JHR
Non Destructive Examination benches: current status and prospects

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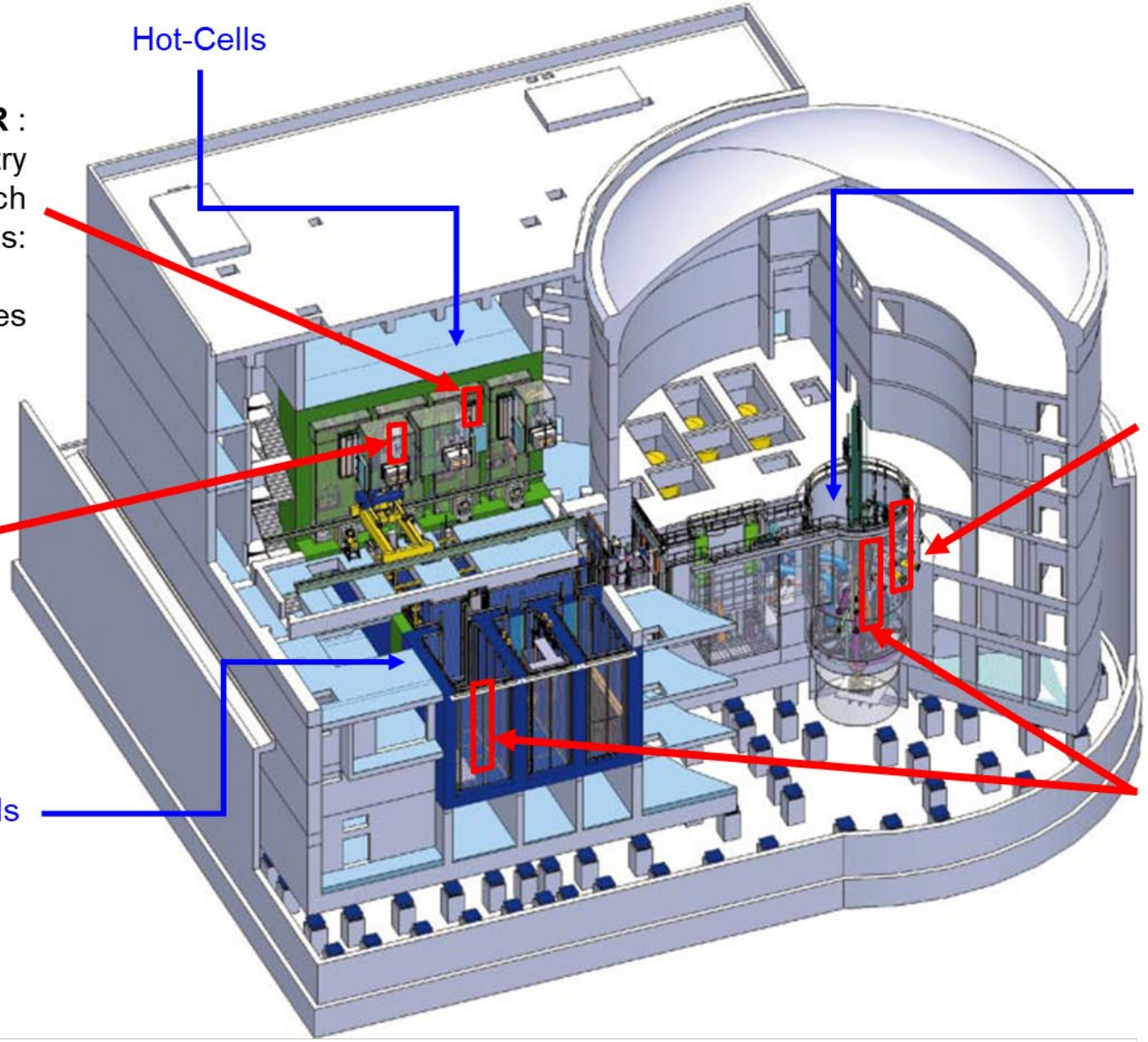
1. Jules Horowitz Reactor (JHR) and its Non-Destructive Examination (NDE) benches



HGXR :
Hot-cell **G**amma spectrometry and **X-R**ay imaging bench +other NDE cassettes:

NDE of irradiated fuel samples

HNDE-Mat:
Material Examination Cell NDE systems :

NDE of irradiated material samples

NIS:
Under-water **N**eutronographic **I**maging **S**ystem:

