

#WS RRFM 2005

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## Irradiation of Fuels and Materials in the Jules HOROWITZ Reactor

The European Union 6<sup>th</sup> F.P. JHR Co-Ordination Action  
(JHR-CA)

Daniel Iracane, [Daniel Parrat](#)

[daniel.parrat@cea.fr](mailto:daniel.parrat@cea.fr)

↪ **Status and renewing MTRs in Europe**

↪ **JHR core performance**

↪ **Experimental capability of the JHR**

↪ **The JHR-CA : Objectives and organization**

↪ **Examples of device conceptual design developed by the JHR-CA**

↪ **Conclusion**

# Renewing the MTR fleet in Europe

- ✓ Essential support for nuclear power programmes over the last 40 years
- ✓ Will be more than 50 years old in the next decade
- ✓ **European MTRs will face increasing probability of shut-down**



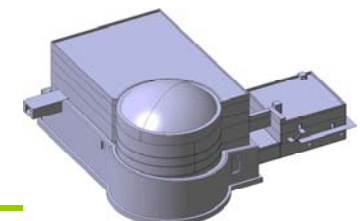
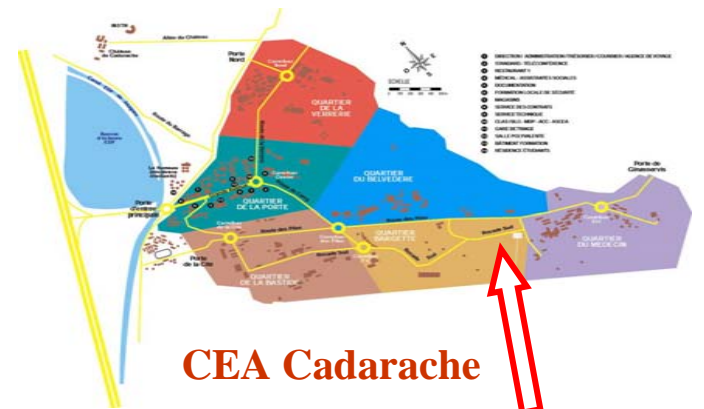
**FEUNMARR** conclusions, October 2002  
(presented at RRFM 2003)

- ↪ There is a strategic need to renew MTRs in Europe
- ↪ A decision to build a first new MTR is required in a very near future
- ↪ This new MTR should establish robust technical links with current MTRs



**The Jules HOROWITZ reactor (JHR) project copes with this context for studies on materials and fuels behaviour under irradiation**

- ↳ Launched by CEA with support of EDF
  - ↳ Oriented as an international R&D users facility
  - ✓ Bilateral contacts with European and international industry
  - ✓ International Advisory Group within OECD/NEA
  - ✓ Expected support of the European Union as an infrastructure of European interest
- 
- ↳ Completion of definition studies in 2005
  - ↳ Construction phase and tests: 2008-2013
  - ↳ Start of operation: 2014



100 MW compact core,  $\Phi$  740 mm, 37-positions and 34-fuel elements core rack

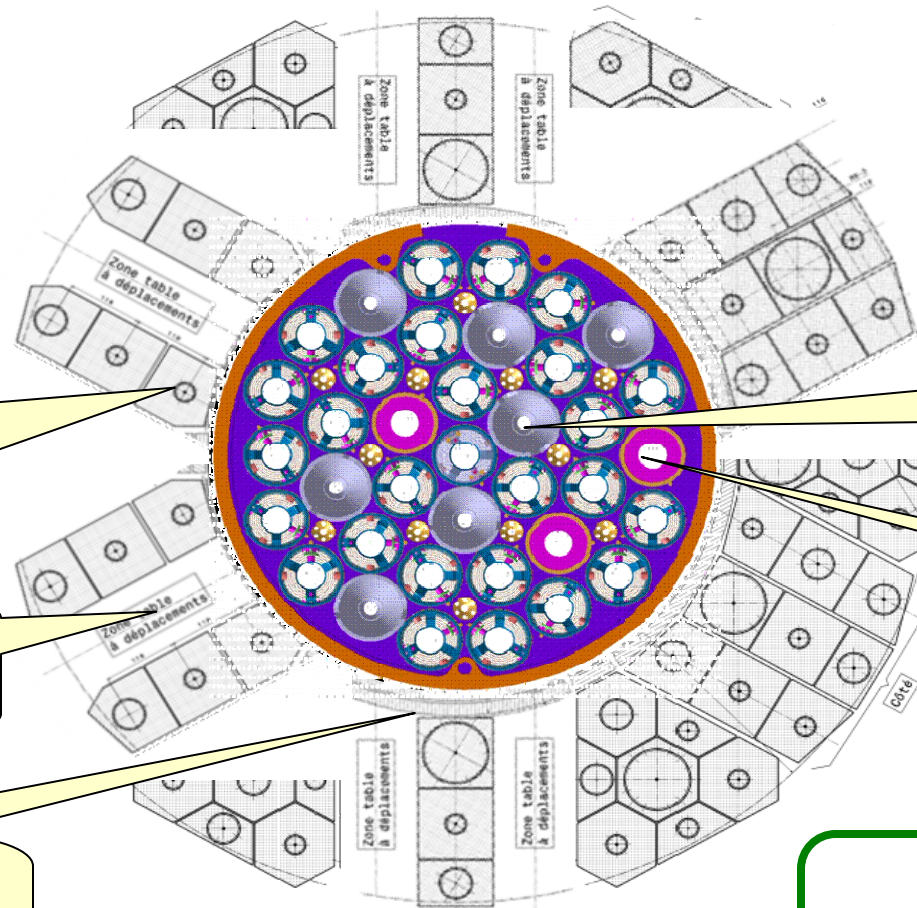
### In reflector:

