

# Tritium Fuel Cycle Division

Powering the Future of Fusion







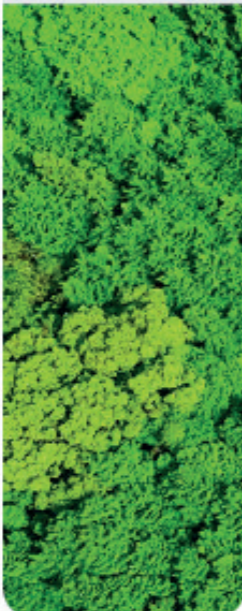

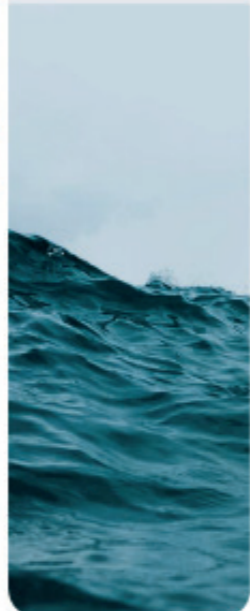

# Why Tritium Matters and Our Priorities

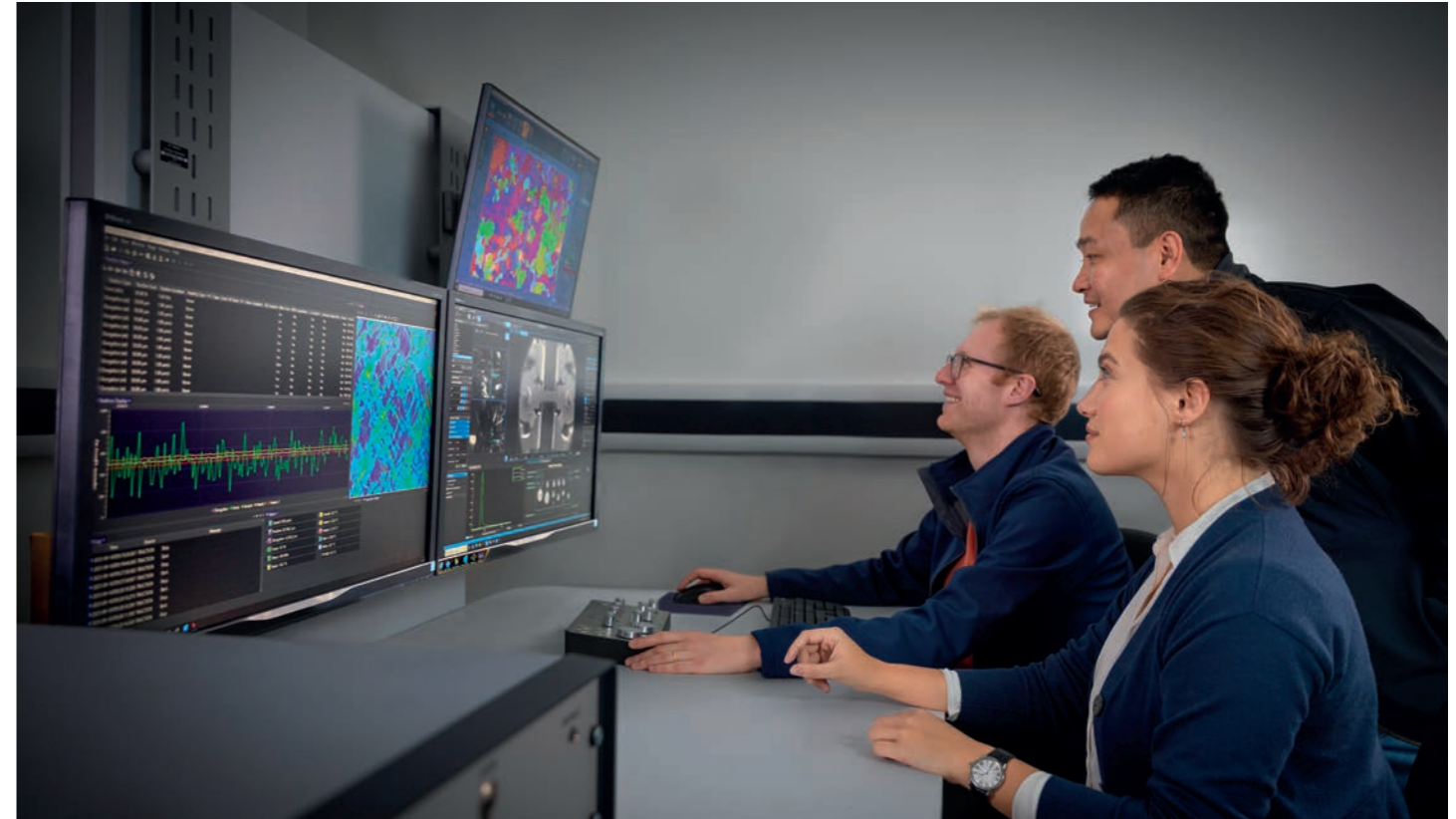
## Why Tritium Matters

The Tritium Fuel Cycle (TFC) Division enables UKAEA's mission of delivering sustainable fusion energy. We develop the technology and expertise needed to make commercial fusion a reality.

Fusion is the process that powers the sun. By recreating it here on Earth, we could generate clean, safe, and virtually limitless energy. Almost all fusion power plant designs rely on tritium as fuel - but it is scarce and requires expert handling. One of fusion's greatest engineering challenges is fuel self-sufficiency: operating