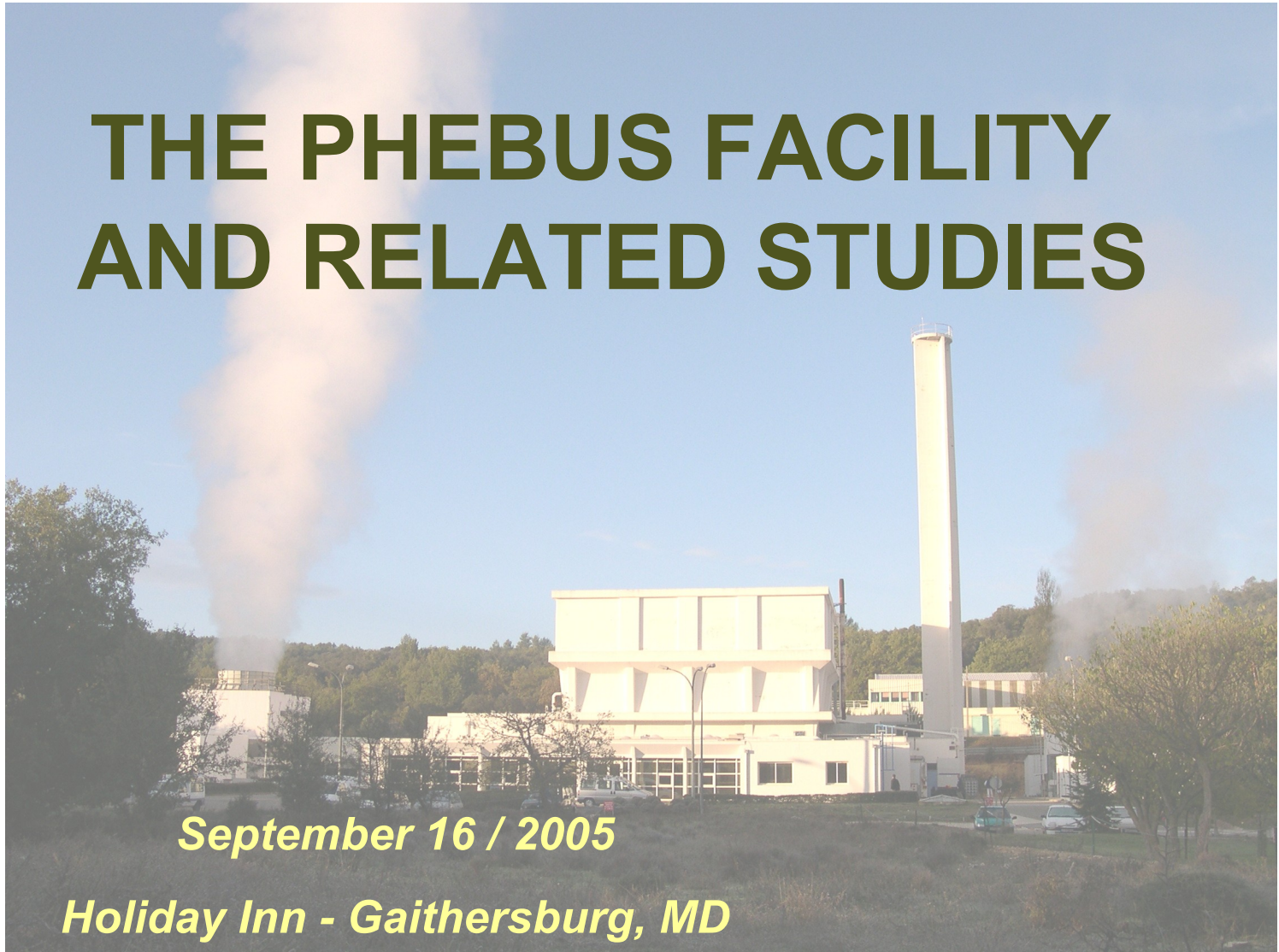


THE PHEBUS FACILITY AND RELATED STUDIES



September 16 / 2005

Holiday Inn - Gaithersburg, MD

OUTLINES



- **Context**
- **PHEBUS FP Programme and FPT3 test**
- **PHEBUS Facility description**
 - ✓ Reactor
 - ✓ Fission Products Lab
- **Main characteristics for other experiments**





➤ **PHEBUS is a research reactor operated by CEA at the Cadarache research centre**

➤ Since its operational start, PHEBUS has been dedicated to safety issues experiences in order to :

- ✓ Achieve integral experiences to improve the knowledge in case of incidental conditions and severe accidents consequences
- ✓ Validate calculation codes through global experiences

At the present time, the arising question concerns the future programs to be carried out in PHEBUS.



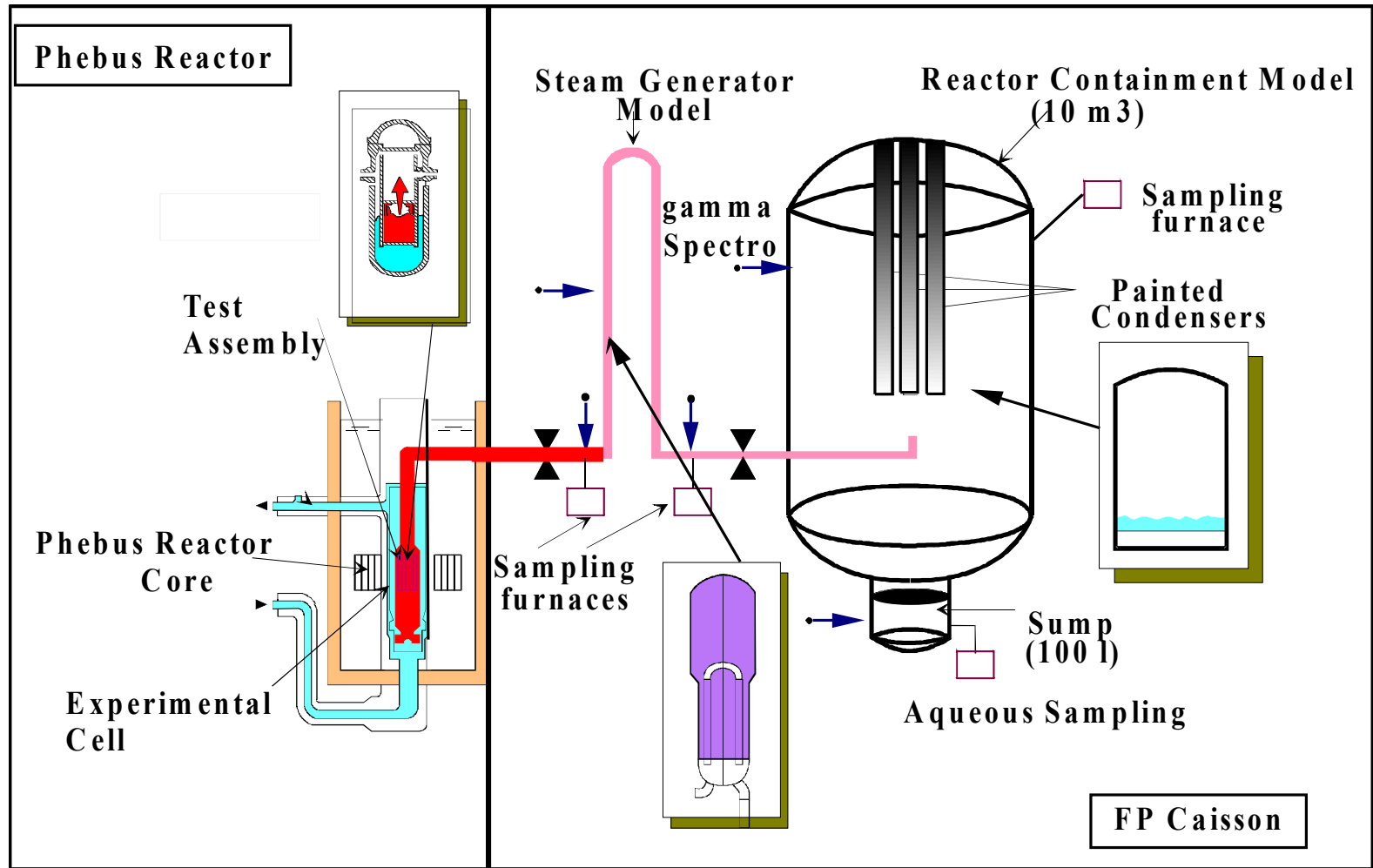
➤ History :

- ✓ 1979 : Operational start of the PHEBUS facility reactor
- ✓ From 1979 to 1990 : programmes LOCA, SDC
- ✓ 1990 : Operational start of the FP Laboratory.