High thermal neutron flux  
(up to  $5 \cdot 10^{14}$  n/cm<sup>2</sup>/s)

Fuel studies  
(up to 500 W/cm  
with a 1% <sup>235</sup>U  
PWR rod)

Displacement systems  
to adjust the fissile power

Gamma shield  
to decrease gamma heating  
in devices



### In core:

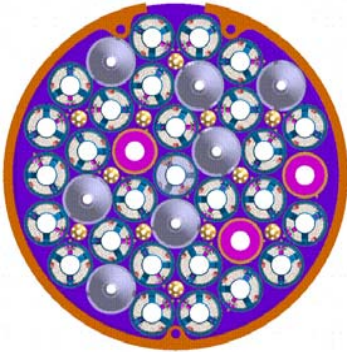
High fast neutron flux  
(up to  $5 \cdot 10^{14}$  n/cm<sup>2</sup>/s)

Material ageing  
(up to 16 dpa/y)

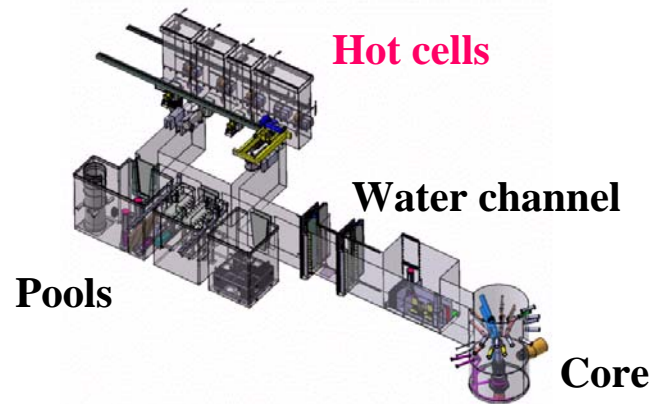
Gen IV fuels (GFR)

Large capacity:  
More than 20 simultaneous  
experiments

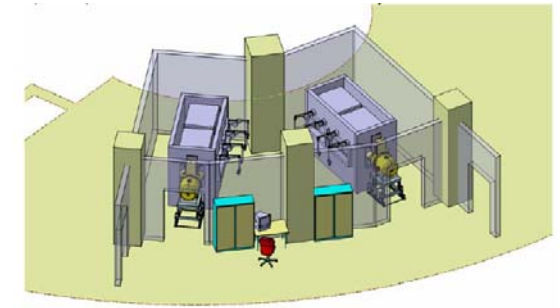
## The JHR experimental capability : To be shared at an international level



High performance core



Examination hot cells  
Alpha hot cell



Fission Product  
Analysis Laboratory

### Collaborations on experimental devices definition and development offer high added value

- ↪ ≈ 10 device families to be developed to address issues for existing, coming power plants and future energy systems
- ↪ Renewing the experimental capability by up-dating
  - ✓ **scientific programs** coupled with state of art modeling
  - ✓ **technology** defining advanced standards

The EU can provides the right vision needed for such an initiative to be a success

**The JHR-CA is the first step**

## **JHR-CA = First European Union contribution to the joint development of a new Material Testing Reactor in Europe**

- ↪ Development of innovative irradiation devices with a high service added value
- ↪ Strong benefit for existing MTRs by cross-fertilization

### **Experts Group**

- ✓ Providing specifications and conceptual designs of innovative devices
- ✓ Meeting current needs
- ✓ Meeting emerging needs (e.g. gas and high T loop, fast transient experiments,...)

