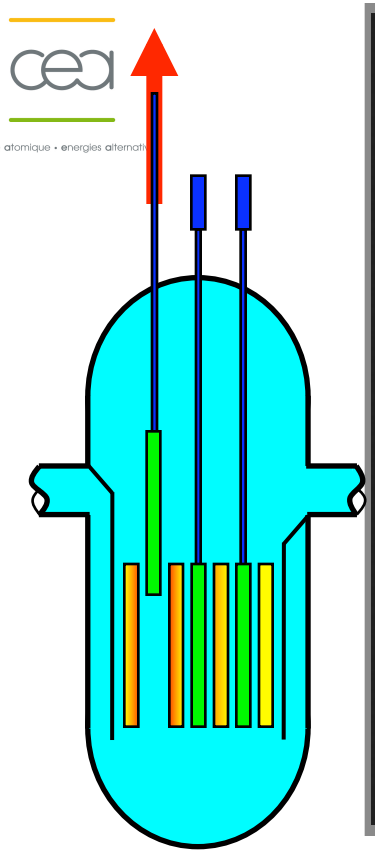
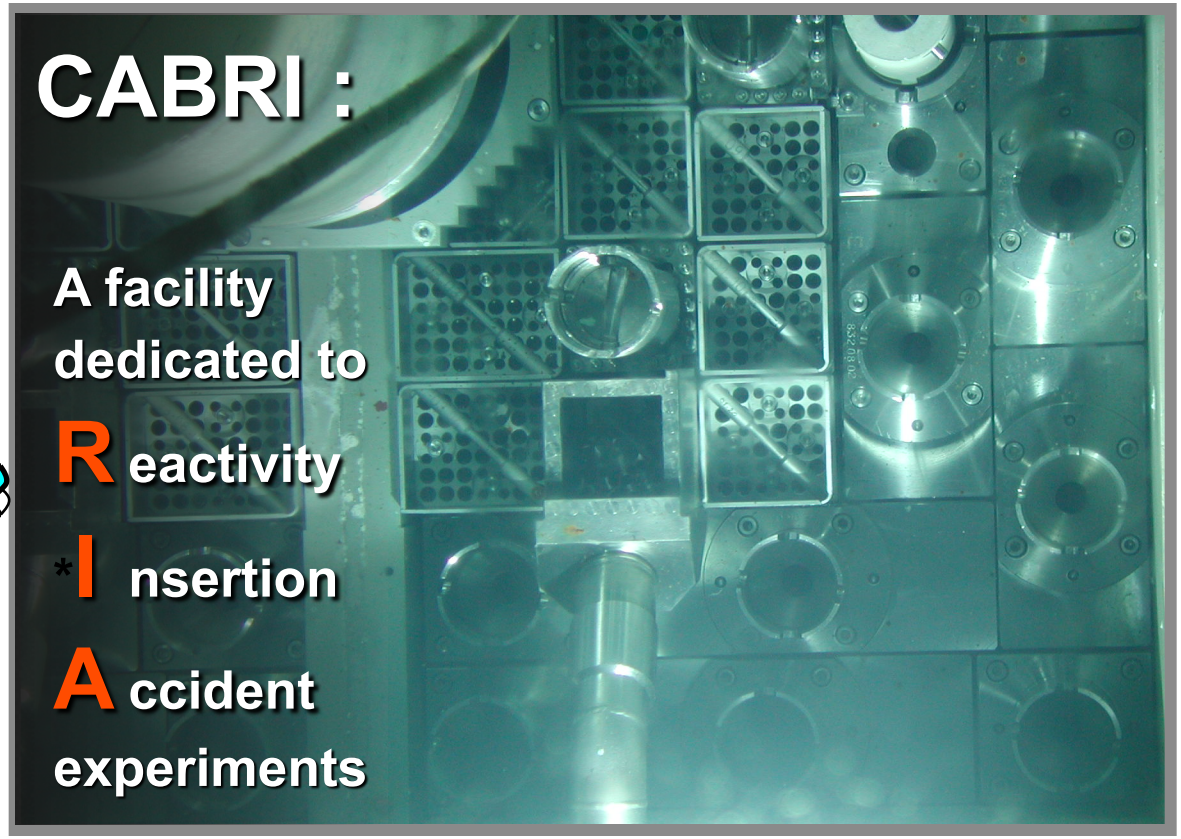
Neutron commissioning in the CABRI Water Loop Facility





G. Ritter,
F. Rodiac,
D. Beretz,
Ch. Jammes,
O. Guéton,

CEA

Nuclear Energy Division
Cadarache Nuclear Research Center
Reactor Studies Department

FRANCE

Upgrading the CABRI facility : Safety + Improvement issues

Construction seismic retrofit
Fire protection
Core Structures strengthening
New ventilation
Core Safety Case
Mechanical Equipments strengthening
Storage Building

Feed core and cooling circuit

Hodoscope

Replacing a major heat exchanger
Inspecting and fixing
Vessels and capacities
Safety brake on the crane
Handling cask
^{3}He circuit
Primary circuit renewal
New Water treatment station
Liquid waste circuit

