



# Research Reactors at the French Atomic Energy Commission - Past, Present and Future -

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# CEA – NUCLEAR ENERGY DIVISION



SACLAY



GRENOBLE

VALRHO

CADARACHE



# CEA – DEN Reactors

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Reactor	Reactor type		First operation
<b>OSIRIS</b>	Material Testing Reactor	Saclay	1966
<b>ISIS</b>	Critical Mock-up	Saclay	1966
<b>ORPHEE</b>	High Neutron Flux source	Saclay	1980
<b>PHENIX</b>	Fast Neutron Reactor	Marcoule	1973
<b>MINERVE</b>	Critical Mock-up	Cadarache	1959
<b>EOLE</b>	Critical Mock-up	Cadarache	1965
<b>MASURCA</b>	Critical Mock-up	Cadarache	1966
<b>CABRI</b>	Safety dedicated RR	Cadarache	1964
<b>PHEBUS</b>	Safety dedicated RR	Cadarache	1977

# Evolution

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- **Evolution of the needs**

- Development of Simulations Tools
  - Increase in analytical experiments
    - Instrumentation
    - Post Irradiation Testing
- 4th generation of reactors
  - Representativity (flux, spectrum)

- **Evolution of the legal and technical framework**

- Periodic Safety Review
- New Regulations, Normalizations ...
- Integration of Experience Feedback and best practices

- **How does our facilities meet requirements for the future ?**

- **Capital Costs and delay to meet new requirements are they justified?**

# EVOLUTION OF REGULATORY FRAMEWORK

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- **Periodic Safety Review**

- The June 13th., 2006 law on Nuclear Safety and transparency
- Keep a constant quality during the lifetime of the plant :  
**conformity checking**
- Safety Improvement according to technical and regulatory framework evolutions and operating feed-back : **Safety Re-assessment**
- **List of studies & modifications: New Safety Report**

- **Regulatory and technical framework**

- Fundamental Safety Rules : Seismic, external hazards
  - Seism : Safe Shutdown Seism, Paleo Seism, site effects
    - *New larger loadings*
- Regulation : Internal fire hazard
- Best technical practices, new normalization :
  - RCC : RCC-MX for Research Reactors (Al and Zr alloys)
  - ISO, European or French Normalisation : venting
- Operating feedback: Human & Organizational factors

# CRITICAL MOCK-UP

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## First requirements



***Obtain information on the main physical process of nuclear energy production :***

### ***Neutron physics***

- Nuclear data on reactor fuel array, fission distribution :
  - MASURCA, EOLE
- Integral Cross sections measurement : MINERVE
- Radiation Protection
- Education : Nuclear Engineering Courses

# MAQUETTES CRITIQUES

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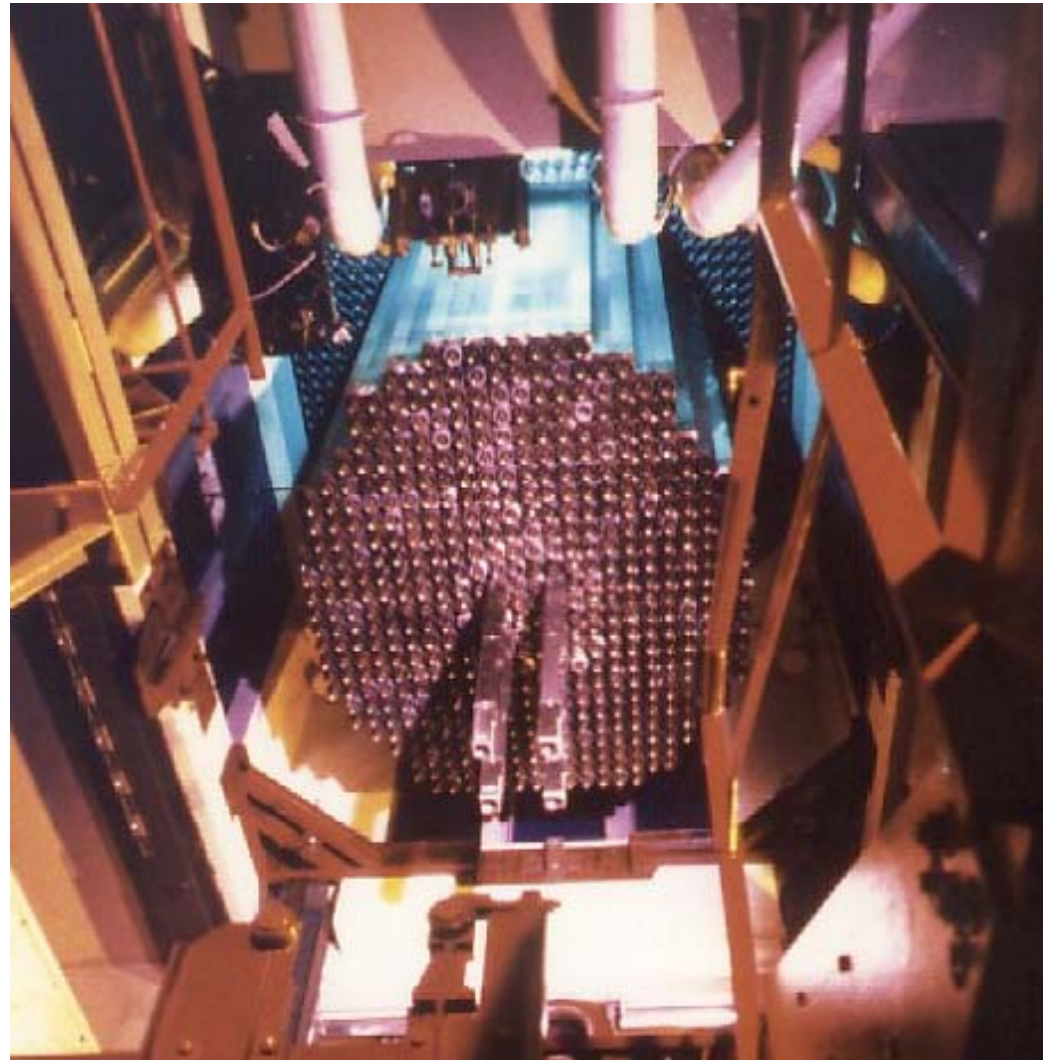
## MASURCA

