



# Tyvek reflectance study for the outer detector of the Hyper- Kamiokande experiment

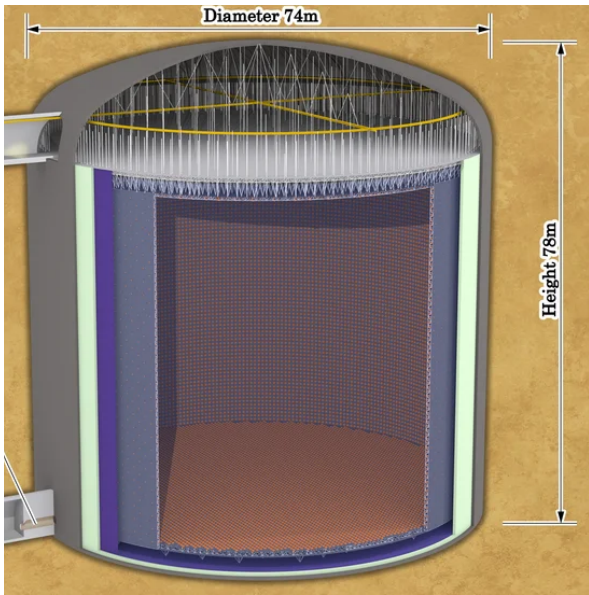
Sania Lewis

*King's College London*

IOP Joint APP and HEPP Annual Conference

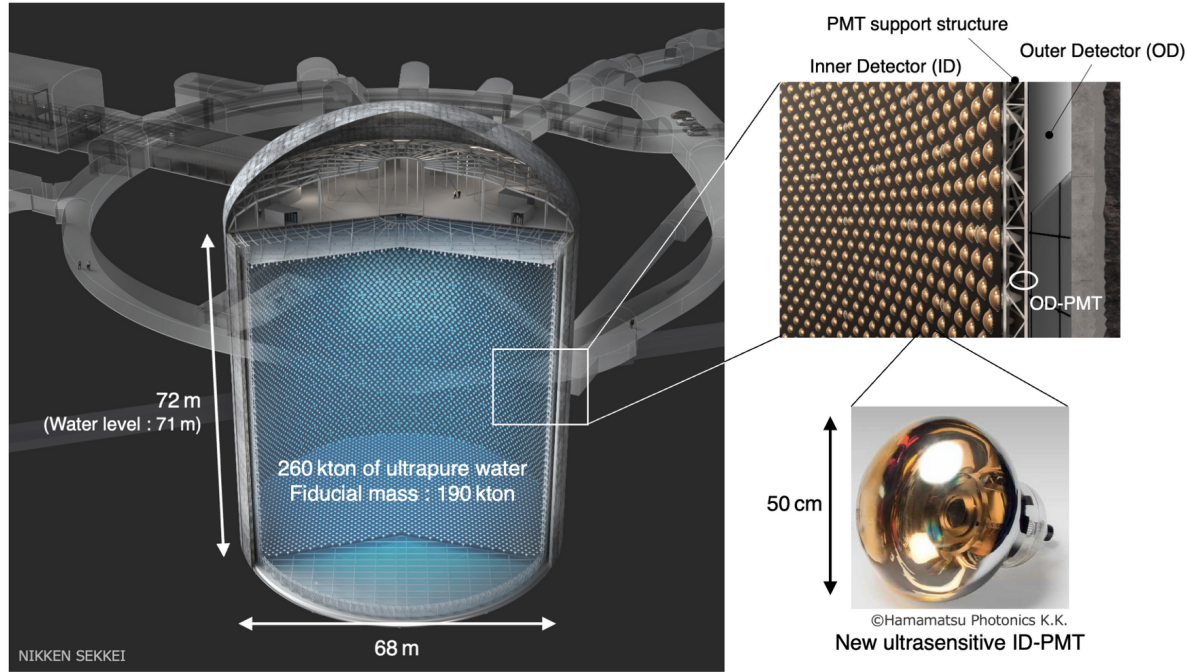
09/04/26

# The Hyper-Kamiokande Experiment



- Hyper-K is a next generation water Cherenkov neutrino detector under construction in Japan.
- The main tank dimensions are about 71m tall and 68m wide
- 250kT of ultra pure water, 8x size of its predecessor Super-Kamiokande (SK)
- It will make high precision measurements of key neutrino oscillation parameters and will search for exotic phenomena such as proton decay and other BSM physics with unprecedented precision.

