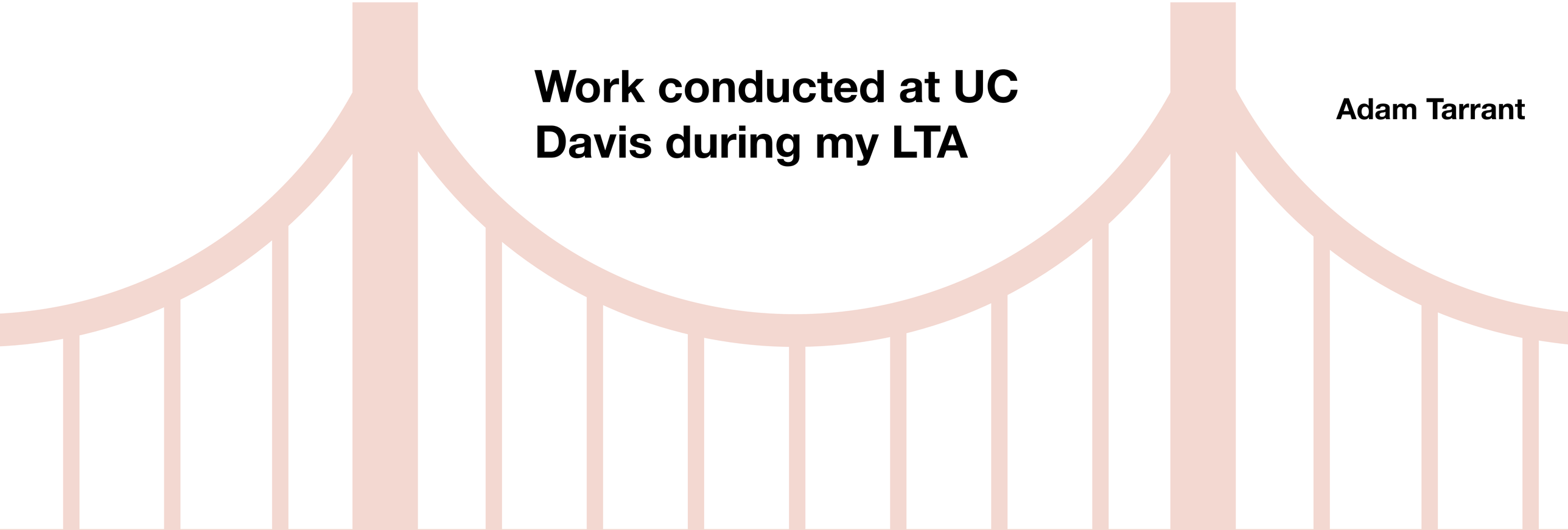
Measuring the attenuation of light in WbLS

Work conducted at UC Davis during my LTA

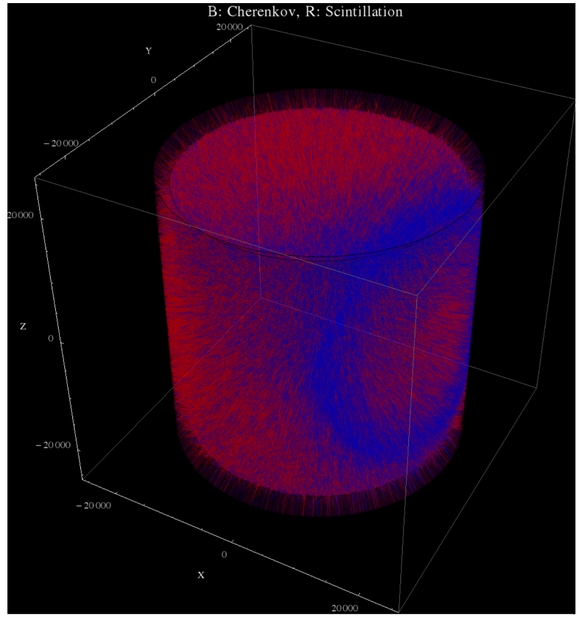
Adam Tarrant



UNIVERSITY OF LIVERPOOL

What is WbLS

- Water based Liquid Scintillator (WbLS) is a mix of water and scintillator (in ratios in the range (9:1) and less).
  - Hope to gain the advantage and reduce the disadvantages from the different medium



B. Land (Berkeley)

Cherenkov detectors (water)

- Limited by Cherenkov Threshold
- Poor energy resolution at low energy (10MeV) (due to low light yield)

Liquid Scintillator

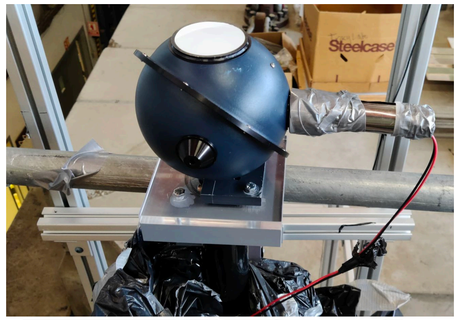
- Expensive to buy in large quantities
- Loss of direction (and energy at high Energy)

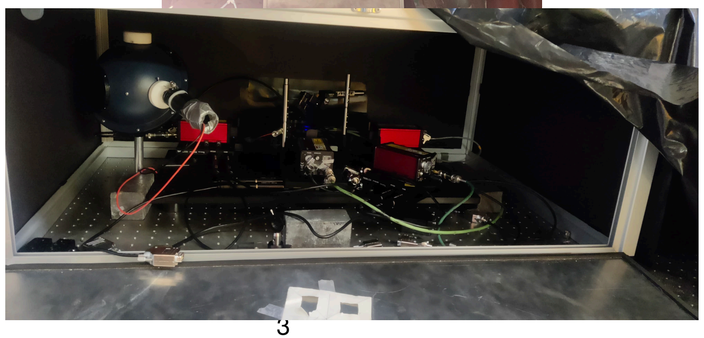
- Other additives like Gadolinium can for neutron capture.
- Useful in studies ranging from neutrino less double beta decay to diffuse supernova backgrounds

