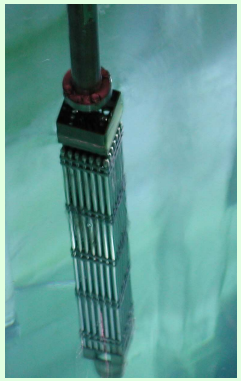
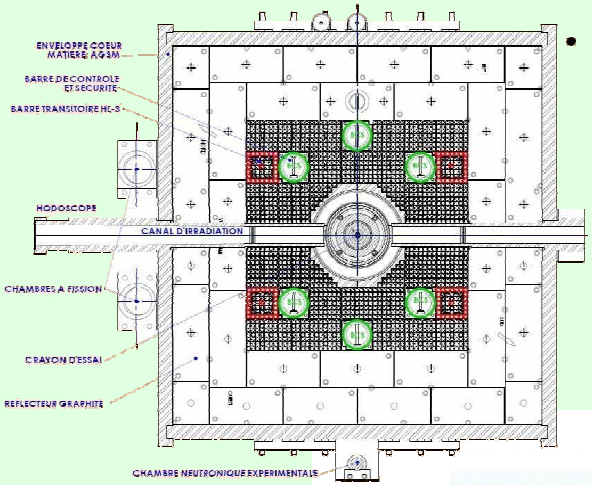
CABRI – CEA/CADARACHE – France
IGORR - 2009

PRESENTATION OF THE CABRI REACTOR

Driver core

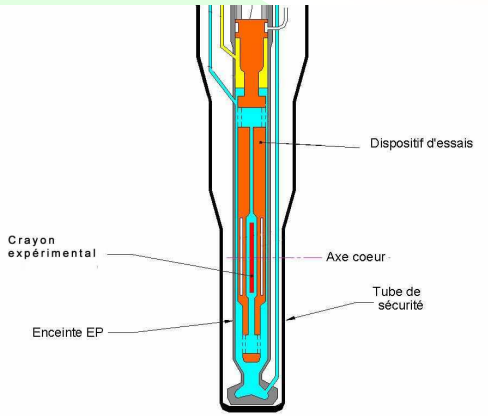


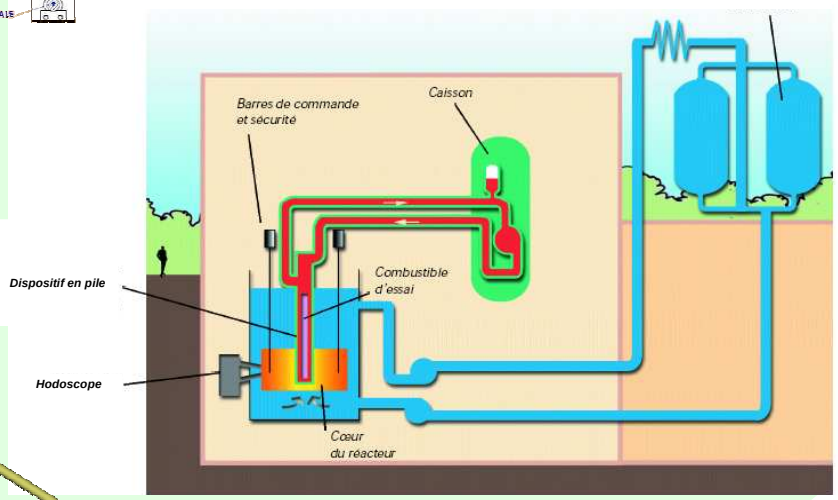
Cross section of the core



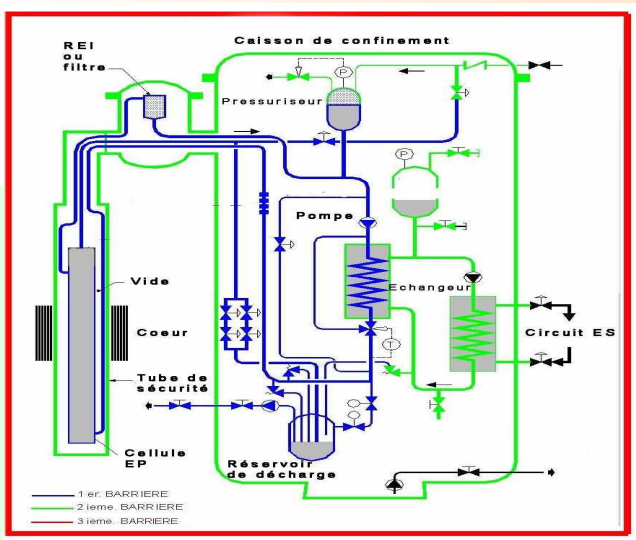
- *UO_2 enriched at 6% in U235*
- *1488 pins*
- *cladding in stainless steal 304L*
- *Fissile height 800 mm*

