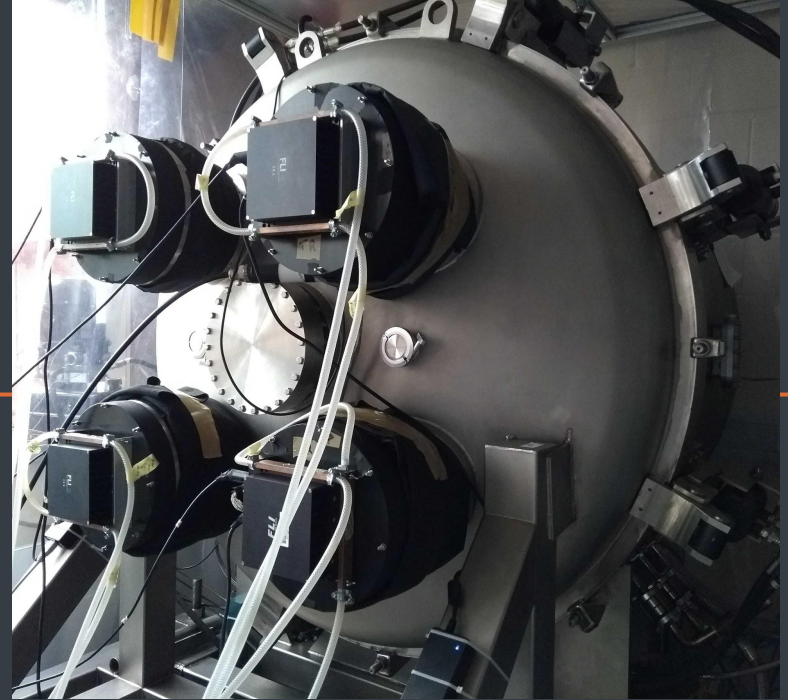




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OF LONDON

# Commissioning of a High-Pressure TPC with Hybrid Optical and Charge Readout

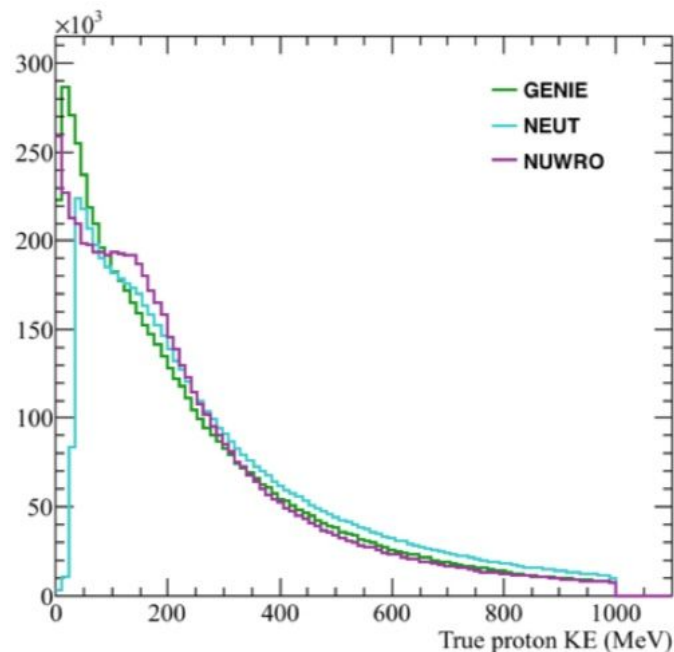
Harrison Ritchie-Yates on behalf of  
P-355  
Royal Holloway, University of London  
22 October 2019



# Introduction



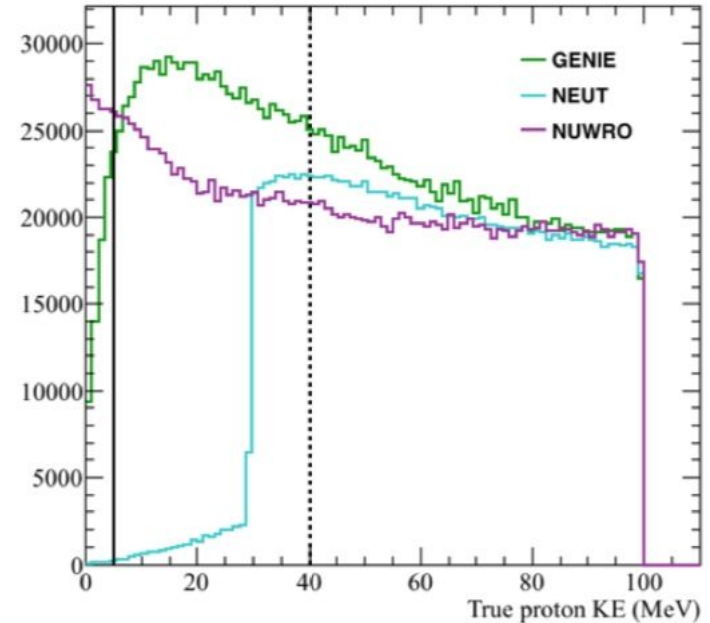
- A gaseous TPC designed to solve a problem in neutrino physics.
- Goals
  - Characterise final state interactions (FSI) of nucleons produced in  $\nu$ -nucleus interactions.
  - Make measurements of the proton-argon cross-section for low-momentum protons.
- Monte Carlo generators disagree on FSIs below 250 MeV/c.



