

Water Tank-Based Measurement System for Optical Modules of Neutrino Telescopes

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- Investigation of ultra high energy cosmic ray sources is a fundamental task in Astroparticle Physics
- Information is obtained by detection of different messenger particles
- Why neutrinos?
 - Not deflected by magnetic fields
 - Not absorbed like photons
 - Weakly interacting
 - Only produced by hadronic interactions

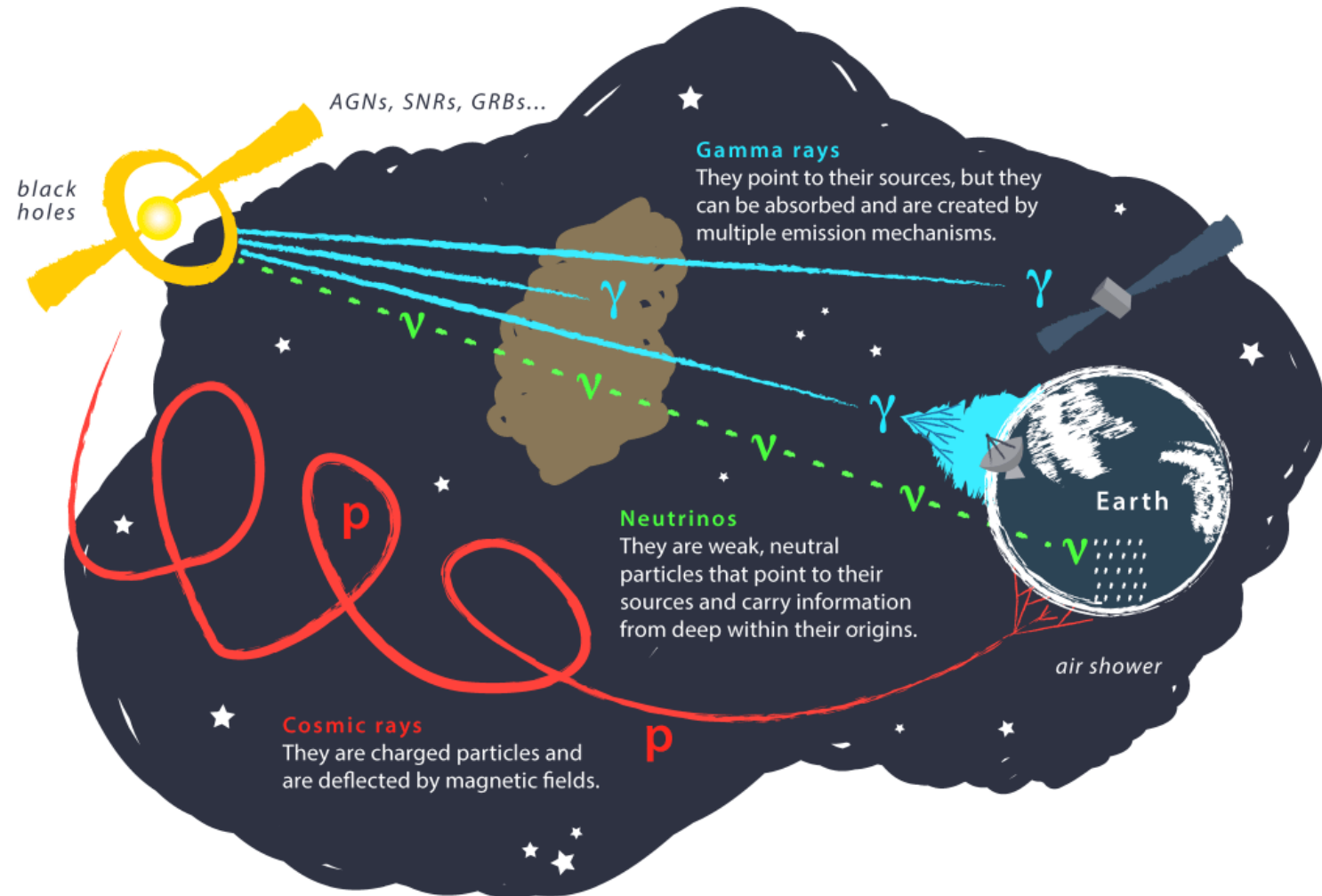
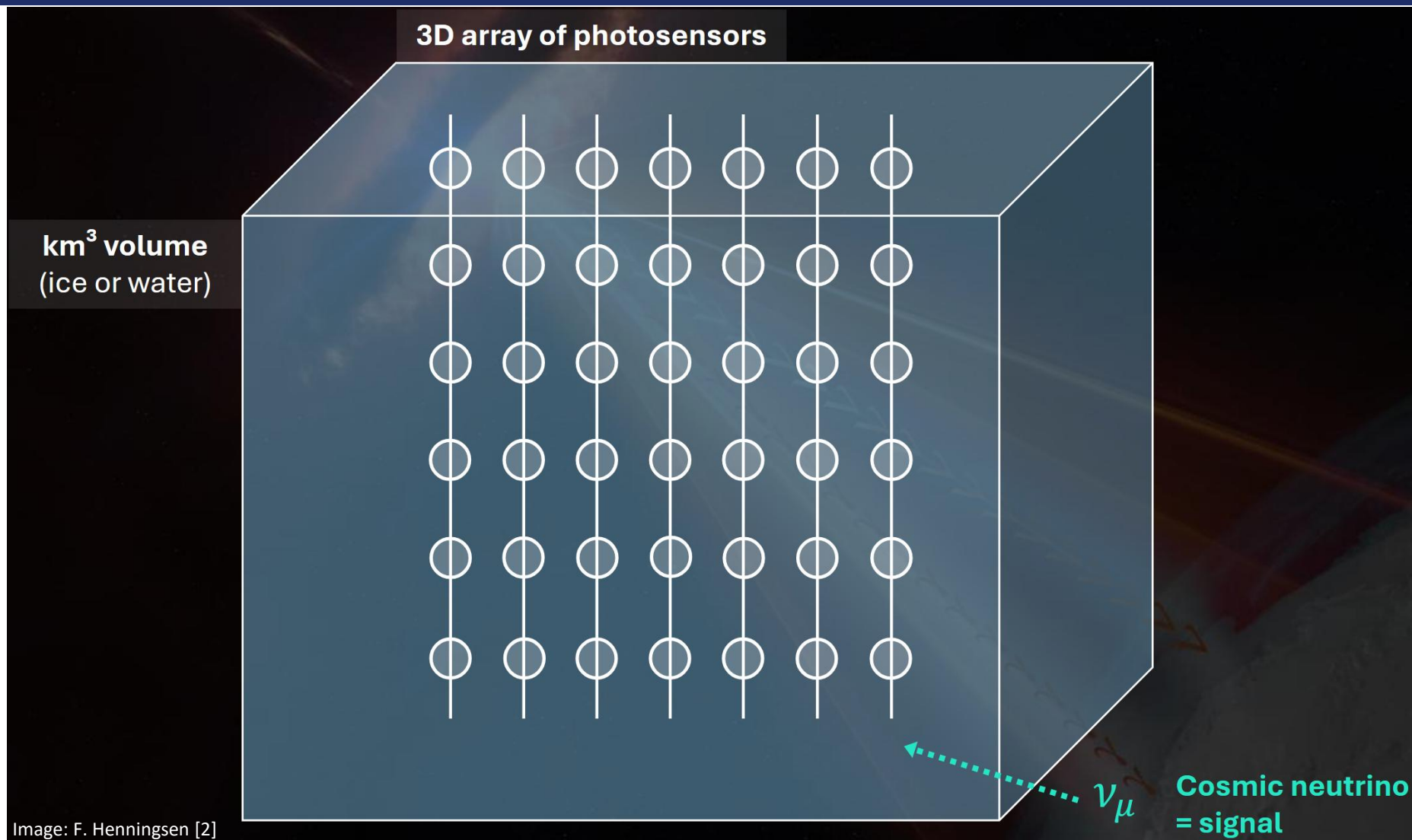
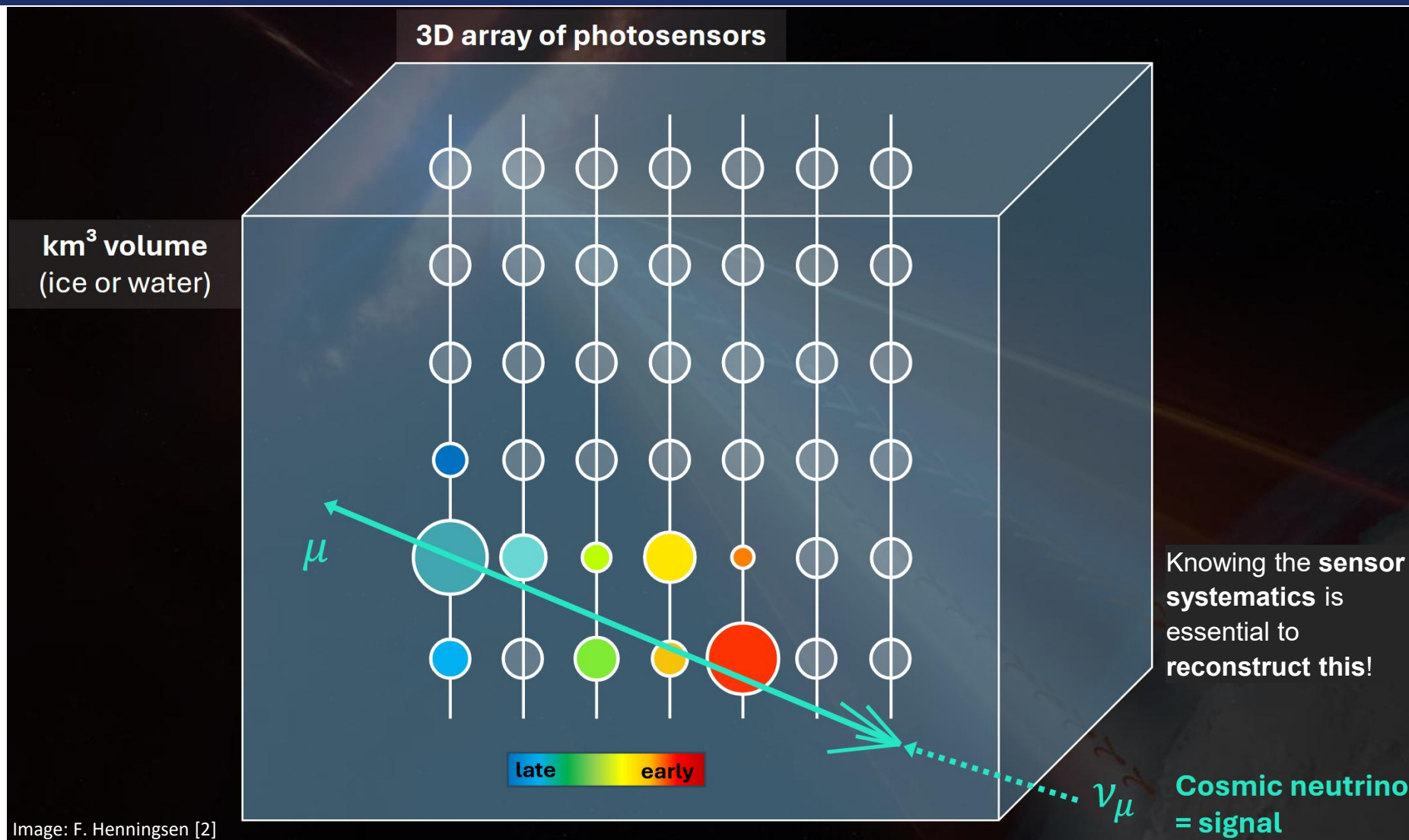


