is found, limits on W_R production are estimated using a multibin technique based on the ROOSTATS package [34]. The bin width of 200 GeV, comparable to the mass resolution for a reconstructed W_R boson with mass below 2.5 TeV, is chosen for the $M_{\mu\mu jj}$ distributions used to compute the limits. The background inputs to the limit calculation use the results of the exponential fit, while the signal input is taken directly from the $M_{\mu\mu jj}$ distribution for each signal W_R mass assumption. Uncertainties are included as nuisance parameters in the limit calculations. A $\mathrm{CL_S}$ limit setting technique [35,36] is used to estimate the 95% confidence level (CL) excluded region as a function of the W_R cross section multiplied by the $W_R \to \mu\mu jj$ branching fraction

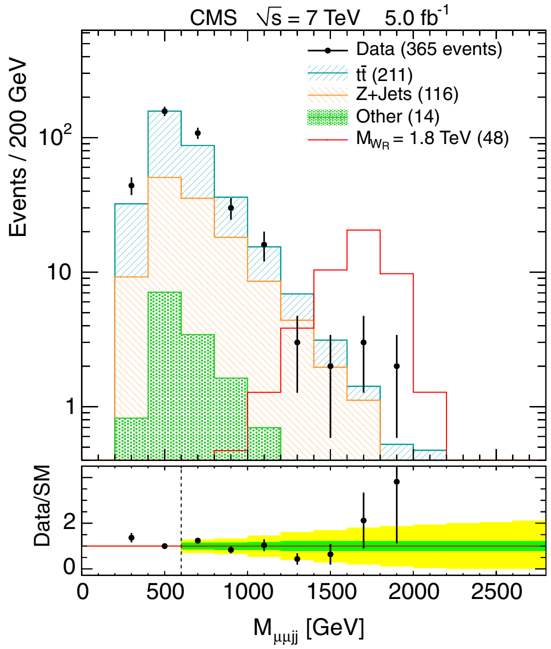

FIG. 1 (color online). Distribution of the invariant mass $M_{\mu\mu jj}$ for events in data (points with error bars) with $M_{\mu\mu} > 200$ GeV and for simulated background contributions (hatched stacked histograms). The signal mass point $M_{W_R} = 1800$ GeV, $M_{N_\mu} = 1000$ GeV, is included for comparison (open red histogram). The number of events from each background process (and the expected number of signal events) is included in parentheses in the legend. The data are compared to SM expectations in the lower portion of the figure. The total background uncertainty (outer band) and the background uncertainty after neglecting the uncertainty due to background modeling (inner band) are included as a function of $M_{\mu\mu jj}$ for $M_{\mu\mu jj} > 600$ GeV.

and W_R mass. The observed and expected limits are found to be in agreement. These results (available in tabular form in the Supplemental Material [37]) can be used for the evaluation of models other than those considered in this Letter.

Limits as a function of W_R mass for a right-handed neutrino with $M_N = \frac{1}{2}M_{W_R}$ are presented in Fig. 2. The theoretical expectation in Fig. 2 assumes that only N_μ contributes to the W_R decay width, as mentioned previously. Assuming degenerate N_ℓ ($\ell = e, \mu, \tau$) masses allows $W_R \to eN_e$ and $W_R \to \tau N_\tau$ decays in addition to $W_R \to q\bar{q}$ and $W_R \to \mu N_\mu$ and effectively decreases the expected $W_R \to \mu\mu jj$ production rate by approximately 15%.

For the model considered in this Letter, Fig. 3 indicates the range of excluded N_μ masses as a function of W_R mass by comparing the observed (expected) upper limit and the predicted cross section for each mass point. These limits extend to $M_{W_R} = 2.5$ TeV, and exclude a wide range of heavy neutrino masses for W_R mass assumptions below this maximal value.

In summary, we have presented a search for the right-handed heavy muon neutrinos (N_μ) and bosons (W_R) of the left-right symmetric extension of the standard model. We find that our data sample is in agreement with expectations from standard model processes and therefore set a limit on the W_R and N_μ masses. For models with exact left-right symmetry (the same coupling to the right-handed and left-handed sectors), we exclude heavy right-handed neutrinos for a range of $M_{N_\mu} < M_{W_R}$, dependent on the value of M_{W_R}. For these models, the excluded region in the two-dimensional parameter space (M_{W_R}, M_{N_μ}) extends to $M_{W_R} = 2.5$ TeV.

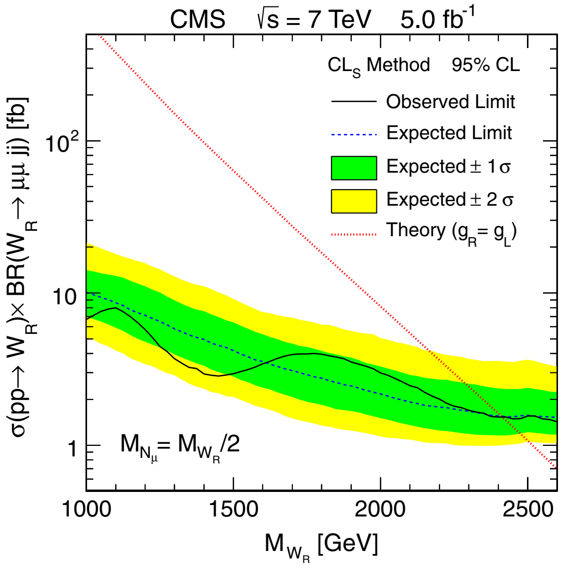

FIG. 2 (color online). The 95% confidence level exclusion limit on the W_R production cross section times branching fraction for $W_R \to \mu\mu jj$ as a function of M_{W_R} for $M_{N_\mu} = \frac{1}{2}M_{W_R}$. This limit is compared to expectations given the theoretical model described in the text.

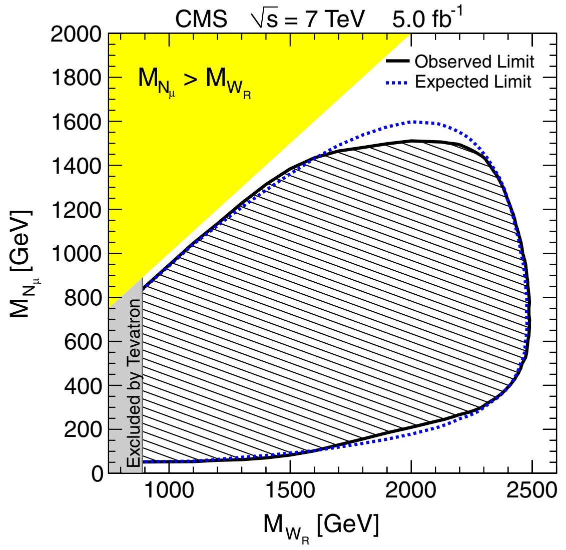

FIG. 3 (color online). The 95% confidence level exclusion region in the (M_{W_R}, M_{N_μ}) plane, assuming the model described in the text. The Tevatron exclusion region for W_R production [16] is included in the figure.

These results represent the most sensitive limits to date on W_R production assuming a single heavy neutrino flavor contributes significantly to the W_R decay width.

We congratulate our colleagues in the CERN accelerator departments for the excellent performance of the LHC machine. We thank the technical and administrative staff at CERN and other CMS institutes, and acknowledge support from: BMWF and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, and FAPESP (Brazil); MES (Bulgaria); CERN; CAS, MoST, and NSFC (China); COLCIENCIAS (Colombia); MSES (Croatia); RPF (Cyprus); MoER SF0690030s09 and ERDF (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRT (Greece); OTKA and NKTH (Hungary); DAE and DST (India); IPM (Iran); SFI (Ireland); INFN (Italy); NRF and WCU (Korea); LAS (Lithuania); CINVESTAV, CONACYT, SEP, and UASLP-FAI (Mexico); MSI (New Zealand); PAEC (Pakistan); MSHE and NSC (Poland); FCT (Portugal); JINR (Armenia, Belarus, Georgia, Ukraine, Uzbekistan); MON, RosAtom, RAS, and RFBR (Russia); MSTD (Serbia); SEIDI and CPAN (Spain); Swiss Funding Agencies (Switzerland); NSC (Taipei); TUBITAK and TAEK (Turkey); STFC (United Kingdom); and DOE and NSF (USA).

[1] C. Giunti and M. Laveder, arXiv:hep-ph/0310238v2.
[2] J. Beringer *et al.* (Particle Data Group), Phys. Rev. D **86**, 010001 (2012).
[3] J. C. Pati and A. Salam, Phys. Rev. D **10**, 275 (1974).
[4] R. N. Mohapatra and J. C. Pati, Phys. Rev. D **11**, 2558 (1975).
[5] G. Senjanovic and R. N. Mohapatra, Phys. Rev. D **12**, 1502 (1975).
[6] W.-Y. Keung and G. Senjanovic, Phys. Rev. Lett. **50**, 1427 (1983).
[7] R. N. Mohapatra and G. Senjanovic, Phys. Rev. Lett. **44**, 912 (1980).
[8] S. Chatrchyan *et al.* (CMS Collaboration), Phys. Lett. B **717**, 109 (2012).
[9] R. Gavin, Y. Li, F. Petriello, and S. Quackenbush, Comput. Phys. Commun. **182**, 2388 (2011).
[10] R. Hamburg, W. van Neerven, and T. Matsuura, Nucl. Phys. **B359**, 343 (1991).
[11] R. Hamburg, W. van Neerven, and T. Matsuura, Nucl. Phys. **B644**, 403 (2002).
[12] G. Beall, M. Bander, and A. Soni, Phys. Rev. Lett. **48**, 848 (1982).
[13] A. Maiezza, M. Nemevsek, F. Nesti, and G. Senjanovic, Phys. Rev. D **82**, 055022 (2010).
[14] V. M. Abazov *et al.* (D0 Collaboration), Phys. Rev. Lett. **100**, 211803 (2008).
[15] T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. Lett. **103**, 041801 (2009).
[16] V. M. Abazov *et al.* (D0 Collaboration), Phys. Lett. B **699**, 145 (2011).
[17] G. Aad *et al.* (ATLAS Collaboration), Phys. Rev. Lett. **109**, 081801 (2012).
[18] S. Chatrchyan *et al.* (CMS Collaboration), arXiv:1208.0956 [Phys. Lett. B (to be published)].
[19] G. Aad *et al.* (ATLAS Collaboration), Eur. Phys. J. C **72**, 2056 (2012).
[20] S. Chatrchyan *et al.* (CMS Collaboration), JINST **3**, S08004 (2008).
[21] T. Sjöstrand, S. Mrenna, and P. Skands, J. High Energy Phys. 05 (2006) 026.
[22] J. Botts, J. G. Morn, J. F. Owens, J. Qiu, W.-K. Tung, and H. Weerts, Phys. Lett. B **304**, 159 (1993).
[23] S. Alioli, P. Nason, C. Oleari, and E. Re, J. High Energy Phys. 06 (2010) 043.
[24] T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, S. Schumann, F. Siegert, and J. Winter, J. High Energy Phys. 02 (2009) 007.
[25] S. Agostinelli *et al.* (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[26] CMS Collaboration, CMS Report No. CMS-PAS-MUO-10-002, 2010.
[27] S. Chatrchyan *et al.* (CMS Collaboration), J. High Energy Phys. 05 (2011) 093.
[28] CMS Collaboration, CMS Report No. CMS-PAS-PFT-10-002, 2010.
[29] M. Cacciari, G. P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 063.
[30] S. Chatrchyan *et al.* (CMS Collaboration), Phys. Rev. D **84**, 092004 (2011).
[31] PDF4LHC Working Group, arXiv:1101.0536v1.
[32] H.-L. Lai, M. Guzzi, J. Huston, Z. Li, P. M. Nadolsky, J. Pumplin, and C.-P. Yuan, Phys. Rev. D **82**, 074024 (2010).
[33] A. D. Martin, W. J. Stirling, R. S. Thorne, and G. Watt, Eur. Phys. J. C **64**, 653 (2009).
[34] L. Moneta, K. Belasco, K. S. Cranmer, A. Lazzaro, D. Piparo, G. Schott, W. Verkerke, and M. Wolf, Proc. Sci., ACAT2010 (2010) 057 [arXiv:1009.1003].
[35] A. L. Read, J. Phys. G **28**, 2693 (2002).
[36] T. Junk, Nucl. Instrum. Methods Phys. Res., Sect. A **434**, 435 (1999).
[37] See the Supplemental Material http://link.aps.org/supplemental/10.1103/PhysRevLett.109.261802 for a tabular summary of the observed and expected limits for $\sigma(pp \to W_R) \times \mathcal{B}(W_R \to \mu\mu jj)$ as a function of M_{W_R} and M_N.

