Jules Horowitz Reactor project: a future Material Test Reactor in support to nuclear industry, regulators and R&D institutes; status as of mid-2023 following major reassessment of the project and setting-up of « pre-JHR » phase before start-up of the reactor.

Dr Gilles Bignan & All

French Atomic and Alternatives Energies Commission (CEA)

JHR project International Affairs Manager

gilles.bignan@cea.fr

IGORR-TRTR conference 2023

French Energy Policy :

New orientations given by French President in February 2022 with the objective of Net Zero by 2050

❶ **Energy sobriety:** reduction of energy consumption by 40% in 2050

❷ **Increase of low carbon energy production**

– **Strong increase in renewables** (PV, in-land and off-shore wind, geothermals)

▶ **CEA strongly involved in PV and hydrogen technologies**

– **Launch of a new nuclear program targeting 25 GW new capacity by 2050**

✓**LTO (lifetime extension** > 50 years of existing NPPs subject to safety consideration)

✓Launch of « **New Buid program** » with **6 EPR2** (3x twins as proposed by EDF) and study for **8 more EPR2**

▶ **CEA already engaged in R&D program for NPP lifetime assessment up to 40y... to be further continued for 50y+**

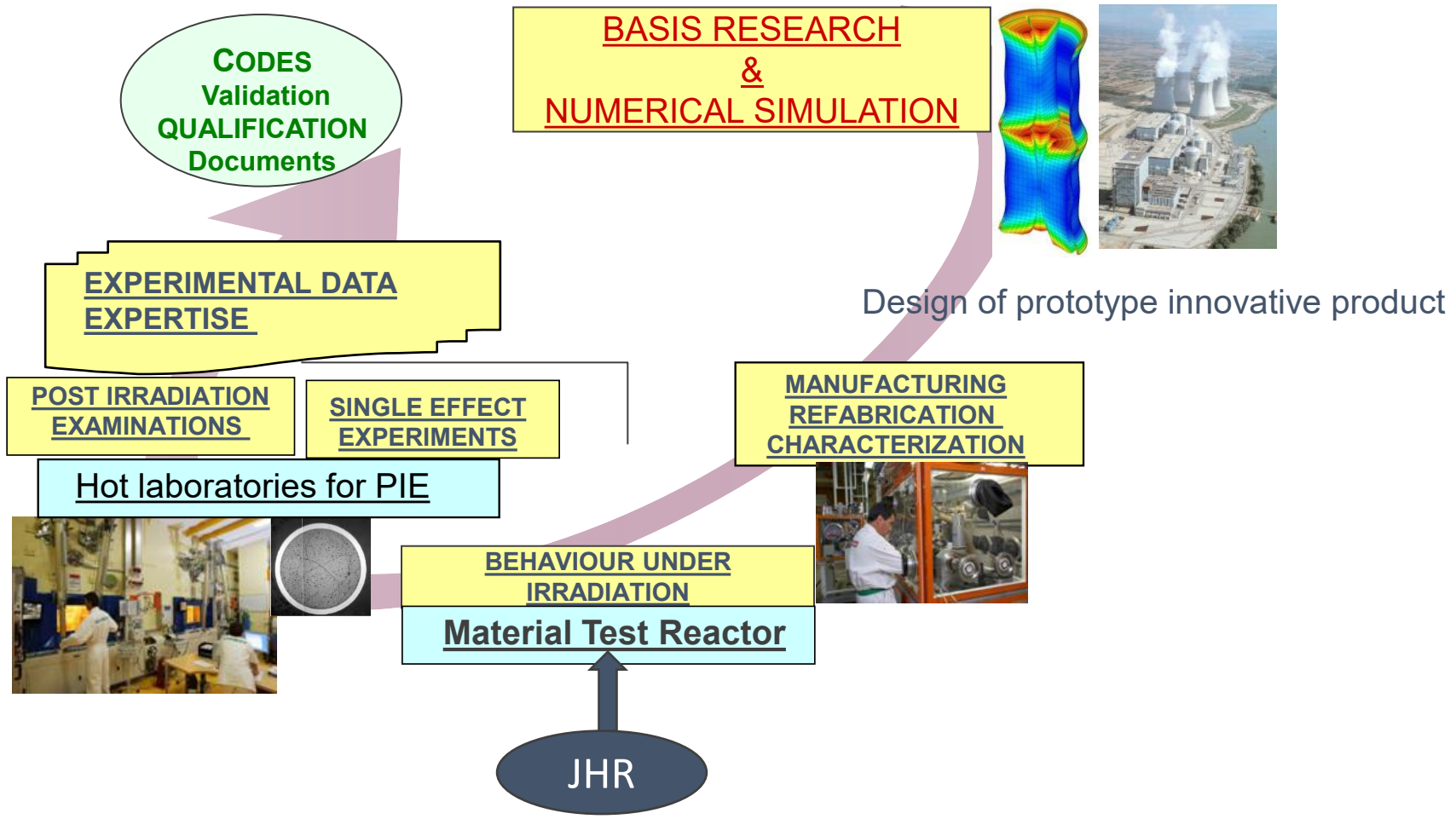
✓**Innovation program for SMR/AMR with 1 b€ public funding** : support of industrial French SMR program NUWARD and call for new projects for AMR (start-ups), targeting a prototype by 2030

▶ **CEA strongly involved in NUWARD and in innovative nuclear energy production systems**

→**New law called « acceleration for building new nuclear facilities » endorsed by the senate and the parliament in May 2023**

