Monitoring

Theme Summary

Many components in a nuclear power plant are inaccessible once installed, or too radioactive to handle. Therefore, remote inspection and testing is a key tool for monitoring performance and testing for defects.

Equally, radioactive waste materials are stored in large volume packages that are not designed to be accessed for assessment. Thus, there is a need to develop scanning and detection methods to be able to identify and characterise materials within structures.

Research in this area includes:

- Muon scattering tomography – non-destructive scanning technique utilising highly penetrating, naturally occurring cosmic muons to image the interior of closed objects form a safe distance.
- Ultrasonic array and imaging
- Radiation dose monitoring – devices for autonomous, real-time data collection in hazardous environments.

Theme Leads

Dr Jaap Velthuis, University of Bristol

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Jaap's research interests lie in the field of detectors, detection and imaging. He focuses on the design, development and characterisation of novel radiation detectors, the accompanying data analysis and radiation damage effects in detectors and electronics.

Professor Paul Wilcox, University of Bristol

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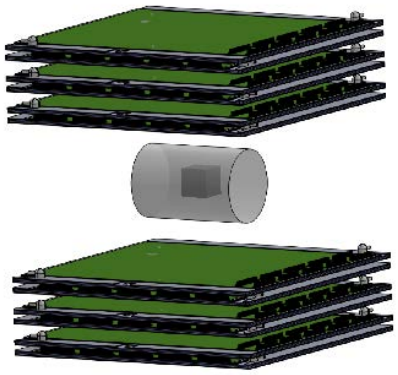
Paul's research interests centre on non-destructive testing, structural health monitoring and ultrasonic imaging feeding into structural integrity assessments. He also has interests in signal processing, smart structures and the analysis of big data.

Research capabilities and facilities

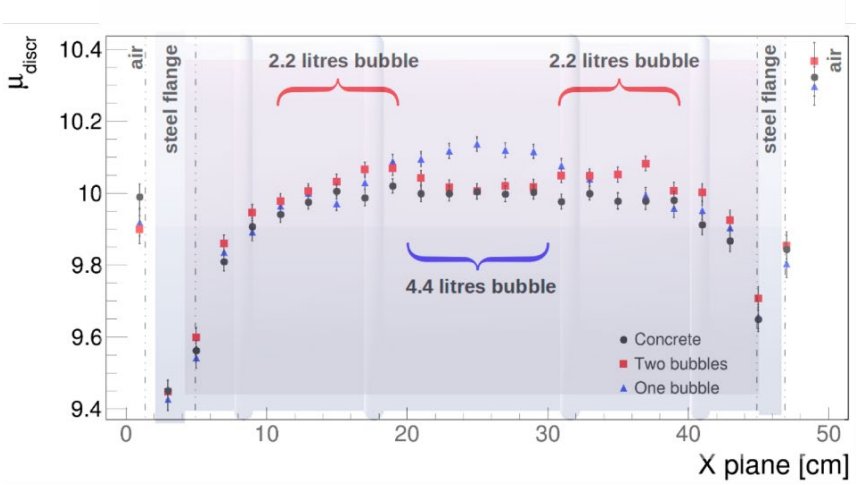
Muon Scattering Tomography for nuclear waste management

Key academics: Dr Jaap Velthuis

Muon Scattering Tomography (MST) is a non-invasive scanning technique developed to examine the content of large volume nuclear waste packages. It can for example be applied to locate and identify small lumps of high-Z materials and detect gas bubbles in concrete or bitumen-filled nuclear waste containers. This allows continuous monitoring of pre-packaged nuclear waste. Other applications are in structural integrity inspections of large objects.



Using MST, we have demonstrated that the exact locations of 6mm diameter rebars can be found in 50cm thick concrete floors and walls. This can better inform structural integrity assessments and maintenance decisions, vital for long-term infrastructure in nuclear environments.



Non-destructive testing and evaluation

Key academics: Professor Paul Wilcox, Professor Anthony Croxford

Research in this area focuses on advanced sensor and imaging technology, that seeks to development the next generation of automated inspection, digital sensing networks and data analysis.

