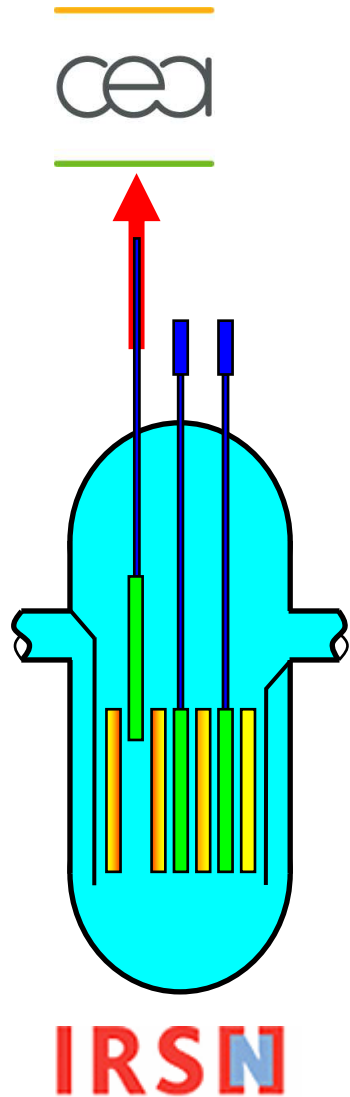
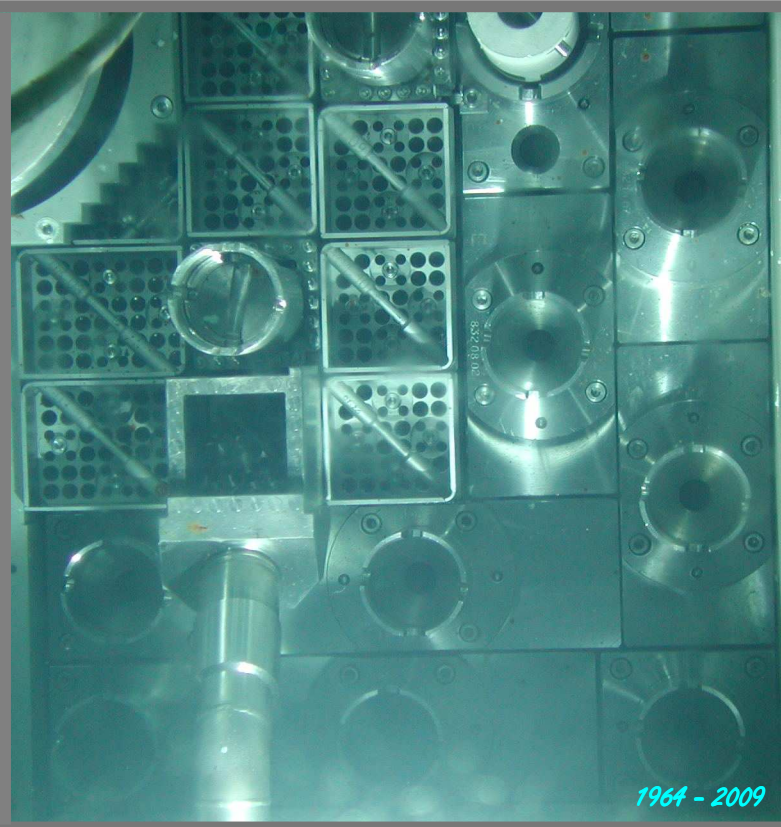


Upscaling CABRI core knowledge for a new safety case



CABRI :

