Application of a Simple Device to Measure the Vertical Distribution of Radioceasium Concentration in Soil, Fukushima.

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Agenda

- Background & objective
- Detail of a device
- Evaluation of the device (method)
- Results & Discussion
- Conclusion

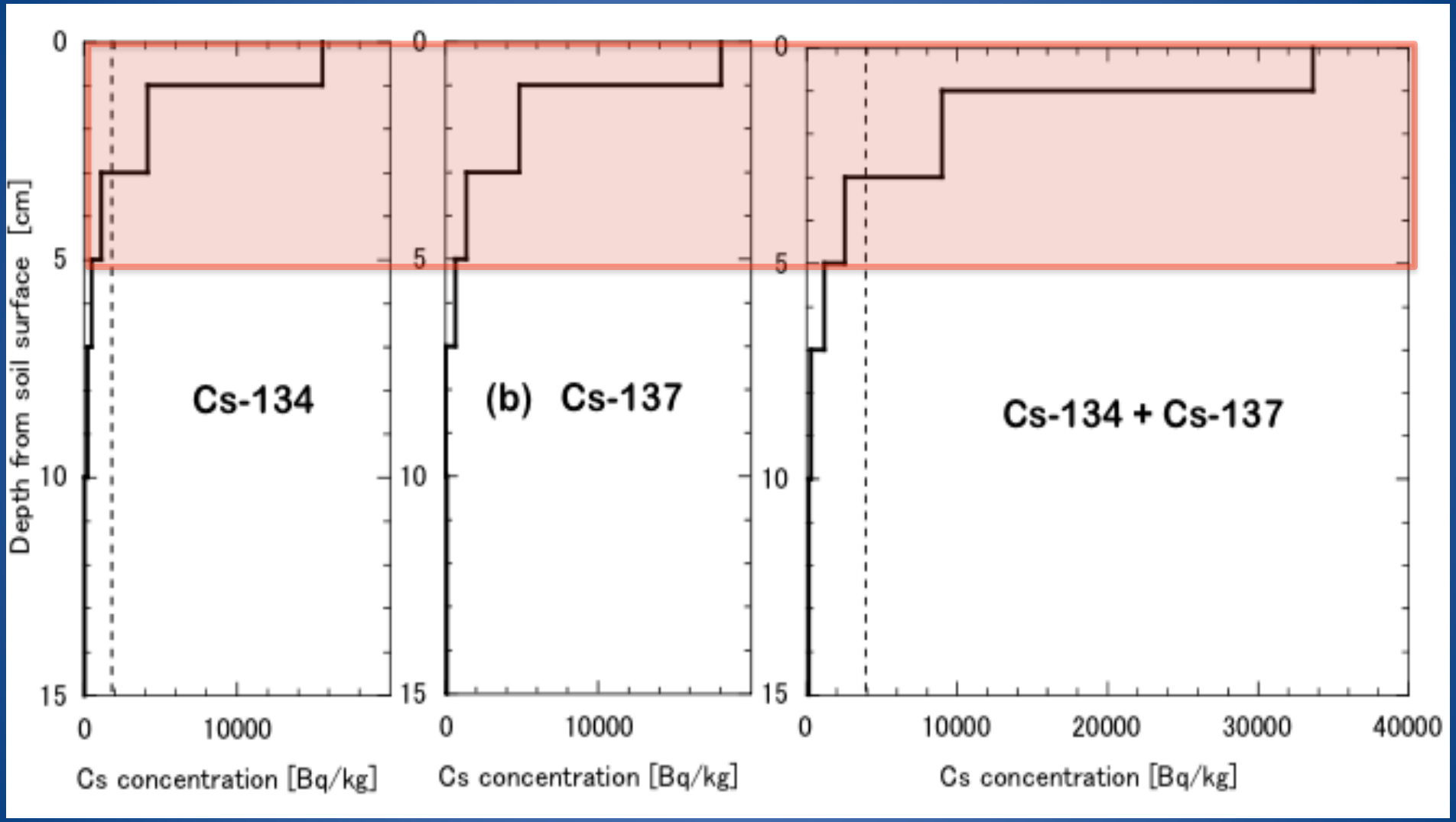
Fukushima Daiichi Nuclear Disaster

http://blog.goo.ne.jp/yampr7/e/
3252e0611ebc1eabd36195cede8a2231

Radioactive materials made agricultural field gone

- Normally agricultural field however this field is polluted by radioactive materials (e.g. ^{134}Cs, ^{137}Cs).

Vertical distribution of radioceasium concentration in soil.