NDE of fuel samples in dedicated containers

UGXR:
2 **U**nder-water **G**amma spectrometry and **X-R**ay imaging benches:

NDE of fuel or material irradiation devices

1. Jules Horowitz Reactor (JHR) and its Non-Destructive Examination (NDE) benches

Expected performances

	UGXR – under-water	HGXR – in hot cell
Acceptable objects / maximum size	- **JHR irradiation devices** - Max dimensions : Ø200 mm, height 6500 mm - Max weight : 500 kg	- **Fuel samples:** Fuel rods, plates, JHR fuel assembly… - Max dimensions : Ø160 mm, height 1150 mm - Max weight : 30 kg
gamma scanning 1D/2D	- Relative and quantitative axial and transversal Fission Products distribution, Power and Burn-Up evaluation - Burn-Up : +/- 6 % (2 σ) on ^{137}Cs **- < 72 h examination for a 600 mm fuel column (standard axial scan)**	- Relative and quantitative axial and transversal Fission Products distribution, Power and Burn-Up evaluation - Burn-Up : +/- 4 % (2 σ) on ^{137}Cs **- < 12 h examination for a 600 mm fuel column (standard axial scan)**
X-ray camera	- X-ray detection* : 6.6 lp/mm	- X-ray detection* : 8 lp/mm
X-ray radiography / tomography	- **High resolution : target 100 µm** - About 30/40 minutes for 10 cm radiogram/ HR tomogram	- **High resolution : target 70 µm** - About 30/80 minutes for 10 cm radiogram/ HR tomogram
(x,y) movement	**Typical elementary step = 100µm ± 20µm; repeatability ± 50µm**	
Z movement	**Typical elementary step = 100µm ± 50µm; repeatability ± 50µm**	
Rotation movement	**Typical elementary step = 0.1° ± 0.03°; repeatability ± 0.03°**	

*Power of resolution of the X-ray camera line, either for radiography or tomography

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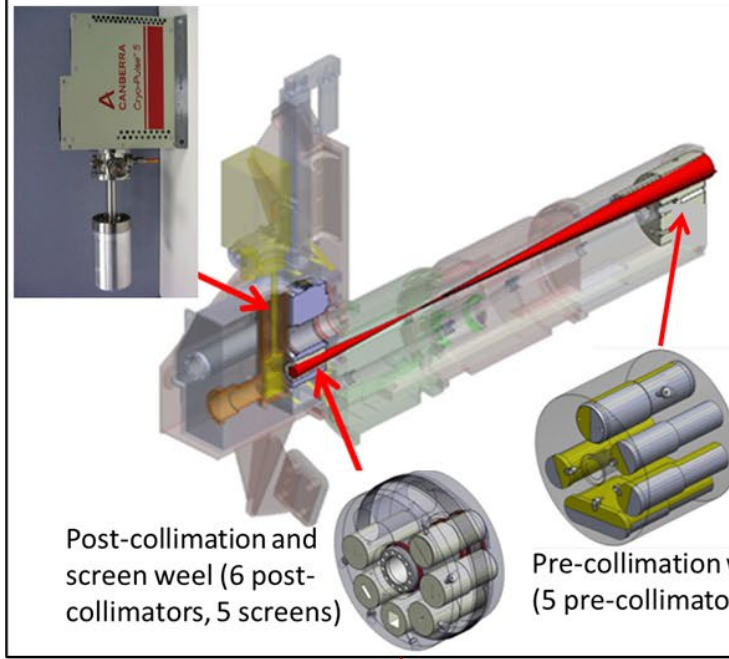
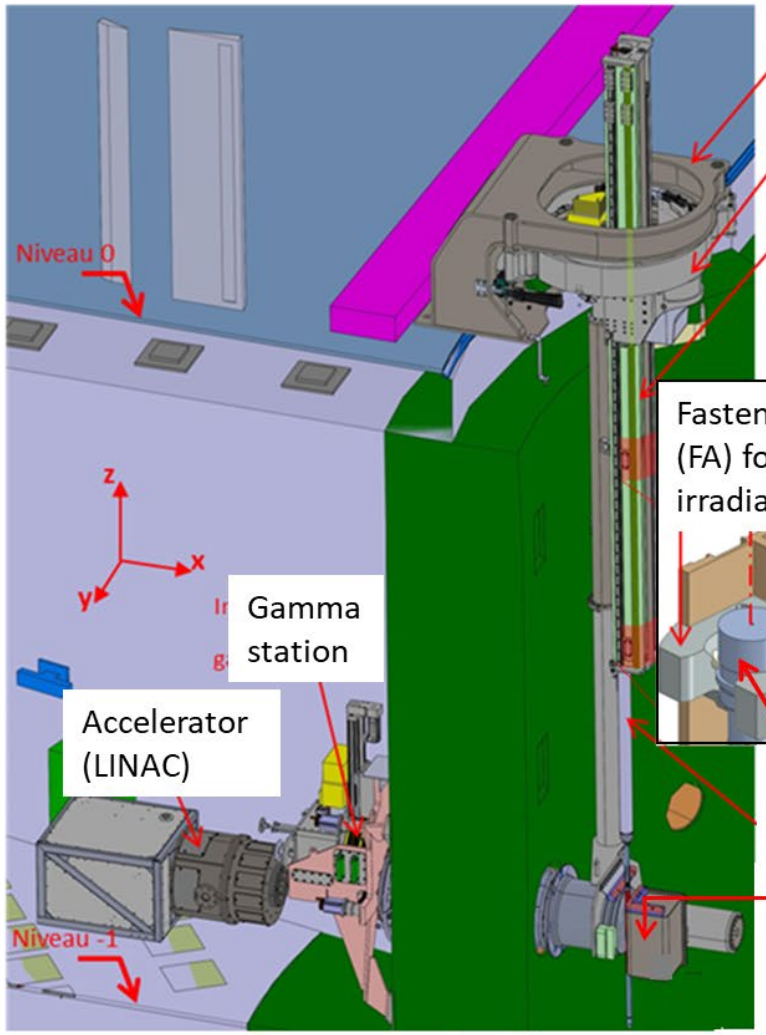
2. Design and operating of the under-water UGXR bench

