

July 7, 2025

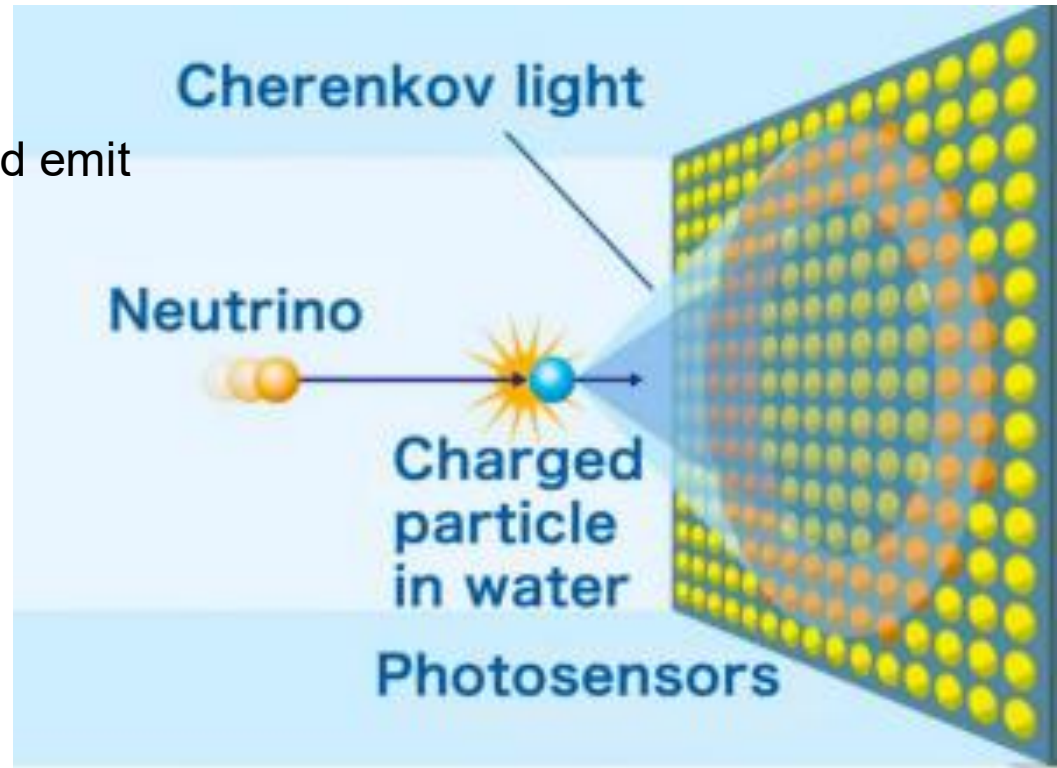
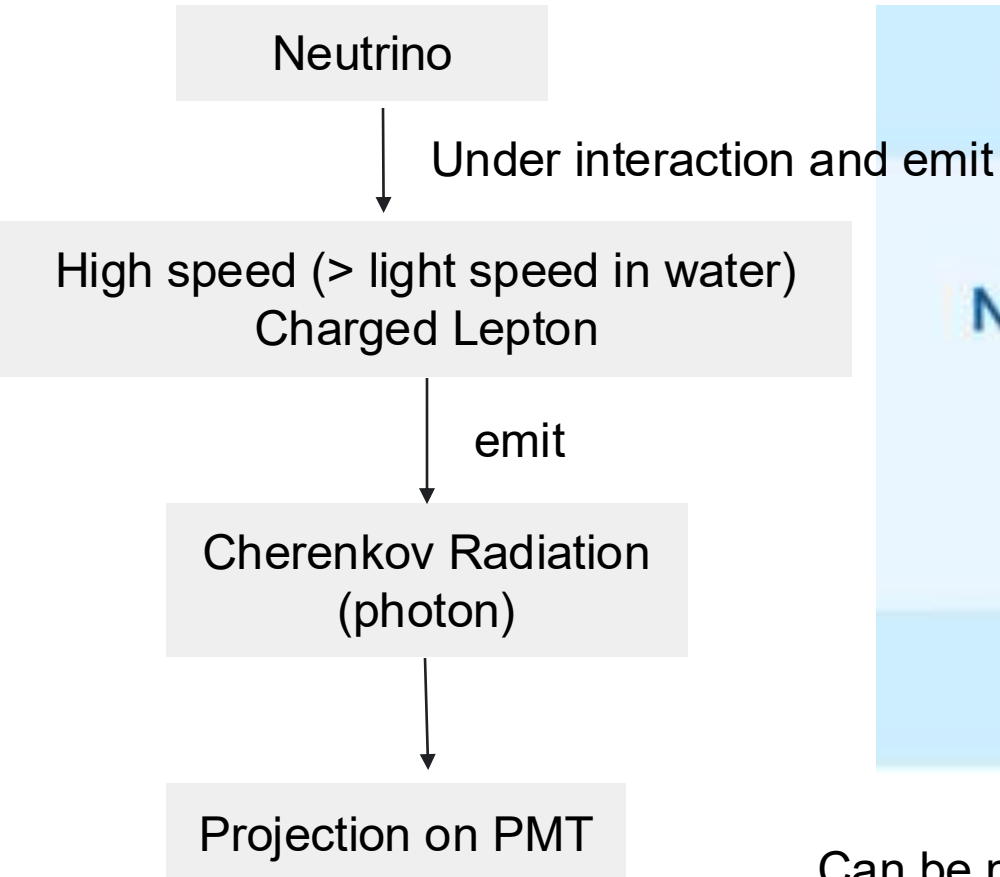
Lam Ching Hui (Nico)
The Chinese University of Hong Kong

Content

- Theory
- Goal/Motivation
- Introduction to OpticSIREN
- Model Comparison (v1.1, vX.Y, v1.Y) (16-20/6)
- Training Data Checking (23-27/6)
- Isotropic Emission (30/6-4/7)
- Future work / to-do

*Some Image in this ppt credited by Ka Ming Tsui

Theory



Can be modelled by Monte Carlo (MC) simulation

Introduction to OpticSIREN

However, Optimization with calibration data in MC method is computational expensive and suffer High Dimensionality issue



So, machine learning model with Fast and Automatic Computation and is developed => **OpticSIREN**

OpticSIREN

Photon Position

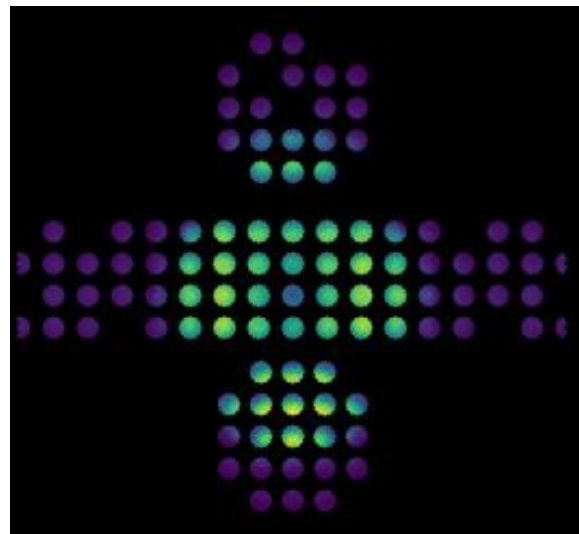


Photon Angle



OpticSIREN

Reconstructed Data



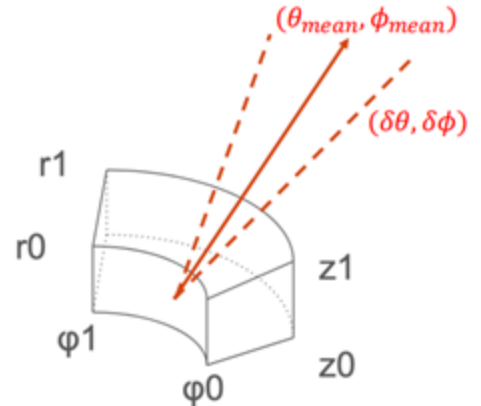
PMT response

This is what I will do for this summer:

Calibrated the OpticSIREN with MC data by various Calibration Source

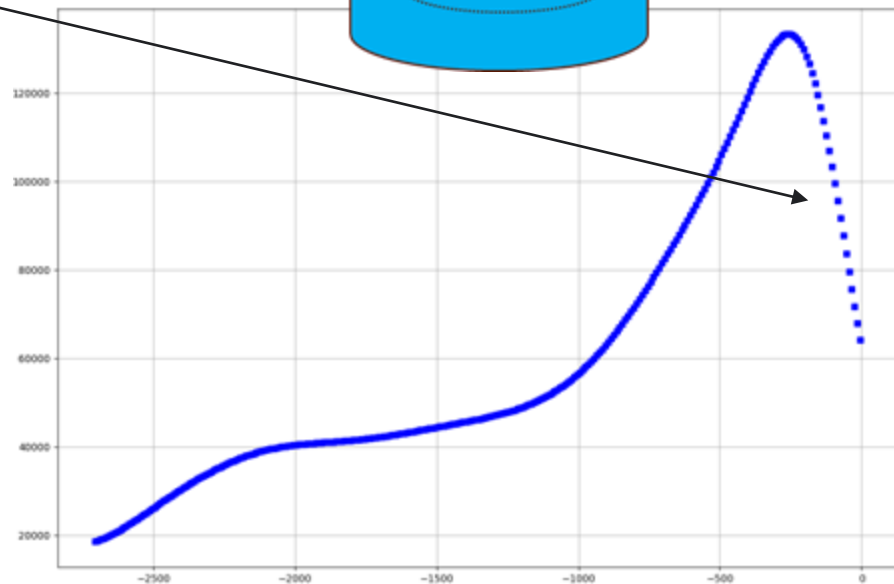
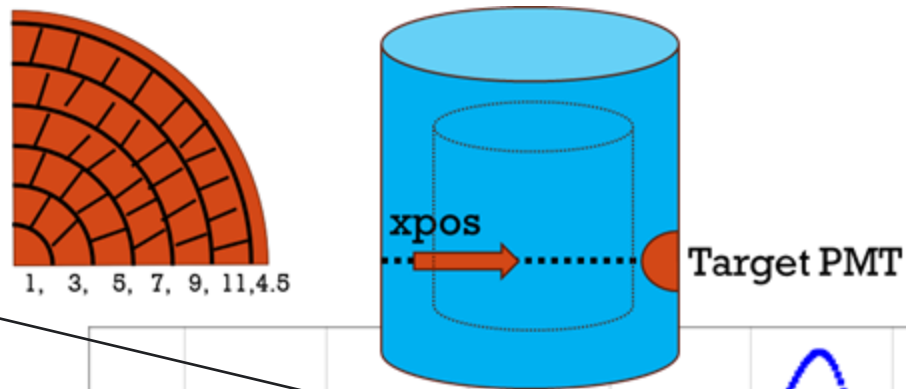
Introduction to OpticSIREN

- Training (MC) Data For WCTE with certain binning
- Inputs: photon starting position and direction
- Outputs: charge prediction per PMT (1843 in total)
- Loss: $\text{Poisson}(Q_{\text{targ}}, Q_{\text{pred}}) * Q_{\text{targ}}$



Unsolved Problem

- **No training data** close to the detector wall/PMTs
- ⇒ Visibility drops to 0
- **Binning is too large** in the last r bin
- ⇒ Visibility is underestimated

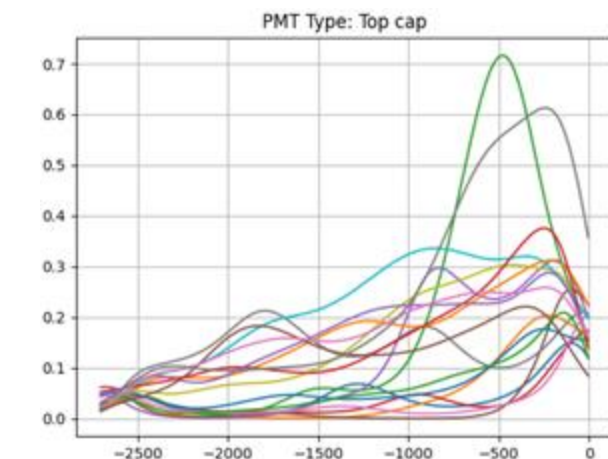
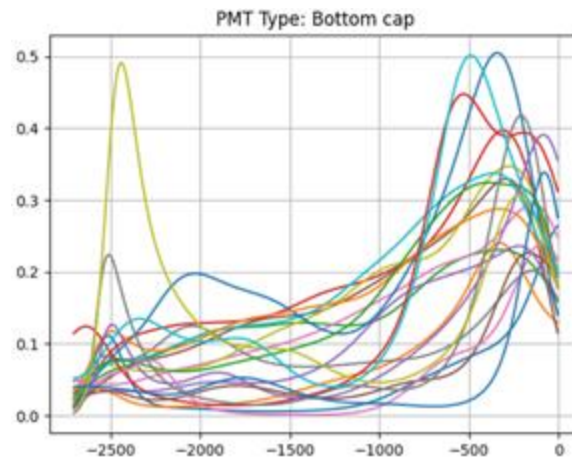
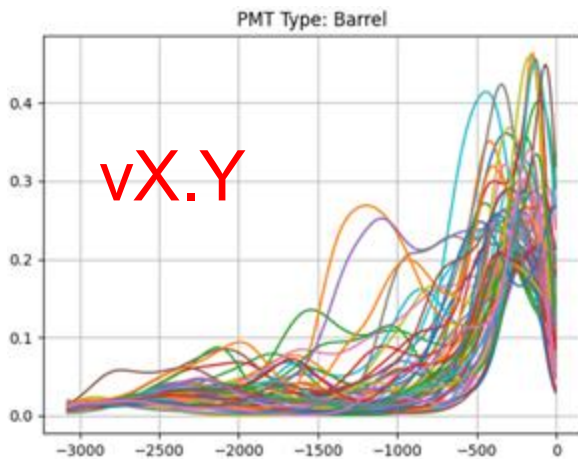
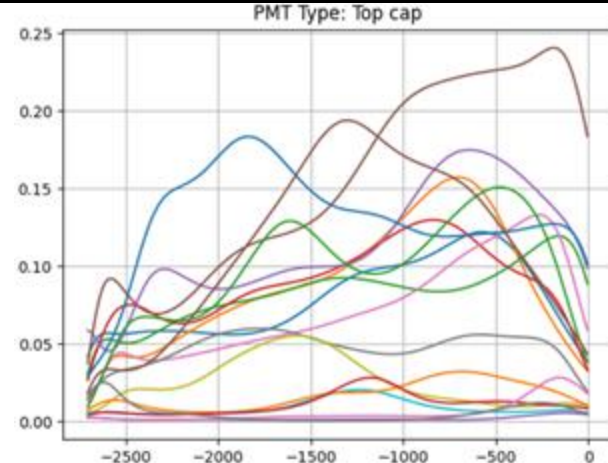
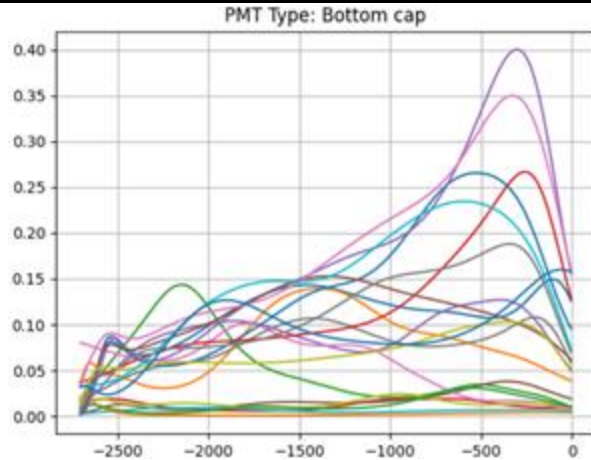
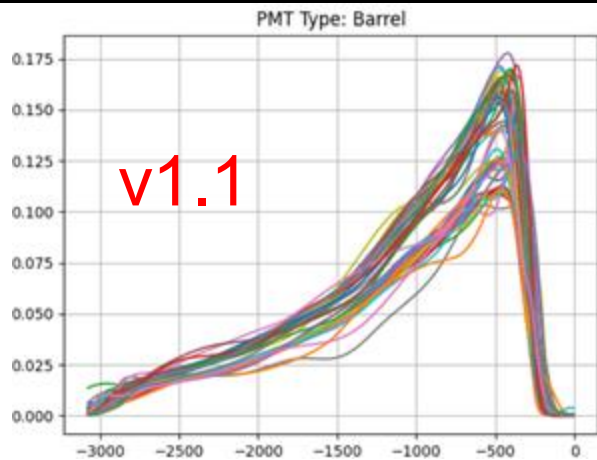


v1.1 => Original OpticSIREN

vX.Y => Fine tune with new binning data

v1.Y => Retrain with full dataset

Model Comparison (v1.1, vX.Y)



Model Comparison (v1.1, vX.Y, v1.Y)

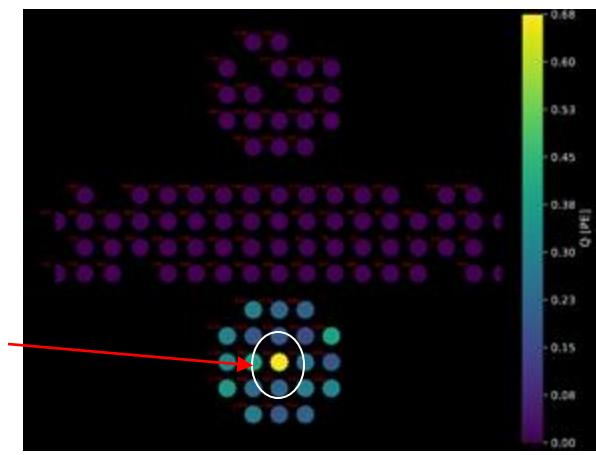
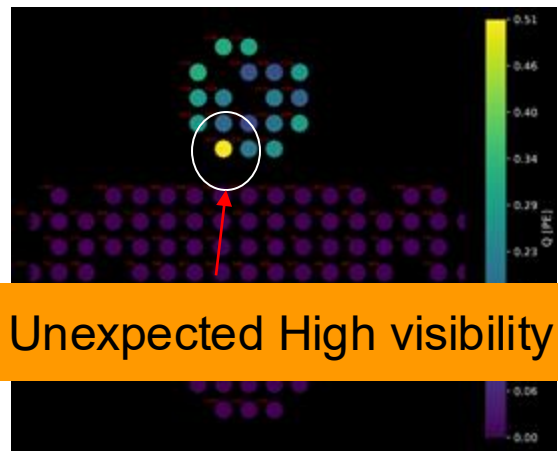
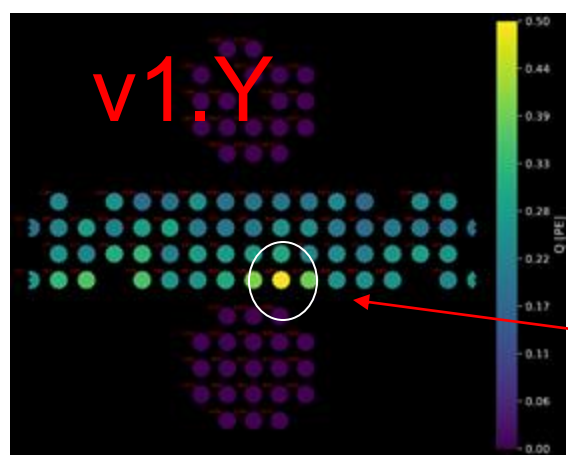
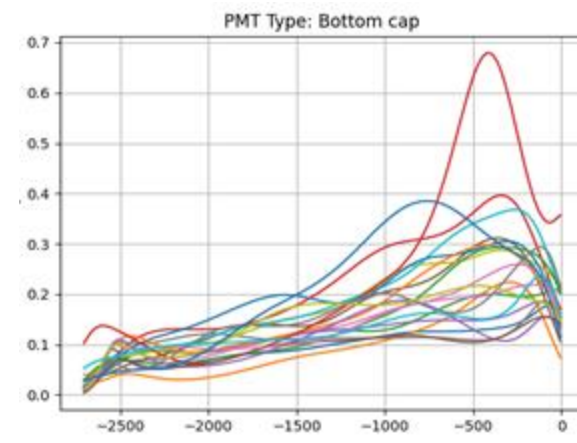
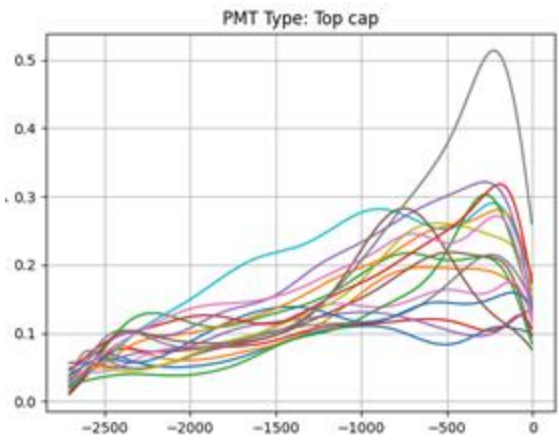
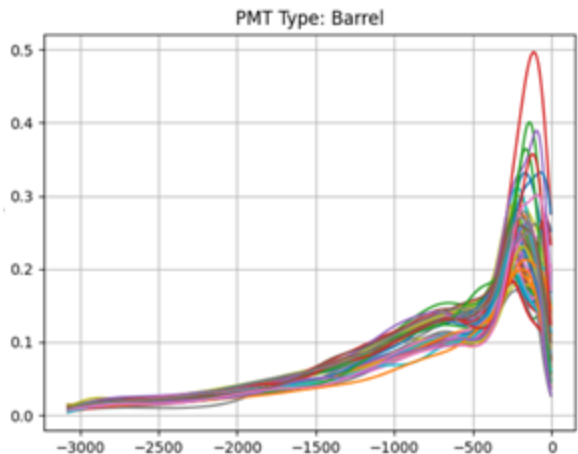
Summary of the comparison of model vX.Y and v1.1

	vX.Y	v1.1
Training range	Larger	Smaller
PMT Response	Much Higher	Much Smaller
Distribution (across each PMT)	More uniform	Less uniform
Trend (along sampling pos.)	Similar	Similar

- Not so obvious to conclude any spatial pattern from PMT response graph (from 2D display)

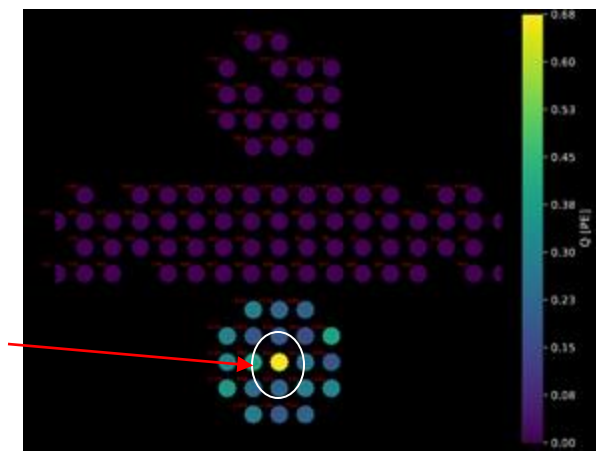
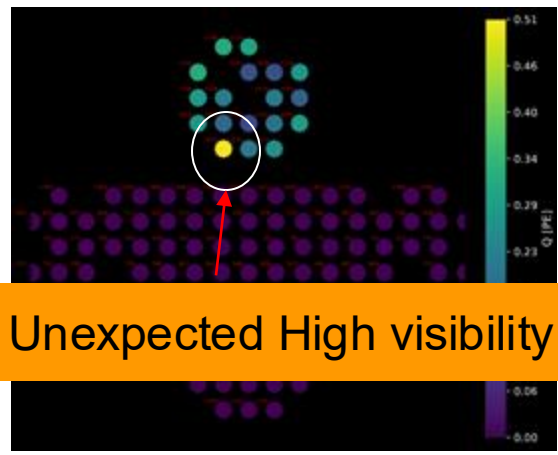
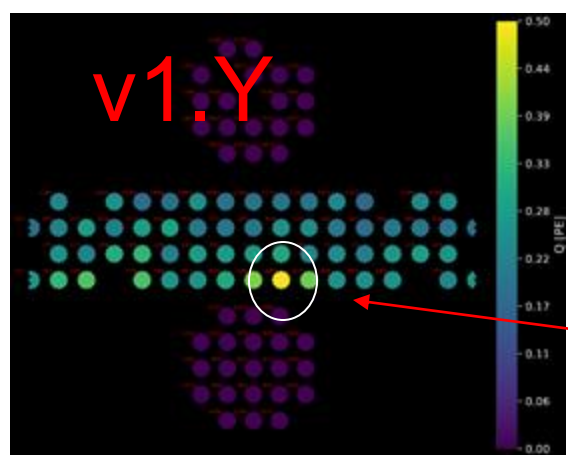
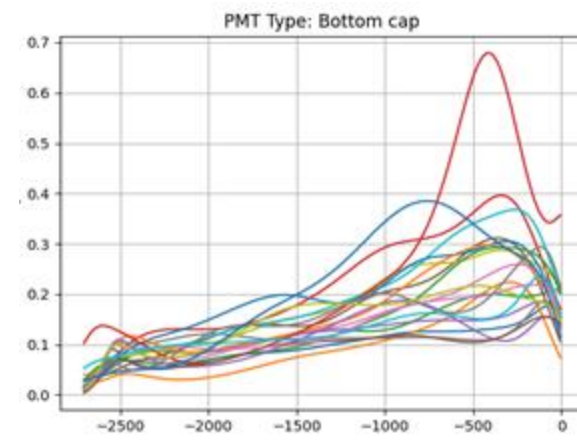
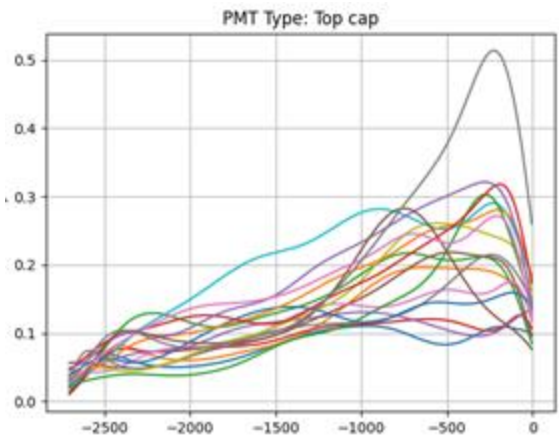
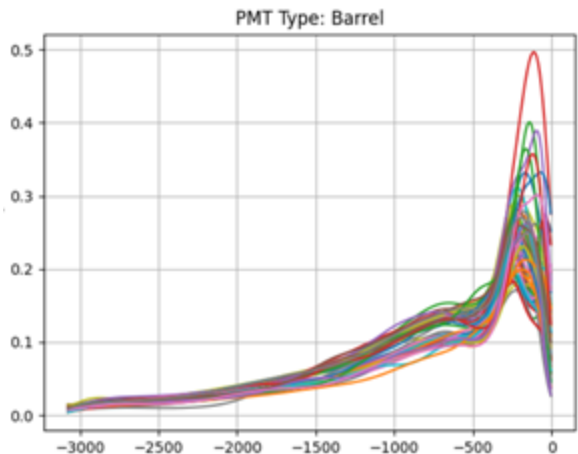
The re-train of whole model should be reconsidered ⇒ v1.Y

Model Comparison (v1.2)



Unexpected High visibility

Model Comparison (v1.2)



