P-ONE

The Pacific Ocean Neutrino Experiment And Simulation of Atmospheric Muons

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Doctoral Seminar - 2026,
10-03-2026

Motivation for building P-ONE

- Study astrophysical neutrinos.
- Contribute to Multi-messenger Astronomy.
- Points straight to the Source.
- New Neutrino Source Discoveries.
- Increase statistics and to give complementary sky coverage.
- New Physics.

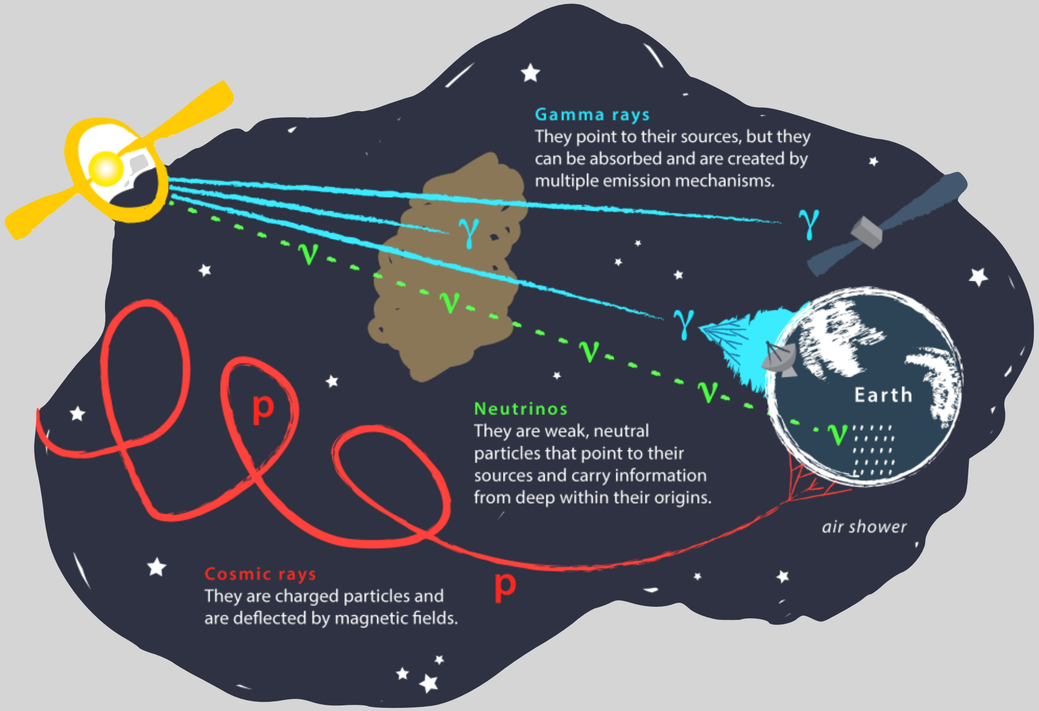


Image credit: IceCube

We need more neutrinos: Expanding the Neutrino Net

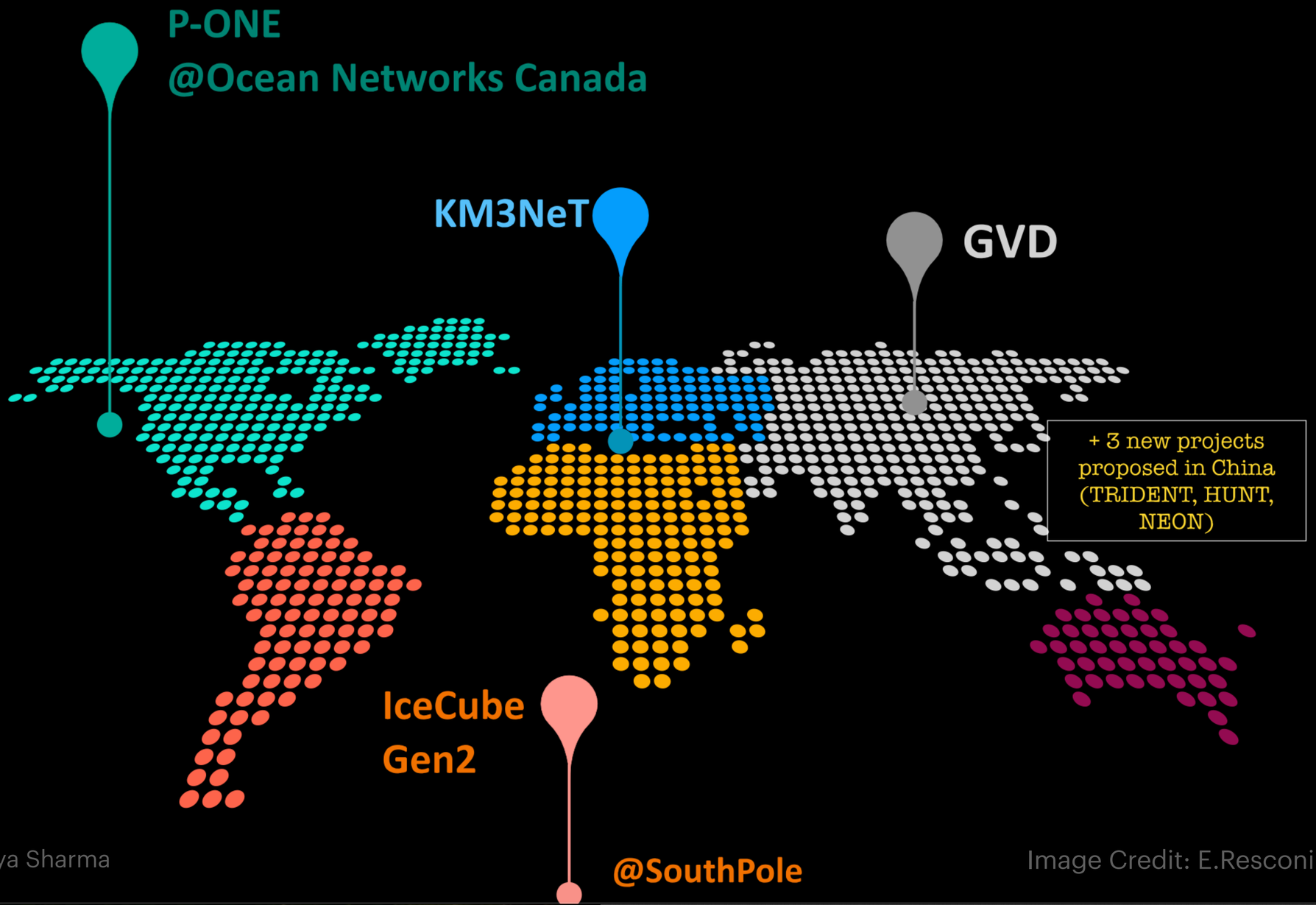
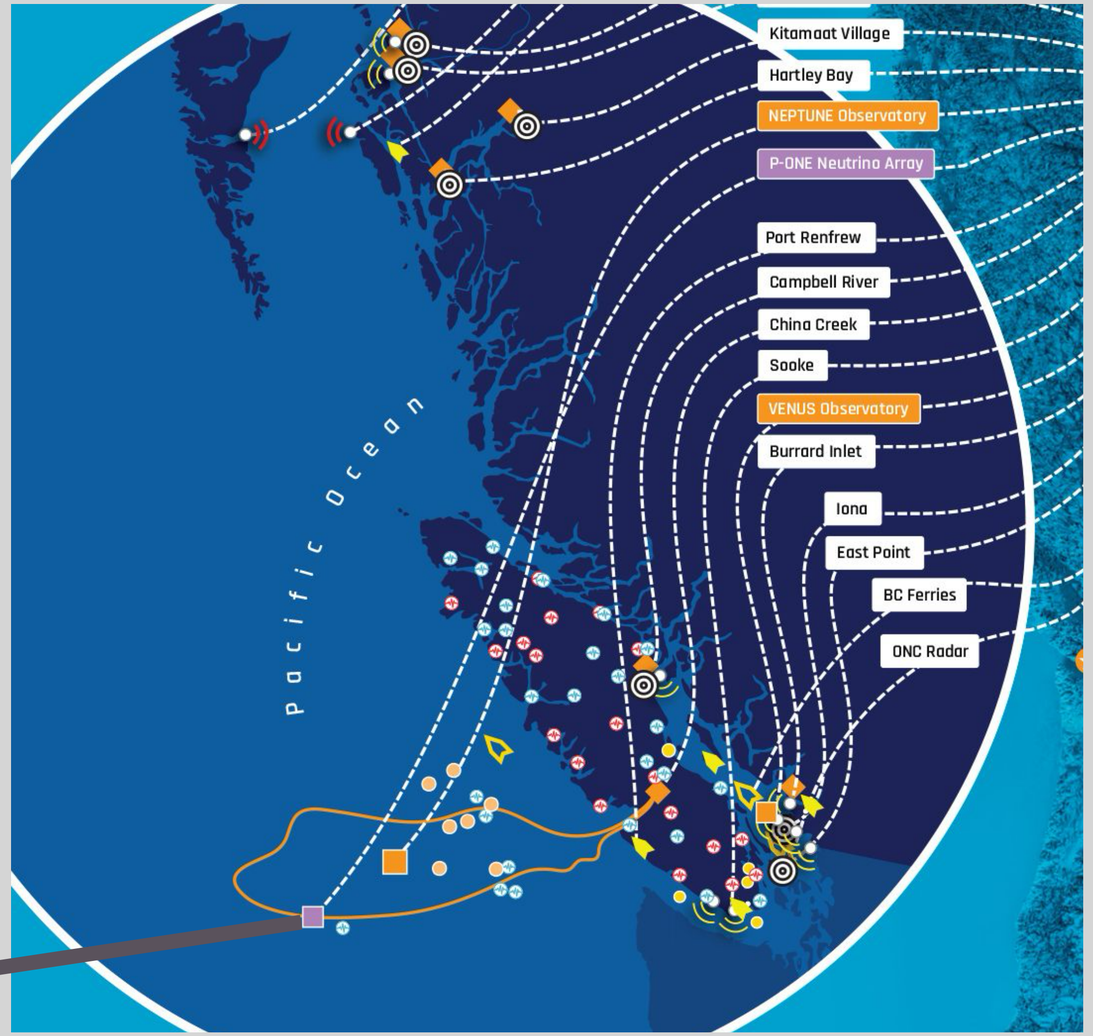