# Inner and Outer Detector



[1]

- There is an inner (ID) and outer detector and the outer detector (OD) acts as a cosmic ray muon veto (~4 million per day).
- The OD is outfitted with 3600 8 cm PMTs with wavelength shifting plates.
- Cosmic ray muons also produce neutrons and unstable isotopes which then decay via beta or gamma emission – this results in a dangerous background.
- To collect as much light as possible for the OD veto, a highly reflective material, Tyvek is used.
- To optically isolate ID from OD, need Tyvek with a black side and white side (BW). The outer wall can have both white sides (WW)

# What is Tyvek?



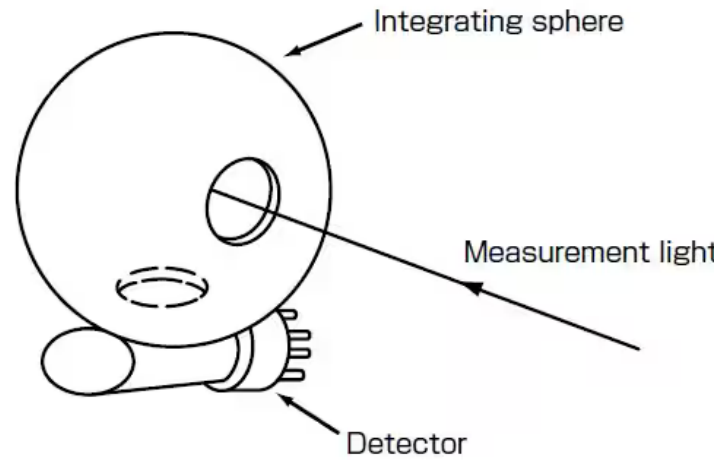
Tyvek installation in Super-Kamiokande [3]

- Tyvek is a material created from spun high-density polyethylene fibers. It significantly increases the light collection within the OD. The PMT is surrounded by a wavelength shifting plate which re-emits the direct Cherenkov light into lower wavelengths.
- Both OD and ID are filled in ultra-pure water.
- Only in air measurements conducted in the past.
- This study aims to make reflectivity measurements of the Tyvek both in air and in water to verify the Tyvek samples we choose have greater than 90% reflectivity in the wavelength range of 250 – 500nm.

