UK Atomic Energy Authority

Fusion Technology Facilities

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Fusion TECHNOLOGY

Fusion is now entering the 'delivery era'

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ITER Organisation

UKAEA's Mission

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"Lead the delivery of sustainable fusion power and maximise scientific and economic benefits"

Fusion needs integrated solutions

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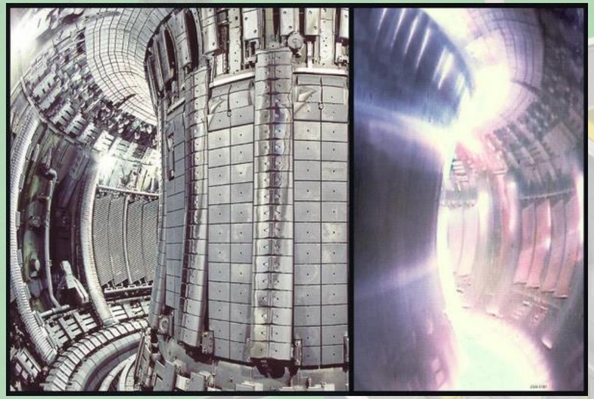
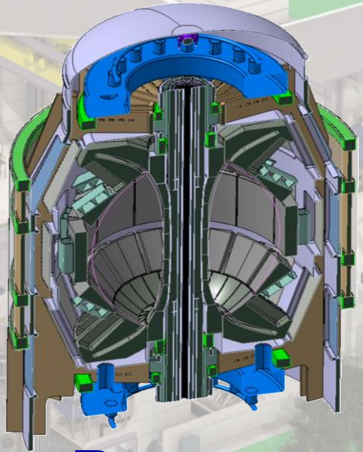
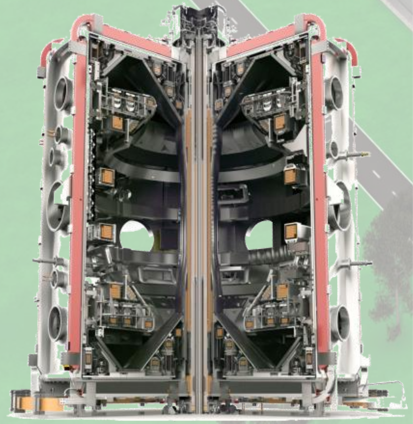


High performance plasmas in JET



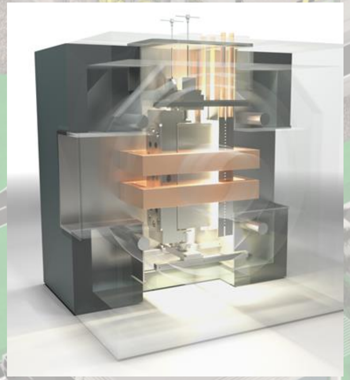
Reactor Design STEP and DEMO

Advanced computing and digital design



Heat exhaust in MAST Upgrade

Develop materials in Materials Research Facility (MRF)



Test components in Fusion Technology Test Facilities (FTF)

Tritium handling in Hydrogen-3 Advanced Technology (H3AT)

Robotic handling in RACE

FT Development Themes

- **Fusion power plant design parameters and standards**
- **Innovation and designing with uncertainty**
- **Nuclear data & irradiation management**
- **Prediction and validation of in-service behaviour**
- **Manufacturing and inspection fit-for-fusion** (inc. in-vessel repair)
- **Component performance under combined loads**
- **Technology for high magnetic fields**

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Fusion TECHNOLOGY

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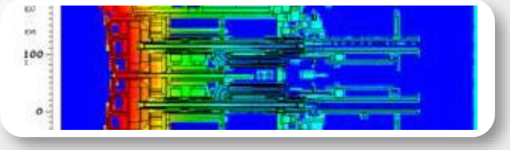
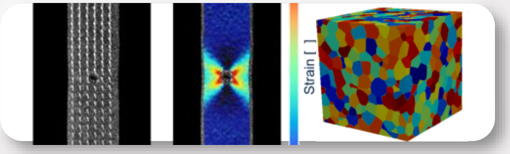
Applied Radiation Technology



