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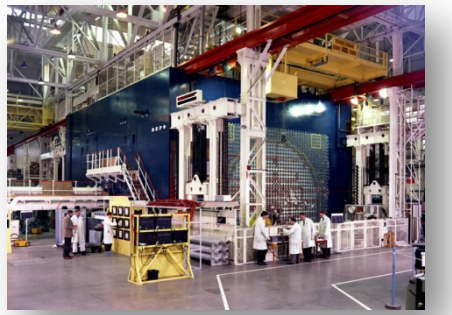
Research Centre for Radwaste & Decommissioning

Nuclear Graphite Research

Dr. Abbie Jones, Profs Paul Mummery and Barry Marsden

Nuclear Engineering Decommissioning
The University of Manchester



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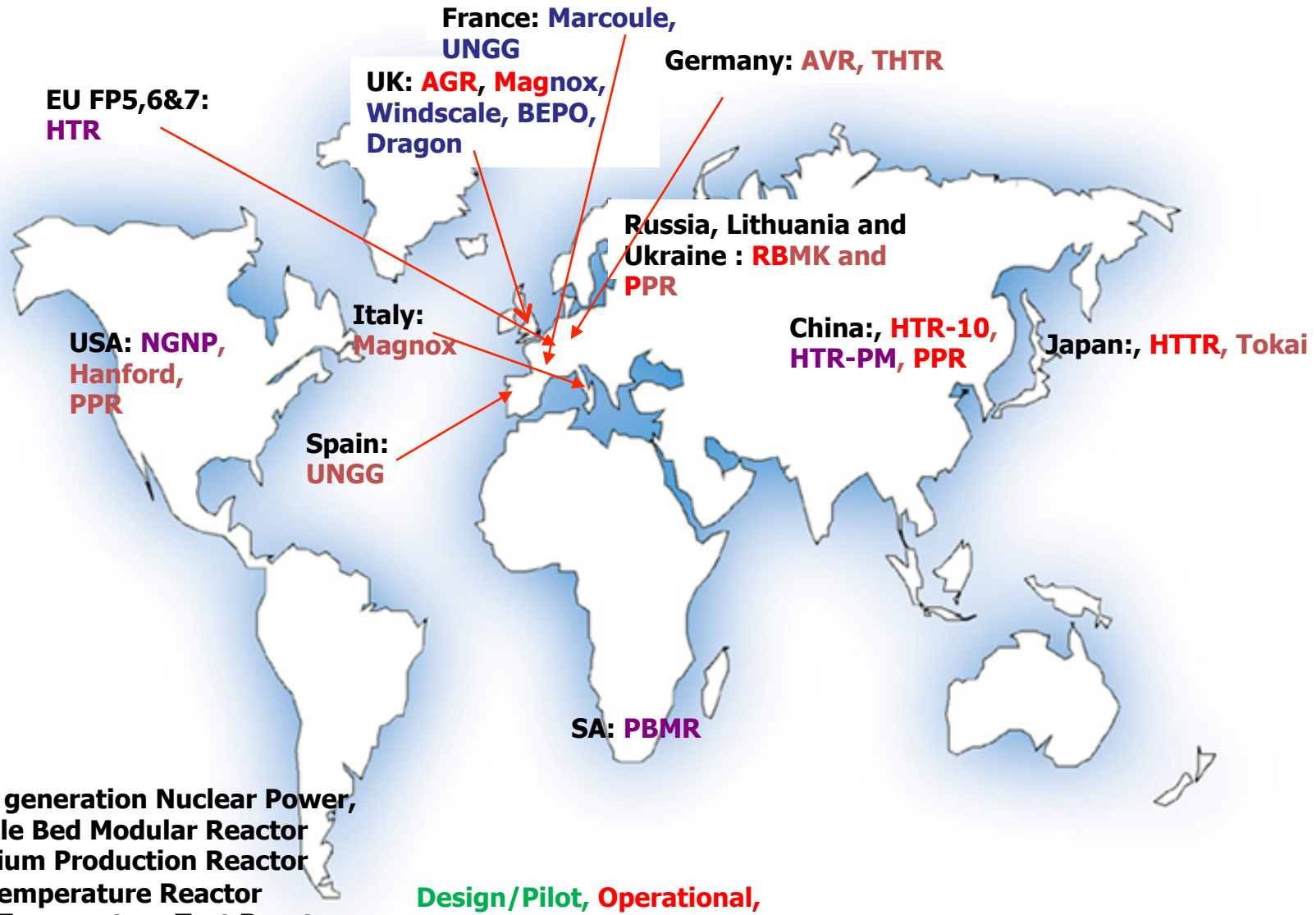
Graphite moderated reactors: Past, present and future



