



**ATR NSUF User's Week 2011
Working Lunch**



*JAEA Earthquake and Tsunami
Overview and Recovery*

**June 10, 2011
Idaho Falls, ID**

**Takafumi Aoyama, Principal Research Engineer,
Japan Atomic Energy Agency (JAEA),
4002 Narita, O-arai, Ibaraki, 311-1393 Japan, T:+81-29-267-4141**

Date: Friday, June 10, 2011 ('day 90')

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- 1. Prologue**
- 2. March 11, 2011 14:46**
- 3. Summary of Fukushima Daiichi NPS accident**
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- 5. What happened to JAEA facilities**
- 6. Lessons learned**
- 7. Epilogue**

March 11, 2011 14:46

Timeline of Epicenter



No.

Time

Epicenter

Mag.

1

March 11, 2:46 PM

Iwate Sanriku oki

M 9.0

Timeline of Epicenter



No.	Time	Epicenter	Mag.
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2	March 11, 3:15 PM	Ibaraki oki	M 7.7

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11	April 12, 2:07 PM	Central Fukushima	M 6.4

Summary of 1F accident

Status of Nuclear Power Station in East Japan area after the Earthquake



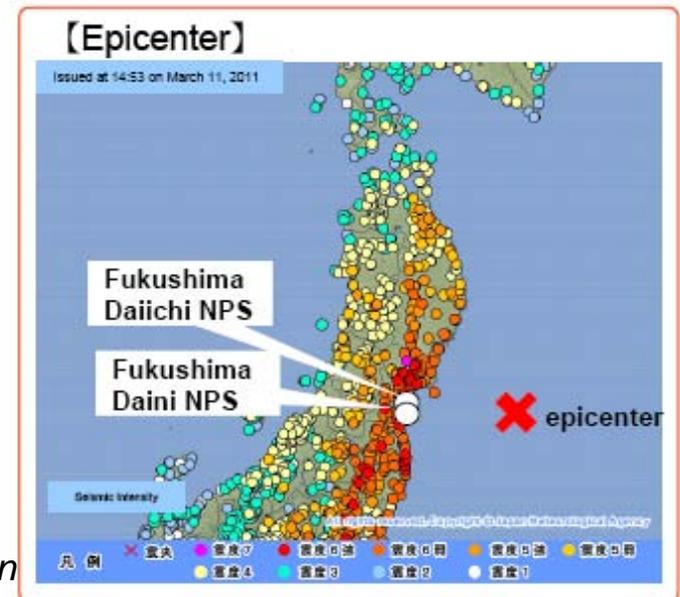
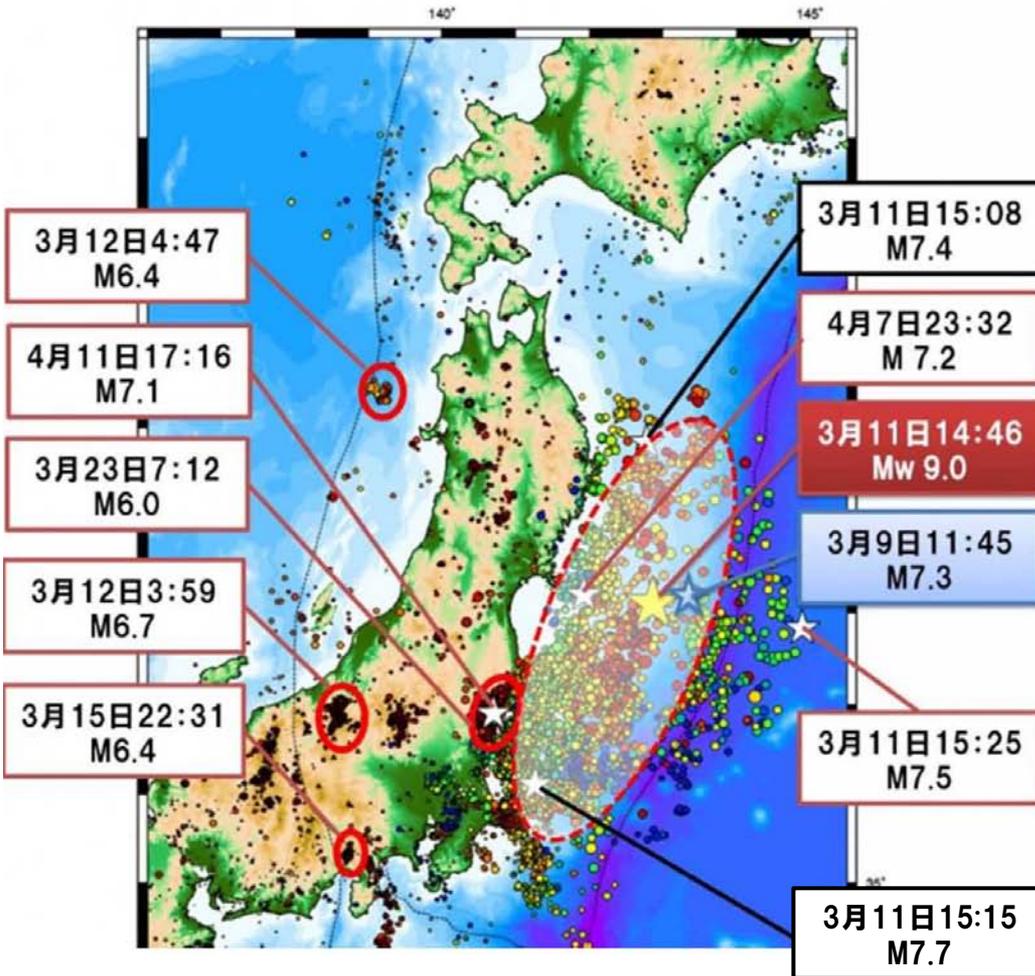
Site	Onagawa (Unit 1-3)	2F (Unit 1-4)	Kashiwazaki-Kariwa (Unit 1-7)	Tokai Daini
SCRAM	○(all unit)	○ (all unit)	Not affected (all unit) Continue operating	○
External Power Supply	×, ○,○	○ (all unit)		×
D/G Power Supply	△, N/A, N/A	N/A (all unit)		△

○ Success
 △ Success (Partially)
 × Lost
 N/A Not applicable

3.11 Earthquake and aftershock

Statement by the Headquarter for Earthquake Research, *11March2011*

The Earthquake Research Committee evaluated earthquake motion and tsunami for the individual region off-shore of Miyagi prefecture, to the east off-shore south of Sanriku along the trench, and to the south off-shore of Ibaraki prefecture, but occurrence of the earthquake that is linked to all of these regions is "out of hypothesis".

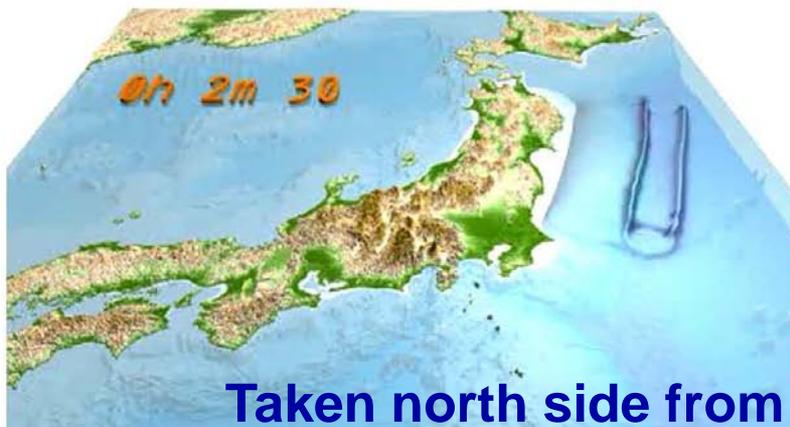


[SOURCE]
 Fukushima Accident : An overview
 ICAPP 2011, 3 May 2011 Akira OMOTO, University of Tokyo, Japan

3.11 Tsunami

1F1-3 Plant response immediately after the earthquake

- 14.46 Earthquake followed by Reactor SCRAM, LOOP, EDGs start, IC/RCIC in operation
- 15.38-41 Tsunami followed by complete (AC/DC) blackout and (mostly) isolation from the Ultimate Heat Sink



Taken north side from radwaste building in 1F



[SOURCE]

Fukushima Accident : An overview

ICAPP 2011, 3 May 2011 Akira OMOTO, University of Tokyo, Japan

Released from Tokyo Electric Power Co (TEPCO)

LOOP : Loss of Offsite Power

EDG : Emergency Diesel Generator

RCIC : Reactor Core Isolation Cooling

IC : Isolation Condenser

Current Status of 1F plant (as of May 31, 2011)

		#1 460MW	#2 784MW	#3 784MW	#4 784MW	#5 784MW	#6 1,100MW	
Pre-Earthquake Status		Operating			Shutdown for Outage			
After Earthquake	Shutdown	○ Automatic Shutdown			—	—	—	
	Cooling	Reactor	△ Offsite Power Freshwater	△ Offsite Power Freshwater	△ Offsite Power Freshwater	— Fuels have been removed	○ Cold Shutdown	○ Cold Shutdown
		Pool	△	△	△	△	○	○
	Containment		X Highly contaminated water	X Highly contaminated water	X Highly contaminated water	△	○	○

○ :functioning △: non-functioning (work in progress) X: non-functioning (not working)

Recommended links about Fukushima Daiichi Nuclear Plant accident

- Tokyo Electric Power Company, Incorporated.
<http://www.tepco.co.jp/en/nu/fukushima-np/index-e.html>
- Ministry of Education, Culture, Sports, Science & Technology
<http://www.mext.go.jp/english/>
- International Congress on Advances in NPPs - Nice (ICAPP)
<https://www.sfen.fr/ICAPP-11>
- NHK (Japan Broadcasting Corporation)
<http://www3.nhk.or.jp/daily/english/society.html>
- STANFORD UNIVERSITY
<http://cisac.stanford.edu/events/6615>

JAEA support to Fukushima

Assistance to the Accident of 1F by JAEA

JAEA, with its full scale effort, is assisting activities concerning the accident of the 1F.

