DOM-Cal

DOM-Resident Calibration Software

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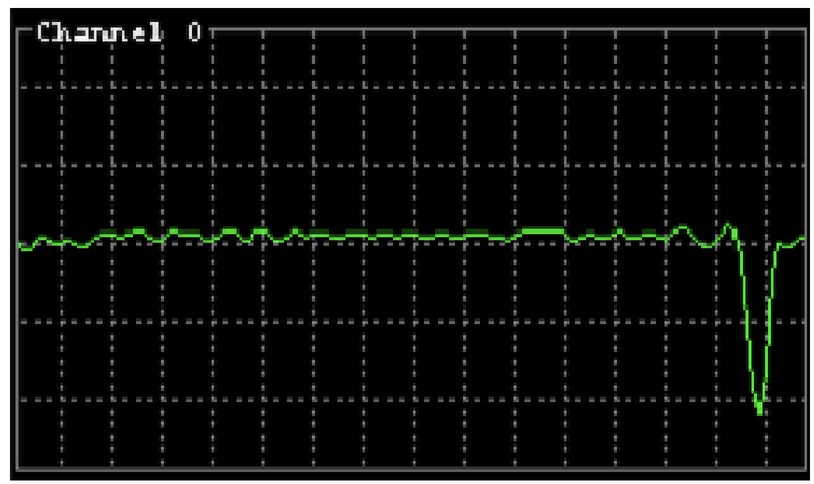
July 29, 2004

Overview

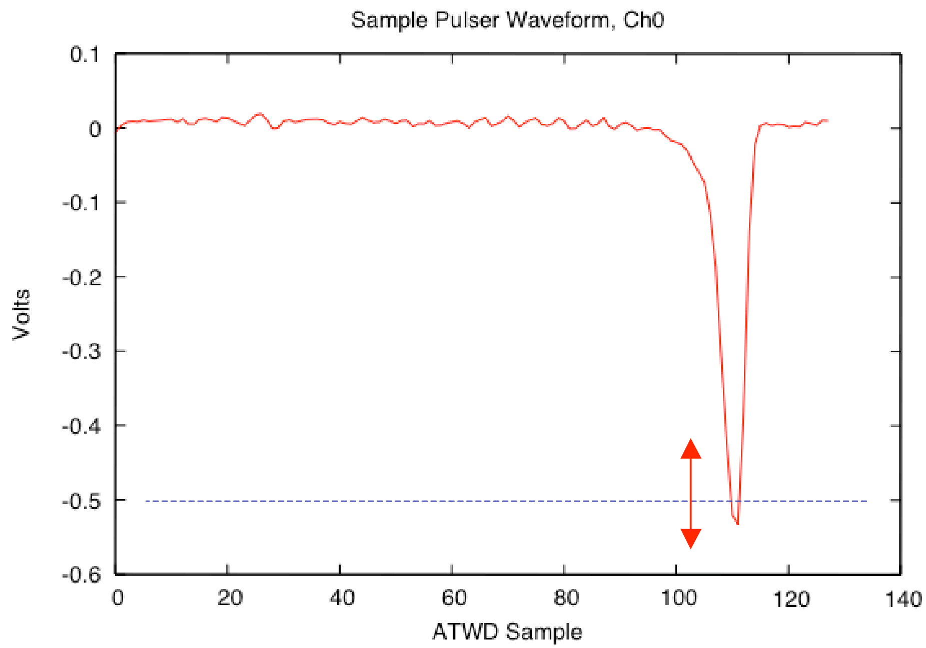
- Stand-alone program runs on DOM mainboard
- Calibrates ATWDs, amplifiers, and PMT gain
- Stores results on DOM flash filesystem
- Authors: J. Kelley, J. Braun (derived from K. Hanson's `domcal.py`)

