



Development and characterization of the JNE concentrator

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Outline

Part 01 Introduction

Part 02 Test facility

Part 03 Validation

Part 04 Discussion

01 Introduction



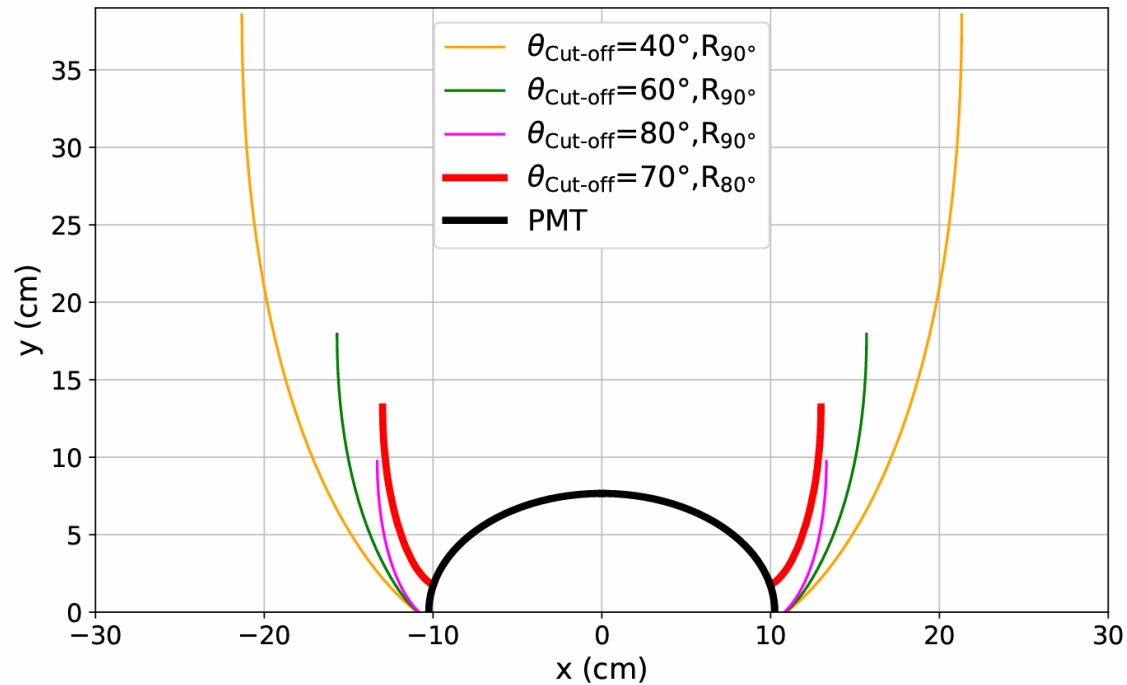
The energy resolution of the JNE detector is closely related to its overall photon collection efficiency, which is improved by equipping the PMTs with light concentrators.

➤ Light concentrator

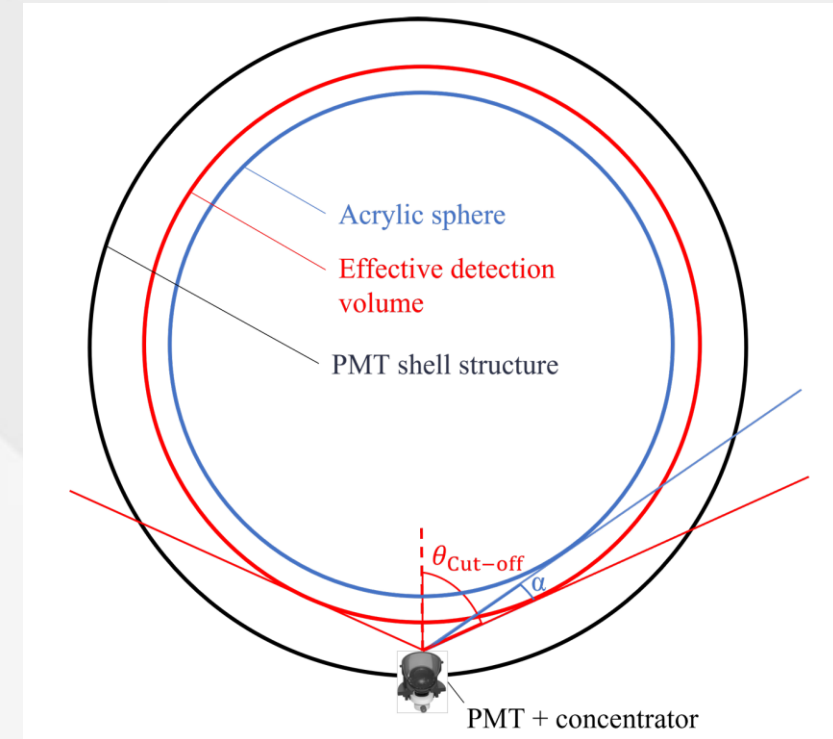
- Economical and effective approach to improve PMT coverage
- Wide field of view and high geometric collection efficiency



01 Introduction



The cross-section of the PMT and concentrator with different cut-off angles $\theta_{\text{Cut-off}}$ in the xy plane.



The cut-off angle $\theta_{\text{Cut-off}}$, installation error angle α and effective detector volume of a single PMT equipped with a concentrator.

➤ Al Coating process

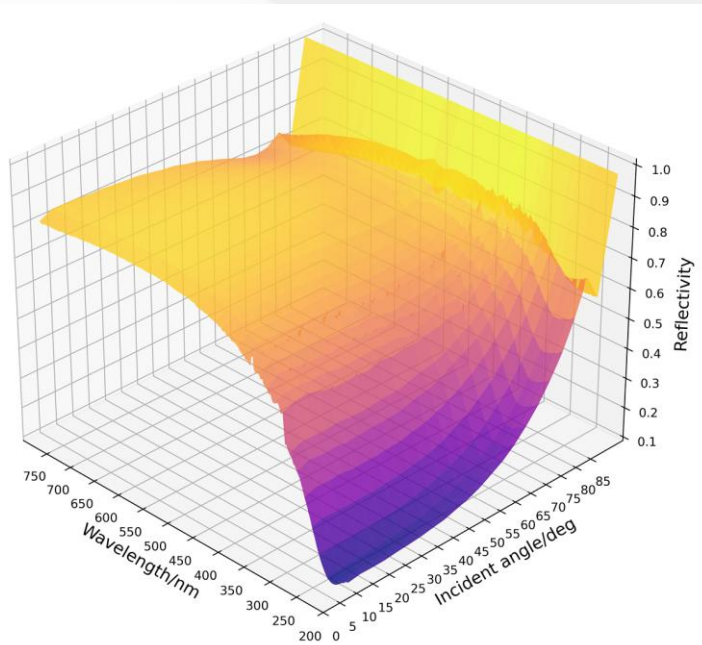
- Lanzhou University(left)
 - ❑ Evaporation: Electron beam
- Wanhao Coating(right)
 - ❑ Evaporation: Resistor



