

# What we learn from the large-scale soil sampling for radioactive nuclides emitted from the Fukushima Dai-ichi nuclear power plant accident?

Mamoru Fujiwara

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Kyoto, Japan

1. What happened in the Japanese academic community after the TEPCO Fukushima Dai-ichi NPP accident?
2. What was worried about the radioactive fallouts?
3. What were the difficulties?
4. What we studied from the accident for future?
5. What should we prepare for urgent accidents?

**Location of Japan's Nuclear Power Plants (NPPs)**

**About 50 NPPs**

March 11, 2011 Earthquake Epicenter

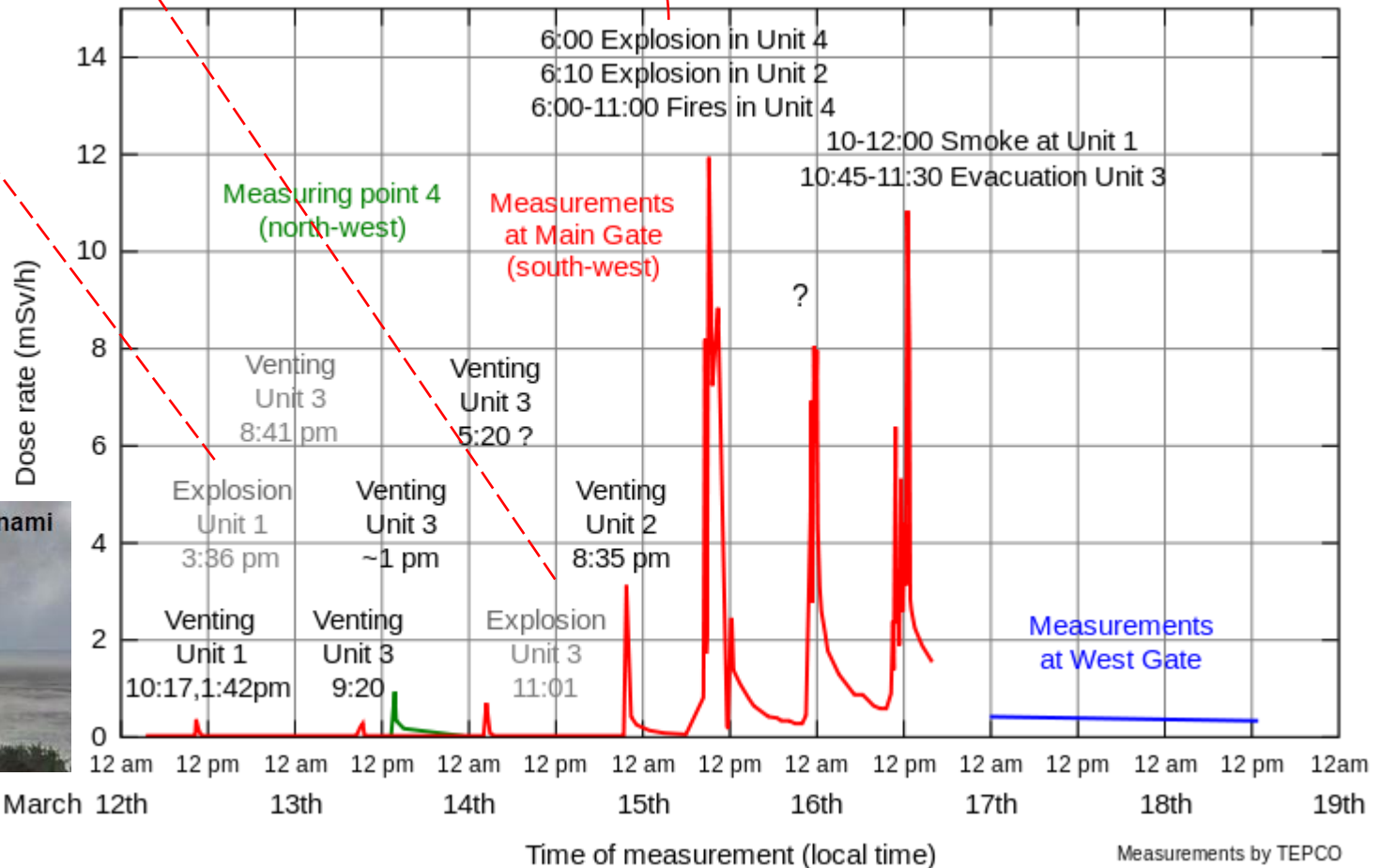
Fukushima Daiichi

Fukushima Daini

## About 50 NPP in Japan

# M9 earthquake on 3.11, 2011

# Fukushima Daiichi



## 14 m height Tsunami



3.11 2011

March 12th

13th

14th

15th

16th

17th

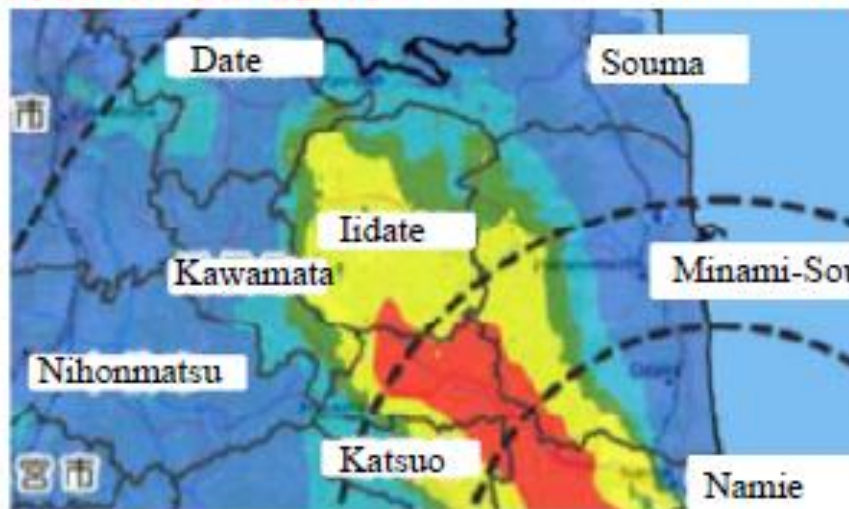
18th

19t



# Cs-137 Fallout in Fukushima

<http://radiationprotection.tumblr.com/>



Corresponding fallout (by color)