Unexpected High visibility

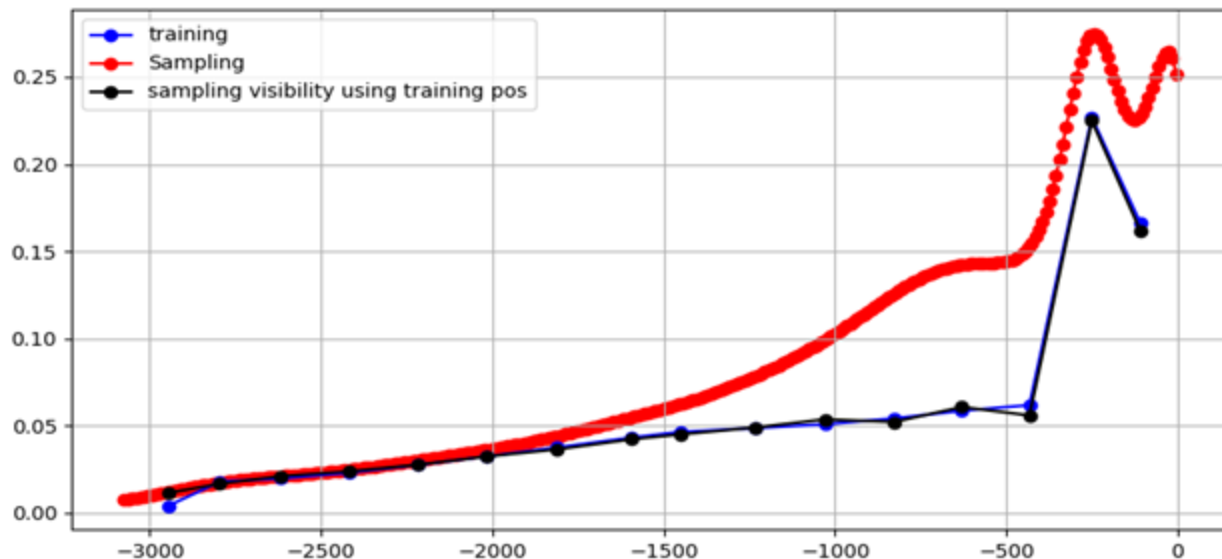
Training Data Checking

A need for comparing the distribution of

1. Training visibility vs Training pos
2. Sampling visibility vs Sampling pos
3. Sampling visibility vs Training pos

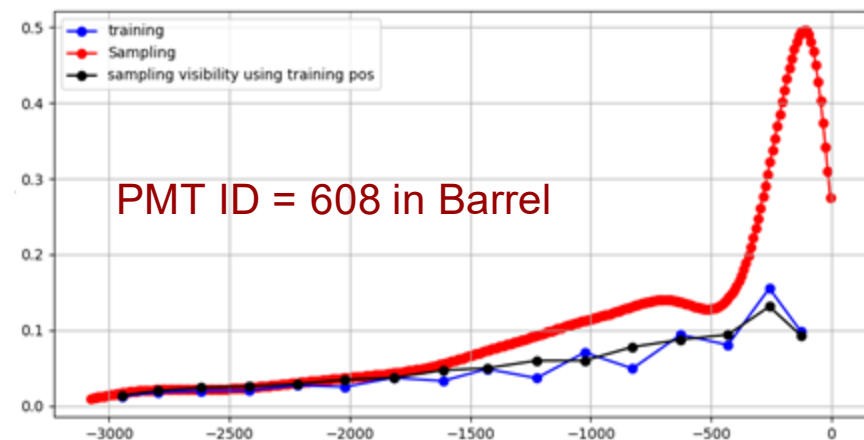
aim

1+3: How Good the OpticSIREN is
2+3: How Good the Interpolation is



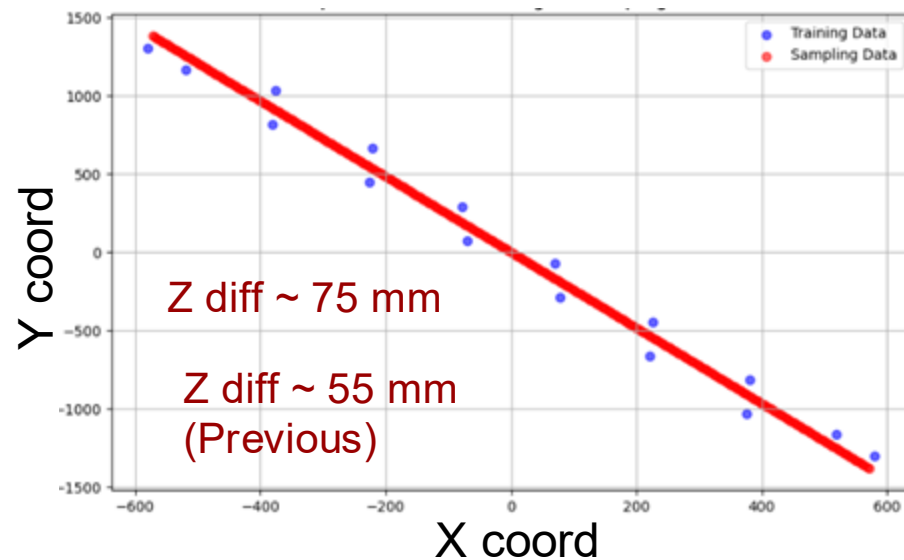
Expected Behaviour

Training Data Checking

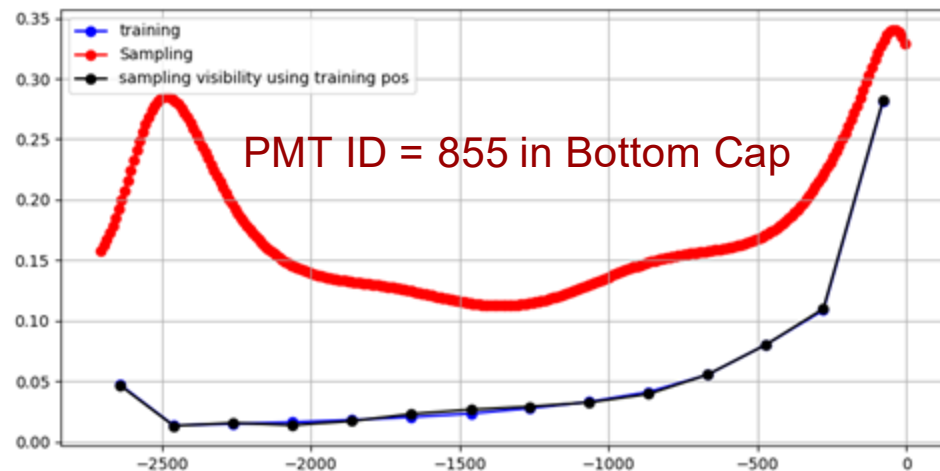
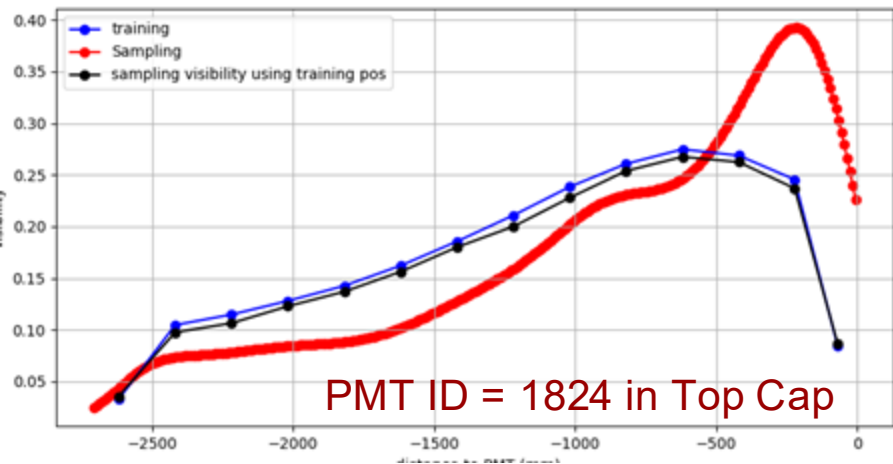


1. Spatial pos of training data and sampling data
2. Check how far the sampling point from Training Bin Center

1. Well Trained OpticSIREN
2. Catch the Trend
3. Interpolation is not ok



Training Data Checking

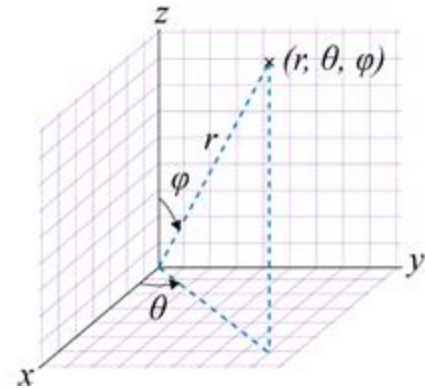


	XY distance (same training z bin center)
Z = [-1080, 1120] (mm)	100 mm
Z < -1080 or Z > 1120 (mm)	50 mm

Isotropic Emission

Previous -> Check the PMT response from trained OpticSIREN

Isotropic Emission -> Calibration Source for fine tuning the trained OpticSIREN (v1.Y) with MC data



Isotropic Emission (ongoing)

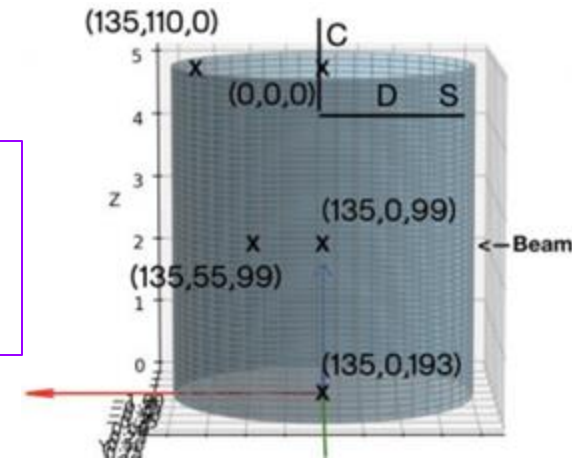
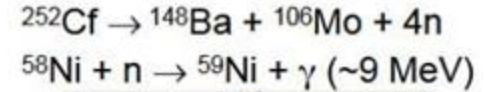
- For a photon source with intensity $I(\theta, \phi)$ at position \vec{x} in the detector, the hit prediction N_i by OpticSiren O for PMT- i is:

$$N_i = \iint I(\theta, \phi) O(\vec{x}, \theta, \phi) d\Omega$$

- Converting to numerical integration

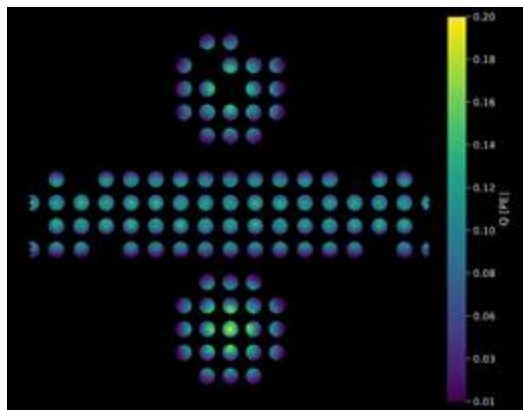
$$N_i = \sum_{j,k} I(\theta_j, \phi_k) O(\vec{x}, \theta_j, \phi_k) (\Delta \cos\theta) (\Delta\phi)$$

Decay source decays -> produce neutron to interact with Ni -> emit photon -> Isotropic emission (same Intensity)



Isotropic Emission (ongoing)

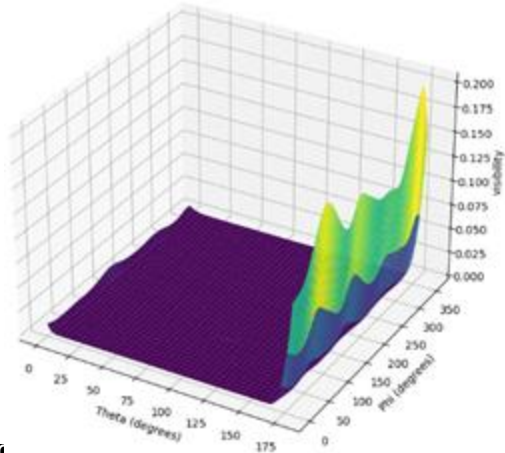
PMT ID = 855 With source at (0,0,0)



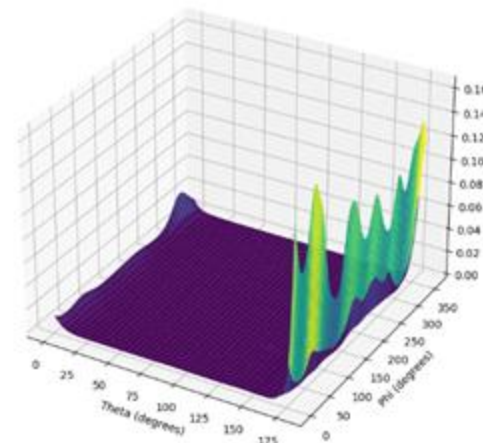
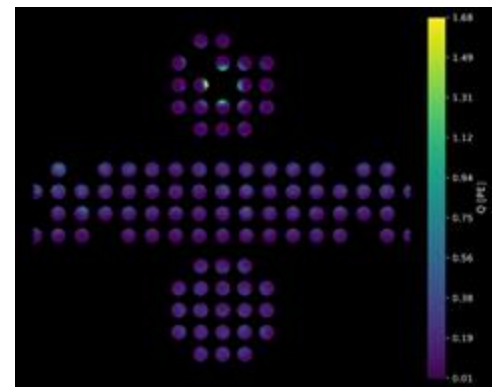
Convergence test is done on the ang binning size
-> Small enough binning

Peak theta ~ 179.75 degree
(855 angular location)

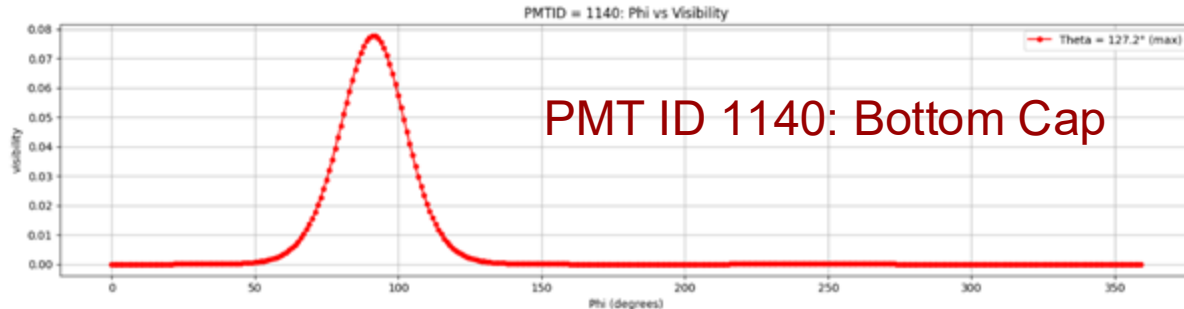
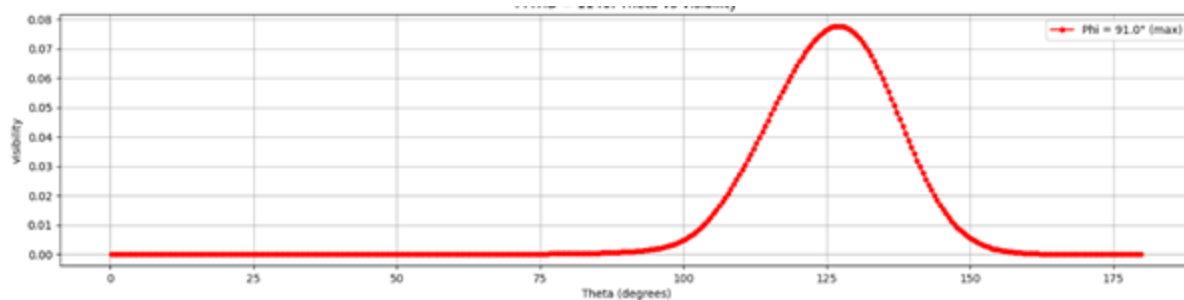
Phi shows more variety
(↓ vector doesn't have phi dependence)



PMT ID = 855 With source at (0,0,1357)

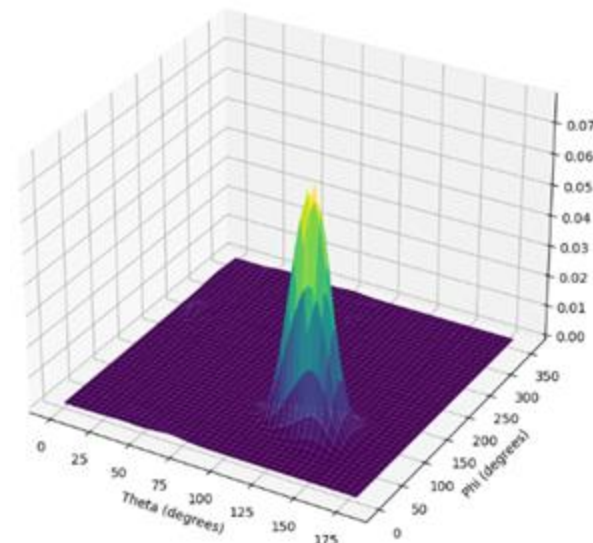
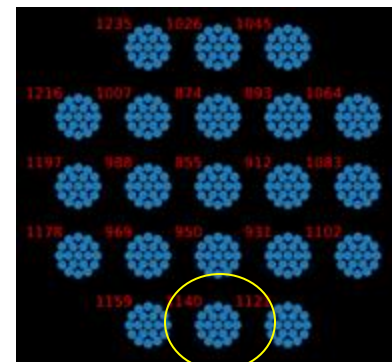


Isotropic Emission (ongoing)



PMT ID 1140: Bottom Cap

Max phi ~ 91 degree
Max Theta ~ 127.2 degree



Future work / to-do

- Calibrate OpticSIREN on neuron network weighting
- Apply other types of source for testing?
- Model the response \sim Observation

July 14, 2025

Lam Ching Hui (Nico)
The Chinese University of Hong Kong

Content

- Isotropic Emission
- Soaking Test
- Future work / to-do

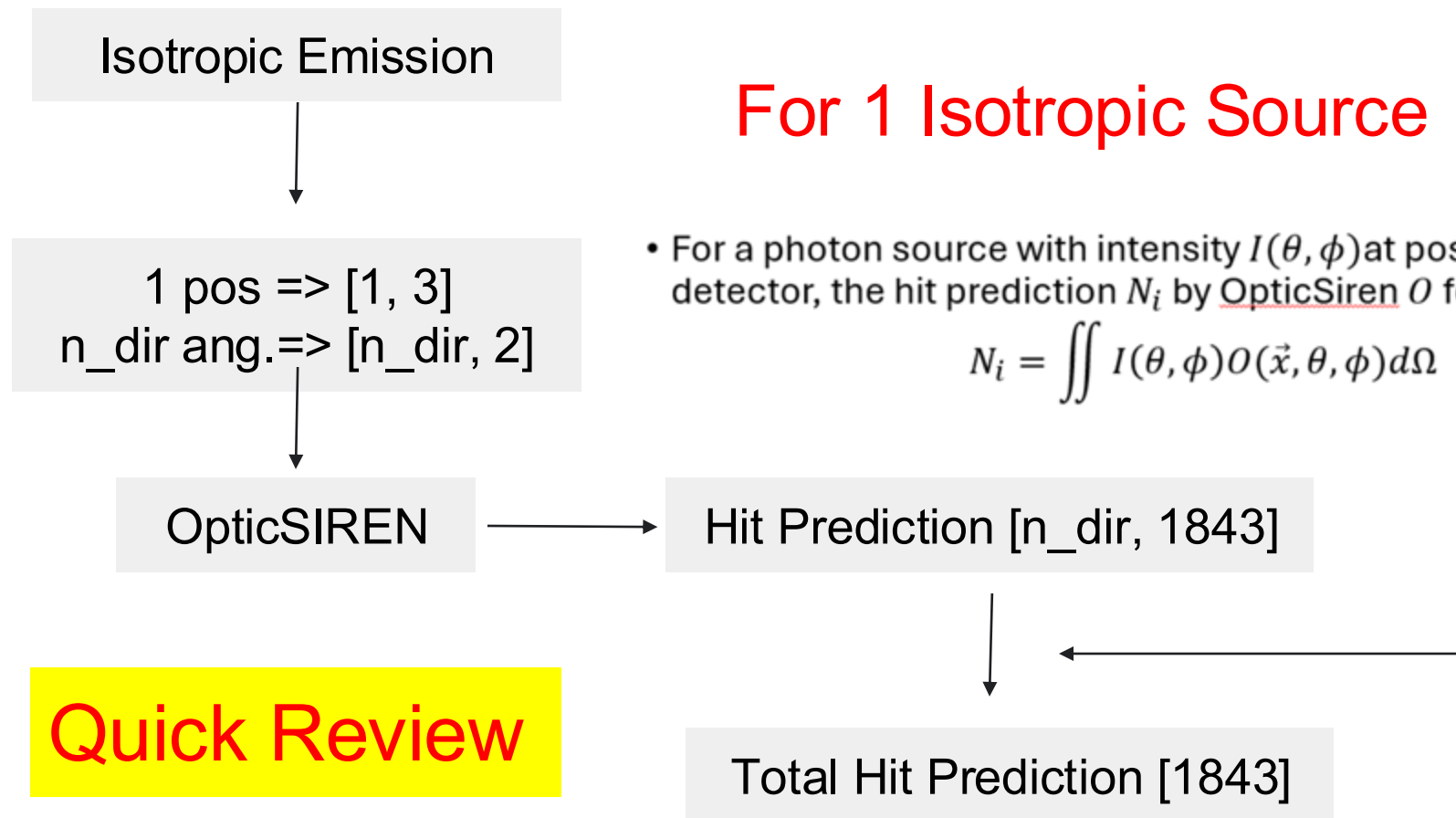
*Some Image in this ppt credited by Ka Ming Tsui

Isotropic Emission

For 1 Isotropic Source

- For a photon source with intensity $I(\theta, \phi)$ at position \vec{x} in the detector, the hit prediction N_i by OpticSiren O for PMT- i is:

$$N_i = \iint I(\theta, \phi) O(\vec{x}, \theta, \phi) d\Omega$$



Quick Review

Isotropic Emission

For N Isotropic Source

Hit Prediction [N, n_dir, 1843]



integration

Total Hit Prediction [N, 1843]

output from OpticSIREN v1.Y

loss is already at minimal at start, training beyond
=> over-fitting the model

Act as Ground Truth Target
for Fine Tuning OpticSIREN

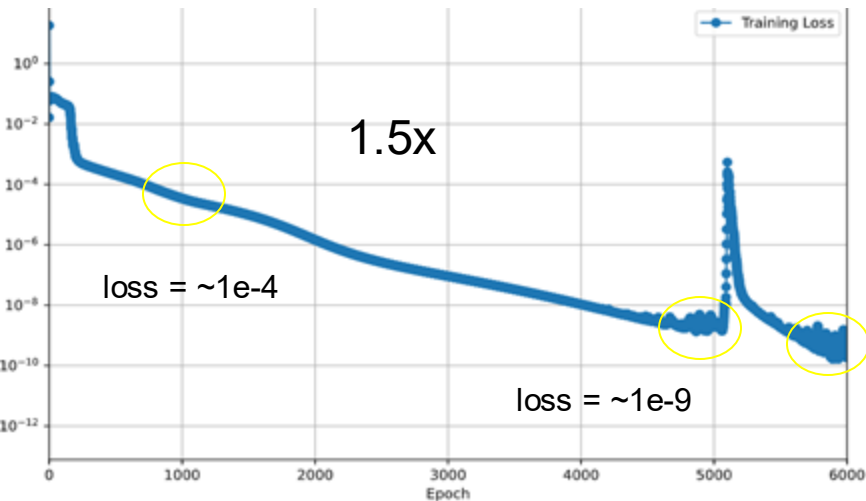
Aim for testing the pipeline for WCTE Data, which is the Ground Truth Target for training in the future

Isotropic Emission

we scale up the ground truth value (randomly)
and check the gradient descent

3 source positions is using

Loss Function: Mean Square Loss

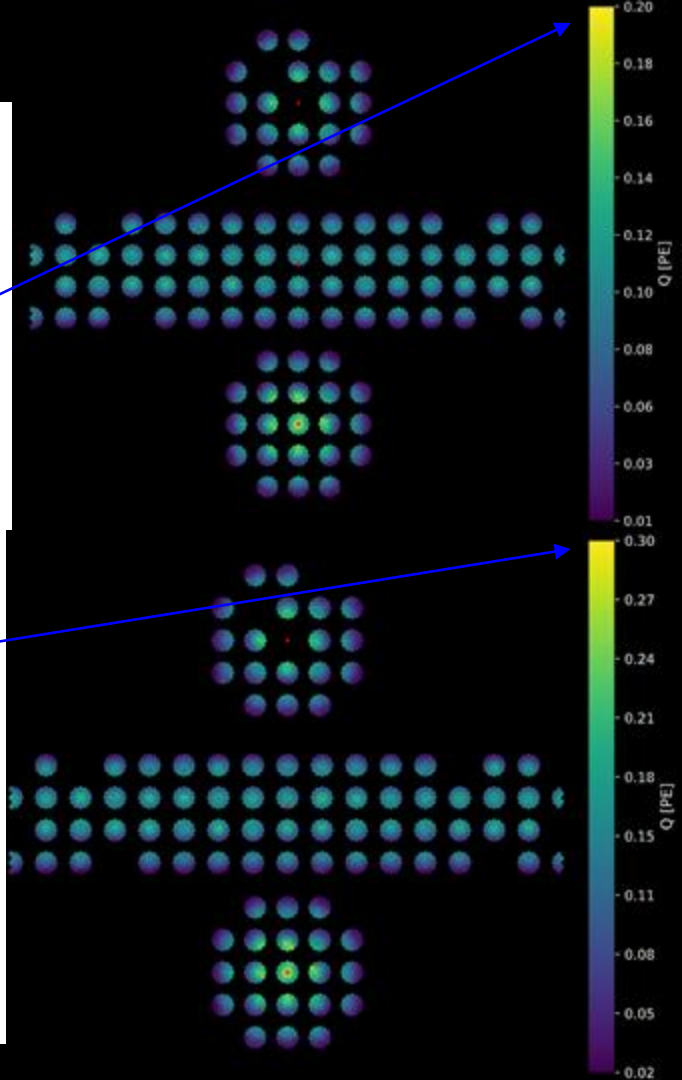


Peak at 0.2

diff 1.5x

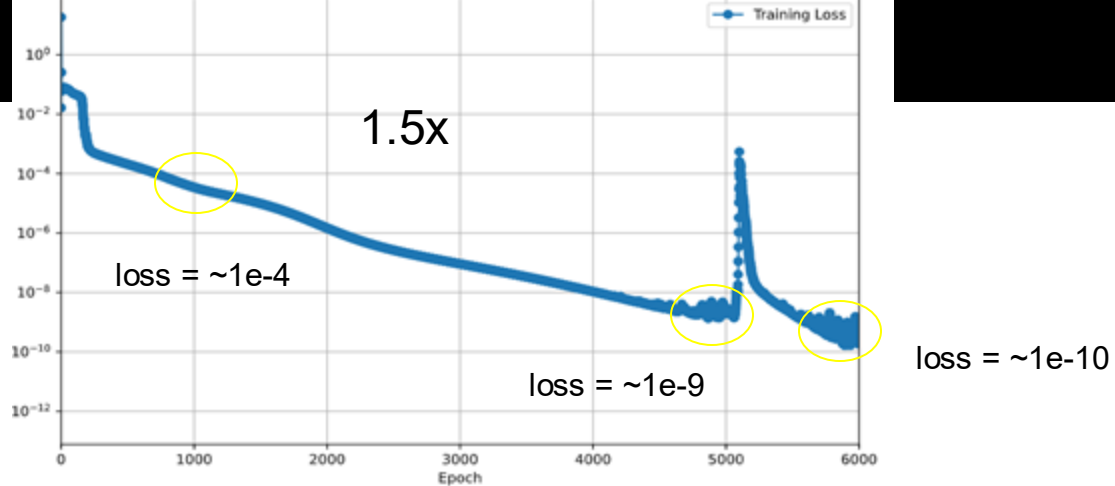
Peak at 0.3

loss = $\sim 1e-10$



Isotropic Emission

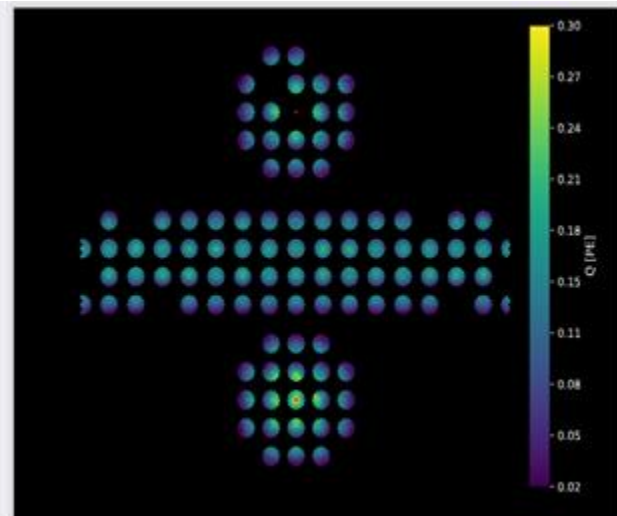
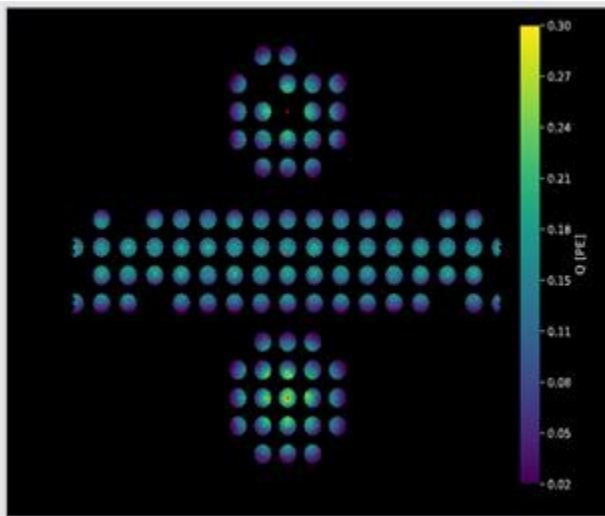
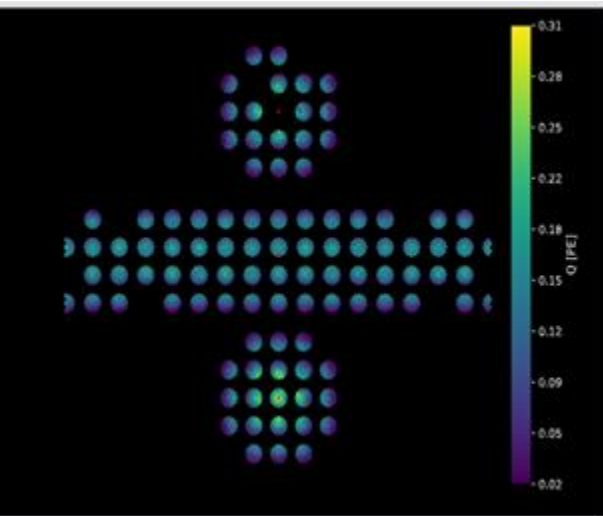
More or less the same?



