

Hall A Moller Polarimeter DAQ Upgrade

B. Sawatzky

**PREx Collaboration Meeting
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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% \rightarrow 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 $> 1\mu\text{A}$

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

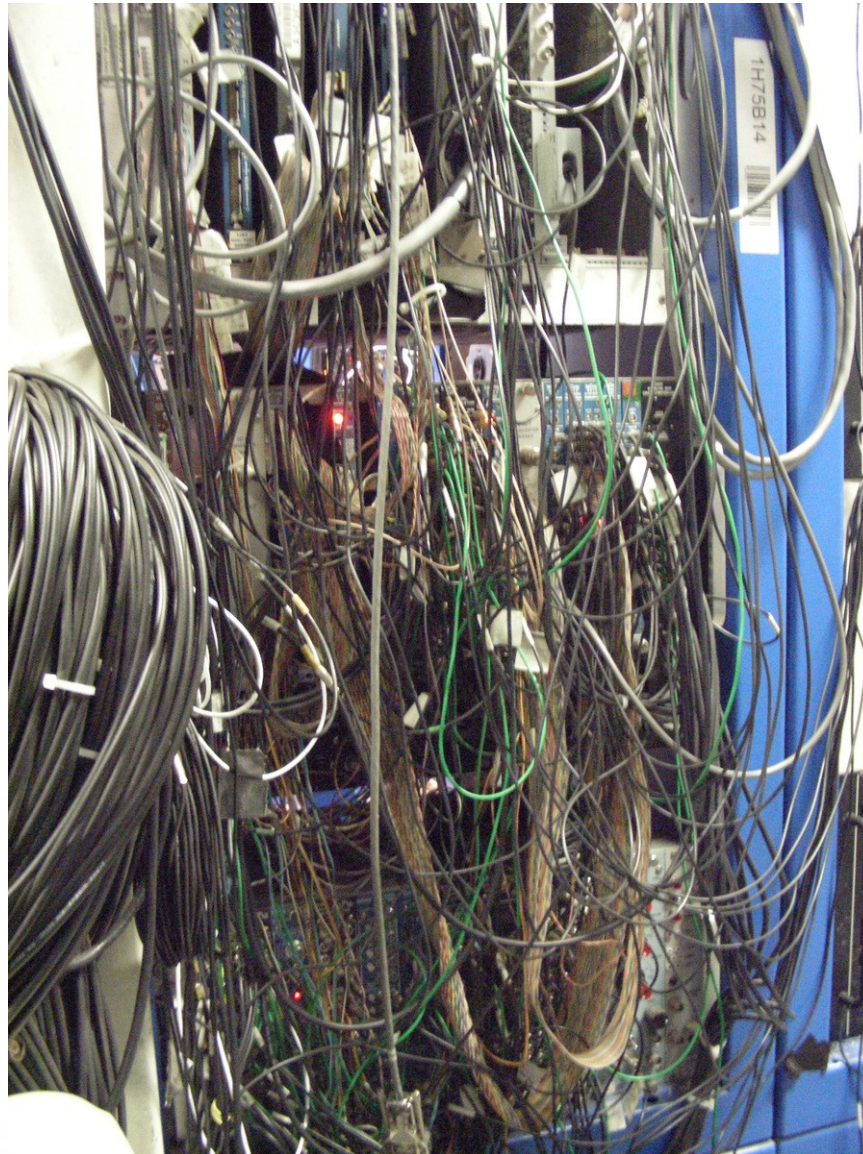
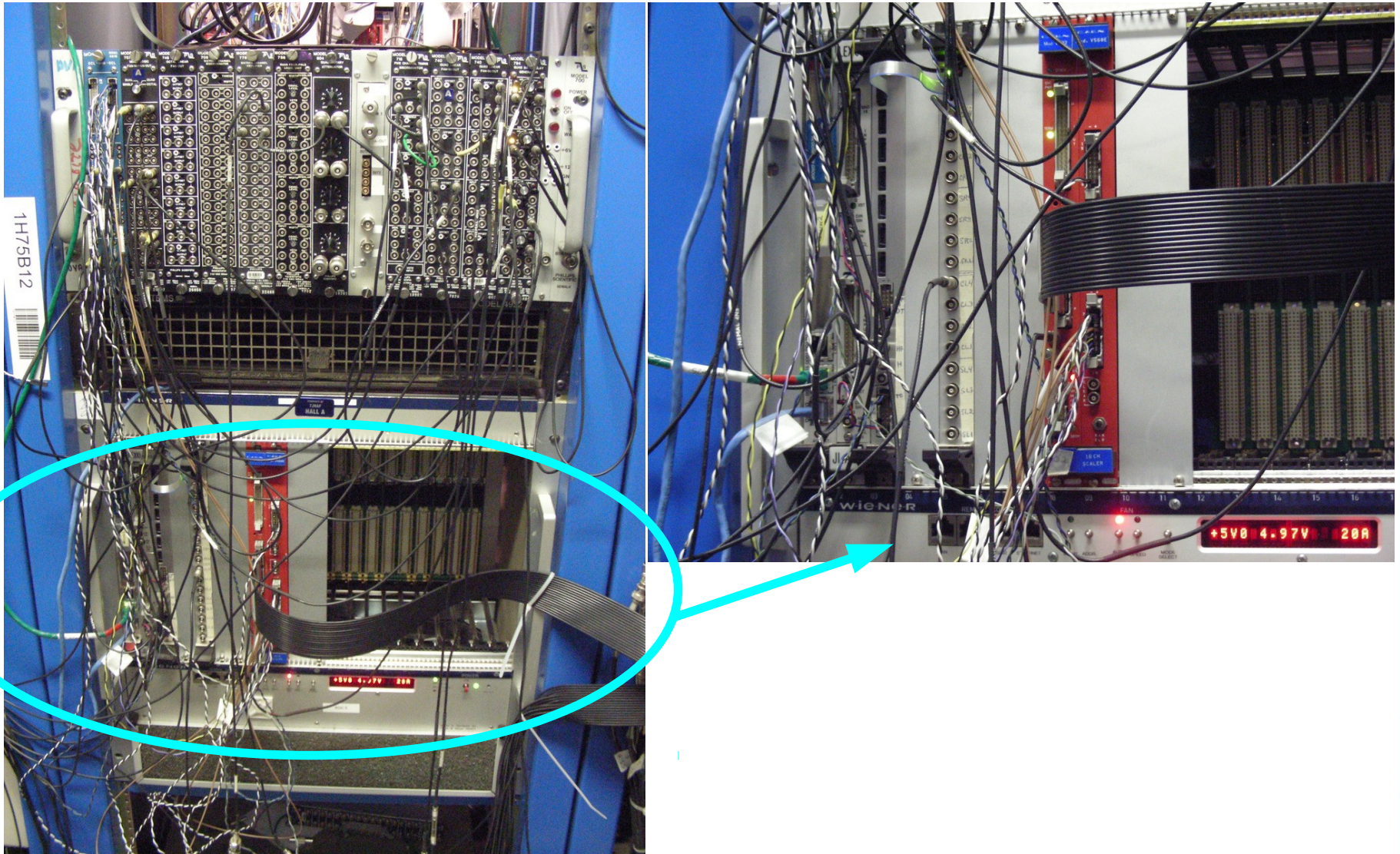


