Water Turbidity Measurement-Algorithm

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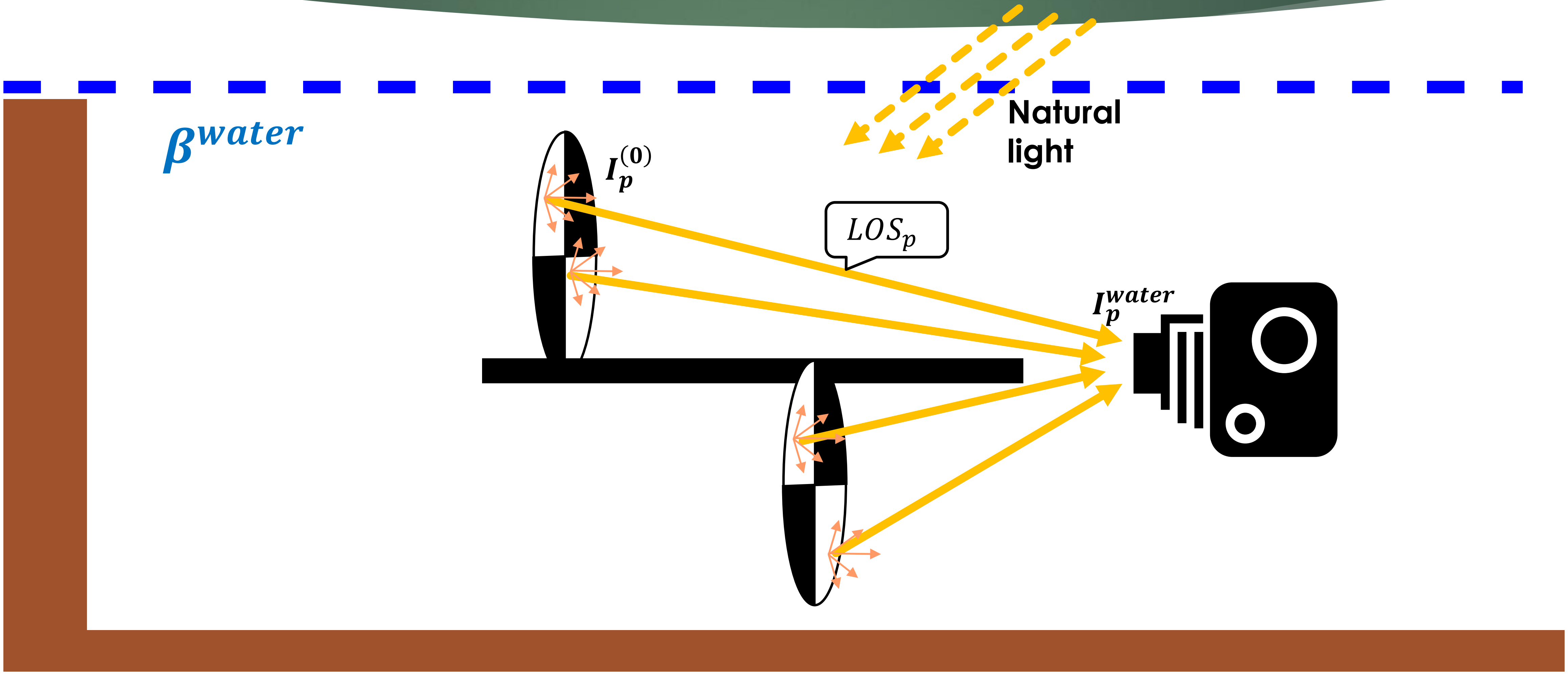
RTE

$$I_p^{water} \triangleq I_p^{(0)} \mathrm{e}^{-\int_{X \in LOS_p} \beta^{water} dX} + I_p^{Ambient}$$

Where:

$$\beta^{water} \triangleq \underbrace{\beta_A^{water}}_{Absorption} + \underbrace{\beta_s^{water}}_{Scatter}$$