epoch 1000

epoch 5000

epoch 6000



Isotropic Emission

```
Traceback (most recent call last):
  File "/home/nicolam1010/OpticSiren/bin/train-opticSiren_isotropic.py", line 94, in <module>
    fire.Fire(main)
  File "/usr/local/lib/python3.10/dist-packages/fire/core.py", line 135, in Fire
    component_trace = _Fire(component, args, parsed_flag_args, context, name)
  File "/usr/local/lib/python3.10/dist-packages/fire/core.py", line 468, in _Fire
    component, remaining_args = _CallAndUpdateTrace(
  File "/usr/local/lib/python3.10/dist-packages/fire/core.py", line 684, in _CallAndUpdateTrace
    component = fn(*varargs, **kwargs)
  File "/home/nicolam1010/OpticSiren/bin/train-opticSiren_isotropic.py", line 89, in main
    sopt = SOptimizer_isotropic(cfg)
  File "/home/nicolam1010/OpticSiren/optics/apps/SOptimizer_isotropic.py", line 62, in __init__
    dataset.to(self._device)
  File "/home/nicolam1010/OpticSiren/optics/io/dataset_isotropic.py", line 85, in to
    self._pmtQ.to(device)
torch.cuda.OutOfMemoryError: CUDA out of memory. Tried to allocate 56.06 GiB (GPU 0; 31.73 GiB total capacity; 8.63 MiB already allocated; 30.40 GiB free; 26.00 MiB reserved in total by PyTorch)
```

Facing some memory issues of GPU when I try to use more source position

Current Source Position: 3

Target Source Position: 63 (just some random numbers)

The Soaking Test

Soaking test @ ICRR building-B1: [supervised by Ka Ming Tsui and Patrick]

Goal:

- Check the Transmittance of Water containing Blacksheet (material inside the tank) over a period of time

Step:

- Soak BlackSheet used in the detector, into ultra pure water
- Put them in containers, soak for a period of time
- Use Spectrophotometer to measure water (soaked) transmittance

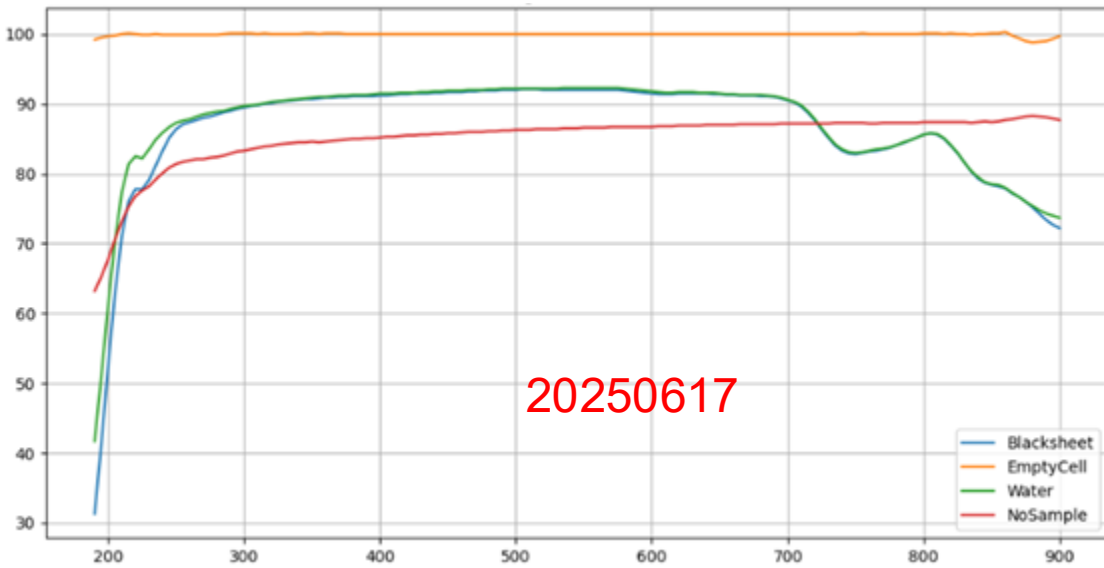
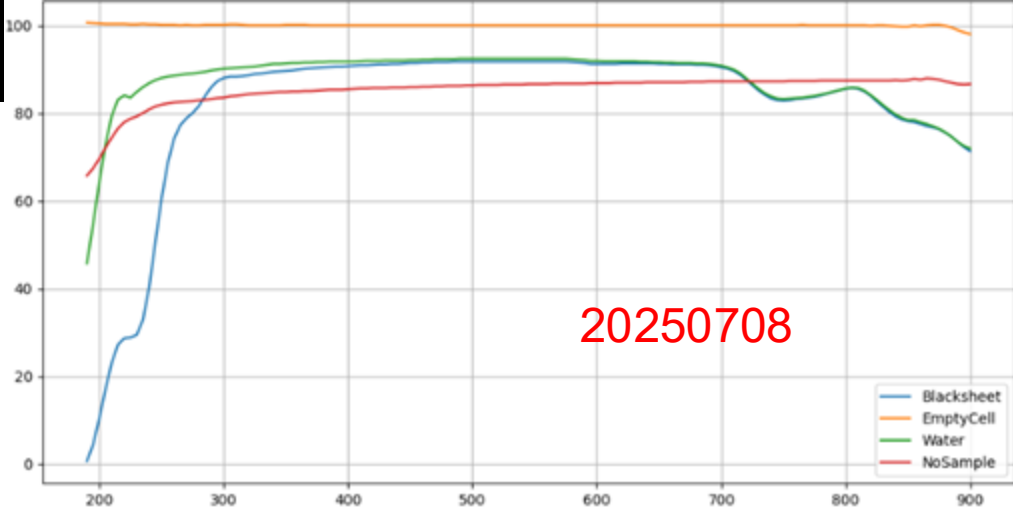
Test Time:

- 2025 0617
- 2025 0708
- more in the future

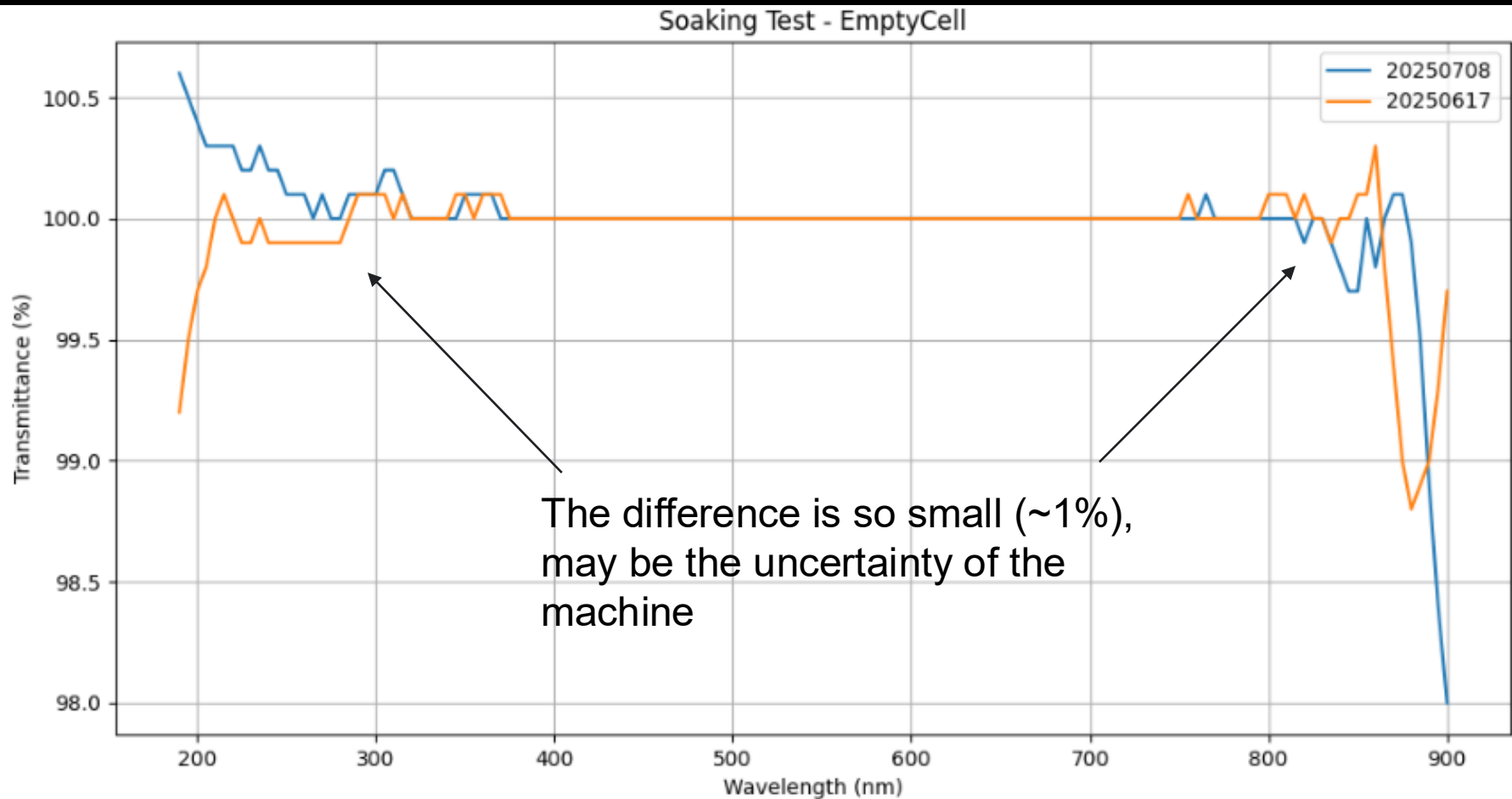


Soaking Test Result

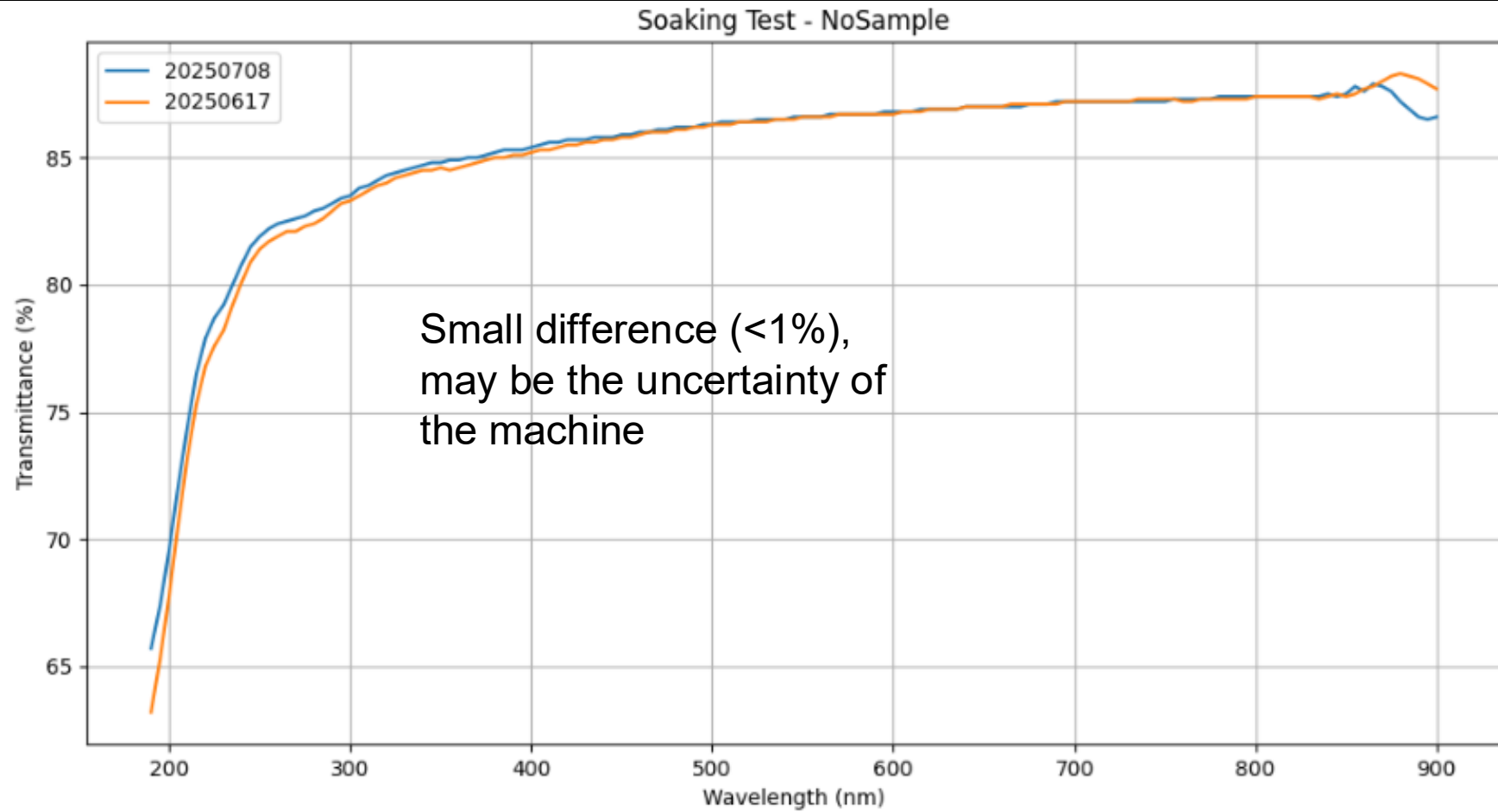
x axis: Wavelength (nm)
y axis: Transmittance (%)



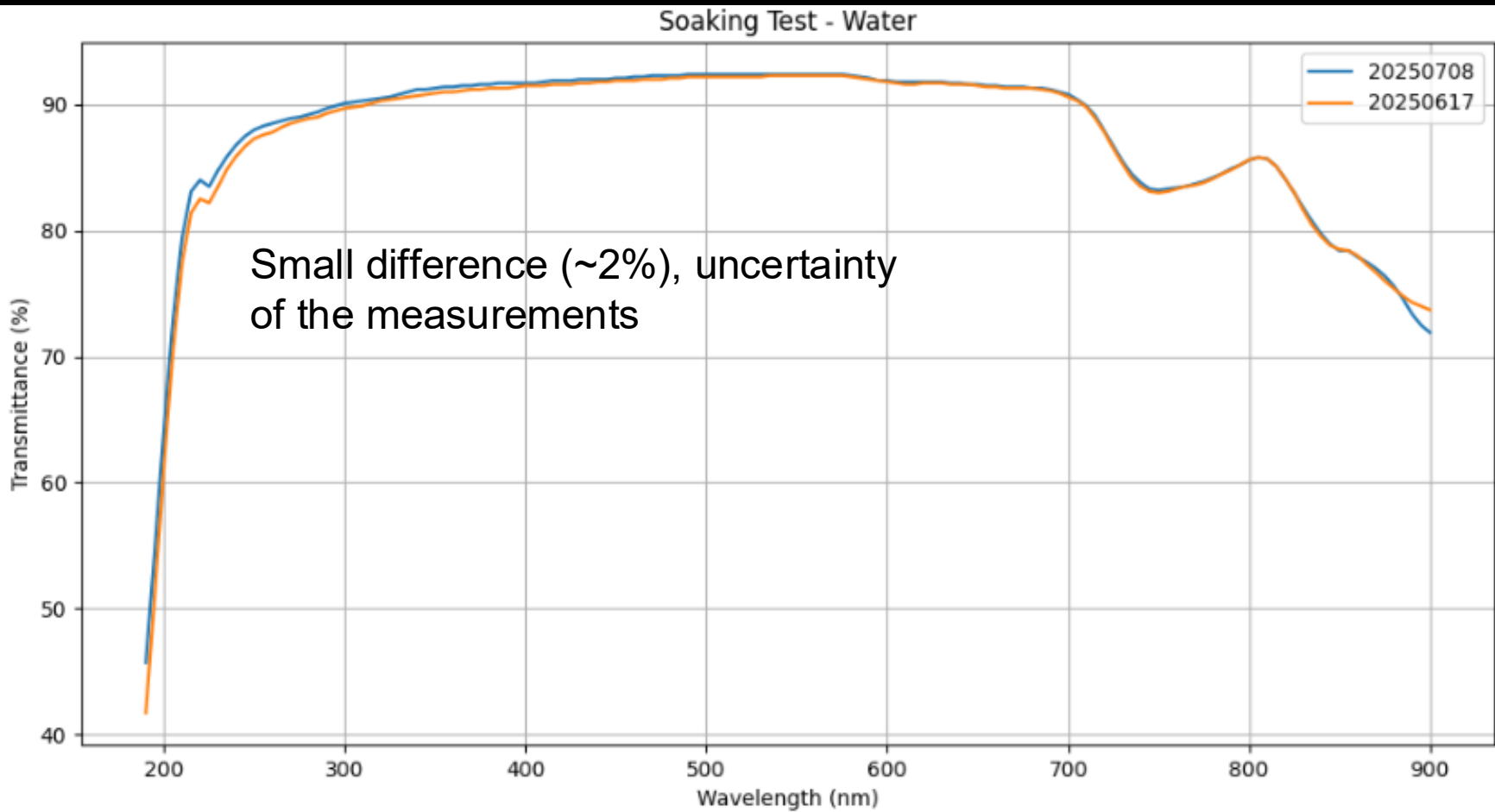
Soaking Test Result - Empty Cell



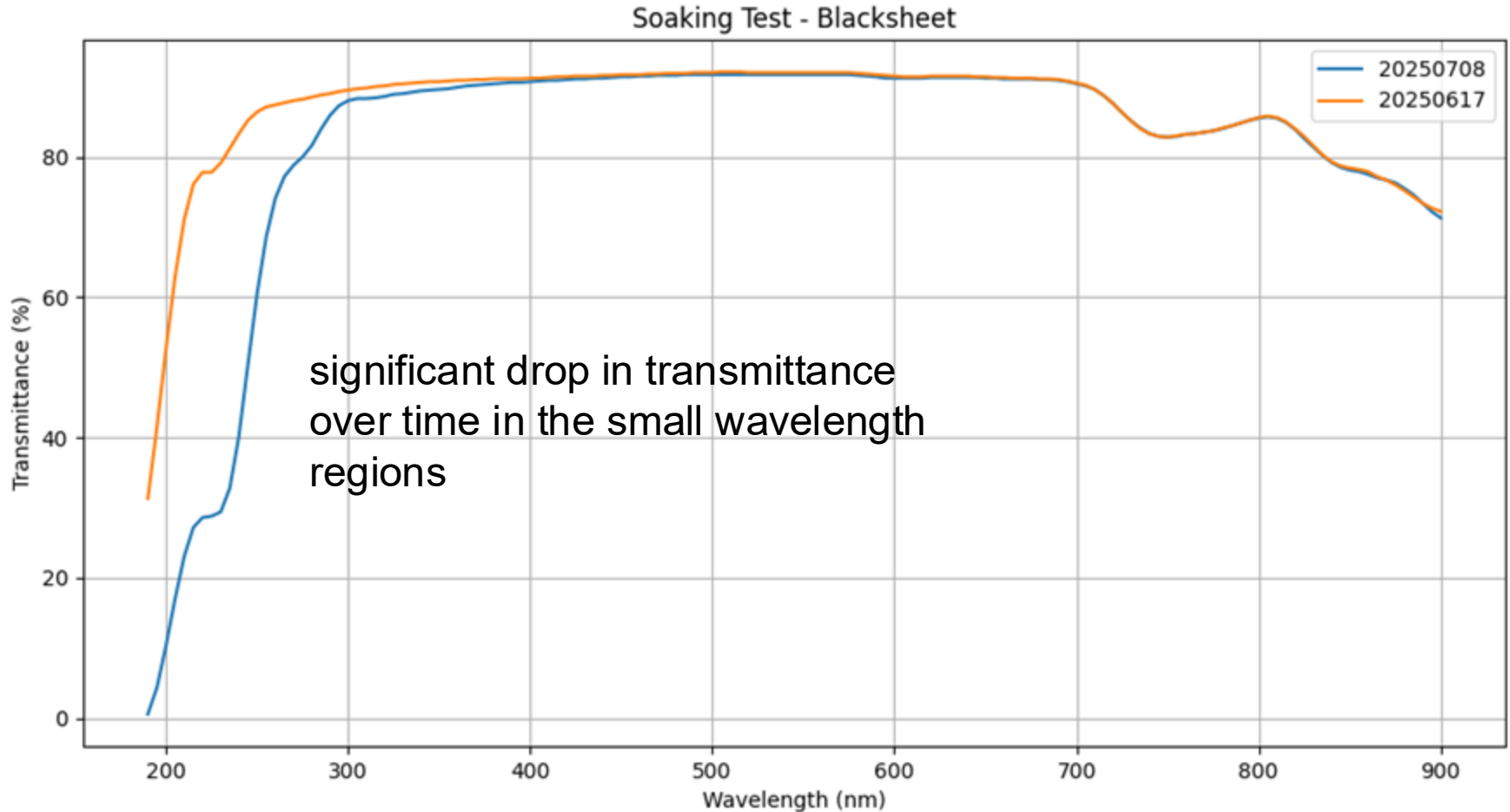
Soaking Test Result - Glass With No Sample



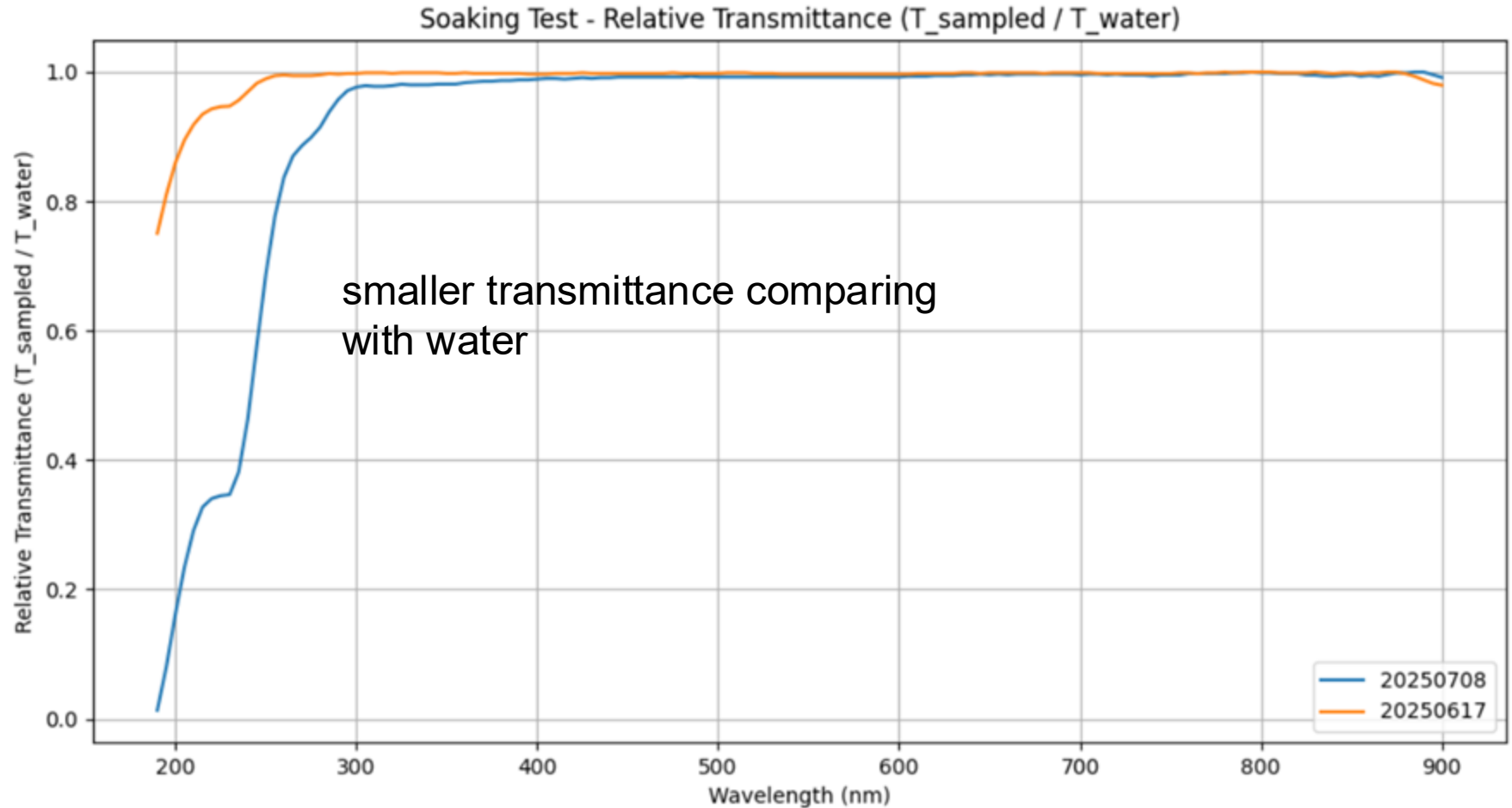
Soaking Test Result - Glass With Water Only



Soaking Test Result - Glass With BlackSheet



Soaking Test Result - Relative Transmittance of BlackSheet



Future work / to-do

- Calibrate OpticSIREN on neuron network weighting
- Take more Soaking Test Result

July 22, 2025

Lam Ching Hui (Nico)
The Chinese University of Hong Kong

Content

- Quick Review: Formalism
- Calibration of Isotropic Emission
- Soaking Test
- Future work / to-do

Quick Review: Formalism

For a photon source with intensity $I(\theta, \phi)$ at position \vec{x} in the detector, the hit prediction N_i by OpticSiren O for PMT- i is:

$$N_i = \iint I(\theta, \phi) O(\vec{x}, \theta, \phi) d\Omega$$

I = intensity Profile of the source

O = mPMT visibility from OpticSIREN

N = total mPMT visibility from the measurement (fake data)

Current Pipeline (Isotropic Emission)	future/Operation
Create Isotropic Emission by using OpticSIREN v1.2 with given Intensity (I)	Putting Ni Ball with measurable Intensity (I)
Scale up the Total Hit Predictions (e.g. $\times 1.5N$) => Create fake data (N)	Measure total PMT visibility (N)
Fine tuned the model based on v1.2 (O)	Fine tuned the model based on v1.2 (O)

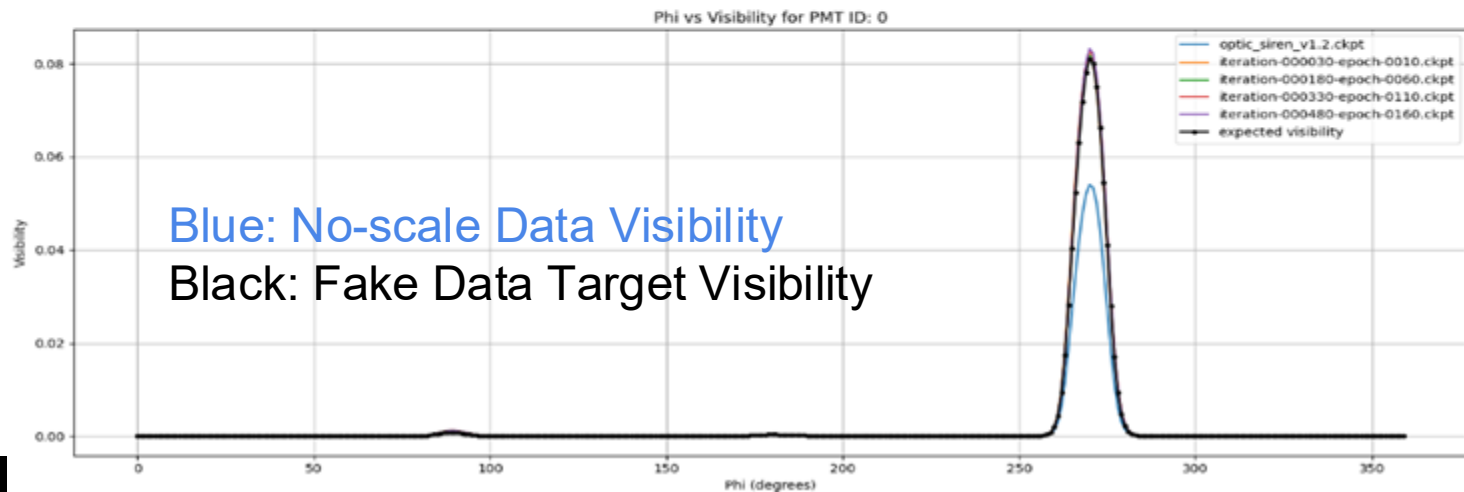
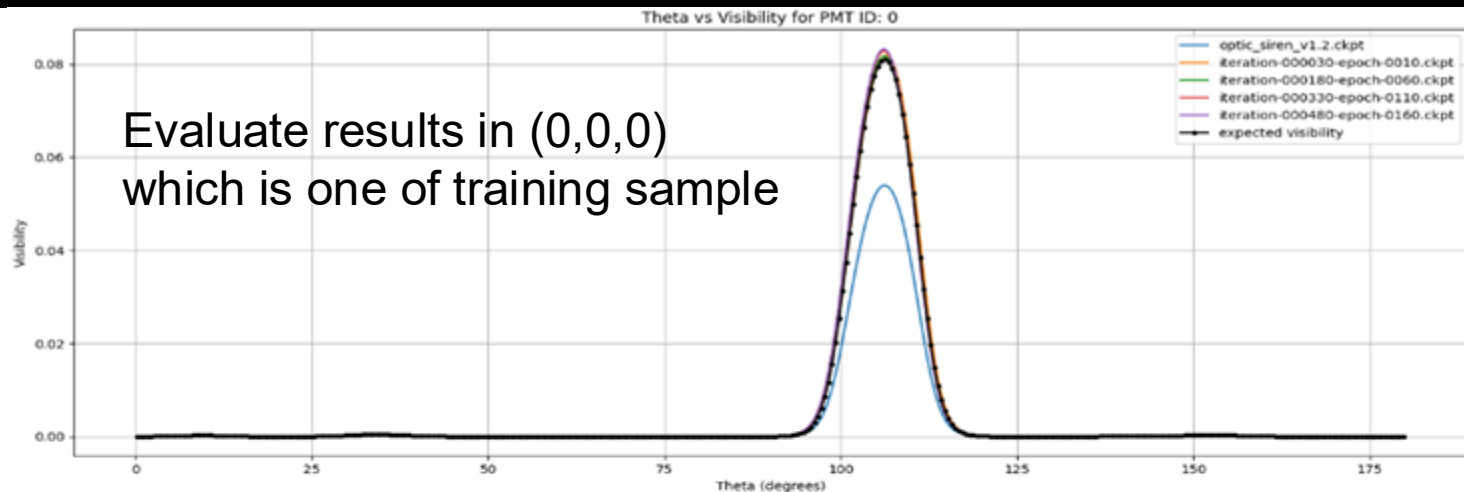
But In general, the calibration pipeline works on **any point source** with a **known intensity profile**