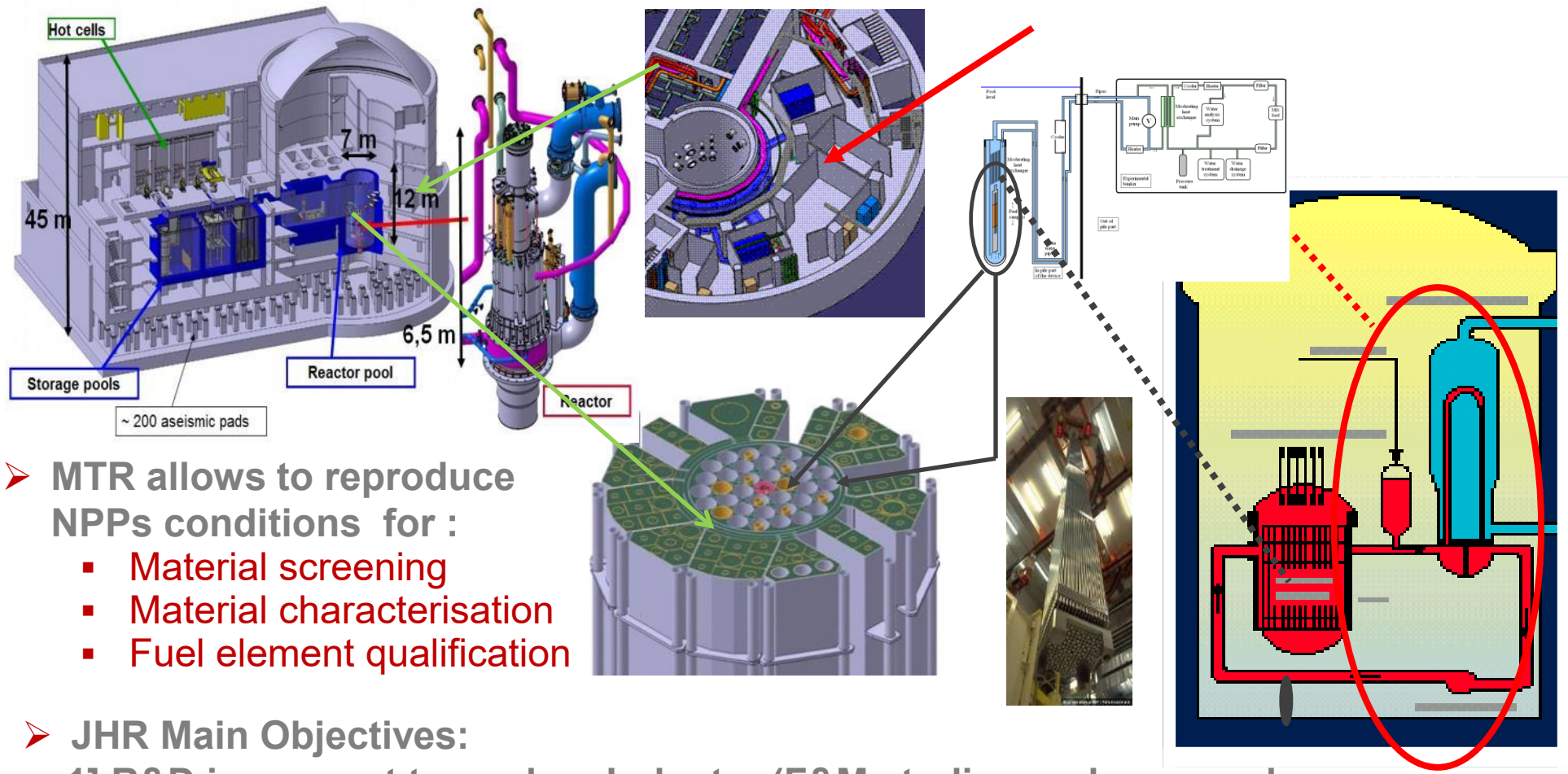
→**JHR –once in operation- will become a key research reactor in support to the presnet French fleet (56 NPPs) and the future one**

The Key-Role of MTR in support of NPPs for F&M qualification under irradiation considering an ageing fleet in Europe



JHR the only MTR Under construction
in Europe- EC/ESFRI Landmark

The appropriate answer to the Industry, R&D and TSO needs : JHR Project



- MTR allows to reproduce NPPs conditions for :
  - Material screening
  - Material characterisation
  - Fuel element qualification

- JHR Main Objectives:
  1] R&D in support to nuclear Industry (F&M studies under normal, incidental and accidental situations)
  2] Radio-isotopes supply for medical application
  3] A key tool to support expertise

JHR Experimental capacity

1. JHR hosting capabilities

In reflector
Up to 3.5E14 n/cm².s (th)

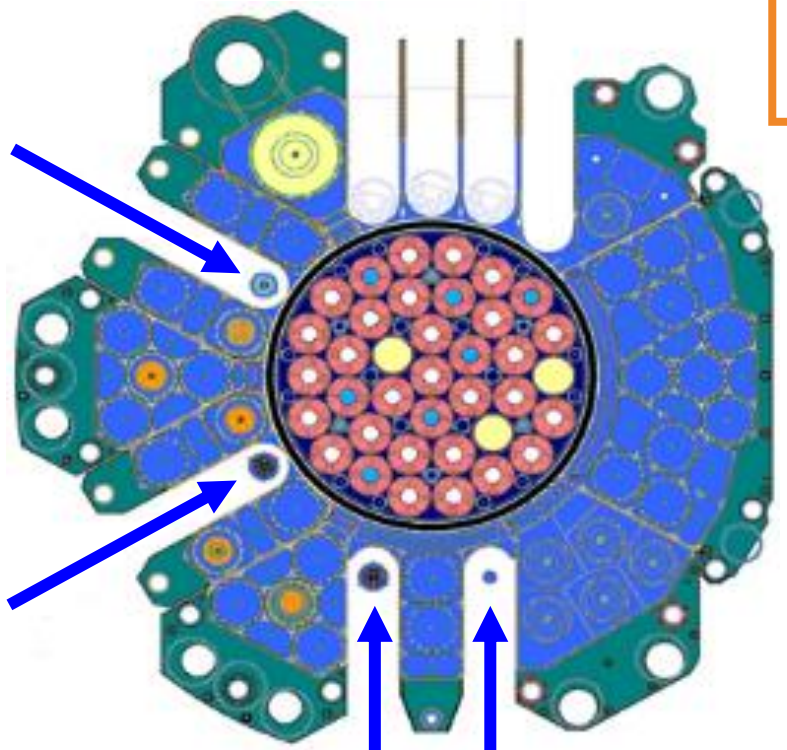
Fixed irradiation positions
(Φ100 mm & Φ200 mm)
and 4 displacement systems

In core
Up to 5.5E14 n/cm².s (E> 1 MeV)
Up to 1.E15 n/cm².s (E> 0.1 MeV)

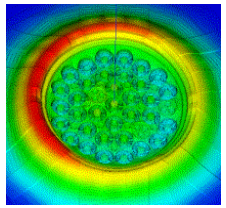
7 small locations (Φ ~ 32 mm)
3 large locations (Φ ~ 80 mm)

LWR fuel experiments
+
Material ageing
(low ageing rate
Exple : RPV material)

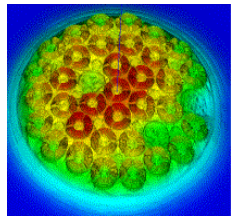
Material ageing
(high ageing rate)
+
Gen IV fuel experiments



Thermal neutron flux



Fast neutron flux



Displacement devices
450 mm stroke
Vmax = 6 mm/s

→A large range of neutron fluxes and spectra

First fleet of experimental devices under development (dedicated to LWR testing)

MICA (x3) :

For material testing under high dpa and accurate temperature control

ADELINE:

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

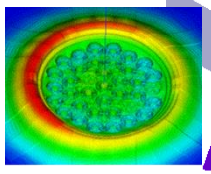


IMAGE FLUX THERMIQUE

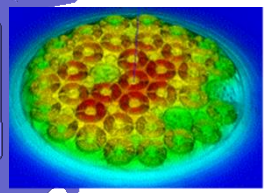
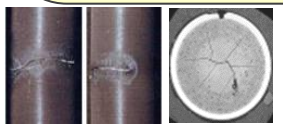


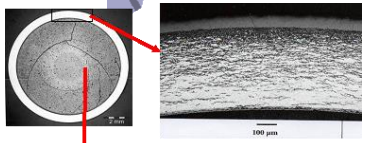
IMAGE FLUX RAPIDE



ADELINE (transient)
Displacement system

OCCITANE :

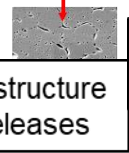
For Reactor Pressure Vessel steel testing