Image: J. A. Aguilar and J. Yang, IceCube/WIPAC, [1]

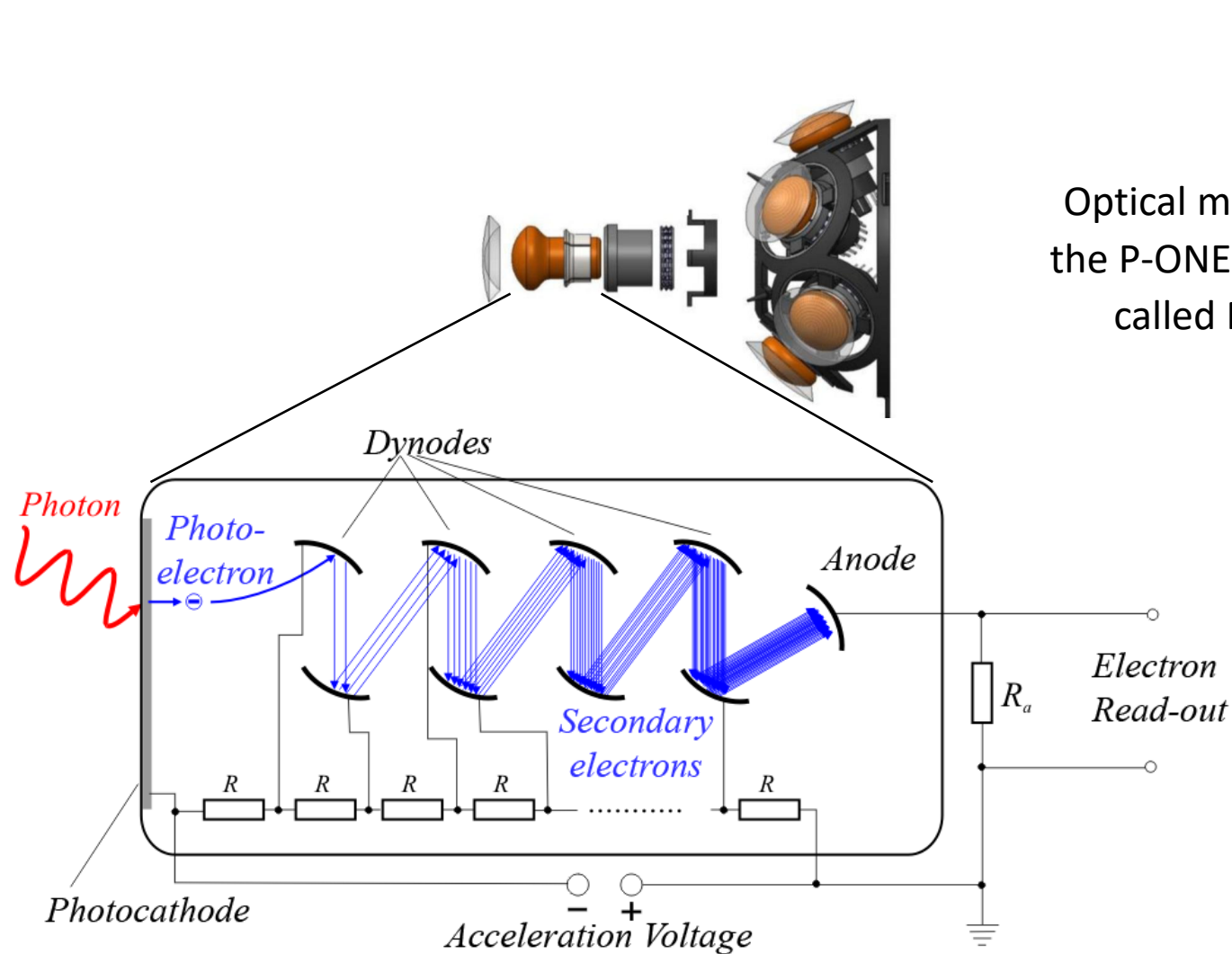




Photomultiplier Tubes (PMTs)

General

- PMTs are highly sensitive light detectors
- Based on the photoelectric effect
- Exponential amplification of photoelectron via dynodes



Optical module of
the P-ONE detector
called P-OM



Image: Wikimedia, Photomultiplier, [8]

Image: F. Henningsen [2]

- Sensitivity of PMTs depends on the incident direction of incoming photons

What do you need to measure angular acceptance:

- Well understood light source
- Device for rotating optical module
- **Water tank**

$\Theta > 0^\circ$, ang. acc. < 1

$\Theta = 0^\circ$, ang. acc. $= 1$

$\Theta < 0^\circ$, ang. acc. < 1

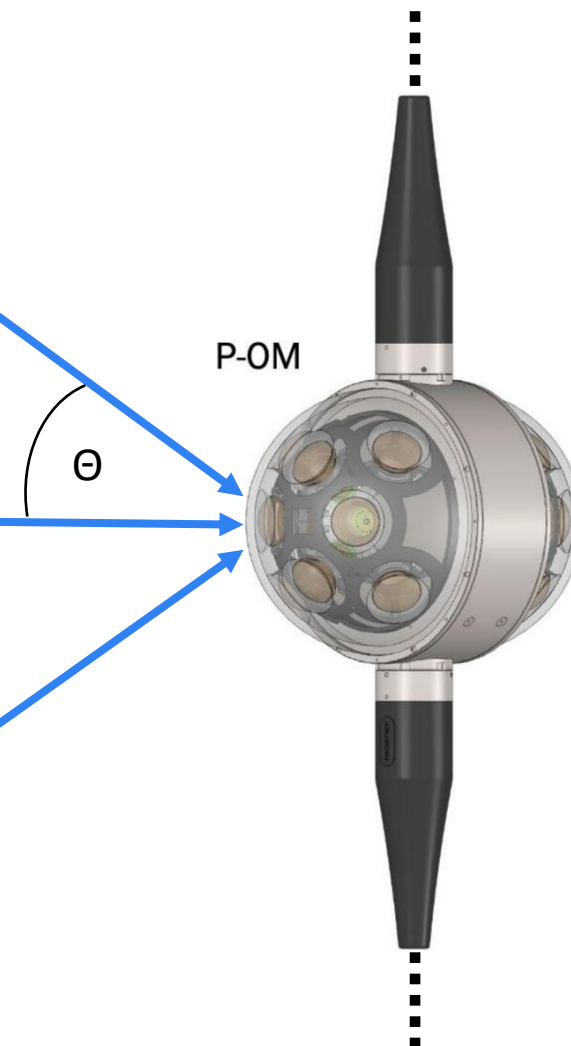
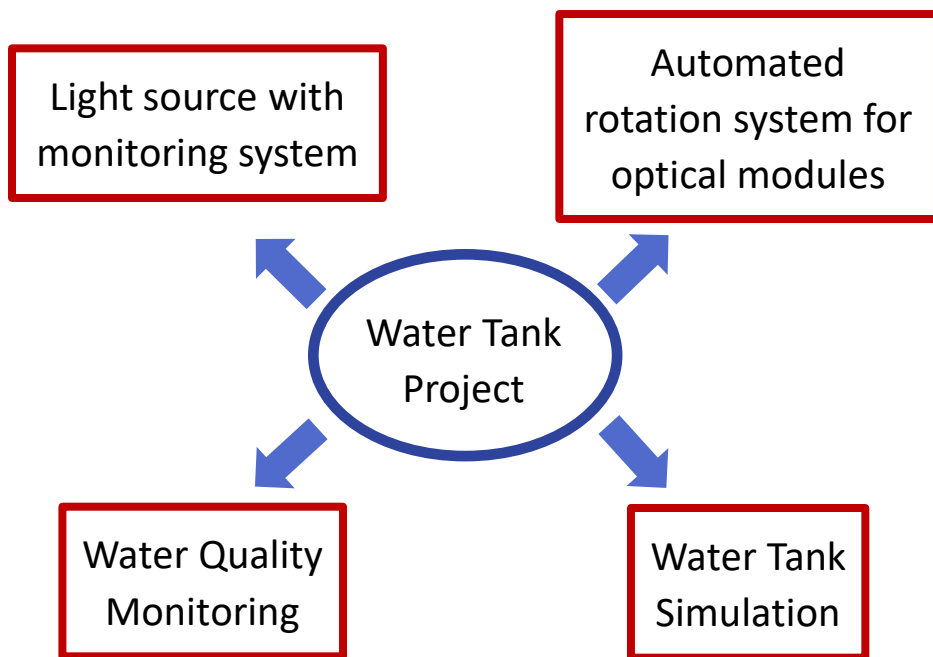


Image: F. Henningsen [2]

Long-term goal:

Automated measurement system for
optical modules of neutrino telescopes
(not only P-ONE)