Bq/m<sup>2</sup>

10<sup>7</sup>

10<sup>6</sup>

10<sup>5</sup>

10<sup>4</sup>

10<sup>3</sup>

10<sup>2</sup>

10

1.0

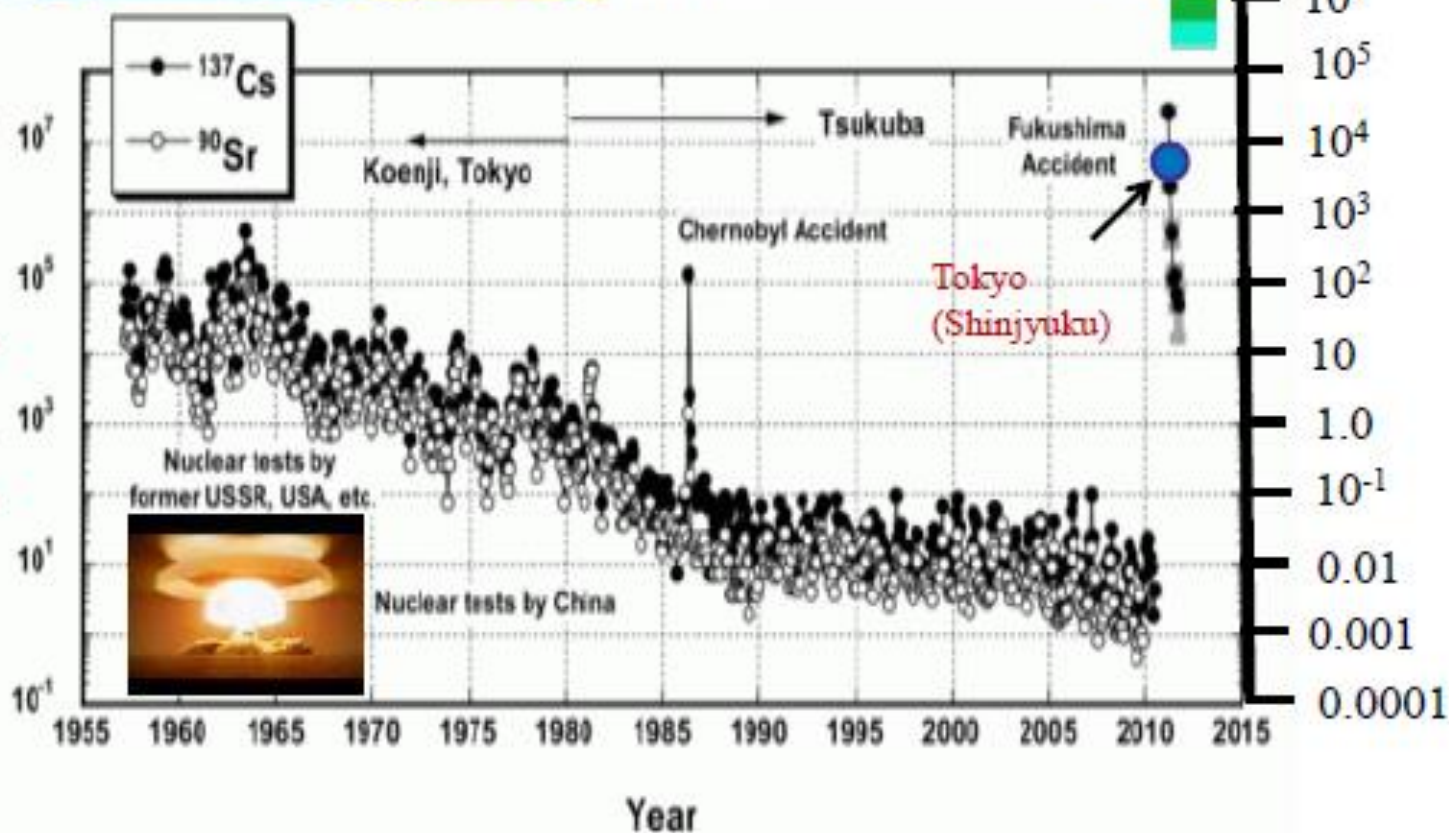
10<sup>-1</sup>

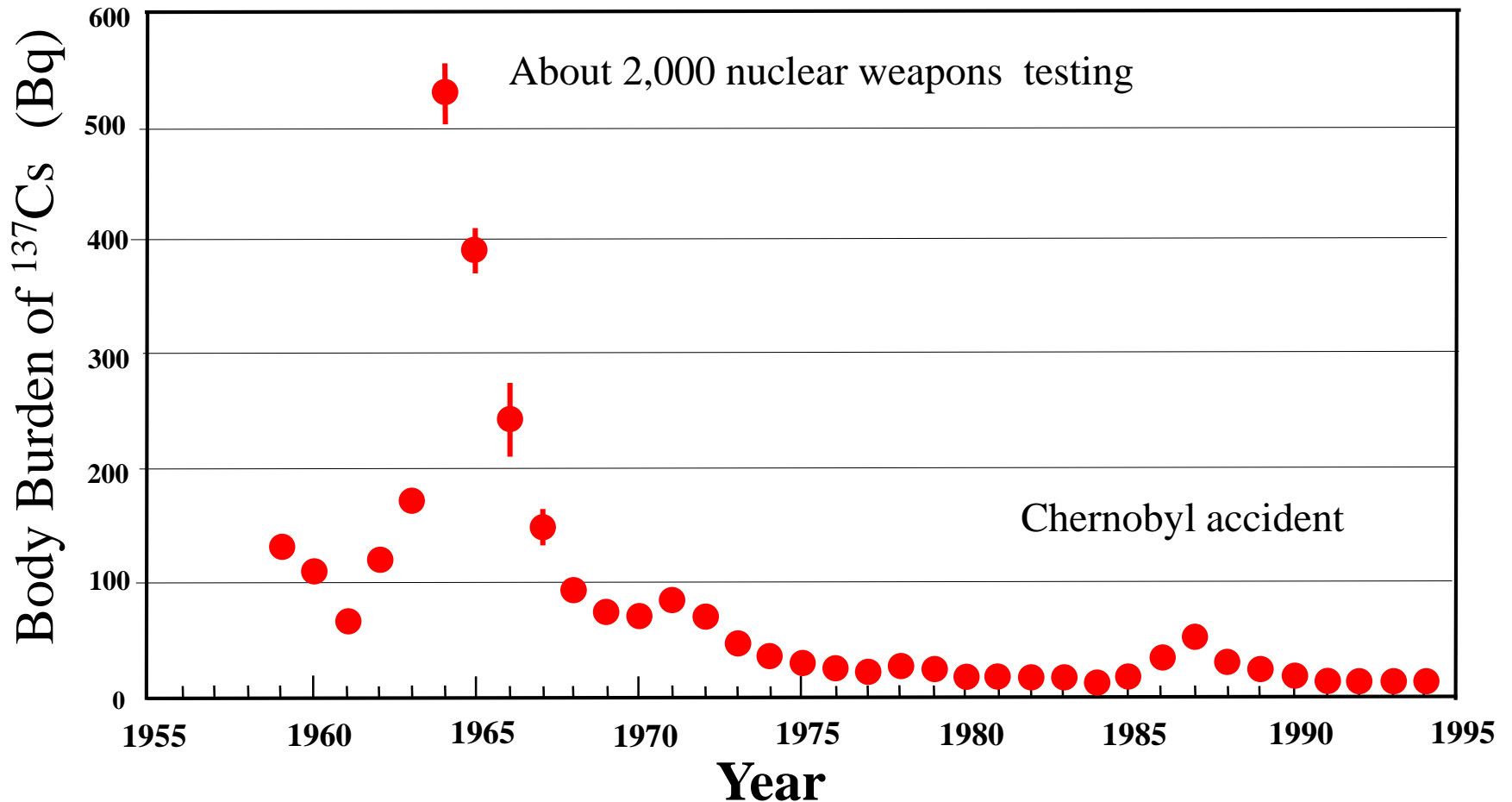
0.01

0.001

0.0001

Monthly fallout of <sup>90</sup>Sr and <sup>137</sup>Cs around Tokyo (mBq/m<sup>2</sup>/month)





