PROJECT ANNEX
TO THE IMPLEMENTING ARRANGEMENT
BETWEEN
THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA
AND
THE DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY OF THE UNITED KINGDOM
FOR
RESEARCH AND DEVELOPMENT IN ENERGY AND PHYSICAL SCIENCE FIELDS
CONCERNING COOPERATION IN THE AREA OF NEUTRINO AND ACCELERATOR SCIENCE AND TECHNOLOGY FOR HIGH ENERGY PHYSICS

The Department of Energy of the United States of America (DOE) and the Department for Business, Energy and Industrial Strategy of the United Kingdom (BEIS), hereinafter referred to as the "Agencies":

Acting pursuant to Section VI of the Implementing Arrangement between the Department of Energy of the United States of America and the Department for Business, Energy and Industrial Strategy of the United Kingdom for Research and Development in Energy and Physical Science Fields, signed in Washington, D.C. on April 10 and 11, 2019, hereinafter referred to as the "Implementing Arrangement";

Desiring to establish a framework for cooperation and collaboration in neutrino and accelerator science and technology between laboratories and collaborating institutions

funded by DOE in the United States and by BEIS and its supporting agencies and public bodies in the United Kingdom; and

Recognizing the value and mutual benefits of collaboration in these areas that will lead to greater understanding of the fundamental nature of the universe, and facilitate progress in other basic research disciplines and applied areas for the advancement of science and technology in the Agencies' countries,

HAVE REACHED THE FOLLOWING UNDERSTANDING:

Section 1
Definitions

For purposes of this Project Annex, the definitions in Section I of the Implementing Arrangement apply.

Section 2
Objective and Scientific Goals

A. The objective of this Project Annex is to establish the framework for cooperation in neutrino and accelerator science and technology between the Agencies. Cooperative activities are expected to be conducted by DOE's Fermi National Accelerator Laboratory ("Fermilab"), BEIS's executive agency United Kingdom Research and Innovation, acting through its Science and Technology Facilities Council ("STFC"), and other associated Participants, including national laboratories, research centers, and universities of both Agencies.

B. This Project Annex is subject to the provisions of the Implementing Arrangement, which is itself subject to the Agreement between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland on Scientific and Technological Cooperation, signed at Washington on September 20, 2017 (the "S&T Agreement"). In the event of any conflict between the provisions of the S&T Agreement or the Implementing Arrangement on the one hand and this Project Annex on the other hand, the provisions of the S&T Agreement and the Implementing Arrangement are intended to prevail.

C. STFC intends to participate in the Fermilab-hosted Short- and Long-Baseline Neutrino Programs, which are directed to the understanding of the physics of neutrinos. The scientific goals of these Programs include, but are not limited to, the following:

1. Provide unprecedented insights into the oscillation neutrino physics using the highest intensity neutrino beams in the world;
2. Measure neutrino parameters such as the CP-violating phase, δCP, resolve the mass hierarchy and precisely measure the oscillation angles Θ_{23} and Θ_{13};
3. Explore anomalous hints of new physics by measuring neutrino oscillations, particularly to learn about whether a new family of Sterile neutrinos exists;
4. Study the interactions of neutrinos with argon nuclei to high precision; and
5. Further develop the technologies, including those of liquid argon time projection chambers, required for the planned international Long-Baseline Neutrino Program.

Section 3
Areas of Cooperation

Cooperation under this Project Annex may include, but is not limited to, the following areas:

A. Scientific Cooperation

1. Research and development and simulation of detectors
2. Maintenance and operation of detectors
3. Analysis of data and dissemination of scholarly publications
4. Training of graduate students and junior scientists
5. Exchange of personnel for reviews and project activities

B. Technical and Engineering Cooperation

1. Detector technology for the Deep Underground Neutrino Experiment (DUNE), hosted by the United States
    a. Liquid Argon Time Projection Chamber components
    b. Detector design and fabrication
    c. High-precision charged particle tracking
    d. Electromagnetic and hadron calorimeters
    e. Muon detectors
    f. Data acquisition systems
    g. High-performance electronics
    h. High-performance computing

