Jules Horowitz Reactor – the Future of European Materials Testing Reactors

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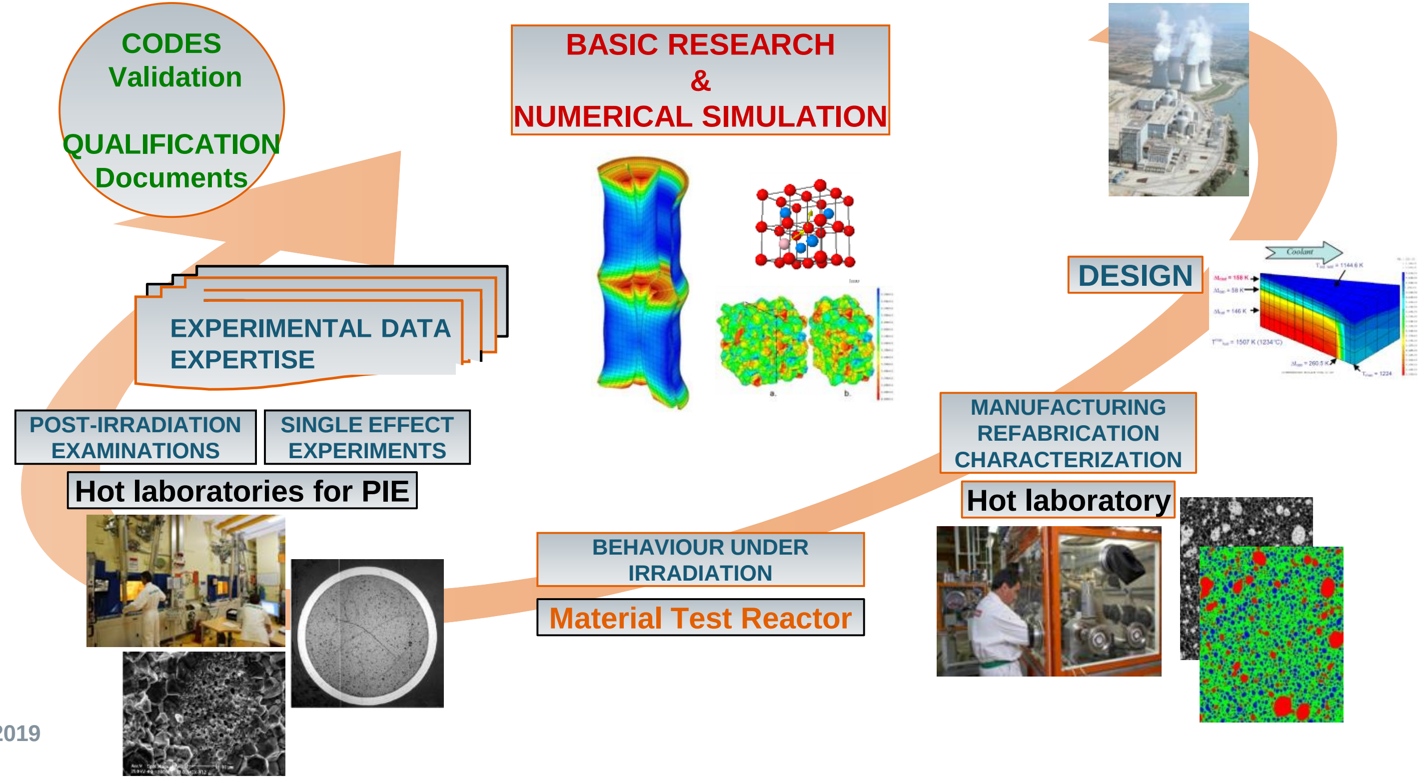
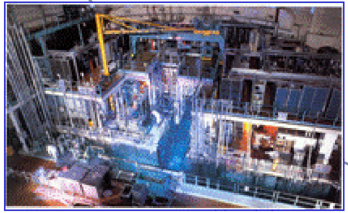
Role of Materials Testing Reactors (MTR)
R&D in Support of the Nuclear Power Industry