NGNP: Next generation Nuclear Power,
PBMR: Pebble Bed Modular Reactor
PPR: Plutonium Production Reactor
HTR: High Temperature Reactor
HTTR: High Temperature Test Reactor
UNGG: Uranium Naturel Graphite Gaz

Design/Pilot, Operational, Decommissioning

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Graphite moderated reactors: future

USA

NGNP

NEWS MEDIA CONTACT: FOR IMMEDIATE RELEASE:

(202) 586-4940 Monday, March 8, 2010

Secretary Chu Announces $40 Million to Develop the Next Generation Nuclear Plant

WASHINGTON, DC - U.S. Secretary of Energy Steven Chu today announced selections for the award of approximately $40 million in total to two teams led by Pittsburgh-based Westinghouse Electric Co. and San Diego-based General Atomics for conceptual design and planning work for the Next Generation Nuclear Plant (NGNP). The results of this work will help the Administration determine whether to proceed with detailed efforts toward construction and demonstration of the NGNP. If successful, the NGNP Demonstration Project will demonstrate *high-temperature gas-cooled reactor technology* that will be capable of producing electricity as well as process heat for industrial applications and will be configured for low technical and safety risk with highly reliable operations. Final cost-shared awards are subject to the negotiation of acceptable terms and conditions.

China

HTR-PM

40 yr life, 700 tonnes graphite IG-110
He cooled, 750°C outlet, 2 x 250MW

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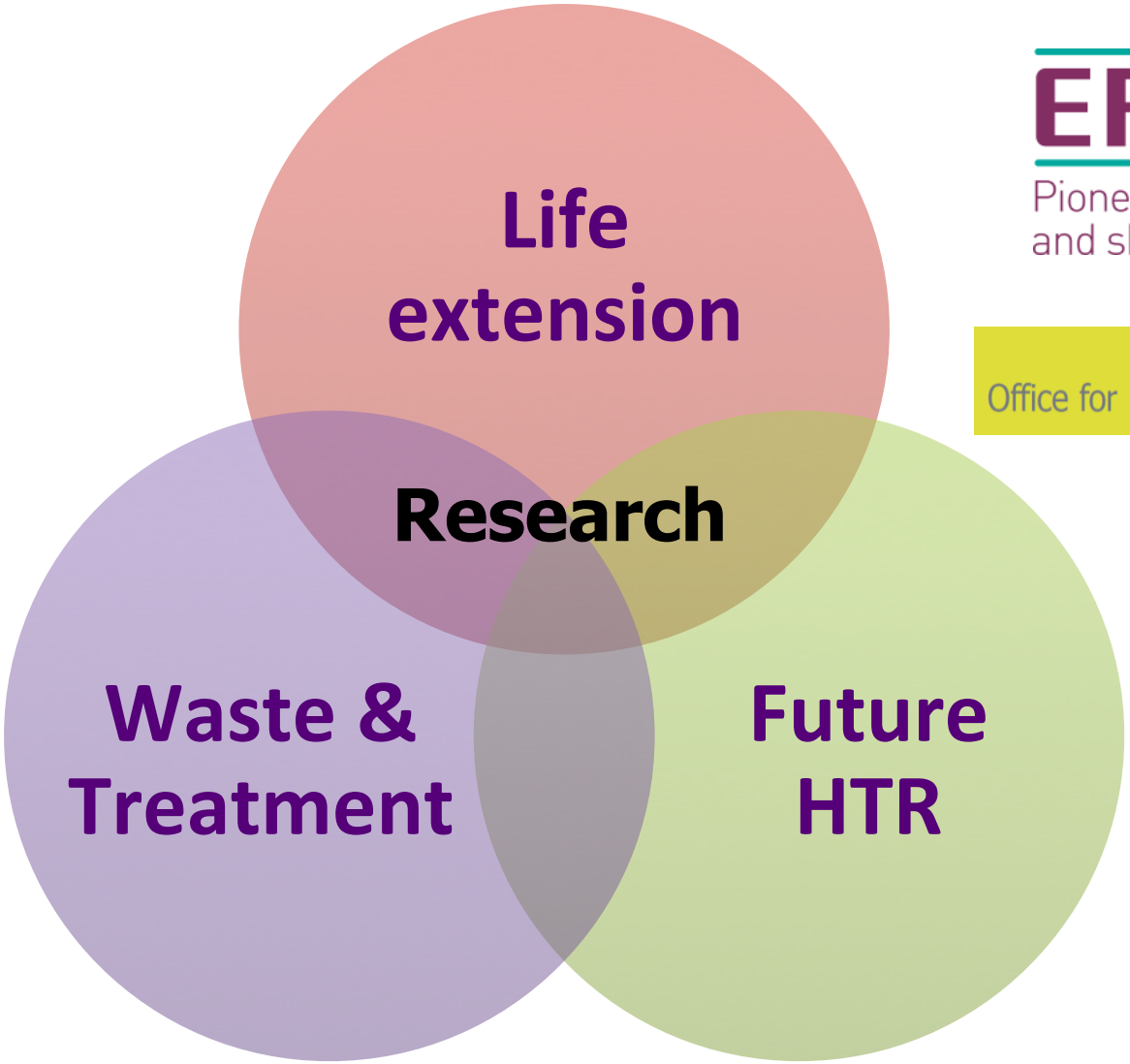
Graphite moderated reactor research:



ARBOWASTE

IAEA
International Atomic Energy Agency

NDA
Nuclear Decommissioning Authority

EPSRC
Pioneering research and skills

An agency of HSE
Office for Nuclear Regulation

HSE
Health & Safety Executive

SEVENTH FRAMEWORK PROGRAMME

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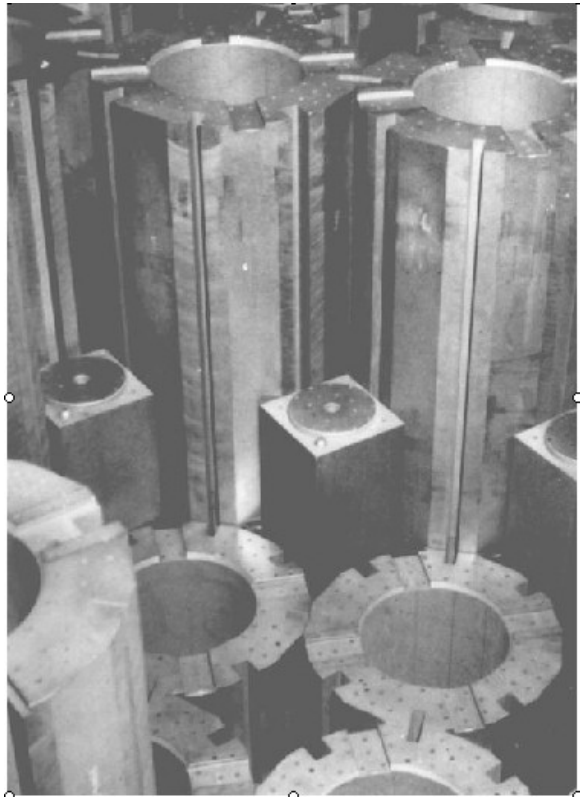
EPSRC
Pioneering research and skills

FUN-GRAF

Fundamentals of current and future uses of nuclear graphite



EPSRC Nuclear Fission - Call for Consortia
Sept 10 – Feb 14
Funding £1.5M supported by EPSRC for 3.5Years