S. Chatrchyan,[1] V. Khachatryan,[1] A. M. Sirunyan,[1] A. Tumasyan,[1] W. Adam,[2] E. Aguilo,[2] T. Bergauer,[2] M. Dragicevic,[2] J. Erö,[2] C. Fabjan,[2,b] M. Friedl,[2] R. Frühwirth,[2,b] V. M. Ghete,[2] J. Hammer,[2] N. Hörmann,[2] J. Hrubec,[2] M. Jeitler,[2,b] W. Kiesenhofer,[2] V. Knünz,[2] M. Krammer,[2,b] I. Krätschmer,[2] D. Liko,[2] I. Mikulec,[2] M. Pernicka,[2,a] B. Rahbaran,[2] C. Rohringer,[2] H. Rohringer,[2] R. Schöfbeck,[2] J. Strauss,[2] A. Taurok,[2]

W. Waltenberger,[2] C.-E. Wulz,[2,b] V. Mossolov,[3] N. Shumeiko,[3] J. Suarez Gonzalez,[3] M. Bansal,[4] S. Bansal,[4]
T. Cornelis,[4] E. A. De Wolf,[4] X. Janssen,[4] S. Luyckx,[4] L. Mucibello,[4] S. Ochesanu,[4] B. Roland,[4] R. Rougny,[4]
M. Selvaggi,[4] H. Van Haevermaet,[4] P. Van Mechelen,[4] N. Van Remortel,[4] A. Van Spilbeeck,[4] F. Blekman,[5]
S. Blyweert,[5] J. D'Hondt,[5] R. Gonzalez Suarez,[5] A. Kalogeropoulos,[5] M. Maes,[5] A. Olbrechts,[5] W. Van Doninck,[5]
P. Van Mulders,[5] G. P. Van Onsem,[5] I. Villella,[5] B. Clerbaux,[6] G. De Lentdecker,[6] V. Dero,[6] A. P. R. Gay,[6] T. Hreus,[6]
A. Léonard,[6] P. E. Marage,[6] A. Mohammadi,[6] T. Reis,[6] L. Thomas,[6] C. Vander Velde,[6] P. Vanlaer,[6] J. Wang,[6]
V. Adler,[7] K. Beernaert,[7] A. Cimmino,[7] S. Costantini,[7] G. Garcia,[7] M. Grunewald,[7] B. Klein,[7] J. Lellouch,[7]
A. Marinov,[7] J. Mccartin,[7] A. A. Ocampo Rios,[7] D. Ryckbosch,[7] N. Strobbe,[7] F. Thyssen,[7] M. Tytgat,[7] S. Walsh,[7]
E. Yazgan,[7] N. Zaganidis,[7] S. Basegmez,[8] G. Bruno,[8] R. Castello,[8] L. Ceard,[8] C. Delaere,[8] T. du Pree,[8] D. Favart,[8]
L. Forthomme,[8] A. Giammanco,[8,c] J. Hollar,[8] V. Lemaitre,[8] J. Liao,[8] O. Militaru,[8] C. Nuttens,[8] D. Pagano,[8] A. Pin,[8]
K. Piotrzkowski,[8] J. M. Vizan Garcia,[8] N. Beliy,[9] T. Caebergs,[9] E. Daubie,[9] G. H. Hammad,[9] G. A. Alves,[10]
M. Correa Martins Junior,[10] T. Martins,[10] M. E. Pol,[10] M. H. G. Souza,[10] W. L. Aldá Júnior,[11] W. Carvalho,[11]
A. Custódio,[11] E. M. Da Costa,[11] D. De Jesus Damiao,[11] C. De Oliveira Martins,[11] S. Fonseca De Souza,[11]
H. Malbouisson,[11] M. Malek,[11] D. Matos Figueiredo,[11] L. Mundim,[11] H. Nogima,[11] W. L. Prado Da Silva,[11]
A. Santoro,[11] L. Soares Jorge,[11] A. Sznajder,[11] A. Vilela Pereira,[11] T. S. Anjos,[12,d] C. A. Bernardes,[12,d] F. A. Dias,[12,e]
T. R. Fernandez Perez Tomei,[12] E. M. Gregores,[12,d] C. Lagana,[12] F. Marinho,[12] P. G. Mercadante,[12,d] S. F. Novaes,[12]
Sandra S. Padula,[12] V. Genchev,[13,f] P. Iaydjiev,[13,f] S. Piperov,[13] M. Rodozov,[13] S. Stoykova,[13] G. Sultanov,[13]
V. Tcholakov,[13] R. Trayanov,[13] M. Vutova,[13] A. Dimitrov,[14] R. Hadjiiska,[14] V. Kozhuharov,[14] L. Litov,[14]
B. Pavlov,[14] P. Petkov,[14] J. G. Bian,[15] G. M. Chen,[15] H. S. Chen,[15] C. H. Jiang,[15] D. Liang,[15] S. Liang,[15] X. Meng,[15]
J. Tao,[15] J. Wang,[15] X. Wang,[15] Z. Wang,[15] H. Xiao,[15] M. Xu,[15] J. Zang,[15] Z. Zhang,[15] C. Asawatangtrakuldee,[16]
Y. Ban,[16] Y. Guo,[16] W. Li,[16] S. Liu,[16] Y. Mao,[16] S. J. Qian,[16] H. Teng,[16] D. Wang,[16] L. Zhang,[16] W. Zou,[16] C. Avila,[17]
J. P. Gomez,[17] B. Gomez Moreno,[17] A. F. Osorio Oliveros,[17] J. C. Sanabria,[17] N. Godinovic,[18] D. Lelas,[18]
R. Plestina,[18,g] D. Polic,[18] I. Puljak,[18,f] Z. Antunovic,[19] M. Kovac,[19] V. Brigljevic,[20] S. Duric,[20] K. Kadija,[20]
J. Luetic,[20] D. Mekterovic,[20] S. Morovic,[20] A. Attikis,[21] M. Galanti,[21] G. Mavromanolakis,[21] J. Mousa,[21]
C. Nicolaou,[21] F. Ptochos,[21] P. A. Razis,[21] M. Finger,[22] M. Finger, Jr.,[22] Y. Assran,[23,h] S. Elgammal,[23,i]
A. Ellithi Kamel,[23,j] S. Khalil,[23,i] M. A. Mahmoud,[23,k] A. Radi,[23,l,m] M. Kadastik,[24] M. Müntel,[24] M. Raidal,[24]
L. Rebane,[24] A. Tiko,[24] P. Eerola,[25] G. Fedi,[25] M. Voutilainen,[25] J. Härkönen,[26] A. Heikkinen,[26] V. Karimäki,[26]
R. Kinnunen,[26] M. J. Kortelainen,[26] T. Lampén,[26] K. Lassila-Perini,[26] S. Lehti,[26] T. Lindén,[26] P. Luukka,[26]
T. Mäenpää,[26] T. Peltola,[26] E. Tuominen,[26] J. Tuominiemi,[26] E. Tuovinen,[26] D. Ungaro,[26] L. Wendland,[26]
K. Banzuzi,[27] A. Karjalainen,[27] A. Korpela,[27] T. Tuuva,[27] M. Besancon,[28] S. Choudhury,[28] M. Dejardin,[28]
D. Denegri,[28] B. Fabbro,[28] J. L. Faure,[28] F. Ferri,[28] S. Ganjour,[28] A. Givernaud,[28] P. Gras,[28]
G. Hamel de Monchenault,[28] P. Jarry,[28] E. Locci,[28] J. Malcles,[28] L. Millischer,[28] A. Nayak,[28] J. Rander,[28]
A. Rosowsky,[28] M. Titov,[28] S. Baffioni,[29] F. Beaudette,[29] L. Benhabib,[29] L. Bianchini,[29] M. Bluj,[29,n] C. Broutin,[29]
P. Busson,[29] C. Charlot,[29] N. Daci,[29] T. Dahms,[29] M. Dalchenko,[29] L. Dobrzynski,[29] A. Florent,[29]
R. Granier de Cassagnac,[29] M. Haguenauer,[29] P. Miné,[29] C. Mironov,[29] I. N. Naranjo,[29] M. Nguyen,[29] C. Ochando,[29]
P. Paganini,[29] D. Sabes,[29] R. Salerno,[29] Y. Sirois,[29] C. Veelken,[29] A. Zabi,[29] J.-L. Agram,[30,o] J. Andrea,[30] D. Bloch,[30]
D. Bodin,[30] J.-M. Brom,[30] M. Cardaci,[30] E. C. Chabert,[30] C. Collard,[30] E. Conte,[30,o] F. Drouhin,[30,o]
J.-C. Fontaine,[30,o] D. Gelé,[30] U. Goerlach,[30] P. Juillot,[30] A.-C. Le Bihan,[30] P. Van Hove,[30] F. Fassi,[31] D. Mercier,[31]
S. Beauceron,[32] N. Beaupere,[32] O. Bondu,[32] G. Boudoul,[32] J. Chasserat,[32] R. Chierici,[32,f] D. Contardo,[32]
P. Depasse,[32] H. El Mamouni,[32] J. Fay,[32] S. Gascon,[32] M. Gouzevitch,[32] B. Ille,[32] T. Kurca,[32] M. Lethuillier,[32]
L. Mirabito,[32] S. Perries,[32] L. Sgandurra,[32] V. Sordini,[32] Y. Tschudi,[32] P. Verdier,[32] S. Viret,[32] Z. Tsamalaidze,[33,p]
C. Autermann,[34] S. Beranek,[34] B. Calpas,[34] M. Edelhoff,[34] L. Feld,[34] N. Heracleous,[34] O. Hindrichs,[34] R. Jussen,[34]
K. Klein,[34] J. Merz,[34] A. Ostapchuk,[34] A. Perieanu,[34] F. Raupach,[34] J. Sammet,[34] S. Schael,[34] D. Sprenger,[34]
H. Weber,[34] B. Wittmer,[34] V. Zhukov,[34,q] M. Ata,[35] J. Caudron,[35] E. Dietz-Laursonn,[35] D. Duchardt,[35]
M. Erdmann,[35] R. Fischer,[35] A. Güth,[35] T. Hebbeker,[35] C. Heidemann,[35] K. Hoepfner,[35] D. Klingebiel,[35]
P. Kreuzer,[35] M. Merschmeyer,[35] A. Meyer,[35] M. Olschewski,[35] P. Papacz,[35] H. Pieta,[35] H. Reithler,[35]
S. A. Schmitz,[35] L. Sonnenschein,[35] J. Steggemann,[35] D. Teyssier,[35] S. Thüer,[35] M. Weber,[35] M. Bontenackels,[36]
V. Cherepanov,[36] Y. Erdogan,[36] G. Flügge,[36] H. Geenen,[36] M. Geisler,[36] W. Haj Ahmad,[36] F. Hoehle,[36] B. Kargoll,[36]
T. Kress,[36] Y. Kuessel,[36] J. Lingemann,[36,f] A. Nowack,[36] L. Perchalla,[36] O. Pooth,[36] P. Sauerland,[36] A. Stahl,[36]
M. Aldaya Martin,[37] J. Behr,[37] W. Behrenhoff,[37] U. Behrens,[37] M. Bergholz,[37,r] A. Bethani,[37] K. Borras,[37]
A. Burgmeier,[37] A. Cakir,[37] L. Calligaris,[37] A. Campbell,[37] E. Castro,[37] F. Costanza,[37] D. Dammann,[37]