Fast Neutron  
Mock-up (1963)

PSR : 2008

### Main Safety Issues

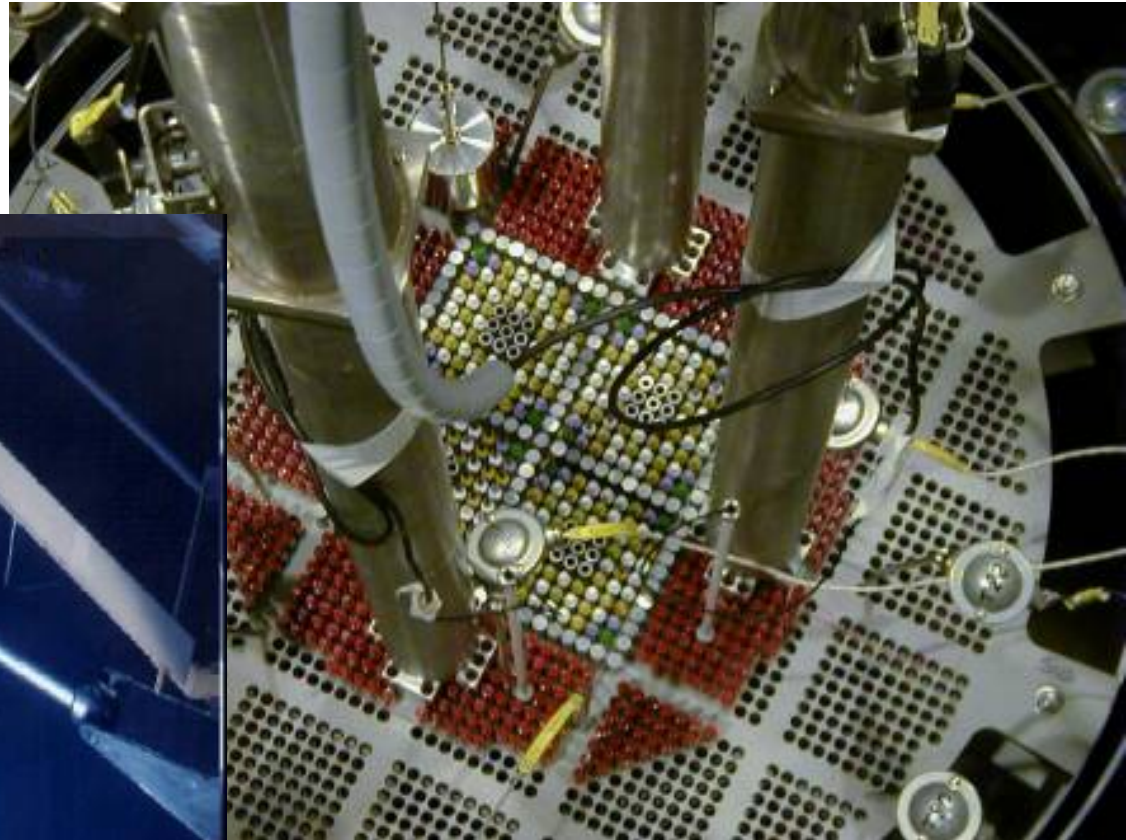
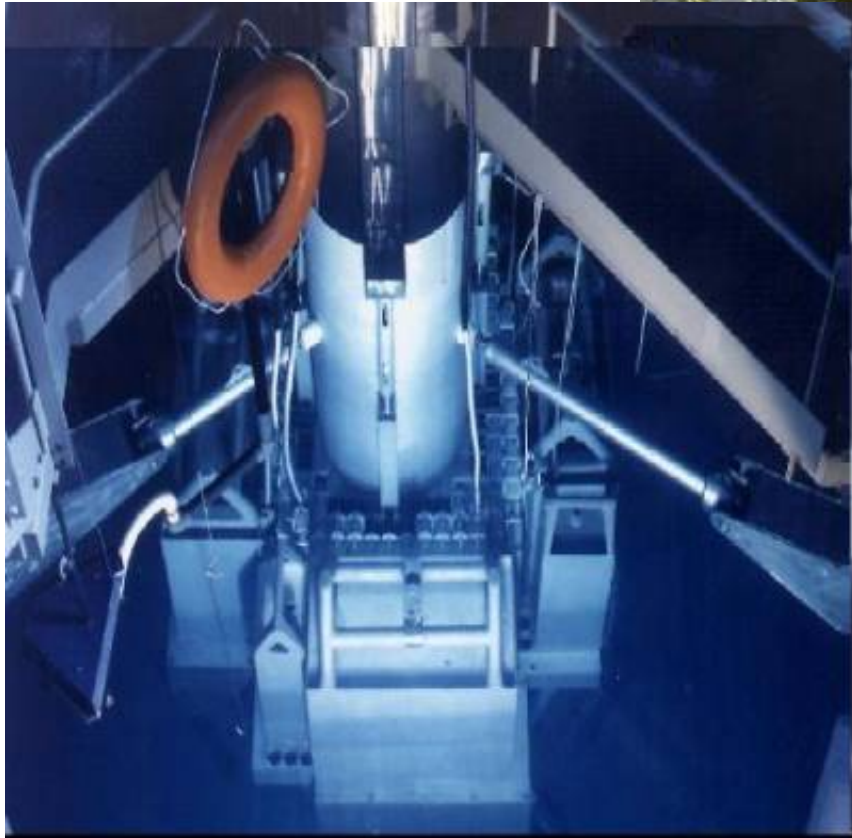
- Containment
- Seismic
- Fuel storage



