n3He Frequency Analysis - Initial FFT Results

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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
  - 16 samples averaged for each of 49 recorded time bins per pulse
  - $16/(50\ \mathrm{kHz}) = 0.32\ \mathrm{ms}$ per time bin
  - $15.68\ \mathrm{ms}$ of data taking per neutron pulse
  - $0.98\ \mathrm{ms}$ 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.

FFT Frequency and Resolution Limits

- Nyquist–Shannon sampling theorem states the maximum frequency, f_{max}, is $1/2$ the sampling frequency
- A FFT with an input of N samples returns a real and imaginary array of length $N/2$.
- The frequency bin resolution is then

$$\Delta f = \frac{f_{max}}{N/2} \tag{1}$$

- for a constant sampling rate the longer data is taken the better the frequency resolution.
- For the target chamber:

$$f_{max} = \frac{1}{2}\frac{1}{0.00032} = \frac{1}{2}3125 \text{ Hz} = 1562.5 \text{ Hz} \tag{2}$$

$$\Delta f = \frac{1562.5 \text{ Hz}}{24991 * 49} = \frac{1562.5 \text{ Hz}}{1224559} = 0.00128 \text{ Hz} \tag{3}$$

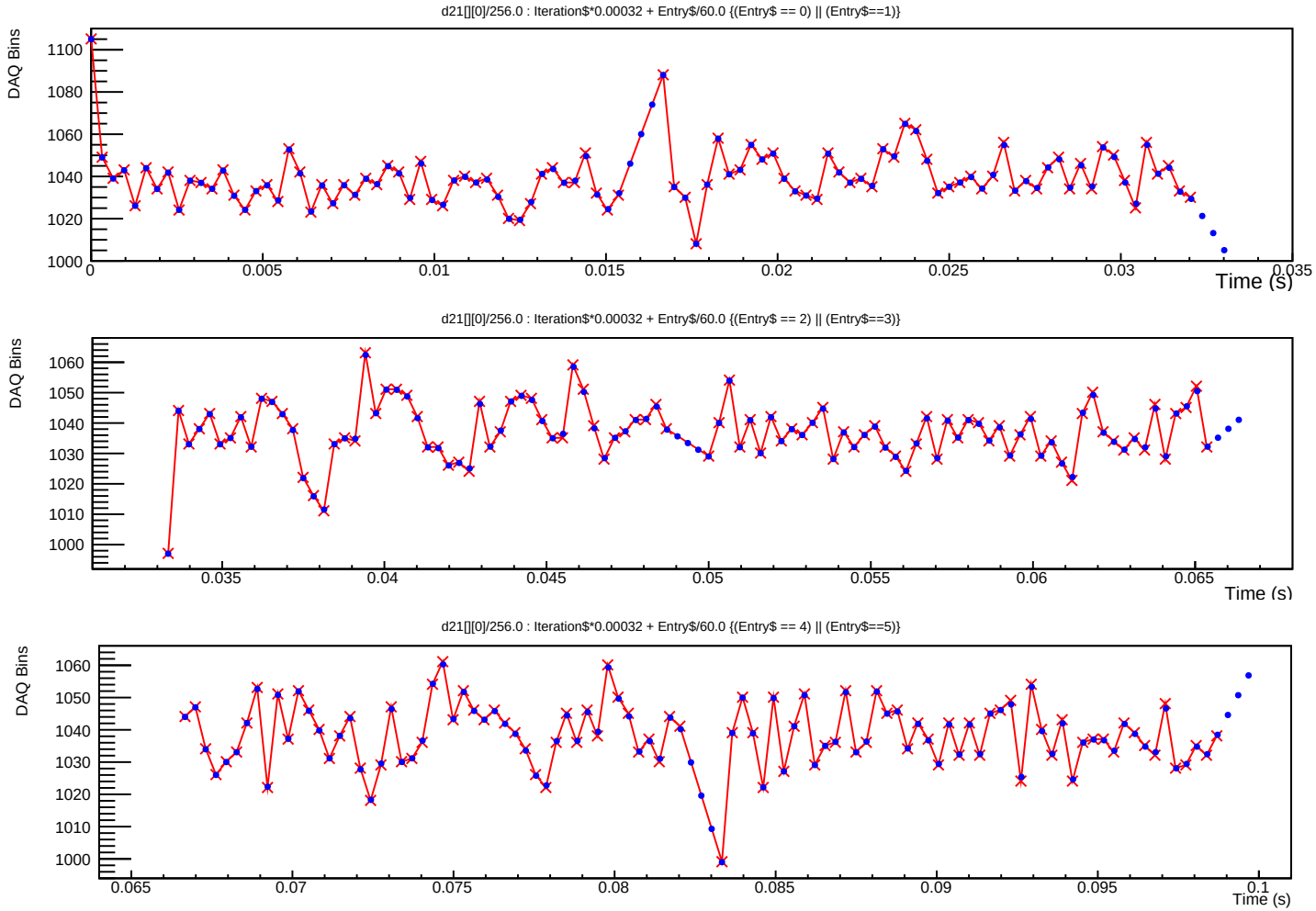
Resampling Motivation

- 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 to allow FFT algorithms to be applied.
- Each additional time bin increases the FFT processing and memory requirements during analysis.
- The goal is then to minimize the number of new samples while smoothly interpolating between the existing data points in a useful way.

