DE LA RECHERCHE À L'INDUSTRIE

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*Waste Management Symposium 2015*
*Phoenix*

# SCIENTIFIC SUPPORT FOR NUCLEAR DECOMMISSIONING IN FRANCE

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# CEA Decommissioning: At stakes, Objectives, Strategy

**Rigorous management of fuel cycle « back end » :**

- **Dismantling of shutdown nuclear facilities**
- **Retrieval, conditioning of legacy wastes**

**CEA objective : carry out in safety and in respect of cost and delay all DD&R program.**
**Priorities :**

- Clean up and decommissioning of all nuclear facilities now enclosed in cities Centres of Grenoble & Fontenay aux Roses,
- Marcoule : dismantling of UP1 processing facility
- Respect end dates (decrees & safety objectives)

**CEA's strategy (regulatory framework : nuclear laws 2006 TSN & wastes) :**

- **Immediate and total decommissioning when feasible.**
- **Technical and economical optimization pursuit**
- **End state : Removal of all dangerous material** (in particular radioactive ones).
  - If impossible : decommissioning with constraints
- **Solid and liquid waste : minimization, optimization of categorization, on line evacuation**

# CEA's D&D UNIQUENESS

**580 M€/year**
**815 CEA employees and about 2500 employees from supply chain**

- **Huge facilities variety :**
  - **Reactors :** pond, fast breeder, gas graphite, …
  - **Accelerators & irradiators,**
  - **Laboratories, workshops & plant**
  - **Waste treatment facilities, storage facilities**
- **No scale nor «series effect»**
- **Different sizes :**
  - **Reactor : Ulysse INSTN -> Phénix (NPP)**
  - **LAMA -> building 18 FAR -> APM -> UP1**
- **R&D facilities,**
  - **Modifications traceability, history**
  - **Various waste,…**
- **Chemical treatment, irradiated spend fuels:**
  - **Contamination level could be high :**

    **(FAR, Marcoule APM & UP1,…)**
- **Historical nuclear sites**

# COST & FUNDING


- **Regulatory framework:**
  - TSN Law (Transparency and Nuclear Safety)
  - "Waste Law" of 2006

- **Financial obligations: Art. 20 of the "2006 Law"**
  - Future D&D program must be totally charged,
  - Control committees
  - Annual reports, external reviews

***Three-yearly report (2013)***

- **Civilian fund : 2001, Defense Fund : 2005**

- **National Nuclear Politic Committee Council February, 12th, 2010 :**
  - **Guarantees about funding**
  - **Agreement signed between State and CEA October, 19th 2010**
  - **Amounts : ~ 600 M€ per year (TOTAL > 10 G€)**

