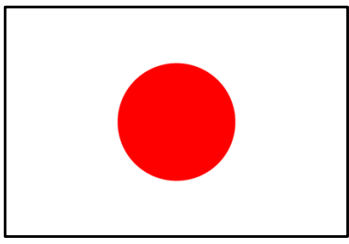


Trace of radiocesium-bearing particles in masks worn by members of the public in Fukushima

Shogo Higaki^a, Yuichi Kurihara^b and Yoshio Takahashi^b

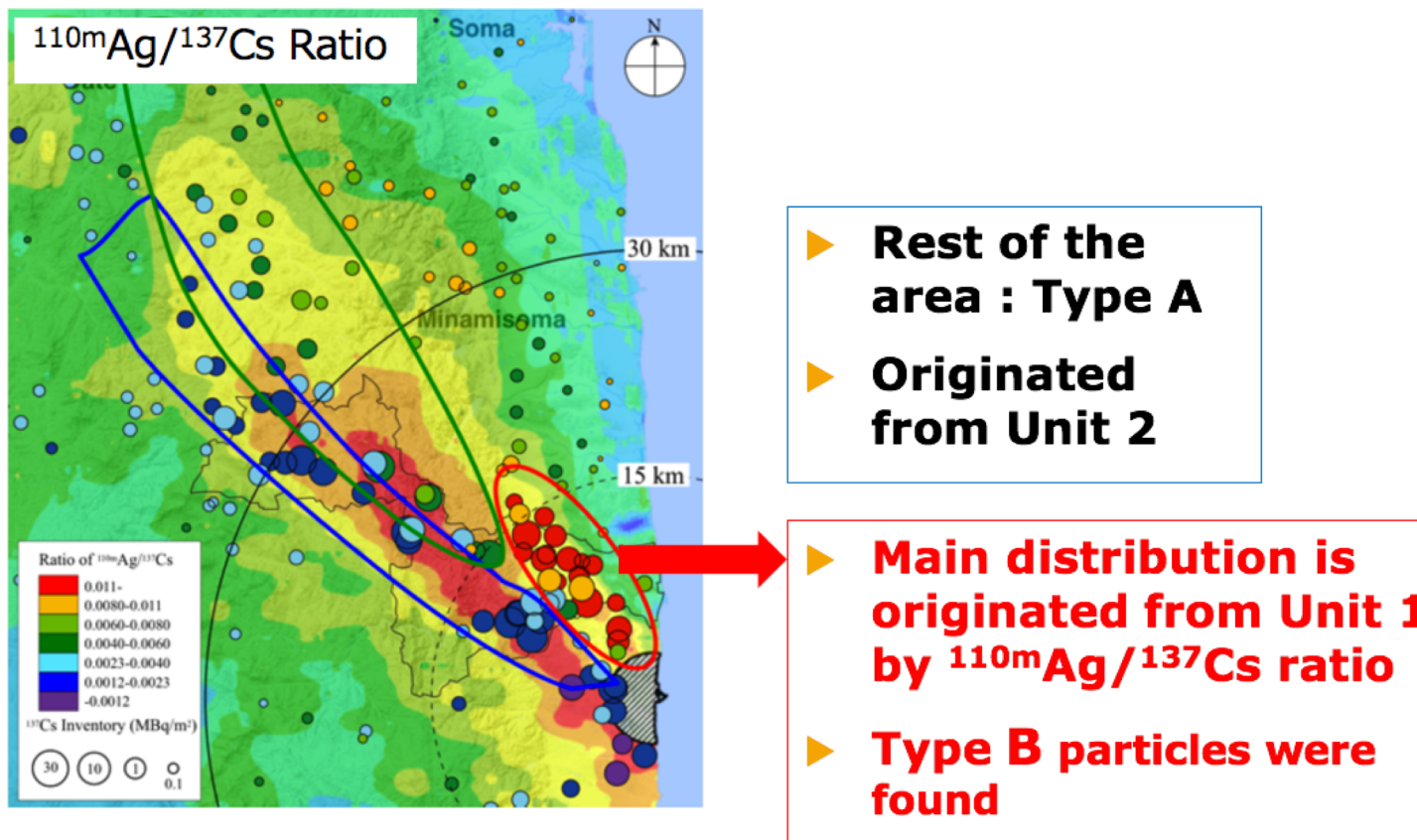
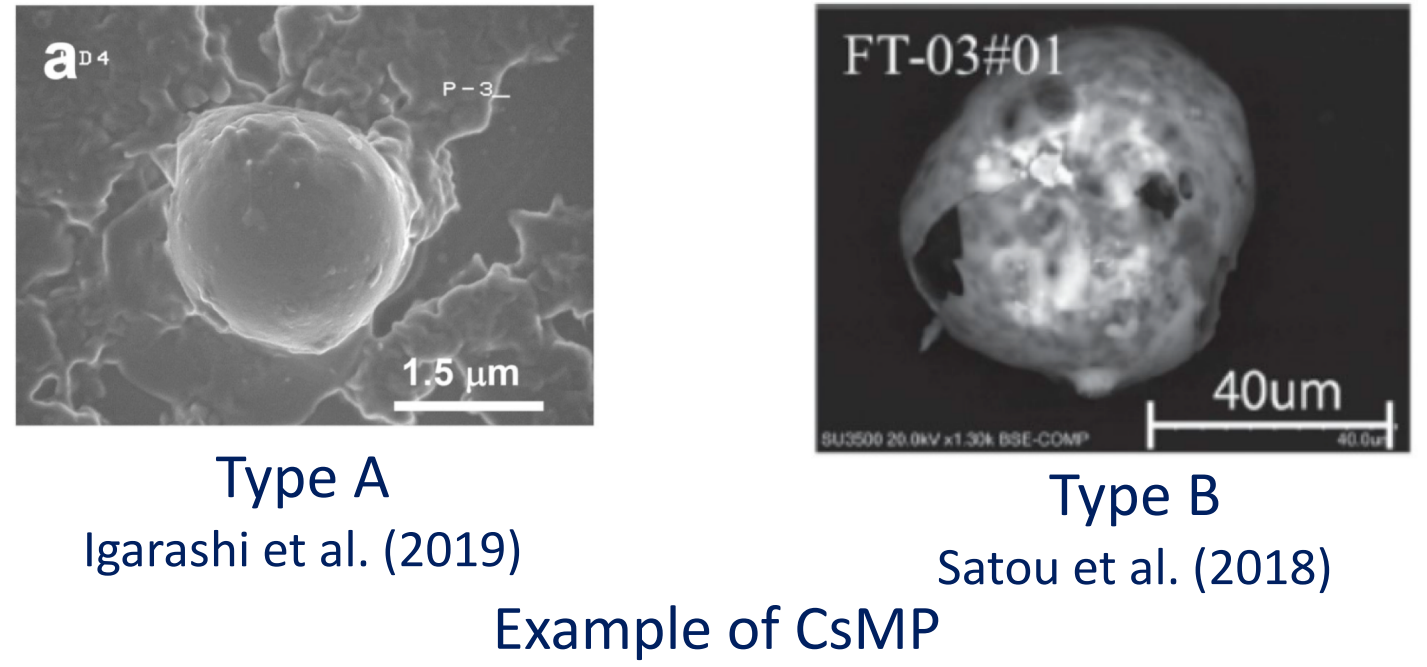
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Introduction

