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

Andreas Gaertner, 08/07/2020

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Neutrino telescopes

- Search for astrophysical neutrino sources
- Detect Cherenkov light of secondary particles created in neutrino interactions
- Large grid of optical modules (photomultiplier tubes) placed in transparent medium

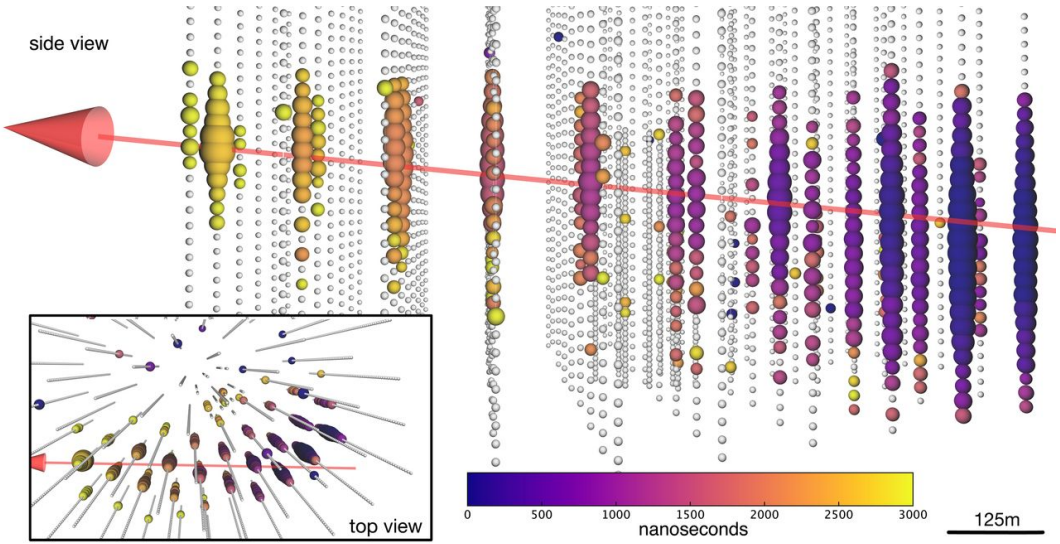

Image: IceCube Collaboration

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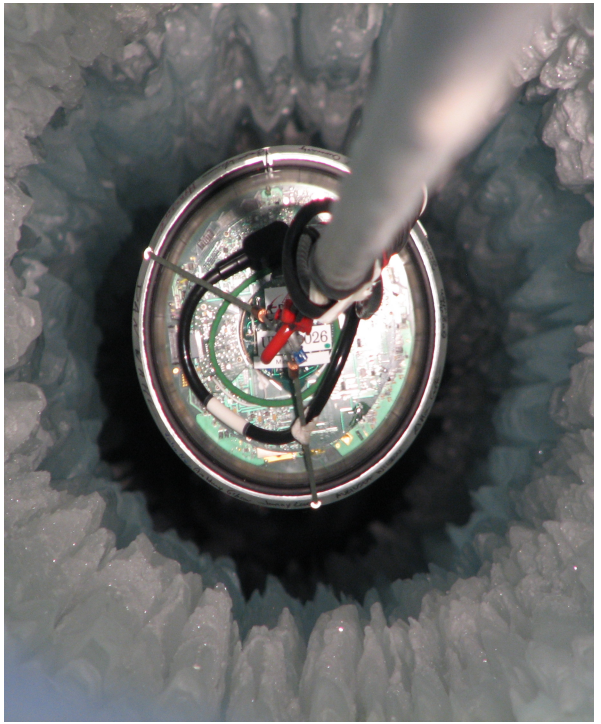
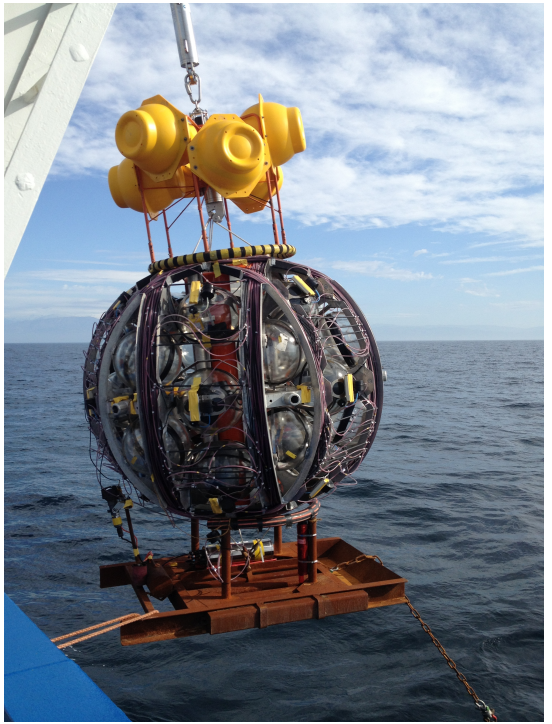
Neutrino telescopes

