

Coll 1: ALPS-Collaboration

HARTMUT GROTE¹, DANIEL BROTHERTON², JOSEPH GLEASON², HAROLD HOLLIS², RYAN NETRVAL², DAVID TANNER², SANDY CROATTO³, HENRY FRÄDRICH³, KATHARINA-SOPHIE ISLEIF³, FRIEDERIKE JANUSCHEK³, KARSTEN GADOW³, TODD KOZLOWSKI³, AXEL LINDNER³, ISABELLA OCEANO³, DAVID REUTHER³, ANDREAS RINGWALD³, JOSE ALEJANDRO RUBIERA GIMENO³, JOERN SCHAFFRAN³, UWE SCHNEEKLOTH³, CHRISTINA SCHWEMMBAUER³, AARON SPECTOR³, LI-WEI WEI³, GULDEN OTHMAN⁴, MANUEL MEYER⁵, ELMERI RIVASTO⁵, KANIOAR KARAN⁷, BENNO WILLKE⁶, GUIDO MÜLLER⁷, ALDO EJLLI⁷, AYMAN HALLAL⁷, and DIETER TRINES³ — ¹Cardiff University — ²University of Florida — ³Deutsches Elektronen-Synchrotron (DESY) — ⁴University of Hamburg — ⁵University of South Denmark — ⁶Leibniz University Hannover — ⁷Max-Planck Institute for Gravitational Physics

Coll 2: ANNIE-Collaboration

MARVIN ASCENCIO-SOSA¹, ZARA BAGDASARIAN^{2,3}, JOHN BEACOM⁴, MARC BERGEVIN⁵, MARC BREISCH⁶, GIAN CACERES VERA⁷, STEVEN DAZELEY⁵, STEVEN DORAN¹, EVANGELIA DRAKOPOULOU⁸, SIJITH EDAYATH¹, RORY EDWARDS⁹, JONATHAN EISCH¹⁰, YUE FENG¹, VINCENT FISCHER¹⁰, ROB FOSTER¹¹, STEVEN GARDINER¹⁰, PAUL HACKSPACHER⁷, CAREN HAGNER¹², JULIE HE⁷, BENEDICT KAISER⁶, FRANK KRENNRICH¹, TOBIAS LACHENMAIER⁶, FRANKLIN LEMMONS¹³, DAVID MAKSIMOVIC¹⁴, MATTHEW MALEK¹¹, JOHANN MARTYN¹⁴, ANDREW MASTBAUM¹³, CARRIE MCGIVERN¹⁰, JAMES MINOCK¹⁵, MICHAEL NIESLONY¹⁴, MARCUS O'FLAHERTY⁹, GABRIEL OREBI GANN^{2,3}, TEAL PERSHING⁵, LEON PICKARD^{2,3}, NAVANEETH POONTHOTTATHIL¹⁶, BEN RICHARDS⁹, MAYLI SANCHEZ¹⁷, DANIEL TOBIAS SCHMID¹⁴, MICHAEL SMY¹⁸, MALTE STENDER¹², ANDREW SUTTON¹⁷, ROBERT SVOBODA⁷, EMRAH TIRAS^{19,20}, MARK VAGINS¹⁸, VENKATESH VEERARAGHAVAN¹, JINGBO WANG¹³, AMANDA WEINSTEIN¹, MATTHEW WETSTEIN¹, MICHEL WURM¹⁴, and TIANQI ZHANG⁷ — ¹Iowa State University, Department of Physics and Astronomy, Ames, IA 50011 U.S.A. — ²University of California, Berkeley, Physics Department, Berkeley, CA 94720 U.S.A. — ³Lawrence Berkeley National Laboratory, Nuclear Science Division, Berkeley, CA 94720 U.S.A. — ⁴Ohio State University, Department of Physics, Columbus, OH 43210 U.S.A. — ⁵Lawrence Livermore National Laboratory, Livermore, CA 94550 U.S.A. — ⁶Eberhard Karls Universität, Kepler Center for Astro and Particle Physics, Tübingen 72076, Germany — ⁷University of California at Davis, Department of Physics and Astronomy, Davis, CA 95616, U.S.A. — ⁸N.C.S.R. "Demokritos", Institute of Nuclear and Particle Physics, Agia Paraskevi 15341, Greece — ⁹University of Warwick, Department of Physics, Coventry CV4 7AL U.K. — ¹⁰Fermi National Accelerator Laboratory, Batavia, IL 60510, U.S.A. — ¹¹University of Sheffield, Department of Physics and Astronomy, Sheffield, S10 2TN, U.K. — ¹²Universität Hamburg, Institut für Experimentalphysik, Hamburg 22761, Germany — ¹³South Dakota School of Mines and Technology, Physics Department, Rapid City SD, 57701 U.S.A. — ¹⁴Johannes Gutenberg Universität, Institut für Physik, Mainz 55128, Germany — ¹⁵Rutgers University, Department of Physics and Astronomy, Piscataway, NJ 08854 U.S.A. — ¹⁶Indian Institute of Technology Kanpur, Department of Physics, Kanpur 208016, India — ¹⁷Florida State University, Department of Physics, Tallahassee, FL 32306 U.S.A. — ¹⁸University of California at Irvine, Department of Physics and Astronomy, Irvine CA, 92697 U.S.A. — ¹⁹Erciyes University, Department of Physics, Kayseri, 38030, Türkiye — ²⁰University of Iowa, Department of Physics and Astronomy, Iowa City, IA 52242 U.S.A.

Coll 3: ANTARES-KM3NET-ERLANGEN-Collaboration

MICHAEL CHADOLIAS, ALBA DOMI, THOMAS EBERL, TAMAS GAL, NICOLE GEISSELBRECHT, KAY GRAF, LUKAS HENNIG, JÜRGEN HÖSSL, OLEG KALEKIN, ULI KATZ, CLAUDIO KOPPER, ROBERT LAHMANN, RODRIGO GRACIA RUIZ, JUTTA SCHNABEL, JOHANNES SCHUMANN, BASTIAN SETTER, and CHRISTIAN HAACK — Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Deutschland

Coll 4: CALICE-D-Collaboration

OLE BACH¹, KARSTEN GADOW¹, PETER GÖTTLICHER¹, KATJA KRÜGER¹, ANTOINE LAUDRAIN¹, JIA-HAO LI¹, MATHIAS REINECKE¹, FELIX SEFKOW¹, DARIA SELIVANOVA¹, MALINDA DE SILVA¹, ZOBAYER GHAFOR², STAN LAI², JULIAN UTEHS², ANDRÉ WILHAHN², ERIK BUHMANN³, ERIKA GARUTTI³, GREGOR KASIECZKA³, MICHAEL MATYSEK³, STEPHAN MARTENS³, JACK ROLPH³, CAR-

MEN VILLALBA³, KONRAD BRIGGL⁴, HANS CHRISTIAN SCHULTZ-COULON⁴, WEI SHEN⁴, RAINER STAMEN⁴, ZHENXIONG YUAN⁴, ANDREA BROGNA⁵, VOLKER BÜSCHER⁵, LUCIA MASETTI⁵, ASA NEHM⁵, SEBASTIAN RITTER⁵, MARISOL ROBLES-MANZANO⁵, ANNA ROSMANITZ⁵, ULRICH SCHÄFER⁵, CHRISTIAN SCHMITT⁵, ALFONS WEBER⁵, QUIRIN WEITZEL⁵, FABIAN HUMMER⁶, and FRANK SIMON⁶ — ¹Deutsches Elektronen Synchrotron DESY — ²Universität Göttingen — ³Universität Hamburg — ⁴Universität Heidelberg — ⁵Universität Mainz — ⁶Karlsruhe Institute of Technology (KIT), Institute for Data Processing and Electronics (IPE)

