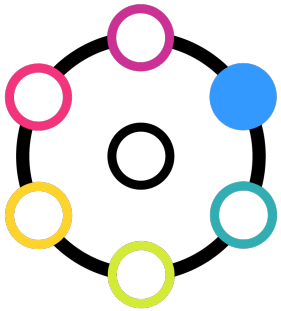


P-ONE

Accurate Optical Module Models in IceTray for P-ONE

Bennett Winnicky-Lewis
University of Victoria
WNPPC: February 13, 2026

What is P-ONE?

- Water based neutrino telescope to be deployed off the coast of Vancouver Island.
- Adds to the growing global network of neutrino telescopes.

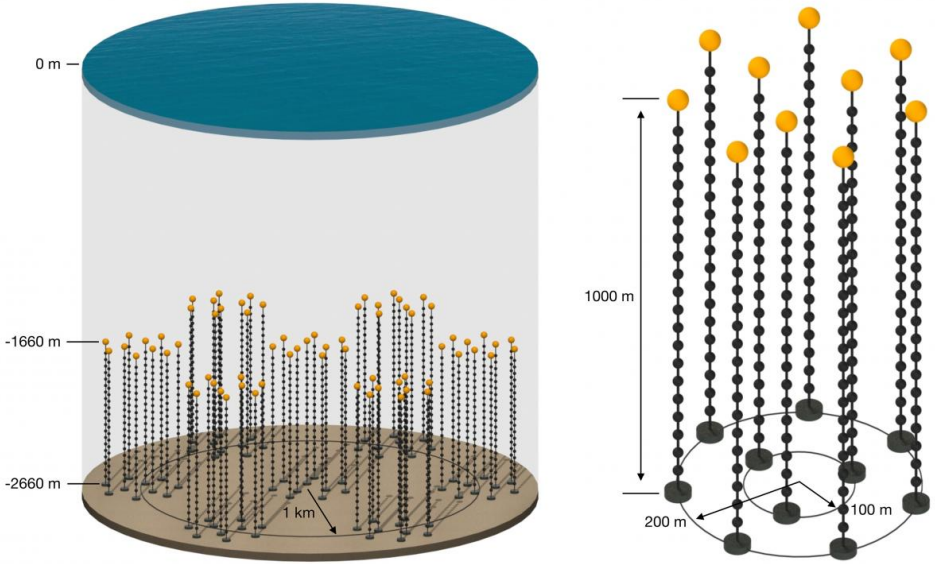


Image: https://www.pacific-neutrino.org/

Why do we need simulations?

- Allows us to test different geometry configurations for the full detector.
- Optimize the layout for angular resolution.

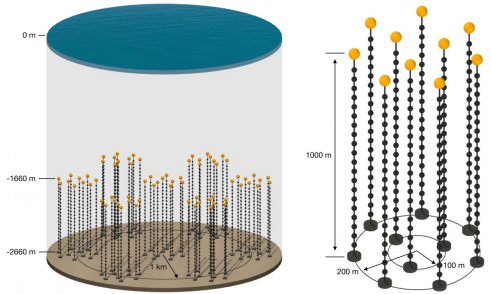
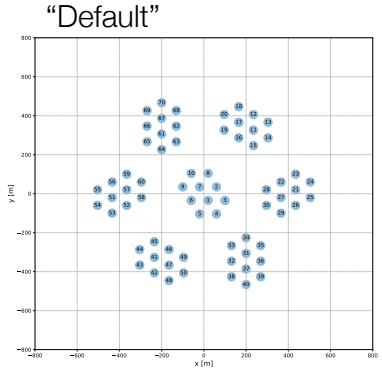
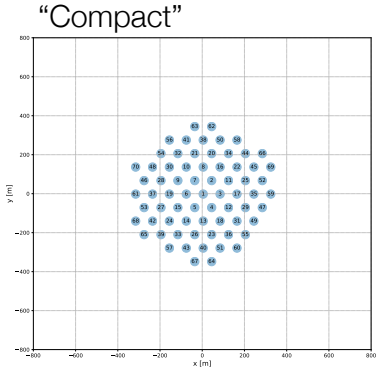
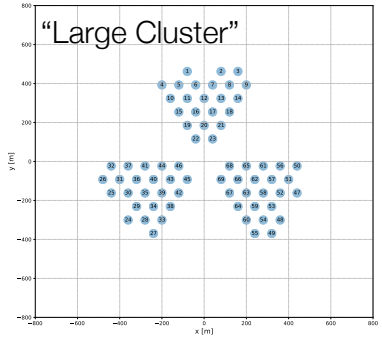
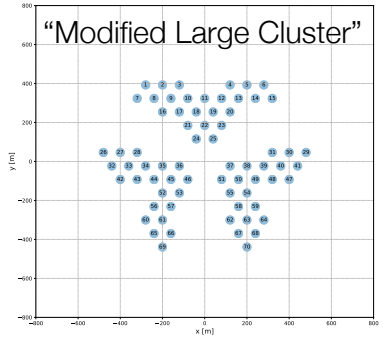


Image: T. DeYoung, M. Fernanda Rodriguez, MSU









Why do we need simulations?

$$\text{Figure of Merit} \propto \frac{1}{\sqrt{\sigma}}$$

σ = Angular Resolution

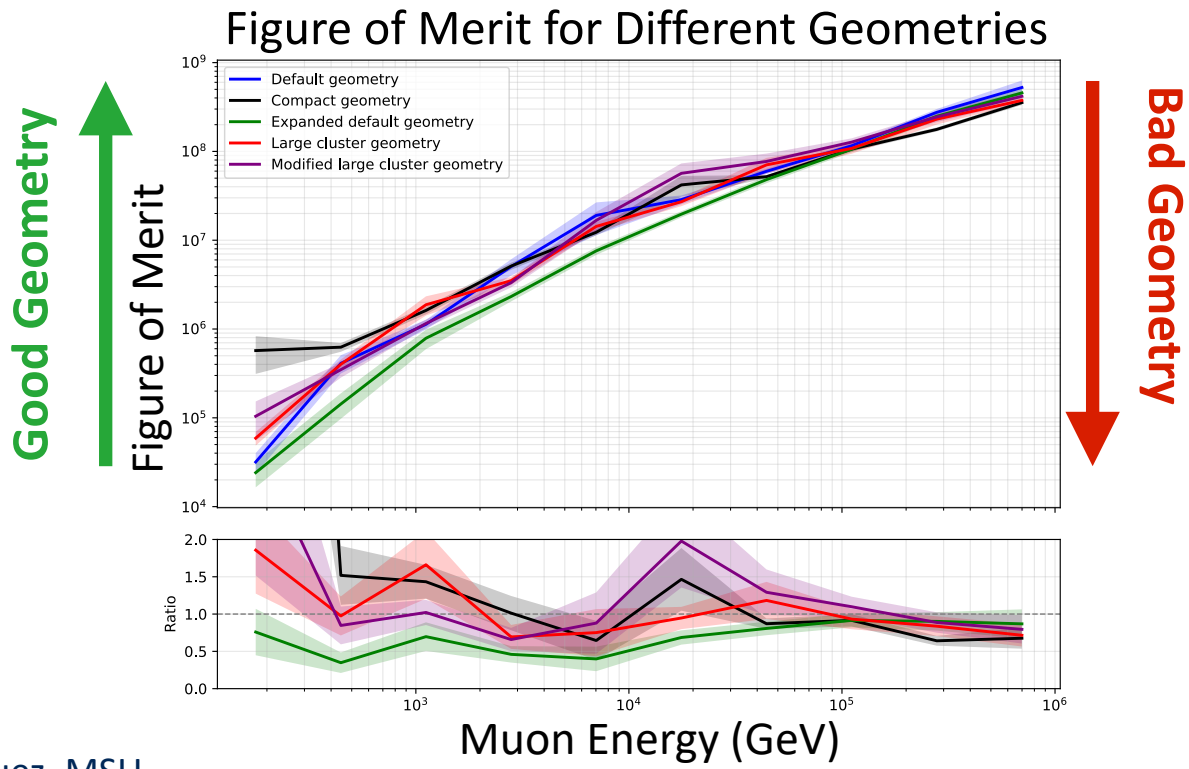


Image: T. DeYoung, M. Fernanda Rodriguez, MSU

What will P-ONE see?

- Light signals that are emitted from secondary particles in neutrino interactions.
- Other things in the ocean produce light.

