Restart Status of Japanese NPPs, Filtered Containment Venting System (FCVS), New Regulatory Requirements & Super Engineer Education Project

Presented at IRPA-14 Plenary Session on Fukushima Accident, (Cape Town, May 8-13, 2016)

ISOE ALARA Symposium, January 10, 2017

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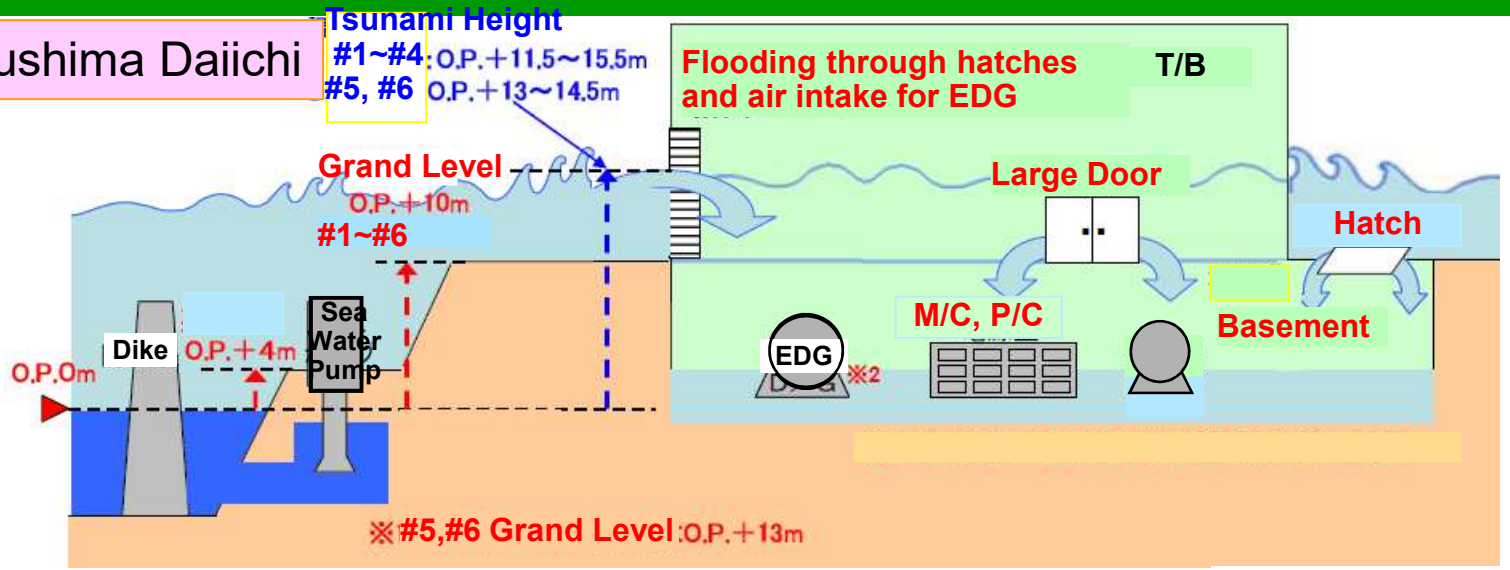
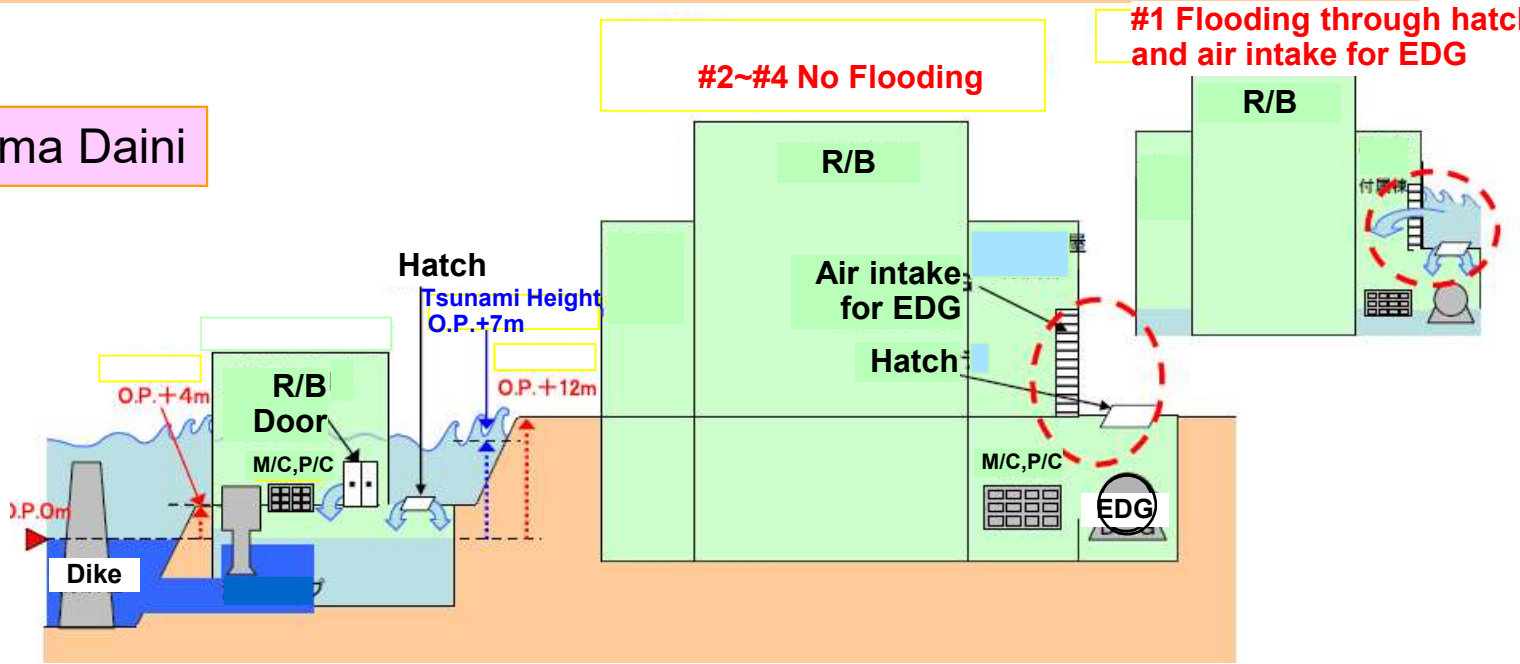
Professor, Nuclear & Environmental Systems,
Hokkaido University

Tsunami Flooding Area in each NPP

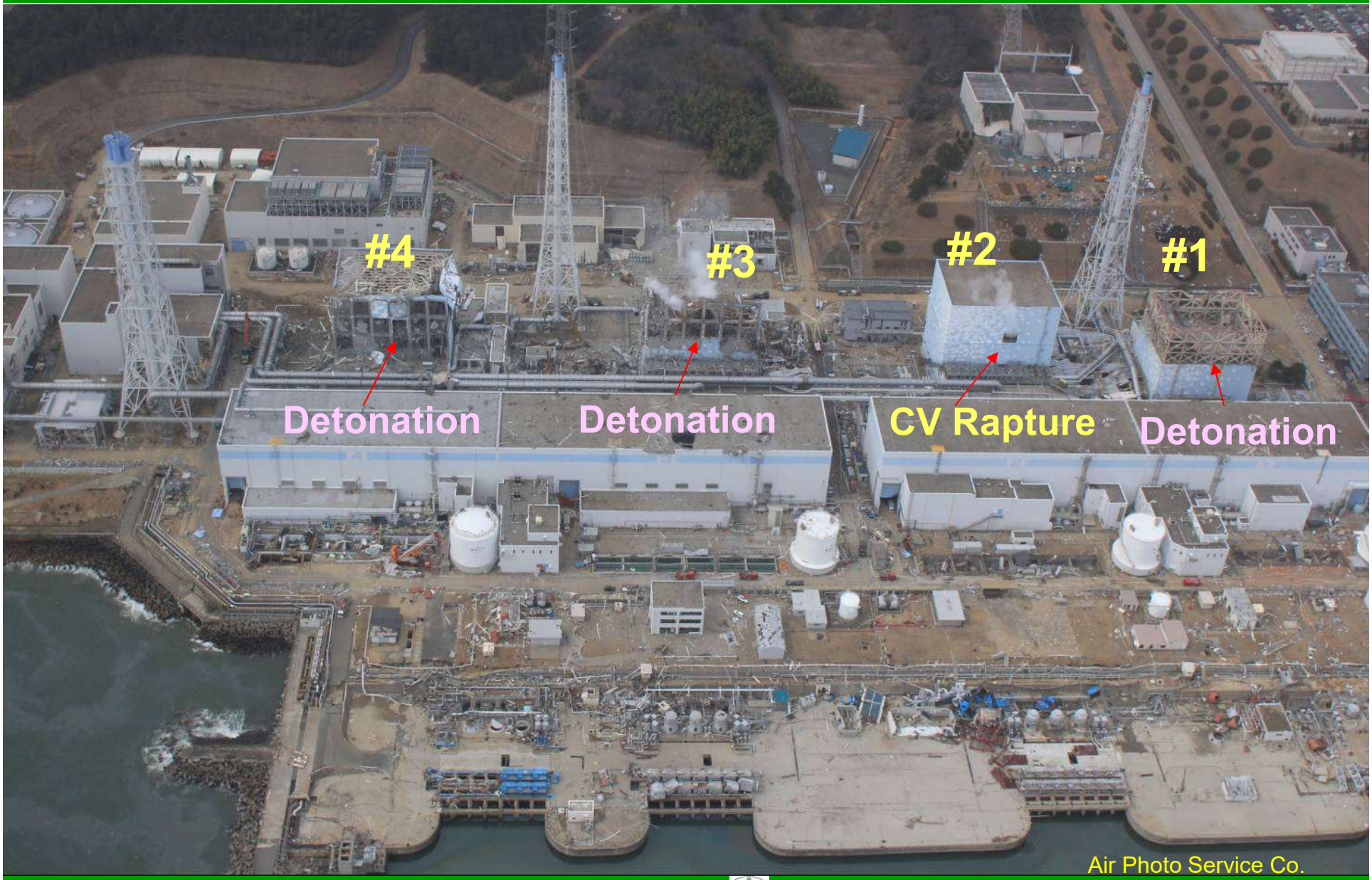
Fukushima Daiichi



Fukushima Daini

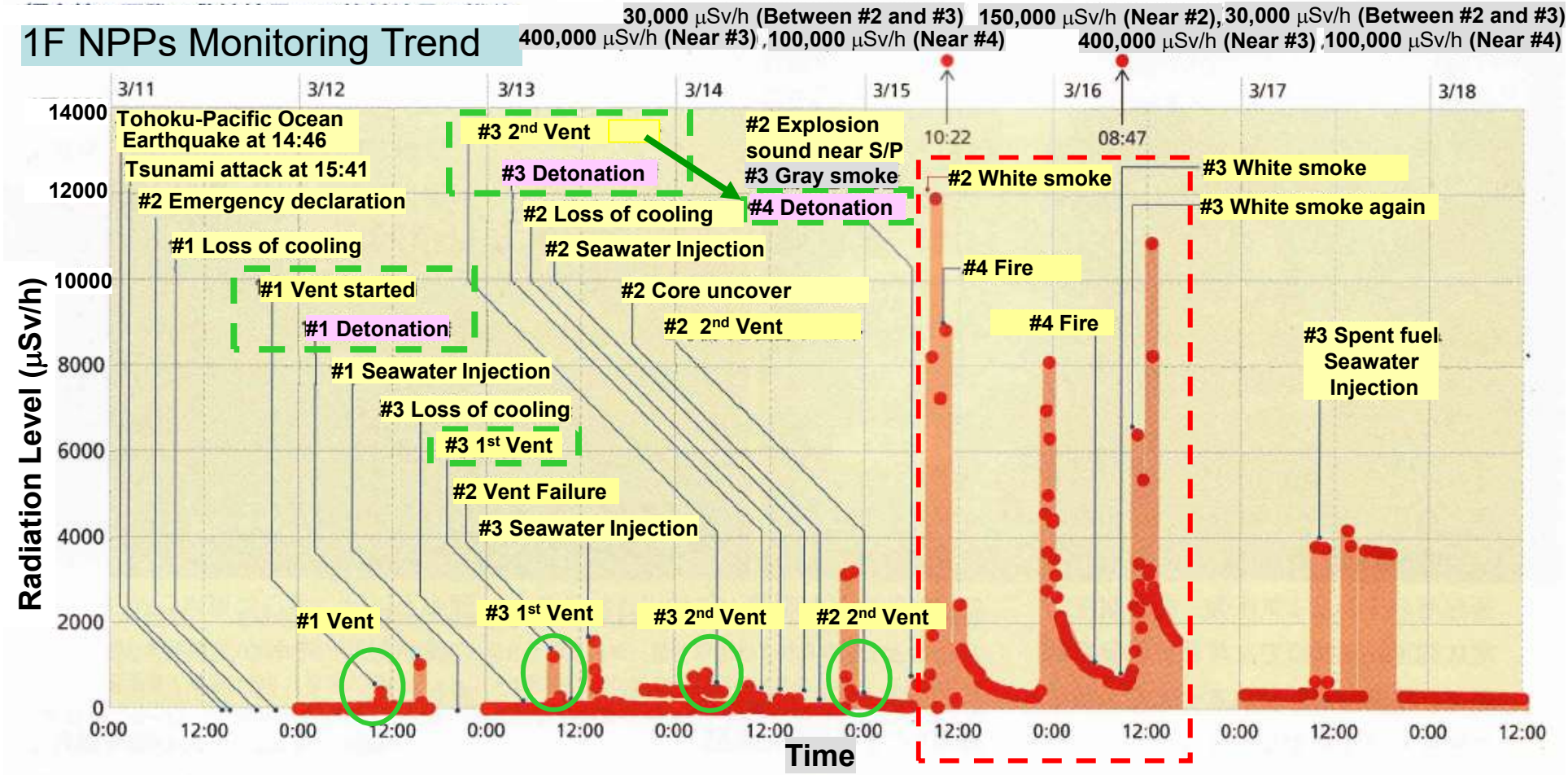


Hydrogen Explosion and CV Rapture



Radiation level increased after CV rapture

- H_2 detonation were occurred after vent operation (#1, #3, #4)
- Radiation level increased soon after #2 CV rapture

