Development of gamma camera for localization of radiation hotspots using the Timepix

An effective system with divergent pin-hole collimator designed for high intensity radiation hotspots in Fukushima Daiichi NPS

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Timepix with Si or CdTe chip

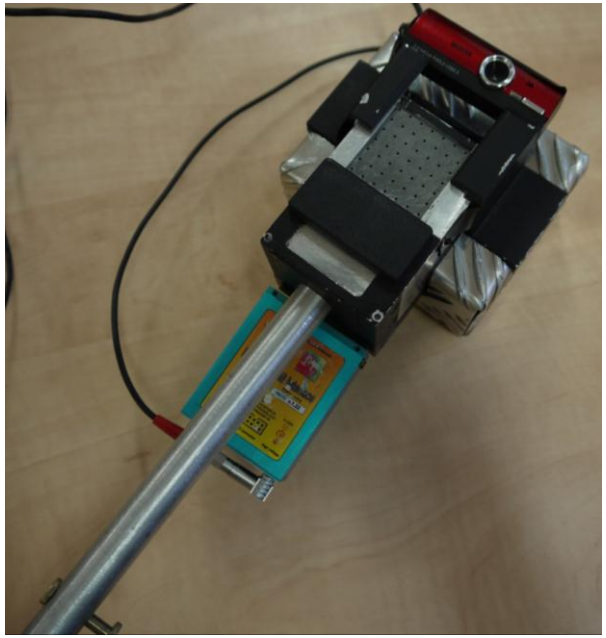
USB interface

Pin-hole collimator

Lead shielding

Laptop + camera

Prototype of gamma camera

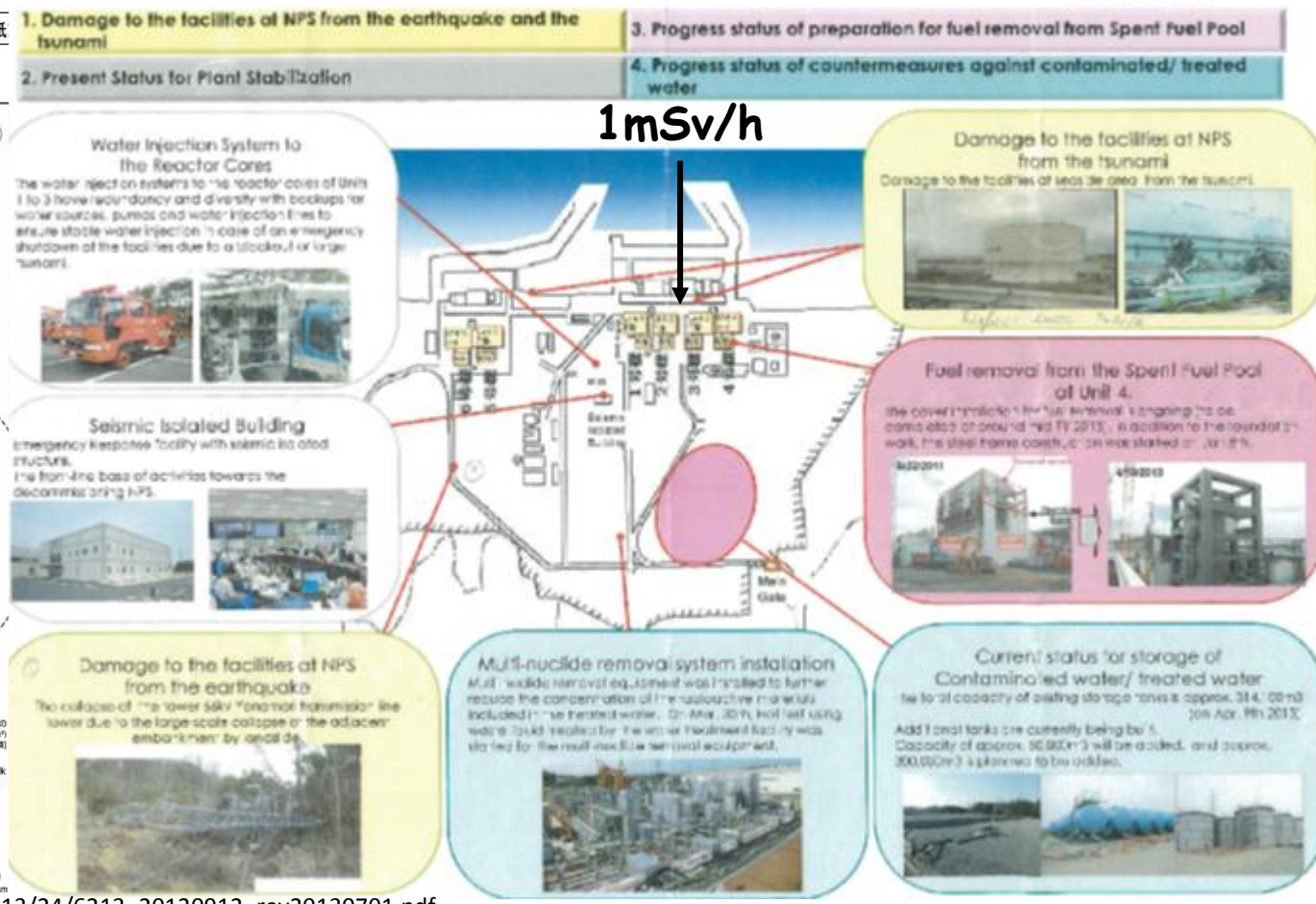


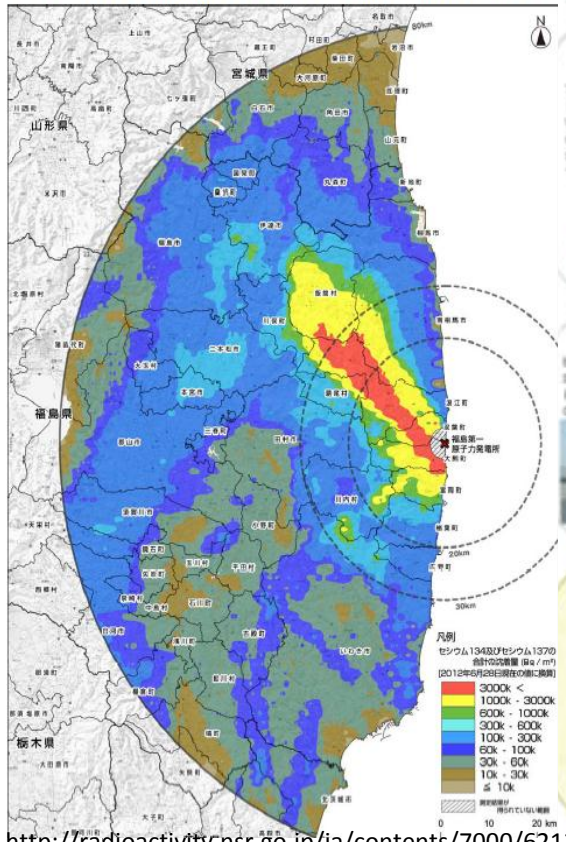
