



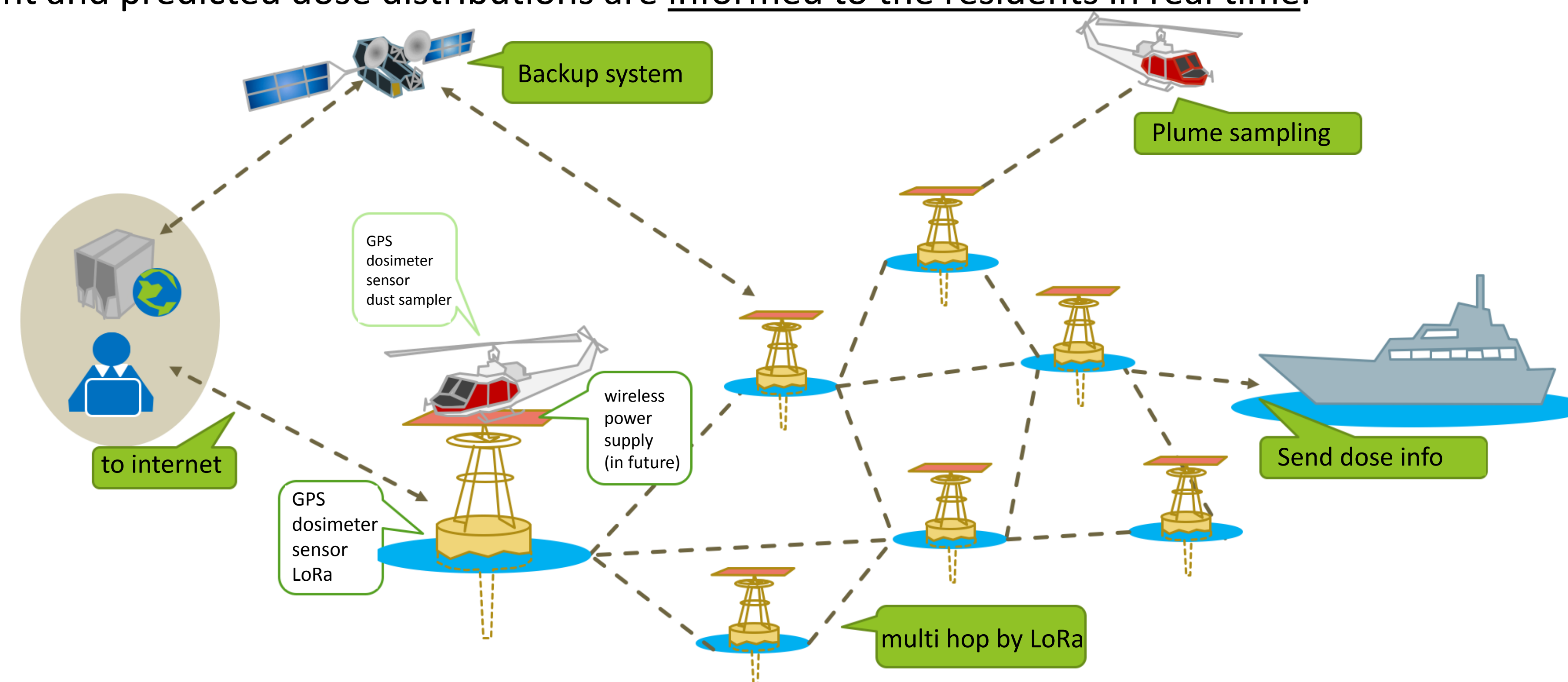
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Motivation

- To detect immediately a possible nuclear weapon test, a mobile system for real time monitoring of radiation and radionuclides in the environment should be useful.
 - In addition, such a system would help residents in the affected area to keep their safety in the emergency situation.
 - The authors have learned from the Fukushima Daiichi accident that real time monitoring is very important for conducting evacuations safely and appropriately and also risk communications with the members of the public.
 - On the other hand, radiation monitoring in a coastal area is more difficult than that inland.
- **Real time monitoring network systems applicable to a coastal area were investigated.**

Overview of System

- A network composed of buoys and drones equipped with dosimeters are provided.
- The instruments are connected by IoT, while it does not necessarily require Internet.
- Current and predicted dose distributions are informed to the residents in real time.