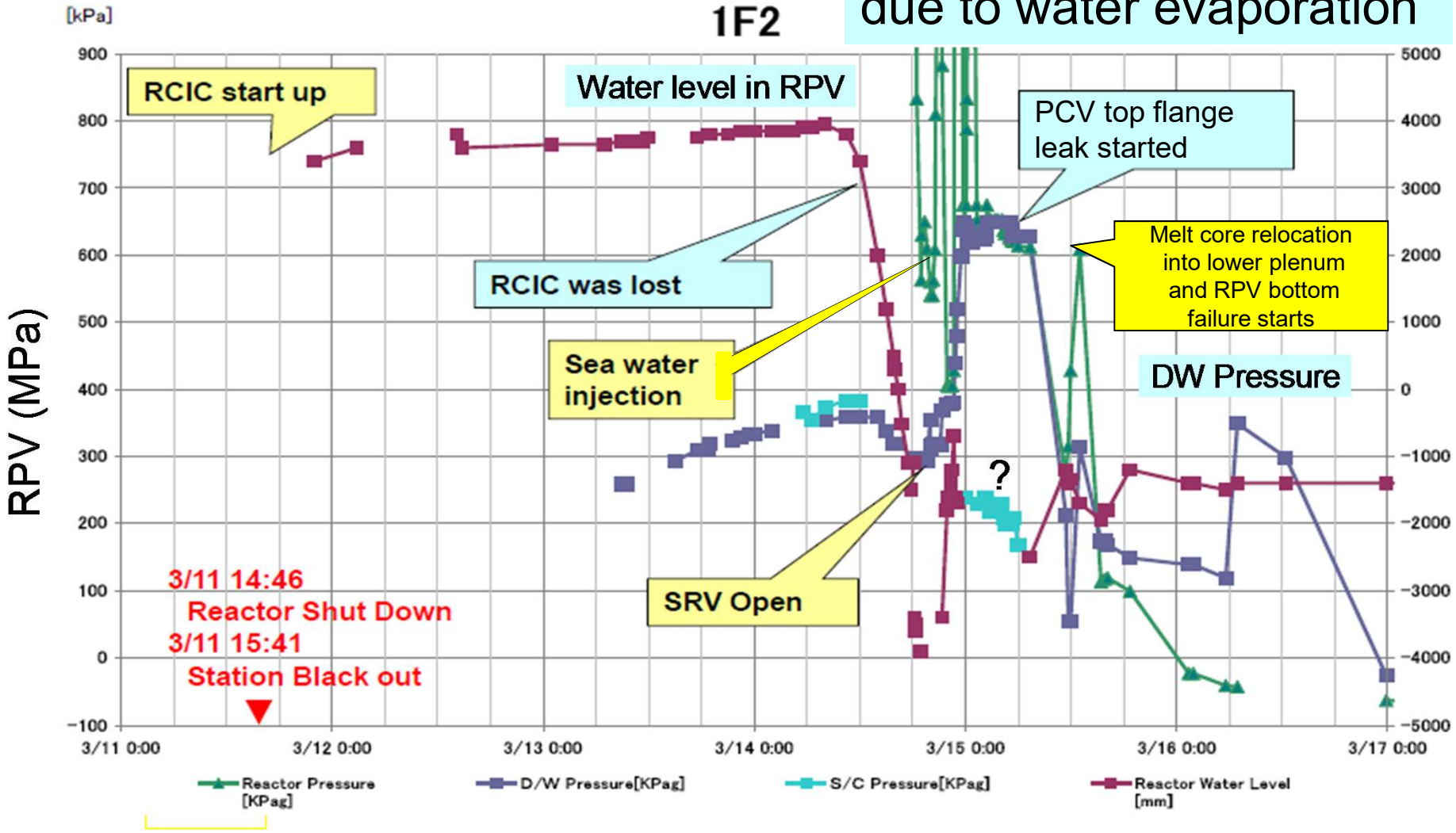


Nikkei Science, July 2011

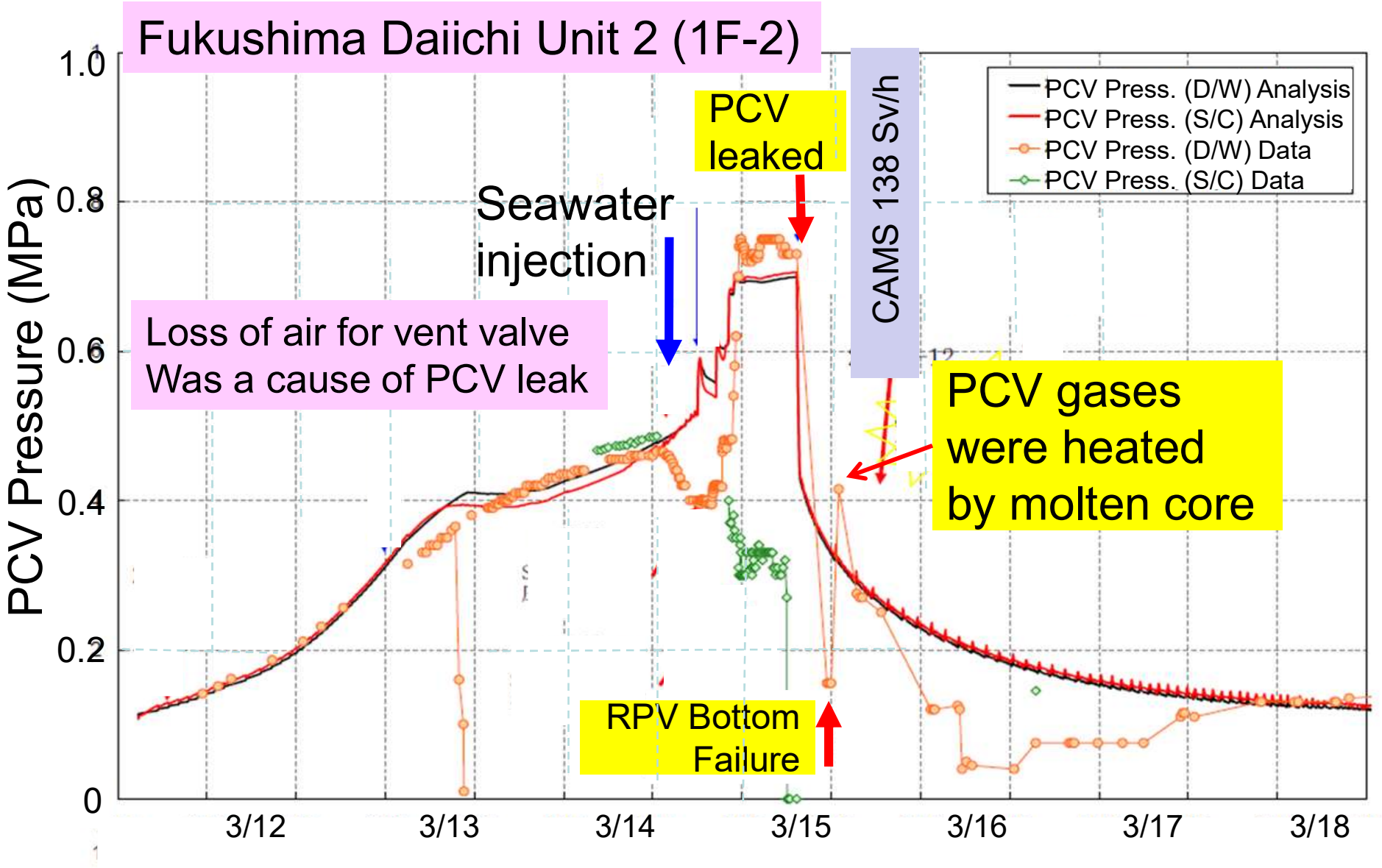
After water injection on March 15

Fukushima Daiichi Unit 2 (1F-2)

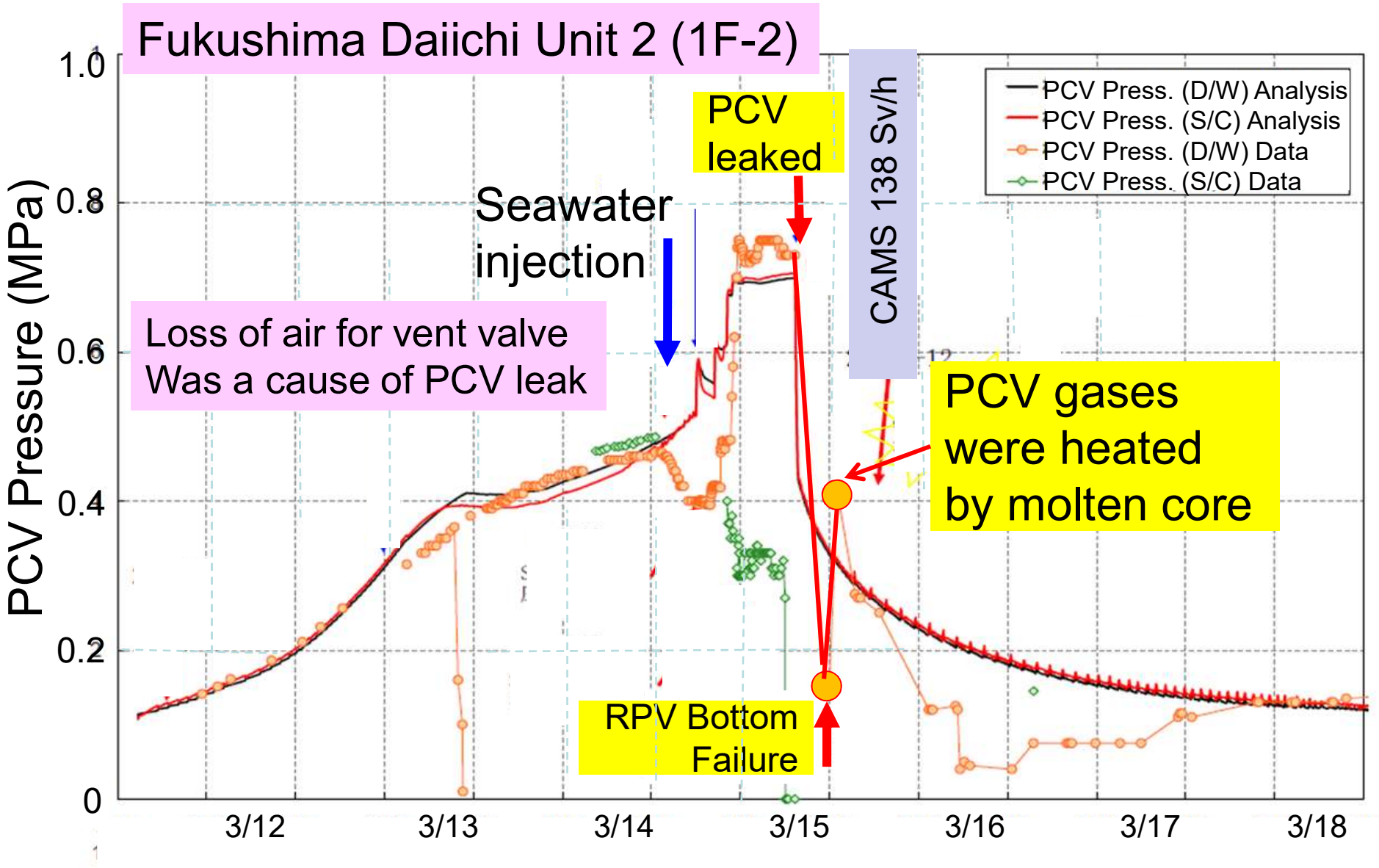
RPV Pressure fluctuation due to water evaporation



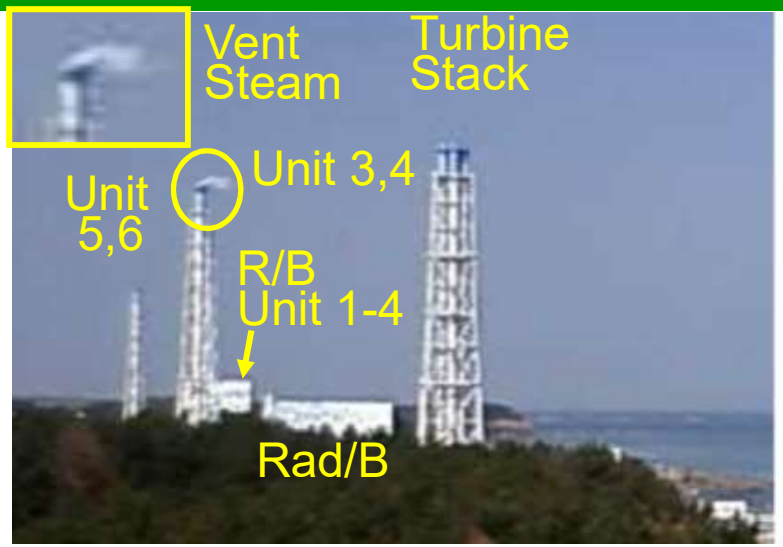
Cause of Contamination on March 15



Cause of Contamination on March 15

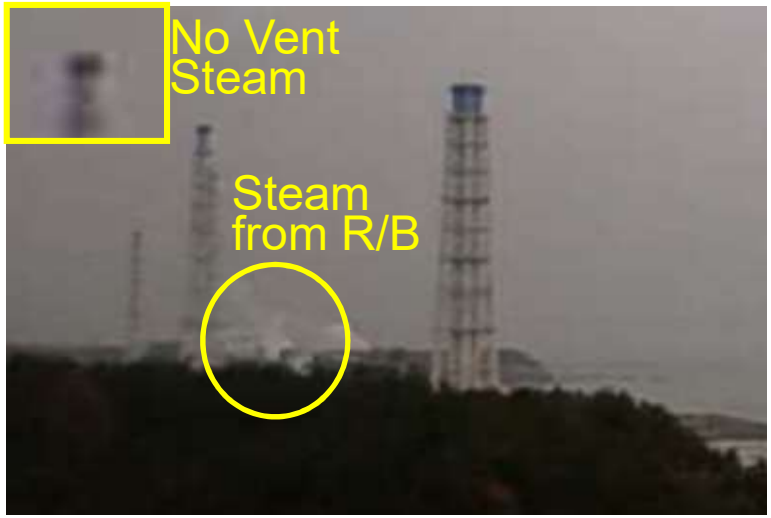


Vent failed both Unit 2 and 3 on March 15



(a) 13:00, March 13

(b) 15:00, March 13



(c) 16:00, March 15

(d) 17:00, March 15

Direct leak from PCV of 1F-2 and 1F-3

(a) 13:00, March 13

(e) Unit2, 8:58, March 15

(b) 7:00, March 15

(d) Unit3, 7:31, March 15

(c) 10:00, March 16

(e) Unit3, 9:51, March 16

Loss of air for vent valves cause the PCV direct leaks, and the cause of contamination around Fukushima-Daichi

