Irradiation of materials and fuels in OSIRIS

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INDUSTRIALS' and PARTNERS' NEEDS

- Existing nuclear power plants
  - Optimisation of fuel performances
  - Behaviour of materials

  + specific studies
- Future types of nuclear power plants
  - Fuel qualification
  - Structural materials

THE EXPERIMENTAL PLATFORM

- The OSIRIS complex
  - OSIRIS reactor
  - Hot cells
  - ISIS reactor
- The hot laboratories
  - LECI at Saclay Center
  - LECA-STAR at Cadarache Center
- Research teams

OSIRIS GENERAL VIEW

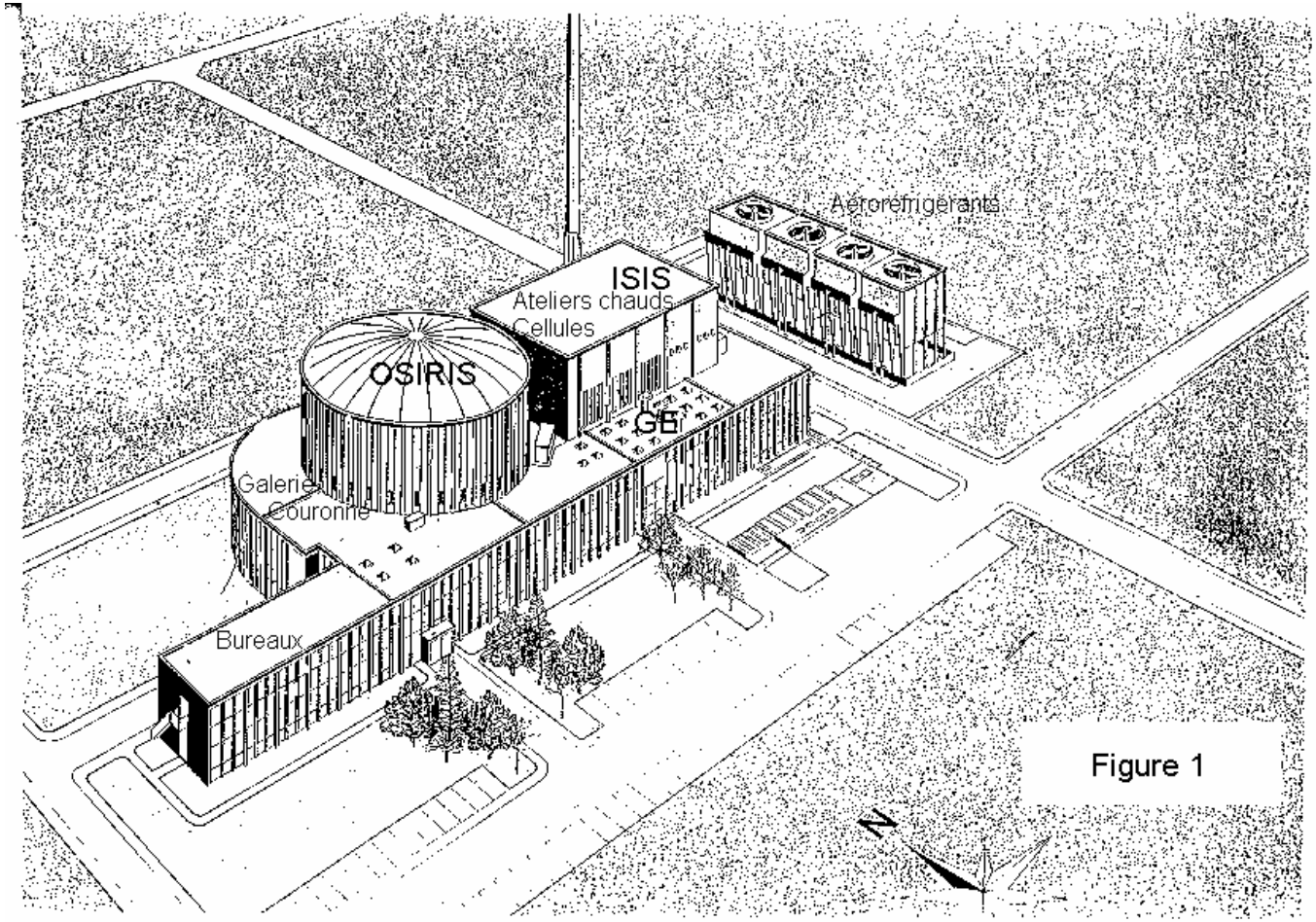
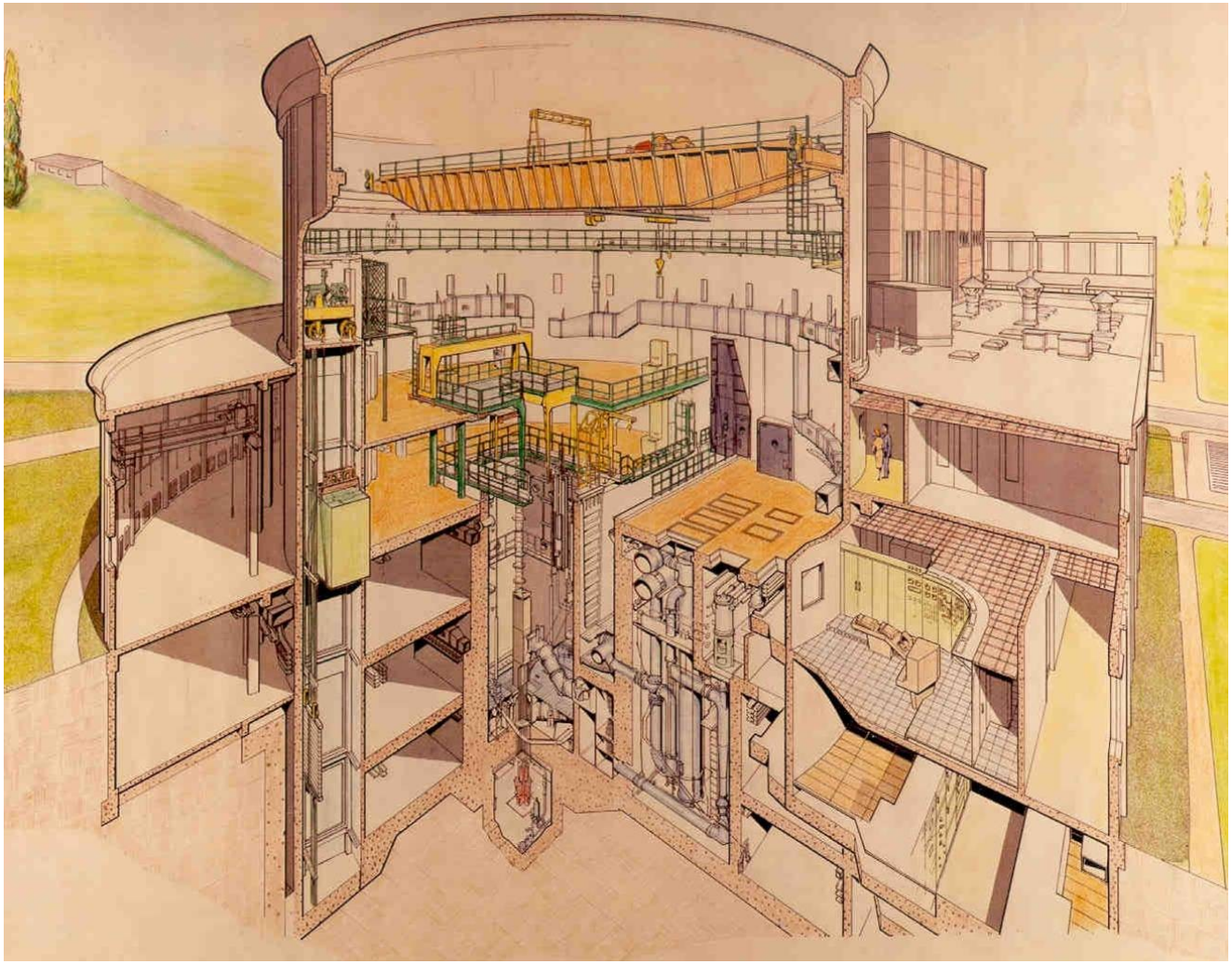
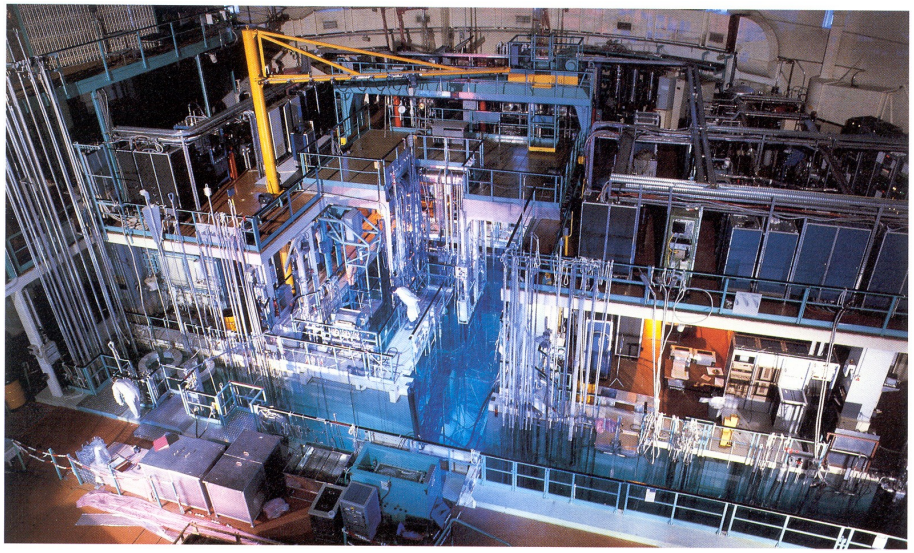


