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AREVA solutions for Fukushima clean-up

Journée SFRP "Fukushima : 4 ans après"
11 mars 2015 – Paris

Jean-Christophe Piroux

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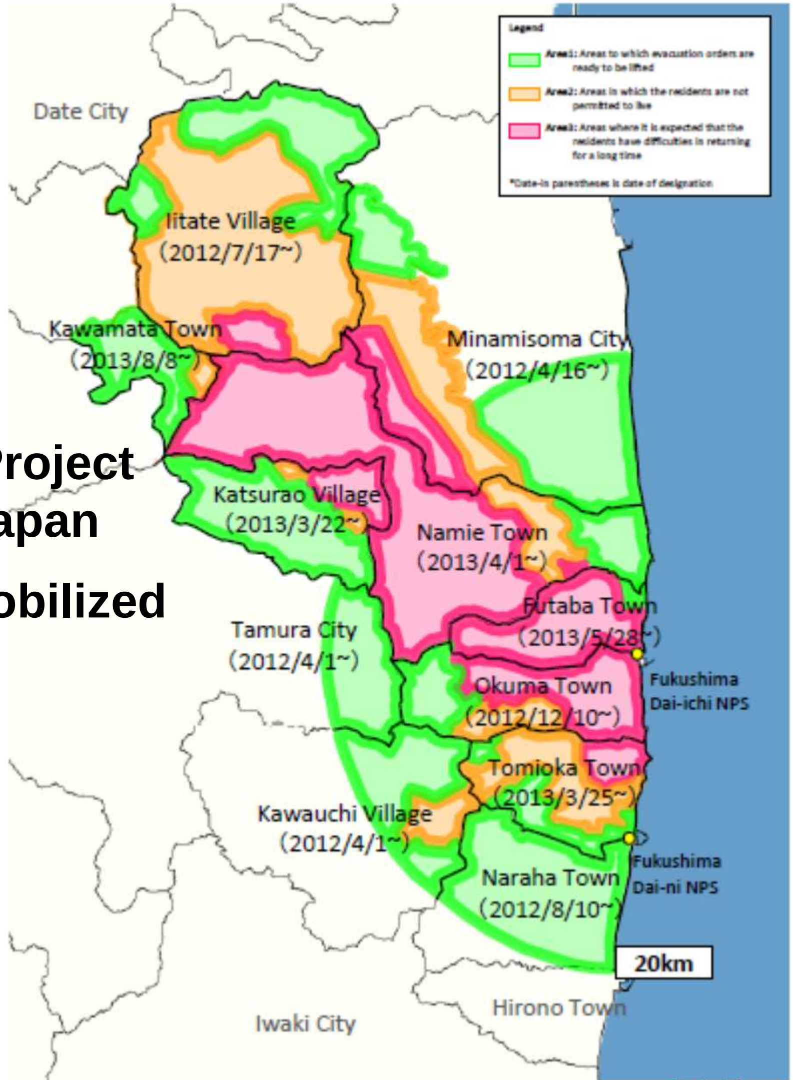
AREVA is present since March 11th



- **AREVA sent within one week an airplane with absorbers, Masks, Mobile Van & Radiation measuring devices**
- **A world-wide AREVA Team for Fukushima Project was identified in two weeks and staffed in Japan**
- **More than 20 AREVA Worldwide Experts mobilized with more than 200 people involved**

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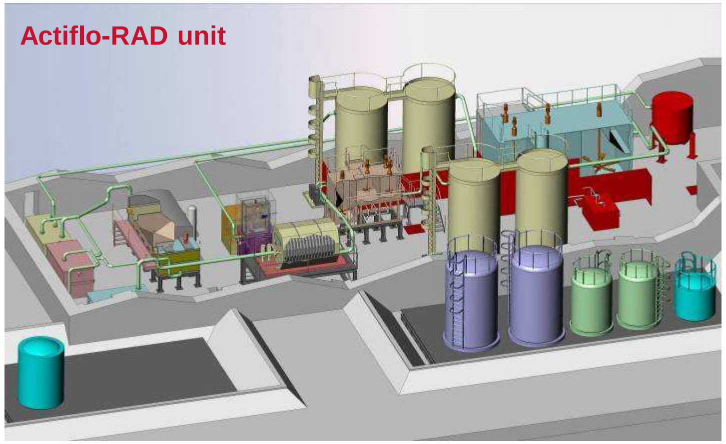
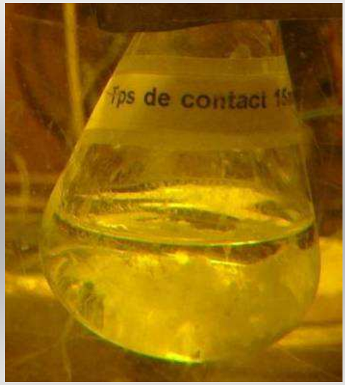
First emergency response: Actiflo-Rad: Water Treatment system delivered in 2 months!



- Co-precipitation process, Cs decontamination, DF >10^4
- High throughput 880m^3/d
- Small size, installed in an existing building
- Designed using proven technologies and existing industrial equipment, applied to the Fukushima context
- Multicultural project in partnership with Veolia and JGC
- Usual design & construction time: 2.5 years

April 2011 ***June 2011***



Laboratory tests

Equipments arriving at J-Village

Construction in RW building

Commissioning

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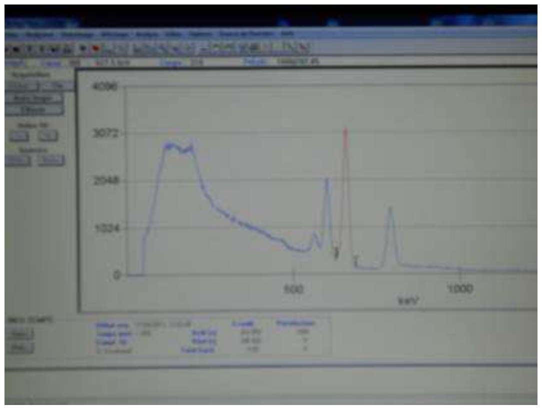
Underwater measurement device

- **ROV for underwater inspection equipped with spectrogammametry**
  - **Capable to operate down to 150 m**
  - **Measurement of sediments contamination**
- **Detection technology**
  - **LaBr probe with countermeasures to handle water column shielding issues**
  - **Underwater localization**
  - **Patented system**

H300 ROV control system - © Copyright ECA Hytech



Gamma Spectrometry of lakebed with geolocalized contamination data

Testing of submarine unit in France before shipment to our first customer

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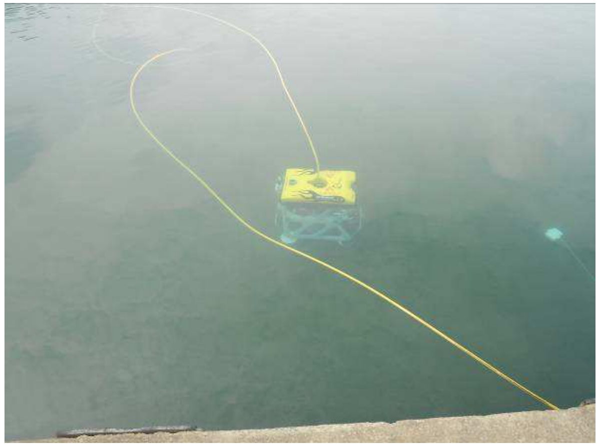
Results of first underwater measurement device in Japan



- **Tested successfully in Japan together with our first customer, a reference nuclear energy research institute in Japan**
  - **Validation of all the features**
    - GPS, underwater positioning
    - Mobility & Control
    - Cs monitoring
  - **First Results**
    - Test site in *part of a Fukushima prefecture Lake* used as a drinking water reservoir has no lakebed contamination.

