The place of EOLE, MINERVE and MASURCA facilities in the R&D activities of the CEA.

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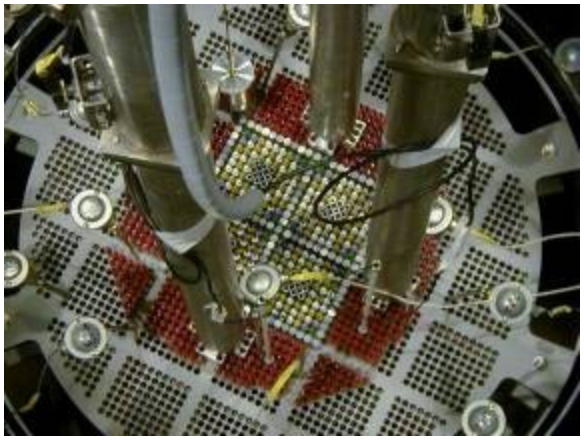
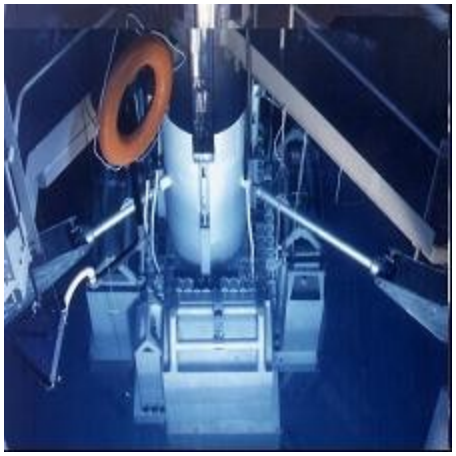
The EOLE, MINERVE and MASURCA Neutron Integral Experimental programs play an important role in the CEA research activities in :

- Pu utilisation in PWR and ABWR,
- support of french PWR and future EPR,
- waste incineration,
- physics of hybrid systems, involving a sub-critical reactor coupled with an external accelerator (ADS),
- new reactors (Jules Horowitz Reactor,..),
- new concepts of GEN-IV Forum with the Gas Cooled Reactor.



