

# Engineering Research at CCFE



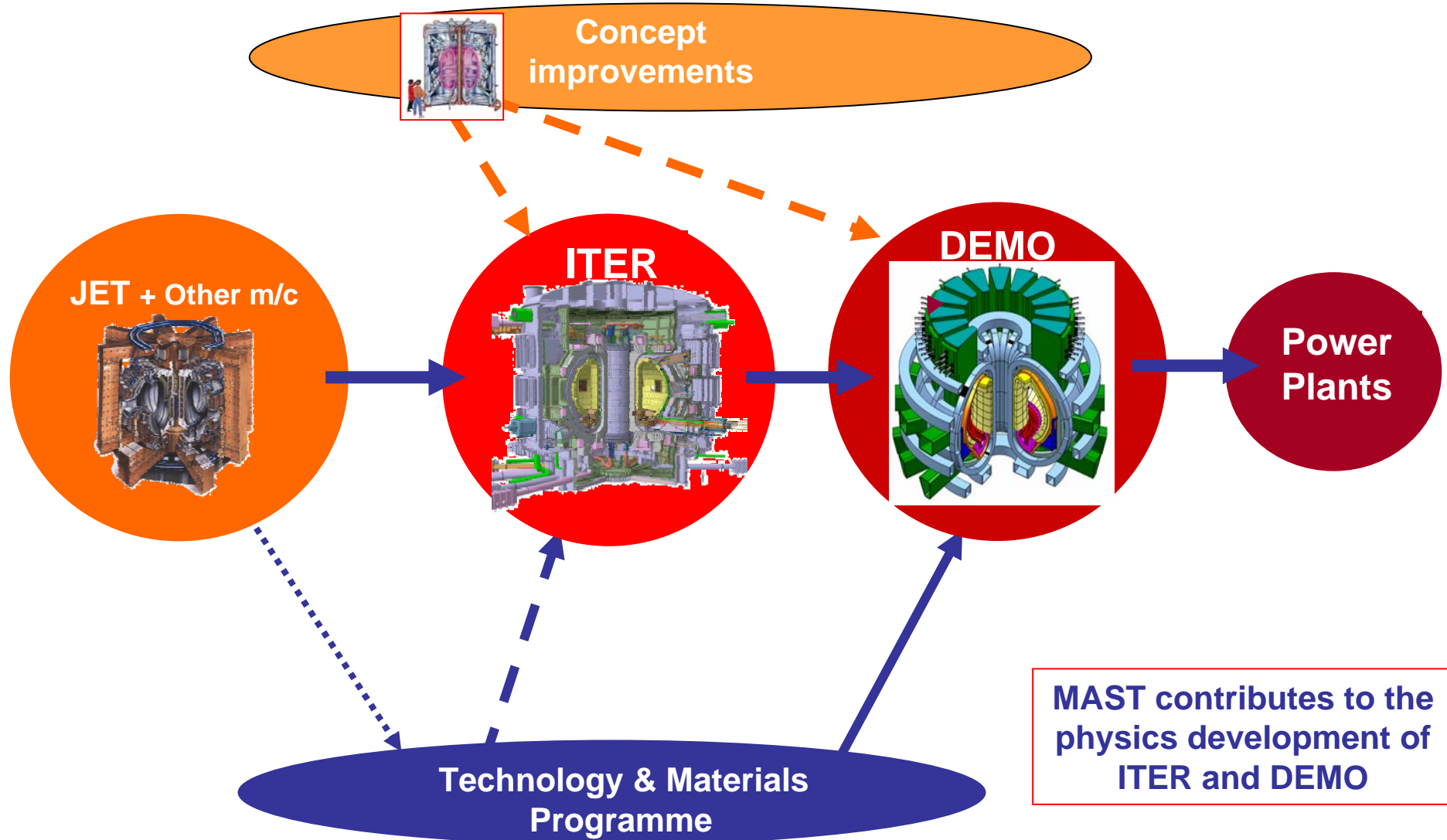
**“I think the most important practical problem, which maybe more of an engineering challenge than a scientific one, is to build economically viable nuclear fusion power stations”**