# Introduction



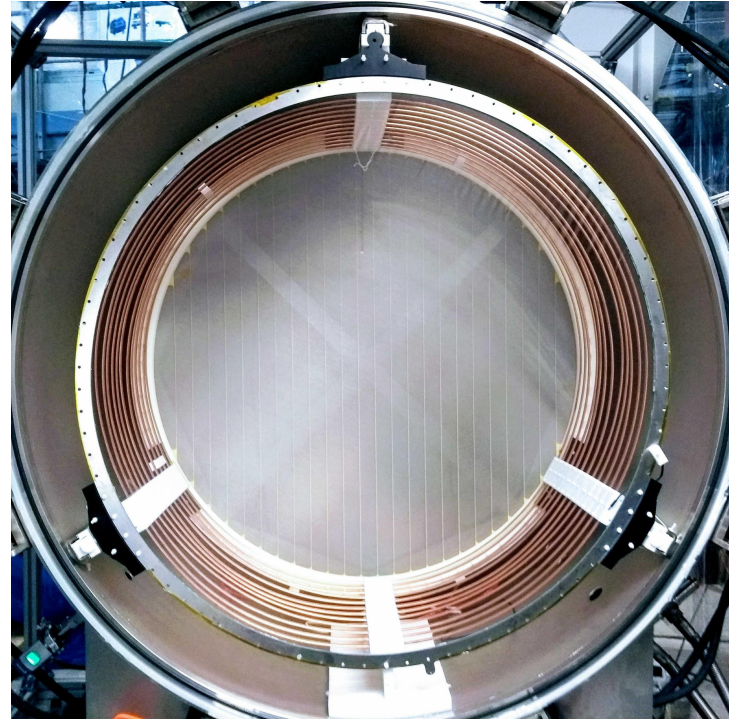
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# TPC Setup



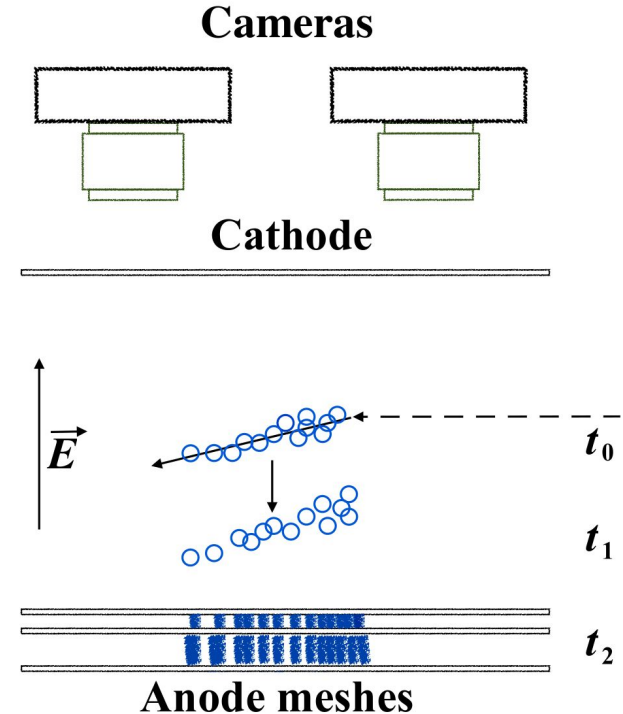
- HPTPC is a High Pressure gaseous Time Projection Chamber (TPC) featuring hybrid charge and optical readout.
- Housed in a pressure vessel length 730 mm x 1400 mm diameter, rated to 5 bar absolute.
- Features steel mesh electrodes and a low-mass field cage.
- Designed to be operated in a proton beam or using radioactive sources.



# TPC Setup



- Active volume consists of drift and amplification regions, defined by a field cage and steel mesh electrodes.
- A 447 mm drift region consists of a cathode mesh and 12 field cage rings of diameter 1110 mm.  $E_{\text{drift}} < 500 \text{ V/cm}$ .
- The amplification region is constructed from 3 unsegmented anode meshes.
- 4 CCD cameras are mounted behind cathode for optical readout.