Ground side

Gamma detector: GeHP, associated to a high counting rate chain



Collimation feedthrough

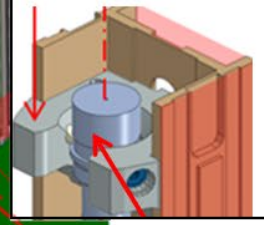


Fixed frame

Upper mobile part moving the irradiation device in rotation in the horizontal plane

Under-water arm moving the irradiation device vertically

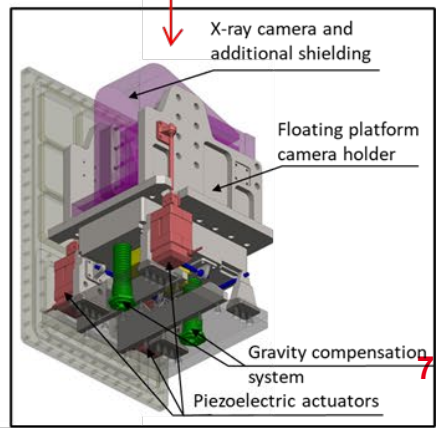
Fastening adaptor (FA) for JHR irradiation device



JHR irradiation device

Under-water side

High resolution X-ray camera in a watertight container



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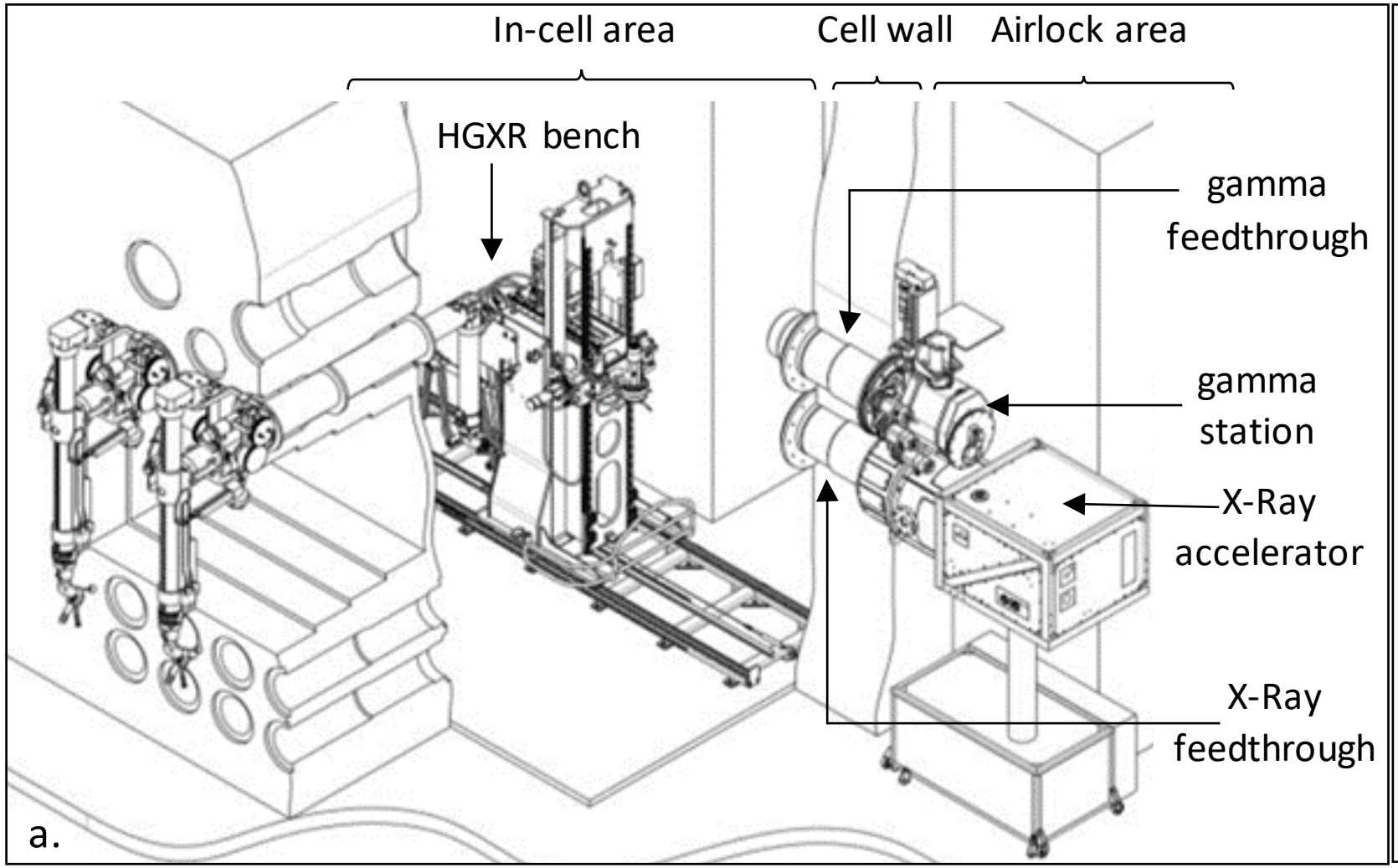
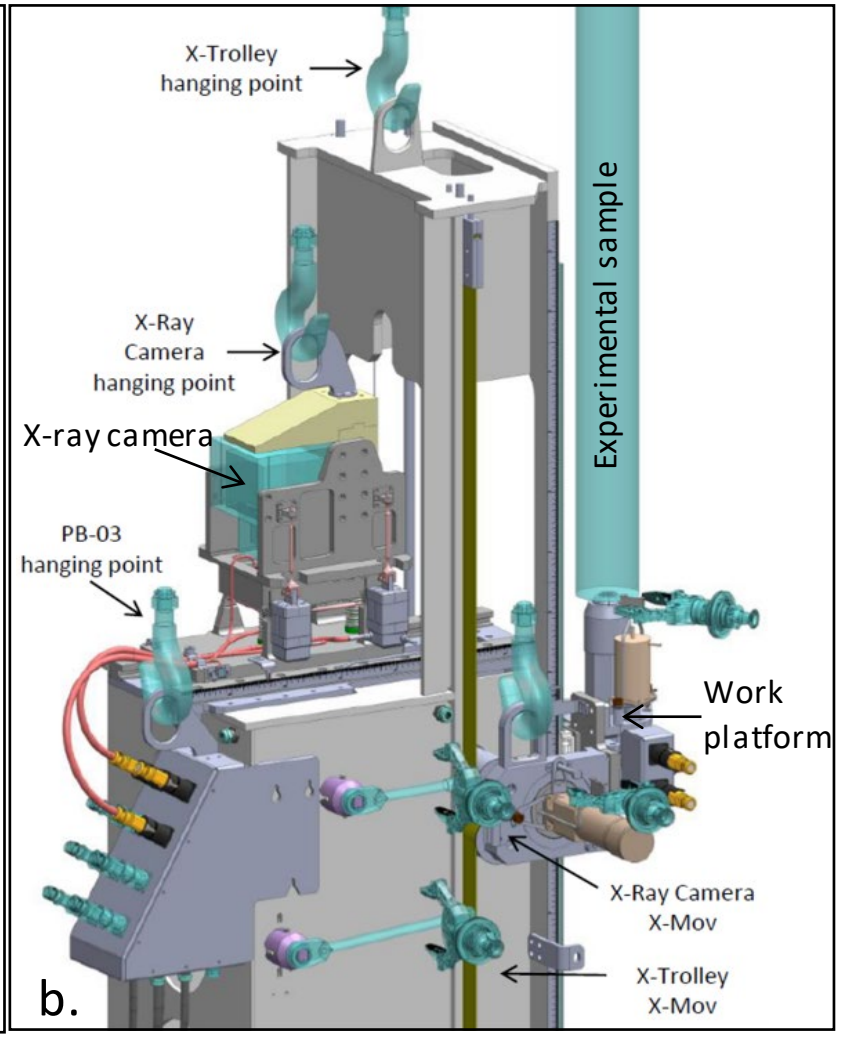
3. Design and operating of the hot-cell HGXR bench