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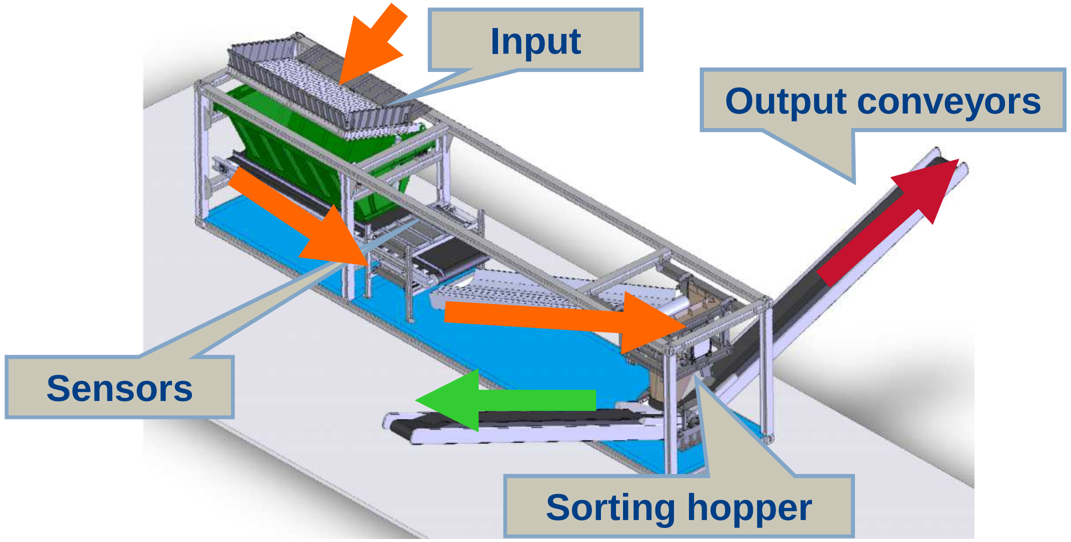
Contaminated Soil Sorting Unit
Field test at Tomioka Town, Fukushima Pref.

- **Millions of tons of soil have to be processed**
  - **Contamination stays within a depth of 5 to 15 cm**
  - **Contamination concentrates on localized "leopard spots":**
    → more than half of the suspected soil is not contaminated

- **Automated high-throughput sorting of soil**
  - **Up to 100 t/h**
  - **Detection limit adjustable below 100 Bq/kg**
  - **Mobile unit in 2 ISO containers**
  - **Patented process**



Testing in France before shipment to the Japanese demonstration site

Testing Place in Ookuma city near Fukushima Daiichi NPP

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Demonstration test of a contaminated soil sorting system

Project executed by : AREVA NC Japan Project (KK)

Project Summary

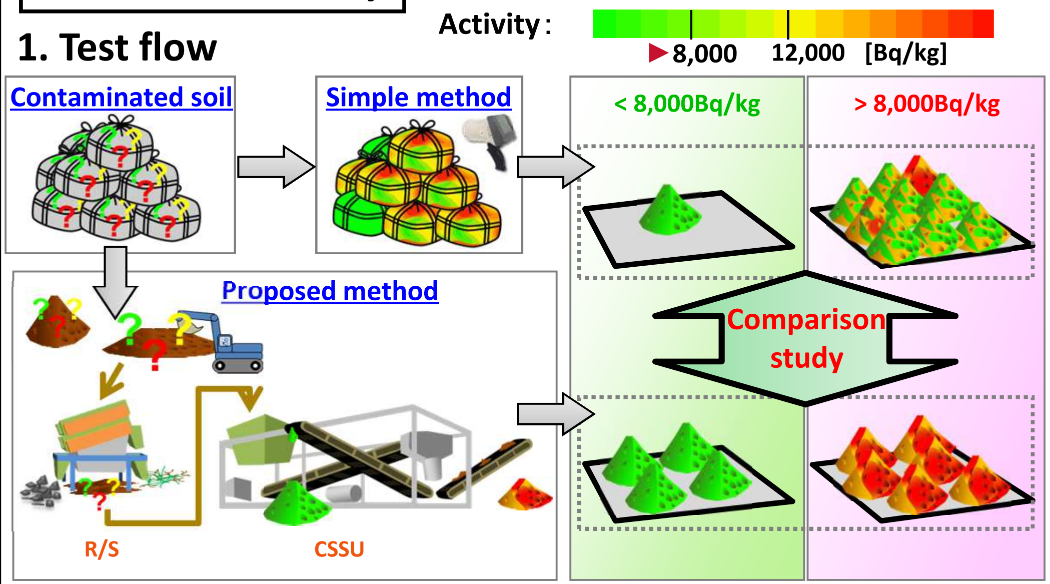
This demonstration test consisted in verifying the performances of a practical-scale contaminated soil sorting unit (hereafter CSSU) in terms of precision and throughput speed. Additionally, the treating capacity of soil with different characteristics was also assessed through the use of a roll screen (hereafter R/S) system as a preprocess for sorting out foreign material intermingled in soil.

Implementation content

Decontamination bulk bags containing radioactive soils from decontamination work with activity over 8,000 Bq/kg were selected from a temporary storage area and classified into 3 categories based on their surface dose rates measured by the simple measurement method. The soils contained in the bags of each section were then sorted using a system combining the R/S system and the CSSU system, and the share of soils with lower activity that can be separated was studied. The share of volume reduction of contaminated soil as a result of the removal of foreign material through R/S was also studied.

Technical Summary

1. Test flow

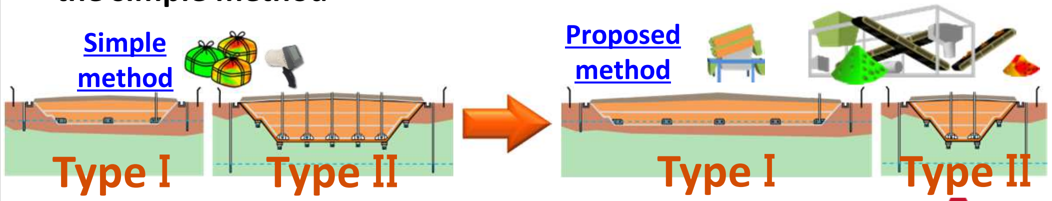


2. Test Objectives

(1) Verification of pre-process conditions for sorting soil

(2) Understanding the volume reduction rate obtained by removing organic material

(3) Separation (with the studied system) of soil with activity below 8,000 Bq/kg from soil with activity over 8000 Bq/kg measured by the simple method



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Results

► (An average error of 7.2% (n=19) was obtained when measuring the activity of soil sorted below 8,000 Bq/kg by the CSSU with a Ge detector.

1) Pre-process conditions and treatment capacity of sortable soil

► Sorting of foreign material by R/S (20mm, 50mm) to obtain soil applicable to CSSU was verified. A 100 t/h throughput was verified for both the R/S (50 mm) and the CSSU.

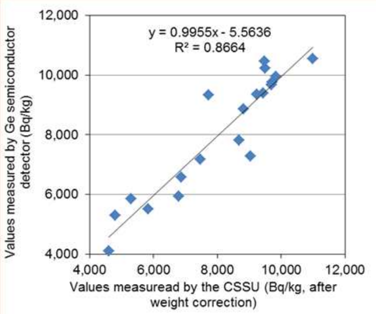
System - Conditions	Speed (t/h) *1		Applicability to CSSU (sorting of foreign material)	Results & Considerations
	Moisture content 13%	Moisture content 16%		
R/S (20mm, 17° inclination)	49	Processing impossible	Applicable at 13% moisture content	Roots, etc. were efficiently sorted to the light weight side. Stones with ~ϕ30mm also efficiently removed, with the comparatively smaller ones being sorted to the light weight side. At higher moisture content, soil aggregate and sorting became difficult.
R/S (50mm, 20° inclination)	95	44	Applicable	Roots, etc. efficiently sorted to light weight side. Higher efficiency of separating roots from soil compared to R/S(20mm). Comparatively smaller stones were sorted to the light weight side. Sorting remained possible at higher moisture content, but the processing speed reduces due to adherence of soil.
CSSU	100	61*2	—	As variations of bulk density due to accumulation, etc. of soil when feeding into CSSU are a cause in activity detection error, the necessity for the system to embed weight correction was revealed.

