

# Present status of experiment for Zirconium-96 two neutrino emission double beta decay

The XXXI International Conference on Neutrino Physics and Astrophysics (NEUTRINO 2024)

June 16 – 22 2024 Milan, Italy

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Supported by Grant-in-Aid for Scientific Research on Innovative Areas 20H05241, 19H05093 and Scientific Research (B) 22H01243, 23K22514

## 1. ZICOS (<sup>96</sup>Zr DBD experiment)

### ◆ Neutrinoless Double Beta Decay

#### ● Lifetime and neutrino mass

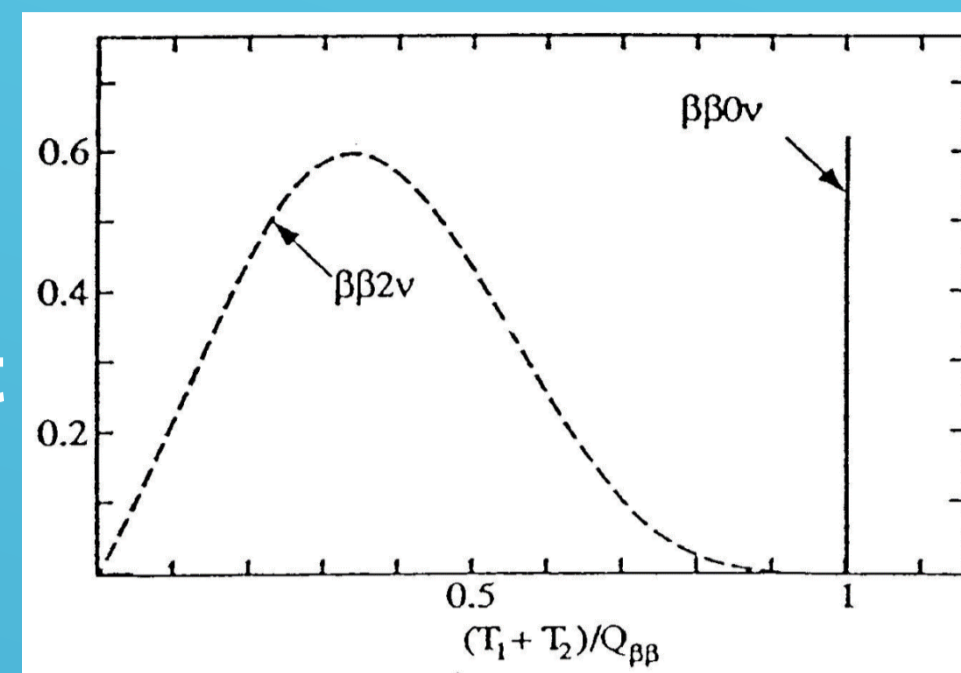
$$[T_{1/2}(0^+ \rightarrow 0^+)]^{-1} = G_{0\nu}(E_0, Z) |M_{0\nu}|^2 < m_\nu >^2$$

