Status of the DOM main board simulation

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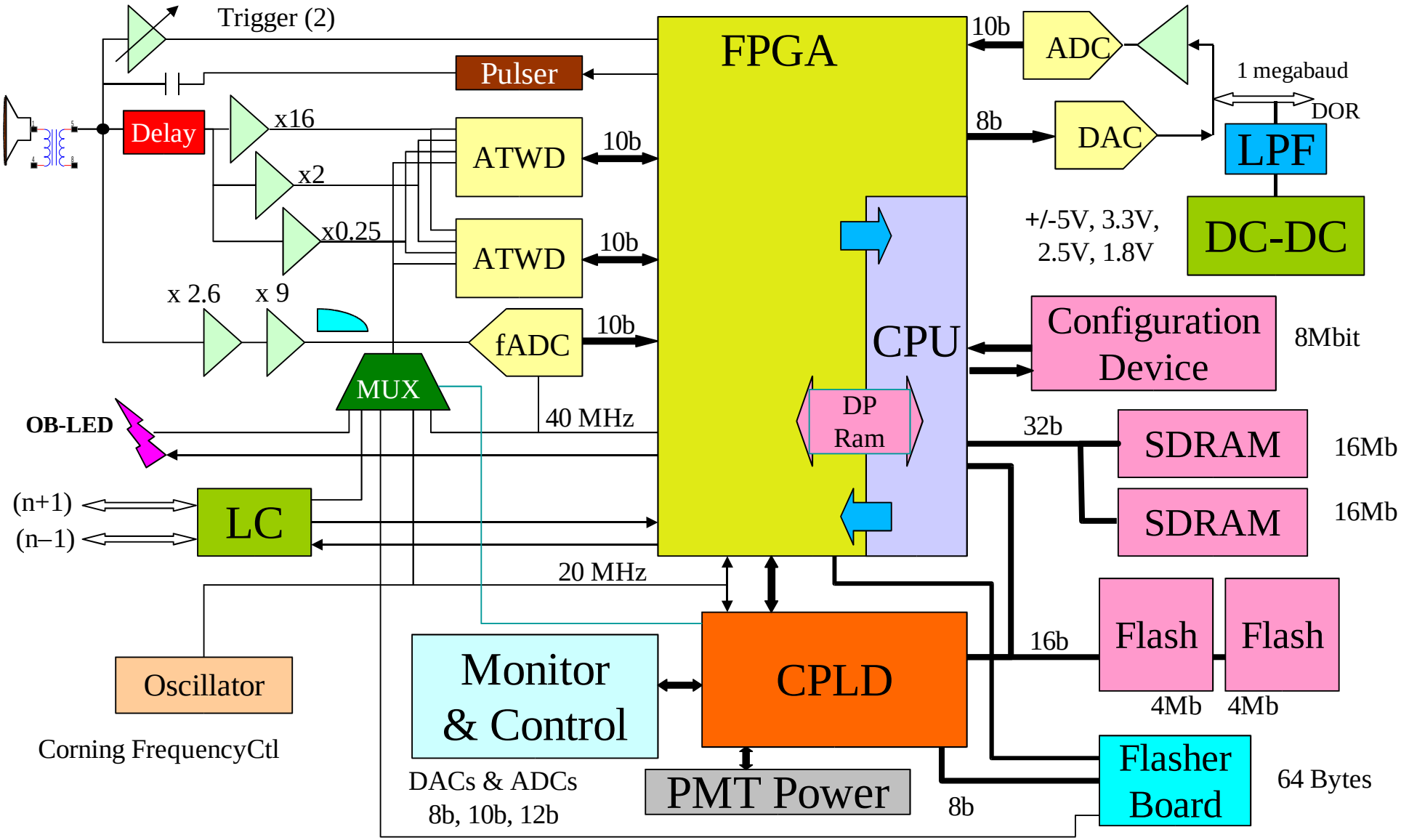
IceCube collaboration meeting

March 2005

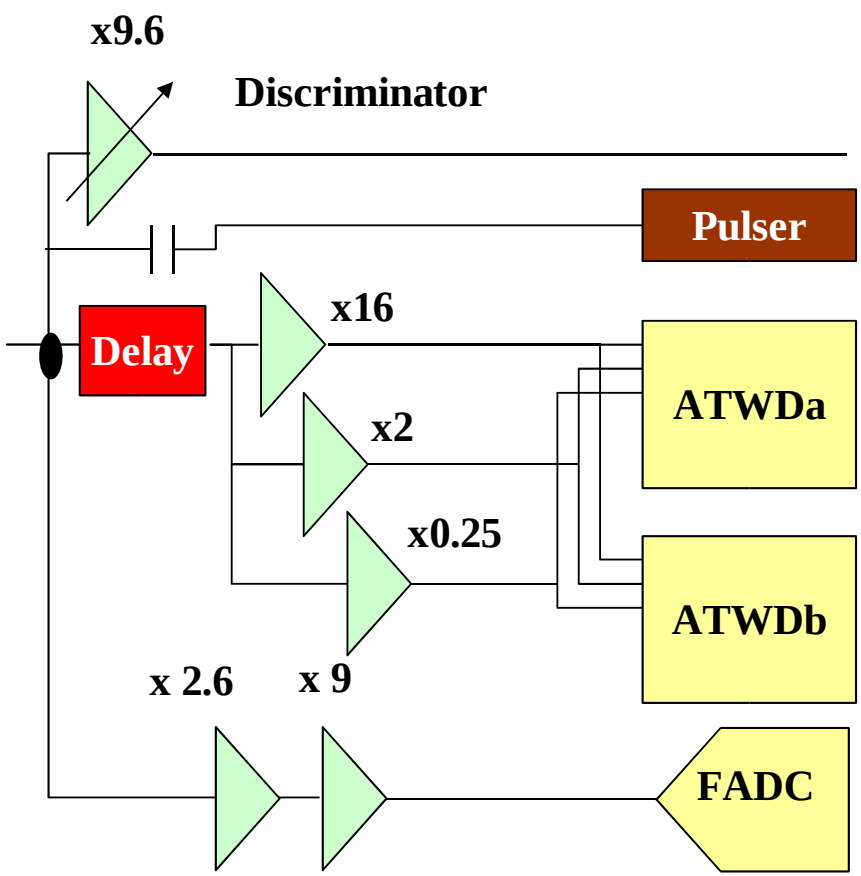
Outline

- DOM main board electronics
- What is simulated
- Finding the ATWD and FADC response functions using STF data
- STF (Simple Test Framework) tests and results
- ATWD pulser test
- FADC pulser test
- ATWD noise test
- Comparison of simulated and real SPE waveforms
- Local coincidence
- To do

