

# The Pacific Ocean Neutrino Experiment: Progress and Prospects

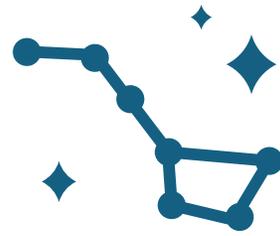
Beatrice Crudele – on behalf of the P-ONE collaboration



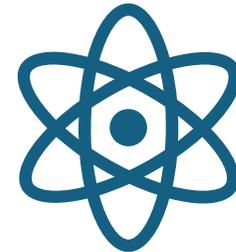
# P-ONE goal



Develop scalable technological solutions for next-generation neutrino telescopes



Open our view to the Southern Sky

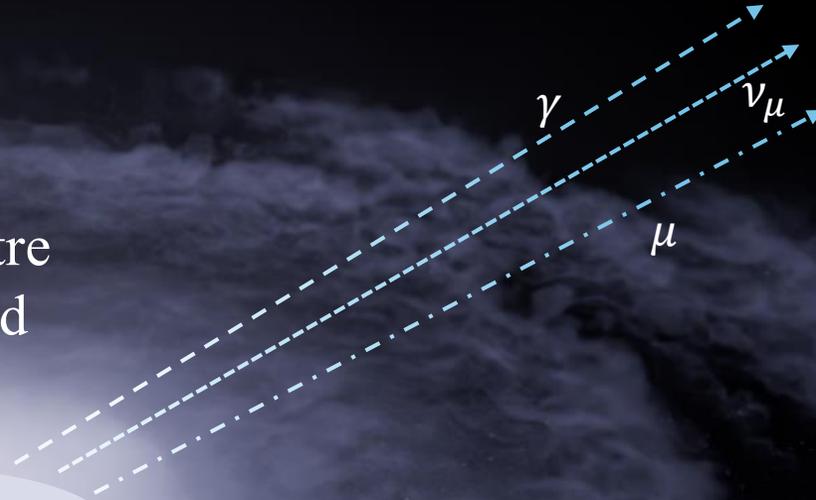


Enable the detection of very-high energy neutrinos from many astrophysical sources

# Discovery opportunities

- Neutrinos can provide complimentary measurements of astrophysical sources
- Full view of the Southern Sky
- Resolve sources within the Galactic Centre
- Observe transient and AGNs from beyond our galaxy

Galactic Center



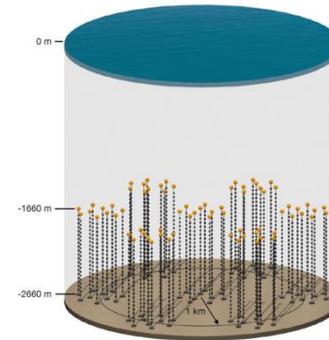
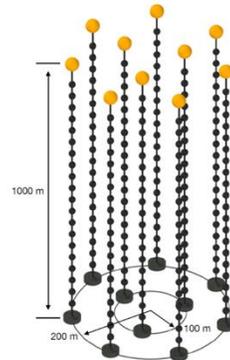
Particles can be accelerated up to PeV energies



- Further implication on beyond standard model physics

# P-ONE timeline

STRAW<sub>b</sub>



2018-2023

2026

2026-2028

>2030

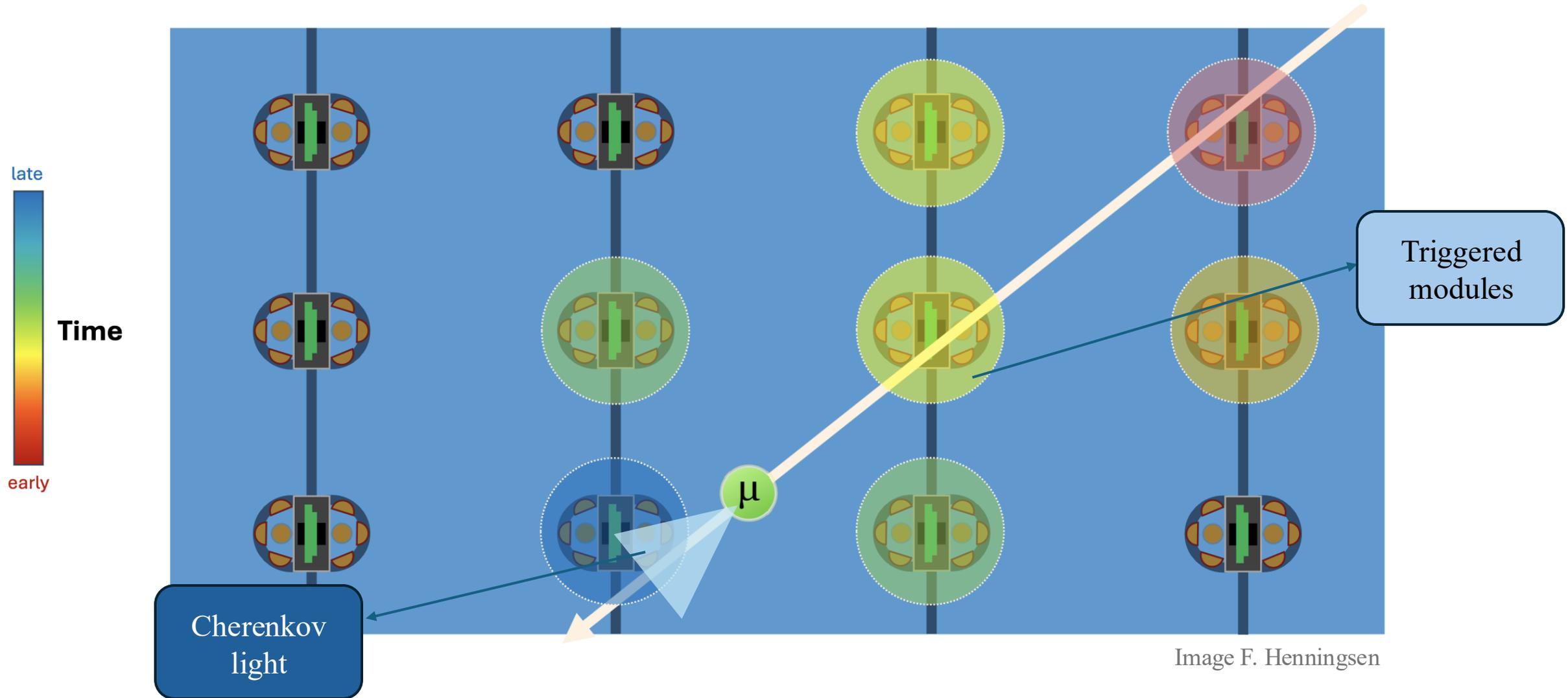
Pathfinder

P-ONE 1

Demonstrator

Full detector

# Detection Concept

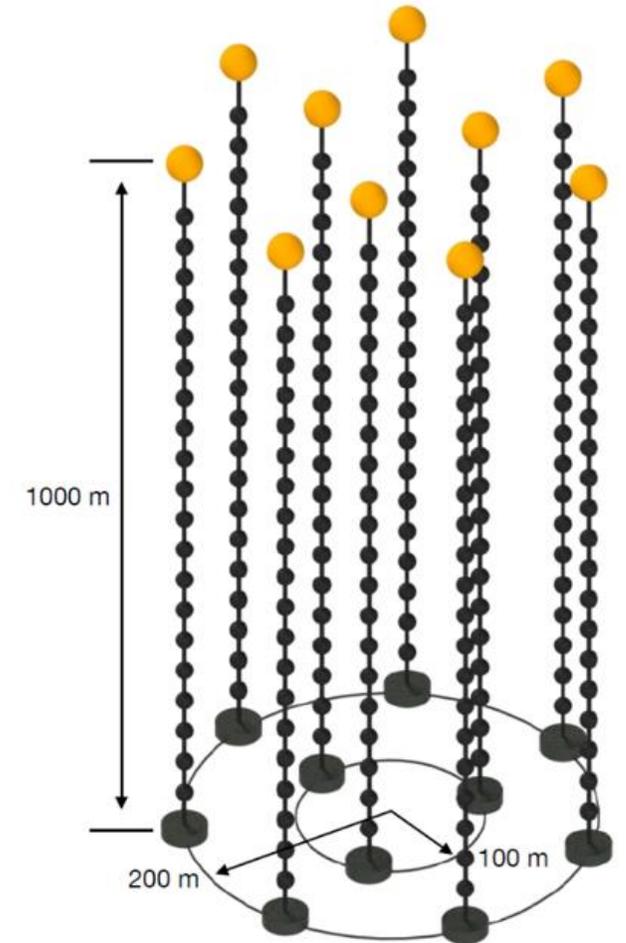


# P-ONE detector line

- 1 km long mooring line with 20 modules
- Connector-less design
- Optical and calibration modules
- Acoustic & optical calibration systems
- Sub-ns time synchronization between modules (0.1nsec)
- DAQ: Digitize waveform @ 210MHz