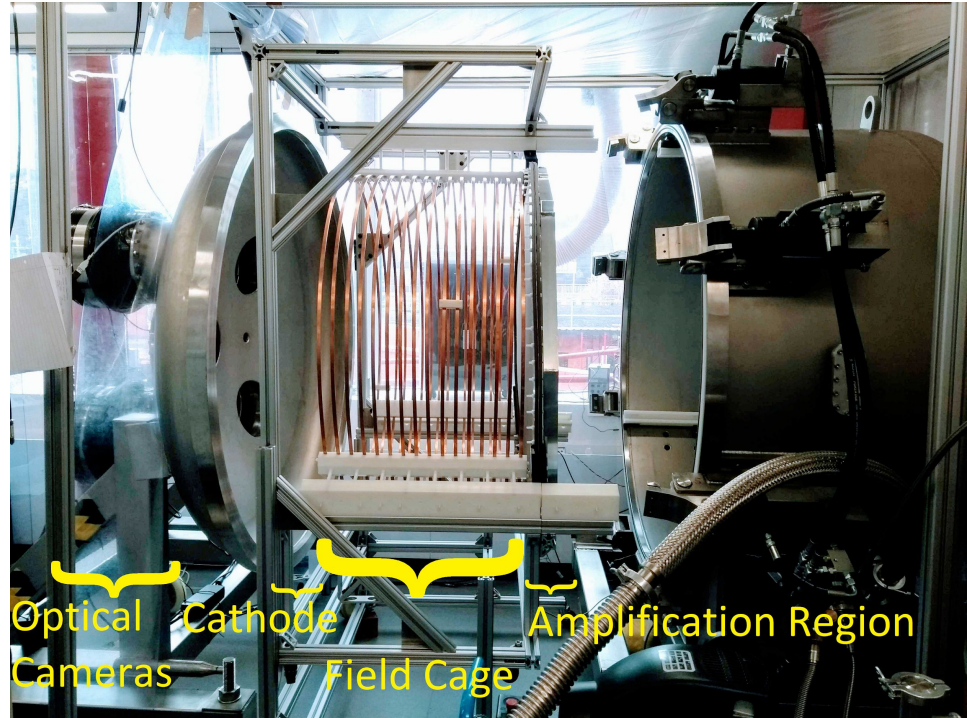




# TPC Setup



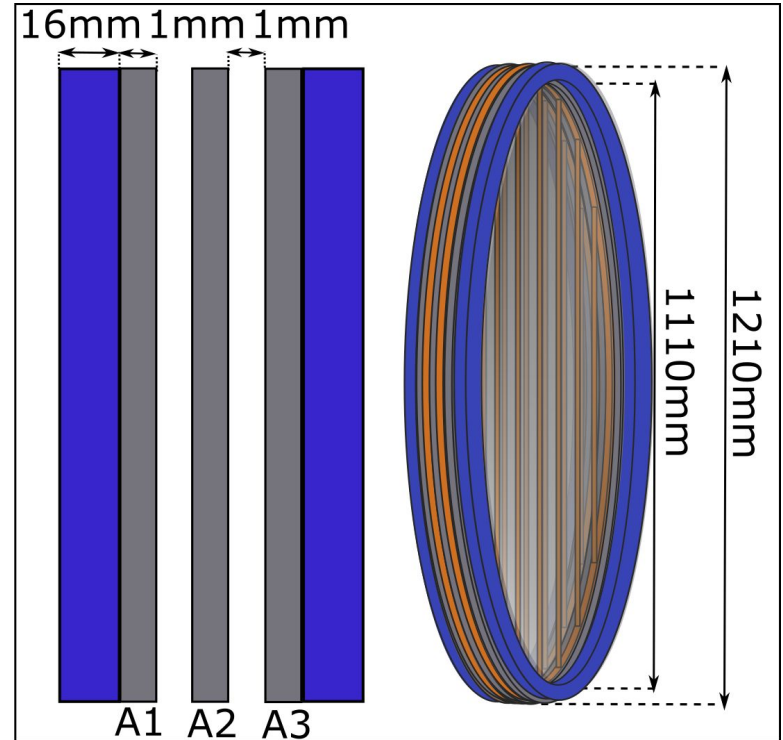
- Low-mass field cage allows the TPC to be operated in a beamline.
- Pressure vessel and hydraulics system allows for operation up to 5 bar absolute pressure.
- Fine optical readout + broad charge readout provides tracking information at a low cost.



# Amplification region



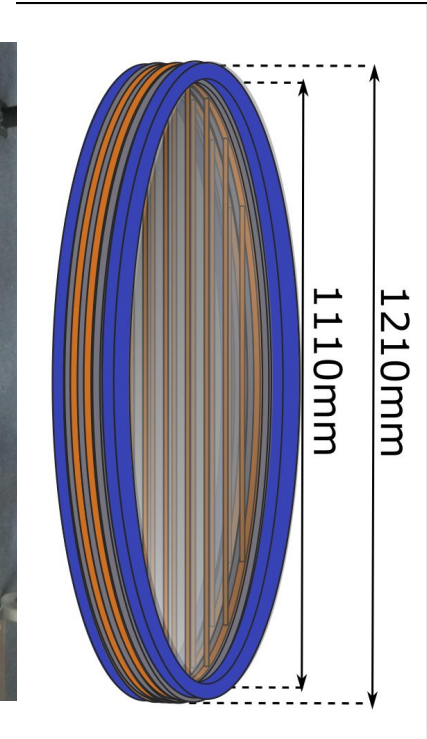
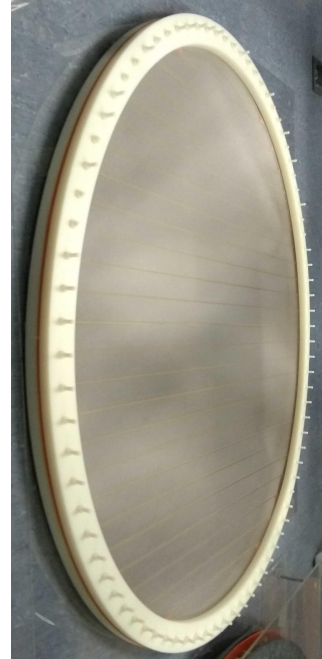
- 3 high tension steel anode meshes, tensioned to  $19 \pm 1$  N/cm using a Gruning G-STRETCH 210 stretching machine, and glued to 1 mm thickness steel rings.
- Anodes are 100 lpi mesh, 25 micron wire, with an optical transparency of 89%.
- Anodes separated by 1 mm polyester, and supported by 16 mm nylon rings.
- 3 channels for charge readout.



