

As the international research and development base, "International Collaborative Research Building" was constructed near the 1F as a core of the Collaborative Laboratories for Advanced Decommissioning Science. A network will be established, where competent people from domestic and foreign universities, research institutes, and companies can interact, to promote research/development and human resource development towards decommissioning by collaborative effort of academia-industry-government.

Naraha Center for Remote Control Technology Development

-Development of remote control instruments etc.-



Naraha Town, Fukushima Prefecture

application



Sector of Fukushima Research and Development



Collaborative Laboratories for Advanced Decommissioning Science

-A platform to collect the wisdom of experts from around the world-

CLADS Main Building



Tomioka Town, Fukushima Prefecture

At Tokai and Oarai in Ibaraki Prefecture, utilizing JAEA's special facilities for handling nuclear fuels and radioactive materials, and irradiation facilities.

application

Okuma Analysis and Research Center

(Partly open)
-Analysis of radioactive nuclides, etc.-



Okuma Town, Fukushima Prefecture
(next to the 1F site)

Utilization of results

Fukushima Environmental Safety Center

Research and development on environmental dynamics, radiation monitoring, etc.

"From off-site to on-site"

Cooperation with academia, industry, and government.

[Tokyo Electric Power Company·IRID·NDF]

Cooperation with Tokyo Electric Power Company, International Research Institute for Nuclear Decommissioning (IRID), Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF)

[Domestic and foreign universities, research institutes, and industries]

Cooperative course with the University of Tokyo, Tohoku University, Tokyo Institute of Technology, etc. Collaborative research and information exchange with international organizations, research institutes in USA, UK, France, and private companies, etc.

[Fukushima Prefecture, The Ministry of Environment]

Cooperation with Fukushima Prefectural Center for Environmental Creation, Fukushima Technology Center, etc.

Main efforts of the Collaborative Laboratories for Advanced Decommissioning Science

(I) Establishment of a platform to collect the wisdom of experts from around the world

Sector of Fukushima Research and Development Fukushima Research institute

Collaborative Laboratories for Advanced Decommissioning Science

Research Co-ordination and Promotion Office

Office for Tomioka Collaborative Laboratories Operation Management

Fuel Debris Research and Analysis Division

Waste Management Division

Accident Progression Evaluation Division

Remote System and Sensing Technology Division

※At present, the research and development are conducted using existing facilities in JAEA.

(II) Enhancement of in and outside Japan research on decommissioning

- Inviting foreign researchers
- Collaborative research with foreign research institutes
- Forming a working group including external researchers and experts in the fields necessary to decommissioning.



Fukushima Research Conference(FRC)

(IV) Establishment of an information dissemination function

In cooperating with the National Diet Library, JAEA arranges information released by the government and Tokyo Electric Power Company(TEPCO) on the basis of IAEA's nuclear accident information categories and transmit the information as the "JAEA Archive".
Transmitting information on documents is included JAEA's original research results.



(III) Enhancement of human resources development in mid-and-long term

Integrating analysis technologies from various fields and developing human resources by opening cooperative course with institutions adopted for the "Decommissioning Basic Research: Human Resource Development Program" hosted by the Ministry of education, Culture, Sports, Science and Technology.

In order to gather a variety of talented people, the cross-appointment system are utilized.