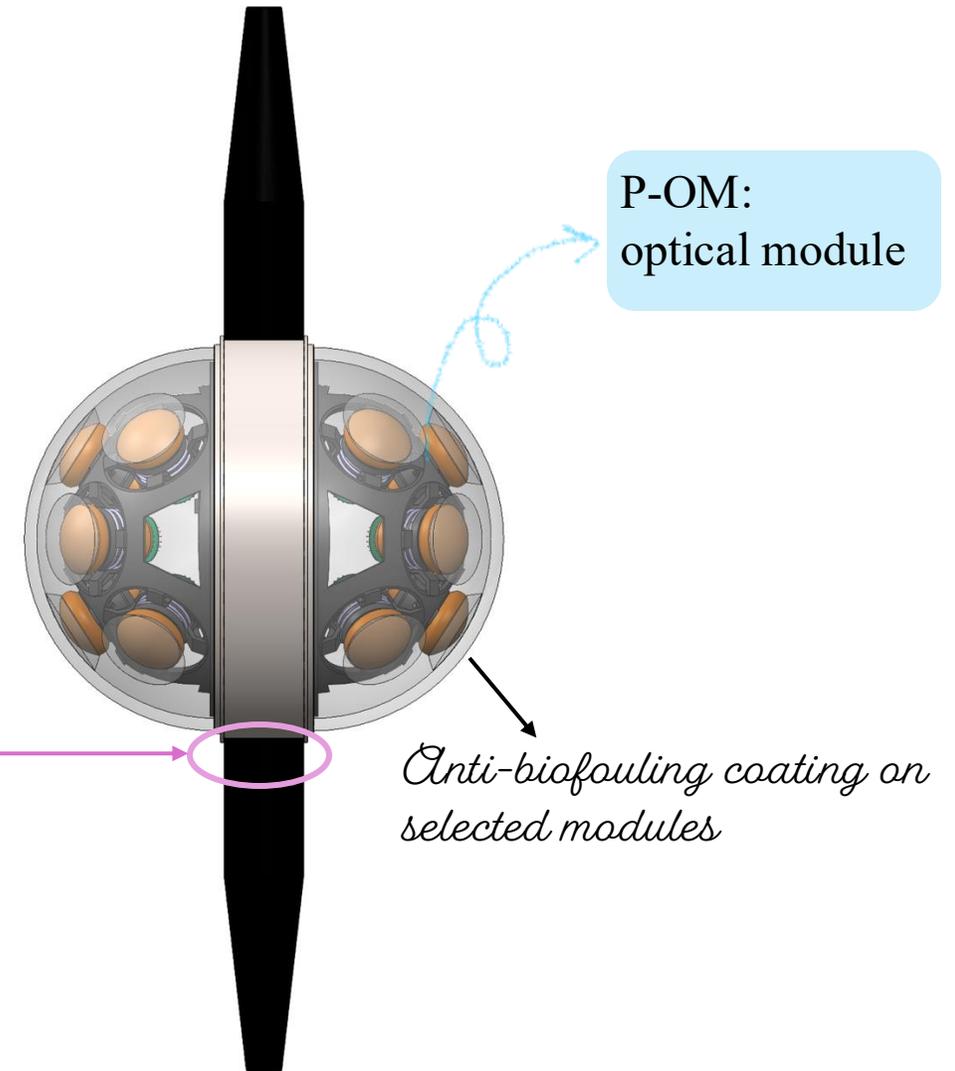
18 optical  
modules

2 calibration  
modules

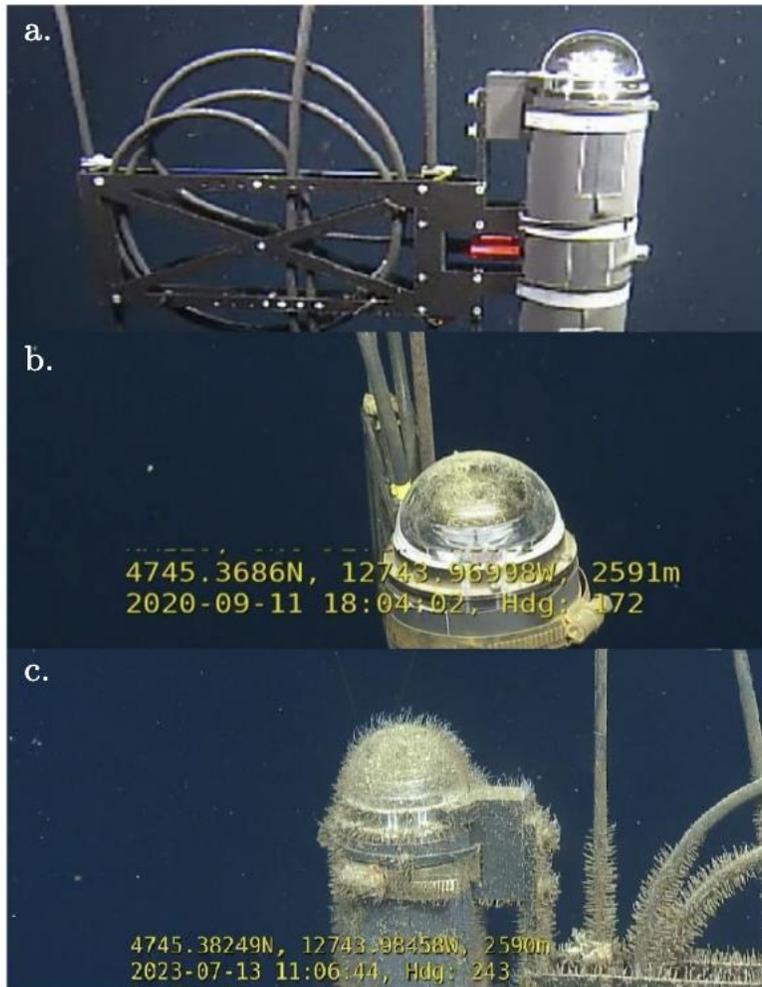


# P-ONE detector line

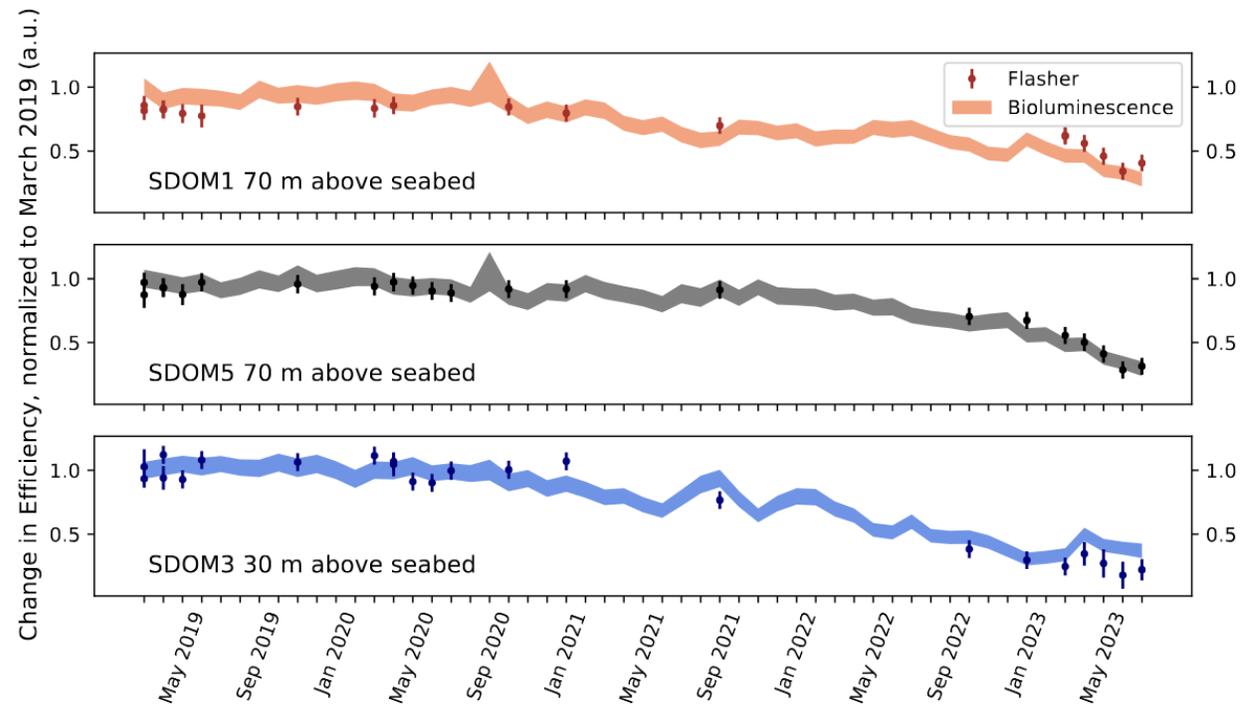
- 1 km long mooring line with 20 modules
- Connector-less design
- Optical and calibration modules
- Acoustic & optical calibration systems
- Sub-ns time synchronization between modules (0.1nsec)
- DAQ: Digitize waveform @ 210MHz



# Biofouling

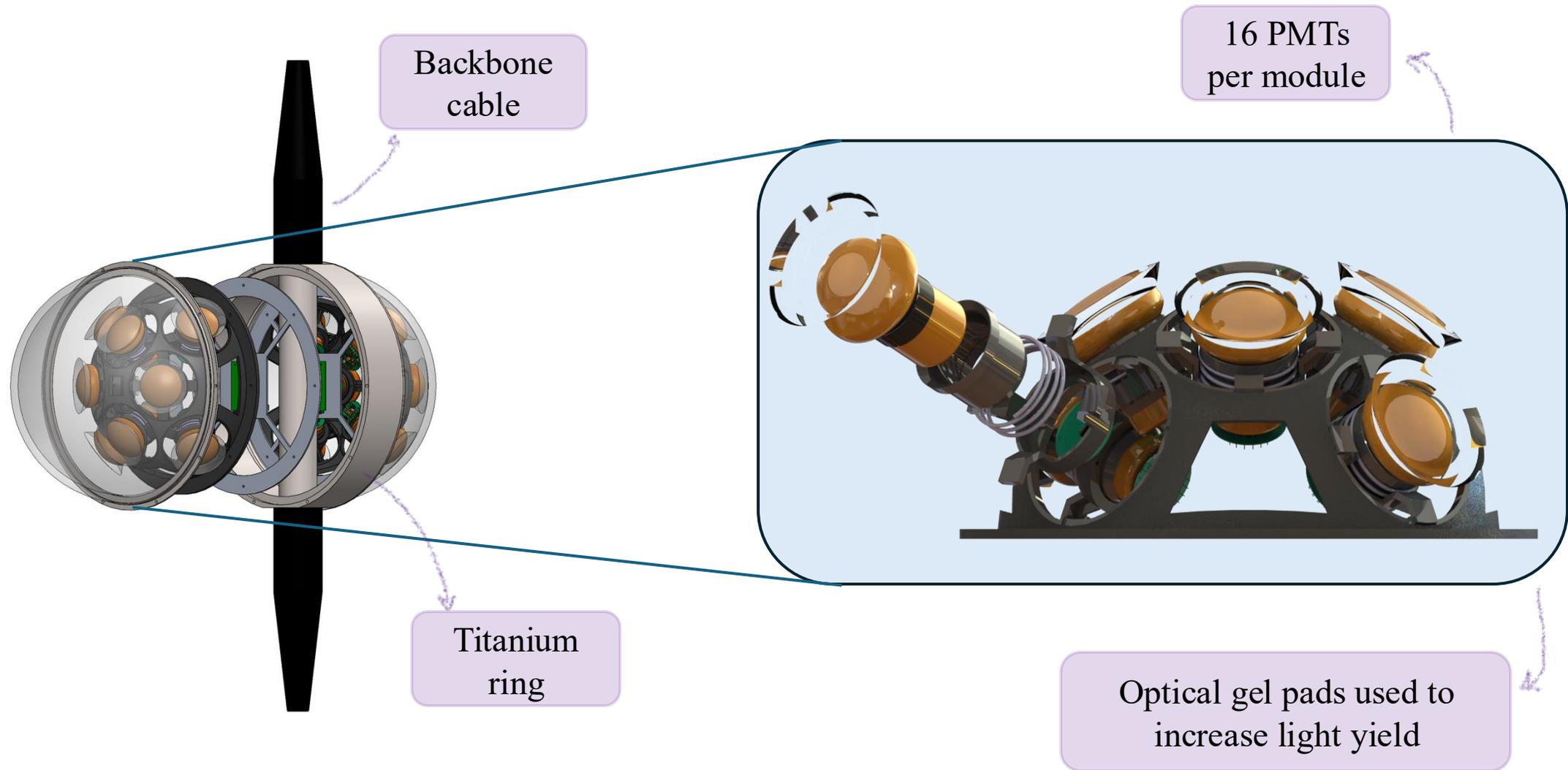


- Upward-facing optical surfaces saw around a 65% drop in efficiency.
- Downward-facing surfaces mostly clear
- Can be checked with flashers
- Mitigation with biofouling coating



