P-ONE in a Box

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P-ONE

- P-ONE is a future neutrino observatory aiming to instrument a cubic kilometre of ocean in the Cascadia Basin off the coast of Vancouver Island
- Cascadia Basin is an ideal site as Ocean Networks Canada's (ONC) NEPTUNE network offers existing power and network connections
- The location is also ideally suited for complementing the neutrino sky coverage of existing observatories such as IceCube and KM3Net
- P-ONE will study sources of high energy neutrinos, such as Galactic Nuclei (AGNs) and black holes, contribute to multi-messenger astronomy, measure the diffuse neutrino flux, and take part in ocean monitoring through measurements of bioluminescence

P-ONE Model

- Interactive, 1:1000 scale model of P-ONE
- P-ONE strings are represented by a strand of LEDs
- P-ONE Optical Modules (P-OMs) are represented by ping-pong balls
- The illumination of the LEDs represents the detection of Cherenkov light by PMTs in the P-OMs
- Three buttons trigger specific flavours of neutrino interaction and detection (electron, muon, or tau)
- A clock displays the elapsed time in nanoseconds
- Learners see and interact with both the shape and timing differences of the different types of neutrino interactions

Model Construction

- LED Strands are suspended by weaving them through four layers of foam board cut with perpendicular slits
  - One layer is cut in 'x' and the other in 'y'
- This allowed the ping pong balls to be threaded and held in place with elastics prior to being suspended in the box
- Support structure is built from extruded aluminum bars
  - Special attention was given to supporting the upper layer of foam to reduce sagging
- All side except the front are covered by black foam board
- An Arduino processes inputs from the buttons, controls the LEDs, and updates the clock
- All electrical wires are located in the gap below the bottom layer of black foam

Types of Neutrino Interactions

When high energy neutrinos (TeV–PeV scale) interact with water, the produced secondary particles leave a characteristic fingerprint of Cherenkov light, which can be used to identify the flavour of the initial neutrino.

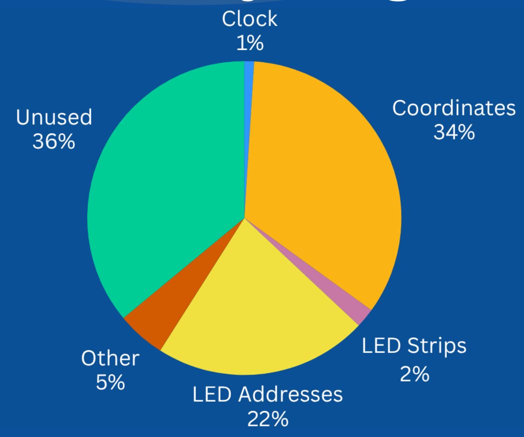
- **Electron neutrino:** quickly triggers an electromagnetic cascade leading to a spherical signature
- **Muon neutrino:** produces a muon that leaves a kilometre-scale track passing through the detector
- **Tau neutrino:** produces a "double bang" event where the initial interaction results in a cascade and the subsequent tau decay produces a second, spatially separated, cascade

Code

- All code is implemented on an Arduino Mega 2560 Rev3
  - First time coding for the Arduino architecture!
- Main challenge was fitting the program in 8kb of RAM

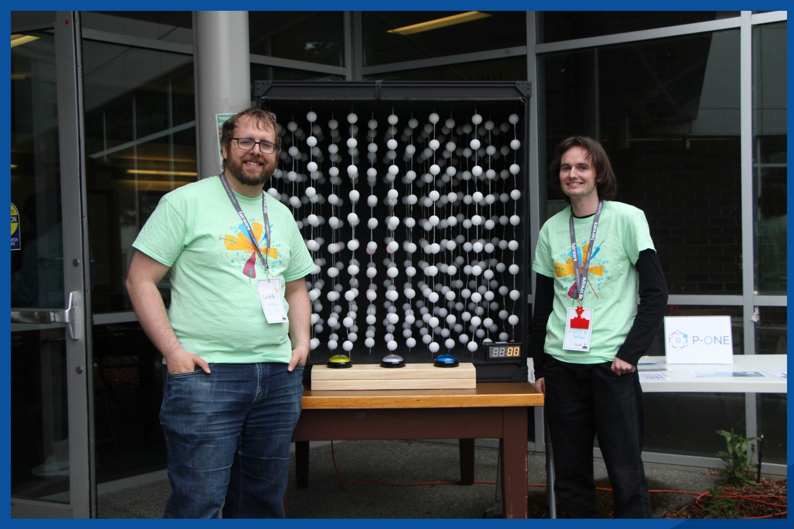
Github

Memory Usage



Outreach Experience

- Displayed at Science Rendezvous 2025 at the University of Victoria to an audience of ~1200 participants
- Run by two volunteers trading off over the 6 hour event
- Generated lots of interest from learners of all ages:
  - Why so big?
  - Why underwater?
  - What are neutrinos? And why do we want to see them?
- People were interested to hear about a project happening nearby that partners with a local organization (ONC)
- Outdoor location was not ideal, difficult to see lights even though it was overcast
- Leaflets highlighting detector components, location, and physics principles saw a lot of use



List of Equipment

- 7 Adafruit NeoPixel Pebble LED 10m Strands
- 3 Arcade Buttons
- 1 7-segment clock display
- 1 Arduino Mega 2560 Rev3
- 460 ping pong balls
- 460 elastics
- 18m of extruded aluminum
- foam board sheets

Total cost ~$650
(excluding aluminum frame and foam board)

P-ONE String →

P-ONE Optical Module (P-OM) →

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