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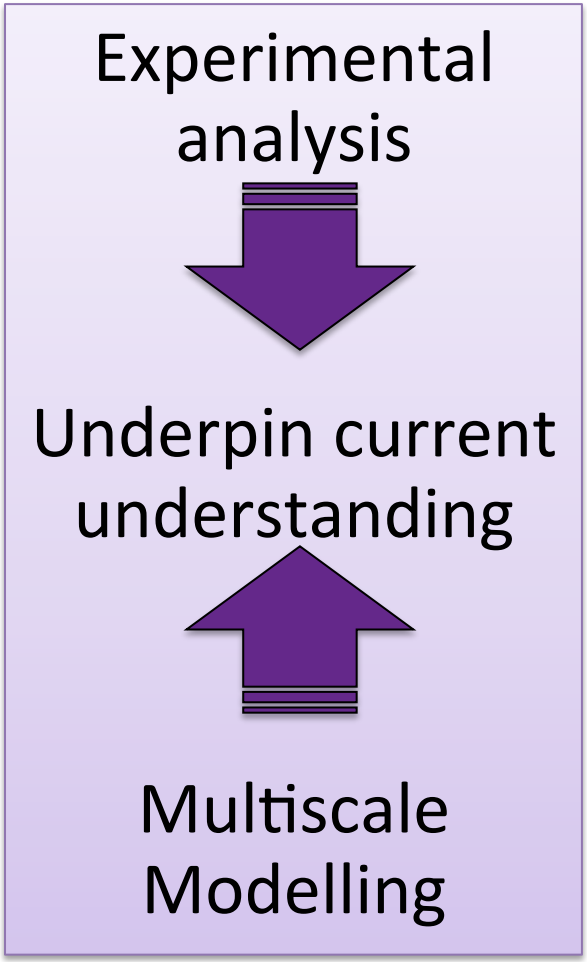
Strategy

- Post-irradiation examination using state-of-the-art electron microscopy, with theoretical support for structural analysis.
- In-situ irradiation experiments in TEM
- State-of-the-art cold neutron scattering for structure and vibrational properties
- Materials modelling based on first principles calculation, with parameter passing from atomic scale to crystallite scale to polycrystalline scale to …
- … component level Finite Element modelling.
- Enhanced impact by underpinning : ***AGR, HTR, PBMR, VHTR, NGNP*** designs



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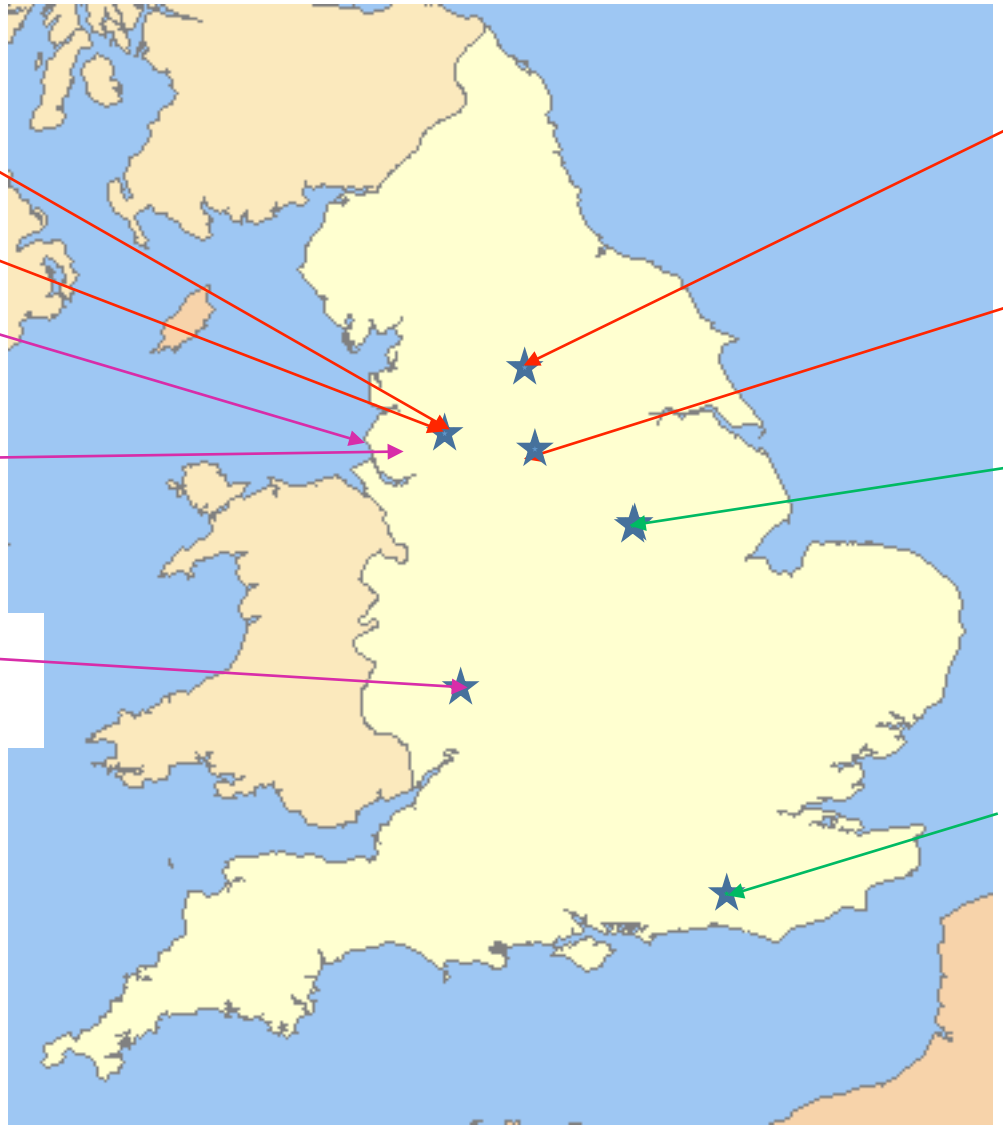
Consortium and supporters



