R&D Activities at IRID

International Research Institute for Nuclear Decommissioning

Outline of IRID

1. Name

International Research Institute for Nuclear Decommissioning (IRID)

2. Location of Main Office

5F 3Toyo Kaiji Building, 23-1 Nishi-shinbashi 2-chome, Minato-ku
Tokyo 105-0003, Japan
website: http://www.irid.or.jp/en

3. Membership (18)

Research Institutes: Japan Atomic Energy Agency (JAEA),
National Institute of Advanced Industrial Science and Technology

Manufacturers, etc.: TOSHIBA Corporation, Hitachi-GE Nuclear Energy, Ltd.,
Mitsubishi Heavy Industries, Ltd., ATOX Co., Ltd.

Electric Utilities, etc.: Hokkaido Electric Power Co., Inc., Tohoku Electric Power Co., Inc.,
Tokyo Electric Power Co., Inc., Chubu Electric Power Co., Inc.,
Hokuriku Electric Power Company, Kansai Electric Power Co., Inc.,
The Chugoku Electric Power Co., Inc., Shikoku Electric Power Co., Inc.,
Kyushu Electric Power Co., Inc., The Japan Atomic Power Company,
Electric Power Development Co., Ltd., Japan Nuclear Fuel Limited

IRID's R&D projects in FY2015

Evaluation of Long Term Integrity of spent fuel (FY 2015-2016)

Decontamination/ Dose Reduction

- Remotely Operated Decontamination Equipment (FY 2015)

Repair and Water Leakage Stoppage of PCV

- Water Stoppage Technology of PCV (FY 2015)
- Full-Scale Test (FY 2015)

Debris Retrieval

- PCV/RPV Integrity Evaluation (FY 2015)
- Fundamental Retrieval Technology for Fuel Debris & Reactor Internals (FY 2015-2016)
- Criticality Control in Fuel Debris Retrieval (FY 2015)
- Upgrading of Retrieval Method for Fuel Debris & Reactor Internals (FY 2015-2016)
- Collecting, Transferring and Storing of Fuel Debris (FY 2015-2016)

Investigation/Analysis in the Reactor

Investigation

- Detection of Fuel Debris (FY 2015)
- Investigation Inside PCV (FY 2015)
- Investigation Inside RPV (FY 2015)

Characterization

- Accident Progression Analysis (FY 2015)
- Identifying Properties of Fuel Debris (FY 2015-2016)

Radioactive Waste Treatment/Disposal

- Solid Waste Treatment and Disposal (FY 2015-2016)

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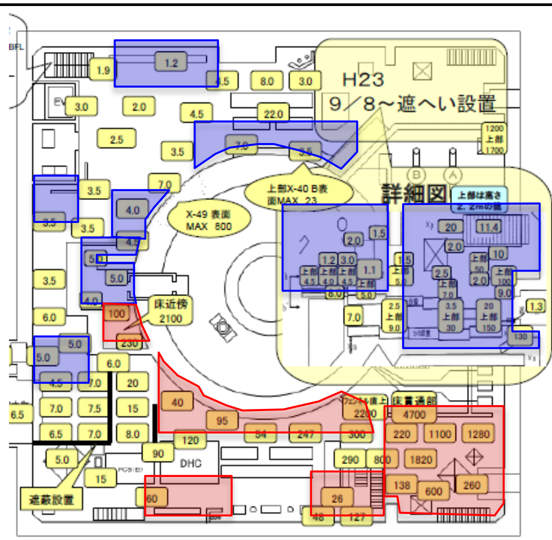
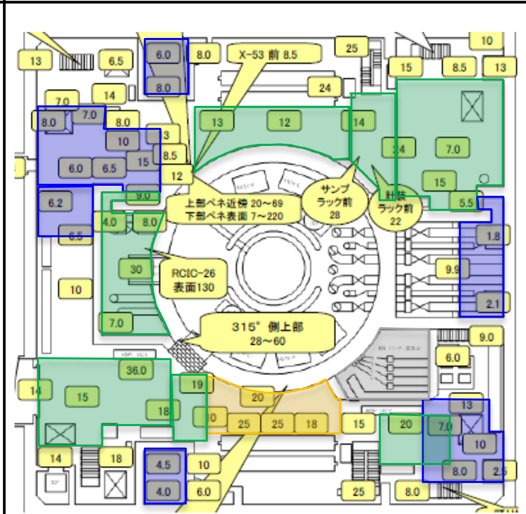
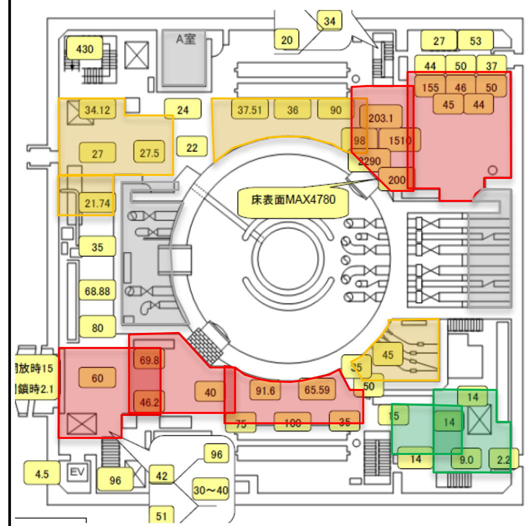
Dose Rate Goals after decontamination

◆ Dose rate reduction goals to be achieved using the decontamination equipment
(the necessity of PCV leakage investigation and repair work, and overall dose reduction scenario)
3 mSv/h for work area   5 mSv/h for access route

	Unit 1	Unit 2	Unit 3
Necessity of dose reduction* and the dose rate			
Dose rate in the reactor building	Low as a whole: about 1-10 mSv/h Higher in south area and at some points in southeast area: 5,000 mSv/h	Before Oct. 2014: 2-60 mSv/h After Oct. 2014: about 5-10 mSv/h (Decontamination in lower/middle parts and shielding were conducted)	High as a whole: about 20-100mSv/h

* Mapping results of the dose rates at planned operation areas(with needs of dose reduction) derived from PCV investigation and repair project

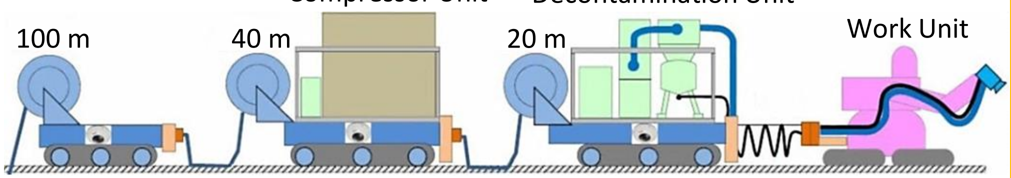
- 3 mSv/h to10mSv/h
- 10 mSv/h to 20mSv/h
- 20 mSv/h to 50mSv/h
- More than 50mSv/h
- Out of study due to the lack of data

IRID

Results and Future Plan of Decontamination Equipment Development

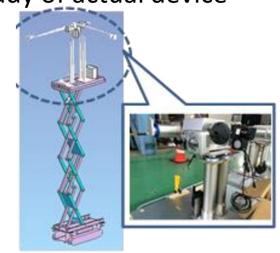
Upper floors

- FY2013: design
- FY2014-2015 : production, verification test, applicability study of actual device

