GArPix for the HPTPC

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DUNE LArTPC Pixel Workshop

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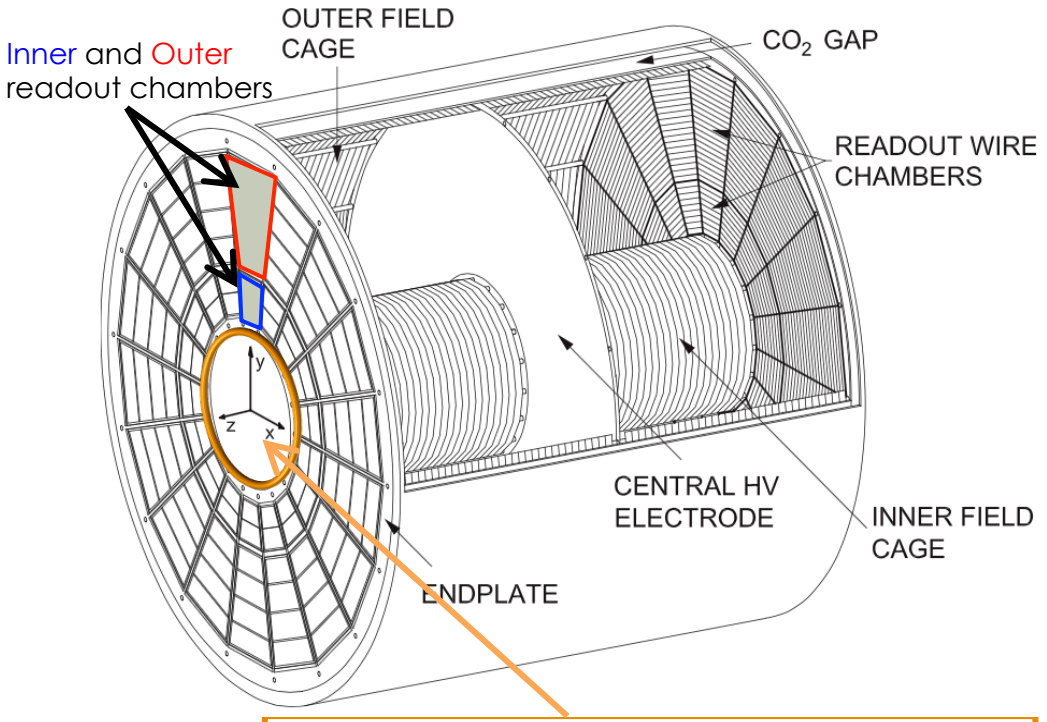
HPTPC pixels

- A repurposed ALICE TPC for DUNE ND will have ~694000 pixels
  - 570k existing pads in IROCs + OROCs
  - 124k new, to fill in central barrel regions
- The ALICE front-end readout system does not come along with the chambers, so we need a low-noise low-power solution. LArPix?
- A common pixel readout for LAr + GAr will simplify DAQ and detector operations



In ALICE, this is central region is instrumented with a silicon vertex tracker

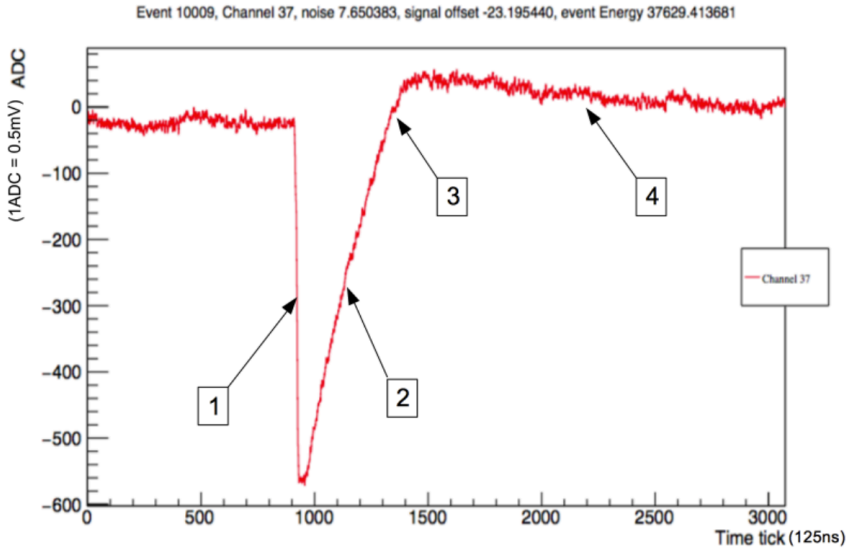
Table 4.2: Readout pads.