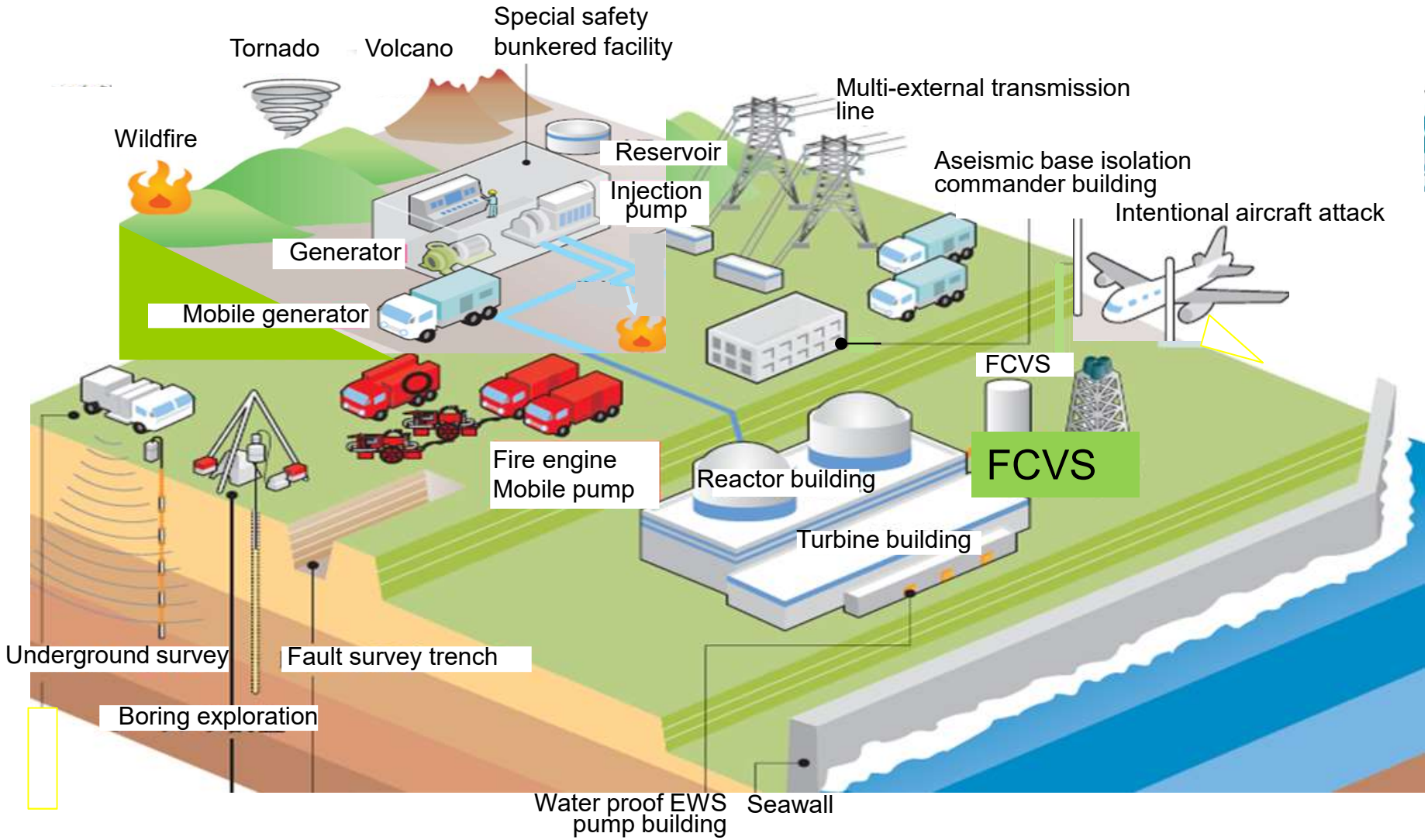
Causes of SA and Countermeasures

(P) Protection (R) Resilience

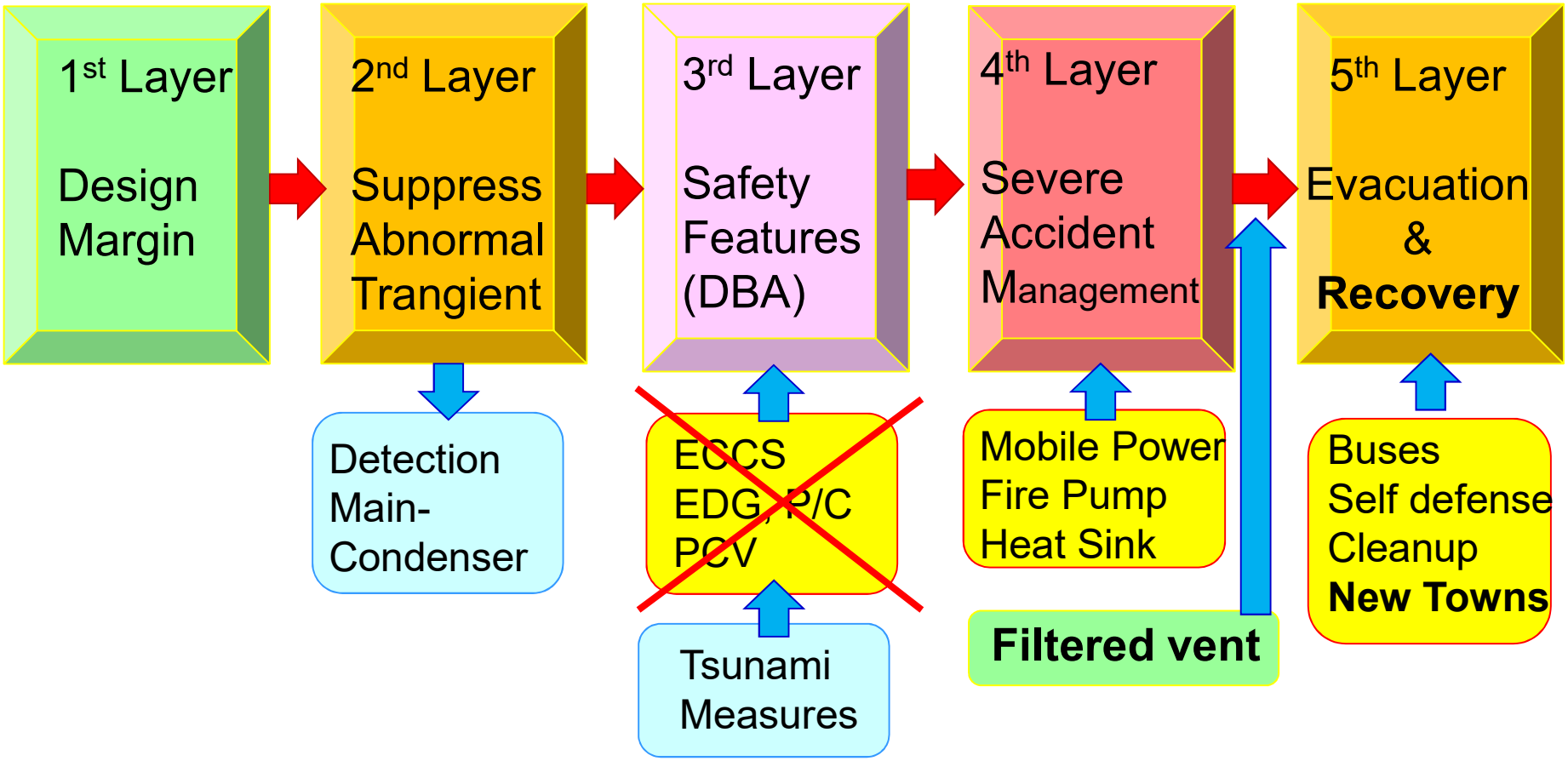
Loss of external Power by Earthquake	(P)Enhance aseismic device (R)Recover Ext. Power Cable
Loss of EDG, P/C DC Battery, I&C and phone	(P)Water proof door, hatches (R)Mobile power/pump on hill
Loss of water in Core Meltdown, Hydrogen	(P)Diversity of water injection, (R)Recover heat sink and PAR
Loss of containment function, heat damage	(P)CV cooling, FCVS (R)Water Cannon, R/B Cover
Slow judgment to protect against nuclear disasters	(P)New nuclear regulatory (R)Quck action by response center

PAR: Hydrogen Passive Autocatalytic Recombine

New Regulatory Requirements



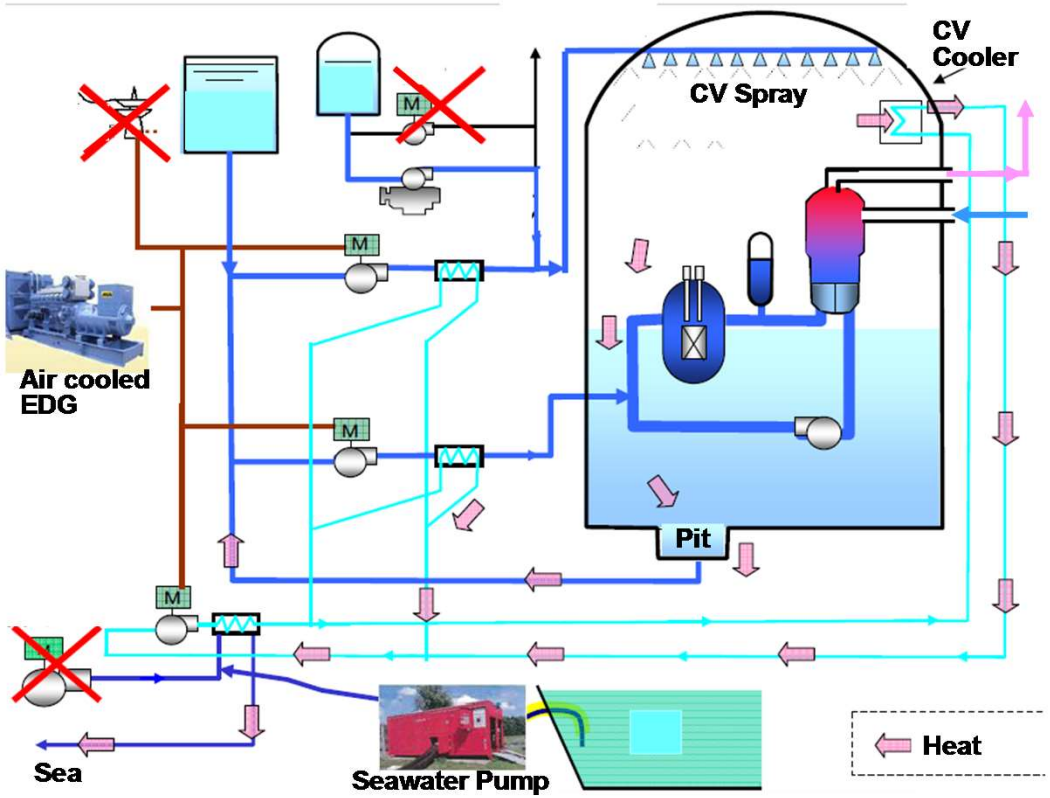
Defense in Depth

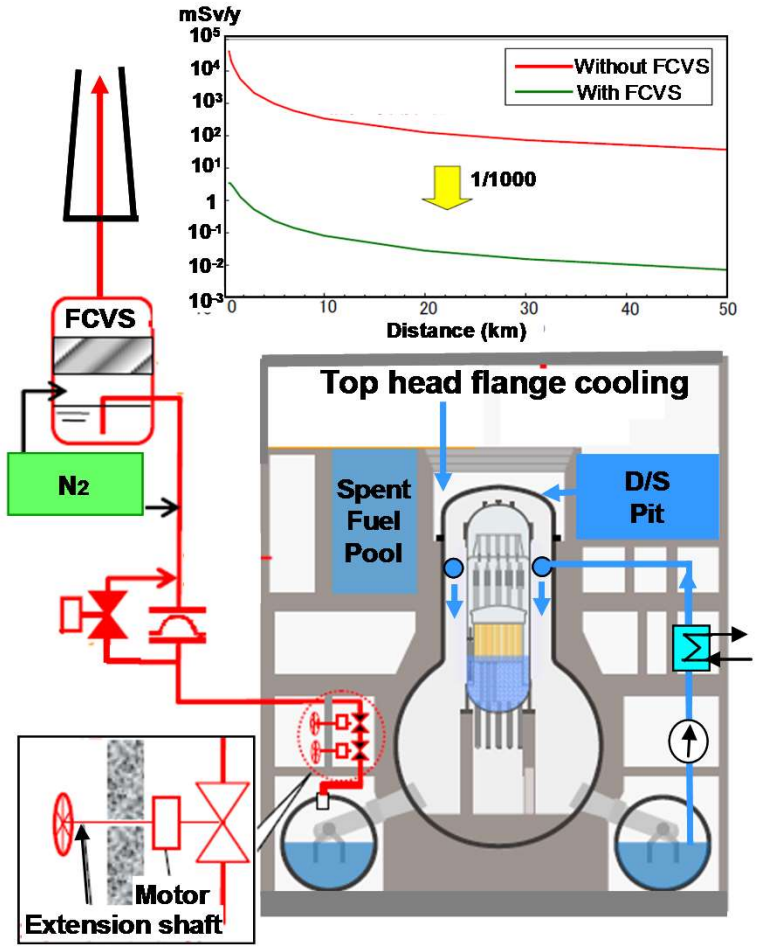


Protect CV and PCV cooling

PWR: CV Spray, CV recirculation cooling, PAR

BWR: PCV Spray and RHR, Filtered vent





Peach Bottom has Water Proof Doors

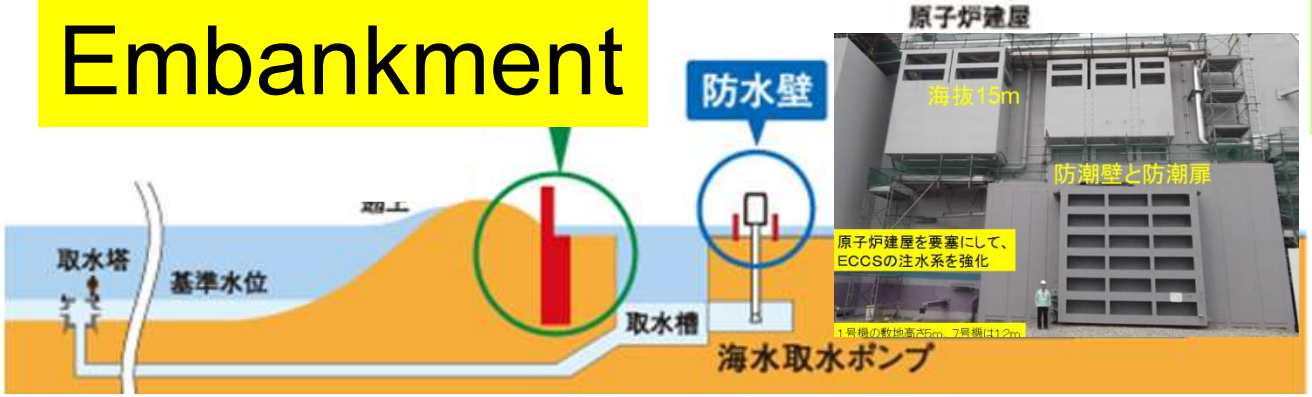
Countermeasure for Tsunami, based on the Defense in Depth Philosophy

Mobile Cars on Hill

Water Proof Wall and Doors

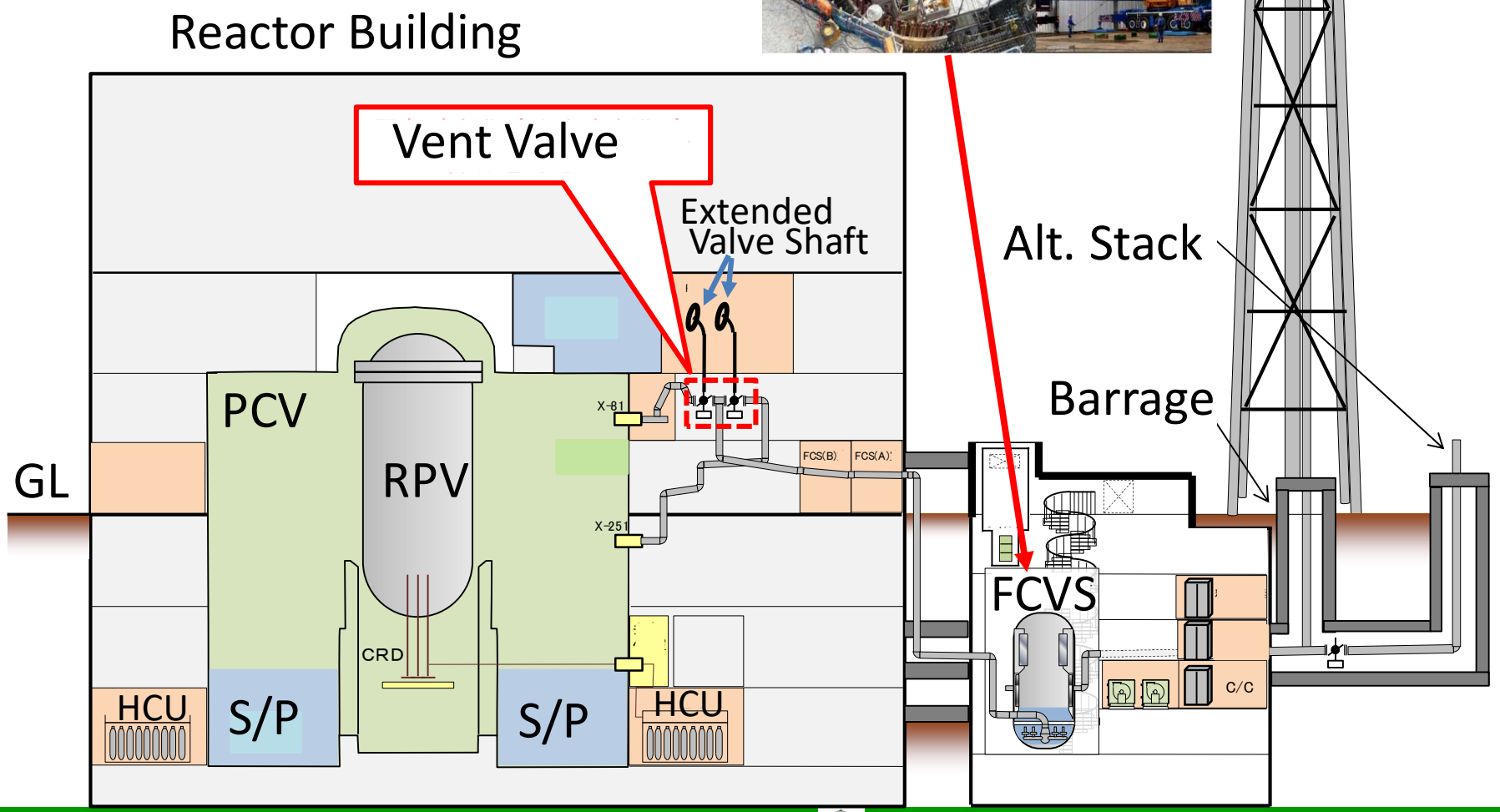
Water Proof Door for EDG and Pumps

Embankment

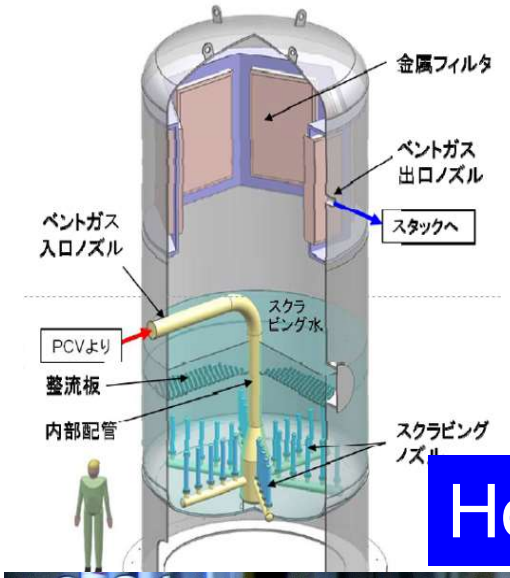


FCVS will be installed under ground Pit

- FCVS will be installed under ground Pit (Banker)



