n3He Frequency Analysis - FFT Results Comparisions

M. McCrea
University of Kentucky

January 19, 2018

Wire Numbering

y z Beam

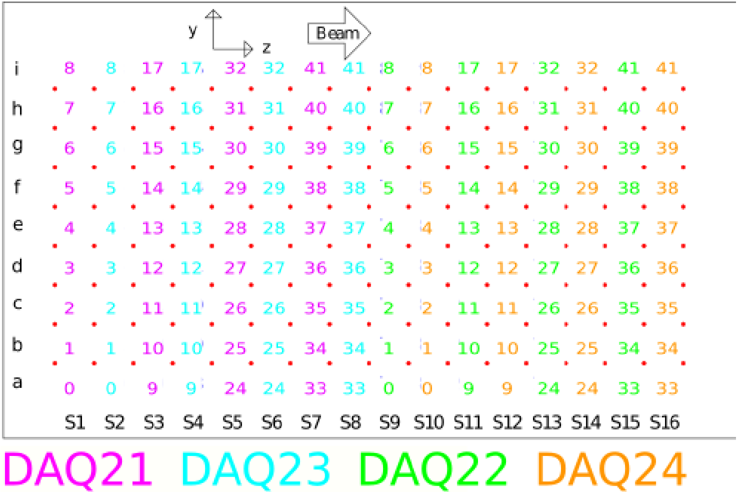
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
i	8	17	26	35	44	53	62	71	80	89	98	107	116	125	134	143
h	7	16	25	34	43	52	61	70	79	88	97	106	115	124	133	142
g	6	15	24	33	42	51	60	69	78	87	96	105	114	123	132	141
f	5	14	23	32	41	50	59	68	77	86	95	104	113	122	131	140
e	4	13	22	31	40	49	58	67	76	85	94	103	112	121	130	139
d	3	12	21	30	39	48	57	66	75	84	93	102	111	120	129	138
c	2	11	20	29	38	47	56	65	74	83	92	101	110	119	128	137
b	1	10	19	28	37	46	55	64	73	82	91	100	109	118	127	136
a	0	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135

- HV — 17 HV Frames with 8 wires each
- Signal — 16 signal Frames with 9 wires each

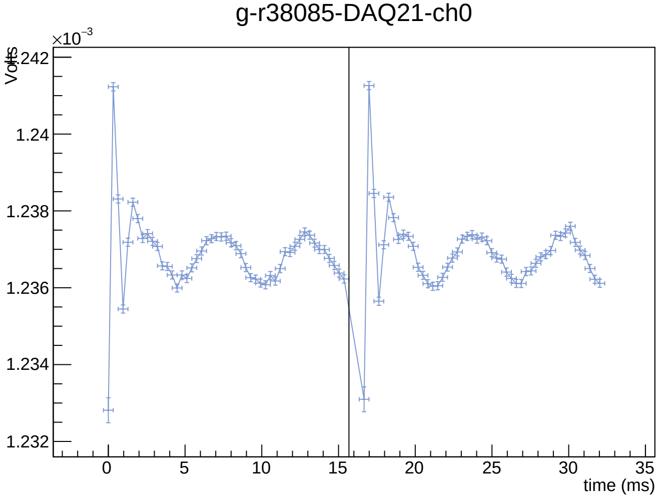
DAQ to Wire Mapping

- 4 Clean DAQs were used for data taking
- each DAQ had 48 channels
- 144 wires / 4 DAQs = 36 wires per DAQ
- 12 channels per DAQ were not instrumented