# MAQUETTES CRITIQUES

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## EOLE - MINERVE





# CRITICAL MOCK-UP

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## EOLE – MINERVE



PSR 2010

- Seism
- Venting
- Electricity
- Internal fire
- Fuel handling
- New Safety analysis

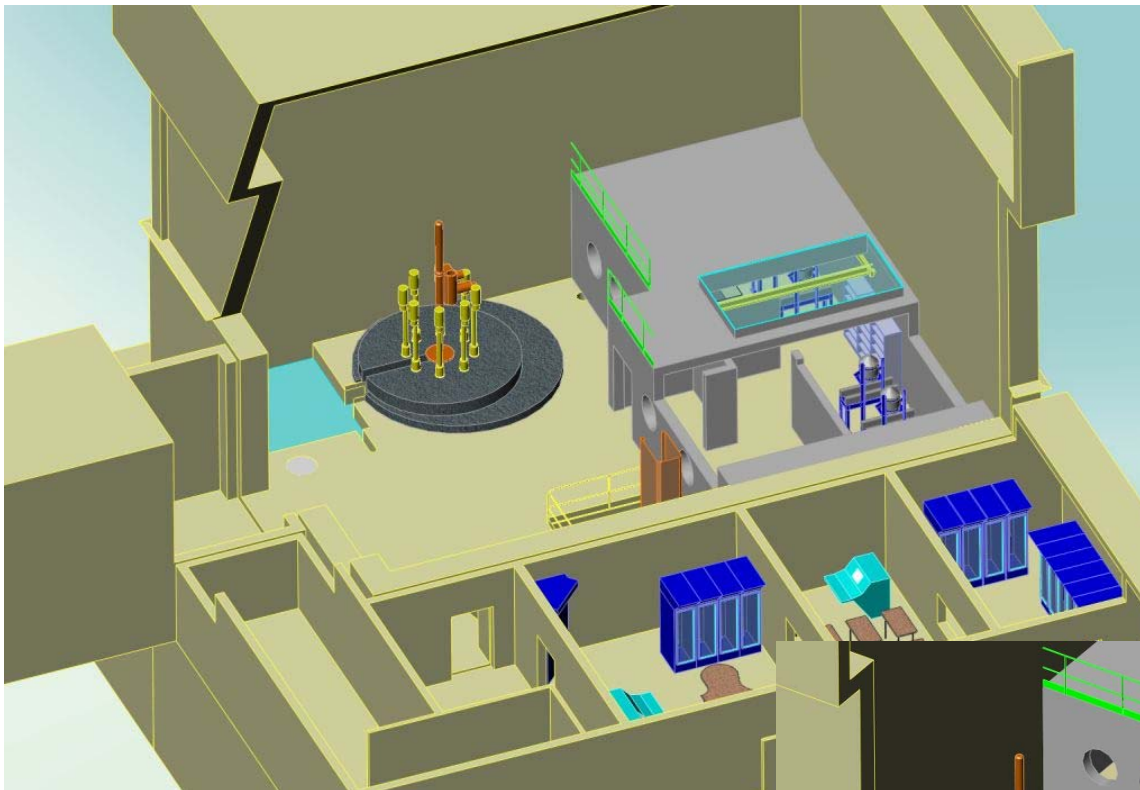


