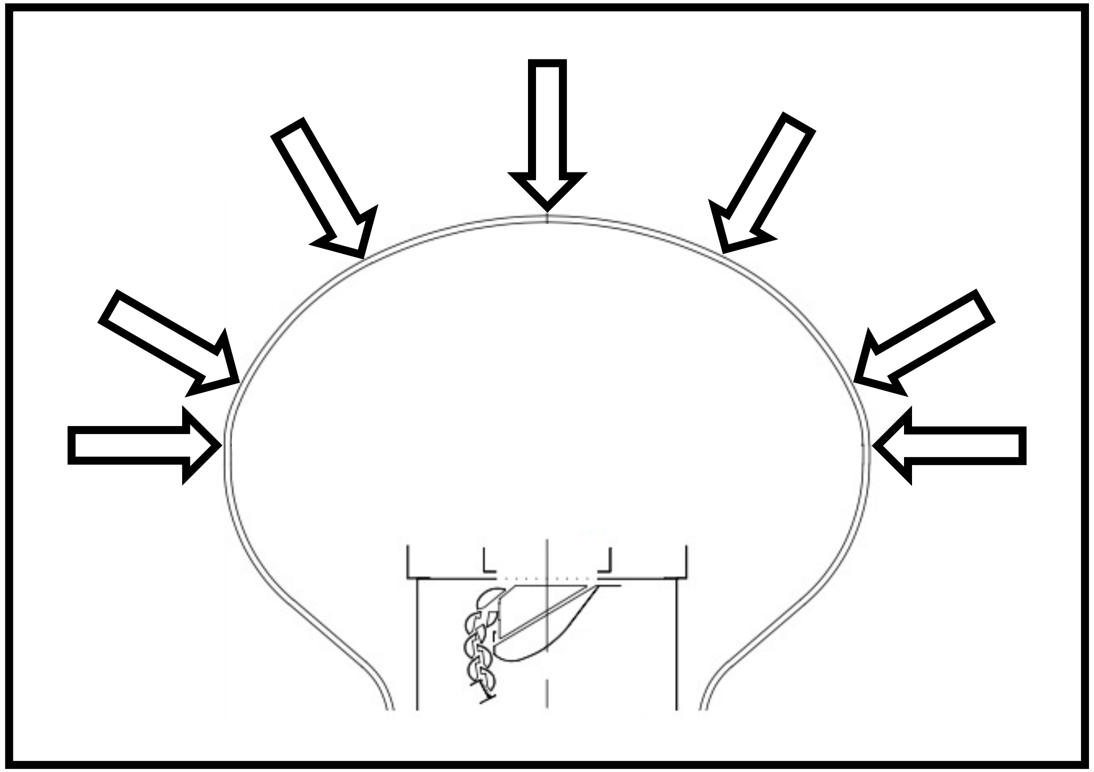
PMT Uniformity Measurement

Shogo Horiuchi

Introduction

Uniformity of HK PMT

- HK PMT has a large photosensitive area and its shape of the B&L PMT dynode is asymmetric. Therefore, properties of PMT could depend on surface photon incident position.

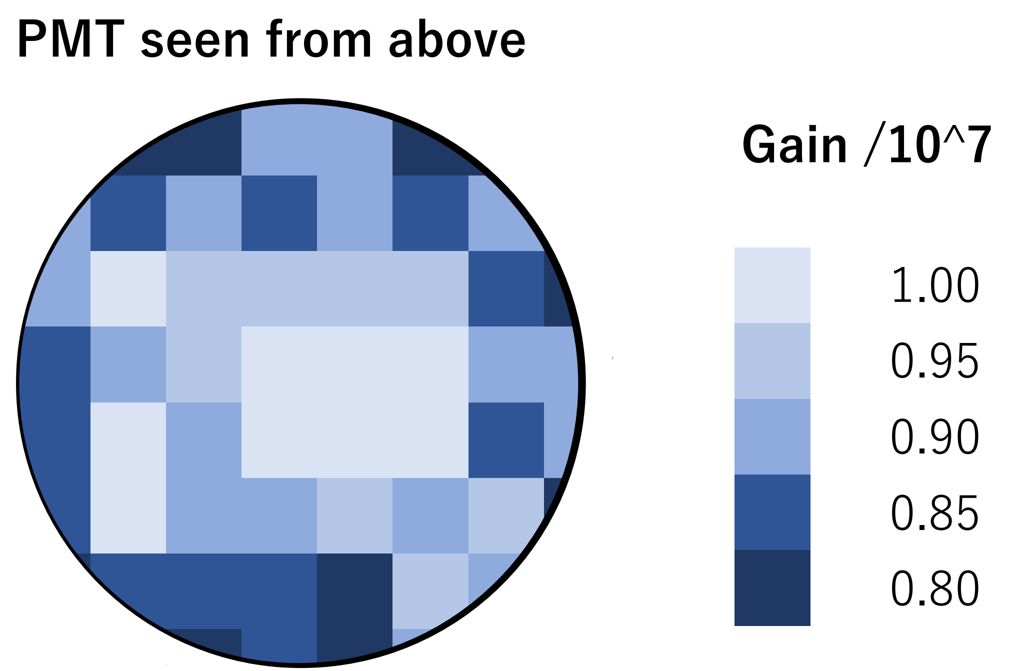


Introduction

Purpose of Research

1. **Make a precise response map and find area that has very different properties**
   - Below is a hypothetical map of PMT demonstrated by observed gain.

