Development of the database for low-background studies in Kamioka

Low Radioactivity Techniques 2017

2017 May 24th (Wed)

@Ewha Womans University, Seoul, Korea.

Yuuki Nakano (Kamioka Observatory)

Yasuo Takeuchi (Kobe University)

Supported by Grant-in-Aid for Scientific Research on Innovation Areas #26104008

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Fund for Japanese underground studies

■ Fund

- KAKENHI (Grand-in-Aid for Scientific Research on Innovation Areas)
- "Revealing the history of the universe with underground particle and nuclear research"
- Year: 2014 April → 2019 March.
- Fund: 10 million US $.
- More than 70 Researchers (Leader: K. Inoue (Tohoku Univ.)).

http://www.lowbg.org/ugnd/

■ 5 groups are organized.

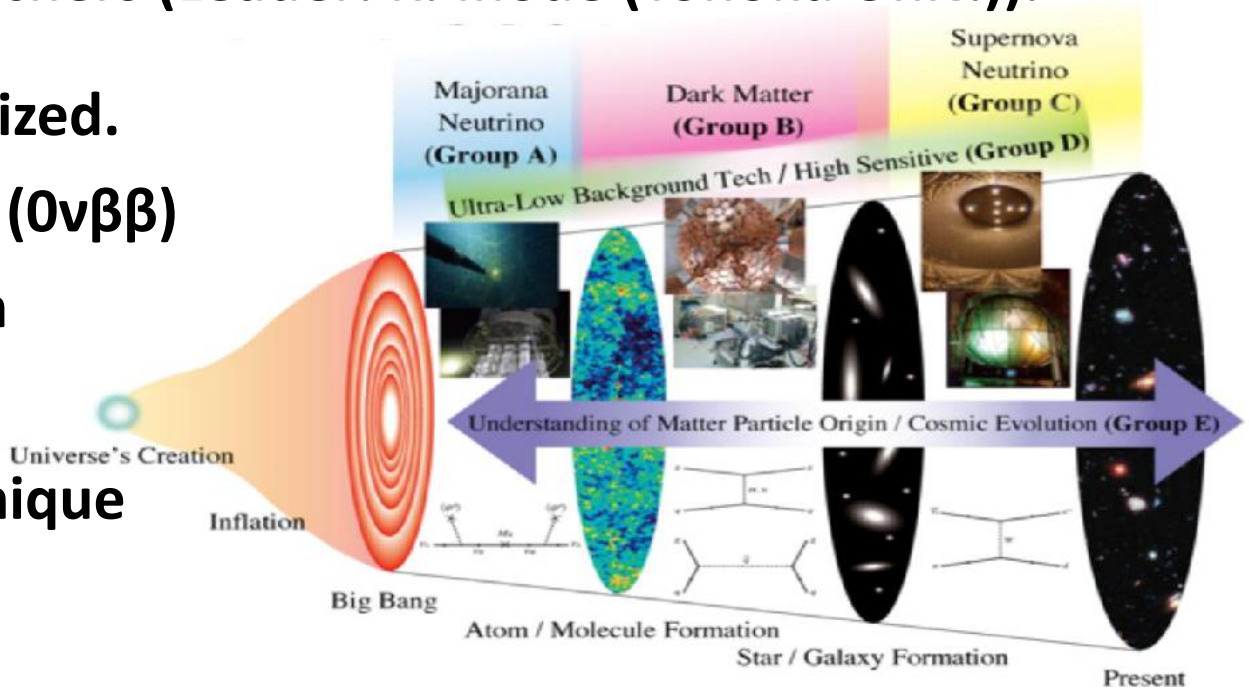
(A) Majorana ν search (0νββ)