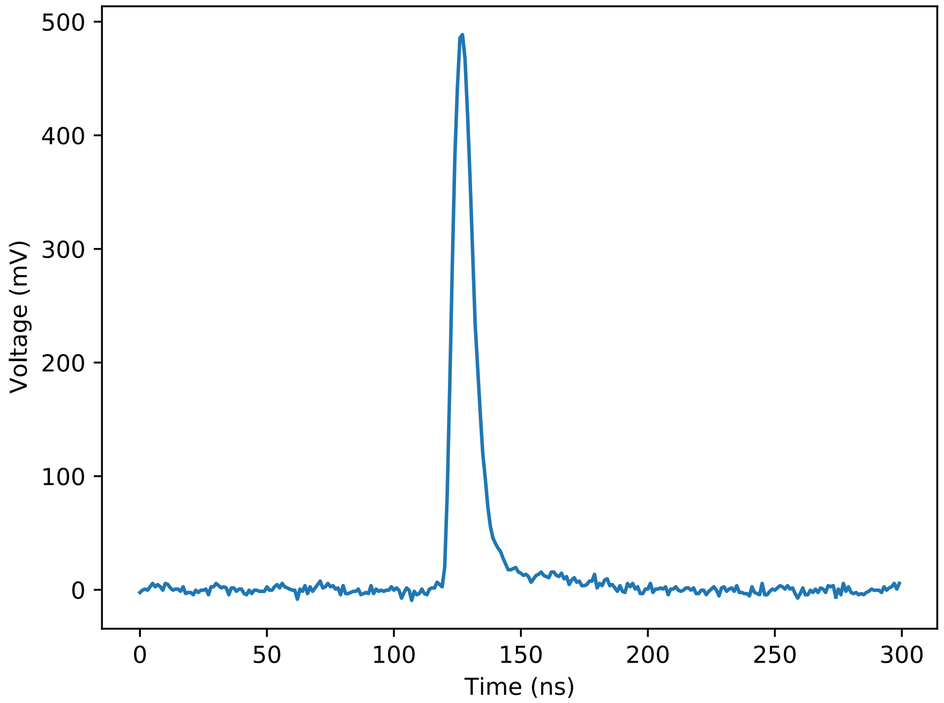
UNIVERSITY OF LIVERPOOL

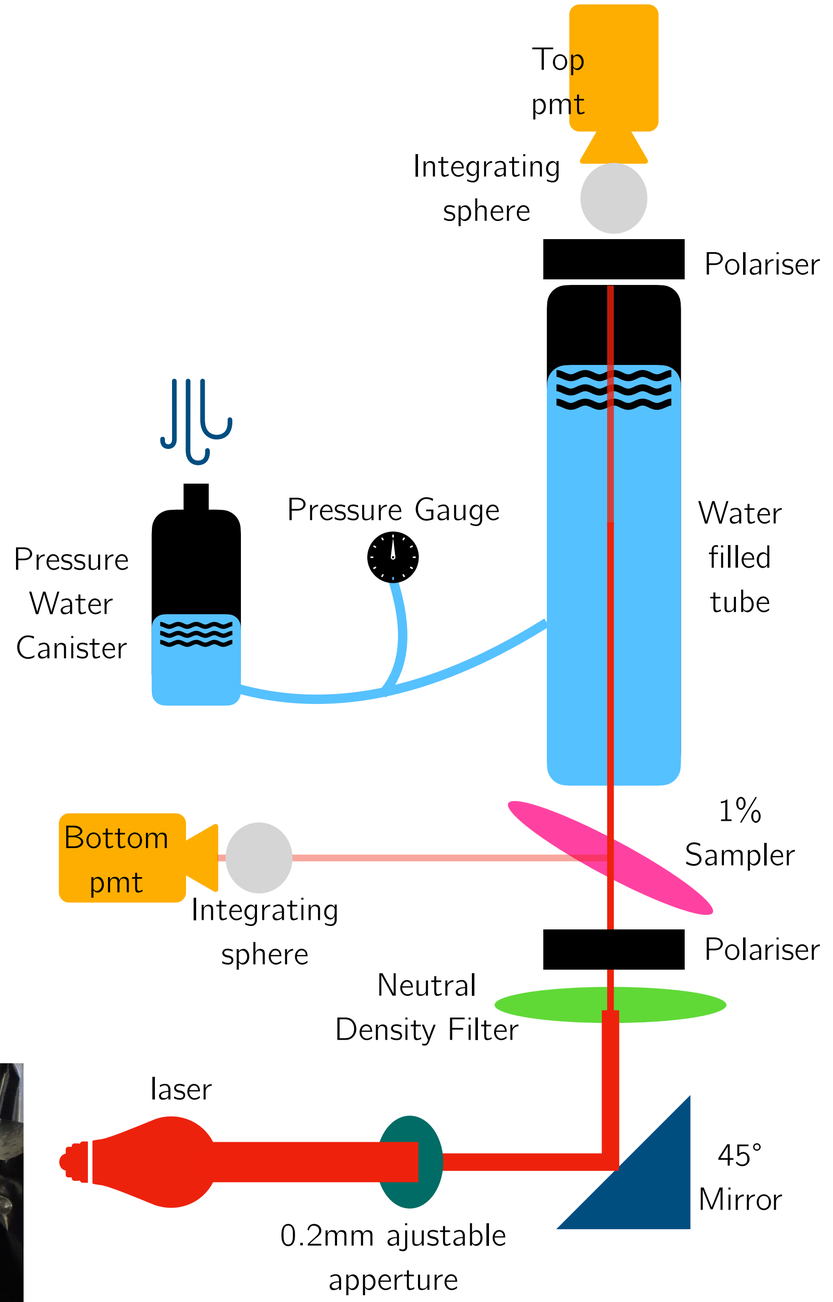
SAMD

- Scattering and Attenuation Measuring Device (SAMD)
- Want to measure the attenuation of light in WbLS to improve simulations
- First test in water



