令和2年共同利用発表会

ICP質量分析器を用いた，スーパーカミオカンデ等，地下実験のための極微量放射性不純物元素の測定

- 研究組織：
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- 採択額：
  - 物件費　88,000円，旅費 300,000円，総額388,000円
    - 研究支援ありがとうございました.

Contents

- Introduction / reminder
- Methods and result
- Plan
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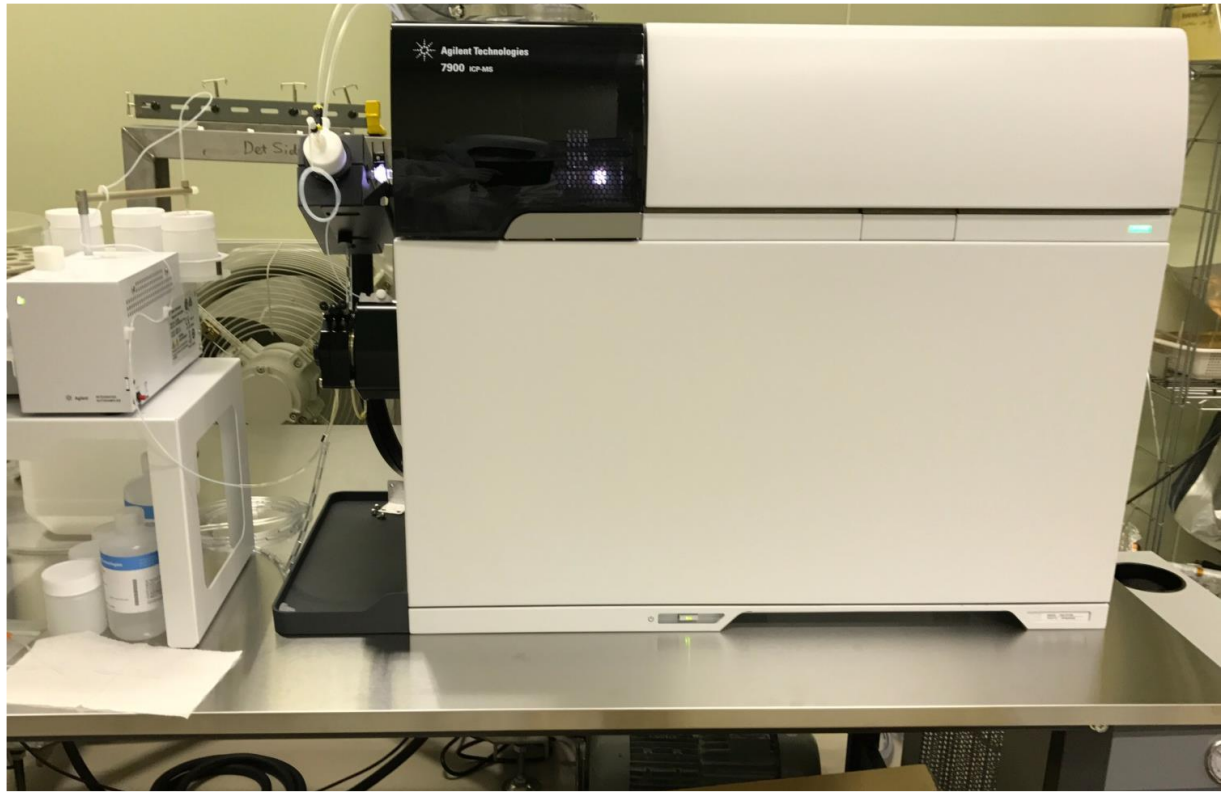
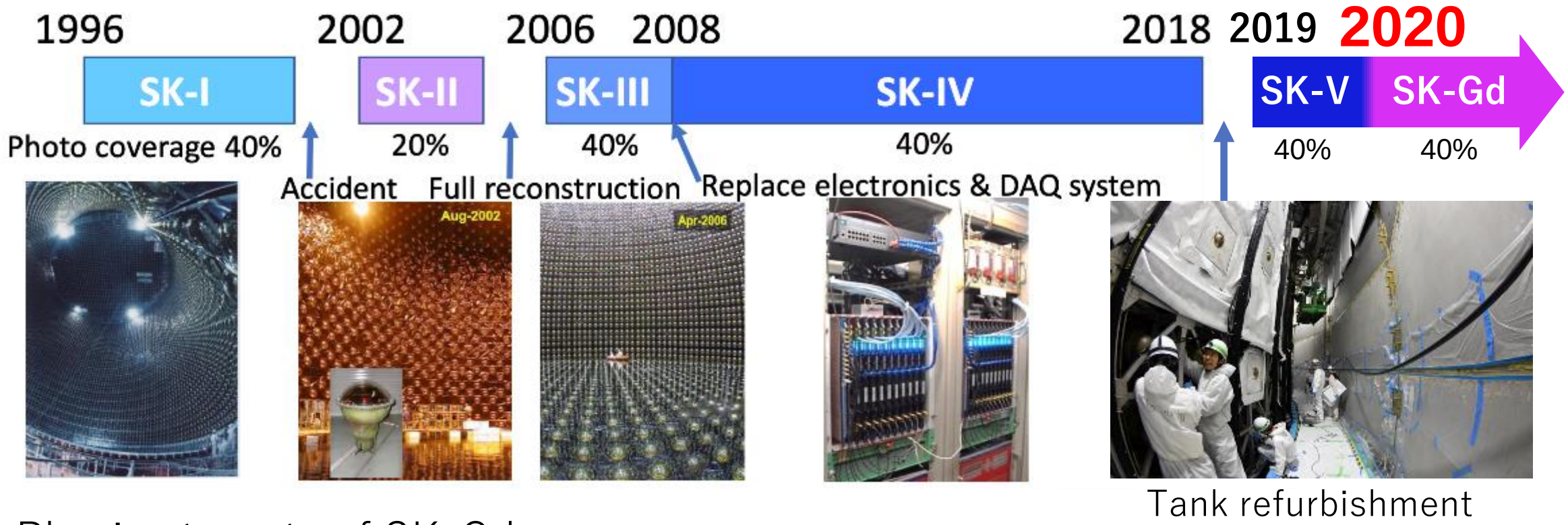
Kamioka ICPMS