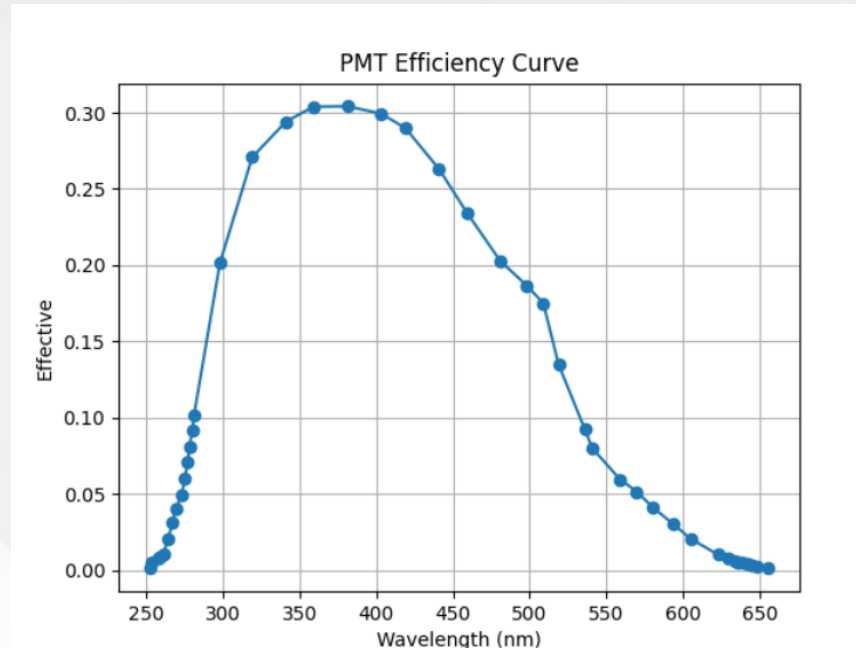
01 Introduction



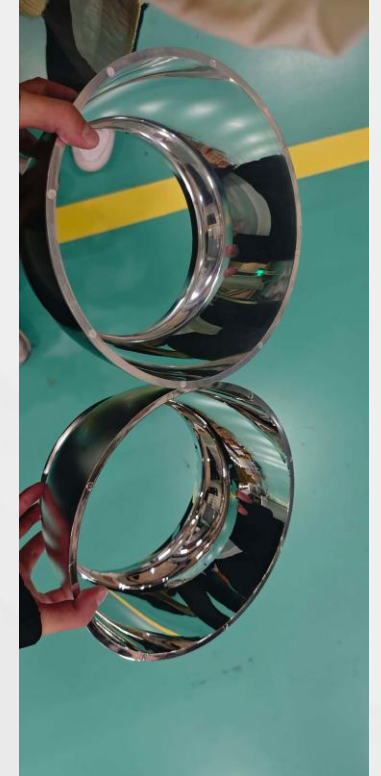
➤ Light bowl design



The reflectivity of the coated aluminum versus wavelength and incident angle.



PMT QE curve



01 Introduction



➤ PMT Background Test

➤ ABS

Material Element	417(ppm)	757k(ppm)	dye ABS(ppm)	SNO(ppm)
U238	0.0079 ± 0.0032	<0.0074	0.0920 ± 0.0056	0.006 ± 0.015
Th232	<0.0044	<0.0071	<0.0085	0.035 ± 0.044
K (natural)	11.8 ± 2.5	23.3 ± 3.6	18.8 ± 2.3	60 ± 30

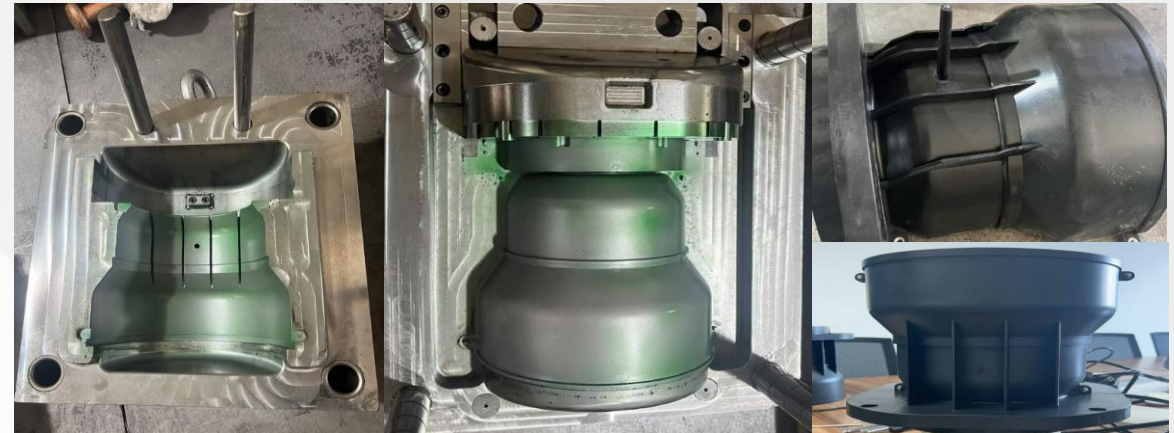
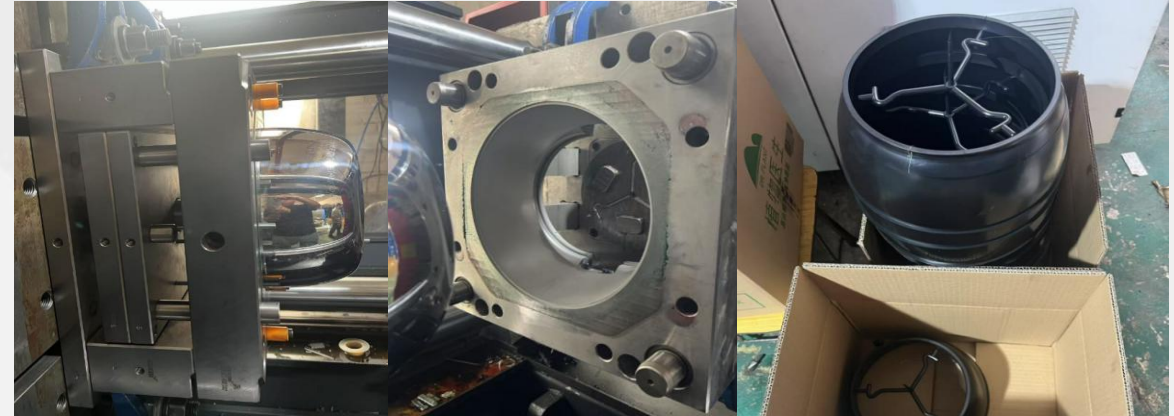
SNO-STR-92-006