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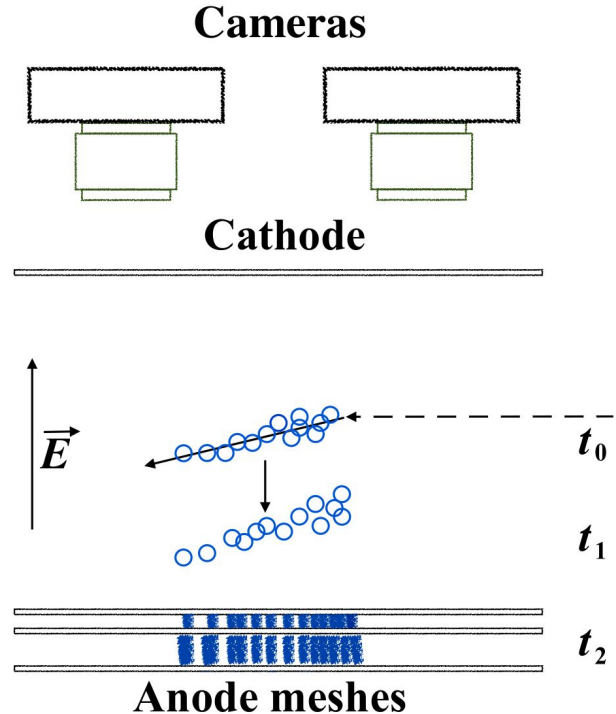




# Optical Readout



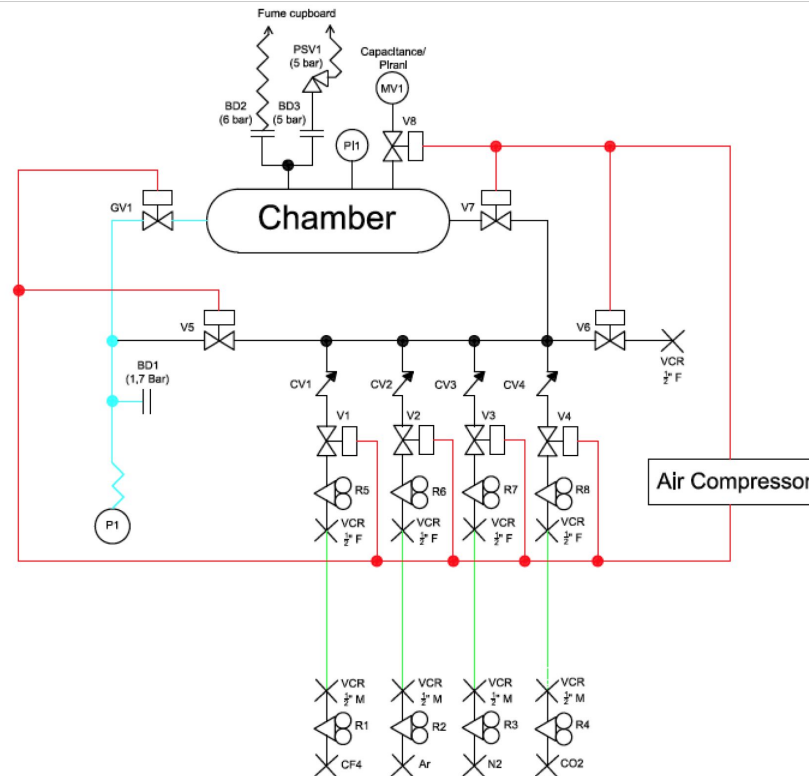
- Optical Readout is provided by four FLI Proline PL09000s with 3056 x 3056 pixels, of size 12 x 12  $\mu\text{m}$ , focused on the amplification region, vixel size of 230 $\mu\text{m}$ .
- Ionisation electrons from charged particles propagating through the TPC move in the drift field to the amplification region where avalanche charge multiplication and scintillation photon production occurs.
- Optical readout provides tracking information in the amplification plane.