*1 Actual highest measured processing speed, with the exception of feeding latency time

*2 Applicable to CSSU with soil modification. Without modification, the soil formation prevented a correct activity sorting

●Verification of CSSU sorting precision

The soils sorted by CSSU correlated well when compared with measures by a Ge semiconductor detector to verify the sorting precision (see below figure), with a 0.86 determination coefficient.



(2) Understanding the volume reduction rate by removing organic material

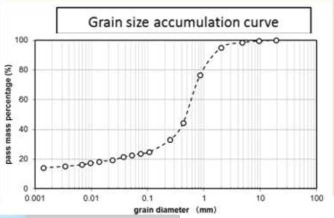
The soil used for this demonstration comes originally from a playground containing almost no roots or impurity elements hence a low 0.3% volume reduction rate.


Picture 1 - overview of foreign material sorting with R/S (50mm)


Picture 2 - results of foreign material removal by R/S (left: soil, center: light material, right: heavy material)

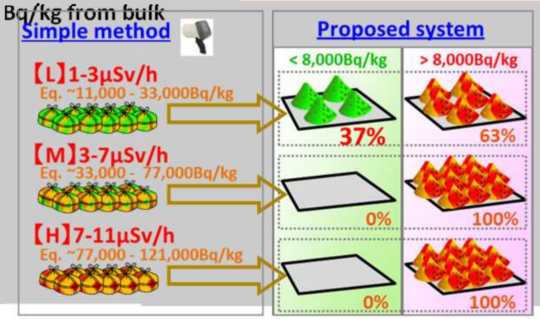
●Characteristics of soil used for the tests

The soil used (playground), was fine-grained soil, containing ~24% fine grain (silt and clay) under 0.075mm



(3) Activity sorting test

When sorting soil having a surface dose rate (simple measurement method) between 1-3μSv/h (11,000~33,000 Bq/kg), the share of soil sorted as below 8,000 Bq/kg was 37%. No soil was sorted as under 8,000 Bq/kg from bulk bags over 3μSv/h.




►Picture 3 - overview of activity sorting with CSSU

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Industrial solution proposed: Evacrystal-Rad, a multi-nuclide removal equipment for contaminated water

- **EVACRYSTAL-RAD is a combination of proven processes developed by AREVA for nuclear treatment and by VEOLIA for industrial water treatment**

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▶ AREVA Nuclear processes

VEOLIA WATER Solutions & Technologies

▶ HPD® Evapo crystallization processes

Drying-pelletizing (AREVA)

Columns (AREVA)

Evaporation-crystallization (HPD)

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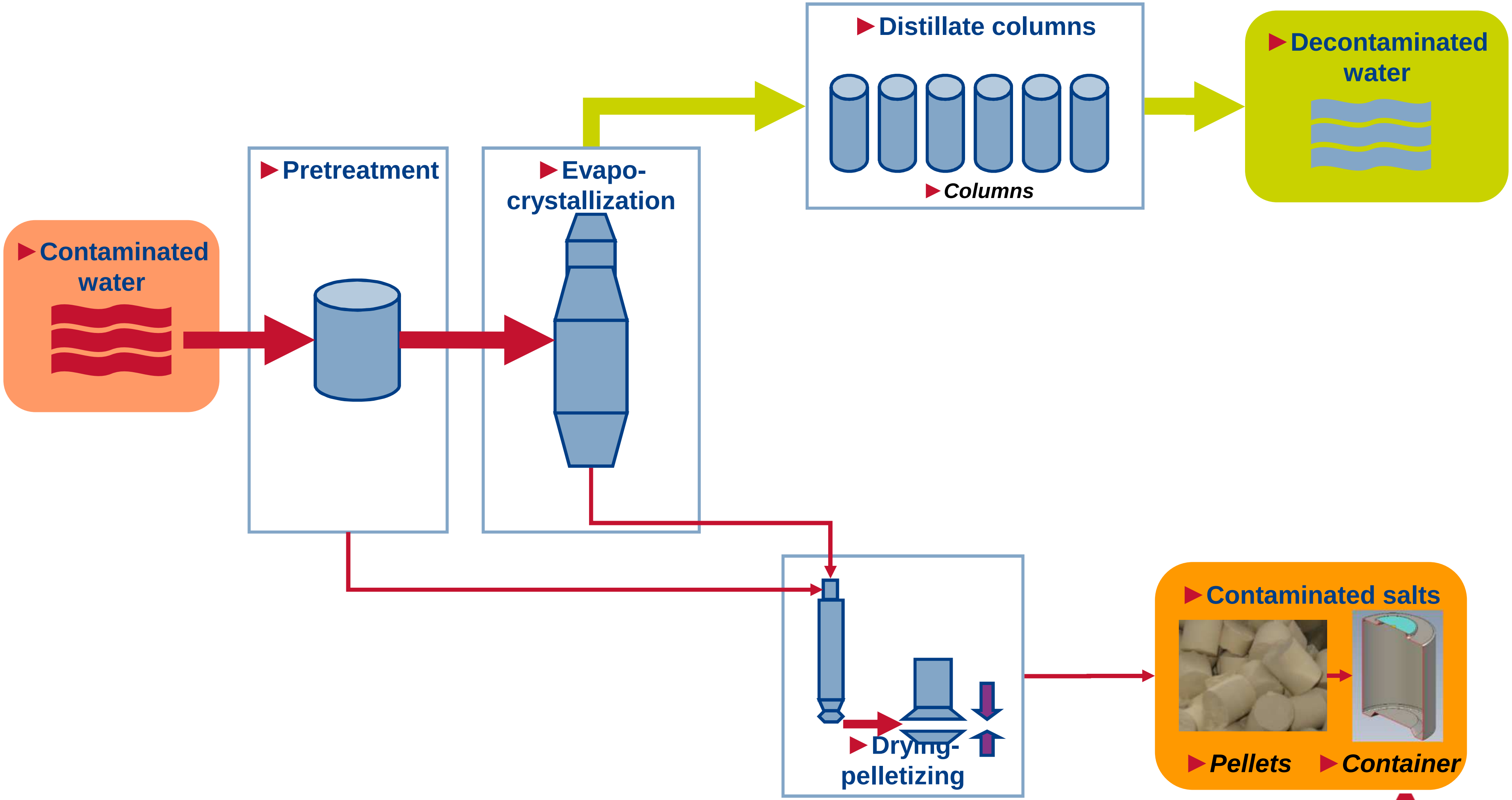
EVACRYSTAL-RAD
Simplified process overview



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EVACRYSTAL-Rad key benefits

- **Effluents are treated by Evaporation such as in large majority of worldwide nuclear sites and in Zero Liquid Discharge facilities**
- **Evaporation technology reduces the contaminated effluent volume to be further treated:**
  - **High Decontamination Factor for all radionuclides (excepted for tritium)**
  - **99% of volume in distillates – no salty flow for easy in-column final decontamination.**
- **Drying-compaction solution reduces the volume of contaminated solid waste**
- **Solution compliant with an additional post-treatment for tritium management**
- **Credible alternative allowing:**
  - **Overall risks reduction for the Fukushima water treatment issues**
  - **Additional capacities to the current solutions in-development**
  - **Integration within the overall water treatment scheme of Fukushima Daichi**

