Development and Operational Status of the Nationwide Continuous Seawater Radioactivity Monitoring System in Korea

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Presentation Outline

01

Introduction

Nationwide radiation monitoring system in Korea

02

Operational Status

Establishment of seawater radioactivity monitoring network(SeRaNet) system

03

Activity Quantification

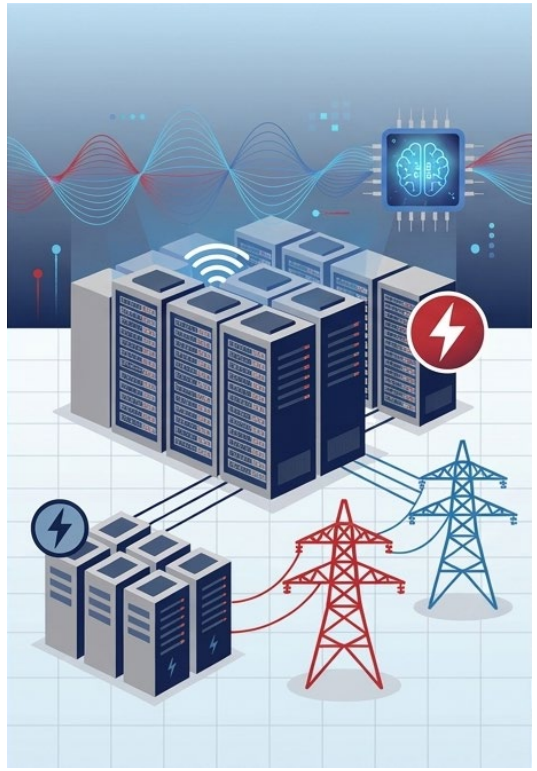
Calculation
Efficiency

04

Upgrades of devices

On-land type device

01 Introduction



Surging global electricity demand driven by hyperscaler data centers

