Introduction to the Culham Centre for Fusion Energy (CCFE)

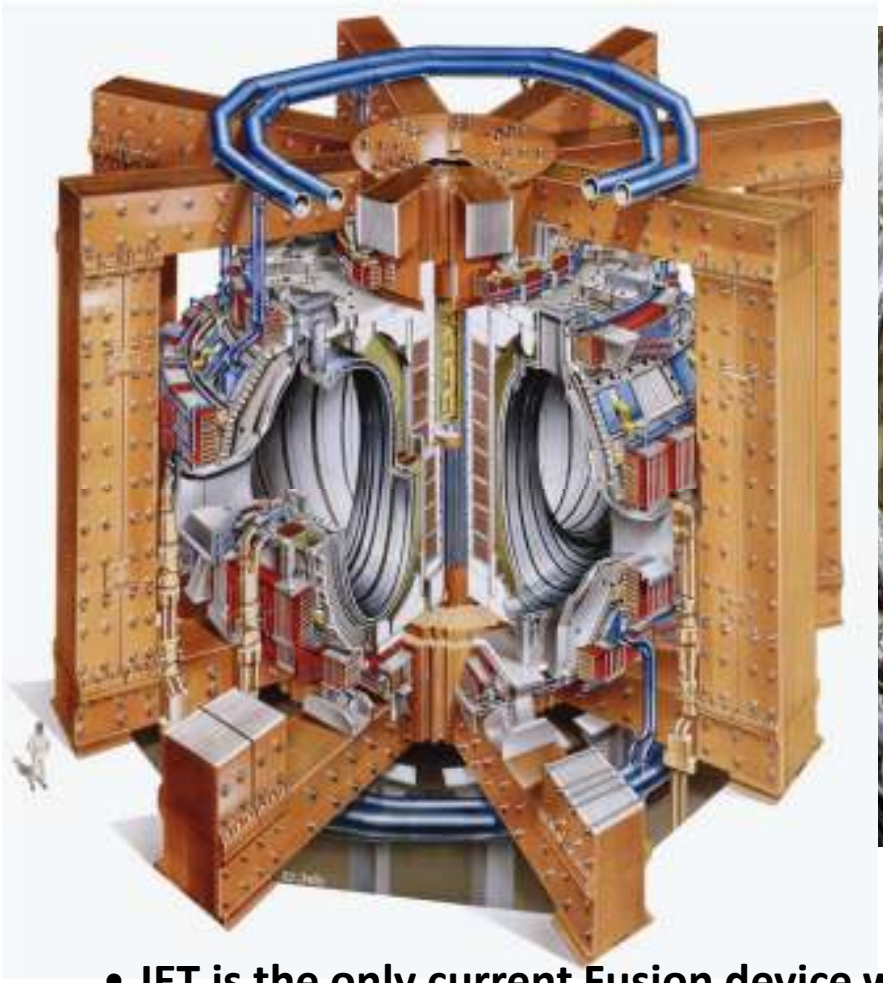
By Stuart Knipe
(Head of Tritium & Vacuum Unit)

