German-Japanese Symposium on Technological and Educational Resources for the Decommissioning of Nuclear Facilities

R&D on Treatment and Disposal of Radioactive Waste resulting from Accident at Fukushima Daiichi NPS

April 21, 2015

International Research Institute for Nuclear Decommissioning

Japan Atomic Energy Agency

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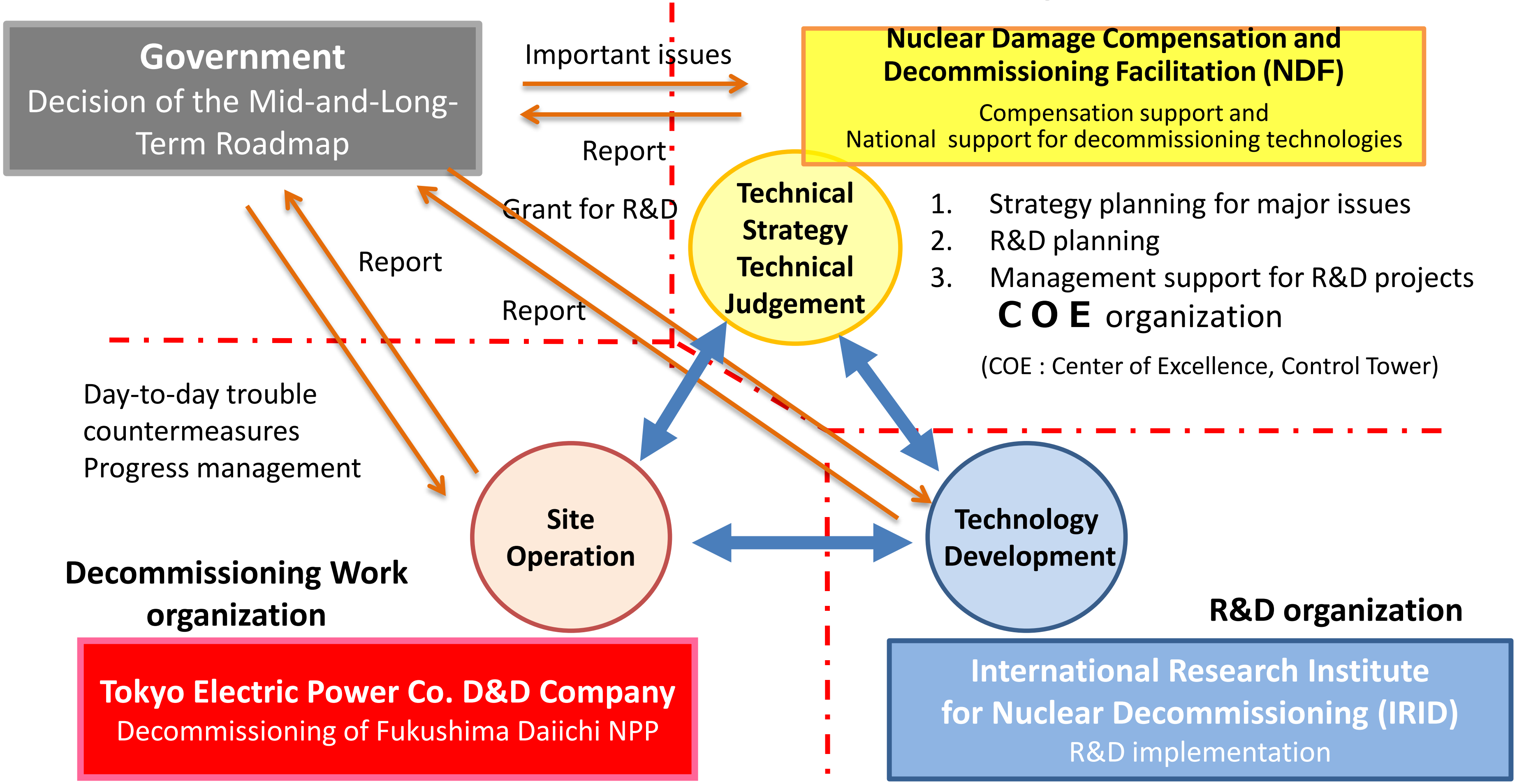
Role-Sharing of Fukushima-Daiichi Decommissioning and Contaminated Water Management



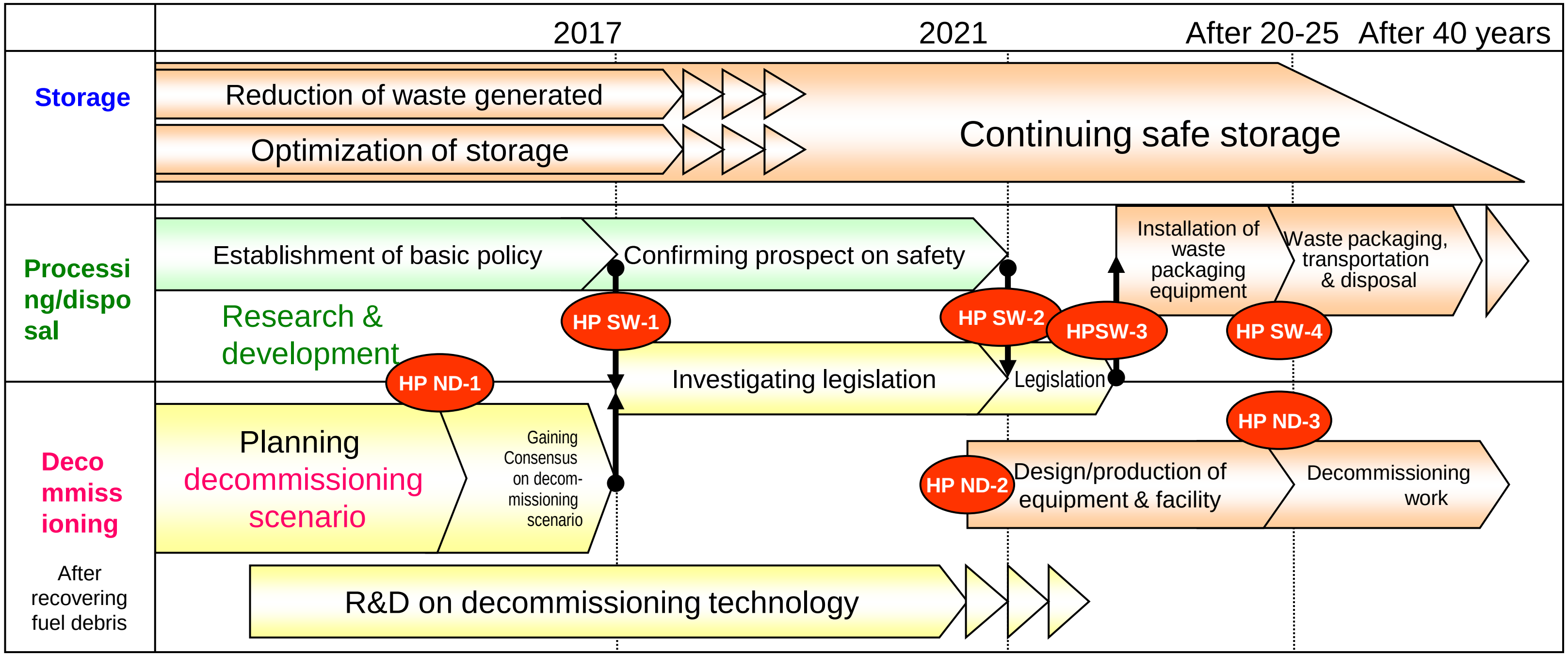
Location of Responsibility :