Super-Kamiokande Gd project just started



Physics targets of SK-Gd:

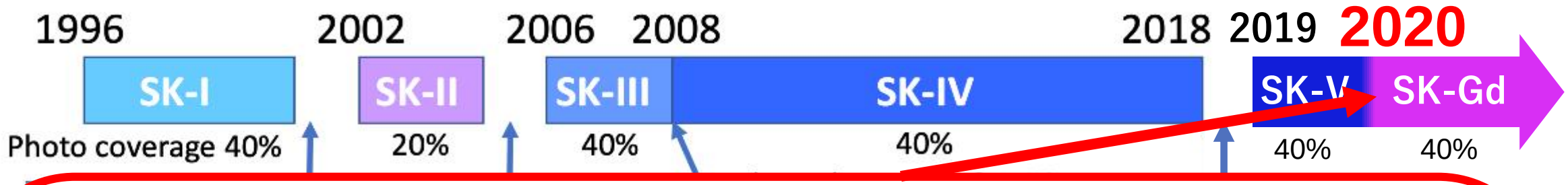
(1) Discovery of Supernova relic neutrino (SRN)

(2) Galactic supernovae (pointing accuracy, and Si-burning ν)

(3) Reduction of BG for proton decay, solar ν , or reactor ν

(4) Neutrino/anti-neutrino discrimination

Super-Kamiokande Gd project just started



13 ton of $Gd_2(SO_4)_3 \cdot 8H_2O$
(hereafter : Gd sulfate powder)

First Gd loading (0.01 % Gd concentration) to SK in last summer!

Cf. H.Ito san's talk in this morning.

Requirements of RI in Gd powder

Requirement for each isotope (0.1% Gd concentration =final goal)

Isotope	SRN	Solar
^{238}U	< 5	-
^{226}Ra	-	< 0.5
^{232}Th	-	< 0.05
^{228}Ra	-	< 0.05
^{228}Th	-	< 0.05
^{235}U	-	< 3
^{227}Ac/Th	-	< 3

Unit：mBq/kg(Gd sulfate powder)

← γ and neutrons from S.F.

←^{214}Bi : β（Q=3.27MeV）

^{208}Tl : γ（=2.6MeV）

neutrons from decay chain
< solar ν BG level.