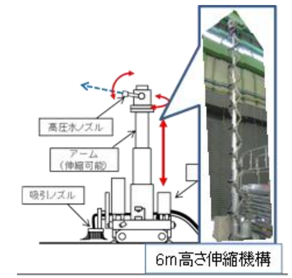


High places

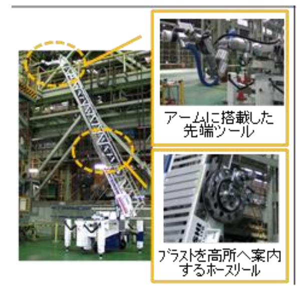
- FY2013 : design, production
- FY2014-2015 : improvement, verification test, applicability study of actual device



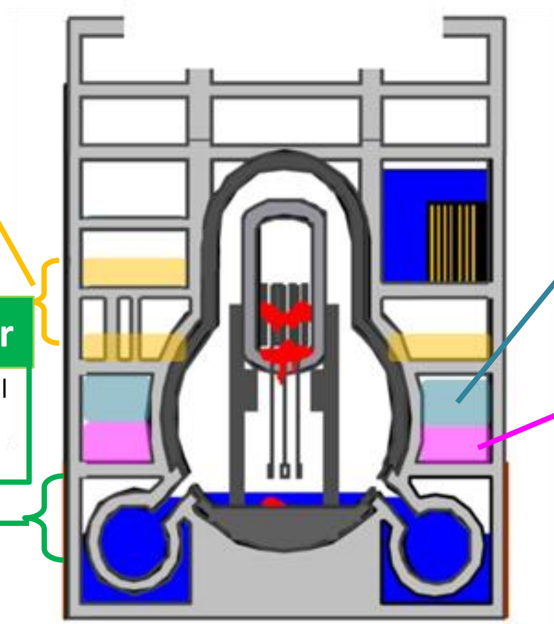
Dry ice blast



High pressure water jet



Suction/Blast



Underground floor

- FY2014 : Study of technical challenges, development planning

Low places <Development completed>

- FY2011-2012 : design, production, test in 2F
- FY2013 : improvement, verification test (factory, 1F)

Suction/Blast

High pressure water jet

Dry ice blast

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Investigation Inside PCV (FY 2015)

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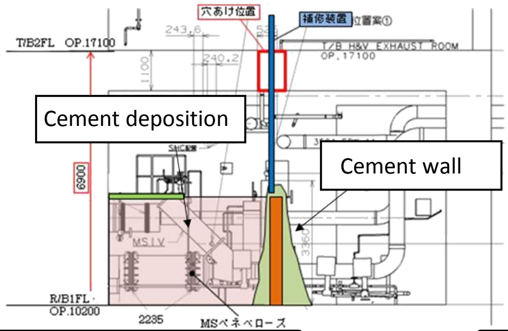
Solid Waste Treatment and Disposal (FY 2015-2016)

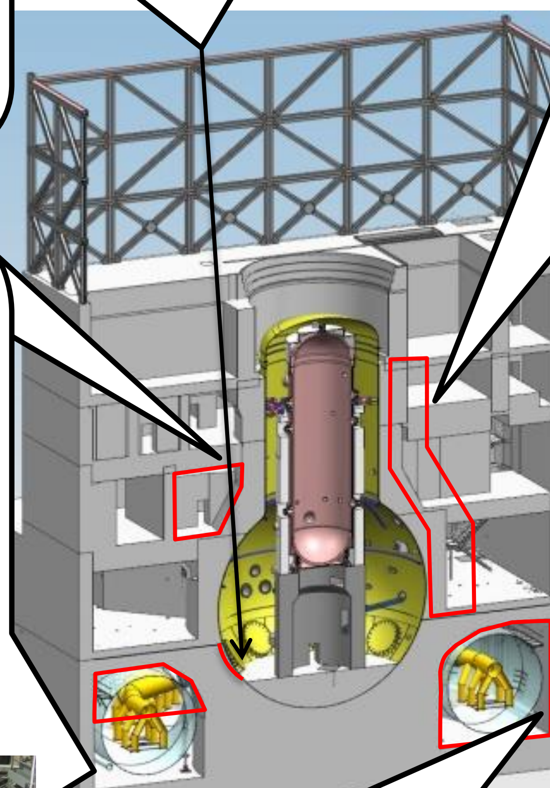
Target Areas for Water Leakage Stoppage at PCV

PCV Penetration (Small rooms)

Cement Depositing

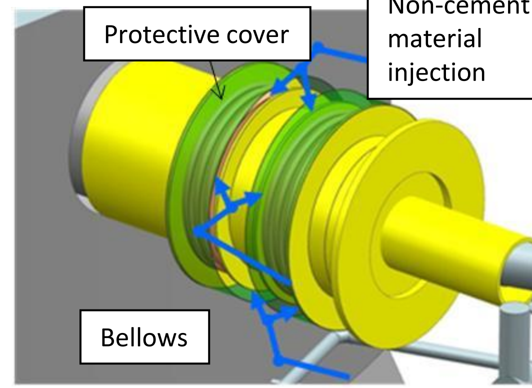


D/W Shell (repair)



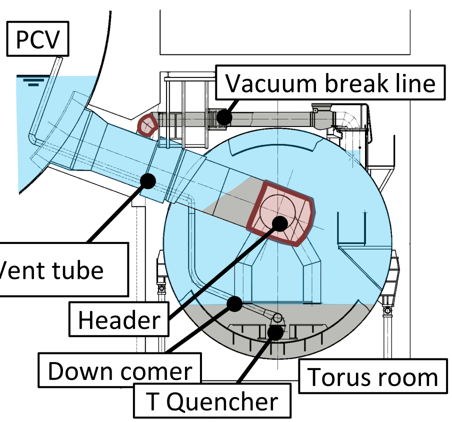
PCV Penetration (Open spaces)

Non Cement (temporal)
Cement (Long term)