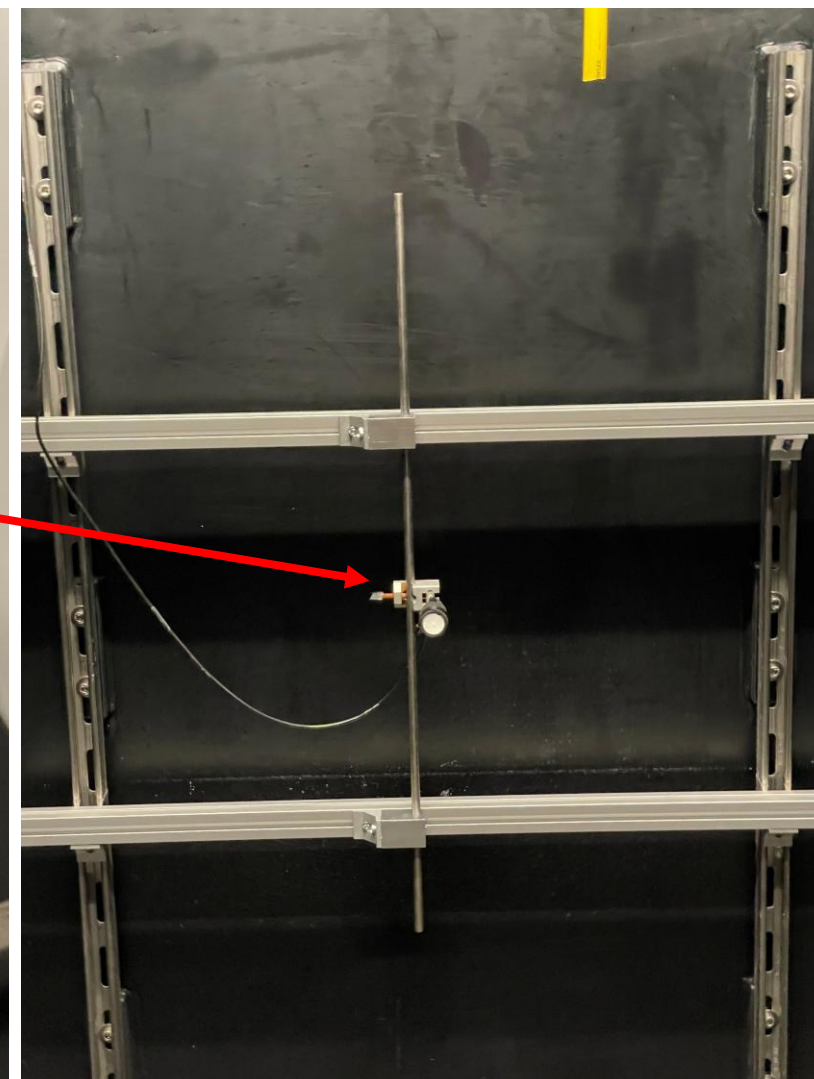
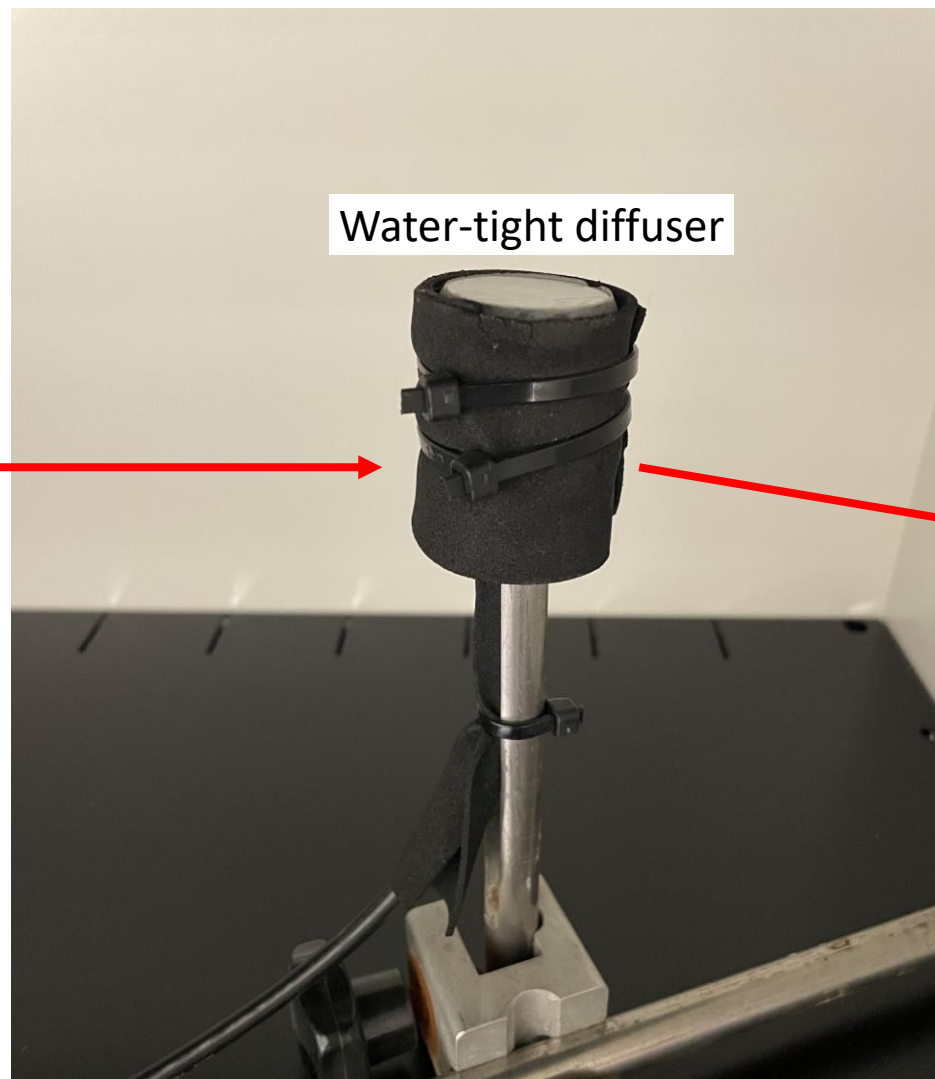
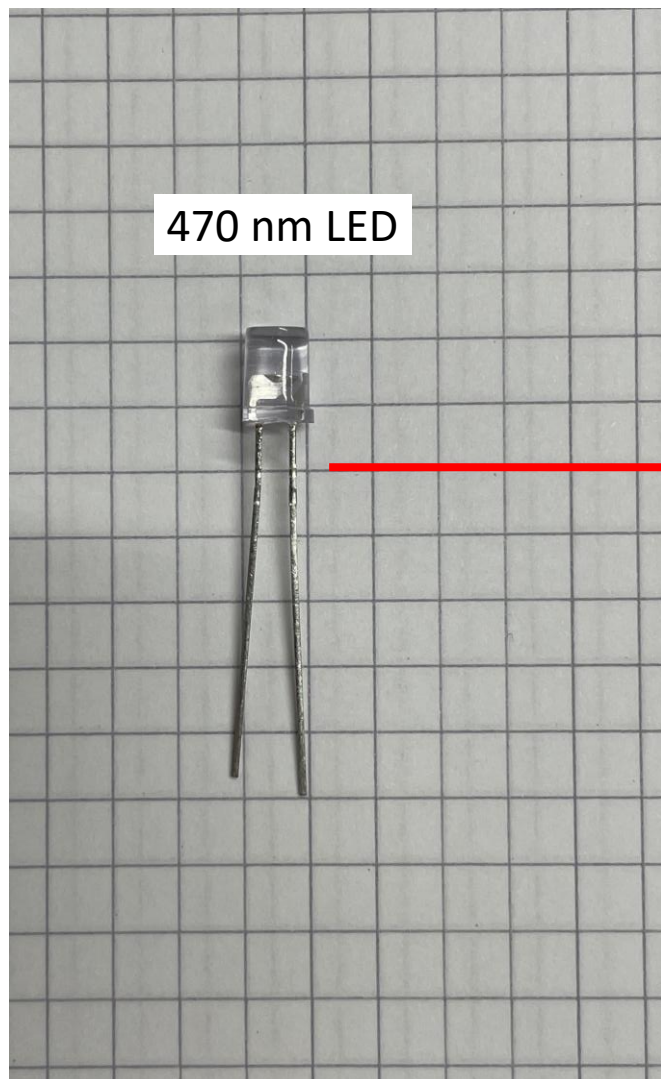
Upcoming Measurement

- Colleagues from Munich come to ECAP next week and bring a P-OM hemisphere of P-ONE



