Fabrication and Performance Test of Scintillator Free-replaceable Type Detector for Comparison of Inorganic Scintillator Performance

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Introduction

- **Real time detection system: conceptually designed for monitoring beta- and gamma-ray in groundwater of decommissioning site.**
- **Necessities**
  - **Periodic groundwater monitoring at the site before/after the decommissioning of nuclear facilities.**
  - **Long-term groundwater radioactivity monitoring (especially, case of restrictive release after restoration of the decommissioning site.).**
- **Goals**
  - **Fabricate a scintillator free-replaceable type detector to select a scintillator to be used for gamma monitoring.**
  - **Confirm the possibility of utilizing the fabricated detector.**
- **This study**
  - **Performance evaluation experiment using a NaI(Tl) scintillator.**
  - **Analyze energy calibration, energy resolution and full energy peak efficiency of fabricated detector using a NaI(Tl) scintillator.**

Materials and Methods

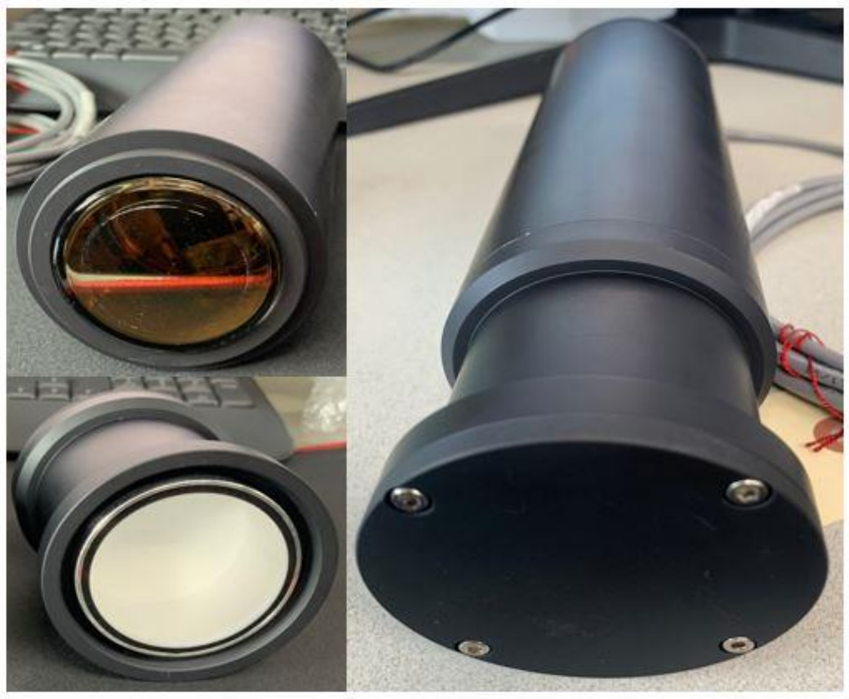

Fig. 1. Left: separated view of the detector. Right: combined view of the detector.

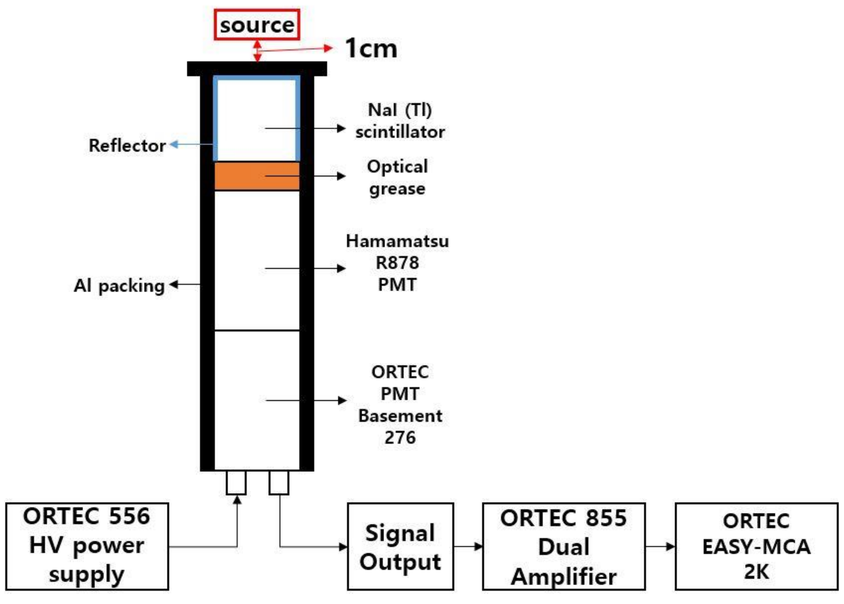

Fig. 2. Schematic diagram of the experimental setup and detection system.