Vent Piping, Down Comer

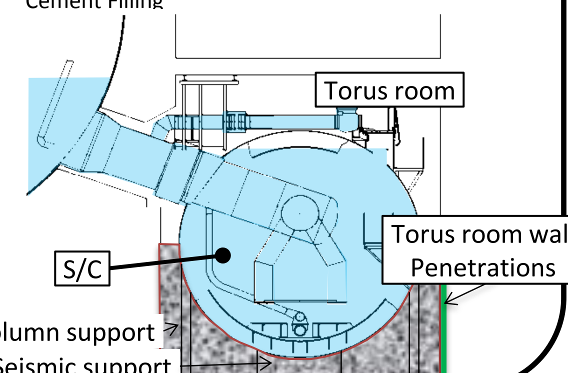
Cement Filling



A half-scale test

S/C Support, Torus Room Penetrations

Cement Filling



PCV Connecting Piping in torus room

Cement Depositing

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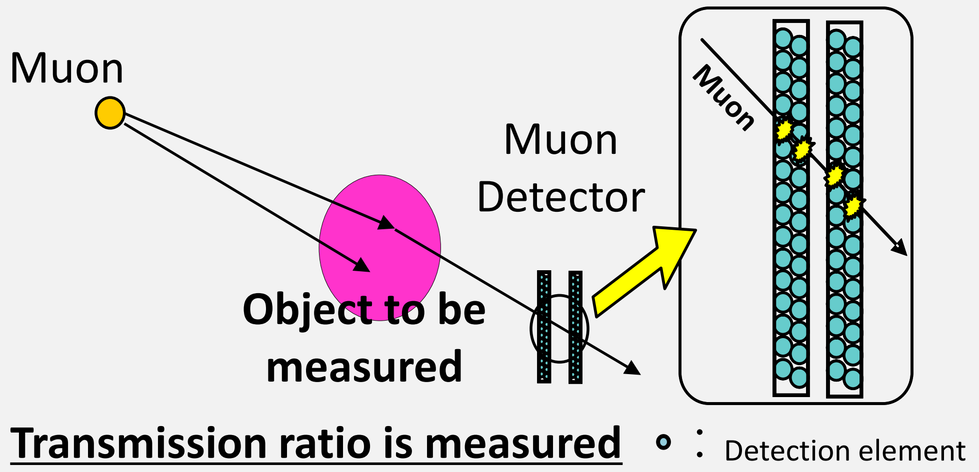
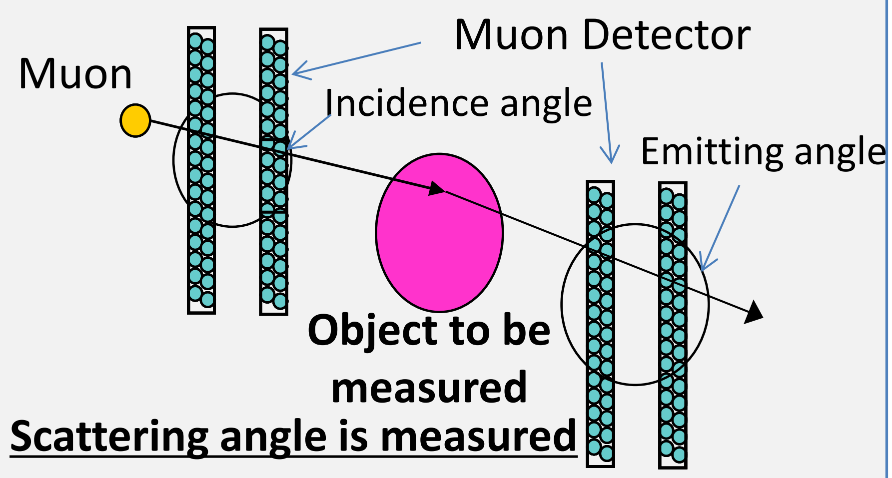
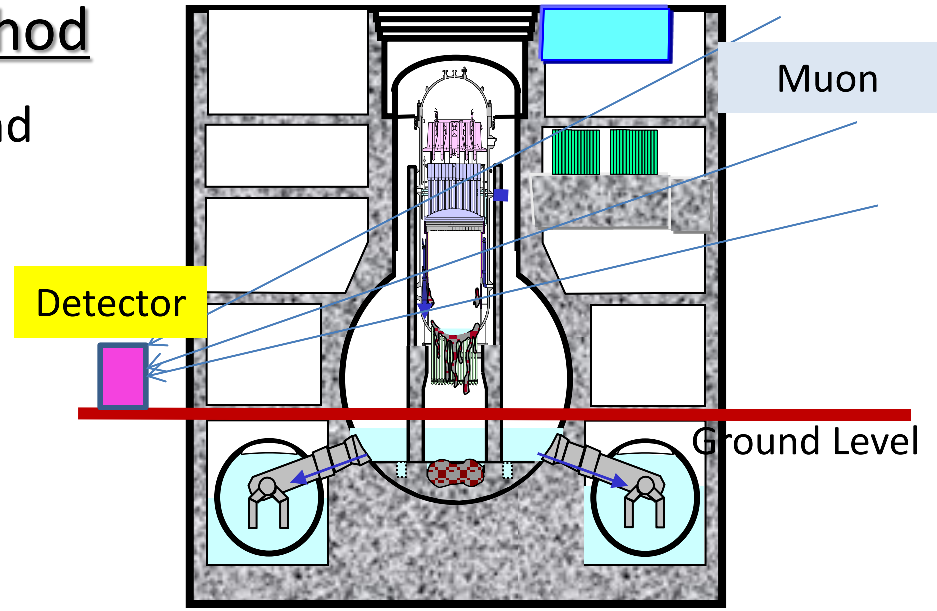
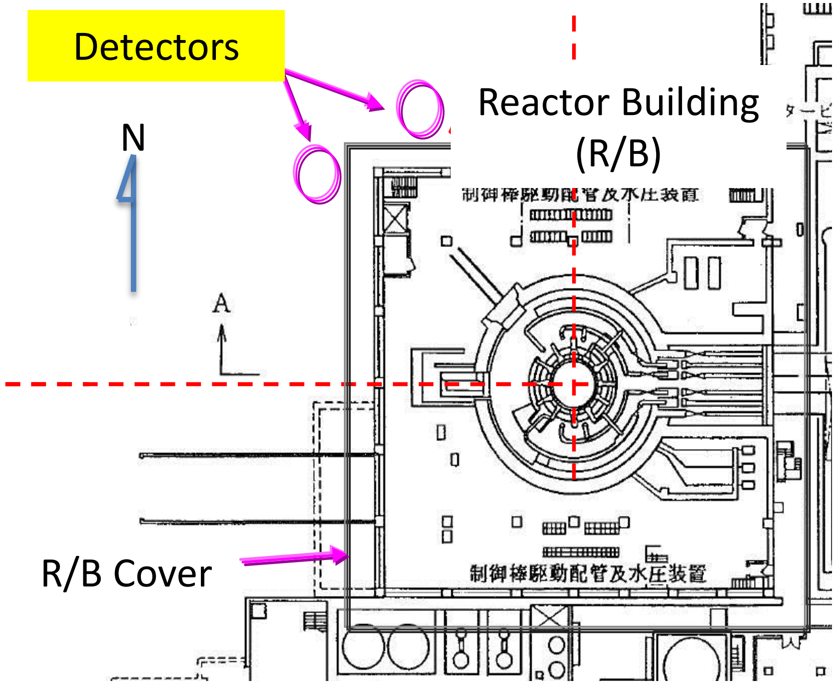
Assessing Conditions inside Reactor by Muon Observation Technology

