

Presentation at the Reviewer Meeting of Research Grant by Ministry of Environment

***Assessment of the Initial Radiation  
Exposure to Residents in Iitate village  
up to Evacuation after the Fukushima-1  
NPP Accident***

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Research Reactor Institute

Kyoto University

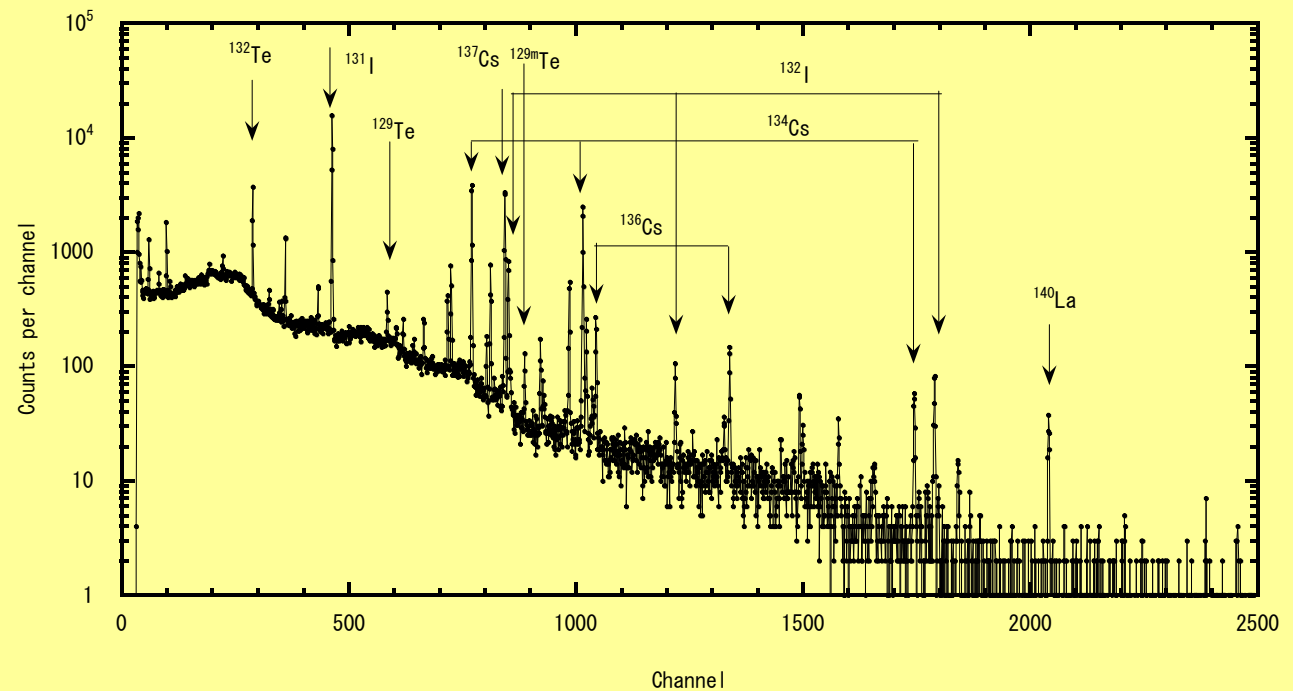
December 4, 2013

At NSRA, Shinbashi, Tokyo

# ***Our study before this Year: Soil sampling and gamma-ray analysis***

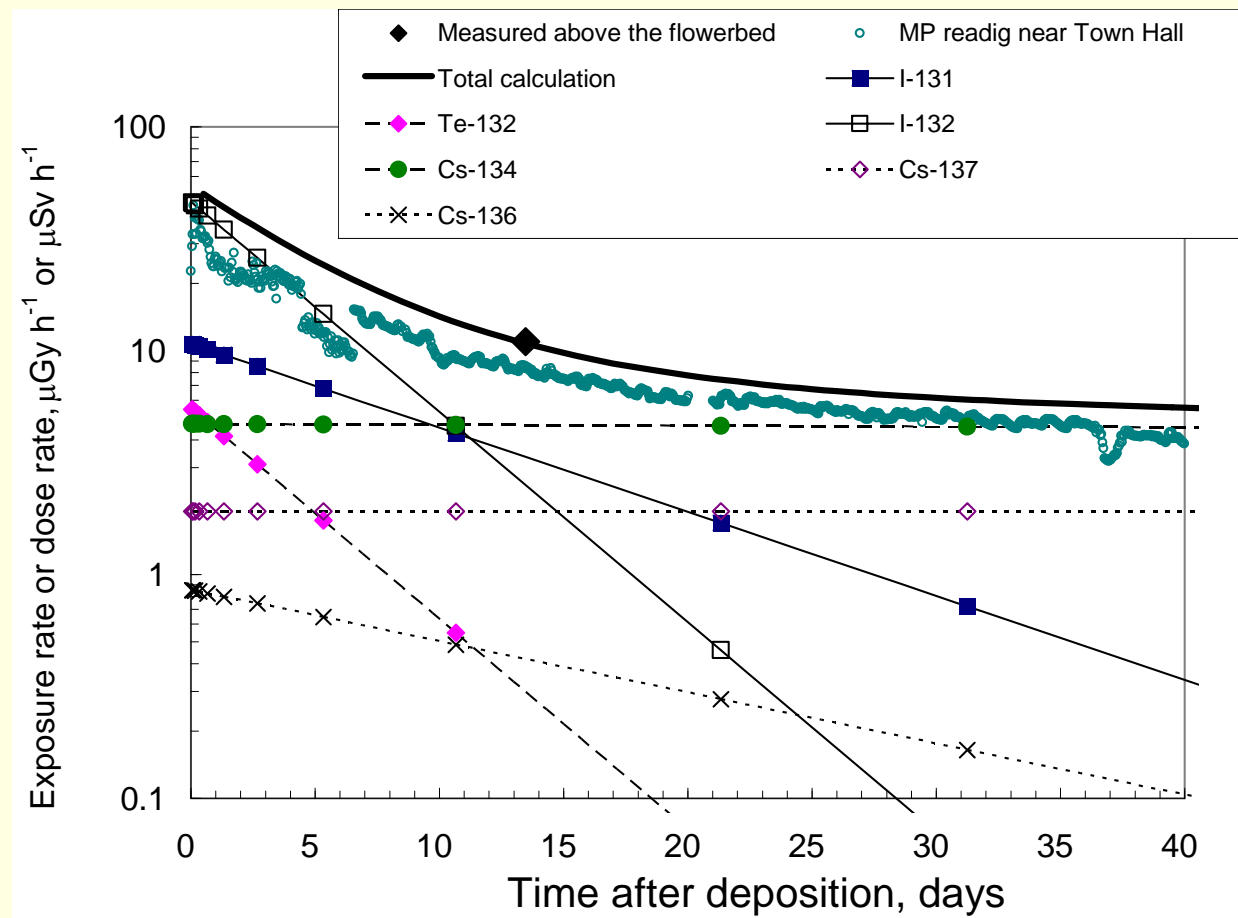


**March 29, 2011**



# ***Our study before this year: Reconstruction of radiation exposure rate based on radionuclide deposition***

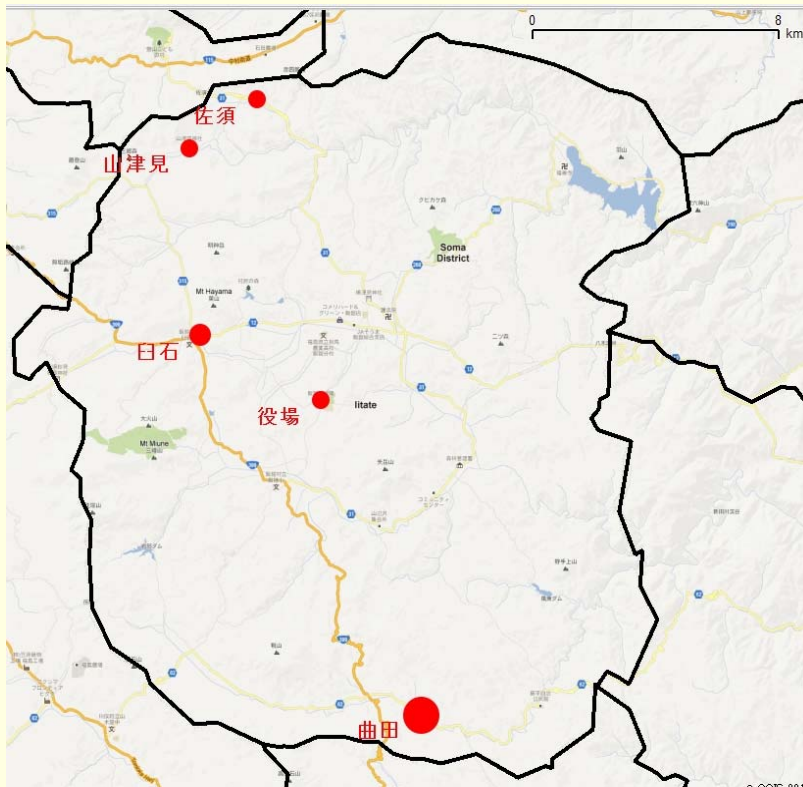
Comparison between measurement and calculation: Soil sample was taken at MADEINA house at 100 m from the monitoring post.



Only nuclides of Te132/I132, I131, Cs134, Cs137 contributed radiation exposure. Beck's conversion factor (BNL-378, 1980) are used to calculate exposure rate from deposition density.

# Our study before this year: Radionuclide composition in soil samples in Iitate village

Radioactivity ratio in 5 soil samples taken on March 29, 2011.



Deposition ratios of I131 and Te132 to Cs137.  
Corrected at 18:00 of March 15, 2011.

	Cs137 kBq/m <sup>2</sup>	I131/Cs137 ratio	Te132/Cs137 ratio
Usuishi	956	9.6	6.9
Sasu	774	10.9	8.9
Yamazumi	588	10.1	10.0
Town Hall	672	8.2	7.9
Magata	2188	7.0	8.0
Average		9.2 ± 1.5	8.3 ± 1.2

Sample location. The size of red circle indicates Cs137 deposition

The same composition can be assumed even though the amounts of Cs137 are different.



