Taking Data
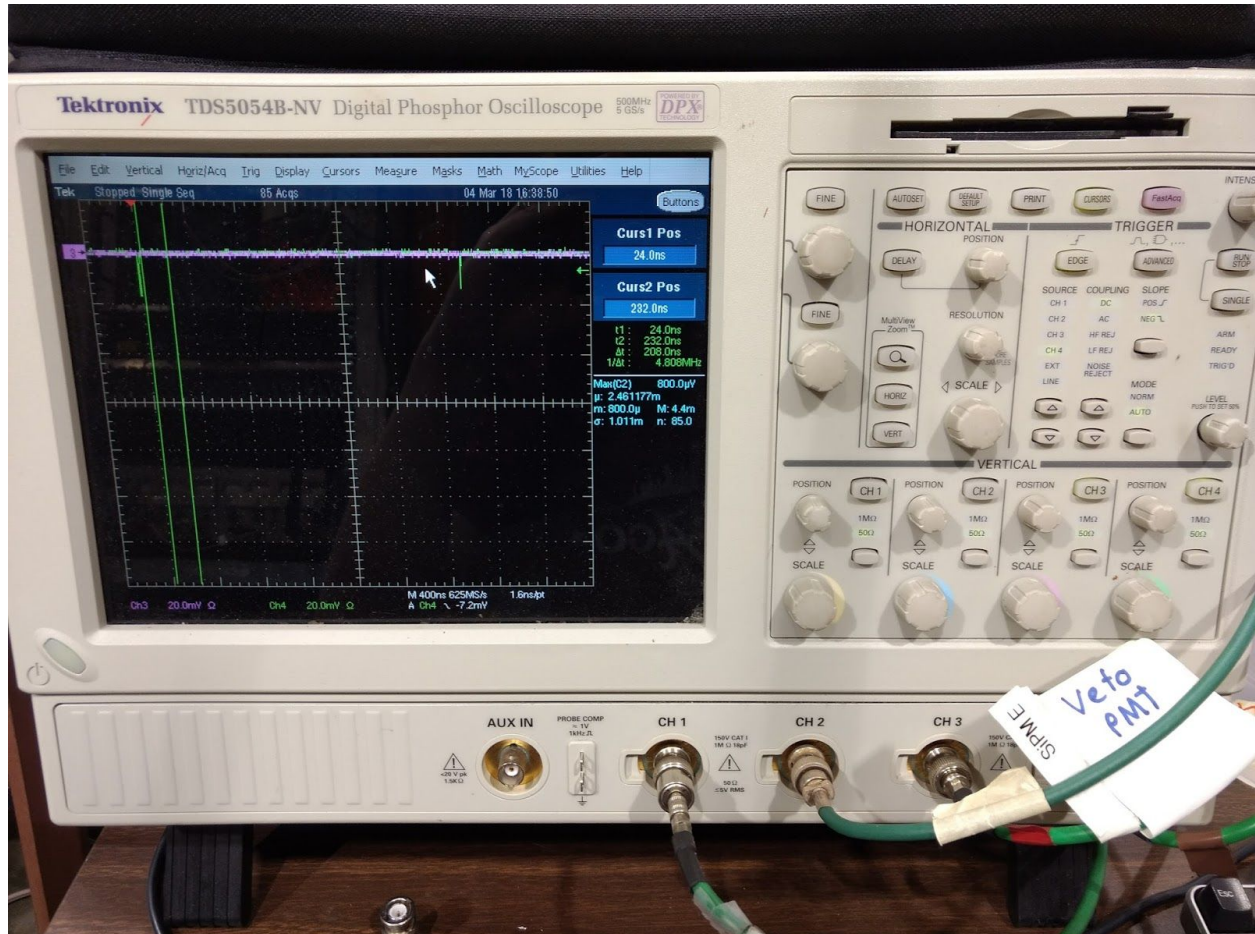
1.) On oscilloscope Deactivate channel 1. Activate channels 3,4.
2.) Set trigger to channel 4, negative. Set threshold to -7.2 mV. Set trigger horizontal position to the first major tickmark.
3.) Scope settings: channels: 20 mV divisions, x-axis 400 ns at 1.6 ns per point
4.) The scope should look as follows:

5.) Move source position to desired location. Always come at desired point from below.
6.) Recommend taking off-bar cosmic background calibration point at position 9000 first
7.) Take on-bar points at position 8000, 6000, 3000, 1000. 100 units (one revolution on the dial) = 0.5 inches
8.) Go to /home/uboonedaq/EDIT2018/TallBo_daq
9.) Execute: source setup.sh
10.) Execute ./wunderbar
11.) Answer the questions:

"What folder do you want to save in?" today's date (i.e 03-06-18)
"Which trigger type are you using (LED, SiPM, PMT)?" LED
"Which bar are you testing? Insert the bar number (from 1 to 12)" 1
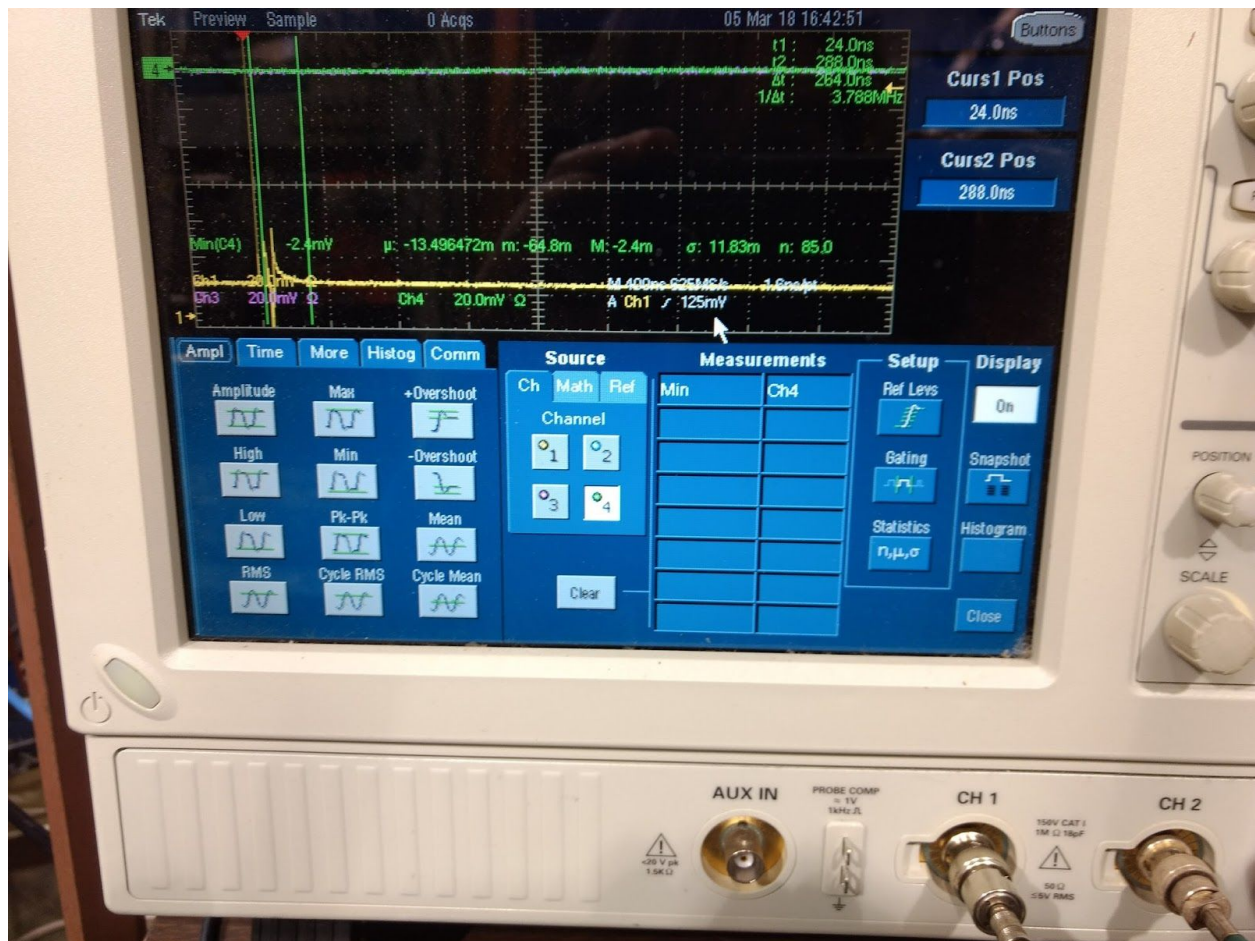"What is the position of the bar?" Position

      12.)   Close computer and collect data. Data will appear in
            /home/uboonedaq/EDIT2018/TallBo_data/03-XX-18
      13.)   After data collection has finished, move source to next point and continue.

