MicroBooNE Electronics

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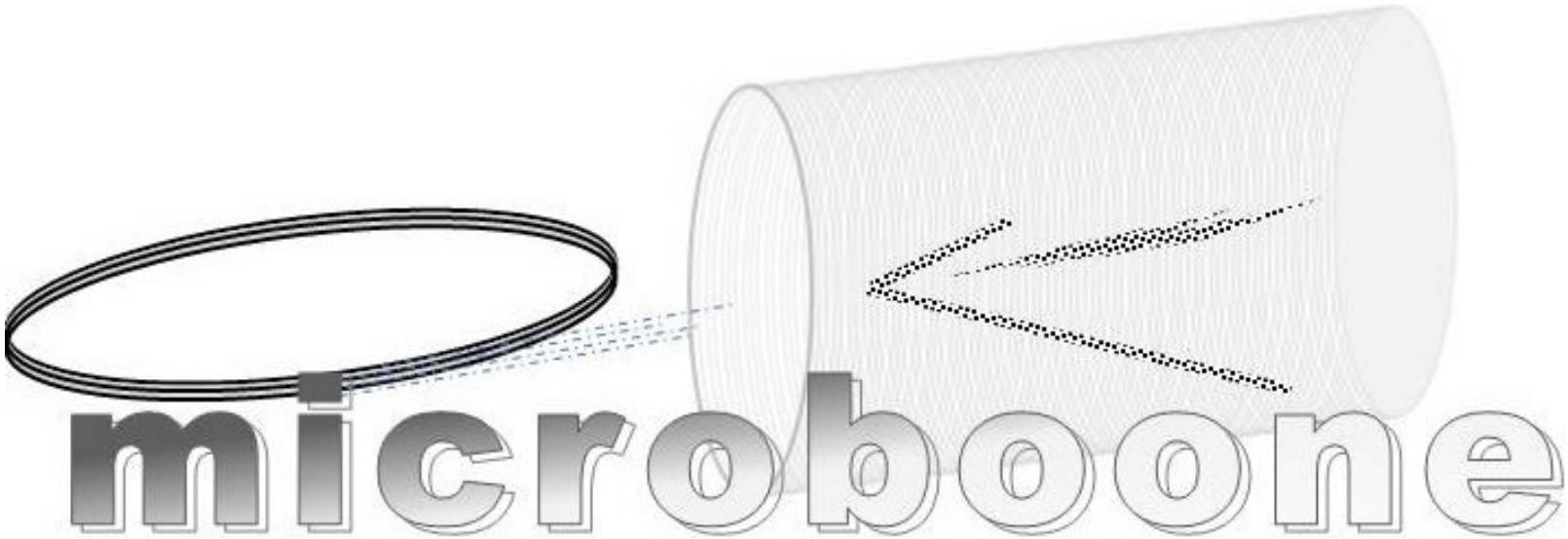
APS: Denver, CO