EOLE facility

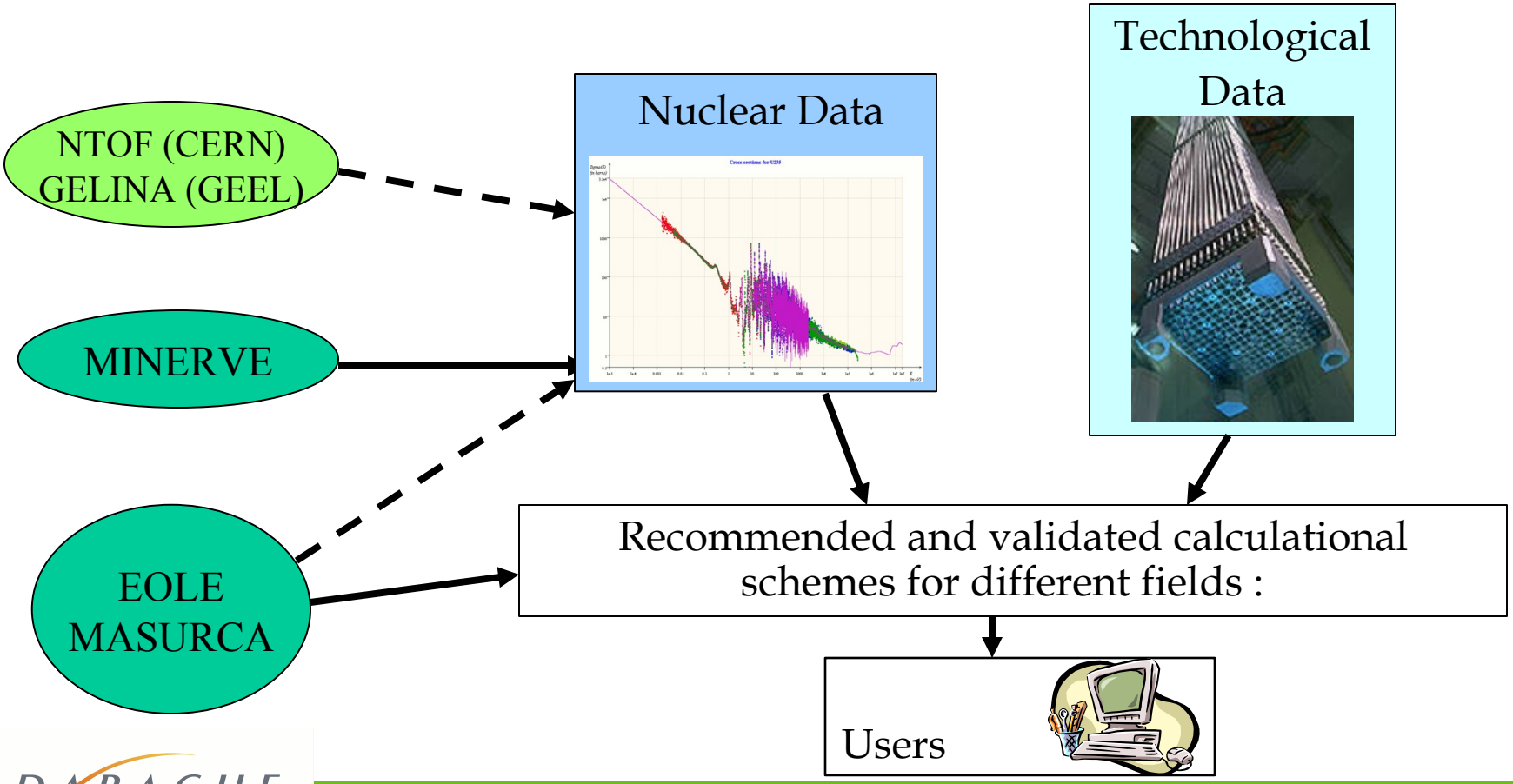


MINERVE facility

MASURCA facility

In particular, the critical facilities of the CEA Cadarache play an important part in the process of Neutron Physics Simulation through :

Validation of calculation schemes (codes and nuclear data)



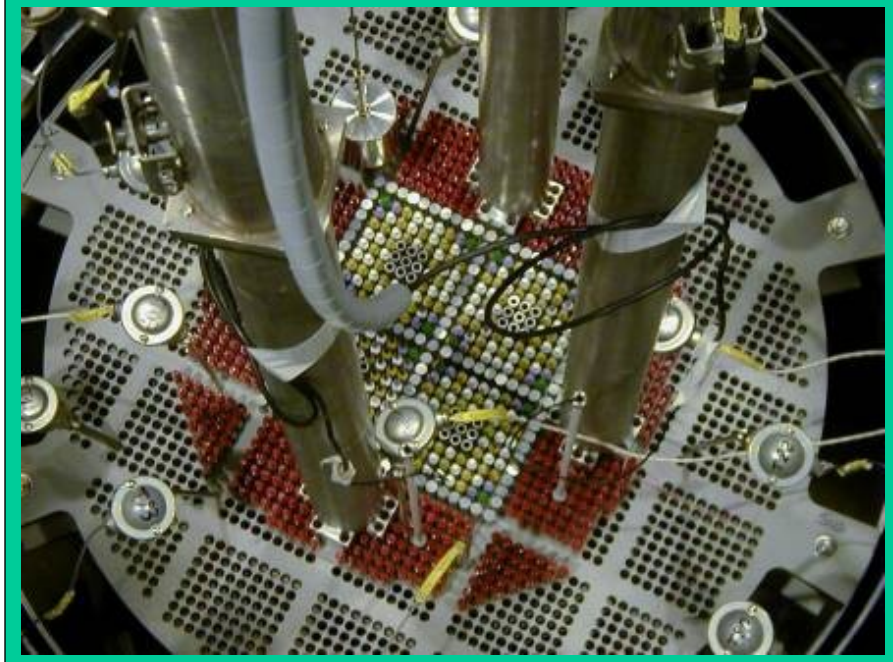
EOLE Facility

Dedicated to the neutronic studies of water moderated lattices, such as PWR or BWR ones.

(First criticality 1965)

In a concrete offering biological shielding for a flux level up to 10^9 neutrons/cm^2/sec in the core, EOLE is a pool type reactor composed of a cylindrical vessel of AG3 (diameter=2.3m and Height=3m) with an over structure of stainless steel able to contain various types of core and related structures.

The water circuit has been designed to control the volume, the composition (boron) and the temperature (5°C to 85°C) of the moderator.



FUBILA Reference mock-up for 100% MOX High burn Up BWR modelization

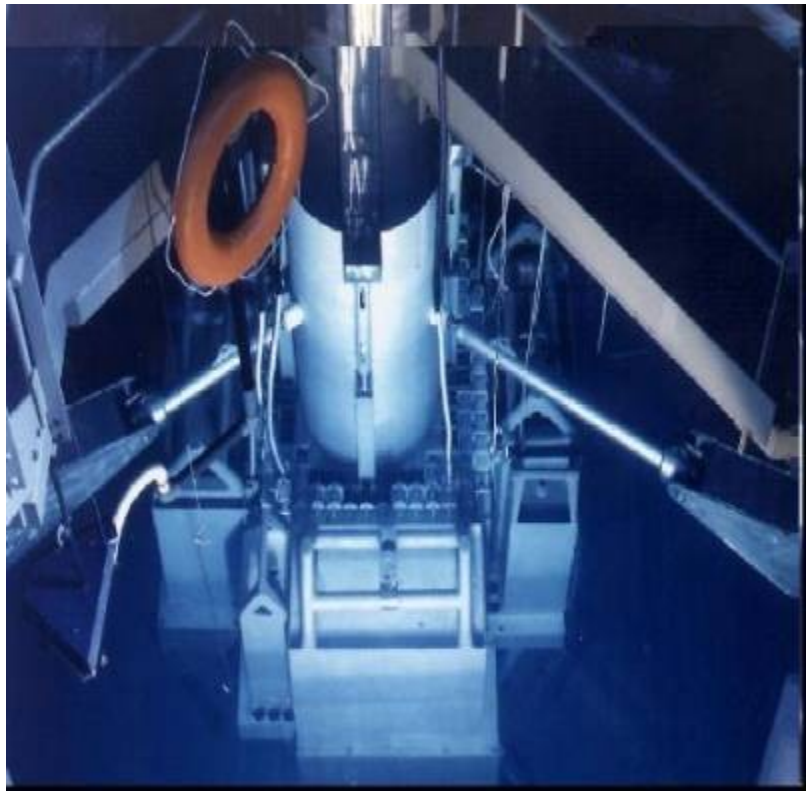
MINERVE Facility

Improvement of cross-section libraries for Fast and Thermal Reactors with Uranium or MOX fuels. (First criticality 1959)

MINERVE is a pool type reactor operating at a maximum power of 100 W.