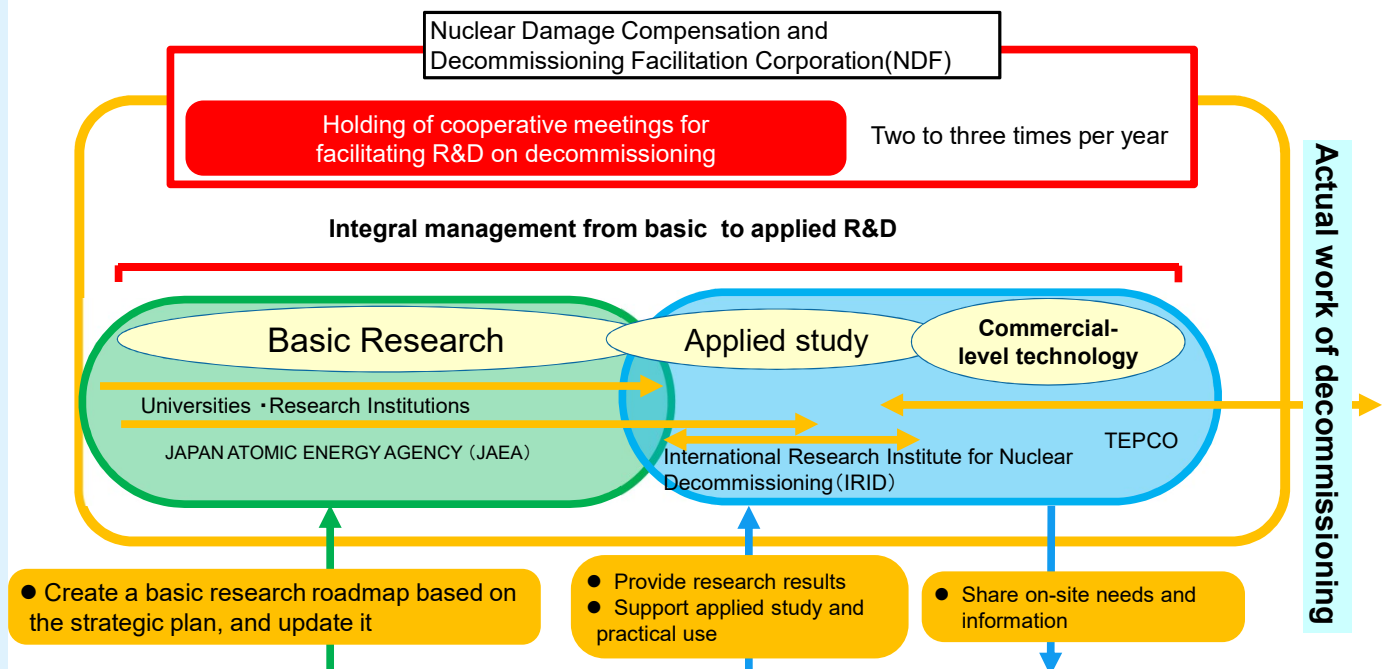


Platform for basic research on decommissioning project

Activities as a platform for basic research on decommissioning projects

- ◆ Serve as a council for promotion of basic research toward decommissioning of 1F, jointly managed by JAEA (CLADS) and the business operators who were publicly recruited and selected by MEXT for its human resource development (HRD) projects.
 - The platform is widely open up to the world in order to involve as many researchers as possible in and outside Japan.
- ◆ Have working meetings, joined by NDF, IRID, TEPCO, and other related organizations as observers.
- ◆ Construct a mechanism of the platform for participating members to perform vigorous activities at International Collaborative Research Building.
- ◆ Attract potential research members by publicly informing R&D topics.
 - **Fulfill a central role in promoting basic research toward decommissioning of 1F**
 - **Foster and employ human resources for R&D**
 - **Utilize International Collaborative Research Building**

Positioning of the platform



Platform for basic research on decommissioning project

- ◆ Fulfill as a council for promotion of basic research toward decommissioning of 1F JAEA (CLADS) and the business operators who were publicly recruited and selected by MEXT for its human resource development (HRD) projects.
 - The platform is widely open up to the world in order to involve as many researchers as possible in and outside Japan.
- ◆ **“Bazaar” Approach**
 - Spell out the purpose of the platform, create a basic research roadmap based on the strategic plan, and update it in a timely manner.
 - Have multiple players compete for the goal bringing together their expertise, technologies, and idea by Industry-academia collaboration.
 - Realize dynamic mutual interaction among the basic research and the project and provide achievements on a timely manner.
 - Actively participate in the consolidation and effective use of International Collaborative Research Building.
 - Manage long-term risks by digging up unexposed issues.
 - Set up research groups for R&D activities.

