The University of Manchester

Dalton Nuclear Institute

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Dalton Nuclear Institute

The Nuclear Community at Manchester

www.manchester.ac.uk/dalton

Introduction from the Director

Dalton Cumbrian Facility near Sellafield

The Dalton Nuclear Institute was launched in July 2005 to act as the focus to drive the coordination and growth of Manchester's nuclear capability and to become a world leading centre of nuclear research and education.

Named after John Dalton, the Dalton Nuclear Institute is a major driving force in nuclear research in Manchester and the Northwest, building upon a distinguished history in nuclear sciences.

John Dalton presented his atomic theory to the Manchester Literary and Philosophical Society just over 200 years ago. He was one of the founding fathers of the Manchester Mechanics Institute, which was to become the University of Manchester Institute of Science and Technology (UMIST) and later The University of Manchester.

Ernest Rutherford was appointed the Langworthy Professor of Physics in 1907 and embarked on the final stages of his research into the nature of the alpha particle. With his assistant, Hans Geiger, he developed a method to count alpha particles produced by the disintegration of radium. He received the Nobel Prize in Chemistry in 1908 for investigations into the disintegration of the elements and the chemistry of radioactive substances.

Niels Bohr joined Rutherford in 1912, to continue work on nuclear structure. Bohr was awarded the Nobel Prize for Physics in 1922 for his fundamental contributions to understanding atomic structure and quantum mechanics. In 1911 James Chadwick graduated from the School of Physics and spent the next two years with Rutherford, where he worked on various radioactivity problems, gaining his M.Sc. degree in 1913. Chadwick was awarded a Nobel prize in 1935 for the discovery of the neutron.

John Cockcroft studied Mathematics at Manchester in 1914, later returning to study Electrical Engineering. He also worked under Rutherford in the Cavendish Laboratory and was awarded the Nobel Prize in Physics in 1951 for his pioneering work on the splitting of atomic nuclei by artificially accelerated atomic particles and also for his contribution to modern nuclear power.

Within thirty years nuclear activities were blossoming in the Northwest of England. The first nuclear sites were established in 1946 at Risley, Springfields, Windscale and Capenhurst. In 1956 the world's first commercial nuclear reactor started at Calder Hall in West Cumbria. The Universities' Research Reactor, jointly owned by the Universities of Manchester and Liverpool, opened in 1962 at Risley and was used for performing neutron activation work prior to decommissioning in 1992.

In 1999 the Centre for Radiochemistry Research was established as the first British Nuclear Fuels (BNFL) University Research Alliance. The Materials Performance Centre was established in 2002 to perform research into materials in nuclear applications.

The Dalton Nuclear Institute was launched in 2005 to build on the successes of the two University Research Alliances and act as the engine to drive the coordination and growth of Manchester's nuclear expertise base.

Today, the Dalton Nuclear Institute is fully engaged in the international civil nuclear power renaissance, through focused Research Centres addressing challenges as diverse as nuclear plant life extension, new nuclear build, fuel technology, decommissioning, and waste management and disposal.

The University of Manchester is one of the premier nuclear research and higher learning universities in the world. The Dalton Nuclear Institute provides the prime focus for Manchester's capability across the full range of nuclear science and engineering.

The challenge of a safe and secure energy supply within a low carbon economy has created the environment for a renaissance in civil nuclear power. New skills and research are required to support plant life extension, new nuclear build, future reactor systems and nuclear waste management and disposal.

The Dalton Nuclear Institute is strengthening Manchester's capability to deliver high-level skills and focused research that provides a major contribution to address such global challenges. The University, Regional and Central Government, Research Councils and Industry have invested £100 million over the last 10 years to establish leading nuclear research, academic staff and research facilities at Manchester.

Research is focused within a growing number of interdisciplinary Research Centres in key technology areas. Representing a research community of over 250 people, these Centres undertake fundamental and applied research across the full nuclear fuel cycle; from fuel technology, plant life extension and new nuclear build to the processing and disposal of nuclear waste. The new £20 million Dalton Cumbrian Facility will establish a unique facility for radiation science and chemistry at Westlakes, with access to the facilities within the National Nuclear Laboratory's Central Laboratory on Sellafield site.

Higher Learning in nuclear-related disciplines includes Manchester's management of the existing NTEC Nuclear MSc, the leadership of the Nuclear FiRST Doctoral Training, and the Nuclear Industrial Doctorate Centre in partnership with Imperial College (London) and in collaboration with other universities. Dalton's membership of the National Skills Academy for Nuclear, a growing Continual Professional Development programme, and outreach to schools all demonstrate the University's commitment to nuclear higher learning.

