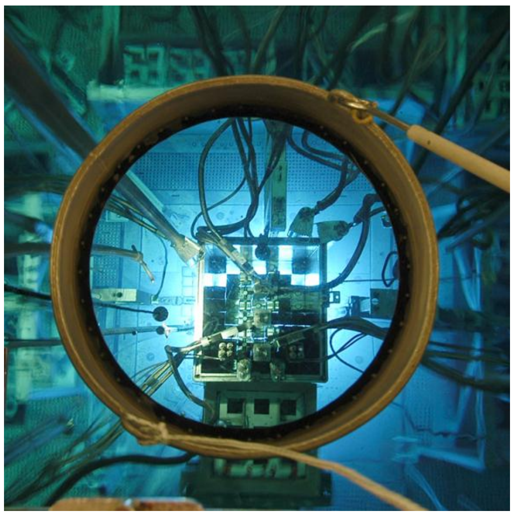
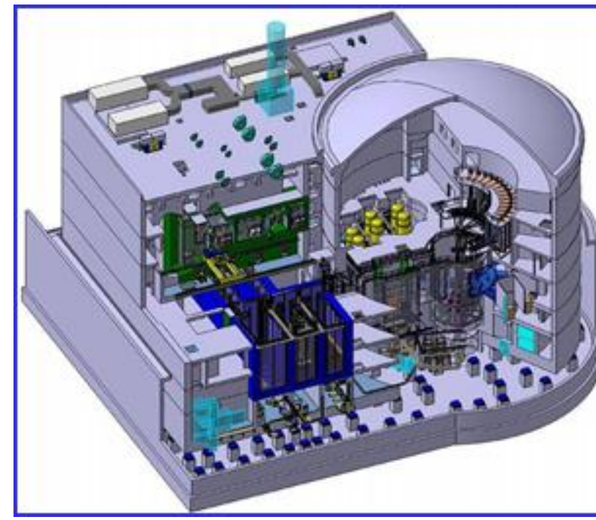
Sustaining Material Testing Capacity in France: From OSIRIS to JHR





to support industry and public organizations in R&D irradiation programs on nuclear fuel and materials