【Items】

- Environmental radiation monitoring
- Environmental radioactivity analyses
- Resident public consulting
- Providing scientific advice and technical supports
- Equipment Support

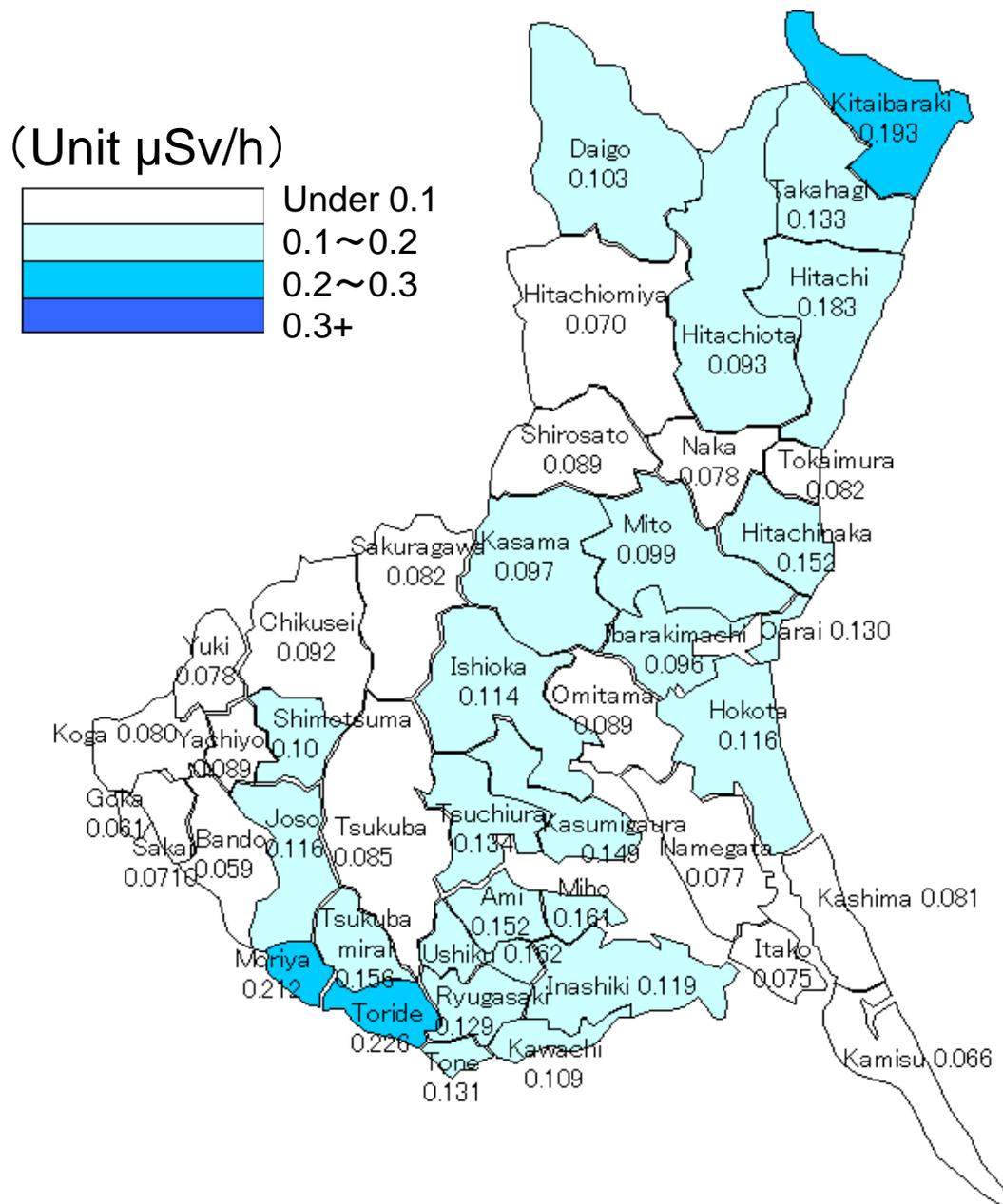
Environmental Radiation Monitoring

- Environmental radiation monitoring outside of a 20 km radius of 1F screening survey of body contamination are conducted.
- Continuous environmental radiation monitoring and radioactivity measurements.



Assistance to Ibaraki Prefecture by JAEA Oarai

Radioactivity levels
in all Ibaraki
municipalities
(as of May 25, 2011)



The value of radioactivity is taken from the measuring station closest to each city hall 24

Resident Public Consulting

(NEAT : Nuclear Emergency Assistance & Training Center)

- Resident health consultation hotlines have been installed at NEAT and have been responding about **400 inquiries per day**. The hotlines were reinforced with help of related organizations and will continuously provide services.



Providing Scientific Advice and Technical Supports

- JAEA served remote and robotics to observe, monitor high radiation area upon request from TEPCO.



Consultation concerning radiation of Fukushima Prefecture

In Fukushima Prefecture, there is a consultation concerning the radiation, and JAEA assists it.





Taking Relief supplies for Fukushima prefecture

Whole body counter car

Monitoring car





Decontamination car



Body surface counter car



JAEA Fukushima support center



Device for radiation measurement



Plan of radiation measurement

Scenery of going to bed until April



Environmental monitoring
of a schoolyard



JAEA Retirees to support Fukushima



Decontamination in the buildings by means of remote control

Goal

**Decrease in radiation dose for restoration work
in Reactor and Turbine Buildings of Fukushima
Daiichi Nuclear Power Station**

Means

**Pouring deionized water or polishing using the
remote control robot developed by JAEA**

Object

**Cesium which were accumulated on the floor
in Reactor and Turbine Buildings**

What happened to
JAEA facilities

Location Map of Research Centers in JAEA

Tsuruga

Prototype fast breeder Monju,
Decommissioning of Advanced
Thermal Reactor Fugen



Tono

High-level rad-
waste research



Horonobe

High-level rad-
waste research



Aomori

Decommissioning of
nuclear facilities, Broader
Approach technologies for
nuclear fusion energy R&D



Ningyotoge

Decommissionin
g of uranium
enrichment
plants



Tokai

Basic research,
Safety studies,
Neutron Science,
Nuclear fuel-cycle
technologies,
Rad-waste
management and
disposal, etc.



Kansai

Photon & Synchrotron
Radiation Science



Takasaki

Radiation application



Naka

Fusion R&D, ITER
support

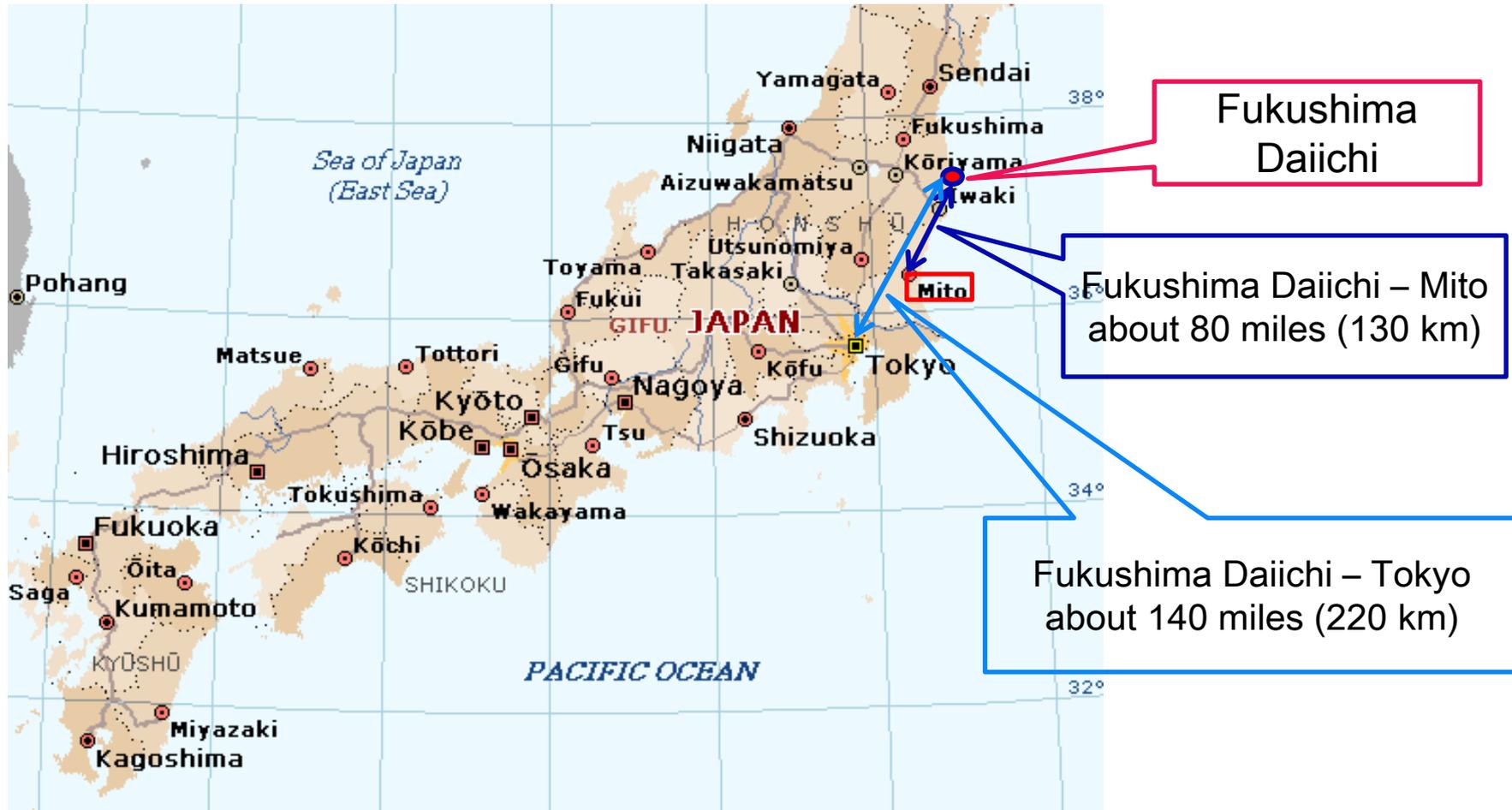


Oarai

Experimental reactors
Joyo, HTTR and JMTR;
Advanced reactor R&D
including FBR cycle
commercialization



How far from Fukushima Daiichi to Mito (Ibaraki prefecture) and Tokyo?