External engagement encompasses Manchester's regional, national and international links with other universities, industry and Government. Manchester is a partner with Serco and the Battelle Memorial Institute managing the UK's National Nuclear Laboratory. The University has strategic nuclear research partnerships with EDF/British Energy, Rolls-Royce, Serco Technical Services and Westinghouse. Research agreements provide the focus for collaboration with international players including the US National Laboratories and Tsinghua University (China).

I hope you find the information within this brochure useful and if you would like any further information please don't hesitate to contact myself, or any of our academic leaders.

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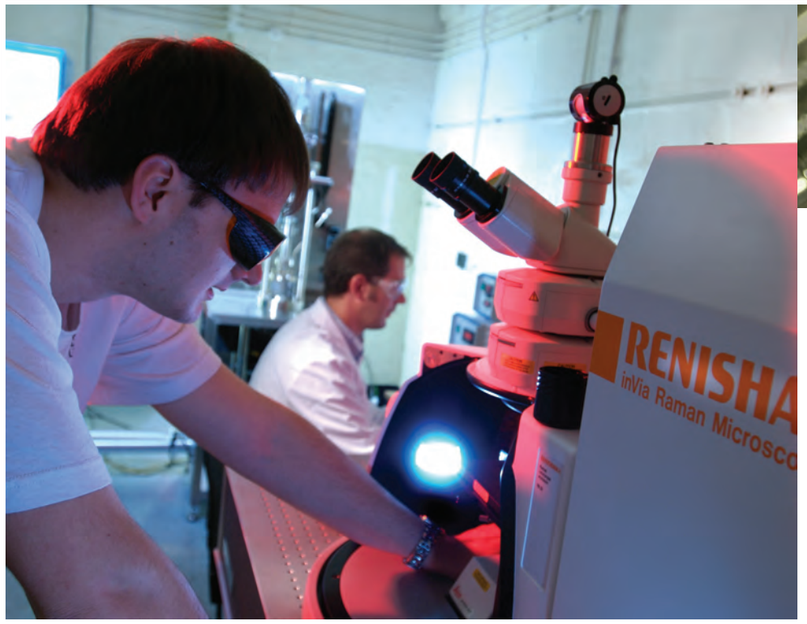
Research



Over the past ten years the portfolio of nuclear research and educational activity at Manchester has ramped up significantly and now stands at over £100 million with well over 250 researchers involved.

Research spans several faculties within the University including Engineering & Physical Sciences, Medical & Human Sciences and Humanities, with strengths in areas such as:

- Nuclear Materials Performance: Structural Steels, Fuel and Graphite
- Radiochemistry
- Nuclear Modelling & Computation
- Geological Disposal of Nuclear Waste
- Nuclear Reactor Thermal Hydraulics and Fluid Simulation
- Nuclear Fusion Research
- Radio-Biological Research
- Dosimetry & Epidemiology
- Nuclear Policy and Regulation
- Stakeholder Issues and Decision Analysis
- Nuclear Physics
- Medicine and Innovative Technology
- Sustainability
- Process engineering and control

Each area has research teams ranging from 10 to 60 people and "order books" of up to £2 million per year. The University has a recognised strength in Materials Performance and Radiochemistry in the form of the University Research Alliances originally established by British Nuclear Fuels (BNFL).

The following pages describe these and other interdisciplinary research centres that have been established to address issues across the full nuclear fuel cycle, with the facilities necessary to conduct leading fundamental and applied research.

Centre for Nuclear Energy Technology (C-NET)

The Dalton Institute, in collaboration with the Northwest Regional Development Agency (NWDA) established the Centre for Nuclear Energy Technology (C-NET) in 2009. C-NET is focused on nuclear reactor technology, and will lead the research and capability development needed to ensure that the UK is able to successfully deploy a new generation of nuclear power stations, as well as continuing to support the safe operation of the existing nuclear fleet. C-NET builds on existing capabilities across the University in key disciplines such as materials performance, computational fluid dynamics, applied nuclear physics, and structural integrity, and will augment these with new academic appointments designed to offer the full range of capabilities needed to support new reactor systems.

The investment in C-NET will total some £16 million over the next 5 years, including an initial investment of £4.4 million from the NWDA to provide new academic appointments in thermal-hydraulics, structural integrity, radiation damage, reactor physics and nuclear data, and nuclear licensing, safety and policy. The NWDA investment also provides key experimental facilities in flow testing, microstructural examination, and fuel technology, as well as providing a significant new capability in reactor physics analysis. In addition to the engineering and scientific aspects associated with reactor technology, C-NET will also focus on the economic, management, and socio-political aspects of nuclear energy, including risk perception, environmental impact and life-cycle assessment, and project delivery.

