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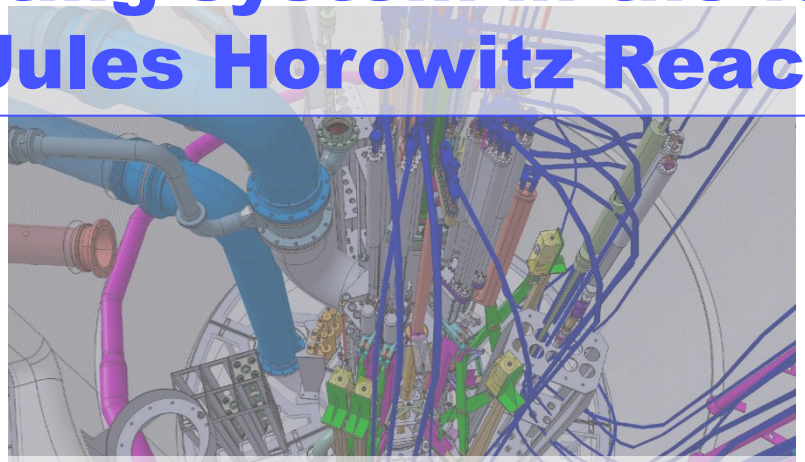
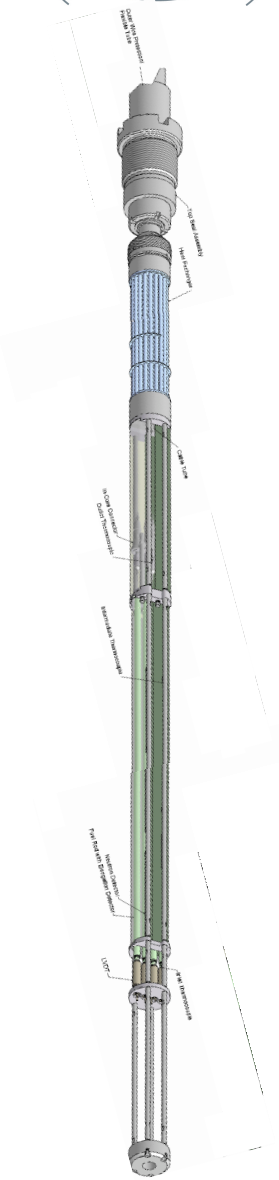
The MADISON experimental hosting system in the future Jules Horowitz Reactor





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Layout

- The MADISON device in the JHR experimental capacity
- CEA-IFE Halden collaboration
- Description of the current design
- The irradiation rig
- The loop system
- Instrumentation

MADISON device in JHR facility

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On displacement device

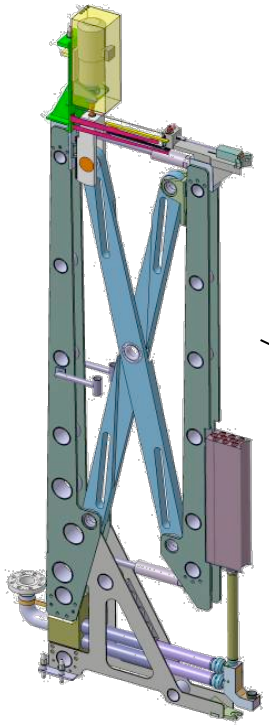
Fuel studies
550 W/cm
1% enriched ^{235}U
PWR fuel

