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1. Objective of This Study

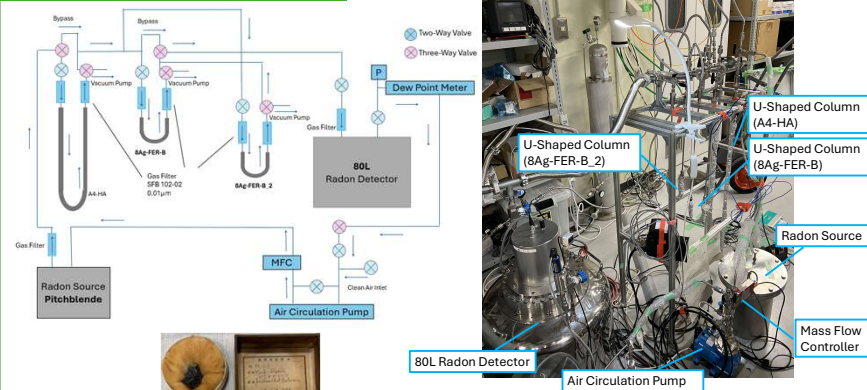
- In underground experiments, Rn-222 (radon), a naturally occurring radioactive noble gas, is a significant source of background events.
 - Super-Kamiokande employs activated carbon for radon adsorption and removal.
- ⇒ As a candidate for a more compact radon removal system in Hyper-Kamiokande, **silver-exchanged zeolite (8Ag-FER-B)** is being investigated as an alternative adsorbent.

- It was found that the Tosoh ferrierite (FER), the raw material used for the conventional 8Ag-FER-B, contained 0.5–1.0% potassium (K) ions.
- In dark matter search experiments and neutrinoless double-beta decay experiments, the naturally occurring radioactive isotope K-40 can be a source of background events.

Since 2026, a new 8Ag-FER-B has been produced using ferrierite containing negligible amounts of K ions (hereafter referred to as 8Ag-FER-B_2).

⇒ **Comparison of the radon adsorption performance between 8Ag-FER-B and 8Ag-FER-B_2.**

3. Experimental Setup



Pitchblende
A uranium-rich mineral containing uranium oxides.
Used as a natural radon source in this study.

- Pitchblende** was used as a radon source.
- A4-HA** zeolite was used for dehumidification.
- Radon concentration downstream of a silver-exchanged zeolite column was measured using a radon detector.

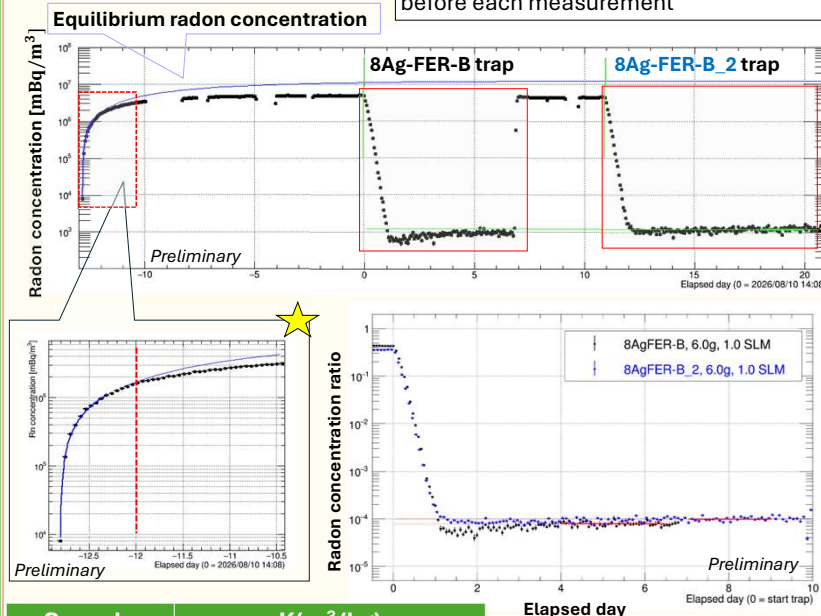
6. Comparison of the Radon Adsorption Performance of Two Types of 8Ag-FER-B

