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Hokkaido University Special Lecture
The Latest Information on the
Fukushima Nuclear Power Plant

Environmental Radioactive Substances: Data from the School of Engineering

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Contents

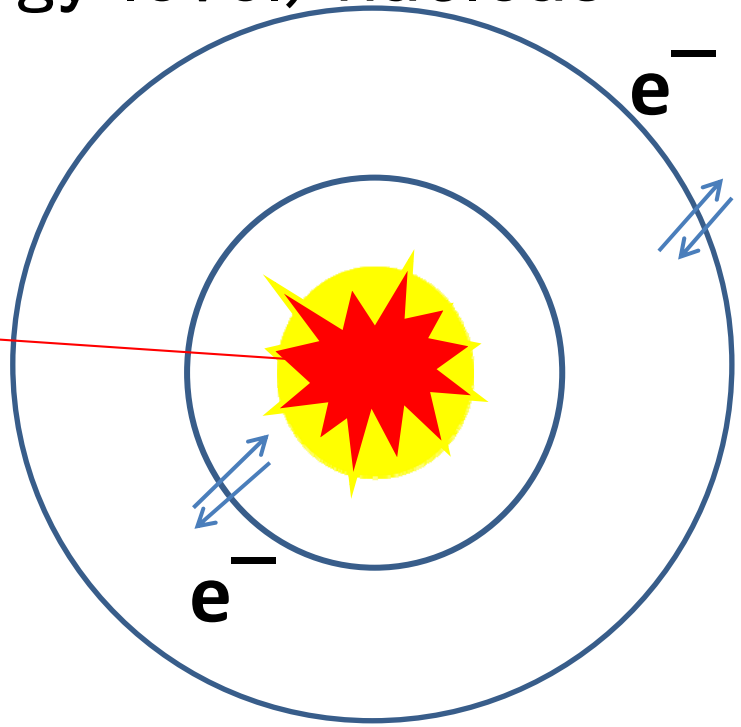
1. What is radioactive substances?
2. Radioactive substances in the environment?
3. What are measures of radioactive substance and radiation?
4. Data from the School of Engineering
5. Summary

What is a radioactive atom (radionuclide)?

Atom with unstable (high energy level) nucleus

Decay

Radiation (α, β, γ)



Identification of a radionuclide

Emitting radiation
- Type (α, β, γ)
- Energy (E)
- Emission ratio
- Half life ($T_{1/2}$)

What is radioactivity?

Number of radionuclides decaying in a unit time

Unit : Becquerel (Bq)

$$\frac{dN}{dt} = -\lambda N$$

Radioactivity (A) (Bq = s^{-1})

N: Number of radionuclides at time t

t: Time (s)

λ : Decay constant

How to represent a radionuclide

For example,

Radioactive potassium

^{40}K

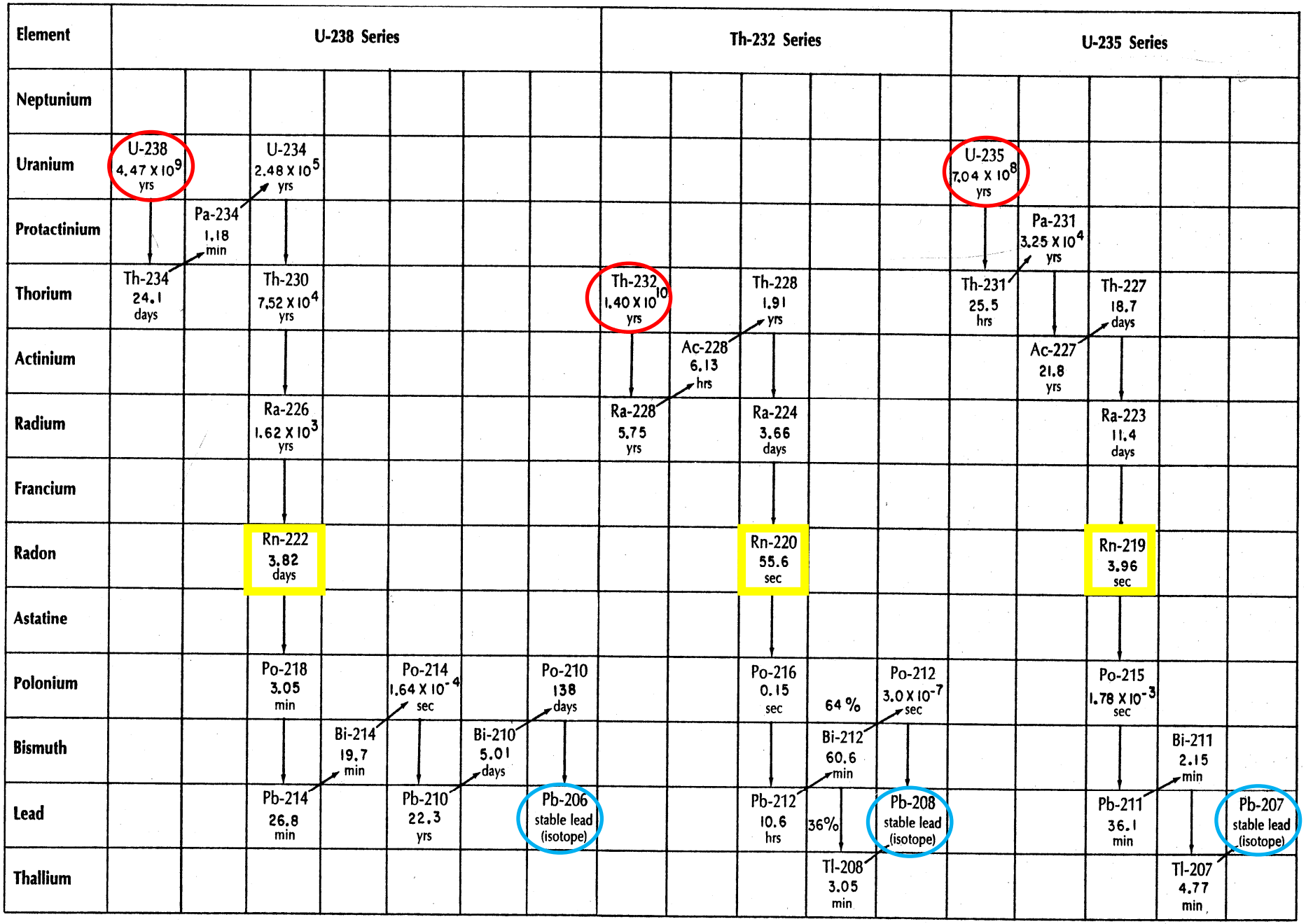
(K-40, Potassium-40)