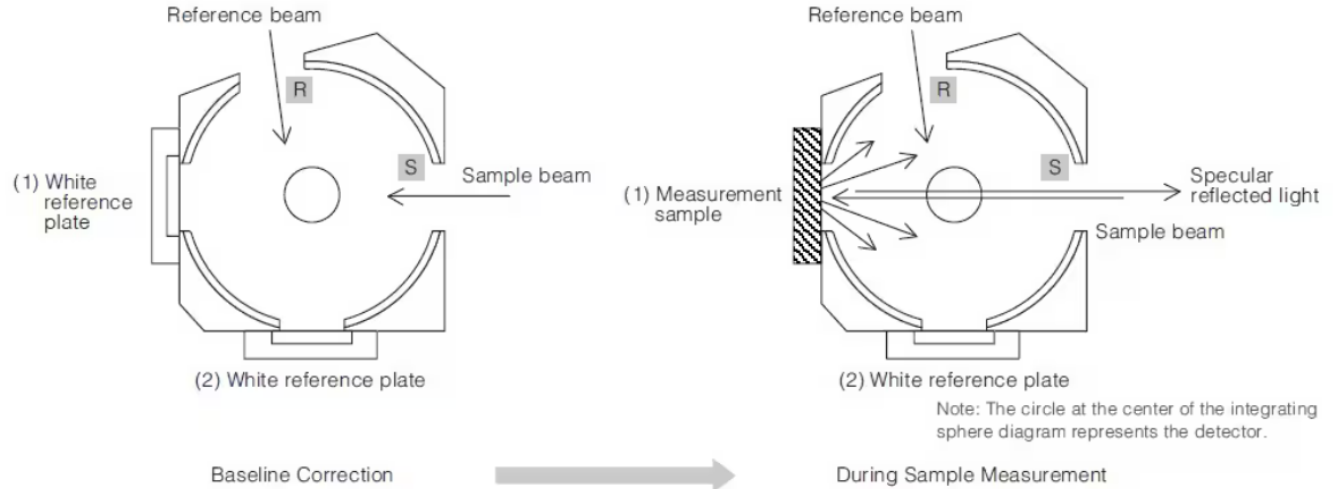
09/04/26

Sania Lewis

# Integrating sphere



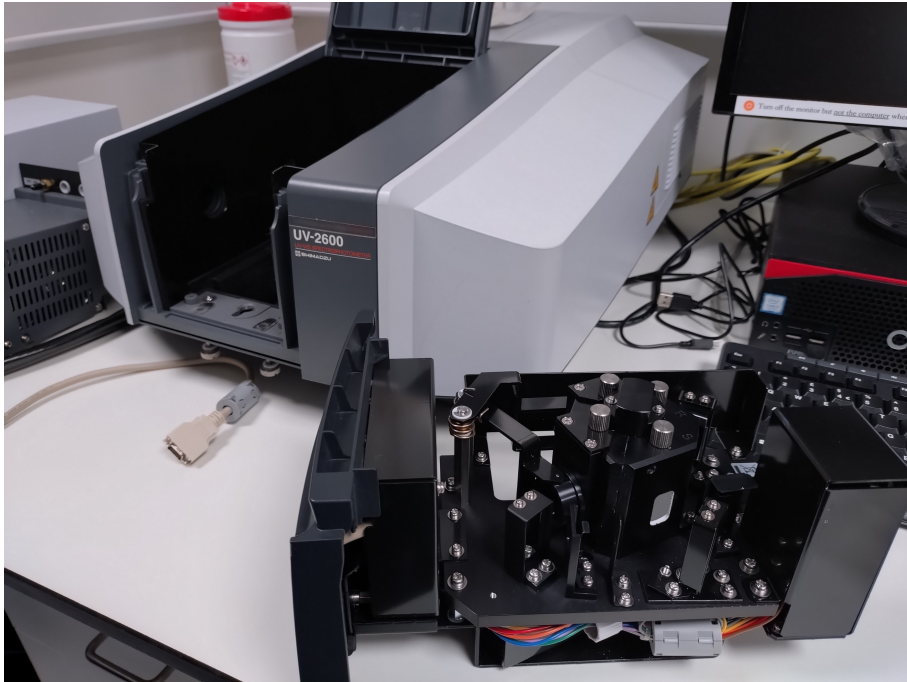
Top down view



Simple integrating sphere diagram [2].

Baseline correction process for diffuse measurements

# Instrumentation



SHIMADZU UV-2600: UV-VIS Spectrophotometer and ISR-2600 integrating sphere attachment.