Analysis on Fuel Debris Behavior

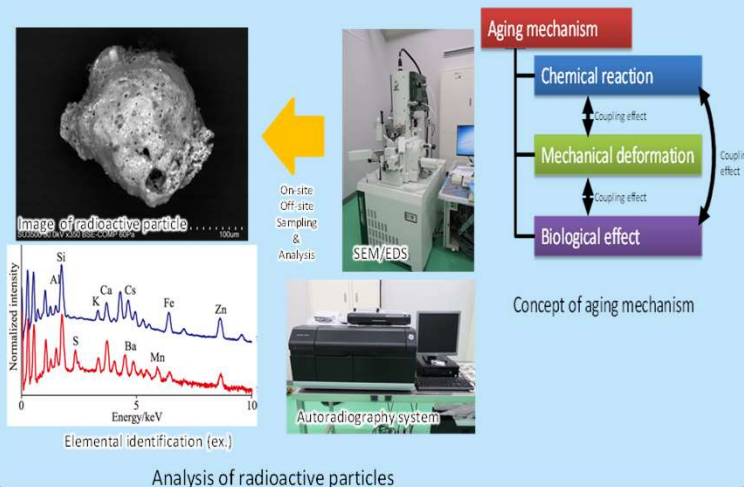
Fundamental studies on aging mechanism of fuel debris and analysis of radio-active fine particles towards decommissioning after severe accidents

◆ R&D on aging mechanism of fuel debris

⇒ Investigating aging mechanism of fuel debris to consider methodologies of estimation on fuel debris characteristics at a certain time in long-term decommissioning work.

◆ R&D on radioactive fine particles

⇒ Extracting various kinds of information and analysis results of radioactive fine particles regarding actual progression of severe accident in order to develop severe accident simulation and estimation method of fission product distribution.



Behavior analysis of radioactive micro-particles

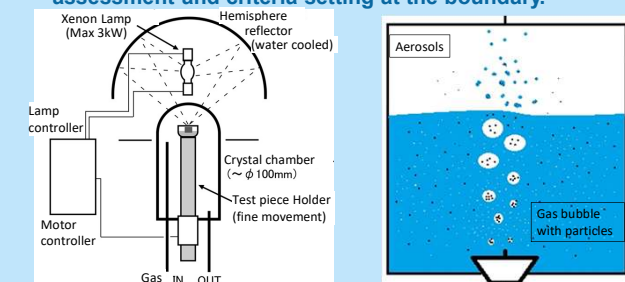
Clarify the microscopic behavior of radioactive micro-particles produced during the retrieval of fuel debris to ensure confinement.

◆ Clarification of the mechanisms of generation, transportation and migration of the radioactive micro-particles

⇒ Clarify the behaviors of generation, transportation and migration of the radioactive micro-particles generated during debris removal. Provide the knowledge of its behavior at underwater / aerial, air-liquid interface and develop the in-situ measurement technology.

◆ The strategy of confinement and dose evaluation

⇒ Conduct the fundamental evaluations on the filter permeation of wet dust, air dose rate due to nuclear reaction of radioactive micro-particles, aim to provide knowledge on exposure assessment and criteria setting at the boundary.



Radioactive particle generation test by focusing heating.

Laser Observation and Numerical Simulation for radioactive micro-particles at air-liquid interface

Analysis of Corrosion Mechanism in Specific Environment

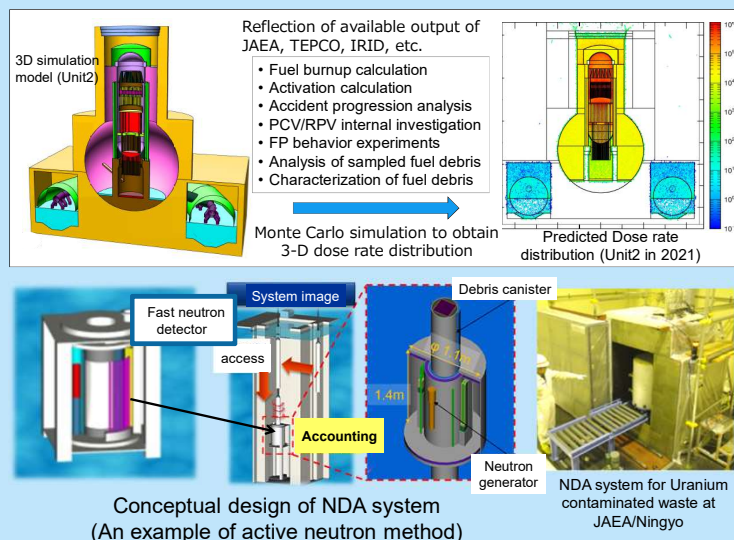
Contributing to the optimization of 1F decommissioning procedure and to nuclear material accountancy of retrieved fuel debris.