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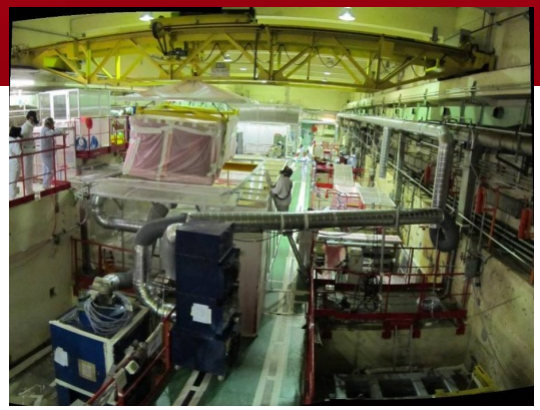
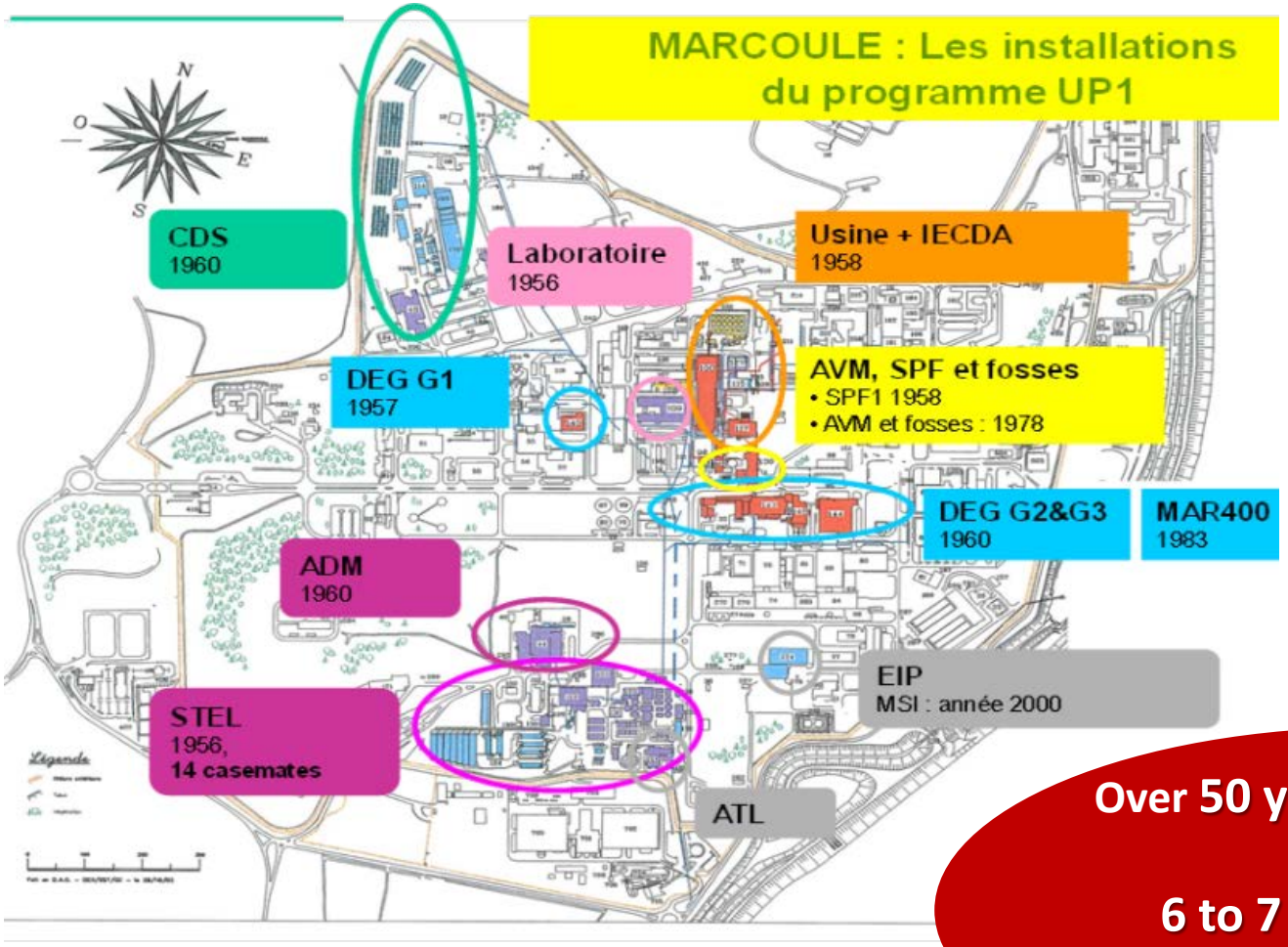
# THE BIGGEST CEAs'DD&R PROGRAM : UP1






**Over 50 years of operations**

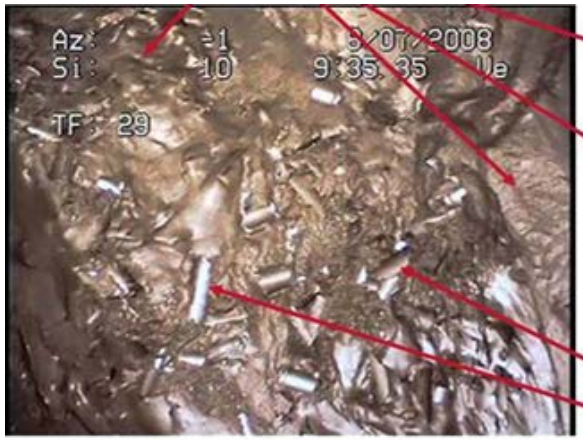
**6 to 7 billions euros, including dismantling, waste retrieval and conditioning**