Buoys: To measure the doses of ocean surface and under sea.

Drones: To fill in the gaps of buoys network and sampling radioactive particles of plumes in the atmosphere.

IoT: To communicate in real time using LoRa(920MHz) multi-hop connection and satellite access for backup.

R&D items

- Optimization of dosimeter
- LoRa connection on ocean surface
- Design buoys as airtight containers.
- Power supply system for drones
- Plume sampling system for drones

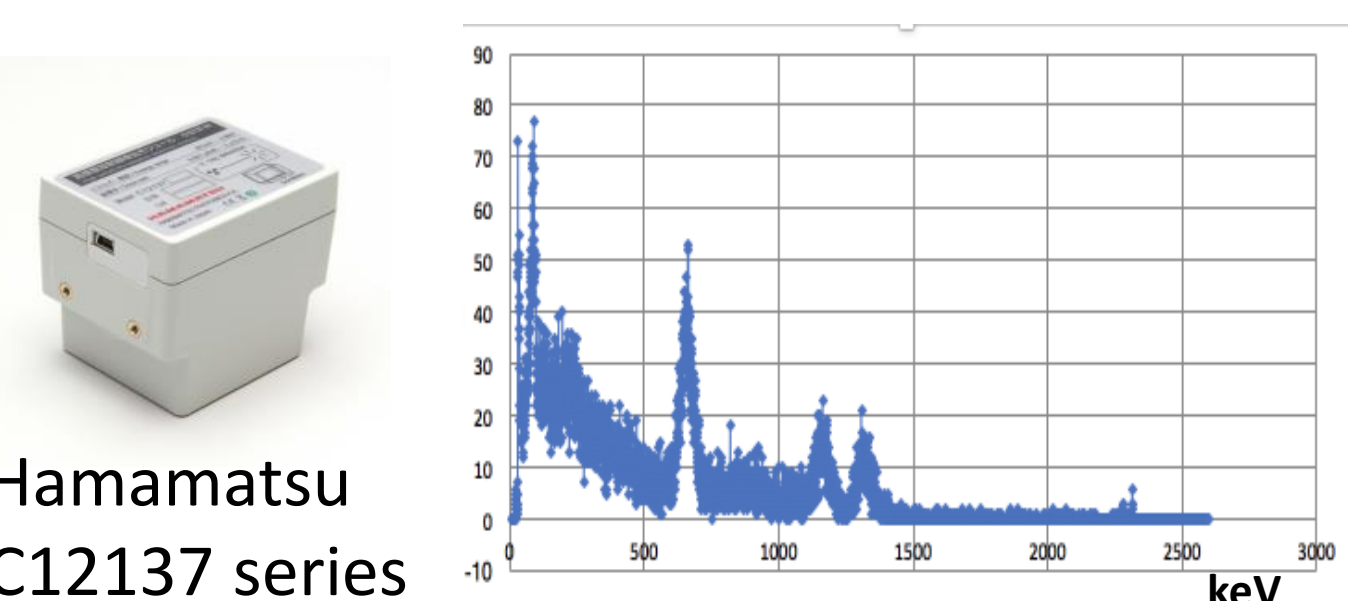
Optimization of dosimeter

- Requirements**
 - Radionuclide identifiable
 - Energy spectra measurable
 - Low power consumption
 - Light weight (< 1kg)
 - Tolerable against salt damage
 - Airtight container attached
- Desirable abilities**
 - Position sensitivity
 - Short measurement time

→ **CsI or NaI scintillation detectors** are candidates.