**Annual average of  $^{137}\text{Cs}$  body burden of 20 Japanese male adults as a function of elapsed year around the atomic bomb tests in the world.**

**Ref: M. Uchiyama, Y. Nakamura, and S. Kobayashi, Health Physics 71, 320-325 (1996).**

**Infection speed of health fear  
is very fast (Fear Syndrome).**

**“Our own thinking mostly  
takes place from the individual  
personal view point.”**

**(Perspectivism by Nietzsche)**

# Time sequence after Fukushima accident (2011)

- 3.11: 14:46 M9 earthquake
- 3.11: 19:03 Declaration of a Nuclear Emergency Situation
- 3.11: 21:23 Evacuation from 3 km zone
- 3.12: 15:36 Explosion of NPP #1
- 3.12: 18:25 Evacuation from 20 km zone
- 3.14: 11:01 Explosion of NPP #3
- 3.15: 06:10 Explosion of NPP #4
- 3.15: 11:01 Evacuation from 30 km zone
- 3.16: Nuclear Physics group meeting at RCNP
- 3.17-4.10 Air borne measurements by US DOE
- 3.20 Nuclear Physics group → Screening
- 3.23 First SPEEDI results was given.
- 3.29 Tokyo University (CNS) called Marine and Earth scientists for collaboration.
- 3.31: Proposal for soil map of RCNP → MEXT
- 4.11: Discussion for Group organization at RCNP.
- 4.13: Discussion in Tokyo with all the groups.
- 4.20: Detailed protocol discussed in Tokyo
- 5.01-05 Pilot soil sampling
- 5.19 Soil Map project was formally recognized as a government project.
- 5.26 MEXT Committee was established.
- 6.4- start of the soil sampling project
- 8.2 Ambient dose map
- 8.29  $^{134}\text{Cs}$ ,  $^{137}\text{Cs}$  map
- 9.21  $^{131}\text{I}$  map
- 9.30  $^{239}\text{Pu}$ ,  $^{90}\text{Sr}$  map
- 10.31  $^{129\text{m}}\text{Te}$ ,  $^{110\text{m}}\text{Ag}$  map

# Nuclear Physics Group joins for Screening

March 16 Emergency Discussion on the rescue operation of Fukushima people.

About 50 nuclear scientists join this discussion.

18 Talk with MEXT for calling scientists to join the program.

MEXT suggests us to join the screening work in Fukushima.

19 Call for joining.

20 Strategy meeting for dispatching nuclear scientists.

21 First group went to Fukushima by car from RIKEN in Tokyo.

23 Second group went to Fukushima by car from RIKEN in Tokyo.

24 Thyroid check ( ~ March 30 )

25 Third group went to Fukushima by car from RIKEN in Tokyo.

...

**Screening Activities continue until 20 August, 2011**



# Nuclear Physics Group joins for Screening

We understand that

1. After the Tokai-mura JCO accident on 30 September 1999 ([http://en.wikipedia.org/wiki/Tokaimura\\_nuclear\\_accident](http://en.wikipedia.org/wiki/Tokaimura_nuclear_accident)), emergency teams for only health are organized and are kept to work at the government level.
2. Every day, more than 100 people joined this screening work in March/April after the Fukushima Daiichi NPP accident.
3. Only about 20 nuclear physics scientists joined in the initial campaign.