3.11 in Joyo

Consultation on the resumption of Joyo with JAEA retiree, who experienced Joyo construction and operation



Joyo: Annual Inspection(shutdown)
Primary, Secondary Loop: Sodium charged

the Great East Japan Earthquake
External power outage

DG No.1



Start up 2 diesel electric generators (DGs)

Result of Plant System Checking
- No damage

Filling up fuel and Cooling water for DGs

System Checking on each aftershock (above level 4)
- No damage

External power recovered (March 19)
Switched from DGs to commercial power

2 DGs stand by

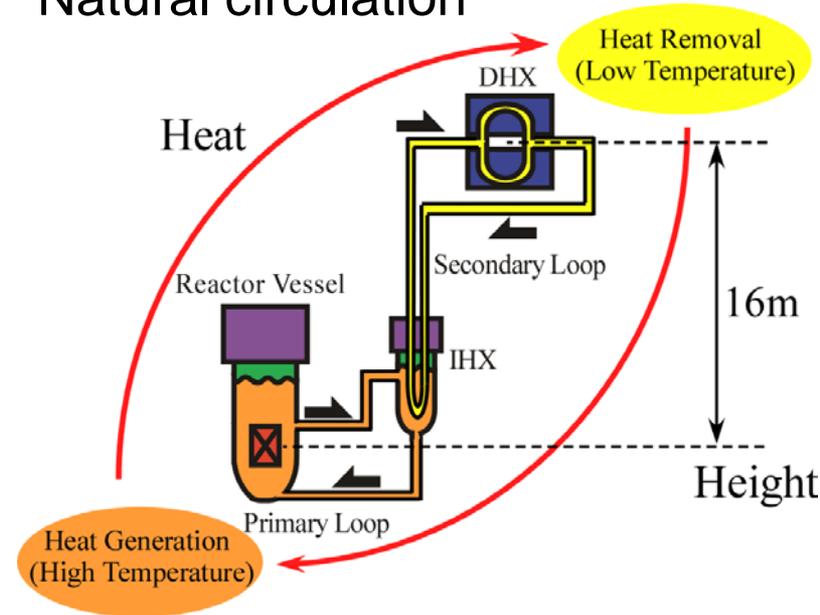


Safety of Joyo in case of a tsunami and blackout

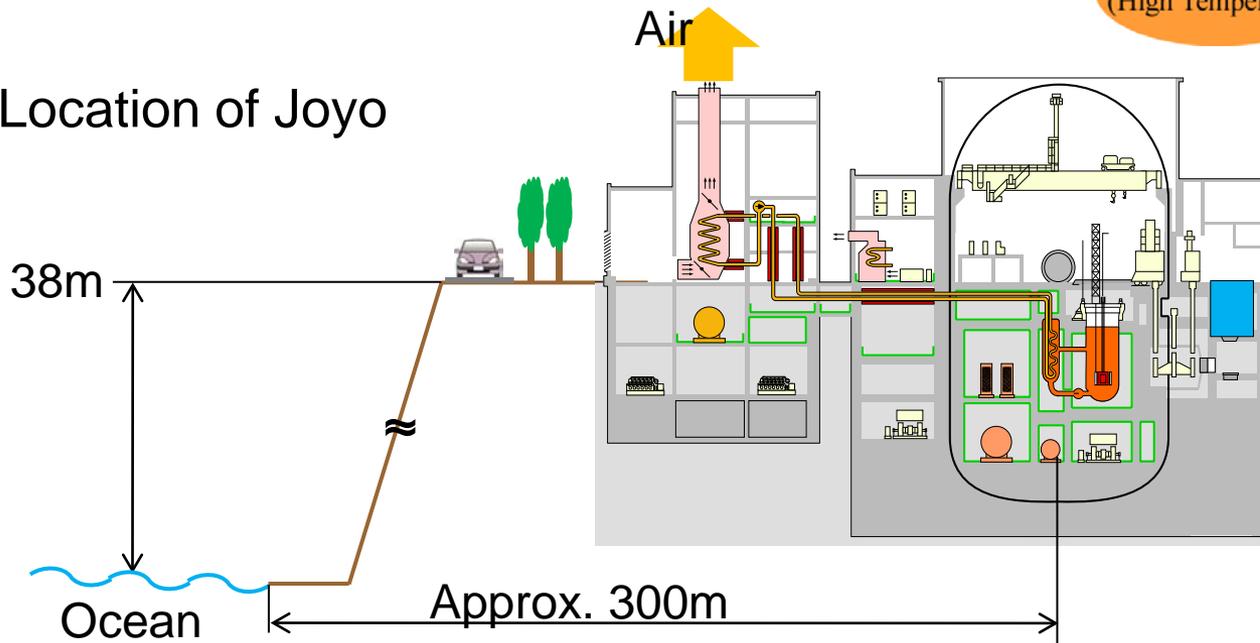
【Reactor】

- Joyo is located at 38 meters above sea level.
- The heat is released into air in the secondary loop finally.
- Decay heat can be removed by a natural circulation of sodium.

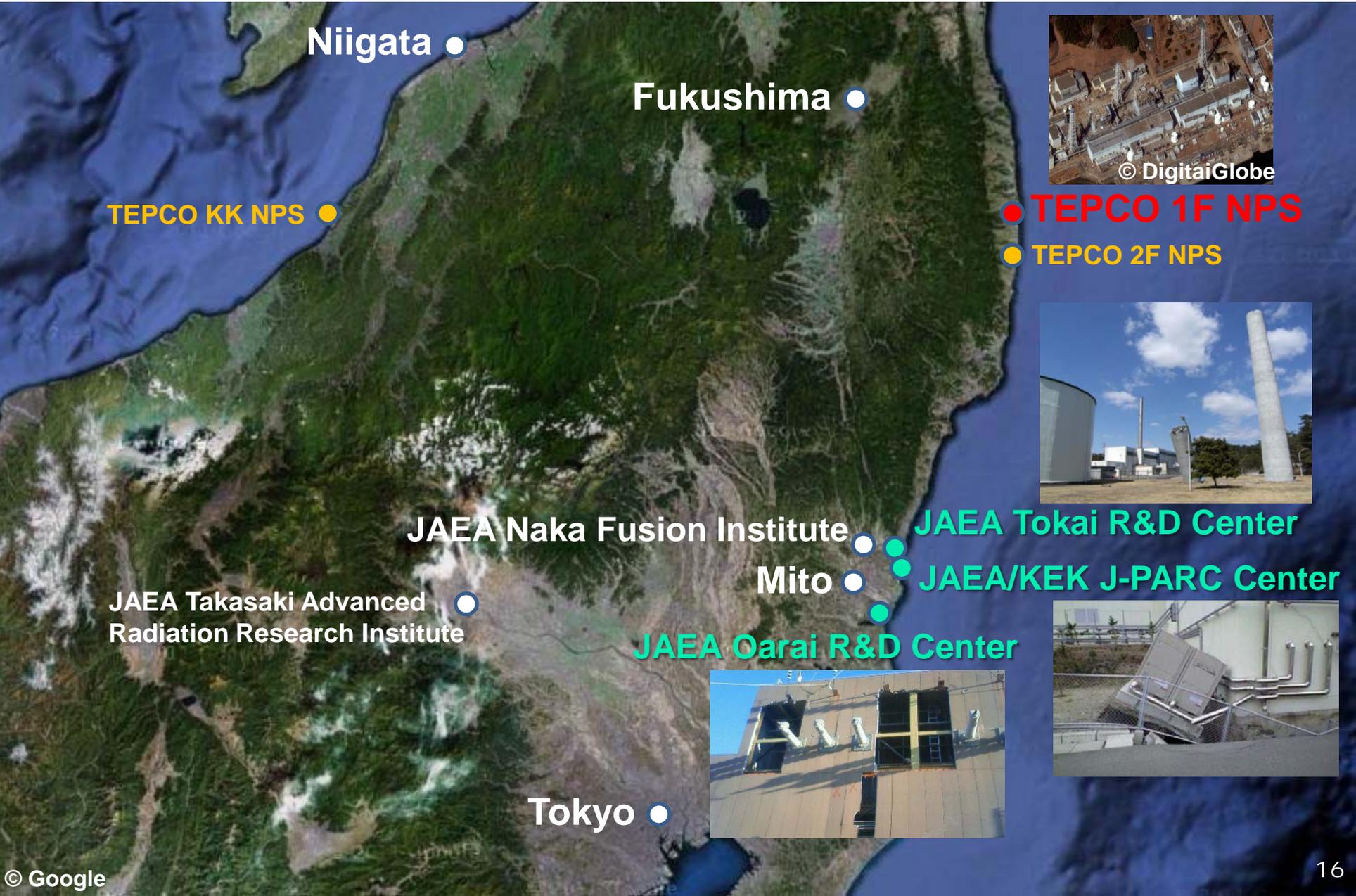
Natural circulation



Location of Joyo



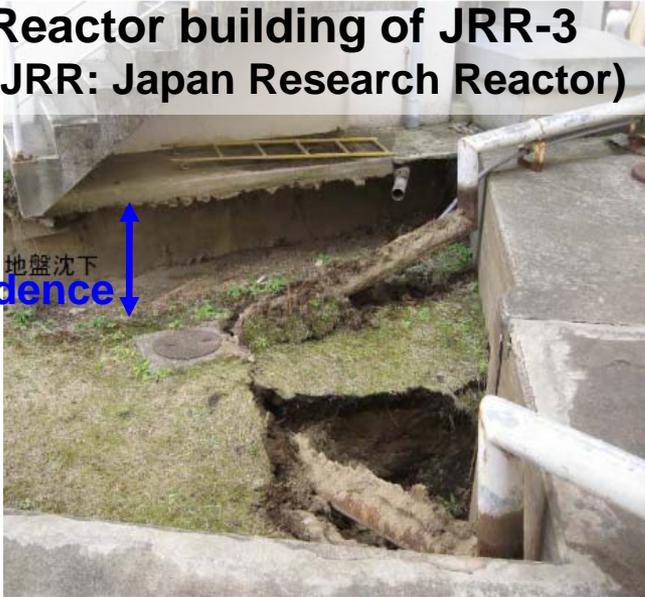
JAEA's Institutes in East Japan area



① Tokai Research and Development Center (1) Nuclear Science Research Institute

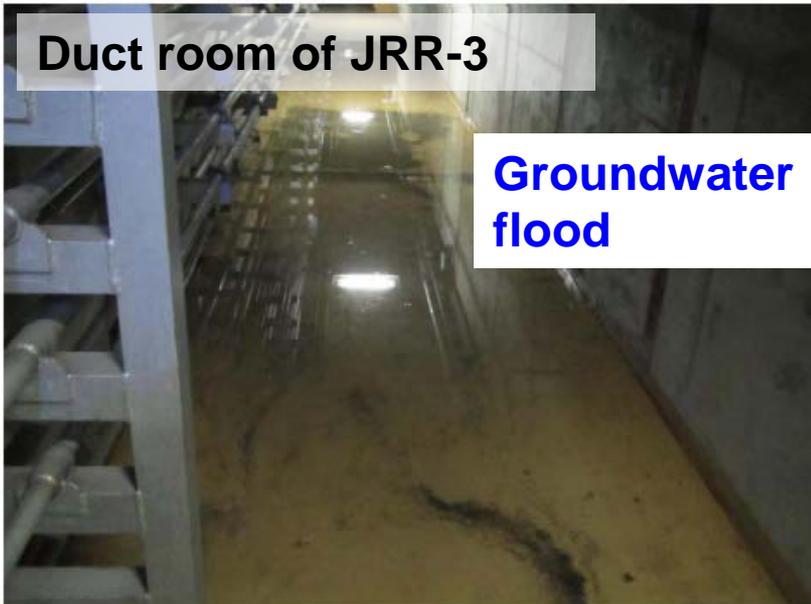
Reactor building of JRR-3
(JRR: Japan Research Reactor)