Our Approach

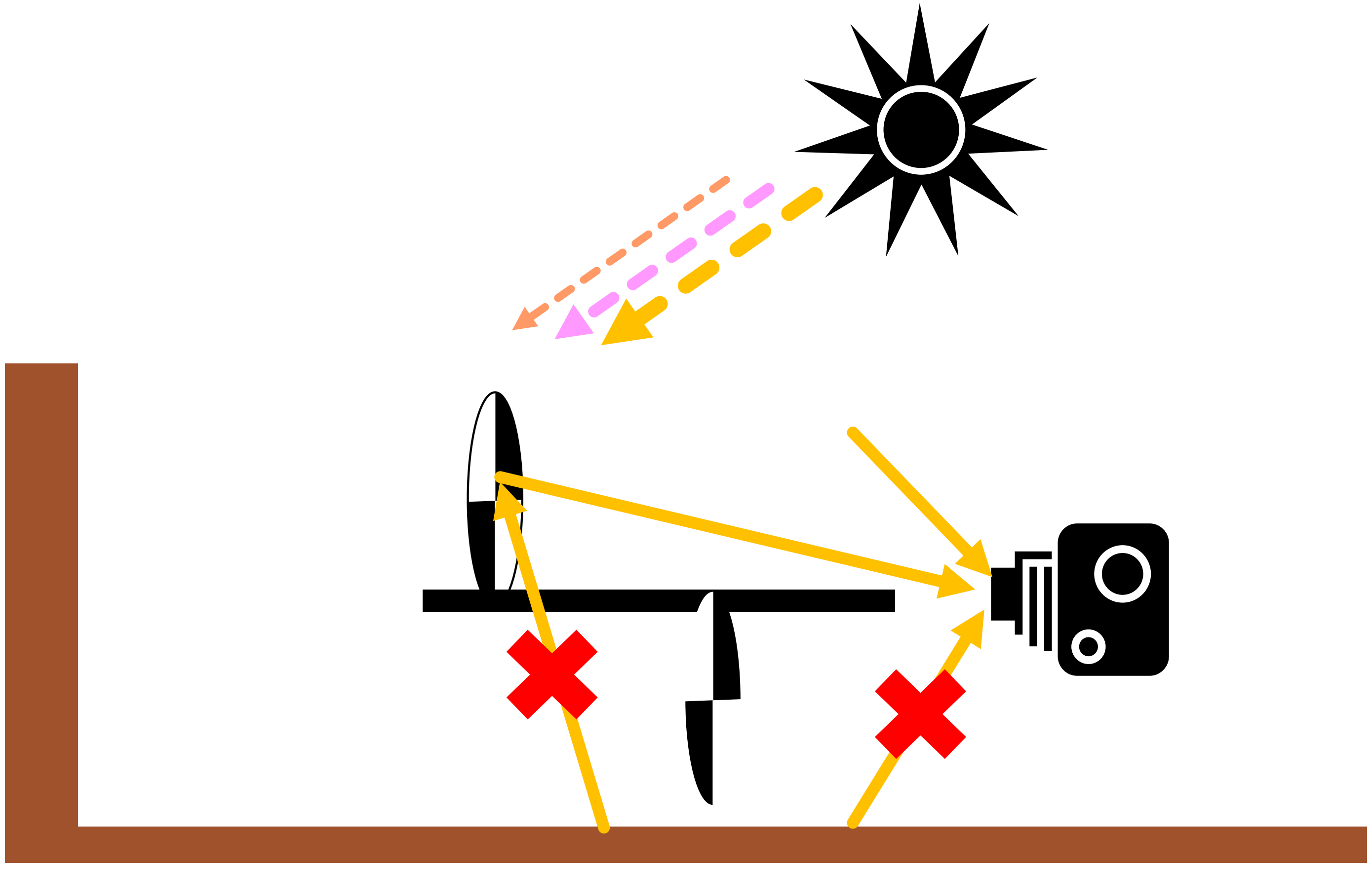


Basic Assumptions

- Consistency of water turbidity in water body $\Rightarrow \boldsymbol{\beta^{water} = const.}$
- Invariant to light source.
- Water body is big enough ⇒ No reflectance from surroundings.

From the above:

$$I_p^{water} = I_p^{(0)} e^{-\beta^{water} \cdot \Delta x} + I_p^{Ambient}$$



Calculating β^{water} with 2 Targets

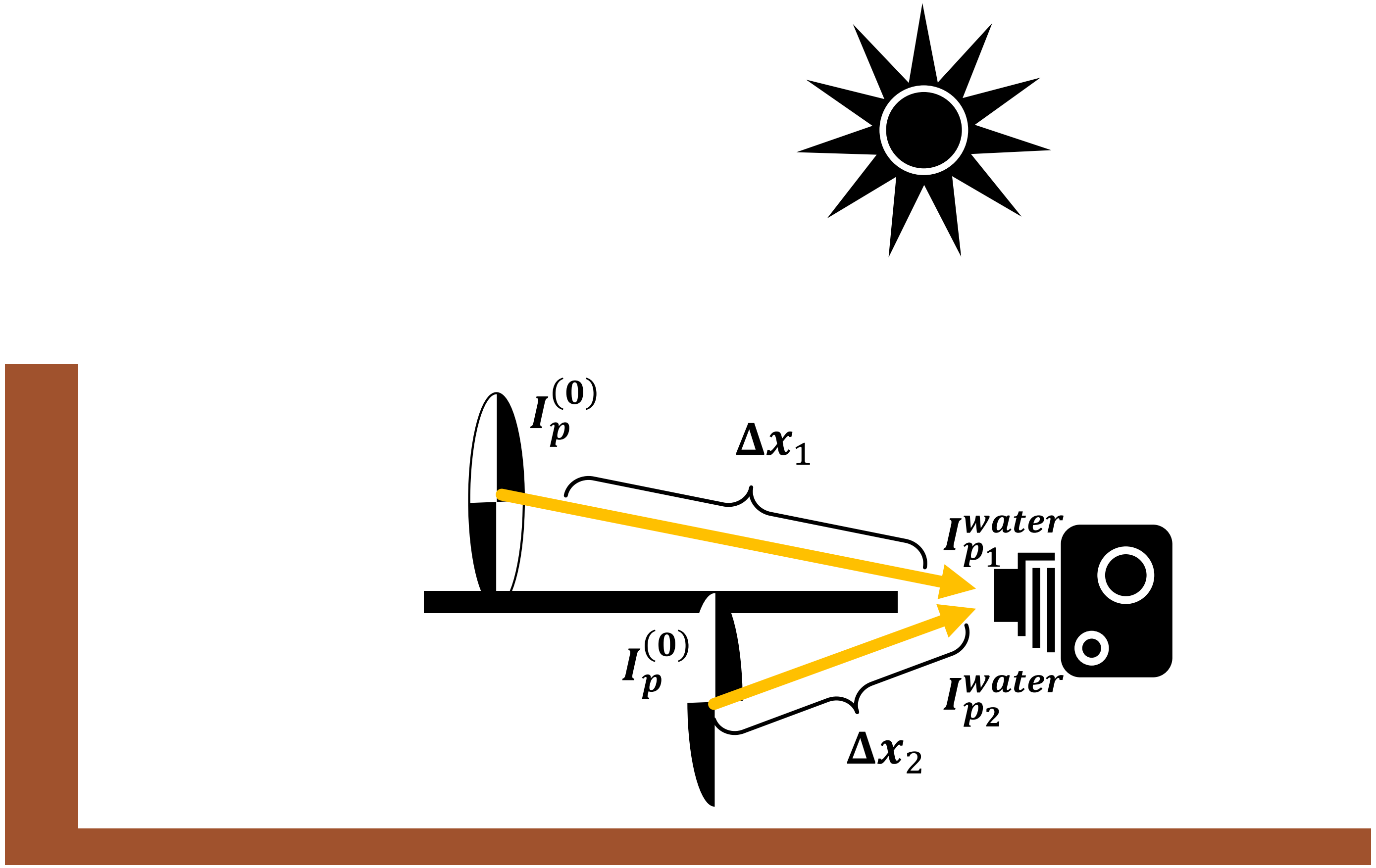
From 1st target:

$$I_{p_1}^{water} = I_p^{(0)} e^{-\beta^{water} \cdot \Delta x_1} + I_{p_1}^{Ambient}$$

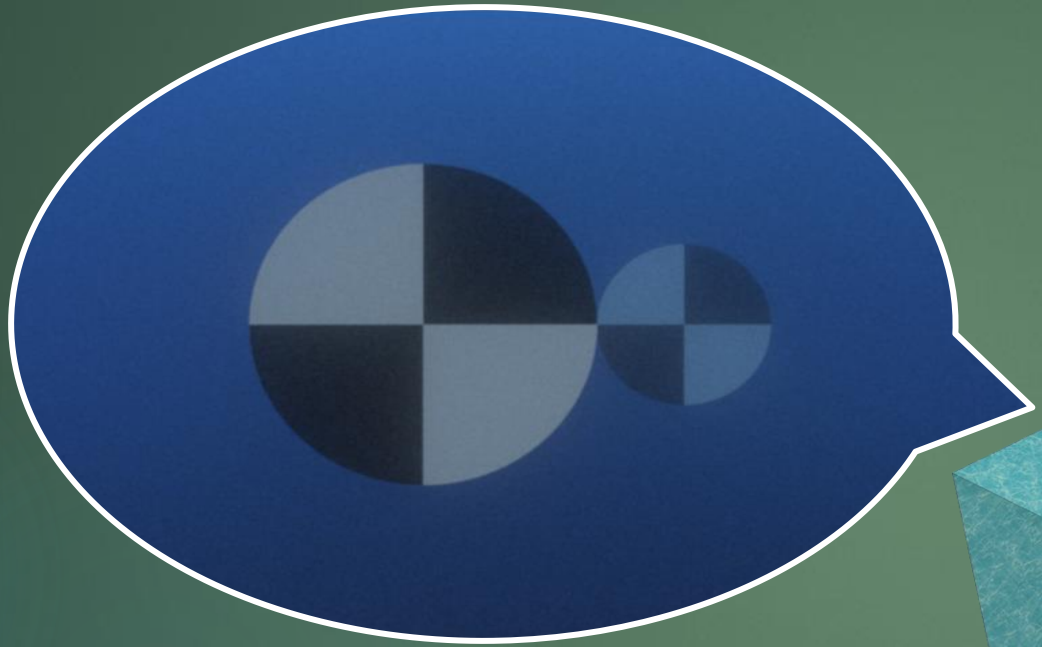
From 2nd target:

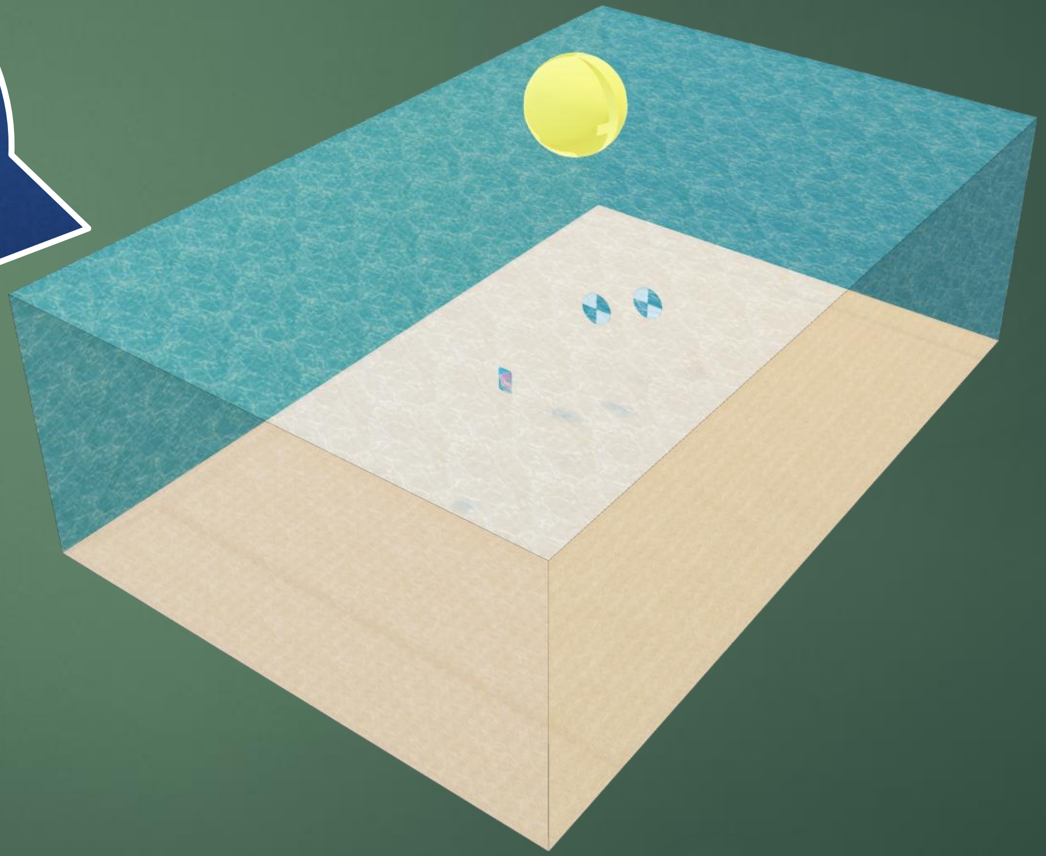
$$I_{p_2}^{water} = I_p^{(0)} e^{-\beta^{water} \cdot \Delta x_2} + I_{p_2}^{Ambient}$$

$$\boxed{\beta^{water} = -\frac{ln\left(\frac{I_{p_1}^{water} - I_{p_1}^{Ambient}}{I_{p_2}^{water} - I_{p_2}^{Ambient}}\right)}{\Delta x_1 - \Delta x_2}}$$

