IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE
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Periodic Safety Review Management for French Research Reactors

Technical Support Organisation Viewpoint

D. RIVE

International Conference on Research Reactors,
5-9 November 2007, Sydney

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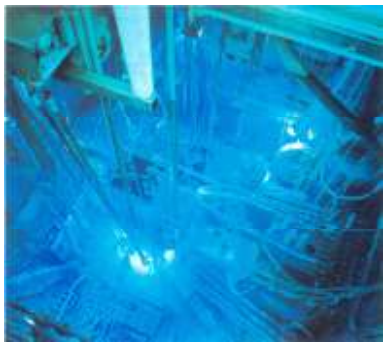
1. Overview



Research reactors:

- More than 30 RR since ZOE
- 11 in operation:
  - PHENIX (350MW)
  - OSIRIS (70 MW)
  - ORPHEE (14 MW), RHF (58.3 MW)
  - CABRI (25 MW), PHEBUS (38 MW)
  - MASURCA (5 kW), EOLE (10 kW)
    MINERVE (100 kW), ISIS (700 kW)
  - Neutronography reactor inside PX
- 1 new project: RJH

1. Overview

Key features and specificities of RR

- **Uses** (material test, basic research, code qualification, safety test, training, medical, …)
- **Operating time** (few seconds, hundred of days)
- **Power** (100 W ➔350 MW)
- **Cooling systems** (H2O, D2O, Sodium, Gaz)
- **Rather old** (1960 – 1980)
- **Operators** and **Researchers** in reactor building ➔ human and organisational factors
- **1 main operator** (CEA), 3 major sites

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2. Periodic Safety Review context
   - ✓ Regulatory aspect
   - ✓ ASN/IRSN Expectations/Requirements

3. Experience Feedback
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   - ✓ Examples

Periodic safety review (PSR): regulatory aspects

French regulation:

- Law 2006-686 on transparency and security in the nuclear field, published in the *Official Gazette* on 13 June 2006
- Application decree of TSN law
- ASN Guide of December 2005 relating to PSR of CEA BNI

Periodic safety review: Regulatory aspects

The operator of a BNI has to conduct a periodic safety review every ten years.

Main objectives:

- To assess the situation of the plant with regard to the applicable safety requirements,
- To up-date risks and hazards,
- To improve the safety level.

Periodic safety review: Regulatory aspects

Safety review should consider:

- The state of the installation,
- The operational experience feedback,
- Improvement of technical knowledge,
- Applicable rules for similar installations,
- Human and organizational factors.

This review shall include a safety review of all **experimental devices** the operator intends to maintain in operation.

Periodic safety review: Content

General principles implemented for NPP have been adopted for RR

Two main parts:

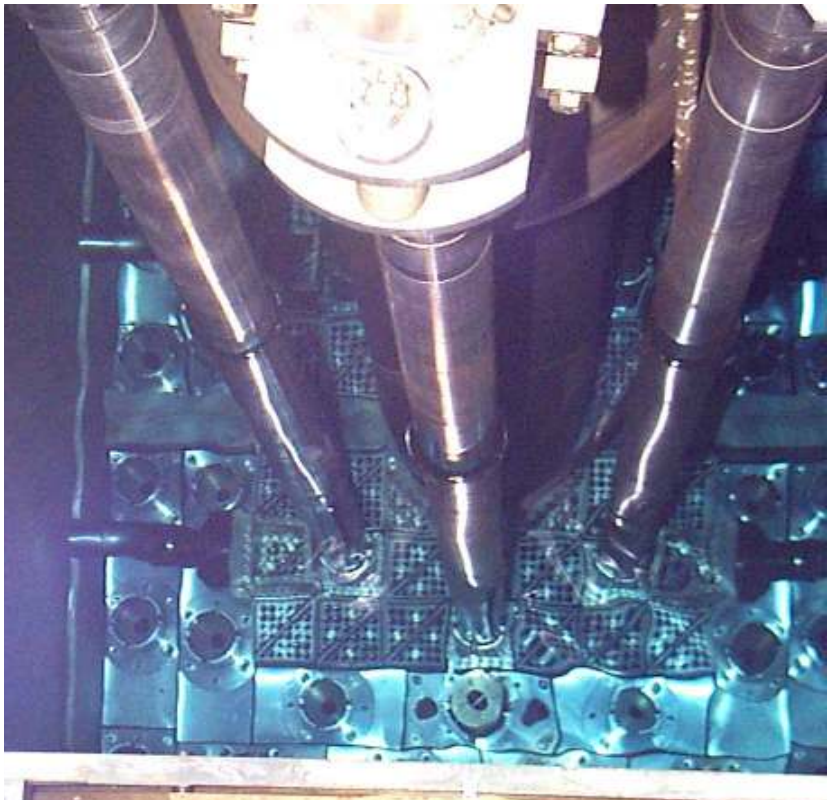
- Conformity check to the applicable safety reference files (SAR, GOR, ...)
- Reassessment of the safety requirements to improve the safety level

Periodic safety review: Content

Conformity check must:

- Take into account modifications
  - ✓ to the installation (equipment, operating modes, organization, …)
  - ✓ resulting from ageing
- Be based on in-depth inspection
  - ✓ of active and passive equipment
  - ✓ with non destructive or even destructive testing

The CABRI reactor is used for better understanding nuclear fuel behaviour in the event of RIA