Example image of potential response map



Introduction

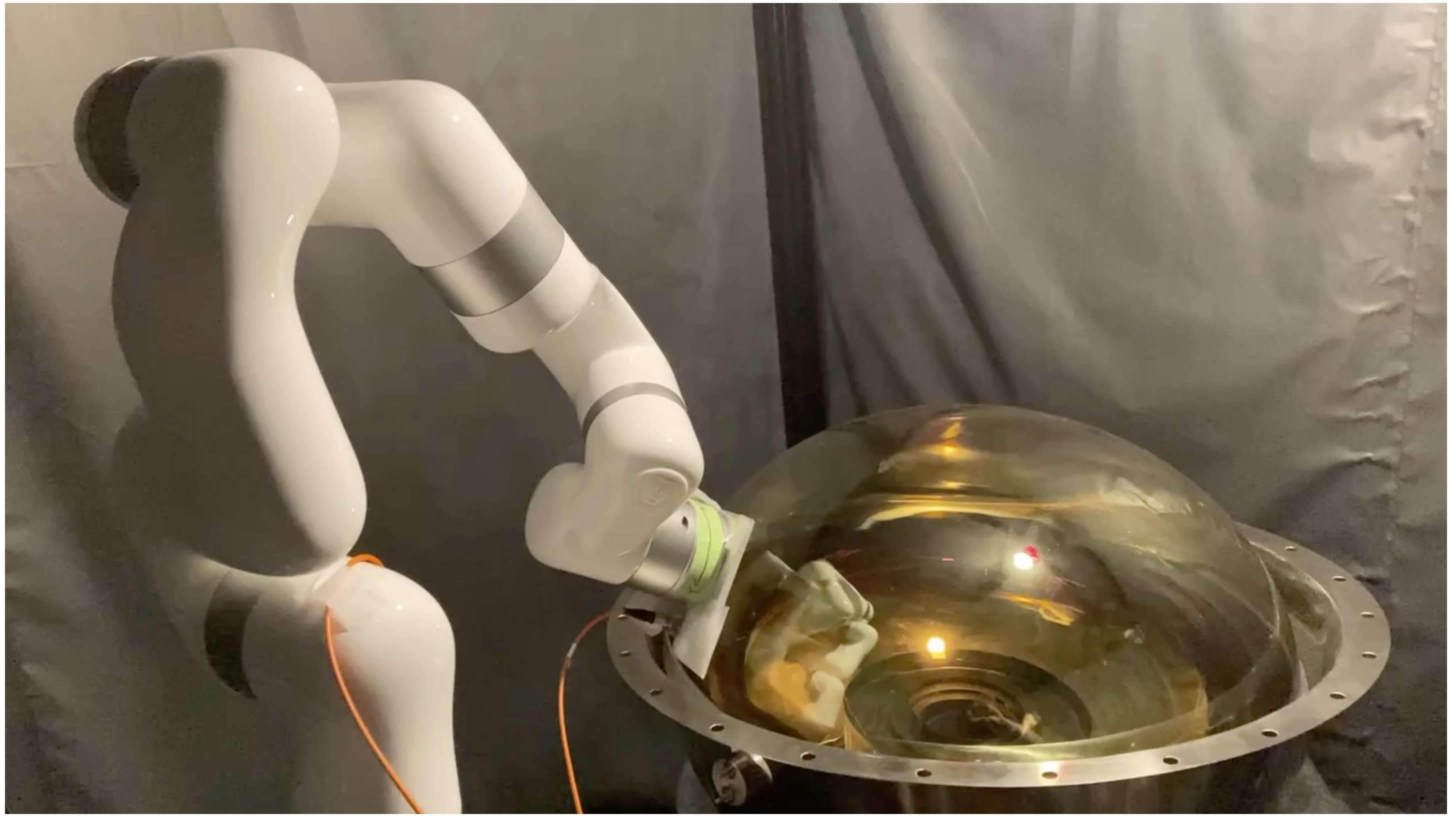
Purpose of Research

2. **Identify the parameter that influence the uniformity of response**
    - **Such as magnetic field, high voltage, tempreture, etc.**
    - **The influential parameter will be measured at the precalibration.**

Measurement Method

Robot Arm

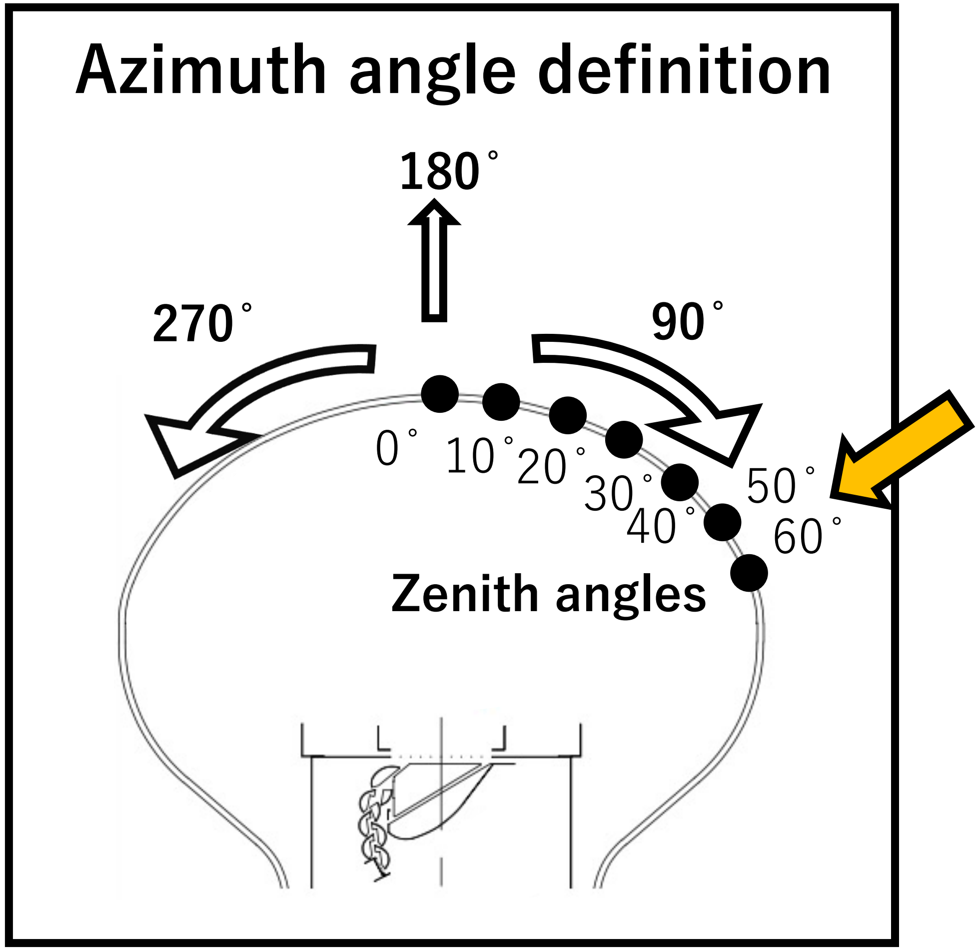
- **In order to make a precise response map, photon incident position should be changed continuously.**
  By using a robot arm, optical fiber can move smoothly.



