

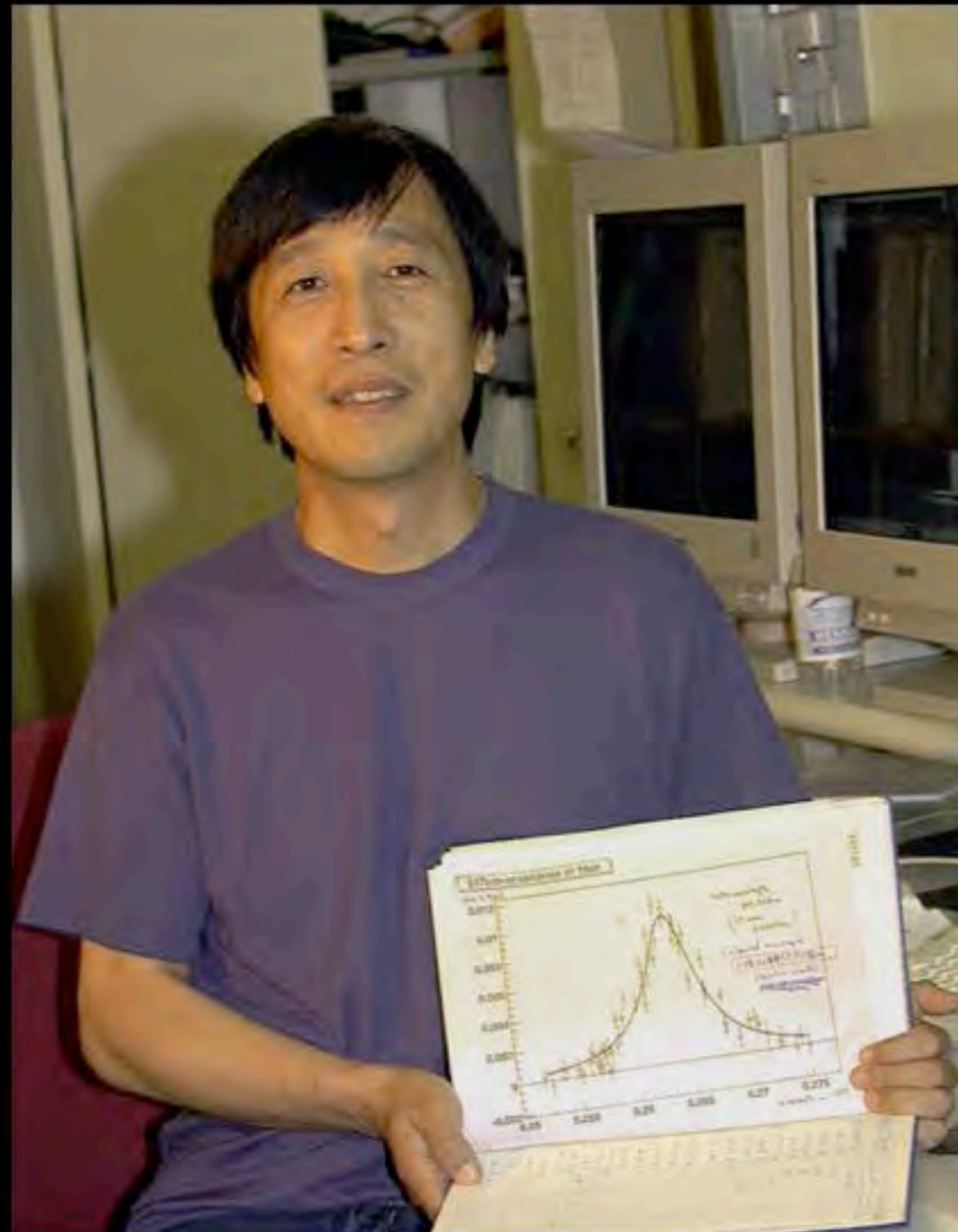
Internal and external radiation exposures of residents after the Fukushima Dai-ichi NPP accident

Ryu Hayano, U. Tokyo, Physics

Part 1

Why am I here today?

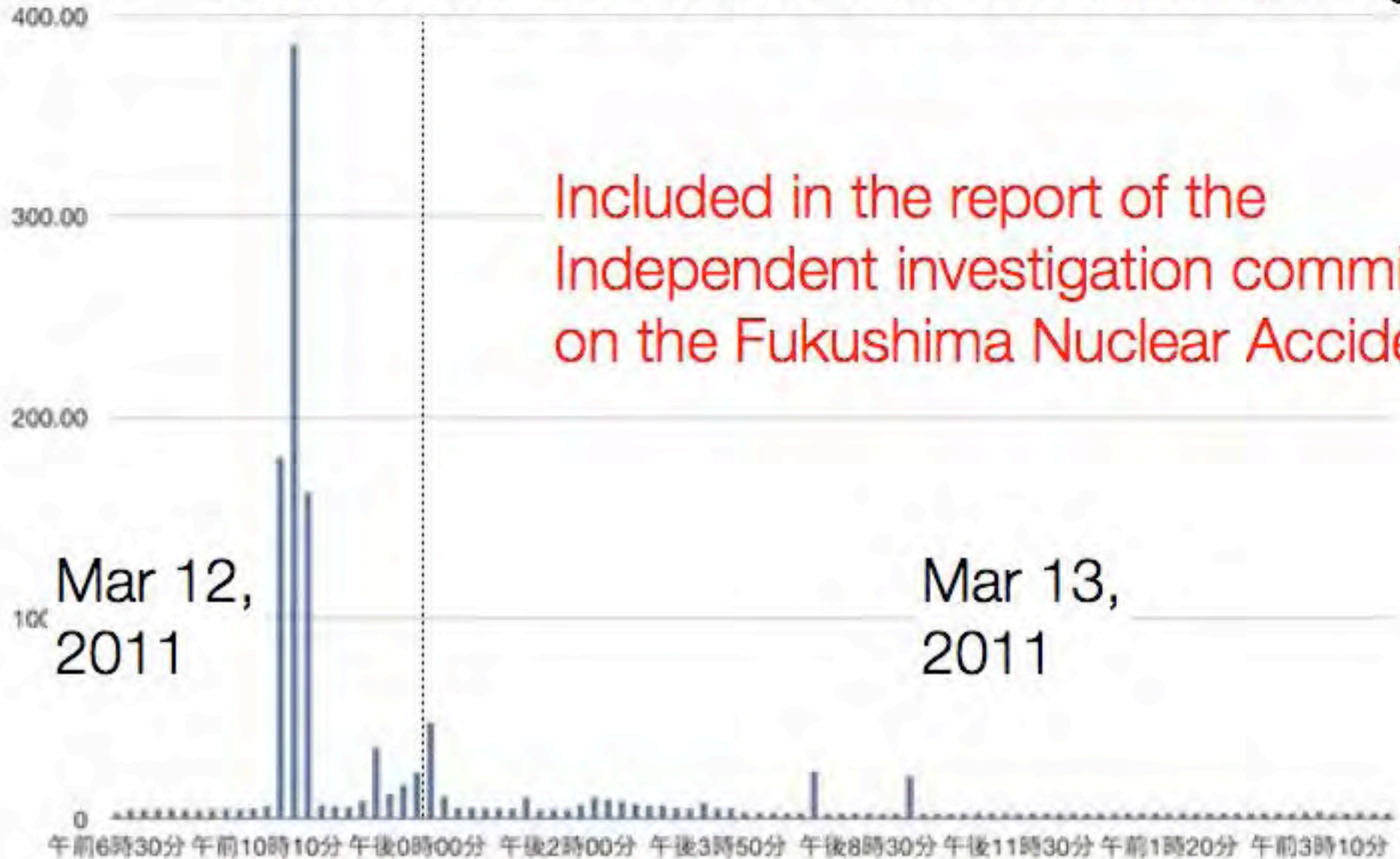
Before the accident studying “antimatter” at CERN



My first graph: Mar 13, 2011, 07:49



$\mu\text{Sv/h}$ Dose rate @ Fukushima Dai-ichi main gate



Included in the report of the Independent investigation commission on the Fukushima Nuclear Accident

Ranked 7th
among the most influential twitter accounts

twitter  is a
bi-directional media

Proposed to MEXT vice minister, 2011/9/21

Funded by MEXT, JFY 2012 & 2013

三次補正予算 食品のサンプル検査

新規提案 給食一食まるごと検査



School lunch in Fukushima
practically radiocesium free

Helping MDs with WBC measurements
(initially there were lots of confusions...)