(B) Dark matter search

(C) Supernova (relic) ν

(D) Ultra-low BG technique

(E) Theory

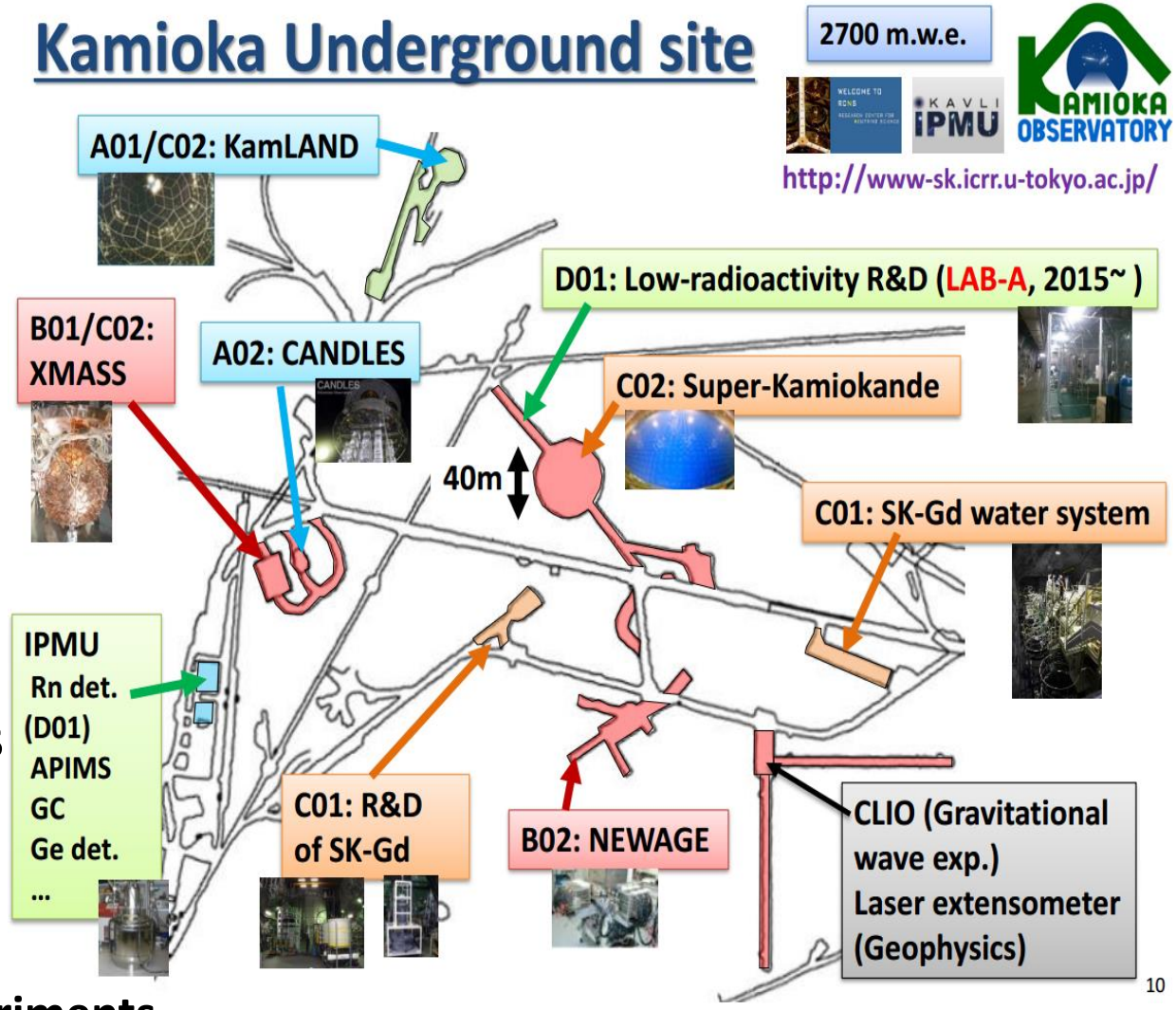


Underground experimental site in Japan

Kamioka Observatory hosted by ICRR, The University of Tokyo.

- (A) Majorana ν (0νββ)
  - KamLAND
  - CANDLES
- (B) Dark matter
  - XMASS
  - NEWAGE
- (C) Supernova (relic) ν
  - Super-Kamiokande
  - R&D for SK-Gd
- (D) Low BG techniques
  - Ge detector
  - Rn detector
  - ICP-MS etc…

→ available among experiments



Motivation for developing the database

■ Experimental status in Japanese community

- Several world-leading physics results have been obtained in Kamioka.
- Reducing BG is necessary to achieve higher sensitivity.
- Main BG source → Detector component (Common problem).