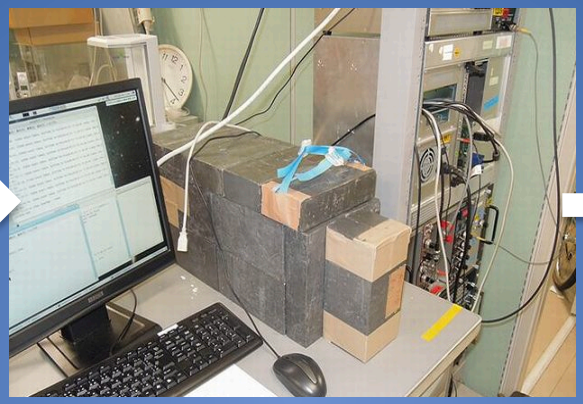


Shiozawa et al. (2011): Vertical concentration profiles of radioactive cesium and convective velocity in soil in a paddy field in Fukushima. Radioisotopes 60 : 323-328

Procedure of concentration measurement and decontamination of radioceasium in agricultural field

【Current method】

Soil sampling



Analysis

Decontamination

【Ideal method】

Device

In-situ method

Decontamination

http://www.fukushima-saisei.jp/index.html

Procedure of concentration measurement and decontamination of radioceasium in agricultural field

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Soil sampling

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【Ideal method】

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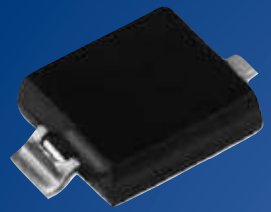
Objective

To develop a device using photodiode for measuring radioceasium concentration at each depth level.

- Current method takes a lot of time and cost, labor.
- Device is urgently needed to measure radioceasium concentration in soil.



What is Photodiode ?

Feature: Semiconductor diode as detector of light

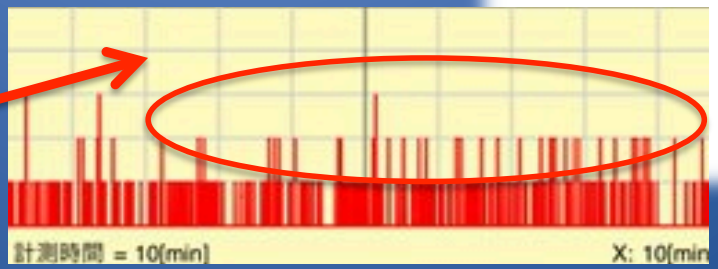
Advantage: Low-cost, Resistance of physical stress

Disadvantage: Low-sensibility

<u>Measurement principle</u>
Electrical current flows when radiation come into the semiconductor.