ATWD Calibration

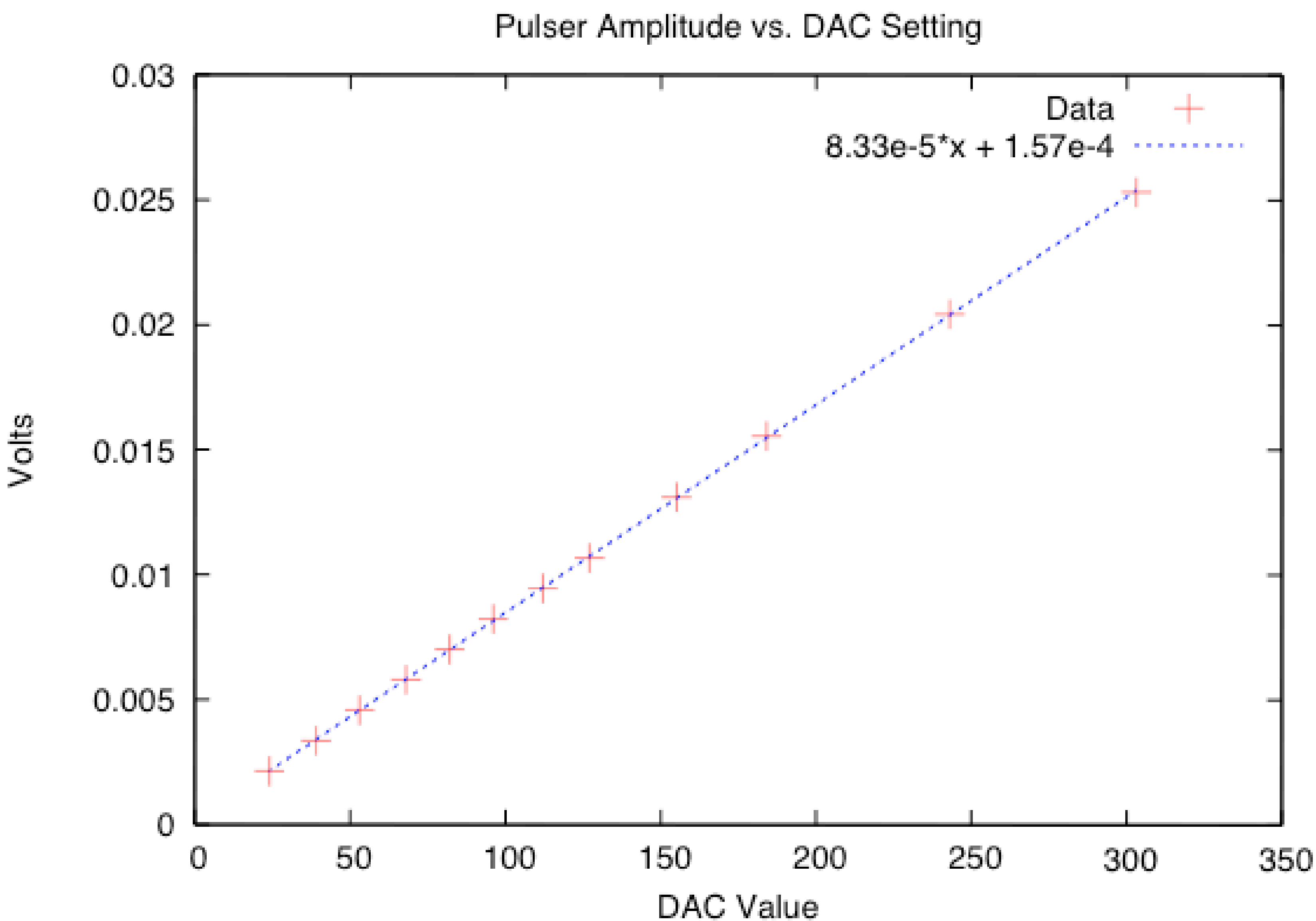
- Calibrate ATWD Y-axis to voltage
  - Pulser calibration
  - ATWD bin calibration
  - Amplifier calibration
- Calibrate ATWD X-axis to time
- Runs in ~1 minute