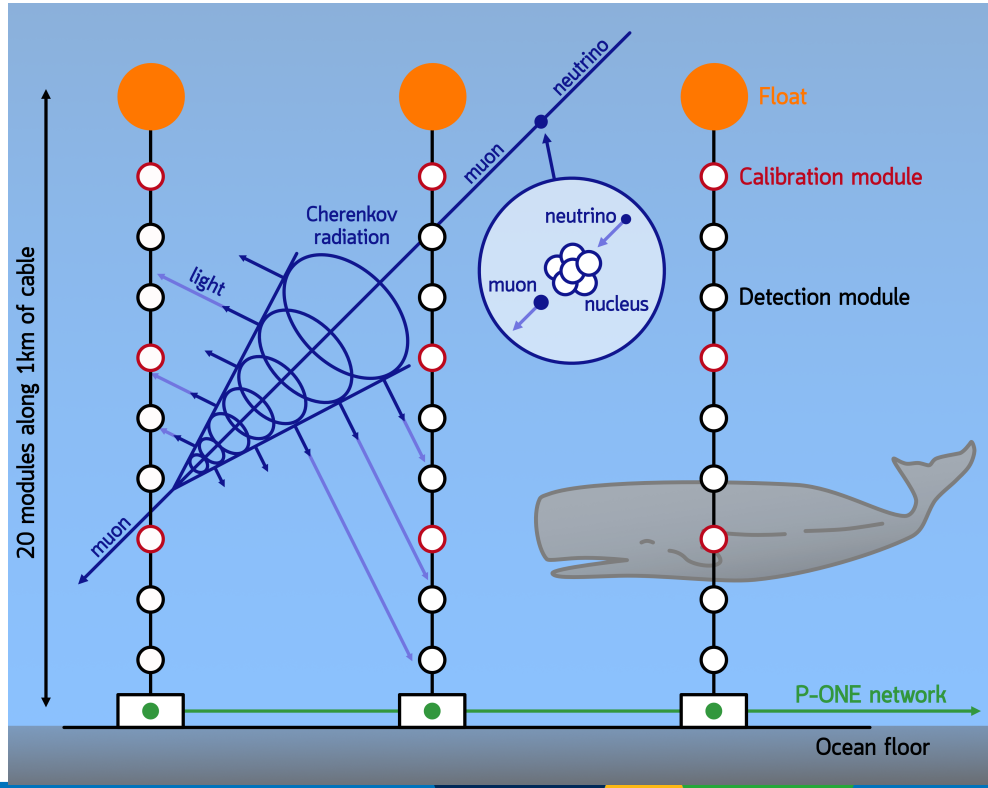


Image: Alexia Alexander Wight, UCL

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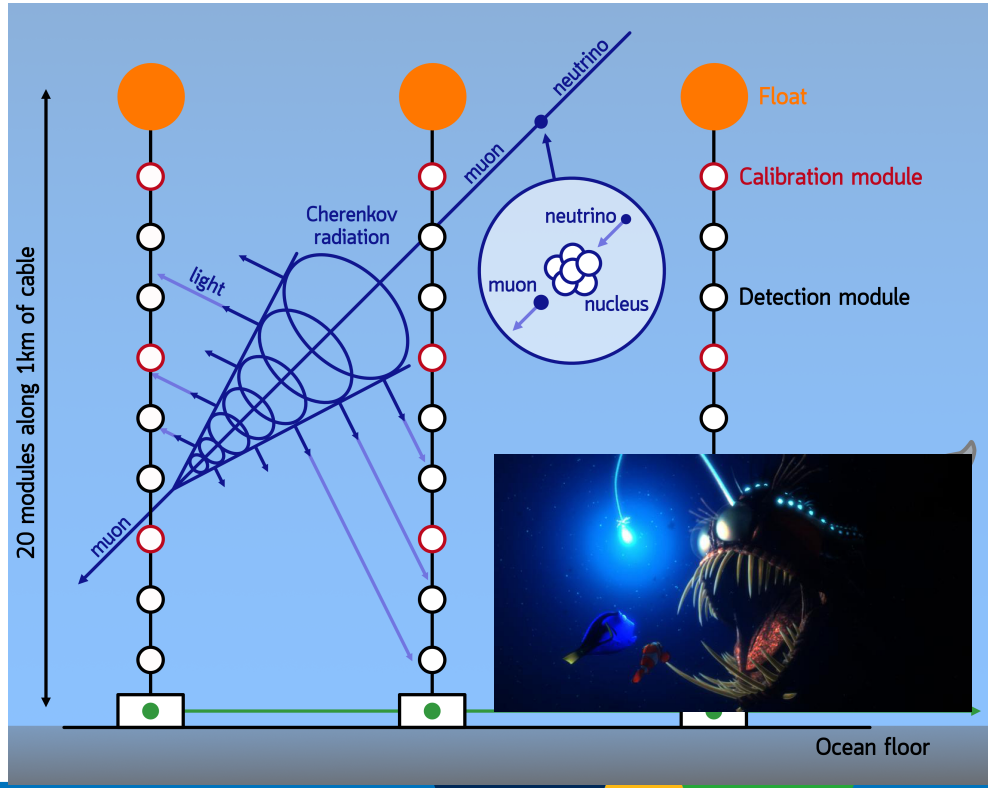
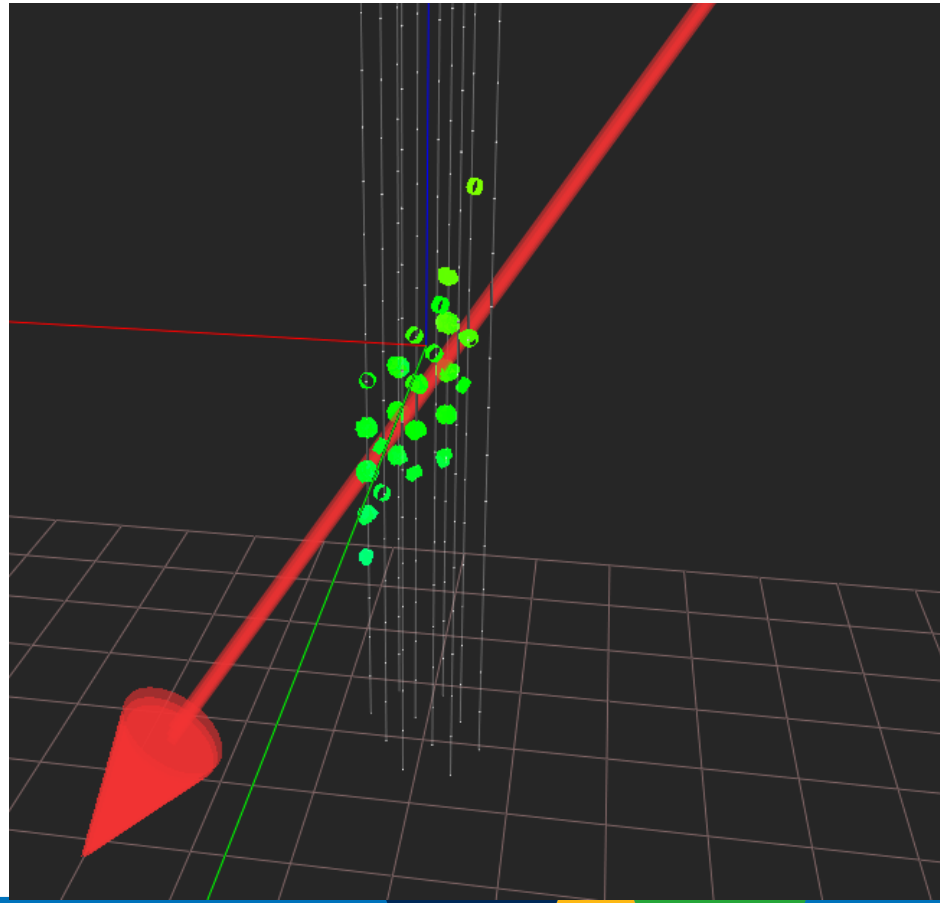


Image: Alexia Alexander Wight, UCL

What will P-ONE see?

- Astrophysical neutrinos
- Atmospheric muons
- Bioluminescence
- ^{40}K emissions



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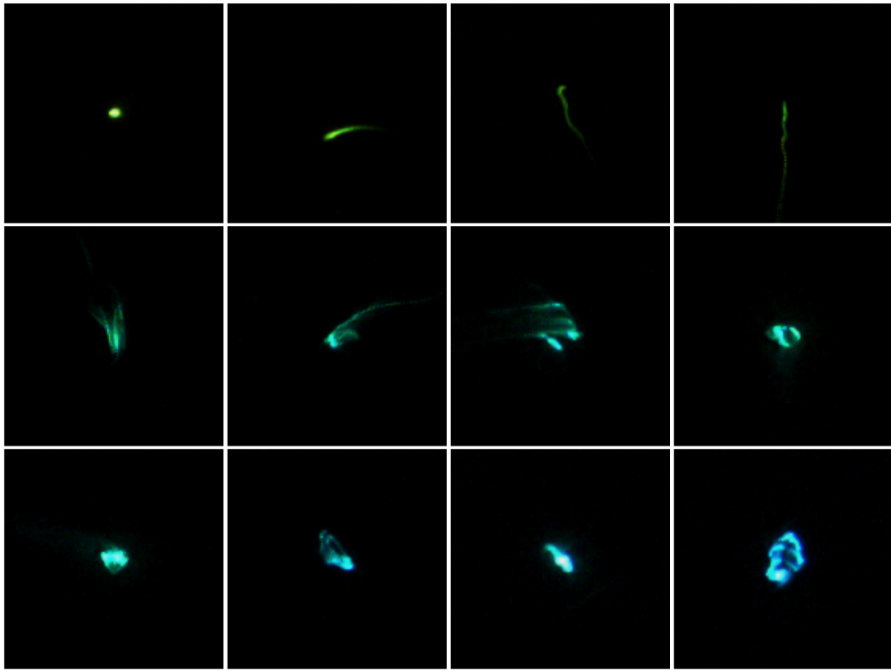


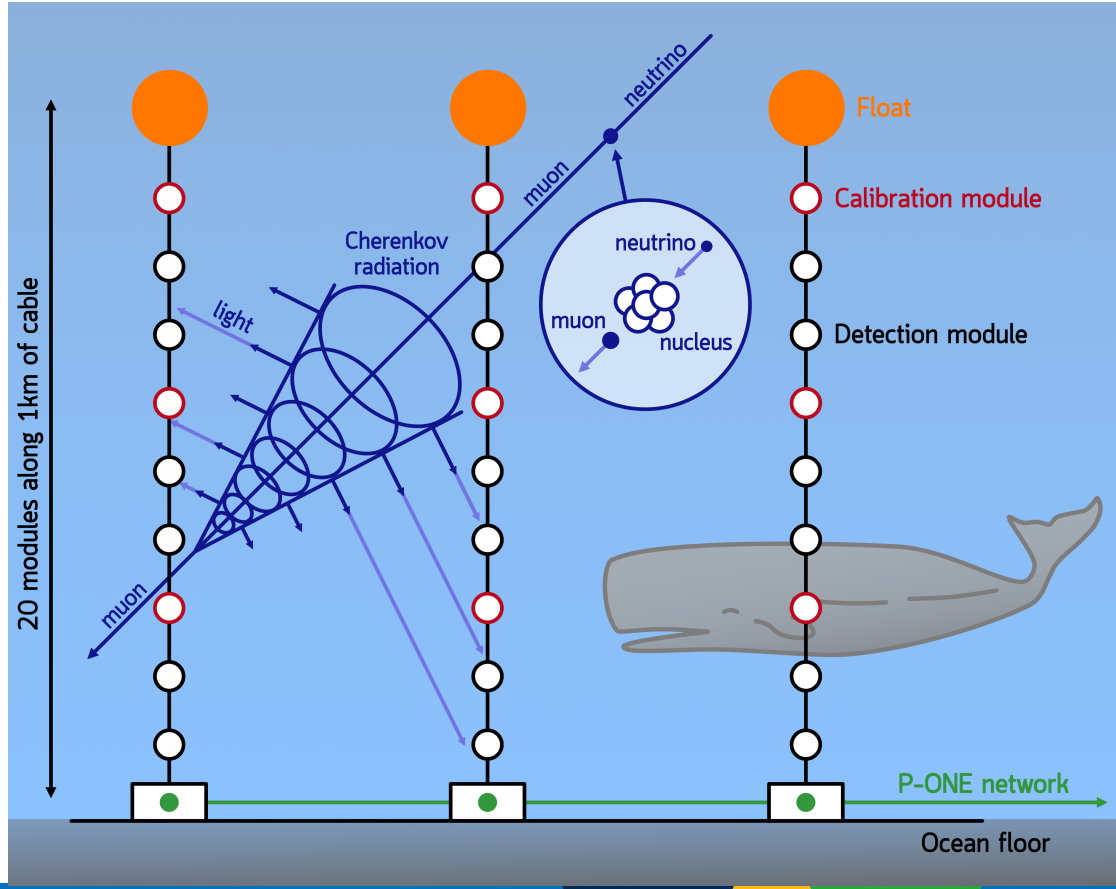
Image: C. Spannfellner et al, *Pathfinders of the Pacific Ocean Neutrino Experiment*

How do the simulations work?

- Main simulations and analysis are done using the IceTray software, created by the IceCube Collaboration.
- Able to modify existing modules to fit P-ONE specifications.

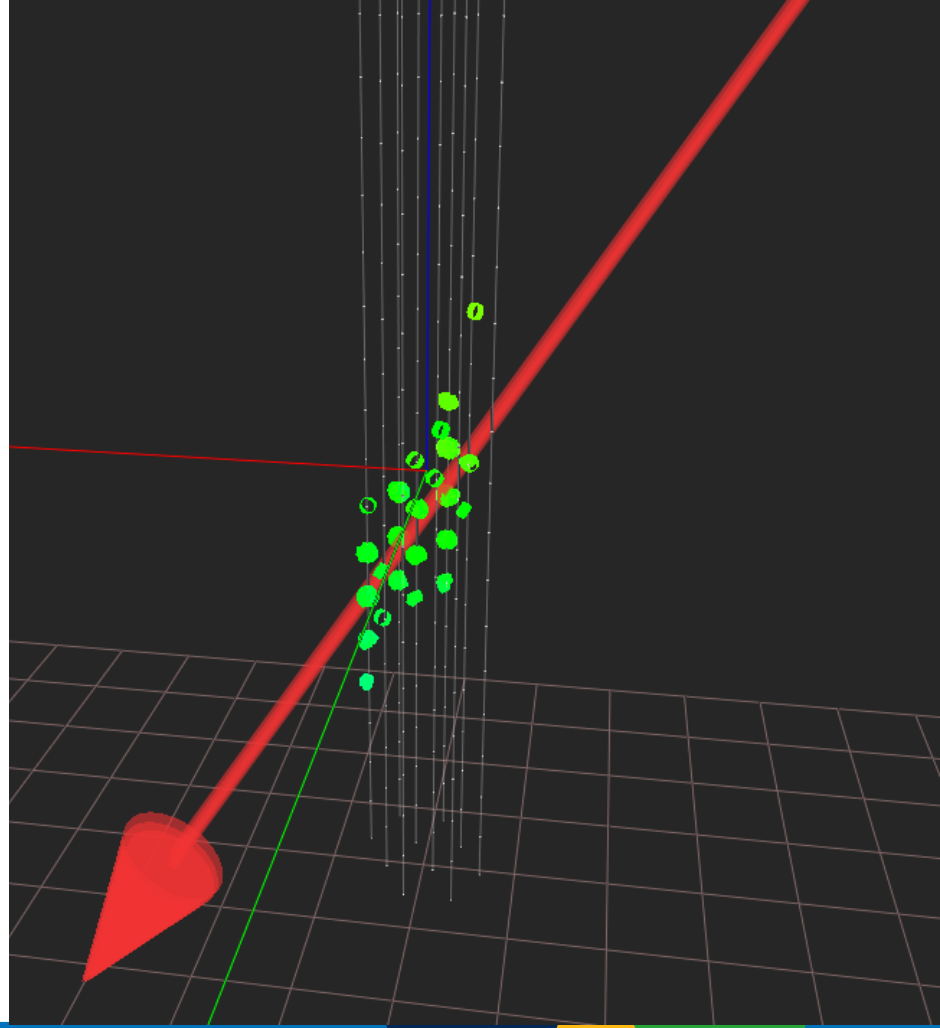
Expected event

- What do we expect from a muon event?
- The optical modules (OMs) will detect light and read out signal data.