Measurement Method

Robot Arm

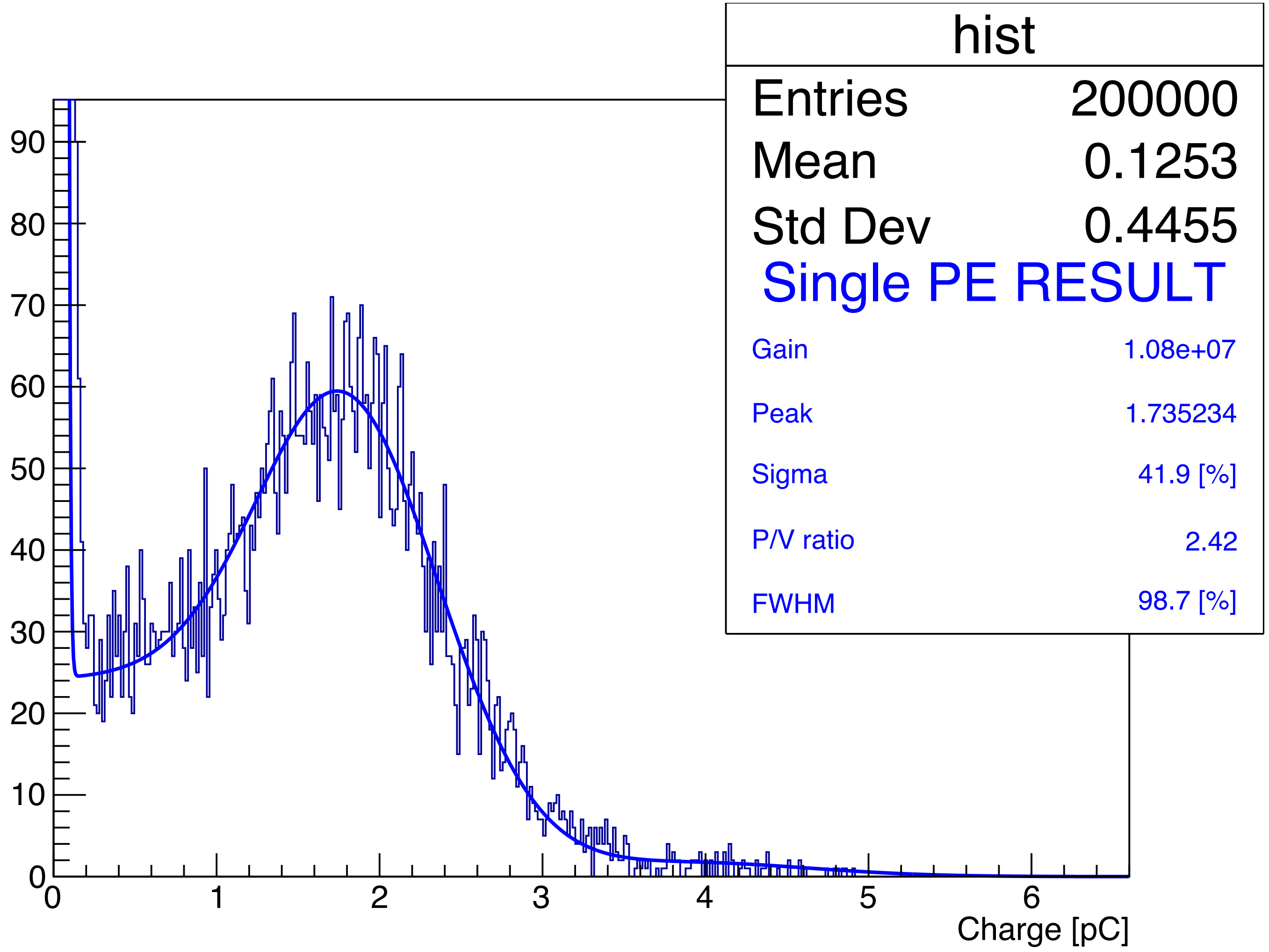
- Although the robot arm can move to any position, I measured only three azimuth angles this time.
- Photon incident angle is aliways vertical to the surface of the PMT.
- Zenith angle is defined by the The photon incident angle.



Result and Analysis

Position dependency of 1 photoelectron gain

- This is the result of 1pe gain at the center of the PMT (zenith angle = 0°).
- 1 p.e. gain is obtained by theoretical fit function. (next slide)

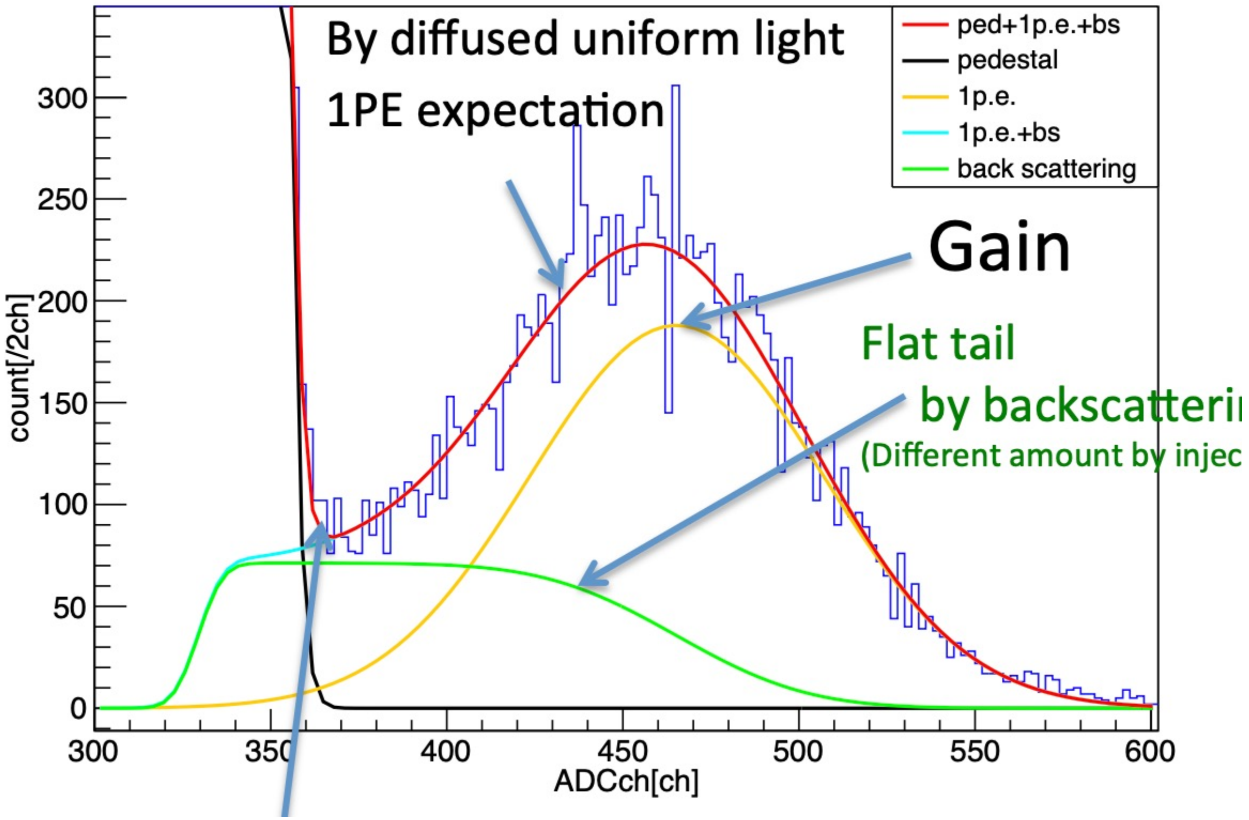


Result and Analysis

Position dependency of 1 photoelectron gain

Pedestal
Gaussian
Flat inelastic backscattering distribution

$$\underline{N_0 \exp\left(-\frac{(x-\mu_0)^2}{2\sigma_0^2}\right)} + \underline{N_1 \exp\left(-\frac{(x-\mu_1)^2}{2\sigma_1^2}\right)} + \underline{N_2\left(erf\left(\frac{x-\mu_0}{\sigma_0}\right) - erf\left(\frac{x-\mu_1}{\sigma_1}\right)\right)}$$