Upcoming Measurement

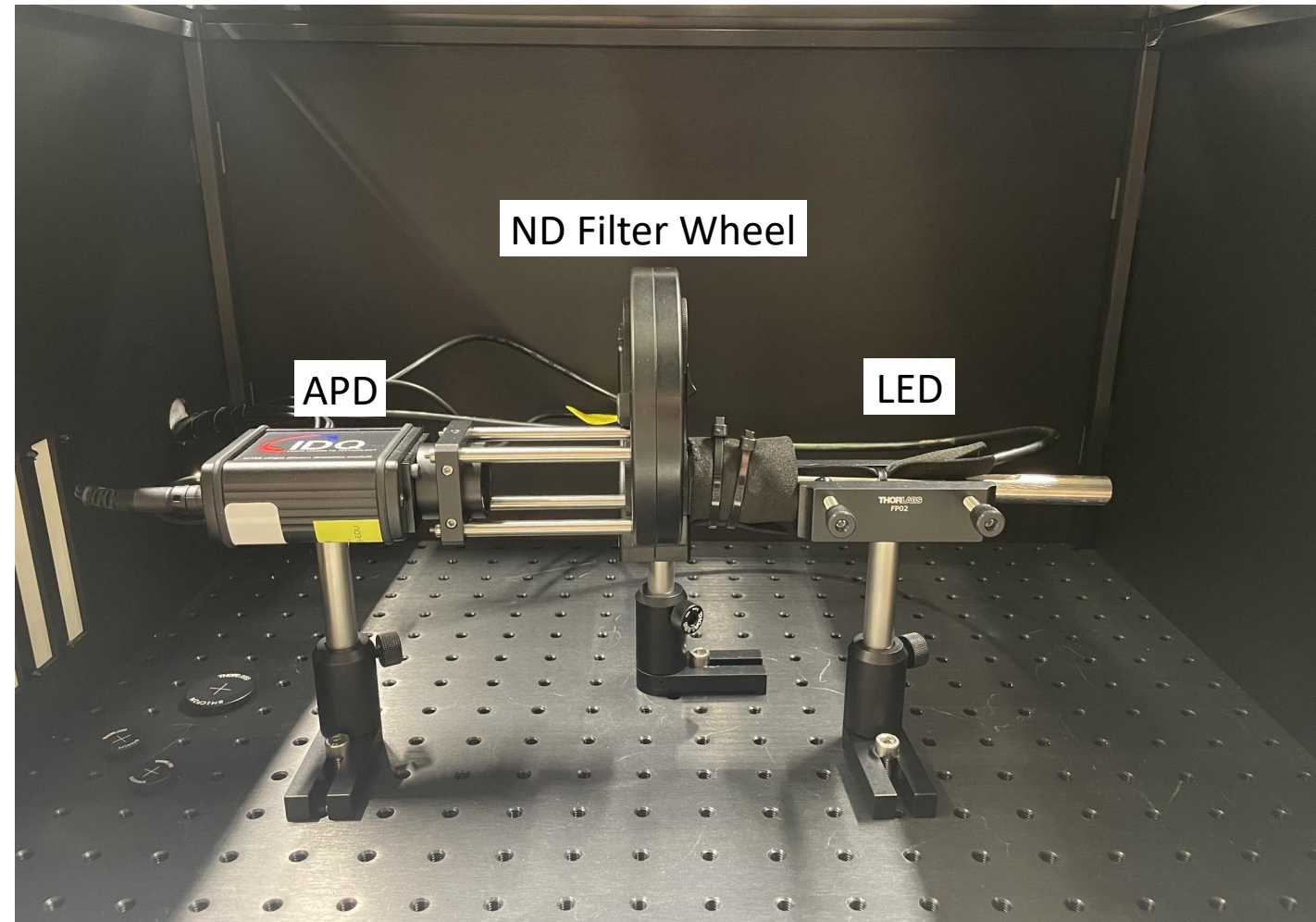
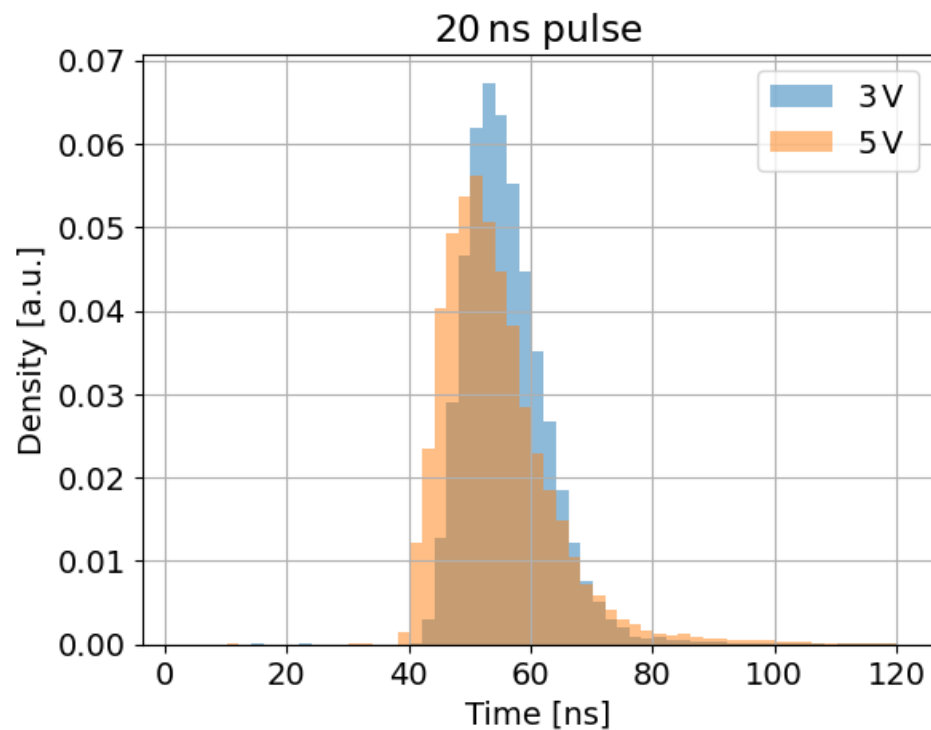
LED



Upcoming Measurement

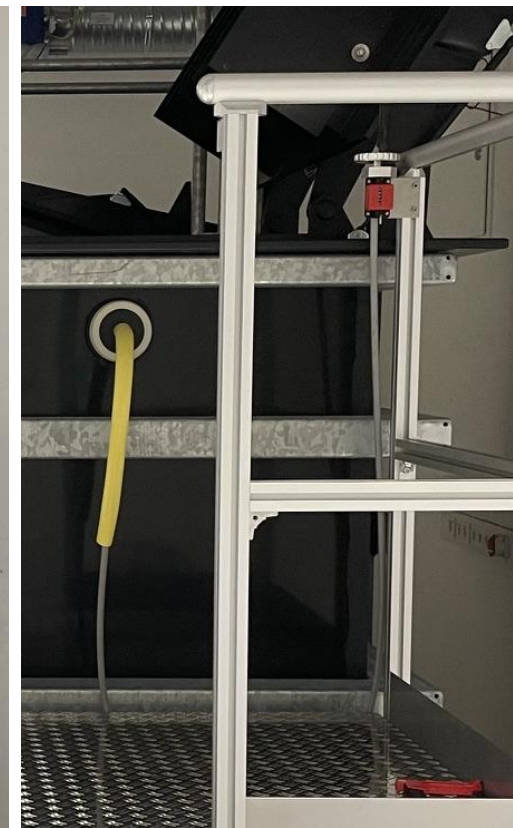
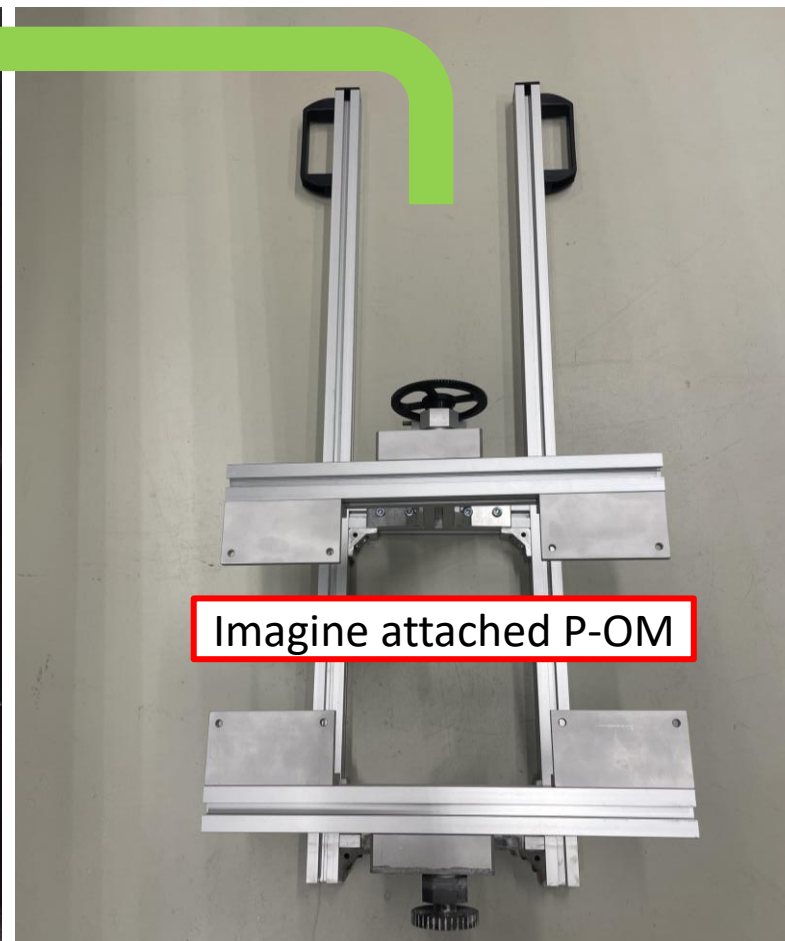
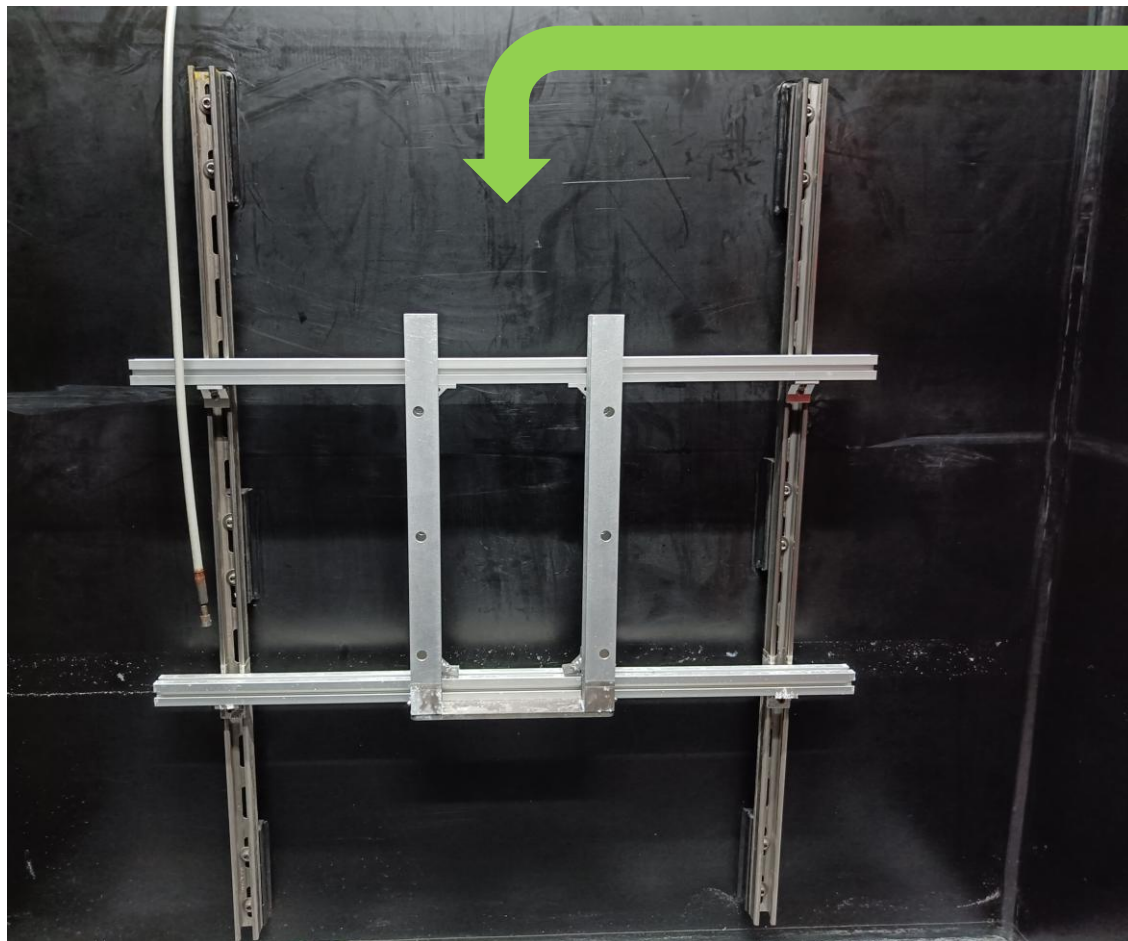
Time Profile Measurement with APD