**Shut down of the facility in 10 years**

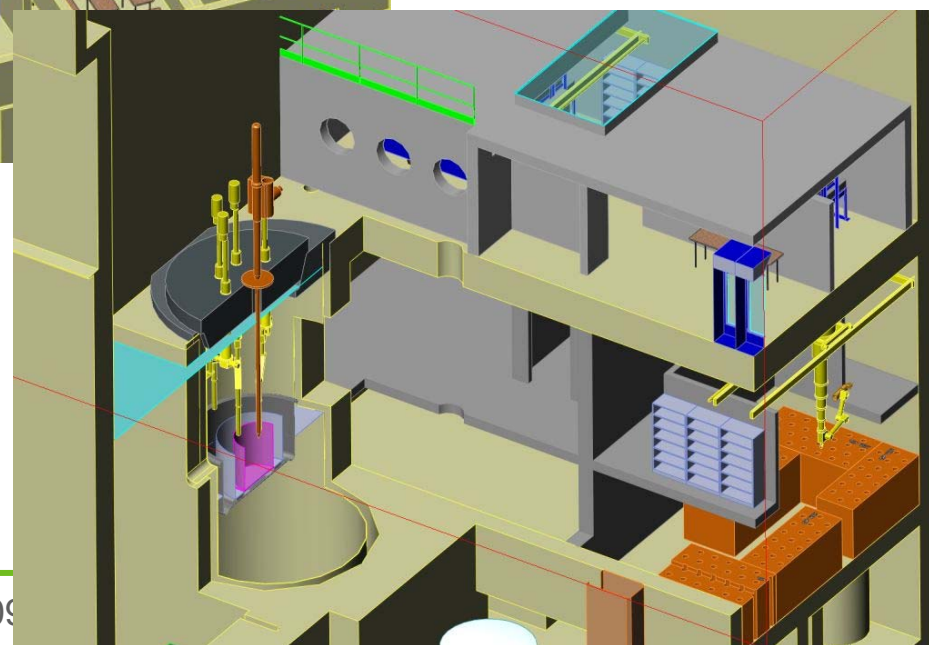
***New facility in the PHEBUS Containment under study***

# CRITICAL MOCK-UP

cea



**EOLE +**



DEN-DISN/MCIS / IGORR 27-31 October 2009

# MATERIAL TESTING REACTOR

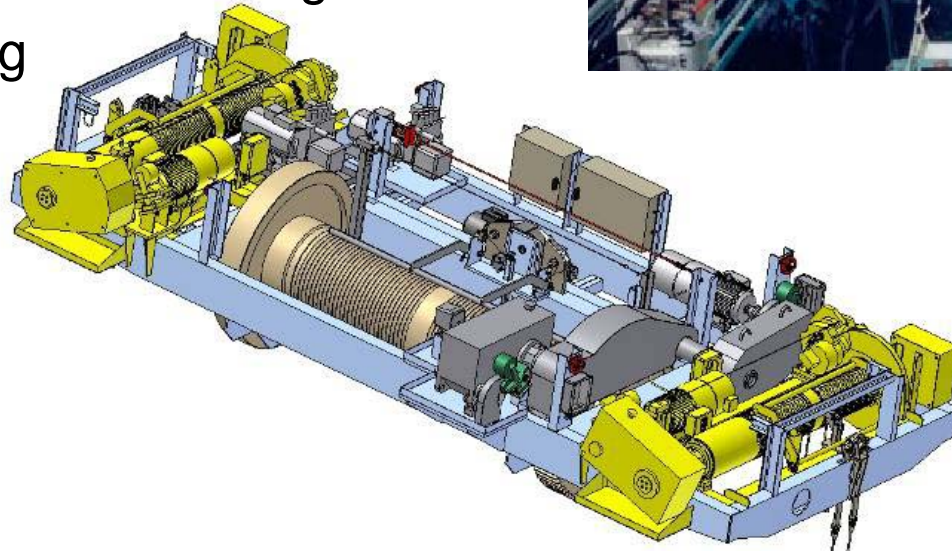
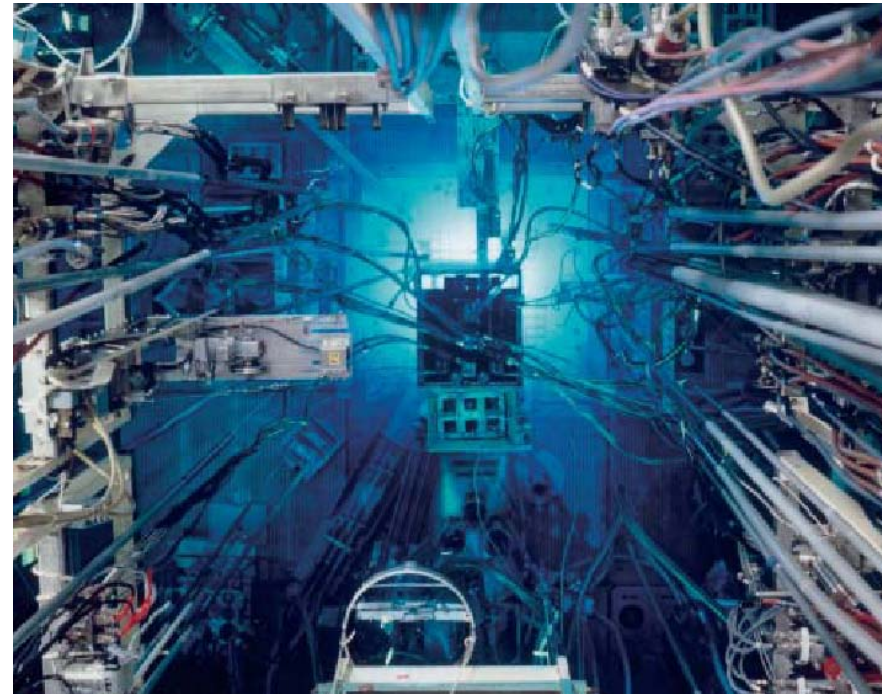
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## OSIRIS