# Radioactivity Screening

**About 113,000 inhabitants were evacuated.**

**Kohriyama 2011. 3. 22**

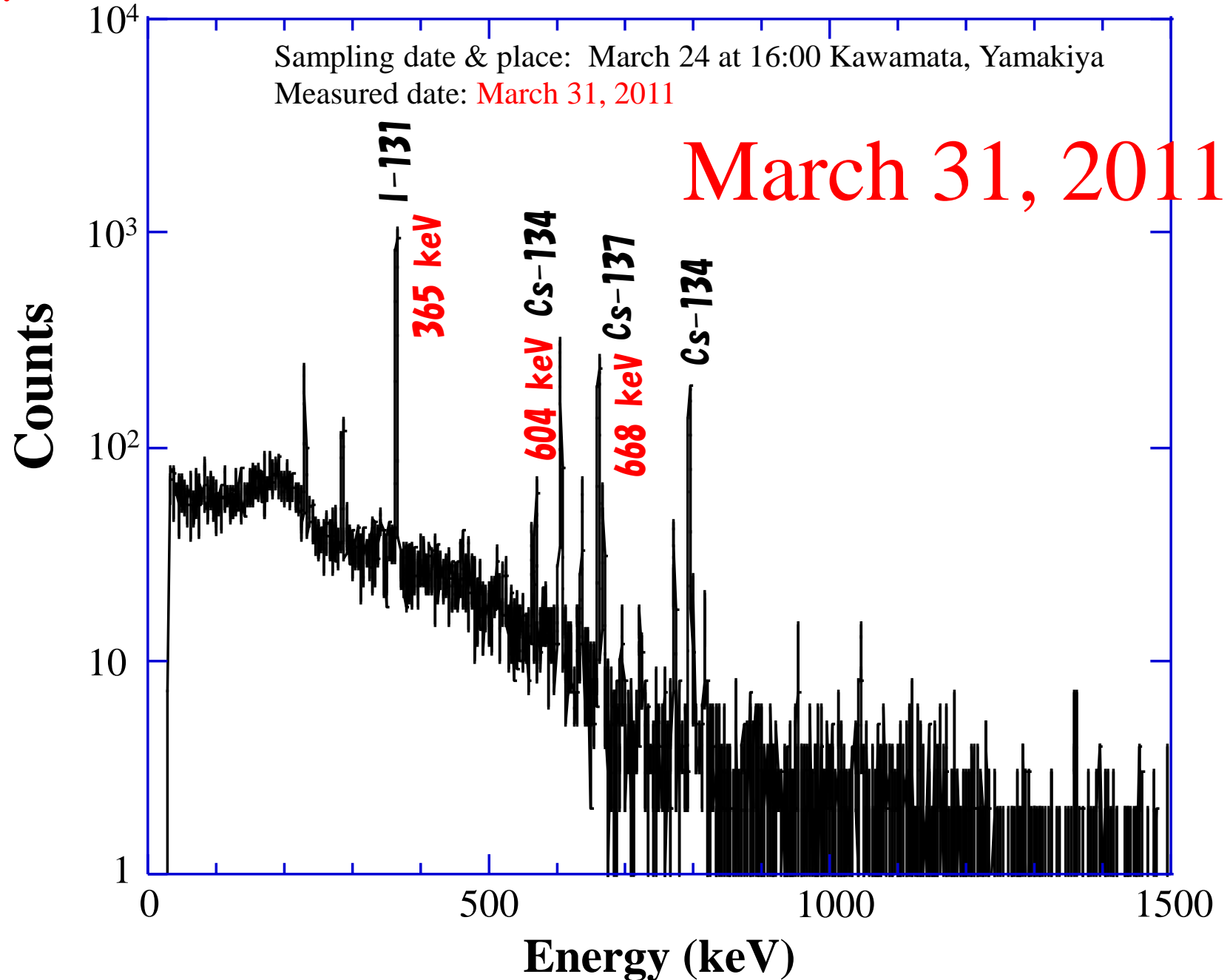


**Yamakiya, Kawamata 2011. 3. 24**

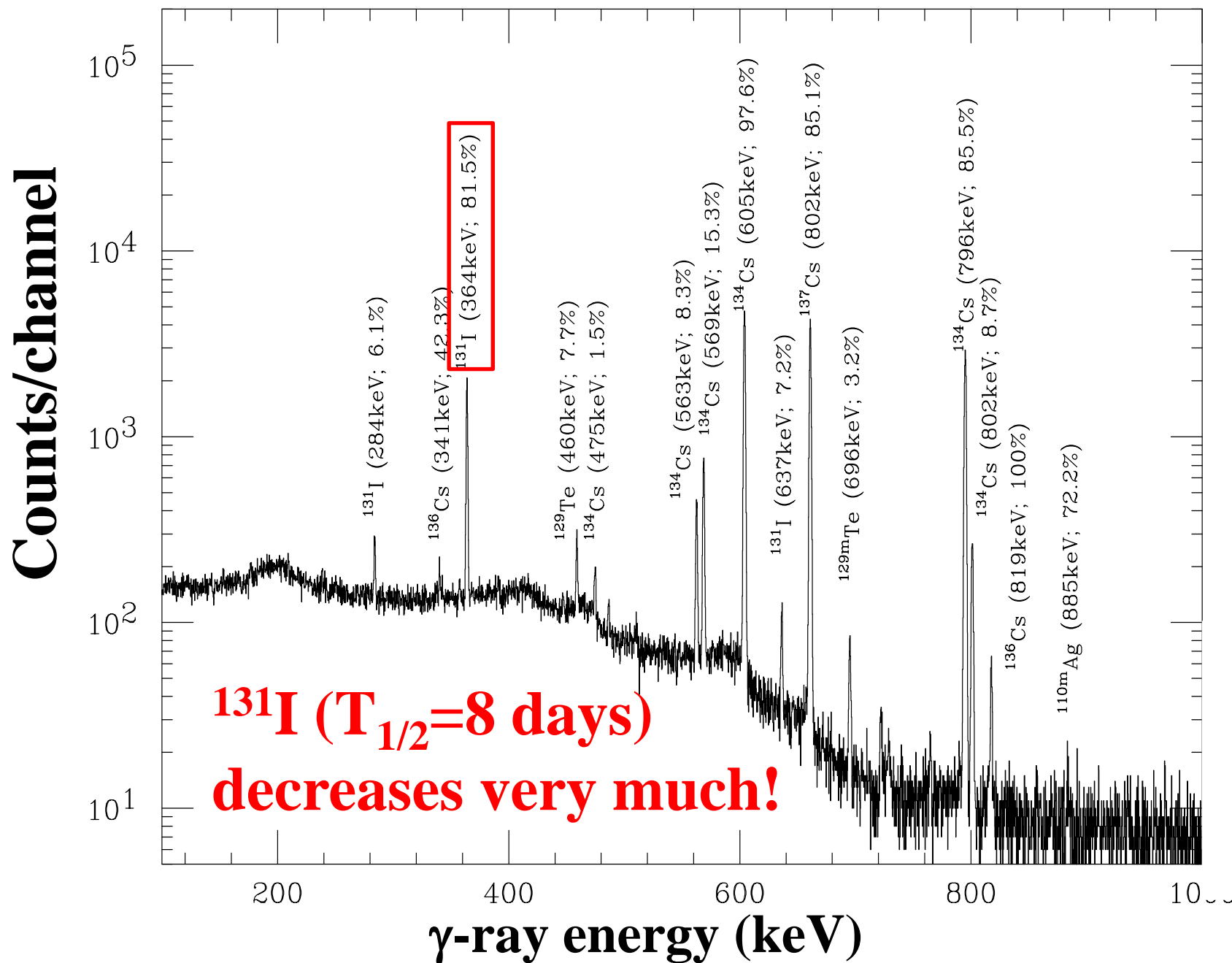


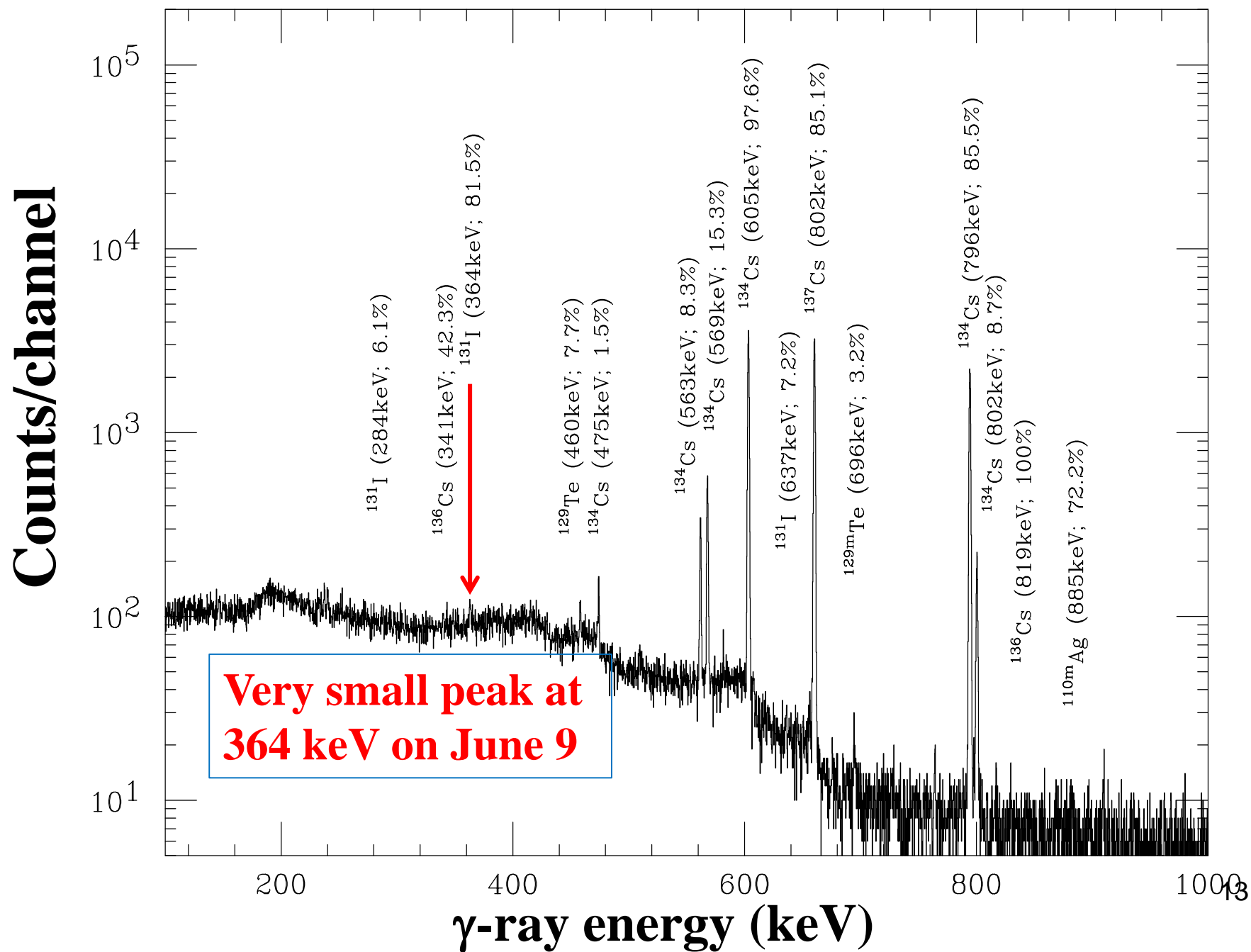
Thyroid Screening for Children  
(2011.3.24-30)