◆ Prediction of dose rate distribution

⇒ Prediction of the dose rate distribution in PCV or retrieved fuel debris based on the simulation of accident, experiments and measured values by PCV/RPV internal investigations.

◆ Non-destructive assay (NDA) technology for nuclear material accountancy of fuel debris

⇒ Development of the NDA system based on the active and/or passive neutron and gamma measurement to contribute to safety management of retrieved fuel debris.



Development for Hydrogen Safety Engineering

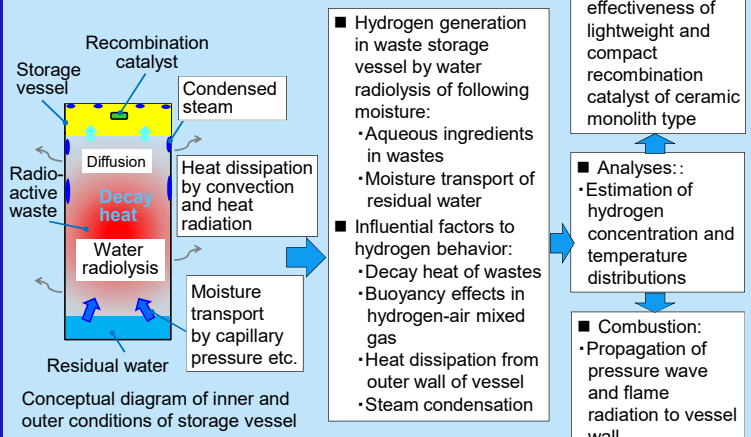
Development of technology to ensure long-term safe storage of radioactive waste by analyzing hydrogen behavior in a waste storage vessel and by applying mitigation methods to suppress an increase in hydrogen concentration.

◆ Analyses of hydrogen behavior

⇒ To assess hydrogen safety in waste storage including such behavior as diffusion and stratification while considering, through analysis technique, decay heat of wastes, buoyancy effects of hydrogen mixed gas, and combustion effects of pressure wave and flame radiation on storage vessel wall.

◆ Mitigation method to suppress increase in hydrogen concentration

⇒ By using hydrogen recombination catalyst, a passive or non-powered mitigation method is to be developed applied to enable long-term safe waste storage.



Various kinds of wastes are generated at Fukushima Daiichi Nuclear Power Station. In order to proceed decommissioning the site, establishing waste management technologies including storage, processing and disposal, are indispensable. We have been conducting R&Ds with aiming at followings;

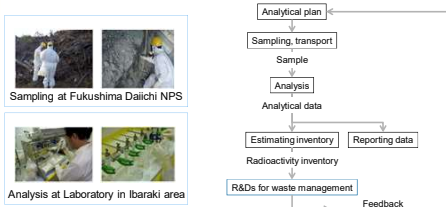
- To provide technology, which satisfy the needs, and to help sooner and efficient decommissioning,
- To support to reach the milestone of the road-map^{*1}; "provide technically feasible methodologies of processing and disposal."

^{*1} Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station, September 26, 2017.

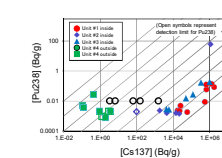
Characterizing waste

Radiochemical composition will be clarified by analysis for establishing waste management technology.

- Various waste is analyzed to investigate contamination behavior. And data is available via internet.