- **Gamma-ray detected by using fabricated detector combined with a NaI(Tl) scintillator.**
  - **Source: calibrated gamma sources of ^{60}Co, ^{133}Ba, ^{137}Cs (12.9 kBq, 24.5 kBq, 159.3 kBq, Spectrum Techniques).**
  - **Detecting time: 30 minutes for each source.**
  - **NaI(Tl) scintillator: 2 X 2 inch cylindrical scintillator.**
  - **Free-replaceable: bolt-nut shape (PMT-scintillator).**
- **Checking: Energy calibration, energy resolution and full energy peak efficiency of the NaI(Tl) detector.**

Results and Discussions

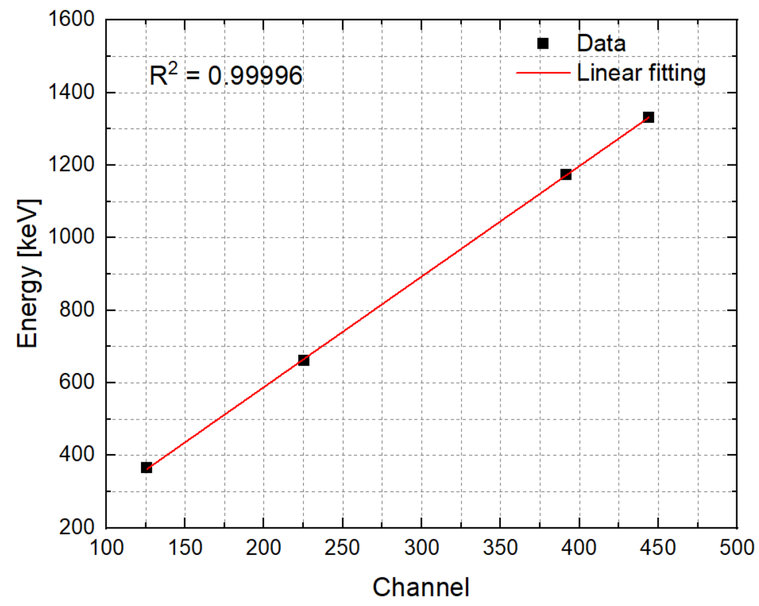

Fig. 3. Energy calibration of NaI(Tl) detector.

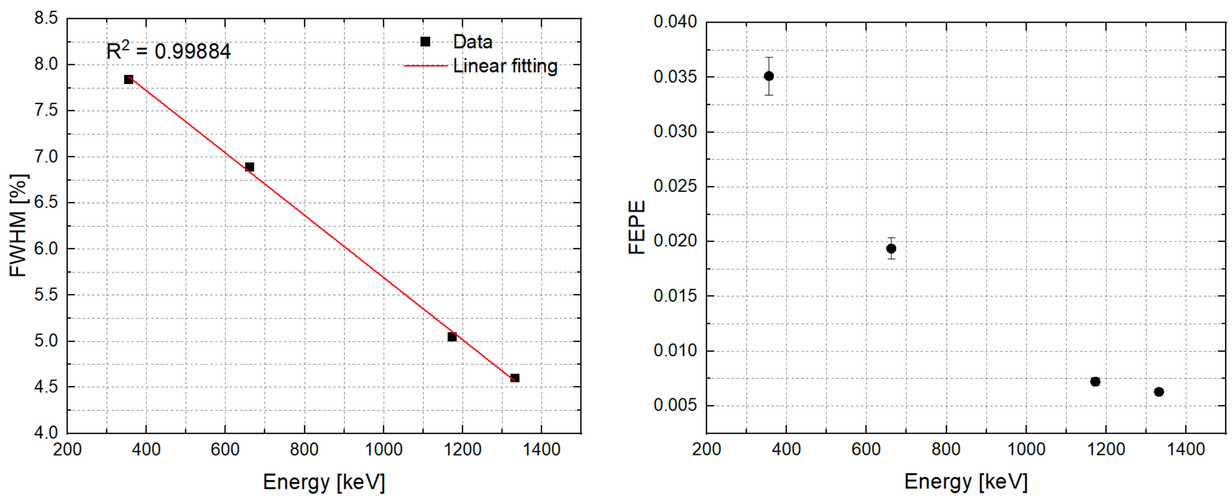

Fig. 4. Left: Energy resolution of NaI(Tl) detector.
Right: FEPE of NaI(Tl) detector.

- **Four peaks (1.170 and 1.330 MeV of ^{60}Co, 0.356 MeV of ^{133}Ba and 0.662 MeV of ^{137}Cs) were identified in the energy spectrum → Energy calibration based on Gaussian fitting (R^2 = 0.99996).**
- **Energy resolution of NaI(Tl) detector at 356, 662, 1130, 1170 keV were 7.7, 6.8, 5.1, 4.6%, respectively.**
- **Absolute full energy peak efficiency of NaI(Tl) detector at 356, 662, 1130, 1170 keV were 0.035, 0.019, 0.0072, 0.0063, respectively. → Detection efficiency formed a typical exponential decay function.**

Conclusion

- **Conclusion**
  - **Fabrication of scintillator free-replaceable type detector.**
  - **Performance test of the detector using a NaI(Tl) scintillator.**
  - **Energy calibration was performed using the obtained energy spectrum.**
  - **Energy resolution and FEPE of NaI(Tl) detector were derived.**
  - **Enough performance to compare other inorganic scintillators.**
- **Future study**
  - **Comparison experiments using other inorganic scintillators.**
  - **Choice of a scintillator which has high efficiency.**
  - **Experiment of real time gamma monitoring in groundwater.**