01 Introduction

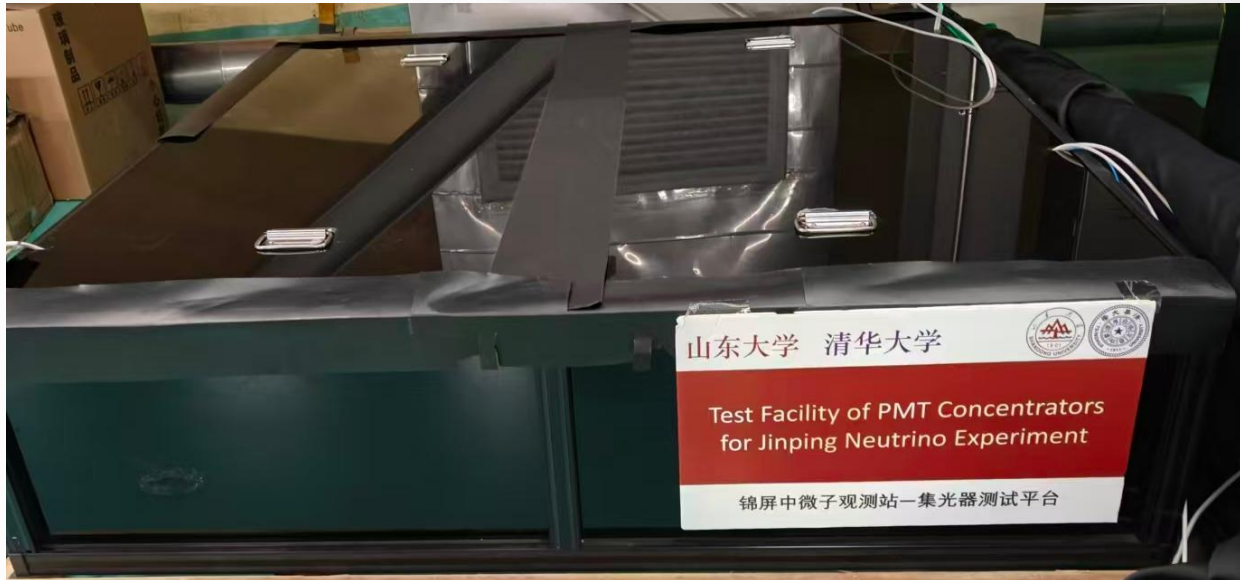


➤ All components of the light collector can be mass-produced.

- light bowl
- clamp cylinder
- rubber ring



02 Test facility



Actual photo of the Test facility

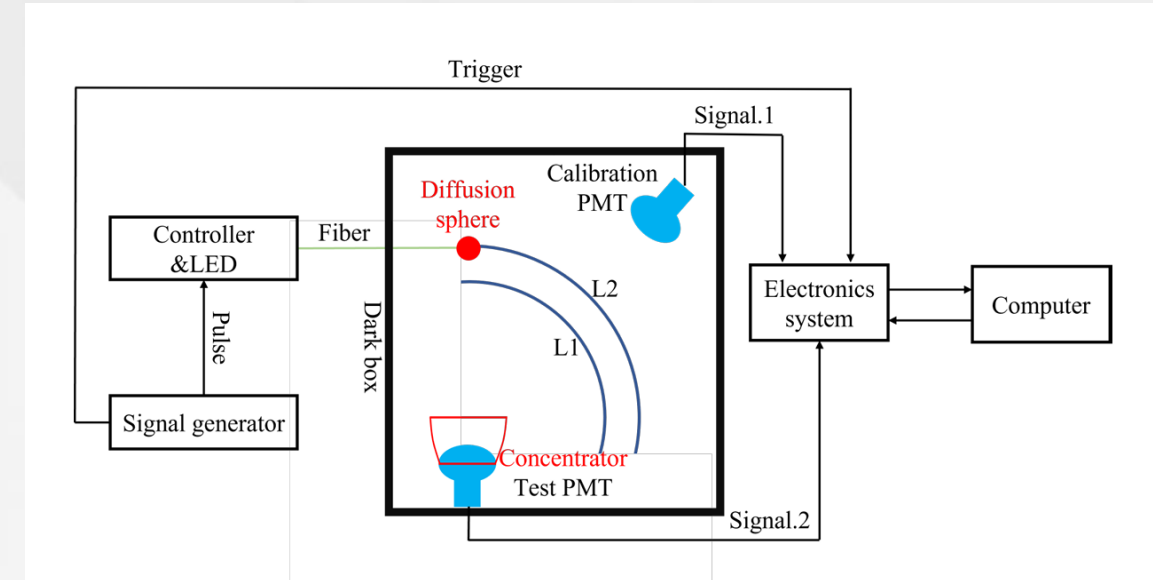
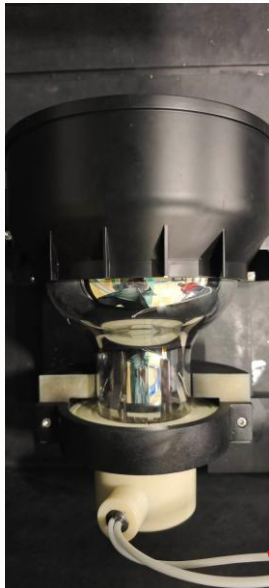
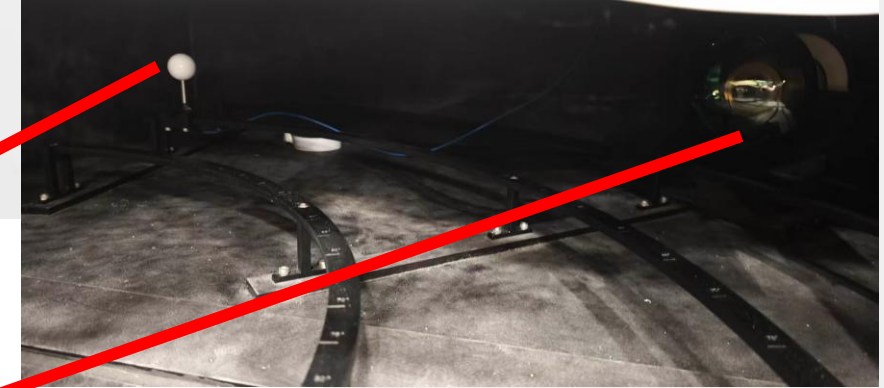
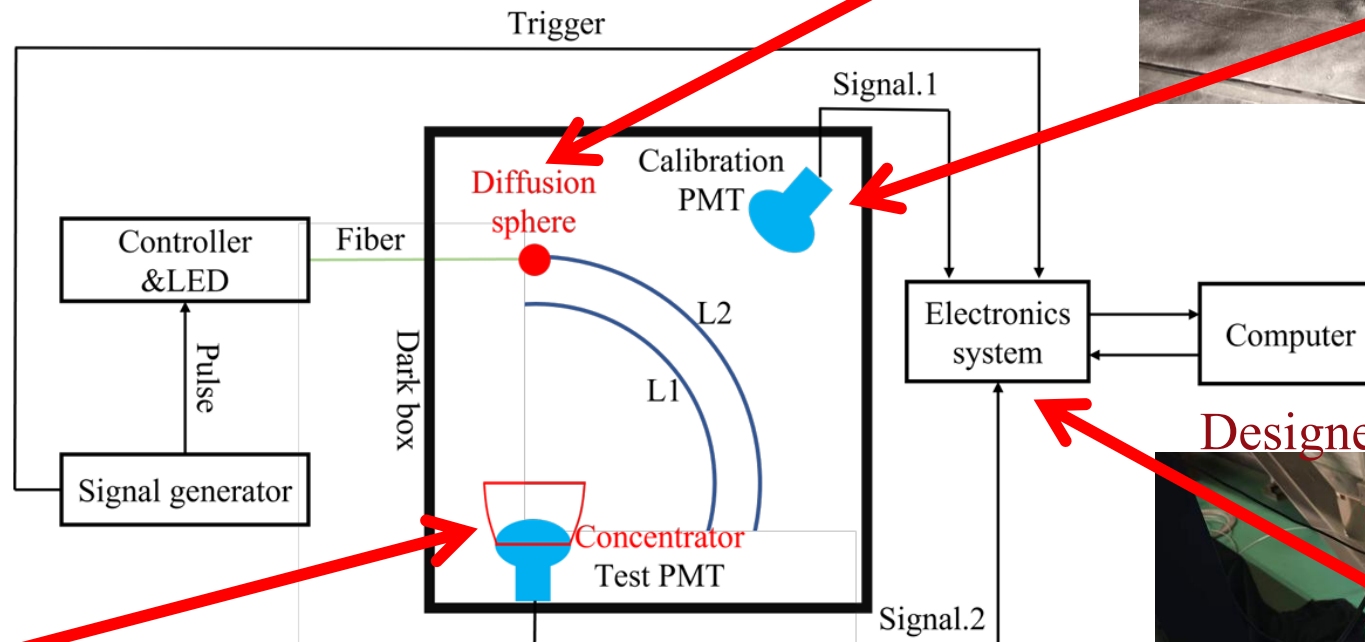