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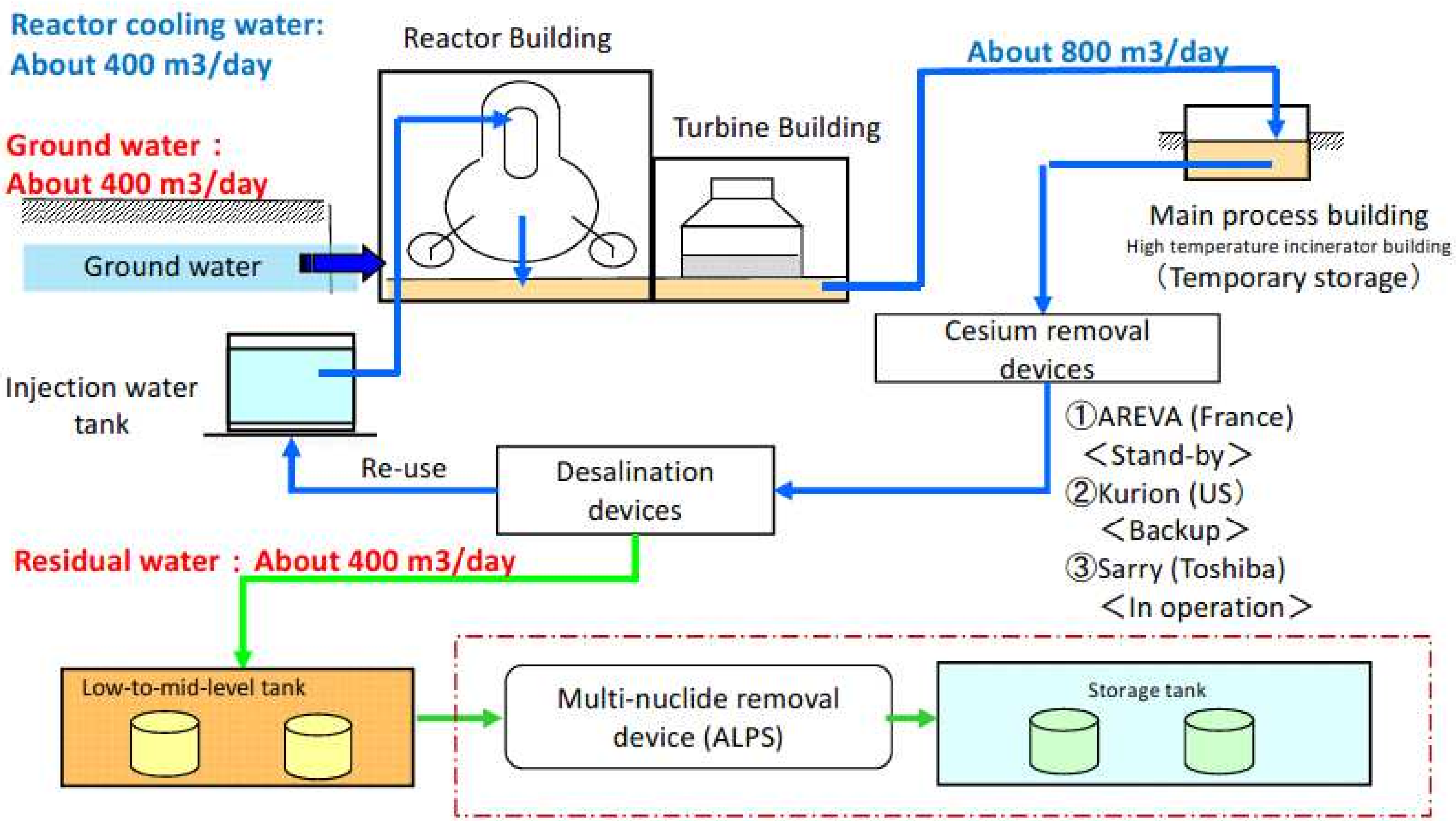
Contaminated water treatment system Overview

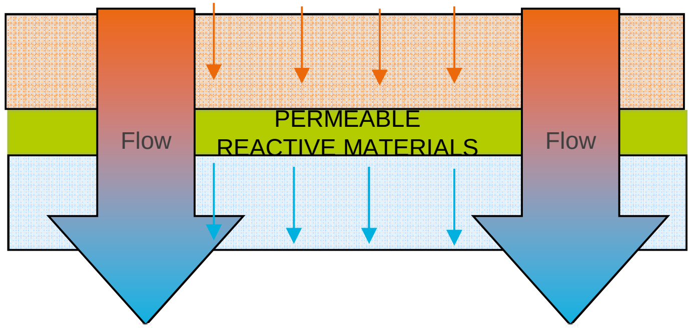


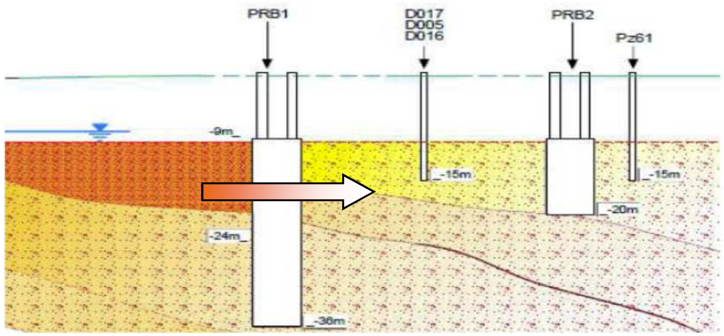
►**Source : METI presentation feb. 2014**

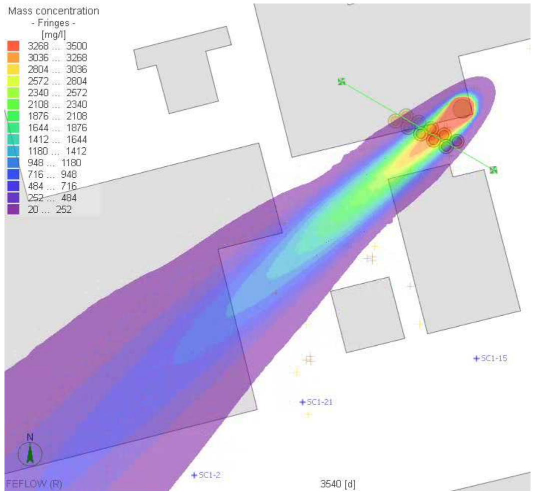
Soil decontamination by capture of radionuclides - study

PERMEABLE REACTIVE BARRIERS (PRB)