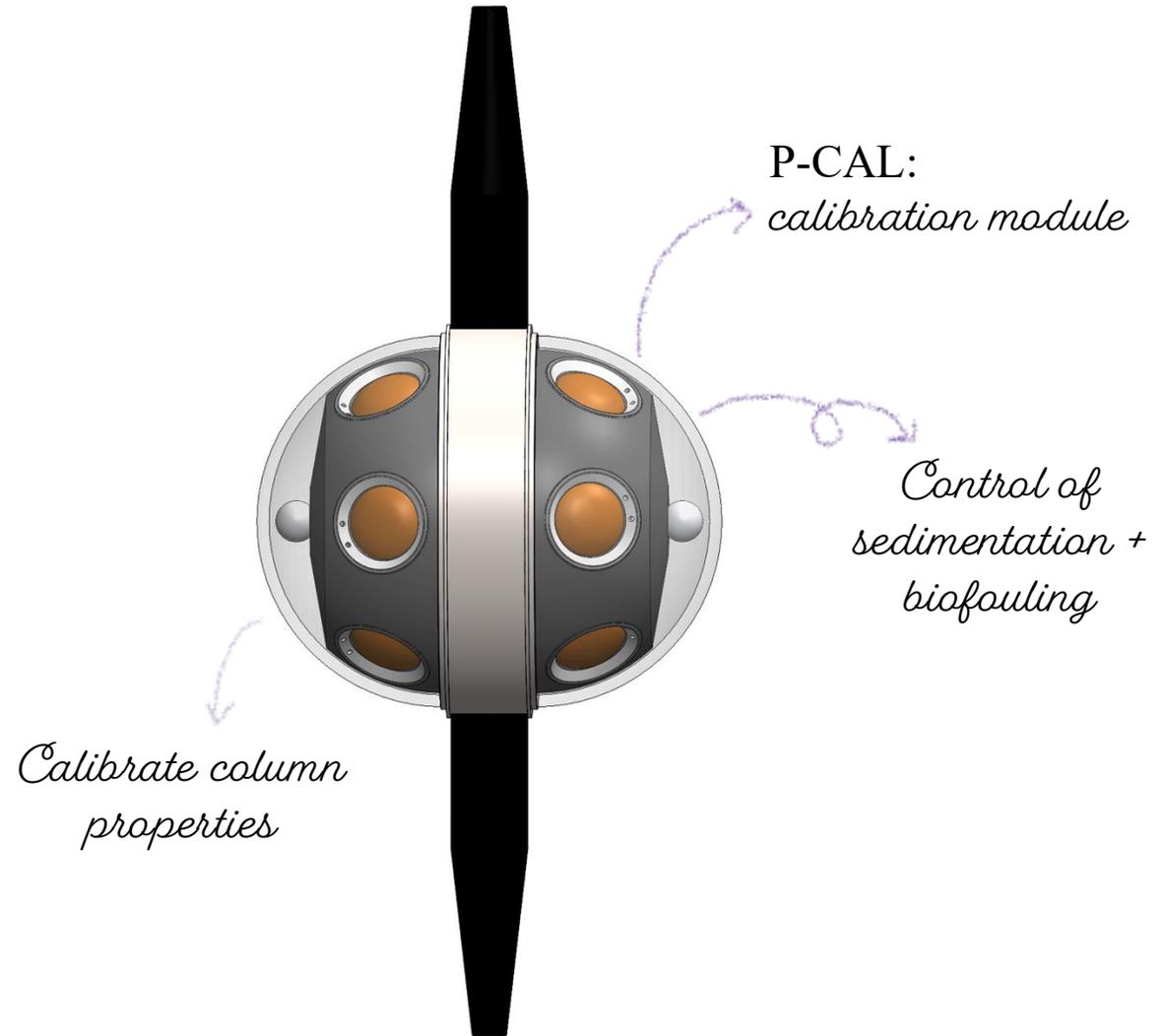
Images and plots: Braeden Veenstra et al.  
Credit: arXiv:2507.09086

# Optical module



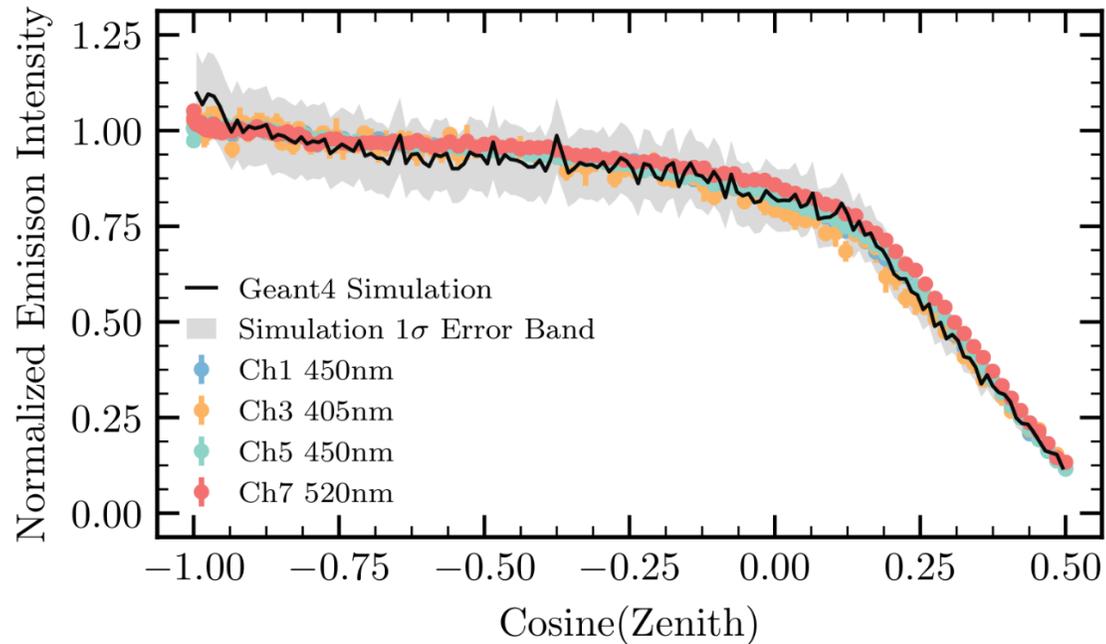
# P-ONE detector line

- 1 km long mooring line with 20 modules
- Connector-less design
- Optical and calibration modules
- Acoustic & optical calibration systems
- Sub-ns time synchronization between modules (0.1nsec)
- DAQ: Digitize waveform @ 210MHz