#### ● Energy spectrum and lifetime measurement

• monochromatic energy at Q-value

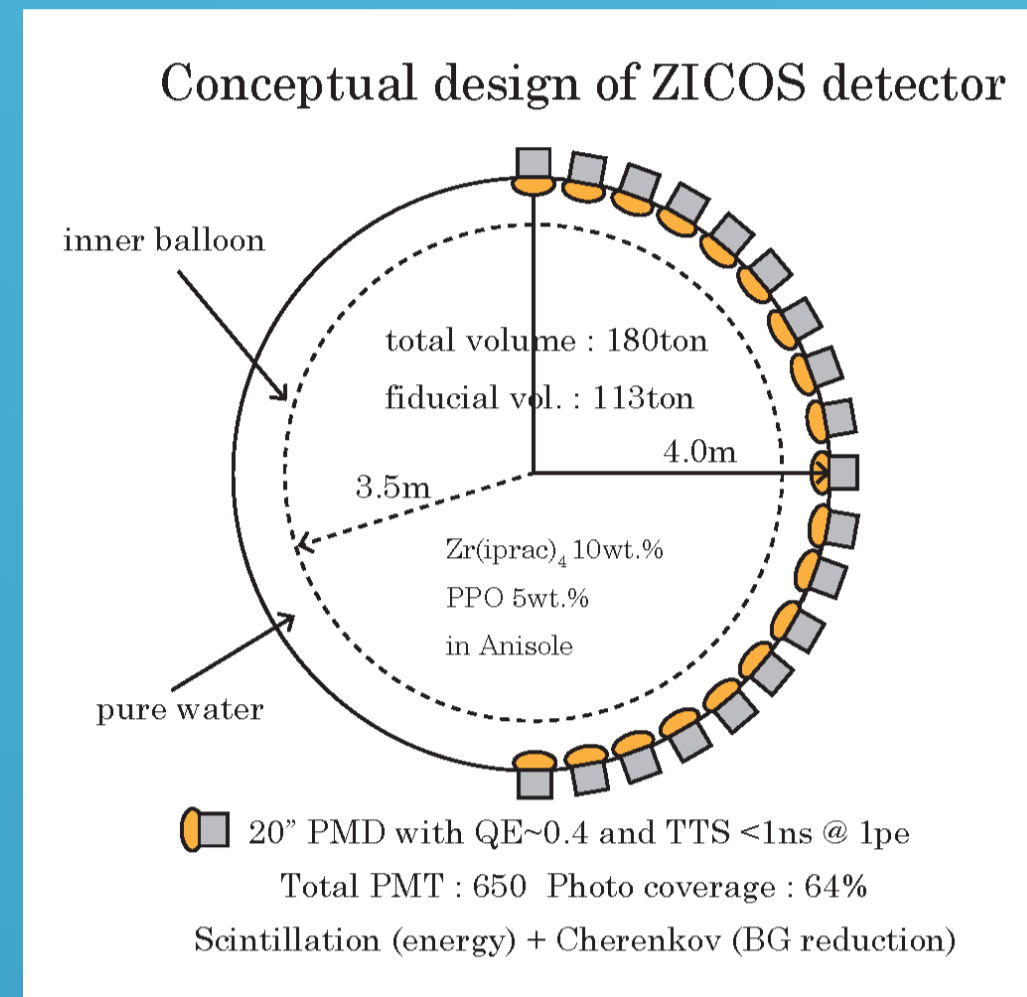
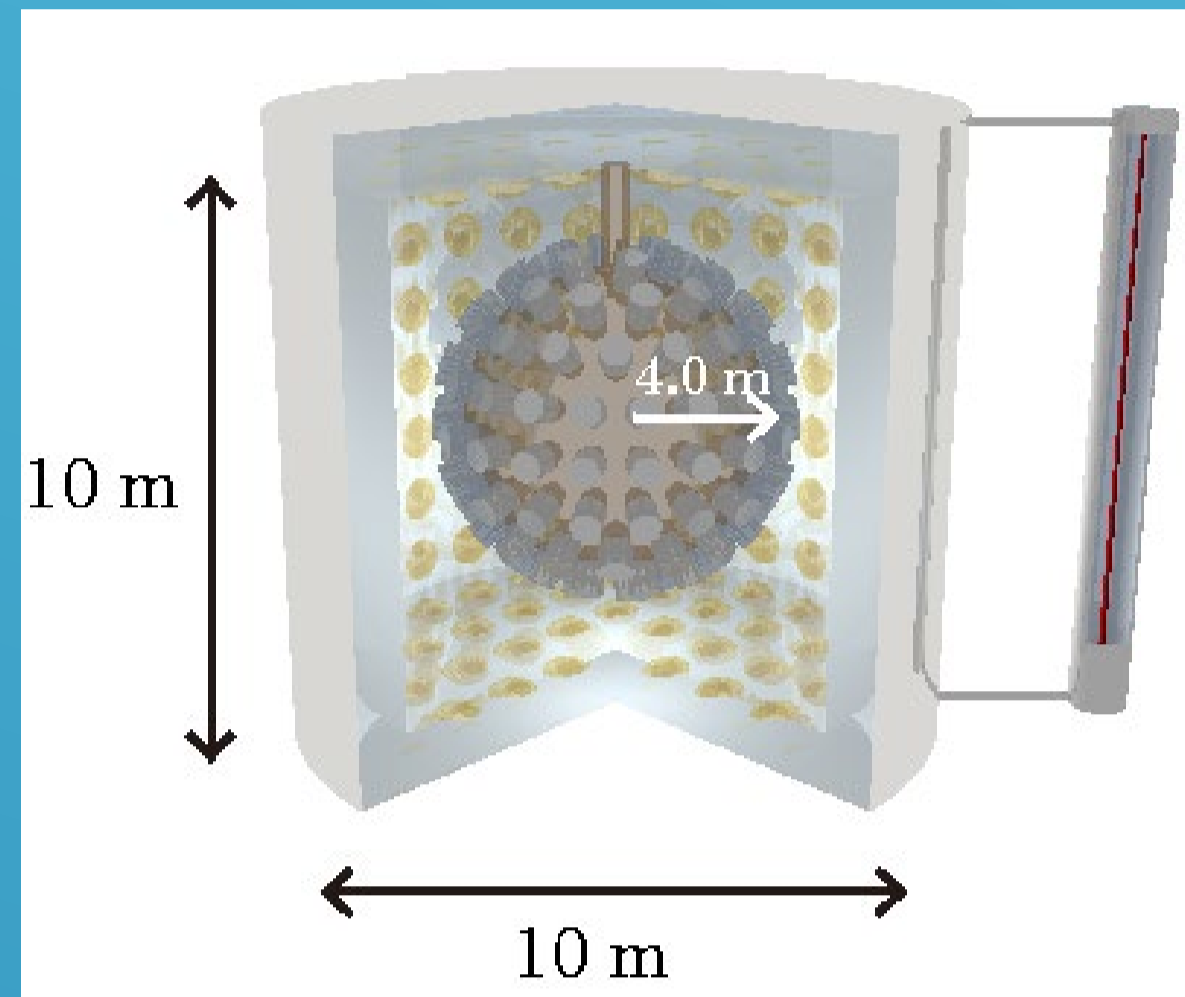
•  $T_{1/2} \sim a(Mt/\Delta E B)$  a: abundance M: mass