**Brian Cox, 11<sup>th</sup> September 2010, The Guardian**



**David Hancock, CCFE Engineering Outreach**

Fusion 'Fast Track' (after King et al)



- **Technology** is the major challenge for a demonstration reactor -- DEMO.
  - **University** strengths in engineering can help enormously to place UK in a central role in this coming phase.
  - Eventually this will enable **UK industry** to participate in the fusion economy.
  - Many **synergies** exist with inertial confinement and fission.
- Some technology themes of interest to CCFE:
    - **Divertor and high heat flux components**
    - **Materials and compatibility with DEMO plasma**
    - **Fusion first wall and blanket**
    - **Tritium inventory control and processing**
    - **Remote handling**
    - **and many more!**

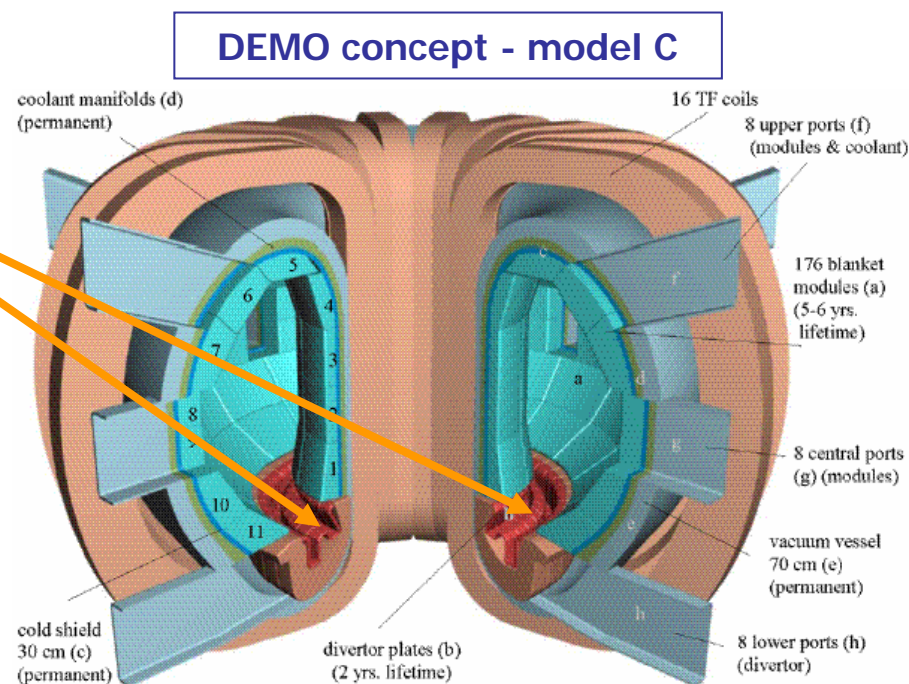
## the Divertor and high-heat-flux components

### Heat Transfer Enhancement for Power Plant Divertors

Jack Nicholas

CASE PhD started September 2011

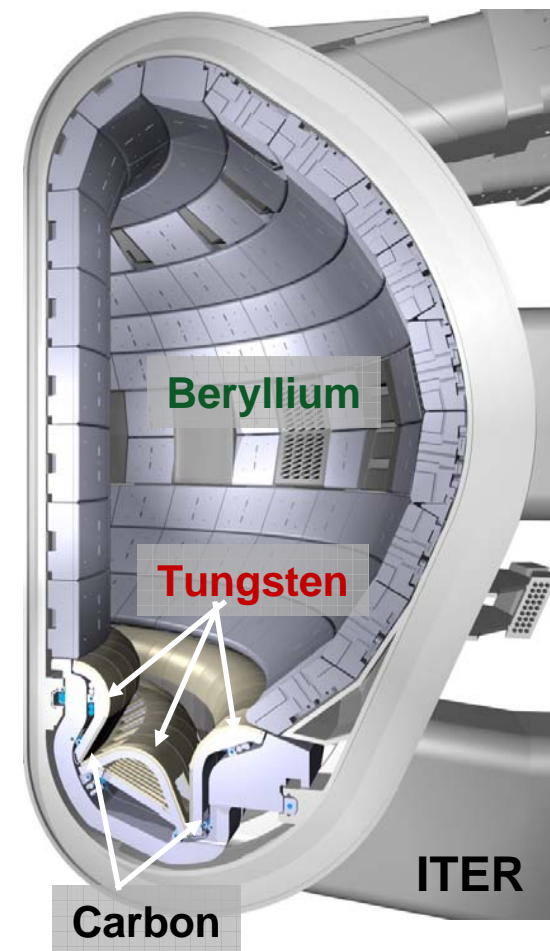
- A Tokamak Divertor
  - Takes the directed exhaust of heat and particles (including He 'ash' from thermalised alphas)
  - provides a barrier to keep sputtered impurities out of the plasma