The core is submerged under 3 meters of water and is used as a driver zone for the different experiments located in a central cavity with a size of about 70cm × 70cm.

Several lattices can be built in the central cavity, corresponding to different neutron spectra from water reactor and/or reprocessing plants (thermal or epithermal) to a fast reactor.



The refurbishment of the facility started in 2001 and was completed at the end of 2002.

MASURCA Facility

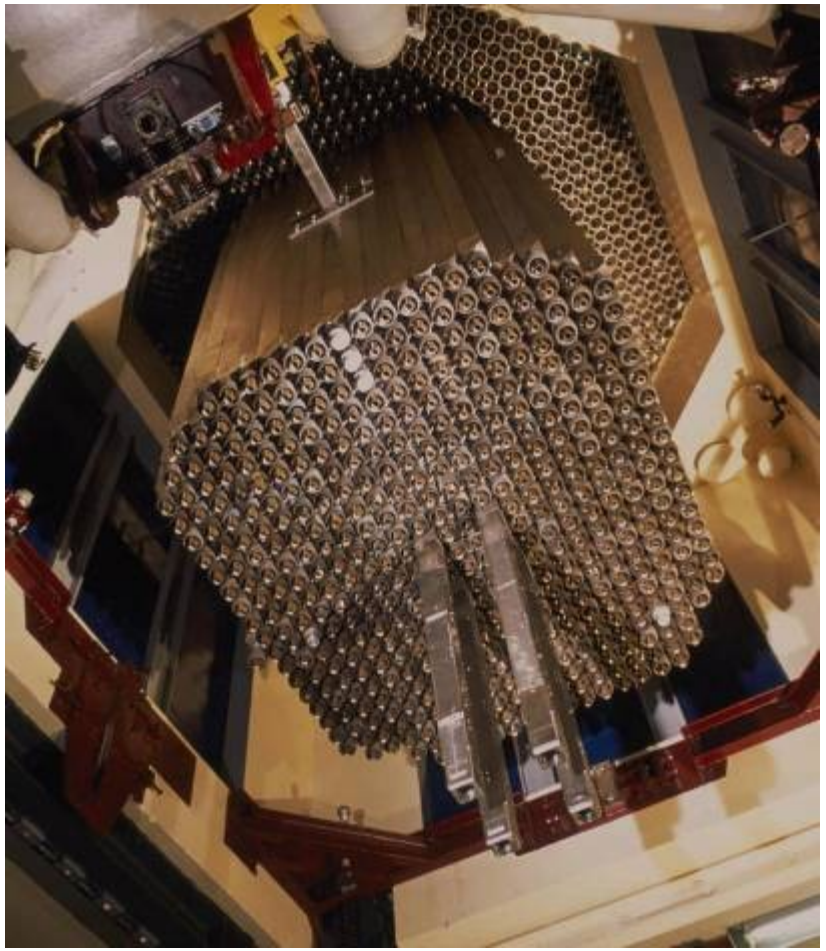
Dedicated to the neutronic studies of fast and semi-fast reactor lattices.

(First criticality 1966)