	Pad size [mm^2]	Number of rows	Number of pads
Inner chamber ($84.1 < r < 132.1$ cm)	4×7.5	64	5 732
Outer chamber ($134.6 < r < 198.6$ cm)	6×10	64	6 038
Outer chamber ($198.6 < r < 246.6$ cm)	6×15	32	4 072
TPC total		160	570 312

Modifying LArPix to GArPix

Some modifications are needed to make the LArPix ASIC suitable for reading out the HPTPC

- **Trigger polarity**
  - LArPix currently triggers on positive polarity signals
  - HPTPC signals are negative, fast rise time (<1 ns) with long tail due to motion of positive ions



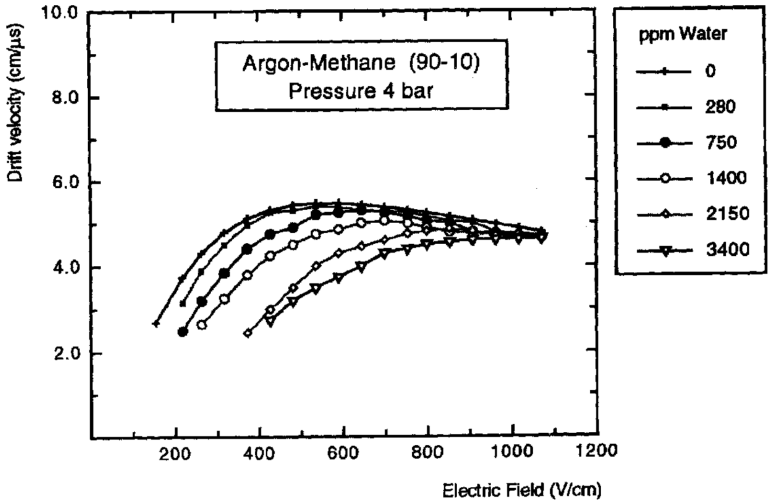
1. Fast transient due to multiplication in the gain region.
2. Slow decay of the signal due to ions moving away from the pad plane towards.
3. Signal crosses 0V when ions reach the cathode wire plane.
4. Long tail due to ions drifting in the field cage volume.

Typical signal in IROC test stand (with Ortec 109A preamp, no ALICE preamp/shaper)

Modifying LArPix to GArPix

Digitizing speed

- LArPix currently supports system clocks in the range of 2.5 – 20 MHz, can sample once every 11 clock cycles
  - In LAr, can achieve timing resolution (spatial resolution in drift direction) that is comparable to 3-4mm pad spacing via 5MHz clock
  - LAr vs. GAr drift velocity
    - LAr drift velocity 1.6 mm/us for field of 500V/cm
    - GAr drift velocity ~**5 cm**/us (depends on exact gas mixture and pressure chosen)
  - Even operating at 20MHz, not fast enough for GAr
    - 0.05us/cycle x 11 clock cycles x 5cm/us = 2.75cm spatial resolution in drift direction



Short-Term Plans (GOAT Test Stand)

- Detail the characteristics of the IROC signals to determine needs for LArPix modification (capacitance, signal amplitude, rise time, etc.)
  - Necessary input to determine the full extent of modifications that will be needed
- Adapt existing IROC test stand (~5500 pads) to work with current LArPix version as a first test. Need to:
  - Invert IROC signals
    - Talking to FNAL EEs next week
  - Reduce gain (easy)
  - Probably will design an intermediate board to invert and route signals to ASICs
  - Use same control board as in Bern test (or maybe can use the improved control board designed by Bern?)

