

Addendum 2

**CONCERNING THE
DEEP UNDERGROUND NEUTRINO EXPERIMENT PROGRAM**

**Under the
PROJECT ANNEX
TO THE IMPLEMENTING ARRANGEMENT
BETWEEN
THE MINISTRY OF EDUCATION, UNIVERSITIES AND
RESEARCH OF THE ITALIAN REPUBLIC
AND
THE DEPARTMENT OF ENERGY
OF THE UNITED STATES OF AMERICA
FOR COOPERATION
IN THE AREAS OF HIGH ENERGY,
ASTROPARTICLE AND NUCLEAR PHYSICS
CONCERNING NEUTRINO PHYSICS RESEARCH**

The Ministry of Universities and Research of the Italian Republic (MUR) and the Department of Energy of the United States of America (DOE), hereinafter referred to as the "Parties":

ACTING pursuant to Section 6.B of the Project Annex Concerning Neutrino Physics Research of July 17, 2015 (the "Project Annex"), which the Parties entered into pursuant to Section 4 of the Implementing Arrangement between the Ministry of Education, Universities and Research of the Italian Republic and the Department of Energy of the United States of America for Cooperation in High Energy, Astroparticle, and Nuclear Physics Research and Related Fields and Technologies of July 17, 2015 (the "Implementing Arrangement");

RECOGNIZING that MUR is the successor agency to the former Ministry of Education, Universities and Research of the Italian Republic for cooperation under the Project Annex and Implementing Arrangement; and

DESIRING to augment the Project Annex with a description of the international Deep Underground Neutrino Experiment Program at the Long-Baseline Neutrino Facility, hosted by the United States, and an outline of the scope of their respective work and responsibilities associated with the international Deep Underground Neutrino Experiment Program,

Have agreed as follows:

Section 1 – Objective and Participants

- A. The objective of this Addendum 2 to the Project Annex is to describe the international Deep Underground Neutrino Experiment (DUNE) Program at the Long-Baseline Neutrino Facility (LBNF), hosted by DOE's Fermi National Accelerator Laboratory (Fermilab), and to define the scientific and technical cooperation and responsibilities of the respective Parties in the DUNE Program.
- B. The cooperative activities described in Section 3 of this Addendum 2 shall be performed by DOE's Fermilab for DOE, and MUR's Istituto Nazionale di Fisica Nucleare (INFN) for MUR, hereinafter individually referred to as "Participant" or collectively as the "Participants."

Section 2 – The DUNE Program

- A. The DUNE Program is directed to the understanding of the physics of neutrinos. The scientific goals of this Program include, but are not limited to, the following:
 - 1. Provide unprecedented insights into oscillation neutrino physics using the highest intensity neutrino beams in the world;
 - 2. Measure neutrino parameters such as the CP-violating phase, δ_{CP} , resolve the neutrino mass hierarchy, and precisely measure the oscillation angles Θ_{23} and Θ_{13} ;
 - 3. Study the interactions of neutrinos with argon nuclei to high precision;
 - 4. Explore hints of new physics by searching for non-standard neutrino interactions using the next generation of large underground detectors; and
 - 5. Further develop the advanced instrumentation technologies required for future international DUNE and LBNF Programs.

- B. The DUNE Program is comprised of two experimental neutrino detector facilities. Both are located along the neutrino beamline that originates from Fermilab and are needed to achieve the science goals of the Program.
- C. The two DUNE experimental detector facilities are:
1. The DUNE Far Detector (hereinafter "DUNE FD"): Situated 1,500 meters underground at the Sanford Underground Research Facility in South Dakota, this detector is designed to study neutrino interactions using liquid argon time projection chambers; and
 2. The DUNE Near Detector (hereinafter "DUNE ND"), located 574 meters downstream from the neutrino beam source at Fermilab in Illinois and 1,300 kilometers from the DUNE FD.
- D. At the time of signature of this Addendum 2, the DUNE experimental detector systems to which INFN shall contribute include:
1. Two liquid argon modules in the DUNE FD for a total of 34 kilotons, one known as the "horizontal drift" module and a second one known as the "vertical drift" module; and
 2. A DUNE ND assembly which will include an on-axis neutrino detector identified as System for on-Axis Neutrino Detection (SAND), it being understood that: a) INFN's contribution to SAND is a critical part of the overall international DUNE Program though it is outside the current U.S. LBNF/DUNE project (and its associated project completion), which is being undertaken by DOE in accordance with DOE Order 413.3B regarding project management for the acquisition of capital assets; and b) the SAND installation schedule is planned to be coordinated with Fermilab and the DUNE Program.