Land
subsidence



Duct room of JRR-3

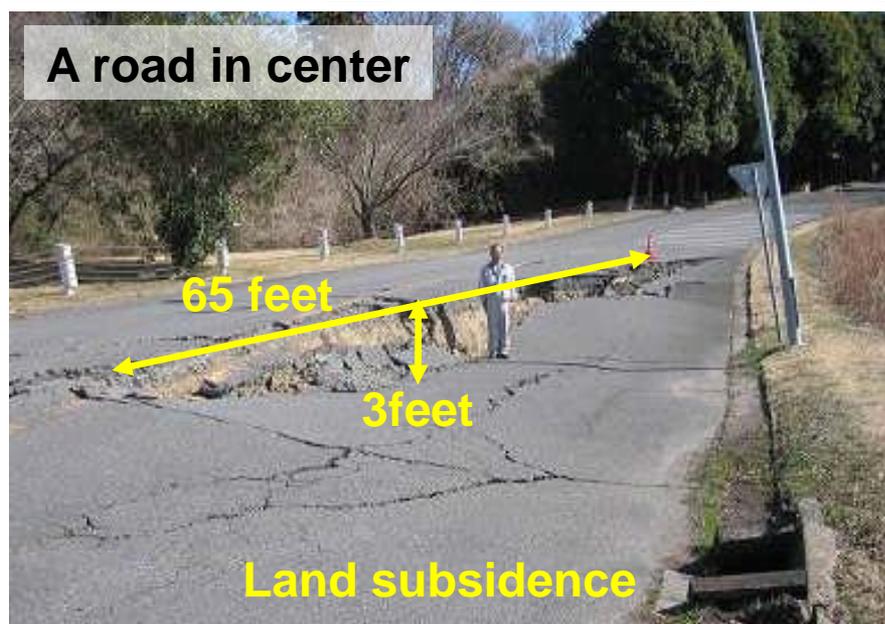
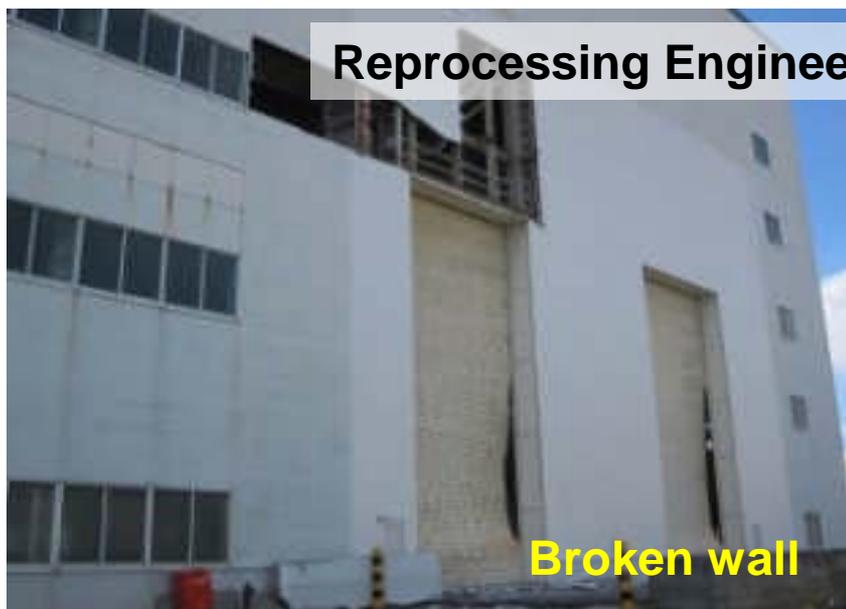
Groundwater
flood



Exhaust tower of JRR-2



① Tokai Research and Development Center (2) Nuclear Fuel Cycle Engineering Laboratories



② J-PARC Center



Front road of the Linac

Around the Neutrino Facility



Land subsidence



Air conditioning unit of the Neutrino Facility

Experiment hall of the Material and Life Science Experimental Facility



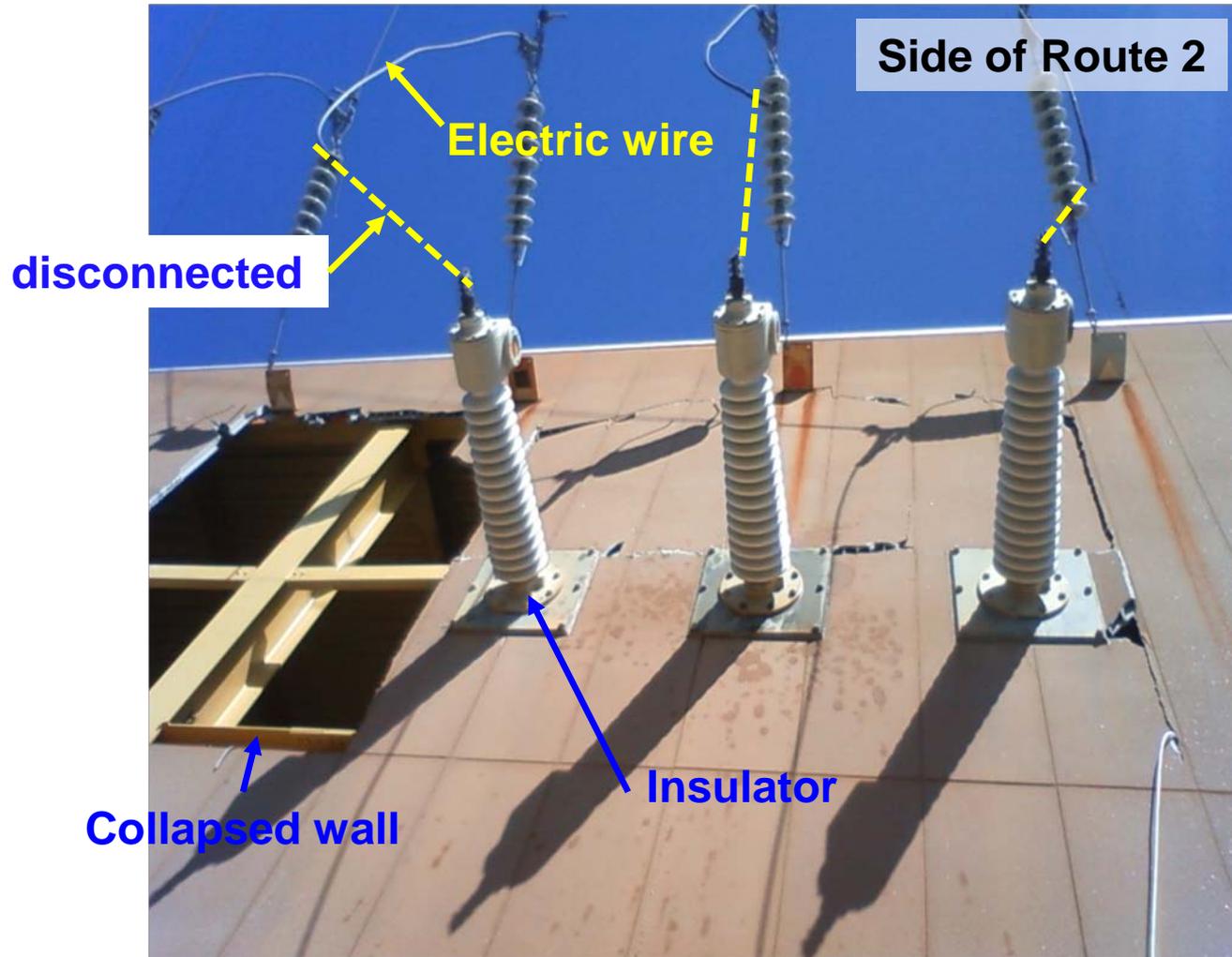
Concrete shields



Deviation of concrete shields

③ Oarai Research and Development Center

**Electricity receiving and transforming facilities
(Side of Route 2 which has three Insulators and electric wires)**



Lessons learned

Lessons Learned from 1F Accident

Introduction

- To take into account the lessons learned from 1F accident is crucial to avoid a similar accident of nuclear power plants worldwide.
- Based on open information, AESJ summarized the lessons in several topics and give examples of countermeasures as proposals.

Topics

1 .Earthquake

2. Tsunami

3. Station Blackout

4. Loss of Heat Sink

5. Accident Management

6. Hydrogen Explosion

7. Spent Fuel Pool

8. Safety Research

9. Regulation and Safety Design

10. Organizational and Crisis Management

11. Public Information Disclosure

12. Emergency Safety Management

[SOURCE]

Lesson Learned from 1F Accident , Atomic Energy Society of Japan

1. Tsunami

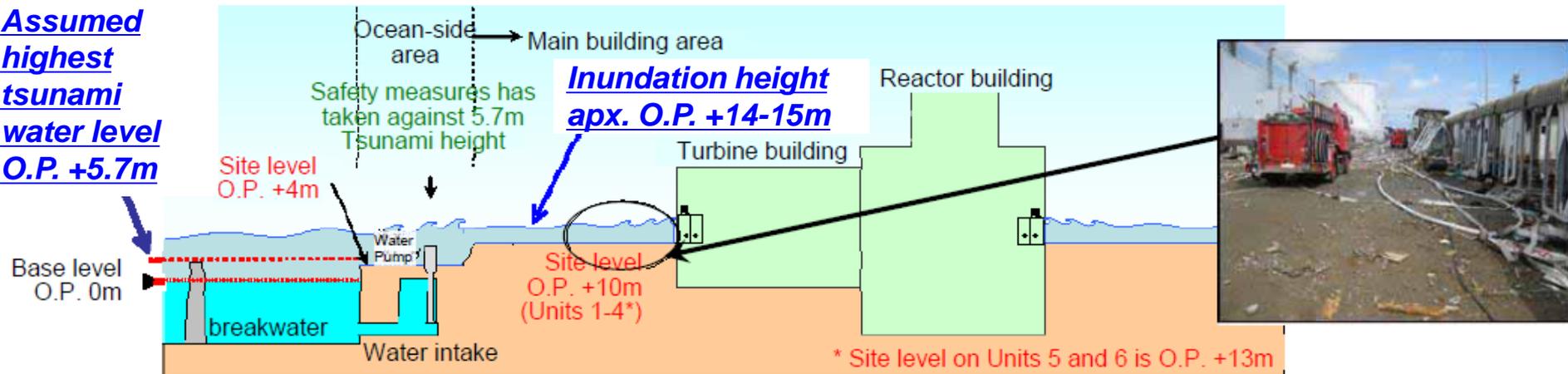
Lessons

- Estimated tsunami was too small.
- Safety System and Components were damaged because of seawater flooding, resulting in severe accidents.