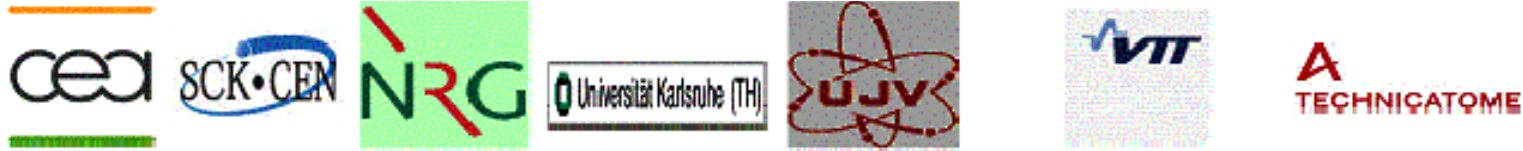
**2004**  
**2005**

### **Users Group**

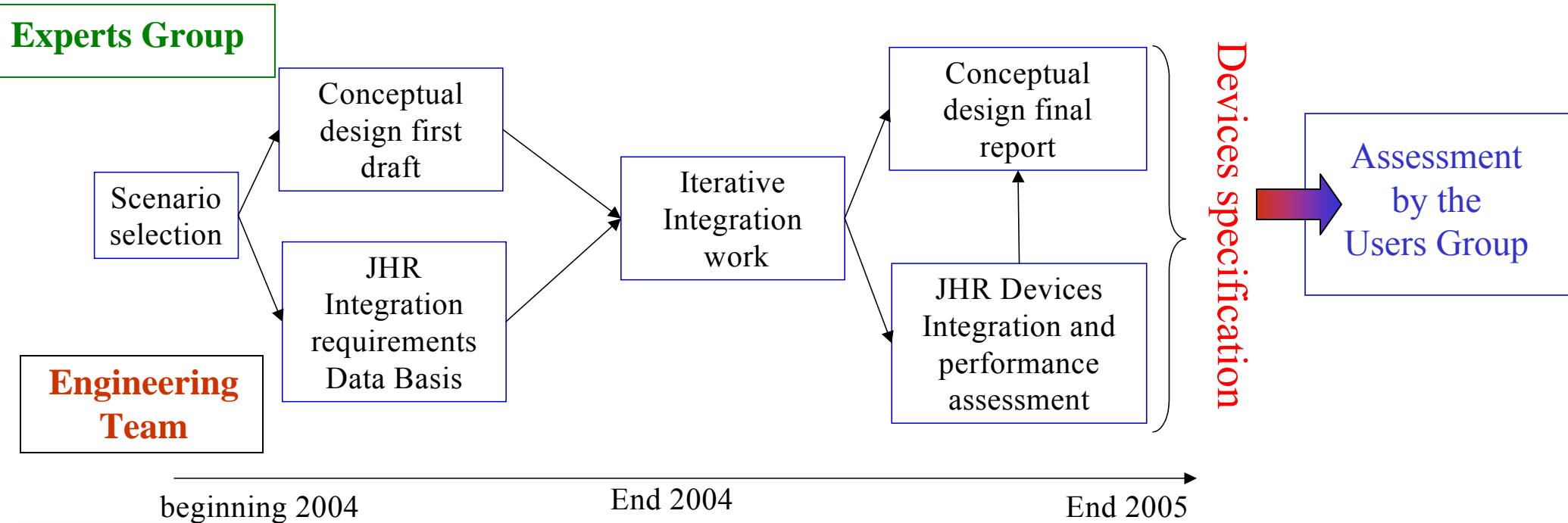
- ✓ Making sure that the JHR Project provides a service-oriented irradiation platform responding to their needs
- ✓ Sharing information on the detailed design and performances versus needs

# The JHR-CA : Participants and operation

## Experts Group



## Users Group



## ↪ Six technical workpackages

- ✓ WP1: Materials behaviour under high temperature conditions and high fast neutron flux
- ✓ WP2: In-pile mechanical testing device with on-line environment, stress and strain control
- ✓ WP3: Corrosion under irradiation
- ✓ WP4: Cluster of PWR fuel rods placed in a PWR loop
- ✓ WP5: High T / high P capsule for HTR/VHTR fuel elements
- ✓ WP6: Medical applications