the tritium fuel cycle without relying on an external supply. Solving this places TFC at the heart of fusion power plant delivery. Our research develops the technology and processes needed to manage tritium safely and efficiently so that fusion power plants can one day run continuously and cleanly.

### BENEFITS OF FUSION

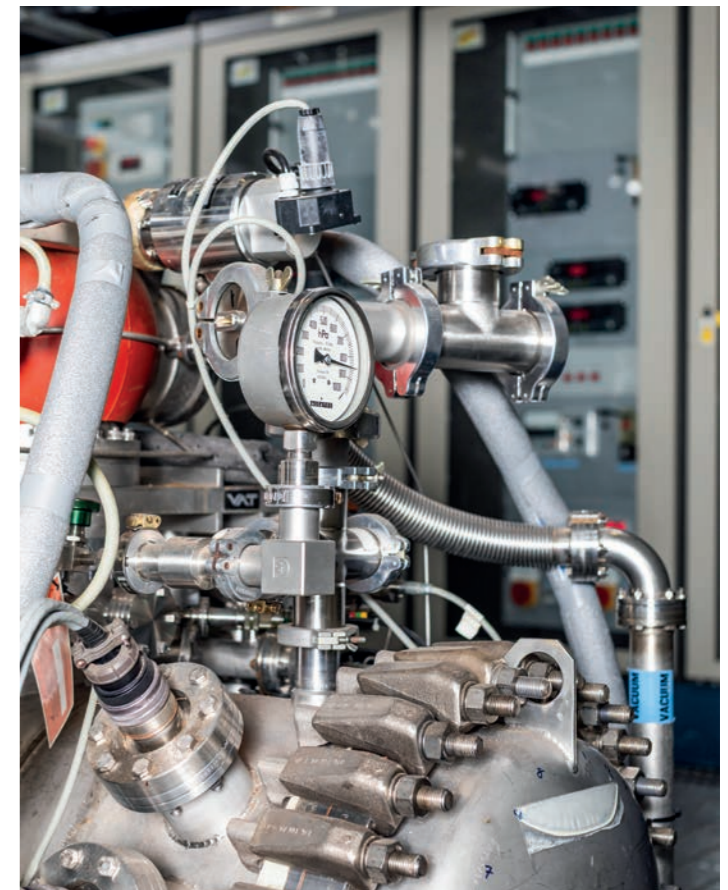
 <b>Low carbon</b>	 <b>Continuous</b>	 <b>Sustainable</b>	 <b>High fuel efficiency</b>
Fusion energy is carbon-free at the point of generation.	Fusion energy is continuously deployable, as it does not depend on external factors such as wind or sun.	Fusion fuel is abundant in our seas and the Earth's crust.	Fusion produces more energy per gram of fuel than any other process that could be achieved on Earth.
			