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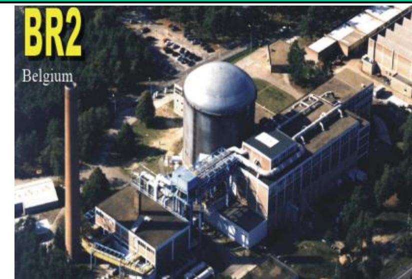
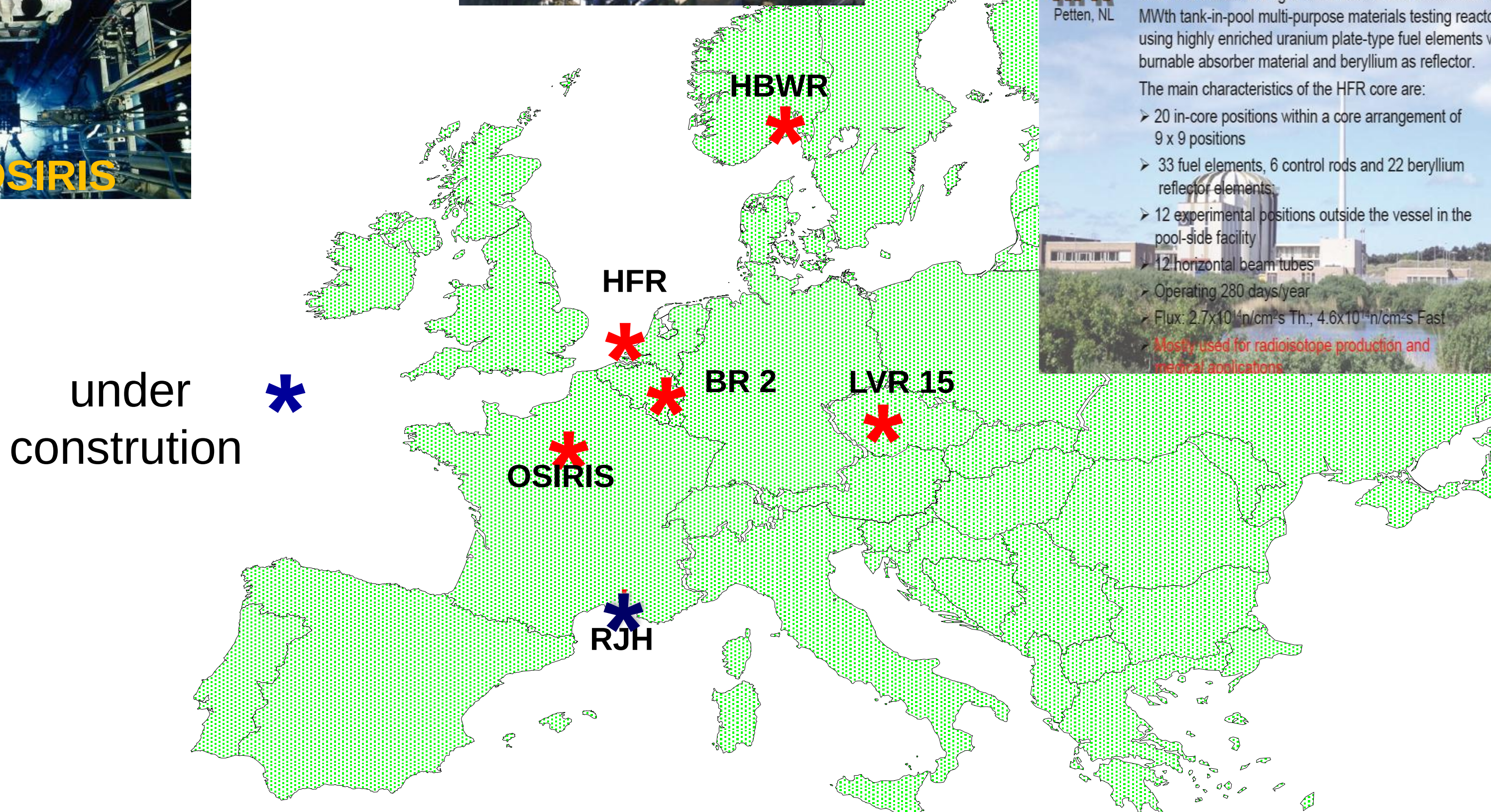
Context: An ageing fleet of MTR in Europe

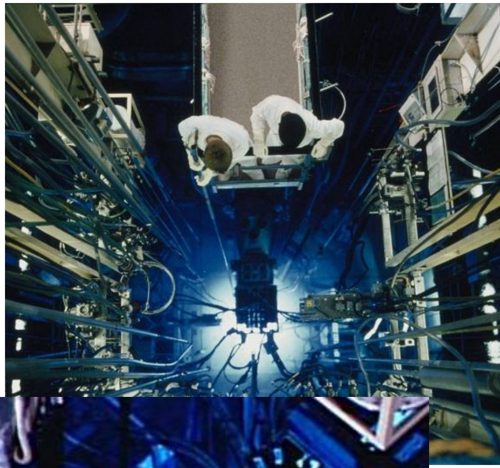
Necessity to at least one new MTR in Europe (ESFRI, SNE-TP…





The OSIRIS reactor

- **Main characteristics of OSIRIS research reactor :**
  - **Open core pool type**
  - **Compact core : 57*57*60 cm^3**
  - **Fuel**
    - ***38 standard elements***
    - ***6 control elements with Hafnium as absorber***
    - ***U3Si2Al plates (enriched to 19.75 %)***
  - **Moderator, coolant & biological protection : H_2O**
  - **Thermal power : 70 MW**
  - **Maximum neutron flux**
    - ***fast (E>1 MeV) : 2.5 E14 n/cm²/s***
    - ***thermal : 2.5 E14 n/cm²/s***



