

Status and prospect of the **ANKOK** project

: Low mass WIMP dark matter search using double
phase argon detector

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TAUP2017

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WASEDA University

Outline

: Introduction

- Double phase liquid argon detector
- Physics goal and strategy of the ANKOK project

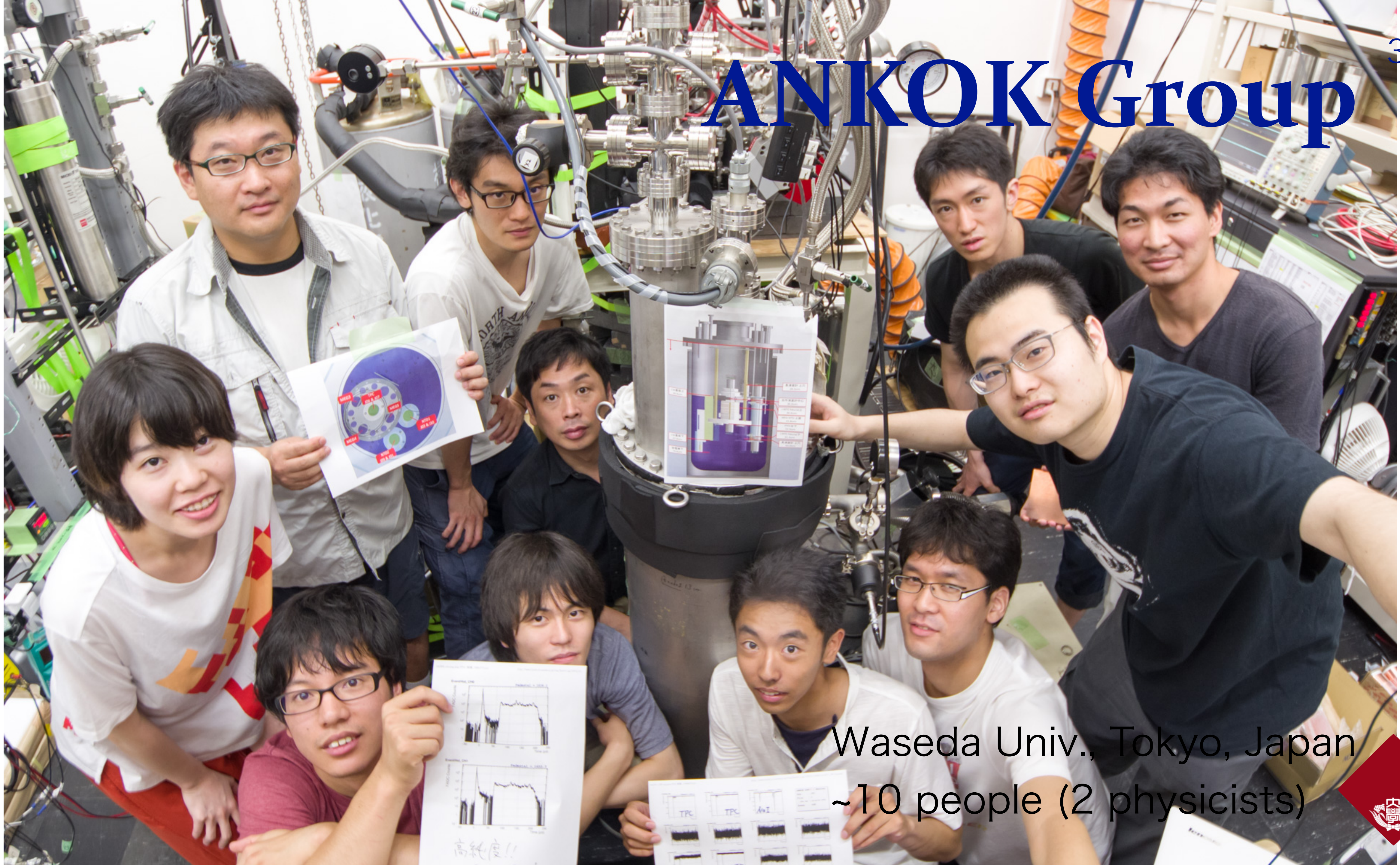
: Status of R&D

- Test stand at Waseda
- Two strategies to lower energy threshold
 - : Detailed understandings of liquid argon response
 - : Development and applications of new SiPM device

: Summary and Future Prospects



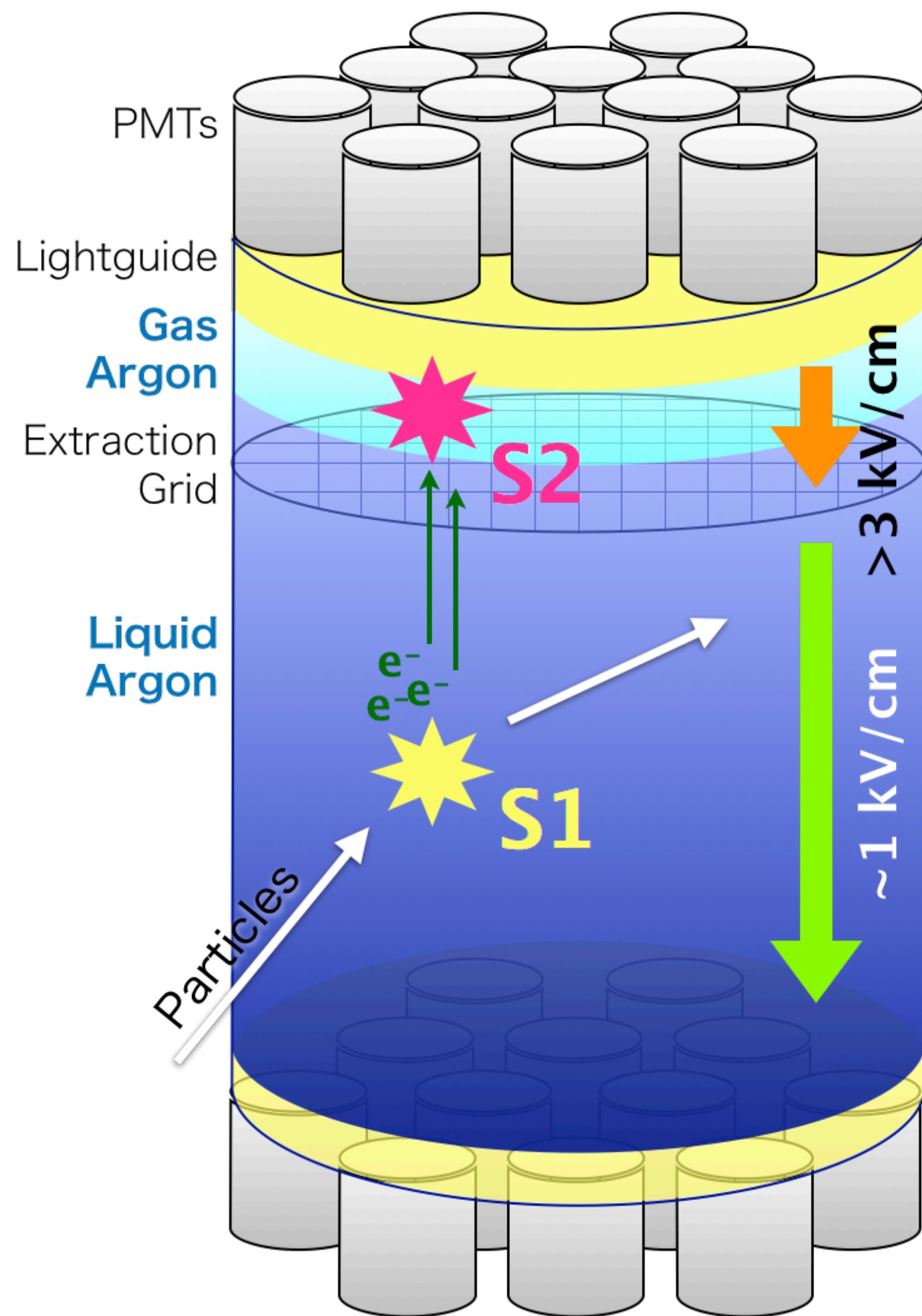
ANKOK Group



Waseda Univ., Tokyo, Japan
~10 people (2 physicists)



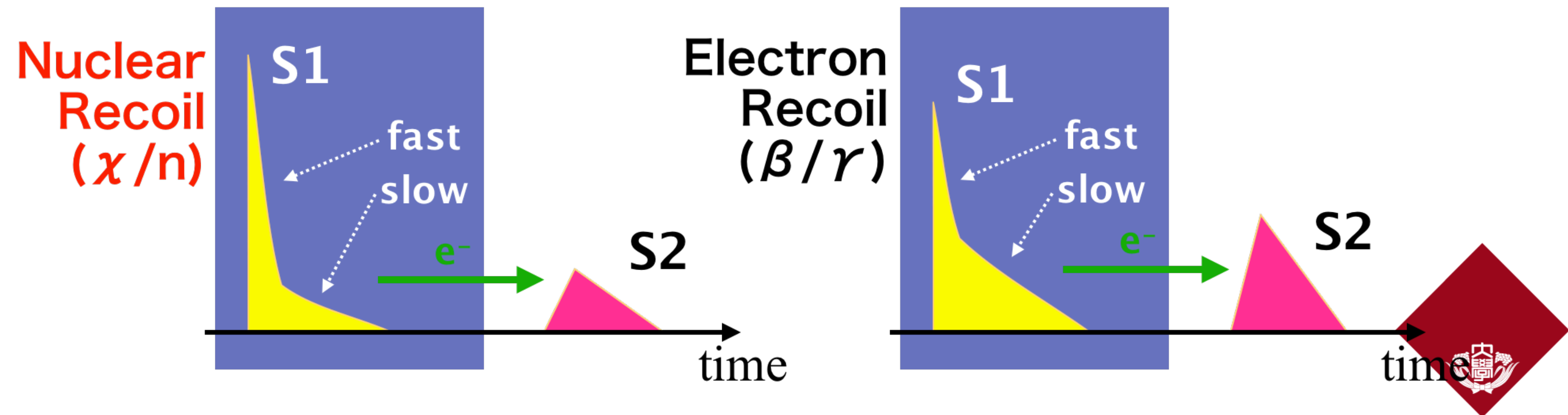
Double Phase Argon TPC Detector ⁴



ANKOK detector is based on double phase argon time projection chamber.

Good **particle identification power** due to :

- Pulse shape discrimination (**PSD**), and
- **S2/S1** (ionization to excitation) ratio.



Goal of ANKOK

: Search for “10 GeV/c² region” WIMP dark matter by **Argon**.

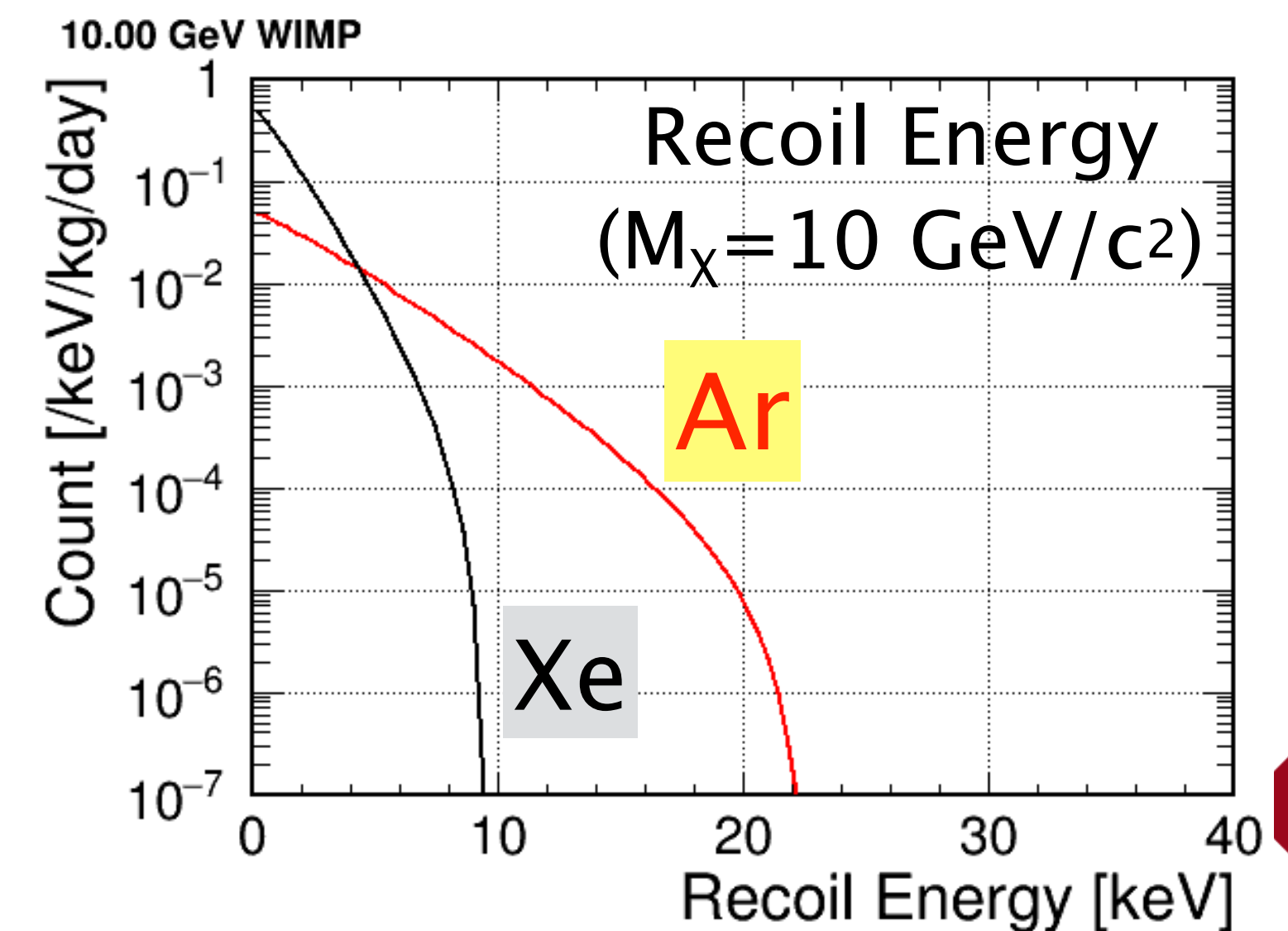
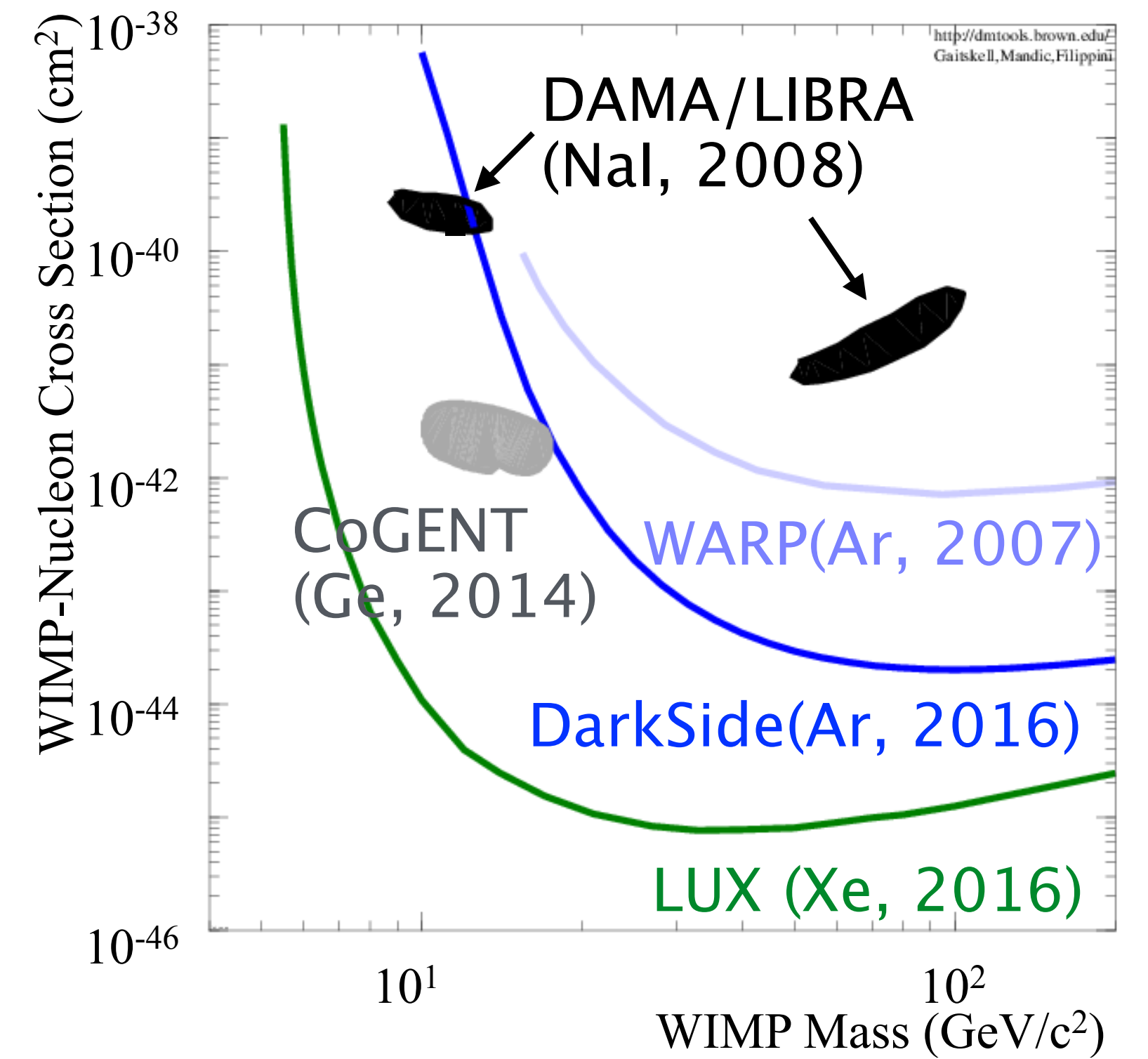
- Ar : A = 18 (similar to Na) & noble gas.
- No experiments searched “DAMA region” by argon.