The fit function consits of 3 terms

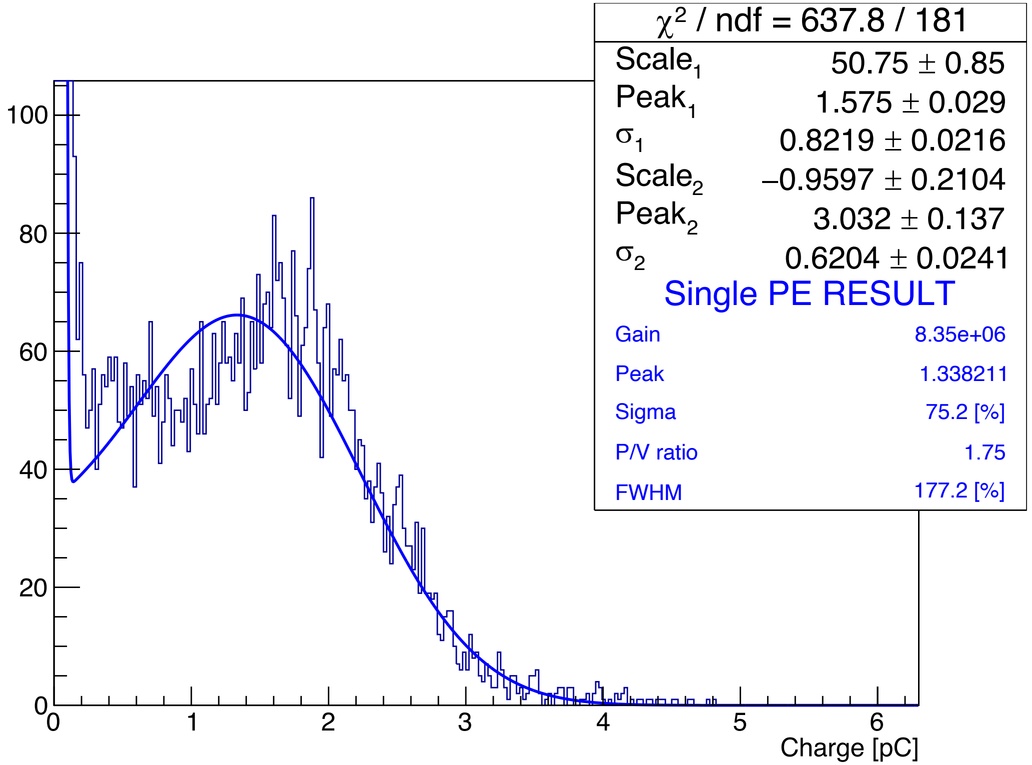
- Pedestal : 0 pe peak
- Gaussian: 1 pe peak
- Flat inelastic backscattering distribution : Flat tail by backscattering, etc.

1 pe gain is obtained by the 1 pe gaussian

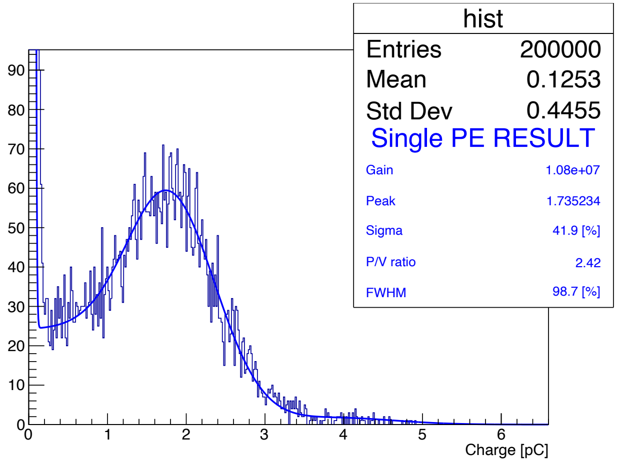
Result and Analysis

■ Position dependency of 1 photoelectron gain

- When the zenith angle is large, the fitting quality get worse.
- This result has expected from the calculation of electron trajectry.