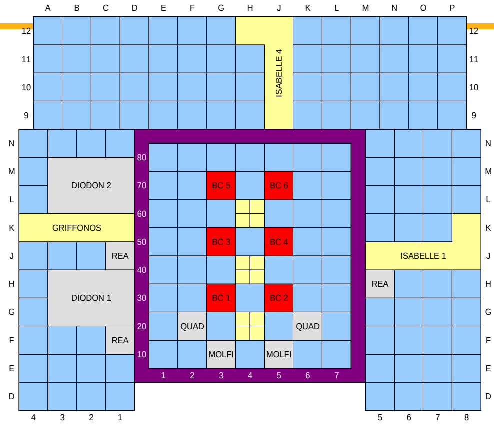
The main goal of OSIRIS reactor is to carry out irradiation tests of fuel and structural materials of nuclear power plants, and to produce radioisotopes

The current status of OSIRIS

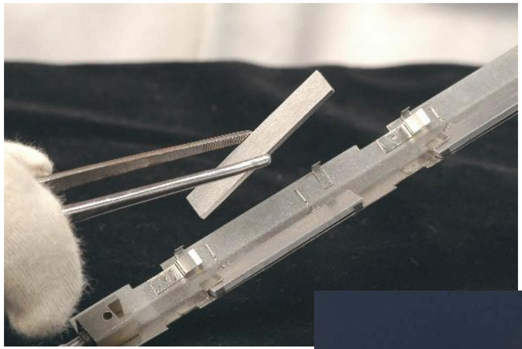
- **Annual operation :**
  - **180 operating days (8 cycles)**
  - **Intercycles of around 10 days**
  - **Two specific maintenance periods in spring and summer**

- **Operation extended up to middle of this decade**
  - **Specific up grades required by the Safety Authority performed in 2009-2010**
    - ***Truck hatch***
    - ***Polar Cranes***
    - ***Control rod room (-15 m)***
    - ***Ventilation system***

Material irradiation devices (OSIRIS CHOUCA)



- **Goals:**
  - **Material irradiations (grids, fuel clad, pressure tubes, vessel, guide tubes, …)**
  - **Parametric studies, qualification, thermal mechanic behavior**
  - **Various reactors :**
    - ***Gen 2, 3 and 3+ (Steel, Zircaloy, …)***
    - ***Gen 4 (SiC, ODS…)***
    - ***MTR (Aluminum alloys)***
- **Main characteristics**
  - **Irradiated in core or in periphery of core**
  - **Temperature :**
    - ***from 250 to 400 °C (+/-15°C) – NaK***
    - ***Up to 1100°C – gas***
  - **6 independent electrical heating elements to automatically adjust the temperature**
- **Instrumentation**
  - **Thermocouples**
  - **Dosimeters of Fe, Cu and AlCo types**
  - **In situ dimensional measurements**



Material irradiation devices (JHR MICA & CALIPSO)

Main characteristics

- MICA: same as CHOUCA
- CALIPSO: 250°C to 450°C

  integrated electromagnetic pump to circulate the NaK medium (to improve heat removal from sample materials surfaces => better temperature control).

Know-how transfer :

- take into account the OSIRIS feed-back for the design of JHR devices (to reduce thermal gradients on samples, to simplify hot lab operations, …)
- develop more innovative sample holders (highly instrumented) and test some parts in OSIRIS : ex MELODIE