Image Credit: E.Resconi

P-ONE Location

- **Location:** Cascadia Basin
- **Infrastructure Operator:** Oceans Network Canada (ONC)
- **Temperature:** 2^0 C
- **Water Currents:** (0.1 m/s)



P-ONE

Image credit: ONC

P-ONE

- **Volume:** 1 km^3
- **Depth:** 2.66 km
- **Total Clusters:** 7
- **Strings/Cluster:** 10
- **Modules/String**: 20

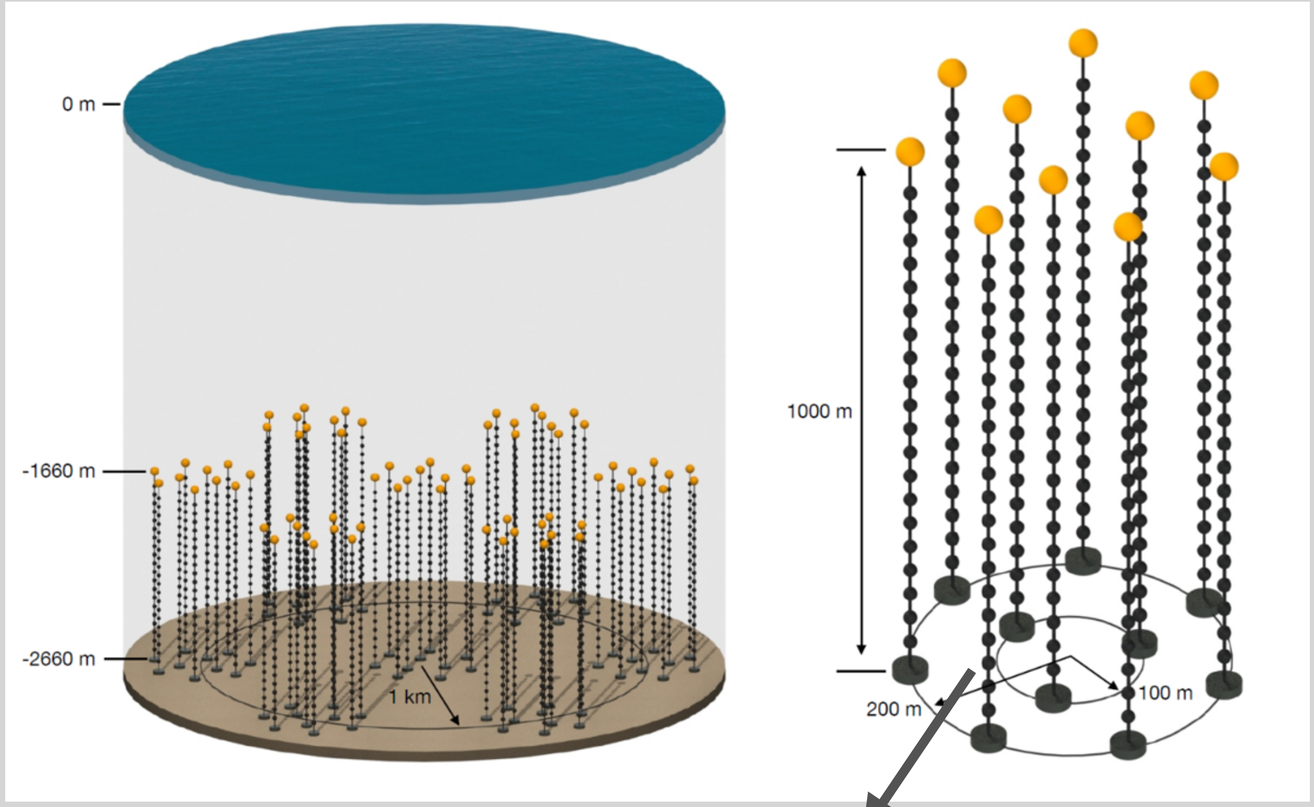
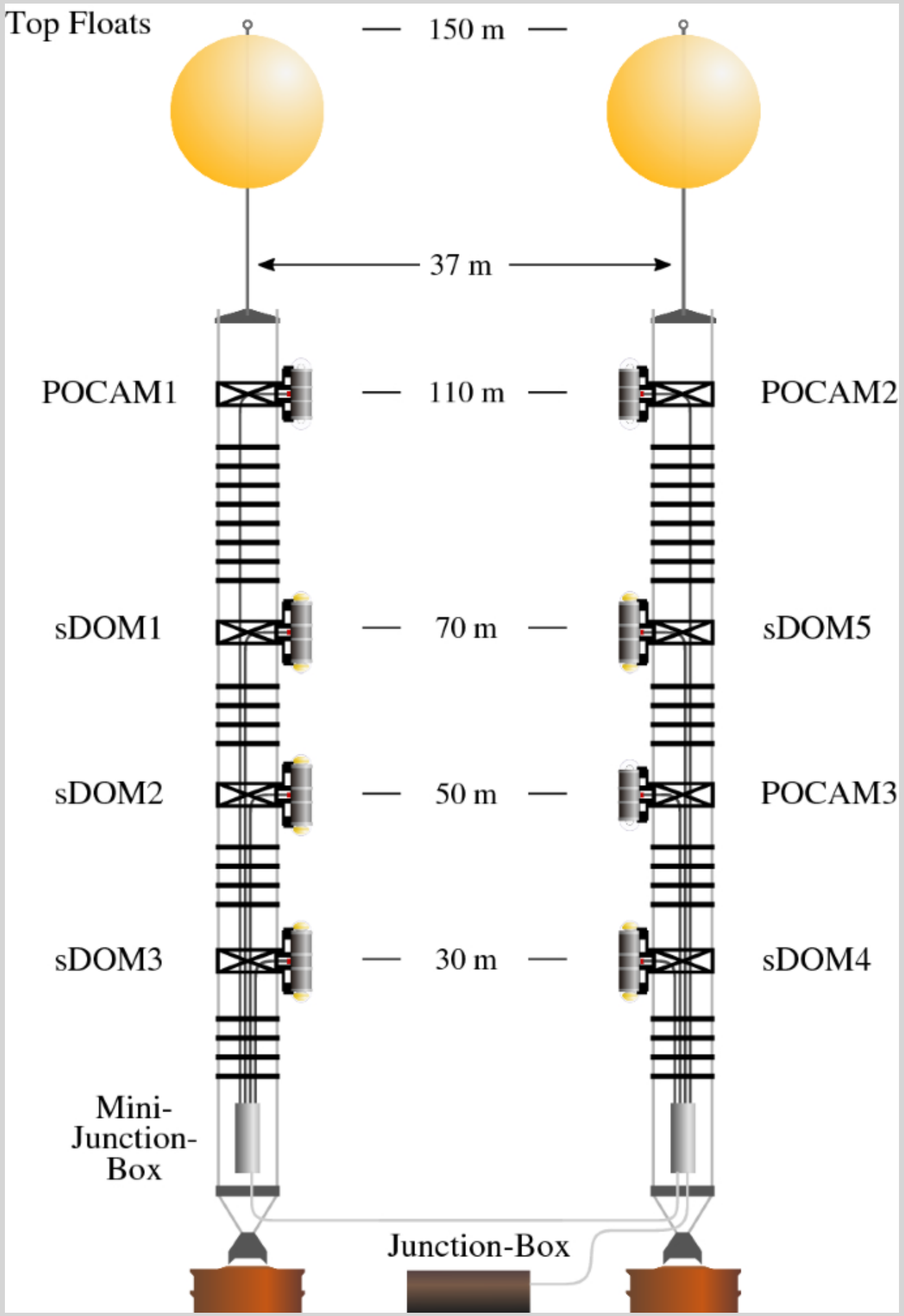


Image credit: P-ONE

Milestones Achieved

- **STRAW: STR**ings for **A**bsorption length in **W**ater .
- **Deployed:** June, 2018.
- **150** m long.
- 2 strings, 37 m apart.
- **98.3%** up time(with ONC outages and shutdowns for maintenance)