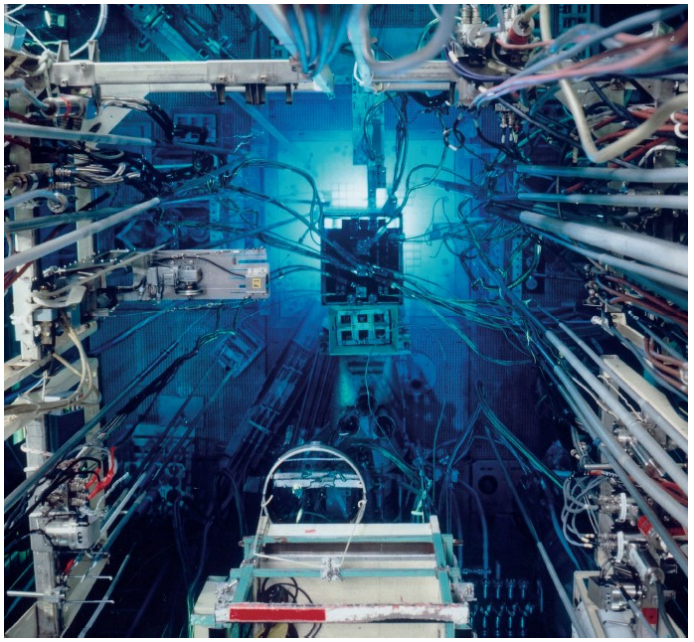
Figure 1

VERTICAL SIGHT



OSIRIS : THE POOL

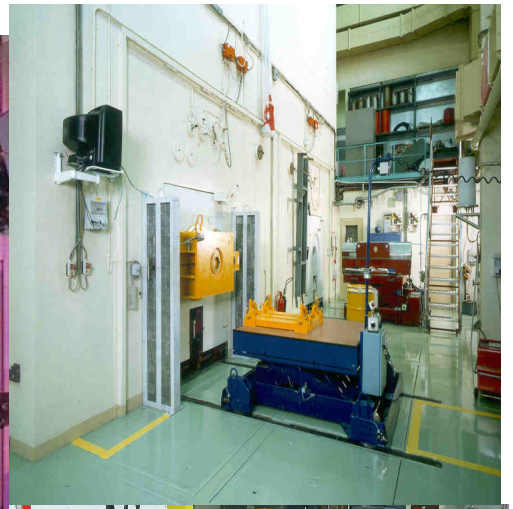




Open core pool reactor
Fuel U_3Si_2Al (19.75 %)
Moderator, coolant, biological protection : H_2O
Reflector : H_2O + Be

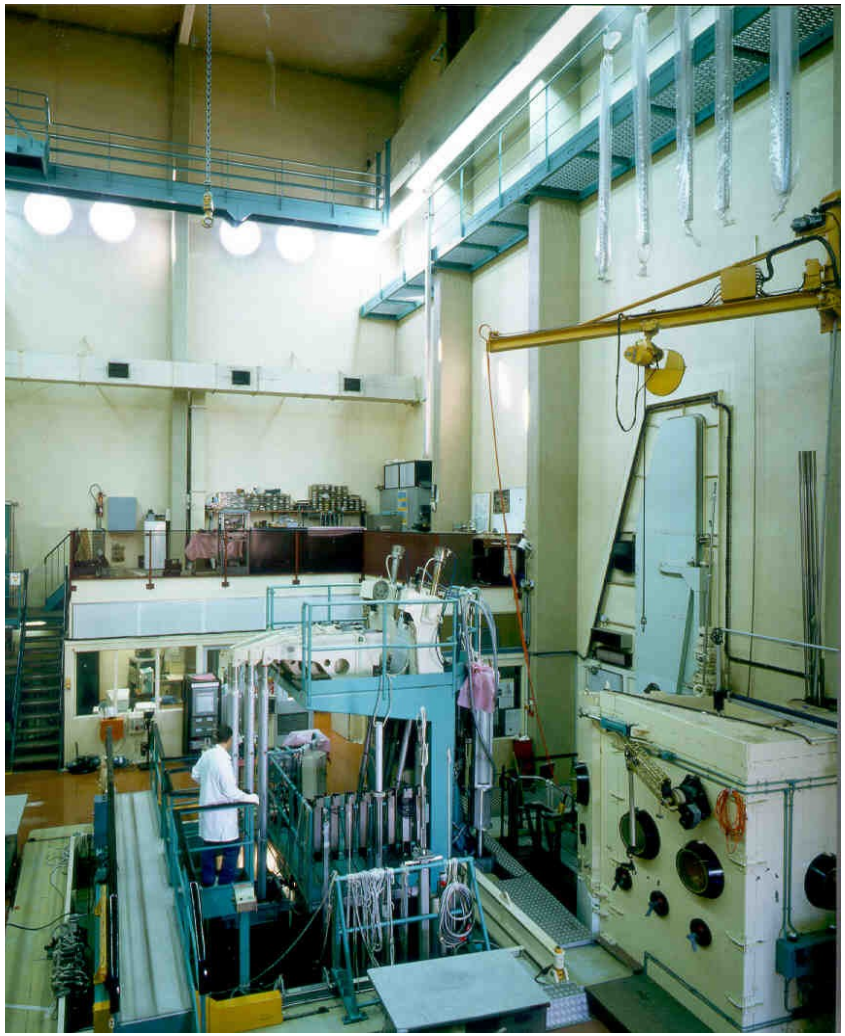
Average heat flux : 125 W/cm^2
Max heat flux : 310 W/cm^2
Neutron fast flux : 4.5 10^{14} n/cm^2/s
Neutron thermal flux : 3.10^{14} n/cm^2/s