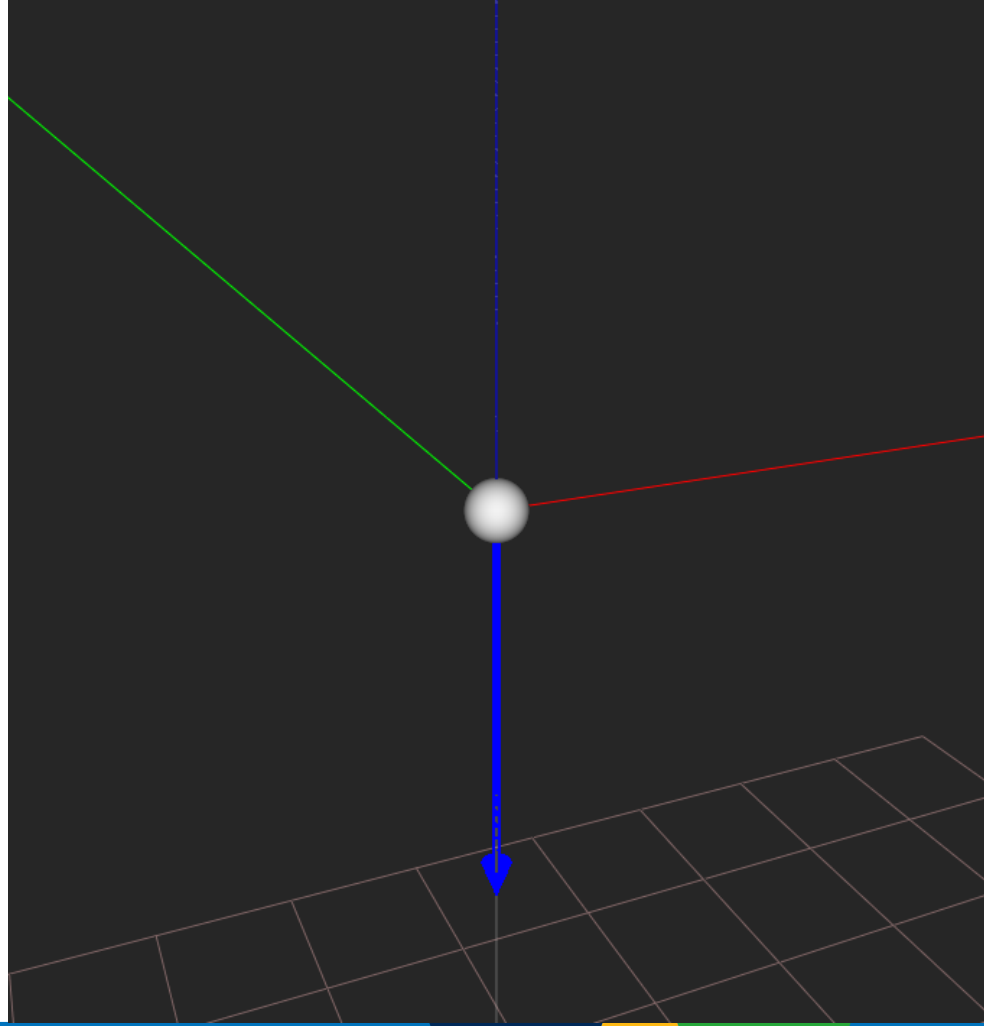
Simulated event

- A muon event in the simulation interface.
- Arrow represents muon path.
- Bubbles represent OMs that have detected light.



Old IceTray OM Model

- Single sphere.
- No accurate PMT orientation.



Real optical module

- Made up of two half-spheres separated by titanium ring.
- Contains 16 PMTs and various calibration equipment.

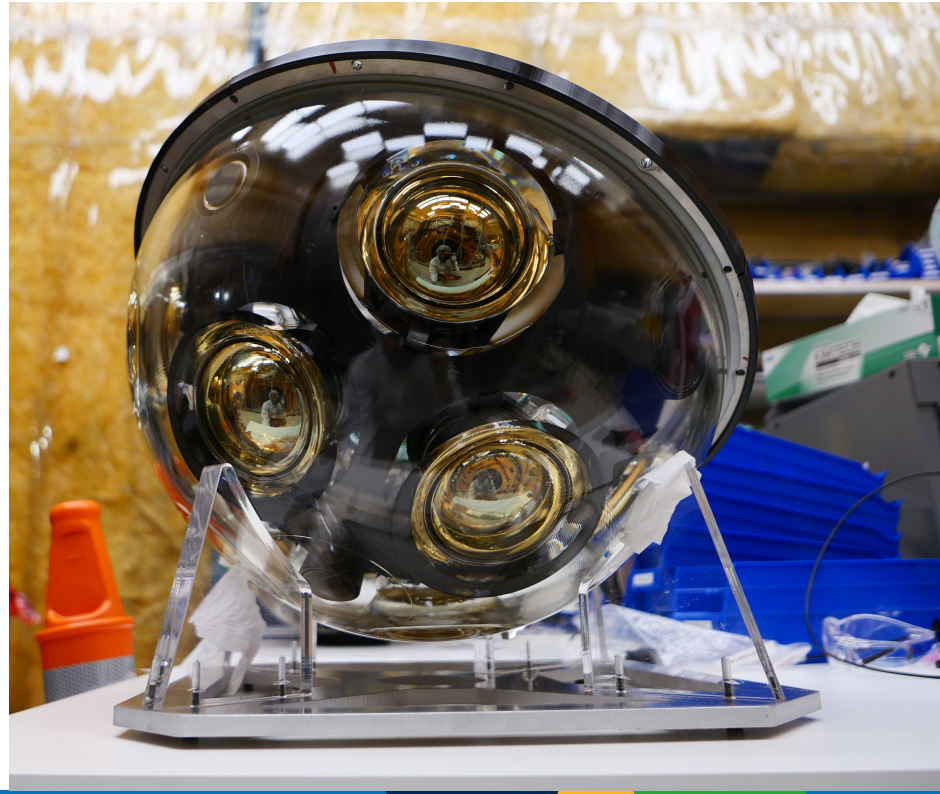


Image: Ben Nührenbörger, SFU

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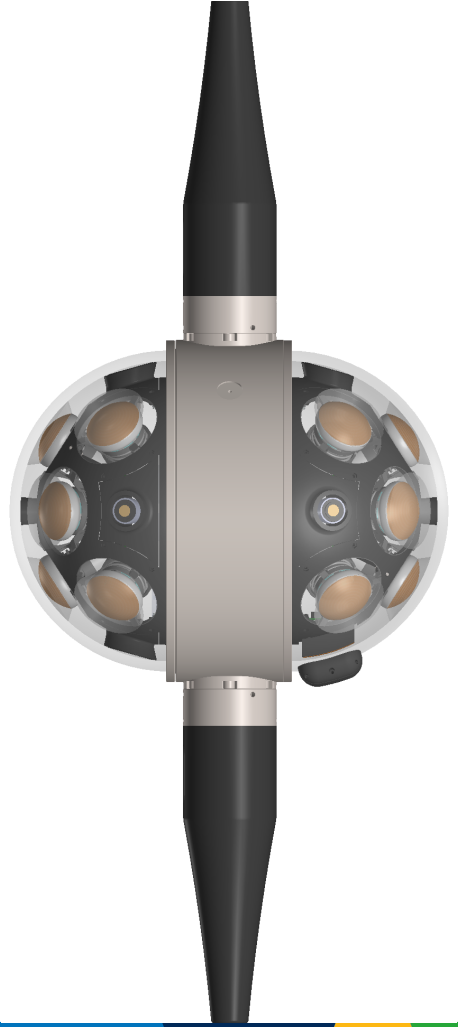
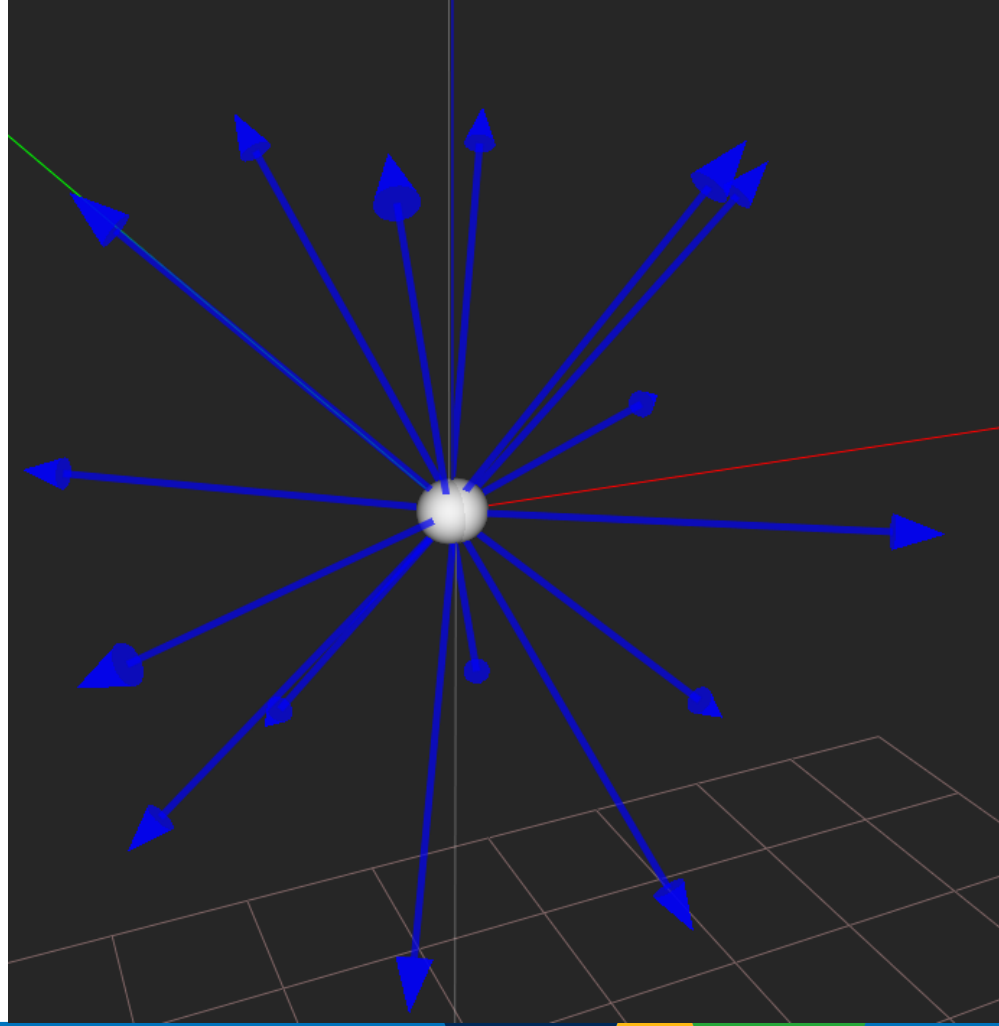


