# Locating Fuel Debris inside the Unit 3 Reactor Using a Muon Measurement Technology at Fukushima Daiichi Nuclear Power Station (Interim Report)

July 27, 2017

TEPCO

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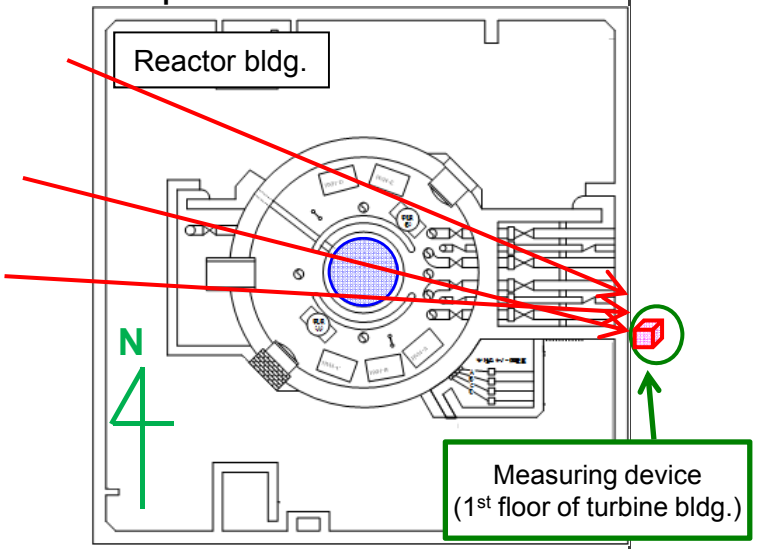
IRID

The contents of this document is what TEPCO carries out as a part of the project developed by the International Research Institute for Nuclear Decommissioning (IRID)

# Overview

- As the step of gathering information about fuel debris distribution toward a removal of fuel debris, muon measurement using a transmission method that obtains quantitative distribution in the Reactor Pressure Vessel (RPV) from transmittance of muon particles which have passed through the reactor have been carried out in Unit 1 and 2.
  - Unit 1 : No massive fuel in the core area (Feb.-May., May.-Sept., 2015)
  - Unit 2 : High-density materials that is considered fuel debris at the lower area of RPV (Mar.-July., 2016)

- Unit 3 muon measurement has been carried out since May, 2017. The measuring status is reported.



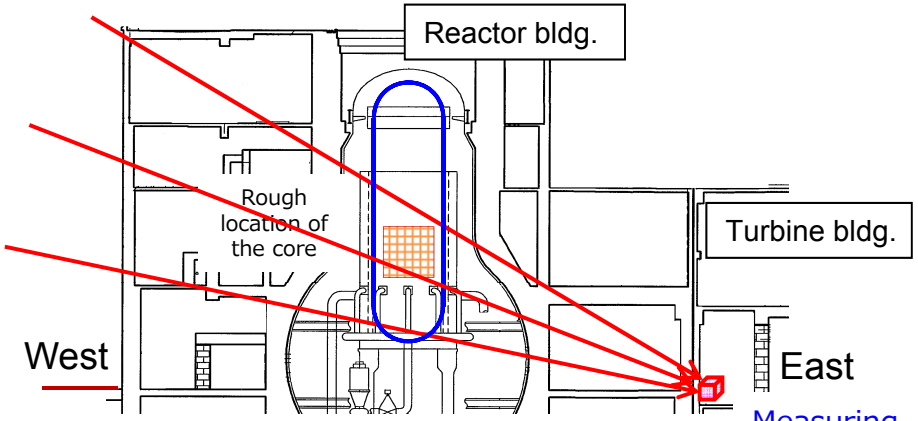

Installation location of muon measuring device


Installation of muon measuring device
(small-sized unit, approx.1m × 1m × 1.3m(height))