Filtered Containment Venting system



AgX RASA

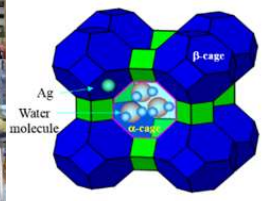
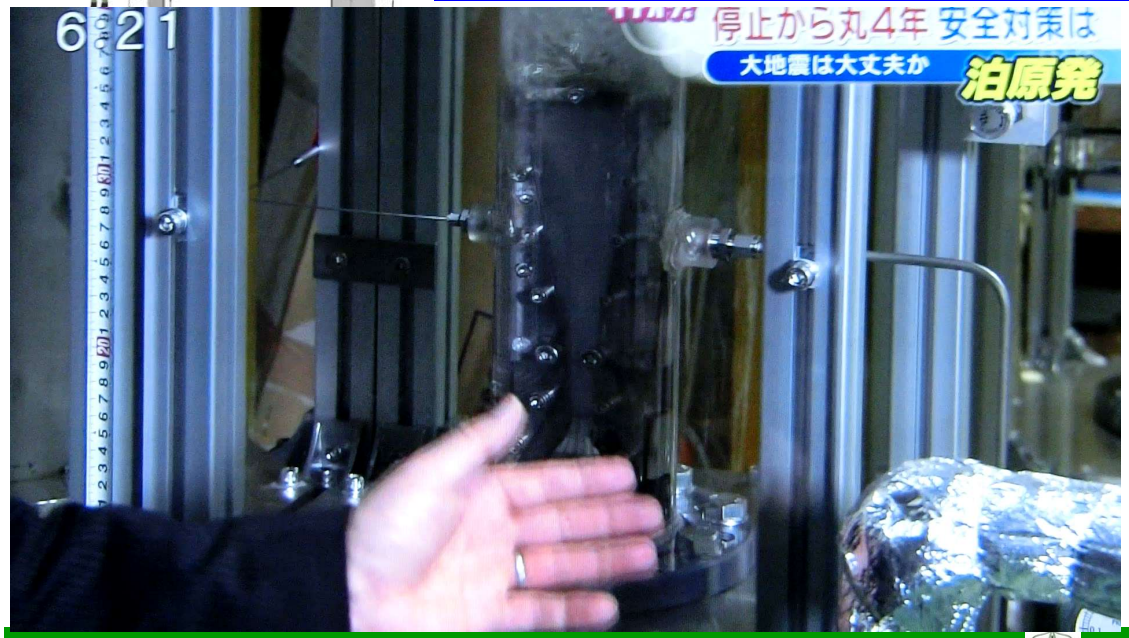


Figure 2 A-type silver-zeolite.

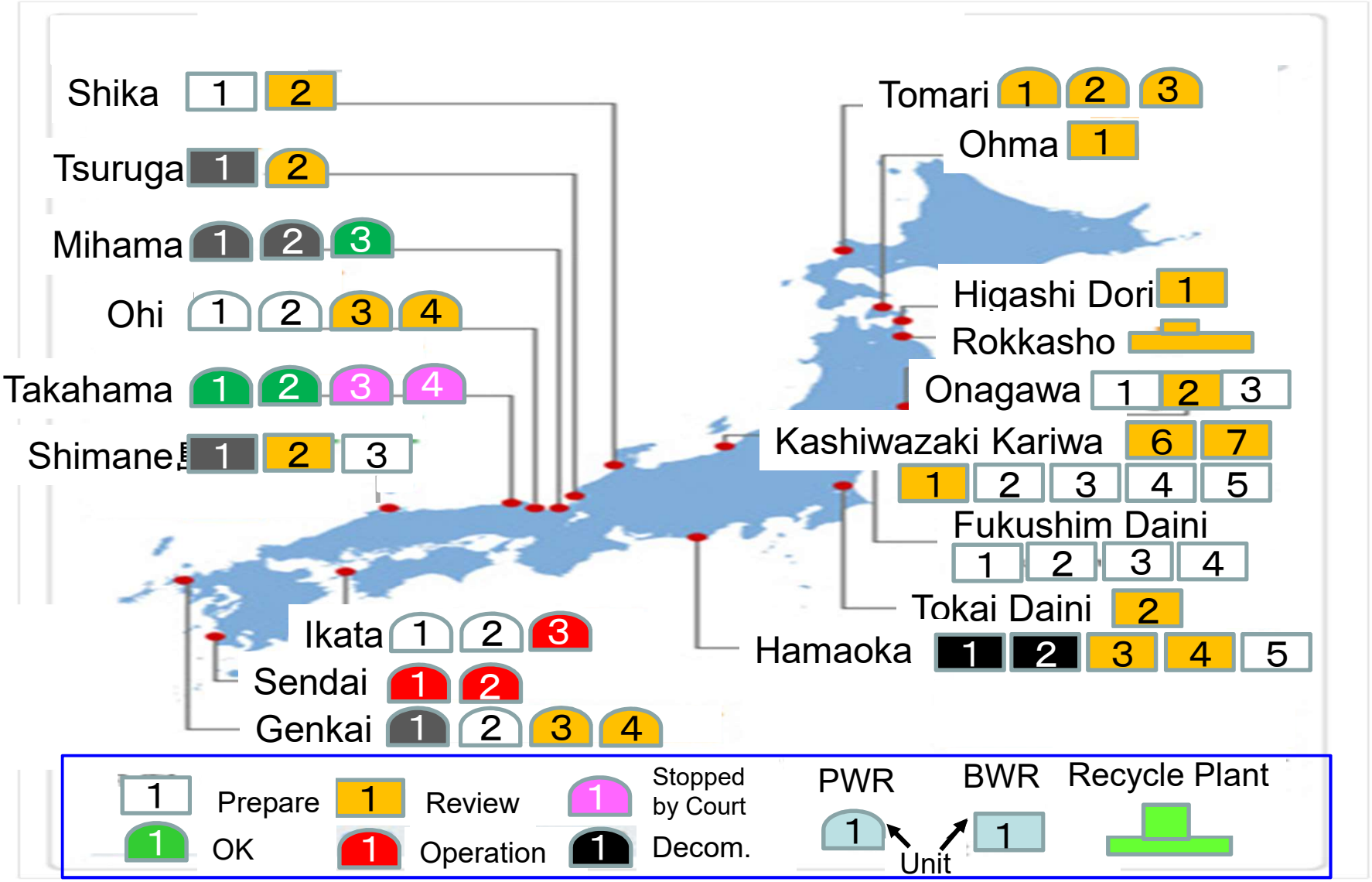
Kashiwazaki Kariwa
TEPCO

Hokkaido University



FCVS Installation Chubu and TEPCO

Prestart Status of Japanese NPPs



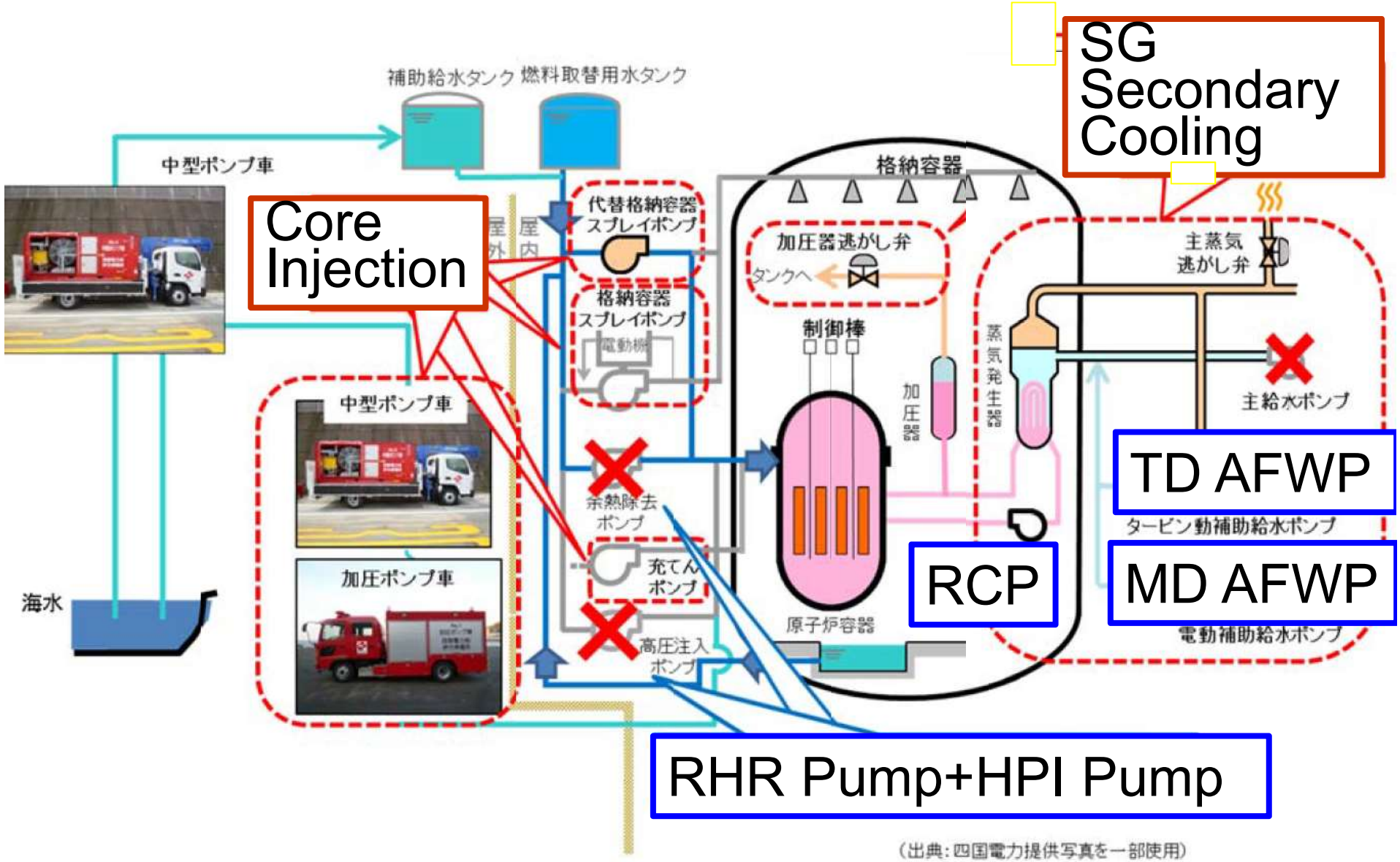
Sendai 1, 2 restarted in 2015

Congratulations for Restart Sendai NPP Unit 1 and 2 (890MWeX2)