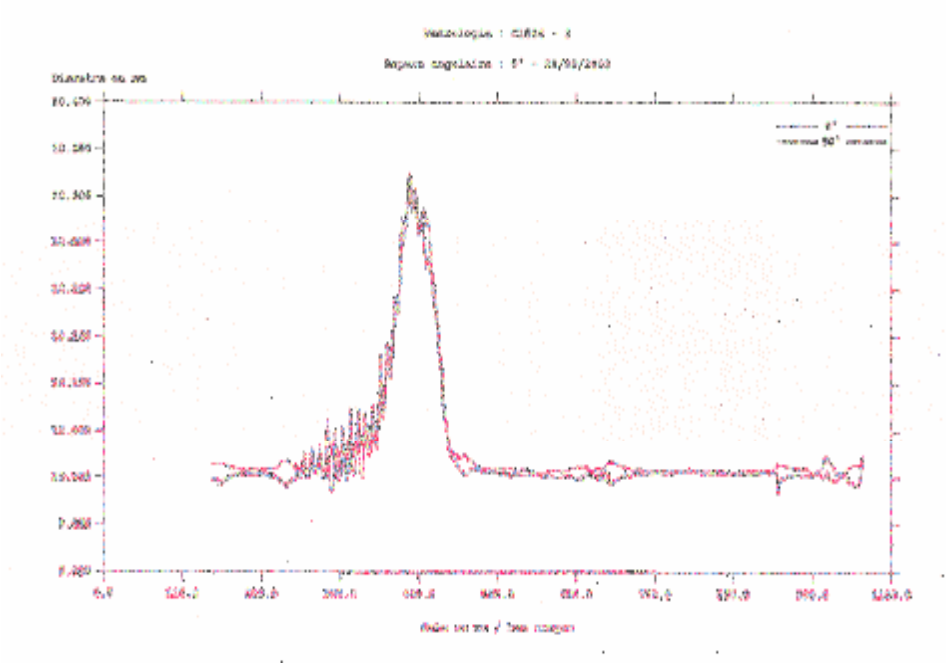


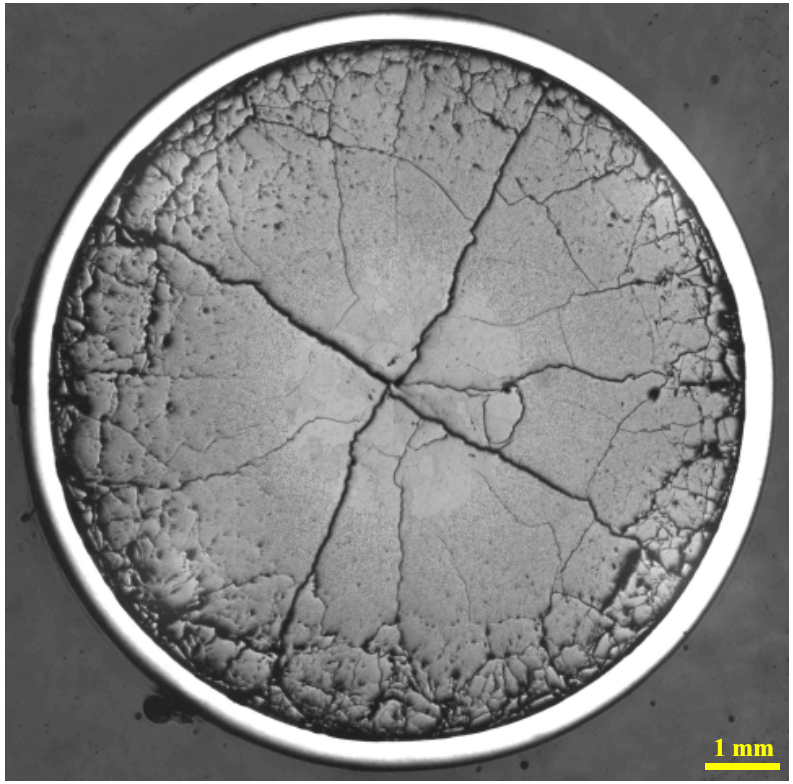
Conformity check

An important issue during the 1st phase of PSR concern the state of the driver core and of the 1st fuel barrier

Inspections were performed on 10 fuel rods and 1 of them was subjected to axial and radial cuttings

Profilometries and radial cutting of a CABRI rods





They allowed to identify:

- Axially regularly spaced folds over the cladding
- Notable radial deformation for 2 rods
- Substantial granulometry in the middle of fuel pellet which is a sign of meltdown

Periodic safety review: Content

Safety reassessment must:

- Examine or even (re)define
  - ✓ operating conditions,
  - ✓ internal and external hazards
- Be an opportunity to check the application of the Defence in-Depth Principle
- Take into account events since latest PSR
  - ✓ at the installation
  - ✓ at similar installations in France and abroad

Periodic safety review: PSR processus

The operator submit to ASN:

- **Orientation report** specifying mainly:
  - ✓ Future use of the installation
  - ✓ Issues to be addressed thoroughly
  - ✓ Methods used for conformity check
- **Review report** including:
  - ✓ Conclusions of operator review,
  - ✓ Provisions for:
    - correction of identified discrepancies,
    - improvement of the safety level.

Periodic safety review: PSR processus

- Technical examination by IRSN
  - ✓ Assessment report
  - ✓ Presentation to the Advisory Committee for nuclear reactors (AC)
- AC opinion
- ASN decision
- Implementation, updating
- ASN supervision

Periodic safety review: PSR schedule

- **T0** — **Submission of main option report**
  - To+3m — ASN feedback
- **T1** — **Operator Safety Review: ≈1 year**
  - T0+18m — submission of PSR report
- **T2** — **TSO assessment: ≈ 1 year**
  - T0+30m — Advisory Committee
  - ASN decision about operating licence
- **T3** — **Operator implementation**
  - ASN supervision

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Periodic safety review: Experience feedback

- 1999: OSIRIS
- 2002: RHF, PHENIX
- 2004: CABRI
- 2006: MASURCA
- 2008-2010: ORPHEE, EOLE, MINERVE

Periodic safety review: Experience feedback

- The main aspects concern:
  - ✓ The seismic resistance
  - ✓ The reliability of the safety systems
  - ✓ The structure ageing
  - ✓ The improvements in the Defence-in-Depth application
- Major generic subjects:
  - ✓ Fire hazard/zoning, handling risks
  - ✓ Core cooling systems & confinement capability
  - ✓ Human and organisational factors

Conclusion

CONCLUSION

Safety approach, safety requirements for Research Reactors have changed, evolved over time.