MADISON
(BU cooking)
Displacement system

MADISON :

For fuel testing under nominal conditions



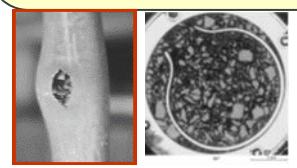
Clad corrosion
Crud,…

Fuel µstructure
FG releases

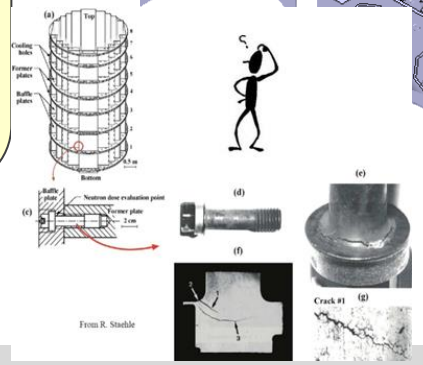
Second fleet of experimental devices under development (dedicated to LWR testing)

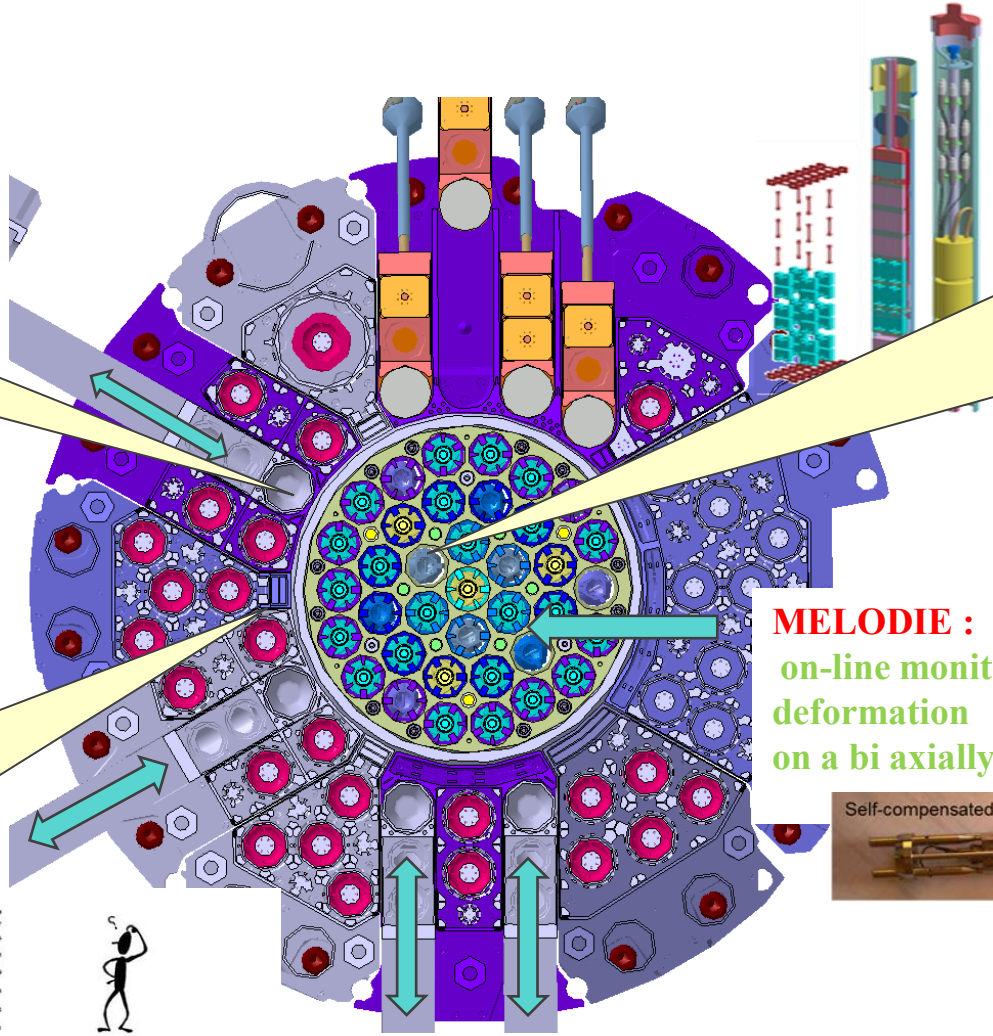
LORELEI :

fuel testing under accidental conditions (LOCA)



CLOE : Corrosion loop for "Zr alloy Corrosion" and "Irradiation Assisted Stress Corrosion Cracking"





MADISON2

Advanced MICA (x2)

For material testing under high dpa and accurate temperature control (+ mechanical loading)

MELODIE :

on-line monitoring of bi-axial deformation
on a bi axially-loaded clad sample

JHR OPERATING RULES

JHR consortium gathers organizations which take part financially and get permanent access to JHR experimental capacities
(1 representative / organization)

JHR International Consortium :
Research centers & Industrial companies

Studsvik, EDF, CEA, AREVA, CGN, FRAMATOME, TechnicAtome, Ciemat (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas), SCK•CEN (Studiecentrum voor Kernenergie / Centre d'Etude de l'Energie Nucléaire), National Nuclear Laboratory, VTT, ÚJV, DAE, IAEC

In several cases, the organization (member of the JHR consortium) is itself the representative of a national domestic consortium which gathers organizations among industry, R&D organizations, TSO, or Safety Authority...
CEA is mandated by the Governing Board to enlarge to consortium before start-up of operation

New organisation as of March 2020 following 2019 audit from the French Government

Overall JHR Roadmap validated by the French authorities

After the Recovery Action Plan implementation (2019-2020), the 2021-2023 roadmap is under implementation

- stabilization of the detailed design and 3D model
- Closure of remaining technical open issues
- Manufacturing and qualification of critical equipment
- Preparation of the electromechanical installation

Project Review milestone in order to assess:

- Remaining activities and associated risks
- Project schedule up to start-up and first experiments
- Cost at completion

- Full speed installation

Major construction highlights during the years 2021-2022-2023

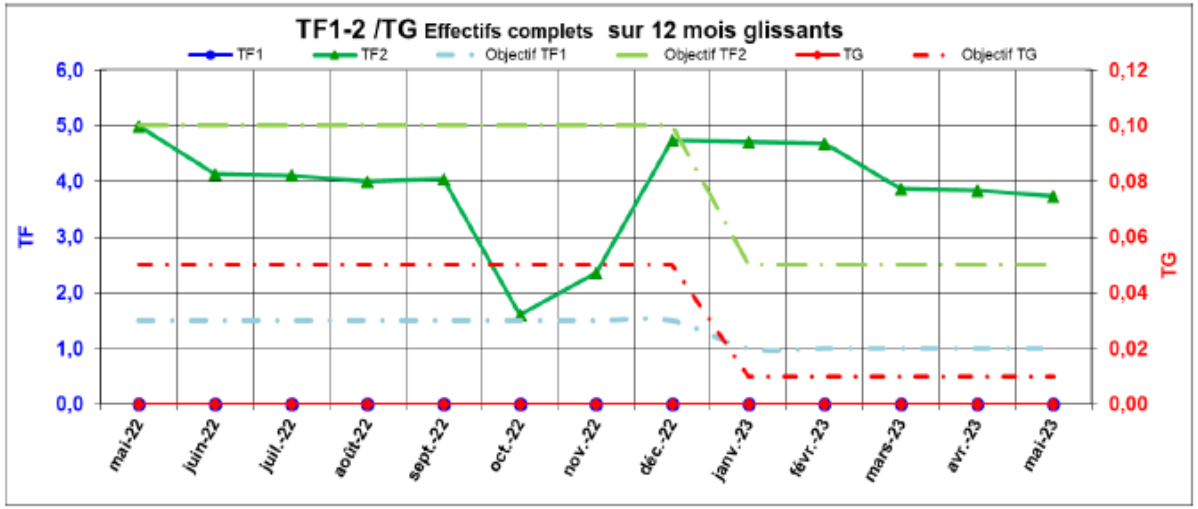
More info see JHR website : https://jhrreactor.com