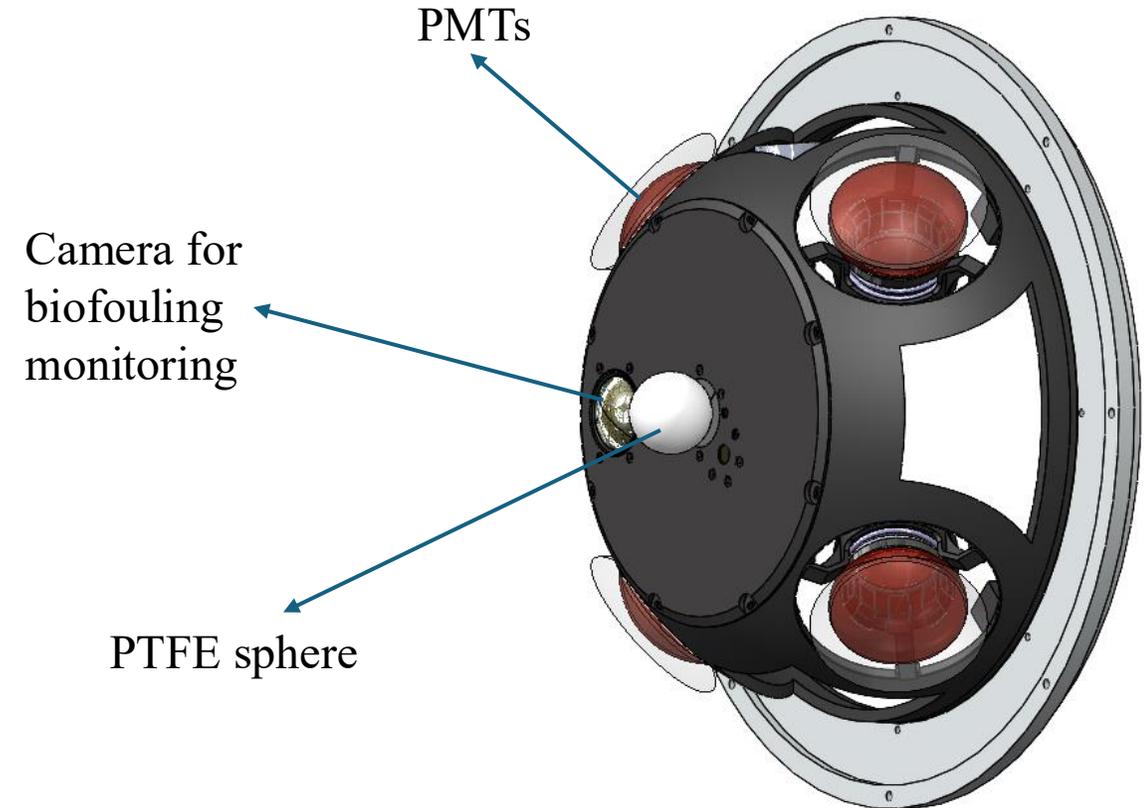




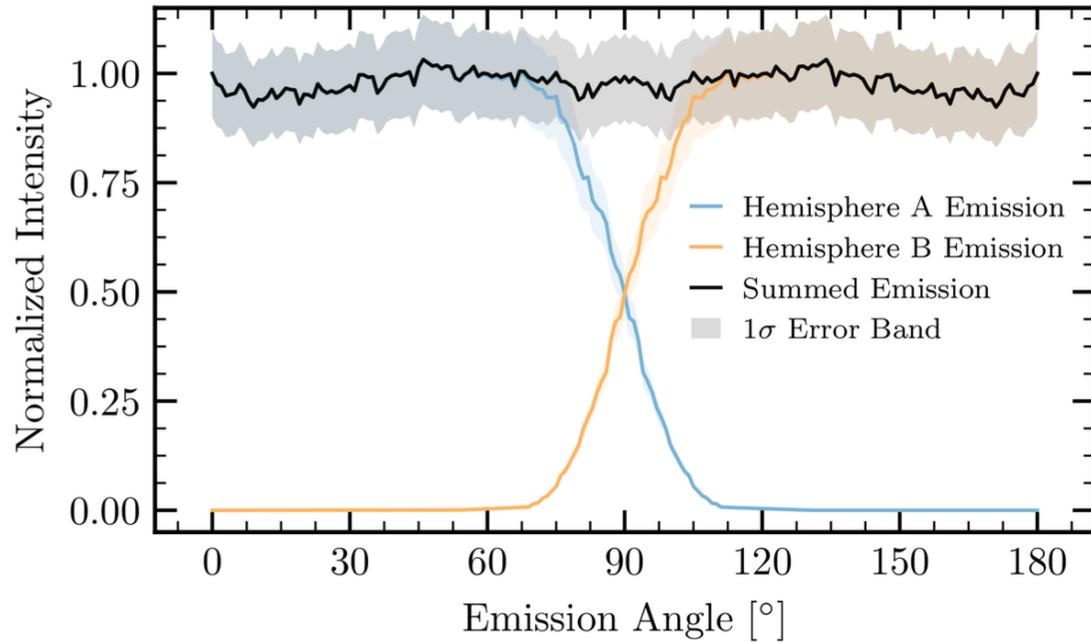
# Calibration System



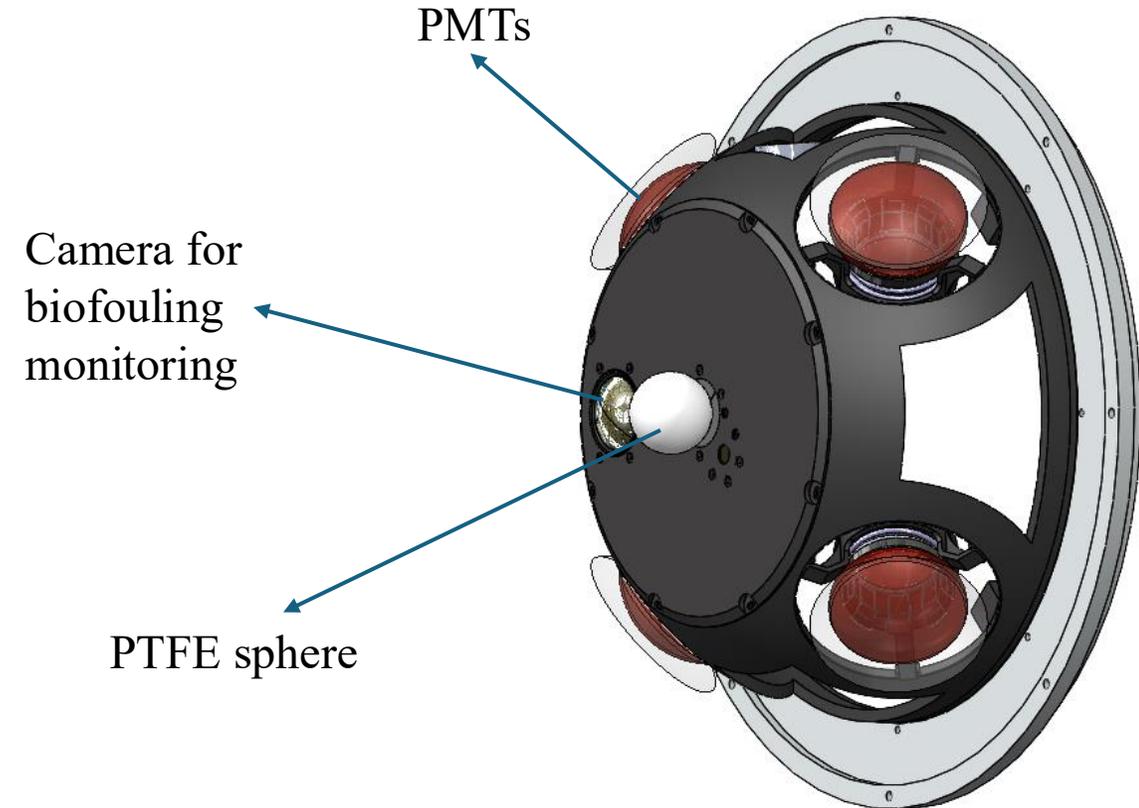
Images and plots: Dilraj Ghuman, Jakub Stacho, Felix Henningsen



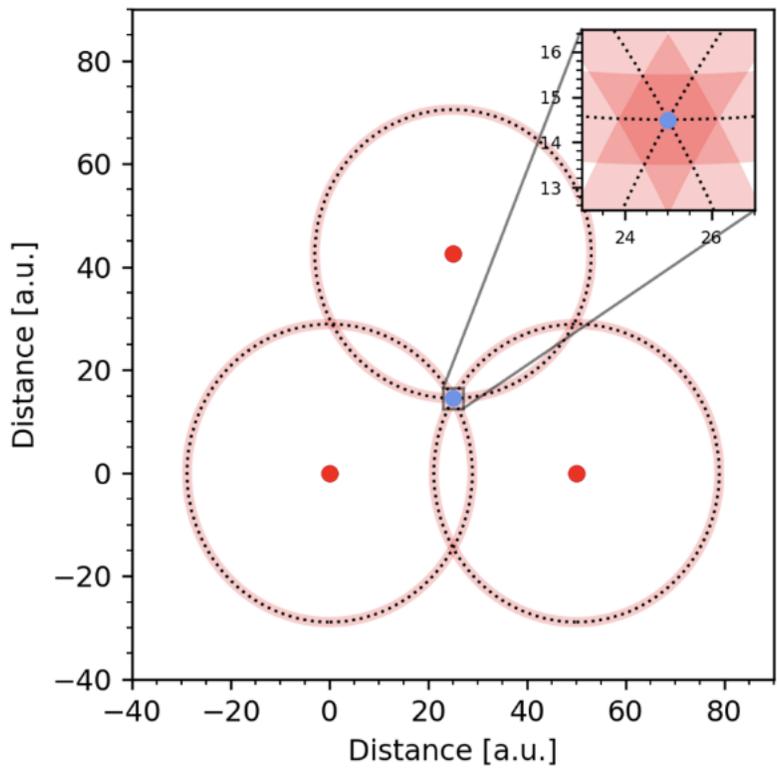
# Calibration System



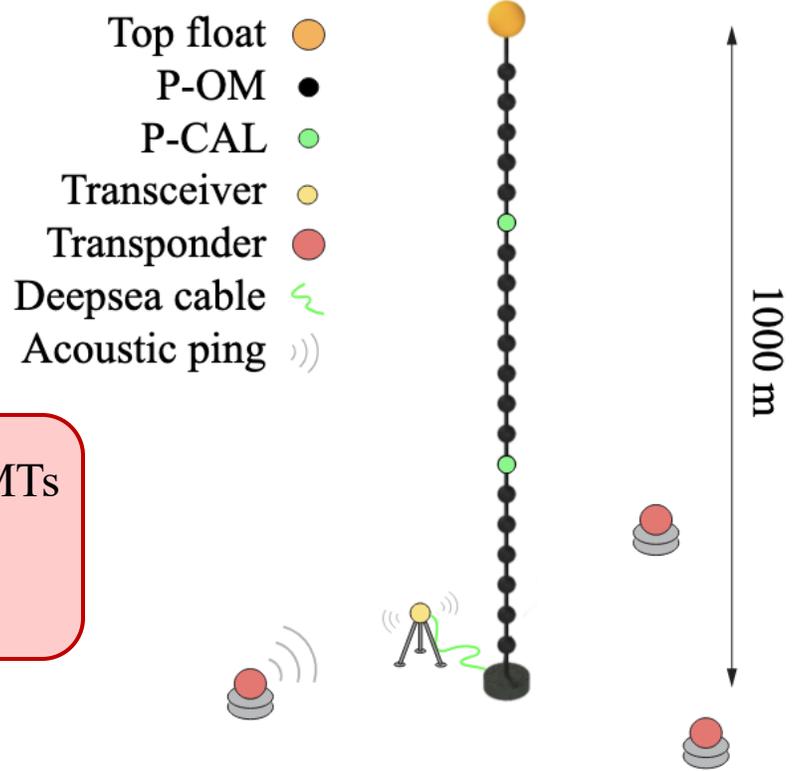
Images and plots: Dilraj Ghuman, Jakub Stacho, Felix Henningsen



# Acoustic receiver

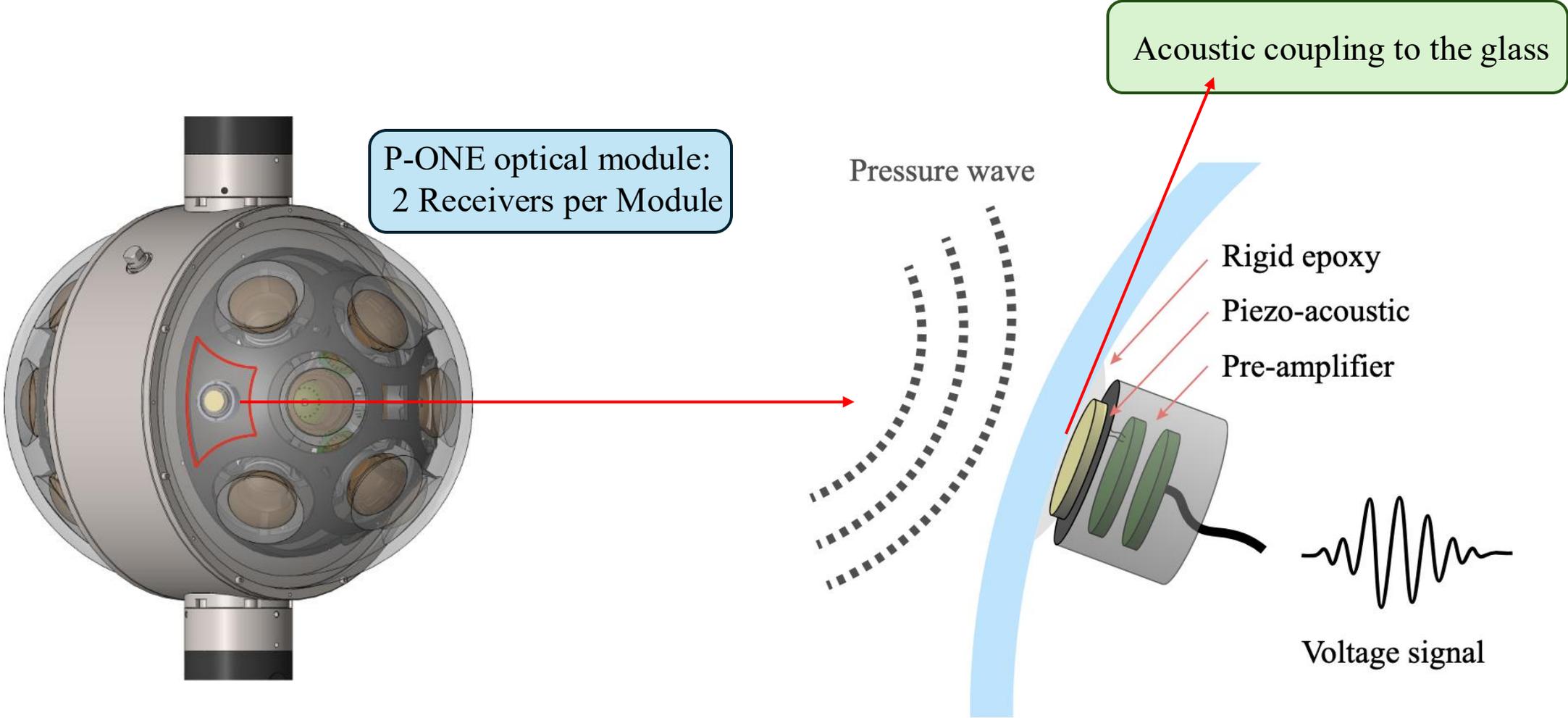


~1 ns resolution of P-ONE PMTs requires a relative positioning resolution  $\geq 20$  cm



