PRACTICAL APPLICATION OF COMPUTER PROGRAM PANTHERE FOR WORKERS' RADIATION PROTECTION.

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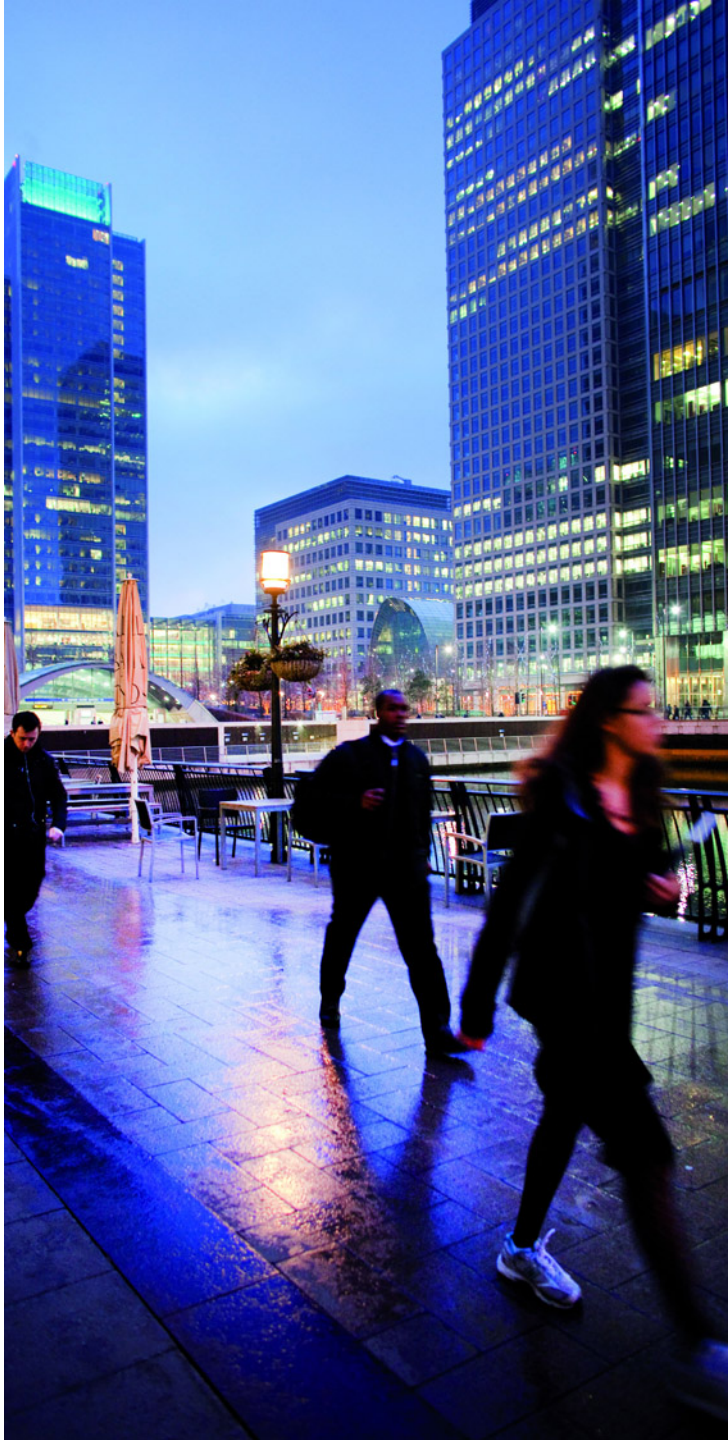