10.1140/epjc/s10052-021-09872-5



Milestones Achieved

- Attenuation length Calculation

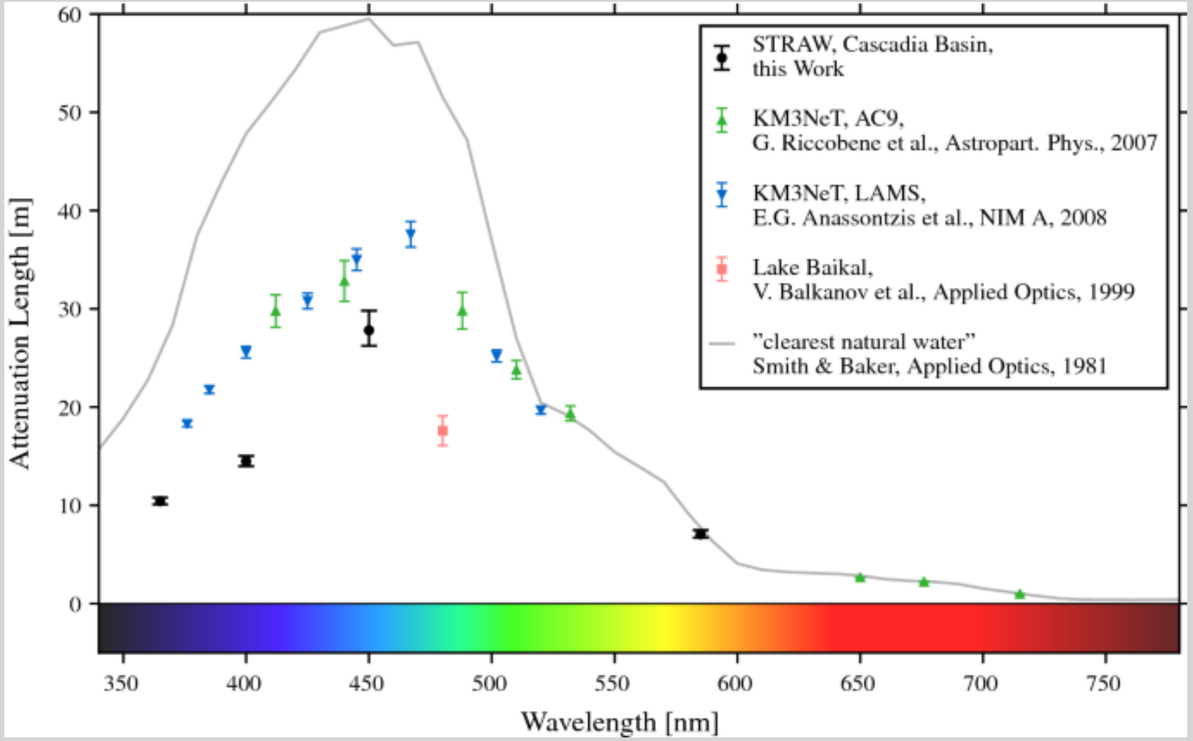
(27.7 m at 450 nm)

Spacing b/w modules

- Study of Ambient Background source

Helps in designing of DAQ and Triggers

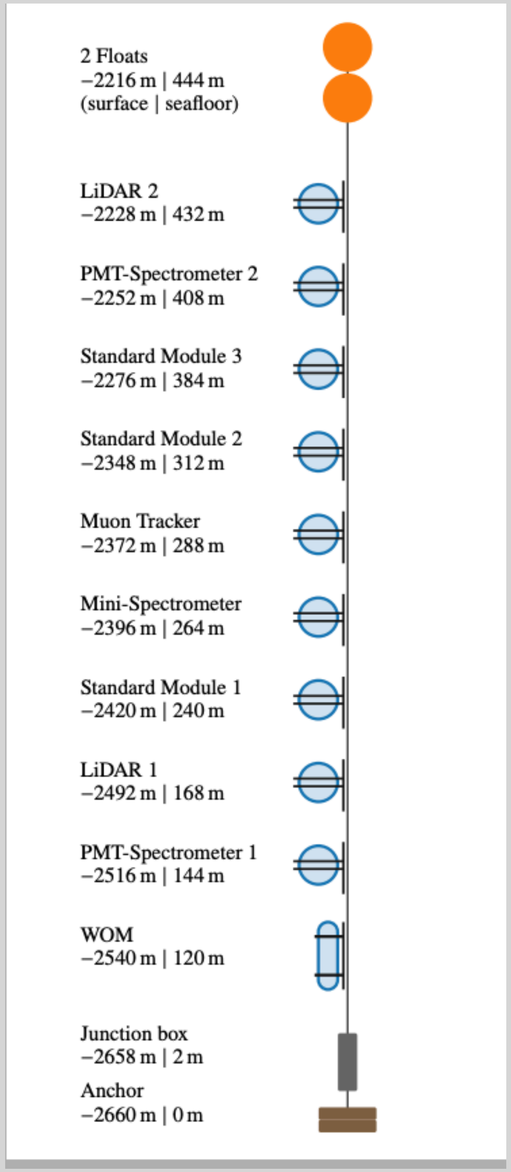
10.1140/epjc/s10052-021-09872-5



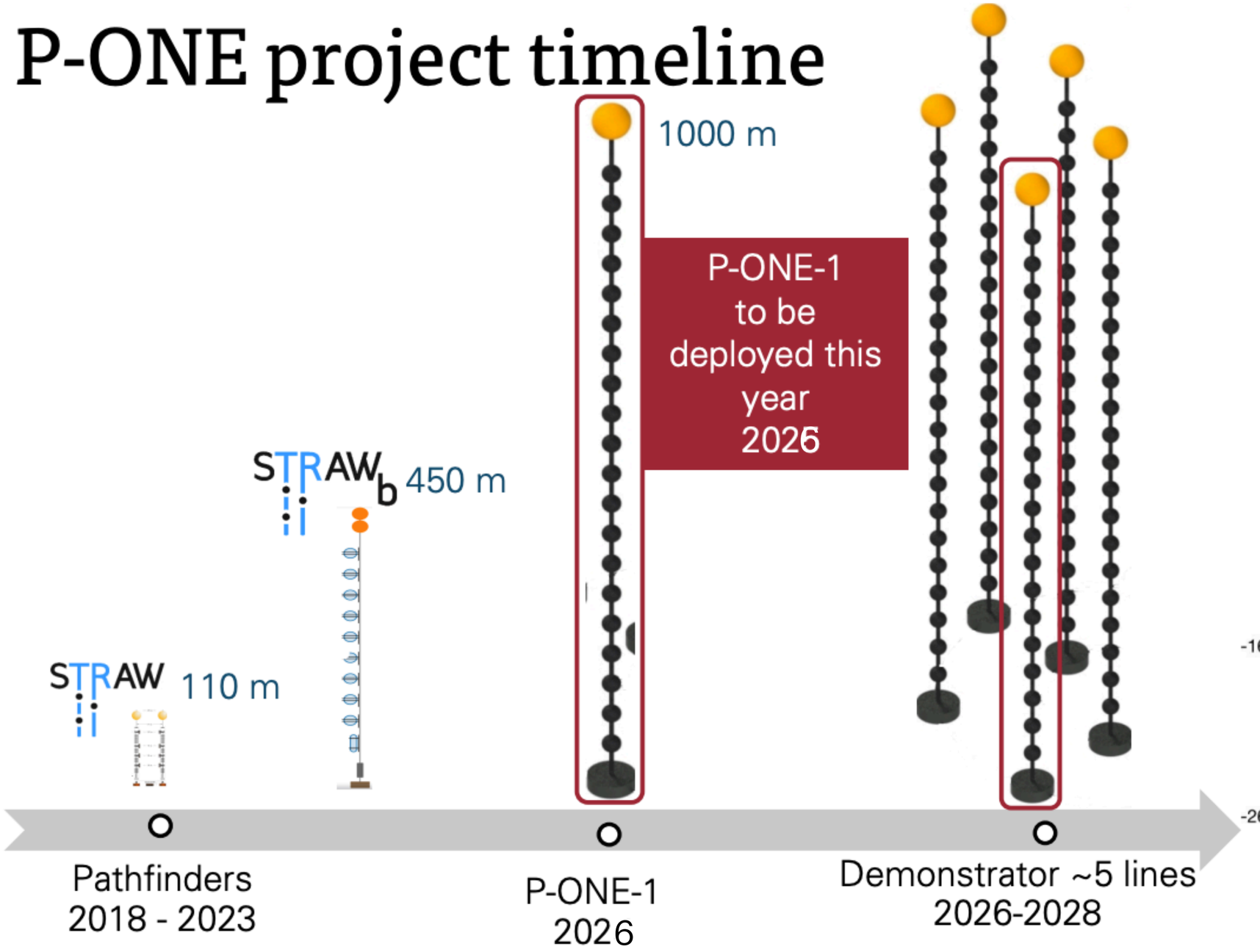
Milestones Achieved (STRAW-b)