1. Supervising the whole nation's decommissioning work, guidance to projects, recommendations for correction etc.: **Government**
2. Comprehensive strategic management for decommissioning technologies, development planning, international cooperation, guidance and advice for TEPCO etc.: **NDF**
3. Critical decommissioning technology development on a mid-and-long term basis: **IRID**
4. Decommissioning operation implementation and safety management, technology development for the site application: **TEPCO D&D Company**

Mid- and Long-Term Roadmap for Radioactive Waste Management

Generation of waste → Storage & management → Processing (Conditioning) → Disposal

Depends on decommissioning scenario | Segregation, volume reduction, long-term storage | Needs research & development based on properties of waste



HP: Point of decision as to whether to proceed to the next process. Additional research and development and review of schedule and work will also be discussed and decided.

HP SW-1: Making basic policy for processing & disposing of solid waste (2017)
HP SW-2: Confirmation of prospect on safety for processing & disposing of solid waste (2021)
HP SW-3: Determination of specifications and production method of waste package (third term)
HP SW-4: Prospect of installing waste package production equipment and disposal of waste (third term)

HP ND-1: Planning decommissioning scenario (2015)
HP ND-2: Determination of techniques for decontamination and dismantling equipment (third term)
HP ND-3: Prospect of waste disposal and end of necessary research and development (third term)

System for Implementing Research and Development

Contaminated Water and Decommissioning Issues Team

Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NFD)

R&D program Presentation/Report

International Research Institute for Nuclear Decommissioning (IRID)

- Japan Atomic Energy Agency (JAEA)
- Tokyo Electric Power Co. (TEPCO)
- TOSHIBA
- Hitachi-GE Nuclear Energy
- Mitsubishi Heavy Industries
- ATOX

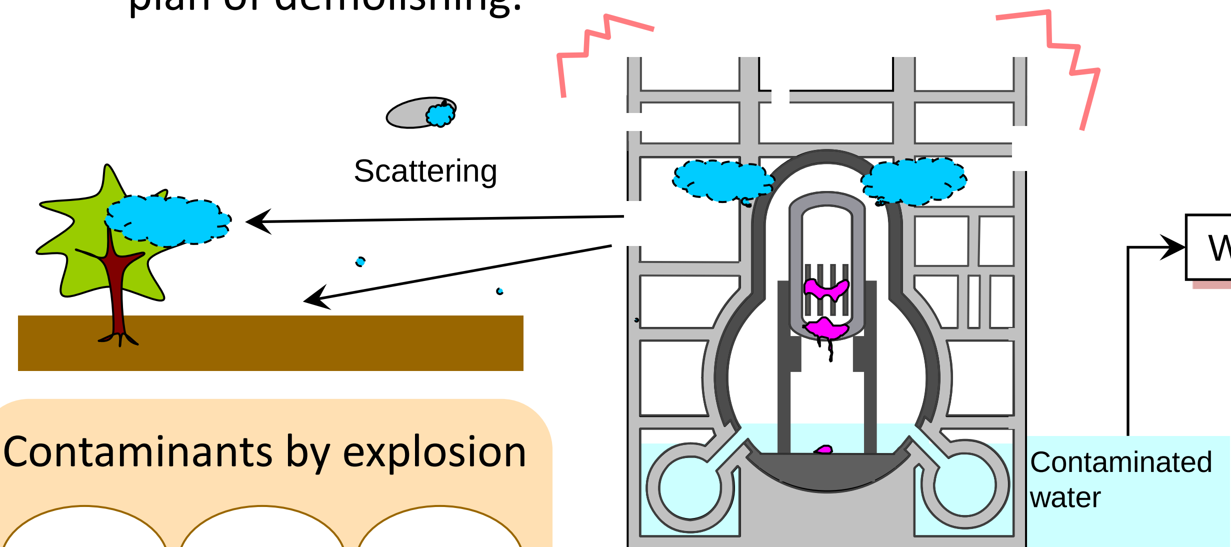
Establishment of cooperative relation

Collecting various information and opinions from home and abroad

- Universities, manufacturers, related organizations, etc., at home and abroad
  - Information sharing
  - Conducting joint research, etc.
- Academia, international organizations, etc., at home and abroad
  - Setting up task force in Atomic Energy Society of Japan
  - Setting up expert council at OECD/NEA

Major Wastes and Their Generation

- Contaminated with radioactivity originated from damaged fuel and activated material.
- Different in their contamination status owing to progress of accident.
- Analytical data is limited due to wide and deep contamination.
- Wastes generated should be estimated with consideration on status and future plan of demolishing.



Contaminants by explosion

Rubble | Vegetation | Soil

- Contaminated with radioactive aerosol/dust
- Widely contaminated, vast amount
- Collected and stored for decreasing dose rate

Fuel debris/Demolishing waste

- Extremely high dose rate, difficult in sampling
- Vast amount

Secondary waste from water treatment

Adsorbents etc. | Apparatus, tanks, pipes etc.

- Chemical separation brings varied compositions for wastes
- Sampling some wastes is difficult due to high dose rate
- Behavior of radionuclides can be predicted based on design of decontamination process

Comparison between Wastes from Accident and Operation

Item of uncertainty	Degree of countermeasure	
	Waste from operation	Waste from accident
Generation of waste [quantity, type, period]	◎	△
Handling (collecting/classifying) [difficulty]	◎	△
Characterization [sufficiency of information, difficulty of sampling, representativeness of sample]	○	△
Technologies for processing and packaging waste	○	? - △
Burial and disposal methods and safety assessment	△ - ○	?
Regulations, technical standards, guidelines, siting	△ - ○	?