There are many radionuclides in our environment!

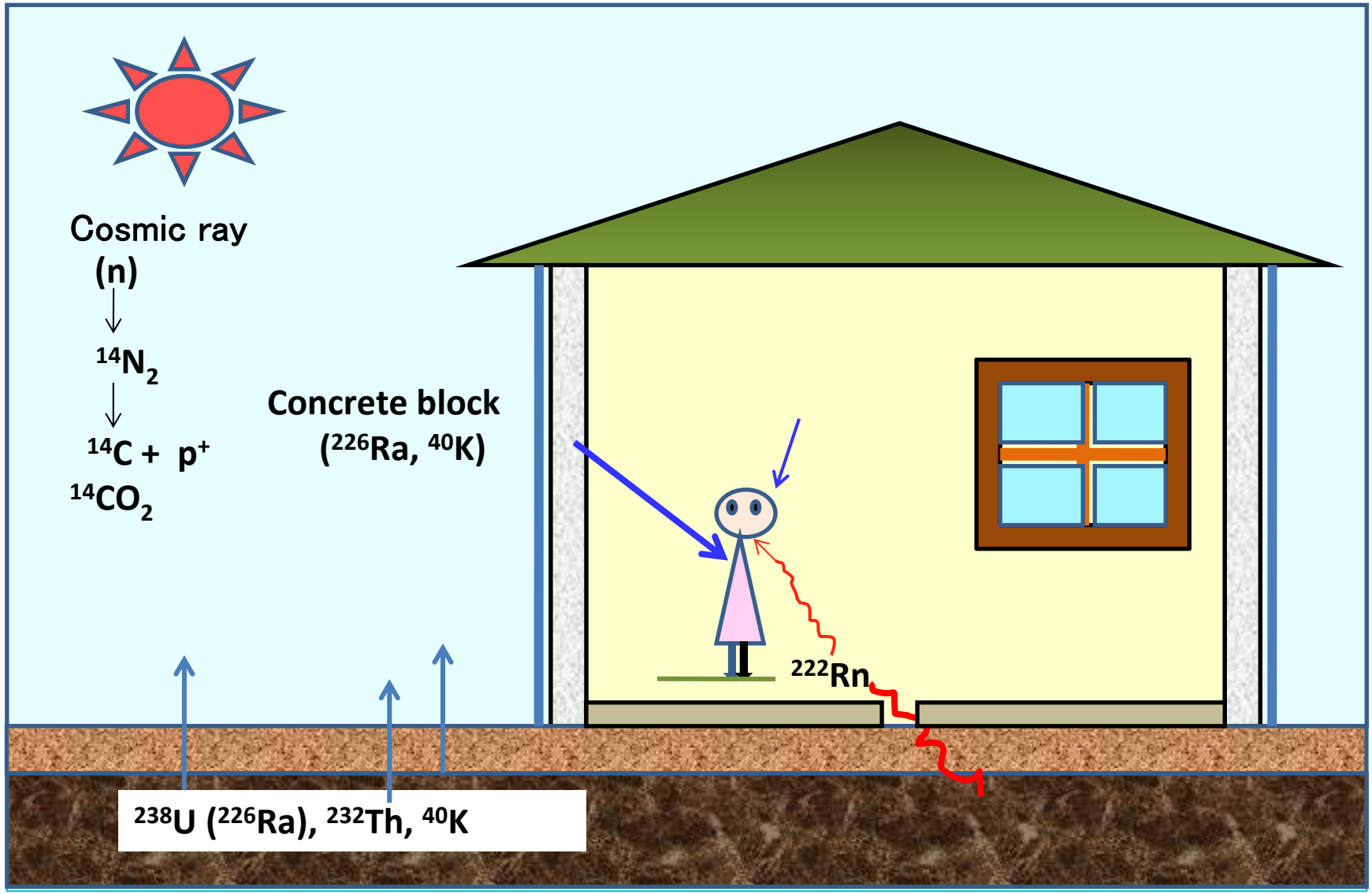
Classification of radionuclides

1. Primordial radionuclides with long half life ($T_{1/2}>10^8$ y) (^{40}K, ^{238}U, ^{232}Th)
2. Cosmic ray produced radionuclides (^{3}H, ^{7}Be, ^{14}C etc.)
3. Anthropogenic radionuclides (^{60}Co, ^{90}Sr, ^{137}Cs, ^{131}I, ^{99m}Tc etc.)

Natural Radionuclides in three Decay series (^{238}U, ^{232}Th, ^{235}U)



Natural Radiation



What is radiation exposure?

As you know now,

You are continually Exposed to natural radiation

Radiation exposure

- External exposure (→)
- Internal exposure (→)

Radiation dose (Sv) :

External dose

+

Internal dose

Sievert (Sv): A unit to measure the amount of radiation energy (J) per unit of mass (kg) considering the type and biological effects of radiation

What is Sv, really?