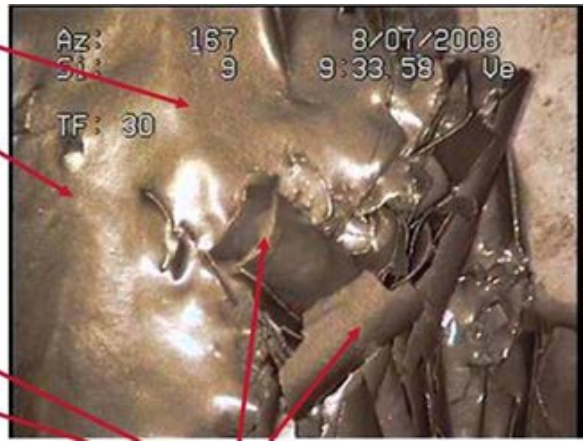
# UP1: WIDE RANGE OF HLW WASTE AND LARGE AMOUNT

**75 types of legacy wastes, located in18 different locations:**

- ~ 3150 glass canisters
- ~ 1630 t of HLW Mg clads
- ~ 1300 t of powdery waste
- ~ 1300 drums of alpha-waste
- 60 000 drums of bituminized waste
- Active areas = 140 000 m3
- 26 000t of waste from active areas
- civil engineering structures, Contaminated equipments, Miscellaneous

- Very different in they chemical and radionuclide composition
- long-lived radionuclides
- Re-disposal required

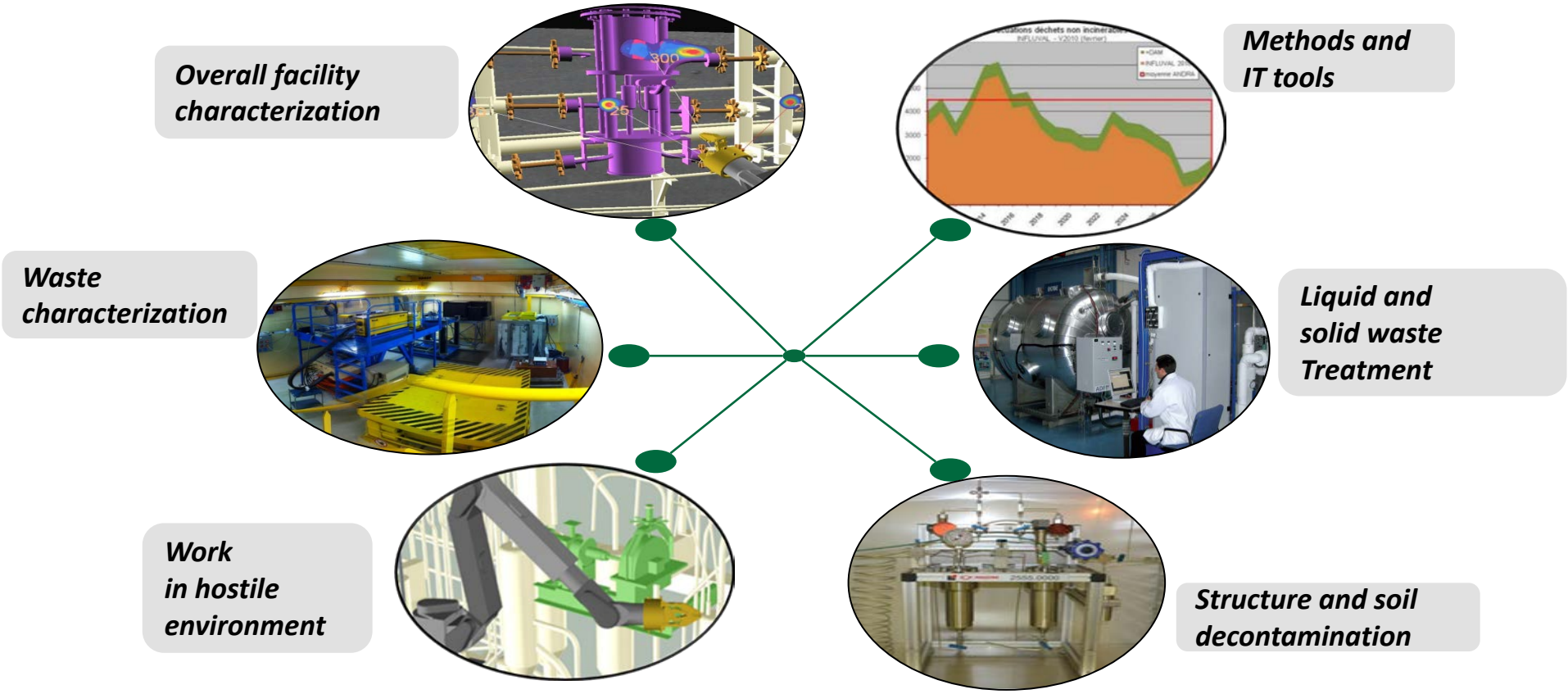



# CEA D&D R&D, technologies and processes

- R&D has a special role to help decrease costs, schedules , dose uptake,  waste and to improve work safety & security