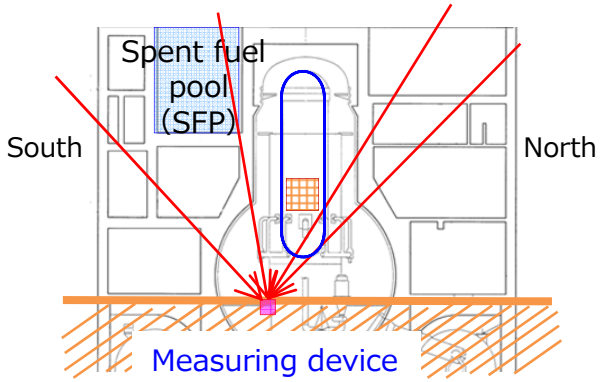
# Measurement principle of the muon transmission method

- Muon is the secondary cosmic ray generated in the collision of cosmic ray from space with atmosphere. Muon has high energy and characteristics to pass through materials.

- By measuring muon particles which have passed through the reactor building, images of fuel debris distribution inside the RPV are captured like X-ray pictures from their transmittance. (Higher density materials that less muon can pass through make darker shadow.)



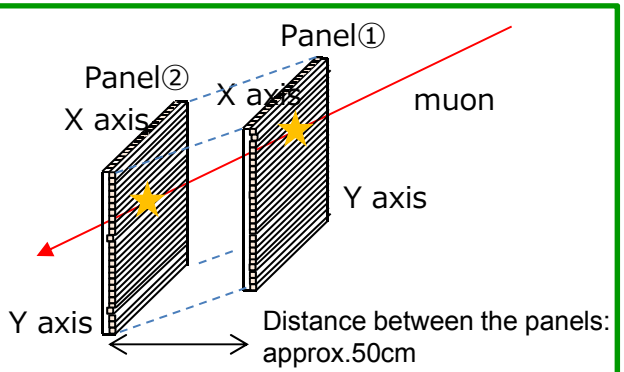

Measurement image of muon particles that pass through the reactor building (East-west cross section)




Measurement image of muon particles that pass through the reactor building (North-south cross section)

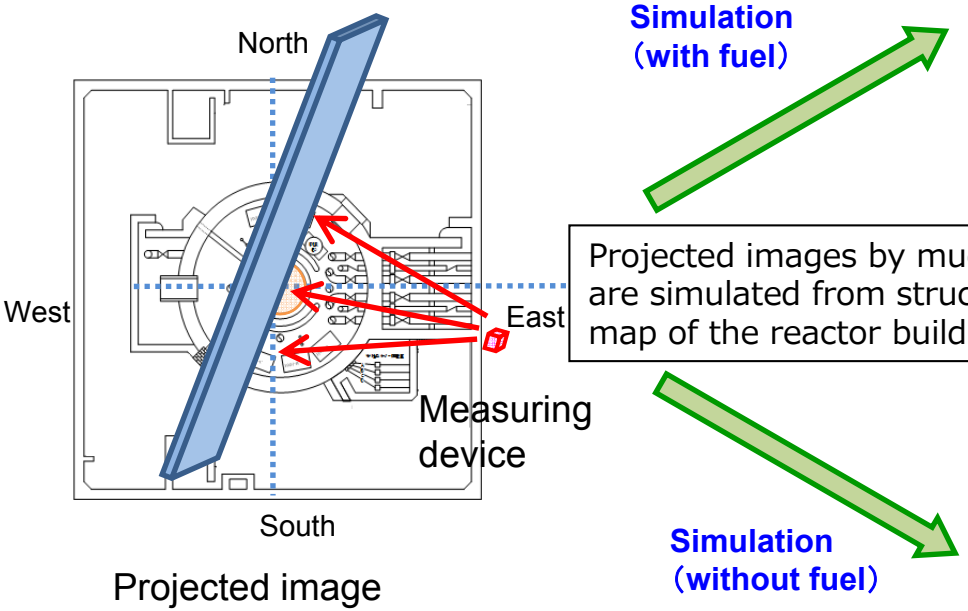
## Measurement principle of the muon transmission method (image)

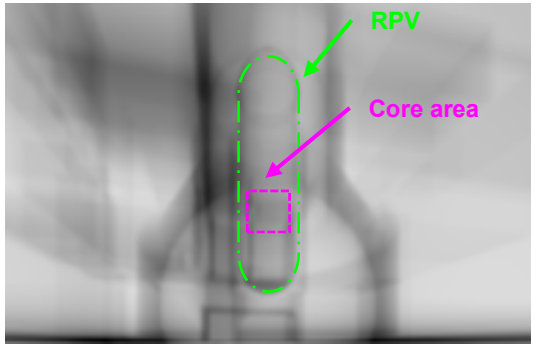
Two panels (plastic scintillators) inside the muon measurement device detects incoming cosmic rays muon and calculate their trace on where they have pass through from the coordinates on the panels.