illustration of the Test facility

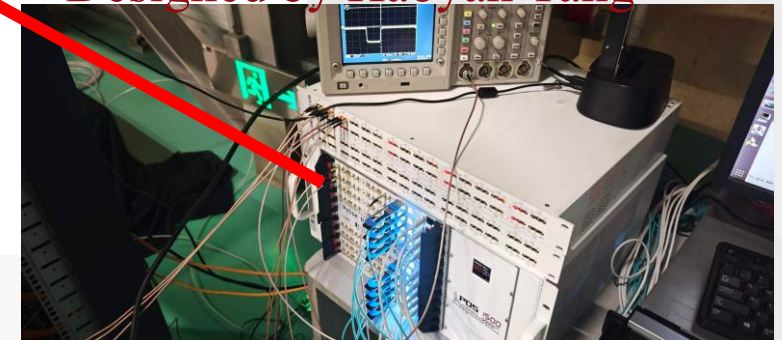
02 Test facility



8 inch-PMT with Concentrator



Designed by Haoyan Yang



➤ Three experiments

- Customized light concentrator: check the light bowl curve, Air
 - Published in: Nucl.Instrum.Meth.A 1080 (2025) 170755 • e-Print: 2502.20712 [hep-ex]
- Mold-produced light concentrator: check the light bowl curve, Air
 - underwater: match the actual usage environment.

➤ With the same analysis method

➤ Analysis method

- LED sample: 365nm, 415nm, 465nm, 480nm
- Calculate the trigger rate R of the LED signal in each Run, N_{hit} : number of PMT firings in the signal interval, N_{noise} : the estimated dark noise level, N_{total} : the total number of signals generated.

$$R = (N_{\text{hit}} - N_{\text{noise}}) / N_{\text{total}}$$

- λ : the expected value of the Poisson distribution

$$\lambda = -\log (1 - R)$$

$$\eta = \lambda_{\text{TestPMT}} / \lambda_{\text{CaliPMT}}$$

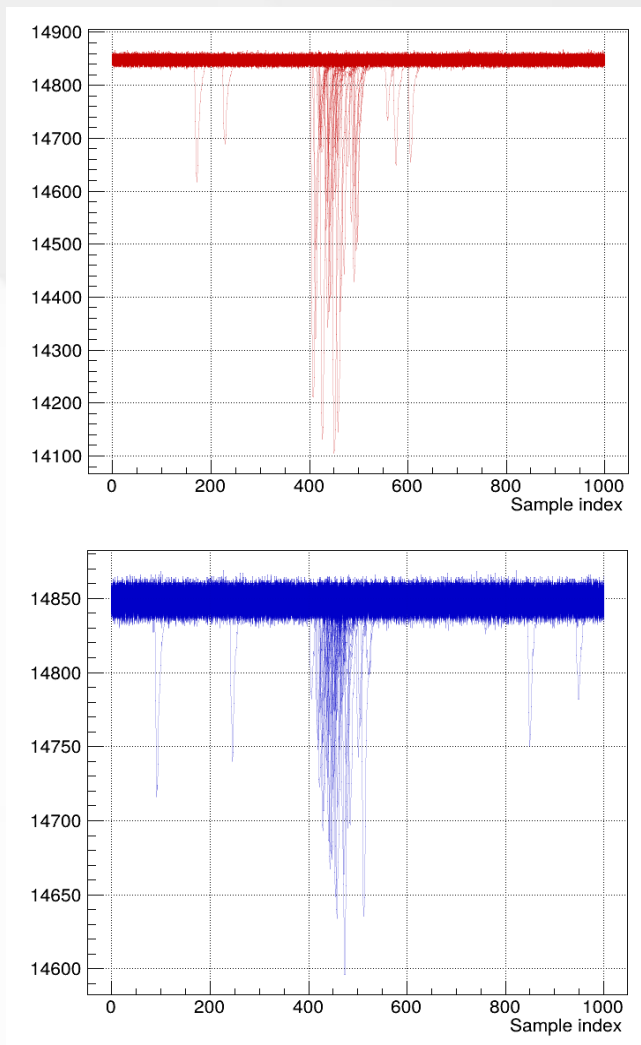
- Comparing the η values from two data acquisitions, one with the light collector and one without

