



Chasing Neutrinos: A Hands-on Journey with LArTPCs

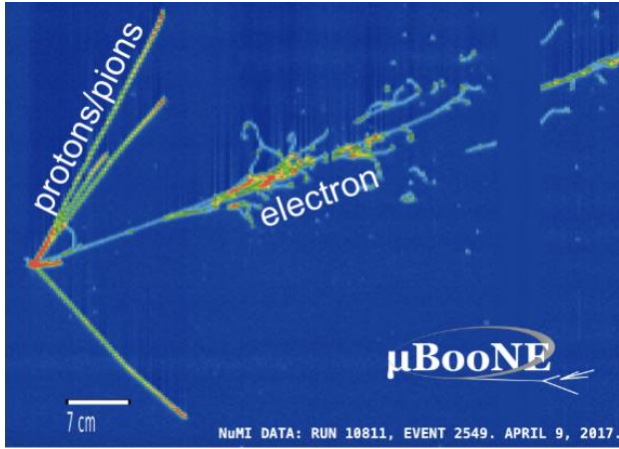
Andrew Gallagher

Quarknet Talks

8/2/2023

What is a LArTPC?

- Liquid Argon Time Projection Chamber
- New type of detector
- Reconstructs neutrino-argon interactions in 3D
- Detects ionization electrons from secondary particles
- Just a vat of argon, some wires, and a special camera

