Testing the effect of packaging materials on activity measurement using 4πβ-γ coincidence counting

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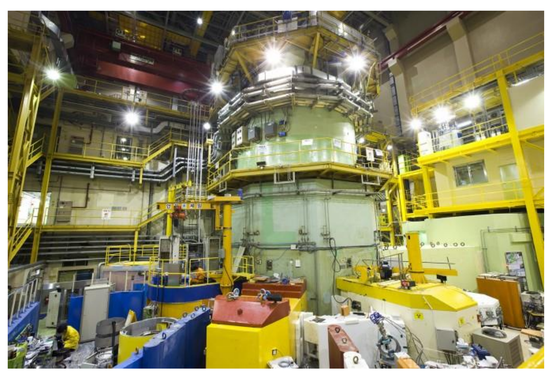
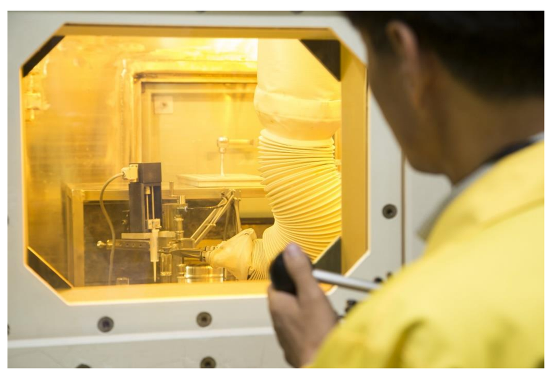
Introduction

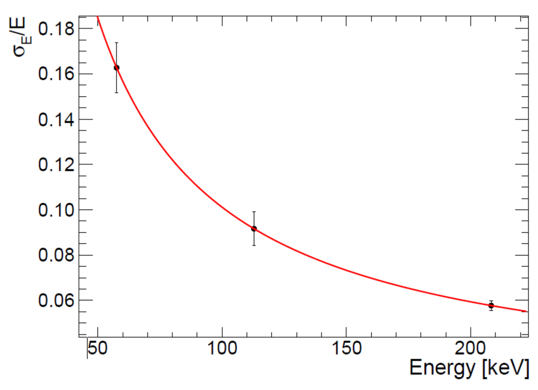
- Radioisotope (RI) production in HANARO (^{177}Lu, ^{166}Ho, ^{60}Co, etc.)
- β/γ spectra & radioactivity measurement for reactor-produced RI, in a narrow space (hot cell) → mini size activity measurement system

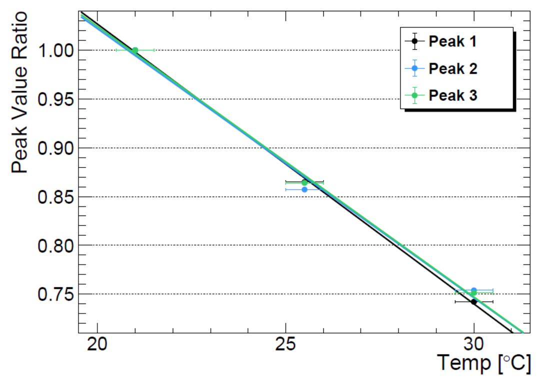

Research reactor HANARO


Hot cell at KAERI

Characteristic of the System

- Resolution of γ detectors: ~5% @ 662 keV
- Temperature dependence
  - 3% gain change for ±1 ℃ change
  - activity fluctuation: < 0.4% for ±1 ℃ change