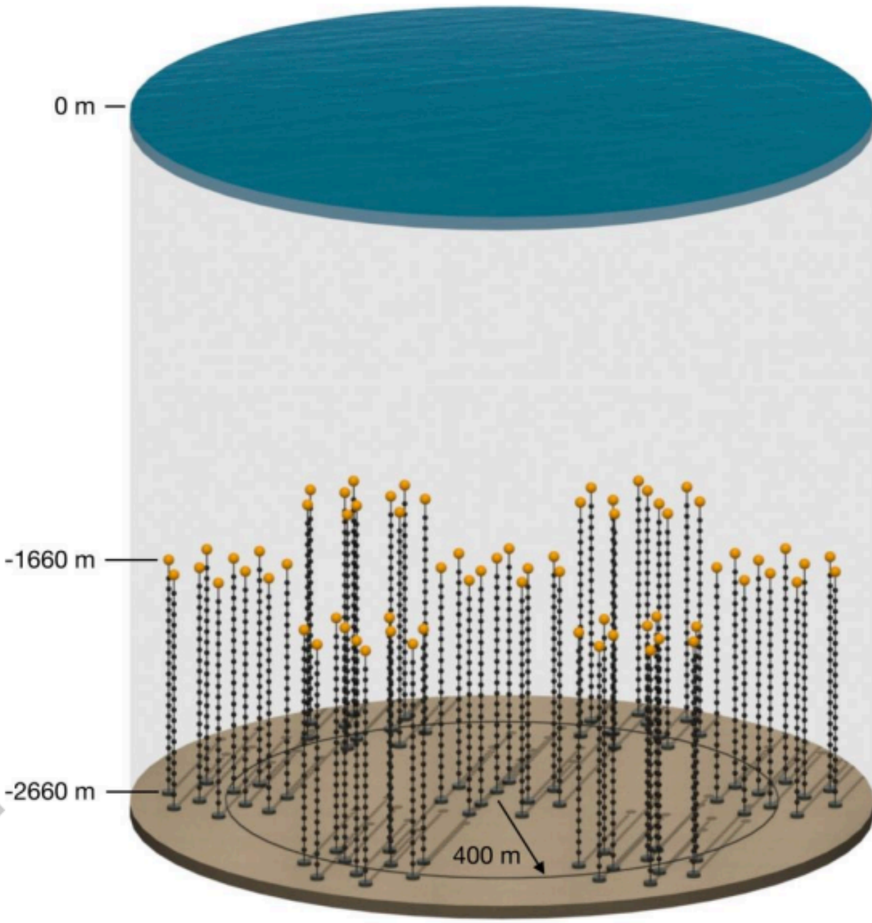
- **Deployed:** June, 2020.
- **450** m long.
- 1 strings, 40 m apart from STRAW.
- Study of Environmental Backgrounds.
- Gain Experience for construction and deployment for P-ONE.

K. Holzapfel *et al* 2024 *JINST* **19** P05072



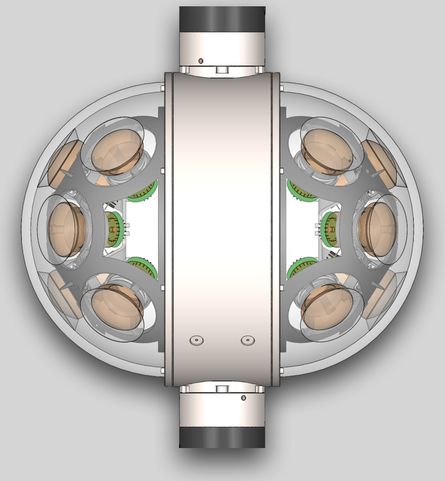
P-ONE project timeline





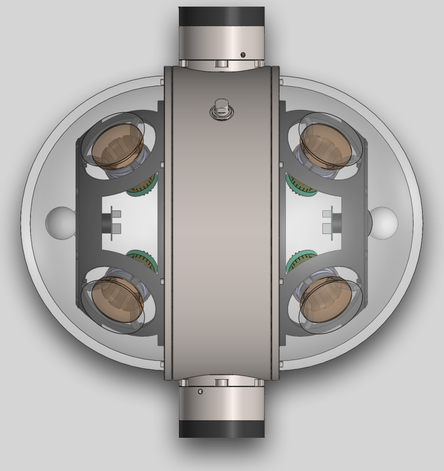
P-ONE-1

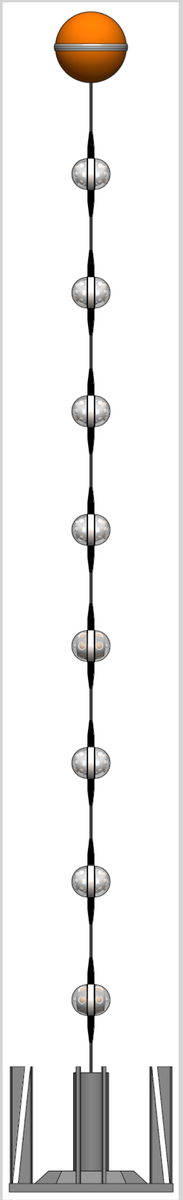
- **1000 m** Long.
- **20** Detection Modules
- **18 P-OM** (16 PMTs)
- **2 P-CAL** (8 PMTs)
- P-CAL: **300 m** and **650 m**
- All components are ready, testing is being done.