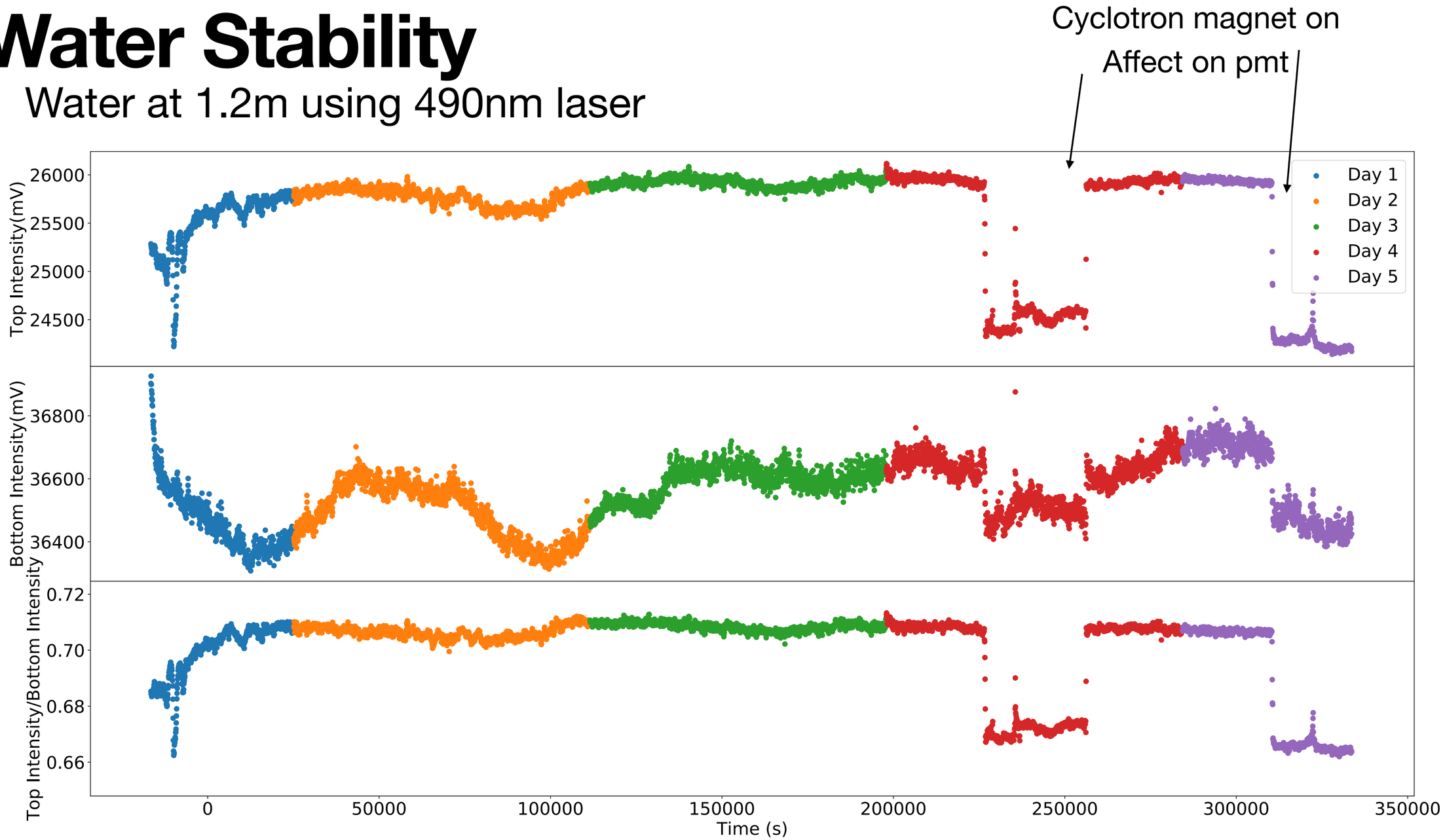






Water Stability

- Water at 1.2m using 490nm laser



UNIVERSITY OF LIVERPOOL

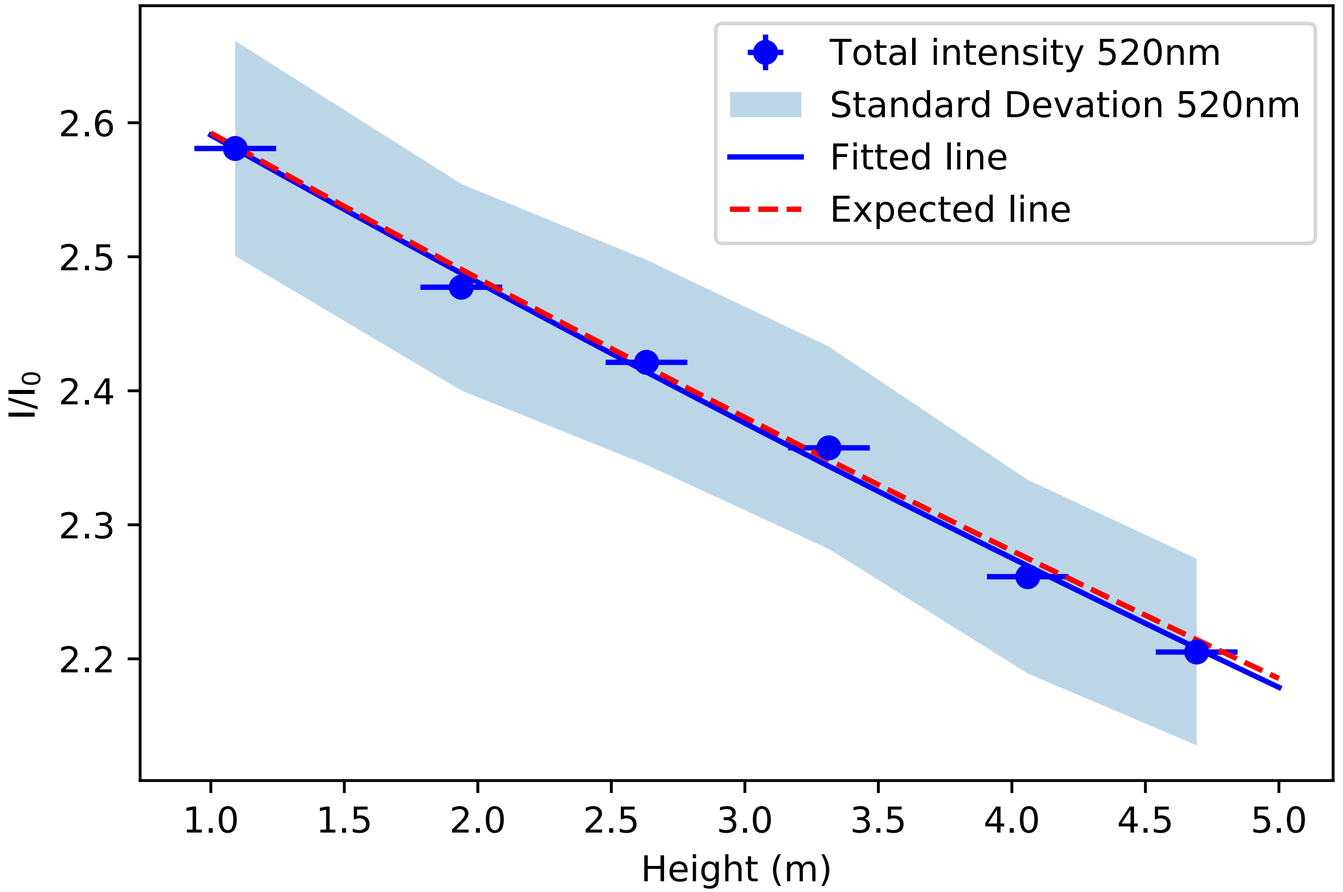
Measuring the attenuation

520nm

- Did a test run in HPLC water
- Fitted an exponential to the data

$$\frac{I}{I_o} = \epsilon e^{\frac{-H}{z}}$$

- Found the attenuation length is
- 23.1m
- Expected value is 24.4m
  - This is explained by the scattering —> $\frac{I}{I_o} = \epsilon e^{-H(a+b)}$



UNIVERSITY OF LIVERPOOL

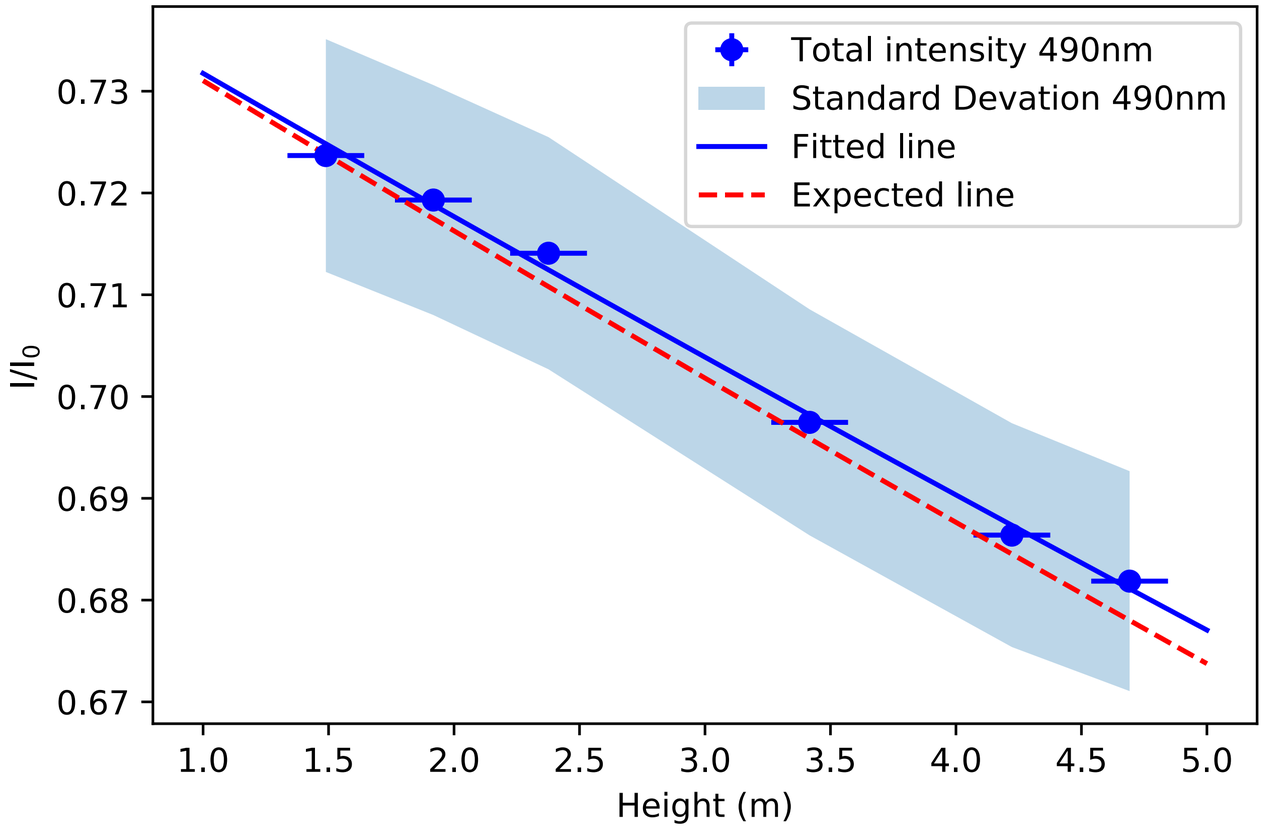
Measuring the attenuation

490nm

- Did a test run in HPLC water
- Fitted an exponential to the data

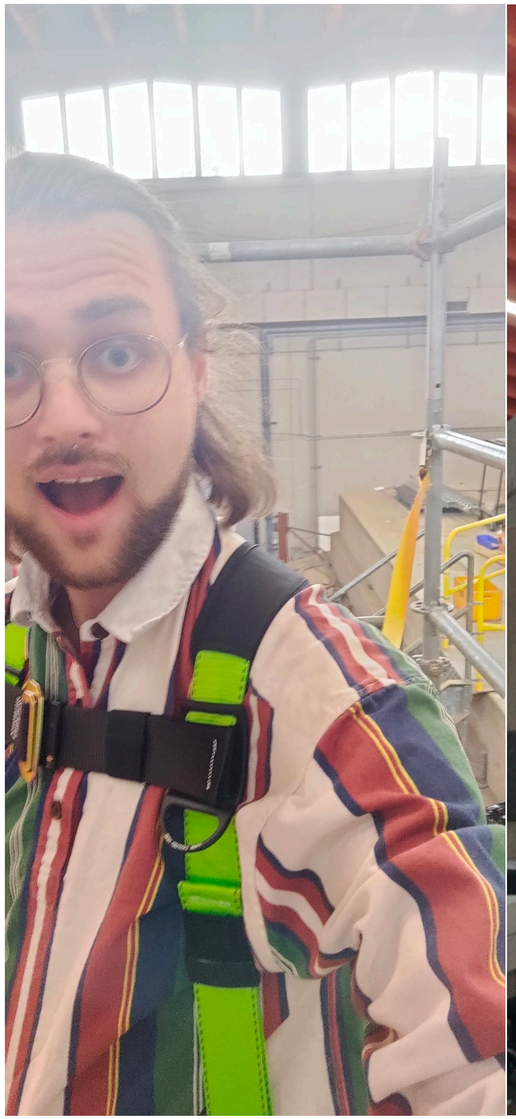
$$\frac{I}{I_o} = \epsilon e^{\frac{-H}{z}}$$