# ***Our study before this year: Cs137 deposition map based on NNSA aerial survey data***

*Operational Topic*

## **ENVIRONMENTAL MEASUREMENTS IN AN EMERGENCY: THIS IS NOT A DRILL**

Stephen V. Musolino,\* Harvey Clark,† Thomas McCullough,† and Wendy Pemberton†

**Health Phys. 102(5):516-526; 2012**



**Helicopter survey by  
NNSA**

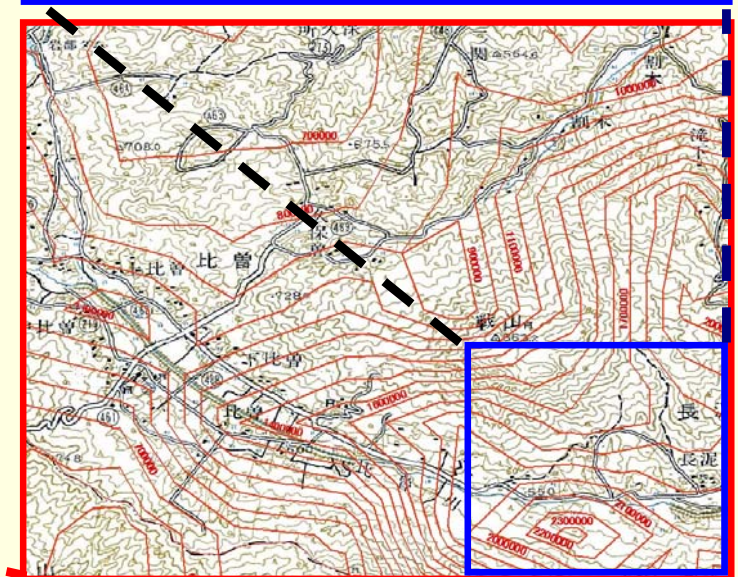
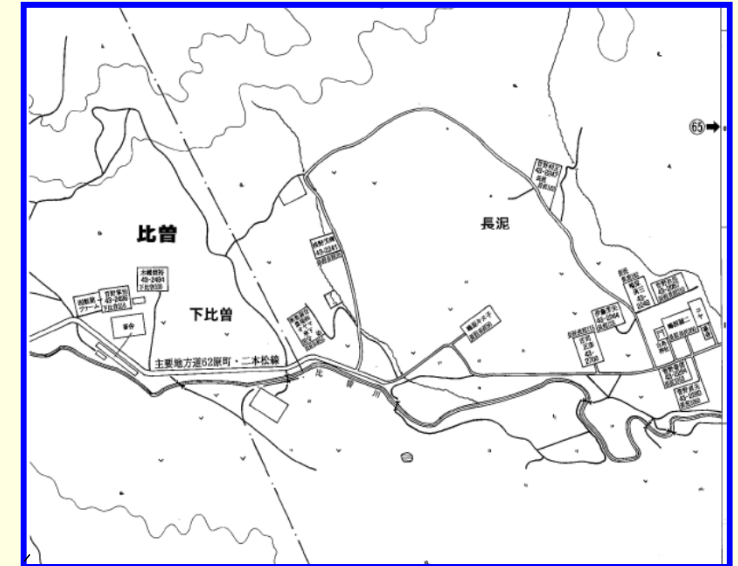
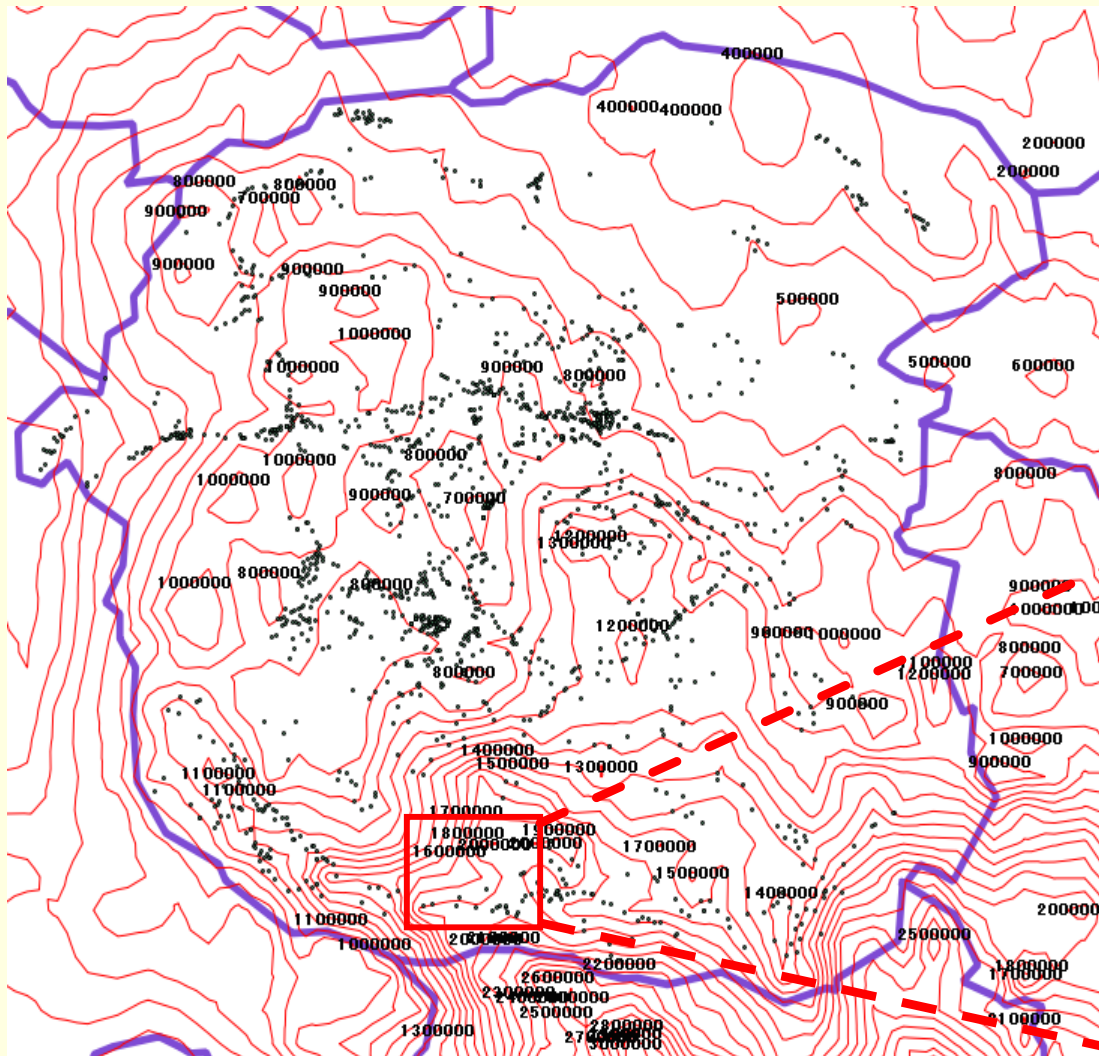


**Trajectories of air survey above Iitate  
village.**

**Green(plane): 15<sup>th</sup> April and 3<sup>rd</sup> May**

**Black(helicopter): 1<sup>st</sup> April**

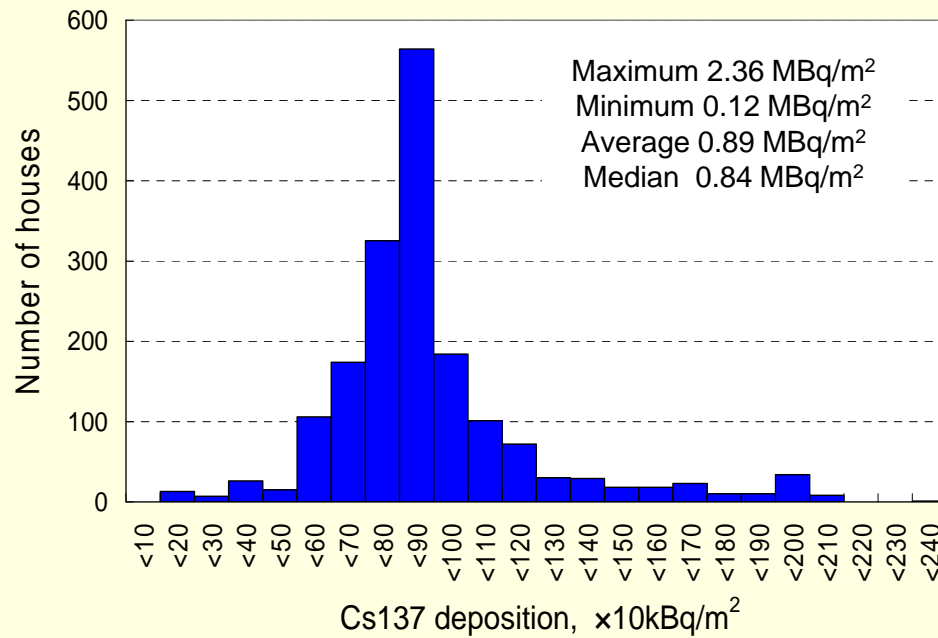
# Study before this year: Estimation of initial Cs137 deposition for all house positions in Iitate village



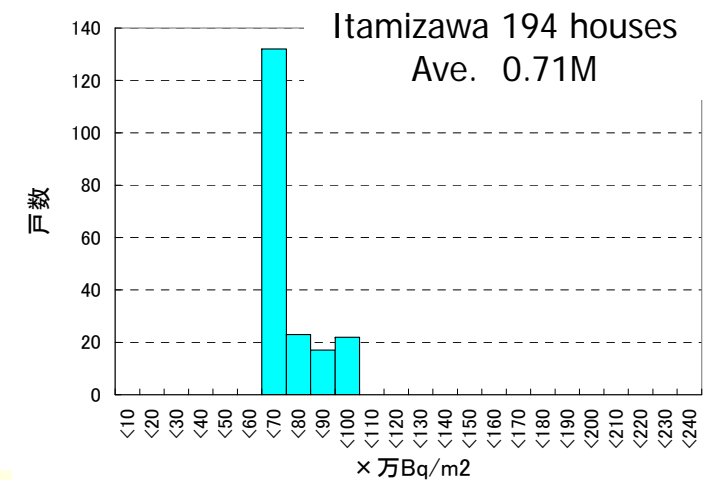
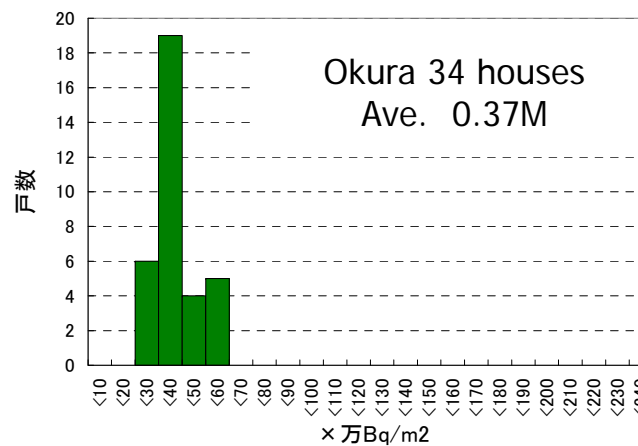
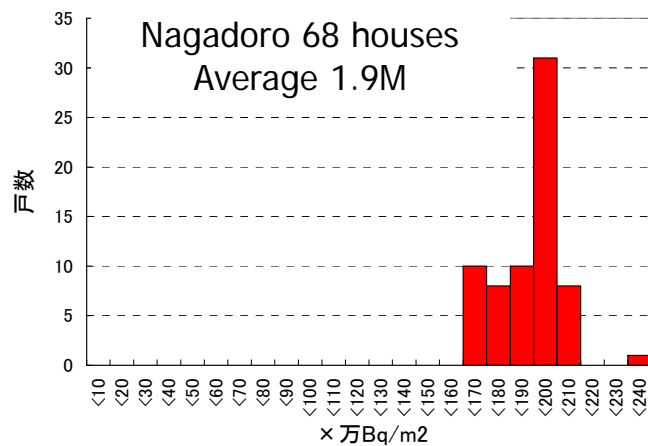
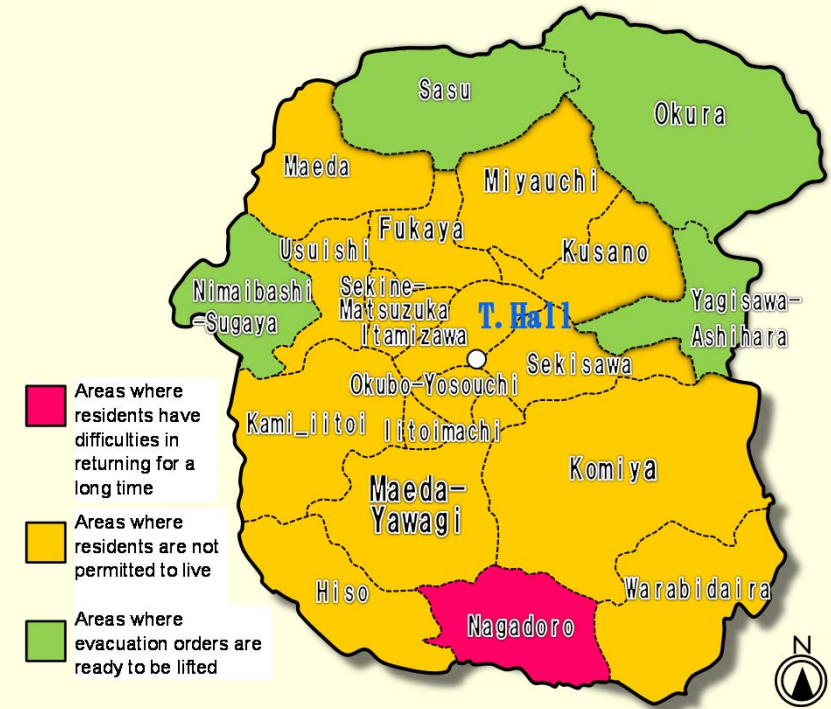
Cs137 counter map based on NNSA data