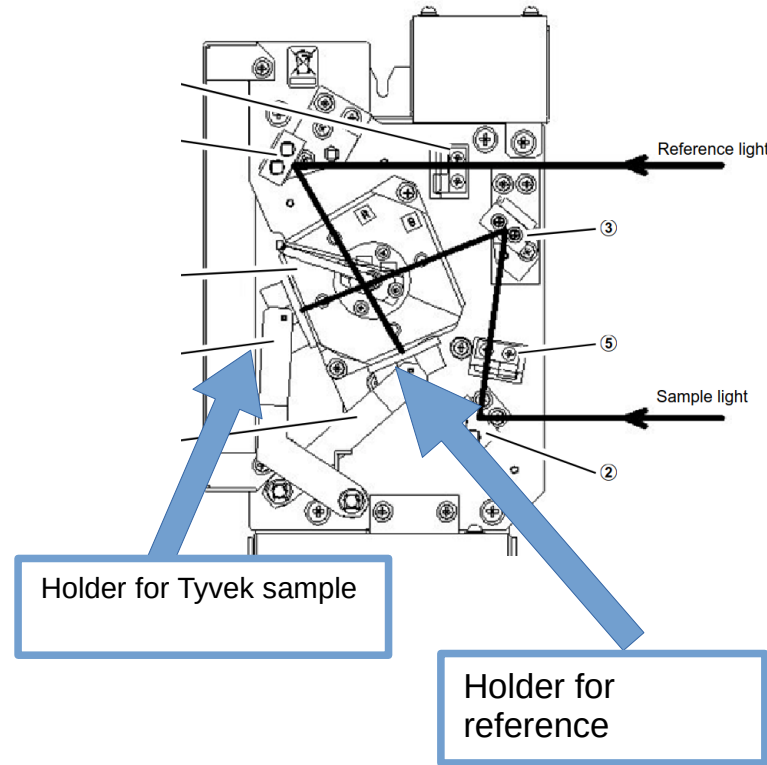
- Single monochromator model with a wavelength range of 220 – 1400nm with the integrating sphere attachment.
- Light source: 50W halogen lamp and deuterium lamp, with wavelength switching between 290 to 370nm.

# Instrumentation

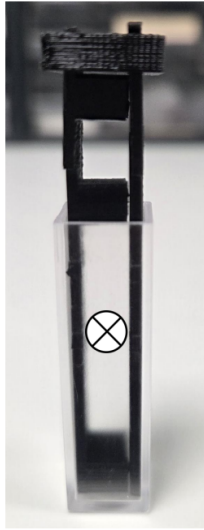


Holder for Tyvek sample

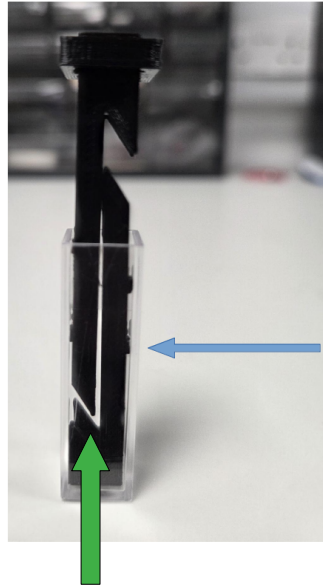
Holder for reference



# Holder design



No sample currently in holder



Tyvek sample will be placed here with its flat surface perpendicular to incoming measurement beam

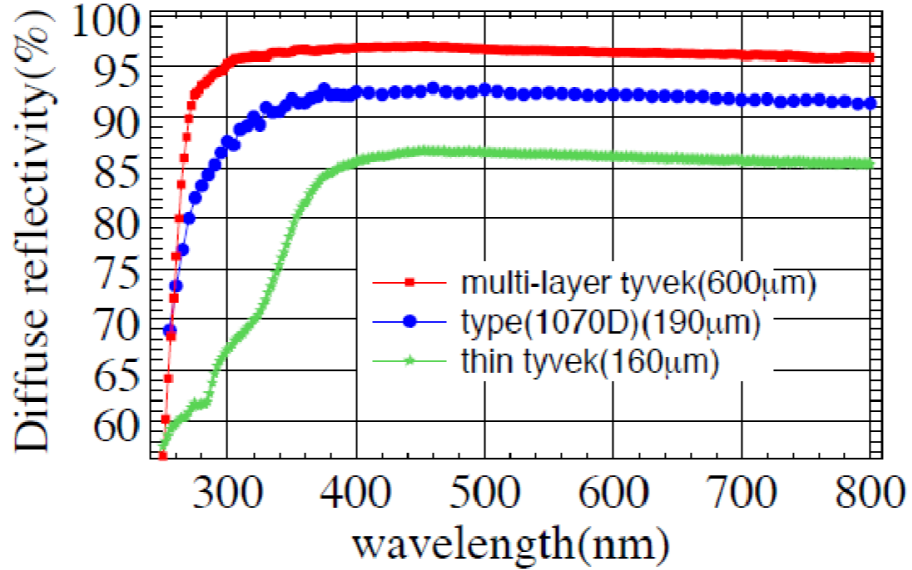
- Measurements were taken using a quartz cuvette and 3D printed holder.
- Blue arrows shows direction of incoming measurement beam.
- Black 3D printed holder designed to hold the Tyvek in precise position and allow for both in air and water measurements.