1488 Fuel rods
- UO_2 (6% ^{235}U)
- Clad : Stainless steel
- Fissile region : 60x60x80cm

Test rod

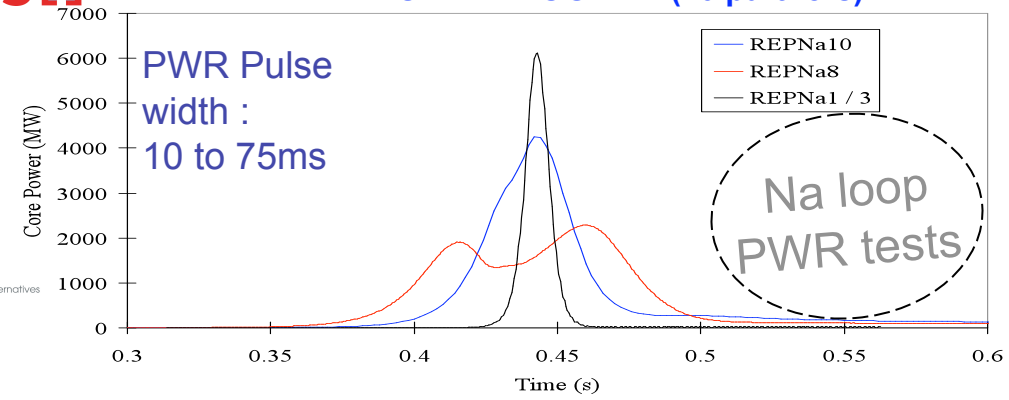
Pressurized Water Loop

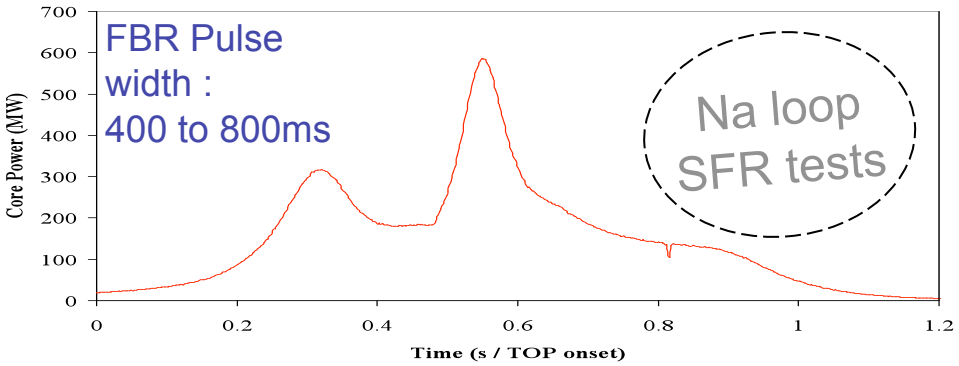
(off core components)

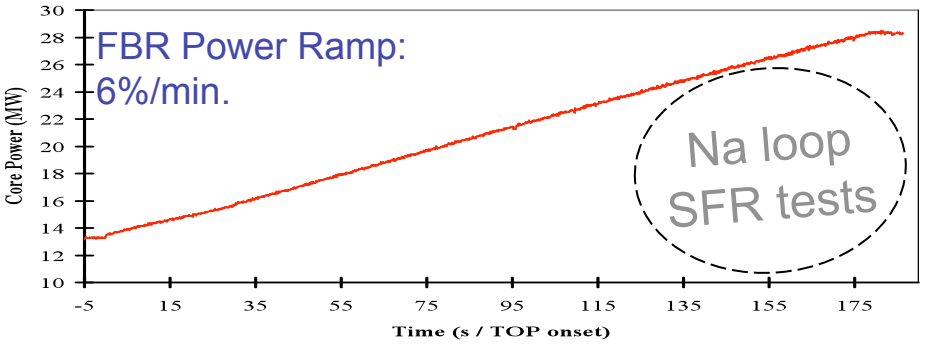
Seismic retrofit

CABRI + Project : From sodium to HP water cooling

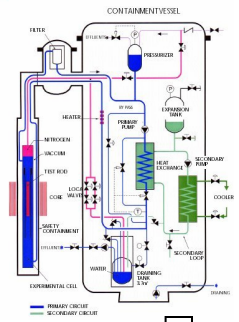
IRSN : CABRI INTERNATIONAL PROGRAM (20 partners)