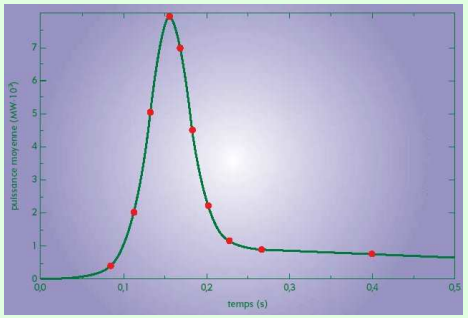
Experimental device at the center of the driver core

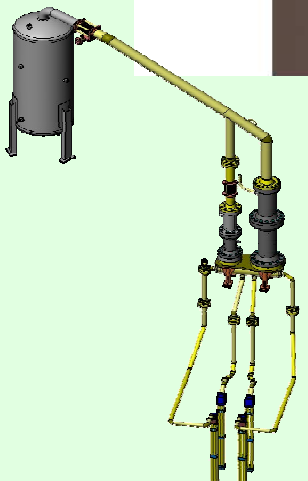




Test loop

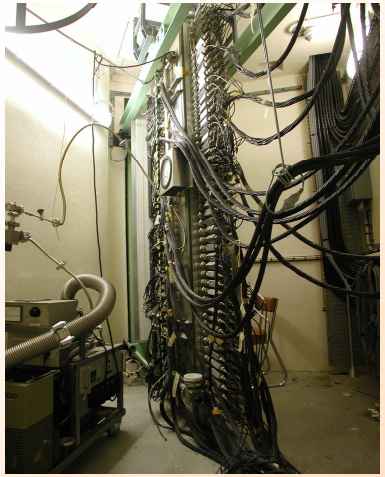






Neutrons measurement device coming from the expérimental fuel pin (fission chambers axialy positioned)

Hodoscope : Measurement of neutron signal during the test



CABRI: The experimental programmes

- **CABRI was a facility in support to FBR fuel studies**

…..but also to PWR fuel studies.

- **Since the end of 70's 59 tests on FBR's fuel and 14 tests on PWR's fuel were performed.**

- **The new Water Loop Programme (WLP):**
  - devoted to the behaviour of advanced PWR fuel mainly under **Reactivity Initiated Accident**:
    - High burn-up fuels,
    - New cladding materials,
    - MOX fuel.
  - managed by IRSN, this international programme is placed under the auspices of OECD: Contributions of France, United States, Germany, Switzerland, United Kingdom, Sweden, Spain, Finland,…….

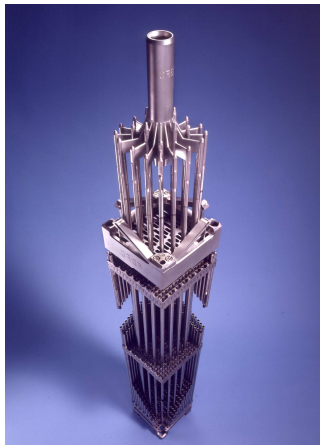
But sodium is not water….WLP supports the implementation of a pressurised water loop in place of the sodium one.

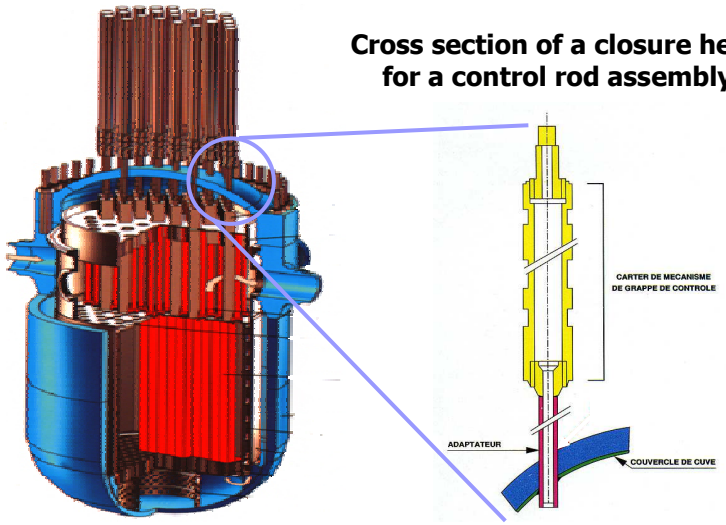
A REACTIVITY INSERTION ACCIDENT (RIA)