Photo of new DAQ rack



FADC internal trigger criteria:

$$CR = \sum_{i=1}^4 \sum_{j=1}^2 P_i^j > \text{threshold}$$

$$CL = \sum_{i=1}^4 \sum_{j=1}^2 P_i^j > \text{threshold}$$

$$SL = (\sum_{j=1}^2 S1^j > \text{thr}) \text{ or } (\sum_{j=1,2} S2^j > \text{thr}) \text{ or } (\sum_{j=1,2} S3^j > \text{thr}) \text{ or } (\sum_{j=1,2} S4^j > \text{thr})$$

$$SR = (\sum_{j=1}^2 S5^j > \text{thr}) \text{ or } (\sum_{j=1,2} S6^j > \text{thr}) \text{ or } (\sum_{j=1,2} S7^j > \text{thr}) \text{ or } (\sum_{j=1,2} S8^j > \text{thr})$$

'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.

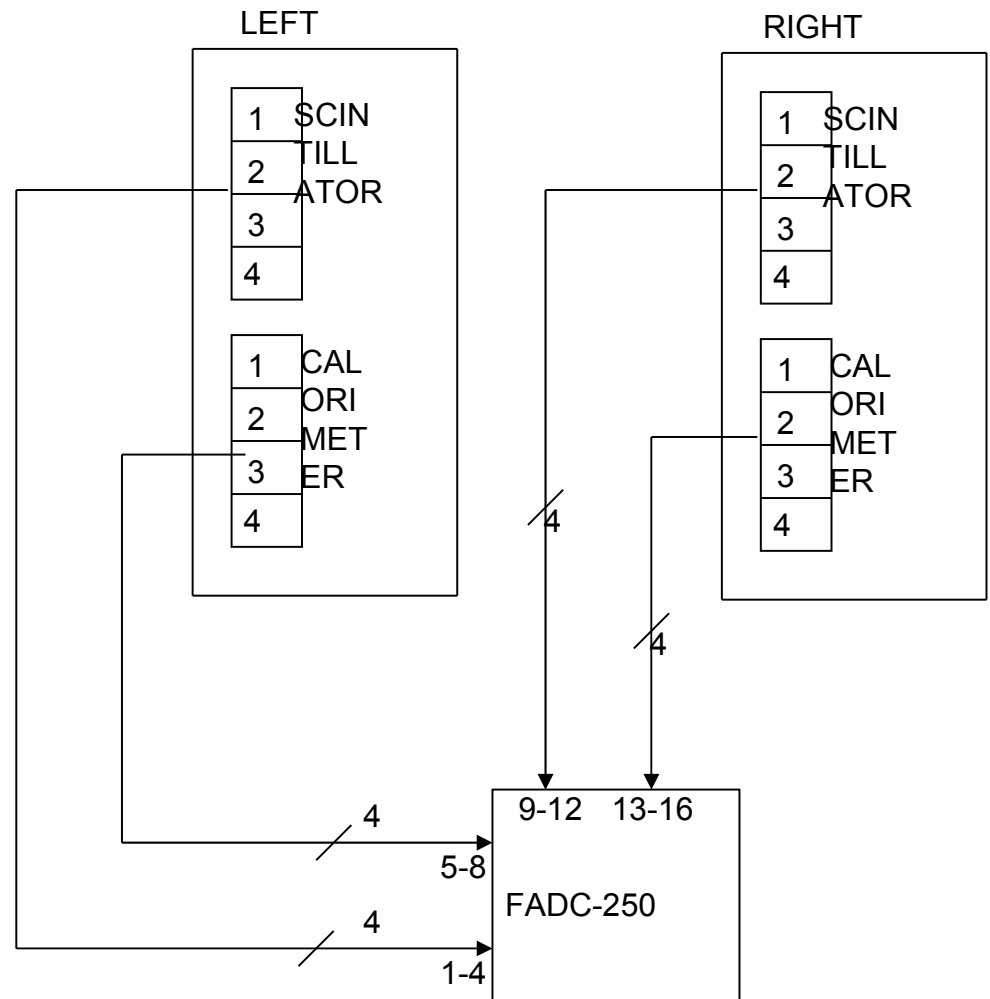
'HELICITY' Trigger (external trigger):

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)