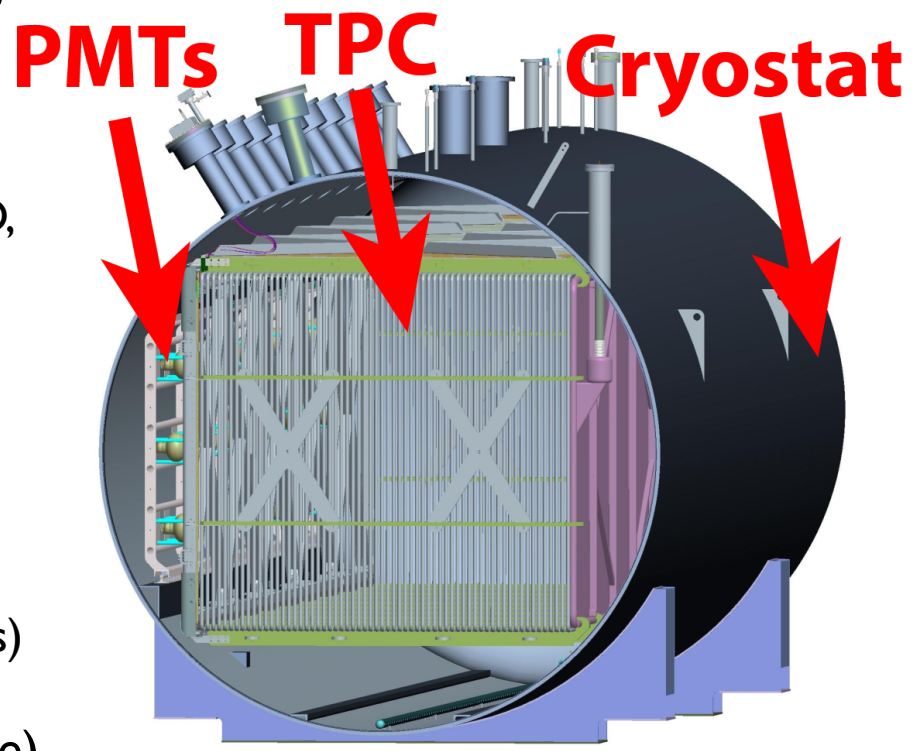


Outline

- General MicroBooNE
- TPC Electronics
  - Data volumes, data flow
- PMT Electronics
  - Data volumes, data flow
  - Triggering
- Supernova readout