Since many organs and tissues are exposed to various radiation, it is better to use "**effective dose**" (E), which is included the effects of radiation type and also biological effects. The unit is "Sv".

mSv = 0.001 Sv

Causes of radiation exposure

External exposure + Internal exposure

Radiation dose from natural sources (mSv/y)

Mean dose value in the world:

2.4 mSv (External dose: 0.9 mSv)

Mean annual radiation dose in Japan

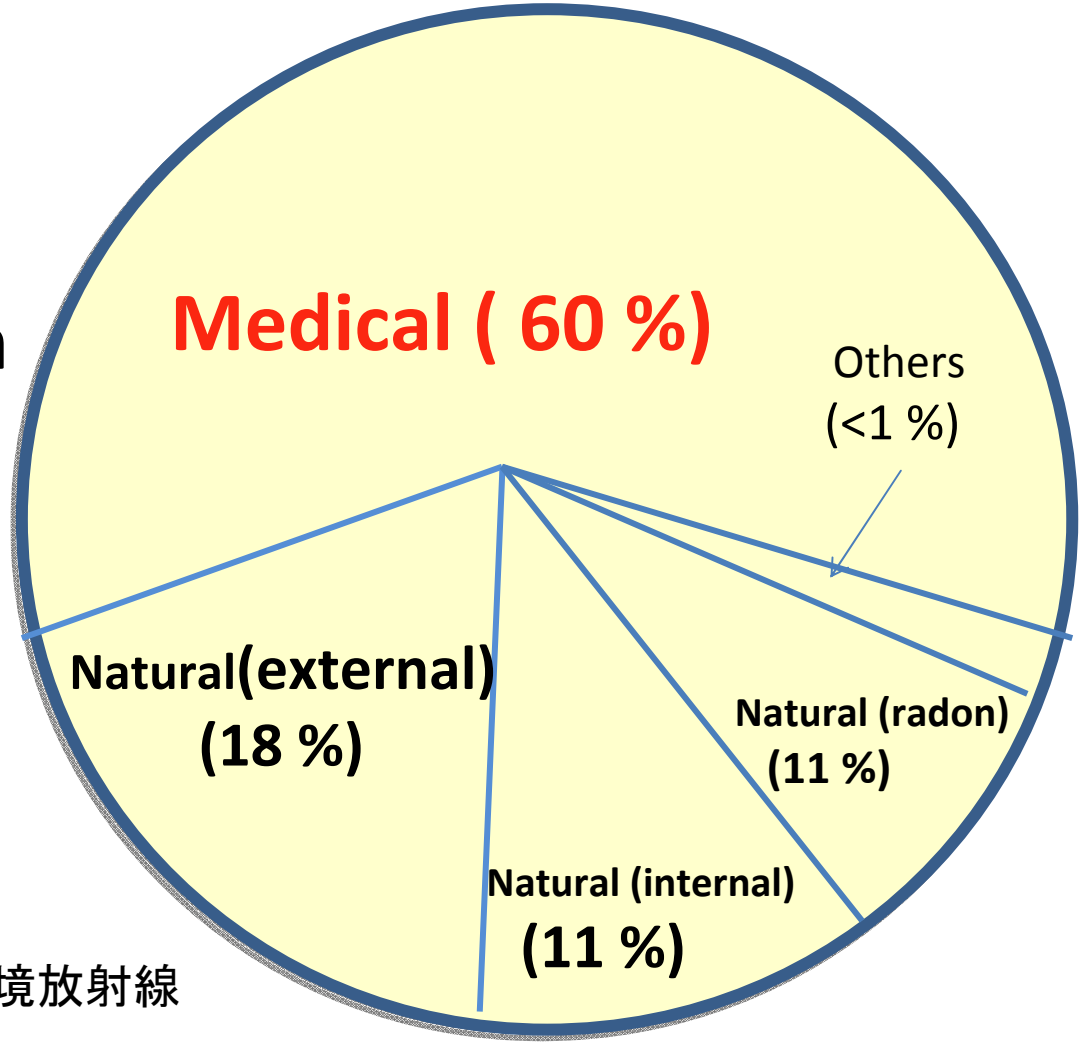
**1.4 mSv (External dose: 0.7 mSv)*

* The value is varied to a great extent depending on the location.

Effective doses from natural and human sources

Annual radiation dose for people in Japan

3.75 mSv/y



原子力安全協会(編):生活環境放射線 (1992) をもとに作成

When an accident happens at a nuclear power plant,

Different radioactive substances released from the plant are to be observed in the environment at various places depending on distance from the site and also on elapsed time after the accident.

Typical radionuclides to be observed with gamma ray measurements

^{131}I

$^{134}, ^{137}Cs$

Identification of the radionuclides with

Gamma energy (MeV)

Half life ($T_{1/2}$)

Emission ratio (–)

^{131}I ($T_{1/2}$ = 8.04 d)

0.080(2.6), 0.284(6.1), **0.364(81)**,

0.637(7.3), 0.723(1.8)

^{134}Cs ($T_{1/2}$ = 2.06 y)

0.563(8.4), 0.569(15), 0.605(98), 0.796(85),

0.802(8.7), 1.365(3)

^{137}Cs ($T_{1/2}$ = 30.17 y)

0.662(90)

Data from the School of Engineering

(since Mar. 14 2011)