Safety first
Occupational and nuclear safety are our first priorities

- **Occupational Safety : 2 years record without lost-time accident reached in 2022**
  - End of May 2023: 140 days without any work accident
  - Safety policy implemented by every company at site under the coordination of CEA

TF1: 0,0	TF2: 3,7	TG: 0,00

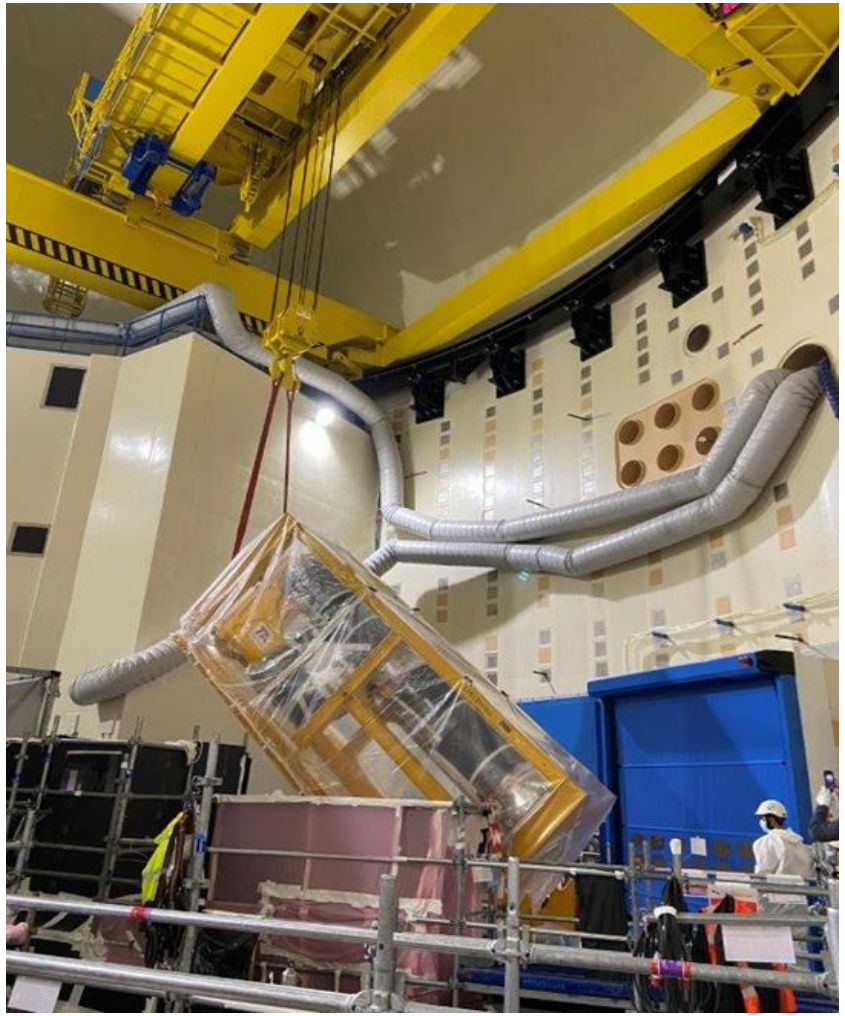
TF1 : nombre d'Accident de Travail Avec Arrêt (ATAA) survenus sur les 12 derniers mois rapporté à 1 million d'heures travaillées.
TF2 : nombre d'ATAA + d'ATSA (Sans Arrêt) survenus sur les 12 derniers mois rapporté à 1 million d'heures travaillées.
Effectifs pris en compte dans les indicateurs : productifs et improductifs tous lots ainsi que le personnel projet RJH

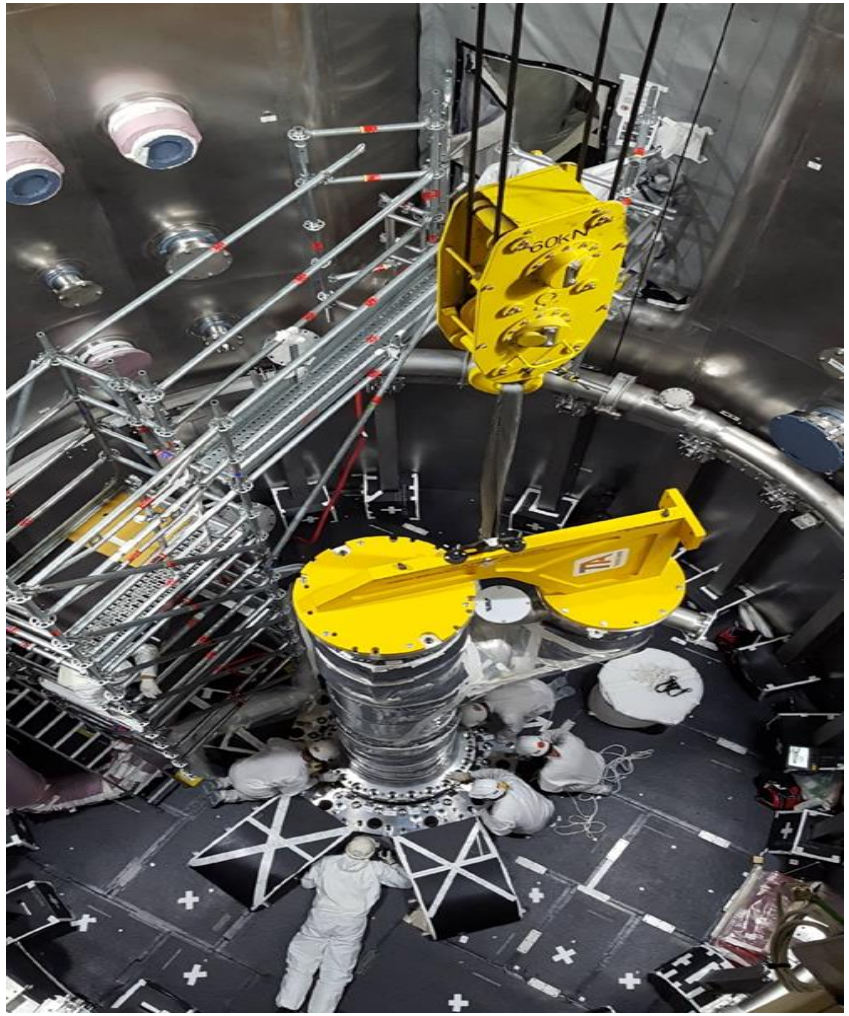


- **High-level safety:**
  - Safe design following up-to-date regulations and standards (seismic resistance, post Fukushima enhanced safety rules)
  - Safety culture training for all team members
  - Kick-off of anticipated examination by ASN