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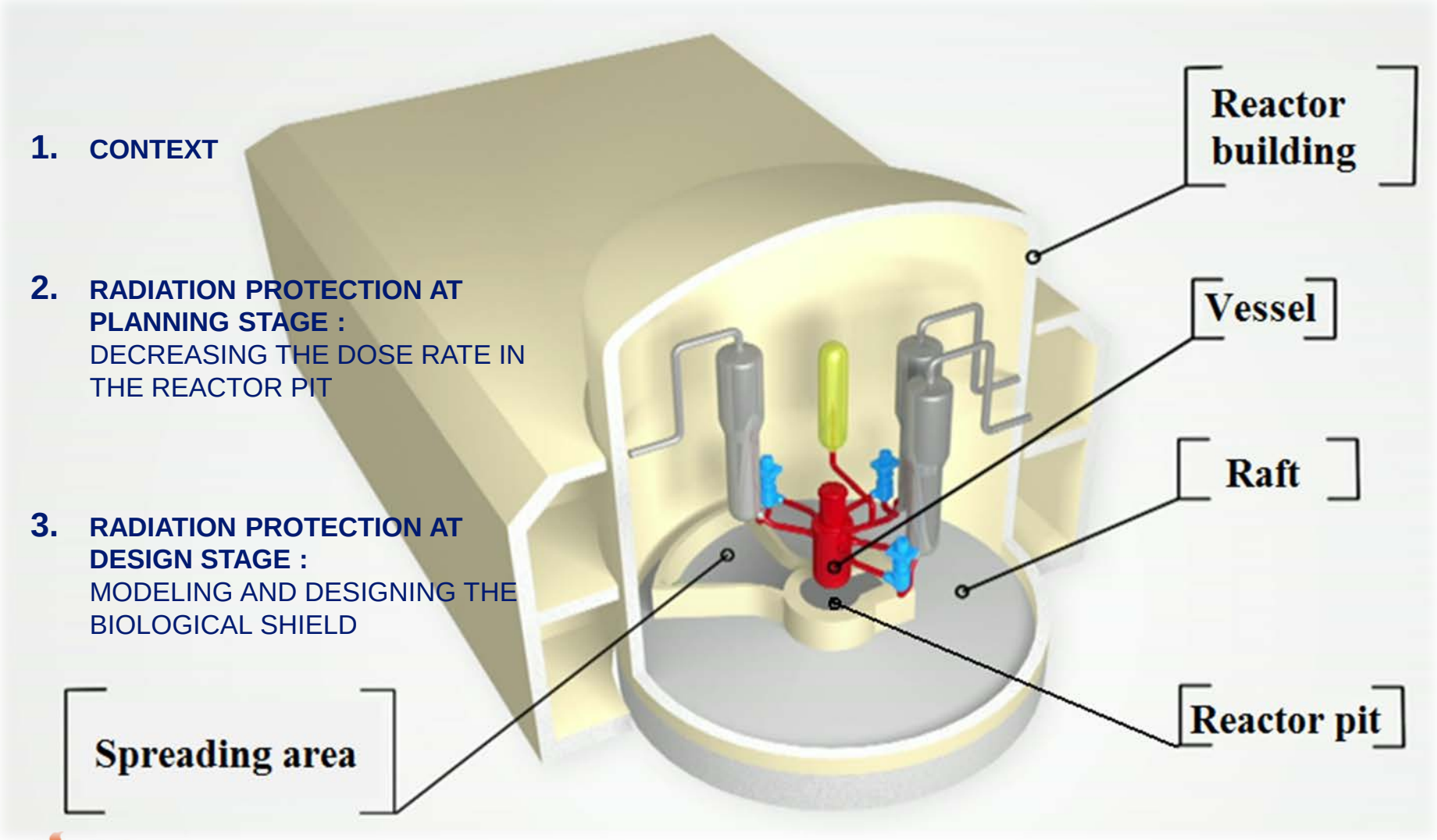


CONTEXT

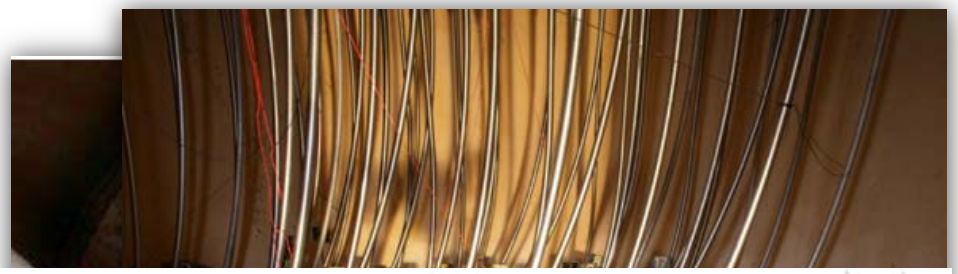
- **A new context after the Fukushima's nuclear accident**
  - Before Fukushima : a major accident is highly unlikely in the safety approach.
  - After Fukushima : the consideration of some major accidents and their impacts are reinforced.