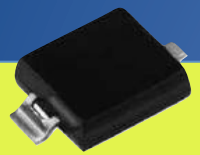
【Pocket Geiger】

<u>Photodiode detects radiation.</u>

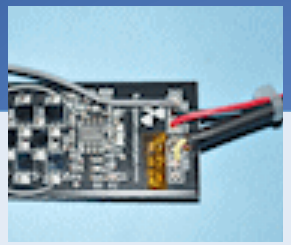


http://www.radiation-watch.org/p/blog-page.html

Overview of our system



Photodiode



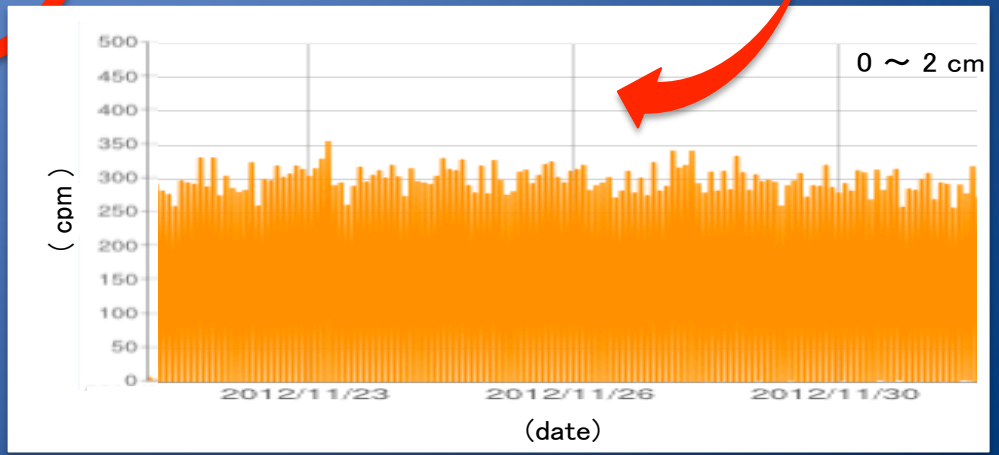
Substrate

Transduction substrate

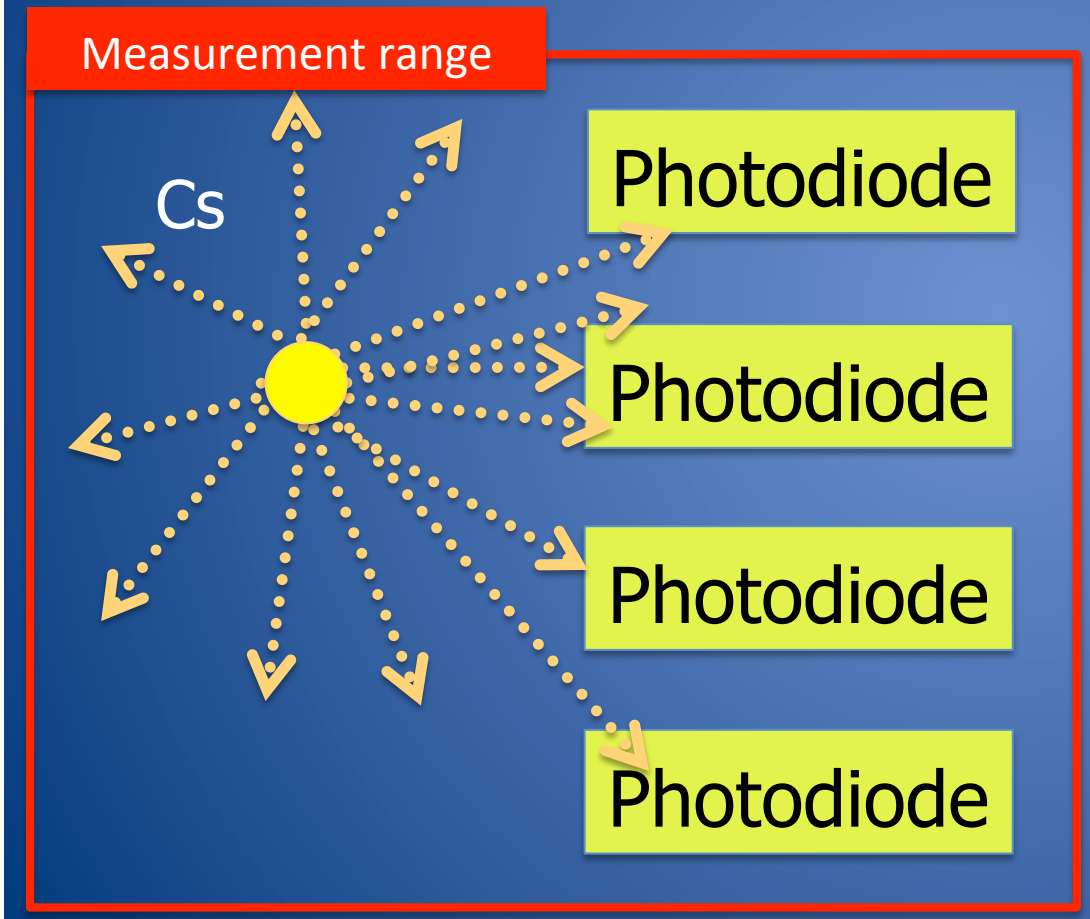
(X-ability Inc.)

Data logger

(DECAGON Inc.)



How to measure the radioactivity at each depth level (1)



- Every photodiodes can detect radiation.
- Quite difficult to measure in each depth.

Are you hungry ?