: Recoil energy for 10 GeV/c² WIMP is about 20 keV.

- Potential to search the low mass WIMP.

: ³⁹Ar background (β -decay, ~1 Bq/kg)

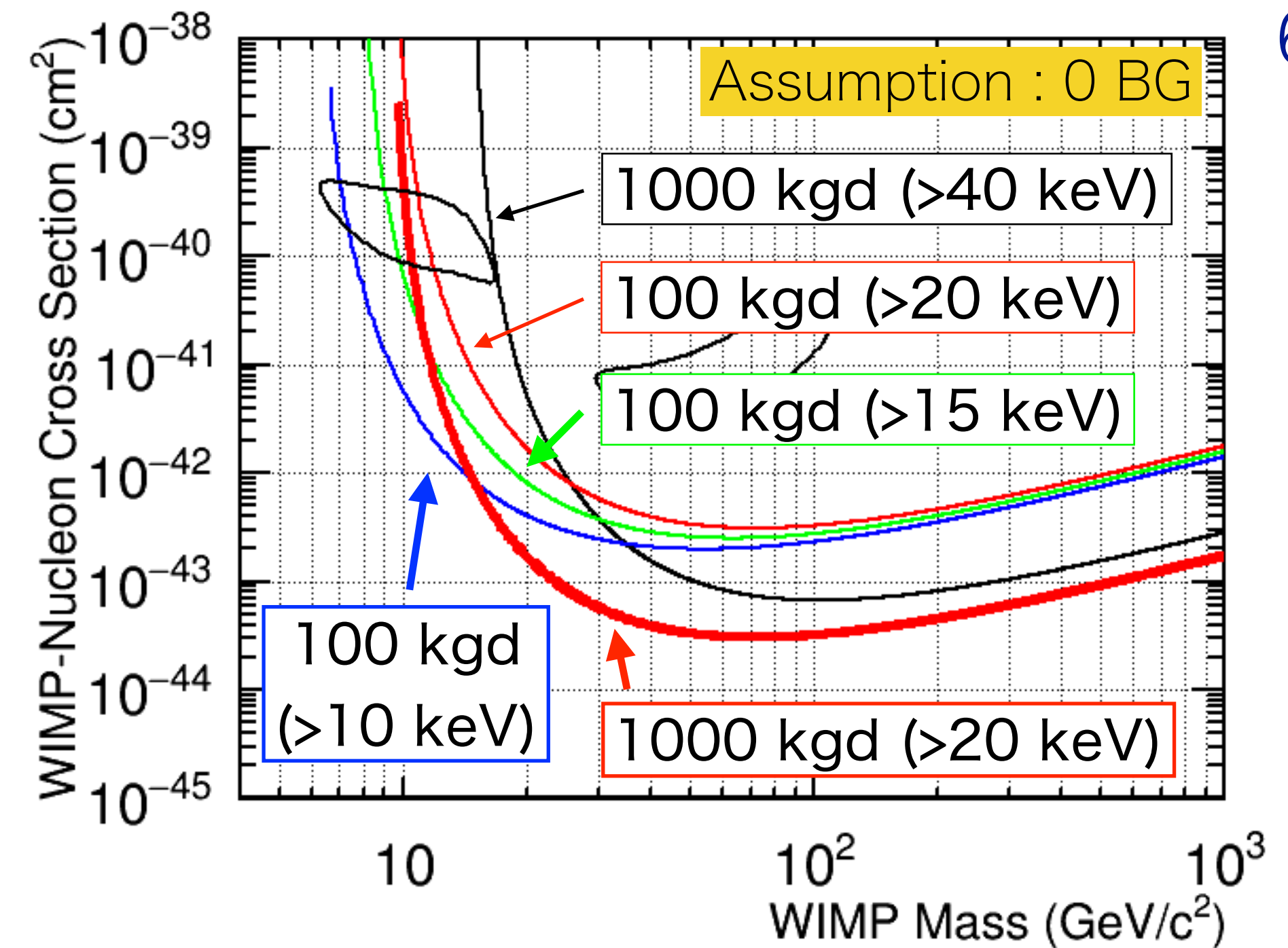
- Need sufficient rejection power with PSD and S2/S1 in low energy region.



Goal of ANKOK

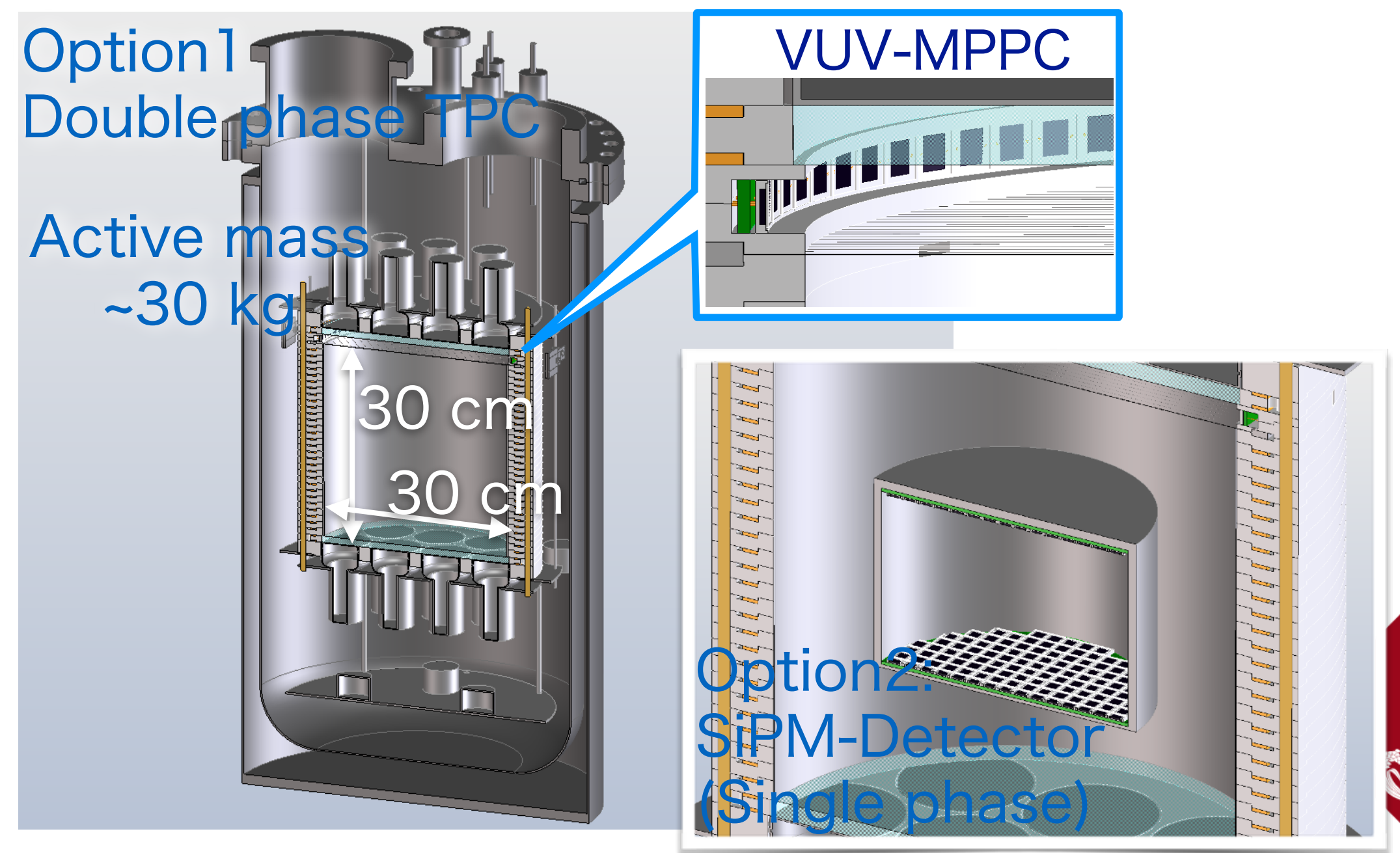
: Two ways to search the low mass WIMP.

- 1) 1000 kg×days, 20 keV threshold
- 2) 100 kg×days, 10 keV threshold



To achieve low energy threshold, we focus on :

- (1) Liquid argon response under high electric field (PSD⊗S2/S1),
- (2) Development of new SiPM device. (Applicable to TPC and “PSD-specified” high light yield detector.)



