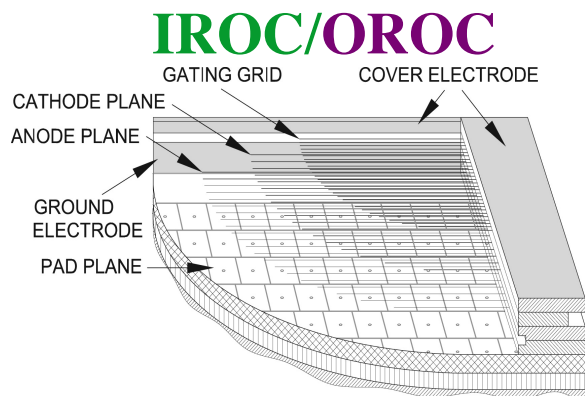
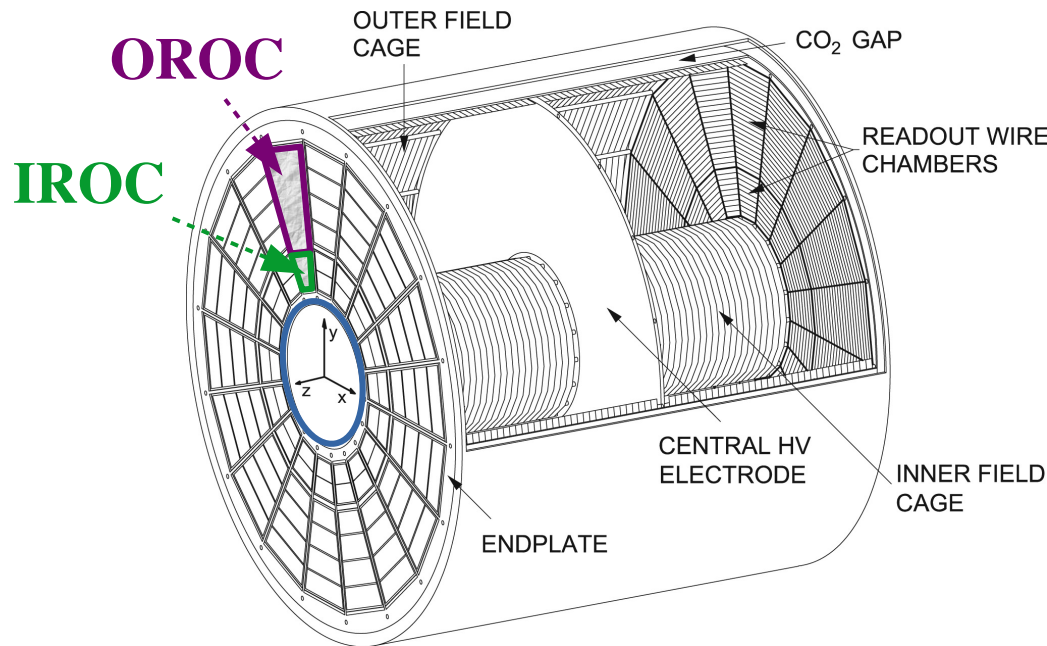


Update on FNAL Gaseous Argon Operation of ALICE TPC, GOAT

Tanaz Angelina Mohayai, on behalf of GOAT team
DUNE Near Detector Workshop @ DESY
October 22, 2019

A Test Stand to Test ALICE IROC

- Test ALICE TPC **Inner** and **Outer** Readout Chambers (**IROC** and **OROC**) for DUNE:
 - ★ ~600k channels become available for use in HPgTPC as ALICE goes under a planned upgrade



ALICE TPC

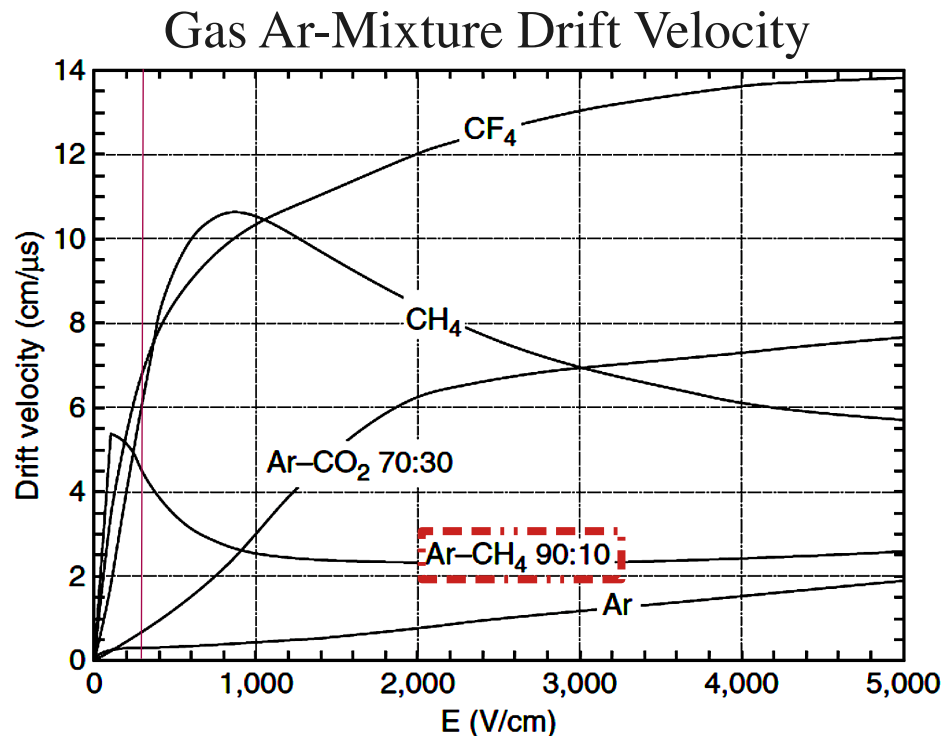


| | Pad size [mm ²] | Number of rows | Number of pads |
|---|-----------------------------|----------------|----------------|
| Inner chamber ($84.1 < r < 132.1$ cm) | 4×7.5 | 64 | 5732 |
| Outer chamber ($134.6 < r < 198.6$ cm) | 6×10 | 64 | 6038 |
| Outer chamber ($198.6 < r < 246.6$ cm) | 6×15 | 32 | 4072 |
| TPC total | | 160 | 570312 |

A Test Stand to Test ALICE IROC

- Test ALICE TPC **Inner** and **Outer** Readout Chambers (**IROC** and **OROC**) for DUNE:
 - ★ ~600k channels become available for use in HPgTPC as ALICE goes under a planned upgrade
 - ★ In synergy with LArTPC ND, developing new FE electronics:
 - LArPix, as the low-power, low-noise solution – getting adapted for HPgTPC where v_d (drift V) is faster & signal is different

LAr V_d : 1.6 mm/us
for same field

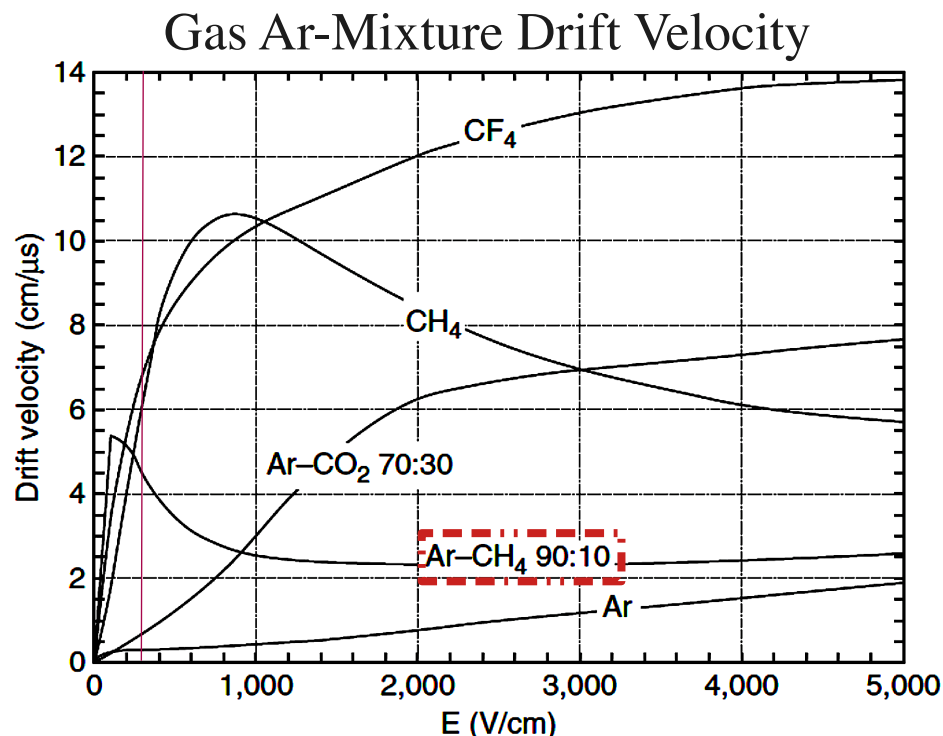


From D. Bortoletto's talk: https://indico.cern.ch/event/318529/attachments/612837/843122/daniela_l3.pdf

