Development of Real Time Calibration Systems for the Pacific Ocean Neutrino Experiment

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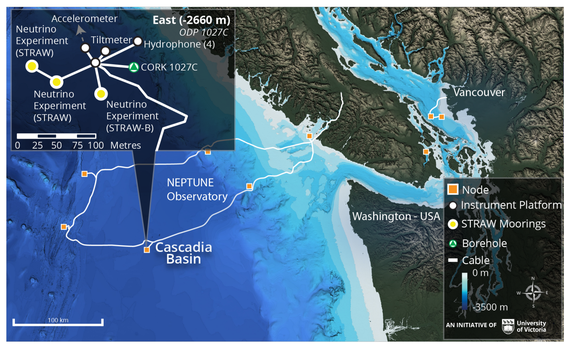
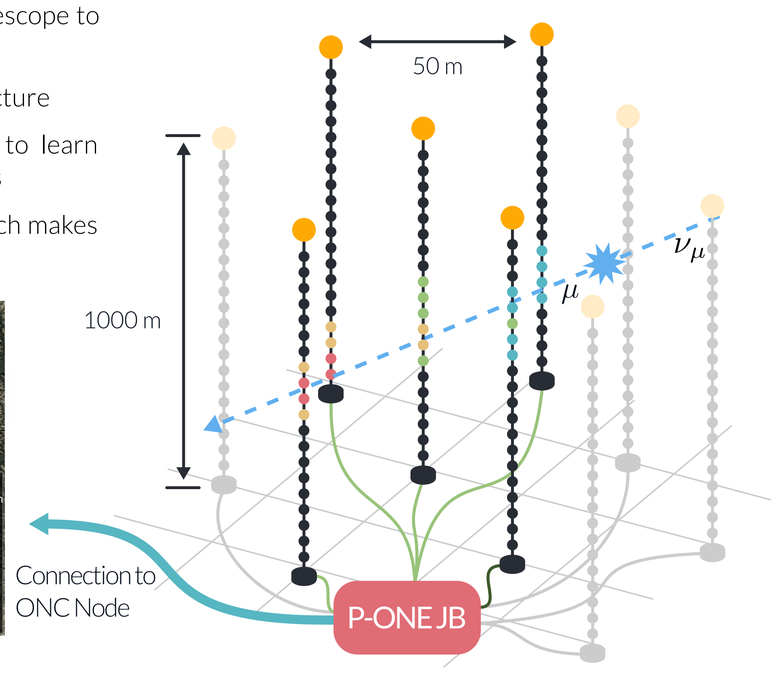
The Pacific Ocean Neutrino Experiment (P-ONE)

P-ONE is a proposed cubic-kilometer neutrino telescope to be deployed off the coast of Vancouver Island.

- Use existing Ocean Networks Canada infrastructure
- Observe high energy astrophysical neutrinos to learn about their sources and production mechanisms
- Detector environment constantly changing which makes real time calibration critical





P-ONE Calibration Module (P-CAL)

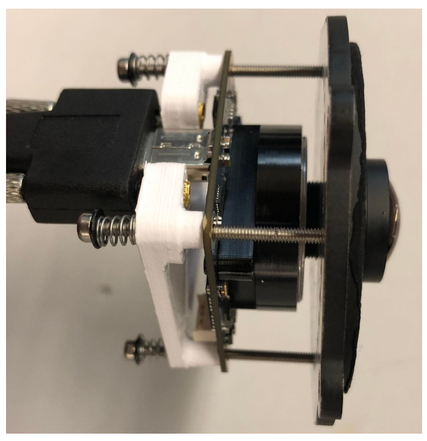
P-ONE will include a variety of calibration sources for both localized and ranged measurements within the detector. Our lab at SFU is developing special calibration modules.

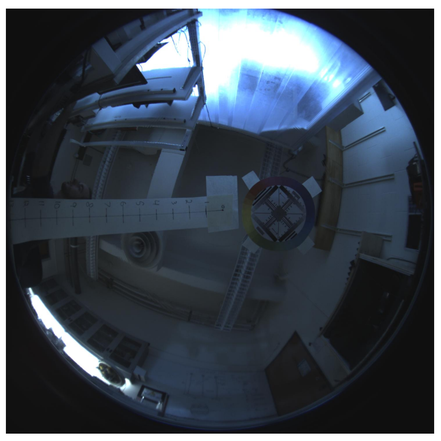
- Combination of the P-ONE Optical Module (P-OM) light detecting PMTs with a well calibrated diffuse light flasher
- Camera system for monitoring biofouling
- Flasher beacons used to measure dispersion in water
- Diffuse flasher used to measure attenuation properties
- Acoustic receiver system for position calibration

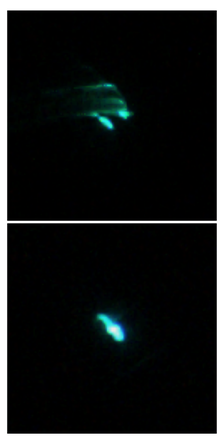
Biofouling and Sedimentation Monitoring

Marine snow will settle on the top surface of the module over time. This can lead to living organisms forming on the module surface which can block light and impact detection efficiencies.