Image: Christian Spannfellner, TUM

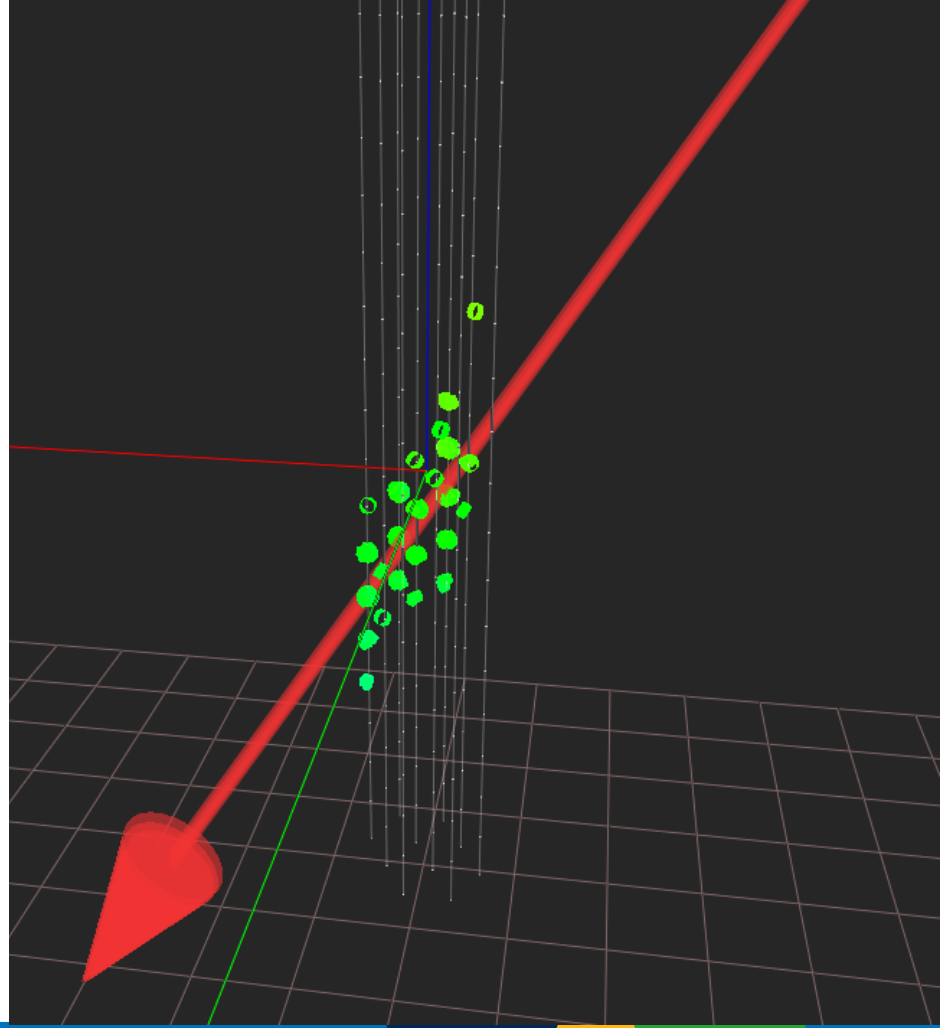
Updated OM model

- Made up of two spheres (within limitations of IceTray).
- Correct orientations for 16 PMTs.
- Corrected PMT photosensitive area and other minor settings.



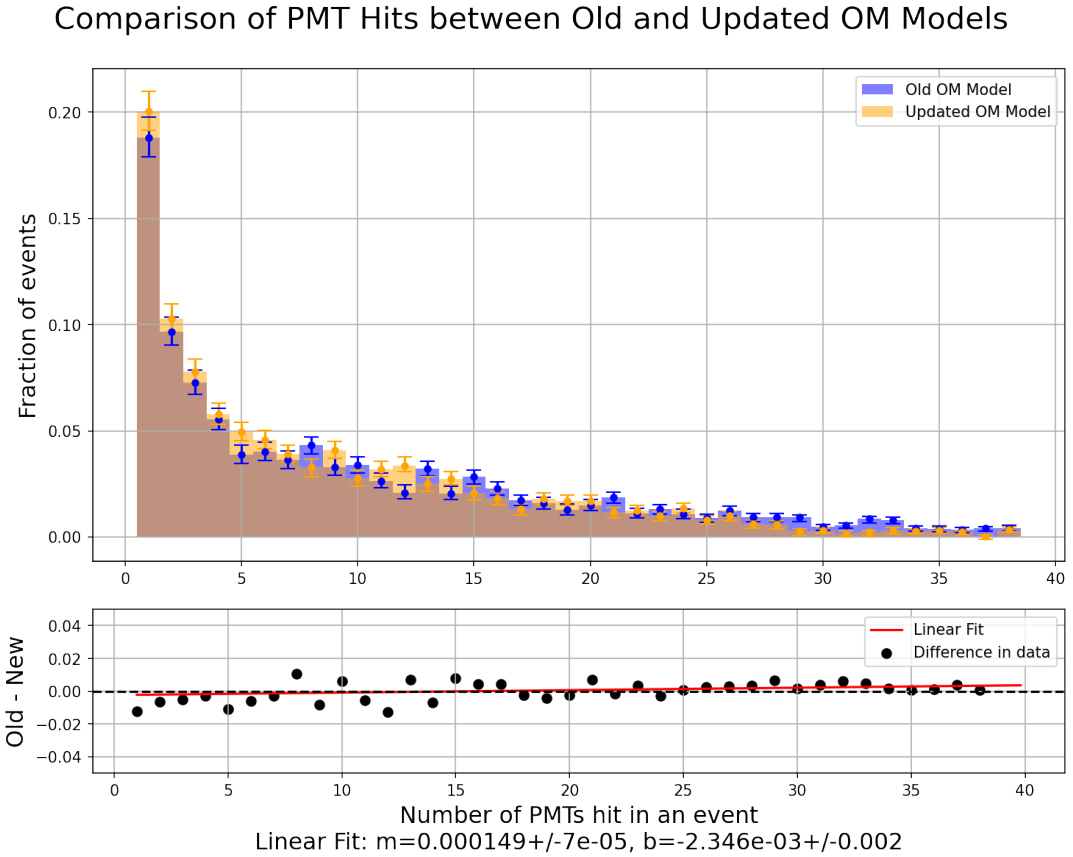
Simulations

- Ran simulations of muon events of these different models using IceTray.
- Same muon events for each OM type.



Simulation stats

- Minimal difference between models.
- Photon acceptance happens once all photons hit the OM surface.



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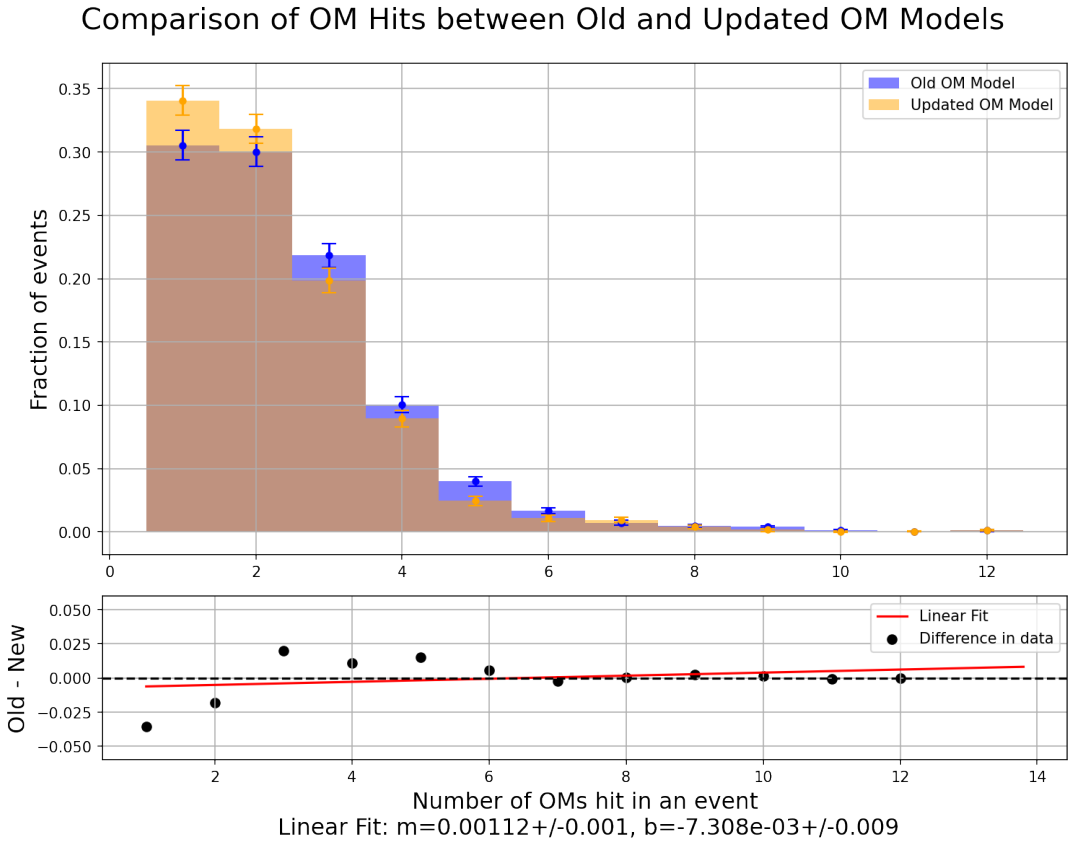
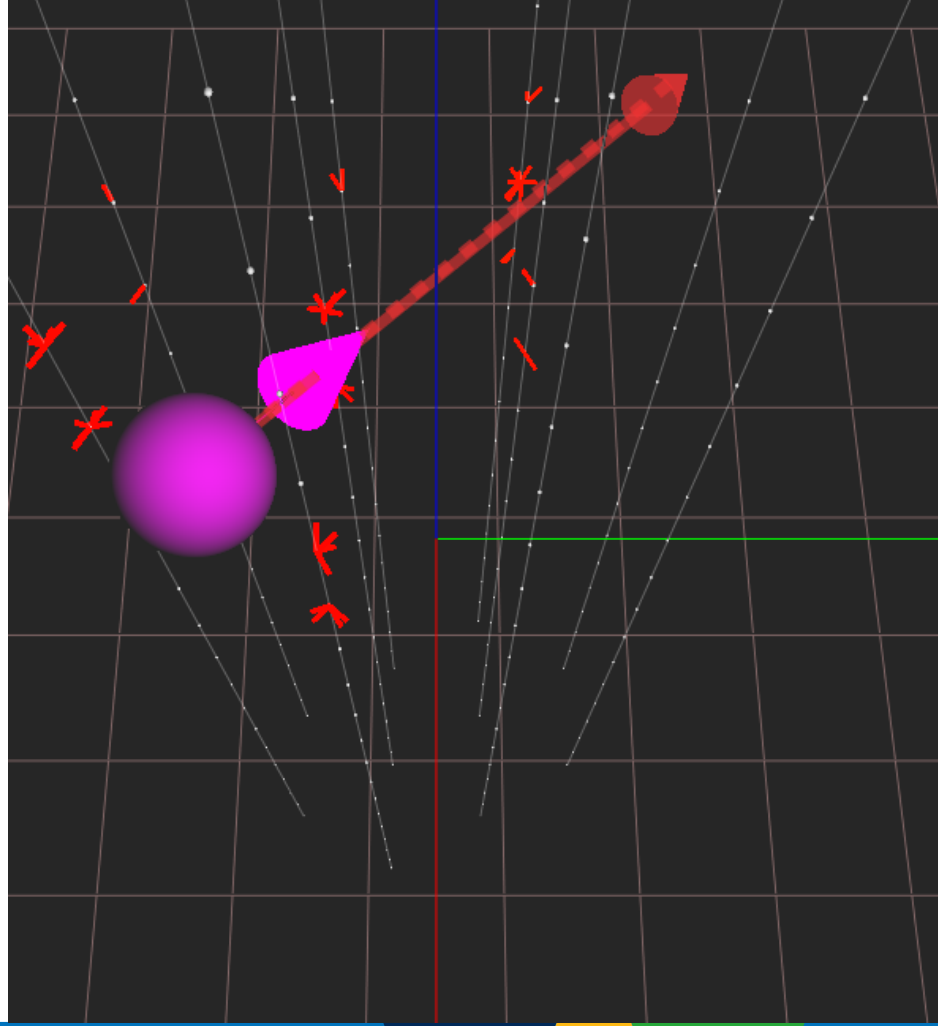


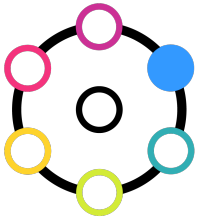
Conclusions

- Updated OM models to better represent physical detector.
- More information available in simulation files.
- Minimal difference due to method of photon acceptance.