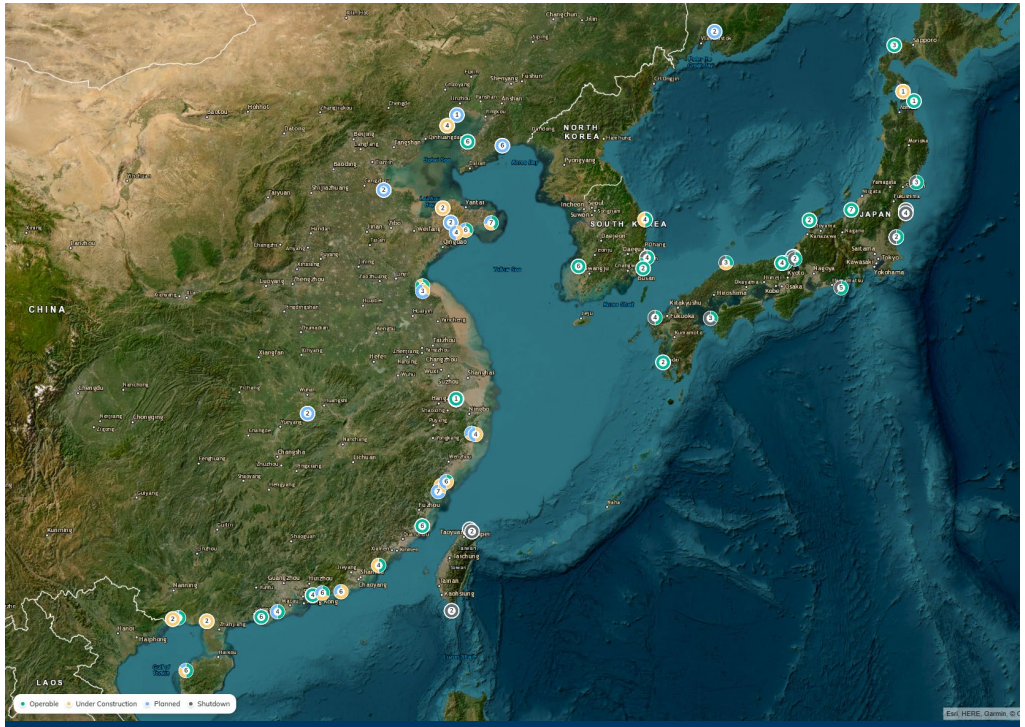


Potential of **nuclear energy as a key power source** in future

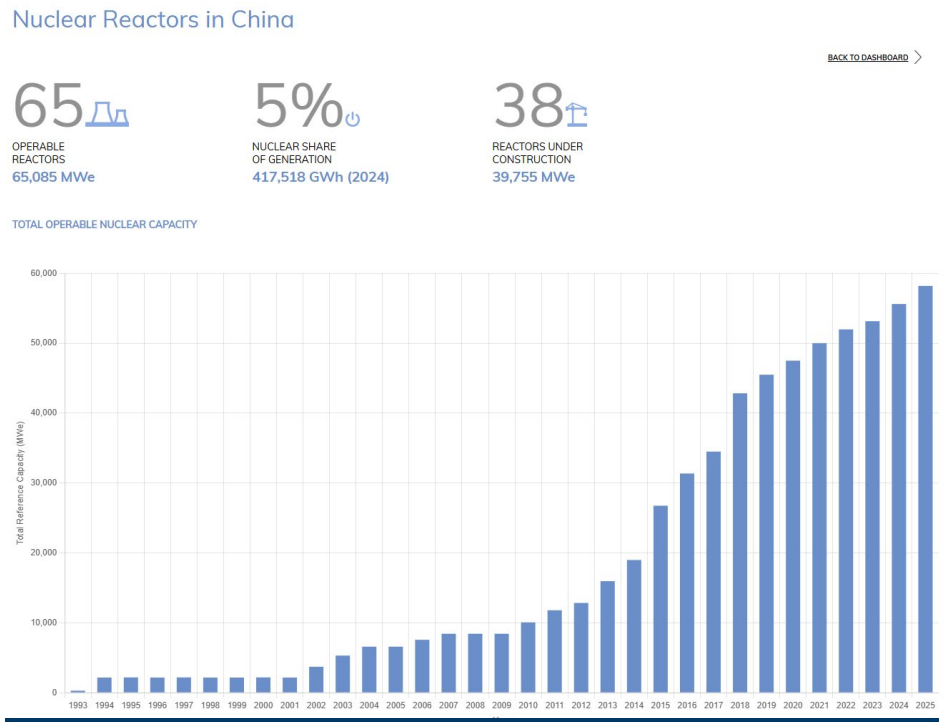


NPP accidents as **a potential risk** (e.g. Fukushima accident)

01 Introduction



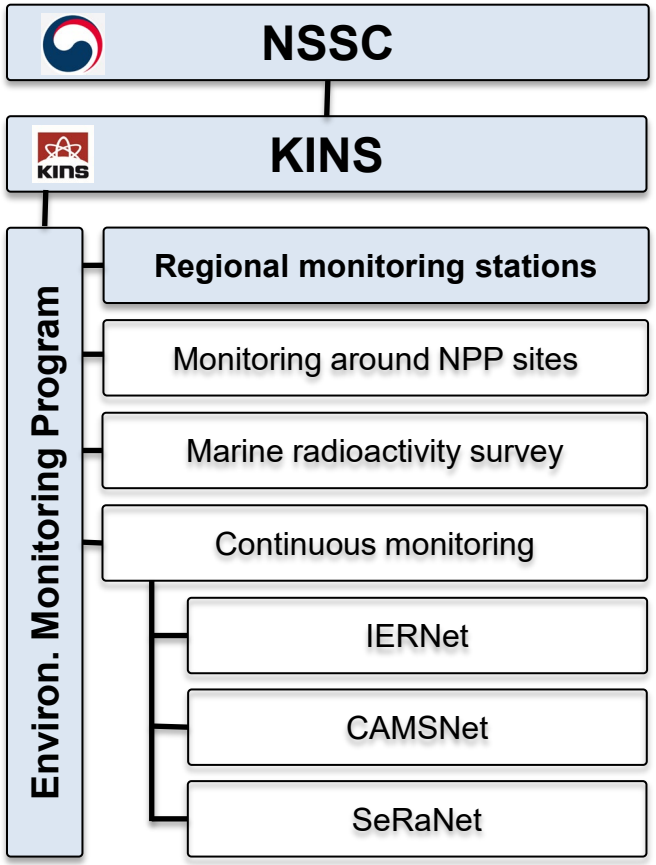
Chinese NPPs: Operable & Under construntion & Planned



Total reference capacity of Chinese NPPs

https://world-nuclear.org

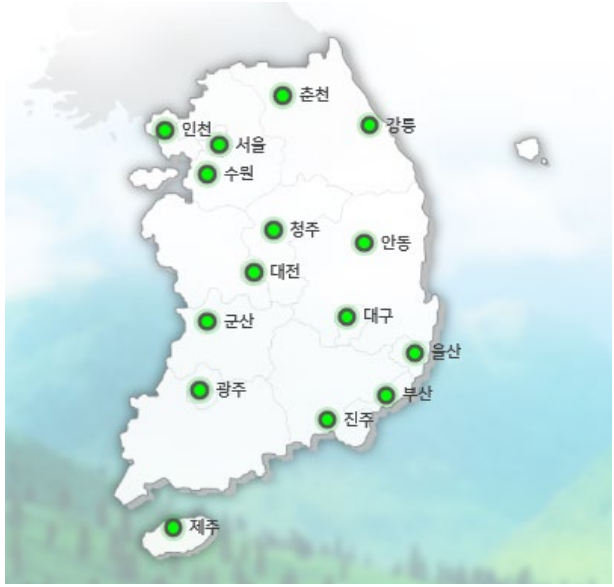
Rapidly expanding Chinese NPPs are raising public concern in Korea over unforeseen accident.