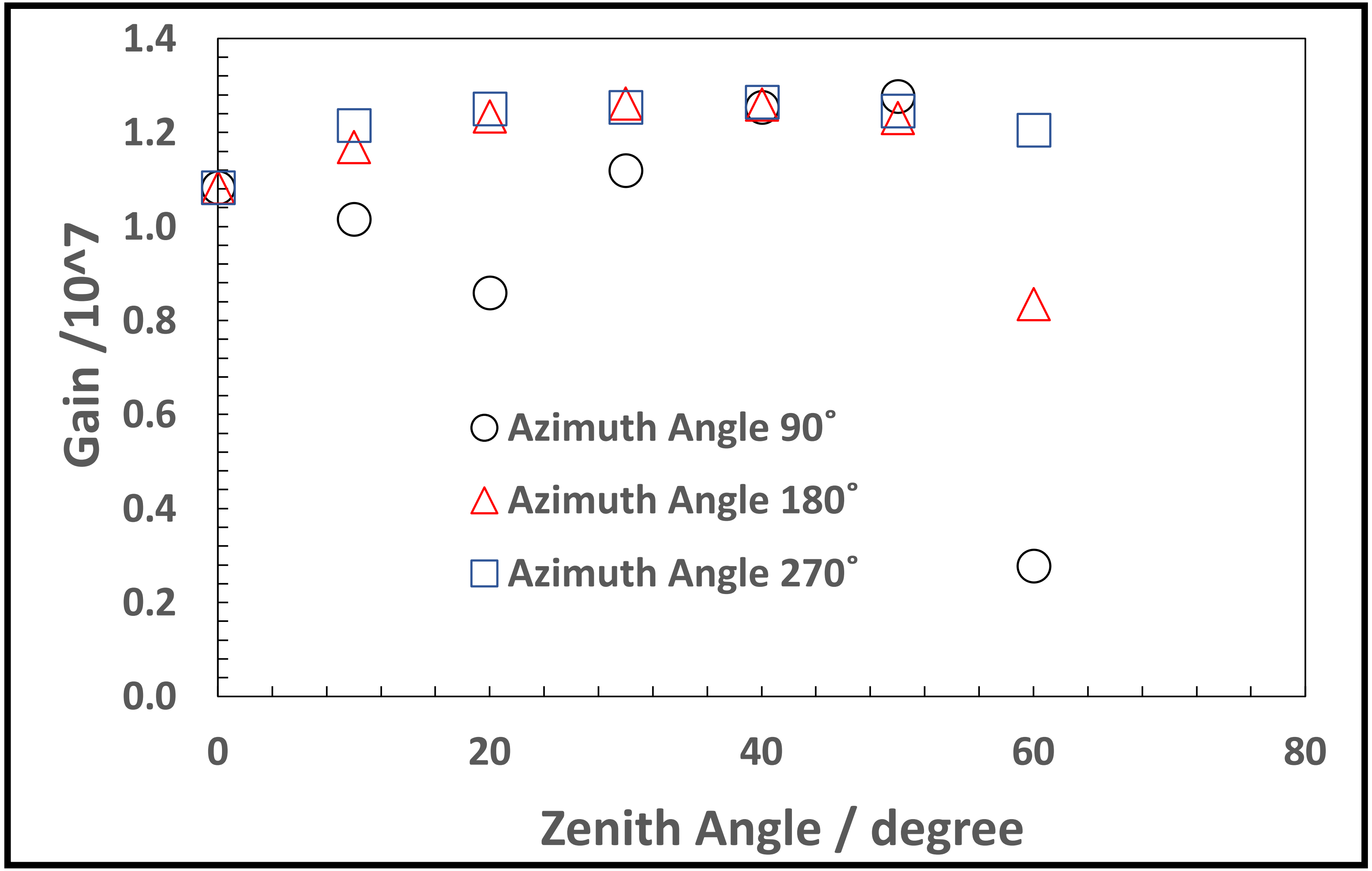
Azimuth angle: 180° zenith angle : 60°

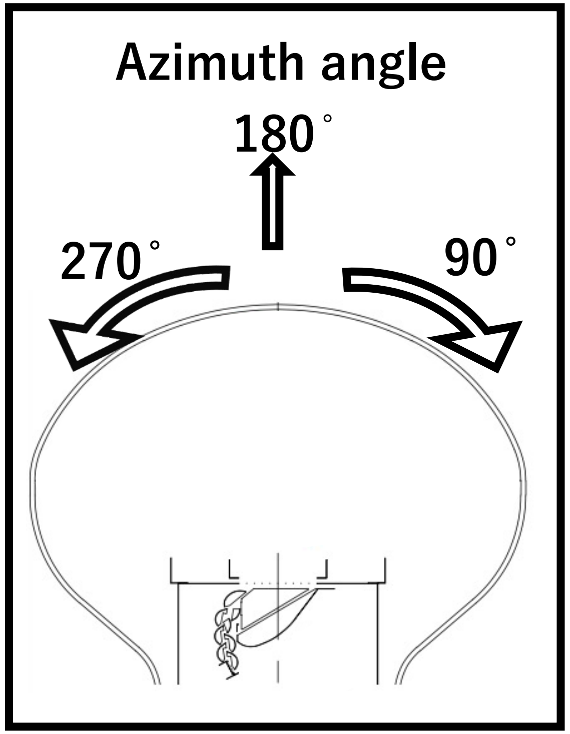


zenith angle : 0°

Result and Analysis

Position dependency of 1 photoelecton gain



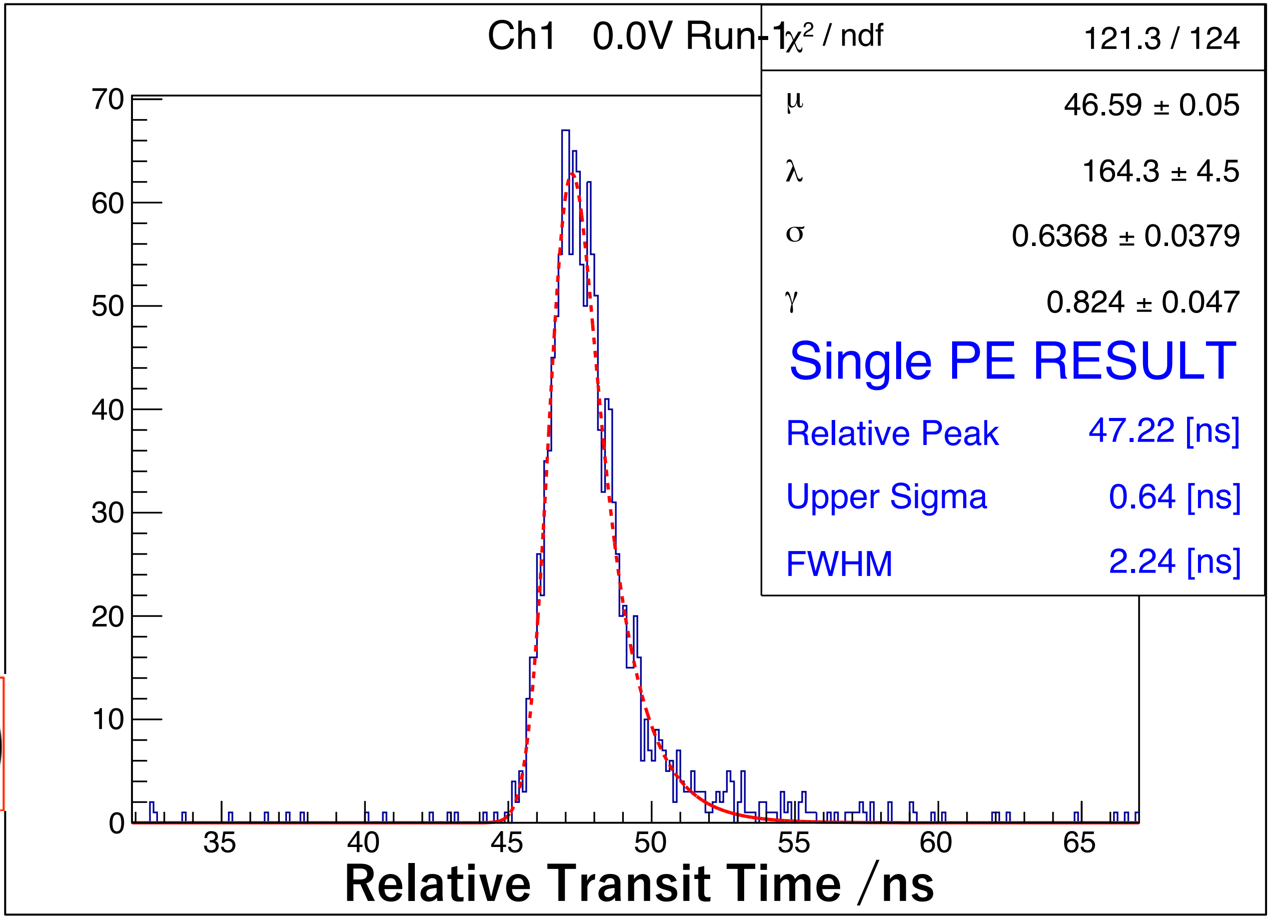


Result and Analysis

Position dependency of 1 photoelectron T.T.S

- This is the result of T.T.S. measurement at the center of the PMT.
- Best modeling for Box&Line PMT in HK simulation is "Exponential modified gaussian":