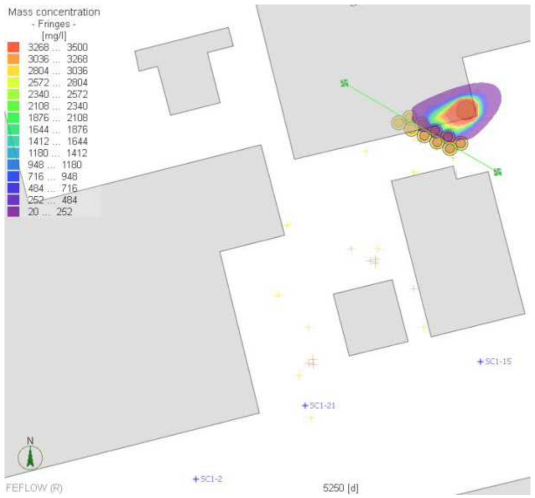
All the wall is permeable







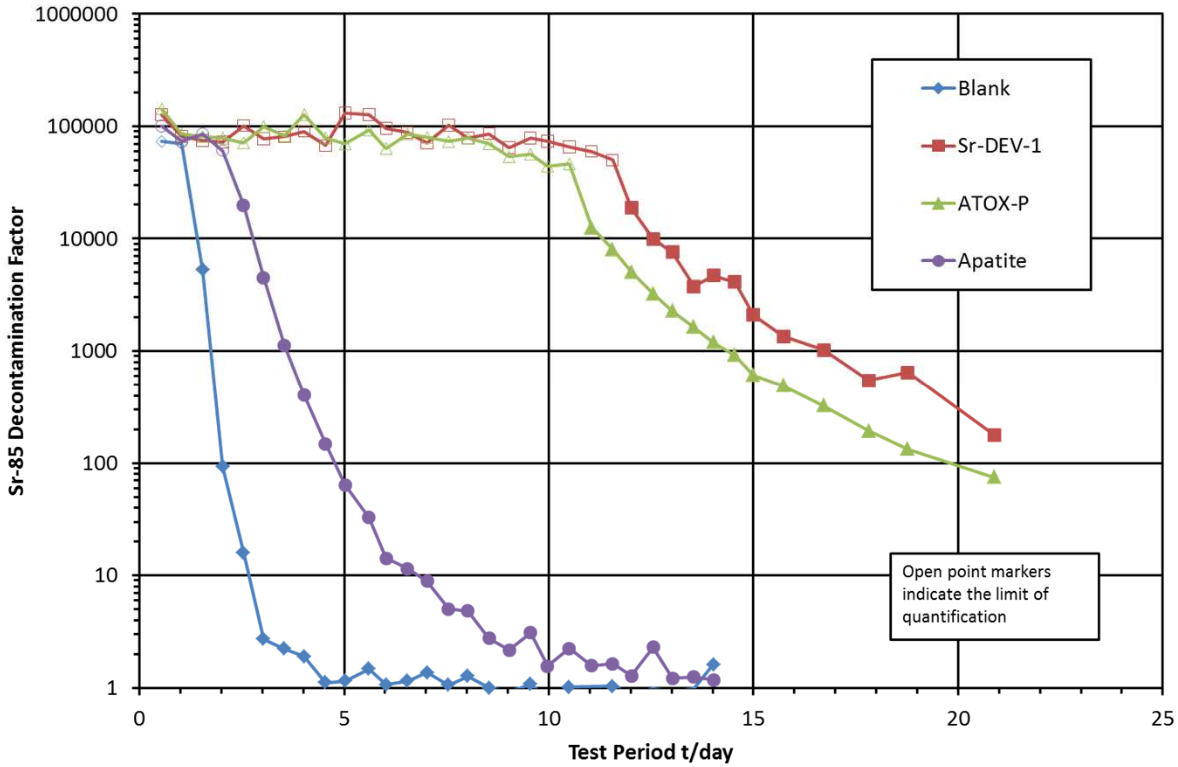
Plume without Reactive Barrier



Plume with Reactive Barrier

Soil decontamination by capture of radionuclides - study

- **Main steps of the project :**
  - **Inactive tests (SITA) → Selection of best products**
  - **Active tests) (AREVA)→ Performance assesment**
  - **Confirmation tests with Fukushima soil & water (Japan-ATOX)**



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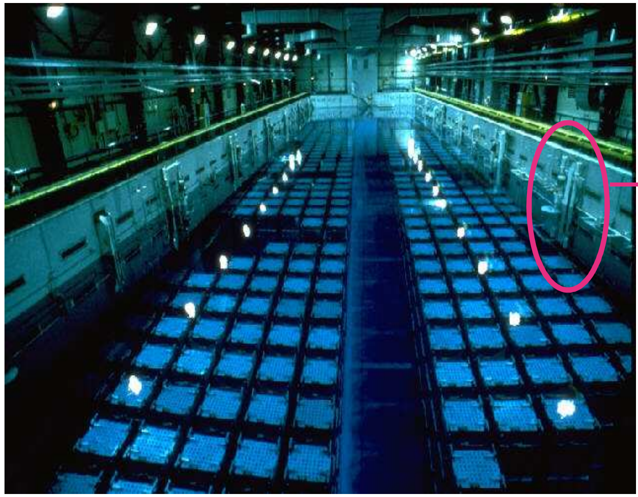
Harbor seawater treatment

Objective of the project

- **Conduct a demonstration project to perform verification tests of seawater purification technologies to confirm removal performance of Cesium and Strontium (+ other RN) in view of treating contaminated water in the port adjacent to the Fukushima Daiichi Nuclear Power Station.**

Fundamental idea

- **Use and AREVA's NYMPHEA underwater purification system.**
- **Find the best adsorbent & its configuration (granulate, filter…) to fill the NYMPHEA's cartridge, to meet the Fukushima specifications**



Project file :

- **Client: IRID**
- **Consortium ANADEC – ATOX – AREVA**
- **Dates :**
  - start : July 31st 2014
  - End : march 31st 2014

