Testing, Operation, and Analysis of a Photosensitive LArTPC

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TinyTPC and Photosensitive Dopants

LArTPCs detect charge and light from particle interactions to study neutrinos indirectly. TinyTPC, a compact LArTPC with a pixelated readout system (LArPix), aims to improve energy measurements for low-energy events by enhancing ionization charge collection. **It will explore the effects of photosensitive dopants and xenon in liquid argon.** Isobutylene, with ionization energy near argon's scintillation energy, efficiently converts scintillation light into a detectable ionization signal.

Diagnosing High Voltage Breakdown

- **Previous Limitation**: Could only achieve up to 3.5kV due to electrical breakdowns, aimed for 5kV.
- **Debugging Process**: We conducted tests using a small dewar filled with liquid argon and nitrogen. This involved:
  - Testing different ground configurations
  - Monitoring the TPC resistance

Ramping High Voltage supply for testing (left), Dunk test (middle), Dewar full of LAr (right)

- **Issue Identification:** High voltage feedthrough flange.
- **Solution:** We replaced the faulty flange, but the new one was later found to have issues in pure argon gas.

Performing tests on TinyTPC mounted to the cryostat (left), Top of cryostat lid (right)

- TinyTPC was deployed in the Blanche cryostat in the Proton Assembly Building (PAB)
- The detector was mounted to the lid to collect data for a month.

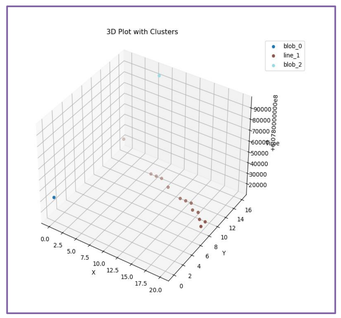
Adding Th228 Source

We added a Th-228 source, which creates Compton electrons in the argon. These have a known shape and energy that can be used to **study the low energy resolution and charge enhancement** of the detector.

These plots were processed with a script I developed to make plots and **monitor data in real time** and upload them to be **viewed remotely** during runs

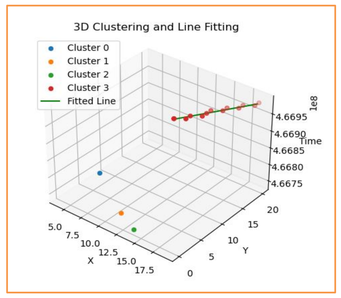
Clustering Muons vs Source Data

1) I used a **density based clustering** algorithm (DBSCAN) to initially sort possible muon tracks from small radioactive interaction events and noise
- Leapfrog logic to be **computationally cheap**



Initial Sorting Example

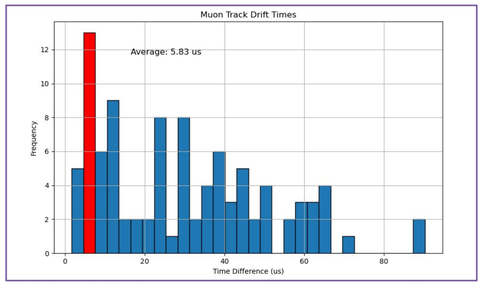
2) I used **random sample consensus** (RANSAC) as an iterative line fitting algorithm to find **cleanest tracks** that were most likely to be from a muon



Refined Sorting Example

3) Muon tracks are further sorted by ones that are known to **pass through the anode** of the TPC, in order to determine the **drift time**

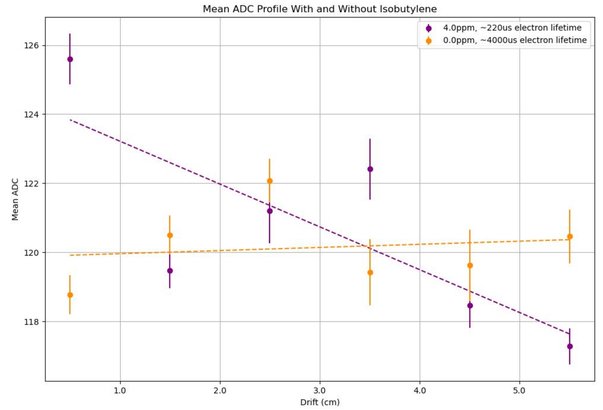
From the drift times, the **drift length** of the particle is calculated, which is then plotted against the charge of the points in the track to see the charge enhancement



Drift time distribution, showing most tracks only passed through part of the TPC through the cathode as expected

Charge Enhancement Results*

***First EVER plot demonstrating the charge enhancing results of isobutylene in LAr**



This plot shows roughly **a 5% charge gain using 4ppm of isobutylene**
- Charge gain effects decrease with distance from the anode as a lot of impurities were introduced upon injecting the isobutylene
- Electron lifetime was much lower with 4.0ppm of isobutylene vs none

Next Steps

Current Run:
- We've added xenon to the LAr to test if it still shows enhanced charge effects and produces light

Future Runs:
- Test with a new high-voltage flange at 5 kV.
- Use a new filter for injection to achieve higher purity after injecting isobutylene

Old high voltage flange

Clustering:
- Analyze small radioactive events
- Use sorted muon tracks to calibrate the TPC by calculating track dx for each pixel, then use the dADC/dx Landau distribution for ADC to energy conversion.

Acknowledgements

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