The C-NET vision is to be recognised as a leading centre for reactor technology, contributing to the global renaissance in nuclear energy. It will focus on providing industrial R&D support and contribute to academic thinking in four key areas:

- New nuclear build: supporting the deployment and operational performance of UK new nuclear build systems
- Support to existing reactors: providing R&D support to extend the lifetime of existing plants
- Naval propulsion: supporting the R&D requirements of current and next generation systems;
- International advanced reactor development: collaborative international research into future reactor systems

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Northwest
REGIONAL DEVELOPMENT AGENCY

Materials Performance Centre (MPC)

Materials performance is fundamental to the nuclear industry in clean up and decommissioning, plant operation and life extension as well as potential new build. The MPC is the largest nuclear materials research centre in UK academia, with over 70 researchers and over £25 million research income.

The MPC sustains strategic research partnerships with:

- EDF
- British Energy
- National Nuclear Laboratory
- Serco TAS

Research within the MPC is addressing all aspects of the nuclear lifecycle through five key technical themes:

- **Corrosion and Environmentally-Assisted Cracking**
  Understanding the corrosion mechanisms of materials in extreme environments is providing the drive to establish new approaches to predict the relationship between environment, microstructure and stress.
- **Structural Integrity**
  Developments in experimental and numerical techniques including surface strain mapping, weld modelling, residual stress characterisation and fracture modelling are enabling conservatisms in current assessment methods to be more fully understood.
- **Nuclear Graphite**
  Understanding the relationship between graphite microstructure and properties and applying this understanding to model behaviour through life is providing new input to support graphite performance in reactors and to assess decommissioning options.
- **Fuel Cladding Materials**
  Zirconium is a metal which is vital to the nuclear industry, but not widely studied within UK academia. The MPC is taking the lead to establish a focus for zirconium alloy research. Research also addresses the management of irradiated stainless steel fuel cladding and braces.
- **Predictive Modelling**
  Models of deformation and failure processes in materials are being developed alongside novel experimental approaches to improve the reliability of predictions of materials performance in service. The establishment of a new high performance computer cluster is adding impetus to model development over all scale-lengths – including atomic-scale simulations, crystal plasticity finite element methods and continuum mechanics (including weld and fracture modelling).

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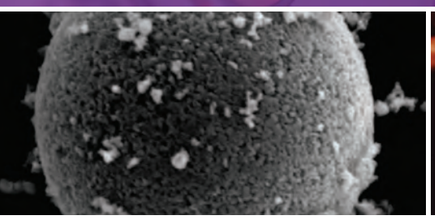
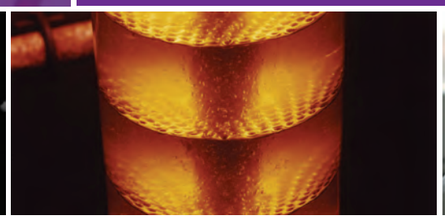
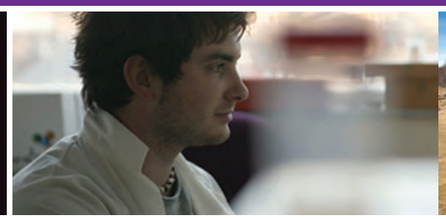


The Centre for Radiochemistry Research (CRR)

The chemical form of the radioactive elements is a key control on their behaviour in natural and engineered environments. Experimental work with radioactive materials, particularly high specific activity radioisotopes, is very demanding, and the CRR has unique facilities, to support work with a range of highly active materials, including plutonium.

To support its research, the CRR has a unique range of modern spectroscopic and analytical equipment, all in facilities which permit its use with highly radioactive materials. These include electronic, vibrational and nuclear magnetic resonance spectroscopes; colloid characterisation and a full suite of radiometric equipment. The laboratories include a suite of Controlled Area laboratories, together with the protocols for safe work with highly active materials.

- **Environmental Radiochemistry**

  The environmental radiochemistry research programme explores the form, transport and fate of radioactive isotopes in the environment. The topics we study include: development of novel analytical techniques for determination of ultra-trace concentrations in complex samples; the fate of anthropogenic nuclides from the Sellafield discharges; development of transport models to predict migration of radionuclides in the geosphere; interactions with microbial communities.

- **Chemistry of Nuclear Waste Disposal**

  In the UK, over 50 years of civil and military nuclear power have left a complex legacy of waste. Government has decided that this will be disposed of underground. Our research in this area includes: defining physical and chemical forms of radionuclides in old fuel storage ponds; assessing the performance of glass, ceramic and cement wasteforms; developing decontamination methods for contaminated steel and concrete surfaces; developing mechanistic speciation and transport models to support disposal safety cases.