Step 1: Pulser Calibration

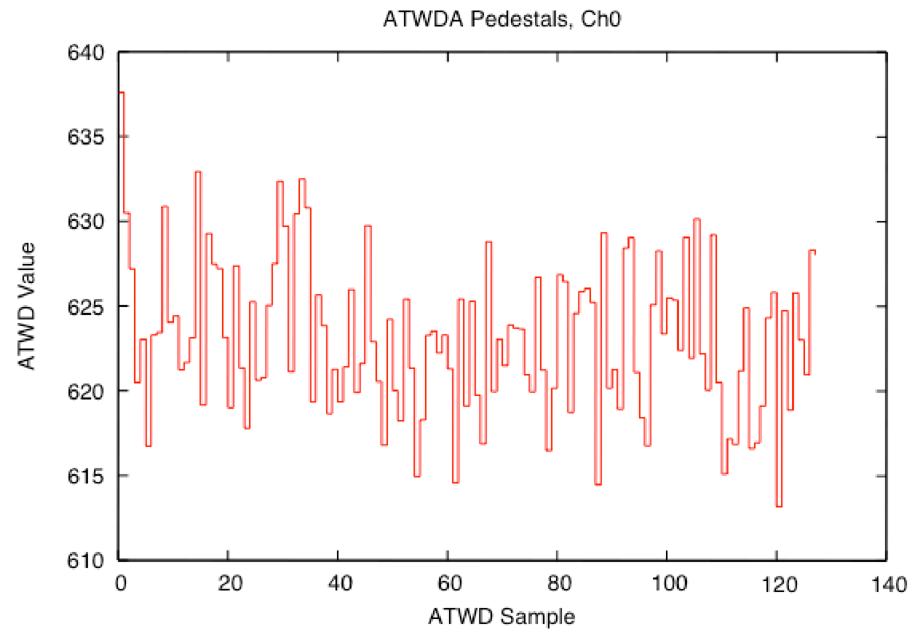


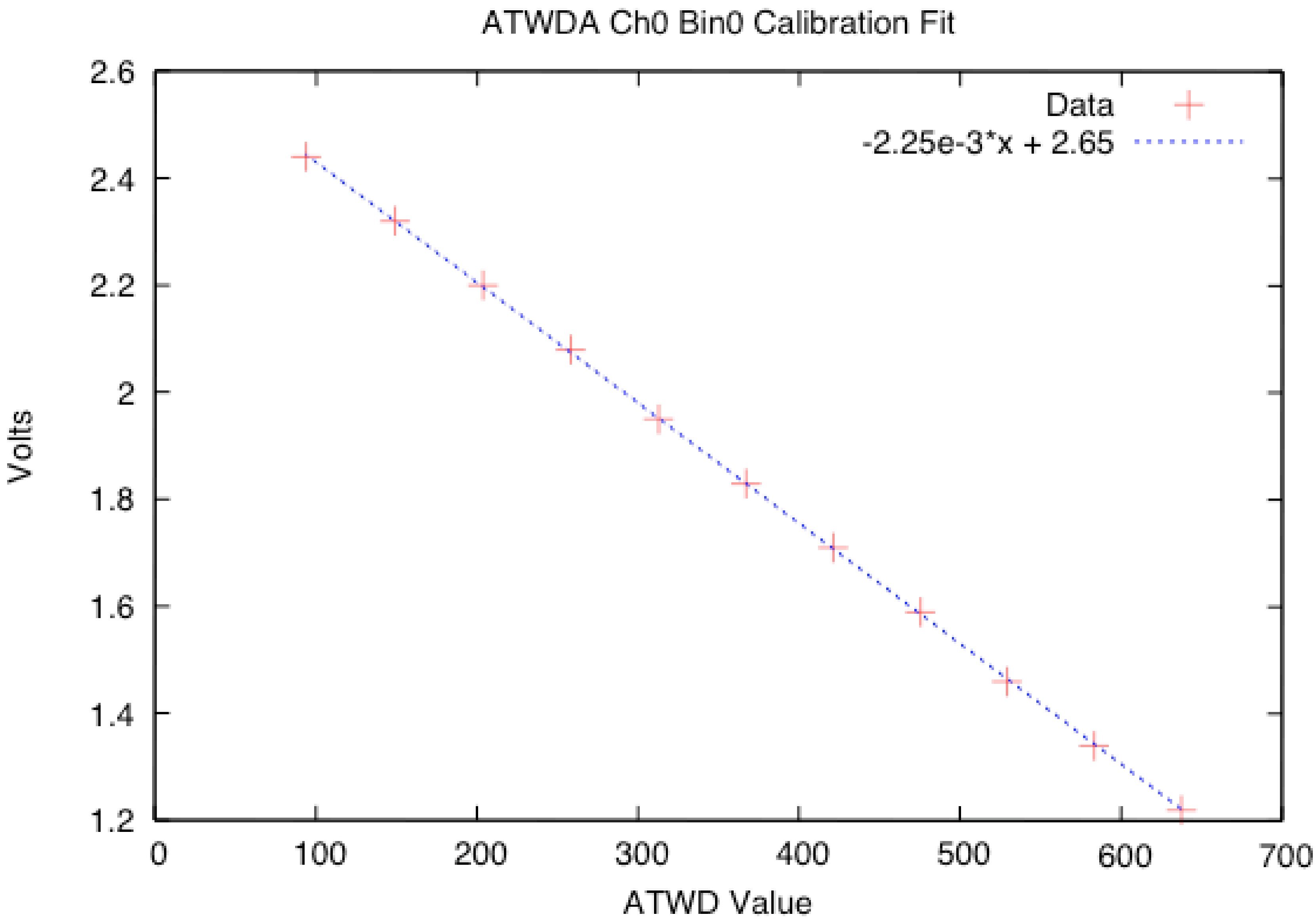
- Set pulser to known frequency and discriminator to known level
- Monitor trigger rate while adjusting pulser amplitude
- Translate amplitude DAC at 50% rate point to true amplitude (V), using known discriminator level
- Fit amplitude DAC to voltage relationship