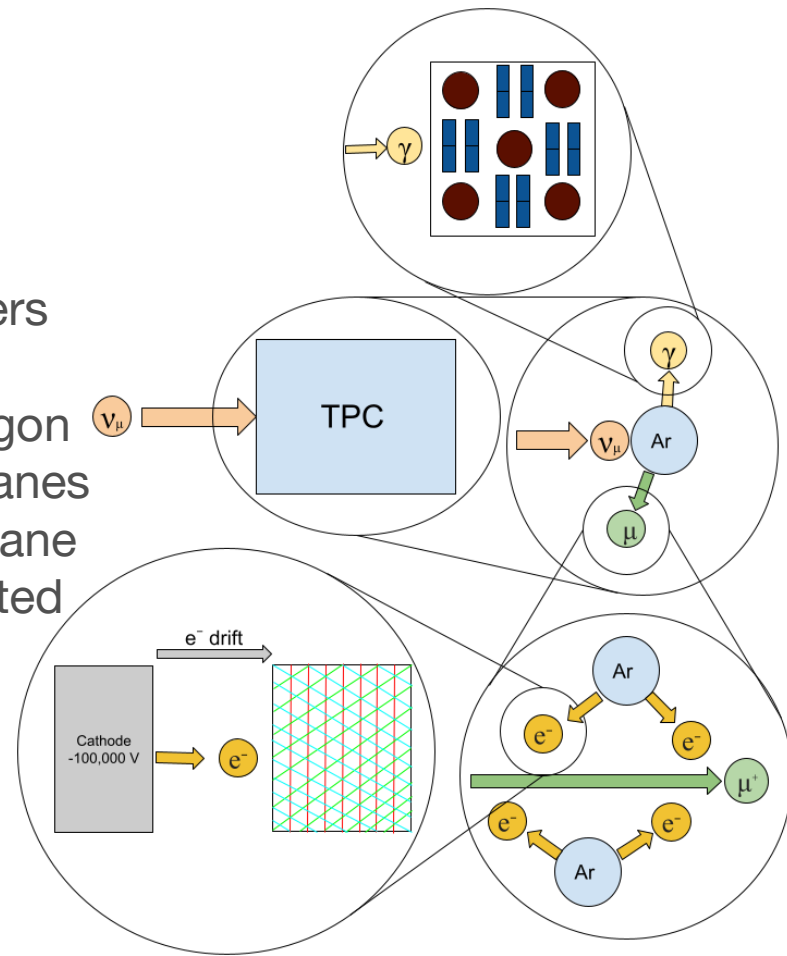


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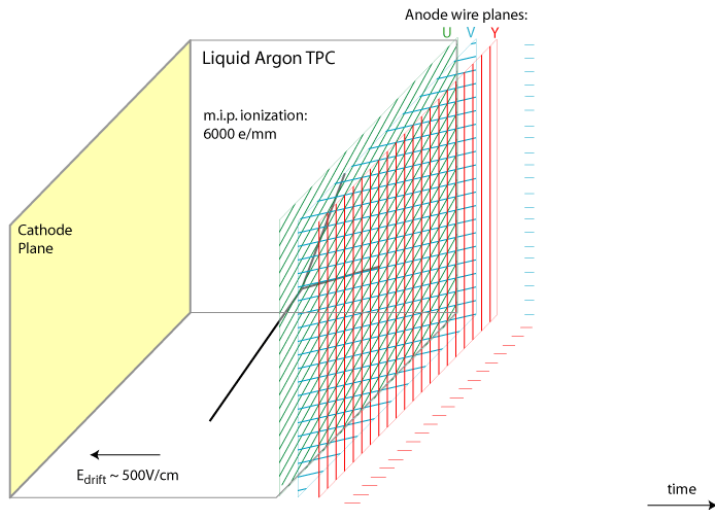


How does a LArTPC work?

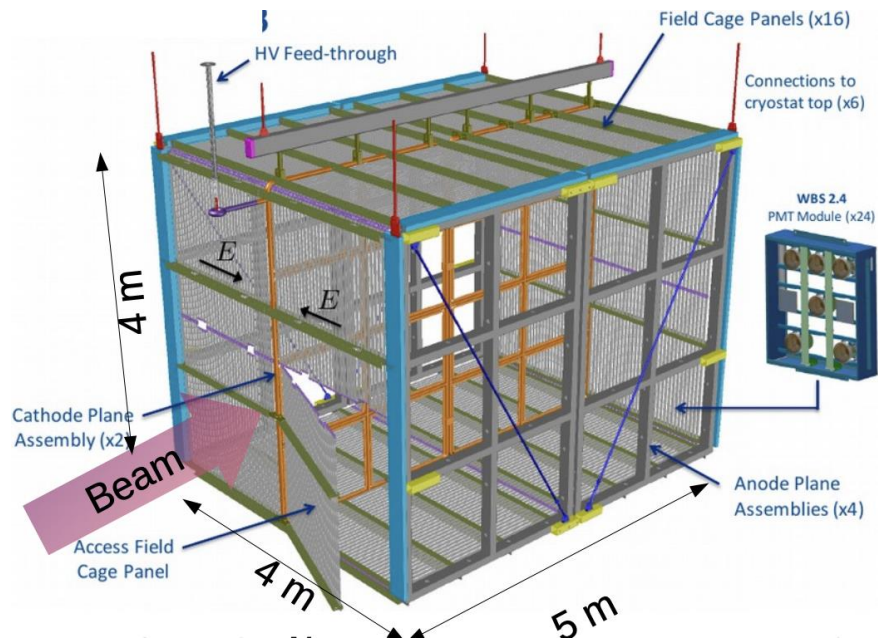
- Neutrino beam shot into the TPC
- Neutrinos interact with argon atoms
- Releases daughter particle, photons, and others
- Photons get detected and time is marked
- Daughter particle separates electrons from argon
- Electrons pushed via electric field to 3 wire planes
- Electrons induce voltage as they pass each plane
- Velocity, direction, and acceleration is calculated
- Neutrino Interaction is reconstructed



How does a LArTPC work?



