Indications of suppression of excited Υ states in Pb-Pb collisions at √sNN=2.76 TeV

CMS Collaboration; Chatrchyan, S; Amsler, C; Chiochia, V

Abstract: A comparison of the relative yields of Υ resonances in the (+)(-) decay channel in Pb-Pb and pp collisions at a center-of-mass energy per nucleon pair of 2.76 TeV is performed with data collected with the CMS detector at the LHC. Using muons of transverse momentum above 4 GeV/c and pseudorapidity below 2.4, the double ratio of the Υ(2S) and Υ(3S) excited states to the Υ(1S) ground state in Pb-Pb and pp collisions, [Υ(2S+3S)/Υ(1S)](Pb-Pb)/[Υ(2S+3S)/Υ(1S)](pp), is found to be 0.31(-0.15)(+0.19)(stat)±0.03(syst). The probability to obtain the measured value, or lower, if the true double ratio is unity, is calculated to be less than 1%.

DOI: https://doi.org/10.1103/PhysRevLett.107.052302

Posted at the Zurich Open Repository and Archive, University of Zurich
ZORA URL: https://doi.org/10.5167/uzh-58574
Journal Article
Accepted Version

Originally published at:
CMS Collaboration; Chatrchyan, S; Amsler, C; Chiochia, V (2011). Indications of suppression of excited Υ states in Pb-Pb collisions at √sNN=2.76 TeV. Physical Review Letters, 107(5):052302.
DOI: https://doi.org/10.1103/PhysRevLett.107.052302
Suppression of excited Y states in PbPb collisions at \( \sqrt{s_{\text{NN}}} = 2.76 \text{ TeV} \)

The CMS Collaboration

Abstract

A comparison of the relative yields of Y resonances in the \( \mu^+\mu^- \) decay channel in PbPb and pp collisions at a centre-of-mass energy per nucleon pair of 2.76 TeV, is performed with data collected with the CMS detector at the LHC. Using muons of transverse momentum above 4 GeV/c and pseudorapidity below 2.4, the double ratio of the Y(2S) and Y(3S) excited states to the Y(1S) ground state in PbPb and pp collisions, \( [Y(2S + 3S)/Y(1S)]_{\text{PbPb}}/[Y(2S + 3S)/Y(1S)]_{\text{pp}} \), is found to be 0.31 \( ^{+0.19}_{-0.15} \) (stat.) \( ^{\pm 0.03} \) (syst.). The probability to obtain the measured value, or lower, if the true double ratio is unity, is calculated to be less than 1%.

Submitted to Physical Review Letters

*See Appendix A for the list of collaboration members*
Quantum chromodynamics (QCD) predicts that strongly interacting matter undergoes a phase transition to a deconfined state, often referred to as the quark-gluon plasma (QGP), in which quarks and gluons are no longer bound within hadrons. Calculations in lattice QCD indicate that the transition should occur at a critical temperature \( T_c \approx 175 \text{ MeV} \), corresponding to an energy density \( \epsilon_c \approx 1 \text{ GeV/fm}^3 \).

If the QGP is formed in heavy-ion collisions, it is expected to screen the confining potential of heavy quark-antiquark pairs, leading to the melting of charmonium and bottomonium states: \( J/\psi, \psi(2S), \chi_{cJ}, Y(1S), Y(2S), Y(3S), \) and \( \chi_b \). The melting temperature depends on the binding energy of the quarkonium state. The ground states, \( J/\psi \) and \( Y(1S) \), are expected to dissolve at significantly higher temperatures than the more loosely bound excited states. Quenched lattice QCD calculations originally predicted that the \( Y \) states melt at \( 1.2 T_c(3S), 1.6 T_c(2S), \) and above \( 4 T_c(1S) \), while modern spectral-function approaches with complex potentials favour somewhat lower dissolution temperatures. This sequential melting pattern is generally considered a “smoking-gun” signature of the QCD deconfinement transition. However, a large fraction of the observed \( 1S \) yield in elementary collisions is caused by feed-down contributions from decays of heavier states (around 50% for the \( Y(1S) \) [6]). Therefore the melting of the excited states is expected to result in a significant suppression of the observed \( 1S \) yields, even if the medium is not hot enough to directly dissolve the ground states.

Observations of \( J/\psi \) and \( \psi(2S) \) suppression between proton-nucleus and heavy-ion collisions were reported by the NA38 [7], NA50 [8, 9] and NA60 [10] fixed-target experiments at the Super Proton Synchrotron (SPS), respectively in SU, PbPb and InIn collisions, at centre-of-mass energies per nucleon pair \( \sqrt{s_{NN}} \) of about 20 GeV. The PHENIX experiment, at the Relativistic Heavy Ion Collider (RHIC), extended the \( J/\psi \) suppression measurements to AuAu collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \) [11]. At RHIC, bottomonia production becomes measurable [12], though with limited integrated luminosities. PHENIX observed that the dimuon yield in the \( Y \) mass region for minimum bias AuAu collisions is less than 64%, at the 90% confidence level, of the value expected by extrapolating the pp yields [13].

A new era of detailed studies of the bottomonium family in heavy-ion collisions has started at the Large Hadron Collider (LHC). The measurement reported in this Letter is performed with the data recorded by the Compact Muon Solenoid (CMS) experiment during the first PbPb LHC run, at the end of 2010, and during the pp run of March 2011, both at \( \sqrt{s_{NN}} = 2.76 \text{ TeV} \). The integrated luminosity used in this analysis corresponds to 7.28 \( \mu \text{b}^{-1} \) for PbPb and 225 \( \text{nb}^{-1} \) for pp collisions, the latter corresponding approximately to the equivalent nucleon-nucleon luminosity of the PbPb run. The excellent momentum resolution of the CMS detector results in well-resolved \( \Upsilon \) peaks in the dimuon mass spectrum. The CMS collaboration has previously studied \( \Upsilon \) production in pp data at \( \sqrt{s} = 7 \text{ TeV} \) [14], using techniques to extract the \( \Upsilon \) yields that are very similar to the ones used in the study reported in this Letter.

A detailed description of the CMS detector can be found in [15]. Its central feature is a superconducting solenoid of 6 m internal diameter, providing a magnetic field of 3.8 T. Within the field volume are the silicon pixel and strip tracker, the crystal electromagnetic calorimeter, and the brass/scintillator hadron calorimeter. Muons are measured in gas-ionisation detectors embedded in the steel return yoke. In addition, CMS has extensive forward calorimetry, in particular two steel/quartz-fiber Čerenkov hadron forward (HF) calorimeters, which cover the pseudorapidity range \( 2.9 < \eta < 5.2 \).

In this analysis, \( \Upsilon \) mesons are identified through their dimuon decay. The silicon pixel and strip tracker measures charged-particle trajectories in the range \( \eta < 2.5 \). The tracker consists of 66M pixel and 10M strip detector channels, providing a vertex resolution of \( \sim 15 \mu \text{m} \) in the
transverse plane. Muons are detected in the $|\eta| < 2.4$ range, with detection planes based on three technologies: drift tubes, cathode strip chambers, and resistive plate chambers. Due to the strong magnetic field and the fine granularity of the silicon tracker, the muon transverse momentum measurement ($p_T$) based on information from the silicon tracker alone has a resolution between 1 and 2% for a typical muon in this analysis.

In both the PbPb and pp runs, the events are selected by the CMS two-level trigger. At the first, hardware level, two independent muon candidates are required in the muon detectors. No selection is made on momentum or pseudorapidity, but in the pp case more stringent quality requirements are imposed for each muon in order to reduce the higher trigger rate. In both cases, the software-based higher-level trigger accepts the lower-level decision without applying further criteria. From reconstructed $J/\psi \rightarrow \mu\mu$ decays, the single-muon trigger efficiencies are measured and found to be consistent between the PbPb, $(96.1 \pm 1.0)\%$, and the pp, $(95.5 \pm 0.6)\%$, data sets, for muons with $p_T > 4$ GeV/$c$.

In the PbPb data, events are preselected offline if they contain a reconstructed primary vertex made of at least two tracks, and a coincidence in both HF calorimeters of energy deposits in at least three towers of 3 GeV each. These criteria reduce contributions from single-beam interactions (e.g. beam-gas and beam-halo collisions with the beam pipe), ultra-peripheral electromagnetic collisions, and cosmic-ray muons. A small fraction of the most peripheral PbPb collisions is not selected by these requirements, which accept $(97 \pm 3)\%$ of the hadronic inelastic cross section [16]. For the pp run, a similar event filter is applied, relaxing the HF coincidence to one tower in each HF, with at least 3 GeV deposited. This filter removes only 1% of the pp events satisfying the dimuon trigger.

The muon offline reconstruction is seeded with $\simeq 99\%$ efficiency by tracks in the muon detectors, called standalone muons. These tracks are then matched to tracks reconstructed in the silicon tracker by means of an algorithm optimised for the heavy-ion environment [17,18]. For muons from $\Upsilon$ decays the tracking efficiency is $\simeq 85\%$. This efficiency is lower than in pp, as in PbPb the track reconstruction is seeded by a greater number of pixel hits to reduce the large number of random combinations arising from the high multiplicity of each event. Combined fits of the muon and tracker tracks are used to obtain the results presented in this Letter. The heavy-ion dedicated reconstruction algorithm is applied to the pp data in order to avoid potential biases, arising from different tracking efficiencies of the two reconstruction algorithms, when comparing the two data sets.

Identical very loose selection criteria are applied to the muons in the pp and PbPb data. The transverse (longitudinal) distance from the event vertex is required to be less than 3 (15) cm. Tracks are only kept if they have 11 or more hits in the silicon tracker and the $\chi^2$ per degree of freedom of the combined (tracker) track fit is lower than 20 (4). The two muon trajectories are fit with a common vertex constraint, and events are retained if the fit $\chi^2$ probability is larger than 1%. This removes background arising primarily from displaced heavy quark semileptonic decays. As determined from Monte Carlo simulation of the $\Upsilon(1S)$ signal, these selection criteria are found to reduce the efficiency by 3.9%, consistent with the signal loss observed in both pp and PbPb data. The available event sample limits to 20 GeV/$c$ the dimuon transverse momentum range probed in this study.