Pulser Amplitude vs. DAC Setting
Data
8.33e-5*x + 1.57e-4
Volts
DAC Value
0
0.005
0.01
0.015
0.02
0.025
0.03
0
50
100
150
200
250
300
350

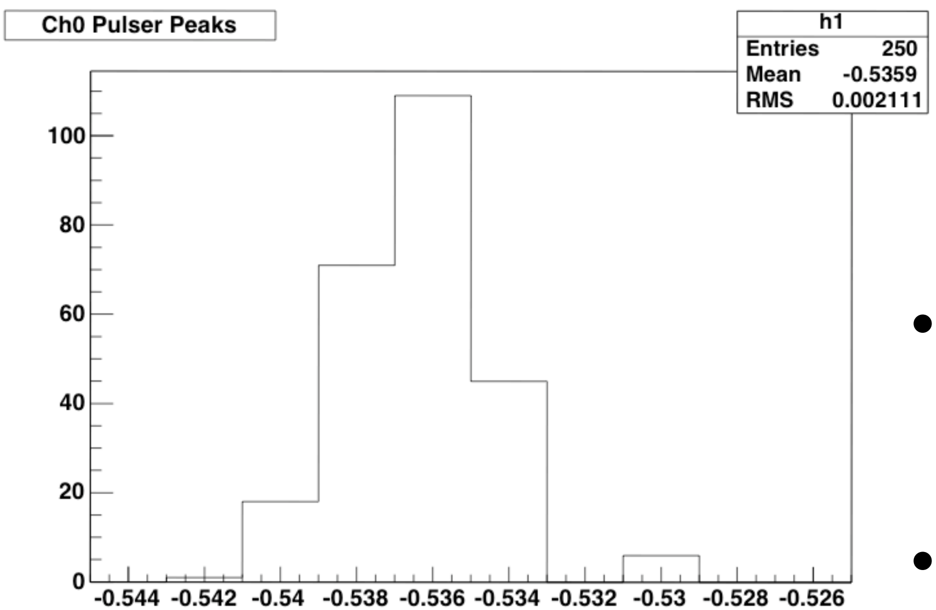
Step 2: ATWD Bin Calibration

- Set front-end pedestal (bias) voltage to known value
- Record average ATWD pedestal — baseline shifts as bias is changed
- Fit relationship for each ATWD, channel, *and bin* (accounts for pedestal pattern!)
- DC bias is independent of channel amplification