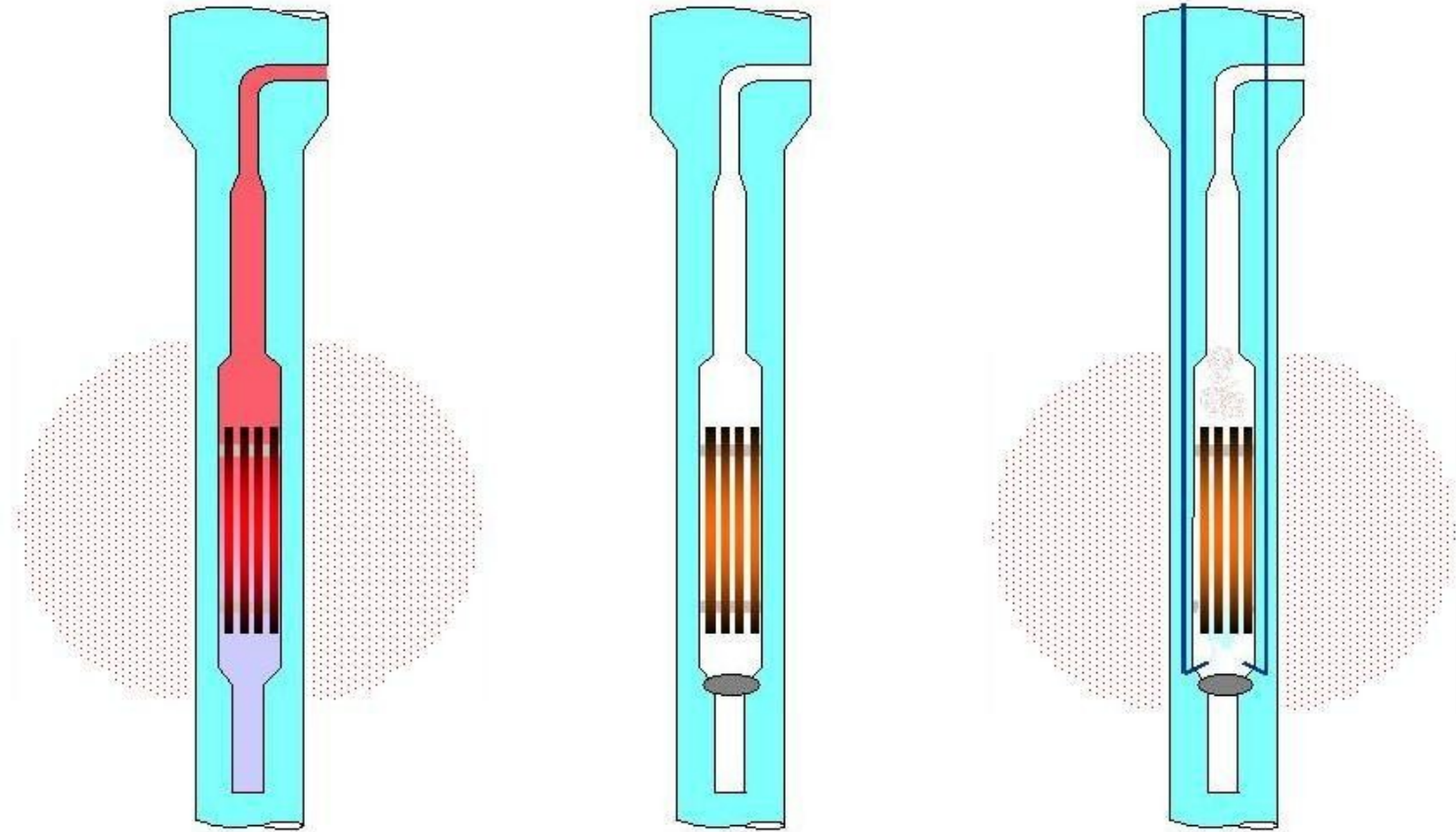
Global seism reinforcement.

- While achieving international programmes managed by IRSN, the PHEBUS facility has allowed a better understanding of core degradation modes and fission products release.





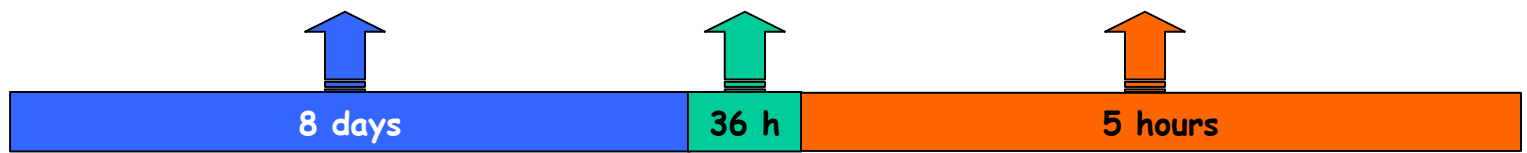
The **international** PHEBUS FP Programme reproduces (on a reduced scale 1/5000 vs 900 MW PWR) a core meltdown accident in a P.W.R.



Fuel Re-irradiation

Transition phase

Expérimental phase

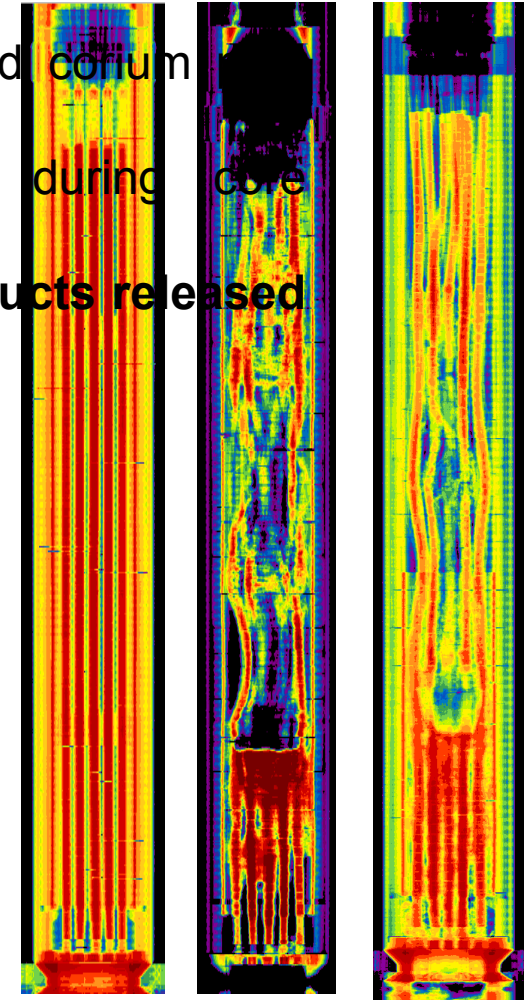


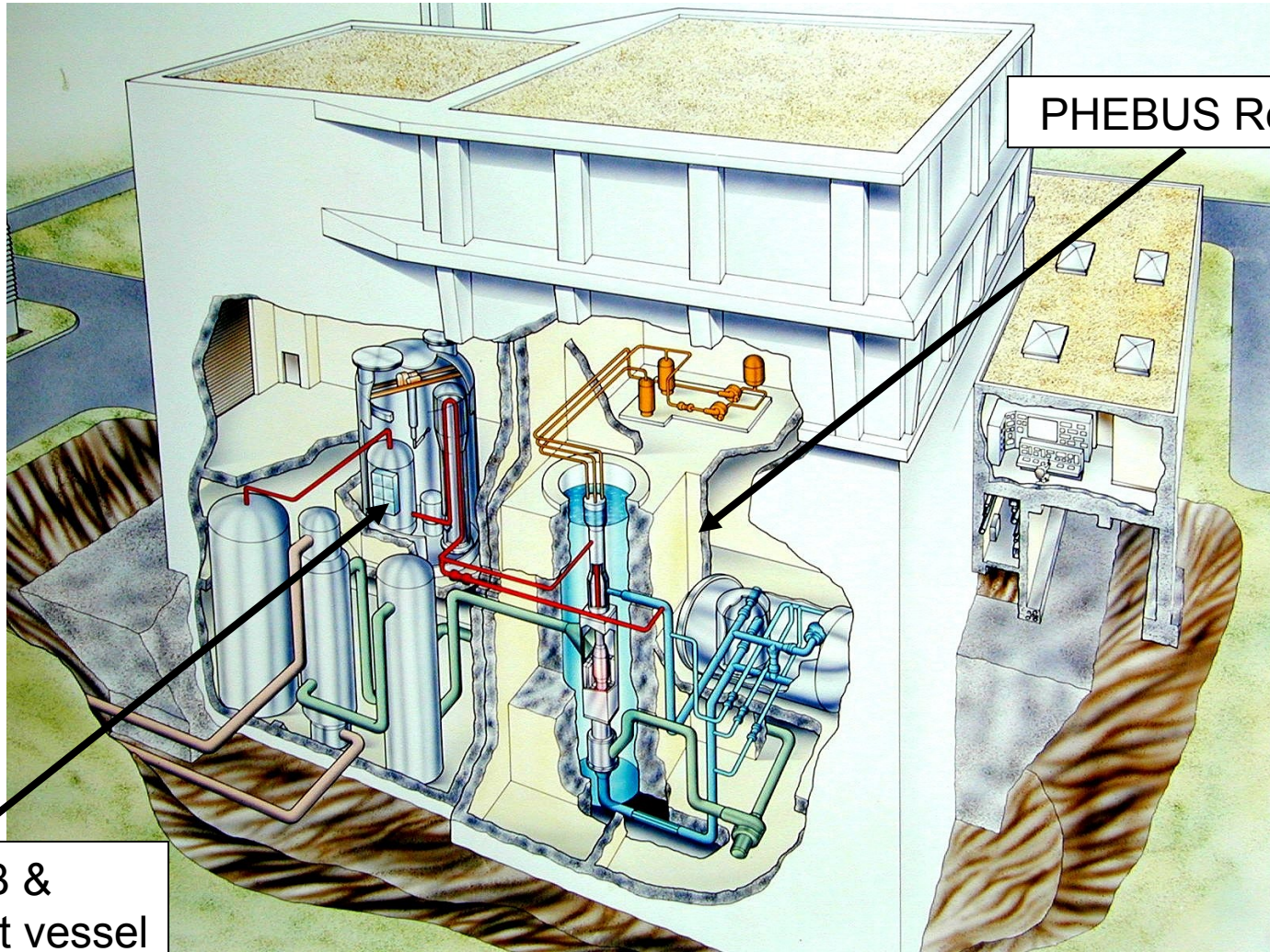
FP Programme main improvements :