Physics Target	Experiment	Material	Reference
Majorana ν (0νββ)	KamLAND-Zen	Contamination on balloon film	Nucl. Phys. A 946, 171 (2016)
Dark matter (WIMP search)	XMASS	Al seal, copper	Nucl. Instr. Meth. A 717, 78 (2013)
	NEWAGE	μ – PIC	PTEP 043F01 (2015) T. Hashimoto (Session 7)
Supernova ν (Relic ν flux)	Super-Kamiokande (SK-Gd project)	Gd-sulfate powder	S. Ito (Session 2)

- Screening has been done by each experiment.
- Good material has been shared while bad material has not been mentioned.
- Development of the database is required to share good/bad material information.

Design of the database

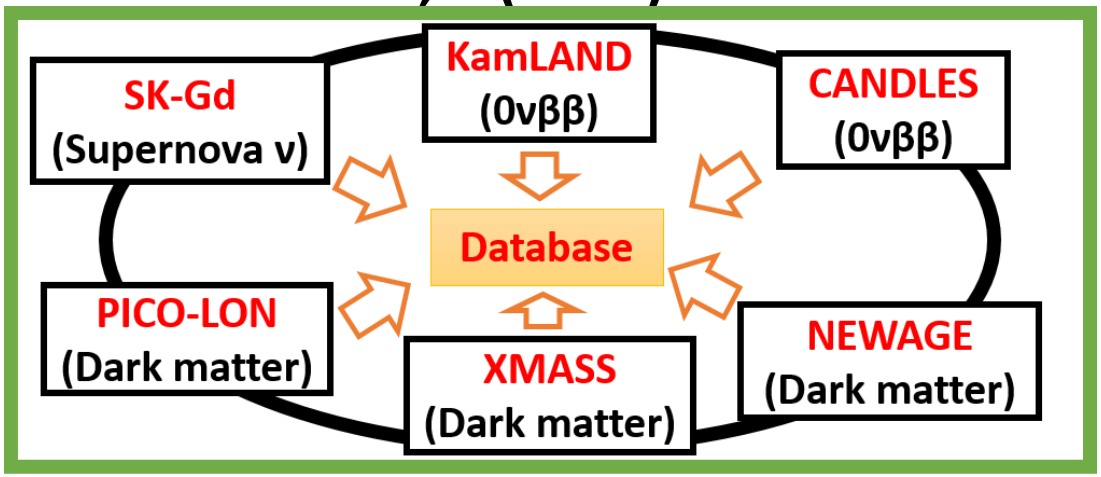
Design of the database

Engine: apache, CouchDB

Thank you very much!

Software: persephone (developed by radiopurity.org)

- Nucl. Instr. Meth. A 839, 6 (2016).



Upgrades of importCSV.py

importCSV.py converts the CSV format file into the JSON format.

This python program originally requires 2 steps to convert.

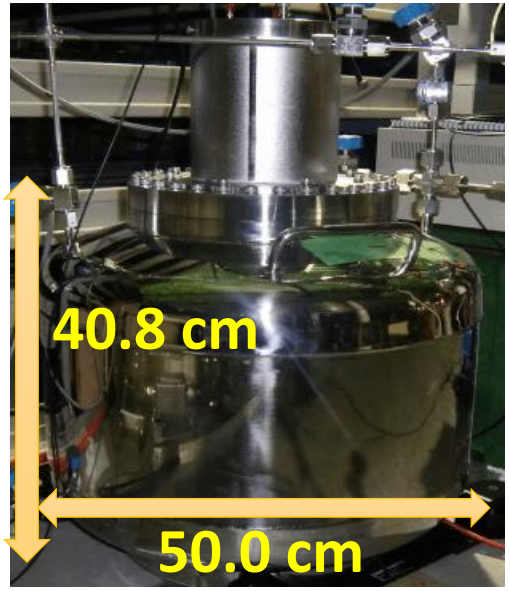
Modified the source code to convert the file format by one action.