- CMOS camera with a fish-eye lens in the P-CAL allows us to take photos from within the glass
- Understanding the level of biofouling helps us adjust efficiency factors of both light detection and calibration light emission
- In addition can be used to study bioluminescence [1]
- Selected sensors and lens to maximize image clarity and field of view of the camera system



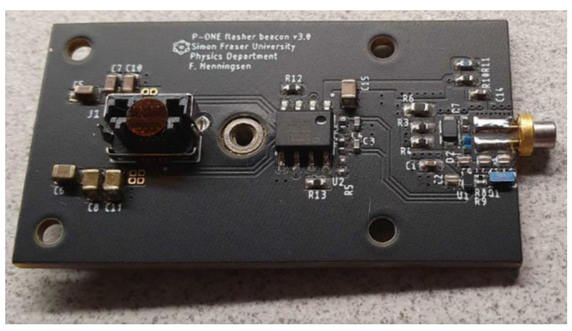


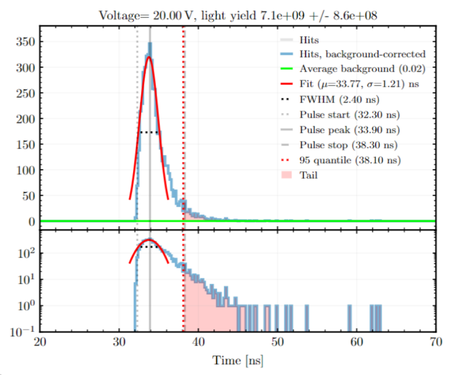


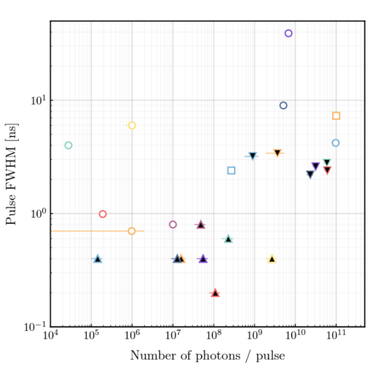
Flasher Beacon Inter-Module Calibration

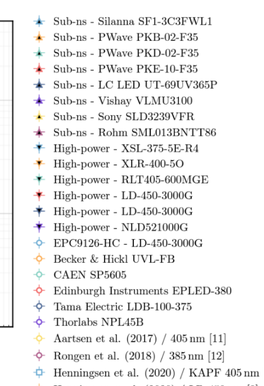
For optical calibration of local water properties between pairs of modules in the detector. Flasher beacons emit up and down the mooring line towards neighbouring modules to measure dispersion.

- Developed sub-nanosecond light pulsers using novel GaNFET driving technology [2]
- Every module, not only the P-CAL, is equipped with these beamed light flashers
- Wavelengths between 365 - 520 nm are used to cover the whole transparency window of ocean water
- Measured many combinations of diodes and gate drivers during development





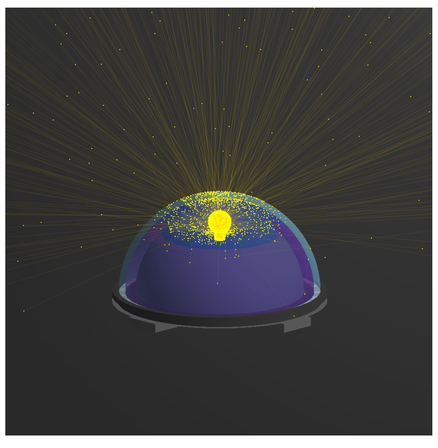


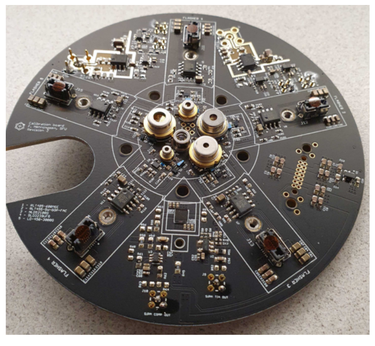


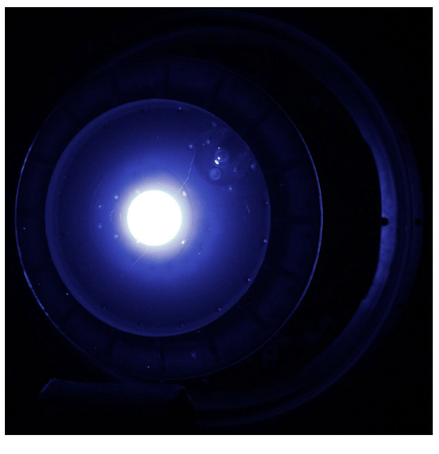
Diffuse Flasher Ranged Optical Calibration