PWR reference accident - Ejection of the control rod

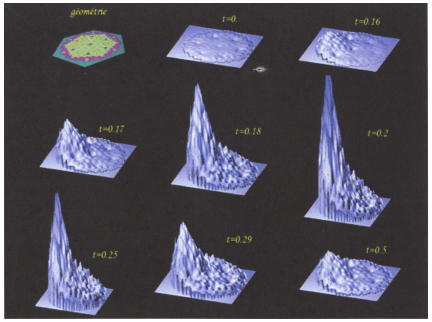
Objective

Study of the behaviour of UO2 fuels at high burnup and MOX fuels in RIA-type accident conditions





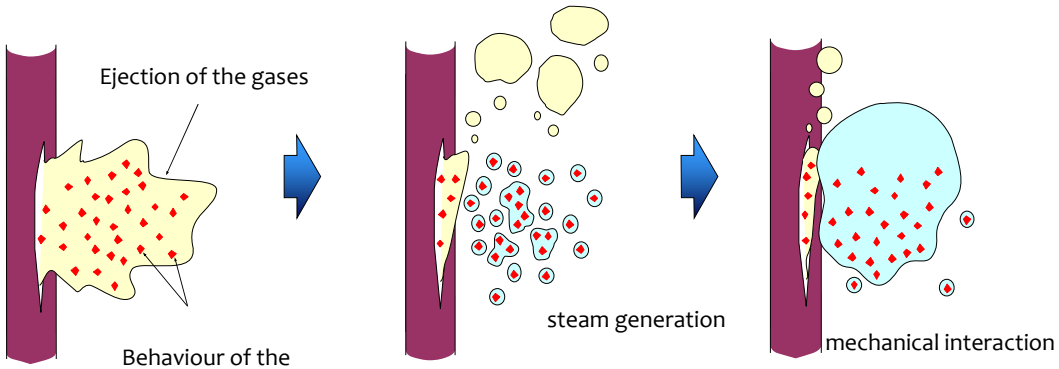
Cross section of a closure head for a control rod assembly



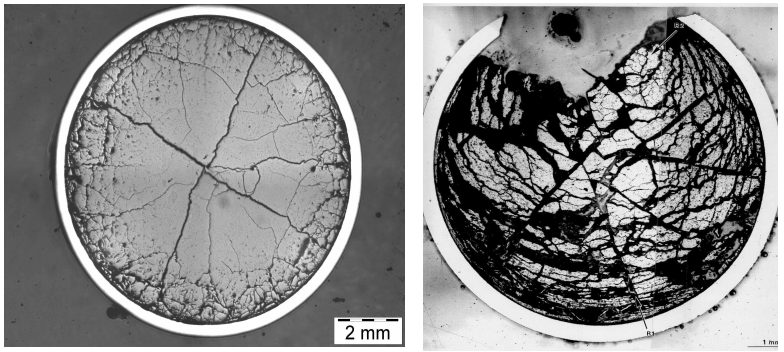
Evolution of the power in the core after the ejection of a control rod

Problems involving the fuel

☞ **Quantification of the fraction of ejected fuel and the pressure wave (fuel/water reaction)**



☞ **Behaviour of the clad and of the fuel**



Before

After

CABRI Water Loop : The modifications in two items

- **The change of the experimental loop**

  - Dismantling of the sodium loop (2003)
  - Dismantling of the SCARABEE reactor
  - Implementation of the water loop (2004 -2009)
  - Adaptation of the control command and fluids (2005-2009)
  - Modification of liquid wastes circuits (2005-2009)

The modification needs a Decree from the government assessed on

⇒a public inquiry (2003): a report on the modification of the facility, including risk and impact studies,

⇒a safety review: preliminary (2002) and provisional (2007/2009) safety reports

⇒End of the safety review (2009)

