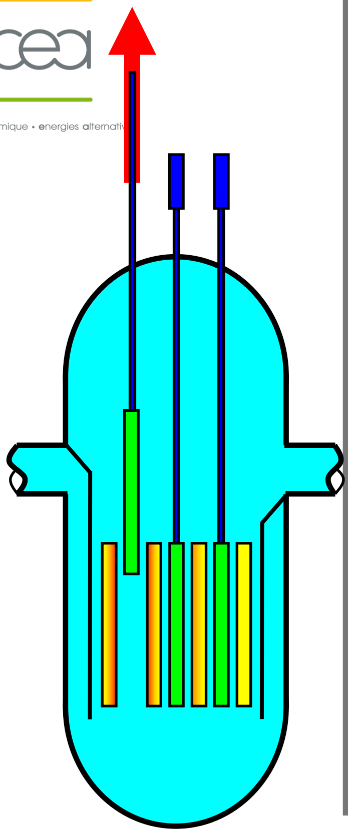
Neutron commissioning in the CABRI Water Loop Facility



CABRI :

A facility dedicated to **R** eactivity *** I** nsertion **A** ccident experiments

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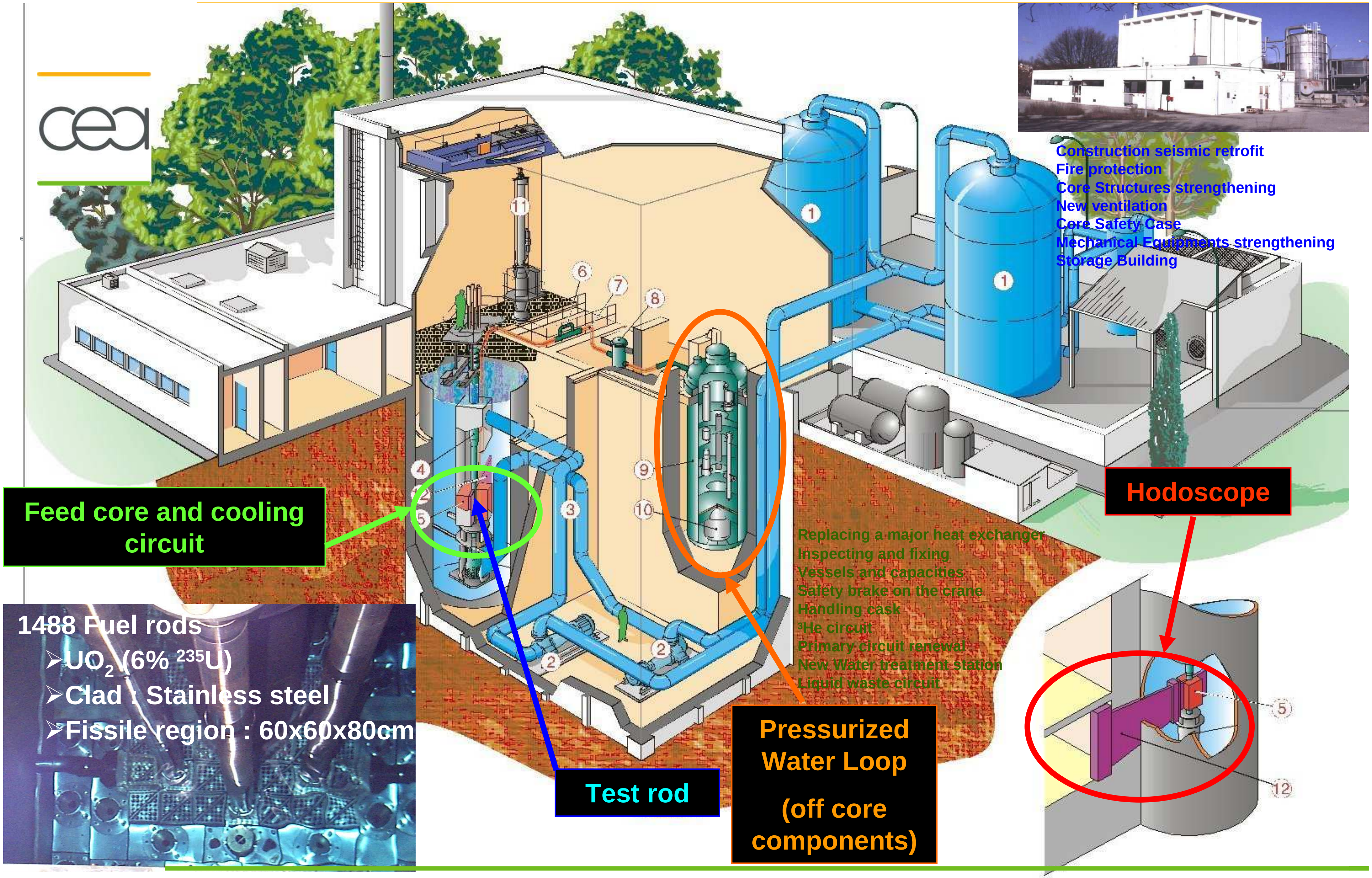
FRANCE

