Use of Multiphysics in Predicting Plant Performance in Accident Conditions.

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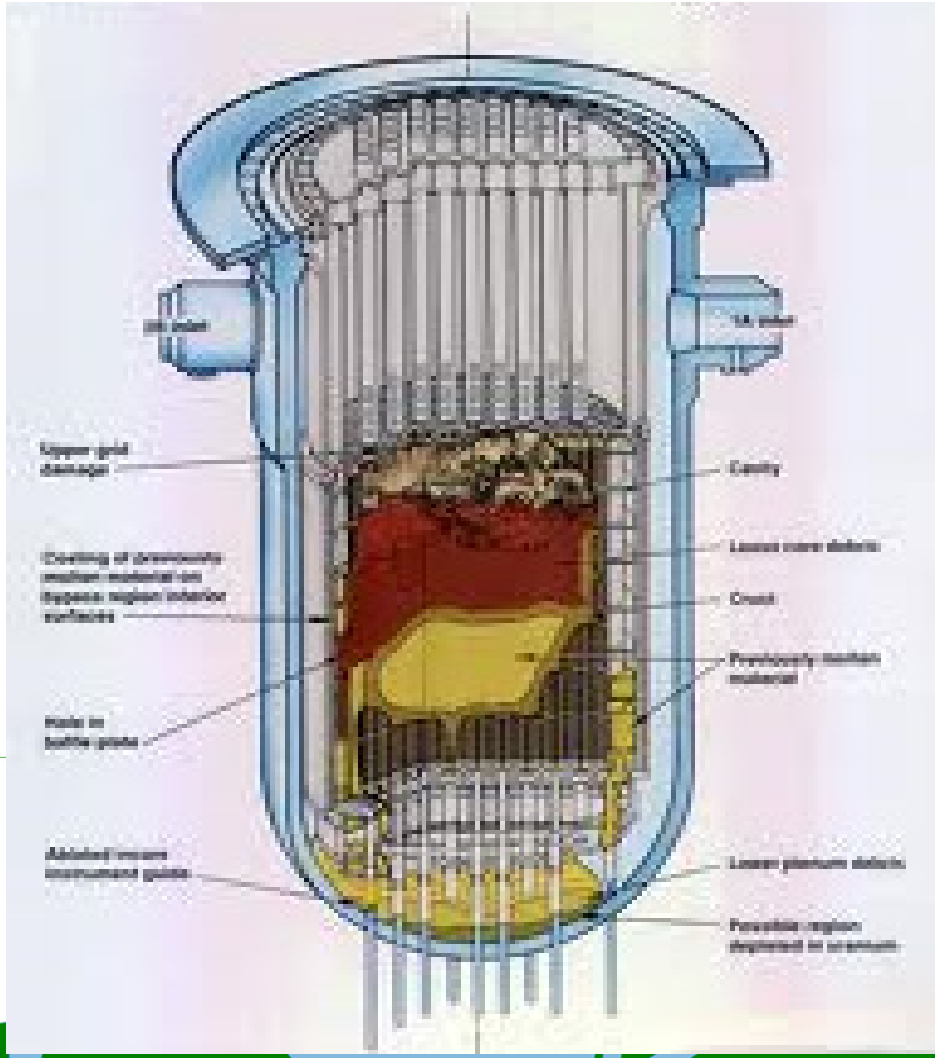
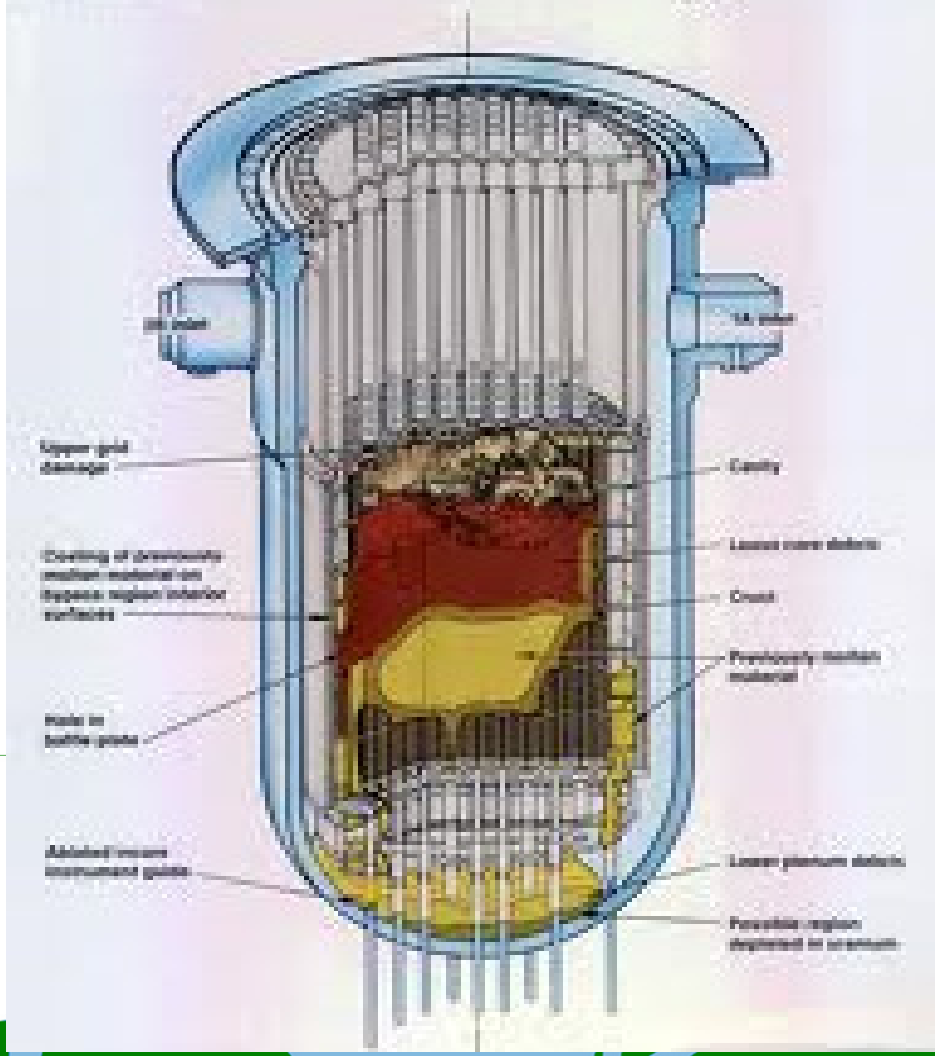
Accident Progression and Management