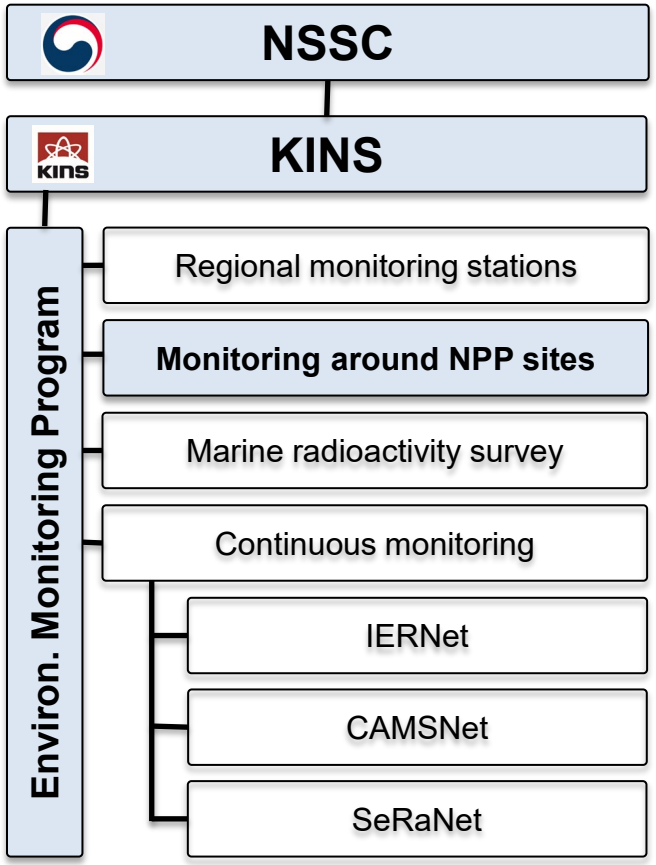


Regional radioactivity monitoring stations

- Monitor gross beta & gamma radioactivity in the airborne dust, fallout, precipitation and tap water
- 15 stations



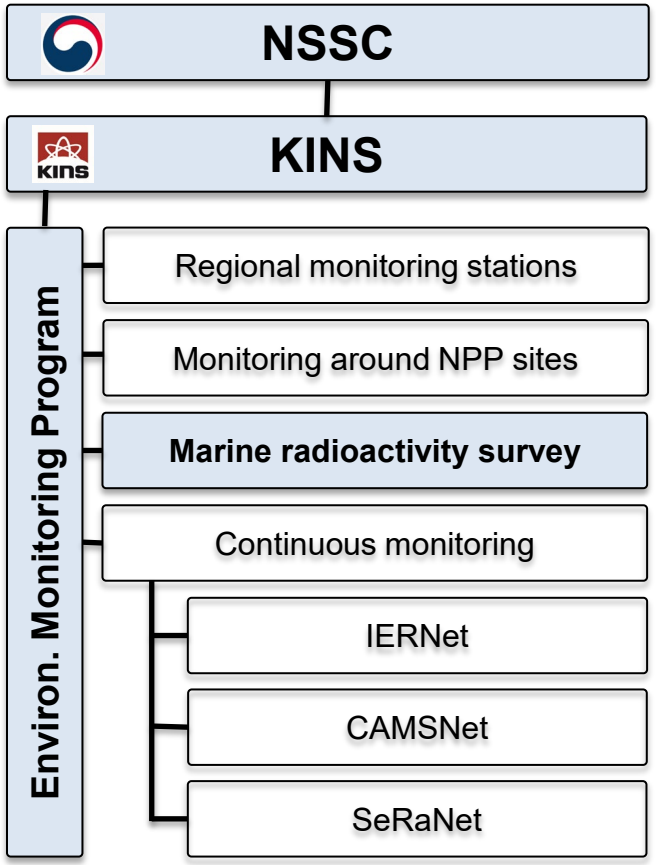




Monitoring around NPP sites

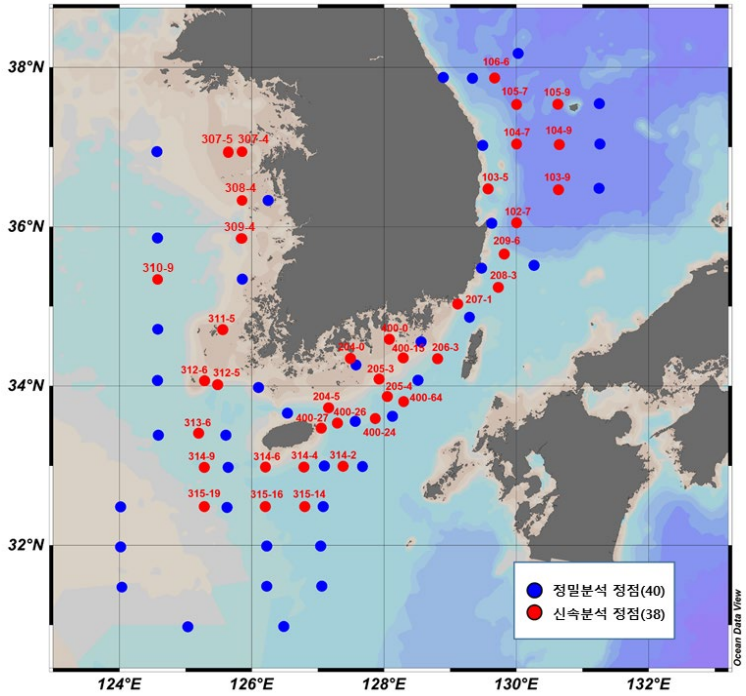
- KINS perform independently monitoring program to verify nuclear operator's results
  → Commercial reactor, Research reactor, Fuel fabrication facility, Nuclear waste disposal site

Sample types			Monitoring items	Frequency
Radiation			Ambient Gamma dose rate (ERMS)	Continuous
			Integrated Dose (TLD)	Quarterly
Radioactivity	Terrestrial	Soil	γ	Semi-annually
			^{90}Sr, $^{239+240}$Pu, ^{239,240}Pu ratio, U	Annually
		Sediment (marine/river)	γ	Semi-annually
			^{90}Sr, $^{239+240}$Pu, ^{239,240}Pu ratio, U	Annually
		Air	^{3}H, ^{14}C	Monthly
		Pine tree needles	^{3}H, ^{14}C	Monthly
	Water	Seawater	γ, ^{3}H	Quarterly
			^{90}Sr, $^{239+240}$Pu, ^{239,240}Pu ratio	Semi-annually
		Groundwater	γ, ^{3}H, ^{99}Tc, ^{129}I, U, ^{90}Sr, $^{239+240}$Pu, ^{239,240}Pu ratio	Semi-annually
		Surface water	γ	Quarterly
		Rainwater	γ, ^{3}H	Monthly
	Food	Milk	γ	Quarterly
			^{90}Sr	Semi-annually
			^{3}H, ^{14}C	Monthly
		Cabbage	γ	Annually
		Rice	γ	Annually
	Marine biota	Flsh	γ	Semi-annually
		Seaweed	γ	Semi-annually