Flow of analysis and utilizing data



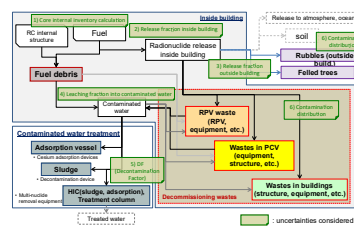
Concentration of ²³⁸Pu and ¹³⁷Cs in rubble collected around/inside reactor buildings²



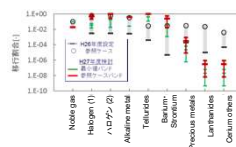
"FRAnDLI" as database³

Estimating method is under development for radioactivity inventory of waste including generated in future.

- Mathematical Model is investigated to describe radioactivity transfer. Analytical data is utilized to reproduce contamination.



Model of transport for estimating radioactivity in waste

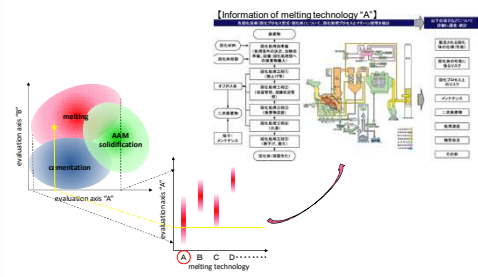


Parameter of radioactivity transfer to contaminated waste as an example (uncertainty was decreased by using analytical data)

Processing waste

Method is developed to choose promising conditioning technology for various wastes.

- Approach is investigated to choose conditioning method, which conform to future disposal system.
- Applicability of cement and new material (alkaline activated material, like geopolymers) is surveyed.
- Conditioning with better confinement and stability is pursued.

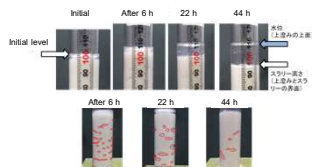


Supposed flow for making approach to choose promising technique.

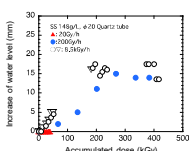
Storing waste

Technology for safe storage of secondary waste from water treatment is investigated.

- Concerning water overflow from container of slurry, behavior of increase in water level was reproduced by gamma irradiation experiment



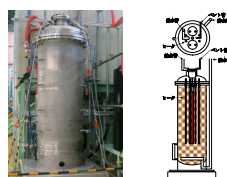
Gamma-ray irradiation (8.5 kGy/h) on simulated carbonate slurry; increase in level (upper) and bubble retention (lower).⁴



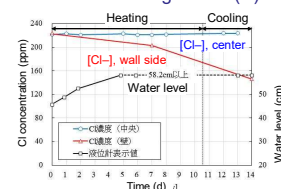
Increase in water level with accumulated dose. (at solid concentration of 148 g/L)

Estimating change in state of secondary waste during long-term storage is investigated.

- To estimate behavior of internal temperature, water and salt, full-scale drying test was carried out by using vessel containing zeolite adsorbent.



Full-scale vessel for drying test (L) and heater configuration (R)

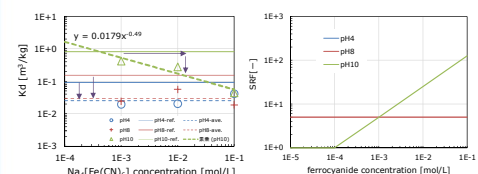


Change of water level and [Cl-] with heating inside vessel

Disposing of waste

To realize waste disposal, system concept is investigated, as well as affect to nuclide migration by waste.

- Waste disposal technology, which is coordinated with waste characteristics and processing method, is developed. To accommodate with decommissioning strategy and public acceptance, integrated management approach is investigated.
- Effect of chemicals on sorption of radioactivity is studied.