In order to further reduce the background in the $\Upsilon$ mass region, only muons with a transverse momentum ($p_T^{\mu}$) higher than 4 GeV/$c$ are considered, resulting in a $\Upsilon$ acceptance of approximately 25% for the $|y^{\Upsilon}| < 2.4$ rapidity range. This requirement improves the significance of the $\Upsilon(1S)$ signal in PbPb data and is applied to both data sets. The acceptance of a $\Upsilon$ state depends on its mass, since the excited states give rise to higher-momenta muons. In con-
sequence, requiring higher \( p_T^\mu \) increases the acceptance for the excited states relative to the ground state. In the corresponding analysis performed with the higher-statistics (3.1 \( \text{pb}^{-1} \)) 7 TeV data [14], looser criteria were applied (\( p_T^\mu > 3.5 \text{ GeV}/c \) and \( |\eta^\mu| < 1.6 \), or \( p_T^\mu > 2.5 \text{ GeV}/c \) and \( 1.6 < |\eta^\mu| < 2.4 \)), where \( \eta^\mu \) is the muon pseudorapidity. The stricter (\( p_T^\mu > 4 \text{ GeV}/c \)) requirements used here enhance the \( \Upsilon(2S + 3S)/\Upsilon(1S) \) yield ratio by \( \approx 60\% \) in the pp data at 2.76 TeV. It was checked that, applying the same reconstruction algorithm and the same \( p_T^\mu \) requirements, the \( \Upsilon(2S + 3S)/\Upsilon(1S) \) yield ratio is consistent between the 2.76 and 7 TeV pp data sets.

The dimuon invariant mass spectra with the selection criteria applied are shown in Fig. 1 for the pp and PbPb data sets. Within the 7–14 GeV/\( c^2 \) mass range, there are 561 (628) oppositesign muon pairs in the pp (PbPb) data set. The three \( \Upsilon \) peaks are clearly observed in the pp case, but the \( \Upsilon(2S) \) and \( \Upsilon(3S) \) are barely visible over the residual background in PbPb collisions.

An extended unbinned maximum likelihood fit to the two invariant mass distributions of Fig. 1 is performed to extract the yields, following the method described in [14]. The measured mass lineshape of each \( \Upsilon \) state is parameterised by a “Crystal Ball” (CB) function, i.e. a Gaussian resolution function with the low-side tail replaced by a power law describing final state radiation (FSR). Since the three \( \Upsilon \) resonances partially overlap in the measured dimuon mass, they are fit simultaneously. Therefore, the probability distribution function (PDF) describing the signal consists of three CB functions. In addition to the three \( \Upsilon(nS) \) yields, the \( \Upsilon(1S) \) mass is the only parameter left free, to accommodate a possible bias in the momentum scale calibration. The mass differences between the states are fixed to their world average values [19] and the mass resolution is forced to scale with the resonance mass. The \( \Upsilon(1S) \) resolution is fixed to the value estimated in the simulation, 92 MeV/\( c^2 \), which is compatible with the resolution obtained from both the PbPb and pp data. The low-side tail parameters are also fixed to the values obtained via simulation. Finally, a second-order polynomial is chosen to describe the background in the 7–14 GeV/\( c^2 \) mass-fit range.

The quality of the unbinned fit is checked \textit{a posteriori} by comparing the obtained lineshapes to the binned data of Fig. 1. The \( \chi^2 \) probabilities are 74\% and 77\%, respectively for pp and PbPb.

The ratios of the observed yields of the \( \Upsilon(2S) \) and \( \Upsilon(3S) \) excited states to the \( \Upsilon(1S) \) ground state in the pp and PbPb data are:

\[
Y(2S + 3S)/\Upsilon(1S)|_{pp} = 0.78^{+0.16}_{-0.14} \pm 0.02, \quad \text{(1)}
\]

\[
Y(2S + 3S)/\Upsilon(1S)|_{PbPb} = 0.24^{+0.13}_{-0.12} \pm 0.02, \quad \text{(2)}
\]

where the first uncertainty is statistical and the second is systematic.

The systematic uncertainties are computed by varying the lineshape in the following ways: (1) the CB-tail parameters are varied randomly according to their covariance matrix and within conservative values covering imperfect knowledge of the amount of detector material and FSR in the underlying process; (2) the resolution is varied by \( \pm 5 \text{ MeV}/c^2 \), which is a conservative variation given the current understanding of the detector performance and reasonable changes that can be anticipated in the \( \Upsilon \)-resonance kinematics between pp and PbPb data; (3) the background shape is changed from quadratic to linear while the mass range of the fit is varied from 6–15 to 8–12 GeV/\( c^2 \); the observed root-mean-square of the results is taken as the systematic uncertainty. The quadrature sum of these three systematic uncertainties gives a relative uncertainty on the ratio of 10\% (3\%) on the PbPb (pp) data.

The ratio of the \( \Upsilon(2S + 3S)/\Upsilon(1S) \) ratios in PbPb and pp benefits from an almost complete cancellation of possible acceptance and/or efficiency differences among the reconstructed re-
Figure 1: Dimuon invariant-mass distributions from the pp (a) and PbPb (b) data at $\sqrt{s_{NN}} = 2.76$ TeV. The same reconstruction algorithm and analysis criteria are applied to both data sets, including a transverse momentum requirement on single muons of $p_T^\mu > 4$ GeV/c. The solid lines show the result of the fit described in the text.
sonances. A simultaneous fit to the pp and PbPb mass spectra gives the double ratio

$$\frac{Y(2S + 3S)/Y(1S)}{Y(2S + 3S)/Y(1S)}_{\text{PbPb}} = 0.31^{+0.19}_{-0.15} \text{ (stat.)} \pm 0.03 \text{ (syst.)}, \quad (3)$$

where the systematic uncertainty (9%) arises from varying the lineshape as described above in the simultaneous fit, thus taking into account partial cancellations of systematic effects.

The single muon lower momentum requirement is a posteriori varied from 3 to 5 GeV/$c$, and it is found that $p_T$ requirements other than 4 GeV/$c$ provide lower double ratios. Fitting the pp and PbPb spectra with free and independent mass resolution parameters leads to an increase of the double ratio by 15%.

To evaluate possible imperfect cancellations of acceptance and efficiency effects in the double ratio, a full GEANT4 [20] detector simulation is performed. The effect of the higher PbPb underlying event activity is considered by embedding, at the level of detector signals, Y(1S) and Y(2S) decays simulated by PYTHIA 6.424 [21] in PbPb events simulated with HYDJET [22]. Track characteristics, such as the number of hits and the $\chi^2$ of the track fit, have similar distributions in data and simulation. As mentioned above, the trigger efficiency is evaluated with data, by using single-muon-triggered data events, and reconstructing J/$\psi$ signal with and without the dimuon trigger requirement. The same exercise is carried out with the simulation and it agrees with the efficiency measured in data at the 2% level. The track efficiency in the silicon detector is measured with standalone muons, applying all selection criteria. The efficiencies in data and simulation agree within the 4% statistical uncertainty of the efficiency determined from data.

The difference in reconstruction and selection efficiencies between the Y states is less than 5% and the variation with charged particle multiplicity is less than 10% from pp to central PbPb collisions, producing a maximum change of 0.5% on the double ratio. The good agreement between single-muon trigger efficiencies extracted from data for the pp and PbPb trigger requirements, applied to the Y(1S) and Y(2S) trigger efficiencies derived from simulation, leads to a negligible effect on the double ratio. The single-muon trigger efficiencies extracted from data agree within 1.5% for the pp and PbPb trigger requirements, and the Y(1S) and Y(2S) trigger efficiencies agree within 3%, according to simulation: the potential trigger bias on the double ratio is negligible. The magnitudes of the statistical and systematic uncertainties on the double ratio, respectively 55% and 9%, are significantly larger than the systematic uncertainties associated with possible imperfect cancellation of acceptance and efficiency effects. Therefore no additional uncertainty from these sources is applied.

Finally, using an ensemble of one million pseudo-experiments, generated with the signal lineshape obtained from the pp data (Fig. 1a), the background lineshapes from both data sets, and a double ratio (Eq. 3) equal to unity within uncertainties, the probability of finding the measured value of 0.31 or below is estimated to be 0.9%. In other words, in the absence of a suppression due to physics mechanisms, the probability of a downward departure of the ratio from unity of this significance or greater is 0.9%, i.e. that corresponding to 2.4 sigma in a one-tailed integral of a Gaussian distribution.

Other studies from the CMS experiment show that the Y(1S) itself is suppressed by about 40% [23] in minimum bias PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. Since a large fraction of the Y(1S) yield arises from decays of heavier bottomonium states [6], this Y(1S) suppression could be indirectly caused by the suppression of the excited states reported in this Letter.

Production yields of quarkonium states can also be modified, from pp to PbPb collisions, in the absence of QGP formation, by cold nuclear matter effects [24]. However, such effects
should have a small impact on the $\Upsilon$ double ratio reported here. The nuclear modifications of the parton distribution functions (shadowing) should have an equivalent effect on the three $\Upsilon$ states, because their production involves very similar partons, cancelling in the ratio, at least to first order. The same should happen to any other initial-state nuclear effect. In principle, the larger and more loosely bound excited quarkonium states are more likely to be broken up by final-state interactions while traversing the nuclear matter, something extensively studied in the context of charmonium suppression at lower energies [25]. This “nuclear absorption” becomes weaker with increasing energy, and should be negligible at the LHC. At RHIC energies, the STAR experiment [26] has reported a $\Upsilon(1S + 2S + 3S)$ yield in dAu collisions of $0.78 \pm 0.28 \pm 0.20$ times the yield expected by scaling pp collisions, compatible with the absence of absorption. Furthermore, the double ratio presented here would only be sensitive to a difference between the nuclear dependencies of the three states and already at much lower energies the Fermilab E772 experiment observed [27], in proton-nucleus collisions, no such difference, within uncertainties, between the $\Upsilon(1S)$ and the sum $\Upsilon(2S + 3S)$.