Takahama 3, 4 are ready to restart

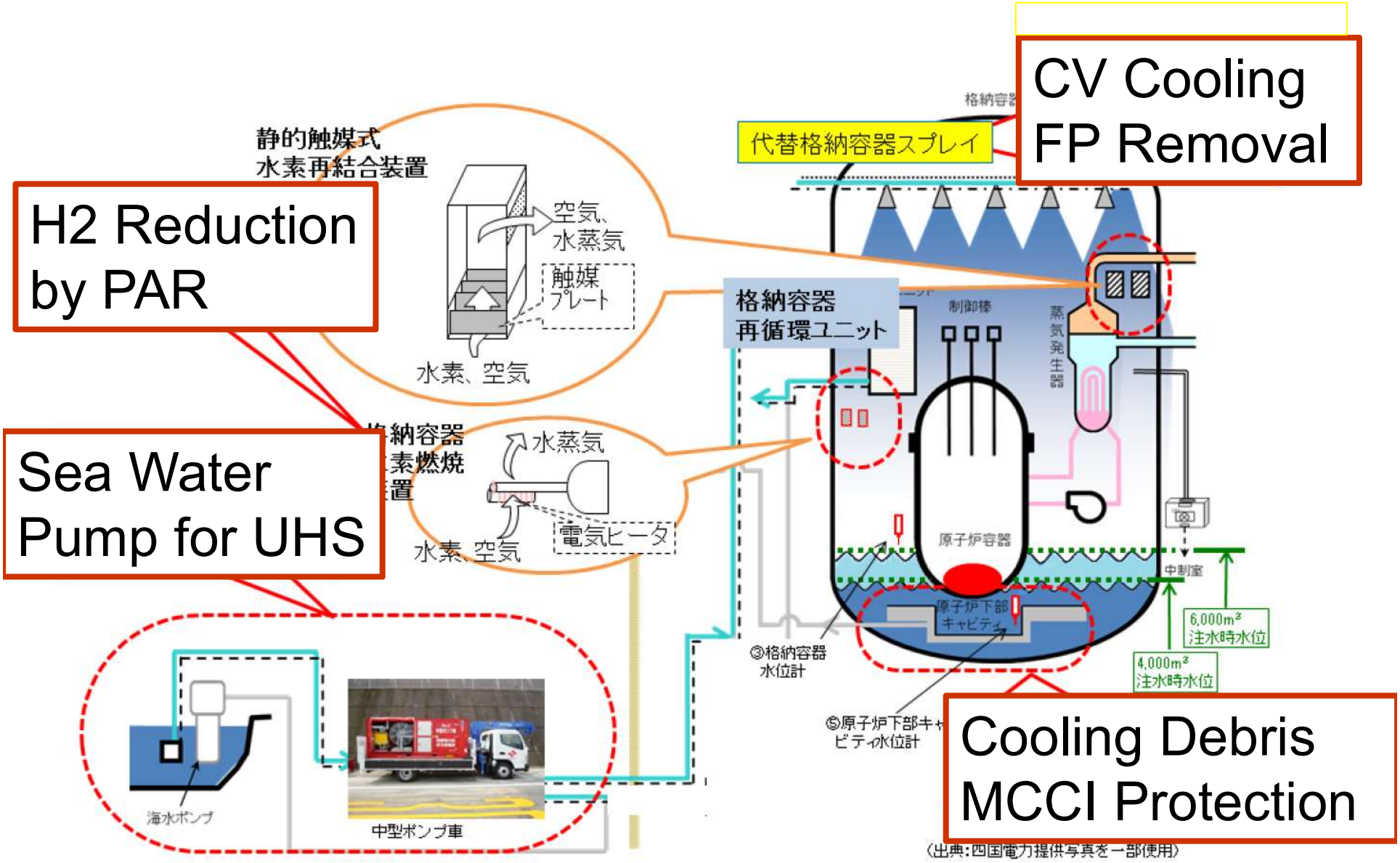
Ikata 3 Restarted on Aug. 12, 2016

Depressurization & Core Cooling for PWR



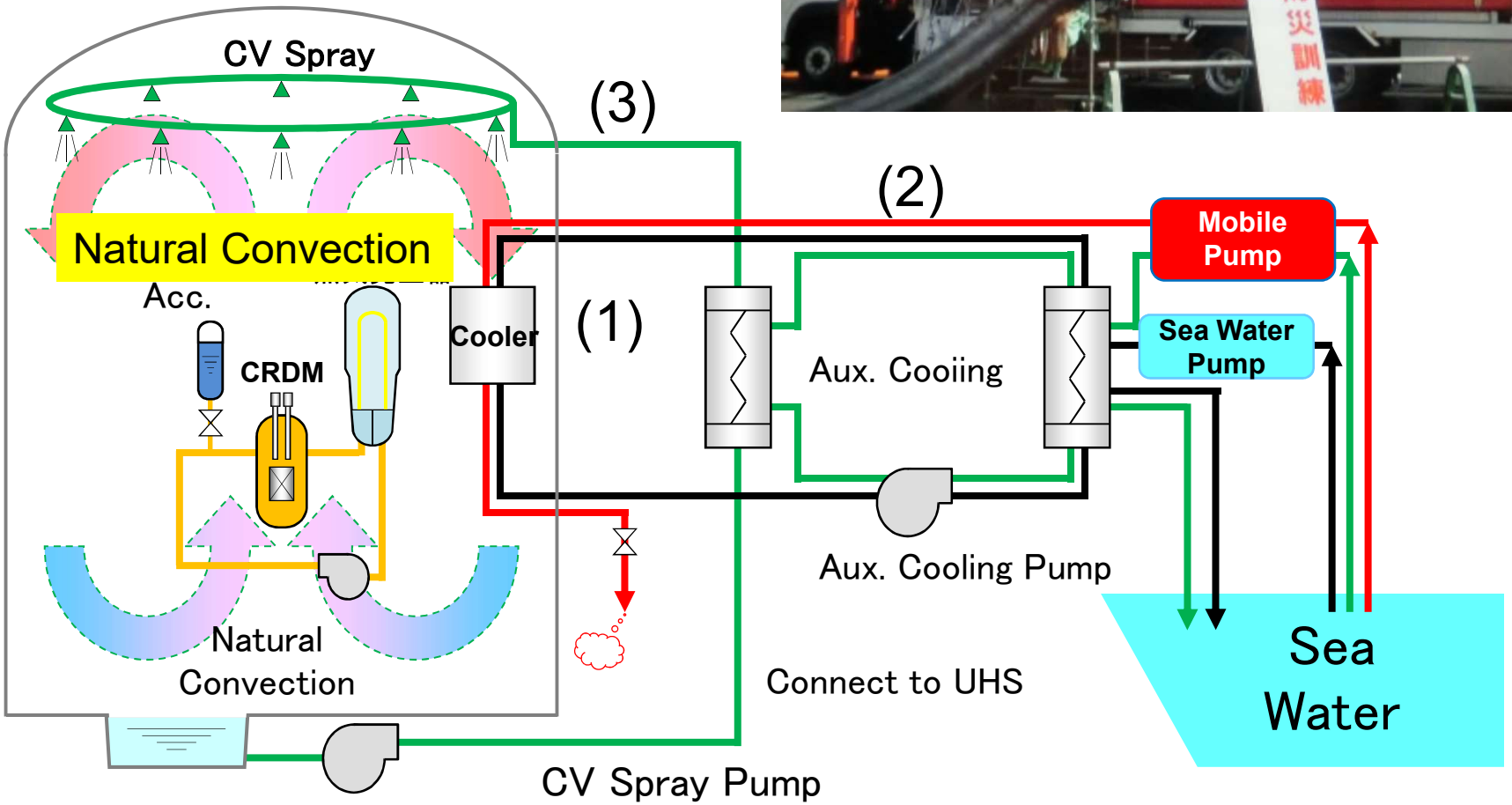
（出典：四国電力提供写真を一部使用）

Containment Vessel Cooling after BDBA

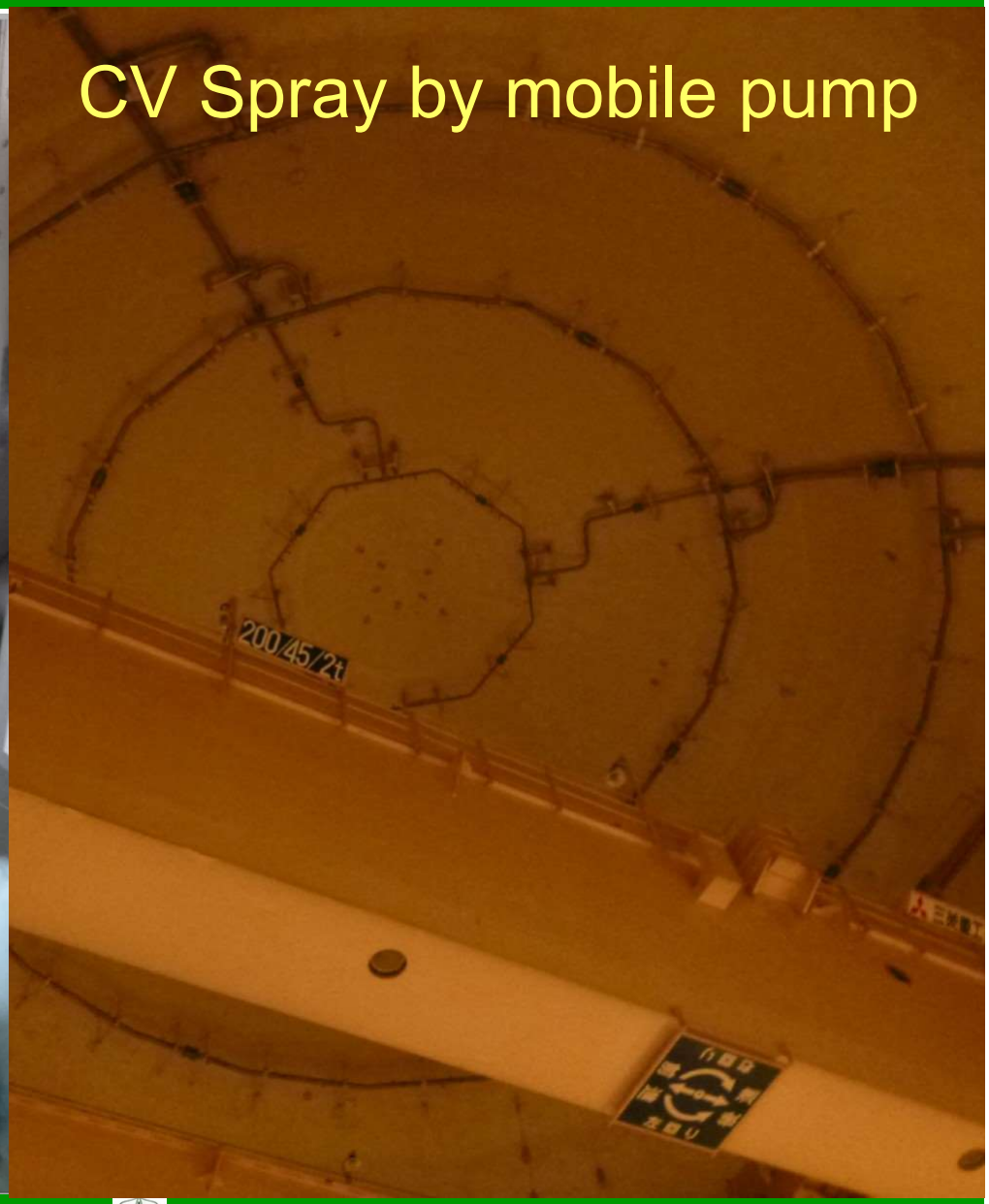


CV Cooling: Mobile Pump for Cooling

(1)CV Cooling unit
(2)Seawater (3) CV Spray



Resilience for CV Cooling



Resilience for H_2 Accumulation

Tsunami Protection: Water proof door

Mortar Driven Water Injection Pump

Diesel Engine Driven Water Injection Pump (Diversity is important)

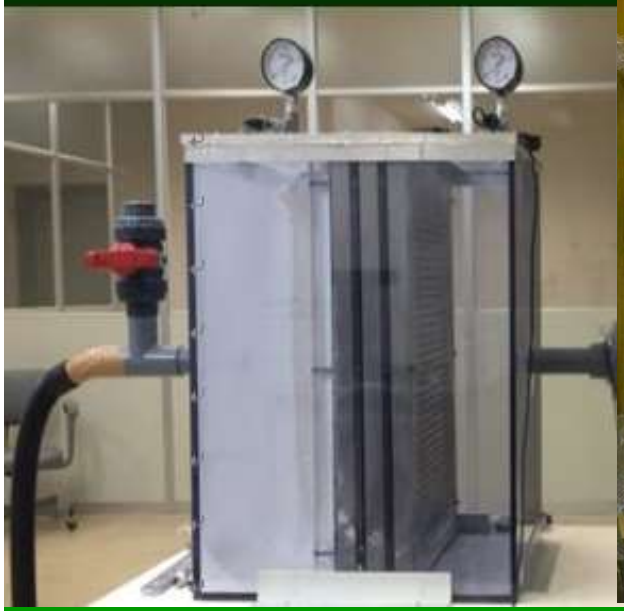
Resilience for Water Injection: Motor Driven Pump (Diversity)

MEXT Project for Nuclear Human Resource Development

Development of a high efficiency multi-nuclide aerosol filters for radiation protection during a process of cutting core debris at Hokkaido University

Rasa

Kimura Chemical Plants



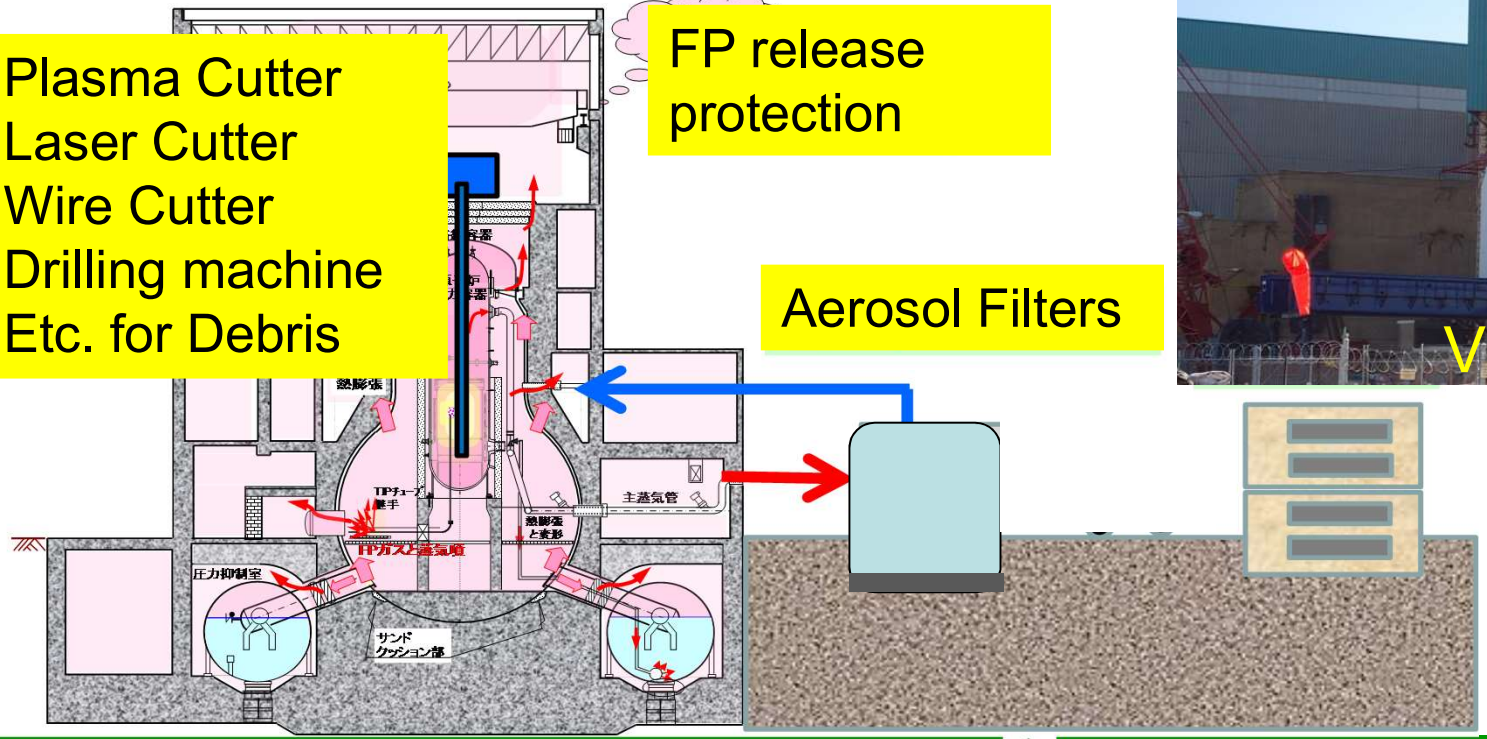
For Fukushima-Daiichi Decommissioning Radiation protection during a process of cutting core debris should be needed.

- In order to develop an air clean up system for radiation protection during a cutting core debris of the Fukushima Daiichi NPP as a process of their decommissioning, a high efficiency filters should be developed, such as a wet-type aerosol filter, a metal fiber filter, a silver zeolite

Plasma Cutter
Laser Cutter
Wire Cutter
Drilling machine
Etc. for Debris

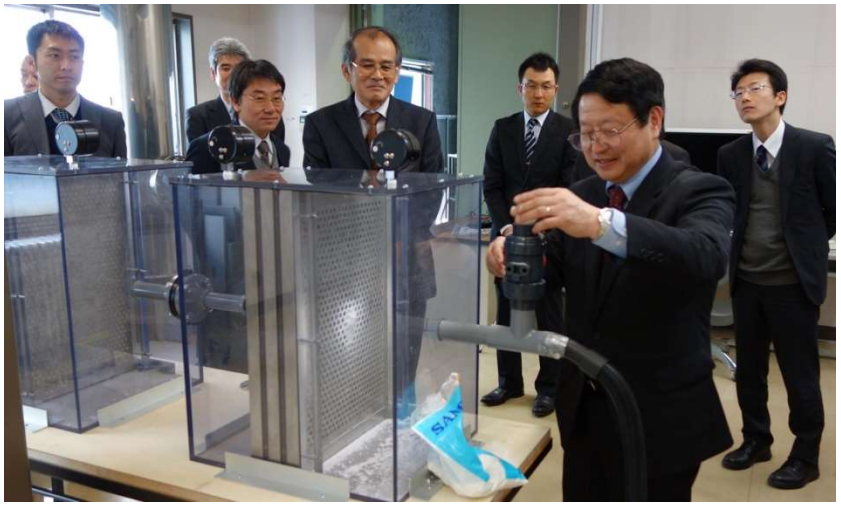
FP release protection

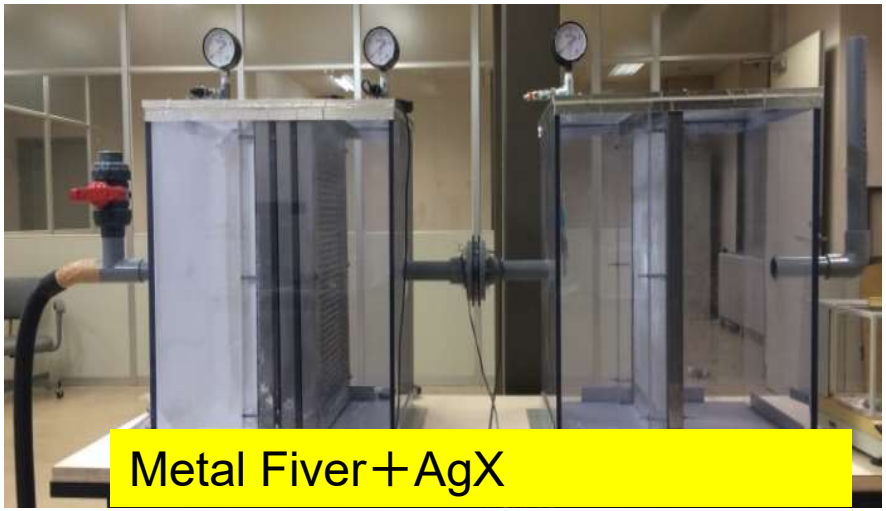
Aerosol Filters



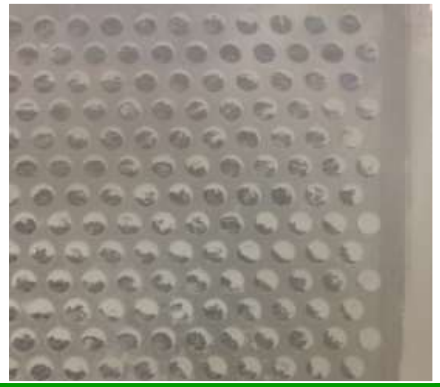
Metal Fiver Filter Test

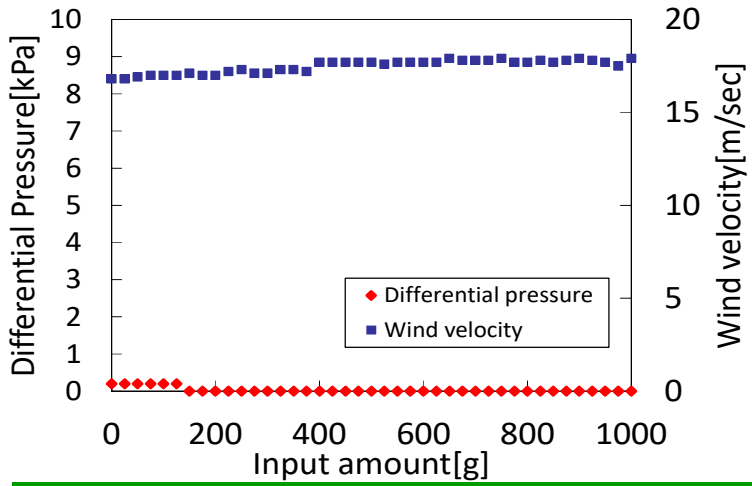
- High performance Metal Fiver Filter with AgX, supplied by RASA