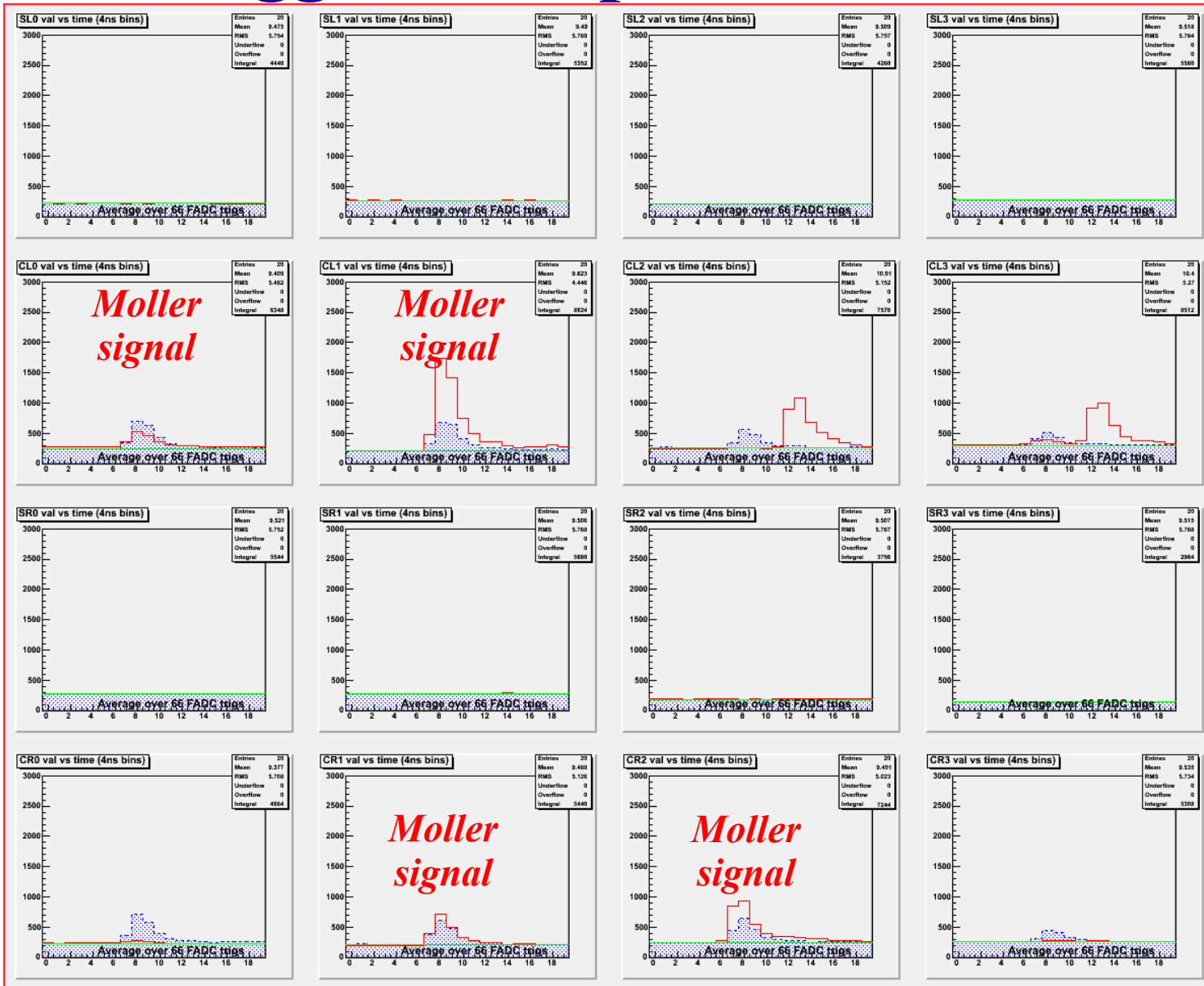
FADC Moller DAQ Trigger Types



'Data' Trigger example: *Moller* + ?

Cal. 'Left'

