LARIAT DAQ Overview

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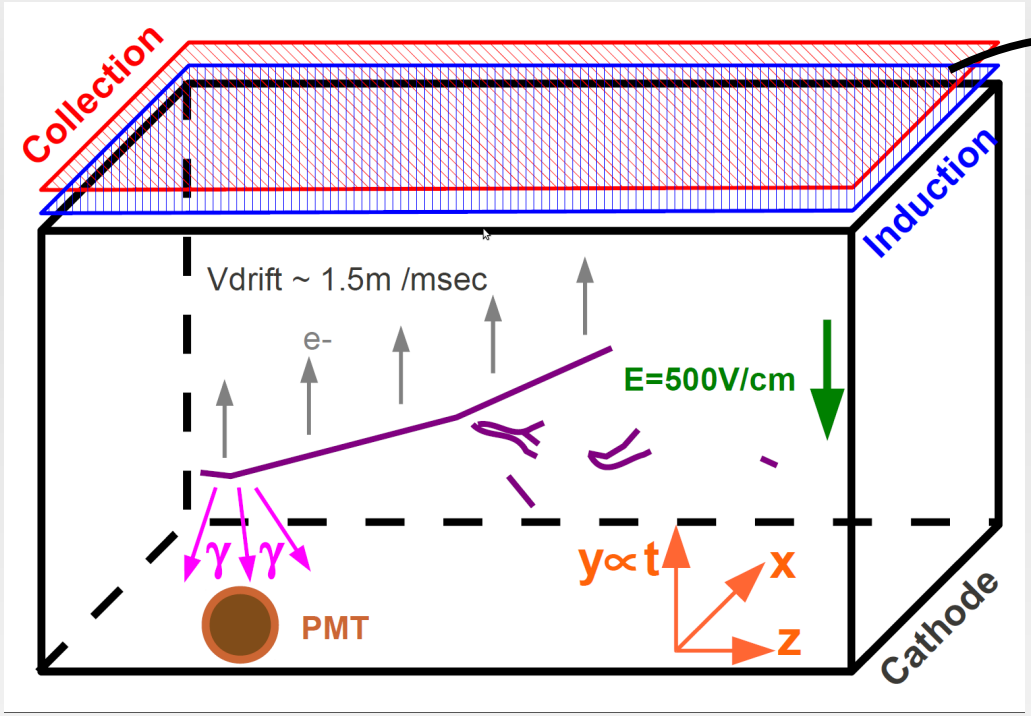
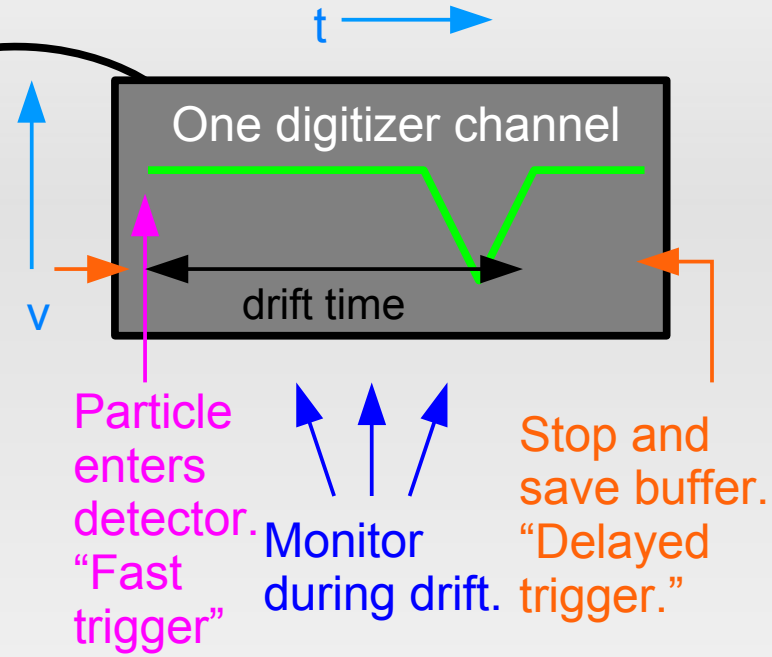
Basic situation





- Digitzers @ ~4MHz readout to circular buffer
- Cannot buffer whole 4s spill (10's of Mb/chan)
- Readout always "triggered". Must decide when to stop
- Need to monitor pileup during drift time.