Light, portable and cheap device aimed on imaging of spatial distribution of multiple gamma sources:

^{241}Am (60 keV), ^{131}I (364.5 keV), ^{137}Cs (661.6 keV), ^{60}Co (1173.2 keV, 1332.5 keV)

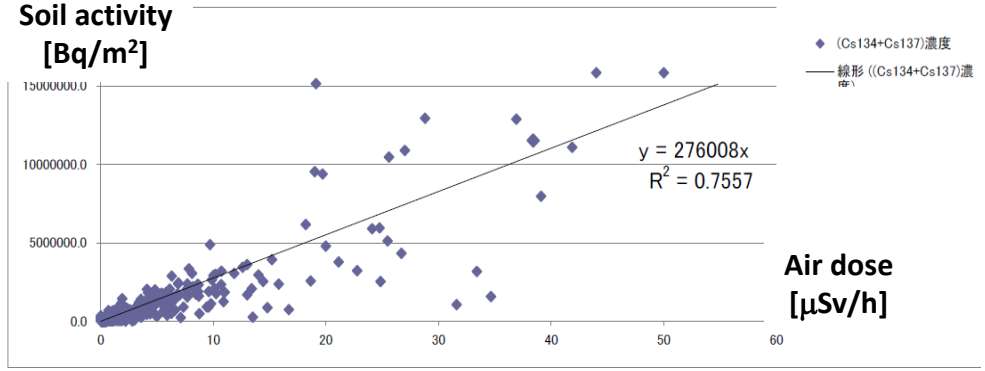
Motivation

From the excursion to Fukushima Daiichi NPS (Courtesy of Tokyo Electric Power Company, INC.)





http://radioactivity.nsr.go.jp/ja/contents/7000/6213/24/6213_20120912_rev20130701.pdf



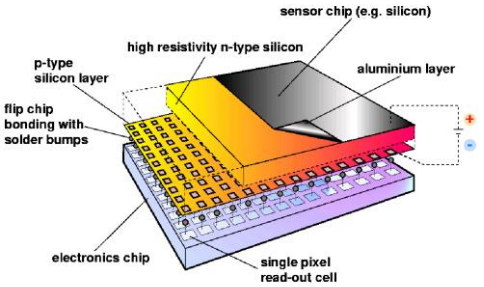
Total dose during 3hours of the excursion was low (21μSv) but intense radiation hotspots still exist.