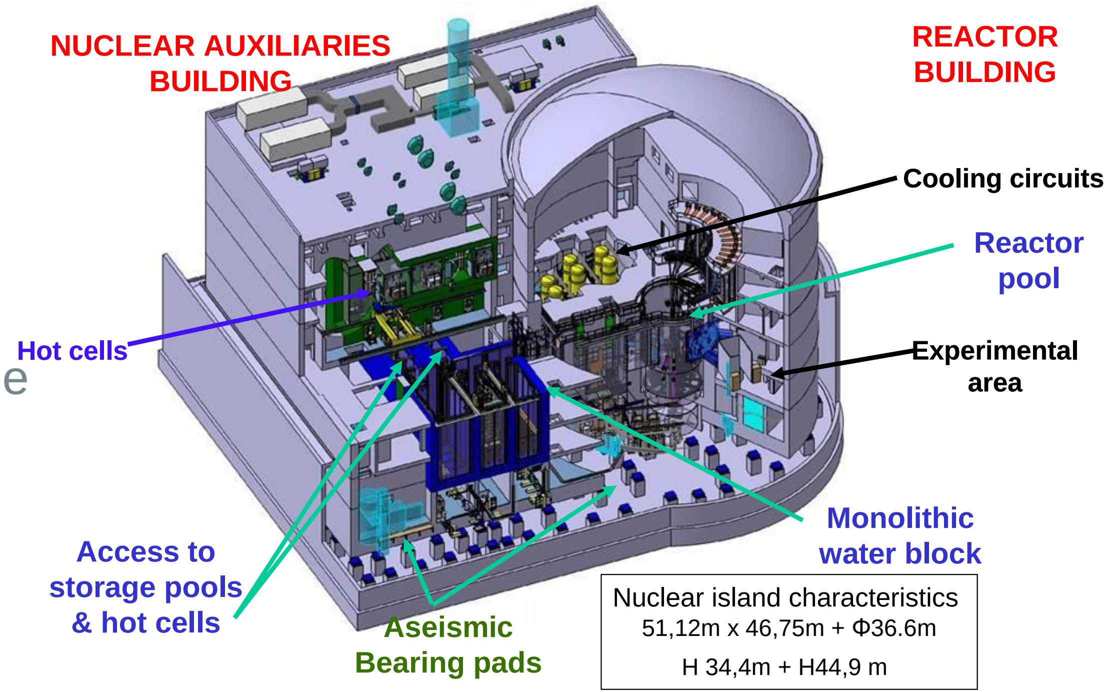
Age of current EU main MTRs in 2019 (years)

BR2 (BE)	56
HALDEN (NO)	shutdown
HFR (NL)	58
LVR 15 (CZ)	61
MARIA (PL)	46
OSIRIS (FR)	shutdown
PHENIX (FR)	shutdown
R2 (SE)	shutdown



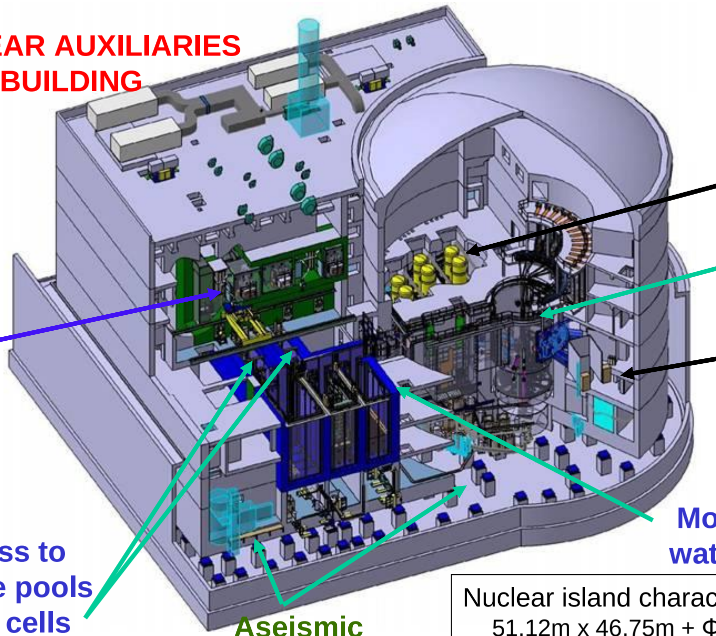
Jules Horowitz Reactor
Response to Industry Needs

- CEA is developing experimental devices for material studies under irradiation in normal or accidental conditions
- JHR allows for the small scale (100 MWth) reproduction of representative in-reactor test conditions for:
  - material screening
  - material characterization
  - fuel element qualification



Jules Horowitz Reactor
Response to Industry Needs

- JHR is designed to:
  - provide a high neutron flux
  - run highly instrumented experiments
  - support advanced modeling needs
  - operate experimental devices capable of simulating NPP environment
  - respond to the experimental need of current and future generations of power reactors
  - provide a major part of radioisotopes for medical purposes in Europe.