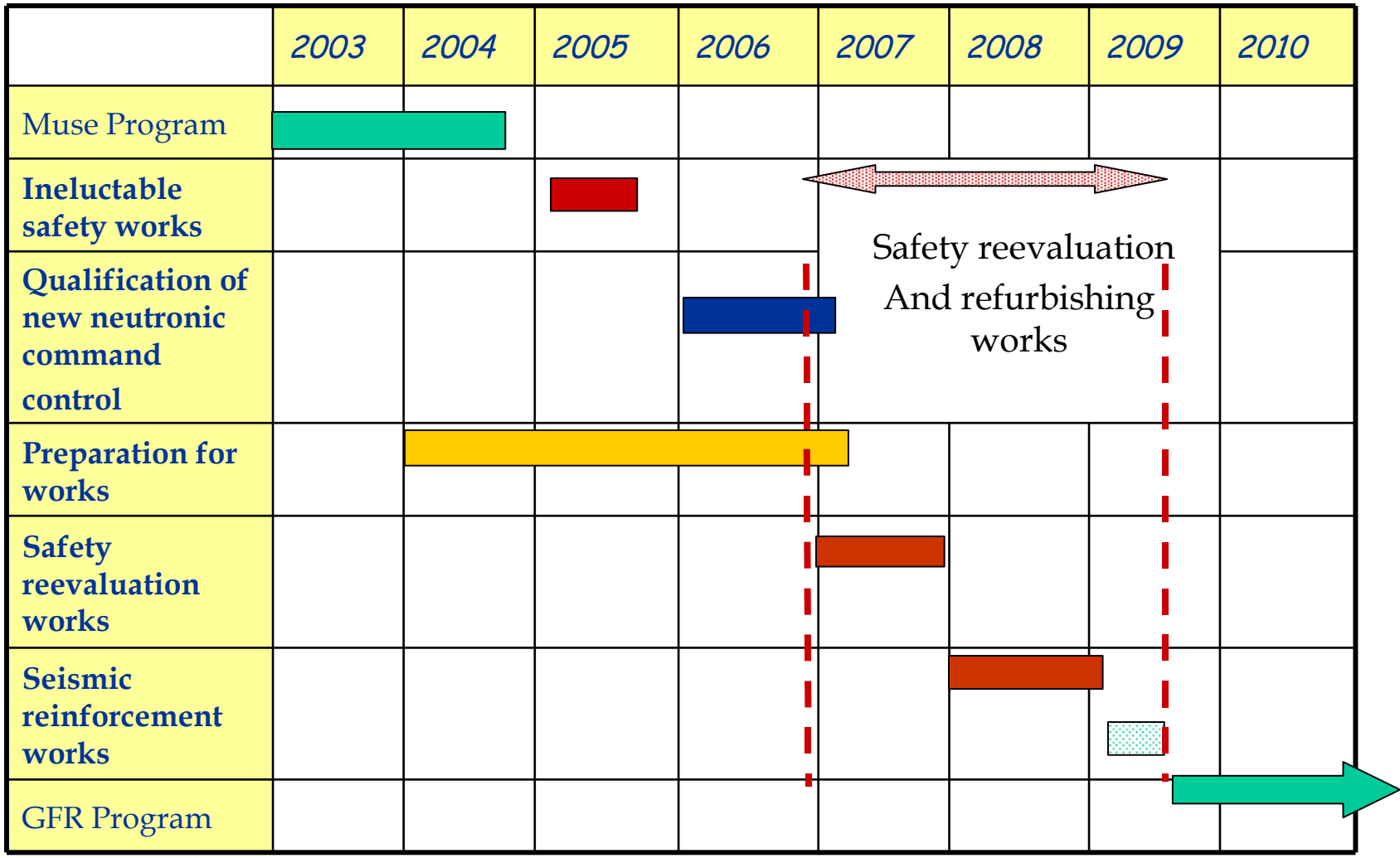
MASURCA is an airflow cooled fast reactor operating at a maximum power of 5kW.

The core has a volume of 6000 liters and is composed of 1000 hanged tubes loaded with pellets of steel, Na, fuel (U_5O_2-PuO_2 25%, or Pu metal) and media to be tested.

The refurbishment of the facility started in 2004 and will be completed at the end of 2009.



The MASURCA Schedule



Associated neutron experimental Programs :

- **main achieved programs,**
- **present programs,**
- **Perspectives,**

in the EOLE, MINERVE and MASURCA facilities.

EOLE : Study of MOX lattices for the PWR and the ABWR

1989-1995 : EPICURE : Validation of calculational schemes for 30% MOX load in french PWRs.

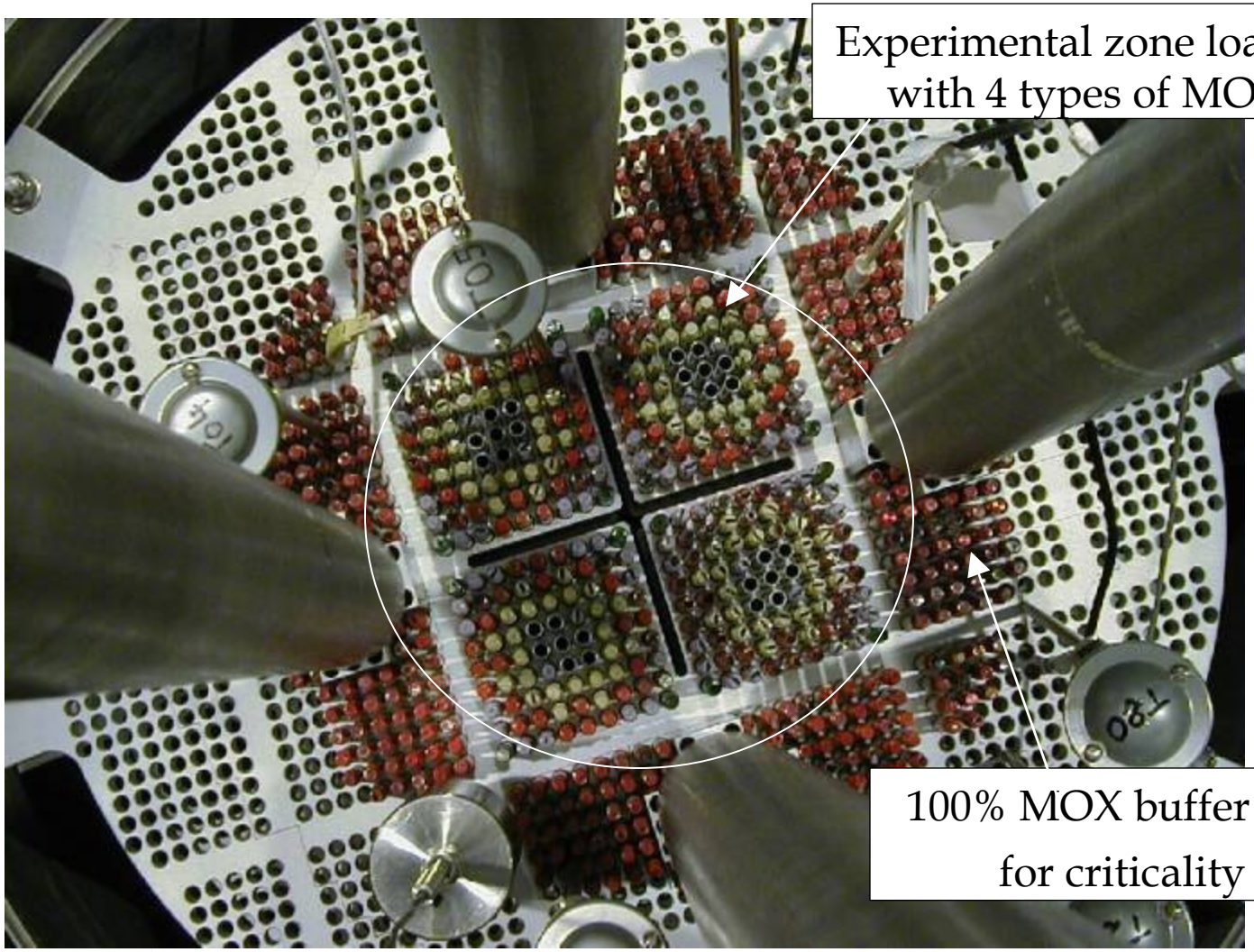
1996-2000 : MISTRAL : Experimental programme in support to French and Japanese Studies for 100% MOX cores in Advanced Light Water Reactor (ALWR). This program consisted of four specific core: three regular lattices (one UOX and two MOX) having a moderation ratio (H/HM) varying from 5 to 6, and a mock-up lattice (H/HM~6) simulating advanced 17×17-PWR assemblies (full MOX) were investigated.