Images: Dilraj Ghuman, Jakub Stacho, Felix Henningsen  
 Credit: arXiv:2504.13323

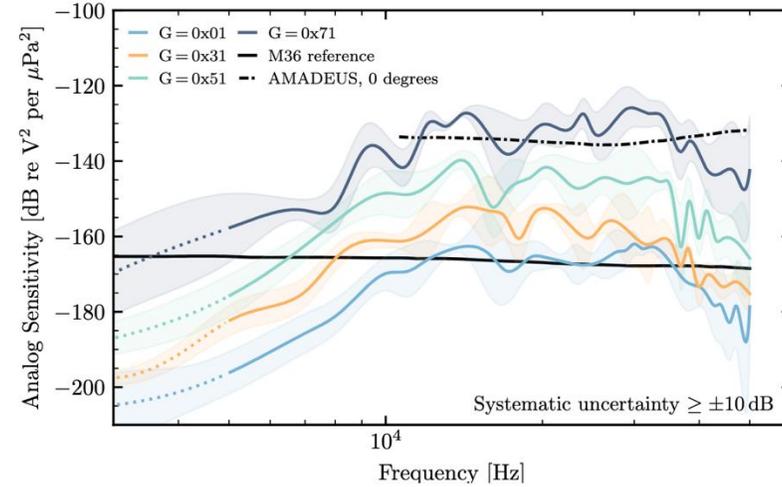
# Acoustic receiver



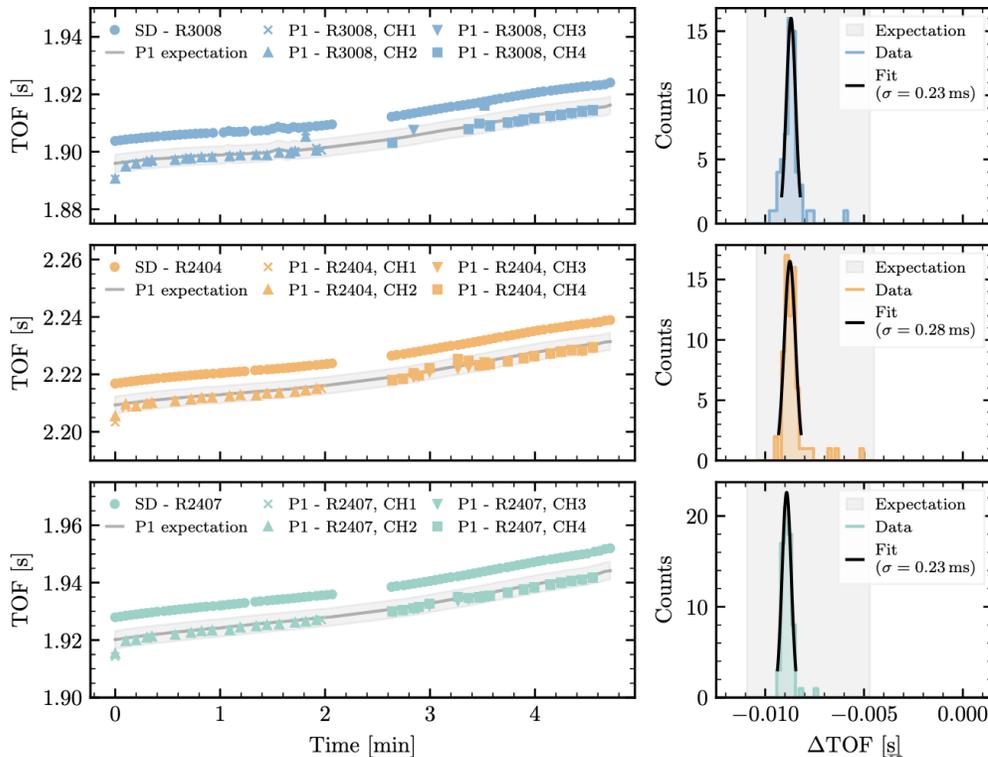
Images: Dilraj Ghuman, Jakub Stacho, Felix Henningsen  
Credit: arXiv:2504.13323

# Acoustic receiver

- Absolute sensitivities of up to  $-125$  dB re  $V^2/\mu Pa^2$
- Frequency range of 10–40 kHz

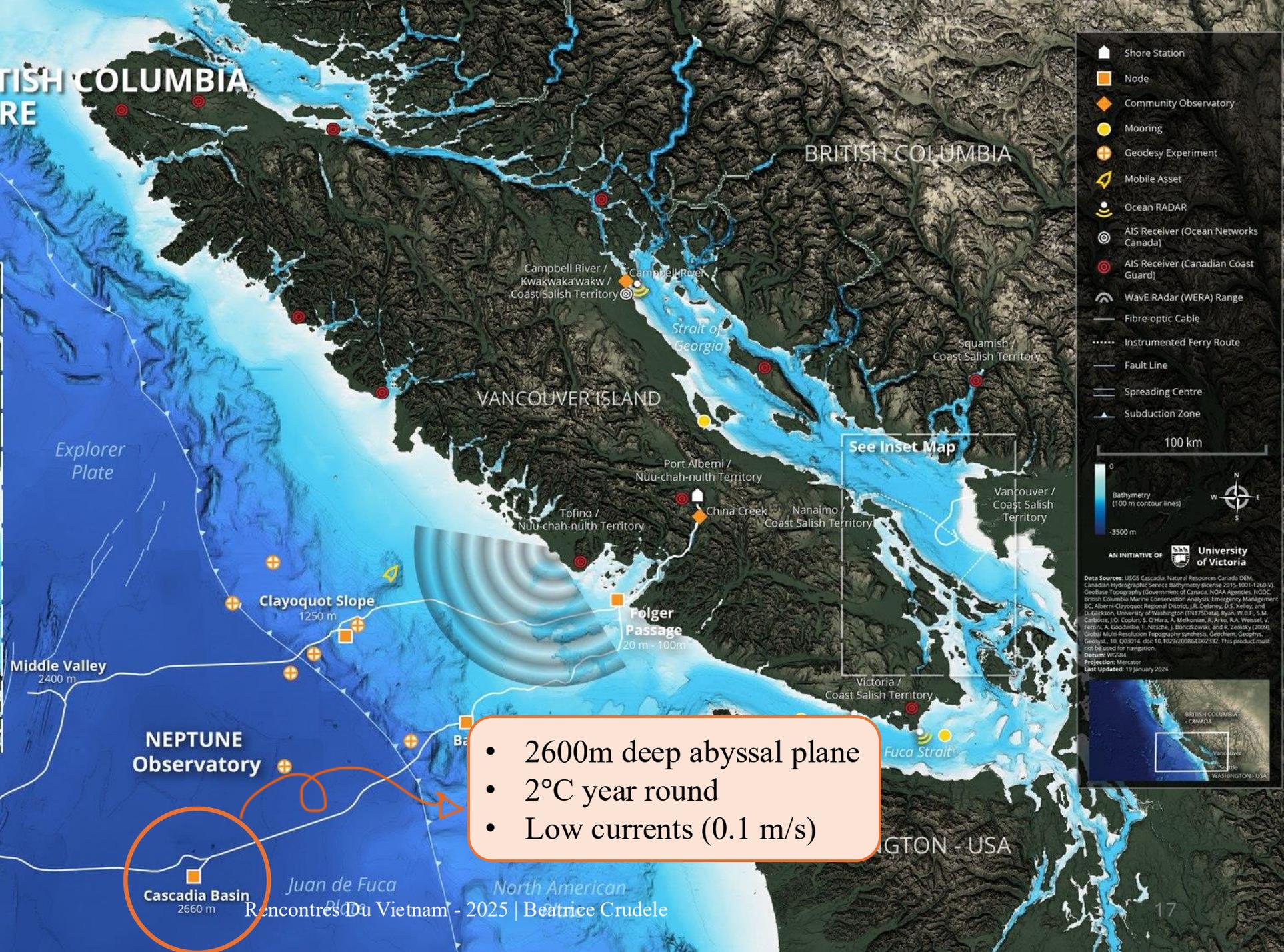


Plots: Dilraj Ghuman, Jakub Stacho, Felix Henningsen



- Positioning measurement campaign in the ocean
- 3 autonomous acoustic pingers, cabled acoustic interrogator, P-ONE prototype module deployed from ship
- Peak-finding detection algorithm: high accuracy ( $< 30$  cm) @ distances of up to 1600 m

# SOUTHERN BRITISH COLUMBIA INFRASTRUCTURE



- 2600m deep abyssal plane
- 2°C year round
- Low currents (0.1 m/s)

Legend:

- Shore Station
- Node
- Community Observatory
- Mooring
- Geodesy Experiment
- Mobile Asset
- Ocean RADAR
- AIS Receiver (Ocean Networks Canada)
- AIS Receiver (Canadian Coast Guard)
- Wave Radar (WERA) Range
- Fibre-optic Cable
- Instrumented Ferry Route
- Fault Line
- Spreading Centre
- Subduction Zone