P-OM

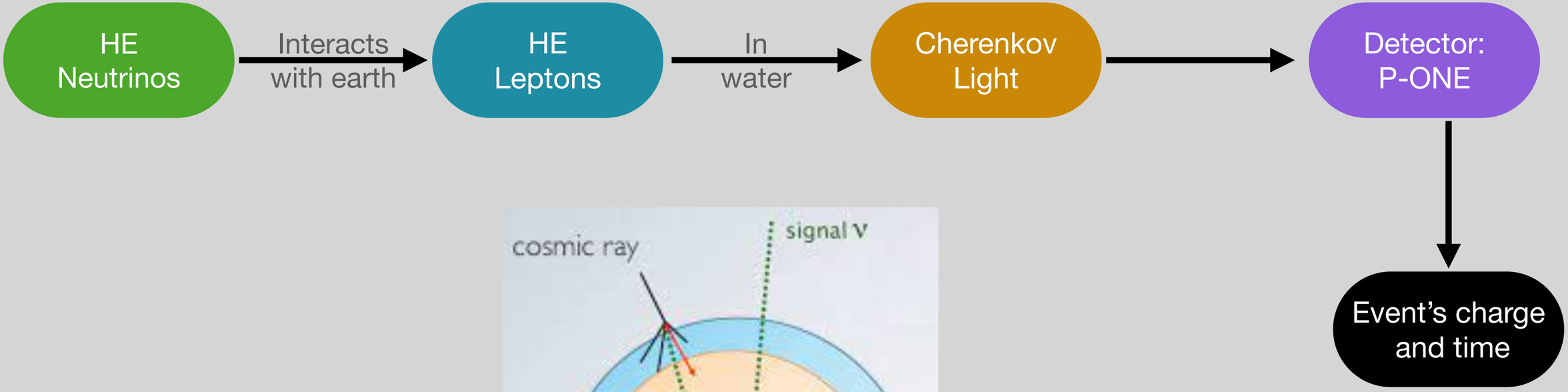
P-CAL

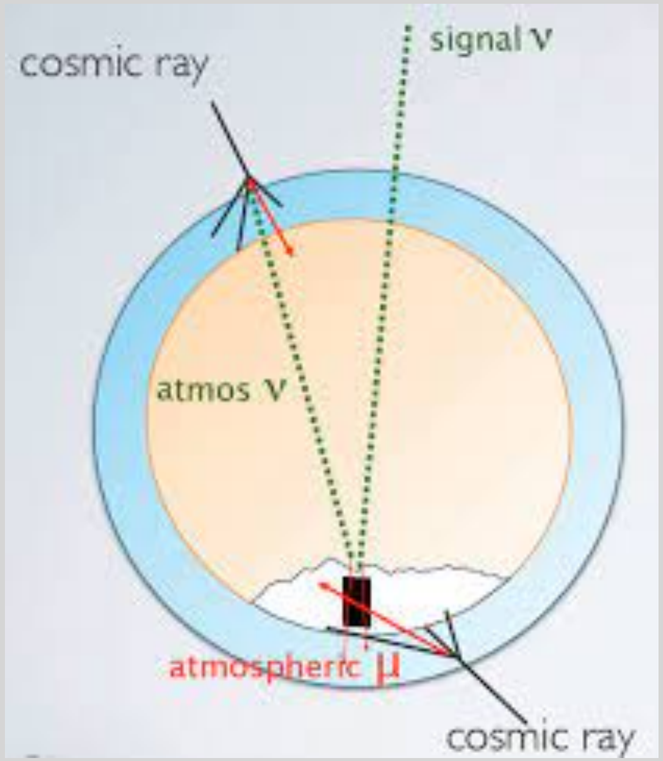


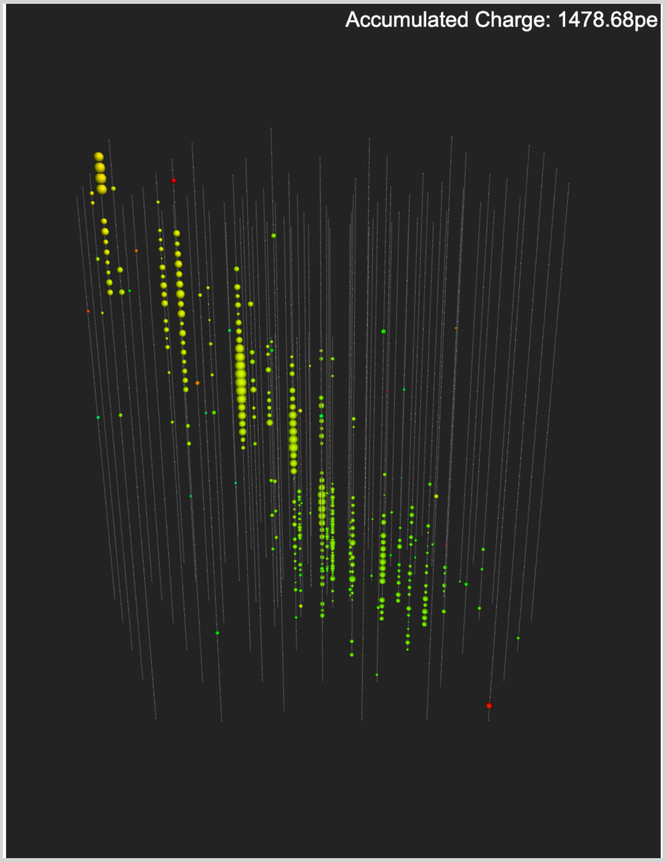


Mock Drawing of P-ONE-1

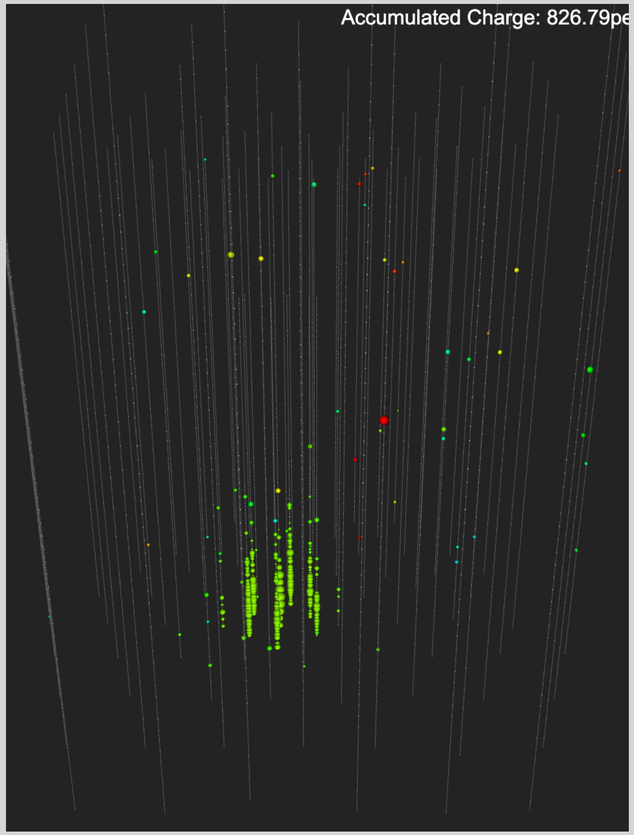
Detection Principle and role of Atmospheric Muons







Track Event (muons)



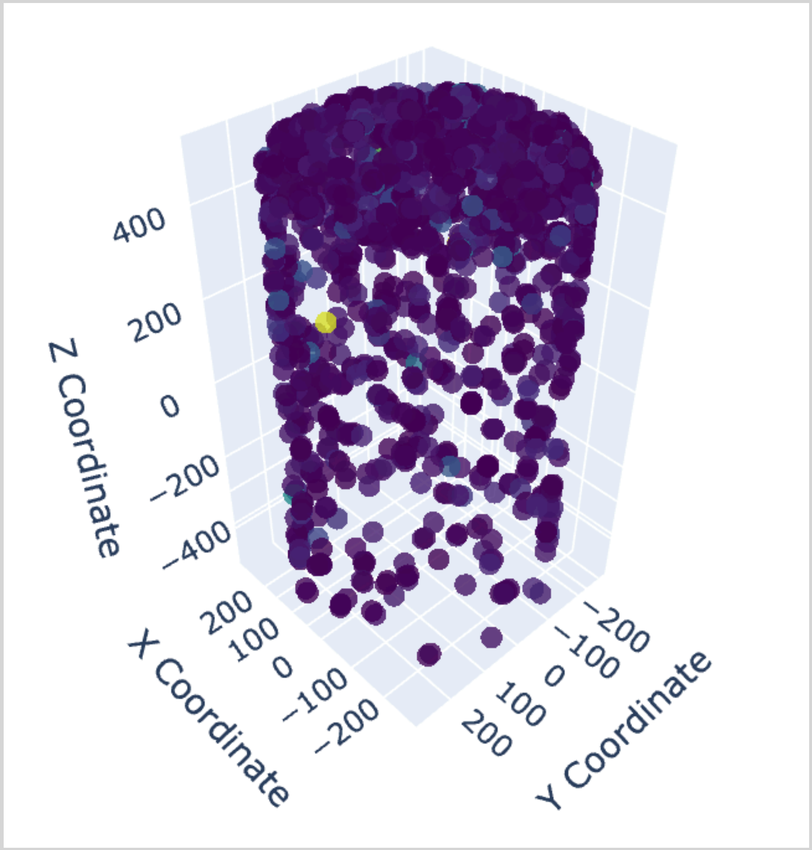
Cascade Event (electrons)

Simulation of Atmospheric Muons

- **Dominant Background(10^6:1).**
- **Rigorous simulations needed.**
- **Simulation tool: MUPAGE**
- **Events generated over a cylindrical can surrounding the actual volume of the detector.**
- **Generates two output files:**

Kinematics of muons generated

Livetime of generated muons



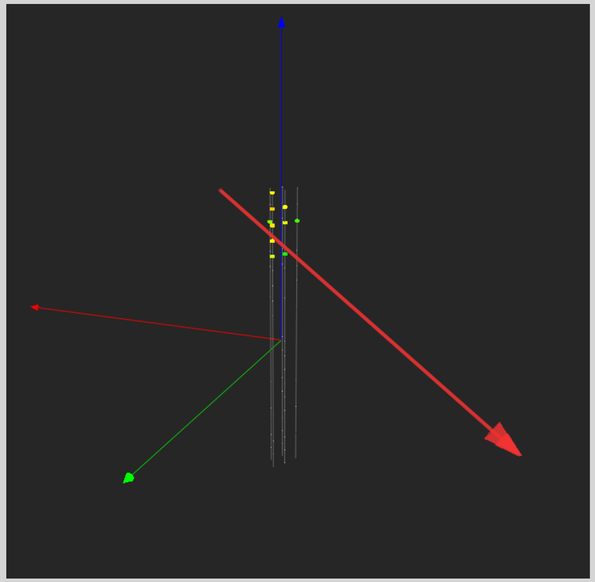
Modelling 1-year of data for P-ONE1

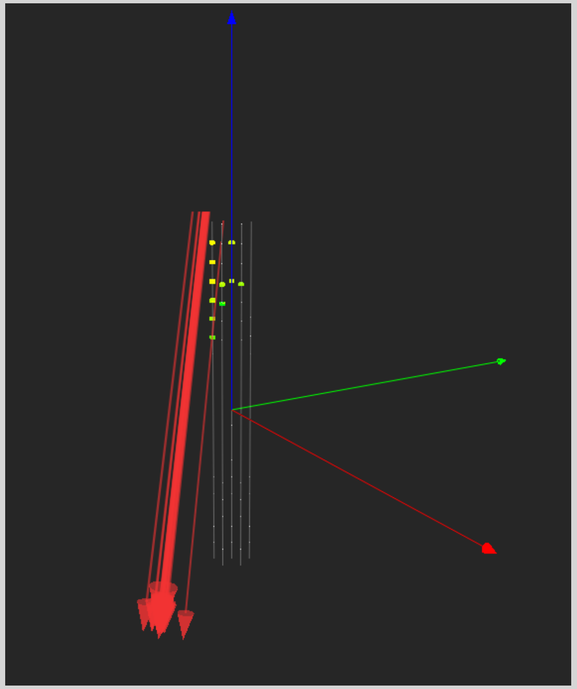
Multiplicity Range	For M=1	For M=2	For M=3	For M= 4-10	For M=11-100	For M=101-1000
No of Files Generated	**73**	73	52	177	71	17
No of Events/ file	**10^6**	10^6	10^6	10^6	10^6	$5x10^4$
Rate of events (Hz)	**2.29**	2.30	1.66	5.62	2.25	0.028

* **Calculation of no. of file is dependent on the lifetime of each file from each category = 365 days/(livetime in days)**

Progress with generated Data

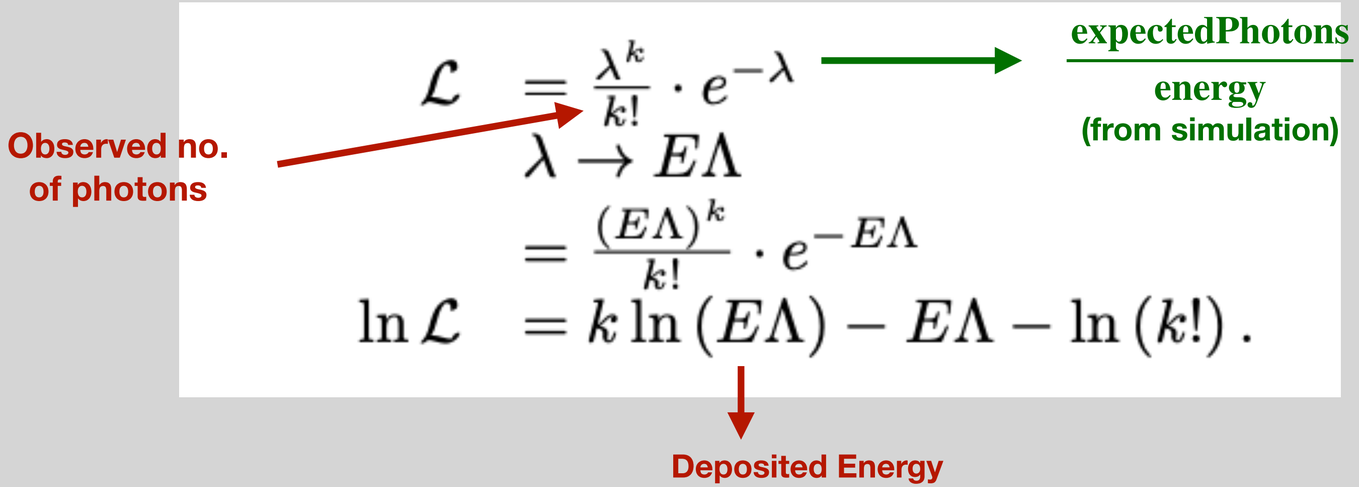
- **MUPAGE** integration with analysis framework of P-ONE, called **p-one offline (**based on IceTray).
- Muons are being **propagated** with the tools present in that framework.
- **Detector response** is also seen.