- Accident progression into Severe Accident conditions
- Degradation of fuel, core and supporting structures
- Relocation of the molten material
- RPV Failure
- Ex-vessel Cooling
- MCCI
- Long term cooling



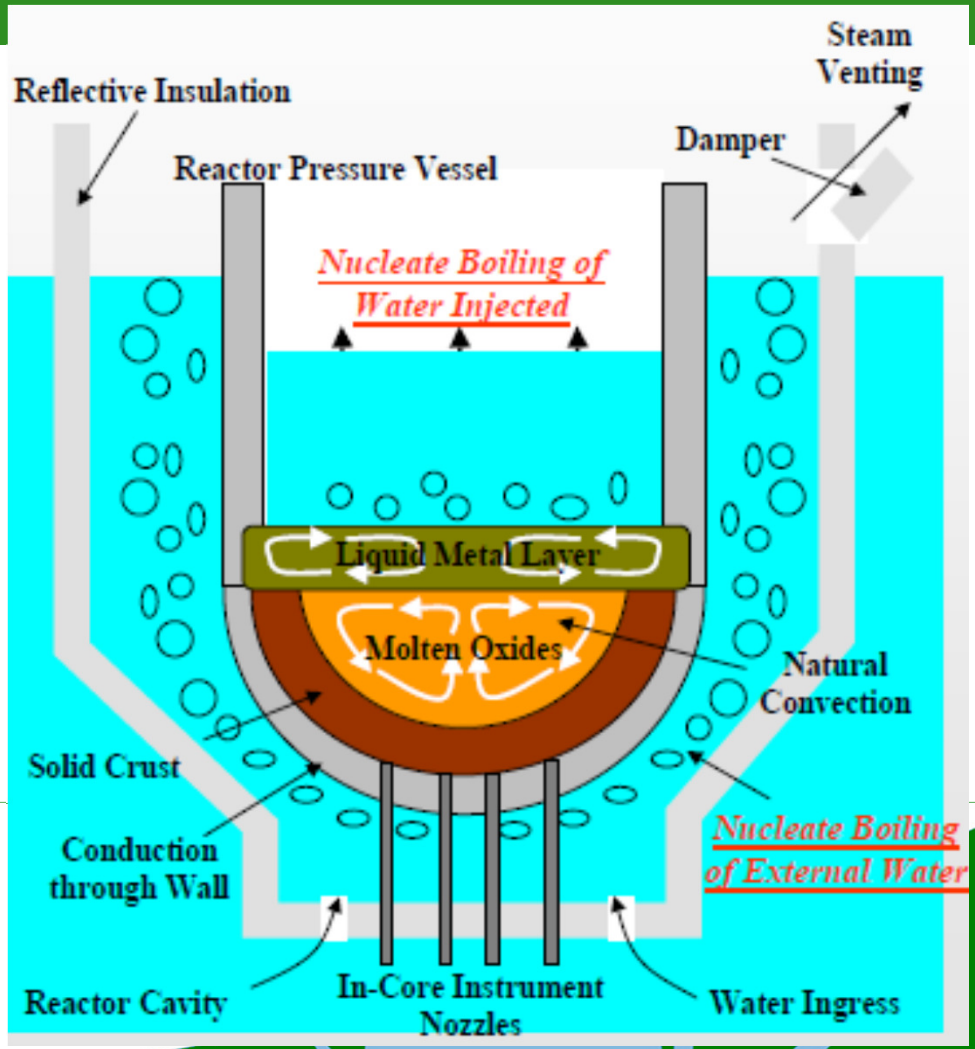
Accident Progression and Management

- Hydrogen generation and management
- Hydrogen explosion mitigation
- Mitigation measures
- Degraded Environment



Accident Progression and Management

- The way core debris flows to lower part of the vessel
- Water behaviour outside of vessel
- Structural thinning and creep of vessel wall
- Non-newtonium debris convection flow inside vessel, plus conduction and radiation heat transfer
- Separation of metallic and ceramic materials