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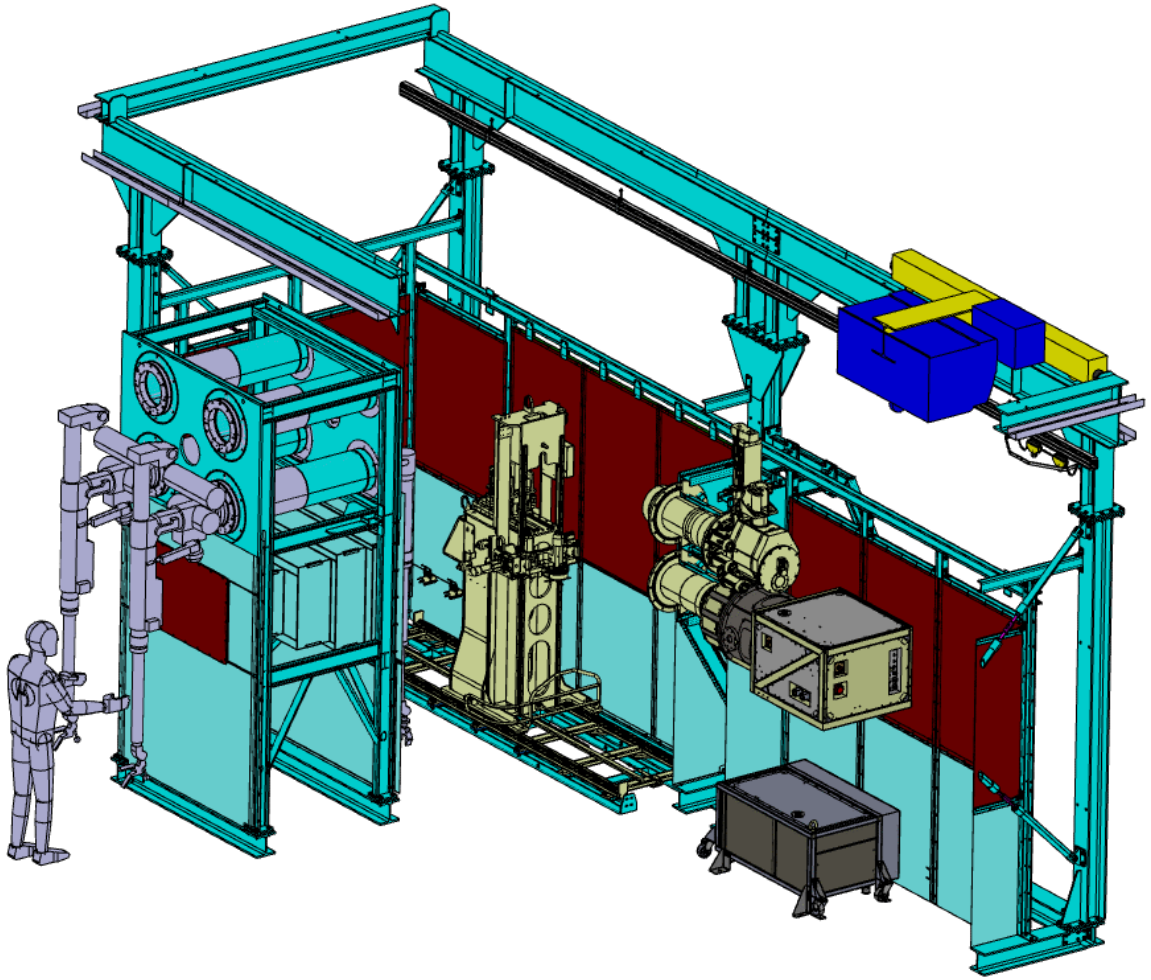
5. « Cold » conditions for representative testing UGXR benches

