STRAW and STRAW-b: Pathfinder missions for P-ONE, a new neutrino telescope in the Pacific ocean

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Neutrino astronomy

Since neutrinos travel through space unperturbed by matter or electromagnetic fields, they allow us to probe the universe in new ways. Recently the IceCube neutrino telescope was able to find the first source of high-energy astrophysical neutrinos, the blazar TXS 0506+056 [1]. Around the globe new neutrino telescopes are constructed to help us understand the role of neutrinos in the universe. These telescopes instrument large volumes of clear water or ice with photomultiplier tubes, and detect the Cherenkov light of particles produced in neutrino interactions.

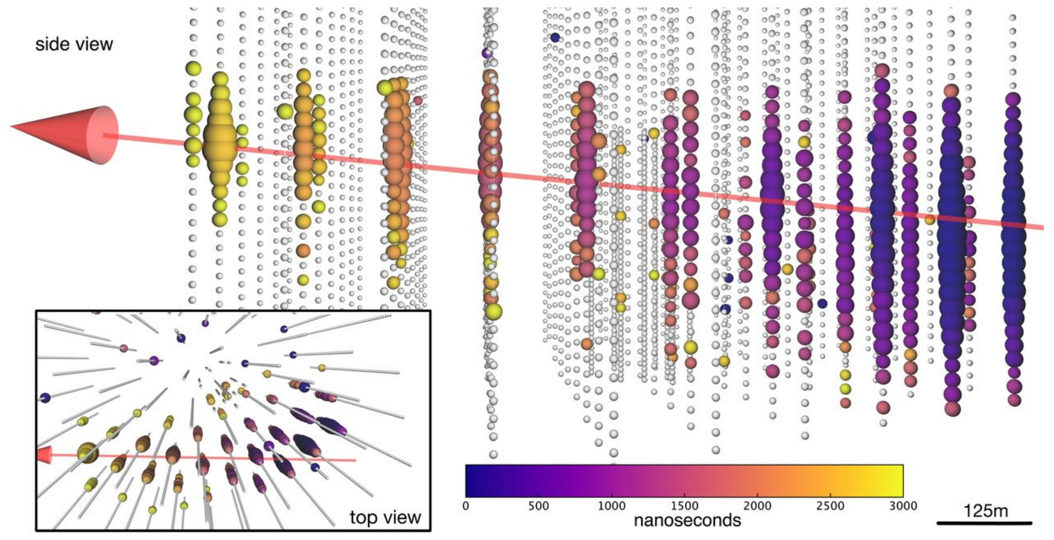

Figure 1: A visualisation of the detector response of IceCube for a high-energy event. Source: IceCube Collaboration

The Pacific Ocean Neutrino Experiment (P-ONE)

We propose the construction of a new cubic-kilometer-scale neutrino telescope in the Pacific Ocean near Vancouver Island [2].

- Using preexisting NEPTUNE infrastructure of Ocean Networks Canada (ONC)
- Site location will fill large gap in high-energy sky coverage of other detectors
- Collaboration with ONC to simplify underwater engineering and maintenance
- Aimed at neutrino energies of 10 TeV to 10 PeV

First pathfinder mission: STRAW

To test the viability of our detector concept we built the first pathfinder mission, the Strings for Absorption length in Water (STRAW) [4].

- measure absorption and scattering properties of water and bioluminescence background
- two 150 m strings, 4 modules each
- POCAM light emitter, creating isotropic nanosecond light pulses
- SDOM light detector, containing two photomultiplier tubes
- built within 8 months, deployed in June 2018
- continuously monitoring site
- preliminary results: site properties comparable to other neutrino detector sites [5], absorption length ≈ 30 m at 465 nm