# Gas System



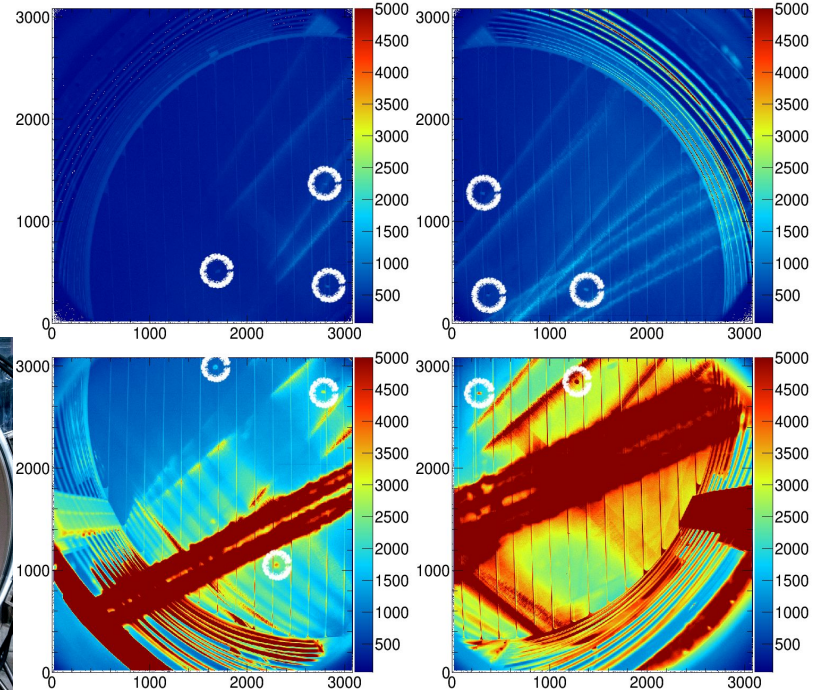
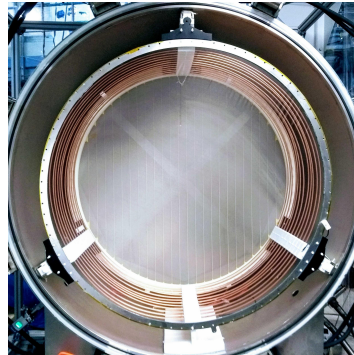
- Vessel is evacuated to  $\sim 1 \times 10^{-6}$  barA before filling using a Agilent Triscroll 800 dry pump.
- Operated at a range of pressures from atmospheric pressure up to 5 bar absolute, and a range of gas mixtures of Ar, Ar-CO<sub>2</sub>, and Ar-CO<sub>2</sub>-N<sub>2</sub>, typically with 95-99% Argon.
- Gas system allows for mixing of gases from 4 different inputs.



# Optical Readout



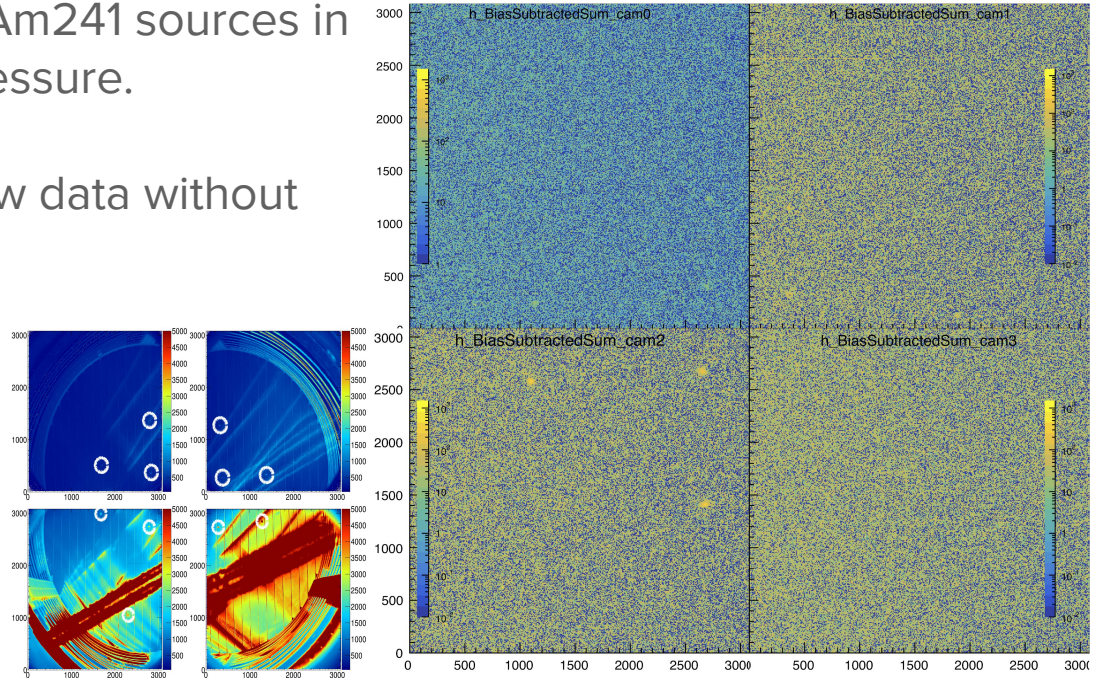
- Image: Simultaneously recorded frames during a spark event.
- Each camera images a  $71 \times 71 \text{ cm}^2$  quadrant of the amplification region.
- The locations of 5  $\text{Am}^{241}$  sources inside the vessel are indicated by white rings.



# Optical Readout



- Image: Light yield from Am241 sources in pure argon at 3 barA pressure.
- Sources are visible in raw data without pedestal subtraction.
- Relative light yield compared for different gas mixes.