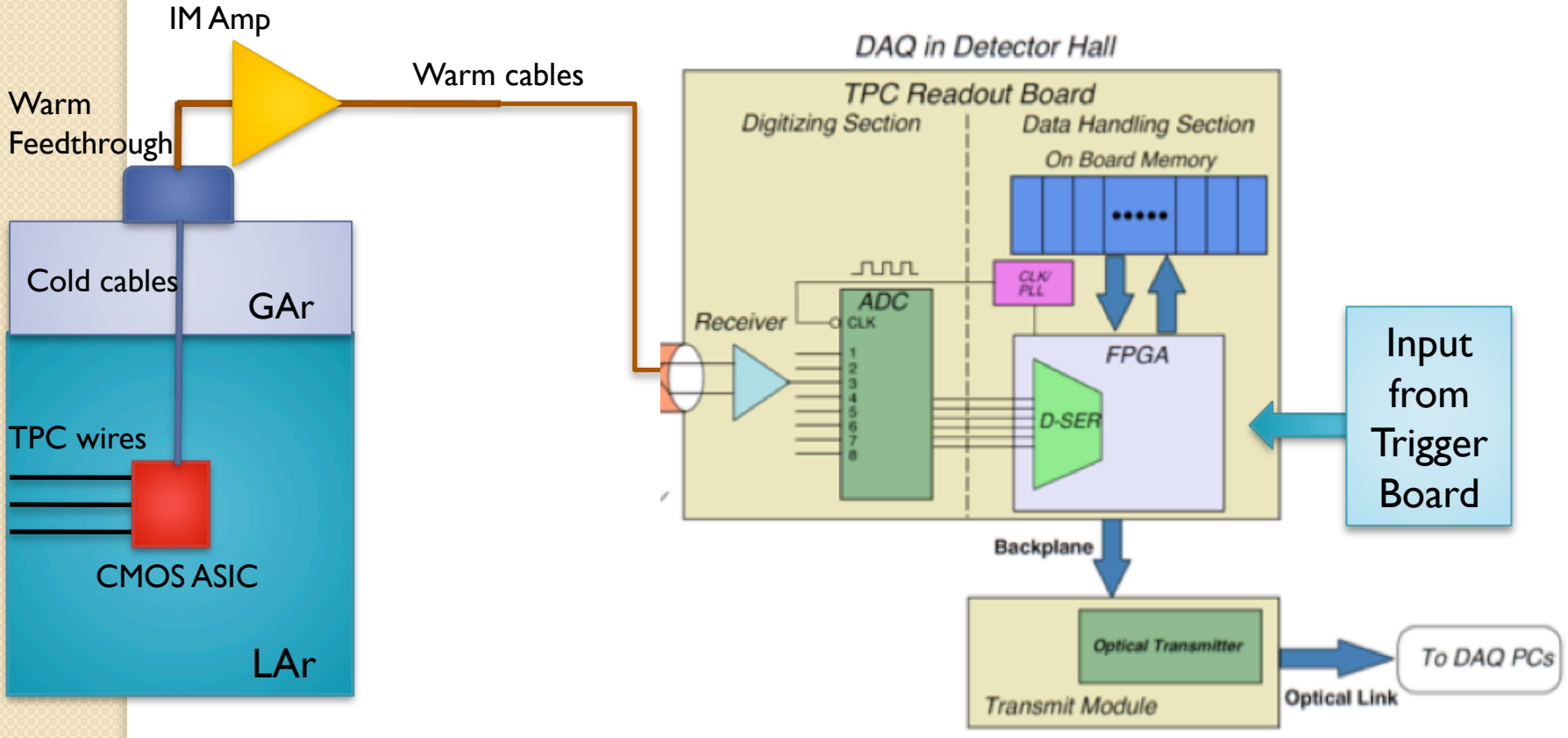
General MicroBooNE

- Liquid Argon TPC: 170ton LAr, 86ton active.
- 32 cryogenic PMTs: triggering and timing information.
  - Also reconstruction, cosmic ID, etc.
- TPC:
  - 3mm wire spacing
  - 2.5m drift (1.6ms)
  - 500V/cm
  - 3 wire readout planes (Y, U, V)
  - **8256 channels** (cold preamps)
- Located *on surface*: ~5kHz cosmics (8 per 1.6ms drift time)



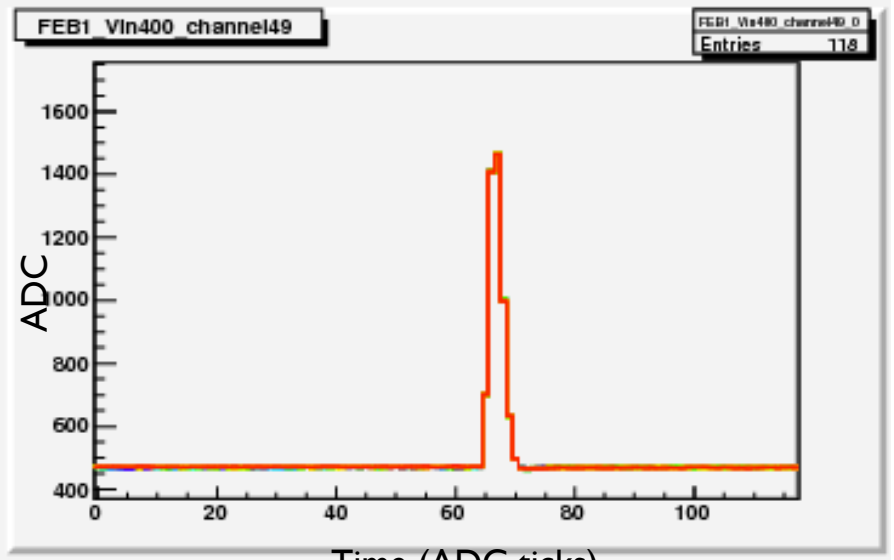
TPC Electronics

- Includes cold electronics, warm interface electronics, digitizing/data handling electronics, cabling, signal feedthroughs.