Natural sources of transparent Cherenkov medium

- Fresh water (Gigaton Volume Detector, Lake Baikal)
- Ice (IceCube, Antarctica)
- Sea water (KM3Net, Mediterranean)



IceCube string being lowered into a borehole
Image: Mark Krasberg, IceCube/NSF



KM3Net mooring line before deployment
Image: KM3NeT

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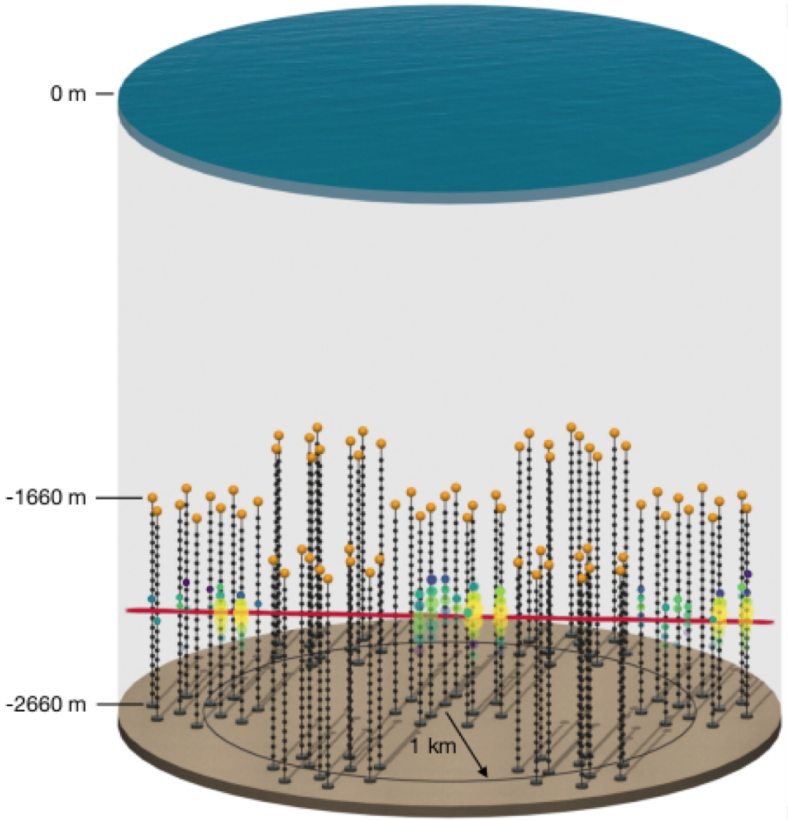
Pacific Ocean Neutrino Experiment

- Proposed new neutrino telescope near Vancouver Island
  - Cascadia Basin, 2°C year round, 2.6km deep abyssal plain
- Cubic kilometer detector, optimized for 10TeV-12PeV
- Complementary sky coverage to other neutrino telescopes
- Uses existing ONC infrastructure



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Ocean Networks Canada (ONC)

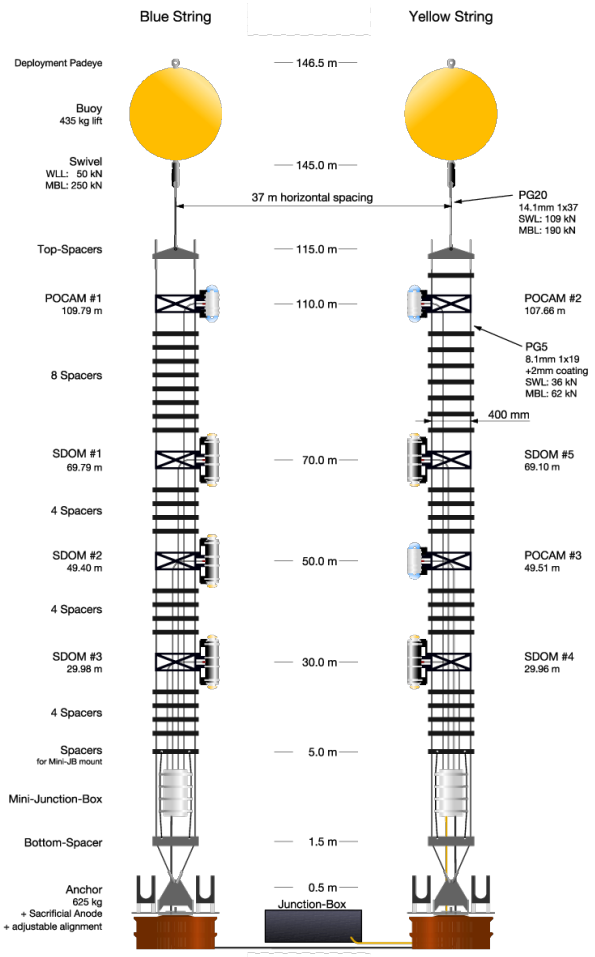
- Main challenge of marine neutrino telescopes: infrastructure
- Ocean Networks Canada provides infrastructure for various scientific disciplines in Pacific, Atlantic and Artic Sea
- Neptune observatory: 800km underwater cable loop with several nodes
- “Plug and play” power and network connection