Nuclear island characteristics
51,12m x 46,75m + Φ36.6m
H 34,4m + H44,9 m

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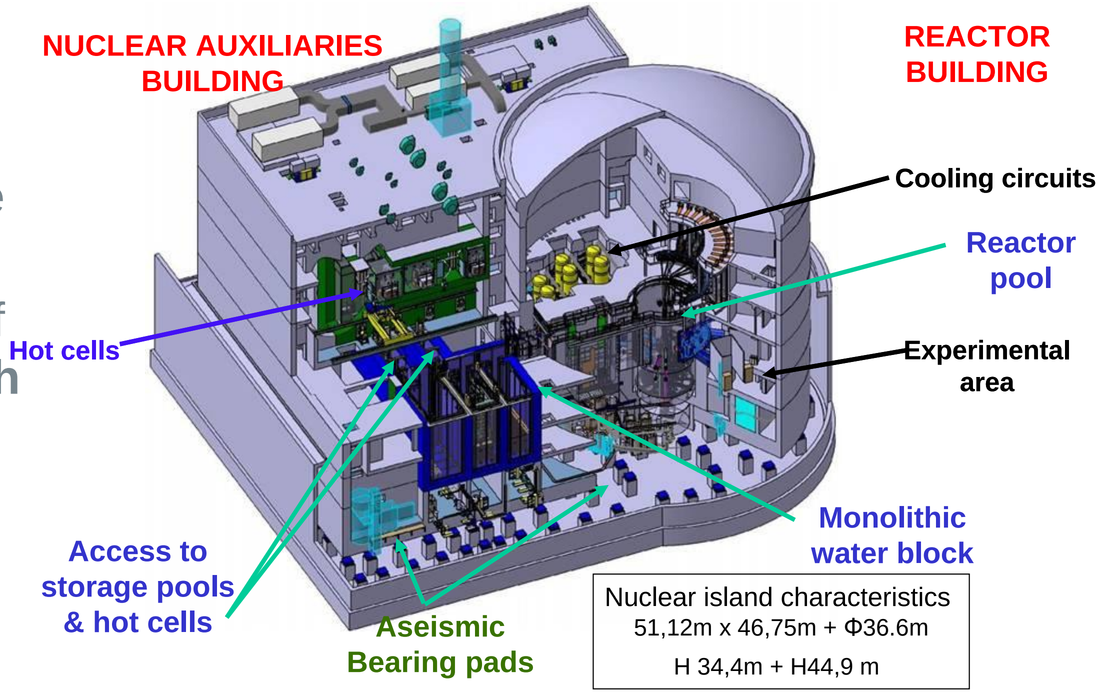
Response to Industry Needs

- Labeled as an **European Strategic Forum Research Infrastructure** (ESFRI) since 2008
- Will become important part of **European Nuclear Research Infrastructures** (NRI)