Coll 5: CLOUD-Collaboration

CLOE GIRARD-CARILLO and SUSANNA WAKELY — Johannes Gutenberg University, Mainz, Germany

Coll 6: CMOS Strips-Collaboration

SPYRIDON ARGYROPOULOS¹, JAN-HENDRIK ARLING², MARTA BASELGA⁵, NAOMI DAVIS², LEENA DIEHL⁴, JOCHEN DINGFELDER³, INGRID-MARIA GREGOR^{2,3}, MARC HAUSER¹, TOMASZ HEMPEREK⁸, FABIAN HÜGGING³, KARL JAKOBS¹, MICHAEL KARAGOUNIS⁶, ROLAND KOPPENHÖFER¹, KEVIN KRÖNINGER⁵, FABIAN LEX¹, ULRICH PARZEFALL¹, ARTURO RODRIGUEZ RODRIGUEZ⁷, BIRKAN SARI⁵, NIELS SORGENFREI⁴, SIMON SPANNAGEL², DENNIS SPERLICH¹, TIANJANG WANG³, JENS WEINGARTEN⁵, and IVETA ZATOCILOVA¹ — ¹Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — ²DESY, Hamburg, Germany — ³Universität Bonn, Bonn, Germany — ⁴CERN, Meyrin, Switzerland — ⁵Technische Universität Dortmund, Dortmund, Germany — ⁶Fachhochschule Dortmund — ⁷Littelfuse, Lampertheim, Germany — ⁸DECTRIS Ltd., Baden-Daettwil, Switzerland

Coll 7: CONUS-Collaboration

NICOLA ACKERMANN, SOPHIE ARMBRUSTER, HANNES BONET, CHRISTIAN BUCK, WERNER MANESCHG, AURELIE BONHOMME, MANFRED LINDNER, JANINA HAKENMUELLER, JANINE HEMPLING, THOMAS RINK, EDGAR SANCHEZ-GARCIA, HERBERT STRECKER, GERD HEUSSER, and KAIXIANG NI — Max-Planck Institut fuer Kernphysik, Heidelberg, Germany

Coll 8: COSINUS-Collaboration

FLORIAN REINDL^{1,2}, JOCHEN SCHIECK^{1,2}, DANIEL SCHMIEDMAYER^{1,2}, CHRISTOPH SCHWERTNER^{1,2}, STEPHAN FICHTINGER¹, MARKUS FRIEDL¹, FELIX WAGNER¹, LEONIE EINFALT^{1,2}, PHILIPP SCHREINER^{1,2}, MARIANO CABABIE^{1,2}, ALEX STENDAHL³, KATRI HUITU³, MATTI HEIKINHEIMO³, FERNANDO FERRONI^{4,5}, LORENZO PAGNANINI^{4,5}, ANDREI PUIU^{4,5}, NATALIA DI MARCO^{4,5}, MATTHEW JAKE STUKEL^{4,5}, STEFANO PIRRO⁴, IOAN DAFINEI⁴, KAROLINE SCHAEFFNER⁶, FEDERICA PETRICCA⁶, FRANZ PROEBST⁶, GODE ANGLOHER⁶, MICHELE MANCUSO⁶, MARTIN STAHLBERG⁶, VANESSA ZEMA⁶, MORITZ KELLERMANN⁶, MUKUND BHARADWAJ⁶, TORSTEN FRANK⁶, KUMRIE SHERA⁶, MAXIMILIAN HUGHES⁶, MAXIMILIAN GAPP⁶, KILIAN HEIM⁶, YONG ZHU⁷, SHIHAI YUE⁷, ZENGWEI GE⁷, ADRIANO FILLIPONI⁸, GIANNI PROFETA⁸, and CESARE TRESCA⁸ — ¹HEPHY, Wien, Austria — ²TU Wien, Wien, Austria — ³HIP, Helsinki, Finland — ⁴INFN, Rom, Italy — ⁵LNGS/GSSI, Assergi, Italy — ⁶MPP, Garching, Germany — ⁷SICCAS, Shanghai, China — ⁸University of L'Aquila, L'Aquila, Italy

Coll 9: FACT-Collaboration

JAYANT ABHIR¹, DOMINIK BAACK², MATTEO BALBO³, ADRIAN BILAND¹, KATHARINA BRAND⁴, THOMAS BRETZ^{1,5}, JENS BUSS², DANIELA DORNER^{1,4}, LAURA EISENBERGER⁴, DOMINIK ELSAESSER², PATRICK GÜNTHER⁴, DOROTHEE HILDEBRAND¹, SYED HASAN¹, KARL MANNHEIM⁴, MAXIMILIAN NOETHE², ALEKSANDER PARAVAI⁴, FELIX PFEIFLE⁴, WOLFGANG RHODE², BERND SCHLEICHER^{1,4}, VITALII SLIUSAR³, MARCEL VORBRUGG⁴, and ROLAND WALTHER³ — ¹ETH Zurich, Institute for Particle Physics and Astrophysics, Otto-Stern-Weg 5, 8093 Zürich, Switzerland — ²TU Dortmund, Experimental Physics 5, Otto-Hahn-Str. 4a, 44227 Dortmund, Germany — ³University of Geneva, Department of Astronomy, Chemin d'Ecogia 16, 1290 Versoix, Switzerland — ⁴Julius-Maximilians-Universität Würzburg, Fakultät für Physik und Astronomie, Institut für Theoretische Physik und Astrophysik, Lehrstuhl für Astronomie, Emil-Fischer-Str. 31, D-97074 Würzburg, Germany — ⁵also at GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

Coll 10: H.E.S.S.-Collaboration

STEFAN WAGNER — Max-Planck-Institut für Kernphysik H.E.S.S. Experiment P.O. Box 103980 D-69029 Heidelberg Germany