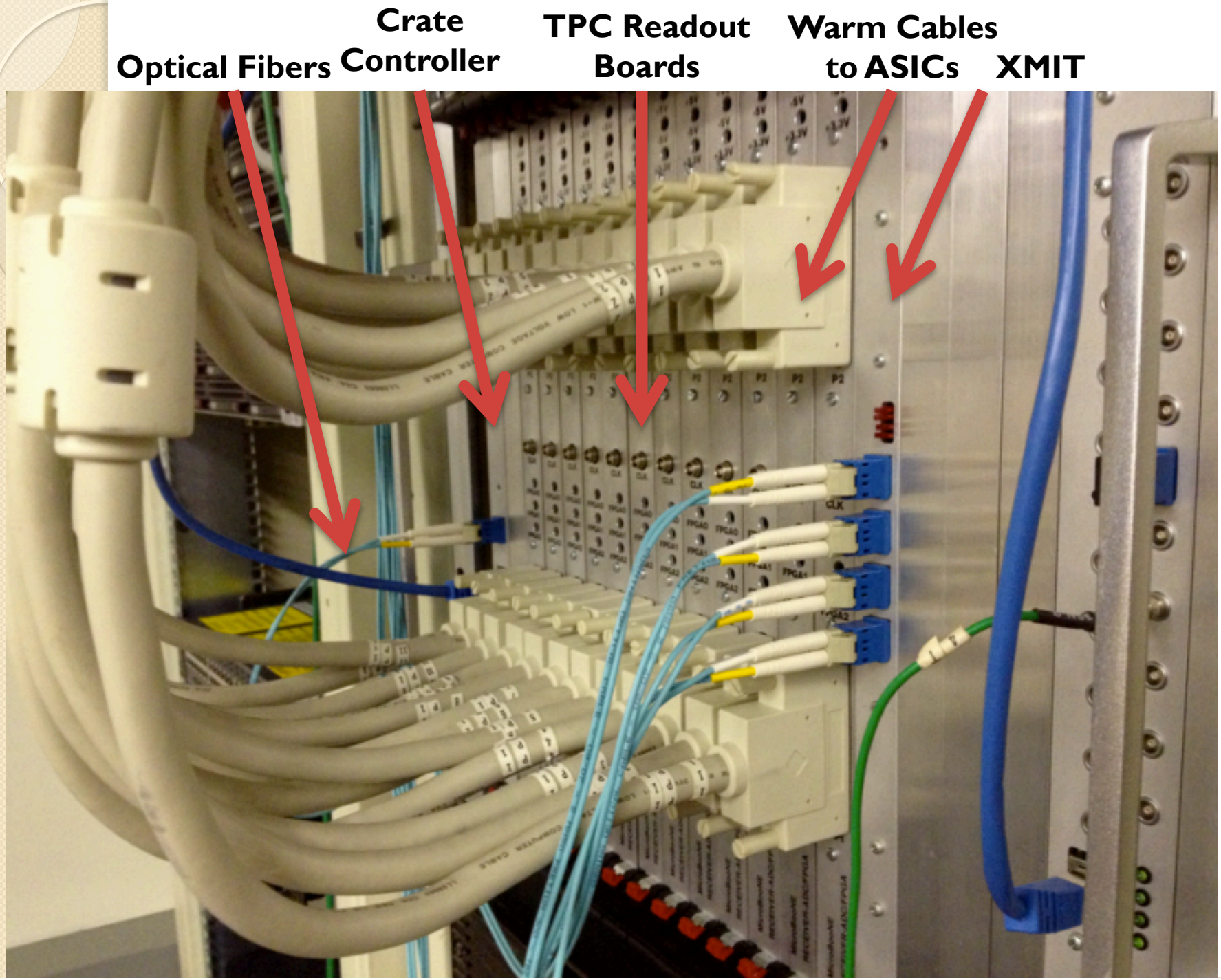


TPC Electronics

- Combination of induction (bipolar) and collection (unipolar) channels.
  - Differing baselines configured in ASICs.
- 2 MHz 12-bit ADC sampling rate (0.5 μ sec/ tick)
- 4 x 1.6ms frame readout duration
  - Trimmed in FPGA: 1.6ms before beam trigger, 3.2ms after
- 64 channels/board: ~130 boards (9 crates)