◎: Fully understood or good prospect, ○: Fair prospect, △: Limited ,?: Cannot be discussed

- Waste generated from operation has its own problem but is **fairly under control**.
  - Information on basic properties of waste, including quantity at present, future change, activity and chemical substances contained in individual waste is identified.
  - Both unprocessed and processed wastes are appropriately stored and managed in accordance with the current regulations.
  - Regulations and standards, as well as disposal method and safety assessment method, have been in place.
- Many uncertainties poses important technical problems to disposal of waste from the accident at Fukushima Daiichi. Solving these uncertainties and bringing the waste under control are the major goals of countermeasures and technology development.

IRID

Amount of Wastes Currently Stored
– Rubble and Felled Trees –

- Rubble outside collected after accident and those generated from works to retrieve fuel assemblies / fuel debris as well as trees cut down to install water tanks and facilities and to make storage area have been stored
- Wastes including rubble and trees are stored at several locations in Fukushima Daiichi NPS site

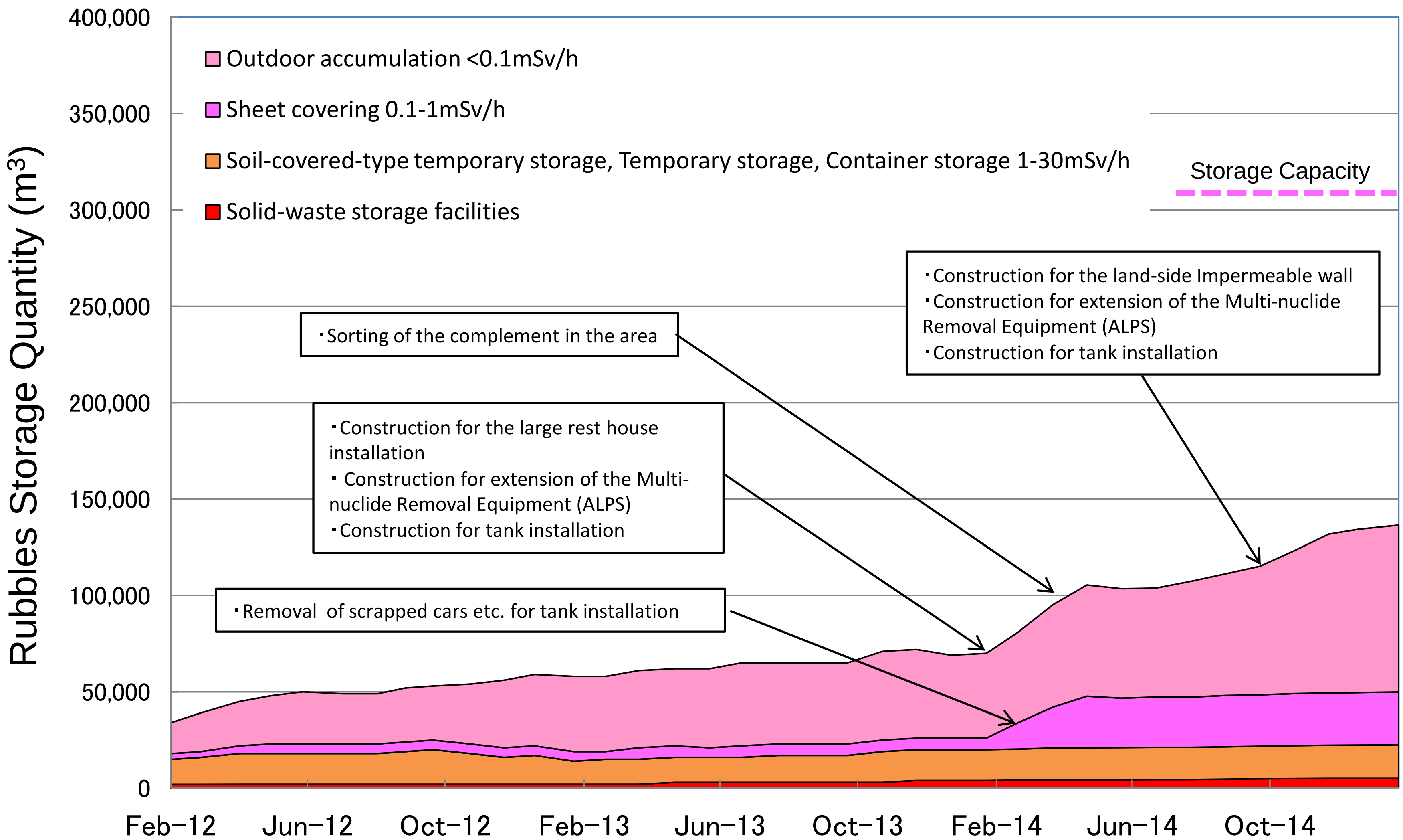
Locations of waste storage *

Amount of wastes as of 31 January 2015 *

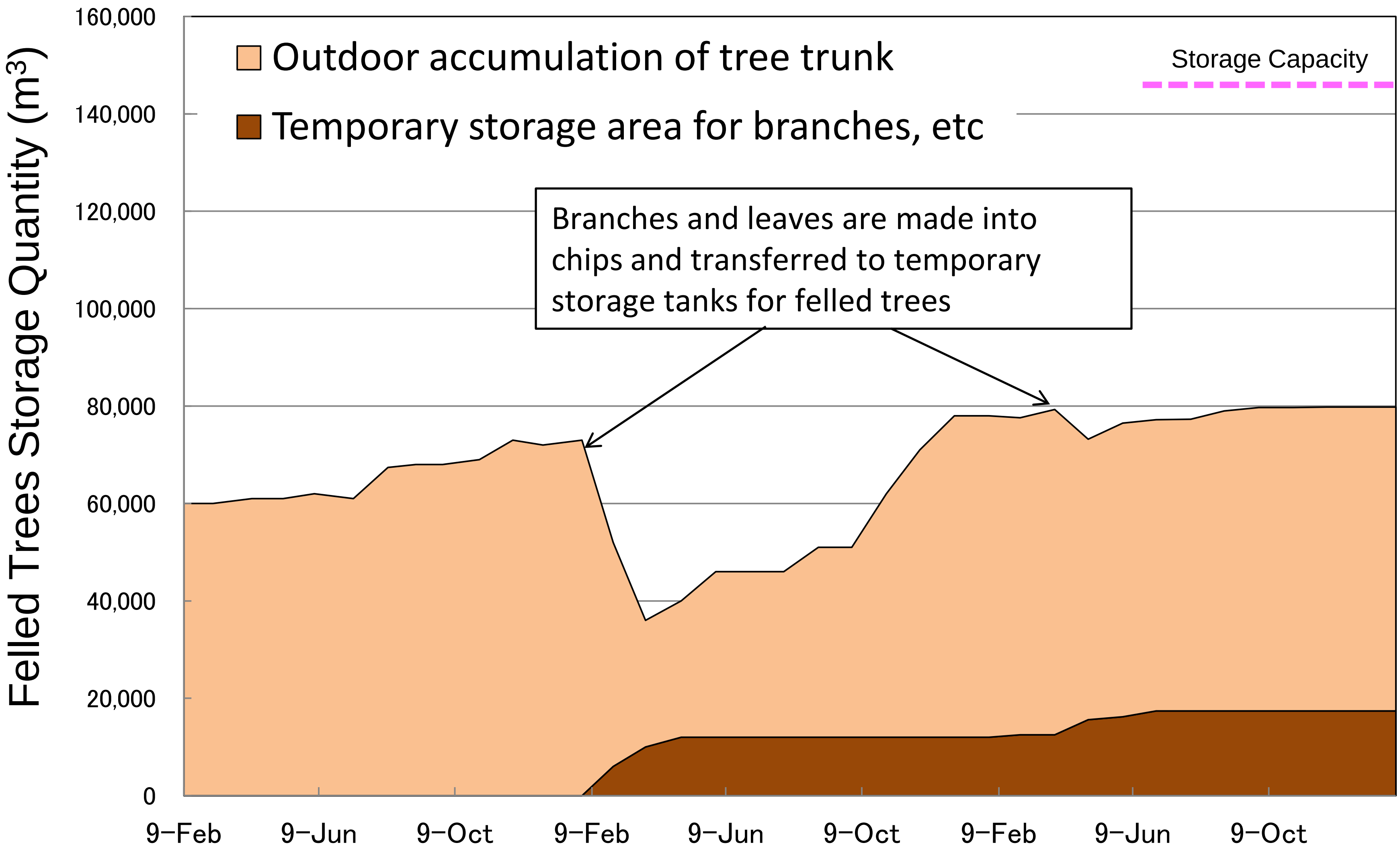
Waste	Storage	Amount
Rubble	Solid waste storage	5,100 m^3
	Temporary storage covered with soil, temporary storage, container (1–30 mSv/h)	17,400m^3
	Covered with sheet (0.1–1 mSv/h)	27,400 m^3
	Outdoor pile (<0.1mSv/h)	88,600 m^3
Felled Tree	Outdoor pile for trunk, root, branch, leaf	62,400 m^3
	Temporary storage for branch and leaf	17,400 m^3

