

# Calibrating an Ocean Floor Observatory

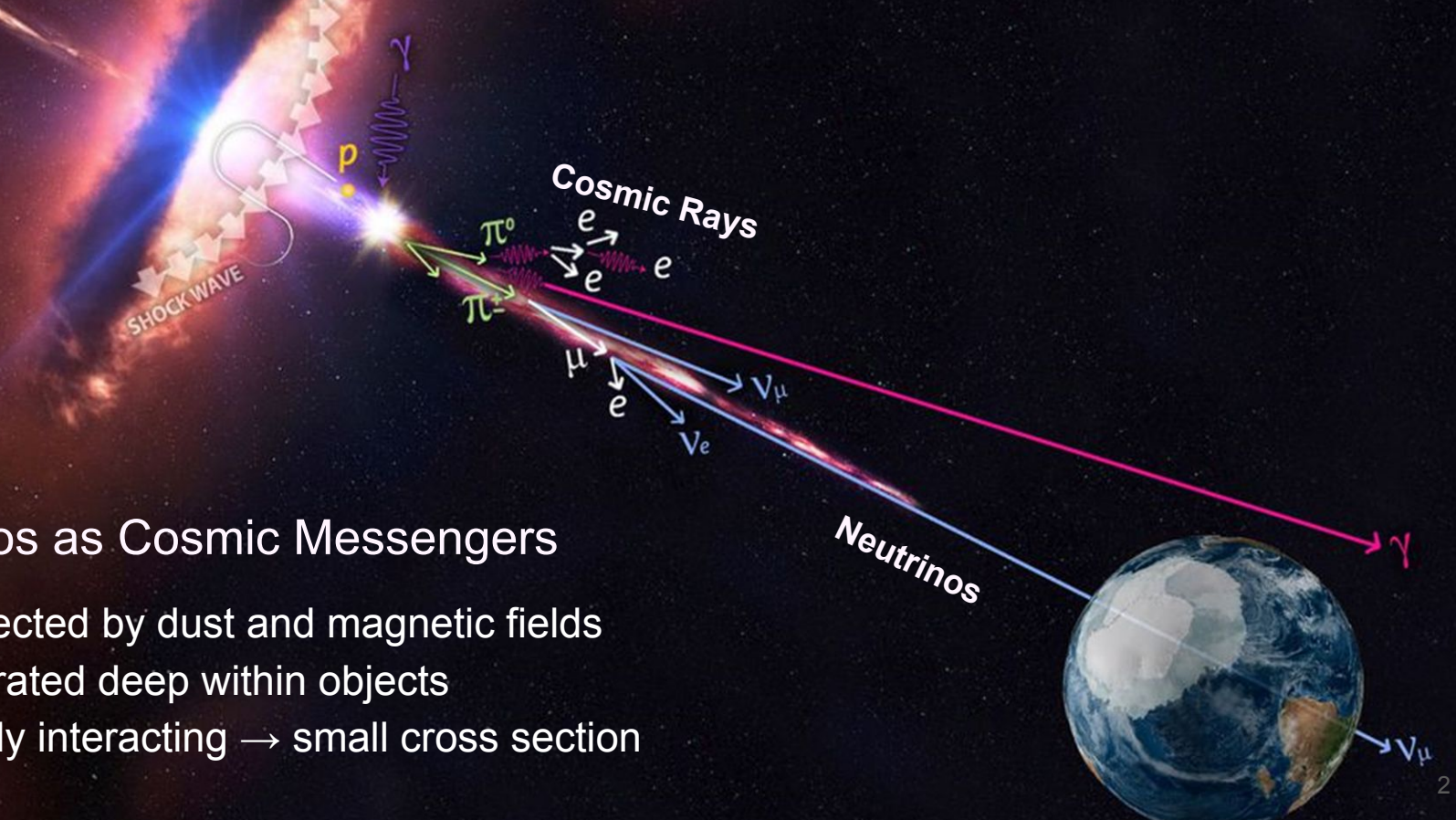
*Conquering Currents at the Pacific Ocean Neutrino Experiment (P-ONE)*