Lead Plate

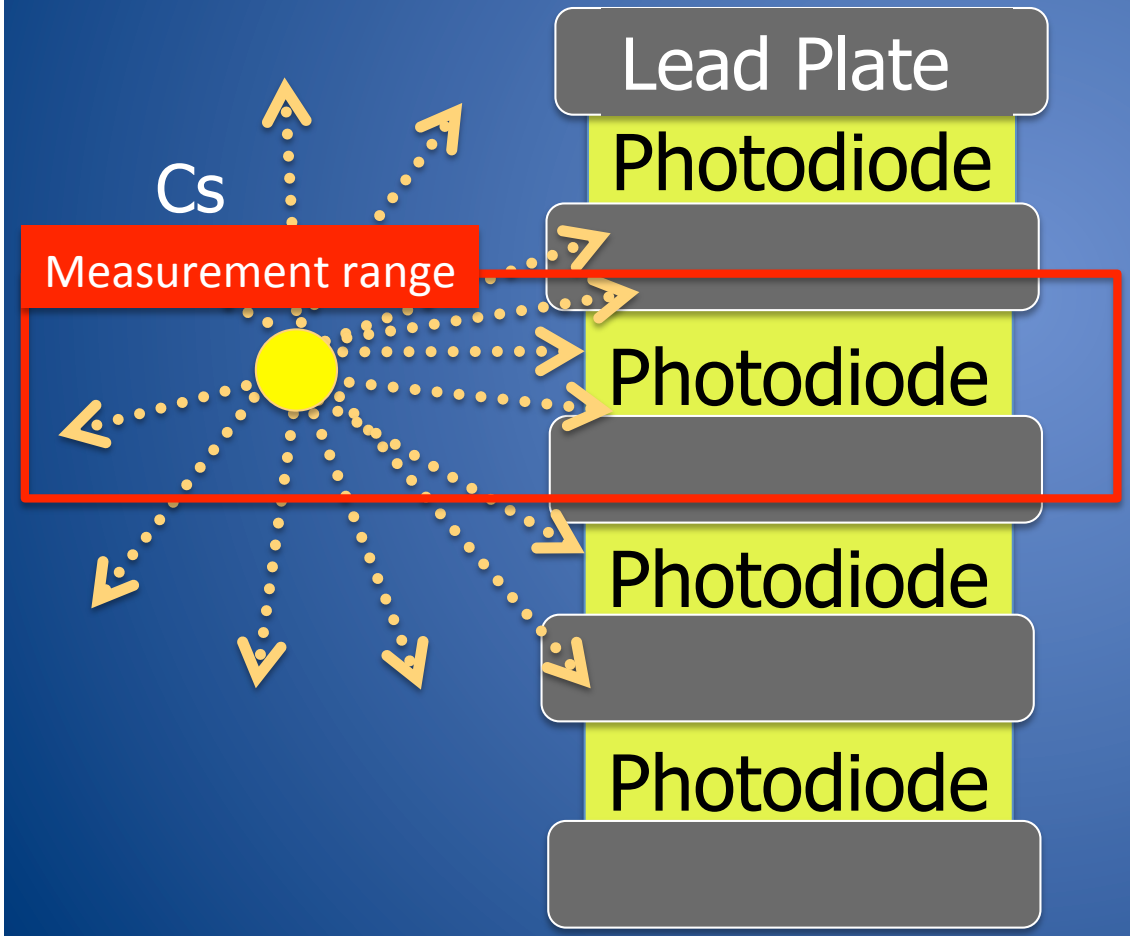
Epoxy

Photodiode

Epoxy

Lead Plate

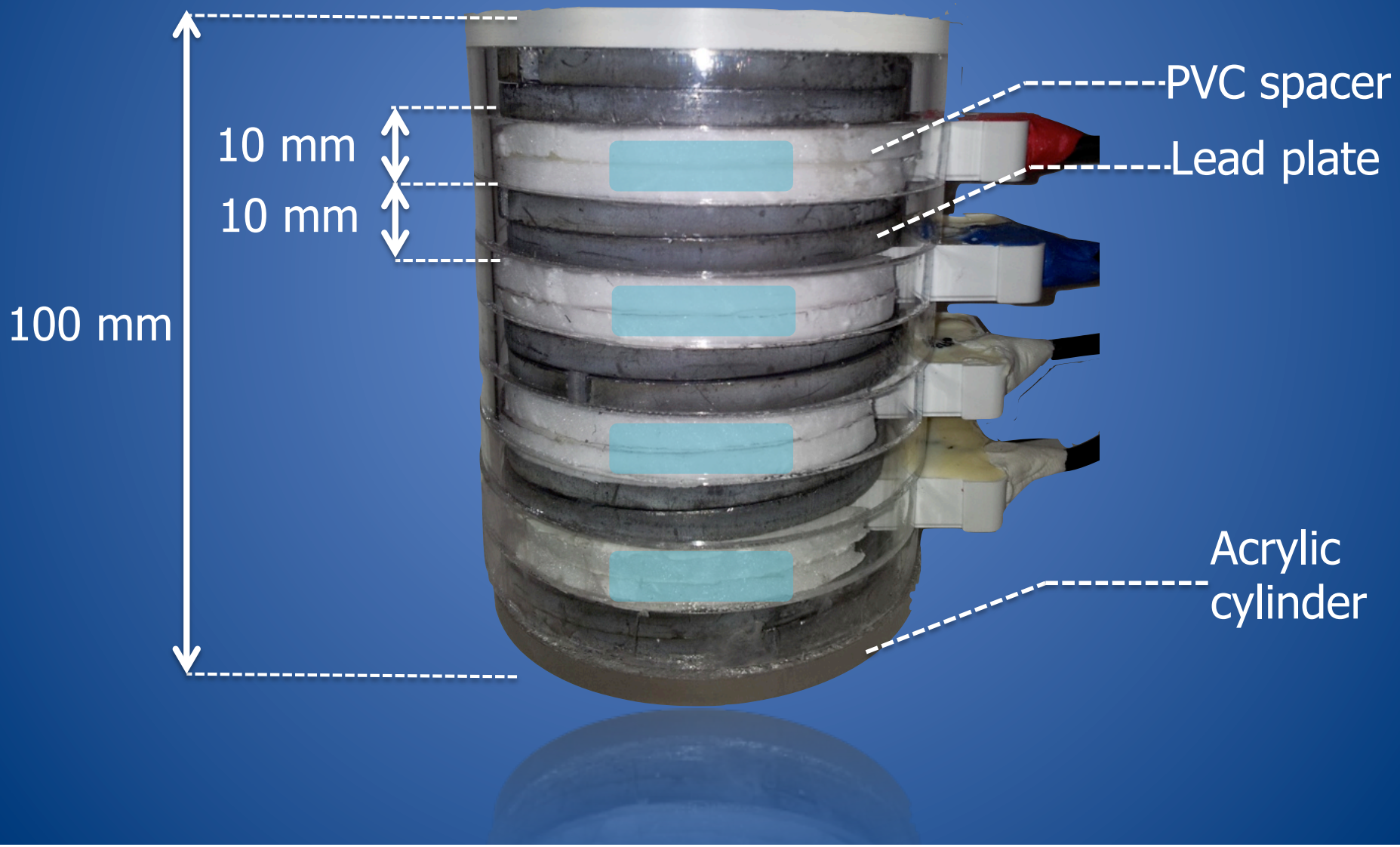
How to measure the radioactivity at each depth level (2)