* Referred from "Status of waste management of rubble and tree," TEPCO, 26 Feb 2015 . (in Japanese)

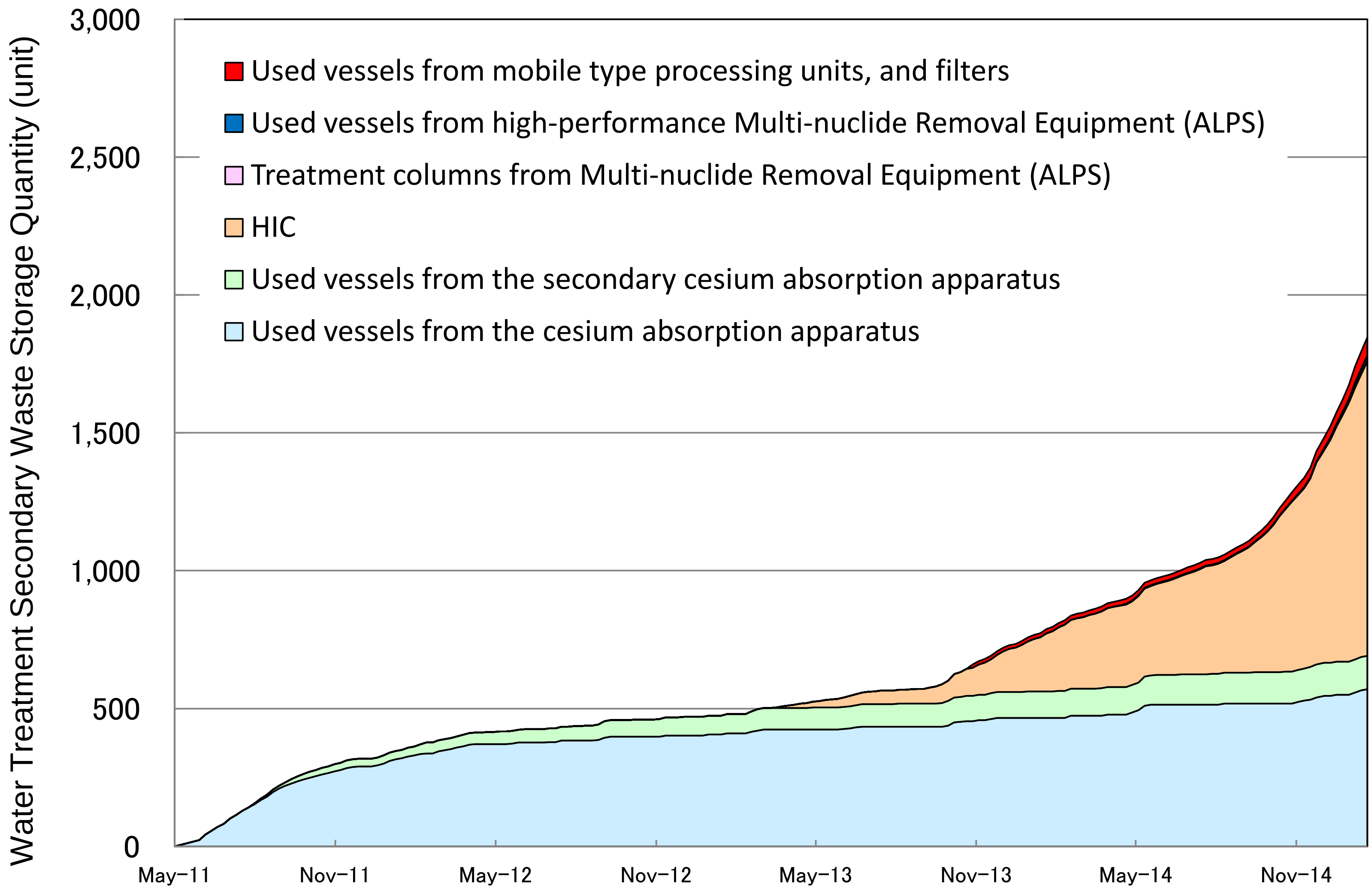
Changes in the Storage Amount of Rubble



Changes in the Storage Amount of Felled Trees



Changes in the Storage Amount of Secondary Waste Generated from Contaminated Water Treatment



Technologies/R&D Items concerning Processing and Disposal

Waste Stream Study

Waste Stream: A flow of accident waste from its generation and storage to its processing and disposal

Information related to the policy and system, technology information (including precondition) on treatment and disposal

Integrated judgment and adjustment for each research result, presentation of required agenda towards implementation of safe and rational treatment and disposal

Individual R&D items（Basic R&D that will give knowledge necessary for establishing Waste Stream)

Identifying Properties

[Targets] The safety assessment of processing and disposal, and information accumulation required for waste management / Development of the analysis method for nuclides which are difficult to be measured applied at analysis facility

Study on Processing of Waste

[Targets] Preparing Processing / Technology catalogue and narrowing down and presenting applicable candidates of technologies for waste conditioning

Study on Long-Term Storage Method

[Targets]Presentation of long-term storage / stabilization policy on water treatment secondary waste

Study on Disposal of Waste

[Targets] Presentation of applicable disposal concept for each kind of waste and its evaluation method

Database Development

[Targets] Database development of waste property, processing and disposal methods etc. (Information sharing with third party organizations)

Inventory, harmful substance property etc.