1mSv/h ~ 275MBq/m²

Technical details of the gamma camera

- Timepix

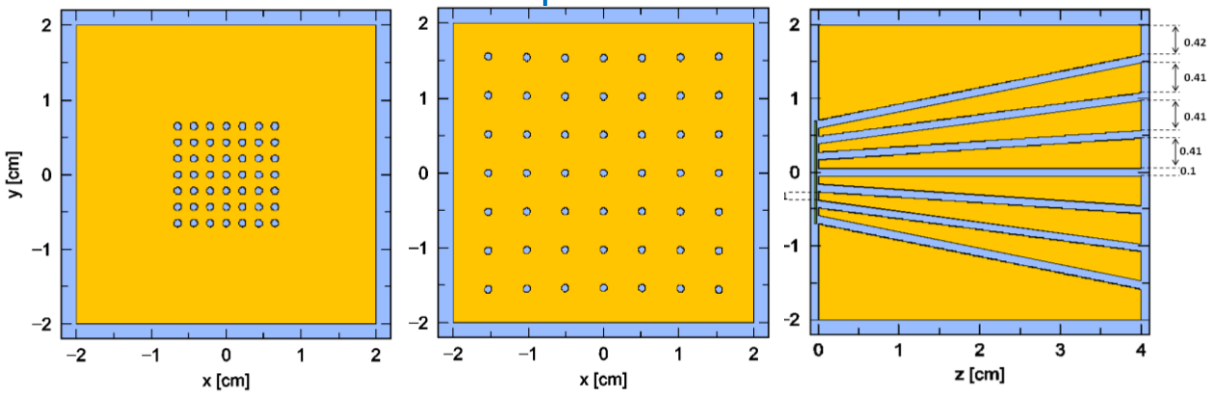
semiconductor pixel detector which is able to detect single particles, their positions, deposited energies (in TOT mode) and their time of arrival.



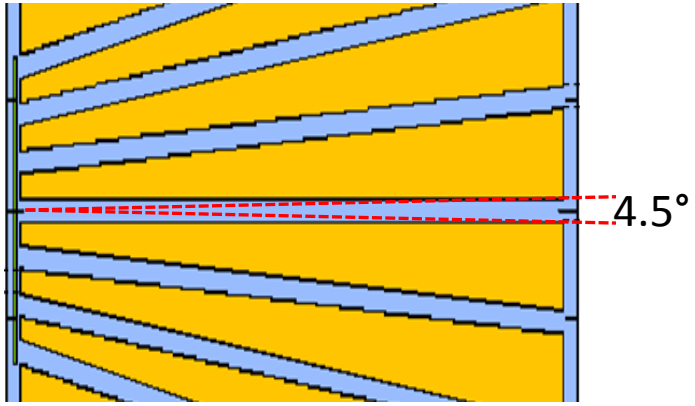
- Collimator design

Lead cube 40 x 40 x 40 mm^3, mass: 708 g
Pin-holes: 7x7 equidistant diverging pin-holes 1mm
Pin-holes distances : 1mm at bottom, 4.1mm on top
Pin-holes angles: 4.2°, 8.4°, 12.5°
Field of view: 25° (much higher than for parallel collimator)

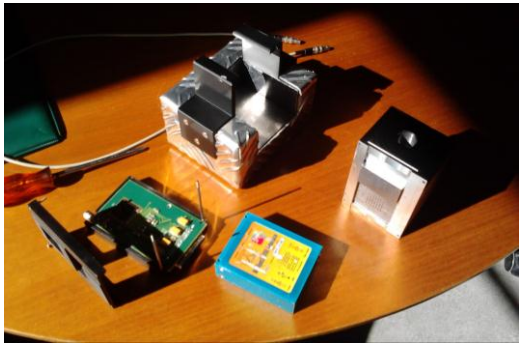
Bottom view | Top view | Central cut



- Angular resolution:



- Shielding design
  - To eliminate noise coming from all directions
  - 2cm of lead 10x attenuate 660keV gamma (^{137}Cs)