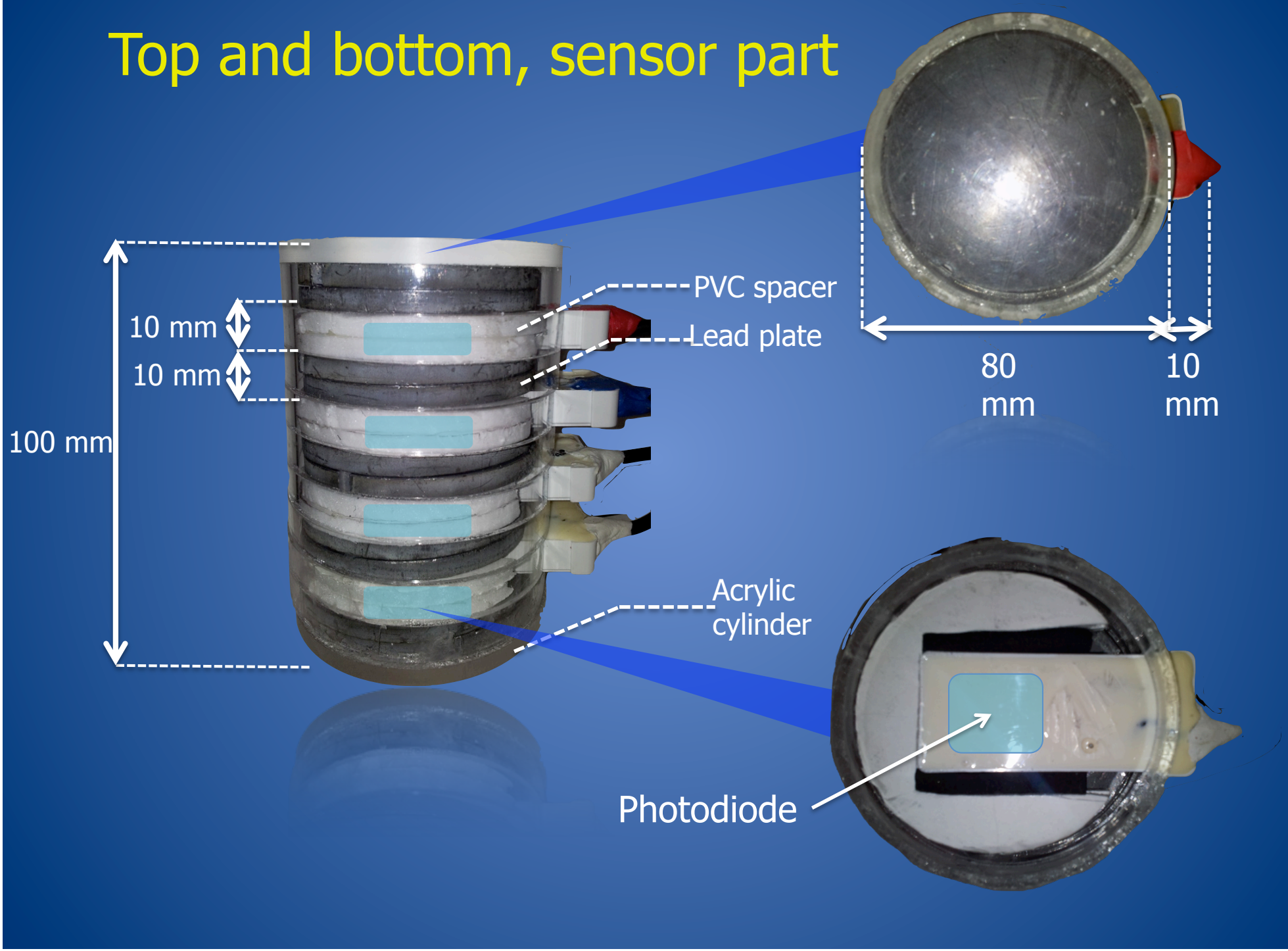
- Shield Effect of lead plate makes photodiode measure at each depth level.
- If lead plate has no limit, sensors can detect one layer well. However, lead plate is insufficient, we need to think ratio of "leak" at other layers.

A device for measuring the vertical distribution of radioactivity in soil using photodiode