Resampling Method 2 - Linear Interpolation

- Cern Root has linear interpolation built in as part of the MathMore library
- By supplying a time and DAQ value to the interpolator for all time bins in a pulse, and the first time bin of the next pulse to the linear interpolator any intermediary values can be calculated.
- For the 0.00032 s time bin width 52.08333 fit per neutron pulse.
- This was truncated to 52 time bins for the linear interpolation.

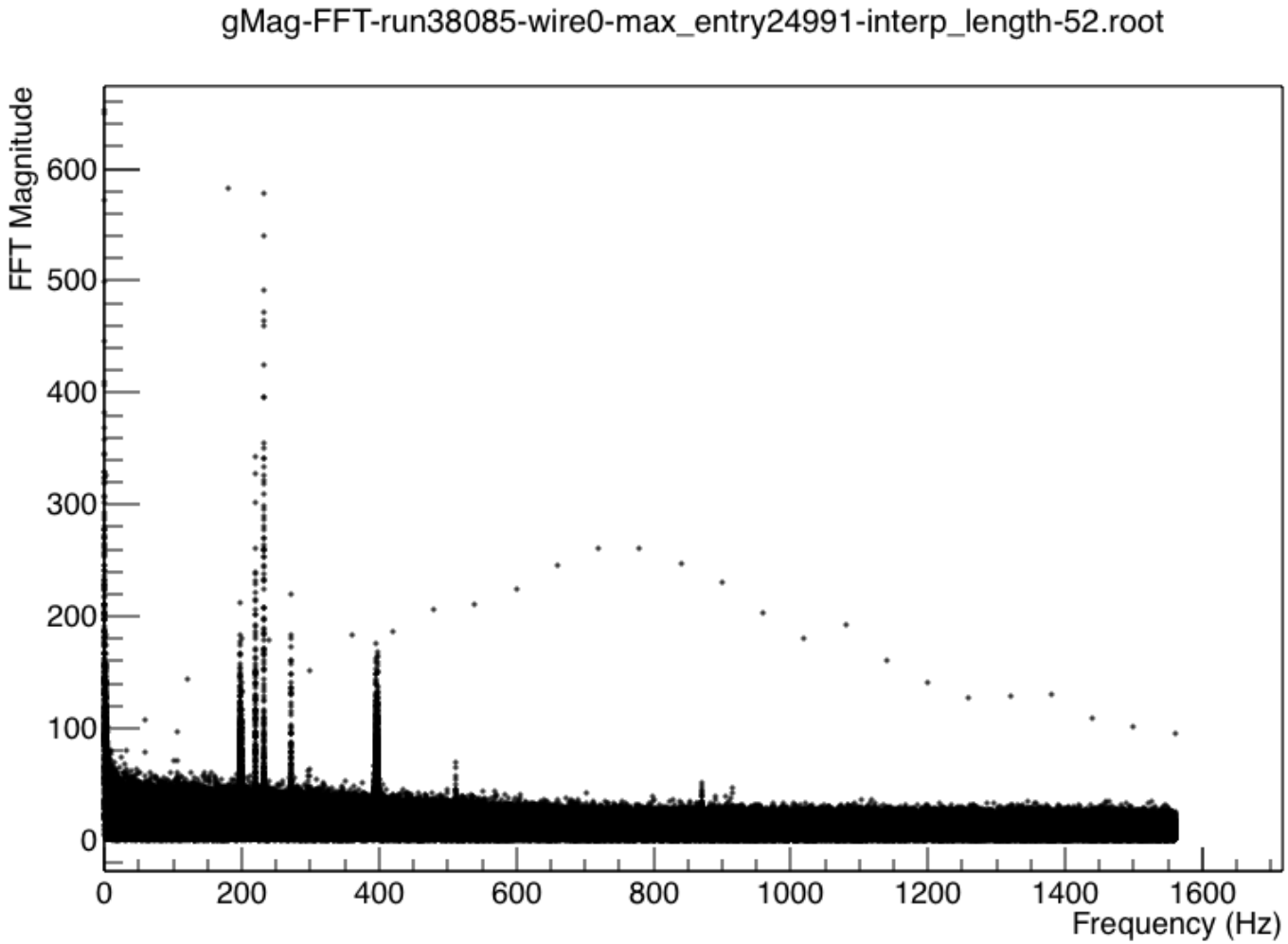
Linear Interpolation Results - First 6 pulses



Red is original data points, blue interpolated data points.