Section 3 – Areas of Cooperation

- A. INFN shall contribute resources in the form of hardware and scientific, engineering, and technical personnel as follows:
1. In collaboration with other members of the DUNE collaborating institutions (hereinafter "DUNE Collaboration"), scientific contributions include, but are not limited to, the following areas:
 - i. Design, research and development, fabrication, and operations of detectors;

- ii. Computational simulation of neutrino physics processes;
 - iii. Analysis of data and dissemination of scholarly publications;
 - iv. Training of graduate students and junior scientists;
 - v. Exchange of personnel for reviews and project activities; and
 - vi. Public engagement and outreach activities.
- 2. Contributions to the software and computing resources and architecture of the DUNE experiment.
- 3. For the DUNE FD, in-kind contributions for the following items:
 - i. The DUNE FD light collection system, by providing a share of the associated silicon photomultipliers, optical components, and related electronics. The contributions will be included for both the horizontal drift module and for the vertical drift module.
- 4. For the DUNE ND, in-kind contributions for the following items:
 - i. The magnet and calorimeter system that were deployed in the KLOE experiment's detector at the DAΦNE collider at INFN's Frascati National Laboratory (hereinafter "KLOE Components"), it being understood that INFN's activities for the KLOE Components shall include their necessary refurbishment, maintenance, and subsequent delivery to Fermilab in accordance with the schedule and acceptance criteria to be developed by the DUNE Collaboration in consultation with the Participants. Once delivered, the refurbished KLOE Components shall form detector subsystems of the SAND detector;
 - ii. Cryogenic components for the magnet and for the Liquid Argon target to be built, installed, and operated in collaboration with Fermilab;
 - iii. Electronics, power supplies, and trigger systems for the SAND calorimeter and magnet; and
 - iv. Contribution to the development of the inner tracking system of SAND and of an active compact Liquid Argon target to be installed within the volume of the refurbished KLOE Components.
- 5. Support of overall DUNE experimental operations by providing:
 - i. Support for the maintenance and repair of INFN-provided systems; and
 - ii. Support for scientists to undertake the institutional share of physics data-taking shifts within the DUNE Collaboration, as required for the efficient and safe operations of the DUNE detectors.

B. Fermilab shall contribute resources as follows:

- 1. Provide facilities for the execution of the DUNE Program, including:

- i. Accelerators and the associated neutrino beamline for DUNE;
 - ii. Experimental halls including infrastructure such as AC power distribution, computer and data networking, and building cranes;
 - iii. Safe working environments to conduct activities; and
 - iv. Engineering support for external cryogenic systems, cryogenic system integration, and process control systems to be built, installed by INFN, and operated in collaboration with INFN.
 - 2. Support for the installation of the DUNE ND and FD in their respective experimental halls. This support shall include:
 - i. Providing technical coordination for each detector and associated subsystems; and
 - ii. Providing certain specialized technical services such as crane operation and welding services.
 - 3. Along with the DUNE Collaboration, support for the commissioning, experimental, and physics operation of DUNE that shall include:
 - i. Technical staff to operate the cryogenics systems; and
 - ii. Physics control room facilities located near the DUNE ND and FD experimental halls.
 - 4. Provide oversight of activities regarding environmental and safety standards; provide support for carrying out safety reviews and obtaining necessary operational readiness clearances; and provide the necessary training for users to carry out the functions of installation, maintenance, and operation of the detectors.
- C. The Parties may consider making subsequent plans of further in-kind contributions to the program identified under this Addendum 2, which shall be documented in subsequent Project Annexes pursuant to Section 4 of the Implementing Arrangement, or in amendments to this Addendum 2 in accordance with Section 8.C.

Section 4 – Contributions and Other Written Instruments

- A. INFN shall provide funding for the DUNE FD, of up to \$20 million in total (following standard DOE accounting practice), as in-kind contributions to the scope of work identified in paragraph A.3 of Section 3 of this Addendum 2.
- B. INFN shall provide funding for the DUNE ND for a total of \$100 million (following standard DOE accounting practice), of which up to \$70 million is the value of the

KLOE Components specified in paragraph A.4.i of Section 3 of this Addendum 2 and up to \$30 million is to be allocated for the KLOE refurbishing, the SAND components, cryogenic system, and activities specified in paragraphs A.4.i through A.4.iv of Section 3 of this Addendum 2.