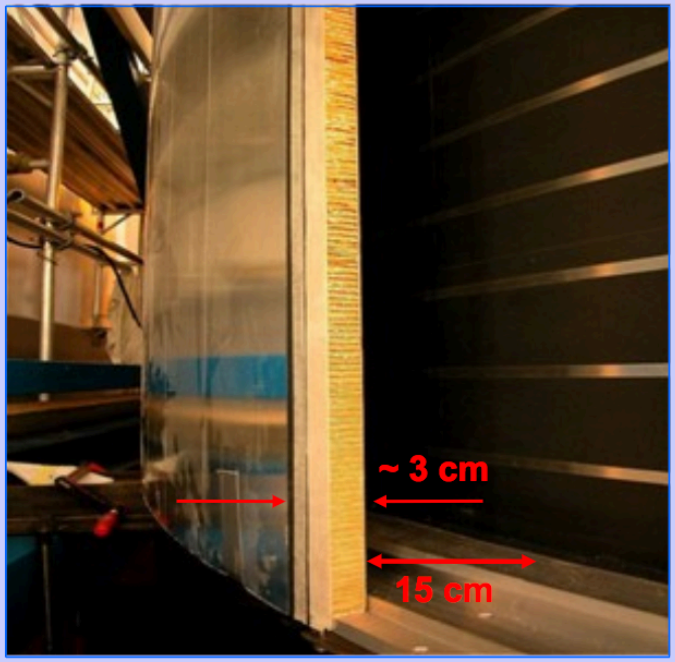
Longer-Term Plans (LArPix → GArPix)

- LBNL ASIC engineer will be able to dedicate effort to modifying LArPix starting in 6 months
  - Estimates that it will take 1-2 months of effort to implement the necessary changes
  - Add time for ASIC production → should have working GArPix version in ~10 months
    - Timing works ok with current plan for ProtoDUNE-ND

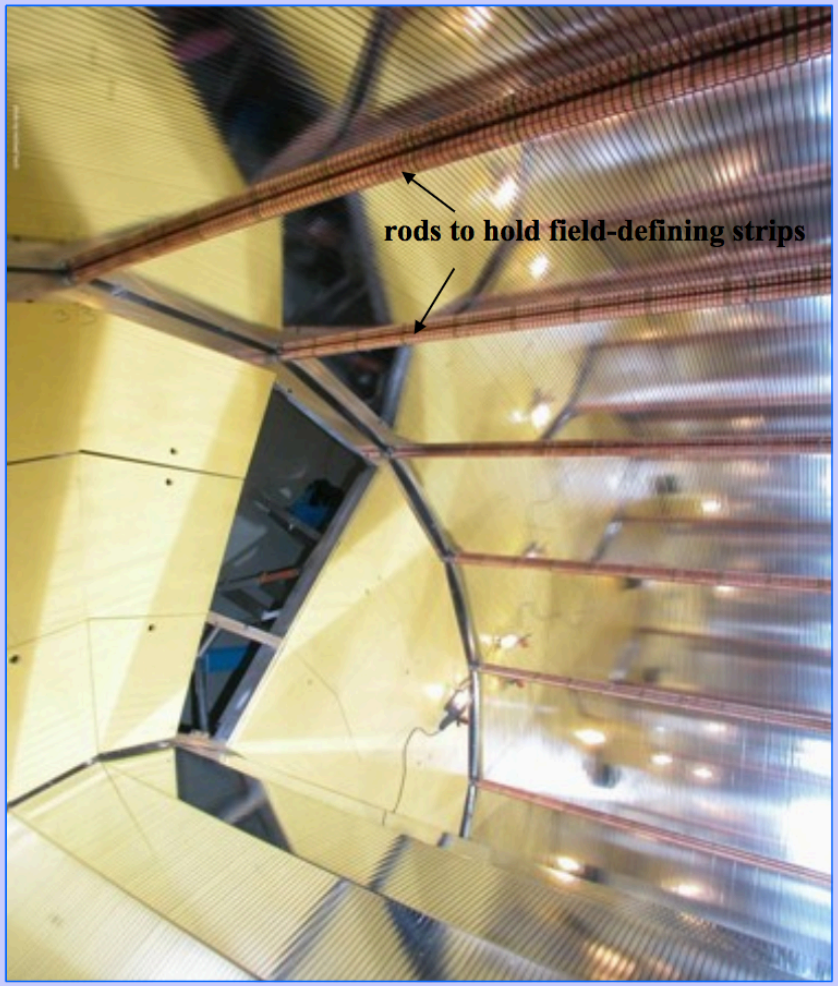
- ProtoDUNE-ND: ArgonCube 2x2 + HPTPC with IROC (~10k pads)