Collaboration between NUPEC (NUclear Power Engineering Corporation), EDF, FRAMATOME.

2000-2002 : BASALA : Experimental programme in support to Japanese Studies for high moderated 100% MOX 9X9 ABWR (Advanced Boiling Water Reactor). Two experimental cores based on lattices simulating hot (287°C, void 40%) and cold (20°C and void 0%) conditions

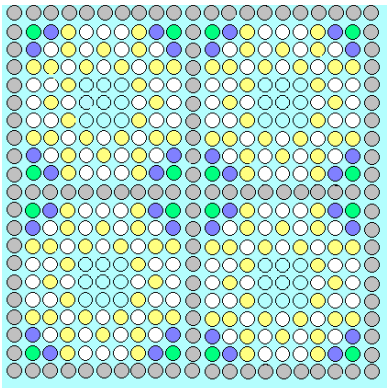
Collaboration between NUPEC et COGEMA.

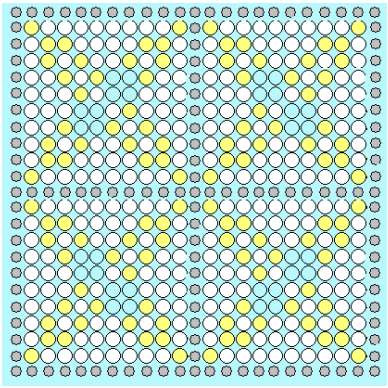
BASALA-C General view



The FUBILA program in EOLE

- **OBJECTIVES :** This program is a very important step for the licensing of the OHMA's 100% MOX ABWR Japanese Nuclear Power Plants. The FUBILA program consists of the simulation of 6 configurations of cores :
  - 4 heterogeneous sub-assemblies of 9×9 ABWR MOX fuel pins with a concentration of Pu varying from 3% to 12% with a MOX driven zone :
    - ✓ Reference core,
    - ✓ 2D Void 40%
    - ✓ 2D Void 70%,
    - ✓ Axial Void,
    - ✓ Naturel B4C control rod.
  - 4 heterogeneous sub-assemblies of 10×10 ABWR MOX fuel pins.
- **PARTNERS :** JNES (Japan).
- **PLANNING :** December 2004 to March 2006 with a possible extension.



