# シンチレーター原料の高純度化
## ～NaI(Tl)の高純度化を例にして～

K.Fushimi

# Summary

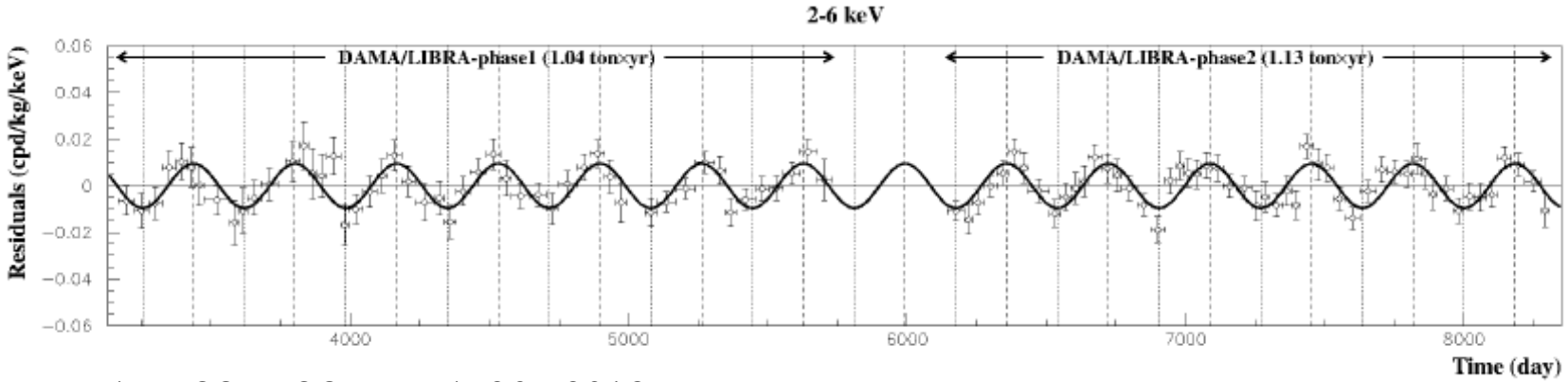
- Highly radiopure and large volume NaI(Tl)
  - 12.7 cm diameter X 12.7 cm height.
  - 9 modules was funded in 2019.
  - $^{40}$K has been removed successfully!
  - Still high BG by $^{210}$Pb (2019 March).
  - Pb reduction is testing.
- Annual modulating signal
  - Verify DAMA/LIBRA and COSINE by NaI(Tl) with higher sensitivity.

# Status of NaI(Tl) purification (~April 2019)

| RI | Ingot26 (2015) | Ingot37 (2016) | Ingot71 (2018) | Ingot76 (2019) | Goal |
|---|---|---|---|---|---|
| Size | 3”ϕX3” | 4”ϕX3# | 3”ϕX3” | 5”ϕX4”(*) | 5”ϕX5” |
| $^{40}$K (ppb) | 2630 | 120 | <20 | <20 | <20 |
| $^{232}$Th (ppt) | 0.4 ± 0.5 | 3.7 ± 0.5 | 1.7 ± 0.2 | -- | <4 |
| $^{238}$U (ppt) | 4.7 ± 0.3 | 5.9 ± 0.3 | 9.7 ± 0.8 | 4.4 ± 0.2 | <10 |
| $^{210}$Pb (μBq/kg) | 30 ± 7 | 2300 | 1076 | ~1000 | <50 |
| Method | Resin for Pb | I26+cation resin | double re-crystallization | Pb resin + double re-crystallization | |

# 1. Why NaI(Tl) ?

DAMA/LIBRA-phase1+DAMA/LIBRA-phase2 (2.17 ton × yr)