Now in France, the great Safety Principles applied for the safety evaluation of any Research Reactors are very similar to those used for the Nuclear Power Plants.

CONCLUSION

For example, requirements relating to internal and external hazards, to redundancy and separation of protection system, to containment building, leaktightness have been gradually established and applied.

Nevertheless, some rules established for NPP are applied to RRs with adaptations, graded approach due to specific features of research reactors (short operating time).

CONCLUSION

PSR is a key issue in the life of a facility.

- It requires important means, resources
- It can lead to important work during and also after the PSR

Nevertheless, PSR is an efficient means:

- To check the conformity
- To improve the safety level
- To take a decision for the reactor operation towards the next decade

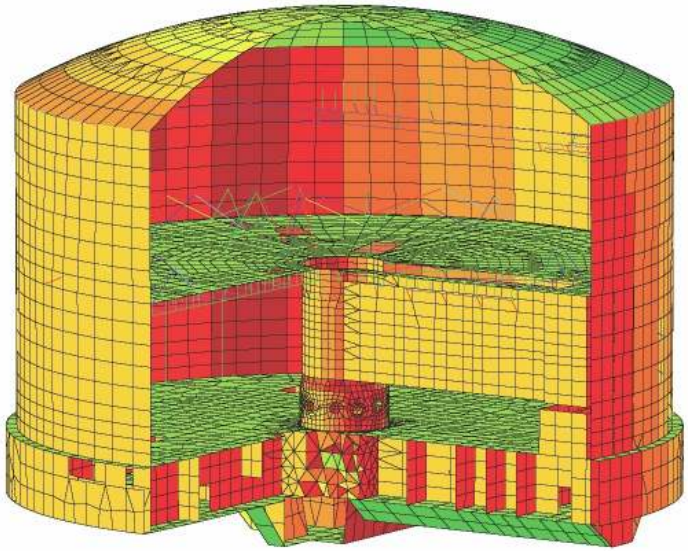
Thank you for your attention

High Flux Reactor

Main conclusions regarding seismic safety analysis

It was necessary:

- To define and implement solutions in order to manage the risk of interaction between the reactor building and the neighbouring buildings