C. Diez Pardos,[37] G. Eckerlin,[37] D. Eckstein,[37] G. Flucke,[37] A. Geiser,[37] I. Glushkov,[37] P. Gunnellini,[37] S. Habib,[37] J. Hauk,[37] G. Hellwig,[37] H. Jung,[37] M. Kasemann,[37] P. Katsas,[37] C. Kleinwort,[37] H. Kluge,[37] A. Knutsson,[37] M. Krämer,[37] D. Krücker,[37] E. Kuznetsova,[37] W. Lange,[37] J. Leonard,[37] W. Lohmann,[37,r] B. Lutz,[37] R. Mankel,[37] I. Marfin,[37] M. Marienfeld,[37] I.-A. Melzer-Pellmann,[37] A. B. Meyer,[37] J. Mnich,[37] A. Mussgiller,[37] S. Naumann-Emme,[37] O. Novgorodova,[37] J. Olzem,[37] H. Perrey,[37] A. Petrukhin,[37] D. Pitzl,[37] A. Raspereza,[37] P. M. Ribeiro Cipriano,[37] C. Riedl,[37] E. Ron,[37] M. Rosin,[37] J. Salfeld-Nebgen,[37] R. Schmidt,[37,r] T. Schoerner-Sadenius,[37] N. Sen,[37] A. Spiridonov,[37] M. Stein,[37] R. Walsh,[37] C. Wissing,[37] V. Blobel,[38] H. Enderle,[38] J. Erfle,[38] U. Gebbert,[38] M. Görner,[38] M. Gosselink,[38] J. Haller,[38] T. Hermanns,[38] R. S. Höing,[38] K. Kaschube,[38] G. Kaussen,[38] H. Kirschenmann,[38] R. Klanner,[38] J. Lange,[38] F. Nowak,[38] T. Peiffer,[38] N. Pietsch,[38] D. Rathjens,[38] C. Sander,[38] H. Schettler,[38] P. Schleper,[38] E. Schlieckau,[38] A. Schmidt,[38] M. Schröder,[38] T. Schum,[38] M. Seidel,[38] J. Sibille,[38,s] V. Sola,[38] H. Stadie,[38] G. Steinbrück,[38] J. Thomsen,[38] L. Vanelderen,[38] C. Barth,[39] J. Berger,[39] C. Böser,[39] T. Chwalek,[39] W. De Boer,[39] A. Descroix,[39] A. Dierlamm,[39] M. Feindt,[39] M. Guthoff,[39,f] C. Hackstein,[39] F. Hartmann,[39,f] T. Hauth,[39,f] M. Heinrich,[39] H. Held,[39] K. H. Hoffmann,[39] U. Husemann,[39] I. Katkov,[39,q] J. R. Komaragiri,[39] P. Lobelle Pardo,[39] D. Martschei,[39] S. Mueller,[39] Th. Müller,[39] M. Niegel,[39] A. Nürnberg,[39] O. Oberst,[39] A. Oehler,[39] J. Ott,[39] G. Quast,[39] K. Rabbertz,[39] F. Ratnikov,[39] N. Ratnikova,[39] S. Röcker,[39] F.-P. Schilling,[39] G. Schott,[39] H. J. Simonis,[39] F. M. Stober,[39] D. Troendle,[39] R. Ulrich,[39] J. Wagner-Kuhr,[39] S. Wayand,[39] T. Weiler,[39] M. Zeise,[39] G. Anagnostou,[40] G. Daskalakis,[40] T. Geralis,[40] S. Kesisoglou,[40] A. Kyriakis,[40] D. Loukas,[40] I. Manolakos,[40] A. Markou,[40] C. Markou,[40] C. Mavrommatis,[40] E. Ntomari,[40] L. Gouskos,[41] T. J. Mertzimekis,[41] A. Panagiotou,[41] N. Saoulidou,[41] I. Evangelou,[42] C. Foudas,[42] P. Kokkas,[42] N. Manthos,[42] I. Papadopoulos,[42] V. Patras,[42] G. Bencze,[43] C. Hajdu,[43] P. Hidas,[43] D. Horvath,[43,t] F. Sikler,[43] V. Veszpremi,[43] G. Vesztergombi,[43,u] N. Beni,[44] S. Czellar,[44] J. Molnar,[44] J. Palinkas,[44] Z. Szillasi,[44] J. Karancsi,[45] P. Raics,[45] Z. L. Trocsanyi,[45] B. Ujvari,[45] S. B. Beri,[46] V. Bhatnagar,[46] N. Dhingra,[46] R. Gupta,[46] M. Kaur,[46] M. Z. Mehta,[46] N. Nishu,[46] L. K. Saini,[46] A. Sharma,[46] J. B. Singh,[46] Ashok Kumar,[47] Arun Kumar,[47] S. Ahuja,[47] A. Bhardwaj,[47] B. C. Choudhary,[47] S. Malhotra,[47] M. Naimuddin,[47] K. Ranjan,[47] V. Sharma,[47] R. K. Shivpuri,[47] S. Banerjee,[48] S. Bhattacharya,[48] S. Dutta,[48] B. Gomber,[48] Sa. Jain,[48] Sh. Jain,[48] R. Khurana,[48] S. Sarkar,[48] M. Sharan,[48] A. Abdulsalam,[49] D. Dutta,[49] S. Kailas,[49] V. Kumar,[49] A. K. Mohanty,[49,f] L. M. Pant,[49] P. Shukla,[49] T. Aziz,[50] S. Ganguly,[50] M. Guchait,[50,v] A. Gurtu,[50,w] M. Maity,[50,x] G. Majumder,[50] K. Mazumdar,[50] G. B. Mohanty,[50] B. Parida,[50] K. Sudhakar,[50] N. Wickramage,[50] S. Banerjee,[51] S. Dugad,[51] H. Arfaei,[52,y] H. Bakhshiansohi,[52] S. M. Etesami,[52,z] A. Fahim,[52,y] M. Hashemi,[52,aa] H. Hesari,[52] A. Jafari,[52] M. Khakzad,[52] M. Mohammadi Najafabadi,[52] S. Paktinat Mehdiabadi,[52] B. Safarzadeh,[52,bb] M. Zeinali,[52] M. Abbrescia,[53a,53b] L. Barbone,[53a,53b] C. Calabria,[53a,53b,f] S. S. Chhibra,[53a,53b] A. Colaleo,[53a] D. Creanza,[53a,53c] N. De Filippis,[53a,53c,f] M. De Palma,[53a,53b] L. Fiore,[53a] G. Iaselli,[53a,53c] G. Maggi,[53a,53c] M. Maggi,[53a] B. Marangelli,[53a,53b] S. My,[53a,53c] S. Nuzzo,[53a,53b] N. Pacifico,[53a] A. Pompili,[53a,53b] G. Pugliese,[53a,53c] G. Selvaggi,[53a,53b] L. Silvestris,[53a] G. Singh,[53a,53b] R. Venditti,[53a,53b] P. Verwilligen,[53a] G. Zito,[53a] G. Abbiendi,[54a] A. C. Benvenuti,[54a] D. Bonacorsi,[54a,54b] S. Braibant-Giacomelli,[54a,54b] L. Brigliadori,[54a,54b] P. Capiluppi,[54a,54b] A. Castro,[54a,54b] F. R. Cavallo,[54a] M. Cuffiani,[54a,54b] G. M. Dallavalle,[54a] F. Fabbri,[54a] A. Fanfani,[54a,54b] D. Fasanella,[54a,54b] P. Giacomelli,[54a] C. Grandi,[54a] L. Guiducci,[54a,54b] S. Marcellini,[54a] G. Masetti,[54a] M. Meneghelli,[54a,54b,f] A. Montanari,[54a] F. L. Navarria,[54a,54b] F. Odorici,[54a] A. Perrotta,[54a] F. Primavera,[54a,54b] A. M. Rossi,[54a,54b] T. Rovelli,[54a,54b] G. P. Siroli,[54a,54b] N. Tosi,[54a] R. Travaglini,[54a,54b] S. Albergo,[55a,55b] G. Cappello,[55a,55b] M. Chiorboli,[55a,55b] S. Costa,[55a,55b] R. Potenza,[55a,55b] A. Tricomi,[55a,55b] C. Tuve,[55a,55b] G. Barbagli,[56a] V. Ciulli,[56a,56b] C. Civinini,[56a] R. D'Alessandro,[56a,56b] E. Focardi,[56a,56b] S. Frosali,[56a,56b] E. Gallo,[56a] S. Gonzi,[56a,56b] M. Meschini,[56a] S. Paoletti,[56a] G. Sguazzoni,[56a] A. Tropiano,[56a,56b] L. Benussi,[57] S. Bianco,[57] S. Colafranceschi,[57,cc] F. Fabbri,[57] D. Piccolo,[57] P. Fabbricatore,[58a] R. Musenich,[58a] S. Tosi,[58a,58b] A. Benaglia,[59a] F. De Guio,[59a,59b] L. Di Matteo,[59a,59b,f] S. Fiorendi,[59a,59b] S. Gennai,[59a,f] A. Ghezzi,[59a,59b] S. Malvezzi,[59a] R. A. Manzoni,[59a,59b] A. Martelli,[59a,59b] A. Massironi,[59a,59b] D. Menasce,[59a] L. Moroni,[59a] M. Paganoni,[59a,59b] D. Pedrini,[59a] S. Ragazzi,[59a,59b] N. Redaelli,[59a] S. Sala,[59a] T. Tabarelli de Fatis,[59a,59b] S. Buontempo,[60a] C. A. Carrillo Montoya,[60a] N. Cavallo,[60a,dd] A. De Cosa,[60a,60b,f] O. Dogangun,[60a,60b] F. Fabozzi,[60a,dd] A. O. M. Iorio,[60a,60b] L. Lista,[60a] S. Meola,[60a,ee] M. Merola,[60a] P. Paolucci,[60a,f] P. Azzi,[61a] N. Bacchetta,[61a,f] P. Bellan,[61a,61b] D. Bisello,[61a,61b] A. Branca,[61a,f] R. Carlin,[61a,61b] P. Checchia,[61a] T. Dorigo,[61a] U. Dosselli,[61a] F. Gasparini,[61a,61b] U. Gasparini,[61a,61b] A. Gozzelino,[61a] K. Kanishchev,[61a,61c] S. Lacaprara,[61a] I. Lazzizzera,[61a,61c] M. Margoni,[61a,61b] A. T. Meneguzzo,[61a,61b] M. Nespolo,[61a,f] J. Pazzini,[61a,61b] P. Ronchese,[61a,61b] F. Simonetto,[61a,61b] E. Torassa,[61a]