Manchester:

Salford:

HSE/NII:

AMEC (SERCO)

British Energy and NNL:

:Leeds

Huddersfield

:Nottingham

:Sussex

Theory/computation, Experiment, Industry

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CARBOWASTE

'Treatment and Disposal of Irradiated Graphite and other Carbonaceous Waste'

- 6M€ EURATOM Framework 7 Project
- Consortium of 30 European partners (6 from UK)
- UoM work focuses on:-
  - WP3 Characterisations
  - WP4 Treatment
  - WP6 Long term behaviour

Work Package 1

- Identify magnitude of problem and major options from toolbox

Work Package 2

- Retrieval of i-graphite and interim storage considerations

Work Package 3

- Characterise structure, properties and contamination of i-graphite

Work Package 4

- Select i-graphite treatment options and determine decontamination factors

Work Package 5

- Re-use/ recycle and manufacture of new products

Work Package 6

- Determine long term disposal behaviour and waste packages/ conditioning

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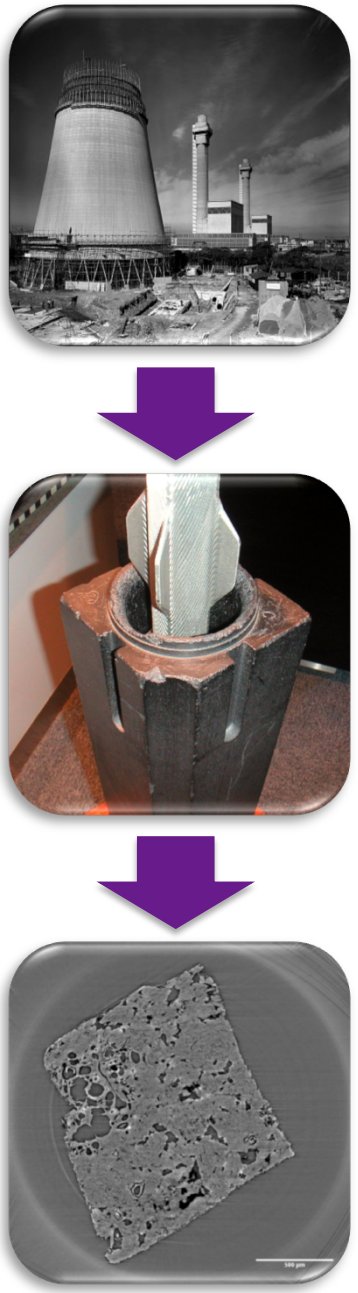
Disposal Options for irradiated graphite

- **Characterise**
  - Origin of Isotopes in the graphite
  - Location of radioisotopes within the microstructure
- **Reduce isotopic content**
  - Pre-treatment of materials prior to disposal
- **Remove**
  - Direct chemical and physical thermal treatment using controlled chemical processes
- **Contain**
  - Encapsulation
  - Requires an understanding of the final waste form behaviour under repository conditions