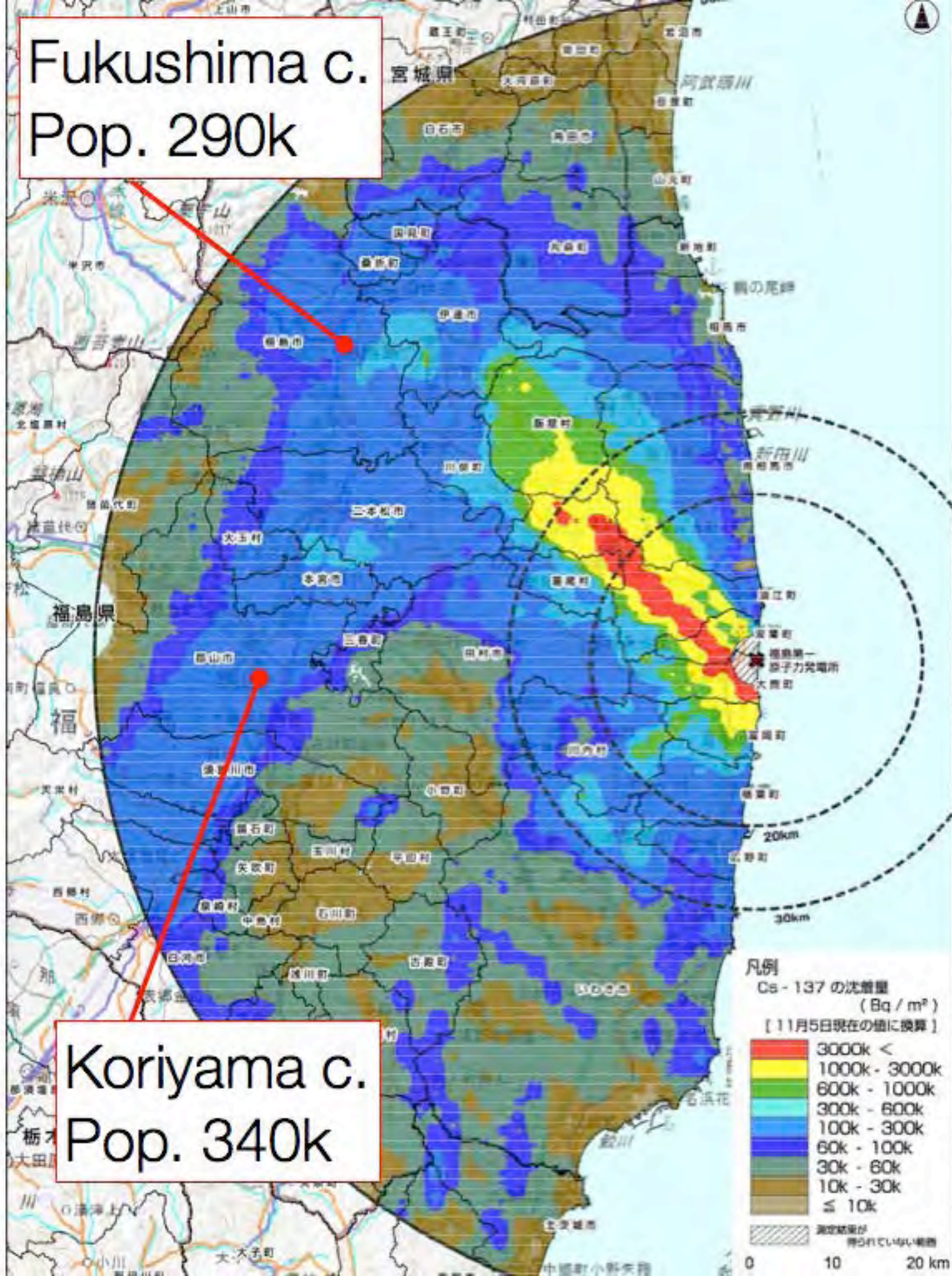


Part 2

Internal Exposure (daily ingestion of radiocesium)

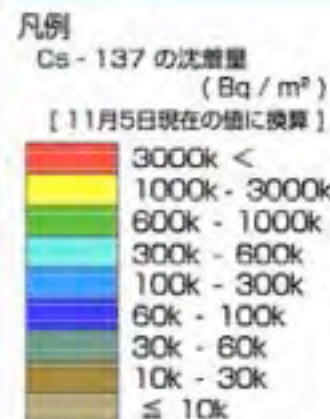
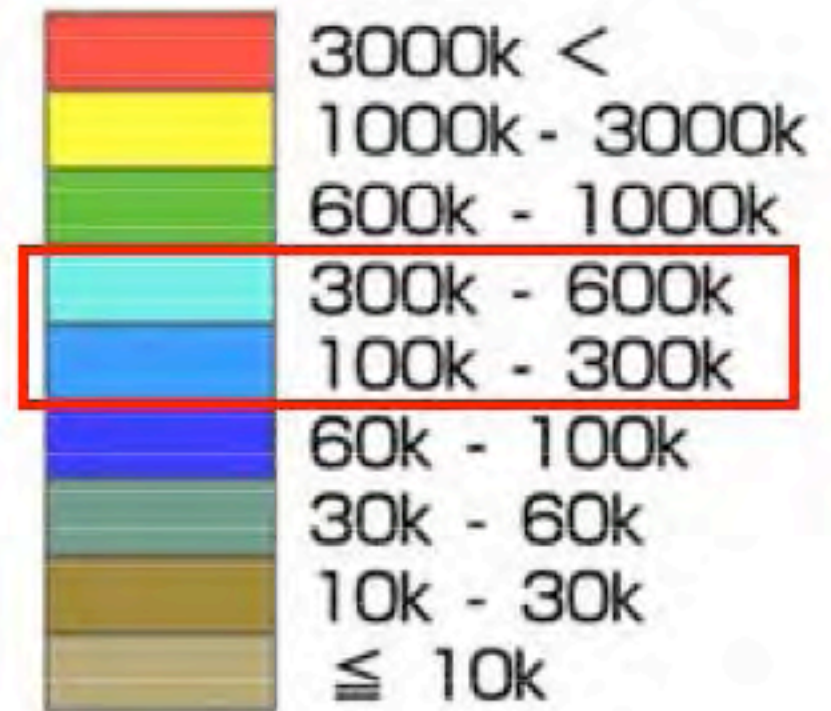


Fukushima c.
Pop. 290k



Koriyama c.
Pop. 340k

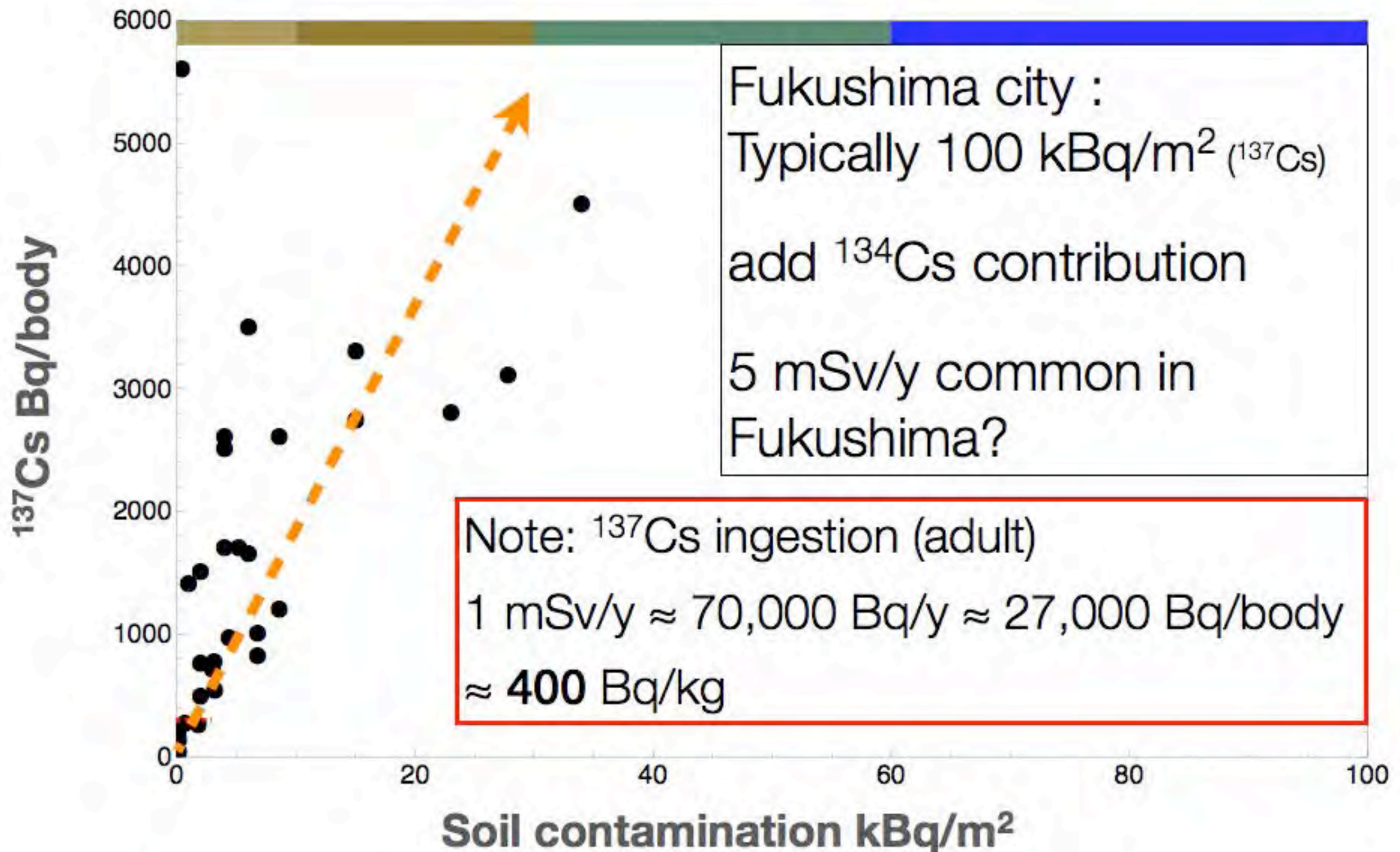
^{137}Cs deposition
(2011/11/5)