Upgrading the CABRI facility : Safety + Improvement issues



Seismic retrofit

CABRI + Project : From sodium to HP water cooling

IRSN : CABRI INTERNATIONAL PROGRAM (20 partners)

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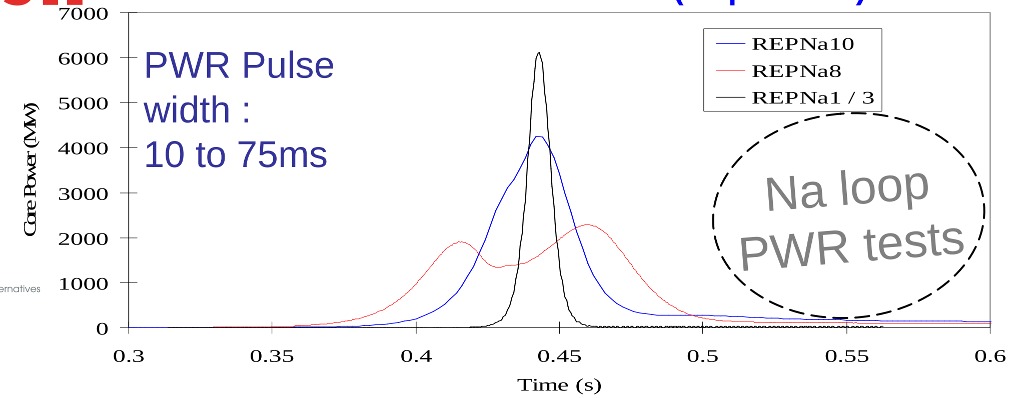
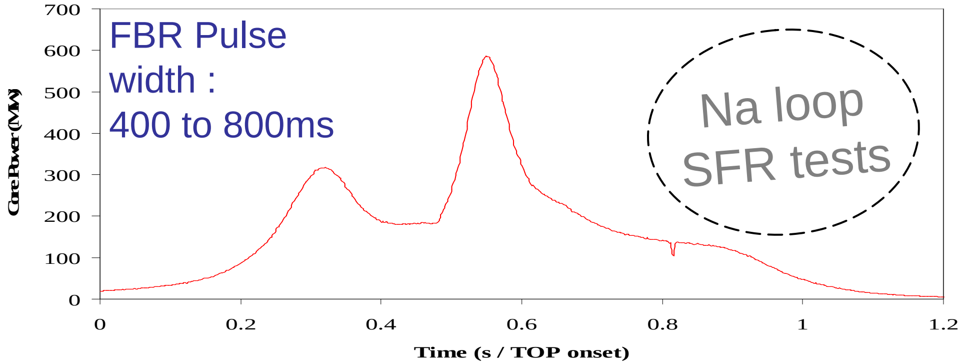
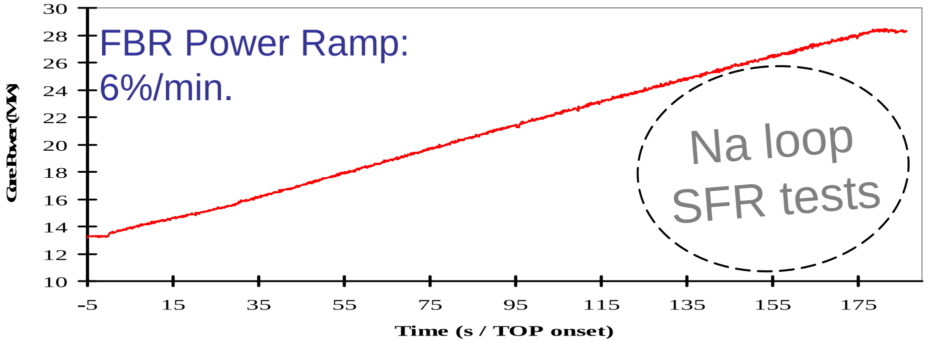
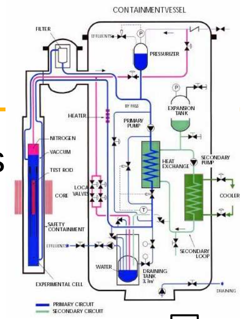
energie atomique • energies alternatives