- To reinforce the connection between first floor and containment building

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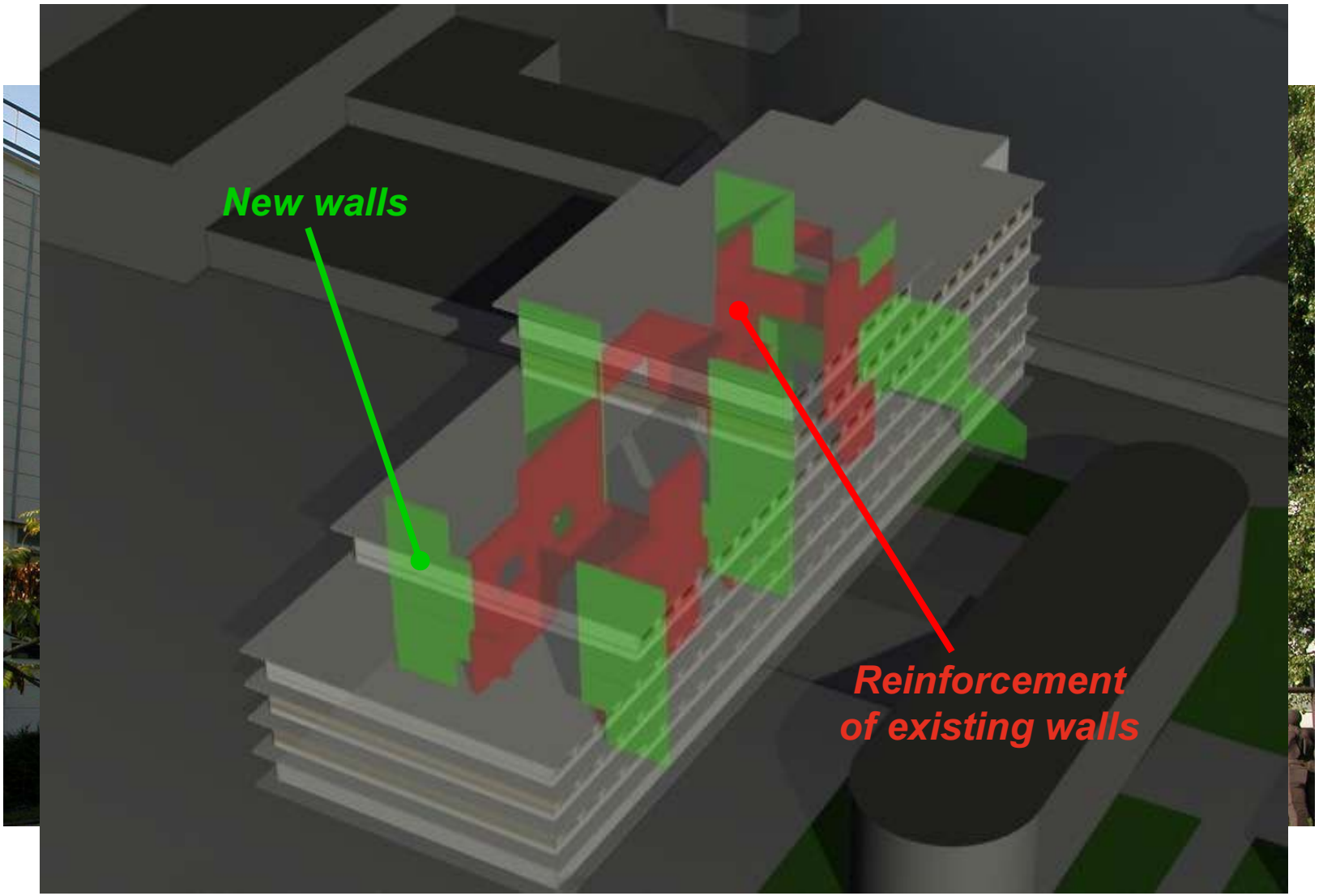
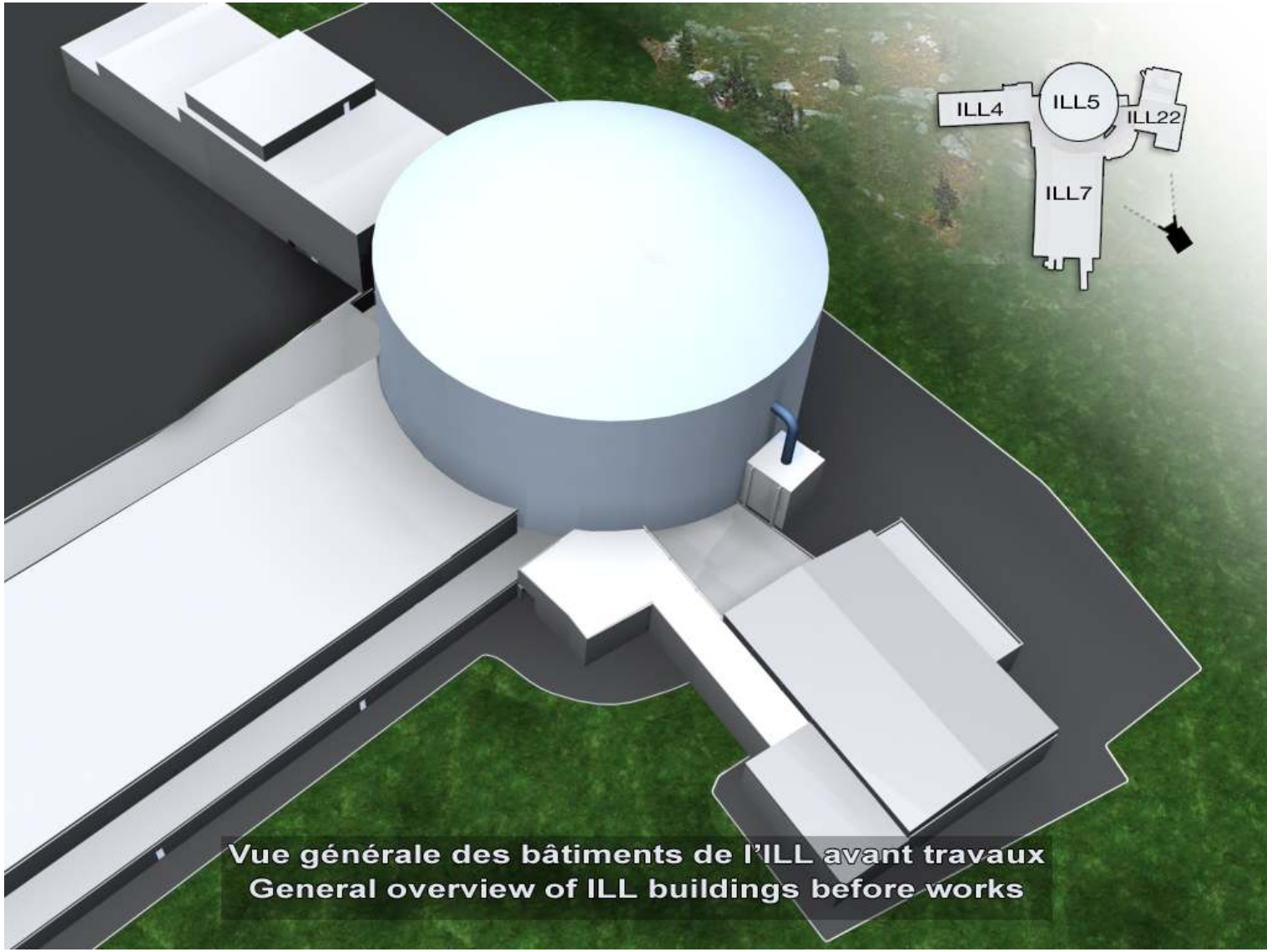
High Flux Reactor: ILL7 & ILL22