Histogramming in the Oscilloscope
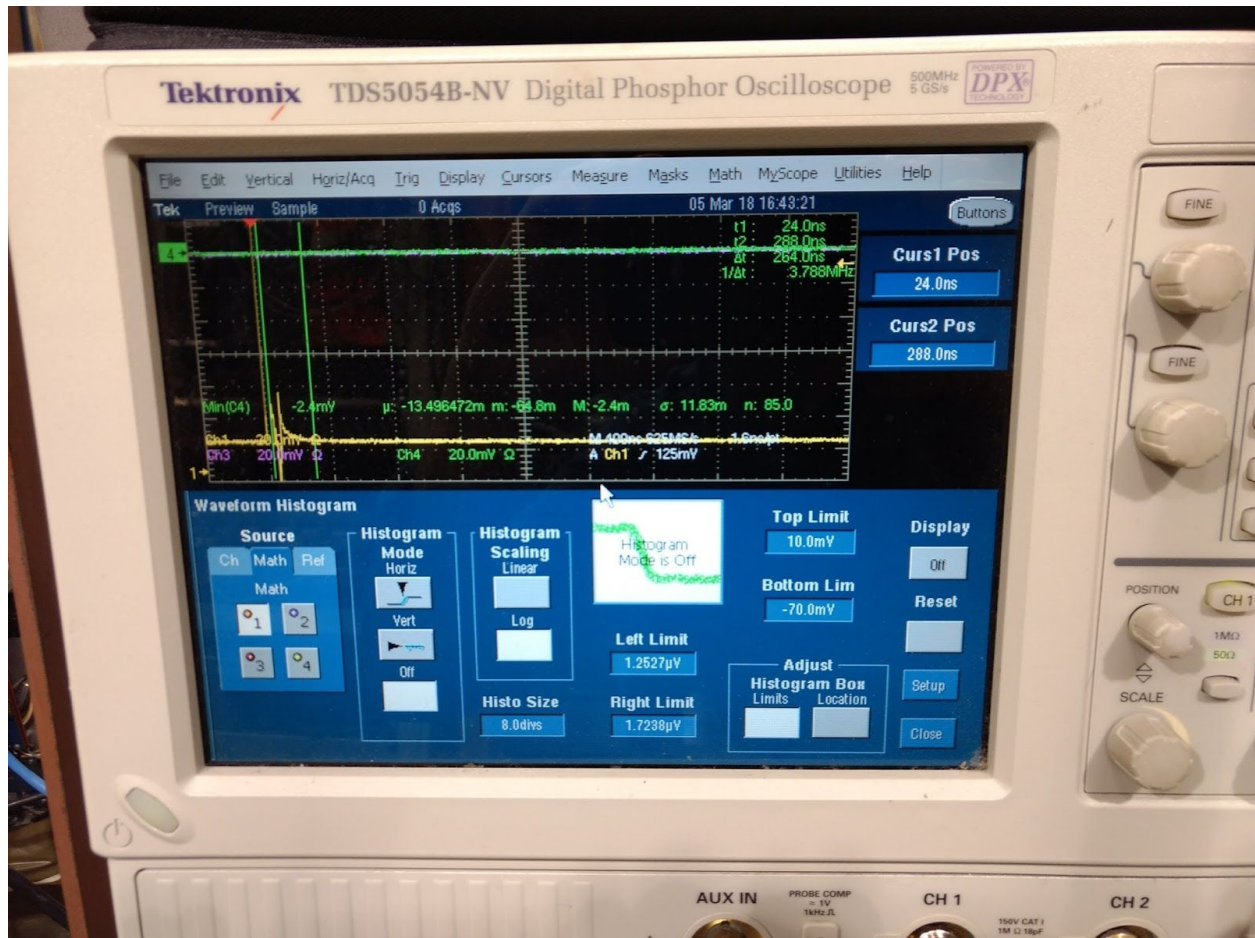
    1.) From top menu select Measure -> Measurement Setup A window appears as shown
        below.

    2.) Select the desired channel and choose the measurement type (i.e. measuring the min of
        channel 4)
    3.) Close measurement window. Then select from top menu Math -> Math Setup A window
        appears as below

4.) Select measurement for the math equation. Selection 0 position for the equation (3.0div in image) and scale between divisions.

5.) Close Math window. Open Measure -> Waveform Histogram to produce window below

6.) Select math equation. Select a vertical histogram. Adjust vertical cursors on scope to desired window. Select top and bottom limits of histogram scale. Turn the display on.