A Test Stand to Test ALICE IROC

- Test ALICE TPC **Inner** and **Outer** Readout Chambers (**IROC** and **OROC**) for DUNE:
 - ★ ~600k channels become available for use in HPgTPC as ALICE goes under a planned upgrade
 - ★ In synergy with LArTPC ND, developing new FE electronics:
 - LArPix, as the low-power, low-noise solution – **need to take v_d dependence on pressure into account**

LAr V_d : 1.6 mm/us
for same field



From D. Bortoletto's talk: https://indico.cern.ch/event/318529/attachments/612837/843122/daniela_l3.pdf

A Test Stand to Test ALICE IROC

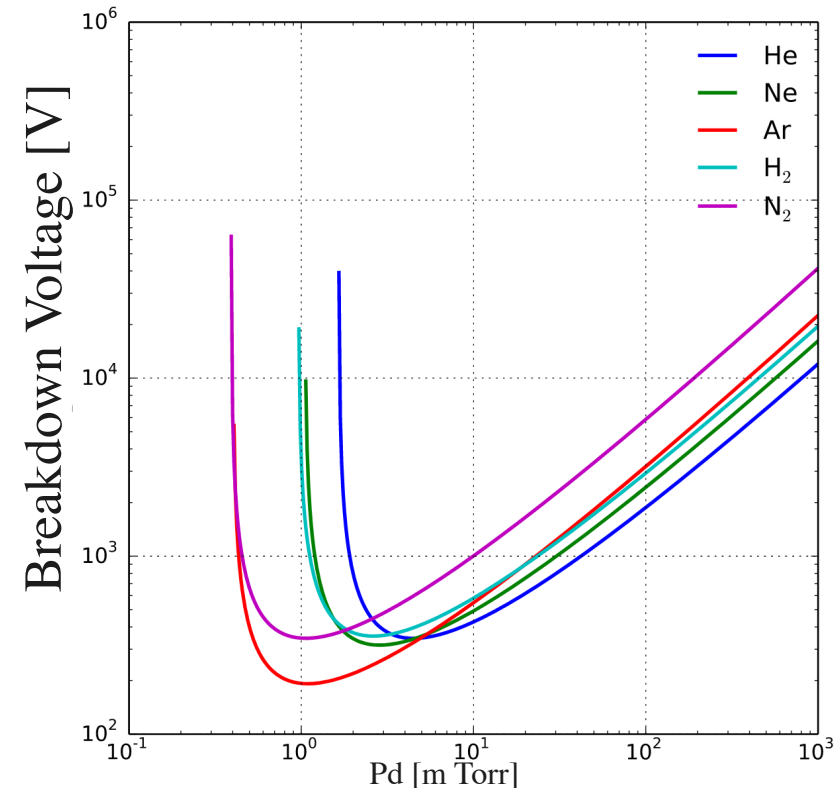
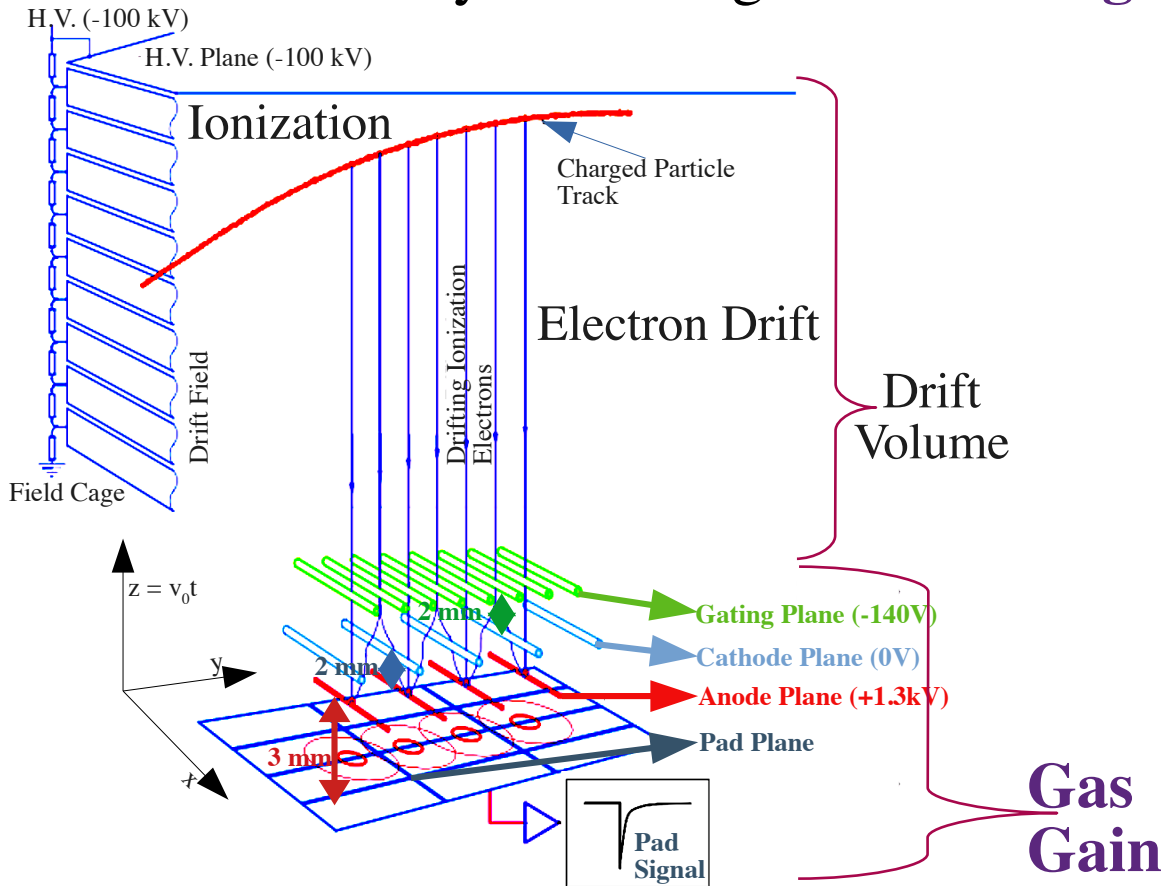
- Test ALICE TPC **Inner** and **Outer** Readout Chambers (**IROC** and **OROC**) for DUNE:
 - ★ ALICE operated them @ 1 atm
 - ★ We will operate them @ **higher pressure** so need to ensure that they work – figure of merit: **gain**

