The μBooNE Experiment

μBooNE: 170 Ton Liquid Argon Time Projection Chamber neutrino detector
- On Booster Neutrino Beamline at Fermilab (~ 1 GeV neutrinos)
- R&D - Investigate miniBooNE “low-energy excess” - Cross Sections
- Potential to observe neutrino events from a supernova within our galaxy
- TPC will give us morphology of neutrino interactions
- Signal from TPC and PMTs ➔ powerful and exciting detector!

- TPC data will be read out in two modes: “neutrino” and “supernova”:
  - neutrino: trigger on beam events
  - Supernova: record data continuously and wait for alert ➔ Recording all data requires lossy data compression

μBooNE’s Time Projection Chamber Readout Chain

Cold electronics:
- Signal amplification and shaping
- Low temp. and short cables ➔ noise reduced by factor of ~3
- Calibration tools to pulse wires

Intermediate Amp.

TPC Crate in LArTF Detector Hall

Wire Calibration: Pulse Generated Waveform

 ν readout

PCle (one per Crate) ➔ To DAQ

XMIT (Transmit) Board

Trigger received from PMT Crate

Controller Board

Token passing FEM-by-FEM ➔ send to DAQ on optical fibers

Front End Module (x15)

ADC (10 MHz)

Decimation (1 MHz)

FPGA (compression)

ν DRAM buffer

supernova DRAM buffer

Supernova Readout and Data Compression

Warm electronics:
- A/D conversion in 12 bit words
- Data compression ➔ different for supernova and ν readout
- Communication with PMT trigger board
- Data sent out to DAQ system

Study of Variance Scheme on Simulated Events

Compression Factor: Tot Data / Saved Data ➔ Calculated from cosmos (rate ~ 5 KHz)

Fraction of Charge Collected
- Looked at simulated 10 MeV e

Trade-off ➔ find balance

Ionization electrons drift in 500 V/cm field towards three wire-planes.
Induced current on wires gives us signal:
- Digitize at 2 MHz
- Three planes ➔ PMTs ➔ 3D track reconstruction
- Total of 8256 wires, Wire separation is 3 mm.
- Amount of charge deposited ➔ calorimetric reconstruction & particle ID

Concept behind μBooNE’s Time Projection Chamber

- Two “induction” planes
  - One “collection” plane
  - Drift speed at 500 V/cm: ~ 1.6 mm/μs

Data in frames:
- 3200 2 MHz samples
  - 1.6 ms ➔ time for e− to drift across detector.

Two readout modes:
- Supernova (continuous)
- ν (beam events)

“ν” readout mode:
- Store data when a trigger is received from the PMT Crate
  ➔ For more, see poster by David Kaleko at Neutrino14
- Many triggers: Beams, PMTs, Calibration, Laser 1/2500 Beam spills with ν-event. Require beam + PMT trigger ➔ 1/20

Data Rates:
- 4.8 ms x 2 MHz samples x 2 bytes/sample x 8256 wires.
  - BNB (10Hz) ➔ ~ 1.5 GB/s. BNB+PMT trigger ➔ ~ 12 MB/s. Huffman ➔ ~ 1.2 MB/s

How μBooNE’s TPC Works

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- μBooNE will be sensitive to supernova neutrino events Channel:
  \[ ν_e + ^{37}Ar \rightarrow e^- + ^{38}K^+ \]

- Expect ~ 10s of events for a supernova within our galaxy.

- Hard to trigger on ➔ Instead wait for SuperNova Early Warning System (SNEWS)

Need to:
- Record data continuously
- Hold on to it for ~ 1 hour
- Compression “on the fly” ➔ must be fast!

Leave out quiet regions & save interesting pulses

Interested in 10s of MeV electron tracks from supernova

Compression Scheme will depend on:
- Baseline stability ➔ Noise levels ➔ Signal Shape ➔ Optimize based on Detector

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- How much Data?
  - Sample @ 2 MHz x 2 bytes/data-word x 8256 wires ➔ 33 GB/sec
  - Must compress by ~ x80 to be within experiment’s data-writing limits