OSIRIS : HOT CELLS



OSIRIS : CONTROL ROOM

ISIS



Neutronic mock-up
700 kW

Using :
•Testing new core configurations, new fuel elements or irradiation experiments
•Dosimetry
•Neutron flux and gamma heating maps, reactivity effects
•Fission chambers qualification
•Gamma-ray irradiation
•Teaching

DEVICES vs NEEDS (1)

FUEL KNOWLEDGE AND DEVELOPMENT FOR EXISTING NPPs

- Fuel behaviour under representative thermal-hydraulic and chemical conditions

  -> pressurised water loops :

  power ramps and power cycles
- Studies on new fuels in order to minimise fission gases discharge -> GRIFFONOS device
- MTR fuel : IRIS device

Fuel Irradiation devices (1)

ISABELLE 1 Loop

- 1 rod in PWR conditions
- Power ramps up to 620 W/cm on fresh or pre-irradiated fuel

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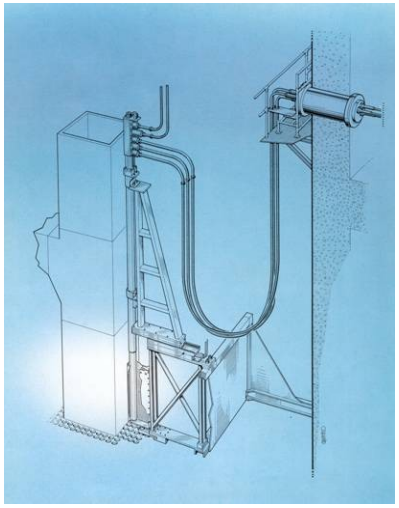
- Pin-clad interaction
- M5 concept
- MOX
- CROMOX (doped MOX)
- Fuel behaviour during class 2 transcients



ISABELLE 4 Loop

- 4 rods in PWR conditions
- Fuel plates

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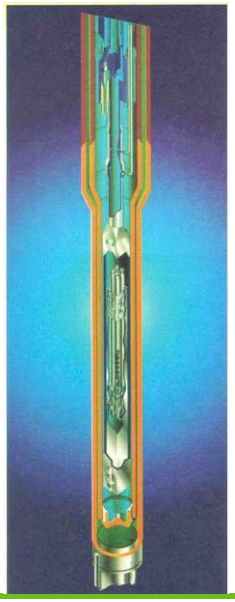
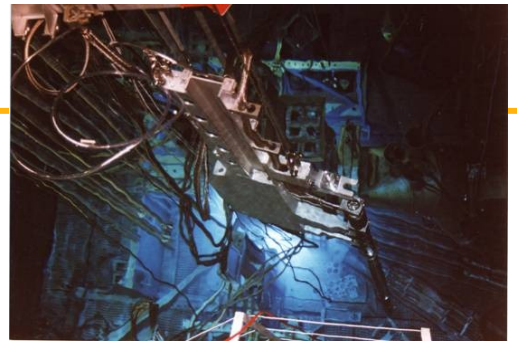
- Parametric studies
- Qualification, cycles
- Conditioning



Fuel Irradiation devices (2)



GRIFFONOS

- 1 rod near PWR conditions
- Instrumented analytical irradiations :
  - fission gases release
  - heart temperature

→

- MOX
- CROMOX (doped MOX)
- BWR ramps

IRIS

Fuel plates qualification for MTR

→

UMo (RJH, FRM2, …)

DEVICES vs NEEDS (2)

MATERIAL IRRADIATION

- Vessel steel studies (end of life) -> IRMA – BARITON devices
- End of life of internal materials -> CHOUCA device in core or in the periphery (clad, internals, control rods)

Material Irradiation devices

CHOUCA

- In core material irradiations (250 – 400 °C)
- In situ measurements
- Parametric studies, qualification, thermomechanical aging