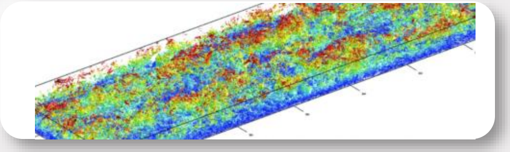
Power Plant Integration

Applied Materials



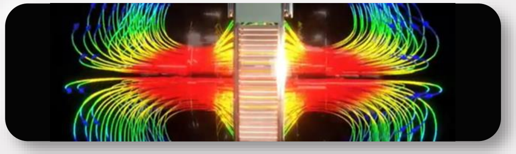
Manufacturing and Qualification

Thermal Hydraulics



Engineering Innovation

Fusion Test Facilities



Fusion Technology Facilities - Current

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RADlab

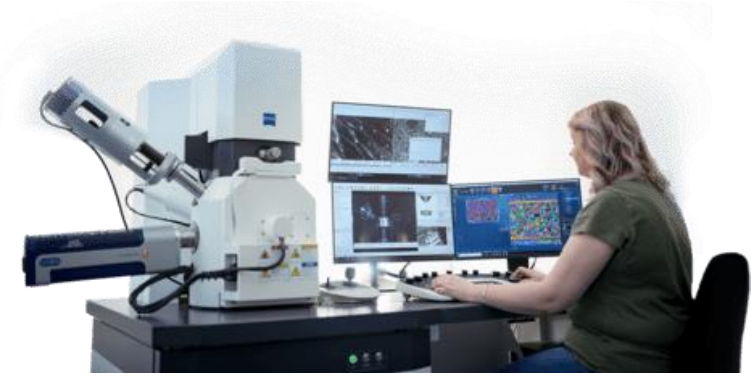
Radiological Assay and Detection Lab (RADLab) housing neutron diagnostics and the UKAEA ADRIANA (Advanced Digital Radiometric Instrumentation for Applied Nuclear Activities) instrument suite.

- Digital systems for environmental radioactivity assay
- Broad energy germanium (BEGe™)
- Small anode germanium (SAGe™) detector systems
- Diamond detectors
- Thermoluminescent dosimeter (TLD)

HIVE

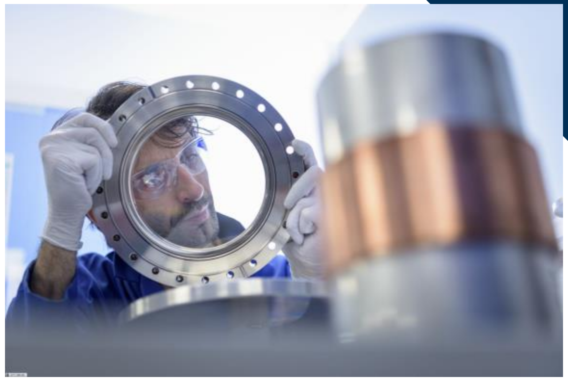
High heat flux testing

- 10-15 MW/m^2
- Heating by induction
- 30*30mm sample under test size



Applied Materials Technology Laboratory

- Materials testing and characterisation
- Small-scale sample testing
- Design codes and standards for fusion
- Application specific material selection
- Digital Image Correlation (DIC) for stress, strain, and deformation capture and modelling
- Tensile and compression of up to 50kN
- Rotational torsion
- Temperatures of 1200°C to -190°C



Special Techniques Group

- Diffusion bonding
- Optical viewports
- Vacuum brazing
- Air furnacing
- Thin film operations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Sheffield Hallam University

NUCLEAR AMRC

Rolls-Royce

TWI

SHEFFIELD FORGEMASTERS

AMRC ADVANCED MANUFACTURING RESEARCH CENTRE

The University Of Sheffield.

BOEING

McLaren

CHIMERA

Combined Loads Testing Facility

Component Size	1.7m x 0.5m x 0.7m
Testing Environment	Vacuum or inert gas
Water Cooling	200°C, 15 bar – 385°C, 155 bar
Surface Heating	0.5 MW/m^2 over $1m^2$
Simulated Volume Heating	Up to 100 kW
Static Magnetic Field	4 Tesla
Magnetic Impulse	dB/dT ~12 T/s
Static Magnet	Split pair LHe superconducting magnets with NbTi conductor
Pulsed Magnet	Water cooled copper conductor