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

AFAQ
ISO 9001
ISO 14001
OHSAS 18001

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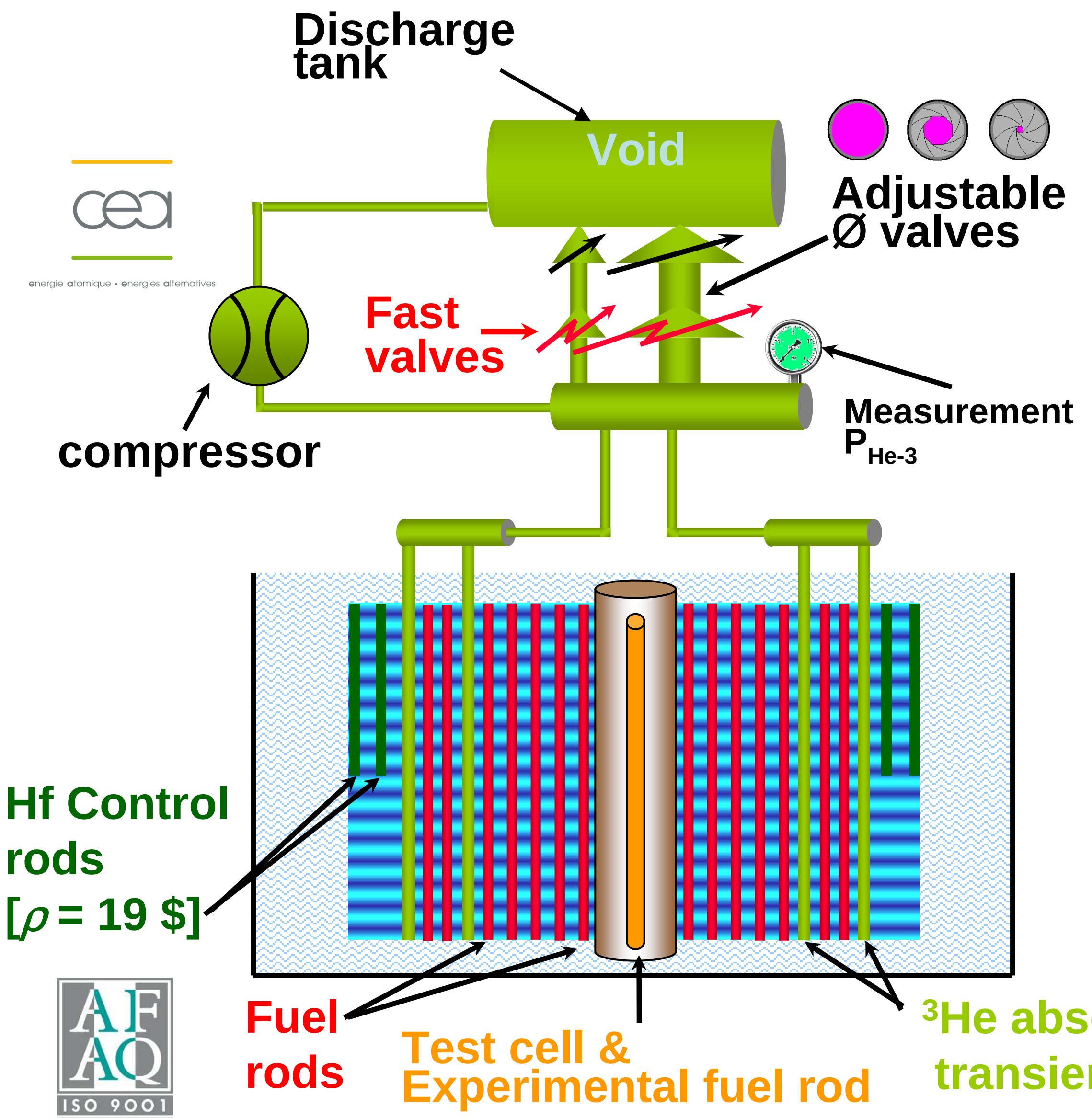
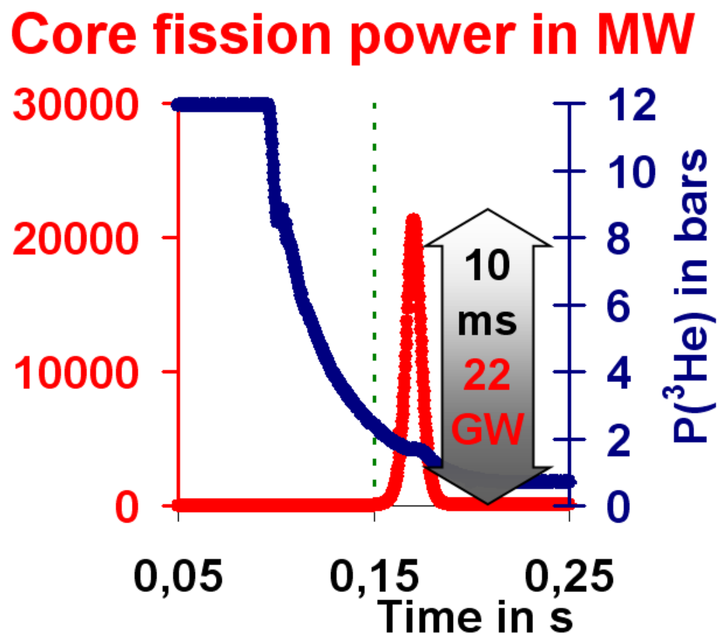
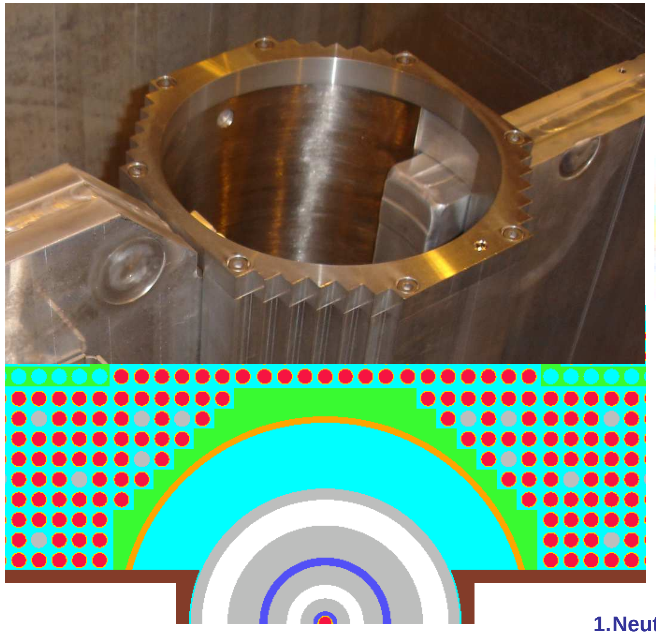
CABRI principle of operation