Laboratories and Workshops

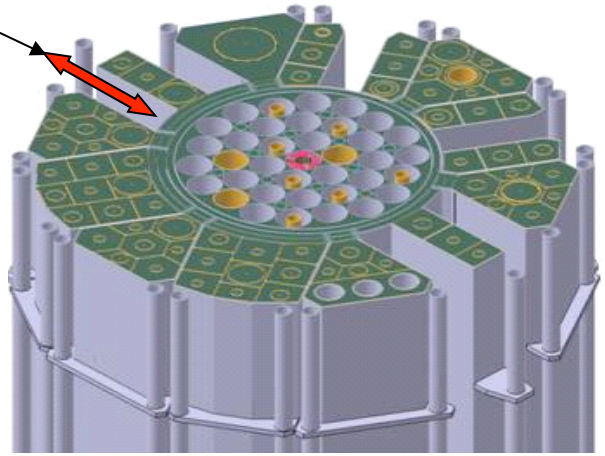
100 MW

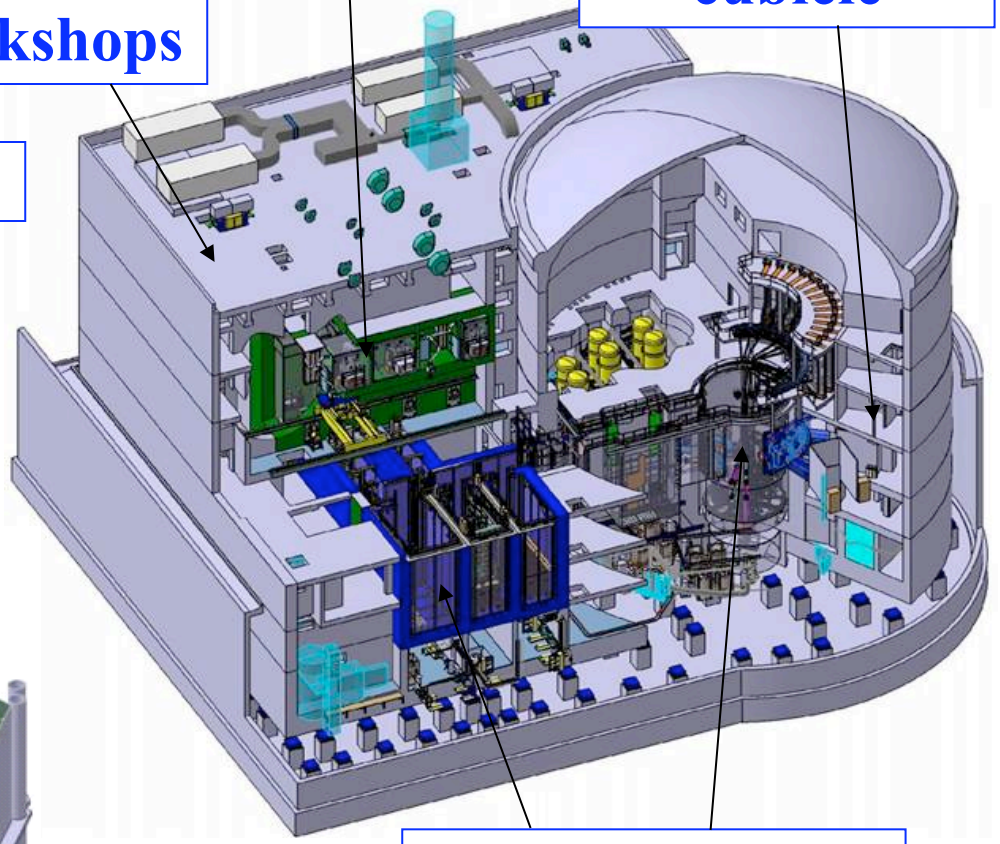
Hot cells

Experimental cubicle



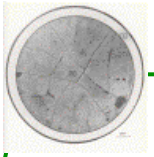
In reflector
Thermal neutron flux:
$5.5\ 10^{14}$ n/cm².s



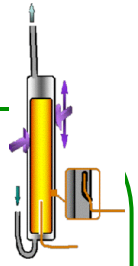


Non destructive examinations

MADISON device among JHR PWR fuel experimental devices



Selection, characterisation and qualification of fuel products



MADISON loop
Standard = 4 rods rig

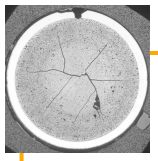
- Fuel product vs BU/LHGR
- Fuel microstructure selection
- Long term irradiations (creep, corrosion, crack growth…)
- Slow power variations
- Batch conditioning (ramp…)

Multi-rod rig
Homogeneous conditions
Rod failure not expected

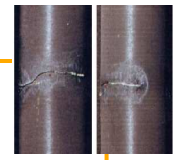
MADISON loop
1 rod rig

- Single effect experiments (FG release,…)
- Fuel microstructure selection
- Properties of fuel material
- Metrology under flux (PCMI…)