t: meas.time  $\Delta E$ : energy res. B: BG rate



**Low background rate, Large target mass and High energy resolution**

### ◆ Detector Design for ZICOS Experiment



#### Detector :

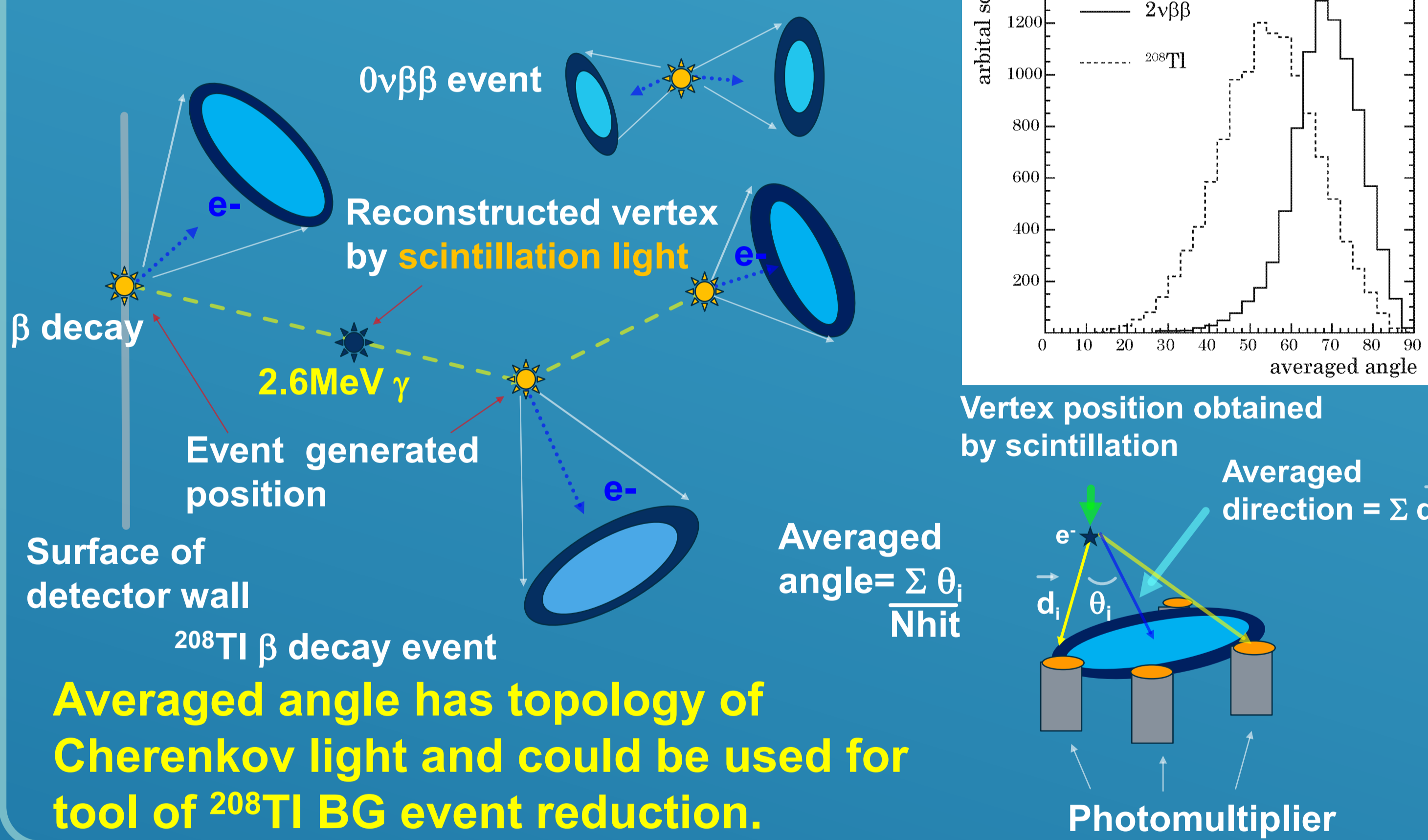
- 1) 180tons LS : 10 wt.% tetrakis-(isopropyl acetoacetato)zirconium : Zr(iPrac)<sub>4</sub> 5 wt.% PPO in Anisole.
- 2) Fast rise time and TTS PMT with 64% photo coverage.

#### Expected performance :

- 1) Energy resolution  $\sim 2.8\%$  @ 3.35MeV
- 2)  $T_{1/2}(0\nu\beta\beta) > 10^{27}$  years if both 1/20 BG reduction using Topology of Cherenkov light and 50% <sup>96</sup>Zr enrichment could be achieved.

## 2. How to reduce <sup>208</sup>Tl BG events

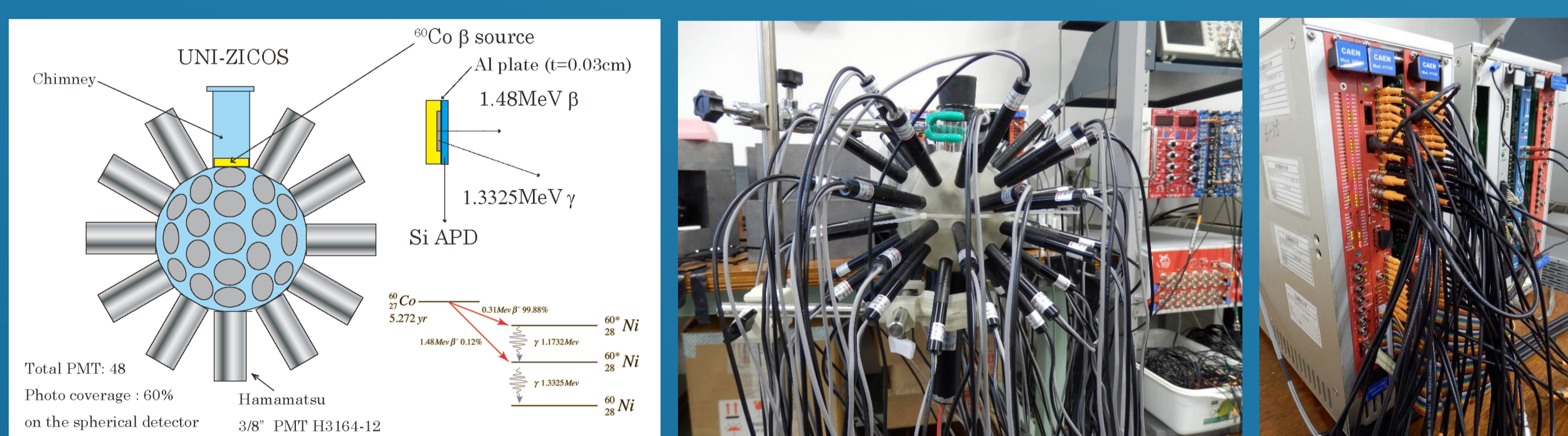
### ◆ Conceptual Idea using Cherenkov Lights