Scale: 0 to 100 km

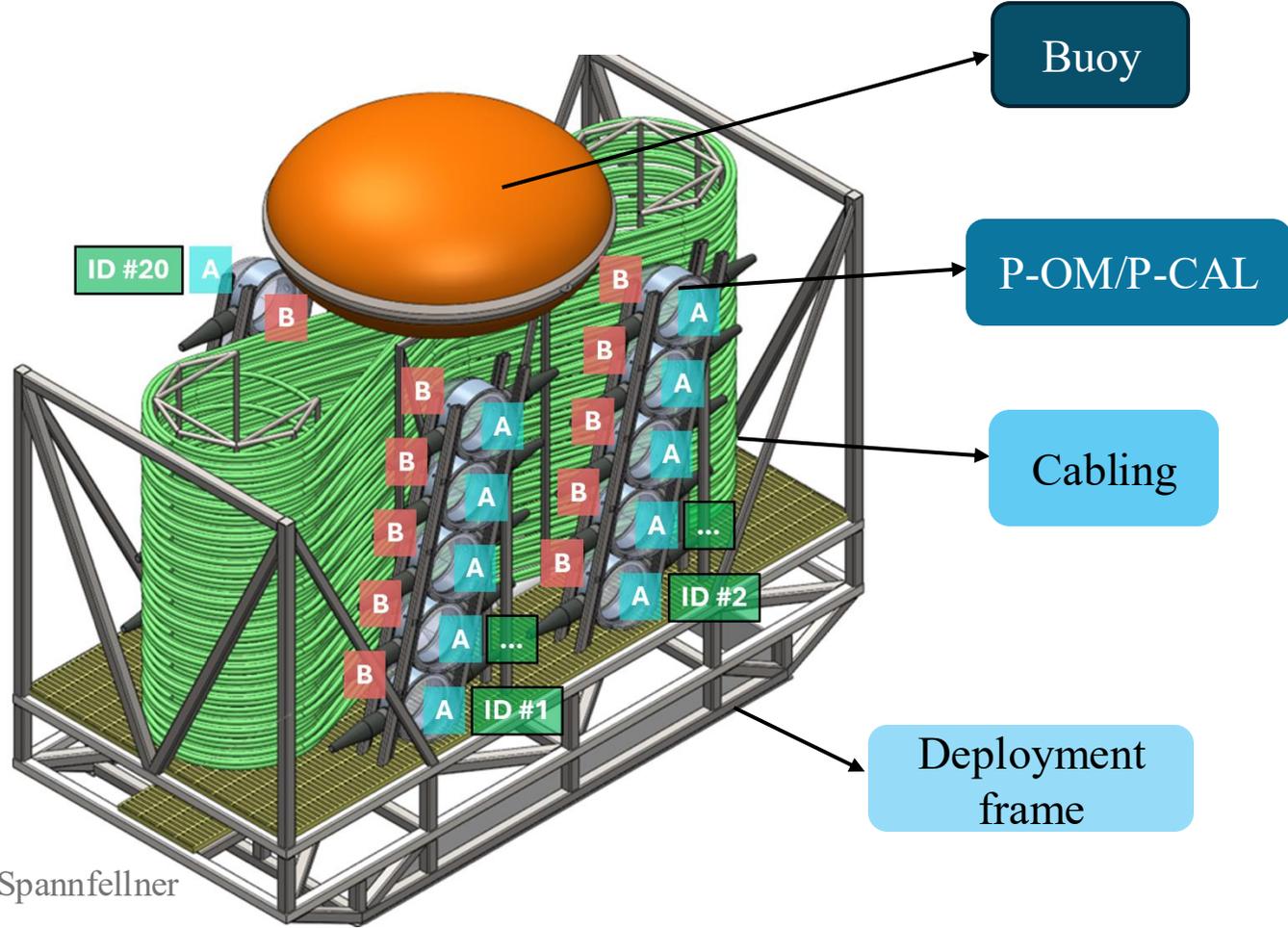
Bathymetry (100 m contour lines): -3500 m

AN INITIATIVE OF University of Victoria

Data Sources: USGS Cascadia, Natural Resources Canada DEM, Canadian Hydrographic Service Bathymetry (license 2015-1001-1260-V), Geobase Topography (Government of Canada, NOAA Agencies, NCCO, British Columbia Marine Conservation Analysis, Emergency Management BC, Alberni-Clayoquot Regional District, J.R. Delaney, D.S. Kelley, and D. Gidycz, University of Washington (NWTS/Dr. Ryan, W.B.R., S.M. Carlotta, J.O. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weisell, V. Ferris, A. Goodwillie, F. Niesche, J. Bonczkowski, and R. Zensky (2009)), Global Multi-Resolution Topography Synthesis, Geoscientific Data Service, 10.1029/2008GC002332. This product must not be used for navigation.

Datum: WGS84  
Projection: Mercator  
Last Updated: 19 January 2024

# Deployment of first string



- Pre-packaged
- Fully-instrumented
- 3m height

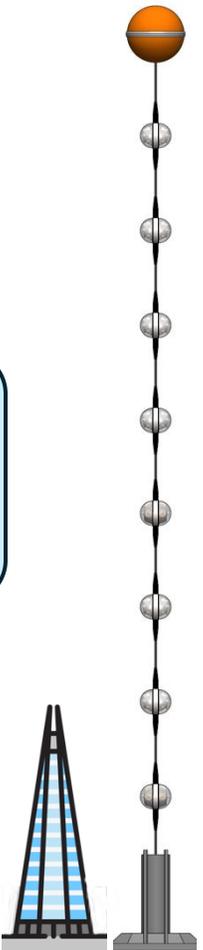


Image C. Spannfellner

# P-ONE 1

---

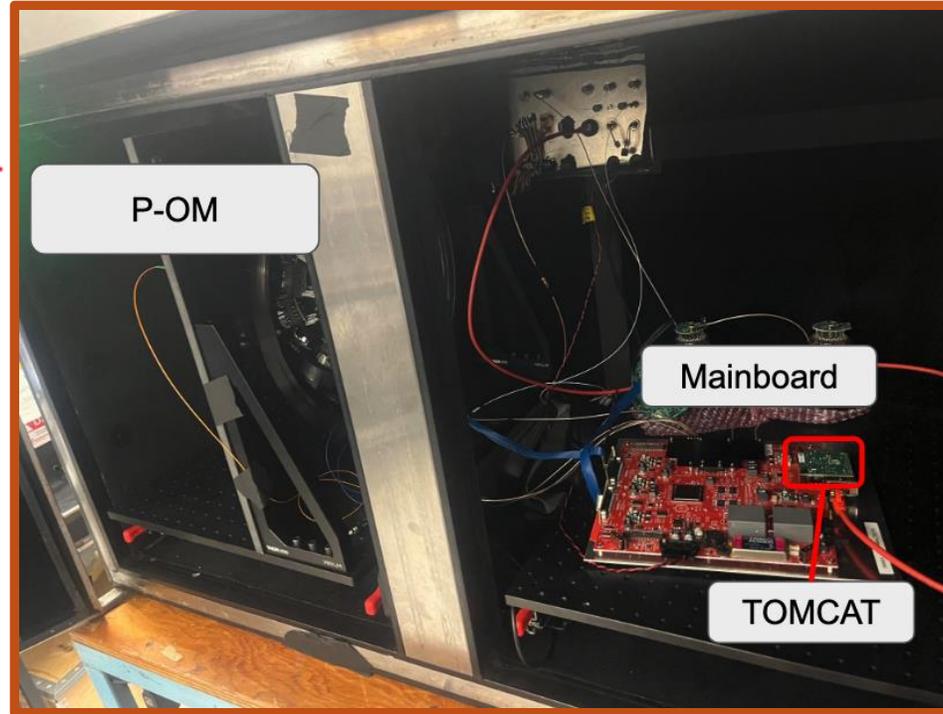
- Hemispheres have been shipped with mounted PMTs from TUM
- All modules have been received at TRIUMF
- Deployment frame has been moved into the clean room
- Backbone cable contains optical fibres which are cut and spliced, then fully spooled on frame at McCartney facilities



# MINT

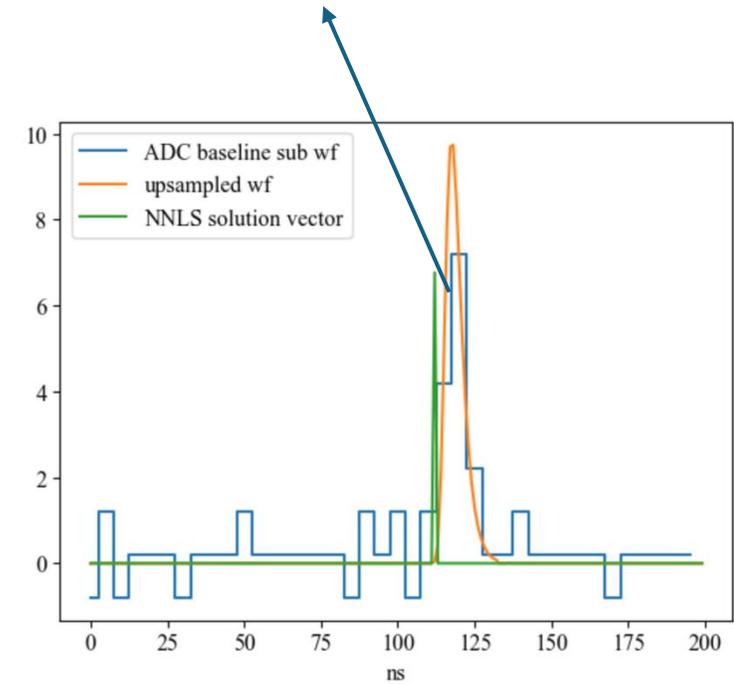
Images P. Krause

- Full set-up for **testing** and **calibration** has been prepared at SFU



Optical module connected to mainboard and timing system (TOMCAT)