Highly instrumented irradiation on single rod
Rod failure not expected



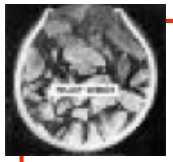
Margins mastery



ADELINE loop
Standard = 1 rod rig

- Incidental situations: power ramps…
- Post-failure behaviour
- Thresholds: $T_{melting}$, lift-off…

High performance
Management of degraded fuel

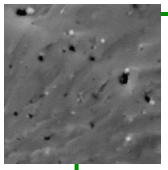


Safety experiments

- LOCA
- Fast transients
- FCI

Phenomenology

LOCA = LORELEI capsule (1 rod)



Basis knowledge acquisition

- Fuel microstructure selection
- Properties of fuel material

Data for modeling
Cooking capsule (+ sample geometry)

CEA-IFE Halden collaboration

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• Interest of the collaboration

- Take advantage of IFE long experience and include best practices:
  - ✓ Design, manufacturing and operation of experimental loops
  - ✓ Technology of irradiation rig
  - ✓ In core instrumentation
  - ✓ Instrumentation and Control
  - ✓ Chemistry monitoring of experimental loops (BWR tests)

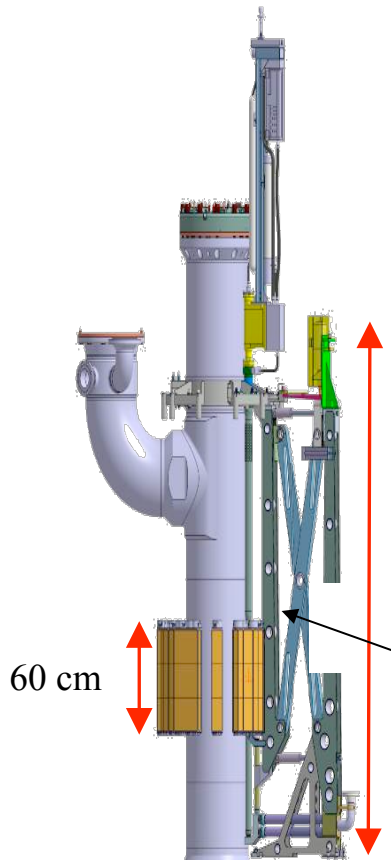
Institute for Energy Technology

The OECD Halden Reactor Project

• Main phases of the project

- Feasibility phase:
  - ✓ From June 2008 to March 2010
  - ✓ Ability to adapt IFE device to JHR geometry and safety standards
  - ✓ Feasibility demonstrated
  - ✓ First design of the loop system and irradiation rig
- Detailed design phase:
  - ✓ Targeted between 2011 and 2012
  - ✓ Detail design of all components with detailed manufacturing process
  - ✓ Safety analysis
- Manufacturing phase:
  - ✓ Targeted between 2013 and 2014
  - ✓ Manufacturing of the experimental device
  - ✓ Mounting and delivery to JHR site
- Availability scheduled for the beginning of JHR operation