Data Analysis
1.) Sample analysis programs located in /home/uboonedaq/EDIT2018/TallBo_analysis
2.) A sample LED calibration run and PMT triggered run are located in /home/uboonedaq/EDIT2018/TallBo_analysis/sampleData
3.) The root files contain the tree "waveformdata" with branches for each oscilloscope channel. Branch "ch3wfms" is the cosmic veto branch and "ch4wfms" is the readout PMT. Each event is one 2500 sample waveform. Points are spaced at 1.6 ns. Entries are stored in units of volts.
4.) TallBoPulseAnalysisPMT.py and TallBoPulseAnalysisLED.py are python scripts that can convert ROOT files into summary charge, amplitude, and pedestal histograms for further analysis. Integration windows have been set based on trigger location
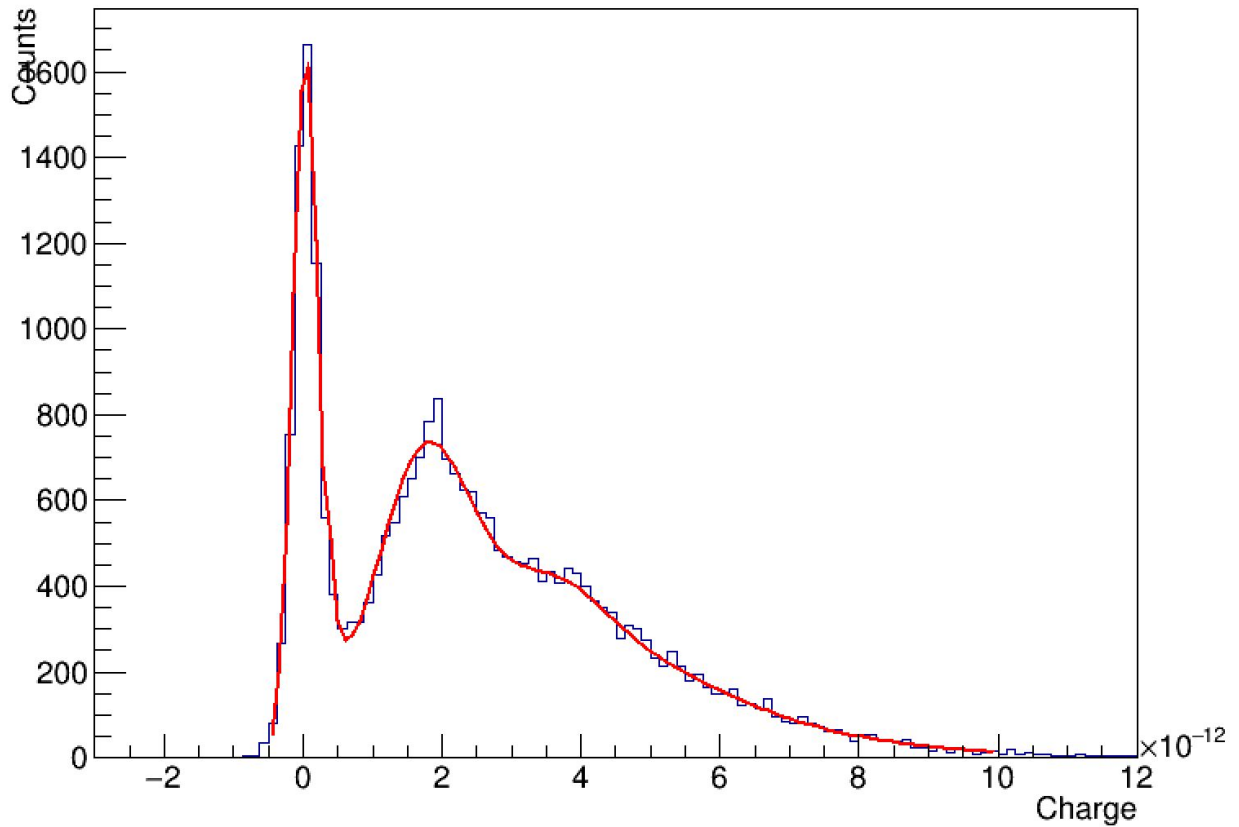
5.) FitterLED.C performs a fit to the LED calibration data to extract a measurement of the PMT gain and FWHM of the single PE distribution. The fit is done to a gaussian convolved with a Poisson distribution of the form