Gas Gain

$$G(T, P) = \left(k \rho_0 \frac{T}{P} \right)^\alpha$$

$$k = \frac{VR}{r_a \ln(r_c/r_a) E_{min}}$$

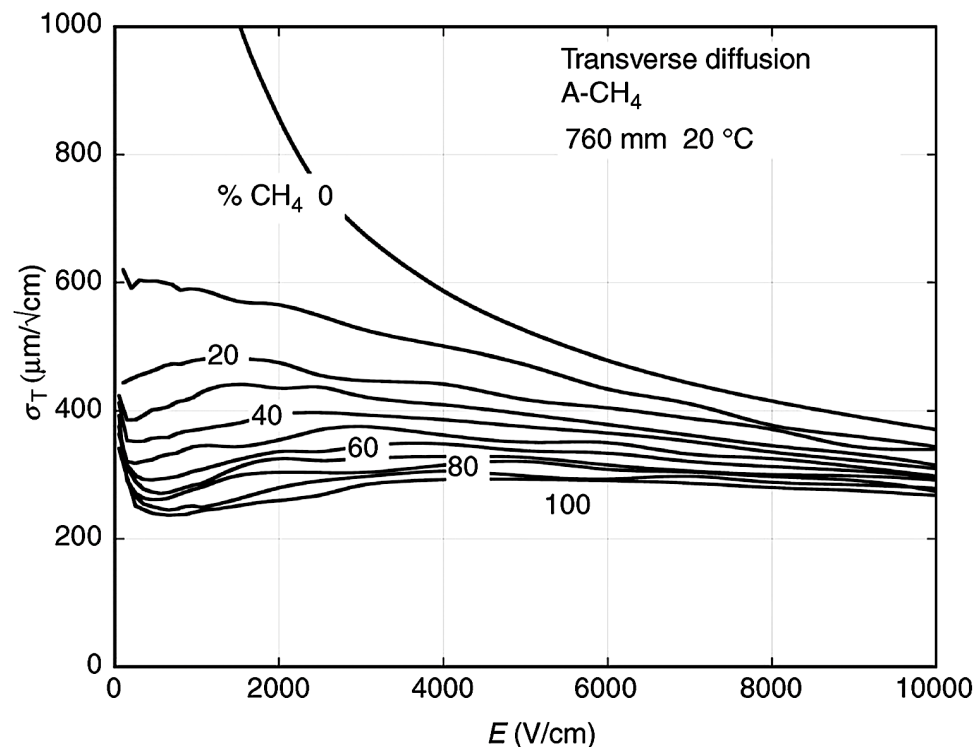
$$\alpha = \frac{V \ln 2}{\ln(r_c/r_a) \Delta V}$$



Lieberman, Michael A.; Lichtenberg, Allan J. (2005). Principles of plasma discharges and materials processing (2nd ed.)

A Test Stand to Test ALICE IROC

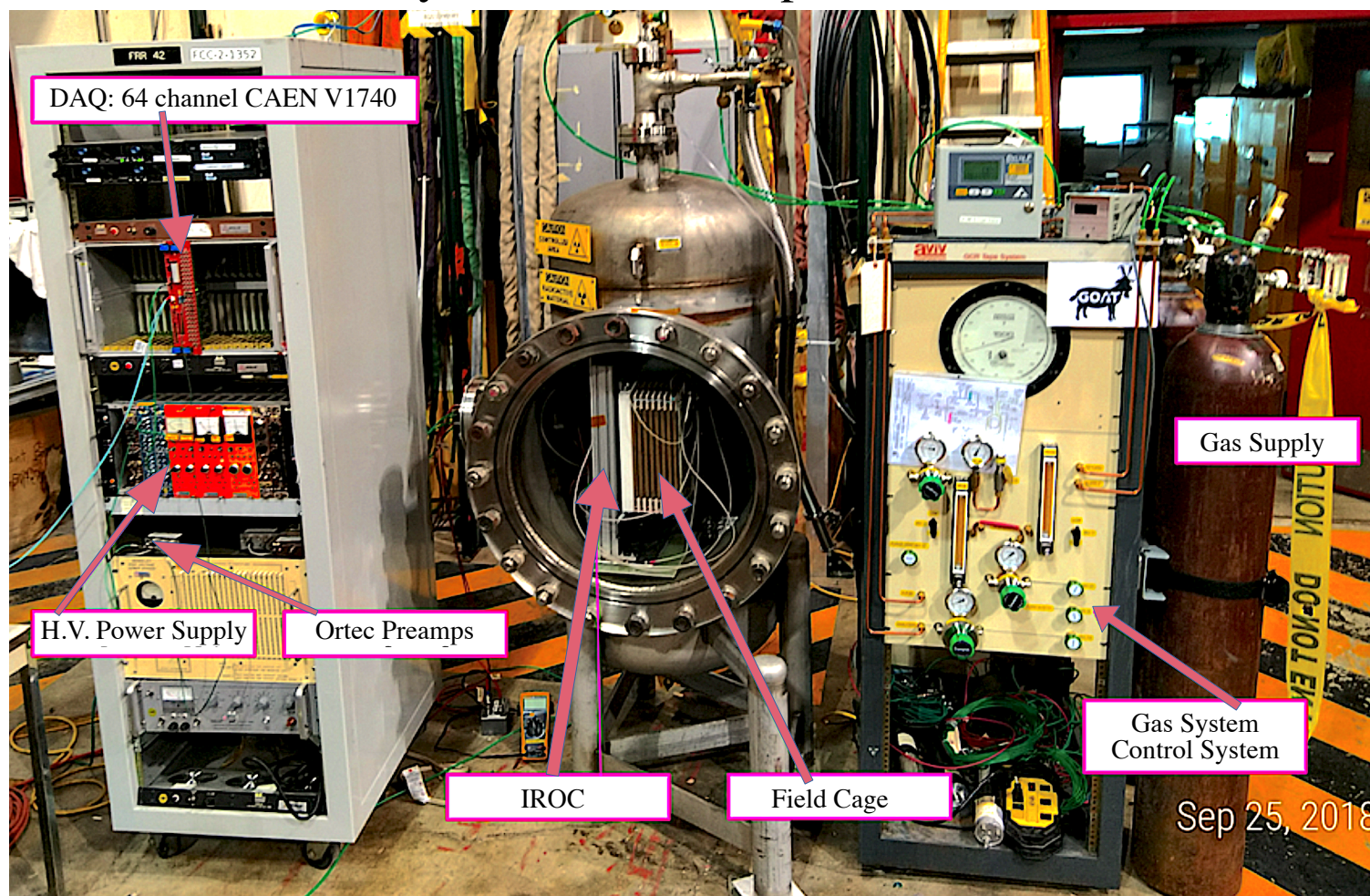
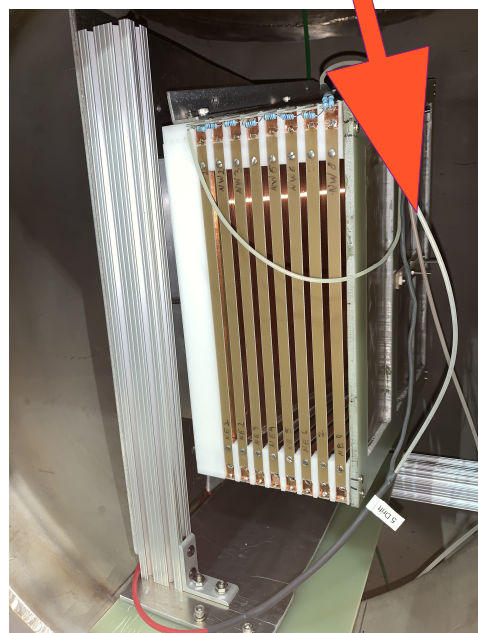
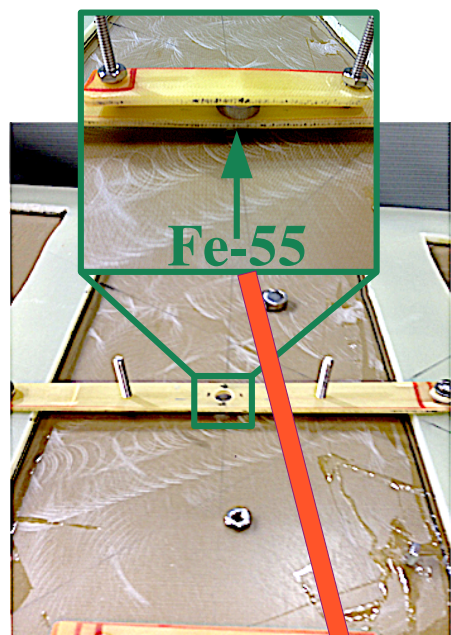
- Test ALICE TPC **Inner** and **Outer** Readout Chambers (**IROC** and **OROC**) for DUNE:
 - ★ ALICE operated them @ 1 atm with **Ne-CO₂-N₂**
 - ★ We will operate them **@ higher pressure with Ar-? (TBD) gas mixture** – main concerns: photon feedback, recombination



Sauli, F. “Gaseous Radiation Detectors: Fundamentals and Applications,” Cambridge: Cambridge University Press