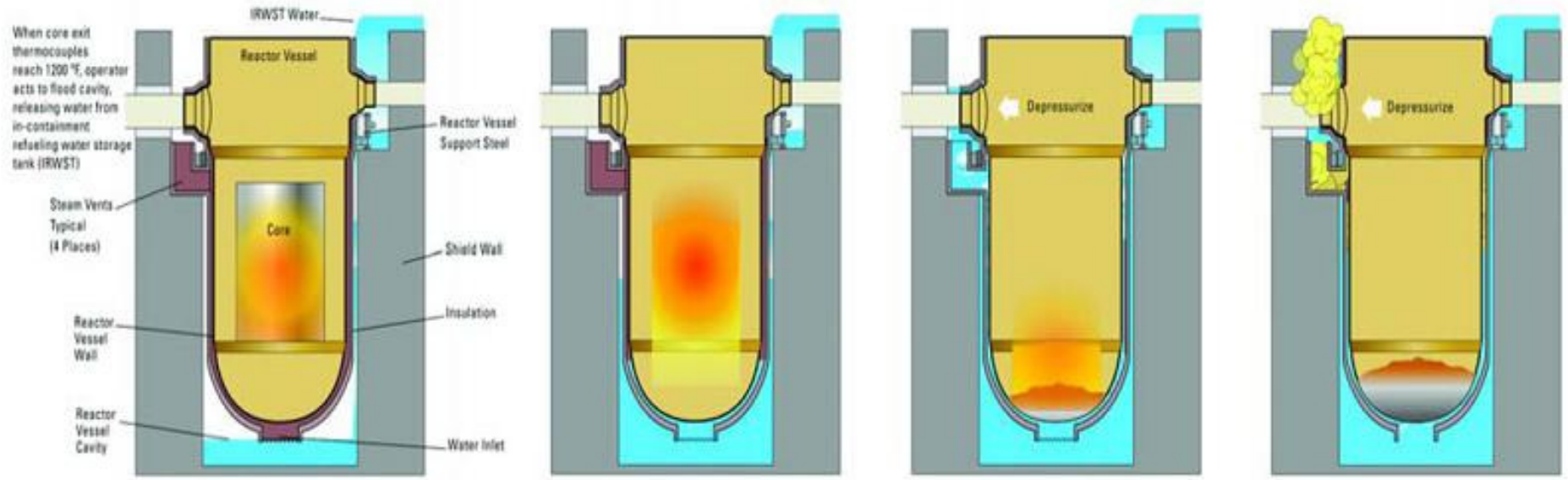
Key Aspects of Modelling Requirements

- The way core debris flows within the vessel,
- Mode of failure,
- Presence of water outside of vessel,
- Potential for fuel/coolant interaction,
- Molten Core Concrete Interaction (MCCI)

- Corium transfer, cooling and stabilisation

Core Degradation & In-Vessel Retention

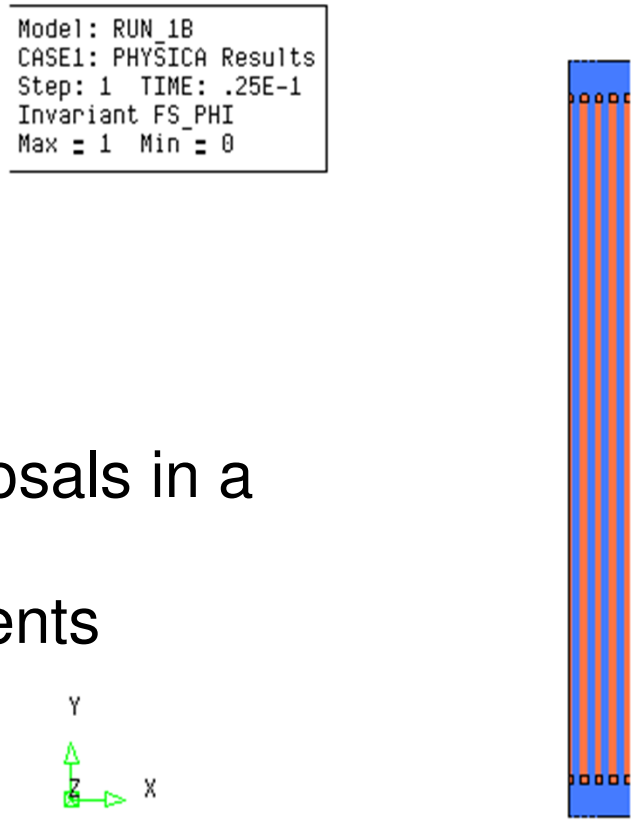
- Core degradation
- Core melt, relocation
- In-vessel melt retention