# $\gamma$ -ray measurements of fallout radioactivity



Soil A (May 9)







# Radioactivity Fallout Measurements

- March 16** Emergency Discussion on the rescue operation of Fukushima people. About 50 nuclear scientists join this discussion.
- 17** Discussion at the headquarter of Osaka University.  
**Full agreement for the rescue operation in Osaka University.**
- 18** Osaka University decided to pay every effort for the rescue operation for the refugee people due to the East Japan M9 Tsunami disaster on 3.11 2011. This included the soil sampling project after the Nuclear Power Plant accident.  
MEXT and Osaka University agreed to used a **1 Million dollar** budget in 2011.
- 25-29** **Fujiwara and Hoshi** of Hiroshima University prepared the first proposal for the soil radioactivity map.  
First group went to Fukushima by car from RIKEN in Tokyo.
- 31** Proposal paper was discussed at the Science Council of Japan.
- April 2** **Osaka University decided to use 0.1 M\$ for preparing the soil sampling instrument.** Original draft was sent to Dr. Shibata, one of the member of the committee.
- 4** Science Council of JAPAN sent Emergency statement to the government cabinet.
- 13** A scientist collaboration team started for the soil measurement
- May 1-5** Pilot program was done. **Protocol for sampling and measurement was completed.** Headquarter, Logistics and Hotel management were done by Osaka group.
- June 4** Soil sampling started in the Fukushima area.

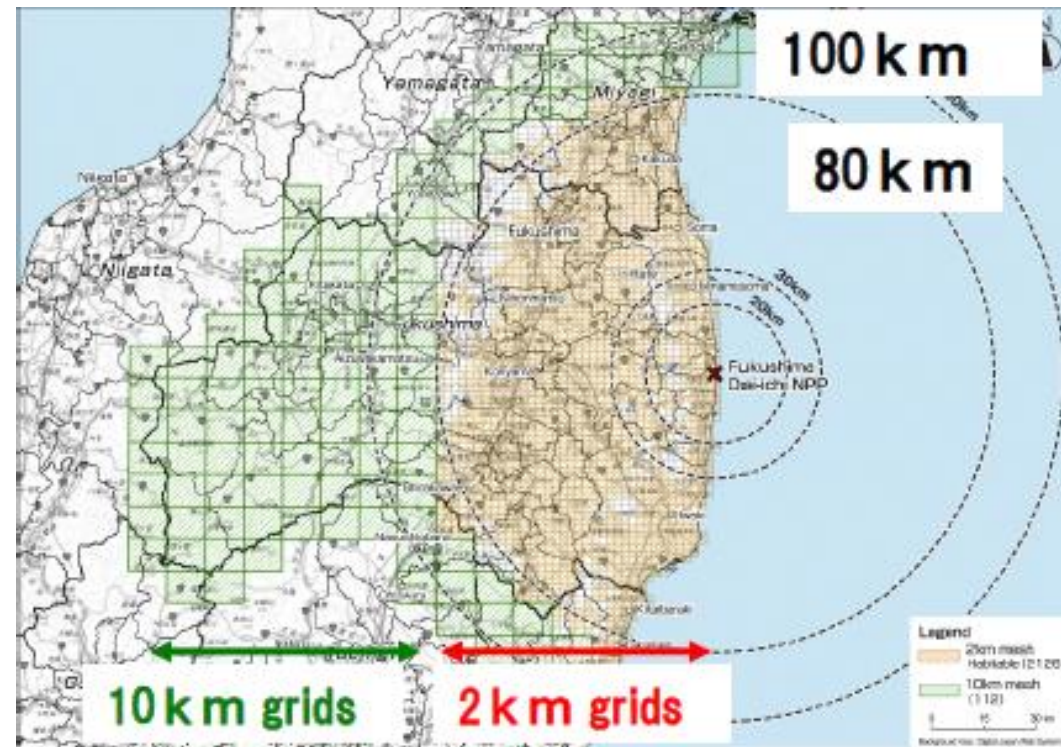
# Distribution map of radioactive fallouts around the Fukushima site

1. Mapped area: Within 80 km from the NPP: 2 km x 2 km grids,  
80-100 km from the NPP : 10 km x 10 km grids.
2. Locations: about 2,200 with each 5 samples → 11,000 soil samples.  
300 samples for RI percolation.
3. First survey period in 2011:  
Dose rate and Soil Sampling:  
(1) June 6 – June 14, (2) June 27 – July 8.  
Dose rate measurements by car: June 6 – June 13.

## Measurement Team:

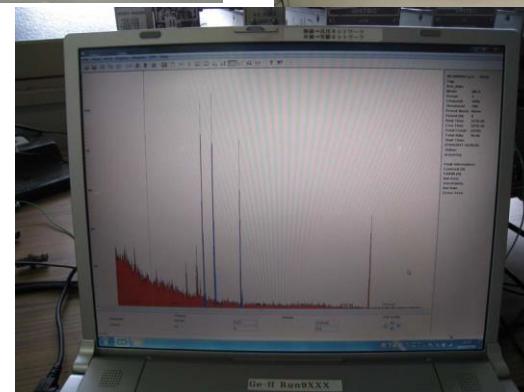
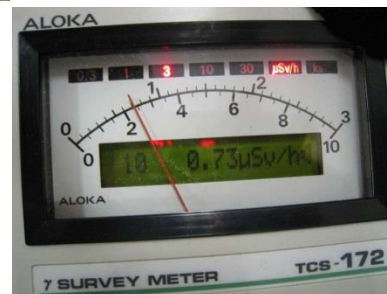
1. Sampling:  
107 organizations, 440 scientists,
2.  $\gamma$ -ray measurements with  
Ge detectors :  
24 organizations, 291 scientists

Start as the MEXT program with  
a collaboration of many  
university teams.