August 15, 2022

Hamish Johnson



### Multi-Messenger Source

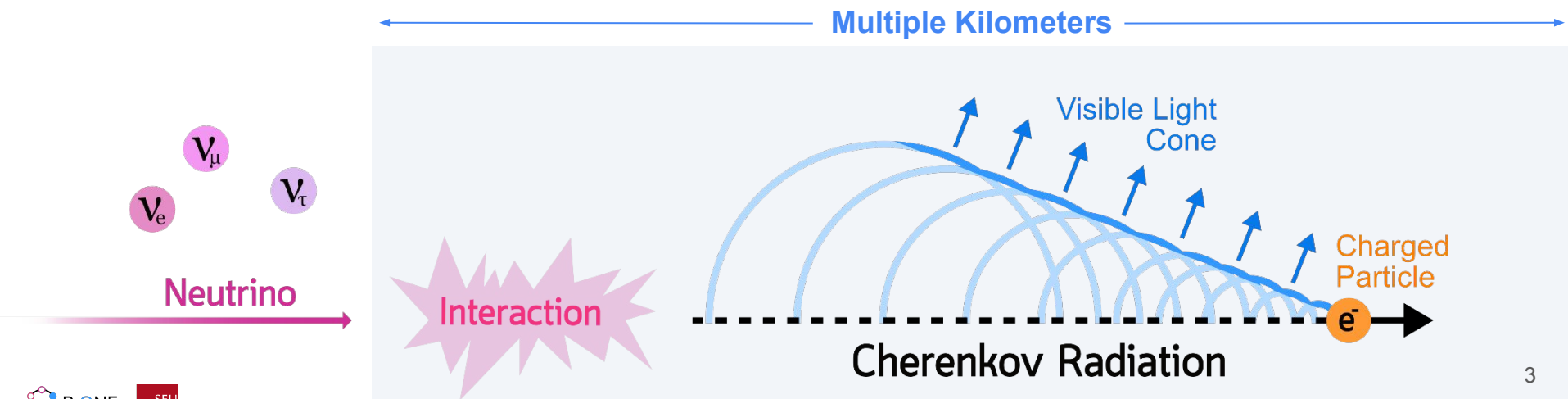


### Neutrinos as Cosmic Messengers

- Unaffected by dust and magnetic fields
- Generated deep within objects
- Weakly interacting  $\rightarrow$  small cross section

# Overview

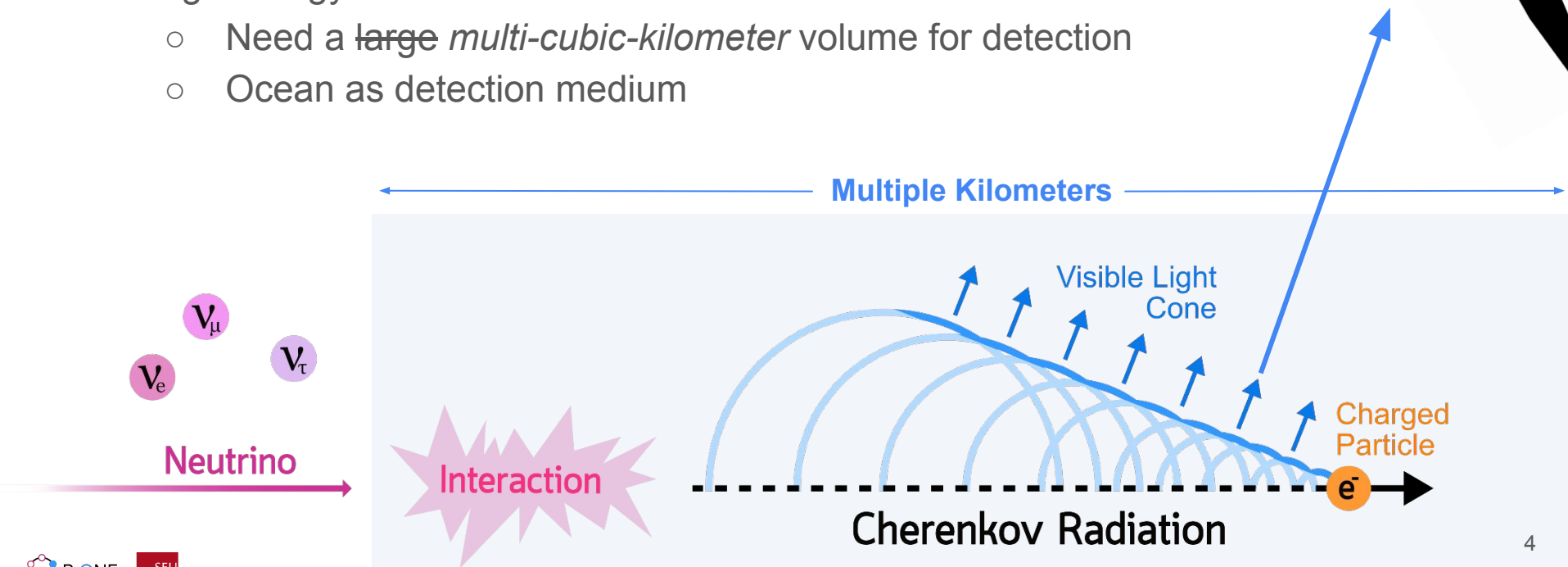
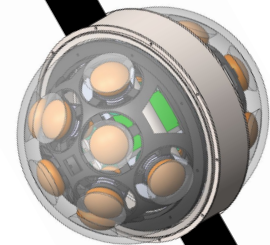
- Neutrino telescope
- Detect Cherenkov radiation
- High energy and low cross-section
  - Need a ~~large~~ *multi-cubic-kilometer* volume for detection
  - Ocean as detection medium



# Overview

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- Detect Cherenkov radiation
- High energy and low cross-section
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Detector Module