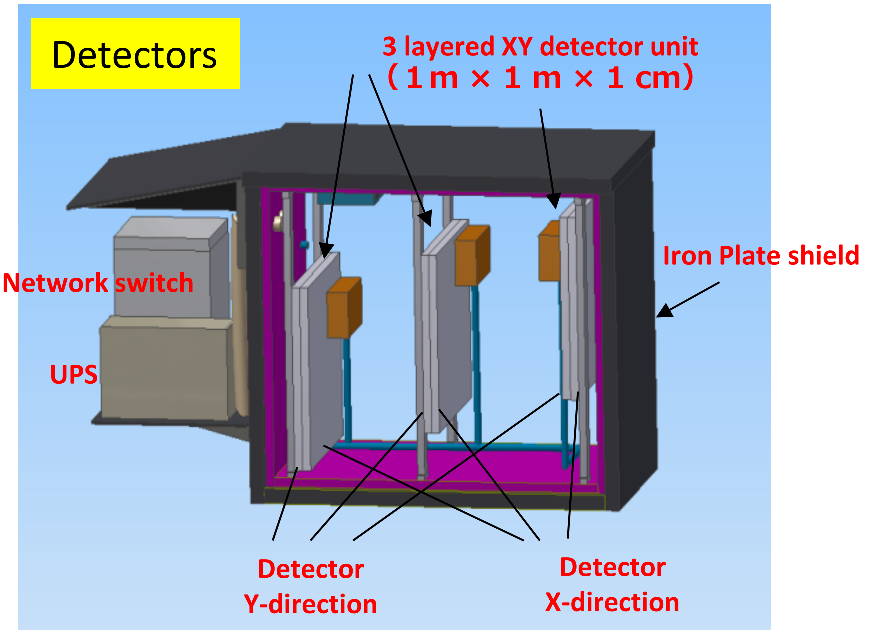
Transmission Method	Scattering Method
	
Can detect existence/non-existence of an object on Muon flying direction （two-dimensions）	**Can detect existence/non-existence of an object at Muon scattering area （three-dimensions）**
Can image fuel debris at a spatial resolution of about 1 m	**Can Image fuel debris at a spatial resolution of about 30 cm**
Detector: One small-size detector (easy installation and quick application)	Detector: One pair of large-size detectors (needs wider space and longer time to install)
	Can distinguish heavy element such as Uranium

Measurement by Transmission Method

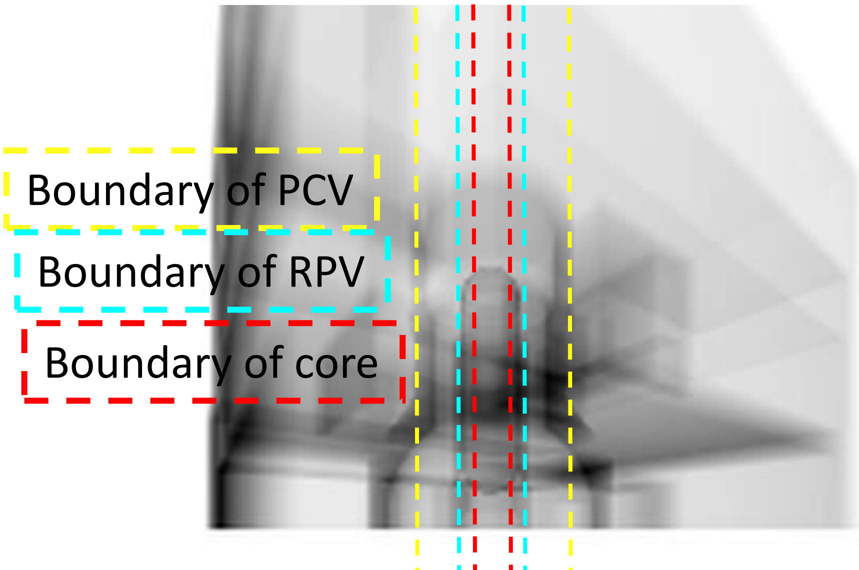
- Detectors were installed at the north and north-west corners of Unit 1 reactor building (late January, 2015)
- Measured from February through May
- Detectors were shielded by 10 cm thick iron plates



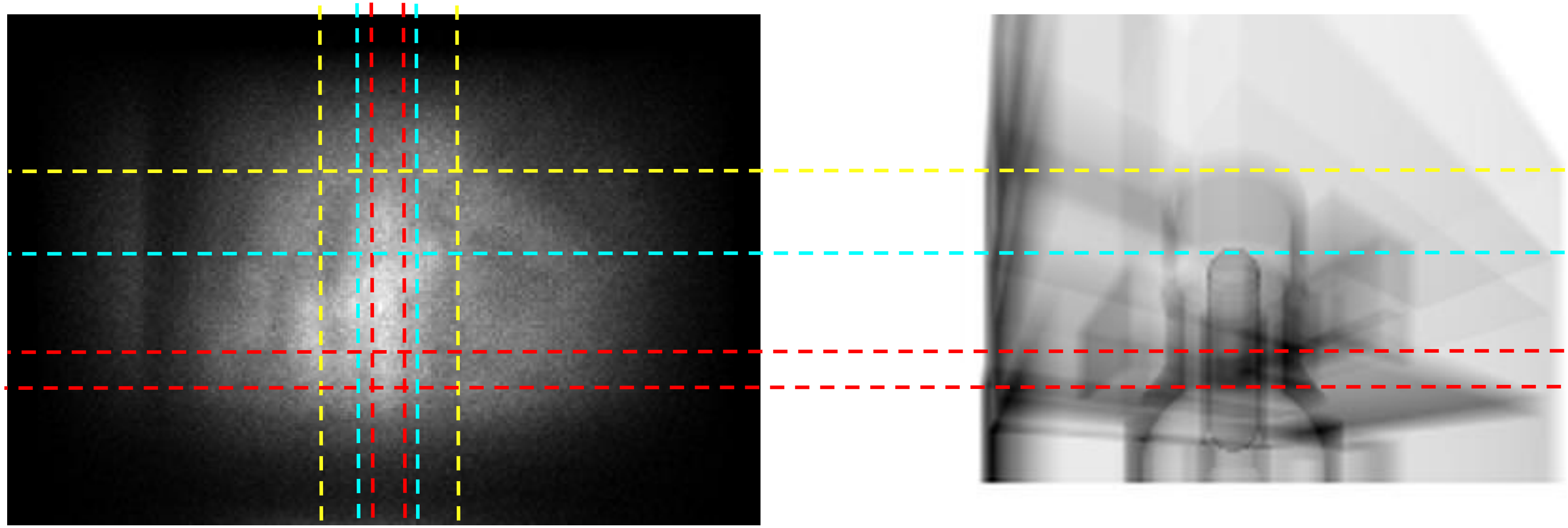




Estimation of Fuel Debris Location Based on Comparison between Design Image and Measurement

