

# Memorandum of Understanding

## Concerning

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

This Memorandum of Understanding (MOU) is among Fermi National Laboratory, Science and Technology Facilities Council, the Chancellor Masters and Scholars of Oxford University, Brookhaven National Laboratory, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, Michigan State University, European Spallation Source, Los Alamos National Laboratory, Argonne National Laboratory, and Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Center of Energy, Environmental and Technological Research), referred to herein as the "Participants".

DESIRING to cooperate on the response of materials to Radiation Damage In Accelerator Target Environments (RaDIATE), specifically that resulting from high energy particle beam interactions with matter; and

RECOGNIZING 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 accelerator target facilities,

The Participants have reached the following understanding:

#### **1.0 Planned Cooperation**

Possible cooperation under this MOU includes, but is not limited to:

- 1.1 Materials under investigation:
  - 1.1.1 Polycrystalline fine-grained graphite
  - 1.1.2 Commercially available structural grades of beryllium
  - 1.1.3 Tungsten and high-density tungsten alloys
  - 1.1.4 Carbon-Carbon composite materials
  - 1.1.5 Titanium alloys
  - 1.1.6 Austenitic stainless steels
  - 1.1.7 Tantalum
  - 1.1.8 Aluminium alloys
  - 1.1.9 Nickel-based super-alloys
  - 1.1.10 Ferritic-martensitic steels
  - 1.1.11 Other target, beam window, and collimator candidate 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/Creep-fatigue
  - 1.2.5 Thermal expansion
  - 1.2.6 Dimensional stability (swelling, void formation) and irradiation creep
  - 1.2.7 In-situ and post-irradiation annealing characteristics
  - 1.2.8 General corrosion characteristics (weight loss)
  - 1.2.9 Microstructural evaluation
  
- 1.3 Typical irradiation environments under investigation (as appropriate for each material/application):
  - 1.3.1 Particle energy (1 MeV – 400 GeV)
  - 1.3.2 Irradiation temperature (100 - 2000 C)
  - 1.3.3 Atmosphere (inert, vacuum, Low-humidity air, water)
  - 1.3.4 Displacements per atom (greater than 0.1 DPA)

## **2.0 Relationship to Other Programs**

The subject areas cited in Section 1.0 may support elements of a coherent program that may include (but is not limited to):

- 2.1 Neutrino Super-beams (e.g. Long Baseline Neutrino Facility, HyperK)
- 2.2 Pulsed high-power proton source (Fermilab PIP-2) experimental facilities
- 2.3 The International Design Study for the Neutrino Factory
- 2.4 The Muon Collider Design Study
- 2.5 The potential future upgrades of the ISIS pulsed neutron source
- 2.6 The Facility for Rare Isotope Beams
- 2.7 The Spallation Neutron Source (SNS) First Target Station
- 2.8 The SNS Second Target Station
- 2.9 The European Spallation Source Target Station
- 2.10 LANSCE Isotope Production Facility
- 2.11 Lujan Scattering Facility
- 2.12 GSI – FAIR (Facility for Anti-proton and Ion Research)
- 2.13 The International Fusion Materials Irradiation Facility (IFMIF)
- 2.14 The Intermediate Voltage Electron Microscope (IVEM)-Tandem Facility
- 2.15 The Extreme Materials Beamline (XMAT)

## **3.0 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.

#### 4.0 General Considerations

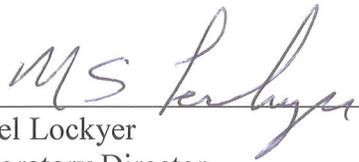
- 4.1 This MOU establishes a framework for organizing and executing the RaDIATE program via a multi-institutional collaboration. The general organizing principles of the collaboration include the following:
  - 4.1.1 Fermi National Accelerator Laboratory intends to manage the RaDIATE program, including 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 created 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 to be 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 in accordance with Section 4.5.
- 4.5 The Participants may discontinue this MOU at any time in writing by mutual consent. 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.
- 4.6 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.
- 4.7 Upon mutual written consent, the Participants may invite additional organizations to participate in cooperative activities conducted under this MOU.

- 4.8 The conduct of cooperative activities contemplated by this MOU is subject to the availability of funding, personnel, and other resources.
- 4.9 This MOU supersedes the Memorandum of Understanding Concerning Cooperation in the Area of Radiation Damage In Accelerator Target Environments signed July 22, 2013.

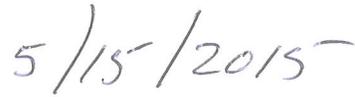
Signed in twelve originals.



For Fermi National Accelerator Laboratory:



Nigel Lockyer  
Laboratory Director



Date:  
Place: Batavia



For Science and Technology Facilities Research Council:



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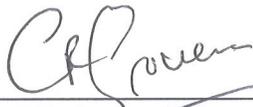
Andrew Taylor  
Executive Director  
National Laboratories

20 APRIL 2015

Date:  
Place: Didcot



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



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Professor Chris Grover  
Head of Department of Materials

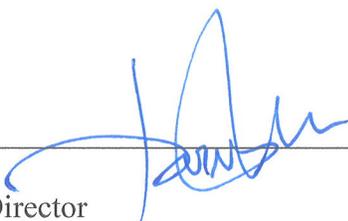


Date:  
Place: Oxford



For Brookhaven National Laboratory:

Doon Gibbs  
Laboratory Director

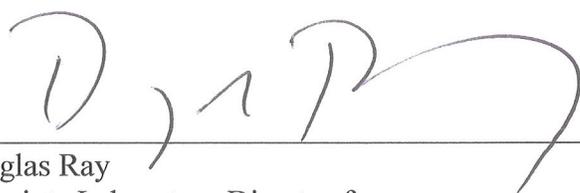


4/10/15

Date:  
Place: Upton



For Pacific Northwest National Laboratory:



May 4, 2015

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Douglas Ray  
Associate Laboratory Director for  
Fundamental and Computational Sciences

Date:  
Place: Richland



For Oak Ridge National Laboratory:

*Paul Langan*

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Paul Langan  
Associate Laboratory Director  
Neutron Sciences Directorate

*4/8/15*

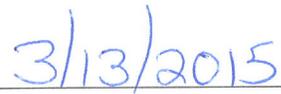
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For Michigan State University:



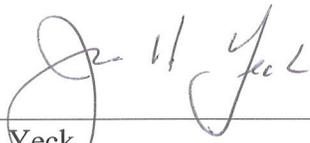
Dan Evon  
Director, Contract and Grant Administration



Date:  
Place: East Lansing



For European Spallation Source:



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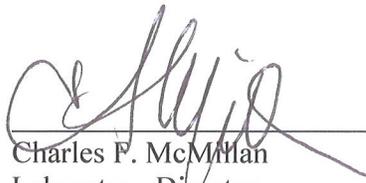
James Yeck  
Chief Executive & Director General

07 May 2015

Date:  
Place: Lund



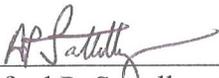
For Los Alamos National Laboratory:

  
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Charles F. McMillan  
Laboratory Director

5/11/15  
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Date:  
Place: Los Alamos



For Argonne National Laboratory:



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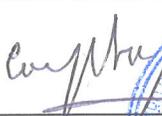
Alfred P. Sattelberger  
Deputy Laboratory Director for Programs

4/9/15

Date:  
Place: Lemont



For Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas:



D. Cayetano Lopez  
General Director



Date: 24 MAR. 2015  
Place: Madrid