Necessary waste information items etc.

Inventory, contaminant property etc.

Important nuclide, needed data etc.

Required condition of waste body etc.

Property of waste body etc.

Property information of waste body

Information about disposal technology

Technical information on treatment and waste conditioning

Overview of Research Items

Items	Details of the Implementation
Identifying Properties	● To understand the property of waste required for the study on long-term storage method and the development of treatment and disposal technology regarding the waste adsorption material, sludge, etc. which are water treatment secondary wastes ● To understand properties, such as adhesion situation of radioactive substance required for the development of treatment and disposal technology regarding the rubble, felled trees, soil and the demolition waste etc. generated due to demolition work ● To develop analytical technology for difficult-to measure nuclides required for the study on treatment and disposal technology in which the analysis method is not established, and the evaluation method of inventory
Study on Long-Term Storage Method	● To study long-term storage methods against hydrogen generating, heat generating, corrosion, etc. because the water treatment secondary waste needs to be stored under a stable condition until treatment and disposal technology is established
Study on Processing of Waste	● To respond to the case in which sufficient storing performance is not secured, in studying long-term storage methods for water treatment secondary waste, and conduct fundamental study on the processing technology for waste conditioning ● To research the existing treatment technologies (waste conditioning technology) and based on the results, to develop the technology for waste conditioning and identify waste properties
Study on Disposal of Waste	● To confirm the existing disposal concept and the applicability of safety evaluation method, based on results regarding 'Identifying Property' and 'Study on Processing of Waste', and to identify issues required for processing and disposal and study solutions to the issues ● Regarding waste with difficult application of the existing disposal concept or the safety evaluation method, to study new processing and disposal technology
Database Development	● To develop a database for organizing R&D results and information

Collecting Analysis Samples

■ Rubble, Felled Trees

Sampling concrete and pebbles from the area around Unit 1, 3 and 4 on which the rubbles were scattered
Felled trees are sampled from two storage areas and the pine branches and leaves from around Unit 3

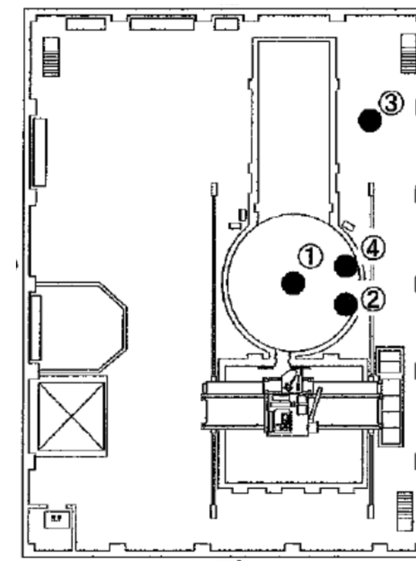
■ Concrete Pieces, Thermal Insulator

Fist-sized concrete pieces are selected at the time of transfer from large amount of rubbles collected in the obstacle removal operations by the remote heavy machine "ASTACO-SoRa“ on the first floor of the reactor building at Unit 1 and 3

■ Boring Core

The surface coat (about 40 mm in diameter) located near the center (Fig.(2)) among four core samples from the fifth operation floor of the reactor building at Unit2

Boring Core Sampling Spots



Fifth operation floor of the reactor building at Unit 2 ●: Sampling spots

The radionuclide for analysis

■ The following radionuclides are selected referring to the radionuclides for evaluation in the existing disposal system

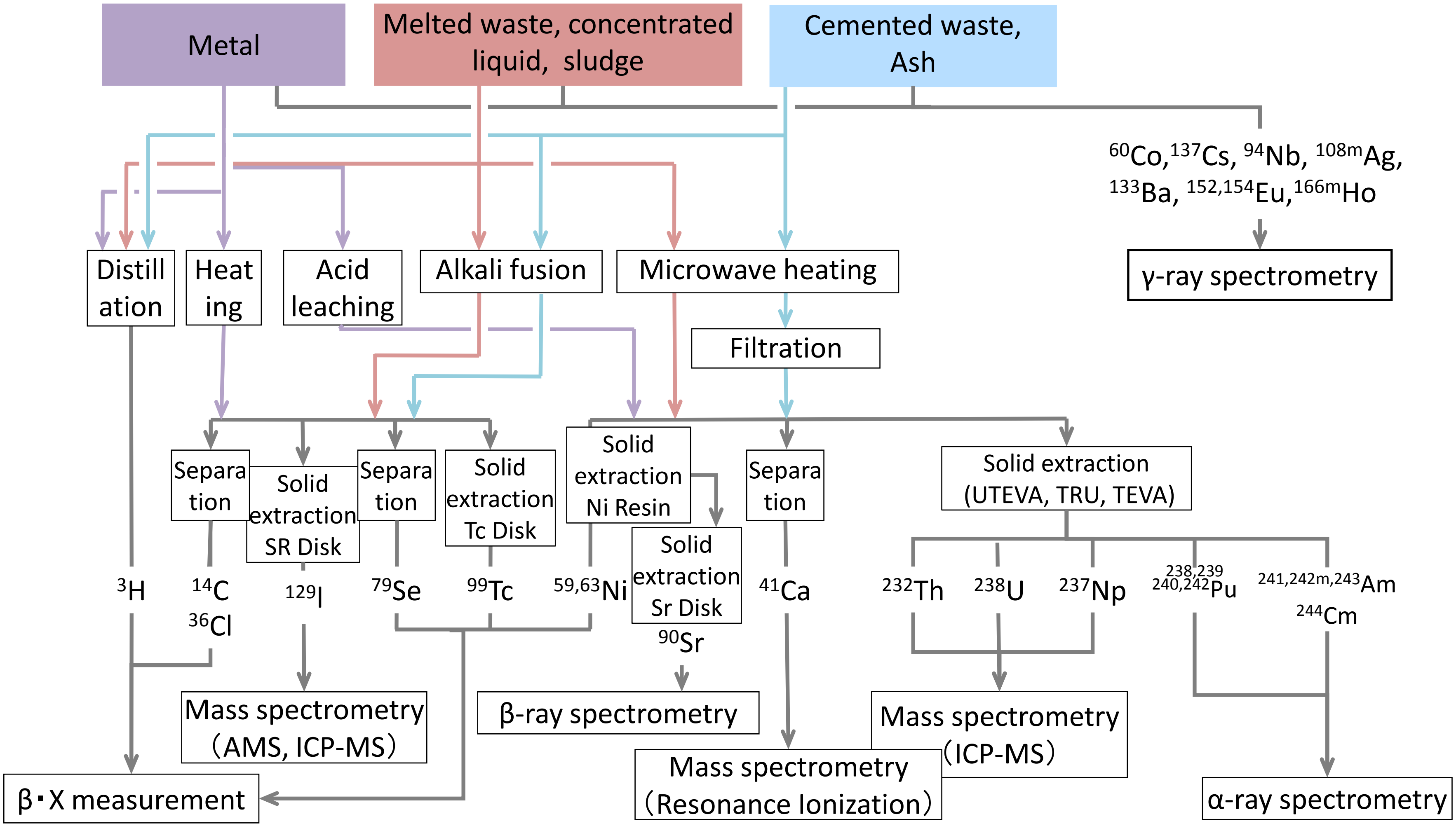
γ-ray nuclide : ^{60}Co, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu

β-ray nuclide : ^{3}H, ^{14}C, ^{36}Cl, ^{41}Ca, ^{59}Ni, ^{63}Ni, ^{79}Se, ^{90}Sr, ^{99}Tc, ^{129}I, ^{241}Pu

α-ray nuclide : $^{233, 234, 235, 236, 238}$U, ^{237}Np, ^{238,239,240,242}Pu, ^{241,242m,243}Am, ^{244,245,246}Cm

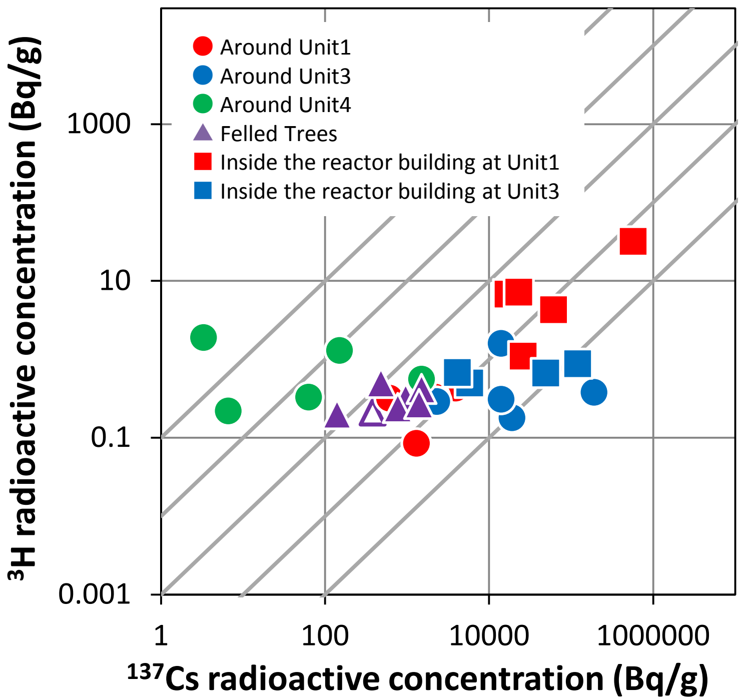
Organized Analytical Method

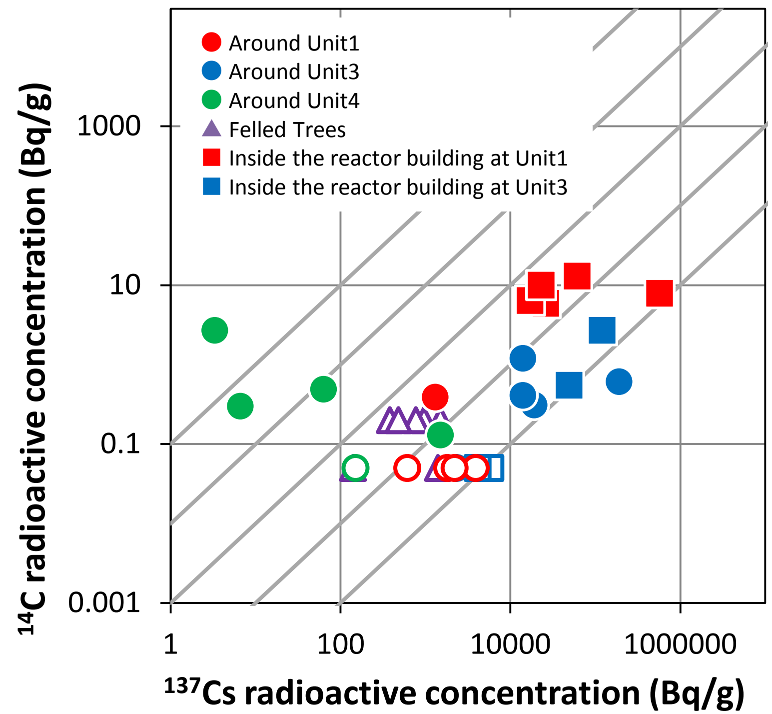
- Analytical method originally developed for laboratory wastes from our R&D activities has been employed with modification



* JAEA-Technology 2009-051 (2009). (in Japanese)