- CEA leads R&D actions and develops expertise in 6 main axis



# 1) OVERALL FACILITY CHARACTERIZATION
## R&D ON INITIAL, IN-OPERATION AND FINAL MEASUREMENT

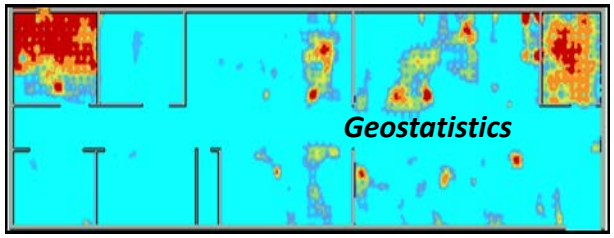
▶ ***EARNINGS*** **to map facilities and soil, to localize hot spots, to identify radionuclides, to estimate radioactivity, to define and validate a D&D scenario**

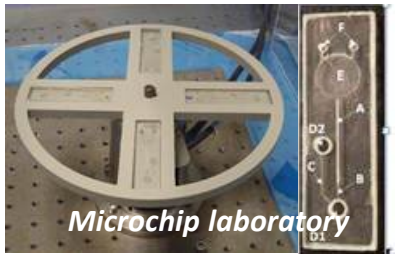
- Control hazards management, cost and delay
- Reduce the doses integrated by operator
- Optimize samplings

▶ ***IMPROVEMENTS***

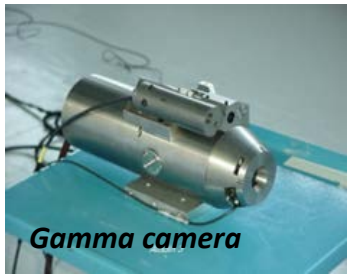
**Optimization of D&D scenarios, from the identification of characterization objectives through to the final physical and radiological inventory**

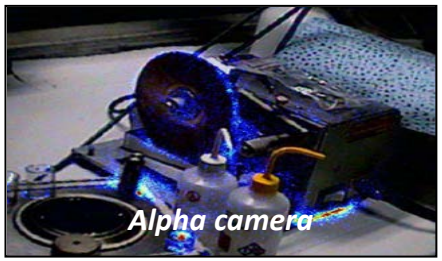
- Non destructive gamma measurements (concrete contamination)
- Alpha and gamma Cameras : Pu inside glove boxes
- LIBS : in situ laser measurement of species
- Geostatistics method to optimize measurements and sampling
- Autoradiography