Images: Ocean Networks Canada

First pathfinder mission - STRAW

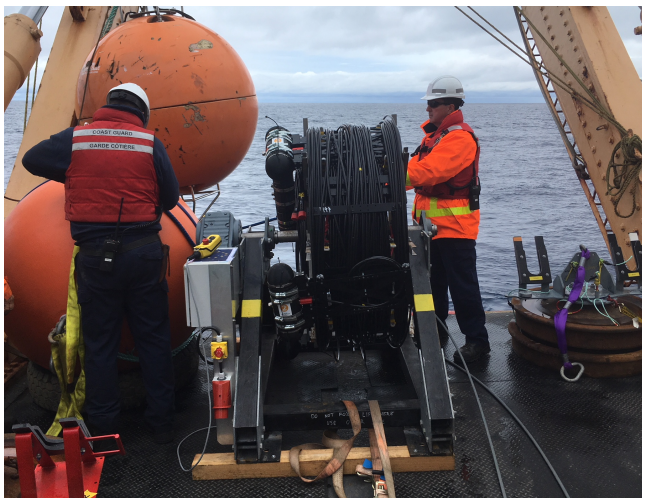
„Test optical properties and infrastructure of the site by mimicking a neutrino detector“

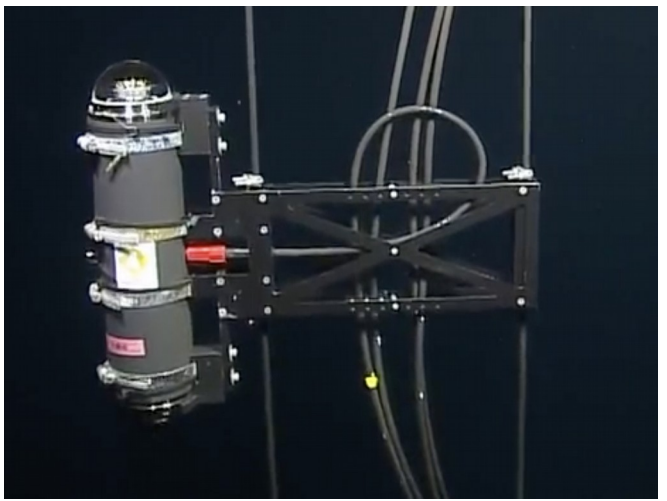
- Two strings (130m, 4 modules each)
- SDOMs (STRAW digital optical modules) for background (radioactivity, (bio-)luminescence) measurement
- POCAMs emit calibrated light pulses that can be used for absorption length and scattering measurements over the visible spectrum

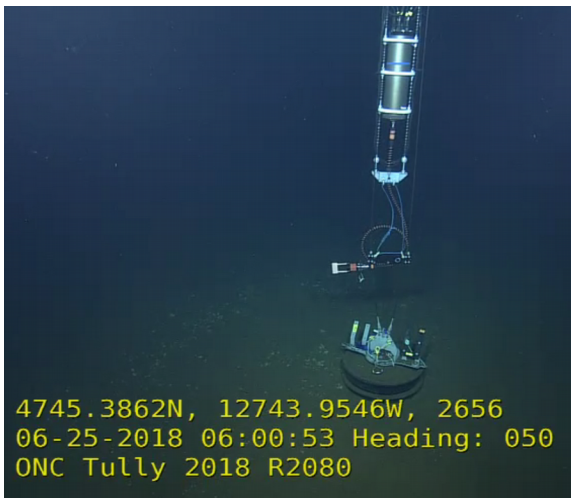


First pathfinder mission - STRAW

- built within 8 months by Ocean Networks Canada and Technical University of Munich
- Deployed in June 2018
- Continuously taking data since March 2019