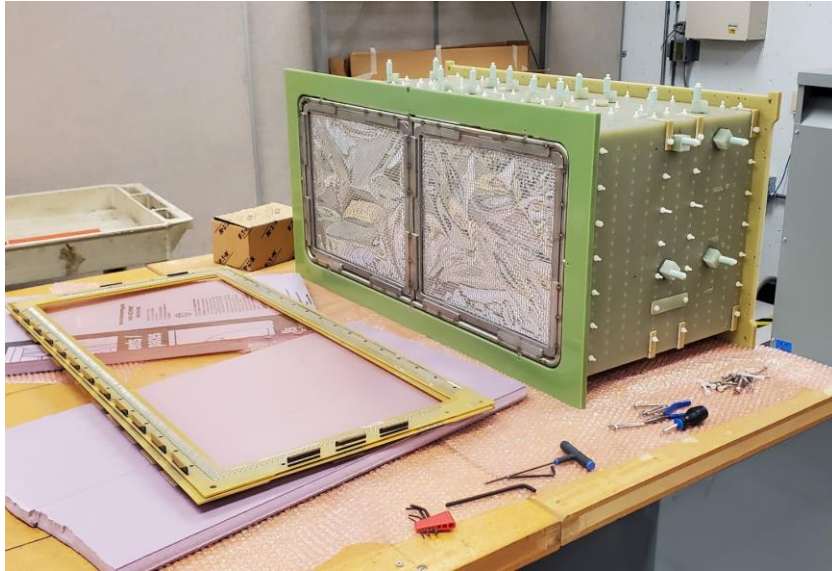
<https://lar.bnl.gov/wire-cell/>



<https://shorturl.at/allMX>

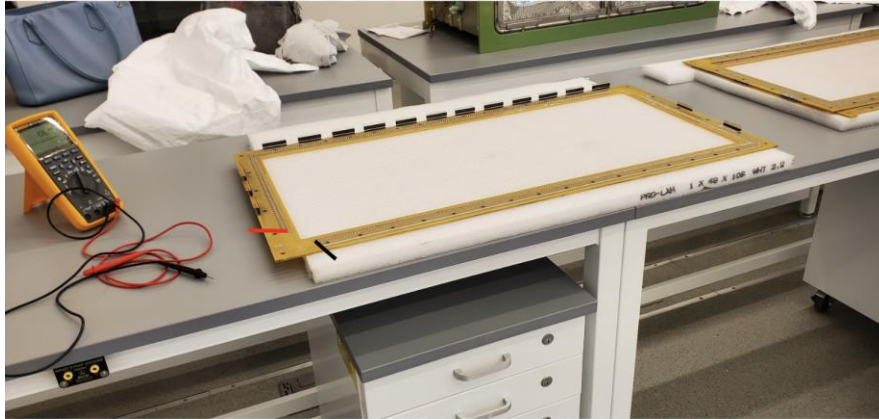
Pretty simple... right?

- Instruments need to be incredibly precise
- Preparing a detector requires LOTS of tests
- Moved ArCS to IERC and began testing

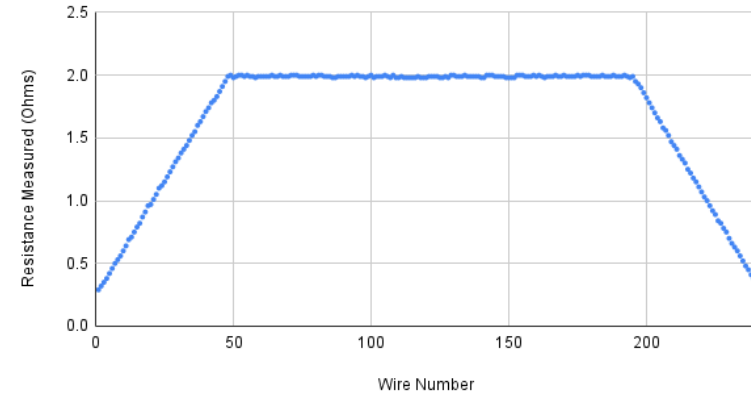


Continuity testing

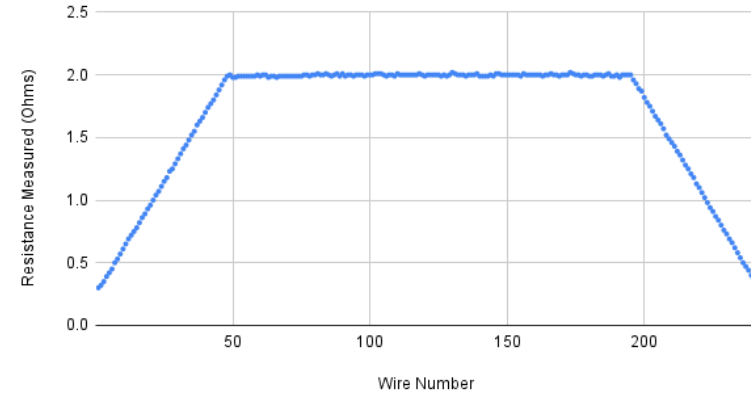
- To check integrity of wires
- Resistance is proportional to wire length
- Wires are short, long, then short again