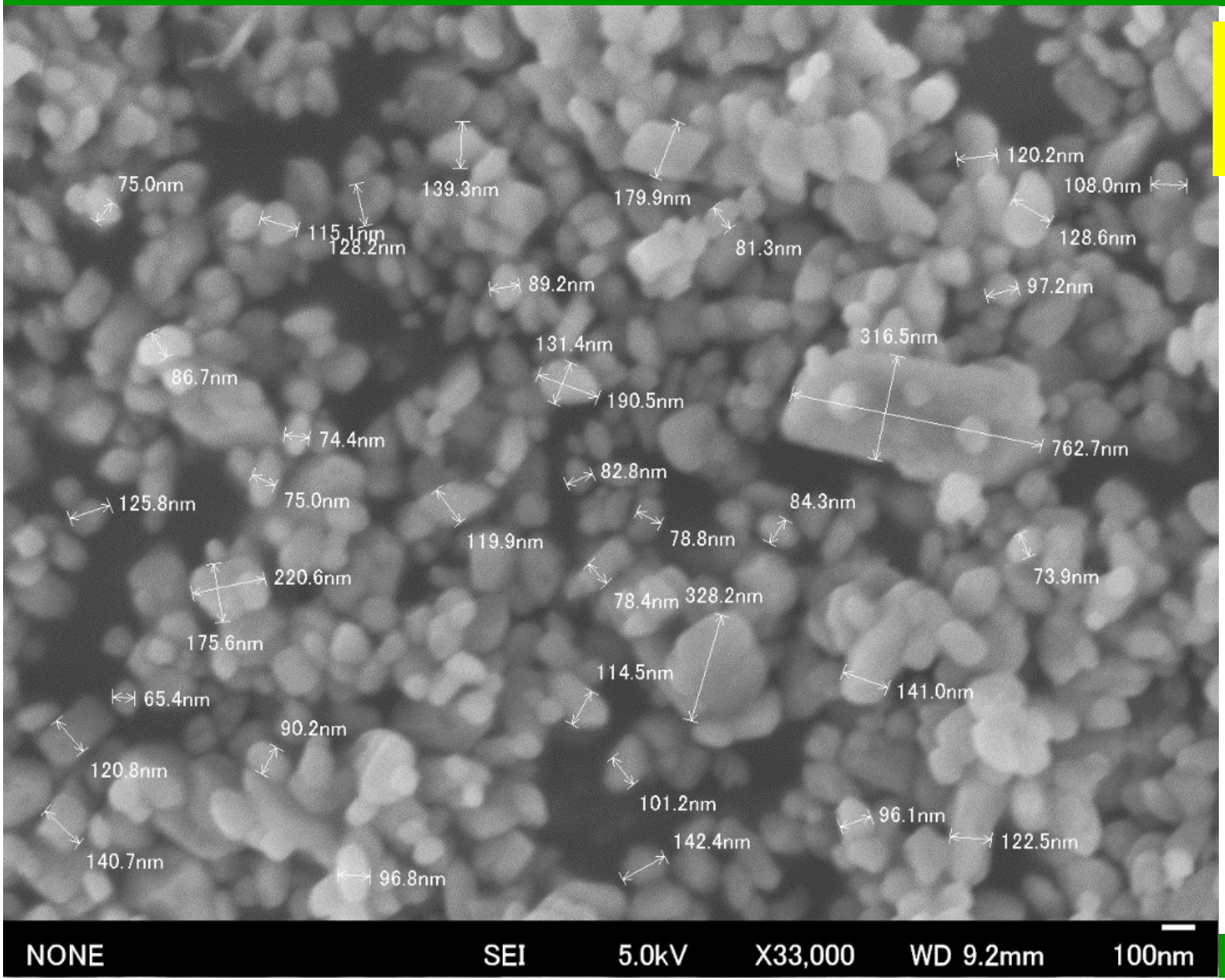


- 0.06μm BaSO4 25gX40 batches＝1kg
  There are no particle at the down stream of the filter（DF＞10,000）
- Differential Pressure was almost constant



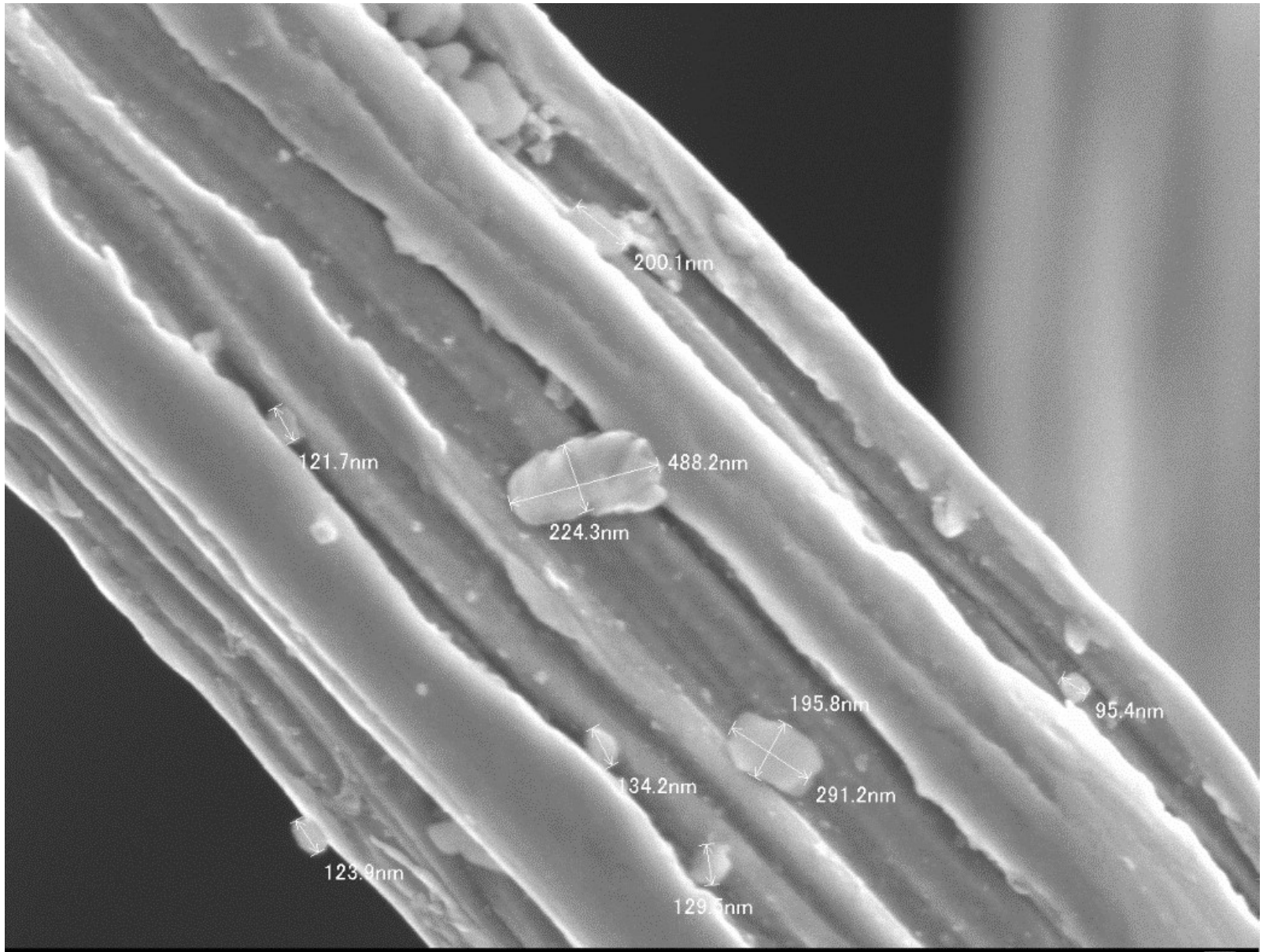


Trapped nano powder of BaSO4

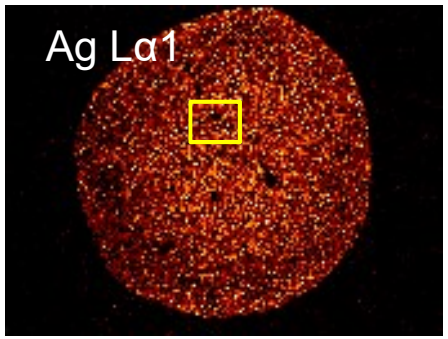


65nm
～700nm

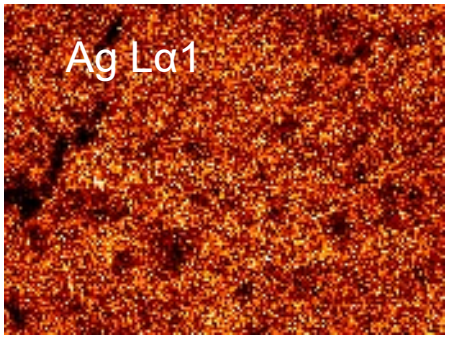
Metal Fiber Filter Trapped nano size Powder



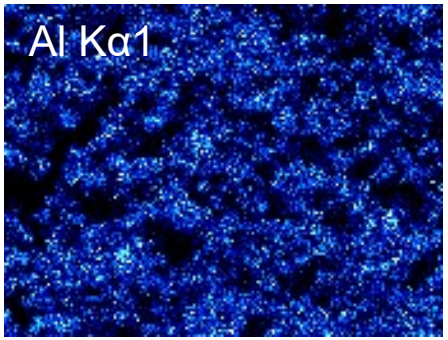
Iodine Absorbed Analysis Result in a AgX Particle



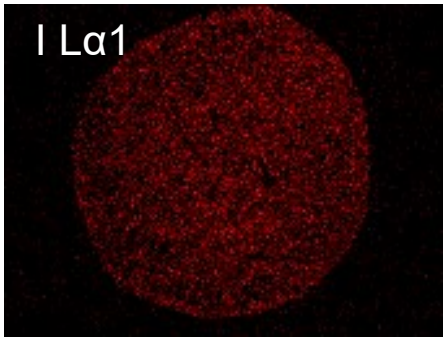
1mm



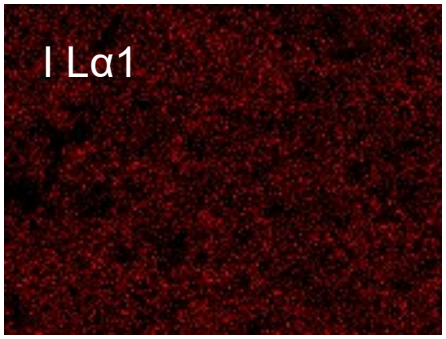
20μm



20μm

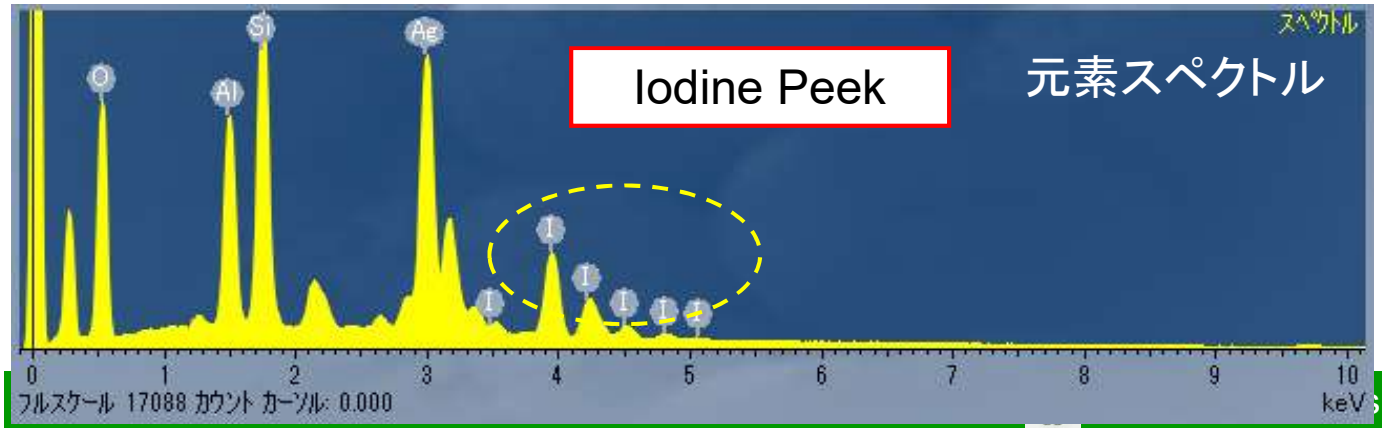


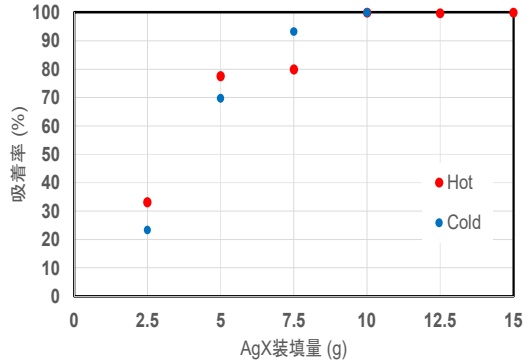
1mm



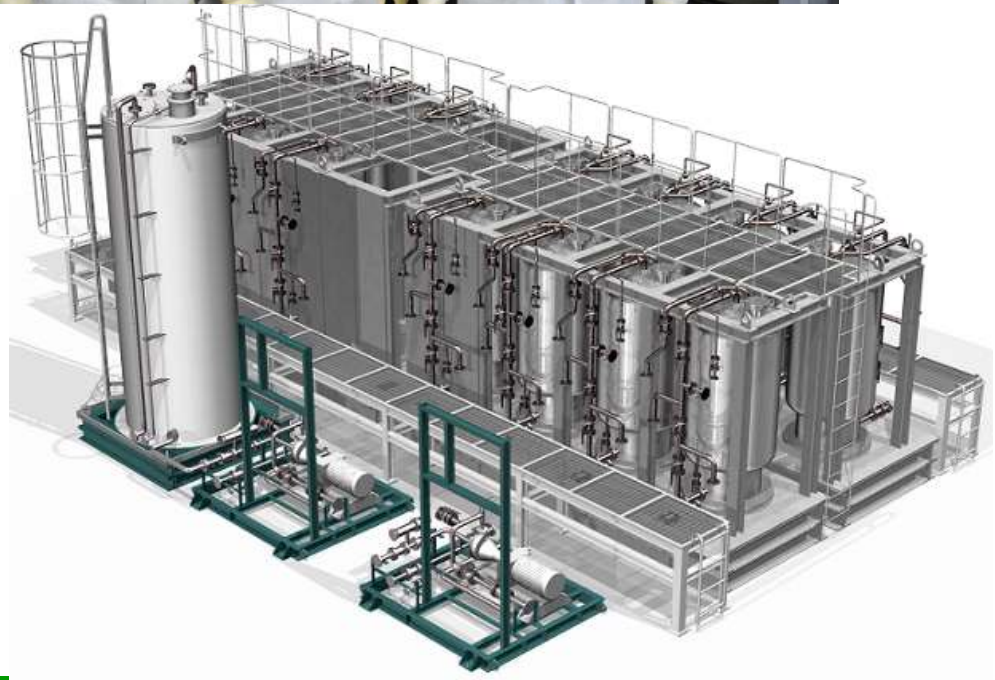
20μm

Iodine was captured even at the center of a AgX particle





Advanced Liquid Processing System (ALPS)



Treat the contaminated water by removing radionuclides

750
Tons/day in first installed system

2,000
Tons/day with first installed system
+ additional system
+ high-performance system