— Shutdown in 2015

cea PSR : 2009

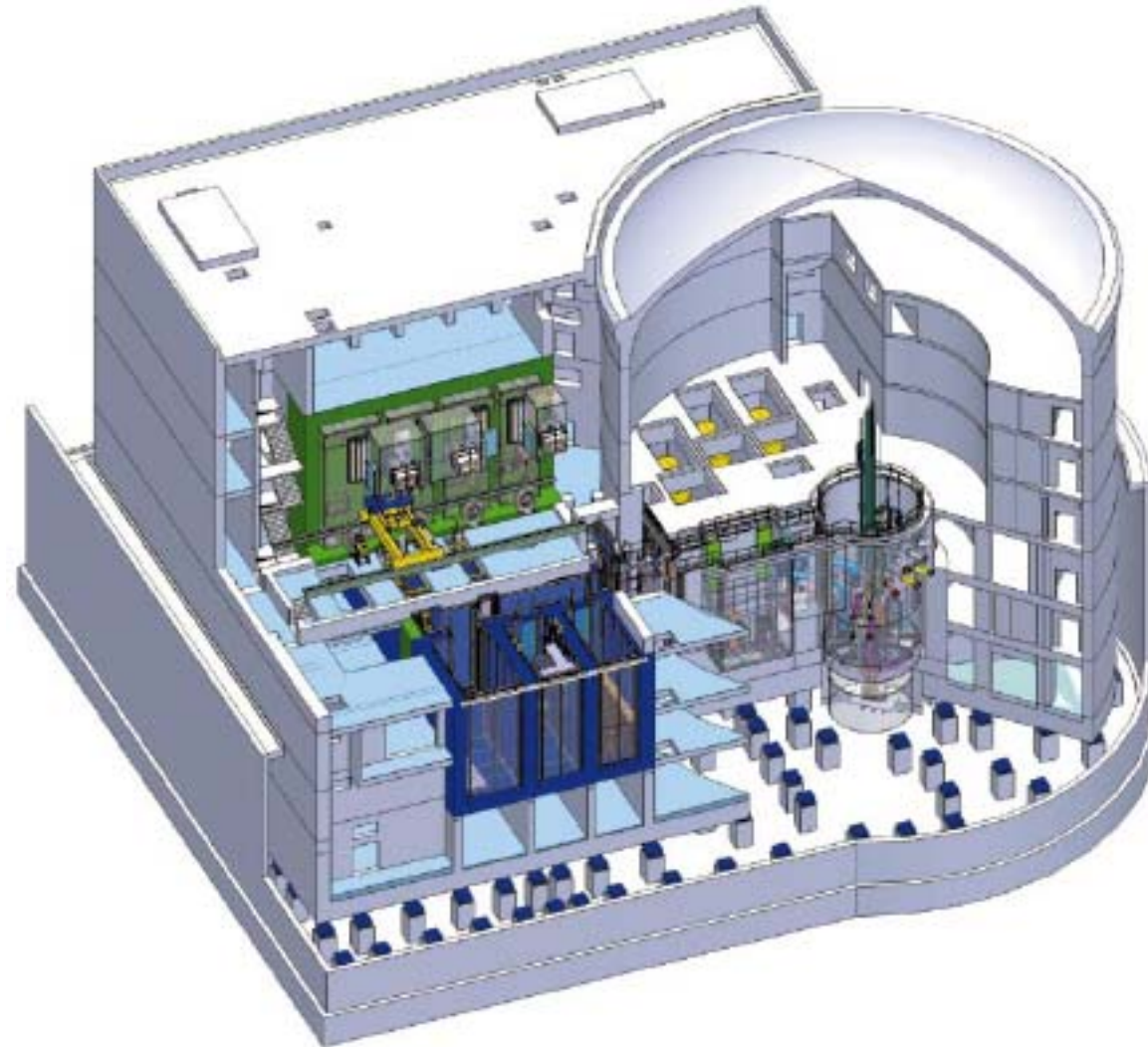
- Seism
- Containment
  - Safety venting
  - Leak tightness
- Reactor Core Cooling
- Handling