## Our Priorities

TFC aims to deliver fuel cycle technology for sustainable fusion energy. Our expertise is centred on: -

- **Current operations** - Over 30 years of safe real-world tritium handling giving us the expertise and facilities to lead the way in fusion fuel cycle development.
- **Delivering facilities** - Critical for demonstrating the closed loop continuous fuel cycles necessary for power plants.
- **Tritium research** - Understanding fundamental behaviour and how to build on that to deliver the necessary processes and tools.
- **Skilled people** - Building the skilled workforce the fusion sector needs to move from research to commercial operation.

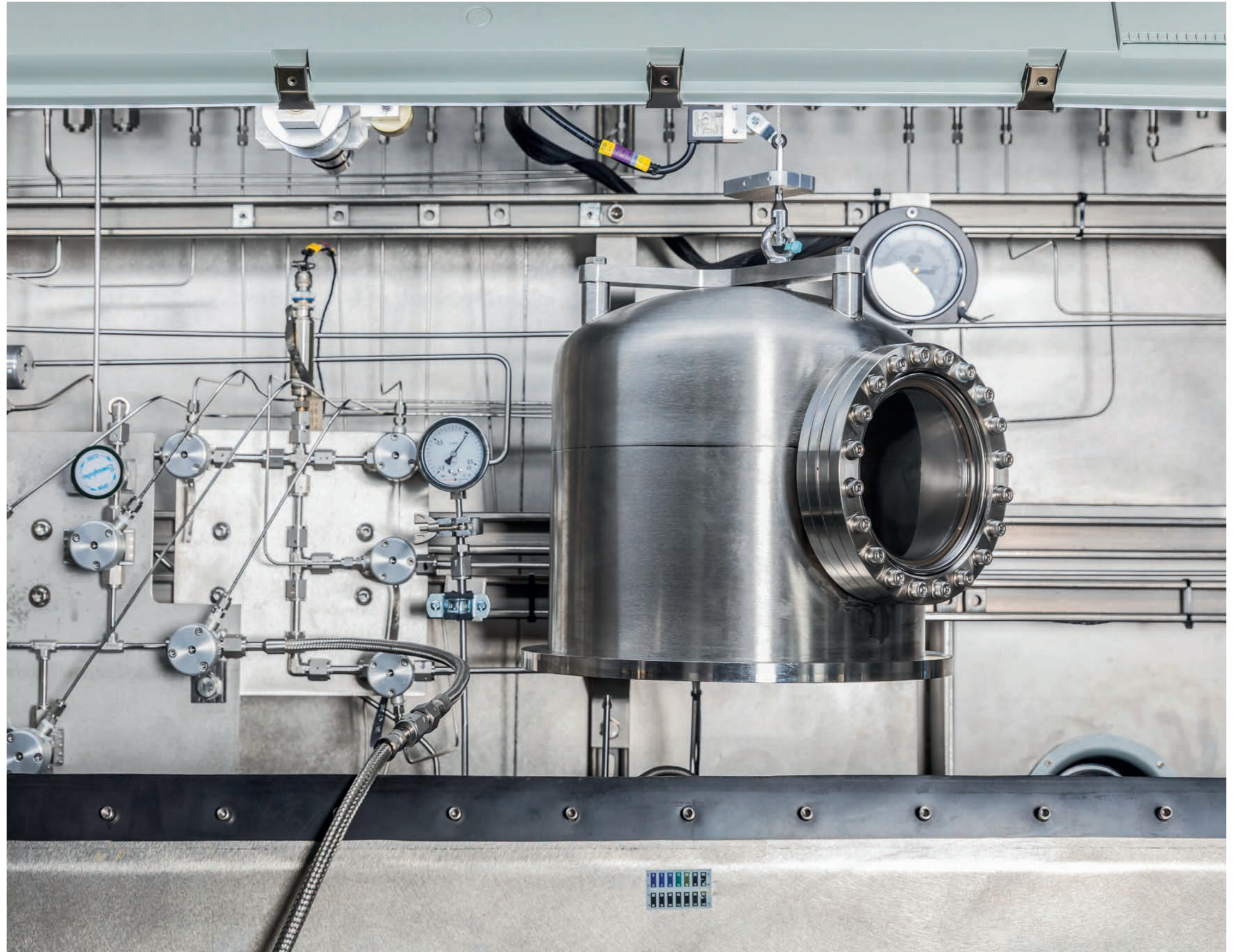


# Current Operations

## Current Operations

Our specialist facilities at Culham cover the full spectrum of tritium technologies, from tritium analysis and materials testing to waste processing. We also conduct research focused on test analytics and tracking how fusion power plant inventory changes over time.

- **Beryllium Handling Facility** - Operations include decontaminating items, waste processing, size reduction and maintenance of vessel components and diagnostics.
- **Tritium Analysis Laboratory** - Pyrolysis testing of samples informs tritium activity levels, safe handling procedures, and regulatory compliance.
- **Waste processing and storage facilities** - Internal and external waste is received, sorted and either prepared for disposal via approved disposal routes or goes into storage.
- **Plastic Fabrication Workshop** - Makes bespoke containment solutions for use across fusion and adjacent industries.
- **Active Gas Handling System** - Ventilating the Joint European Torus (JET) to remove tritium by off-gassing; the system currently contains high levels of tritium from JET's operational history. AGHS also acts as a User Facility, enabling external access to the facility infrastructure. The experimental VPT and HERA capabilities within the AGHS will be coming online during the next financial year, and EUROPA will be commissioned at a later date.