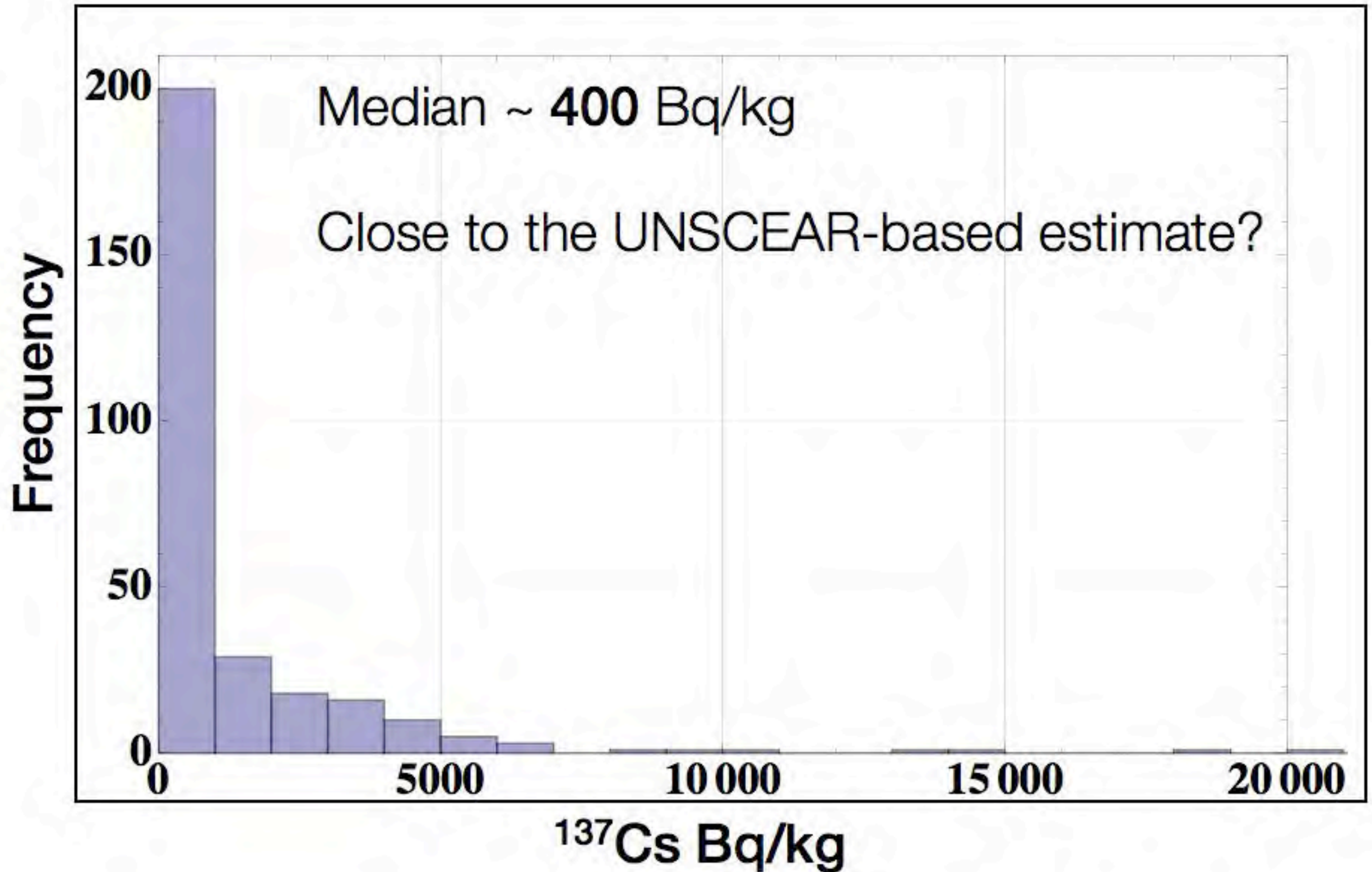
0 10 20 km

UNSCEAR 1988:

100kBq/m² → 2 mSv/y internal exposure



Wild boar in Fukushima (2011-2013)



Internal radiocesium contamination of adults and children in Fukushima 7 to 20 months after the Fukushima NPP accident as measured by extensive whole-body-counter surveys

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Hideo SATOU,^{*4} Katsumi SATO,^{*4} Shin MASAKI^{*4} and Yu SAKUMA^{*4}

(Communicated by Toshimitsu YAMAZAKI, M.J.A.)

Abstract: The Fukushima Dai-ichi NPP accident contaminated the soil of densely-populated regions in Fukushima Prefecture with radioactive cesium, which poses significant risks of internal and external exposure to the residents. If we apply the knowledge of post-Chernobyl accident studies, internal exposures in excess of a few mSv/y would be expected to be frequent in Fukushima.

Extensive whole-body-counter surveys ($n = 32,811$) carried out at the Hirata Central Hospital between October, 2011 and November, 2012, however show that the internal exposure levels of residents are much lower than estimated. In particular, the first sampling-bias-free assessment of the internal exposure of children in the town of Miharu, Fukushima, shows that the ^{137}Cs body burdens of all children ($n = 1,383$, ages 6–15, covering 95% of children enrolled in town-operated schools) were below the detection limit of 300 Bq/body in the fall of 2012. These results are not conclusive for the prefecture as a whole, but are consistent with results obtained from other municipalities in the prefecture, and with prefectural data.

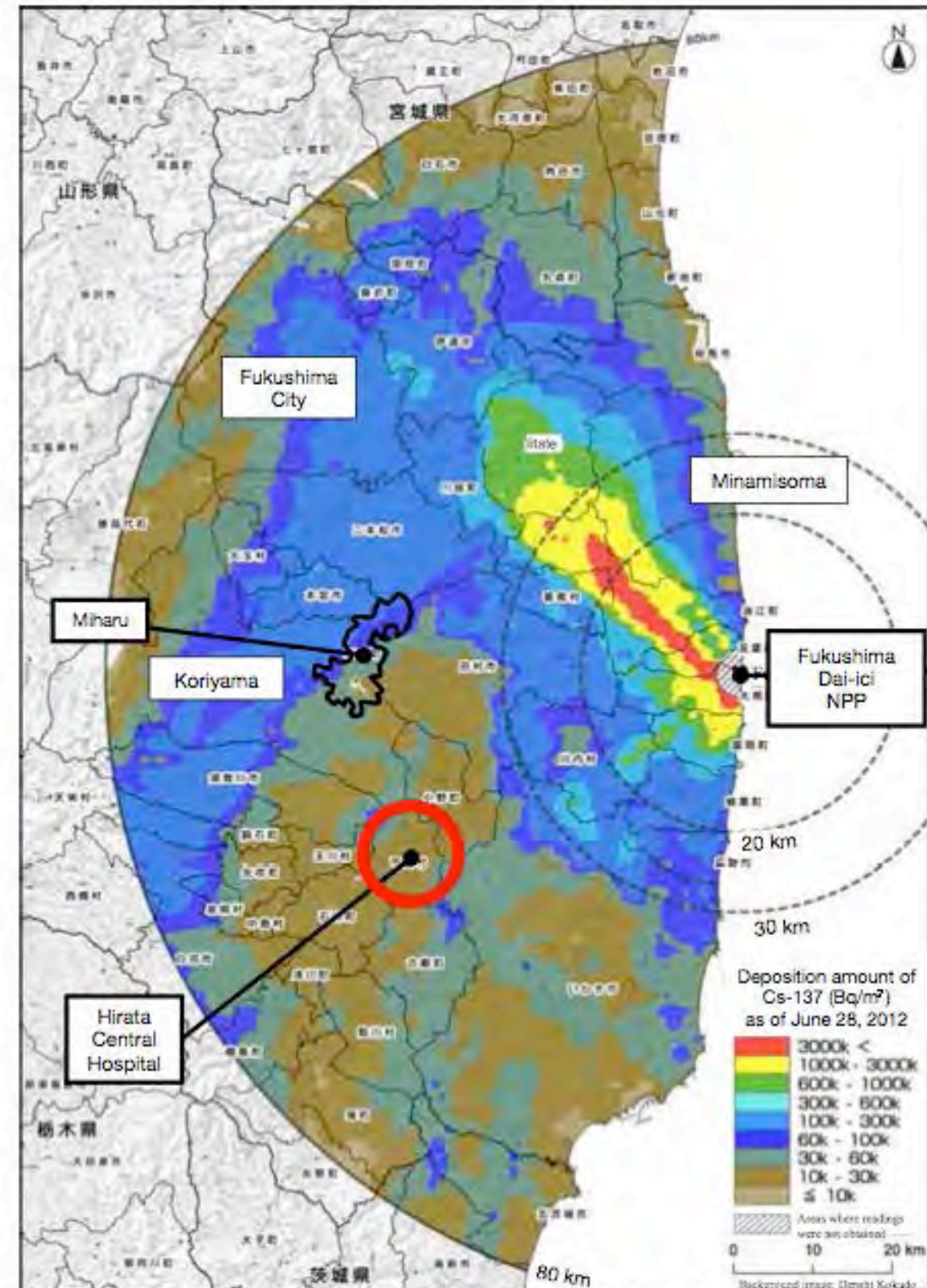
Keywords: Fukushima Dai-ichi NPP accident, radioactive cesium, whole-body counting, committed effective dose

WBC measurement at Hirata Central Hospital

- ▶ FASTSCAN (2-min)
- ▶ Detection limit 300 Bq/body
 $\approx 0.02\text{mSv/y} \approx 10\%$ of ^{40}K
- ▶ Use step (for children)