Description of the Test Stand

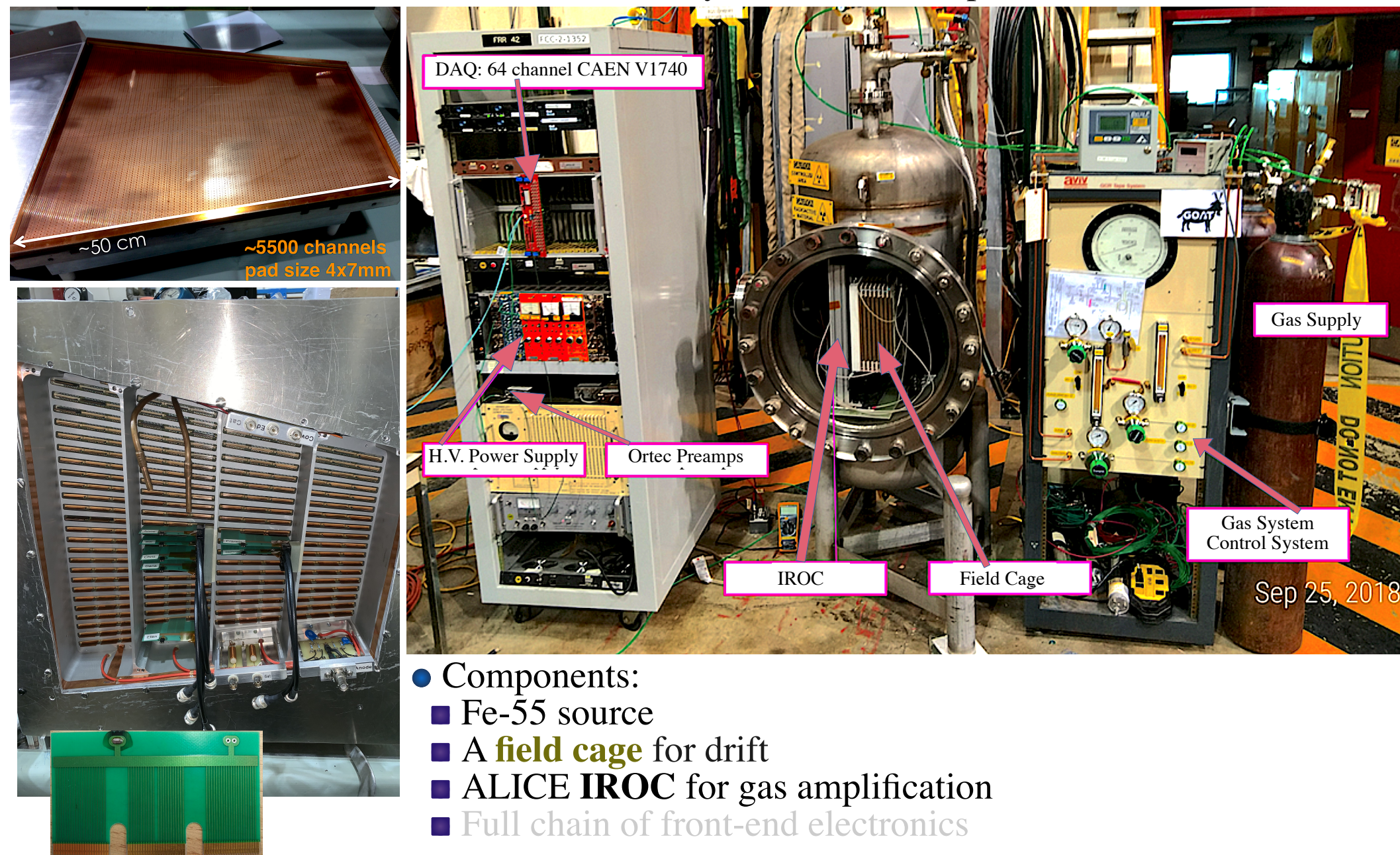
relatively more out-dated picture of GOAT



- Components:
 - Fe-55 source
 - A **field cage** for drift
 - ALICE **IROC** for gas amplification
 - Full chain of front-end electronics

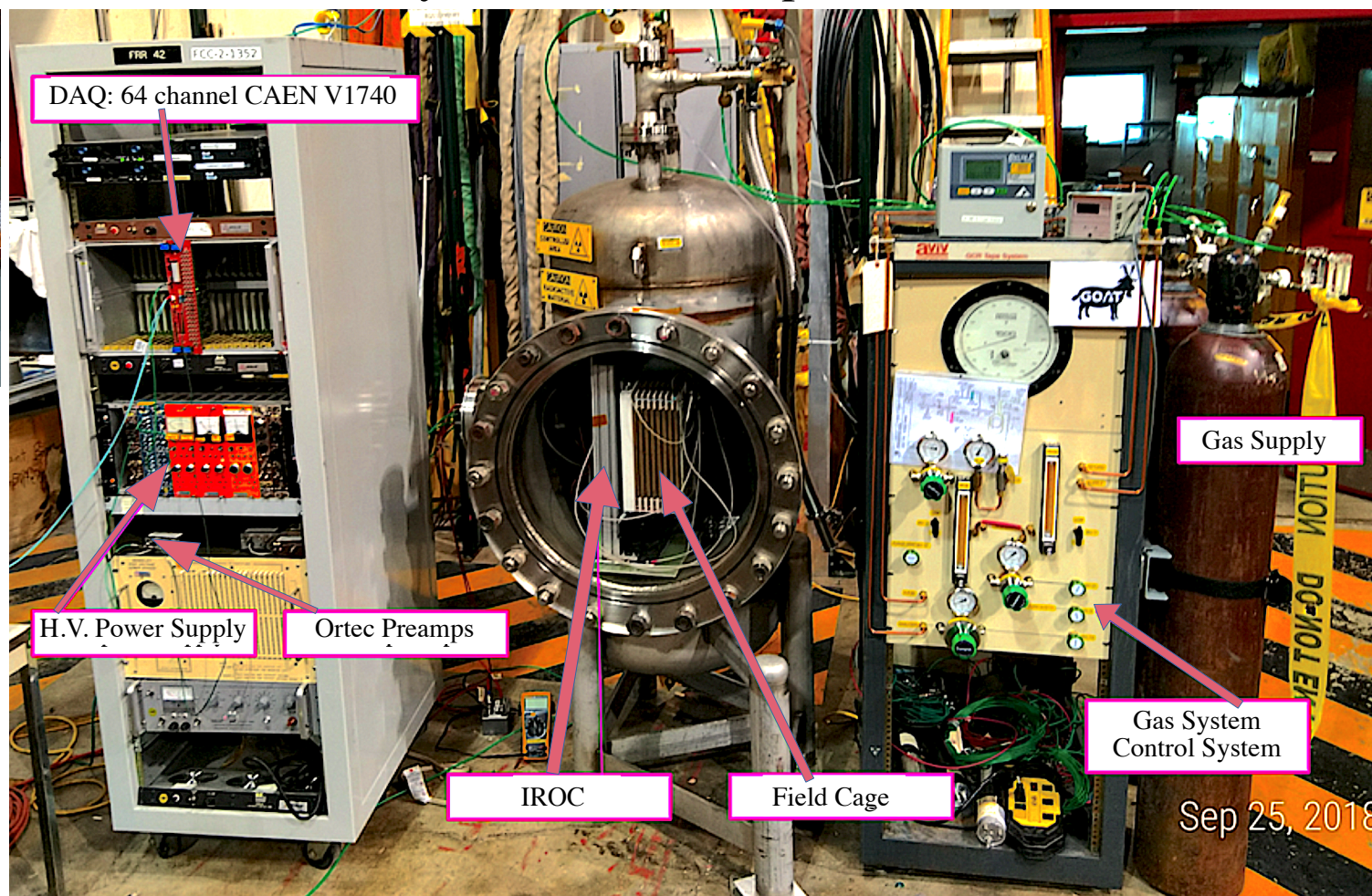
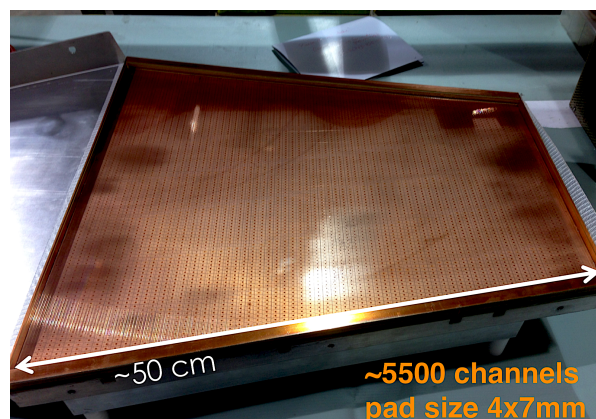
Description of the Test Stand