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Technical Dévelopment

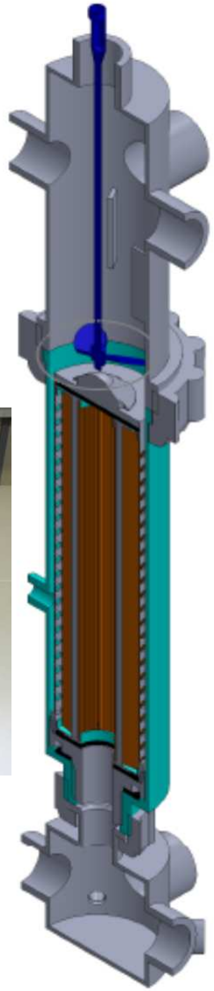
▶ **Laboratory test**

Flow rate = 12 L/h

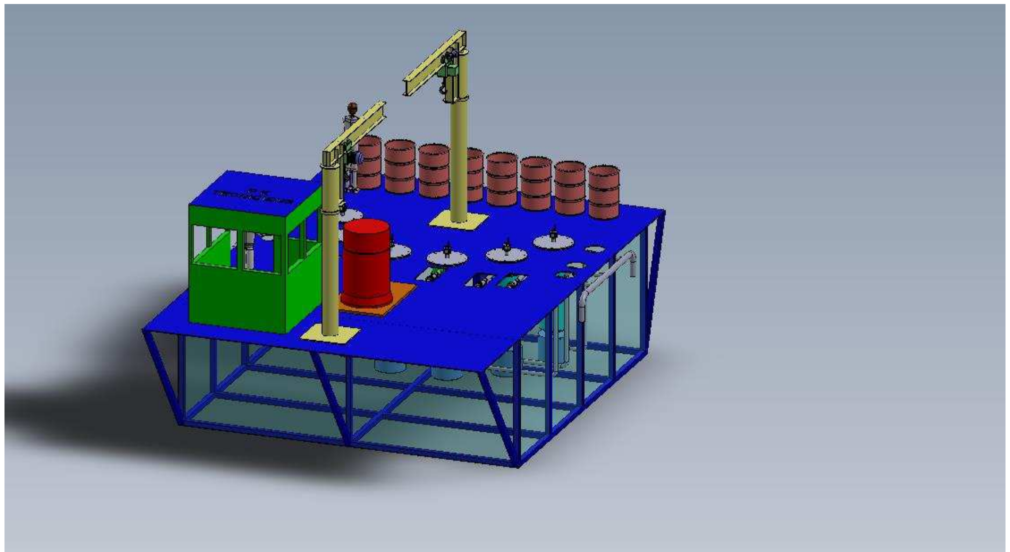
▶ **Fonctionnalized sheets filter**

▶ **Mini Nymphea Design and test**

Flow rate = 0.5 to 5 m3/h ; 1 L sorbent

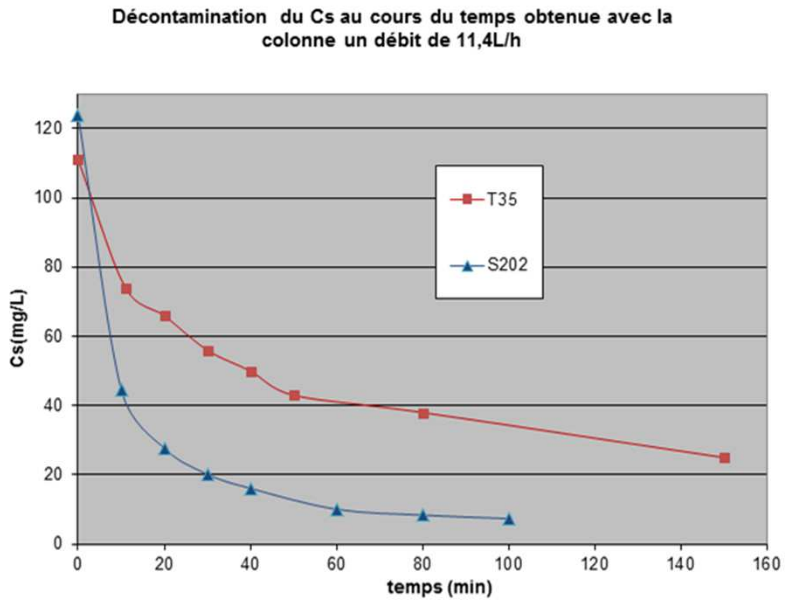


▶ **Industrial Platform Design**

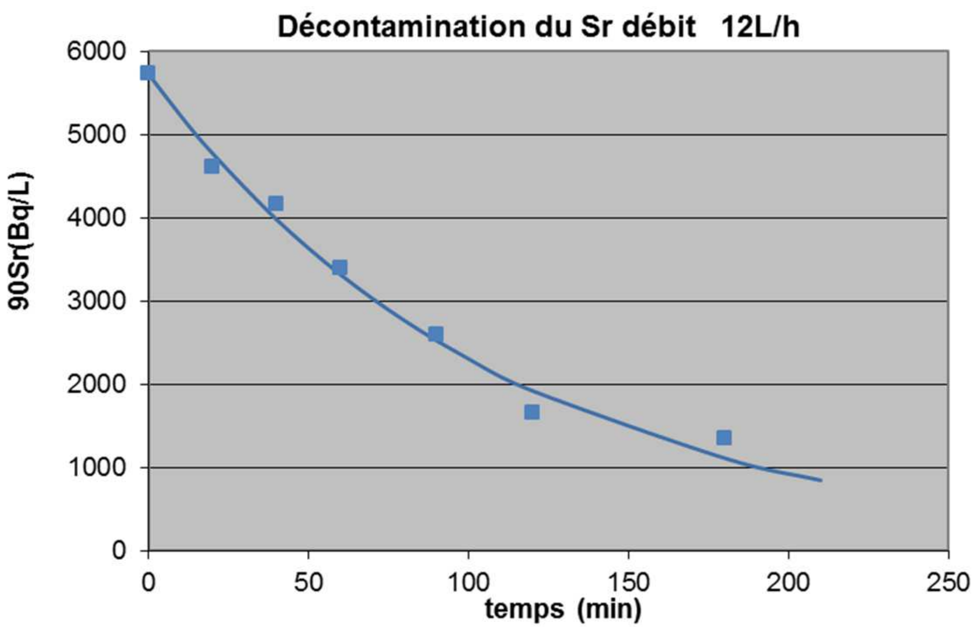


Laboratory tests
Sorbents test and Development

- **Inactive and active tests performed by AREVA HRB and CEA MARCOULE**



- **Test new Cs sorbent developed by CEA MARCOULE « Sorbmatech »**
  - **High selectivity Cs / Na**
  - **High Kinetic**



- **Test new Sr sorbent in current development**
  - **High selectivity Sr / Ca (10 time > commerciale zeolites)**

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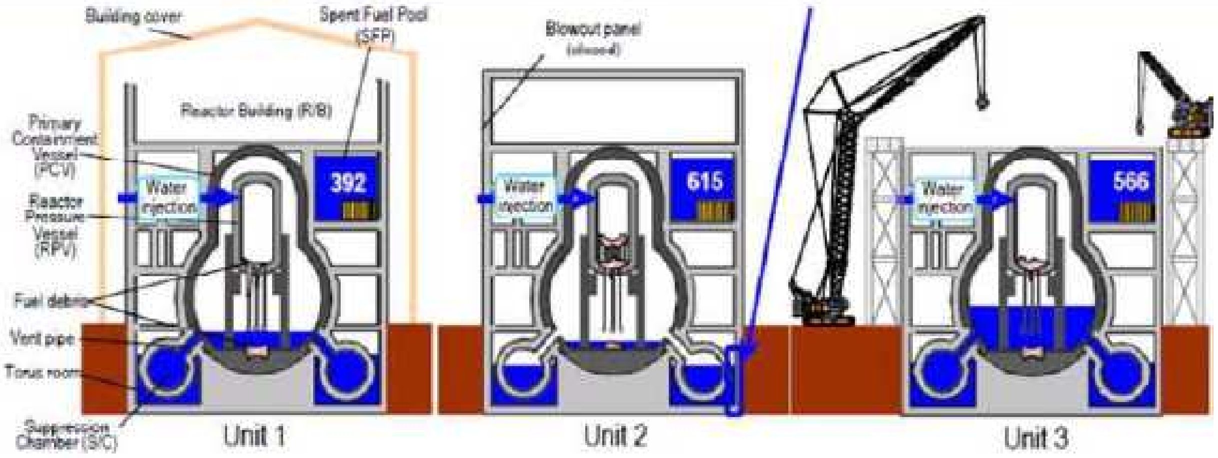
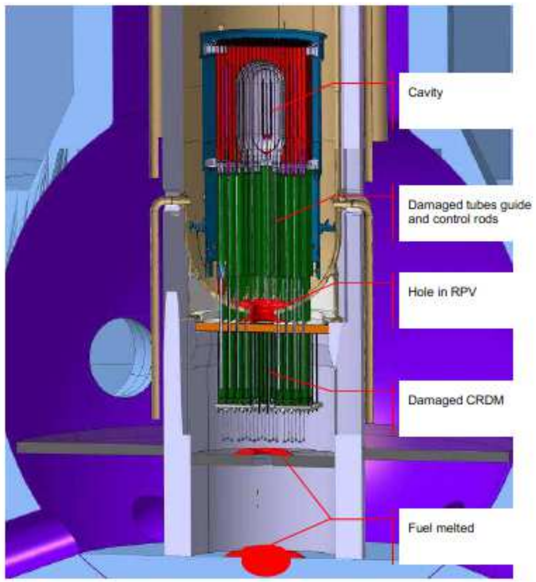
Fuel Debris Removal – Site Status

	REACTOR 1	REACTOR 2	REACTOR 3
Reactor Model	BWR3 (smaller)	**BWR4**	BWR4
Building status	Damaged du to explosion	**Intact**	Very damaged du to explosion
Fuel status	Most of the fuel has fallen down into the PCV	**Partially melted: - in the RPV - in the PCV**	Partially melted: - in the RPV - in the PCV