Isotropic Emission

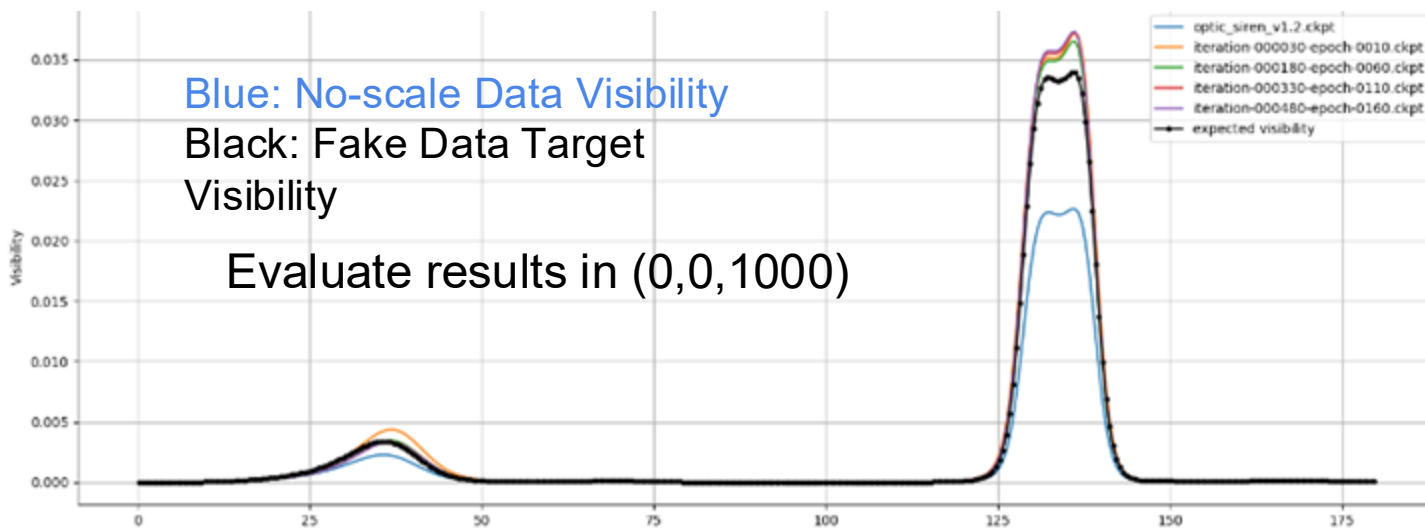
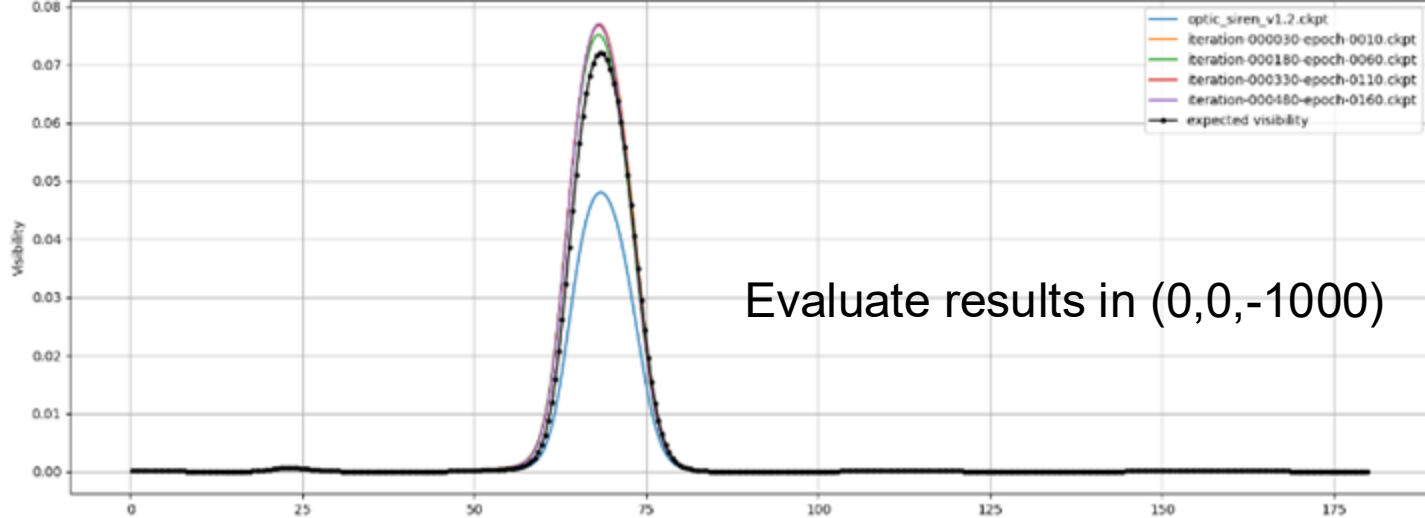
Evaluate the result at

1. Training Source Position -> Double check the gradient descent
2. Other Source Position -> Check if the fine tuned model is generalized

Isotropic Emission

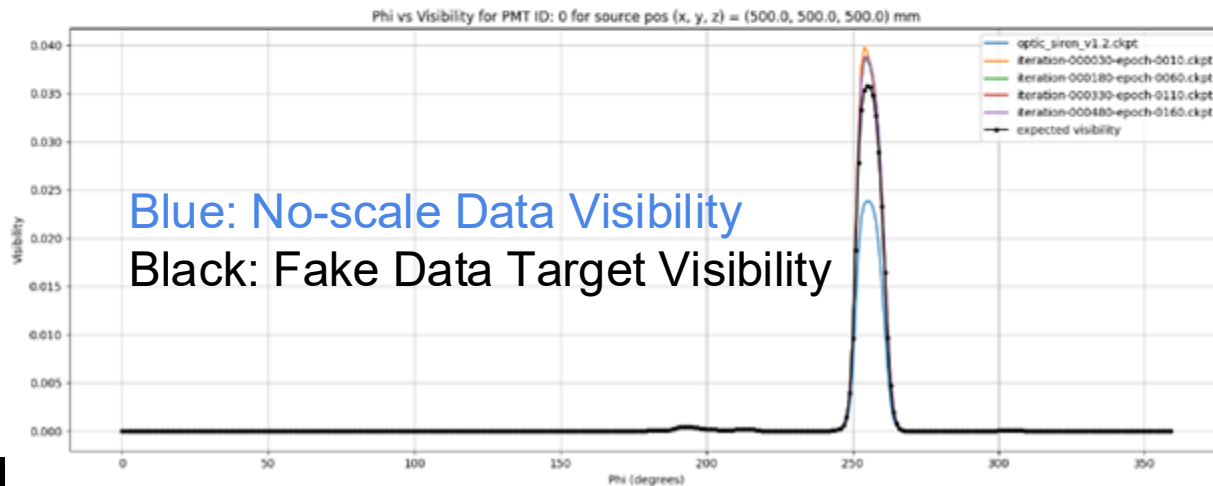
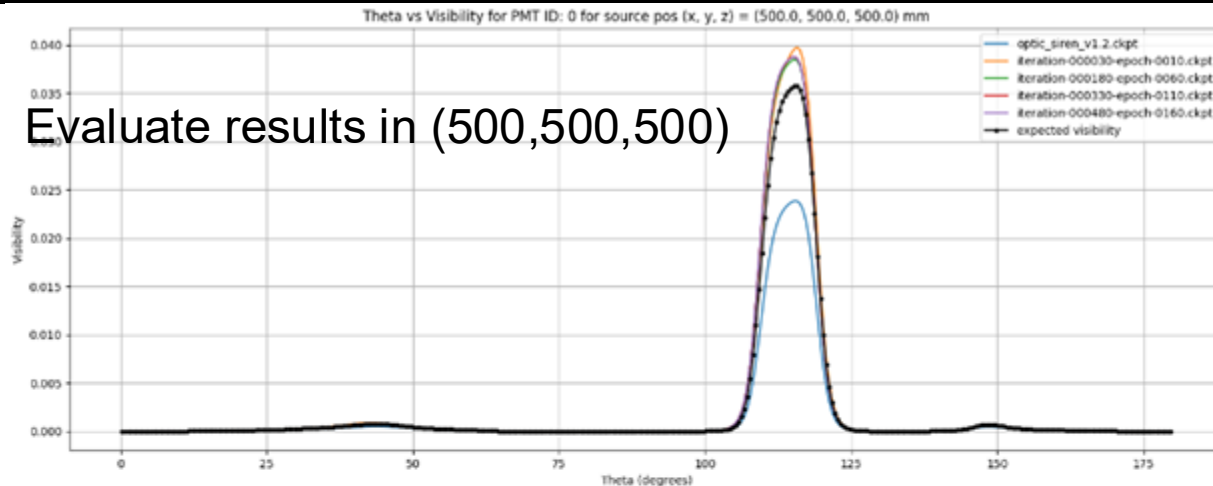


Isotropic Emiss



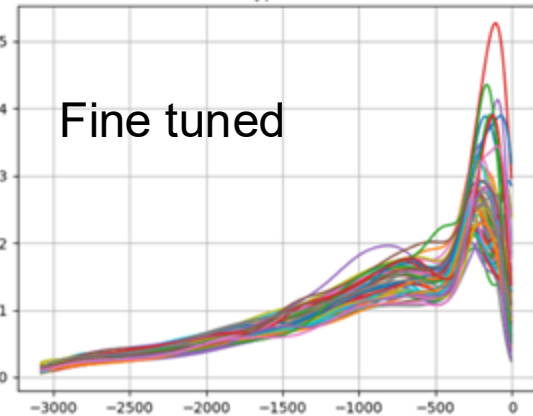
Isotropic Emission

Evaluate results in (500,500,500)

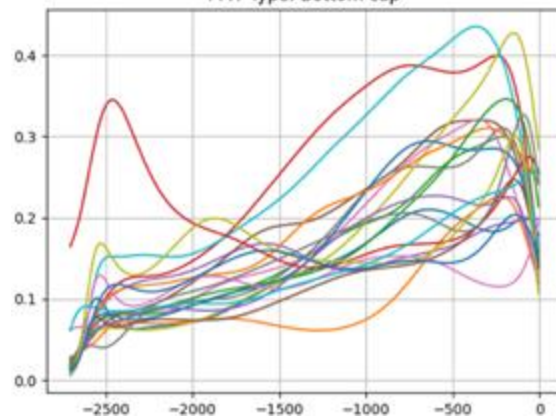


Isotropic Emission

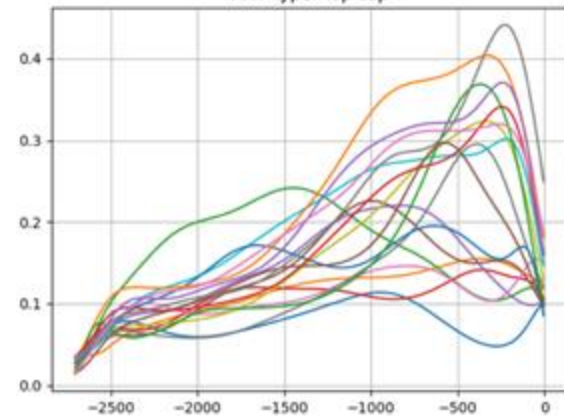
PMT Type: Barrel



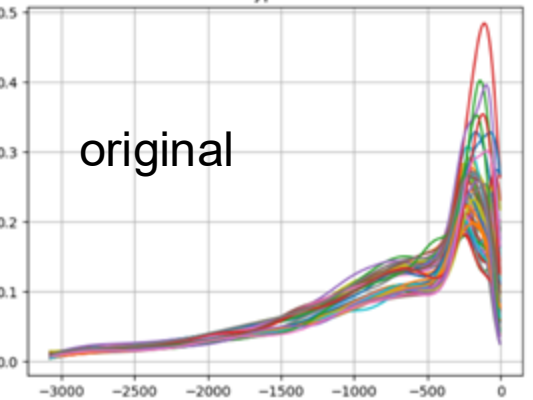
PMT Type: Bottom cap



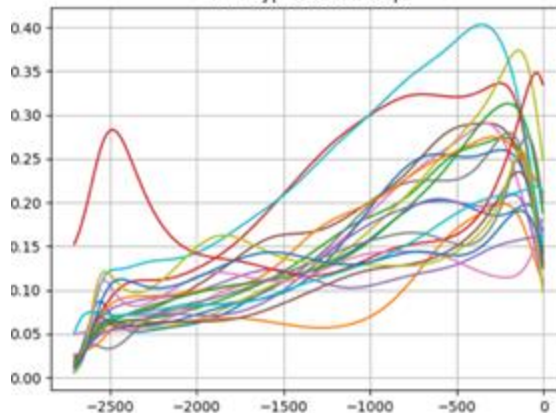
PMT Type: Top cap



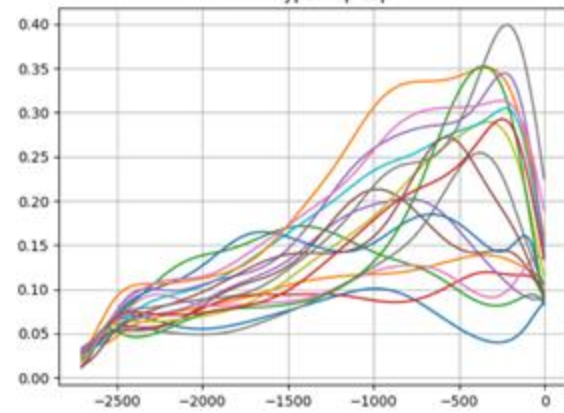
PMT Type: Barrel



PMT Type: Bottom cap

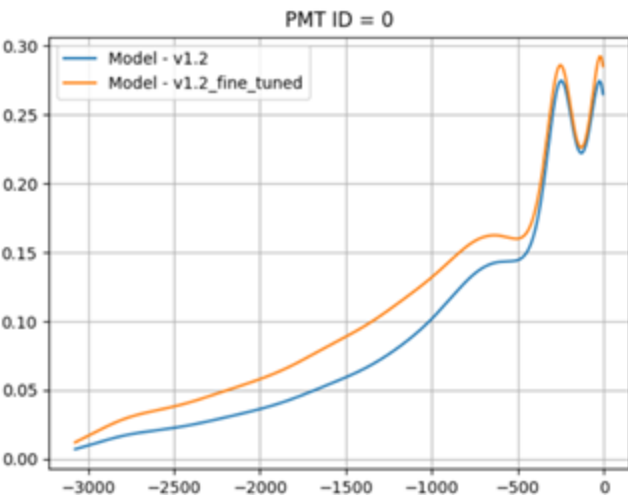


PMT Type: Top cap

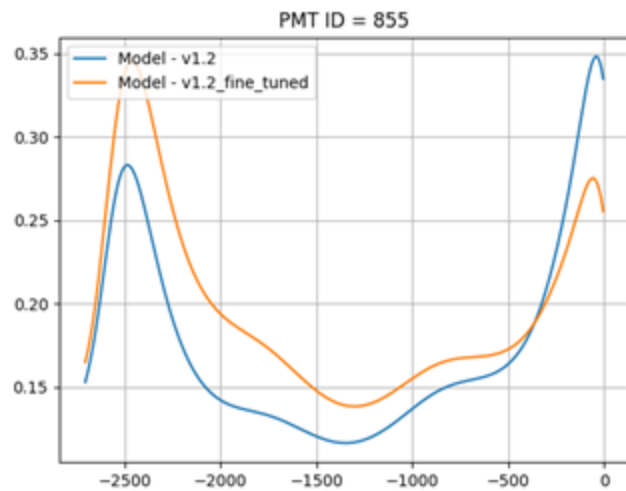


Isotropic Emission

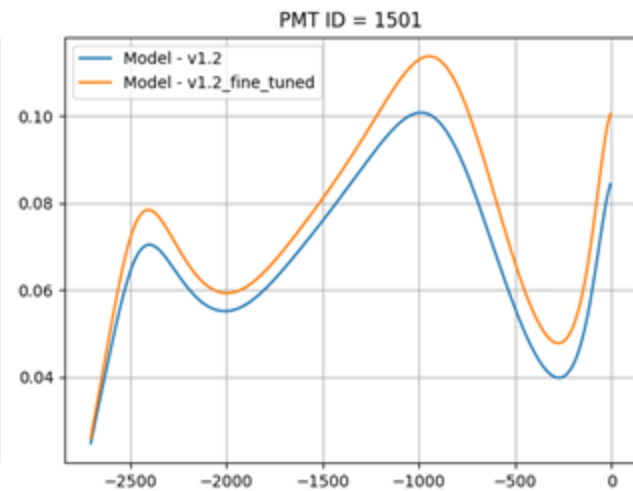
Barrel



Bottom Cap



Top Cap



Shape

Visibility Scaling => not ~ 1.5 => Too few training point?

The Soaking Test

Soaking test @ ICRR building-B1: [supervised by Ka Ming Tsui and Patrick]

Test Time:

- 2025 0617
- 2025 0708
- 2025 0722

Future work / to-do

- Calibrate OpticSIREN on neuron network weighting
- Take more Soaking Test Result

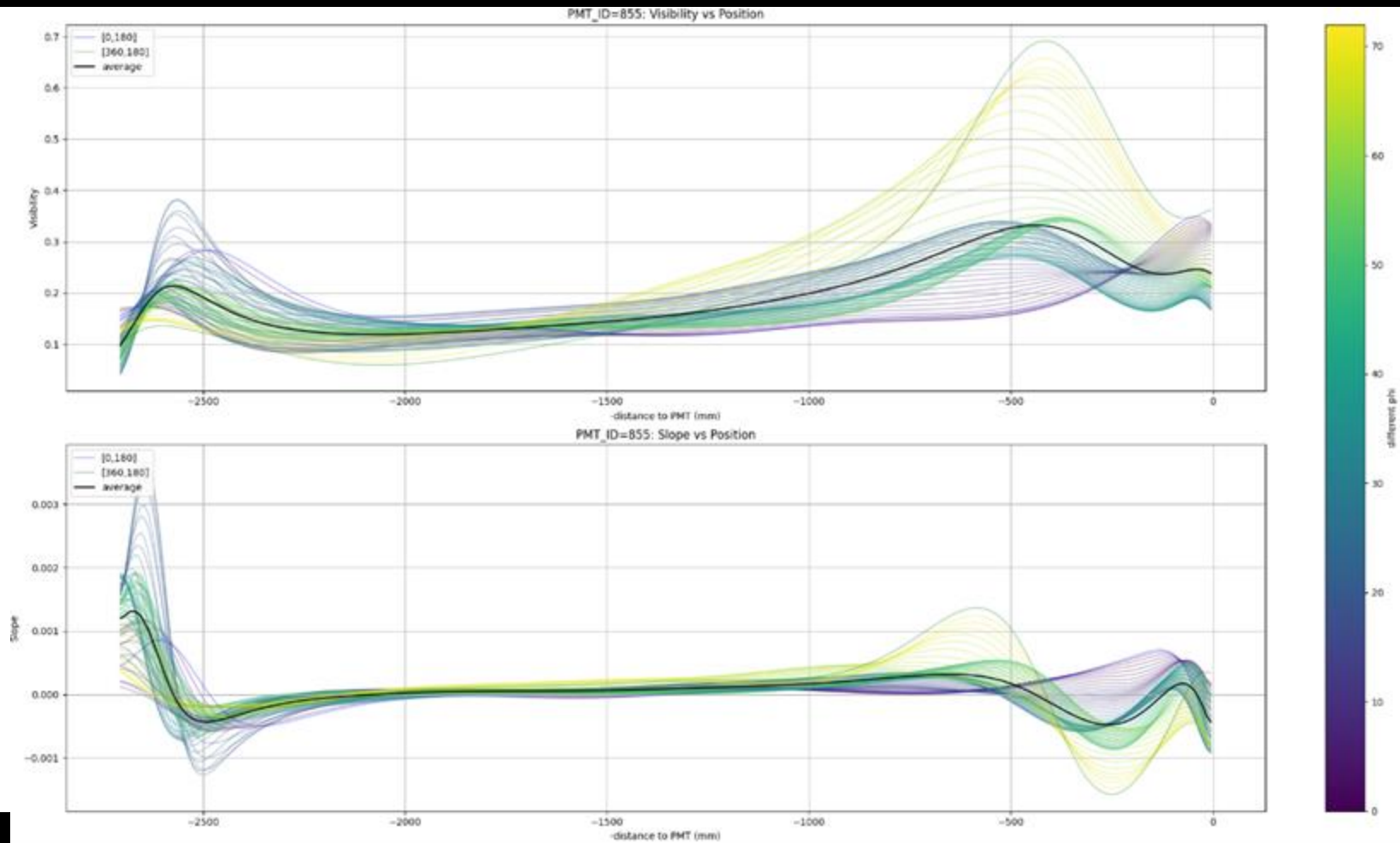
July 28, 2025

Lam Ching Hui (Nico)
The Chinese University of Hong Kong

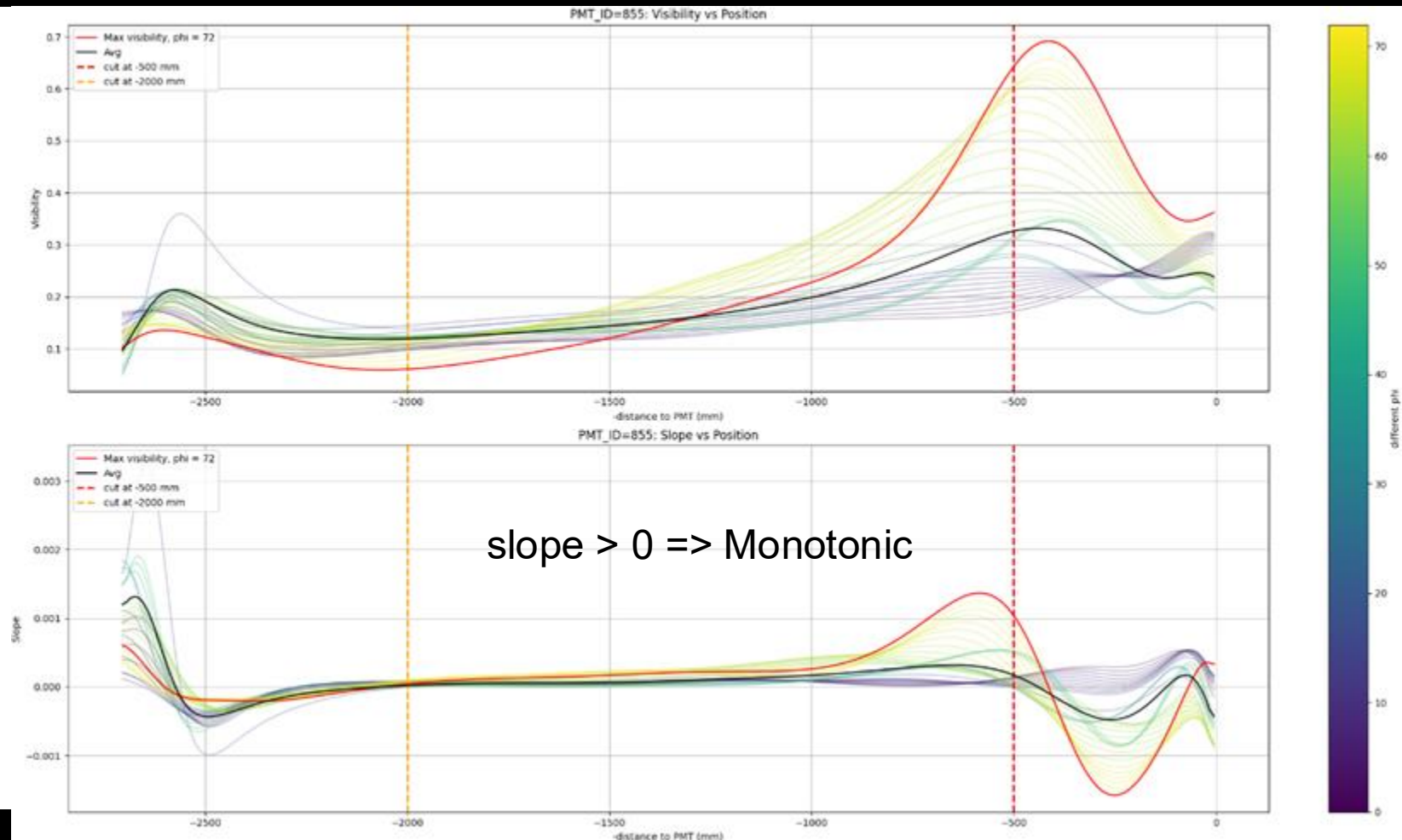
Content

- Angular Issue
- Soaking Test
- Future work / to-do

Angular Issue



Angular Issue



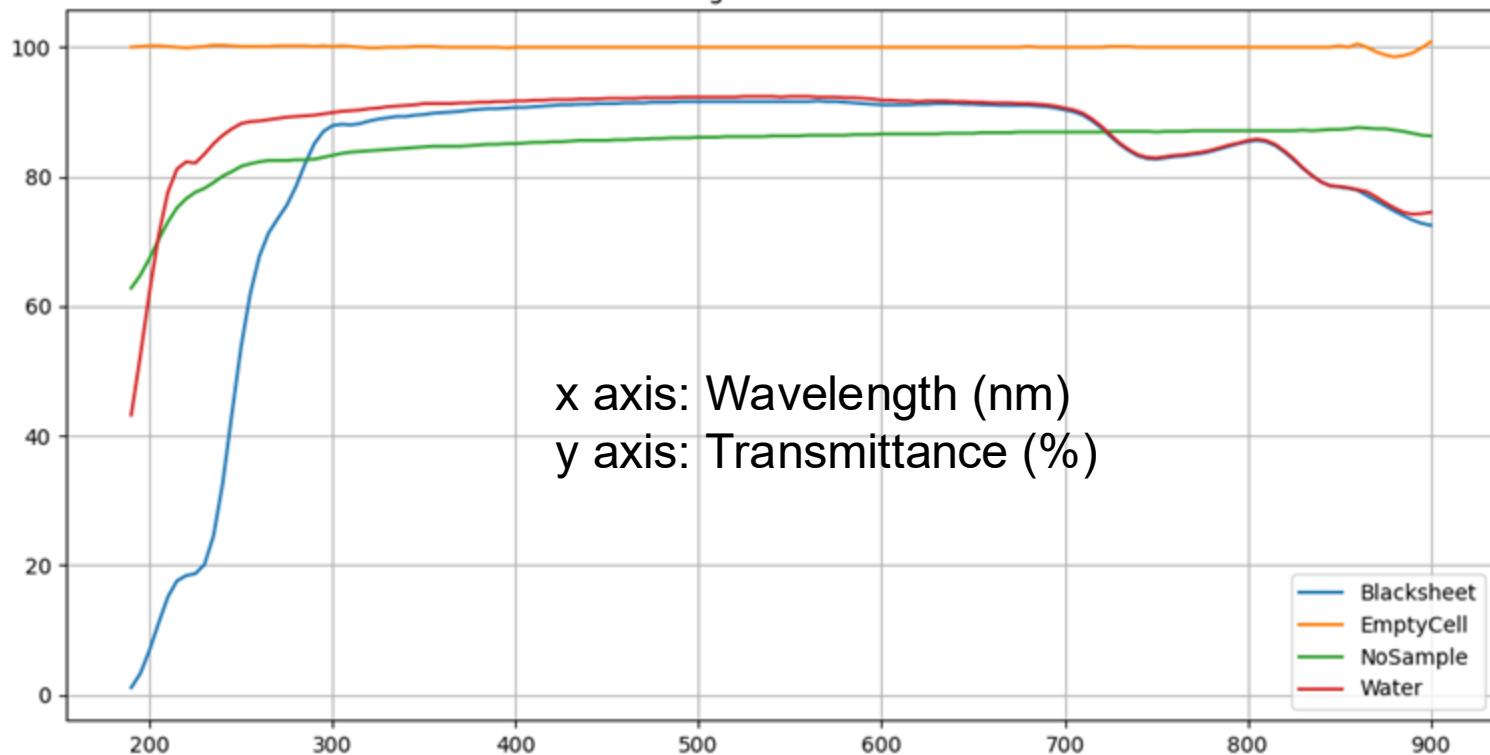
The Soaking Test

Soaking test @ ICRR building-B1: [supervised by Ka Ming Tsui and Patrick]