DOM main board electronics



DOM main board electronics



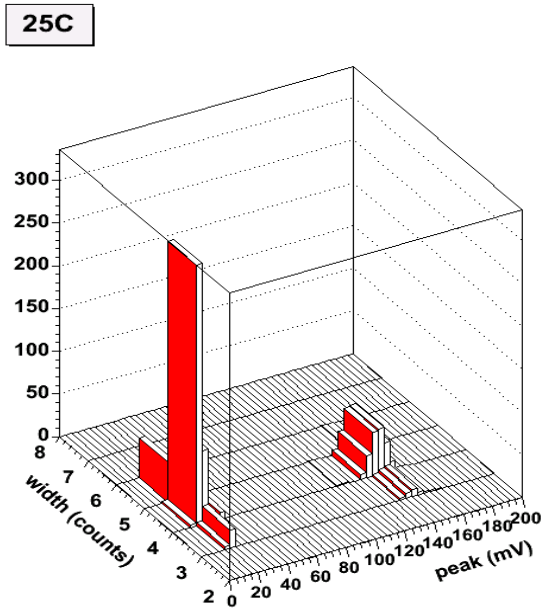
- **Discriminator:** adjustable threshold
- **Delay line:** 70 ns before ATWDs
- **Dead time & ATWD ping-ponging:** begin readout with ATWDa; ATWDb becomes live 6.4 ns after ATWDa readout is done; after ATWDb fires, 0.1 ms for ADC
- **Clock phase:** ATWD begins sampling on next leading edge of 40 MHz clock cycle
- **Saturation:** assuming 124 count baseline, saturation at 900 counts
- **ATWD gains**
- **Sampling:** 3.3 ns wide bins for ATWDs; 25 ns wide bins for FADC

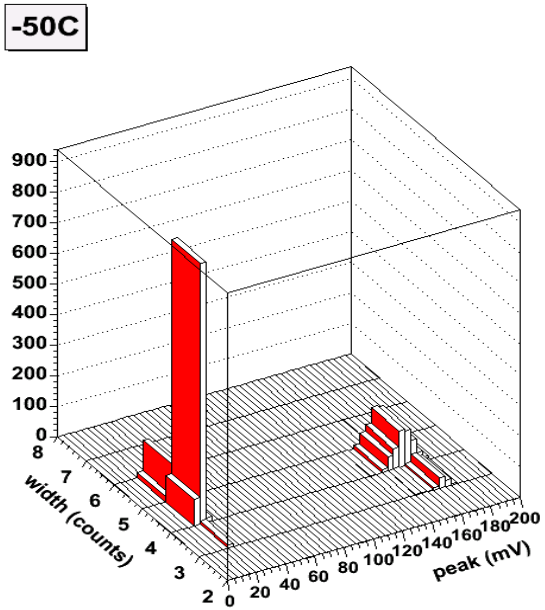
Finding the ATWD and FADC response functions

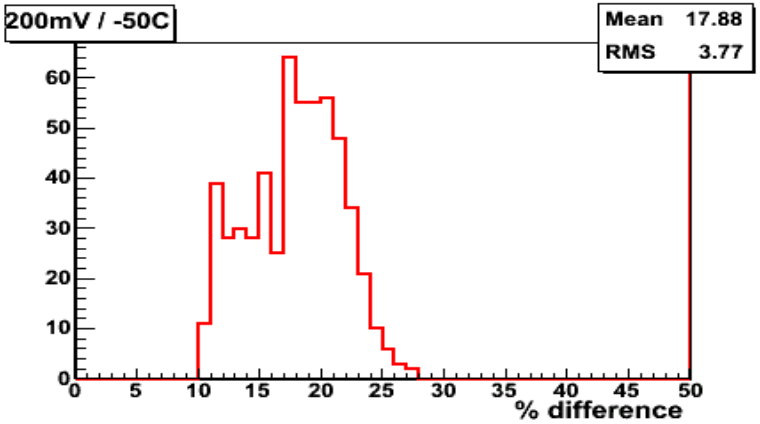
- **PLAN:** Use input from STF (Simple Test Framework) data to realistically simulate MB electronics response
- Various tests on DOM MB components conducted and results reside in MySQL database in XML files
- Query on: V5 boards and tests conducted after July 2004
- Results from ATWD pulser test, discriminator scan test, FADC pulser test, ATWD noise test analyzed
- Temperatures at which tests were conducted (with most statistics): -50 C & 25 C

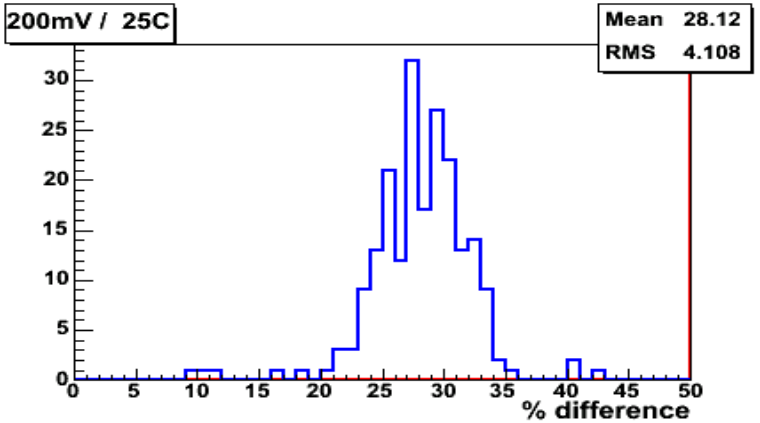
ATWD pulser test

- Pulses injected at point in electronics where PMT would produce signal
- Pulser amplitudes (with most statistics): 5, 40, 200 mV
- Average waveforms accumulated for given pulse in ATWDs and peak and widths recorded
- Pass: if measured width (FWHM) is within 2 counts of expected width if 4 counts & measured peak is within 50% of expected peak



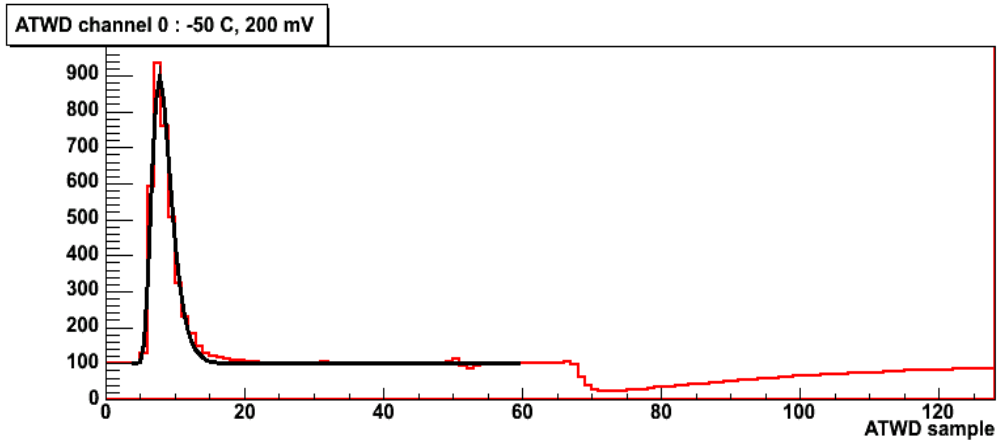


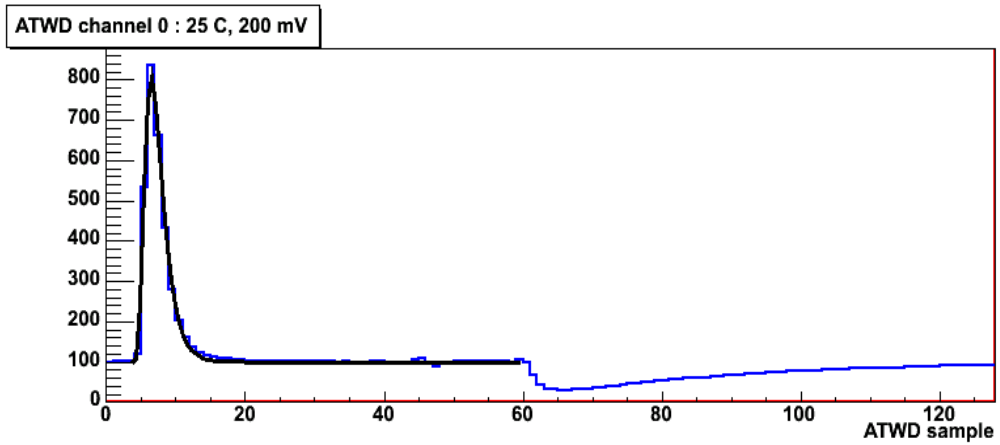




- Width of the pulse does not appear to depend on temperature
- Amplitude distributions exhibit a temperature dependence ("10% effect")