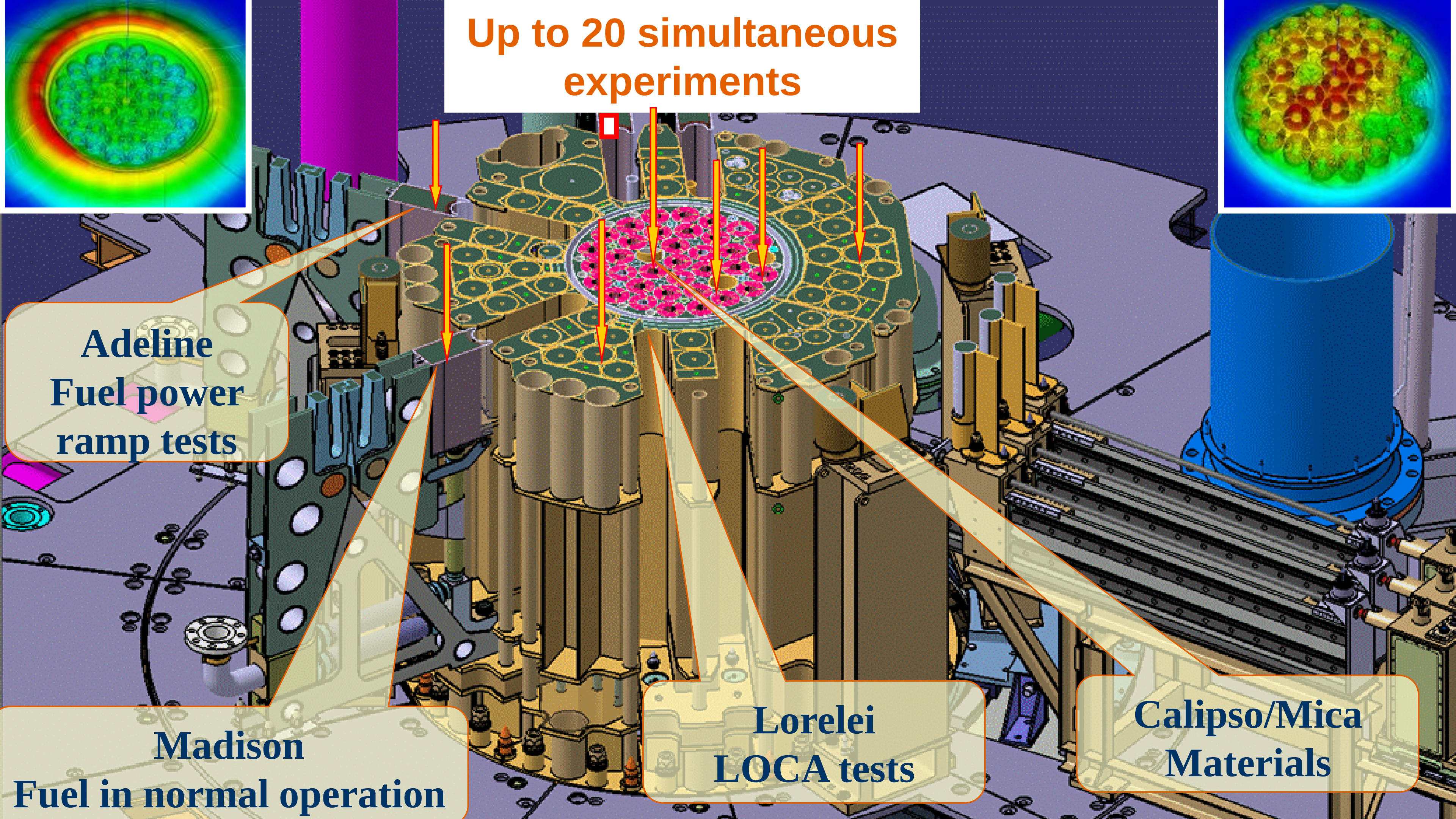


Jules Horowitz Reactor
Response to Industry Needs

- Support
  - existing nuclear power plant (NPP) operation (material reliability, fuel performance and safety, …)
  - development/qualification of advanced materials and
- Develop expertise and support education and training of nuclear industry staff and researchers
- Support future decisions related to NPP construction/concept assessments

Jules Horowitz Reactor
JHR Consortium

- **CEA** – owner and nuclear operator with all liabilities
- **JHR Consortium Members Owners of Guaranteed Access Rights**
  - in proportion of their financial commitment to the construction
  - with a proportional voting right in the Consortium Board
- Members can use totally or partly their access rights
  - for implementing proprietary programs with full property of results and/or for participating to the Joint International Programs open to non-members
  - to address issues of common interest & key for operating NPPs


Up to 20 simultaneous experiments
Adeline
Fuel power ramp tests
Madison
Fuel in normal operation
Lorelei
LOCA tests
Calipso/Mica
Materials

Jules Horowitz Reactor
Devices at Start-up

ADELINE

For fuel testing under off-normal conditions
Power transient,
post clad failure fuel behavior,
Lift-off experiment…