Silver-Exchanged Zeolite Samples

- 8Ag-FER-B**
- 8Ag-FER-B_2**

Measurement Conditions

- Mass of silver-exchanged zeolite: **6.0 g**
- Flow rate: **0.9–1.0 L/min**
- Column evacuation and baking at 300°C** before each measurement



Sample	K(m³/kg) Preliminary
8Ag-FER-B	$(1.27 \pm 0.02) \times 10^4$
8Ag-FER-B_2	$(1.01 \pm 0.02) \times 10^4$

2. Silver-exchanged zeolite

Recent studies have reported that silver-exchanged zeolites exhibit exceptionally high radon adsorption performance.

8Ag-FER-B

$m: 20 \times 10^{-3} \text{ kg}$
 $RT: 30.12 \pm 0.05 \text{ day}$
 $K: 6506 \pm 81 \text{ m}^3/\text{kg}$

4. Evaluation of K

$$K = (F \times RT) / m$$

K : Radon adsorption coefficient [m^3/kg] F : Gas flow rate [m^3/day]
 RT : Radon retention time in the U-shaped column [day]
 m : Mass of adsorbent [kg]

$$\text{Radon concentration ratio} = T / (RT + T) = 0.080 / (F \times RT + 0.080)$$

T : Radon residence time in the radon detector [day]

$$\Rightarrow K = \left(\frac{1}{\text{Radon concentration ratio}} - 1 \right) \cdot \frac{F \times T}{m}$$

Radon concentration ratio
= Radon concentration after passing through the column
= Equilibrium radon concentration in bypass mode

5. Fitting Function

Equilibrium Radon Concentration

$$= A \times \left(1 - 2^{-\frac{x-T_0}{\tau_{1/2}(\text{Rn-222})}} \right) \times \left(1 - 2^{-\frac{x-T_0}{\tau_{1/2}(\text{Po-218})}} \right) \times \left(1 - 2^{-\frac{x-T_0}{\tau_{1/2}(\text{Pb-214})}} \right) \times \left(1 - 2^{-\frac{x-T_0}{\tau_{1/2}(\text{Bi-214})}} \right) + B$$

A : Equilibrium radon concentration

B : Background

T_0 : Start time of radioactive equilibrium

x : Elapsed time (day)

$\tau_{1/2}(\text{Rn-222})$: Half-life of 222Rn (3.8235 days)

$\tau_{1/2}(\text{Po-218})$: Half-life of 218Po (3.1 min)

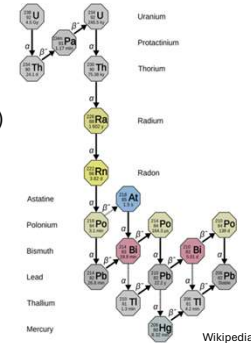
$\tau_{1/2}(\text{Pb-214})$: Half-life of 214Pb (26.8 min)

$\tau_{1/2}(\text{Bi-214})$: Half-life of 214Bi (19.9 min)

• **Fit A, B, and T_0**

⇒ **Equilibrium radon concentration:**

$$(A + B) \pm \sqrt{(\sigma_A^2 + \sigma_B^2)}$$



7. Discussion

- The measured values are consistent with the radioactive-equilibrium curve before Elapsed day = -12. After that point, the measured values fall below the fit, suggesting possible **counting losses due to DAQ limitations**. ★
 - The equilibrium radon concentration for 8Ag-FER-B_2 was estimated using an extension of the 8Ag-FER-B equilibrium fit rather than an independent fit.
- ⇒ Counting losses and the method used to determine the equilibrium radon concentration may have affected the evaluation of the radon concentration ratio and the adsorption coefficient K.

8. Future Work

- Upgrade the DAQ computer system (Intel Atom N450 → Intel Core i7-14700)
- ⇒ **Mitigate counting losses caused by DAQ processing limitations.**
- Further investigate the noble-gas adsorption mechanism of silver-exchanged zeolites.
- ⇒ **Evaluate the radon adsorption performance of various silver-exchanged zeolites in argon gas.**