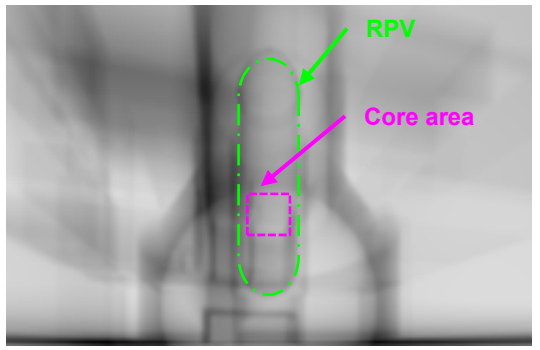
# Result image using the muon transmission method

- By measuring muon particles which have passed through the reactor building, the reactor building is seen through.
- By projecting on the cross section though the reactor, images of fuel debris in the reactor core and the bottom of RPV are captured like X-ray pictures.




Simulation conditions
・Reactor core and lower area of RPV: With fuel
・Inside SFP: Filled with water

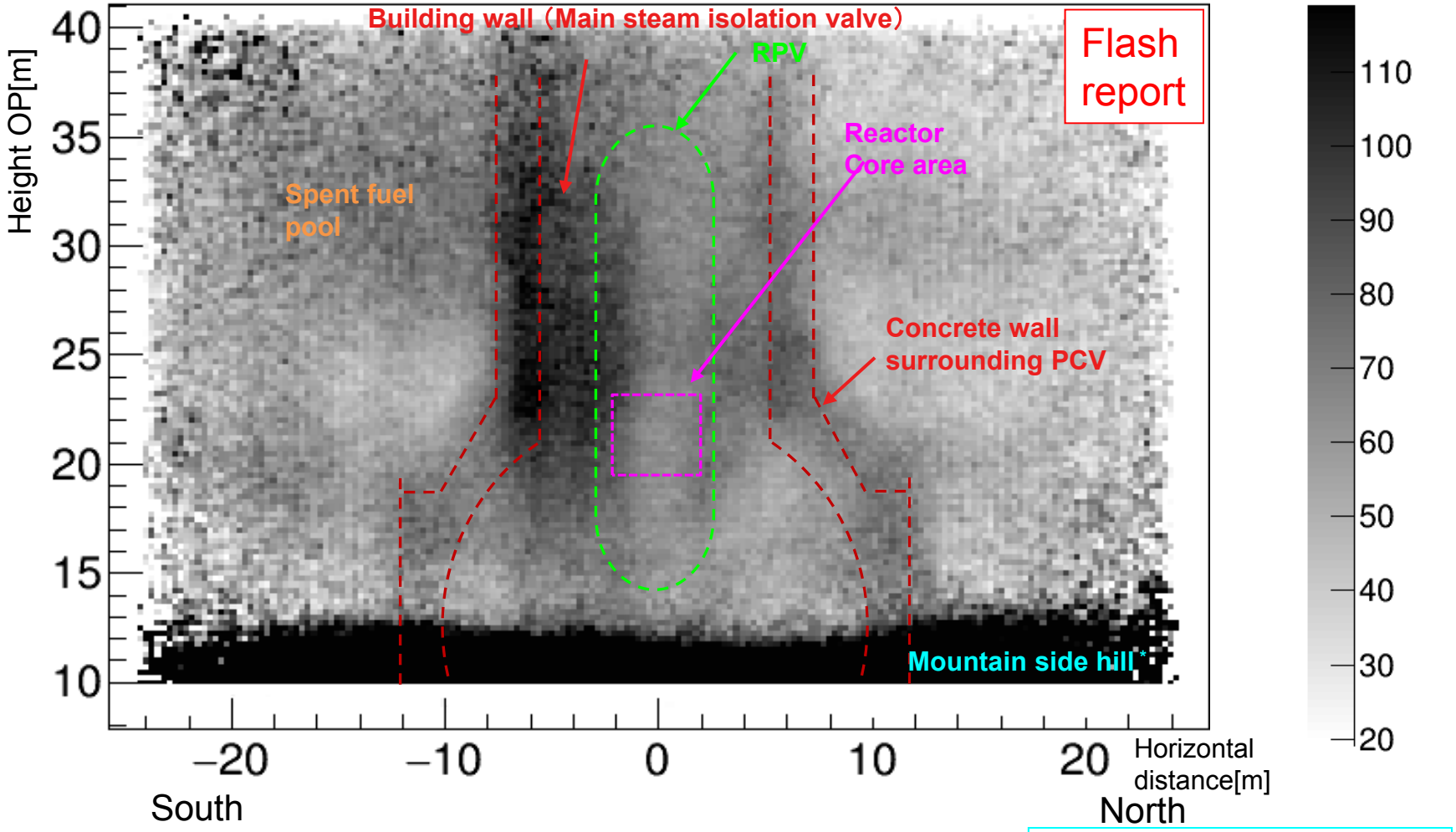



Simulation conditions
・Reactor core and lower area of RPV: Without fuel
・Inside SFP: Filled with water

# Result of Unit 3 muon measurement (Quantitative distribution)

- Quantitative distribution of unit 3 from measurement up to date is as the picture bellow. (The interpretation is shown on the following pages.)

(As of July 20, 2017)

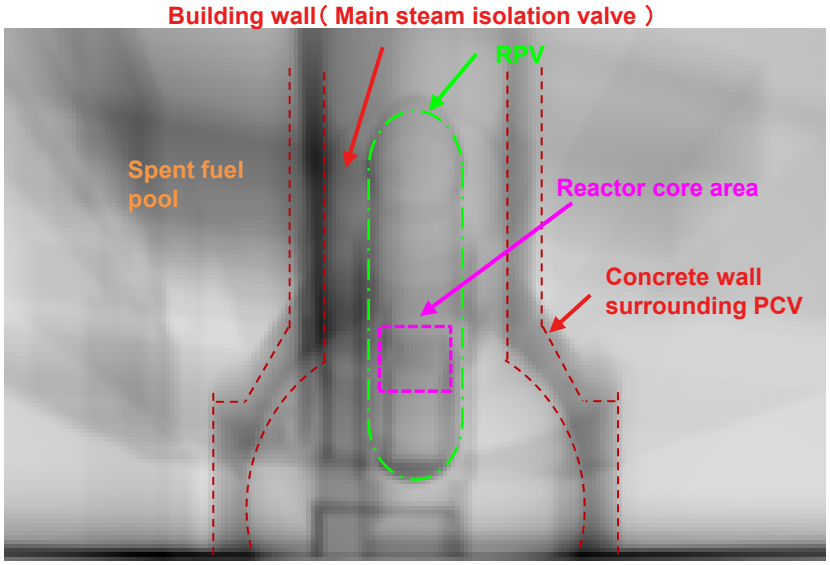



*Shape of shadow mostly matches up with the hill-crest.