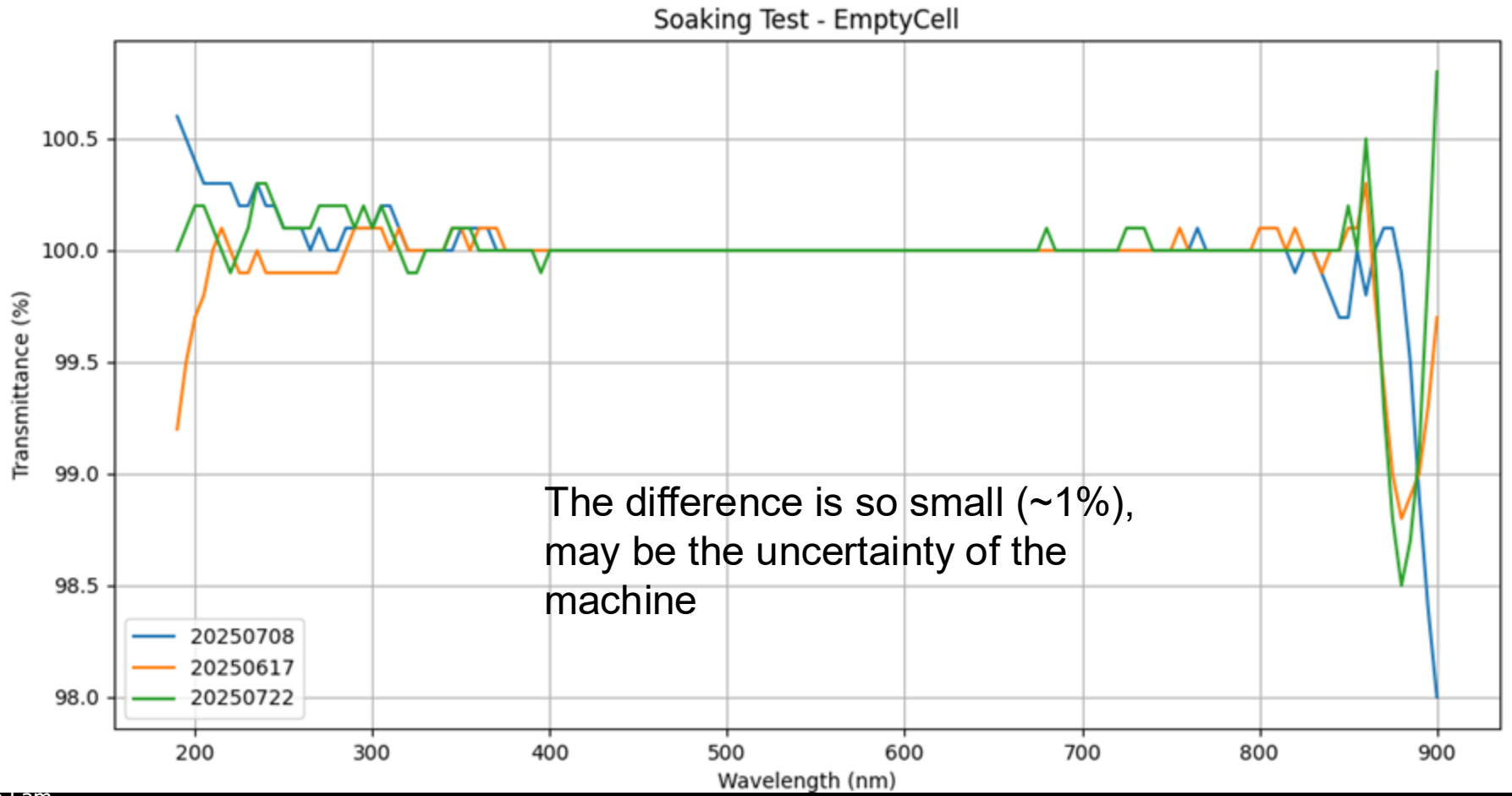
Soaking Test - 20250722

Test Time:

- 2025 0617
- 2025 0708
- 2025 0722

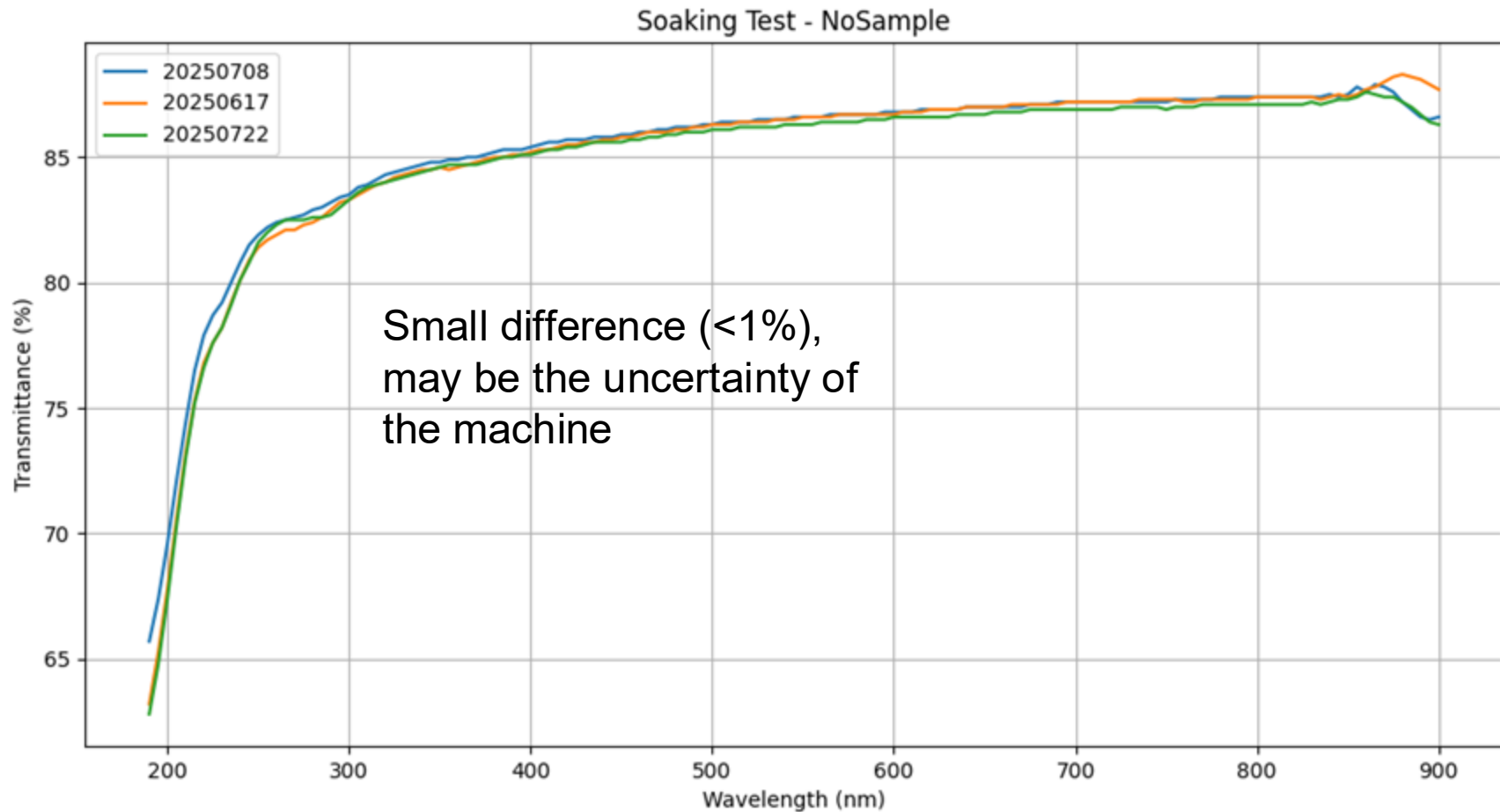


Soaking Test Result - Empty Cell

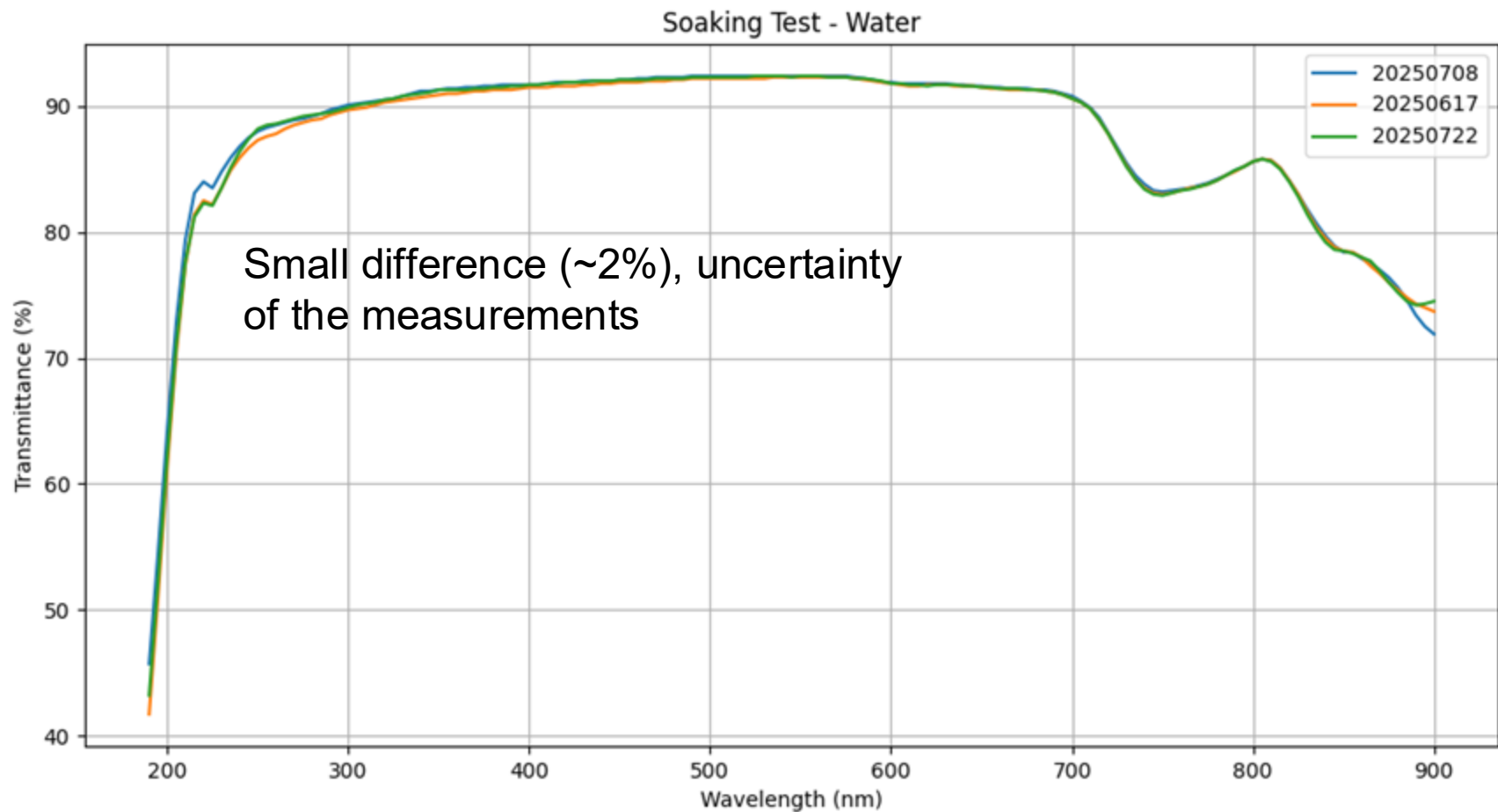


The difference is so small (~1%),
may be the uncertainty of the
machine

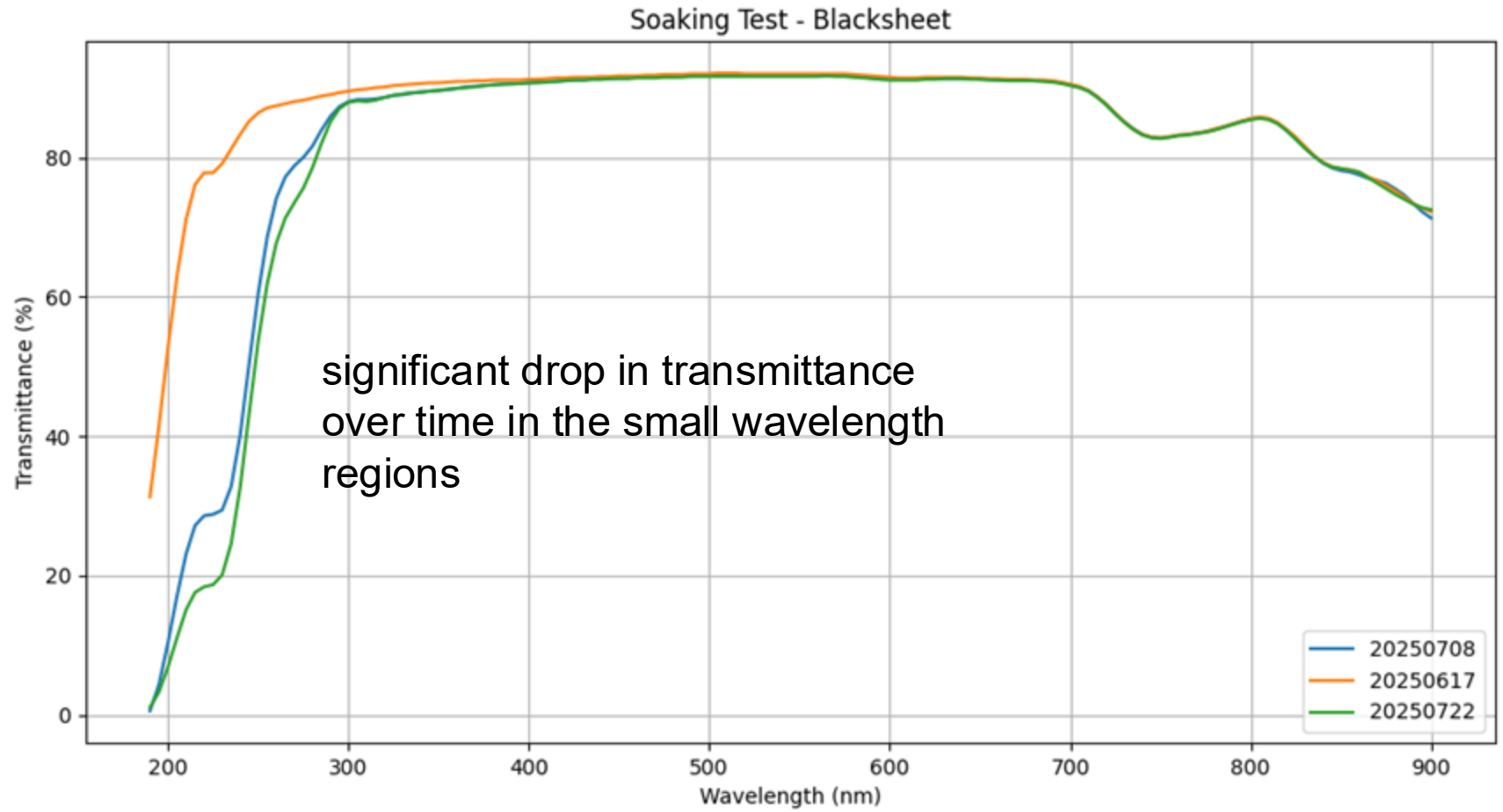
Soaking Test Result - Glass With No Sample



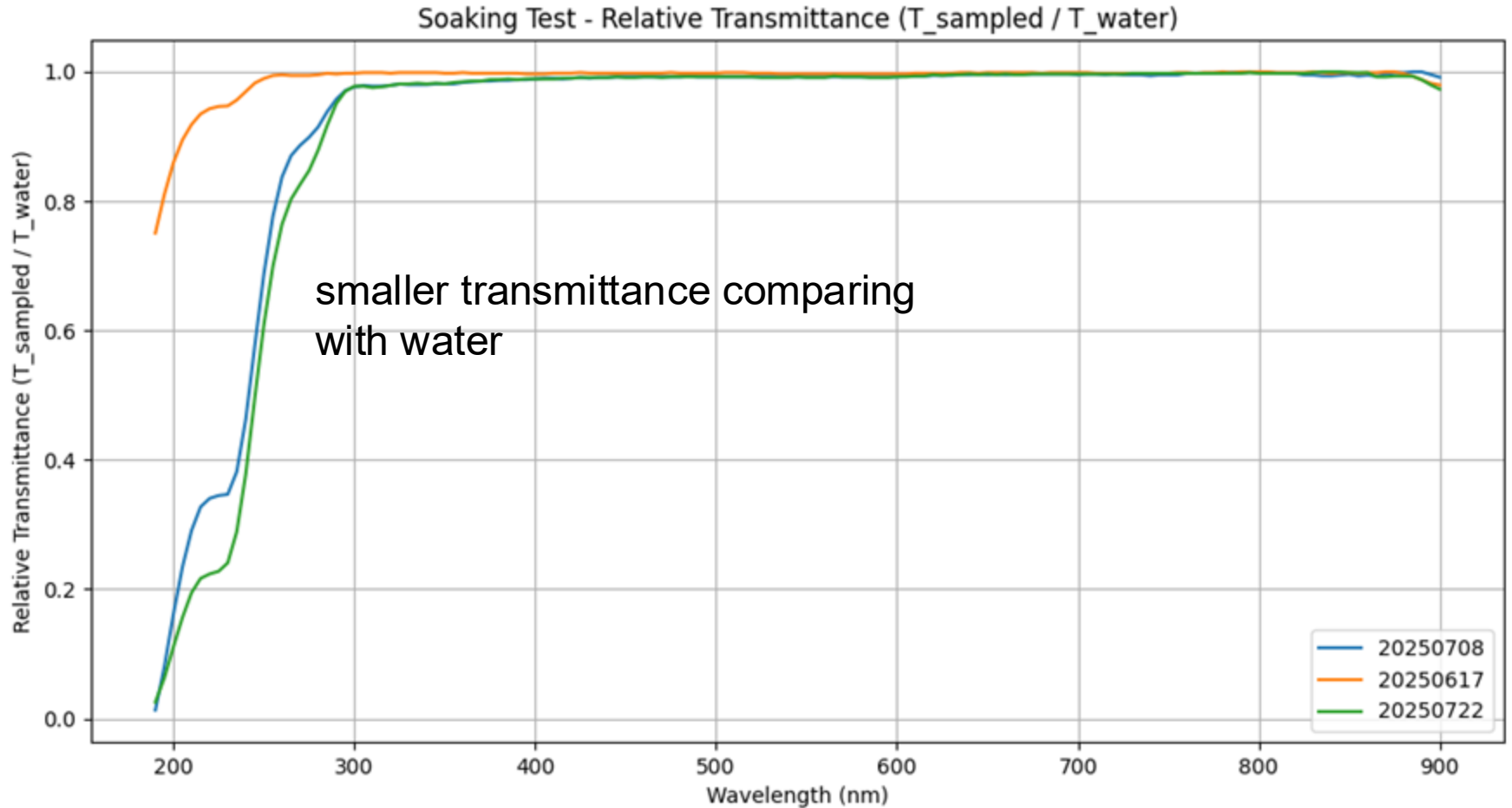
Soaking Test Result - Glass With Water Only



Soaking Test Result - Glass With BlackSheet



Soaking Test Result - Relative Transmittance of BlackSheet



Future work / to-do

- Find a good way to take care Angular Issue
- Evaluate the fine tuned model in different source positions
- Take more Soaking Test Result

Aug 18, 2025 (last)

Lam Ching Hui (Nico)
The Chinese University of Hong Kong

Content

- Review
- Level 1: Normal Incidence
- Level 2: Arbitrary Point to PMT
- Soaking Test
- Future work / to-do

Review

Current Pipeline (Isotropic Emission)	future/Operation
Create Isotropic Emission by using OpticSIREN v1.2 with given Intensity (I)	Putting Ni Ball with measurable Intensity (I)
Scale up the Total Hit Predictions (e.g. x1.5N) => Create fake data (N)	Measure total PMT visibility (N)
Fine tuned the model based on v1.2 (O)	Fine tuned the model based on v1.2 (O)

- Create Isotropic Source
- Create a set of fake data (scaled up SIREN output by some factor)
- Fine tuned OpticSIREN with fake data

- Evaluate training source pos (previous discussion)
- Evaluate other source pos (today)

Checking

Training Source Position:

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \phi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \phi = [0, 90, 180, 270]$

Scale Up the original data by:

- a. **1.5** times
- b. Random value from **Gaussian Distribution $N(1.5, 0.1)$** individually

For 1.5x fake data, we do two levels of checking:

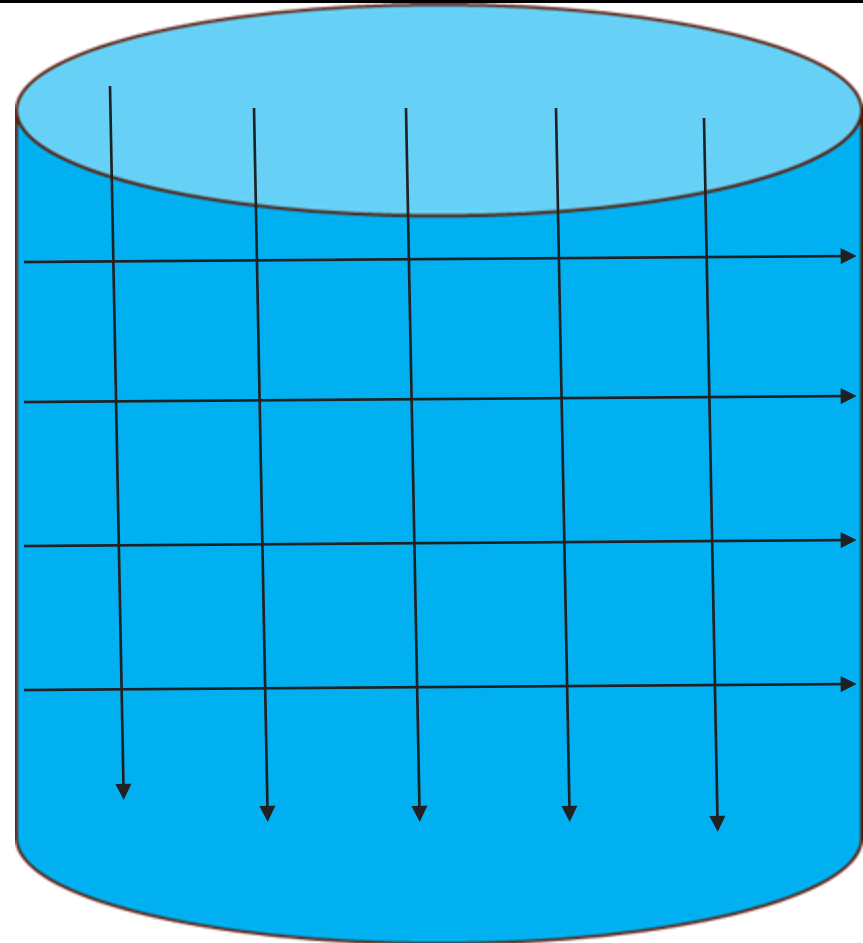
- a. **Level 1: Normal Incidence**
- b. **Level 2: Arbitrary Point to PMT**

Level 1: Normal Incidence

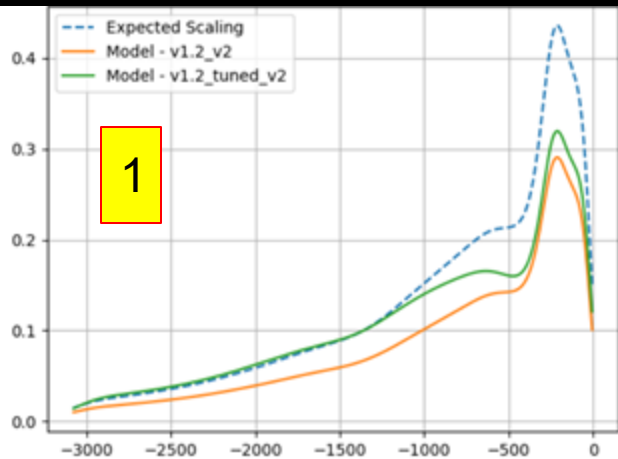
Testing Source Position:
Sampling Line of Normal incidence of the
center of PMT

Each point in the black line is the source
position pointing to specific PMT

Consider Normal Incidence of Photon to PMT



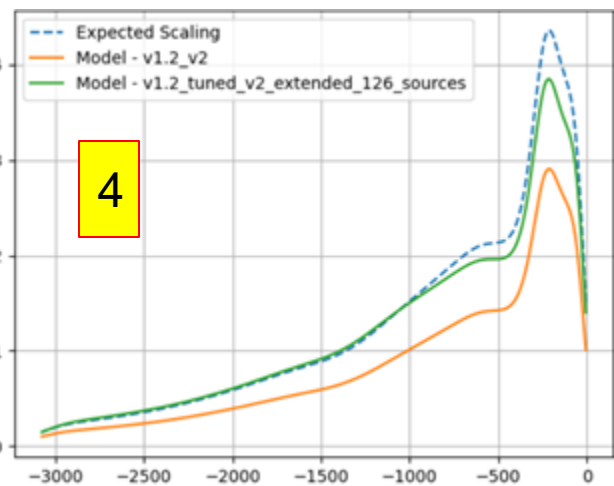
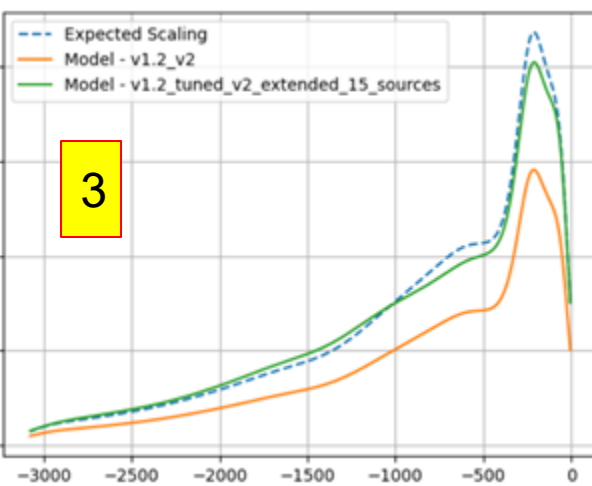
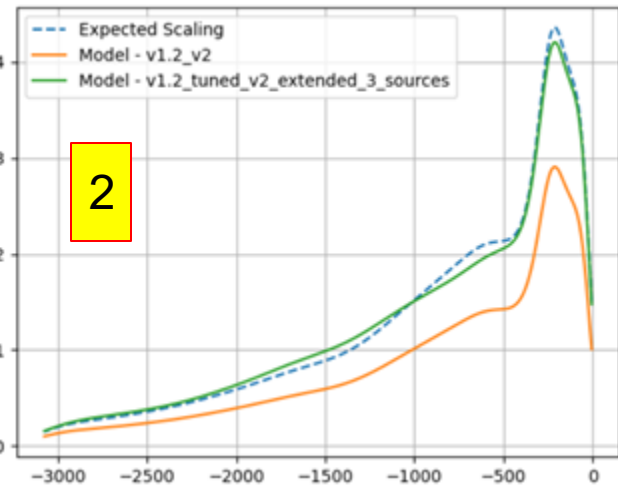
Level 1: Normal Incidence (Barrel)



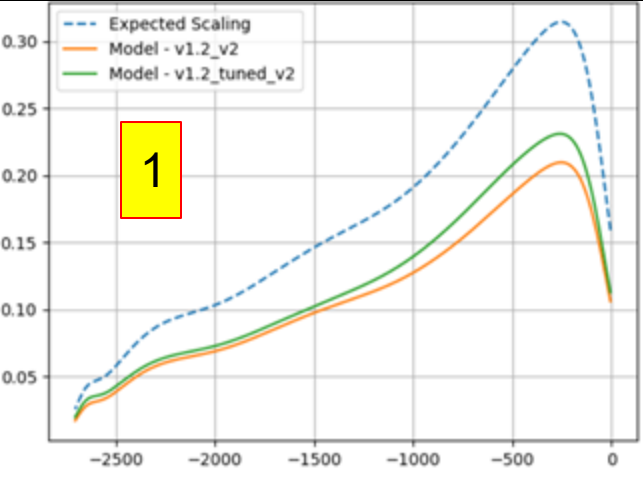
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Distance from PMT
y: Visibility
dotted: expect scaling

PMT = 19 (Barrel)



Level 1: Normal Incidence (Bottom)

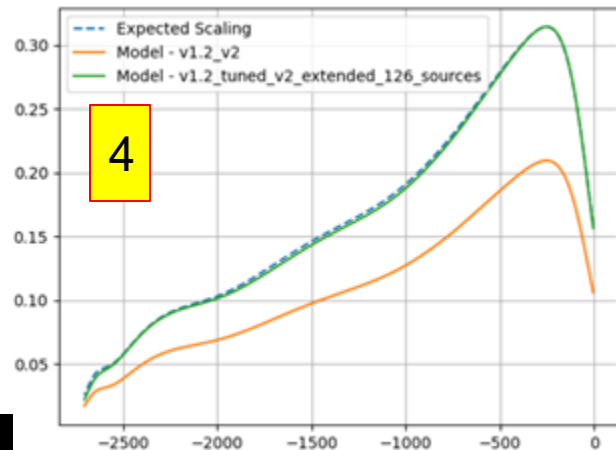
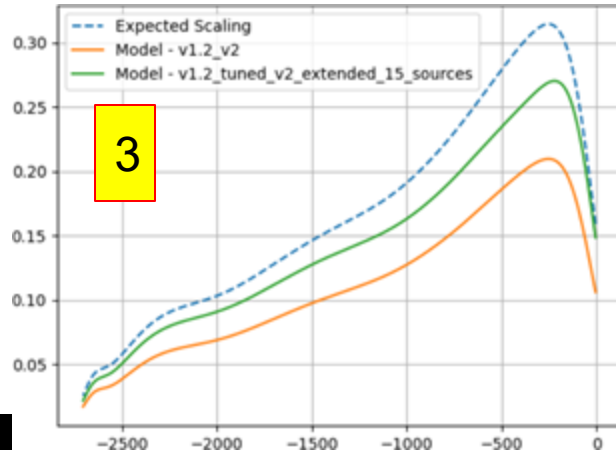
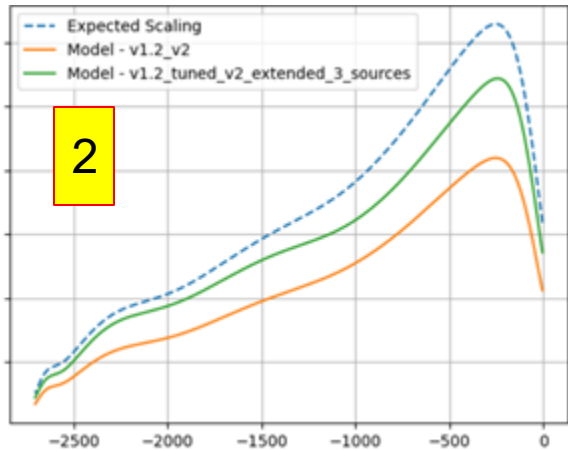