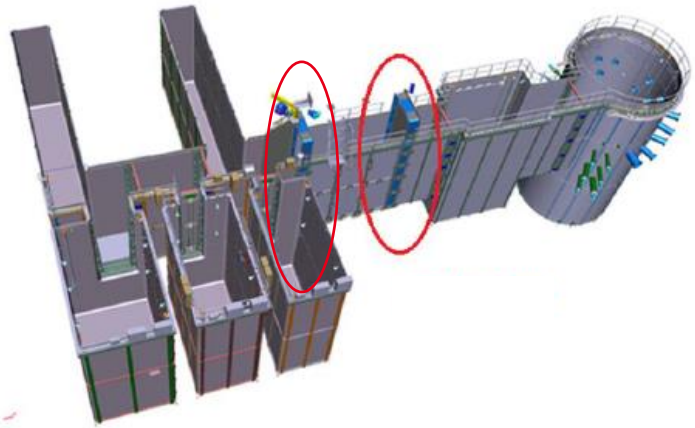
Project progress

Core vessel implementation





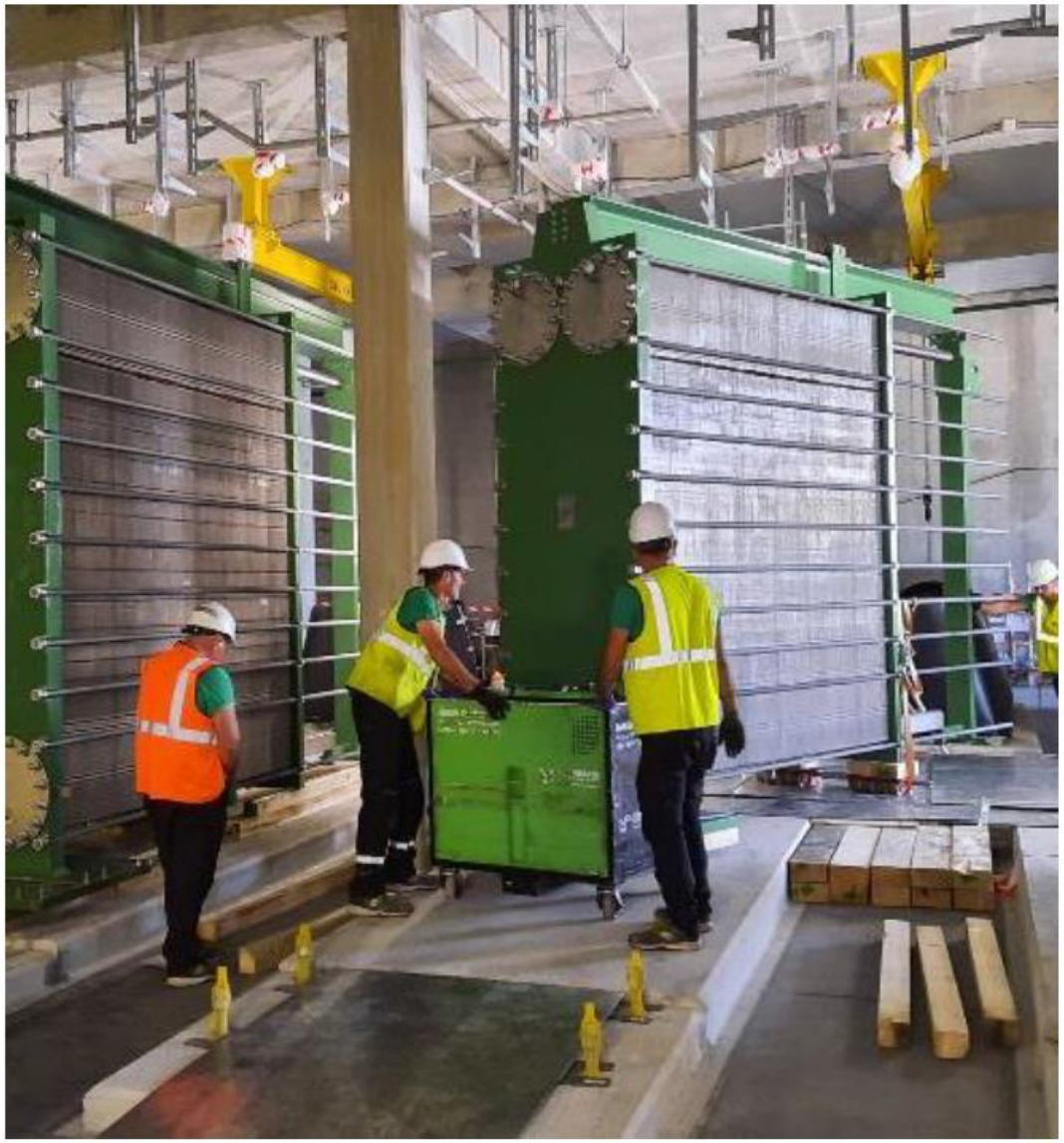
Under water gate
Introduction of the door frame