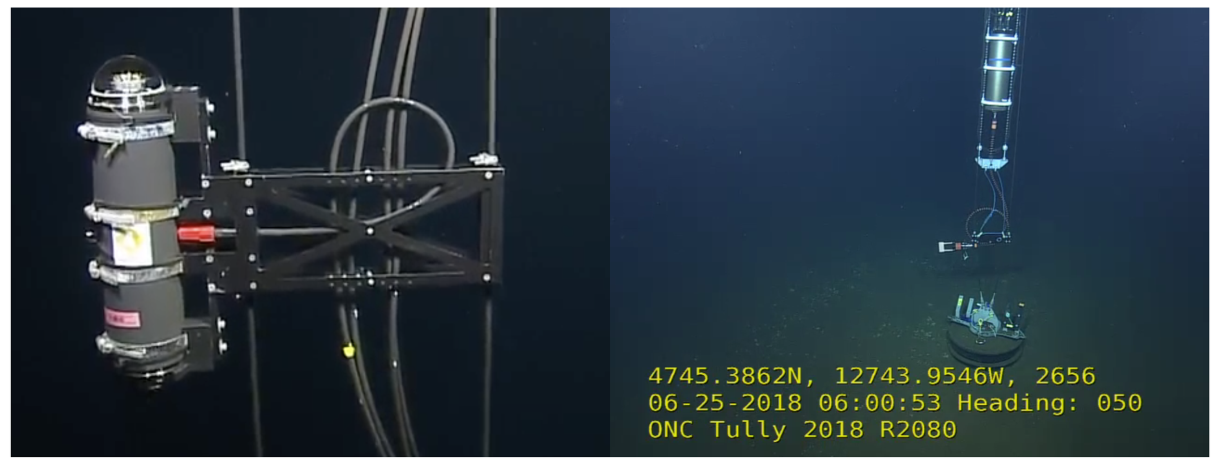

Figure 2: Image of a STRAW module (left) and the STRAW anchor assembly (right) after deployment. Source: Ocean Networks Canada

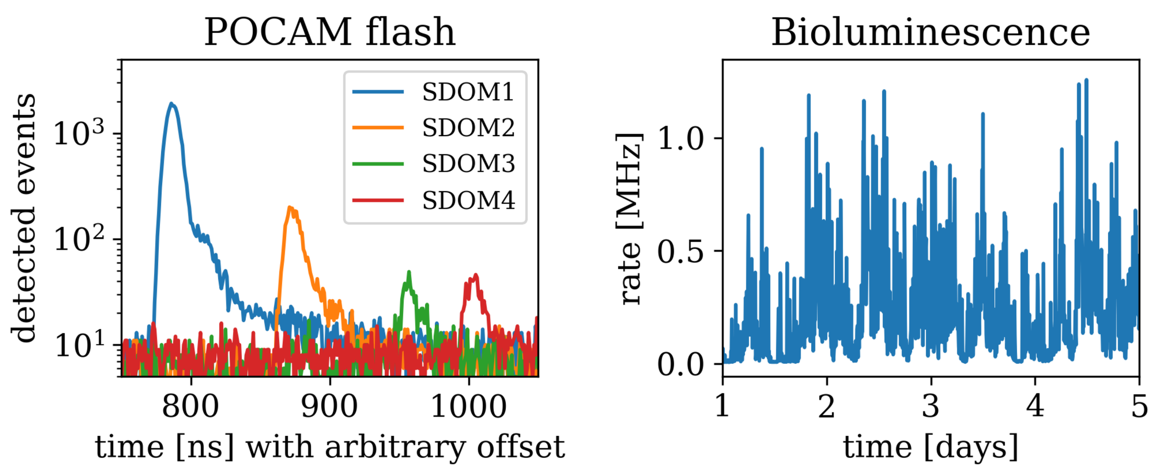

Figure 3: Data taken by the STRAW experiment. Left: A 10 ns light pulses is created by a POCAM flasher. We can see the attenuated pulse in the SDOM detectors. Right: Bioluminescence background of a single SDOM, hourly average. We can see a 12-hour tidal pattern.