ATWD fits

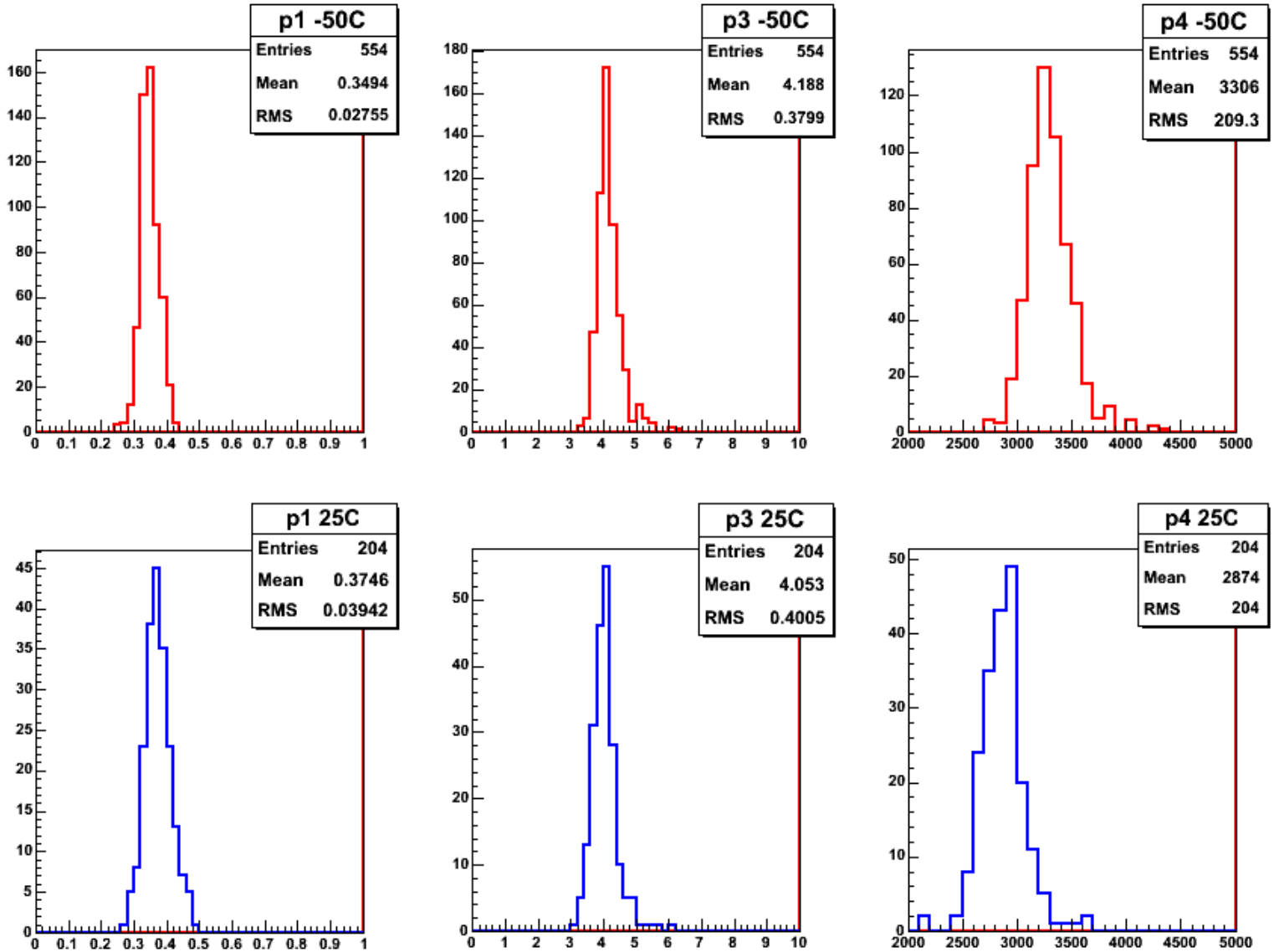




Lognormal function provides a reasonable fit to the ATWD waveforms:

$$f(t) = \frac{C}{t\sigma\sqrt{2\pi}} \exp\left(- \frac{\ln(t/m)^2}{2\sigma^2} \right)$$