Auxiliary building

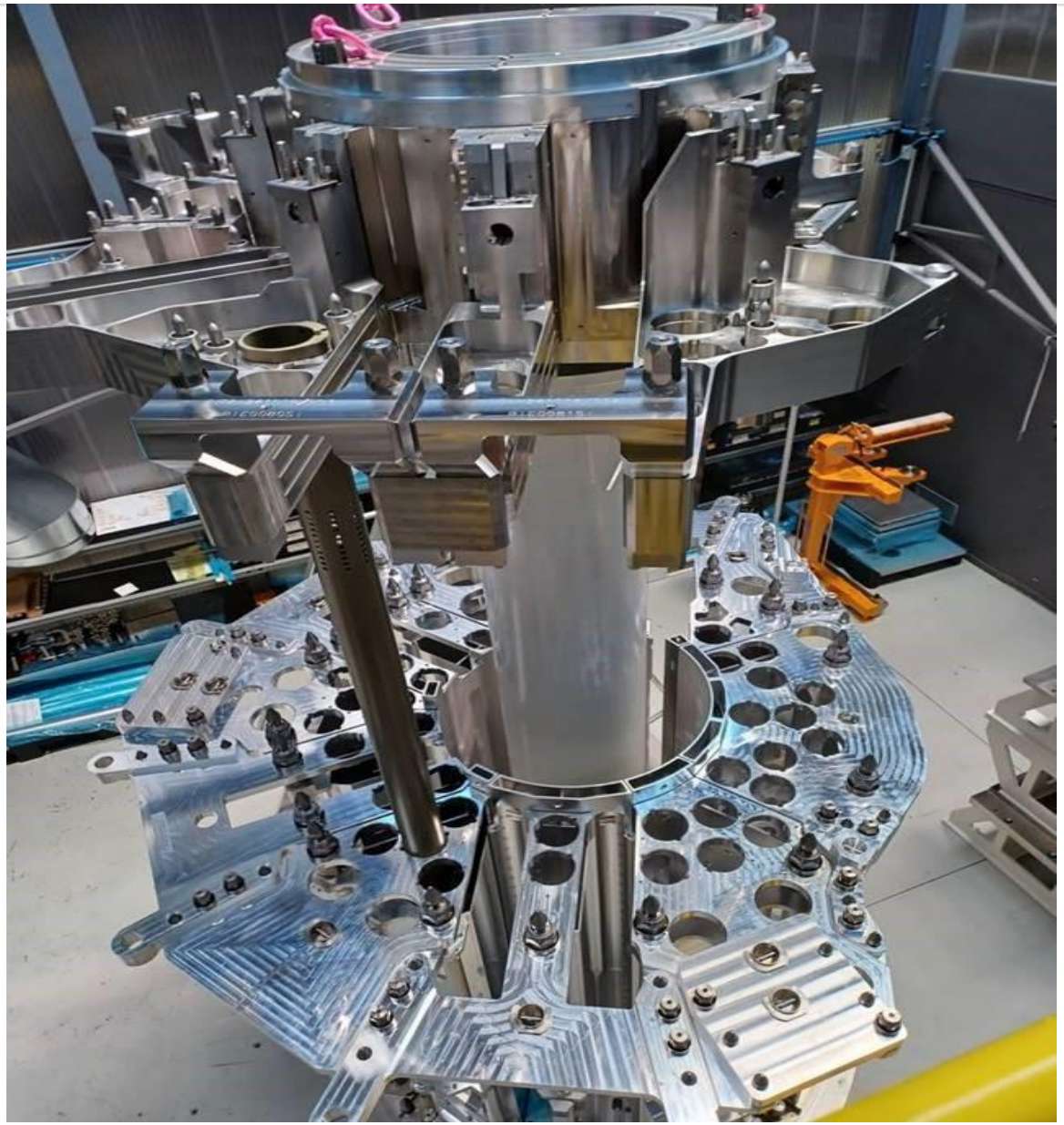
Reactor building

Mounting of Secondary/Tertiary Heat Exchangers



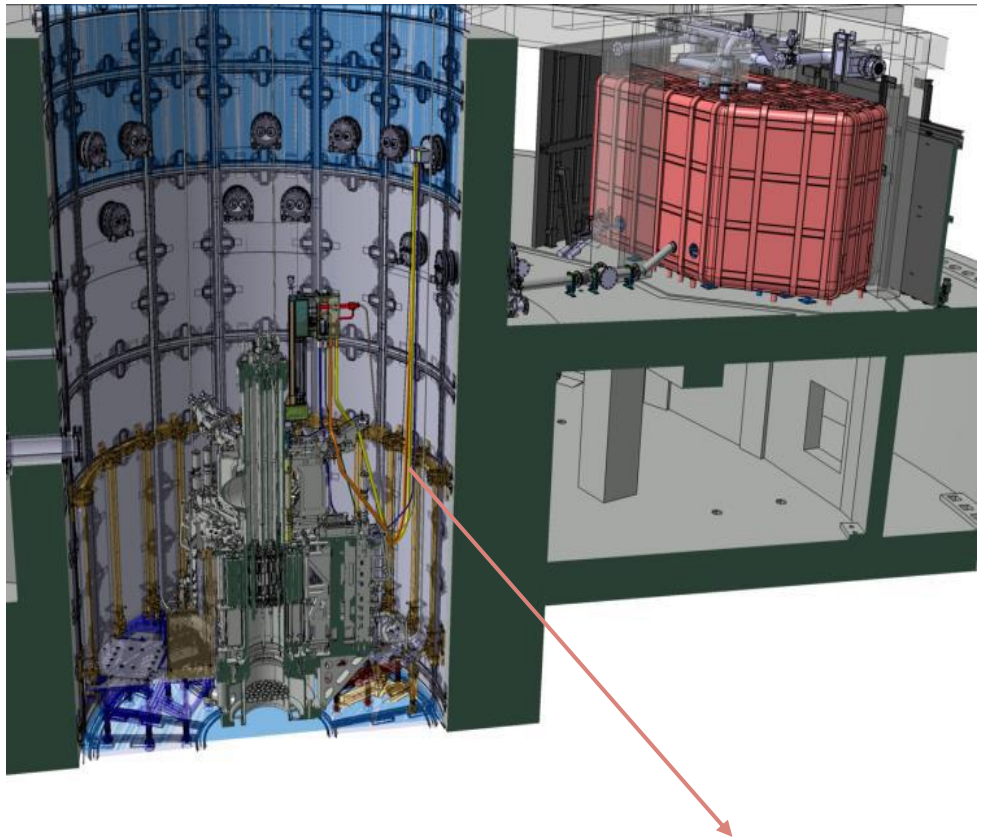
BMR+0 : Montage échangeurs RSS

In Factory operation: Mounting of the reflector

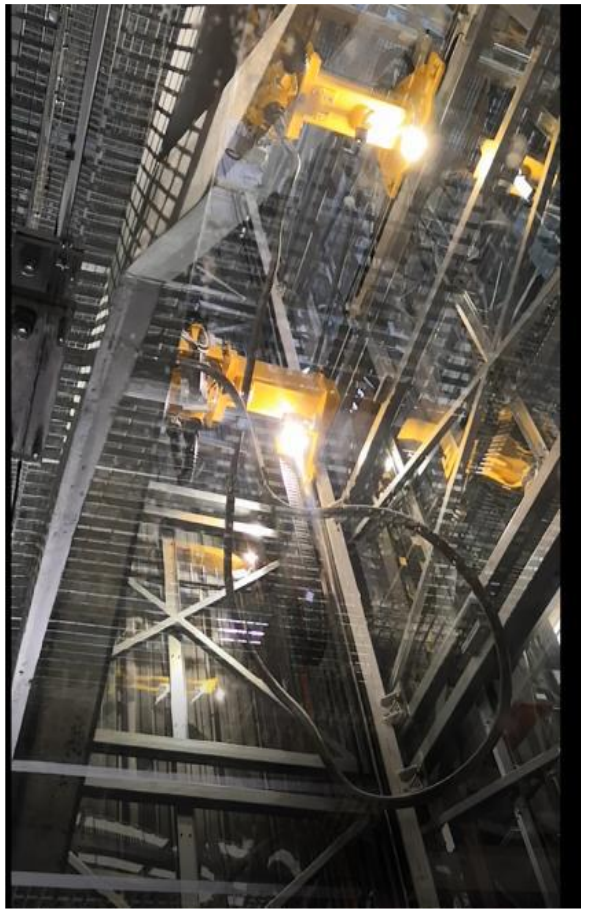


ADELINE / UNDERWATER PIPES - FATIGUE TESTS