U < 400 ppt
Th < 13 ppt

We set requirements so that these will be less than current BG levels in Super-K

Reminder: Trace measurement of U,Th by ICP-MS

- ICP-MS@Kamioka
  - Agilent 7900
  - Sensitivity for U,Th ; ppq level
- U,Th in Gd sulfate powder
  - Matrix effect* by Gd reduces the sensitivity for U and Th.
- Need to separate Gd and U,Th

ICP-MS in Kamioka Clean room

*Matrix effect: Introduction of high concentration material (in our case Gd) results in the absorption of the plasma energy, and the efficiency to ionize the target atoms (U/Th) gets reduced.

Evaluation of super-low level U/Th

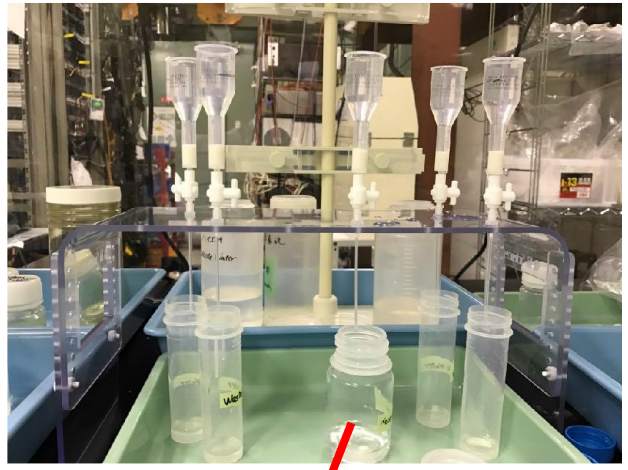
S. Ito san , Ichimura san , and Takaku san

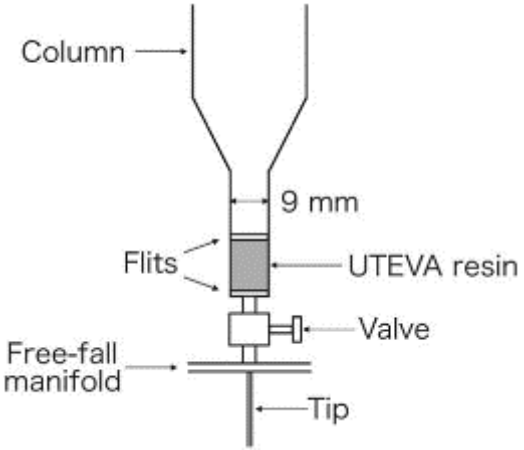
- We have developped a method to measure super-low level U/Th in Gd powder
- Requiements:

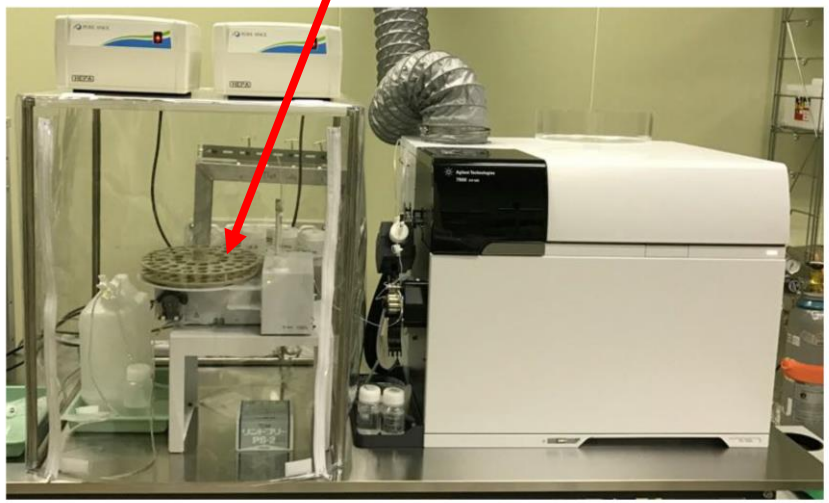
  $^{238}U < 400ppb$ (5mBq/kg),

  $^{232}Th < 12ppt$ (0.05mBq/kg)

  - Separation and extraction of U/Th from Gd solution using resin
    - To remove matrix effect of Gd
    - S.Ito et al. PTEP 2017 113H01