Coll 11: IceCube Collaboration-Collaboration

S SHEFALI — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

Coll 12: LEGEND-Collaboration

N. ABRALL¹, N. ACKERMANN², M. AGOSTINI³, A. ALEXANDER³, C. ANDERIOU⁴, G. R. ARAUJO⁵, M. ATZORI CORONA⁶, F.T. AVIGNONE III^{7,8}, M. BABICZ⁵, W. BAE⁹, A. BAKALYAROV¹⁰, M. BALATA¹¹, I. BARABANOV¹², A.S. BARABASH¹⁰, P.S. BARBEAU^{13,14}, C.J. BARTON¹⁶, L. BAUDIS⁵, C. BAUER², V. BELOV²⁵, E. BERNIERI¹⁶, L. BEZRUKV¹², K.H. BHIMANI^{17,14}, V. BIANCACCI^{33,11}, E. BLALOCK^{20,14}, A. BOLOZSYDNA²¹, W.M. BONIVENTO⁶, S. BORDEN²², G. BORCHI²³, B. BOS^{17,14}, E. BOSSIO²⁵, A. BOSTON²⁶, V. BOTHE², R. BOUABID^{13,14}, R. BRUGNERA^{18,19}, N. BURLAC¹⁶, M. BUSCH^{13,14}, D. BUTTA²³, M. CADEDU⁶, A. CALDWELL²⁷, S. CALGARO^{18,19}, S. CAPRA⁴², N. CARGIOLI⁶, M.C. CARMINATI²³, R.M.D. CARNEY¹, C. CATTADORI²⁹, Y.-D. CHAN¹, S.Y. CHENG²², A. CHERNOGOROV¹⁹, P.-J. CHIU⁵, C.D. CHRISTOFFERSON³⁰, P.-H. CHU³¹, M. CLARK^{17,14}, V. COCCO⁶, J.A. COLON RIVERA^{13,14}, T. COMELLATO²⁵, R.J. COOPER¹, I.A. COSTA¹⁶, V. D'ANDREA¹⁶, R. DECKERT²⁵, J.A. DETWILER²², A. DI GIACINTO¹¹, N. DI MARCO^{33,11}, J. DOBSON³, K.-M. DONG¹⁵, A. DROBIZHEV¹, G. DURAN^{17,14}, YU. EFREMENKO³⁴, S.R. ELLIOTT³¹, E. ENGELHARDT^{17,14}, S. ENOMOTO²², E. ESCH⁴⁹, M.T. FEBBRARO⁸, F. FERELLA¹¹, D.E. FIELDS²⁸, C. FIORINI²³, M. FOMINA³⁷, H. FOX³⁸, N. FUAD³⁶, F. GABRIELE⁶, D. GAHAN⁶, R. GALA^{20,14}, C. GALIBIATTI³⁹, A. GALINDO-URIBARRI⁸, A. GANGAPASHEV¹², P. GARCA ABIA⁴⁰, A. GARFAGNINI^{18,19}, S. GAZZANA^{11,41}, A. GERACI⁴², C. GHIANO¹¹, S. GIRI^{17,14}, D. GNANI¹, M. GOLD²⁸, C. GOOCH²⁷, G. GRÜNAUER⁴⁹, C.R. GRACE¹, M.P. GREEN^{20,14,8}, G.F. GRINYER⁴⁴, A. GROBOV¹⁰, J. GRUSZKO^{17,14}, I. GUINN⁸, V.E. GIUSEPPE⁸, V. GURENTSOV¹², Y. GUROV³⁷, K. GUSEV^{37,25}, B. HACKETT²⁷, D.X. HADDOCK²⁸, F. HAGEMANN²⁷, M. HARANCZYK⁴⁵, C.R. HAUPE^{17,14}, C. HAYWARD³⁸, C. HECKMAYER⁴⁹, F. HENKES²⁵, R. HENNING^{17,14}, J. HERRERA^{20,14}, D. HERVAS AGUILAR^{17,14}, J. HINTON², R. HODAK³⁵, H. HOFFMANN⁴⁶, W. HOFMANN², D. HUFF⁴⁷, M. HULT⁴⁸, A. IANNI¹¹, A. IANNI³⁹, C.J. JILLINGS^{55,56}, J. JOCHUM⁴⁹, R. JONES³⁸, D. JUDSON²⁶, M. JUNKER¹¹, J. KAIZER⁵⁰, V. KAZALOV¹², H. KHUSHBAKHT⁴⁹, M. KIDD⁵¹, T. KIHM², K. KILGRUS⁴⁹, A. KLIMENKO³⁷, K.T. KNÖPFLE², I. KOCHANEK¹¹, S.I. KONOVALOV¹⁰, I. KONTUL⁵⁰, L.L. KORMOS³⁸, V.N. KORNOUKHOV²¹, P. KRAUSE²⁵, H. KRISHNAMOORTHY⁸, J. KUMAR⁴⁹, V.V. KUZMINOV¹², J.M. LÓPEZ-CASTAÑO⁸, M. LABICHE²⁴, K. LANG⁹, M. LAUBENSTEIN¹¹, E. LEÓN^{17,14}, B. LEHNERT¹, A. LEONHARDT²⁵, N. LEVASHKO¹⁰, A. LI^{17,14}, M. LINDNER², I. LIPPI¹⁹, J. LIU¹⁵, A. LUBASHEVSKIY³⁷, B. LUBSANDORZHIEV¹², N. LUSSARDI⁴², Y. MÜLLER⁵, C. MACOLINO^{32,11}, B. MAJOROVITS²⁷, F. MAMEDOV³⁵, W. MANSCHG², G. MARSHALL³, R.D. MARTIN⁵², E.L. MARTIN^{17,14}, R. MASSARCYK³¹, A. MAZUMDAR³¹, A. MEHTA²⁶, D.-M. MEI¹⁵, S.P. MEIRELES^{32,11}, S. MERTENS²⁵, E. MILLER²², M. MISIASZEK⁴⁵, I. MIZRA³⁴, E. MONDRAGON²⁵, M. MORELLA^{33,11}, B. MORGAN⁵³, T. MROZ⁴⁵, D. MUENSTERMANN³⁹, C.J. NAVE²², I. NEMCHENOK³⁷, M. NEUBERGER²⁵, J. NEWBY⁸, G. OREBI GANN^{1,54}, P. ORGANTINI³⁹, F. PAISSAN¹⁶, V. PALUSOVA³⁵, P. PAPADAKIS²⁴, L. PAPP²⁵, L.S. PAUDEL¹⁵, K. PELCZAR⁴⁸, J. PEREZ PEREZ⁴⁵, L. PERTOLDI^{25,19}, V. PESUDO⁴⁰, W. PETTUS³⁶, F. PIASTRA⁵, M. PICHOTTA⁴⁶, P. PISERI⁴², A.W.P. POON¹, S. PORDES³⁹, P.P. POVINEC⁵⁰, A. PULLIA⁴², W.S. QUINN³, D.C. RADFORD⁸, Y.A. RAMACHERS⁵³, A. RAMIREZ⁴⁷, L. RAUSCHER⁴⁹, A. RAZETO¹¹, M. RESCHUK¹⁹, A.L. REINE^{17,14}, A. RENSHAW⁴⁷, S. RIBOLDI⁴², K. RIELAGE³¹, L. ROMERO⁴⁰, C. ROMO-LUQUE³¹, N. ROSSI¹¹, S. ROZOV³⁷, T.C. RULAND⁸, N. RUMYNTSEVA^{25,37}, J. RUNGE^{13,14}, R. SAAKYAN³, S. SAILER², G. SALAMANNA¹⁶, F. SALAMIDA^{32,11}, G. SALEH^{18,19}, D.J. SALVAT³⁶, V. SANDUKOVSKY³⁷, R. SANTORELLI⁴⁰, C. SAVARESE³⁹, S. SCHÖNERT²⁵, A.-K. SCHÜTZ¹, D.C. SCHAPER³¹, S.J. SCHLEICH³⁶, J. SCHREINER², O. SCHULZ²⁷, M. SCHWARZ²⁵, B. SCHWINGENHEUER², C. SEIBT⁴⁶, O. SELIVANENKO¹², E. SHEVCHIK³⁷, M. SHIRCHENKO³⁷, Y. SHITOV³⁷, H. SIMGEN², I. STEKL³⁵, A. STERI⁶, T. STEZELBERGER^{1,49}, M. STOMMEL⁵⁸, S.A. SULLIVAN², R.R. SUMATHI⁴³, K. SZCZEPANIEC⁴⁵, F. SIMKOVIC³⁵, M. SKOROKHVATOV¹⁰, A. SMOLNIKOV³⁷, J.A. SOLOMON^{17,14}, G. SONG²², A.C. SOUSA³⁰, R. STEFANIZZI⁶, L. TAFFARELLO¹⁹, D. TAGNANI¹⁶, R. TAYLOR³⁶, D. TEDESCHI⁷, T.N. THORPE³¹, S. TORRES-LARA⁴⁷, R. TOUSIF²⁸, V. TRETYAK³⁷, M. TURQUETI¹, E.E. VAN NIEWENHUIZEN^{13,14}, R.L. VARNER⁸, L. VARRIANO²², S. VASILYEV³⁷, A. VERESNIKOVA¹², K. VETTER^{1,57}, C. VIGNOLI¹¹, C. VOGL²⁵, K. VON STURM^{18,19}, A. WARREN¹⁵, D. WATERS³, S.L. WATKINS³¹, C. WIESINGER²⁵, J.F. WILKERSON^{17,14,8}, M.