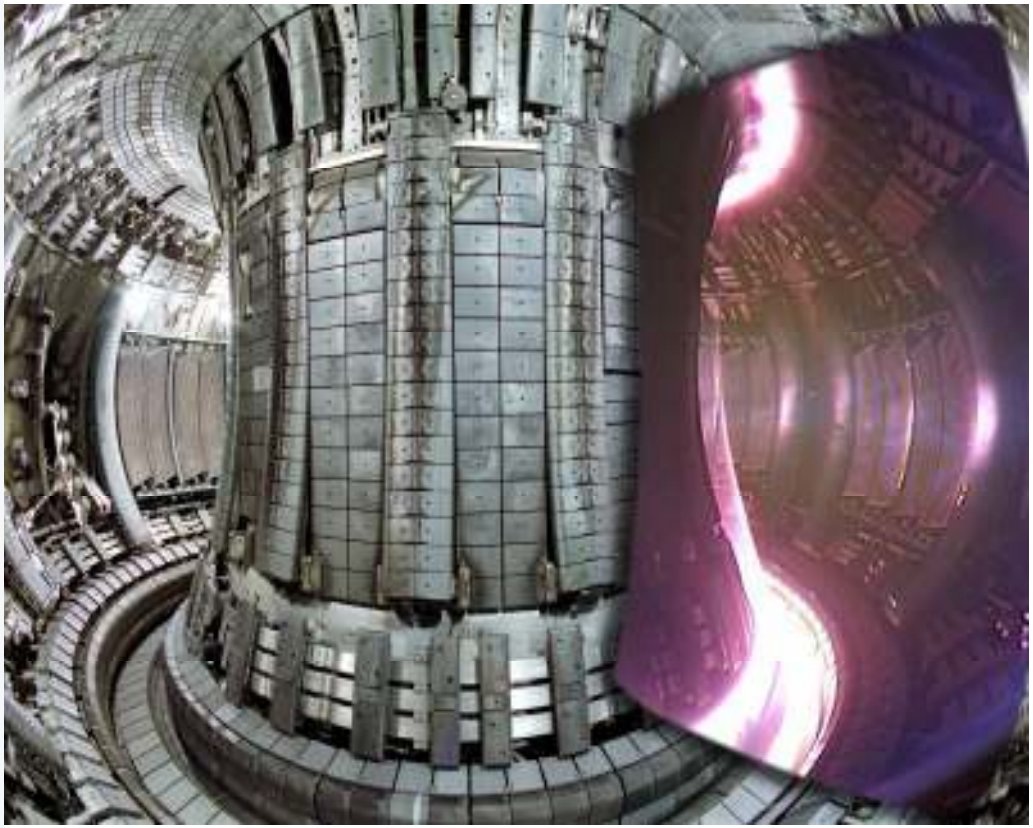
CCFE is the fusion research arm of the **United Kingdom Atomic Energy Authority**

Culham Centre For Fusion Energy

- Operates JET (Joint European Torus) on behalf of the European Commission.
- Operates MAST (Mega Amp Spherical Tokamak) as part of the UK domestic program.
- Theory and Modelling research.
- Technology and Materials programme.
- International Thermonuclear Experimental Reactor (ITER) contracts
- DEMO (Demonstration Fusion Reactor) work under European consortium.
- **Tritium Science and Engineering**

CCFE Operates JET





- JET is the only current Fusion device with a Tritium Fuelling capability

CCFE Expertise

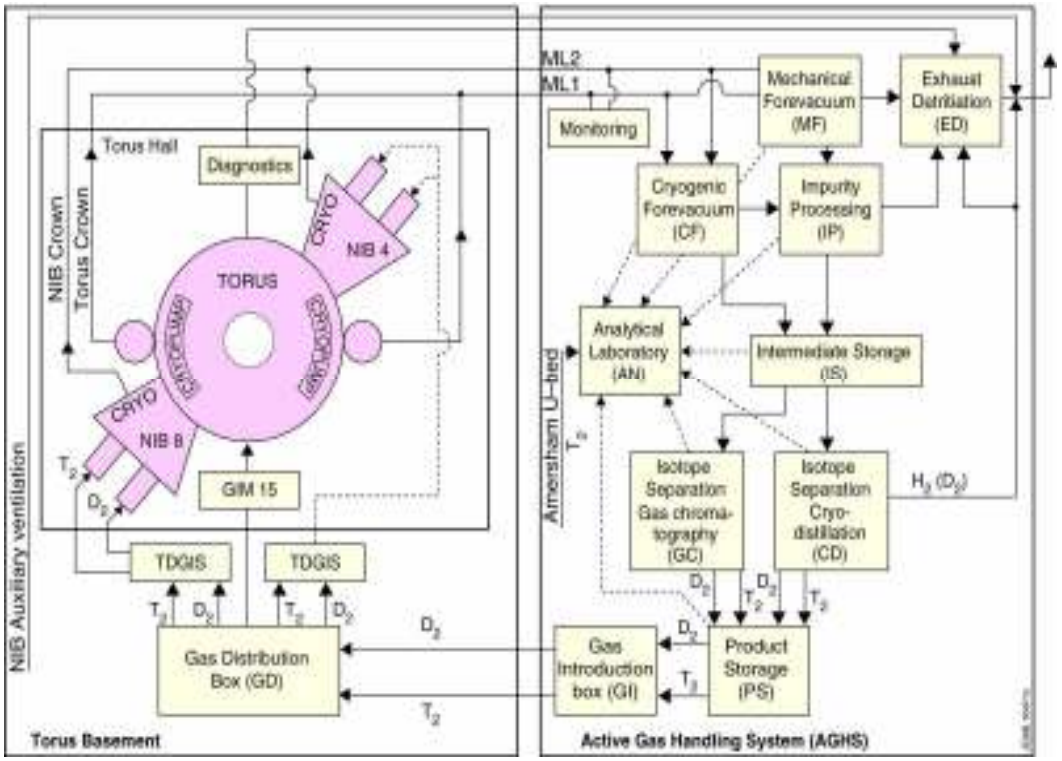
- A dedicated Tritium Science and Engineering Group with over 20 Scientists and Engineers
- Over 20 years of Operational, Research & Development expertise with tritium systems
- Founding member of UK Tritium Users Group
  - Established to ‘encourage and maintain effective information exchange on tritium issues and studies’
  - leading to the sharing and exploitation of "best practice" methodologies in tritium operations and waste treatment.