# Collaborations for soil sampling in June-July, 2011

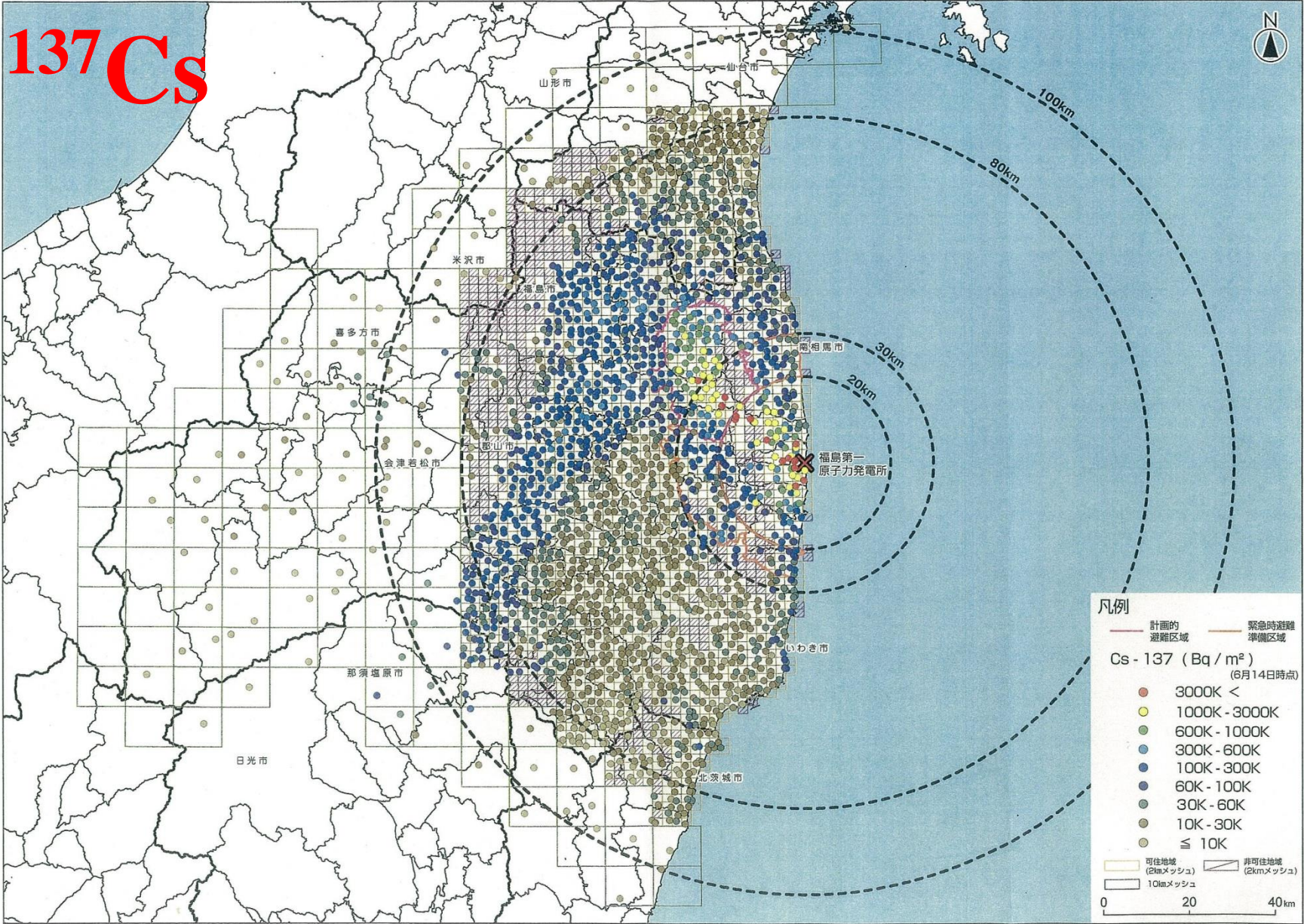
1. Osaka University
2. Osaka Electro Communication University
3. Kanazawa University
4. Kyusyu University
5. Kyoto University
6. KEK
7. Konan University
8. Saga University
9. Tokyo Metropolitan University
10. Shinsyu University
11. Tsukuba University
12. Gifu University
13. Tokyo Institute of Technology
14. University of Tokyo
15. Tohoku University
16. Tokyshima University
17. Niigata University
18. Nihon University
19. JAEA
20. Japan Chemical Analysis Center
21. Miyazaki University
22. RIKEN
23. Rikyo University
24. Two private companies.





K. Saito, I. Tanihata, M. Fujiwara, et al., Journal of Environmental Radioactivity 139 (2015) 308.

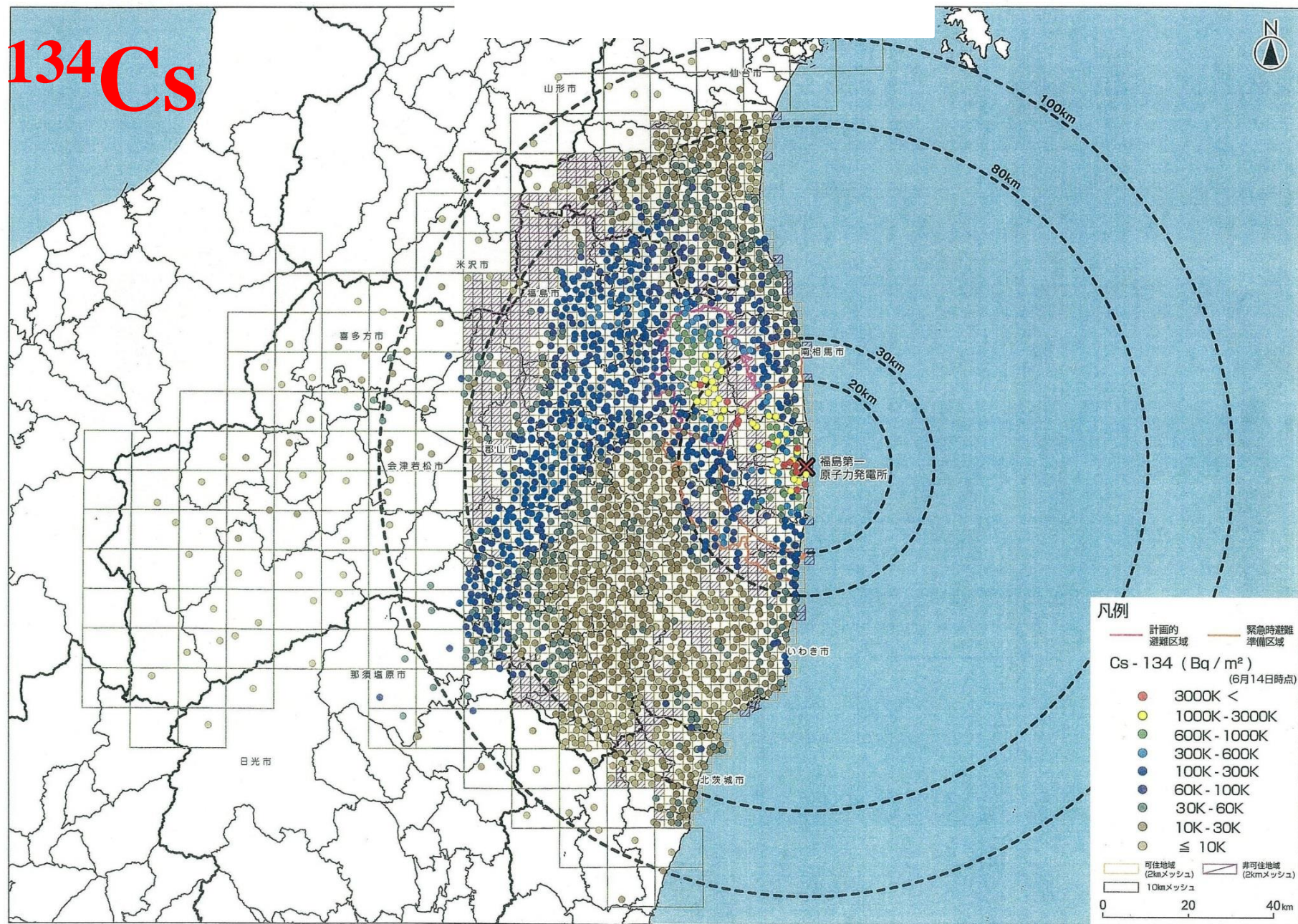
S. Mikami et al., Journal of Environmental Radioactivity 139 (2015) 320.