Collection Plane Continuity Test



Induction Plane Continuity Test

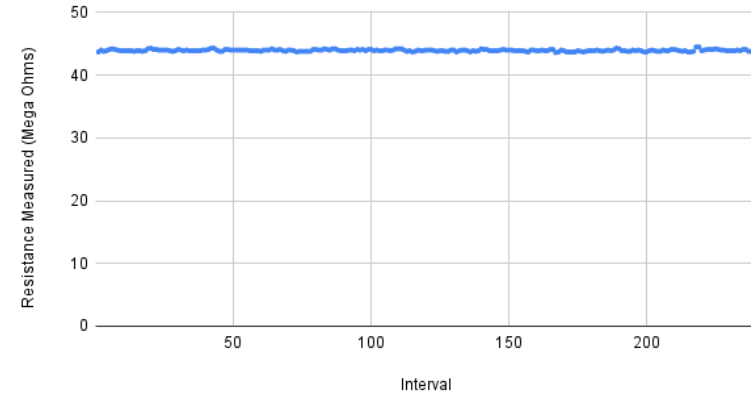


Isolation testing

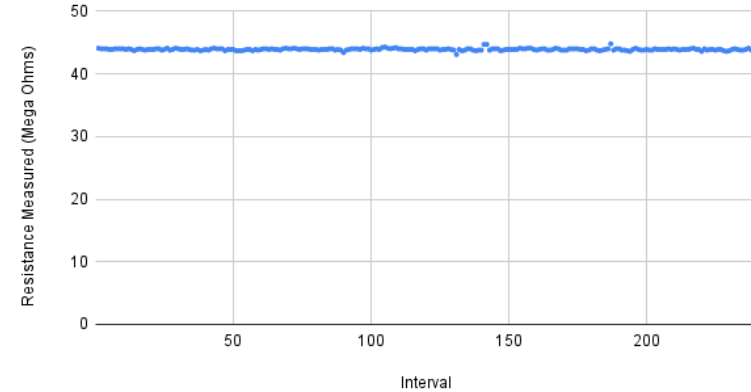
- To see if the wires are properly isolated
- Wires are all the same distance apart
- Steady resistance