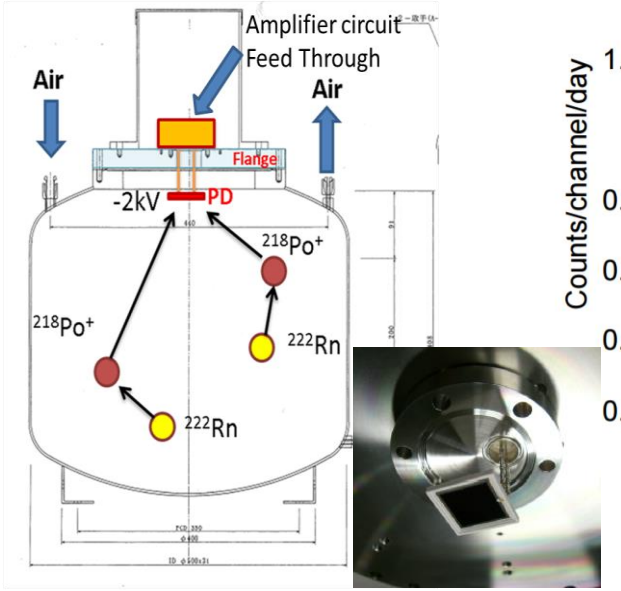
Typical contents (Overview of Low-BG programs in Kamioka)

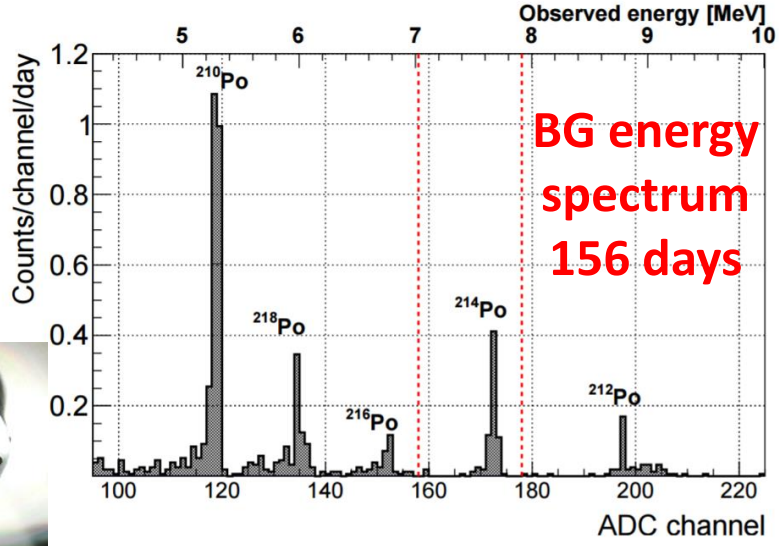
- **ICP-MS (S. Ito, Session 2)**
  - Gd-sulfate powder for SK-Gd project.
  - Achieve 10^{-9} g/g for U/Th-series.
- **Surface α-ray measurement w/ TPC (T. Hashimoto, Session 7)**
  - Re-use NEWAGE detector to measure α-ray from the material surface.
- **High sensitivity α-ray counter (K. Kobayashi, Session 2)**
  - Measure ~10 mBq/kg level of ^{210}Pb/^{210}Po in copper.
- **Low-level Rn measurement programs**
  - Developed the high sensitivity Rn detector.
  - Rn emanation from the material surface.
  - Monitoring system for the mine air in Kamioka experimental site.

High sensitivity Rn detector

- **80 litter Rn detector [Nucl. Instr. Meth A. in press]**
  - **Collect positively-charged daughter nuclei of Rn (^{218}Po, ^{214}Po).**
  - **The inner surface is electropolished.**
  - **Sensitivity: ~0.5 mBq/m^3 level for single day measurement.**
  - **Background: ~0.7 count/day (~0.3 mBq/m^3) for ^{214}Po.**
  - **Use for air and novel gas measurement [PTEP 033H01 (2015)].**