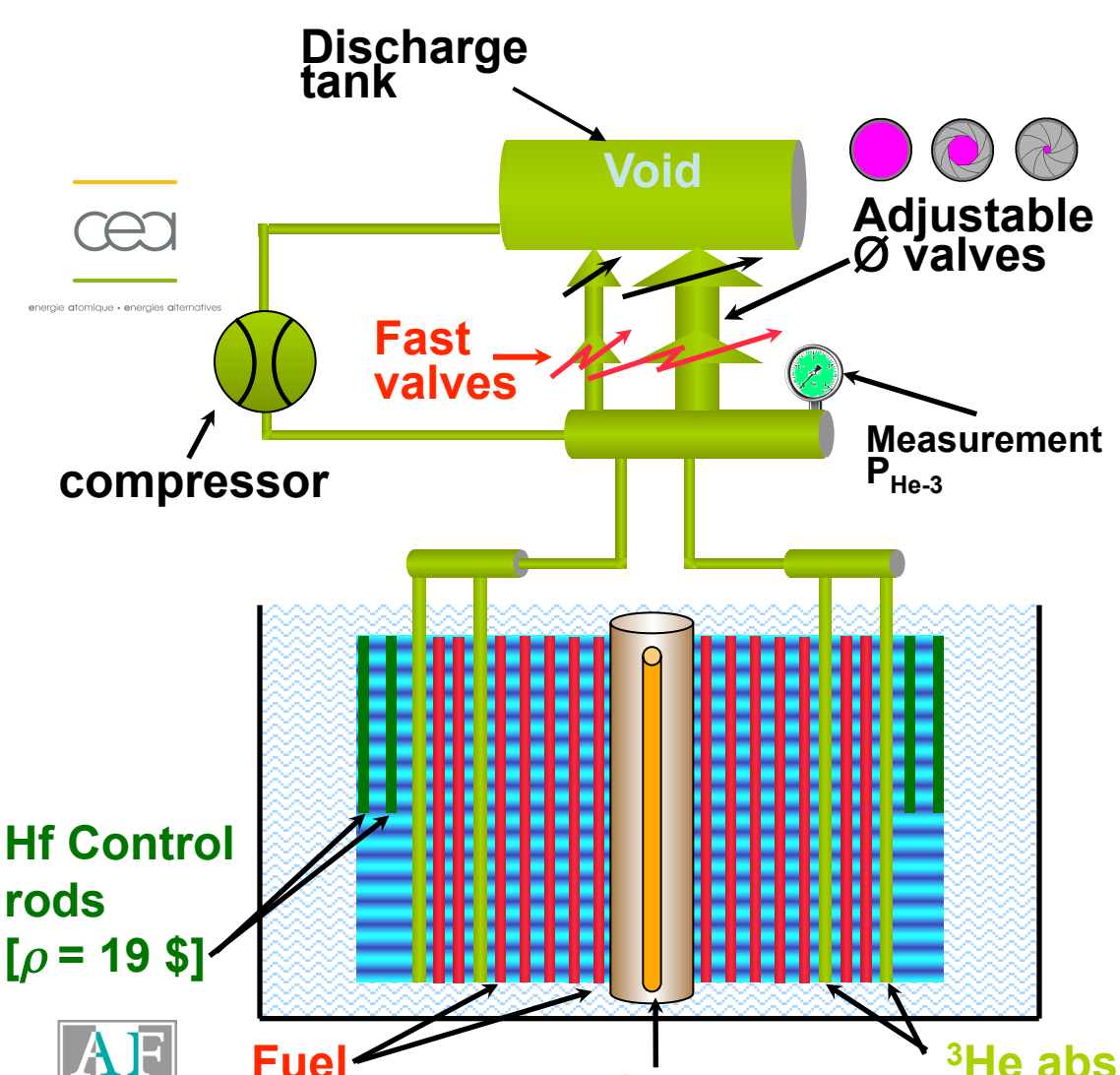


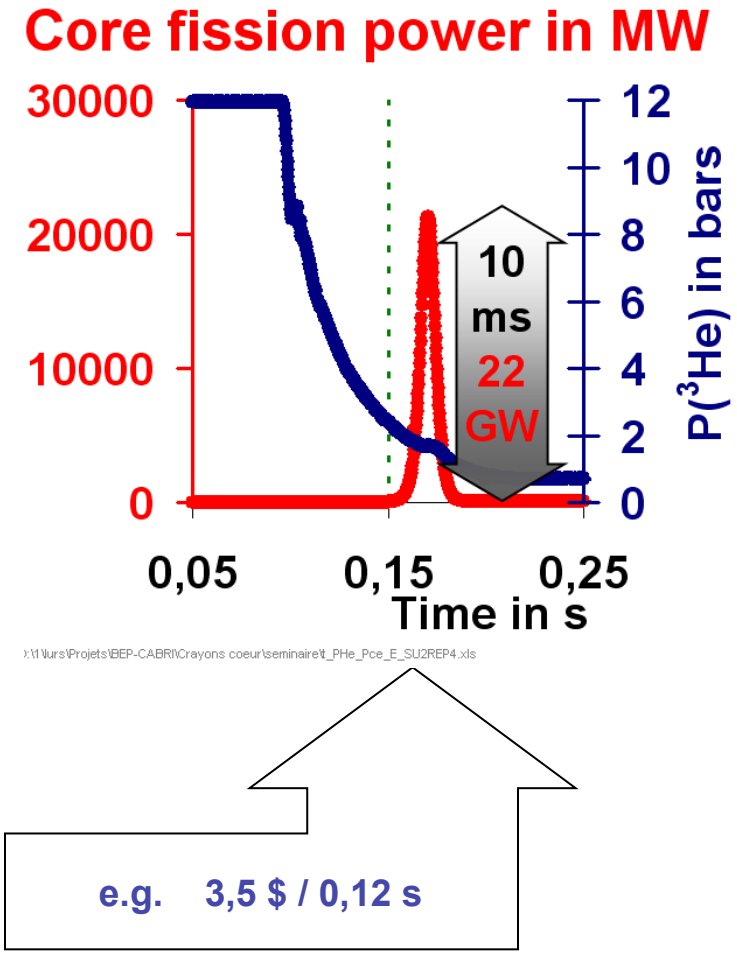


- 3rd generation requirements
  - **PWR Representativity**
  - **Test rod post failure analysis**
  - **Testing new fuels (HBU)**
  - **Safety margins re-assessment**