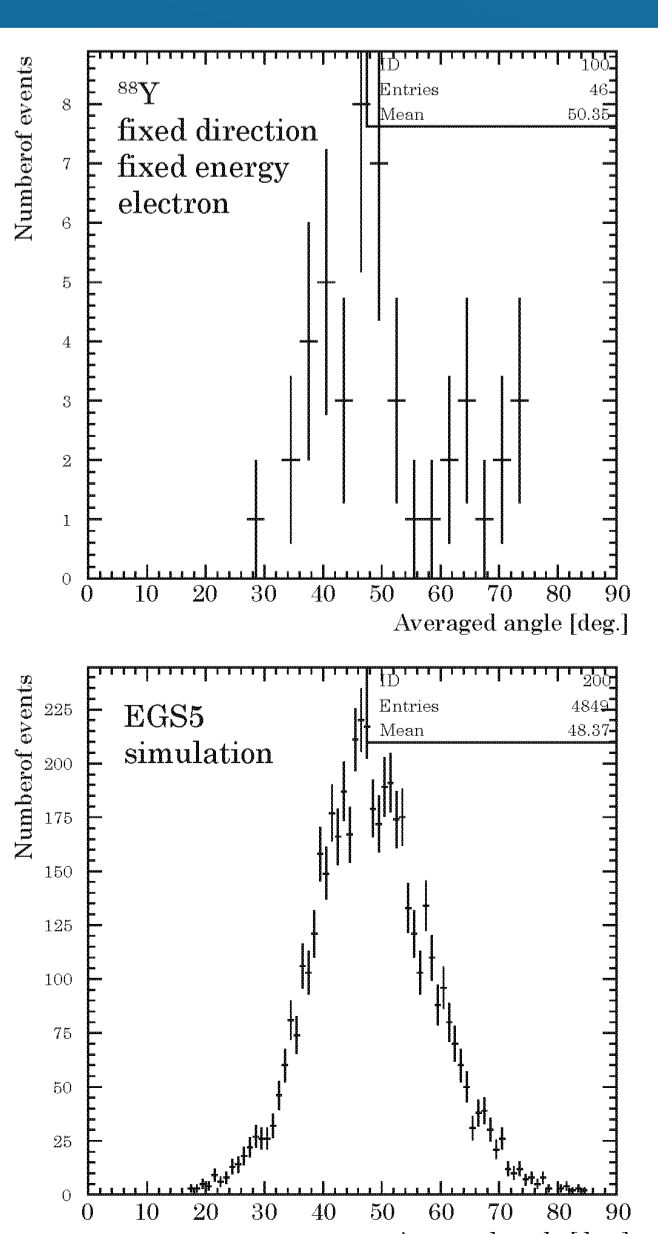
**Averaged angle has topology of Cherenkov light and could be used for tool of <sup>208</sup>Tl BG event reduction.**

## 3. Demonstration of BG reduction

### ◆ Direct Observation of Averaged Angle for Cherenkov Lights



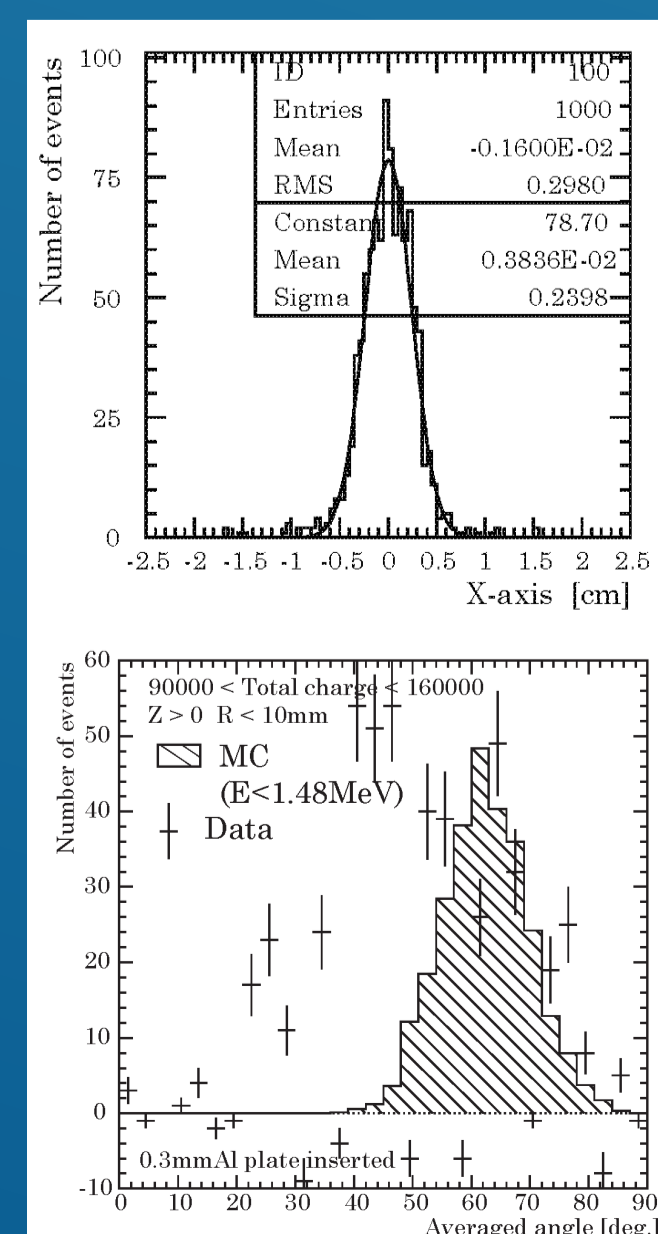
#### ◆ Observed Averaged Angle using <sup>88</sup>Y FDFE Events



- Averaged angle was clustered around 45 deg for electrons with fixed direction and fixed energy.
- Simulation indicates also a peak around 48 deg. as expected.

**Averaged angle is really observed.**

#### ◆ Expected Averaged Angle using <sup>60</sup>Co Beta-Gamma

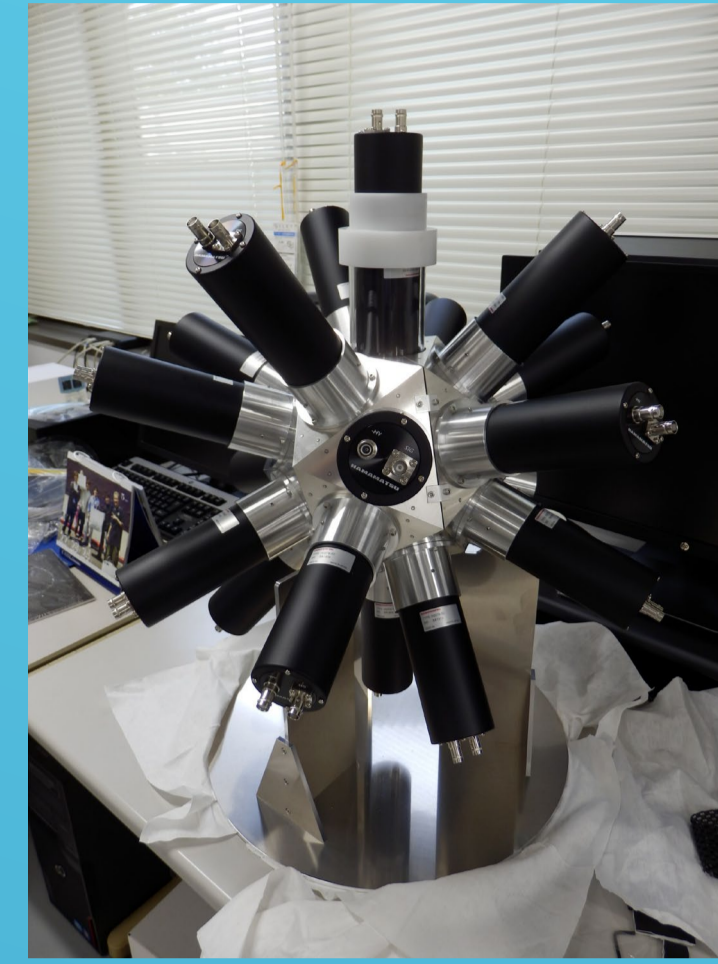


- Vertex position was reconstructed by assuming all PMTs have same effective charge.
- Averaged angle of <sup>60</sup>Co  $\beta\gamma$  events has a peak around 60 deg.