1. Radiation dose rate (μSv/h)

2. Detection of radionuclides in dust samples collected daily with a dust sampler

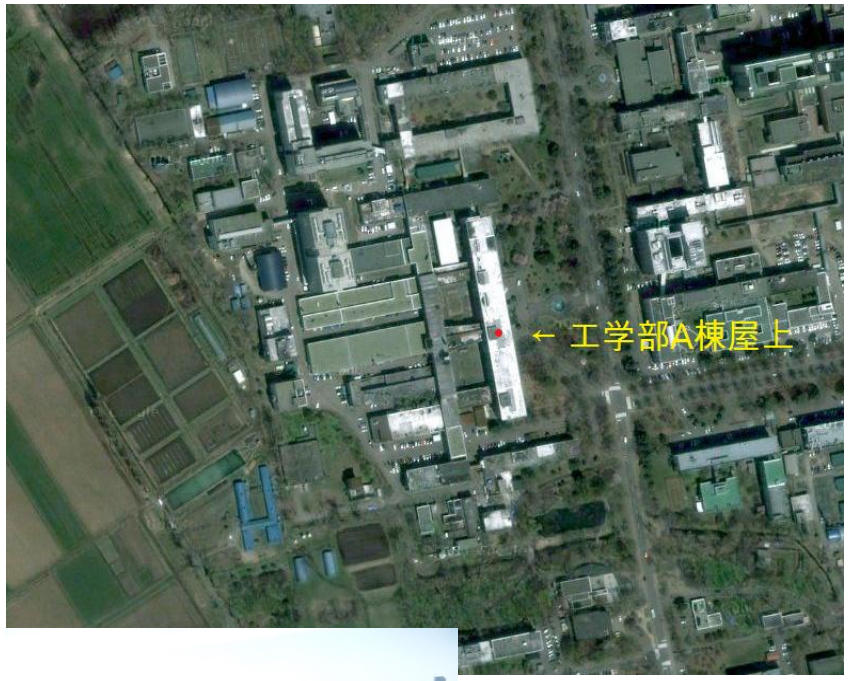
1. Radiation Dose Rate

Observation points:

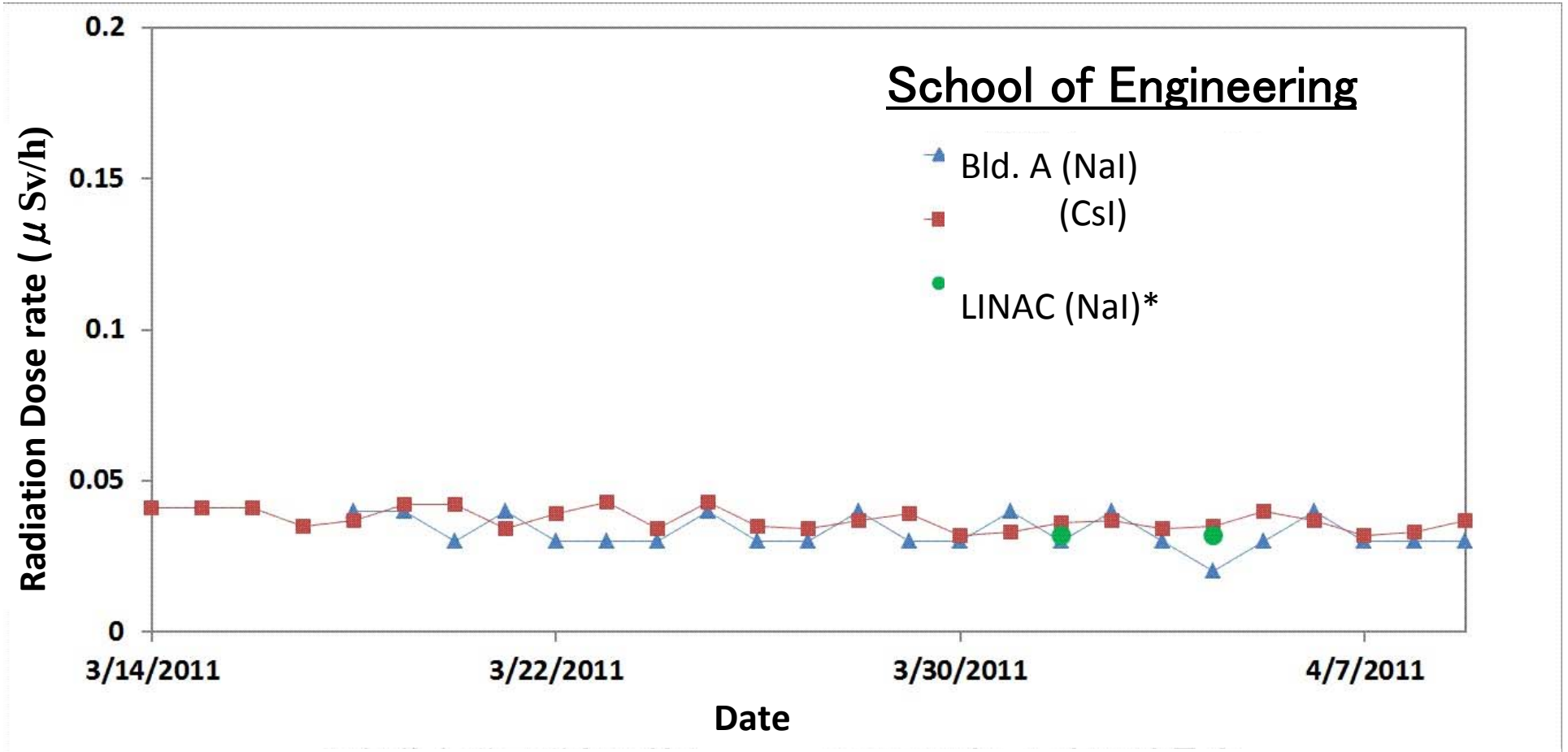
1. School of Eng. Bld. A roof
   1.3m from the floor (23.5 m from the ground) 1:30pm
2. School of Eng. LINAC
   Border of the controlled area
   1m from the ground 1:30pm

Instruments:

1. CsI Scintillation Counter
   (Horiba Radi PA-1000)
   NaI Scintillaiton Survey meter
   (Aloka, TCS-161)
2. NaI Scintillaiton Survey meter
   (Aloka, TCS-161)