e.g. 3,5 $ / 0,12 s

Neutron commissioning : What needs ?



Objectives

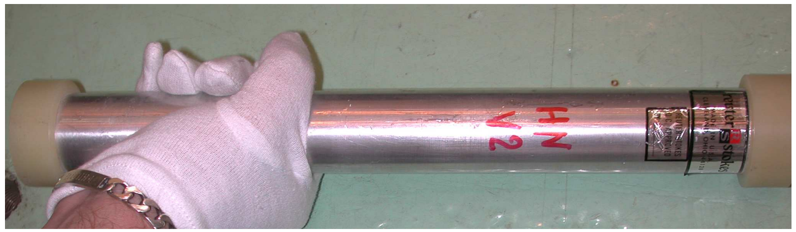
- Safety of operations
  - •A new core ?
- Quality of experiments
  - •What parameters ?

Reactivity features

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

Power and Energy features

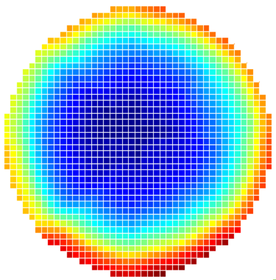
- Ion chambers calibration
- Power distribution

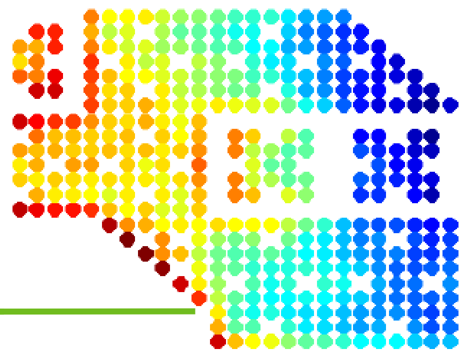


Computations : Steady state

- 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 : $\rho(P_{He\text{-}3})$
        - 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}





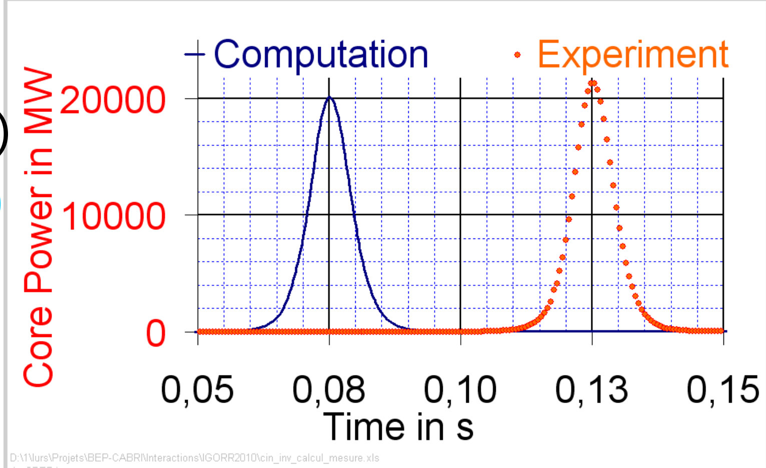
3D TRIPOLI 4 MC
Power distribution

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

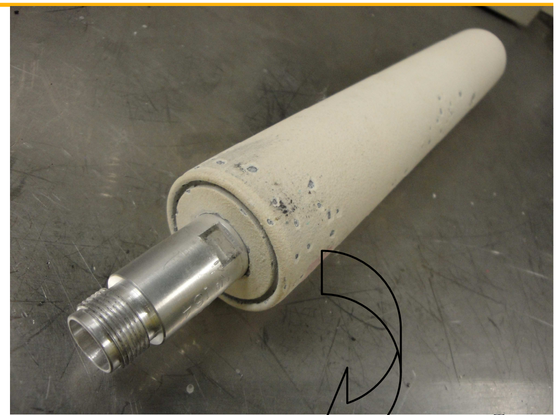
Very good agreement in transient conditions