Auto-sampler is covered by clean booth.→**Class 100**

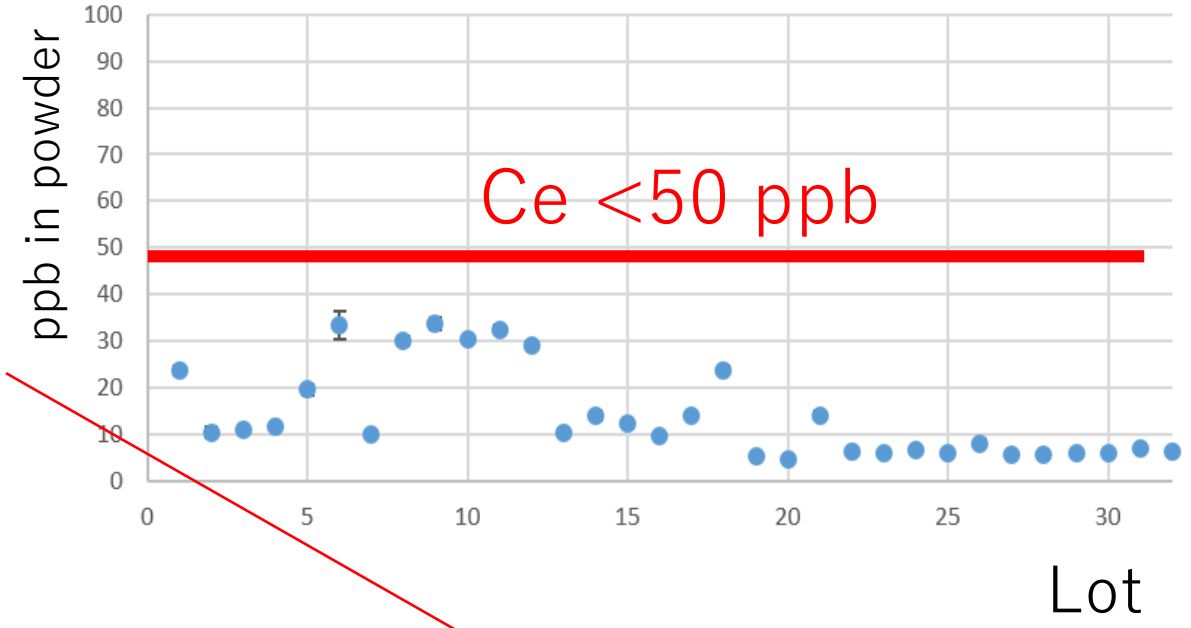
Screening of Gd sulfate powder

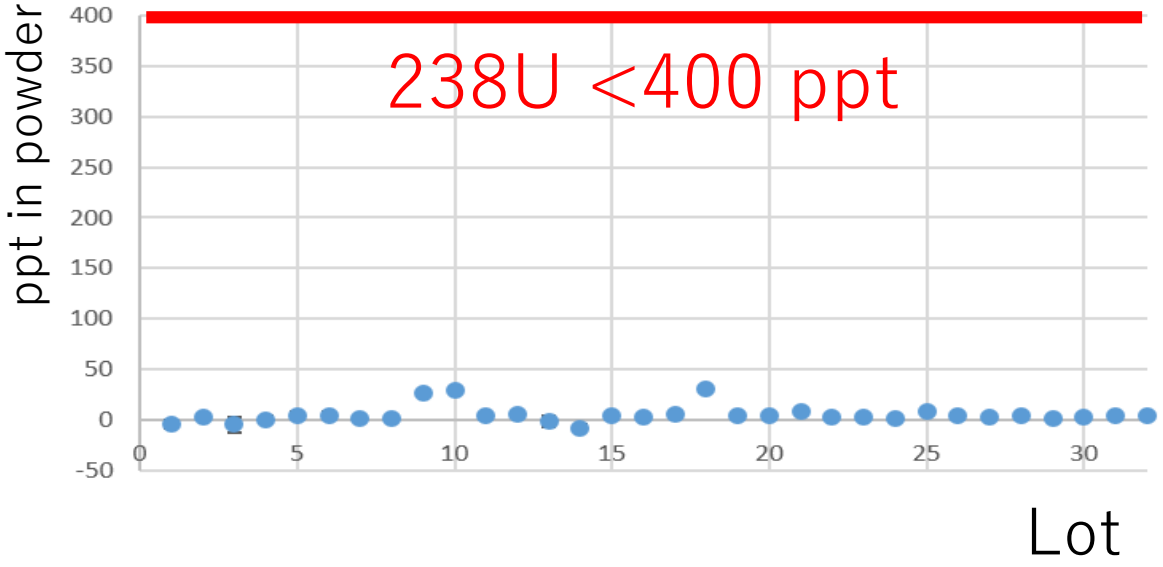
- We bought 15.4 ton
  - For the first loading (+ spare)
  - ~500kg for one lot
  - 32 lots in total.
- For each lot;
  - U, Th and Ce by ICP-MS
    - Ce is not radio-impurity
      but it can be wavelength shifter
      (Absorb invisible Č photons
        and emit visible photons)
  - All radio-impurities
    (including decay chain of U, Th)
    by Ge (Ichimura san's talk)