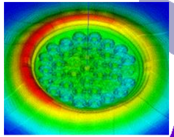
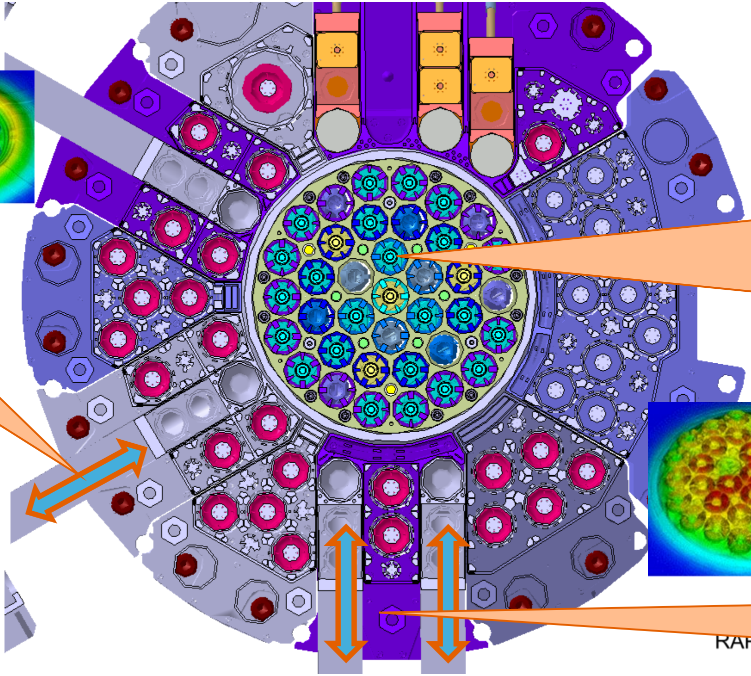
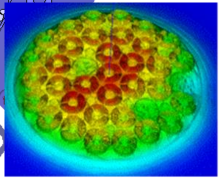


IMAGE FLUX THERMIQUE



ADELINE (transient)
Displacement system



RAPIDE

MICA (x3)

For material testing under high dpa and accurate temperature control

(+ mechanical loading)

MADISON
(BU cooking)
Displacement system

MADISON

For fuel testing under nominal conditions

Jules Horowitz Reactor
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Power transient,
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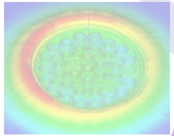

IMAGE FLUX THERMIQUE

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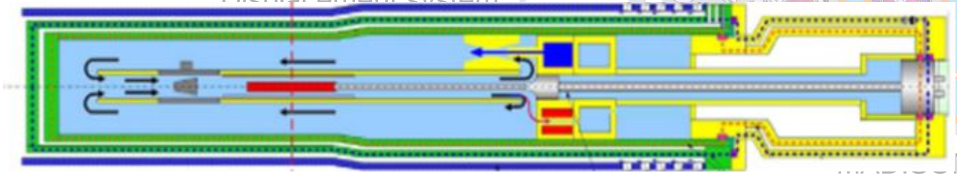
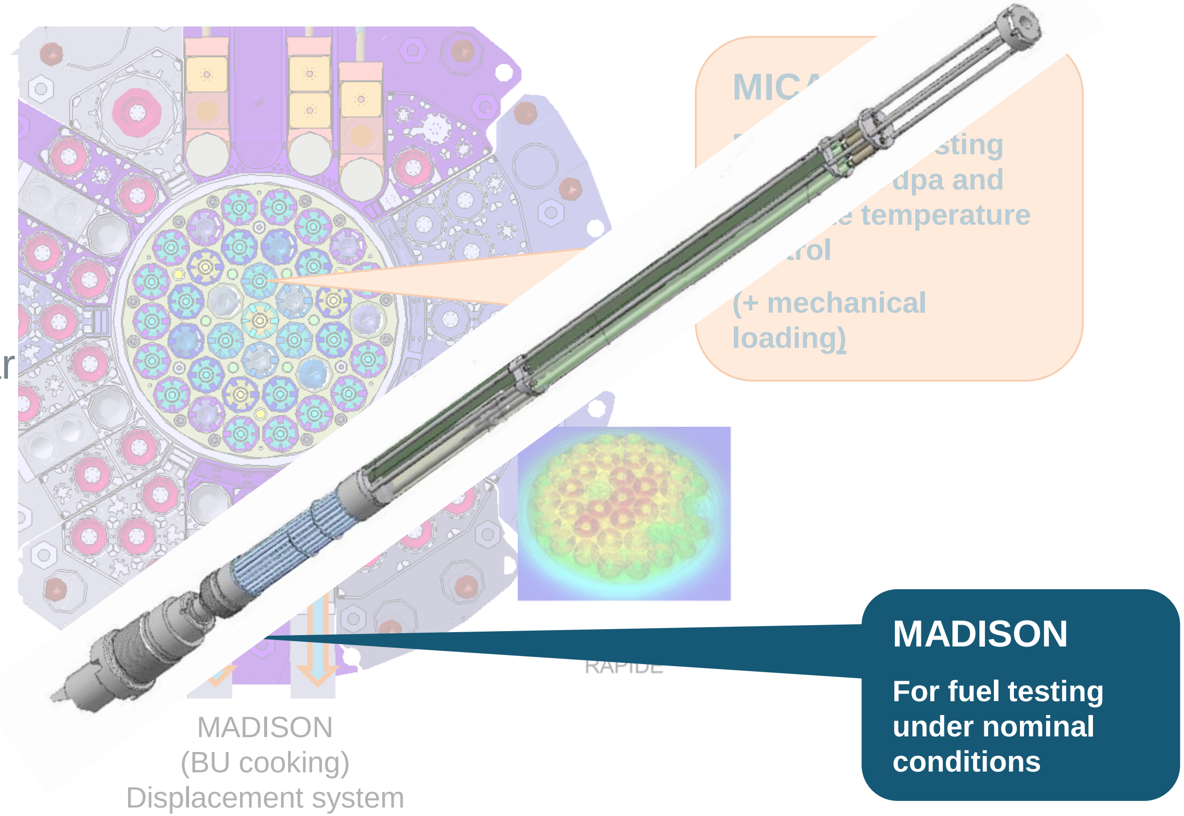