Time series data on radiation dose rate measured in the School of Engineering since Mar. 14 2011



*A series of data before the accident (Mar. 11 2011) has been reserved in the LINAC facility (http://www2.qe.eng.hokudai.ac.jp/nuclear-accident/dose/dose.html)

2. Detection of Radionuclides in Dust

Observation point:

School of Eng. Bld. A roof at 1.3m from the floor (23.5 m from the ground)

Dust sampling:

Dust sampler (TH-D5101/HVA-1, Chiyoda Technol. Co.Ltd.), Filter (HE-40T, ADVANTEC), 24hrs (Mean flow rate:700L/min)

Gamma spectrometry*:

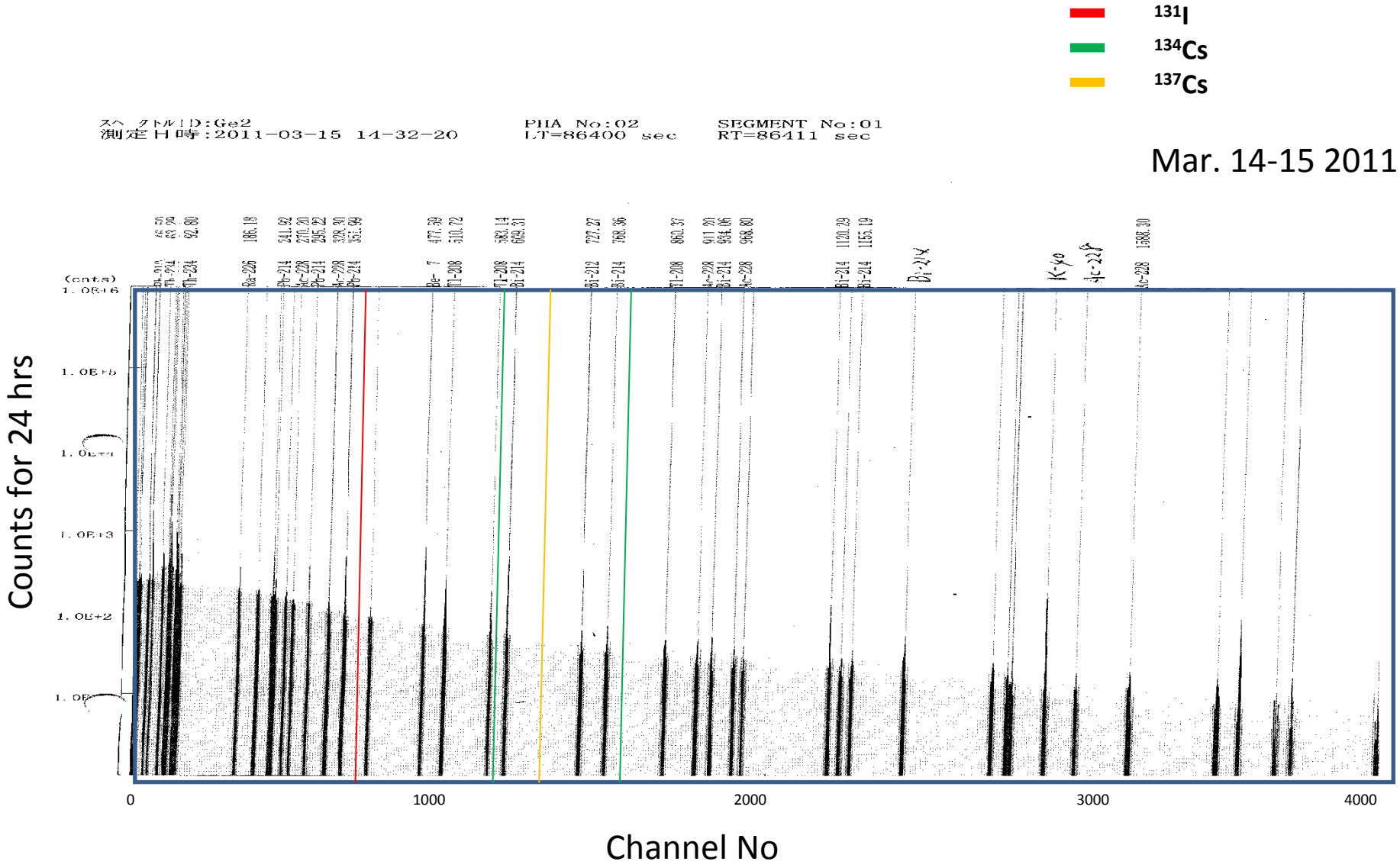
Dust sample (dried at 60° C for 30min)