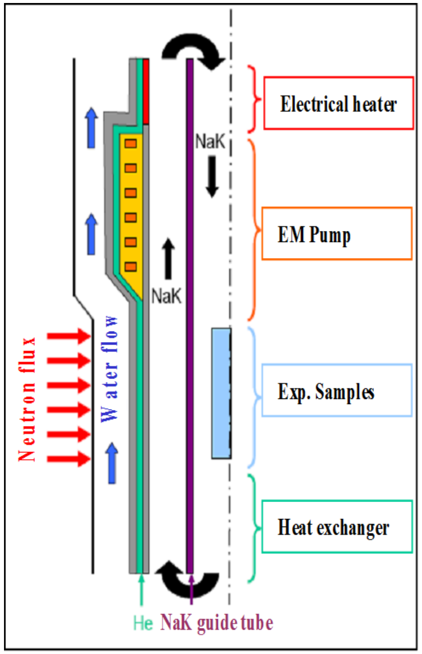
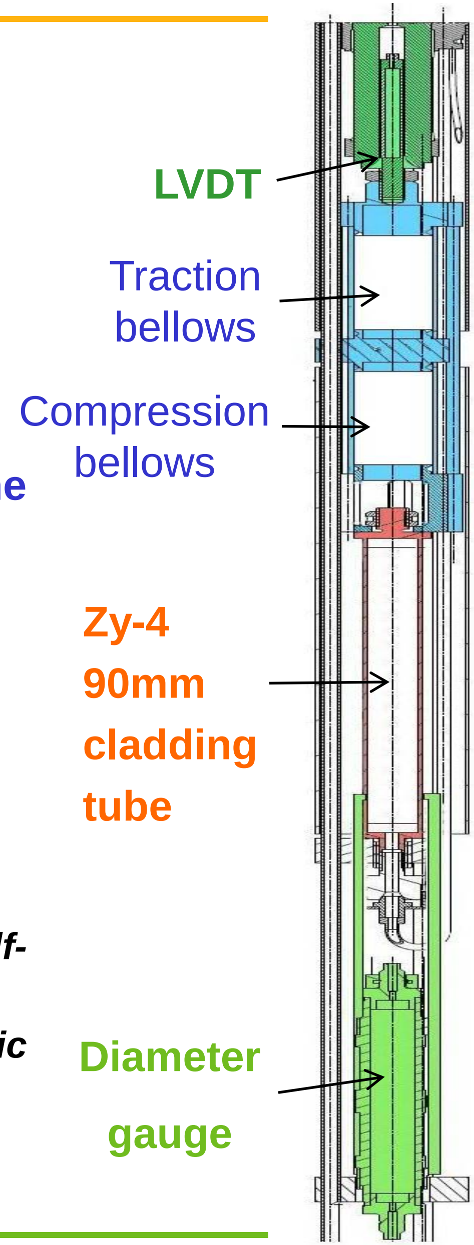


Diagram of the CALIPSO loop

Preparing JHR with OSIRIS: the MELODIE experiment

- **Goal :** to assess the interest of a biaxial stresses, online-controlled concept for the creep study of fuel cladding

- **Key features :**
  - **Irradiation start in OSIRIS : 2012**
  - **Joint CEA-VTT team in the framework of the JHR project**
  - **350°C, static NaK coolant**
  - **Stress limits σr – σz : 120 – 180 MPa**
  - **Online-controlled biaxial stress by :**
    - ***Sample pressurization***
    - ***Push-pull axial loading cell***
  - **Online biaxial measurement :**
    - ***Elongation measurement with a self-compensating LVDT (by IFE Halden)***
    - ***Diameter measurement with an electromagnetic gauge (DG) designed by IFE and CEA***



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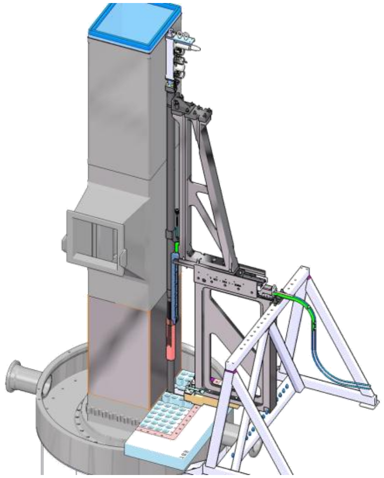
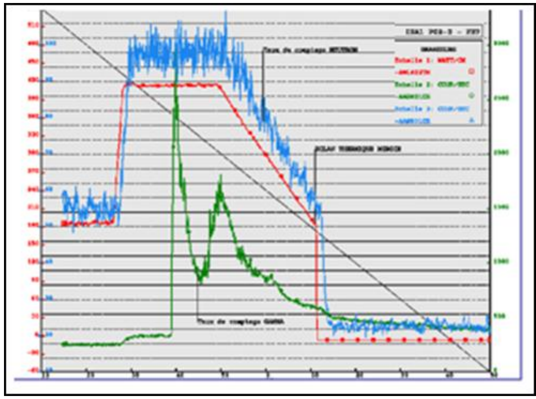
Fuel irradiation device (OSIRIS ISABELLE1 loop)