# MATERIAL TESTING REACTOR

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## JULES HOROWITZ REACTOR

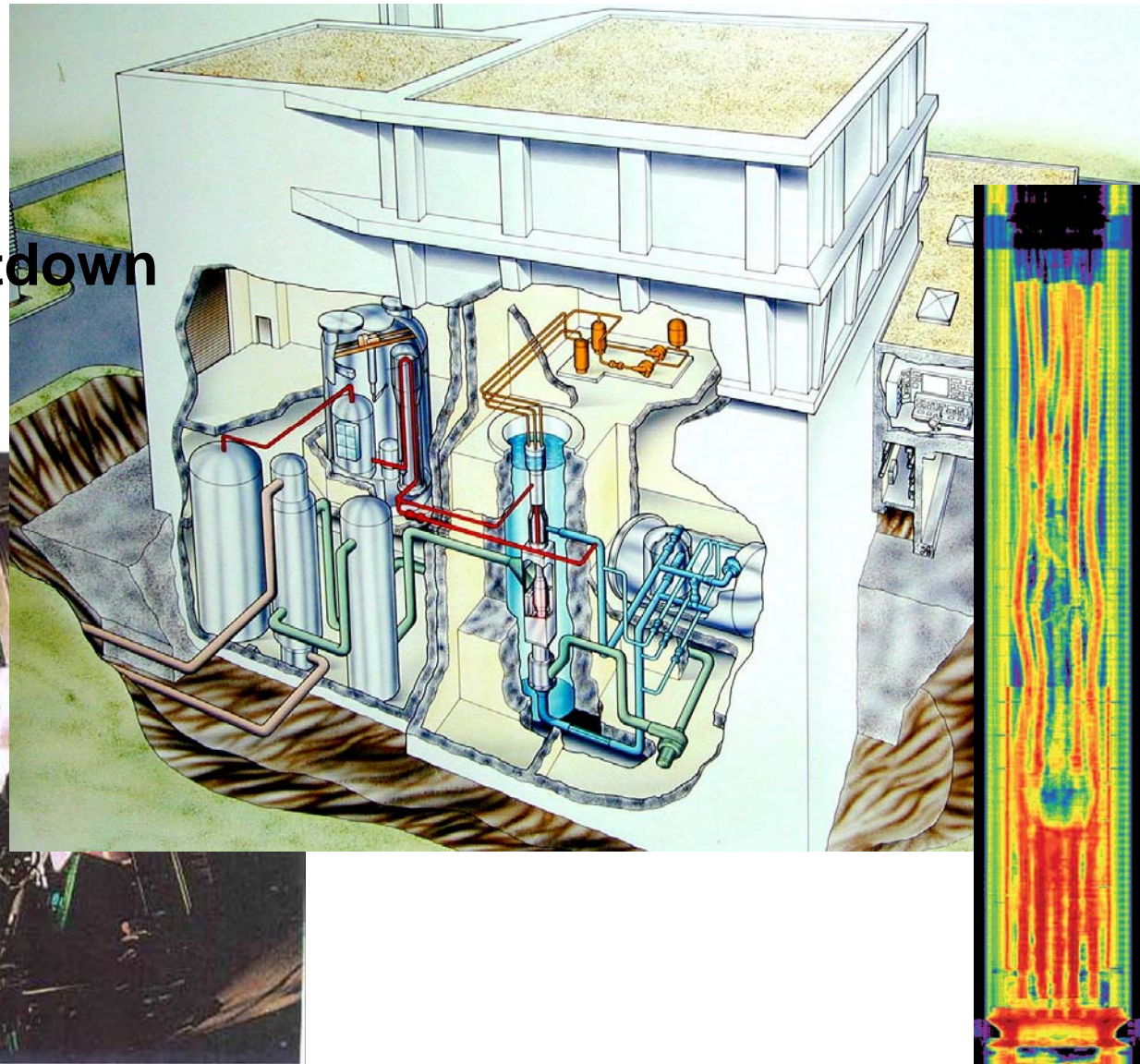
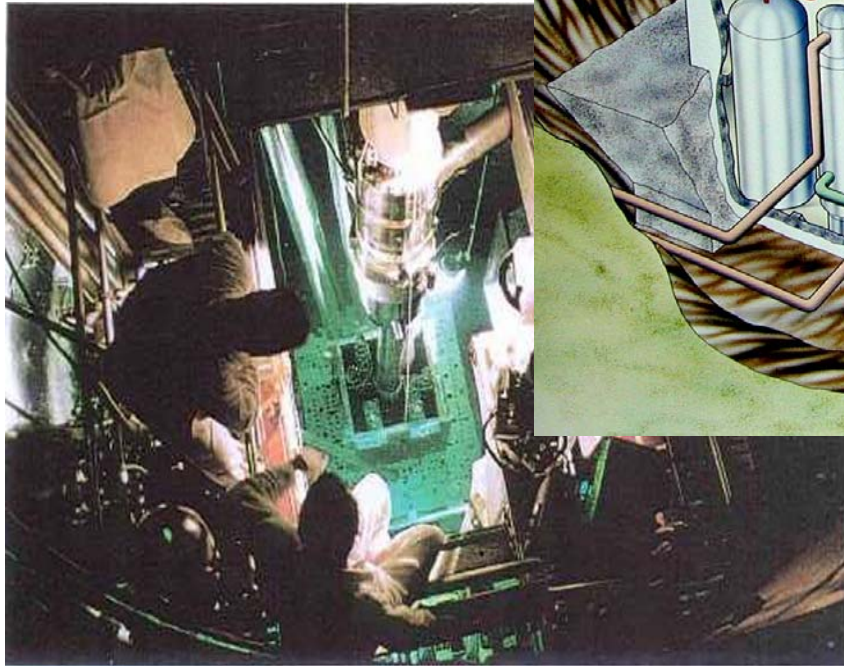