Correlation between ^{3}H, ^{14}C and ^{137}Cs Concentration





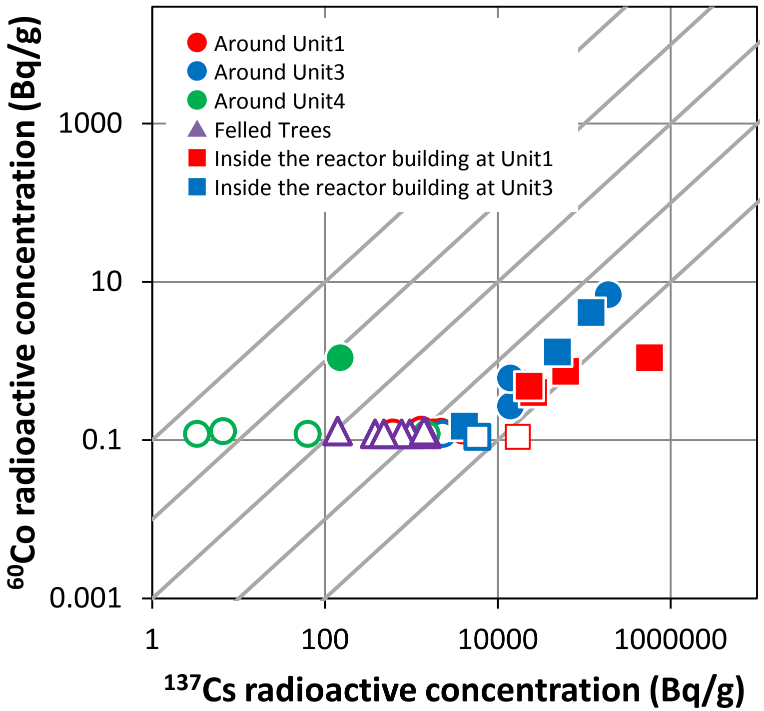
- $^{3}H/^{137}Cs = 0.008\%$[1]
- Calculated value of the reactor core[2] $= 0.5\%$
- ^{3}H of rubbles near and in the reactor building are distributed averagely

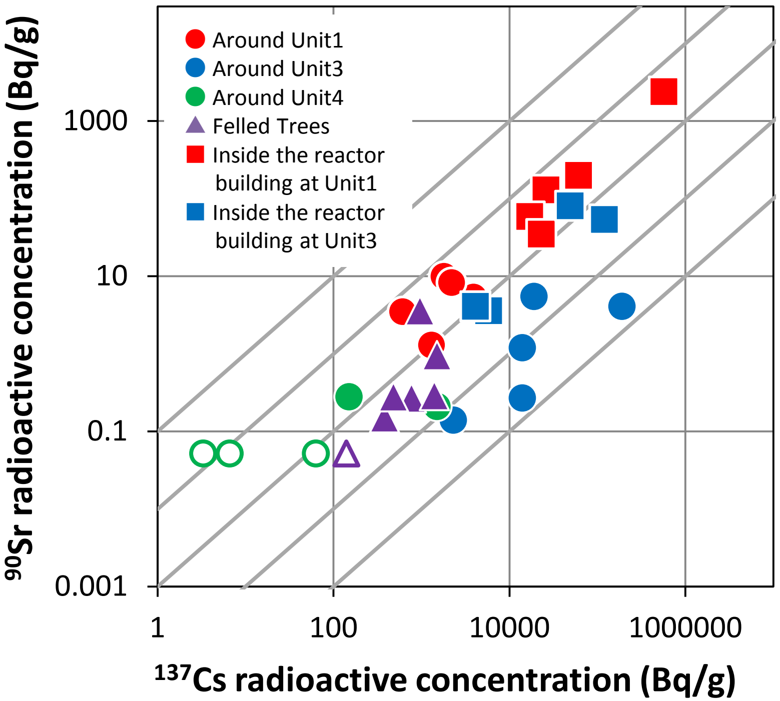
- $^{14}C/^{137}Cs = 0.007\%$[1]
- Calculated value of the reactor core[2] $= 0.0001\%$
- ^{14}C of rubbles near and in the reactor building are distributed averagely

[1] The ratio of the rubble in the reactor building (logarithm average value)
[2] The ratio of the reactor core by calculation

(Radioactivity concentration data was corrected attenuation on 11 March 2011)

Correlation between ^{60}Co, ^{90}Sr and ^{137}Cs Concentration





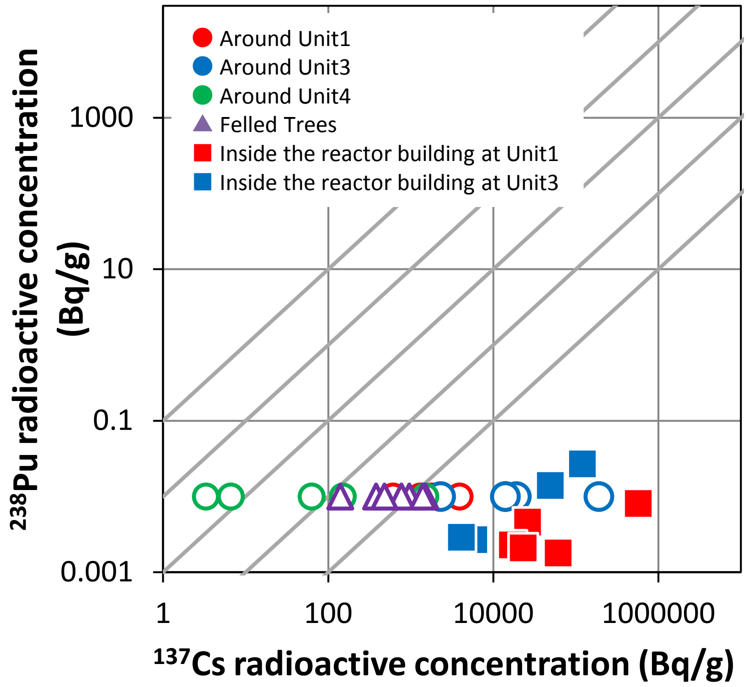
- $^{60}Co/^{137}Cs = 0.002\%$[1]
- Calculated value of the reactor core[2] = 0.001%
- Samples from Unit 1 and 3 including rubbles around the reactor building tend to be proportional to ^{137}Cs concentration
- Detected from the core coat

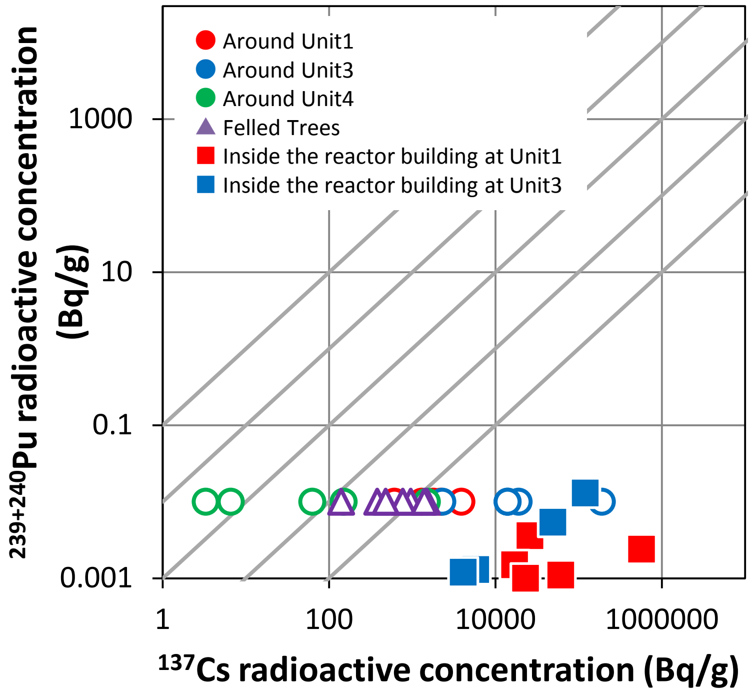
[1] The ratio of the rubble in the reactor building (logarithm average value)
[2] The ratio of the reactor core by calculation