Thank you!

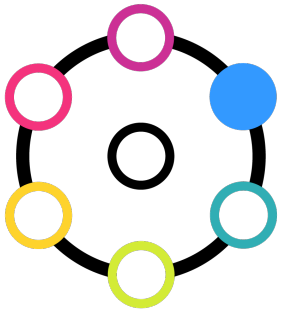
Arthur B. McDonald
Canadian Astroparticle Physics Research Institute



P-ONE

This work was completed at the University of Victoria. We acknowledge and respect the Lək̓ʷəŋən (Songhees and Xʷsepsəm̓/Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

UVIC



P-ONE

Backup Slides

P-ONE Location

- Planned to use the existing Ocean Networks Canada (ONC) undersea observatory.
- Current plans to change deployment location to avoid MPA.

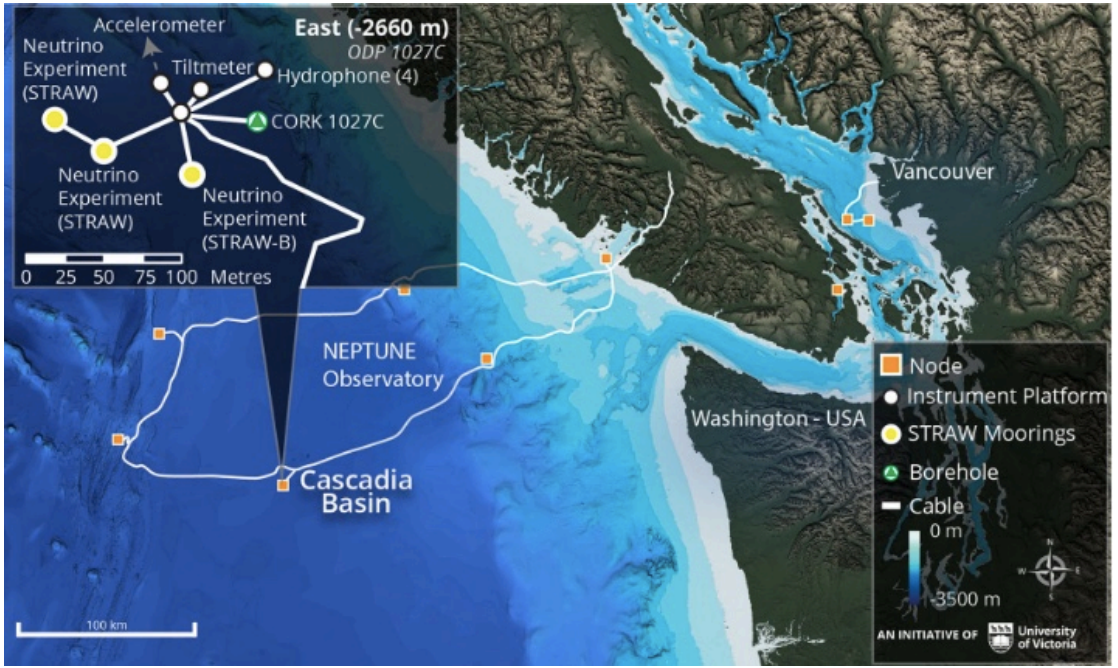


Image: https://www.pacific-neutrino.org/

Why do we need P-ONE?

- Neutrino telescopes are most sensitive to areas just below the horizon.
- Adds needed coverage band from the Pacific Ocean.

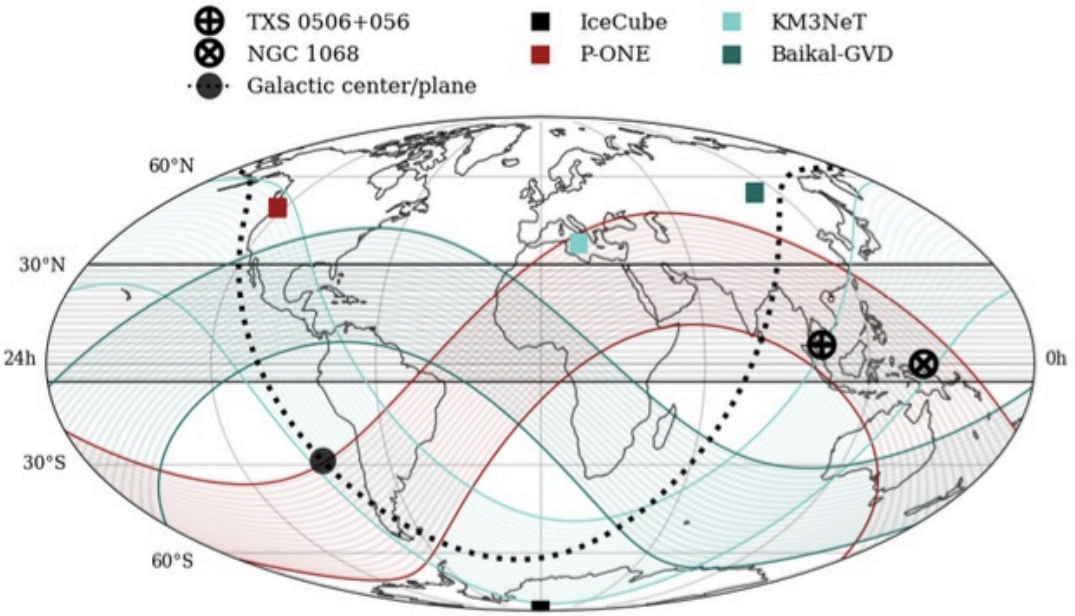


Image: M. Huber, TUM

Why do we need P-ONE?

- Neutrinos can pass through intermediate material, allowing us to trace them directly back to their source.

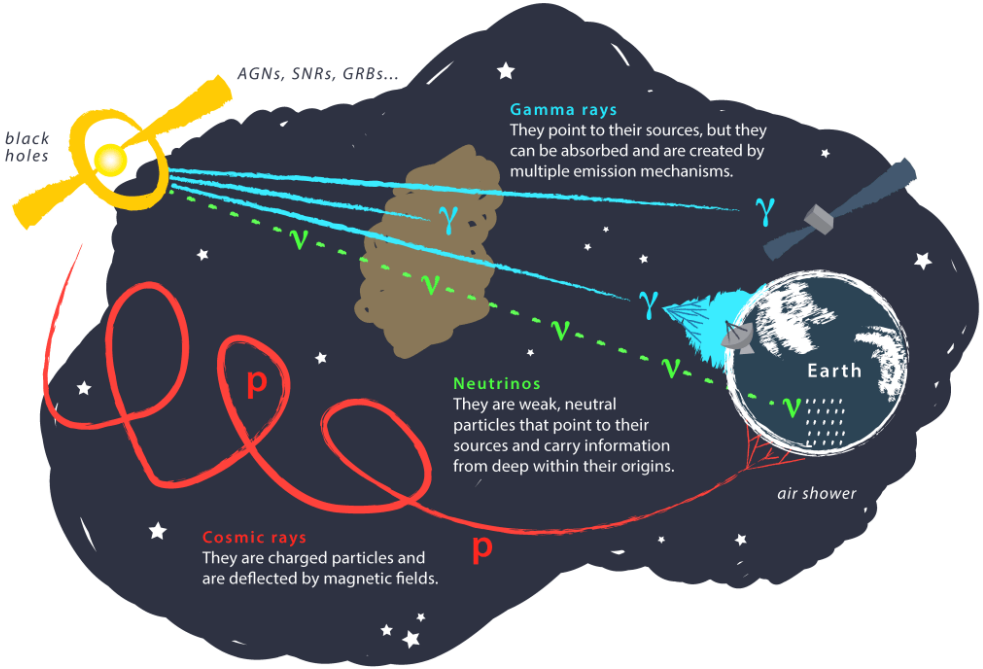


Image: Juan Antonio Aguilar and Jamie Yang. IceCube/WIPAC

Why do we need simulations?

$$\text{FoM} = \sqrt{\sum_i \frac{A_{\text{eff},i}}{4\pi\sigma_i}}$$

$A_{\text{eff},i}$ = Effective area in energy bin i

σ_i = Angular Resolution

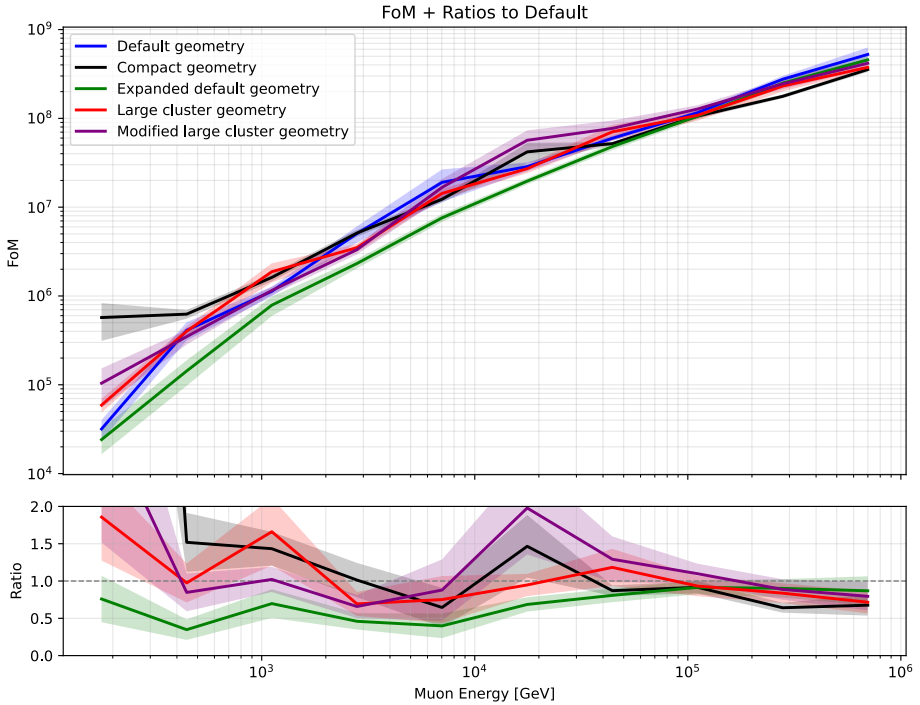


Image: T. DeYoung, M. Fernanda Rodriguez, MSU

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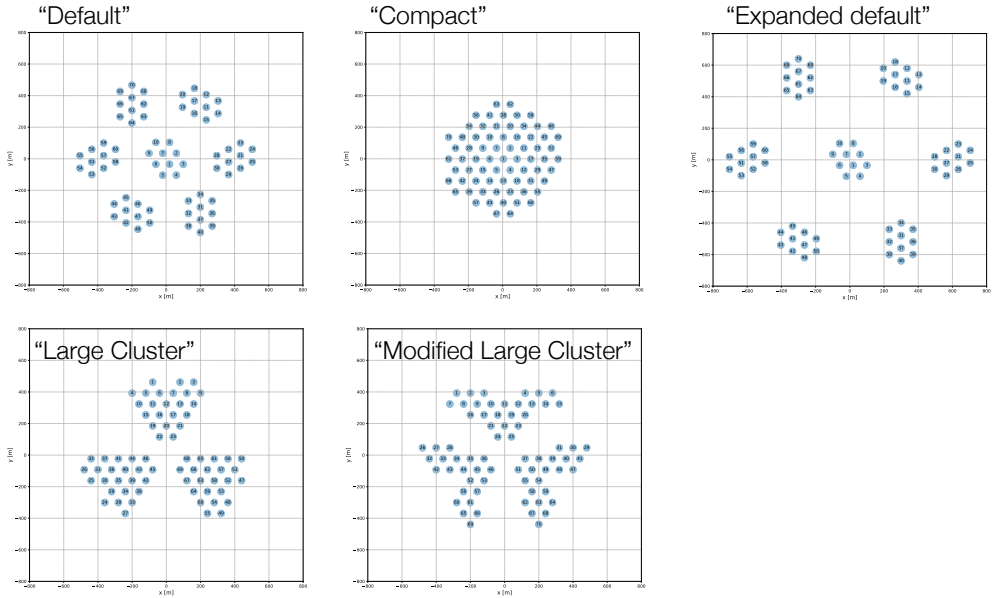