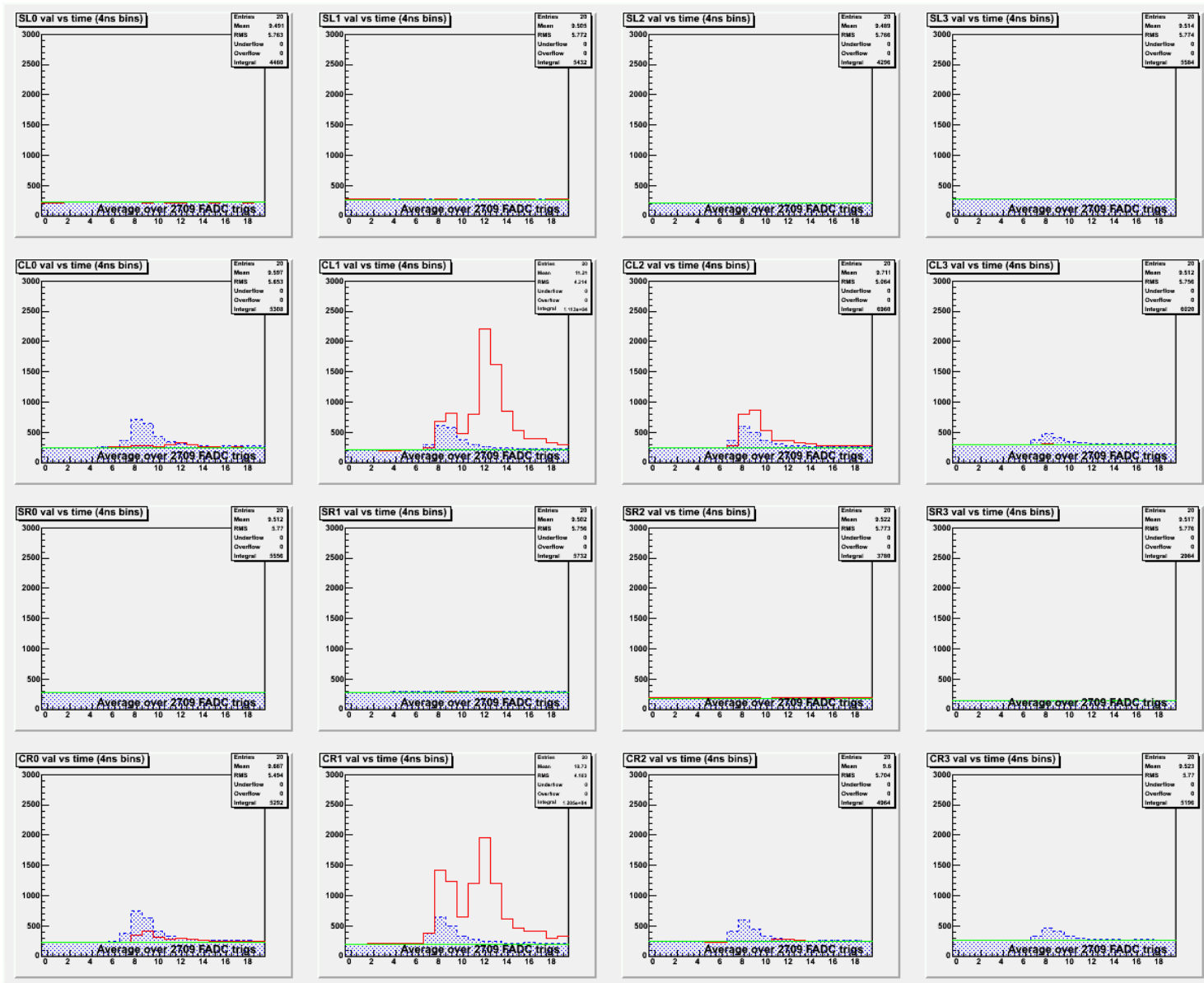
Cal. 'Right'



'Data' Trigger example: *Pile-up