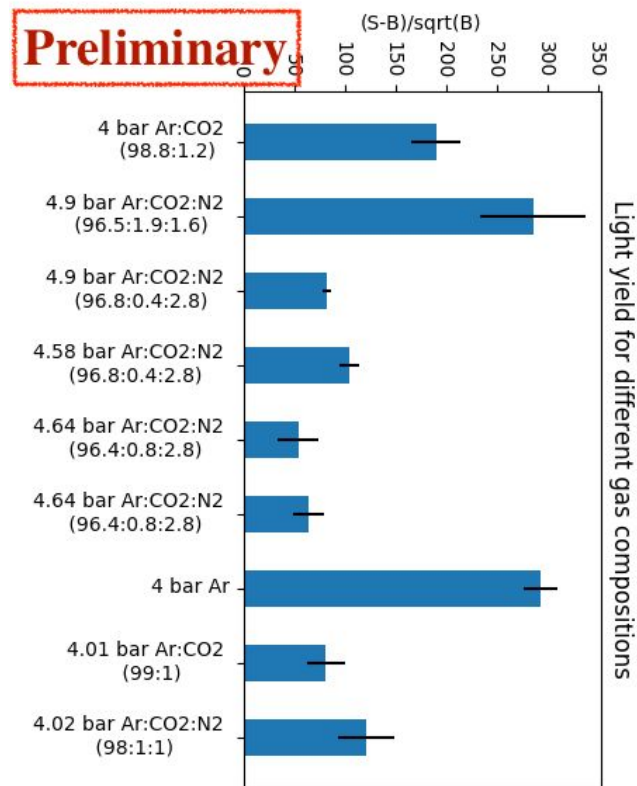
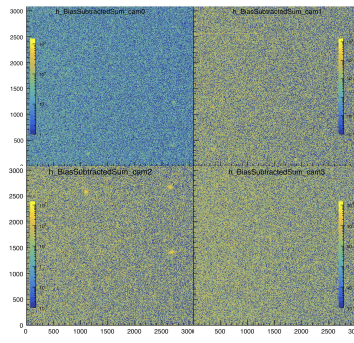




# Optical Readout



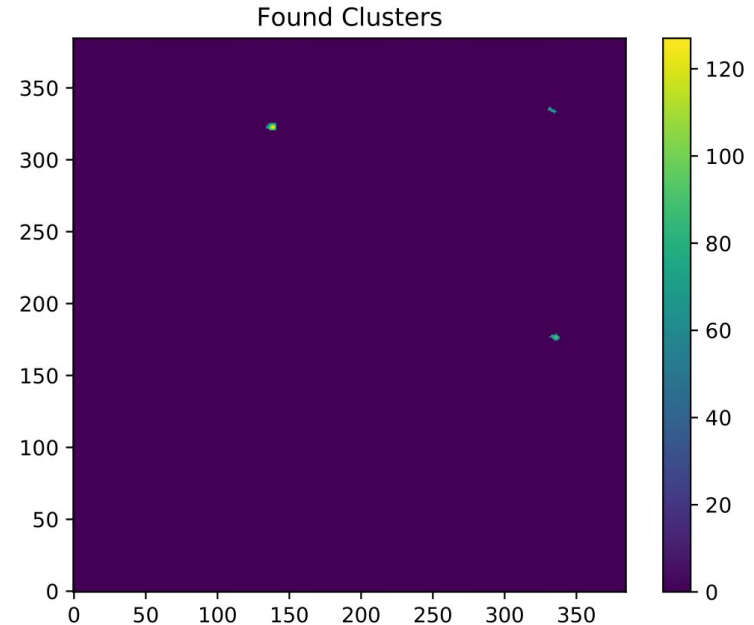
- Image: Light yield from Am241 sources in pure argon at 3 barA pressure.
- Sources are visible in raw data without pedestal subtraction.
- Relative light yield compared for different gas mixes.



# Clustering & Small Tracks



- Algorithm designed to find clusters in the optical readout.
- This has been optimised using the known source positions.
- This algorithm will be used to reconstruct tracks in the amplification region for data taken in the T10 beamline.