- Found the attenuation length is
- 51.5m
- Expected value is 55.2m
  - This is explained by the scattering —> $\frac{I}{I_o} = \epsilon e^{-H(a+b)}$



UNIVERSITY OF LIVERPOOL

Next steps



- Remove magnetic field affects.
- Test all laser wavelengths in the type 1 (very clean) water
- Calculate our systematic uncertainties
- Make measurement of WbLS

Thank you for Listening
Thank you to UC Davis for hosting me

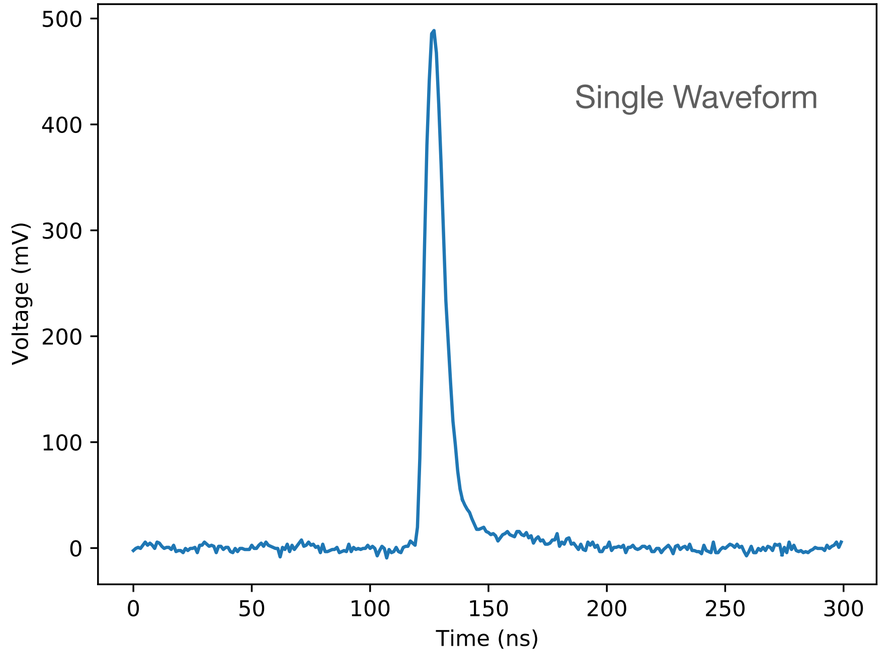
UNIVERSITY OF LIVERPOOL

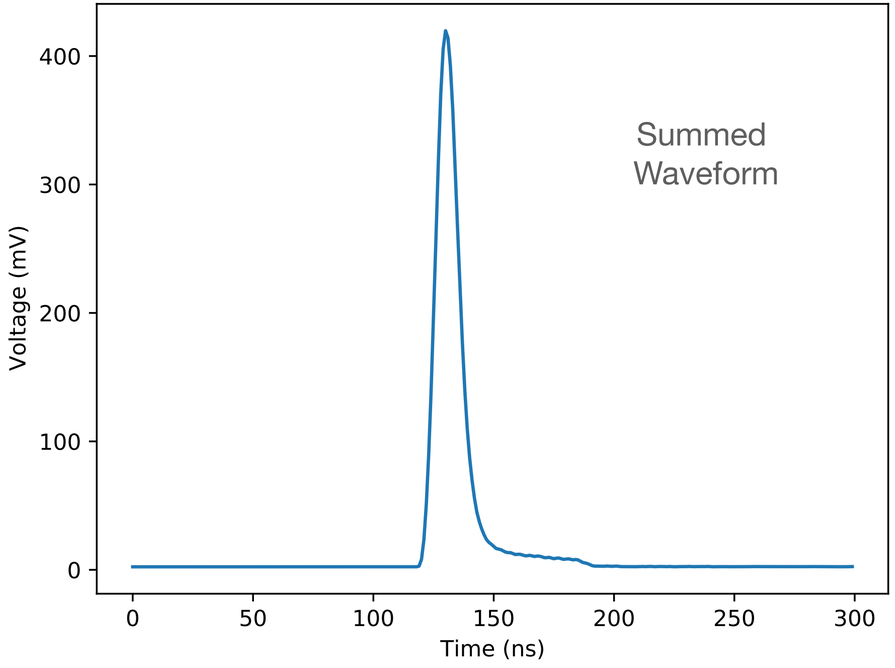
Background

Waveforms

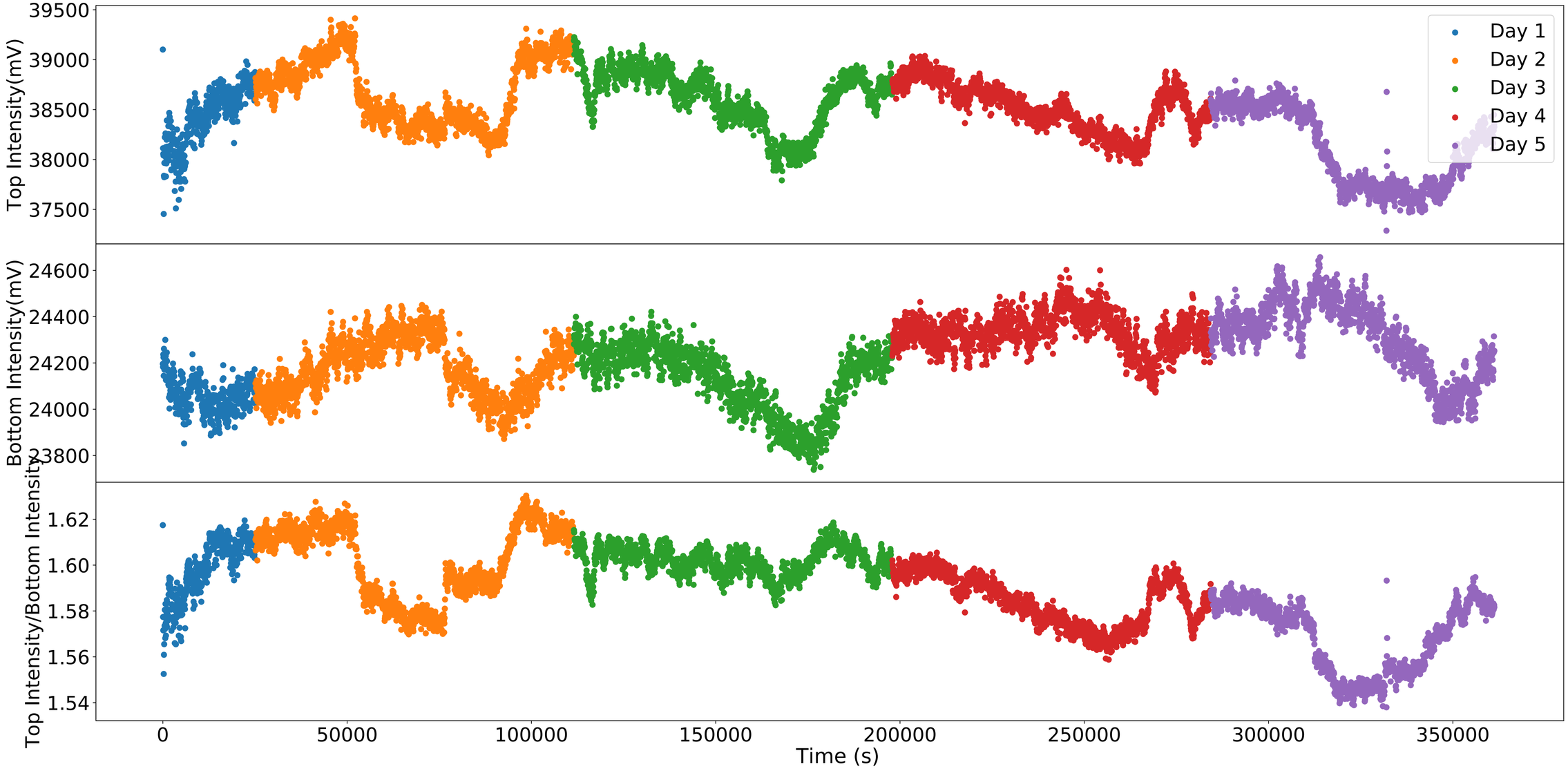
- Make our intensity measurement 3 different ways