1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

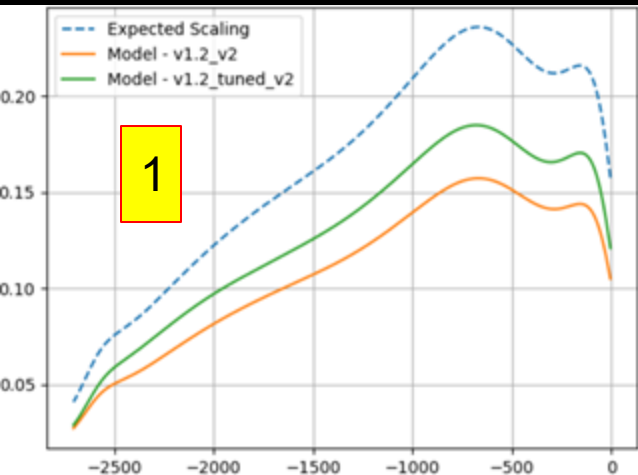
x: Distance from PMT
y: Visibility
dotted: expect scaling

PMT = 1026 (Bottom)

Training source on the sampling line



Level 1: Normal Incidence (Top)

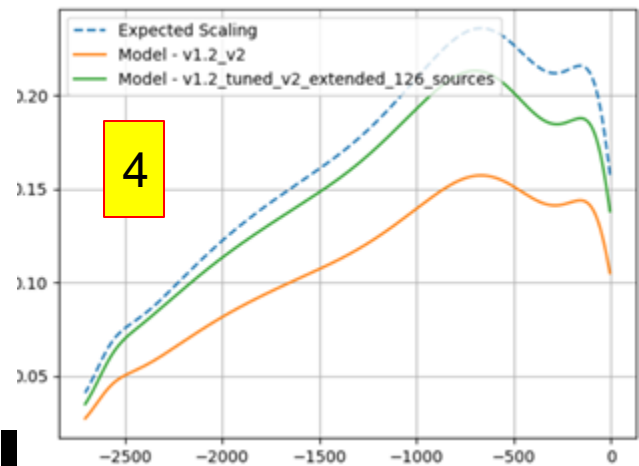
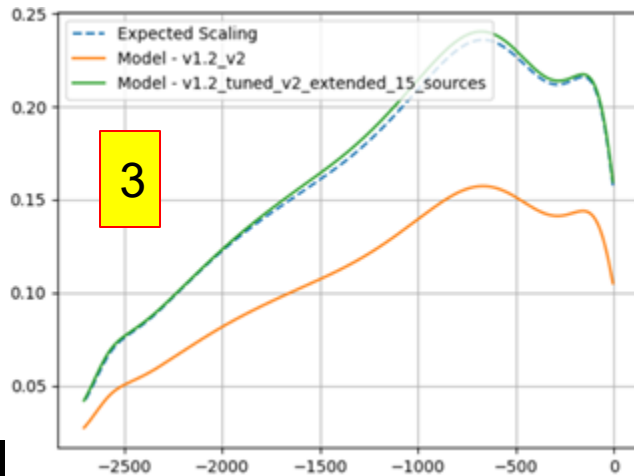
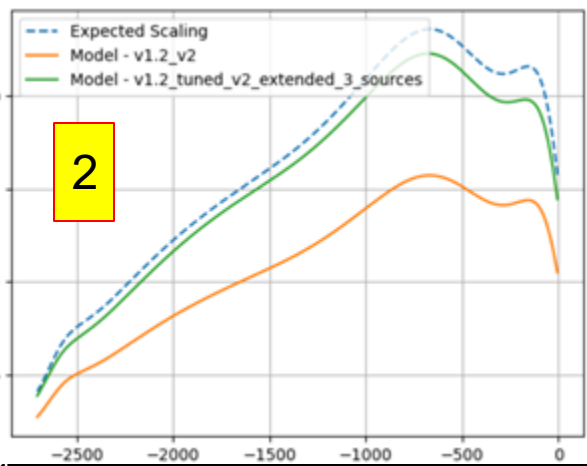


1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Distance from PMT
y: Visibility

PMT = 1615 (Top)

No training source on the sampling line



Level 1: Normal Incidence

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Observation:

1. In general, Top and Bottom Cap shows worse tuning effect than Barrel
2. Placing training source closer to edge \rightarrow get better calibration in general
3. More sources \neq Better Calibration
4. Having training source on the sampling line \neq Better Calibration

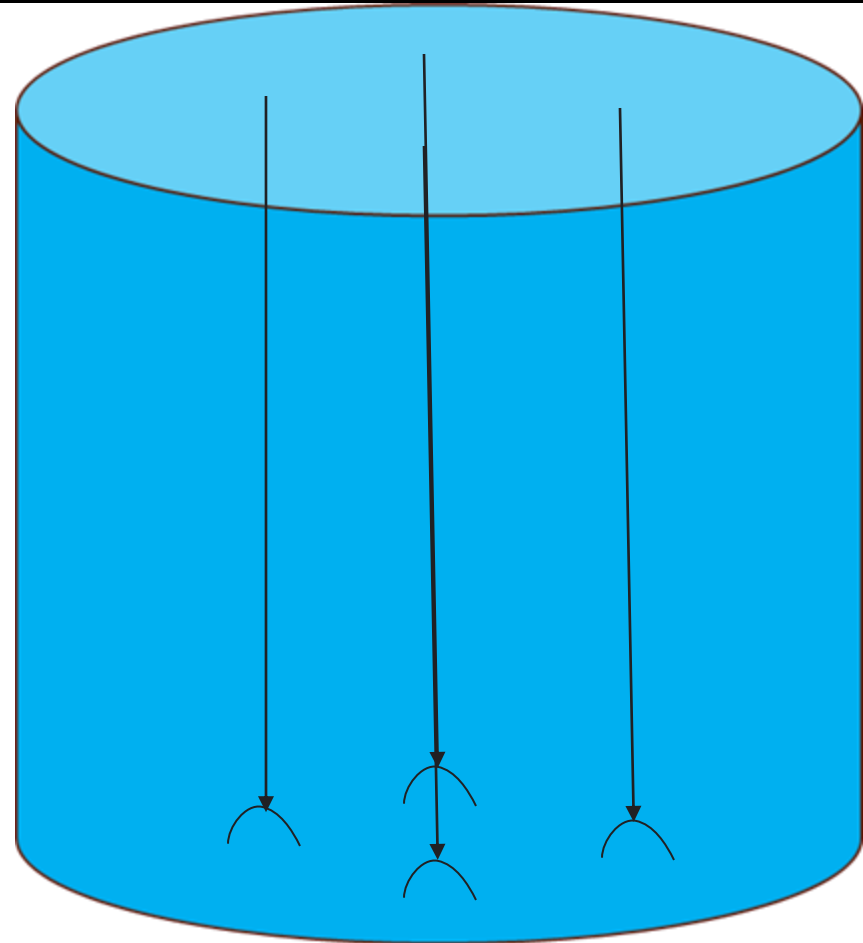
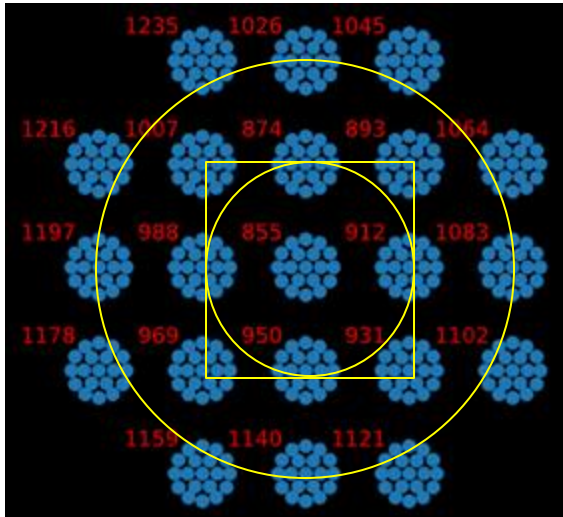
Level 1: Normal Incidence

Check for same r:

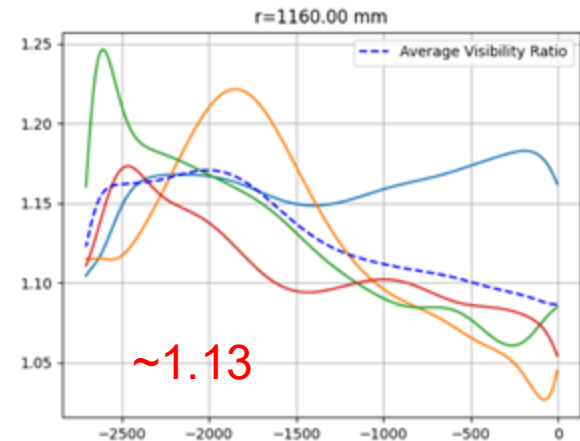
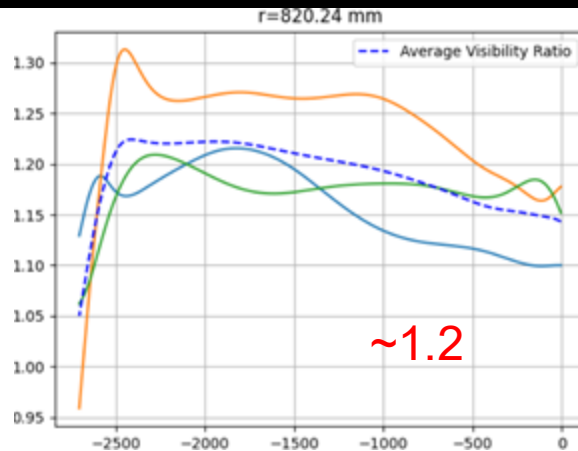
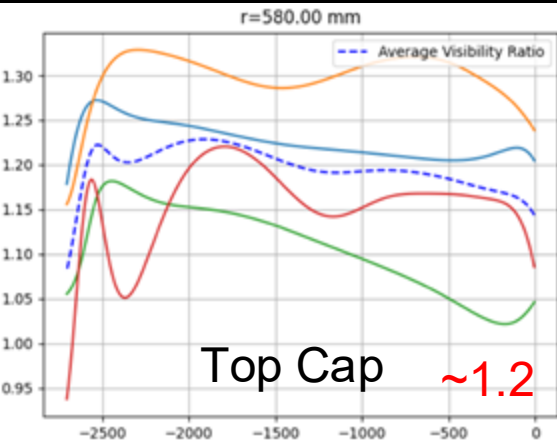
r ~ 580mm: PMT 874,912,950,988

r ~ 820mm: PMT 893,931,969,1007

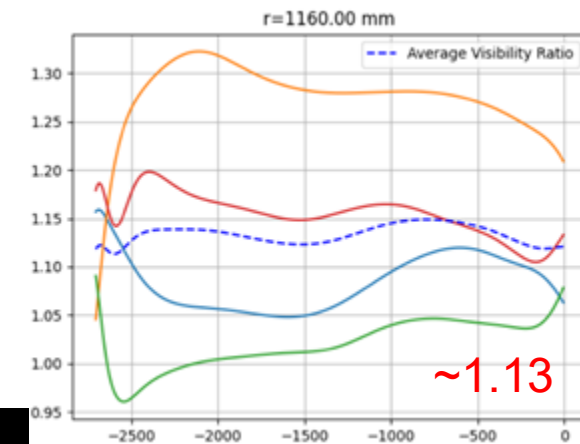
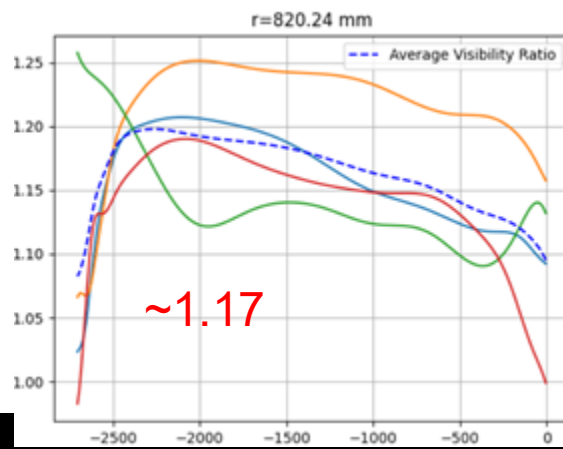
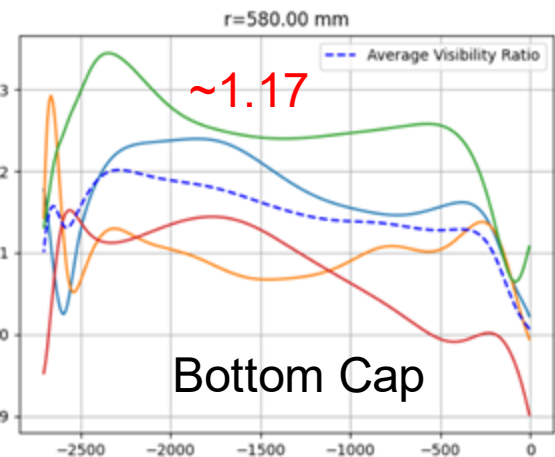
r ~ 1160mm: PMT 1026,1083,1140,1197



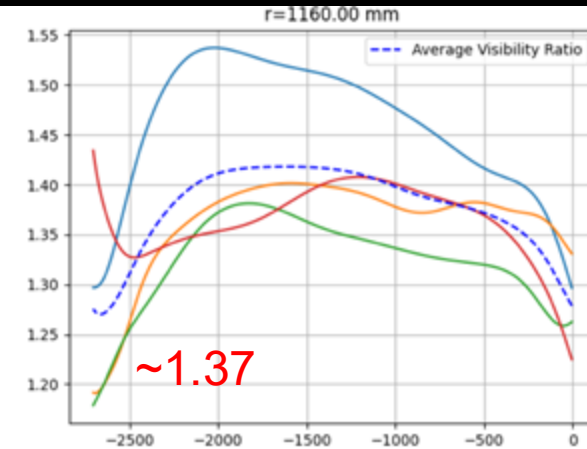
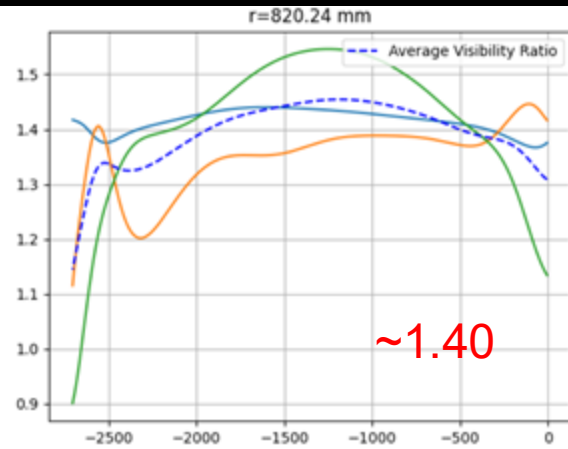
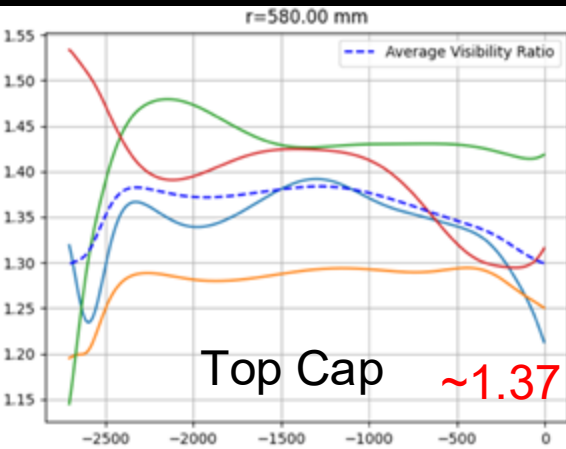
Level 1: Normal Incidence (3 sources)



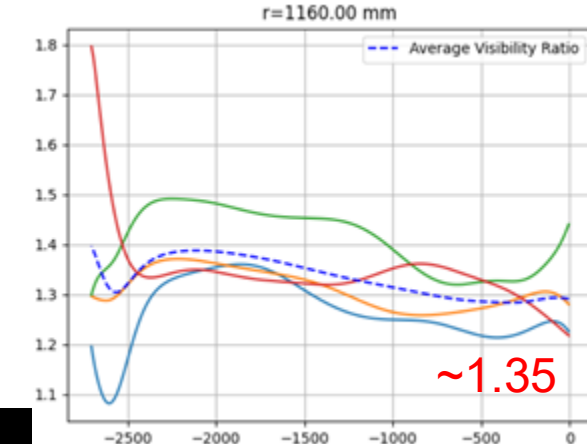
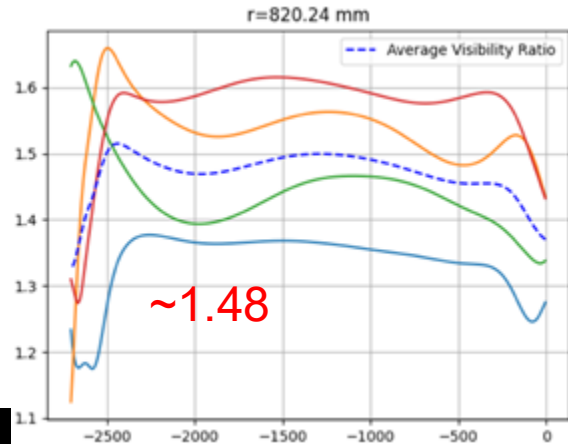
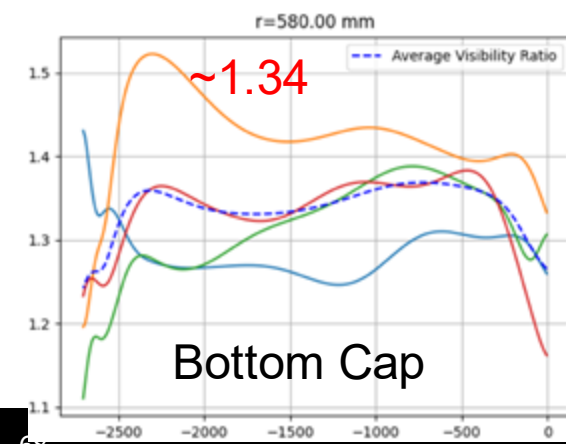
avg. of all PMT in the same r ↓ with ↑ r



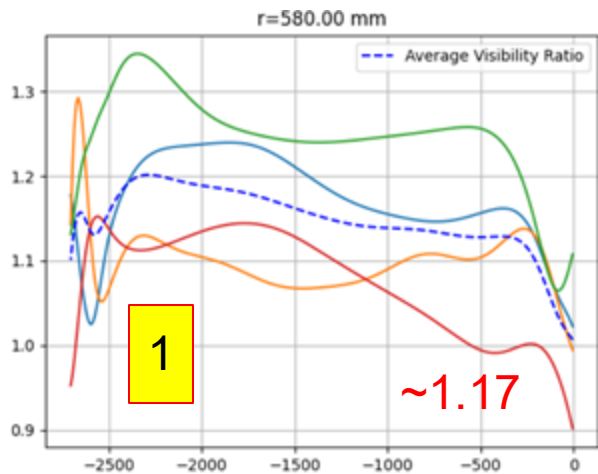
Level 1: Normal Incidence (extended 3 sources)



avg. of all PMT in the same r (first ↓ then ↑) with ↑ r



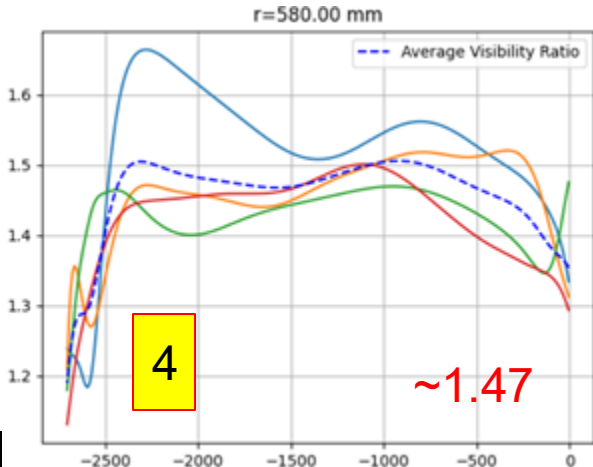
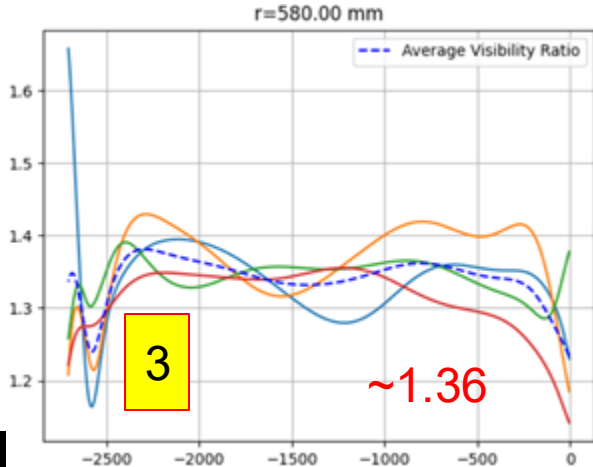
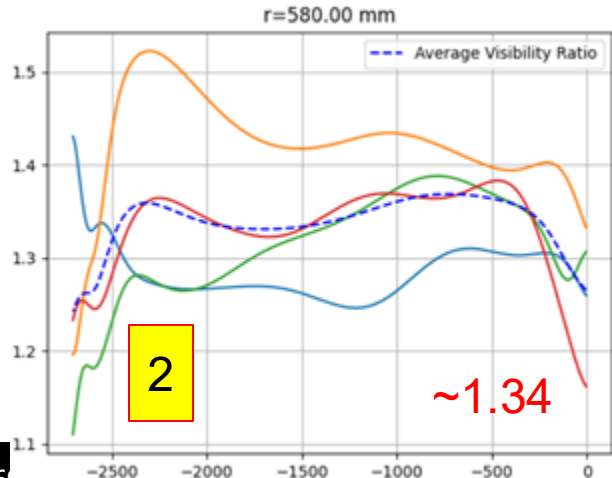
Level 1: Normal Incidence (bottom)



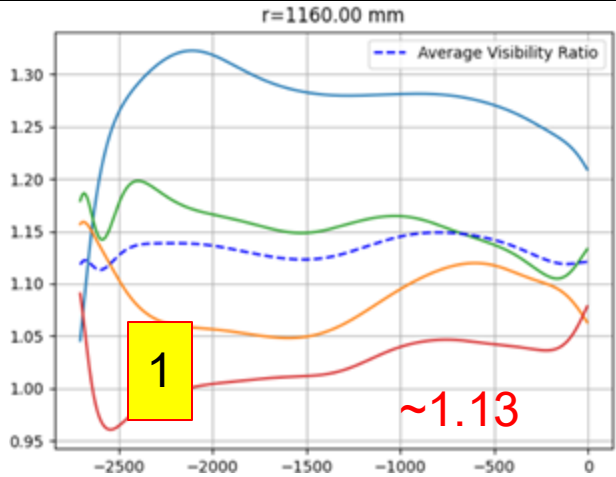
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Distance from PMT
y: Visibility

Bottom Cap at ~580 mm



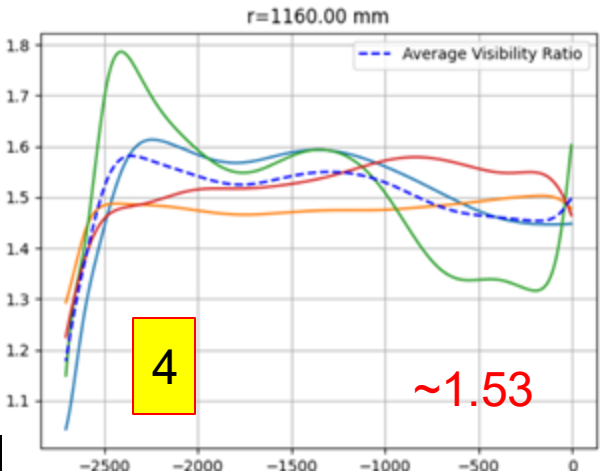
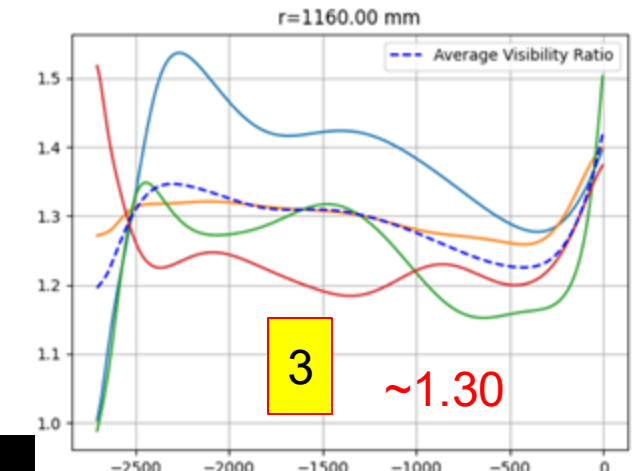
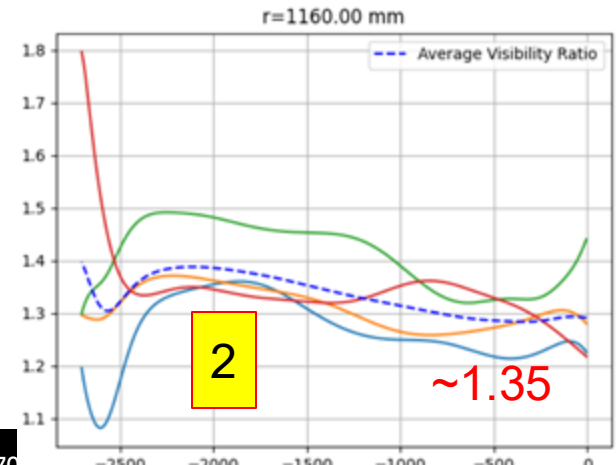
Level 1: Normal Incidence (bottom)



1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Distance from PMT
y: Visibility

Bottom Cap at ~ 1160 mm



Level 1: Normal Incidence

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Observation:

1. avg. of all PMT in the same r \downarrow with $\uparrow r$ for case 1
2. avg. of all PMT in the same r (first \downarrow then \uparrow) with $\uparrow r$ for case 2,3,4
3. More uniform and closer to 1.5x with more training source

Level 2: Arbitrary point to PMT

Testing Source Positions (r, phi, z):

r: [0,1500], regular interval=100

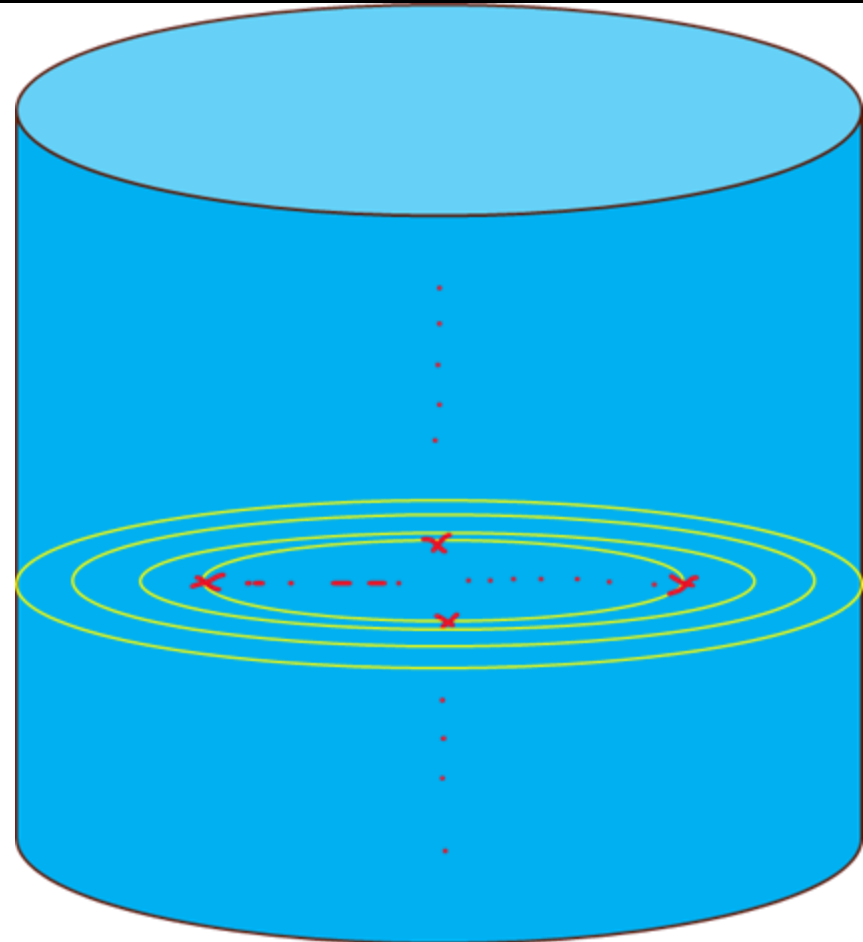
z: [-1300,1300], regular interval=100

phi: [0, 2 π), regular interval=2 π /4

Detector height ~[-1338,1338]

