Hall A Moller Polarimeter DAQ Upgrade

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Overview

• What do we gain from the DAQ upgrade?
• What does the DAQ upgrade involve?
  – Hardware description
  – Capabilities
  – Trigger definitions
• What is the present status of the upgrade?
  – Some plots of production data with extracted asymmetries
  – Todo list...
Why do we want the DAQ upgrade?

- Help improve the systematic error from 2% → 1%
  - FADC data grants full information about detector systematics/performance
  - Negligible DAQ deadtime (pipelined design)
  - Intrinsic HW deadtime (ie. pile-up) can be trivially identified/measured using sample data

- Replace old/obsolete DAQ hardware
  - existing DAQ is 12 years old, no spares, rate limited
  - FADC design is fast & flexible

- Accommodate the new segmented aperture detector
  - 8 paddles (4 per arm) instead of 2
  - present aperture paddles overload at > 1uA
What is involved in the DAQ Upgrade?

• System built around a JLab F250 Flash ADC
  – 16 analog inputs (8 calo. blocks, 8 scint. paddles)
  – 4 ns sample time, 12 bits/sample resolution
  – FPGA device → flexibility of software with the speed and response time of hardware

• Custom FADC firmware
  – FADC generates our triggers, no signal splitters, discriminators, or summing modules needed
  – Thresholds, sample windows, trigger prescales all software controlled
  – Fairly straight forward to add new features to the firmware (turn around on the order of a week)
What is involved in the DAQ Upgrade?

- Also some auxiliary support modules (read out during every MPS interval)
  - CAEN v560 scaler (16 channels)
    - BCM, Moller target position, 100 kHz clock
    - (plus redundant counters for cross checks)
  - CAEN v792 QDC (16 channels)
    - MPS, QRT, HEL flags
    - (plus redundant data for cross checks)
  - Easy to add/read other modules if needed
What is involved in the DAQ Upgrade?

- New dedicated DAQ computer: *hamoller.jlab.org*
  - fast, modern machine: 4 CPU cores, 2TB of RAID10 storage for local data and scratch
  - shares adaqfs file system, usual accounts
  - goal is to support zero-deadtime streaming data from DAQ at full 160kHz coincidence rate (no prescaling) → sustained ~50 MB/sec

- ROOT-based analyzer using PODD (Hall A analyzer framework)
  - new decoding routines added to handle FADC
  - still a work in progress, but quite functional
Photo of old DAQ electronics
Photo of new DAQ rack
FADC internal trigger criteria:

\[ \text{CR} = \sum_{i=1}^{4} \sum_{j=1}^{2} P_{j_i} > \text{threshold} \]

\[ \text{CL} = \sum_{i=1}^{4} \sum_{j=1}^{2} P_{j_i} > \text{threshold} \]

\[ \text{SL} = (\sum_{j=1}^{2} S_{1j} > \text{thr}) \text{ or } (\sum_{j=1,2} S_{2j} > \text{thr}) \text{ or } (\sum_{j=1,2} S_{3j} > \text{thr}) \]

\[ \text{SR} = (\sum_{j=1}^{2} S_{5j} > \text{thr}) \text{ or } (\sum_{j=1,2} S_{6j} > \text{thr}) \text{ or } (\sum_{j=1,2} S_{7j} > \text{thr}) \]

'DATA' Trigger (OR of 'internal' trigger cond.):

- CL.AND.CR prescaled from 1 to 2000
- CL prescaled from 1 to 2000
- CR prescaled from 1 to 2000

Information recorded:

- digitized waveforms
- helicity state
- status counters, etc.

'HELCIY' Trigger (external trigger):

- MPS leading edge (30 – 2000 Hz)

Information recorded:

- Helicity, MPS, QRT states, BCM,
- Moller Target ladder position information,
- 100 kHz clock,
- status counters, etc.

- FADC 'Software' scaler data:
  - CL singles, CR singles
  - CL and CR
  - CL and SL
  - CR and SR
  - CL and CR and SL and SR
  - CL and CR and (SL and SR delayed > 100 ns)
'Data' Trigger example:  \textit{Moller} + ?

Cal. 'Left'

Cal. 'Right'
'Data' Trigger example:  *Pile-up Exhibit A*

Cal. 'Left'

Cal. 'Right'
'Data' Trigger example: Pile-up Exhibit B

Cal. 'Left'

Cal. 'Right'

Moller signal

Moller signal

Moller signal

Moller signal
Total Energy Histogram

Integrated energy for Calorimeter 'Right' Block-sum

- FADC Threshold
- Electron Signal
- FADC Pedestal
- Pile-up

Entries: 148300
Mean: 2.476e+04
RMS: 1628
Underflow: 0
Overflow: 0
Integral: 1.483e+05
Rates and Extracted Asymmetries

My CLCR Instantaneous Rate

Run 203

Using on-board Scalers in FADC

(Old DAQ got ~80 kHz) ???

~ 130 kHz

My Flash ADC Instantaneous Rate

By counting pulses in FADC, then mult. by PS factor

Asymmetry for FADC sig for CL and CR

By counting FADC pulses

(Note, PS x 50, causes spikes)

Asymmetry for FADC(x) vs Scaler(y)

Asymmetries

Old Moller DAQ A = 5.23 %
New DAQ (thin) 5.16% (Scalers)
5.13% (Counts FADC pulses)
To Do List

• Add EPICS logger to CODA data stream
  – Moller field status, BPM information, etc...

• Firmware bump w/ modified readout list will grant 50% bump in DAQ throughput ('background' DMA)

• Complete systematic hardware checks
  • Ahmed's talk (Saturday)

• Continue to enhance analysis software
  – online data display (i.e. panguin style)
  – finish porting complete analysis algorithm from old PAW analyzer to ROOT analyzer (finalize all corrections, etc.)
  • Mindy's talk (Saturday)