Current Status

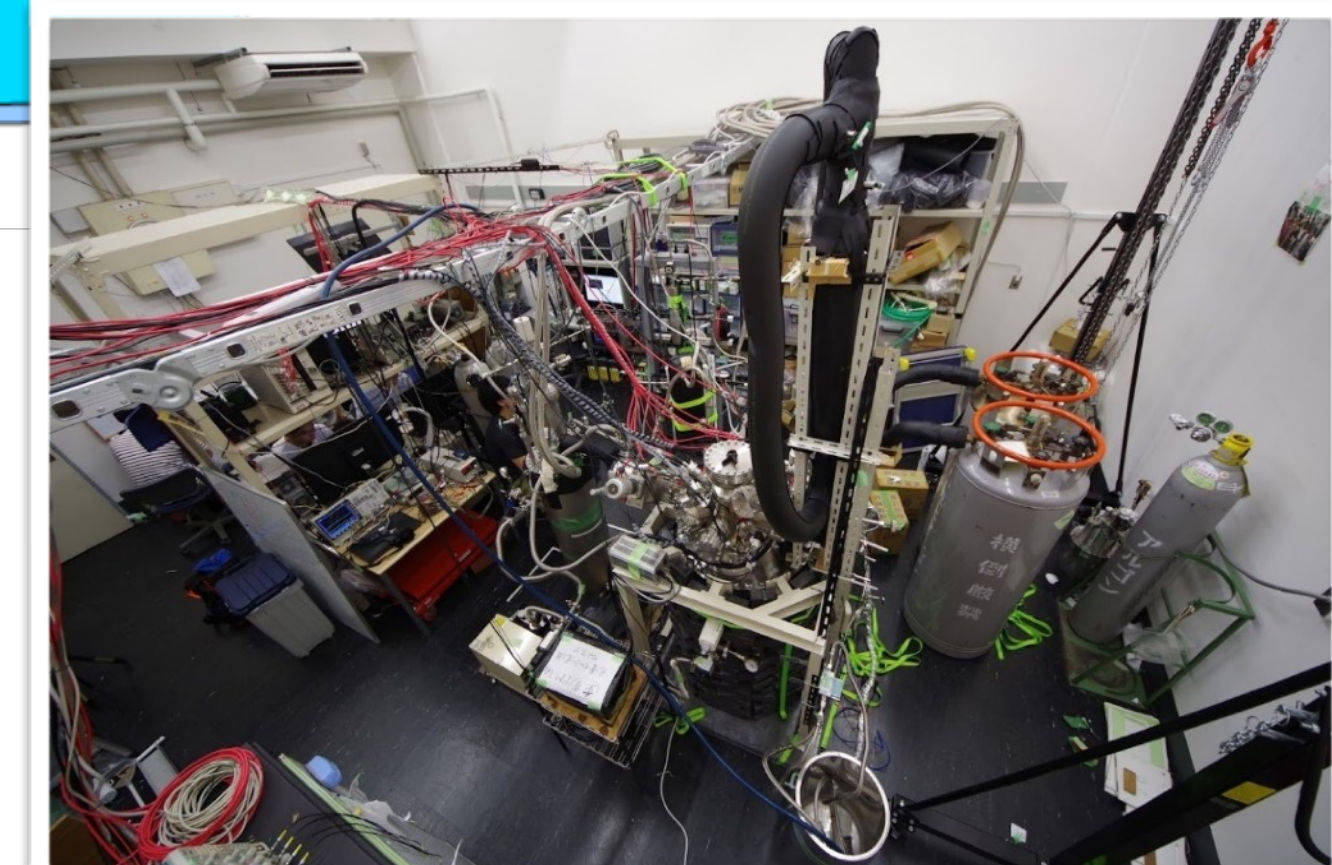
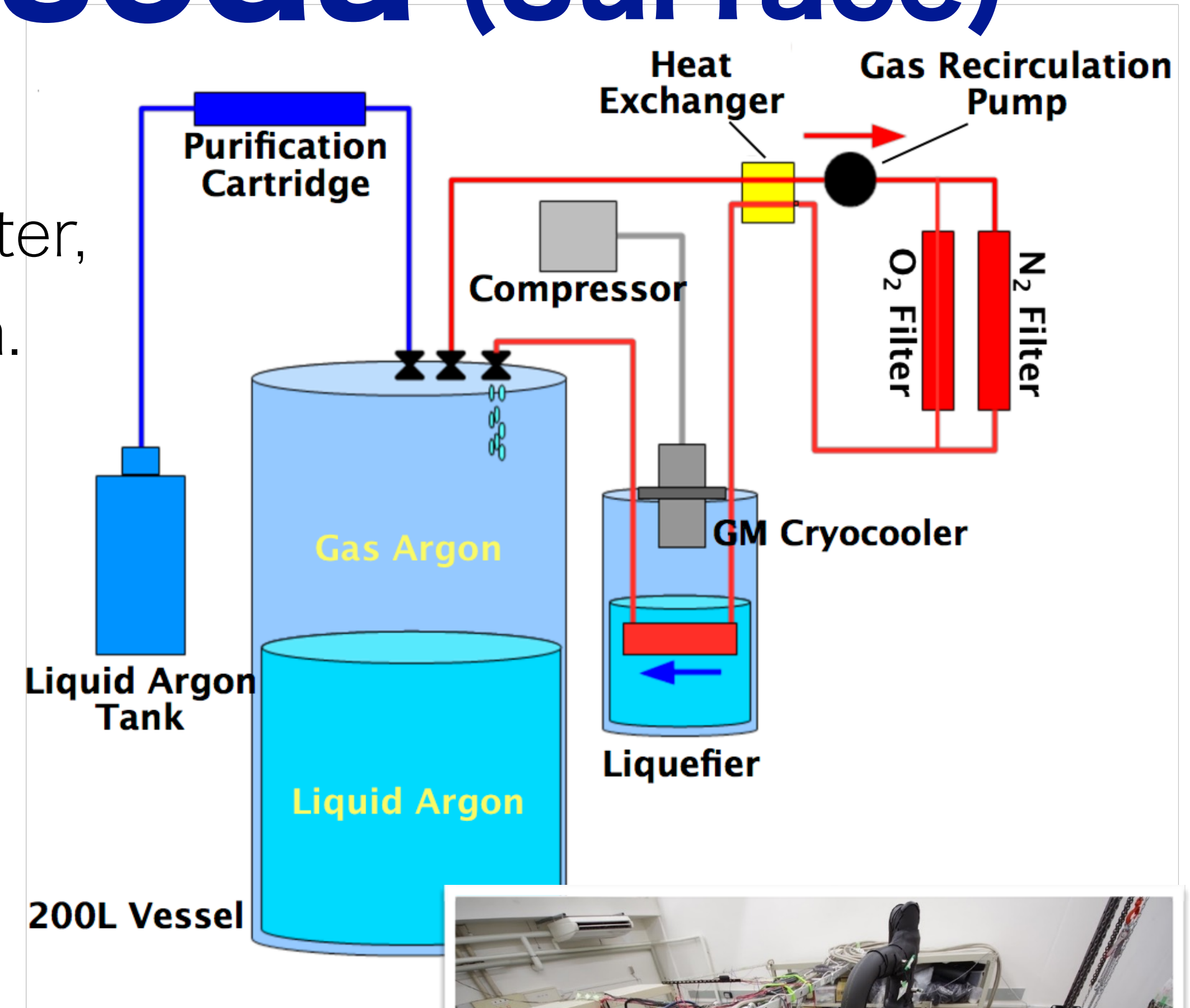
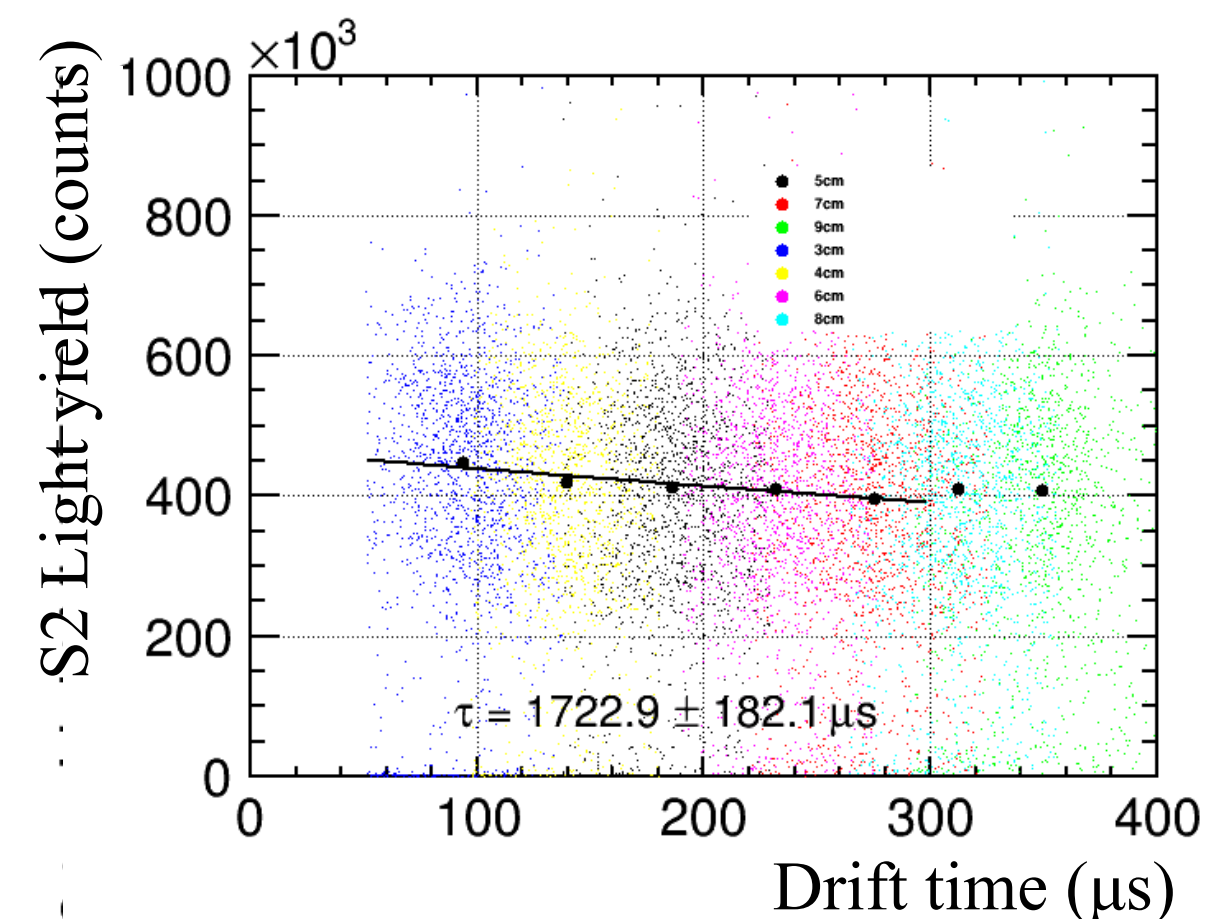
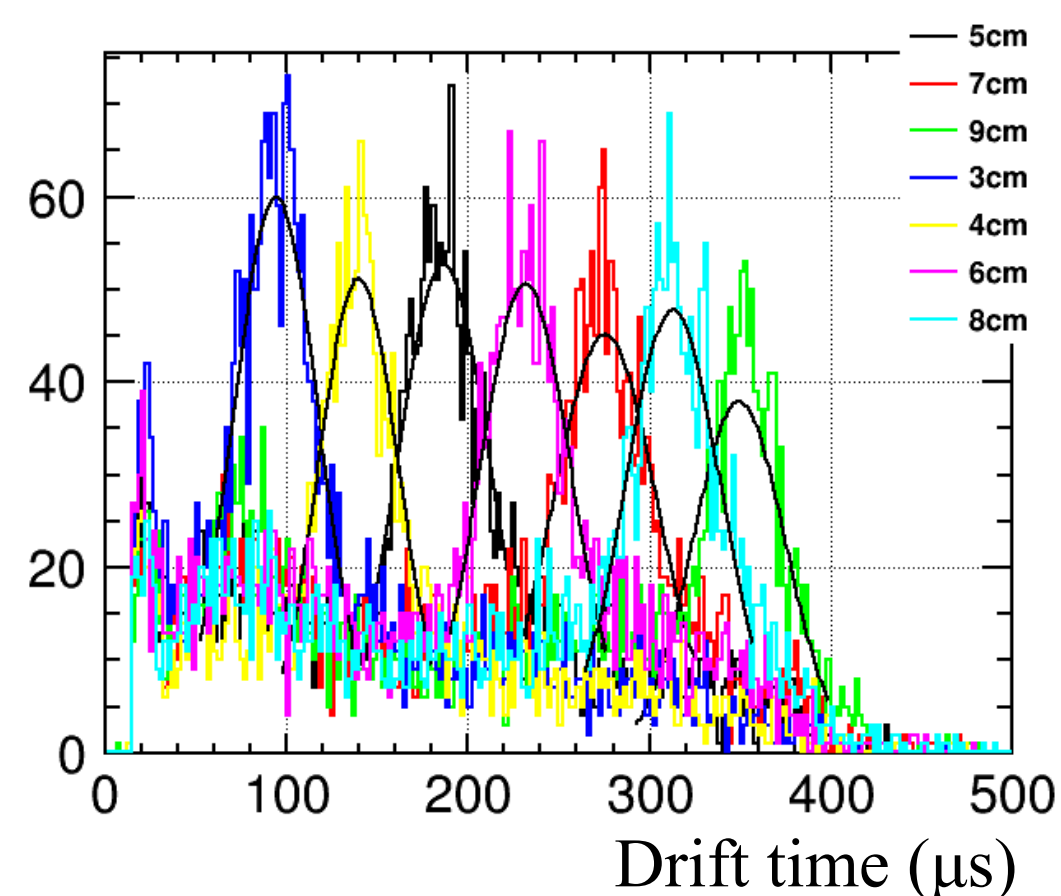


Teststand at Waseda (Surface)

- : 200L cryostat and liquefier,
- : Liquid argon (LAr) filling through cryogenic filter,
- : Gas argon (GAr) recirculation and liquefaction.

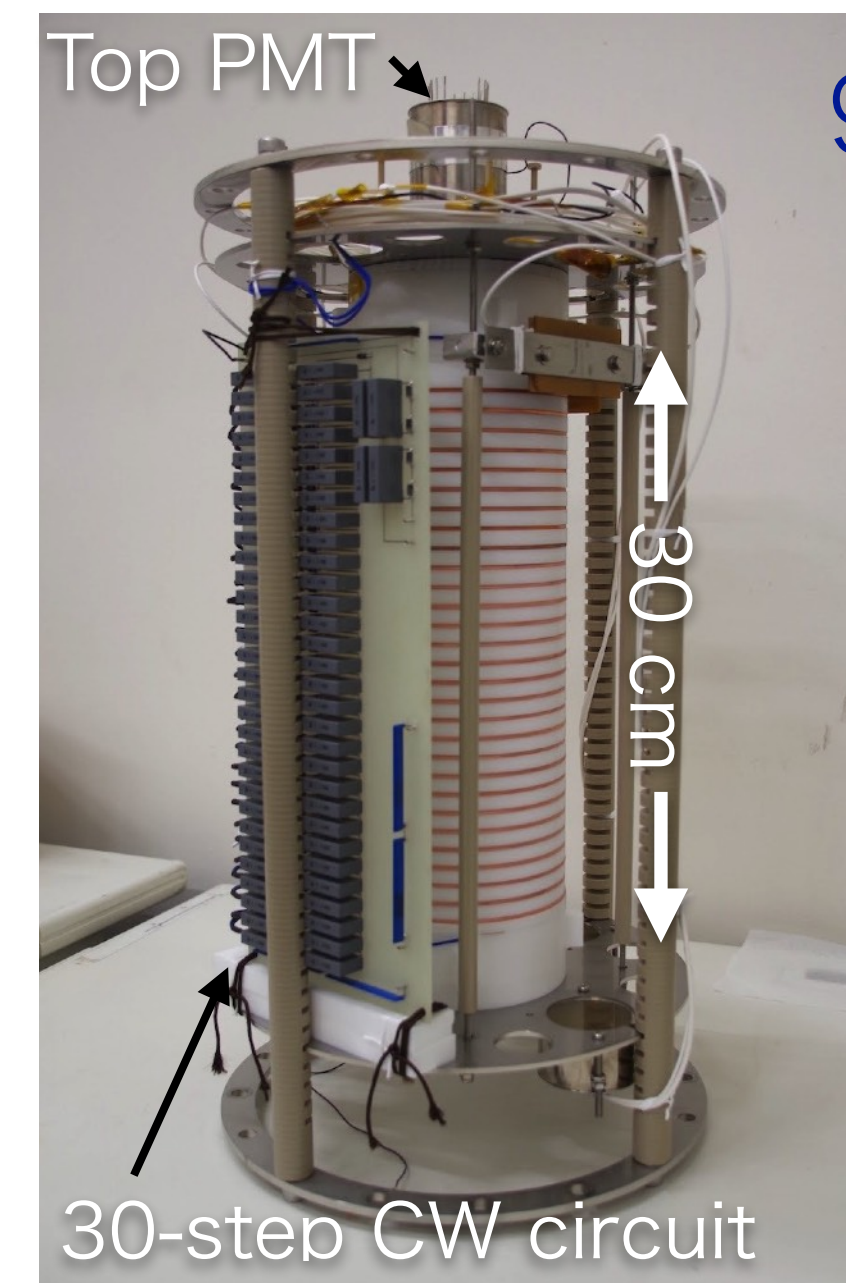
We achieved :

- ~1 month of **stable operation**,
 - 0.5 mm **liquid surface control**,
 - **Contamination removal** from LAr.
- (Electron lifetime $\tau \sim 1.5$ ms).