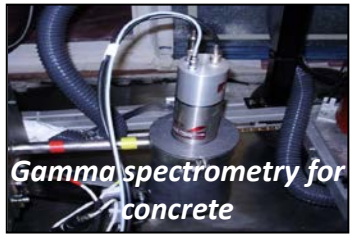







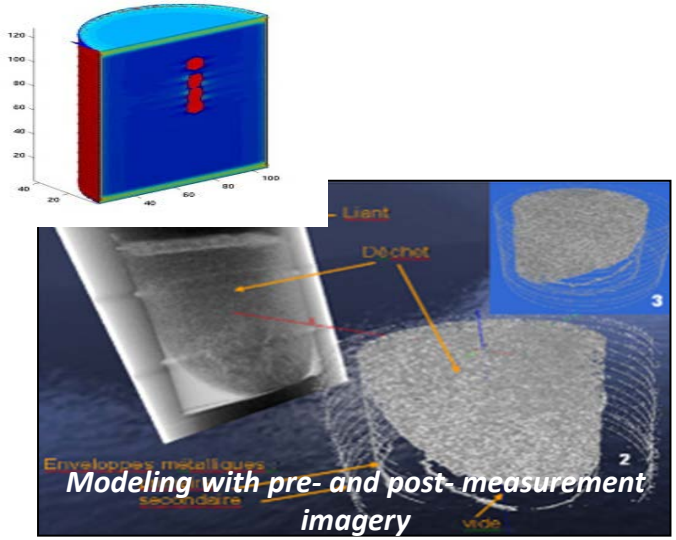





# 2) WASTE CHARACTERISATION

## *EARNINGS*

- Waste minimization
- Optimize a characterization process

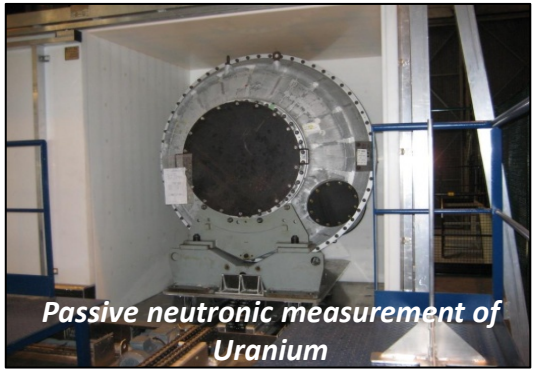


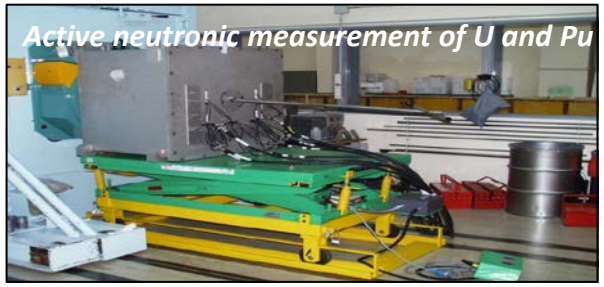
*Modeling with pre- and post- measurement imagery*

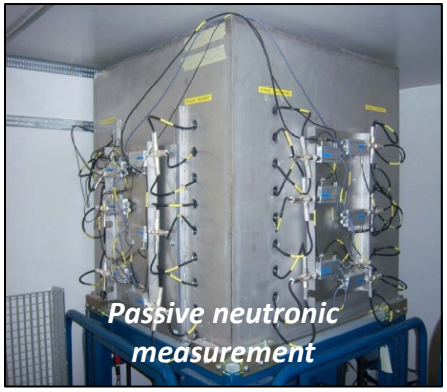
## *IMPROVEMENTS*

- non destructive analysis:
  - γ et α imaging
  - γ spectrometry
  - Neutronic measurement
- Destructive analysis :
  - beta long live analysis


*Waste characterization in glove boxes*


*Passive neutronic measurement of Uranium*


*Active neutronic measurement of U and Pu*


*Passive neutronic measurement*

# 3) WORK IN HOSTILE ENVIRONMENTS
## HIGH ACTIVITIES OPERATIONS: ROBOTICS, VIRTUAL REALITY, …

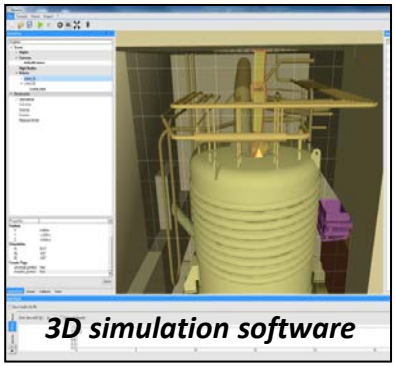
### *EARNINGS*

- Validate intervention scenario feasibility
- Reduce the doses integrated by operators
- Minimize cost, delay, waste volume, cuttings
- Compare alternative scenarios
- Qualify remotely-controlled equipment (robots, tele-operated equipment, cutting processes,…)
- Ensure our equipment will be accepted by Safety Authorities

### *IMPROVEMENTS*

- Design, adaptation of fine-tuning innovative systems for computer-assisted tele-operation actions, as well as carriers: remote handling MAESTRO
- Development of laser cutting processes in air or under water to improve cutting yields while limiting the aerosols and waste generated.
- Development of 3D simulation software and virtual reality: Immersive Room for training
- Test and demonstration platform for cold qualification,
- Pilot job sites for qualification under real conditions.