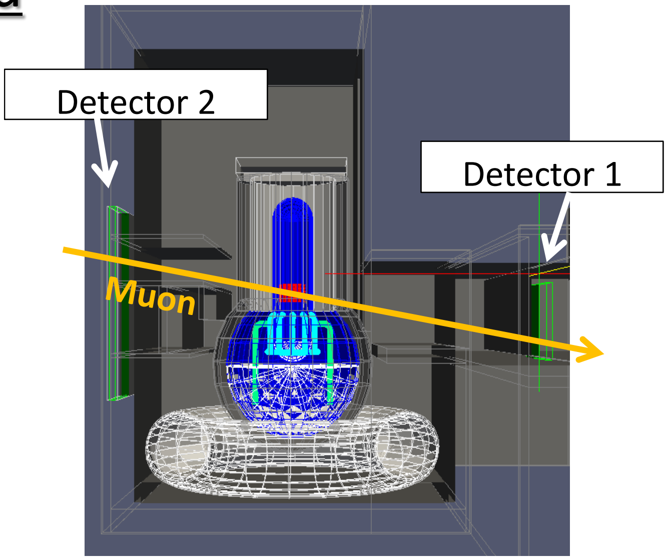


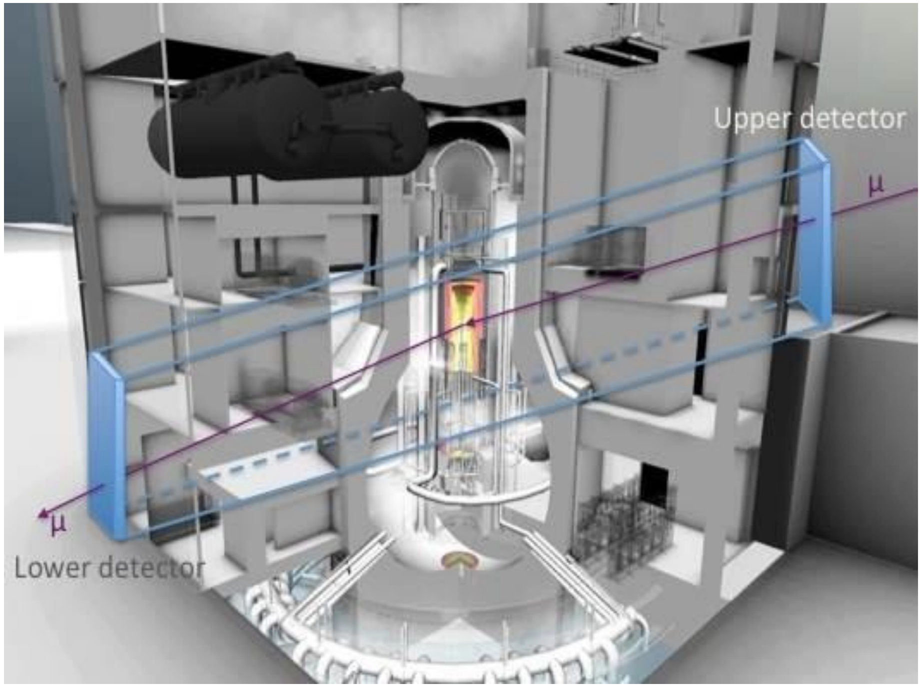
- Measured data, though it does not clearly indicate, shows that equipment, etc. are detected at locations where they are supposed to exist based on the design documents
- The boundaries of the PCV and the RPV in the image acquired from measurement matches those in the image drawn from design data.
- High density material (fuel debris) is not detected at the area where fuel assemblies are originally installed.

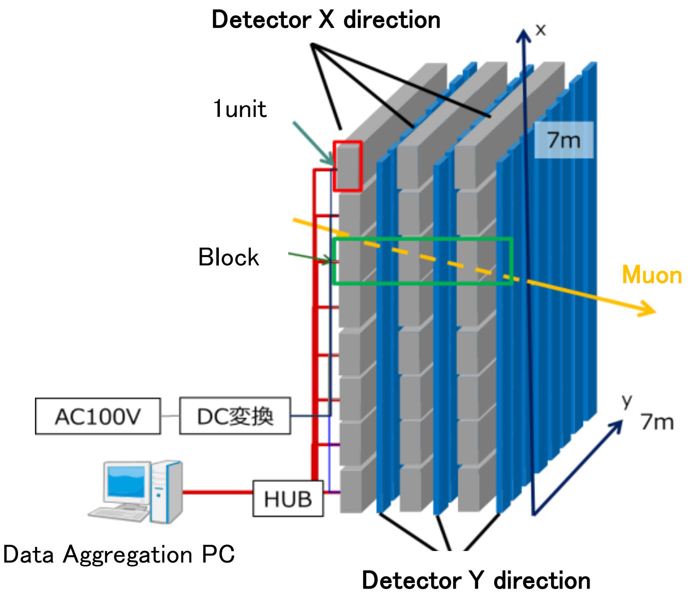


Measurement by Scattering Method

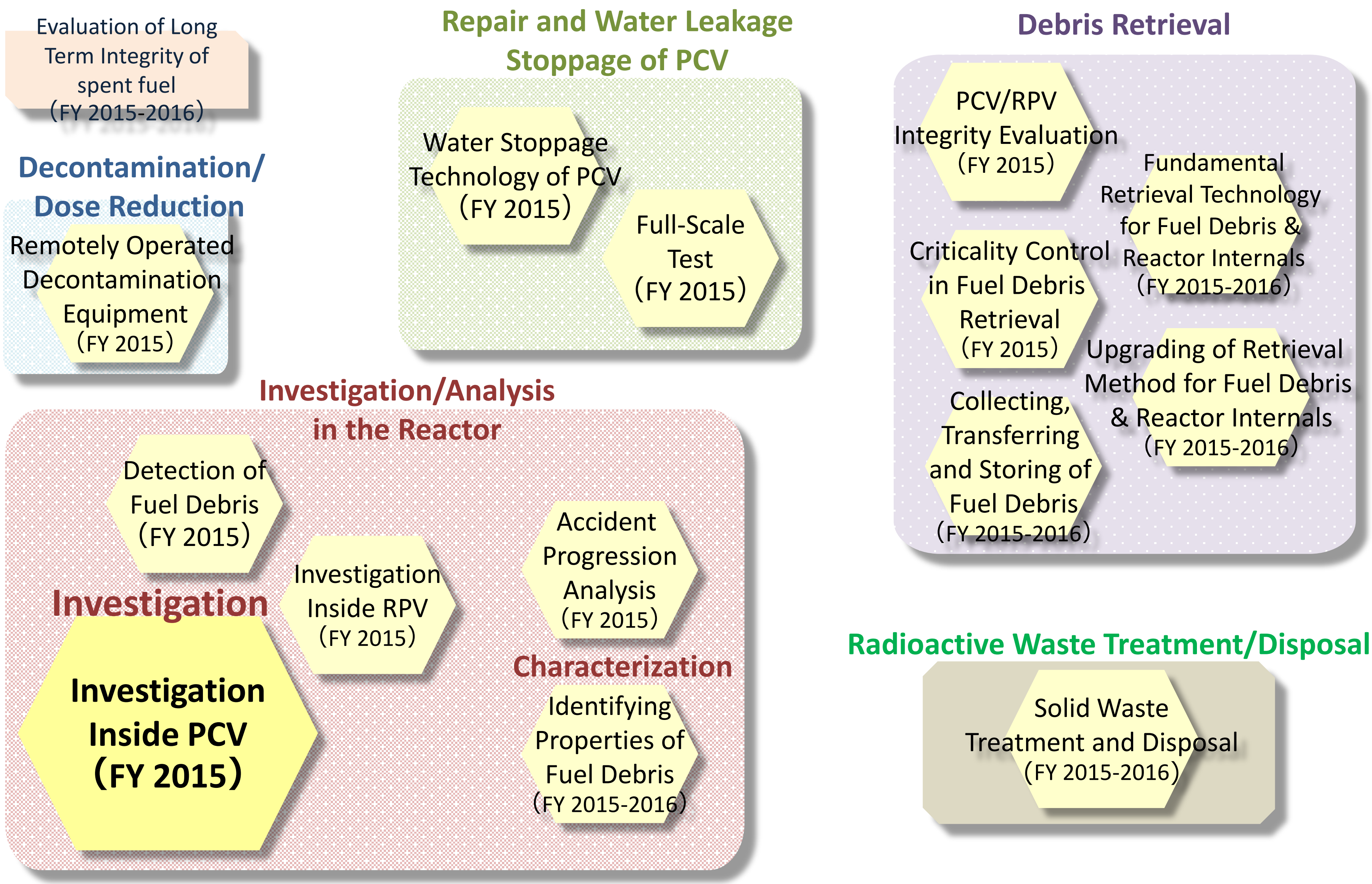
- Detectors will be installed in front of the R/B and 2nd Floor in T/B (Operation Floor) at Unit 2
- Background radiation should be eliminated by shielding and algorism
- The detector in front of the R/B should be shielded by 8 cm thick iron plates
- The detector on the second floor of the T/B will not be shielded because of low background radiation