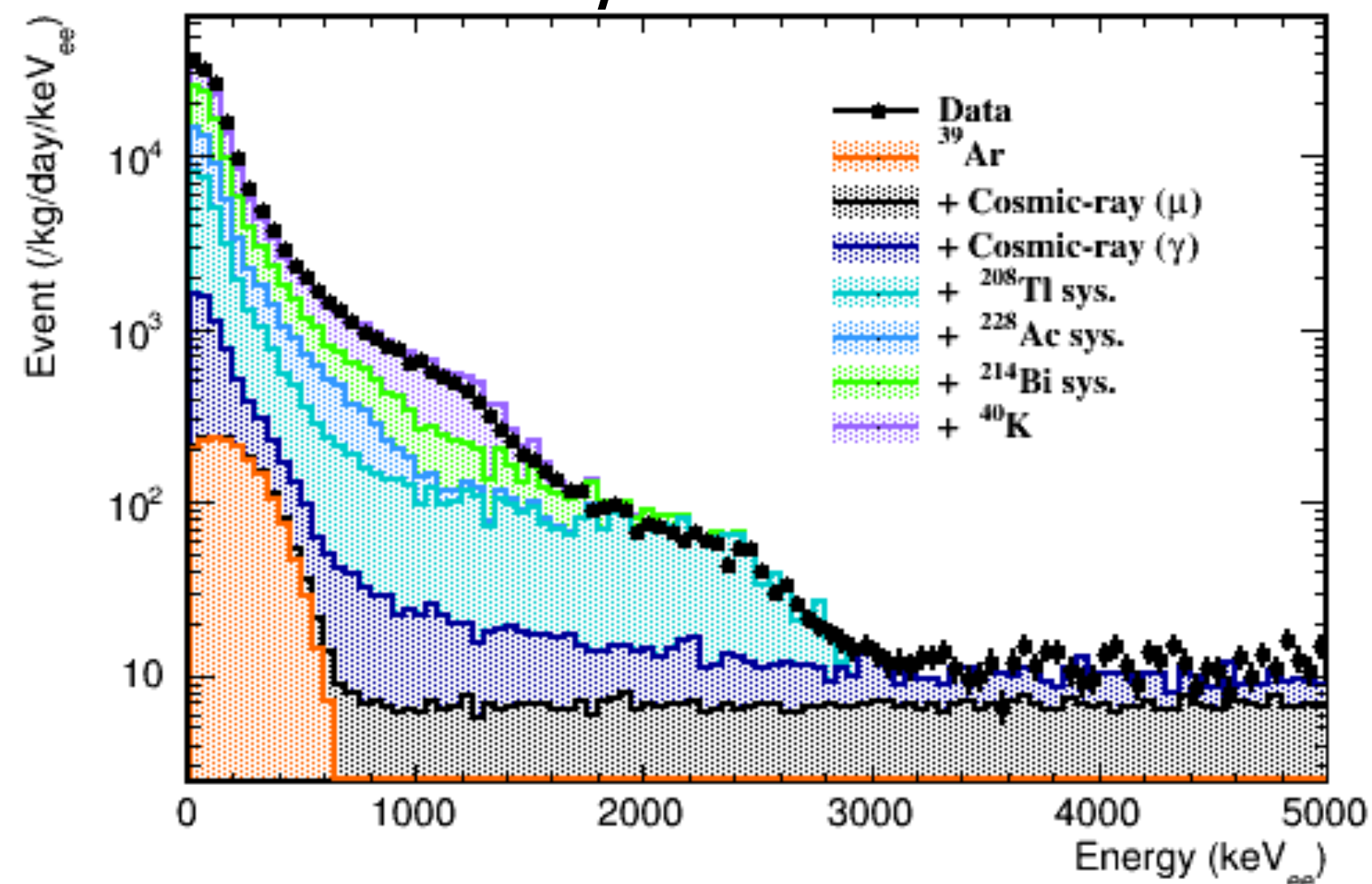


Observation of ^{39}Ar

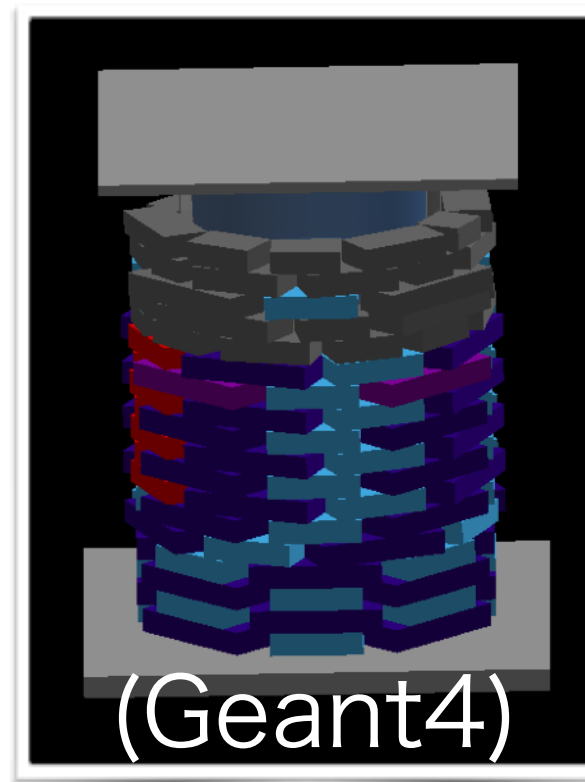
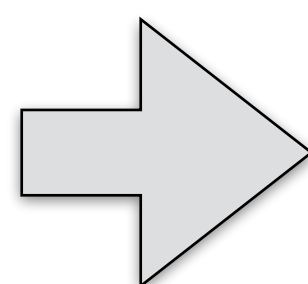
- : Prototype detector
 - Double phase argon TPC holding 2 PMTs.
 - ~1.5 kg fiducial volume (ϕ 6.4 cm, h30 cm)
- : Independent measurement of environmental gamma-ray flux by NaI scintillator.



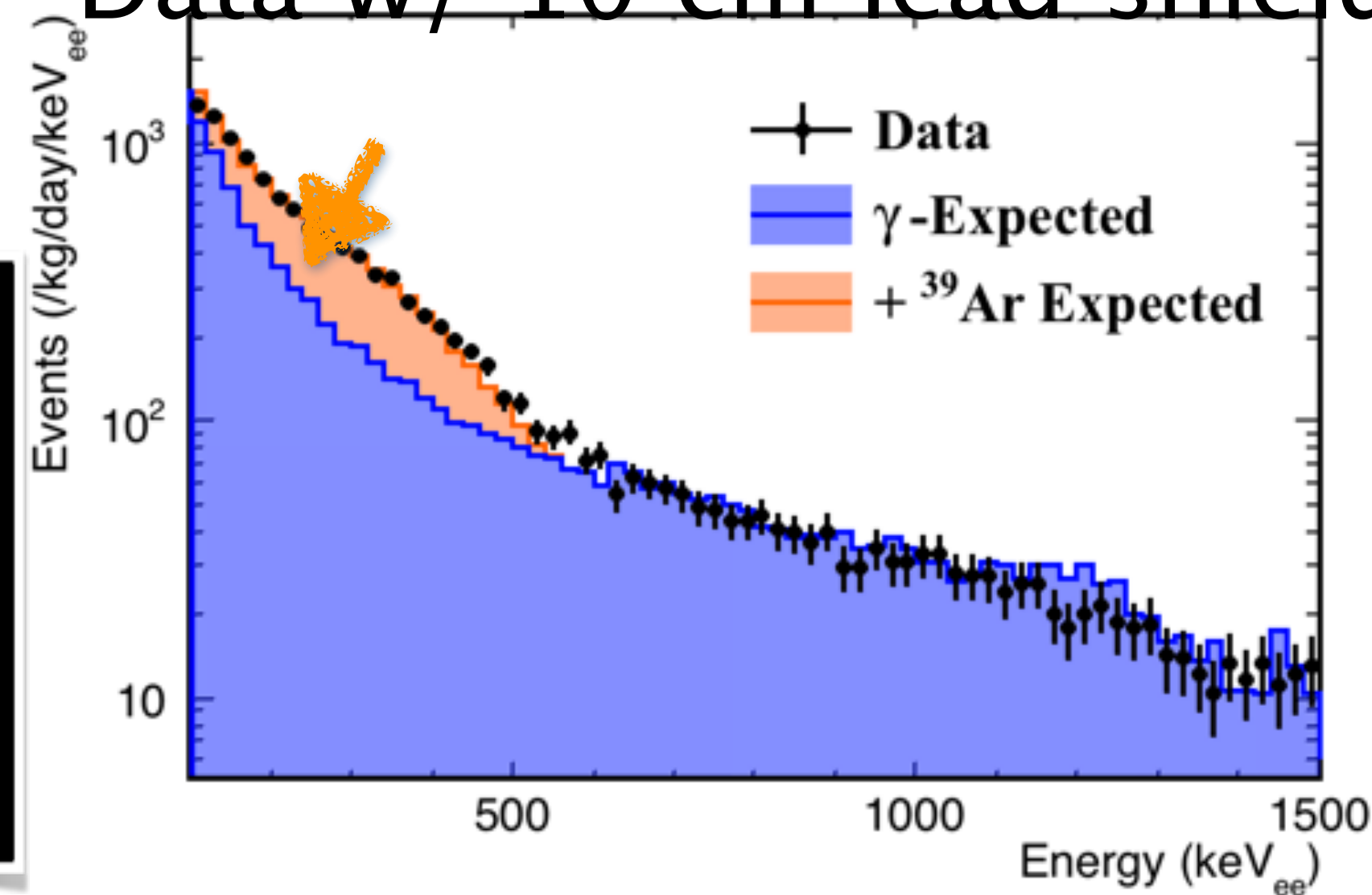
Data w/o lead shield



Environmental- γ : ^{39}Ar ~ 100:1



Data w/ 10 cm lead shield

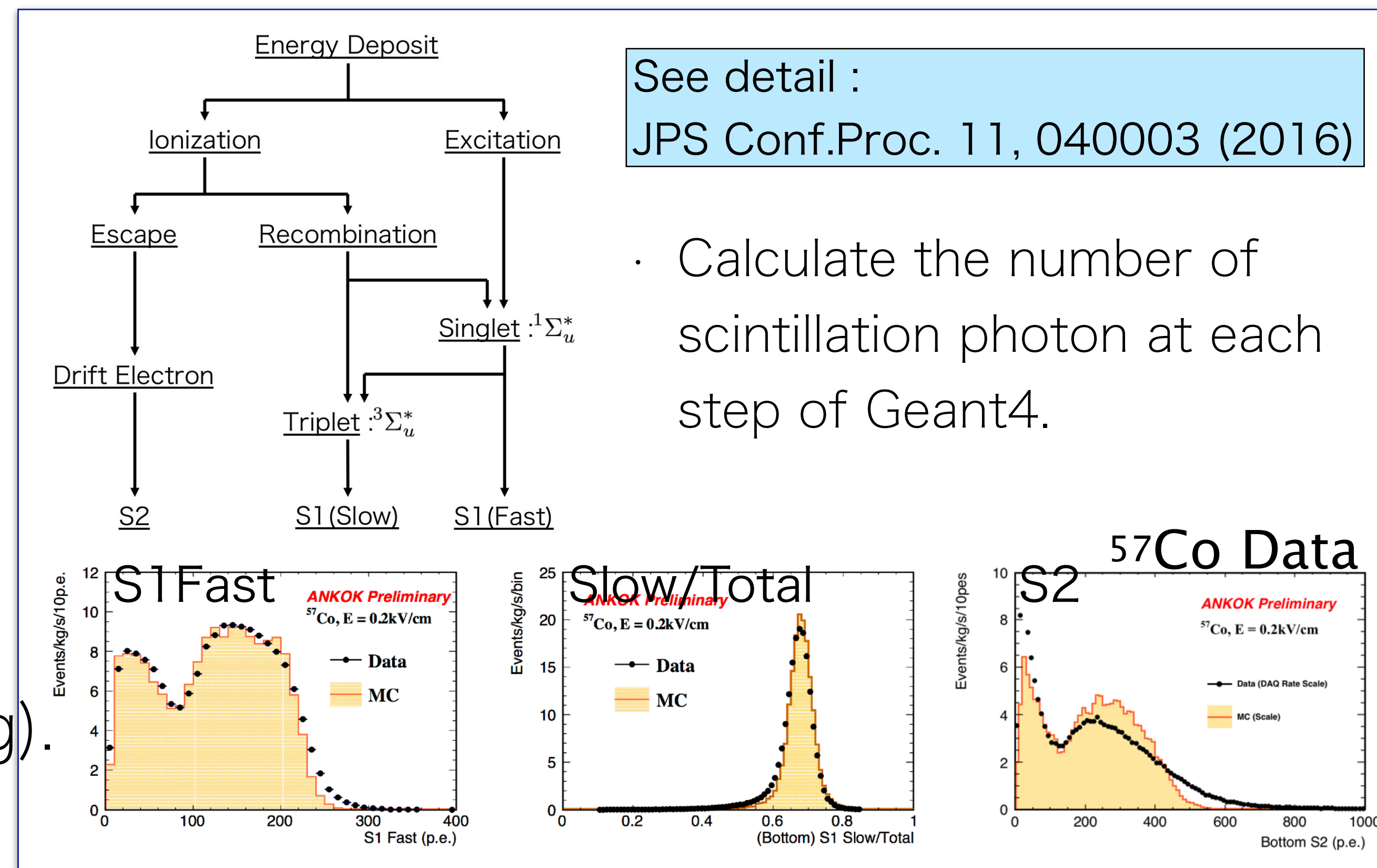
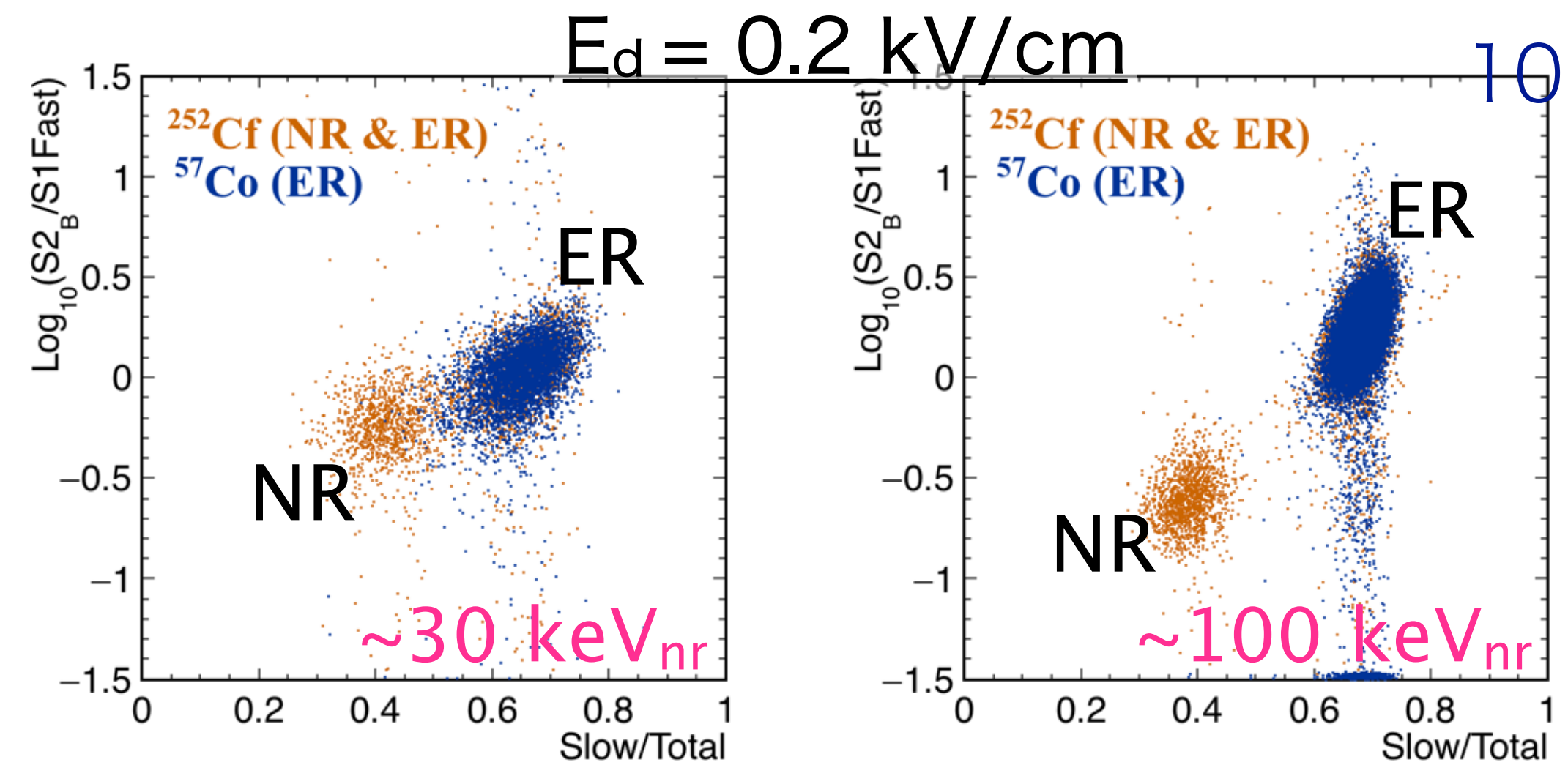