- Radiocesium-bearing micro particles (CsMP) were one of the forms of radiocesium emitted from the reactor involved in the Fukushima accident.
 - Type A CsMP are smaller (1–10 μm) and high specific ¹³⁷Cs activity, Type B CsMP are larger (70–400 μm) and low specific activity.
 - In our previous study*, radiocesium adhering to masks worn by members of the public lived in eastern Japan in the Spring of 2012 was measured (*Higaki et al. *Health Phys.*, **107** 117–134 (2014)) .
 - The exposure dose by inhalation was a maximum of 0.494 μSv for eight weeks in the Spring of 2012, and that radiocesium adhering to soil was the source of inhalation exposure.
 - However, the effective doses of internal exposure due to inhalation by members of the public after 2013, and the ratio of CsMP in total radiocesium, remain unknown.
- The amounts of radiocesium adhered to the non-woven fabric masks worn by members of the general public living in Fukushima Prefecture in the Spring of 2013 and 2014 were investigated and the proportion of CsMP contained in the total radiocesium was measured.



Distribution of CsMP around the FDNPP

Experiments

Study subjects

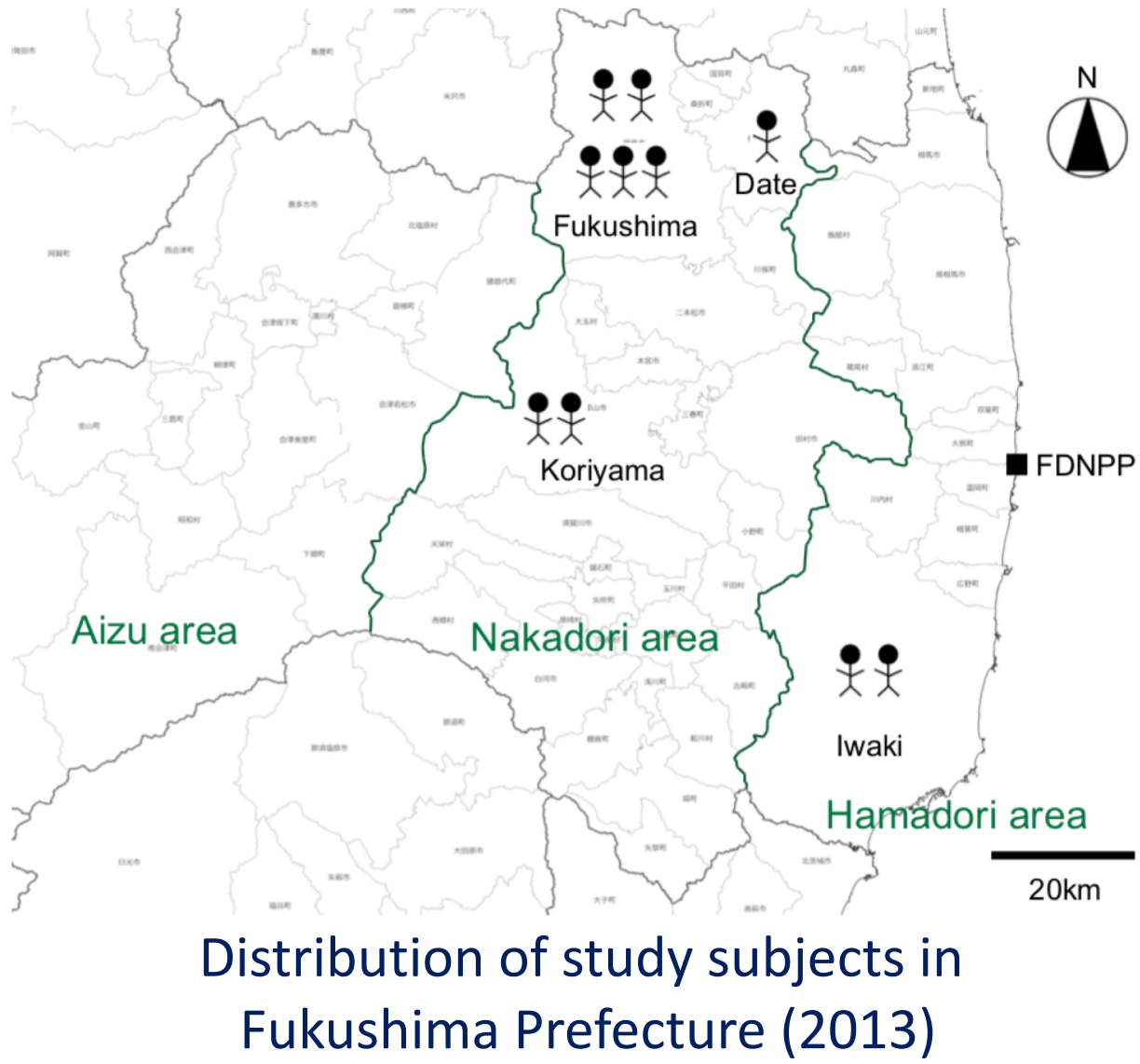
ID	City of residence	Gender	Age in 2014	2012*	2013	2014
Fukushima-1	Date	F	61	○	-	-
Fukushima-2	Fukushima	F	46	○	○	-
Fukushima-3	Fukushima	F	45	○	-	-
Fukushima-4	Fukushima	F	43	○	○	○
Fukushima-5	Fukushima	F	59	○	○	○
Fukushima-6	Koriyama	M	45	○	○	○
Fukushima-7	Koriyama	M	57	○	○	○
Fukushima-8	Iwaki	M	45	○	-	-
Fukushima-9	Iwaki	M	43	○	○	○
Fukushima-10	Iwaki	F	35	○	○	○
Fukushima-11	Date District	F	56	-	○	○
Fukushima-12	Fukushima	F	41	-	○	○
Fukushima-13	Fukushima	F	42	-	○	○
Fukushima-14	Aizuwakamatsu	M	20	-	-	○
Fukushima-15	Aizuwakamatsu	F	57	-	-	○
Fukushima-16	Date District	F	56	-	-	○
Fukushima-17	Fukushima	F	28	-	-	○
Fukushima-18	Fukushima	F	54	-	-	○
Fukushima-19	Fukushima	F	51	-	-	○