R.Bernabei, CSLNGS, March 26, 2018

$A\cos[\omega(t-t_0)]$ ;
continuous lines: $t_0$ = 152.5 d, T = 1.00 y

**2-6 keV**

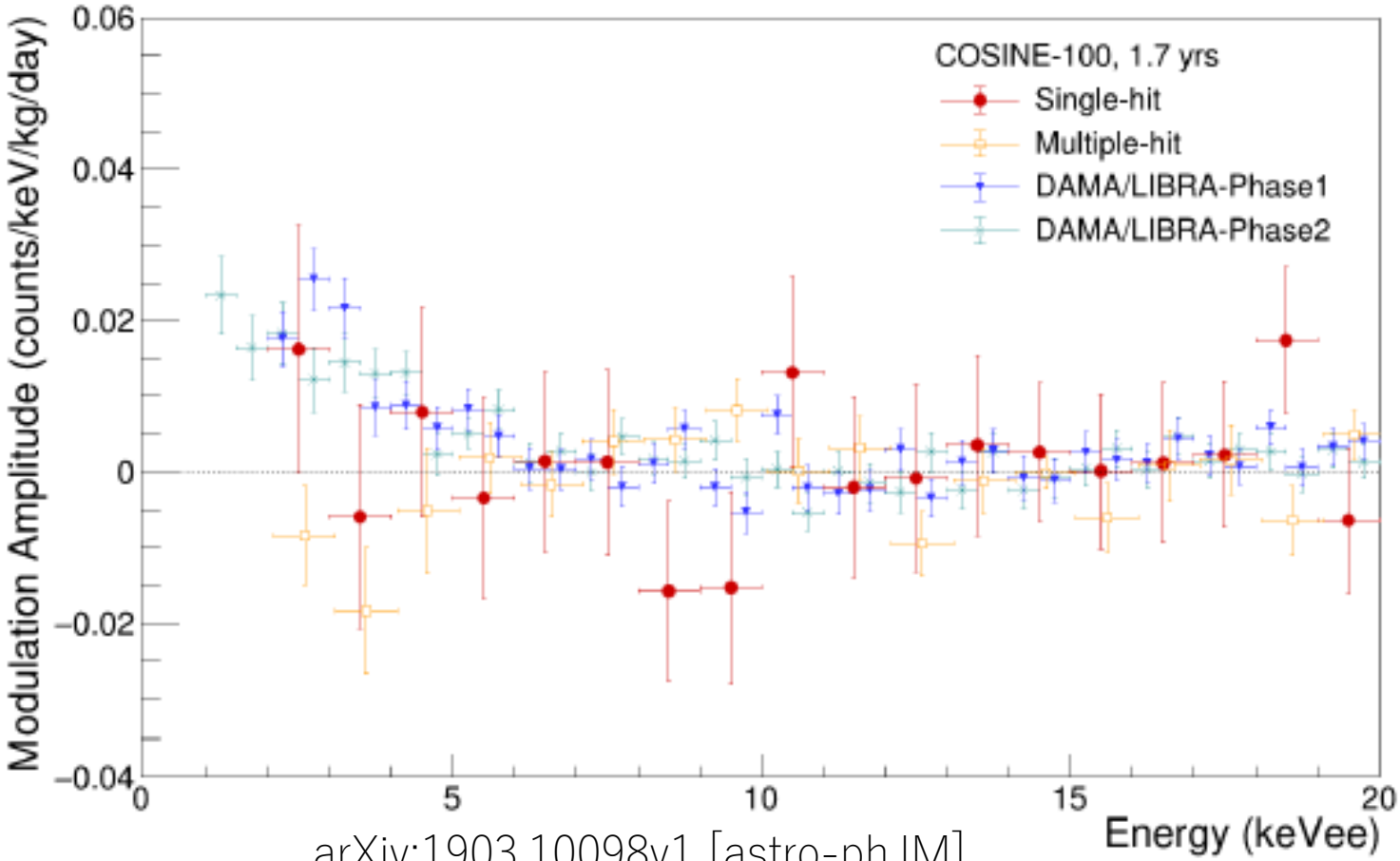
A=(0.0095±0.0008) cpd/kg/keV

$\chi^2$/dof = 71.8/101 **11.9σ C.L.**

- Only NaI(Tl) scintillator gives significant signal.

# 1. Recently.... COSINE-100

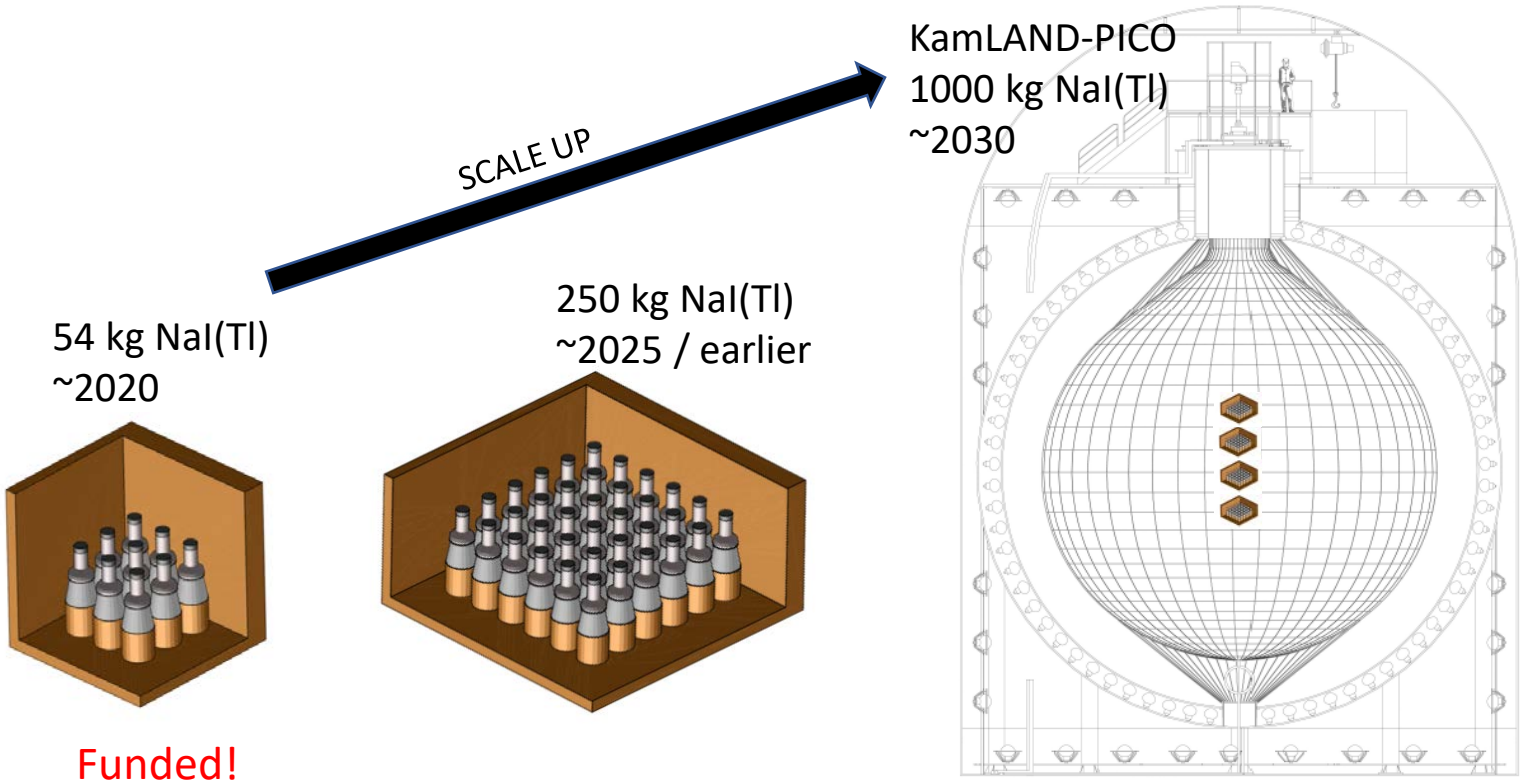
- BG = 2.7 /day/keV/kg @ 2-6 keVee
- Amplitude = $0.0092 \pm 0.0067$ /day/keV/kg
- Less statistic accuracy.