Marine radioactivity survey

- Spatial scope: offshore & open seas
- The number of sampling stations have increased gradually after Fukushima accident
- 78 stations: precise analysis(40), rapid analysis(38)

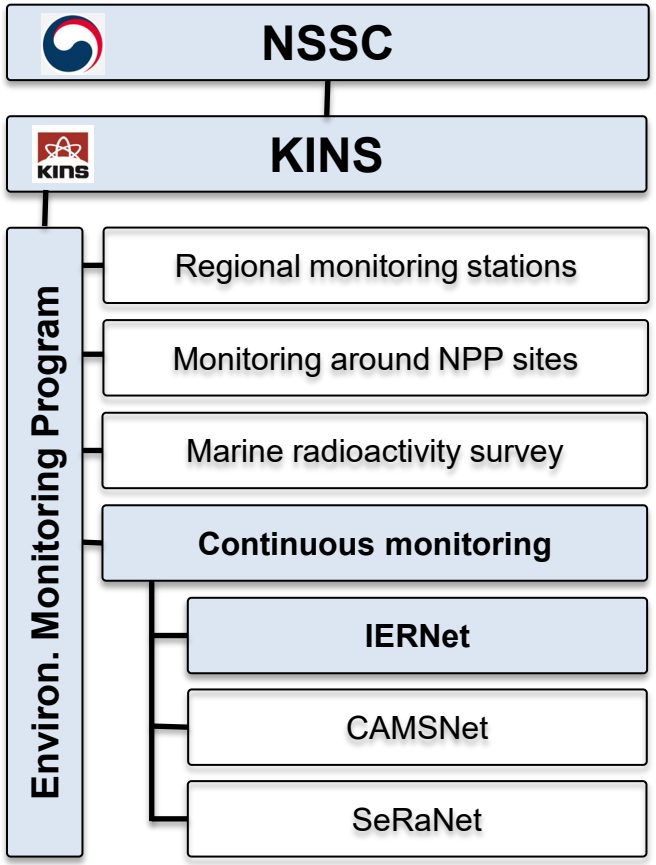


<Precise analysis>

Sample types		Monitoring items	Frequency
Seawater	Surface	γ ^{3}H ^{90}Sr, Pu	1-2/month Quarterly Annually
	Depth profile	γ ^{3}H, ^{90}Sr, Pu	Semi-annually Annually
Marine biota		γ ^{90}Sr, Pu	Semi-annually Annually
Marine Sediment		γ ^{90}Sr, Pu	Semi-annually Annually

<Rapid analysis>

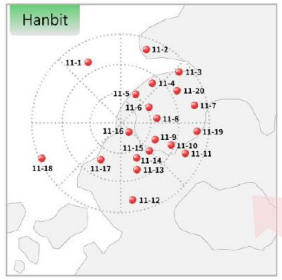
Sample types		Monitoring items	Frequency
Seawater	Surface	^{134}Cs, ^{137}Cs ^{3}H	2/month

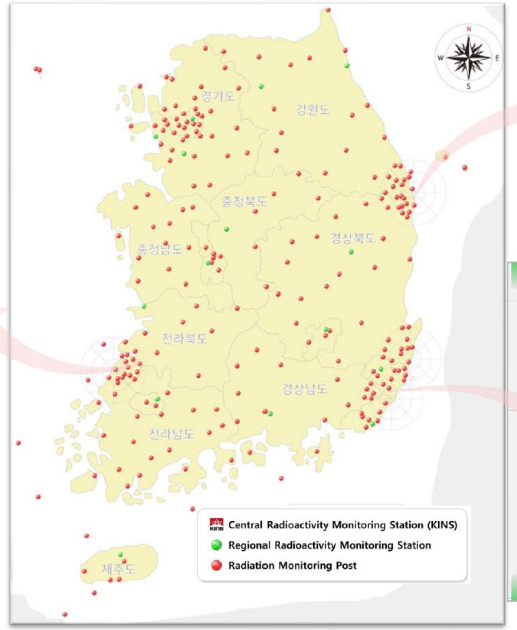


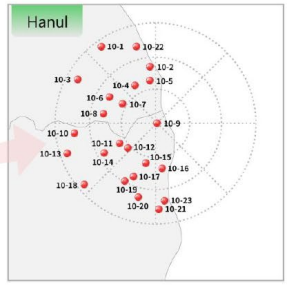
Integrated Environmental Radiation Monitoring Network(IERNet)

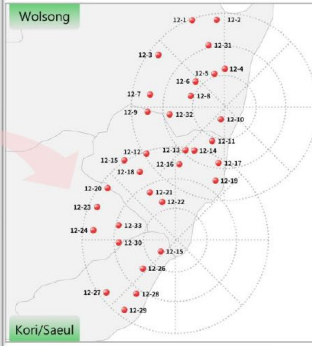
- Monitoring ambient gamma dose rate using high-pressure ionization chamber (HPIC) (mSv/hr)
- 252 stations (in 2026) → Monitoring post has been gradually increasing each year