2500 CYCLES OF FATIGUE TESTS WITOUT LOSS OF TIGHTNESS NOR DEFORMATION



Under Water Pipes



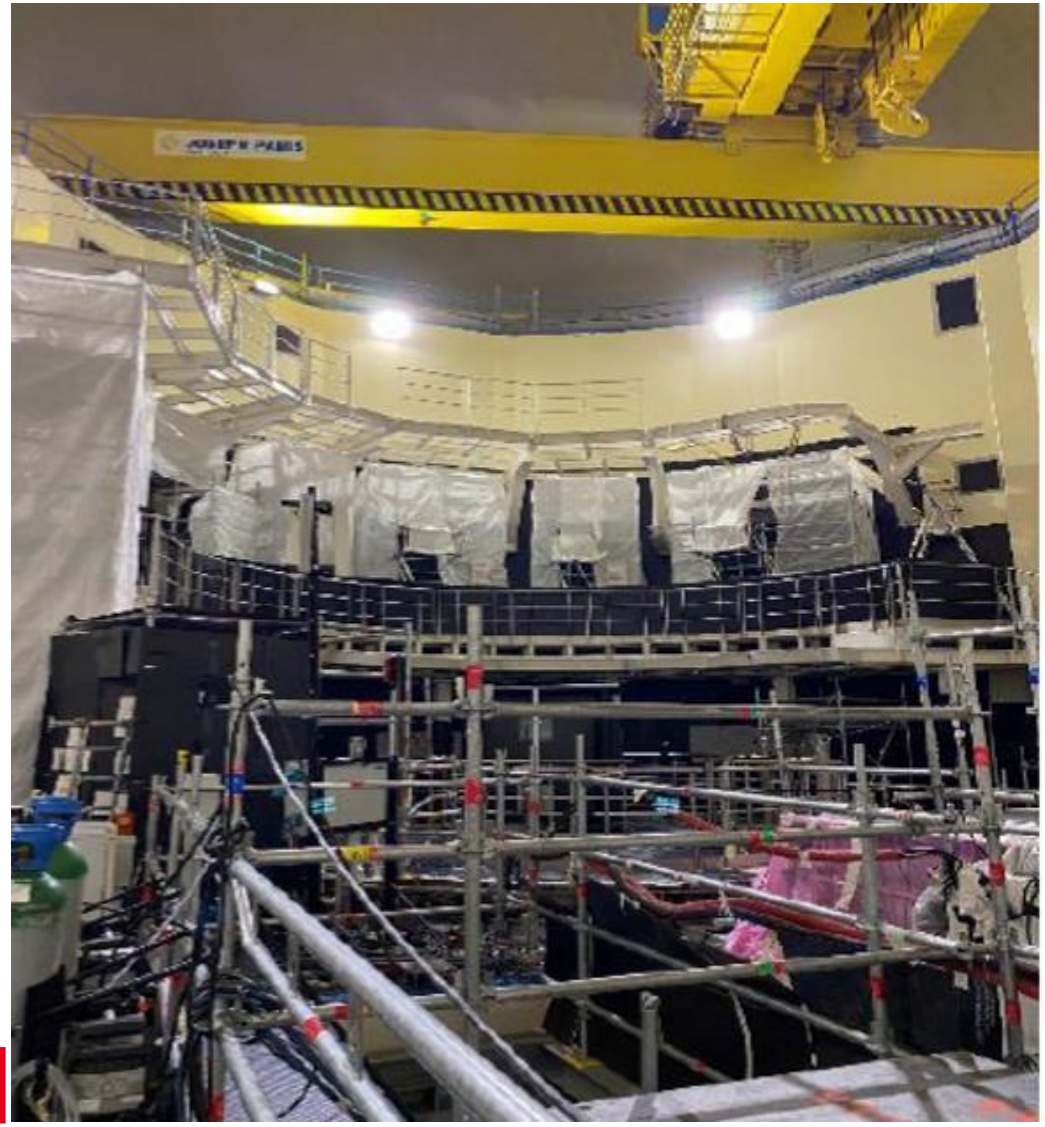
Test Bench

MOCK-UP OF MADISON LOOP AT IFE HALDEN

Madison Loop

Dummy Rig

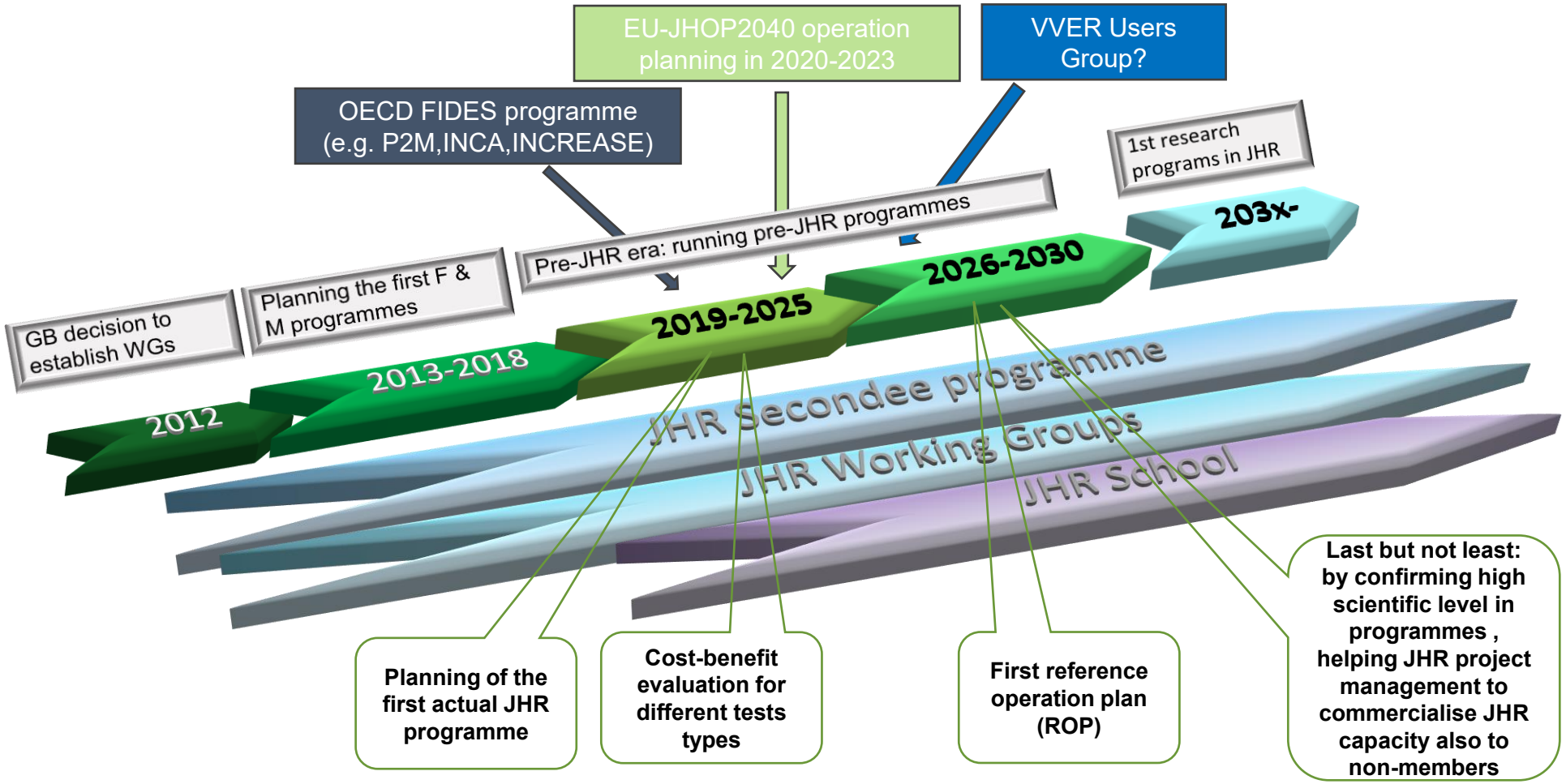
Completion of DLC - Supporting structure of experimental devices