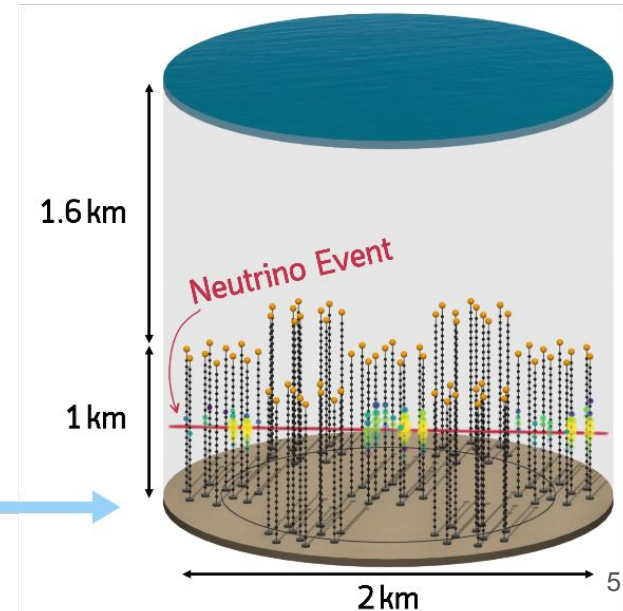
# What is P-ONE?

- Next generation neutrino telescope
- International collaboration
- Makes use of Ocean Networks Canada infrastructure
- Proposed:
  - 70 strings
  - 20 detectors per string



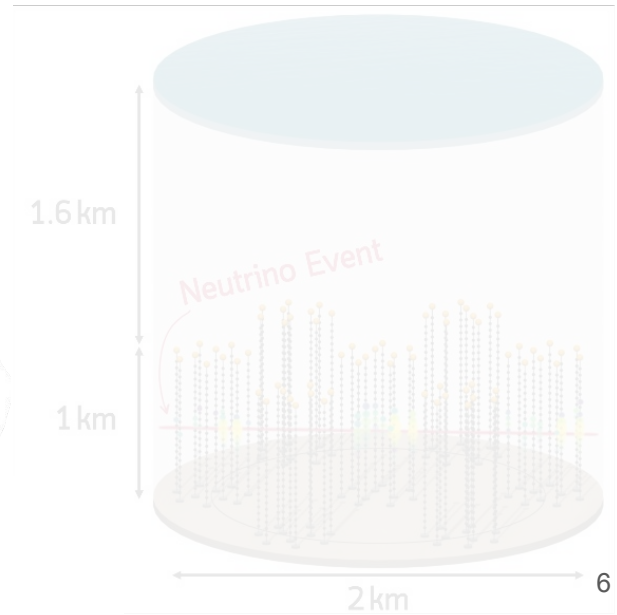
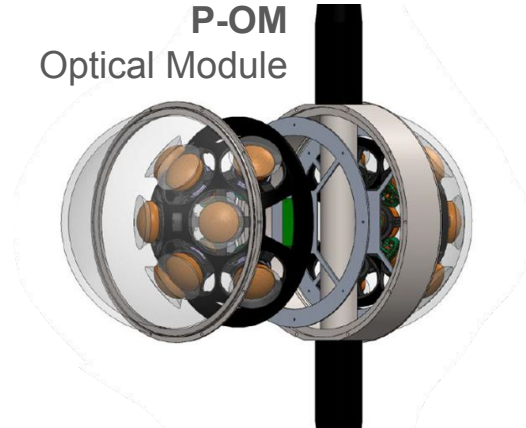
P-ONE-1