Images: Ocean Networks Canada

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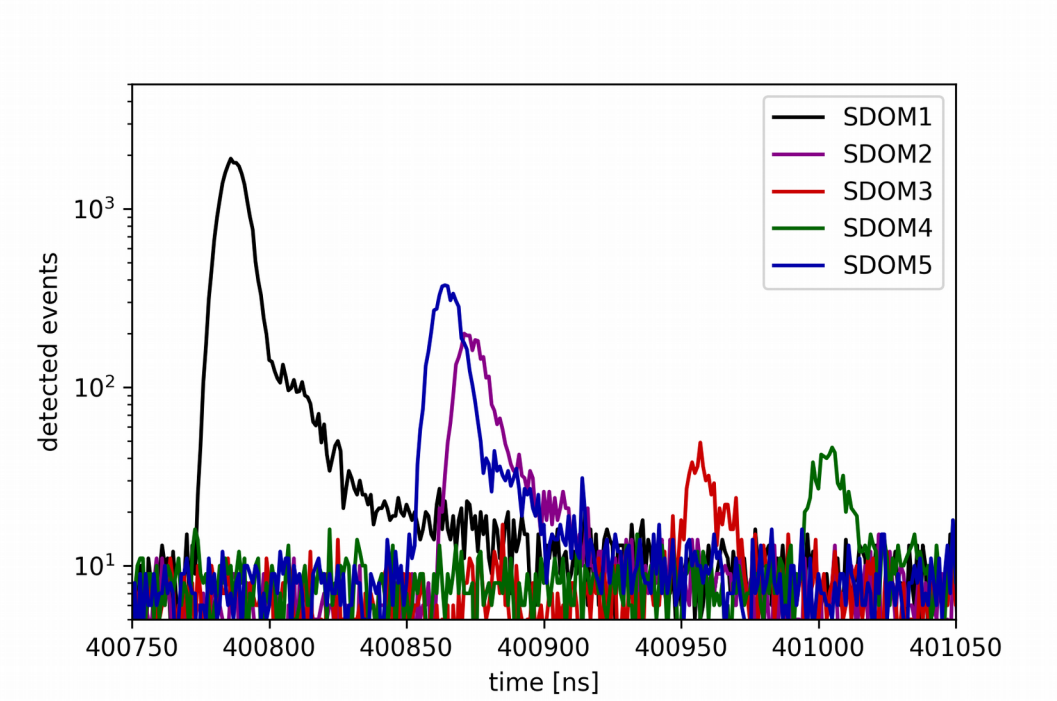
A look at the STRAW data

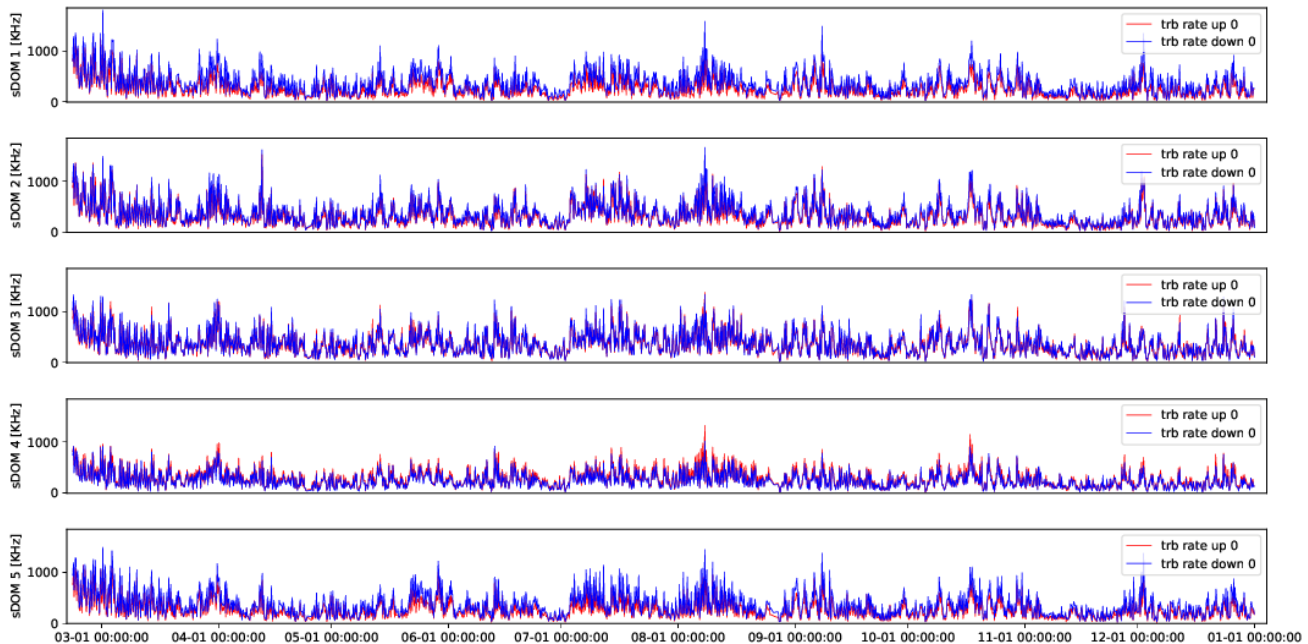
- Nanosecond scale : optical properties
  - Absorption
  - Scattering
  - Radioactivity
- Optical parameters to be published in next months
  - Water quality seems comparable to Mediterranean sites