1. Total Intensity.
   - Integrate under raw waveforms and average
2. Peak Height
   - Take the average peak height of the waveform
3. Sum Average
   - Sum all waveforms
   - Normalise and integrate

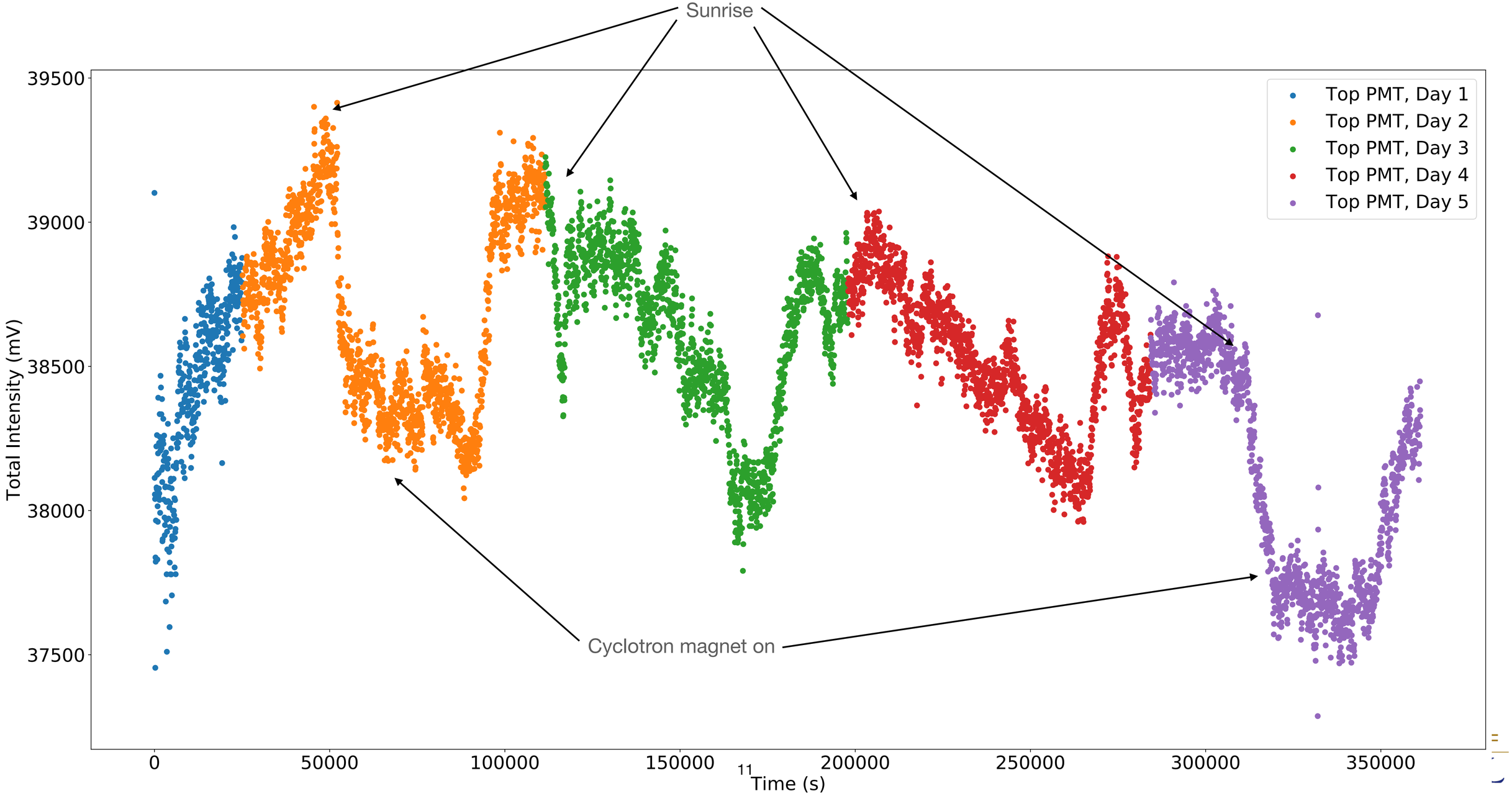




Water Stability • Water at 2.8m using 520nm laser



Water Stability



Polarisation and scattering

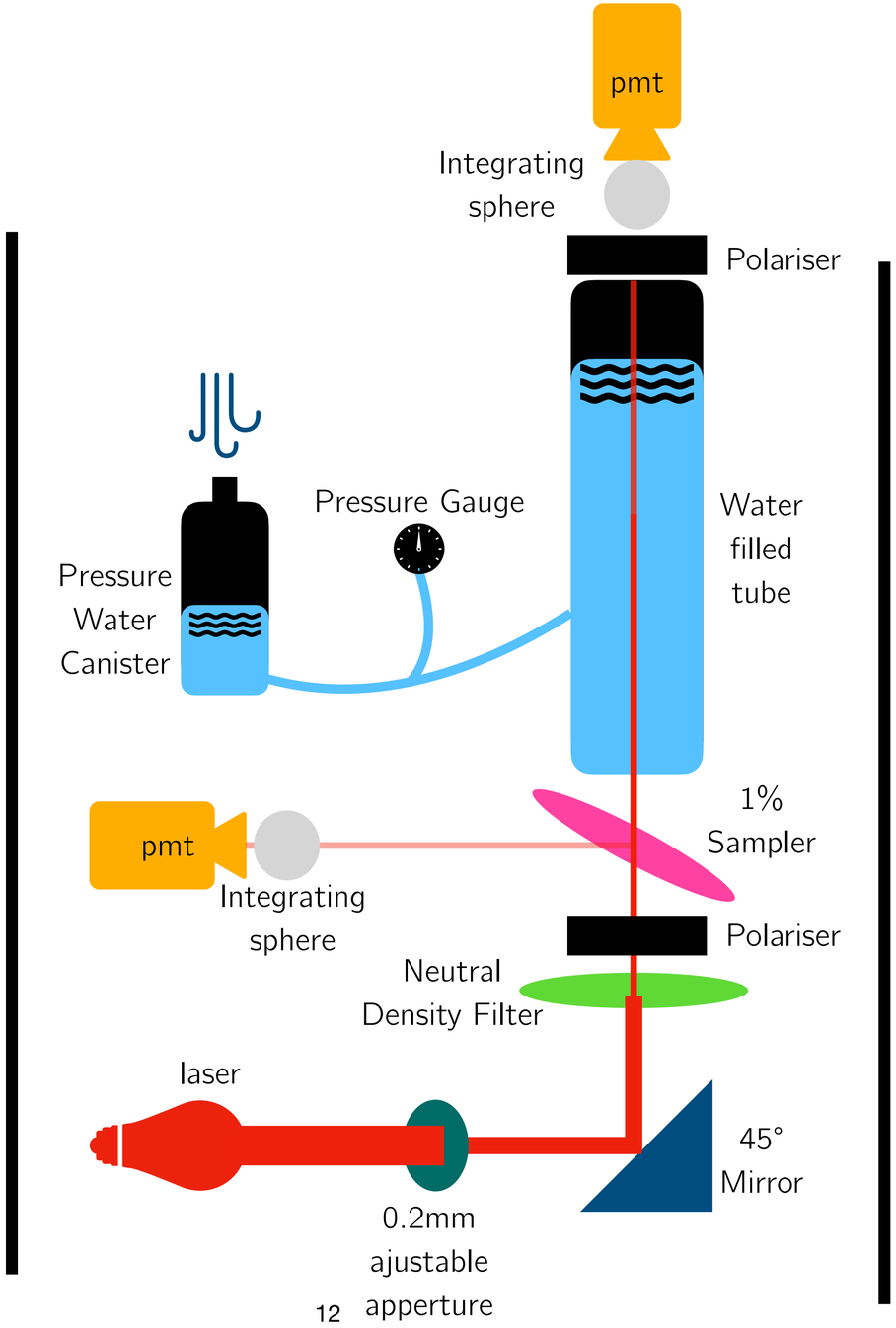
- Think there is scattering occurring in the tube
- This light is uncollimated
- Thought of using a polariser to remove uncollimated light