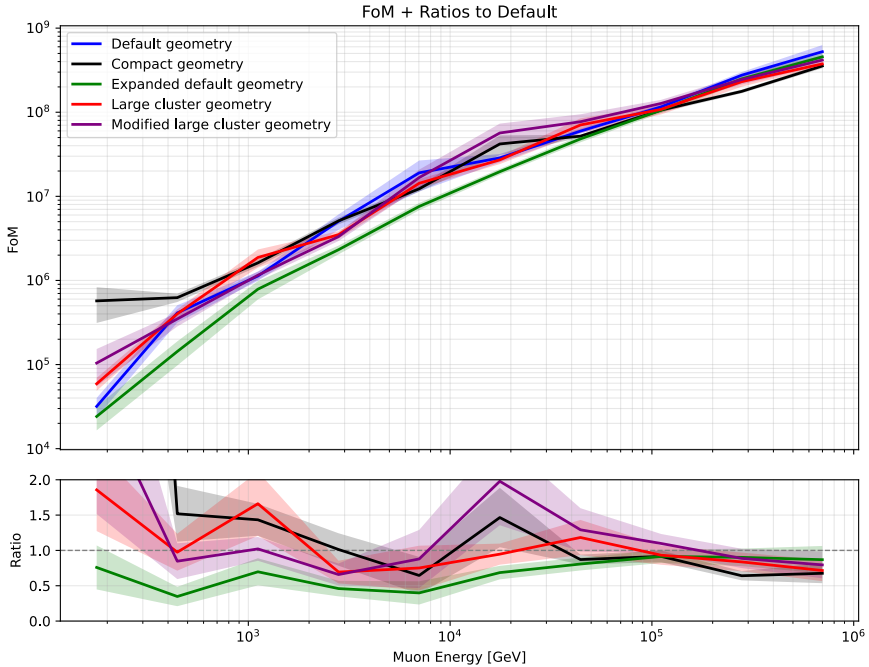
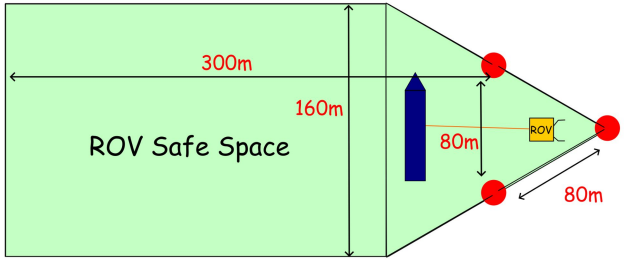


Image: T. DeYoung, M. Fernanda Rodriguez, MSU

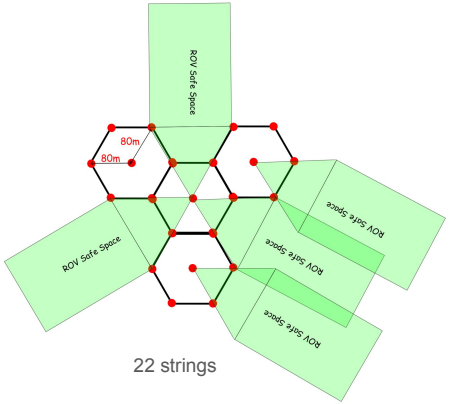
ONC ROV Constraints

Statement:

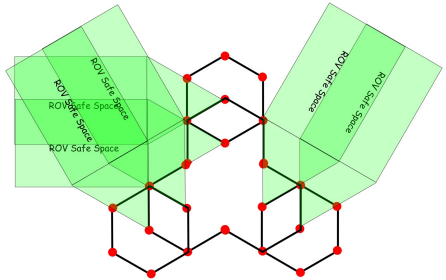
- The ROV can perform maintenance at the base of the string for strings that form a 80m equilateral triangle if there is an ROV safe space of 300m x 160m in **any** direction



This can result in many geometrical shapes for each cluster and helps define the distance between the clusters.
Examples (completely made up):



22 strings

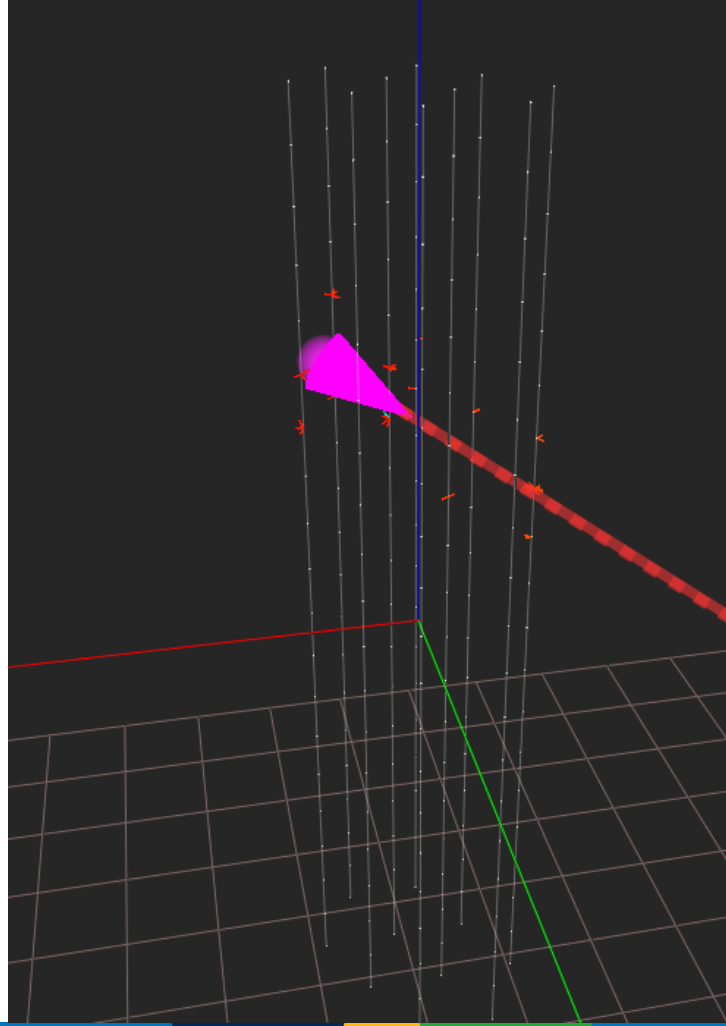


24 strings

Images: A.J. Baron, Deg Hembroff, Ocean Networks Canada

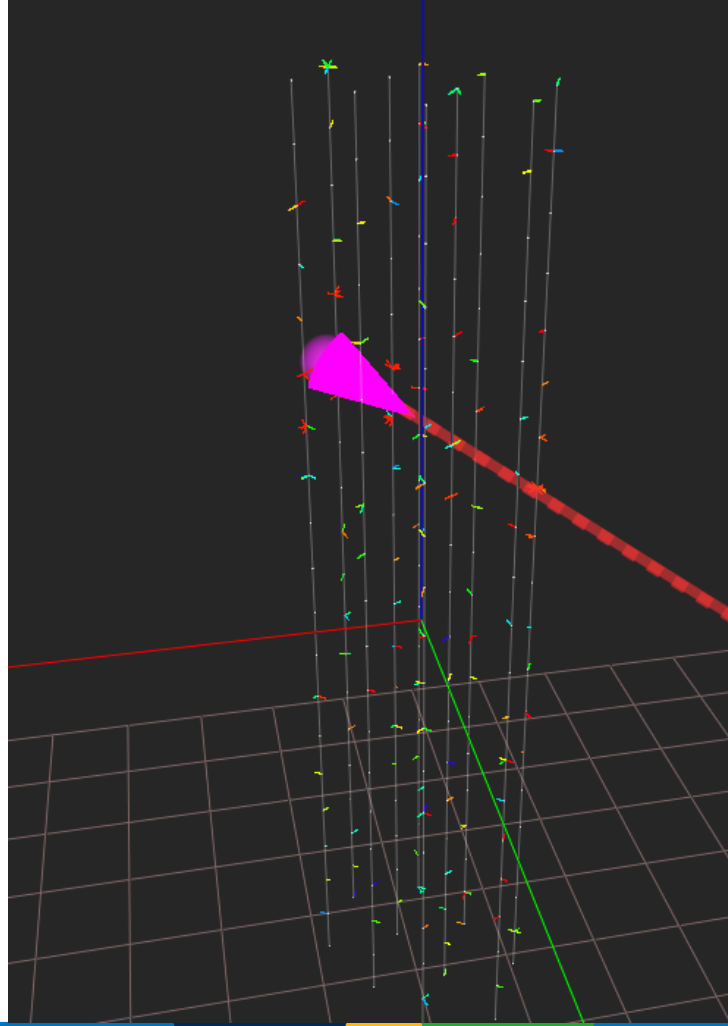
Simulated Event

- A muon event in the simulation interface.
- Arrow represents muon path.
- Small arrows represent OMs that have detected light.



Simulated Event

- A muon event in the simulation interface.
- Arrow represents muon path.
- Small arrows represent OMs that have detected light.
- Now with noise.