Countermeasures

- Hardware preparation to protect safety System, Structure and Components from tsunami.
- Revision of tsunami estimation. Quantitative Risk Analysis for tsunami.
- Strengthening of sea embankment.

**Assumed
highest
tsunami
water level
O.P. +5.7m**



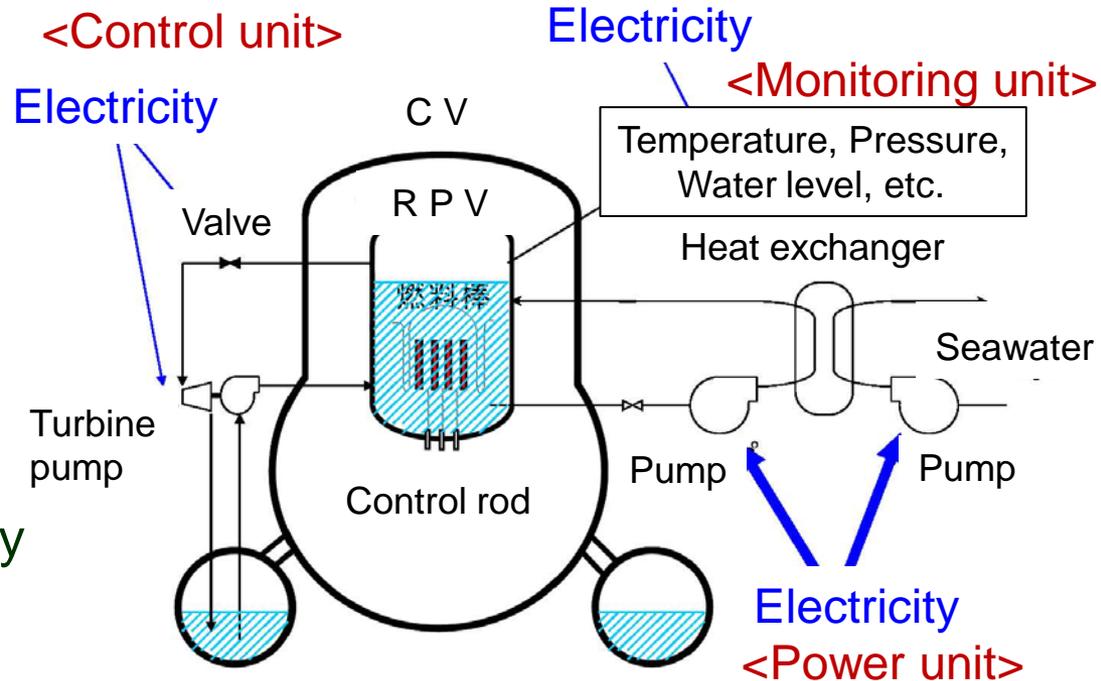
2. Station Blackout

Lessons

- a. Safety review for station blackout was insufficient.
- b. Long term station blackout caused the accidents progression.

Countermeasures

- (1) Revision for guidelines in safety reviews.
- (2) Diversifying power supplying system such as power supply cars and small generators.
- (3) Power supply preparation for important components and reactor monitoring system in case of station blackout.



Released from TEPCO

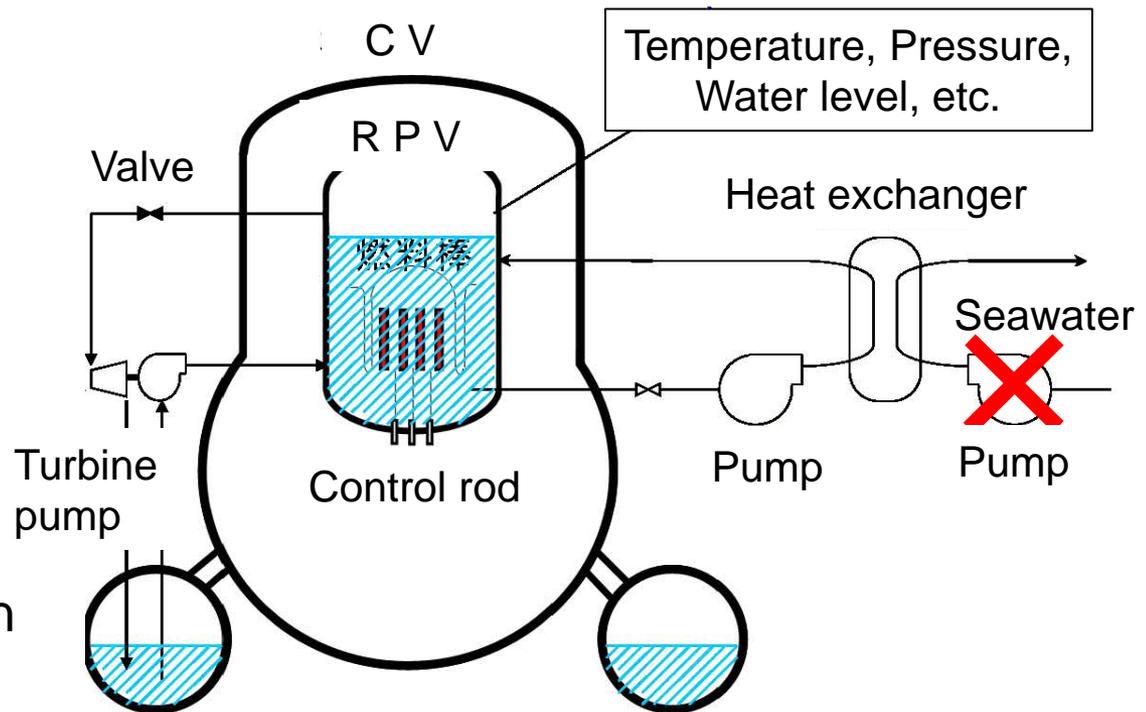
3. Loss of Heat Sink

Lessons

- a. Seawater cooling system is vulnerable to tsunami.
- b. Core damage might be delayed if the power was available.

Countermeasures

- (1) Preparation of the spare components such as seawater pump motor.
- (2) Water-tightness of seawater pump, such as waterproof wall or waterproof building.
- (3) Training for water injection using fire-engines.
Preparation of hardware.



4. Spent Fuel Pool

Lessons

- a. Spent fuel pool cooling was failed.
- b. Containment of radioactive materials in spent fuel pool is difficult

Countermeasures

- (1) Reconsideration of AM for spent fuel pool under blackout. For example:
 - Preparation of water injection using fire engines.
 - Equipment of flexible hose to enable water injection from outside.
- (2) Spare power to enable monitoring of pool temperature and leakage.



Inside of Spent Fuel Pool in Unit 4



**Concrete
pumping
vehicle**

Water Injection from outside

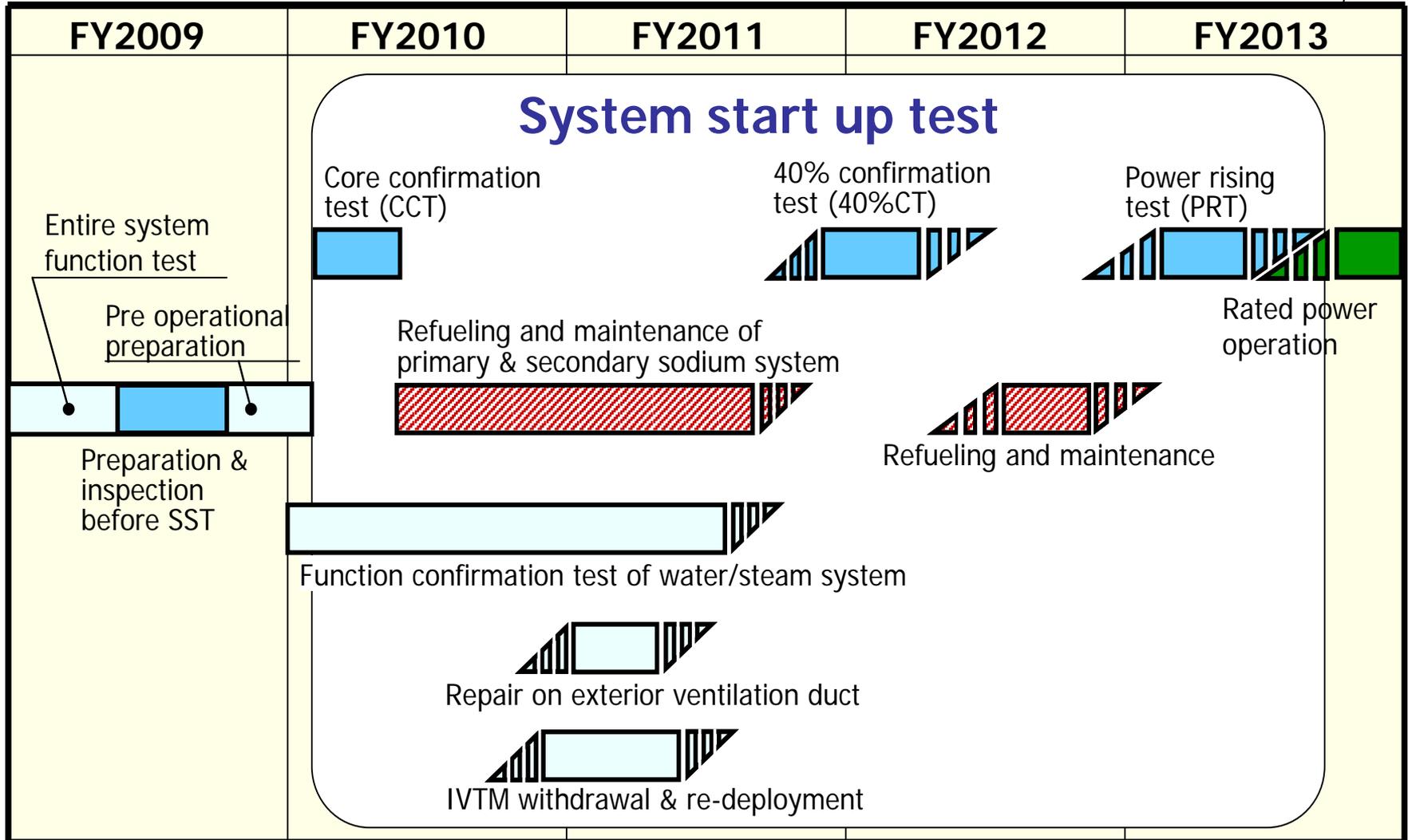
Summary of Important Lessons

- 1. Estimated tsunami was too small. Safety System and Components were damaged because of seawater flooding, resulting in severe accidents.***
- 2. Long term station blackout caused the accidents progression.***
- 3. Seawater cooling system was vulnerable to tsunami.***
4. Reactor parameter monitoring was difficult without electricity.
5. Containment of radioactive materials in spent fuel pool is difficult.
6. Safety design for external event was insufficient.