S. Vanini,[61a,61b] P. Zotto,[61a,61b] G. Zumerle,[61a,61b] M. Gabusi,[62a,62b] S. P. Ratti,[62a,62b] C. Riccardi,[62a,62b]
P. Torre,[62a,62b] P. Vitulo,[62a,62b] M. Biasini,[63a,63b] G. M. Bilei,[63a] L. Fanò,[63a,63b] P. Lariccia,[63a,63b] G. Mantovani,[63a,63b]
M. Menichelli,[63a] A. Nappi,[63a,63b,a] F. Romeo,[63a,63b] A. Saha,[63a] A. Santocchia,[63a,63b] A. Spiezia,[63a,63b]
S. Taroni,[63a,63b] P. Azzurri,[64a,64c] G. Bagliesi,[64a] T. Boccali,[64a] G. Broccolo,[64a,64c] R. Castaldi,[64a]
R. T. D'Agnolo,[64a,64c,f] R. Dell'Orso,[64a] F. Fiori,[64a,64b,f] L. Foà,[64a,64c] A. Giassi,[64a] A. Kraan,[64a] F. Ligabue,[64a,64c]
T. Lomtadze,[64a] L. Martini,[64a,ff] A. Messineo,[64a,64b] F. Palla,[64a] A. Rizzi,[64a,64b] A. T. Serban,[64a,gg] P. Spagnolo,[64a]
P. Squillacioti,[64a,f] R. Tenchini,[64a] G. Tonelli,[64a,64b] A. Venturi,[64a] P. G. Verdini,[64a] L. Barone,[65a,65b] F. Cavallari,[65a]
D. Del Re,[65a,65b] M. Diemoz,[65a] C. Fanelli,[65a] M. Grassi,[65a,65b,f] E. Longo,[65a,65b] P. Meridiani,[65a,f] F. Micheli,[65a,65b]
S. Nourbakhsh,[65a,65b] G. Organtini,[65a,65b] R. Paramatti,[65a] S. Rahatlou,[65a,65b] M. Sigamani,[65a] L. Soffi,[65a,65b]
N. Amapane,[66a,66b] R. Arcidiacono,[66a,66c] S. Argiro,[66a,66b] M. Arneodo,[66a,66c] C. Biino,[66a] N. Cartiglia,[66a]
S. Casasso,[66a,66b] M. Costa,[66a,66b] N. Demaria,[66a] C. Mariotti,[66a,f] S. Maselli,[66a] E. Migliore,[66a,66b] V. Monaco,[66a,66b]
M. Musich,[66a,f] M. M. Obertino,[66a,66c] N. Pastrone,[66a] M. Pelliccioni,[66a] A. Potenza,[66a,66b] A. Romero,[66a,66b]
M. Ruspa,[66a,66c] R. Sacchi,[66a,66b] A. Solano,[66a,66b] A. Staiano,[66a] S. Belforte,[67a] V. Candelise,[67a,67b] M. Casarsa,[67a]
F. Cossutti,[67a] G. Della Ricca,[67a,67b] B. Gobbo,[67a] M. Marone,[67a,67b,f] D. Montanino,[67a,67b,f] A. Penzo,[67a]
A. Schizzi,[67a,67b] T. Y. Kim,[68] S. K. Nam,[68] S. Chang,[69] D. H. Kim,[69] G. N. Kim,[69] D. J. Kong,[69] H. Park,[69]
D. C. Son,[69] T. Son,[69] J. Y. Kim,[70] Zero J. Kim,[70] S. Song,[70] S. Choi,[71] D. Gyun,[71] B. Hong,[71] M. Jo,[71] H. Kim,[71]
T. J. Kim,[71] K. S. Lee,[71] D. H. Moon,[71] S. K. Park,[71] M. Choi,[72] J. H. Kim,[72] C. Park,[72] I. C. Park,[72] S. Park,[72]
G. Ryu,[72] Y. Choi,[73] Y. K. Choi,[73] J. Goh,[73] M. S. Kim,[73] E. Kwon,[73] B. Lee,[73] J. Lee,[73] S. Lee,[73] H. Seo,[73] I. Yu,[73]
M. J. Bilinskas,[74] I. Grigelionis,[74] M. Janulis,[74] A. Juodagalvis,[74] H. Castilla-Valdez,[75] E. De La Cruz-Burelo,[75]
I. Heredia-de La Cruz,[75] R. Lopez-Fernandez,[75] J. Martínez-Ortega,[75] A. Sánchez-Hernández,[75]
L. M. Villasenor-Cendejas,[75] S. Carrillo Moreno,[76] F. Vazquez Valencia,[76] H. A. Salazar Ibarguen,[77]
E. Casimiro Linares,[78] A. Morelos Pineda,[78] M. A. Reyes-Santos,[78] D. Krofcheck,[79] A. J. Bell,[80] P. H. Butler,[80]
R. Doesburg,[80] S. Reucroft,[80] H. Silverwood,[80] M. Ahmad,[81] M. I. Asghar,[81] J. Butt,[81] H. R. Hoorani,[81] S. Khalid,[81]
W. A. Khan,[81] T. Khurshid,[81] S. Qazi,[81] M. A. Shah,[81] M. Shoaib,[81] H. Bialkowska,[82] B. Boimska,[82] T. Frueboes,[82]
M. Górski,[82] M. Kazana,[82] K. Nawrocki,[82] K. Romanowska-Rybinska,[82] M. Szleper,[82] G. Wrochna,[82] P. Zalewski,[82]
G. Brona,[83] K. Bunkowski,[83] M. Cwiok,[83] W. Dominik,[83] K. Doroba,[83] A. Kalinowski,[83] M. Konecki,[83]
J. Krolikowski,[83] M. Misiura,[83] N. Almeida,[84] P. Bargassa,[84] A. David,[84] P. Faccioli,[84] P. G. Ferreira Parracho,[84]
M. Gallinaro,[84] J. Seixas,[84] J. Varela,[84] P. Vischia,[84] I. Belotelov,[85] P. Bunin,[85] M. Gavrilenko,[85] I. Golutvin,[85]
I. Gorbunov,[85] A. Kamenev,[85] V. Karjavin,[85] G. Kozlov,[85] A. Lanev,[85] A. Malakhov,[85] P. Moisenz,[85] V. Palichik,[85]
V. Perelygin,[85] S. Shmatov,[85] V. Smirnov,[85] A. Volodko,[85] A. Zarubin,[85] S. Evstyukhin,[86] V. Golovtsov,[86]
Y. Ivanov,[86] V. Kim,[86] P. Levchenko,[86] V. Murzin,[86] V. Oreshkin,[86] I. Smirnov,[86] V. Sulimov,[86] L. Uvarov,[86]
S. Vavilov,[86] A. Vorobyev,[86] An. Vorobyev,[86] Yu. Andreev,[87] A. Dermenev,[87] S. Gninenko,[87] N. Golubev,[87]
M. Kirsanov,[87] N. Krasnikov,[87] V. Matveev,[87] A. Pashenkov,[87] D. Tlisov,[87] A. Toropin,[87] V. Epshteyn,[88]
M. Erofeeva,[88] V. Gavrilov,[88] M. Kossov,[88] N. Lychkovskaya,[88] V. Popov,[88] G. Safronov,[88] S. Semenov,[88]
I. Shreyber,[88] V. Stolin,[88] E. Vlasov,[88] A. Zhokin,[88] A. Belyaev,[89] E. Boos,[89] M. Dubinin,[89,e] L. Dudko,[89]
A. Ershov,[89] A. Gribushin,[89] V. Klyukhin,[89] O. Kodolova,[89] I. Lokhtin,[89] A. Markina,[89] S. Obraztsov,[89]
M. Perfilov,[89] S. Petrushanko,[89] A. Popov,[89] L. Sarycheva,[89,a] V. Savrin,[89] A. Snigirev,[89] V. Andreev,[90] M. Azarkin,[90]
I. Dremin,[90] M. Kirakosyan,[90] A. Leonidov,[90] G. Mesyats,[90] S. V. Rusakov,[90] A. Vinogradov,[90] I. Azhgirey,[91]
I. Bayshev,[91] S. Bitioukov,[91] V. Grishin,[91,f] V. Kachanov,[91] D. Konstantinov,[91] V. Krychkine,[91] V. Petrov,[91]
R. Ryutin,[91] A. Sobol,[91] L. Tourtchanovitch,[91] S. Troshin,[91] N. Tyurin,[91] A. Uzunian,[91] A. Volkov,[91] P. Adzic,[92,hh]
M. Djordjevic,[92] M. Ekmedzic,[92] D. Krpic,[92,hh] J. Milosevic,[92] M. Aguilar-Benitez,[93] J. Alcaraz Maestre,[93]
P. Arce,[93] C. Battilana,[93] E. Calvo,[93] M. Cerrada,[93] M. Chamizo Llatas,[93] N. Colino,[93] B. De La Cruz,[93]
A. Delgado Peris,[93] D. Domínguez Vázquez,[93] C. Fernandez Bedoya,[93] J. P. Fernández Ramos,[93] A. Ferrando,[93]
J. Flix,[93] M. C. Fouz,[93] P. Garcia-Abia,[93] O. Gonzalez Lopez,[93] S. Goy Lopez,[93] J. M. Hernandez,[93] M. I. Josa,[93]
G. Merino,[93] J. Puerta Pelayo,[93] A. Quintario Olmeda,[93] I. Redondo,[93] L. Romero,[93] J. Santaolalla,[93] M. S. Soares,[93]
C. Willmott,[93] C. Albajar,[94] G. Codispoti,[94] J. F. de Trocóniz,[94] H. Brun,[95] J. Cuevas,[95] J. Fernandez Menendez,[95]
S. Folgueras,[95] I. Gonzalez Caballero,[95] L. Lloret Iglesias,[95] J. Piedra Gomez,[95] J. A. Brochero Cifuentes,[96]
I. J. Cabrillo,[96] A. Calderon,[96] S. H. Chuang,[96] J. Duarte Campderros,[96] M. Felcini,[96,ii] M. Fernandez,[96] G. Gomez,[96]
J. Gonzalez Sanchez,[96] A. Graziano,[96] C. Jorda,[96] A. Lopez Virto,[96] J. Marco,[96] R. Marco,[96] C. Martinez Rivero,[96]
F. Matorras,[96] F. J. Munoz Sanchez,[96] T. Rodrigo,[96] A. Y. Rodríguez-Marrero,[96] A. Ruiz-Jimeno,[96] L. Scodellaro,[96]
I. Vila,[96] R. Vilar Cortabitarte,[96] D. Abbaneo,[97] E. Auffray,[97] G. Auzinger,[97] M. Bachtis,[97] P. Baillon,[97] A. H. Ball,[97]