- **Actinide Coordination Chemistry**

  This programme focuses on understanding radionuclide behaviour at the molecular level. We are presently studying: actinide polyoxometalte chemistry; dissolution of actinide materials (fuels and wasteforms); speciation in molten salts and ionic fluids; controlled hydrolysis and cluster formation in actinide systems; design of ligands for control of oxidation states.

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Dalton Cumbrian Facility (DCF)

The University of Manchester and the Nuclear Decommissioning Authority (NDA) have jointly invested £20 million to establish new research capabilities in Radiation Science and Nuclear Engineering Decommissioning centred in West Cumbria.

The focus of this investment is the creation of a new research base, the Dalton Cumbrian Facility (DCF), on Westlakes Science and Technology Park. It will incorporate computer modelling stations and large-scale experimental laboratories for radiation science, including irradiation facilities and associated analytical equipment, as well as office accommodation and seminar rooms for CPD delivery. The irradiation facilities at the heart of the investment are:

- a 5 MV ion accelerator capable of supplying 10 MeV protons and 15 MeV helium ions as well as a variety of partially stripped heavy (eg metal) ions,
- a self shielded ^{60}Co gamma irradiator,
- a controlled atmosphere chamber incorporating a low-energy electron gun.

The radiation sources will be complemented by analytic and surface equipment for the examination of irradiated materials. The analytic capabilities of the DCF will include chromatography - HPLC, GC, IC and GPC; mass analysis - MS; spectrometry - IR, uv-vis; scattering - resonance Raman; and surface adsorption - BET. These chemistry techniques will be complemented by dual ion beam FIB. Typical applications of the analytic equipment include:

- measuring gas production (GC);
- analyzing anions and cations in solution (IC);
- measuring polymers and other organics (HPLC);
- determining macromolecular weight distributions (GPC);
- isotopic analysis (MS);
- standard optical absorption spectrometry and reflectance measurements (uv-vis);
- molecular structure (IR);
- surface analysis (Raman).

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Radiation Sciences

The Radiation Sciences programme performs research at the forefront of the fields of radiation chemistry and physics, and of radiation damage to materials, thereby providing world leading expertise to the nuclear industry, especially in the areas of decontamination and decommissioning, and nuclear waste management treatment and storage.

A multi-pronged approach employing experiments in conjunction with simulation and theory is used to investigate fundamental radiation-induced processes that underlie the problems encountered in the stewardship of radioactive materials, in the lifetime extension of operating nuclear power plant and in the development of advanced nuclear systems. Research topics include:

- **Effects of radiation on polymers.** Polymers are encountered in many environments throughout the nuclear portfolio. There are concerns about their physical and chemical degradation, and about the production of potentially explosive and corrosive gases such as H_2 and HCl. In addition, it has been suggested that solid organic materials decompose in an irradiation field to form liquids which can then act as a transport medium for radionuclides and provide a route to the biosphere.
- **Radiolysis of water-ceramic oxide and water-PuO_2 mixed-phase systems.** There is significant radiation-induced chemistry between oxide particulates and adsorbed water and hydrocarbons. This chemistry is a complicating factor for (long-term) nuclear waste management and storage. This work is being carried out in collaboration with the National Nuclear Laboratory.
- **Radiation chemistry of water-cement systems.** Grouting of radioactive wastes is the generally accepted immobilization and packaging method for nuclear waste, but a number of complicating questions remain concerning the energy transfer from the solid matrix to water, the presence of reducing agents and of nitrate in wastes and the effect of long-term irradiation.
- **Water coolant chemistry.** Water is a common coolant and shield material, and is constantly exposed to mixed radiation fields producing, amongst other things, H_2 and O_2; however, the effects of small amounts of colloids, of metal surfaces and impurities, including other atmospheres, are poorly characterized.
- **Radiation-induced corrosion.** The role of radiolysis in the corrosion of metals is central to problems across the nuclear power portfolio from plant operation to the long term storage of wastes. A mechanistic understanding of many radiation-assisted corrosion phenomena, important for predicting long term safety, is lacking.

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Nuclear Physics

The University of Manchester has a long and well established history in nuclear physics research, starting with the pioneering experiments of Ernest Rutherford in the early years of the 20th Century. It was at Manchester that Rutherford demonstrated the existence of the atomic nucleus using alpha-particle scattering experiments and performed the first demonstration of nuclear transmutation.