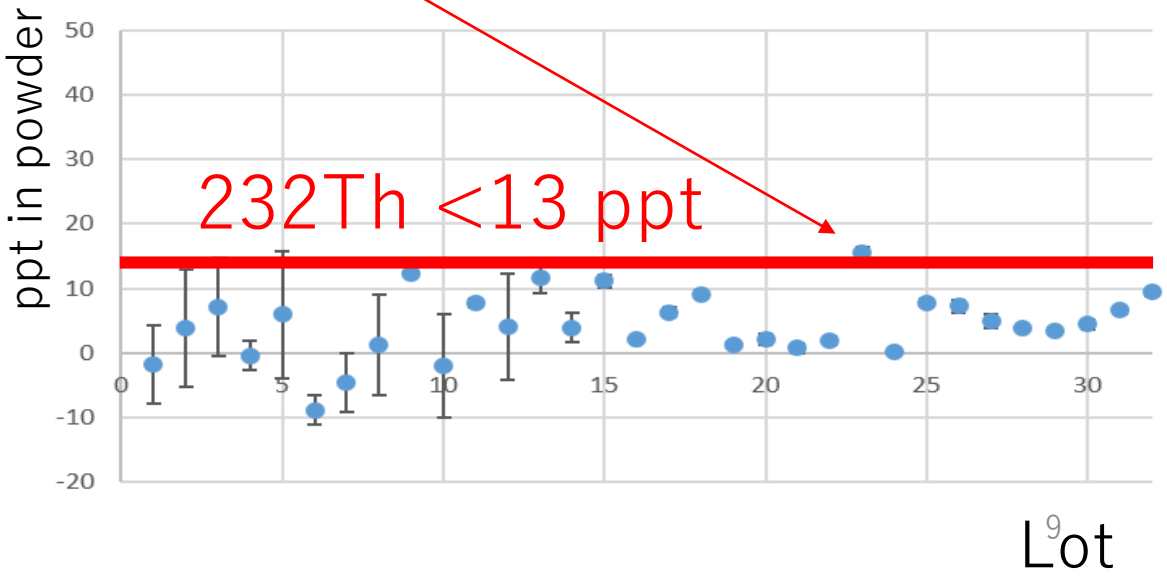
ICP-MS summary

- All lots meets our requirements except for Th of one lot (Th : 15.5 ± 1.0ppt)
  - Value is slightly lager than the requirement.
  - Th232 should be OK on average.

S.Ito san, Okada san, Ichimura san, H.Ito san



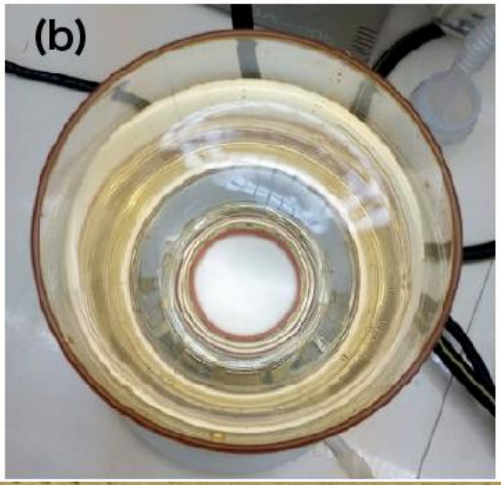




Improved Ra measurement by Ge detector using resin

S.Ito san, Okada san, Ichimura san, H.Ito san, and Takaku san

- Similar technique can be used to separate Ra from Gd.
  - Make Gd sulfate solution
  - Use a disk containing resin which can absorb Ra (AnaLig-Ra01).
  - Pass the solution through the disk.
  - Measure the disk by Ge detector
- Detail will be given by Ichimura san