- Need to understand light pulses of our LED
- Measure time profile using an **avalanche photodiode (APD)**

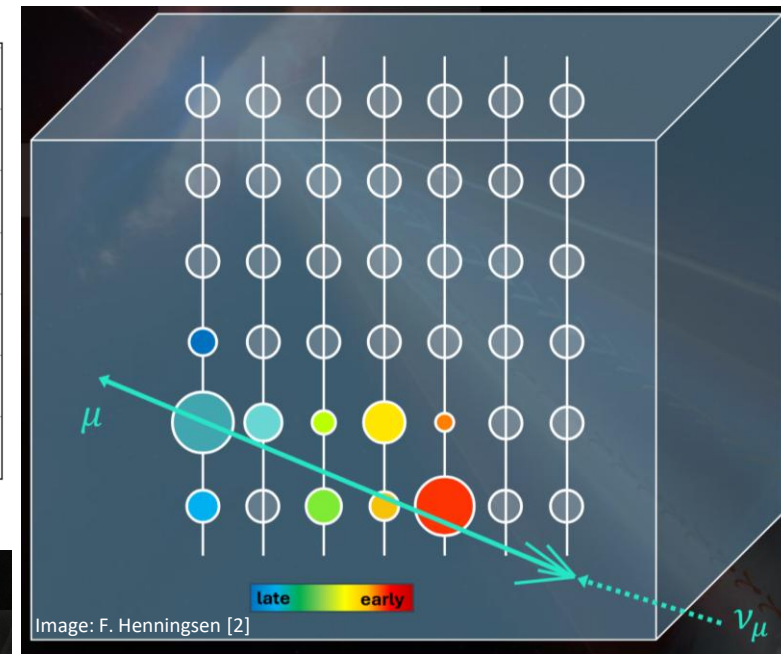
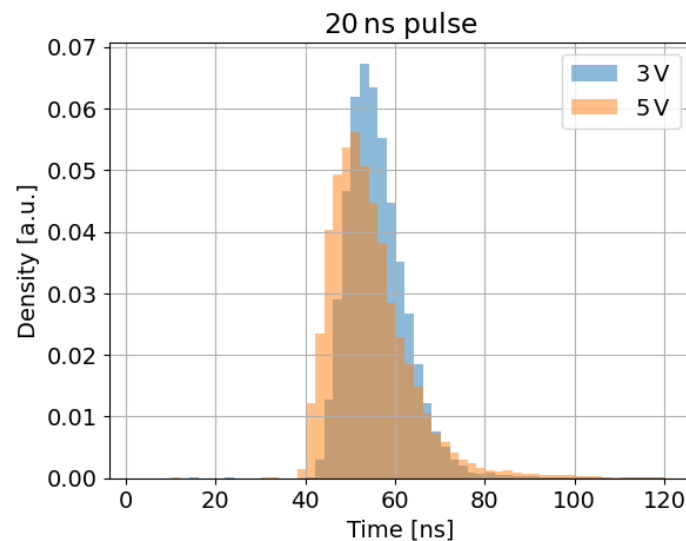


Upcoming Measurement

Optical Module Mount

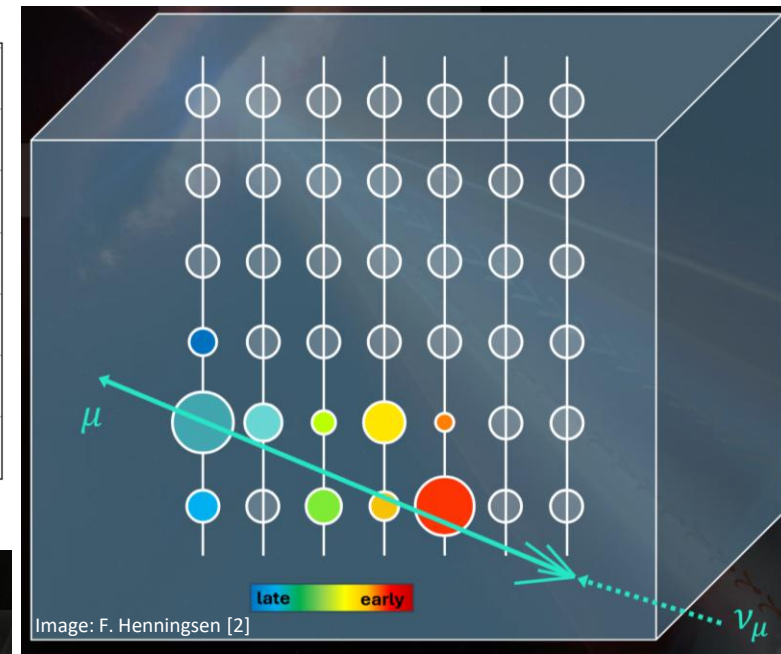
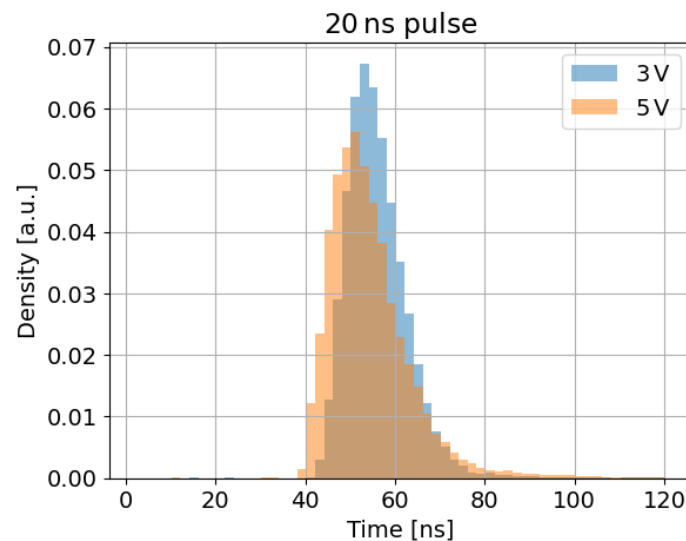


- Recently started working on a measurement system for optical modules of neutrino telescopes
- First measurement next week with a P-OM hemisphere
- Lots of work ahead, results will follow...



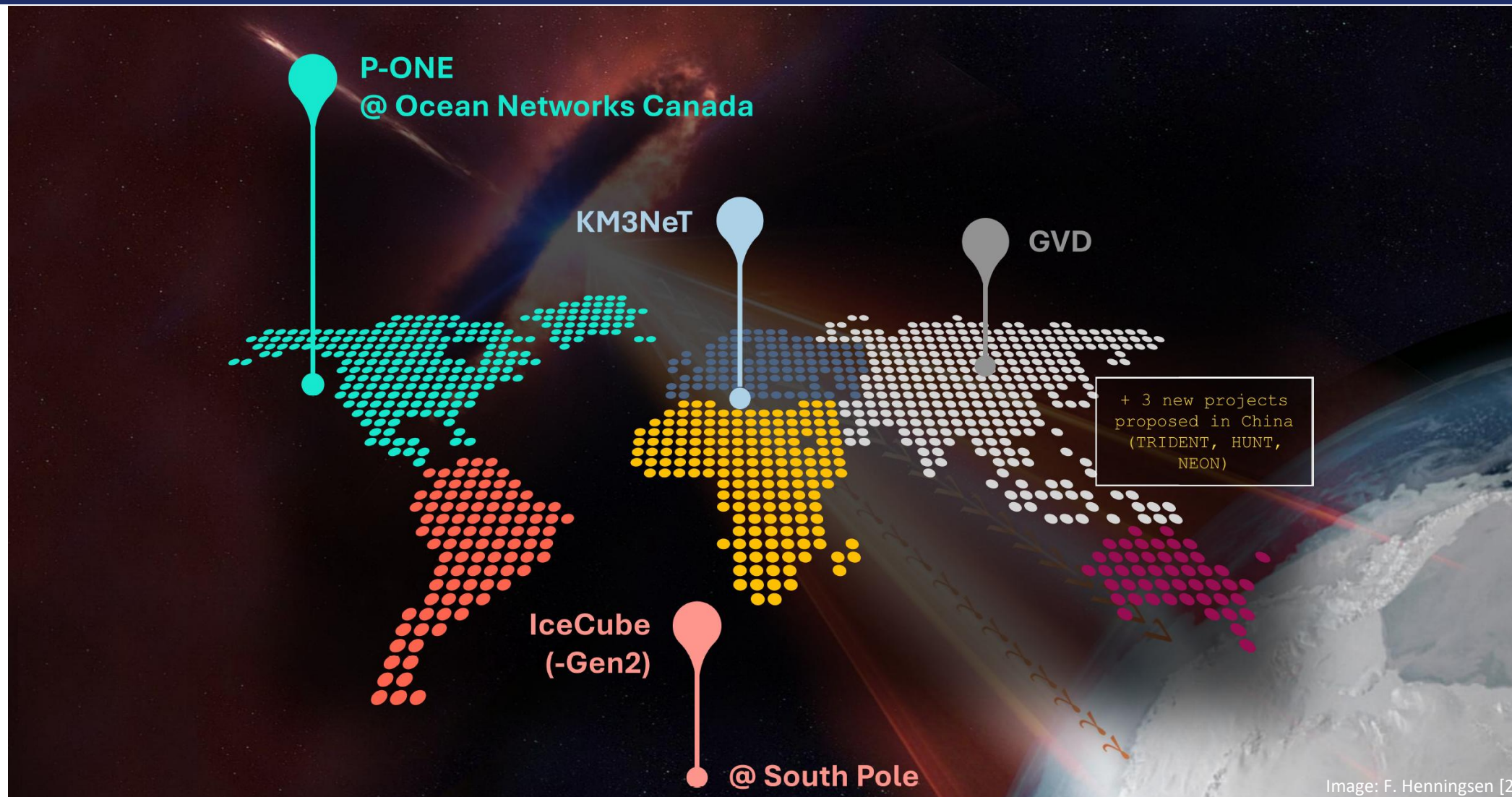
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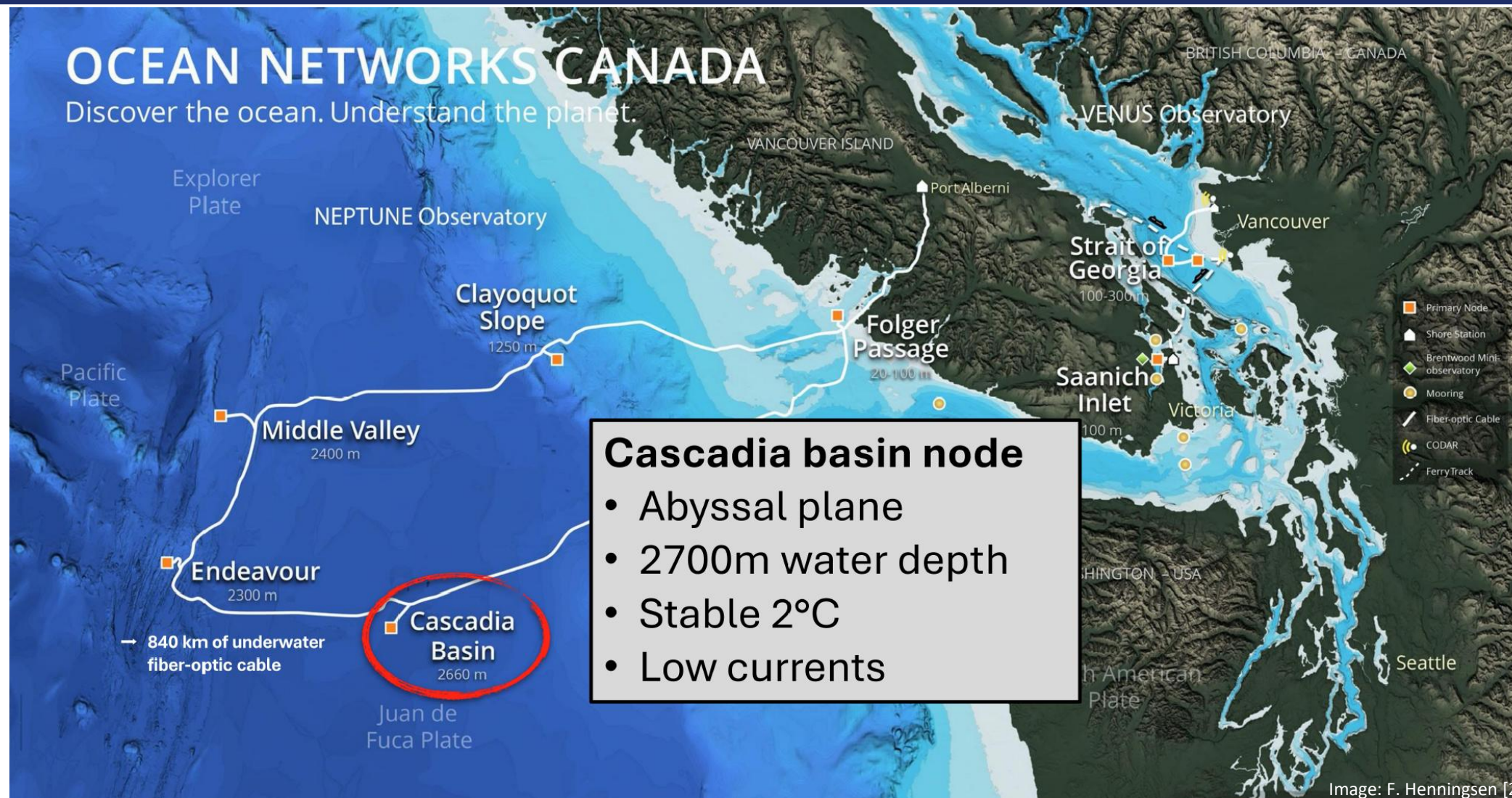
Thank you!