Materials

Fuels

Medical

## ↪ Two cross-cutting topics

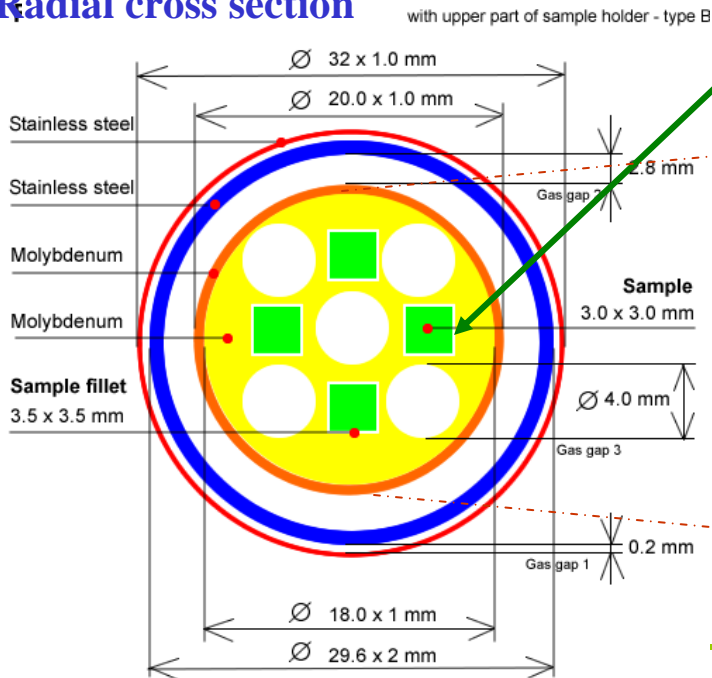
- ✓ WP7: Optimisation of the devices fleet operation
- ✓ WP8: Integration assessment of WP1 to WP6 in the JHR design

## ↪ Other topics : Pressure vessels steels, Safety experiments

## HELIOS test loop for in-core material irradiation at high temperature and high dose rate

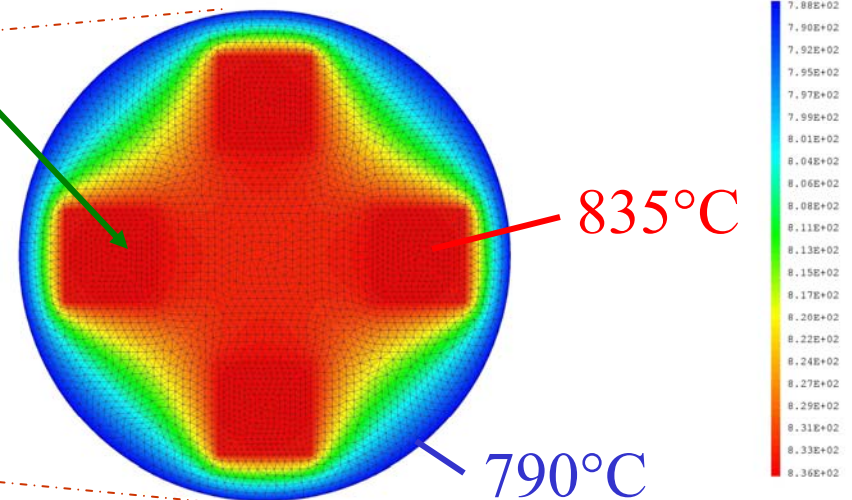
- ↪ Helium gas loop at 7 MPa and nominal temperature up to 1200°C
- ↪ Typical materials: SiC based ceramics and composites, ODS (Oxide Dispersion strengthened Steels) and ZrC (high temperature reactors, fusion)
- ↪ Maximum dose rate: 16 dpa/y