Resin disk
47mmΦ, 0.5mm T

Plan

- We will dissolve more Gd in near future (~2022?)
  - To get 0.02 to 0.03 Gd concentration in SK
  - Corresponding to 13-26 tons of Gd sulfate powder
- Next screening campaign will start in this year.
  - The company can make 1 ton per lot.
  - Reduce number of measurements
- R&D of U, Th measurement for KAMLAND etc.

Kishimoto san, Ichimura san

Summary

- SK-Gd has been started since last summer.
  - ~ 13 tons of Gd sulfate powder was dissolved to SK water.
    = 0.01% Gd concentration
- We finished screening of Gd sulfate powder before that
  - All meets our requirement
- Next loading and screening campaign will come soon
  - We want to increase Gd concentration to 0.02-0.03%

RI in Gd powder before R&D

Requirement for each isotope assuming 0.2% Gd sulfate loading

Isotope	SRN	Solar	Before 2015
^{238}U	< 5	-	50
^{226}Ra	-	< 0.5	5
^{232}Th	-	< 0.05	
^{228}Ra	-	< 0.05	10
^{228}Th	-	< 0.05	100
^{235}U	-	< 3	32
$^{227}Ac/Th$	-	< 3	300

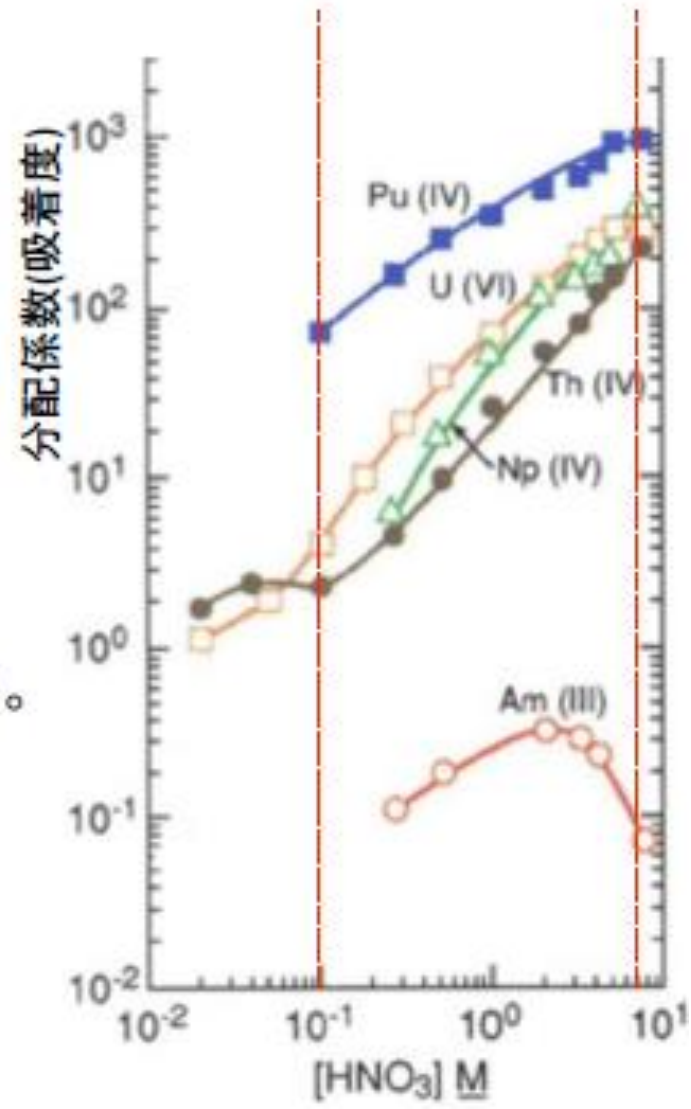
Unit：mBq/kg($Gd_2(SO_4)_3$) $8H_2O$

1/10 ~ 1/1000 reductions were needed!