(BU cookir
Displacement system

- ***Advanced Device for Experimenting up to Limits Irradiated Nuclear fuel Elements***
  - dedicated to nuclear fuel testing under **off-normal conditions**, up to failure
  - device designed specifically for power ramp experiments on nuclear fuel
  - optimized to reach a high linear power (up to 620 $W \cdot cm^{-1} min^{-1}$) and a high power ramp rate (up to 700 $W.cm^{-1} min^{-1}$)

Jules Horowitz Reactor
Devices at Start-up

- ***Multi-rod Adaptable Device for Irradiations of experimental fuel Samples Operating in Normal conditions***
  - dedicated to the study of nuclear fuel under **nominal operating conditions** (no anticipated cladding failure)
  - located in the reflector on a displacement device
  - can be used short- and long-term irradiations

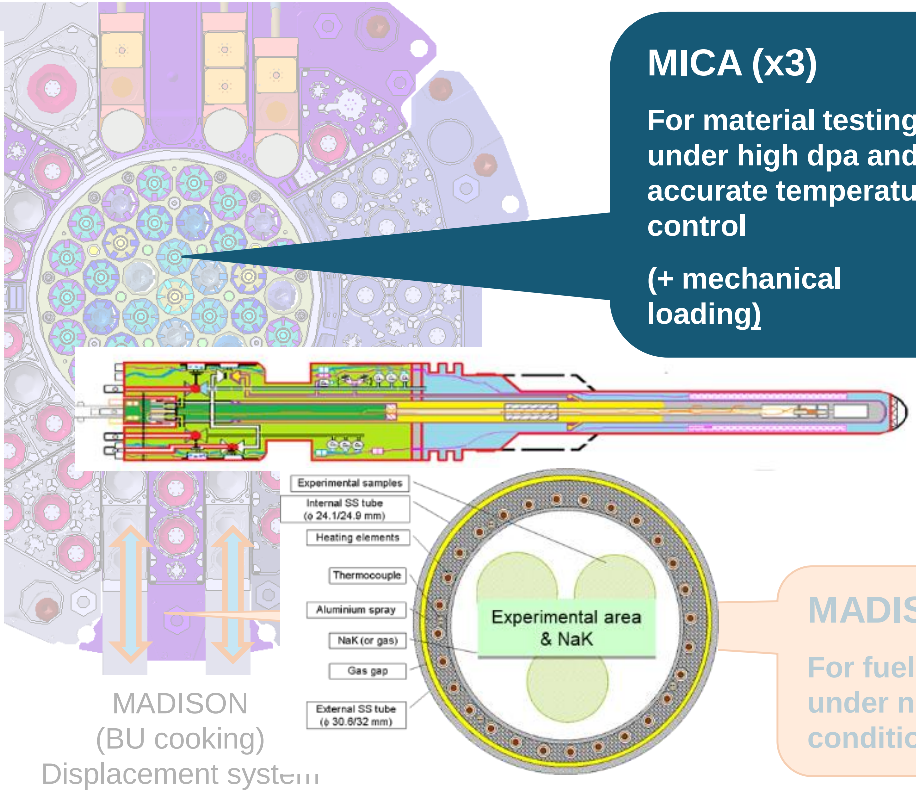


Jules Horowitz Reactor
Devices at Start-up

- ***Material Irradiation CApsule***
  - **material property investigations** (neutron flux, neutron fluence, temperature, possibly stress, etc.)
  - capsules located in the core (center of a fuel element)
  - achieve doses up to 10 – 12 dpa·y^{-1}, with temperature control (< 450 °C)

  - two types of MICA
    - static MICA (NaK filled)
    - dynamic MICA, equipped with **MeLoDIE**