  - **Vacuum Pump Train (VPT)** – A rig that assesses the tritium compatibility and performance of a modified scroll pump, while verifying auxiliary systems intended for the H3AT facility against tritium-handling requirements.
  - **HERA** - A glovebox for real-time tritium analysis in gas streams using mass spectrometry and Raman spectroscopy, with capacity for a third analytical instrument and testing of a palladium catalyst for Q2 species equilibration.
  - **EUROPA** – A high-temperature tritium permeation setup measuring permeation rates through various materials at temperatures up to 550°C and pressures up to 1 bar(a), while addressing the fusion fuel cycle challenges of containment loss and gas/fluid contamination.





## Capabilities in the Materials Research Facility

The Materials Research Facility (MRF), within the UKAEA's Materials Division, hosts a range of capabilities and expertise focused on developing materials for the nuclear industry. Given the natural overlap with TFC's activities with materials, the following TFC capabilities are housed within the MRF:

- **TDS** (Thermal Desorption Spectrometer) is used to measure outgassing of samples to determine the amount of tritium in them.
- **DELPHI** (Device for Exposure to Low-energy Plasma of Hydrogen Isotopes) is a plasma-based linear device used to study hydrogen isotope retention in fusion-relevant materials.
- **LTPR** (Low Temperature Permeation Rig) is an experimental rig measuring tritium permeation through materials at near-room temperatures (up to 300°C), generating data to inform packaging and waste storage solutions for long-term tritium containment.
- **THEIA** – a hydrogen sorption analysis facility that investigates the adsorption and desorption behaviour of hydrogen isotopes in materials such as zeolites and palladium, operating across a wide range of cryogenic to high temperatures and pressures.
- **PMR** – Palladium Membrane Reactor – Test inactive operational process within an ITER relevant design.