arXiv:1903.10098v1 [astro-ph.IM]

# PICOLON Project

- Pure Inorganic Crystal Observatory for LOw-energy Neutr(al)ino
  BG level ~ 1 /day/keV/kg at 1 $keV_{ee}$
  Total mass 56 kg → 250 kg → 1 ton



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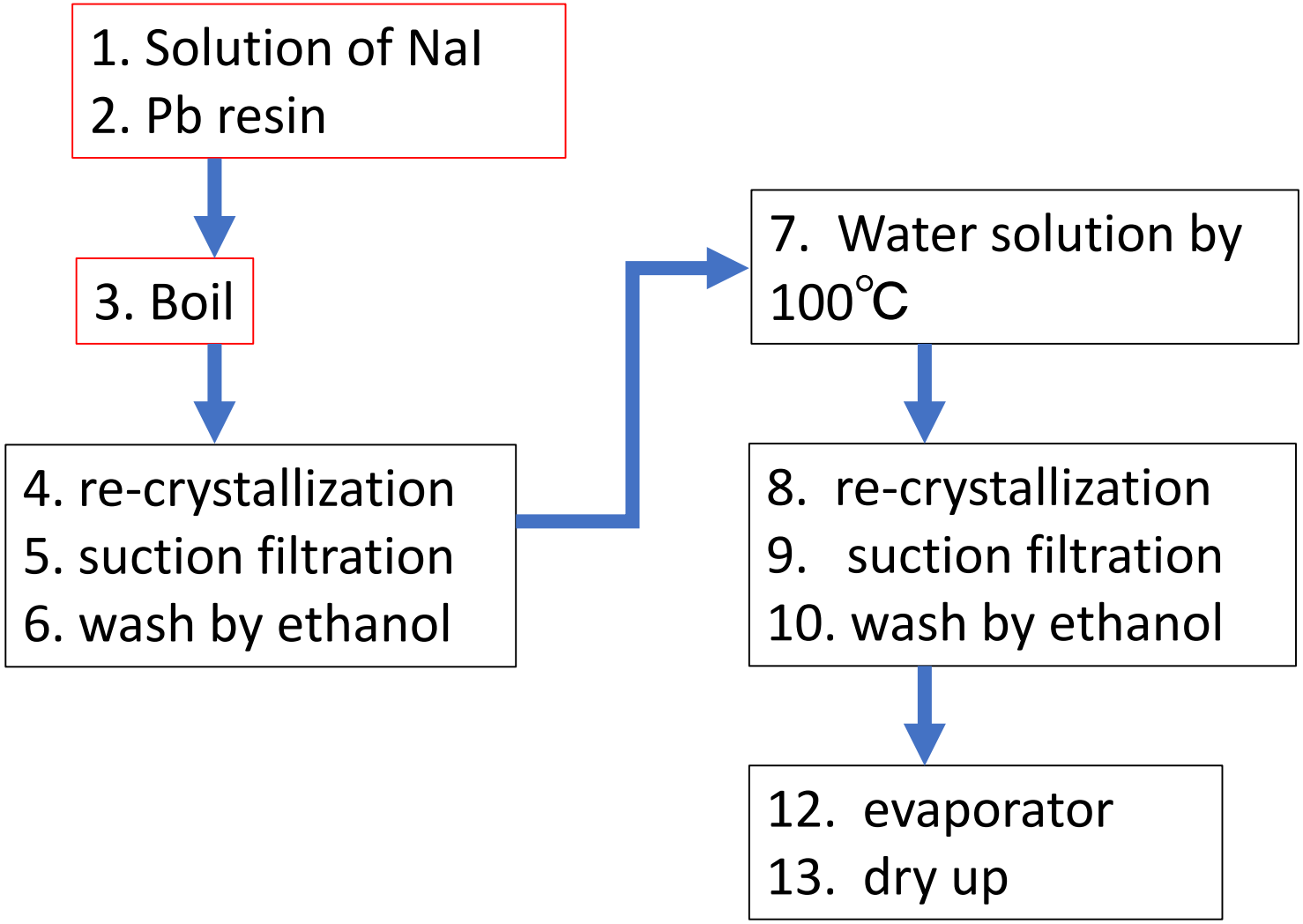
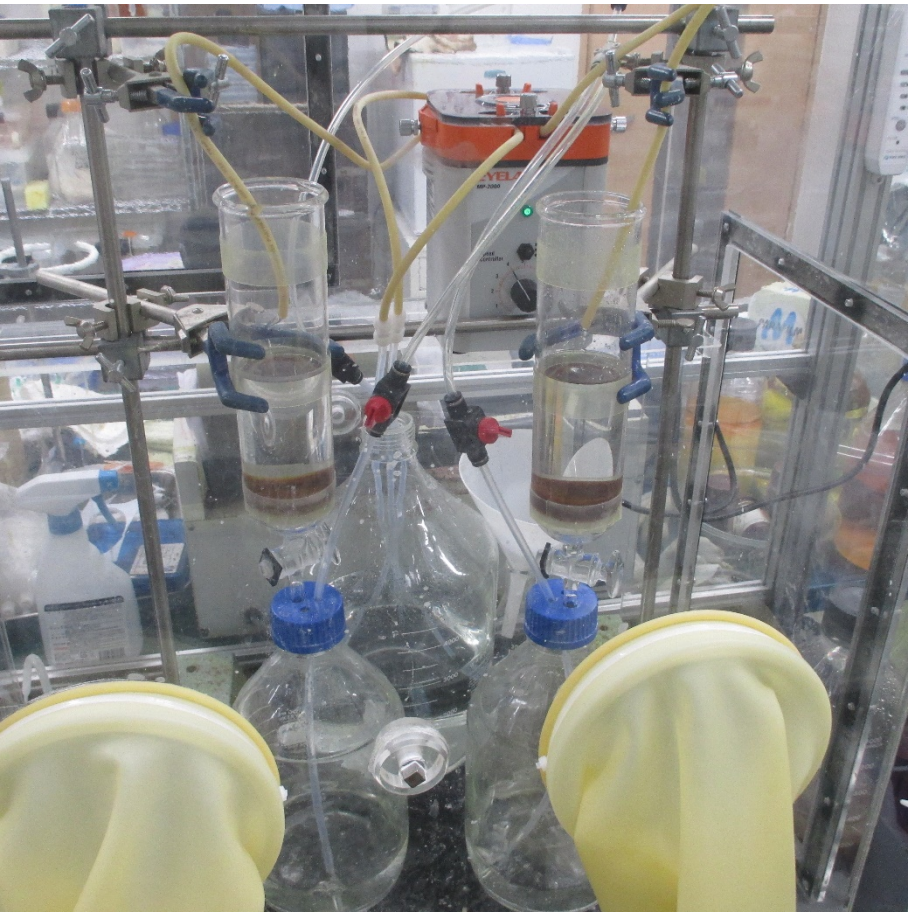
# Recent Ingot, #76