Exhibit A*

Cal. 'Left'

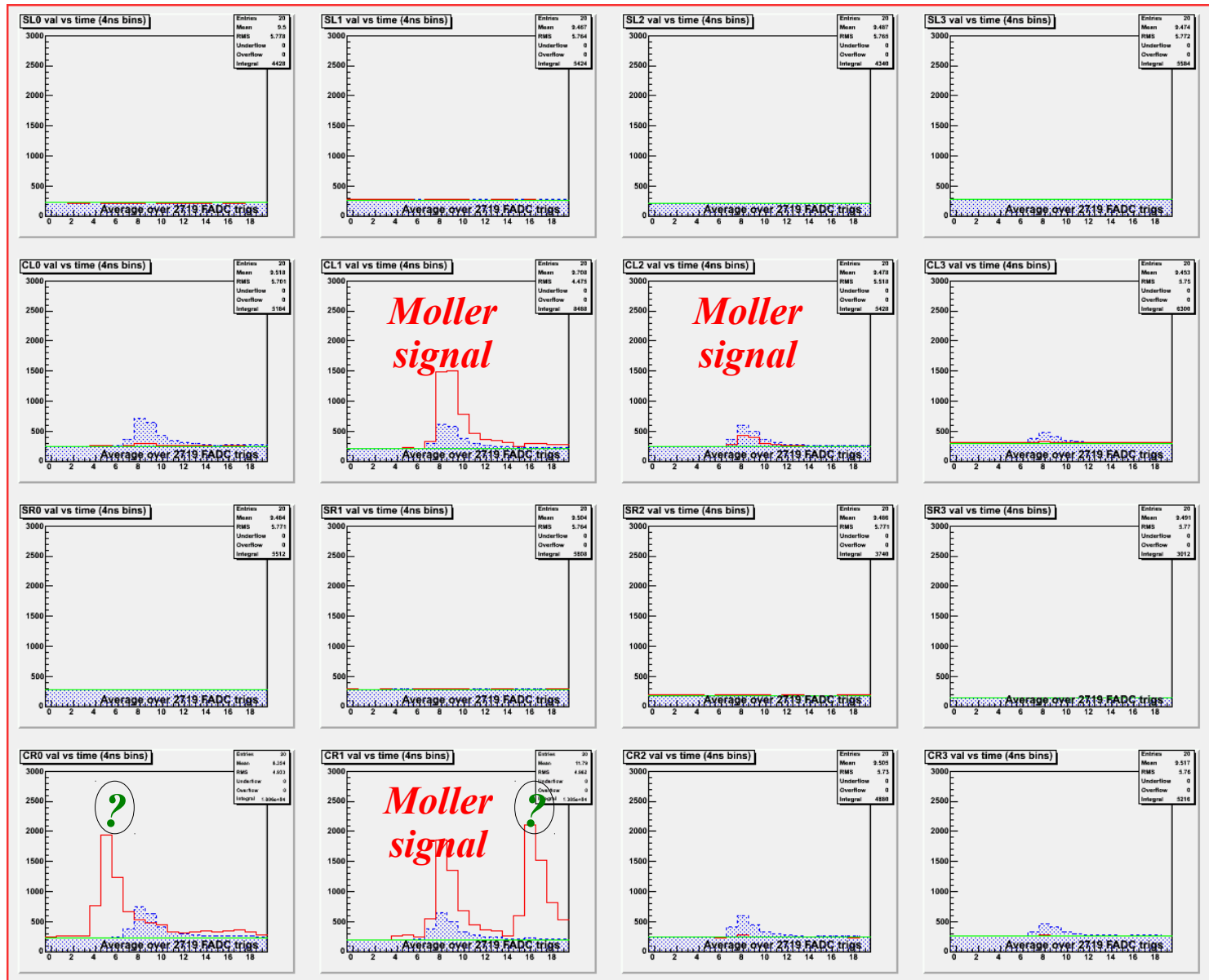
Cal. 'Right'