Detail of size, material of the device



Top and bottom, sensor part

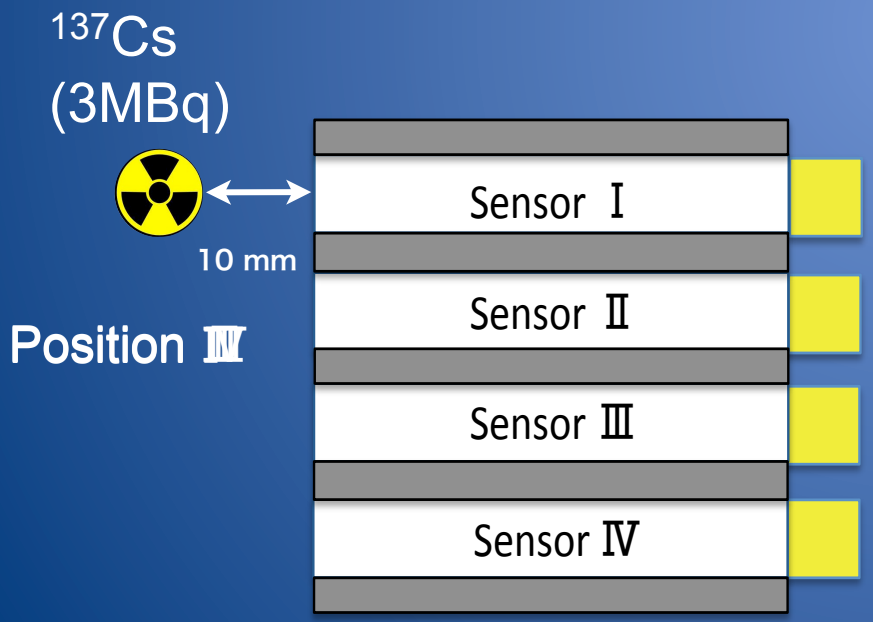


Evaluation of the device

1. Evaluation of radiation emitted from points of radiation (Directionality experiment)

（1） Measure counting rate (cpm)
（2）Calculate "Leakage coefficient"

$$L_{ij} = \frac{C_j}{C_i}$$



L_{ij} = Leakage coefficient

C_i = Counting rate of radiation detected by sensor located at same depth with the source point

C_j = Counting rate of radiation detected by sensor located at different depth with the source point

2. Proposal of correction formula

To reduce radioactivity effect from outside of measurement.

$$C_{mea\ j} = \sum C_{cor\ i} L_{ij}$$

$C_{mea\ j}$ = Measured counting rate (cpm)
$C_{cor\ i}$ = Corrected counting rate (cpm)
L_{ij} = Leakage coefficient

3. Field measurement (Iitate-Village, FUKUSHIMA)

Soil sampling

1) Take soil and cut every 2 cm.

2) Analyze radiocesium concentration by Ge semiconductor detector.

Device

1) Set the device in undisturbed paddy field.
2) Collect data of counting rate (measured counting rate) .

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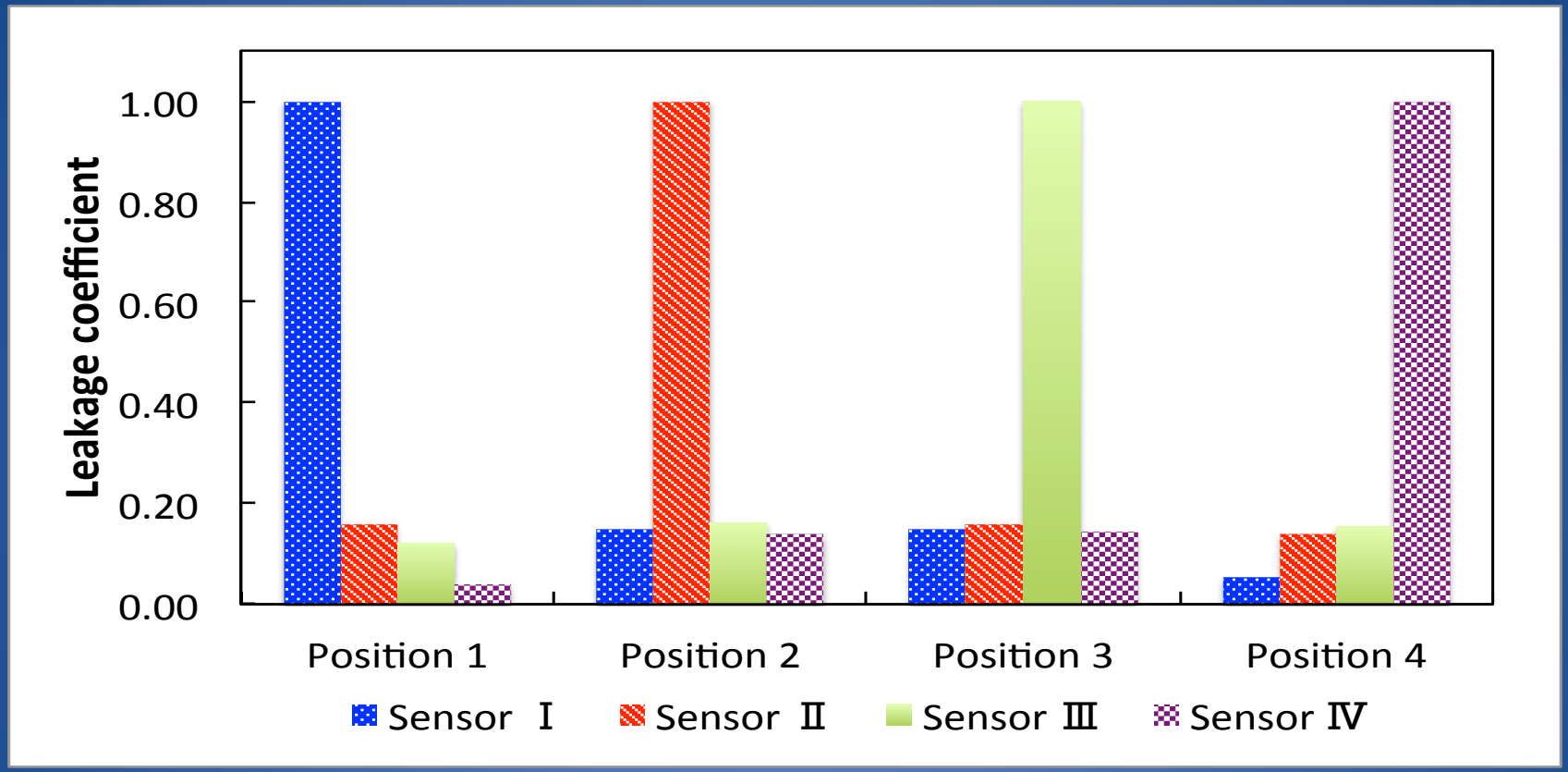
Results & Discussion