A facility dedicated to
Reactivity
***I**nsertion
Accident experiments



G. Ritter
F. Jeury

CEA

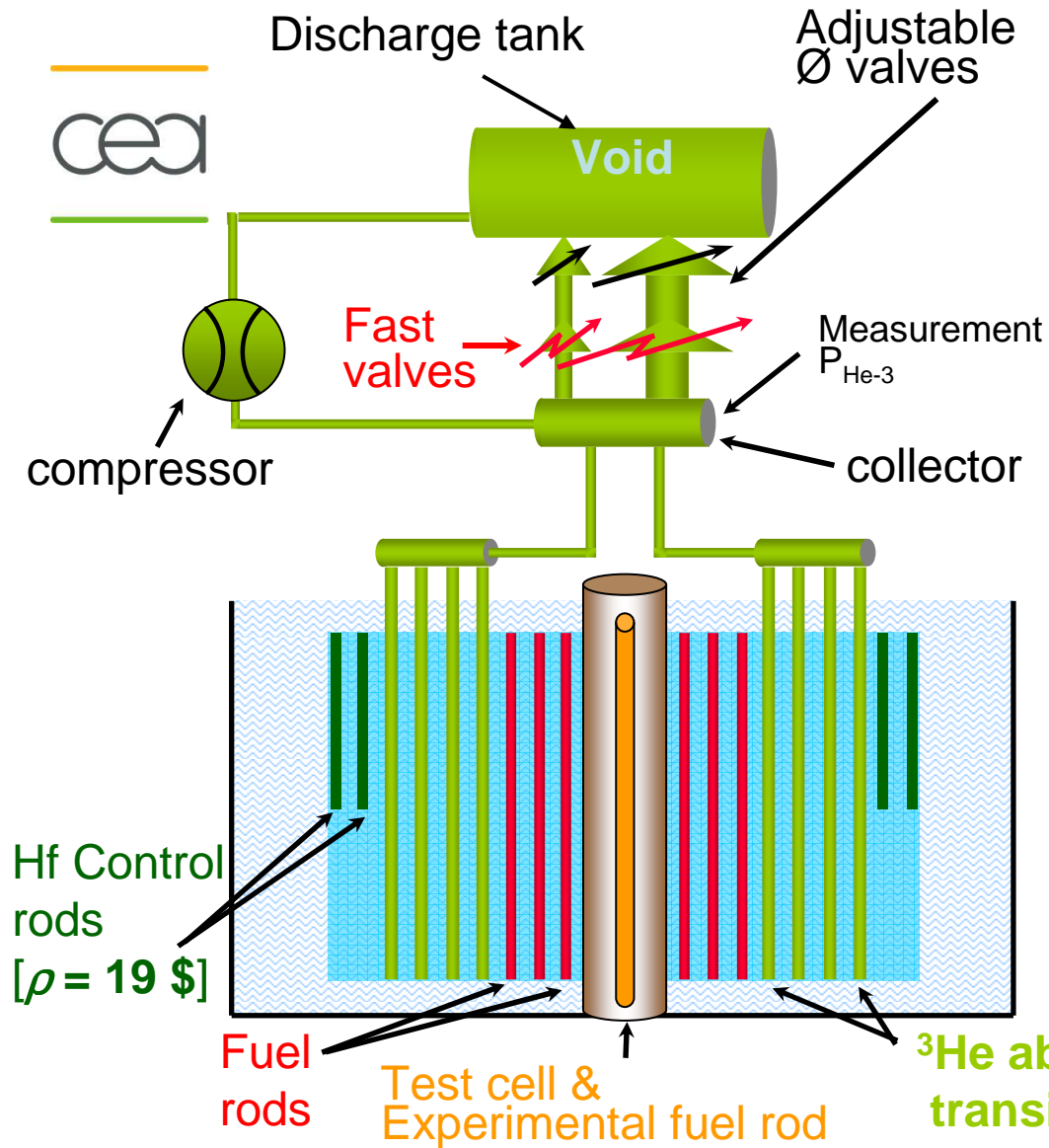
Nuclear
Energy
Directorate

1488 Fuel rods

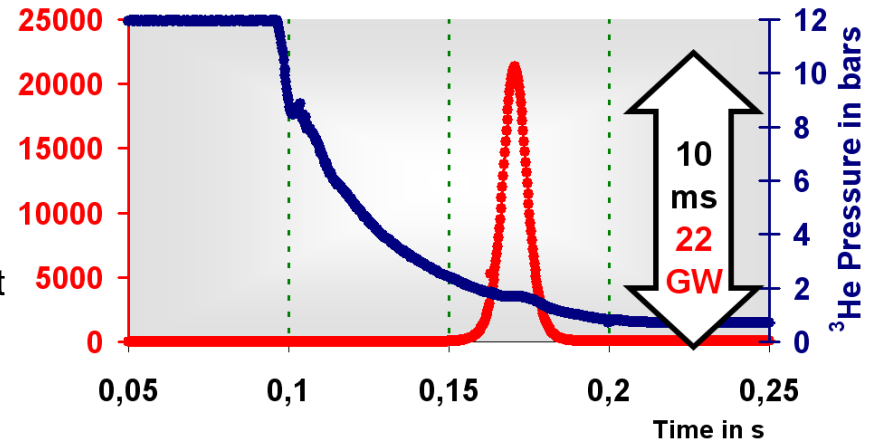
- UO₂ (6% ²³⁵U)
- Clad : Stainless steel (A304)

➤ Fissile region : 60x60x80cm

CABRI principle of operation



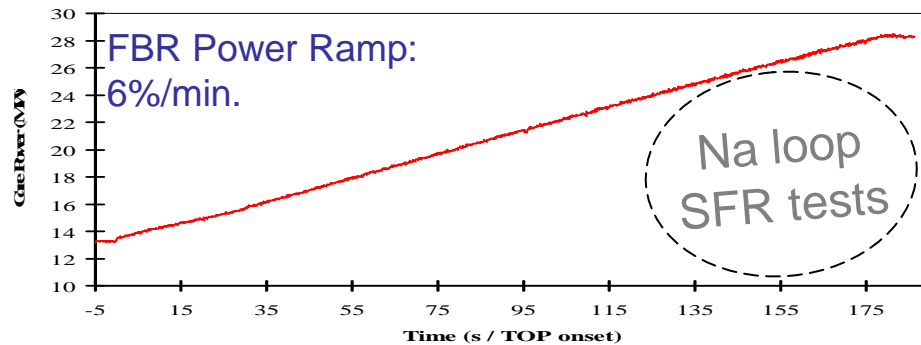
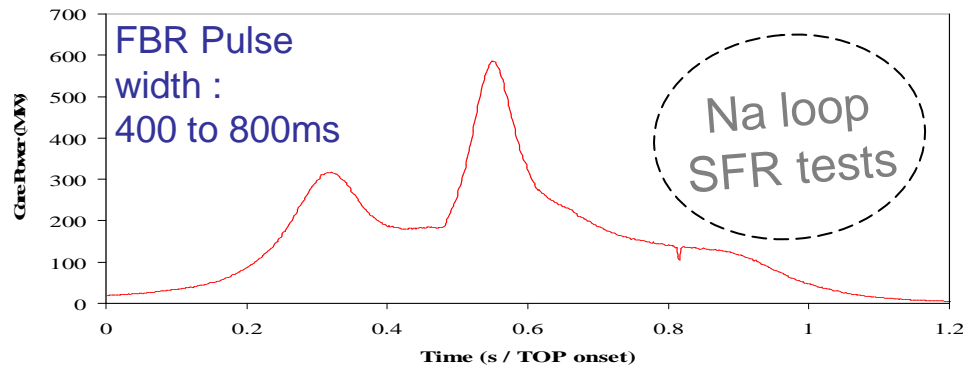
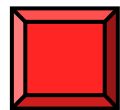
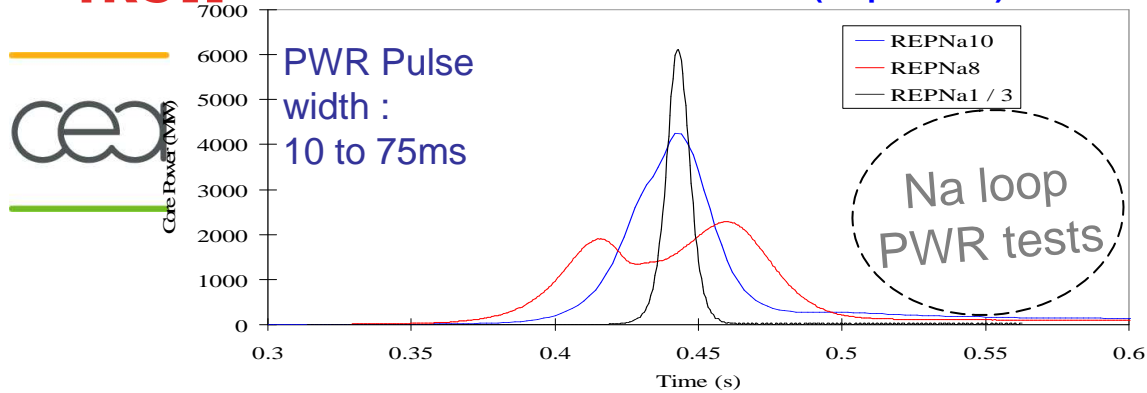
Core fission power in MW



