

Memorandum of Understanding  
among

Fermi National Accelerator Laboratory

Science and Technology Facilities Research Council

The Chancellor Masters and Scholars of the University of Oxford

Brookhaven National Laboratory

Pacific Northwest National Laboratory

Concerning

Cooperation in the Area of Radiation Damage In Accelerator Target  
Environments  
(the RaDIATE Collaboration)

This Memorandum of Understanding (MOU) sets forth the understanding of the signatories, referred to herein as the “Participants”, concerning cooperation on the response of materials to Radiation Damage In Accelerator Target Environments (RaDIATE), specifically high energy proton particle beam. The Participants recognize their mutual interest in those activities which develop a better understanding of radiation damage mechanisms and the associated thermal and mechanical properties response for materials of interest to future high power proton beam target facilities.

Possible cooperation under this MOU includes, but is not limited to, the areas of cooperation identified in 1.0.

**1.0 Planned Cooperation**

1.1 Materials under investigation:

- 2.1.1 Polycrystalline fine-grained graphite
- 2.1.2 Commercially available structural grades of beryllium
- 2.1.3 Tungsten and high-density tungsten alloys
- 2.1.4 Carbon-Carbon composite materials

- 1.2 Properties under investigation:
  - 1.2.1 Thermal diffusion (heat capacity, conduction)
  - 1.2.2 Tensile properties (yield & ultimate strengths, elastic modulus, ductility)
  - 1.2.3 Fracture toughness
  - 1.2.4 Fatigue
  - 1.2.5 Thermal expansion
  - 1.2.6 Dimensional stability (swelling, void formation)
  - 1.2.7 In-situ and post-irradiation annealing characteristics
  - 1.2.8 General corrosion characteristics (weight loss)
  
- 1.3 Irradiation environments under investigation (as appropriate for each material/application):
  - 2.3.1 Proton energy (100 MeV – 120 GeV)
  - 2.3.2 Irradiation temperature (500-1400 C)
  - 2.3.3 Atmosphere (inert, vacuum, Low-humidity air)
  - 2.3.4 Displacements per atom (0.1 – 10 DPA)

## **2. Relationship to Other Programs**

The above areas of cooperation may support elements of a coherent program that may include (but is not limited to):

- 2.1 Long Baseline Neutrino Experiment
- 2.2 Pulsed high-power proton source (Project X) experimental facilities
- 2.3 The International Design Study for the Neutrino Factory
- 2.4 The Muon Collider Design Study
- 2.5 The potential future upgrade of the ISIS pulsed neutron source towards a megawatt primary beam power.

## **3. Forms of Cooperation**

- 3.1 Short and long-term visits to each other's facilities, subject to appropriate written arrangements
- 3.2 Exchange of publicly available information
- 3.3 Conduct of workshops, seminars, and other meetings.

## **4. General Considerations**

- 4.1 This MOU establishes a framework for organizing and executing the RaDIATE program via a multi-institutional collaboration. The general organizing principles of the Collaboration include the following:

- 4.1.1 Fermi National Accelerator Laboratory intends to manage the RaDIATE program, including through the appointment of the Program Manager.
- 4.1.2 The Program Manager is to oversee execution of the RaDIATE program. This includes organization and management of the program activities, development of schedules, preparation of periodic progress reports, and setting the direction for future program activities. The Program Manager is to deal directly with individual Participants on program matters.
- 4.1.3 A Collaboration Council is to be established to advise and assist the Program Manager in the area of inter-institution coordination. The Collaboration Council is to consist of representatives, one designated by each Participant, who are to act as contact persons to whom correspondence is to be addressed.
- 4.2 This MOU does not create any legally binding obligations between or among the Participants.
- 4.3 Each Participant is responsible for the costs it incurs in participating in cooperative activities under this MOU.
- 4.4 Cooperative activities under this MOU may commence upon signature by the Participants and continue for a 5-year period unless earlier discontinued. A Participant that wishes to discontinue its participation in the activities contemplated by this MOU should endeavor to provide the other Participants at least 30 days written prior notice. This MOU may be modified by the mutual consent of all Participants in writing.
- 4.5 Each Participant should conduct the cooperation under this MOU in accordance with applicable laws and regulations to which it is subject, and international agreements to which its Government is a party.
- 4.6 Upon mutual written consent, the Participants may invite additional organizations to participate in cooperative activities conducted under this MOU.
- 4.7 The conduct of cooperative activities contemplated by this MOU is subject to the availability of funding, personnel, and other resources.

Signed in quintuplicate:

For Fermi National Accelerator Laboratory:



6/21/13

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Stuart Henderson  
Associate Laboratory Director for Accelerators

Date

For Science and Technology Facilities Research Council:



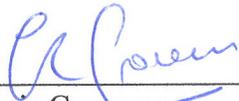
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Andrew Taylor  
Executive Director  
National Laboratories

Date

For The Chancellor Masters and Scholars of the University of Oxford:



7/11/13

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Professor Chris Grovenor  
Head of Department of Materials

Date

For Brookhaven National Laboratory:



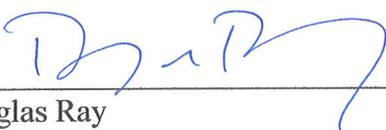
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Doon Gibbs  
Laboratory Director

Date

For Pacific Northwest National Laboratory:



7/22/13

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Douglas Ray  
Associate Laboratory Director for  
Fundamental and Computational Sciences

Date