The nuclear physics research group at The University of Manchester is one of the largest in the UK. The group consists of five academic staff with a variety of research interests within the general area of experimental nuclear structure physics. These include determining the structure and properties of exotic nuclei, nuclear isomers and fission fragments using gamma-ray-, particle- and laser-spectroscopy techniques. The work is funded by the Science and Technology Facilities Council, STFC. Most of the experimental work is carried out at major international facilities, such as at Argonne National Laboratory (USA), Jyväskylä (Finland), CERN (Switzerland), GANIL (France), GSI (Germany), and the ILL reactor at Grenoble (France).

The group is active in the major international initiatives for new radioactive nuclear ion beams facilities such as FAIR, (Facilty for Antiproton and Ion Research) at GSI, SPIRAL2 at GANIL and HEI-ISOLDE at CERN.

The presence of the nuclear group in the School of Physics & Astronomy allows it to offer many popular nuclear-related core and option modules on undergraduate and graduate (MSc, EngD, PhD) programmes. The School also provides well-equipped nuclear laboratories for undergraduate practical work, MPhys project work, and postgraduate training.

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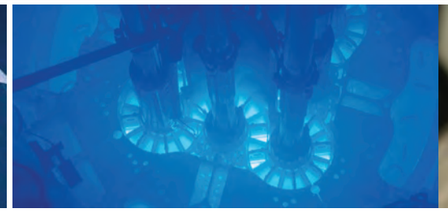

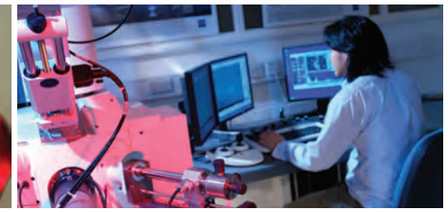


BNFL Research Centre for Radwaste Disposal

The UK is committed to both the deep geological disposal of our nuclear waste legacy and to the building of new nuclear power stations. The challenge now is to develop safe underground repositories for these radioactive wastes. Through a generous endowment from British Nuclear Fuels Limited (BNFL), the University has established a centre for research into radwaste disposal.

Research into radwaste disposal is the supreme multi-disciplinary challenge, requiring expertise across the University and its collaborators. To provide public confidence in geological disposal we need to develop a multi-barrier system with a very high level of understanding of:

- Stable wasteforms as minerals structures and glasses
- Containers capable of withstanding radioactivity, heat and corrosion.
- Engineering design of the whole repository barrier system.
- Development of backfillers for waste containers and the repository vaults made of clays, cements and polymers
- Geofluid chemistry in the near and far field and its interactions with all repository components.
- The nature of the host geosphere around the repository including its structure, its hydrology and geochemistry.
- Modelling of all aspects of the development of the repository and its interactions, from wasteform performance to the effect of climate changes
- Radionuclide, actinide and transuranic behaviour in groundwater and their interactions with all aspects of the geosphere and biosphere
- Environmental assessments, safety cases & social economic engagement.

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Nuclear Engineering Decommissioning

Our effort focuses on reducing the liability for future generations associated with the decommissioning of UK nuclear plant.

Nuclear Engineering Decommissioning involves the pursuit of leading-edge fundamental and applied research to deliver understanding and innovative solutions to the challenges facing the nuclear decommissioning industry from post-operational clean-out to (but not including) disposal.

The vision for the Nuclear Engineering Decommissioning Research Centre is to build a new capability by creating a total systems approach, providing a key contribution to the UK decommissioning strategy encompassing a multi-disciplinary approach that includes an understanding of:

- Multi-criteria decision making;
- Structural assessment and materials performance;
- Operational research;
- Waste characterization;
- Innovative technologies such as robotics, smart materials, instrumentation;
- Radiochemistry and species migration;
- Probabilistic risk assessment and safety analysis;
- Socio-economic considerations;
- Environmental impact assessment.

A balance of theoretical and experimental research into mechanical, civil and chemical engineering supports wider perspectives of sustainability and technology transfer. Of course, decommissioning is not unique to the nuclear industry so we actively incorporate contributions from other industries, including the oil and gas and pharmaceutical industries.

Making extensive use of the Dalton Cumbrian Facility and engineering rig halls based in West Cumbria, means that the activity is at the heart of the UK's decommissioning liability and ensures that the Centre has access to the best experience and capability.

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Thermal Hydraulics and CFD

Manchester has a long tradition in heat and fluid flow research, going back to the end of the 19th century with Osborne Reynolds. Today, The University of Manchester has strong research groups in computational and experimental fluid mechanics, with international reputations in turbulence modelling and experimental thermal hydraulics.