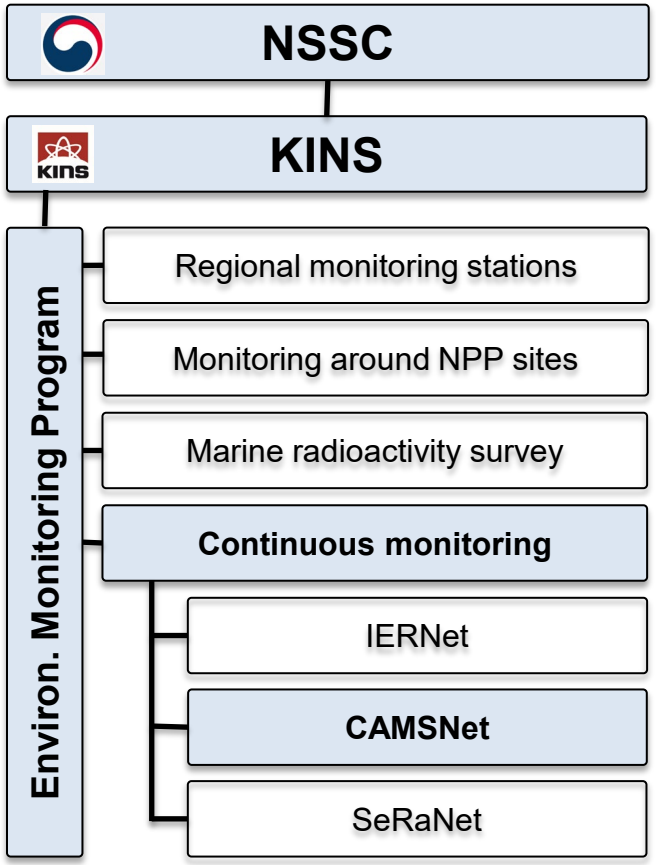












Continuous Airborne-dust Monitoring System Network(CAMSNet)

- Continuously monitor gross alpha & beta in roll-type air filter
- 15 stations (in regional radioactivity monitoring stations)



CAMS (FHT-59S2)



02 Operational status • Seawater Radioactivity Monitoring Network(SeRaNet)

SeRaNet

Seawater Radioactivity Monitoring System

- **Objective**: Surveillance on inflow of high-level radioactive seawater originated from domestic or foreign source
- **Since July 2018**
- **Number of stations: 21**
  · Tidal station(15), Buoy(4), Harbor(1), Ferry(1)
- **Target nuclides:** gamma emitter(^{137}Cs)
- **Detector type:** NaI(Tl) scintillator

MINIMUM DETECTABLE CONCENTRATION (MDC)

< 5 Bq/L

Derived from ^{137}Cs ROI in 15-minute gamma spectra

WHO GDWQ of ^{137}Cs: 10 Bq/L



SeRaNet station distribution

Tidal station(15)

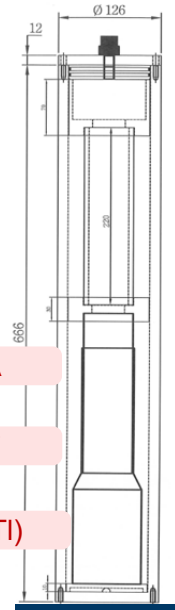




Ferry(1)







MCA

PMT

NaI(Tl)

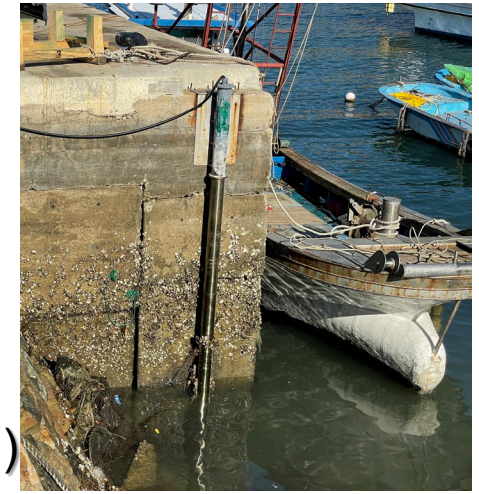


Seawater Radiation Monitor

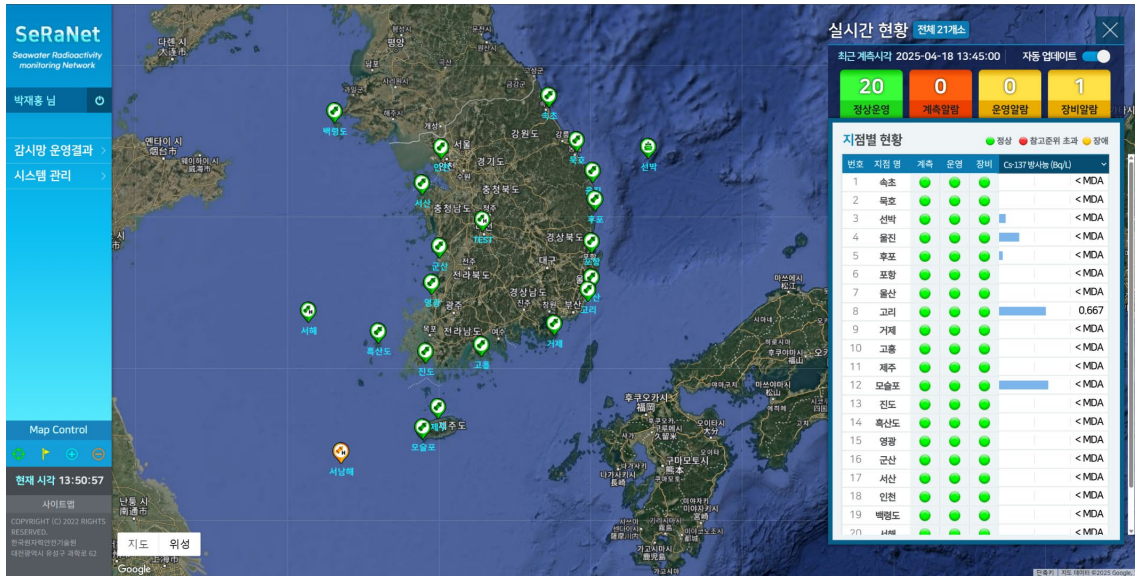
Buoy(4)