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

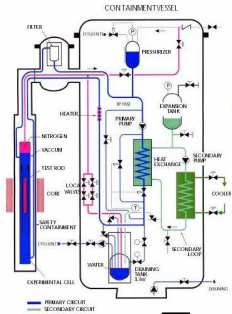
CABRI + Project : From sodium to HP water cooling

IRSN : CABRI INTERNATIONAL PROGRAM (20 partners)



➤ 3rd generation requirements

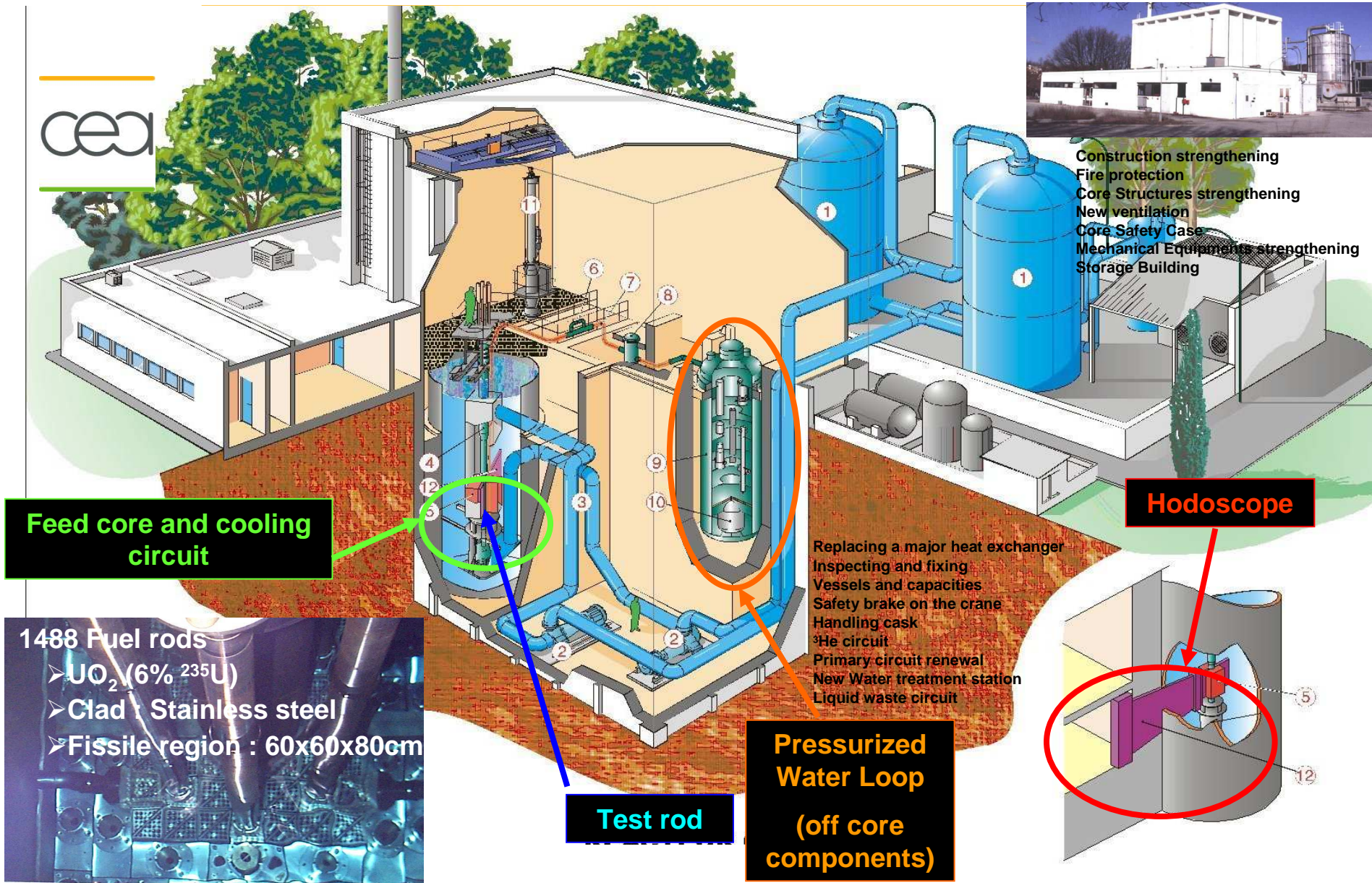
- PWR Representativity
- Test rod post failure analysis
- Testing new fuels (HBU)
- Safety margins re-assessment



Upgrading the CABRI facility : Safety + Improvement issues



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



Feed core and cooling circuit



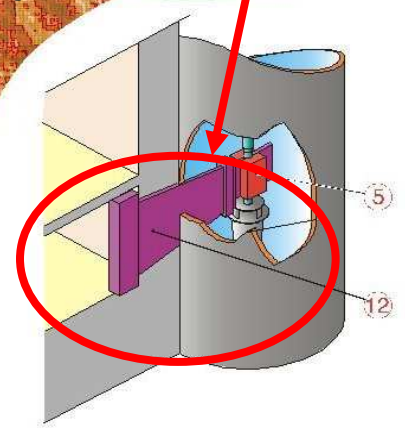
- 1488 Fuel rods
- UO_2 (6% ^{235}U)
 - Clad : Stainless steel
 - Fissile region : 60x60x80cm

Test rod

Pressurized Water Loop (off core components)