Future high-statistics heavy-ion and proton-nucleus runs at the LHC will provide further quarkonia measurements, which should help disentangle nuclear from medium effects and aid the interpretation of the result reported in this Letter.

In summary, a comparison of the relative yields of $\Upsilon$ resonances has been performed in PbPb and pp collisions at the same centre-of-mass energy per nucleon pair of 2.76 TeV. The double ratio of the $\Upsilon(2S)$ and $\Upsilon(3S)$ excited states to the $\Upsilon(1S)$ ground state in PbPb and pp collisions, $[\Upsilon(2S + 3S)/\Upsilon(1S)]_{\text{PbPb}}/[\Upsilon(2S + 3S)/\Upsilon(1S)]_{\text{pp}}$, is found to be $0.31 ^{+0.19}_{-0.15} \text{ (stat.)} \pm 0.03 \text{ (syst.)}$, for muons of $p_T > 4 \text{ GeV/c}$ and $|\eta| < 2.4$. The probability to obtain the measured value, or lower, if the true double ratio is unity, has been calculated to be less than 1%.

Acknowledgments

We wish to 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: FMSR (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); Academy of Sciences and NICPB (Estonia); Academy of Finland, ME, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRT (Greece); OTKA an 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); PAEC (Pakistan); SCSR (Poland); FCT (Portugal); JINR (Armenia, Belarus, Georgia, Ukraine, Uzbekistan); MST and MAE (Russia); MSTD (Serbia); MICINN and CPAN (Spain); Swiss Funding Agencies (Switzerland); NSC (Taipei); TUBITAK and TAEK (Turkey); STFC (United Kingdom); DOE and NSF (USA). Individuals have received support from the Marie-Curie programme and the European Research Council (European Union); the Leventis Foundation; the A. P. Sloan Foundation; the Alexander von Humboldt Foundation; the Associazione per lo Sviluppo Scientifico e Tecnologico del Piemonte (Italy); the Belgian Federal Science Policy Office; the Fonds pour la Formation à la Recherche dans l’industrie et dans l’Agriculture (FRIA-Belgium); and the Agentschap voor Innovatie door Wetenschap en Technologie (IWT-Belgium).
References

[1] F. Karsch, “Lattice QCD at high temperature and density”, Lect. Notes Phys. 583 (2002) 209, [arXiv:hep-lat/0106019]

[2] T. Matsui and H. Satz, “J/ψ Suppression by Quark-Gluon Plasma Formation”, Phys. Lett. B178 (1986) 416, doi:10.1016/0370-2693(86)91404-8

[3] H. Satz, “Colour deconfinement and quarkonium binding”, J. Phys. G32 (2006) R25, [arXiv:hep-ph/0512217]

[4] C.-Y. Wong, “Heavy quarkonia in quark gluon plasma”, Phys. Rev. C72 (2005) 034906, [arXiv:hep-ph/0408020]

[5] C. Miao, A. Mocsy, and P. Petreczky, “Quarkonium spectral functions with complex potential”, Nucl. Phys. A855 (2011) 125, doi:10.1016/j.nuclphysa.2011.02.028

[6] CDF Collaboration, “Production of Y(1S) mesons from χb decays in p ¯p collisions at $\sqrt{s} = 1.8$ TeV”, Phys. Rev. Lett. 84 (2000) 2094, [arXiv:hep-ex/9910025]

[7] NA38 Collaboration, “$\psi$’ and J/ψ production in p W, p U and S U interactions at 200-GeV/nucleon”, Phys. Lett. B345 (1995) 617, doi:10.1016/0370-2693(94)01614-I

[8] NA50 Collaboration, “A new measurement of J/ψ suppression in Pb-Pb collisions at 158 GeV per nucleon”, Eur. Phys. J. C39 (2005) 335, [arXiv:hep-ex/0412036]

[9] NA50 Collaboration, “$\psi$’ production in Pb-Pb collisions at 158 GeV/nucleon”, Eur. Phys. J. C49 (2007) 559, [arXiv:nucl-ex/0612013]

[10] NA60 Collaboration, “J/ψ production in indium-indium collisions at 158-GeV/nucleon”, Phys. Rev. Lett. 99 (2007) 132302, doi:10.1103/PhysRevLett.99.132302

[11] PHENIX Collaboration, “J/ψ production vs centrality, transverse momentum, and rapidity in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV”, Phys. Rev. Lett. 98 (2007) 232201, [arXiv:nucl-ex/0611020]

[12] STAR Collaboration, “Upsilon cross section in p+p collisions at $\sqrt{s} = 200$ GeV”, Phys. Rev. D82 (2010) 012004, [arXiv:1001.2745]

[13] PHENIX Collaboration, “J/ψ Elliptic Flow, High $p_T$ Suppression and Upsilon Measurements in A+A Collisions by the PHENIX Experiment”, Nucl. Phys. A830 (2009) 331c, [arXiv:0907.4787]

[14] CMS Collaboration, “Upsilon production cross section in pp collisions at $\sqrt{s} = 7$ TeV”, (2011), [arXiv:1012.5545] Accepted for publication by Phys. Rev. D.

[15] CMS Collaboration, “The CMS experiment at the CERN LHC”, JINST 3 (2008) S08004, doi:10.1088/1748-0221/3/08/S08004
[16] CMS Collaboration, “Observation and studies of jet quenching using dijet momentum imbalance in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the CMS detector”, (2011). arXiv:1102.1957 Submitted to Phys. Rev. C.

[17] CMS Collaboration, “Track reconstruction in heavy ion events using the CMS tracker”, Nucl. Instrum. Meth. A566 (2006) 123. doi:10.1016/j.nima.2006.05.023

[18] CMS Collaboration, “CMS physics technical design report: Addendum on high density QCD with heavy ions”, J. Phys. G34 (2007) 2307. doi:10.1088/0954-3899/34/11/008

[19] Particle Data Group Collaboration, “Review of particle physics”, J. Phys. G37 (2010) 075021. doi:10.1088/0954-3899/37/7A/075021

[20] GEANT4 Collaboration, “GEANT4: A simulation toolkit”, Nucl. Instrum. Meth. A506 (2003) 250. doi:10.1016/S0168-9002(03)01368-8

[21] T. Sjöstrand, S. Mrenna, and P. Skands, “PYTHIA 6.4 physics and manual”, JHEP 05 (2006) 026. arXiv:hep-ph/0603175 doi:10.1088/1126-6708/2006/05/026

[22] I. P. Lokhtin and A. M. Snigirev, “A model of jet quenching in ultrarelativistic heavy ion collisions and high-p(T) hadron spectra at RHIC”, Eur. Phys. J. C45 (2006) 211–217. arXiv:hep-ph/0506189 doi:10.1140/epjc/s2005-02426-3

[23] CMS Collaboration, “Quarkonium production in PbPb collisions at $\sqrt{s_{NN}}=2.76$ TeV”, (2011). CMS-PAS-HIN-10-006. To be released.

[24] R. Vogt, “Cold Nuclear Matter Effects on J/psi and Upsilon Production at the LHC”, Phys. Rev. C81 (2010) 044903. arXiv:1003.3497 doi:10.1103/PhysRevC.81.044903

[25] C. Lourenco, R. Vogt, and H. K. Woehri, “Energy dependence of J/psi absorption in proton-nucleus collisions”, JHEP 02 (2009) 014. arXiv:0901.3054 doi:10.1088/1126-6708/2009/02/014

[26] STAR Collaboration, “Upsilon production in p + p, d + Au, Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV in STAR”, J. Phys. Conf. Ser. 270 (2011) 012026. doi:10.1088/1742-6596/270/1/012026

[27] D. M. Alde et al., “Nuclear dependence of the production of Upsilon resonances at 800-GeV”, Phys. Rev. Lett. 66 (1991) 2285. doi:10.1103/PhysRevLett.66.2285
A The CMS Collaboration

Yerevan Physics Institute, Yerevan, Armenia
S. Chatrchyan, V. Khachatryan, A.M. Sirunyan, A. Tumasyan

Institut für Hochenergiephysik der OeAW, Wien, Austria
W. Adam, T. Bergauer, M. Dragicevic, J. Erö, C. Fabjan, M. Friedl, R. Frühwirth, V.M. Ghete, J. Hammer³, S. Hänsel, M. Hoch, N. Hörmann, J. Hrubec, M. Jeitler, W. Kiesenhofer, M. Krammer, D. Liko, I. Mikulec, M. Pernicka, B. Rahbaran, H. Rohringer, R. Schöfbeck, J. Strauss, A. Taurok, F. Teischinger, P. Wagner, W. Waltenberger, G. Walzel, E. Widl, C.-E. Wulz

National Centre for Particle and High Energy Physics, Minsk, Belarus
V. Mossolov, N. Shumeiko, J. Suarez Gonzalez

Universiteit Antwerpen, Antwerpen, Belgium
S. Bansal, L. Benucci, E.A. De Wolf, X. Janssen, J. Maes, T. Maes, L. Mucibello, S. Ochesanu, B. Roland, R. Rougny, M. Selvaggi, H. Van Haevermaet, P. Van Mechelen, N. Van Remortel

Vrije Universiteit Brussel, Brussel, Belgium
F. Blekman, S. Blyweert, J. D’Hondt, O. Devroede, R. Gonzalez Suarez, A. Kalogерopoulos, M. Maes, W. Van Doninck, P. Van Mulders, G.P. Van Onsem, I. Villella

Université Libre de Bruxelles, Bruxelles, Belgium
O. Charaf, B. Clerbaux, G. De Lentdecker, V. Dero, A.P.R. Gay, G.H. Hammad, T. Hreus, P.E. Marage, L. Thomas, C. Vander Velde, P. Vanlaer

Ghent University, Ghent, Belgium
V. Adler, A. Cimmino, S. Costantini, M. Grunewald, B. Klein, J. Lellouch, A. Marinov, J. Mccartin, D. Ryckbosch, F. Thyssen, M. Tytgat, L. Vanelderen, P. Verwilligen, S. Walsh, N. Zaganidis