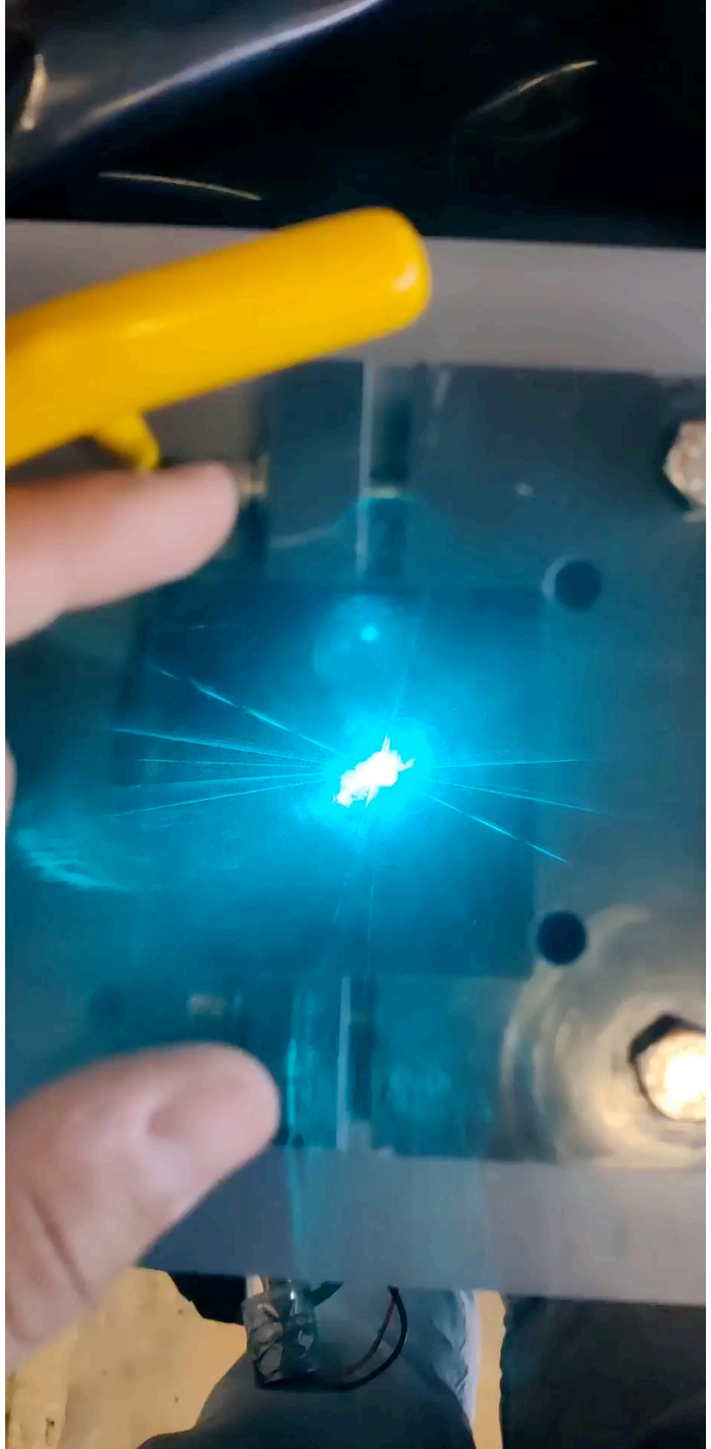
or

- Cutting out circular polarisation

or

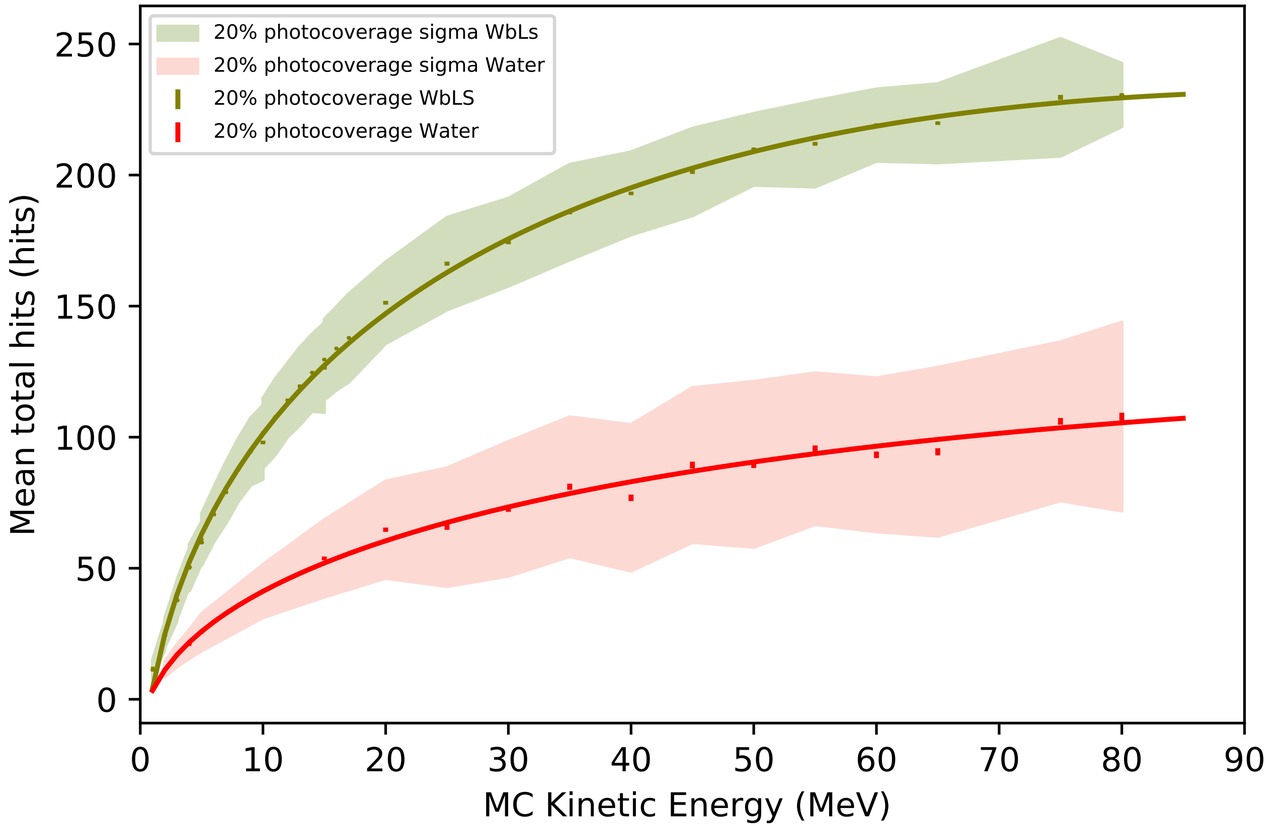
- Removed unpolarised sunlight





WbLS in simulations

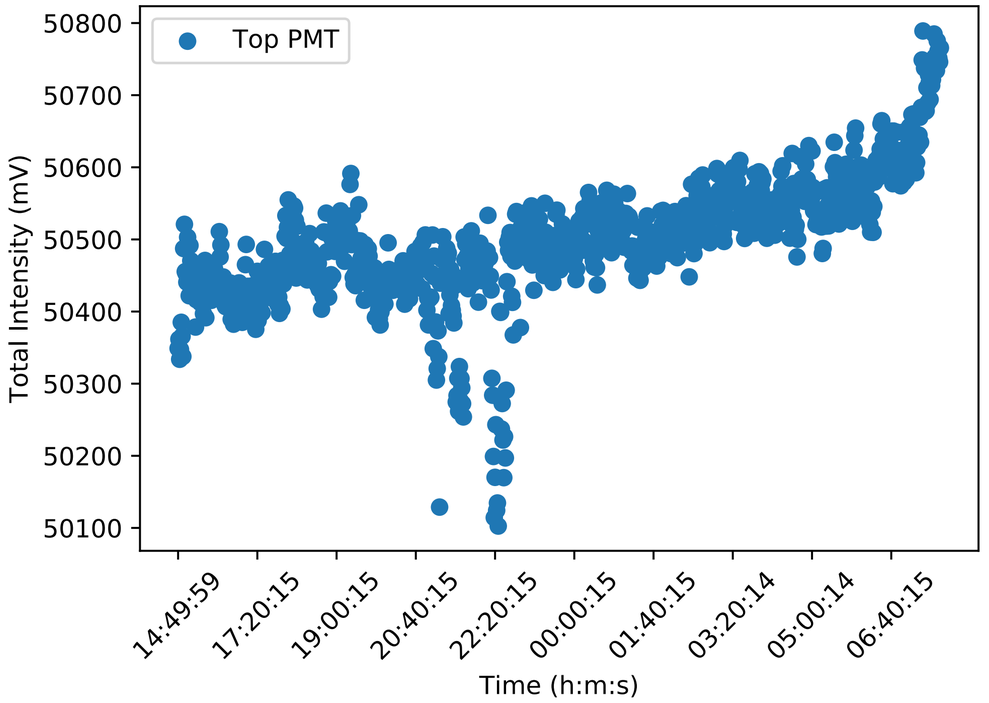
- It was noted that there was no late time photons expected with Liquid scintillator
- The time profile of WbLS and dopped water are different
- WbLS not acting as expected
- Need to measure the attenuation to improve simulations