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

Hodoscope

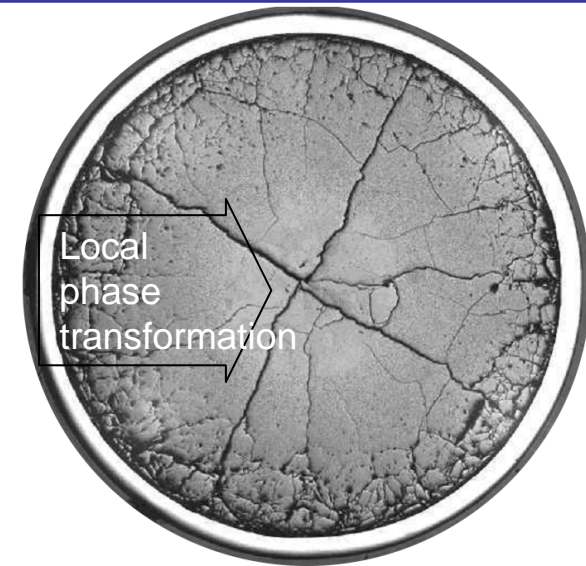
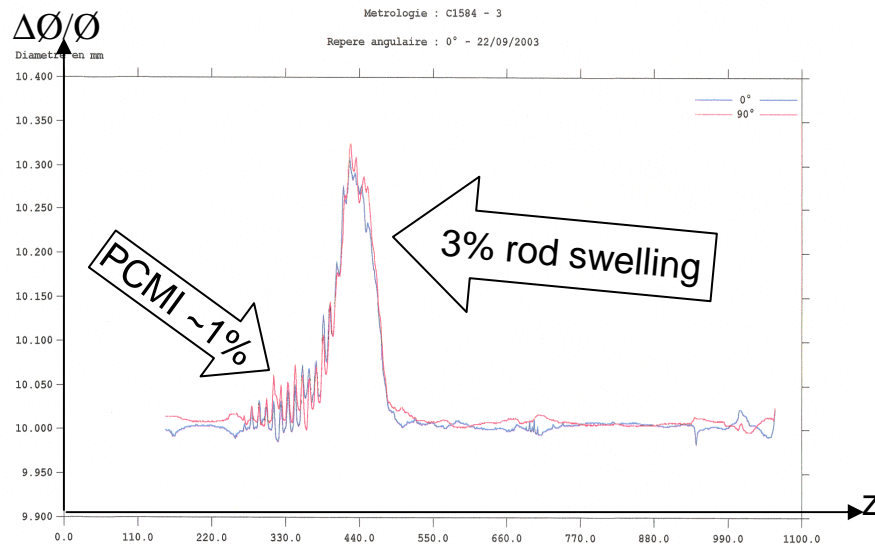


Why worry about a 3 EFPD's old core ?

2003 : Hot rods examination program

- 6 rods, **PCMI** in the lower part ($\sim 1\% \Delta \varnothing$),
- 2 rods, bell shape rod **swelling** ($3\% \Delta \varnothing$) due to local UO_2 phase transformation at the pellet center ($\sim 10\%$ mass).