CABRI principle of operation

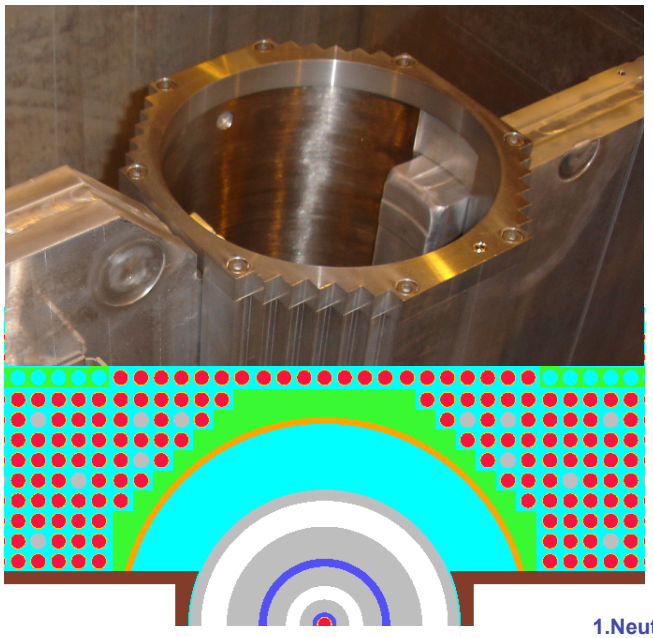




Neutron commissioning : What needs ?

Objectives

- Safety of operations
  - •A new core ?
- Quality of experiments
  - •What parameters ?



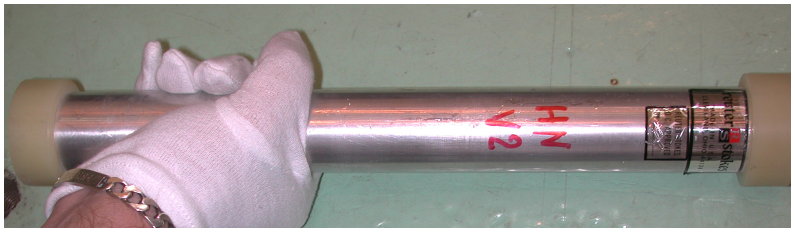
Reactivity features

- Hafnium rods worth
  - •Integral
  - •Differential
- ^{3}He rods worth
- Central volumes filling/voiding worth
- Core kinetics parameters β,l, neutron feedbacks

1.Neutron physics
2.Air conditionning and buildings
3.Reactor Containment
4.Handling and Lifting
5.A : Conventional circuits
10.B : Special circuits
11.Command and Control
12.General operations and Power testing
13.Experimental devices

Power and Energy features

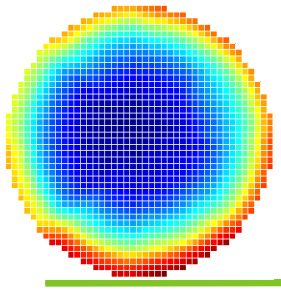
- Ion chambers calibration
- Power distribution

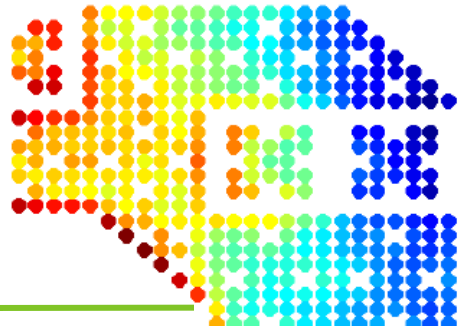


Computations : Steady state

- Almost new fuel (2,3 EFPD BU) + No durable high power operation
  - •No need for depletion computation.
- Full 3D *TRIPOLI 4* Monte-Carlo neutron + γ transport
  - •Flux and reaction rates ➔ Space and energy distributions
    - •Rodwise peaking factors, Coupling, Dosimetry, γ heating
  - •Reactivities
    - •^{3}He capture : $\rho(P_{He-3})$
    - •Neutron feedbacks : Doppler, Isothermal, Coolant Flow coefficients

- MCNP w JEFF3.1 nuclear data library,
  - •kinetics parameters : β =756 pcm, l = 29,2 µs, $K_{Doppler}$=136 cts/$K^{0,5}$





3D TRIPOLI 4 MC
Power distribution

Computations : Transients

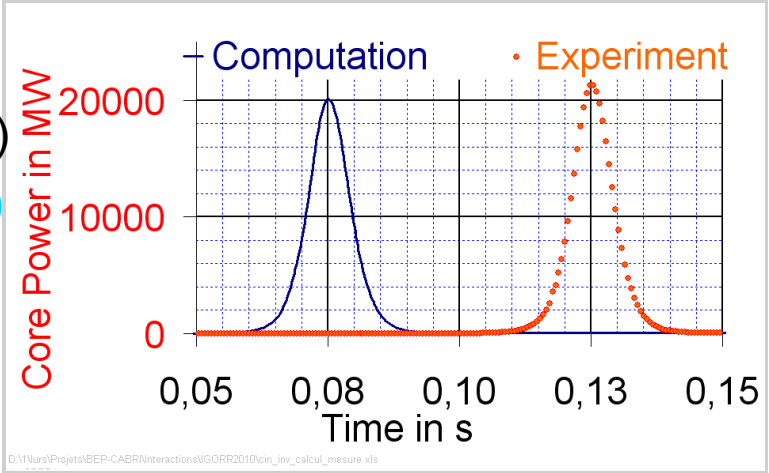
- RIA conditions

IRSN SCANAIR (Heat transfer + Mechanics)