D. Barney,[97] J. F. Benitez,[97] C. Bernet,[97,g] G. Bianchi,[97] P. Bloch,[97] A. Bocci,[97] A. Bonato,[97] C. Botta,[97]
H. Breuker,[97] T. Camporesi,[97] G. Cerminara,[97] T. Christiansen,[97] J. A. Coarasa Perez,[97] D. D'Enterria,[97]
A. Dabrowski,[97] A. De Roeck,[97] S. Di Guida,[97] M. Dobson,[97] N. Dupont-Sagorin,[97] A. Elliott-Peisert,[97] B. Frisch,[97]
W. Funk,[97] G. Georgiou,[97] M. Giffels,[97] D. Gigi,[97] K. Gill,[97] D. Giordano,[97] M. Girone,[97] M. Giunta,[97] F. Glege,[97]
R. Gomez-Reino Garrido,[97] P. Govoni,[97] S. Gowdy,[97] R. Guida,[97] S. Gundacker,[97] M. Hansen,[97] P. Harris,[97]
C. Hartl,[97] J. Harvey,[97] B. Hegner,[97] A. Hinzmann,[97] V. Innocente,[97] P. Janot,[97] K. Kaadze,[97] E. Karavakis,[97]
K. Kousouris,[97] P. Lecoq,[97] Y.-J. Lee,[97] P. Lenzi,[97] C. Lourenço,[97] N. Magini,[97] T. Mäki,[97] M. Malberti,[97]
L. Malgeri,[97] M. Mannelli,[97] L. Masetti,[97] F. Meijers,[97] S. Mersi,[97] E. Meschi,[97] R. Moser,[97] M. U. Mozer,[97]
M. Mulders,[97] P. Musella,[97] E. Nesvold,[97] T. Orimoto,[97] L. Orsini,[97] E. Palencia Cortezon,[97] E. Perez,[97]
L. Perrozzi,[97] A. Petrilli,[97] A. Pfeiffer,[97] M. Pierini,[97] M. Pimiä,[97] D. Piparo,[97] G. Polese,[97] L. Quertenmont,[97]
A. Racz,[97] W. Reece,[97] J. Rodrigues Antunes,[97] G. Rolandi,[97,jj] C. Rovelli,[97,kk] M. Rovere,[97] H. Sakulin,[97]
F. Santanastasio,[97] C. Schäfer,[97] C. Schwick,[97] I. Segoni,[97] S. Sekmen,[97] A. Sharma,[97] P. Siegrist,[97] P. Silva,[97]
M. Simon,[97] P. Sphicas,[97,ll] D. Spiga,[97] A. Tsirou,[97] G. I. Veres,[97,u] J. R. Vlimant,[97] H. K. Wöhri,[97] S. D. Worm,[97,mm]
W. D. Zeuner,[97] W. Bertl,[98] K. Deiters,[98] W. Erdmann,[98] K. Gabathuler,[98] R. Horisberger,[98] Q. Ingram,[98]
H. C. Kaestli,[98] S. König,[98] D. Kotlinski,[98] U. Langenegger,[98] F. Meier,[98] D. Renker,[98] T. Rohe,[98] L. Bäni,[99]
P. Bortignon,[99] M. A. Buchmann,[99] B. Casal,[99] N. Chanon,[99] A. Deisher,[99] G. Dissertori,[99] M. Dittmar,[99]
M. Donegà,[99] M. Dünser,[99] J. Eugster,[99] K. Freudenreich,[99] C. Grab,[99] D. Hits,[99] P. Lecomte,[99] W. Lustermann,[99]
A. C. Marini,[99] P. Martinez Ruiz del Arbol,[99] N. Mohr,[99] F. Moortgat,[99] C. Nägeli,[99,nn] P. Nef,[99] F. Nessi-Tedaldi,[99]
F. Pandolfi,[99] L. Pape,[99] F. Pauss,[99] M. Peruzzi,[99] F. J. Ronga,[99] M. Rossini,[99] L. Sala,[99] A. K. Sanchez,[99]
A. Starodumov,[99,oo] B. Stieger,[99] M. Takahashi,[99] L. Tauscher,[99,a] A. Thea,[99] K. Theofilatos,[99] D. Treille,[99]
C. Urscheler,[99] R. Wallny,[99] H. A. Weber,[99] L. Wehrli,[99] C. Amsler,[100,pp] V. Chiochia,[100] S. De Visscher,[100]
C. Favaro,[100] M. Ivova Rikova,[100] B. Kilminster,[100] B. Millan Mejias,[100] P. Otiougova,[100] P. Robmann,[100]
H. Snoek,[100] S. Tupputi,[100] M. Verzetti,[100] Y. H. Chang,[101] K. H. Chen,[101] C. Ferro,[101] C. M. Kuo,[101] S. W. Li,[101]
W. Lin,[101] Y. J. Lu,[101] A. P. Singh,[101] R. Volpe,[101] S. S. Yu,[101] P. Bartalini,[102] P. Chang,[102] Y. H. Chang,[102]
Y. W. Chang,[102] Y. Chao,[102] K. F. Chen,[102] C. Dietz,[102] U. Grundler,[102] W.-S. Hou,[102] Y. Hsiung,[102] K. Y. Kao,[102]
Y. J. Lei,[102] R.-S. Lu,[102] D. Majumder,[102] E. Petrakou,[102] X. Shi,[102] J. G. Shiu,[102] Y. M. Tzeng,[102] X. Wan,[102]
M. Wang,[102] B. Asavapibhop,[103] N. Srimanobhas,[103] A. Adiguzel,[104] M. N. Bakirci,[104,qq] S. Cerci,[104,rr] C. Dozen,[104]
I. Dumanoglu,[104] E. Eskut,[104] S. Girgis,[104] G. Gokbulut,[104] E. Gurpinar,[104] I. Hos,[104] E. E. Kangal,[104]
T. Karaman,[104] G. Karapinar,[104,ss] A. Kayis Topaksu,[104] G. Onengut,[104] K. Ozdemir,[104] S. Ozturk,[104,tt]
A. Polatoz,[104] K. Sogut,[104,uu] D. Sunar Cerci,[104,rr] B. Tali,[104,rr] H. Topakli,[104,qq] L. N. Vergili,[104] M. Vergili,[104]
I. V. Akin,[105] T. Aliev,[105] B. Bilin,[105] S. Bilmis,[105] M. Deniz,[105] H. Gamsizkan,[105] A. M. Guler,[105] K. Ocalan,[105]
A. Ozpineci,[105] M. Serin,[105] R. Sever,[105] U. E. Surat,[105] M. Yalvac,[105] E. Yildirim,[105] M. Zeyrek,[105] E. Gülmez,[106]
B. Isildak,[106,vv] M. Kaya,[106,ww] O. Kaya,[106,ww] S. Ozkorucuklu,[106,xx] N. Sonmez,[106,yy] K. Cankocak,[107]
L. Levchuk,[108] J. J. Brooke,[109] E. Clement,[109] D. Cussans,[109] H. Flacher,[109] R. Frazier,[109] J. Goldstein,[109]
M. Grimes,[109] G. P. Heath,[109] H. F. Heath,[109] L. Kreczko,[109] S. Metson,[109] D. M. Newbold,[109,mm] K. Nirunpong,[109]
A. Poll,[109] S. Senkin,[109] V. J. Smith,[109] T. Williams,[109] L. Basso,[110,zz] K. W. Bell,[110] A. Belyaev,[110,zz] C. Brew,[110]
R. M. Brown,[110] D. J. A. Cockerill,[110] J. A. Coughlan,[110] K. Harder,[110] S. Harper,[110] J. Jackson,[110] B. W. Kennedy,[110]
E. Olaiya,[110] D. Petyt,[110] B. C. Radburn-Smith,[110] C. H. Shepherd-Themistocleous,[110] I. R. Tomalin,[110]
W. J. Womersley,[110] R. Bainbridge,[111] G. Ball,[111] R. Beuselinck,[111] O. Buchmuller,[111] D. Colling,[111] N. Cripps,[111]
M. Cutajar,[111] P. Dauncey,[111] G. Davies,[111] M. Della Negra,[111] W. Ferguson,[111] J. Fulcher,[111] D. Futyan,[111]
A. Gilbert,[111] A. Guneratne Bryer,[111] G. Hall,[111] Z. Hatherell,[111] J. Hays,[111] G. Iles,[111] M. Jarvis,[111]
G. Karapostoli,[111] L. Lyons,[111] A.-M. Magnan,[111] J. Marrouche,[111] B. Mathias,[111] R. Nandi,[111] J. Nash,[111]
A. Nikitenko,[111,oo] A. Papageorgiou,[111] J. Pela,[111] M. Pesaresi,[111] K. Petridis,[111] M. Pioppi,[111,aaa]
D. M. Raymond,[111] S. Rogerson,[111] A. Rose,[111] M. J. Ryan,[111] C. Seez,[111] P. Sharp,[111,a] A. Sparrow,[111] M. Stoye,[111]
A. Tapper,[111] M. Vazquez Acosta,[111] T. Virdee,[111] S. Wakefield,[111] N. Wardle,[111] T. Whyntie,[111] M. Chadwick,[112]
J. E. Cole,[112] P. R. Hobson,[112] A. Khan,[112] P. Kyberd,[112] D. Leggat,[112] D. Leslie,[112] W. Martin,[112] I. D. Reid,[112]
P. Symonds,[112] L. Teodorescu,[112] M. Turner,[112] K. Hatakeyama,[113] H. Liu,[113] T. Scarborough,[113] O. Charaf,[114]
C. Henderson,[114] P. Rumerio,[114] A. Avetisyan,[115] T. Bose,[115] C. Fantasia,[115] A. Heister,[115] J. St. John,[115]
P. Lawson,[115] D. Lazic,[115] J. Rohlf,[115] D. Sperka,[115] L. Sulak,[115] J. Alimena,[116] S. Bhattacharya,[116]
G. Christopher,[116] D. Cutts,[116] Z. Demiragli,[116] A. Ferapontov,[116] A. Garabedian,[116] U. Heintz,[116] S. Jabeen,[116]
G. Kukartsev,[116] E. Laird,[116] G. Landsberg,[116] M. Luk,[116] M. Narain,[116] D. Nguyen,[116] M. Segala,[116]