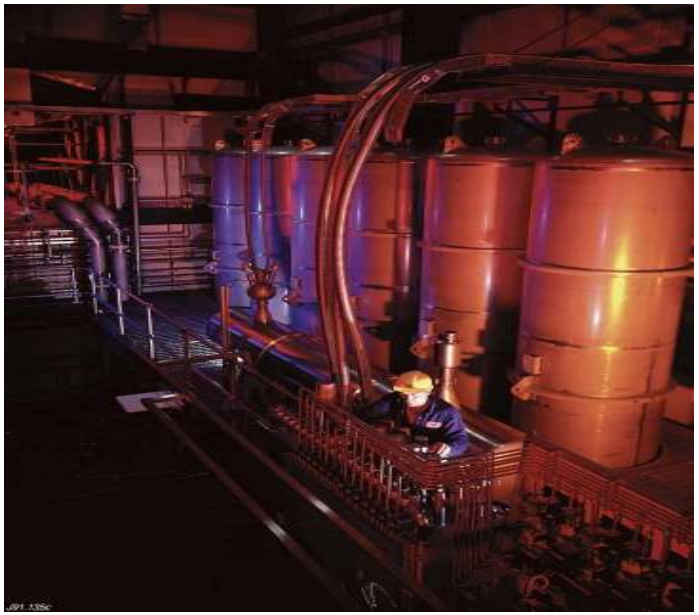
Tritium Sources and Users

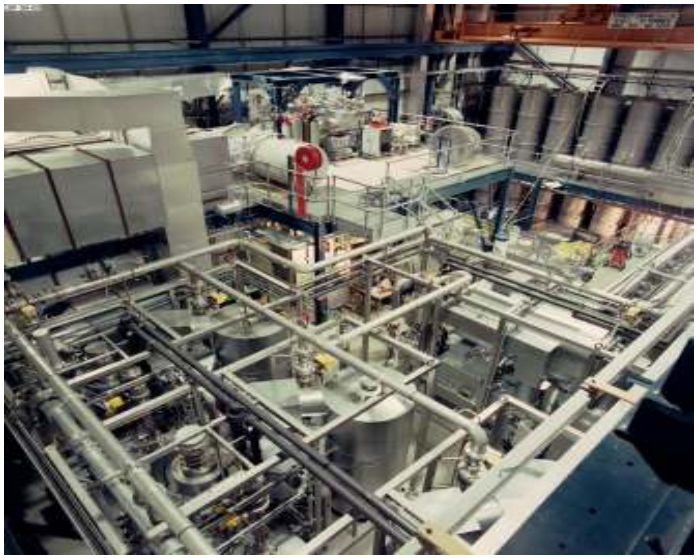
- Atmospheric via cosmic rays
  - Natural inventory = 3.5kg, 200g produced every year [1]
  - Small amounts additionally produced within the Earth
- Nuclear weapons tests
  - Residual atmospheric tritium levels amount to 1.26 10^7 TBq (35kg) [1]
- Nuclear fission power plants
  - Fission products and nuclear fuel reprocessing
  - Activation of deuterium in CANDU/heavy water reactors
- **Fusion facilities**
- Nuclear weapons research/production
- Radio-nuclide labelling
  - Particularly significant due to the production of tritiated organic molecules
- Luminescent devices