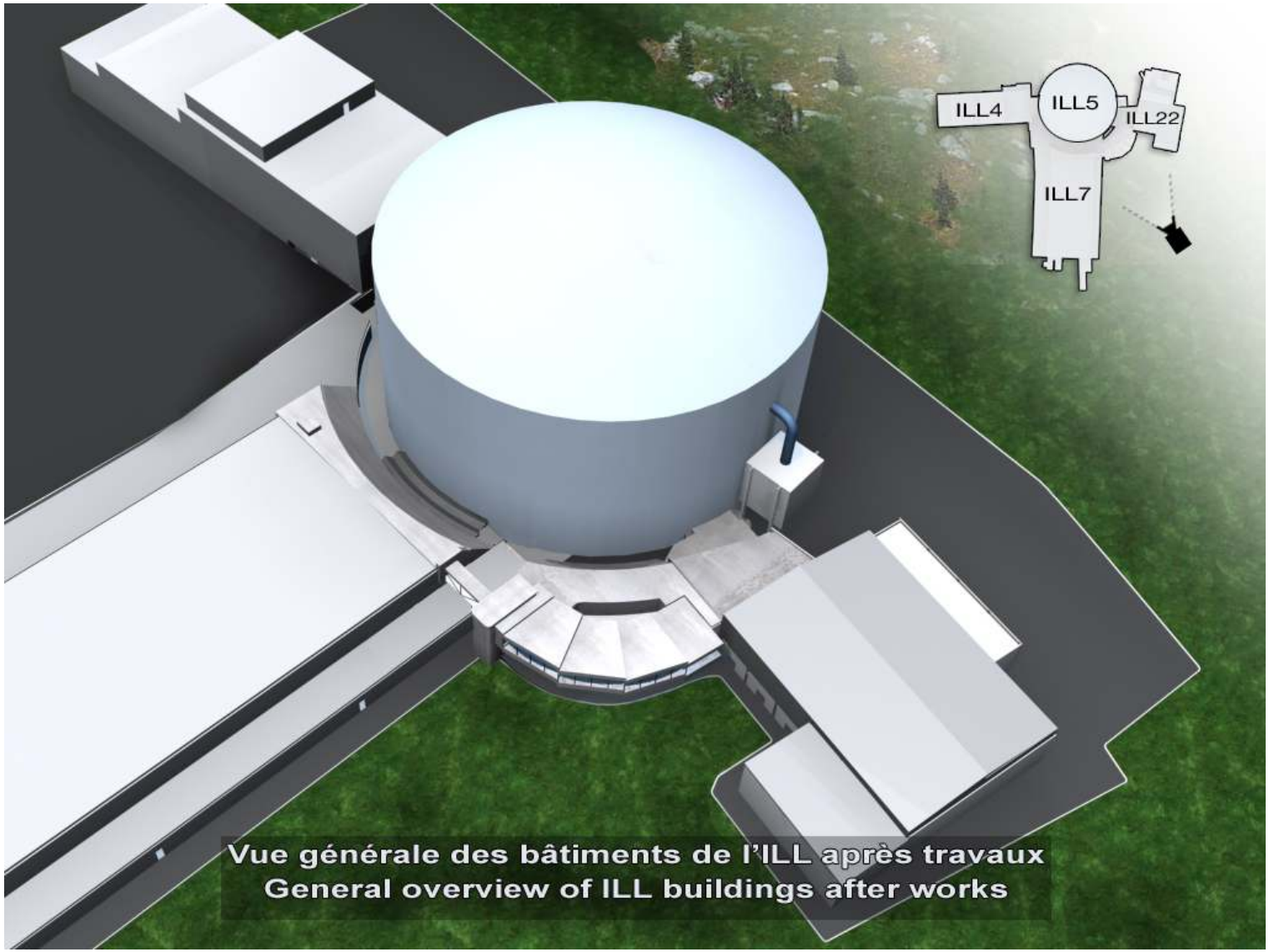
High Flux Reactor: ILL4



High Flux Reactor: ILL7 & ILL22

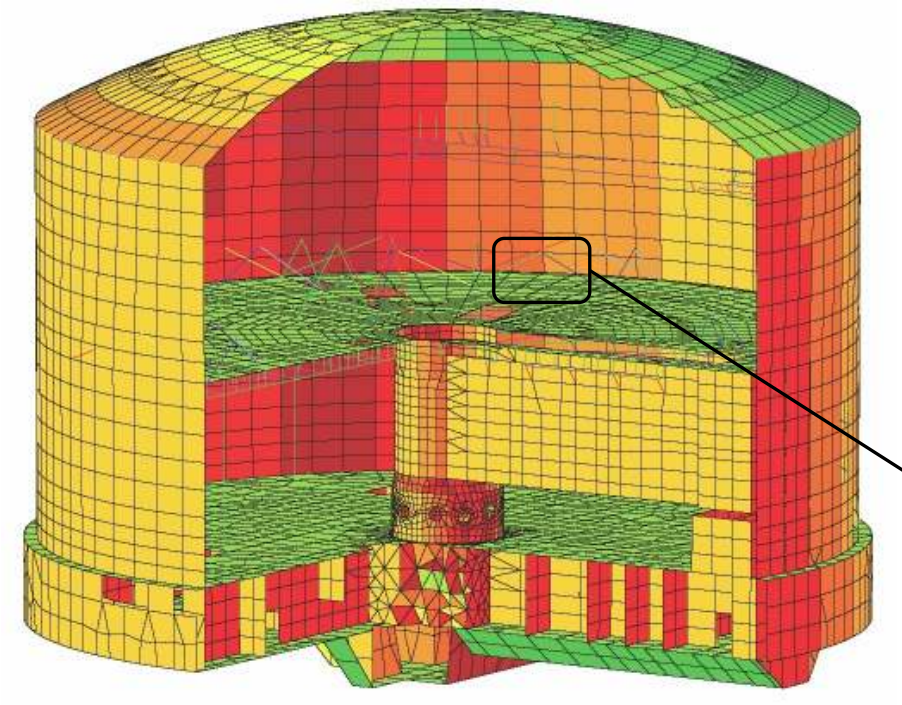


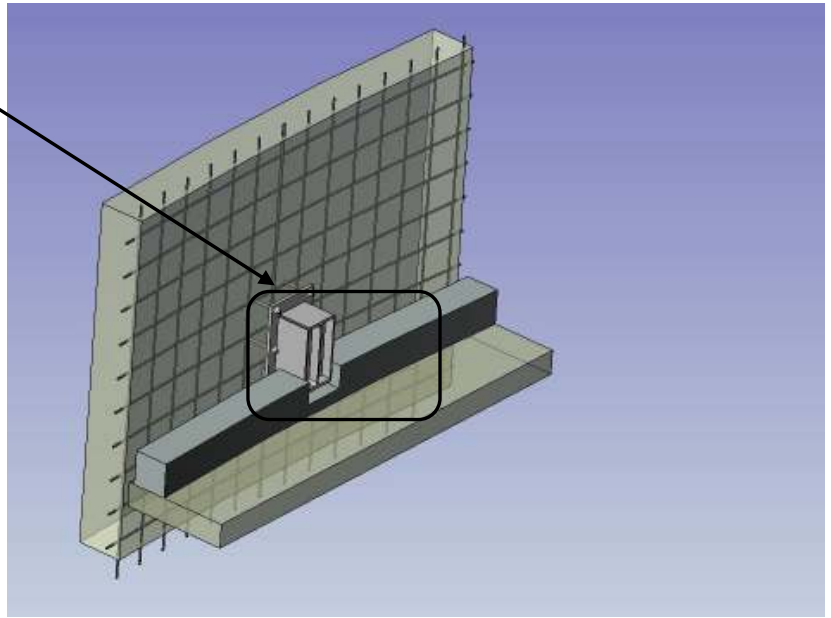
High Flux Reactor: ILL7 & ILL22



High Flux Reactor: ILL7 & ILL22

High Flux Reactor





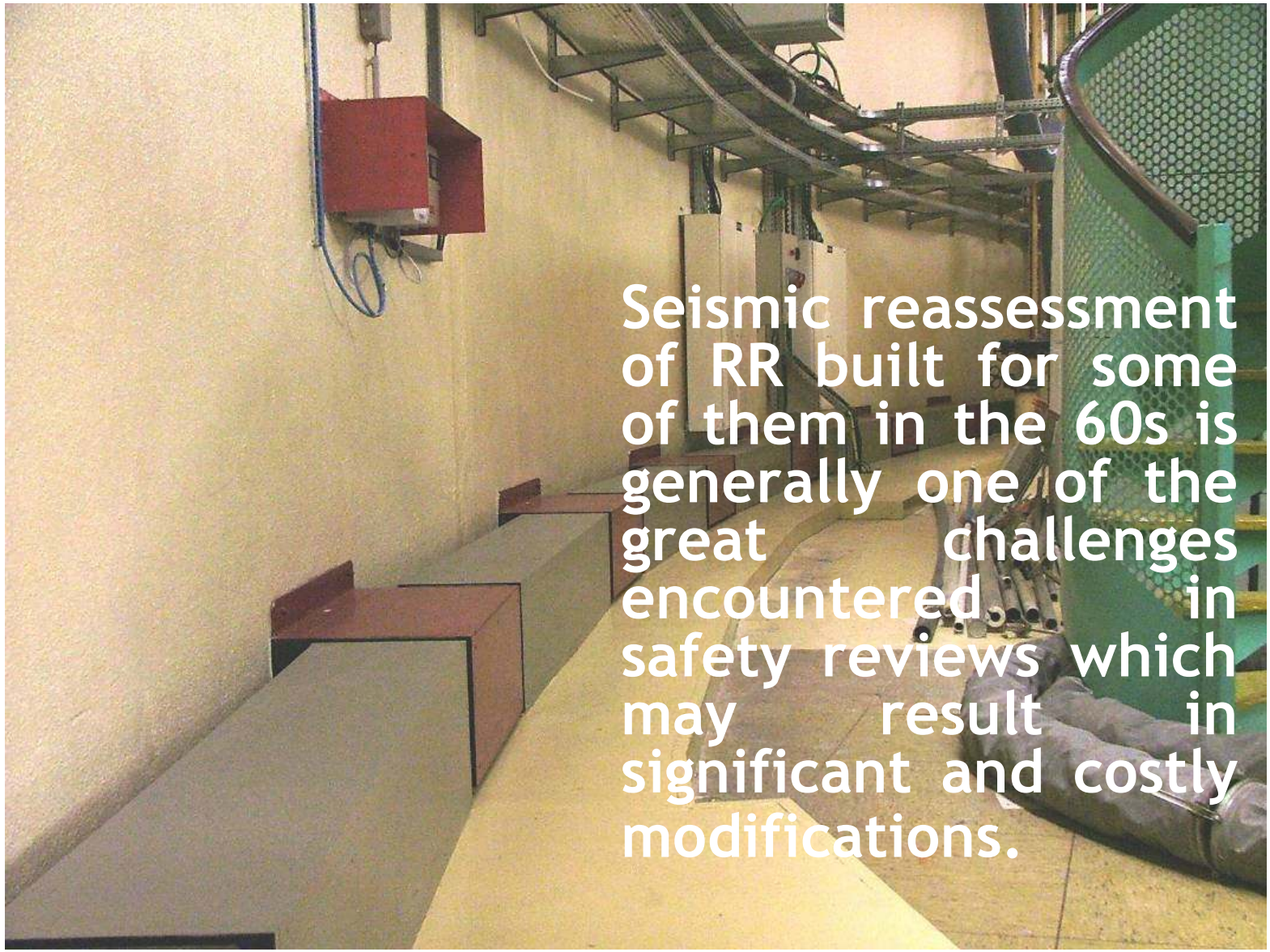
Reinforcement of the connection between the first floor and the containment building

High Flux Reactor

High Flux Reactor

High Flux Reactor

High Flux Reactor



Seismic resistance

The **PHEBUS** reactor is used to study in core meltdown situation, fission product behaviour and transport form PWR fuel to the environment via the reactor primary system and the containment building.

Latest Periodic safety review

The **MINERVE** reactor is used for cross-section measurement by oscillation of samples.

The reactor was completely unloaded and its pool drained in 2001 in order to renovate the reactor control and instrumentation system.

The work ended in late 2002.