•Operations domain (T_{clad}, T_{fuel}, ε_{clad})

DULCINEE (reactor kinetics)

•Reactivity, Power, Energy.



40 Years experience tool for CABRI pulse characterizations (fortran 77)

- •Rod bundle + Plate geometry (1 radial D + ½ axial D)
- •Water + sodium coolant, Fractured fuel model available
- •3 steps ↺ : ⌞ Temperature – Reactivity – Power ⌟

Validation : CAPRI TH + CABRI CC reactor experiments

Ideal agreement on steady state

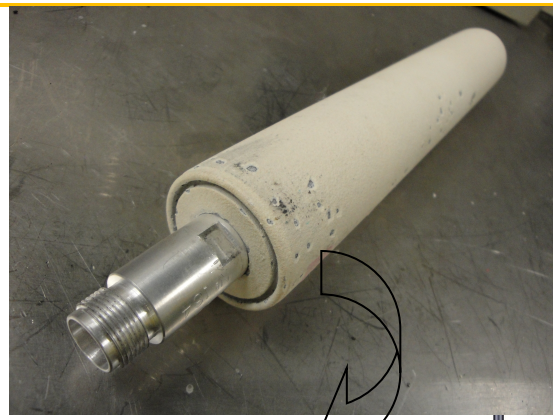
Very good agreement in transient conditions

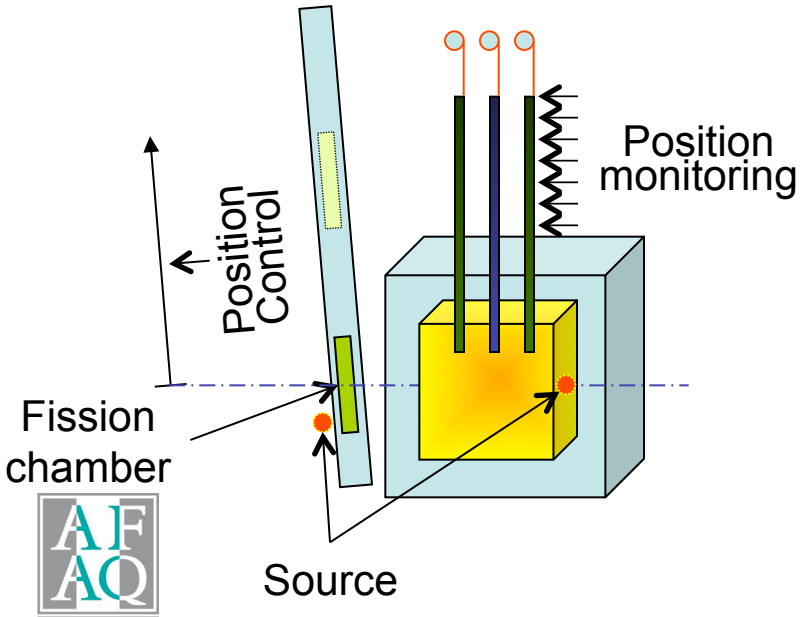
Current status : kinetics parameters re visited and validated in 2008

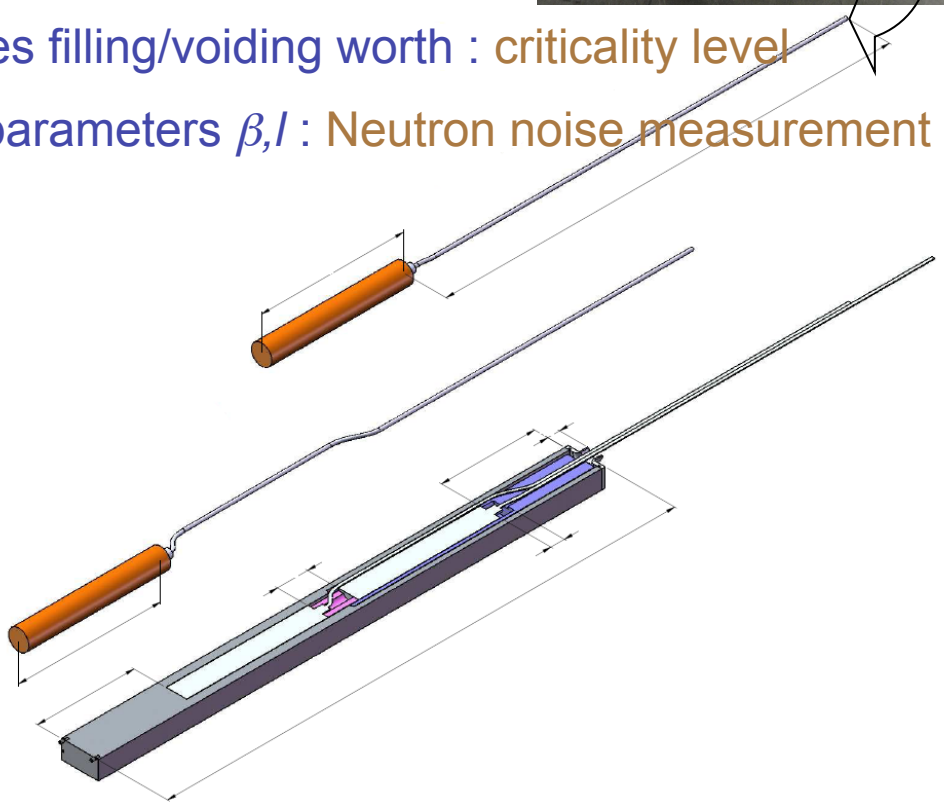
New smart data processing + user interface