POCAM pulse as seen in all five SDOM detectors

A look at the STRAW data

- Second to year scale : bioluminescence
- Variations corresponding to seasonal and tidal changes



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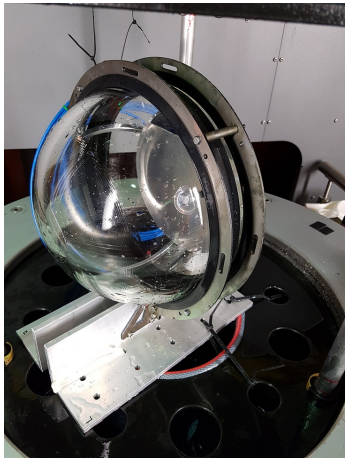
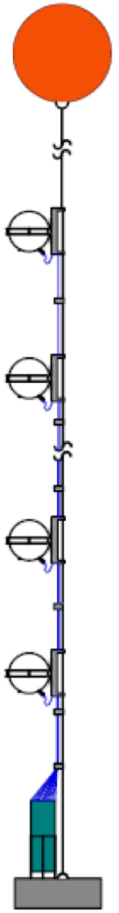
Second pathfinder mission - STRAW-b

- Test deployment of longer (0.5km) mooring line

- Ten different modules for a variety of measurements
  - LIDAR
  - Spectrometer
  - Camera
  - Muon tracker



- Hardware and electronics almost finished
- To be deployed during next ONC deployment season (September 2020)



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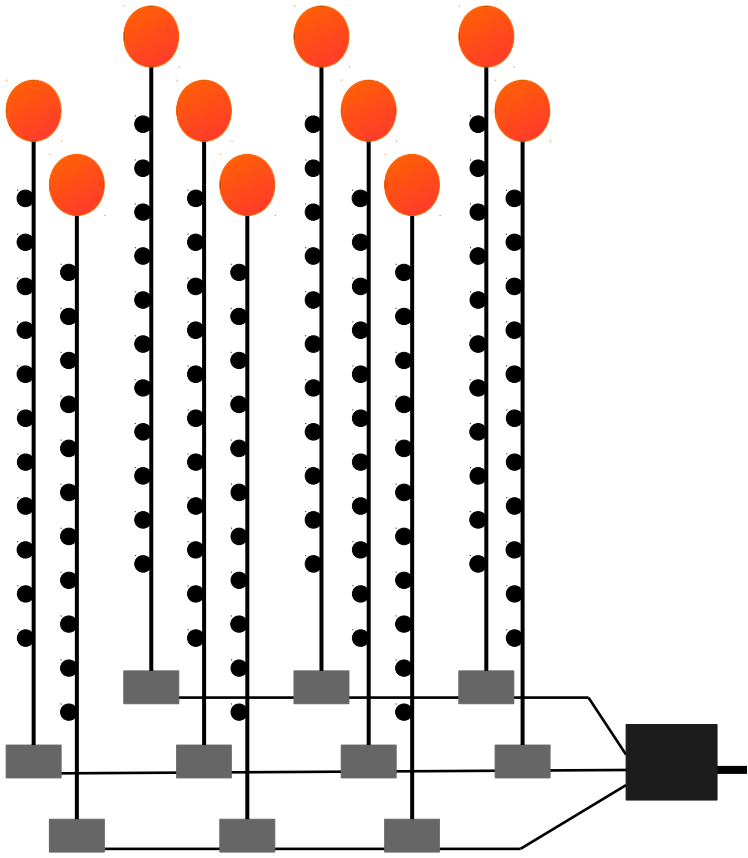
Next step : P-ONE Explorer

- 10 string (1/6th km^3) detector section
- planned deployment in 2023-2024 during four weeks operation
- 20 optical modules and 2 calibration modules per string