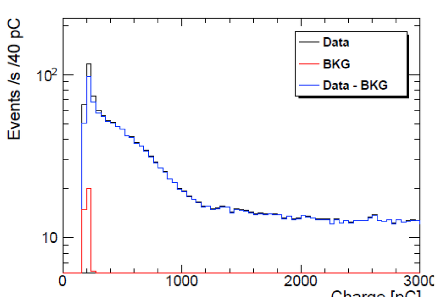

Resolution curve

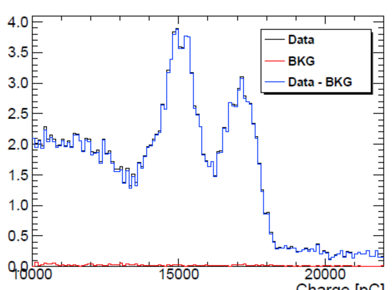

Gain - temperature

Position Dependence

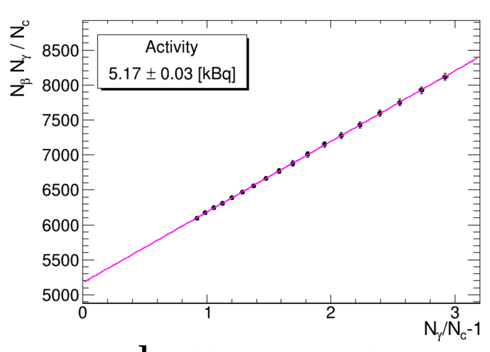
- Configuration for 4πβ-γ coincidence counting
  - radionuclide sample in aqueous solution
  - uniform distribution of radionuclide sample
- Solid-state radionuclide sample
  - cannot uniformly distributed
  → testing position dependence
- Testing position dependence using ^{60}Co wire
  - neutron irradiation to ^{59}Co wire in HANARO


^{60}Co wire

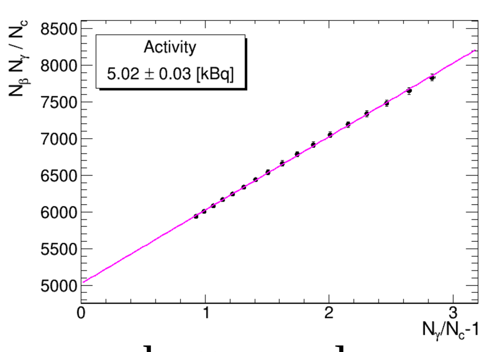

β spectrum


γ spectrum

- Position dependence for activity measurement
→ center ≥ edge, middle (max.) > bottom > top

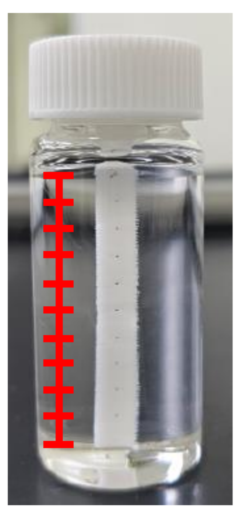


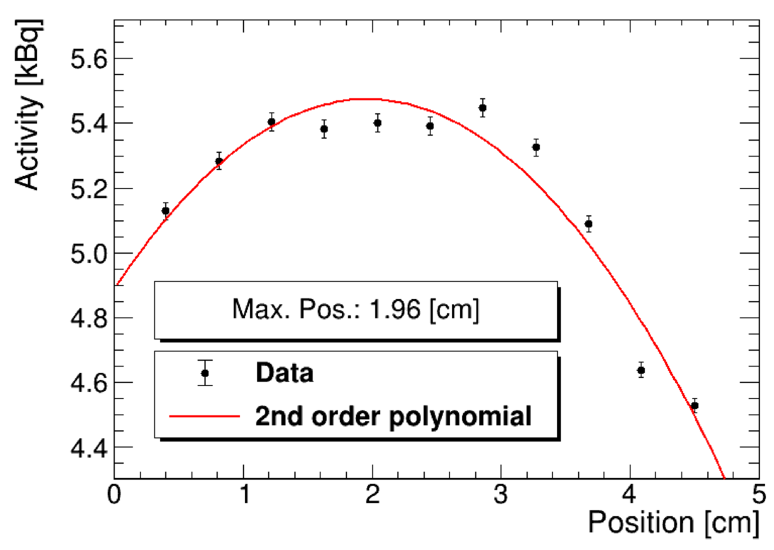
bottom center



bottom edge

- middle (max.) > bottom > top





4πβ-γ coincidence system

- Measurement of correlated β and γ from the radioactive decays of produced radioisotope
- Estimating absolute radioactivity of the radioisotope (Efficiency-extrapolation method)
- $\frac{N_\beta N_\gamma}{N_c} = N\left[1 + C\left(\frac{1-\varepsilon_{\beta m}}{\varepsilon_{\beta m}}\right)\right] = N\left[1 + C\left(\frac{1-N_c/N_\gamma}{N_c/N_\gamma}\right)\right]$

Activity Measurement System

- Developed in 2023 / activity measurements were validated using the reference materials
- Composition: detection part (β/γ detectors) + DAQ system
- Detecting material: Liquid scintillator (β, Ultima Gold AB), NaI crystal (γ, Saint-Gobain)
- SiPM array: scintillation light sensor
  (SiPM: Hamamatsu SP13360-1350PE, array production: Notice Korea)
- DAQ system: FADC (flash analog-to-digital converter) + server