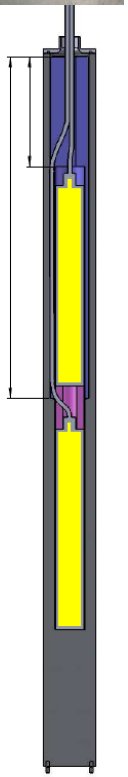
Reactivity measurements

- Hafnium rods worth : criticality level
  - Integral : MSA ($\rho \times N$ = Constant)
  - Differential : kinetics approach
  - Time wise : Position during the fall
- ^{3}He rods worth : criticality level
- Central volumes filling/voiding worth : criticality level
- Core kinetics parameters β, l : Neutron noise measurement

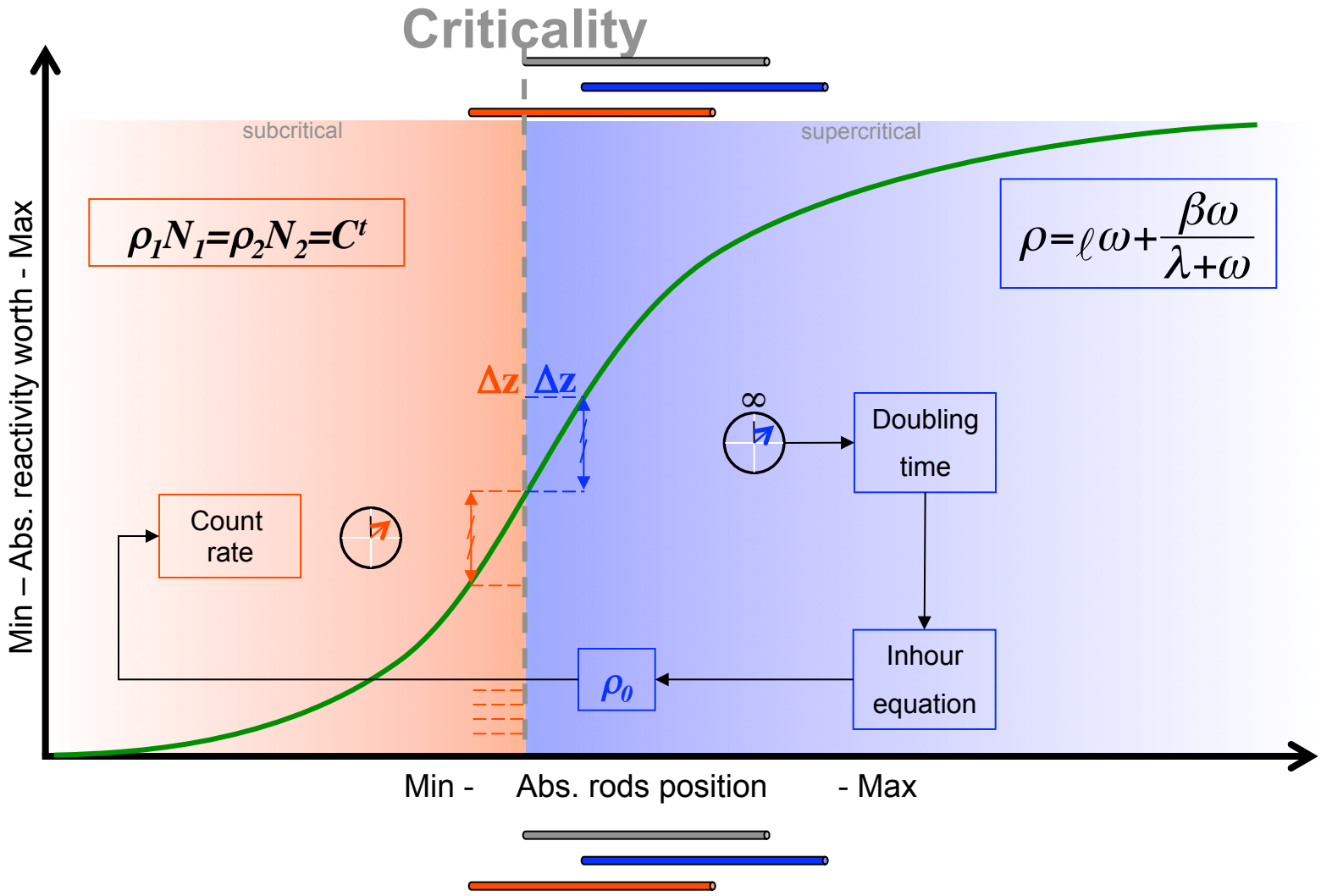






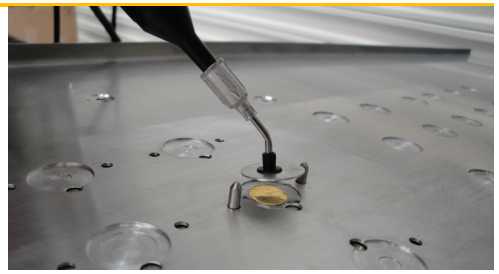