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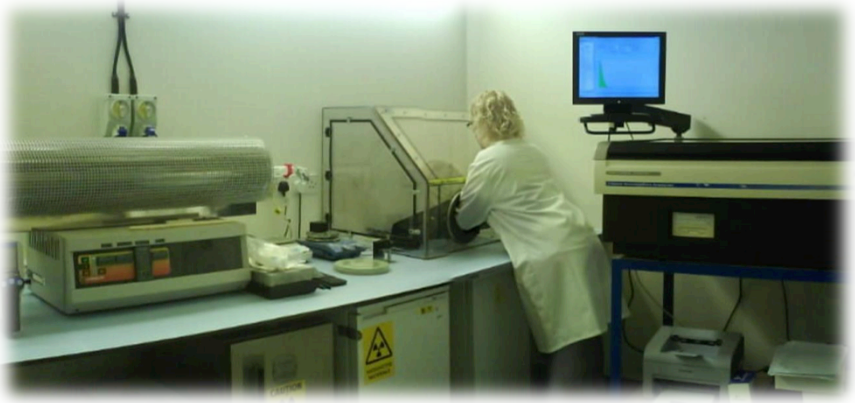
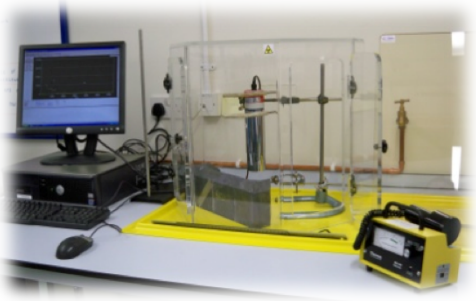
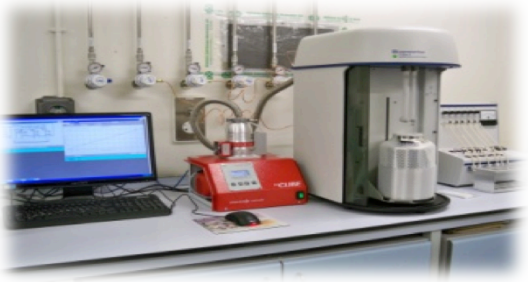
UoM Irradiated Graphite Facilities

Controlled graphite laboratories

- Treatment and Purification of graphite
- Isotope identification
- ^{14}C and Tritium Thermal Treatment
- Pre washing chemical treatments
- Repository condition Leaching
- Beta Scintillation analysis
- Gamma spectroscopy
- ICP-Mass spectrometry
- Isotope modelling







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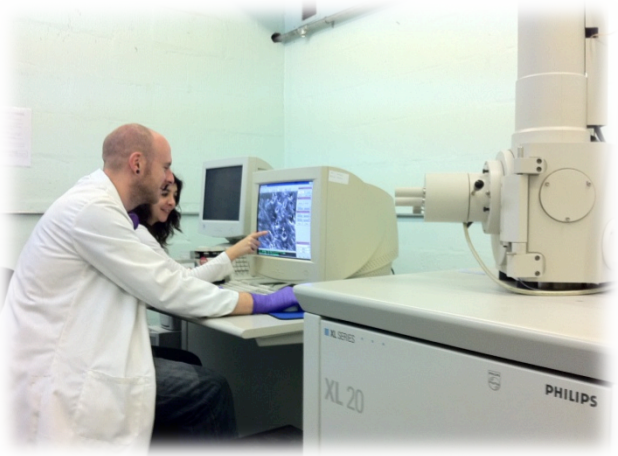
Irradiated Graphite Facilities