Suite of Thermal Hydraulic Relevant Facilities at FTF

Dedicated Thermal Hydraulics

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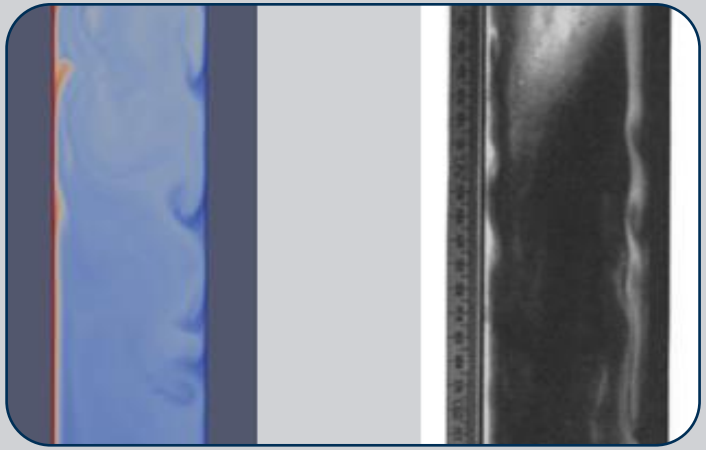

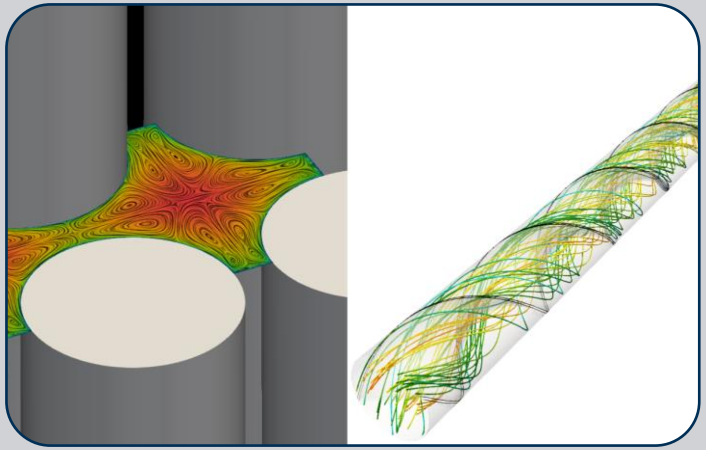

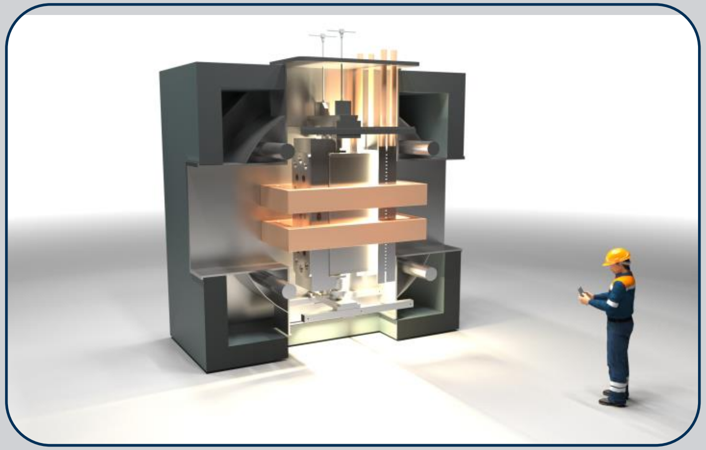

SmalLab

Small-scale testing of isolated flow phenomena.

Understanding turbulence phenomena for benchmarking digital codes

Anna

Large-scale testing of single / multi-phase flows

Providing high-resolution data at high-temperature reactor conditions for further benchmarking.

Extensive collaboration across fission, fusion, and other industries

CHIMERA

Component-scale single phase water flows

Testing in full fusion-relevant conditions including magnetic field effects and upgrades to include liquid metal flows

(For Info Only slide) Typical Facility Parameters

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Coolant(s)	Water	Water	Water + LiPb
Power Input	~1 kW	250 kW	600 kW
Pressure	Atm.	15.5 MPa	15.5 MPa
Temperature	< 50 °C	328 °C	328 °C
Flow Rate	< 0.1 kg/s	3.5 kg/s	10.8 kg/s
Diagnostic Resolution	High	High	Low

* P, T & flow parameters for water conditions only

SmalLab

Small-scale testing of isolated single-phase water flow phenomena

ANNA

Large-scale single and multi-phase water flows

CHIMERA

Component-scale single phase water flows

Pegasus

Digital twin for design, virtual qualification, and real-time condition monitoring