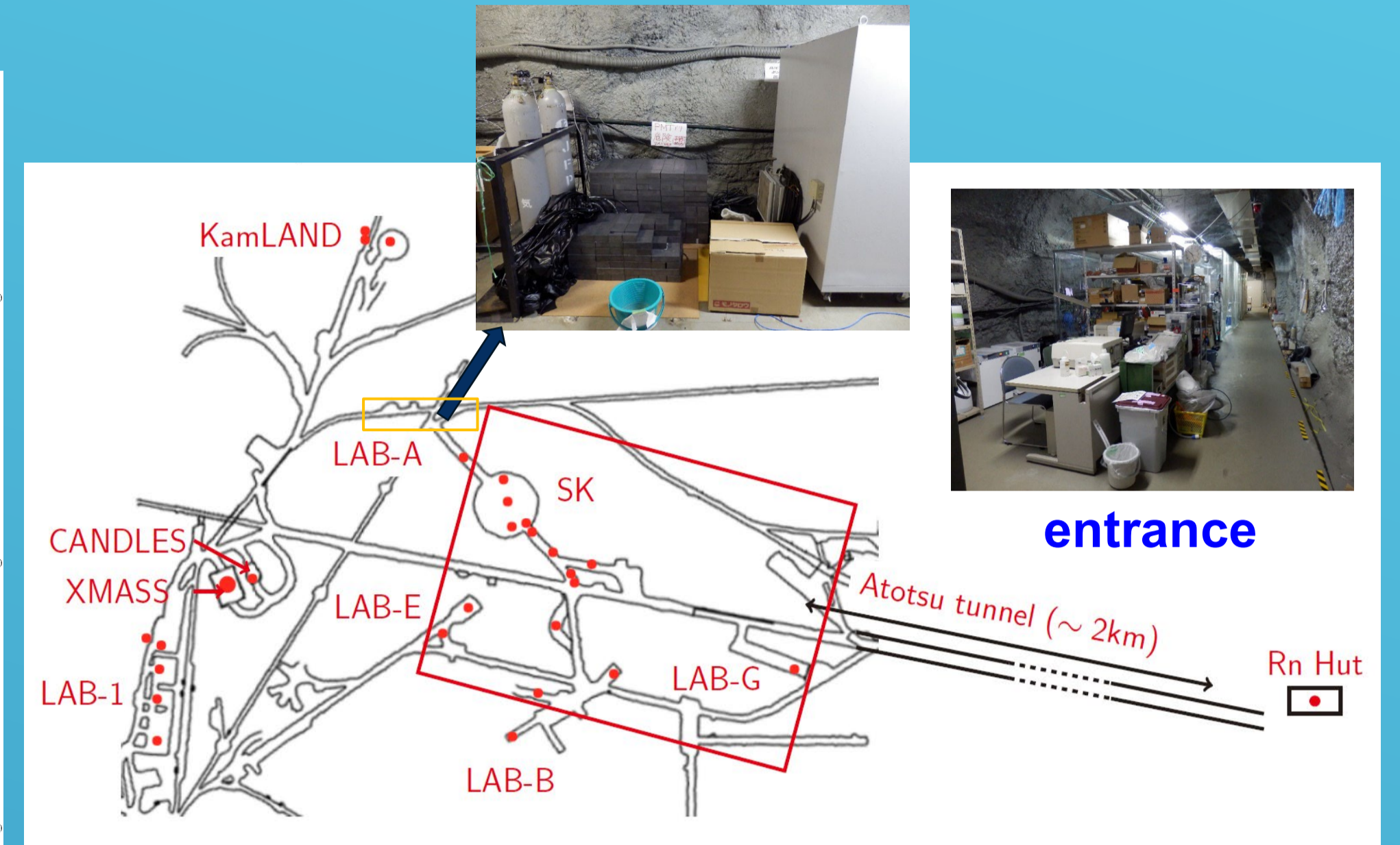
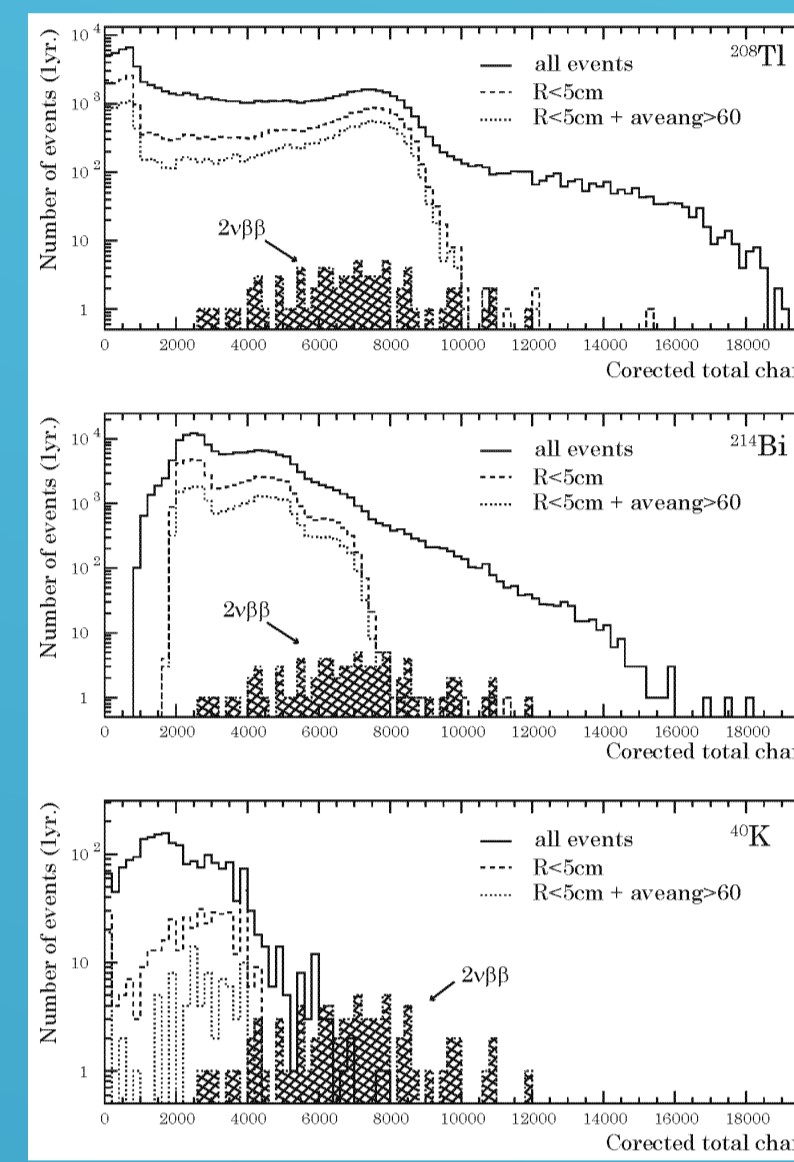
**Averaged angle could reduce <sup>208</sup>Tl BG events.**