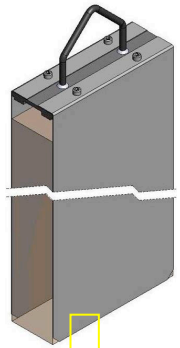
Reactivity standard

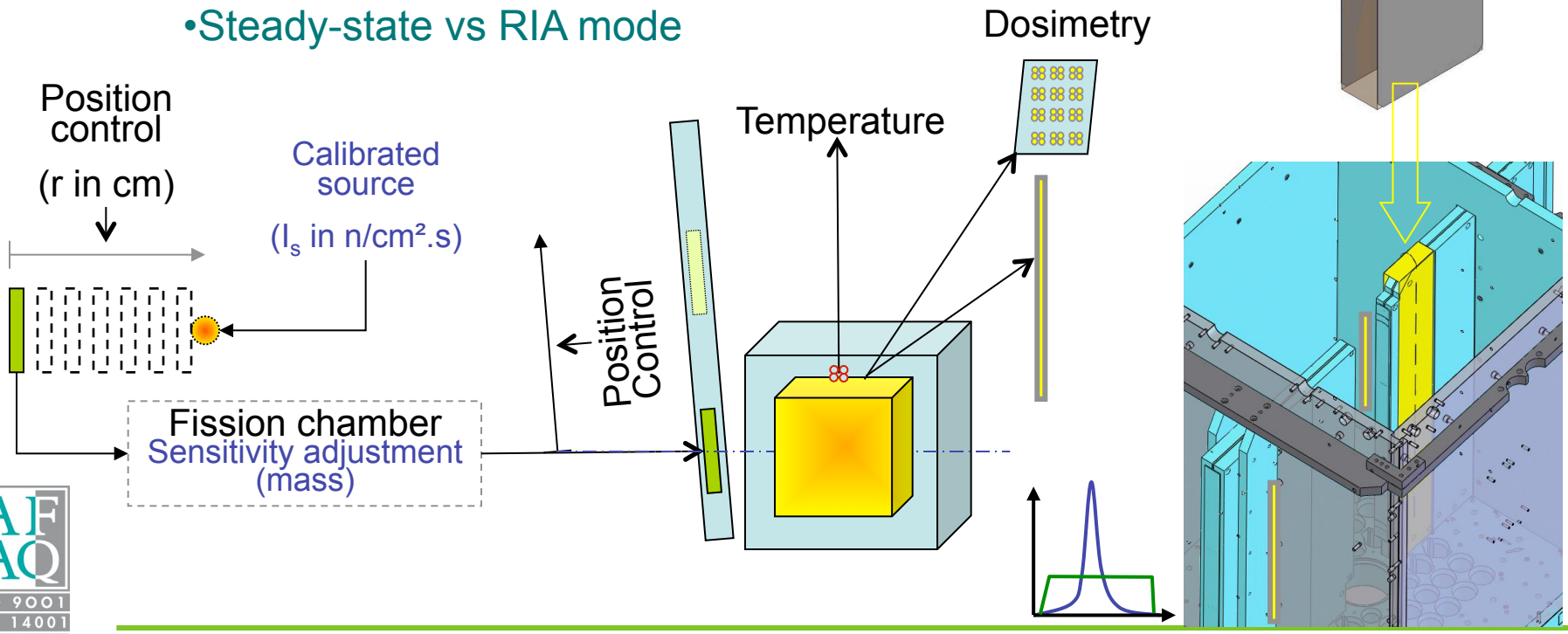


Power and Energy Measurements

- Ion chambers calibration
  - Start up : Count rate vs Design (Computed)
  - High power : Heat balance vs Count rates
- Power distribution dosimetry
  - Start up : across core power distribution
  - Coupling with experimental area
- Energy dosimetry
  - Steady-state vs RIA mode







What Plan For Neutron Commissioning ?