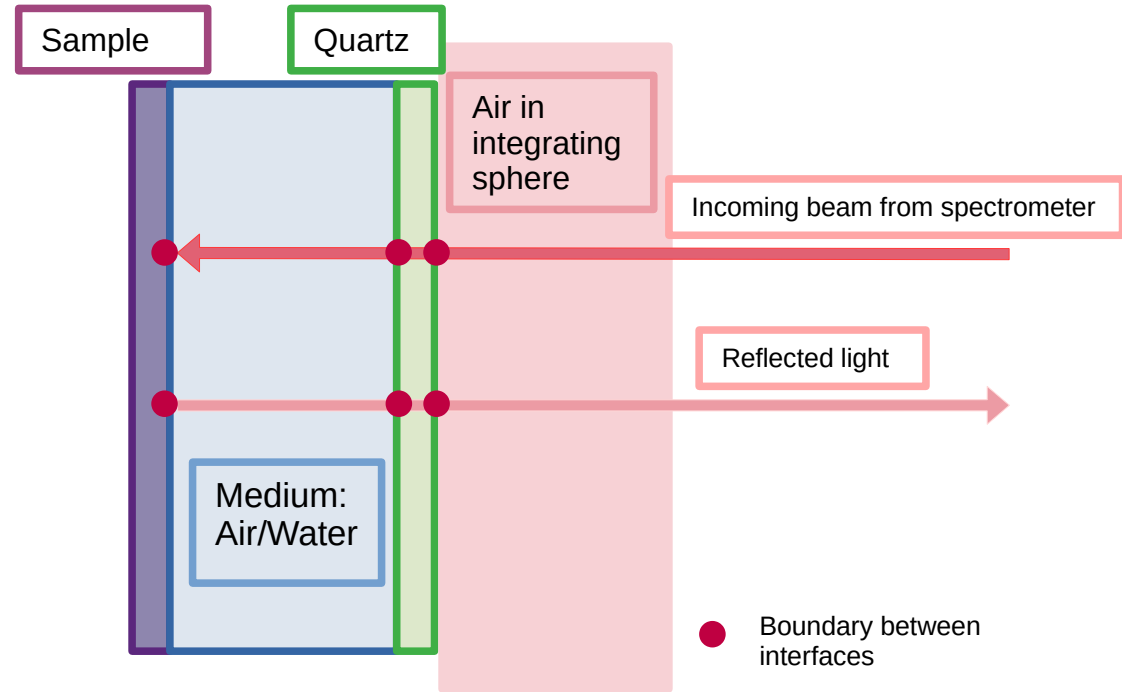
A quartz cuvette was used to allow light in the UV region through.