Fuel Pin Degradation

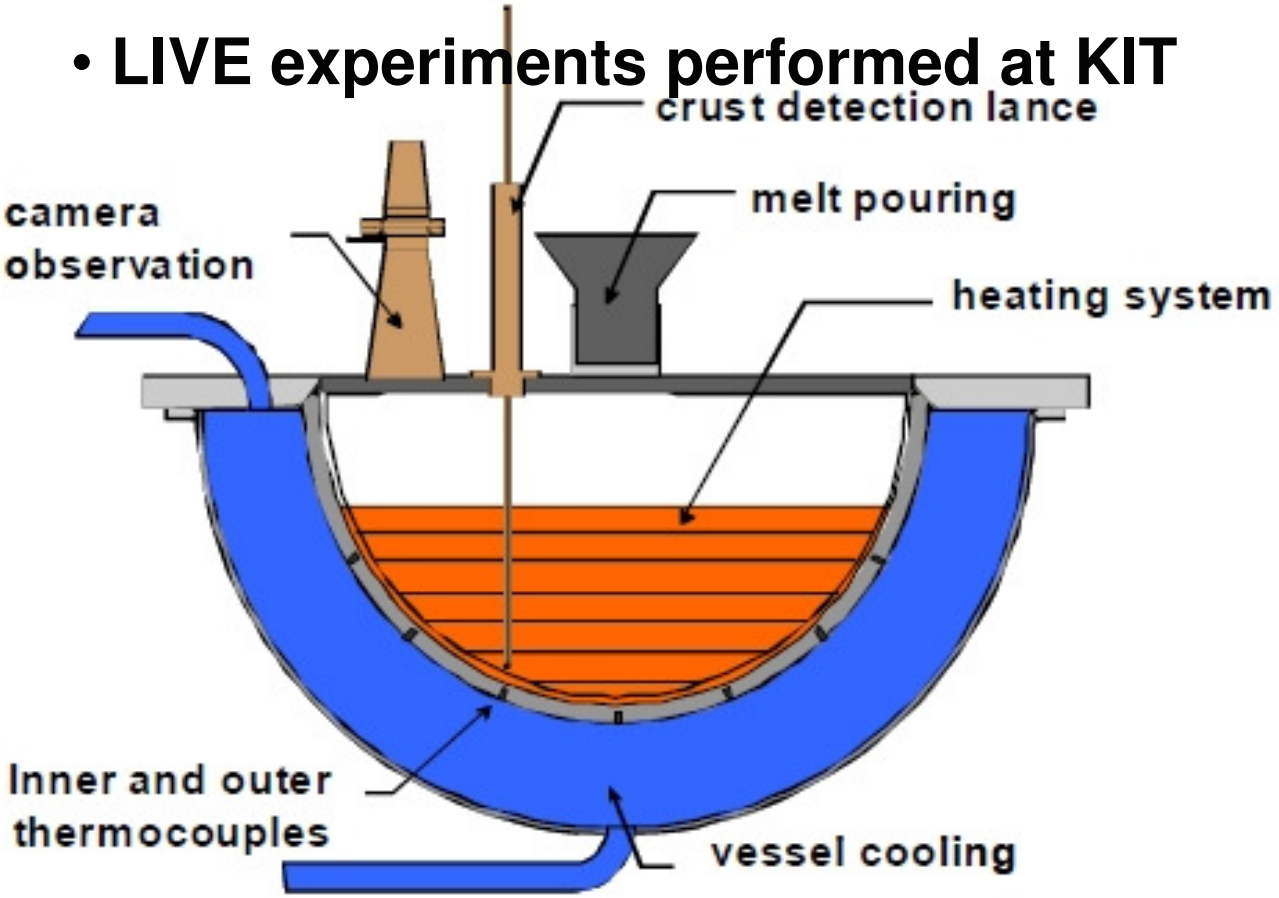
Supporting Research Activities

- Technical
- Research
  - Establish research need
  - Stakeholder interaction skills
- Planning and Delivery
  - Preparation of research proposals in a variety of environments
  - Understand project requirements
  - Resource management
  - Delivery of projects to time