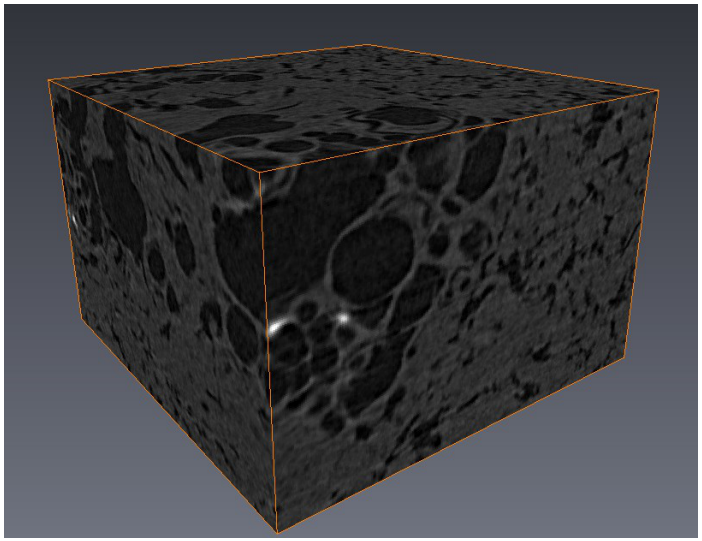
Two supervised Characterisation Labs

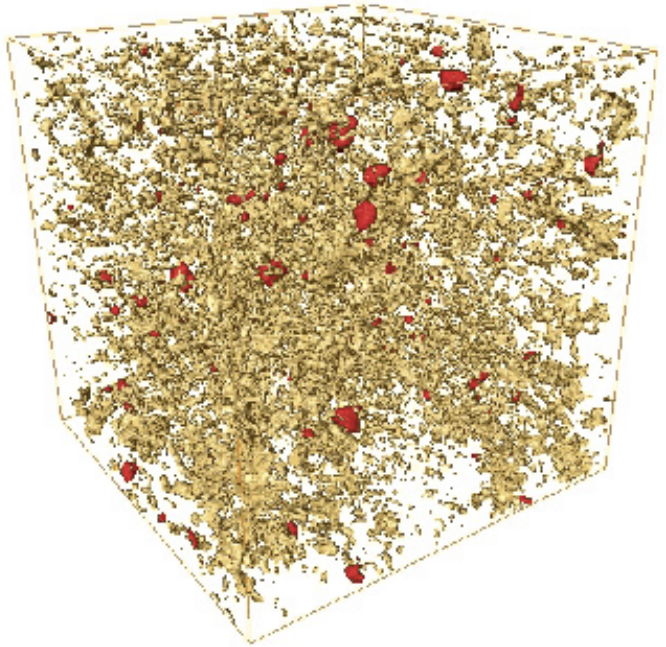
- Scanning Electron Microscopy with EDX – elemental analysis and impurity distribution
- Polarised Optical Microscopy
- Laser confocal microscopy
- Isotopic Modelling FISPACT
- X-ray Tomography
- X-ray Diffraction
- Dynamic Young's' modulus
  - IET
  - Ultrasonic
- Raman Spectroscopy
- Helium Pycnometry
- Thermal Analysis instrumentation



Isotopic Distribution & Location

- Tomography - Porosity characterisation
- Before and after scans allow the changes due to thermal treatment to be observed and a understanding of location of weight loss, pore size distribution, open/ closed pore ratio





Remove isotopic content

Chemical thermal treatment

- Oxidation and isotope separation
- Use controlled chemical processes under inert gas conditions
- ^{14}C and ^{3}H released faster than the graphite is oxidised
  - (40% ^{14}C and 60% ^{3}H)
- Off-gas collection separation of ^{14}C and ^{3}H

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Current Projects

- EPSRC
  - Fundamentals of current and future uses of nuclear Graphite 1PhD
  - DIAMOND Consortium – irradiated waste, 1PhD
- Partner in two FP7 European Union Projects
  - ARCHER – Generation IV VHTR technology – 1 PDRA
  - CARBOWASTE – irradiated graphite waste – 1PDRA, 1 PhD & EngD
- HSE(ND)
  - Graphite Technical Advisory Committee (Management and secretariat)
  - Whole core Modelling – 1PDRA
  - Microstructure/property relationship in irradiated Gilsocarbon graphite. (EngD with HSL)
  - Database and statistical modelling of irradiated Gilsocarbon graphite – PDRA, with MC&S (USA)
  - Development of a mechanistically based statistical model for predicting the structural integrity of AGR graphite moderator bricks – with HSL and University of Birmingham – 1 PDRA
- NDA
  - Characterisation of irradiated graphite waste (BEPO) - PhD
- Urenco
  - Investigation of a novel reactor concept
- IAEA – Creep CRP – with INL and Boise State University
- Various consultancies ,HSE, SGL, UKAEA