ATWD fit parameters



σ: shape parameter → p1
m: scale parameter → p3
C: overall scale → p4

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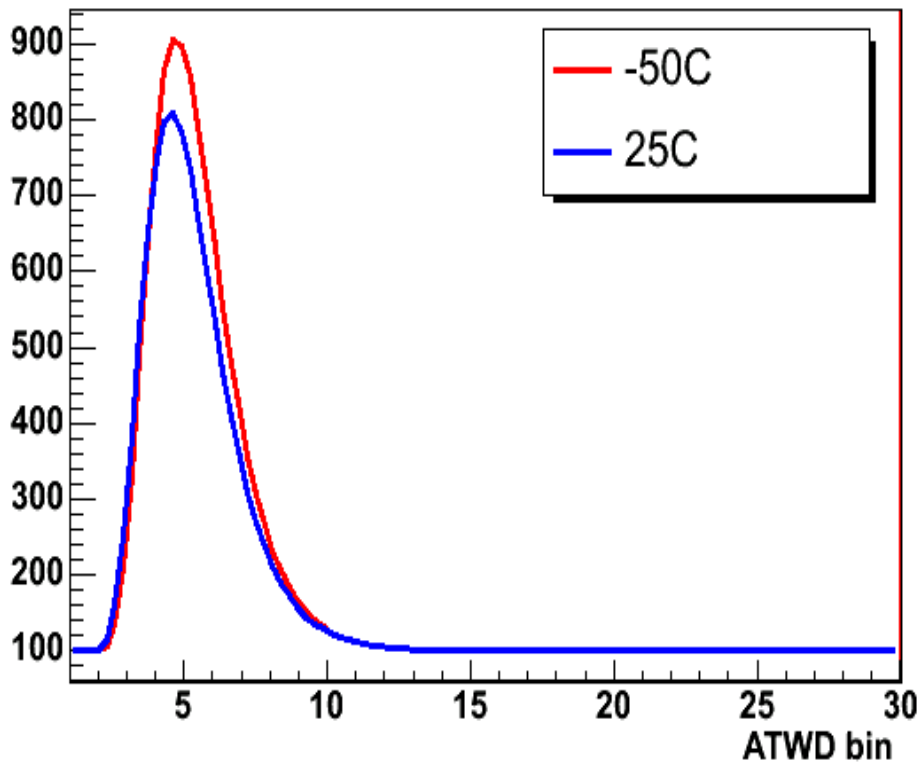
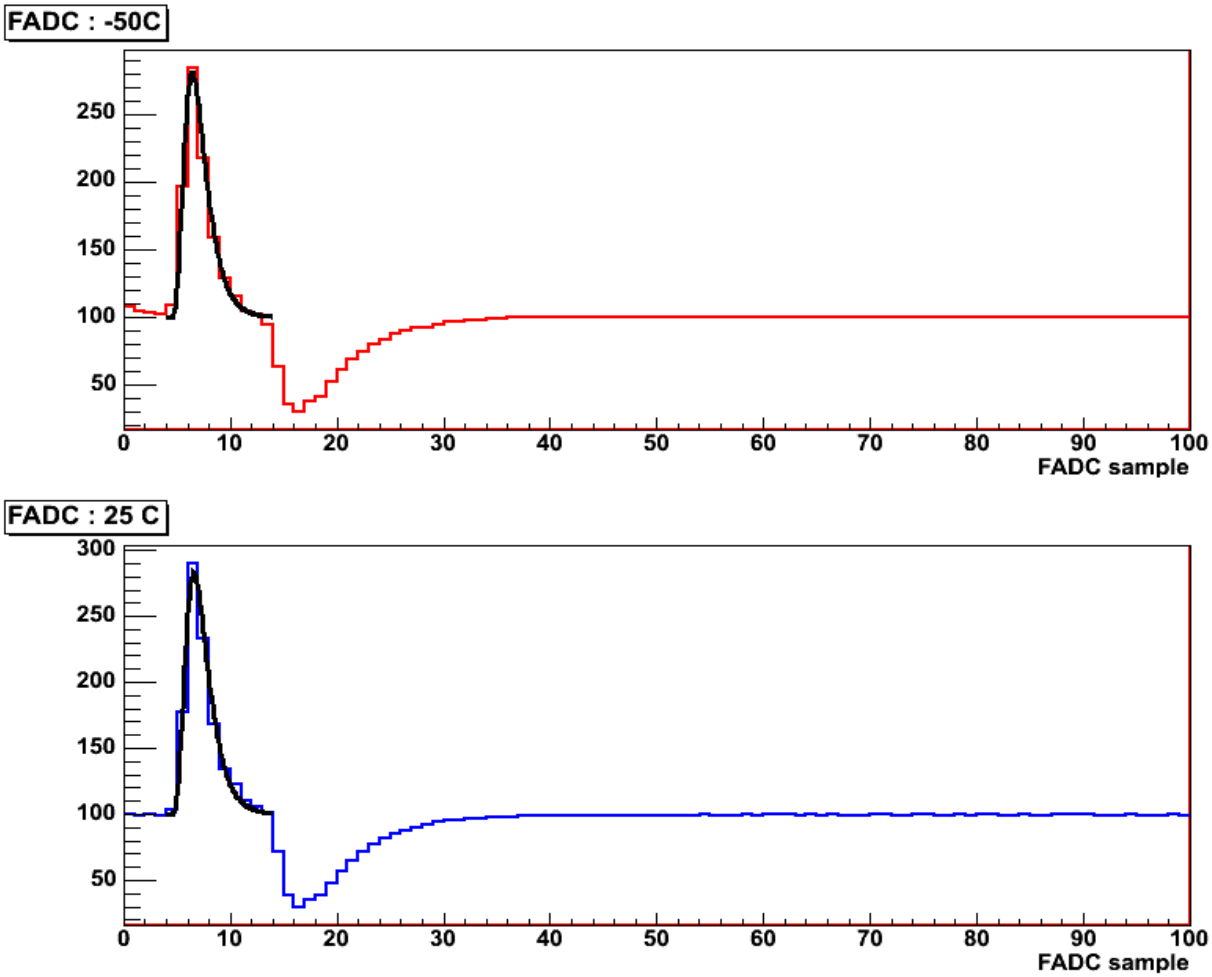
ATWD response function



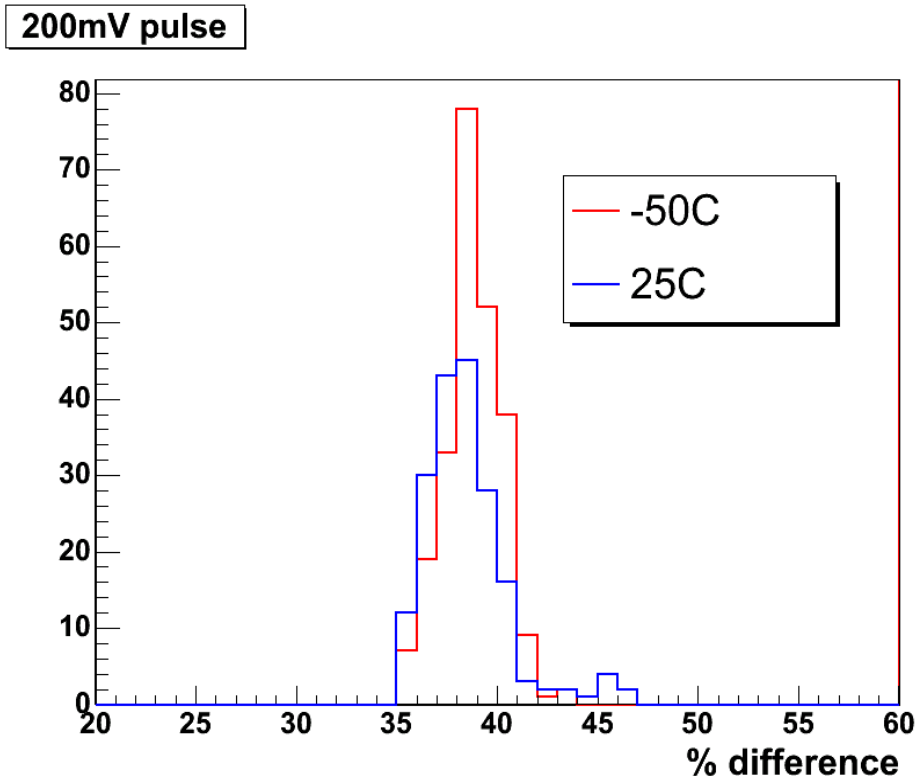
- At least from data at two temperatures: width of the pulse is essentially unaffected by temperature and amplitude dependence is relatively small
- In DOMsimulator lognormal response function (with best-fit parameter values for scale and shape parameters) is convolved with PMT pulse from ROMEO (PMT simulation)
- The overall scaling up or down of the pulse is determined from the PMT pulse amplitude and the ATWD gains