ATWDA Ch0 Bin0 Calibration Fit
Data
-2.25e-3*x + 2.65
Volts
ATWD Value
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
0
100
200
300
400
500
600
700

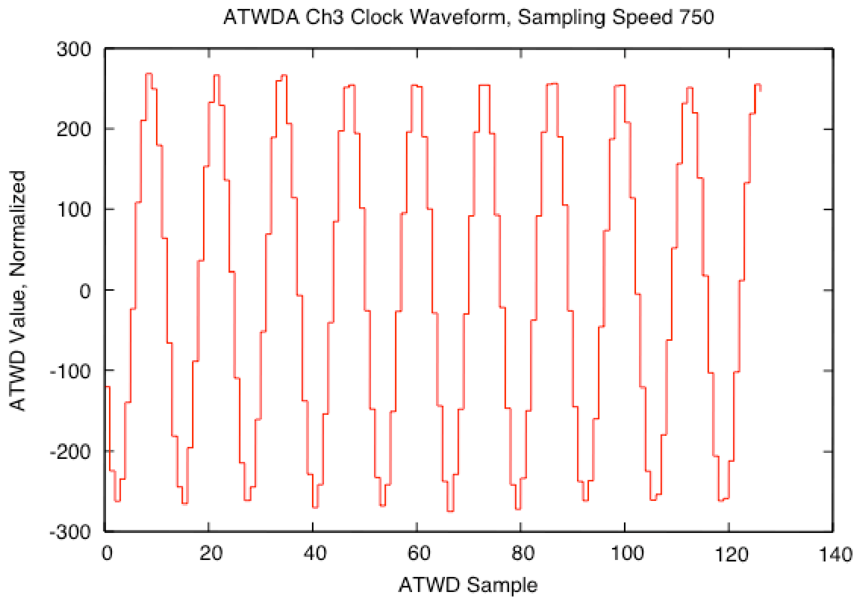
Step 3: Amplifier Calibration

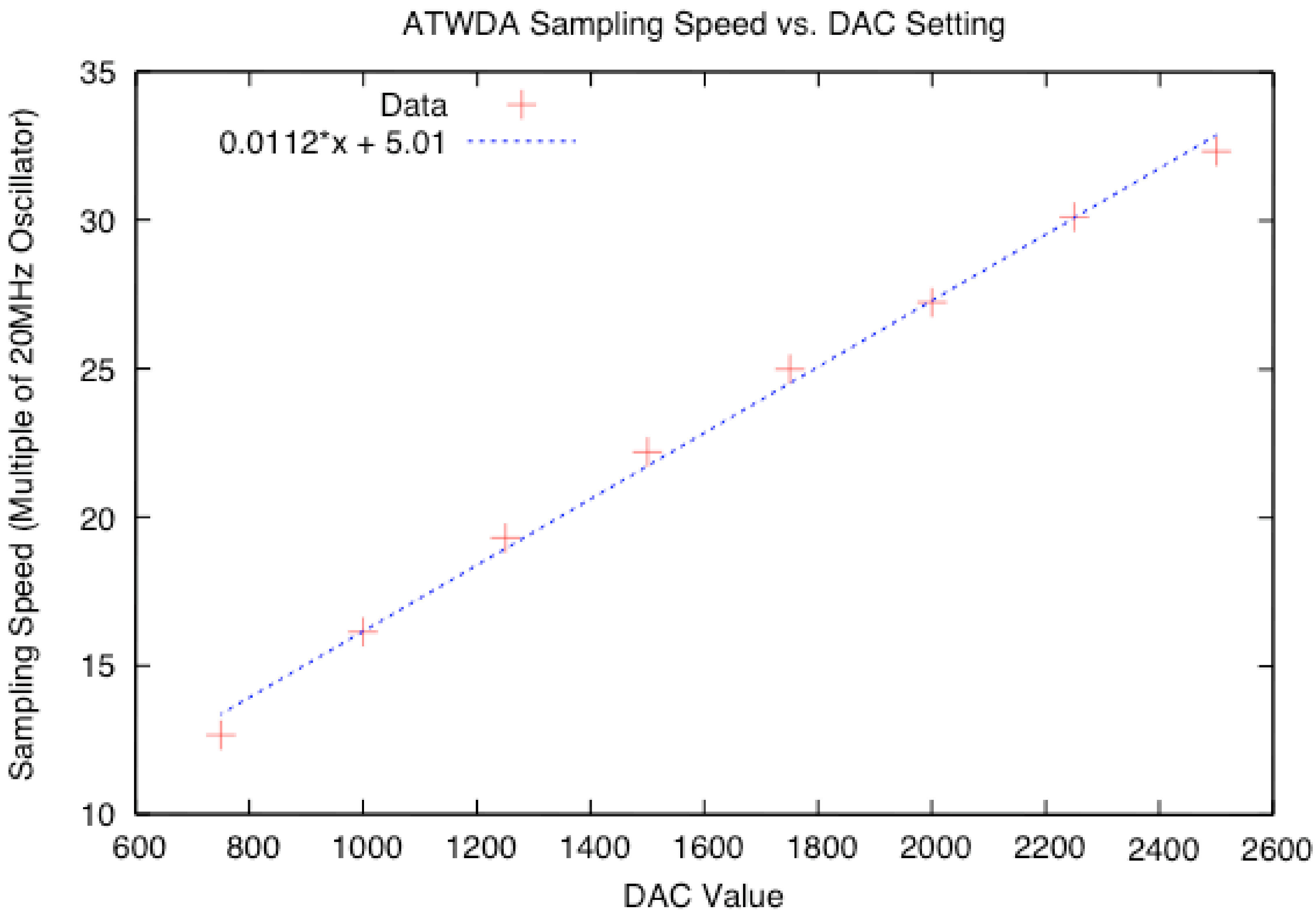


- Capture pulser waveforms of appropriate amplitude, find peak, convert to volts (from step 2)
- Convert pulser amplitude to volts (from step 1)
- Find mean and error of amplification for each channel

Step 4: Sampling Speed Calibration

- Capture clock waveforms using ATWD channel 3
- Count average number of positive zero-crossings