- **Goals:**
  - **test new fuel rods (with new clad material, new pellet size, or new type of fuel) until clad failure to determine technological limit**
  - **by realizing power ramps representative of class 2 incidental transients**

- **Main characteristics**
  - **periphery pressurized loop with PWR or BWR conditions**
  - **UO2, MOX, high burn-up fuels**
  - **moving device perpendicularly to OSIRIS core, slaved to neutron flux (SPND) to guarantee the speed, and stopped according to thermal power to guarantee the target**
  - **very good accuracy of the target's linear heat rate**
  - **clad failure monitoring : gamma detector, delayed neutron detector, and on-line gamma spectrometry**
  - **expansion of the rod monitored by LVDT elongation sensor.**

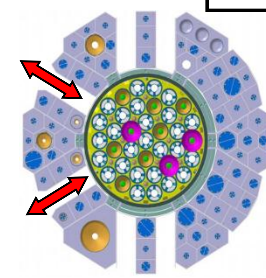


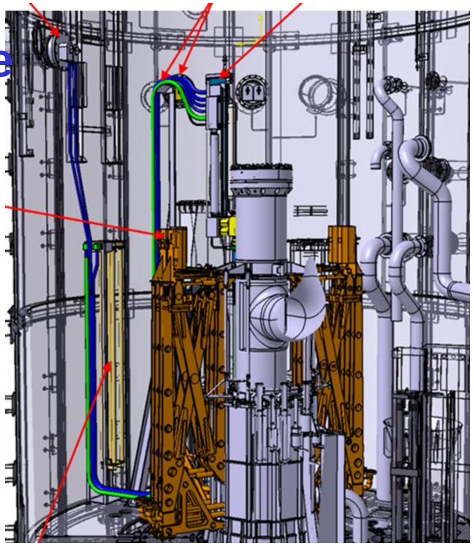
Fuel irradiation device : JHR ADELINE

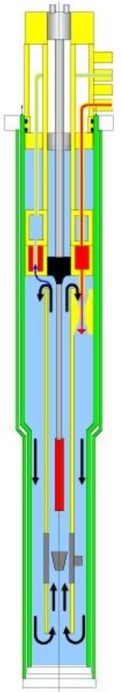
Main characteristics

- **sample holder (which contains possibly instrumented fuel: fuel centerline thermocouple and back-pressure sensor to analyze fission products and helium release kinetics -> used**
  in OSIRIS GRIFFONOS loop)
- **instrumentation holder (which contains the thermocouples for thermal balance)**

ADELINE







Know-how transfer :

- **take into account the OSIRIS feed-back for design of JHR loop (**easy device handling, minimizing thermal leaks and pressure losses, reducing time of cladding failure detection so improving the loop operation**, …)**
- **make more ramps per cycle avoiding connecting/reconnecting phases and hot cells transfer**

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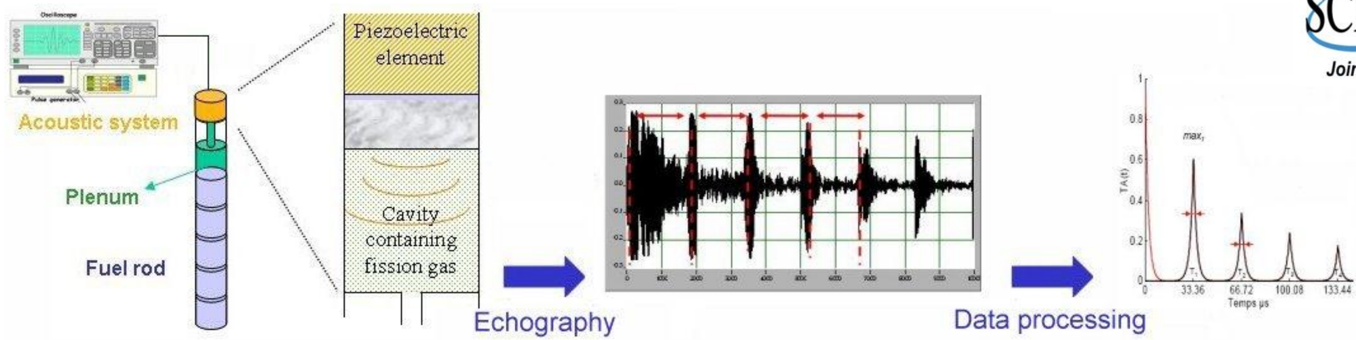
CEA Strategy for future Irradiation Capacity: Improve on-line analysis for JHR