Live Experiment

- **LIVE experiments performed at KIT**



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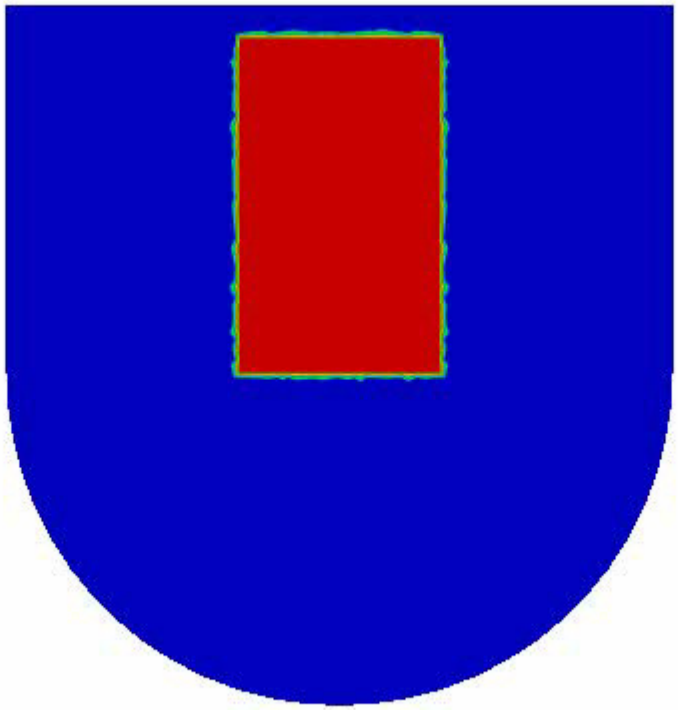