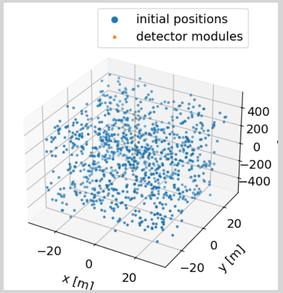


Reconstruction Techniques

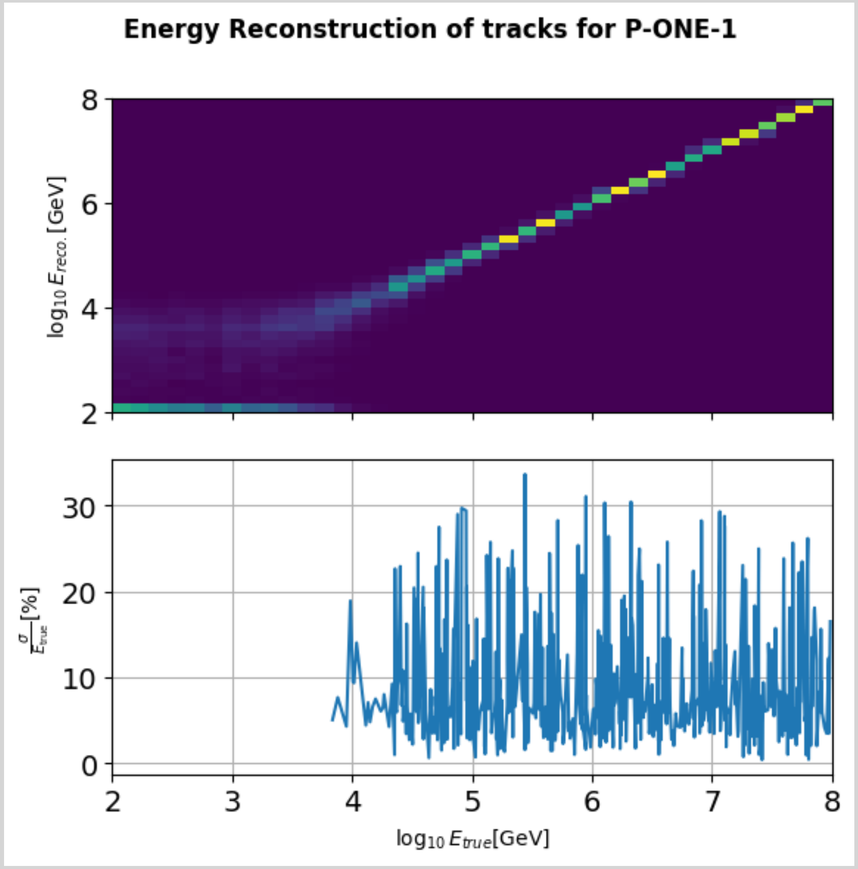
- **Log Likelihood Minimization Method.**
- **The energy of the event is directly proportional to light yield.**
- **Light yield functions for cascades and tracks are different.**