Detector Radius ~1519

1728 Source Positions in Total



Level 2: Arbitrary point to PMT

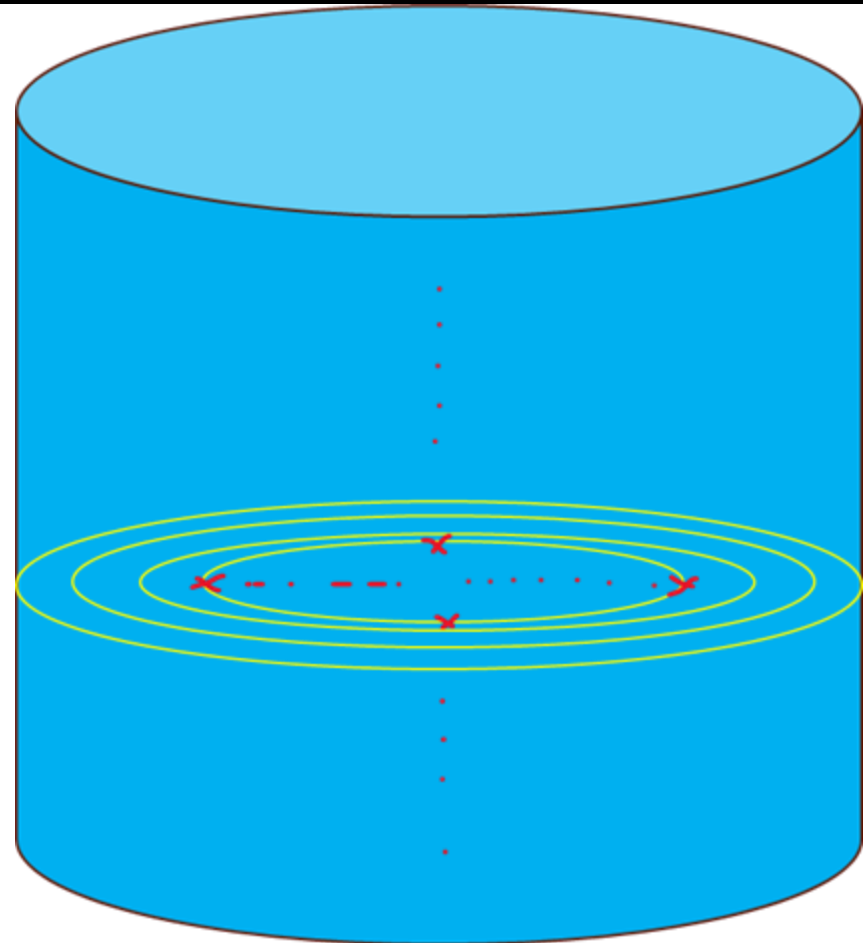
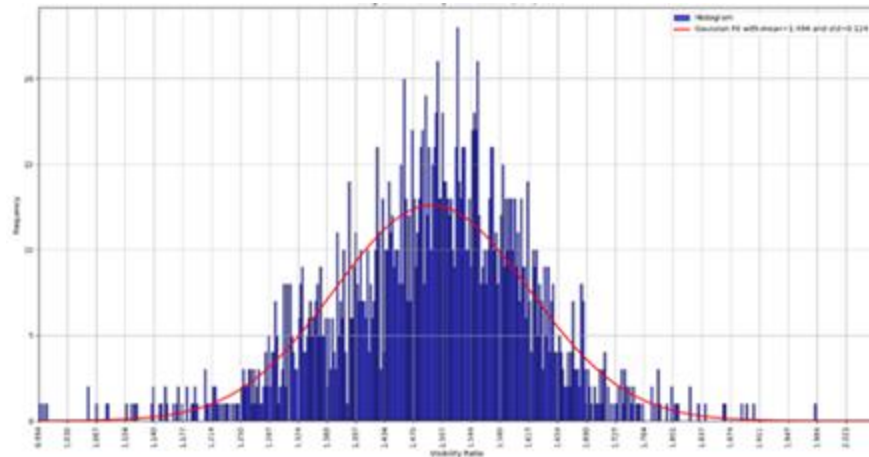
For each source position:

Photon is emitted towards each mPMT

= 1843 directions in Total

-> Histogram of visibility ratio can be plotted

-> Gaussian Fit to obtain **mean** and **std**

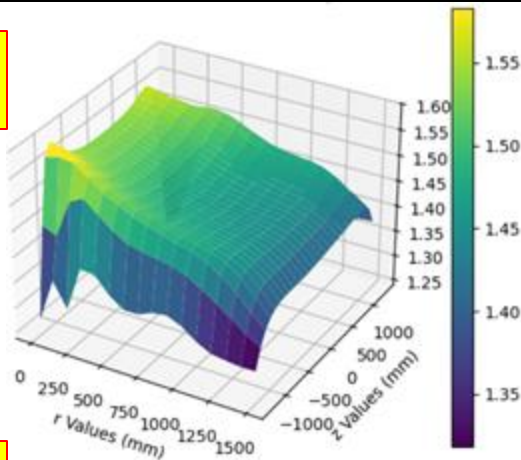


Level 2: Arbitrary point to PMT

- We expect the fine tune pipeline does not have much phi dependence
- > verified with the checking
 - > Small std among 4 phi angles (\sim std/mean ranges from 0.00065 to 0.02982)
 - > avg. out the phi direction

Level 2: Arbitrary point to PMT

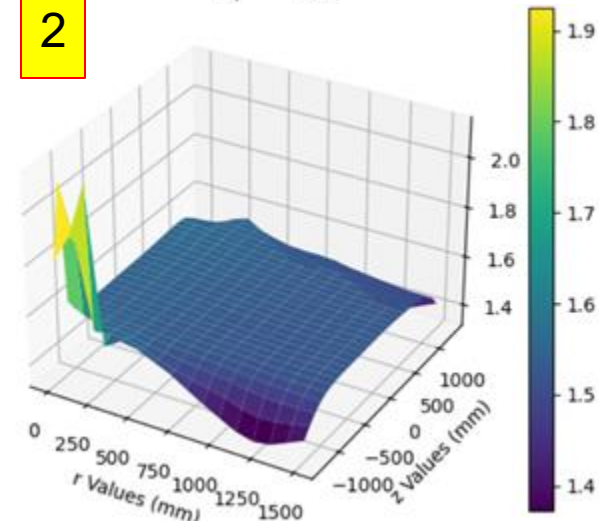
1



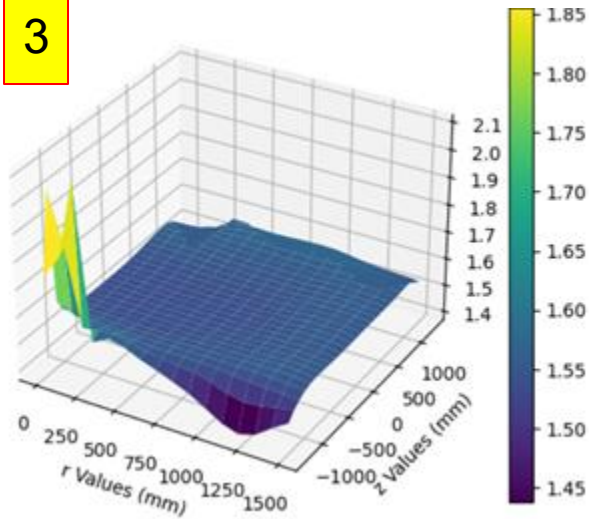
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: r values
y: z values
z: Visibility ratio

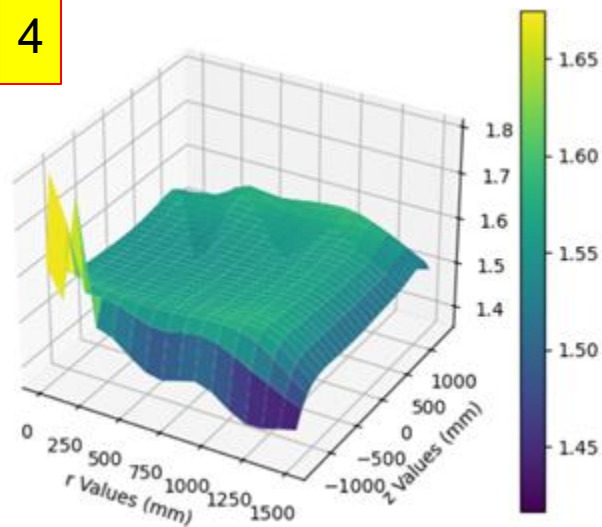
2



3

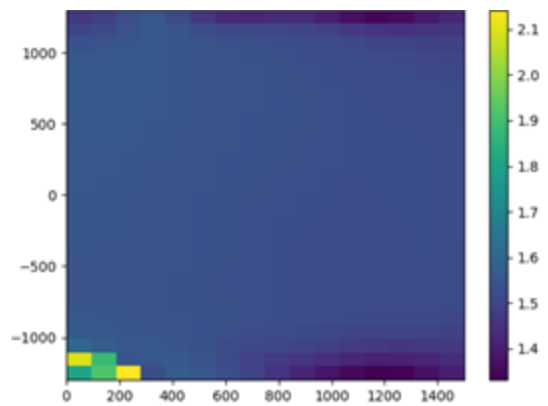


4



Level 2: Arbitrary point to PMT

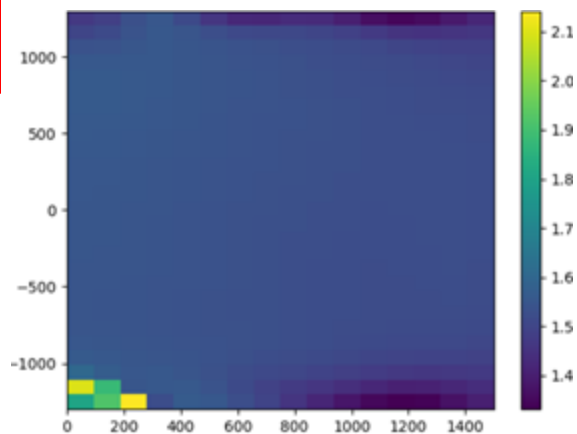
1



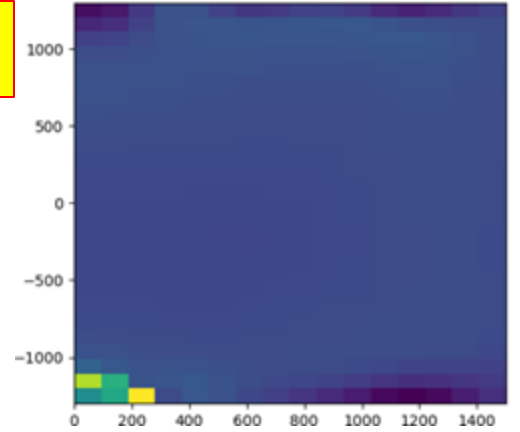
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: r values
y: z values
z: Visibility ratio

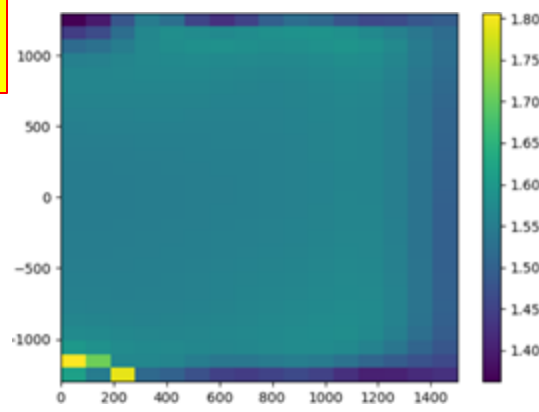
2



3

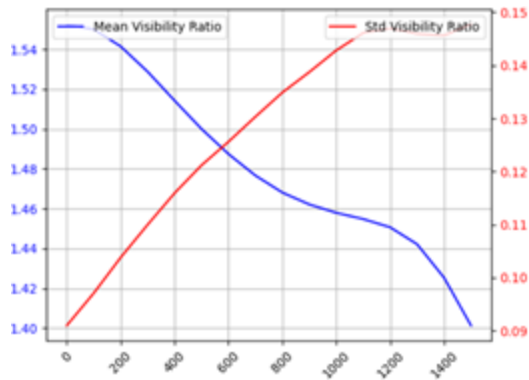


4



Level 2: Arbitrary point to PMT

1

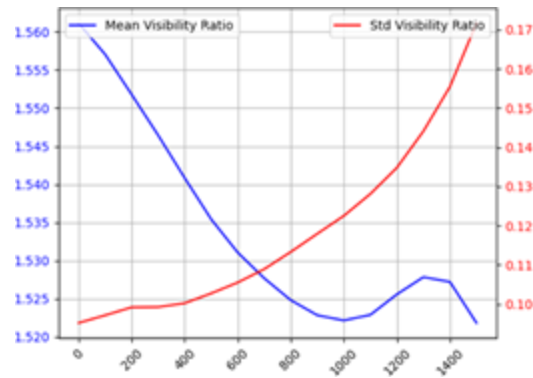


1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

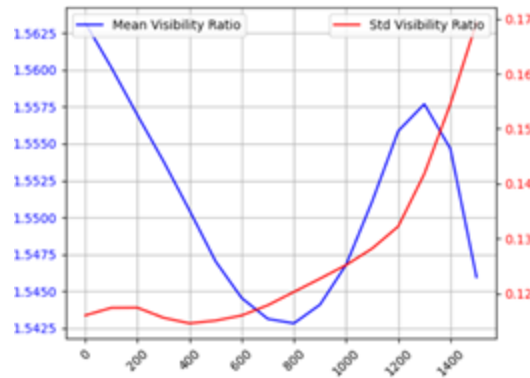
x: r values
y: Visibility ratio
certain z

red: std
blue: Mean

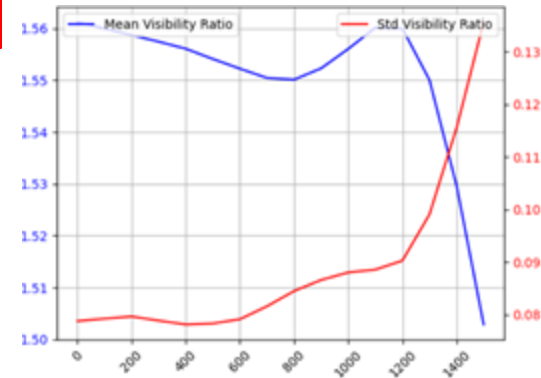
2



3

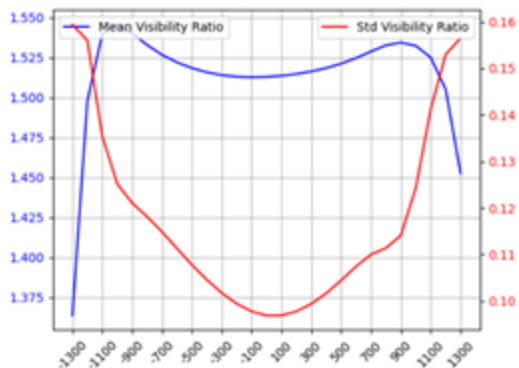


4



Level 2: Arbitrary point to PMT

1

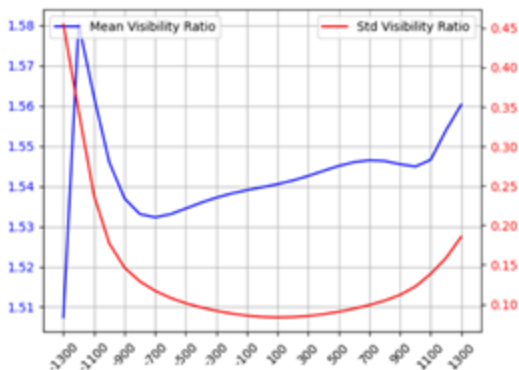


1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

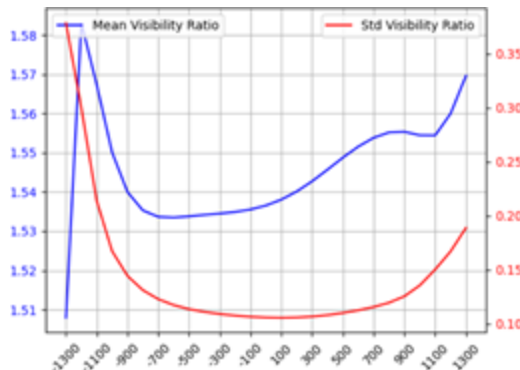
x: z values
y: Visibility ratio
certain r

red: std
blue: Mean

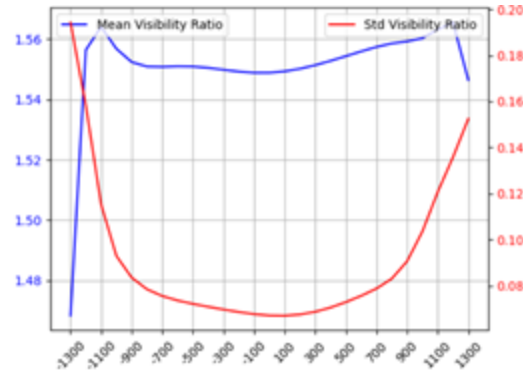
2



3



4



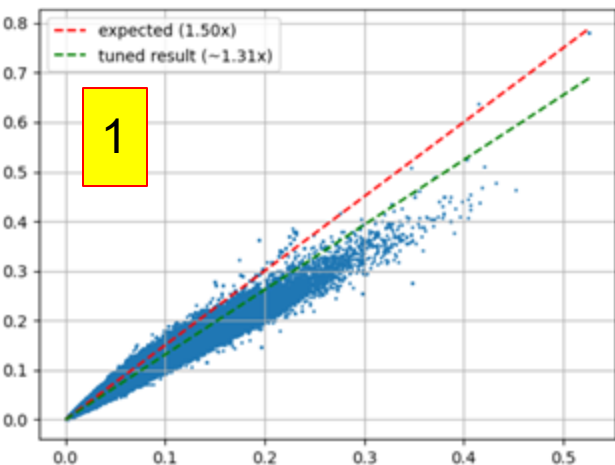
Level 2: Arbitrary point to PMT

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Observation:

1. For case 1 and certain z , the visibility ratio is decreasing with r
2. For all cases and certain r , the visibility ratio is more stable within $z = [-1000, 1000]$
3. The fluctuation of visibility ratio is much smaller after extending the source position
4. visibility ratio is $\sim 1.53-1.56$
5. Place more sources near bottom?

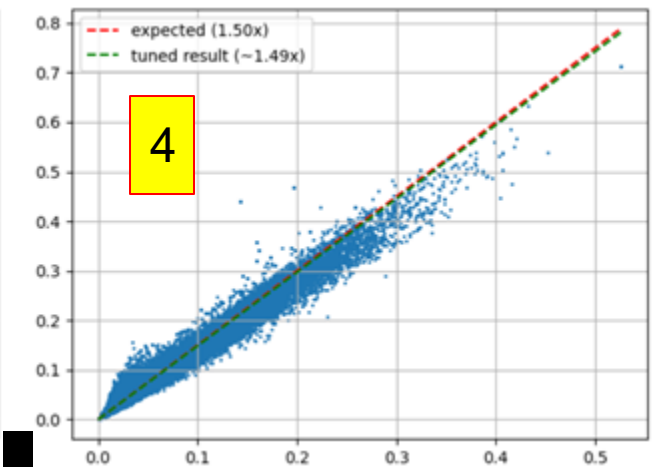
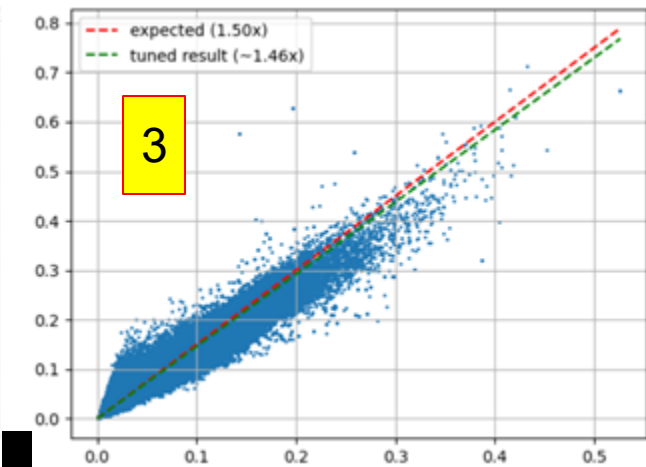
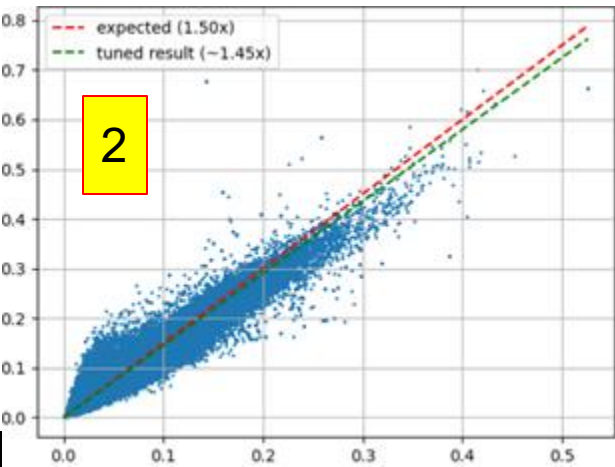
Level 2: Arbitrary point to PMT (1.5x Visibility Corr.)



1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Pre-tuned Visibility
y: Tuned Visibility
dotted line: $y=1.5x$

Scale by 1.5x



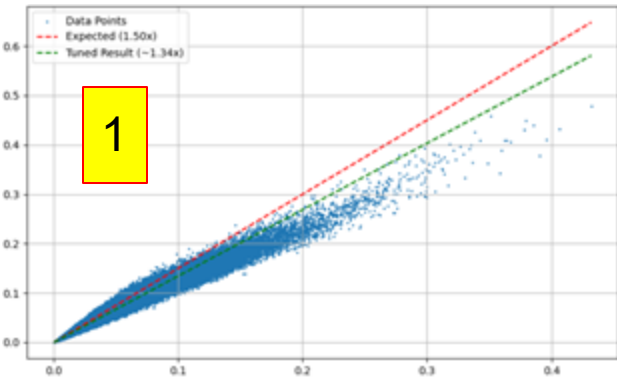
Level 2: Arbitrary point to PMT (1.5x Visibility Corr.)

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Observation:

1. Case 1: fit towards ratio ≈ 1.31
2. Case 2: fit towards ratio ≈ 1.45 (training source closer to edge \rightarrow Better tuning)
3. Case 3: fit towards ratio ≈ 1.46 (More r but not $z \rightarrow$ not much improvement)
4. Case 4: fit towards ratio ≈ 1.49 (More r and $z \rightarrow$ Further Better tuning and spread)

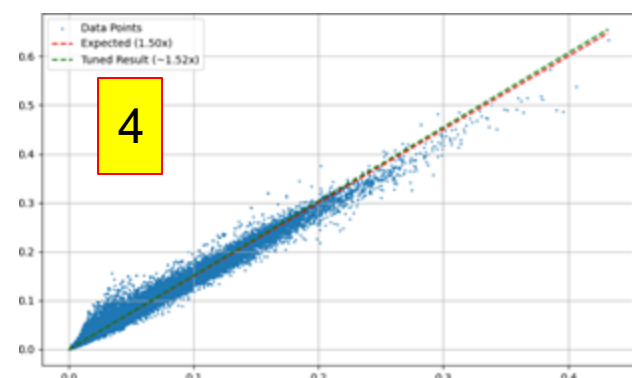
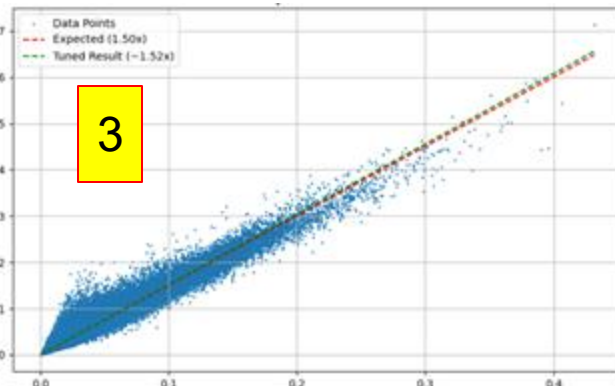
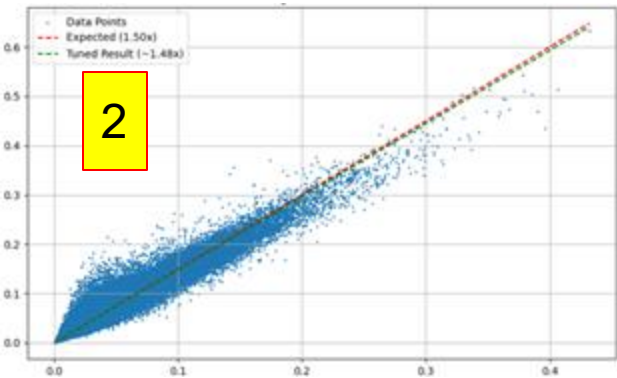
Level 2: Arbitrary point to PMT (Barrel)



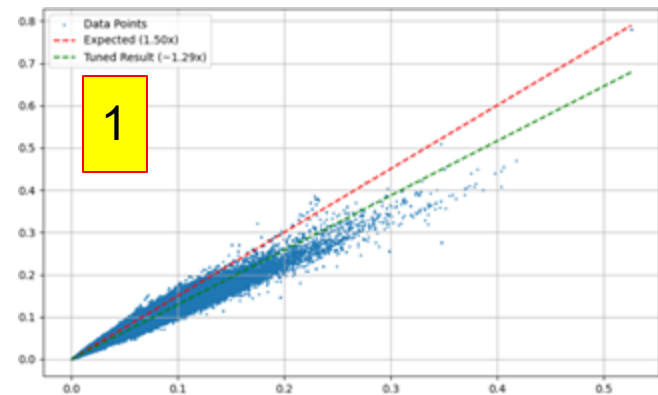
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Pre-tuned Visibility
y: Tuned Visibility
Red dotted line: $y=1.5x$

1. 1.34
2. 1.48
3. 1.52
4. 1.52



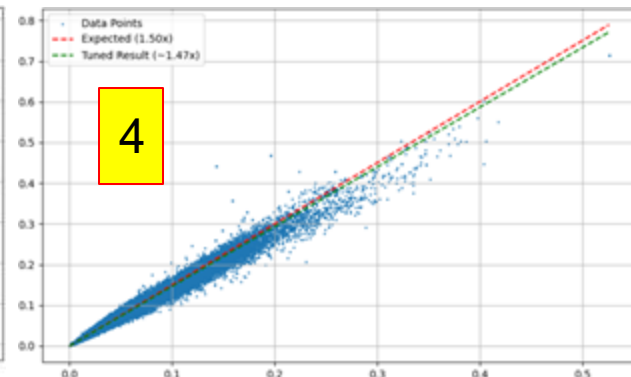
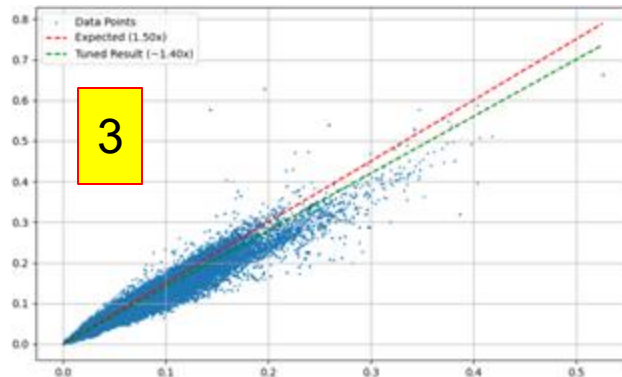
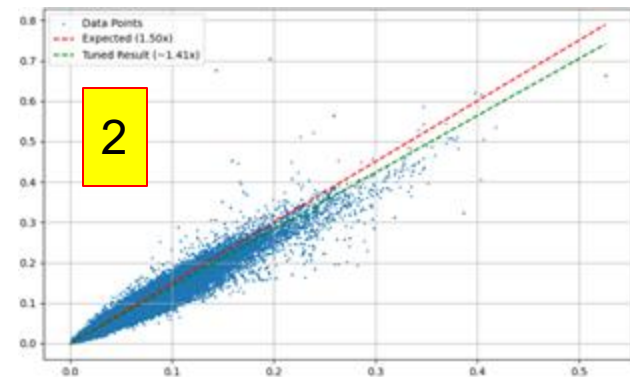
Level 2: Arbitrary point to PMT (Bottom)



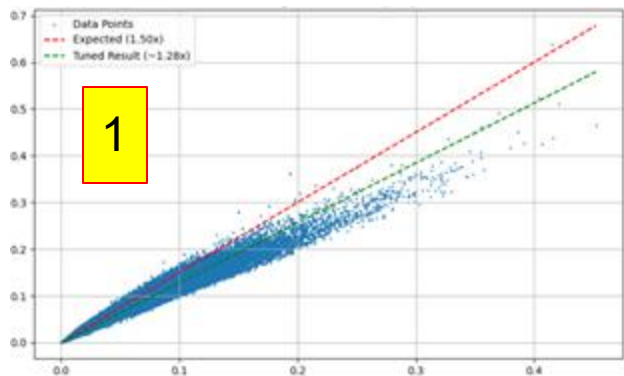
1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Pre-tuned Visibility
y: Tuned Visibility
Red dotted line: $y=1.5x$

1. 1.29
2. 1.41
3. 1.40
4. 1.47



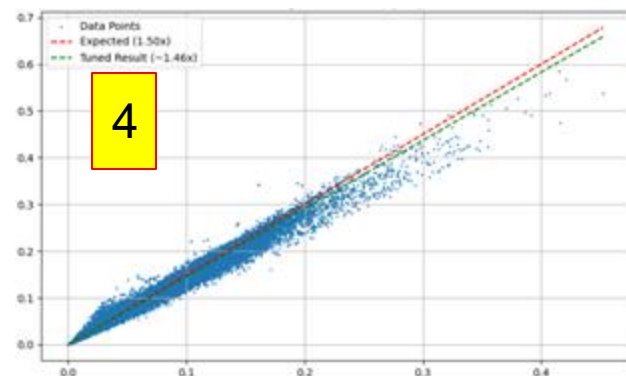
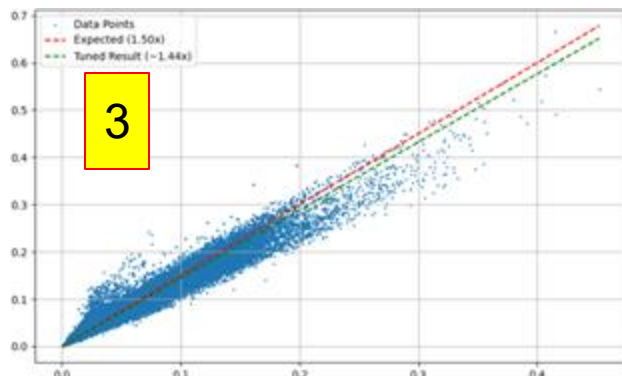
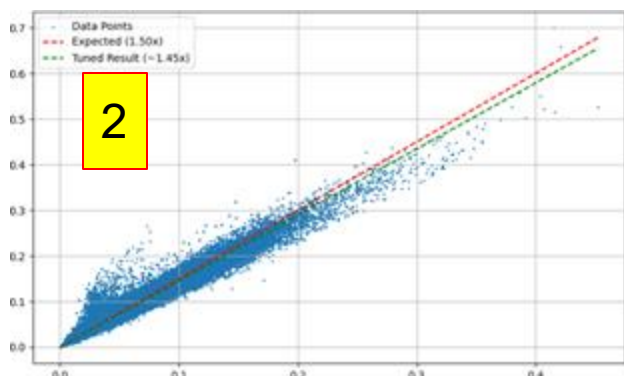
Level 2: Arbitrary point to PMT (Top)



1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

x: Pre-tuned Visibility
y: Tuned Visibility
Red dotted line: $y=1.5x$

1. 1.28
2. 1.45
3. 1.44
4. 1.46



Level 2: Arbitrary point to PMT (1.5x Visibility Corr.)