Harbor(1)



02 Operational status • Seawater Radioactivity Monitor





Seawater Radioactivity Monitoring Network(SeRaNet) operation system interface

- Receive data from the monitors by LTE or satellite communication
- Inspecting SOH of monitors
- Automatically analyze spectrum and evaluate & control the data

$$Activity(Bq/L) = \frac{Net\ count\ rate\ (cps)}{Efficiency(\varepsilon) \times Effective\ volume(V(L)) \times Gamma\ emission\ probability(\gamma)}$$

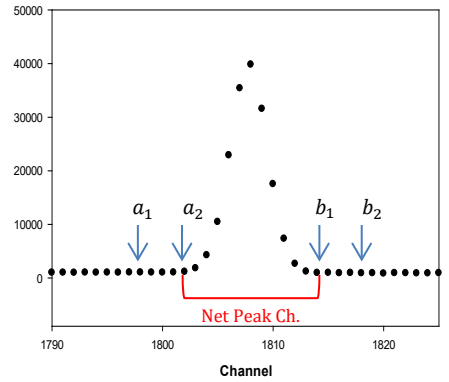
Net Count rate

$$n_t = \sum_{i=a_2}^{b_1} n_i$$

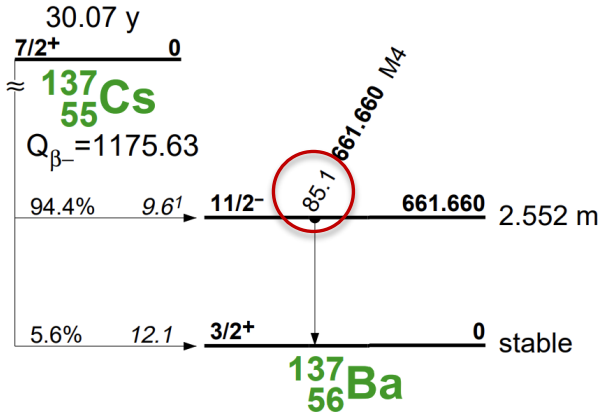
$$n_b = \left(\sum_{i=a_1}^{a_2-1} n_i + \sum_{i=b_1+1}^{b_2} n_i\right) \frac{(b_1 - a_2 + 1)}{(a_2 - a_1 + b_2 - b_1)}$$

$$n = n_t - n_b$$

n : net count n_t : total count
n_b : bkg count a_i, b_i : ch. number
n_i : i ch. count

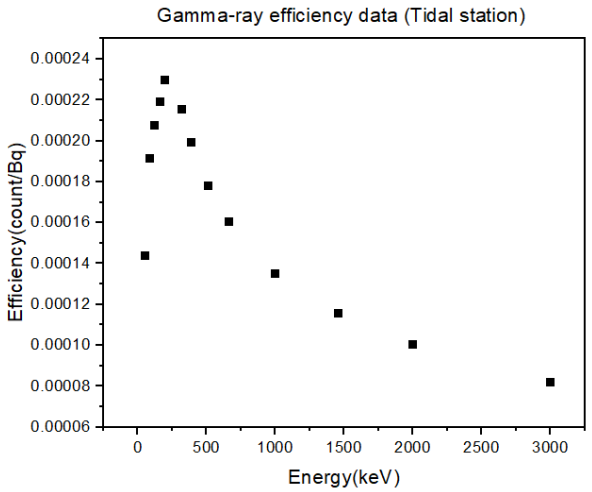


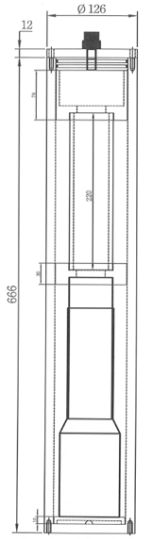
Gamma emission probability

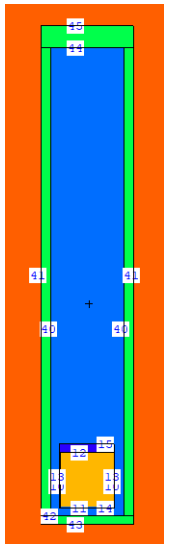


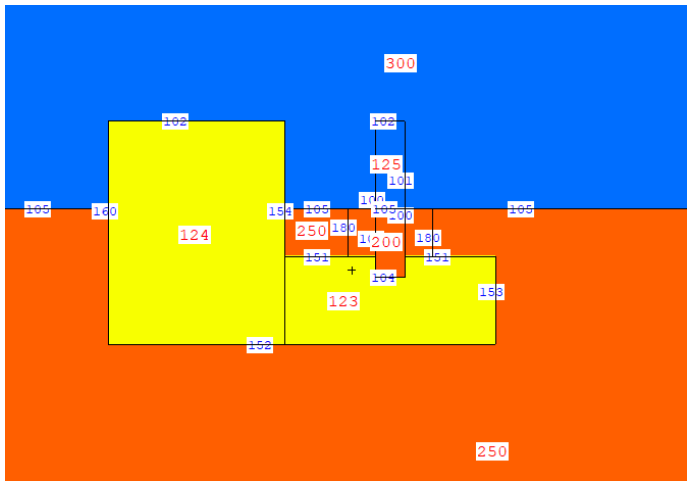
$$Activity(Bq/L) = \frac{Net\ count\ rate\ (cps)}{Efficiency(\varepsilon) \times Effective\ volume(V(L)) \times Gamma\ emission\ probability(\gamma)}$$