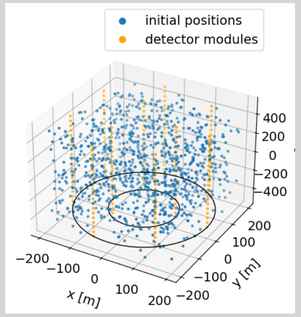


Energy Reconstruction for tracks

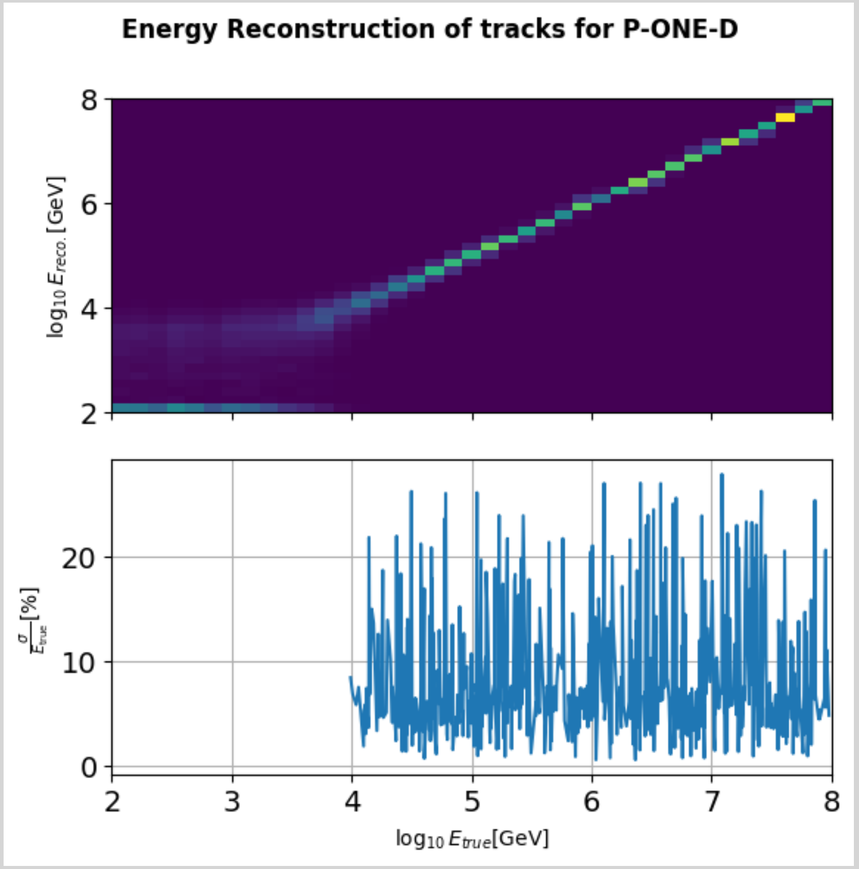


For P-ONE1





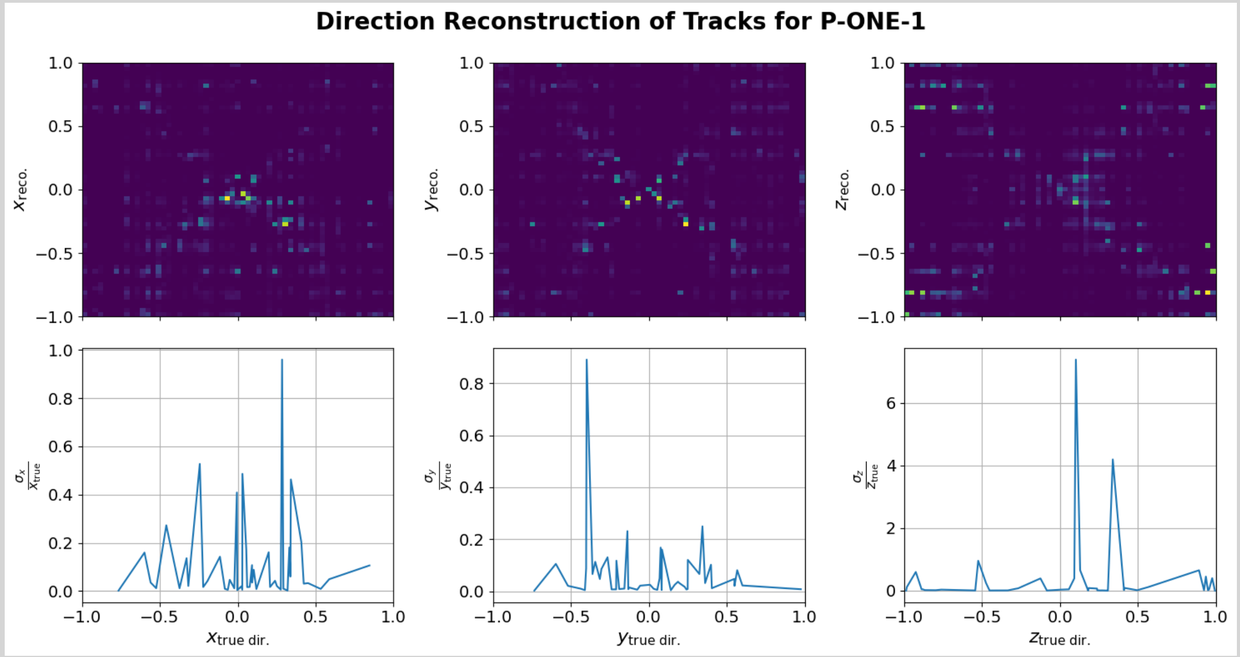
For P-ONE-D

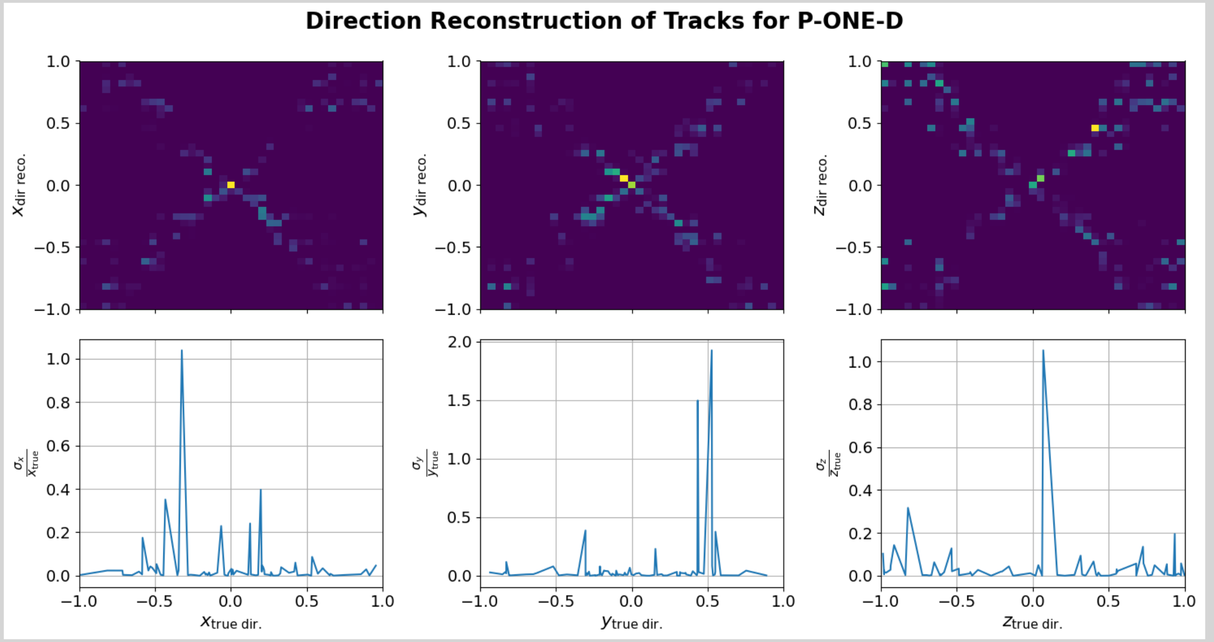


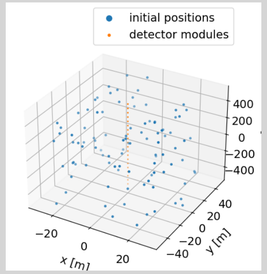
EVENTS:1000

Direction Reconstruction for tracks

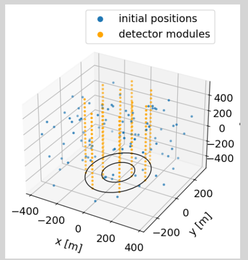
EVENTS:100







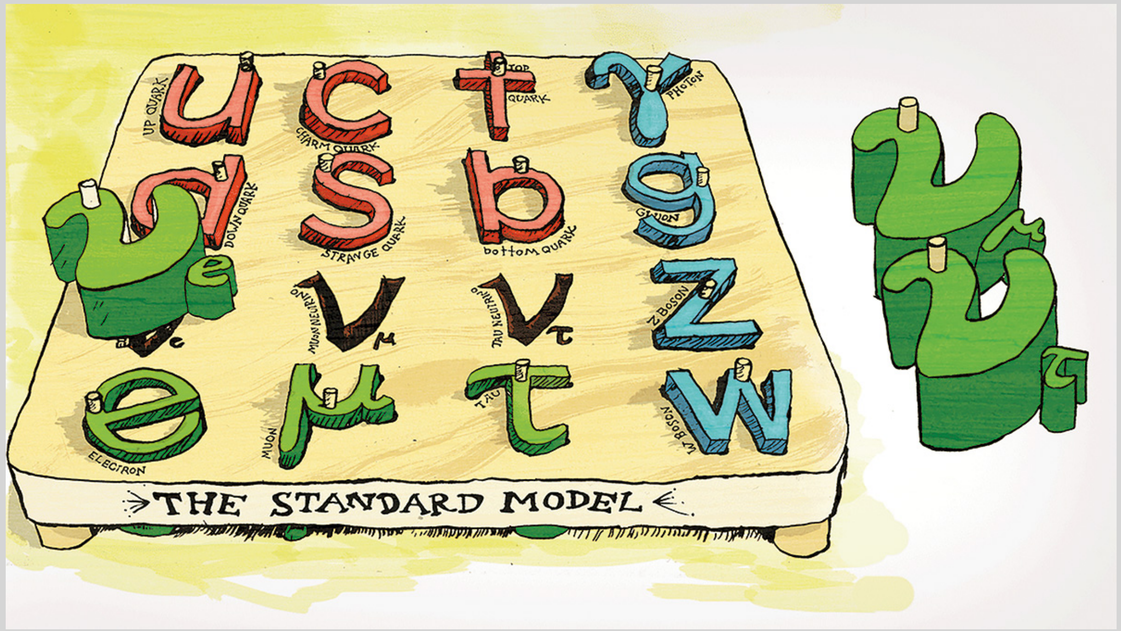
For P-ONE1

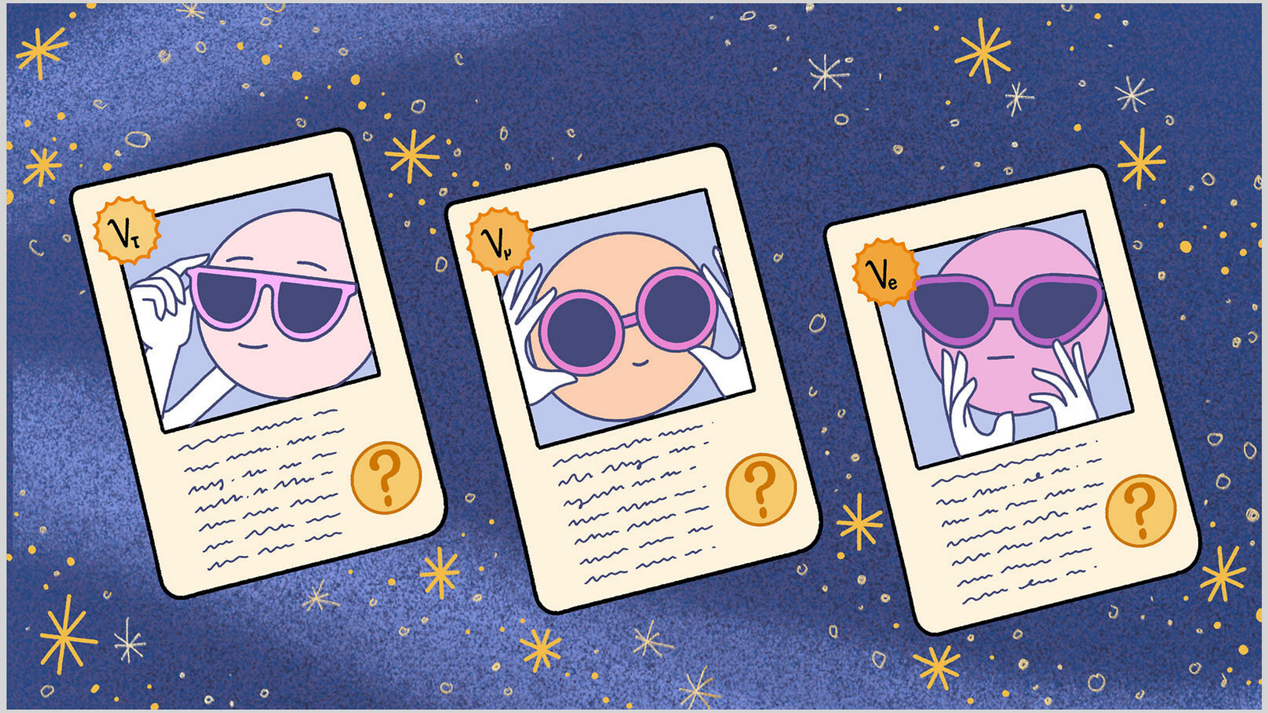


For P-ONE-D

Outlook and Summary

- Simulation of atmospheric muons are at good stage for P-ONE-1.
- Modelling for their rejection is under process.
- Reconstruction techniques has also been studied extensively.

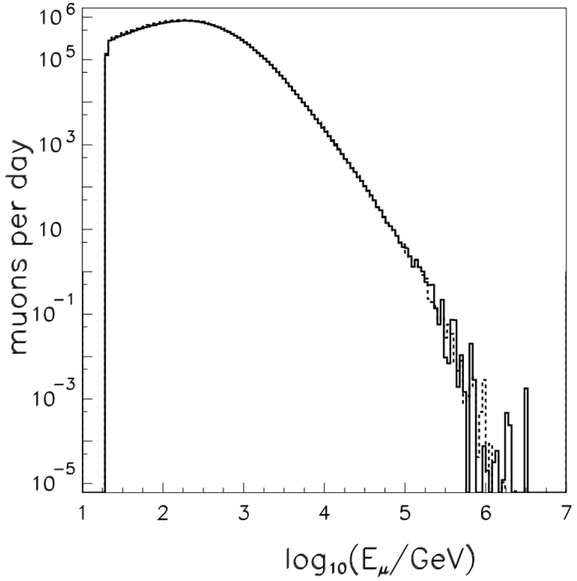




Thank you for your attention!!!