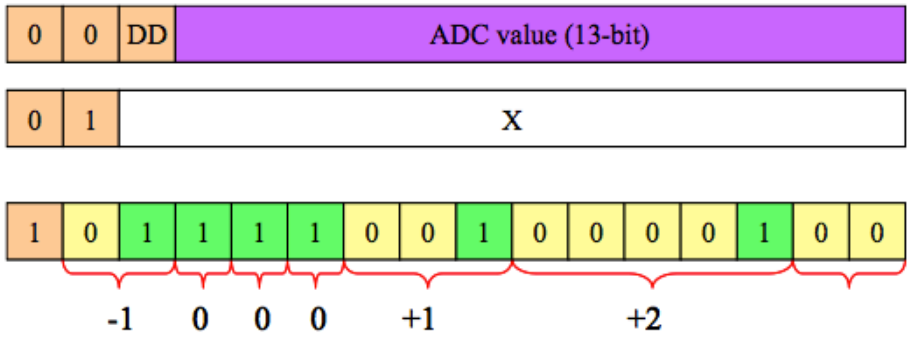
Sample calibration pulses: charge inserted onto ASICs, then read out/digitized. Note lower baseline at ~450 ADC (induction channel)


Optical Fibers
Crate Controller
TPC Readout Boards
Warm Cables to ASICs
XMIT

TPC Electronics: Data Volumes

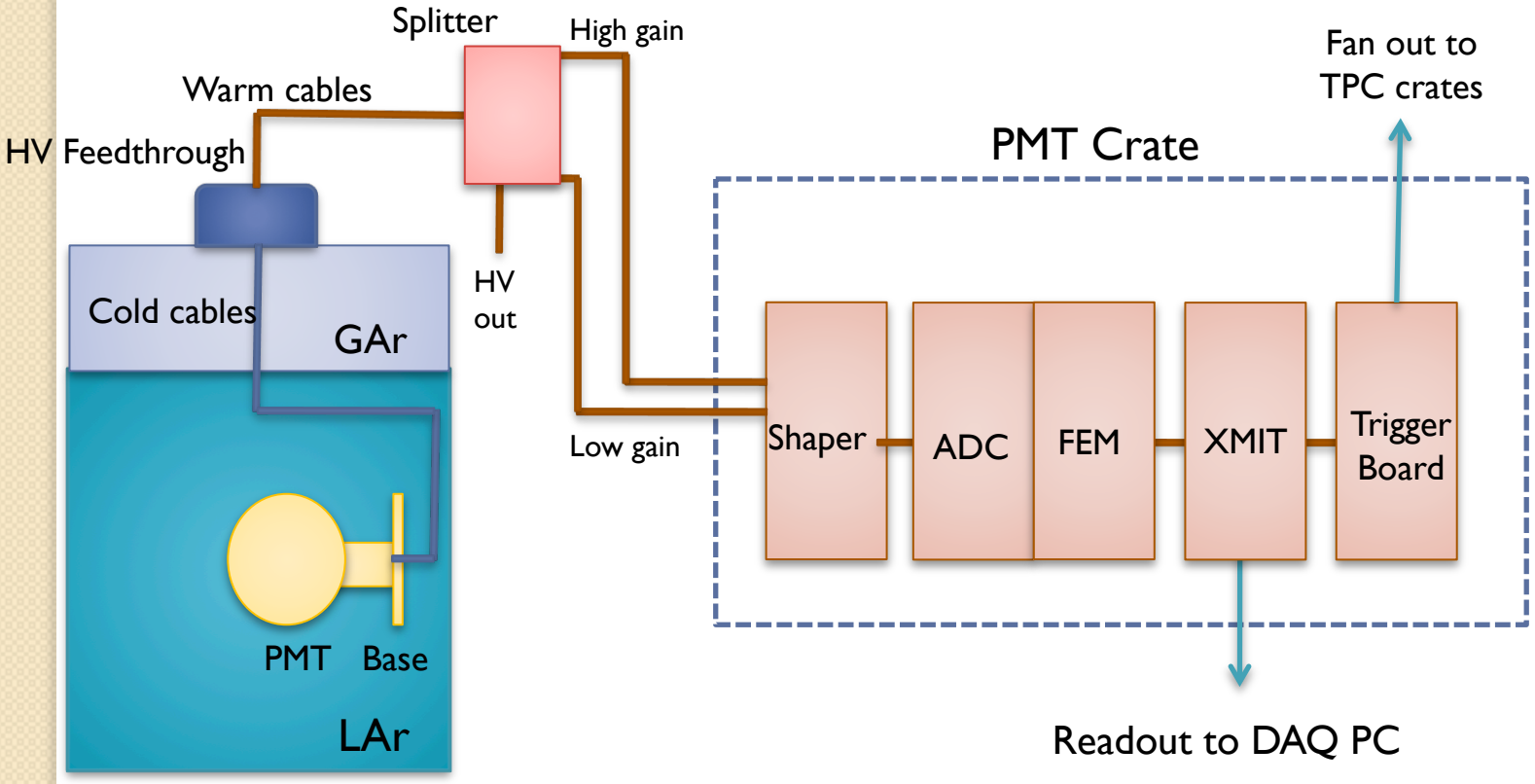
- Beam spill rate of 10Hz, not every spill has neutrino events.
- ~160 MB TPC data per event (uncompressed data volume)
- Lossless data reduction: Huffman Coding
  - Successive data samples vary slowly in time.
  - Up to factor 10-15 reduction possible. Expected 8x.
- Average data volume further reduced by requiring PMT trigger in coincidence with beam gate.