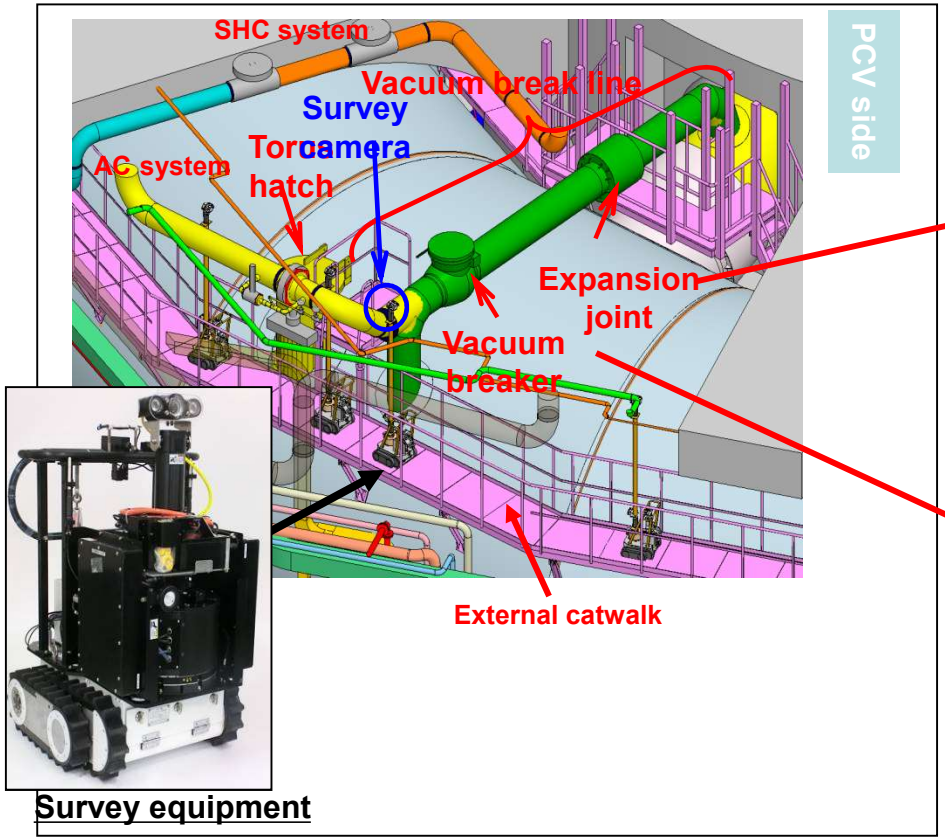
120,000+
Tons of contaminated water processed so far

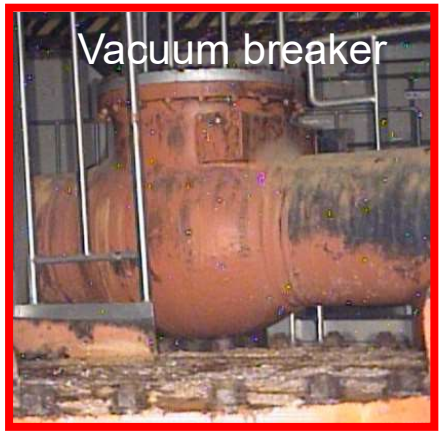
REMOVE SOURCES OF CONTAMINATION

Robotics for Resilience Action at Fukushima Daiichi NPS

Survey at Basement Floor of Unit 1 Reactor Building

Robots Survey and repair toward filling PCV with water

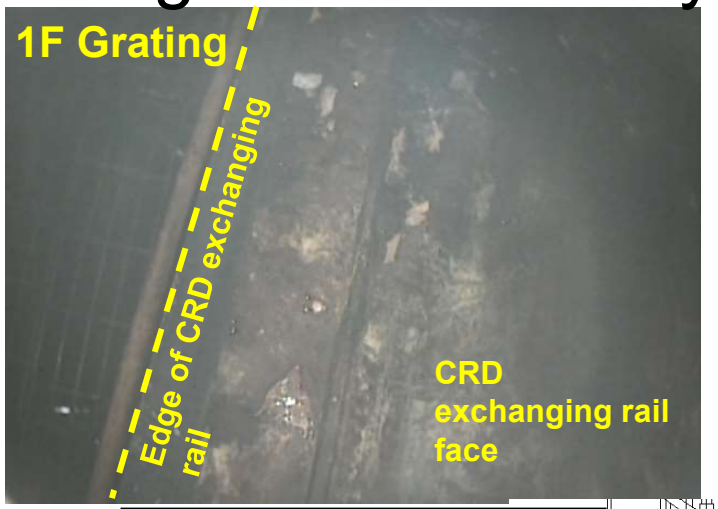




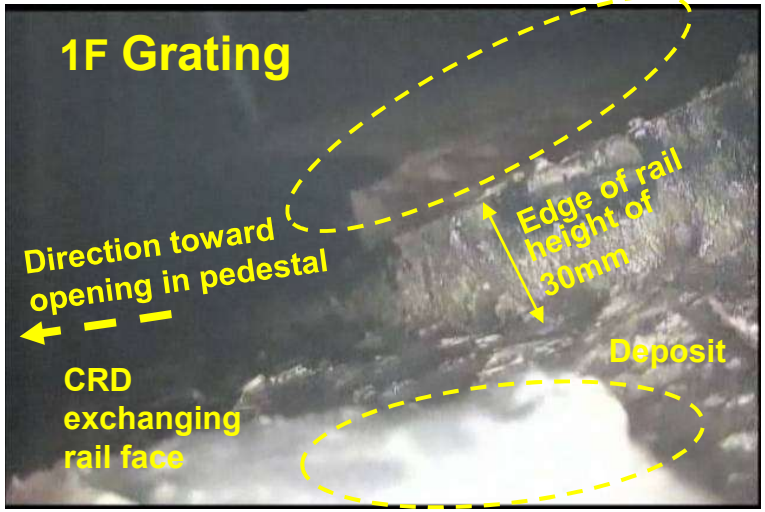
Investigation into Bottom of Unit 2 RPV (2/2)

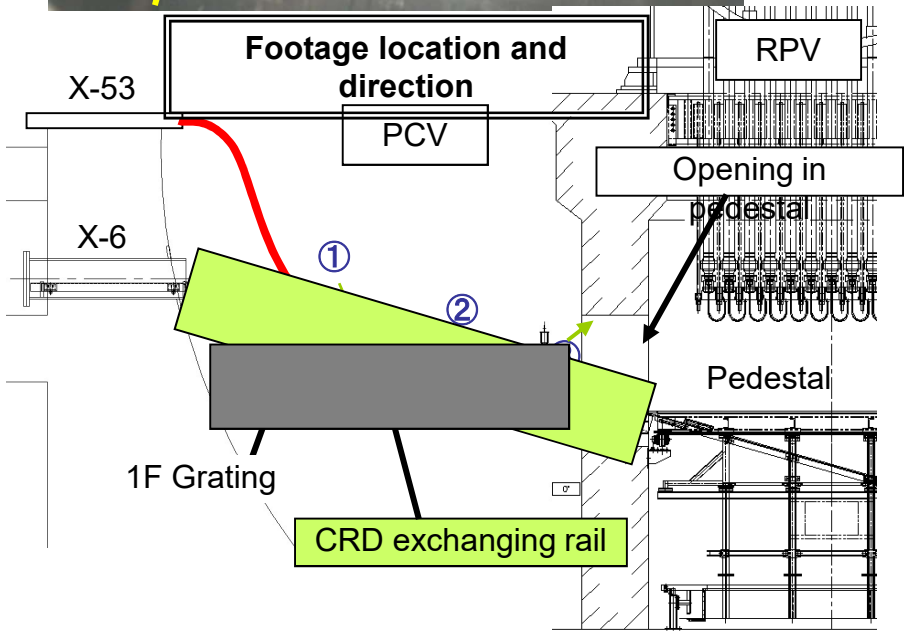
Finding Core Debris by Robotics

①

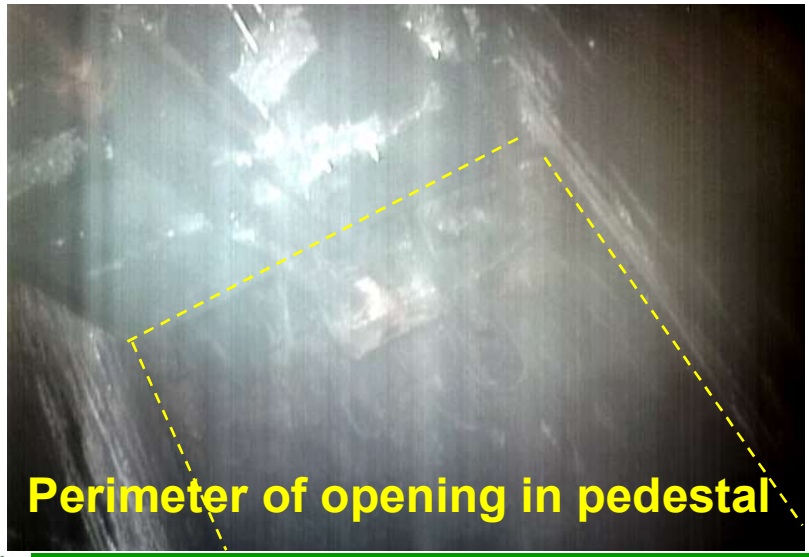


②



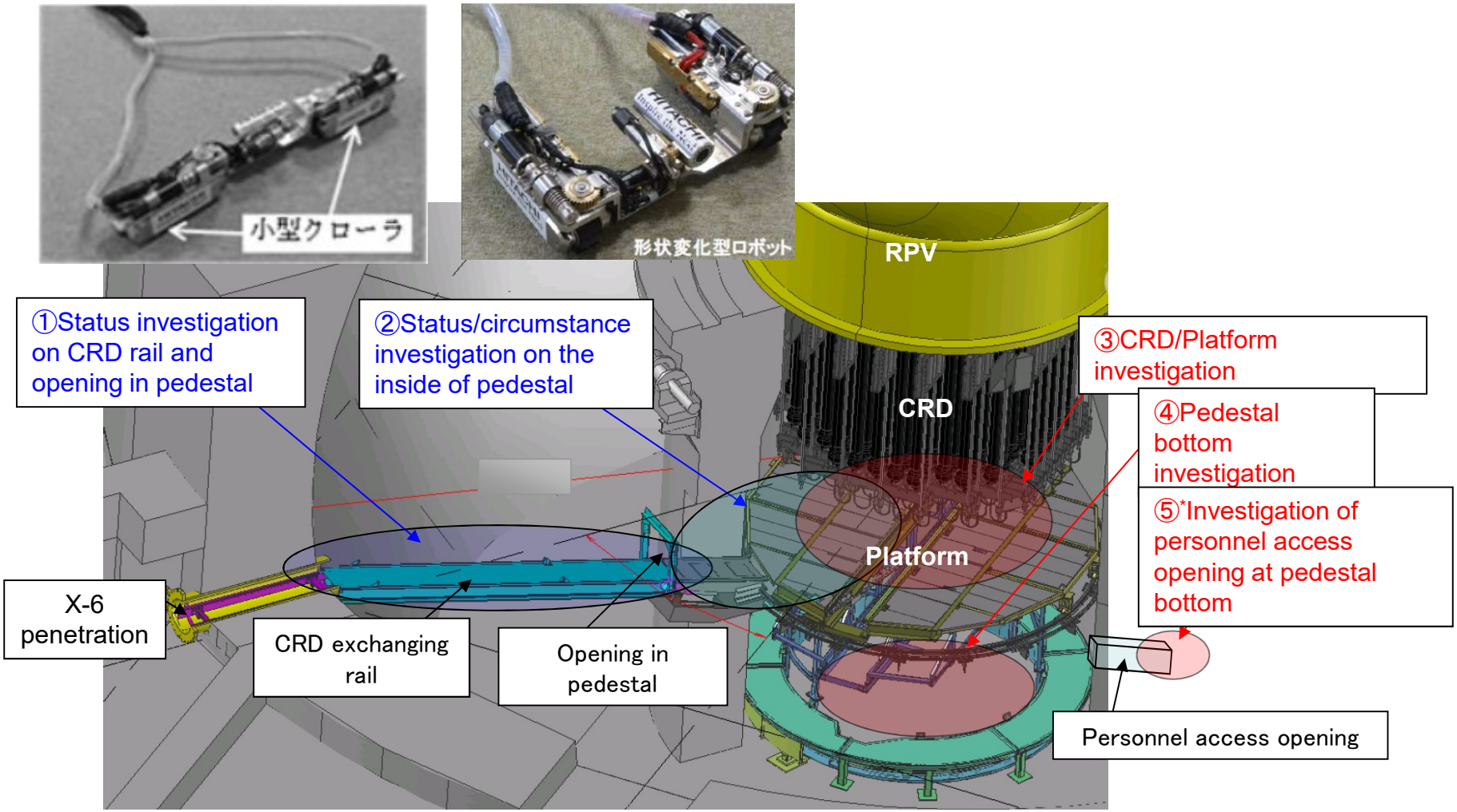


③



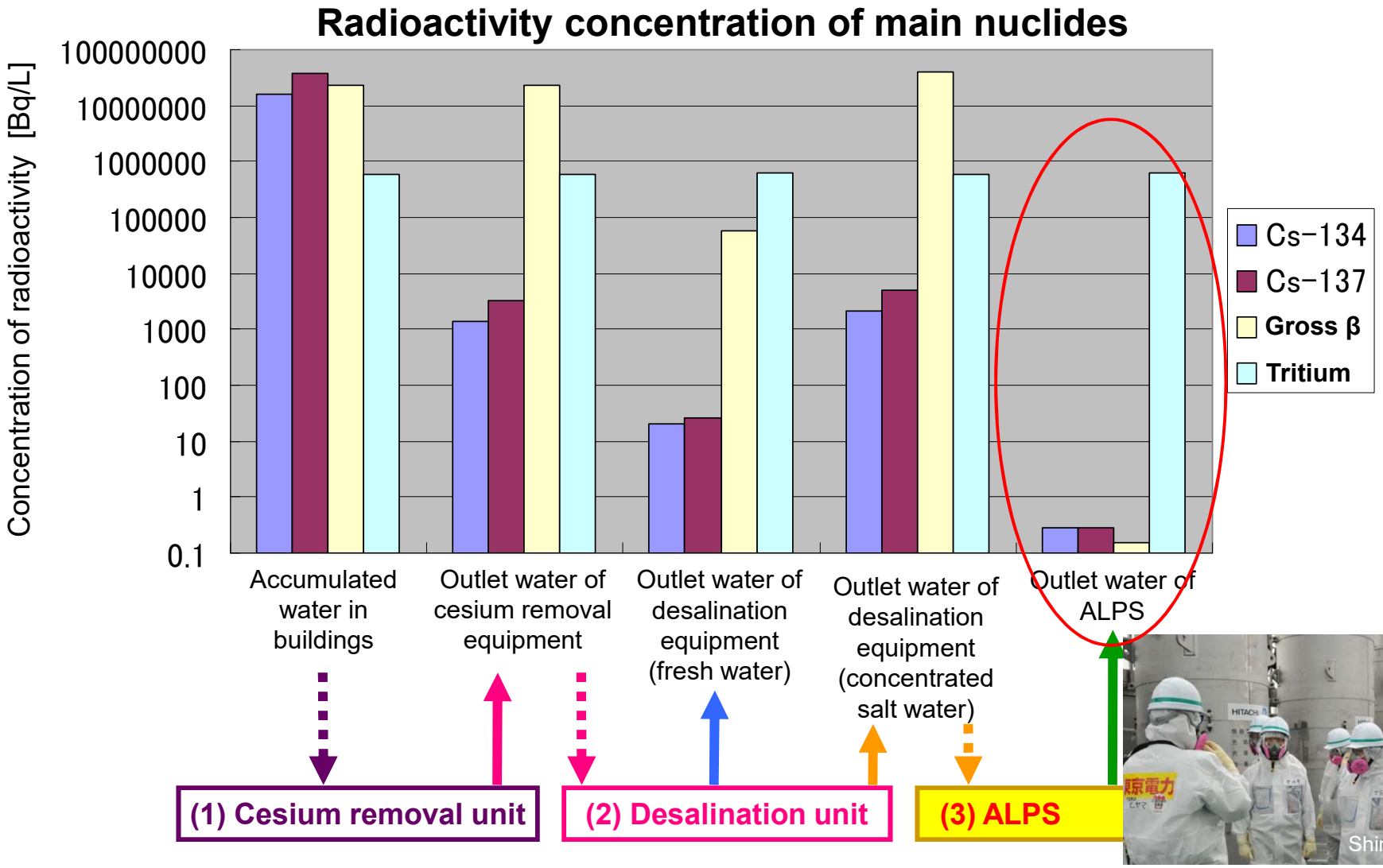
Investigation into Bottom of Unit 2 RPV (1/2)

Transformer Type Robot for Investigation debris at pedestal



＊ As for ⑤, access from the outside of pedestal is also considered.