Change in sorption of radionuclides on artificial barrier caused by chemical compound (Example of system of Np-montmorillonite-ferrocyanide)

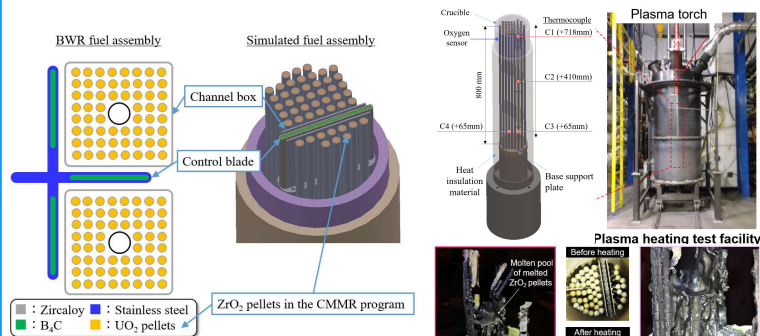
1F Accident Progression Evaluation

[Objective] • • Contribute to 1F decommissioning providing information of post-accident reactor condition with model simulation and experiments for accident progression through comparison with plant data and inspection. The obtained knowledge will be reflected to safety researches.

[Main research themes]

(1) Experimental study focusing on core melting with BWR design

Observe core material melting/relocation with BWR design simulating accident conditions with high-temperature plasma-heating technology.



(2) Analysis and evaluation of 1F-accident progression behavior

Conduct 1F-accident analysis and evaluation reflecting above-mentioned experiments in the light of plant data and inspection so that BWR-specific accident progression and resultant reactor condition can be clarified contributing to 1F decommissioning and safety researches.



Fuel Degradation Modelling

[Objective] • • Contributing to progress in severe accident analysis and accident management by experimental knowledge and detailed modeling for fundamental process in severe accident based on material science.

[Main research themes]

(1) Control blade degradation test

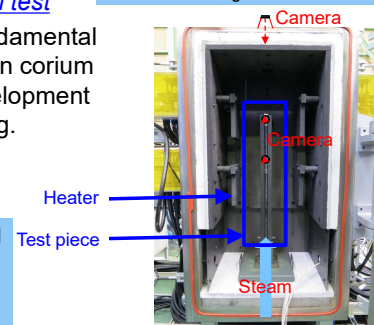
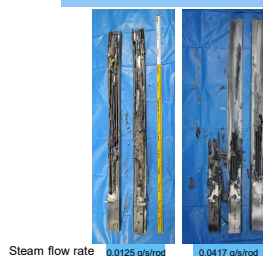
Experimental knowledge on fundamental process of control blade degradation using developed facilities in collaboration with institutes and universities, and development of detailed mechanistic modeling.

(2) Solidification in molten corium test

Control blade degradation test facility

Experimental knowledge on fundamental process of solidification in molten corium for lower cooling rate, and development of detailed mechanistic modeling.

Elucidation of threshold condition for control blade degradation, depending on steam flow rate



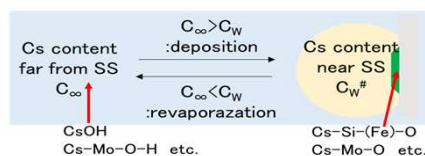
FP Chemistry

[Objective] • • Contributing to the analysis of in-reactor status by providing fundamental knowledge and model for the chemical behavior of Cesium (Cs).

[Main research theme]

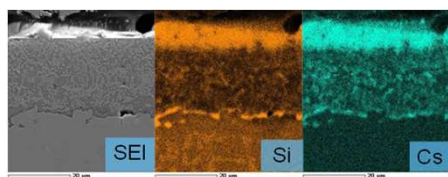
(1) Cs chemisorption modeling

Fundamental study on the reaction between Cs and stainless steel (SS) under high temperature accidental condition of 1F (basic experiments and model construction); to contribute to evaluation of Cs localization and adhesion behaviors.



- Visiting researcher
- Collaboration on analysis and experiment

Example of Cs adhesion model



The institute of applied energy

VTT, Finland

Nagaoka university of technology

An example of Cs adhesion experiment
Possibility of formation of Cs-Si-O compounds and intrusion into SS up to several tens μm was observed.



(2) Advanced surface analysis technology

Hard X-ray photoelectron spectroscopy for direct determination of chemical state of chemisorbed Cs.