- Fit multiple of clock frequency versus sampling speed DAC




ATWDA Sampling Speed vs. DAC Setting
Data
0.0112*x + 5.01
Sampling Speed (Multiple of 20MHz Oscillator)
DAC Value
35
30
25
20
15
10
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600

HV Gain Calibration

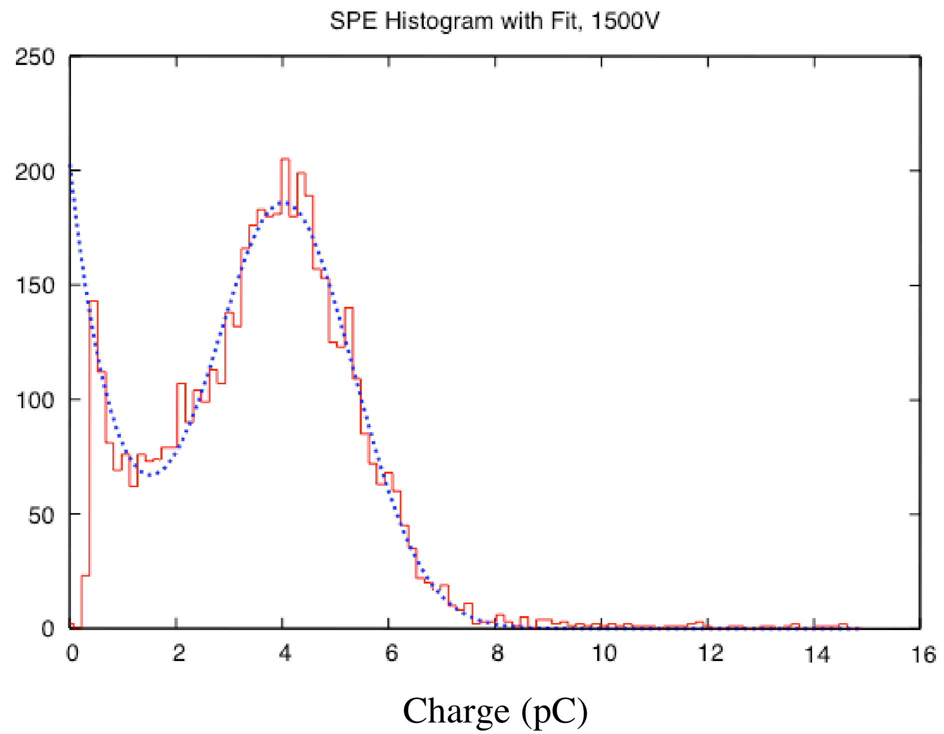
- Integrate SPE waveforms
  - Dynamically choose channel 0 or 1 to avoid saturation
  - Use previous calibration data to convert to pC
- Fit charge histogram
- Find peak and valley
- Fit log(HV) versus log(gain), using only good points
- Runs in 5-10 minutes