DAQ to Wire Position Mapping

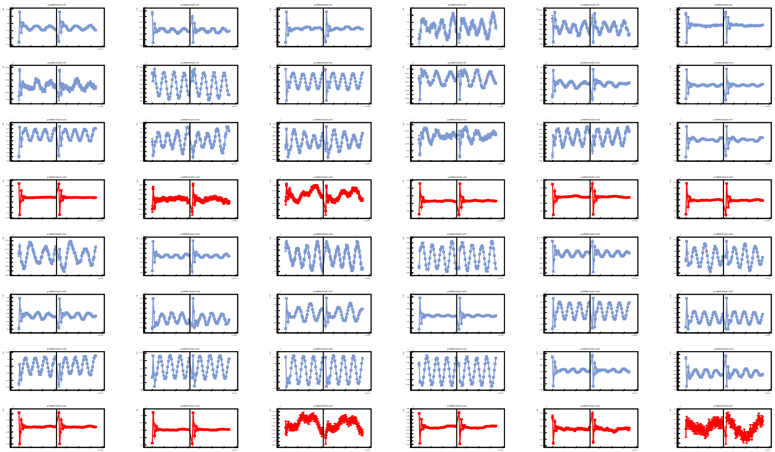


Average Wire Signal Averaged Over Pulse Pairs



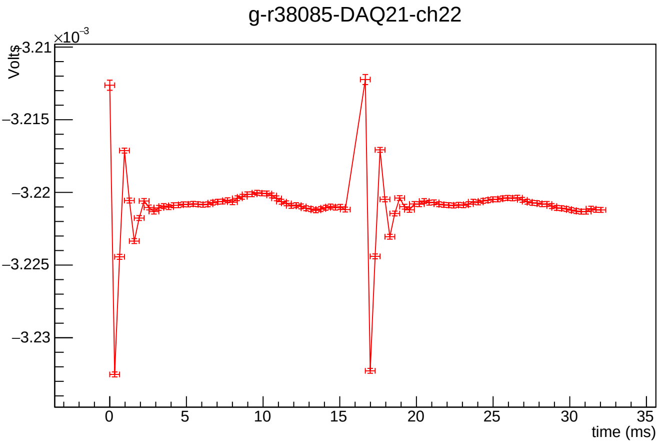
Horizontal Error bars are time bin width, vertical error bars are the standard error of the average of the time bin signal over the run. All even pulses are averaged for the run on the left, and all odd pulses on the right.

All channels from DAQ21



x-axis are the same, y-axis are different. Blue plots are DAQ channels connected to wires, red plots are not connected.

Average Wire Signal Averaged Over Pulse Pairs

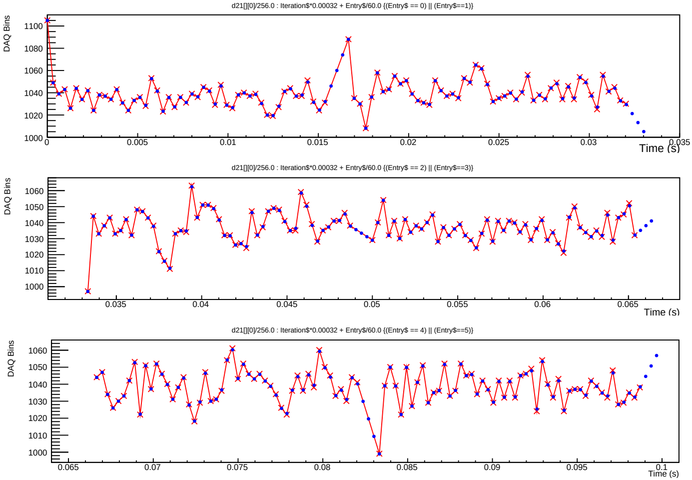


Horizontal Error bars are time bin width, vertical error bars are the standard error of the average of the time bin signal over the run.