Doi: 10.1016/j.nima.2017.04.037

Rn emanation measurement

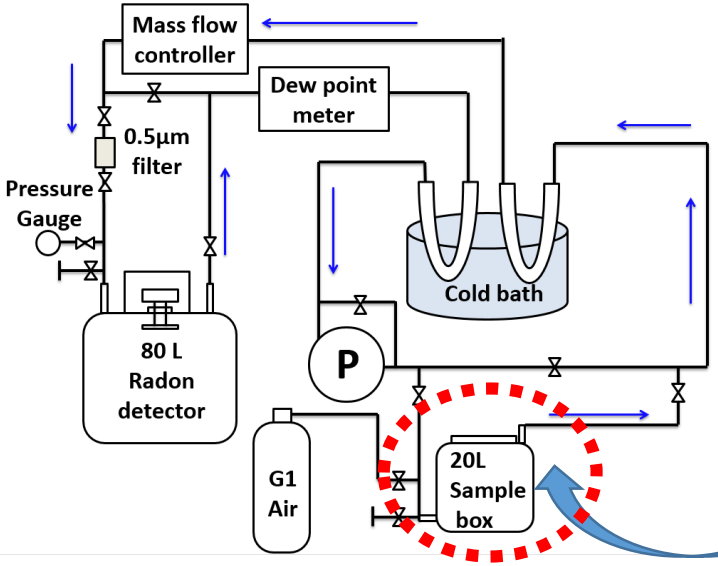
■ Setup and method

LRT2015, H. Sekiya

- Rn detector and sampling box
- Put materials (Rubber gaskets) and circulate air in the closed system.
- Measure Rn concentration and normalize with the size of material.

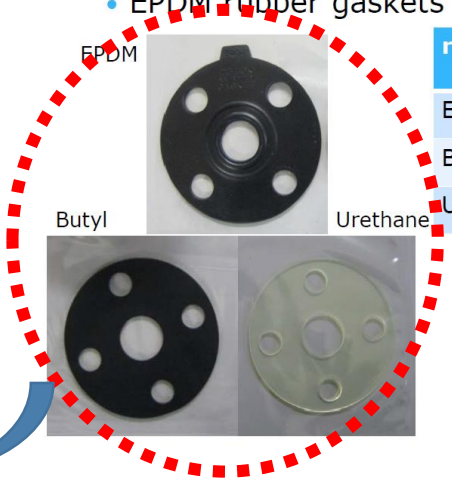
■ Experimental Results

- Urethane is low-Rn level while EPDM/Butyl is Rn rich.
- Material screening is on-going → Results are registered to the Database.



Rn emanation from rubber gaskets

- EPDM rubber gaskets are used in SK.



rubbers	Rn emanation /1 gasket	Rn emanation / m²
EPDM	1.82 ±0.03 mBq	0.809±0.013 Bq
Butyl	3.58 ±0.04 mBq	1.59 ±0.02 Bq
Urethane	0.013±0.004 mBq	5.8±1.8 mBq

- N.B. This is NOT the emanation to water.
- EPDM is Rn rich! Urethane is good.
- The gaskets must be replaced.

Rn concentration monitor

■ 1 litter Rn detector [Paper submitted]

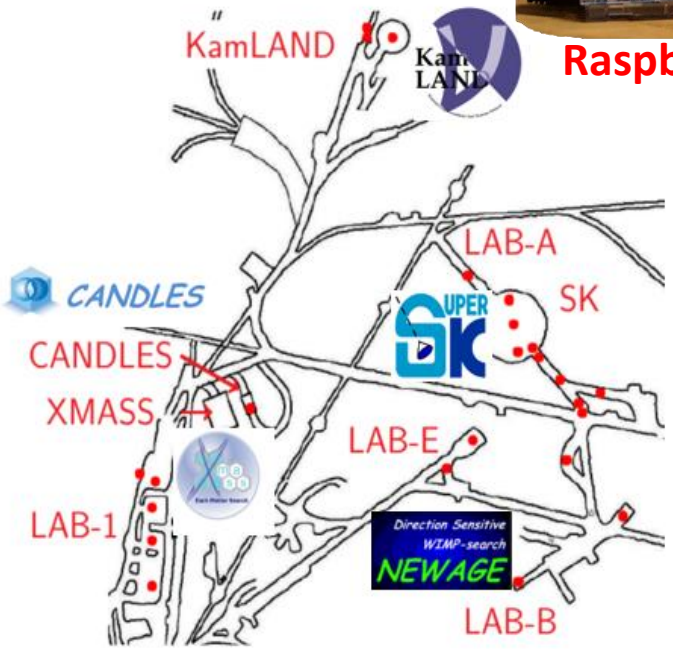
- Same techniques with the small detector volume.
- Sensitivity: 1 Bq/m^3 ~10 kBq/m^3 level.
- Raspberry Pi for electronics.