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Experiment / physical Asset
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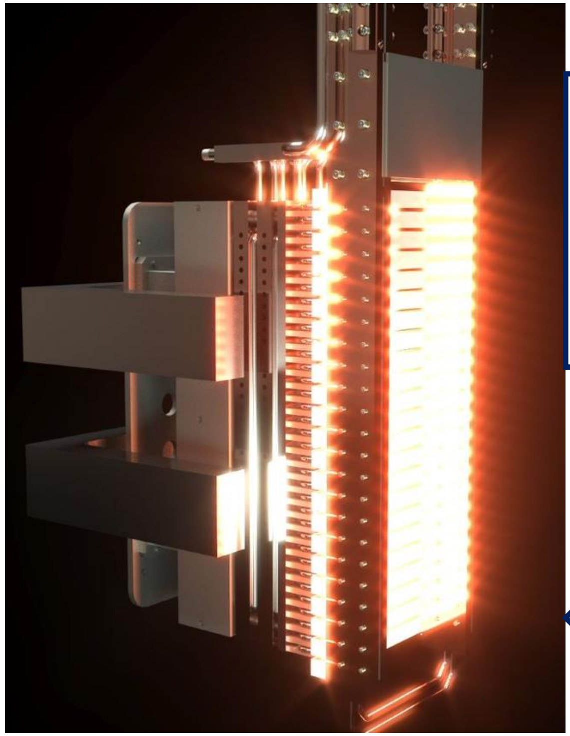
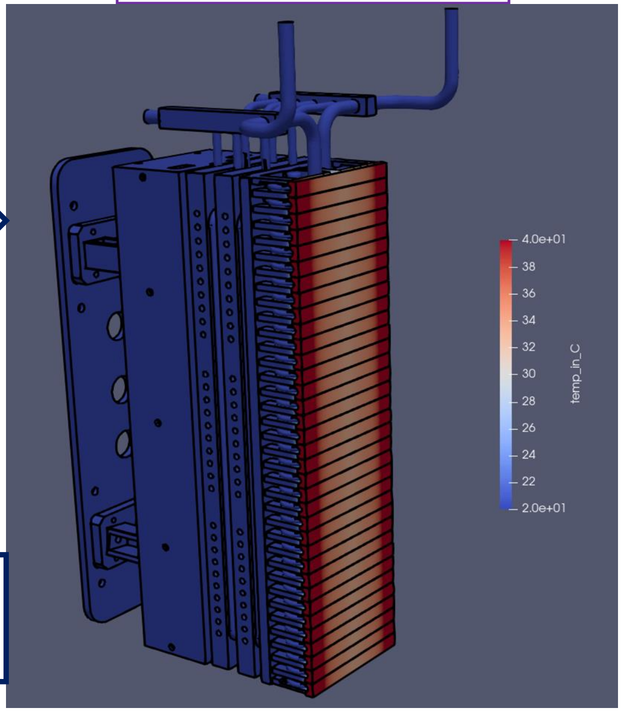


Sensor measurements

Synchronise digital twin

Control signals

Digital Twin
Pegasus
Integrated systems model



Elsa

Reproducing a fusion relevant environment for testing demountable HTS connections, at cryo temps in a magnetic field