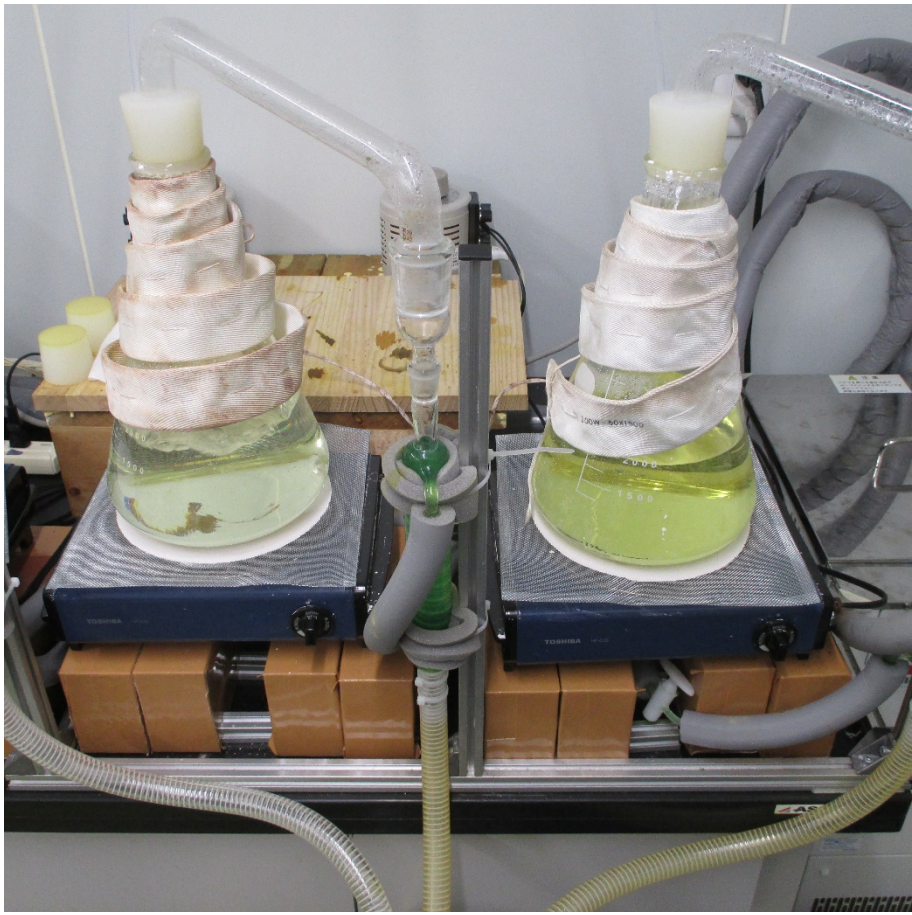
- Pb reduction resin + double re-crystallization