Method

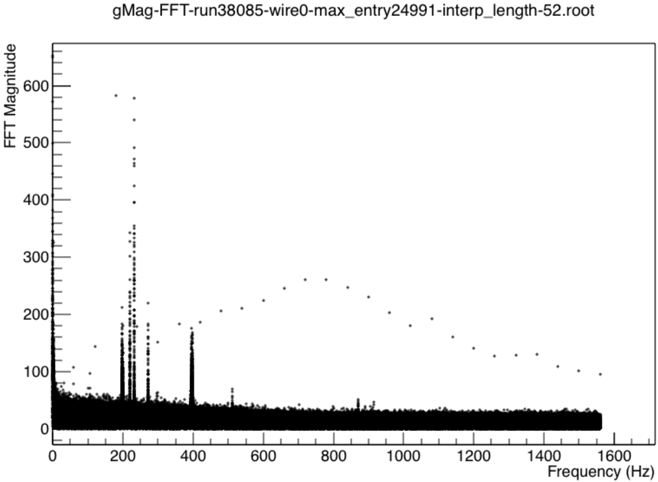
- Use linear interpolation between the existing data points to give 52 evenly space time bins per DAQ frame from the original 49 time bins using the interpolation functionality from Cern Root's MathMore library.
- After interpolating a complete run use Cern Root's FFT capability to perform an FFT of the data.
- Analyze FFT results to find frequencies of interest

Linear Interpolation Results - First 6 pulses



Red is original data points, blue interpolated data points.

FFT Magnitude - r38085 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

Tuesday Run List

Tuesday Run List

Date Range	Initial Run	Final Run			
T1	17784	17834	T9	32503	32535
T2	19114	19158	T10	45032	45054
T3	20444	20493	T11	46416	46466
T4	21869	21919	T12	49663	49697
T5	24011	24061	T13	51076	51127
T6	26461	26503	T14	52467	52517
T7	27729	27755	T15	56073	56076
T8	30058	30074			

Runs were taken between 9:00am and 4:00pm while beam was off for maintenance, and the total time each Tuesday the beam was off time was variable.

Subsets of these runs will be used to examine the stability over time of the frequencies present in each wire.

Model of Wire Noise

- The target chamber wires can be modeled as damped harmonic oscillators driven by external vibrations
- The external vibrations can be assumed to have a broad spectrum, this spectrum may be white or may have some peaks present.
- Vibrations of the wires are most easily excited at their resonance frequency.
- Due to the vibrations the spacing between pairs of wires will vary at the vibration frequencies of both wires.
- Changes of position in the wires held at a constant potential induces a current in the wires.

Model Expectations

- An FFT of the wire output current will show the frequencies signal frequency that are present in the signal from the wires, preamps, and DAQ combined.
- Five peaks are expected, one for the signal wire, and 4 for the surrounding high voltage wires
- Peaks related to the 60 Hz DAQ transient are expected
- Two adjacent signal wires will be expected to have the same peaks from the two HV wires between them.
- Odd harmonics can be induced in the wires by the vibration of the signal planes themselves.
- Next to nearest neighbors should have a reduced effect due to their increased distance forim the signal wire

Future Work

- On a subset of runs begin identifying origin of features in FFT spectral density
  - 60 Hertz peaks likely come from DAQ transient and are fairly consistently located
  - Low intensity background that likely comes from preamps, check noise vs $\sqrt{Hz}$
  - Most wires have a group of peaks at $180 - 260$ hertz, likely from vibrations of nearby wires
  - other un-identified peaks need further examination
- Perform FFT on a small subset of runs
  - examine relationship between signals and FFTs in detail
  - develop peak identification tools
  - See what features are specific to the DAQ by comparing instruments and un-instrumented DAQ channels
- Perform FFT and large subset of beam off runs, then locate and identify all peaks of interest to see if frequencies are constant or long time periods
- See how the RMS of the asymmetry calculated over a run changes with the integration window

n3He DAQ Time Binning

- neutron pulses are at 60 Hz
- $1/60 = 0.0166667$ seconds between neutron pulses
- Clean DAQ
  - 50 kHz sample rate
  - 16 samples averaged for each of 49 recorded time bins per pulse
  - $16/(50\ \mathrm{kHz}) = 0.32\ \mathrm{ms}$ per time bin
  - 15.68 ms of data taking per neutron pulse
  - 0.98 ms dead time per pulse
- $t(t, k) = (16.6667 \times k + 0.32 \times t)\ \mathrm{ms}$

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.