■ Monitoring network

- About 30 detectors in the mine.
- Typical values → Database

  Tunnel (summer): 2418 ± 139 Bq/m^3.

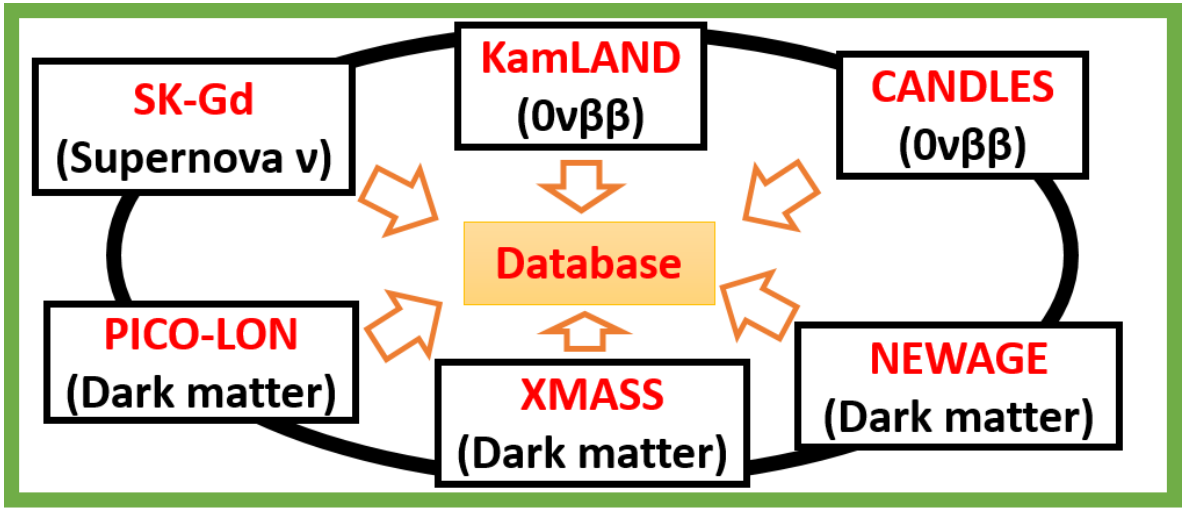
  SK (above tank): 98 ± 15 Bq/m^3.
- Observe low Radon concentrations in the experimental area.



Plan for the data management

■ During fund (2014 April – 2019 March)

- Evaluate/measure radioactivity by each experiment.
- Collect results of material screening.
- Currently, more than 200 samples are registered.
- Share information among Japanese community until 2019 March.



■ After fund (2019 April)

- Planning to share data for the outside (Under discussion).

Summary

- **Development of Low-BG techniques is necessary to improve the sensitivity for new physics.**

- **Database has been developed in order to collect the information about radioactivity of materials.**
  - **Based on radiopurity.org**
  - **Database is available only among Japanese community until 2019 Mar.**
  - **After 2019 April, data will be shared for the outside. (under discussion)**

- **Several Low-BG programs are on-going in Kamioka.**

Backup

Abstract

Needless to say, it is important to select ultra-low background materials for dark matter and 0νββ detectors. All materials and components must be evaluated before the detector construction.

This presentation will focus on developing a database for such purpose based on the open source database, Persephone (radiopurity.org).

The aim of this project is to share information on low-radioactivity materials measured by several techniques in Kamioka observatory among Japanese community.

Improvements of the functions of the database and the typical contents will be shown. In addition, several running programs for screening low-radioactive materials at Kamioka will be discussed.

Current experimental status in Kamioka

■ Overview of the experimental result in Kamioka

- Several world-leading results has been obtained (written in Red).

Target	Experiment (Result)	Reference
Majorana ν (0νββ)	KamLAND-Zen	Phys. Rev. Lett. 117, 082503 (2016)
Dark matter (WIMP search)	XMASS	Phys. Lett. B 759 (2016) 272-276
	NEWAGE (w/ directional information)	PTEP 043F01 (2015)
Supernova ν (Relic ν flux)	Super-Kamiokande	Astropart. Phys. 60, 41 (2015)
	KamLAND	Astrophys. J. 745, 193 (2012)

■ Problems

- Reducing BG is necessary to achieve higher sensitivity.
- Detector component should be low-BG