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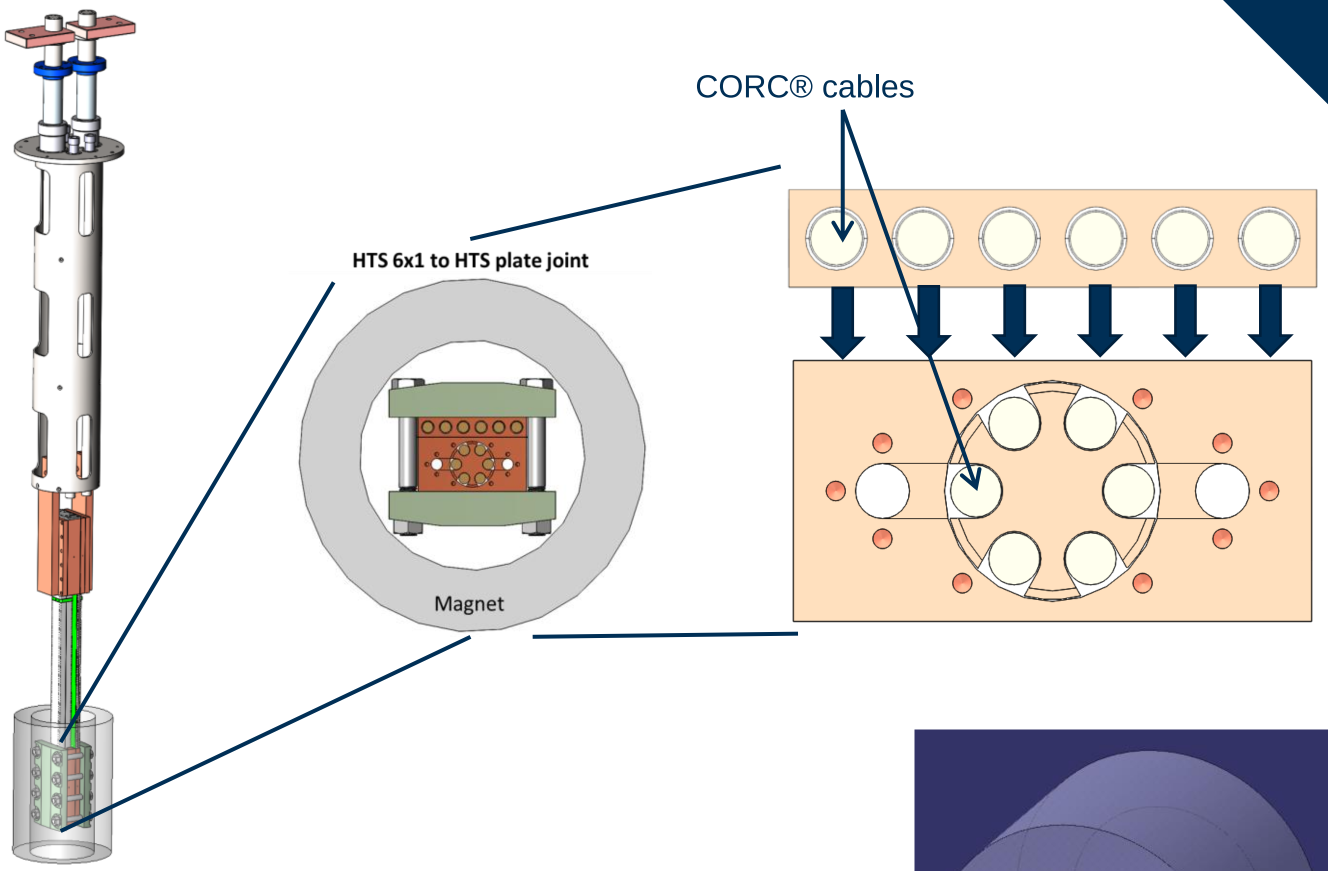
Based in UKAEA south Yorkshire, Elsa intends to test and develop magnet components and re-mountable joints under cryogenic-magnetic environments. These components will support STEP and other projects.

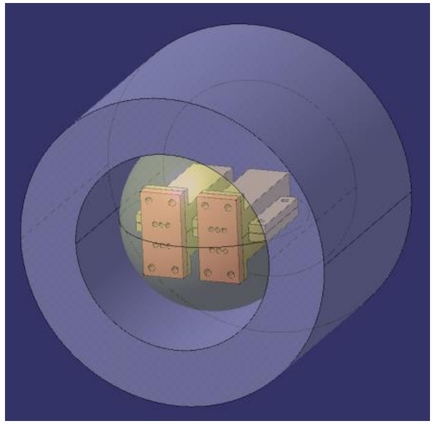
The rig comprises of three main elements:

- **Cryostat** with 4T superconducting magnet, and Variable Testing Insert (VTI) capable of hosting temperatures from 4.2K – 20K, to 77K.
- **Data Acquisition System** (DAQ)
- **Cryoplant** with control system for Helium and liquid nitrogen transfer

Elsa will provide data for parameters such as:

- **Thermal stability** e.g. ohmic heating
- **Electrical performance** and current distribution
- **Termination resistance** and its relationship to joint performance





The UUT's will be large components such as multiple re-mountable joints in parallel

FTF Objectives

- De-risking components and assemblies before installation in Tokamak
- Substantiating digital predictive models
- Simulate affects of plasma perturbations e.g. disruption
- Verifying design based qualification
- Supporting regulatory approval
- Certifying manufactured solutions

Thank You