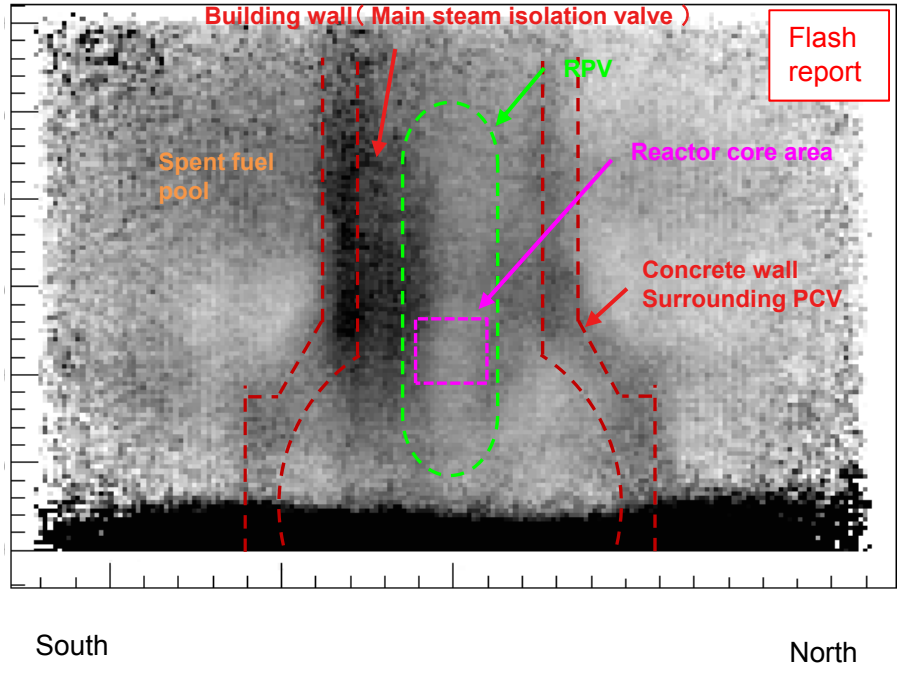
# Main structure in the reactor building (comparison with simulation)

- By measuring muon particles which passed through the reactor building, main structures in the reactor building including the concrete wall surrounding PCV, the spent fuel pool and wall of building were recognized.
  - Shadows of quantitative distribution by muon measurement match with the location of main structures in the reactor building based on structure map.

(As of July 20,2017)