Université Catholique de Louvain, Louvain-la-Neuve, Belgium
S. Basegmez, G. Bruno, J. Caudron, L. Ceard, E. Cortina Gil, J. De Favereau De Jeneret, C. Delaere, D. Favart, A. Giammanco, G. Grégoire, J. Hollar, V. Lemaitre, J. Liao, O. Militaru, C. Nuttens, S. Ovyn, D. Pagano, A. Pin, K. Piotrzkowski, N. Schul

Université de Mons, Mons, Belgium
N. Beliy, T. Caebers, E. Daubie

Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil
G.A. Alves, L. Brito, D. De Jesus Damiao, M.E. Pol, M.H.G. Souza

Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil
W.L. Aldá Jnior, W. Carvalho, E.M. Da Costa, C. De Oliveira Martins, S. Fonseca De Souza, L. Mundim, H. Nogima, V. Oguri, W.L. Prado Da Silva, A. Santoro, S.M. Silva Do Amaral, A. Sznajder

Instituto de Física Teórica, Universidade Estadual Paulista, Sao Paulo, Brazil
C.A. Bernardes², F.A. Dias, T.R. Fernandez Perez Tomei, E. M. Gregores², C. Lagana, F. Marinho, P.G. Mercadante², S.F. Novaes, Sandra S. Padula

Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria
N. Darmenov¹, V. Genchev¹, P. Iaydjiev¹, S. Piperov, M. Rodozov, S. Stoykova, G. Sultanov, V. Tcholakov, R. Trayanov
University of Sofia, Sofia, Bulgaria
A. Dimitrov, R. Hadjiiska, A. Karadzhinova, V. Kozhuharov, L. Litov, M. Mateev, B. Pavlov, P. Petkov

Institute of High Energy Physics, Beijing, China
J.G. Bian, G.M. Chen, H.S. Chen, C.H. Jiang, D. Liang, S. Liang, X. Meng, J. Tao, J. Wang, J. Wang, X. Wang, Z. Wang, H. Xiao, M. Xu, J. Zang, Z. Zhang

State Key Lab. of Nucl. Phys. and Tech., Peking University, Beijing, China
Y. Ban, S. Guo, Y. Guo, W. Li, Y. Mao, S.J. Qian, H. Teng, B. Zhu, W. Zou

Universidad de Los Andes, Bogota, Colombia
A. Cabrera, B. Gomez Moreno, A.A. Ocampo Rios, A.F. Osorio Oliveros, J.C. Sanabria

Technical University of Split, Split, Croatia
N. Godinovic, D. Lelas, K. Lelas, R. Plestina³, D. Polic, I. Puljak

University of Split, Split, Croatia
Z. Antunovic, M. Dzelalija

Institute Rudjer Boskovic, Zagreb, Croatia
V. Brigljevic, S. Duric, K. Kadija, S. Morovic

University of Cyprus, Nicosia, Cyprus
A. Attikis, M. Galanti, J. Mousa, C. Nicolaou, F. Ptochos, P.A. Razis

Charles University, Prague, Czech Republic
M. Finger, M. Finger Jr.

Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt
Y. Assran⁴, A. Ellithi Kamel, S. Khalil⁵, M.A. Mahmoud⁶

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia
A. Hektor, M. Kadastik, M. Müntel, M. Raidal, L. Rebane, A. Tiko

Department of Physics, University of Helsinki, Helsinki, Finland
V. Azzolini, P. Eerola, G. Fedi

Helsinki Institute of Physics, Helsinki, Finland
S. Czellar, J. Härkönen, A. Heikkinen, V. Karimäki, R. Kinnunen, M.J. Kortelainen, T. Lampén, K. Lassila-Perini, S. Lehti, T. Lindén, P. Luukka, T. Mäenpää, E. Tuominen, J. Tuominen, E. Tuovinen, D. Ungaro, L. Wendland

Lappeenranta University of Technology, Lappeenranta, Finland
K. Banzuzi, A. Karjalainen, A. Korpela, T. Tuuva

Laboratoire d’Annecy-le-Vieux de Physique des Particules, IN2P3-CNRS, Annecy-le-Vieux, France
D. Sillou

DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France
M. Besancon, S. Choudhury, M. Dejardin, D. Denegri, B. Fabbro, J.L. Faure, F. Ferri, S. Ganjour, F.X. Gentit, A. Givernaud, P. Gras, G. Hamel de Monchenault, P. Jarry, E. Locci, J. Malcles, M. Marionneau, L. Millischer, J. Rander, A. Rosowsky, I. Shreyber, M. Titov, P. Verrecchia
Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France
S. Baffioni, F. Beaudette, L. Benhabib, L. Bianchini, M. Bluji, C. Broutin, P. Busson, C. Charlot, T. Dahms, L. Dobrzynski, S. Elgammal, R. Granier de Cassagnac, M. Haguenauer, P. Miné, C. Mironov, C. Ochando, P. Paganini, D. Sabes, R. Salerno, Y. Sirois, C. Thiebaux, B. Wyslouch, A. Zabi

Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS-IN2P3, Strasbourg, France
J.-L. Agram, J. Andrea, D. Bloch, D. Bodin, J.-M. Brom, M. Cardaci, E.C. Chabert, C. Collard, E. Conte, F. Drouhin, C. Ferro, J.-C. Fontaine, D. Gelé, U. Goerlach, S. Greder, P. Juillot, M. Karim, A.-C. Le Bihan, Y. Mikami, P. Van Hove

Centre de Calcul de l’Institut National de Physique Nucleaire et de Physique des Particules (IN2P3), Villeurbanne, France
F. Fassi, D. Mercier

Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France
C. Baty, S. Beauceron, N. Beaupere, M. Bedjidian, O. Bondu, G. Boudoul, D. Boumediene, H. Brun, J. Chasserat, R. Chierici, D. Contardo, P. Depasse, H. El Mamouni, J. Fay, S. Gascon, B. Ille, T. Kurca, T. Le Grand, M. Lethuillier, L. Mirabito, S. Perries, V. Sordini, S. Tosi, Y. Tschudi, P. Verdier

Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, Georgia
D. Lomidze

RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany
G. Anagnostou, S. Beranek, M. Edelhoff, L. Feld, N. Heracleous, O. Hindrichs, R. Jussen, K. Klein, J. Merz, N. Mohr, A. Ostapchuk, A. Perieanu, F. Raupach, J. Sammet, S. Schael, D. Sprenger, H. Weber, M. Weber, B. Wittmer

RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany
M. Ata, E. Dietz-Laursonn, M. Erdmann, T. Hebbeker, C. Heidemann, A. Hinzmann, K. Hoepfner, T. Klimkovich, D. Klingebiel, P. Kreuzer, D. Lams, J. Lingemann, C. Magass, M. Merschmeyer, A. Meyer, P. Papacz, H. Pieta, H. Reithler, S.A. Schmitz, L. Sonnenschein, J. Steggemann, D. Teyssier

RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany
M. Bontenackels, M. Davids, M. Duda, G. Flügge, H. Geenen, M. Giffels, W. Haj Ahmad, D. Heydhausen, F. Hoeble, B. Kargoll, T. Kress, Y. Kuessel, A. Linn, A. Nowack, L. Perchalla, O. Pooth, J. Rennefeld, M. Sauerland, A. Stahl, M. Thomas, D. Tornier, M.H. Zoeller

Deutsches Elektronen-Synchrotron, Hamburg, Germany
M. Aldaya Martin, W. Behrenhoff, U. Behrens, M. Bergholz, A. Bethani, K. Borras, A. Cakir, A. Campbell, E. Castro, D. Dammann, G. Eckerlin, D. Eckstein, A. Flossdorf, G. Flucke, A. Geiser, J. Hauk, H. Jung, M. Kasemann, I. Katkov, P. Katsas, C. Kleinwort, H. Kluge, A. Knutsson, M. Krämer, D. Krücker, E. Kuznetsova, W. Lange, W. Lohmann, R. Mankel, M. Marienfeld, I.-A. Melzer-Pellmann, A.B. Meyer, J. Mnich, A. Mussgiller, J. Olzem, A. Petruchkin, D. Pitzl, A. Raspereza, A. Raval, M. Rosin, R. Schmidt, T. Schoerner-Sadenius, N. Sen, A. Spiridonov, M. Stein, J. Tomaszewska, R. Walsh, C. Wissing

University of Hamburg, Hamburg, Germany
C. Autermann, V. Blobel, S. Bobrovskyi, J. Draeger, H. Enderle, U. Gebbert, M. Görner,
T. Hermanns, K. Kaschube, G. Kaussen, H. Kirschenmann, R. Klanner, J. Lange, B. Mura, S. Naumann-Emme, F. Nowak, N. Pietsch, C. Sander, H. Schettler, P. Schleper, E. Schlieckau, M. Schröder, T. Schum, H. Stadie, G. Steinbrück, J. Thomsen

Institut für Experimentelle Kernphysik, Karlsruhe, Germany
C. Barth, J. Bauer, J. Berger, V. Buege, T. Chwalek, W. De Boer, A. Dierlamm, G. Dirkes, M. Feindt, J. Gruschke, C. Hackstein, F. Hartmann, M. Heinrich, H. Held, K.H. Hoffmann, S. Honc, J.R. Komaragiri, T. Kuhr, D. Martschei, S. Mueller, Th. Müller, M. Niegel, O. Oberst, A. Oehler, J. Ott, T. Peiffer, G. Quast, K. Rabbertz, F. Ratnikov, N. Ratrikova, M. Renz, C. Saout, A. Scheurer, P. Schieferdecker, F.-P. Schilling, G. Schott, H.J. Simonis, F.M. Stober, D. Troendle, J. Wagner-Kuhr, T. Weiler, M. Zeise, V. Zhukov11, E.B. Ziebarth

Institute of Nuclear Physics "Demokritos", Aghia Paraskevi, Greece
G. Daskalakis, T. Geralis, S. Kesisoglou, A. Kyriakis, D. Loukas, I. Manolakos, A. Markou, C. Markou, C. Mavrommatis, E. Ntomari, E. Petrakou