# Study before this year: Cs137 deposition distribution at 20 settlements in Iitate village.

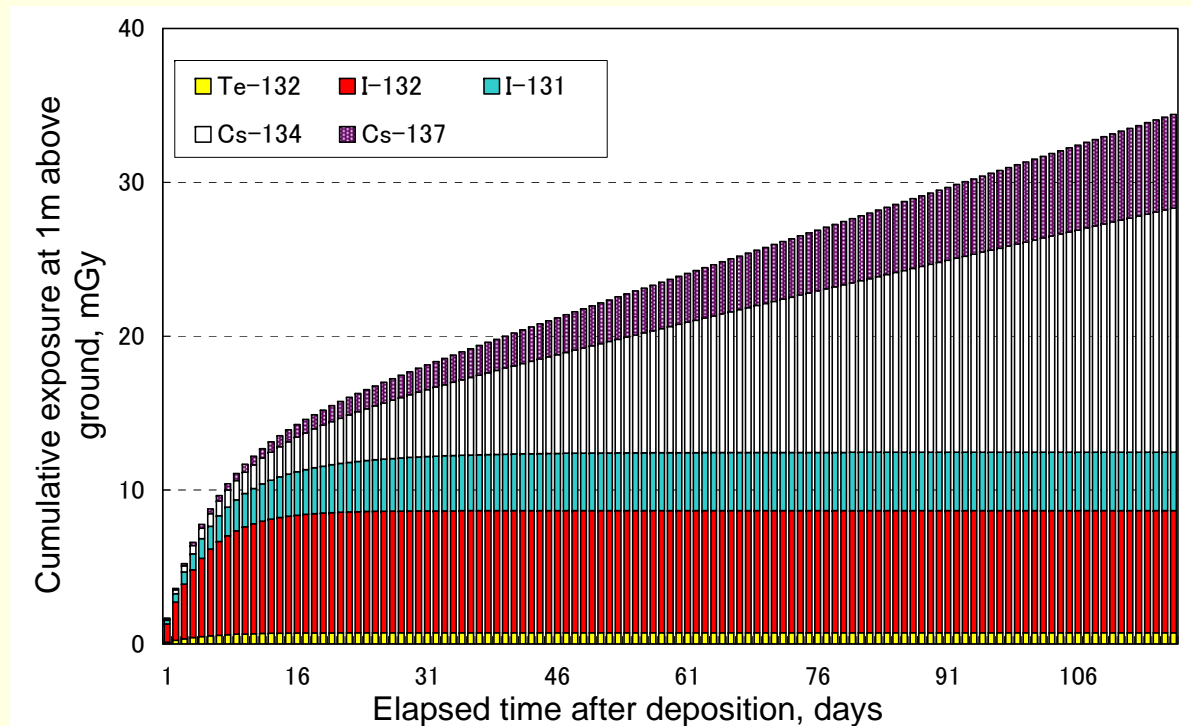


Histogram of Cs137 deposition in Iitate village. 1768 houses.



# Study before this year: Cumulative exposure at 1 m above ground after deposition

Per 1 MBq/m<sup>2</sup> of initial Cs137 deposition



Cumulative radiation exposure at 1 m above ground after the radioactivity deposition on May 15<sup>th</sup> per Cs137 deposition of 1 MBq/m<sup>2</sup>.

**Assuming the deposition at 18:00 of March 15 at a time and staying outside until 12:00 of June 30 (107 days after), the cumulative exposure is obtained to be 32.6 mGy.**



***Consequently,  
individual external exposure can be  
estimated with “reasonable grounds”  
only when we can get information about  
personal behavior after the accident.***

## Task of this year: Iitate village initial dose assessment project

- Interview by the project member with Iitate village residents about behaviors of their family from the earthquake on March 11 up to July 31, 2011.
- Based on the interview information, individual dose is estimated to obtain the average exposure of Iitate village as well as each settlement.
- Target number of interview is 500 (30 % of the whole village).

# ***Project members for interview in 2013***

***Office address: Skae-machi 10-5, Fukushima city***

Akashi S.	Reportage Institute	Sakuma J.	Rikkyo University
Ieda O.	Hokkaido University	Sawai M.	NPO CNIC
Ishida K.	Femin newspaper	Shiroshita H.	Kwansai University
Ichikawa K.	Office Brain Co. Ltd.	Sugai M.	Kokugakuin University
Itonaga K.	Nippon University	Sagawa Y.	Project staff
Uragami K.	Nippon University	Sawano N.	Kanazawa Seiryō University
Endo S.	Hiroshima University	Nasu K.	Fukushima-to-Iwaijima project
Ohtaki M.	Hiroshima University	Niwada S.	Reportage Institute
Ozawa S.	NPO EAS	Hatakeyama H.	Freelance writer
Kamisawa C.	NPO CNIC	Hayasi G.	Tohoku University
Kawano N.	Hiroshima University	Furitsu K.	Hyogo College of Medicine
Kitoh S.	University of Tokyo	Watanabe M.	NPO CNIC

Project office was opened near JR  
Fukushima station in July.

Approaching methods to litate residents.

- Letters were sent to 1680 litate families asking to accept interview.
- Our member visited temporary housings to take interviews.
- Telephone call to litate residents asking appointment for interview.



# Example of interview sheet

家屋番号 994

## 聞き取り記録 (第5案)

実施日 時刻	2013年10月9日 13時20分
聞き取り担当者	島田 理仁
聞き取り担当者	
場所	仮設住宅

➤ 名前: \_\_\_\_\_ (生年月日: 昭和 平成 37 年 月 日)

➤ 飯館村の自宅住所: 福島県相馬郡飯館村 \_\_\_\_\_ (213)

➤ 現在の住所: \_\_\_\_\_

➤ 現在の住所の種類: (仮設住宅) 借り上げ住宅 その他 ( )

➤ 連絡用電話番号: \_\_\_\_\_

質問1: 原発事故が起きたに同居していた家族

姓名 (または名のみ)	続柄	生年月日	職業	現在、同居か、どちらかに○
1 本人	本人	昭和37	無職	-
2 妻	妻	昭和34	会社員	(同) 別
3 母	母	昭和11	無職	(同) 別
4 子	子	昭和26	見物係	(同) 別
5 子	子	昭和39	無職	(同) 別
6 子	子	昭和61		同 (別) A
7 子	子	昭和66	小学3年	同 (別)
8		昭和 平成		同 別
9		昭和 平成		同 別
10		昭和 平成		同 別

\*別居先が複数の場合は、別の横にA、B、C... とつける。 \*\*続柄については、男か女が分かるように記入

✧ 差し支えなければ、別居している方の連絡先:

一別居A: 住所 \_\_\_\_\_ 電話番号 \_\_\_\_\_

一別居B: 住所 \_\_\_\_\_ 電話番号 \_\_\_\_\_

一別居C: 住所 \_\_\_\_\_ 電話番号 \_\_\_\_\_

## ＜所在地確認表＞

名前 \_\_\_\_\_ 番号 994-1

3月	4月	5月	6月	7月
1日(水)	1日(木)	1日(金)	1日(土)	1日(日)
2日(木)	2日(金)	2日(土)	2日(日)	2日(月)
3日(金)	3日(土)	3日(日)	3日(月)	3日(火)
4日(土)	4日(日)	4日(月)	4日(火)	4日(水)
5日(日)	5日(月)	5日(火)	5日(水)	5日(木)
6日(月)	6日(火)	6日(水)	6日(木)	6日(金)
7日(火)	7日(水)	7日(木)	7日(金)	7日(土)
8日(水)	8日(木)	8日(金)	8日(土)	8日(日)
9日(木)	9日(金)	9日(土)	9日(日)	9日(月)
10日(金)	10日(土)	10日(日)	10日(月)	10日(火)
11日(土)	11日(日)	11日(月)	11日(火)	11日(水)
12日(日)	12日(月)	12日(火)	12日(水)	12日(木)
13日(月)	13日(火)	13日(水)	13日(木)	13日(金)
14日(火)	14日(水)	14日(木)	14日(金)	14日(土)
15日(水)	15日(木)	15日(金)	15日(土)	15日(日)
16日(木)	16日(金)	16日(土)	16日(日)	16日(月)
17日(金)	17日(土)	17日(日)	17日(月)	17日(火)
18日(土)	18日(日)	18日(月)	18日(火)	18日(水)
19日(日)	19日(月)	19日(火)	19日(水)	19日(木)
20日(月)	20日(火)	20日(水)	20日(木)	20日(金)
21日(火)	21日(水)	21日(木)	21日(金)	21日(土)
22日(水)	22日(木)	22日(金)	22日(土)	22日(日)
23日(木)	23日(金)	23日(土)	23日(日)	23日(月)
24日(金)	24日(土)	24日(日)	24日(月)	24日(火)
25日(土)	25日(日)	25日(月)	25日(火)	25日(水)
26日(日)	26日(月)	26日(火)	26日(水)	26日(木)
27日(月)	27日(火)	27日(水)	27日(木)	27日(金)
28日(火)	28日(水)	28日(木)	28日(金)	28日(土)
29日(水)	29日(木)	29日(金)	29日(土)	29日(日)
30日(木)	30日(金)	30日(土)	30日(日)	30日(月)
31日(金)	31日(土)	31日(日)	31日(月)	31日(火)