Environmental- γ : ^{39}Ar ~ 1:1



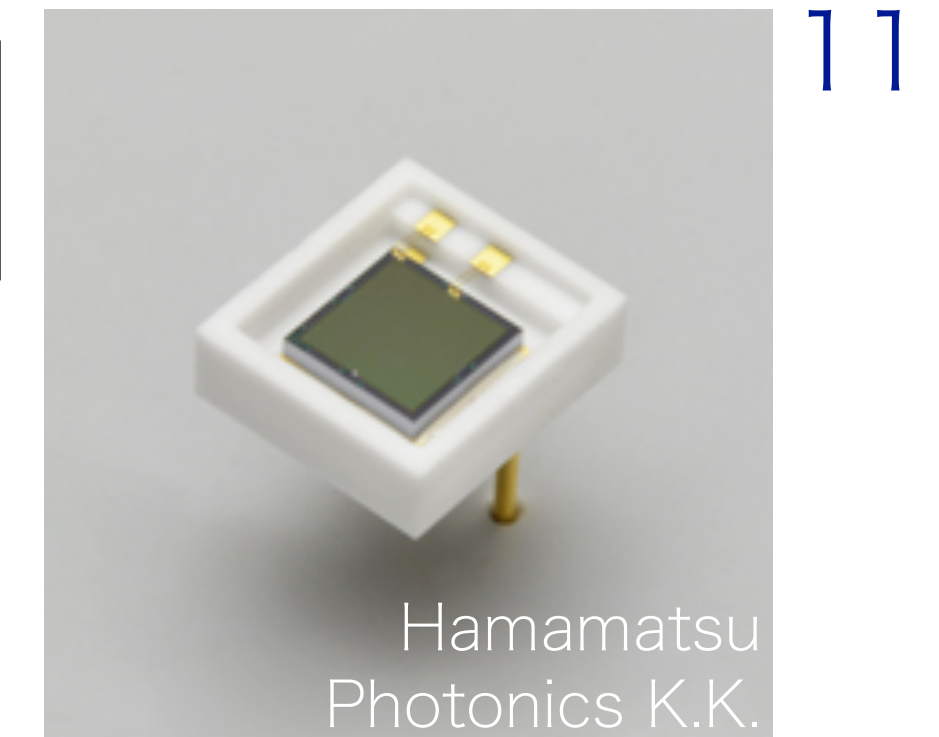
LAr Response

- : Good PID performance is shown in the prototype detector.
- : Take some approaches to get detailed understandings of LAr response in electric field.
- Implement own Ar response model to the simulation. (refer to NEST package for Xe)
- Acquire and analysis high electric field data (ongoing).



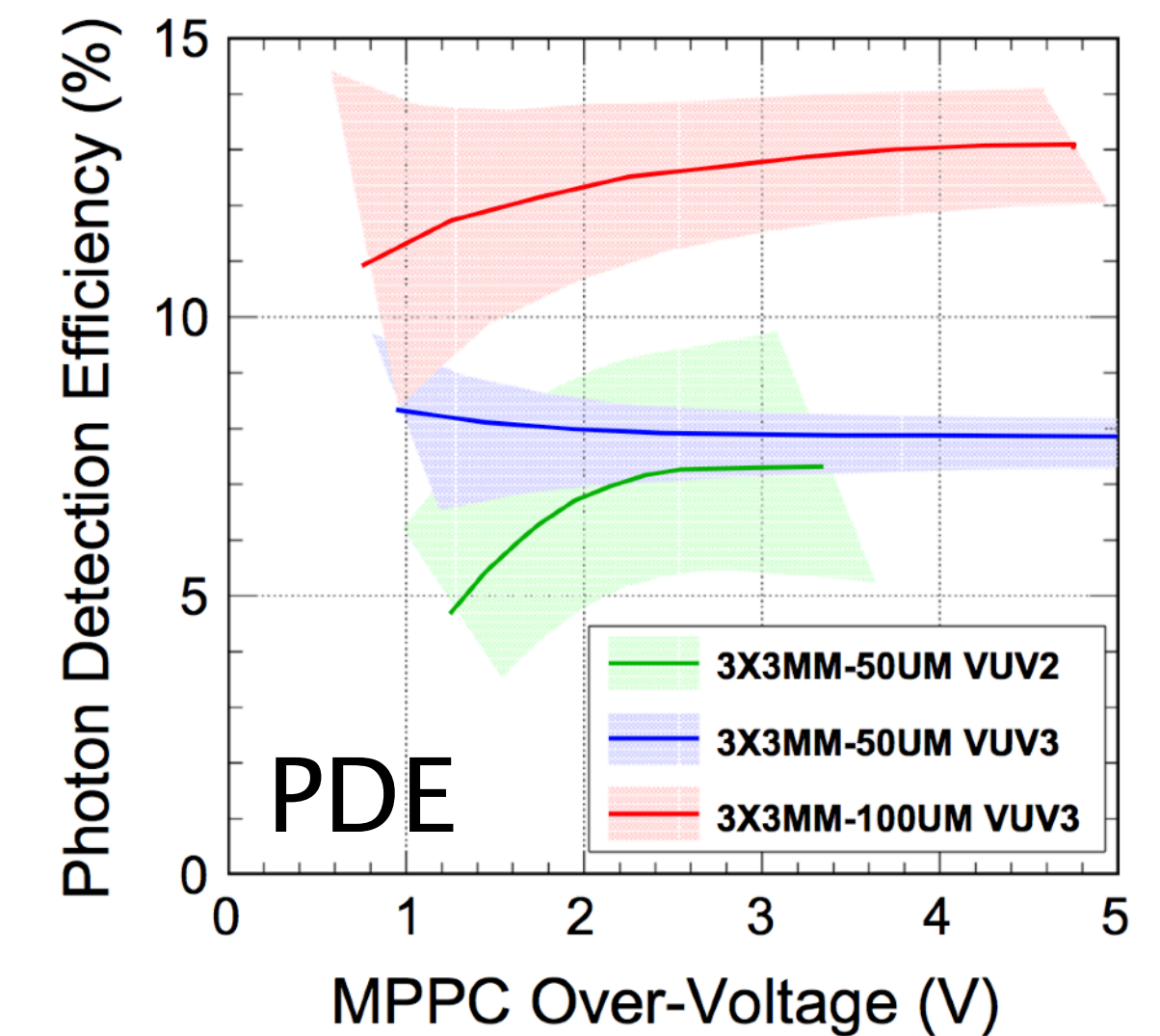
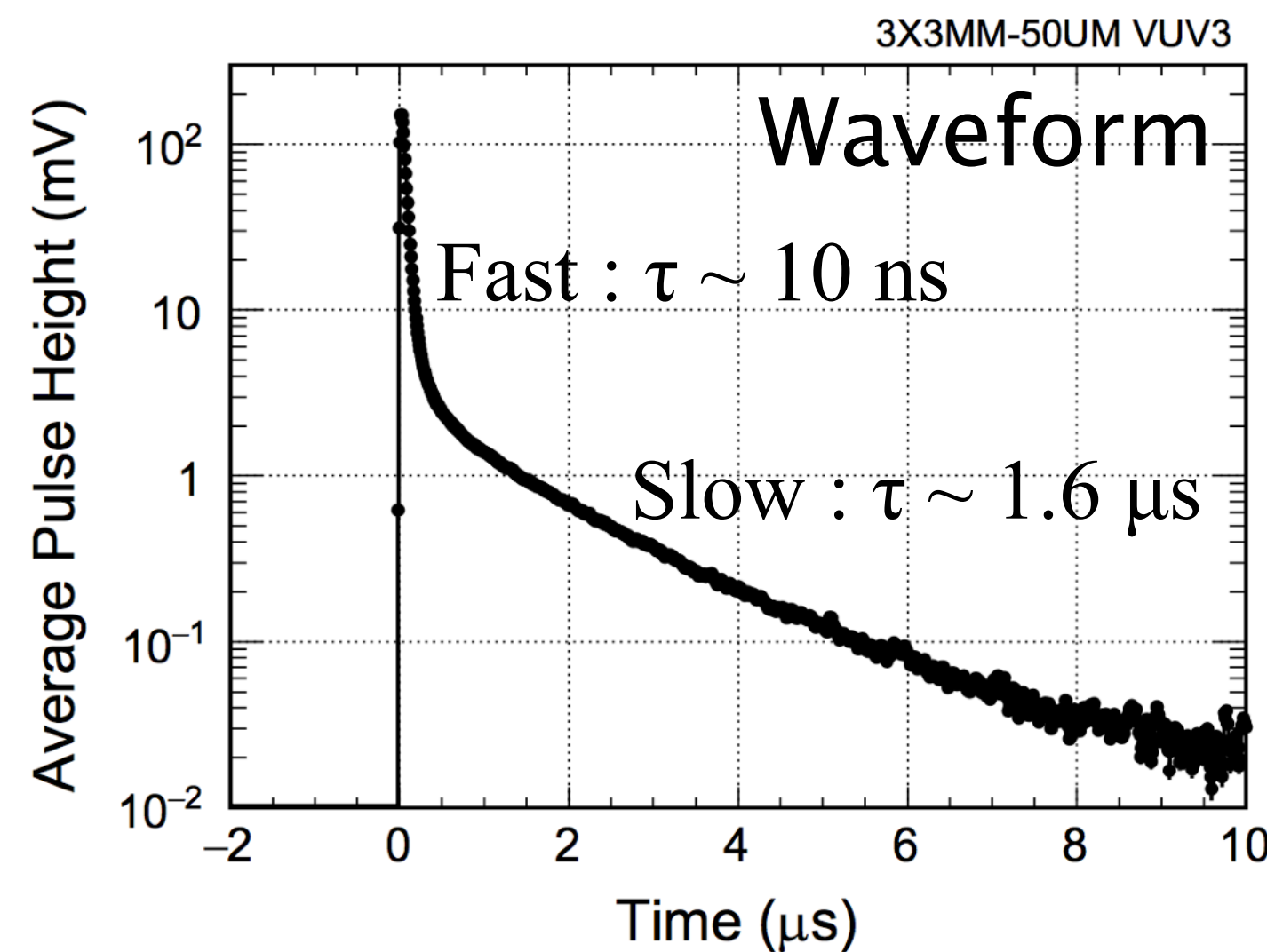
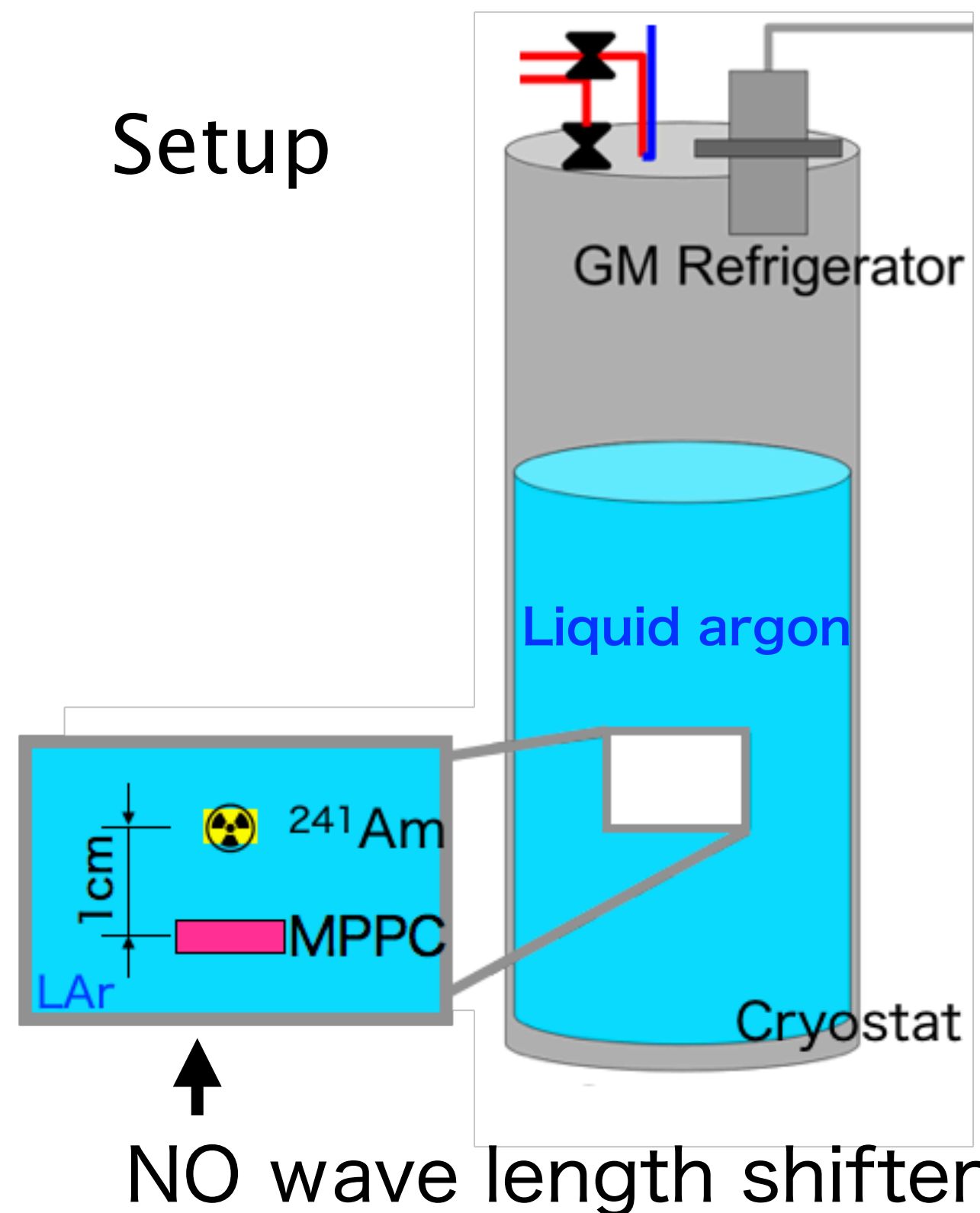
VUV-MPPC

See detail :
NIM A 833, 239-244 (2016)



- : SiPM developed by HAMAMATSU.
- : Sensitive to vacuum ultra violet (VUV) light ($\lambda = 128$ nm).