WILLERS²⁵, C. WISEMAN²², M. WOJCIK⁴⁵, D. XU³, E. YAKUSHEV³⁷, T. YE⁵², C.-H. YU⁸, V. YUMATOV¹⁰, N. ZARETSKI¹⁰, I. ZHITNIKOV³⁷, D. ZINATULINA³⁷, K. ZUBER⁴⁶, and G. ZUZEL⁴⁵ —
¹Institute for Nuclear and Particle Astrophysics and Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — ²Max-Planck-Institut für Kernphysik, Heidelberg, 69117, Germany — ³University College London, London, WC1E 6BT, United Kingdom — ⁴Department of Chemistry, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada — ⁵Physik-Institut, University of Zürich, Zürich, 8057, Switzerland — ⁶Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Cagliari, Italy — ⁷Department of Physics and Astronomy, University of South Carolina, Columbia, SC 29208, USA — ⁸Oak Ridge National Laboratory, Oak Ridge, TN 37830, USA — ⁹Department of Physics, University of Texas at Austin, Austin, TX 78712, USA — ¹⁰National Research Centre "Kurchatov Institute", Moscow, 123098, Russia — ¹¹Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Gran Sasso, I-67100 Assergi (AQ), Italy — ¹²Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, 119991, Russia — ¹³Department of Physics, Duke University, Durham, NC 27708, USA — ¹⁴Triangle Universities Nuclear Laboratory, Durham, NC 27708, USA — ¹⁵Department of Physics, University of South Dakota, Vermillion, SD 57069, USA — ¹⁶Roma Tre University and INFN Roma Tre, Rome, I-00146, Italy — ¹⁷Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27514, USA — ¹⁸Dipartimento di Fisica e Astronomia dell'Università di Padova, 35121, Italy — ¹⁹Padova Istituto Nazionale di Fisica Nucleare, Padova, 35131, Italy — ²⁰Department of Physics, North Carolina State University, Raleigh, NC 27607, USA — ²¹National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 115409 Moscow, Russia — ²²Center for Experimental Nuclear Physics and Astrophysics, and Department of Physics, University of Washington, Seattle, WA 98195, USA — ²³Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria Sezione di Elettronica, Milano, 20133, Italy — ²⁴Science and Technology Facilities Council (STFC) Daresbury Laboratory, Daresbury, Cheshire, WA4 4AD, UK — ²⁵Department of Physics, TUM School of Natural Sciences, Technische Universität München, 85748 Garching b. München, Germany — ²⁶University of Liverpool, Liverpool, L69 3BX, United Kingdom — ²⁷Max-Planck-Institut für Physik, München, 80805, Germany — ²⁸Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM 87131, USA — ²⁹Istituto Nazionale di Fisica Nucleare, Milano Bicocca, Milano, 20126, Italy — ³⁰South Dakota Mines, Rapid City, SD, 57701, USA — ³¹Los Alamos National Laboratory, Los Alamos, NM 87545, USA — ³²Department of Physical and Chemical Sciences University of L'Aquila, L'Aquila, 67100, Italy — ³³Gran Sasso Science Institute, L'Aquila, 67100, Italy — ³⁴Department of Physics and Astronomy, University of Tennessee, Knoxville, TN 37916, USA — ³⁵Czech Technical University, Institute of Experimental and Applied Physics, CZ-12800 Prague, Czech Republic — ³⁶Center for Exploration of Energy and Matter, and Department of Physics, Indiana University, Bloomington, IN 47405, USA — ³⁷Joint Institute for Nuclear Research, Dubna, 141890, Russia — ³⁸Department of Physics, Lancaster University, Lancaster, LA1 4YW, United Kingdom — ³⁹Physics Department, Princeton University, Princeton, NJ 08544, USA — ⁴⁰Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Madrid, 28040, Spain — ⁴¹Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, I-00044 Frascati (RM), Italy — ⁴²Milano Univ. and Milano Istituto Nazionale di Fisica Nucleare, Milano, 20054, Italy — ⁴³Leibniz-Institut für Kristallzüchtung, Berlin, D-12489, Germany — ⁴⁴Department of Physics, University of Regina, Regina, Saskatchewan, SK S4S 0A2, Canada — ⁴⁵M. Smoluchowski Institute of Physics, Jagiellonian University, Cracow, 31-007, Poland — ⁴⁶Technische Universität Dresden, Dresden, 01069, Germany — ⁴⁷Department of Physics, University of Houston, Houston, TX 77204, USA — ⁴⁸European Commission, Joint Research Centre, Directorate for Nuclear Safety & Security, Geel, 2440, Belgium — ⁴⁹University Tübingen, Tübingen, 55411, Germany — ⁵⁰Department of Nuclear Physics and Biophysics, Comenius University, Bratislava, SK-84248, Slovakia — ⁵¹Tennessee Tech University, Cookeville, TN 38505, USA — ⁵²Department of Physics, Engineering Physics & Astronomy, Queen's University, Kingston, Ontario, K7L 3N6, Canada — ⁵³Department of Physics, University of Warwick, Coventry, CV4 7AL, United Kingdom — ⁵⁴Department of Physics, University of California, Berkeley, CA, 94720, USA — ⁵⁵SNOLAB, Creighton Mine #9, Sudbury, ON P3Y 1N2, Canada — ⁵⁶School of Natural Sciences, Laurentian University, Sudbury, P3E 2C6, Canada — ⁵⁷Department of Nuclear Engineering, University of

California, Berkeley, CA, 94720, USA — ⁵⁸Leibniz-Institut für Polymerforschung Dresden e.V., Dresden, D-01069, Germany

Coll 13: Lohengrin-Collaboration

PHILIP BECHTLE, KLAUS DESCH, HERBI DREINER, OLIVER FREYERMUTH, MARKUS GRUBER, HAZEM HAJJAR, MATTHIAS HAMER, JAN HEINRICH, JOCHEN KAMINSKI, MICHAEL LUPBERGER, TOBIAS SCHIFFER, PATRICK SCHWÄBIG, and MARTIN SCHÜRMAN — Physikalisches Institut Uni Bonn, Nussallee 12, 53115 Bonn

Coll 14: MADMAX-Collaboration

JUAN ARCILA MALDONADO¹, BERNARDO ARY DOS SANTOS GARCIA², DOMINIK BERGERMANN², STÉPHAN BEURTHEY³, ALLEN CALDWELL¹, GIULIO CAPPELLI⁴, VIHAY DABHI³, CRISTINEL DIACONU³, JOHANNES DIEHL¹, BABETTE DÖBRICH¹, GIA DVALI¹, JACOB EGGE⁵, MARKO EKMEZIC⁵, FABRICE GALLO³, ERIKA GARUTTI⁵, STEFAN HEYMINCK⁶, THIBAUT HOUDY⁷, FABRICE HUBAUT³, ANTON IVANOV¹, JOSEF JOCHUM⁸, PIERRE KARST³, ALIREZA KAZEMIPOUR¹, YOANN KERMAÏDIC⁷, STEFAN KNIRCK⁹, MICHAEL KRAMER⁶, DAGMAR KREIKEMEYER-LORENZ¹, CHRISTOPH KRIEGER⁵, GWENAEL LE-GAL⁴, DAVID LEPLA-WEBER¹⁰, AXEL LINDNER¹⁰, MAXIMILIAN LOHMANN², BÉLA MAJOROVITS¹, STEPHAN MARTENS⁵, ALBERTO MARTINI¹⁰, AKIRA MIYAZAKI⁷, ERDEM ÖZ², PASCAL PRALAVORIO³, GEORG RAFFELT¹, ARPIT RANADIVE⁴, JAVIER REDONDO¹¹, ANDREAS RINGWALD¹⁰, NICOLAS ROCH⁴, SAMUEL ROSET³, NABIL SALAMA⁵, JÖRN SCHAFFRAN¹⁰, ALEXANDER SCHMIDT², ANDREW SONNENSCHNEIN⁹, FRANK STEFFEN¹, CHRISTIAN STRANDHAGEN⁸, IGOR USHEROV⁸, HAOTIAN WANG², and GUNDFOLW WIECHING⁶ — ¹MPI für Physik, München — ²RWTH Aachen — ³CPPM, Marseille, Frankreich — ⁴Institut NEEL, CNRS, Grenoble, Frankreich — ⁵Universität Hamburg — ⁶MPI für Radioastronomie, Bonn — ⁷Université Paris-Saclay, CNRS/IN2P3, IJCLab, Frankreich — ⁸Eberhard-Karls-Universität Tübingen — ⁹Fermi National Accelerator Laboratory, USA — ¹⁰DESY Hamburg — ¹¹Universidad de Zaragoza, Spanien