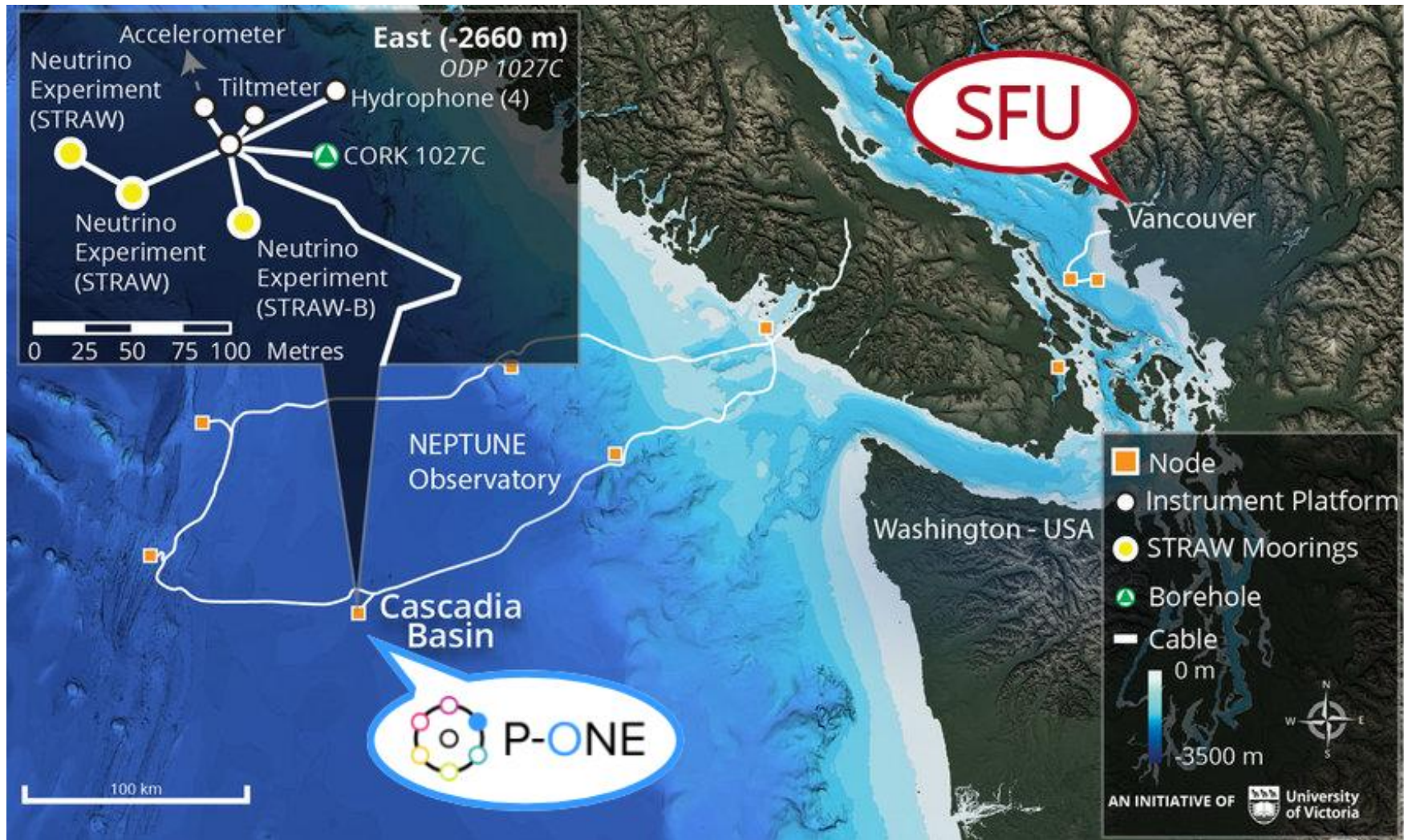
P-ONE demonstrator



# What is P-ONE?

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# Outline

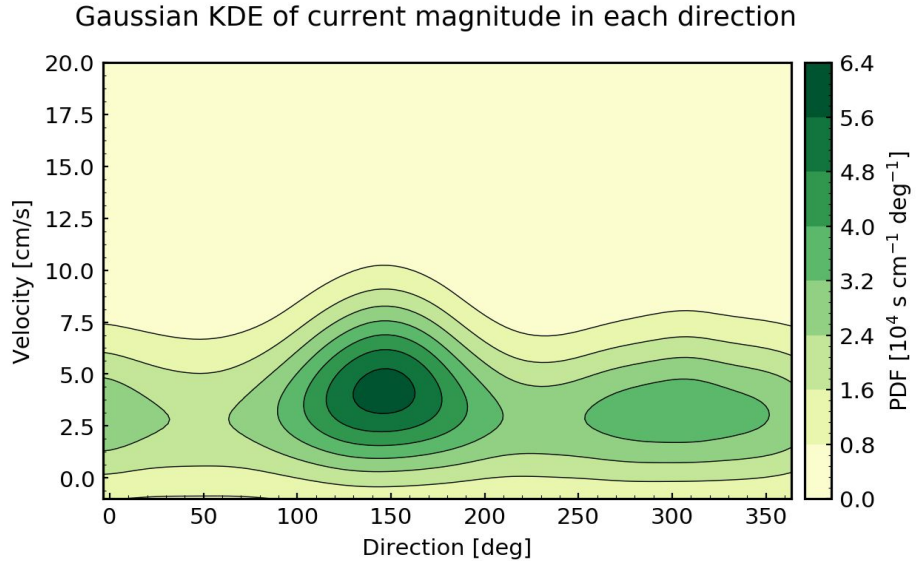
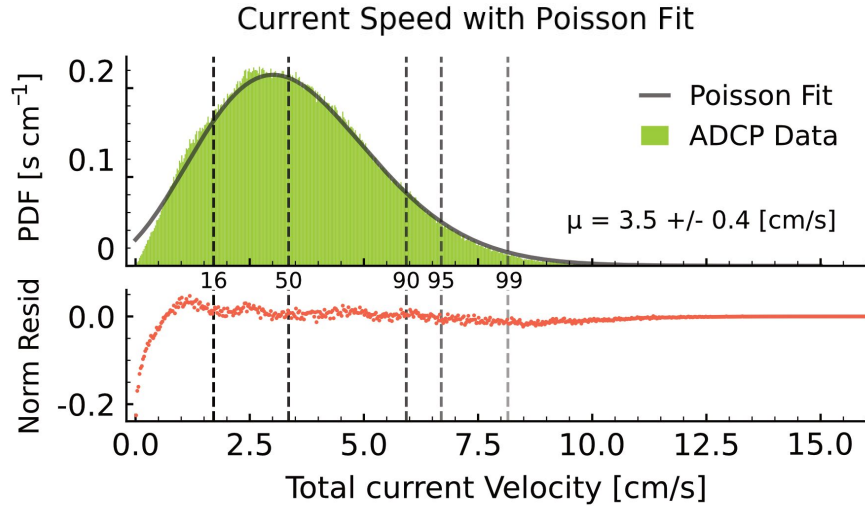
Understanding  
Currents