\*: 飯館村にいた日は縦棒を入れ、他所にいたときは“場所名”を入れる。

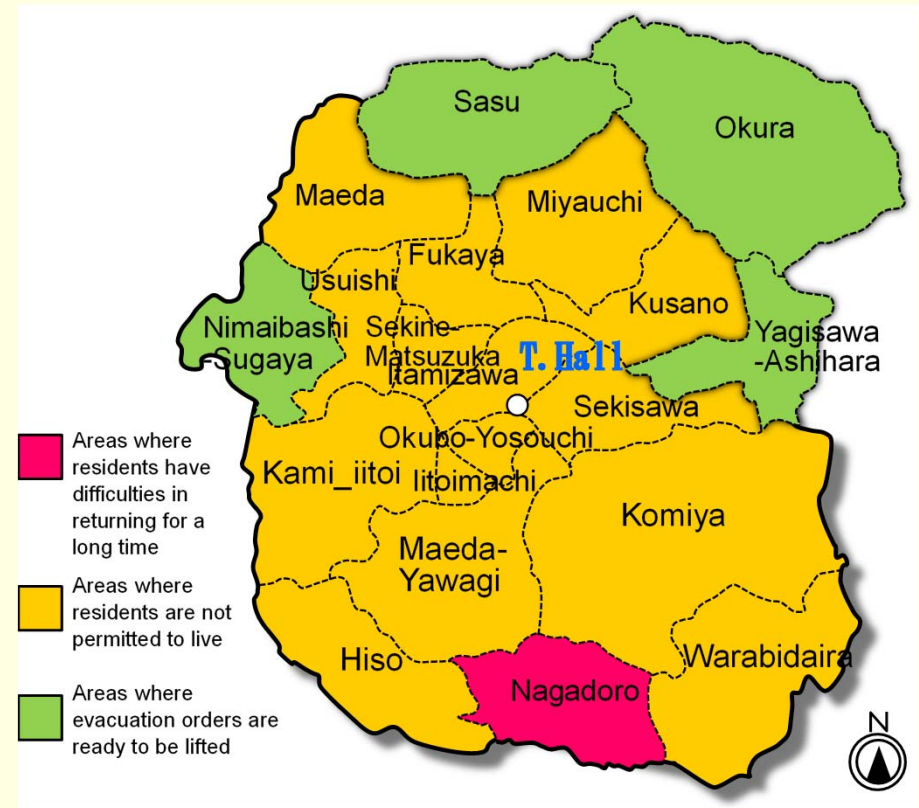
備考: 福島大学に1週間、県の学校、9月初旬に合宿に  
5/28に出た、県の学校 2013/8/1

Daily behavior was recorded about where they were after the earthquake up to July 31th.

# Total number of interview until October,31. 498 families; information on 1812 people

## Percentage of interviewed families

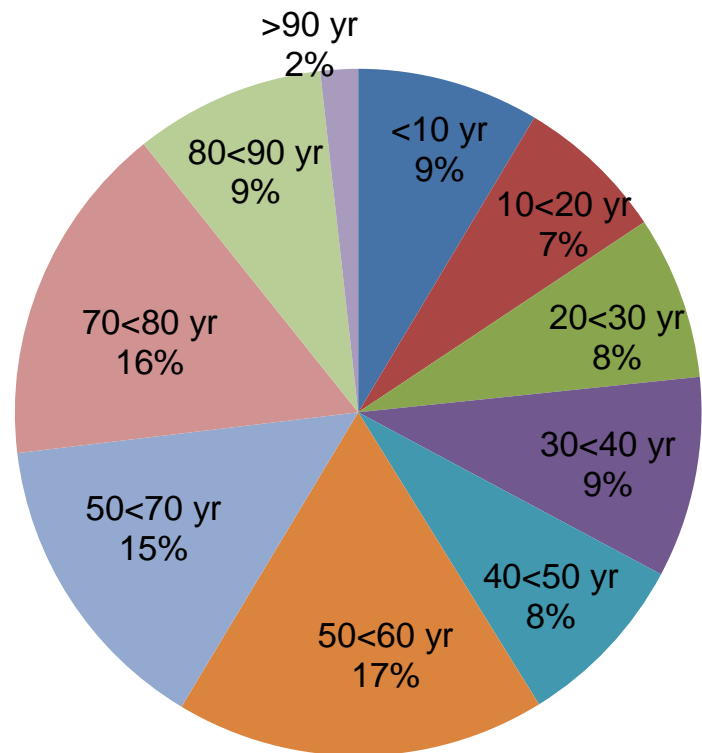
Settlement	Number of houses	Number of interview	%
Kusano	221	64	29.0%
Fukaya	102	20	19.6%
Itamizawa	100	26	26.0%
Sekisawa	77	27	35.1%
Komiya	128	51	39.8%
Yagisawa-Ashiwhara	40	12	30.0%
Okura	34	12	35.3%
Sasu	63	21	33.3%
Miyauchi	72	26	36.1%
Itoimachi	117	27	23.1%
Maeda-Yawagi	90	28	31.1%
Okubo-Sotouchi	68	14	20.6%
Kami_iitoi	124	30	24.2%
Hiso	88	22	25.0%
Nagadoro	68	28	41.2%
Warabidaira	49	16	32.7%
Sekine-Matsuzaka	43	19	44.2%
Usuishi	88	15	17.0%
Maeda	53	26	49.1%
Nimaibashi-Sugaya	60	14	23.3%
Total	1,685	498	29.6%



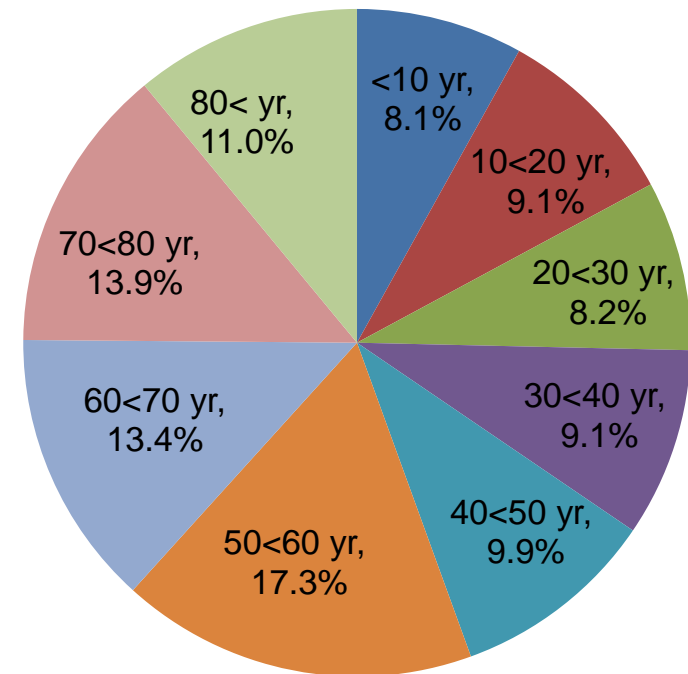
20 settlements in Iitate

About 30 % of families in Iitate were interviewed. Big bias is not seen in values of interview fraction for 20 settlements.

# Age structure of our interview and the whole litate village



Age structure of interviewed 1812 people



Age structure of whole litate village  
(March 1st, 2011: 6,132 people)

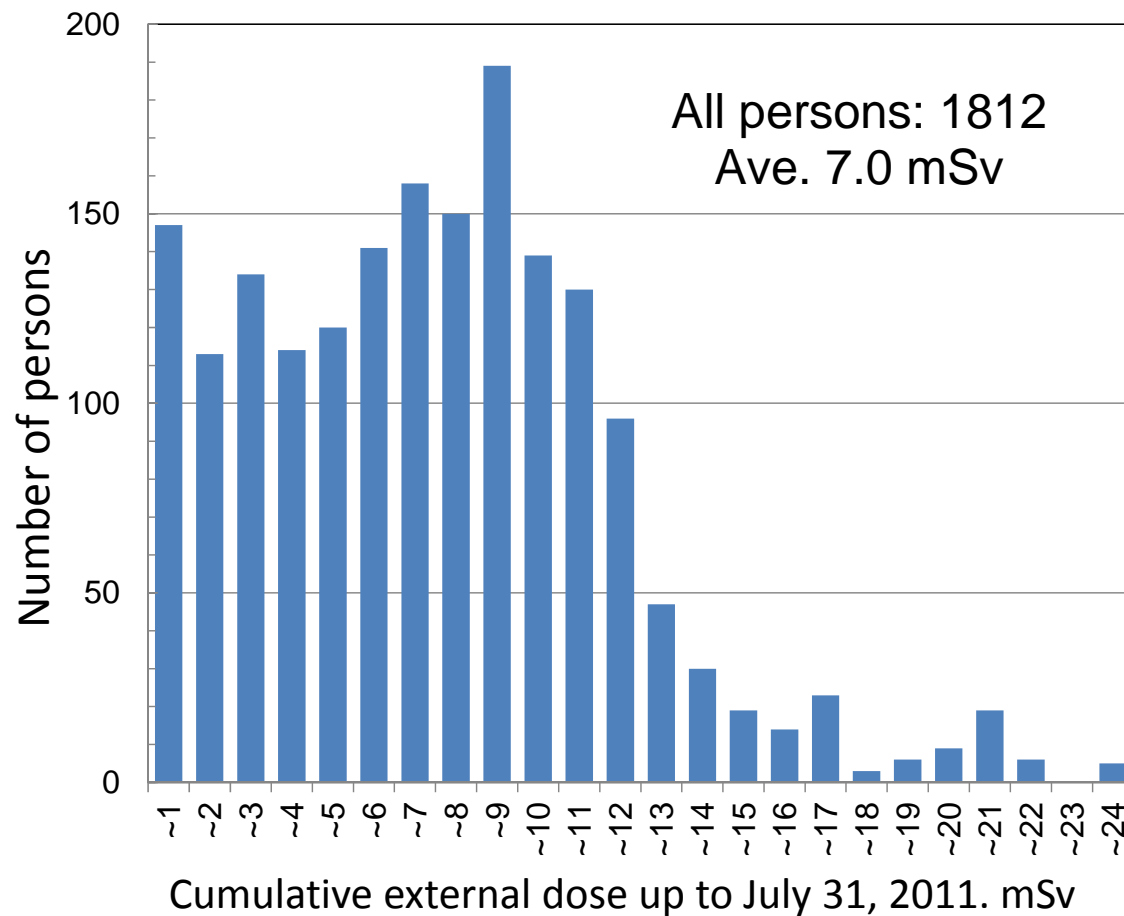
Age structure of our interview data is very similar to the whole population in litate.