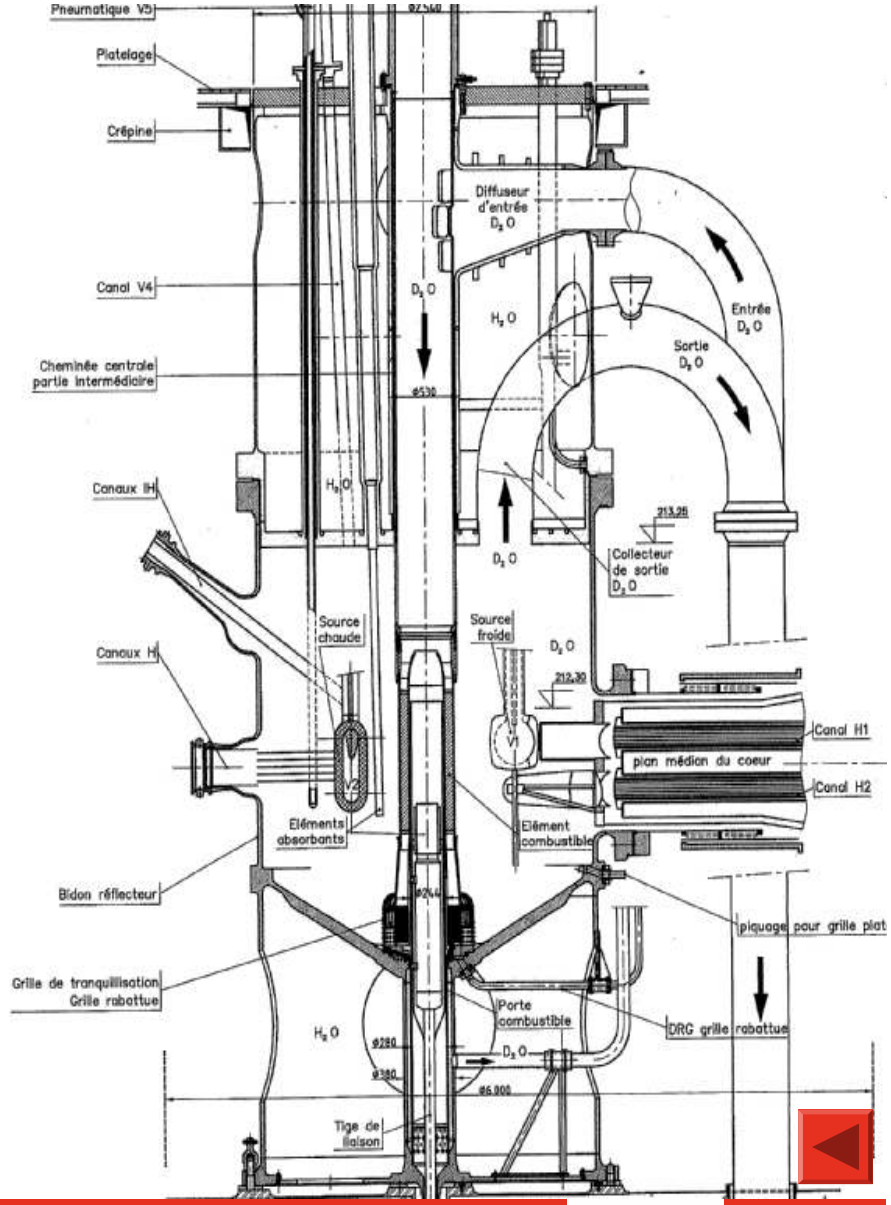
The reactor was restarted in March 2003

Safety approach for improvements of existing plants

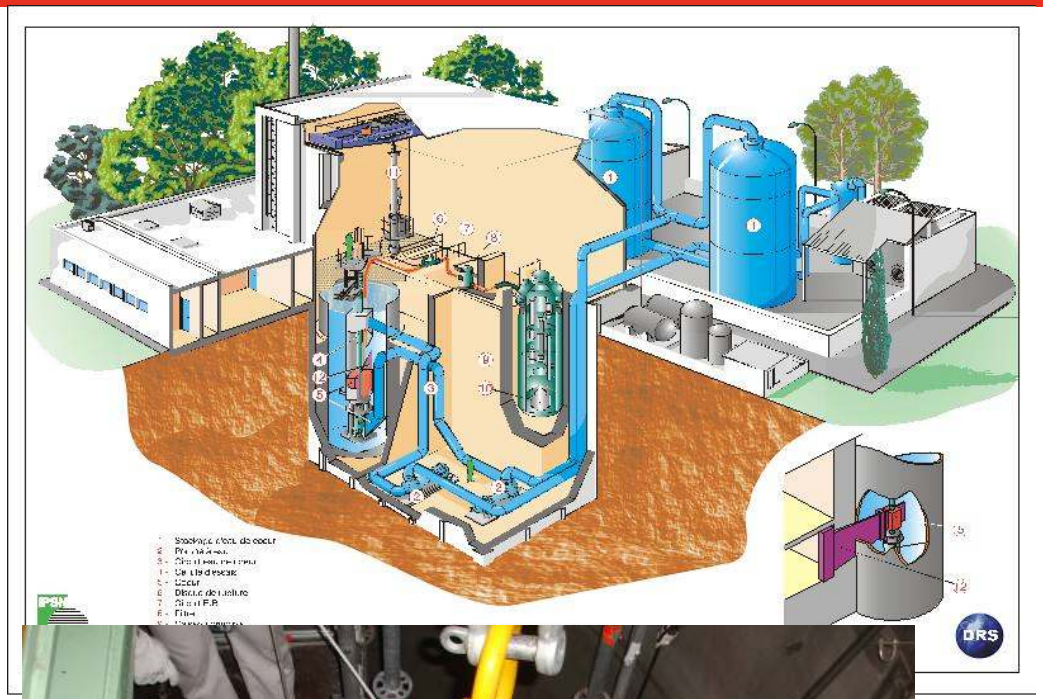
Reliability of safety systems

- Since the design stage, the knowledge on the reliability of safety systems is considerablely improved, especially because of the experience feedback and lessons learned from incidents
- The safety system reliability is exhaustively reassessed, especially with regard of the redundancy and the independence
- The main safety systems achieving the shutdown function and the decay heat removal function might be modified and improved