$$F(x) = \sum_{n=0}^{n=20} \frac{e^{-\mu_{pe}} \mu_{pe}^n}{n!} \frac{1}{\sqrt{2\pi}\sigma_n} e^{\frac{(x-\mu_{ped}-ngq)^2}{2\sigma_n^2}}$$
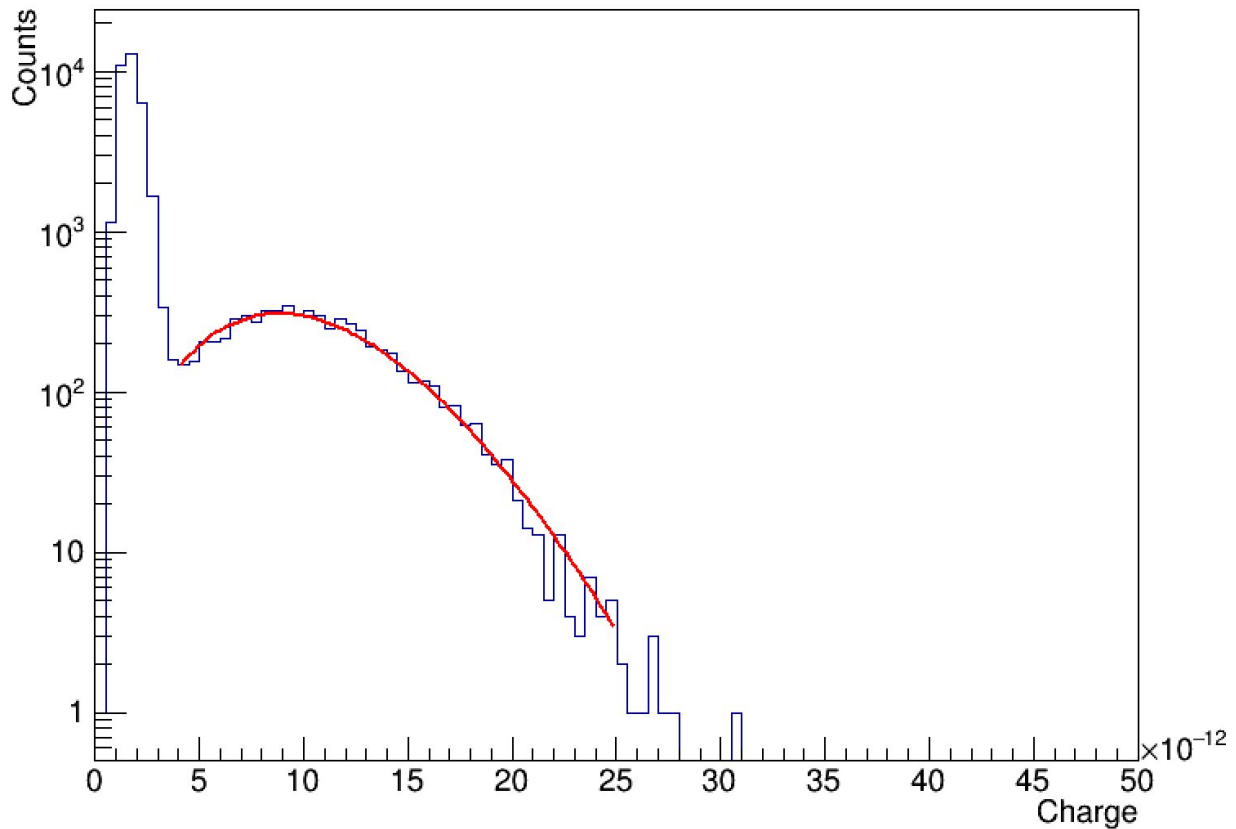
$$\sigma_n = \sqrt{n\sigma_{spe}^2 + \sigma_{ped}^2}$$

6.) An additional exponential component may be needed to fill in the dip between the 0 and 1 PE peaks

7.) An example of a fit to LED calibration data is below

PMT LED calibration

8.) After extracting a fit parameters from the LED calibration, the PMT triggered data can then be fit to measure an attenuation length. The program FitterPMT.C is an example of this. Ideally a "source-off" reference point should be used to subtract off low PE non alpha source noise from the distribution. The PMT gain and intrinsic FWHM of the single PE distribution are held fixed from the LED calibration. An example of a fit to point point of data (without a background subtraction) is shown below

all cuts, bar: 1 position: 1600

9.) By taking several points of data an attenuation length can be extracted.