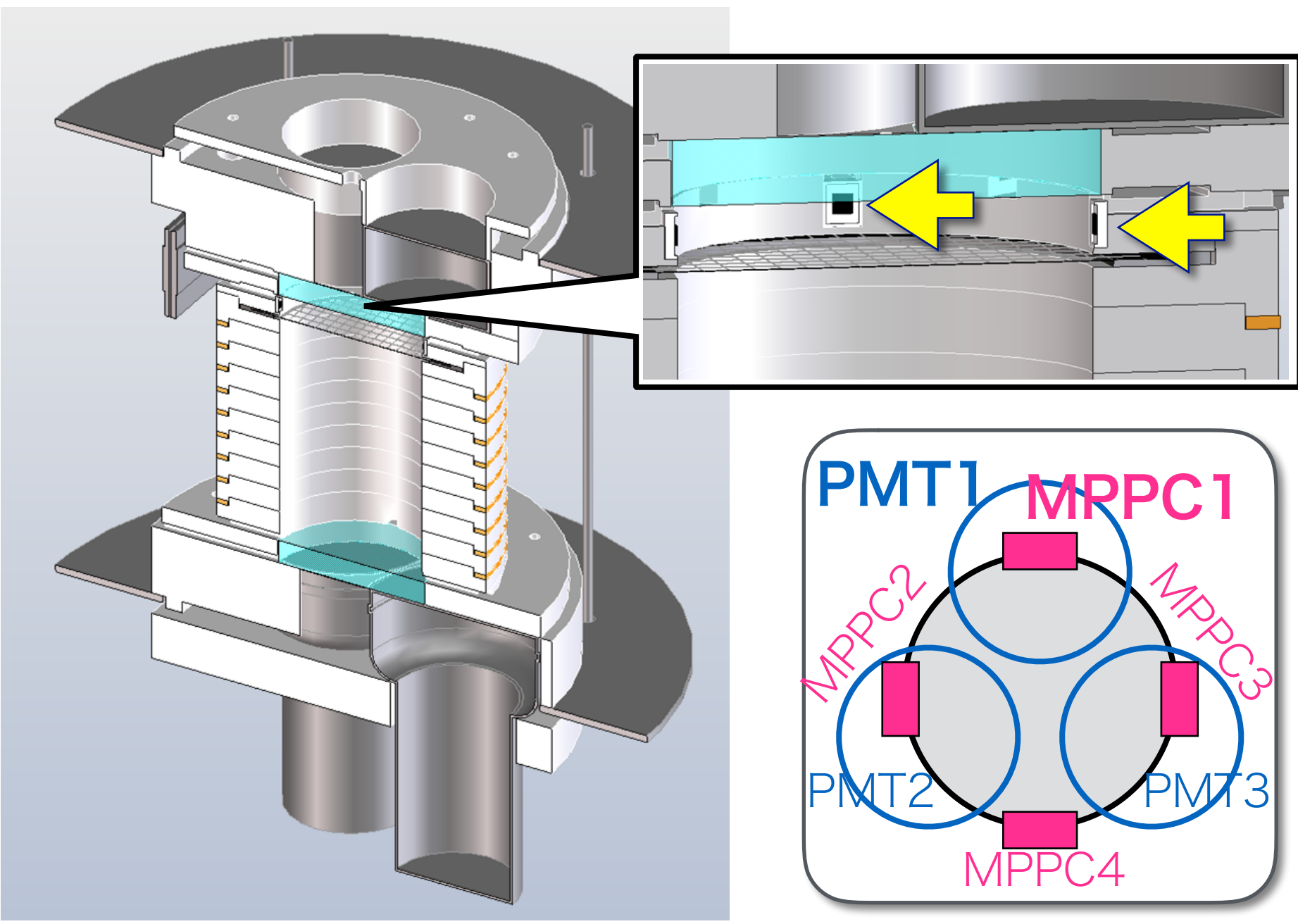
LAr scintillation light detection



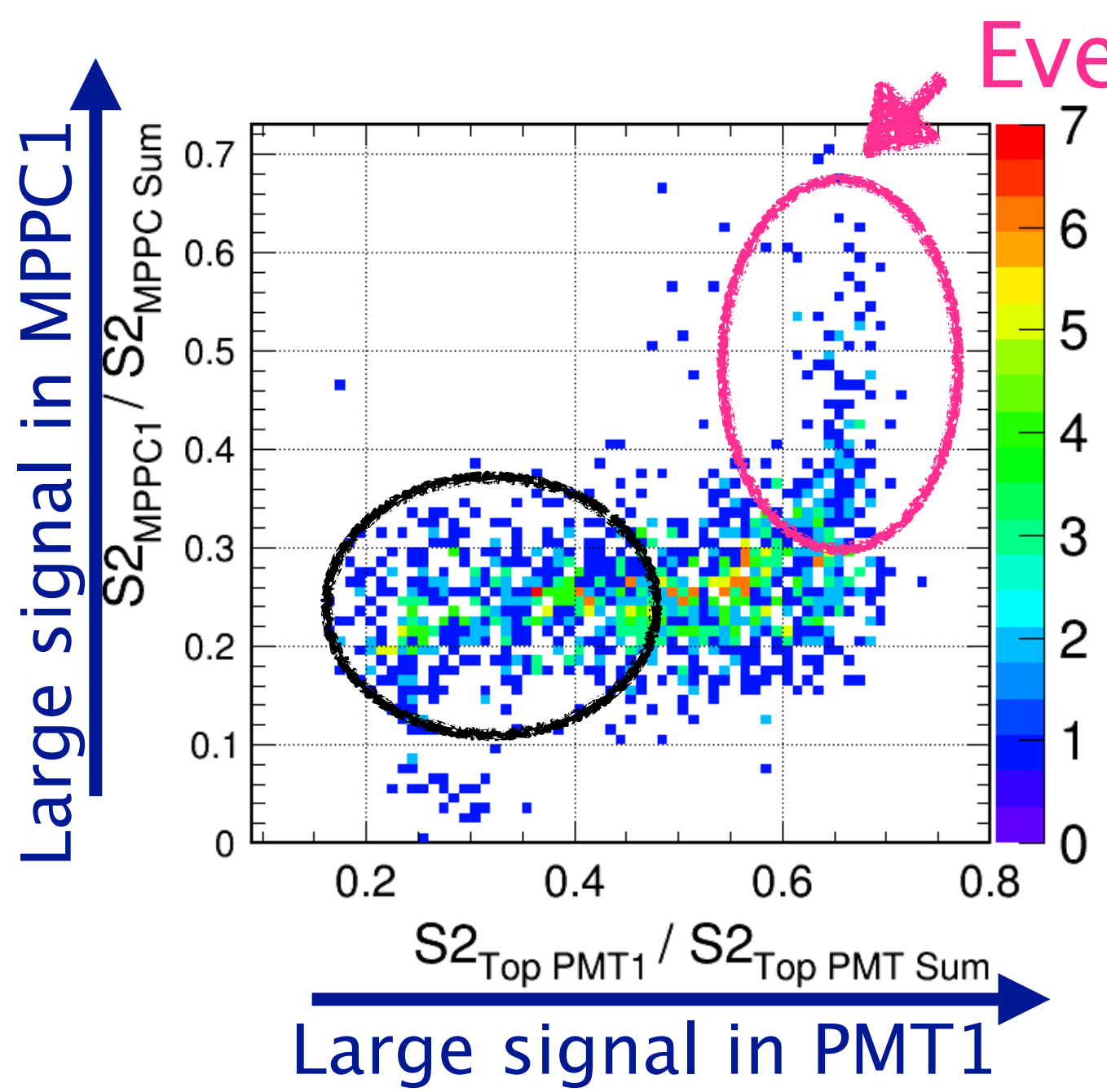
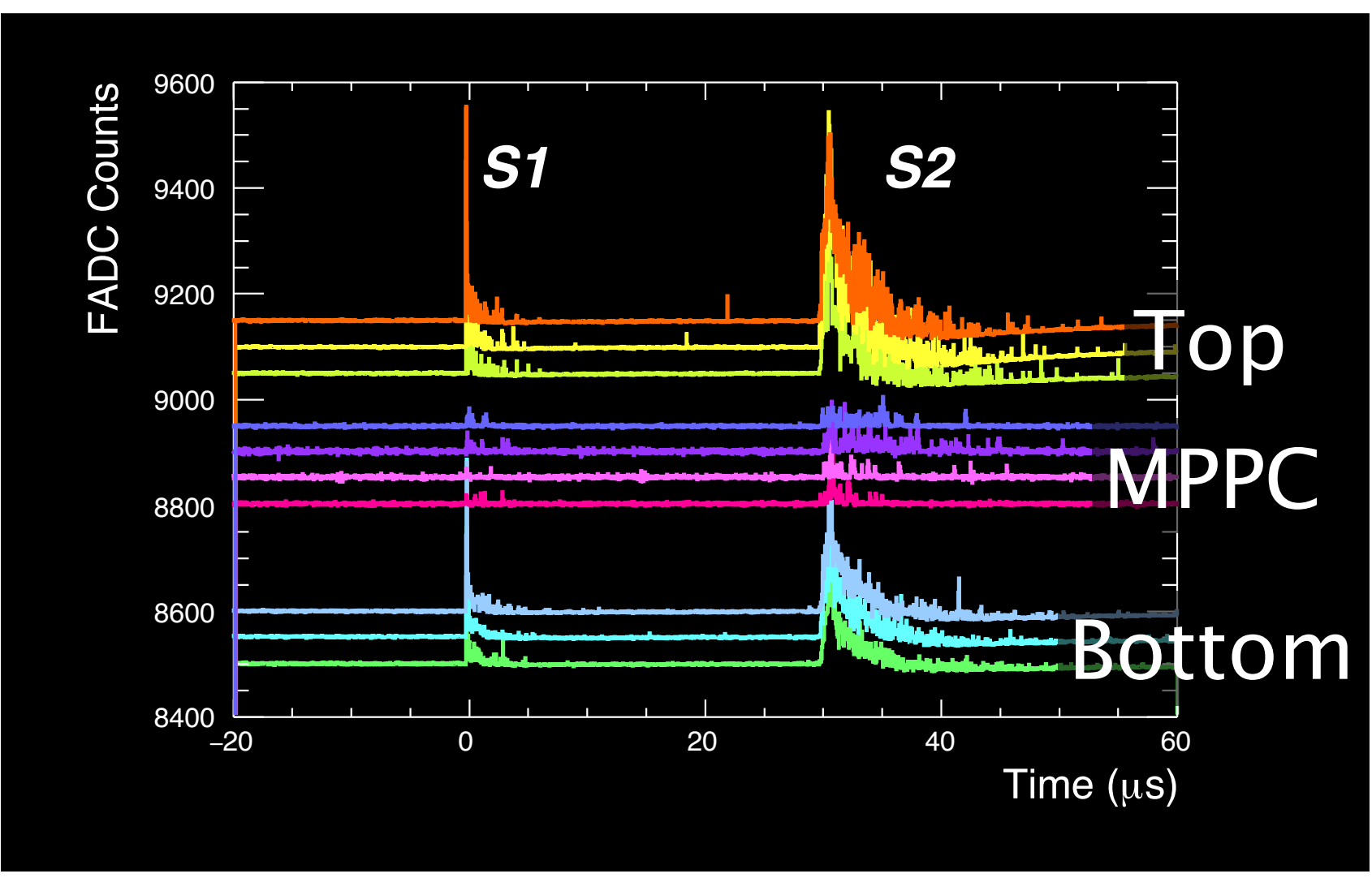
- Direct detection of LAr scintillation light.
- ~13% of photon detection efficiency (PDE).
- Development to improve PDE is ongoing.



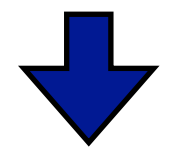
Spatial resolution Improvement with VUV-MPPC



- : 3 PMTs in each of top and bottom side.
- : 4 VUV-MPPCs on liquid surface wall.



Potential to improve spatial resolution near detector wall.



Better fiducialization.