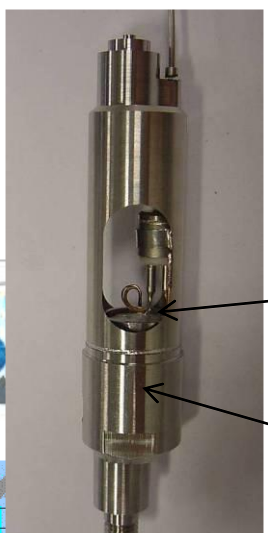
→

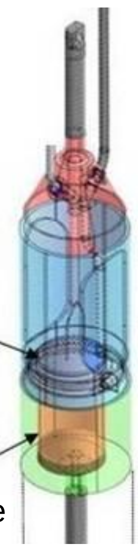
R&D and Innovation on Instrumentation : Recent developments

Fission Gas Release determination using acoustic measurement



Online measurement of the **molar mass** of the gas inside the fuel rod (→ **fraction of released fission gas**)





Acoustic sensor

Cavity connected to the fuel rod

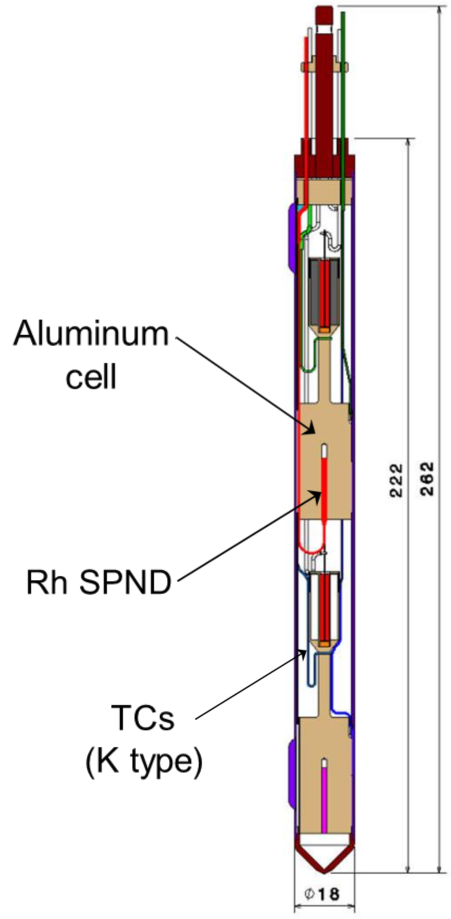
Fuel rod

The sensor is implemented on pre-irradiated PWR fuel rods

→ Operational in OSIRIS reactor since 2010 (REMORA-3 experiment)

Collaboration on photonic and neutronic measurements devices

- **CALMOS in OSIRIS: new calorimetric probe (in-core measurements, mobile system) 2011**
- **continuous axial distribution** of total heating
- measurements **inside and above the core**
- calorimetric probe remaining in the irradiation field only for measurements **(limiting the ageing)**
- simultaneously **thermal flux measurement** (Rhodium SPND)



- **CARMEN2 in JHR: to characterize experimental locations with photonic & neutronic measurements**
- **CARMEN1: 2 mock-ups tested in OSIRIS in 2012**

One with CALMOS mobile probe concept + gamma thermometer (gamma heating measurement)

One with fission chambers and Rhodium SPND (fast/thermal neutron flux measurement)

=> to select the most appropriate detectors

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THANK YOU FOR YOUR ATTENTION….

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