- $^{90}Sr/^{137}Cs = 0.2\%$[1]
- Calculated value of the reactor core[2] = 75%
- The ratio of ^{90}Sr to ^{137}Cs of rubbles near the reactor building is same as that in the reactor building on the average
- ^{90}Sr transition ratio from the reactor core is estimated smaller than ^{137}Cs by about two digits

(Radioactivity concentration data was corrected attenuation on 11 March 2011)

Correlation between ^{238}Pu, $^{239+240}Pu$ and ^{137}Cs Concentration





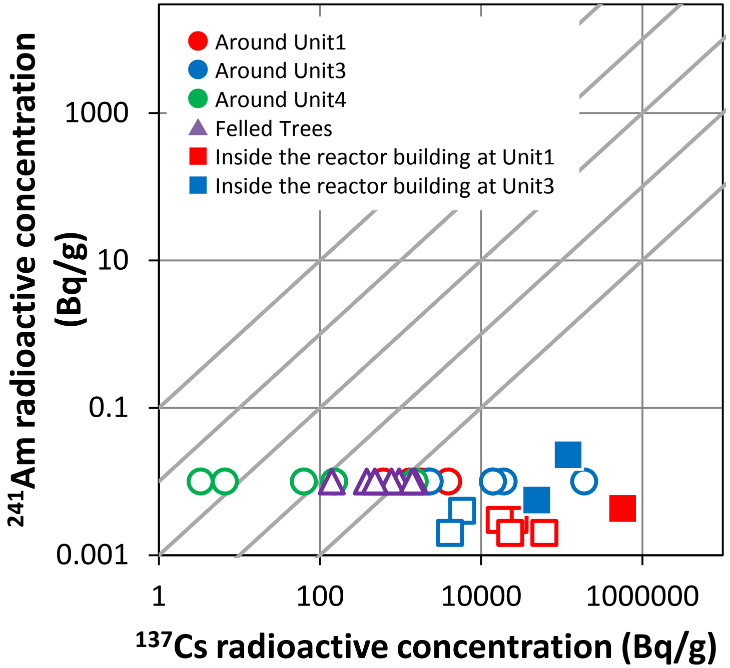
- $^{238}Pu/^{137}Cs = 0.00003\%$[1]
- Calculated value of the reactor core[2] = 2.1%
- ^{238}Pu transition ratio from the reactor core is estimated smaller than ^{137}Cs by about five digits

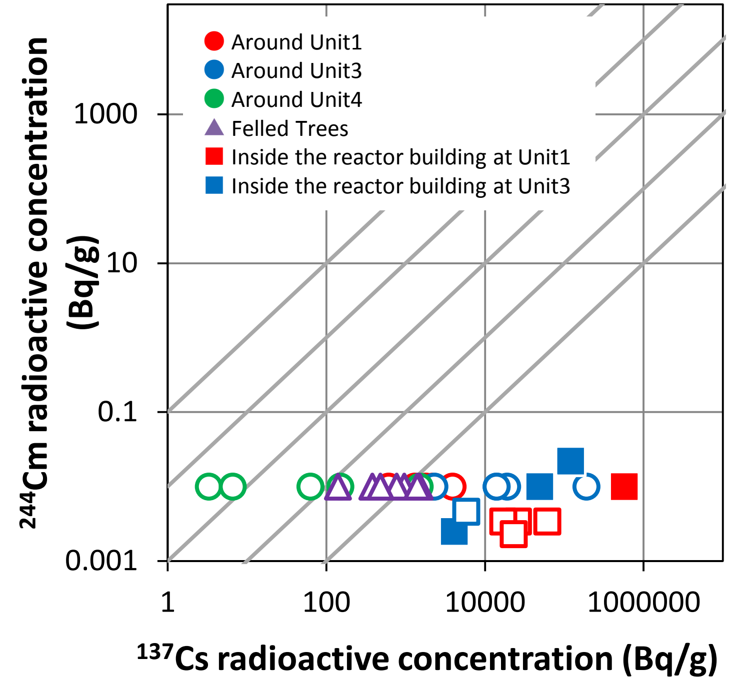
- $^{239+240}Pu/^{137}Cs = 0.00001\%$[1]
- Calculated value of the reactor core[2] = 0.85%
- The behavior is similar to ^{238}Pu

[1] The ratio of the rubble in the reactor building (logarithm average value)
[2] The ratio of the reactor core by calculation

(Radioactivity concentration data was corrected attenuation on 11 March 2011)

Correlation between ^{241}Am, ^{244}Cm and ^{137}Cs Concentration





- $^{241}Am/^{137}Cs = 0.00002\%$[1]
- Calculated value of the reactor core[2] = 0.2%
  (The calculated value at analysis = 1%)
- ^{241}Am transition ratio from the reactor core is estimated smaller than ^{137}Cs by about five digits

- $^{244}Cm/^{137}Cs = 0.00005\%$[1]
- Calculated value of the reactor core[2] = 1.2%
- ^{244}Cm transition ratio from the reactor core is estimated smaller than ^{137}Cs by about five digits

[1] The ratio of the rubble in the reactor building (logarithm average value)
[2] The ratio of the reactor core by calculation

(Radioactivity concentration data was corrected attenuation on 11 March 2011)

Important Study Items for the Future

- It is important to study Waste Stream in an integrated manner based on examination of an individual R&D item
- The important examination items at this stage
  - Information regarding the inventory and coexistence substance in waste
    - To set up the radionuclide inventory in waste, utilizing analytical values, literature value, and the analytical approach together, in consideration of various uncertainties
  - The processing and long-term storage method of waste from generated from treatment of contaminated water
    - A geopolymer is effective in stable solidification of the waste containing the ferrocyanides which adsorb cesium. To continue basic examination, accumulate data and improve evaluation accuracy.
  - The prospect of disposal classification of each waste, and the establishment of classification selection criteria
    - Presentation of disposal classification and establishment of classification selection criteria, based on inventory information and the information (including the information regarding treatment) in consideration of the feature of the accident waste
    - Presentation of the data which utilizes the safety-assessment result etc. and should be acquired preferentially, and the conditions which have significant influence on the safety of disposal
    - Improvement of the accuracy by repeating studies reflecting the newest knowledge

Thank you for listening