## 4. <sup>98</sup>Zr two neutrino emission DBD

### ◆ 2 $\nu$ -ZICOS Detector

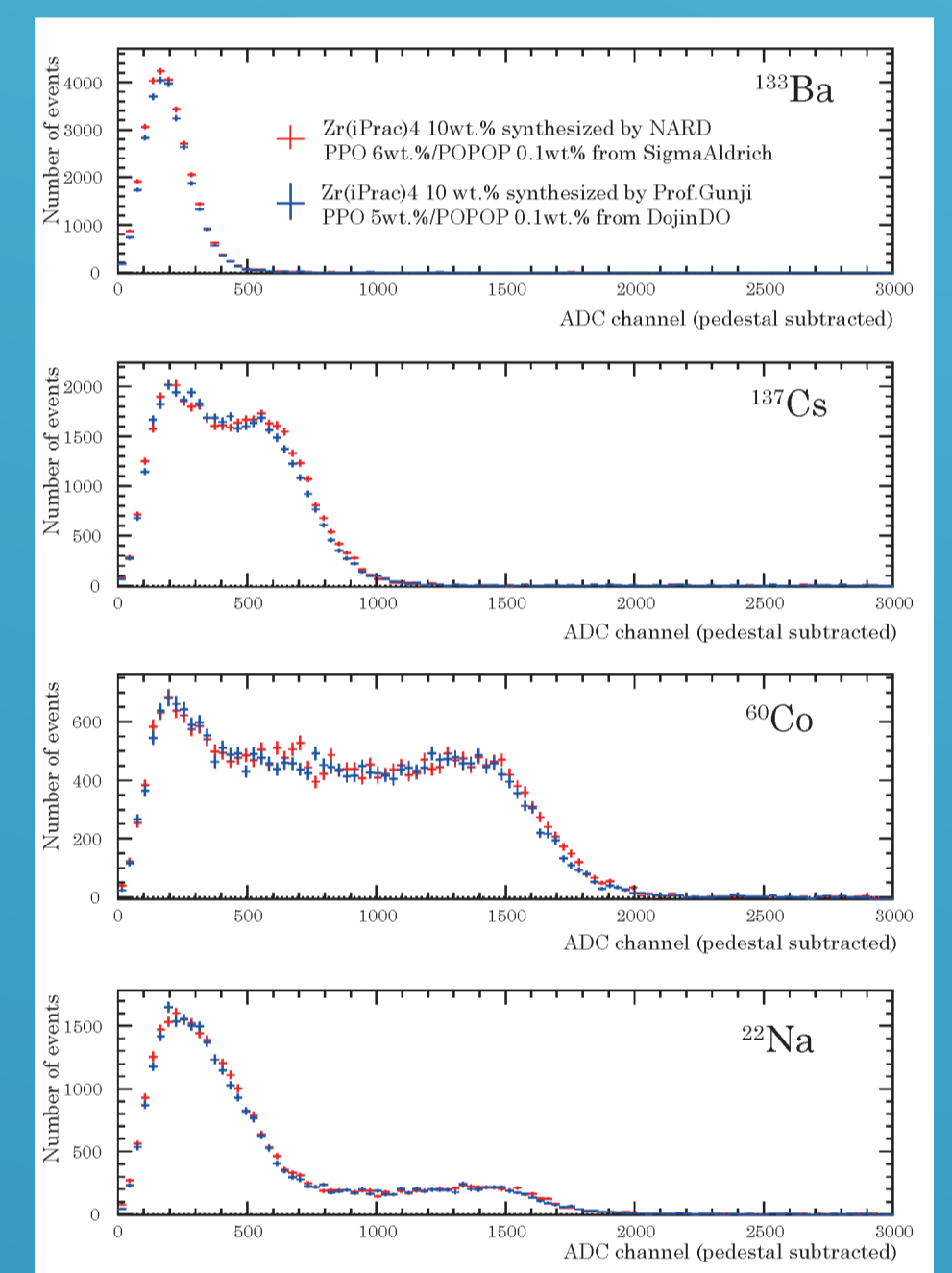


- 16 cm diameter round bottom flask using Ultra-Pure Quartz (GE214) [Th 15ng/g, U 29ng/g]
- 20 low BG 2" PMT Hamamatsu H3378-50
- Al regular icosahedron PMT mounting jig
- ZICOS liquid scintillator [Th < 50ng/g, U < 50ng/g] 1L loaded 100g Zr(iPrac)<sub>4</sub> corresponds 0.4 <sup>96</sup>Zr.
- Expected number of 2 $\nu\beta\beta$  events :  $\sim 100$  per year.
- Experimental site : LAB-A in Kamioka mine