$$f(x) = \frac{\lambda}{2} e^{\frac{\lambda}{2}(2\mu+\lambda\sigma^2-2x)} \mathrm{erfc}\left(\frac{\mu+\lambda\sigma^2-\mathrm{x}}{\sqrt{2}\sigma}\right)$$

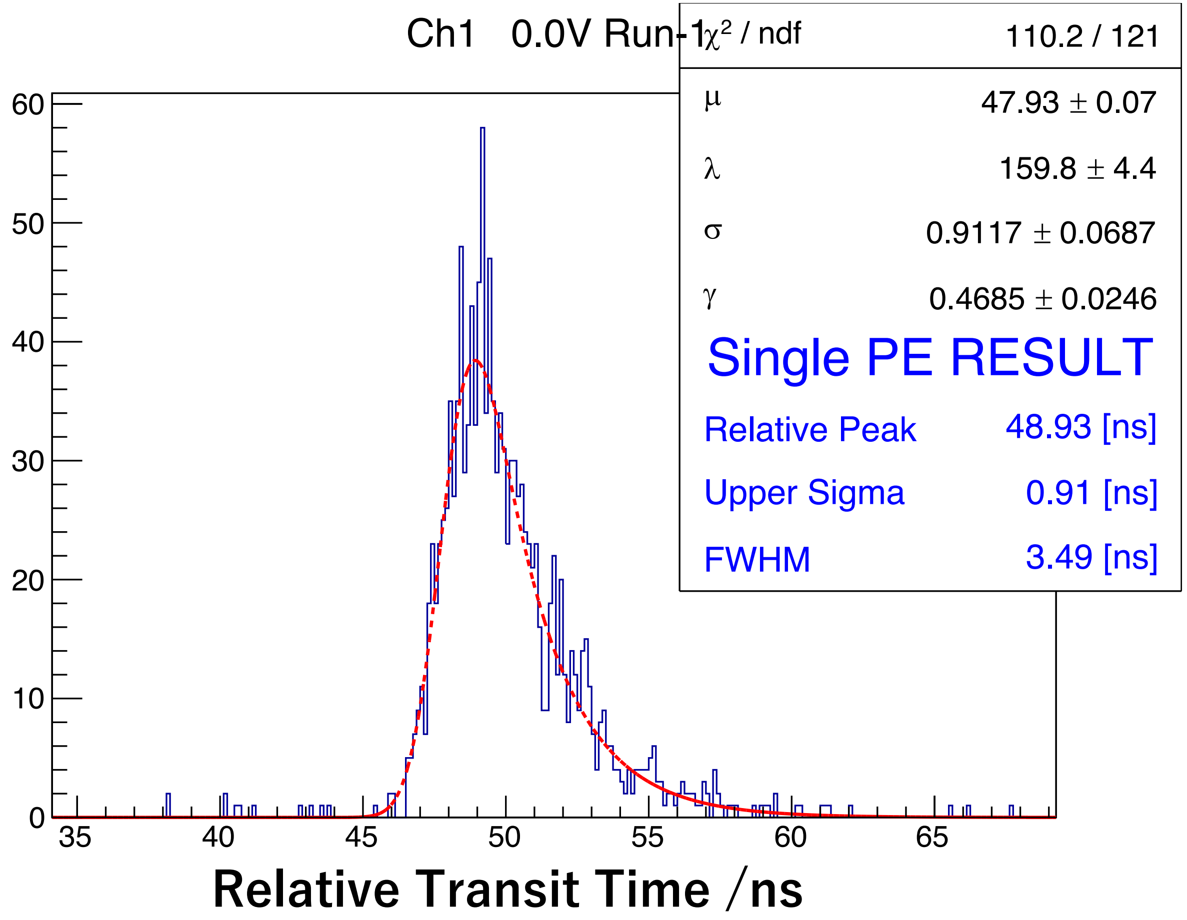


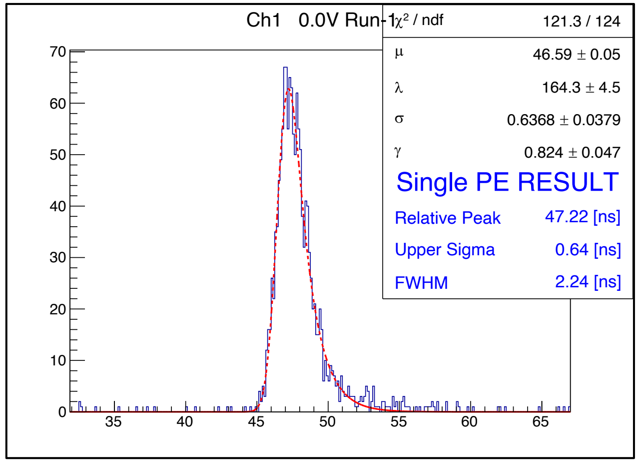
- FWHM of this fit function is used as T.T.S.

Result and Analysis

■ Position dependency of 1 photoelectron T.T.S

- This is the result of T.T.S. measurement when zenith angle = 60˚, azimuth angle = 180˚.