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- [1] J.A. Aguilar and J. Yang, IceCube/WIPAC, <https://icecube.wisc.edu/news/research/2016/10/neutrinos-and-gamma-rays-partnership-to-explore-extreme-universe/>, accessed December 02, 2025
 - [2] F. Henningsen, personal correspondence, 2026
 - [3] Agostini, M., Böhmer, M., Bosma, J. *et al.* The Pacific Ocean Neutrino Experiment. *Nat Astron* **4**, 913–915 (2020). <https://doi.org/10.1038/s41550-020-1182-4>
 - [4] P-ONE website, <https://www.pacific-neutrino.org/p-one>, accessed July 15, 2026
 - [5] F. Henningsen, *Pacific Ocean Neutrino Experiment: Expected performance of the first cluster of strings*, PoS (ICRC2023) 1053, 2023, DOI: <https://doi.org/10.22323/1.444.1053>
 - [6] Wikipedia, Cherenkov radiation, https://en.wikipedia.org/wiki/Cherenkov_radiation, accessed July 15, 2026
 - [7] C. Spannfellner, *Design of the Pacific Ocean Neutrino Experiment's First Detector Line*, PoS (ICRC2023) 1219, 2023, DOI: <https://doi.org/10.22323/1.444.1219>
 - [8] Wikimedia, Photomultiplier, https://commons.wikimedia.org/wiki/File:Photomultiplier_schema_en.png, accessed July 15, 2026

Backup





~1 km³ detector volume,
segmented structure

10 lines per cluster

20 optical modules
per line

16 3.1"-PMTs per module
(Hamamatsu R14374-10)

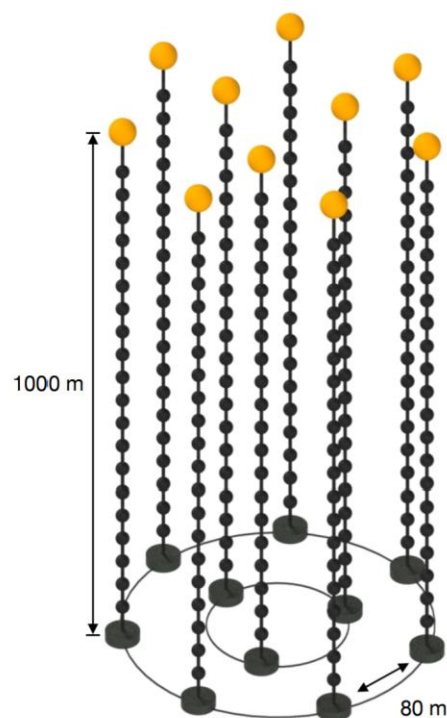
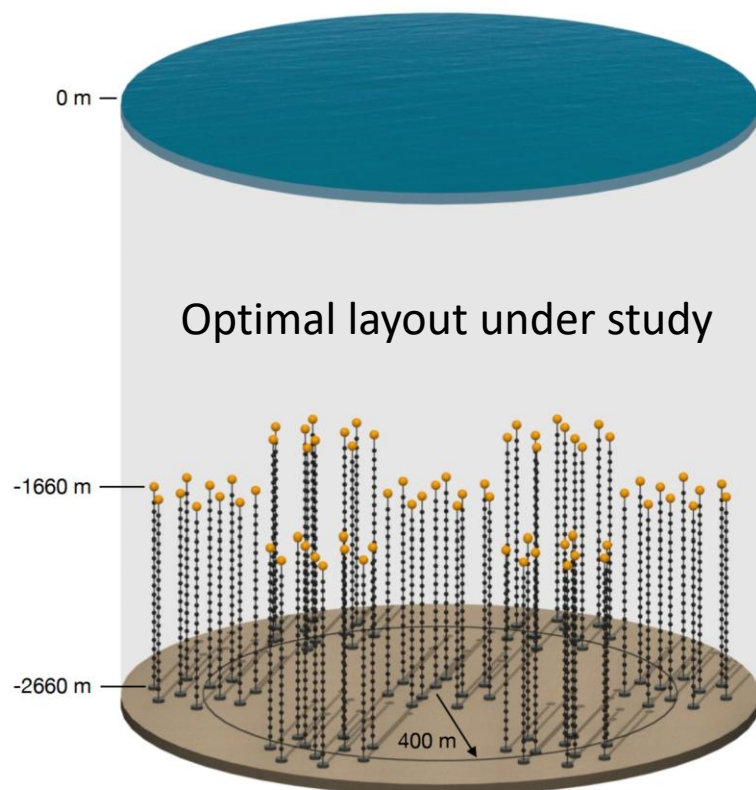


Image: PoS (ICRC2023) 1053, [5]

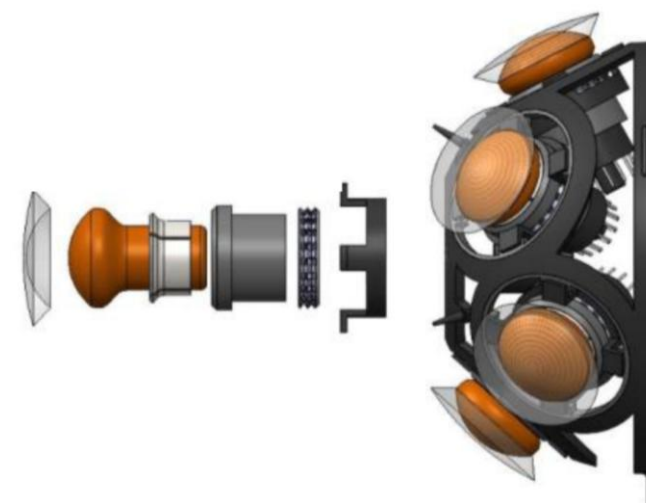


Image: F. Henningsen [2]

Detection Principle

Cherenkov Radiation

- **Neutrinos are detected indirectly** by observing Cherenkov radiation induced by secondary charged particles

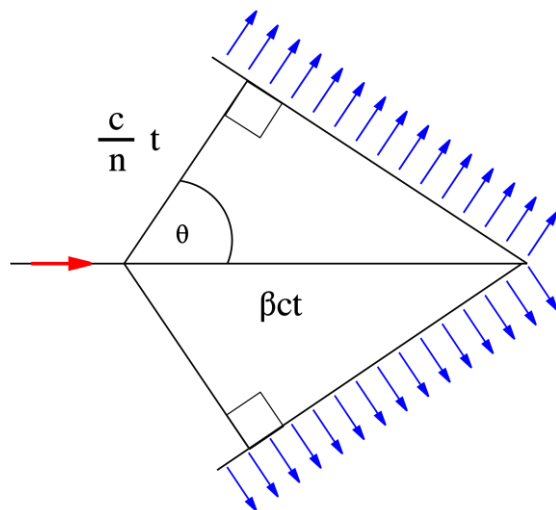


Image: Wikipedia, Cherenkov radiation, [6]