U,Th 吸着樹脂

- 硫酸ガドリニウム中の微量のトリウム、ウランを化学分離して分析

- UTEVA resin
  - 6価のUや4価のアクチノイド(Th)は吸着。
  - 硝酸の濃度により吸着率が変わる。
    - → 7M 硝酸で吸着、0.1M 硝酸で溶離。
    - → Gdは3価の希土類なので、ひっつかない。



PTEP 2017 113H01

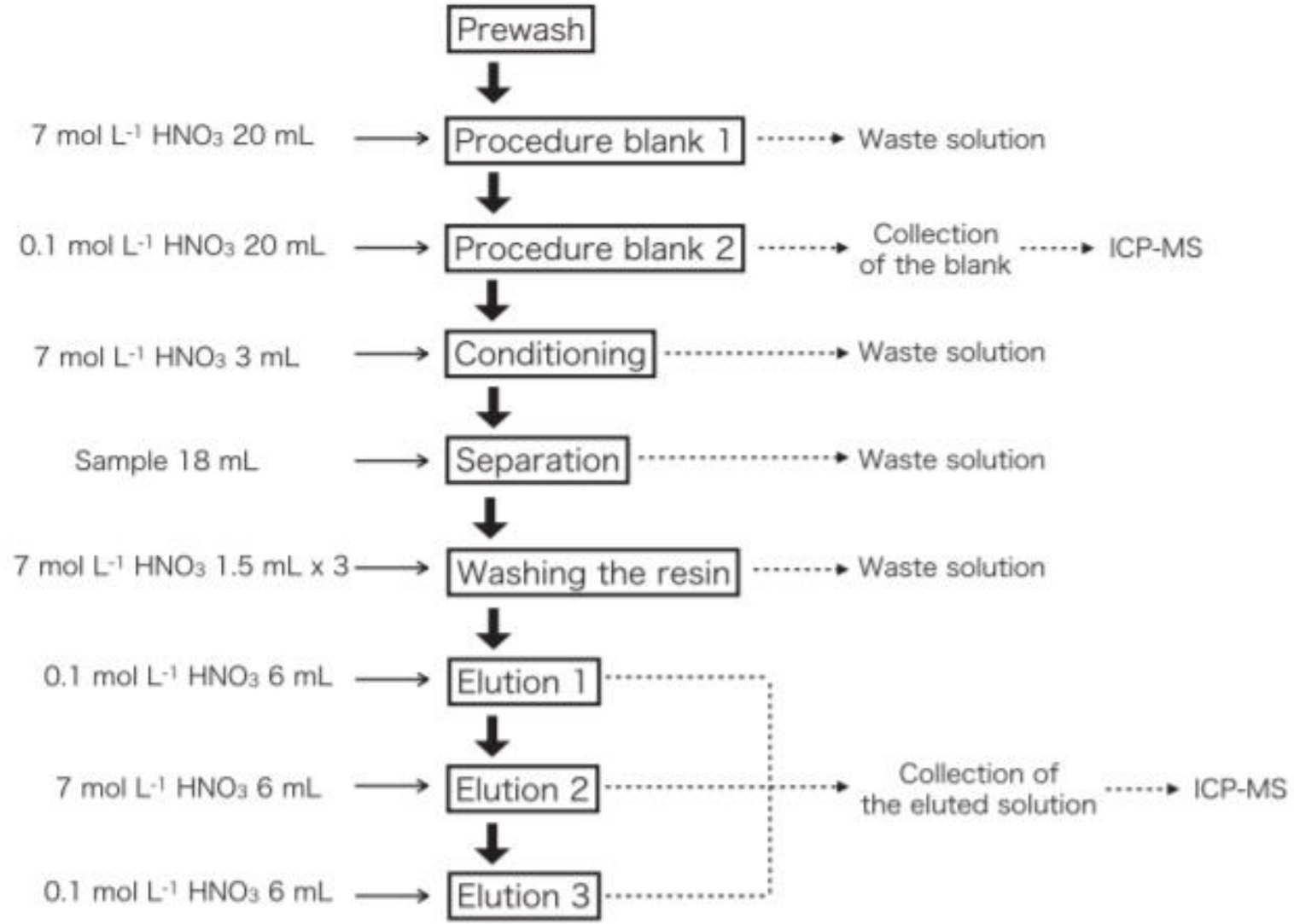


Fig. 6. Diagram of the whole procedure for the solid-phase extraction.