Description of the current design



Experimental cubicle

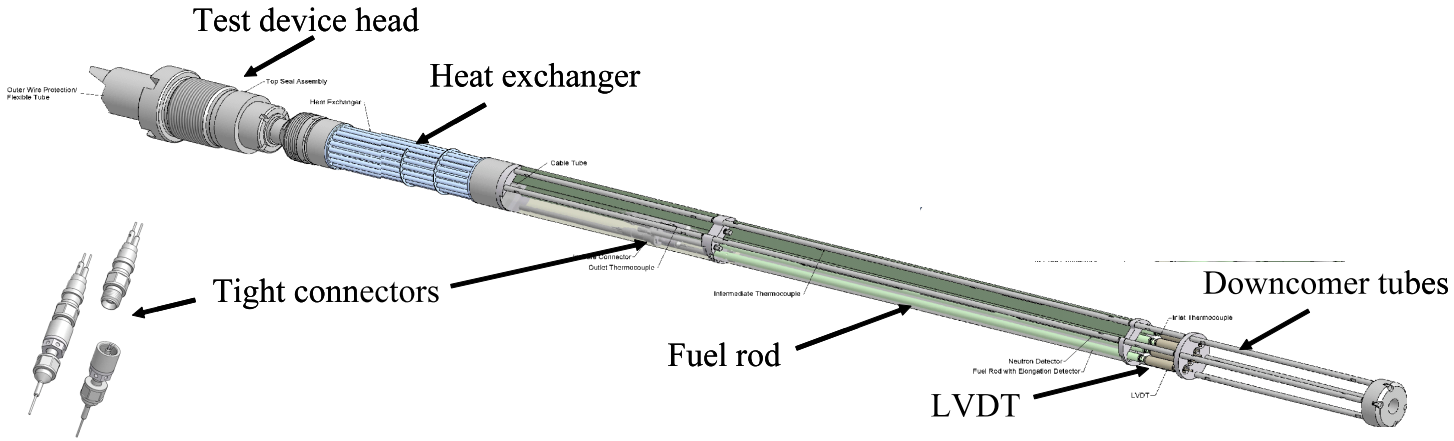
Under water pipes

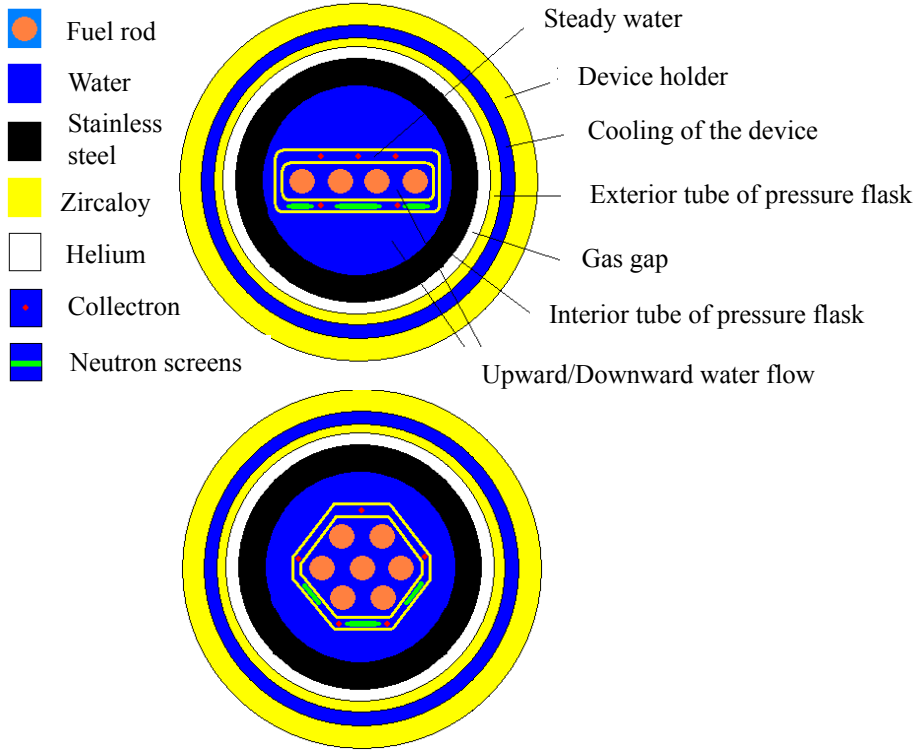
Reactor pool

flexible pipes

In-pile part of the experimental device

The irradiation rig

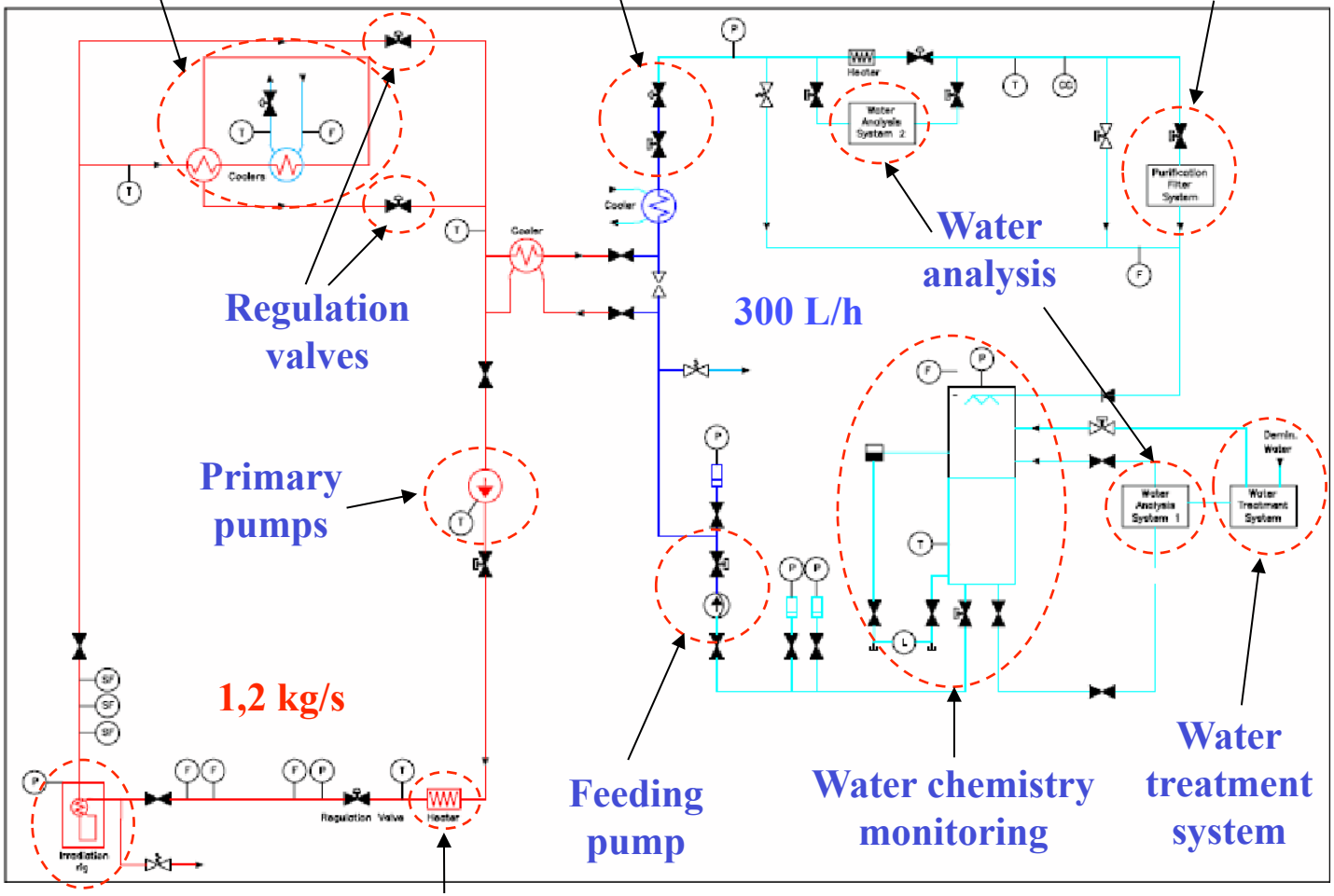