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Publications

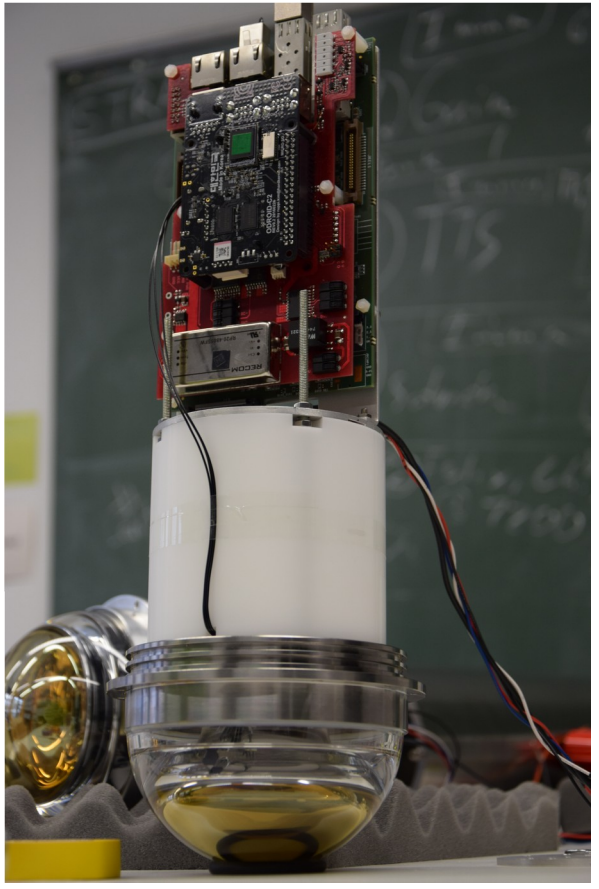
M. Agostini et al., “The Pacific Ocean Neutrino Experiment”, https://arxiv.org/pdf/2005.09493.pdf

M. Boehmer et al., “STRAW (STRings for Absorption length in Water): pathfinder for a neutrino telescope in the deep Pacific Ocean”, DOI: 10.1088/1748-0221/14/02/P02013

Backup - SDOM

STRAW Digital Optical Module

- Two PMTs facing up and down
- Time-over-threshold measurements with 4 thresholds
- SDOMs are synchronized with nanosecond precision



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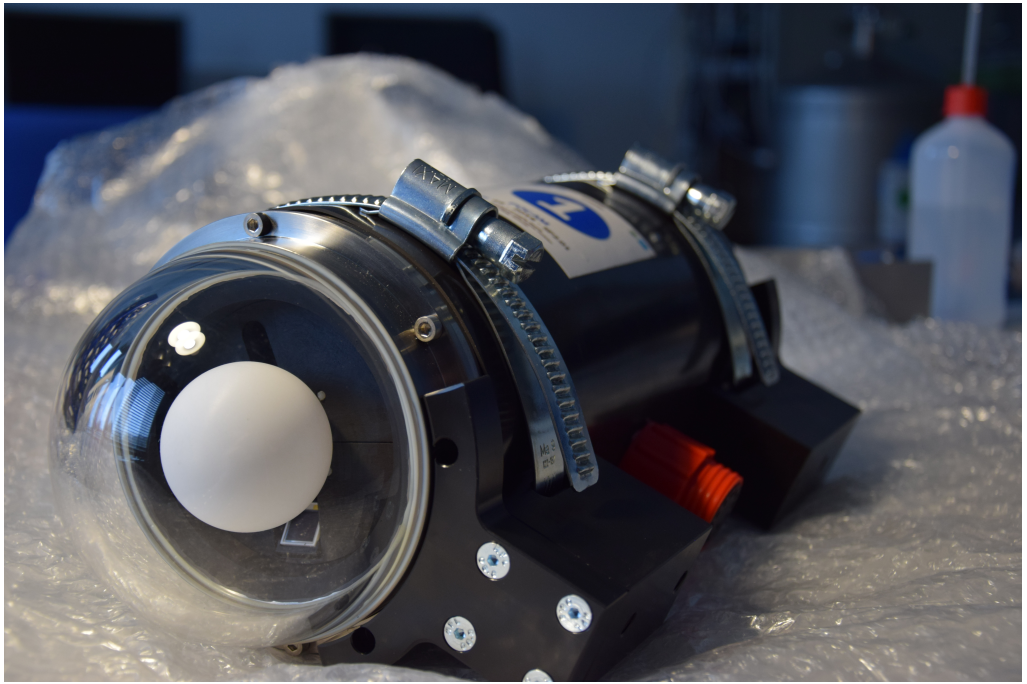
Backup - POCAM

Precision Optical Calibration Module

- Isotropic light source creating nanosecond pulses of 10^9 photons
- Designed for IceCube upgrade
- Successfully tested in Lake Baikal in 2017



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Backup – STRAW Deployment

- Each string (including modules) stored on a winch
- Minimal deck operations
  - Unspooling
  - Functionality test
  - Load transfer to heavy lift line
  - Descent
  - Underwater connection done by ROV