2. Beamline science and technology for the Long-Baseline Neutrino Facility (LBNF), hosted by the United States
    a. High-power, particle-beam systems

b. High-power target facility beam-intercepting components including targets, horns, beam windows, and absorbers
c. High-power target facility machine protection components including collimators, baffles, and beam-on-target monitors
d. High-power target facility component cooling systems
e. High-power target facility radiation protection infrastructure including remote handling and shielding systems
f. Simulation and modeling of physics and thermo-mechanical performance of high-power target facility beam components

3. Accelerator science and technology for the Proton Improvement Plan-II (PIP-II) Linear Accelerator, hosted by the United States
   a. Fabrication of three (3) high-beta 650 MHz (β=0.92, HB650) cryomodules, as an in-kind contribution to the construction phase of the PIP-II Project. This includes the procurement, integration, production, shipment and delivery of three (3) complete cryomodules ready for qualification testing at Fermilab.
   b. Superconducting radio-frequency accelerator technology including cavity manufacture, tooling, testing, and quality assurance
   c. Cryogenic systems including cold mass, pipe-work, instrumentation, and cryogenic interfaces
   d. Cryomodule components including manufacture of cryogenic vessel, heat and thermal shields, alignment fixtures, assembly, and quality management
   e. High-power radio-frequency power handling including couplers, tuners and their operational integration and quality management

4. Short-Baseline Neutrino Program, hosted by the United States
   a. Time Projection Chamber design and fabrication

C. Development of Technical Information

The Agencies plan to develop, either independently or jointly, physics experiments design and parameters, specifications and design tolerances of components, technical requirements, and infrastructure requirements, in conformance with applicable safety and building code standards.

The development of technical information is planned to be done within the framework to be jointly developed by the Agencies' Technical Coordinators designated pursuant to Section VII of the Implementing Arrangement. Technical information may be shared with and between the Participants as appropriate.

Section 4
Participants

Each Agency may invite other government agencies and organizations and private organizations in its country to participate in cooperative activities under this Project Annex, at such Participants' own expense and subject to such provisions as the Agencies may specify in instruments referred to in Section 5.F.6 of this Project Annex and/or Contracts in accordance with Section VIII of the Implementing Arrangement.

Section 5
Forms of Cooperation

Cooperative activities carried out under this Project Annex may include, but are not limited to, the following:

A. Development and Exchange of Technical Information and Experiences, and Collaborative Visits

The Agencies plan to develop, jointly or independently, technical design of the items listed in Section 3. Design and experience developed by the Agencies under this Project Annex may be exchanged in accordance with Section X of the Implementing Arrangement. The Agencies may arrange collaborative visits of scientific and technical personnel. These visits may address research and development programs for the items listed in Section 3.

B. Technology Development

The Agencies plan to explore the need for demonstrations in order to show the technical and economic feasibility of the technologies in areas of cooperation set out in Section 3 of this Project Annex.

C. Ownership of Assets

1. Unless otherwise mutually decided by the Agencies in writing, all equipment purchased by BEIS, STFC, or other BEIS agencies or United Kingdom public bodies for use in the United Kingdom scientific program is intended to be the property of the Government of the United Kingdom of Great Britain and Northern Ireland.

2. Unless otherwise mutually decided by the Agencies in writing, all equipment purchased by DOE for use in the United States scientific program is intended to be the property of the Government of the United States of America.

3. Unless otherwise mutually decided by the Agencies in writing, all equipment sent to BEIS or STFC by DOE as a part of their collaboration under this Project Annex is intended to become the property of, and title is intended to pass to, the Government of the United Kingdom of Great Britain and Northern Ireland in the event and at the time BEIS or STFC provides written confirmation that it has met the acceptance criteria specified in project planning documents and/or other written instruments as identified in paragraph F.6 of this Section.

4. Unless otherwise mutually decided by the Agencies in writing, all equipment sent to DOE by BEIS or STFC as a part of their collaboration under this Project Annex is intended to become the property of, and title is intended to 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 project planning documents and/or other written instruments as identified in paragraph F.6 of this Section.

D. Intellectual Property

The protection and allocation of intellectual property, and the treatment of business-confidential information, are subject to Sections X and XI of the Implementing Arrangement and Annexes I and II to the S&T Agreement. Where necessary, additional relevant provisions applicable to activities undertaken by each Agency's Participants may be specified in instruments referred to in Section 5.F.6 of this Project Annex and/or Contracts in accordance with Section VIII of the Implementing Arrangement, as appropriate.