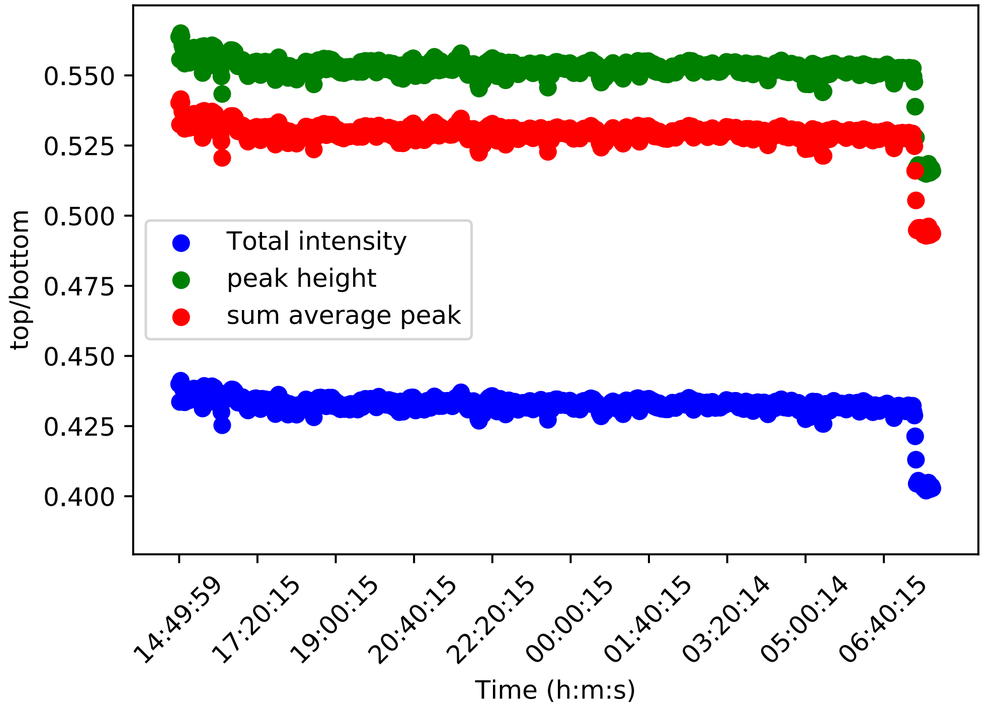


UNIVERSITY OF LIVERPOOL

Dirty water test

- Water at about 2.35m
- A 480nm laser was left running with data taken in 1min intervals
- Top pmt show a decrease in top intensity at 22:00 but as this isn't seen in top/bottom suggest it is laser instability
- The increase in top intensity and decrease in I/Io
  - Is around sunrise. Could this be a light leak?
  - Is around when the cyclotron magnet turned on?





Measuring the attenuation

Do we see reflection

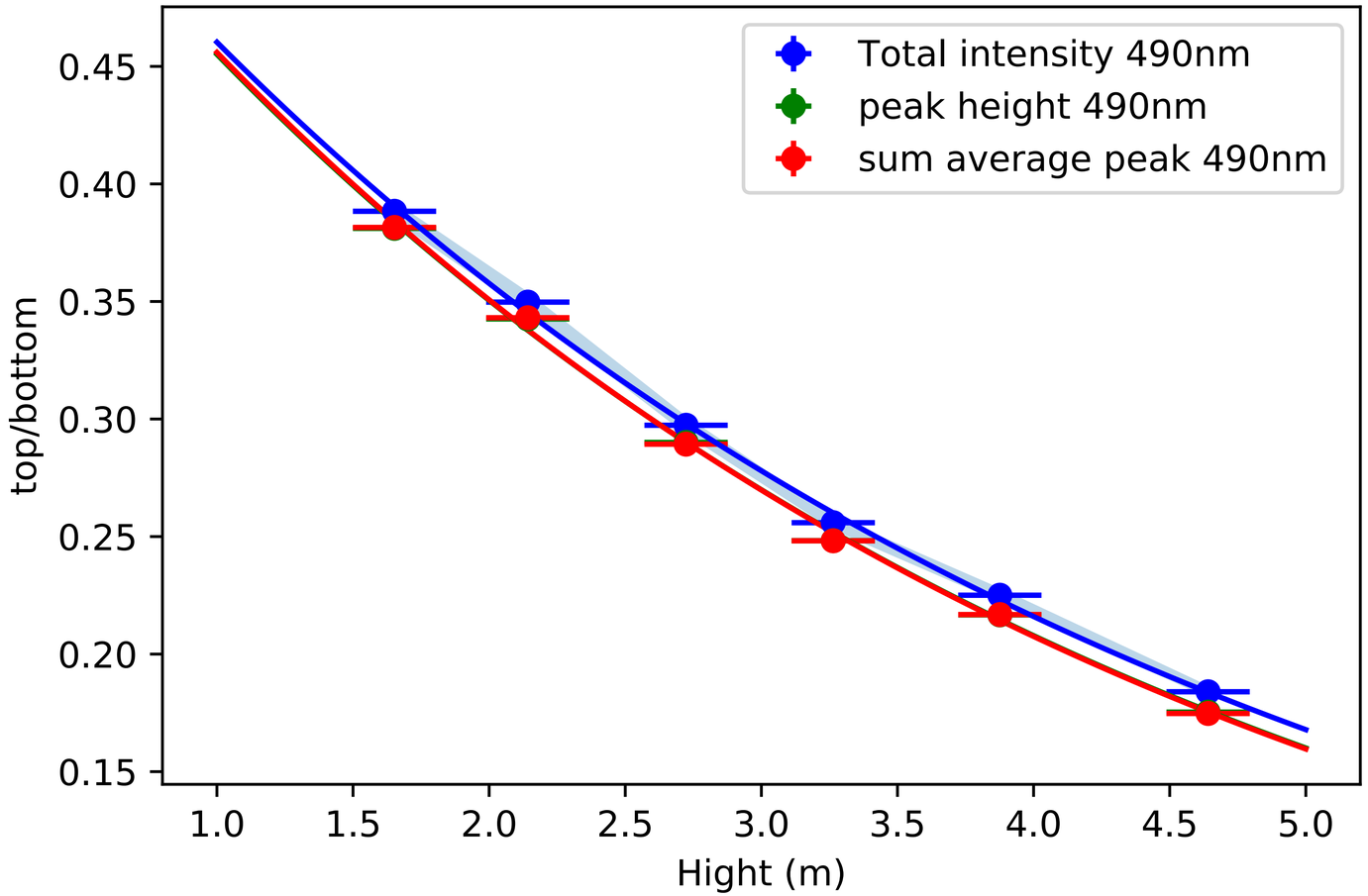
- Did a test run in HPLC water
- Fitted an exponential to the data