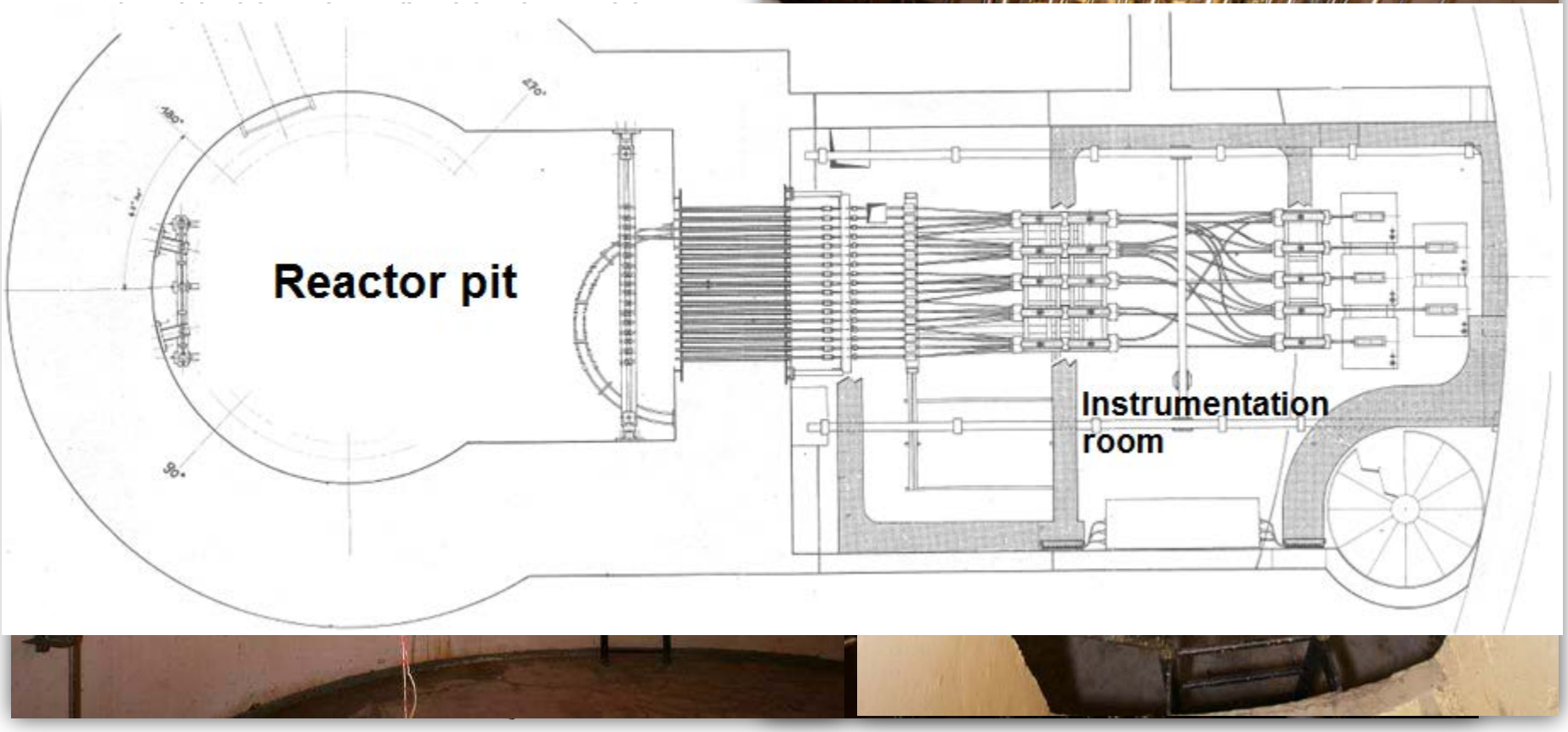
- **EDF shares its nuclear safety goals with the French Nuclear Safety Authority (ASN)**
  - One of EDF proposals (only for 2 French PWRs units) to reach these goals is to :
    - Increase the thickness of the reactor pit's concrete
    - create a new spreading area for corium.

- **These technical operations have two strong dosimetric issues :**
  - Radiation protection at planning stage :
    - Dose rate in the reactor pit is high. During the execution of the work, the dose rate has to be optimized.
  - Radiation protection at design stage :
    - The radiological zoning of spreading area should not be modified. After the execution of the work, a biological shield has to be implemented to protect nuclear workers during the future maintenance.