CESARINE pool and test tower in TOTEM facility

5. « Cold » conditions for representative testing HGXR bench

MARCEL Mock-up cell in TOTEM facility



5. « Cold » conditions for representative testing HGXR bench

Remote handling tests in MARCEL Mock-up cell in TOTEM facility

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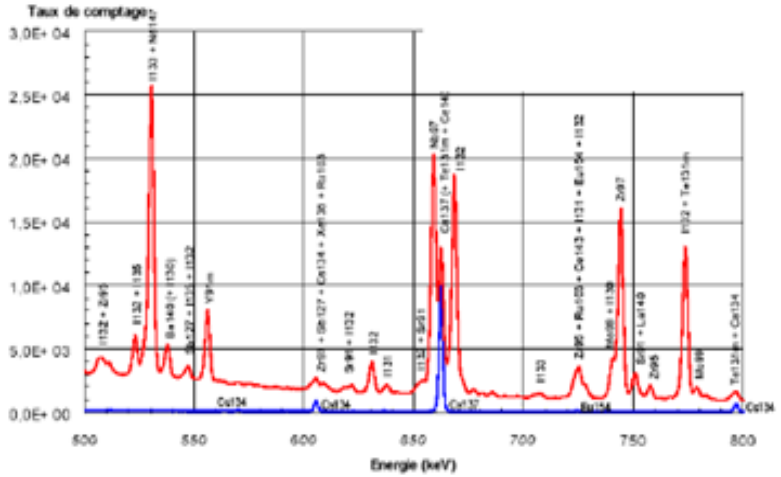
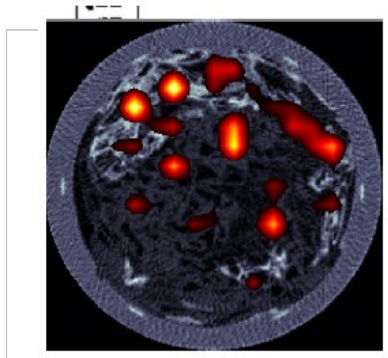
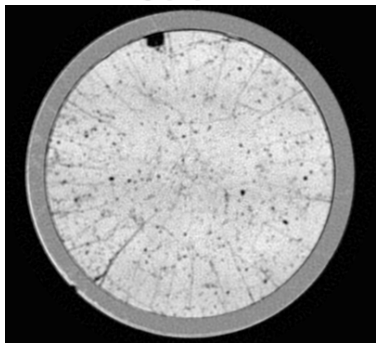
6. Examples of complementary examinations combining gamma spectrometry and high resolution X-ray imaging

Example of gamma spectrum and emission tomography

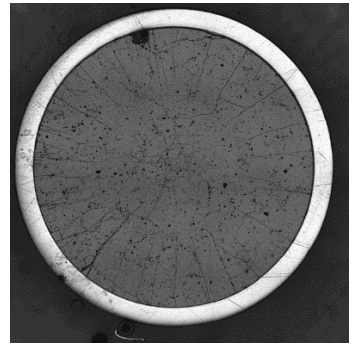




Comparison of a realistic simulation of an non destructive examination by X-Ray tomography (left) and a destructive examination (right)



Realistic simulation of X-ray tomography (source 0.5 mm – detection 50 µm)



Macrography after cutting and metallic coating of a fuel sample

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3. Conclusion

- **UGXR, HGXR benches :**
  - experimental equipment dedicated to gamma spectrometry and high resolution, high energy X-ray imaging of fuel devices and samples irradiated in JHR.
  - will be implemented in the JHR's pools for UGXR and in the fuel examination hot cell for HGXR bench.
  - designed to reach high-resolution performances in an acceptable acquisition time and to accommodate a wide range of irradiation devices and of experimental fuel samples.
- **UGXR and HGXR equipment fully manufactured :**
  - operations involved in experimental measurement sequence and in maintenance will be carried out in "cold conditions", in a pool and in a mock-up cell representative of the JHR environment.
- **Demonstration of operability of these benches is of crucial importance for JHR experimental capability :**
  - on-site non-destructive examination benches are a major asset of JHR for studying and better understanding the behavior of fuels under irradiation.

Thank you for your attention