Coll 15: NA61/SHINE-Collaboration

NEERAJ AMIN — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Hermann-von-Helmholtz-Platz 1, 76344, Eggenstein-Leopoldshafen

Coll 16: Pierre Auger and IceCube-Collaboration

ANDREAS HAUNGS — Karlsruhe Institute of Technology

Coll 17: Pierre-Auger-Collaboration

A. ABDUL HALIM¹³, P. ABREU⁷³, M. AGLIETTA^{55,53}, I. ALLEKOTTE¹, K. ALMEIDA CHEMINANT⁷¹, A. ALMELA^{7,12}, R. ALOISIO^{46,47}, J. ALVAREZ-MUÑIZ⁷⁹, J. AMMERMAN YEBRA⁷⁹, G.A. ANASTASI^{59,48}, L. ANCHORDOQUI⁸⁰, B. ANDRADA⁷, S. ANDRINGA⁷³, L. APOLLONIO^{60,50}, C. ARAMO⁵¹, P.R. ARAÚJO FERREIRA⁴³, E. ARNONE^{64,53}, J.C. ARTEAGA VELÁZQUEZ⁶⁸, P. ASSIS⁷³, G. AVILA¹¹, E. AVOCONE^{58,47}, A. BAKALOVA³³, F. BARBATO^{46,47}, A. BARTZ MOCELLIN⁸⁵, J.A. BELLIDO^{13,70}, C. BERAT³⁷, M.E. BERTAINA^{64,53}, G. BHATTA⁷¹, M. BIANCIOTTO^{64,53}, P.L. BIERMANN¹⁰⁰, V. BINET⁵, K. BISMARCK^{40,7}, T. BISTER^{80,81}, J. BITEAU^{38,93}, J. BLAZEK³³, C. BLEVE³⁷, J. BLÜMER⁴², M. BOHÁČOVÁ³³, D. BONCIOLI^{58,47}, C. BONIFAZI^{8,27}, L. BONNEAU ARBELETCHÉ²², N. BORODAI⁷¹, J. BRACK¹⁰², P.G. BRICHETTO ORCHERA⁷, F.L. BRIECHLE⁴³, A. BUENO⁷⁸, S. BUITINK¹⁵, M. BUSCEMI^{48,62}, M. BÜSKEN^{40,7}, A. BWEMBYA^{80,81}, K.S. CABALLERO-MORA⁶⁷, S. CABANA-FREIRE⁷⁹, L. CACCIANIGA^{60,50}, F. CAMPUZANO⁶, R. CARUSO^{59,48}, A. CASTELLINA^{55,53}, F. CATALANI¹⁹, G. CATALDI⁴⁹, L. CAZON⁷⁹, M. CERDA¹⁰, A. CERMENATI⁴⁶, J.A. CHINELLATO²², J. CHUDOBA³³, L. CHYTKA³⁴, R.W. CLAY¹³, A.C. COBOS CERUTTI⁶, R. COLALILLO^{61,51}, M.R. COLUCCIA⁴⁹, R. CONCEIÇÃO⁷³, A. CONDORELLI³⁸, G. CONSOLATI^{50,56}, M. CONTE^{57,49}, F. CONVENGA^{58,47}, D. CORREIA DOS SANTOS²⁹, P.J. COSTA⁷³, C.F. COVAULT⁸⁴, M. CRISTINZIANI⁴⁵, S.E. CRUZ SANCHEZ³, S. DASSO^{4,2}, K. DAUMILLER⁴², B.R. DAWSON¹³, R.M. DE ALMEIDA²⁹, J. DE JESÚS^{7,42}, S.J. DE JONG^{80,81}, J.R.T. DE MELLO NETO^{27,28}, I. DE MITRI^{46,47}, J. DE OLIVEIRA¹⁸, O. DE OLIVEIRA FRANCO⁴⁹, F. DE PALMA^{57,49}, V. DE SOUZA²⁰, B.P. DE SOUZA DE ERRICO²⁷, E. DE VITO^{57,49}, A. DEL POPOLO^{59,48}, O. DELIGNY³⁵, N. DENNER³³, L. DEVAL^{42,7}, A. DI MATTEO⁵³, M. DOBRÉ⁷⁴, C. DOBRIGKEIT²², J.C. D'OLIVO⁶⁹, L.M. DOMINGUES MENDES^{73,16}, Q. DOROSTI⁴⁵, J.C. DOS ANJOS¹⁶, R.C. DOS ANJOS²⁶, J. EBR³³, F. ELLWANGER⁴³, M. EMAM^{80,81}, R. ENGEL^{40,42}, I. EPICOCO^{57,49}, M. ERDMANN⁴³, A. ETCHEGOYEN^{7,12}, C. EVOLI^{46,47}, H. FALKE^{80,82,81}, G. FARRAR⁸⁸, A.C. FAUTH²², N. FAZZINI⁹⁸, F. FELDBUSCH⁴¹, F. FENU^{42,97}, A. FERNANDES⁷³, B. FICK⁸⁷, J.M. FIGUEIRA⁷,