# Purification process



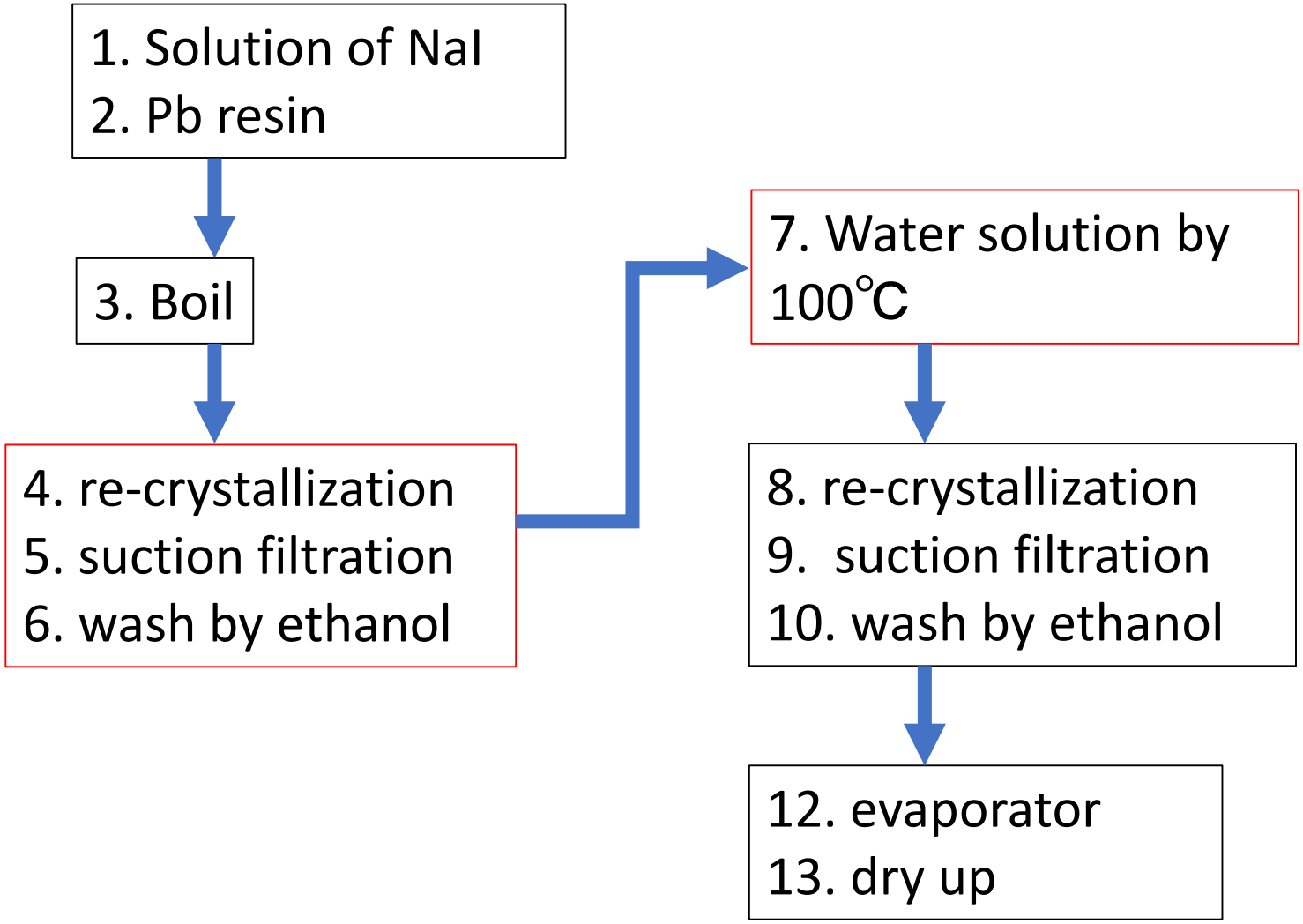
Remove Pb ion by resin.