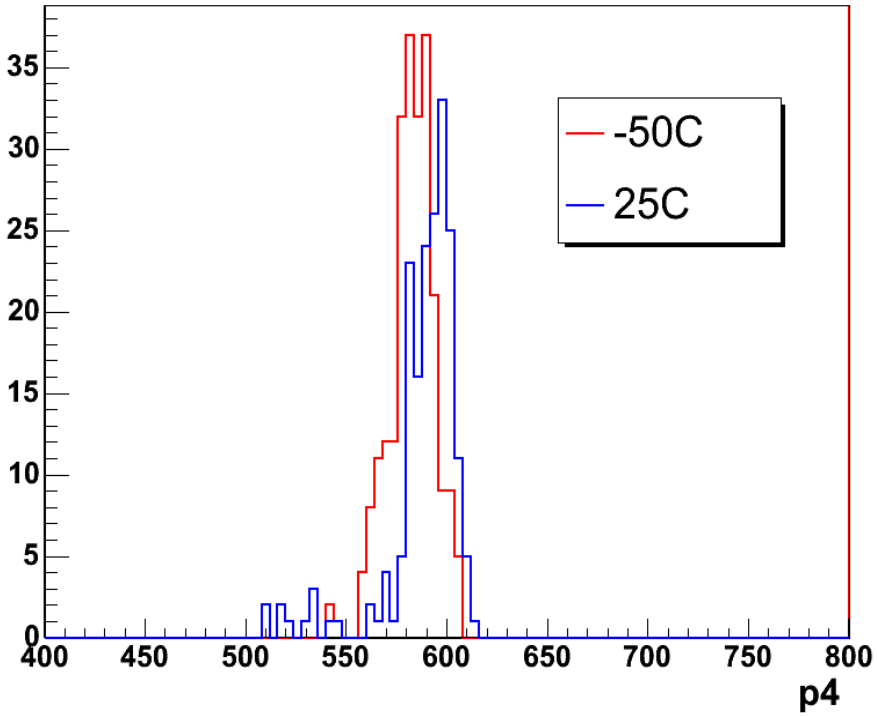
FADC pulser test



Lognormal function also fits FADC pulser waveforms well

FADC pulse amplitudes and fits

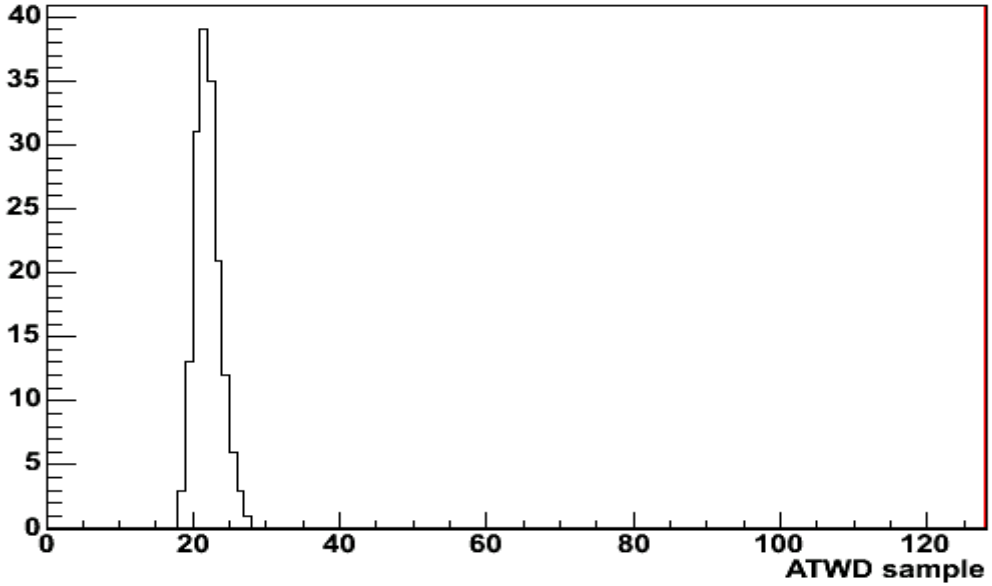


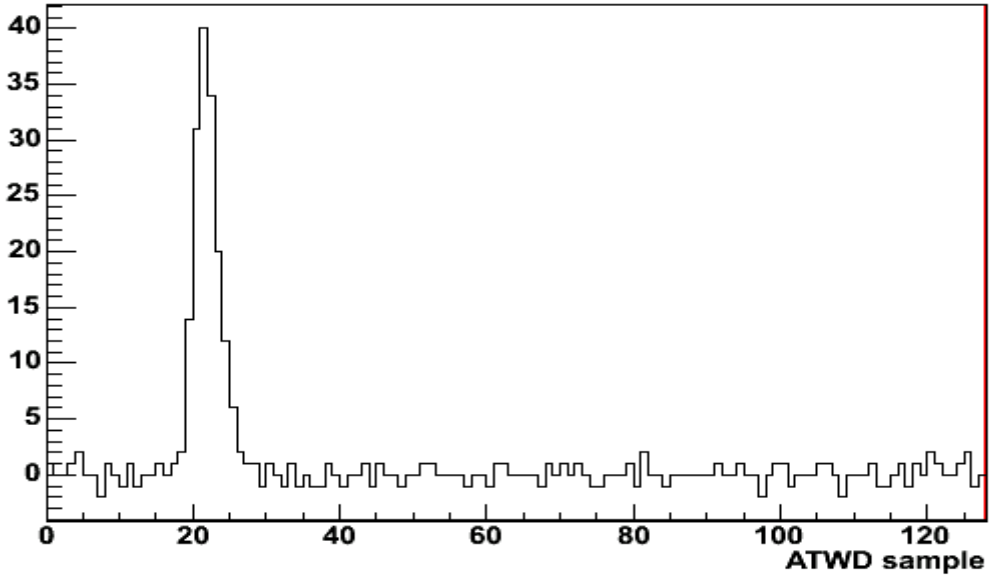


- Distributions of % difference between measured and expected pulse amplitudes does not exhibit same temperature behavior as in ATWDs
- This behavior is reflected in the distributions of the fit parameter p4: the overall scale of the pulse

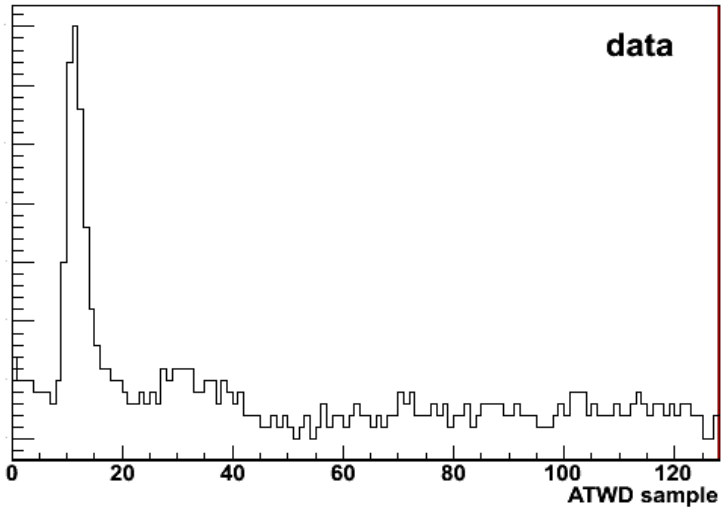
ATWD noise test

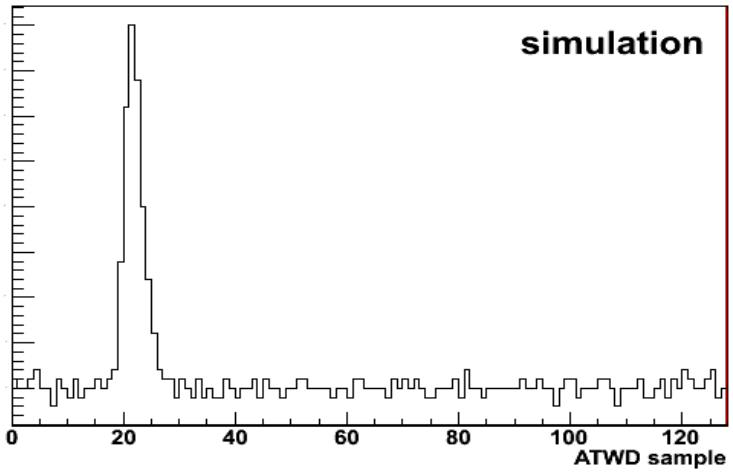
- Take N number of pedestal waveforms and obtain an average pedestal waveform
- Take one waveform from the set and subtract from the average waveform to obtain deviations
- Over ATWD channels RMS deviations <~ 1 count