Additional Slide

Observed Data



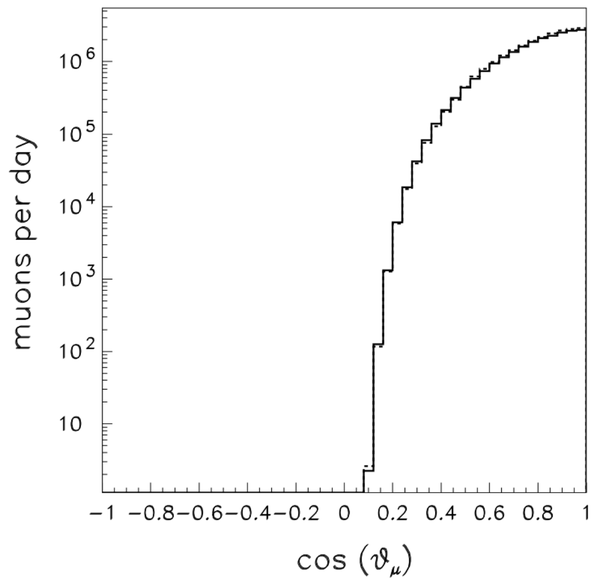
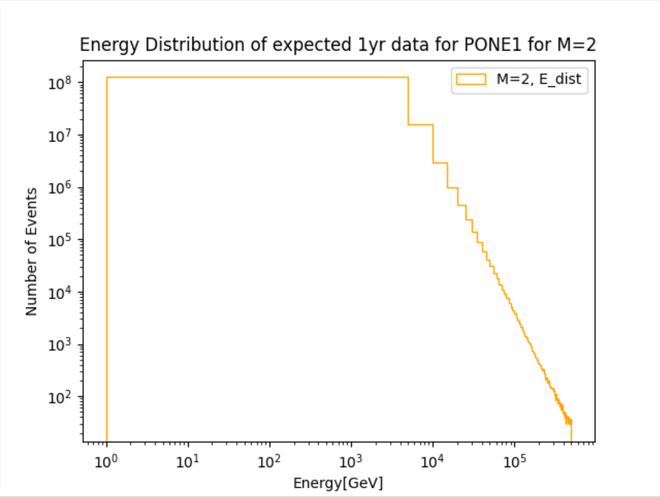
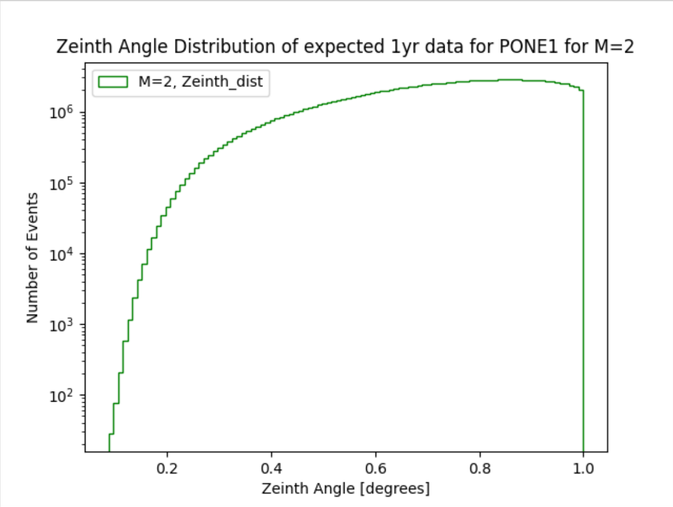


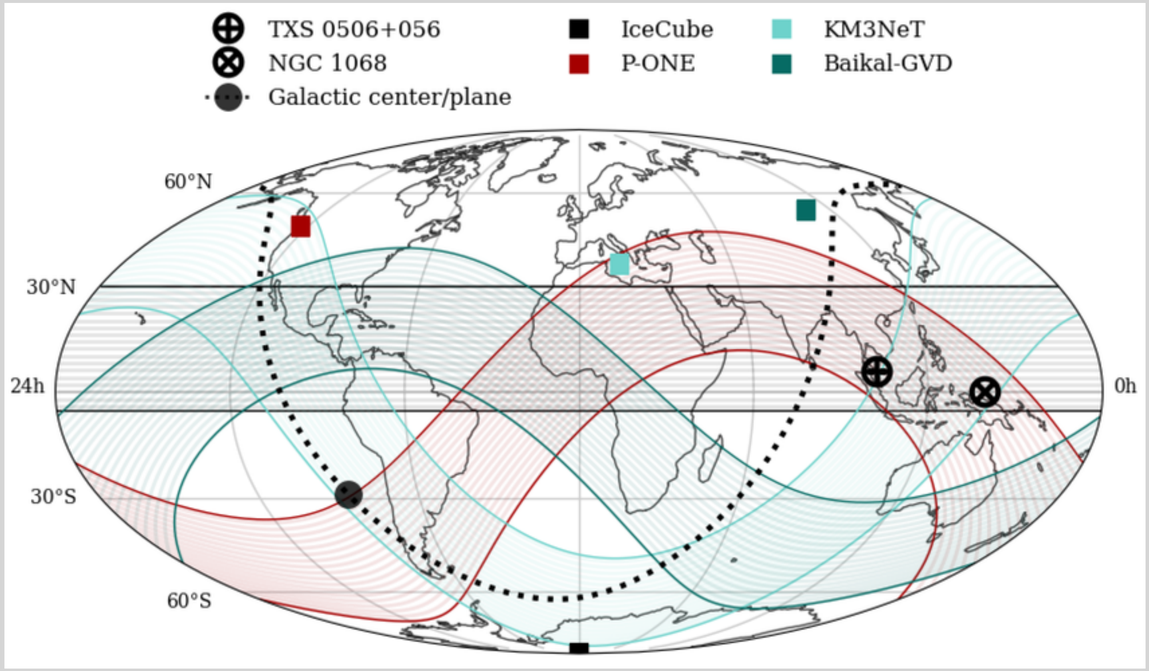
Figure 1. Atmospheric muon flux arriving at the detector surface. Left: Muon energy spectrum. Right: muon angular distribution. The continuous line corresponds to the HEMAS simulation, the dotted line to the CORSIKA simulation

Simulated Data

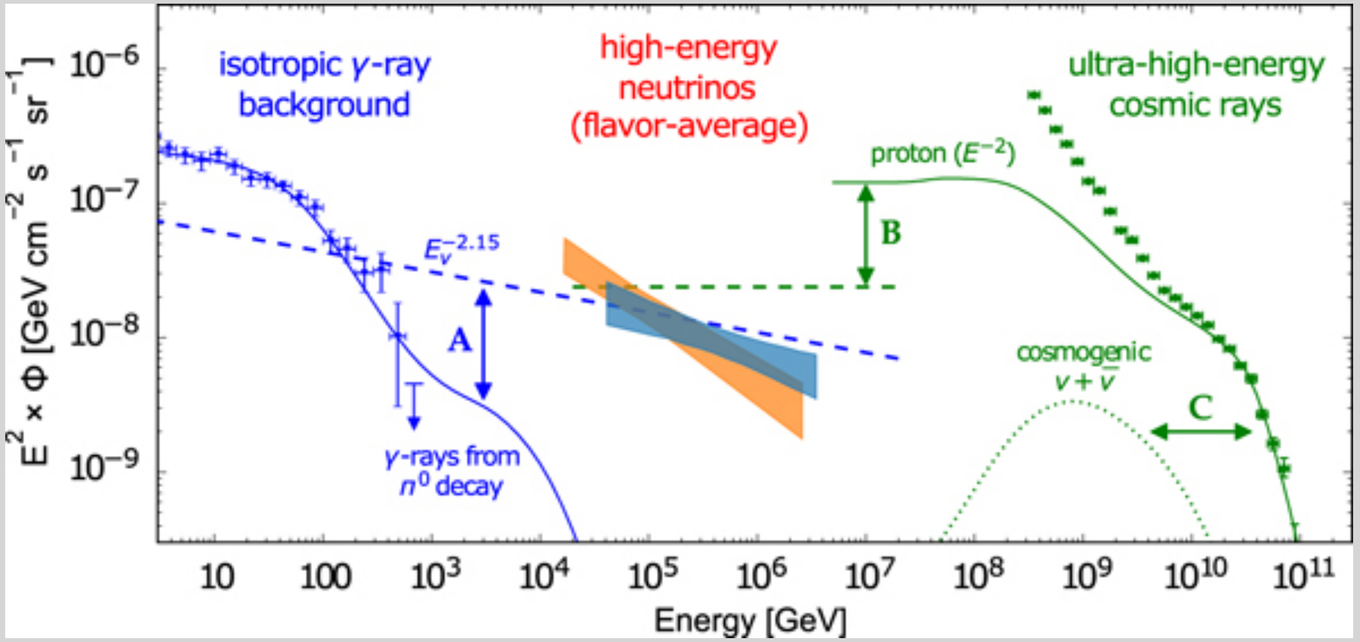




Sky Coverage Map for Different Neutrino telescopes



High Energy Neutrino Regime



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No of Events/ file	**10^6**	10^6	10^6	10^6	10^6	$5x10^4$
Rate of events (Hz)	**2.29**	2.30	1.66	5.62	2.25	0.028
Weight $w = \frac{365 * 24 * 60 * 60}{L * Nfiles}$	**0.9893**	0.9936	1.0067	1.0013	0.9994	0.9811

* Calculation of no. of file is dependent on the lifevime(L) of each file from each category = 365 days/(livetime in days)