relatively more out-dated picture of GOAT



Description of the Test Stand

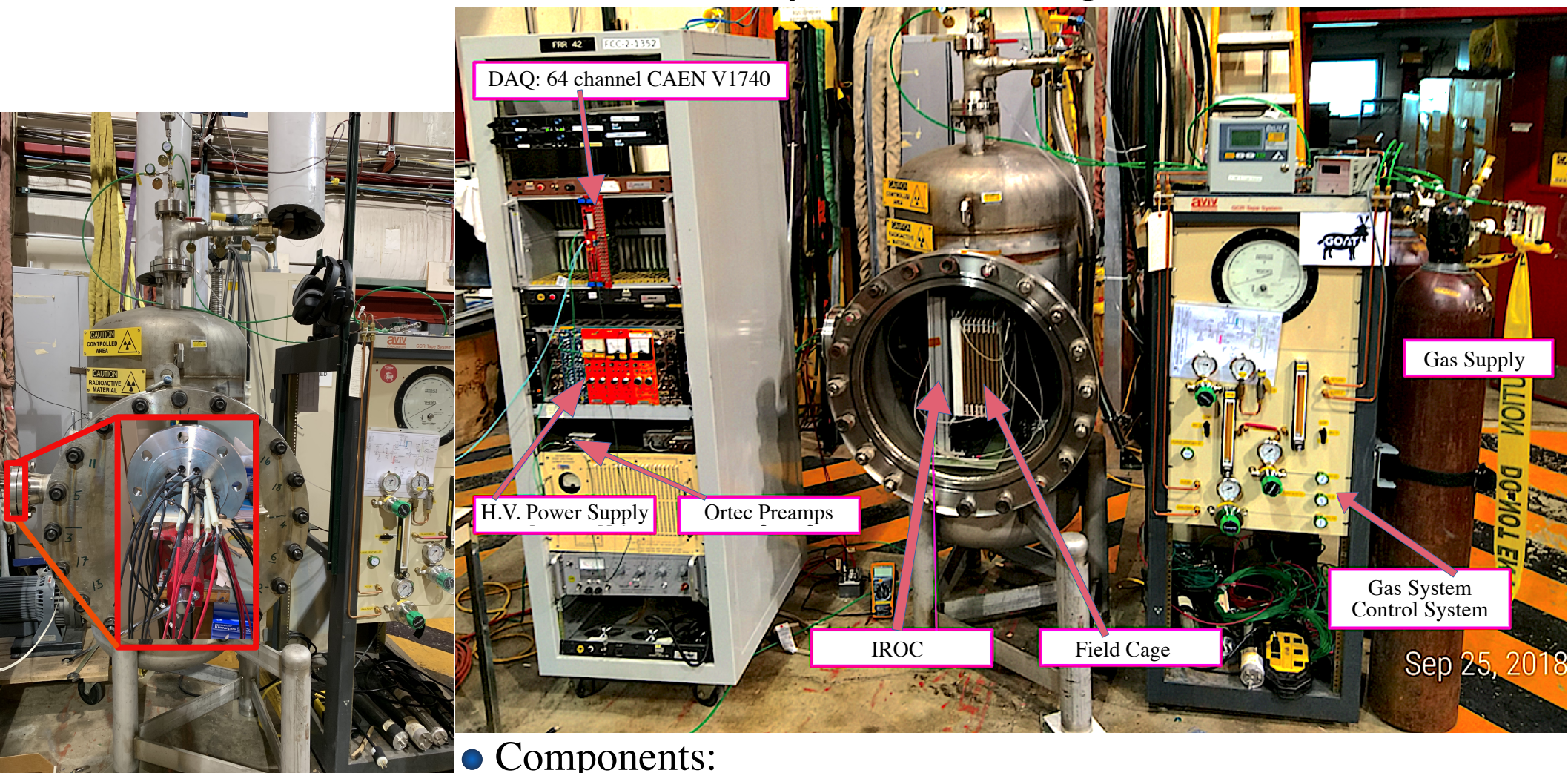
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● Components:

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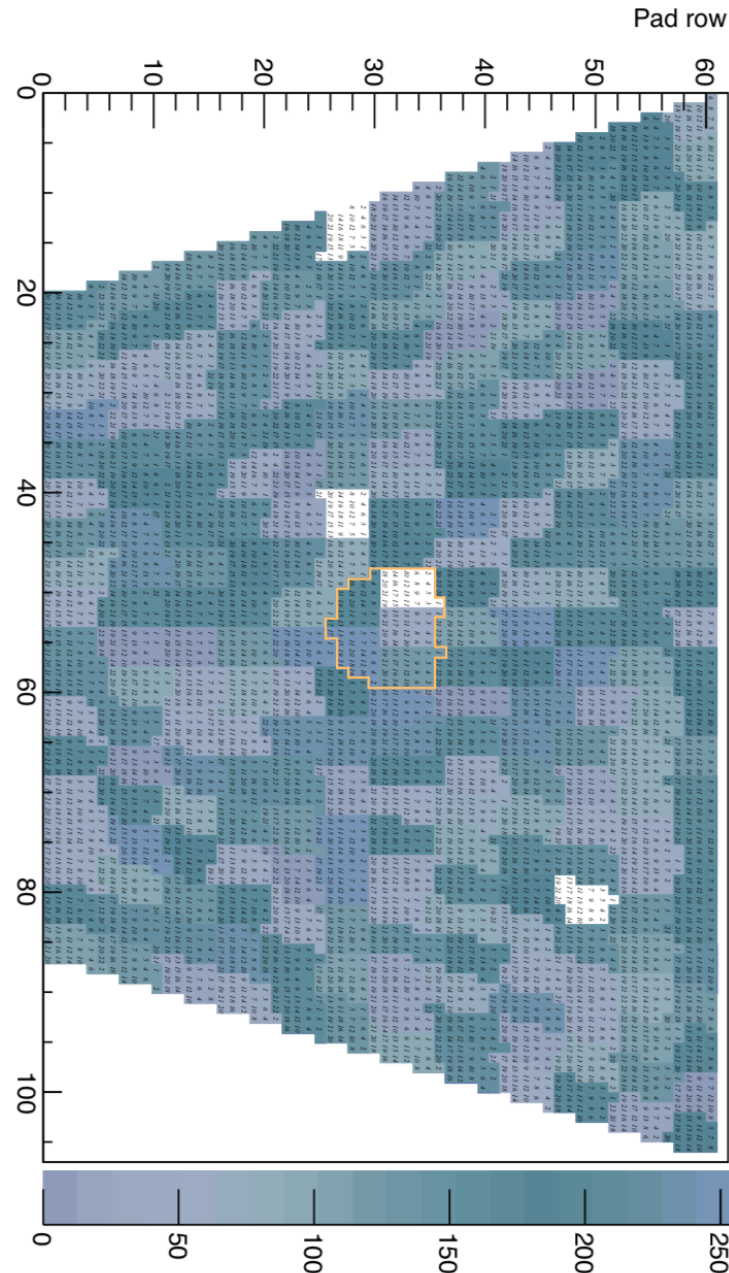
A More Recent GOAT