Neutrino Flux

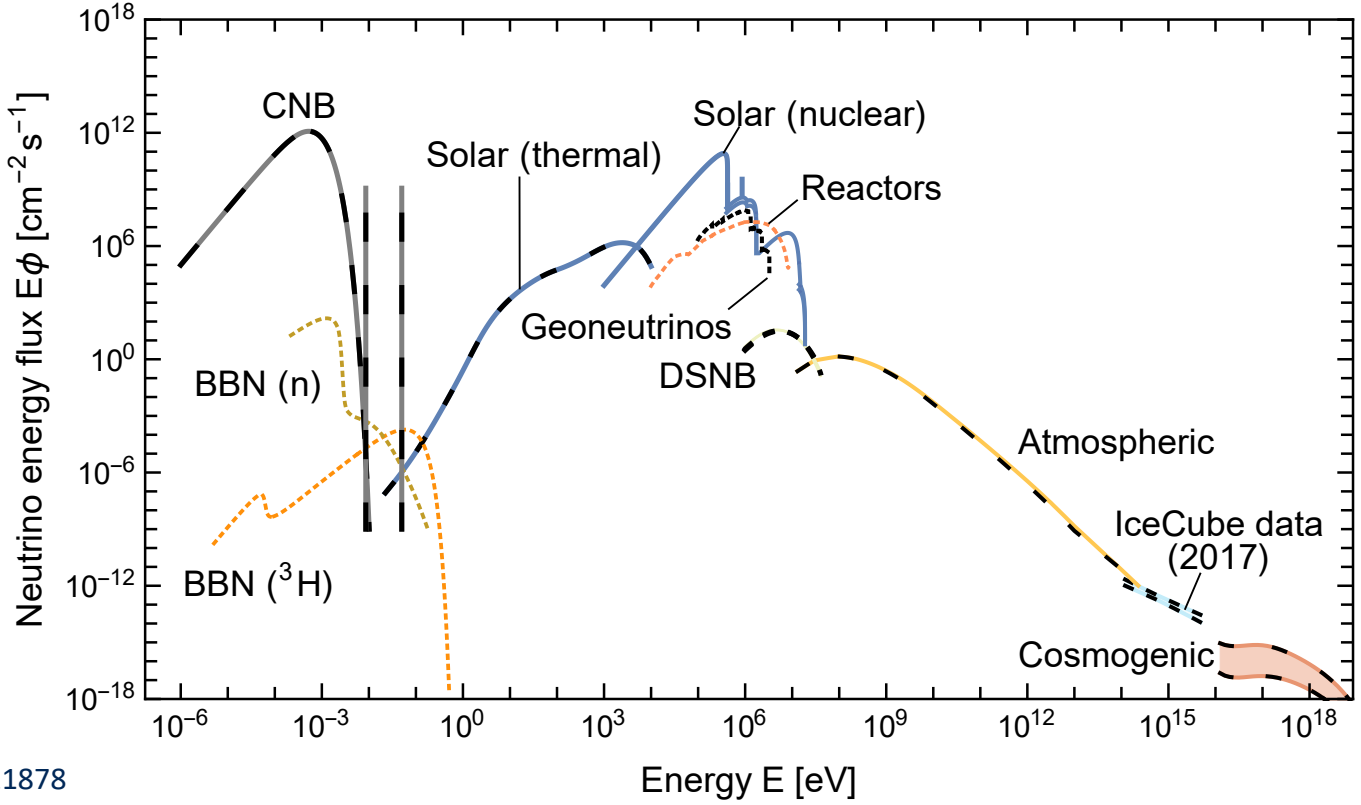
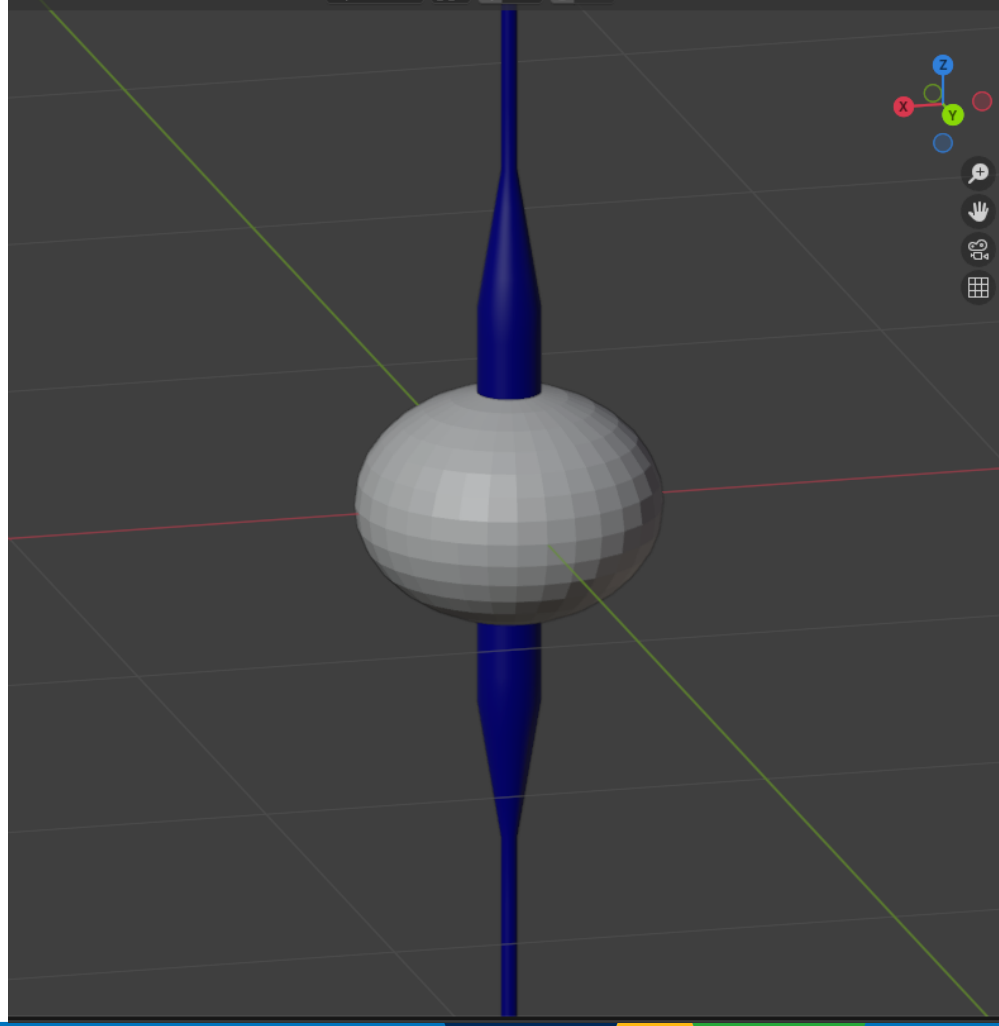


Image: arXiv:1910.11878

Other OM models

- Single sphere with PMT orientations.
- Spheroid OM with PMT orientations.



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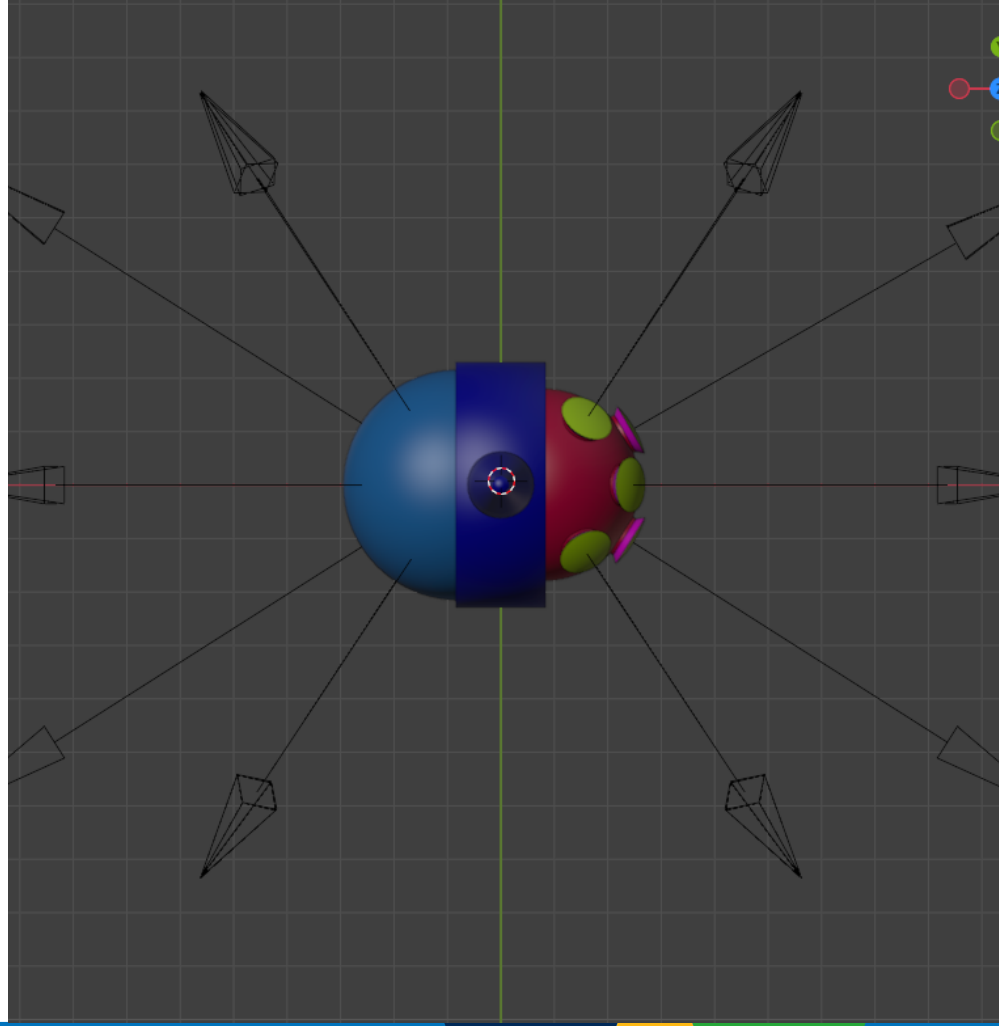

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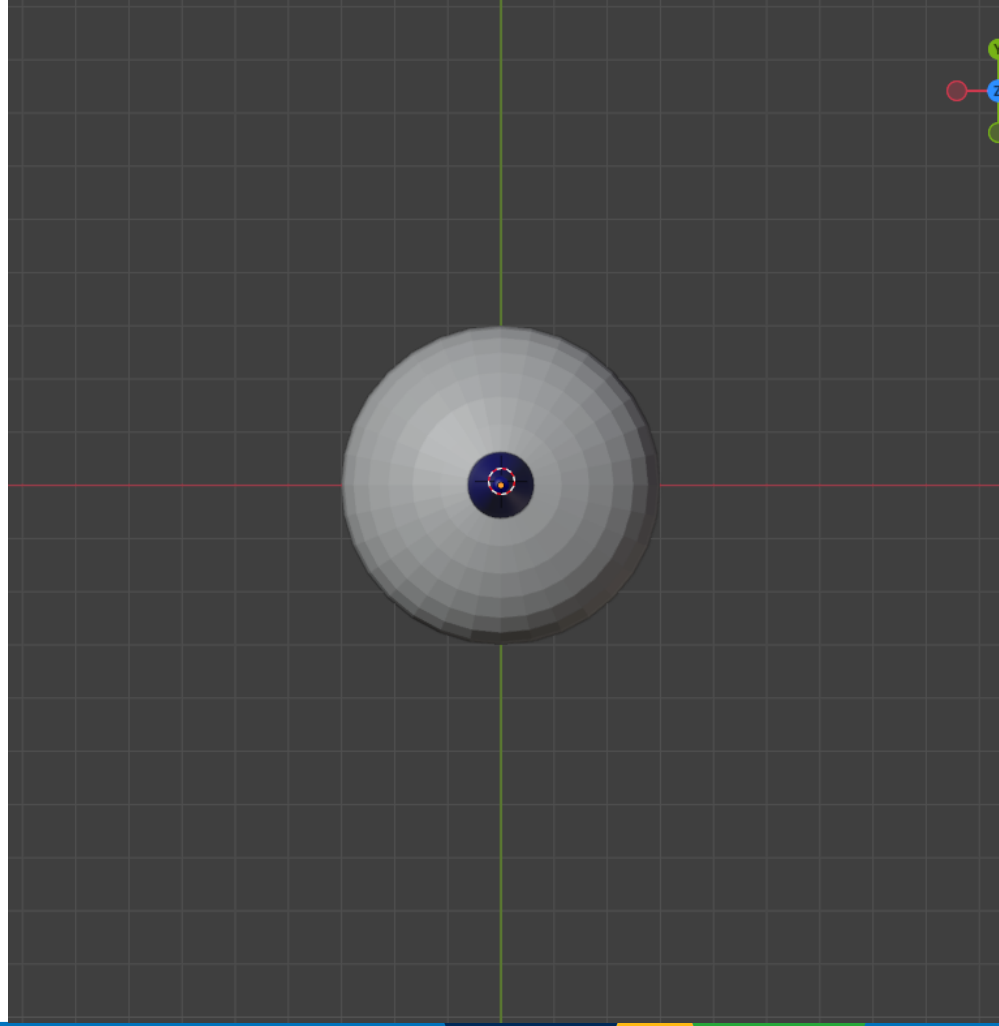
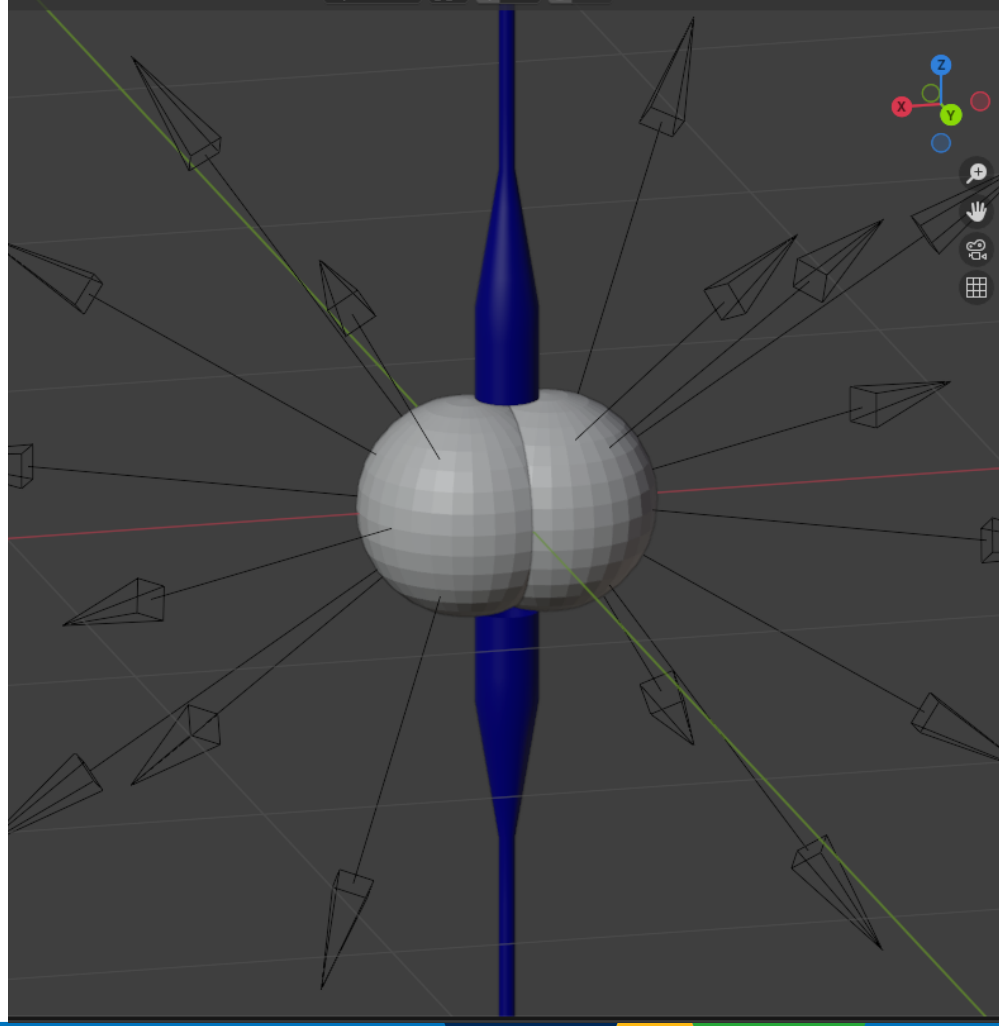