U(n+1)-U(n)	Code
-4 and others	Full 16 bits word
-3	000001
-2	0001
-1	01
0	1
+1	001
+2	00001
+3	0000001



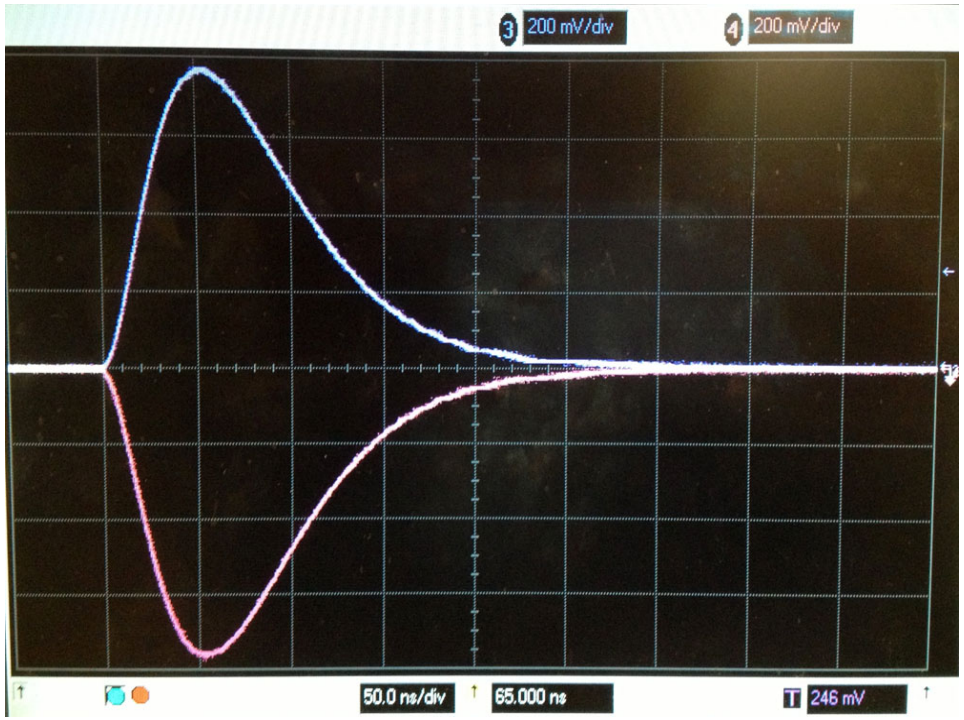
PMT Electronics

- Includes signal shaper boards, PMT feedthrough, HV/signal splitters, and a trigger board.