Collection Plane Isolation Test

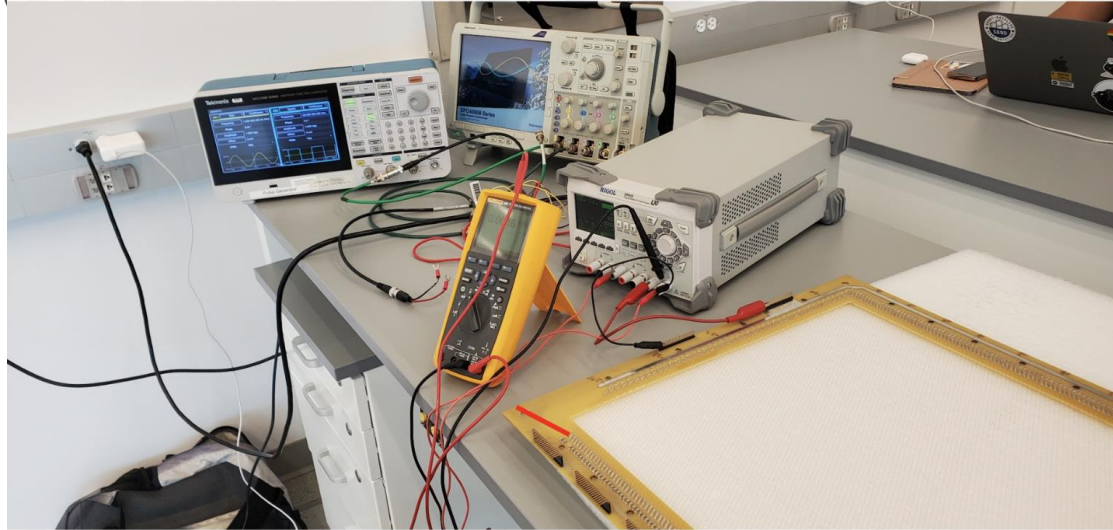


Induction Plane Isolation Test



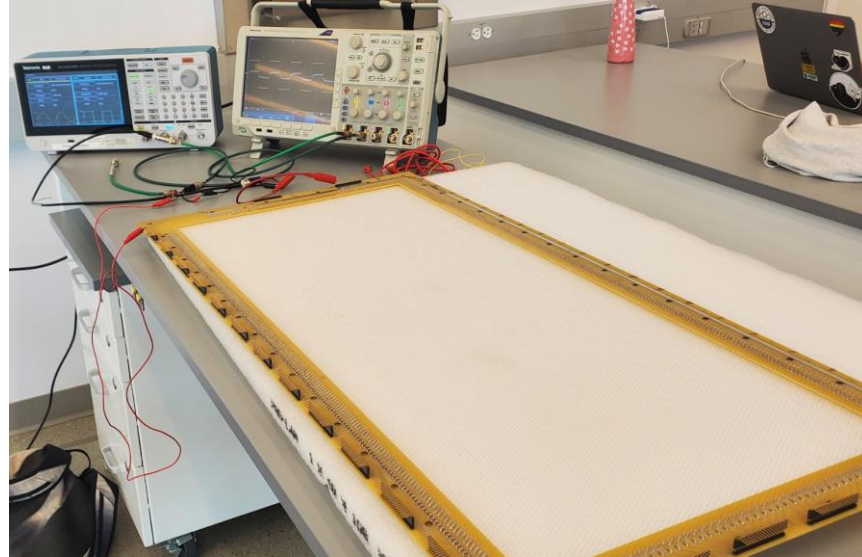
Bias testing

- To see if every wire received the correct voltage
- Small voltage applied to the plane
- Wires tested for correct distribution
- Voltage in every wire was equal
- No graphs :(



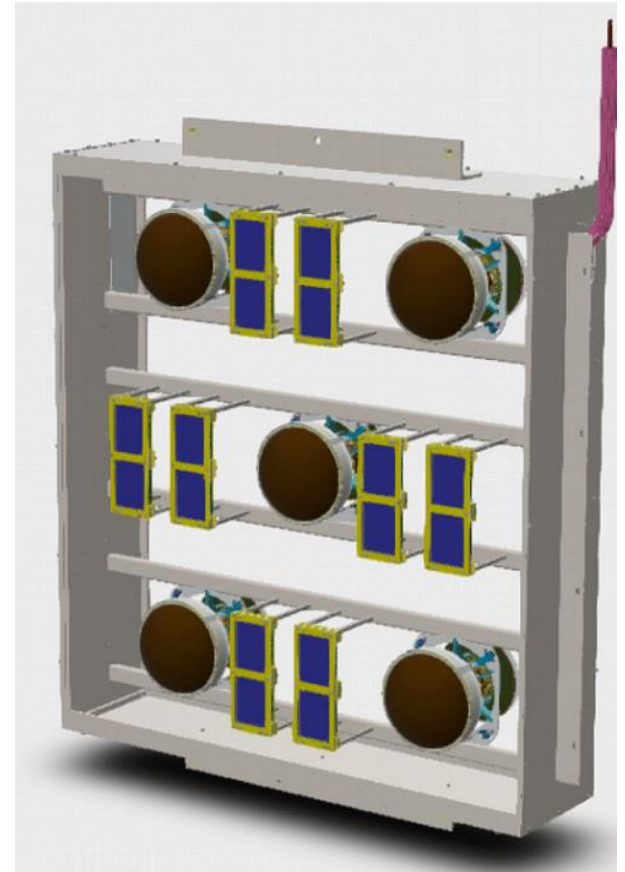
RC Circuit Testing

- To test the resistor and capacitor integrity
- Input a square wave and looked to see if resultant wave was correct
- All wires tested
- Even partially damaged capacitors passed
- No graphs :(