'Data' Trigger example: *Pile-up Exhibit B*

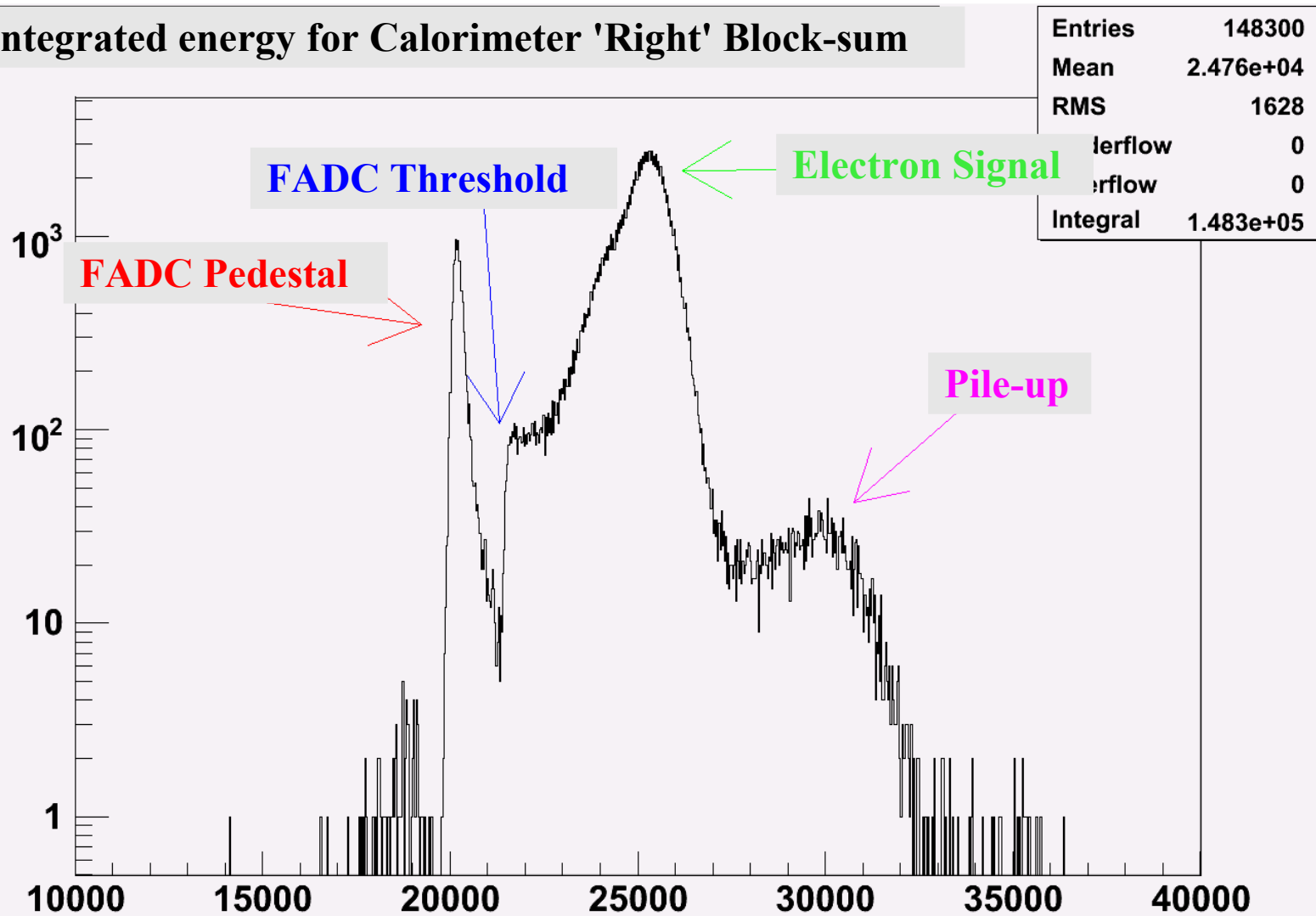
Cal. 'Left'