1. Directionality experiment



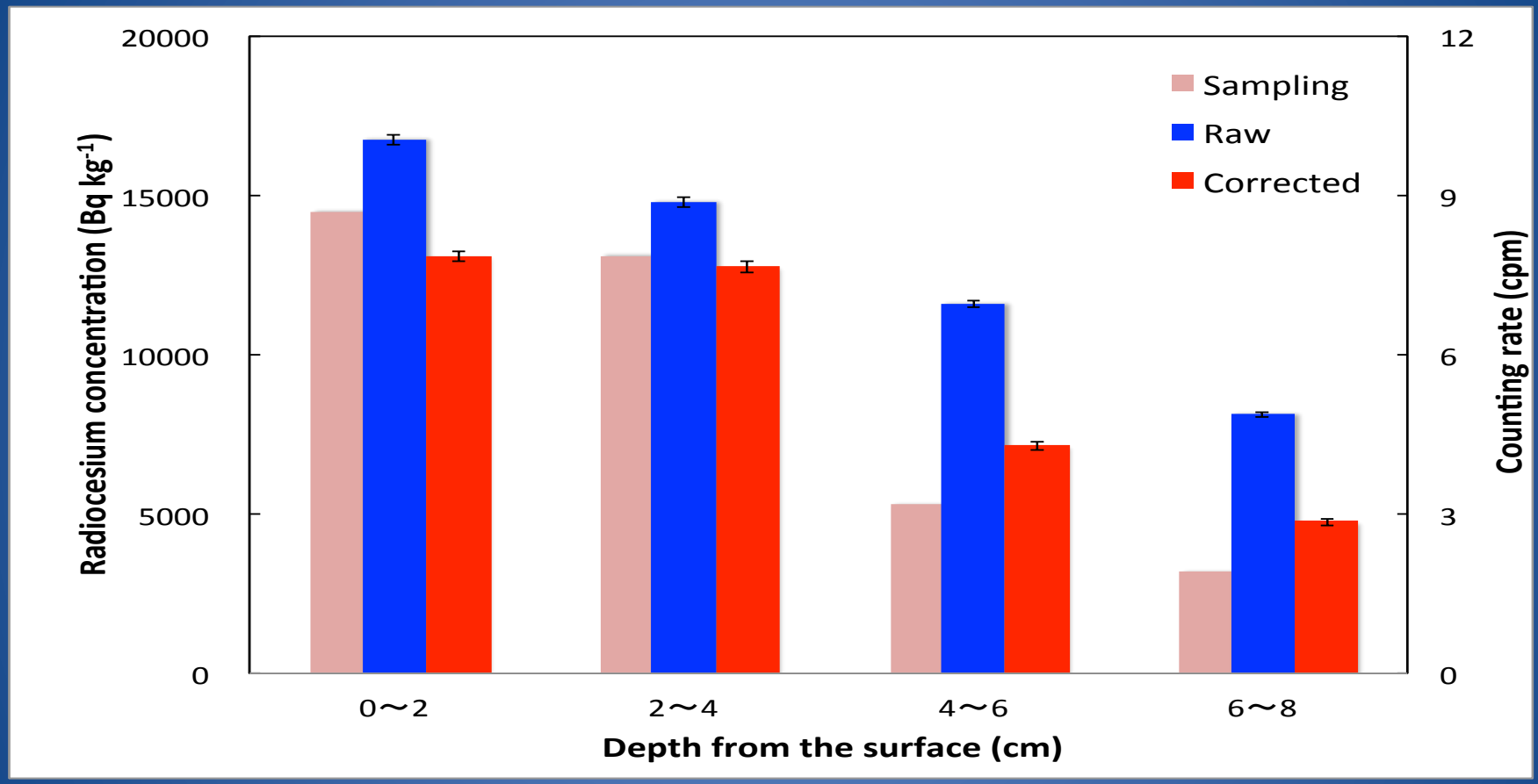
Observed effects from outside of measurement range (0.06 to 0.16). This is considered that lead plate are finite diameter and thickness.