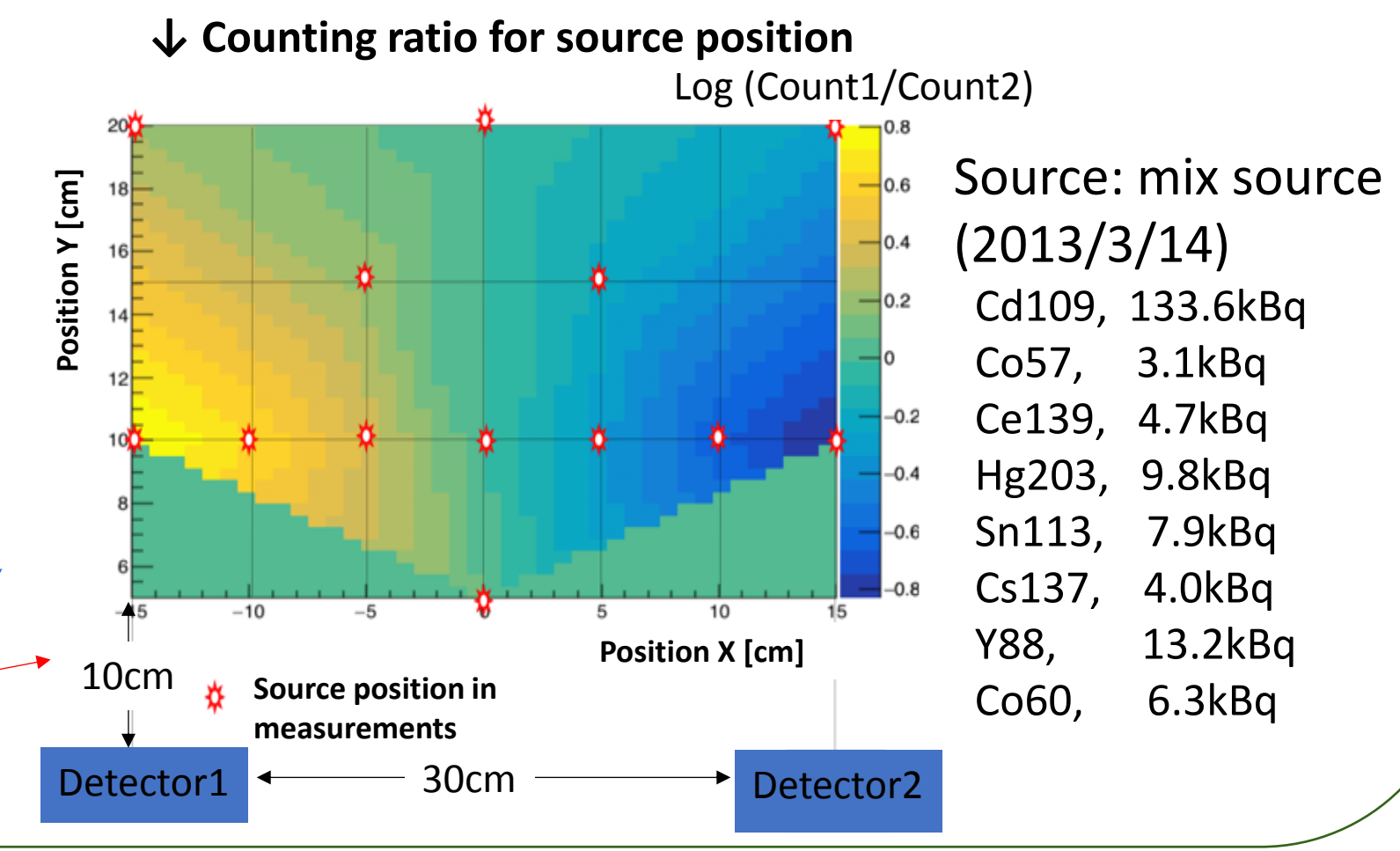
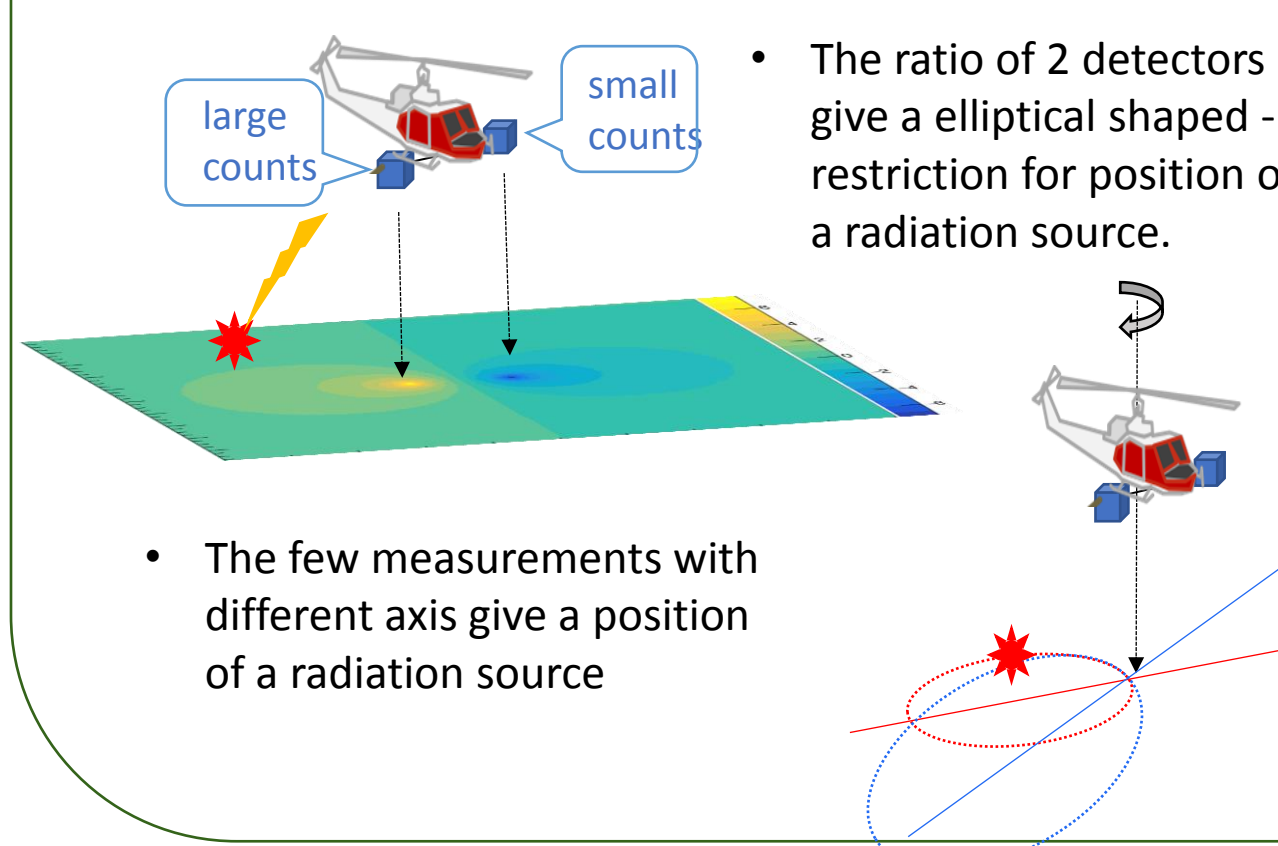
Development for Position Sensitive detector