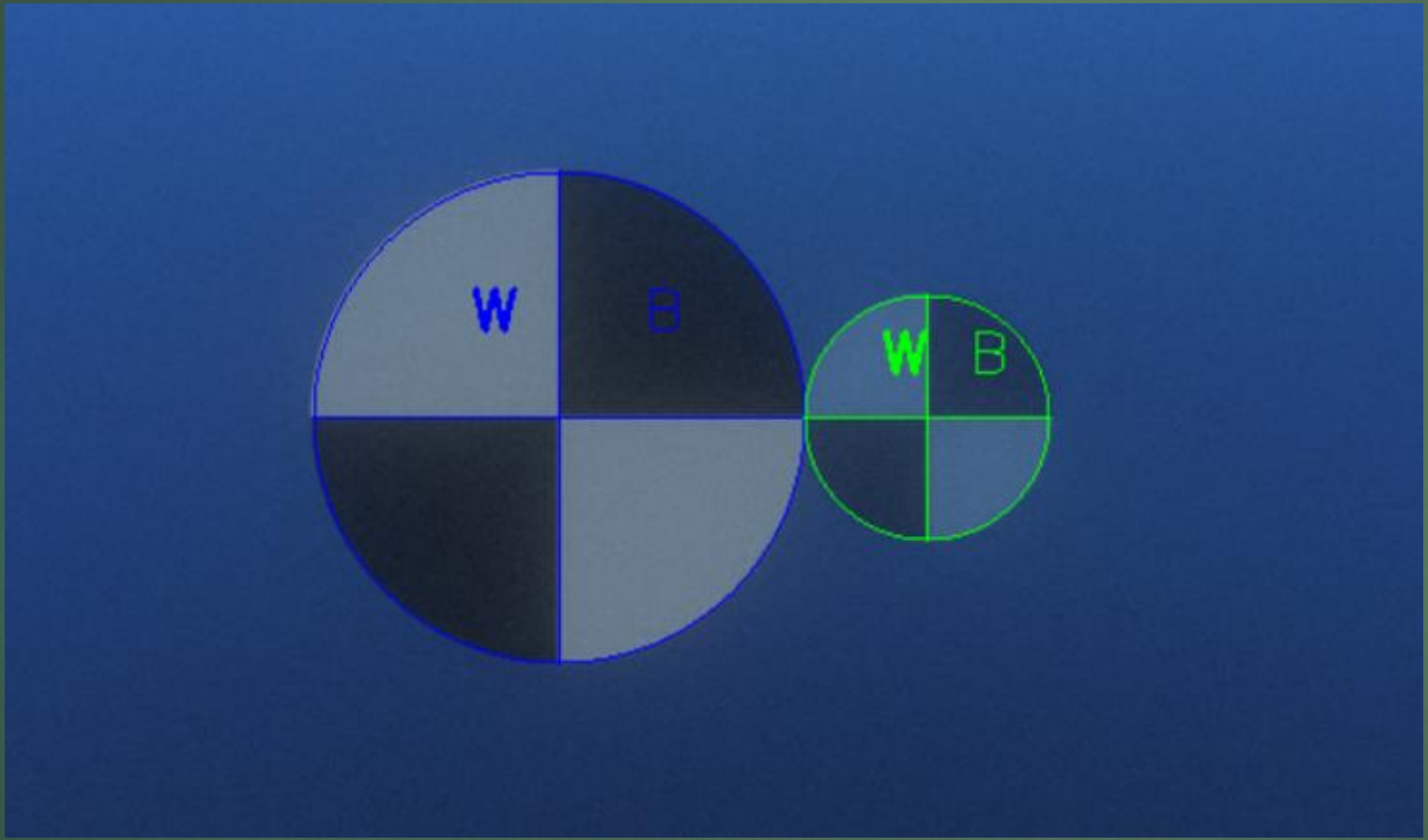


Measurement Setup

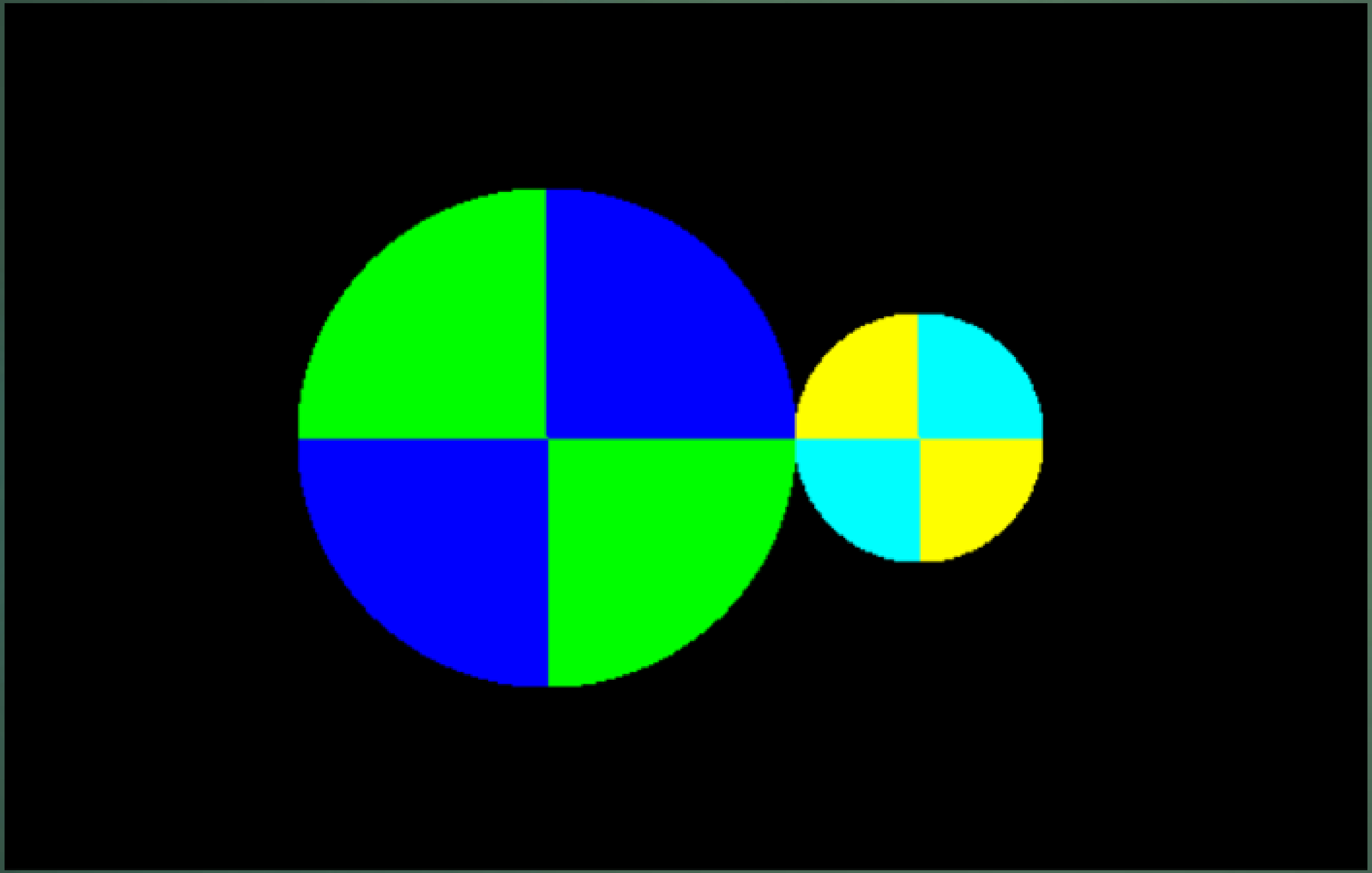




Step I – Detecting the Targets



Step II – Averaging the Quarters



Step III – Calculating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target1 distance: 0.6009615384615384[m] | target2 distance: 1.2019230769230769[m]
t1[B,G,R]: [0.23528907 0.16250007 0.10520586] t2[B,G,R]: [0.2170886  0.09373707 0.03434089]
attenuation blue on white: 0.13396749591827392