$$factor = \eta_{\text{con}} / \eta_{\text{bare}}$$

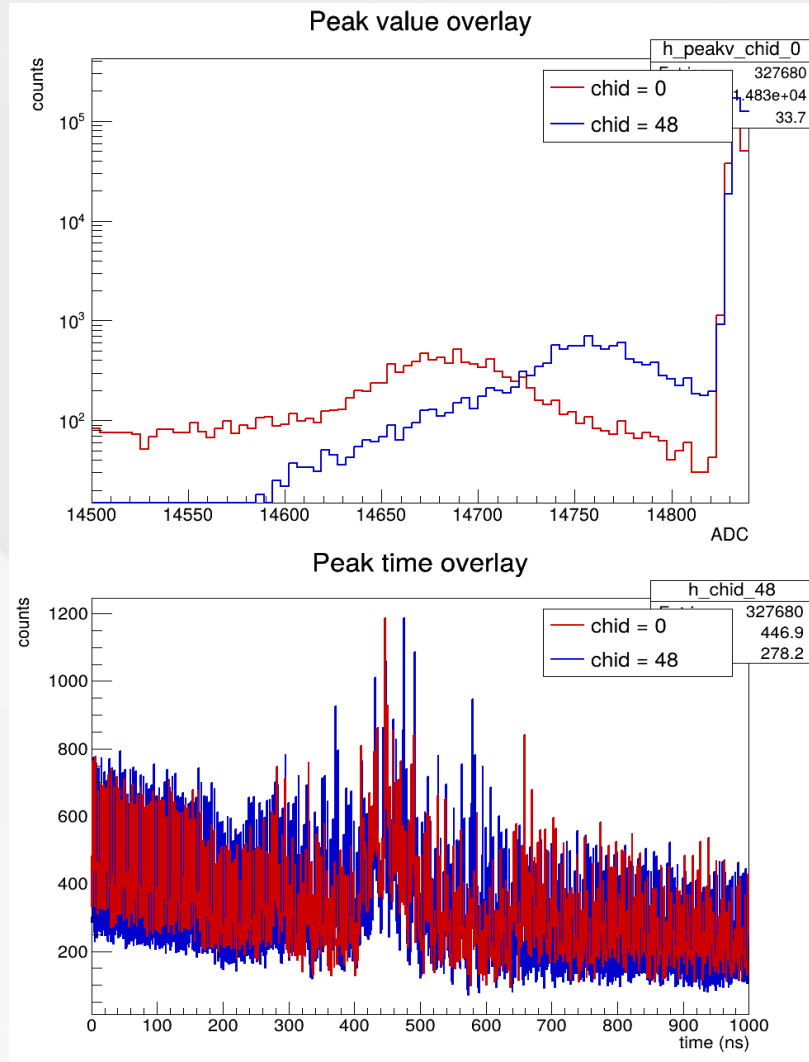
03 Validation



- Red line (id=0) is the Test PMT
- Blue line (id=48) is the Cali PMT



waveform



Peak time and ADC value distribution

03 Validation

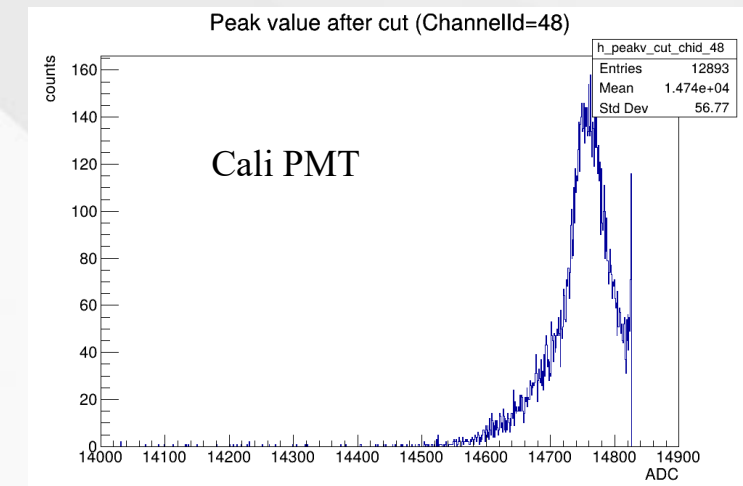
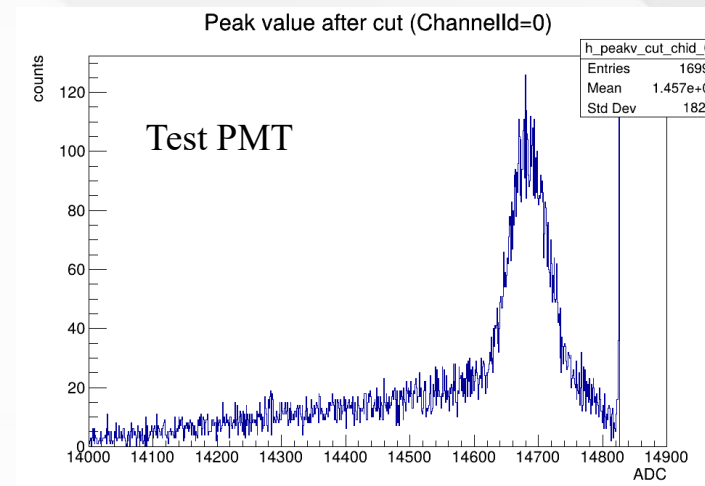
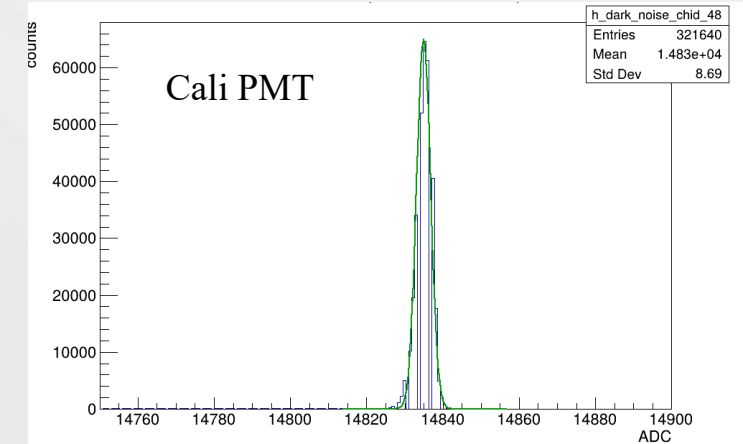
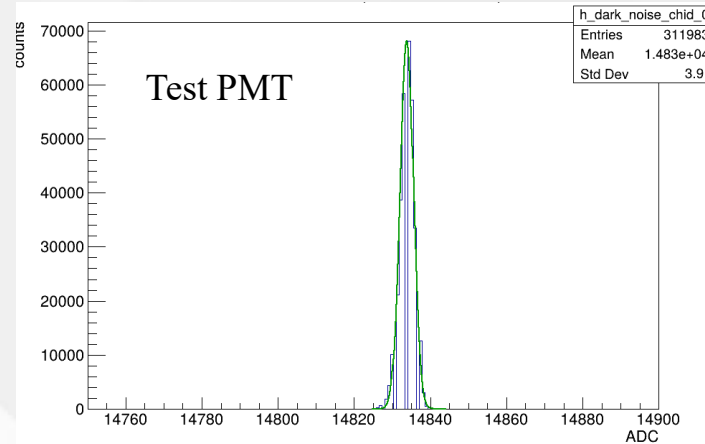