      → part of Finnish in-kind



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(+ mechanical loading)

MADISON

For fuel testing under nominal conditions

Jules Horowitz Reactor
Finnish In-kind Contributions

- **Finnish in-kind contribution entitles a 2 % share of the JHR**
- Includes 3 technical systems:
  - **Mechanical LOading Device for Irradiation Experiments (MeLODIE)** in the reactor core
  - **Underwater Gamma spectrometry and X-ray Radiography (UGXR)** system for non-destructive examination (NDE) to be implemented
    - in the reactor pool environment
    - in the experimental devices storage pool environment
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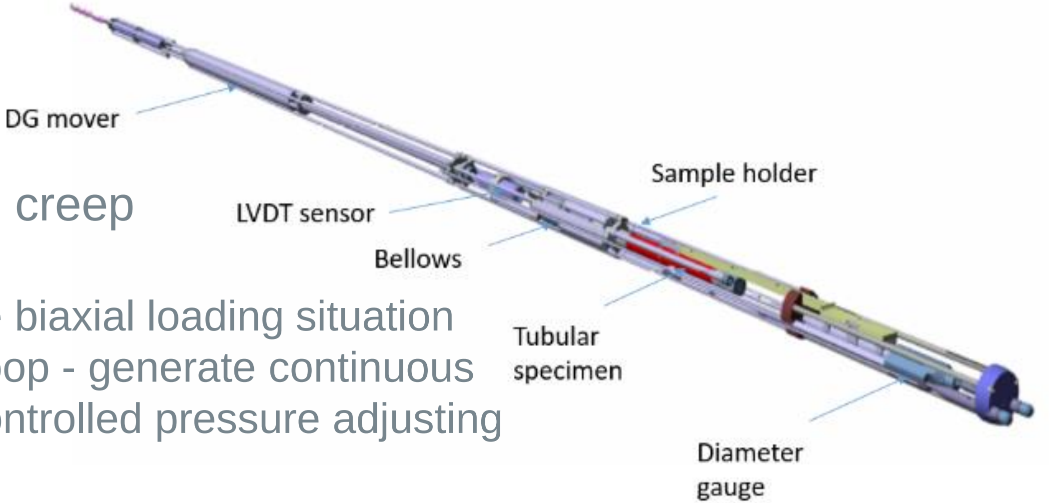
Finnish In-kind Contributions - MeLoDIE

- Instrumented in-core experimental device for the study of fuel cladding irradiation creep behavior under biaxial loading
  - uses pneumatic controls to create biaxial loading situation
  - pressure controlled by a helium loop - generate continuous gas flow for 4 pneumatic servo-controlled pressure adjusting loops which are used to control
    i. the internal pressure of the specimen,
    ii. the pressures of the two bellows of the loading device
    iii. the pressure of the bellows of the mover