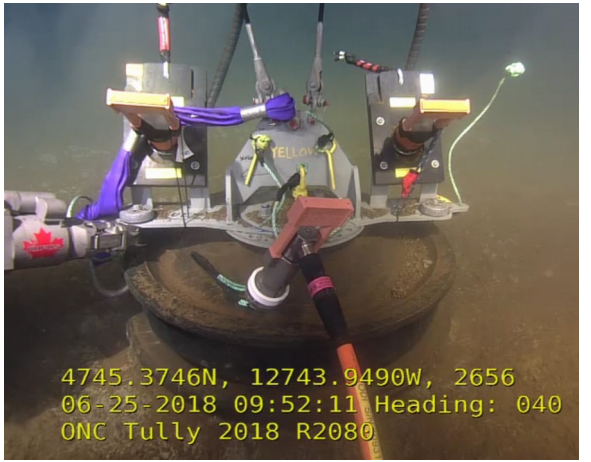
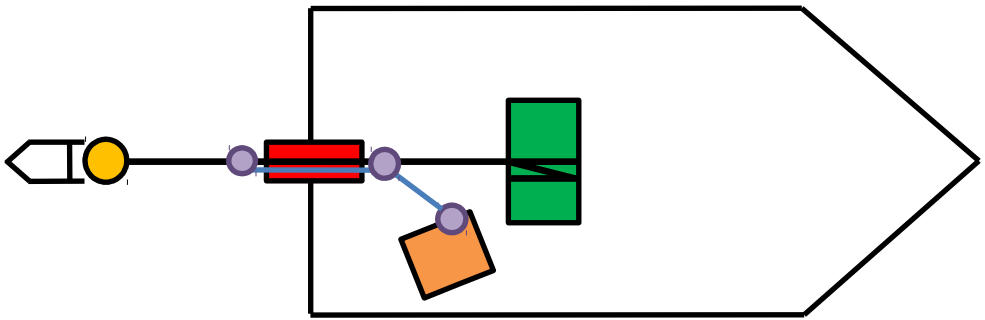


Image: Ocean Networks Canada

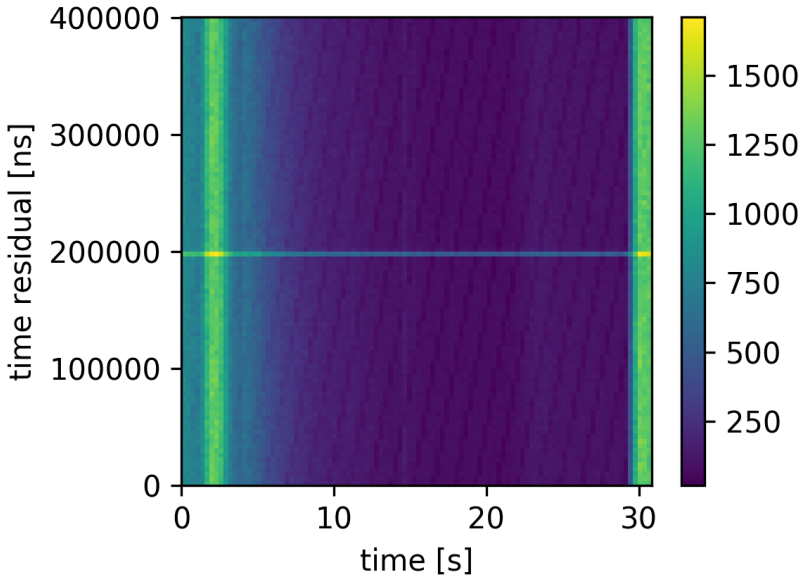
Backup – STRAW-b deployment

- Two component approach
  - Modules are already electrically connected and stored on a tray
    - Easy shipping and testing
    - No large forces act on tray
  - Steel line stored on winch
- Both components are mated on the back deck during deployment

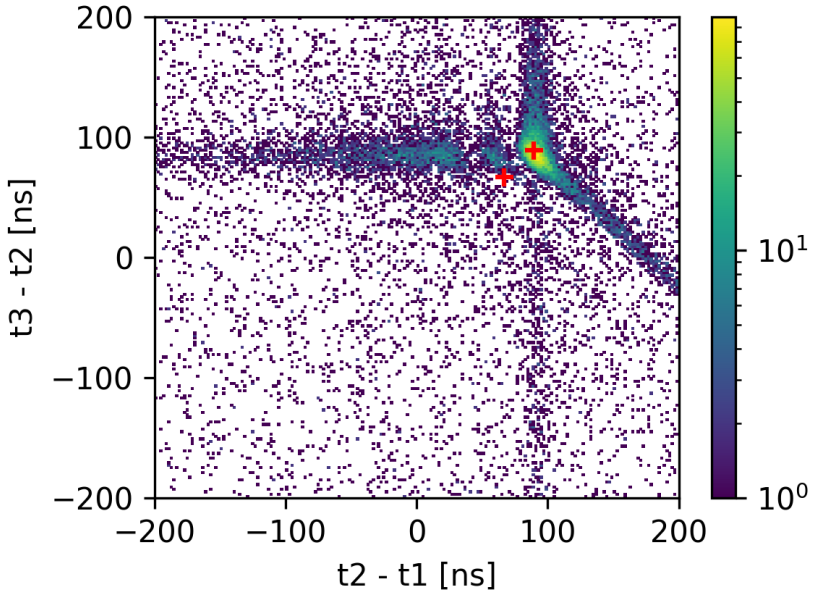


Backup – POCAM signal and bioluminescence

- POCAM signal can be extracted using regularity of signal or multi-SDOM coincidence