Efficiency

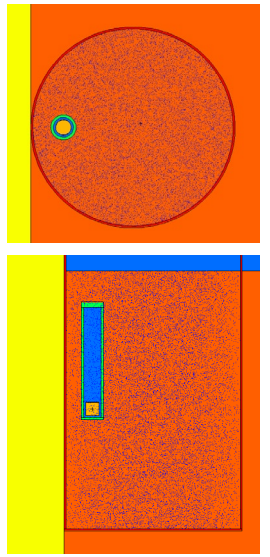






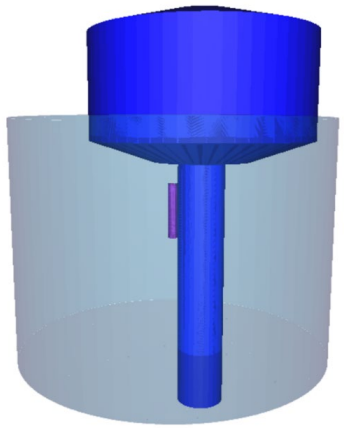


MCNP code (Monte Carlo N-Particle)

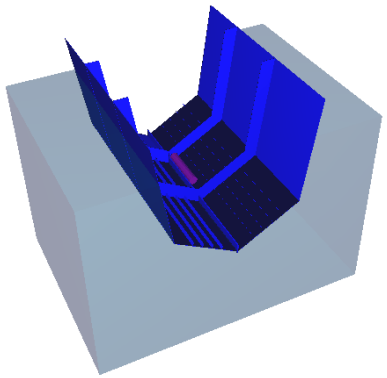


$$Activity(Bq/L) = \frac{Net\ count\ rate\ (cps)}{Efficiency(\varepsilon) \times Effective\ volume(V(L)) \times Gamma\ emission\ probability(\gamma)}$$