Radioactivity of a mask and CsMP

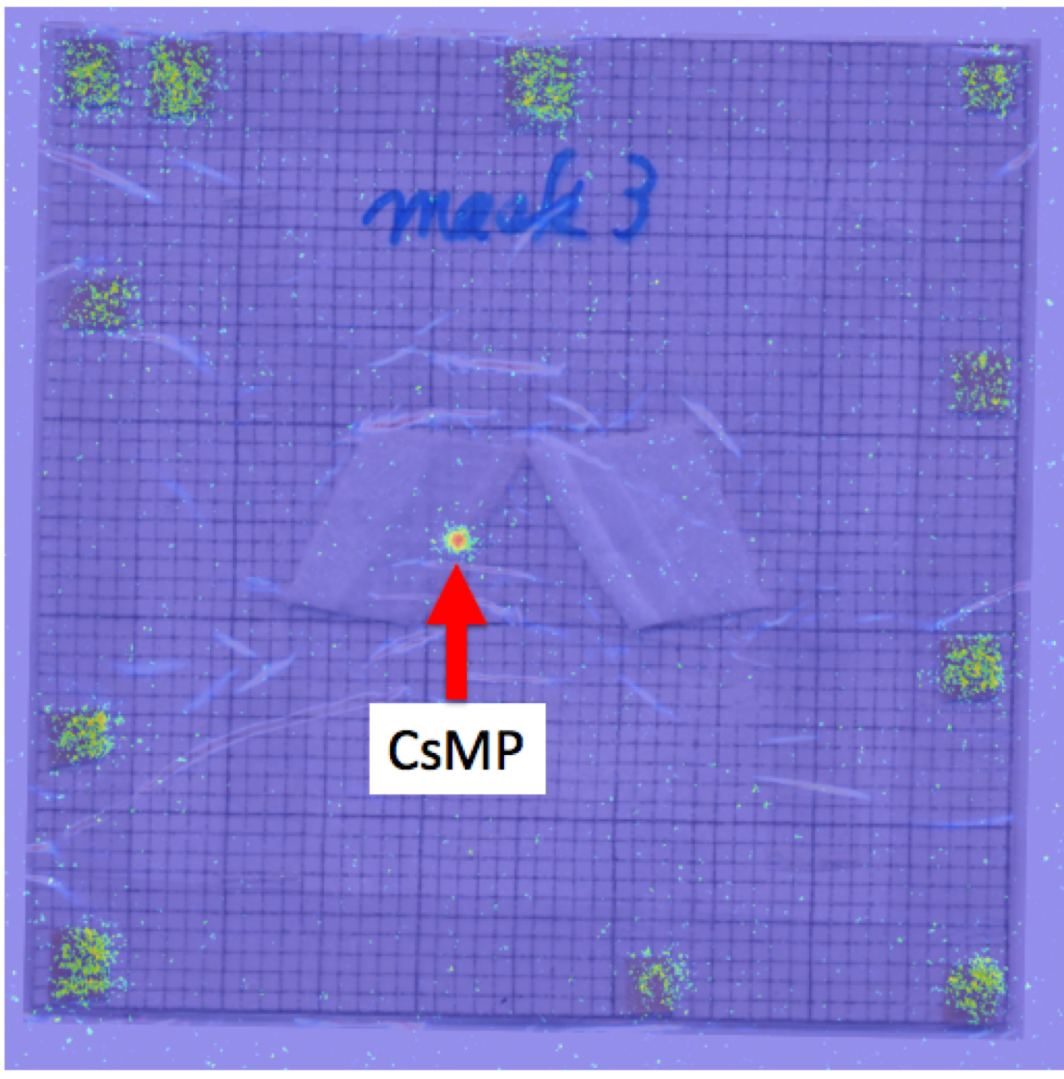
- Quantitative measured by an HPGe system (the detection limits of ¹³⁴Cs and ¹³⁷Cs each were 0.2 Bq each for 6 hours counting).