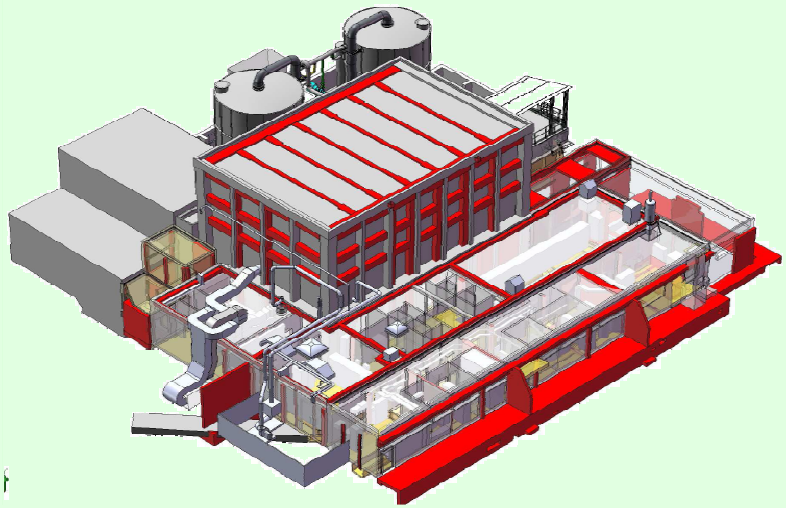
The safety review

- **The methodology is also based on**
  - the use of conception rules issued from standards of present conception codes or particular specifications (Zircaloy). For existing components for which past conception codes were used an equivalence with recent codes is assessed,
  - a systematic verification of the good level of safety standards of the overall facility,
  - a verification of the good level of safety by the examination of out of design accidents,
  - an examination of nuclear, and non nuclear internal risk along with external risk,
  - the specificity of the CABRI operation
    - Short duration of the reactor operation: limitation of the presence of risk associated to control rods up, Helium3 in the core, power, water under high pressure,…

For example the simultaneity of SSE earthquake and reactor operation is considered as an out of design situation.

CABRI Water Loop : The modifications in two items (con't)

- **<u>The upgrade of the facility which guidelines are issued from the safety review and the modernisation of equipment</u>:**
  - **Building and components reinforcement (earthquake), (storage pool, crane, biological protection,…)**
  - **Electricity supply, instrumentation,**
  - **Fire protection**
  - **A complementary programme of inspection to usual maintenance and periodic control**



CABRI: the Water loop: use of Zircaloy for the in core cell

- In order to deposit enough energy in the experimental fuel, the neutronic coupling factor between the driver core and the experimental fuel must be as high as possible. This is particularly accurate for high burn-up fuels. The Zircaloy for the in pile part of the water loop (two concentric shells) is the best candidate.

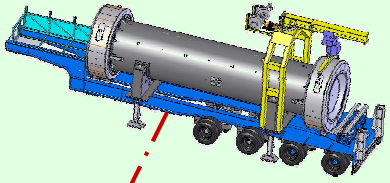
- The in pile cell is a nuclear pressure vessel as the primary circuit of a PWR.
- The validated conception codes (ASME/RCCM) suggest the use of materials with a low anisotropy, a sufficient ductility and toughness to prevent fast fracture, a good experience of fabrication and operation in equivalent conditions.
- A programme to demonstrate the Zircaloy fracture toughness is set up:
  - specific fabrication of a heat ingot,
  - mechanical properties determination on metal and welding samples,
  - fracture mechanics calculation,
  - gathering of all experience and feedback on similar uses of the zircaloy.