The current Thermal Hydraulics and Computational Fluid Dynamics (CFD) group consists of over 12 academics with a variety of research expertise within the fields of computational fluid dynamics and thermal hydraulics. In the CFD area, research expertise includes the mathematical modelling of turbulence through a range of methodologies, the modelling of near-wall turbulence, the simulation of forced, natural and mixed convection flows, the simulation of pulsated and unsteady turbulent flows, conjugate heat transfer and fluid structure interactions. In the experimental thermal hydraulics area, research expertise includes the use of diagnostic techniques such as hot-wire anemometry, laser-Doppler anemometry and particle image velocimetry, the thermo-chromic liquid crystal technique, and flow visualisation methods. Experimental facilities include internal flow forced convection rigs with either air or water as working fluids, a large scale differentially heated tall cavity for natural convection, a high pressure, high temperature test facility and a large-scale general-purpose facility under development through the C-NET initiative. Current research activities are funded by EPSRC (KNOO1 and KNOO2), British Energy, EDF and NWDA through C-NET.

The CFD and thermal hydraulics groups offer specialist undergraduate and postgraduate modules in the school of Mechanical, Aerospace and Civil Engineering (MACE). These include Advanced Computational Fluid Dynamics, Advanced Turbulence Modelling, Advanced Heat Transfer and Advanced Experimental Methods.

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Control and Instrumentation

The Control Systems Group is one of six research groups within the School of Electrical & Electronic Engineering. It has a long established international reputation for its multi-disciplinary research in control and systems engineering. Recently it has made significant contributions in both the theory and practice of chemical process control and plant monitoring. These activities are directly relevant to both nuclear power generation and nuclear decommissioning.

More generally the School of Electrical & Electronic Engineering itself has a broad and deep research portfolio, many aspects of which are cognate with the general area of nuclear power research and training. Areas of this portfolio that are relevant to nuclear power include component condition monitoring, remote and intelligent data acquisition systems, imaging, tomography, autonomous sensor agents combined with wireless sensing and communications, fibre-optic based sensing and monitoring, advanced real-time signal processing and sensor data fusion, industrial control systems design and fault detection.

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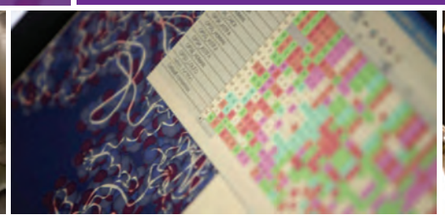



Radiation Epidemiology and Risk Assessment

Professor Richard Wakeford has made significant contributions to the assessment of the risks to health posed by exposure to ionising radiation, especially low-level exposures. His particular expertise is in radiation epidemiology, notably in utero, preconceptional, occupational and environmental exposures and cancer "clusters". He has been a member of national and international expert groups, written extensively on the subject (including many papers in the peer-reviewed literature), and is currently Editor-in-Chief of the Journal of Radiological Protection.

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Manchester Business School (MBS)

Manchester Business School (MBS) is one of the largest full service business schools in Europe, providing undergraduate, postgraduate and executive education in all areas of business and management.

MBS is known for its socio-technical, multi-disciplinary approaches to problem solving. Research strengths and skills of particular interest to Dalton include:

- behavioural studies and human reliability
- decision analysis
- environmental management
- finance, foresight & innovation studies
- knowledge management
- operations management
- project management
- public & private sector governance
- risk communication & management
- supply chain management
- sustainability.

MBS is home to the Decision and Cognitive Sciences Research Centre (DCS) which has an international reputation in multi-criteria decision analysis (MCDA), and has recently held research and consultancy projects relating to assessing nuclear waste repository options, decommissioning of nuclear reactors, nuclear emergency response, as well as risk, safety and security studies, and public participation in a broad range of applications.

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Environmental Geochemistry and Geomicrobiology

The Geomicrobiology group of the Williamson Research Centre for Molecular Environmental Science (housed in the School of Earth Atmospheric and Environmental Sciences) has an established track record studying microbial interactions with radioactive elements. Established in 2001, as part of the Williamson Research Centre for Molecular Environmental Science (£3.5 UK Joint Infrastructure Fund investment), the group is led by Professor Jon Lloyd and conducts multidisciplinary research into the mechanisms and environmental impact of metal biotransformations. A diverse range of techniques are used including microbiology, biochemistry, molecular biology, mineralogy, surface science, computation and spectroscopy.