PMT Electronics

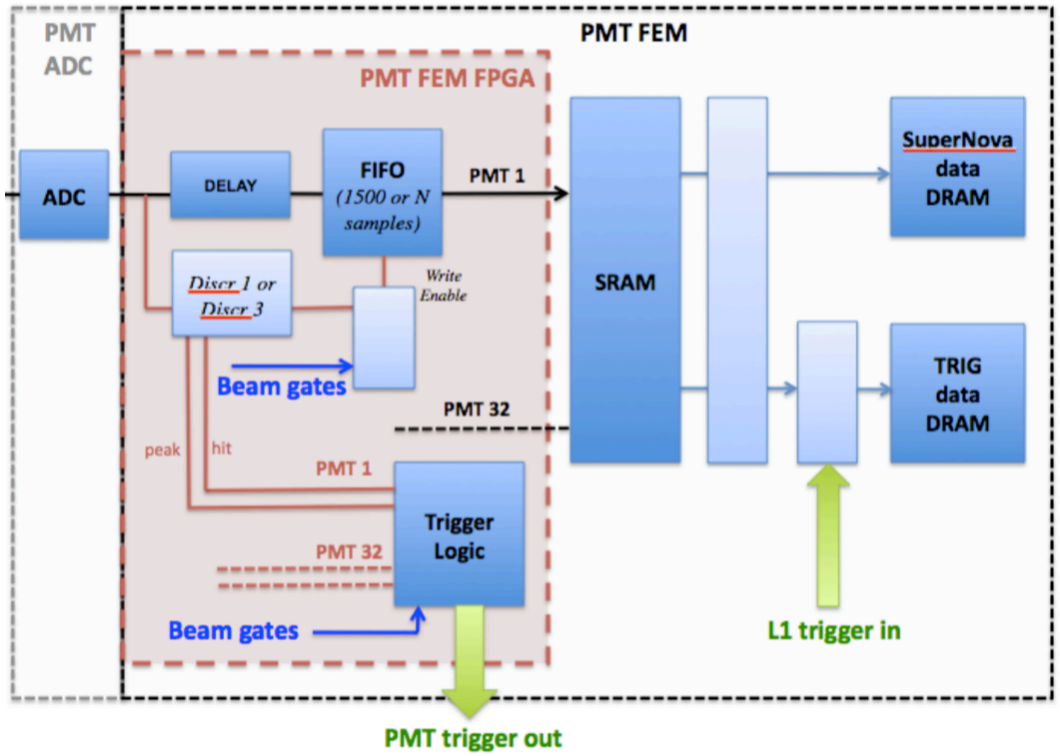
- 64MHz (16ns) digitization.
- Unipolar shaper
  - 60ns shaped peaking time
  - 2-3 digitized samples on rising edge
  - Allows for accurate event start time determination.
- Responsible for generating PMT triggers.