- ⇒ The **core degradation**, corium relocation and corium formation,
- ⇒ The **hydrogen production** by oxidation during core degradation,
- ⇒ The nature and quantities of **radioactive products released** to the environment

The PHEBUS FP test matrix :

- **FPT0 (1993)**
- **FPT1 (1996)**
- **FPT4 (1998)**
- **FPT2 (2000)**
- **FPT3 (2004)**
- **FPT5 => STLOC1 postponed to 2012**





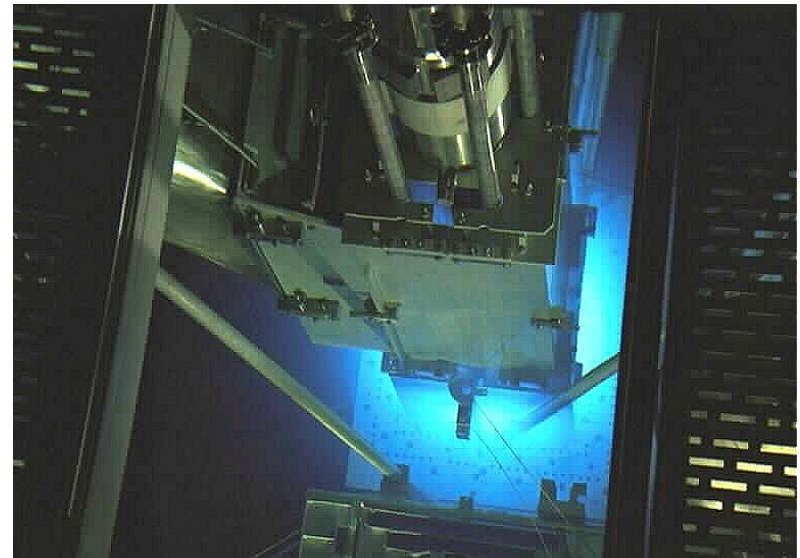
PHEBUS Reactor

FP LAB &
Containment vessel

PHEBUS is a (max) 38 thermal MW pool type reactor
During several days, 20 MW operating can be carried out

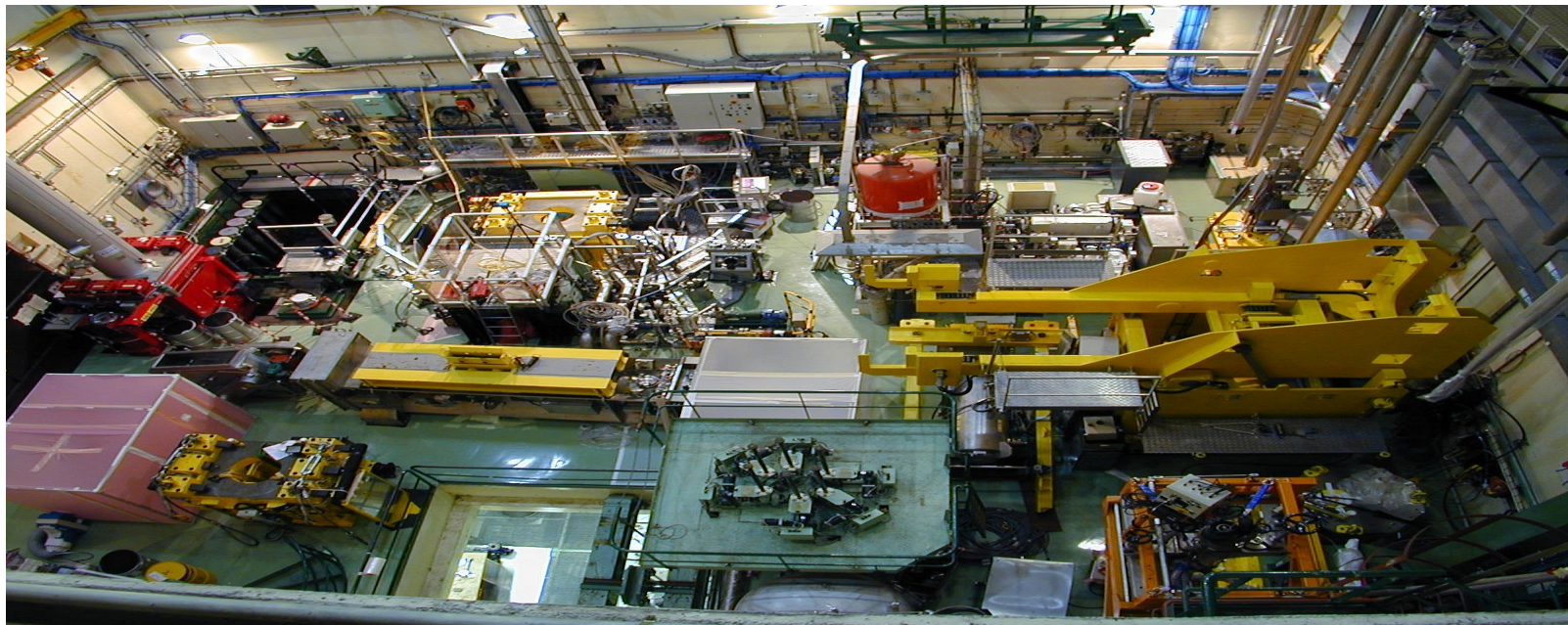
Main components

- A **driver** core dedicated to produce the neutron flux in order to :
 - Create short life fission products in the experimental fuel
 - Bring to the experimental fuel the representative nuclear heating
- A specific in pile **pressurized water loop** (155 b, 320 °C) dedicated to experimental fuel settlement, re-irradiation and degradation.
- A leaktight cell, located vertically at the reactor core centre, in which takes place the experimental fuel device.



The PHEBUS reactor building also includes renewed tools such as :

- A 250 kN handling crane (heavy maintenance in 2004),
- A specific experimental device handling machine (control refurbishing in 2004)
- An immobilizing matrix injection equipment

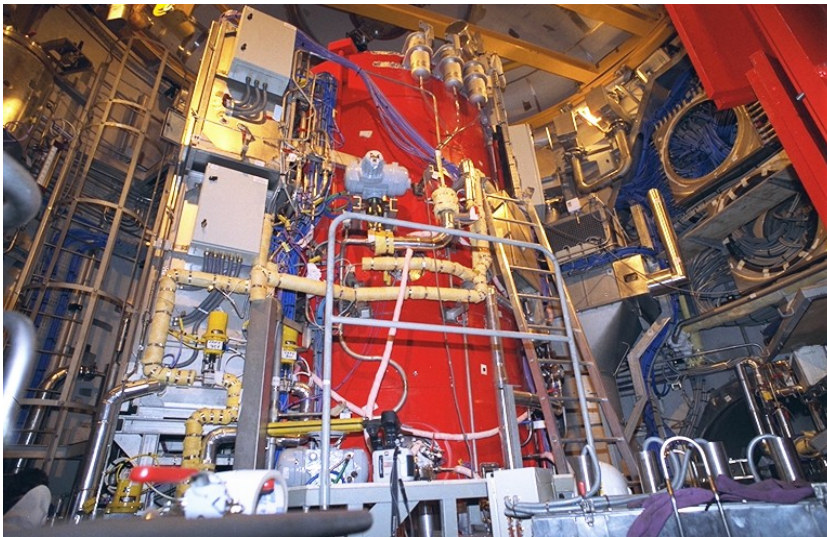


- Storage pools
- An examination and control Equipment (tomographs and radiographs)

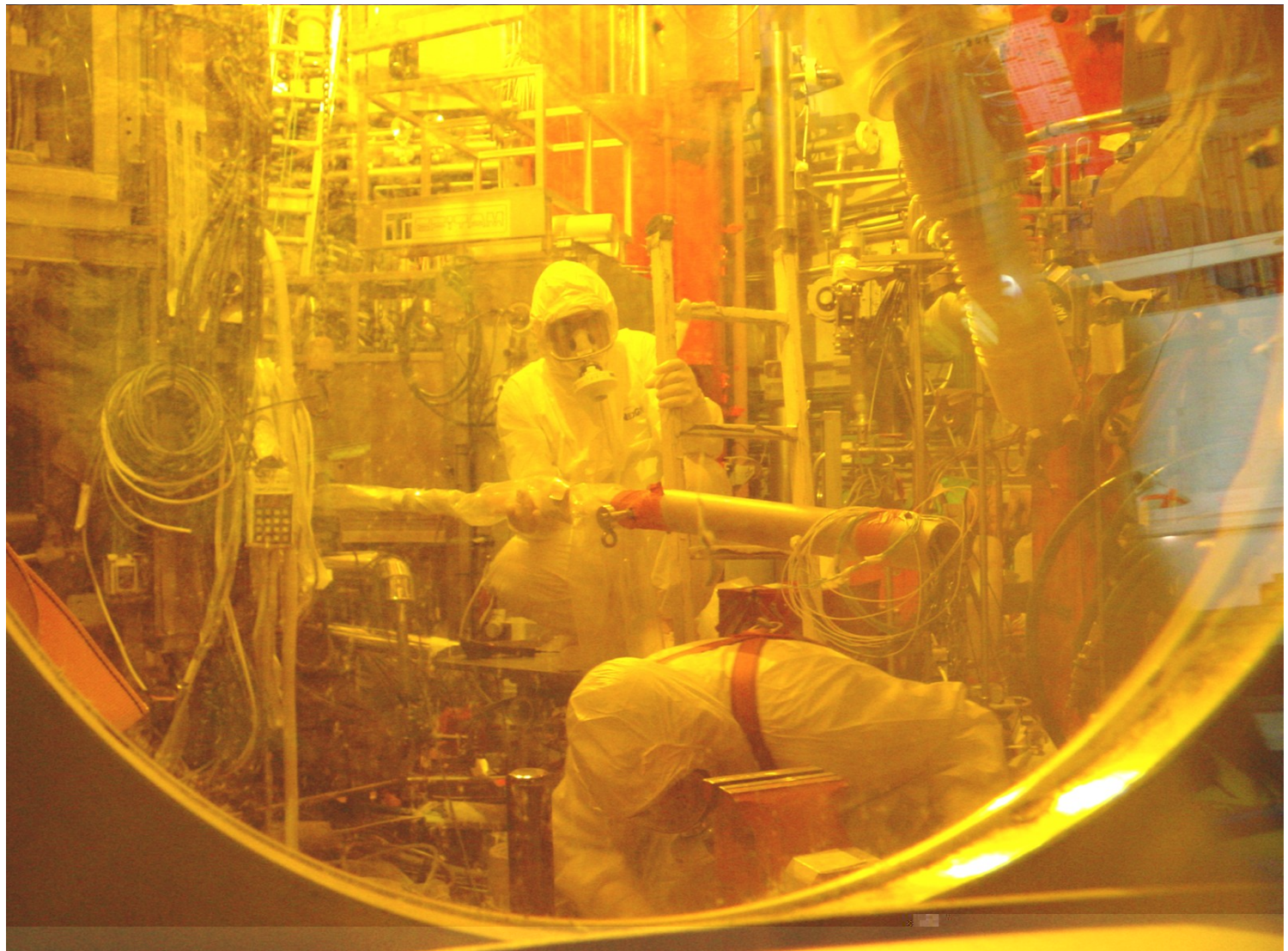
The PHEBUS FP lab was erected in 1990.