The activity measurement system

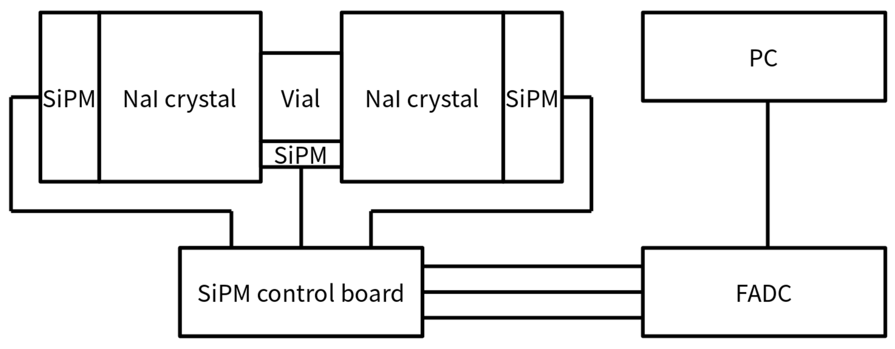
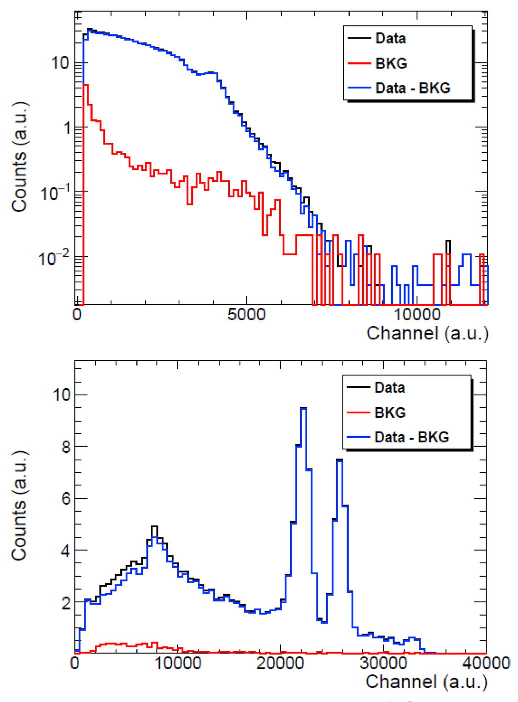
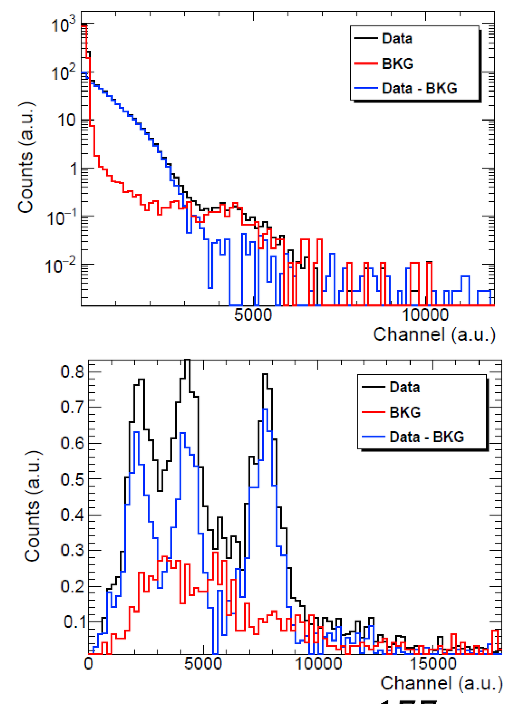