DECREASING THE DOSE RATE IN THE REACTOR PIT

- **The reactor pit :**
  - A very small area (footprint ~ 30 m²)
  - The main activated elements are

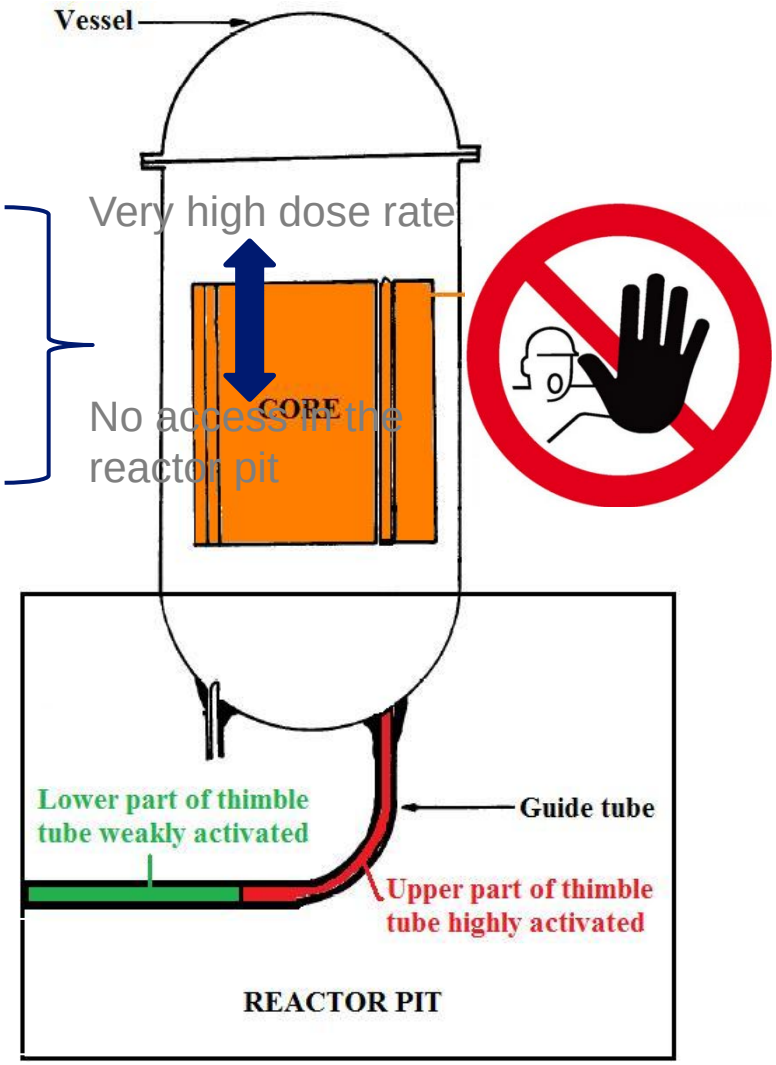




DECREASING THE DOSE RATE IN THE REACTOR PIT

- **Four configurations for two positions of the thimble tubes :**
  - Nuclear power plant in operation :
    1. Thimble tubes are fully inserted for checking neutron flux
    2. Thimble tubes are fully retracted in the reactor pit
  - Nuclear power plant at shutdown state :
    3. Thimble tubes are fully retracted in the reactor pit
    4. Thimble tubes are fully inserted (only when fuel assemblies are still in core)