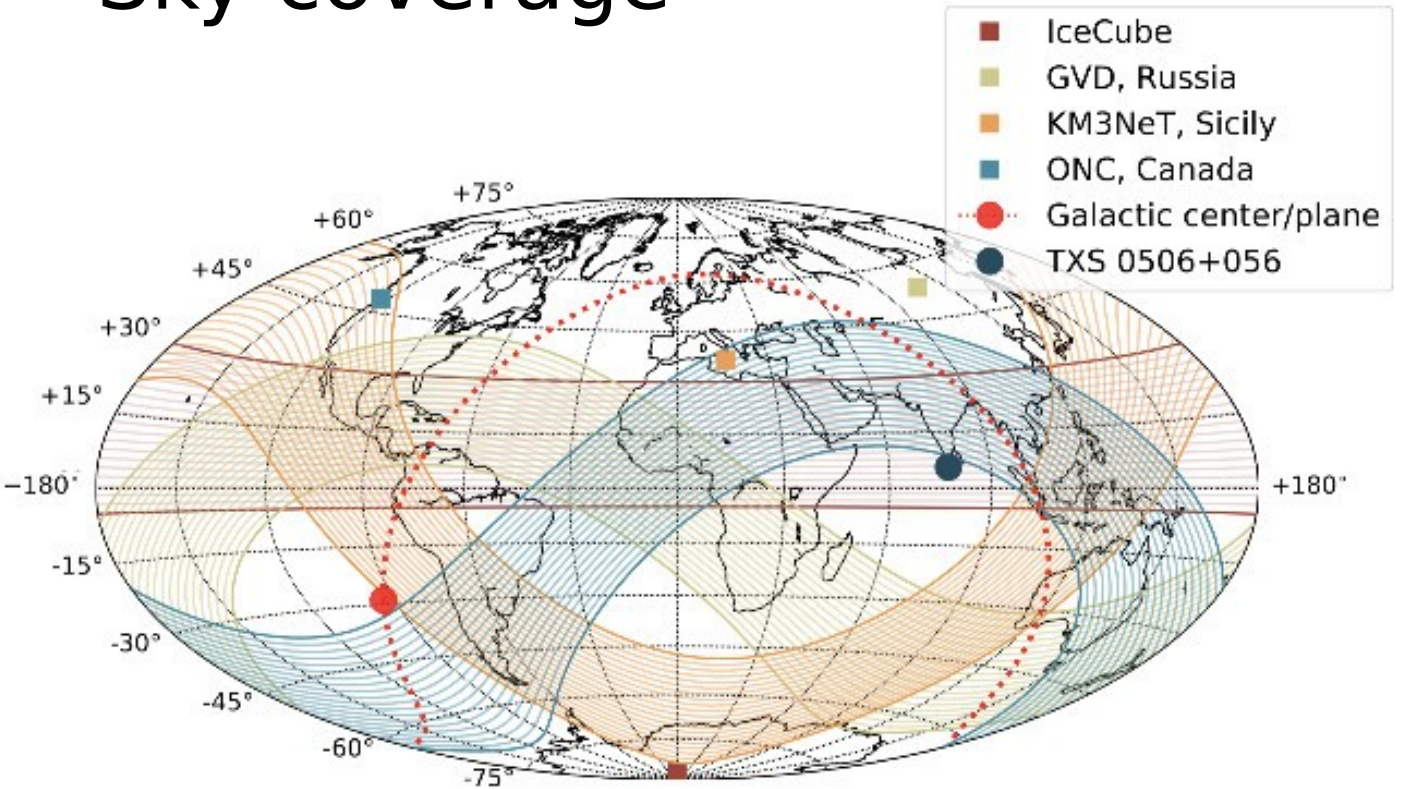


Time vs time residual (time % POCAM period). The POCAM signal is visible as a horizontal line.



Time difference between events in SDOMs 1 and 2, and SDOMs 2 and 3. We see a clear accumulation of events corresponding to the POCAM pulses

Backup – Sky coverage



Coverage of neutrino telescopes at PeV energies

Credit: M. Huber, TUM

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