the price is a very high power loading in the Divertor region –  
 > 10 MW.m<sup>-2</sup> in a DEMO/reactor – already there in JET/ITER but pulsed

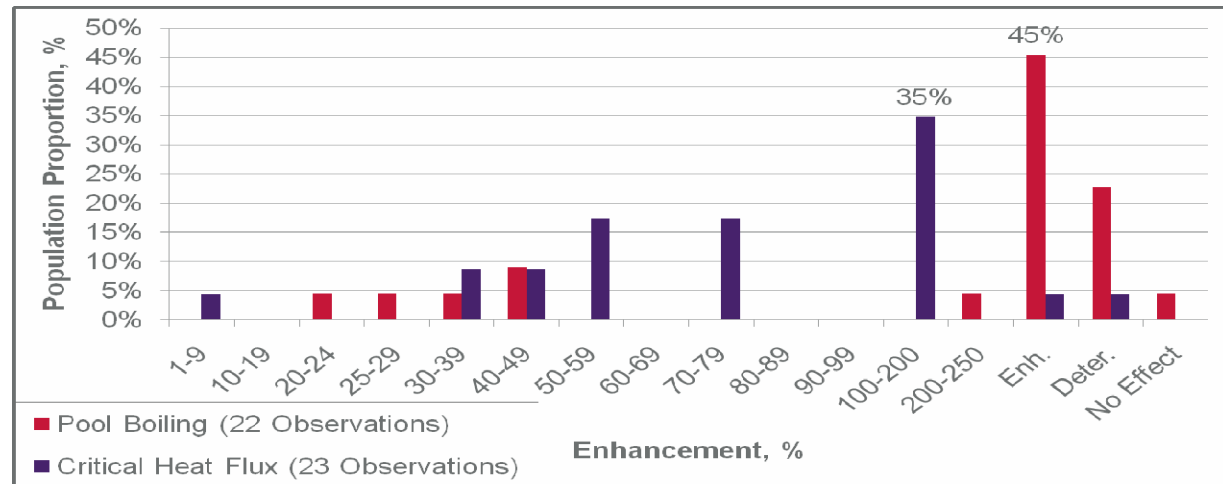
# Technology Theme: the Divertor and high-heat-flux components

- Materials challenges
  - high particle fluxes, minimising erosion – resisting sputtering and chemical erosion
  - high stability under neutron irradiation
  - minimise retention of tritium (reactor inventory) and activation.
  
- Engineering:
  - High heat flux technology – fatigue, component lifetime, CFD etc.;
  - Response to transients, EM loads;
  - Maintainability – remote handling design.
  - Manufacturability in ITER-relevant/ reactor materials (tungsten).



**Nanofluids as Advanced Coolants**  
**Antonis Sergis**  
**CASE PhD started October 2009**

- Enhancement in conduction and convection of around 10-20%
- Enhancement in CHF of 100-200%



**PhD Aims:**

- Discover the mechanisms behind the anomalous heat transfer of Nanofluids
- Test if Nanofluids are suitable as an advanced cooling fluid able to remove extreme heat energy fluxes from the fusion reactor