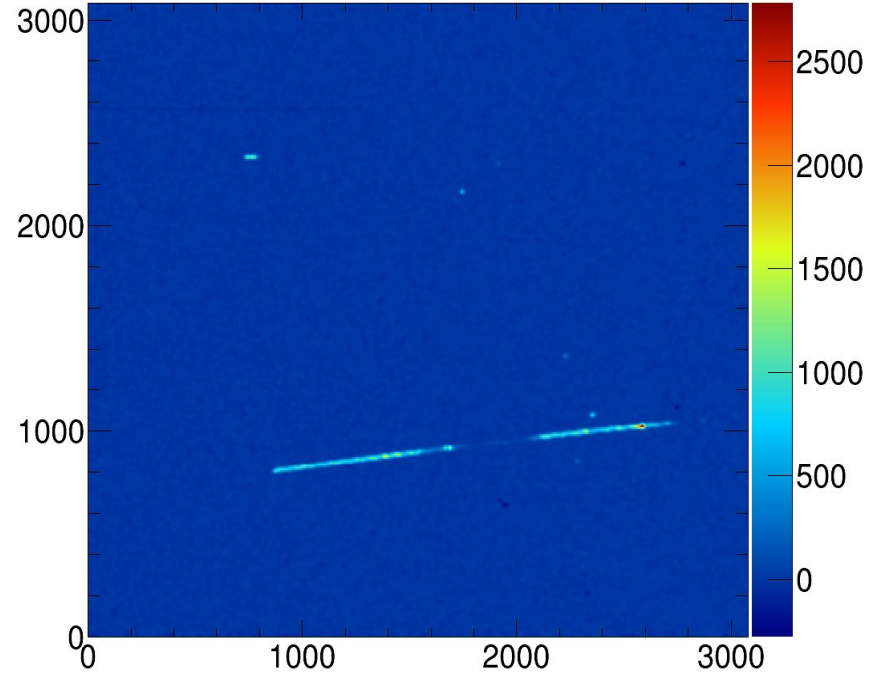




# Tracking



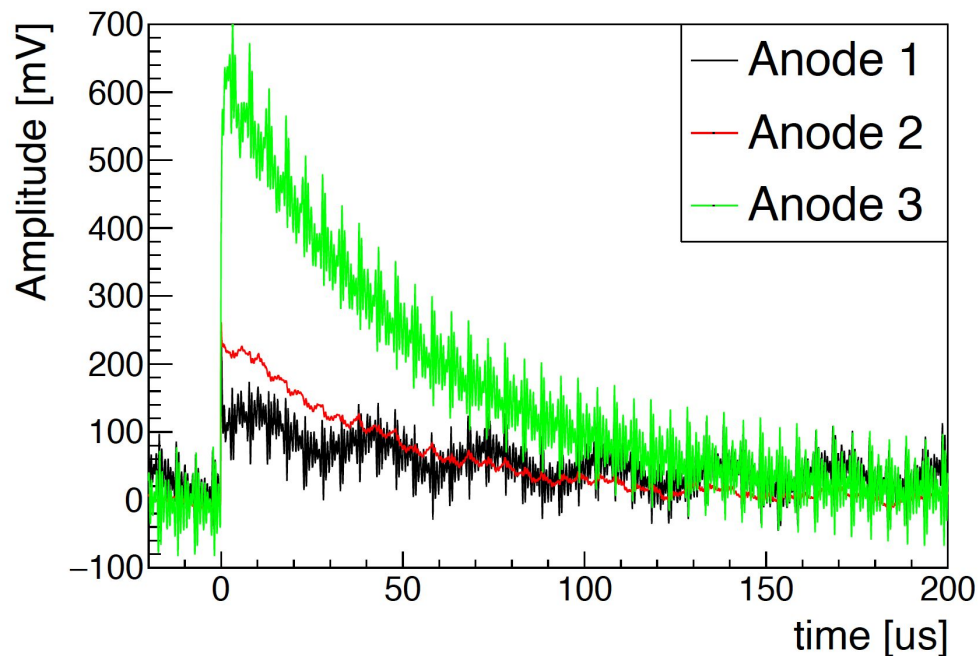
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# Charge Readout

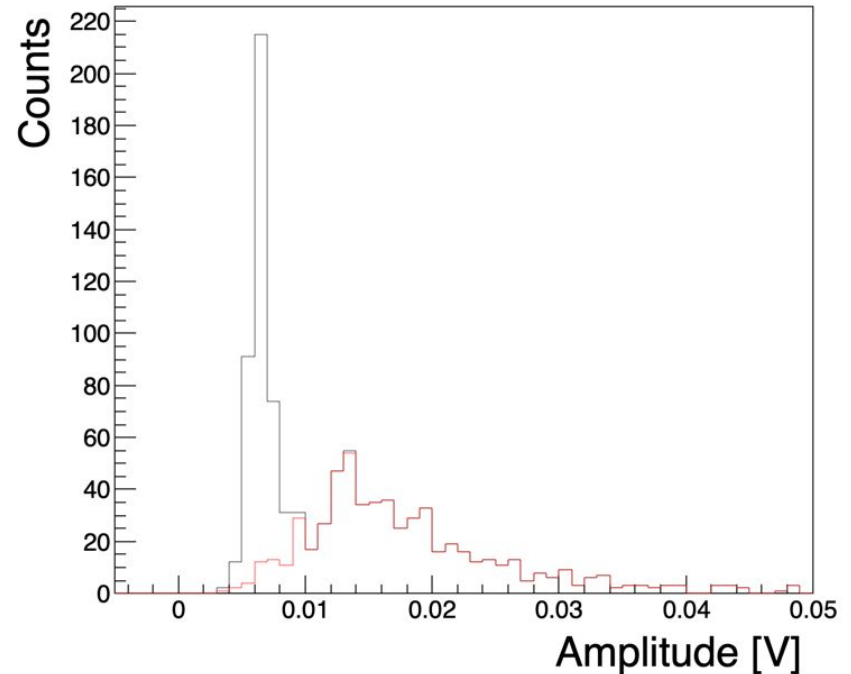


- Charge readout is decoupled from the bias-lines of the three unsegmented anode meshes using a 10 nF capacitor.
- These signals are then fed into CREMAT CR-112 preamp circuits and then digitised.
- Cuts are made to remove waveforms from sparks.



- Image: charge waveform  
amplitude spectrum for data taken with a gas mix of 970 mbarA Argon, 370 mbarA CO<sub>2</sub>.
- With an Fe55 source, we see a single peak in this spectrum, corresponding to the 6 keV X-Ray emission from Fe55.
- No escape peak is visible due to low energy resolution.