Effect to JAEA project

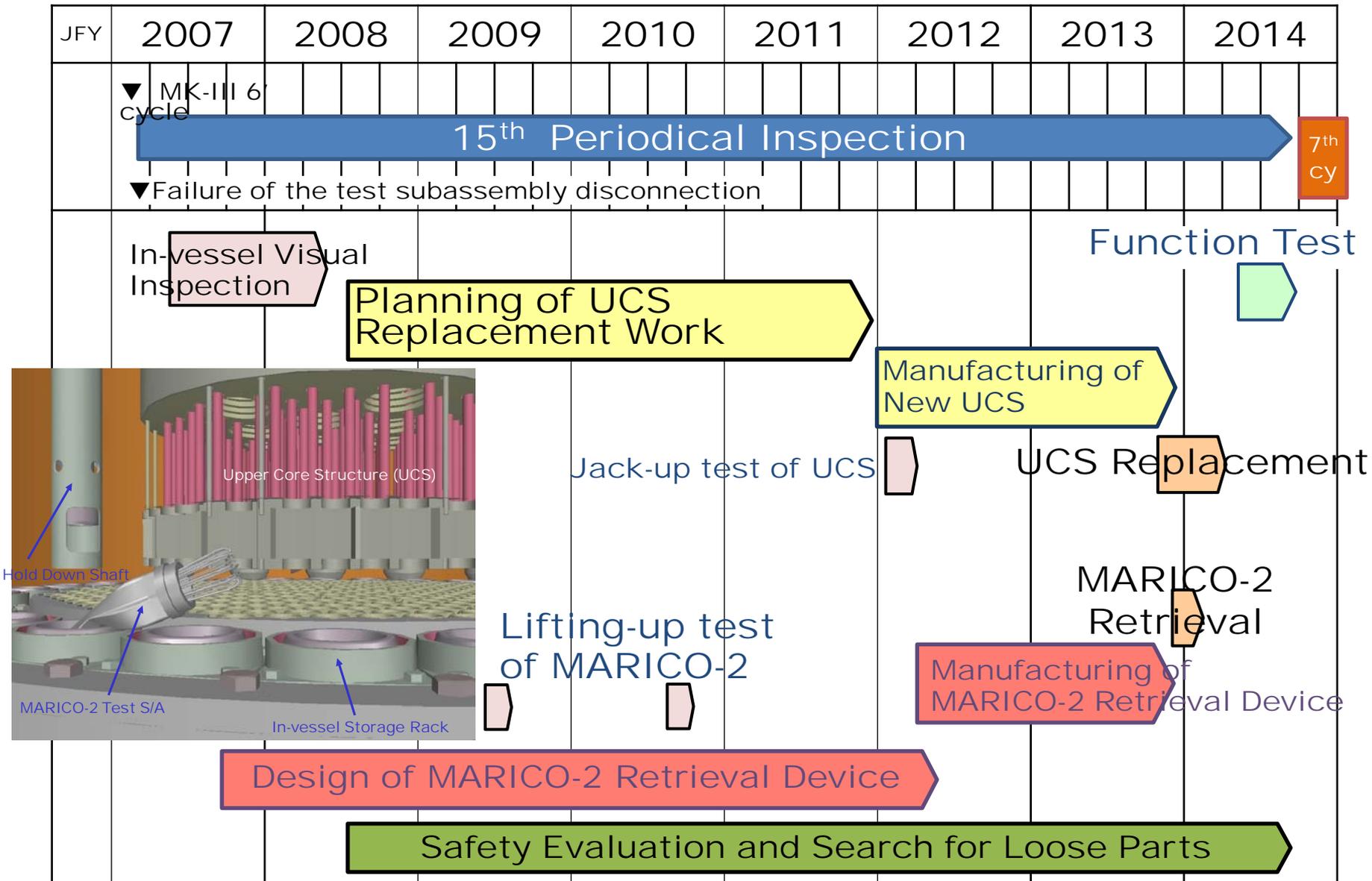
Overview of Monju system start-up test

Press released on December 16, 2010

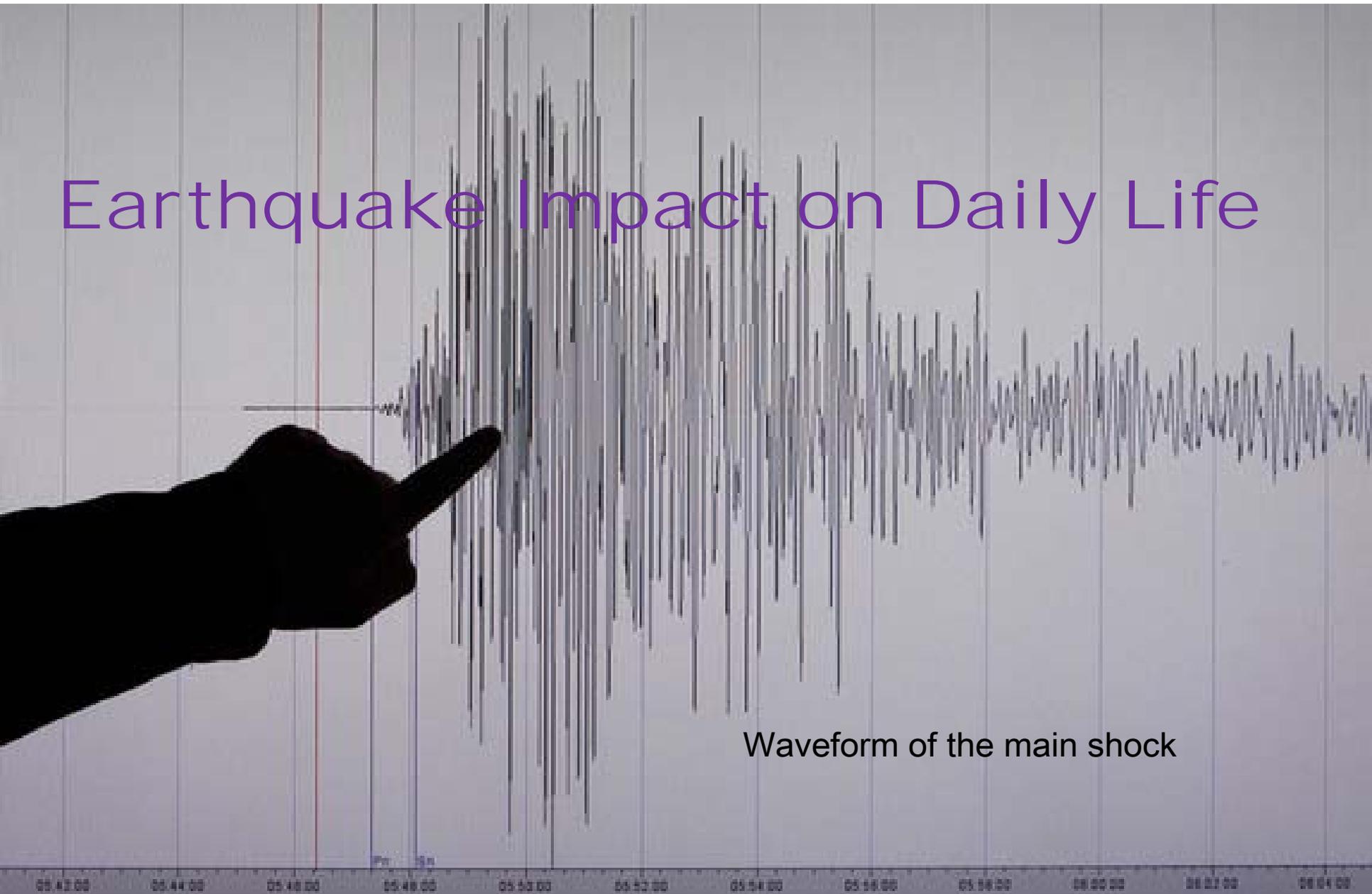


• Remark – 1: The schedule above is changeable even to an accelerated pace depending on the work progress.

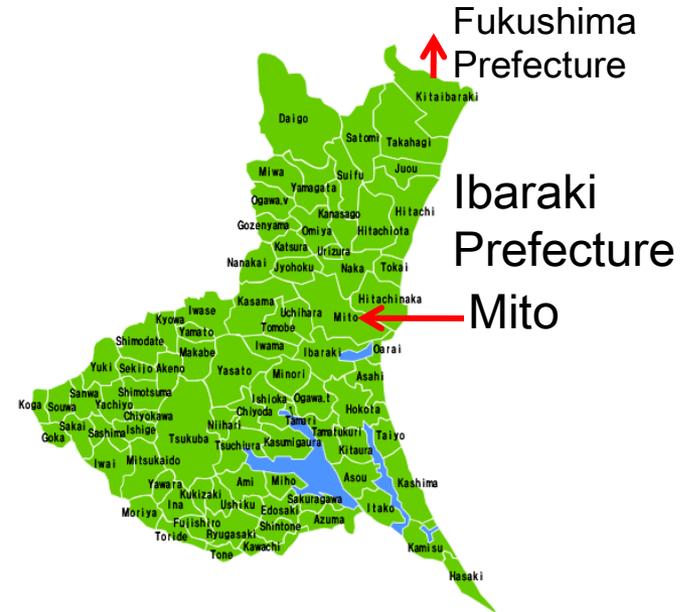
Master Schedule for Joyo Resumption (before March 11th)



Earthquake Impact on Daily Life



Waveform of the main shock



Collapsed gravestones



Mito Toshogu Shrine parking lot
(built to honor Ieyasu TOKUGAWA)

Two people buried alive but dug out.