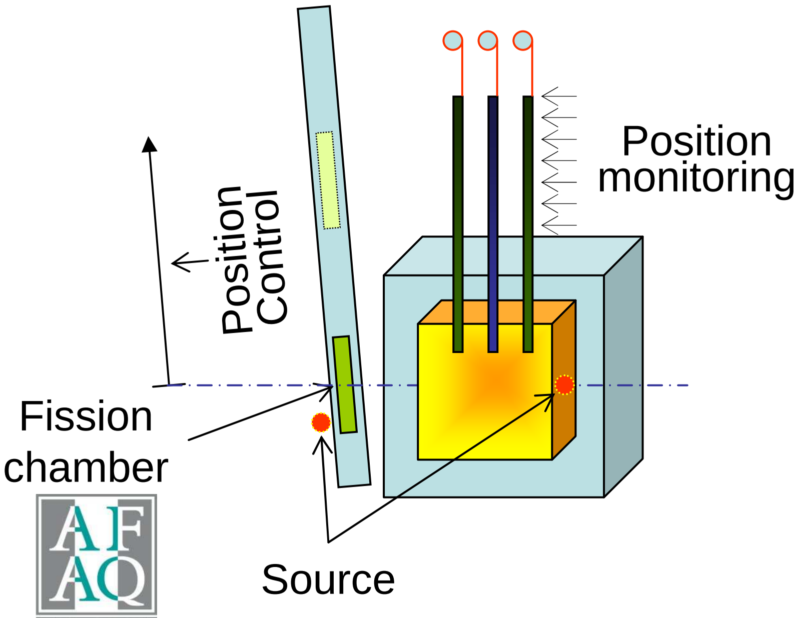
Current status : kinetics parameters re visited and validated in 2008

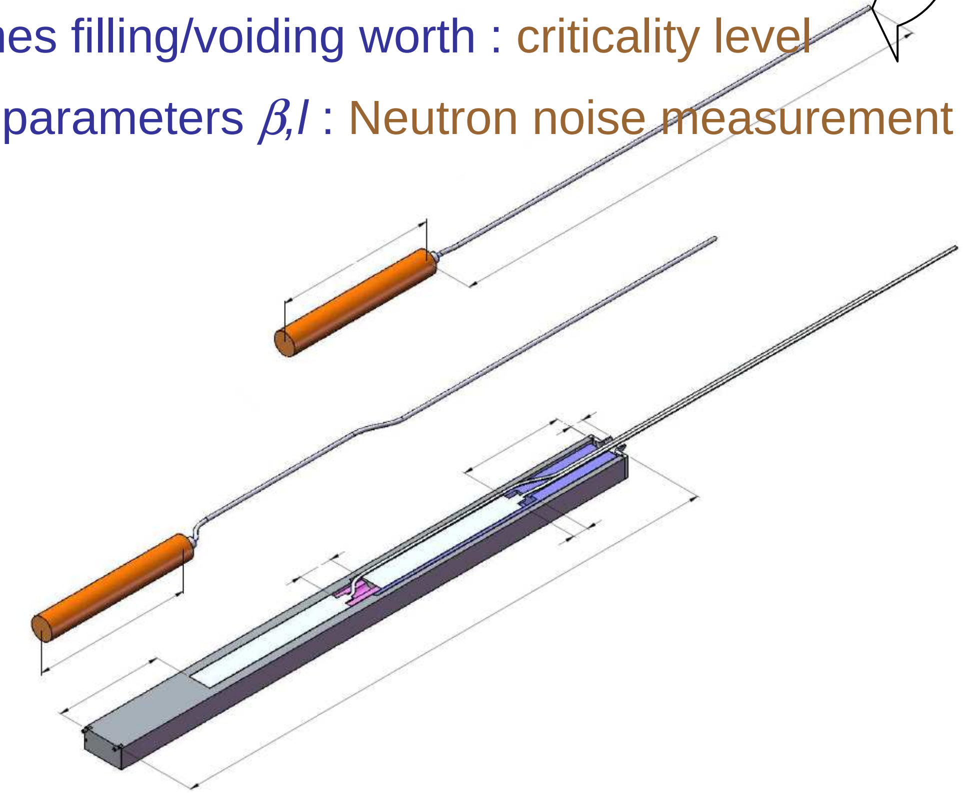
New smart data processing + user interface