## Assumptions used in the process converting cumulative in-field exposure (air KERMA) to external dose (effective dose)

- A transmission factor of 0.4 is applied to all houses in Iitate.
- People are supposed to stay outside and inside houses for 8 hr and 16 hr, respectively.
- Conversion factor of Gy to Sv is assumed to be 0.8 for ages less than 10, while 0.7 is for ages more than 10 yr old.
- Radiation exposure while they were outside or evacuated from Iitate village was neglected for the time being.



# External dose distribution of 1812 persons we got behavior information

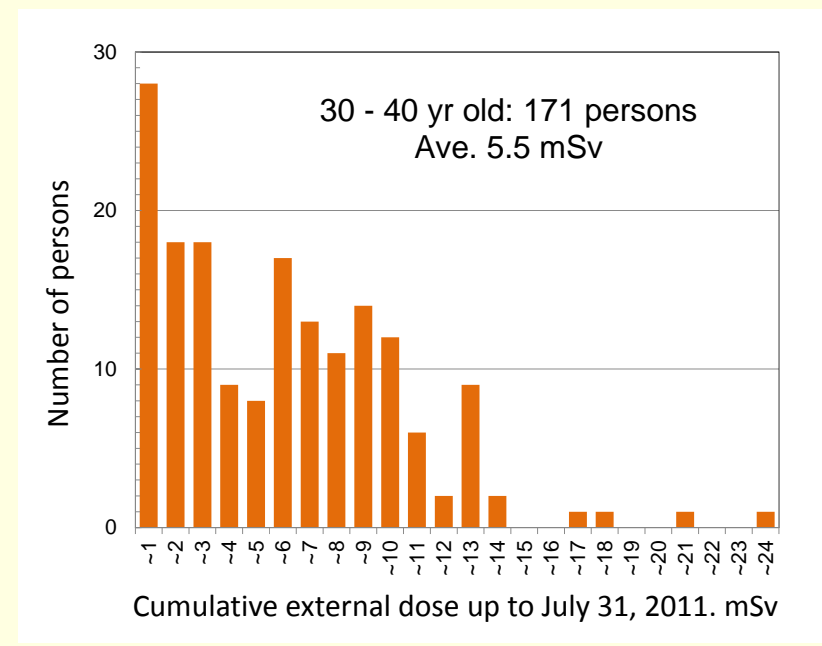
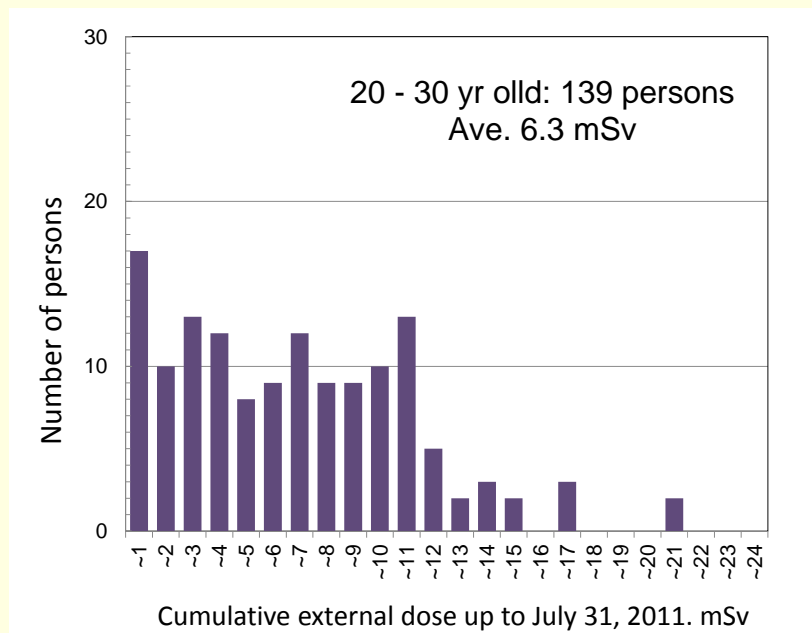
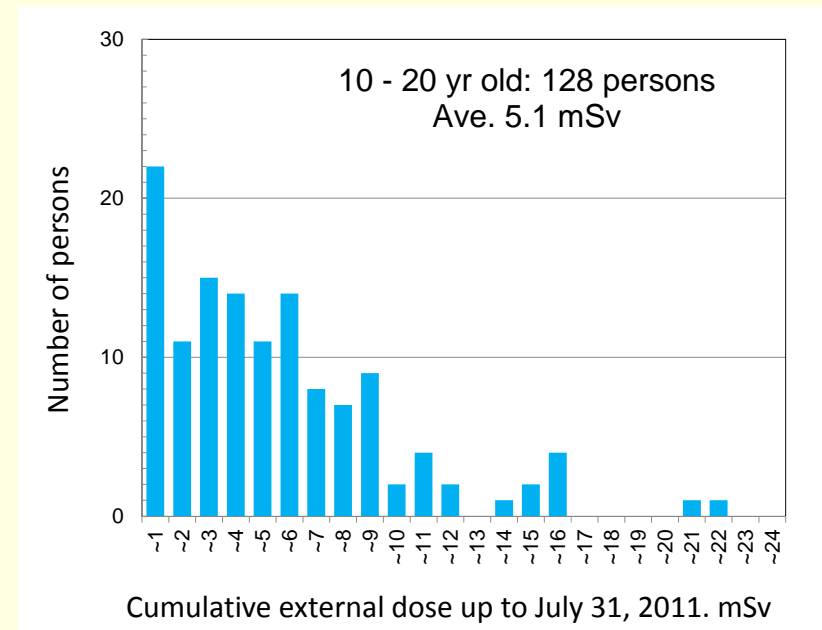
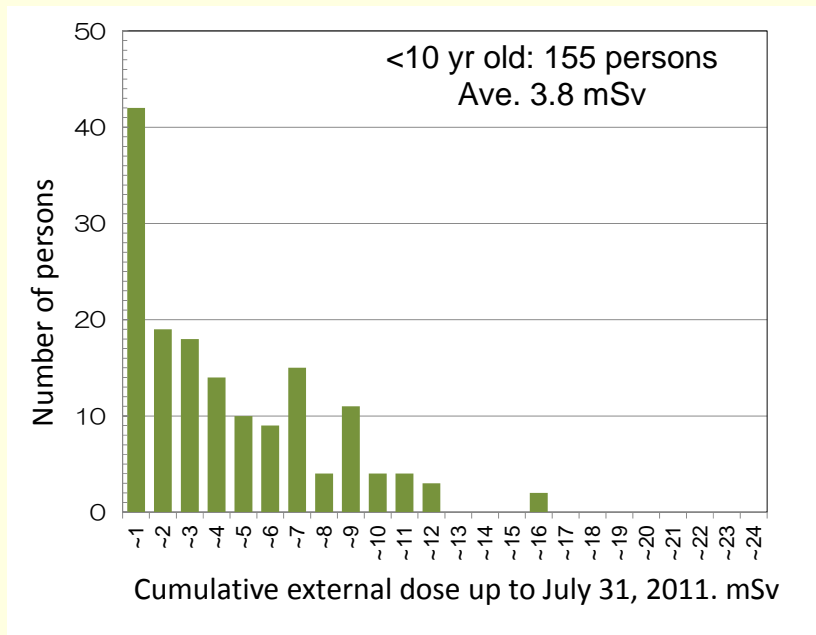


## Average external dose by age group

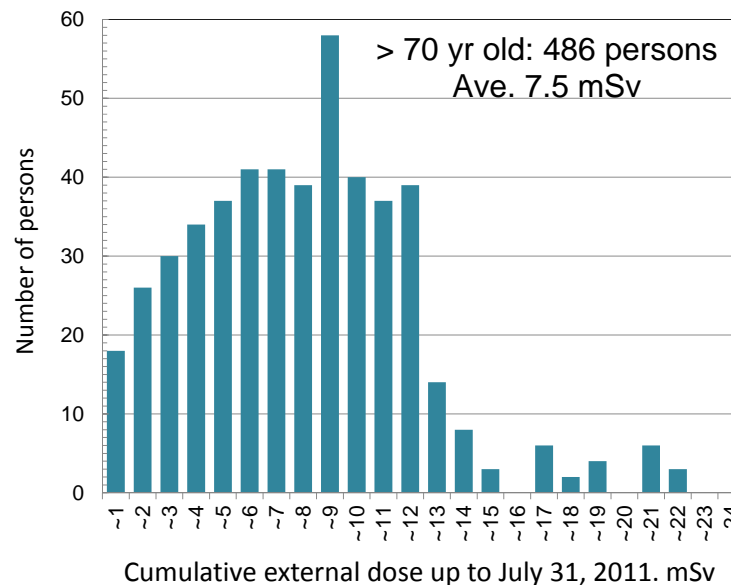
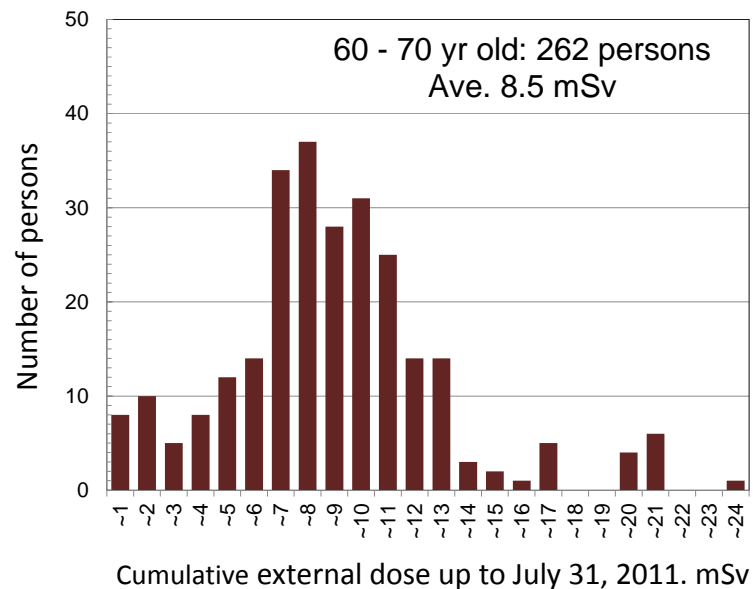
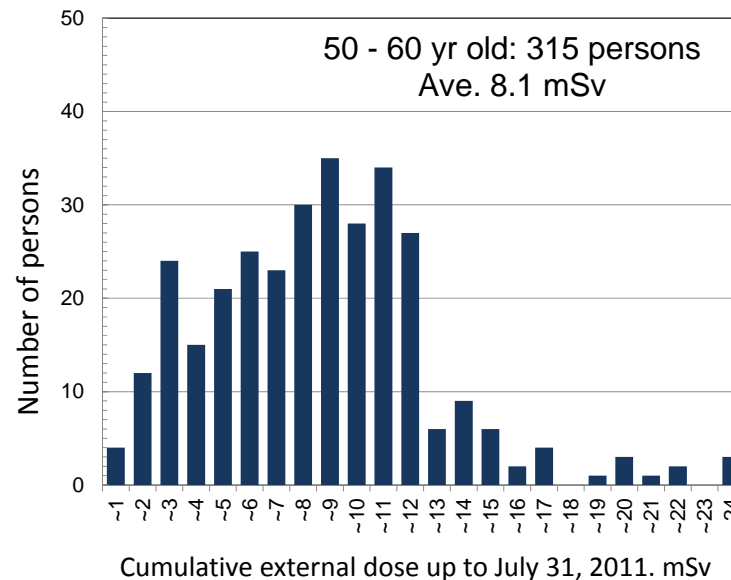
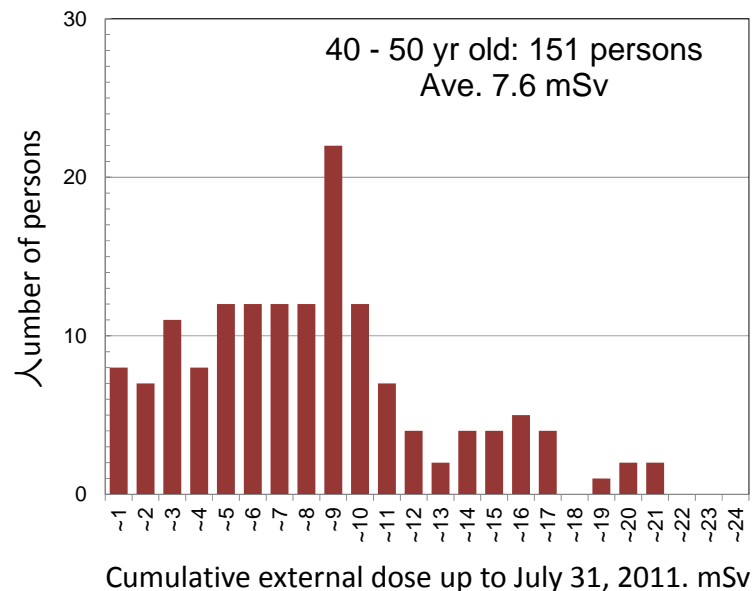
Age group	Number of people	Average external dose, mSv
<10yr	155	3.8
10≤20 yr	128	5.1
20≤30 yr	139	6.3
30≤40 yr	171	5.5
40≤50 yr	151	7.6
50≤60 yr	315	8.1
60≤70 yr	262	8.5
70≤80 yr	292	7.5
>80 yr	194	7.3