Gamma spectrometry (ORTEC GEMX10P) 20hrs

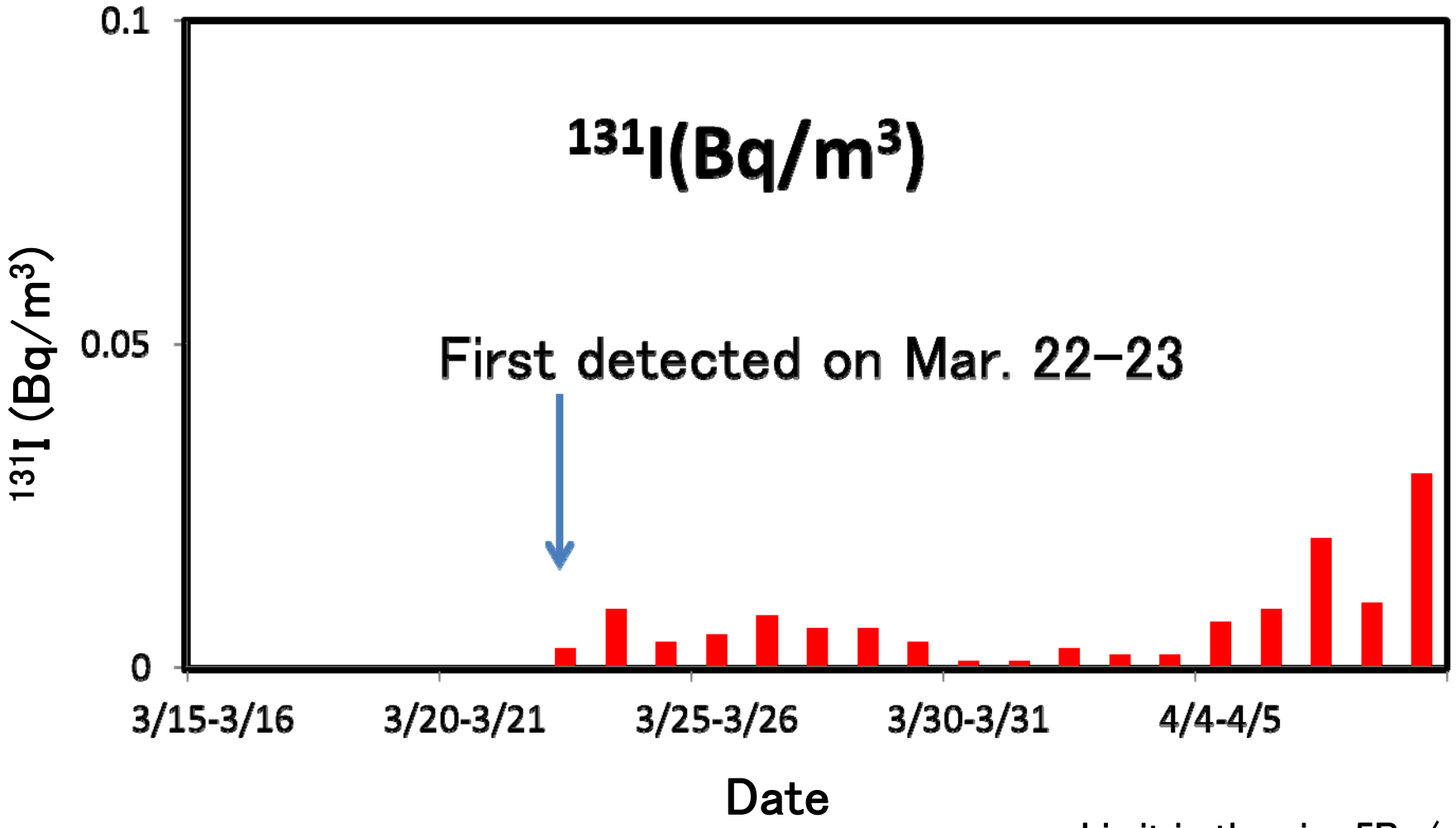
* Conditions for the measurements (http://www2.qe.eng.hokudai.ac.jp/nuclear-accident /dose/dose.html)