A. FILIPČIĆ^{77,76}, T. FITOUSSI⁴², B. FLAGGS⁹⁰, T. FODRAN⁸⁰, T. FUJII^{89,99}, A. FUSTER^{7,12}, C. GALEA⁸⁰, C. GALELLI^{60,50}, B. GARCÍA⁶, C. GAUDU³⁹, H. GEMMEKE⁴¹, F. GESUALDI^{7,42}, A. GHERGHEL-LASCU⁷⁴, P.L. GHIA³⁵, U. GIACCARI⁴⁹, J. GLOMBITZA^{43,95}, F. GOBBI¹⁰, F. GOLLAN⁷, G. GOLUP¹, M. GÓMEZ BERISSO¹, P.F. GÓMEZ VITALE¹¹, J.P. GONGORA¹¹, J.M. GONZÁLEZ¹, N. GONZÁLEZ⁷, D. GÓRA⁷, A. GORGI^{55,53}, M. GOTTOWIK⁷⁹, T.D. GRUBB¹³, F. GUARINO^{61,51}, G.P. GUEDES²³, E. GUIDO⁴⁵, L. GÜLZOW⁴², S. HAHN⁴⁰, P. HAMAL³³, M.R. HAMPPEL⁷, P. HANSEN³, D. HARARI¹, V.M. HARVEY¹³, A. HAUNGS⁴², T. HEBBEKER⁴³, C. HOJVAT⁹⁸, J.R. HÖRANDEL^{80,81}, P. HORVATH³⁴, P. HORVATH³⁴, M. HRABOVSKÝ³⁴, T. HUEGE^{42,15}, A. INSOLIA^{59,48}, P.G. ISAR⁷⁵, P. JANECEK³³, V. JILEK³³, J.A. JOHNSEN⁸⁵, J. JURYSSEK³³, K.-H. KAMPERT³⁹, B. KEILHAUER⁴², A. KHAKURDIKAR⁸⁰, V.V. KIZAKKE COVILAKAM^{7,42}, H.O. KLAGES⁴², M. KLEIFGES⁴¹, F. KNAPP⁴⁰, J. KÖHLER⁴², N. KUNKA⁴¹, B.L. LAGO¹⁷, N. LANGNER⁴³, M.A. LEIGUI DE OLIVEIRA²⁵, Y. LEMA-CAPEANS⁷⁹, A. LETESSIER-SELVON³⁶, I. LHENRY-YVON³⁵, L. LOPES⁷³, L. LU⁹¹, Q. LUCE⁴⁰, J.P. LUNDQUIST⁷⁶, A. MACHADO PAYERAS²², M. MAJERCAKOVA³³, D. MANDAT³³, B.C. MANNING¹³, P. MANTSCH⁹⁸, F.M. MARIANI^{60,50}, A.G. MARIAZZI³, I.C. MARIS¹⁴, G. MARSELLA^{62,48}, D. MARTELLO^{57,49}, S. MARTINELLI^{42,7}, O. MARTÍNEZ BRAVO⁶⁵, M.A. MARTINS⁷⁹, H.-J. MATHES⁴², J. MATTHEWS⁹², G. MATTHIAE^{63,52}, E. MAYOTTE^{85,39}, S. MAYOTTE⁸⁵, P.O. MAZUR⁹⁸, G. MEDINA-TANCO⁶⁹, J. MEINERT³⁹, D. MELO⁷, A. MENSCHIKOV⁴¹, C. MERX⁴², S. MICHAL³³, M.I. MICHELETTI⁵, L. MIRAMONTI^{60,50}, S. MOLLERACH¹, F. MONTANET³⁷, L. MOREJON³⁹, C. MORELLO^{55,53}, K. MULREY^{80,81}, R. MUSSA⁵³, W.M. NAMASAKA³⁹, S. NEGRI³³, L. NELLEN⁶⁹, K. NGUYEN⁸⁷, G. NICORA⁹, M. NIECHCIOL⁴⁵, D. NITZ⁸⁷, D. NOSEK³², V. NOVOTNY³², L. NOŽKA³⁴, A. NUCITA^{57,49}, L.A. NÚÑEZ³¹, C. OLIVIERA²⁰, M. PALATKA³³, J. PALLOTA⁹, S. PANJA³³, G. PARENTE⁷⁹, T. PAULSEN³⁹, J. PAWLOWSKY³⁹, M. PECH³³, J. PEKALA⁷¹, R. PELAYO⁶⁶, L.A.S. PEREIRA²⁴, E.E. PEREIRA MARTINS^{40,7}, J. PEREZ ARMAND²¹, C. PÉREZ BERTOLLI^{7,42}, L. PERRONE^{57,49}, S. PETRERA^{46,47}, C. PETRUCCI^{58,47}, T. PIEROG⁴², M. PIMENTA⁷³, M. PLATINO⁷, B. PONT⁸⁰, M. POTHAST^{81,80}, M. POURMOHAMMAD SHAHVAR^{62,48}, P. PRIVITERA⁸⁹, M. PROUZA³³, S. QUERCHFELD³⁹, J. RAUTENBERG³⁹, D. RAVIGNANI⁷, J.V. REGINATTO AKIM²², M. REININGHAUS⁴⁰, J. RIDKY³³, F. RIEHN⁷⁹, M. RISSE⁴⁵, V. RIZI^{58,47}, W. RODRIGUES DE CARVALHO⁸⁰, E. RODRIGUEZ^{7,42}, J. RODRIGUEZ ROJO¹¹, M.J. RONCORONI⁷, S. ROSSONI⁴⁴, M. ROTH⁴², E. ROULET¹, A.C. ROVERO⁴, P. RUEHL⁴⁵, A. SAFTOU⁷⁴, M. SAHARAN⁸⁰, F. SALAMIDA^{58,47}, H. SALAZAR⁶⁵, G. SALINA⁵², J.D. SANABRIA GOMEZ³¹, F. SÁNCHEZ⁷, E.M. SANTOS²¹, E. SANTOS³³, F. SARAZIN⁸⁵, R. SARMENTO⁷³, R. SATO¹¹, P. SAVINA⁹¹, C.M. SCHÄFER⁴⁰, V. SCHERINI^{57,49}, H. SCHIELER⁴², M. SCHIMASSEK³⁵, M. SCHIMP³⁹, D. SCHMIDT⁴², O. SCHOLTEN^{15,101}, H. SCHOORLEMMER^{80,81}, P. SCHOVÁNEK³³, F.G. SCHRÖDER^{90,42}, J. SCHULTE⁴³, T. SCHULZ⁴², S.J. SCIUTTO³, M. SCORNAVACCHE^{7,42}, A. SEDOSKI⁷, A. SEGRETO^{54,48}, S. SEHGAL³⁹, S.U. SHIVASHANKARA⁷⁶, G. SIGL⁴⁴, G. SILLI⁷, O. SIMA^{74,94}, K. SIMKOVA¹⁵, F. SIMON⁴¹, R. SMAU⁷⁴, R. SMÍDA⁸⁹, P. SOMMERS¹⁰³, J.F. SORIANO⁸⁶, R. SQUARTINI¹⁰, M. STADELMAIER^{50,60,42}, S. STANIČ⁷⁶, J. STASIELAK⁷¹, P. STASSI³⁷, S. STRÄUB⁴⁰, M. STRAU⁴³, T. SUOMIJÄRVI³⁸, A.D. SUPANITSKY⁷, Z.N. SVOZILKOVA³³, Z. SZADKOWSKI⁷², F. TAIRLI¹³, A. TAPIA³⁰, C. TARICCO^{64,53}, C. TIMMERMANS^{81,80}, O. TKACHENKO⁴², P. TOBISKA³³, C.J. TODERO PEIXOTO¹⁹, B. TOMÉ⁷³, Z. TORRÈS³⁷, A. TRAVAINI¹⁰, P. TRAVNICEK³³, C. TRIMARELLI^{58,47}, M. TUEROS³, M. UNGER⁴², L. VACLAVEK³⁴, M. VACULA³⁴, J.F. VALDÉS GALICIA⁶⁹, L. VALORE^{61,51}, E. VARELA⁶⁵, A. VÁSQUEZ-RAMÍREZ³¹, D. VEBERIĆ⁴², C. VENTURA²⁸, I.D. VERGARA QUISPE³, V. VERZI⁵², J. VÍCHA³³, J. VINK⁸³, S. VOROBIOV⁷⁶, C. WATANABE²⁷, A.A. WATSON⁹⁶, A. WEINDL⁴², L. WIENCKE⁸⁵, H. WILCZYŃSKI⁷¹, D. WITTKOWSKI³⁹, B. WUNDERHEILER⁷, B. YUE³⁹, A. YUSHKOV³³, O. ZAPPARRATA¹⁴, E. ZAS⁷⁹, D. ZAVRTANIK^{76,77}, and M. ZAVRTANIK^{77,76} — ¹Centro Atómico Bariloche and Instituto Balseiro (CNEA-UNCuyo-CONICET), San Carlos de Bariloche, Argentina — ²Departamento de Física and Departamento de Ciencias de la Atmósfera y los Océanos, FCEyN, Universidad de Buenos Aires and CONICET, Buenos Aires, Argentina — ³IFLP, Universidad Nacional de La Plata and CONICET, La Plata, Argentina — ⁴Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA), Buenos Aires, Argentina — ⁵Instituto de Física de Rosario (IFIR) - CONICET/U.N.R. and Facultad de Ciencias Bioquímicas y Farmacéuticas U.N.R., Rosario, Argentina — ⁶Instituto de Tecnologías en Detección y Astroparticulas (CNEA, CONICET, UN-