Detectors and readout

Detector	Channels	Readout System	Comments
TPC Wires	480	8x CAEN V1740 64 chan digitizers @ 256ns/sample	
TPC Light	2 PMTs 2 SiPMs	CAEN V1751 8 chan @ 1 ns/sample	
TOF Signal	4PMTs?	CAEN V1751	for offline TOF attempt?? or V1740
TOF time	2?	Phillips 7186 CAMAC or Jin Yuan VME @ 25ps LSB or CAEN VME @ 35ps LSB	discussion below 3 counters would be nice
Cosmic Ray paddles	?	optional: none, analog to V1740, digital to V1740	
Veto paddles	?	as above	
CER	1	analog to V1740 or V1751	I claim we want to read this out
Beam wire chambers	4x128	From Sten Hansen (14th floor) customized, network readout	Digital to V1740 too? Sum of nhits avail?

The Trigger module - V1495

- Acts as a scalar and a logic unit
- Takes in ECL logic signals, e.g., from beam counters.
- Looks for good patterns → Fast trigger issued
- After good pattern, monitors for veto patterns or pileup.
- If all is OK, sends a delayed trigger to the V1740s.
- Various parameters, good and bad patterns, etc., programmable via VME
- Is read out over the VME bus.

Trigger information

- What sort of trigger was it?
- V1495 knows this info
  - Enumerates trigger types (1, 2, 3, 4...)
  - Saves type + clock time to a FIFO for readout after the spill → Working on this
  - Can fan out 16 bits to the V1740 & V1751 which are recorded in the event header
  - Proposal: 4 bits for trigger type, 12 for trigger number. → In testing @ W&M

V1740 vs V1751

- The V1751 cannot buffer a whole drift time so we have to trigger it independently.
  - I suggest using the fast trigger from the V1495.
  - There will be cases when we want to veto the V1740 readout but we'll have already read out the V1751.
  - This is, arguably, a useful feature.
  - Possible danger: V1751 fills up after ~1800 events. But, could try to readout to computer during spill. That's too high a rate anyway....
- If we don't want to do PSD then we could stretch and amplify the TPC PMT signals and stick them into a V1740 → Or do in addition

Synchronization

- We need to make sure that data from the different V1740 modules, the V1751, the wire chambers, time of flight, and the V1495 can be matched up.
- Not entirely settled situation
- Plan : **Match records using onboard clock** which is recorded in the digitizer headers. 1495 also has a clock.
- Reset V1740,1751, and 1495 prior to spill and then free run
- The V1740s will also be cross-synced via daisy chain → *needs skeptical testing*

How do we know when the beam is on?

- Start spill and end spill signals from the accelerator complex. Used to enable a spill gate.
  - Spill triggers will require the spill gate bit to be set.
- End of spill gate, want to read out. How?
  - Idea: have V1495 see end of spill and raise an interrupt on VME bus → D'oh, no can do!
  - I have a way to mock this up using the crate controller.

Interrupt via crate controller

- Controller has on-board pulsers.
- End of spill signal starts an pulser with very wide pulses (26 sec)
- Pulser status written to a register on the controller.
- Computer can poll that register via PCIe.
  - i.e., poll once per ms
- When it goes high, we do whatever readout activities we need, then reset it.

What about cosmic triggers?

- Similar to beam triggers, except the beam points down!
- Use end of beam spill signal to start a cosmic readout gate.
- Triggers require cosmic readout bit set.
- Make sure gate is short enough not to run into the next beam spill.
  - Is there an accelerator signal that reliably preceeds the beam spill by 0.1-1sec or so?

Time of Flight

- Not settled.
- A Phillips Scientific CAMAC module with 25ps time resolution is available.
  - PS 7186 – $3k. Only have one. No spare!
- MINERvA used this module. Code to read it out has been found.
  - Stores a single event.
- Plan A: we reuse the readout program and readout TOF as an independent system *a la* MINERvA.