Matrix of leakage coefficient

$$L_{ij} = \begin{pmatrix} 1.000 & 0.148 & 0.149 & 0.055 \\ 0.160 & 1.000 & 0.161 & 0.142 \\ 0.122 & 0.162 & 1.000 & 0.155 \\ 0.039 & 0.140 & 0.143 & 1.000 \end{pmatrix}$$

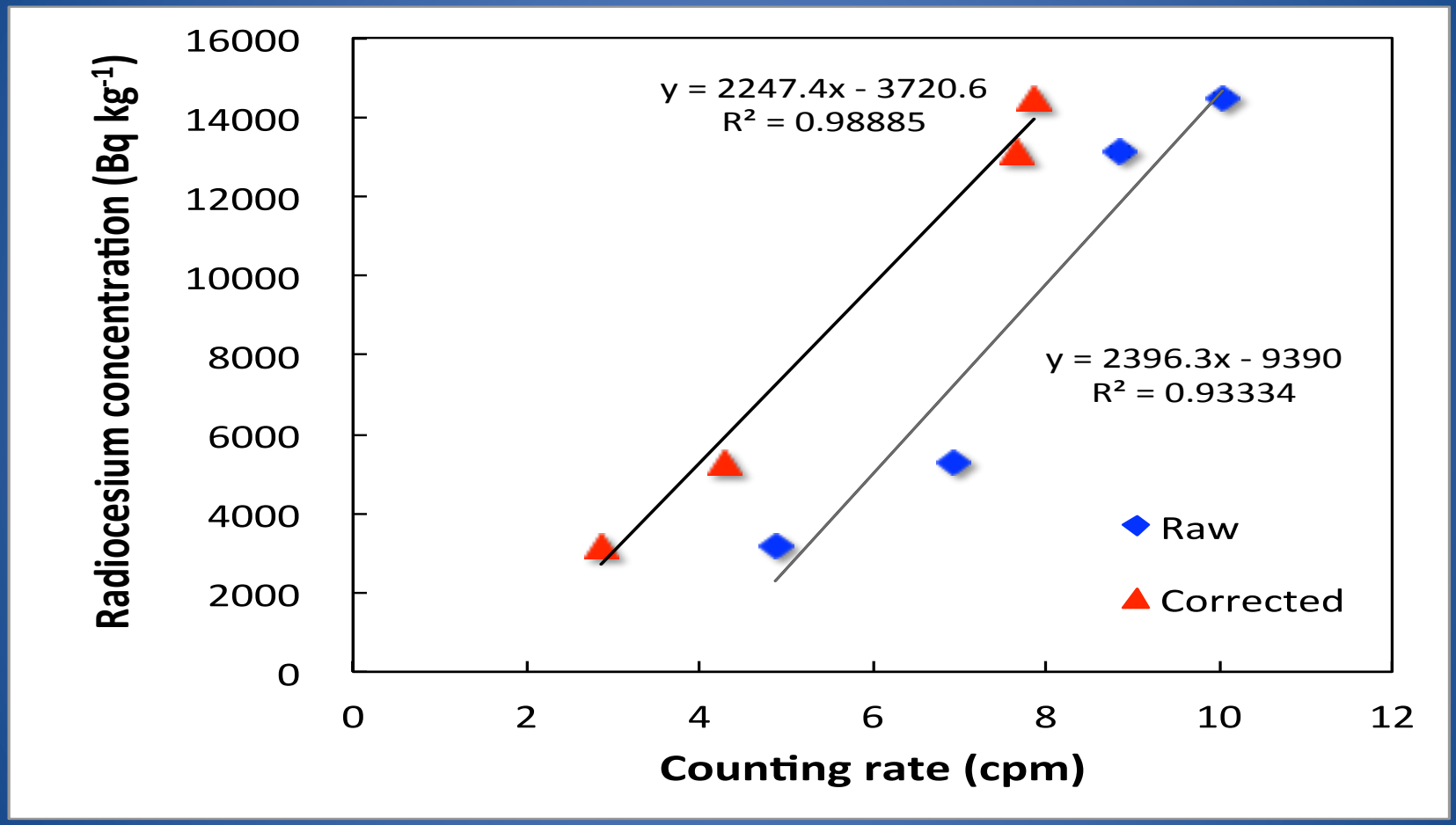
This matrix makes possible to evaluate the effect of leak of other layers.

2. Soil sampling vs. Measured counting rate vs. Corrected counting rate



Correction formula can be used to reduce radioactivity effect from outside of measurement.

3. Relationship between radioceasium concentration by soil sampling and corrected counting rate



Corrected counting rate shows good correlation with radioceasium concentration at each depth level.

Conclusions

- A new device for measuring radioceasium concentration of soil at each depth was developed.
- The device had directionality at each depth level however complete shielding of lead plate was difficult. Therefore, we evaluated the effect of leak as leakage coefficient and calculated corrected counting rate.
- Corrected counting rate and radioceasium concentration showed good correlation.

Acknowledgements

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(The University of Tokyo) .

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Thank you !
Ganbarō, FUKUSHIMA !!