Online Monitoring of L1CT in Run IIa

bonus: experience from Run I

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L1 Cal Monitoring

"Monitoring" can mean many things

→ Anything related to observation of system's operation

Different phases and different customers

- Commissioning/debugging
  - a ton of work (probably more for Run IIa than Run I)
  - will all have to be redone for Run IIb
- Check for run-readiness between stores
- Shifters Support
  - watch for hot towers, non-uniformity, etc
- Instantaneous view of operation (programming, rates)
- Online Hardware Verifier
- Different time scales: hours, weeks, months

Run IIa Monitoring Tools

1) Bob Kehoe's examine/offline analysis
   - Analyze Events
     - Physics runs or No Beam runs
     - Look at noise in towers
     - Compare to Precision Readout
   - Detect problems:
     - Wiring, electronics, noisy channels, timing, etc.
     - Problems are found in L1 hardware *AND* in BLS hardware
   - Understand/improve
     - energy scale, resolution, etc.
     - Generate new L1CT gain constants
   - Generate Plots for Shifters

Run IIa Monitoring Tools

2a) L1 TCC serving monitoring information

- Collects a fresh block of information every ~5 sec.
  - From a triggered crossing, if possible
  - EM and HD Et for 8 consecutive crossings
  - …and for all Trigger Towers.

2b) Simple display program

- ASCII dump of the data in each time slice
  - or a coarse average of the 8 slices
  - or a coarse standard deviation
- use colors to highlight ranges of values
- cf. "L1 Cal Trig Trigger Tower ADC Monitor:" in trics_support_programs.txt in www.pa.msu.edu/hep/d0/ftp/tcc/trics_ii/

Run IIa Monitoring Tools

2) L1TCC monitoring information (cont.)

- This is how we currently get quick system appraisal after L1 or BLS hardware changes
  - check all pedestals adjusted to 8 counts
  - no obviously bad channels, etc
  - $\rightarrow$ system is (probably) ready for data taking

- L1CT sill missing its "CTRO" cards
  - For L3 (and L2) readout and monitoring of final quantities
  - Energy and Momentum Sums and Reference Set Counts carried over whole TT coverage.
  - And-Or Terms sent to the L1FW.

Run IIa Monitoring Tools

3) “Find_DAC”

Because L1CT adds constant voltage to each channel

- Using “Pedestal DAC” programmable by TCC
- To compensate for each trigger tower individual analog offset.
- To allow processing of “negative energies”
- Find_DAC tunes the Pedestal DAC to produce uniform 8 counts of digitized energy for analog input of zero GeV for all EM and HD Towers.
- This happens before the memory lookup for correction, low energy cut, Px/Py Scaling.

Run IIa Monitoring Tools

3) “Find_DAC” (continued)

- Runs on TCC independently of the DAQ system
- Scan through specified Trigger Towers
- Start with “sanity check” of front-end
- Uses fast VME access to build set of histograms
- Produces ASCII file later used to initialize system
- Also report amount of noise in each tower
- Companion tools to compare separate result files
- Helpful during commissioning to find problems
- Helpful during maintenance phase as diagnostics between stores

Run I Monitoring Tools

Two types

A) Low Level:

- test the electronics by itself,
- prove that the system is operating as designed,
- independently of any beam physics.
- Independently of DAQ

B) High Level:

- look at the collected physics and special run data
- try and prove that it is all consistent with itself,
  - has the right symmetries,
  - the right distributions,
  - the right physics, etc.

Run I Monitoring Tools
Low Level Tests (BEFORE beam)

1) L1CT system Test/Exerciser/Diagnostics
   - Run on TCC between stores
   - WITHOUT interfering with rest of DAQ system
   - Randomly modify the simulated trigger tower energies AND randomly modifies the L1CT programmable COOR resources
   - Built-in hardware assistance to change system's inputs for one single crossing and capture result of THAT Crossing in monitoring registers
   - Test loop: Compromise between changing more conditions and processing more crossings
   - Configurable in TT coverage, what gets checked

Run I Monitoring Tools
Low Level Tests (BEFORE beam)

1) L1CT System Tester/Exerciser (continued)
   - Crucial points to design such tests:
     - Maximize amount of electronics switching at once
     - Hardware runs at full speed
     - Capture response at first chance to process THIS information (as opposed to DC response as TCC gets around to reading thousands of registers).
     - Needs hardware assistance built into the system
   - Capturing multiple time slices is even better
     - Monitoring data captures the switch to different inputs for one single crossing and go back to the background conditions

Run I Monitoring Tools
Low Level Tests (BEFORE beam)

2) Pulser runs for precision calibration of Cal
   - Dan Owen wrote test program and led the L1CT commissioning effort for Run I.
   - The pulser injects charge at pre-amp of Cal Front-End
     - We see pulser patterns in the L1 CT data.
     - Set the pulser to mid-scale on a few channels at a time
     - Go through a list of pulser patterns
   - Use mapping of calorimeter cells into trigger towers
     - Predict where and about how much energy L1CT should see
     - Find noisy channels, dead channels, mis-wiring, cross-talk, channels were half the differential signal was missing

     1) Cannot calculate exactly how much energy the L1CT should measure (Qualitative, not Quantitative) but LEARN how much we get then be alerted by departure from nominal.

Run I Monitoring Tools
Low Level Tests (BEFORE beam)

3) Find_DAC
   - cf. Description for Run IIa
   - Compare successive runs:
     - e.g. slow drift = detect problems with L1CT analog front-end capacitors slowly going bad, and replaced them before they completely failed.

Run I Monitoring Tools
Low Level Tests (BEFORE beam)

Usage:

- Between stores, especially after we had worked on L1CT, or after BLS cards were fixed or replaced
  - Run a number of loops of the L1CT Exerciser,
  - take a special L1CT pulser run and analyze data.
- Know right then we are ready for physics
- First line of defense BEFORE next store, and before any physics runs.

Run I Monitoring Tools

High Level Tests (after-the-fact tests)

1) Analysis of L1CT readout data
   - Kathy Streets led this effort
   - calculate energy scale, saturation, resolution
   - studied and watched L1CT on scale of weeks.
   - Understood and improved L1CT energy scale over the course of Run I and replaced all 1280 hand made precision resistor networks
     - (note: energy gain is now programmable).

Run I Monitoring Tools

High Level Tests (after-the-fact tests)

2) Calorimeter Examine

- Jan and Joan Guida were also routinely building L1CT histograms to track the L1CT output as part of their watch of Cal electronics
- alert us when pedestals would drift
- or when we had noisy or dead towers
- Jan and Joan kept watching the system on the scale of months/years.

Run I Monitoring Tools

High Level Tests (after-the-fact tests)

3) L1CT verifier

- Amber and Jill Perkins put together a L1CT Verifier running on Examine
  - An extension of L1SIM (L1FW+L1CT simulator)
  - Compare the computations made by the hardware L1CT to the results from the software simulator.
  - run this program on a subset of the most recent data.
- e.g. alerted us of intermittent Missing Pt problem and we found a cable that had worked itself loose

Run I Monitoring Tools

High Level Tests (after-the-fact tests)

3) L1CT verifier (continued)

- Verifier was an important bit-level check of BOTH the simulator and the L1FW+L1CT hardware, mutually against each other
- also confirmation of validity of trigger and MC studies based on L1SIM.