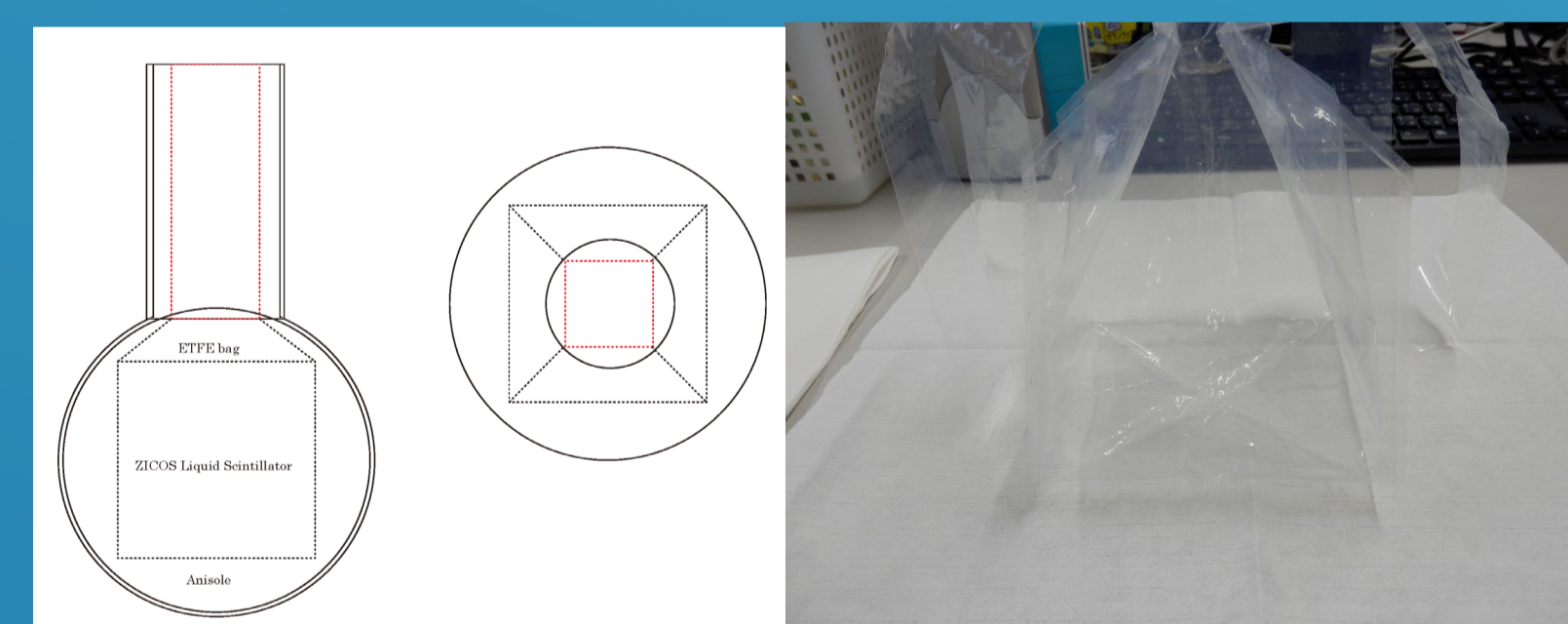
## 5. Present status of 2 $\nu$ -ZICOS exp.

### ◆ Preparation of 2 Little ZICOS Liquid Scintillator



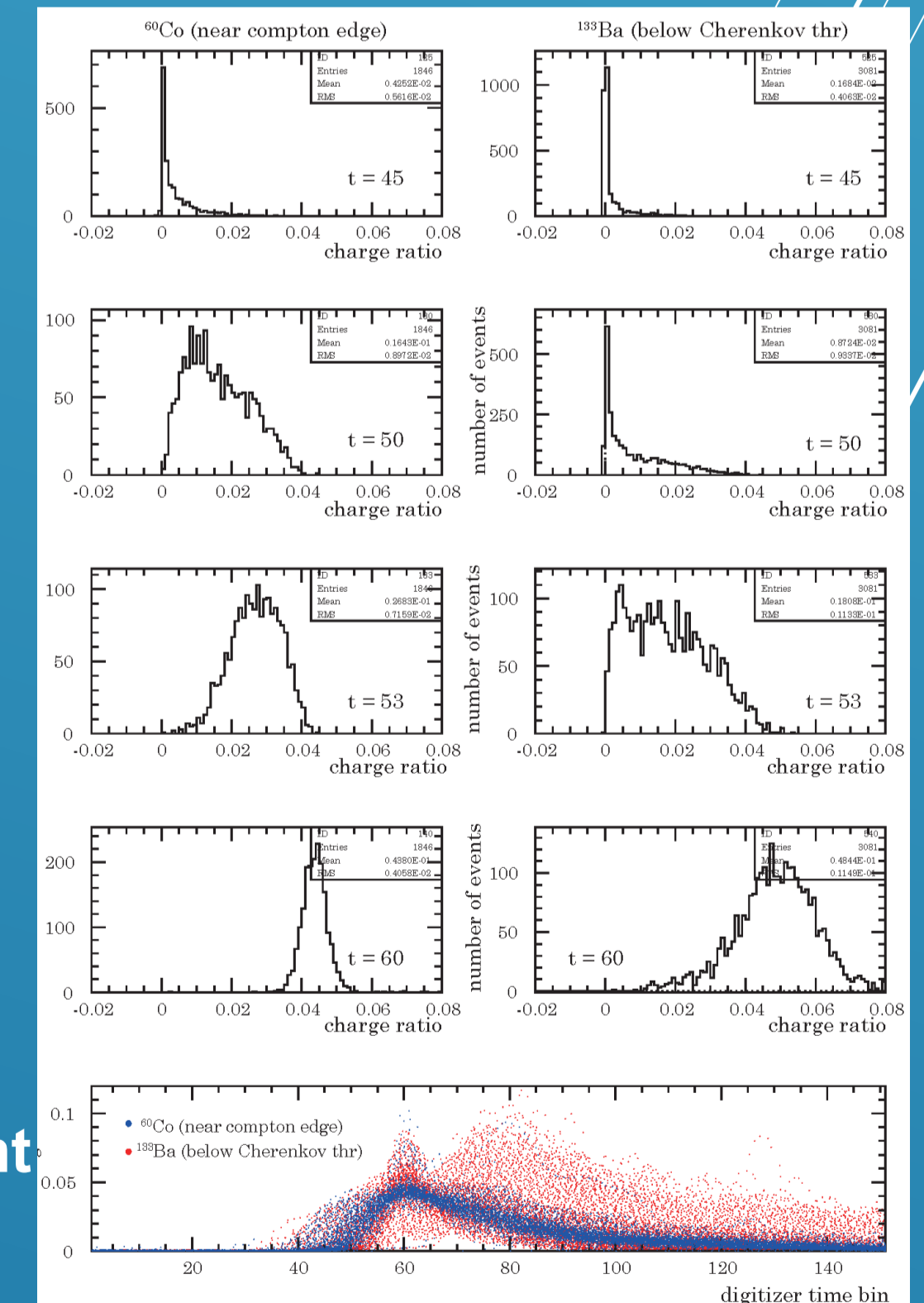
**No difference between liquid scintillator with old Zr(iPrac)<sub>4</sub> synthesized by Prof. Gunji and new Zr(iPrac)<sub>4</sub> synthesized by NARD Institute.**