Large components and structures' conditions are difficult to monitor using conventional NDT where the positioning of measurement sensors varies with each test. Therefore, ultrasonic testing has been developed as an inspection method using guided waves capable of inspecting large areas to deal with the presence of environmental variation and minimise its effects.

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Ultrasonic array and imaging techniques are highly applicable to the nuclear industry as it provides an in-situ monitoring method of areas or installations that either cannot be accessed or removed/dismantled for inspection.

Case Study

Inductosense WAND system for internal corrosion and erosion monitoring

The WAND device (pictured, right) is a handheld tool that can take rapid measurements from hard-to-access areas, which inductively couples with ultrasonic sensors that can be embedded onto structures.

Hitachi tested the WAND system for monitoring pipe wall thickness on nuclear power plants, and found that the sensors were radiation-tolerant and able to undertake different thickness measurements comparable to conventional ultrasonic testing methods.

Radiation dose monitoring and characterisation

Key academics: Dr Peter Martin, Dr Chris Hutson, Professor Tom Scott

Whilst the non-destructive evaluation techniques described above give us insights into structures and materials in inaccessible environments, it is also vital to understand the levels of radioactivity present in facilities, either in operational facilities or in those being decommissioned.

Case Study

Using off-the-shelf sensors for high dose-rate radiation detection

Detecting high dose-rate radiation and gamma rays in strong radiation fields is expensive and inefficient. Research between Bristol and Chinese collaborators has shown that smartphones and commercially available monolithic active-pixel sensors (MAPS) can be used as accurate, low-cost radiation monitoring devices.

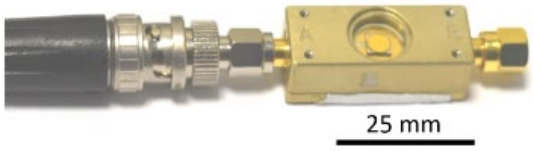
The UK is currently decommissioning legacy facilities and the rest of the current fleet is due to be retired by 2035. Therefore innovative characterisation and monitoring technologies will be required to ensure decommissioning activity is safe, efficient and cost-effective.

Research aims to develop devices and capabilities that allow real-time dose rate measurements to be made remotely from inside difficult to access areas, requiring long-lasting, radiation-tolerant technology.

Case Study

Diamond Detectors for real-time dose rate measurements

Radiation-tolerant, miniature detectors have been developed by the University of Bristol for the non-destructive assay of highly radioactive, hard-to-access environments. These have been deployed in active cells on the Sellafield site, enabling previously impossible dose rate measurements to be made and improving the availability and quality of dose rate data used in safety case justifications.



Facilities

Mobile Muon Detection System

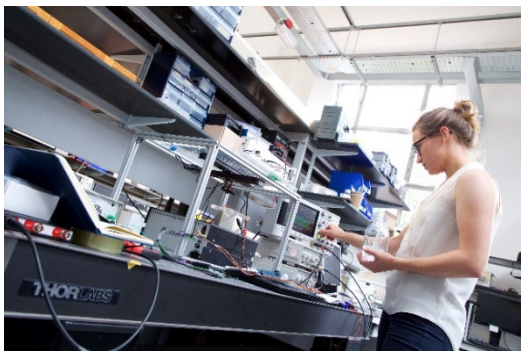
As part of the CHANCE (Characterisation of Conditioned Nuclear Waste for its Safe Disposal in Europe) programme, the University of Bristol has developed mobile muon tomography instrumentation for the non-destructive assay (NDA) of large volume nuclear waste packages.

This set-up includes a test drum for non-active and active qualification experiments and commissioning. The system can be transported to and operated at live facilities to characterize some real, large waste containers.

Non-Destructive Testing Laboratory

The University of Bristol laboratory has specialist kit in the form of:

- a Faraday cage
- an inteferometer
- three phased array controllers
- a large collection of phased arrays
- a high frequency pulser receiver (200MHz)
- a Schlieren system (for wave visualisation)
- a particle manipulation controller



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