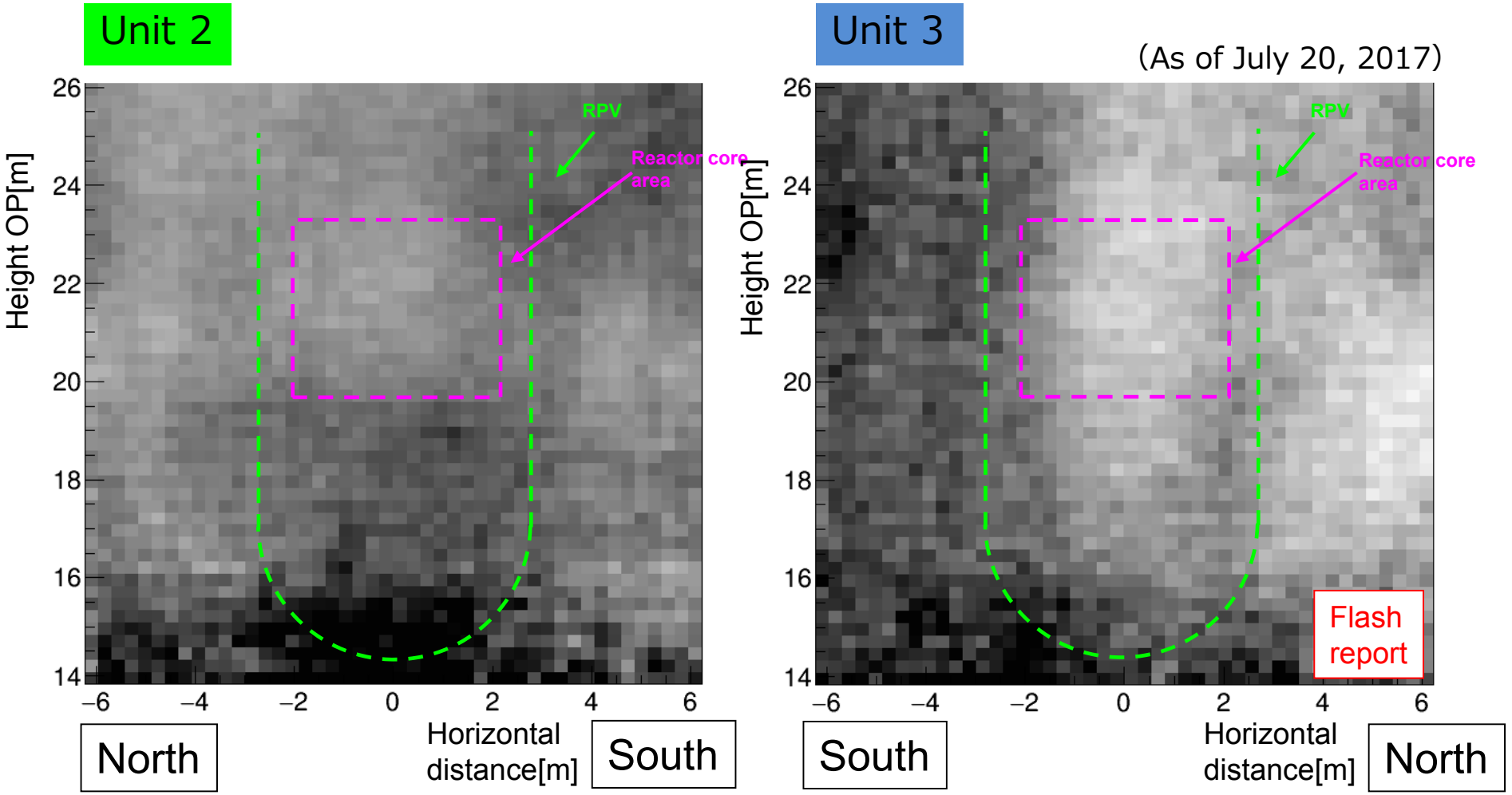

Quantitative distribution by simulation
（Case with fuel debris in core area and at lower area of reactor)




Quantitative distribution by muon measurement

# Quantitative distribution comparison between Unit 2 and 3

- The evaluation at present does not show any massive and high density material in the RPV of unit 3 like the materials found in the RPV of Unit 2.



## Conclusion of the Unit 3 muon measurement (Interim report)

- By measuring muon particles which passed through the reactor building, main structures in the reactor building including the concrete wall surrounding PCV, the spent fuel pool and wall of building were recognized.

- The evaluation at present shows the possibility that some fuel debris remain in the core and at the lower area of RPV, but massive and high density material has not been found.

- The measurement will be continuously carried out. Fuel debris distribution inside RPV is to be evaluated by detail. The result of this interim report might be revised according to the future evaluation.

# (Reference) Comparison between Unit 1-3 muon measurement results and estimation of fuel debris distribution

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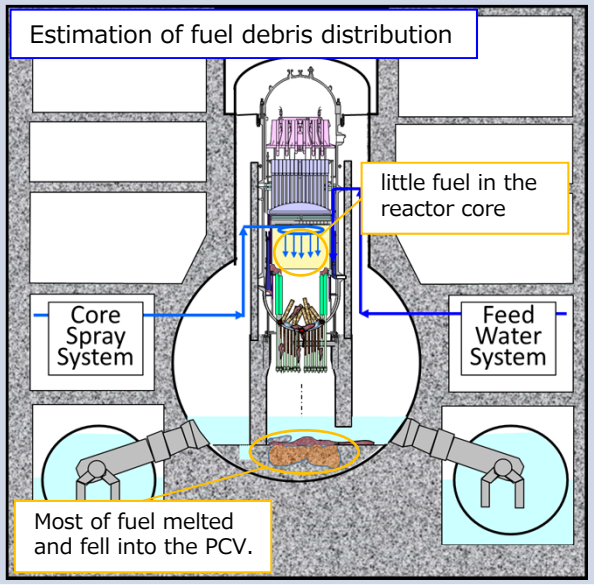
| Results | Unit 1 | Unit 2 | Unit 3 (flash report) |
|---|---|---|---|
| | ・No massive fuel in the core area. (Lower area of the RPV is not measured.) | ・High density materials that is considered fuel debris were found at the lower area of the RPV.<br>・Part of fuel possibly exists in the reactor core area. | ・The evaluation at present shows possibility that some fuel debris remain inside the RPV, but massive and high density material has not been found. (Measurement and detail evaluation are continuing.) |
| | Reflect the result to estimation of fuel debris distribution | Reflect the result to estimation of fuel debris distribution | Results of PCV internal investigation and Muon measurements will be reflected to estimation of fuel debris distribution |