➤ Baseline disturbance correction

- Gaussian fit

$$\square f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

- $ADC < \mu - 5\sigma$



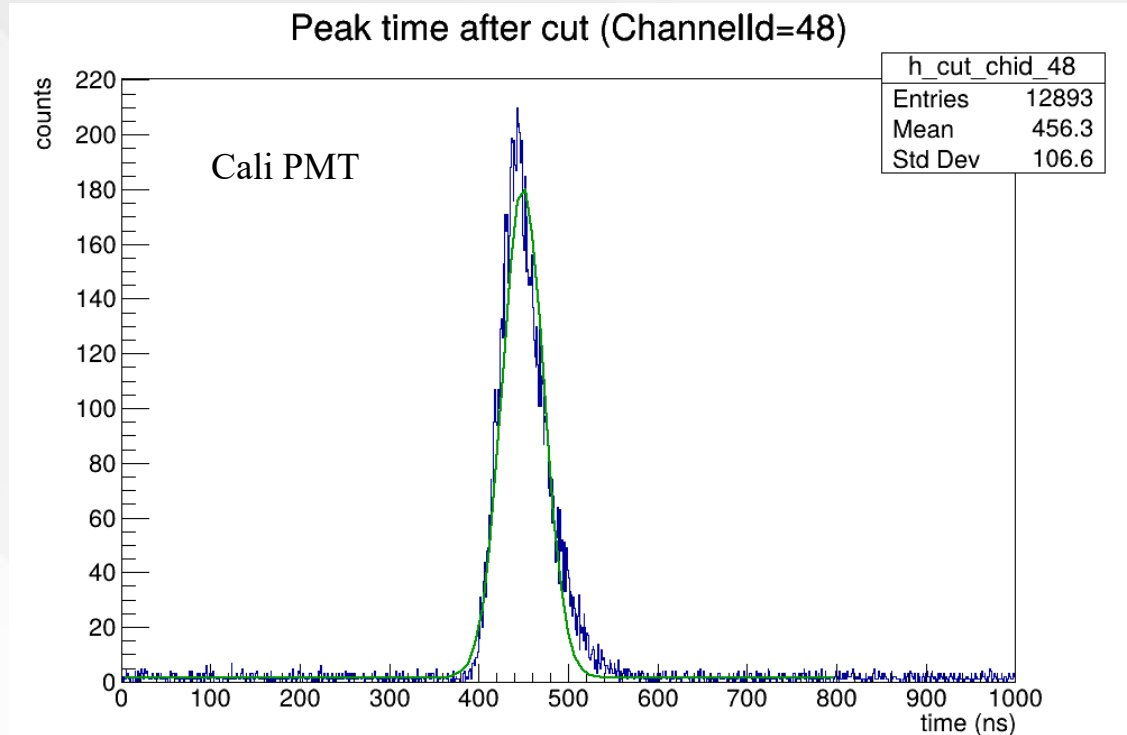
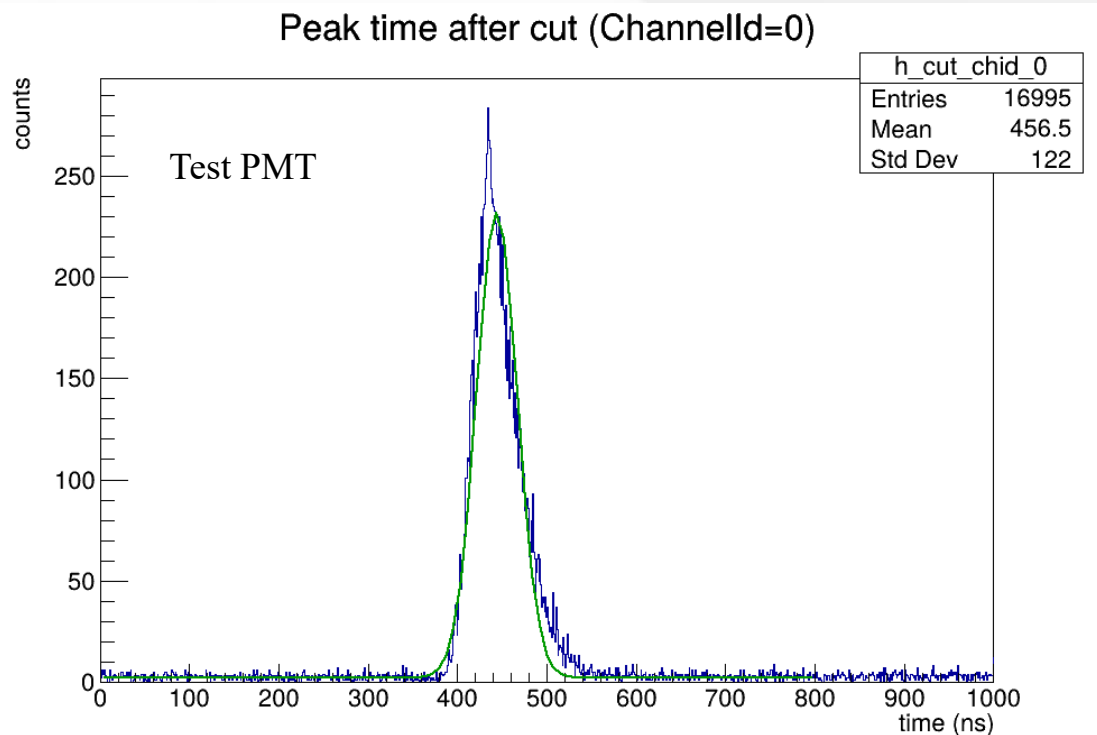
03 Validation



➤ signal window

- Gaussian + A
- Signal time window: $(\mu - 3\sigma, \mu + 3\sigma)$

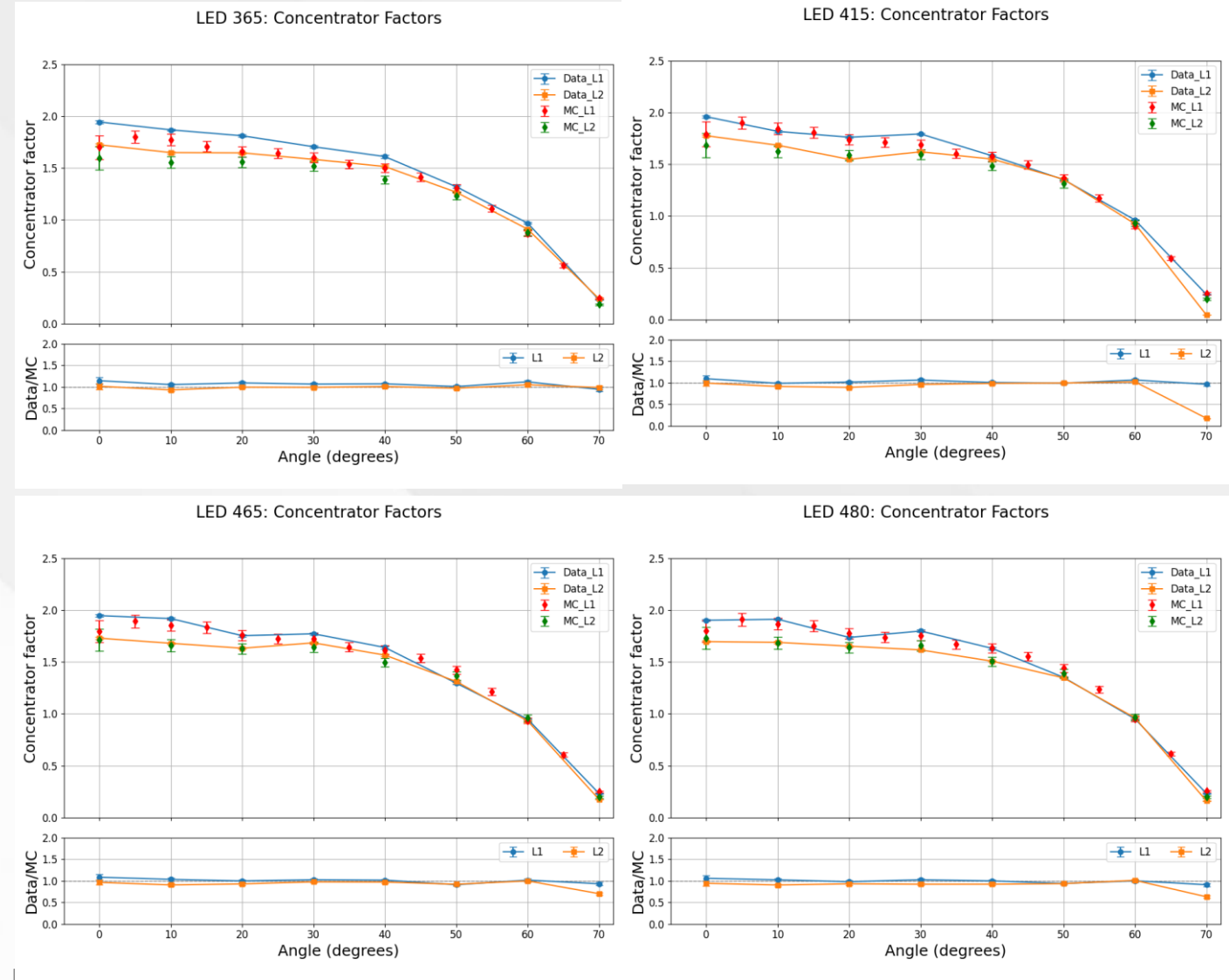
- Fit: $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} + A$



03 Validation



- Angular responses of the concentration factors of data and MC for four wavelengths at rail L1 and L2 in water.
- The ratio of data/MC panels show that the data and MC are **in good agreement**.