IRID's R&D projects in FY2015



Investigation inside the PCV (Unit 1)

[Investigated area] 1st^{t} floor grating outside the pedestal

[Steps for investigation and device development]

(1) Investigation from X-100 penetration (FY 2015)

1. Acquire information about the grating area on the 1st floor (access point to the basement, etc.): B1 (finished)
2. Acquire images showing the outside of the pedestal on the basement floor (esp. access entrance and nearby vent tube) following the results of investigation at the torus room using a small boat in November 2013: B2 (planning)

(2) Investigation from X-6 penetration (FY 2016-2017) (after decontamination around the X-6 penetration)

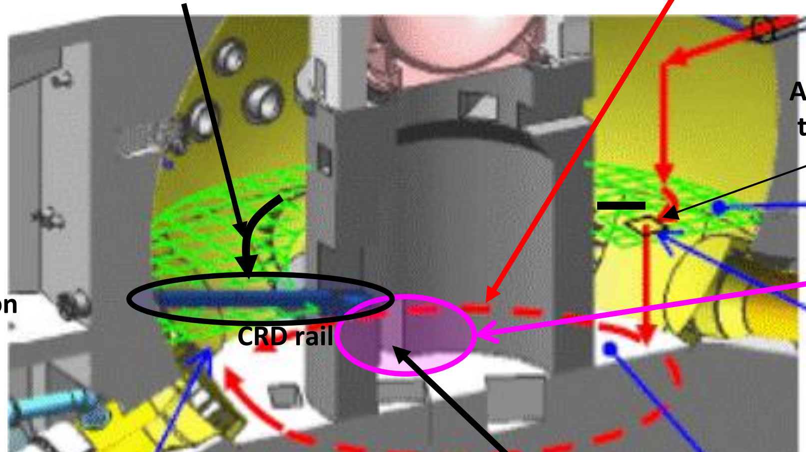
1. Acquire further information about outside the pedestal on the basement floor by using fuel debris shape measurement apparatus: B3

B1. Investigation outside the pedestal on 1st floor grating (completed in April 2015) : from X-100B penetration

B2. Investigation outside the pedestal on the basement floor (planned to be done in FY 2015) : from X-100B penetration

Necessity of further investigation will be decided according to the results of B2

B3. Investigation outside the pedestal on the basement and access entrance (FY 2016-2017) : from X-6 penetration



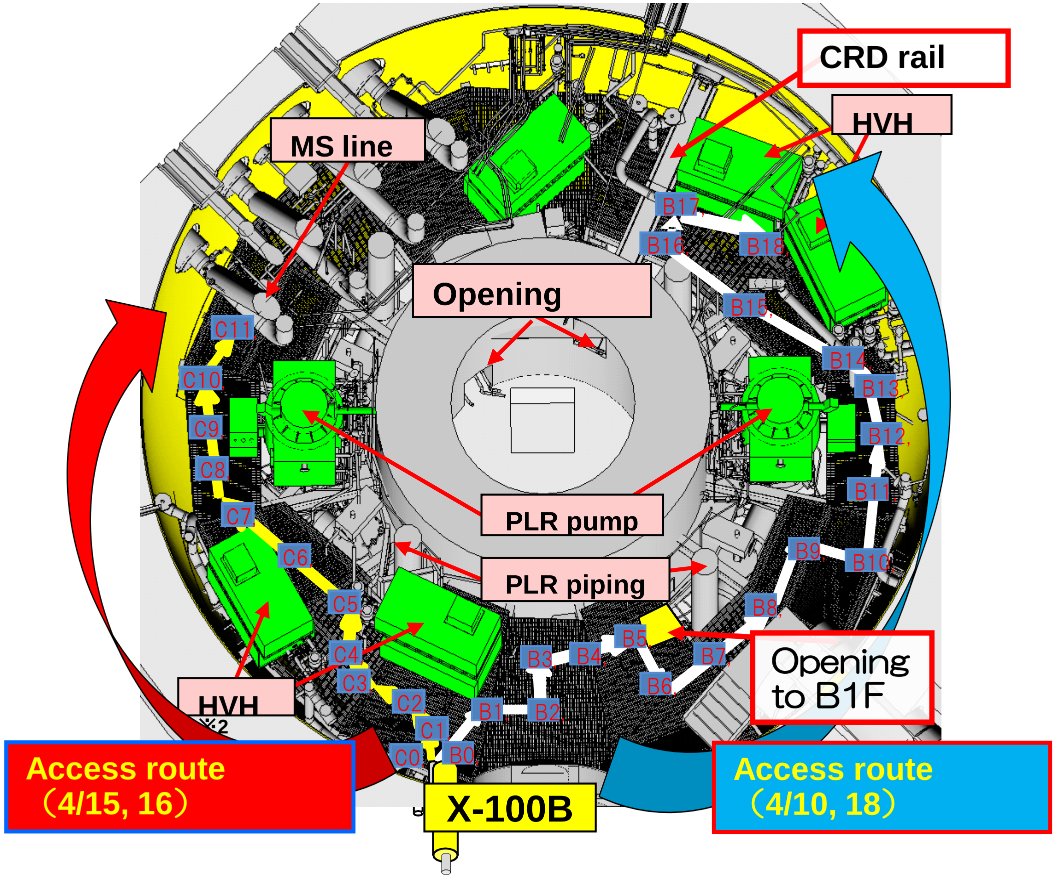
Investigation inside the pedestal is planned to be conducted after investigation of Unit No.2 finishes.

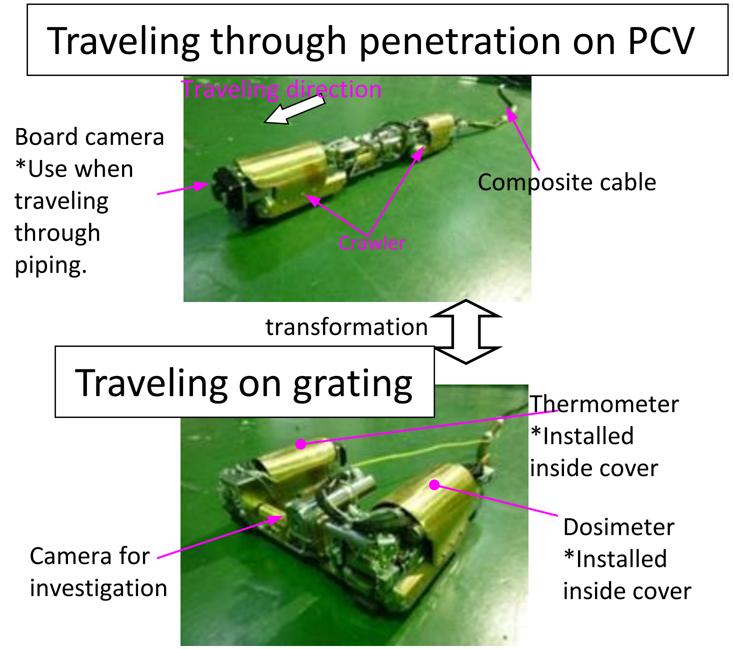
B1 Investigation Completed in April, 2015

(1)Overview of equipment

- Shape-changing crawler equipment
- Inserted from the narrow access entrance (X-100B penetration: ϕ100 mm)
- Travel on the grating stably.