➔ Incident

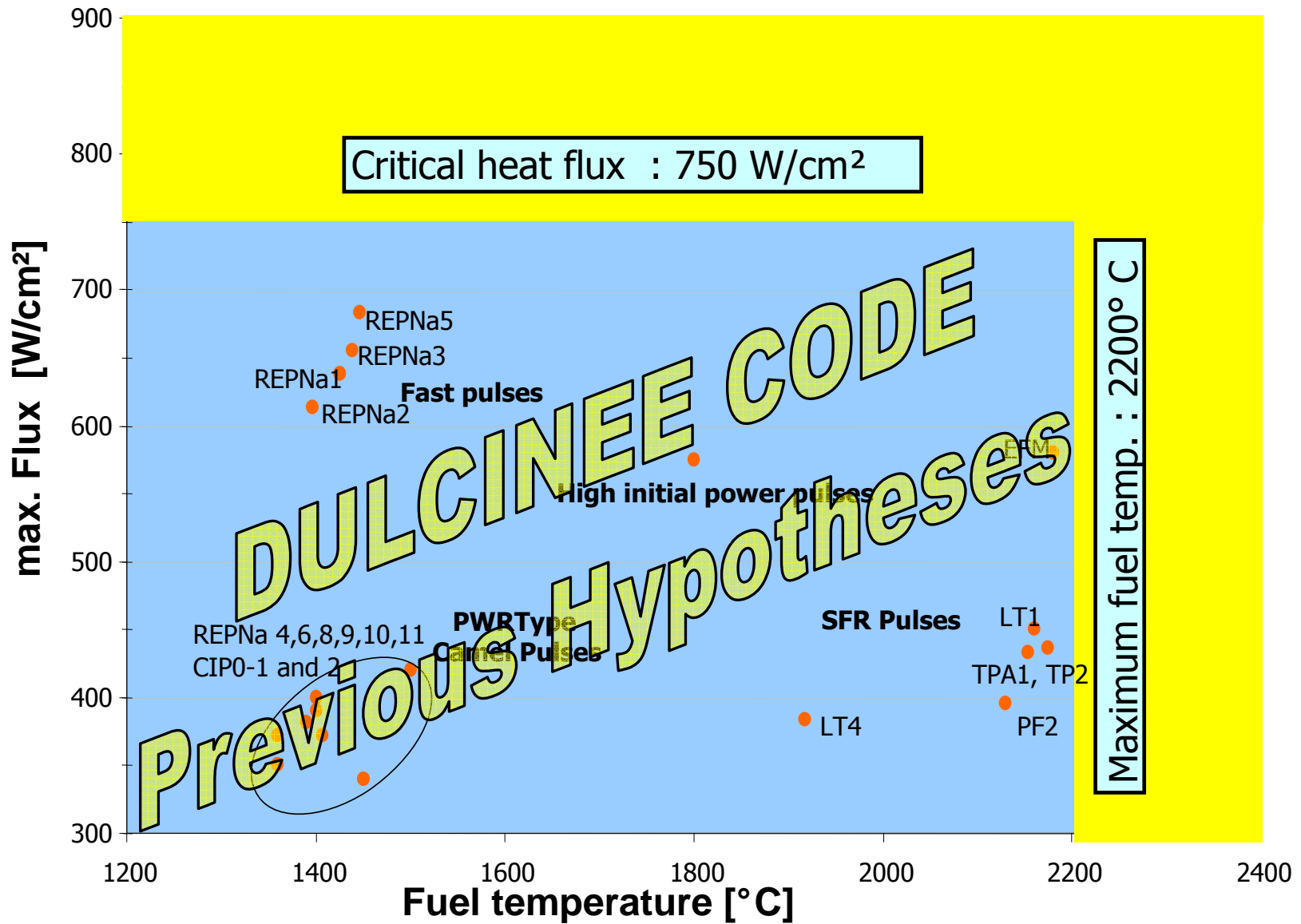


2008 : Safety case presented to the safety authority

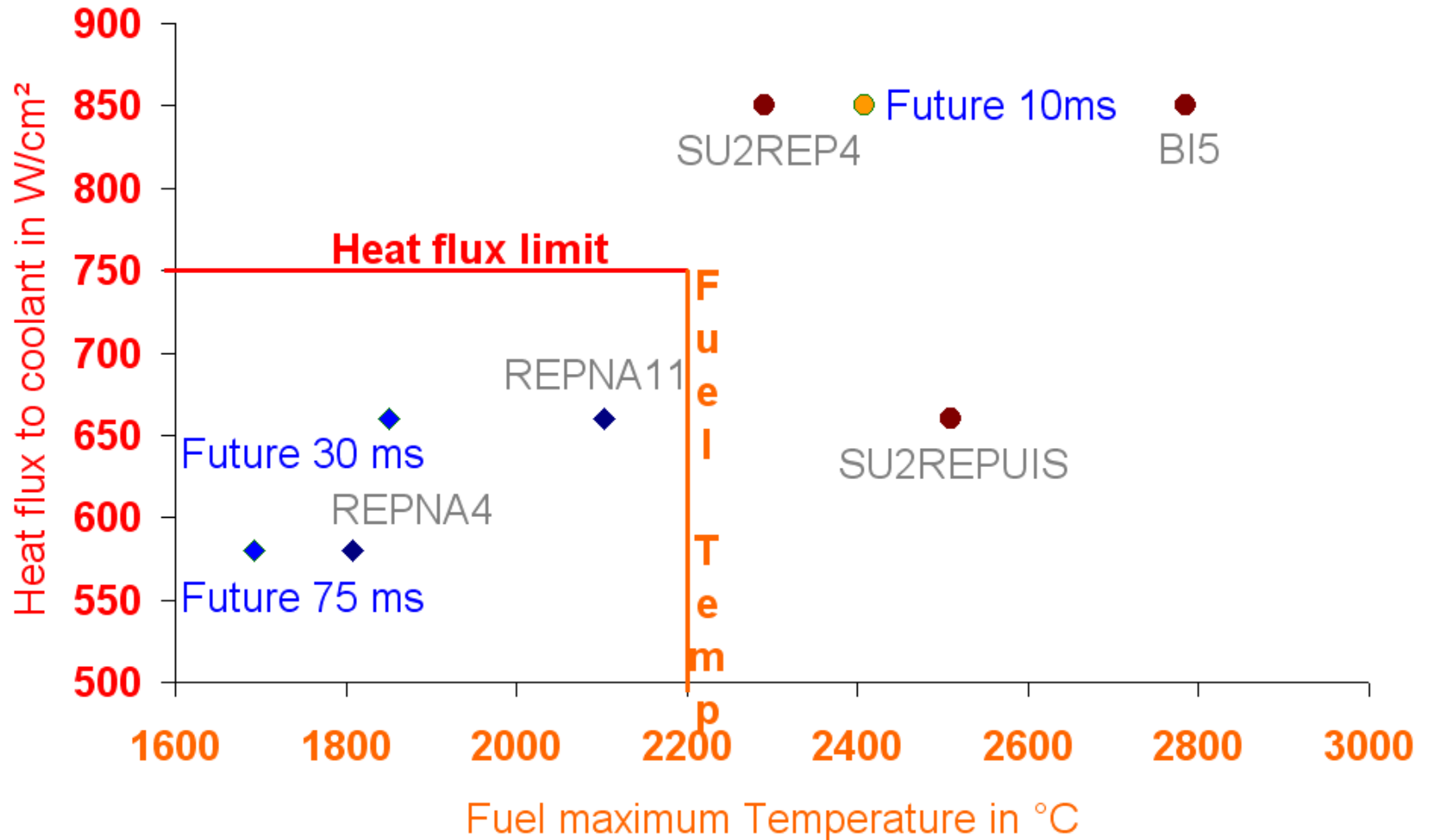
- **Understanding the past** : Computations + measurements and tests on "used" rods + expertises
- **Demonstrating the ability to realize future tests** : Id. + precomputations + validation + comprehensive clad mechanical characterization