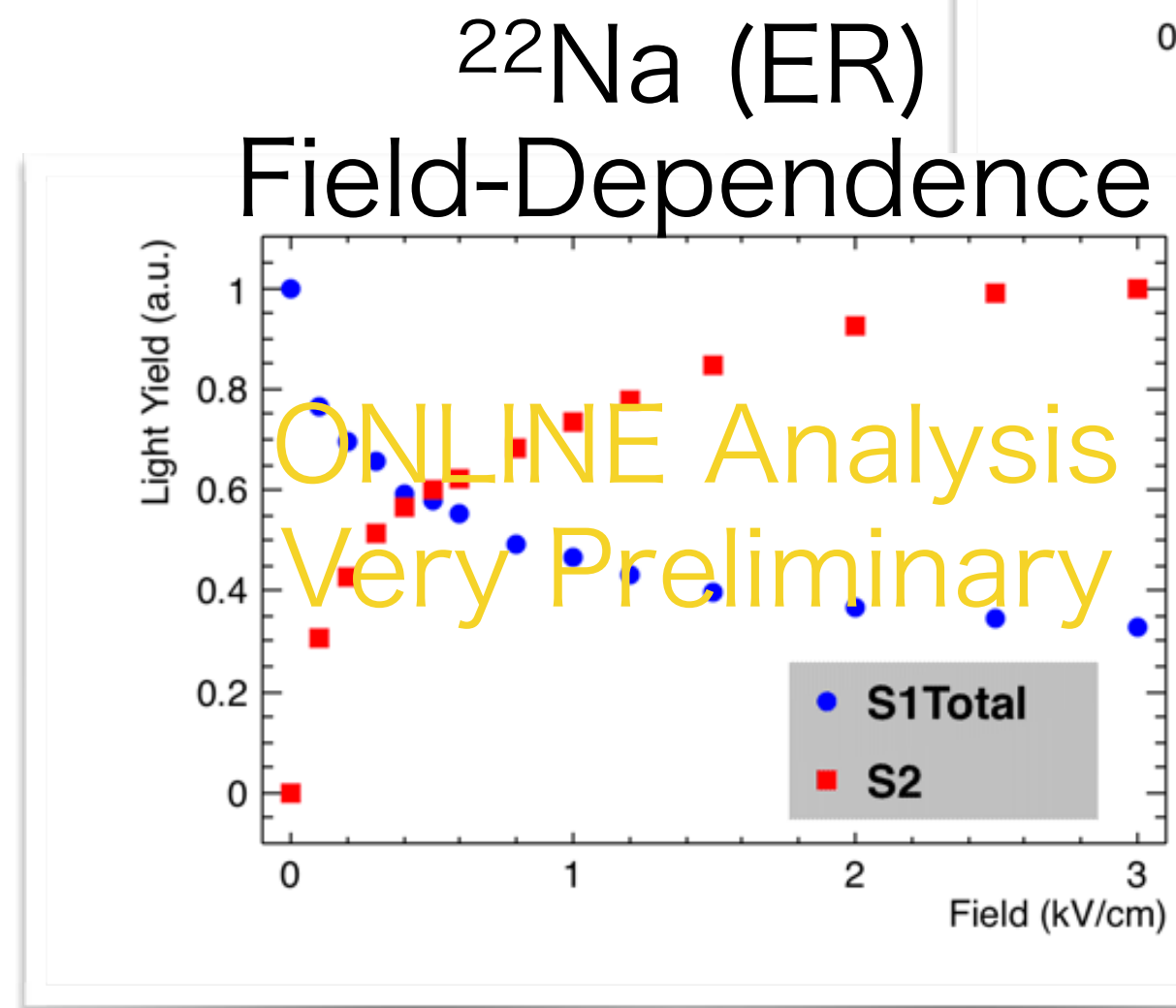
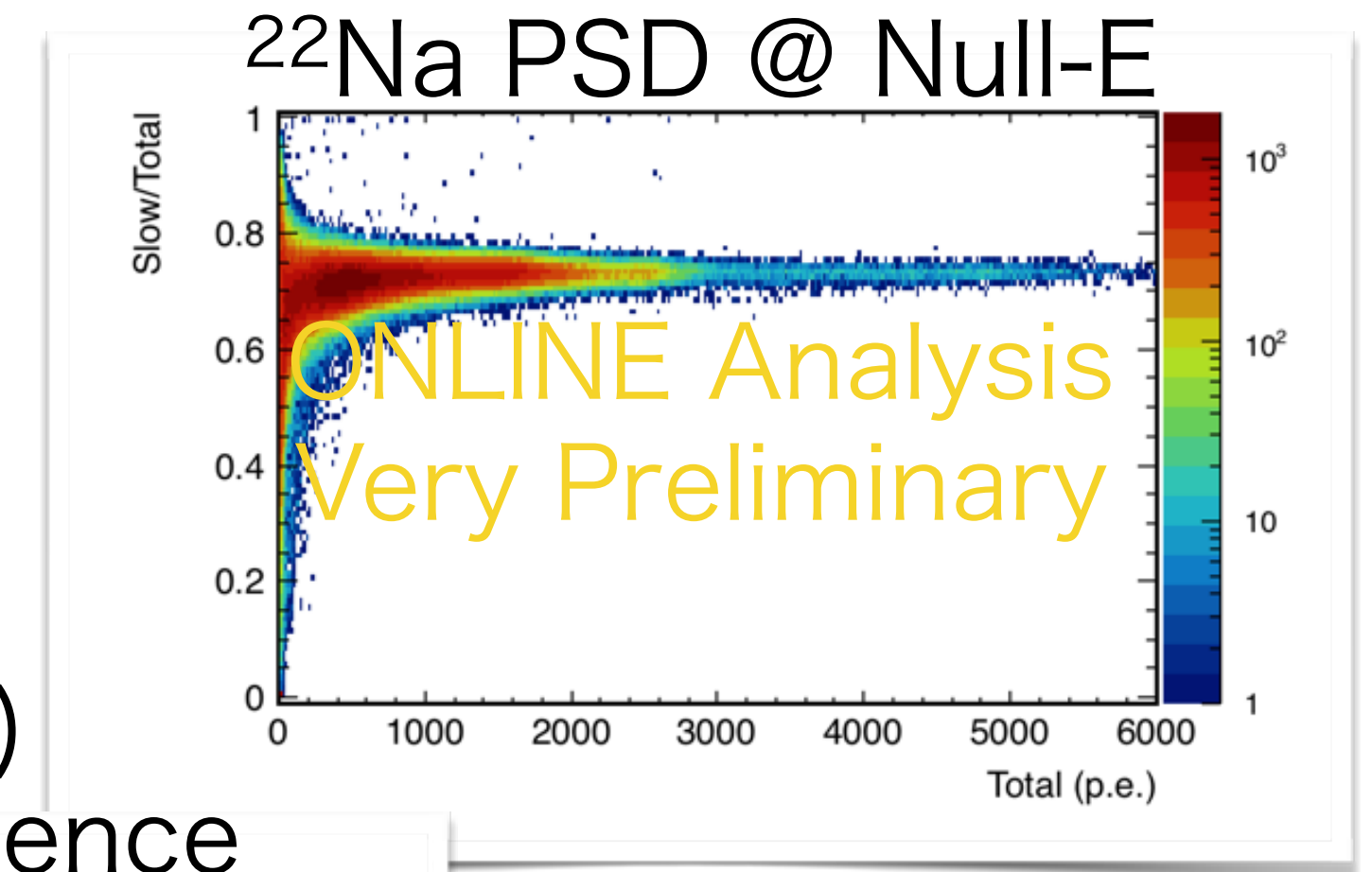
Ongoing Efforts

- Recently, we have collected data with **low energy events** in wide range of electric field ($E_d \lesssim 3.0 \text{ kV/cm}$).

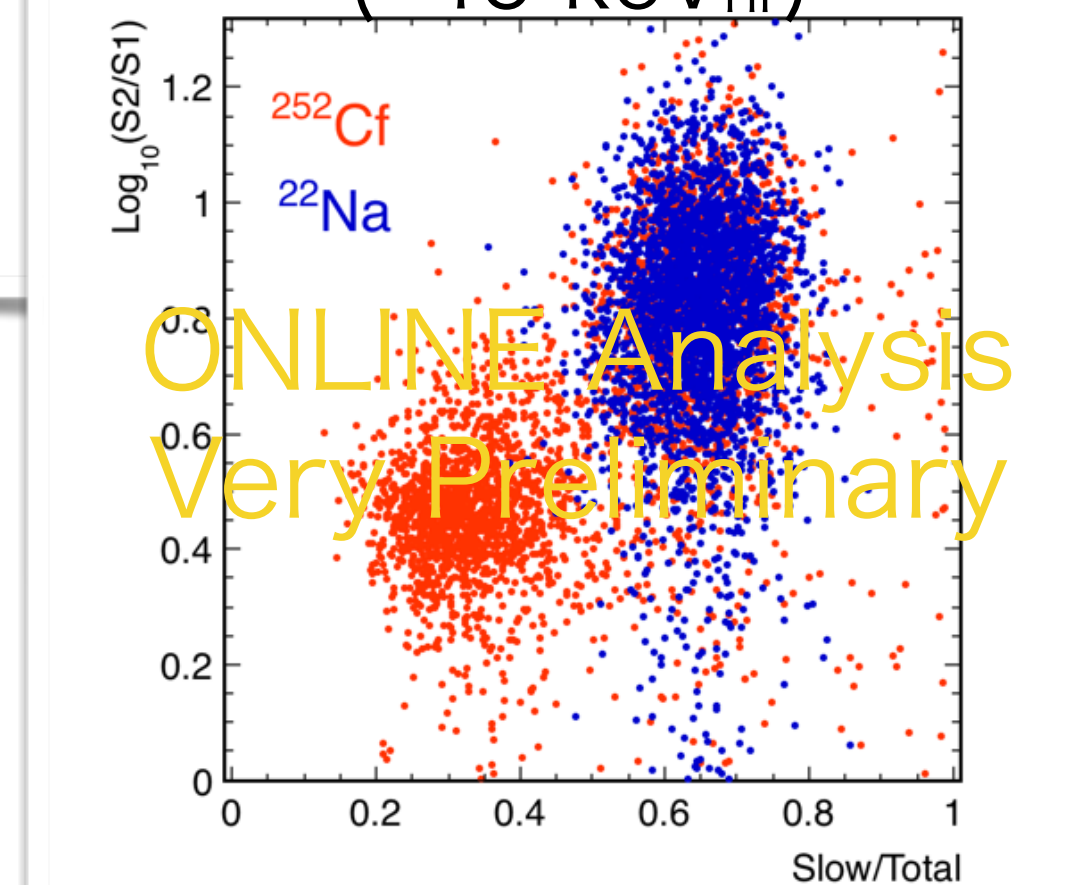


The detailed understandings will be obtained near future.

- We plan to construct small size **high light yield detector** using Normal and/or VUV SiPM.



PID @ 2.0 kV/cm
(~40 keV_{nr})



Summary & Future Prospects ¹⁴

- : ANKOK Dark Matter Search Project.
 - **Low mass ($\sim 10 \text{ GeV}/c^2$) WIMP search by argon**, test of the “DAMA” signal.
 - Compact and inexpensive detector.
- : **Ongoing Efforts for Lower Energy Threshold.**
 - Detailed understandings of LAr response and PID power under electric field.
 - Development of new photo-devise directory sensitive to LAr scintillation light.
- : **Future Prospects.**
 - Understanding of liquid argon response under high electric field.
 - Design and study of high sensitive detector using SiPM.
 - Test low energy threshold detector at surface.
 - > Go Kamioka underground observatory.