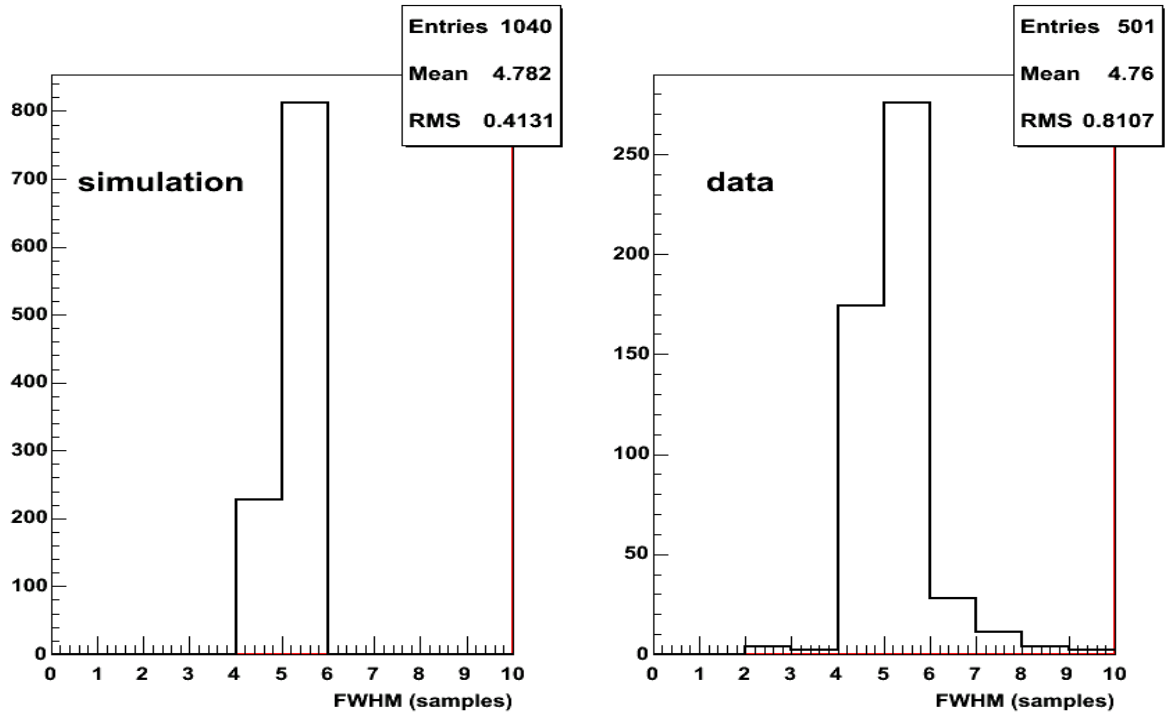
Comparison of real and simulated SPE waveforms





- Comparison of real SPE waveforms (from UW test data) with simulated SPE waveforms required to validate simulation
- UW data: Time resolution laser runs read with FAT-READER
- As determined from FeatureExtractor, output waveforms with 0.5 pe < charge < 1.5 pe
- Simulation "test bench" must include PMT simulation: ROMEO
- Feature at ~ 30 samples in the data appears in many data waveforms (afterpulsing?) -> a more systematic look in the works

Comparison cont'



- Comparison of FWHM distributions (ATWD) for simulated and real waveforms shows reasonable agreement
- More comparison needed

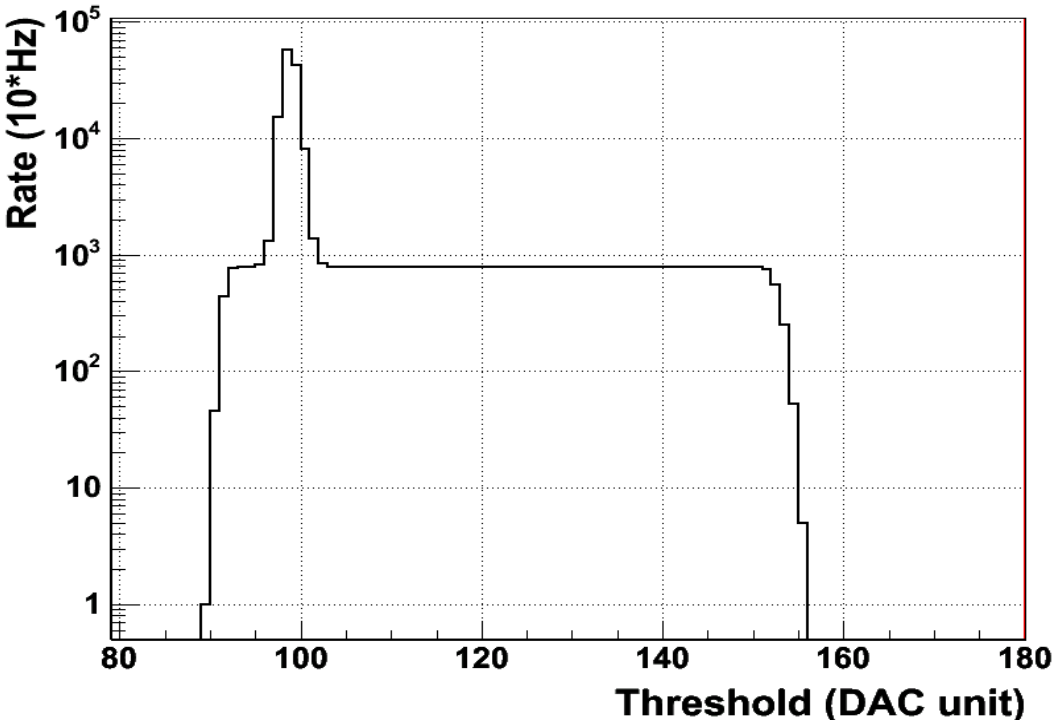
Local coincidence

- When discriminator fires in the DOM, check for nearest neighbor coincidences in a time window of order 100 ns
- If no local coincidences, no DOM launch
- In DOMsimulator: first pass at implementing LC, more work needed, should be done soon

Conclusions and future work

- Data from STF tests used as input for simulation of ATWD & FADC response functions and ATWD noise
- Simulation is contained in DOMsimulator module released with SIMULATION metaproject
- Preliminary comparison of SPE waveforms: so far, looks good
- Temperature dependence: a small affect, the handling of which is set aside for now
- Issues: configuration of adjustable parameters (Db, default config. file...)
- Local coincidence: near top of “things-to-do” stack
- Thanks to A. Goldschmidt, S. Klein, and G. Przybylski for useful help and advice

Discriminator scan test



Beginning threshold (DAC unit):