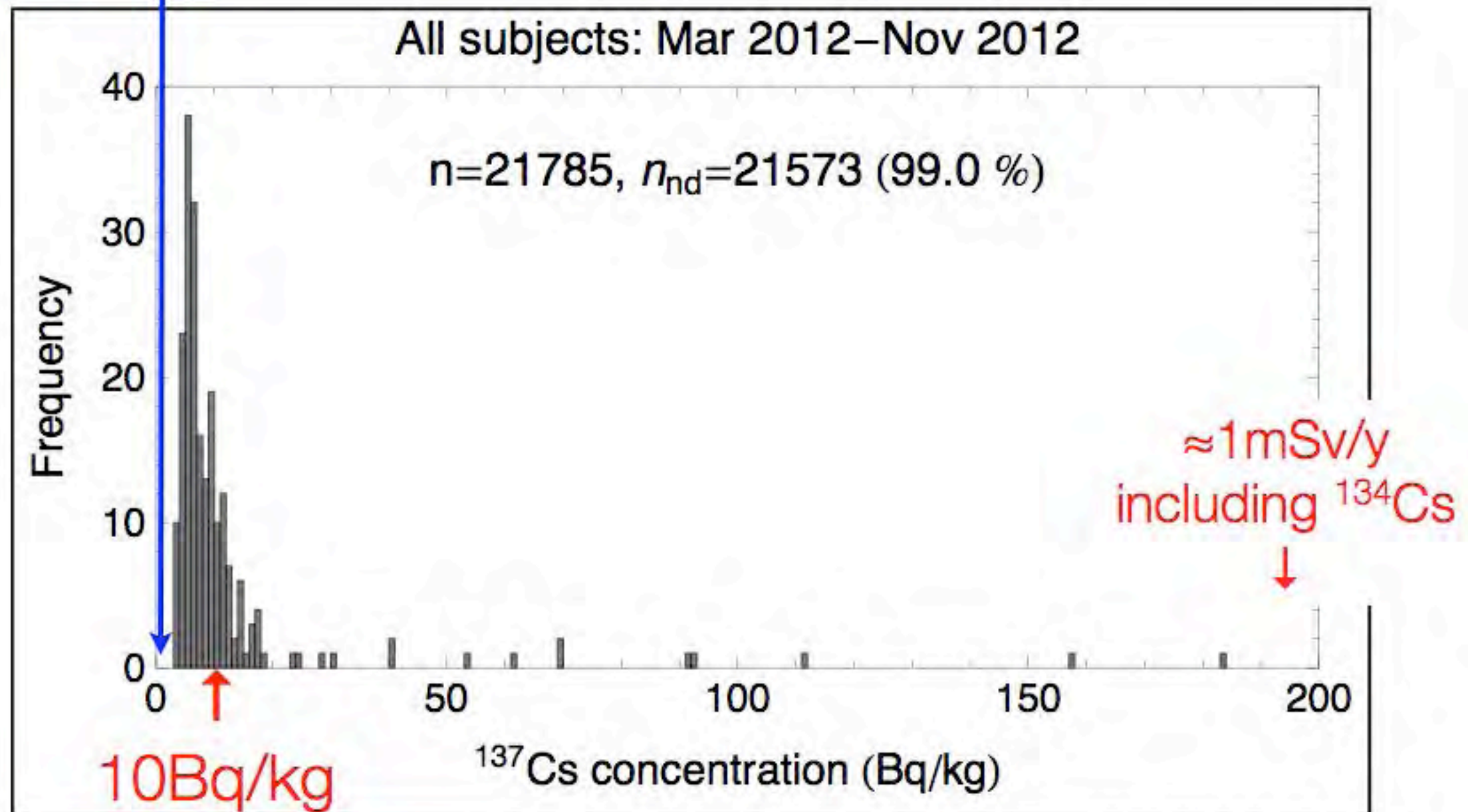
Hirata Central Hospital



from Hayano et al., PJAB 89 (2013) 157

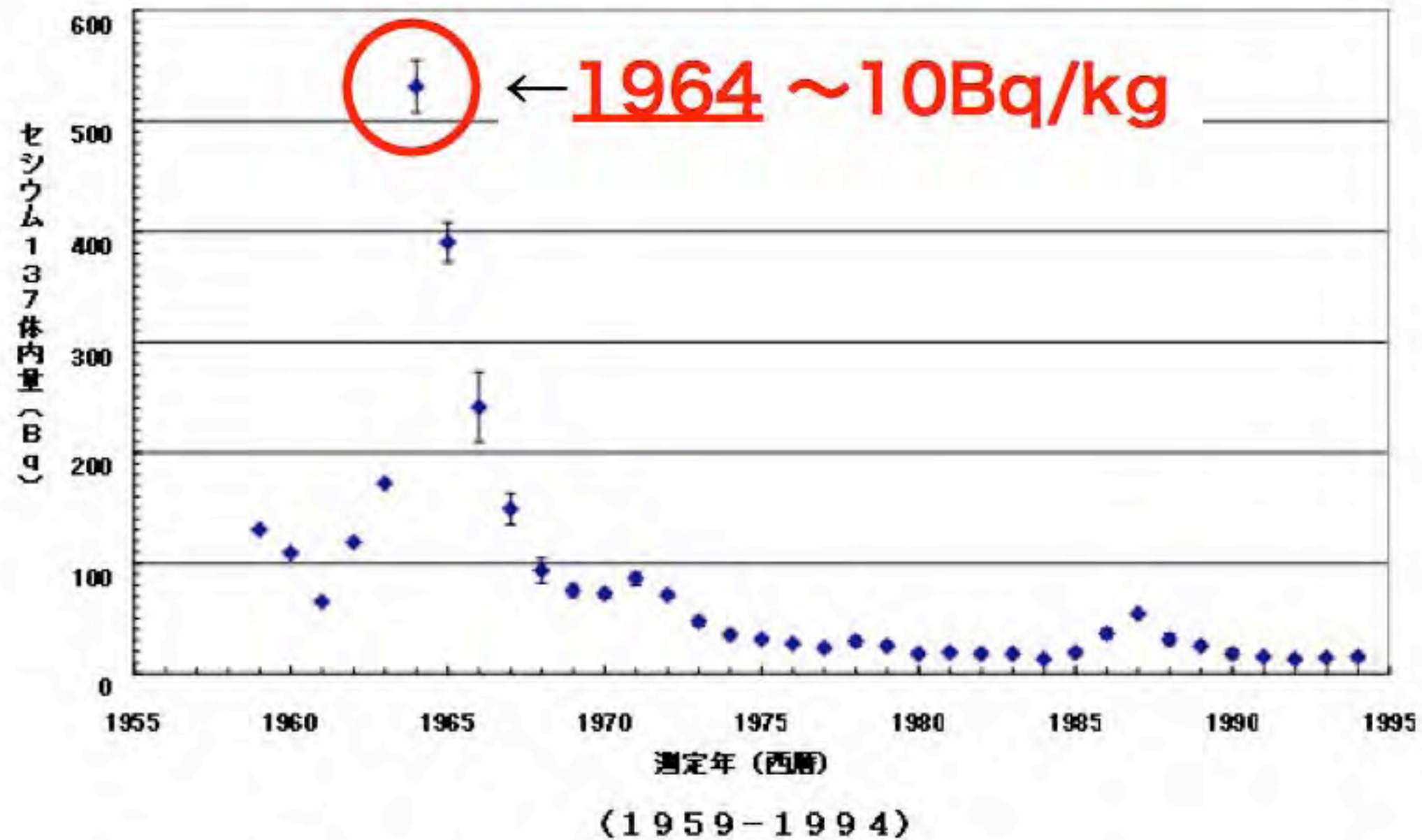
^{137}Cs concentration (Bq/kg) after March 2012

