A Lab Scale Time Projection Chamber (TPC) for Testing the Pixelated Charge Readout Using the Novel Q-Pix Concept in Gas and Liquid Argon Environments

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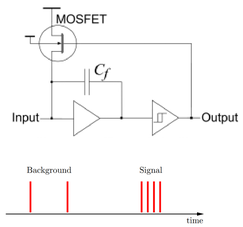
Background and Motivations

- Pixelization of large scale TPC's; e.g., DUNE far detector
- Pixel vs. wire plane:
  - better event reconstruction
  - Larger power consumption, lots of noise, lots of junk data

Alternate solution: Q-Pix

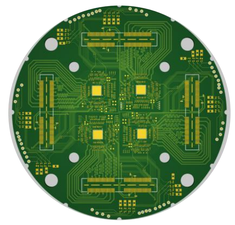
What is Q-Pix?

- Electronic equivalent of "least action"
- Normally "off," but turns on instantly when an event occurs
- Leads to low power, low data rate (less junk data), low noise



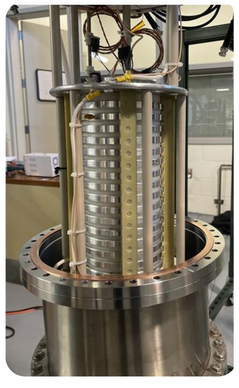
Q-Pix ASIC

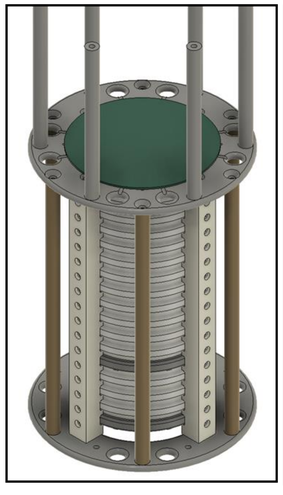
- Q-Pix has been implemented using TSMC's 180nm technology
- Each Q-Pix chip covers 16 channels
- 64 channel board has been developed for preliminary testing

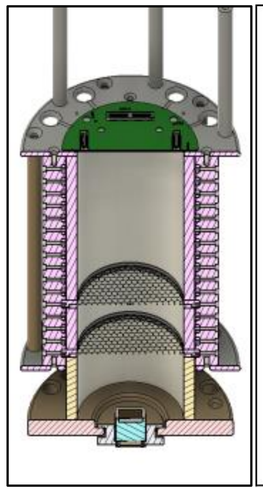


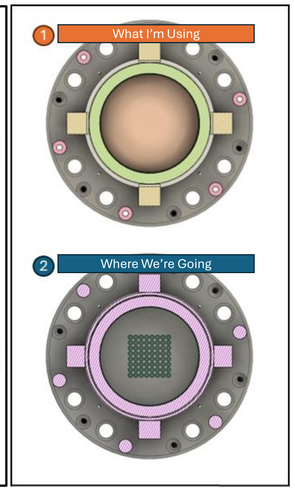
The UTA/H TPC

- Designed by UTA in collaboration with Harvard
- Platform for testing 64 channel Q-Pix board in both gas and liquid environment
- Currently equipped with simple charge collection plane; 'one pixel' readout
- Use of Photo Multiplier Tube (PMT) to detect light from scintillation
- Inner surface of field cage is coated with wavelength-shifter (TPB)
- Transparent cathode mesh
- Second mesh to protect PMT from field cage voltage





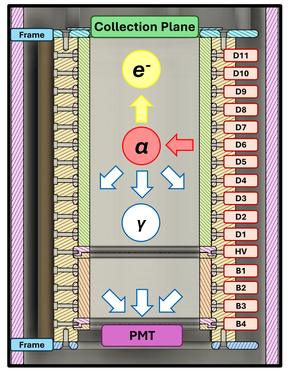


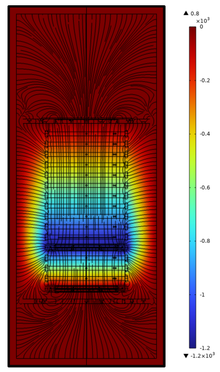


Commissioning the UTA/H TPC

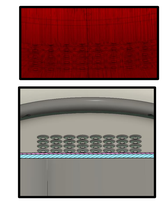
Goal: verify the ability of the TPC to collect both charge and light

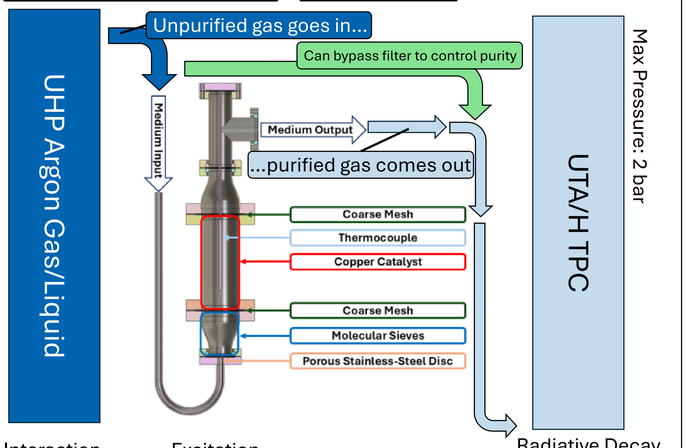
- Observe charge and light signal in pure Argon in both liquid and gas phase
- Show correlation between purity and triplet state lifetime and charge collection efficiency by introducing controlled impurities to the system