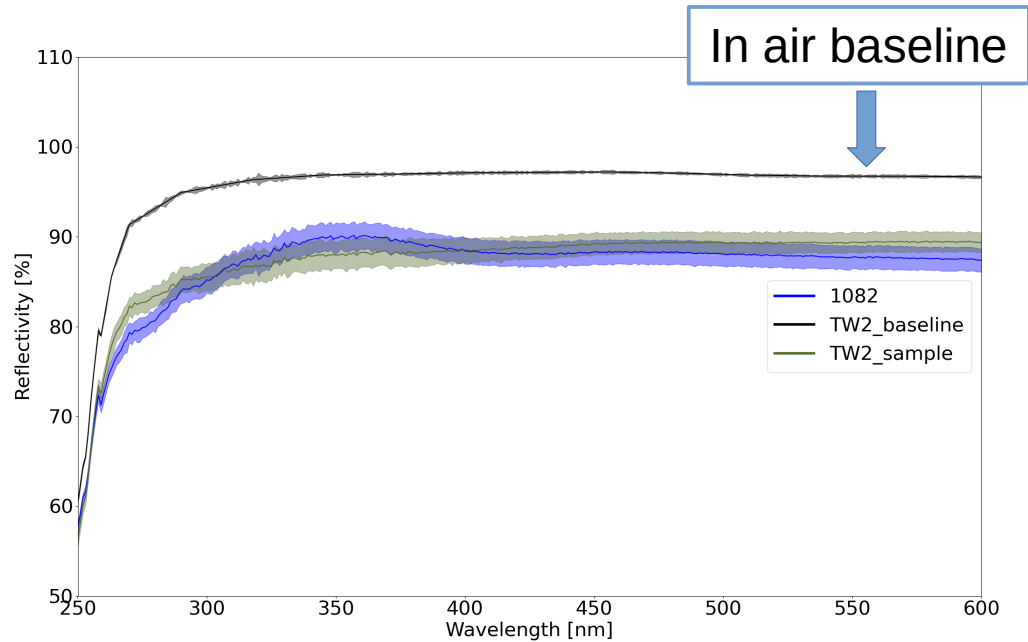
[4]

# Baseline Correction Issue



Different JUNO tyvek samples [1]





Fresnel equation for reflectance at a normal incidence:

$$R_0 = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2$$

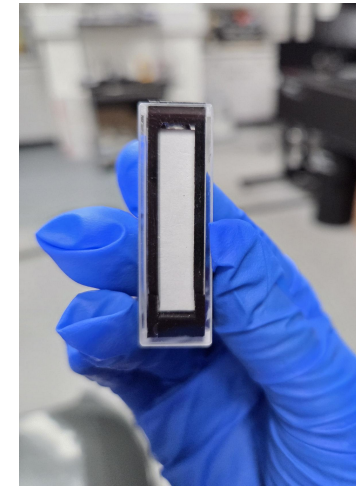
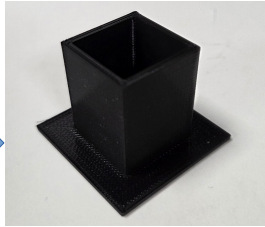
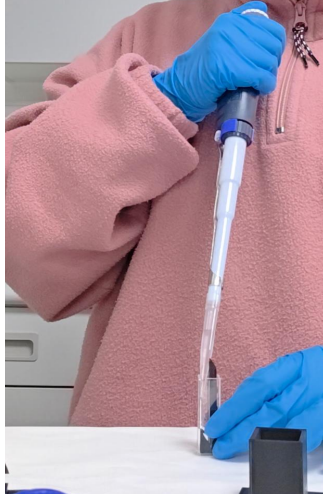
Calculating this using the refractive indices at each boundary gives an expected decrease in the water baseline case, of ~ 10% which is roughly what we are seeing.

Further steps: For a more accurate value, currently working on a GEANT4 based simulation to obtain full wavelength dependent correction.

Reflectance of some selected samples with an in air baseline.

Therefore, for now we use TW2 water baseline, with the assumption that the reflectivity is the same as published results in air.