T. Sinthuprasith,[116] T. Speer,[116] R. Breedon,[117] G. Breto,[117] M. Calderon De La Barca Sanchez,[117] S. Chauhan,[117]
M. Chertok,[117] J. Conway,[117] R. Conway,[117] P. T. Cox,[117] J. Dolen,[117] R. Erbacher,[117] M. Gardner,[117] R. Houtz,[117]
W. Ko,[117] A. Kopecky,[117] R. Lander,[117] O. Mall,[117] T. Miceli,[117] D. Pellett,[117] F. Ricci-tam,[117] B. Rutherford,[117]
M. Searle,[117] J. Smith,[117] M. Squires,[117] M. Tripathi,[117] R. Vasquez Sierra,[117] R. Yohay,[117] V. Andreev,[118]
D. Cline,[118] R. Cousins,[118] J. Duris,[118] S. Erhan,[118] P. Everaerts,[118] C. Farrell,[118] J. Hauser,[118] M. Ignatenko,[118]
C. Jarvis,[118] G. Rakness,[118] P. Schlein,[118,a] P. Traczyk,[118] V. Valuev,[118] M. Weber,[118] J. Babb,[119] R. Clare,[119]
M. E. Dinardo,[119] J. Ellison,[119] J. W. Gary,[119] F. Giordano,[119] G. Hanson,[119] G. Y. Jeng,[119,bbb] H. Liu,[119]
O. R. Long,[119] A. Luthra,[119] H. Nguyen,[119] S. Paramesvaran,[119] J. Sturdy,[119] S. Sumowidagdo,[119] R. Wilken,[119]
S. Wimpenny,[119] W. Andrews,[120] J. G. Branson,[120] G. B. Cerati,[120] S. Cittolin,[120] D. Evans,[120] A. Holzner,[120]
R. Kelley,[120] M. Lebourgeois,[120] J. Letts,[120] I. Macneill,[120] B. Mangano,[120] S. Padhi,[120] C. Palmer,[120]
G. Petrucciani,[120] M. Pieri,[120] M. Sani,[120] V. Sharma,[120] S. Simon,[120] E. Sudano,[120] M. Tadel,[120] Y. Tu,[120]
A. Vartak,[120] S. Wasserbaech,[120,ccc] F. Würthwein,[120] A. Yagil,[120] J. Yoo,[120] D. Barge,[121] R. Bellan,[121]
C. Campagnari,[121] M. D'Alfonso,[121] T. Danielson,[121] K. Flowers,[121] P. Geffert,[121] F. Golf,[121] J. Incandela,[121]
C. Justus,[121] P. Kalavase,[121] D. Kovalskyi,[121] V. Krutelyov,[121] S. Lowette,[121] R. Magaña Villalba,[121] N. Mccoll,[121]
V. Pavlunin,[121] J. Ribnik,[121] J. Richman,[121] R. Rossin,[121] D. Stuart,[121] W. To,[121] C. West,[121] A. Apresyan,[122]
A. Bornheim,[122] Y. Chen,[122] E. Di Marco,[122] J. Duarte,[122] M. Gataullin,[122] Y. Ma,[122] A. Mott,[122] H. B. Newman,[122]
C. Rogan,[122] M. Spiropulu,[122] V. Timciuc,[122] J. Veverka,[122] R. Wilkinson,[122] S. Xie,[122] Y. Yang,[122] R. Y. Zhu,[122]
V. Azzolini,[123] A. Calamba,[123] R. Carroll,[123] T. Ferguson,[123] Y. Iiyama,[123] D. W. Jang,[123] Y. F. Liu,[123] M. Paulini,[123]
H. Vogel,[123] I. Vorobiev,[123] J. P. Cumalat,[124] B. R. Drell,[124] W. T. Ford,[124] A. Gaz,[124] E. Luiggi Lopez,[124]
J. G. Smith,[124] K. Stenson,[124] K. A. Ulmer,[124] S. R. Wagner,[124] J. Alexander,[125] A. Chatterjee,[125] N. Eggert,[125]
L. K. Gibbons,[125] B. Heltsley,[125] A. Khukhunaishvili,[125] B. Kreis,[125] N. Mirman,[125] G. Nicolas Kaufman,[125]
J. R. Patterson,[125] A. Ryd,[125] E. Salvati,[125] W. Sun,[125] W. D. Teo,[125] J. Thom,[125] J. Thompson,[125] J. Tucker,[125]
J. Vaughan,[125] Y. Weng,[125] L. Winstrom,[125] P. Wittich,[125] D. Winn,[126] S. Abdullin,[127] M. Albrow,[127] J. Anderson,[127]
L. A. T. Bauerdick,[127] A. Beretvas,[127] J. Berryhill,[127] P. C. Bhat,[127] K. Burkett,[127] J. N. Butler,[127] V. Chetluru,[127]
H. W. K. Cheung,[127] F. Chlebana,[127] V. D. Elvira,[127] I. Fisk,[127] J. Freeman,[127] Y. Gao,[127] D. Green,[127] O. Gutsche,[127]
J. Hanlon,[127] R. M. Harris,[127] J. Hirschauer,[127] B. Hooberman,[127] S. Jindariani,[127] M. Johnson,[127] U. Joshi,[127]
B. Klima,[127] S. Kunori,[127] S. Kwan,[127] C. Leonidopoulos,[127,ddd] J. Linacre,[127] D. Lincoln,[127] R. Lipton,[127]
J. Lykken,[127] K. Maeshima,[127] J. M. Marraffino,[127] S. Maruyama,[127] D. Mason,[127] P. McBride,[127] K. Mishra,[127]
S. Mrenna,[127] Y. Musienko,[127,eee] C. Newman-Holmes,[127] V. O'Dell,[127] O. Prokofyev,[127] E. Sexton-Kennedy,[127]
S. Sharma,[127] W. J. Spalding,[127] L. Spiegel,[127] L. Taylor,[127] S. Tkaczyk,[127] N. V. Tran,[127] L. Uplegger,[127]
E. W. Vaandering,[127] R. Vidal,[127] J. Whitmore,[127] W. Wu,[127] F. Yang,[127] J. C. Yun,[127] D. Acosta,[128] P. Avery,[128]
D. Bourilkov,[128] M. Chen,[128] T. Cheng,[128] S. Das,[128] M. De Gruttola,[128] G. P. Di Giovanni,[128] D. Dobur,[128]
A. Drozdetskiy,[128] R. D. Field,[128] M. Fisher,[128] Y. Fu,[128] I. K. Furic,[128] J. Gartner,[128] J. Hugon,[128] B. Kim,[128]
J. Konigsberg,[128] A. Korytov,[128] A. Kropivnitskaya,[128] T. Kypreos,[128] J. F. Low,[128] K. Matchev,[128]
P. Milenovic,[128,fff] G. Mitselmakher,[128] L. Muniz,[128] M. Park,[128] R. Remington,[128] A. Rinkevicius,[128] P. Sellers,[128]
N. Skhirtladze,[128] M. Snowball,[128] J. Yelton,[128] M. Zakaria,[128] V. Gaultney,[129] S. Hewamanage,[129] L. M. Lebolo,[129]
S. Linn,[129] P. Markowitz,[129] G. Martinez,[129] J. L. Rodriguez,[129] T. Adams,[130] A. Askew,[130] J. Bochenek,[130]
J. Chen,[130] B. Diamond,[130] S. V. Gleyzer,[130] J. Haas,[130] S. Hagopian,[130] V. Hagopian,[130] M. Jenkins,[130]
K. F. Johnson,[130] H. Prosper,[130] V. Veeraraghavan,[130] M. Weinberg,[130] M. M. Baarmand,[131] B. Dorney,[131]
M. Hohlmann,[131] H. Kalakhety,[131] I. Vodopiyanov,[131] F. Yumiceva,[131] M. R. Adams,[132] I. M. Anghel,[132]
L. Apanasevich,[132] Y. Bai,[132] V. E. Bazterra,[132] R. R. Betts,[132] I. Bucinskaite,[132] J. Callner,[132] R. Cavanaugh,[132]
O. Evdokimov,[132] L. Gauthier,[132] C. E. Gerber,[132] D. J. Hofman,[132] S. Khalatyan,[132] F. Lacroix,[132] C. O'Brien,[132]
C. Silkworth,[132] D. Strom,[132] P. Turner,[132] N. Varelas,[132] U. Akgun,[133] E. A. Albayrak,[133] B. Bilki,[133,ggg]
W. Clarida,[133] F. Duru,[133] J.-P. Merlo,[133] H. Mermerkaya,[133,hhh] A. Mestvirishvili,[133] A. Moeller,[133] J. Nachtman,[133]
C. R. Newsom,[133] E. Norbeck,[133] Y. Onel,[133] F. Ozok,[133,iii] S. Sen,[133] P. Tan,[133] E. Tiras,[133] J. Wetzel,[133]
T. Yetkin,[133] K. Yi,[133] B. A. Barnett,[134] B. Blumenfeld,[134] S. Bolognesi,[134] D. Fehling,[134] G. Giurgiu,[134]
A. V. Gritsan,[134] Z. J. Guo,[134] G. Hu,[134] P. Maksimovic,[134] M. Swartz,[134] A. Whitbeck,[134] P. Baringer,[135] A. Bean,[135]
G. Benelli,[135] R. P. Kenny Iii,[135] M. Murray,[135] D. Noonan,[135] S. Sanders,[135] R. Stringer,[135] G. Tinti,[135]
J. S. Wood,[135] A. F. Barfuss,[136] T. Bolton,[136] I. Chakaberia,[136] A. Ivanov,[136] S. Khalil,[136] M. Makouski,[136]
Y. Maravin,[136] S. Shrestha,[136] I. Svintradze,[136] J. Gronberg,[137] D. Lange,[137] F. Rebassoo,[137] D. Wright,[137]
A. Baden,[138] B. Calvert,[138] S. C. Eno,[138] J. A. Gomez,[138] N. J. Hadley,[138] R. G. Kellogg,[138] M. Kirn,[138]