First set of reconstructed waveforms from PMTs and MINT set-up







# Conclusions

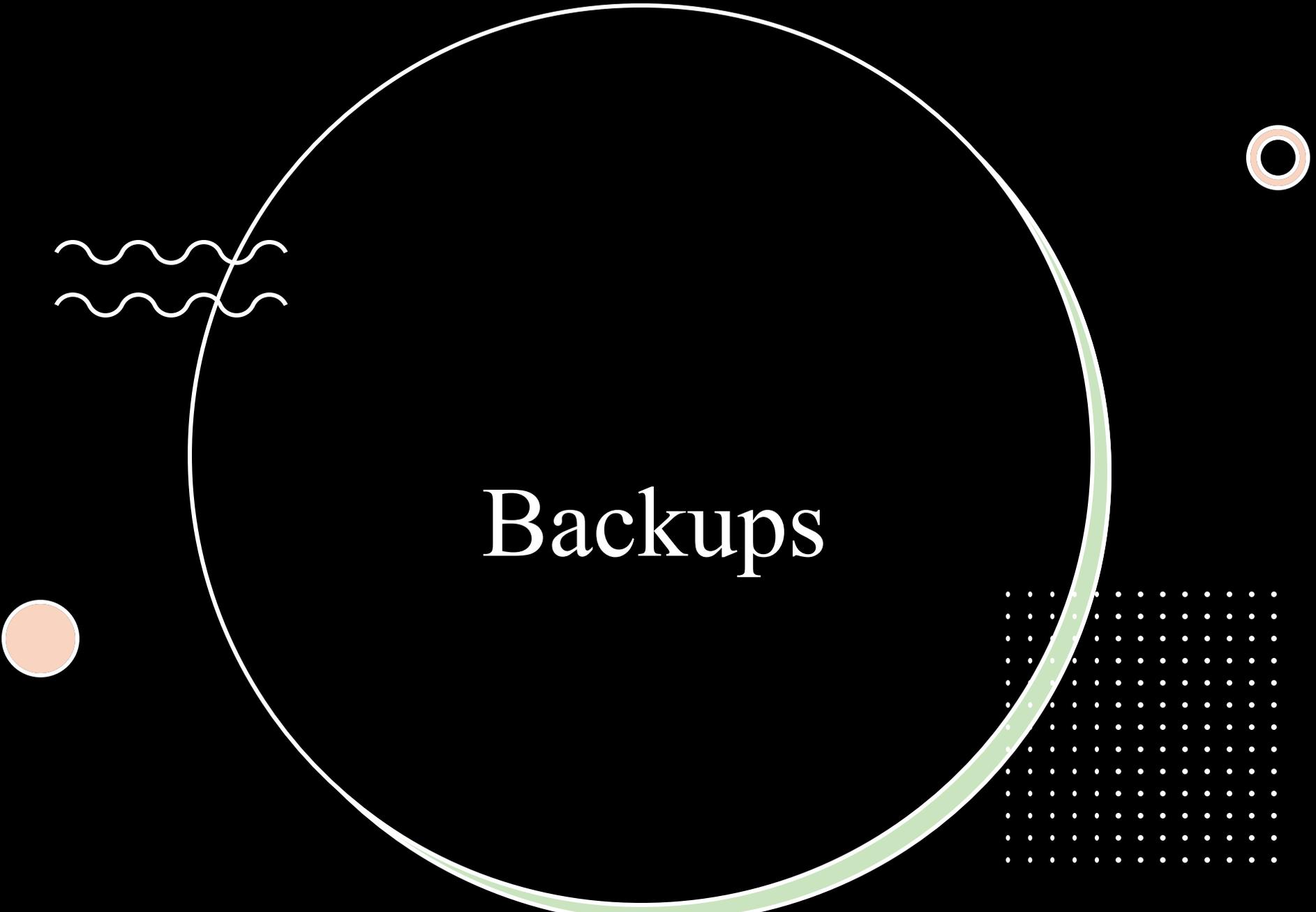
- P-ONE's goal is to search for high energy neutrinos in the southern sky
- Improved angular resolution and innovative design
- Will come online along others in the next decade
- P-ONE 1 is making great progress – deployment follows a technical driven schedule with opportunity for spring 2026
- Many discovery opportunities from our galaxy and beyond



4745.42246N, 12743.9114W, 2662m  
2023-07-12 18:32:06, Hdg: 171  
NA151, Dive#: H1983

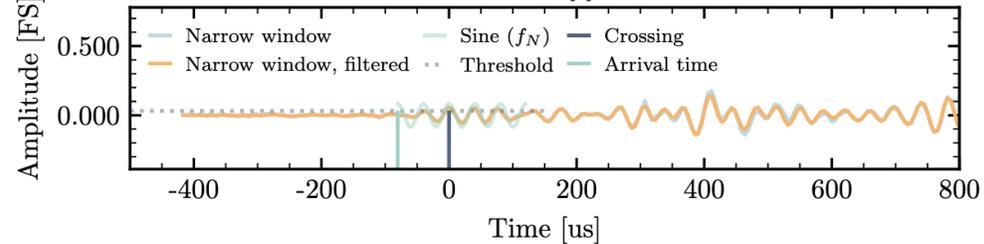
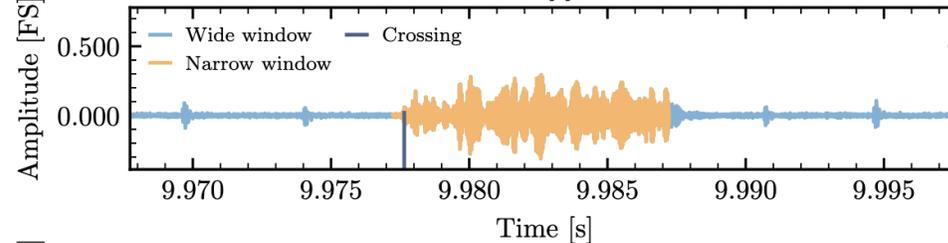
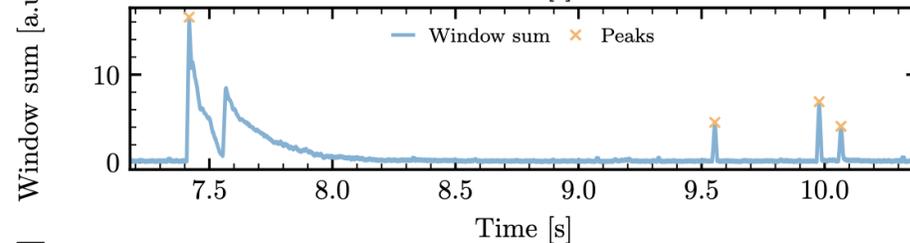
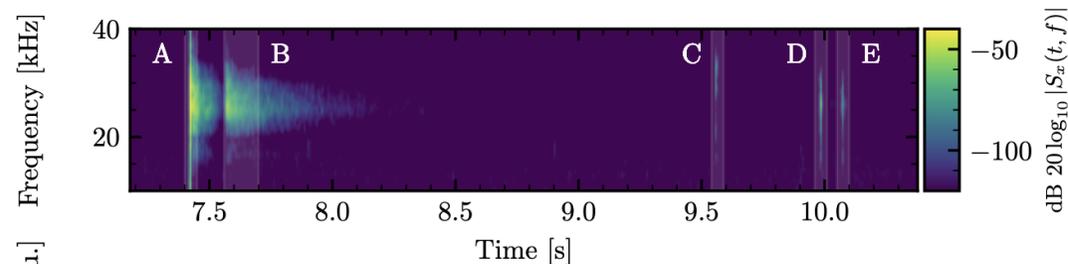
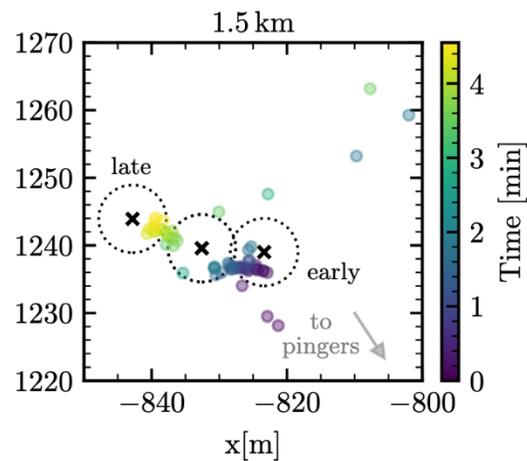
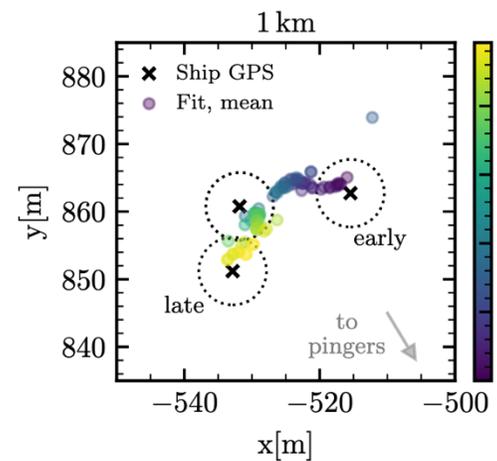
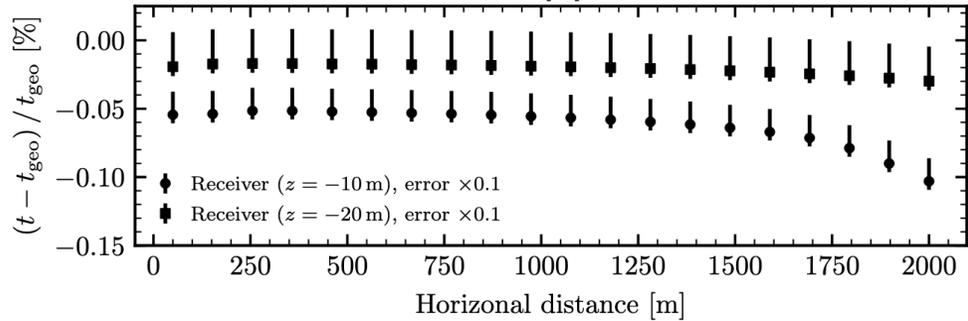
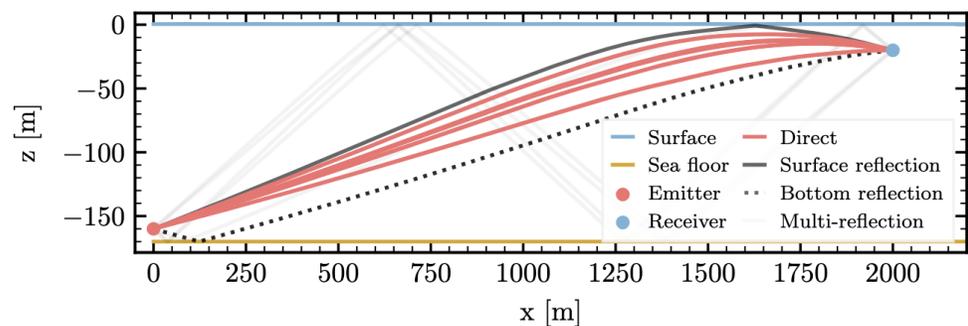
# Thank you