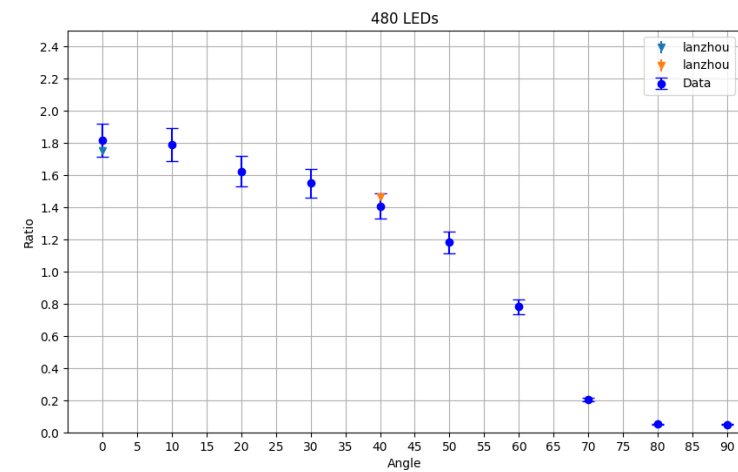
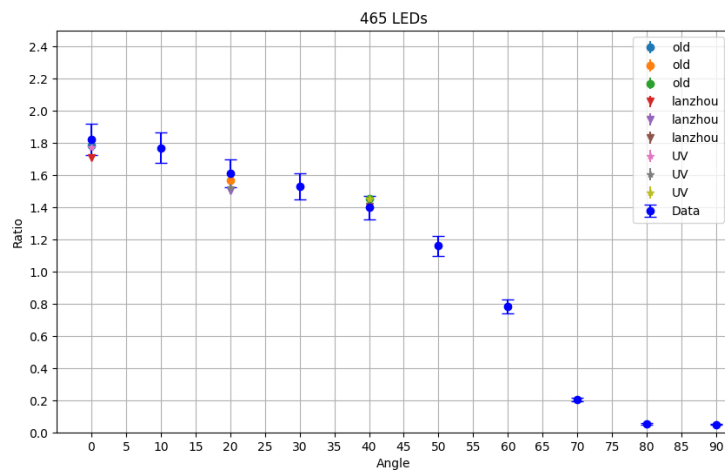
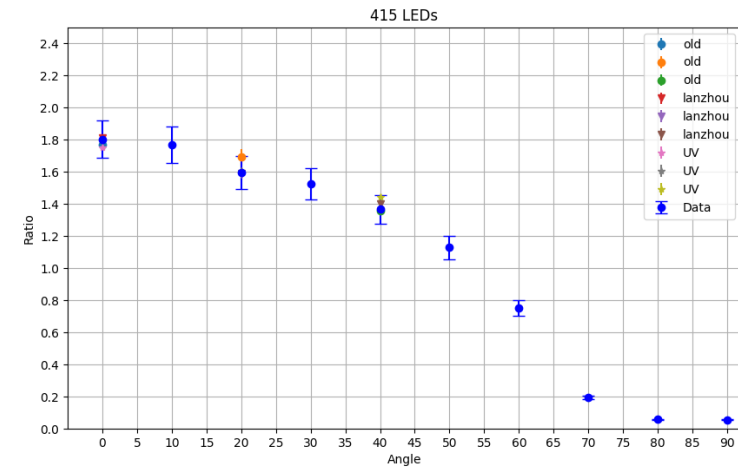
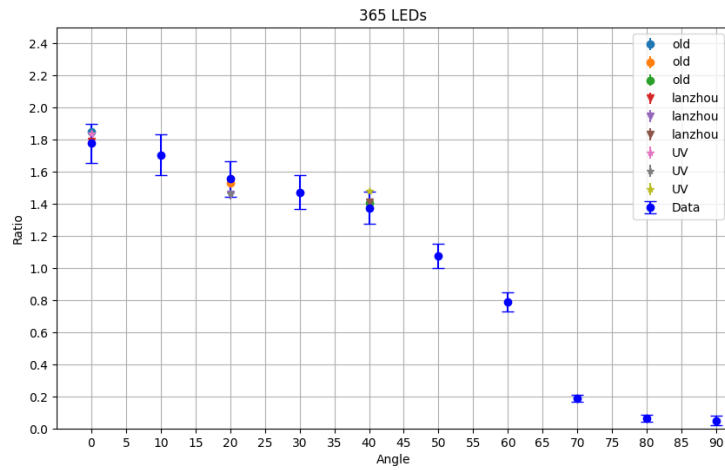
- Air: The performance of the handcrafted concentrator matches well with the mass-produced version.
- Water: The experimental test factor matches well with the MC simulation factor。
- Next to do:
 - Systematic uncertainty
 - ❑ Uncertainty from the diameter of the diffusion ball
 - ❑ The installation of the light concentrator
 - ❑ The installation of the PMT
 - Accelerated aging test