Radionuclides in a dust sample collected from Mar. 14 to 15 2011

^{131}I
^{134}Cs
^{137}Cs

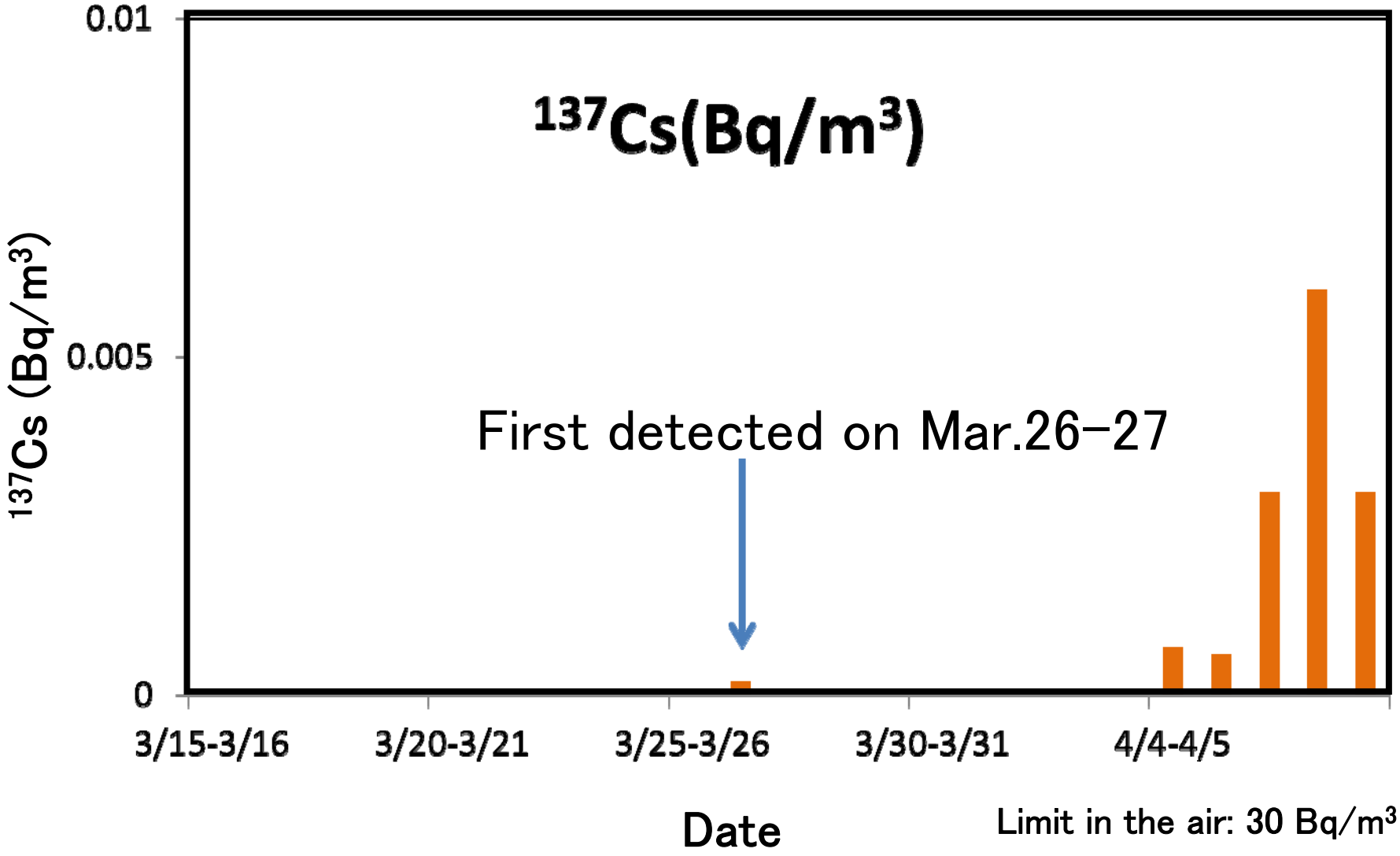


Time series data on ^{131}I activity concentration in dust samples

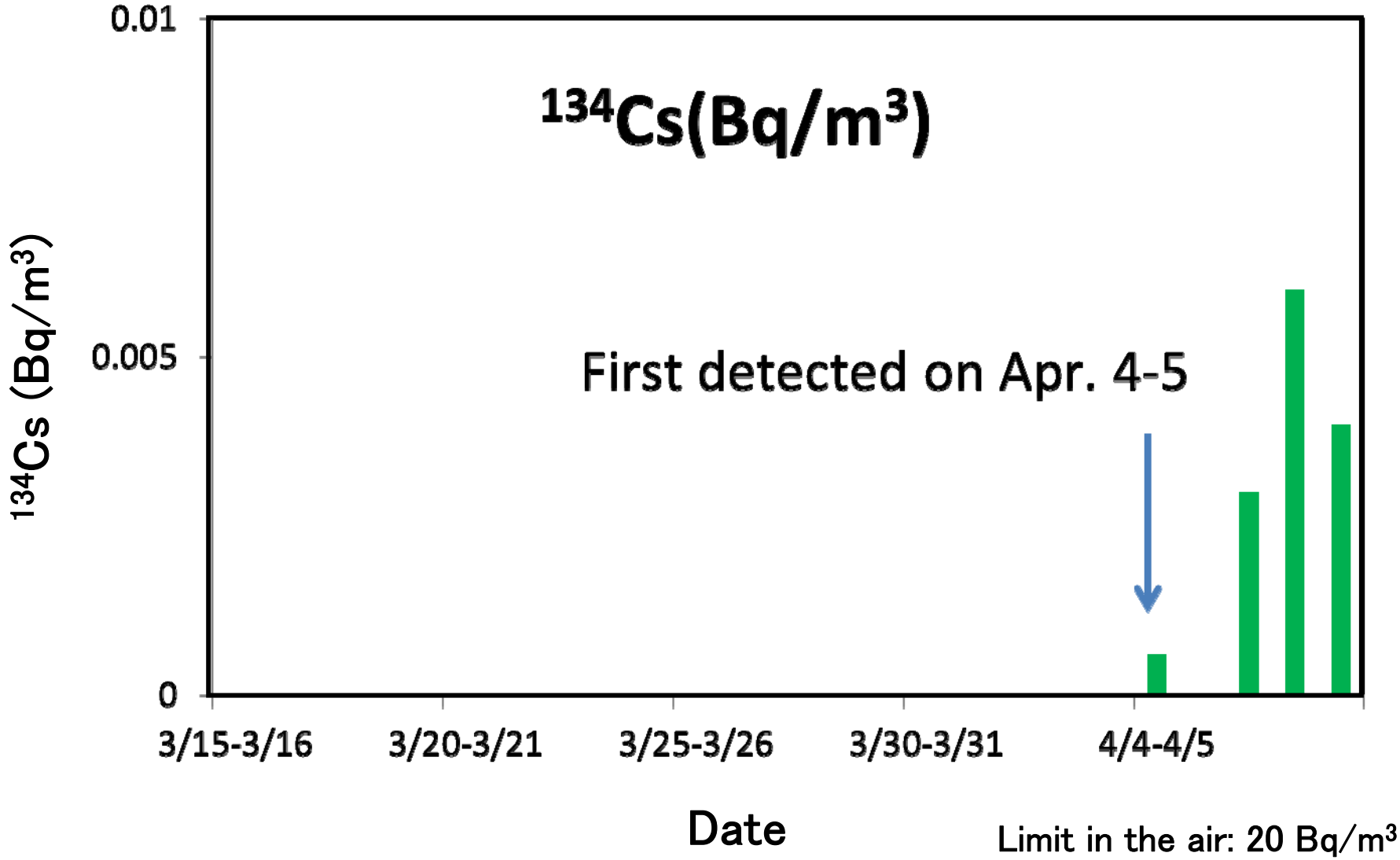


Limit in the air: 5Bq/m^3

Time series data on ^{137}Cs activity concentration in dust samples



Time series data on ^{134}Cs activity concentration in dust samples



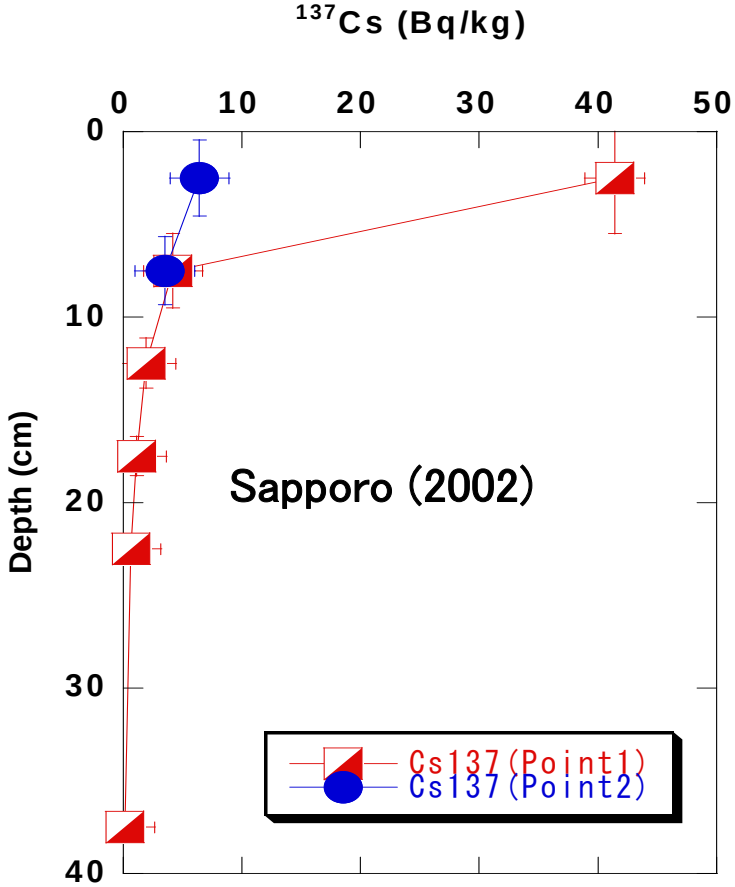
Limit in the air: 20 Bq/m^3

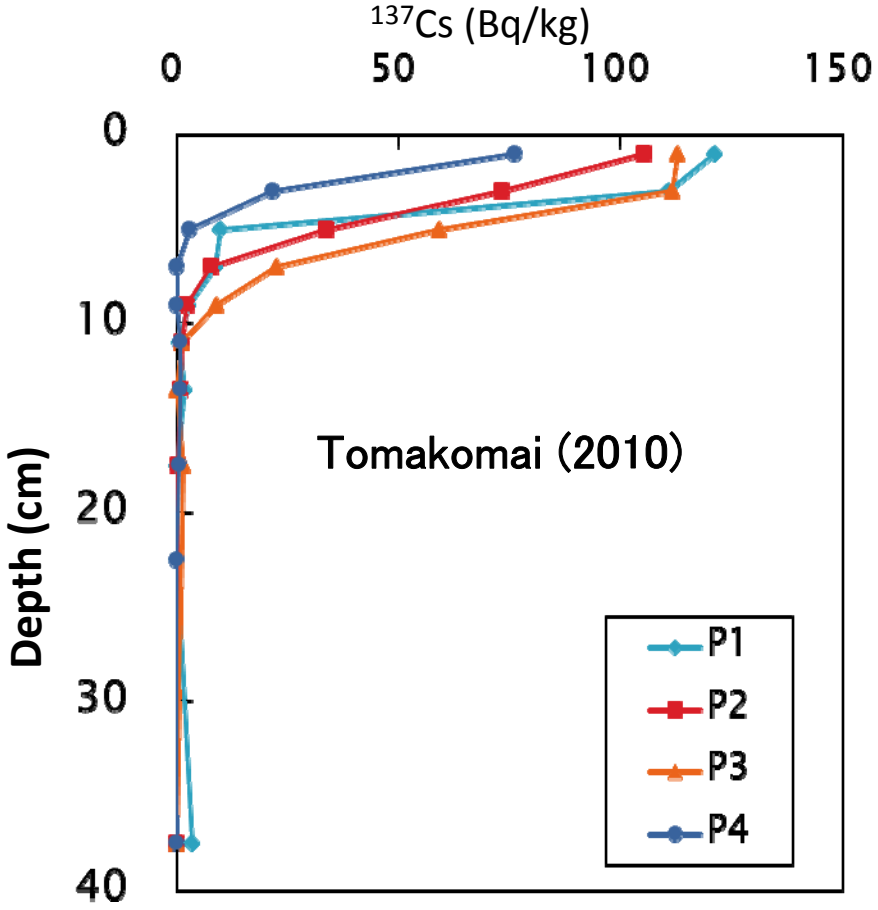
Data before the accident

1. Radiation dose measured at LINAC facility since 2006

2. Activity concentration of ^{137}Cs in soil on the campus of Hokkaido University in 2002

Depth profiles of ^{137}Cs activity concentrations in soil





Findings:

1. Radiation dose rate:

   0.03–0.04 μSv/h

   (Mar. 14–Apr. 10)

2. Detection of radionuclides in dust

   Mar. 22–23: ^{131}I

   Mar. 26–27: ^{131}I, ^{137}Cs

   Apr. 4–5 : ^{131}I, ^{137}Cs, ^{134}Cs

Summary

- There are various radioactive substances in the environment.
- The unit of radioactivity: Bq
- The unit of radiation dose: Sv
- Data from the School of Engineering

  Radiation dose rate: 0.03–0.04 μSv/h

  Radionuclides detected: ^{131}I, ^{134}Cs, ^{137}Cs

  (The activity level is quite low)
- Monitoring has still been continued.

Examples of useful HP:

http://www2.qe.eng.hokudai.ac.jp/nuclear-accident/dose/dose.html (Data)

http://www.iaea.org/news/tsunamiupdate01.html (Daily report)

http://ec.europa.eu/energy/nuclear/radiation_protection/publications_en.htm
(Basic knowledge on radiation)

http://www.nirs.go.jp/ENG/index.html (Radiation protection)

and more...

Thank you for your attention!

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