It mainly contains :

- An **instrumented containment vessel** (350 m³) to receive the fission products released during the experience.
- Hot cells dedicated to experimental samples retrieval, gamma spectrometry measurement, conditioning and storage.



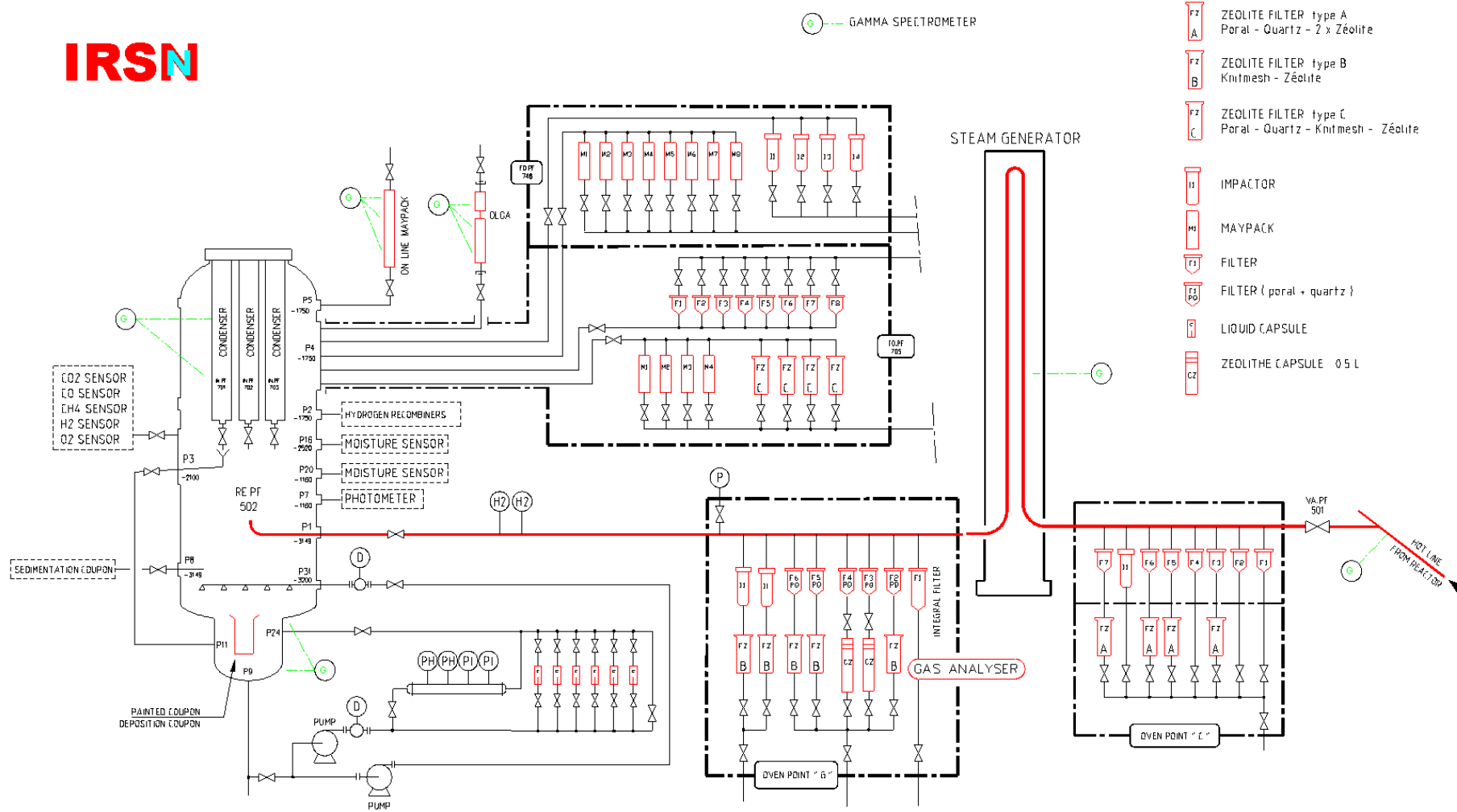
PHEBUS containment vessel



PHEBUS FP circuits 1/2



IRSN

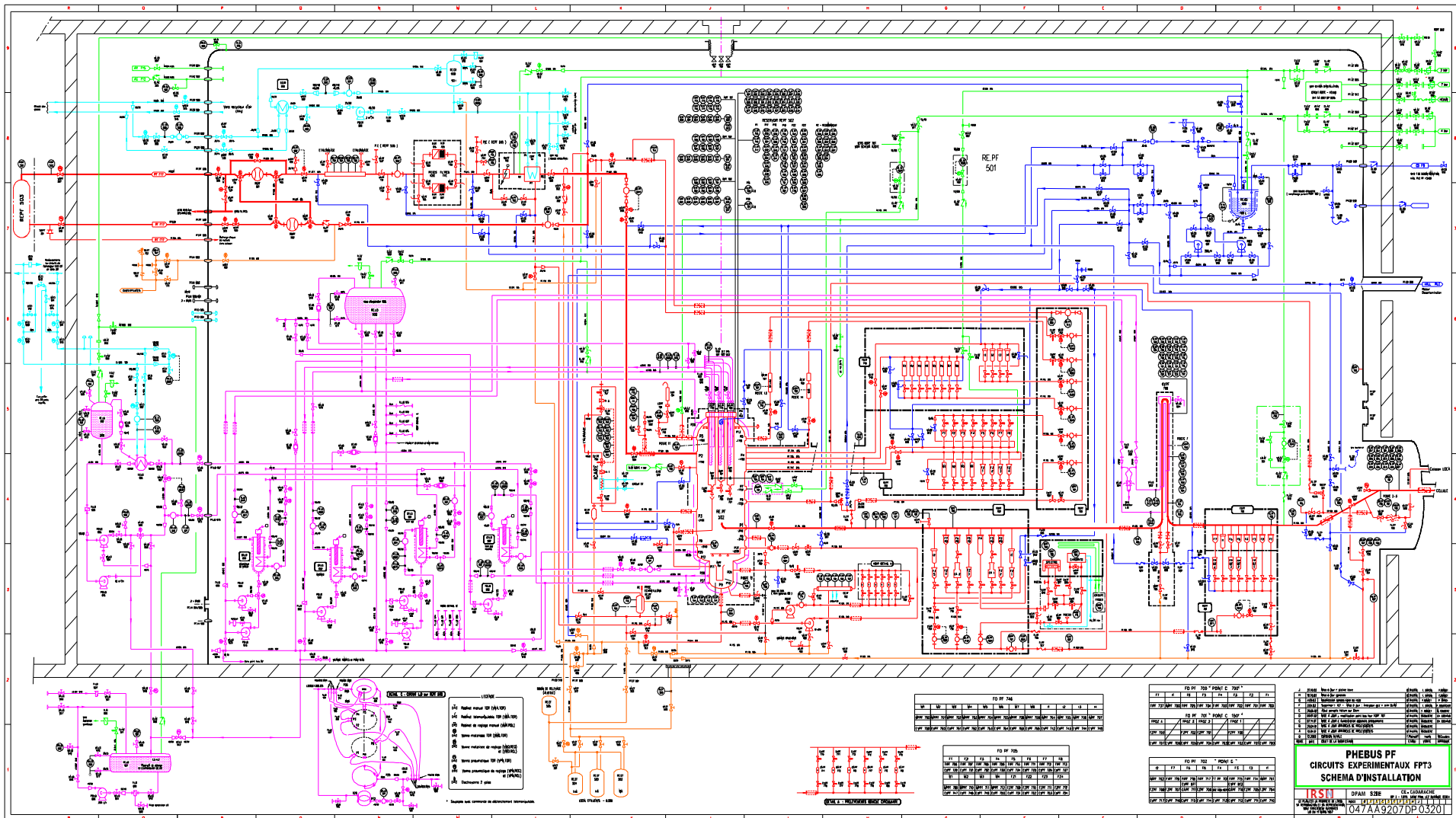


- FZ** ZEOLITE FILTER type A
Poral - Quartz - 2 x Zéolite
- FZ B** ZEOLITE FILTER type B
Knitmesh - Zéolite
- FZ C** ZEOLITE FILTER type C
Poral - Quartz - Knitmesh - Zéolite
- I1** IMPACTOR
- M3** MAYPACK
- F1** FILTER
- F3 P0** FILTER (poral + quartz)
- L** LIQUID CAPSULE
- CZ** ZEOLITHE CAPSULE 0.5 L