How Currents  
Bend Strings

Flasher  
Calibration  
Development



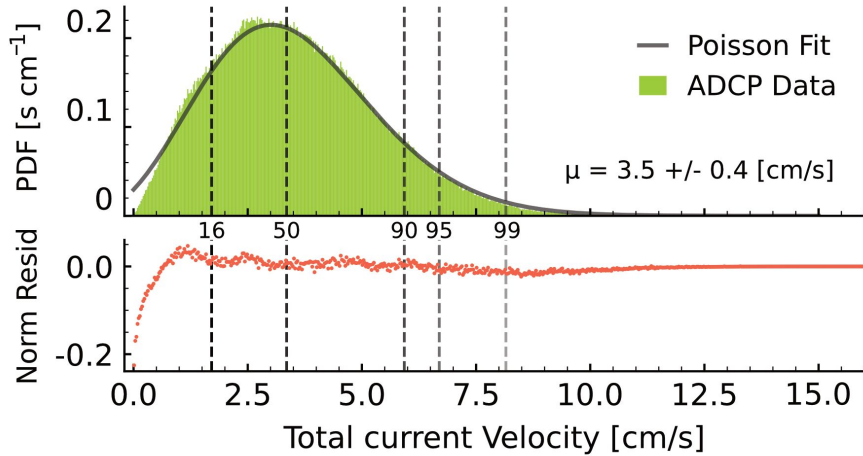
# Current Modeling



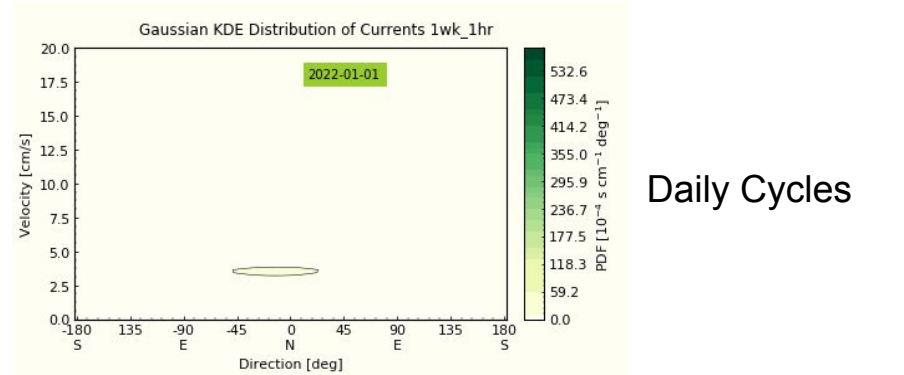
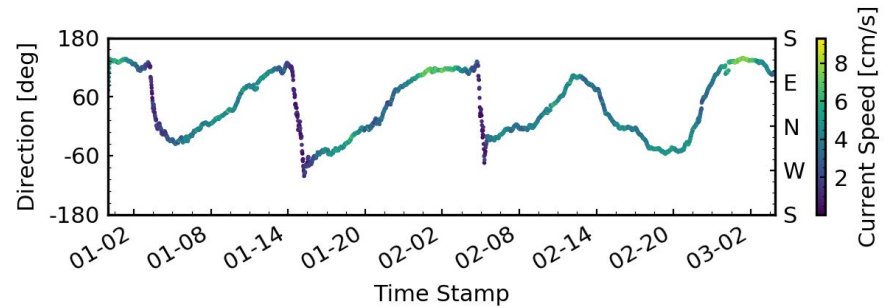
- 99% below 8 cm/s
- Centered at  $3.48 \pm 1.9$  cm/s
- Directional preference
- Migrates over time

# Current Modeling

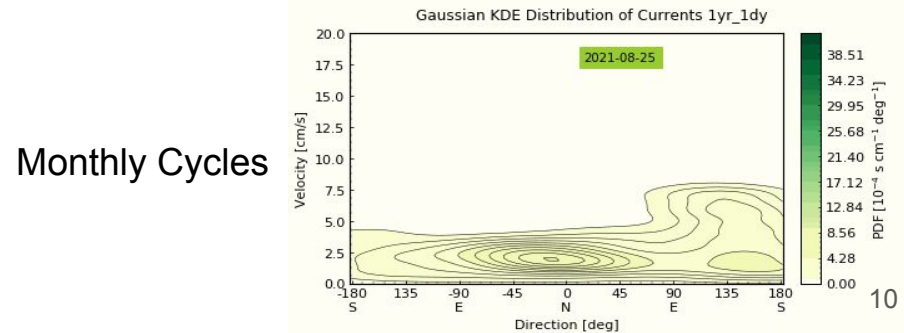
Current Speed with Poisson Fit



- 99% below 8 cm/s
- Centered at  $3.48 \pm 1.9$  cm/s
- Directional preference
- Migrates over time