The maximum value of 23.5 mSv was obtained by a male of 60's in Nagadoro settlement.

# Dose distribution by age groups: less than 40 yr old

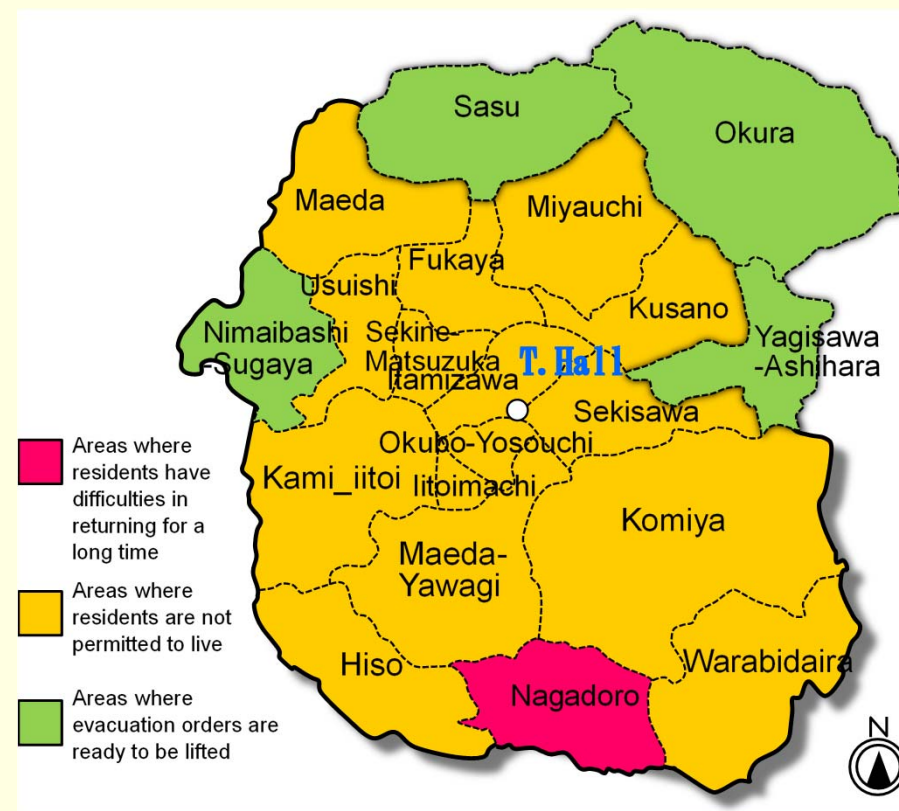


# Dose distribution by age groups: over 40 yr old



# Average dose by settlements

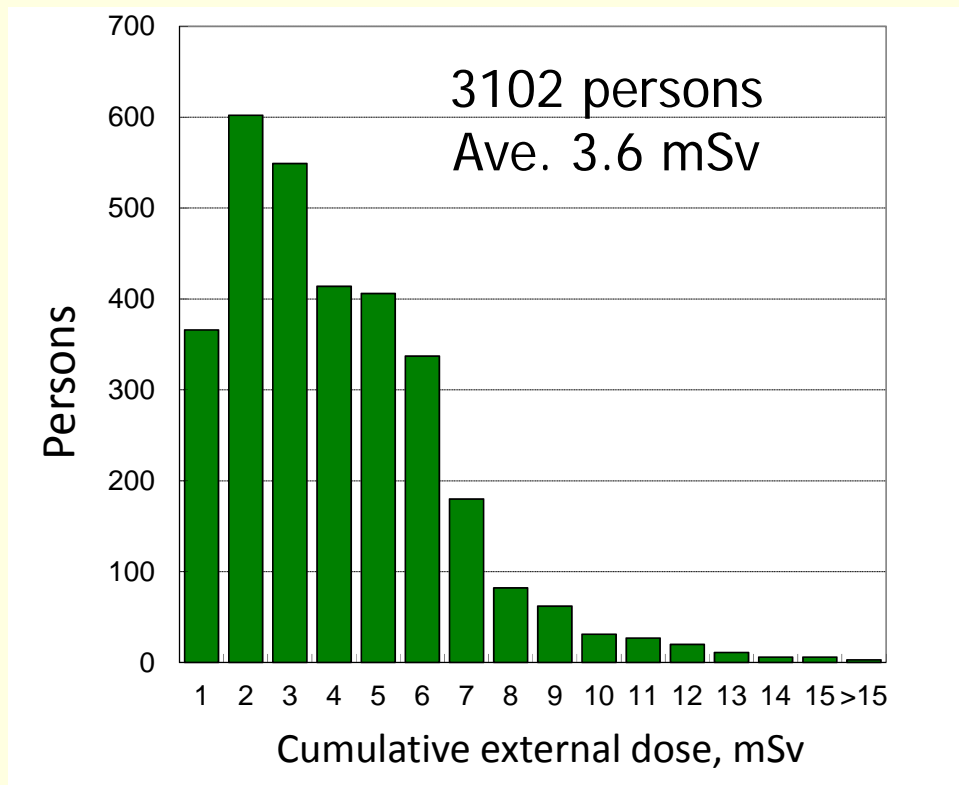
Settlement	Persons	Average Cs-137 contamination, kBq/m <sup>2</sup>	Average external dose, mSv
Kusano	203	682	5.8
Fukaya	71	789	6.3
Itamizawa	96	737	8.0
Sekisawa	77	867	7.8
Komiya	182	934	8.4
Yagisawa-Ashihara	45	546	5.8
Okura	50	343	3.5
Sasu	76	491	4.6
Miyauchi	101	661	5.7
Itoimachi	83	730	5.8
Maeda-Yawagi	103	802	7.1
Okubo-Sotouchi	65	736	6.0
Kami_iitai	117	755	6.2
Hiso	72	1,087	11.0
Nagadoro	104	1,789	12.5
Warabidaira	53	1,321	9.3
Sekine-Matsuzuka	83	763	6.3
Usuishi	58	746	8.1
Maeda	120	685	5.5
Nimaibashi-Sugaya	48	396	3.5
Total persons	1812	814	7.0