SAM), and Universidad Tecnológica Nacional - Facultad Regional Mendoza (CONICET/CNEA), Mendoza, Argentina — ⁷Instituto de Tecnologías en Detección y Astroparticulas (CNEA, CONICET, UNSAM), Buenos Aires, Argentina — ⁸International Center of Advanced Studies and Instituto de Ciencias Físicas, ECT-UNSAM and CONICET, Campus Miguelete - San Martín, Buenos Aires, Argentina — ⁹Laboratorio Atmósfera - Departamento de Investigaciones en Láseres y sus Aplicaciones - UNIDEF (CITEDEF-CONICET), Argentina — ¹⁰Observatorio Pierre Auger, Malargüe, Argentina — ¹¹Observatorio Pierre Auger and Comisión Nacional de Energía Atómica, Malargüe, Argentina — ¹²Universidad Tecnológica Nacional - Facultad Regional Buenos Aires, Buenos Aires, Argentina — ¹³University of Adelaide, Adelaide, S.A., Australia — ¹⁴Université Libre de Bruxelles (ULB), Brussels, Belgium — ¹⁵Vrije Universiteit Brussels, Brussels, Belgium — ¹⁶Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, RJ, Brazil — ¹⁷Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Petropolis, Brazil — ¹⁸Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro (IFRJ), Brazil — ¹⁹Universidade de São Paulo, Escola de Engenharia de Lorena, Lorena, SP, Brazil — ²⁰Universidade de São Paulo, Instituto de Física de São Carlos, São Carlos, SP, Brazil — ²¹Universidade de São Paulo, Instituto de Física, São Paulo, SP, Brazil — ²²Universidade Estadual de Campinas (UNICAMP), IFGW, Campinas, SP, Brazil — ²³Universidade Estadual de Feira de Santana, Feira de Santana, Brazil — ²⁴Universidade Federal de Campina Grande, Centro de Ciências e Tecnologia, Campina Grande, Brazil — ²⁵Universidade Federal do ABC, Santo André, SP, Brazil — ²⁶Universidade Federal do Paraná, Setor Palotina, Palotina, Brazil — ²⁷Universidade Federal do Rio de Janeiro, Instituto de Física, Rio de Janeiro, RJ, Brazil — ²⁸Universidade Federal do Rio de Janeiro (UFRJ), Observatório do Valongo, Rio de Janeiro, RJ, Brazil — ²⁹Universidade Federal Fluminense, EEIMVR, Volta Redonda, RJ, Brazil — ³⁰Universidad de Medellín, Medellín, Colombia — ³¹Universidad Industrial de Santander, Bucaramanga, Colombia — ³²Charles University, Faculty of Mathematics and Physics, Institute of Particle and Nuclear Physics, Prague, Czech Republic — ³³Institute of Physics of the Czech Academy of Sciences, Prague, Czech Republic — ³⁴Palacky University, Olomouc, Czech Republic — ³⁵CNRS/IN2P3, IJCLab, Université Paris-Saclay, Orsay, France — ³⁶Laboratoire de Physique Nucléaire et de Hautes Energies (LPNHE), Sorbonne Université, Université de Paris, CNRS-IN2P3, Paris, France — ³⁷Univ. Grenoble Alpes, CNRS, Grenoble Institute of Engineering Univ. Grenoble Alpes, LPSC-IN2P3, 38000 Grenoble, France — ³⁸Université Paris-Saclay, CNRS/IN2P3, IJCLab, Orsay, France — ³⁹Bergische Universität Wuppertal, Department of Physics, Wuppertal, Germany — ⁴⁰Karlsruhe Institute of Technology (KIT), Institute for Experimental Particle Physics, Karlsruhe, Germany — ⁴¹Karlsruhe Institute of Technology (KIT), Institut für Prozessdatenverarbeitung und Elektronik, Karlsruhe, Germany — ⁴²Karlsruhe Institute of Technology (KIT), Institute for Astroparticle Physics, Karlsruhe, Germany — ⁴³RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany — ⁴⁴Universität Hamburg, II. Institut für Theoretische Physik, Hamburg, Germany — ⁴⁵Universität Siegen, Department Physik - Experimentelle Teilchenphysik, Siegen, Germany — ⁴⁶Gran Sasso Science Institute, L'Aquila, Italy — ⁴⁷INFN Laboratori Nazionali del Gran Sasso, Assergi (L'Aquila), Italy — ⁴⁸INFN, Sezione di Catania, Catania, Italy — ⁴⁹INFN, Sezione di Lecce, Lecce, Italy — ⁵⁰INFN, Sezione di Milano, Milano, Italy — ⁵¹INFN, Sezione di Napoli, Napoli, Italy — ⁵²INFN, Sezione di Roma Tor Vergata, Roma, Italy — ⁵³INFN, Sezione di Torino, Torino, Italy — ⁵⁴Istituto di Astrofisica Spaziale e Fisica Cosmica di Palermo (INAF), Palermo, Italy — ⁵⁵Osservatorio Astrofisico di Torino (INAF), Torino, Italy — ⁵⁶Politecnico di Milano, Dipartimento di Scienze e Tecnologie Aerospaziali, Milano, Italy — ⁵⁷Università del Salento, Dipartimento di Matematica e Fisica E. De Giorgi, Lecce, Italy — ⁵⁸Università dell'Aquila, Dipartimento di Scienze Fisiche e Chimiche, L'Aquila, Italy — ⁵⁹Università di Catania, Dipartimento di Fisica e Astronomia Ettore Majorana, Catania, Italy — ⁶⁰Università di Milano, Dipartimento di Fisica, Milano, Italy — ⁶¹Università di Napoli Federico II, Dipartimento di Fisica *Ettore Pancini*, Napoli, Italy — ⁶²Università di Palermo, Dipartimento di Fisica e Chimica *E. Segre*, Palermo, Italy — ⁶³Università di Roma Tor Vergata, Dipartimento di Fisica, Roma, Italy — ⁶⁴Università Torino, Dipartimento di Fisica, Torino, Italy — ⁶⁵Benemérita Universidad Autónoma de Puebla, Puebla, México — ⁶⁶Unidad Profesional Interdisciplinaria en Ingeniería y Tecnologías Avanzadas del Instituto Politécnico Nacional (UPIITA-IPN), México, D.F., México — ⁶⁷Universidad Autónoma de Chiapas, Tuxtla Gutiérrez, Chiapas, México — ⁶⁸Universidad Mi-