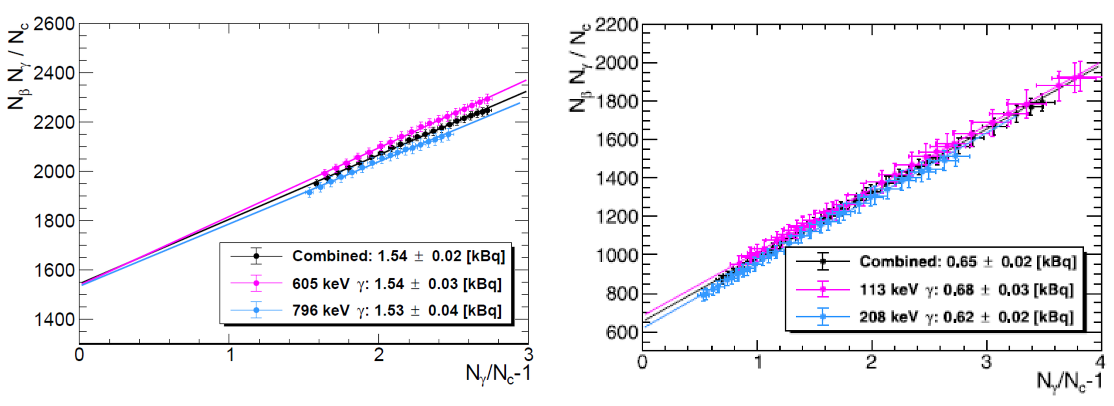
Diagram for the activity measurement system

Measurements using the system

- β/γ spectra & activity measurements for the reference materials ^{177}Lu & ^{134}Cs


β/γ spectra for ^{134}Cs


β/γ spectra for ^{177}Lu

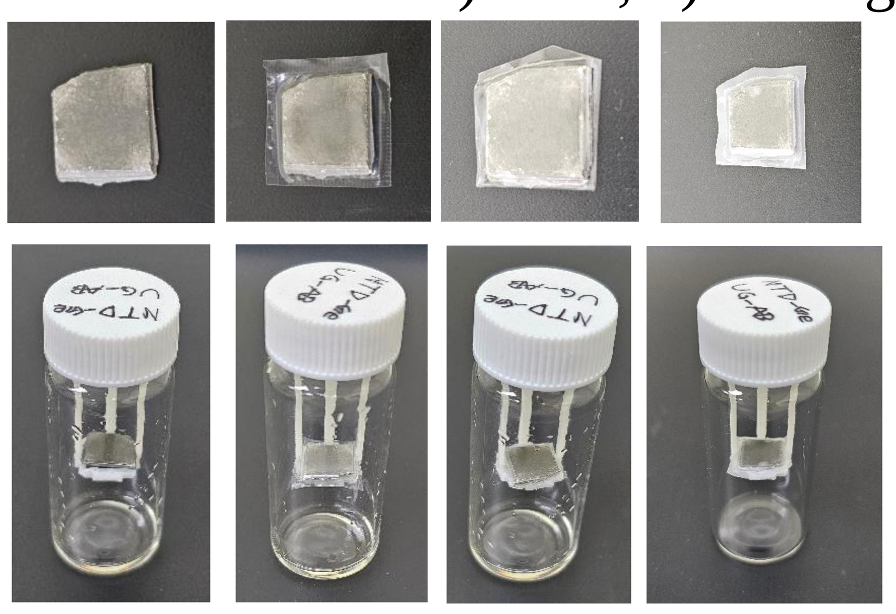


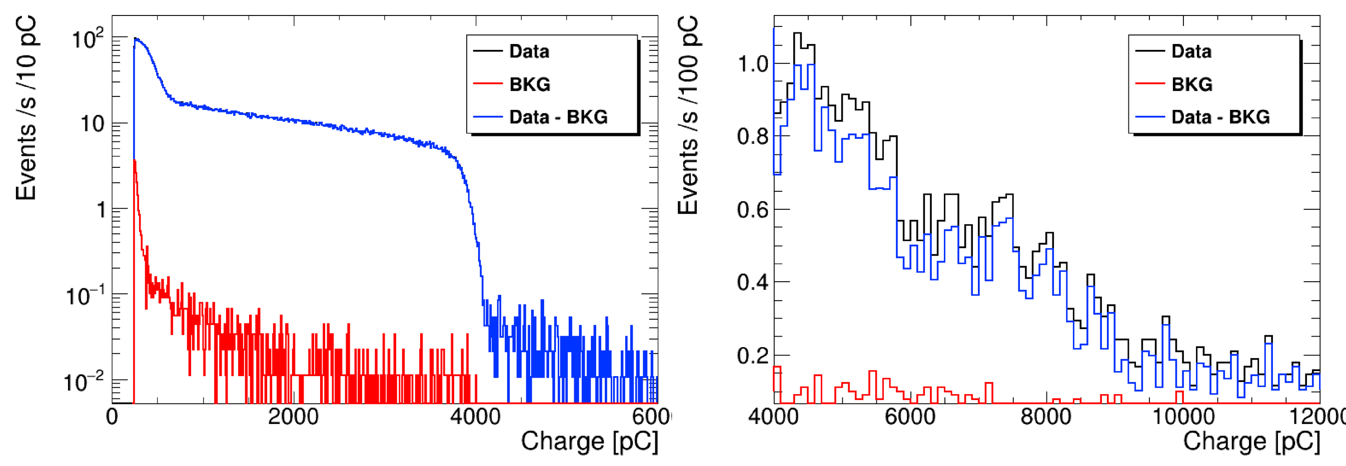
Nulcide	Activity	Reference	Differences
^{134}Cs	1.54 ± 0.03 [kBq]	1.58 ± 0.05 [kBq]	2.2%
^{177}Lu	0.654 ± 0.023 [kBq]	0.637 ± 0.008 [kBq]	2.6%