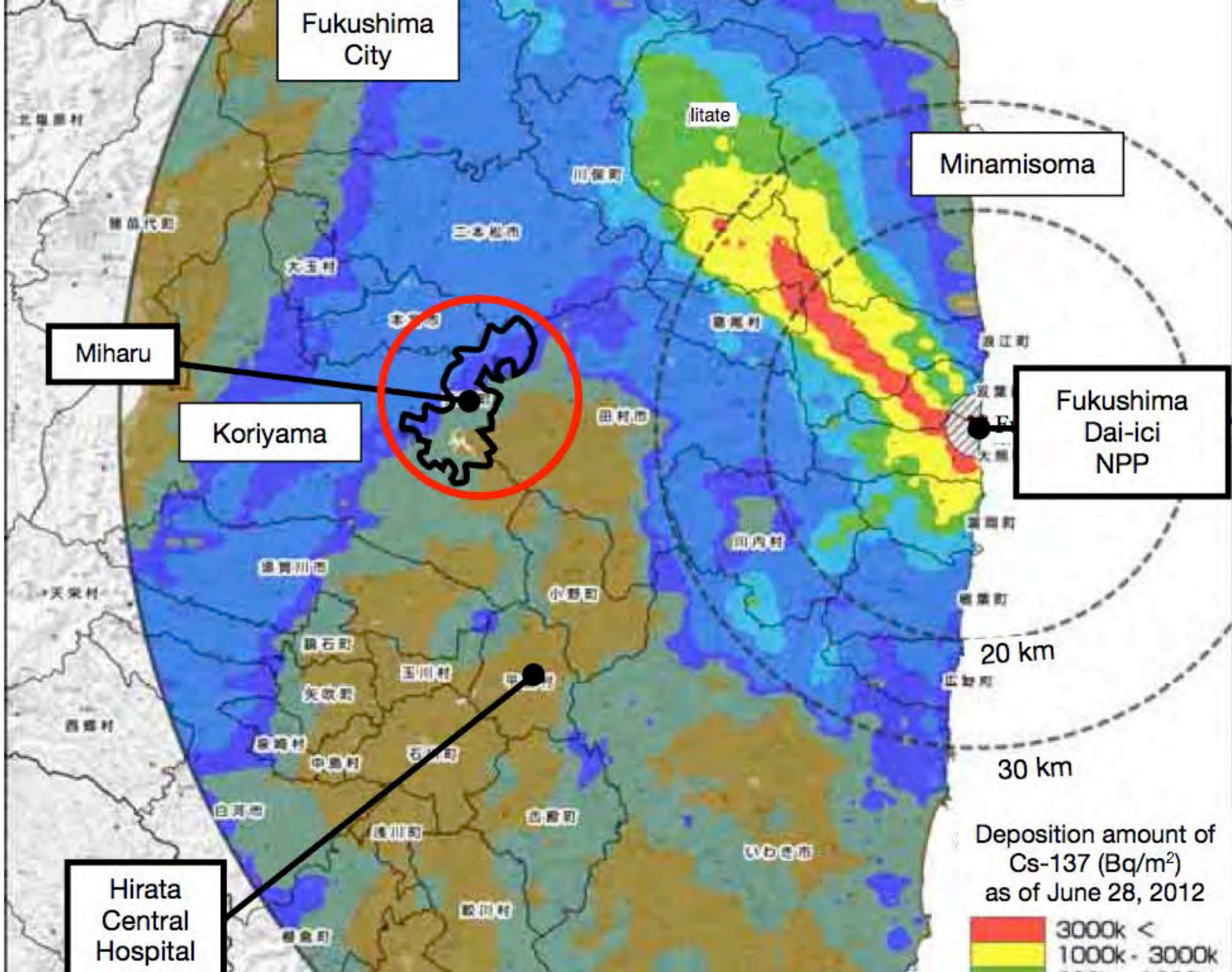
99% were ND



from Hayano et al., PJAB 89 (2013) 157

^{137}Cs in Japanese adult male, 1959-1994





Fukushima City

Minamisoma

Miharu

Koriyama

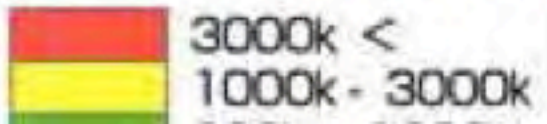
Fukushima Dai-ichi NPP

Hirata Central Hospital

20 km

30 km

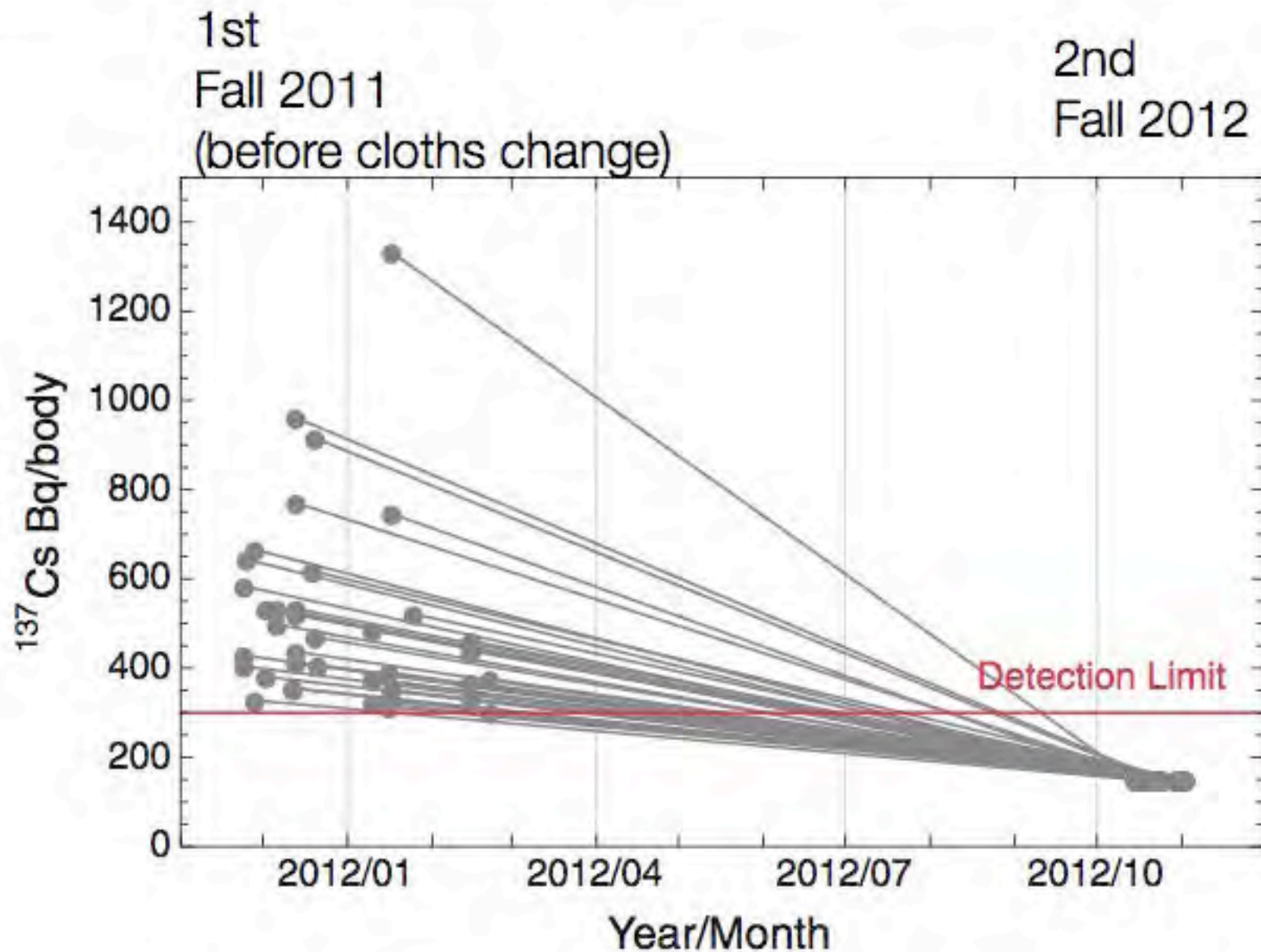
Deposition amount of Cs-137 (Bq/m²) as of June 28, 2012



Miharu-town school children

data without “sampling bias”

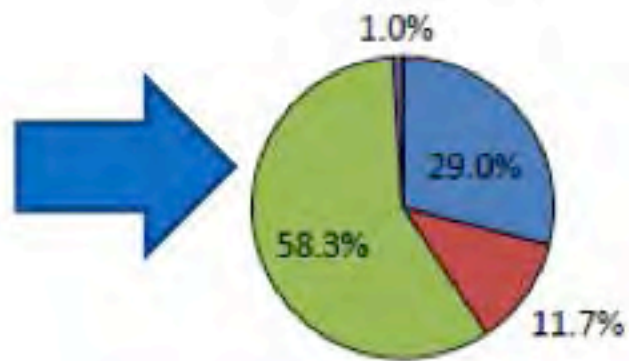
Enrolled in August 25, 2011	Measured in Winter 2011	Coverage	^{137}Cs detected	Enrolled in April 1, 2012	Measured in Fall 2012	Coverage	^{137}Cs detected
1,585	1,494	94.3%	54	1,456	1,383	95.0%	0



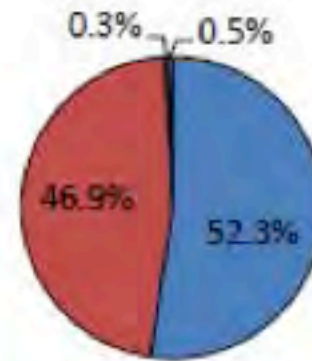
Miharu-town children are eating local rice & vegetables