University of Athens, Athens, Greece
L. Gouskos, T.J. Mertzimekis, A. Panagiotou, E. Stiliaris

University of Ioannina, Ioannina, Greece
I. Evangelou, C. Foudas, P. Kokkas, N. Manthos, I. Papadopoulos, V. Patras, F.A. Triantis

KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary
A. Aranyi, G. Bencze, L. Boldizsar, C. Hajdu1, P. Hidas, D. Horvath12, A. Kapusi, K. Krajczar13, F. Sikler1, G.I. Veres13, G. Vesztergombi13

Institute of Nuclear Research ATOMKI, Debrecen, Hungary
N. Beni, J. Molnar, J. Palinkas, Z. Szillasi, V. Veszpremi

University of Debrecen, Debrecen, Hungary
P. Raics, Z.L. Trocsanyi, B. Ujvari

Panjab University, Chandigarh, India
S.B. Beri, V. Bhatnagar, N. Dhirra, R. Gupta, M. Jindal, M. Kaur, J.M. Kohli, M.Z. Mehta, N. Nishu, L.K. Saini, A. Sharma, A.P. Singh, J. Singh, S.P. Singh

University of Delhi, Delhi, India
S. Ahuja, B.C. Choudhary, P. Gupta, S. Jain, A. Kumar, A. Kumar, M. Naimuddin, K. Ranjan, R.K. Shivpuri

Saha Institute of Nuclear Physics, Kolkata, India
S. Banerjee, S. Bhattacharya, S. Dutta, B. Gomber, S. Jain, R. Khurana, S. Sarkar

Bhabha Atomic Research Centre, Mumbai, India
R.K. Choudhury, D. Dutta, S. Kailas, V. Kumar, P. Mehta, A.K. Mohanty1, L.M. Pant, P. Shukla

Tata Institute of Fundamental Research - EHEP, Mumbai, India
T. Aziz, M. Guchait14, A. Gurtu, M. Maity15, D. Majumder, G. Majumder, K. Mazumdar, G.B. Mohanty, A. Saha, K. Sudhakar, N. Wickramage

Tata Institute of Fundamental Research - HECR, Mumbai, India
S. Banerjee, S. Dugad, N.K. Mondal

Institute for Research and Fundamental Sciences (IPM), Tehran, Iran
H. Arfaei, H. Bakhshiansohi16, S.M. Etesami, A. Fahim16, M. Hashemi, H. Hesari, A. Jafari16,
INFN Sezione di Pisa\textsuperscript{a}, Università di Pisa\textsuperscript{b}, Scuola Normale Superiore di Pisa\textsuperscript{c}, Pisa, Italy
P. Azzurri\textsuperscript{a, c}, G. Bagliesi\textsuperscript{a}, J. Bernardini\textsuperscript{a, b}, T. Boccali\textsuperscript{a, 1}, G. Broccolo\textsuperscript{a, c}, R. Castaldi\textsuperscript{a}, R.T. D’Agnolo\textsuperscript{a, c}, R. Dell’Orso\textsuperscript{a}, F. Fiori\textsuperscript{a, b}, L. Foà\textsuperscript{a, c}, A. Giassi\textsuperscript{a}, A. Kraan\textsuperscript{a}, F. Ligabue\textsuperscript{a, c}, T. Lomtadze\textsuperscript{a}, L. Martin\textsuperscript{a, 22}, A. Messineo\textsuperscript{a, b}, F. Palla\textsuperscript{a}, G. Segneri\textsuperscript{a}, A.T. Serban\textsuperscript{a}, P. Spagnolo\textsuperscript{a}, R. Tenchini\textsuperscript{a}, G. Tonelli\textsuperscript{a, b}, A. Venturi\textsuperscript{a, 1}, P. G. Verdini\textsuperscript{a}

INFN Sezione di Roma\textsuperscript{a}, Università di Roma “La Sapienza”\textsuperscript{b}, Roma, Italy
L. Barone\textsuperscript{a, b}, F. Cavallari\textsuperscript{a}, D. Del Re\textsuperscript{a, b}, E. Di Marco\textsuperscript{a, b}, M. Diemoz\textsuperscript{a}, D. Franci\textsuperscript{a, b}, M. Grassi\textsuperscript{a, 1}, E. Longo\textsuperscript{a, b}, P. Meridiani, S. Nourbakhsh\textsuperscript{a}, G. Organtini\textsuperscript{a, b}, F. Pandolfi\textsuperscript{a, b, 1}, R. Paramatti\textsuperscript{a}, S. Rahatlou\textsuperscript{a, b}, C. Rovelli\textsuperscript{1}

INFN Sezione di Torino\textsuperscript{a}, Università di Torino\textsuperscript{b}, Università del Piemonte Orientale (Novara)\textsuperscript{c}, Torino, Italy
N. Amapane\textsuperscript{a, b}, R. Arcidiacono\textsuperscript{a, c}, S. Argiro\textsuperscript{a, b}, M. Armeodo\textsuperscript{a, c}, C. Biino\textsuperscript{a}, C. Bott\textsuperscript{a, b, 1}, N. Cartiglia\textsuperscript{a}, R. Castello\textsuperscript{a, b}, M. Costa\textsuperscript{a, b}, N. Demaria\textsuperscript{a}, A. Graziano\textsuperscript{a, b, 1}, C. Mariotti\textsuperscript{a}, M. Marone\textsuperscript{a, b}, S. Maselli\textsuperscript{a}, E. Migliore\textsuperscript{a, b}, G. Mila\textsuperscript{a, b}, V. Monaco\textsuperscript{a, b}, M. Musich\textsuperscript{a, b}, M.M. Obertino\textsuperscript{a, c}, N. Pastrone\textsuperscript{a}, M. Pelliccioni\textsuperscript{a, b}, A. Potenza\textsuperscript{a, b}, A. Romero\textsuperscript{a, b}, M. Ruspa\textsuperscript{a, c}, R. Sacchi\textsuperscript{a, b}, V. Sola\textsuperscript{a, b}, A. Solano\textsuperscript{a, b}, A. Staiano\textsuperscript{a}, A. Vilela Pereira\textsuperscript{a}

INFN Sezione di Trieste\textsuperscript{a}, Università di Trieste\textsuperscript{b}, Trieste, Italy
S. Belforte\textsuperscript{a}, F. Cossutti\textsuperscript{a}, G. Della Ricca\textsuperscript{a, b}, B. Gobbo\textsuperscript{a}, D. Montanino\textsuperscript{a, b}, A. Penzo\textsuperscript{a}

Kangwon National University, Chunchon, Korea
S.G. Heo, S.K. Nam

Kyungpook National University, Daegu, Korea
S. Chang, J. Chung, D.H. Kim, G.N. Kim, J.E. Kim, D.J. Kong, H. Park, S.R. Ro, D.C. Son, T. Son

Chonnam National University, Institute for Unive rs and Elementary Particles, Kwangju, Korea
Zero Kim, J.Y. Kim, S. Song

Korea University, Seoul, Korea
S. Choi, B. Hong, M. Jo, H. Kim, J.H. Kim, T.J. Kim, K.S. Lee, D.H. Moon, S.K. Park, K.S. Sim

University of Seoul, Seoul, Korea
M. Choi, S. Kang, H. Kim, C. Park, I.C. Park, S. Park, G. Ryu

Sungkyunkwan University, Suwon, Korea
Y. Choi, Y.K. Choi, J. Goh, M.S. Kim, J. Lee, S. Lee, H. Seo, I. Yu

Vilnius University, Vilnius, Lithuania
M.J. Bilinskas, I. Grigelionis, M. Janulis, D. Martisiute, P. Petrov, T. Sabonis

Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico
H. Castilla-Valdez, E. De La Cruz-Burelo, I. Heredia-de La Cruz, R. Lopez-Fernandez, R. Magaña Villalba, A. Sánchez-Hernández, L.M. Villasenor-Cendejas

Universidad Iberoamericana, Mexico City, Mexico
S. Carrillo Moreno, F. Vazquez Valencia

Benemerita Universidad Autonoma de Puebla, Puebla, Mexico
H.A. Salazar Ibarguen

Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico
E. Casimiro Linares, A. Morelos Pineda, M.A. Reyes-Santos
University of Auckland, Auckland, New Zealand
D. Krofcheck, J. Tam

University of Canterbury, Christchurch, New Zealand
P.H. Butler, R. Doesburg, H. Silverwood

National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan
M. Ahmad, I. Ahmed, M.I. Asghar, H.R. Hooran, W.A. Khan, T. Khurshid, S. Qazi

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland
G. Brona, M. Cwiok, W. Dominik, K. Doroba, A. Kalinowski, M. Konecki, J. Krolikowski

Soltan Institute for Nuclear Studies, Warsaw, Poland
T. Frueboes, R. Gokieli, M. Górski, M. Kazana, K. Nawrocki, K. Romanowska-Rybinska, M. Szleper, G. Wrochna, P. Zalewski

Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal
N. Almeida, P. Bargassa, A. David, P. Faccioli, P.G. Ferreira Parracho, M. Gallinaro, P. Musella, A. Nayak, J. Pela, P.Q. Ribeiro, J. Seixas, J. Varela

Joint Institute for Nuclear Research, Dubna, Russia
S. Afanasiev, I. Belotelov, P. Bunin, I. Golutvin, A. Kamenev, V. Karjavin, G. Kozlov, A. Lanev, P. Moisenz, V. Palichik, V. Perelygin, S. Shmatov, V. Smirnov, A. Volodko, A. Zarubin

Petersburg Nuclear Physics Institute, Gatchina (St Petersburg), Russia
V. Golovtsov, Y. Ivanov, V. Kim, P. Levchenko, V. Murzin, V. Oreshkin, I. Smirnov, V. Sulimov, L. Uvarov, S. Vavilov, A. Vorobyev, An. Vorobyev