Time of Flight

- Plan B: We take the library for the Phillips module and integrate its CAMAC readout into our DAQ
  - perhaps this is plan F
- Plan C: VME module from Jin Yuan.
  - Tech specs are good. Very new, first users.
  - Not ready now, some assembly required.
- Plan D: CAEN V775 35ps module from W&M.
  - 35 event buffer

A TOF worry

- Generally you'd record TOF information for every triggered event.
- This is necessary for the Phillips and CAEN TDCs.
  - do not record any sort of clock reading in their header.
  - Need to synchronize based on trigger number
- Our trigger decision comes long after the TDC has done its work.
- Why is this a problem?

A TOF worry

- Standalone Phillips system:
  - coincidence of paddles issues COMMON start
  - delayed paddle signals form STOPs
  - Time → Amplitude conversion and digitization
  - Board is BUSY. Issues Look-At-Me (LAM)
  - Oblivious computer reads board out.
  - Board ready for more data.
- This generally will repeat during the drift time. We will have a problem matching TOF and TPC data.

TOF: Possible solution #1

- Integrated Phillips system:
  - coincidence of paddles issues COMMON start
  - delayed paddle signals form STOPs
  - Time → Amplitude conversion and digitization
  - Board is BUSY. Issues Look-At-Me (LAM)
  - Smart computer waits till we know if we have a good delayed trigger. Reads out or clears board.
- Not sure how to let the computer know when to readout. Later discussion.

TOF: Possible solution #2

- The V1495 keeps a record:
  - Every fast trigger used to start TDC acquisition cycle.
  - The V1495 keeps a list of the times of these triggers. Used to matchup offline.
- TDC BUSY will need to be fed into the V1495
  - Generally true no matter what we do.
  - Good patterns will require !BUSY

TOF: Possible solution #3

- The V1751 solves things:
  - Every fast trigger sent to the V1751 and the TDC.
  - The V1751 records a clock count in its header.
  - Match the TOF to the V1751 by event number.
  - Then match to the V1740 by time.
- Seems straightforward.

TOF: Possible solution #4

- Does Jin Yuan's TDC record a clock count in the event header?
  - Not currently, but it could.
- If so, we can use that to do the matching.
- How many events can Jin's TDC store?
  - 1024 hits total across all channels

Final Note

- We had generally been thinking about buffering all the data and reading out at the end of the spill.
- Probably have to read the TOF TDC out during the spill.
- Might be sensible to read the V1751 that way too.
- CAEN says, even with the custom firmware, the V1740s can be readout while they are taking data.

Backups and extras

Data → computer?

- V1740 & V1751: PCIe optical link with daisy chaining. Direct to computer.
- V1495: VME bus to crate controller then PCIe to computer
- Wire chambers: Network readout
- TOF: Depends. CAMAC or VME.

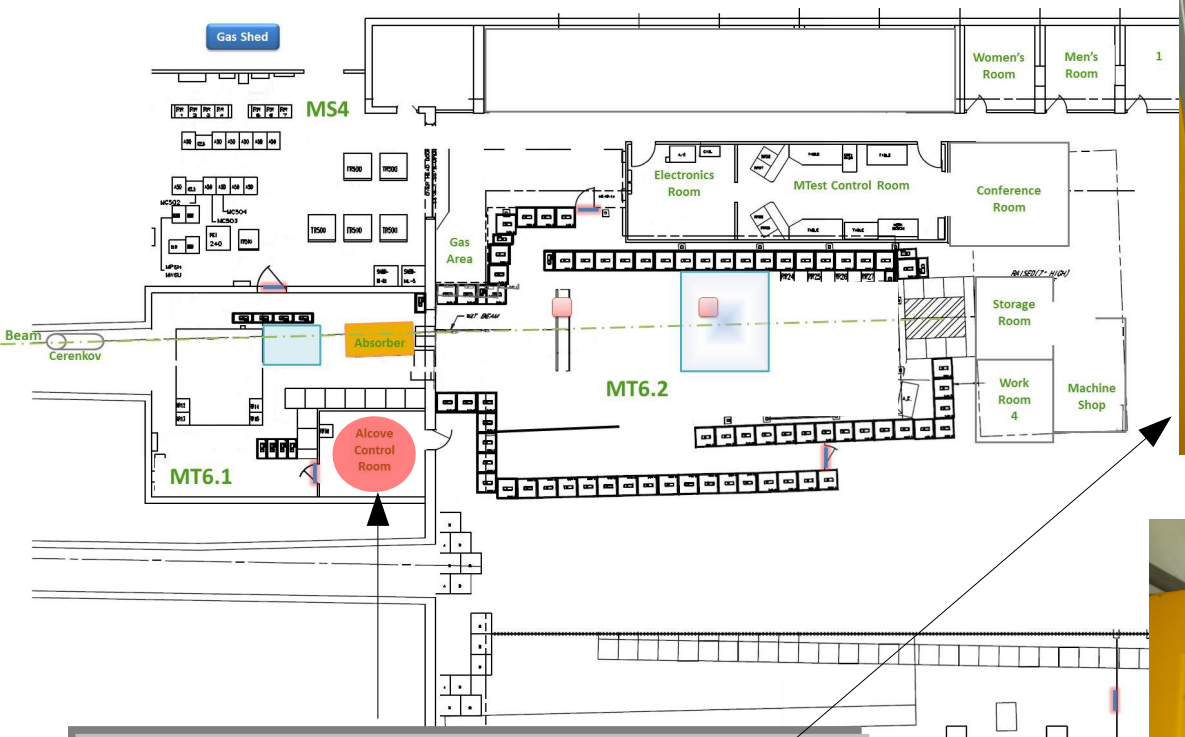
What if I wanna?