REFURBISHMENT PROGRAM OF CABRI FACILITY

CEA CADARACHE

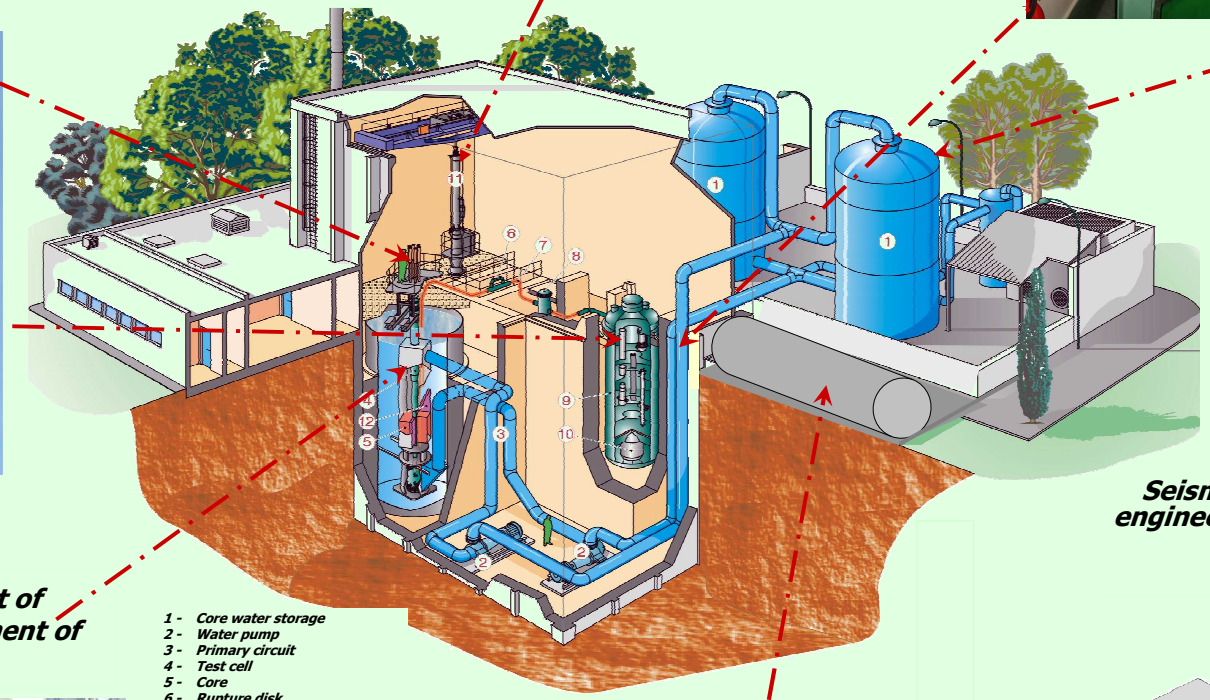
IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

The production of a transport and handling flask



Verification of the core's primary circuit condition

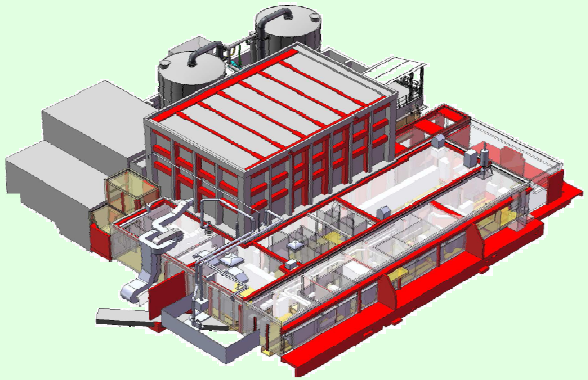
The manufacturing and instalment of a Pressurized Water Loop



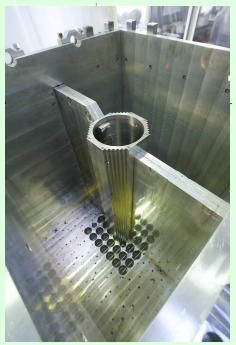
1 - Core water storage
2 - Water pump
3 - Primary circuit
4 - Test cell
5 - Core
6 - Rupture disk
7 - Pressurizer water loop circuit
8 - Filter
9 - Water loop containment
10 - Pressurizer relief tank
11 - Flask of the device
12 - Hodoscope

Renovation of the ventilation

Seismic reinforcement of the civil engineering structures making up the building



Seismic reinforcement of equipment and replacement of the reactor block



Design and production of the High Activity effluent circuits

COMMISSIONNING TEST PROGRAM

CORE MEASUREMENTS
AT 0-POWER

VENTILATION

COMMAND CONTROL
AND
ELECTRICAL SUPPLY

NEW SYSTEMS AND
EQUIPMENTS
(PWR LOOP)