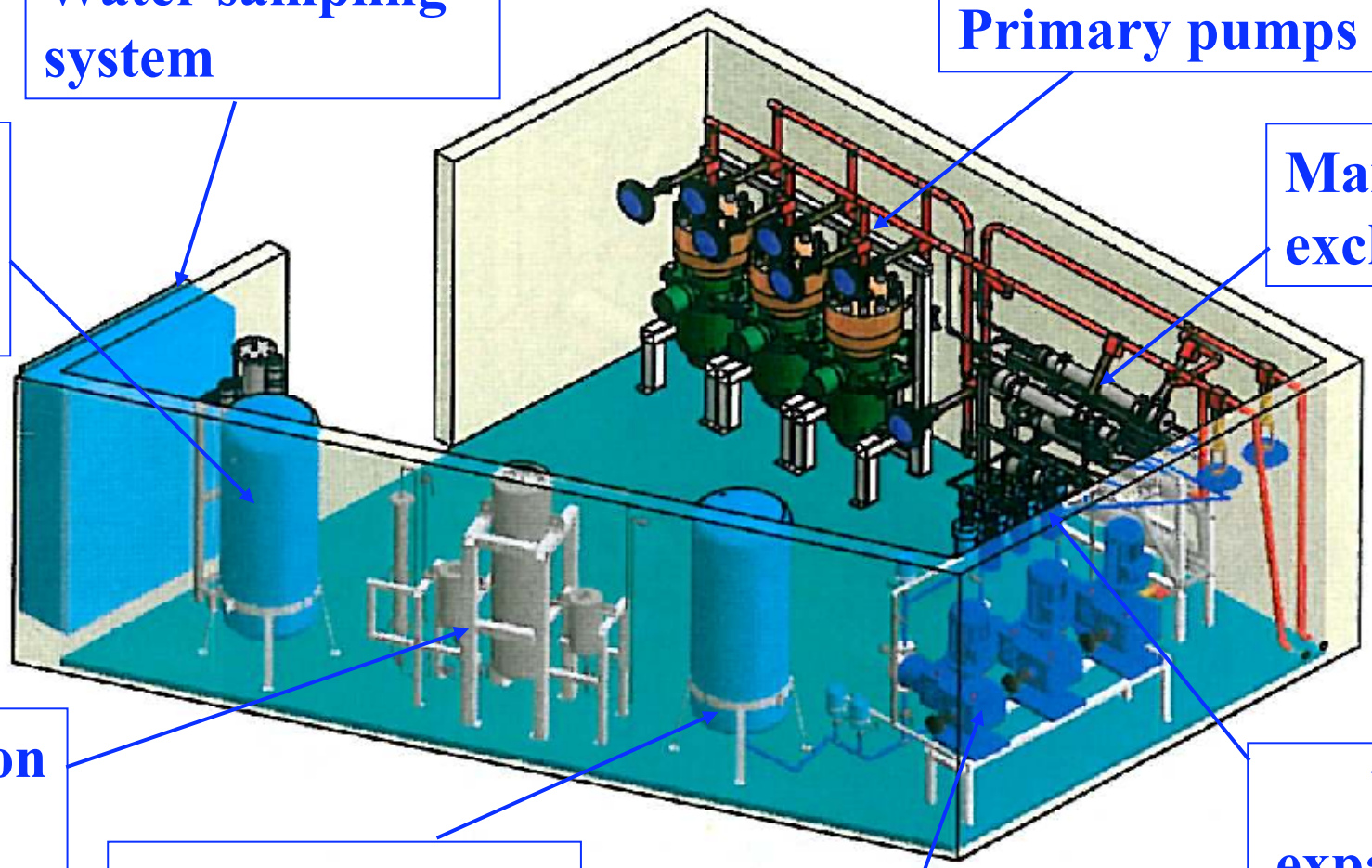
- **Standard version**
  - 4 instrumented samples irradiation rig:
    - ✓ Good homogeneity
    - ✓ Linear power: 400W/cm max
    - ✓ MOX or UO2 fuels
    - ✓ Fresh fuel or high burn up
- **Versatility**
  - Large embarking capacity (8 rods max)
  - Single rod version highly instrumented

Water loop architecture

- **Thermal-hydraulics**
  - PWR/BWR conditions
    - ✓ Pressure
    - ✓ Temperature
    - ✓ Velocity
    - ✓ Void fraction
- **Chemistry**
  - PWR/BWR chemistry
  - Specific chemistry