Institute for Nuclear Research, Moscow, Russia
Yu. Andreev, A. Dermenev, S. Gninenko, N. Golubev, M. Kirsanov, N. Krasnikov, V. Matveev, A. Pashenkov, A. Toropin, S. Troitsky

Institute for Theoretical and Experimental Physics, Moscow, Russia
V. Epshteyn, V. Gavrilov, V. Kaftanov, M. Kossov, A. Krokhotin, N. Lychkovskaya, V. Popov, G. Safronov, S. Semenov, V. Stolin, E. Vlasov, A. Zhokin

Moscow State University, Moscow, Russia
E. Boos, A. Ershov, A. Gribushin, O. Kodolova, V. Korotkikh, I. Lokhtin, A. Markina, S. Obraztsov, M. Perfilov, S. Petrushanko, L. Sarycheva, V. Savrinn, A. Snigirev, I. Vardanyan

P.N. Lebedev Physical Institute, Moscow, Russia
V. Andreev, M. Azarkin, I. Dremin, M. Kirakosyan, A. Leonidov, S.V. Rusakov, A. Vinogradov

State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia
I. Azhgirey, I. Bayshev, S. Bitioukov, V. Grishin, V. Kachanov, D. Konstantinov, A. Korablev, V. Krychkine, V. Petrov, R. Ryutin, A. Sobol, L. Tourchanovitch, S. Troshin, N. Tyurin, A. Uznian, A. Volkov

University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia
P. Adzic, M. Djordjevic, D. Krpic, J. Milosevic

Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain
M. Aguilar-Benitez, J. Alcaraz Maestre, P. Arce, C. Battilana, E. Calvo, M. Cepeda, M. Cerrada,
M. Chamizo Llatas, N. Colino, B. De La Cruz, A. Delgado Peris, C. Diez Pardos, D. Domínguez Vázquez, C. Fernandez Bedoya, J.P. Fernández Ramos, A. Ferrando, J. Flix, M.C. Fouz, P. Garcia-Abia, O. Gonzalez Lopez, S. Goy Lopez, J.M. Hernandez, M.I. Josa, G. Merino, J. Puerta Pelayo, I. Redondo, L. Romero, J. Santaolalla, M.S. Soares, C. Willmott

Universidad Autónoma de Madrid, Madrid, Spain
C. Albajar, G. Codispoti, J.F. de Trocóniz

Universidad de Oviedo, Oviedo, Spain
J. Cuevas, J. Fernandez Menendez, S. Folgueras, I. Gonzalez Caballero, L. Lloret Iglesias, J.M. Vizan Garcia

Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain
J.A. Brochero Cifuentes, I.J. Cabrillo, A. Calderon, S.H. Chuang, J. Duarte Campderros, M. Felcini, M. Fernandez, G. Gomez, J. Gonzalez Sanchez, C. Jorda, P. Lobelle Pardo, A. Lopez Virto, J. Marco, R. Marco, C. Martinez Rivero, F. Matorras, F.J. Munoz Sanchez, J. Piedra Gomez, T. Rodrigo, A.Y. Rodriguez-Marrero, A. Ruiz-Jimeno, L. Scodellaro, M. Sobron Sanudo, I. Vila, R. Vilar Cortabitarte

CERN, European Organization for Nuclear Research, Geneva, Switzerland
D. Abbaneo, E. Auffray, G. Auzinger, P. Baillon, A.H. Ball, D. Barney, A.J. Bell, D. Benedetti, C. Bernet, W. Bialas, P. Bloch, A. Bocci, S. Bolognesi, M. Bona, H. Breuker, K. Bunkowski, T. Camporesi, A. Cerminara, J.A. Coarasa Perez, B. Curé, D. D’Enterria, A. De Roeck, S. Di Guida, N. Dupont-Sagorin, A. Elliott-Peisert, B. Frisch, W. Funk, A. Gaddi, G. Georgiou, H. Gerwig, D. Gigi, K. Gill, D. Giordano, F. Glege, R. Gomez-Reino Garrido, M. Gouzevitch, P. Govoni, S. Gowdy, L. Guiducci, M. Hansen, C. Hartl, J. Harvey, J. Hegeman, B. Hegner, H.F. Hoffmann, A. Honma, V. Innocente, P. Janot, K. Kaadze, E. Karavakis, P. Lecoq, C. Lourenço, T. Mäki, M. Malberti, L. Malgeri, M. Mannelli, L. Masetti, A. Maurisset, F. Meijers, S. Mersi, E. Meschi, R. Moser, M.U. Mozer, M. Mulders, E. Nesvold, M. Nguyen, T. Orimoto, L. Orsini, E. Palencia Cortezon, E. Perez, A. Petrilli, A. Pfeiffer, M. Pierini, M. Pimiä, D. Piparo, G. Polese, A. Racz, W. Reece, J. Rodrigues Antunes, G. Roland, T. Rommerskirchen, M. Rovere, H. Sakulin, C. Schäfer, C. Schwick, I. Segoni, A. Sharma, P. Siegrist, M. Simon, P. Spieculopoulou, M. Stoye, P. Tropea, A. Tsirou, P. Vichoudis, M. Voutilainen, W.D. Zeuner

Paul Scherrer Institut, Villigen, Switzerland
W. Bertl, K. Deiters, W. Erdmann, K. Gabathuler, R. Horisberger, Q. Ingram, H.C. Kaestli, S. König, D. Kotlinski, U. Langenegger, F. Meier, D. Renker, T. Rohe, J. Sibille, A. Starodumov

Institute for Particle Physics, ETH Zurich, Zurich, Switzerland
L. Bäni, P. Bortignon, L. Caminada, B. Casal, N. Chanon, Z. Chen, S. Cittolin, G. Dissertori, M. Dittmar, J. Eugster, K. Freudenberg, C. Grab, W. Hintz, P. Lecomte, W. Lustermann, C. Marchica, P. Martinez Ruiz del Arbol, P. Milenovic, F. Moortgat, C. Nägeli, P. Nef, F. Nessi-Tedaldi, L. Pape, F. Pauss, T. Punz, A. Rizzi, F.J. Ronga, M. Rossini, L. Sala, A.K. Sanchez, M.-C. Sawley, B. Stieger, L. Tauscher, A. Thea, K. Theofilatos, D. Treille, C. Urscheler, R. Wallny, M. Weber, L. Wehrli, J. Weng

Universität Zürich, Zurich, Switzerland
E. Aguilo, C. Amsler, V. Chiochia, S. De Visscher, C. Favaro, M. Ivova Rikova, B. Millan Mejias, P. Otiougova, P. Robmann, A. Schmidt, H. Snoek
National Central University, Chung-Li, Taiwan
Y.H. Chang, K.H. Chen, C.M. Kuo, S.W. Li, W. Lin, Z.K. Liu, Y.J. Lu, D. Mekterovic, R. Volpe, J.H. Wu, S.S. Yu

National Taiwan University (NTU), Taipei, Taiwan
P. Bartalini, P. Chang, Y.H. Chang, Y.W. Chang, Y. Chao, K.F. Chen, W.-S. Hou, Y. Hsiung, K.Y. Kao, Y.J. Lei, R.-S. Lu, J.G. Shiu, Y.M. Tzeng, M. Wang

Cukurova University, Adana, Turkey
A. Adiguzel, M.N. Bakirci34, S. Cerci35, C. Dozen, I. Dumanoglu, E. Eskut, S. Girgis, G. Gokbulut, I. Hos, E.E. Kangal, A. Kayis Topaku36, G. Onengut, K. Ozdemir, S. Ozturk36, A. Polatoz, K. Sogut37, D. Sunar Cerci35, B. Tali35, H. Topakli34, D. Uzun, L.N. Vergili, M. Vergili

Middle East Technical University, Physics Department, Ankara, Turkey
I.V. Akin, T. Aliev, B. Bilin, S. Bilmis, M. Deniz, H. Gamsizkan, A.M. Guler, K. Ocalan, A. Ozpineci, M. Serin, R. Sever, U.E. Surat, E. Yildirim, M. Zeyrek

Bogazici University, Istanbul, Turkey
M. Deliomeroglu, D. Demir38, E. Gülmez, B. Isildak, M. Kaya39, O. Kaya39, M. Özbek, S. Ozkorucuklu80, N. Sonmez41

National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine
L. Levchuk

University of Bristol, Bristol, United Kingdom
F. Bostock, J.J. Brooke, T.L. Cheng, E. Clement, D. Cussans, R. Frazier, J. Goldstein, M. Grimes, D. Hartley, G.P. Heath, H.F. Heath, L. Kreczko, S. Metson, D.M. Newbold42, K. Nirunpong, A. Poll, S. Senkin, V.J. Smith

Rutherford Appleton Laboratory, Didcot, United Kingdom
L. Basso43, A. Belyaev43, C. Brew, R.M. Brown, B. Camanzi, D.J.A. Cockerill, J.A. Coughlan, K. Harder, S. Harper, J. Jackson, B.W. Kennedy, E. Olaiva, D. Petyt, B.C. Radburn-Smith, C.H. Shepherd-Themistocleous, I.R. Tomalin, W.J. Womersley, S.D. Worm

Imperial College, London, United Kingdom
R. Bainbridge, G. Ball, J. Ballin, R. Beuselinck, O. Buchmuller, D. Colling, N. Cripps, M. Cutajar, G. Davies, M. Della Negra, W. Ferguson, J. Fulcher, D. Futyan, A. Gilbert, A. Guneratne Bryer, G. Hall, Z. Hatherell, J. Hays, G. Iles, M. Jarvis, G. Karapostoli, L. Lyons, B.C. MacEvoy, A.-M. Magnan, J. Marrouche, B. Mathias, R. Nandi, J. Nash, A. Nikitenko31, A. Papageorgiou, M. Pesaresi, K. Petridis, M. Pioppi44, D.M. Raymond, S. Rogerson, N. Rompotis, A. Rose, M.J. Ryan, C. Seez, P. Sharp, A. Sparrow, A. Tapper, S. Tourneur, M. Vazquez Acosta, T. Virdee, S. Wakefield, N. Wardle, D. Wardrope, T. Whyntie