choacana de San Nicolás de Hidalgo, Morelia, Michoacán, México — ⁶⁹Universidad Nacional Autónoma de México, México, D.F., México — ⁷⁰Universidad Nacional de San Agustín de Arequipa, Facultad de Ciencias Naturales y Formales, Arequipa, Peru — ⁷¹Institute of Nuclear Physics PAN, Krakow, Poland — ⁷²University of Łódź, Faculty of High-Energy Astrophysics, Łódź, Poland — ⁷³Laboratório de Instrumentação e Física Experimental de Partículas - LIP and Instituto Superior Técnico - IST, Universidade de Lisboa - UL, Lisboa, Portugal — ⁷⁴Horia Hulubei National Institute for Physics and Nuclear Engineering, Bucharest-Magurele, Romania — ⁷⁵Institute of Space Science, Bucharest-Magurele, Romania — ⁷⁶Center for Astrophysics and Cosmology (CAC), University of Nova Gorica, Nova Gorica, Slovenia — ⁷⁷Experimental Particle Physics Department, J. Stefan Institute, Ljubljana, Slovenia — ⁷⁸Universidad de Granada and C.A.F.P.E., Granada, Spain — ⁷⁹Instituto Galego de Física de Altas Enerxías (IGFAE), Universidade de Santiago de Compostela, Santiago de Compostela, Spain — ⁸⁰IMAPP, Radboud University Nijmegen, Nijmegen, The Netherlands — ⁸¹Nationaal Instituut voor Kernfysica en Hoge Energie Fysica (NIKHEF), Science Park, Amsterdam, The Netherlands — ⁸²Stichting Astronomisch Onderzoek in Nederland (ASTRON), Dwingeloo, The Netherlands — ⁸³Universiteit van Amsterdam, Faculty of Science, Amsterdam, The Netherlands — ⁸⁴Case Western Reserve University, Cleveland, OH, USA — ⁸⁵Colorado School of Mines, Golden, CO, USA — ⁸⁶Department of Physics and Astronomy, Lehman College, City University of New York, Bronx, NY, USA — ⁸⁷Michigan Technological University, Houghton, MI, USA — ⁸⁸New York University, New York, NY, USA — ⁸⁹University of Chicago, Enrico Fermi Institute, Chicago, IL, USA — ⁹⁰University of Delaware, Department of Physics and Astronomy, Bartol Research Institute, Newark, DE, USA — ⁹¹University of Wisconsin-Madison, Department of Physics and WIPAC, Madison, WI, USA — ⁹²Louisiana State University, Baton Rouge, LA, USA — ⁹³Institut universitaire de France (IUF), France — ⁹⁴also at University of Bucharest, Physics Department, Bucharest, Romania — ⁹⁵now at ECAP, Erlangen, Germany — ⁹⁶School of Physics and Astronomy, University of Leeds, Leeds, United Kingdom — ⁹⁷now at Agenzia Spaziale Italiana (ASI). Via del Politecnico 00133, Roma, Italy — ⁹⁸Fermi National Accelerator Laboratory, Fermilab, Batavia, IL, USA — ⁹⁹now at Graduate School of Science, Osaka Metropolitan University, Osaka, Japan — ¹⁰⁰Max-Planck-Institut für Radioastronomie, Bonn, Germany — ¹⁰¹also at Kapteyn Institute, University of Groningen, Groningen, The Netherlands — ¹⁰²Colorado State University, Fort Collins, CO, USA — ¹⁰³Pennsylvania State University, University Park, PA, USA

Coll 18: SHADOWS-Collaboration

C. AHDIDA¹, M. ALVIGGI², S. BACHMANN³, W. BALDINI⁴, A. BALLA⁵, M. BARTH³, M. BIGLIETTI⁶, V. BÜSCHER⁷, A. CALCATERRA⁵, V. CAFARO⁸, N. CHARITONIDIS¹, A. CECCUCCI¹, D. CHOUHAN⁷, V. CICERO⁸, P. CIAMBRONE⁵, H. DANIELSSON¹, M. DELLA PIETRA², C. C. DELOU⁷, A. DE ROECK¹, L. DITTMAN³, F. DUVAL¹, L. ESPOSITO¹, G. FELICI⁵, T. FERBER⁹, L. FOGGETTA⁵, E. GAMBERINI¹, M. GATTA⁵, A. GERBERSHAGEN¹⁰, V. GIORDANO⁸, S. HANSMANN-MENZEMER³, P. IENGO¹¹, M. IODICE¹¹, K. JAKOBS¹², J. KIESELER⁹, L. P. KRZEMPEK¹, M. KLUTE⁹, K. KONEKE¹², M. KOVAL¹³, G. LANFRANCHI⁵, A. LAUDRAIN⁷, I. LAX⁸, T. M. LEEFLANG³, G. LEHMANN MIOTTO¹, G. LERNER¹, B. LEVERINGTON³, P. LICHARD¹, K. MASSRI¹, A. MONTANARI⁸, R. MURPHY^{1,14}, T. NAPOLITANO⁵, E. NOWAK¹, L. J. NEVAY¹, S. NIANG¹, A. PAOLONI⁵, G. PAPALINO⁵, U. PARZEFALL¹², B. REGNER⁹, S. RITTER⁷, S. ROSATI¹⁵, T. ROVELLI^{16,8}, S. ROY³, F. SANCHEZ GALAN¹, A. SAPUTI⁴, B. SCHMIDT¹, D. SCHUB³, H. C. SCHULTZ-COULON³, G. SEKHNIADZE², R. STAMER³, F. STUMMER^{1,14}, G. TORRAMEO⁸, N. TOSI⁸, N. TREVISANI⁷, U. UWER³, M. SCHOTT⁷, M. VAN DIJK¹, A. VANNOZZI⁵, C. WANG⁷, R. WANKE⁷, C. WEISER¹², C. WELSCHOFF³, P. WERTELAERS¹⁶, and T. ZICKLER¹ — ¹CERN, European Organization for Nuclear Research, CH-1211 Geneva 23, Switzerland — ²INFN, Sezione di Napoli, Napoli, Italy — ³Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany — ⁴INFN, Sezione di Ferrara, Ferrara, Italy — ⁵INFN Laboratori Nazionali di Frascati, Frascati (Rome), Italy — ⁶INFN, Sezione di Roma III, Roma, Italy — ⁷Johannes Gutenberg Universität Mainz, Mainz, Germany — ⁸INFN, Sezione di Bologna, Bologna, Italy — ⁹Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — ¹⁰PARTREC and University of Groningen, Groningen, The Netherlands — ¹¹INFN, Sezione di Roma III, Roma, Italy — ¹²University of Freiburg, Freiburg, Germany — ¹³Charles University, Prague, Czech Republic — ¹⁴Royal Holloway, University of London, UK — ¹⁵INFN, Sezione di Roma I, Roma, Italy — ¹⁶University of Bologna, Bologna,

Italy

Coll 19: SHiP-SBT-Collaboration

FLORIAN REHBEIN¹, ALESSIA BRIGNOLI², ANDREW CONABOY², CONSTANTIN ECKART², HEIKO LACKER², ANUPAMA REGHUNATH², CHRISTIAN SCHARF², THOMAS BRETZ³, HORST FISCHER⁴, FAIRHURST LYONS⁴, TIM MOLZBERGER⁴, SANTIAGO OCHOA⁴, SANI PATEL⁴, TILMAN ROCK⁴, MARC SCHUMANN⁴, HARALD GLÜCKLER⁵, GHALEB NATOUR^{5,1}, MICHAEL SCHAAP⁵, DAVID ARUTINOV⁶, CHRISTIAN GREWING⁶, FLORIAN RÖSSING⁶, STEFAN VAN WAASEN⁶, ANDRÉ

ZAMBANINI⁶, MANUEL BÖHLES⁷, PATRICK DEUCHER⁷, ANNIKA HOLLNAGEL⁷, JOHANNES MOLINS I BERTRAM⁷, OSCAR WINIKER⁷, MICHAEL WURM⁷, CRISTIANA DI CRISTO⁸, ORESTE FECAROTTA⁸, ANTIMO FIORILLO⁸, GIUSEPPE DEL GIUDICE⁸, ANDREA MIANO⁸, ANDREA PROTA⁸, ANTONIO SALZANO⁸, and OLEG BEZSHYYKO⁹ — ¹RWTH Aachen (DE) — ²HU Berlin (DE) — ³GSI Darmstadt (DE) — ⁴ALU Freiburg (DE) — ⁵FZ Jülich, ZEA-1 (DE) — ⁶FZ Jülich, ZEA-2 (DE) — ⁷JGU Mainz (DE) — ⁸Uni Napoli Federico (IT) — ⁹TSNU Kyiv (UA)