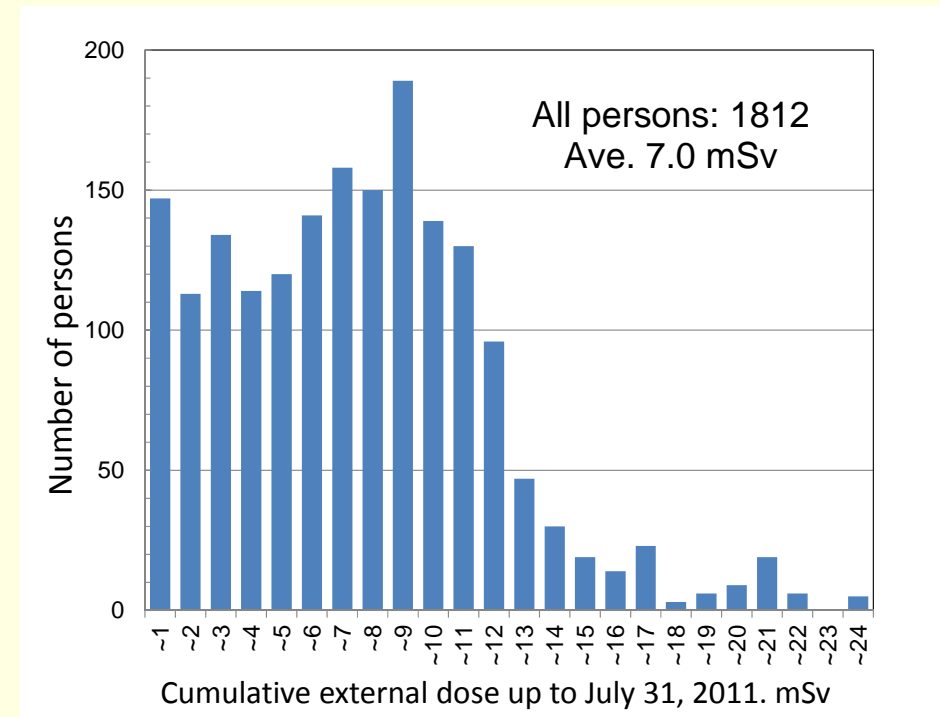
20 settlements in Iitate



# Comparison of our results with that of Fukushima Health Management Survey by Fukushima prefecture



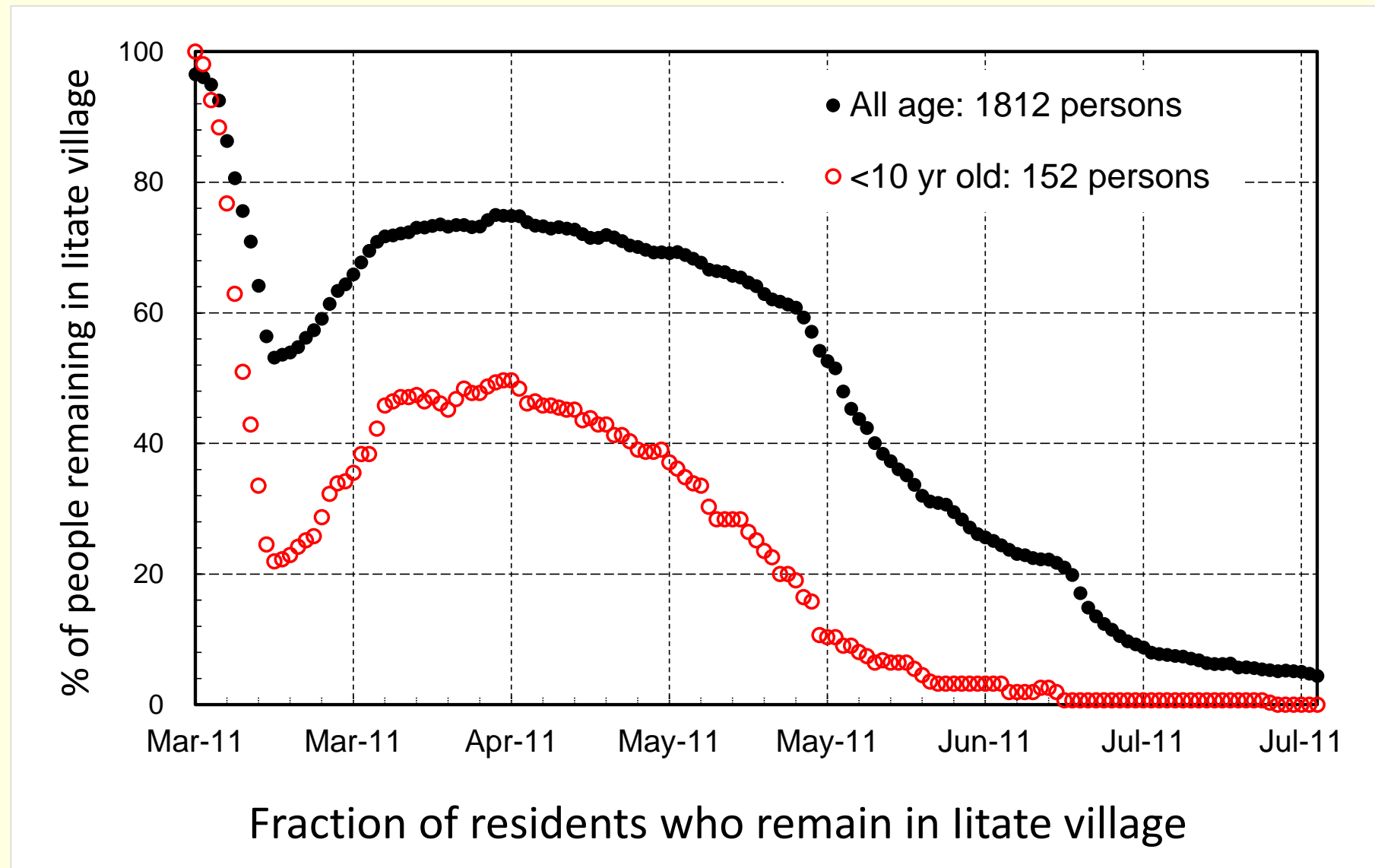
Fukushima Health Management Survey:  
Iitate village, cumulative dose up to July  
11, 2011.



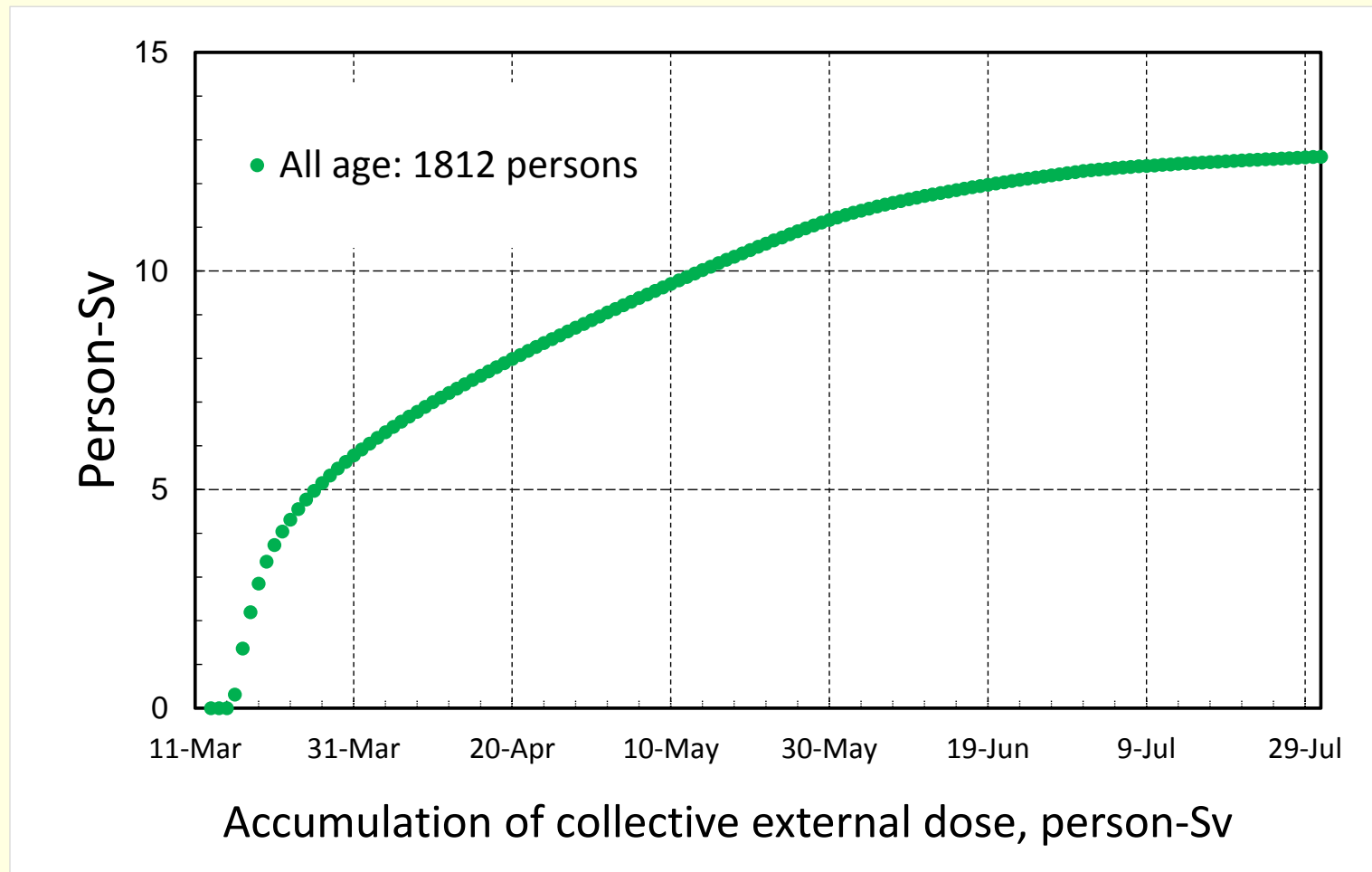
Our results for 1812 persons  
Up to July 31, 2011.

- Our average dose is about two times larger than Fukushima Health Management Survey.
- Considering the basic data used for dose estimation are different each other, two times of dose difference is not serious.

People who evacuated just after the accident once returned home, and then evacuated again after Iitate village was designated as the deliberately evacuation zone on April 22, 2011.



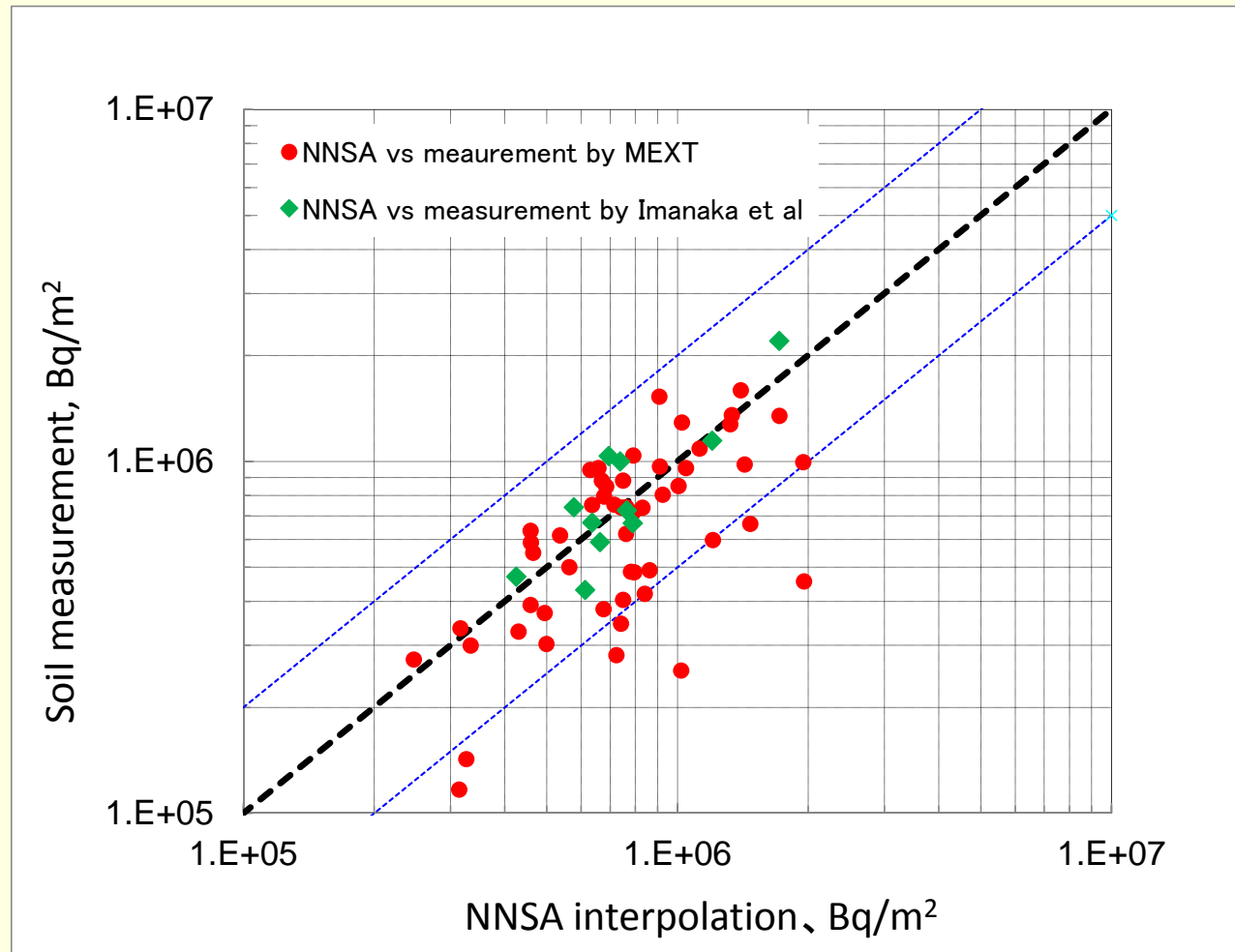
# Collective external dose for 1812 persons



- Collective external dose for 1812 persons investigated amounted to be 12.6 person-Sv, which can be converted 42.7 person-Sv for the whole Iitate village of 6132 persons.
- Assuming cancer-death risk coefficient of  $0.055 \text{ Sv}^{-1}$  by ICRP, 2.3 cases of cancer deaths are expected in Iitate village due to external dose during the early stage after the Fukushima-1 accident, while it increases up to 17 cases when risk coefficient of  $0.4 \text{ Sv}^{-1}$  by J. Gofman is applied.