Activity measurements for ^{134}Cs (left) & ^{177}Lu (right)

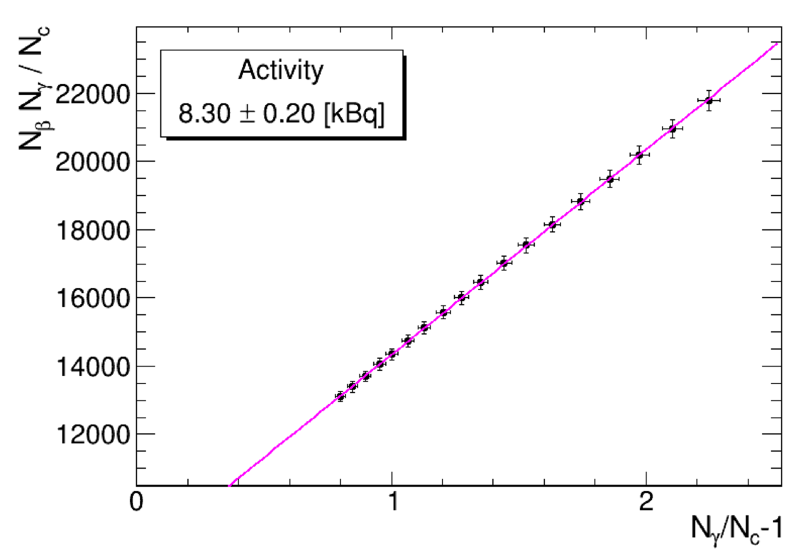
Testing the effect of packaging materials

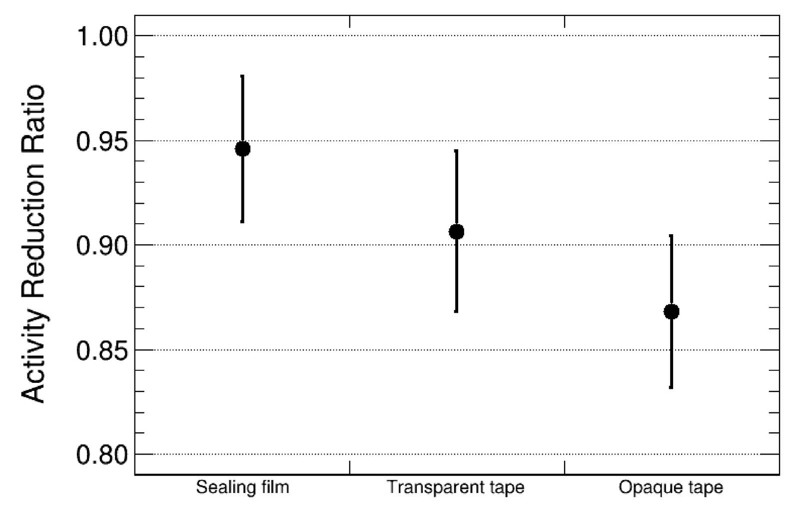
- Testing the effect of packaging materials for activity measurement
  → the material would be used for powdered samples
- Radioactive sample: NTD-Ge
- Tested material: 1) none, 2) sealing film, 3) transparent tape, 4) opaque tape


1) 2) 3) 4)


β (right) and γ (left) spectra for NTD-Ge sample

- Comparing measured activity values w/ packaging materials
  → None > sealing film > transparent tape > opaque tape
  → Activity reduction effect when packaging material is used.





- Study plans
- stability of activity reduction ratio for the same packaging material
- searching other methods for measuring activity of powdered sample