A wall in local shopping area in Mito

Sagging express way in Naka





Twisted railroad tracks and leaning electric light pole in Hitachinaka on Joban Line of East Japan Railway (JR East)





A fallen sign in Mito station



Broken platform and an immobile train



Collapsed railroad embankment and remaining railroad in Hokota on Oarai-Kashima Line of Kashima Rinkai Railway





Big whirlpool by the tsunami
in Oarai
March 11





4.9 m tsunami hit Oarai town

Neighborhood of JAEA Oarai





Tilted but working!
Mito
March 15



Closed “24 hours a day throughout the year” convenience store
Mito
March 18



Panic buying in Tokyo



<http://blog.goo.ne.jp/310shin/e/2192e1251f6de6a55144a9e4a3b4270d>

Fukushima prefecture
Tsunami damage



<http://www.yakuji.co.jp/entry22462.html>

Train washed away uphill from Onagawa Station



Damage of the Great East Japan Earthquake

In Japan

**The worst disaster in Japan
after the end of World War II**

Death toll: 15,310 It may be increased significantly

The disappeared: 8,404

The injured: 5,364

Evacuees: 99,592 (down from the peak 468 thousand,
on March 14)

*as of June 1, 2011, by Tokyo Metropolitan Police Department

- The earthquake led to tsunami, fire, liquefaction phenomenon, Fukushima Daiichi accident, a large range of blackout and so on.
- Tokyo and 9 prefectures had damages.
- The recovery could cost \$185 billion up to \$309 billion.



Soon after **“OUT OF STOCK”**

5-hour or more long line to get 10 liters gasoline
March 18





Made in Japan Tobacco are sold out

Filter factories in north Kanto and Tohoku area were damaged.



Batteries for flash lights are gone
March 23



One month later, dark grocery store to save electricity (ongoing)

People in Ibaraki's favorite food "Natto". Package factories had damages

"One Natto per a household"



Power saving at a liquor store



Power saving at a liquor store





Radiation leaking from Japan's tsunami-damaged nuclear power plant has caused Tokyo's tap water to exceed safety standards for infants to drink.

Government gave out bottled water to households with a baby, nursery schools and kindergartens. March 23



So many people made a long line
to buy bottled water
Tokyo, March 23



Tokyo issued declaration of safety
of water March 24

On March 19, Japan announced that trace radiation was found in raw milk, spinach and other vegetables harvested in Ibaraki and Fukushima etc., and banned the sale.



By April 17, government lifted the ban but they especially leaf vegetables don't sell because of **harmful rumors**.



As of May 26, tea leaves of “tea town of Daigo (north west of Ibaraki)”, is still banned due to exceeded safety standard.

Action for stopping harmful rumors

【Agreement in Summit】

Taking a scientific approach over Japanese products

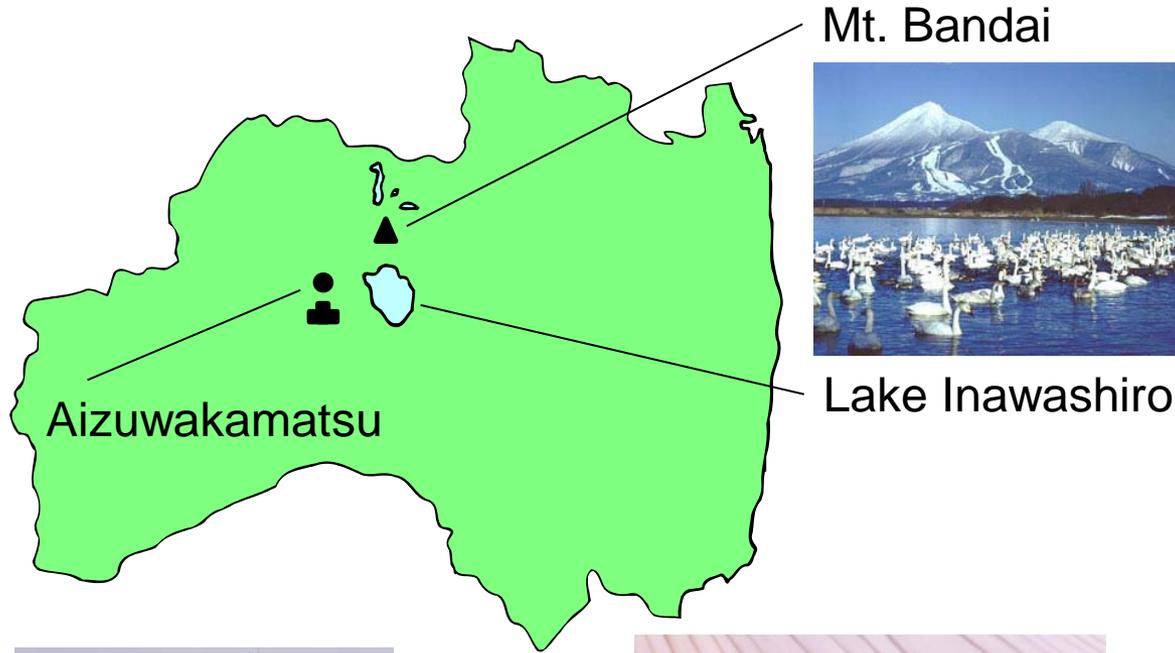


Chinese and South Korean leaders visits to the quake-hit areas. It highlighted the safety of Japanese food.



(Source) <http://www.kantei.go.jp/foreign/index-e.html>

Famous Fukushima Products



Mt. Bandai



Lake Inawashiro



Tsurugajo Castle
at Aizuwakamatsu



会津塗の文鎮(Paperweight)



日本酒栄川(Eisen)

Where are we going?

At Fukushima (May 19th)

I visited six of elementary schools and kindergartens in Fukushima to measure the dose rate in classrooms and in schoolyards. I realized that how much parents and teachers are afraid of receiving radiation. Actually, the dose rate lowered because the surface of schoolyards have been shaved off but still grass or bank, flowerbeds' dose rate marked 2-3 $\mu\text{Sv/h}$. The teachers were disappointed and said "That high? We must tell children not to go there, but they don't listen."

At another elementary school, the principal came along to survey with us under the blazing sun and kept noting our talk enthusiastically. We heard that teachers are continuously asked many questions regarding radiation effects to the children from their parents.

This year they decided not to use their swimming pools nor eradicating weeds. Children commute to/from a school by parents' car everyday and they make children stay at home after school. I'm worried about them.

At the other school I was asked if they should keep the windows closed throughout the day, I told them closing the windows may make the dose rate slightly lower, but there is no big difference. However, if you don't open the window, children would get heat stroke, it would be rather harmful to children's health.

People's concern in Fukushima

When they come back to home (or not) ?

Annual dose limit to be safe to stay

1 mSv/year : Lower of ICRP recommendation

20 mSv/year : Upper of ICRP recommendation

**100 mSv/year : Medical certification based on the
experimental data**

**It is necessary to decontaminate Cesium
(¹³⁷Cs), but vast and not so easy.**

People's opinion

Ibaraki area:

Relatively good, supportive to maintain nuclear energy.

Other area:

Some skeptical and cool to the nuclear policy.
*But, Do not want **electricity** shortage.*

Issue:

How we can overcome this summer.
How to deal with Hamaoka (Chubu E.P.Co)

Epilogue



Torahiko Terada

(寺田 寅彦, 1878 -1935)

Japanese physicist and author who was born in Tokyo. He was a professor at Tokyo Imperial University, a researcher at RIKEN, and worked on a wide range of topics in physics. Also, he was a professor at the Earthquake Research Institute.

Epilogue

“It is easy to fear something too little, or too much. But it seems rather difficult to fear it justly.”

→ **Correct knowledge**

『天災と国防』 by Torahiko Terada

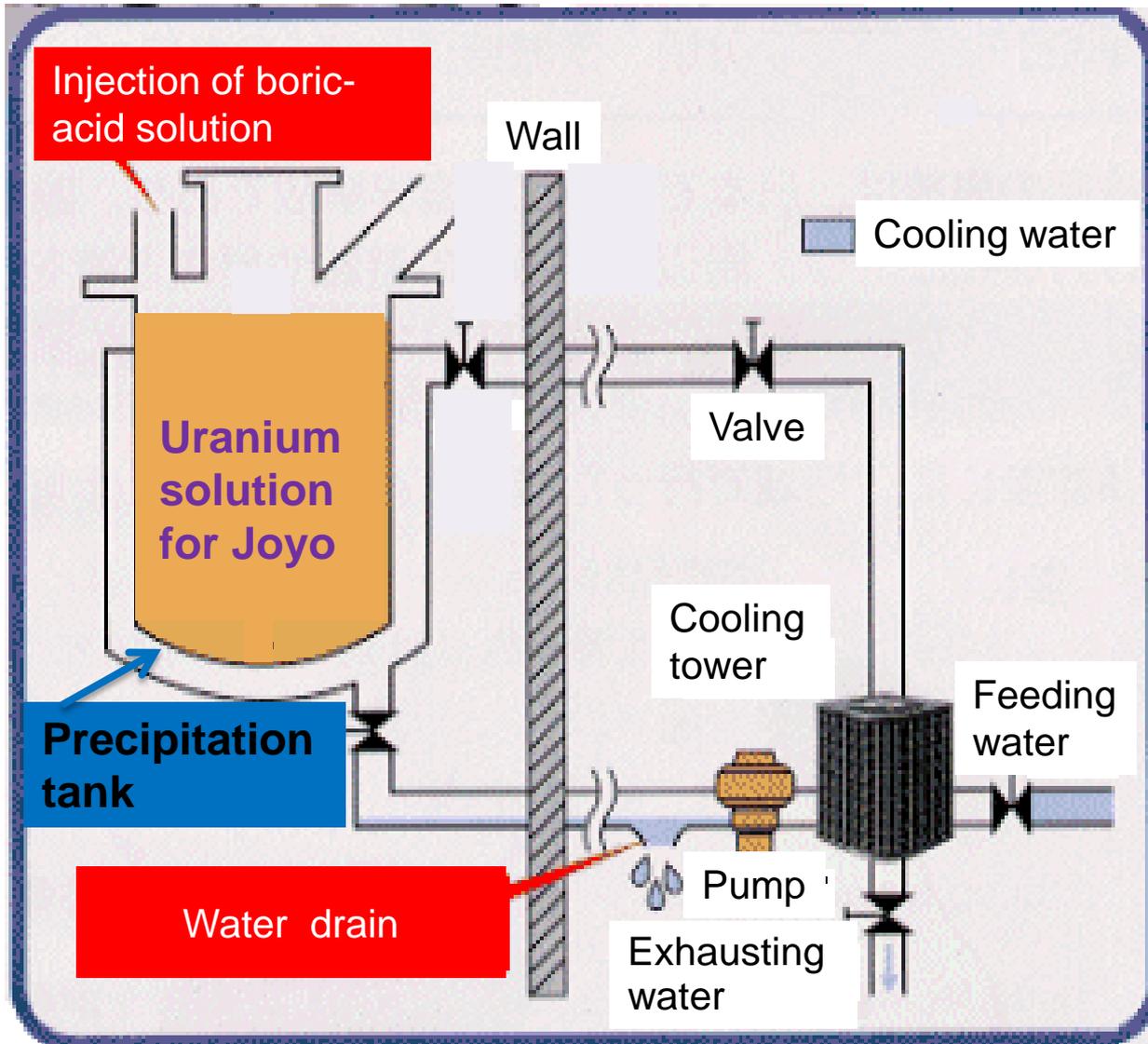
“Natural disaster and National defense”

In ancient times, people lived in coves and were not so affected earthquakes or storm. After a while they built humble houses but they broke easily and were rather safe and easy to remake. At that time people were fully amenable to nature and didn't act against to it.