➔ New safe domain for operation

Former domain for operations



Former domain for operations



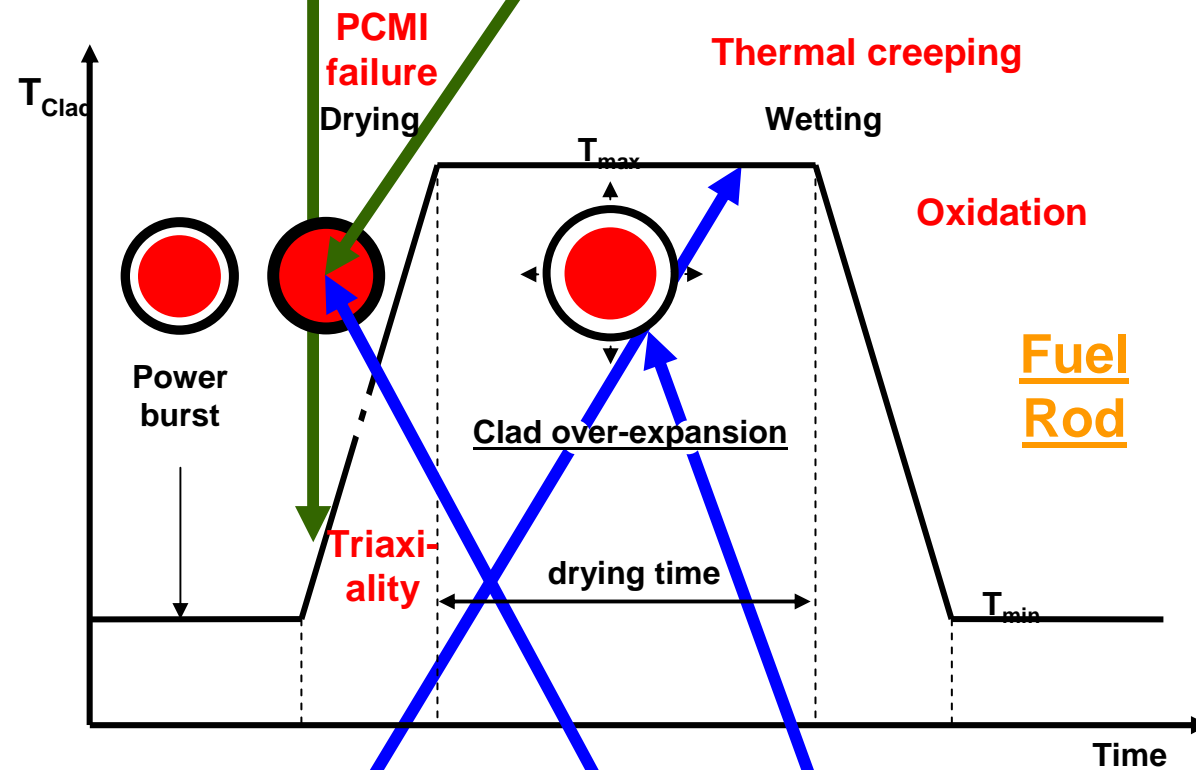
D:\Murs\Projets\BEP-CABRI\Crayons coeur\GT-Gaine\domaine_autorise.xls

Phenomenology



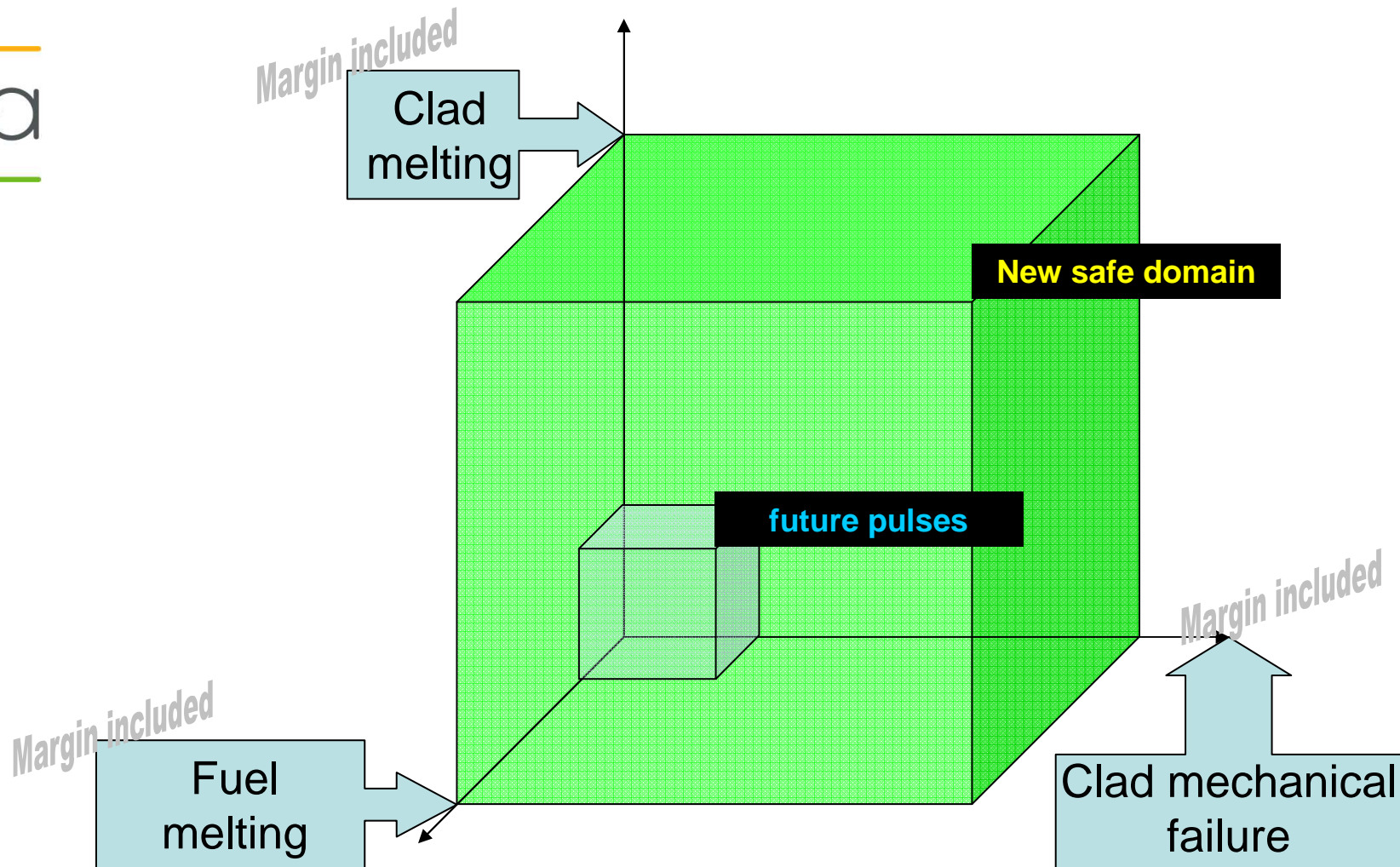
cea

Former domain : Heat flux + Fuel Temperature



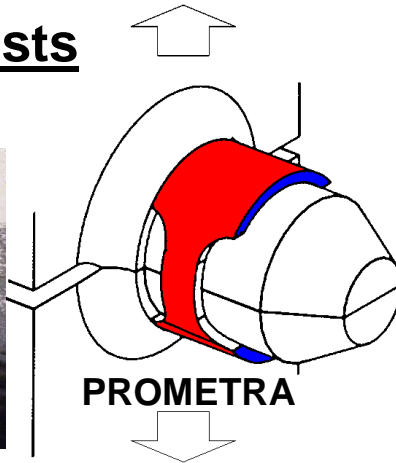
New domain : Clad and Fuel Temperatures + Clad mech. strain