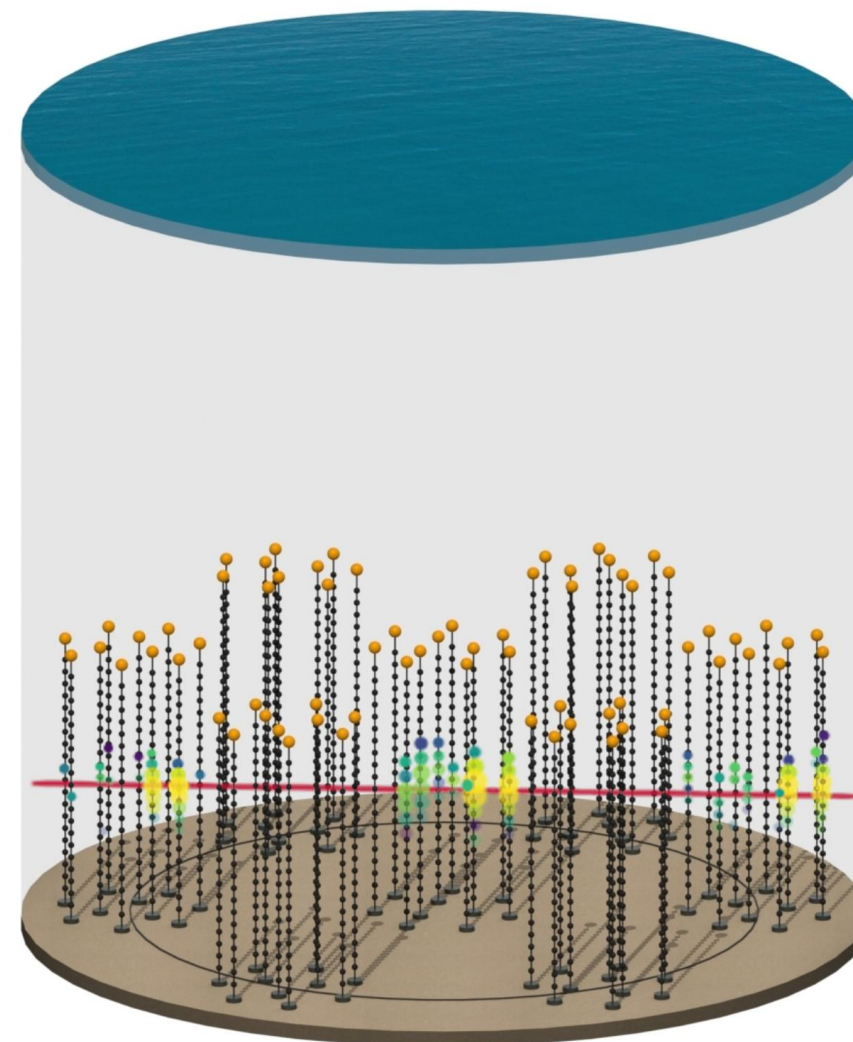
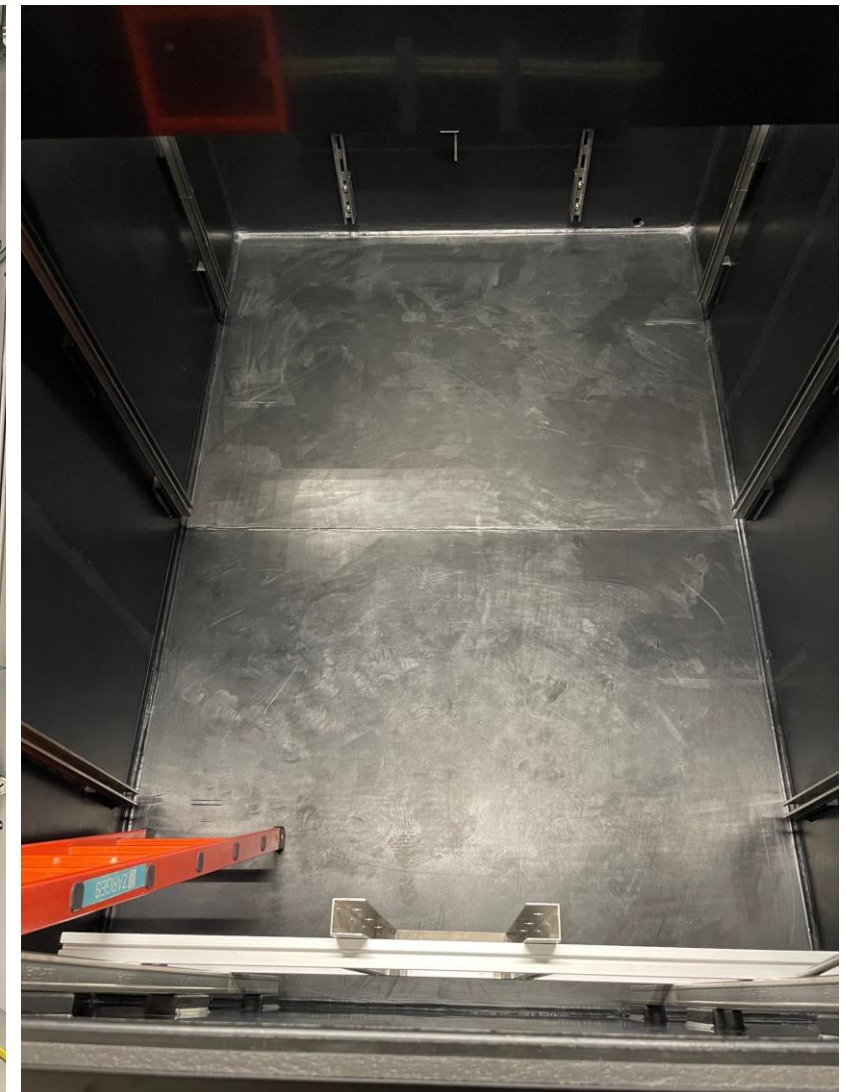
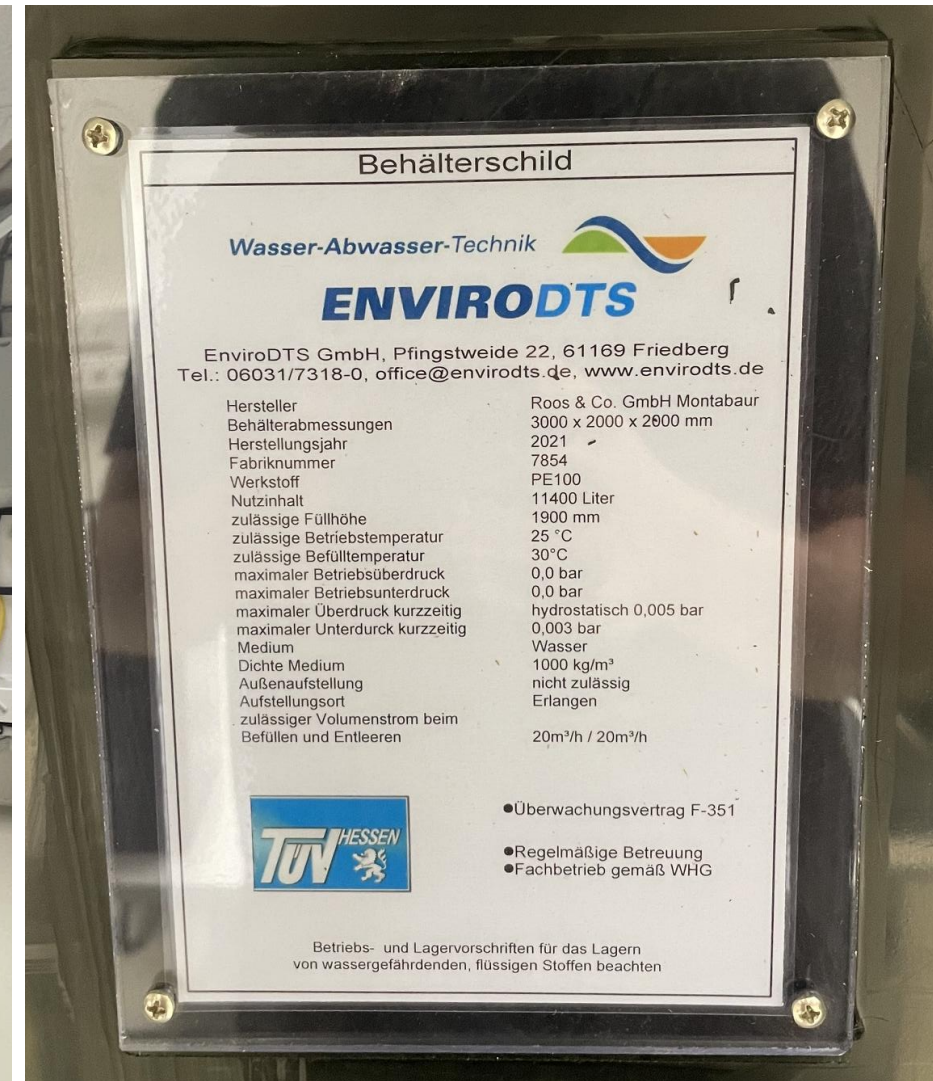


Image: PoS (ICRC2023) 1219, [7]



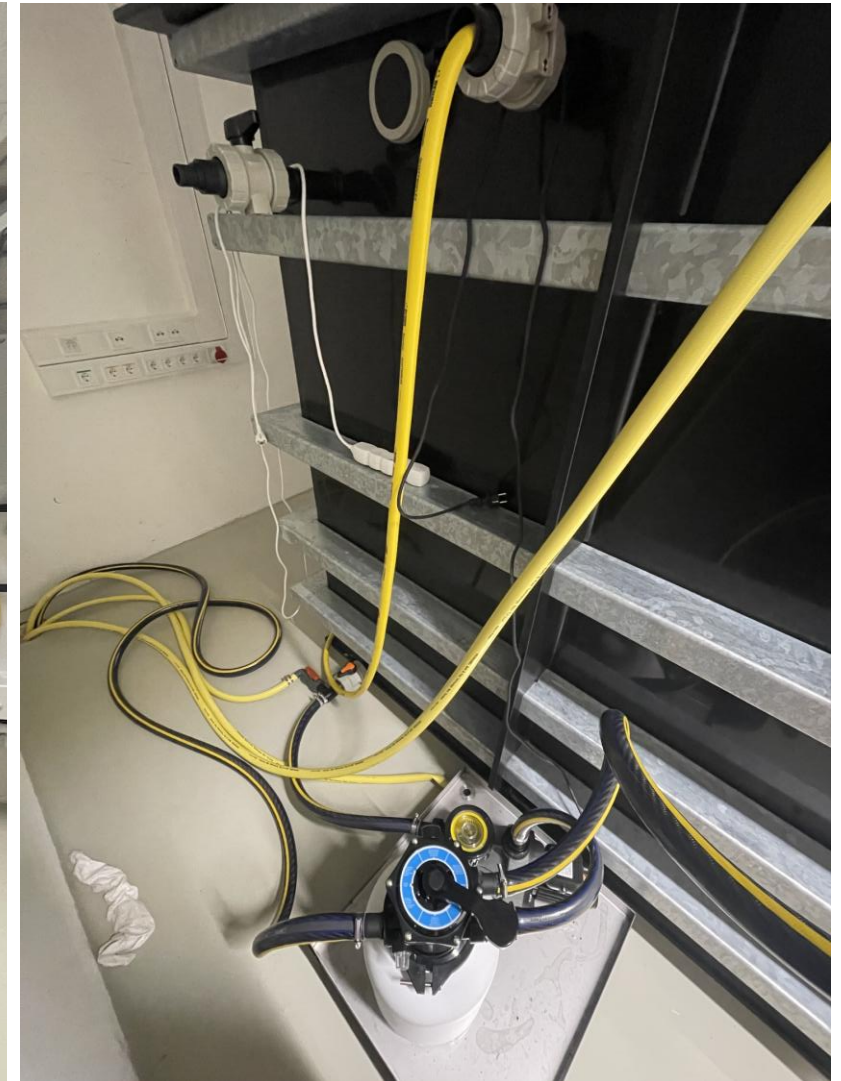
Water Tank

General



Water Tank

General



Long-term goal:

Build a measurement system for optical modules of neutrino telescopes
(not only P-ONE)

- light source, monitoring system for continuous information on shape and intensity of light pulses
- Automated rotation system for optical modules, multiple axes of rotation
- Water quality monitoring system



Upcoming Measurement

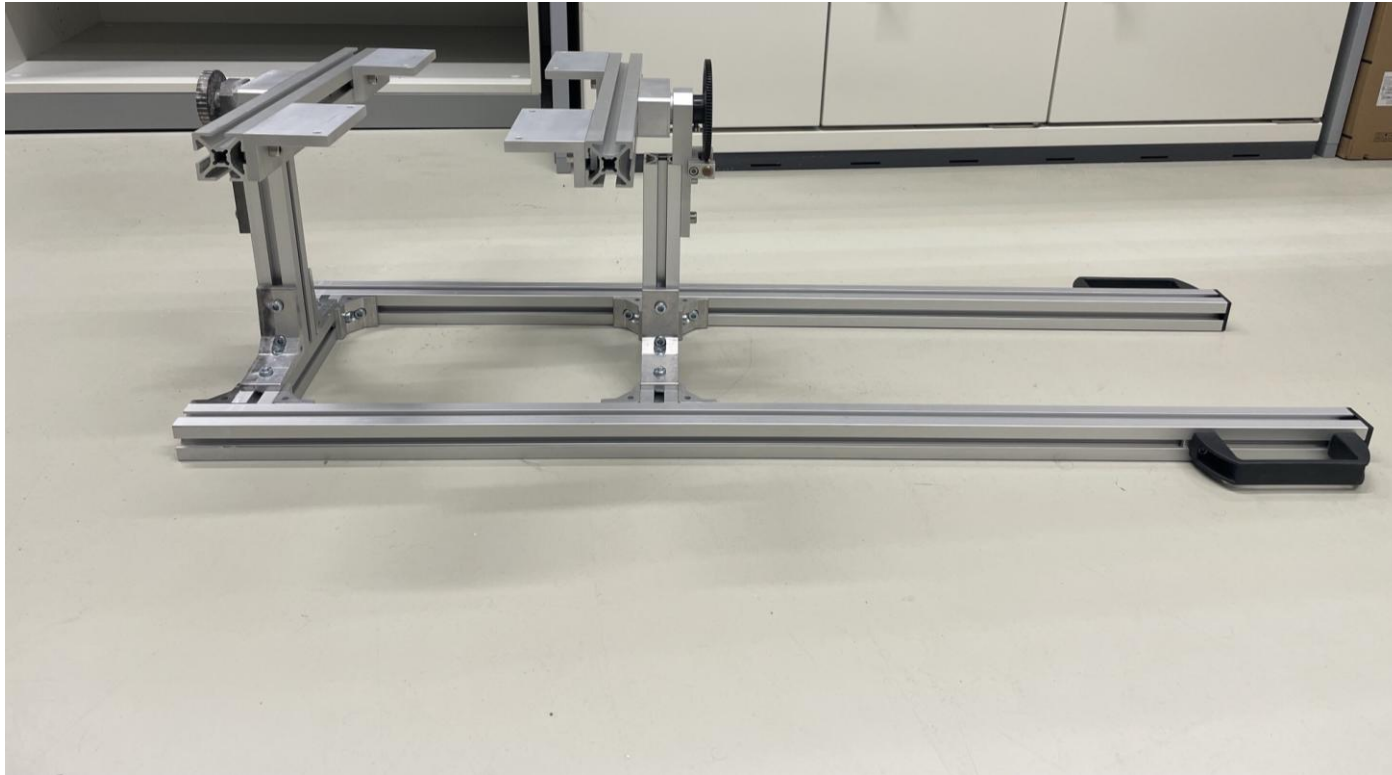
General

- Colleagues from Munich come to ECAP next week and bring a P-OM hemisphere of P-ONE
- Light source: LED HLMP-CB15 by Broadcom/Avago (470 nm)
- Rotation device: self-built holder, rotation by hand via gear



Water Tank

Optical Module Mount

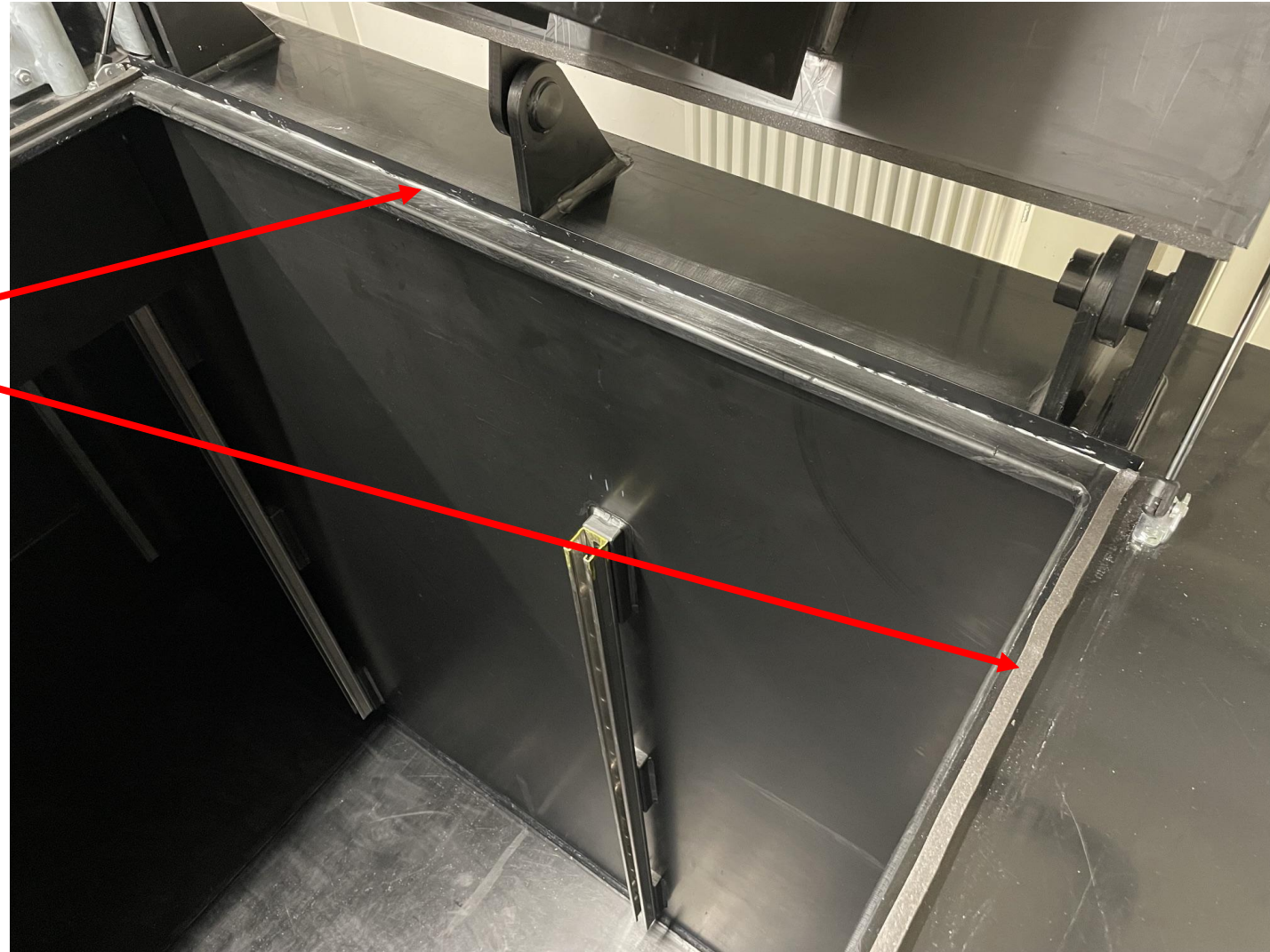


Upcoming Measurement

Water Tank Preparation

Preparing the Water Tank itself:

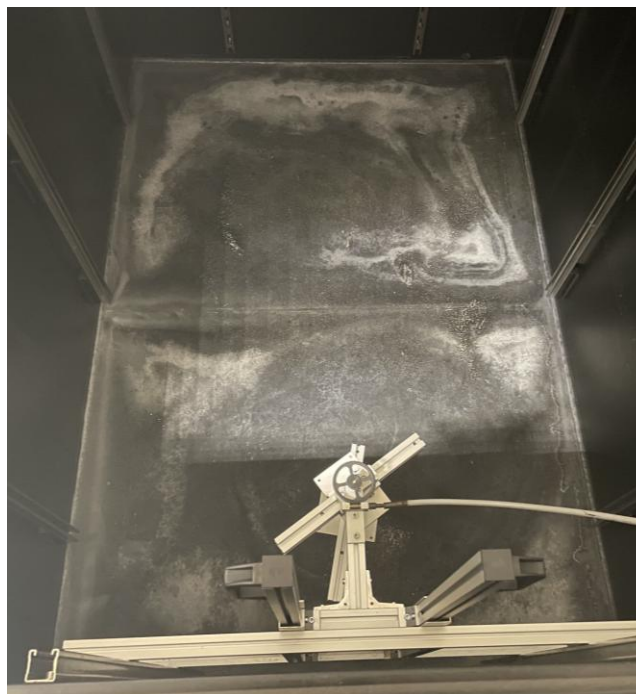
Ensuring it is as light-tight as possible using
black foam and plastic rails



Upcoming Measurement

Water Tank Preparation

Preparing the Water Tank itself:



cleaning