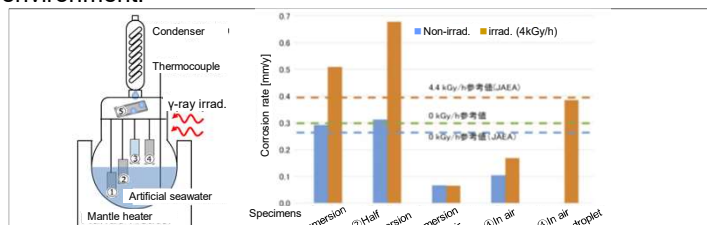
Analysis of Corrosion Mechanism In Specific Environment

[Objective] • • Risk of corrosion degradation for plant materials in 1F site has been increasing with time duration and/or environmental changes by decommissioning procedure. Preventing methods for these corrosion risks are developed based on corrosion mechanism.

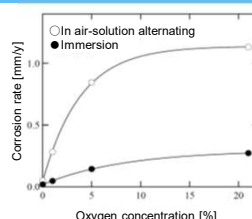
[Main research themes]

(1) Mechanism of Corrosion in Irradiated and in air/water Condition

Study on corrosion mechanism by investigating corrosion behavior in air-liquid alternation environment or radiolysis (water quality) environment.



Corrosion enhanced under irradiation, half-immersion and with droplet



In air-solution alternating condition, the corrosion rate change at low oxygen concentration is remarkable

(2) Evaluation of Corrosion Risk in Each Equipment

Corrosion risk for individual equipment during decommissioning process is analyzed by using investigation sheet, indicating corrosion mitigation method for high risk equipment.

Remote System and Sensing Technology Division

Radiation Detection and Instrumentation Group

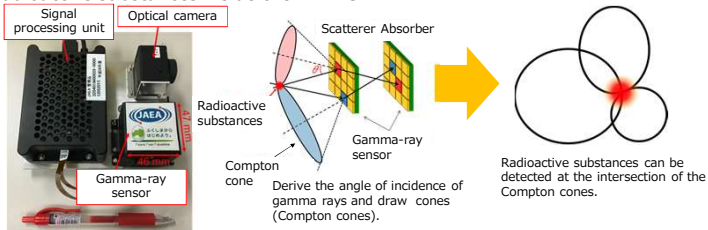
3D Imaging Technology Development Group

Remote Analytical Technology Group

3D Imaging Technology Development Group

Remote radiation imaging system

Our group develops an imaging system to remotely visualize the distribution of radioactive substances inside the FDNPS.



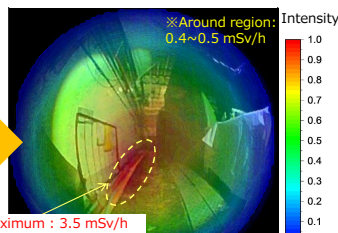
↑ Compact Compton camera

Visualization of radioactive substances inside the FDNPS

● Inside the turbine building of unit 3

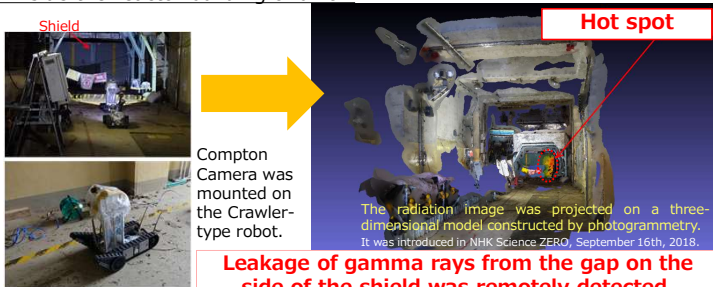


Our group conducted a hot spot search jointly with TEPCO.