FPT3 INSTRUMENTATION PLAN

16.10.2003

PHEBUS FP circuits 2/2



Different options are possible for the future of the PHEBUS facility:

➤ PHEBUS ST-LOC

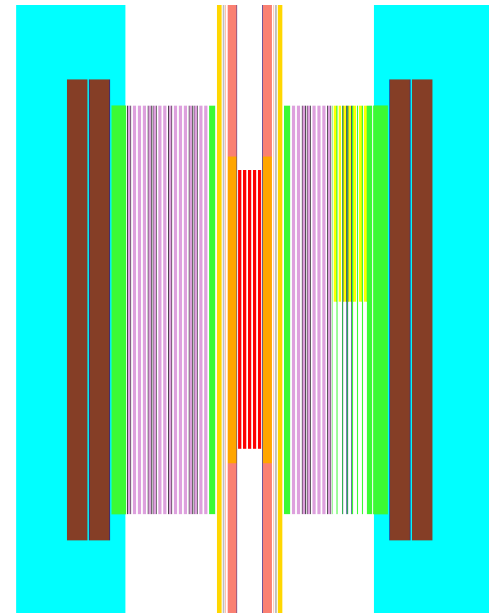
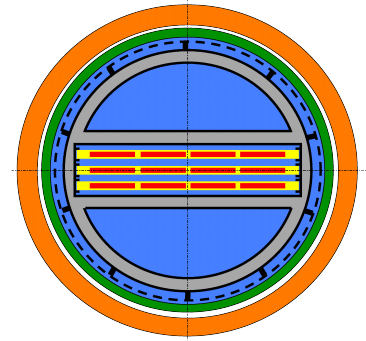
At the present time, an international expert group is studying safety experiences that could require the PHEBUS facility tools

- Long term care and maintenance Program
- Other experimental issues based on the facility capabilities

Conclusion : Experimental capabilities



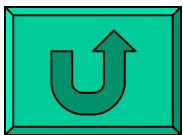
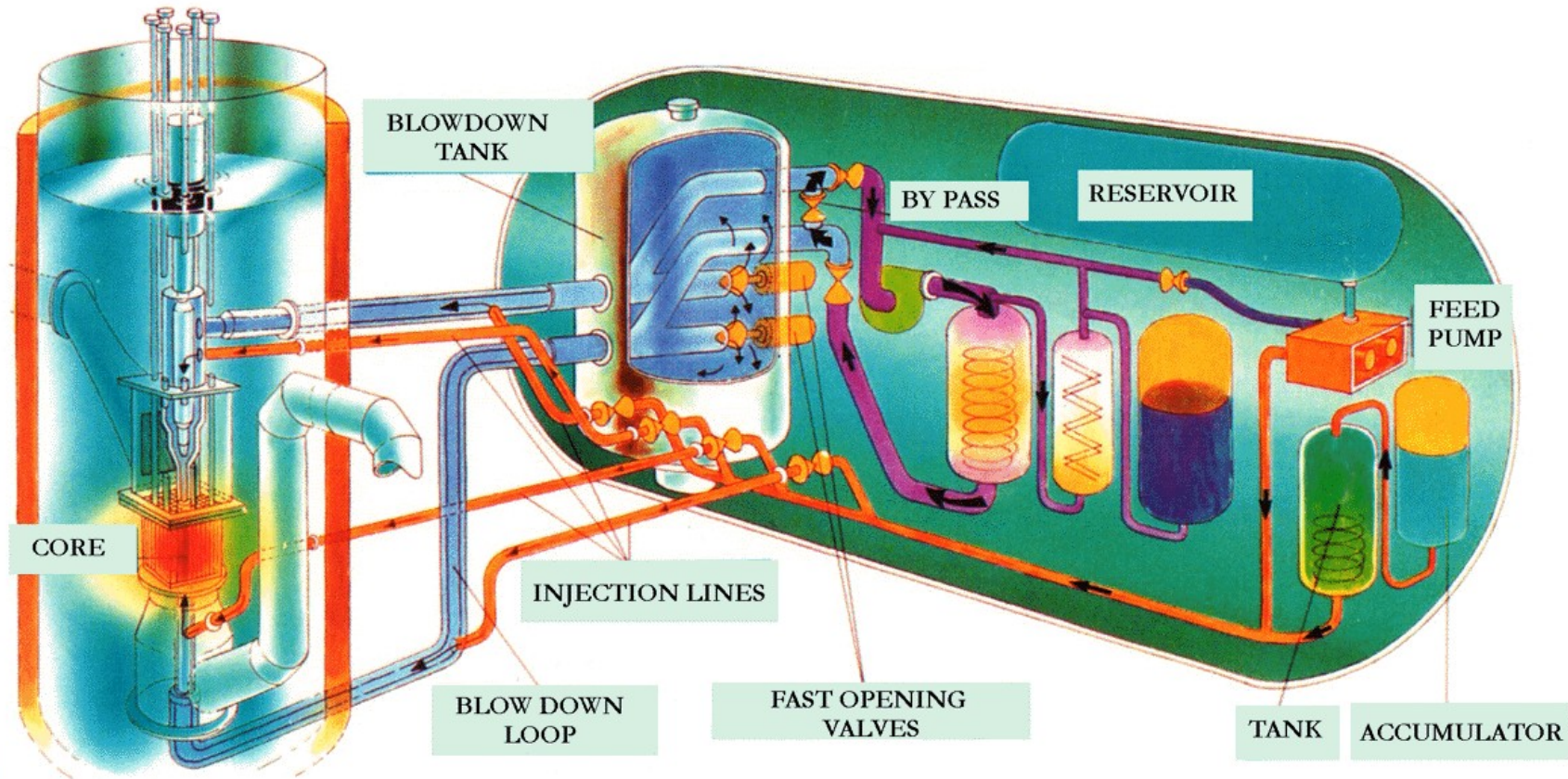
- A pressurized water loop reproducing PWR chemical, thermal and hydraulics conditions (until 160 bar and 320 °C)
- Experimental cell on the core vertical axis : Axisymmetric neutron flux
- Adjustable Cooling flowrate (until 90 m³/h)
- Large Experimental cell diameter (124 mm)
- Driver core active height of 80 cm
- Power reserve allowing the neutronic spectrum adjustment for the experimental test device design
- Highly skilled operators and revamped equipment
- The design and safety requirements of the PHEBUS FP programme allow a large experiences panel in the facility



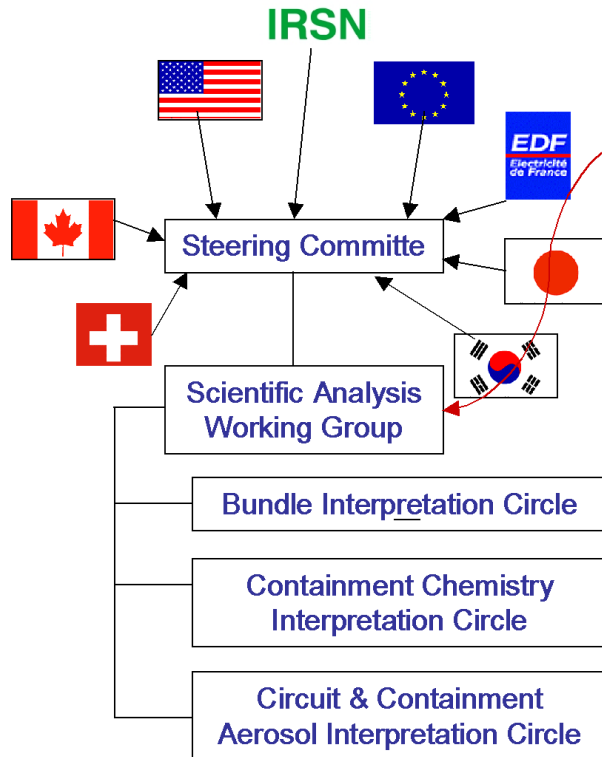
The PHEBUS reactor at work : FPT3 test, November
18, 2004