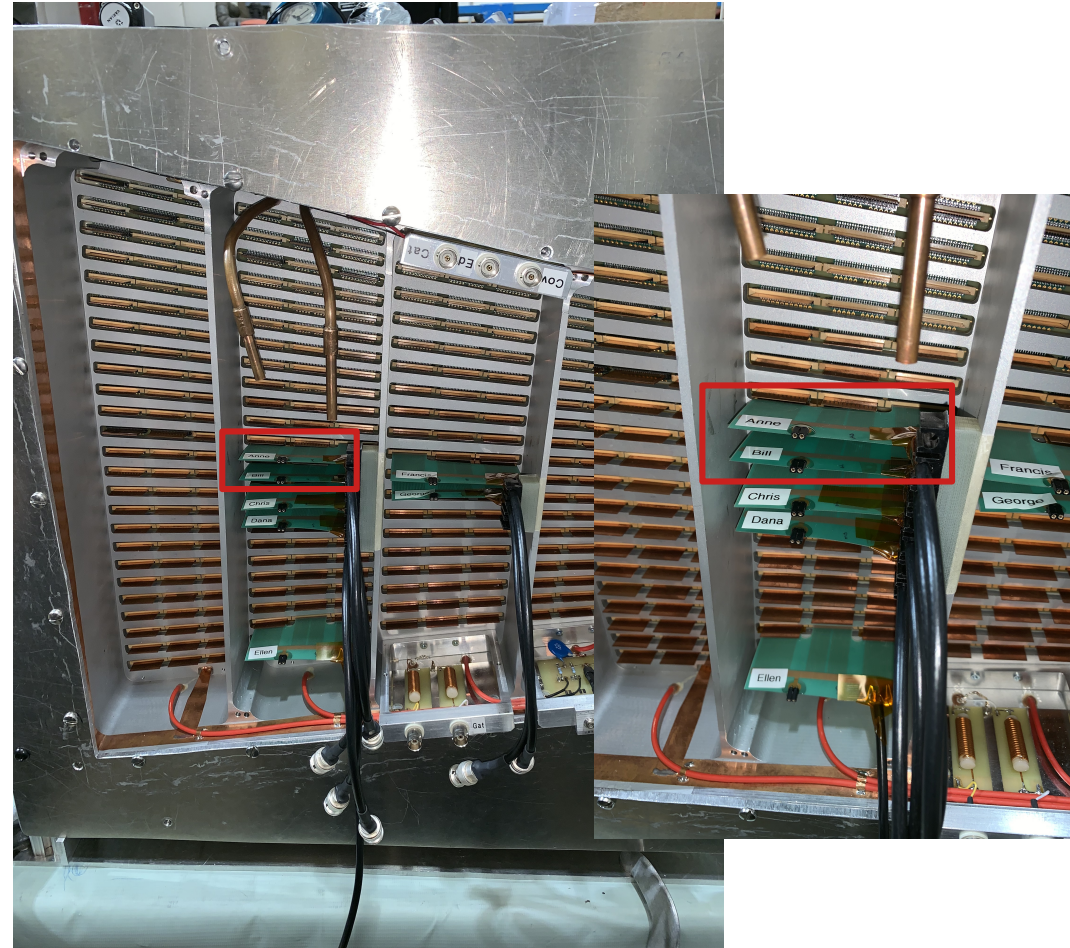
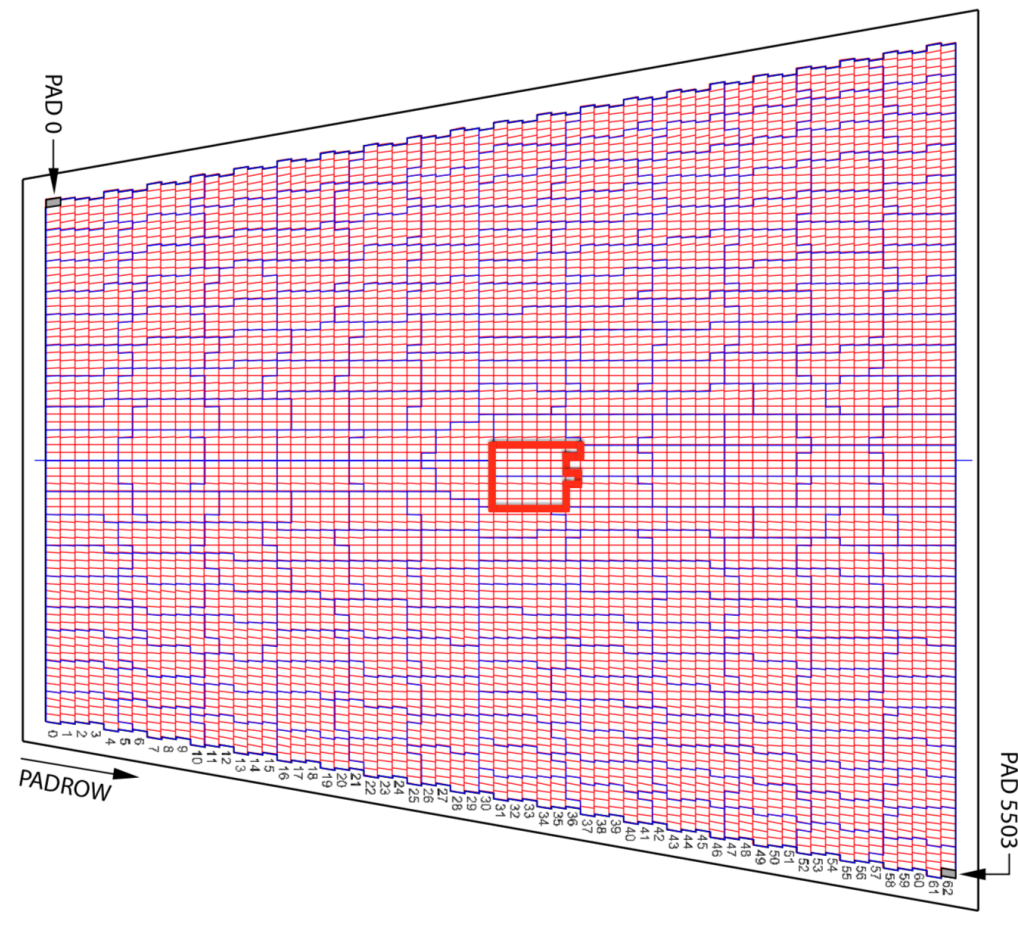
- All system components rated up to 10 atm pressure operation

First Signal Following Recent Upgrades

- Fe-55 source centered behind HV drift electrode irradiating the **center most pads**
- Daisy chained most readout card cards (due to lack of electronics) at min ~23 individual pads chained and max ~46 chained