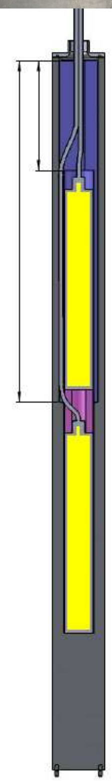
Reactivity measurements

- 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









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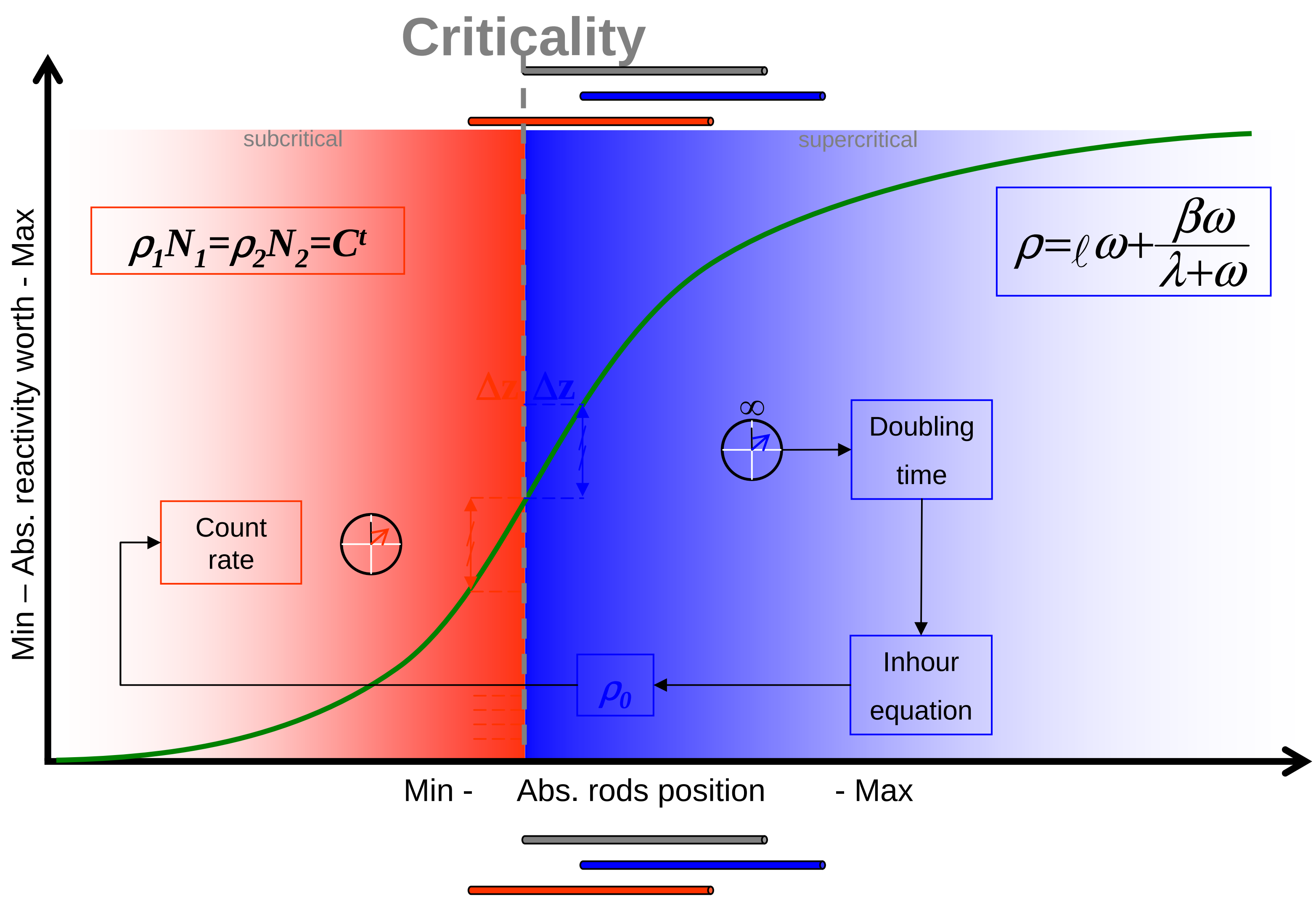
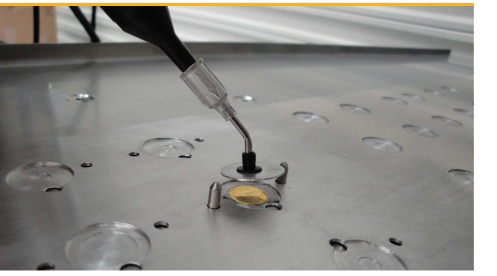
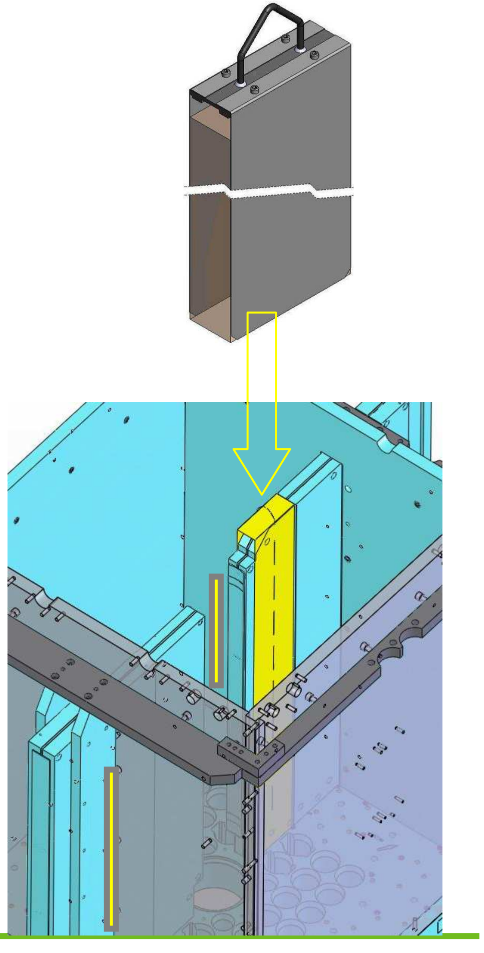
Reactivity standard