- Insert hits into the datastream from beamline counters?
  - Discriminate analog signal and pipe ~1μs logic pulse into an unused 1740 channel.
  - Only see these for events we trigger on.
- What if I wanna know the pulseheight of those hits?
  - Need to stretch/shape/amplify the analog signal. Then input to the V1740.
- What if I really want to record fast signals from the beamline counters?
  - Use a channel on the V1751.

Cast of Characters

- TPC readout CAEN V1740 64 channel digitizers working at 62.5MHz / 2^n
  - we can pick n. n=16 gives 256ns/sample
- TPC PMT readout CAEN V1751 4/8 channel digitizer working at 2/1 GHz
  - cannot digitize whole drift → stop & save independently with fast trigger
- Scalar/Trigger Logic CAEN V1495 FPGA, 50MHz bandwidth
- Wire Chambers FNAL 14th floor / FTBF
  - Independent readout, matchup after spill.

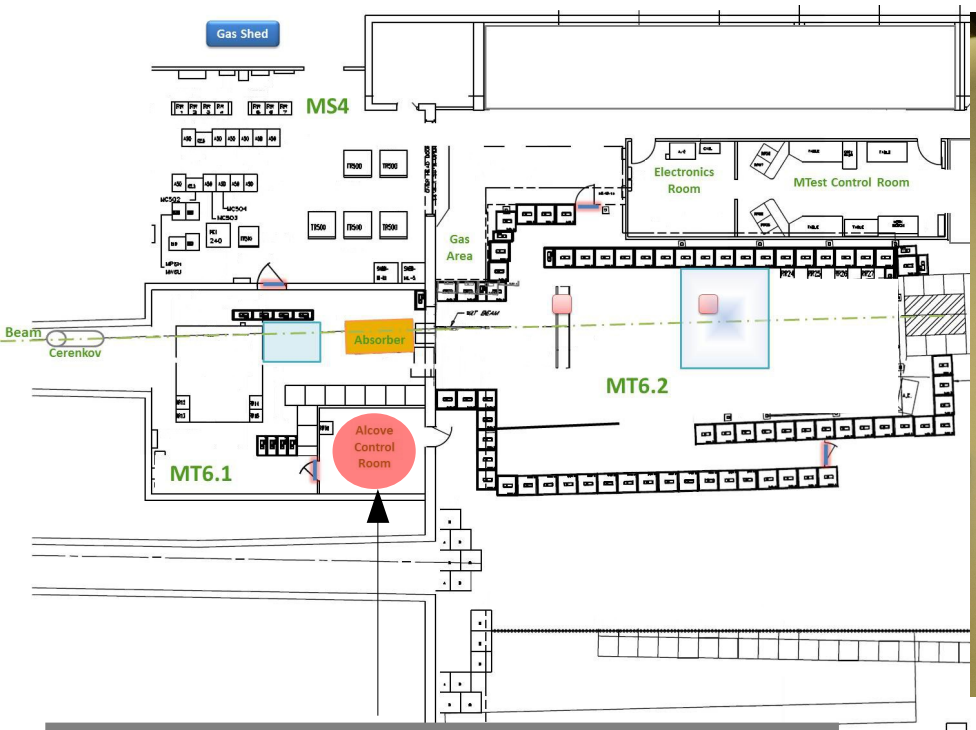
DAQ development

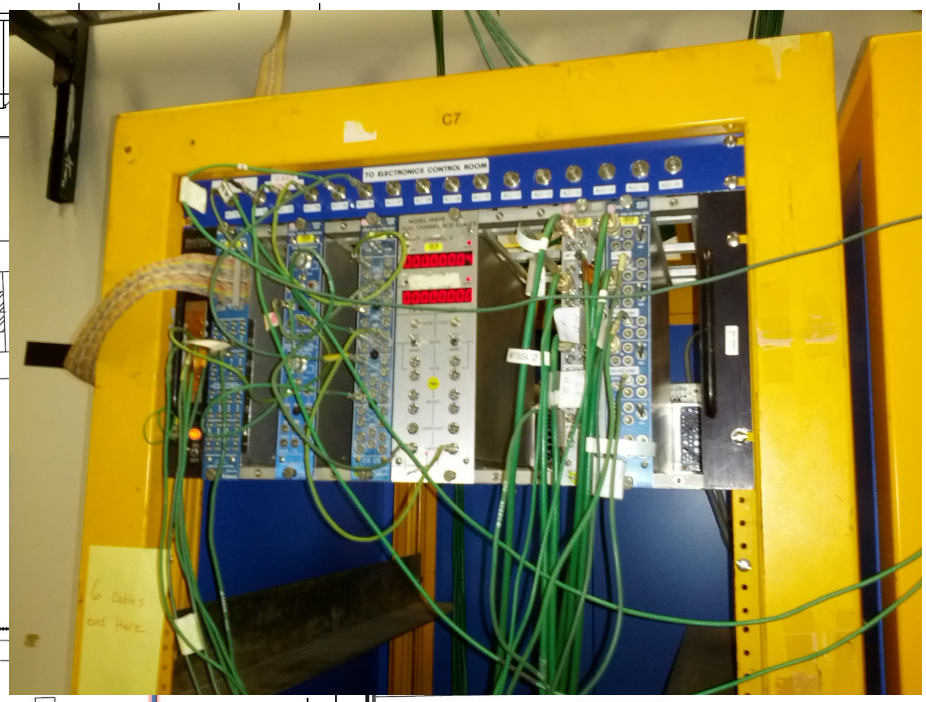


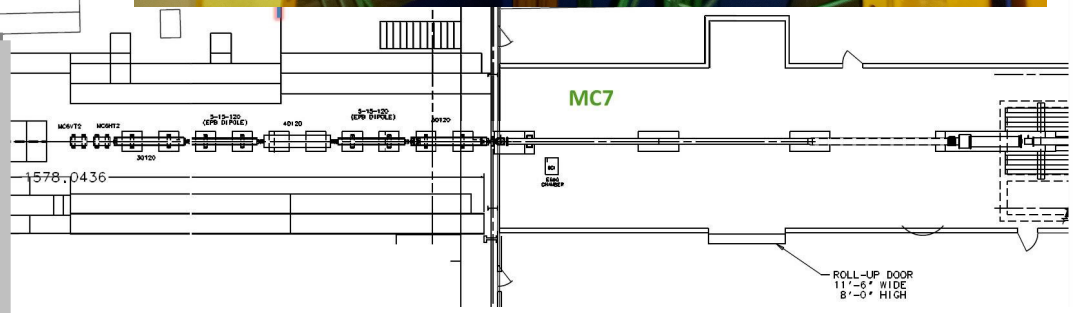
Alcove Control Room
2 VME crates
(1) V1740 + adaptor card
(2) V1495, V2718 controller
Each served by it's own DAQ computer with PCIe optical link

Exactly like W&M setup.
Thank you 14th floor!!

DAQ development







Discrimnated counter outputs available for development!

* beamline SCI and CER counters
* spill start/stop
* Wire chambers