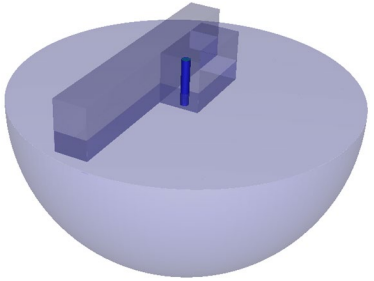
Effective volume



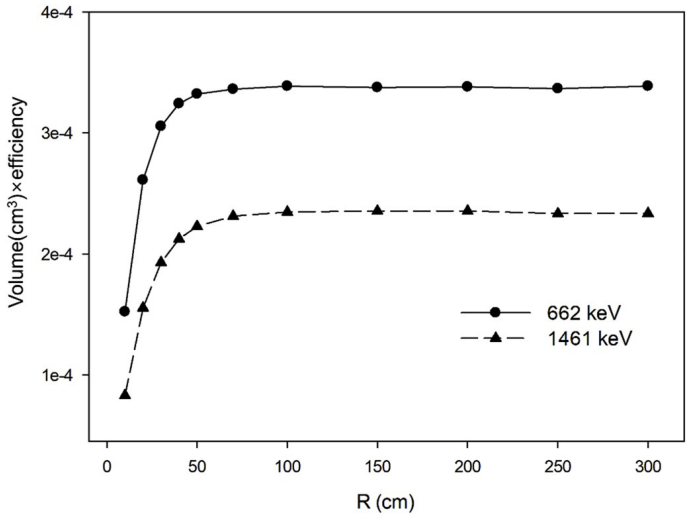
Buoy



Ferry

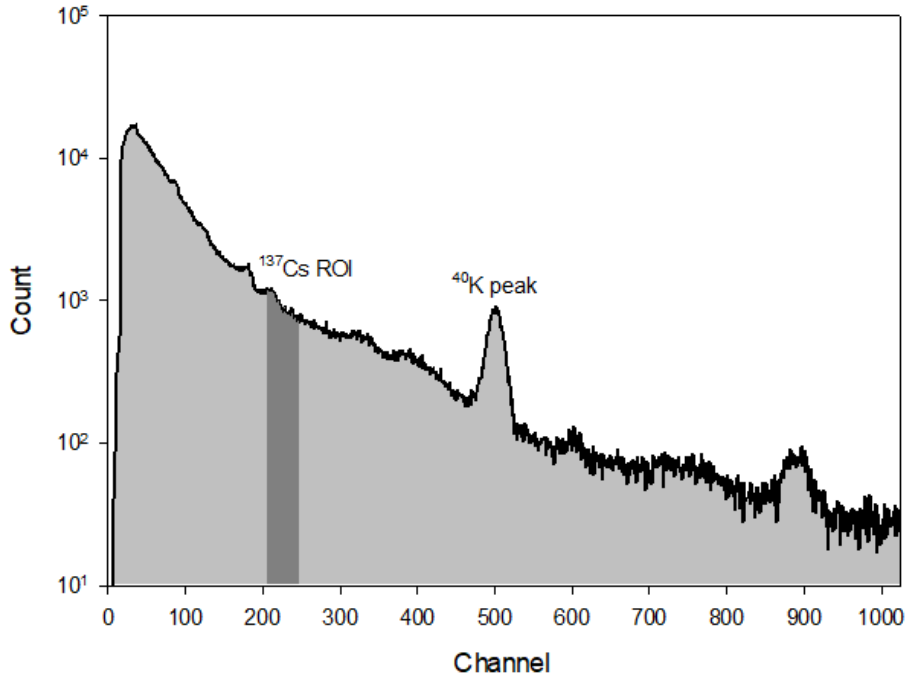


Tidal station

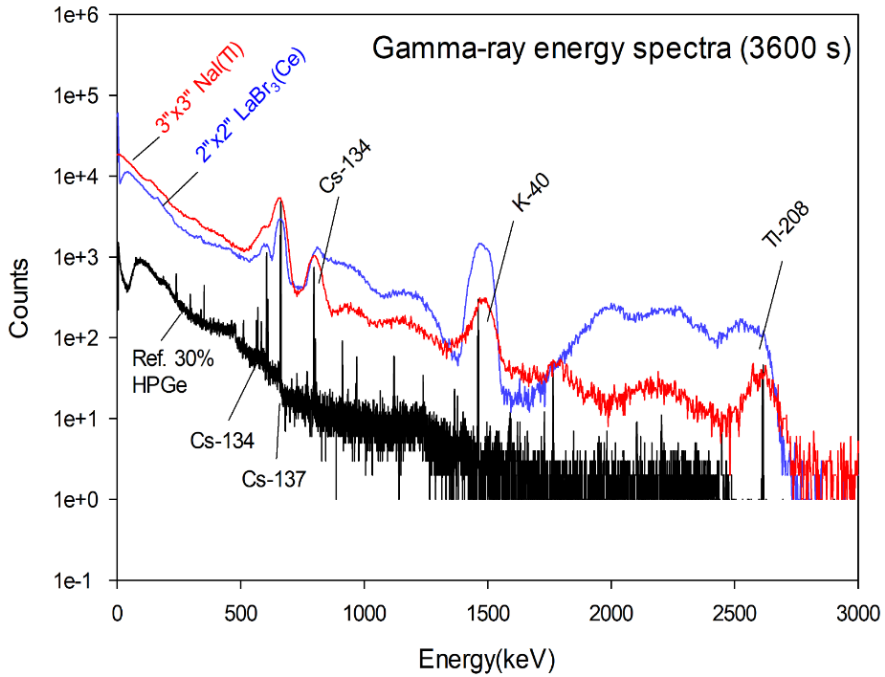


Byun et al. (2020)

A case of spectra from the seawater radioactivity monitor



Comparison of detector type



04 Upgrades of devices • On-land type device

Strength **Standardizing the sample geometry improved the reliability of monitoring**

Strength **High operational stability and easy to maintain**

Supplementary chamber

Intake sample passed through and stored

Detection Chamber

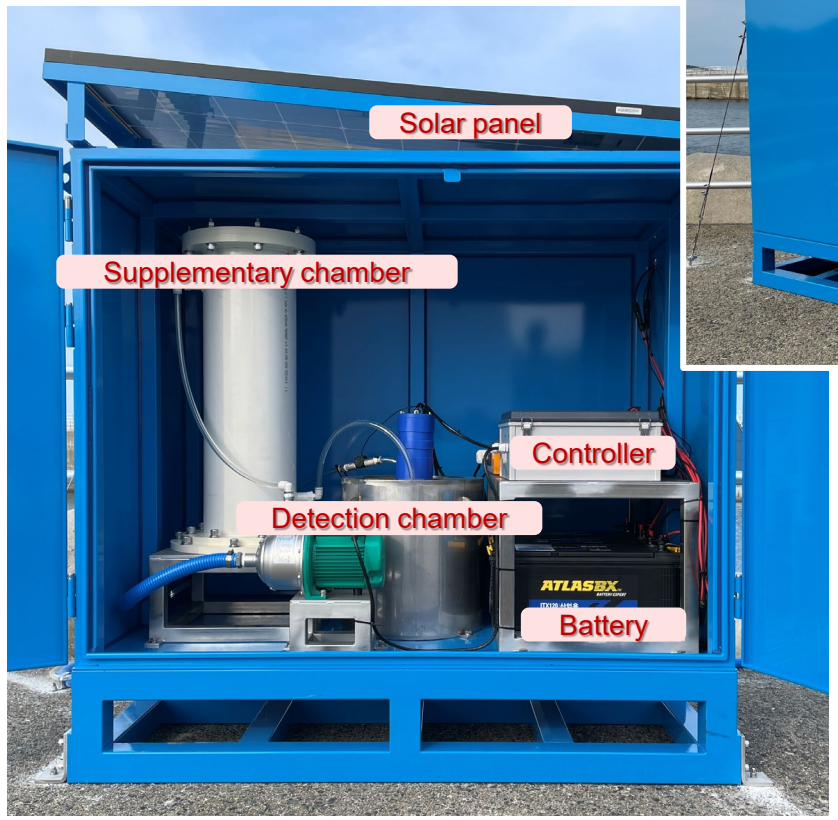
NaI(Tl) Based detection unit
20 L volume
Shielded by 30 mm lead

Power Supply Unit

Solar panel and rechargeable battery

Controller Unit

Data processing and storage
Telecommunication





Korean patent: 10-2425268

Thank You for Your Attention

Questions & Discussion

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