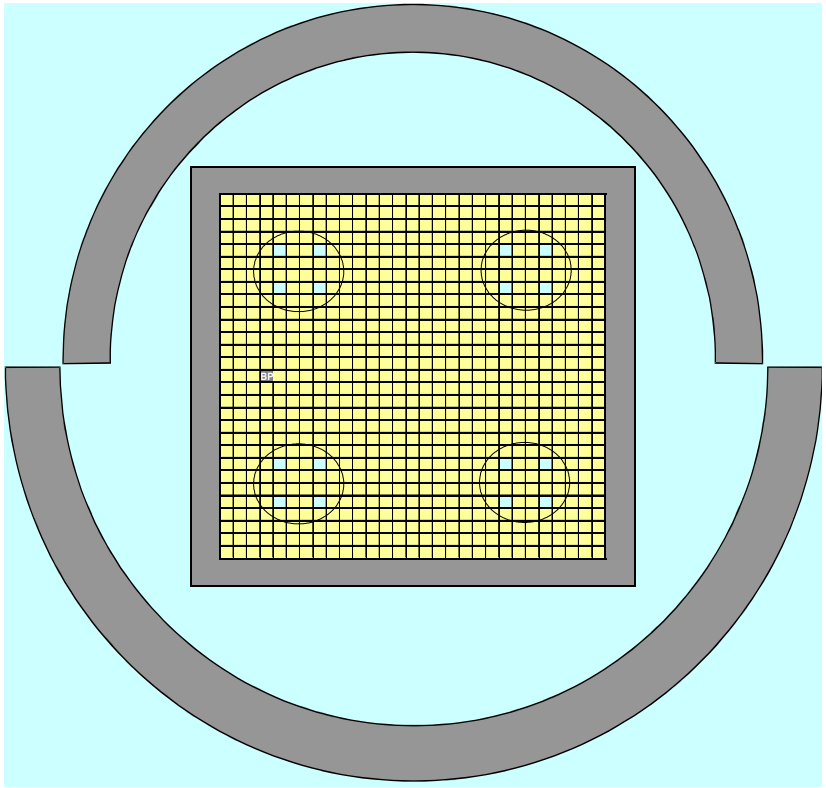


The FLUOLE program in EOLE

- **OBJECTIVES :** Studies of standard reflector, thermal shield for the 1300MWe PWRs.

The measurements will concern:
- the source characterisation of the core
- the neutron fluence characterisation through
  - ✓ Fission chambers
  - ✓ Activation detectors

- **PARTNERS :** EDF.
- **PLANNING :** 2006-2007.



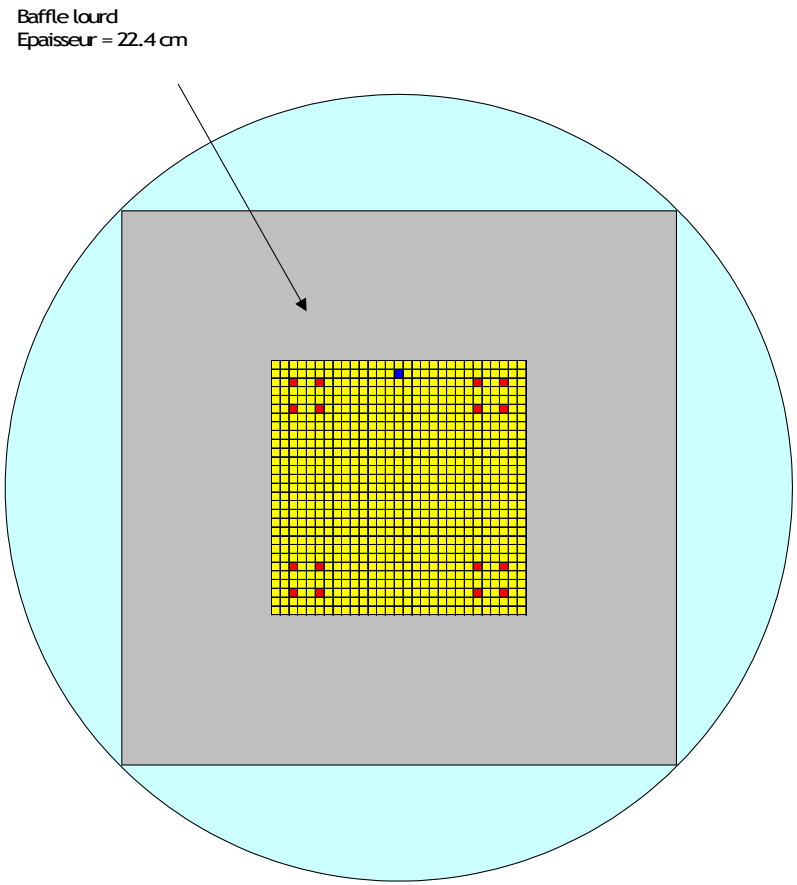
The PERLE Program in EOLE

- **OBJECTIVES :** Validation of calculation scheme for the future EPR and in particular the studies of standard and heavy reflectors.

The measurements will concern:

- the core characterisation
- the neutron propagation in the reflector
  - ✓ Fission chambers
  - ✓ Activation detectors
  - ✓ γ heating in the structures

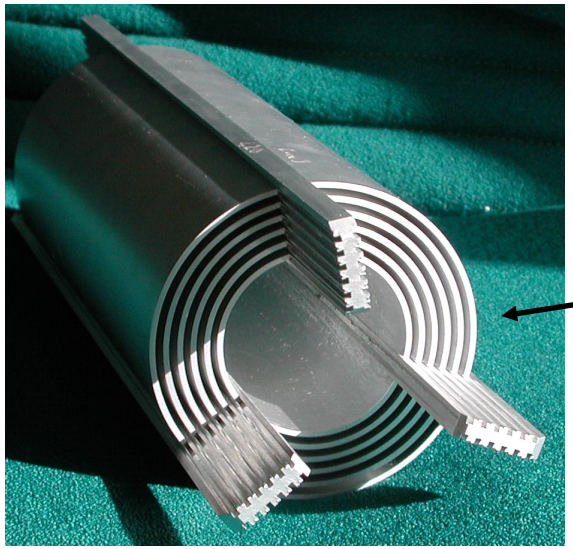
- **PARTNERS :** EDF,FRAMATOME.
- **PLANNING :** 2007.