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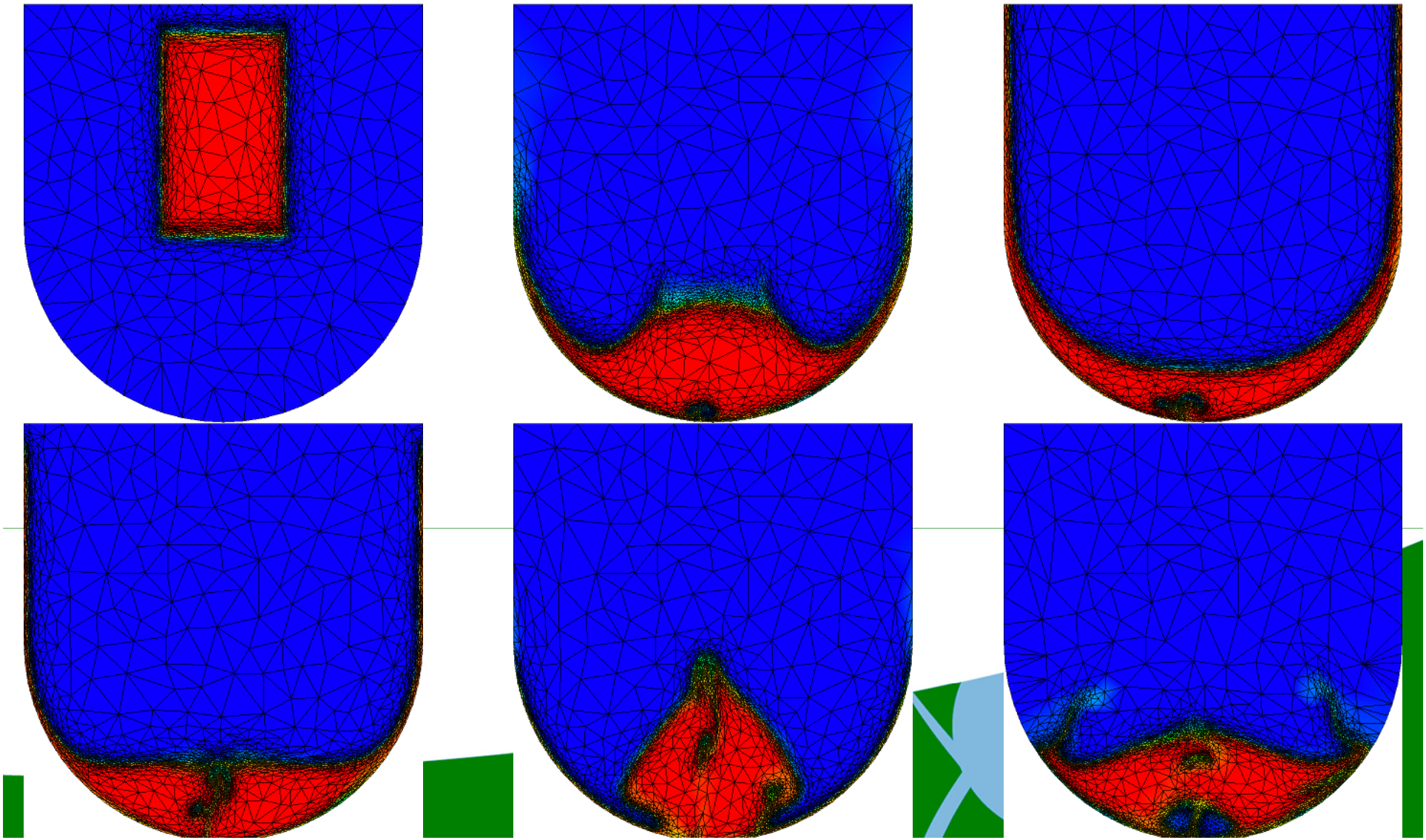
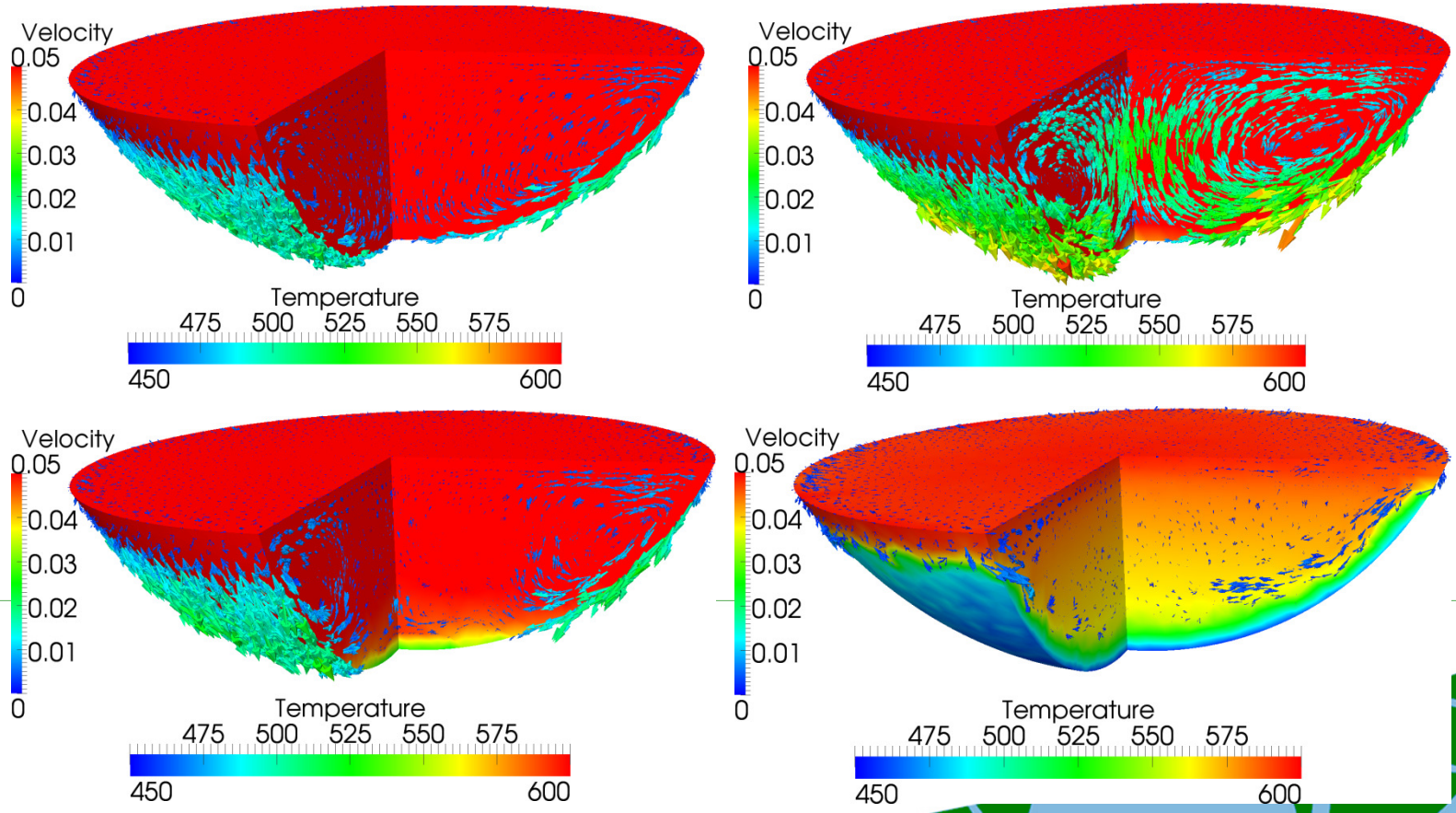