Brunel University, Uxbridge, United Kingdom
M. Barrett, M. Chadwick, J.E. Cole, P.R. Hobson, A. Khan, P. Kyberd, D. Leslie, W. Martin, I.D. Reid, L. Teodorescu

Baylor University, Waco, USA
K. Hatakeyama, H. Liu

The University of Alabama, Tuscaloosa, USA
C. Henderson
Boston University, Boston, USA
T. Bose, E. Carrera Jarrin, C. Fantasia, A. Heister, J. St. John, P. Lawson, D. Lazic, J. Rohlf, D. Sperka, L. Sulak

Brown University, Providence, USA
A. Avetisyan, S. Bhattacharya, J.P. Chou, D. Cutts, A. Ferapontov, U. Heintz, S. Jabeen, G. Kukartsev, G. Landsberg, M. Luk, M. Narain, D. Nguyen, M. Segala, T. Sinthuprasith, T. Speer, K.V. Tsang

University of California, Davis, Davis, USA
R. Breedon, G. Breto, M. Calderon De La Barca Sanchez, S. Chauhan, M. Chertok, J. Conway, P.T. Cox, J. Dolen, R. Erbacher, E. Friis, W. Ko, A. Kopecky, R. Lander, H. Liu, S. Maruyama, T. Miceli, M. Nikolic, D. Pellett, J. Robles, S. Salur, T. Schwarz, M. Searle, J. Smith, M. Squires, M. Tripathi, R. Vasquez Sierra, C. Veelken

University of California, Los Angeles, Los Angeles, USA
V. Andreev, K. Arisaka, D. Cline, R. Cousins, A. Deisher, J. Duris, S. Erhan, C. Farrell, J. Hauser, M. Ignatenko, C. Jarvis, C. Plager, G. Rakness, P. Schlein†, J. Tucker, V. Valuev

University of California, Riverside, Riverside, USA
J. Babb, A. Chandra, R. Clare, J. Ellison, J.W. Gary, G. Giordano, G. Hanson, G.Y. Jeng, S.C. Kao, F. Liu, H. Liu, O.R. Long, A. Luthra, H. Nguyen, B.C. Shen†, R. Stringer, J. Sturdy, S. Sumowidagdo, R. Wilken, S. Wimpenny

University of California, San Diego, La Jolla, USA
W. Andrews, J.G. Branson, G.B. Cerati, D. Evans, F. Golf, A. Holzner, R. Kelley, M. Lebourgeois, J. Letts, B. Mangano, S. Padhi, C. Palmer, G. Petrucciani, H. Pi, M. Pieri, R. Ranieri, M. Sani, V. Sharma, S. Simon, E. Sudano, M. Tadel, Y. Tu, A. Vartak, S. Wasserbaech†, F. Würthwein, A. Yagil, J. Yoo

University of California, Santa Barbara, Santa Barbara, USA
D. Barge, R. Bellan, C. Campagnari, M. D’Alfonso, T. Danielson, K. Flowers, P. Geffert, J. Incandela, C. Justus, P. Kalavase, S.A. Koay, D. Kovalskyi, V. Krutelyov, S. Lowette, N. Mccoll, V. Pavlunin, F. Rebassoo, J. Ribnik, J. Richman, R. Rossin, D. Stuart, W. To, J.R. Vlimant

California Institute of Technology, Pasadena, USA
A. Apresyan, A. Bornheim, J. Bunn, Y. Chen, M. Gataullin, Y. Ma, A. Mott, H.B. Newman, C. Rogan, K. Shin, V. Timciuc, P. Traczyk, J. Veverka, R. Wilkinson, Y. Yang, R.Y. Zhu

Carnegie Mellon University, Pittsburgh, USA
B. Akgun, R. Carroll, T. Ferguson, Y. Iiyama, D.W. Jang, S.Y. Jun, Y.F. Liu, M. Paulini, J. Russ, H. Vogel, I. Vorobiev

University of Colorado at Boulder, Boulder, USA
J.P. Cumalat, M.E. Dinardo, B.R. Drell, C.J. Edelmaier, W.T. Ford, A. Gaz, B. Heyburn, E. Luiggi Lopez, U. Nauenberg, J.G. Smith, K. Stenson, K.A. Ulmer, S.R. Wagner, S.L. Zang

Cornell University, Ithaca, USA
L. Agostino, J. Alexander, D. Cassel, A. Chatterjee, N. Eggert, L.K. Gibbons, B. Heltsley, K. Henriksson, W. Hopkins, A. Khukhunaishvili, B. Kreis, G. Nicolas Kaufman, J.R. Patterson, D. Puigh, A. Ryd, M. Saelim, E. Salvati, X. Shi, W. Sun, W.D. Teo, J. Thom, J. Thompson, J. Vaughan, Y. Weng, L. Winstrom, P. Wittich

Fairfield University, Fairfield, USA
A. Biselli, G. Cirino, D. Winn
Fermi National Accelerator Laboratory, Batavia, USA
S. Abdullin, M. Albrow, J. Anderson, G. Apollinari, M. Atac, J.A. Bakken, L.A.T. Bauer, A. Beretvas, J. Berryhill, P.C. Bhat, I. Bloch, F. Borchardt, K. Burkett, J.N. Butler, V. Chetluru, H.W.K. Cheung, F. Chlebana, S. Cihangir, W. Cooper, D.P. Eartly, V.D. Elvira, S. Esen, I. Fisk, J. Freeman, Y. Gao, E. Gottschalk, D. Green, K. Gunthoti, O. Gutsche, J. Hanlon, R.M. Harris, J. Hirschauer, B. Booherman, H. Jensen, M. Johnson, U. Joshi, R. Khatiwada, B. Klima, K. Kousouris, S. Kunori, S. Kwan, C. Leonidopoulos, P. Limon, D. Lincoln, R. Lipton, J. Lykken, K. Maeshima, J.M. Marraffino, D. Mason, P. McBride, T. Miao, K. Mishra, S. Mrenna, Y. Musienko, C. Newman-Holmes, V. O’Dell, R. Pordes, O. Prokofyev, N. Saoulidou, E. Sexton-Kennedy, S. Sharma, W.J. Spalding, L. Spiegel, P. Tan, L. Taylor, S. Tkaczyk, L. Uplegger, E.W. Vaandering, R. Vidal, J. Whitmore, W. Wu, F. Yang, F. Yumiceva, J.C. Yun

University of Florida, Gainesville, USA
D. Acosta, P. Avery, D. Bourilkov, M. Chen, S. Das, M. De Gruttola, G.P. Di Giovanni, D. Dobur, A. Drozdetskiy, R.D. Field, M. Fisher, Y. Fu, I.K. Furic, J. Gartner, J. Hugon, B. Kim, J. Konigsberg, A. Korytov, A. Kropivnitskaya, T. Kypreos, J.F. Low, K. Matchev, G. Mitselmakher, L. Muniz, C. Prescott, R. Remington, A. Rinkevicius, M. Schmitt, B. Scurlock, P. Sellers, N. Shirkhadel, M. Snowball, D. Wang, J. Yelton, M. Zakaria

Florida International University, Miami, USA
V. Gauld, L.M. Lebolo, S. Linn, P. Markowitz, G. Martinez, J.L. Rodriguez

Florida State University, Tallahassee, USA
T. Adams, A. Askew, J. Bochenek, J. Chen, B. Diamond, S.V. Gleyzer, J. Haas, S. Hagopian, V. Hagopian, M. Jenkins, K.F. Johnson, H. Prosper, L. Quertenmont, S. Sekmen, V. Veeraraghavan

Florida Institute of Technology, Melbourne, USA
M.M. Baarmand, B. Dorney, S. Guragain, M. Hohlmann, H. Kalakhety, R. Ralich, I. Vodopiyanov

University of Illinois at Chicago (UIC), Chicago, USA
M.R. Adams, I.M. Anghel, L. Apanasevich, Y. Bai, V.E. Bazterra, R.R. Betts, J. Callner, R. Cavanaugh, C. Dragoiu, L. Gauthier, C.E. Gerber, D.J. Hofman, S. Khalatyan, G.J. Kunde, F. Lacroix, M. Malek, C. O’Brien, C. Silvestre, A. Smoron, D. Strom, N. Varelas

The University of Iowa, Iowa City, USA
U. Akgun, E.A. Albayrak, B. Bilki, W. Clarida, F. Duru, C.K. Lae, E. Mccliment, J.-P. Merlo, H. Mermerkaya, A. Mestvirishvili, A. Moeller, J. Nachtman, C.R. Newsom, E. Norbeck, J. Olson, Y. Onel, F. Ozok, S. Sen, J. Wetzel, T. Yetkin, K. Yi

Johns Hopkins University, Baltimore, USA
B.A. Barnett, B. Blumenfeld, A. Bonato, C. Eskew, D. Feihning, G. Giurgiu, A.V. Gritsan, Z.J. Guo, G. Hu, P. Maksimovic, S. Rappoccio, M. Swartz, N.V. Tran, A. Whitbeck

The University of Kansas, Lawrence, USA
P. Baringer, A. Bean, G. Benelli, O. Grachov, R.P. Kenny Iii, M. Murray, D. Noonan, S. Sanders, J.S. Wood, V. Zhukova

Kansas State University, Manhattan, USA
A.F. Barfuss, T. Bolton, I. Chakaberia, A. Ivanov, S. Khalil, M. Makouski, Y. Maravin, S. Shrestha, I. Svintradze, Z. Wan
Lawrence Livermore National Laboratory, Livermore, USA
J. Gronberg, D. Lange, D. Wright

University of Maryland, College Park, USA
A. Baden, M. Boutemeur, S.C. Eno, D. Ferencek, J.A. Gomez, N.J. Hadley, R.G. Kellogg, M. Kirn, Y. Lu, A.C. Mignerey, K. Rossato, P. Rumerio, F. Santanastasio, A. Skuja, J. Temple, M.B. Tonjes, S.C. Tonwar, E. Twedt