$$H = ae^{\frac{I}{zI_0}}$$

- Found the attenuation length is ~4.00m: Total integrated intensity

  ~3.83m: Average max peak height

  ~3.81m: Summed waveform peak height



UNIVERSITY OF LIVERPOOL

Measuring the attenuation

490nm

- Did a test run in HPLC water
- Fitted an exponential to the data

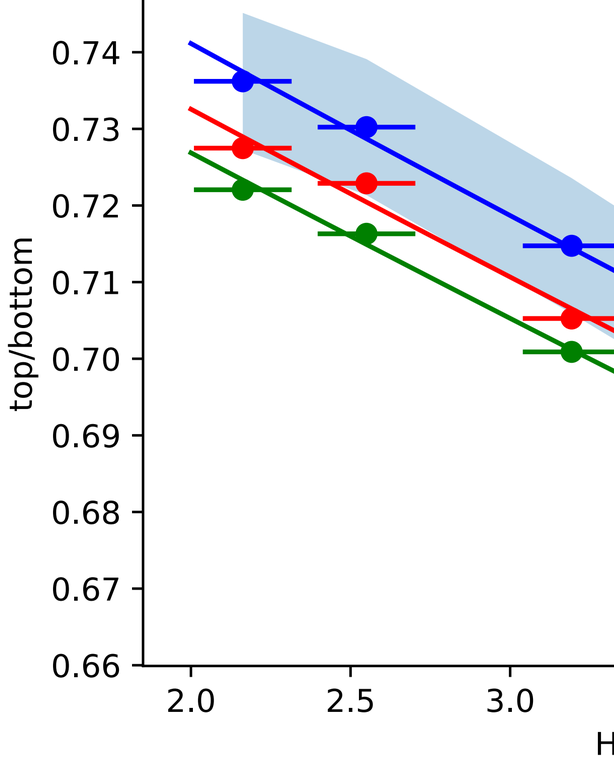
$$H = ae^{\frac{I}{zI_0}}$$

- Found the attenuation length is
- ~32.5m: Total integrated intensity

  ~33.1m: Average max peak height

  ~32.9m: Summed waveform peak height

  ~Average = 32.8m Expected value is 66m

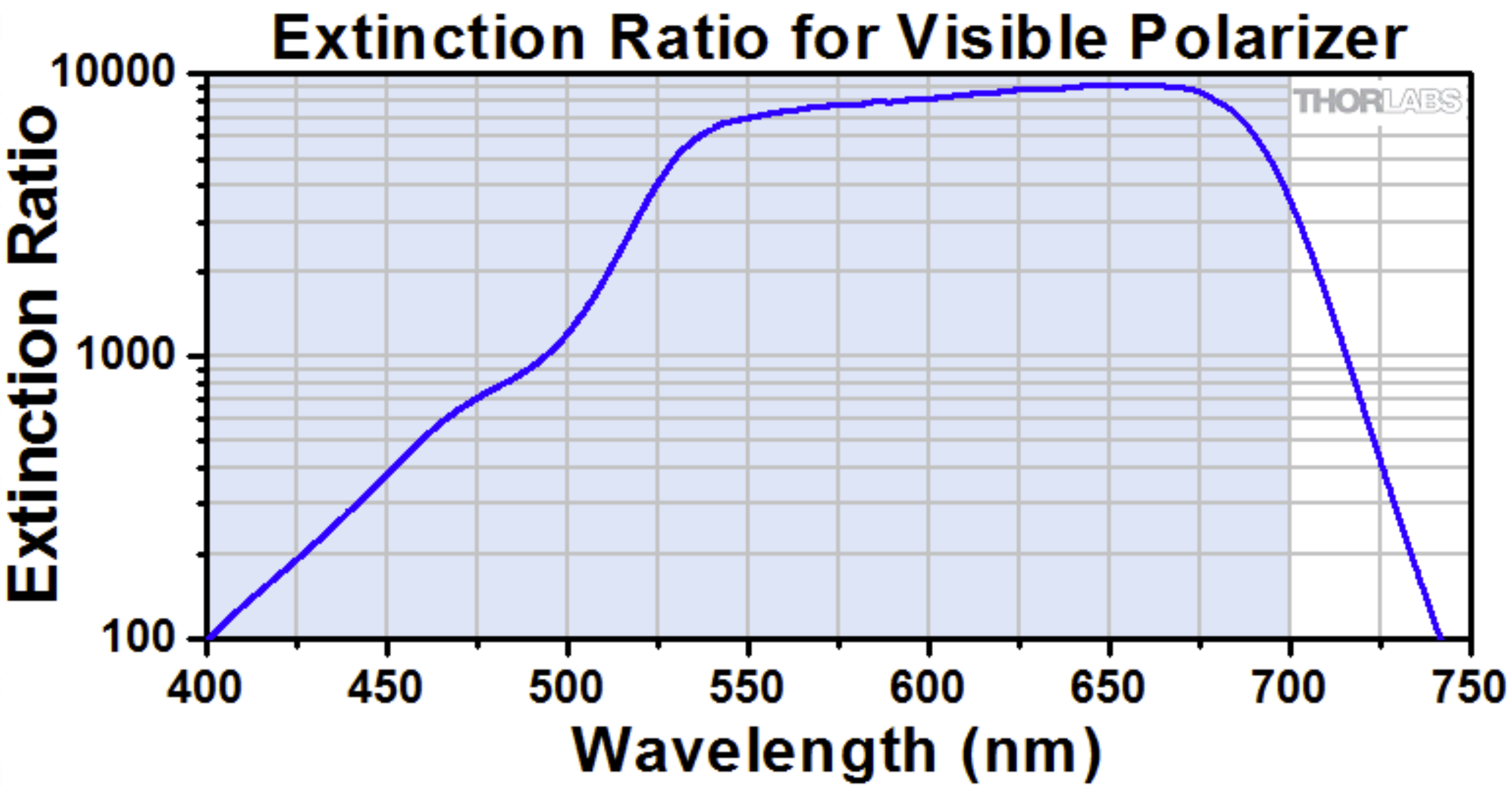


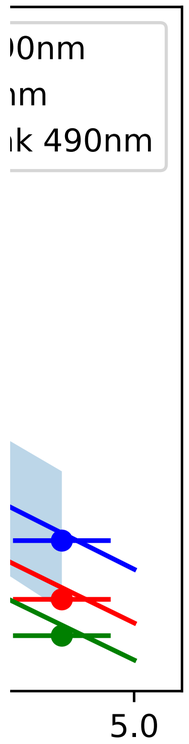
UNIVERSITY OF LIVERPOOL

Measuring the attenuation

520

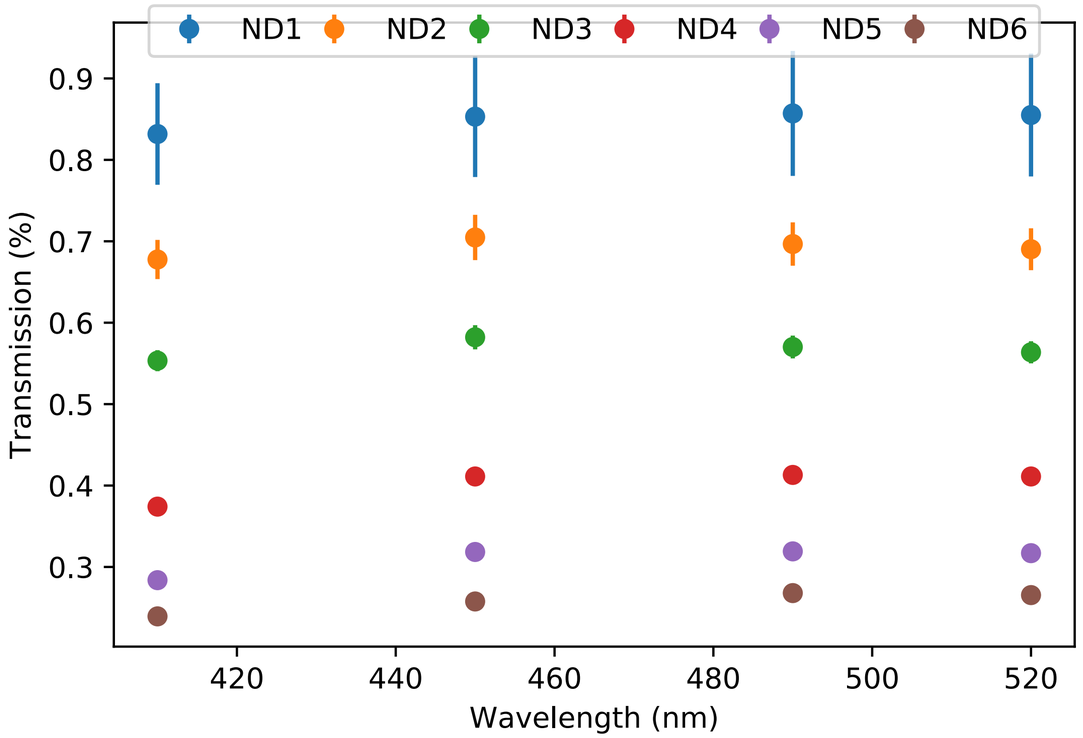
- Did a
- Fitte
- Foun
- ~32.5
- ~33.1
- ~32.9
- ~Ave





UNIVERSITY OF LIVERPOOL

Neutral density filter and transmission



- In the optical system is a neutral density filter used to control the intensity of the light —> transmission
- Wanted to confirm and make own measurement of the transmission (currently used manufacturers)
- Used the UV vis machine to find the absorption

$$T = -\log A$$

UNIVERSITY OF LIVERPOOL