HFR: Core vessel replacement



CABRI: Core vessel replacement



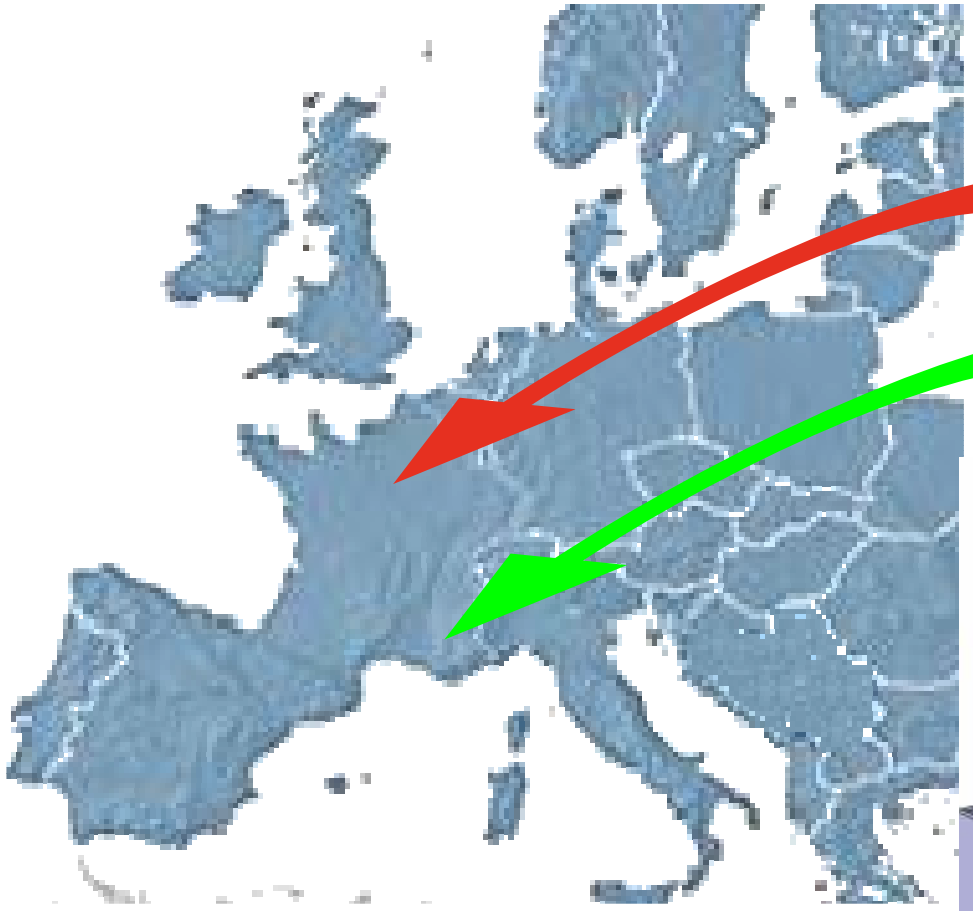
Ageing

ASN asked CEA about the future of the installation. Indeed, ASN feels that given the age of the design (> 40 y), operation of the installation cannot be considered beyond the end of the decade.

An internal safety and performance assessment has shown that even a major refurbishment would not allow to secure and to guarantee the availability of the irradiation experimental capacity.

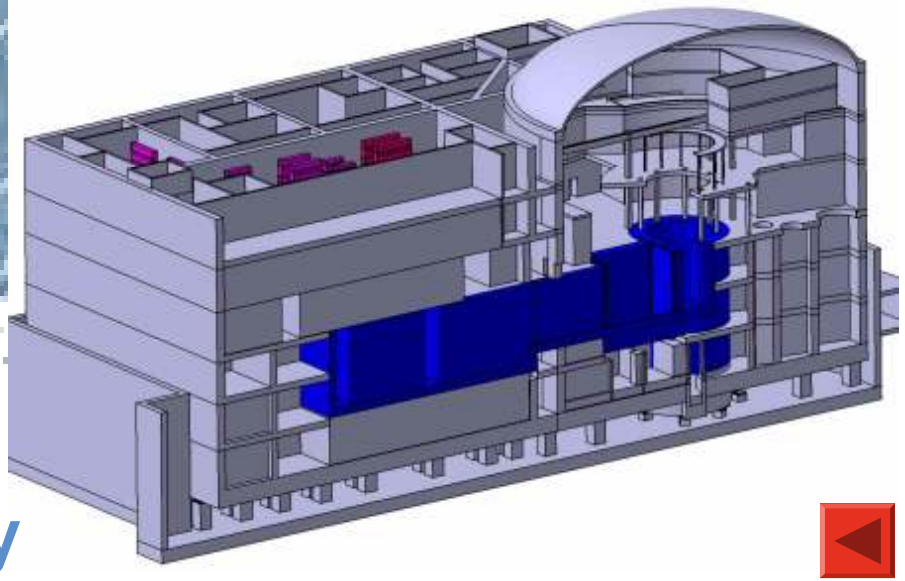
Due to ageing, it is planned to shut down **OSIRIS** at the beginning of the next decade

Jules Horowitz Reactor, a new MTR in Europe



OSIRIS in Saclay

JHR, a 100 MW MTR



Replacement by new installation proves necessary

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Safety approach for improvements of existing plants

The improvements in the Defence in Depth application

- Some events like **Design Extension Conditions**, especially complex sequences, might be not taken into account during the design phase
- These events are assessed, and where this is reasonably possible, prevention and mitigation are improved

➔ Implementation of emergency water make-up system on **OSIRIS** and **RHF** reactors

Thank you for your attention

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