Light Detection

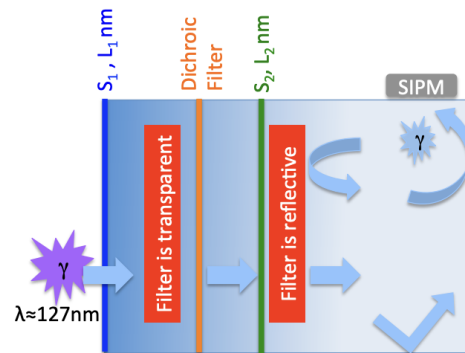
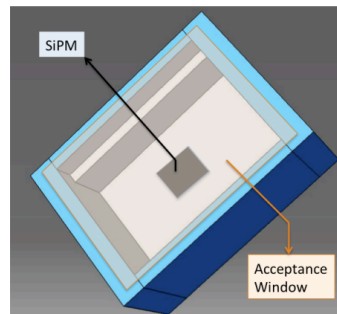
- SBND uses 2 kinds of light detection technology
- Standard PMTs (photomultiplier tubes)
- Experimental ARAPUCAS



<https://shorturl.at/hnuKV>

ARAPUCAs

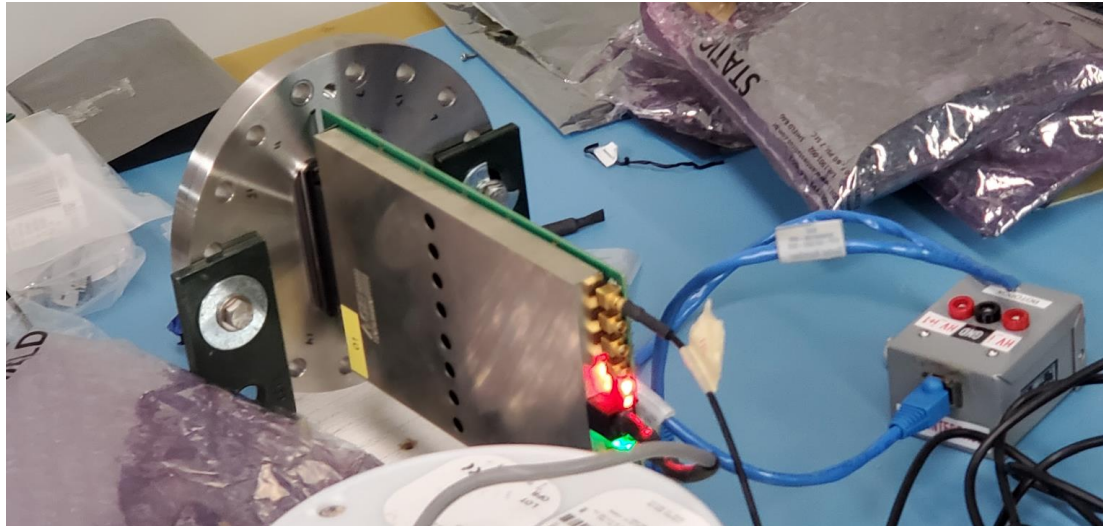
- SiPM (Silicon photomultiplier)
- Designed to give a small sensor a large detection area
- Wavelength of incident photons are shifted down by wavelength shifter
- New wavelength can pass through filter
- Wavelength shifted again
- Bounces off reflective surface
- New wavelength bounces off filter
- Repeats until detected