Charge Histogram Fitting

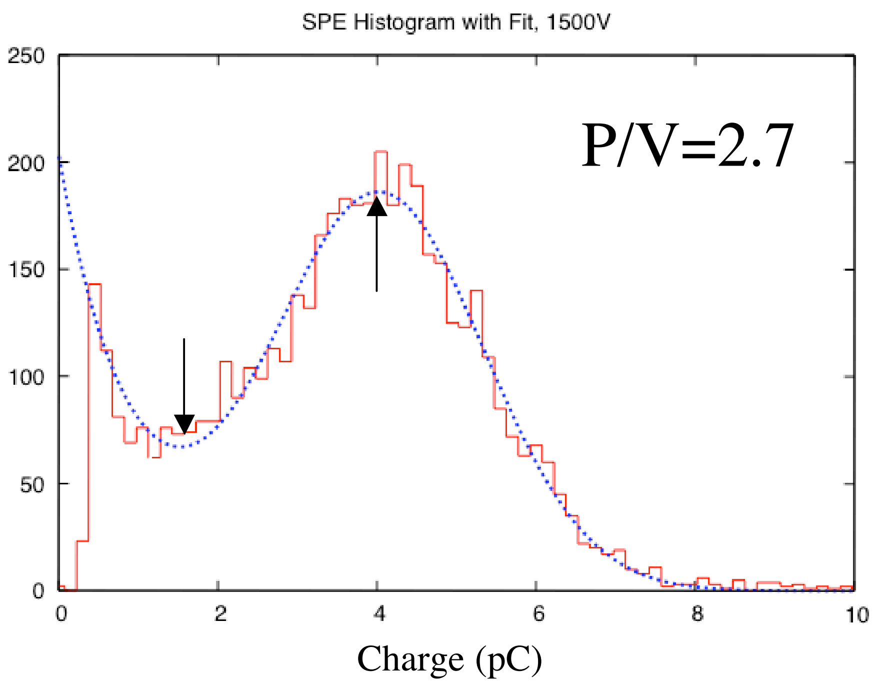
- Nonlinear Levenberg-Marquardt fit to:
  A*exp(-Bx) +
  C*exp(-E (x-D)^2)

- Discard first few bins intelligently, pick starting parameter values

- Runs reasonably fast on DOM (< 5 sec)



