n3He Frequency Analysis - Fast Fourier Transform

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n3He DAQ Time Binning

- neutron pulses are at 60 Hz
- $1/60 = 0.0166667$ seconds between neutron pulses
- Clean DAQ
  - 50 kHz sample rate
  - $50\ \mathrm{kHz} \times 0.01667\ \mathrm{s} = 833$ maximum samples per $T0$
  - 830 were used to allow time for triggering
  - 16 samples averaged for each of 49 recorded time bins per pulse
  - $16/(50\ \mathrm{kHz}) = 0.32\ \mathrm{ms}$ per time bin
  - 35 additional samples lost due to read out time
  - 15.68 ms of data taking per neutron pulse
  - 98 ms dead time per pulse

Section 4.2.4 of Kabir, Md Latiful, "A MEASUREMENT OF THE PARITY VIOLATING ASYMMETRY IN THE NEUTRON CAPTURE ON 3He AT SNS" (2017). Theses and Dissertations–Physics and Astronomy. 45.

Time Bin Centers

Each time bin will be assigned a time according to the midpoint of the sample period

Pulse #	Bin #	Start(ms)	End(ms)	Center(ms)
0	0	0	0.32	0.16
0	1	0.32	0.64	0.48
0	2	0.64	0.96	0.80
0	⋮	⋮	⋮	⋮
0	47	15.04	15.36	15.20
0	48	15.36	15.68	15.52
1	0	16.6667	16.9867	16.8267
1	1	16.9867	17.3067	17.1467
1	⋮	⋮	⋮	⋮
1	48	32.0267	32.3467	32.1867
2	0	33.3333	33.6533	33.4933

or in general time bin t in pulse k will have a center time of

$$t(t,k) = (16.6667 \times k + 0.32 \times t + 0.16)\ \mathrm{ms} \tag{1}$$

Motivation

The goal of the FFT analysis is to look at the frequency components of the measured wire yields, and to see if it can offer a cause the oscillations in the asymmetry correlations. If the cause of the variations is resonance with the wires from an external then each wire is expected to have a consistent frequency somewhat near 210 Hz, but each wire is expected to differ somewhat.

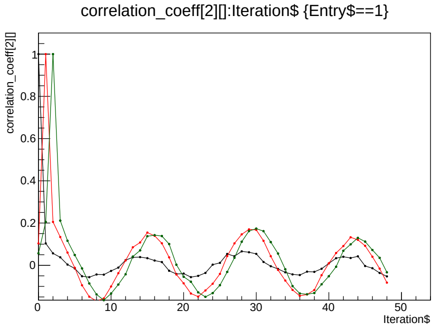

Figure: Correlations for time bins 0,1,2 wire 0 run 17785

Method

- Cern Root has a built in FFT functionality using FFTW (`www.fftw.org/`)
- This FFT package and others require a constant time sampling to work
- The dead time between pulses is not an integer multiple of the time bin length
- This prevent a direct application of Root's FFT package to the data runs
- Two Possible solutions:
  1. Apply the FFT to individual pulses and the combine the results from each pulse in a run
  2. Resample the data by interpolating between the data points to get a set of samples evenly spaced in time

Method 1

- Problems is high noise per pulse, especially when beam is on
- Averaging the pulses may solve the problem

Method 2

- Resampling increases the number of data points by interpolating between the measured pulse values
- Resampling does not increase accuracy of FFT but does create evenly spaced time bins
- This increases FFT processing time and memory requirements
- 833 samples per frame at 0.02 ms re-sample intervals
  - Each current 0.32 ms time bin repeats 16 times
  - Remaining 49 time bins can be interpolated by last and first time bins of two pulses
  - Down sides is very large number of time bins in a run
- 119 samples per frame at 0.1401 ms re-sample intervals
  - Fewer samples for faster processing
  - Downside is more interpolation required as time bins don't align as well