1 - Livre Blanc (White Book) du Tritium, l'Autorité de sûreté nucléaire, 2010

Tritium Operations



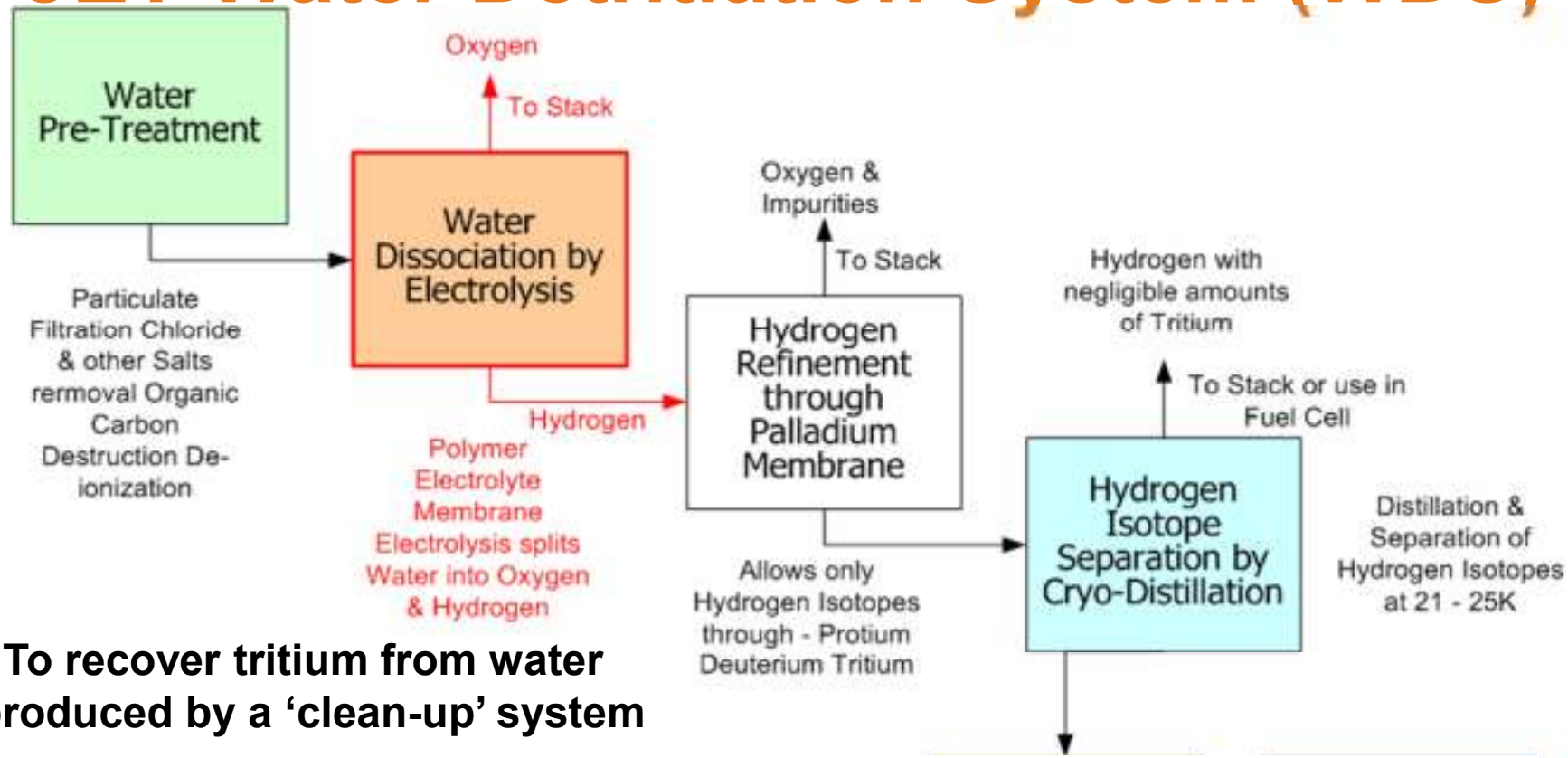




Active Gas Handling System (Tritium Plant)

- Closed loop tritium fuel cycle
- Authorisation for 90g Tritium (32,000 TBq)
- Water Detritiation System Commissioning in 2014

JET Water Detritiation System (WDS)



- **To recover tritium from water produced by a 'clean-up' system**
- **Simple process to meet specific need at JET**
- **<u>Not</u> 'State of the Art'**

Water Detritiation System (WDS)

- Reprocessing plant (Canada) unable to accept water due to chemical impurities
- Simple system employing water purification, electrolysis, hydrogen purification and hydrogen distillation
- Non 'State of the Art' design from considering options available
- Not optimum efficiency
- Capital cost of ~ £1.5M
- Process up to 135 kg of water per day (34m^3 per year based on 250 operating days per year)
- Activity up to 0.18TBq/l (6,000TBq per year)
- No residual water. Full conversion to molecular hydrogen
- Power consumption ~ 130kW (Electrolysers 40kW)

Water Treatment Options

- 4 individual options involving 5 locations were considered in combination to produce 30 options.
    - Purify
    - Concentrate (water)
    - Detritiate
    - Discharge (via an external organisation)
- 10 passed ‘pre-screening’ which included being technically viable to achieve disposal and being able to address existing inventory and future arisings.
- Each option assessed against 16 criteria under 5 headings
- Sensitivity analysis performed against each of the 5 headings. Each normalised before applying a weighting factor of 2.

Criteria and Scoring (1)