- **Modelisation of the damaged core**

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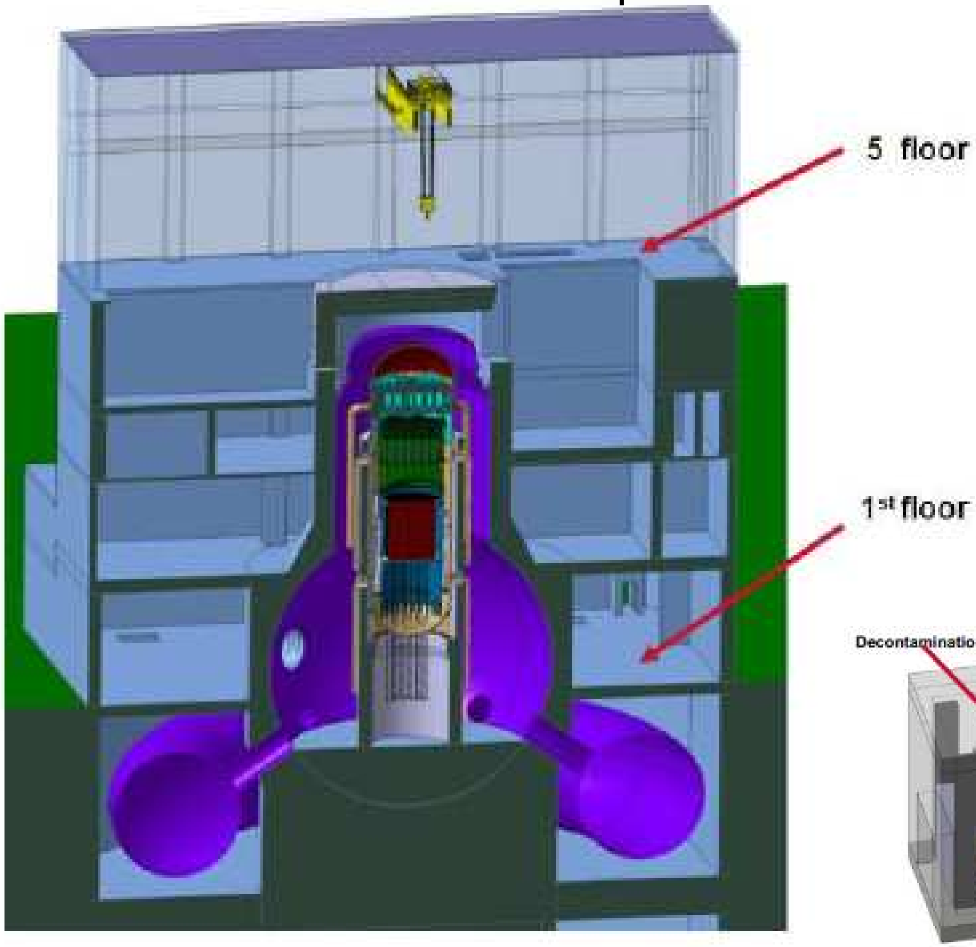
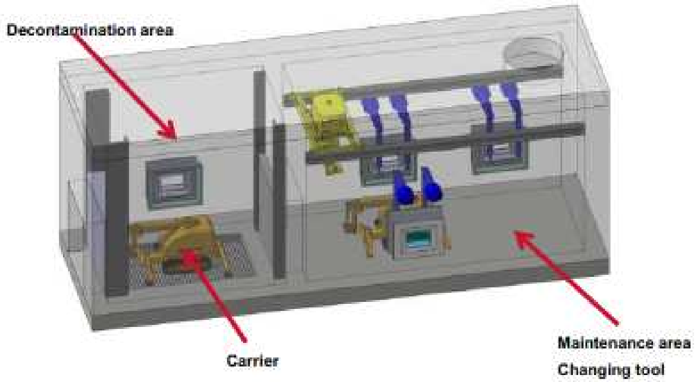
Fuel Debris Removal - study

- **Two Accesses**
  - **From the top : a platform in place of the shield plug**
  - **From the side : a carrier to collect spread corium at the bottom of the PCV**





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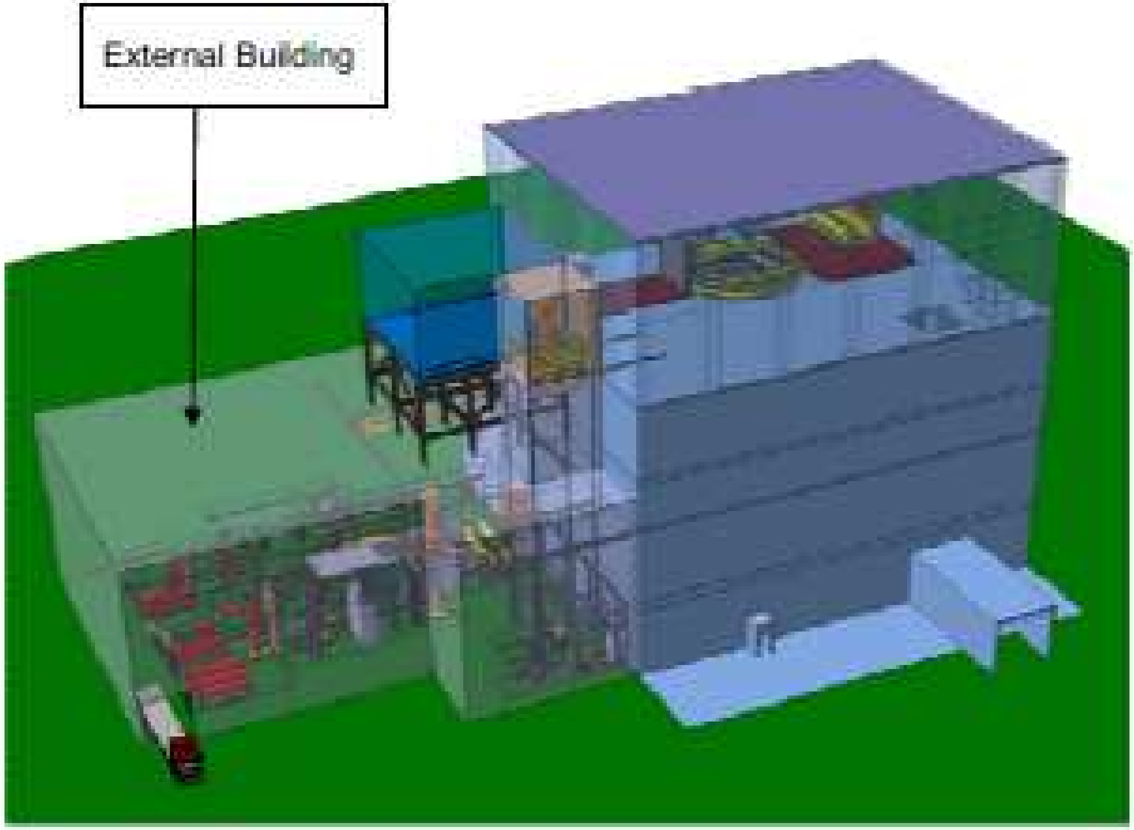
Fuel Debris Removal - study

- **Construction of an External Building**
  - **To access both from the top and from the side**
  - **To re-cut, measure and condition all the removed wastes**