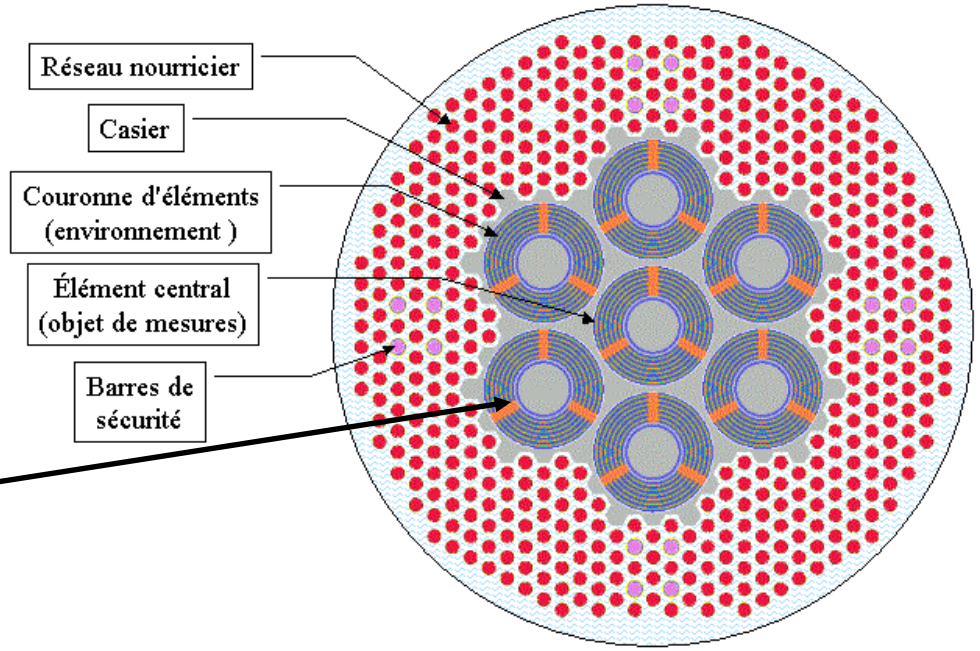


The AMMON program in EOLE

- **OBJECTIVES :** Experimental programme in support to the qualification of HORUS 3D Calculational scheme for the conception of the new MTR : Jules Horowitz Reactor at CEA Cadarache.

- **PARTNERS :** CEA
- **PLANNING :** 2008.





The main achieved programs in MINERVE

- From 1992 to February 2001 : The Burn up Credit program dedicated to the validation of the calculation tools taking into account the safety margin issued from the fifteen main long lived fission products of interest (80% of the total poisoning from FP) in the criticality studies.

- From March 2003 to september 2004 : The High Burn Up Program Reactivity loss per cycle of :

  spent UOX-PWR fuel samples (from 50 to 75 GWd/t).

  spent MOX-PWR fuel samples (from 10 to 55 GWd/t).

- From November 2003 to March 2004 : the VALMONT program for the Validation of capture cross sections of UMoAl fuels in thermal and epithermal spectra (UO_2 and MOX) : qualification of HORUS 3D code system.

The Poisons and New Absorbers Program in MINERVE : the OCEAN program.

- **OBJECTIVES :** Validation of capture cross sections of separated isotopes in thermal and epithermal spectra (UO_2 and MOX):
  - $^{155, 157}$Gd,Gd nat, ^{177,178,179,180}Hf, ^{166,167,168,170}Er,
  - ^{160,161,162,163,164}Dy, ^{151,153}Eu, Eu nat.
- **PARTNERS :** EDF (France), FRAMATOME (France), DoE (US).
- **PLANNING :** October 2004 to december 2005 for the R1-UO_2 Configuration and 2006-2007 for the R1-MOX Configuration.

The OSMOSE Program in MINERVE

- **OBJECTIVES :**the knowledge of the integral absorption cross sections of the heavy isotopes : Th, U, Np, Pu, Am, Cm in a large range of neutron spectra (solvent, PWR UO_2 and MOX, Epithermal and Fast).

  - knowledge on the integral absorption cross sections in the frame of the evaluation of the JEFF3 data file used for core calculations.
  - extend the validity domain of the criticality calculation tools.
  - knowledge of the integral absorption cross sections in the frame of the transmutation and the incineration of minor actinides.
  - extend the validity domain of the calculation tools for the determination of the main parameters (activity, decay heat, irradiation sources) related to the storage of irradiated fuels and waste.

- **PARTNERS :** EDF (France), COGEMA (France), DOE (US)
- **PLANNING :** June 2005 to December 2012 ?