E. Professional Training

The Agencies plan to explore the need to train their respective professionals in technologies listed in Section 3.

F. Contributions from the Agencies:

1. The Agencies intend to make leading scientific and in-kind contributions to each other's scientific programs, as described in Section 3 of this Project Annex.

2. STFC engagements across the combined scope of DUNE, LBNF, and PIP-II, amounting to up to GBP 65 million, are the planned in-kind contributions from BEIS, which include analysis, engineering, design, technology development,

supporting infrastructure, integration, testing, quality assurance, attendance of relevant meetings and construction site visits for prolonged periods as necessary, and specific in-kind deliverables as necessary for the project in the areas described in Section 3 and/or supporting or related areas.

3. To enable and support these contributions, DOE, through Fermilab, plans to contribute the appropriate corresponding specifications, processes, reports, simulations, qualification of components, assembly, training, and other information and procedures.

4. Contributions are expected to follow appropriate quality processes to be identified in the written instruments referred to in paragraph F.6 of this Section, and to satisfy all applicable environmental, safety, health, and radiological control standards. DOE is expected to be responsible for maintaining safe working environments for DUNE, LBNF, and PIP-II activities at DOE facilities, and may intercede in any such cooperative activity to ensure compliance with standards and regulations.

5. The itemized list and schedule of deliverables from both sides is expected to be determined by mutual written decision of the Technical Coordinators.

6. 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 Project Annex may be exchanged and memorialized by and between the Agencies 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 for safety, and adjustments of organizational structure as needed.

7. The Agencies may consider making subsequent plans of further in-kind contributions to the programs identified under Section 3 of this Project Annex, to be documented in subsequent Project Annexes pursuant to Section VI of the Implementing Arrangement, or in modifications to this Project Annex in accordance with Section 8.B.

Section 6
Management

A. The Technical Coordinators designated pursuant to Section VII of the Implementing Arrangement or their designees are expected to jointly plan the technical approach for accomplishing the objective of this Project Annex, and to be responsible for the collaborative program, schedule, and coordination. The Technical Coordinators or their designees also are expected to make progress reports at management meetings to be held at sites on which the participants jointly decide, preferably annually. The Technical Coordinators are expected to be responsible for developing any associated instruments, pursuant to Section 5.F.6 of this Project Annex, and/or modifications to this Project Annex, pursuant to Section 8.B of this Project Annex, that specify design decisions and deliverables.

B. Each Agency is expected to exercise due care of budget, schedule, safety and other applicable requirements in carrying out all the work under this Project Annex.

Section 7
General Provisions

A. Each Agency is expected to conduct the cooperation contemplated by this Project Annex in accordance with applicable laws and regulations to which it is subject, including those relating to export controls, and international agreements to which its government is party.

B. Any questions of interpretation or implementation relating to this Project Annex arising during its term are expected to be resolved by consultations between the Agencies in accordance with Section XV of the Implementing Arrangement.

C. Any ongoing joint activities, projects or experiments under this Project Annex not completed upon the discontinuation of the Implementing Arrangement or this Project Annex may be continued until their completion in accordance with Section XVI of the Implementing Arrangement and the provisions of this Project Annex.

Section 8
Commencement, Duration, Modification and Discontinuation

A. Cooperation under this Project Annex may commence upon signature by both Agencies and continue so long as the Implementing Arrangement remains in effect.

B. This Project Annex may be modified by mutual written consent of the Agencies.

C. The Agencies may discontinue their participation in this Project Annex at any time by mutual written consent. Alternatively, an Agency that wishes to discontinue its participation in this Project Annex is expected to provide at least six (6) months advance written notice to the other Agency.

D. This Project Annex does not create any legally binding obligations between the Agencies.

Signed at London, in duplicate, this 22nd day of January 2020.

FOR THE DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY OF THE UNITED KINGDOM:	FOR THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA:
Chris Skidmore **Minister of State** **Universities, Science, Research and Innovation**	**Christopher Fall** **Director** **Office of Science**