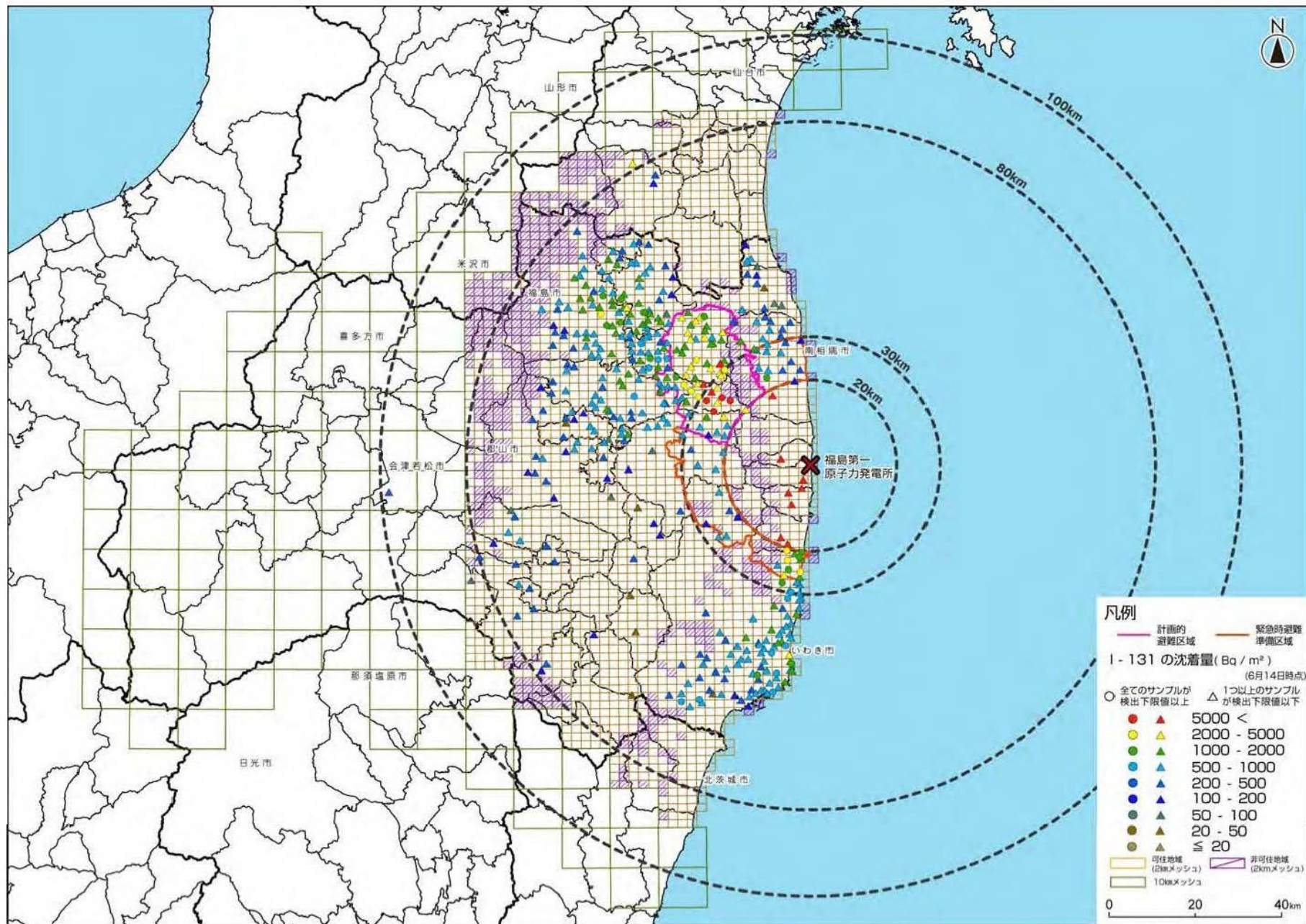
# セシウム134の土壌濃度マップ

**$^{134}\text{Cs}$**





# 131I

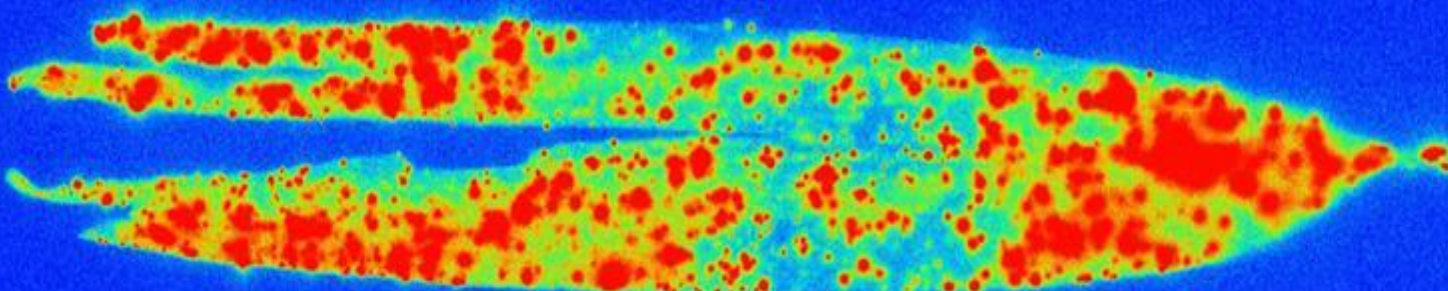
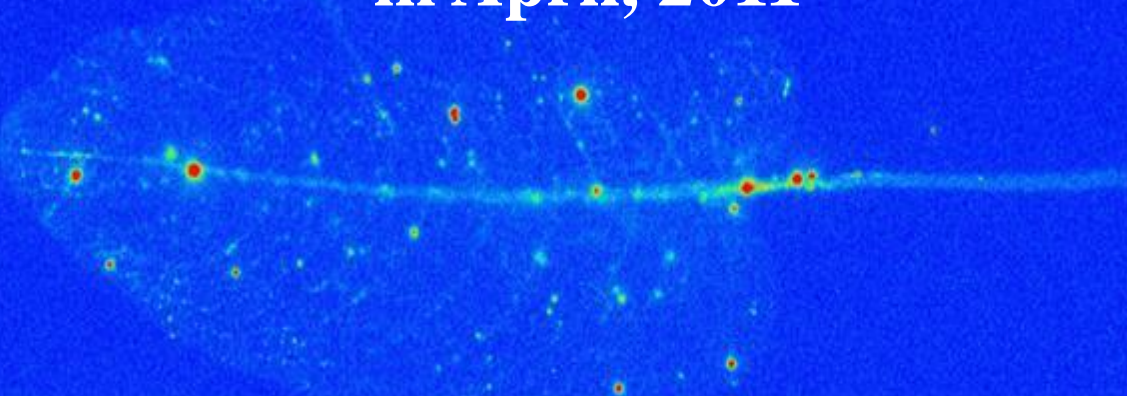
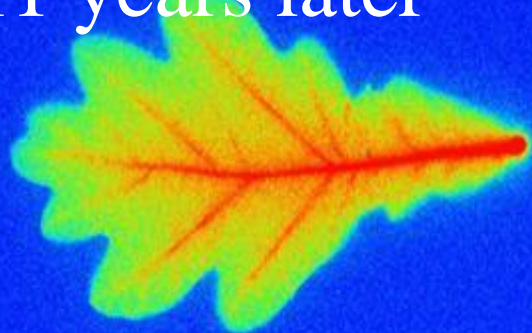




# Measured by Nakajima (Osaka U.)

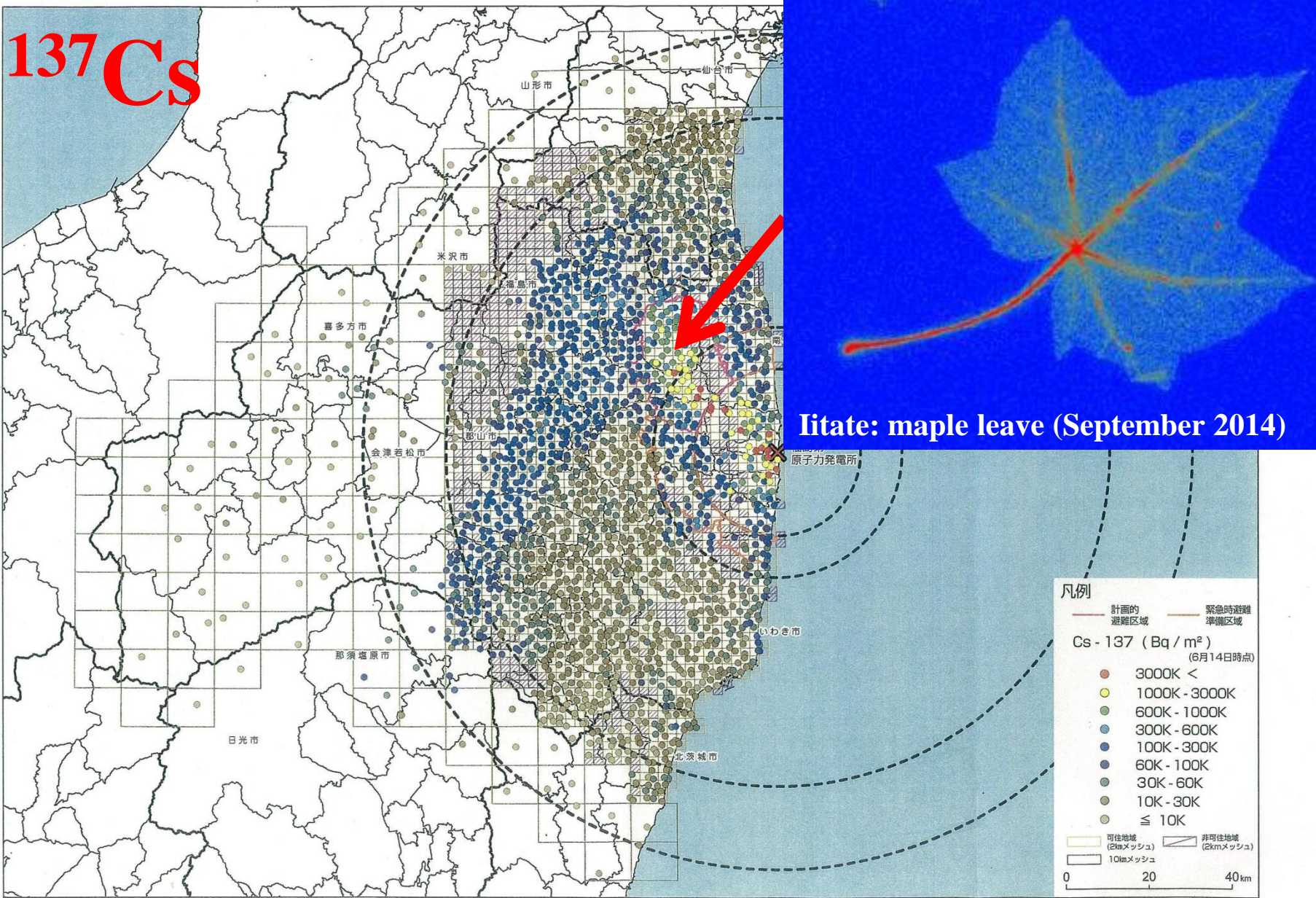
Leave at Chernobyl,  
11 years later

New leave in Fukushima  
in April, 2011



**bamboo grass near Fukushima NPP  
in June 2011.**





## Final Comments

1. We could not start the soil sampling in May 2011. Administration work took a long time. We missed  $^{131}\text{I}$  map.
2. It is important to organize an **implicit** emergency team before the nuclear power plant accident.
3. In case of radioactive fallout mapping, there was no “**preparation protocol**” in Japan.
4. In situ Ge detectors would be a powerful alternative in comparison with the soil sampling method and radioactivity measurements.
5. International collaboration for **future urgent NPP accident**. (It is difficult for us to prepare many detectors in one country.)
6. Most important is good education at the university level for understanding the radiation and its biological effect.

The Fukushima story is not yet ended.

1. Health fear decreases, but economical fear increases.
2. Depopulation in radioactive contamination area in Fukushima has been already accelerated.
3. We have to take drastic measures to improve the situation.

There are many things to be done at present and in future.

Thank you very much  
for your collaboration



# Soil Sampling in the 20 km area of Fukushima No.1 NPP (2012 April 3,4,5)