Daily Cycles

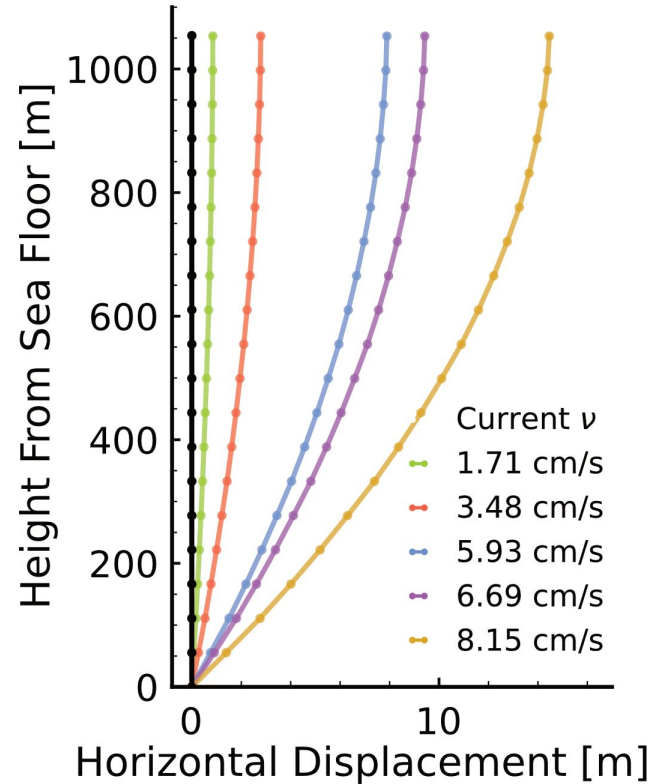


Monthly Cycles

# Current Modeling

Translate currents to effect on detectors structure.

- Oceanographic mooring analysis
- Deep ocean simulations
- Attempted various models

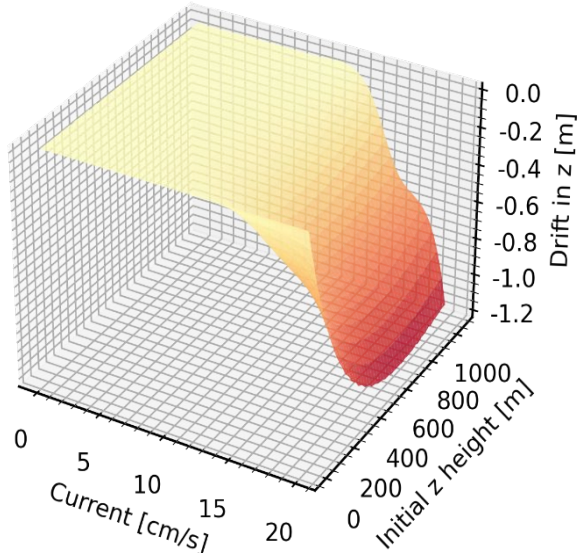


# Current Modeling

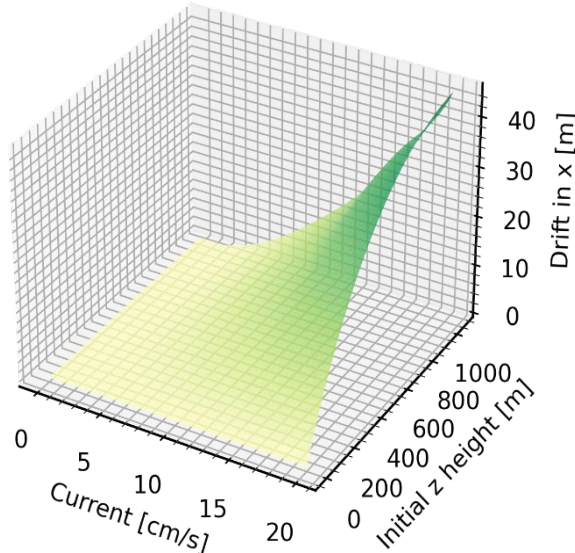
Goal: Simple 2D lookup table to get bending displacement from **current (v)** and node **height (z)**.

- Simulation uses *spline* as a *lookup table*
- Little bending until 6-10 cm/s

Vertical Displacement



Horizontal Displacement



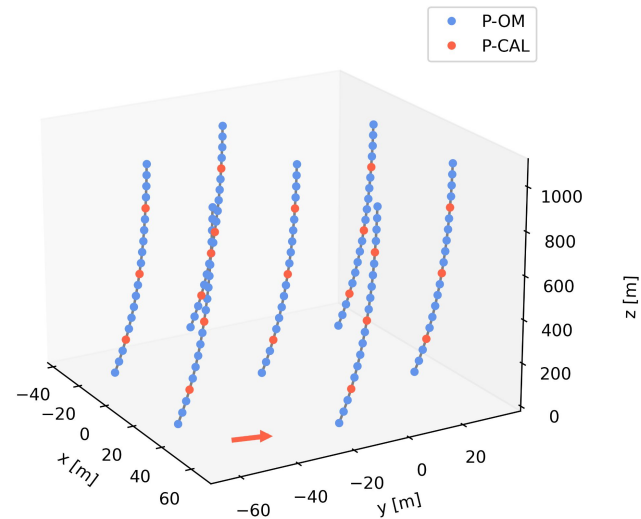
$$\text{Max } \Delta = 45.62 \text{ m}$$