End

yves.belpomo@cea.fr - thierry.dousson@cea.fr



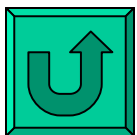
PHEBUS operator : CEA



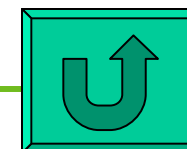
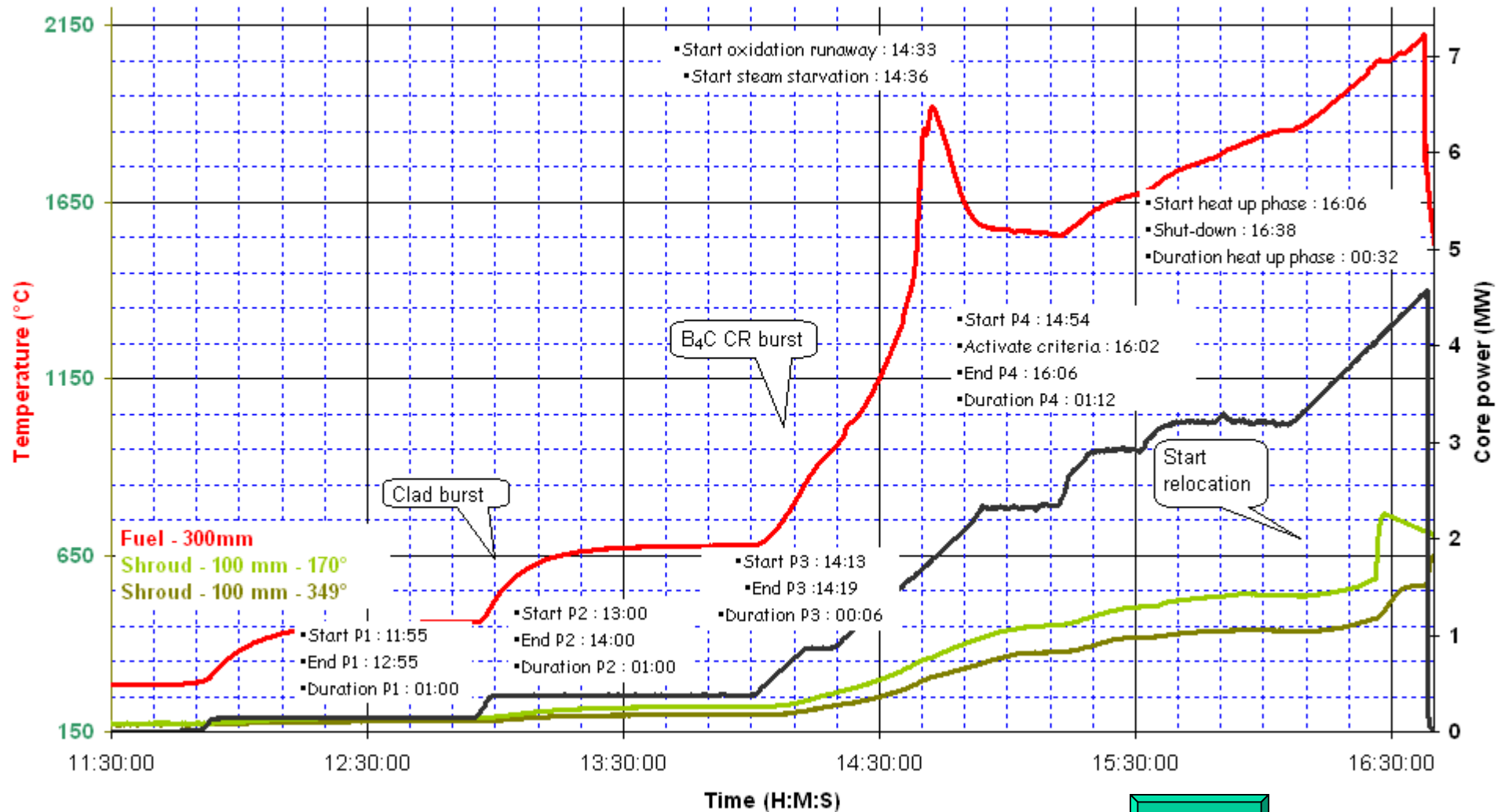
+ Bulgarie, Hongrie, République Tchèque, Roumanie, Slovaquie, Slovénie



**The Phebus network
gathers more
than 40 international
institutes**

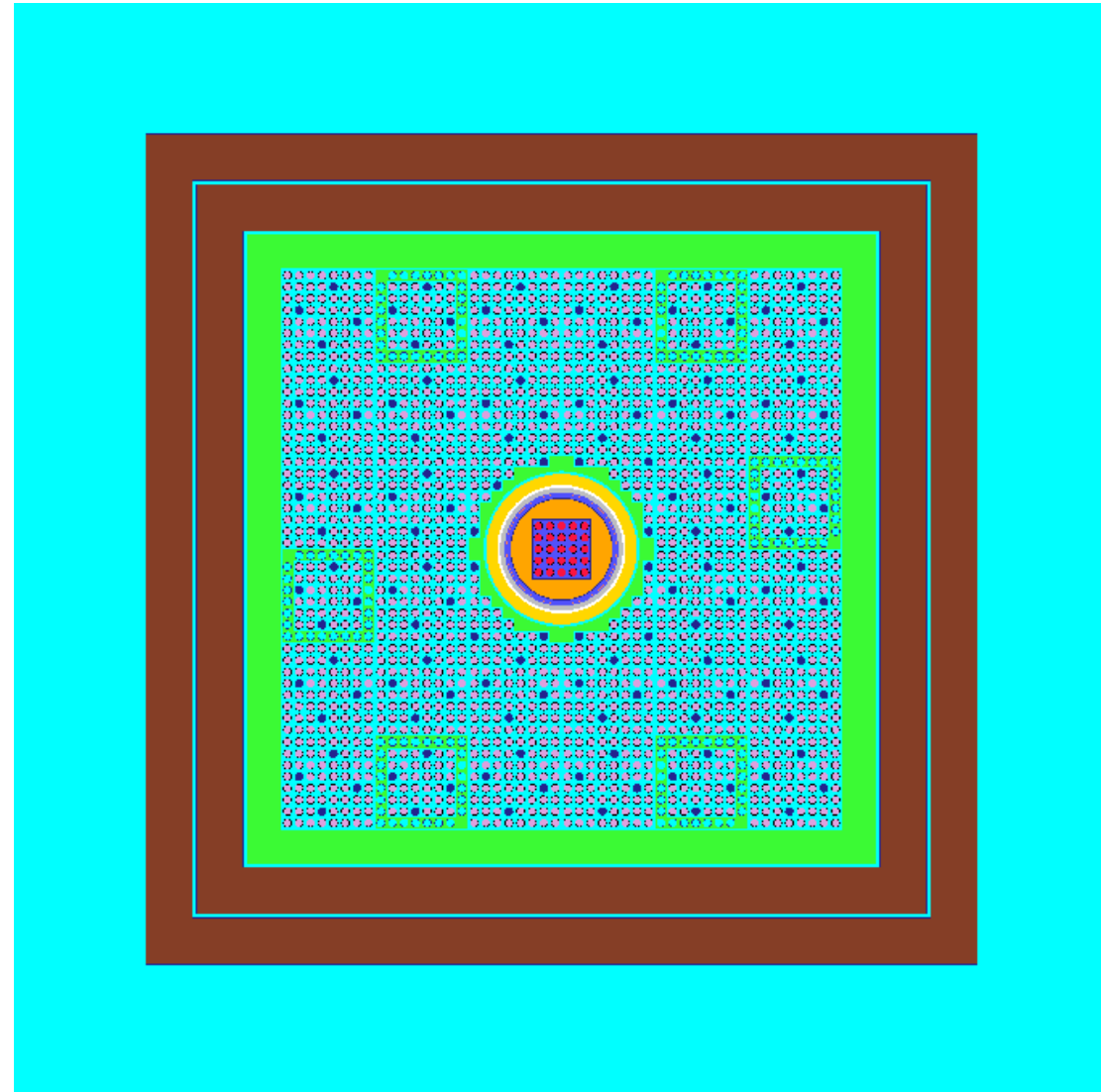


FPT3 Degradation phase (18/11/2004). General chronology





- 36 Fuel elements with a 2.78% enrichment in ^{235}U
- 6 safety control rods (hafnium)
- 4 barriers between the experimental fuel and the pool water
- Graphite reflectors layers