### Radial cross section



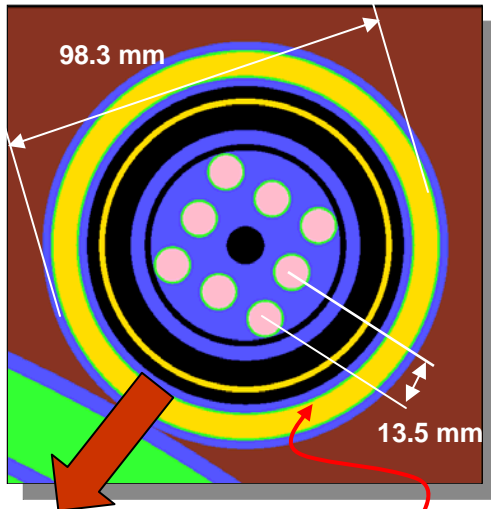
### Cuboid-shaped samples

### Example of 2D temperature distribution calculation (CAST3M)



## Fuel rod cluster irradiation in a PWR loop placed in JHR reflector

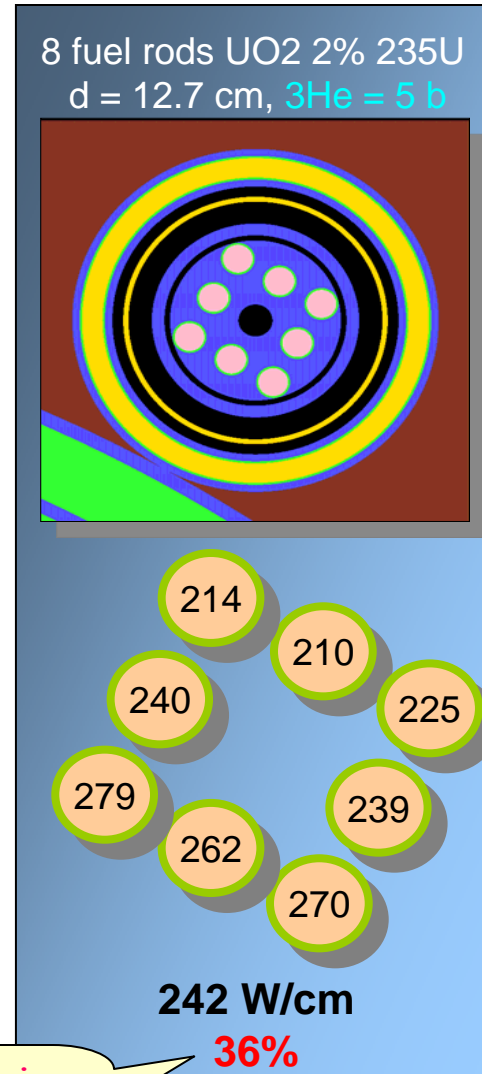
- ↪ Nominal mean linear power of samples: 200W/cm
- ↪ Maximum mean linear power: 400 W/cm
- ↪ Maximum power discrepancy between samples: less than 10%



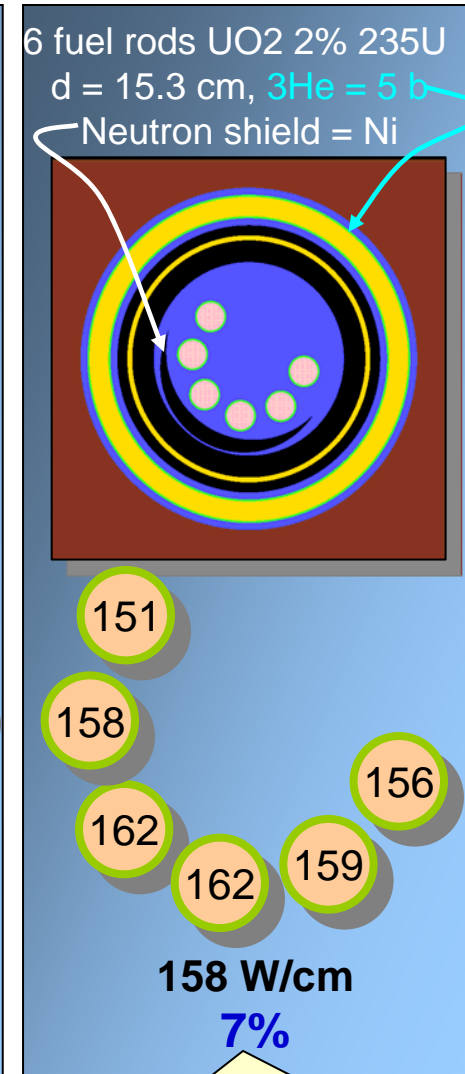
Neutron shield 5.8 mm (3He)

JHR core

Example of mean linear power calculation (TRIPOLI 4 3D)



Original design not satisfying



The new design meets the specifications

↪ **The technical work performed in 2004 in the Experts Group is now assessed by the engineering team in terms of integration in the JHR facility**

- ✓ Definition of the interfaces between the device and the facility
- ✓ Identification of critical points regarding the safety aspects

↪ **It is proposed to launch an Integrated Infrastructure Initiative (I<sup>3</sup>) after the JHR-CA (last call of the 6<sup>th</sup> FP)**

- ✓ To develop some irradiation devices and/or key components, including test definition in existing MTRs
- ✓ To offer access in existing MTRs for testing innovations (Transnational access TALI)
- ✓ To address cross-cutting topics for networking activities (instrumentation, training,...)