Current and recent funding is greater than £5 million (EPSRC, NERC, BBSRC, US-DOE, US-NSF, EC). The group has produced more than 100 publications over the last decade, many focusing on the biogeochemical cycling of actinides and fission products, and has excellent collaborative links with other specialist laboratories in the US, Europe and Japan. Both fundamental and applied projects are ongoing, including work on the bioremediation of sites contaminated with radioactive waste in the US and UK, with recent studies initiated on the potential impact of microbial processes on waste-form performance and the effect of radiation fields on microbial communities.

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Manchester: Integrating Medicine and Innovative Technology (MIMIT)

MIMIT™ is a partnership between The University of Manchester and six Greater Manchester NHS Trusts: Central Manchester University Hospitals NHS Foundation Trust, the Christie NHS Foundation Trust, Manchester Mental Health and Social Care Trust, Salford Primary Care Trust, Salford Royal NHS Foundation Trust, University Hospital South Manchester NHS Foundation Trust.

MIMIT's aim is to develop innovative medical technology-based solutions to address validated unmet clinical needs, by facilitating collaborations between clinicians, academic scientists, engineers, designers and industry partners.

The process begins with an unmet clinical need and is designed to deliver actual patient benefit. It is market led, and the unmet need can be introduced to MIMIT via the nuclear industry as well as from the clinical community. The unmet need is validated through MIMIT's extensive clinical network and the information obtained used as the basis for solution finding. MIMIT draws in expertise across a range of disciplines to ensure that projects arising from this process develop the best and most innovative ideas. Access to rapid prototyping capabilities including nanofabrication technology, operating to industry standards of project management and design control ensure that project activities are efficient and productive and outputs are compliant and high value. Expert intellectual property resources identify protectable project outputs and an understanding of the freedom to operate constraints.

MIMIT sponsors projects and can maximise the value of nuclear industry contributions. In addition it acts as gate keeper and facilitator to securing follow-on research council, medical technology venture capital and government funding.

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Society and Sustainability

Nuclear power is a topic that often provokes extreme viewpoints and many argue that it is not a sustainable energy source. In the wake of the proposed new nuclear build in the UK and around the world, it is crucially important to examine different societal views on nuclear and assess its sustainability over the longer term.

For example, in the School of Chemical Engineering and Analytical Science research into the sustainability of nuclear power is carried out by addressing environmental, economic and social aspects in an integrated manner. We are developing methodologies and approaches to help different stakeholders assess the sustainability of nuclear power on a life cycle basis relative to other energy options, including fossil and renewables. We are working with a range of stakeholders from industry, government and NGOs to help us understand sustainability aspects of importance to them and develop a transparent and unbiased way of assessing the sustainability of nuclear energy.

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Nuclear Policy and Regulation

The Dalton Nuclear Institute has strengthened its research interests by intending to undertake research into nuclear policy and regulation.

It will aim to be a source of policy advice on a wide range of nuclear issues to the Government and its agencies and the nuclear industry as a whole.

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Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

The Nuclear AMRC was formally launched by Business Secretary and First Minister Lord Mandelson in Sheffield on 3 December 2009 and forms part of the Government's Low Carbon Industrial Strategy. The funding announced by Lord Mandelson includes an £8 million investment from central government and the NWDA to strengthen and expand The University of Manchester's nuclear research laboratories and a new £25 million building, funded by central government and Yorkshire Forward, located at the Manufacturing Technology Park on the Sheffield / Rotherham border.

The Nuclear AMRC will be led by the University of Sheffield with Manchester leading on the research. Founding members include Corus/Tata Steel, Rolls-Royce, Westinghouse, Areva and Sheffield Forgemasters. The Nuclear AMRC will be based in the Manufacturing Technology Park with advanced research and development work taking place within The University of Manchester's nuclear laboratories. Manufacturing supply chain engagement, training and accreditation, alongside research innovation within the Sheffield main site, and subsequent dissemination to the supply chain will help members to be market leaders.

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National Nuclear Laboratory

On 6 April 2009, a consortium of Serco, Battelle and The University of Manchester (SBM) formally took over the management of the UK National Nuclear Laboratory (NNL) on behalf of the Department for Energy and Climate Change (DECC).

The NNL was formed out of Nexia Solutions Limited in 2008 and aims to become a valued and successful nuclear science and technology laboratory, world-renowned for its exceptional staff, cutting-edge facilities and excellent value for money. It is an international centre of research and development and provides customers with tailored solutions by applying the appropriate level of technical innovation and intellectual support. Customers include the Nuclear Decommissioning Authority (NDA), Sellafield Ltd, Westinghouse, Ministry of Defence, United Kingdom Atomic Energy Authority (UKAEA), VT Nuclear and British Energy plc. Professor Paul Howarth has been seconded from the Dalton Nuclear Institute to the NNL Board as Director for Science, Technology and Project Delivery.