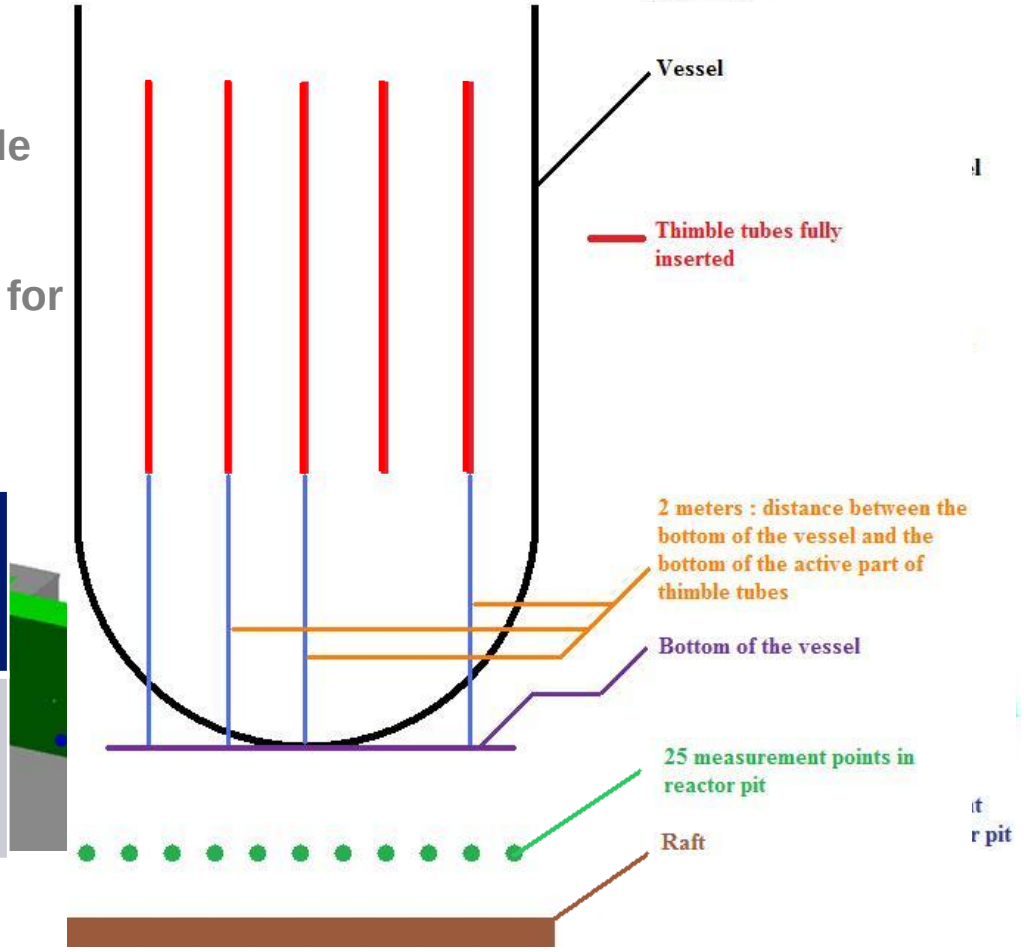
- **Only the 4th configuration allows an access in the reactor pit**



DECREASING THE DOSE RATE IN THE REACTOR PIT

- **Planning constraints → core totally defueled → a compromise between radiation protection and thimble tubes position**
- **3D modeling with Panthere**
- **Parametric study based on the thimble tubes position.**
- **Main objective : to find a value range for thimble tubes position for which the average dose rate is closed to the reference dose rate**

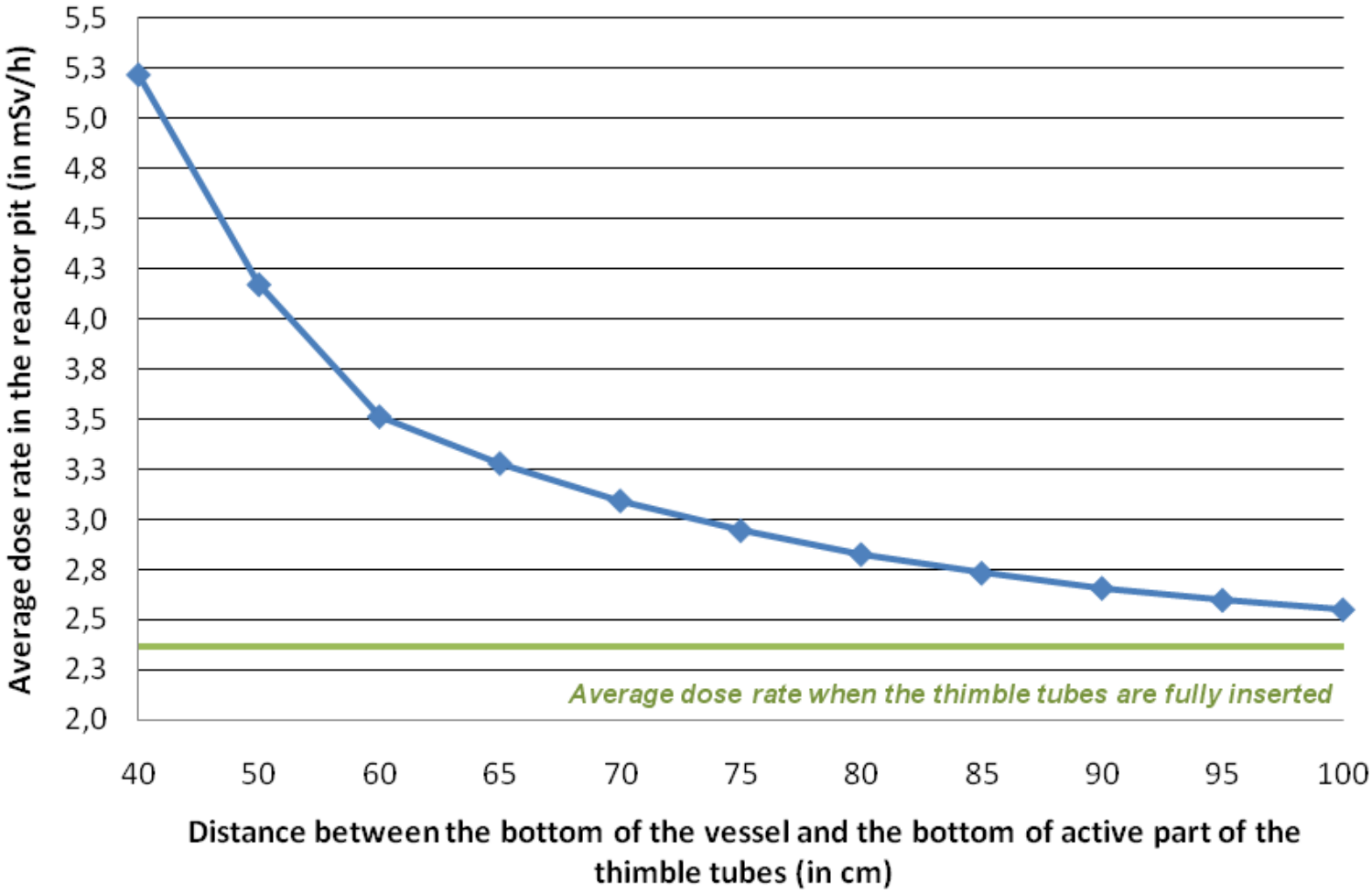
	*In situ measurements (average)	*With modeling (average)
Reference dose rate (in mSv/h)	2.35	2.4