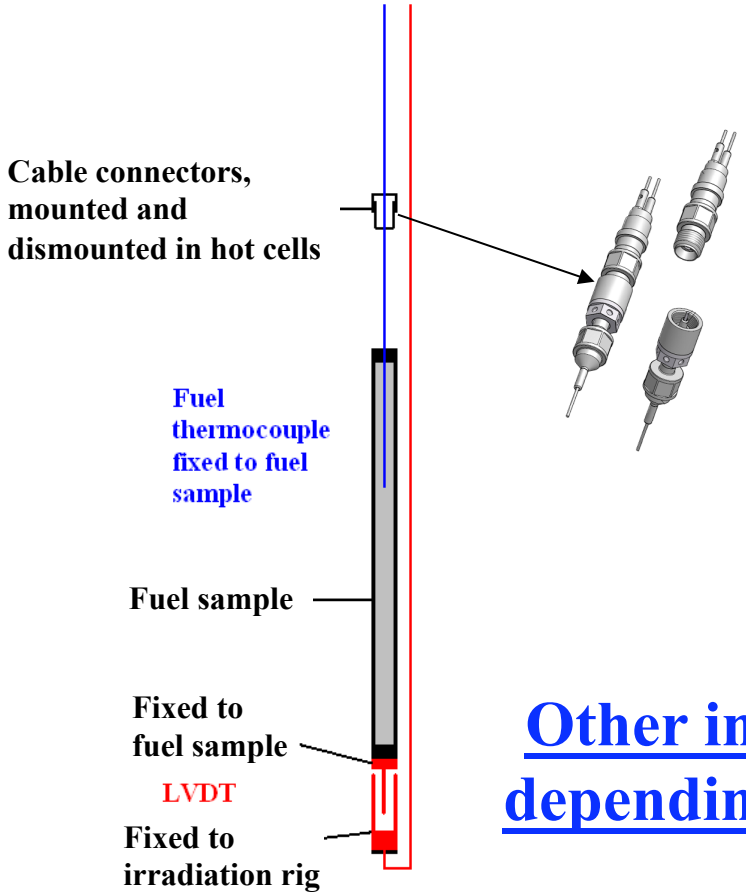
Component integration in Cubicle



Instrumentation

• On fuel sample

- Standard instrumentation
- Evolution possible for specific rigs

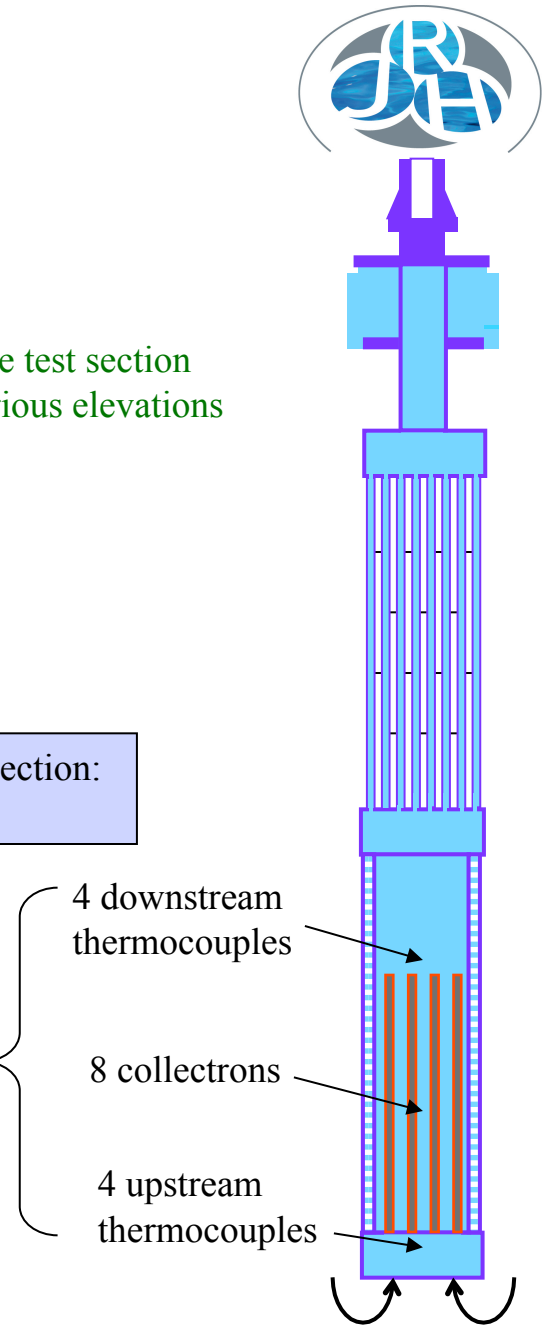


• In the water loop

- Fixed to irradiation rig
  - ✓ Pressure sensors in the test section
  - ✓ Thermocouples at various elevations
  - ✓ Collectrons
- In the cubicle
  - ✓ Main water flow
  - ✓ Pressure sensors
  - ✓ Chemistry
  - ✓ Water activity

On-line thermal balance in the test section:
A 3% precision is targeted.

Thermal balance on fuel samples in upward water channel



Other instrumentation possible depending on experimental needs

Conclusion: MADISON device

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- An Innovative experimental device using the JHR experimental capacity
- Best practices from CEA and IFE-Halden
  - Robust design
  - I&C
  - Thermal-hydraulics
  - Chemistry
- A versatile equipment
  - Hosting capacity
  - I&C
  - Thermal-hydraulics
- Schedule for operation in the beginning of JHR operation to answer experimental needs
- Industrial partners welcomed to submit their experimental needs