## Process for water measurements

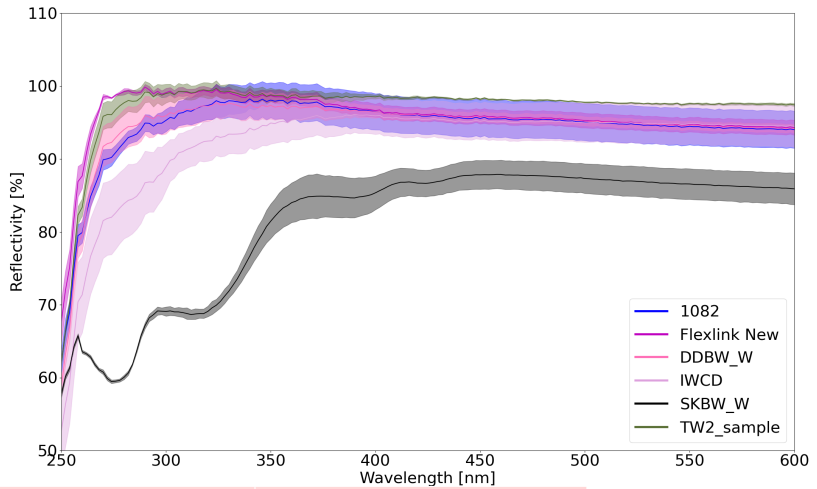


Pipetted 2ml of ultra pure water into cuvette for each sample

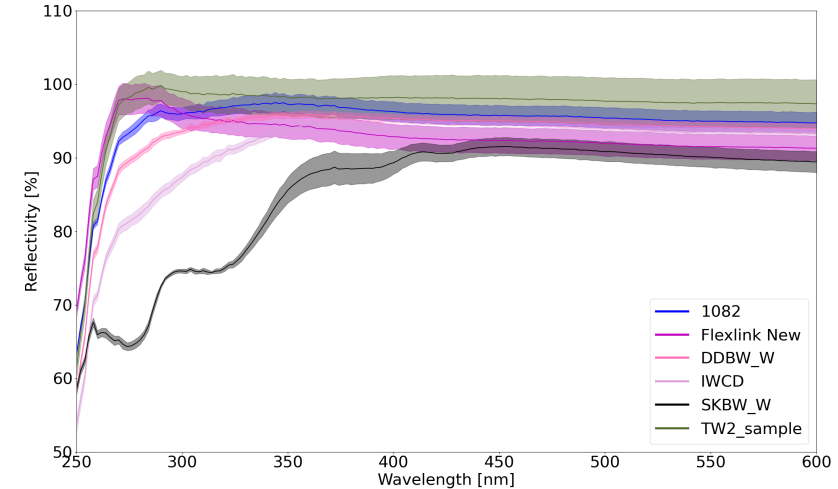
Left the cuvette + holder in the in the degass bath for 2 minutes each time

Cuvette can then be inserted into the cuvette holder attachment piece for the integrating sphere

## Tyvek reflectances in air



## Tyvek reflectances in water



<b>1082</b>	Main white/white (WW) sample
<b>Flexlink</b>	Main Black/White (BW) sample
<b>DDBW</b>	Good sample, too expensive
<b>IWCD</b>	Sample of 1082D Tyvek sourced in Japan by IWCD group
<b>SKBW</b>	BW used in SK
<b>TW2</b>	WW reference from company that supplies JUNO

Main samples of interest to Hyper-K are **1082D** (WW) and **Flexlink** (BW). They both satisfy the requirements of greater than 90% reflectance in the wavelength range of 250 to 500nm.

# Summary

- The goal of this study was to characterise the reflectance of Tyvek material both in air and in water. In water measurement not previously done.
- We designed a 3D printed holder that allowed the Tyvek to be held in place with room in between the incoming beam and the sample.
- Simple calculations of Fresnel equations validate some assumptions made in the measurement process and currently working on a more accurate simulation.
- Finally, by doing this study we were able to verify that the chosen samples of Tyvek in air and water fulfil the requirements for use in the experiment.