New safe domain for operations



Validating safety inside the new domain

Mechanical tests



EDGAR :
Pressure + electrical heating

9,5b
1300°C

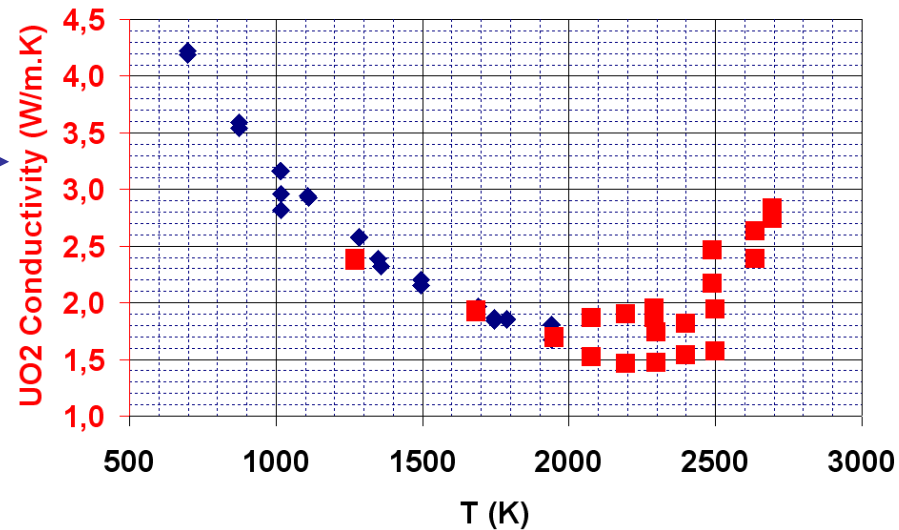
Temperature Driven pressure

Time

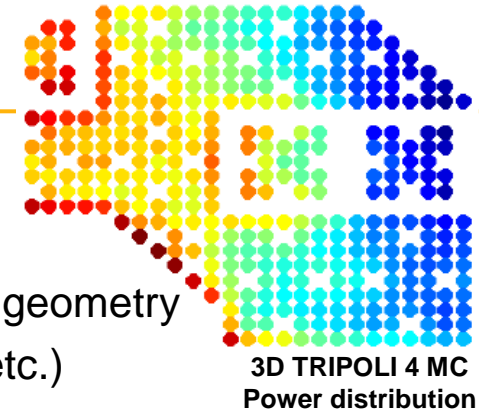
EBM

Fuel properties

- Conductivity →
- Heat capacity
- Macrographs



Computational validation



Steady state conditions

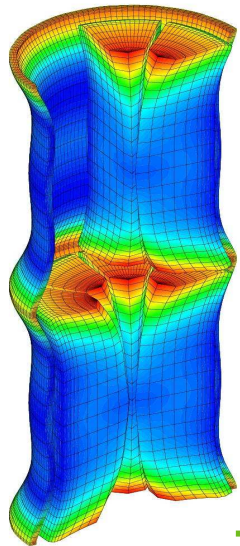


TRIPOLI 4 Monte-Carlo neutron + γ transport in exact core geometry

- Renovating neutron **feedbacks** evaluation (Doppler etc.)



- MCNP with JEFF3.1.1 nuclear data library,
 - Updating **safety** parameters : $\beta = 758 \text{ pcm}$, $l = 27,7 \mu\text{s}$

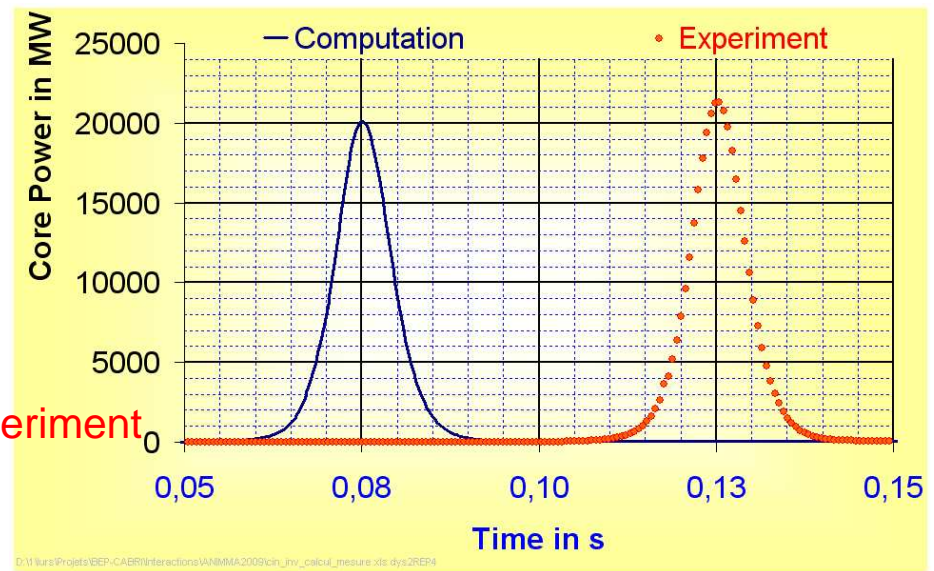


RIA Transients



DULCINEE (kinetics)

- Computations qualified against **experiment**



A large circular graphic composed of many small, overlapping segments, creating a rainbow-like color gradient from blue on the left to red on the right. The text is centered within this circle.