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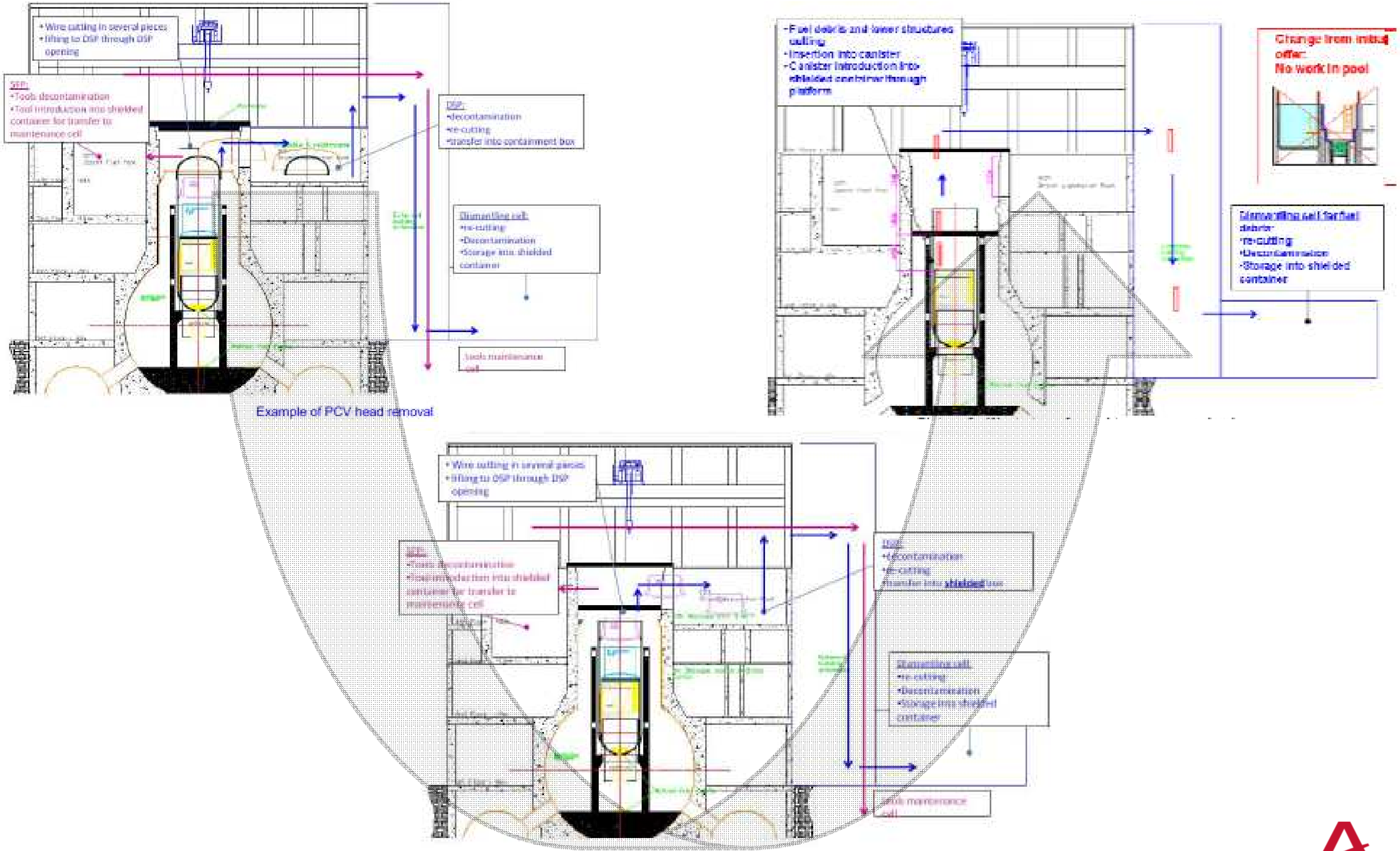
Fuel Debris Removal – Removal Principles



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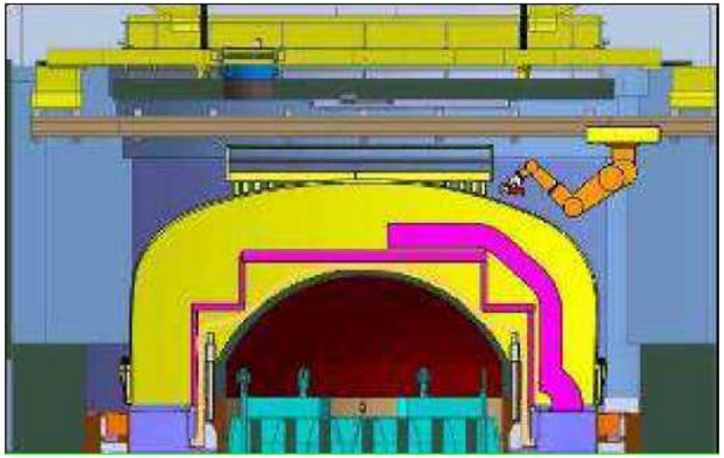
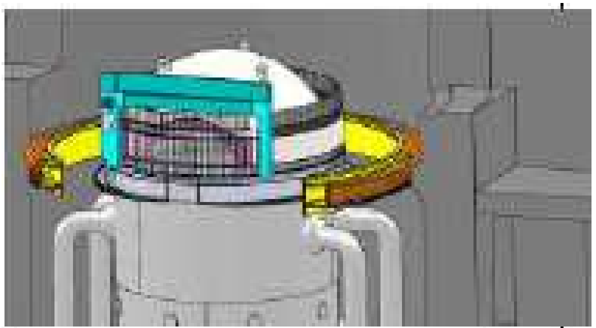
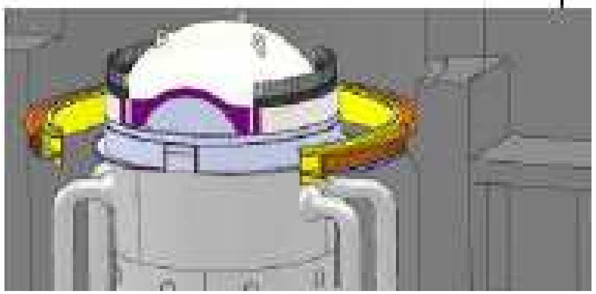
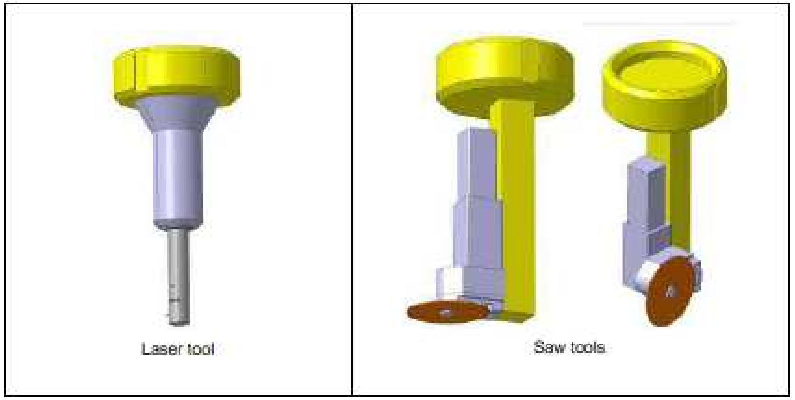
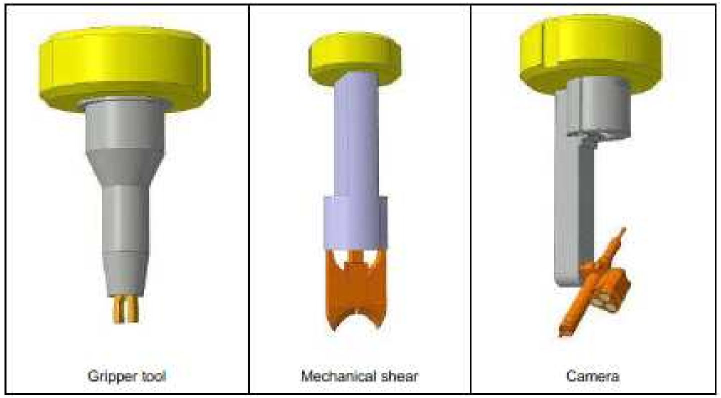
Fuel Debris Removal – Various Cutting Means











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Conclusion

- **AREVA is present to support TEPCO since March 11th,**
- **First involvement was on contaminated water treatment solution (Actiflo-Rad system),**
- **Several Innovative solutions were developed, such as for soil sorting and for lake-bed contamination measurement,**
- **Studies are provided to IRID for the harbour seawater treatment and the soil decontamination by capture of radionuclides,**
- **The Joint-Venture ANADEC set-up in 2014 between AREVA and ATOX targets to favour technology transfers and technical support provided by AREVA in waste management and dismantling / clean-up activities,**
- **Now, other challenges are under analysis such as the spent fuel removal of reactor's pools and the fuel debris removal of the units 1, 2 and 3: AREVA is working actively on that key subjects.**

ご清聴ありがとうございました。

Thank you for your attention

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