$$\text{Max } \theta_{01} = 6.82^\circ$$

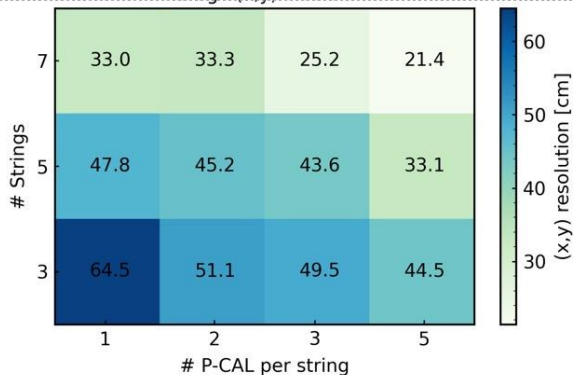
# Current Modeling

Estimate calibration precision in ocean currents.

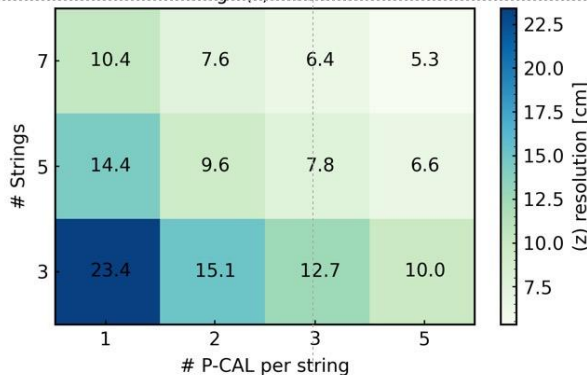
- MCMC simulation of photon arrival times
- Explore **P-CAL** placements
- Reconstruct:
  - Position
  - Orientation
  - Velocity



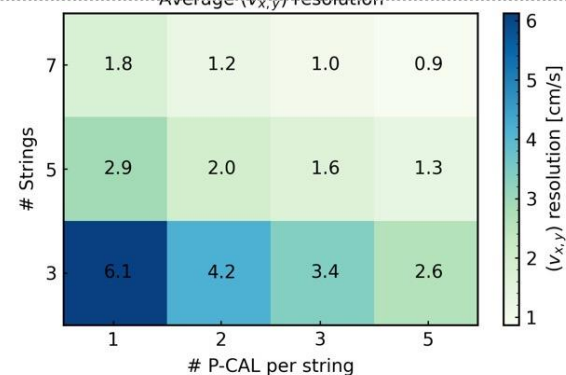
Average (x,y) resolution



Average (z) resolution



Average ( $v_{x,y}$ ) resolution



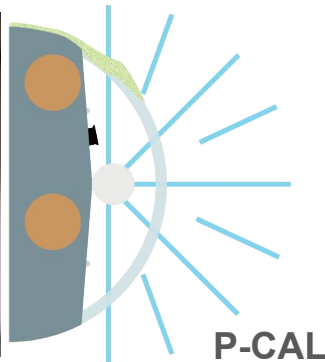
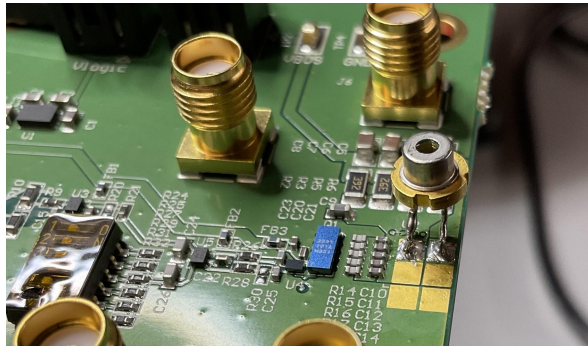
# Light Pulse Calibration

To achieve calibration benchmark

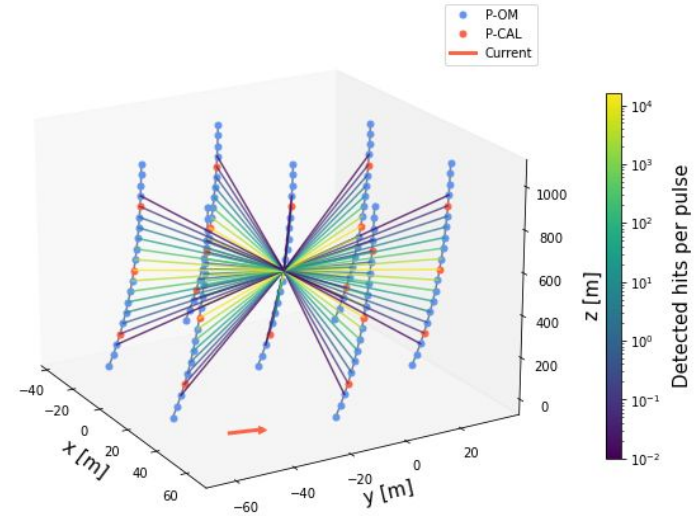
- $10^{10}$  photons per pulse for statistics
- 1-2 ns pulse width for precision