attenuation green on white: 0.9155072860717773
attenuation red on white: 1.8629847412109375
```

Real Values:

Δx_1 = 0.6
Δx_2 = 1.2
$\beta_S^{water}(r, g, b)$ = (0.64, 0.64, 0.64)
$\beta_A^{water}(r, g, b)$ = (0.5, 0.2, 0)
$\beta^{water}(r, g, b)$ = (1.14, 0.84, 0.64)

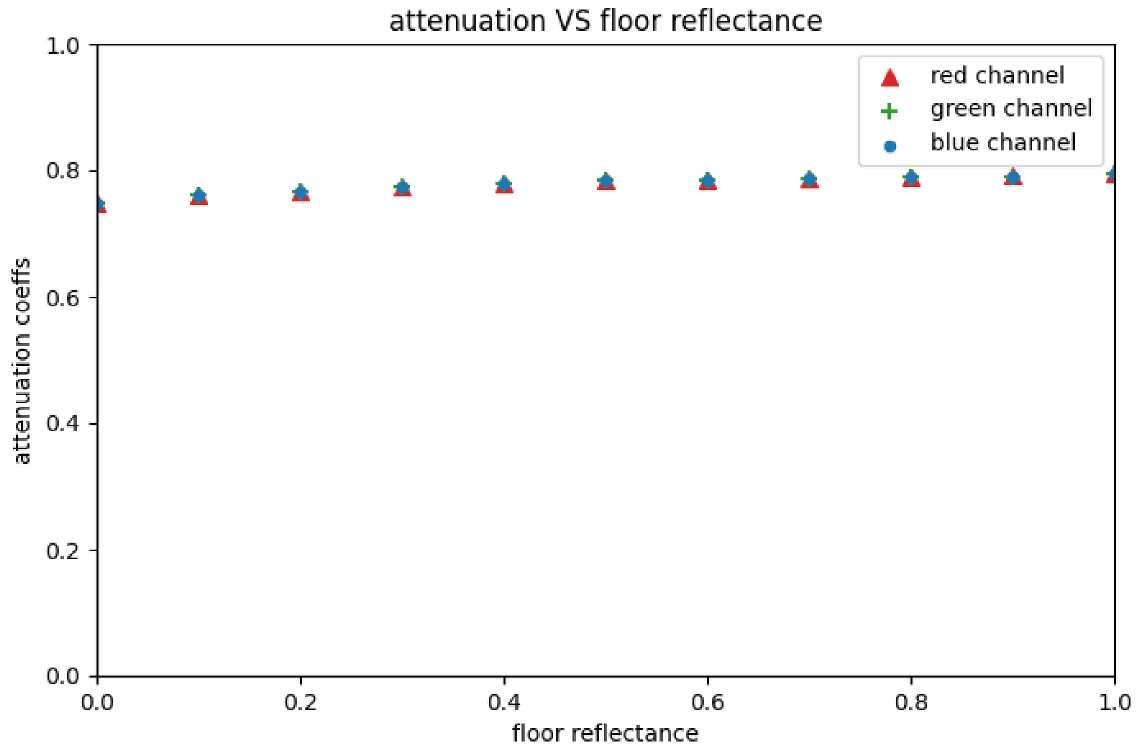
Estimated Values:

Δx_1 = 0.6009
Δx_2 = 1.2019
$\beta_S^{water}(r, g, b)$ = ???
$\beta_A^{water}(r, g, b)$ = ???
$\beta^{water}(r, g, b)$ = (1.86, 0.91, 0.13)