<http://www.town.miharu.fukushima.jp/soshiki/11/kensakekka-kouhyo.html>

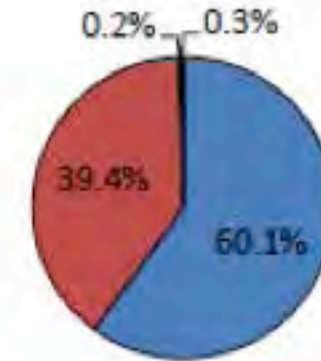
Rice



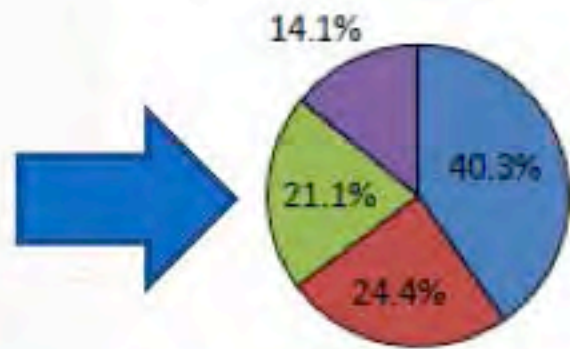
Meat



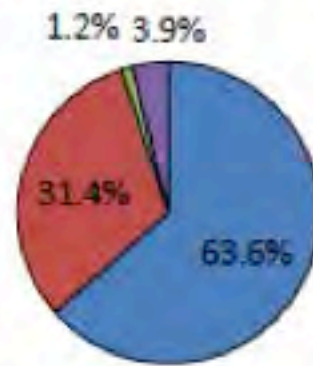
Fish



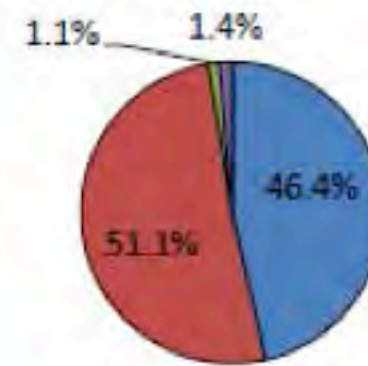
Vegetables



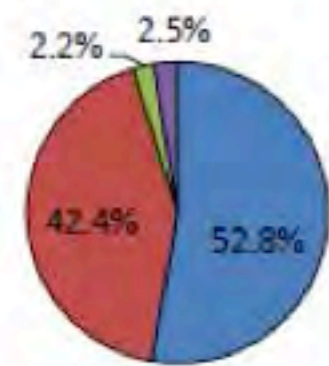
Mushrooms



Milk



Fruit



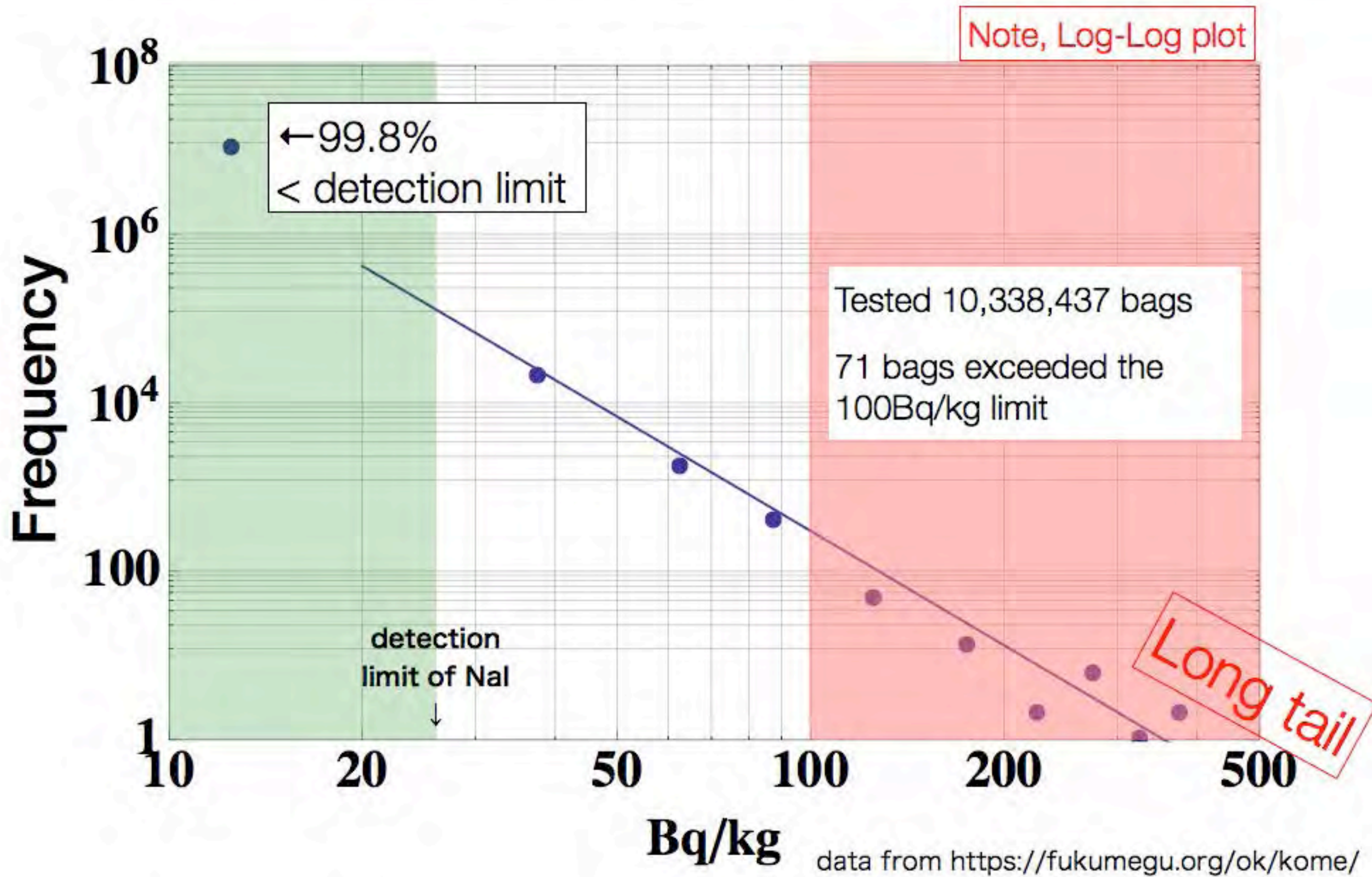
■ supermarket
■ avoid local food

■ supermarket
■ also buy local food

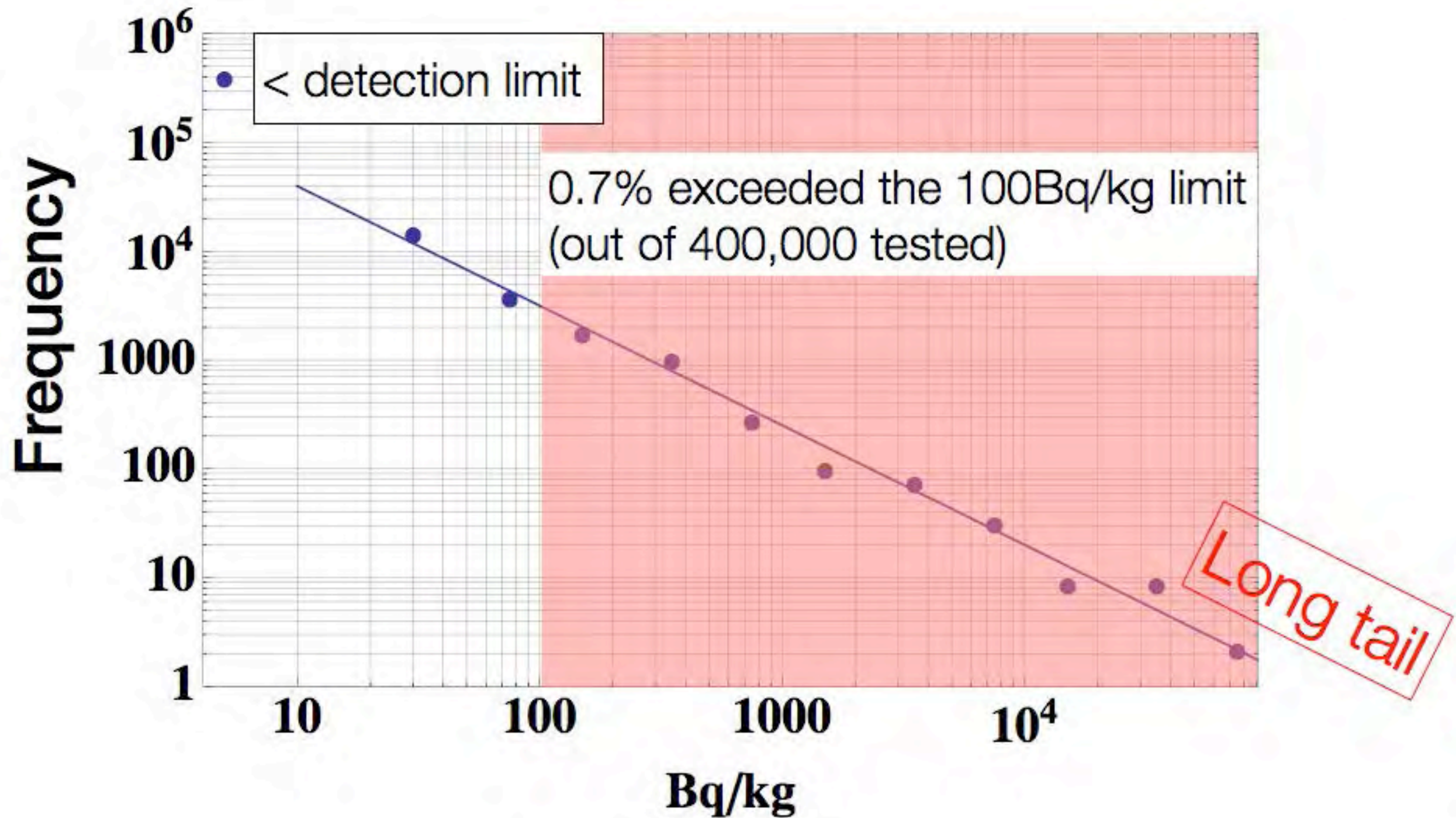
■ home-grown
■ other

Why?