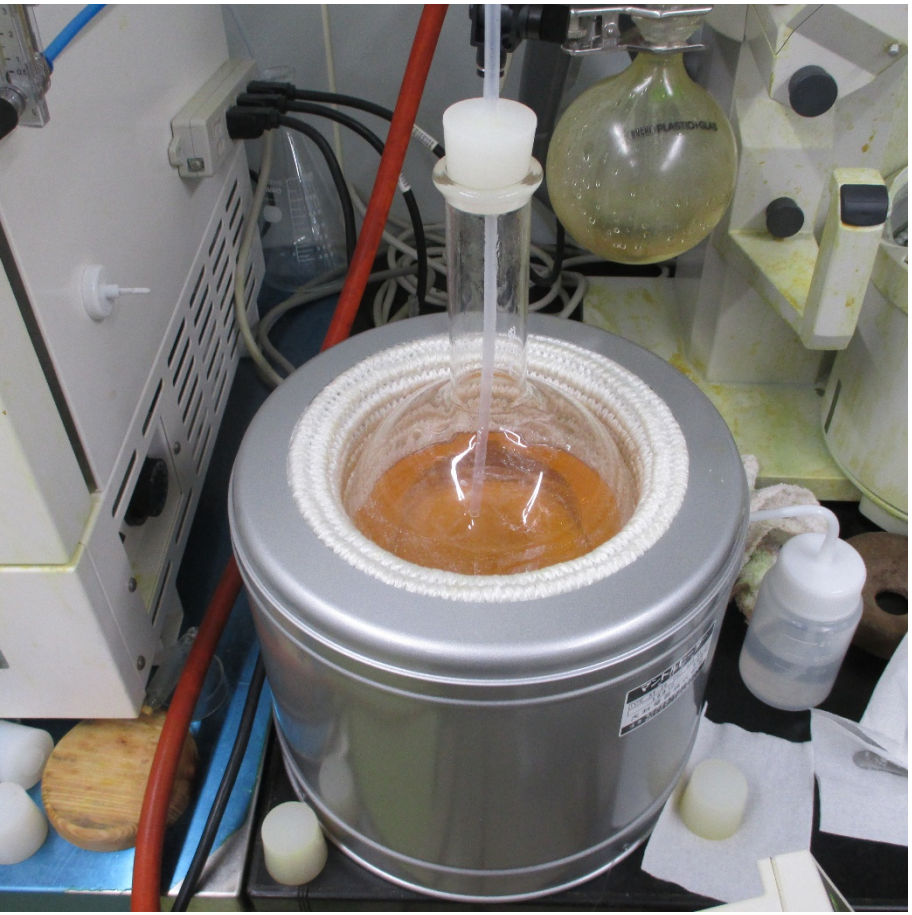
Boil to remove water.

# Recent Ingot, #76

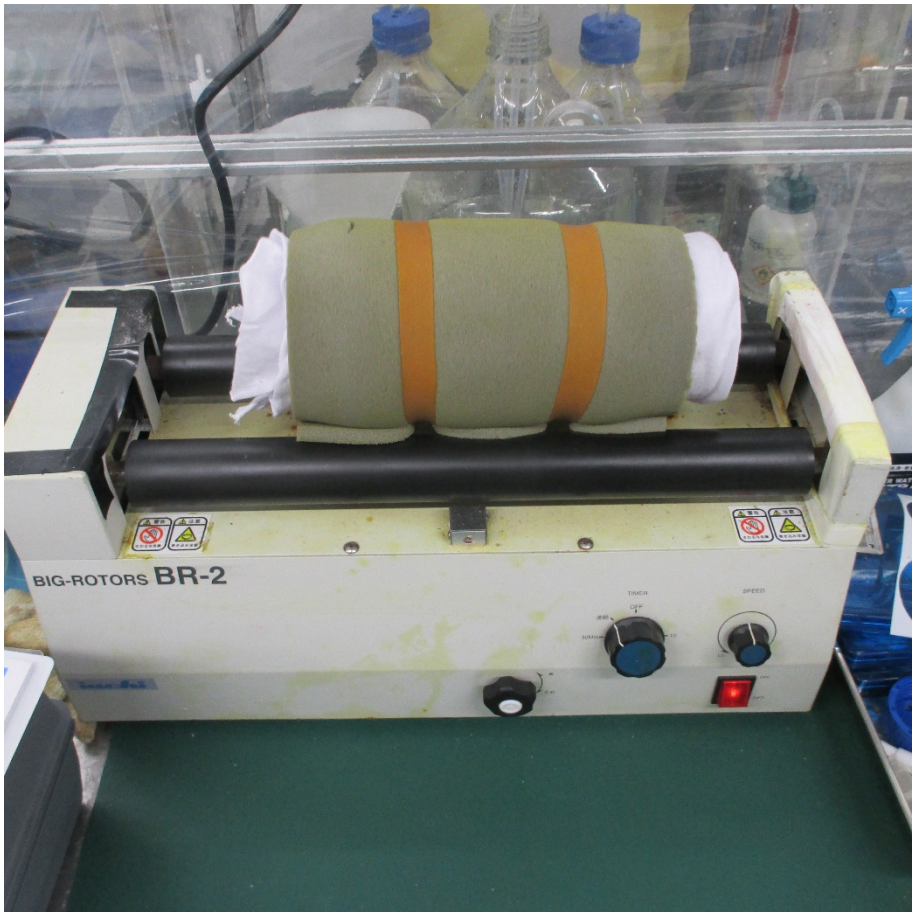
- Pb reduction resin + double re-crystallization