T. Kolberg,[138] Y. Lu,[138] M. Marionneau,[138] A. C. Mignerey,[138] K. Pedro,[138] A. Skuja,[138] J. Temple,[138]
M. B. Tonjes,[138] S. C. Tonwar,[138] A. Apyan,[139] G. Bauer,[139] J. Bendavid,[139] W. Busza,[139] E. Butz,[139] I. A. Cali,[139]
M. Chan,[139] V. Dutta,[139] G. Gomez Ceballos,[139] M. Goncharov,[139] Y. Kim,[139] M. Klute,[139] K. Krajczar,[139,jjj]
A. Levin,[139] P. D. Luckey,[139] T. Ma,[139] S. Nahn,[139] C. Paus,[139] D. Ralph,[139] C. Roland,[139] G. Roland,[139]
M. Rudolph,[139] G. S. F. Stephans,[139] F. Stöckli,[139] K. Sumorok,[139] K. Sung,[139] D. Velicanu,[139] E. A. Wenger,[139]
R. Wolf,[139] B. Wyslouch,[139] M. Yang,[139] Y. Yilmaz,[139] A. S. Yoon,[139] M. Zanetti,[139] V. Zhukova,[139] S. I. Cooper,[140]
B. Dahmes,[140] A. De Benedetti,[140] G. Franzoni,[140] A. Gude,[140] S. C. Kao,[140] K. Klapoetke,[140] Y. Kubota,[140]
J. Mans,[140] N. Pastika,[140] R. Rusack,[140] M. Sasseville,[140] A. Singovsky,[140] N. Tambe,[140] J. Turkewitz,[140]
L. M. Cremaldi,[141] R. Kroeger,[141] L. Perera,[141] R. Rahmat,[141] D. A. Sanders,[141] E. Avdeeva,[142] K. Bloom,[142]
S. Bose,[142] D. R. Claes,[142] A. Dominguez,[142] M. Eads,[142] J. Keller,[142] I. Kravchenko,[142] J. Lazo-Flores,[142]
S. Malik,[142] G. R. Snow,[142] A. Godshalk,[143] I. Iashvili,[143] S. Jain,[143] A. Kharchilava,[143] A. Kumar,[143]
S. Rappoccio,[143] G. Alverson,[144] E. Barberis,[144] D. Baumgartel,[144] M. Chasco,[144] J. Haley,[144] D. Nash,[144]
D. Trocino,[144] D. Wood,[144] J. Zhang,[144] A. Anastassov,[145] K. A. Hahn,[145] A. Kubik,[145] L. Lusito,[145] N. Mucia,[145]
N. Odell,[145] R. A. Ofierzynski,[145] B. Pollack,[145] A. Pozdnyakov,[145] M. Schmitt,[145] S. Stoynev,[145] M. Velasco,[145]
S. Won,[145] L. Antonelli,[146] D. Berry,[146] A. Brinkerhoff,[146] K. M. Chan,[146] M. Hildreth,[146] C. Jessop,[146]
D. J. Karmgard,[146] J. Kolb,[146] K. Lannon,[146] W. Luo,[146] S. Lynch,[146] N. Marinelli,[146] D. M. Morse,[146] T. Pearson,[146]
M. Planer,[146] R. Ruchti,[146] J. Slaunwhite,[146] N. Valls,[146] M. Wayne,[146] M. Wolf,[146] B. Bylsma,[147] L. S. Durkin,[147]
C. Hill,[147] R. Hughes,[147] K. Kotov,[147] T. Y. Ling,[147] D. Puigh,[147] M. Rodenburg,[147] C. Vuosalo,[147] G. Williams,[147]
B. L. Winer,[147] E. Berry,[148] P. Elmer,[148] V. Halyo,[148] P. Hebda,[148] J. Hegeman,[148] A. Hunt,[148] P. Jindal,[148]
S. A. Koay,[148] D. Lopes Pegna,[148] P. Lujan,[148] D. Marlow,[148] T. Medvedeva,[148] M. Mooney,[148] J. Olsen,[148]
P. Piroué,[148] X. Quan,[148] A. Raval,[148] H. Saka,[148] D. Stickland,[148] C. Tully,[148] J. S. Werner,[148] A. Zuranski,[148]
E. Brownson,[149] A. Lopez,[149] H. Mendez,[149] J. E. Ramirez Vargas,[149] E. Alagoz,[150] V. E. Barnes,[150] D. Benedetti,[150]
G. Bolla,[150] D. Bortoletto,[150] M. De Mattia,[150] A. Everett,[150] Z. Hu,[150] M. Jones,[150] O. Koybasi,[150] M. Kress,[150]
A. T. Laasanen,[150] N. Leonardo,[150] V. Maroussov,[150] P. Merkel,[150] D. H. Miller,[150] N. Neumeister,[150] I. Shipsey,[150]
D. Silvers,[150] A. Svyatkovskiy,[150] M. Vidal Marono,[150] H. D. Yoo,[150] J. Zablocki,[150] Y. Zheng,[150] S. Guragain,[151]
N. Parashar,[151] A. Adair,[152] B. Akgun,[152] C. Boulahouache,[152] K. M. Ecklund,[152] F. J. M. Geurts,[152] W. Li,[152]
B. P. Padley,[152] R. Redjimi,[152] J. Roberts,[152] J. Zabel,[152] B. Betchart,[153] A. Bodek,[153] Y. S. Chung,[153]
R. Covarelli,[153] P. de Barbaro,[153] R. Demina,[153] Y. Eshaq,[153] T. Ferbel,[153] A. Garcia-Bellido,[153] P. Goldenzweig,[153]
J. Han,[153] A. Harel,[153] D. C. Miner,[153] D. Vishnevskiy,[153] M. Zielinski,[153] A. Bhatti,[154] R. Ciesielski,[154]
L. Demortier,[154] K. Goulianos,[154] G. Lungu,[154] S. Malik,[154] C. Mesropian,[154] S. Arora,[155] A. Barker,[155]
J. P. Chou,[155] C. Contreras-Campana,[155] E. Contreras-Campana,[155] D. Duggan,[155] D. Ferencek,[155] Y. Gershtein,[155]
R. Gray,[155] E. Halkiadakis,[155] D. Hidas,[155] A. Lath,[155] S. Panwalkar,[155] M. Park,[155] R. Patel,[155] V. Rekovic,[155]
J. Robles,[155] K. Rose,[155] S. Salur,[155] S. Schnetzer,[155] C. Seitz,[155] S. Somalwar,[155] R. Stone,[155] S. Thomas,[155]
M. Walker,[155] G. Cerizza,[156] M. Hollingsworth,[156] S. Spanier,[156] Z. C. Yang,[156] A. York,[156] R. Eusebi,[157]
W. Flanagan,[157] J. Gilmore,[157] T. Kamon,[157,kkk] V. Khotilovich,[157] R. Montalvo,[157] I. Osipenkov,[157] Y. Pakhotin,[157]
A. Perloff,[157] J. Roe,[157] A. Safonov,[157] T. Sakuma,[157] S. Sengupta,[157] I. Suarez,[157] A. Tatarinov,[157] D. Toback,[157]
N. Akchurin,[158] J. Damgov,[158] C. Dragoiu,[158] P. R. Dudero,[158] C. Jeong,[158] K. Kovitanggoon,[158] S. W. Lee,[158]
T. Libeiro,[158] Y. Roh,[158] I. Volobouev,[158] E. Appelt,[159] A. G. Delannoy,[159] C. Florez,[159] S. Greene,[159] A. Gurrola,[159]
W. Johns,[159] P. Kurt,[159] C. Maguire,[159] A. Melo,[159] M. Sharma,[159] P. Sheldon,[159] B. Snook,[159] S. Tuo,[159]
J. Velkovska,[159] M. W. Arenton,[160] M. Balazs,[160] S. Boutle,[160] B. Cox,[160] B. Francis,[160] J. Goodell,[160] R. Hirosky,[160]
A. Ledovskoy,[160] C. Lin,[160] C. Neu,[160] J. Wood,[160] S. Gollapinni,[161] R. Harr,[161] P. E. Karchin,[161]
C. Kottachchi Kankanamge Don,[161] P. Lamichhane,[161] A. Sakharov,[161] M. Anderson,[162] D. Belknap,[162]
L. Borrello,[162] D. Carlsmith,[162] M. Cepeda,[162] S. Dasu,[162] E. Friis,[162] L. Gray,[162] K. S. Grogg,[162] M. Grothe,[162]
R. Hall-Wilton,[162] M. Herndon,[162] A. Hervé,[162] P. Klabbers,[162] J. Klukas,[162] A. Lanaro,[162] C. Lazaridis,[162]
R. Loveless,[162] A. Mohapatra,[162] I. Ojalvo,[162] F. Palmonari,[162] G. A. Pierro,[162] I. Ross,[162] A. Savin,[162]
W. H. Smith,[162] and J. Swanson[162]

(CMS Collaboration)

[1]*Yerevan Physics Institute, Yerevan, Armenia*
[2]*Institut für Hochenergiephysik der OeAW, Wien, Austria*
[3]*National Centre for Particle and High Energy Physics, Minsk, Belarus*

[4]*Universiteit Antwerpen, Antwerpen, Belgium*
[5]*Vrije Universiteit Brussel, Brussel, Belgium*
[6]*Université Libre de Bruxelles, Bruxelles, Belgium*
[7]*Ghent University, Ghent, Belgium*
[8]*Université Catholique de Louvain, Louvain-la-Neuve, Belgium*
[9]*Université de Mons, Mons, Belgium*
[10]*Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil*
[11]*Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil*
[12]*Instituto de Fisica Teorica, Universidade Estadual Paulista, Sao Paulo, Brazil*
[13]*Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria*
[14]*University of Sofia, Sofia, Bulgaria*
[15]*Institute of High Energy Physics, Beijing, China*
[16]*State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China*
[17]*Universidad de Los Andes, Bogota, Colombia*
[18]*Technical University of Split, Split, Croatia*
[19]*University of Split, Split, Croatia*
[20]*Institute Rudjer Boskovic, Zagreb, Croatia*
[21]*University of Cyprus, Nicosia, Cyprus*
[22]*Charles University, Prague, Czech Republic*
[23]*Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt*
[24]*National Institute of Chemical Physics and Biophysics, Tallinn, Estonia*
[25]*Department of Physics, University of Helsinki, Helsinki, Finland*
[26]*Helsinki Institute of Physics, Helsinki, Finland*
[27]*Lappeenranta University of Technology, Lappeenranta, Finland*
[28]*DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France*
[29]*Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France*
[30]*Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France*
[31]*Centre de Calcul de l'Institut National de Physique Nucleaire et de Physique des Particules, CNRS/IN2P3, Villeurbanne, France*
[32]*Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France*
[33]*Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, Georgia*
[34]*RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany*
[35]*RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany*
[36]*RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany*
[37]*Deutsches Elektronen-Synchrotron, Hamburg, Germany*
[38]*University of Hamburg, Hamburg, Germany*
[39]*Institut für Experimentelle Kernphysik, Karlsruhe, Germany*
[40]*Institute of Nuclear Physics "Demokritos", Aghia Paraskevi, Greece*
[41]*University of Athens, Athens, Greece*
[42]*University of Ioánnina, Ioánnina, Greece*
[43]*KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary*
[44]*Institute of Nuclear Research ATOMKI, Debrecen, Hungary*
[45]*University of Debrecen, Debrecen, Hungary*
[46]*Panjab University, Chandigarh, India*
[47]*University of Delhi, Delhi, India*
[48]*Saha Institute of Nuclear Physics, Kolkata, India*
[49]*Bhabha Atomic Research Centre, Mumbai, India*
[50]*Tata Institute of Fundamental Research-EHEP, Mumbai, India*
[51]*Tata Institute of Fundamental Research-HECR, Mumbai, India*
[52]*Institute for Research in Fundamental Sciences (IPM), Tehran, Iran*
[53a]*INFN Sezione di Bari, Bari, Italy*
[53b]*Università di Bari, Bari, Italy*
[53c]*Politecnico di Bari, Bari, Italy*
[54a]*INFN Sezione di Bologna, Bologna, Italy*
[54b]*Università di Bologna, Bologna, Italy*
[55a]*INFN Sezione di Catania, Catania, Italy*
[55b]*Università di Catania, Catania, Italy*
[56a]*INFN Sezione di Firenze, Firenze, Italy*