Extras

ALICE TPC: Low-Mass Field Cage



- Light composite materials for all four cylinders.



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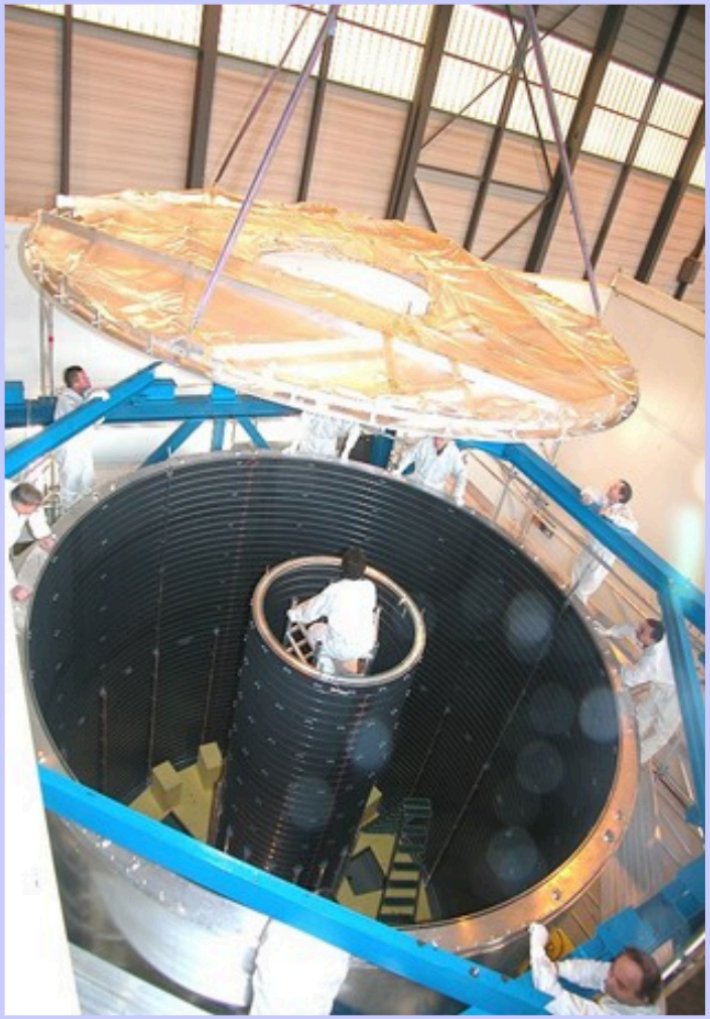
Field Cage Construction (2002-04)



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ALICE Front End Electronics Chain