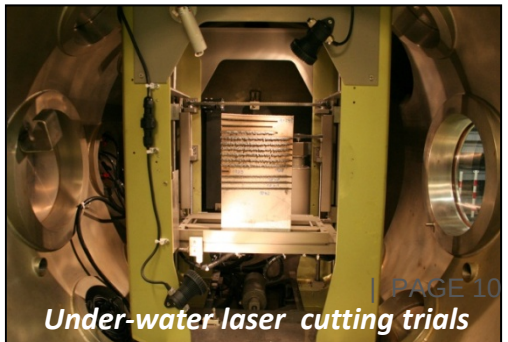

*Immersive Room*


*3D simulation software*


*Laser cutting tool*


*Pilot workshop*


*Remotely-handled arm*


*Under-water laser cutting trials*

# A COMPLETE MODEL : CHARACTERIZATION, SIMULATION, TELE-OPERATION

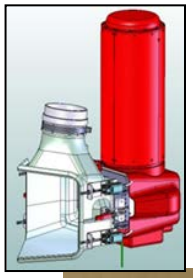
# 4) STRUCTURE AND SOIL DECONTAMINATION

## EARNINGS

- Identify and implement décontaminations techniques for radioactive solids, structures and soils
- Waste optimisation
- Develop and implement decontamination processes for radioactive effluents
- Valorization

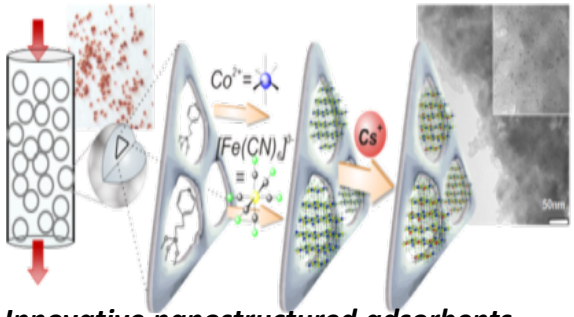
## IMPROVEMENTS

- Technologies adaptable to many geometrical configurations, and to a wide range of materials and natures of contamination:
  - ✓ aspirable self-drying gels,
  - ✓ laser ablation,
  - ✓ viscous foams or active solutions,
  - ✓ float foams or supercritical fluid,
  - ✓ coating gels, …
- Studies of chemical medium formulations with associated physico-chemical characterizations,



*AspiLaser ® technology*

*Decontamination foams*



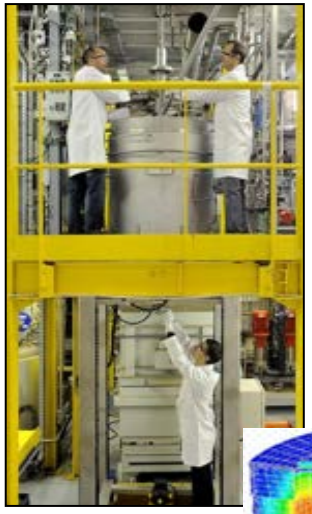

*Innovative nanostructured adsorbents*

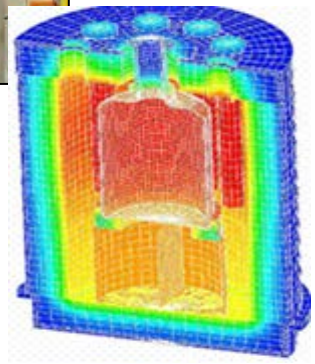
*Supercritical $CO_2$*

# 5) LIQUID AND SOLID WASTE TREATMENT

## EARNINGS

- Develop efficient treatments for complex radioactive wastes (mercurials, sodics, tritiates, Mg from decladding, powders, graphite, sludges, other legacy waste, ..)



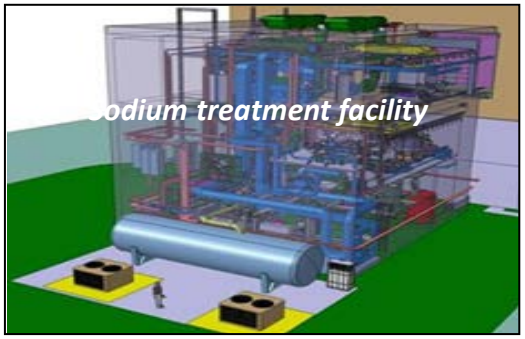
*In-Can Melting*

## IMPROVEMENTS

- design and carry out radioactive waste treatment processes from laboratory scale through to industrialization phases.