*Reactor stopped - thimble tubes fully inserted

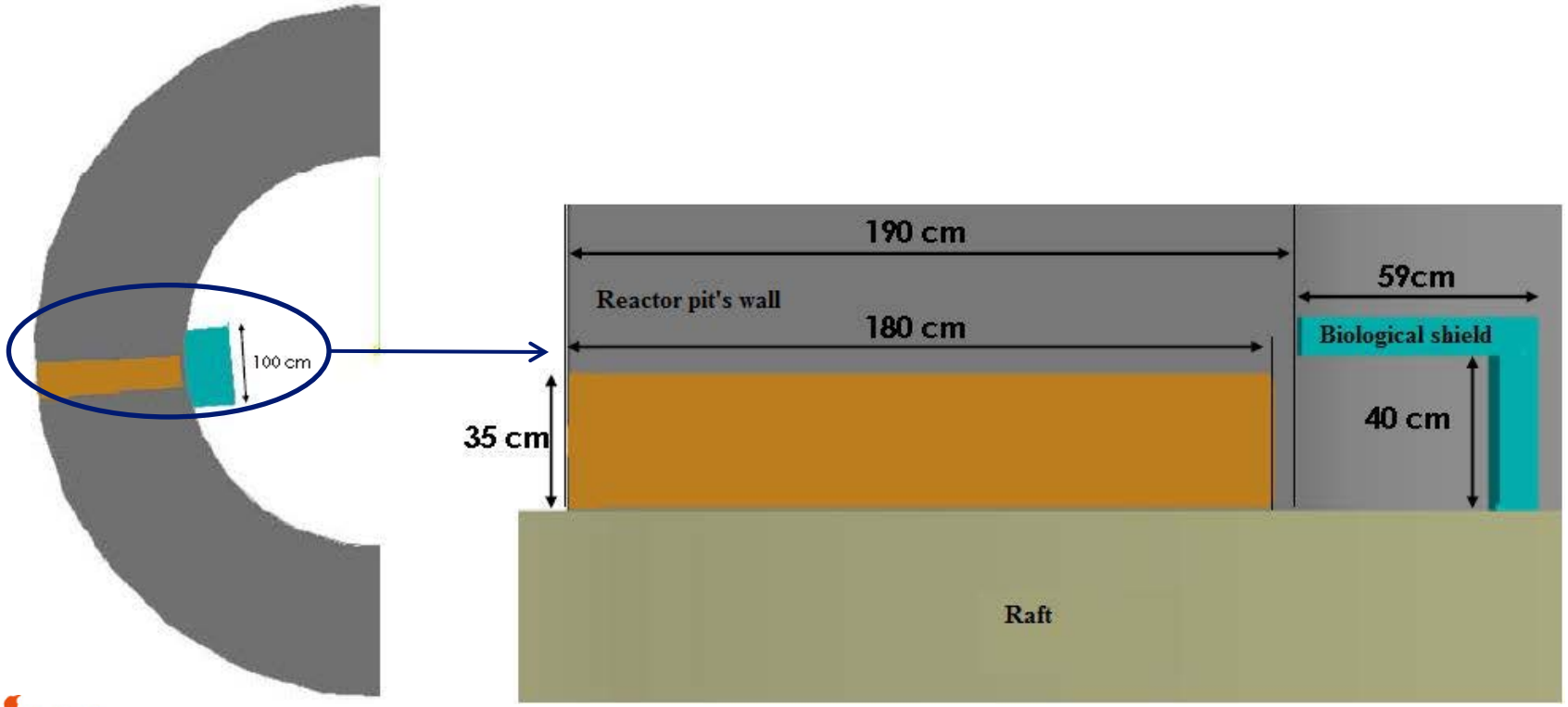
DECREASING THE DOSE RATE IN THE REACTOR PIT