**Thank you for your
attention**

Commissioning Planning and Perspectives

Organisation

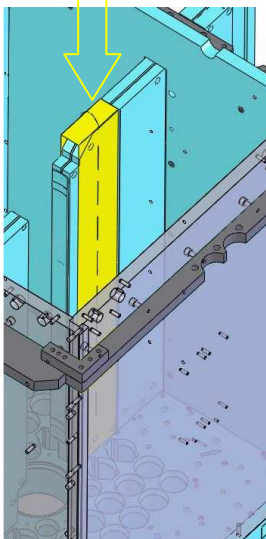
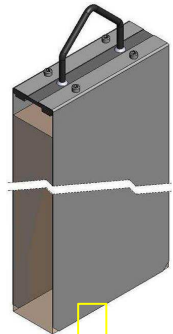
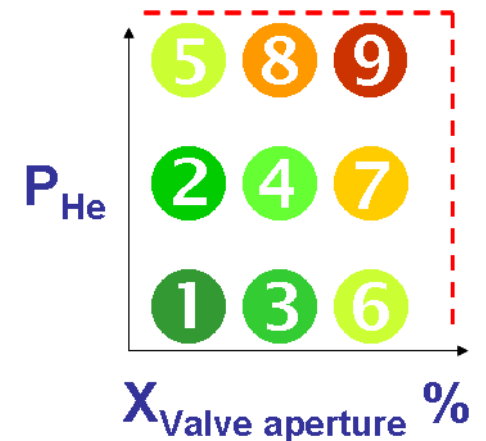
- Reactor commissioning at CEA
- Facility : Operators and Experimentalists
- Support departments
 - Core physics numerical computations
 - Neutron experimentation and dosimetry
 - Instrumentation

Planning

- Core reloading : Late 2009
- 1st criticality : Early 2010
- 1st Power pulse : Mid 2010
- CIP-Q test : Late 2010

Perspectives

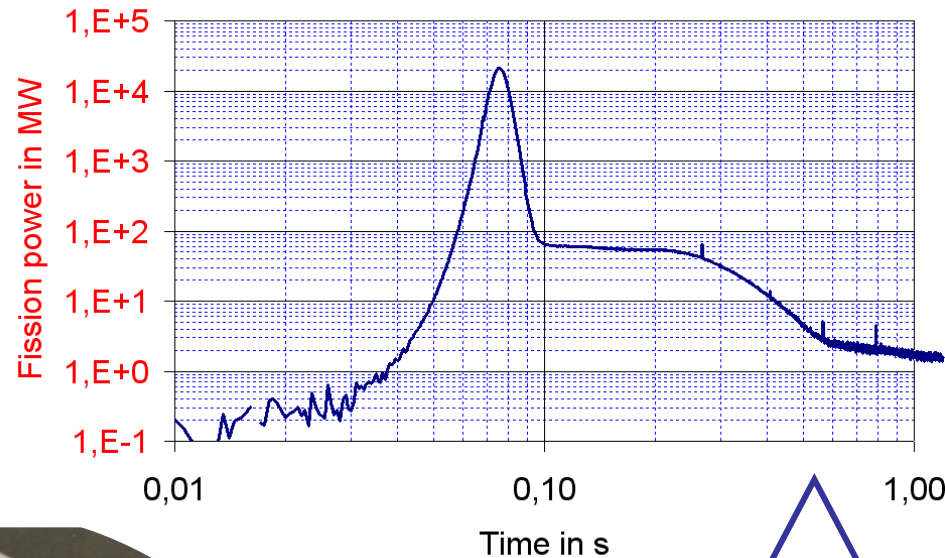
- Starting CABRI (+ 10 tests yet to perform)
- Preparing RES and JHR in Cadarache
- Upcoming experimental and power facilities commissioning



Safety assay of upcoming tests

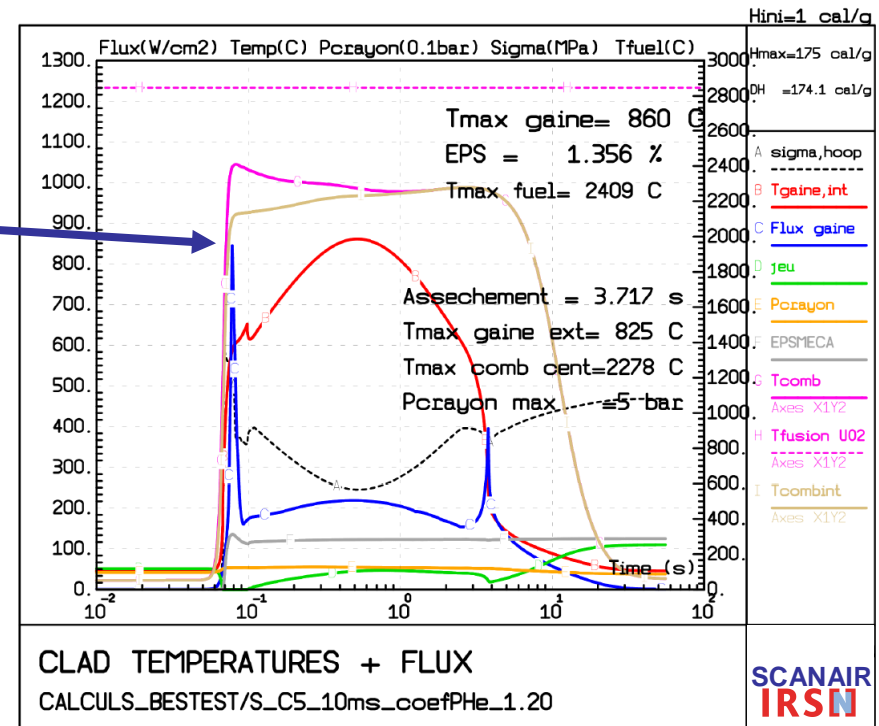


(ex. 10ms-15bars)



Previous experiments
Pulse database

Conser- vatism	ϵ	T_{fuel}	T_{clad}
Fuel		$\lambda, C_p, Q(Z), Q(r),$	
Clad		Pellet-clad Gap, TH	
Coolant		(FC, FB), $P_{fission}$	



CLAD TEMPERATURES + FLUX
CALCULS_BESTEST/S_C5_10ms_coefPHe_1.20



Heat transfer + mechanics + thermal hydraulics computation