Live Experiment



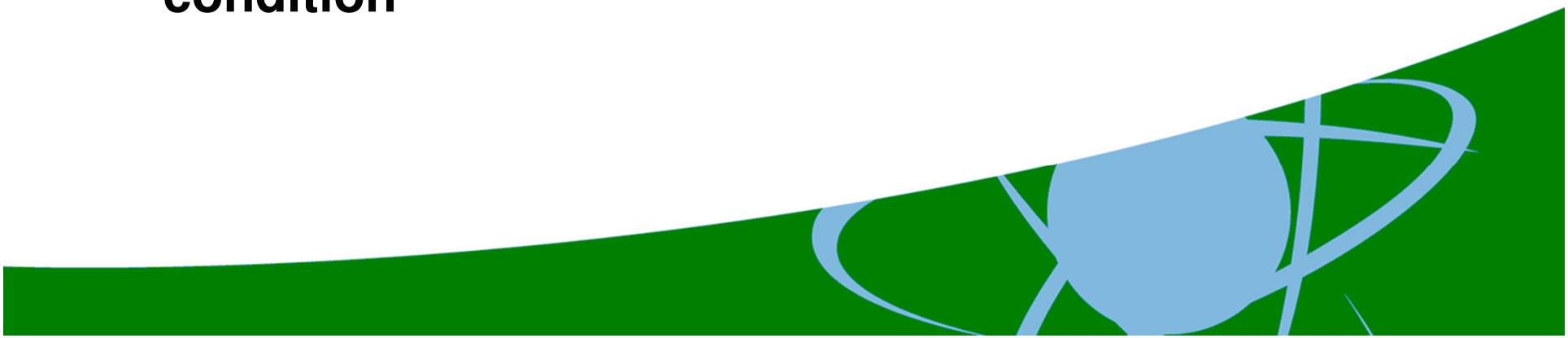
Modelling Tool

FETCH: `http://amcg.ese.ic.ac.uk`

- Open source CFD code developed at Imperial College
- CV-FEM, Continuous & Discontinuous Galerkin
- Multi-phase, Multi-material
- Unstructured meshes
- Anisotropic mesh adaptivity, Mesh movement, Conservative interpolations
- FSI (FEMDEM, immersed body approach, supermesh)
- Hybrid (MPI/OpenMP) parallelism (up to 32k cores)

Modeling approach:

- Three-phase system (liquid, steam, solid)
- Three momentum, internal energy and phase volume fraction equations
- Includes virtual mass and inter-phase pressure term
- Mass transfer is calculated through the Stefan condition



Thank you