- **Results for the value range : between 85cm and 100cm**



MODELING AND DESIGNING THE BIOLOGICAL SHIELD

- Creation of the spreading area = coring the wall of the reactor pit
- Potential risk of a radiological zoning's change in the spreading area
- Biological shield was designed & modeled with Panthere to avoid this risk and to protect nuclear workers during future operations.



MODELING AND DESIGNING THE BIOLOGICAL SHIELD

- **A step-by-step approach shared with the nuclear plant operator :**

1. **3D modeling with in situ measurements's radiological conditions → processing the digital radiological zoning of reference (0.025mSv/h < regulated stay area < 2mSv/h)**

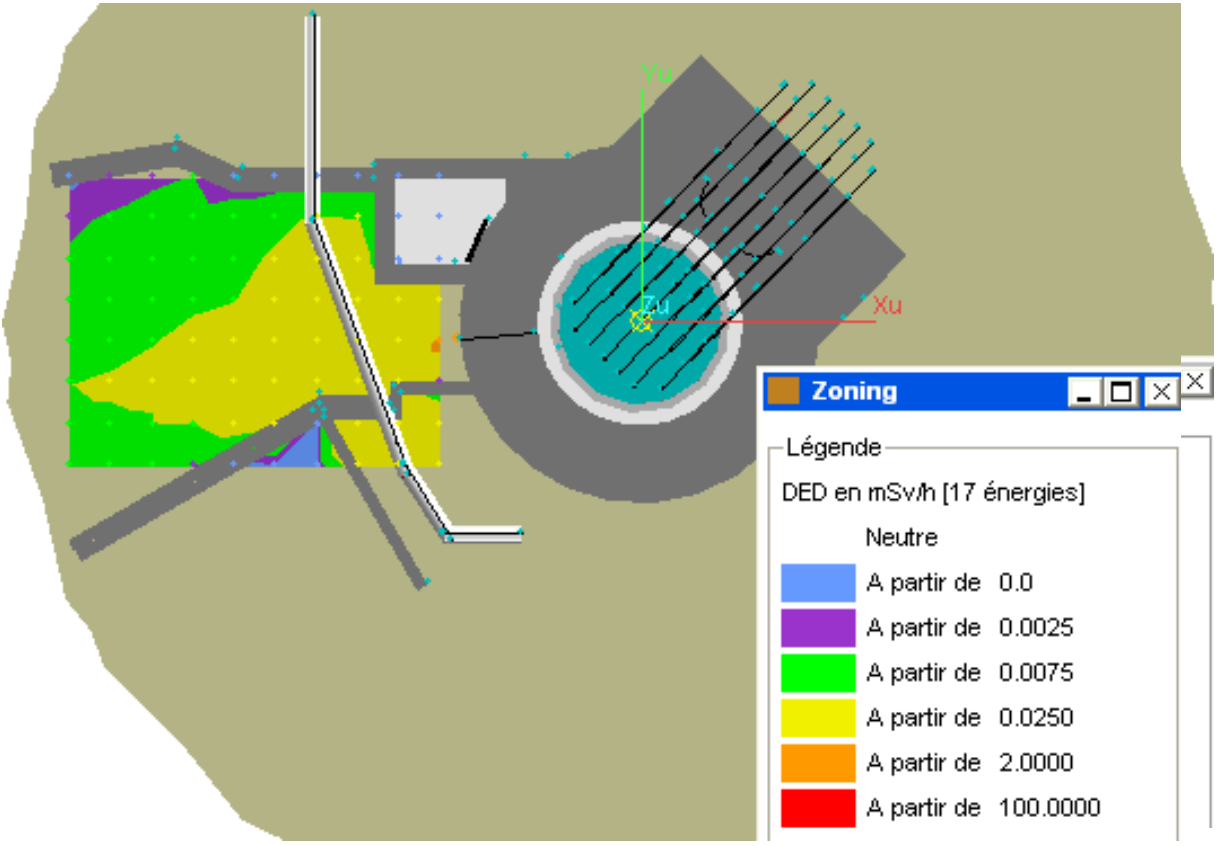
2. **Adding the coring to evaluate its own impact on the radiological zoning**