Updated OM Model

- Made up of two spheres.
- Correct orientations for 16 PMTs.
- Corrected PMT photosensitive area and other minor settings.



Why do we need simulations?

- Test methods for noise cleaning and detector efficiency.
- Primarily done by Rasmus Ørsøe out of TUM

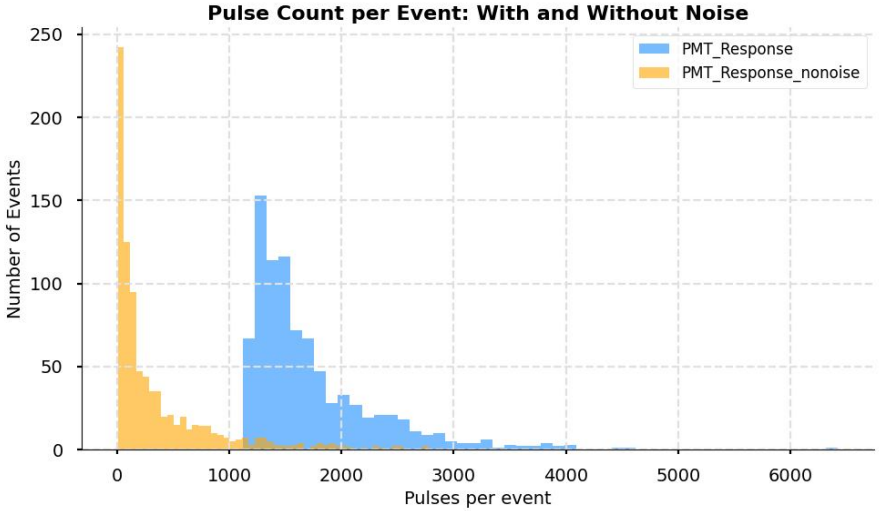
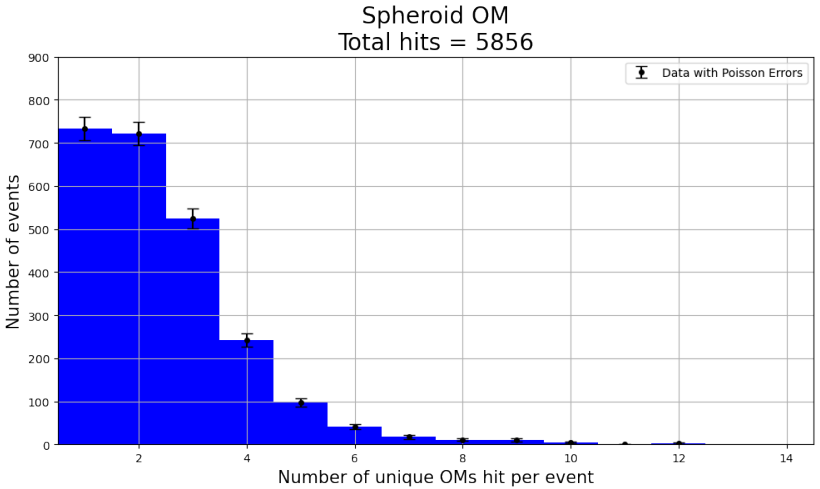
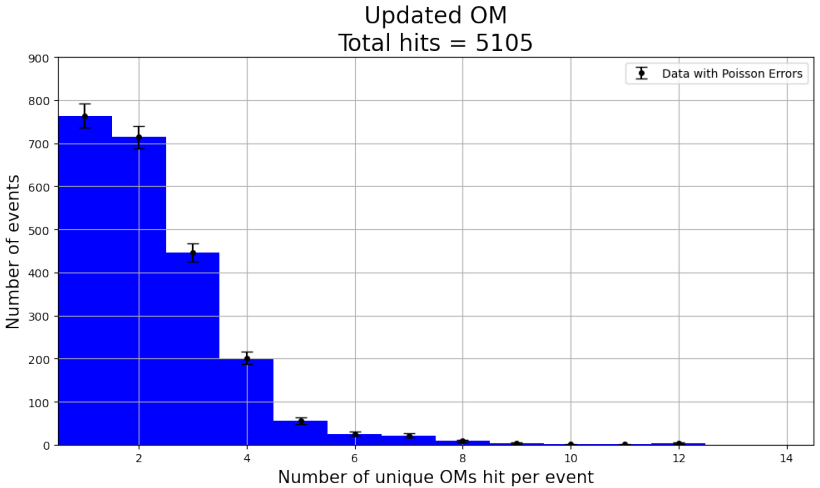


Image: Rasmus Ørsøe, TUM

Simulation Stats

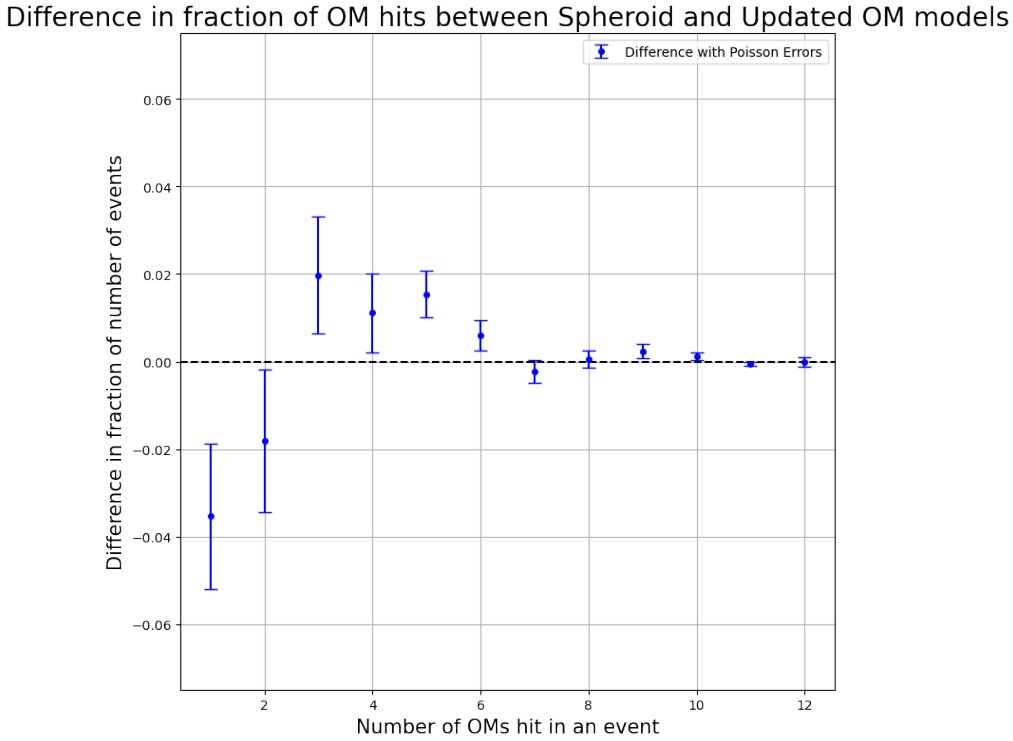
- Spheroid OM receives a large amount of hits.
- The distribution of the number of PMTs and OMs hit per event is quite different to the other models.





Simulation Stats

- Minimal difference between models using the spheres
- Due to photon acceptance happening once all photons hit the OM.



Marine Protected Area

- Designated in June of 2024.

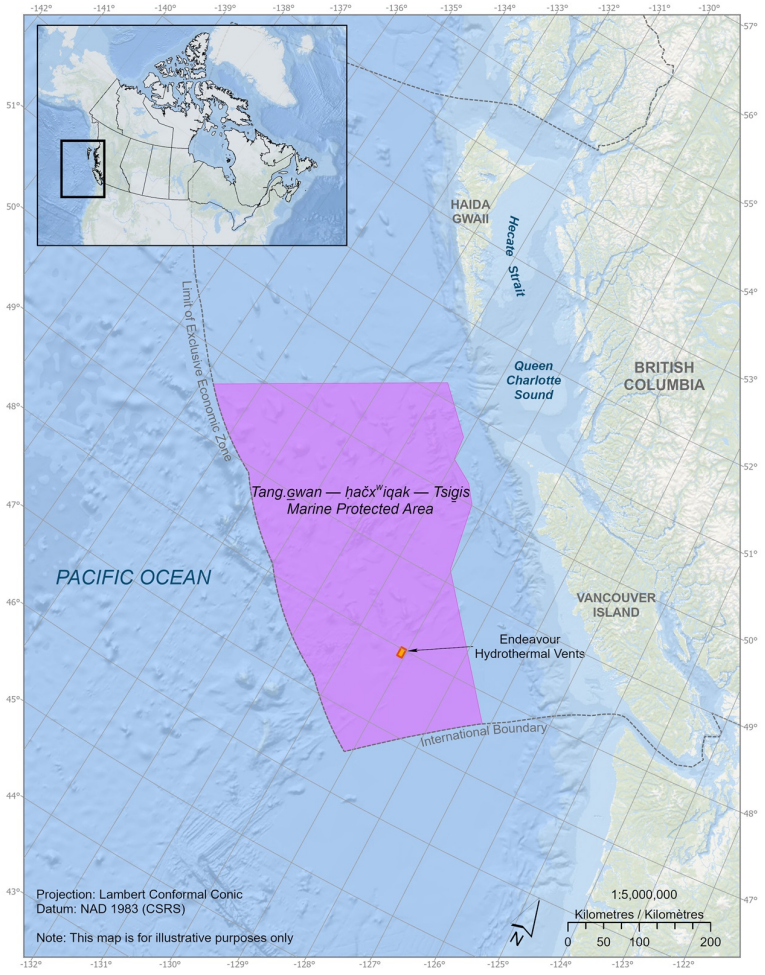


Image: https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/tht/index-eng.html