Preparing JHR international community

- The yearly seminar
- The Secondee Program
- The 3 Working Groups and the preparation
  of future joint programs
- The ICERR designation by the IAEA

JHR time frame and tasks for co-operation

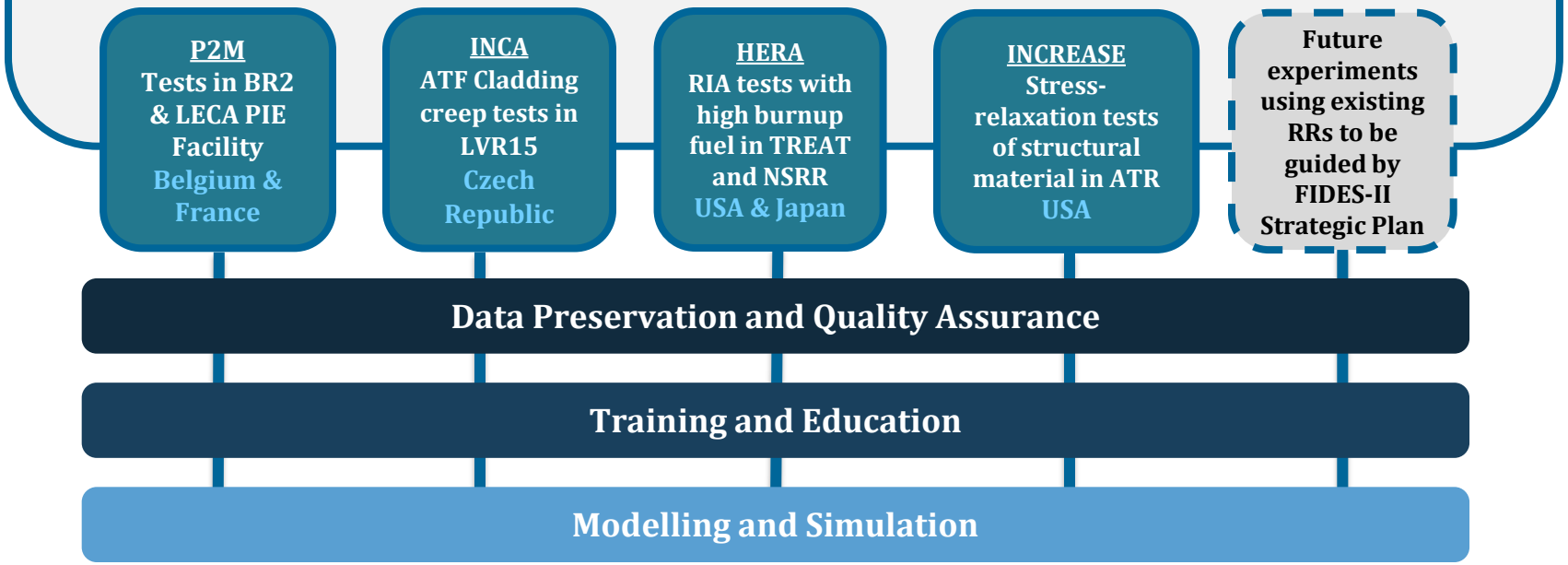


Framework Design

Experimental programs complimented by cross-cutting pillars

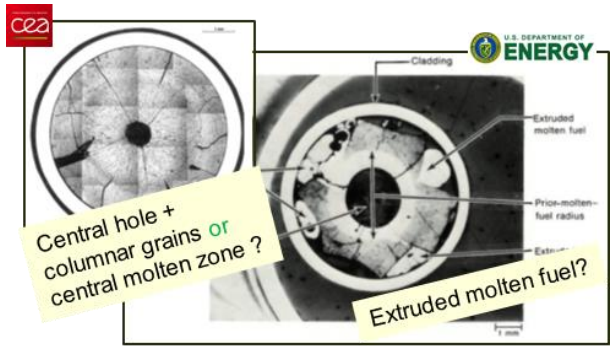
Second Framework for Irradiation Experiments – FIDES-II

- NEA joint undertaking, established pursuant to Article 5 of the NEA Statues in co-ordination with the Nuclear Science Committee (NSC) and the Committee on the Safety of Nuclear Installations (CSNI)
- A stable, sustainable, reliable platform for fuel and material testing using nuclear research reactors (RRs) in NEA member countries
- Generates experimental results and expertise for shared costs
- **FIDES-II Program of Work includes 4 Joint Experimental Programmes (JEEPs) & 3 cross cutting pillars**



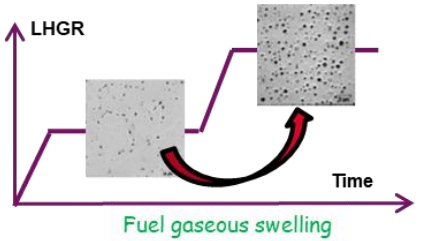
Governing Board Chair:
Raymond Furstenau (NRC, US)
Governing Board Vice-Chair:
Gilles Bignan (CEA, France)
Technical Advisory Group Chair:
Olivier Marchand (IRSN, France)
Technical Advisory Group Vice-Chair:
Daniel Wachs (INL, US)
NEA Secretariat: Michelle Bales

1. Introduction - P2M Objectives



- Limited data are available on power to incipient fuel melting transients
  - Fuel melting during irradiation and residual molten zone after irradiation
  - Mechanisms for central hole & dense zone formation
  - Possible movements of melted fuel
  - Impact of melting on fuel rodlet behavior

- P2M adresses high LHR transients leading to incipient centerline fuel melting without failure
  - Fuel thermal expansion & gaseous swelling
  - Incipient fuel melting & overall impact on fuel behavior
  - Fuel structural & microstructural evolutions
  - Fission gas release
  - Cladding strain



- P2M tests should provide valuable information for the parties involved in the field of nuclear fuel by
  - Providing of reliable data for enhancement of fuel performance code V&V towards partial fuel melting
  - Helping to strengthen actual safety margins with respect to partial fuel melting in various operational conditions
  - Providing of licensing data (usable for new methodologies & fuel products)

Continuation in the JHR ADELINE exp device

Thank you for your attention