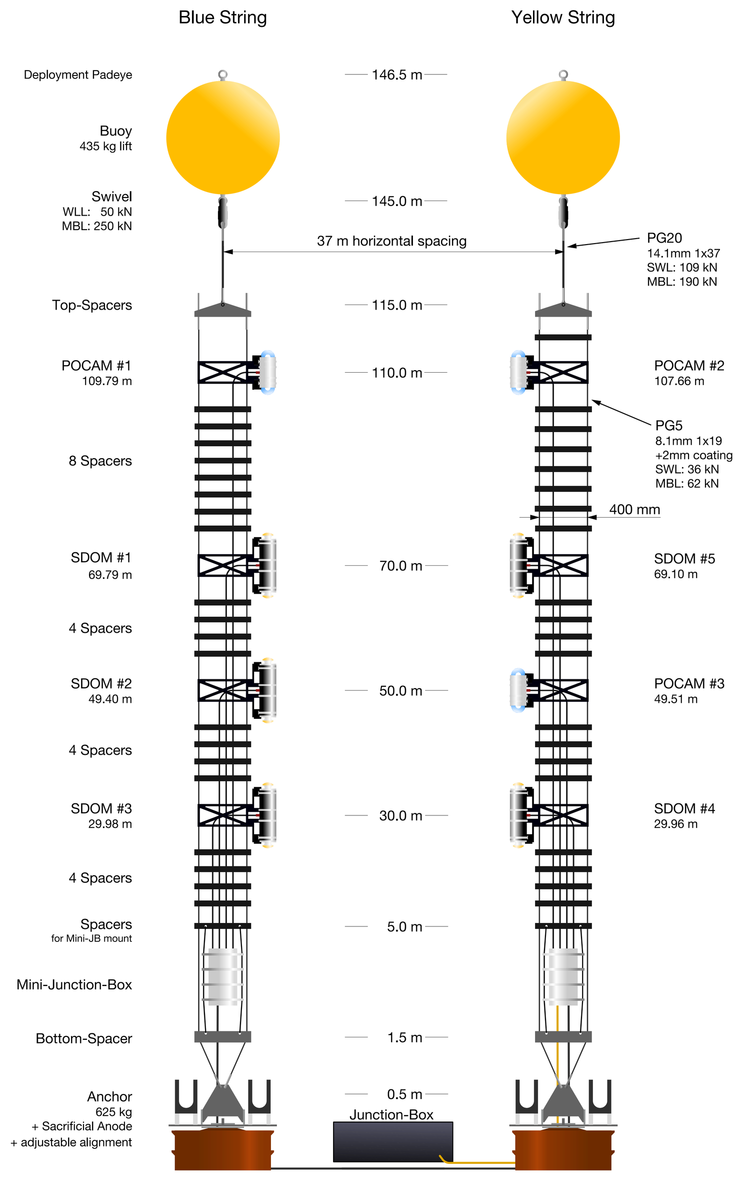

Figure 4: Schematic of the STRAW setup. Light-emitting modules and light-detecting modules are placed along two 150m mooring lines.

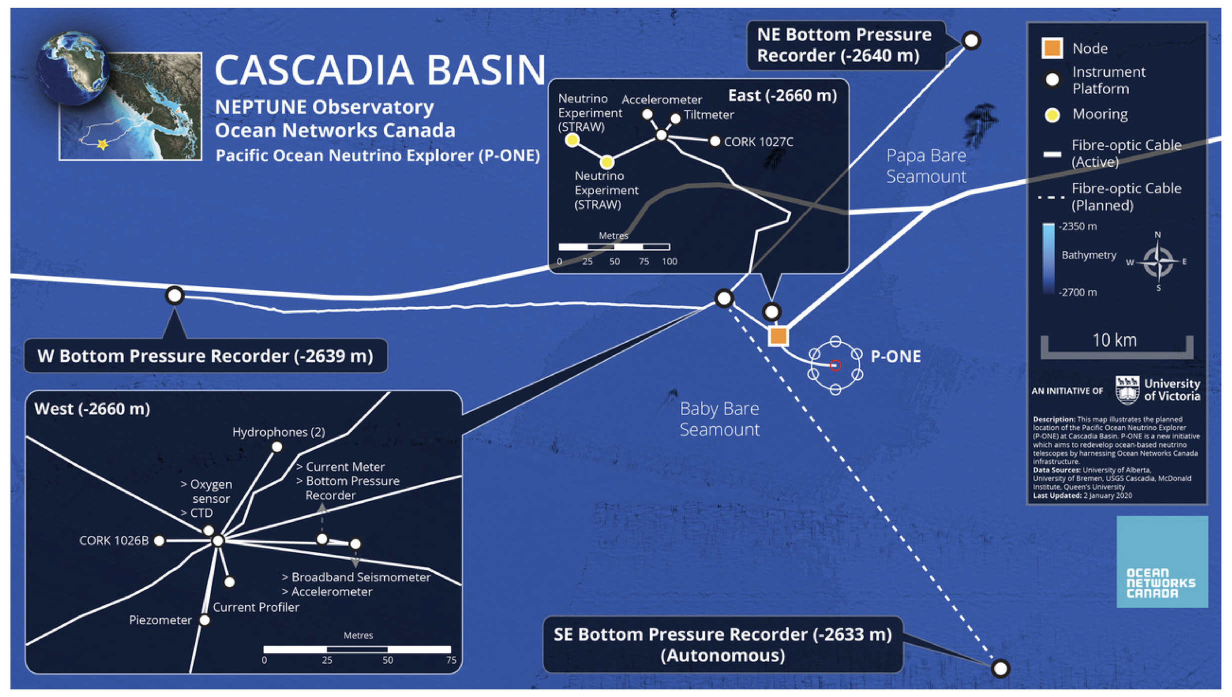

Figure 5: Map of the Ocean Networks Canada infrastructure. The new telescope will be located at Cascadia Basin at a depth of 2.6 km. Source: Ocean Networks Canada

Second pathfinder mission: STRAW-b

- currently in last stages of assembly and testing
- single 0.5 km string with 10 modules
- measure bioluminescence spectrum and muon background
- test new scalable deployment strategy
- planned deployment in September 2020

Next steps: P-ONE Explorer

After the deployment of STRAW-b we will start developing the first section of the larger neutrino telescope. The 10-string P-ONE Explorer is designed to be deployed during a four-week marine operation in 2023/2024, will cover one sixth of a cubic kilometer, and contain 200 multi-photomultiplier modules. The final P-ONE detector can then be constructed from seven of these smaller clusters in subsequent years.