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

	Barrel	Bottom	Top
Case 1	1.34	1.29	1.28
Case 2	1.48	1.41	1.45
Case 3	1.52	1.40	1.44
Case 4	1.52	1.47	1.46

Level 2: Arbitrary point to PMT (Gaussian Visibility Corr.)

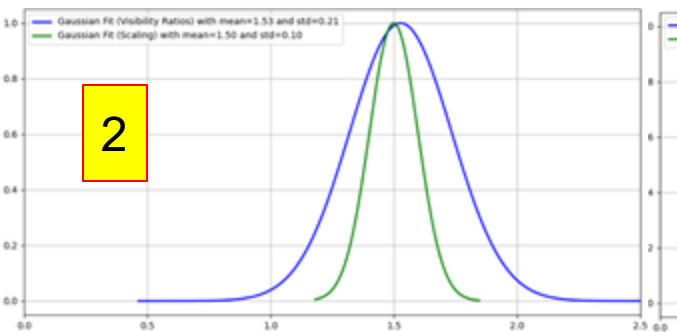
1

1. 3 source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. 3 source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. 15 source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. 126 source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

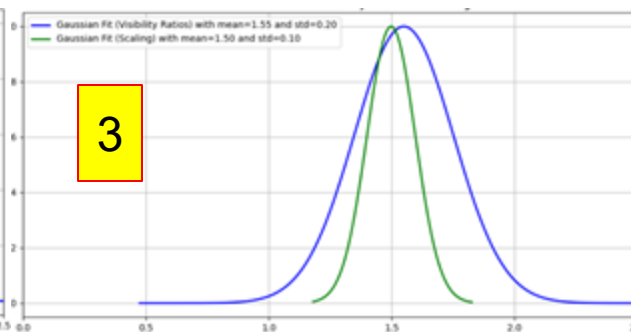
x: Pre-tuned Visibility
y: Tuned Visibility
dotted line: $y=1.5x$

Gaussian scaling
with $N(1.5, 0.1)$

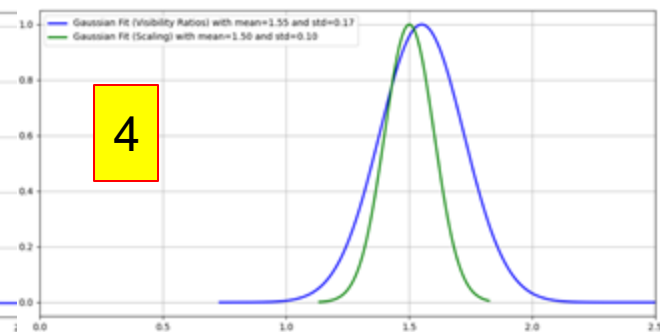
$\mu=1.53, \sigma=0.21$



$\mu=1.55, \sigma=0.20$



$\mu=1.55, \sigma=0.17$



Level 2: Arbitrary point to PMT (Gaussian Visibility Corr.)

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Observation:

1. Case 1: NA
2. Case 2: $\mu=1.53, \sigma=0.21$
3. Case 3: $\mu=1.55, \sigma=0.20$
4. Case 4: $\mu=1.55, \sigma=0.17$ (More sources, smaller spread)

Future direction

1. **3** source positions $\rightarrow (0, 0, 0), (0, 0, \pm 1000)$
2. **3** source positions (**extended**) $\rightarrow (0, 0, 0), (0, 0, \pm 1300)$
3. **15** source positions $\rightarrow z = [0, \pm 1300], r = [0, 1160], \varphi = [0, 90, 180, 270]$
4. **126** source positions $\rightarrow z = (-1300, 1300, 14), r = [0, 580, 1160], \varphi = [0, 90, 180, 270]$

Checking

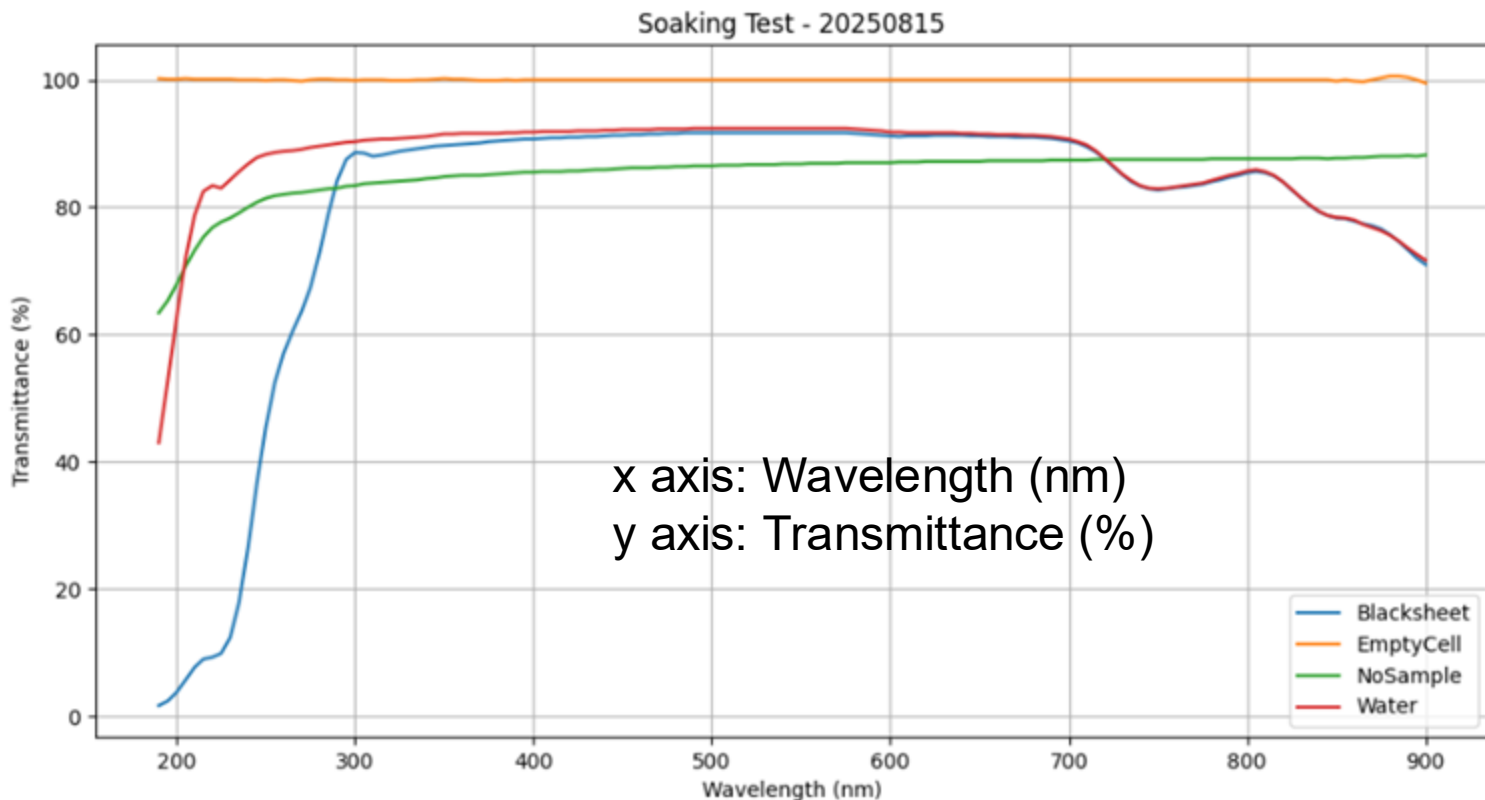
- More phi angles \rightarrow Fill in the detector
- Non-symmetric training source positions (More sources near bottom?)
- Apply different types of scaling (instead of Gaussian)
- Apply real calibration data instead of fake data

The Soaking Test

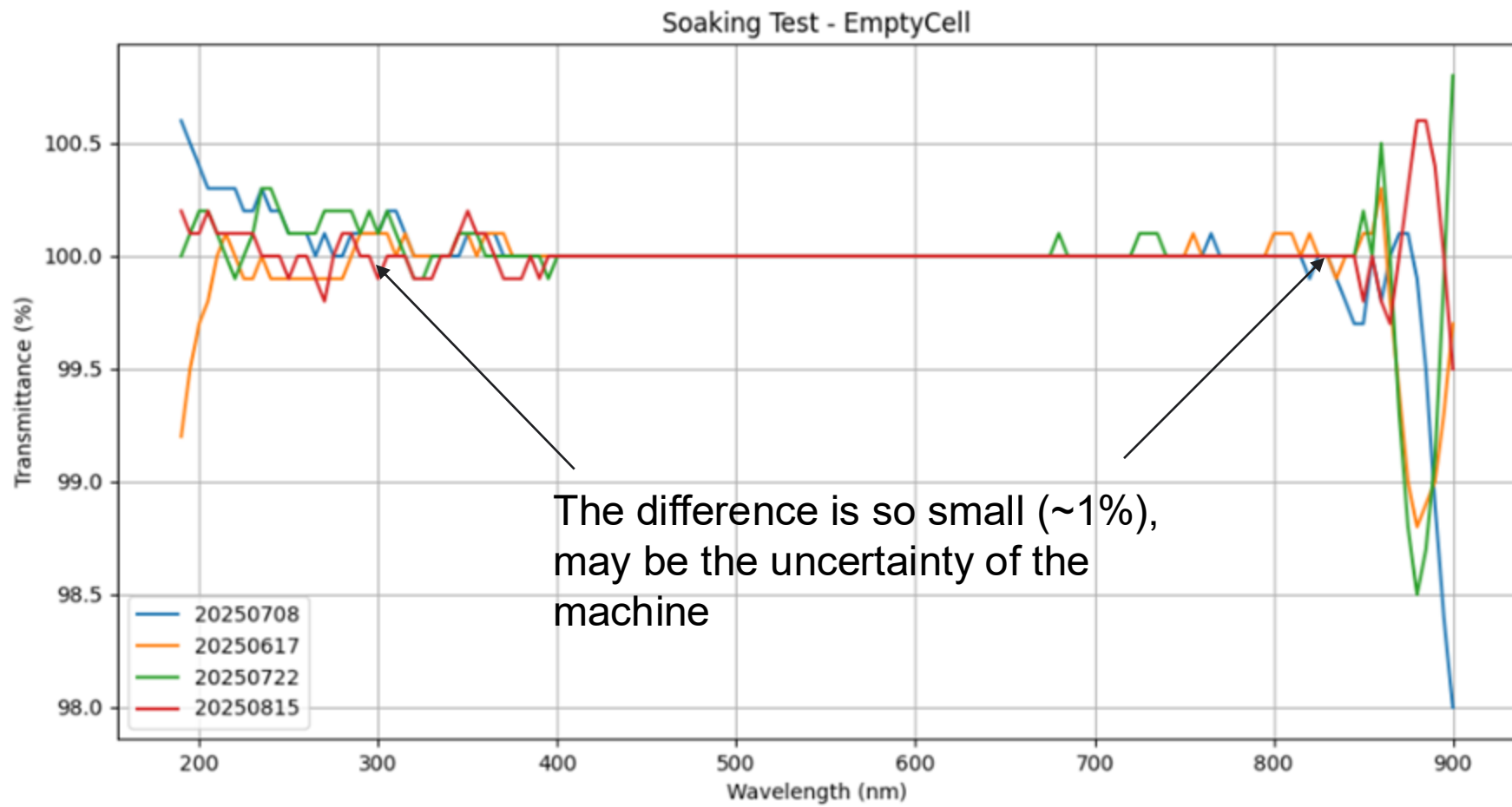
Soaking test @ ICRR building-B1: [supervised by Ka Ming Tsui and Patrick]

Test Time:

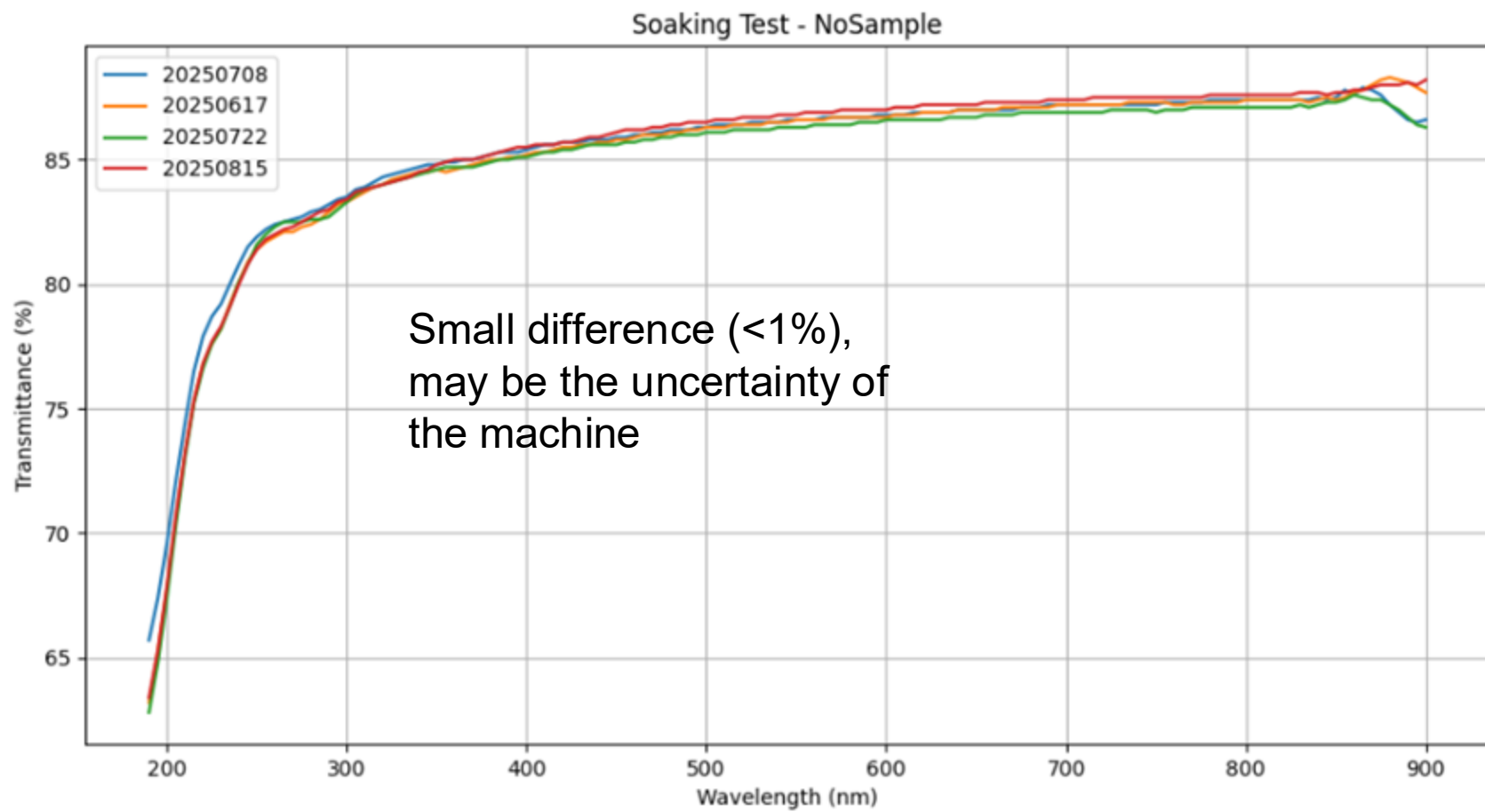
- 2025 0617
- 2025 0708
- 2025 0722
- **2025 0815**



Soaking Test Result - Empty Cell

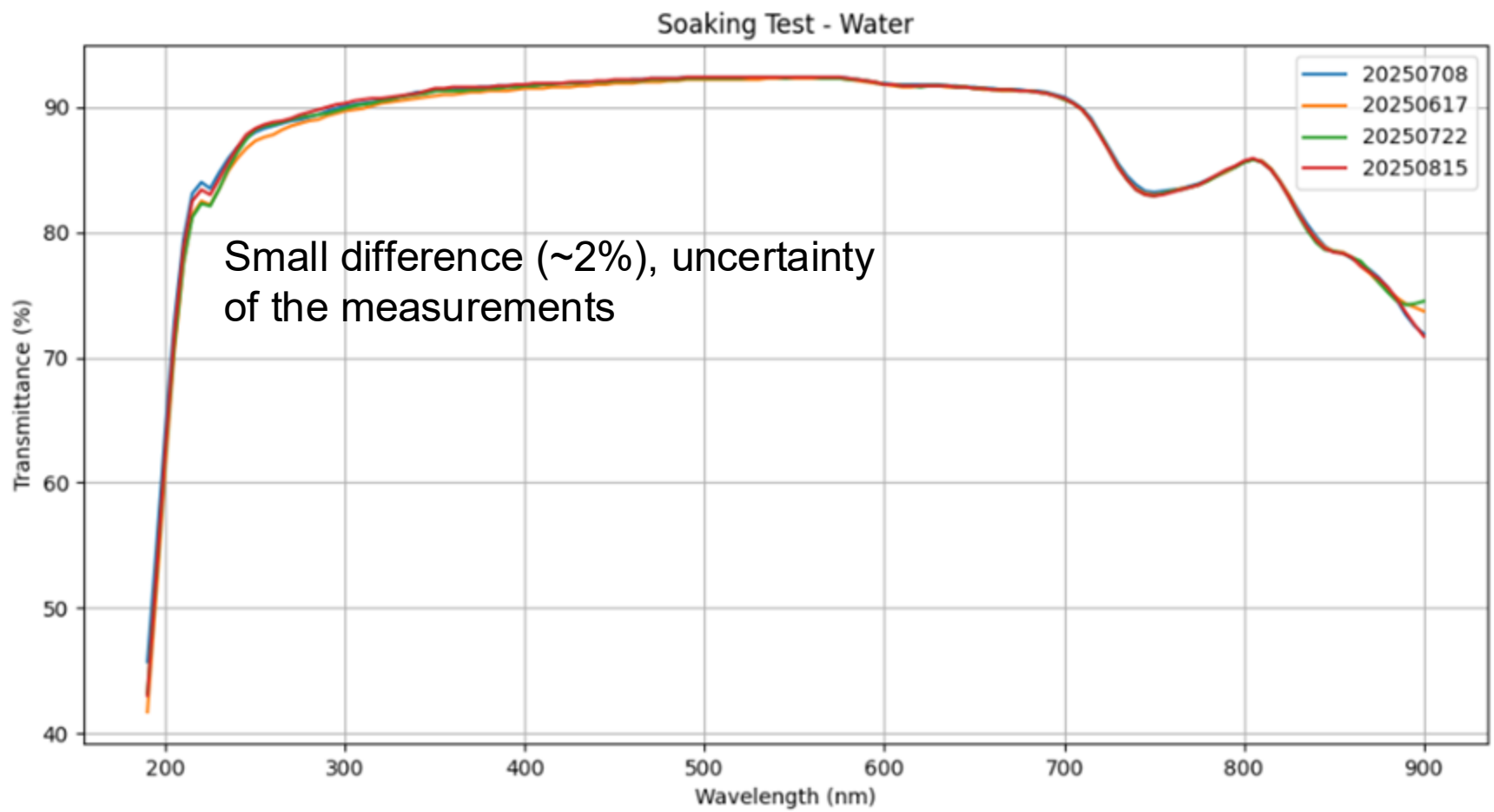


Soaking Test Result - Glass With No Sample



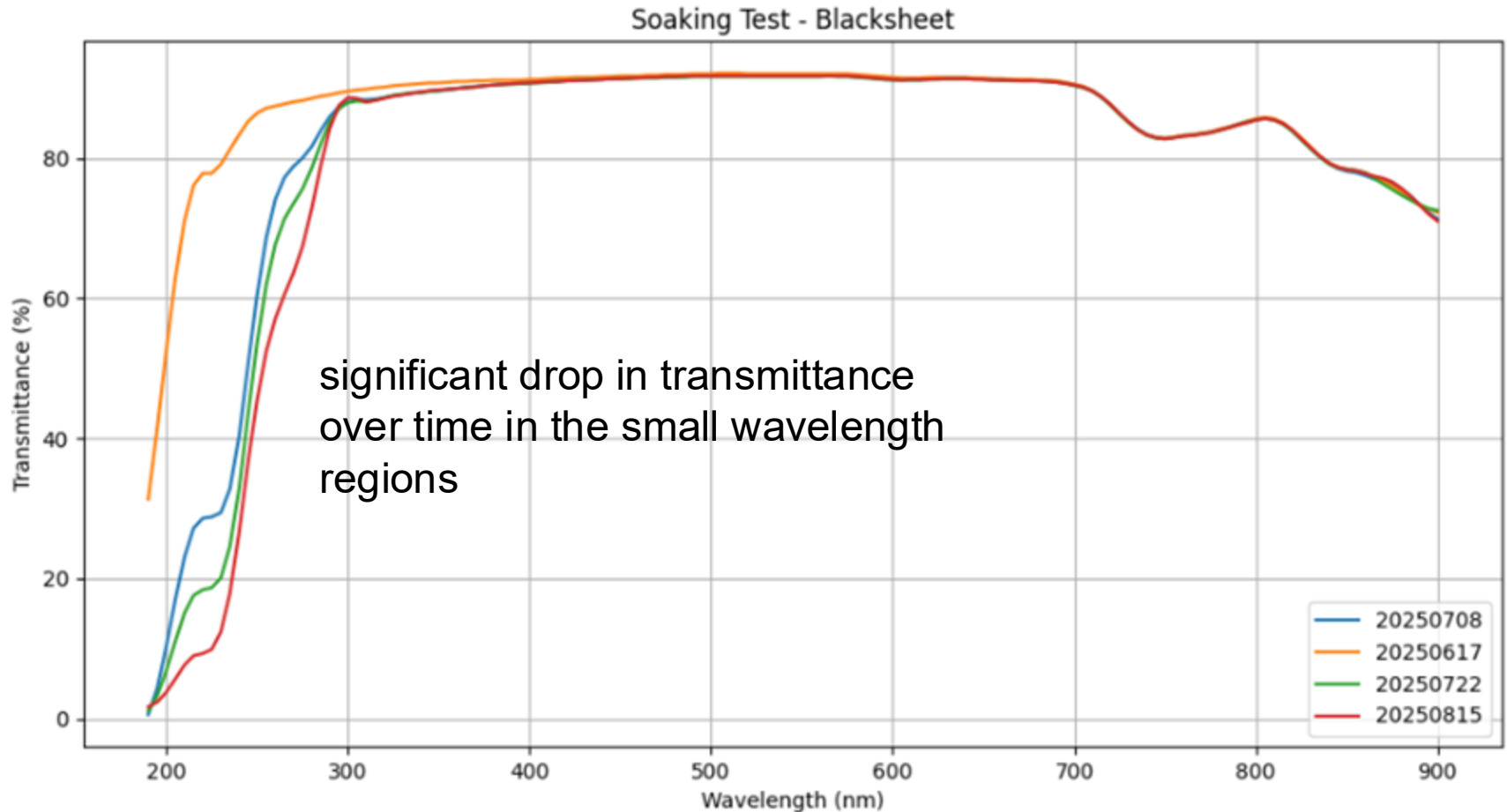
Small difference (<1%),
may be the uncertainty of
the machine

Soaking Test Result - Glass With Water Only

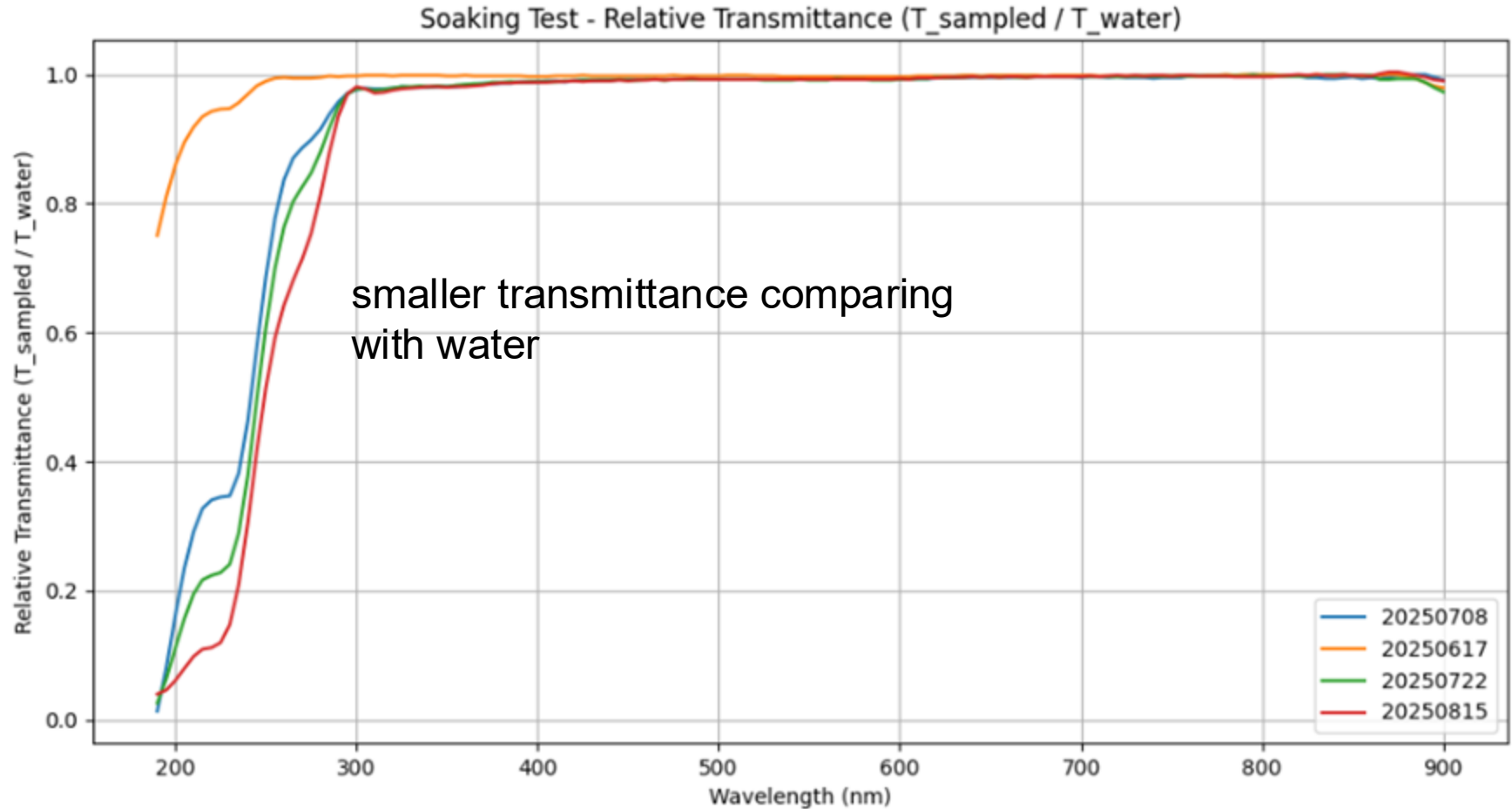


Small difference (~2%), uncertainty of the measurements

Soaking Test Result - Glass With BlackSheet



Soaking Test Result - Relative Transmittance of BlackSheet



Thank you everyone ! This is my last meeting here ! Good Luck !