# Uncertain factors - 1

## NNSA deposition estimates vs. soil measurement data

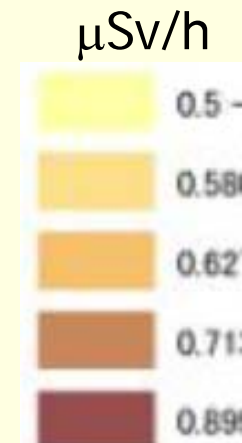
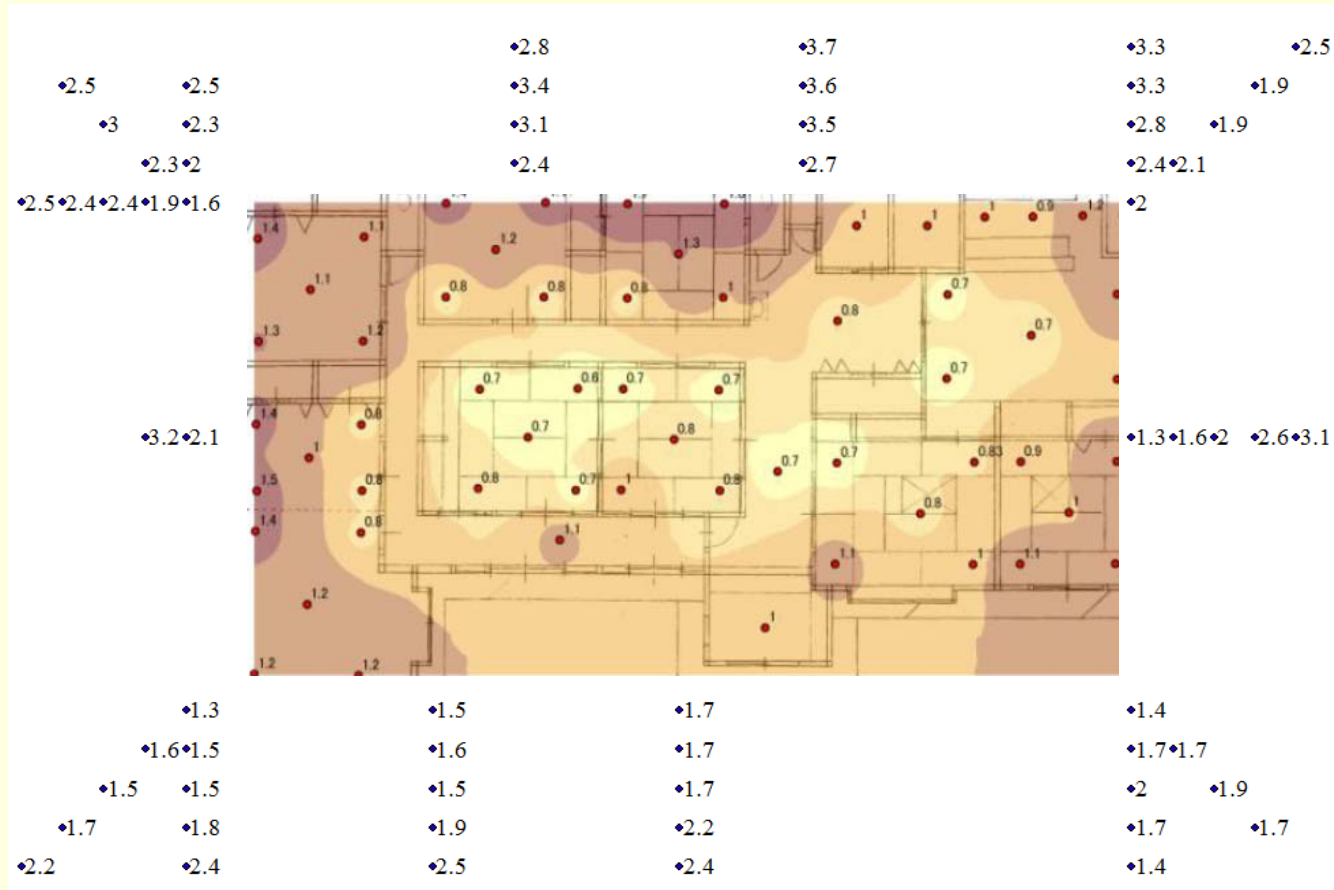


Compared with soil measurements by MEXT (53 points), Cs-137 contamination from NNSA data gave larger values at certain points, while it agreed with measurement by Imanaka et al (11 points). Blue dot lines indicate ratio=2 or  $\frac{1}{2}$ .



# Uncertain factor - 2

## Dose rate distribution outside and inside a typical Japanese one-story wooden house in Iitate village



A transmission factor of 0.4 seems to be reasonable.

# ***Uncertain factor – 3***

## ***Time fraction staying inside and outside houses***

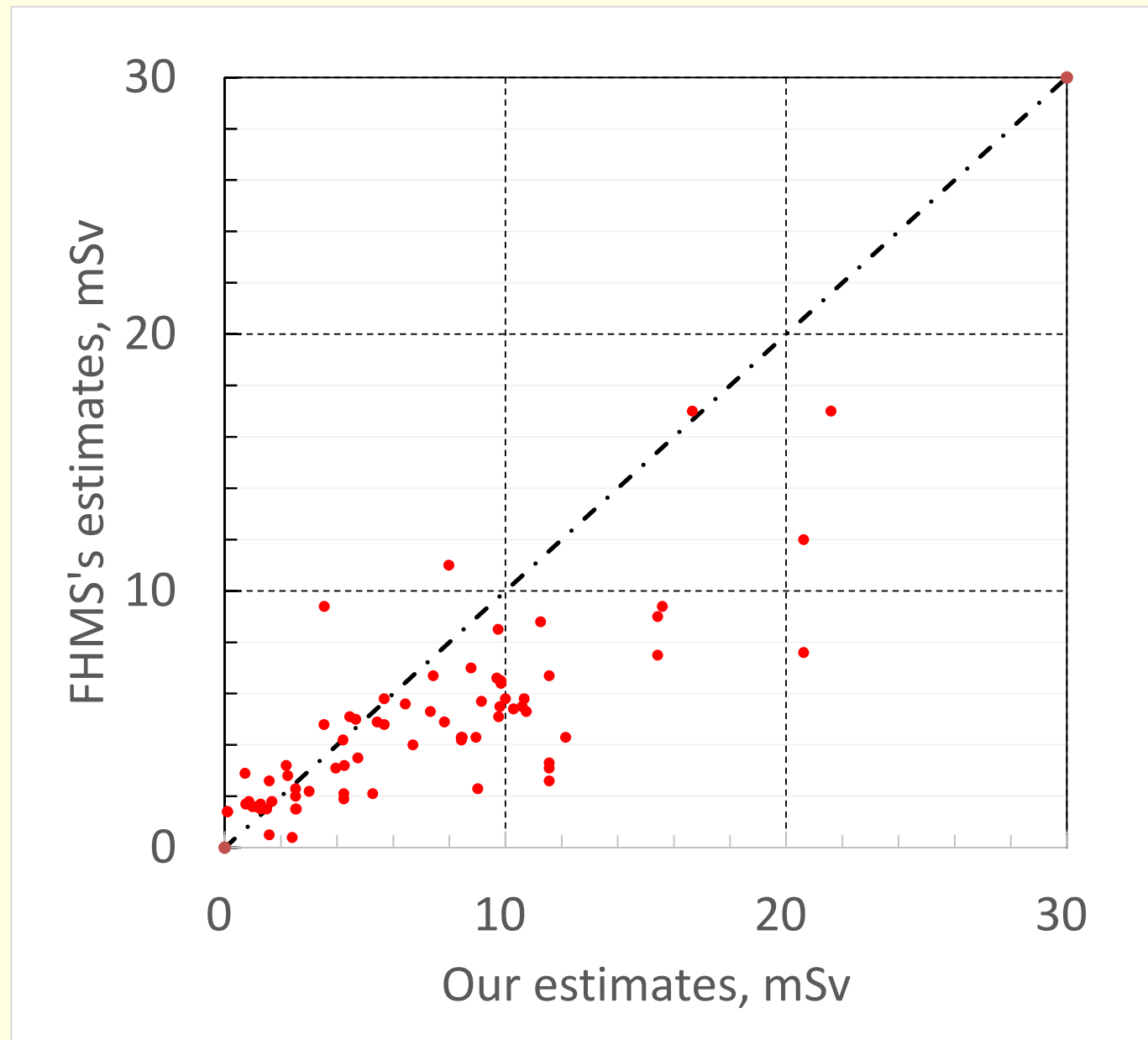
### ***Example of three males in Komiya settlement***

<average time spent per day outside houses>

	Mr. I	Mr. M	Mr. F
March 2011	6.6 hr	8.7 hr	4.5 hr
April 2011	5.3 hr	8.0 hr	4.2 hr
May 2011	6.4 hr	5.0 hr	3.3 hr
<Average>	6.1 hr	7.2 hr	4.0 hr

Our assumption of 8 hr is likely to be overestimated.

# Direct comparison of dose estimates: our results vs. Fukushima Health Management Survey for 73 persons



# Summary

- So far, 498 interviews were taken from litate resident about behaviors of their families until July 31, 2011. In total behavior information on 1,812 persons (about 30 % of the whole residents) was obtained.
  - Biases related with settlements and age groups were not recognized.
- Average cumulative external dose of 7.0 mSv was evaluated until July 31, 2011 in litate village.
  - Our average is are about two times larger than that of FHMS, the reason of which is investigated.
- Collective external dose of 43 person-Sv was estimated for the total residents in litate village.
  - Based on “LNT theory” 2 – 17 cases of cancer deaths are expected among 6,132 residents in litate village.

(Internal dose is not evaluated and will be our future task.)<sub>28</sub>