3. **Designing the biological shield with the following technical requirements:**
   - No prohibited area (dose rate > 100 mSv/h),
   - No limited stay area (2 mSv/h < dose rate < 100 mSv/h) beyond 50 centimeters after the coring
   - Biological shield shall be implanted in the reactor pit and shall not block the coring.

4. **Parametric study based on the lead thickness of the biological shield.**

MODELING AND DESIGNING THE BIOLOGICAL SHIELD

- After several iterations, dose rate objectives were reached with 11 cm thickness of lead.



	Lower limit (in mSv/h)	Upper limit (in mSv/h)
Regulated work area	0.0075	0.025
Regulated stay area	0.025	2
Limited stay area	2	100
Prohibited area	100	

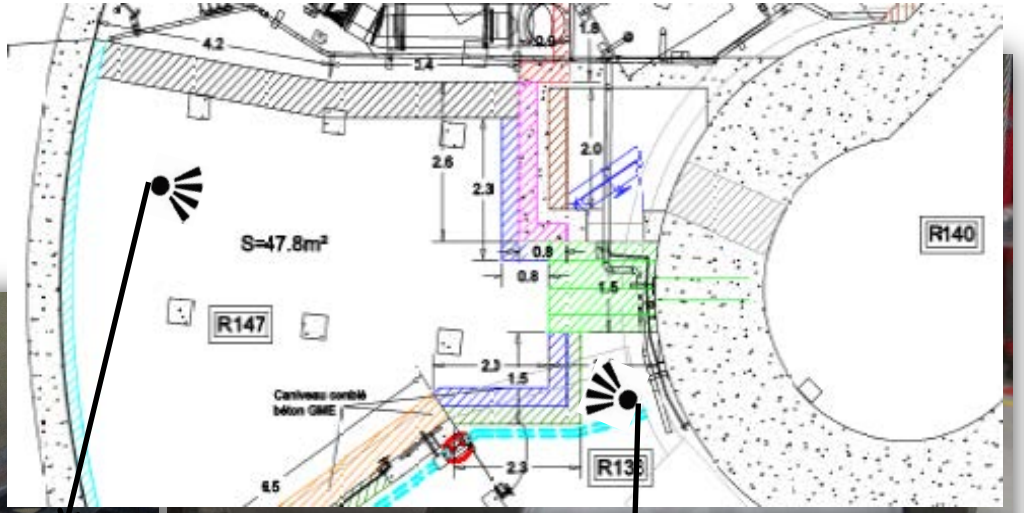
- With the 11 cm lead shield → limited stay area and prohibited area out of the spreading area < 2mSv/h

MODELING AND DESIGNING THE BIOLOGICAL SHIELD

- **The results of this study were shared with the nuclear plant operators and the biological shield was implanted in the reactor pit.**

MODELING AND DESIGNING THE BIOLOGICAL SHIELD

- **Furthermore, a specific biological shield was designed for radiation protection of the workers during execution of the work**



CONCLUSION

- **The planning and design (technical) constraints have to be turned into radiation protection opportunities.**
- **In these 2 examples, radiation protection's impact were detected from the beginning and were integrated into the design and the planning of the technical operations**
- **This allows short and long term solutions and a higher level of radiation protection.**
- **Not only reduce the operational dosimetry but especially the future dosimetry for maintenance which is recurring**