Also monitoring

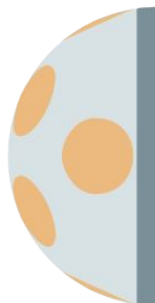
- **Bioluminescence**
- **Marine snow**
- **Optical quality**



P-CAL



z [m]  
Detected hits per pulse

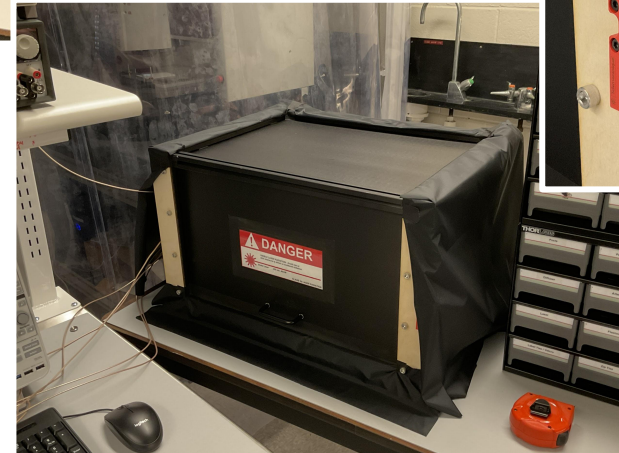
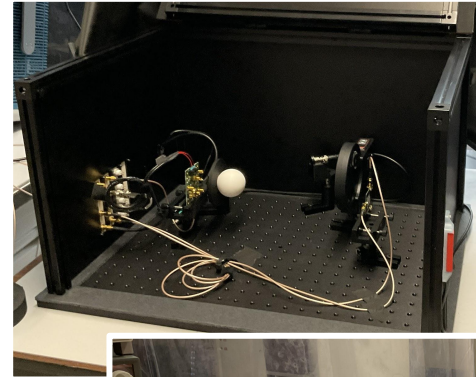
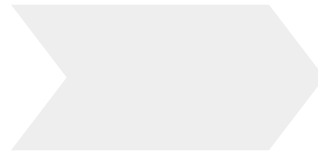
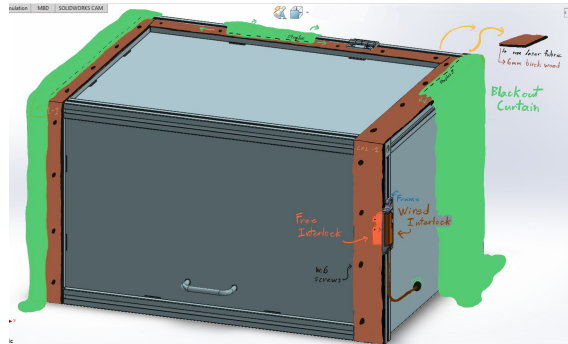


P-OM

# Light Pulse Calibration

Prototyping and development of “CAL1” apparatus

- Characterize diodes and flasher boards
  - Process:
    - Ideate
    - Sketch/design
    - Print/build
    - Realize what is wrong
- Repeat*



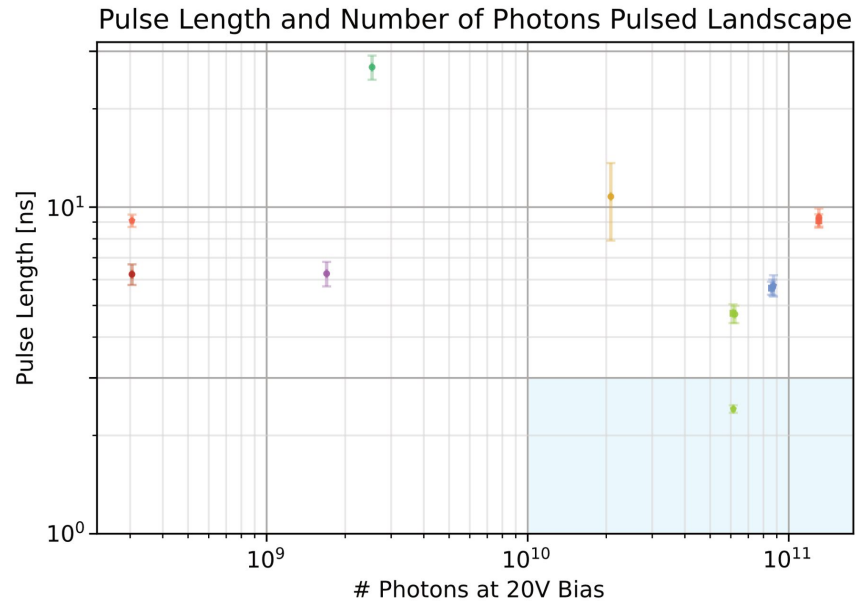
# Light Pulse Calibration

## “Region of Interest”

- Enough photons for good statistics
- Short enough to not interfere with data collection

### Flasher Boards

EPC9126HC	Kapustinsky
1.2 ns	LMG-TUM
5.1 ns	Thor Large
11.5 ns	Thor Small



Short and bright!



# Thank you