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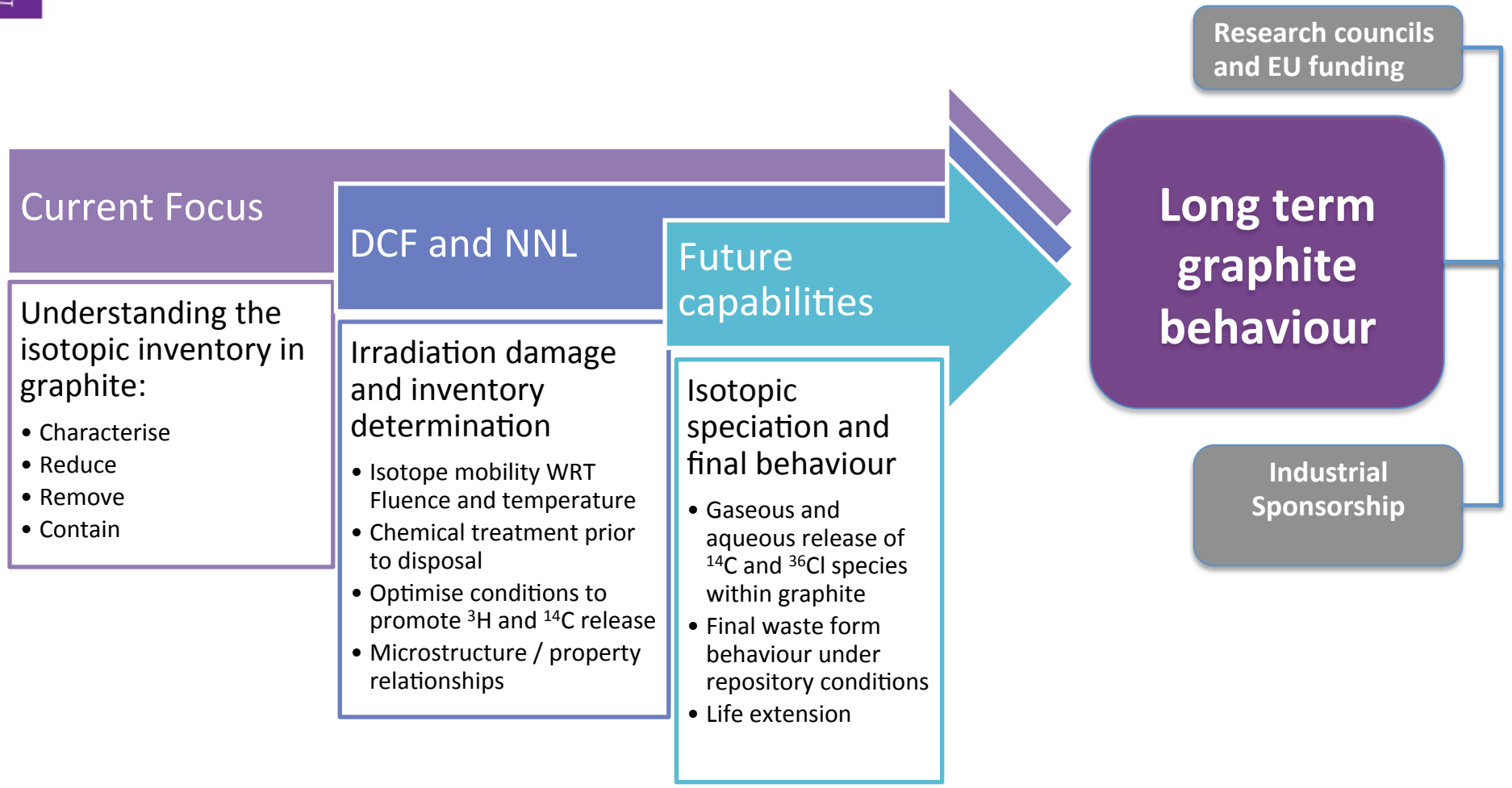
Capability and Future research



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ANY QUESTIONS?