Required operations

Liquid decontamination

RC Dismantling

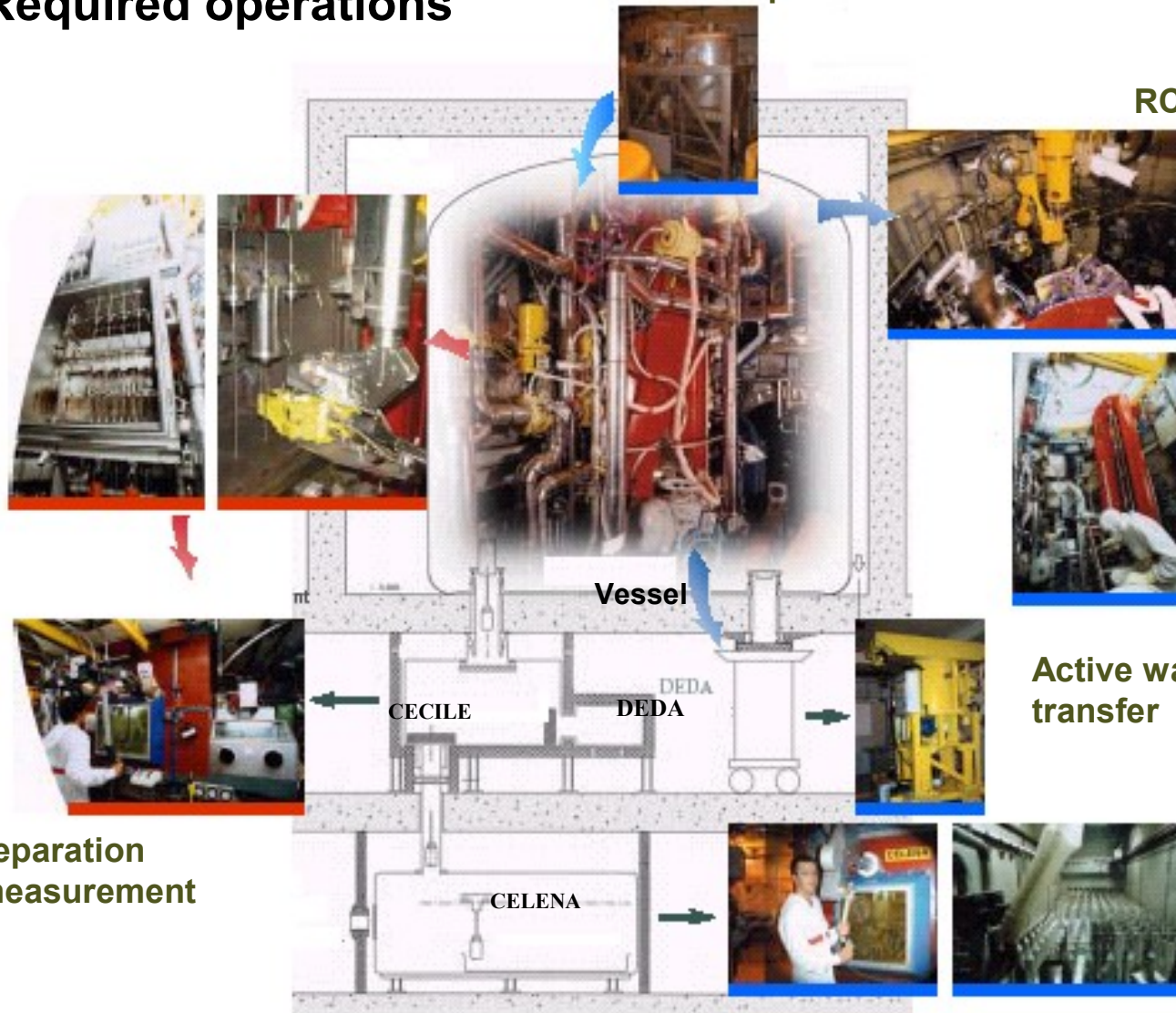
Final dismantling and clean-up

Active waste transfer

Samplings storage

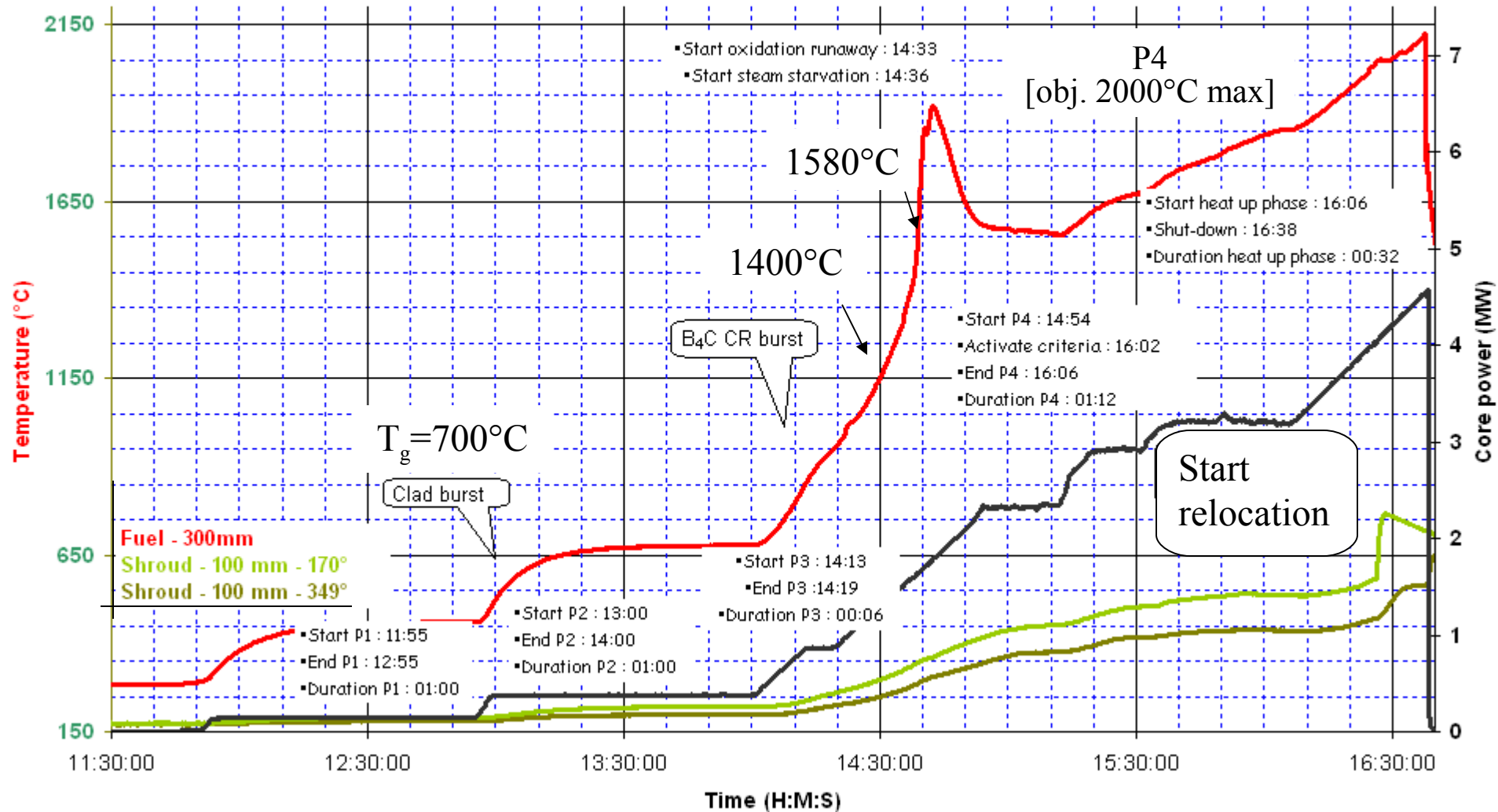
Sampling retrieval

Samplings preparation and gamma measurement



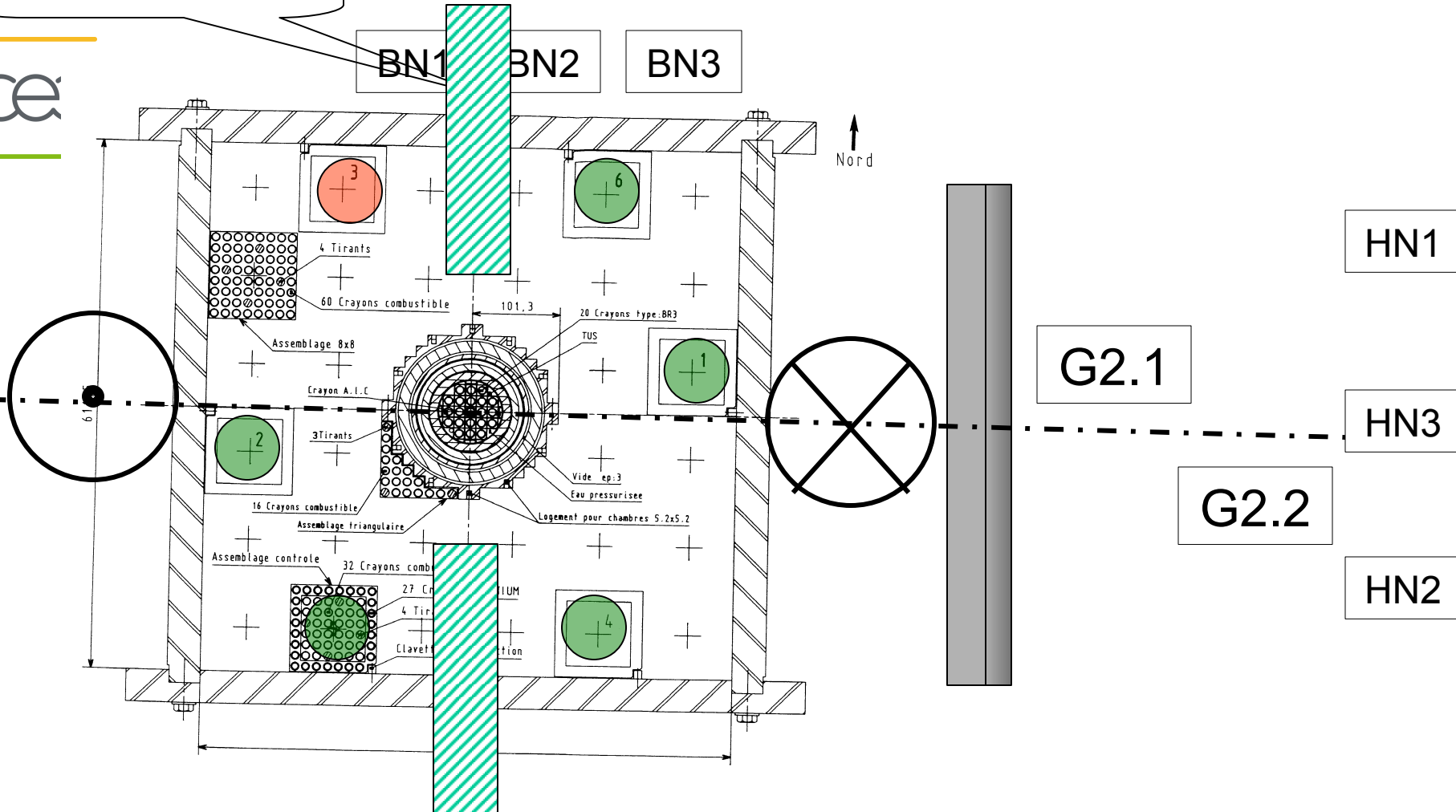
FPT3 main events

FPT3 Degradation phase (18/11/2004). General chronology

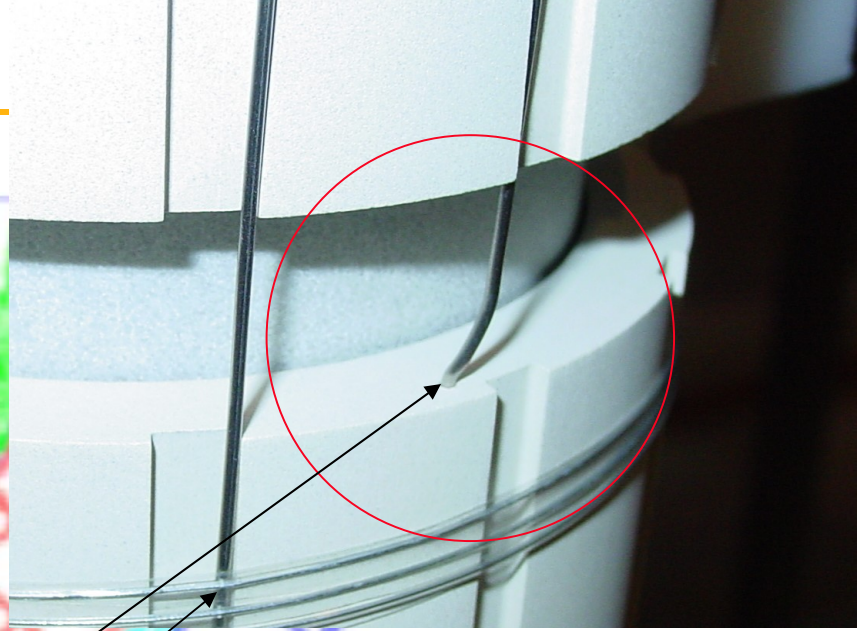
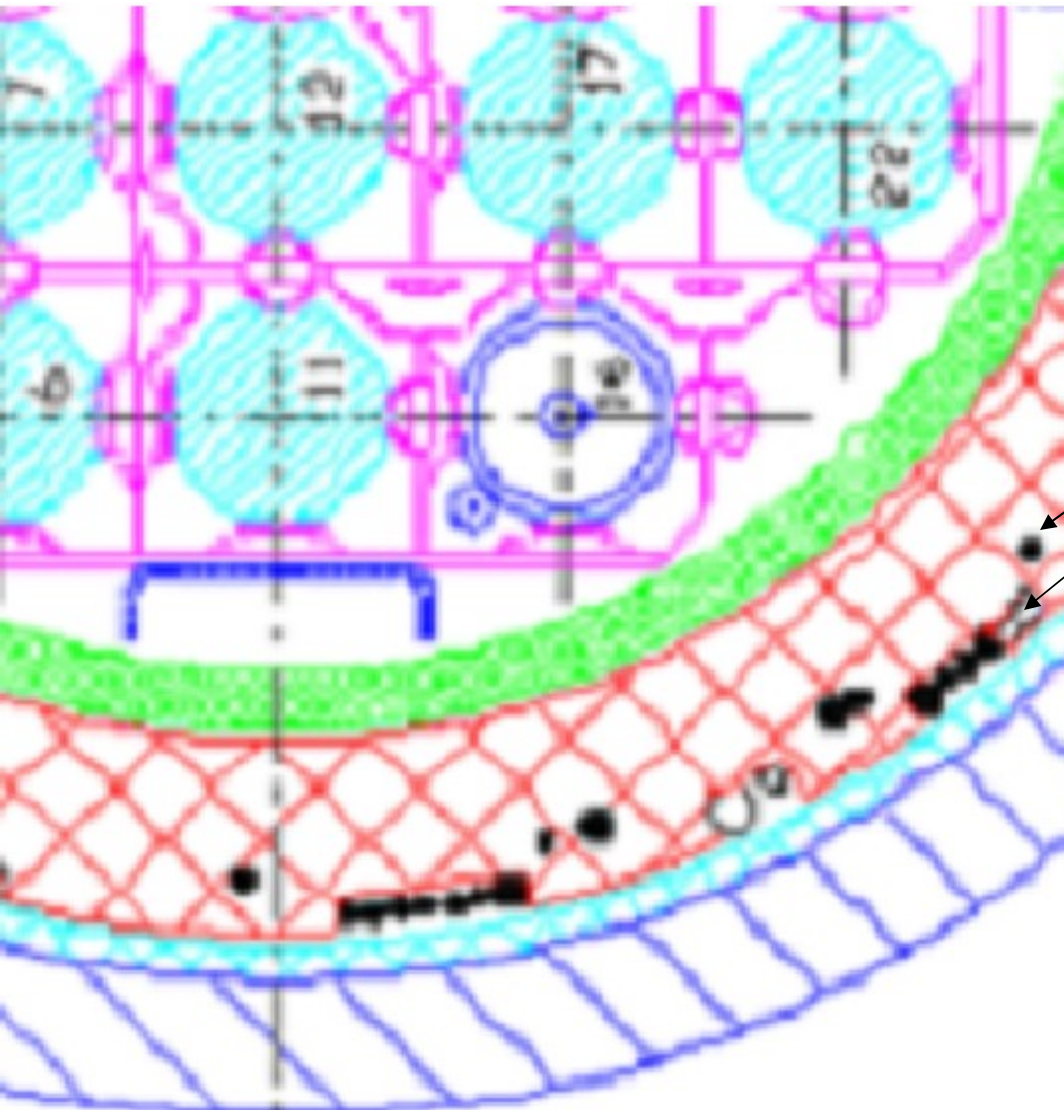


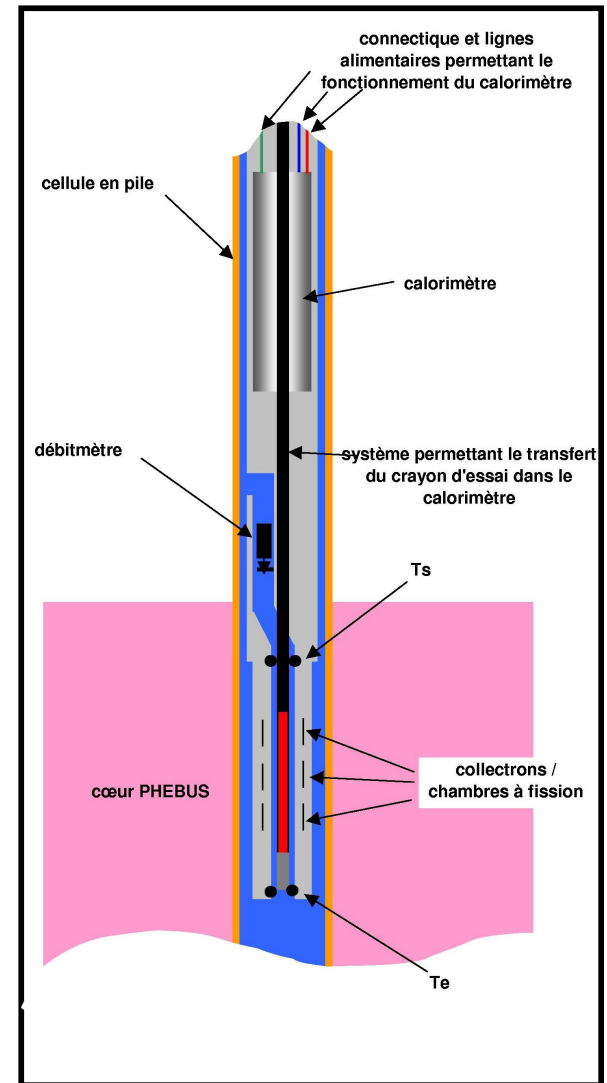
Bras anti envol

Pilotage dégradation sur 4 BCS



Instrumentation boîtier





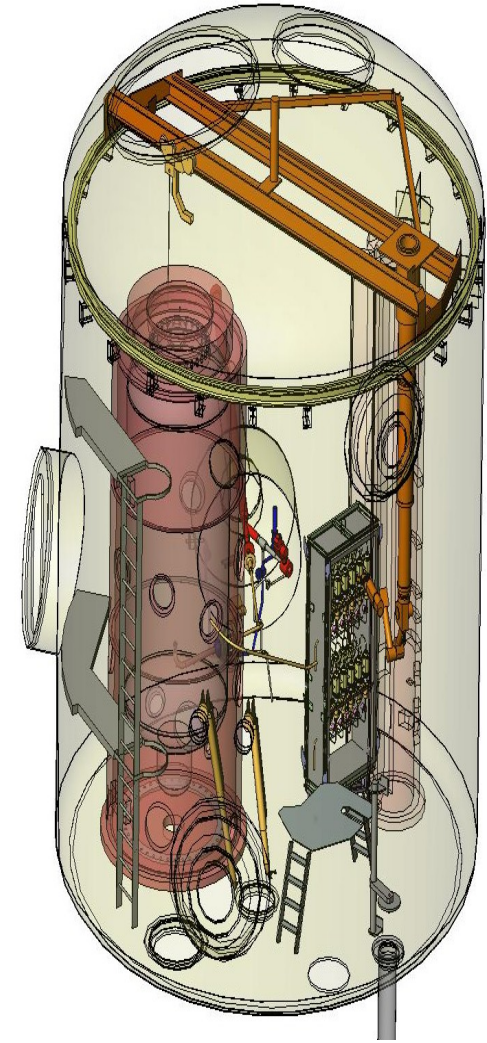
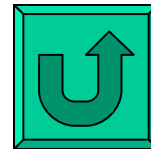


➤ STLOC Programme:

- ✓ Restricted experimental objectives
- ✓ PF LAB vessel required simplified manual interventions

➤ PHEBUS ST-LOC : The test matrix consists in five experiments

- ✓ 3 «FP» type
 - High Burn-Up (52 -->70 GWJ/T)
 - MOX
 - Quench
- ✓ 2 LOCA type (with irradiated fuel)
 - MOX and High Burn-up



➤ The PHEBUS FP lab also includes several equipment in order to deal with :



- Solid waste
 - They are transferred outside the vessel through a device assuming containment and radiological shield.
- Liquid waste
 - They are transferred out of the PHEBUS facility using a transport truck equipped with a double containment liner tank