As civilization progresses, people had ambitions to conquer the nature. They made constructions defying the gravity, water and wind force. But when people thought they won the game with the nature, a natural disaster pounce on lives like a large herd of savage animals. It smashes buildings, sea embankments, wealth and people.

However in the first place, people's creation that defying the nature, made the power of disaster bigger and further. The base of the motion energy, the potential energy was enlarged by our creations. What magnifies disasters is, in fact, none other than civilized ourselves.

(Translated by Aoyama)



Kenji Sumida

Emeritus of Osaka University
 (Former vice-chairman of
 Nuclear Safety Commission
 of Japan)

He headed JCO critical
 accident in Tokai to the end.

The Plague by Albert Camus

There's no question of heroism in all this. It's a matter of common decency. That's an idea which may make some people smile, but the only means of fighting a plague is – common decency.

"What do you mean by 'common decency'?" Rambert's tone was grave.

"I don't know what it means for other people. **But in my case I know that it consists in doing my job.**"

Lecture on Nuclear Regulation



PHSはマナーモードに
設定して下さい。



はじめに

ものを怖がらなさ過ぎたり、
怖がり過ぎたりするのはや
さしいが、

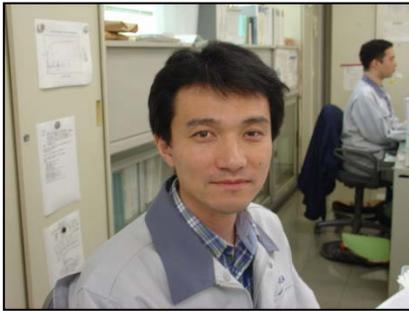
正当に怖がることはなかなか
難しい

寺田寅彦

(随筆「小爆発二件」より)

(大正昭和時代の物理学者・随筆家)

★Team JOYO★



Chikara Ito, Ph.D

★Organizer

“Takafumi’s right hand”



Takafumi Aoyama

★Speaker



Shigetaka Maeda, Ph.D

“Takafumi’s left hand”



Etsuo Tomita

★Fukushima support



Masaya Yamamoto

★1F summary,
Lessons learned



Hiroto Saito (freshman)

★Joyo summary



Tomohiko Masui

★Takafumi’s senior



Sawako Watahiki

★Fukushima FAQ



Takaya Kuroha

★IT expert



Takashi Ishikawa

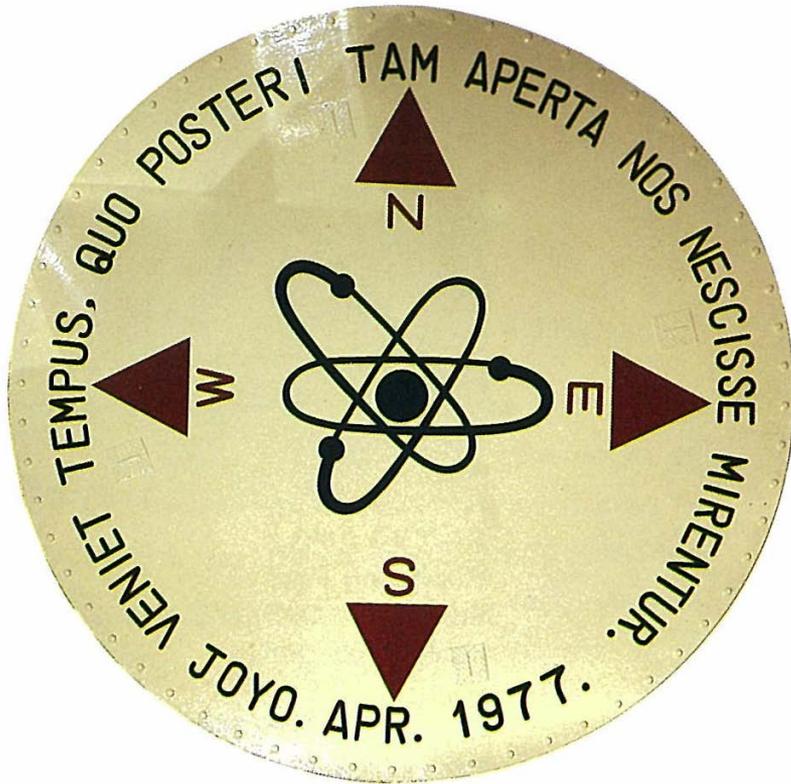
★Effect to JAEA facility



Yoko Ohara

★Life impact,
Linguistic support

Seneca's word

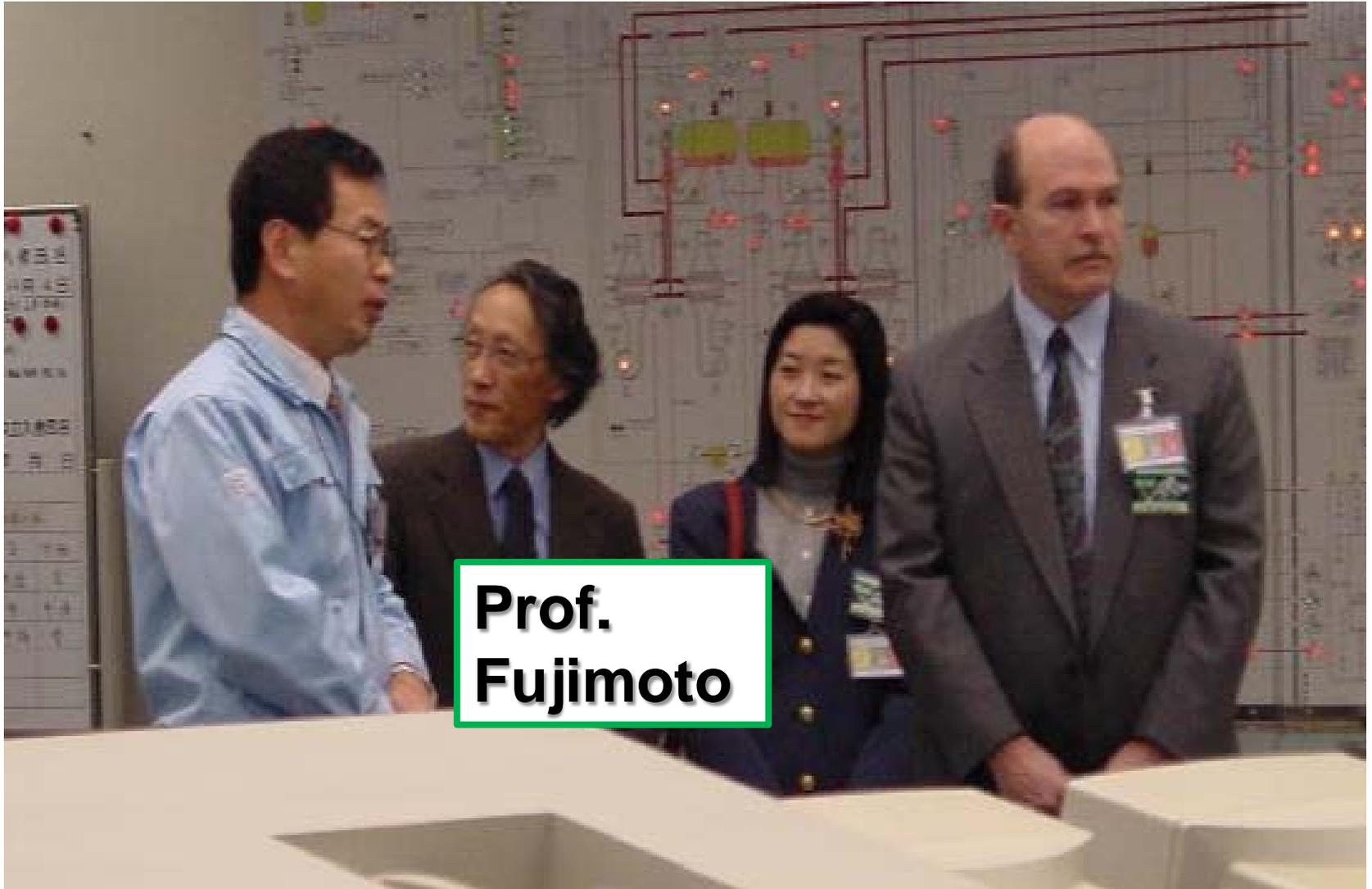


The mark is drawn on the operation floor of Joyo containment vessel to commemorate the first criticality in 1977.

The meaning is as follows;

“The time will come, when our posterity will wonder that we have only now just realized such a self-evident truth.”

Prof. Fujimoto (former President of Ibaraki Christian College)



**Prof.
Fujimoto**

I Look Up When I Walk Down

(Known as “**Sukiyaki Song**”)

Japanese Lyrics by Ei Rokusuke and Music by NAKAMURA Hachidai

Song by **SAKAMOTO Kyu**

Translation by YAMAGISHI Katsuei©

- I look up when I walk down, down the street all alone.
So tears will not wet my cheeks as I walk along.
I remember the spring days I spent with you,
But now every night I'm left all alone.
- I look up when I walk down, down the street all alone.
I count the blurry stars with my tearful eyes.
I remember the summer days I spent with you,
But now every night I'm left all alone.
- I hope for happiness beyond the clouds.
I hope for happiness high up in the sky.
- I look up when I walk down, down the street all alone.
So tears will not wet my cheeks as I walk along.
With tears in my eyes, I walk along;
I walk along the street all alone.

さいごに (Saigoni)

どうもありがとうございました。

Doumo Arigato Gozaimashita

**Thank you very much for your kind
and gentle attention**