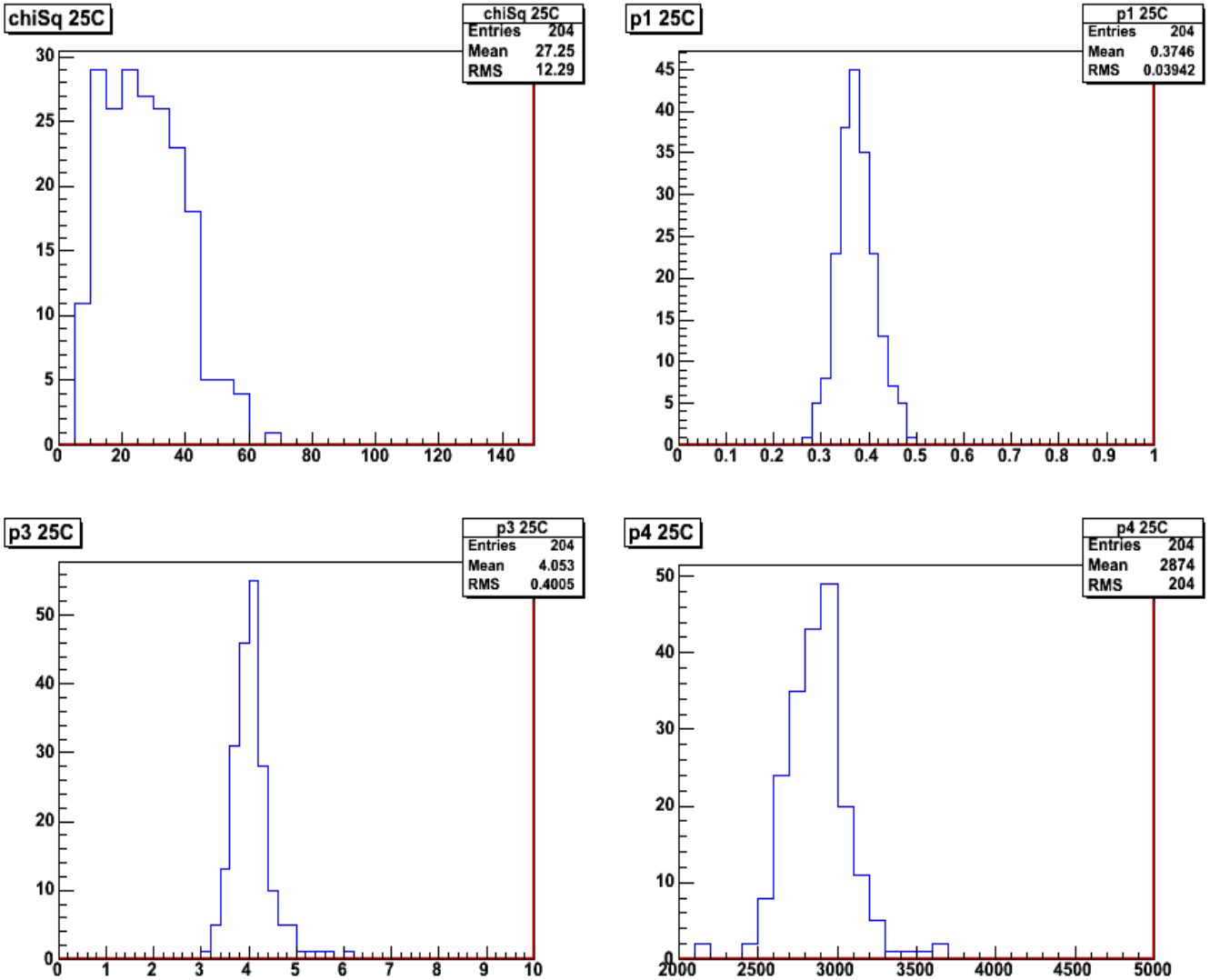
- -50 C : mean = 542.33 sigma = 4.16
- 25 C : mean = 542.61 sigma = 2.96

End threshold (DAC unit):

- -50 C : mean = 588.05 sigma = 4.60
- 25 C : mean = 591.32 sigma = 3.15

- Given a pulse of fixed height, the discriminator threshold is increased while the trigger rate is recorded
- For the threshold range above the noise level and below the pulse height, the trigger rate should be constant
- The threshold values where this constant region begins (where the threshold is above the noise and into the pulse) and ends (right before the threshold exceeds the pulse height) are recorded
- What do the distributions of the end threshold values look like for each temperature?