## Tritium Research Capabilities

Our tritium expertise is recognised globally, and we collaborate with international partners to share knowledge and data to accelerate fuel cycle development worldwide. Underpinning our operational work is an active research programme that draws on — and feeds back into — our facilities and expertise. Our research covers the full tritium lifecycle — from understanding how tritium interacts with materials, to developing the subsystems and analytics needed to handle it safely and efficiently. We also look at how these elements combine at whole-plant scale, ensuring future power stations can manage their tritium inventory effectively and leave no burden of waste for future generations. Our research programme is focused around the following four themes: -

- **Tritium Interactions with Materials**  
We research tritium's interactions with materials to improve hydrogen isotope separation and minimise permeation, maximising the fuel available for the fusion fuel cycle.  
**See section on Capabilities in the MRF.**
- **Developing Subsystems and Analytical Techniques**  
We are advancing integrated tritium handling subsystems with robust analytics.
  - **THALIA** - Testing existing and novel analytical techniques in liquid breeder materials.
- **Plant Architecture and Digital Twins**  
We are using decades of hands-on experience and advanced digital modelling to map how materials and subsystems fit together across the full tritium lifecycle.
  - **Virtual Control Room** - A digital twin of the H3AT facility using models developed as part of the Tritium Inventory Modelling programme.

Visit our website for more examples and information on our operational and experimental facilities.

# Developing Facilities and Developing Skills



## STEP (Spherical Tokamak for Energy Production) programme

TFC's research and facilities directly support UK Fusion Energy's (UKFE) STEP programme, providing the fuel cycle expertise and technology needed to design and deliver the UK's first prototype fusion power plant.

## Developing Skills for the Future

Fusion's success depends on people as much as technology. That's why we are investing in training and nurturing talent at every level - from apprenticeships to a postgraduate programme and PhD sponsorship for fusion-related research.

Our goal is to build a highly skilled workforce that ensures safe, efficient operations and drives innovation. By developing expertise today, we're securing the capability needed to transition from research to commercialisation tomorrow.

## Tritium Training Course

Want to Build Your Skills in Tritium Safety and Handling?

Join our Tritium Training Course to gain the knowledge needed to work confidently with tritium. Whether you are a scientist, engineer or a new starter, our expert team will take you through tritium fundamentals, to future fusion plant concepts and how fuel cycles change.

Join us at Culham Campus, where the course includes tours of both the Tritium and Waste Treatment Plants, or the team can deliver the course at your site, which includes a virtual tour.

## Applied Tritium Learning Programme

If you have already completed our Tritium Training Course and would like to go further, our Tritium Facilities offer an immersive experience, allowing participants to observe live tritium processing operations in the AGHS.

## Waste and Decommissioning

UKAEA brings decades of operational experience in tritiated waste management, built through some of the world's most significant fusion research programmes. Our work spans the full lifecycle of tritiated materials — from characterisation and safe handling through to treatment, size reduction and disposal — offering genuinely integrated solutions for the fusion sector.

Our approach is guided by three core objectives: reducing waste volume and activity; developing safe, compliant and practical waste handling processes; and ensuring fusion waste does not become a burden on future generations.

Current research is advancing techniques for removing tritium from a range of hard materials (including Inconel, stainless steel, copper, beryllium and tungsten) and soft materials such as PPE and plastics, building the evidence base for cost-effective, compliant waste strategies.

The ongoing decommissioning of JET is providing hands-on experience of dismantling highly activated components in a live environment — one of the most technically complex fusion decommissioning projects

in the world. The knowledge developed through this programme is directly transferable to future commercial fusion facilities.

Our facilities include dedicated equipment to support this work:

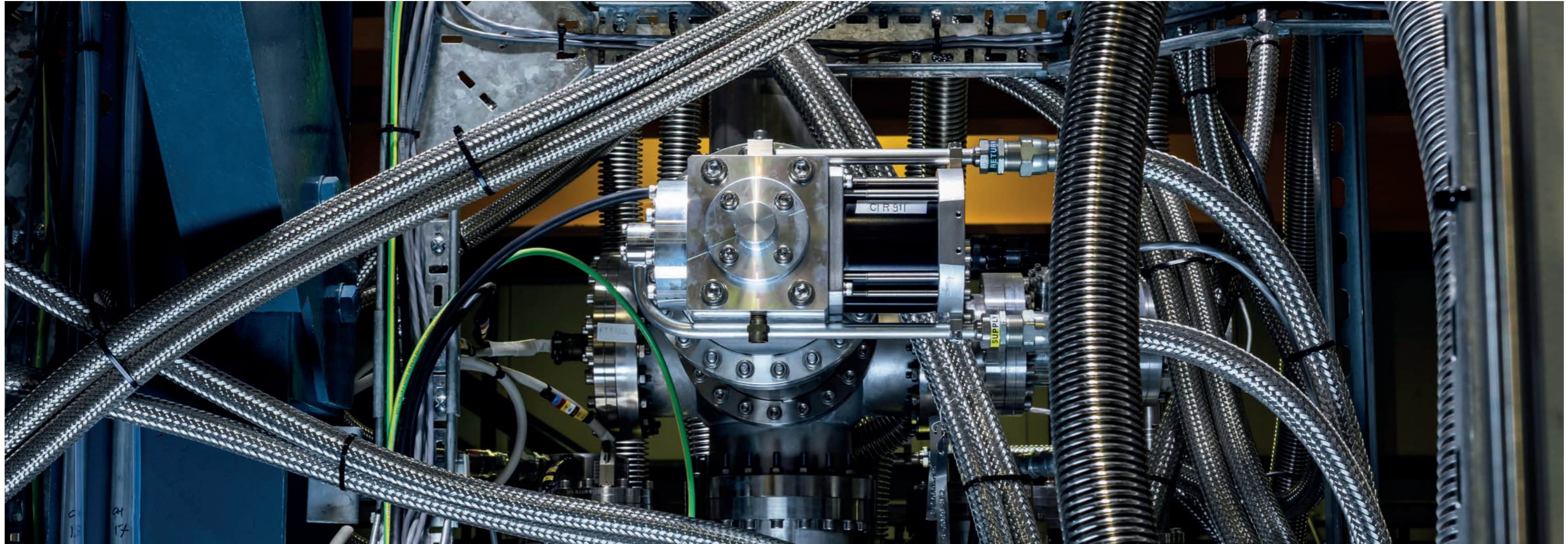
- **FREYA** - Metal melting facility for waste volume reduction, homogenisation and detritiation.
- **Materials Detritiation Facility** - Uses thermal treatment(s) to reduce intermediate-level waste to low-level waste.

## UKAEA-Eni H3AT Facility

UKAEA and Eni are designing and building the H3AT (Hydrogen-3 Advanced Technology) Facility, a continuous, closed loop tritium fuel cycle providing a platform for the development of fuel cycle technology to meet the operational demands of future fusion power plants. This world-class facility provides industry and academia the opportunity to study how to process, store, and recycle tritium.



# Key Benefits for Partners



## Key Benefits for Partners

Working with TFC offers access to expertise, infrastructure, and knowledge that cannot be found anywhere else in the world. Whether you are looking to advance your technology, reduce risk, or contribute to the global fusion effort, partnering with us provides:

- Globally unique tritium handling capabilities, from early stage testing through to operational deployment.
- Accelerated technology development, de-risked through decades of operational, safety and regulatory experience.
- Direct insight from one of the world's most complex fusion decommissioning programmes, with knowledge directly transferable to future facilities.
- Access to an internationally connected research network — with established collaborations across Europe, North America, and Asia, and co-authored research opportunities with a globally linked fusion community.
- A pathway to commercialising tritium technology, with UKAEA-developed IP available for industry partnership and deployment.
- Actively working with UK industry to build tritium fuel cycle capability across the supply chain – helping companies develop the skills and technologies needed to support future fusion power plants.
- A trusted partnership environment, focused on shared progress towards sustainable fusion energy.

Scan to learn more about the research and capabilities of TFC and for information on the next Tritium Training Course



[www.ukaea.org/services/training/#tritium-training-course](http://www.ukaea.org/services/training/#tritium-training-course)

The UK Atomic Energy Authority's mission is to lead the delivery of sustainable fusion energy and maximise scientific and economic benefit



UK Atomic Energy Authority

Find out more  
[www.gov.uk/ukaea](http://www.gov.uk/ukaea)

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