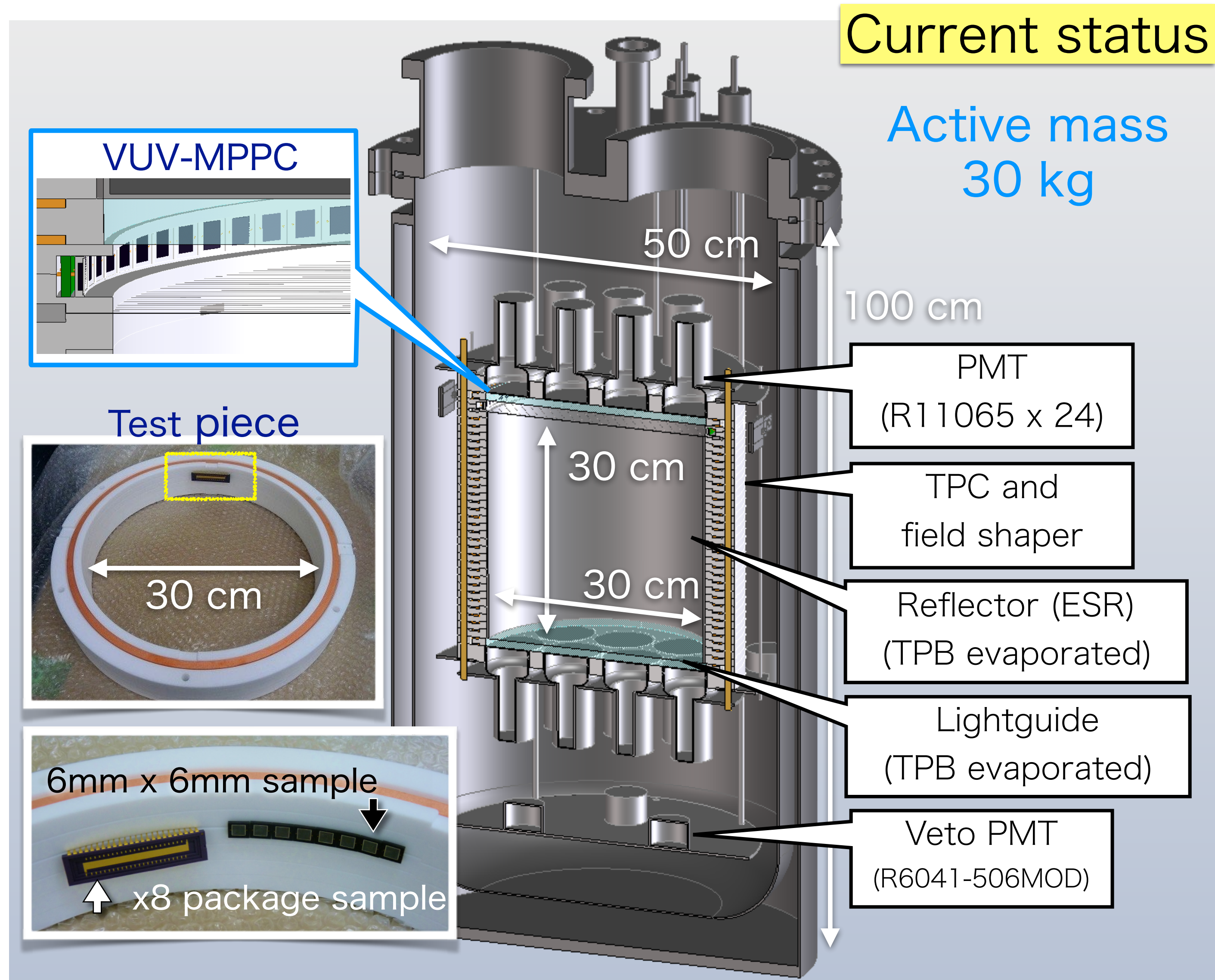
Backup



WASEDA University

30 kg Detector

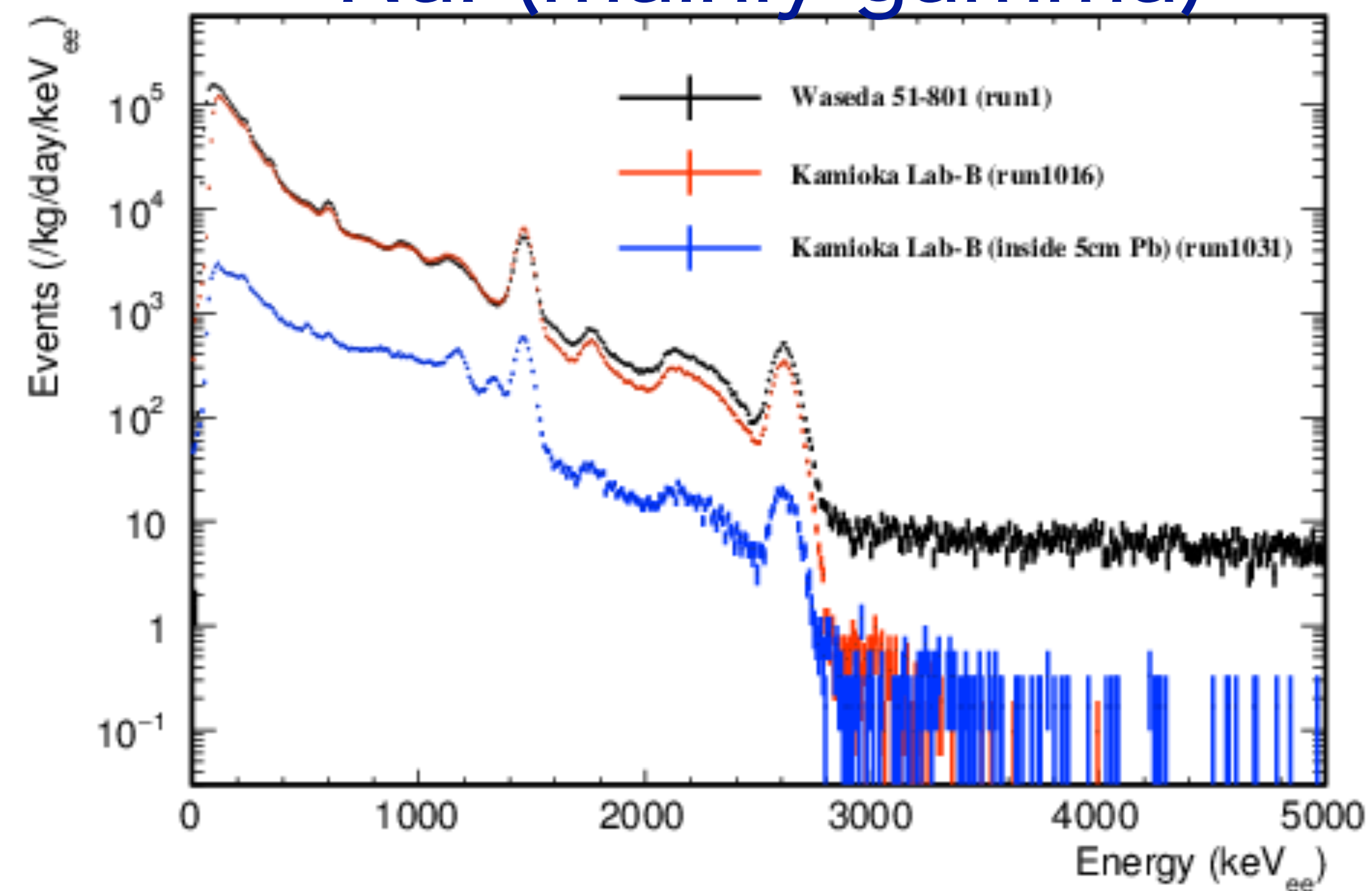
Under design and construction.¹⁶
- 30 kg active mass



Background @ Kamioka

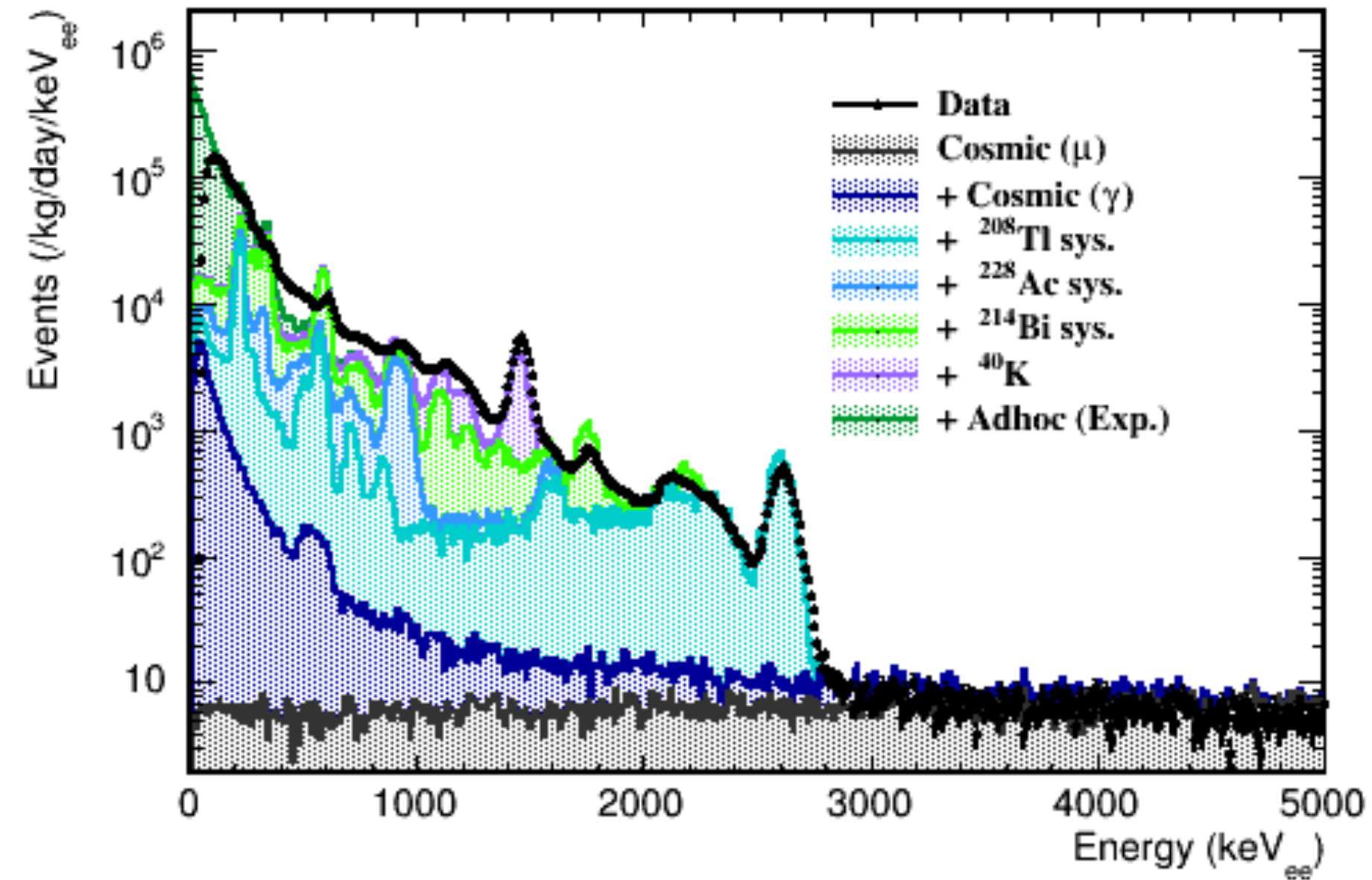
- : Precise measurement of environmental neutron/ γ -ray flux at Kamioka is ongoing.
- Collaboration with NEWAGE, CANDLES, NEWSdm and XMASS.
 - Liquid scintillator, ^3He counter and NaI scintillator.

NaI (mainly gamma)

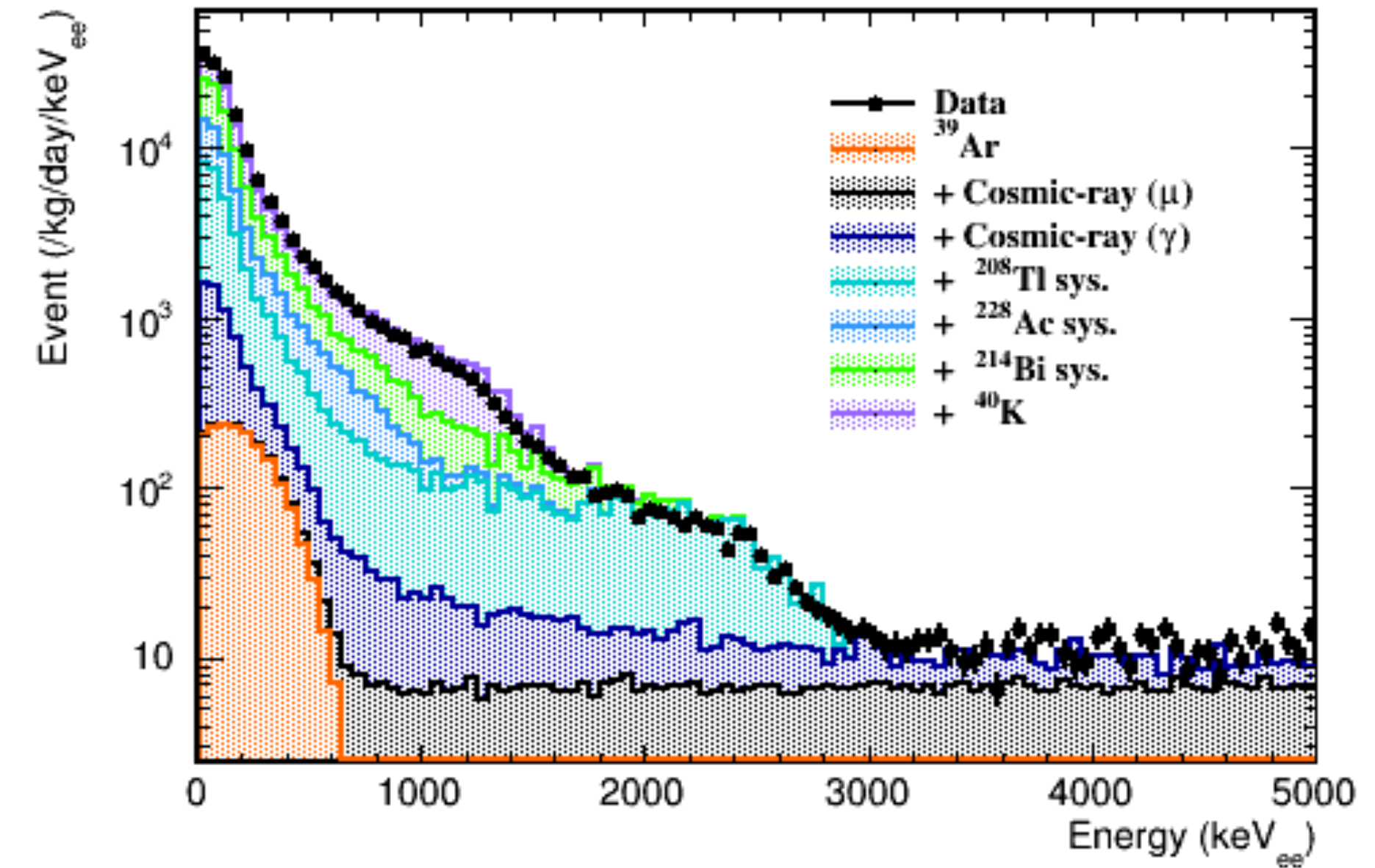


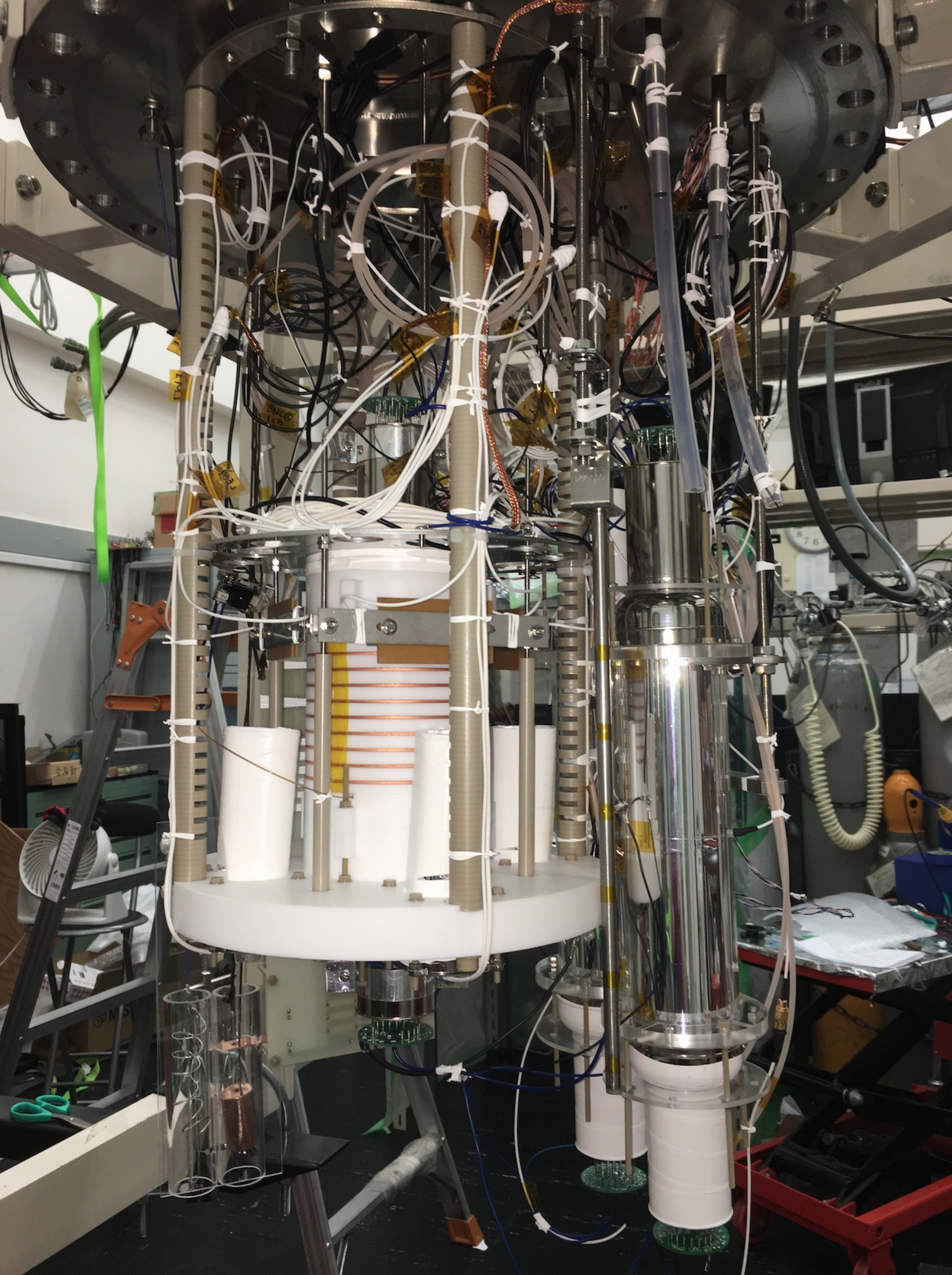
Environmental Gamma

NaI (PHITS[1])



LAr (Geant4)





ANKOK Project

“ANKOK” = 暗黒
(=Darkness, Blackness)

Arugon **N**isougata **K**ensyutuki **O** **K**
(アルゴン2相型検出器)