Validating Assumptions

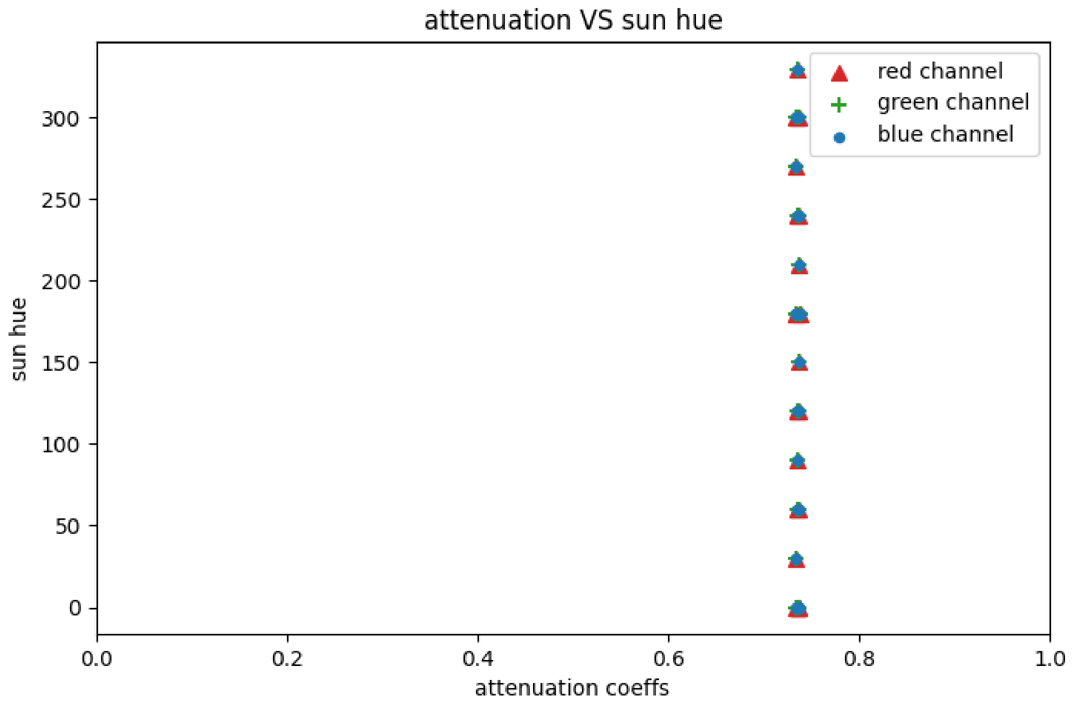
- Water body is big enough ⇒ No reflectance from surroundings.

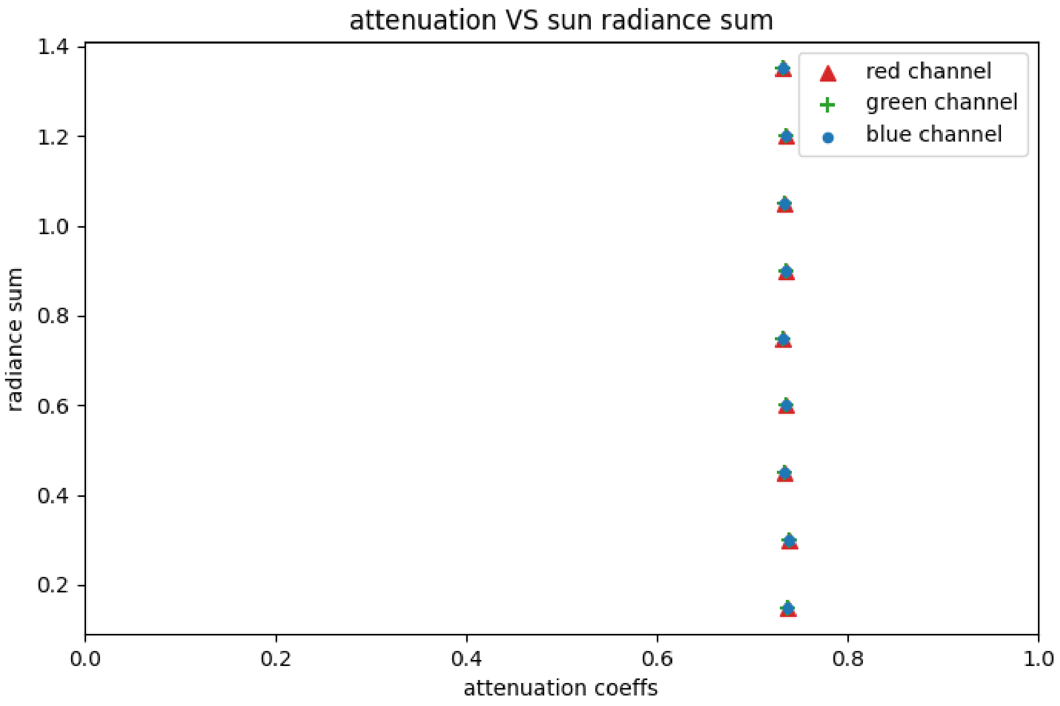
We chose to work with $\boldsymbol{floor\_ref=0}$



Validating Assumptions

- Invariant to light source.

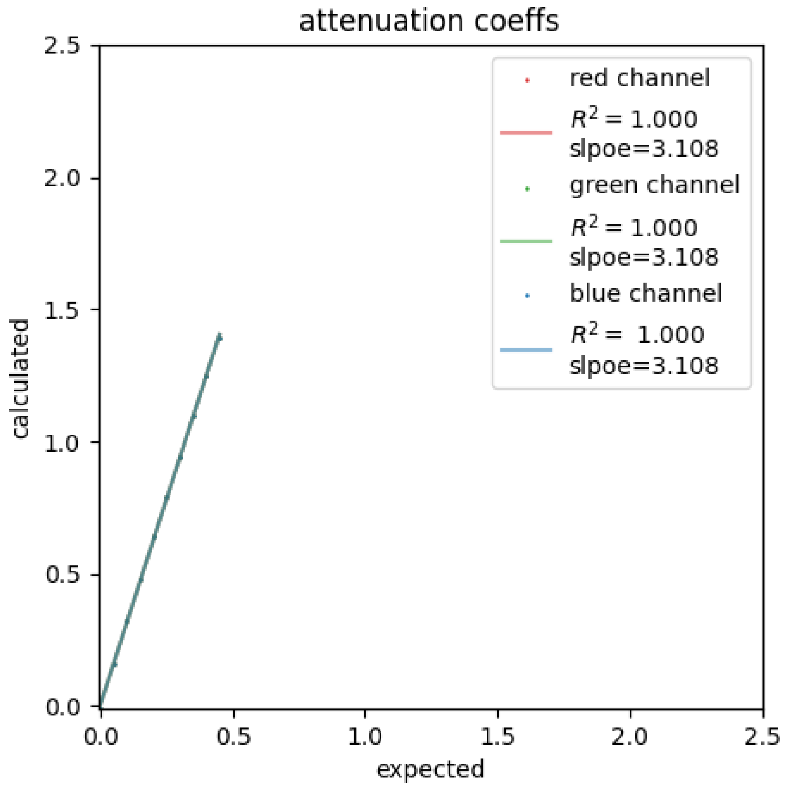




Checking Absorption

- Sweeping only on $\beta_A^{water} \in [0,0.5]$.
- $\beta_S^{water} = (0,0,0)$.

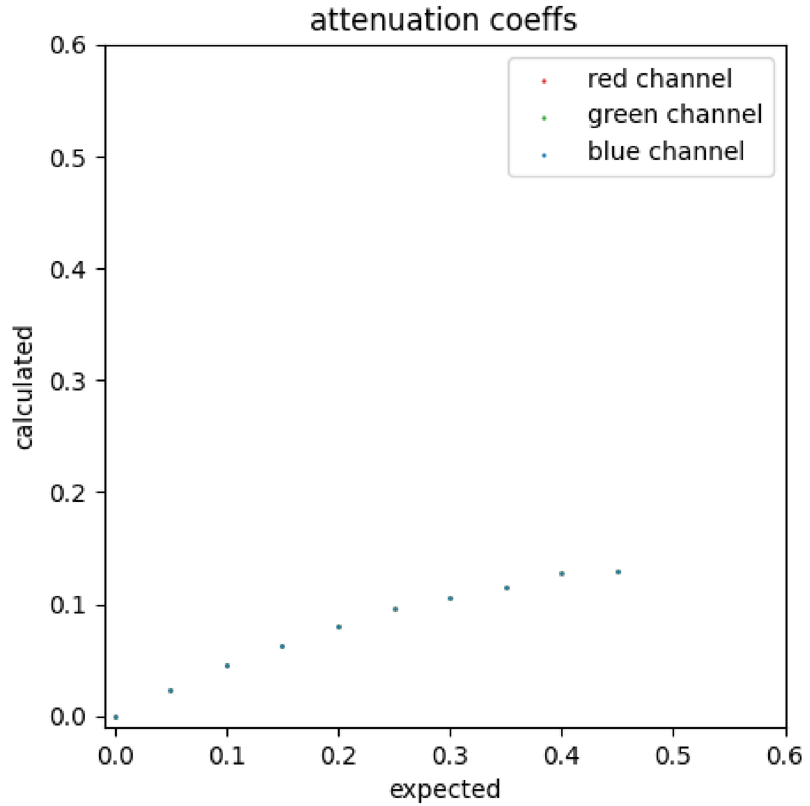
We can see that the behavior is almost perfectly linear with error $< 10^{-3}$, and with slope $= 3.108$



Checking scatter

- Sweeping only on $\beta_S^{water} \in [0,0.5]$.
- $\beta_A^{water} = (0,0,0)$.

We can see that the graph behavior is **not linear**.



Checking scatter with absorption

- Sweeping only on $\beta_s^{water} \in [0,1]$.
- $\beta_A^{water} = (0.5,0.2,0)$.

We can see that the graph behavior is still **not linear** and **different** for each channel.