# Purification process



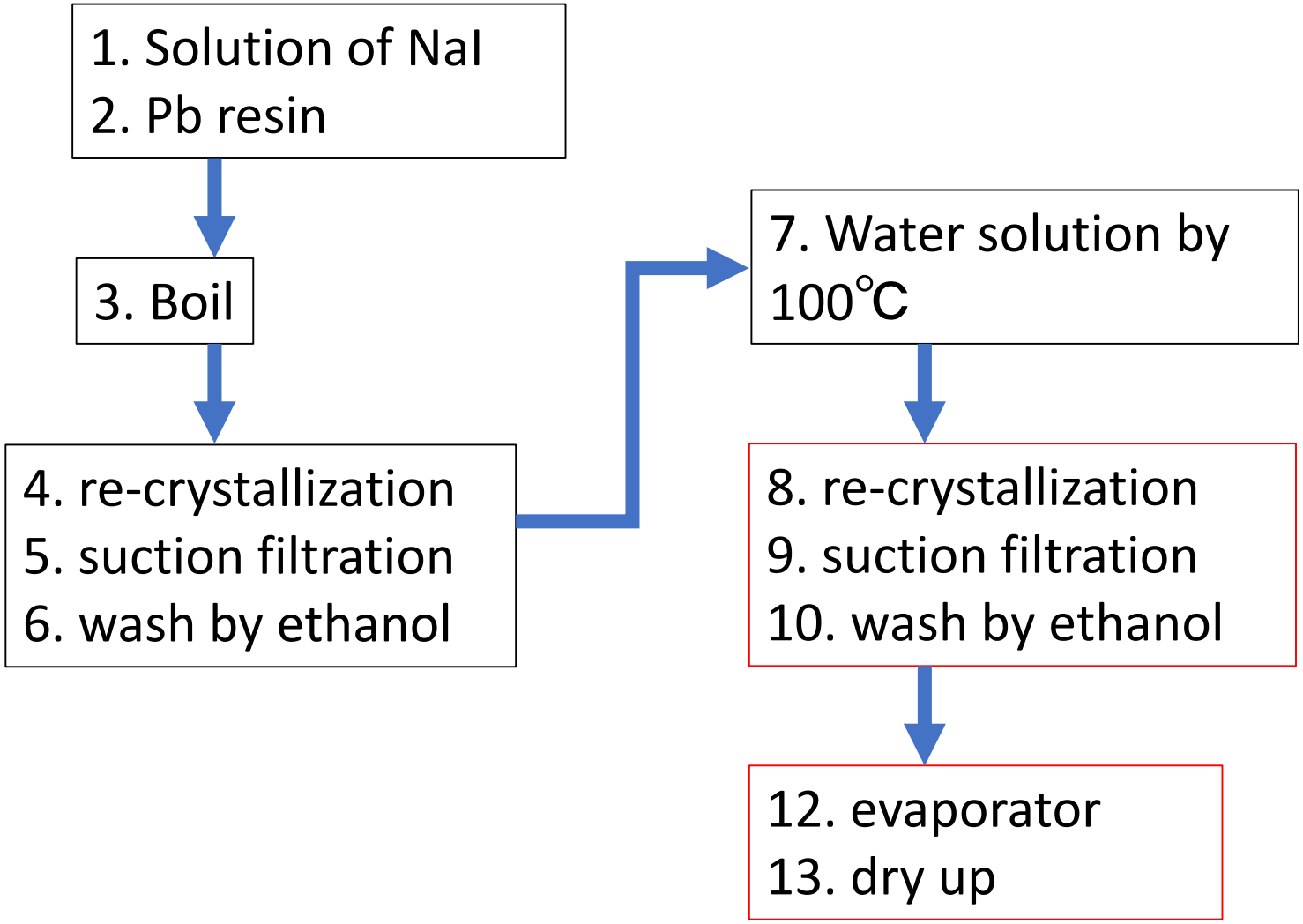
Saturated water solution of NaI @ 100 ℃




Recrystallization by cooling slowly.