# SAFETY DEDICATED TEST REACTOR



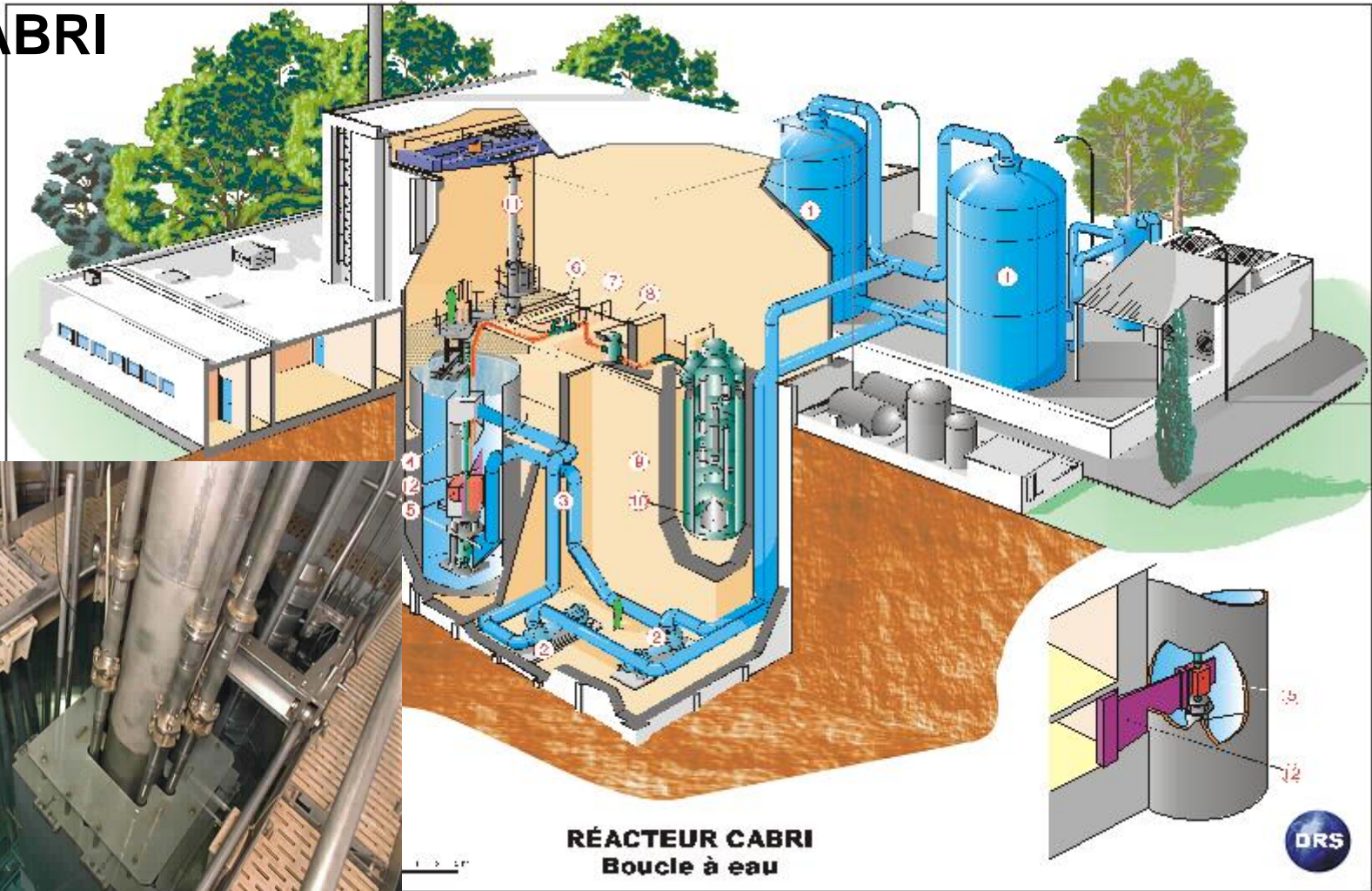
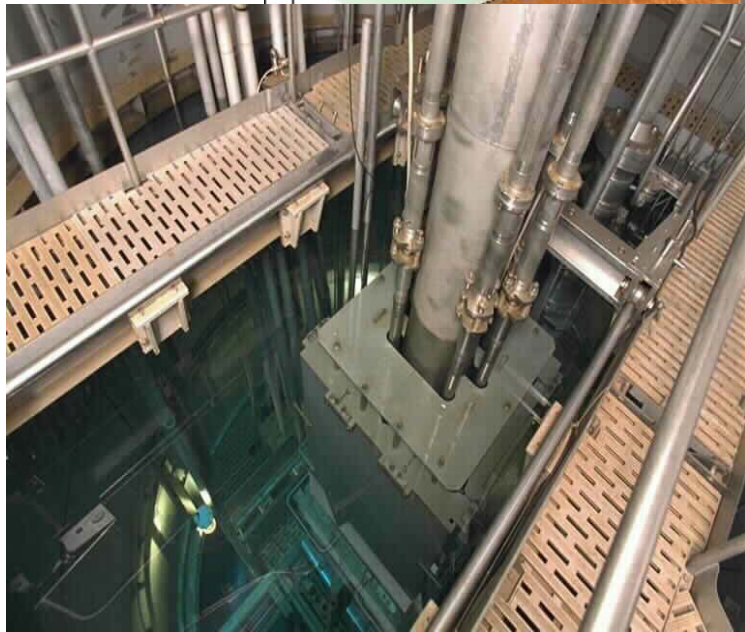
**PHEBUS**