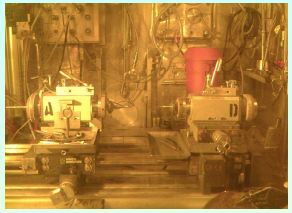
CORE MEASUREMENTS
AT POWER

HANDLING
NEW COMPONENTS

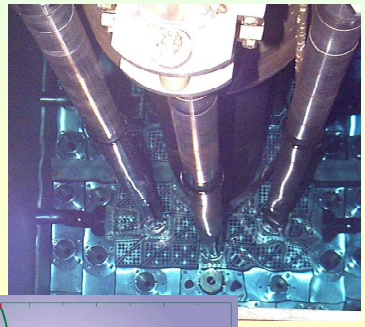
CONDUCTING A TEST IN THE CABRI FACILITY

The removal of an irradiated fuel rod from a PWR plant

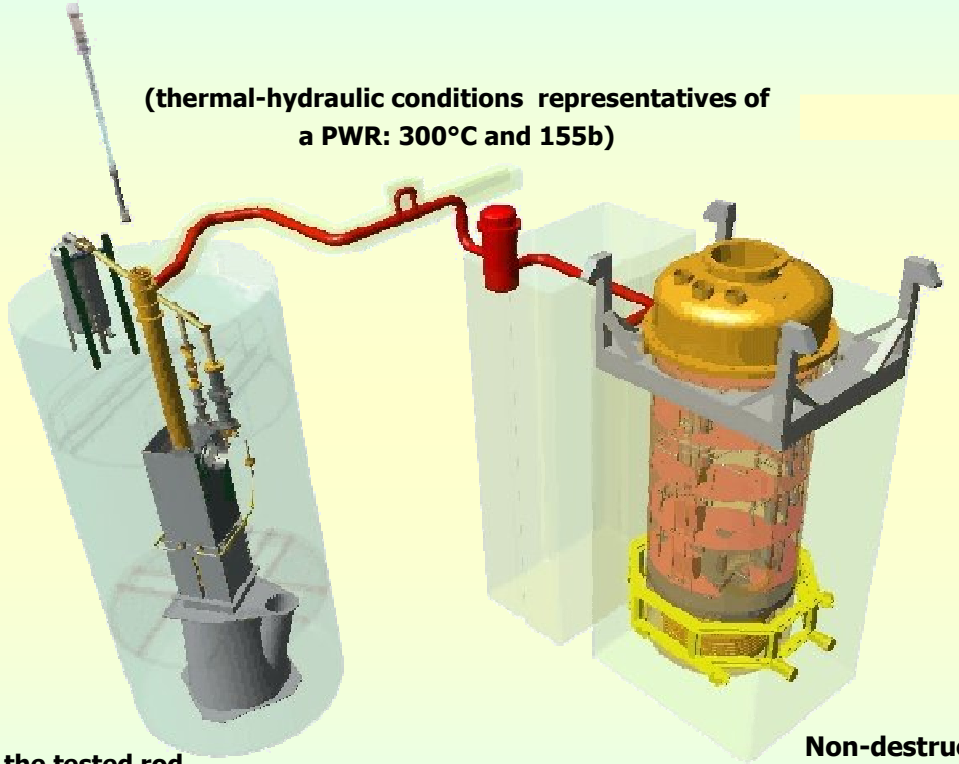
Preparing and inserting the fuel rod to be tested in the test device at the LECA facility and its subsequent transport to the CABRI facility

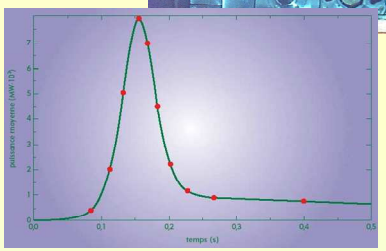


Insertion of the test device in the cell at the centre of the CABRI driver core

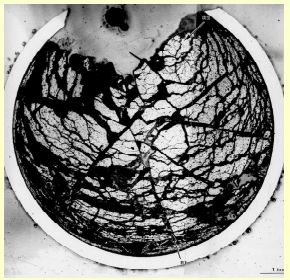


(thermal-hydraulic conditions representatives of a PWR: 300°C and 155b)



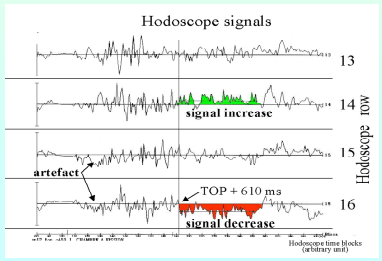


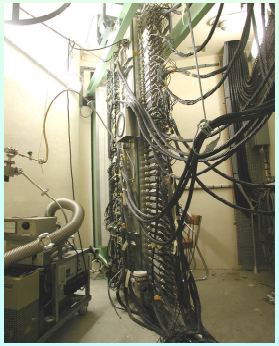
Functioning of the reactor when submitted to excess power



Destructive examinations on the test rod at the LECA facility

Recording fuel movements in the tested rod using a hodoscope





Non-destructive examinations performed on the rod using the IRIS device. (tomography)