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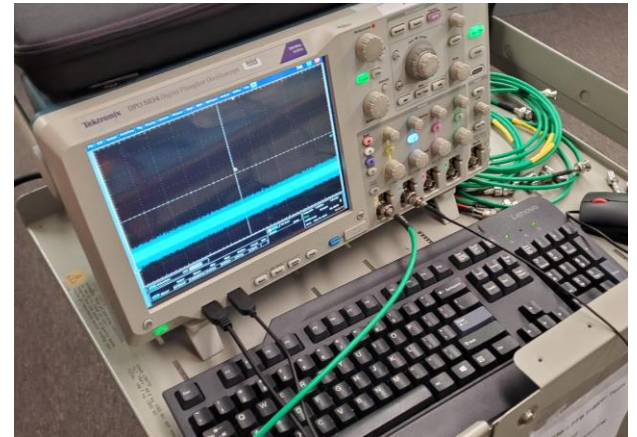
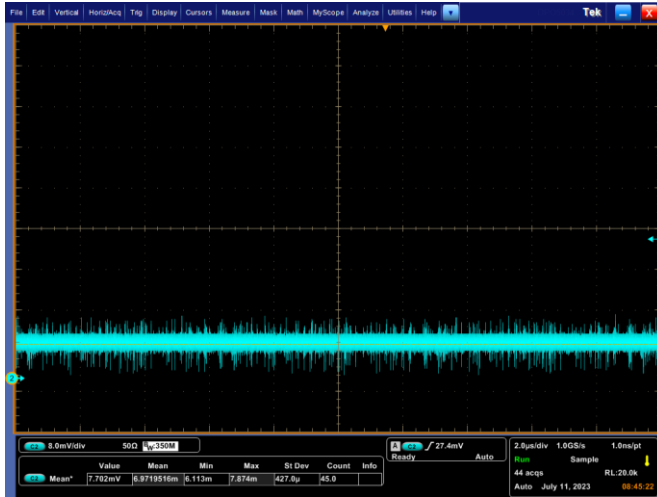
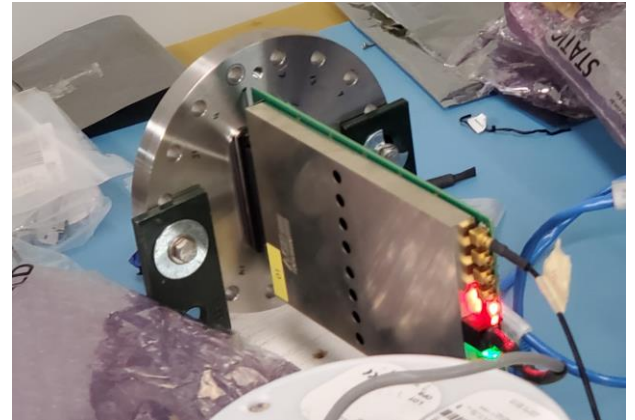
Noise

- Need to eliminate noise for accurate results
- ARAPUCA has noise but is well understood
- The multiplier (APSAIA) has noise that needs to be characterized
- Baseline test and system test



Baseline Test

- Only APSAIA connected to the oscilloscope
- Quite a significant amount of noise
- Noise can now be taken into account in readings



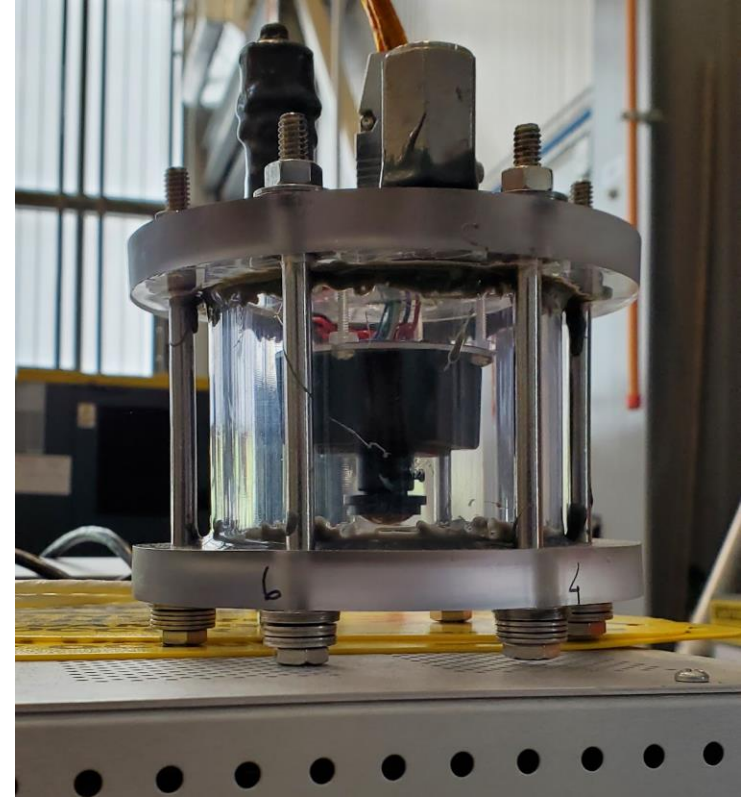
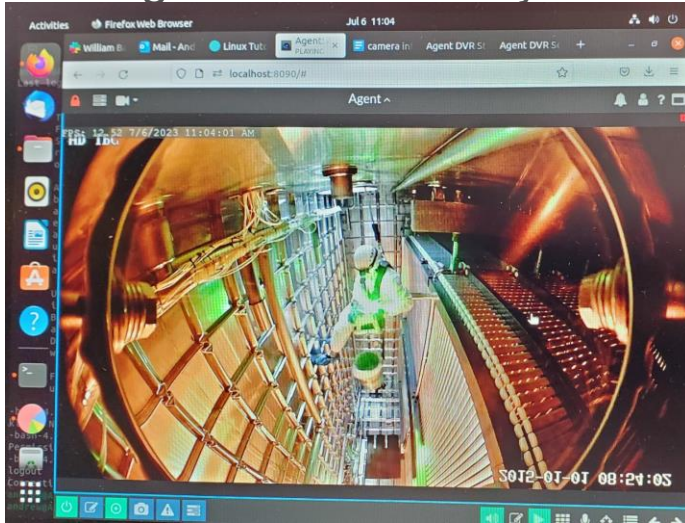
System Test