Massachusetts Institute of Technology, Cambridge, USA
B. Alver, G. Bauer, J. Bendavid, W. Busza, E. Butz, I.A. Cali, M. Chan, V. Dutta, P. Everaerts, G. Gomez Ceballos, M. Goncharov, K.A. Hahn, P. Harris, Y. Kim, M. Klute, Y.-J. Lee, W. Li, C. Loizides, P.D. Luckey, T. Ma, S. Nahn, C. Paus, D. Ralph, C. Roland, G. Roland, M. Rudolph, G.S.F. Stephans, F. Stöckli, K. Sumorok, K. Sung, D. Velicanu, E.A. Wenger, S. Xie, M. Yang, Y. Yilmaz, A.S. Yoon, M. Zanetti

University of Minnesota, Minneapolis, USA
S.I. Cooper, P. Cushman, B. Dahmes, A. De Benedetti, P.R. Dudero, G. Franzoni, A. Gude, J. Haupt, K. Klapoetke, Y. Kubota, J. Mans, N. Pastika, V. Rekovic, R. Rusack, M. Sasseville, A. Singovsky, N. Tambe

University of Mississippi, University, USA
L.M. Cremaldi, R. Godang, R. Kroeger, L. Perera, R. Rahmat, D.A. Sanders, D. Summers

University of Nebraska-Lincoln, Lincoln, USA
K. Bloom, S. Bose, J. Butt, D.R. Claes, A. Dominguez, M. Eads, J. Keller, T. Kelly, I. Kravchenko, J. Lazo-Flores, H. Malbouisson, S. Malik, G.R. Snow

State University of New York at Buffalo, Buffalo, USA
U. Baur, A. Godshalk, I. Iashvili, S. Jain, A. Kharchilava, A. Kumar, S.P. Shipkowski, K. Smith, J. Zennamo

Northeastern University, Boston, USA
G. Alverson, E. Barberis, D. Baumgartel, O. Boeriu, M. Chasco, S. Reucroft, J. Swain, D. Trocino, D. Wood, J. Zhang

Northwestern University, Evanston, USA
A. Anastassov, A. Kubik, N. Odell, R.A. Ofierzynski, B. Pollack, A. Pozdnyakov, M. Schmitt, S. Stoynev, M. Velasco, S. Won

University of Notre Dame, Notre Dame, USA
L. Antonelli, D. Berry, A. Brinkerhoff, M. Hildreth, C. Jessop, D.J. Karmgard, J. Kolb, T. Kolberg, K. Lannon, W. Luo, S. Lynch, N. Marinelli, D.M. Morse, T. Pearson, R. Ruchti, J. Slaunwhite, N. Valls, M. Wayne, J. Ziegler

The Ohio State University, Columbus, USA
B. Bylsma, L.S. Durkin, J. Gu, C. Hill, P. Killewald, K. Kotov, T.Y. Ling, M. Rodenburg, G. Williams

Princeton University, Princeton, USA
N. Adam, E. Berry, P. Elmer, D. Gerbaudo, V. Halyo, P. Hebda, A. Hunt, J. Jones, E. Laird, D. Lopes Pegna, D. Marlow, T. Medvedeva, M. Mooney, J. Olsen, C. Piroué, X. Quan, B. Safdi, H. Saka, D. Stickland, C. Tully, J.S. Werner, A. Zuranski
University of Puerto Rico, Mayaguez, USA
J.G. Acosta, X.T. Huang, A. Lopez, H. Mendez, S. Oliveros, J.E. Ramirez Vargas, A. Zatserklyaniy

Purdue University, West Lafayette, USA
E. Alagoz, V.E. Barnes, G. Bolla, L. Borrello, D. Bortoletto, M. De Mattia, A. Everett, A.F. Garfinkel, L. Gutay, Z. Hu, M. Jones, O. Koybasi, M. Kress, A.T. Laasanen, N. Leonardo, C. Liu, V. Maroussov, P. Merkel, D.H. Miller, N. Neumeister, I. Shipsey, D. Silvers, A. Svyatkovskiy, H.D. Yoo, J. Zablocki, Y. Zheng

Purdue University Calumet, Hammond, USA
P. Jindal, N. Parashar

Rice University, Houston, USA
C. Bouhahouache, K.M. Ecklund, F.J.M. Geurts, B.P. Padley, R. Redjimi, J. Roberts, J. Zabel

University of Rochester, Rochester, USA
B. Betchart, A. Bodek, Y.S. Chung, R. Covarelli, P. de Barbaro, R. Demina, Y. Eshaq, H. Flacher, A. Garcia-Bellido, P. Goldenzweig, Y. Gotra, J. Han, A. Harel, D.C. Miner, D. Orbaker, G. Petrillo, W. Sakumoto, D. Vishnevskiy, M. Zielinski

The Rockefeller University, New York, USA
A. Bhatti, R. Ciesielski, L. Demortier, K. Goulianos, G. Lungu, S. Malik, C. Mesropian

Rutgers, the State University of New Jersey, Piscataway, USA
O. Atramentov, A. Barker, D. Duggan, Y. Gerstlein, R. Gray, E. Halkiadakis, D. Hidas, D. Hits, A. Lath, S. Panwalkar, R. Patel, K. Rose, S. Schnetzer, S. Somalwar, R. Stone, S. Thomas

University of Tennessee, Knoxville, USA
G. Cerizza, M. Hollingsworth, S. Spanier, Z.C. Yang, A. York

Texas A&M University, College Station, USA
R. Eusebi, W. Flanagan, J. Gilmore, A. Gurrola, T. Kamon, V. Khotilovich, R. Montalvo, I. Osipenkov, Y. Pakhotin, J. Pivariski, A. Safonov, S. Sengupta, A. Tatarinov, D. Toback, M. Weinberger

Texas Tech University, Lubbock, USA
N. Akchurin, C. Bardak, J. Damgov, C. Jeong, K. Kovitanggoon, S.W. Lee, T. Libeiro, P. Mane, Y. Roh, A. Sill, I. Volobouev, R. Wigmans, E. Yazgan

Vanderbilt University, Nashville, USA
E. Appelt, E. Brownson, D. Engh, C. Florez, W. Gabella, M. Issah, W. Johns, P. Kurt, C. Maguire, A. Melo, P. Sheldon, B. Snook, S. Tuo, J. Velkovska

University of Virginia, Charlottesville, USA
M.W. Arenton, M. Balazs, S. Boutle, B. Cox, B. Francis, J. Goodell, R. Hirosky, A. Ledovskoy, C. Lin, C. Neu, R. Yohay

Wayne State University, Detroit, USA
S. Gollapinni, R. Harr, P.E. Karchin, P. Lamichhane, M. Mattson, C. Milstène, A. Sakharov

University of Wisconsin, Madison, USA
M. Anderson, M. Bachtis, J.N. Bellinger, D. Carlsmit, S. Dasu, J. Efron, L. Gray, K.S. Grogg, M. Grothe, R. Hall-Wilton, M. Herndon, A. Hervé, P. Klubbers, J. Klukas, A. Lanaro, C. Lazaridis, J. Leonard, R. Loveless, A. Mohapatra, F. Palmonari, D. Reeder, I. Ross, A. Savin, W.H. Smith, J. Swanson, M. Weinberg
†: Deceased
1: Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland
2: Also at Universidade Federal do ABC, Santo Andre, Brazil
3: Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France
4: Also at Suez Canal University, Suez, Egypt
5: Also at British University, Cairo, Egypt
6: Also at Fayoum University, El-Fayoum, Egypt
7: Also at Soltan Institute for Nuclear Studies, Warsaw, Poland
8: Also at Massachusetts Institute of Technology, Cambridge, USA
9: Also at Université de Haute-Alsace, Mulhouse, France
10: Also at Brandenburg University of Technology, Cottbus, Germany
11: Also at Moscow State University, Moscow, Russia
12: Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary
13: Also at Eötvös Loránd University, Budapest, Hungary
14: Also at Tata Institute of Fundamental Research - HECR, Mumbai, India
15: Also at University of Visva-Bharati, Santiniketan, India
16: Also at Sharif University of Technology, Tehran, Iran
17: Also at Shiraz University, Shiraz, Iran
18: Also at Isfahan University of Technology, Isfahan, Iran
19: Also at Facoltà Ingegneria Università di Roma “La Sapienza”, Roma, Italy
20: Also at Università della Basilicata, Potenza, Italy
21: Also at Laboratori Nazionali di Legnaro dell’ INFN, Legnaro, Italy
22: Also at Università degli studi di Siena, Siena, Italy
23: Also at Faculty of Physics of University of Belgrade, Belgrade, Serbia
24: Also at University of California, Los Angeles, Los Angeles, USA
25: Also at University of Florida, Gainesville, USA
26: Also at Université de Genève, Geneva, Switzerland
27: Also at Scuola Normale e Sezione dell’ INFN, Pisa, Italy
28: Also at University of Athens, Athens, Greece
29: Also at California Institute of Technology, Pasadena, USA
30: Also at The University of Kansas, Lawrence, USA
31: Also at Institute for Theoretical and Experimental Physics, Moscow, Russia
32: Also at Paul Scherrer Institut, Villigen, Switzerland
33: Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia
34: Also at Gaziosmanpasa University, Tokat, Turkey
35: Also at Adiyaman University, Adiyaman, Turkey
36: Also at The University of Iowa, Iowa City, USA
37: Also at Mersin University, Mersin, Turkey
38: Also at Izmir Institute of Technology, Izmir, Turkey
39: Also at Kafkas University, Kars, Turkey
40: Also at Suleyman Demirel University, Isparta, Turkey
41: Also at Ege University, Izmir, Turkey
42: Also at Rutherford Appleton Laboratory, Didcot, United Kingdom
43: Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom
44: Also at INFN Sezione di Perugia; Università di Perugia, Perugia, Italy
45: Also at Utah Valley University, Orem, USA
46: Also at Institute for Nuclear Research, Moscow, Russia
47: Also at Los Alamos National Laboratory, Los Alamos, USA
48: Also at Erzincan University, Erzincan, Turkey