Contaminated Water Status



* Sampling was conducted on Nov. 5, 2013 （April 9 to 12, 2013 as for ALPS outlet water）

Super Engineer Education Project

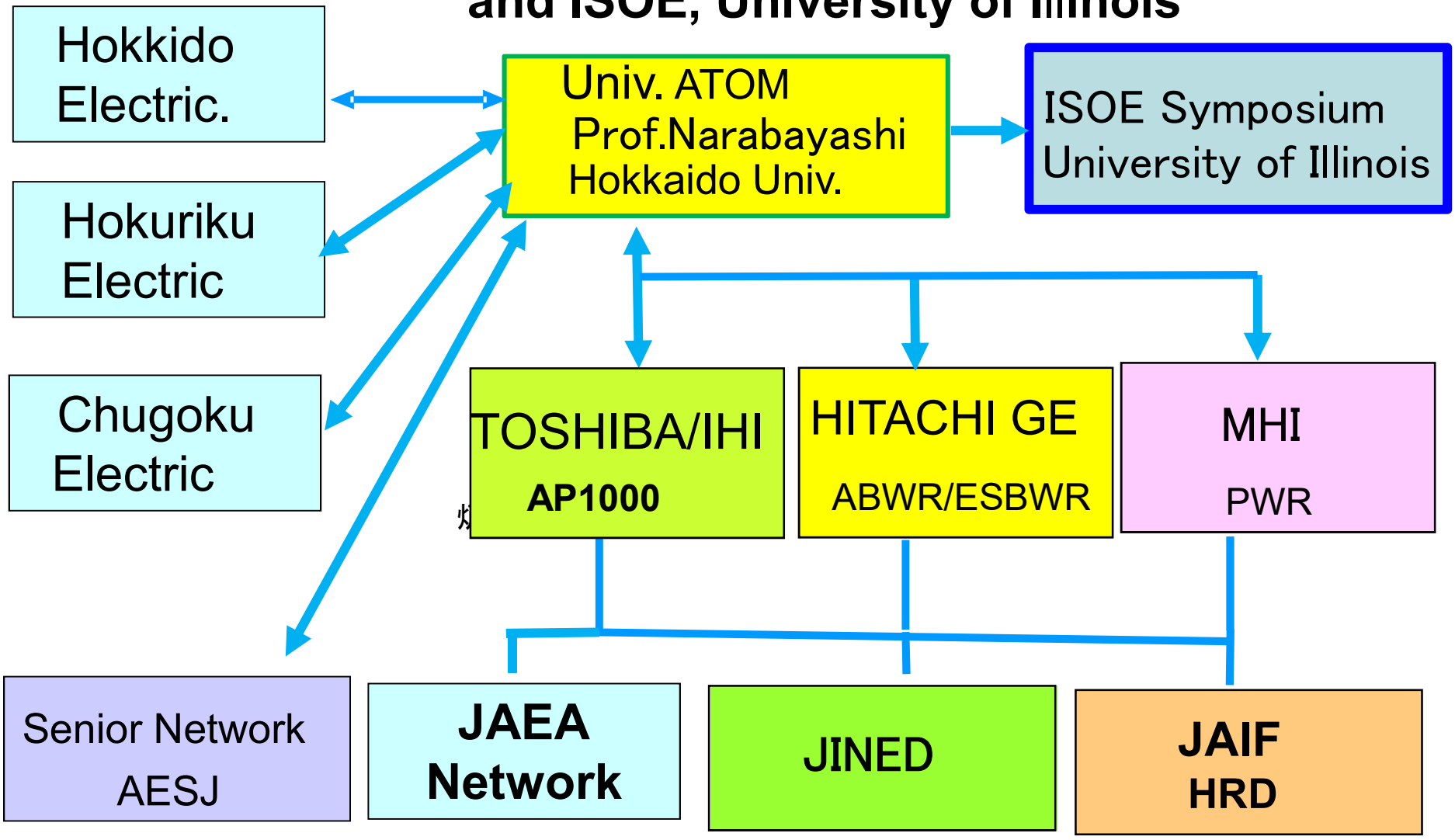
MEXT Project for Nuclear Human Resource Development

Super Engineer Education Project to Achieve Highest Safety at Hokkaido University

*MEXT: Minister of Education, Culture, Sports, Science and Technology

Framework of the Project

■**Collaboration of Universities, Electric Power Co., Vendors and ISOE, University of Illinois**



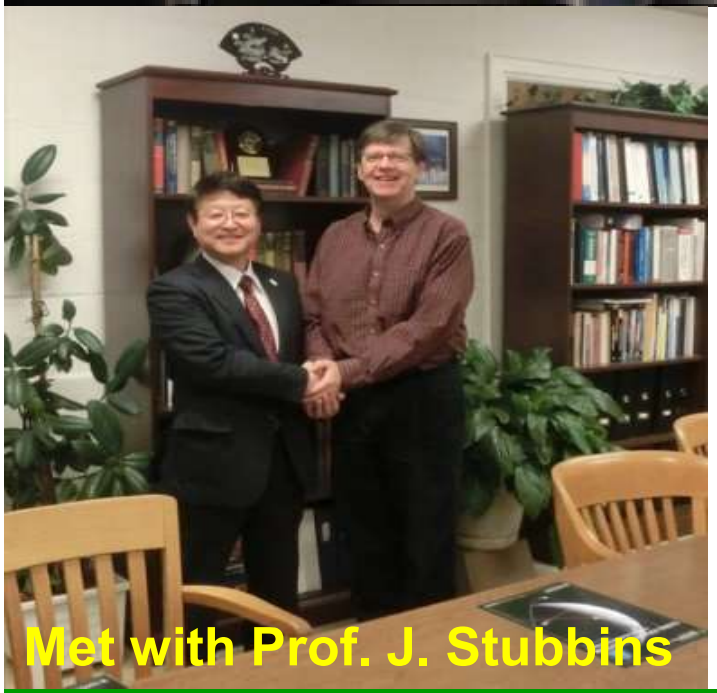
Number of Students Trained in this Project

Students	Major	Number of Students			TOTAL
		FY 2015	FY 2016	FY 2017	
BS 1	All students in Hokkaido	—	50	50	100
BS 2	Civil, Natural Resource, Environment, Electronic	100	100	100	300
BS 3	Nuclear, Mechanical Engineering	120	120	120	360
MS 1,2	Nuclear, Plasma, Radiation, Mechanical	0	70	70	140
NPP Training	19 ATOM Universities	13	13	13	39
Vendor R&D	19 ATOM Universities	13	13	13	39
ISOE/Illinois	Excellent Students	5	5	5	15
TOTAL		251	371	371	993

Students Training Programs for Super Engineer

Lecture by RP managers at ISOE Symposium

Cooperation with University of Illinois from 2015

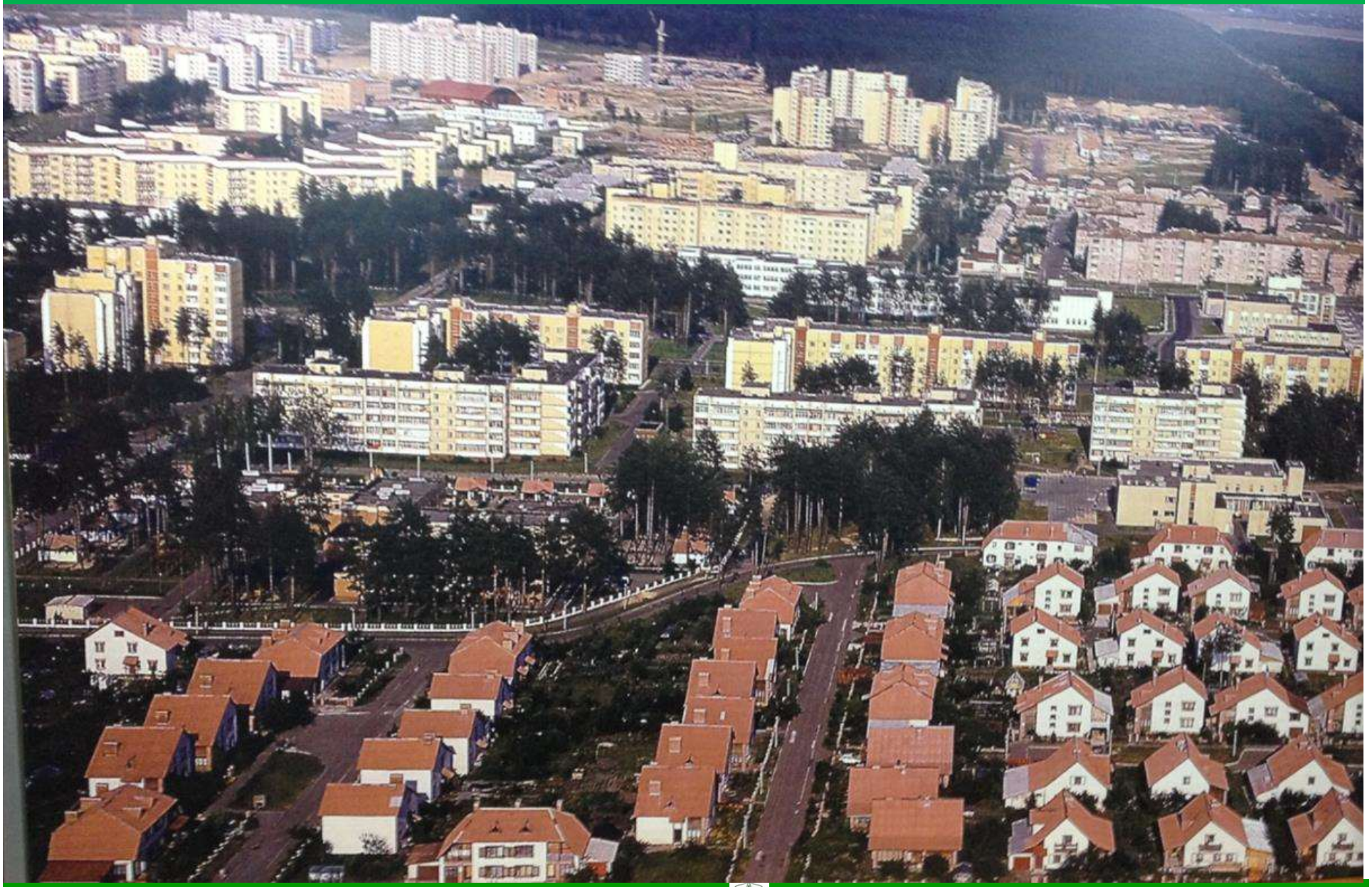


Met with Prof. J. Stubbins

Mr. Takuma was trained at University of Illinois and he entered TEPCO last April

He said “I will help TEPCO to recover”

The Dreamy Town Slavutich in Ukraine



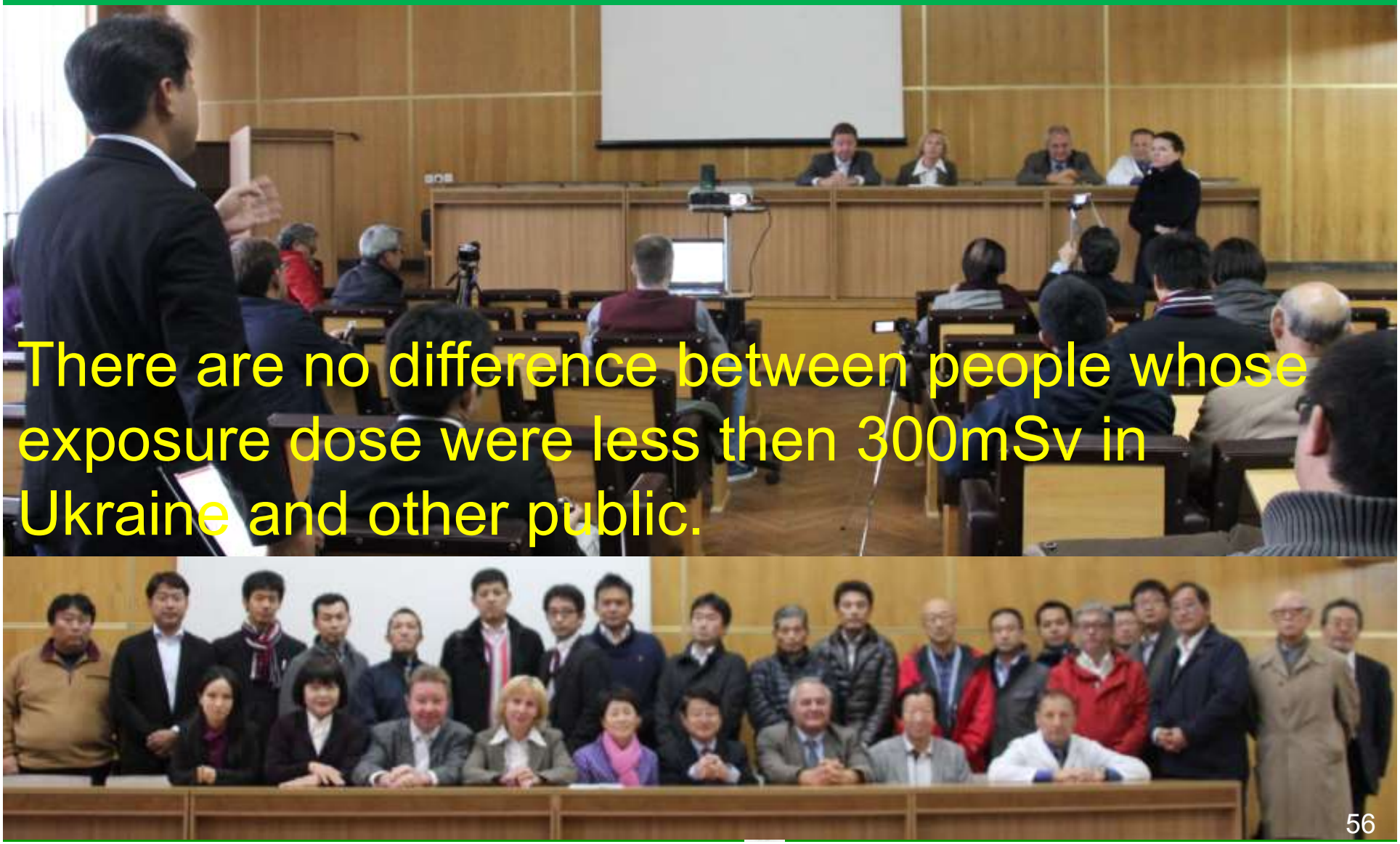
People in Fukushima met the Mayer of Slavutich City on Sep. 2013

Fukushima's People Learned the Good Practice of Slavutich

The Dreamy Town Slavutich in Ukraine

The Dreamy Town Slavutich

Fukushima's People Visited the Research Center for Radiation Medicine of the National Academy of Medical Sciences of Ukraine and were given doctors advice.



Not to be a Victims, but to be a Survivor

Psychological and Neuropsychiatri
Legacy of the Chernobyl Disaster

Information Contamination was much severe than Radiation Contamination

Social-economic benefits to be a "survivor", but not a "victim":

- Legislation:
  - Reasonable social and medical insurance
  - Medicine for health, but not for sick benefits
- Professional re-training
- Reasonable employment

Psychological support and rehabilitation

Mass media weighted and optimistic approach

Conclusion

- From the Lessons of Fukushima-Daiichi Accidents, Japanese NPP has installed safety measures, and Sendai 1 and 2 restarted in 2015. Ikata restarted in 2016. Kashiwazaki-Kariwa(ABWR) will pass to restart in 2017.
- Development of Filtered Venting System (FCVS) with silver zeolite has finished. Installation has started.
- Development of a high efficiency multi-nuclide aerosol filters for radiation protection has already started at Hokkaido University as a MEXT project in Japan.
- Nuclear education is very important to encourage students to be super engineers for future Nuclear Energy supported by MEXT.
- Super Engineer Education Project has been started by the support of ISOE NATC. Thank you very much.