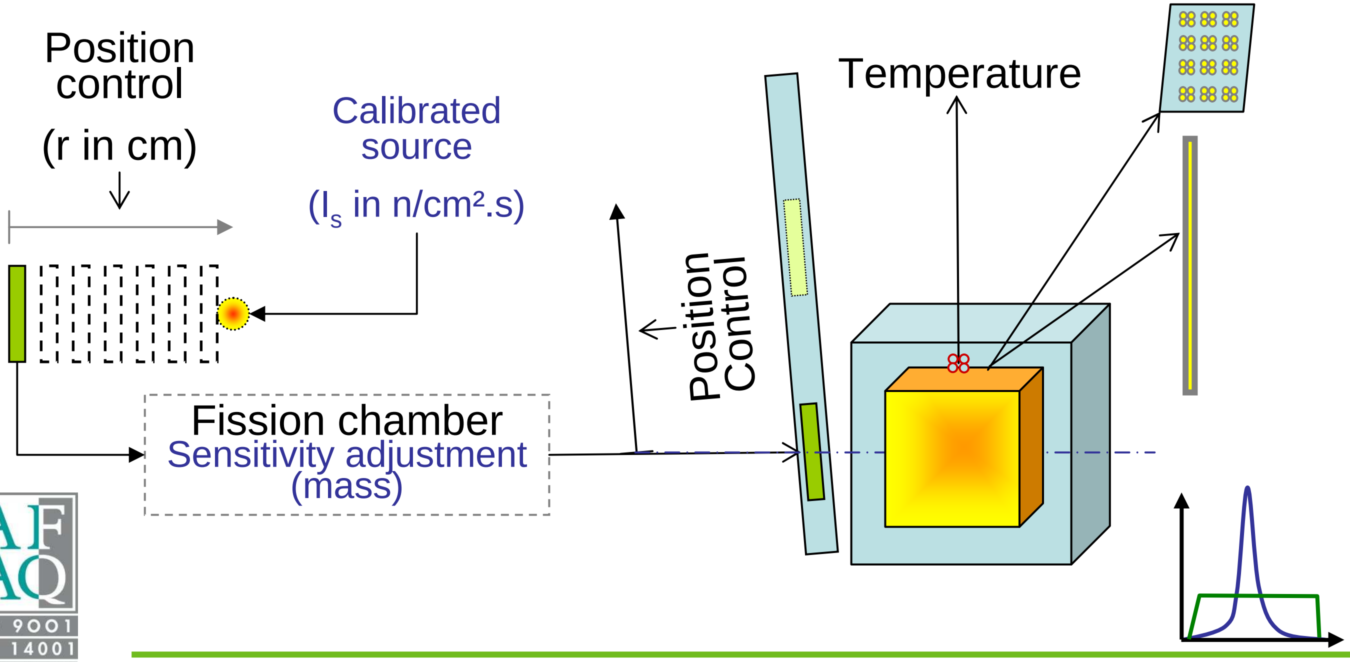


Power and Energy Measurements

- 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



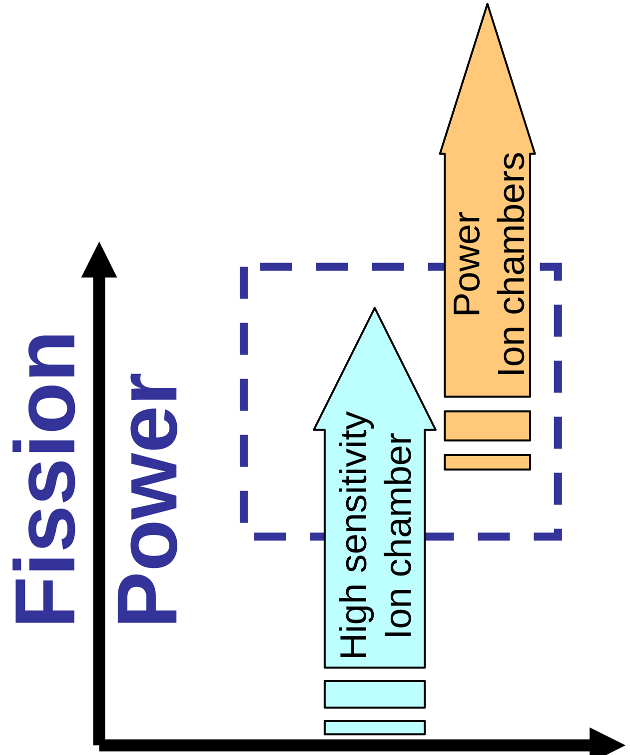




What Plan For Neutron Commissioning ?