Chemical composition and radioactivity measurements of CsMP

- A small piece was cut from the mask containing significant ¹³⁷Cs and was placed into a plastic tube with 1 mL of pure water.
- Vibrated by an ultrasonic cleaner to drop CsMP into pure water.
- Each isolated CsMP was identified by a scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDS) system.



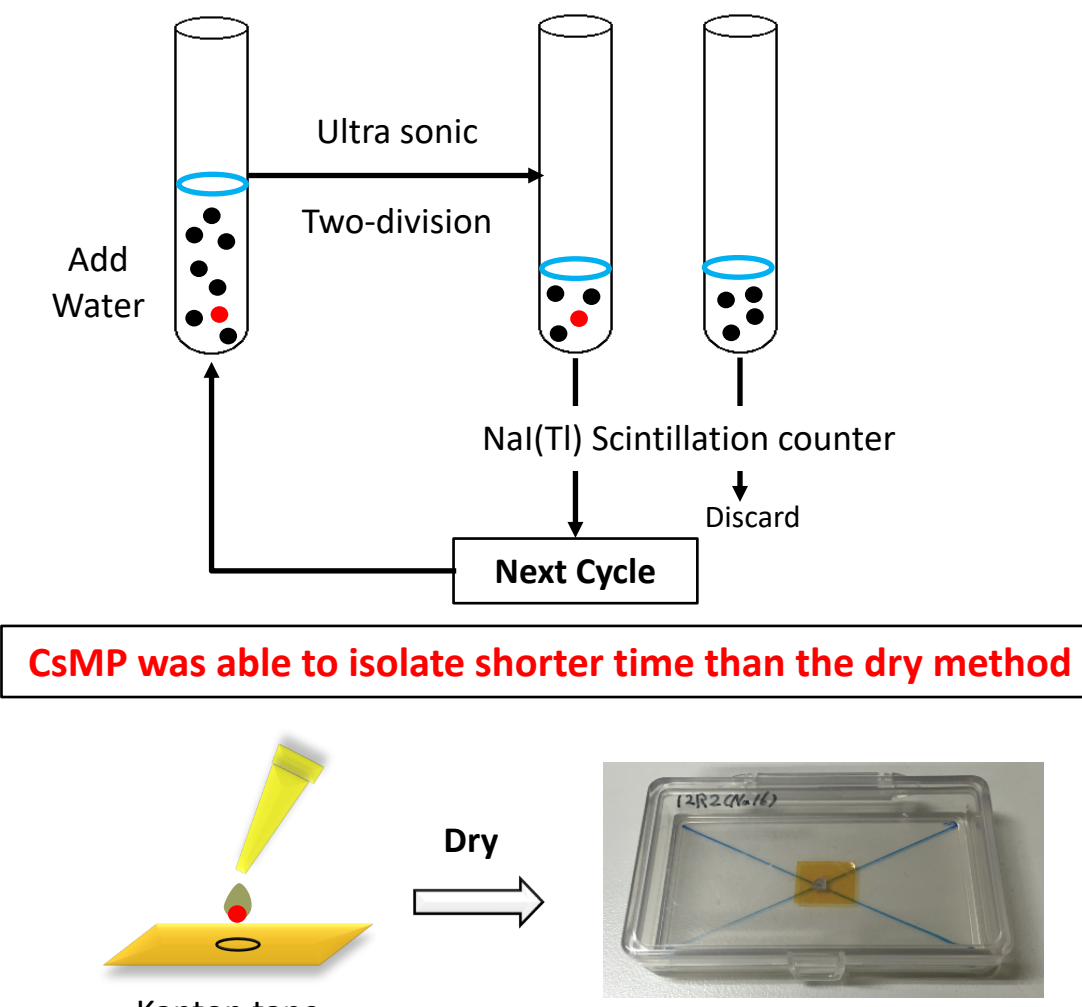
Distribution of study subjects in Fukushima Prefecture (2013)