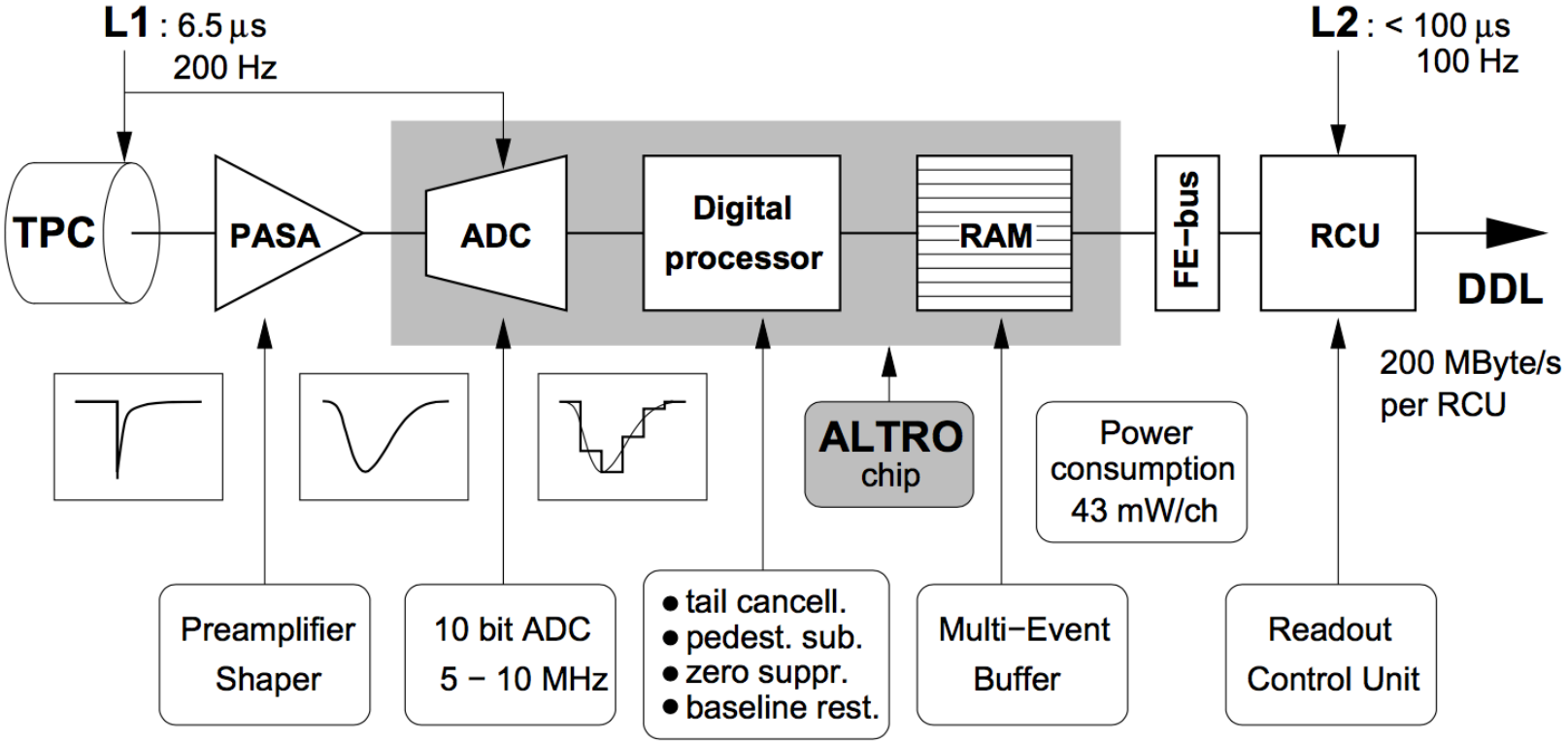
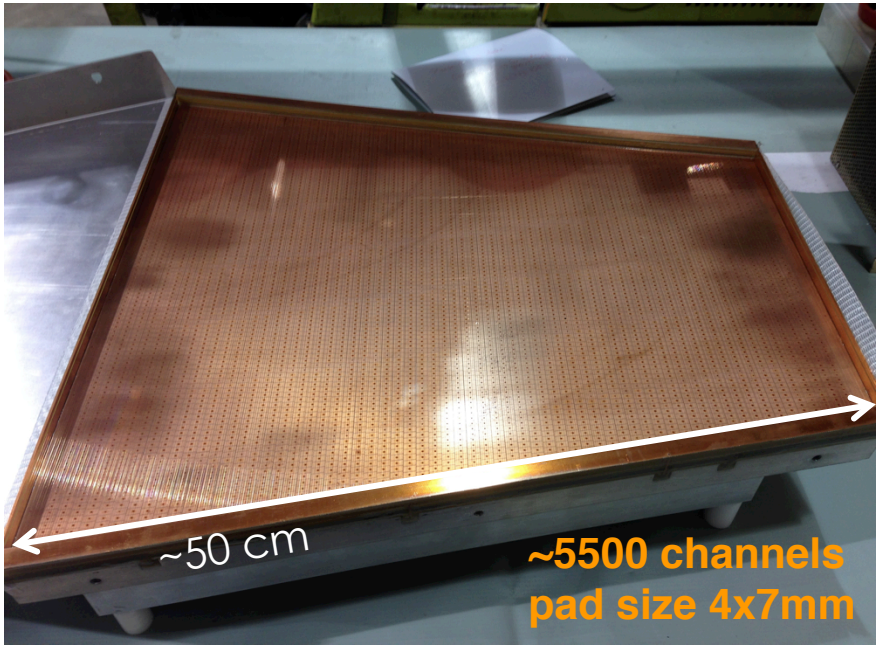