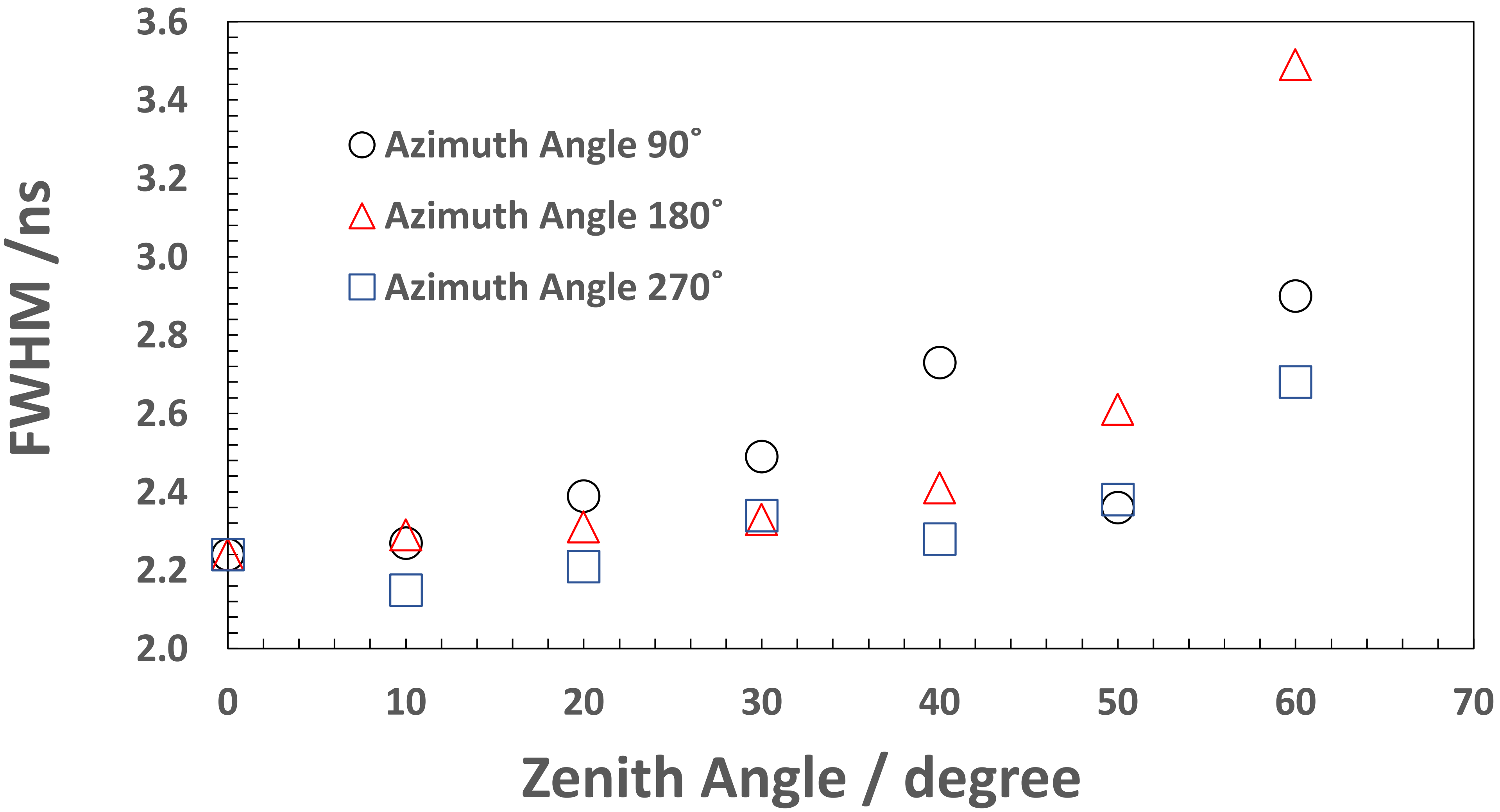




zenith angle : 0˚

Result and Analysis

■ Position dependency of 1 photoelecton T.T.S

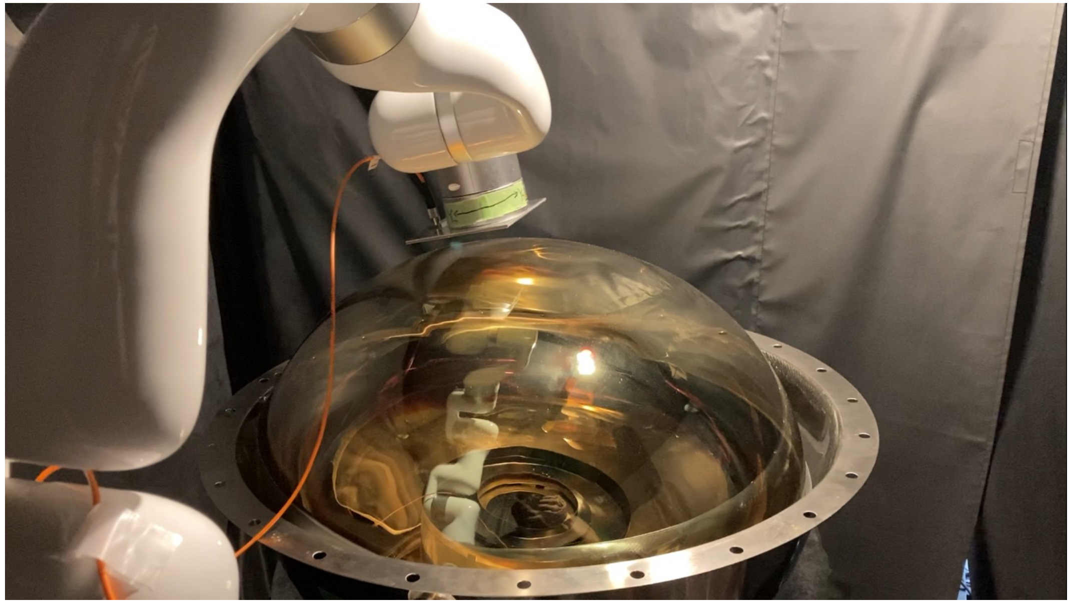


Future prospects

Limitations of measurement at Keio

- **Magnetic field**
  - Because of the robot arm, magnetic field shield cover was removed.