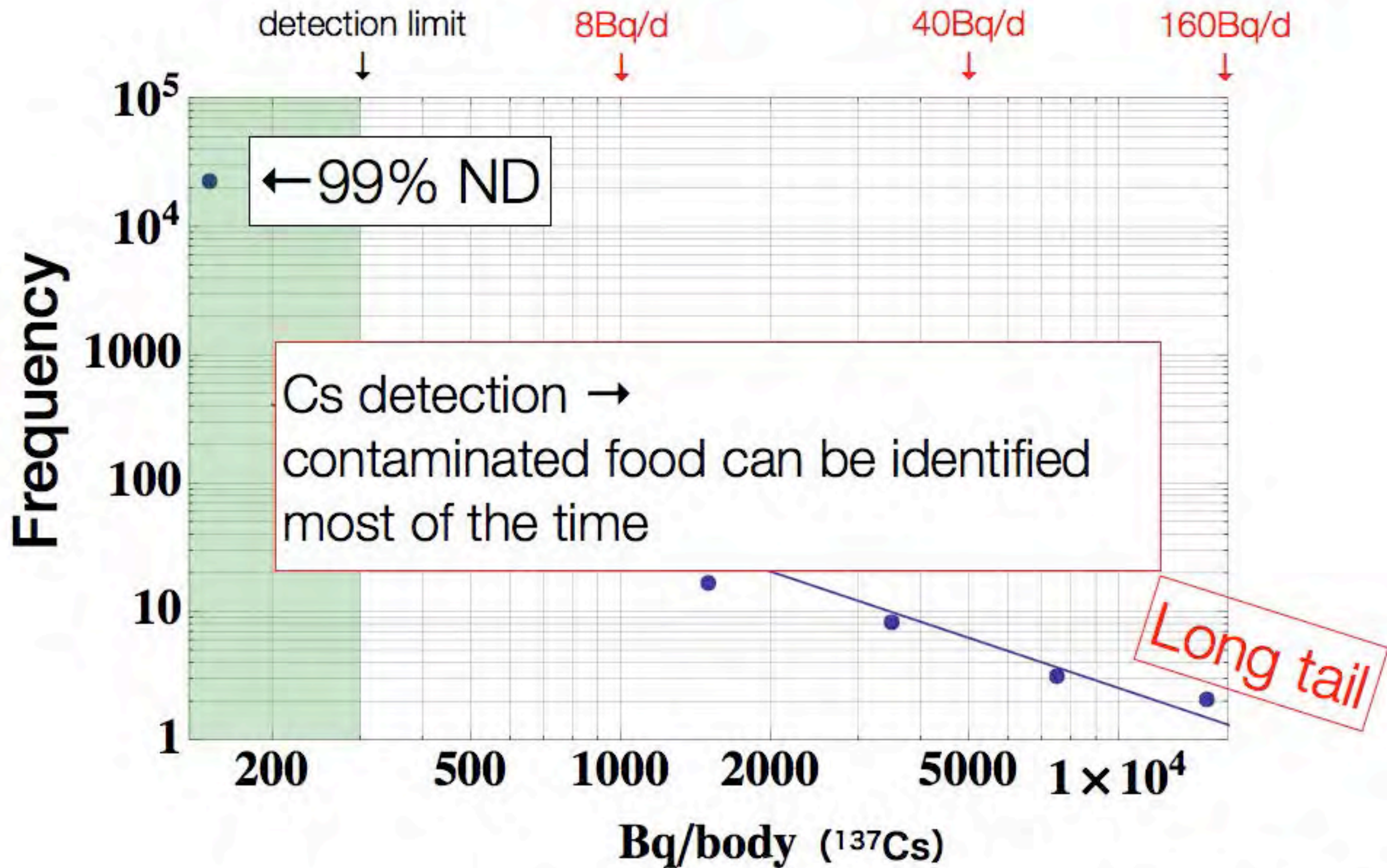
Every bag (30kg each) of brown-rice harvested in Fukushima in 2012 tested for radiocesium



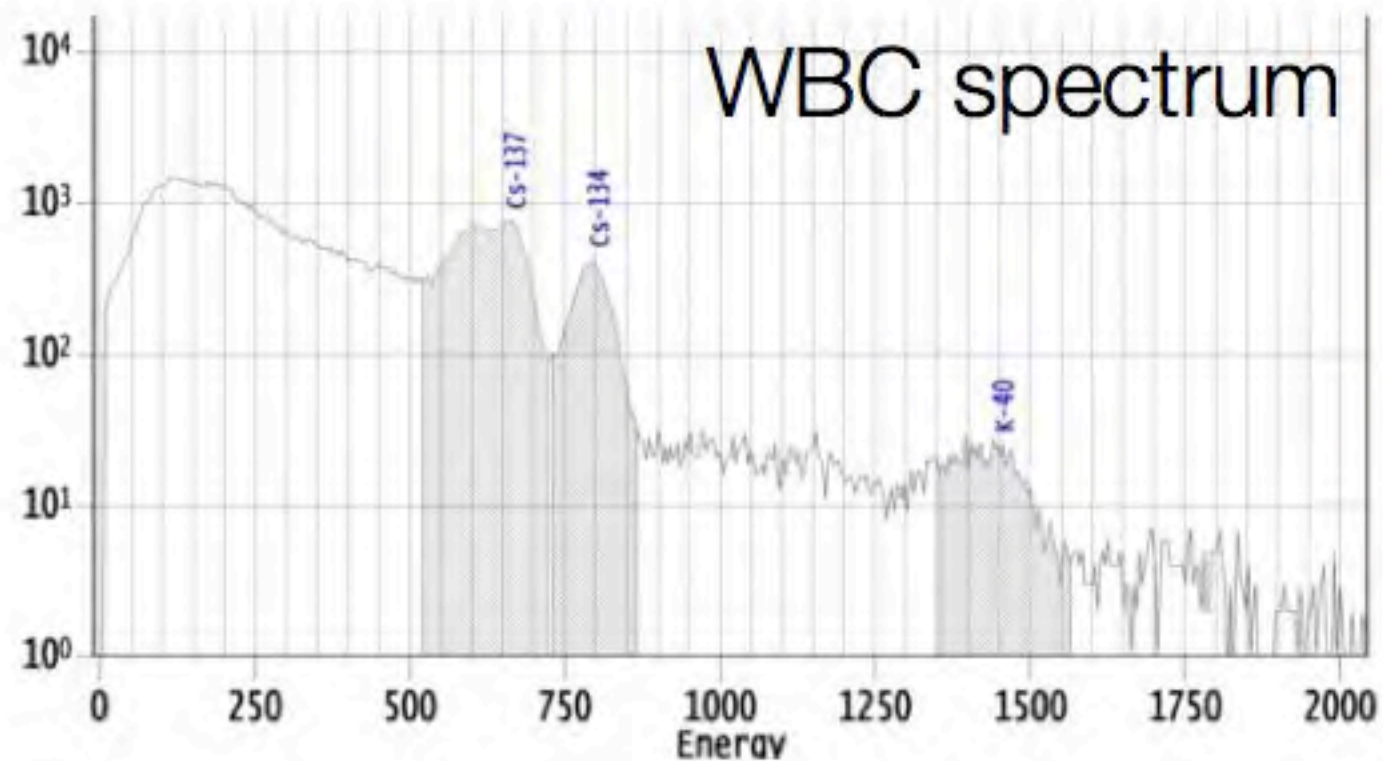
Test results of general foods (2012 Apr ~ , pre-marketing tests)



Hirata-hospital WBC results in log-log plot



70-male, 20,000Bq/body, 0.8mSv/y
140,000 Bq/kg mushroom was found in his pantry



Shiitake mushroom

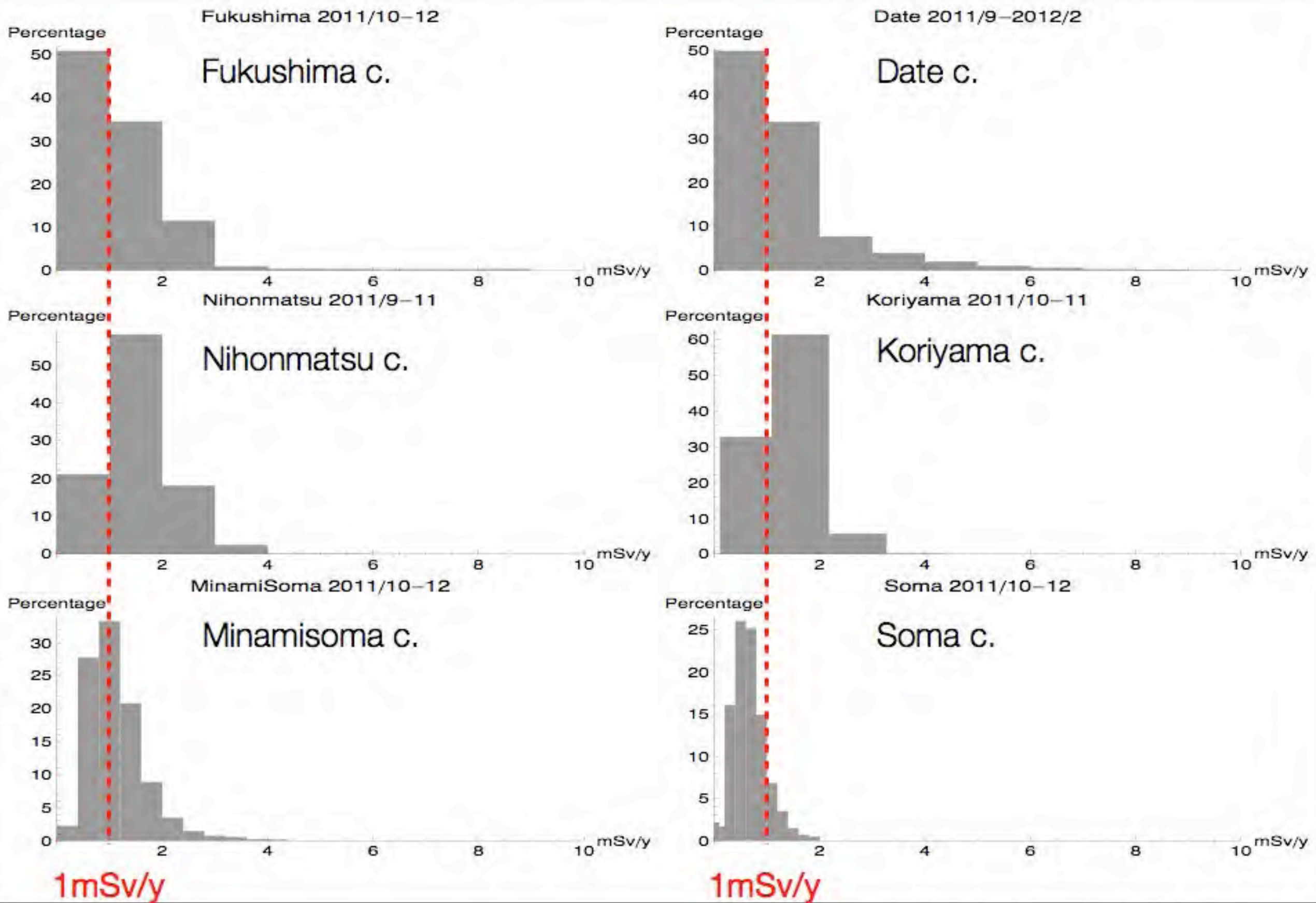
Wild boar, wild mushrooms, ...,
not from markets
not tested for radiocesium
consumed regularly