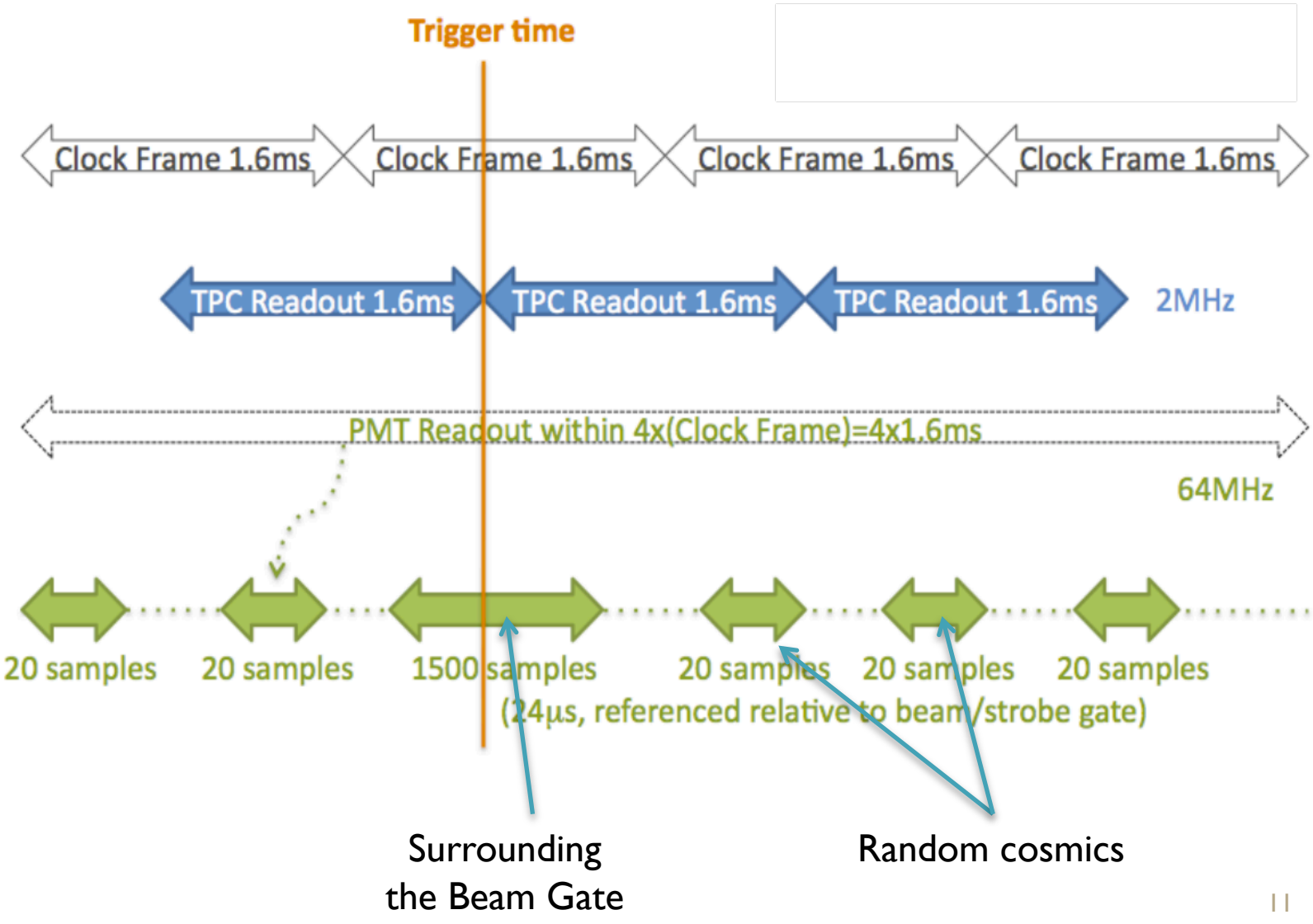
Shaped 25mV 25ns negative square pulse (differentially driven)

Triggering with PMTs

- Several threshold/discriminator/timing conditions implemented in FPGA on PMT Front End Module.
  - Include pulse amplitude on single PMTs, summed coincidences on multiple PMTs, delayed coincidences (Michel electrons).
- Trigger Board inputs:
  - PMT FEMs
  - Beam gates
  - Calibration inputs
- Trigger Board fans out to all TPC crates, and to its own (PMT) crate.



TPC + PMT Readout Data for an Event



Supernova Stream

- Two readout paths: trigger (events) and supernova.
- Continuous readout with temporary data storage awaiting a SNEWS alert.
  - Stores on the order of ~a few hours.
- 30 GB/s data volume
- Additional "dynamic decimation" used for supernova stream
  - Not lossless. Data reduction ~x(1/16)
  - Combined with Huffman to reach required 80x data size reduction.

Conclusion

- MicroBooNE electronics: TPC + PMT
  - Combined cold + warm components
- PMT system produces trigger signals for entire readout and DAQ system.
- Readout functions both in trigger and continuous supernova stream.
- All warm electronics readout channels tested and characterized.
- First crate at Fermilab to be used for cold electronics installation tests.
- Data taking starts beginning of 2014!

THE END

Backup Slides