ATWD fit parameters



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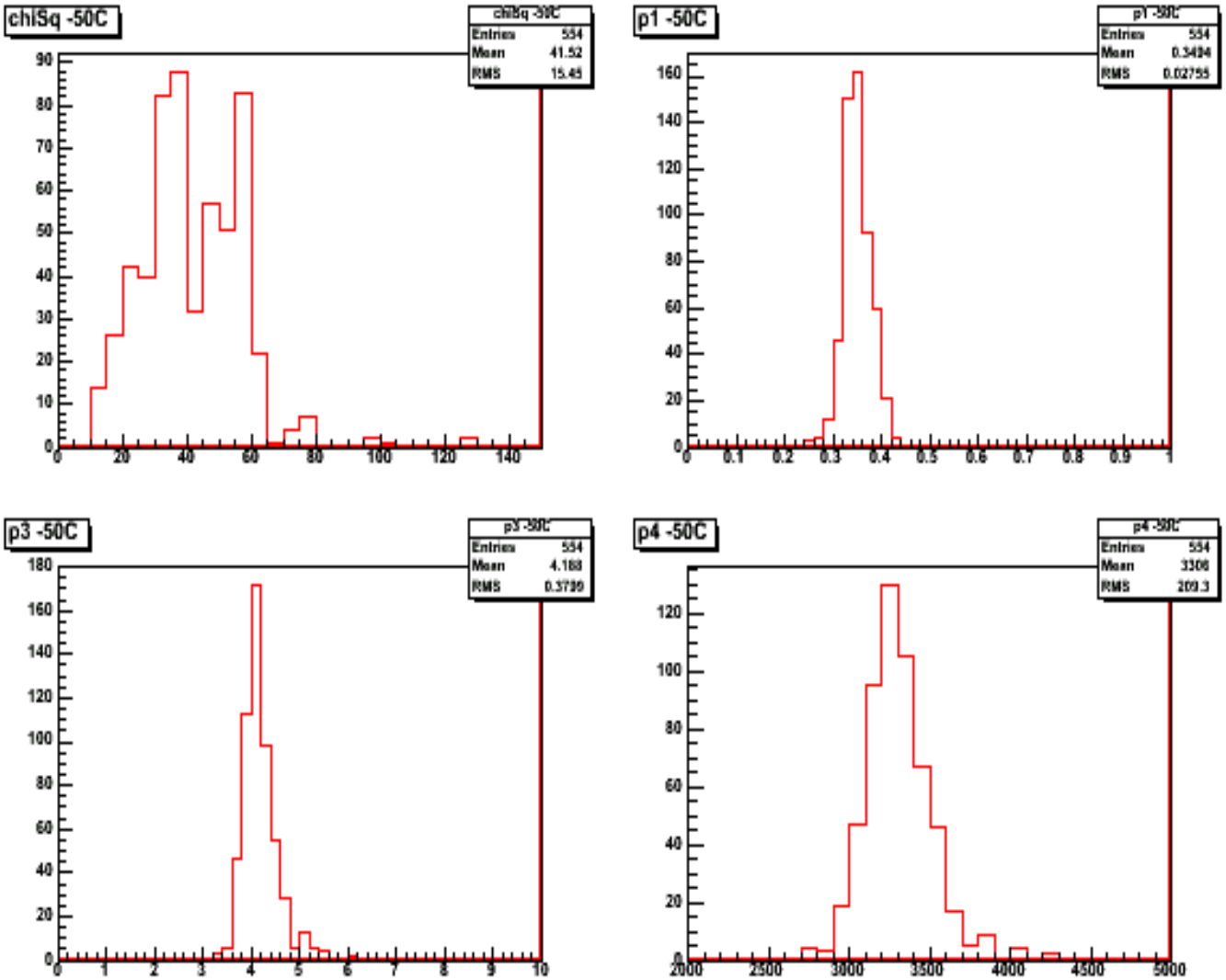
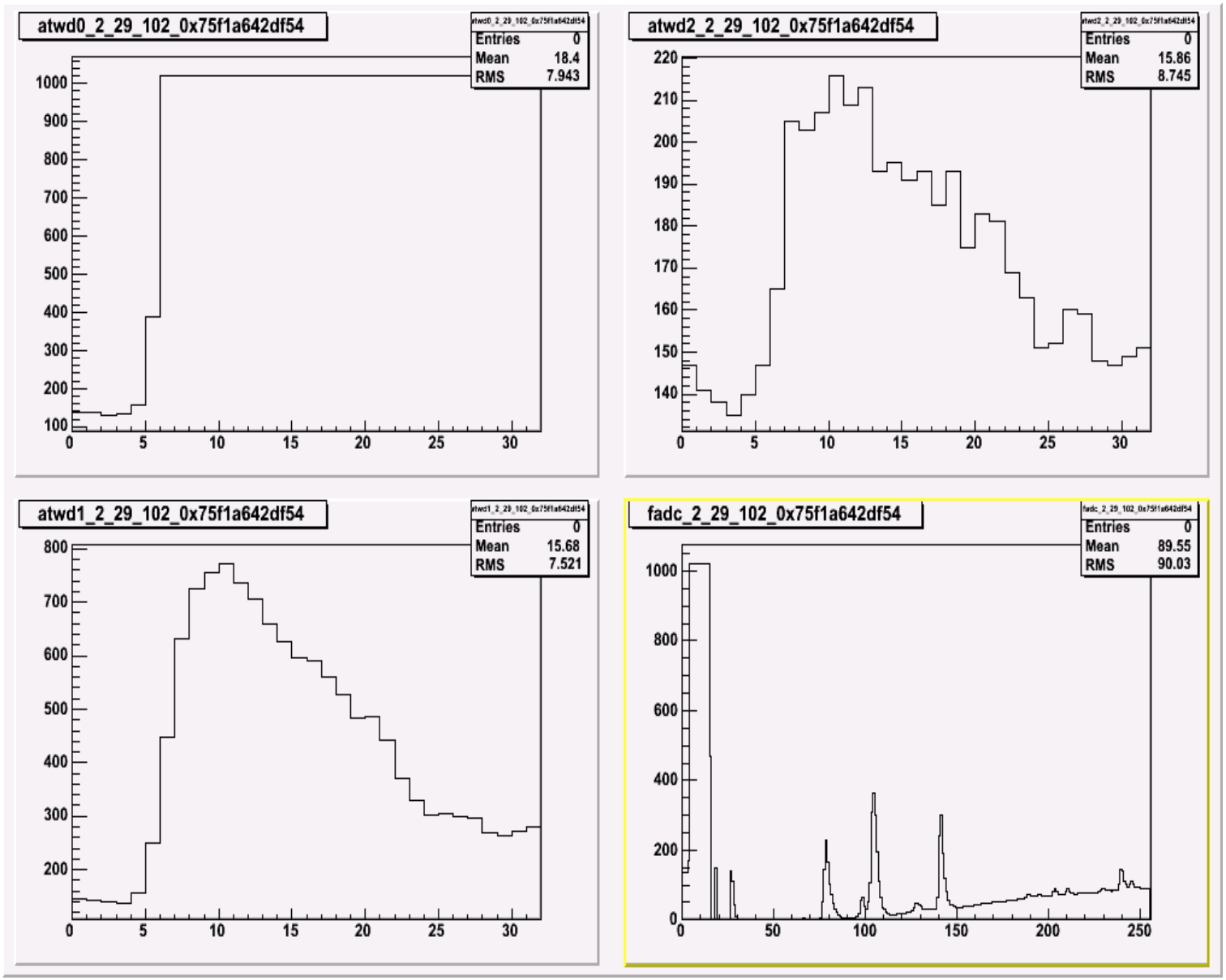
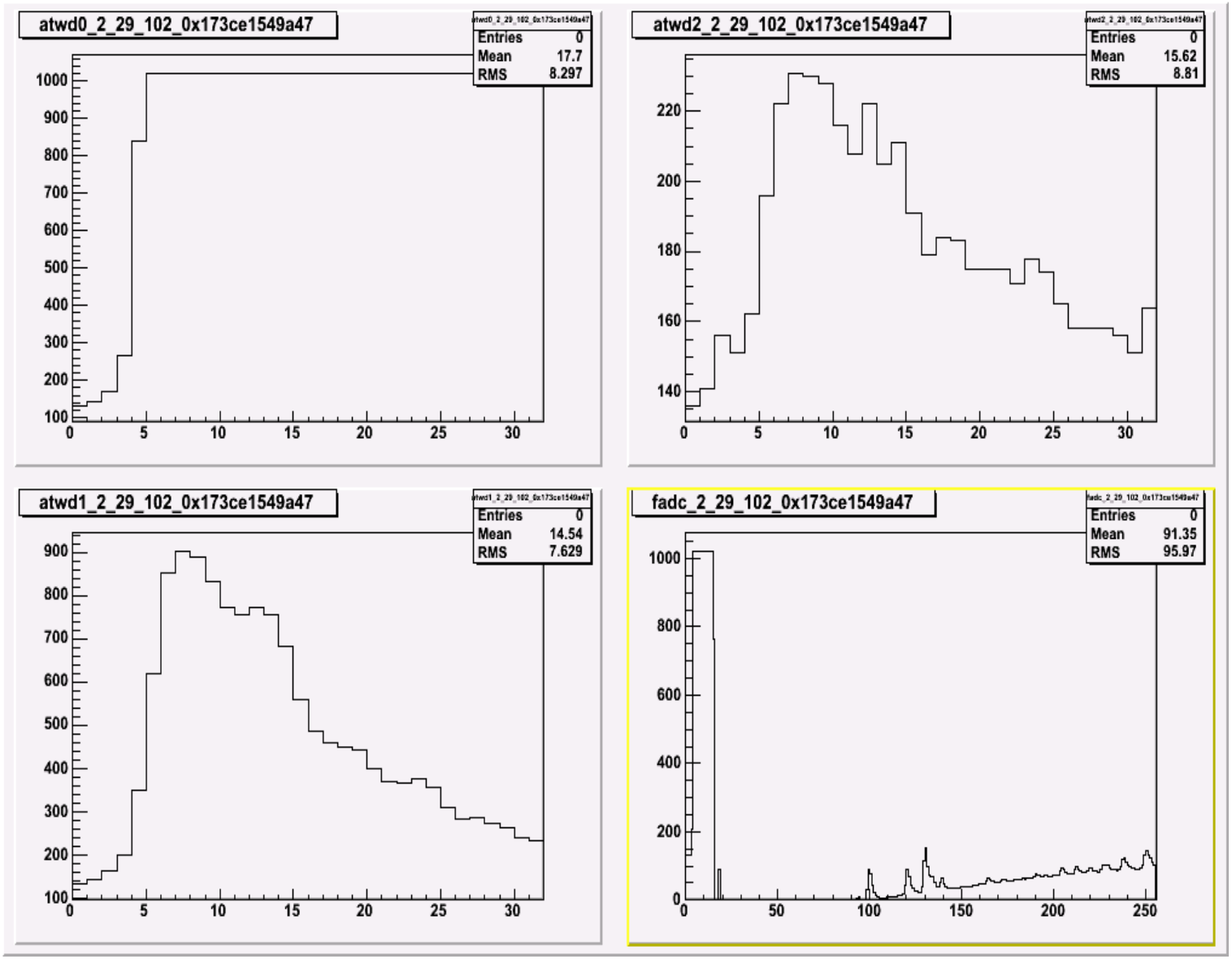


FADC saturation behavior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