A fusion image of a piece of mask and radiocesium distribution of 20 min exposure of imaging plates



3D-masks made of non-woven fabric that block 99.6% of 3 μm particles



Separation method of CsMP from a mask

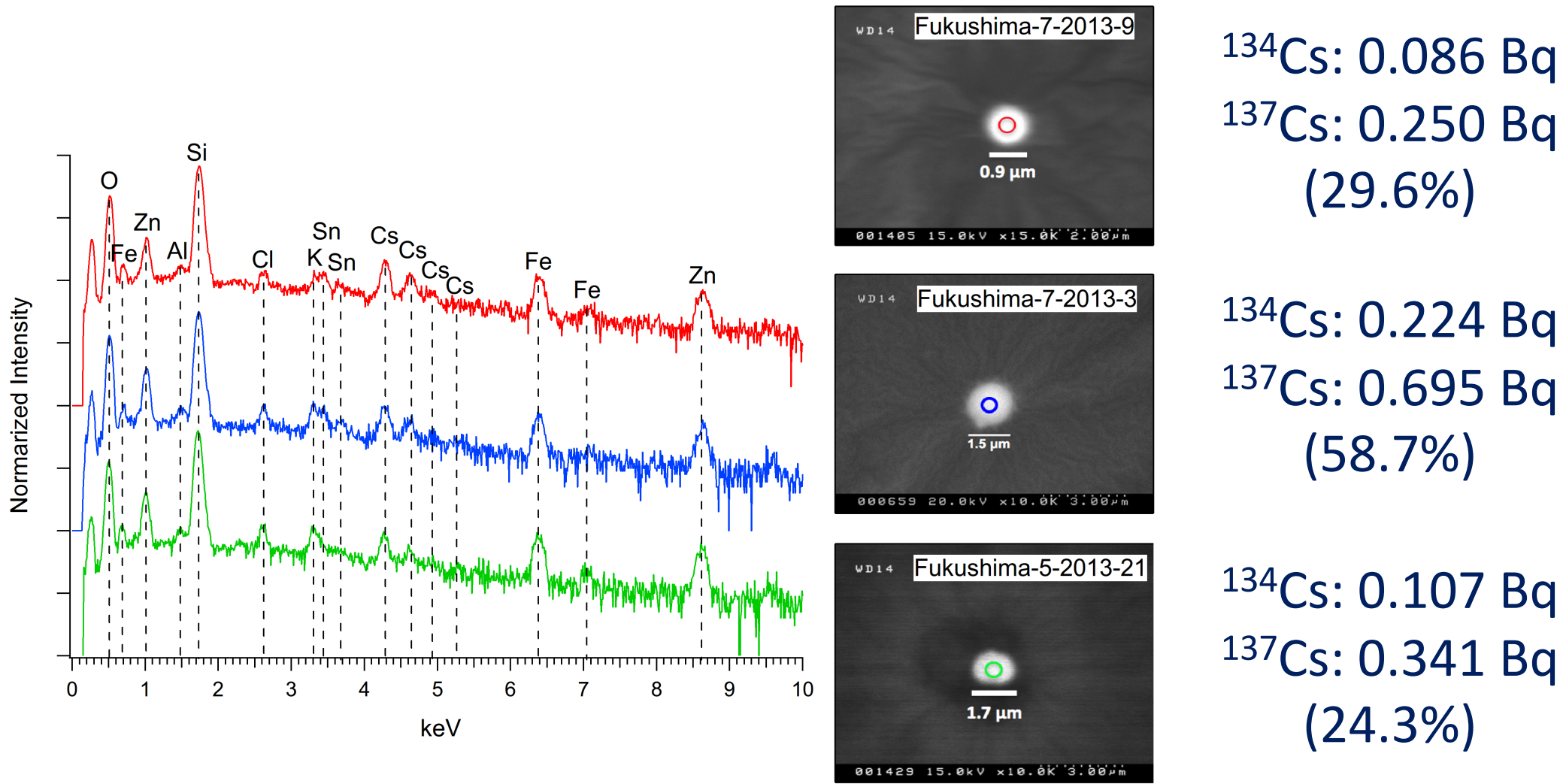
Results and Discussion

- From 2012 to 2014, radiocesium was detected on masks worn by only two subjects: Fukushima-5 (lived in Fukushima City), and Fukushima-7 (Koriyama City).

Year	week	Fukushima-5		Fukushima-7	
		Cumulative ¹³⁷ Cs [Bq]	¹³⁷ Cs per a week [Bq]	Cumulative ¹³⁷ Cs [Bq]	¹³⁷ Cs per a week [Bq]
2012*	8	16±0.32	2.0	21±0.36	2.6
2013	4	3.9±0.1	0.98	4.6±0.2	1.1
2014	4	0.35±0.08	0.087	0.62±0.07	0.16

- Three of the type A CsMP were found on masks.
- Source of radiocesium was not only CsMP, but also radiocesium contaminated fugitive dust.
- The largest internal dose from inhalation was 7.6 μSv in spring 2013, which is negligible compared to the dose limit recommended for members of the public by the ICRP.
- In our previous study*, we collected same type mask sample worn by members of the public who lived in Fukushima prefecture in the spring of 2012.
 - These sample will be investigated by same method and the estimated dose from spring, 2012 will be revised by the new method.

*Higaki et al. *Health Phys.*, **107** 117–134 (2014)



EDS Spectra, SEM image and radioactivity (the ratio of ¹³⁷Cs radioactivity of CsMP to total ¹³⁷Cs collected on each mask) of CsMP

Calculated effective dose of subjects using dose coefficient of By type S based on the current ICRP models and as suggested by Manabe et al. (2019)

	Calculated effective dose [μSv] In 2013				Calculated effective dose [μSv] In 2014			
	By type S based on current ICRP models	By a method suggested by Manabe. et al.			By type S based on current ICRP models	By a method suggested by Manabe. et al.		
		99th percentile values	median	arithmetic mean		99th percentile values	median	arithmetic mean
Fukushima-5	0.093	6.5	0.0013	0.34	0.0067	0.47	0.000094	0.024
Fukushima-7	0.11	7.6	0.0015	0.39	0.0048	0.33	0.000067	0.017