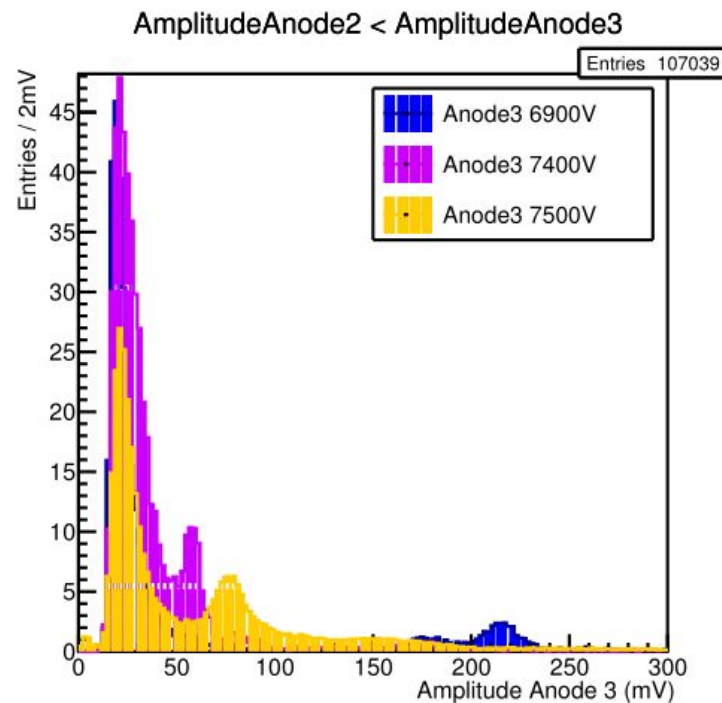
Amplitude Spectrum Anode 3



# Gain Calibration



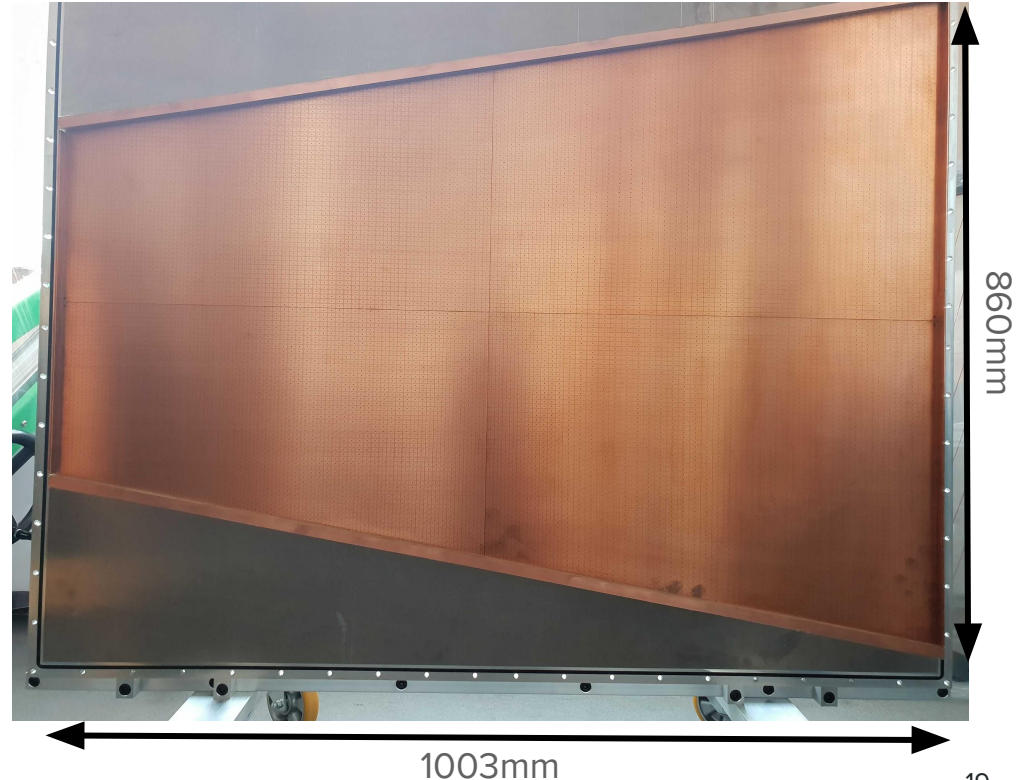
- Image: charge waveform amplitude spectra for data taken at 4800 mbarA Argon, 100 mbarA CO<sub>2</sub>.
- We expect to see the position of this peak increase with higher voltage settings.
- Peak moves with voltage. We do see gain increasing with voltage, but we also observe runs in which the peak does not follow the general trend.



# Further Work



- An ALICE OROC is to be tested in the HPTPC pressure vessel.
- DUNE are planning to use these OROCs in an HPTPC as part of their near detector.
- This will replace the current amplification region with a segmented anode.
- Currently being tested in a test box with radioactive sources.



# Summary



- HPTPC is a High Pressure gaseous Time Projection Chamber (TPC) featuring hybrid charge and optical readout provided by four FLI Proline PL09000 CCD Cameras with vixel size of 230  $\mu\text{m}$ .
- It has been operated at a range of pressures up to 5 bar absolute, and with a range of gas mixes of Ar, Ar-CO<sub>2</sub>, and Ar-CO<sub>2</sub>-N<sub>2</sub>, typically with 95-99% Argon.
- It's main aim is to characterise final state interactions (FSI) of nucleons produced in  $\nu$ -nucleus interactions by making measurements of low-energy proton-argon interactions.
- It also serves as a platform to test TPC technology at high pressure.





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