### ◆ ETFE Cubic Bag for ZICOS LS

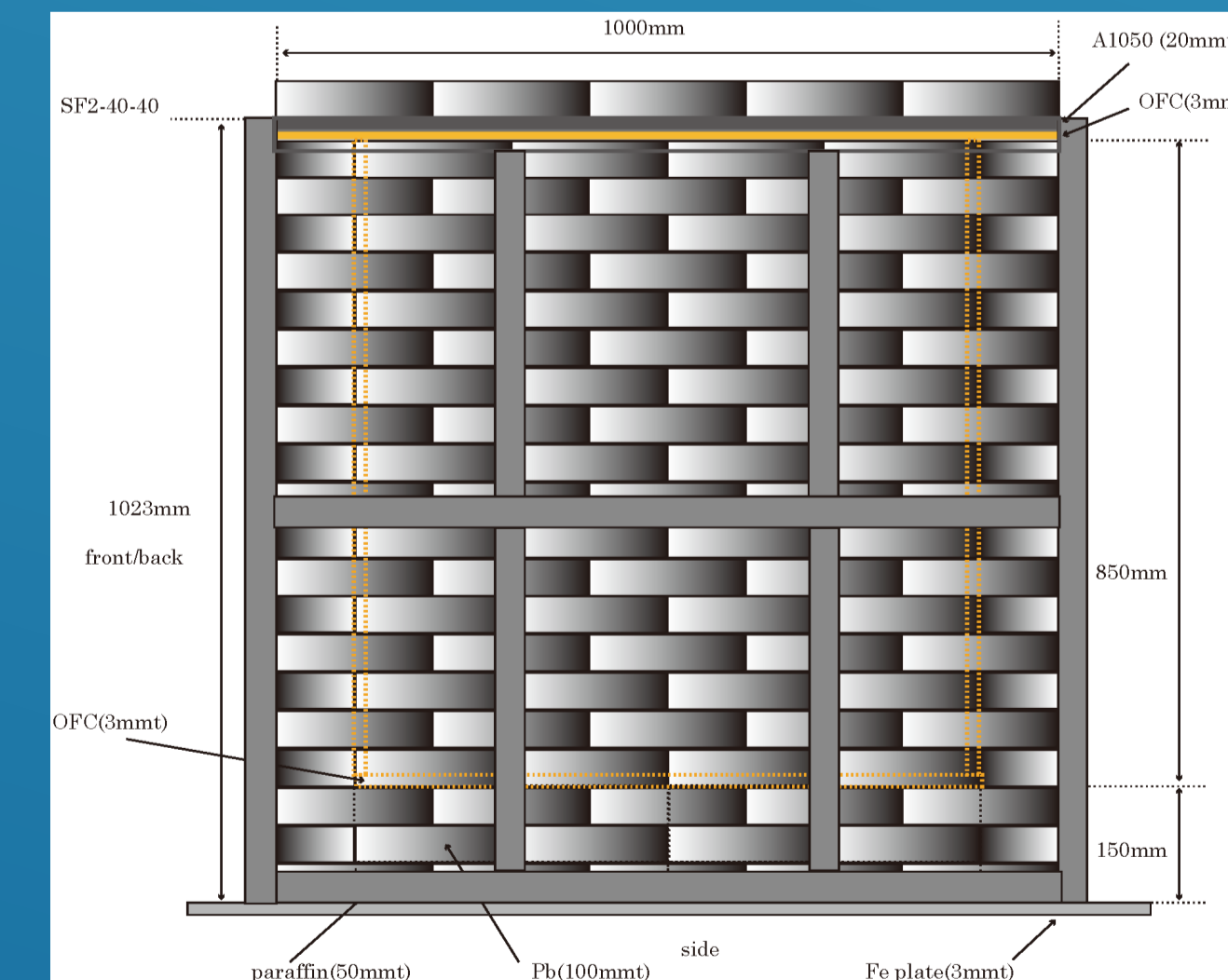


**The transparency of 100 $\mu$ m ETFE :  $0.9566 \pm 0.0027$**

### ◆ PSD using V1742 and H3378-50



### ◆ Design of Radiation Shield



Radiation shield consists of 450 Pb blocks, 3mm OFC plates, 50 paraffin blocks and Al frame + plate on Fe basis.

**PSD to select PMT received Cherenkov light has been established using waveform of V1742 and H3378 PMT.**

## 6. Future plan

- Detector performances such as the energy resolution, the vertex reconstruction, and the averaged angle will be measured soon.
- Accepted for ICRR Inter-University Research Program.
- Need permission from Kamioka Steering Committee.
- Construction schedule after the permission.
  - a. Install clean booth and setup the radiation shield in the clean booth at LAB-A. ( $\sim 1$  month)
  - b. Install 2 $\nu$ -ZICOS detector inside of Radiation shield. ( $\sim 2$  months)
- Data taking hopefully will start in 2025