**Reactor Shutdown**



# SAFETY DEDICATED TESTS REACTOR

## CABRI



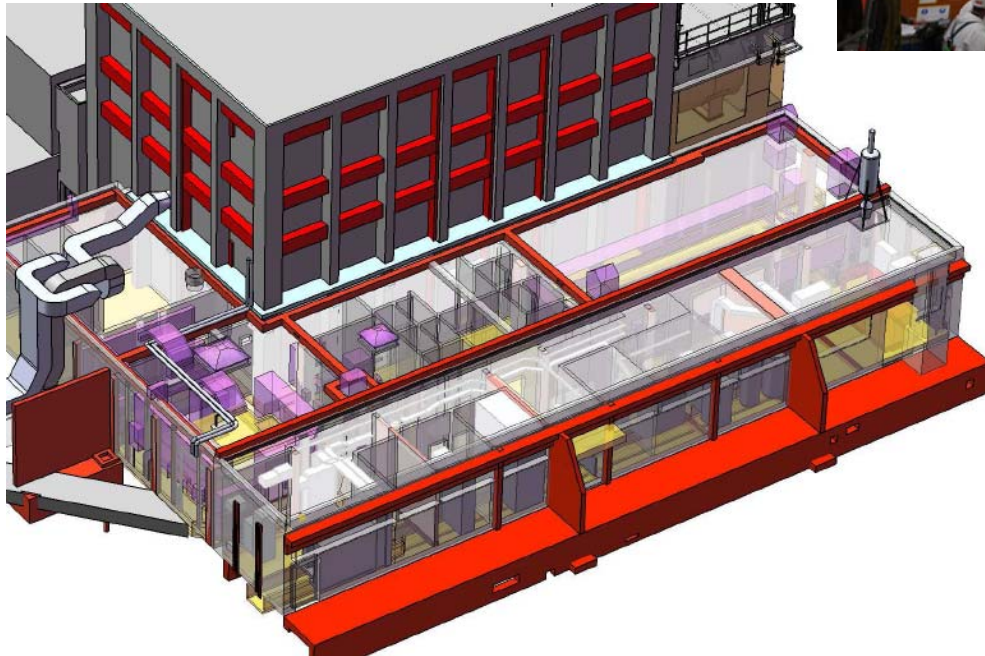
Re-assessment and refurbishment funded by IRSN

# SAFETY DEDICATED TESTS REACTOR



## CABRI

- Water loop
- Large reassessment
  - Venting
  - Seism
    - Components
    - Civil works



Re – start : mi 2010

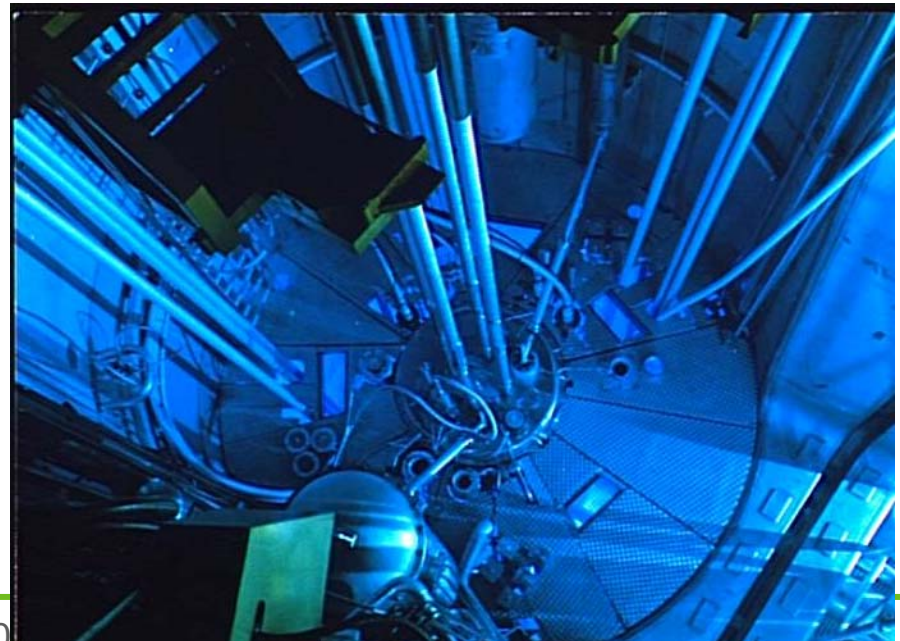
# HIGH NEUTRON FLUX REACTOR

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## ORPHEE

PSR 2010

- External & Internal Hazard
  - Seism, Explosion, Fire
- Safety reassessment
  - Operating conditions methodology





# CONCLUSIONS

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- CEA DEN have to maintain the larger experimental capacity for the R&D programs
  - for the needs of the industry
  - For future reactors
- To maintain this experimental capacity, it is necessary :
  - to deeply analyze the needs
  - to analyze the investment cost
    - To keep the conformity with the current reference status of the facility (Ageing, obsolescence, maintainability ...)
    - To satisfy new regulations or to integrate new technical frameworks
    - To re-assess the reactor safety with up-to date methodologies
- Large Investment Effort : 35 M€/year