NNUF UKAEA-MRF Facility Experiments:

Investigation of proton-irradiation induced damage in POCO graphite

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**Background**

- Student on this project: Eric Jiang (2nd year; Funded by the US Fermi National Accelerator Laboratory)
- Why POCO graphite?

$1.5bn Long Baseline Neutrino Facility (LBNF)
- UK are expected to contribute ~$500 m to Dune and LBNF

**In collaboration with Fermilab (U.S.) and RaDIATE.**

The schematic of Deep Underground Neutrino Experiment (DUNE)

**Neutrino Beam Recipe**

- Magnetic Focusing Horn
- Decay Pipe
- Neutrons, Neutrinos

**Ceramic-Matrix Composites**

CMCs consist of ceramic fibres embedded in a ceramic matrix, offering excellent high-temperature performance and improved fracture toughness compared to monolithic ceramics and metals. We use in situ high temperature tomography, digital volume correlation, nanodentation, high temperature and micro-Raman spectroscopy to investigate their mechanical behaviours in aerospace and nuclear applications.

Researchers: Pavel Ferna-Kreutzer, Guanjie Yuan, Bingyu Liu, Mengji Dai, Dr Dipali Sonawane

**MAX Phases**

MAX-Phases are layered carbides, nitrides and borides with unique and compelling properties suitable for extreme environments such as radiation resistant nuclear reactor parts. The key to harnessing these materials is to understand their microstructural changes as they deform. We use in-situ neutron diffraction to investigate their mechanical behaviour.

Researcher: Ainee Coleman

**TRISO Nuclear Fuel**

TRISO particles contain a kernel of uranium-based material coated in protective carbon and silicon carbide for strength and to stop radioactive products escaping. These ~1 mm particles are packed into a ceramic or graphite pellet to fuel high temperature reactors. We study the structure, residual stresses and thermal/mechanical properties of these particles and pellets using X-ray tomography, electron microscopy, micromechanical testing, Raman spectroscopy, and transient thermomechanical techniques.

Researchers: Heaiju Huang, Dr Alex Leide

**Neutron Detectors**

Neutron detectors are needed for a large range of applications, from materials science to the nuclear industry. Novel materials including nanoparticles are being developed and investigated for the next generation of scintillation-based neutron detectors.

Researchers: Sarah Mann
**Background**

**Aim:** Study the degradation in terms of microstructure, physical and thermo-mechanical properties of POCO graphite.

Graphite fin array, composed of 47 segmented fins.

- **Proton beam direction**
- **Cooling water**
- **Downstream (DS)**
- **Upstream (US)**
- **Horn**

- **Graphite fin**
- Fracture ~15 mm
- ~6 mm
- ~2 mm
- ~20 mm

47 graphite fins
UKAEA (Culham) MRF:

- Receiving and storage of hot samples:
  - Proton irradiated - hot materials beyond university limits
  - Shipped from the USA PNNL to Materials Research Facility, UKAEA (Culham)

- Experiments (two rounds about 14 days in total):
  - Micro-Raman spectroscopy
  - FIB-tomography
  - TEM foils liftouts for post analysis in Bristol

- Key outcome:
  - Overall irradiation damage on the graphite crystallites at various distances away from the beam centre
  - Porosity evolution
  - Successful TEM samples

- Follow-up experiments:
  - TEM analysis
  - Synchrotron beamline diffraction experiments at RAL
  - Comparison with other types of fine grain graphite