[56b]*Università di Firenze, Firenze, Italy*
[57]*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
[58a]*INFN Sezione di Genova, Genova, Italy*
[58b]*Università di Genova, Genova, Italy*
[59a]*INFN Sezione di Milano-Bicocca, Milano, Italy*
[59b]*Università di Milano-Bicocca, Milano, Italy*
[60a]*INFN Sezione di Napoli, Napoli, Italy*
[60b]*Università di Napoli "Federico II", Napoli, Italy*
[61a]*INFN Sezione di Padova, Padova, Italy*
[61b]*Università di Padova, Padova, Italy*
[61c]*Università di Trento (Trento), Padova, Italy*
[62a]*INFN Sezione di Pavia, Pavia, Italy*
[62b]*Università di Pavia, Pavia, Italy*
[63a]*INFN Sezione di Perugia, Perugia, Italy*
[63b]*Università di Perugia, Perugia, Italy*
[64a]*INFN Sezione di Pisa, Pisa, Italy*
[64b]*Università di Pisa, Pisa, Italy*
[64c]*Scuola Normale Superiore di Pisa, Pisa, Italy*
[65a]*INFN Sezione di Roma, Roma, Italy*
[65b]*Università di Roma "La Sapienza", Roma, Italy*
[66a]*INFN Sezione di Torino, Torino, Italy*
[66b]*Università di Torino, Torino, Italy*
[66c]*Università del Piemonte Orientale (Novara), Torino, Italy*
[67a]*INFN Sezione di Trieste, Trieste, Italy*
[67b]*Università di Trieste, Trieste, Italy*
[68]*Kangwon National University, Chunchon, Korea*
[69]*Kyungpook National University, Daegu, Korea*
[70]*Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea*
[71]*Korea University, Seoul, Korea*
[72]*University of Seoul, Seoul, Korea*
[73]*Sungkyunkwan University, Suwon, Korea*
[74]*Vilnius University, Vilnius, Lithuania*
[75]*Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico*
[76]*Universidad Iberoamericana, Mexico City, Mexico*
[77]*Benemerita Universidad Autonoma de Puebla, Puebla, Mexico*
[78]*Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico*
[79]*University of Auckland, Auckland, New Zealand*
[80]*University of Canterbury, Christchurch, New Zealand*
[81]*National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan*
[82]*National Centre for Nuclear Research, Swierk, Poland*
[83]*Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland*
[84]*Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal*
[85]*Joint Institute for Nuclear Research, Dubna, Russia*
[86]*Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia*
[87]*Institute for Nuclear Research, Moscow, Russia*
[88]*Institute for Theoretical and Experimental Physics, Moscow, Russia*
[89]*Moscow State University, Moscow, Russia*
[90]*P.N. Lebedev Physical Institute, Moscow, Russia*
[91]*State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia*
[92]*University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia*
[93]*Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain*
[94]*Universidad Autónoma de Madrid, Madrid, Spain*
[95]*Universidad de Oviedo, Oviedo, Spain*
[96]*Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain*
[97]*CERN, European Organization for Nuclear Research, Geneva, Switzerland*
[98]*Paul Scherrer Institut, Villigen, Switzerland*
[99]*Institute for Particle Physics, ETH Zurich, Zurich, Switzerland*
[100]*Universität Zürich, Zurich, Switzerland*
[101]*National Central University, Chung-Li, Taiwan*
[102]*National Taiwan University (NTU), Taipei, Taiwan*
[103]*Chulalongkorn University, Bangkok, Thailand*

[104]*Cukurova University, Adana, Turkey*
[105]*Middle East Technical University, Physics Department, Ankara, Turkey*
[106]*Bogazici University, Istanbul, Turkey*
[107]*Istanbul Technical University, Istanbul, Turkey*
[108]*National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine*
[109]*University of Bristol, Bristol, United Kingdom*
[110]*Rutherford Appleton Laboratory, Didcot, United Kingdom*
[111]*Imperial College, London, United Kingdom*
[112]*Brunel University, Uxbridge, United Kingdom*
[113]*Baylor University, Waco, Texas, USA*
[114]*The University of Alabama, Tuscaloosa, Alabama, USA*
[115]*Boston University, Boston, Massachusetts, USA*
[116]*Brown University, Providence, Rhode Island, USA*
[117]*University of California, Davis, Davis, California, USA*
[118]*University of California, Los Angeles, Los Angeles, California, USA*
[119]*University of California, Riverside, Riverside, California, USA*
[120]*University of California, San Diego, La Jolla, California, USA*
[121]*University of California, Santa Barbara, Santa Barbara, California, USA*
[122]*California Institute of Technology, Pasadena, California, USA*
[123]*Carnegie Mellon University, Pittsburgh, Pennsylvania, USA*
[124]*University of Colorado at Boulder, Boulder, Colorado, USA*
[125]*Cornell University, Ithaca, New York, USA*
[126]*Fairfield University, Fairfield, Connecticut, USA*
[127]*Fermi National Accelerator Laboratory, Batavia, Illinois, USA*
[128]*University of Florida, Gainesville, Florida, USA*
[129]*Florida International University, Miami, Florida, USA*
[130]*Florida State University, Tallahassee, Florida, USA*
[131]*Florida Institute of Technology, Melbourne, Florida, USA*
[132]*University of Illinois at Chicago (UIC), Chicago, Illinois, USA*
[133]*The University of Iowa, Iowa City, Iowa, USA*
[134]*Johns Hopkins University, Baltimore, Maryland, USA*
[135]*The University of Kansas, Lawrence, Kansas, USA*
[136]*Kansas State University, Manhattan, Kansas, USA*
[137]*Lawrence Livermore National Laboratory, Livermore, California, USA*
[138]*University of Maryland, College Park, Maryland, USA*
[139]*Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
[140]*University of Minnesota, Minneapolis, Minnesota, USA*
[141]*University of Mississippi, Oxford, Mississippi, USA*
[142]*University of Nebraska-Lincoln, Lincoln, Nebraska, USA*
[143]*State University of New York at Buffalo, Buffalo, New York, USA*
[144]*Northeastern University, Boston, Massachusetts, USA*
[145]*Northwestern University, Evanston, Illinois, USA*
[146]*University of Notre Dame, Notre Dame, Indiana, USA*
[147]*The Ohio State University, Columbus, Ohio, USA*
[148]*Princeton University, Princeton, New Jersey, USA*
[149]*University of Puerto Rico, Mayaguez, Puerto Rico, USA*
[150]*Purdue University, West Lafayette, Indiana, USA*
[151]*Purdue University Calumet, Hammond, Indiana, USA*
[152]*Rice University, Houston, Texas, USA*
[153]*University of Rochester, Rochester, New York, USA*
[154]*The Rockefeller University, New York, New York, USA*
[155]*Rutgers, the State University of New Jersey, Piscataway, New Jersey, USA*
[156]*University of Tennessee, Knoxville, Tennessee, USA*
[157]*Texas A&M University, College Station, Texas, USA*
[158]*Texas Tech University, Lubbock, Texas, USA*
[159]*Vanderbilt University, Nashville, Tennessee, USA*
[160]*University of Virginia, Charlottesville, Virginia, USA*
[161]*Wayne State University, Detroit, Michigan, USA*
[162]*University of Wisconsin, Madison, Wisconsin, USA*

[a]Deceased.
[b]Also at Vienna University of Technology, Vienna, Austria.
[c]Also at National Institute of Chemical Physics and Biophysics, Tallinn, Estonia.
[d]Also at Universidade Federal do ABC, Santo Andre, Brazil.
[e]Also at California Institute of Technology, Pasadena, California, USA.
[f]Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland.
[g]Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France.
[h]Also at Suez Canal University, Suez, Egypt.
[i]Also at Zewail City of Science and Technology, Zewail, Egypt.
[j]Also at Cairo University, Cairo, Egypt.
[k]Also at Fayoum University, El-Fayoum, Egypt.
[l]Also at British University, Cairo, Egypt.
[m]Now at Ain Shams University, Cairo, Egypt.
[n]Also at National Centre for Nuclear Research, Swierk, Poland.
[o]Also at Université de Haute-Alsace, Mulhouse, France.
[p]Also at Joint Institute for Nuclear Research, Dubna, Russia.
[q]Also at Moscow State University, Moscow, Russia.
[r]Also at Brandenburg University of Technology, Cottbus, Germany.
[s]Also at The University of Kansas, Lawrence, Kansas, USA.
[t]Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary.
[u]Also at Eötvös Loránd University, Budapest, Hungary.
[v]Also at Tata Institute of Fundamental Research—HECR, Mumbai, India
[w]Now at King Abdulaziz University, Jeddah, Saudi Arabia.
[x]Also at University of Visva-Bharati, Santiniketan, India.
[y]Also at Sharif University of Technology, Tehran, Iran.
[z]Also at Isfahan University of Technology, Isfahan, Iran.
[aa]Also at Shiraz University, Shiraz, Iran.
[bb]Also at Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[cc]Also at Facoltà Ingegneria Università di Roma, Roma, Italy.
[dd]Also at Università della Basilicata, Potenza, Italy.
[ee]Also at Università degli Studi Guglielmo Marconi, Roma, Italy.
[ff]Also at Università degli Studi di Siena, Siena, Italy.
[gg]Also at University of Bucharest, Faculty of Physics, Bucuresti-Magurele, Romania.
[hh]Also at Faculty of Physics of University of Belgrade, Belgrade, Serbia.
[ii]Also at University of California, Los Angeles, Los Angeles, California, USA.
[jj]Also at Scuola Normale e Sezione dell' INFN, Pisa, Italy.
[kk]Also at INFN Sezione di Roma, Università di Roma ‘‘La Sapienza’’, Roma, Italy.
[ll]Also at University of Athens, Athens, Greece.
[mm]Also at Rutherford Appleton Laboratory, Didcot, United Kingdom.
[nn]Also at Paul Scherrer Institut, Villigen, Switzerland.
[oo]Also at Institute for Theoretical and Experimental Physics, Moscow, Russia.
[pp]Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland.
[qq]Also at Gaziosmanpasa University, Tokat, Turkey.
[rr]Also at Adiyaman University, Adiyaman, Turkey.
[ss]Also at Izmir Institute of Technology, Izmir, Turkey.
[tt]Also at The University of Iowa, Iowa City, Iowa, USA.
[uu]Also at Mersin University, Mersin, Turkey.
[vv]Also at Ozyegin University, Istanbul, Turkey.
[ww]Also at Kafkas University, Kars, Turkey.
[xx]Also at Suleyman Demirel University, Isparta, Turkey.
[yy]Also at Ege University, Izmir, Turkey.
[zz]Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.
[aaa]Also at INFN Sezione di Perugia, Università di Perugia, Perugia, Italy.
[bbb]Also at University of Sydney, Sydney, Australia.
[ccc]Also at Utah Valley University, Orem, Utah, USA.

[ddd] Now at University of Edinburgh, Scotland, Edinburgh, United Kingdom.

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

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

[ggg] Also at Argonne National Laboratory, Argonne, Illinois, USA.

[hhh] Also at Erzincan University, Erzincan, Turkey.

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

[jjj] Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary.

[kkk] Also at Kyungpook National University, Daegu, Korea.