Before criticality : reloading the core

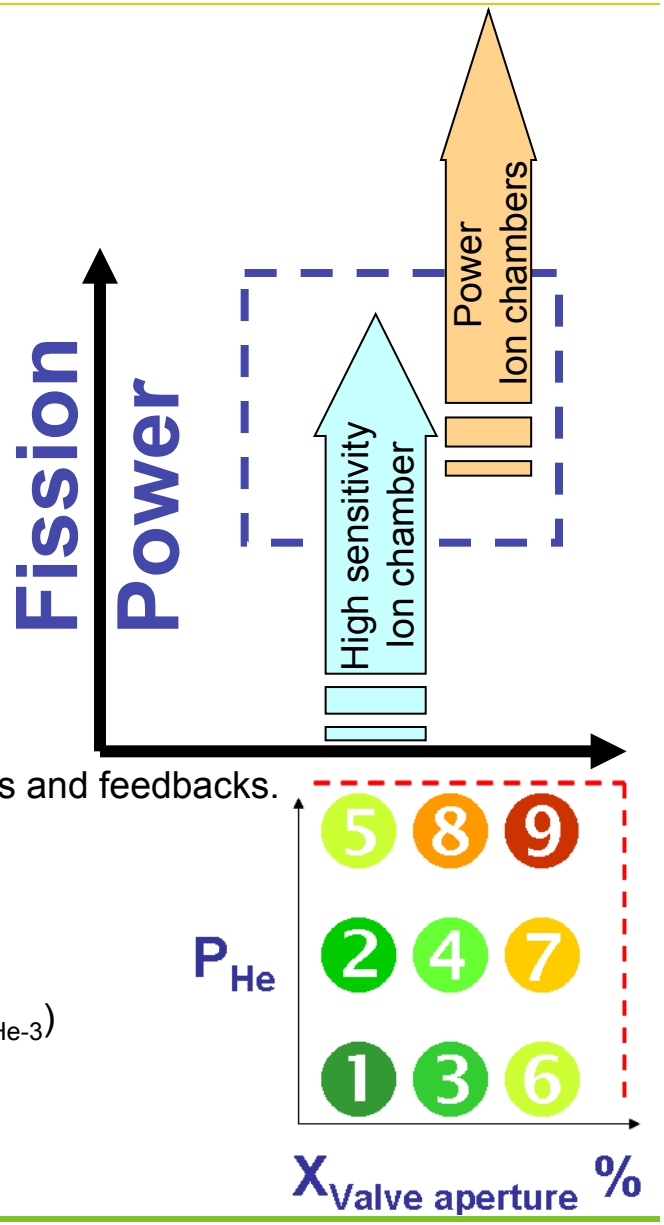
- Initial loading scheme (except 4 hot rods)
- Count rate at beginning of reloading
- Positioning low fluence dosimeters before the fuel
- Installing absorbers before other sub / assemblies

Reaching criticality

- Count rates according to the upcoming subcriticality level
  - Approaching overall core fission power
  - Initial control rods level vs several count rates or
  - Several control rods level at criticality
- After first criticality
  - Extract the dosimeter for counting
  - Measuring kinetics parameters β,λ
  - Weighting rods worth, central volumes contributions and feedbacks.

Power operations

- ^{3}He reactivity weighting (pressure vs control rods level)
- Calibrations
  - Heat balance vs count rate + control rods level f(P_{He-3})
  - Dosimetry
- Start – ups (after testing the ^{3}He circuit)
  - Dummy RIA w/out experimental rod



Organisation, Planning and Perspectives

Organisation

- Reactor commissioning at CEA
  - Facility : Operators and Experimentalists
  - Support departments
    - Core physics numerical computations
    - Neutron experiments and dosimetry
    - Instrumentation

Planning

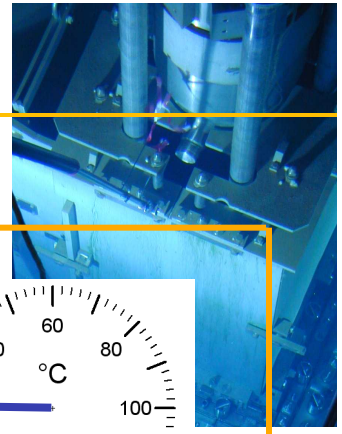
• Core reloading :	Late	**2010**
• 1st criticality :	Early	**2011**
• 1st Power pulse :	Early	**2011**
• CIP-Q test :	Mid	**2011**

Perspectives

- Starting CABRI (+ 10 tests yet to perform)
- Preparing RES and JHR in Cadarache
- Upcoming experimental and power facilities commissioning


Thank you for your attention

Heat balance vs Count rate



Partners of the CIP Program

- Czech Rebublic: Nuclear Research Institute (NRI)
- Finland: STUK - Radiation and Nuclear Safety Authority
- Finland: Fortum Group
- Finland: Technical Research Centre of Finland (VTT)
- Finland: Teollisuuden Voima OY
- France: Commissariat à l'Energie Atomique (CEA)
- France: Electricité de France (EdF)
- France: Institut de Protection et de Sûreté Nucléaire (IPSN)
- Germany: Gesellschaft Für Reaktorsicherheit (GRS)
  Along with a consortium of German utilities
- Hungary: Hungarian Academy of Sciences - Atomic Energy Research Institute (Umbrella agreement only)
- Japan: Japan Atomic Energy Agency
- Republic of Korea: Korean Institute for Nuclear Safety (KINS)
- Slovak Republic: Nuclear Power Plant Research Institute (VUJE)
- Spain: Nuclear Safety Council (CSN)
- Sweden: Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
- Switzerland: Federal Nuclear Safety Inspectorate (HSK)
- United Kingdom: Health & Safety Executive (HSE)
- USA: Office of Nuclear Regulatory Research (at USNRC)
- USA: EPRI