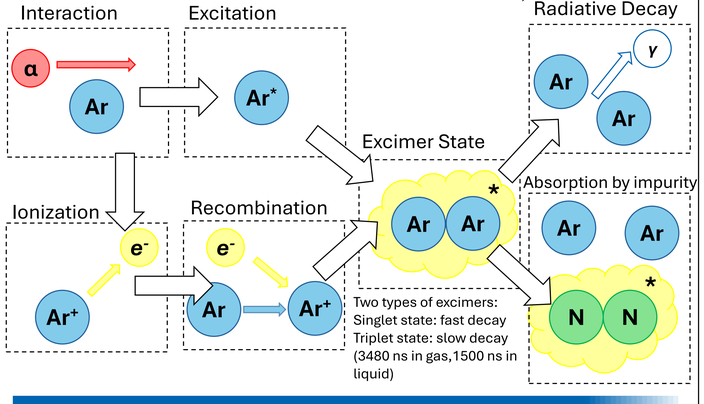




COMSOL simulation demonstrating the field lines terminate on the pixels for the board, ensuring that the charge will be transported to the readout

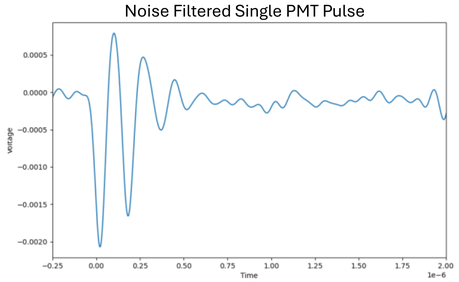




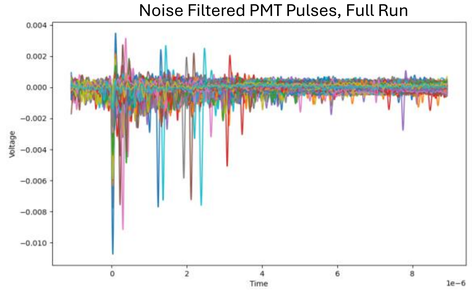


Results: Gas Phase

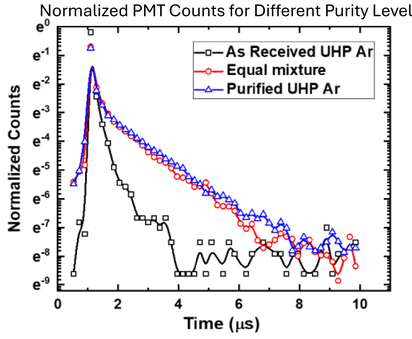
Noise Filtered Single PMT Pulse



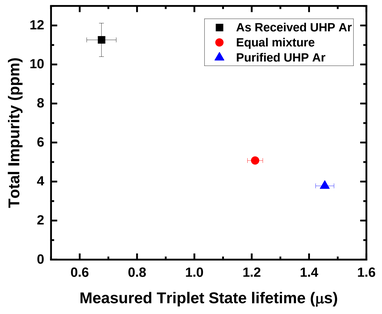
Noise Filtered PMT Pulses, Full Run



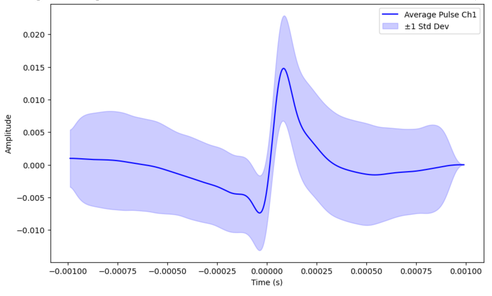
Normalized PMT Counts for Different Purity Levels



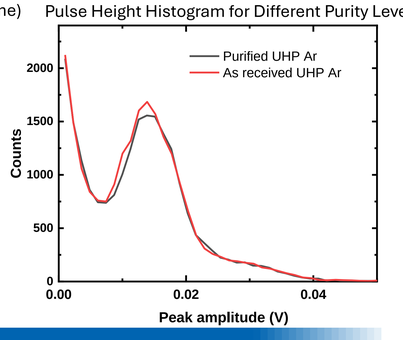
Impurity Level Derived from Measured Lifetime



Average Charge Pulse Across Full Run with Standard Deviation (vs. Time)

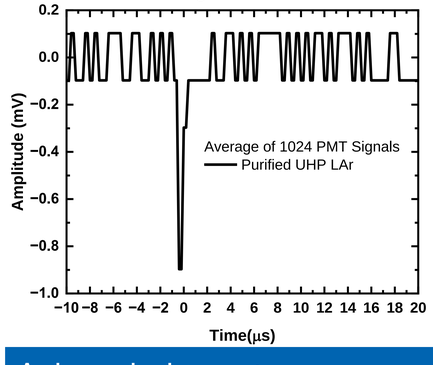


Pulse Height Histogram for Different Purity Levels

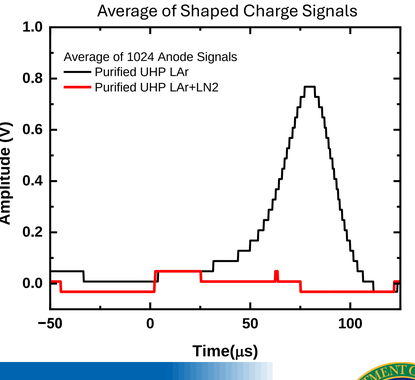


Results: Liquid Phase

Average of PMT Pulses



Average of Shaped Charge Signals



References

Q-Pix: Pixel-scale Signal Capture for Kiloton Liquid Argon TPC Detectors: Time-to-Charge Waveform Capture, Local Clocks, Dynamic Networks, arXiv:1809.10213
Triplet Lifetime in Gaseous Argon, *Eur.Phys.J.A* 55 (2019) 10, 176

Acknowledgments

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