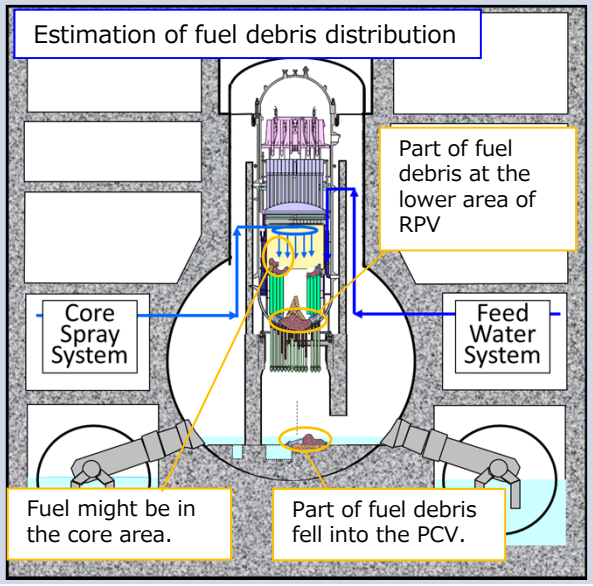
**Current estimation of fuel debris distribution (*)**

**Unit 1**



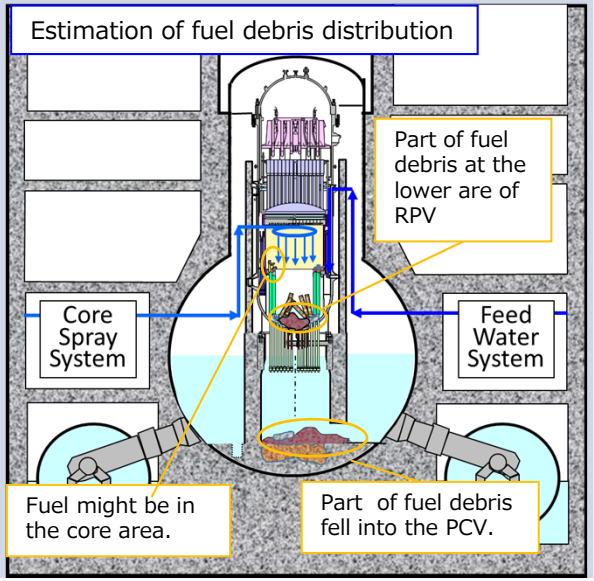

- Most of melted fuel fell into the PVC and there is little fuel in the reactor core.

**Unit 2**




- Part of melted fuel fell into the lower plenum of RPV and the PCV, and part of fuel remain in the reactor core.
- More fuel debris might fall into PCV in Unit 3 than Unit 2.

**Unit 3**

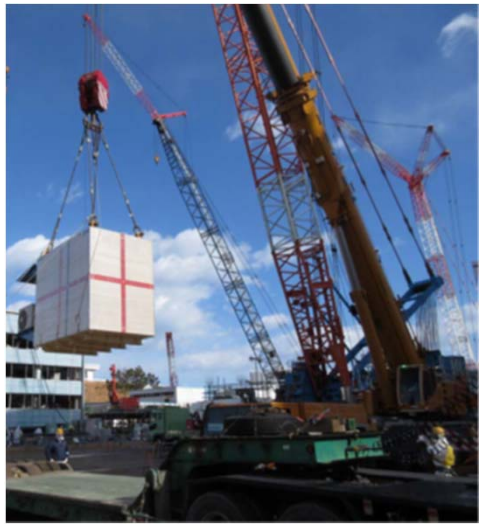



***"Project of Decommissioning and Contaminated Water Management (Upgrading level of grasping state inside reactor)" (IRID, IAE)**

http://ndf-forum.com/program_en.html

IRID IAE

# (Reference) Installation of muon measurement device




Unit 1 Muon transmission method
(Feb.-May, May-Sept., 2015)

Unit 2 Muon transmission method
(small-sized device)
(Mar.-July., 2016)

Unit 3 Muon transmission method
(small-sized device)
(May, 2017-Measurement is ongoing)