- C. The contributions identified in paragraphs A and B of Section 3 of this Addendum 2 are expected to follow appropriate quality assurance and quality control processes to be identified in the written instruments referred to in paragraph D of this Section, and follow all applicable environmental, safety, health, and radiological control regulations and standards.
- D. Additional information on planned scope of work, itemized list of deliverables, or other intended research and development, cooperative activities, or operations activities to be performed under this Addendum 2 may be exchanged and memorialized by and between the Parties and/or their Participants through non-binding written instruments such as project planning documents, letters of intent, or memoranda of understanding. Such instruments may cover, but are not limited to, requirements and specifications of equipment, performance and/or personnel to be exchanged, definition of task responsibilities within a specific area of the project, schedules and milestones, project review processes, risk management, coordination, contributions, standards of safety, and adjustments of organizational structure as needed.

Section 5 – DUNE Resources Review Board

INFN shall be a member of the DUNE Resources Review Board (RRB), composed of representatives of each participating funding agency that makes contributions to the DUNE Program. The DUNE RRB, chaired by a representative of Fermilab, monitors and oversees resource-related matters concerning DUNE, and provides advice to the Fermilab Directorate on these issues.

Section 6 – Contributions by INFN to the DUNE Common Projects

- A. INFN, in cooperation with the DUNE Collaboration, shall contribute, in whole or in part, to the provision of items for the DUNE Program considered as part of common projects which are the responsibility of the overall DUNE Collaboration (hereinafter “Common Projects”). Such items shall be funded directly or indirectly by all participants in the DUNE Collaboration, and their provision shall be subject to approval by the DUNE RRB in accordance with its role identified in Section 5. Such

participant contributions shall be specified in appropriate written instruments as identified in Section 4.D of this Addendum 2.

- B. Cash contributions from INFN, in furtherance of cooperation with the DUNE Collaboration, including contributions to "Common Funds" for costs associated with Common Projects, shall be specified in appropriate written instruments as identified in Section 4.D of this Addendum 2.

Section 7 – Exchange of Equipment and Ownership of Property

- A. All equipment purchased by MUR for use in the Italian scientific program shall be the property of the Government of the Italian Republic or a MUR collaborating institution in Italy.
- B. Notwithstanding Section 8 of the Implementing Arrangement, unless otherwise mutually agreed by the Parties in writing, the Parties agree that all DOE-owned equipment sent to MUR by DOE as part of their collaboration under this Addendum 2 shall become the property of, and title shall pass to, the Government of the Italian Republic in the event and at the time MUR or its designated collaborating institution in Italy provides written confirmation that it has met the acceptance criteria specified in memoranda of understanding and/or other written instruments as identified in Section 4.D of this Addendum 2.
- C. Notwithstanding Section 8 of the Implementing Arrangement, unless otherwise mutually agreed by the Parties in writing, the Parties agree that all MUR-owned equipment sent to DOE by MUR as part of their collaboration under this Addendum 2 shall become the property of, and title shall pass to, the Government of the United States of America in the event and at the time DOE provides written confirmation that it has met the acceptance criteria specified in memoranda of understanding and/or other written instruments as identified in Section 4.D of this Addendum 2.

Section 8 – General Provisions

- A. This Addendum 2 is subject to the terms and conditions of the Project Annex, which is itself subject to the Implementing Arrangement, which is itself subject to and governed by the Agreement between the Government of the Italian Republic and the Government of the United States of America for Scientific and Technological Cooperation of April 1, 1988, as amended and extended.

- B. This Addendum 2 shall enter into force upon signature by the Parties and remain in force so long as the Project Annex remains in force, unless earlier terminated by the Parties.
- C. This Addendum 2 may be terminated at any time by the written agreement of both Parties; or by either Party at its discretion, upon sixty (60) days advance notice in writing to the other Party. This Addendum 2 may be amended by written agreement of the Parties, provided the Project Annex remains in force.

DONE at Washington, this 9th day of April 2024, in duplicate, in the English language.


**FOR THE MINISTRY OF
UNIVERSITIES AND RESEARCH
OF THE ITALIAN REPUBLIC:**



Anna Maria Bernini

Minister of Universities and Research

**FOR THE DEPARTMENT OF
ENERGY OF THE
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Harriet Kung

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