- The trial for position sensitive detector using CsI spectrometers which are satisfied requirements.



Hamamatsu C12137 series

The idea for position sensitive detector

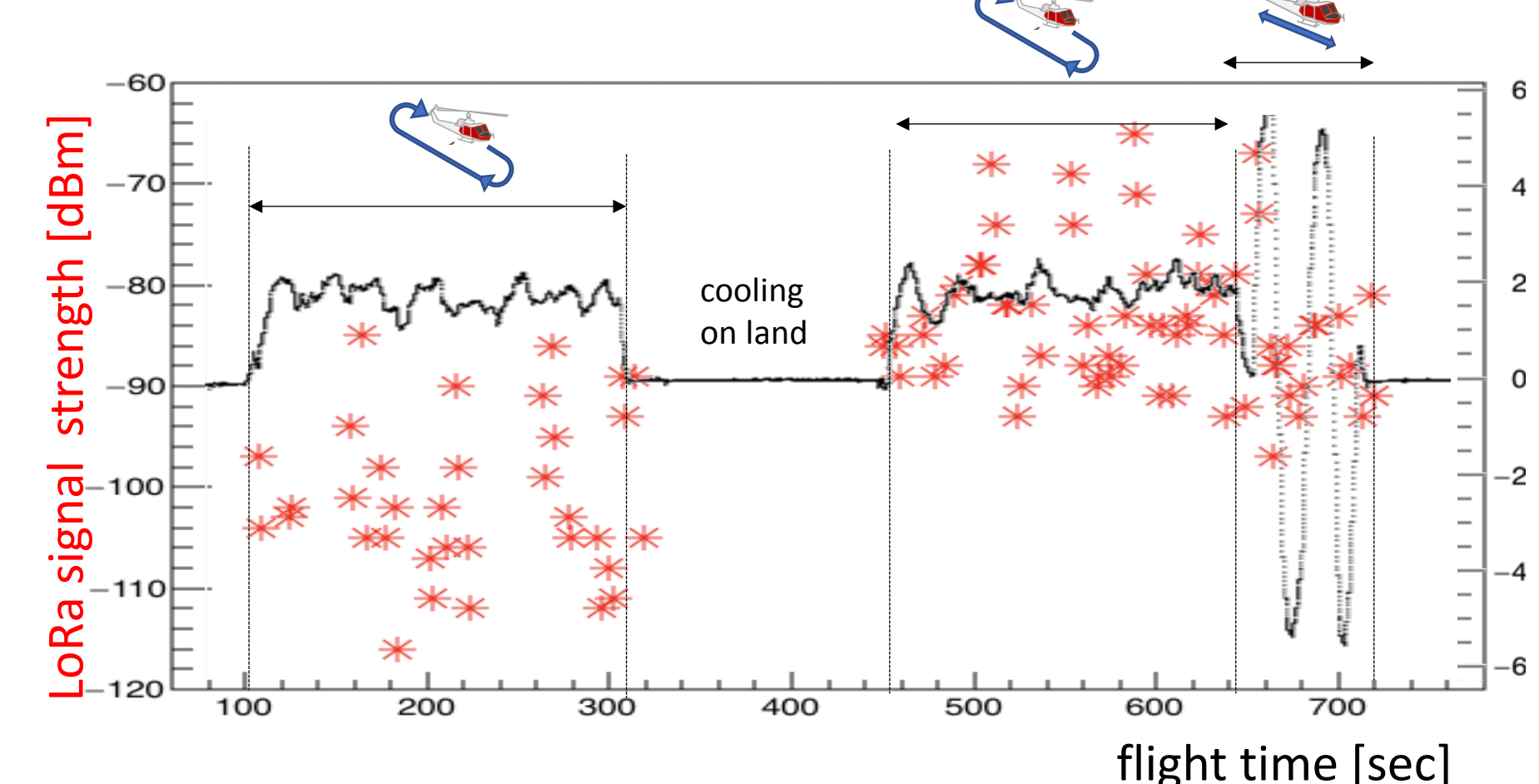
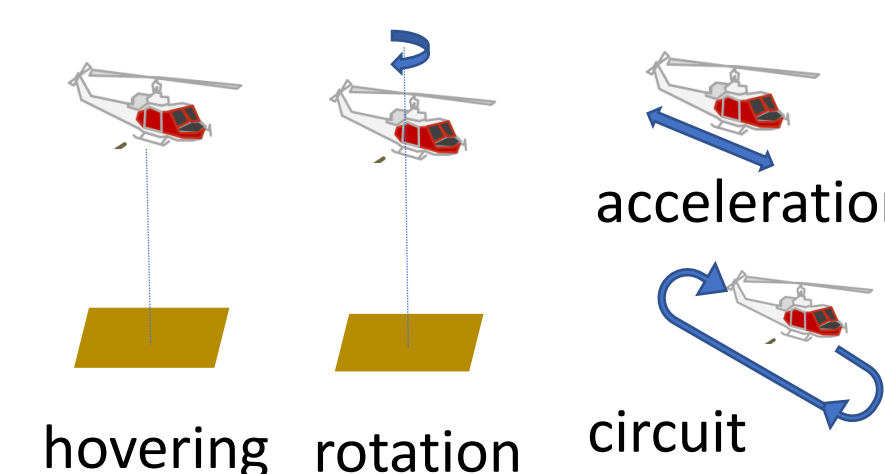