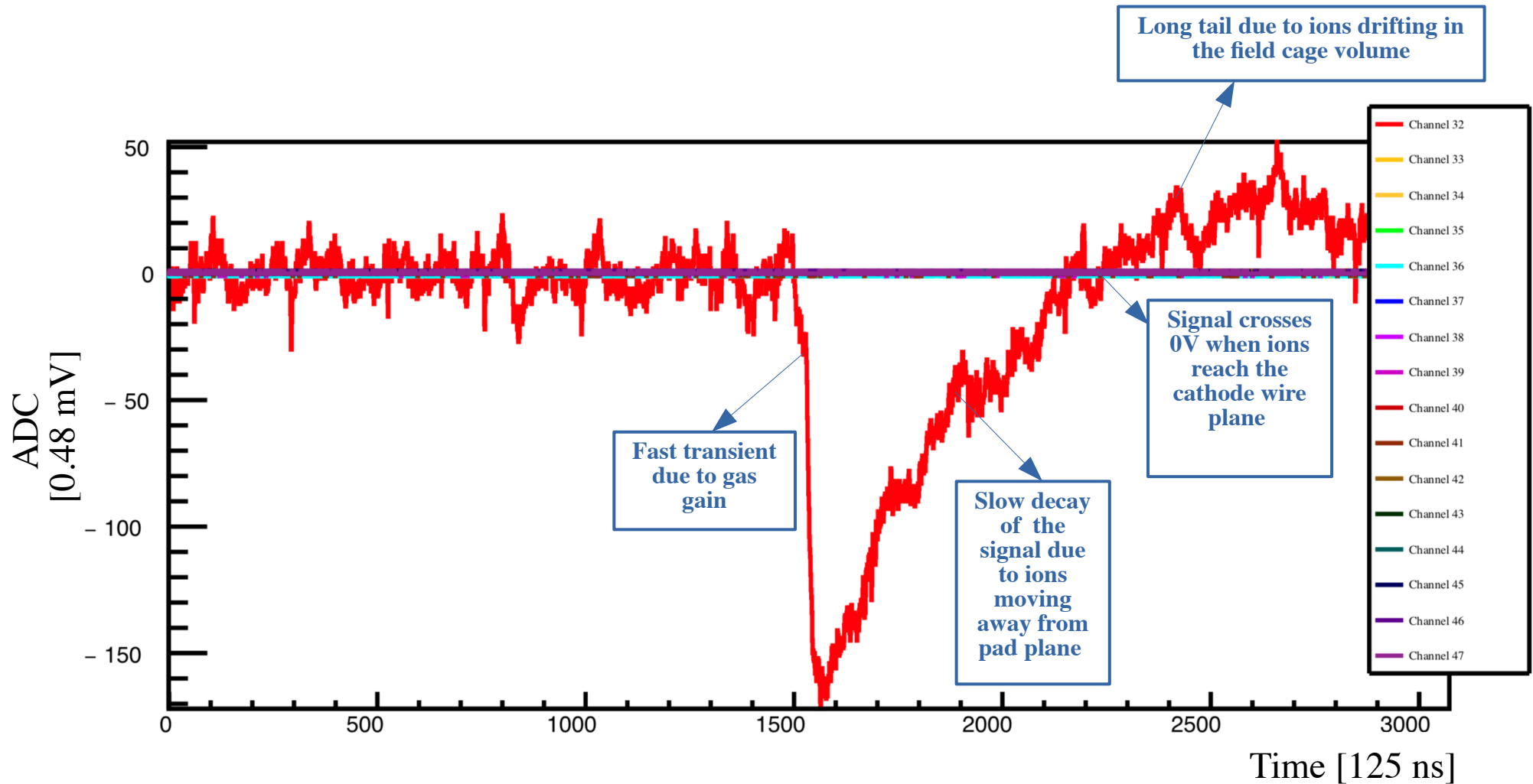


First Signal Following Recent Upgrades



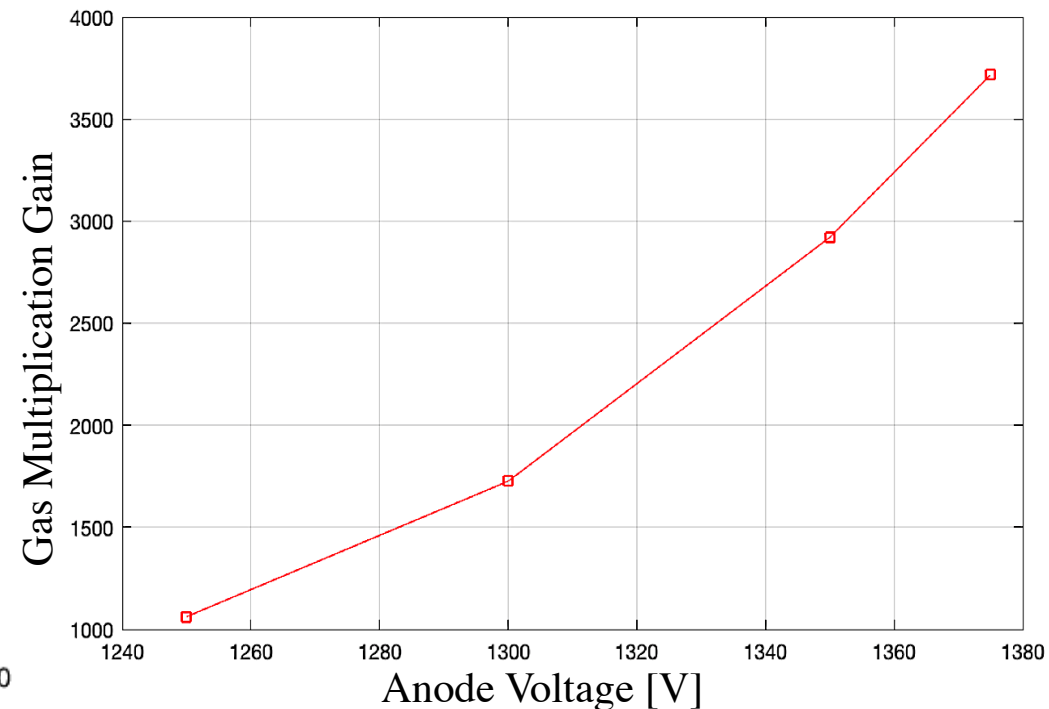
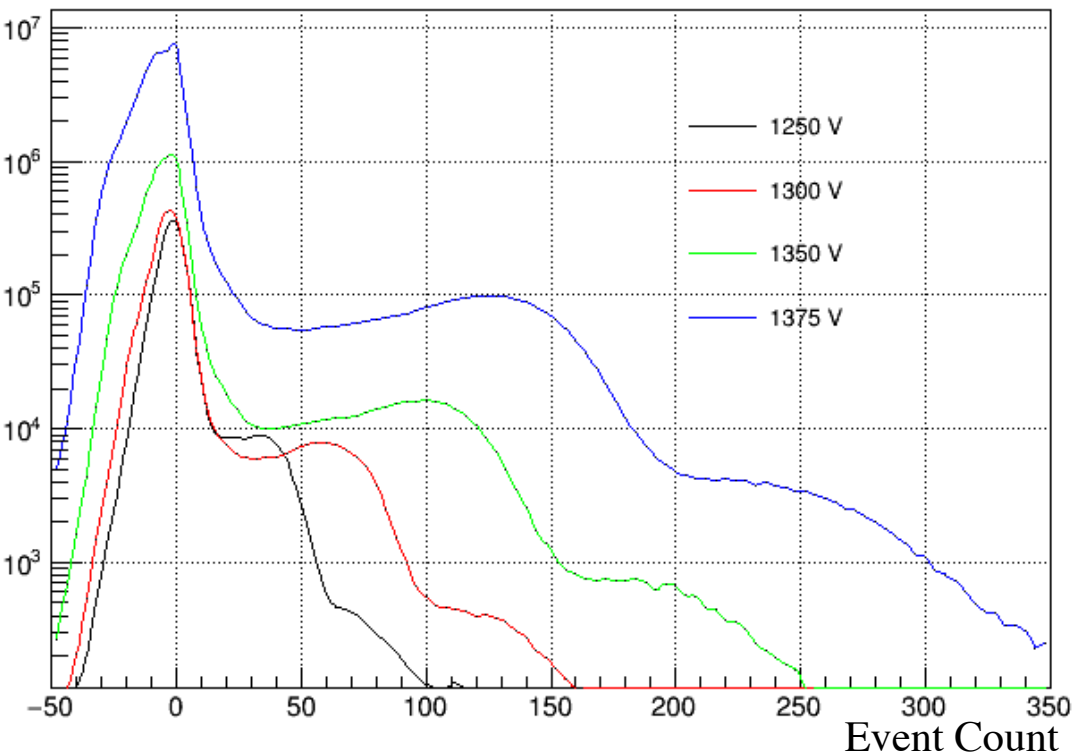
- Recent data collected with 46 pads chained together
- From there, signal goes to FE electronics (an ortec preamp with one readout channel, digitizer, and a DAQ board from LArIAT experiment)