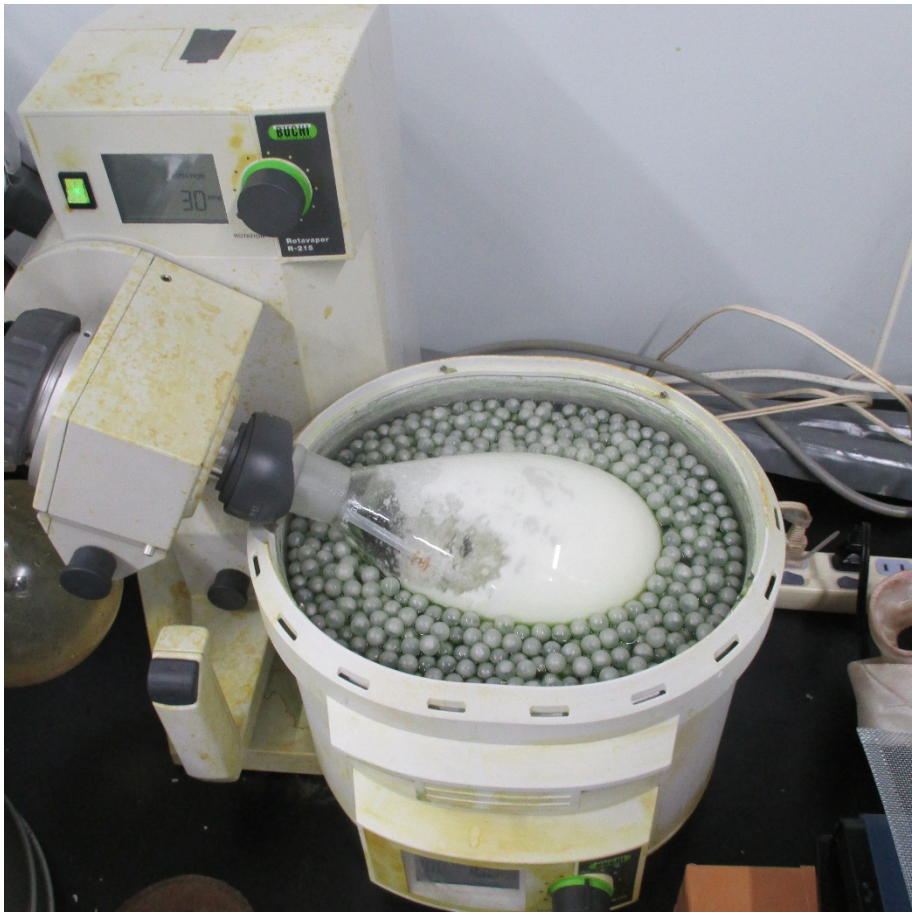
# Recent Ingot, #76

- Pb reduction resin + double re-crystallization



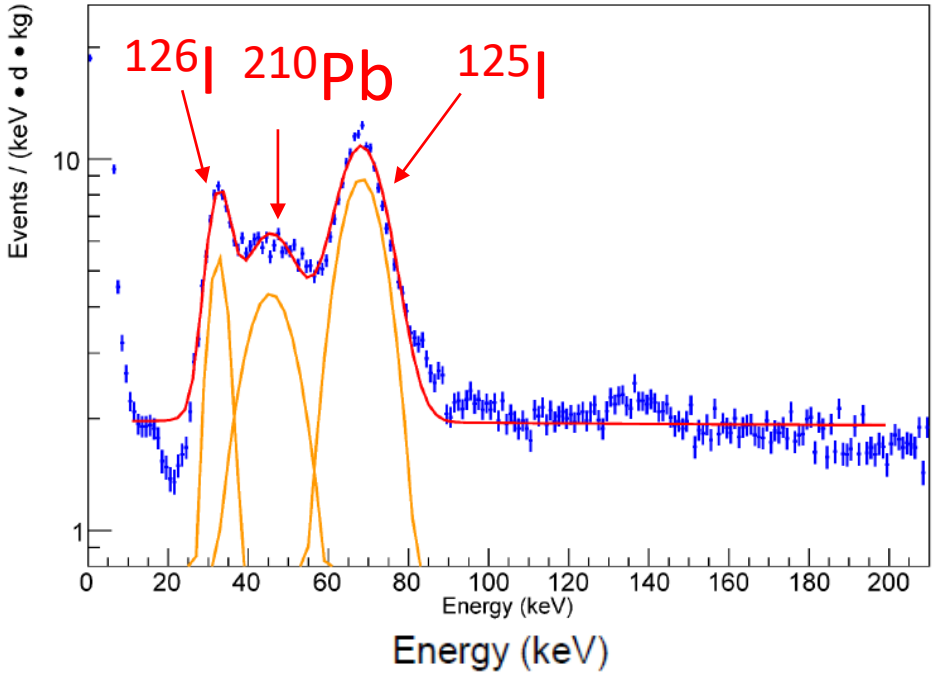
# Purification

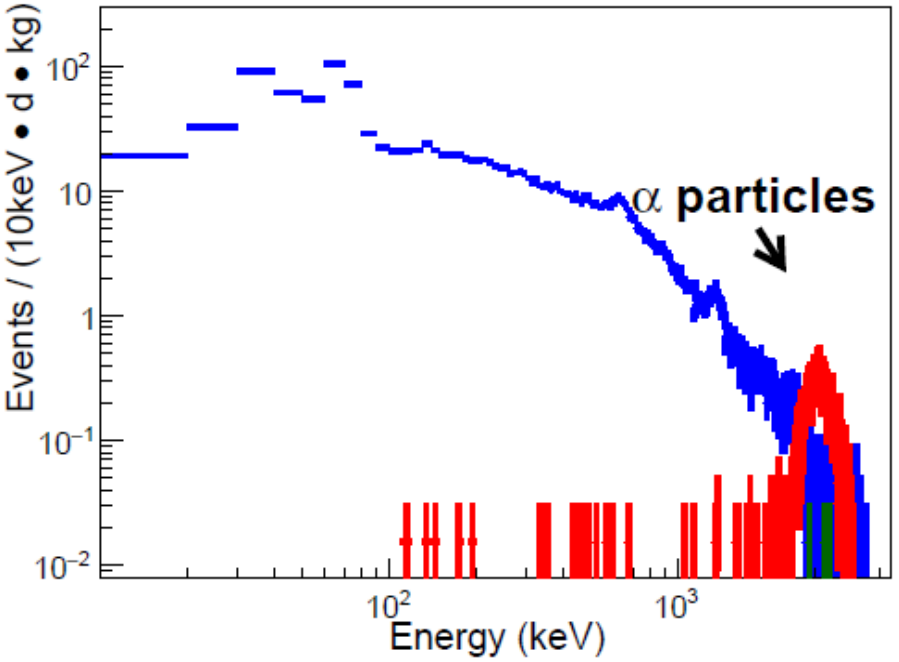

Filtration




Dry up by evaporator.

# BG status of Ingot #76




Still high BG of alpha rays.

~1000 μBq/kg (from $^{210}$Pb γ)

# Possible origins of $^{210}$Pb in NaI(Tl)

| | |
|---|---|
| Insufficient resin? | • Ingot 26 successfully worked.<br>• Verified by $PbI_2$ solution. (Now going on.) |
| Water ? | • Water used re-crystallization is polluted by $^{222}$Rn?<br>• Measurement is done today... |
| Dry-up process? | • Emanation from inner wall of oven?<br>• Oven is continuously evacuated. |
| Crucible? | • NaI crystal and crucible does not interact. |

# Prospects

$^{210}$Pb is the last problem.

- Reduction method is now testing.
- Goal of the purity is approaching.

DM search will be started.

- 5inchX5inch NaI(Tl)
- 9 modules (56 kg total in 2020)