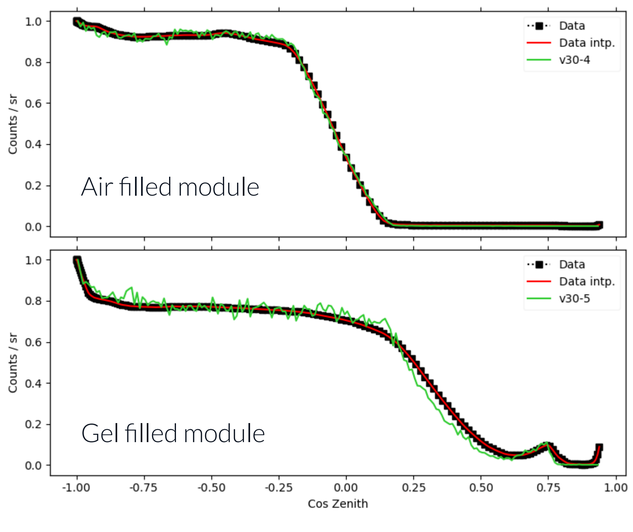
In addition to the beamed flashers, the P-CAL hosts a diffuse flasher system where diodes emit into a PTFE diffusing sphere. When both hemispheres are flashed synchronously, the emission looks isotropic from a distance [3].

- Flashes self-monitored by a photodiode and SiPM allowing for pulse to pulse corrections
- Optical gel used to couple the diffusing sphere to the glass reducing unwanted reflections
- Uses five wavelengths between 365 - 520 nm
- Could potentially be used to optically triangulate module positions
- Currently measuring emission profiles in-lab. Want to optimize module geometry to achieve an isotropic emission of within 2%





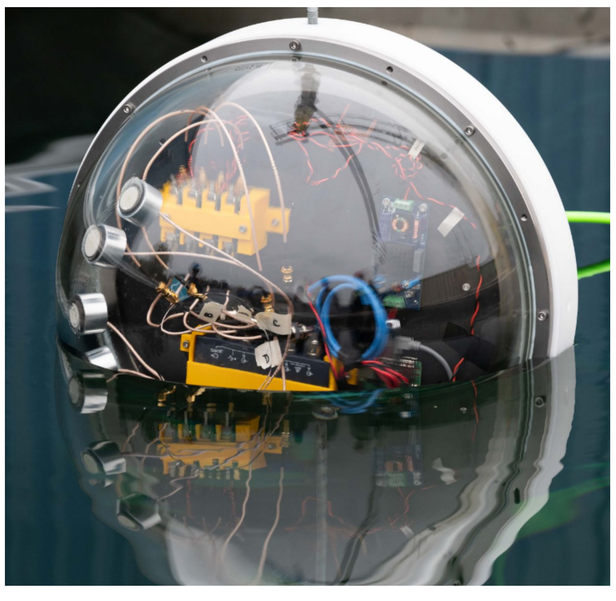


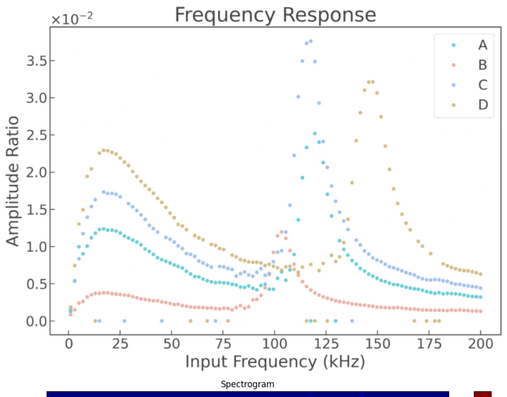


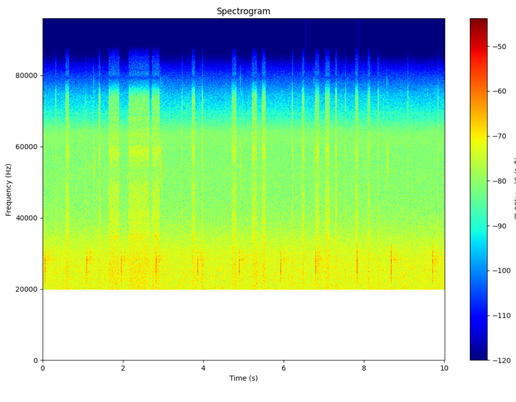
Acoustic Positioning Calibration System

As a trusted source of positioning we use an acoustic system. Transmitting beacons are anchored at known positions on the sea floor. Receivers in each module of the P-ONE array are then used to triangulate the spatial geometry of the array [4].

- Mooring lines constantly drift and bend in ocean currents
- Receivers in each module use a piezoelectric device coupled to the glass hemisphere with epoxy
- System operational at a frequency of around 20 kHz
- Ongoing ocean tests to study in-situ piezoelectric receiver performance
- Currently testing receiver signal amplifier and filter performance







References

[1] K. Holzapfel et al 2023 PoS ICRC2023 1166

[2] F. Henningsen et al 2023 JINST 18 P10010

[3] J. Stacho et al 2023 PoS ICRC2023 1113

[4] D. Ghuman et al 2023 PoS ICRC2023 1112

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