First Signal Following Recent Upgrades



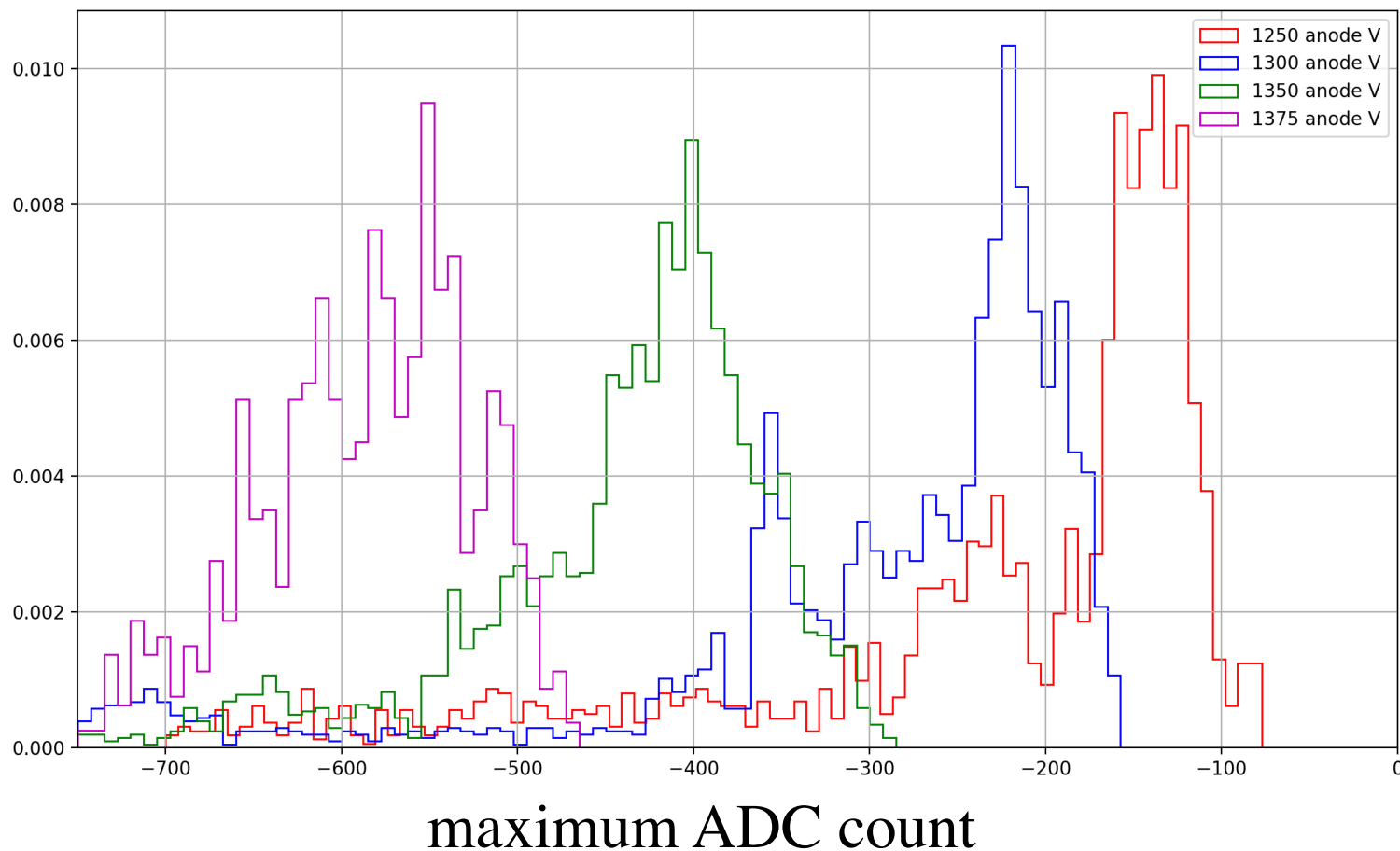
Gas Gain at 1 atm

- Data at 1 atm, 10 ppm O₂ level
- Event count sums over the individual x-ray “jumps” in the raw ADC waveform



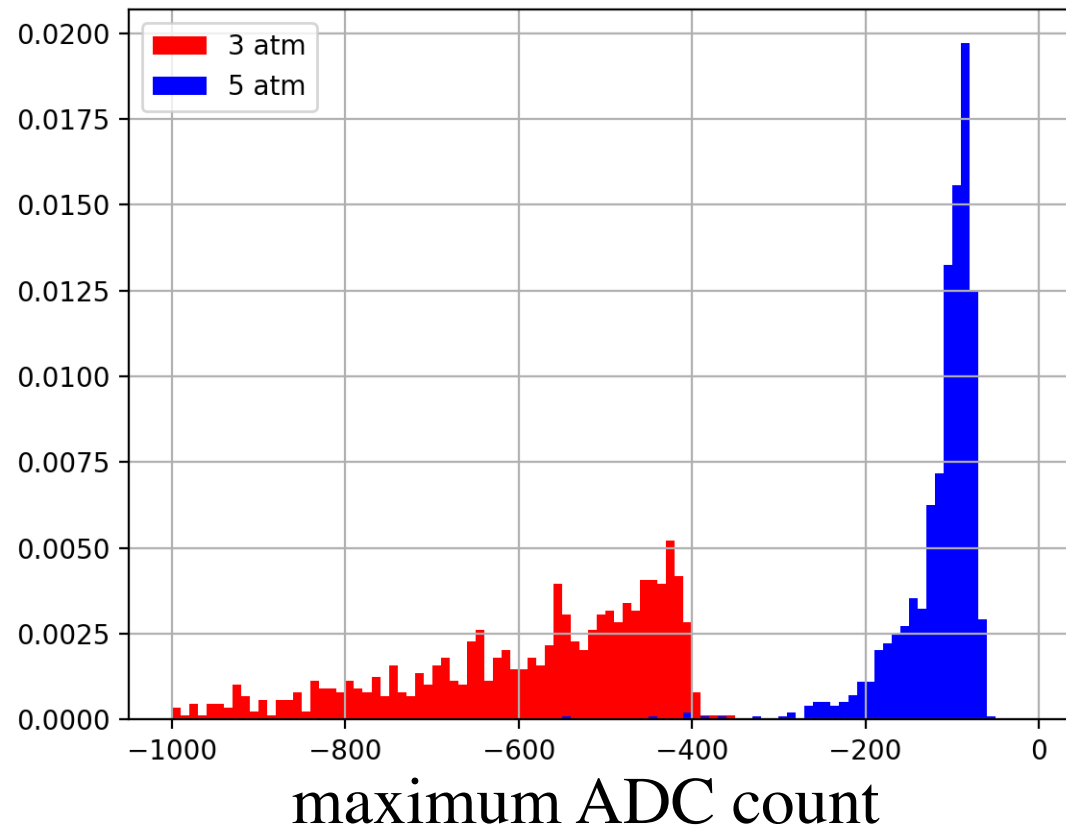
Gas Gain at 1 atm

- Data at 1 atm, 10 ppm O₂ level
- Another approach: maximum raw ADC count



Gas Gain (Max ADC Count) vs Pressure

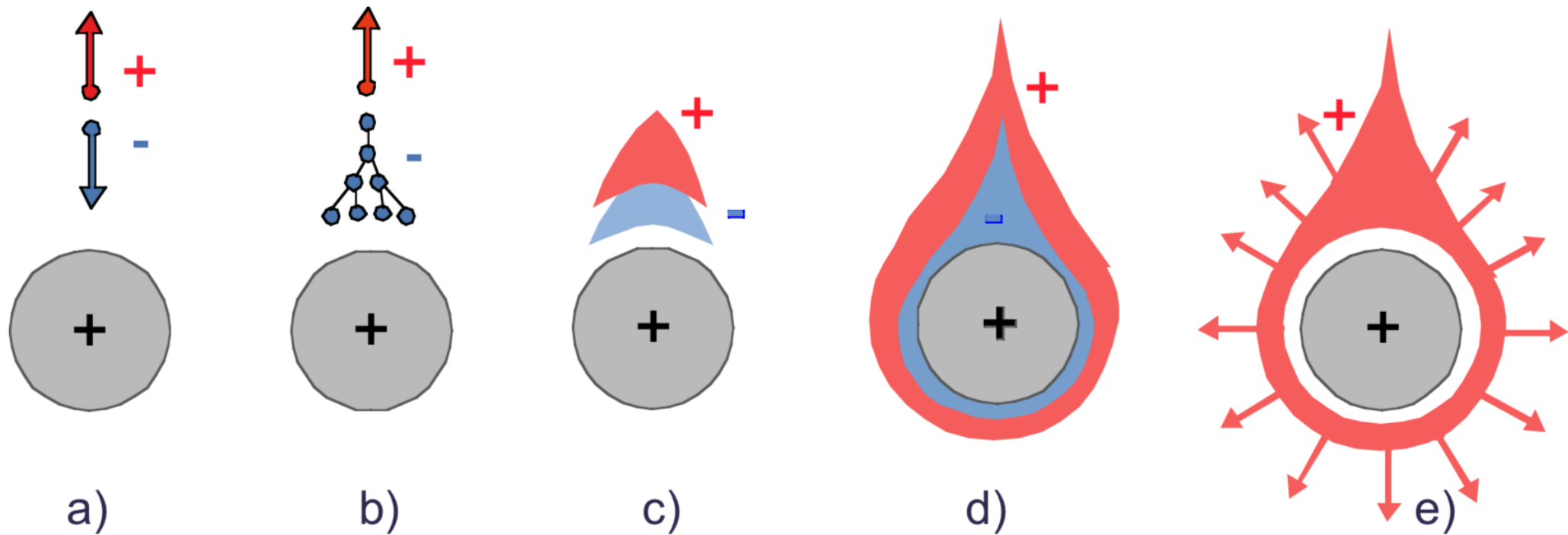
- Increased pressure in steps of 2 atm at 10 ppm O₂ level, with fixed anode voltage of 1.9 kV
- Keeping the anode voltage constant and changing the pressure does affect the gain (as expected)



Summary

- ★ Great amount of work has been done in preparing GOAT for high pressure operation
- ★ We are consistently ramping up the pressure and collecting gain calibration data
- ★ We have calibrated the gain at 1 atm and will be calibrating it at various pressure values
- ★ We plan to use v1 of LArPix soon. We will be inverting the signal to positive polarity for this.
- ★ Stay tuned for more results!

Additional Slides



- a) single primary electron proceeds towards the wire anode
- b) In the region of increasingly high field avalanche multiplication starts
- c) electrons and ions are subject to lateral diffusion
- d) a drop-like avalanche develops which surrounds the anode wire
- e) the electrons are quickly collected ($\sim 1\text{ns}$) while the ions begin drifting towards the cathode generating the signal at the electrodes