Source: mix source (2013/3/14)

- Cd109, 133.6kBq
- Co57, 3.1kBq
- Ce139, 4.7kBq
- Hg203, 9.8kBq
- Sn113, 7.9kBq
- Cs137, 4.0kBq
- Y88, 13.2kBq
- Co60, 6.3kBq

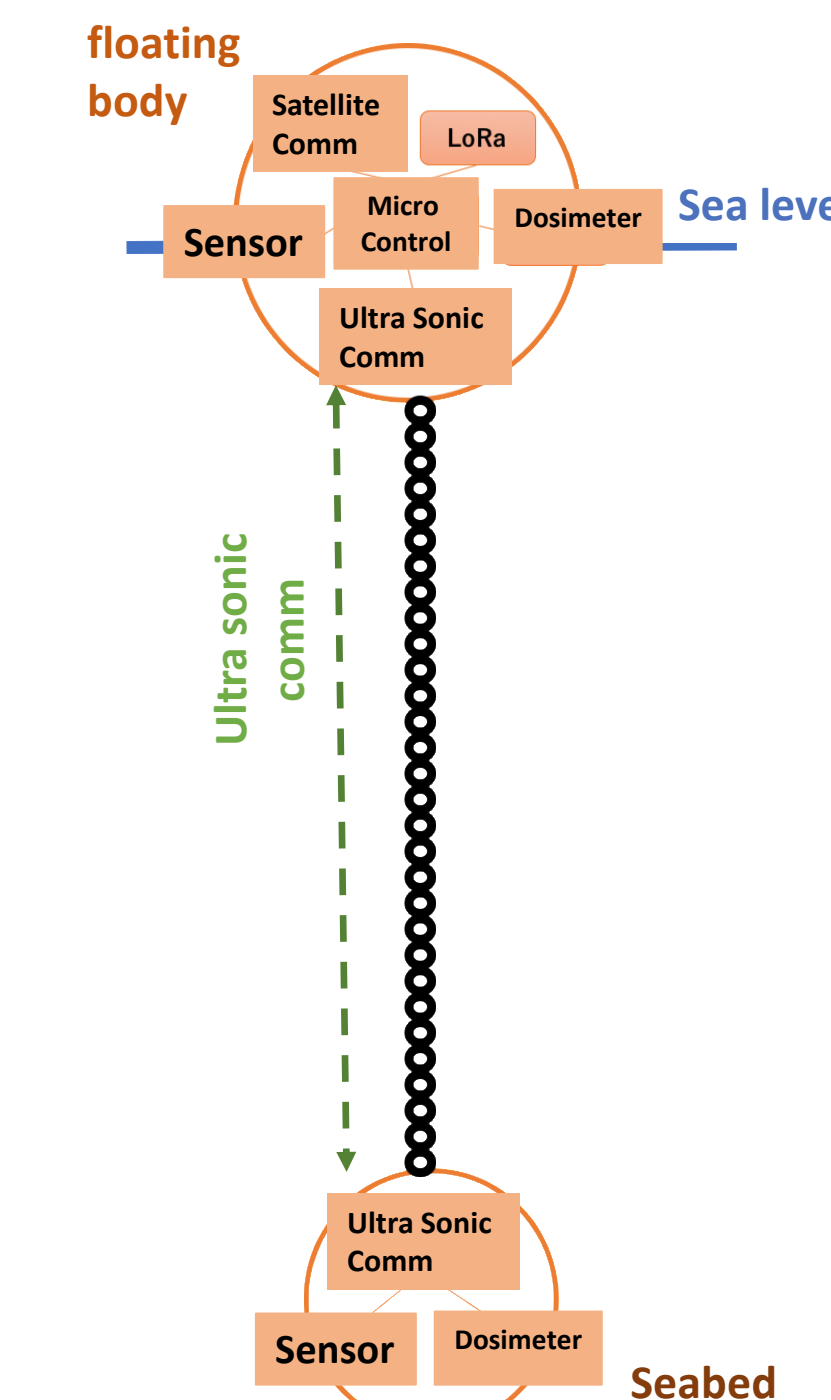
Validation test of IoT in the field

- Install UAV (HIROBO Limited)
- Install LoRa (920MHz, NihonMusen)
- Check interference with UAV radio wave
- Check the effect by movement of UAV



- The strength of LoRa signals were unaffected by the UAV move.
 - It changed after cooling of a UAV motor.
- Needs more detailed studies on the behavior of LoRa

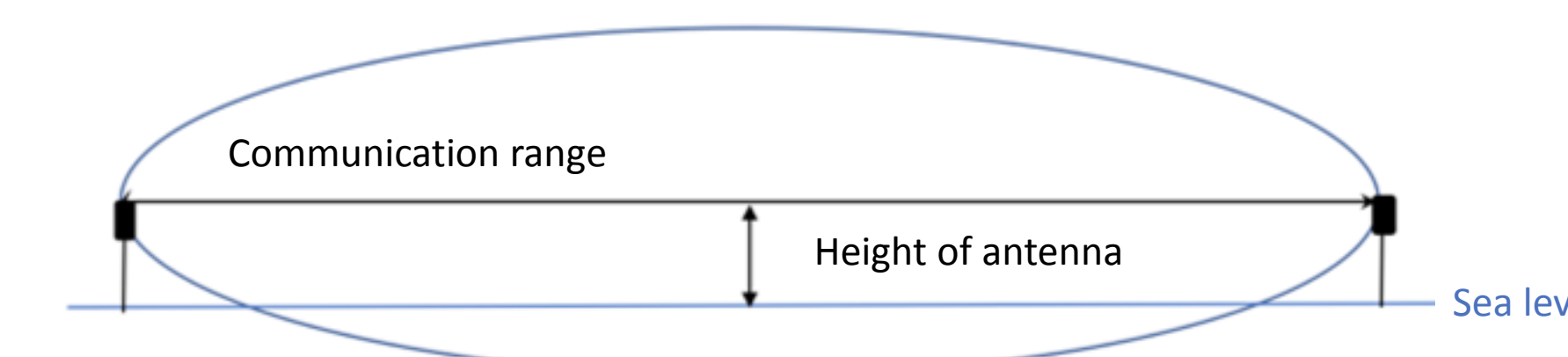
Design of buoys for our system



- The buoys has 2 parts
 - Floating body
 - Moth
- Dosimeter and sensors to measure the marine condition are equipped.
- The floating part contains LoRa for communication with other buoys and UAVs and satellite communication for back up.
- The data are communicated by using ultra sonic, as the tide may cut wires.

The relationship between communication range of LoRa and height of Antennas

Range	Height of antenna
10km	4.0m
5km	2.8m
1km	1.3m
500m	0.9m
100m	0.4m



※To keep 60% of Fresnel zone

Summary

- The radiation monitoring network system applicable to a coastal area was proposed. The system consists of UAVs and buoys which could find hotspots on seabed and radioactive plumes in the atmosphere.
- Candidates for sensors and dosimeters were investigated. Some additional products are to be examined and then a practical monitoring network system will be presented in near future.