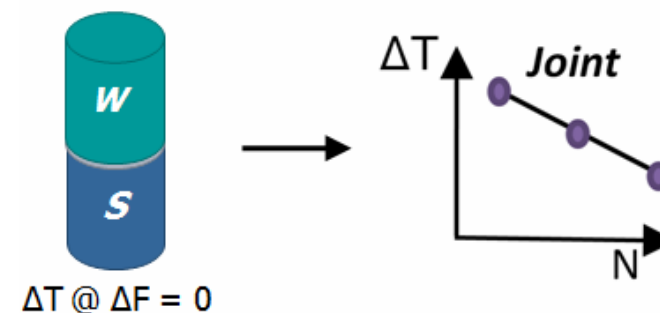
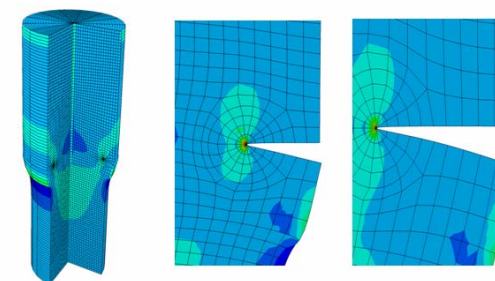
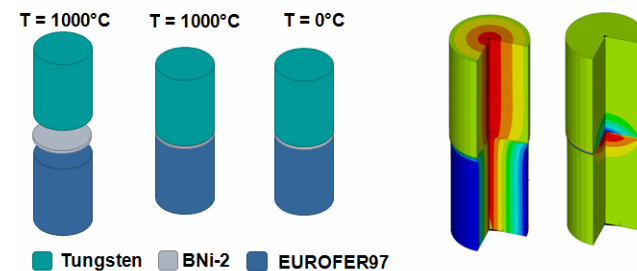
## First wall components

### Fatigue performance of dissimilar brazed joints

Niall Hamilton

CASE PhD started September 2009

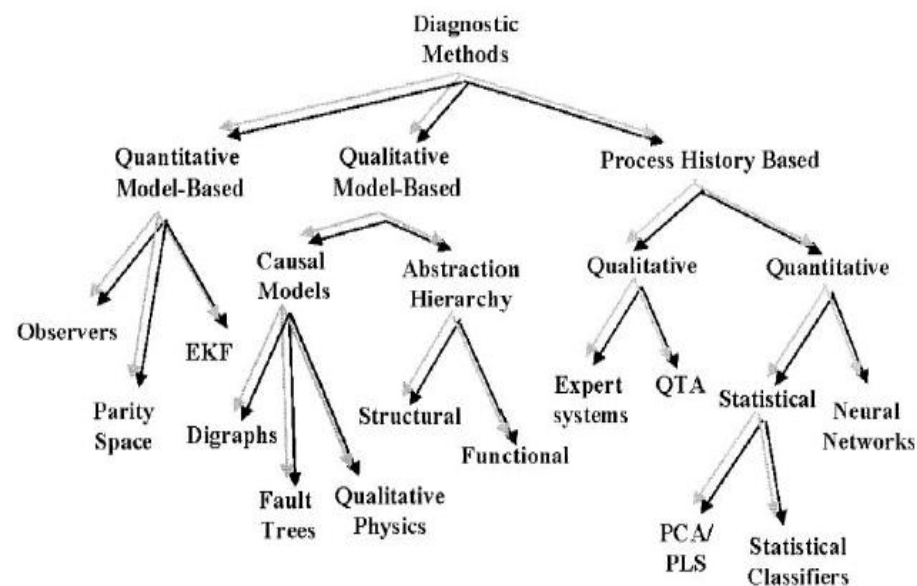
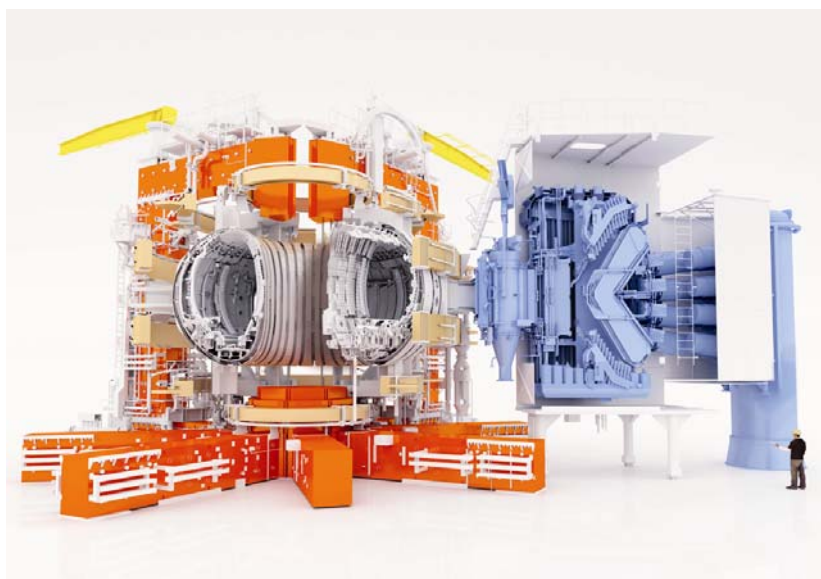
- To understand both the mechanics and metallurgy behind the failure of dissimilar brazed joints under repeated thermal and mechanical loading.
- To develop experimentally validated procedures to assess the fatigue performance of dissimilar brazed joints.
- Experimental work will focus on tungsten to steel brazed joints. This has been highlighted as a critical joint in the DEMO HEMJ divertor.