- Several thermal processes for the treatment of solid or liquid organic radioactive wastes:
  - ✓ incineration,
  - ✓ mineralization of organic liquids by hydrothermal oxidation (DELOS)or by plasma incineration (IDOHL),
  - ✓ Co-precipitation, adsorption
  - ✓ Vitrification (in-can melters)
  - ✓ Embedding with geopolymer,
  - ✓ Mercury, sodium, tritium waste, … treatment

*Geopolymer matrix*

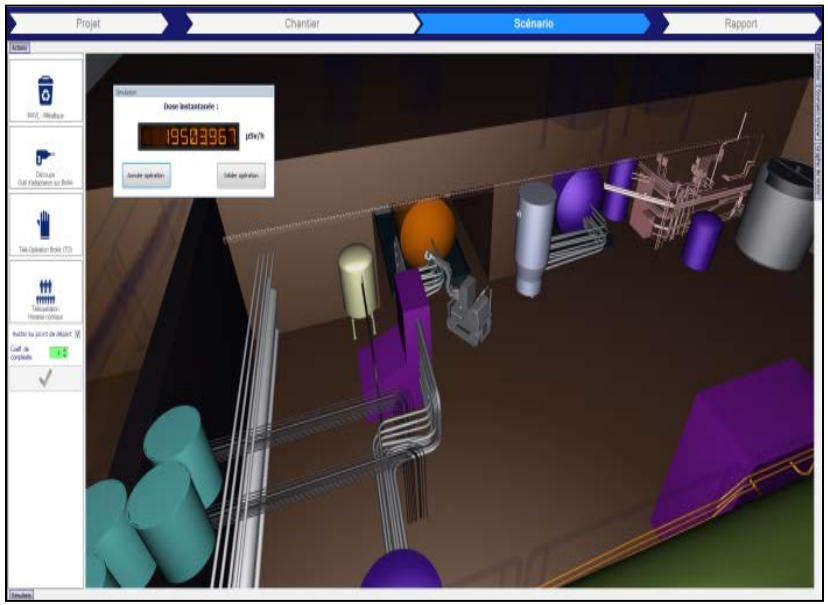
# 6) METHODS AND IT TOOLS

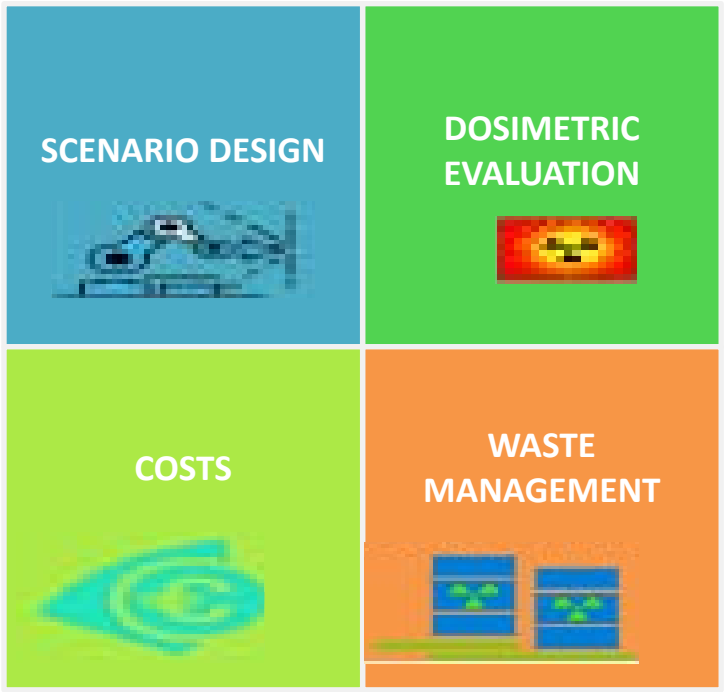
## *EARNINGS*

- Compare dismantling scenarios to optimize costs, scheduling, integrated doses, and amounts of waste generated.
- Know the future dismantling costs for a facility before its construction.

## *IMPROVEMENTS*

- Certified tools and methods to evaluate dismantling forecasts.
- Integrated systems with characterization, simulation 3D, virtual reality



# CONCLUSION

- DD&R is a key mission for CEA Nuclear Energy Division
- This is a Huge Program : D&D the Nuclear facilities on 5 nuclear centers, Recovery of Old Wastes
- Costs of the programs > 10 G€, guaranteed by the French Government
- The position of CEA is unique because of the number of facilities under decommissioning, with contamination levels sometimes very high, and a wide diversity from laboratory scale to industrial plants.
- R&D has a special role to help decrease costs, schedules and amounts of waste and to improve the safety of workshops.
- CEA's objective is to valorize its experience and its R&D developments on national and international basis

**Thank you for your attention**