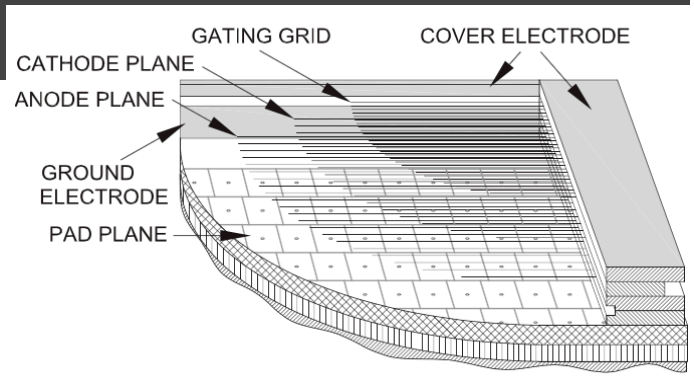
Figure 3.15: Basic compontents of the front end electronics.[2].

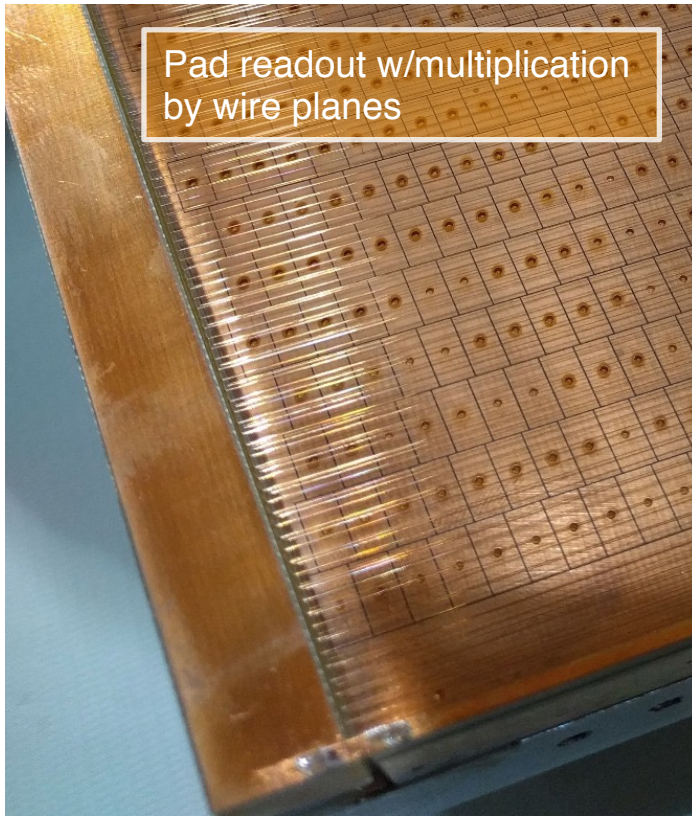
PASA gain & shaping time: 12mV/fC, ~200ns

ALICE performs long tail suppression, digitizing signal several times. DUNE HPTPC will have lower occupancy, likely do not need such extensive tail suppression. Start with low power consumption → may allow simpler cooling and gas system.

IROC Test Stand







GOAT (GAr Operation of the ALICE TPC) test stand

- Demonstrate operation of ALICE readout chamber at higher pressures & characterize performance
- Test chamber performance with various gases

MINERvA/MINOS hall layout