(2) Image of investigation routes



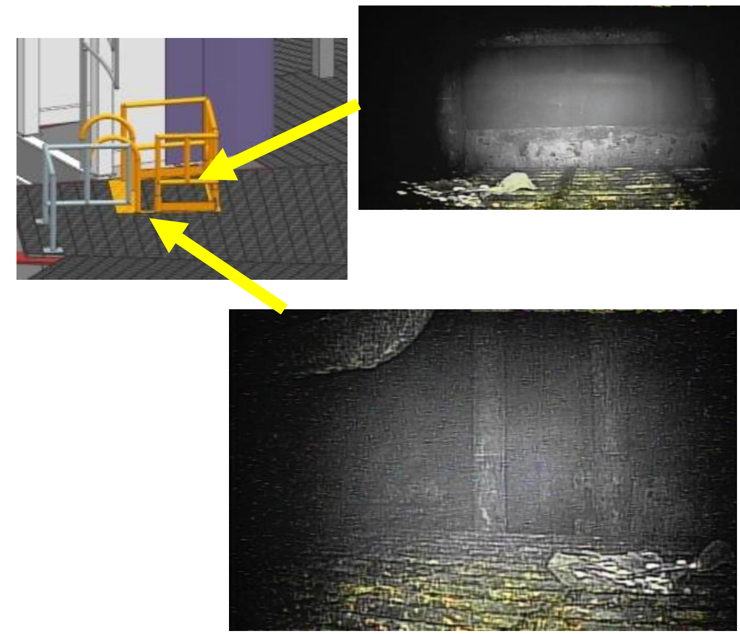


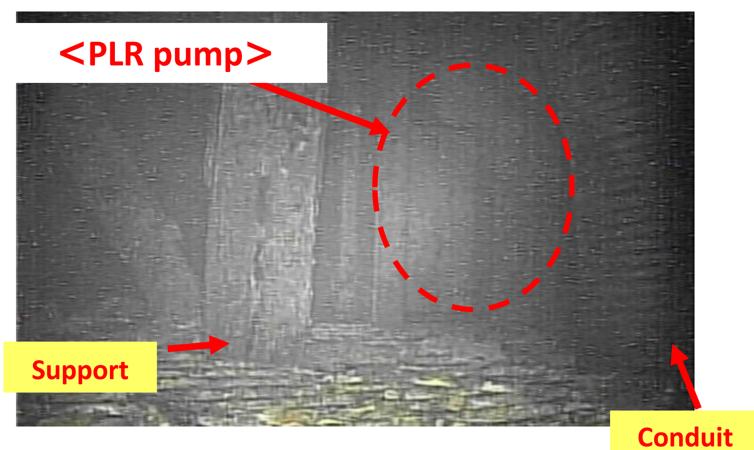
Features of equipment

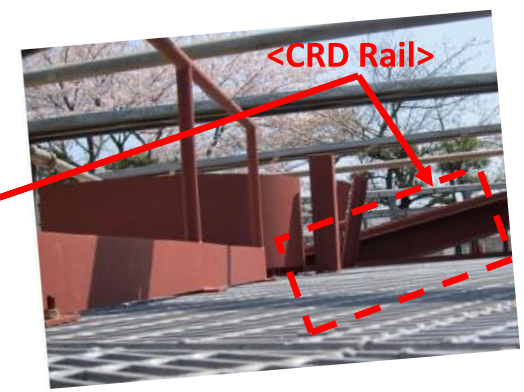
Results of B1 Investigation

Investigated area	Results
Access point to the basement	・For the next investigation (outside the pedestal on the basement), it is confirmed that **there is an access point to the basement** and **no obstacles around it**
CRD rail	・**Could not reach to the CRD rail** ・**Could not recognize the CRD rail by evaluation of image-processed pictures,** which were taken from the farthest reaching point by the investigation camera
En route of investigation	・**No major damage was found** inside the PCV equipment (HVH, PLR Line, pedestal wall, etc.) ・At every investigating point, **temperature and dose rate were recorded.**

<Access point to the basement>







(Image at mock-up facility)

Investigation inside the PCV (Unit 2)

[Investigated area] - On the platform inside the pedestal (Upper surface of platform and CRD housing)
- Basement floor

(1) Investigation from X-6 penetration (Φ115 mm) (FY2015): A2

(2) Investigation from X-6 (Enlarge hole) (FY2016- 2017): A3 and A4

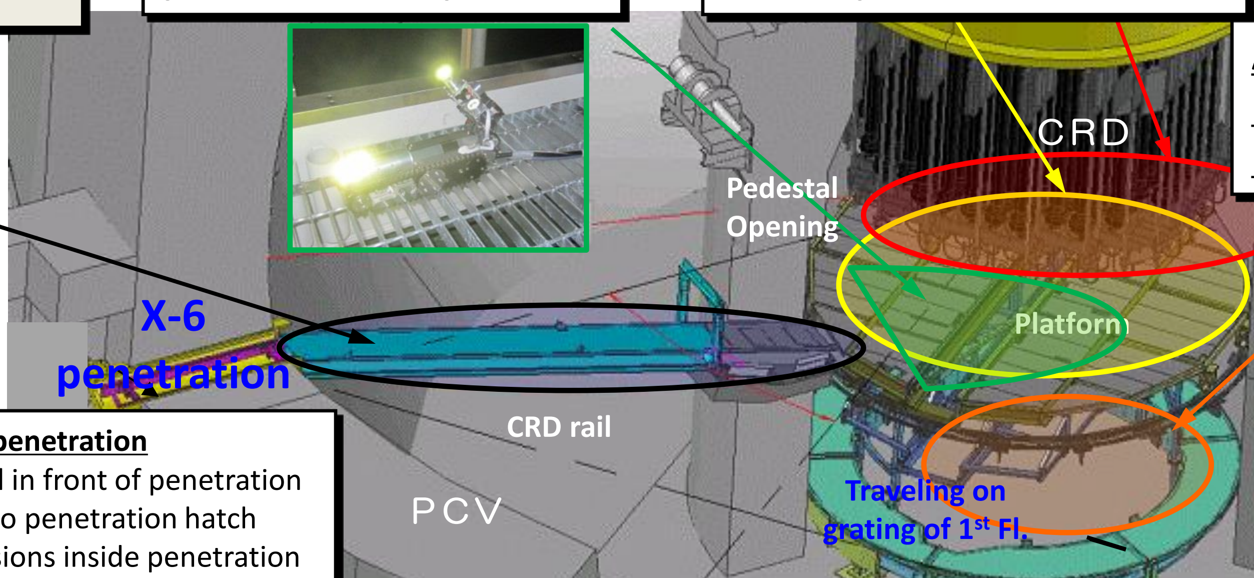
・Insert debris visualization system, investigate inside the pedestal.