- Connected SiPMs and APSAIA to the oscilloscope
- SiPMs in a dark box
- Gives an idea of total system noise
- Allows for a more complete picture of noise



Cameras

- Worked with Bill Badgett on camera software
- Learned how to use and navigate linux
- Configured software for Ubuntu
- Does not work on scientific linux
- Got some good videos of cryostat dives!



Collaborations



Mônica Nunes

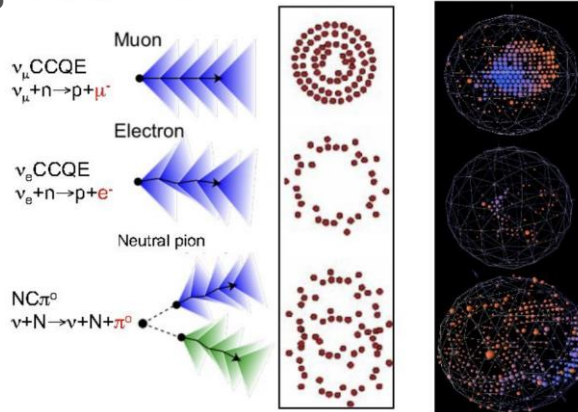
Bill Badget
Pagliuso

Lucca Longhitano

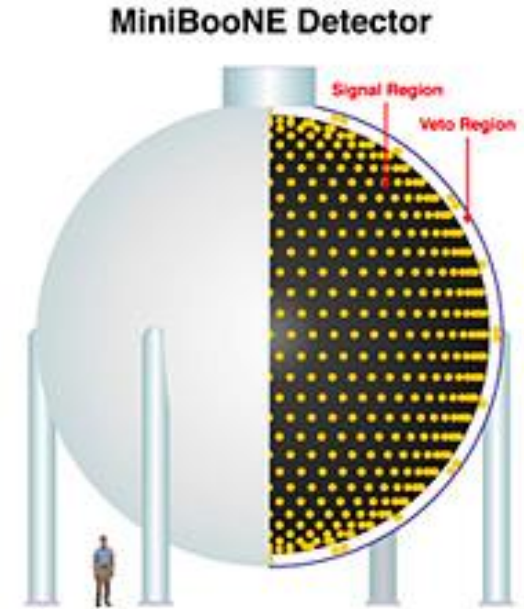
Miguel Angel Hernandez Morquecho

Previous Neutrino Experiments

- Cherenkov Radiation (particles move faster than light)
- detected by many photon detectors
- different particles have different footprints
- some of these footprints look similar (neutral pion + electron)
- results showed more electrons than predicted
- suggests an irregularity within the standard model



Monica Nunes OSU talk



<https://shorturl.at/cyBRY>