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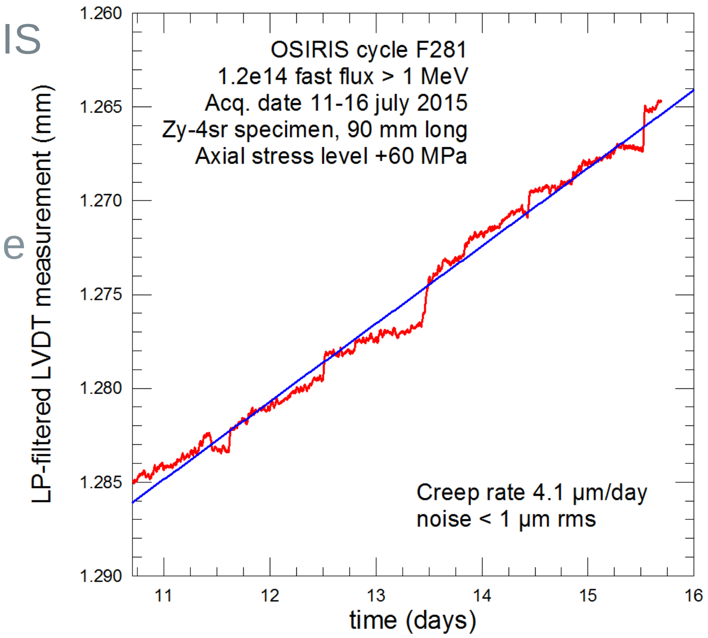
  - installed and tested in OSIRIS in 2015
  - in-core testing of Zircaloy-4 cladding
    - demonstrates devices capability to conduct on-line axial deformation measurements under neutron irradiation



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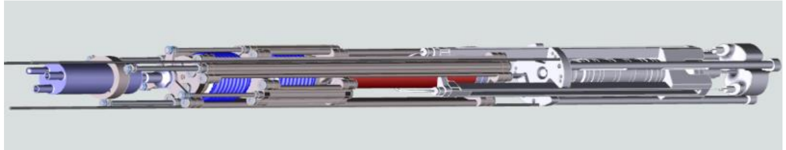
- Ongoing → MeLoDIE II development
  - modifications/adaptations for use in LVR-15



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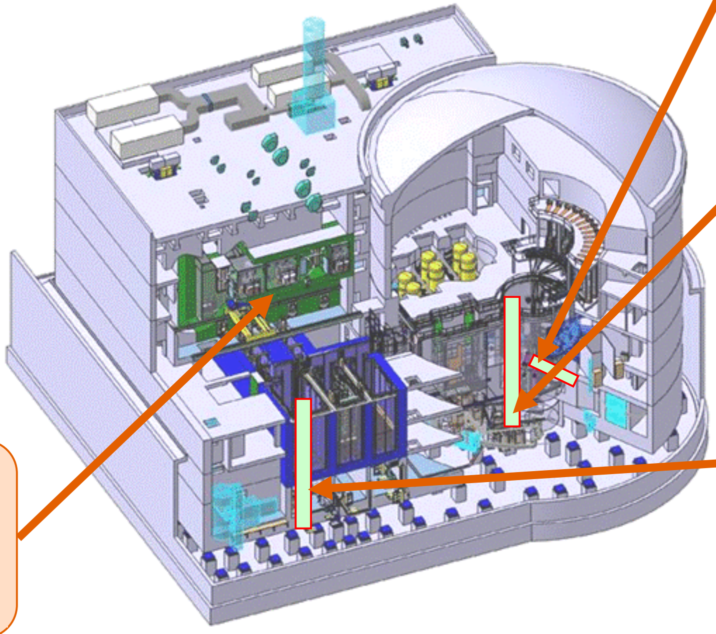
Jules Horowitz Reactor

Finnish In-kind Contributions – UGXR & HGXR

- Objectives
  - initial verification of the experimental loading
  - adjustment of the exper-imental protocol
  - final NDE tests after irradiations



Neutron imaging stand in reactor pool

Test device examination

X-ray & g stands

in reactor pool

(short lived γ emitters ;

examinations during intercycles)

X-ray & g stands in storage pool

Gamma and x-ray scanning system in hot cell

Sample examination

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Finnish In-kind Contributions – UGXR & HGXR

- UGXR & HGXR
  - to measure isotope distribution using gamma scanning or density distribution using X ray scanning of the sample in the irradiation device in the reactor/storage pool (UGXR) or hot cell (HGXR) environment

Jules Horowitz Reactor & Finland
Benefits to Finnish Nuclear Industry

- JHR has been identified as a key part of NRI that will fill the gap left by the aging and/or decommissioned/entering decommissioning MTRs

- Enhance the capacity for materials and fuel testing and research, otherwise not available nationally – concerning current and future needs

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Thank you!

Acknowledgements

Finnish Stakeholders (Business Finland, Fortum, TVO & Fennovoima)

Finnish Research Programme on Nuclear Power Plant Safety

SAFIR2022

beyond the obvious

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