A1. Investigation on CRD rail(Conducted in Aug.2013)

A2. Investigation on platform inside pedestal

A3. Investigation of CRD Hsg and on platform (detail)

A4. Investigation on basement inside pedestal



Step to use X-6 penetration

・Remove shield in front of penetration

・Pierce a hole to penetration hatch

・Remove inclusions inside penetration

Based on the results of internal investigation from A2 to A4, investigation outside pedestal may be conducted.

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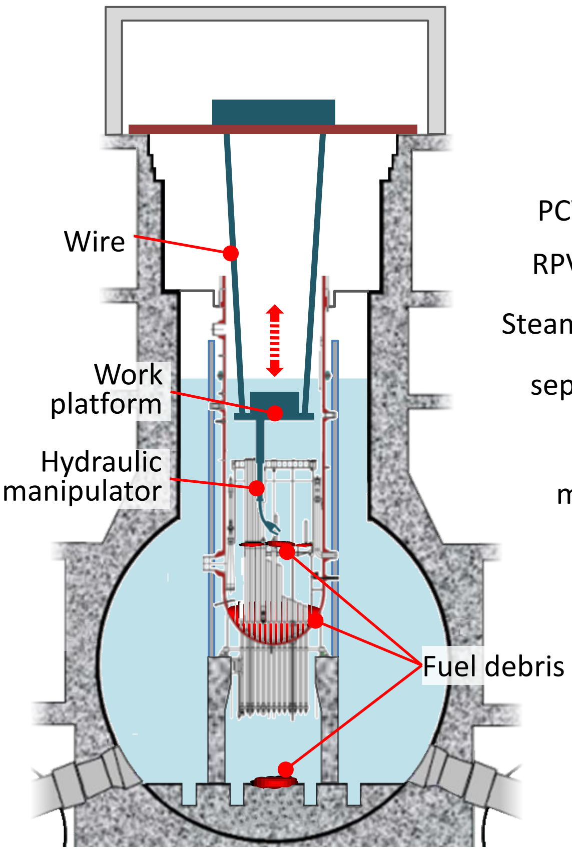
Study of fuel debris retrieval method

We will study multiple method for fuel debris retrieval to meet different condition of damaged PCV and scattering fuel debris at each unit

Submersion method

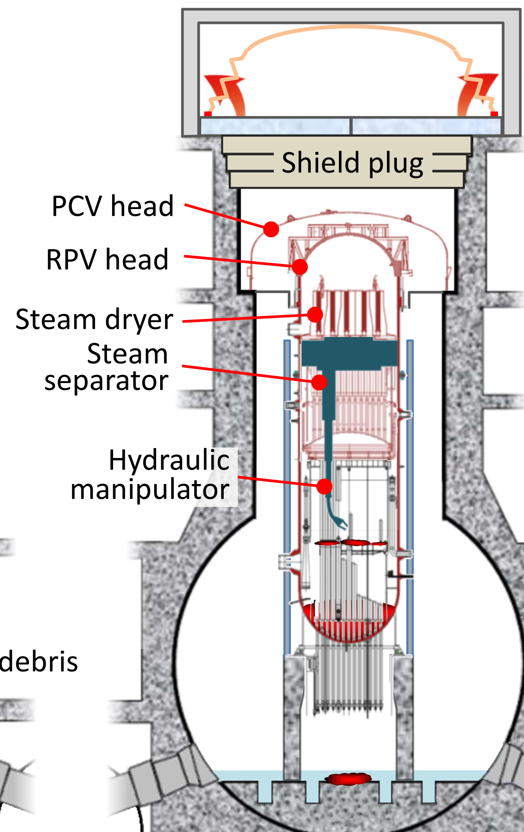
Most favorable approach for minimizing the radioactive exposure of workers

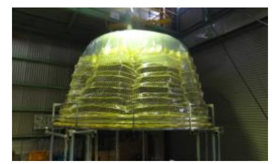


Dry method (partial submersion, in-air work)

Development of technology which prevents scattering radioactive materials from PCV is needed to remove PCV contents in-air work

Top access

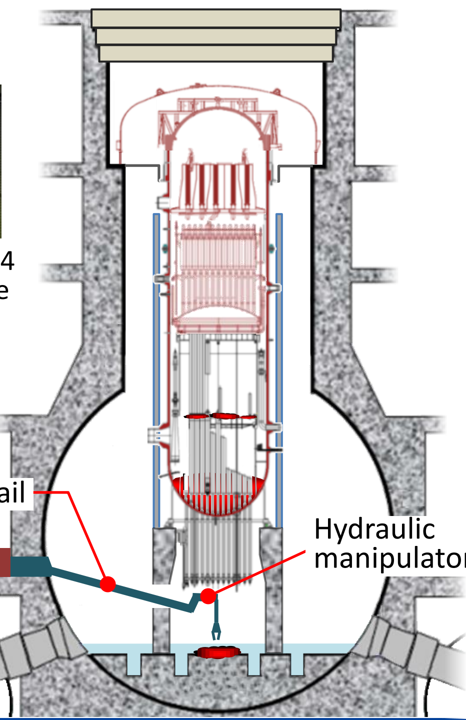




Sealing a PCV head (1:4 scale) with Radioactive material diffusion preventing film

Side access

When fuel debris spreads over pedestal outskirts, the side entry method is to be selected



IRID

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Radioactive Waste Treatment/Disposal

- **Solid Waste Treatment and Disposal (FY 2015-2016)**

Characteristics of Nuclear Waste Generated from Fukushima Daiichi NPS Accident

Type of Waste	Characteristics
Rubble/Felled and removed trees/soil, etc.	・Large quantity and widely distributed ・Poor experience with the treatment and disposal of felled and removed trees and soil ・Surface contamination by scattering/diffusion is main contamination and some contamination is penetrating contamination caused by accumulated water
Secondary waste by water treatment	・Poor experiences of treatment and disposal ・Difficult to collect the waste ・Partial estimation of quantity and kind of nuclide may be possible based on the characteristics of water treatment equipment
Fuel debris/Demolishing waste	・Large amount and high dose rate ・Difficult to sample actual waste due to low accessibility at present

Comparison between Wastes from Accident and Operation

Item of uncertainty	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 the accident-generated waste at the Fukushima Daiichi. **Solving these uncertainties and bringing the waste under control are the major goals** of countermeasures and technology development.

～Toward Fuel Debris Retrieval～

- Fuel debris retrieval at the Fukushima Daiichi Nuclear Power Station is expected to be more difficult compared to that of the accident at the Three Mile Island 2 (TMI-2). It is necessary to put domestic and international wisdom together to develop the whole strategy, method and equipment for fuel debris retrieval.

- In order to complete the fuel debris retrieval, it is necessary to clarify the purpose and goal of relating each project, and then, to develop technologies flexibly by planning with an aim to achieve not partial but overall optimization.

- In making strategy, it is important to consider end-state (what you wish to achieve at the end), study various feasible options and always prepare alternative options.

Thank you for you attention