Heading	Criteria	Notes	Scoring (1 to 5)
Availability/ Practicality	Lead time	Time required for full availability	1 – Greater than 3 years 3 – 1-3 years 5 – Currently available
	Continued availability	Likelihood of continued availability	1 – Route closed in 2-3 yrs 3 – Route available 5-10 yrs 5 – Available for foreseeable future
	Proven technology	Technology proven for use	1 – Theoretical 3 – Proven for samples 5 – Proven at required scale

Criteria and Scoring (2)

Heading	Criteria	Notes	Scoring (1 to 5)
Financial	Start-up cost	Initial cost to set up route	1 – High 3 – Medium 5 – Low
	Operational cost	Running cost: utilities, raw materials, training etc.	1 – High 3 – Medium 5 – Low
	Decommissioning	Decommissioning cost	1 – High 3 – Medium 5 – Low
	Commercial Benefit	Potential for commercial opportunities	1 – Low 3 – Medium 5 – High

Criteria and Scoring (3)

Heading	Criteria	Notes	Scoring (1 to 5)
Environmental	Transport emissions	Emissions/carbon associated with transporting HTO	3 – As current route
	Process energy use	Energy used (excluding transport) for entire route – including off-site	3 – As current route
	Tritium recovery	Does method allow tritium to be recovered for re-use	1 – None recovered 3 – Some recovered 5 – All recovered
	Volume reduction	Overall volume of waste reduction (including secondary waste)	3 – As current route

Criteria and Scoring (4)

Heading	Criteria	Notes	Scoring (1 to 5)
Health and Safety	Proximity Principle	Dispose/manage close to point of production	3 – As current route
	HTO Handling	Risk of exposure during handling	3 – As current route
	Number of processes	Increased opportunity for accidents	3 – As current route