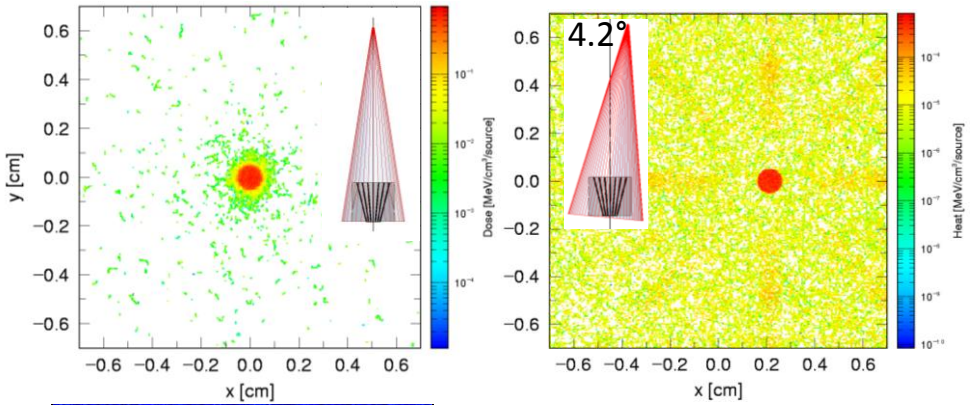


- Ready to go

Monte Carlo simulations

PHITS simulations of spatial distribution of energy depositions in a silicon chip

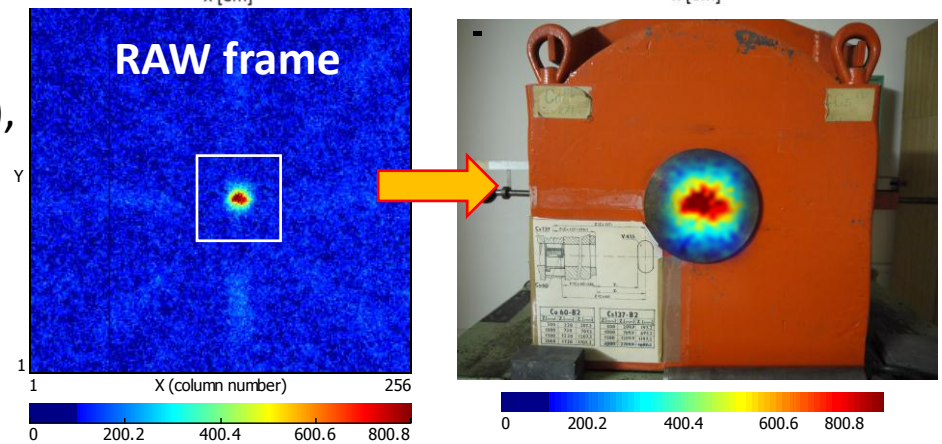
- different positions of ^{137}Cs (0.662 MeV)
- Number of source events: 10^8



Laboratory experiments

^{241}Am (60 keV), ^{131}I (364.5keV), **^{137}Cs** (661.6 keV), ^{60}Co (1173.2 keV, 1332.5 keV)

Superimposition of the camera picture with the Timepix frame

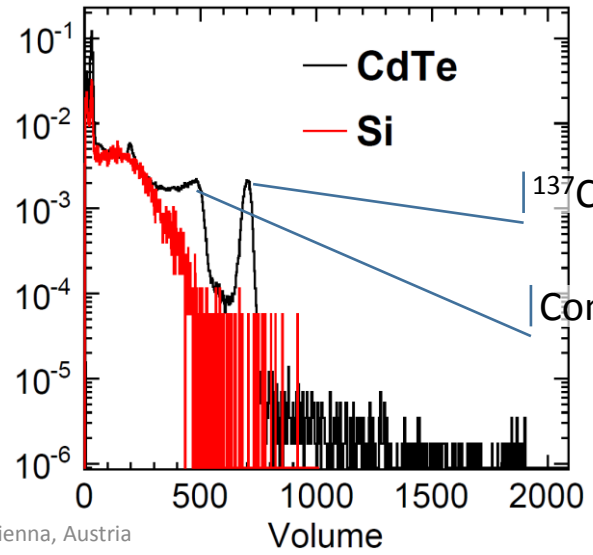


Spectrometry with CdTe

CdTe chip (1000μm) vs Si chip (300μm) spectra in ^{137}Cs source

Application: characterization of the radionuclide

Additional gamma camera components are needed for the CdTe chip:
(1) fan to cool down, (2) external high voltage source



Future work

- Rotational collimator to eliminate the radiation transmissions at the location of collimator's holes.
- Development of software for superimposition of the visible video with the gamma camera frame
- Portable prototype with CdTe chip (including fan and high-voltage source)

Acknowledgement

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- To the Project RANUS-TD for funding the further development.

You are welcome to our poster EX6PO

Thank you for your attention!