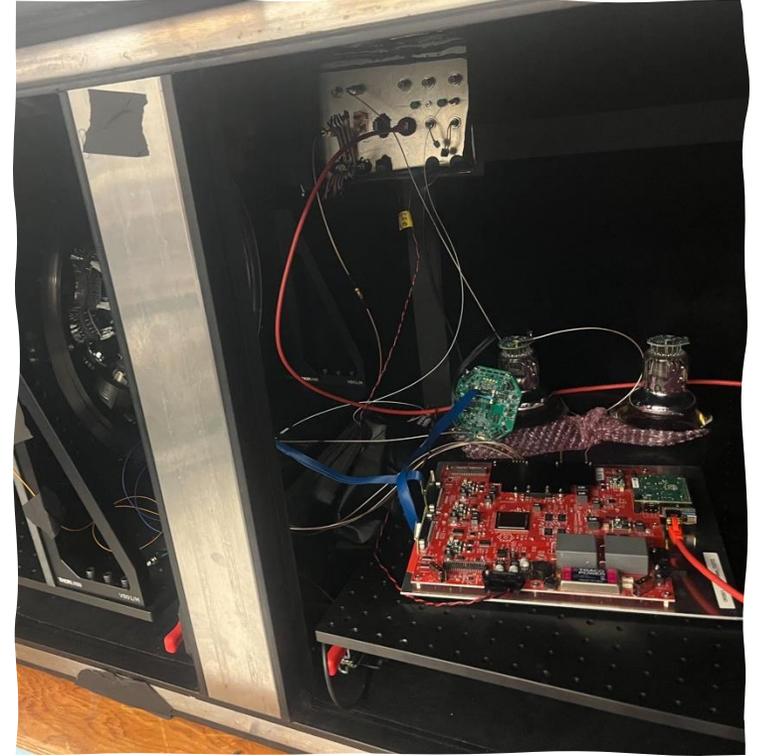
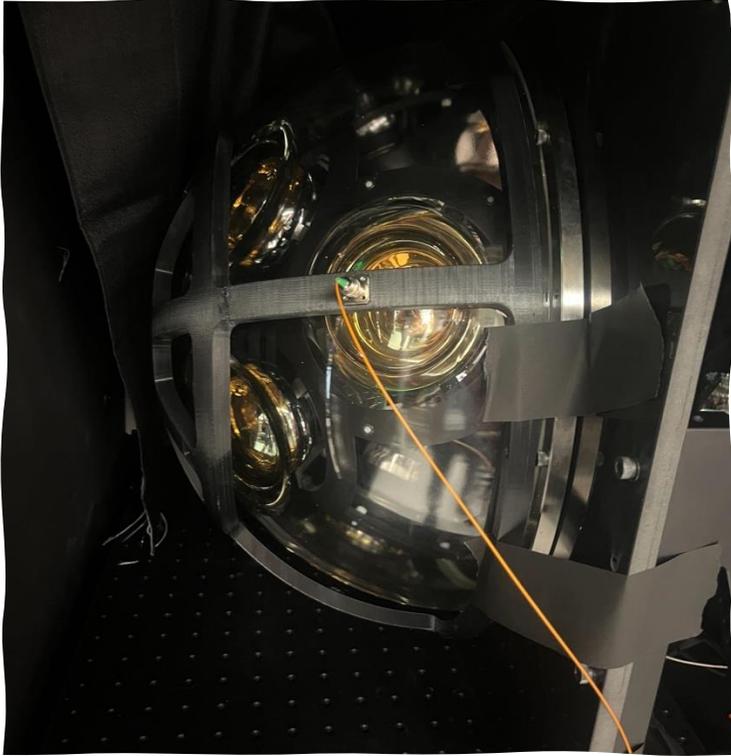
---



# Backups

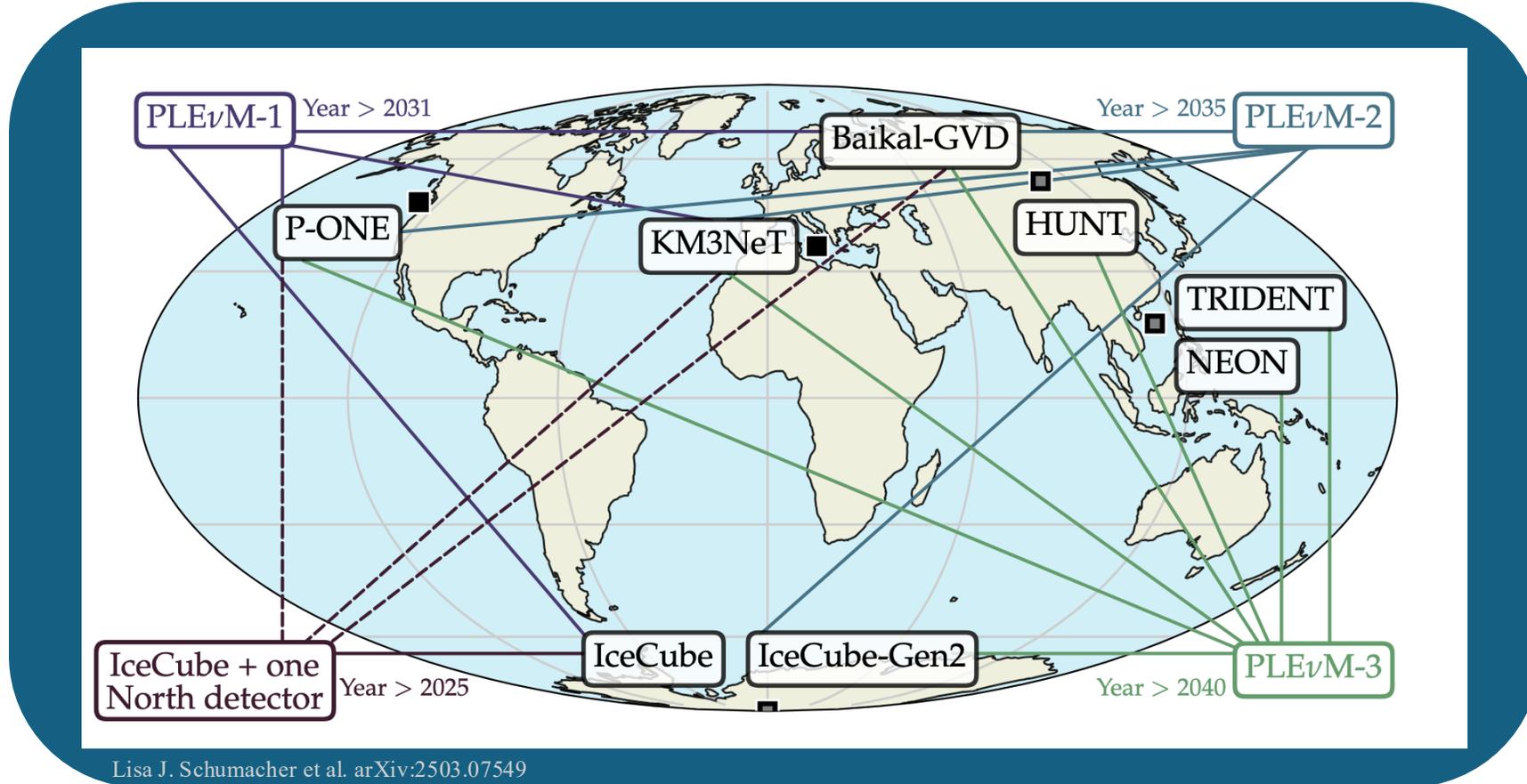
# Acoustic testing



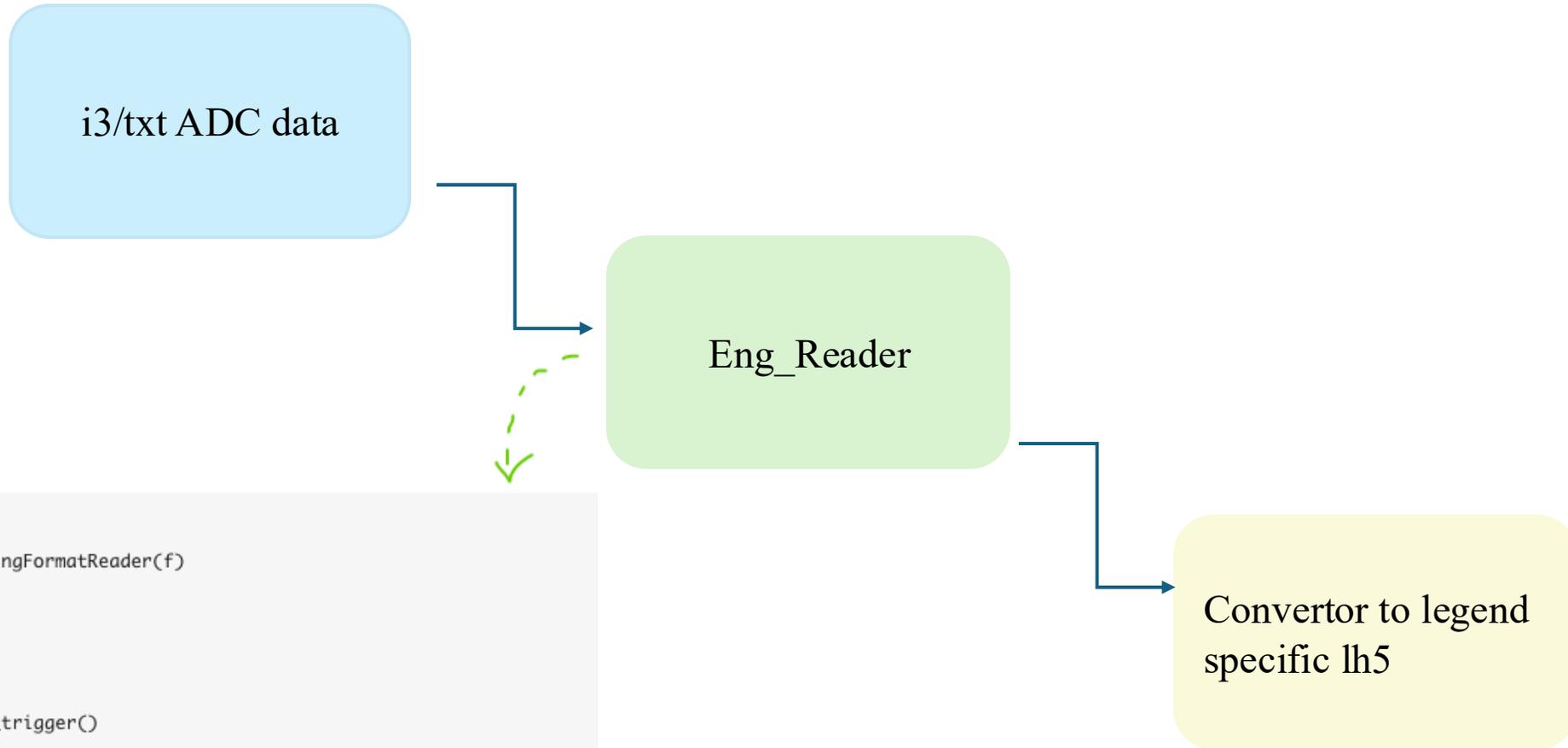


# MINT set-up

# Full web of neutrino telescopes



# Data conversion



```
signal = {}
f = open(f_daq)
r = eng_reader.EngFormatReader(f)

wf_length = 12
passed_wfs = 0
tot_wfs = 0
while True:
    r.read_next_trigger()
    if r.eof:
        break
    tot_wfs+=1
    # append the list of samples from each waveform to the list of
    waveforms
```