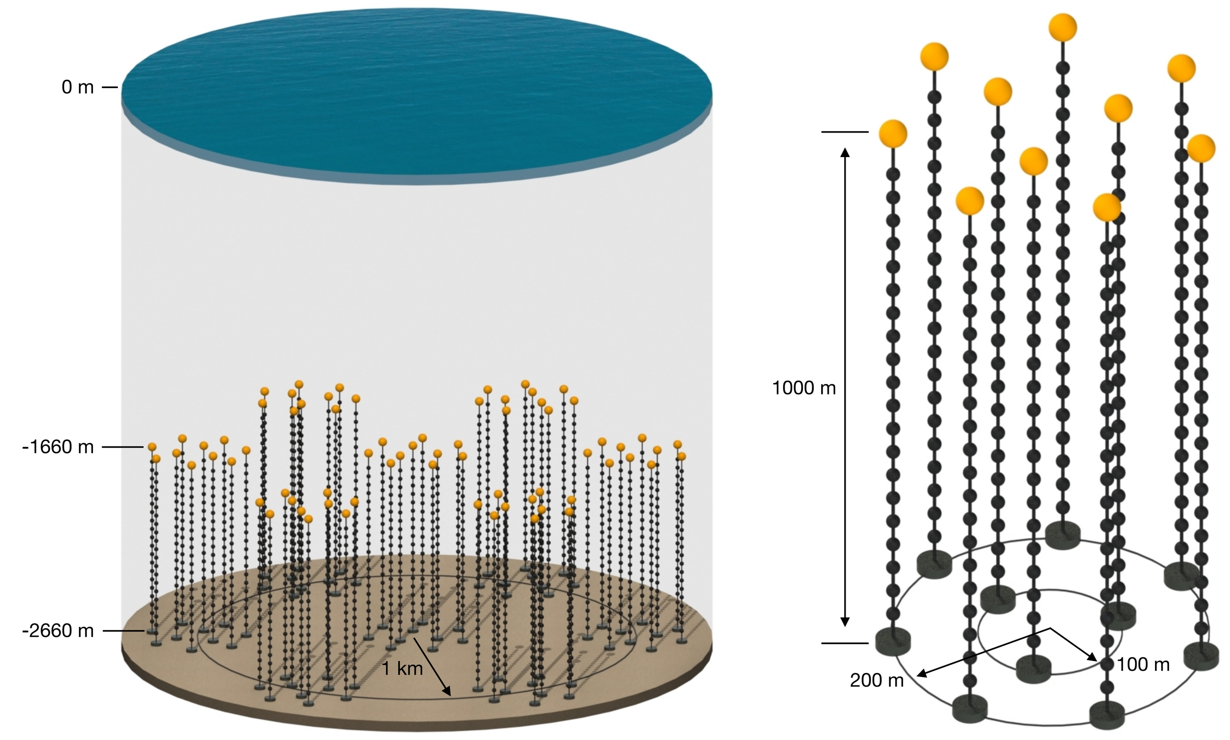

Figure 6: Left: Schematic of the P-ONE telescope, consisting of seven subsections and covering one cubic kilometer. Right: A first subsection of P-ONE, the 10-string P-ONE Explorer.

Sources

[1] IceCube Collaboration, 'Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert', Science 361, 147-151 (2018), arXiv:1807.08794

[2] M. Agostini et al., 'The Pacific Ocean Neutrino Experiment', https://arxiv.org/pdf/2005.09493.pdf

[3] C. R. Barnes et al, 'Final installation and initial operation of the world's first regional cabled ocean observatory (NEPTUNE Canada)', Canadian Meteorological and Oceanographic Society Bulletin Vol. 38, No. 3, June 2010

[4] M. Boehmer et al., 'STRAW (STRings for Absorption length in Water): pathfinder for a neutrino telescope in the deep Pacific Ocean', JINST 14 (2019) 02, P02013, arxiv:1810.13265

[5] ANTARES Collaboration, 'Transmission of light in deep sea water at the site of the Antares neutrino telescope', Astropart.Phys.23:131-155,2005, arXiv:astro-ph/0412126

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