Cal. 'Right'

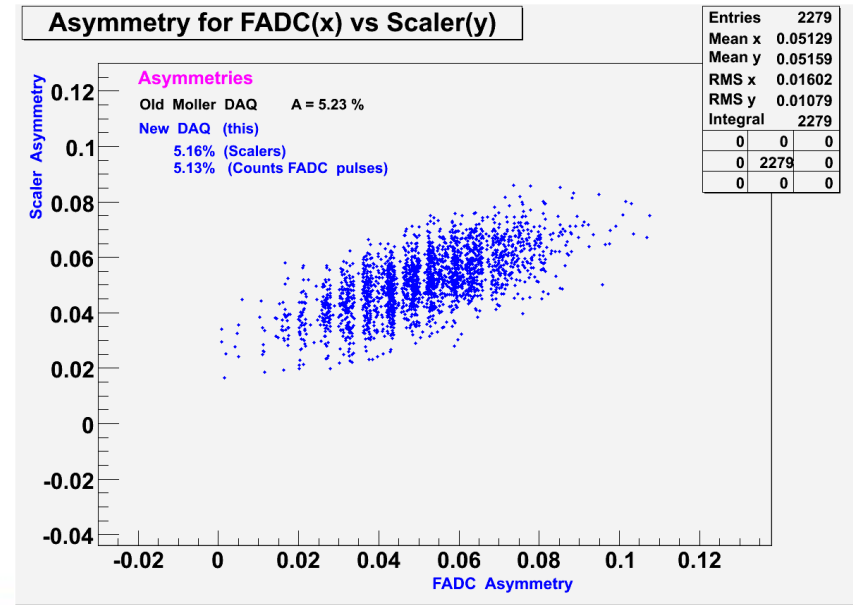
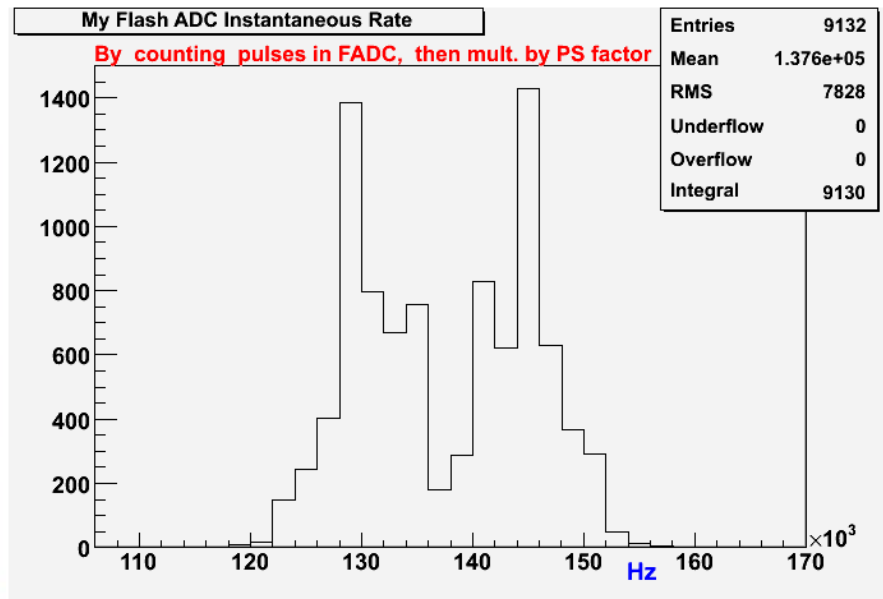
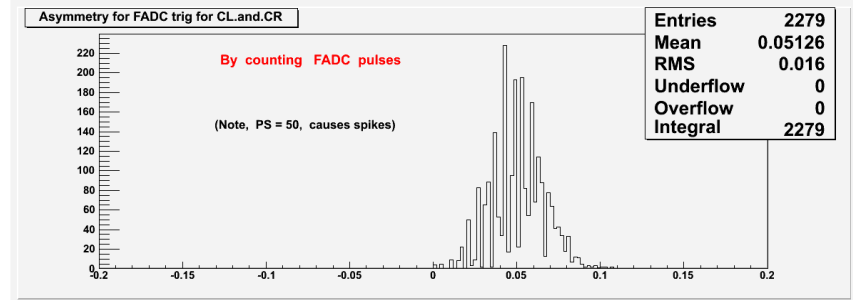
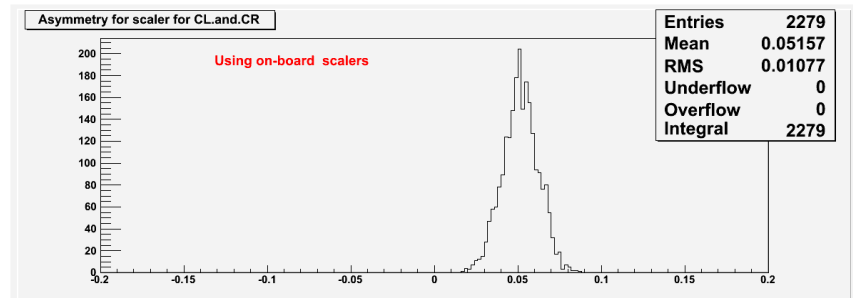
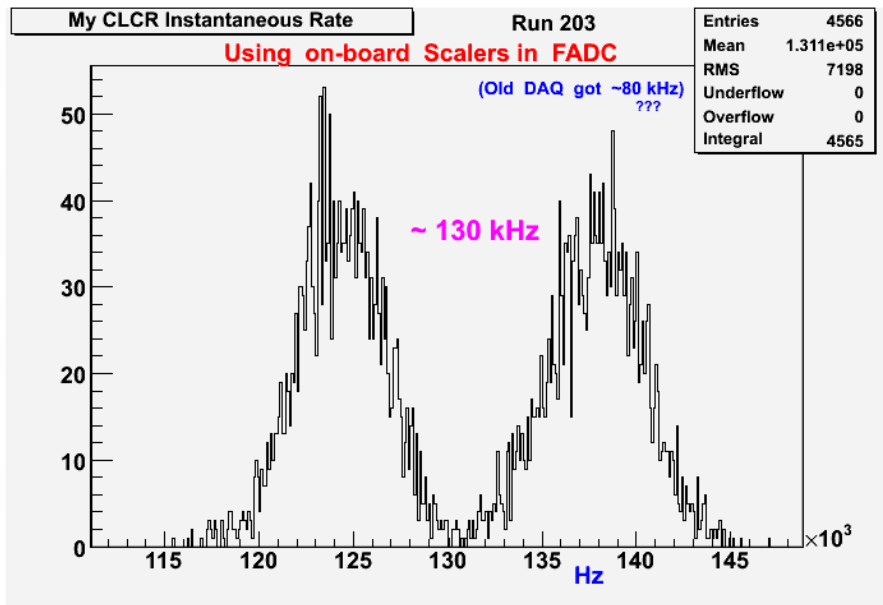


Total Energy Histogram

Integrated energy for Calorimeter 'Right' Block-sum



Rates and Extracted Asymmetries



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. penguin style)
 - finish porting complete analysis algorithm from old PAW analyzer to ROOT analyzer (finalize all corrections, etc.)
 - *Mindy's talk (Saturday)*