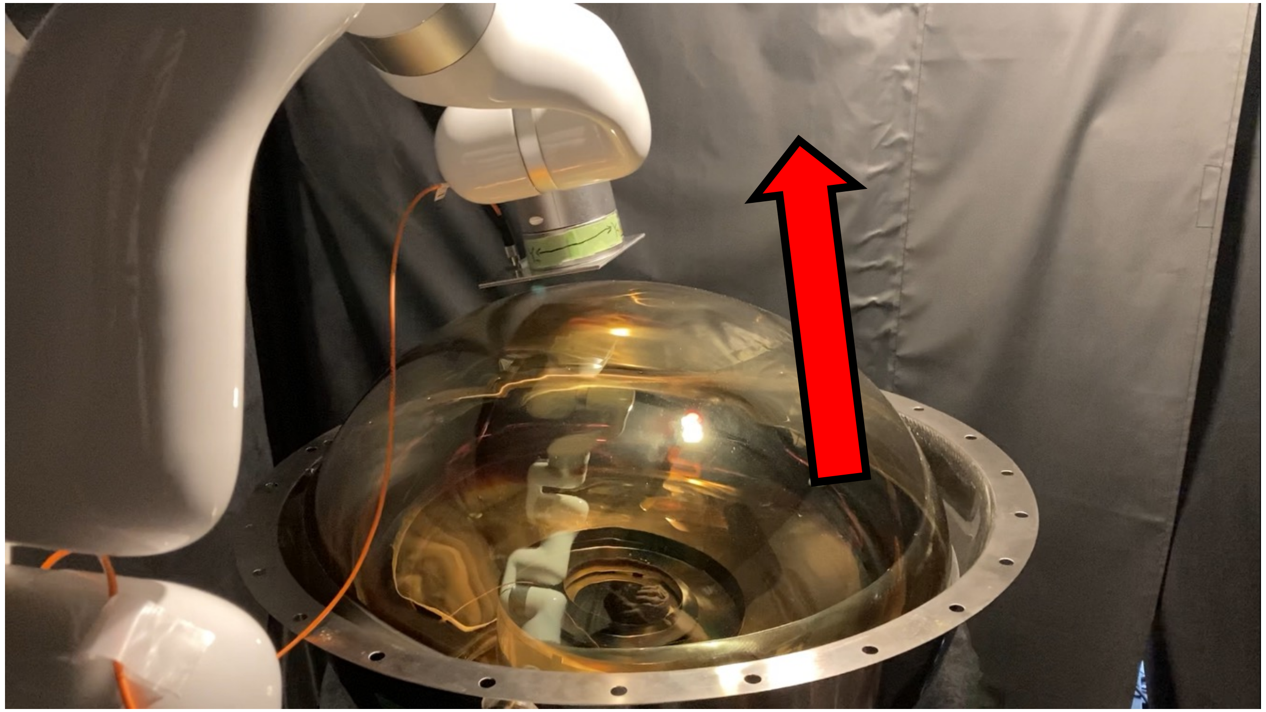
⇨



Future prospects

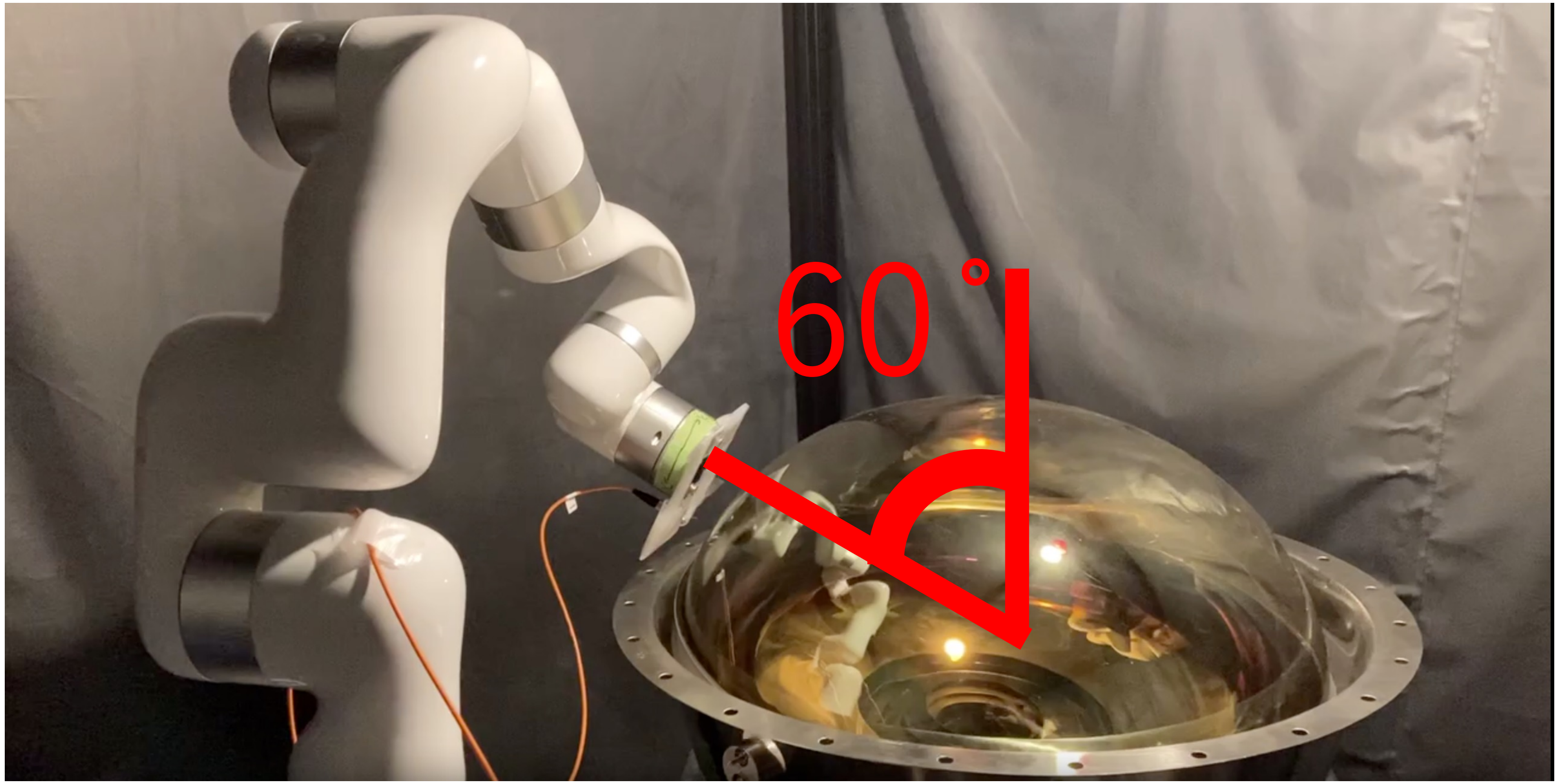
Limitations of measurement at Keio

- **Inclination**
  - The PMT in our laboratoy is strapped and secured with a PMT band.
  - The PMT is inclined 7° due to the band.



Future prospects

- **Limitations of measurement at Keio**
  - Area
    - Because of the band, zenith angle is 0°-60°.



Future prospects

Measurement at Kamioka Lab-B

- **Better Condition**
  - At Kamioka Lab-B, magnetic field can be controlled.
- **More Parameters**
  - non 1pe gain
  - QE
- **Wider Area and smaller steps**
  - zenith and azimuth angle will be more contiuous.