The Program in MASURCA

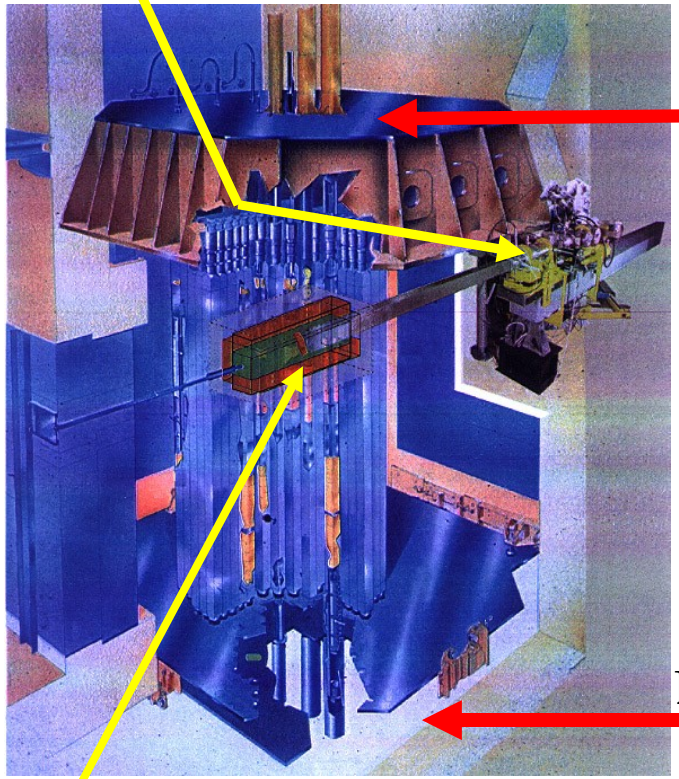
- Since its start-up, the MASURCA facility has provided an important contribution to the development of the core calculation schemes used for the design of Fast Power reactor. MASURCA is a remarkable tool for the validation of experimental techniques; lot of determination used for SUPERPHENIX were tested during the RACINE (1978-1984), the BALZAC (1986-1994) and the CONRAD programmes
- 1994: The BERENICE program was an important experimental benchmark on the βeff determination.
- 1994-1997: The CIRANO program was performed hencing the CAPRA project (plutonium burning cores).
- 1998-1999: The COSMO program for the design of the moderated subassemblies considered for the ECRIX irradiations

The MUSE experimental program for ADS studies in MASURCA

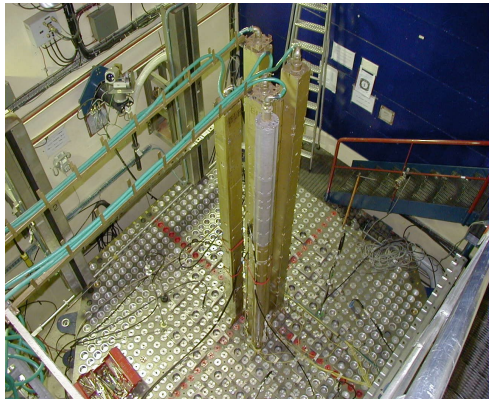
- **OBJECTIVES :** The MUSE (MUltiplication with External Source) program aims at qualifiying experimentally the main physical principles of ADS (Accelerator Driven system) and the associated calculation schemes through mock-up studies of the sub-critical environments coupled to a well-known source of external neutrons (simulation of the spallation source with the GENEPI Accelerator).

  Measurement of fundamental parameter (static and dynamic methods for determination of reactivity level, delayed neutron fraction, radial and axial flux distribution, spectrum indices…)
- **PARTNERS :** CNRS (France), EDF (France), COGEMA (France), FRAMATOME (France), DOE (US), PSI (Switzerland), JAERI (Japan), 5th ECFWP.
- **PLANNING :** January 1995 to august 2004

GENEPI : pulsed neutron generator



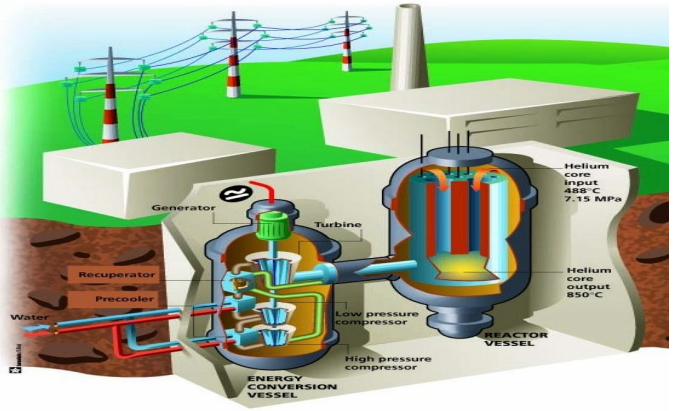
Upper view



Bottom view

The « ENIGMA » Program in MASURCA

- **OBJECTIVES :** Experimental program in support to the physical studies for the development of future system in the framework of GENERATION - IV Forum. This program will consist in two distinct cores:
  - Gaz Cooled Fast Reactor : RCG-R
  - Study and Technological Development Reactor : REDT



- **PARTNERS :** GENERATION IV Forum
- **PLANNING :** 2009 to 2015

Conclusions

The critical facilities of the CEA Cadarache :

- play an essential role to validate plutonium and waste management in existing and future power plants,
- allow to reduce the uncertainties associated to the prediction of most of the new core concept parameters,
- obtain a very large and accurate experimental database for nuclides arising in plutonium and waste management (heavy nuclides, and long lived fission products),
- explore innovative systems and new concepts in terms of new materials and/or fuel designs.