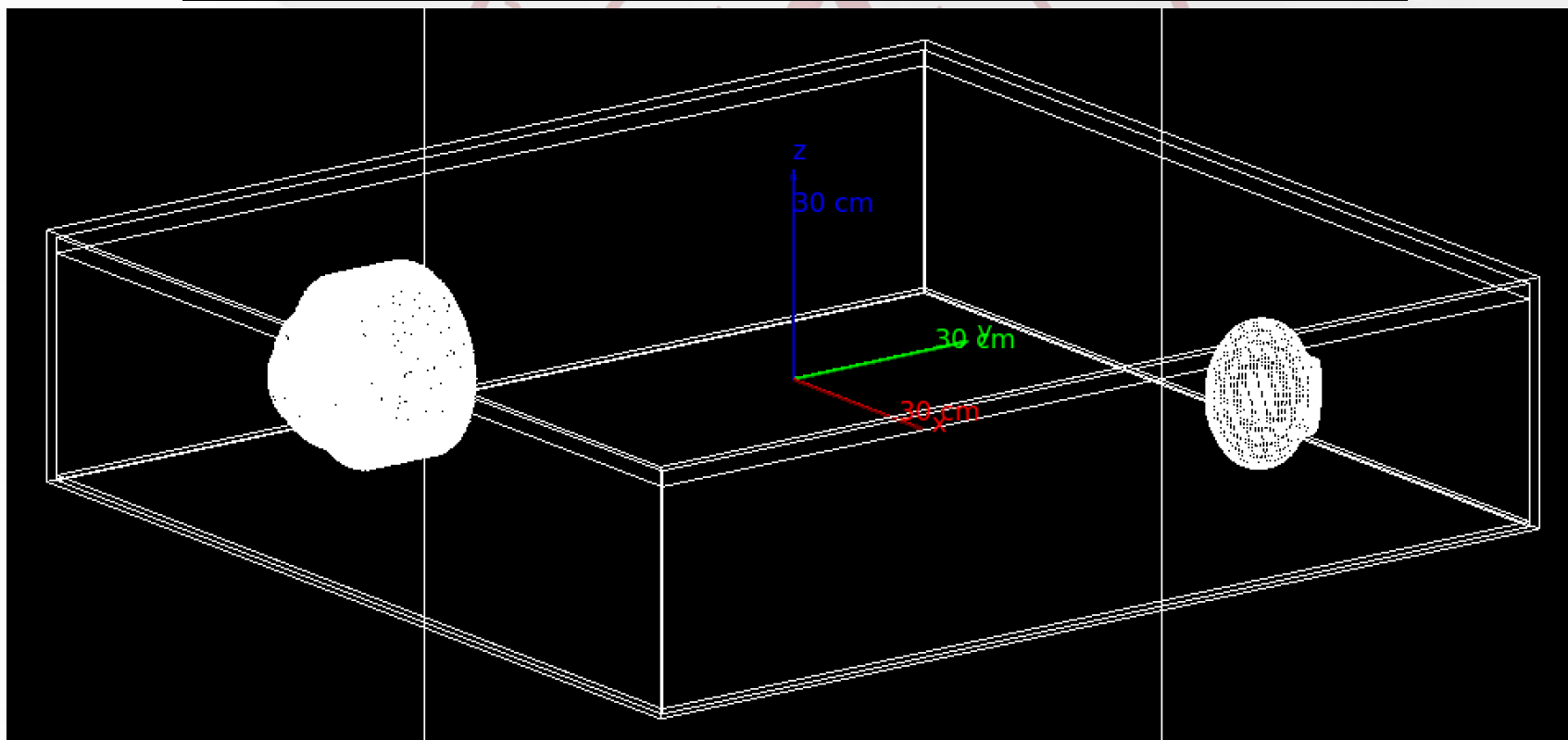
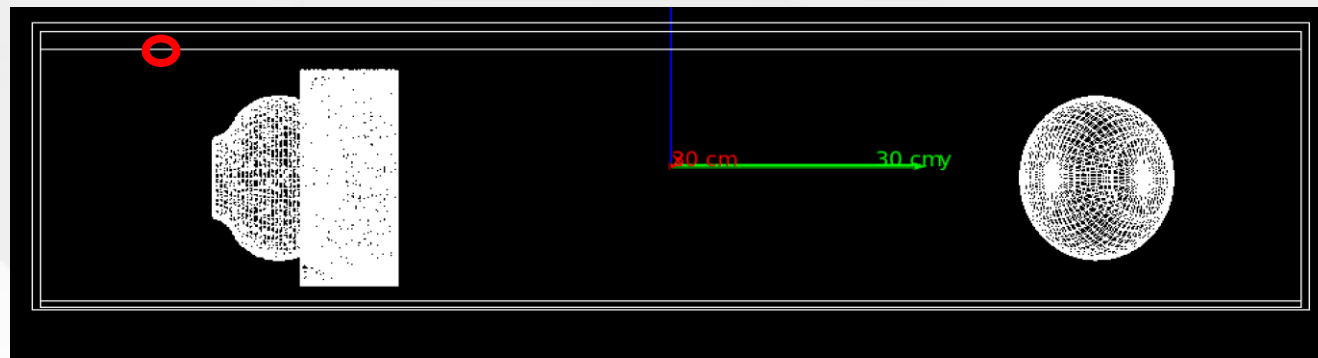


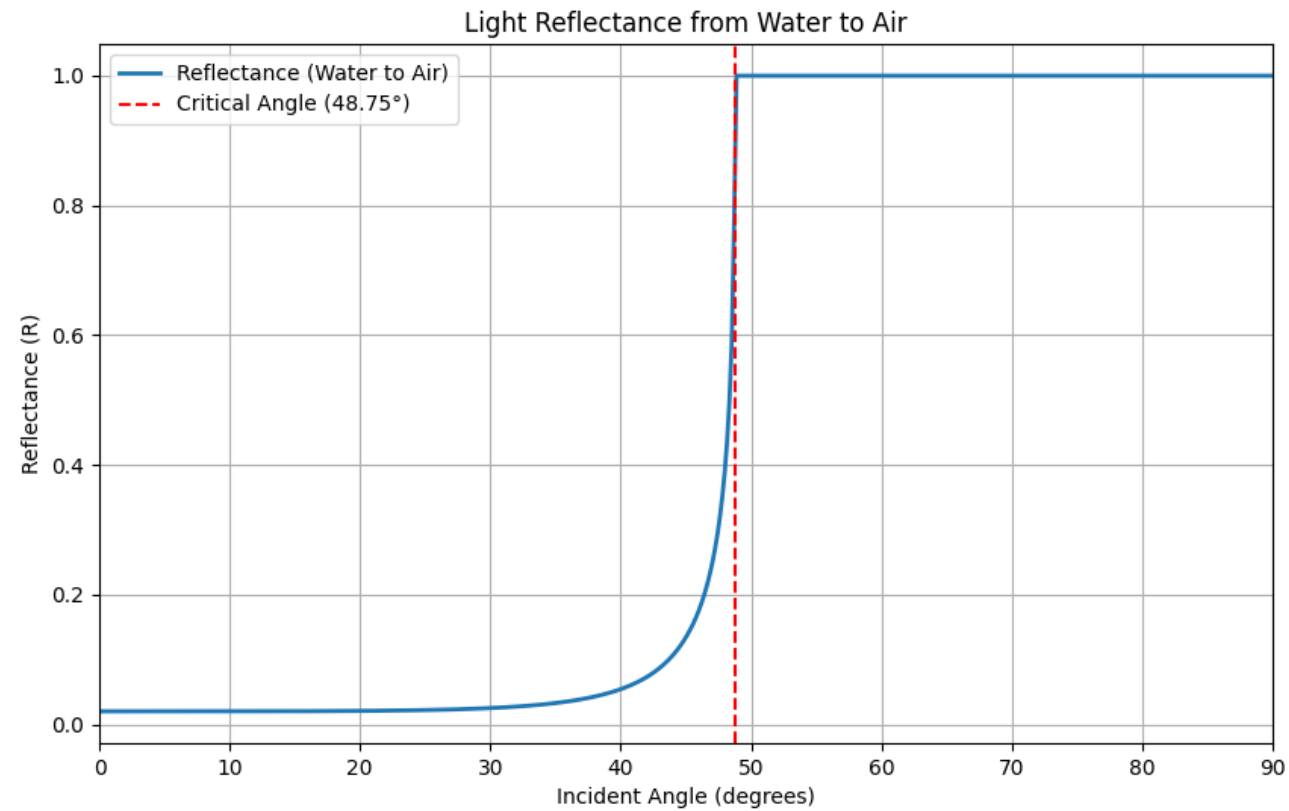
THANKS

Back up

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