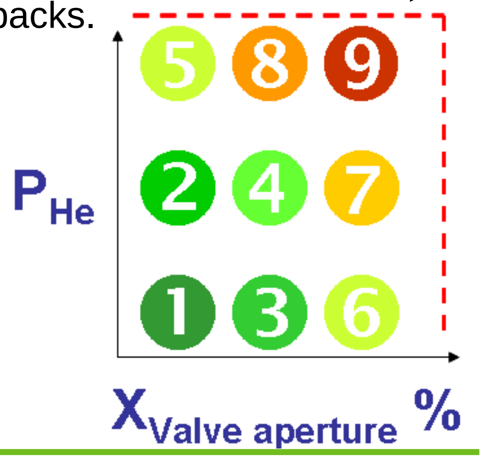
Before criticality : reloading the core

- 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 $f(P_{He\text{-}3})$
  - 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

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AFAQ ISO 9001 ISO 14001 OHSAS 18001

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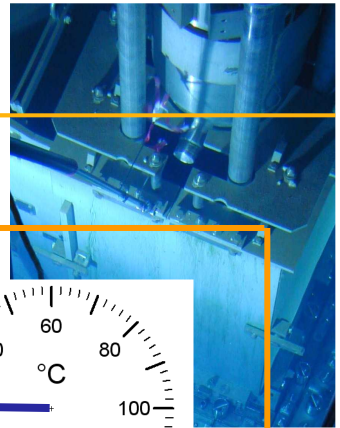
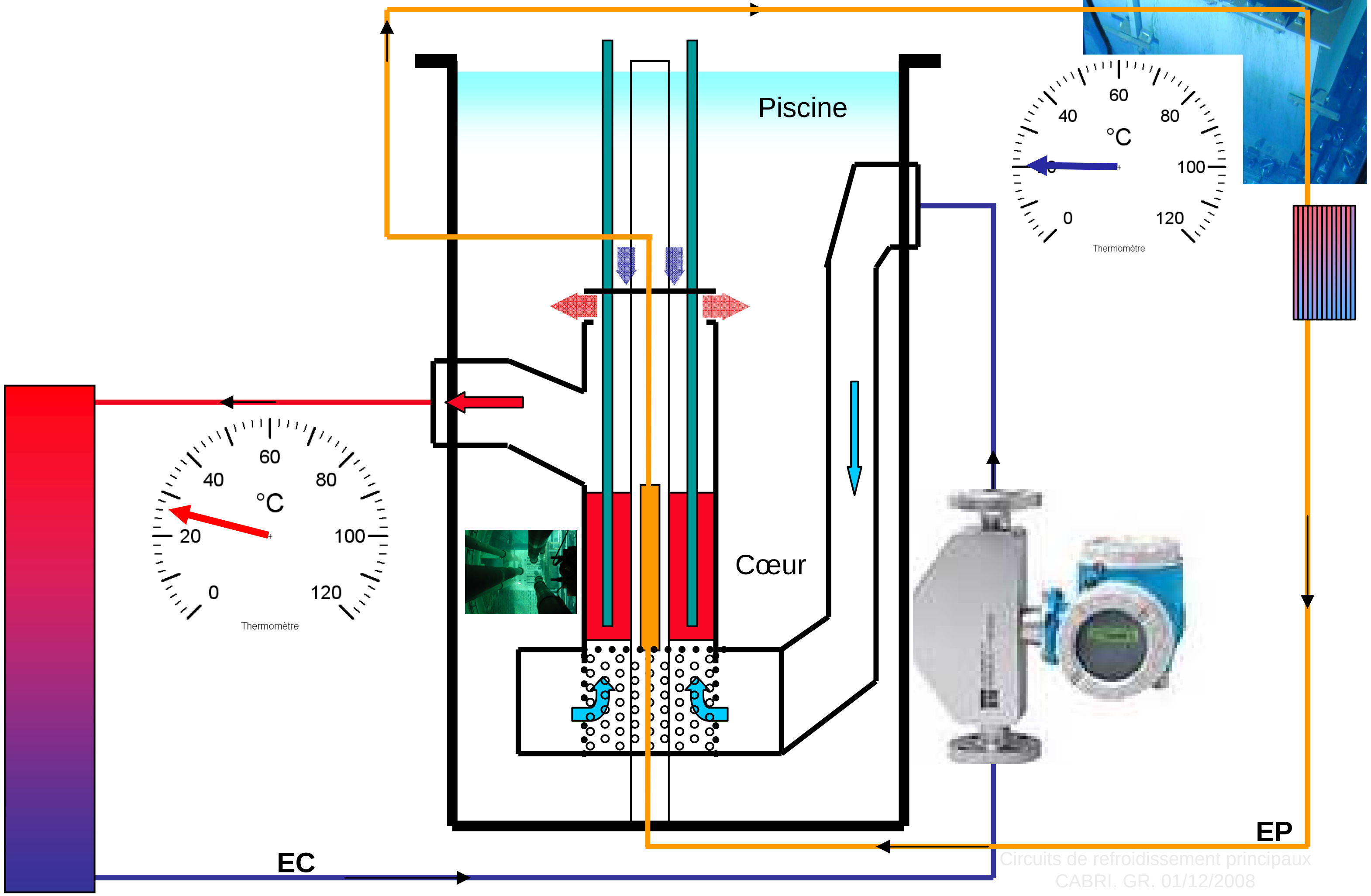
Thank you for your attention

Heat balance vs Count rate





ISO 14001
OHSAS 18001

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