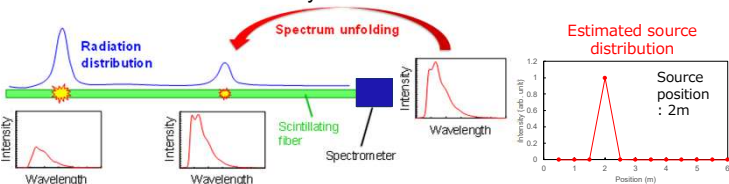
A hot spot was detected at the hose on the floor surface.

● Inside the reactor building of unit 1



Basic study of one-dimensional high dose rate radiation distribution sensing using optical fiber

By applying the unfolding method to the change of emission spectrum delivered through optical fiber, distribution of high dose rate radiation source will be one-dimensionally estimated.

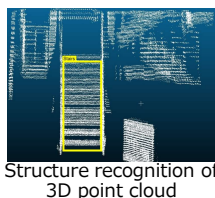


Information presentation tech. for supporting remote operations

Our group develops technologies providing information of the work site and the structures for supporting the remote control operations.



Reconstruction model of working environment



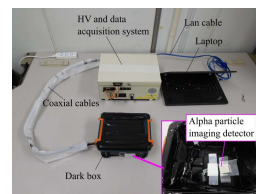
Structure recognition of 3D point cloud

Radiation Detection and Instrumentation Group

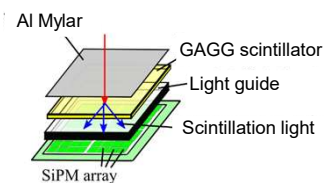
Our group develops alpha and beta particle imaging systems to visualize surface contamination distribution for promoting decontamination activities.

- Development of alpha imaging systems
- Development of beta imaging systems
- Development of dust monitoring systems

Measurement at the Fukushima Daiichi Nuclear Power Station (FDNPS) site

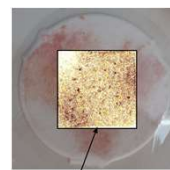


Alpha particle imaging detector



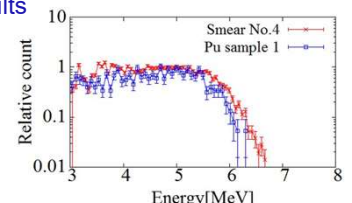
Schematic diagram of the alpha particle imaging detector

Results



Alpha image

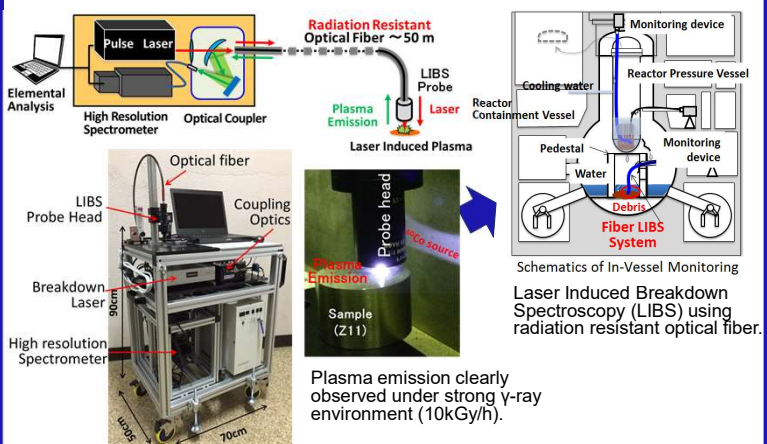
Alpha imaging of a smear sample



Comparison of alpha spectra between a smear paper and a Pu sample (The spectra were similar in shape and value.)

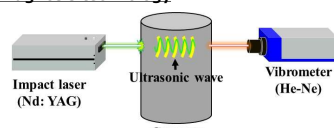
Remote Analytical Technology Group

Laser-based in-Vessel monitoring & analysis technology



Laser material diagnosis & process technology

Laser Diagnosis technology



Ultrasonic waves induced by an Nd:YAG impact are introduced into a concrete block. The waves propagating in block are detected with a laser Doppler vibrometer (LDV) using a He-Ne laser.

Laser Process technology



Remote and non-contact operation of drilling and cutting of a concrete for sampling by quasi-CW fiber laser.