Neutral beam health monitoring

Nick Wright

CASE PhD started October 2009



- **Minimise lost operational time** due to unscheduled maintenance breaks required to repair significant component failures (e.g. component failure and water leak).
- **Maximise the reliability** of the system through elimination of the class of faults that do not stop it from operating outright but rather limit the ability of the system to provide what is required by the operator (e.g. power supplies trip).

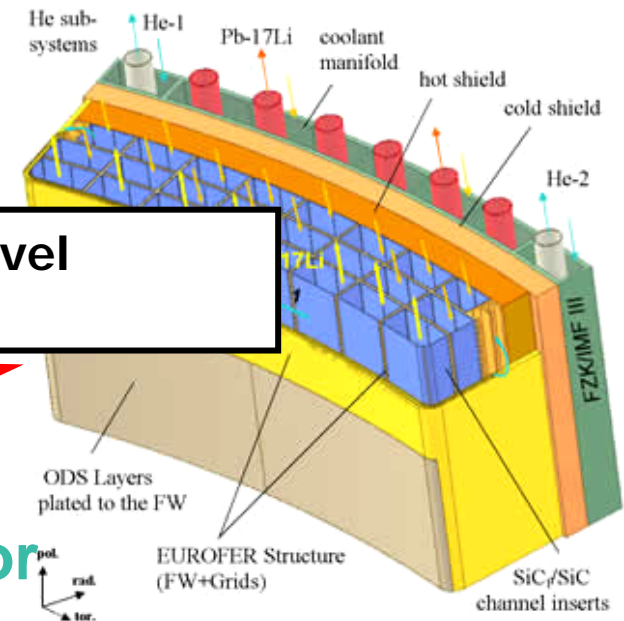
A Multi-Physics Modelling Methodology for Fusion **First wall and Blanket**  
Blankets - Michael Wolfendale - CASE PhD started Oct 2011

- Blankets form the plasma-facing wall of fusion reactors.
- Required in any power-generating fusion reactor for:
  - Heat extraction.
  - Neutron shielding.
  - Tritium breeding.
- Research groups have been studying concepts for many years.
- Design choices have often developed organically.

This PhD aims to develop a systems-level approach to blanket design



ITER reactor



- **The aim is develop a system-level approach to the design of blankets.**
  - Broken down into 3 parts:
- **Part 1: Develop a Systems code basis for blanket analysis.**
  - Assess current systems engineering codes.
  - Emphasis placed on thermal-hydraulics.
- **Part 2: Use computational methods to address key blanket design and Systems code problems.**
  - Existing codes are well validated for water/steam but less so for other coolants.
  - Use of computational fluid dynamics.
- **Part 3: Incorporate mesoscale details into the Systems model.**
  - Study of mesoscale effects to provide input to the Systems model.
  - Create a two-way coupling between the detailed thermal, structural or fluid analyses, and the Systems model.

- Materials and compatibility with DEMO plasma
- Fusion first wall and blanket
- Divertor and high heat flux components
- Tritium inventory control and processing
- Remote handling
- And many more, e.g.
  - Power Extraction (QMUL)
  - MHD simulation (Coventry)
  - Neutronics (Lancaster)