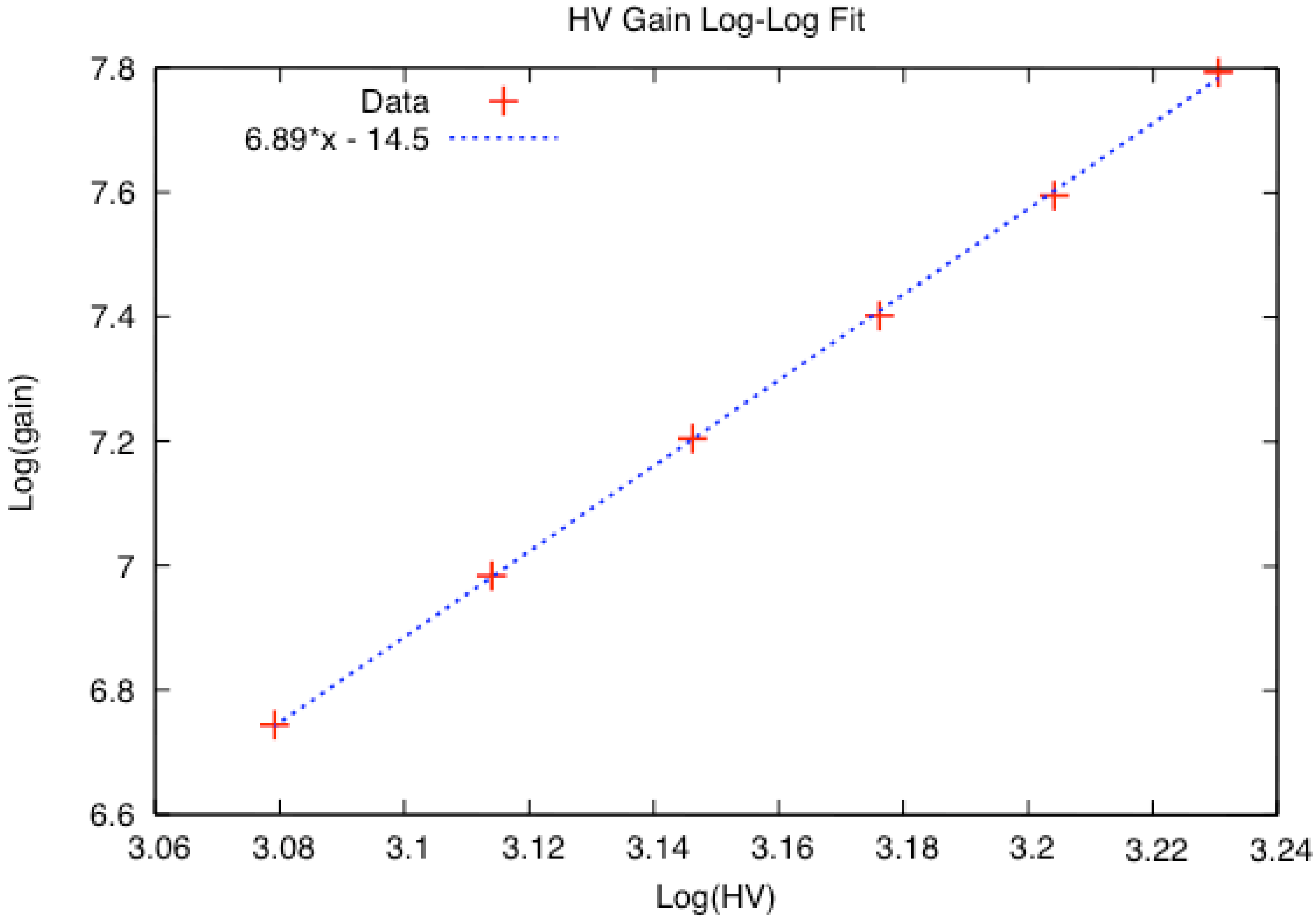
P/V Calculation



- Find valley with Newton's algorithm on derivative of fit
- Approximate peak with Gaussian max
- Heuristics
  - Did fit converge?
  - Is valley in sane location?
  - Is P/V realistic?

Gain vs. HV

- Calculate gain using SPE peak from fit
- Fit log(HV) versus log(gain) for voltages with good data
- Return fit and individual P/V points


HV Gain Log-Log Fit
Data
6.89*x - 14.5
Log(gain)
Log(HV)
7.8
7.6
7.4
7.2
7
6.8
6.6
3.06
3.08
3.1
3.12
3.14
3.16
3.18
3.2
3.22
3.24

Output Data

- Data stored on DOM flash filesystem (binary format)
  - Calibration results
  - DOM state (DACs, ADCs, temperature)

- Java application can control calibration, read binary result file, and create XML file on surface

Open Issues

- ATWDB may have small baseline shift — especially affects channel 2 gain calibration
- HV gain calibration uses hard-coded discriminator setting and doesn't work well at room temperature
- Gain is very reproducible, but exact P/V ratio is variable
- New Rev5.0 ATWDs need different DAC settings — will support all revisions through #defines