→

- Zr alloys :
  - M5
  - Quaternaries
  - CANDU strength tubes
- Internals swelling
- Erbial clads, …

IRMA / BARITON

- Vessel steel (end of life studies)
- Irradiations in the periphery of the core

→

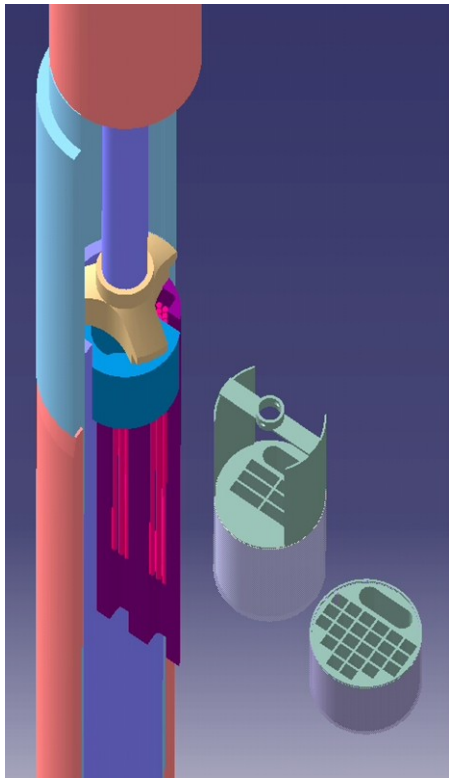
Resilience, toughness, and traction test-bars

DEVICES vs NEEDS (3)

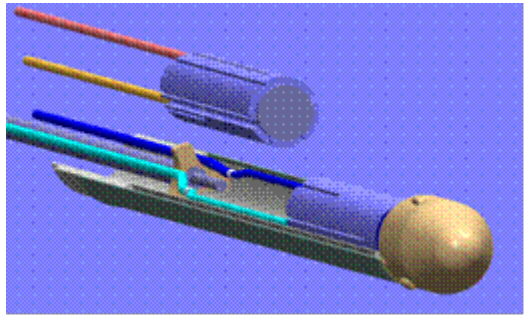
FUEL AND MATERIAL KNOWLEDGE AND DEVELOPMENT FOR FUTURE NPPs

- HTR – VHTR fuel : qualification of the fuel and its making process -> PHAETON device
- High temperature matérials -> simplified version of PHAETON device (graphite for HTR, SiC and W for covers in future fusion reactors)

HTR fuel and materials qualification : PHAETON



- High température irradiations (800 - 1600 °C)
- Fuel and material
- In core : high rapid flux
- At the periphery : cycles and power transcients



- **HTR - VHTR** :
  - Fuel : temperature transcients
  - Qualification of materials
    - Graphite
    - Isolating fibres
    - Various alloys
- **Other Génération IV concepts** :
  - GFR : fuel choice

Specific devices

MERCI

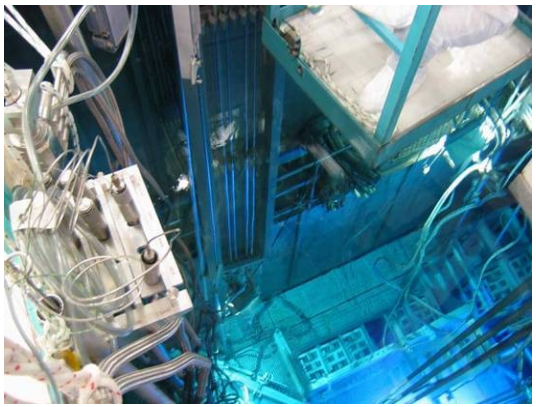
Measure of residual heat → • UO_2 • MOX • High burn-ups

TANOXOS

• 6 little rods (reduced diameter and length)
• Analytic studies
• Central temperature → • Advanced microstructures • CERMET, CERCER

Non destructive tests

- Neutronography
- Gamma Spectrometry
- Underwater metrology



OSIRIS CAPABILITIES