Criteria and Scoring (5)

Heading	Criteria	Notes	Scoring (1 to 5)
Regulatory/ Public Relations	Change to Environmental Permit	Would option require change to Permit	1 – Major or immediate change required 3 – Minor change or change in 2+ years 5 – No change required
	Legislation	Feasible under current/future legislation	1 – Potential for legal breach 3 – Legal breach unlikely 5 – No potential for legal breach
	Public Image	Perceived harm/potential for damage to image	

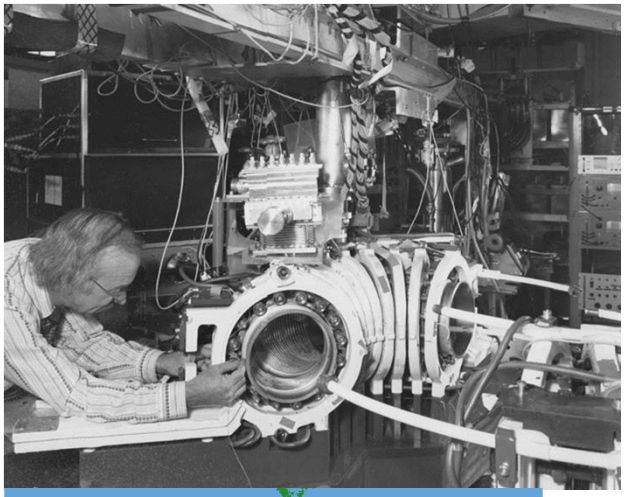
Local Stakeholder Engagement

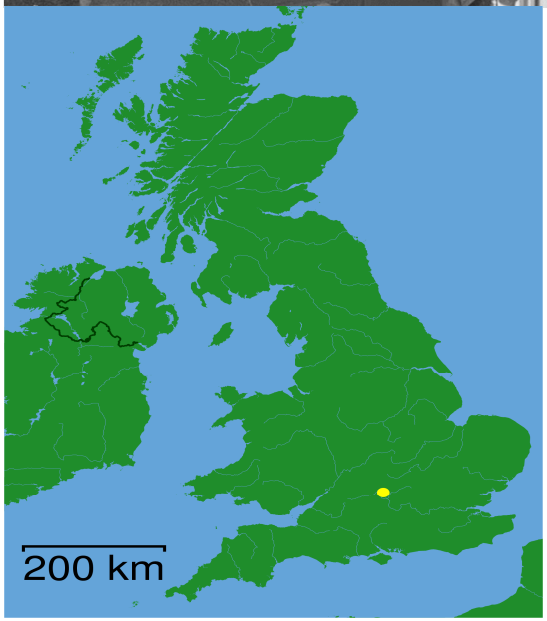
- Twice yearly Culham Local Liaison Committee (LLC)
  - Discussion with local politicians, tenants, local inhabitants (schools and villages) and regulators. Present progress and future plans. Chaired by CCFE Chief Executive
- Close links with local councils – especially economic development teams and planning
- Close links with local MPs (UK Parliament) and MEPs (European Parliament).
- Open evenings/days – one per month, 100 people attending each. Many of them local residents; some dedicated to local villages and towns. Free to attend.

Local Stakeholder Engagement

- ‘Best Available Techniques’ (BAT) Study performed by independent organization to develop Culham Integrated Waste Strategy considering all waste streams not just radioactive.
- Local stakeholders and regulator are an integral part of the BAT study team. Independent technical experts present to provide balanced view.
- Considers all aspects of strategy including traffic, noise, energy, discharges, employment and timescales etc.

History of Culham





Dedicated fusion laboratory since 1965

Selected to host The Joint European Torus (JET) in mid 1970s – JET completed in 1983.

Run by the UK Atomic Energy Authority

The UK Atomic Energy Authority Mission

The Authority's principal mission is to position the UK as a leader in a future, sustainable energy economy by advancing fusion science & technology and related technologies to the point of commercialisation.

Thank you for your attention