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Higher Learning and Continuing Professional Development (CPD)

External Engagement

Schools Outreach

The Dalton Nuclear Institute is leading the EPSRC outreach programme, "So you think you know about nuclear energy!" that is engaging the wider public in the challenges associated with providing low carbon energy in general and nuclear energy in particular. It is in discussion with Manchester Museum of Science and Industry and the Big Bang initiative to engage effectively in raising the profile of nuclear science and engineering to the wider community.

Undergraduate Education

The Dalton Nuclear Institute is driving the development of new undergraduate "with nuclear" degrees at B.Sc. level in Mechanical Engineering (launched 2009).

Nuclear Technology Education Consortium (NTEC)

NTEC is a consortium of leading UK Universities offering an MSc in Nuclear Science & Technology, coordinated by the Dalton Nuclear Institute. This programme offers an extremely broad range of topics for study and is structured in modular format, making it highly suitable for engineers in full-time employment who can undertake a full programme leading to a recognised qualification or study individual modules for CPD purposes.

Key features of the programme:

- Broad portfolio - reactors, cleanup, fusion, environmental, policy
- Short fat modular structure
- Suitable for part-time students
- Suitable for CPD for employees in industry
- Specifically developed to meet the needs of industry
- Individual modules available for CPD

Members of the Nuclear Technology Education Consortium (NTEC) are: the universities of Birmingham, London City, Imperial, Lancaster, Leeds, Liverpool, Manchester, Sheffield, HMS Sultan and Westlakes Research Institute and UHI Millennium Institute.

Continuing Professional Development (CPD) and Executive Education

The Dalton Nuclear Institute is developing a programme of nuclear CPD and Executive Education programmes in partnership with the Manchester Business School to help address the growing national/international nuclear skills agenda.

The Nuclear Engineering Industrial Doctorate Centre

The Nuclear EngD provides outstanding young nuclear Research Engineers with intensive, broadly based training in collaboration with industrial companies so that they are equipped to take up senior roles within the nuclear industry.

Nuclear FiRST (DTC) The Nuclear IDC is led by The University of Manchester in partnership with Imperial London and is supported by the Universities of Sheffield, Leeds, Strathclyde, Birmingham, Surrey and Lancaster.

For further information on education and CPD opportunities please contact

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The Dalton Nuclear Institute is committed to developing effective strategic relationships with external organisations to maximise the benefit of research and skills development to regional, national and international nuclear stakeholders. This includes collaboration with Universities, Industry, Government and Learned Societies.

The University is engaged in an increasing number of collaborative programmes with UK University partners supported through Research Council, Industrial and European grants. These include, for example, Imperial College (London), and the Universities of Birmingham, Bristol, Cambridge, Lancaster, Leeds, Oxford, Sheffield, Strathclyde, and Surrey. Core programmes include the Nuclear Industrial Doctoral Centre in partnership with Imperial College, the Nuclear Fission Doctoral Training Centre in partnership with Sheffield, and the Nuclear Advanced Manufacturing Research Centre in partnership with Sheffield.

Strategic research partnerships with national and international stakeholders allow a longer-term view to be taken on research and skills development. Partnerships, including those with the UK National Nuclear Laboratory, EDF/British Energy, Rolls-Royce, Serco Technical Services and Westinghouse, are enabling long-term research developments to impact more effectively in industrial application and the recruitment of highly qualified and motivated researchers into industry.

The partnership with the Nuclear Decommissioning Authority is establishing the Dalton Cumbrian Facility with a unique set of facilitates for radiation science and engineering decommissioning research. This also provides Third Party Access for academics to utilise the world-leading laboratories in the NNL Central Laboratory at Sellafield.

International collaboration agreements exist with Tsinghua University (China), the Korean Atomic Energy Research Institute, Battelle Memorial Institute (USA), Idaho National Laboratory (USA), Westinghouse and EDF. These provide an international dimension to the research as well as access to international facilities including, for example, the INL Advanced Test Reactor for irradiation experiments, and facilities at the US Universities of Wisconsin and Michigan.

Links with Government Departments and Learned Societies ensure that the academic strengths of the University are helping to advise on policy and foresight initiatives that will ensure the UK plays its part in solving the global challenges of energy supply and security within a low carbon economy.

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The University of Manchester through the Dalton Nuclear Institute has significant capability that is focused on supporting all aspects of the nuclear industry in terms of underpinning science and research, higher learning and external engagement from an independent and impartial perspective.

The aim is to ensure that there is a growing pool of skilled and qualified people to support growing opportunities in the national and international nuclear sector delivered through the highest quality nuclear research and higher learning programmes.

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