Part 3

External Exposure



"Glass badge" results, winter 2011



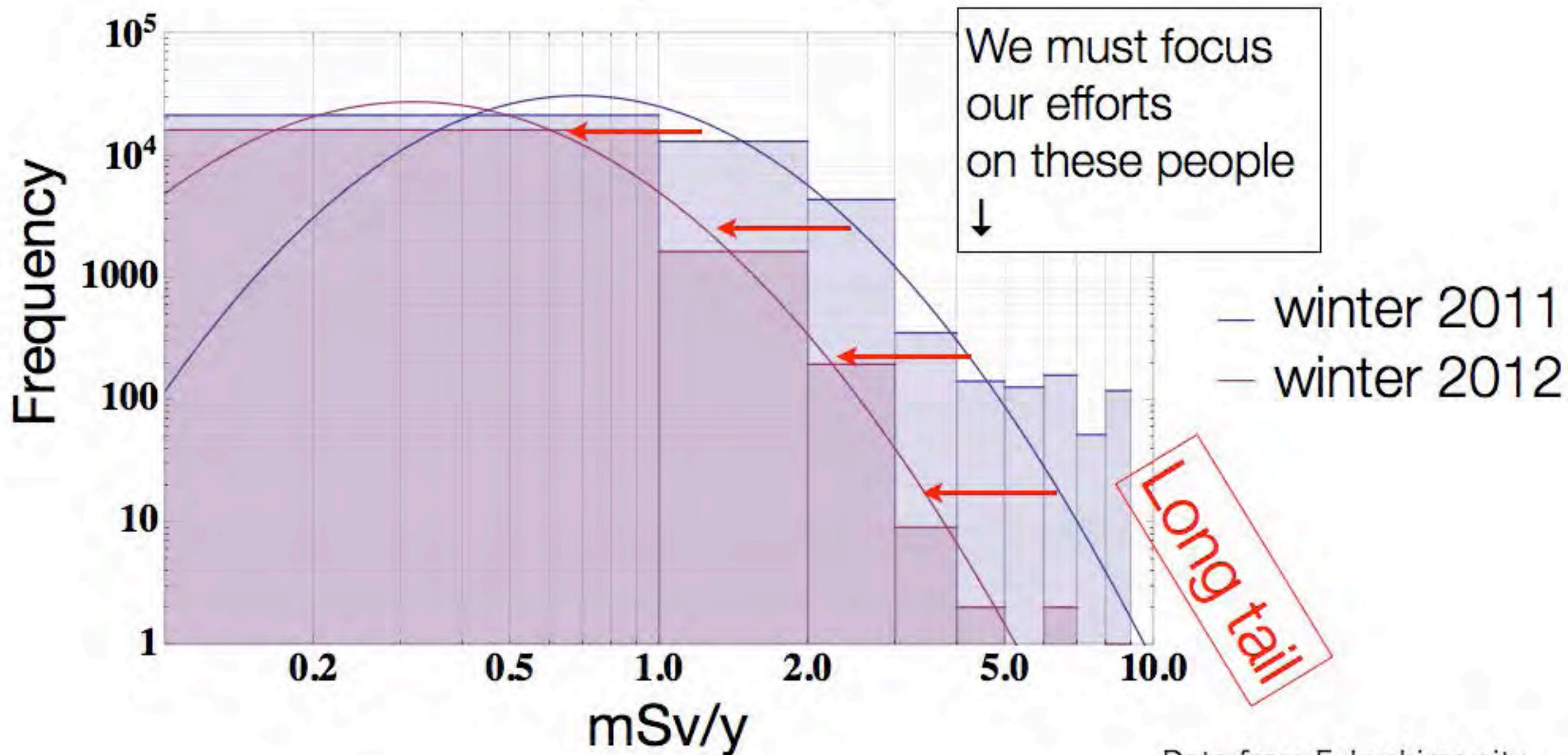
1mSv/y

1mSv/y

2-3 mo. results extrapolated to 1 year

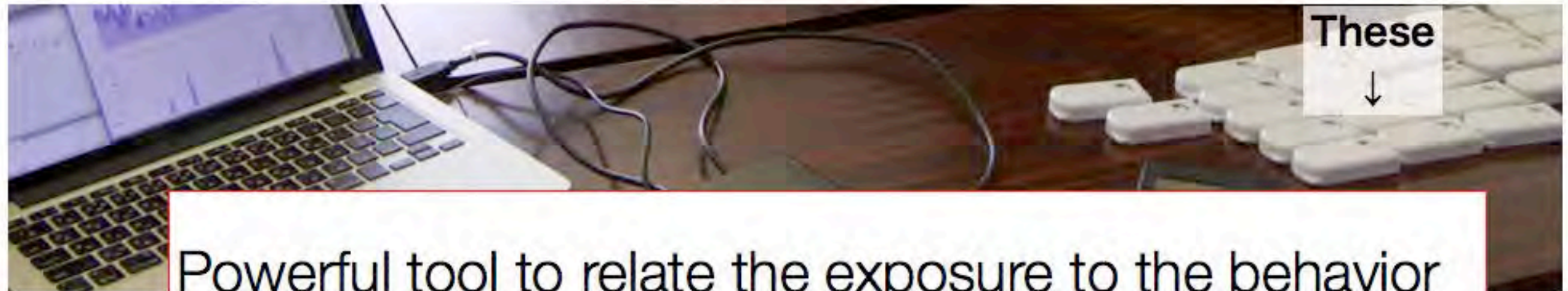
Fukushima city glass badge data in log-log

Fukushima city glass badge



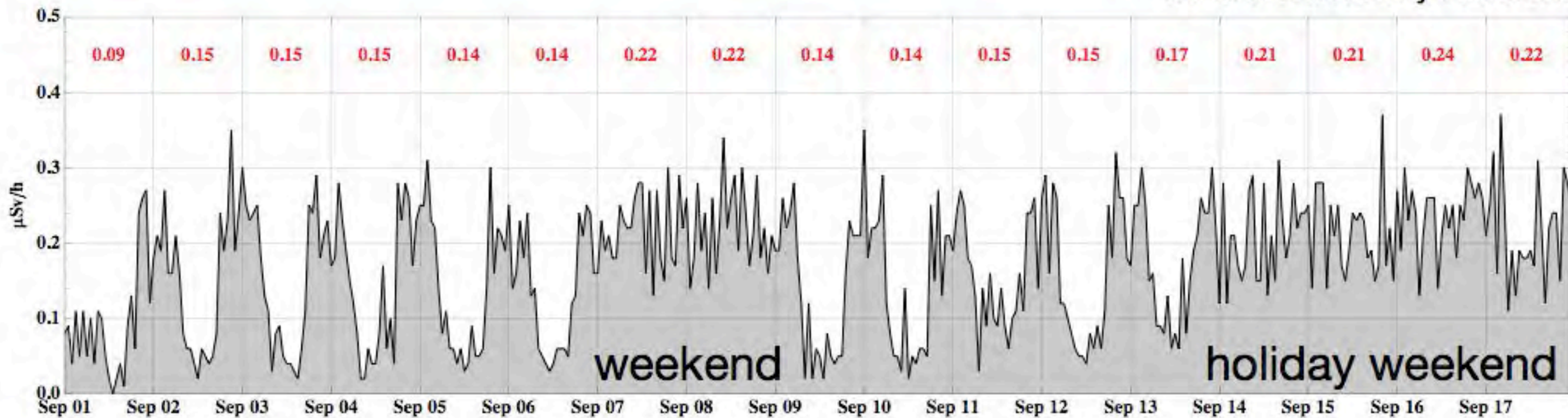
Data from Fukushima city

Personal dosimeter with 1-hour integrated-dose readout



Powerful tool to relate the exposure to the behavior
(and discuss how to reduce risks)

a Fukushima city resident



Summary

What have we learned
in 2.5 years?

1. It is essential that we measure internal+external dose for each individual
2. Internal contamination is much much lower than initially feared
for most people, <10% of K-40 dose
but there is a long tail
3. The risk of external exposure is higher
4. “Long tail” is an important keyword
 1. Must measure many people
 2. Looking at the “average” is insufficient
 3. Important to find the people in the “tail”, explain, consult, devise effective measures to reduce their dose
 4. Fortunately, the number of such people is relatively few in Fukushima