Showing multiple wires in run 38085 wire full frequency range.

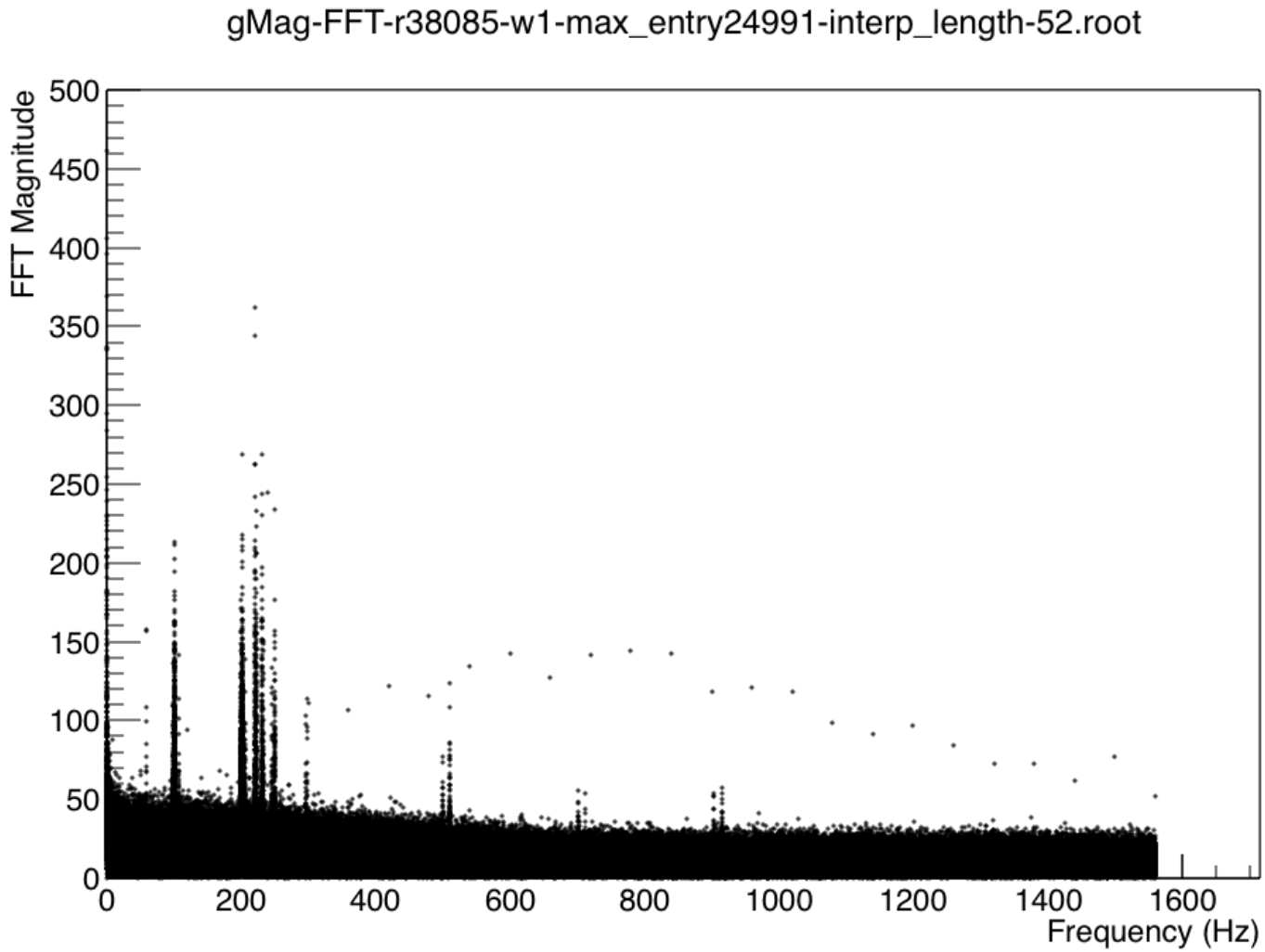
FFT Magnitude - r38085 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

The plot shows the full frequency range of the same data as on slide **??**.

FFT Magnitude - r38085 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

Note: Some peaks have points off the Y-axis range in about 1/3 of plots.

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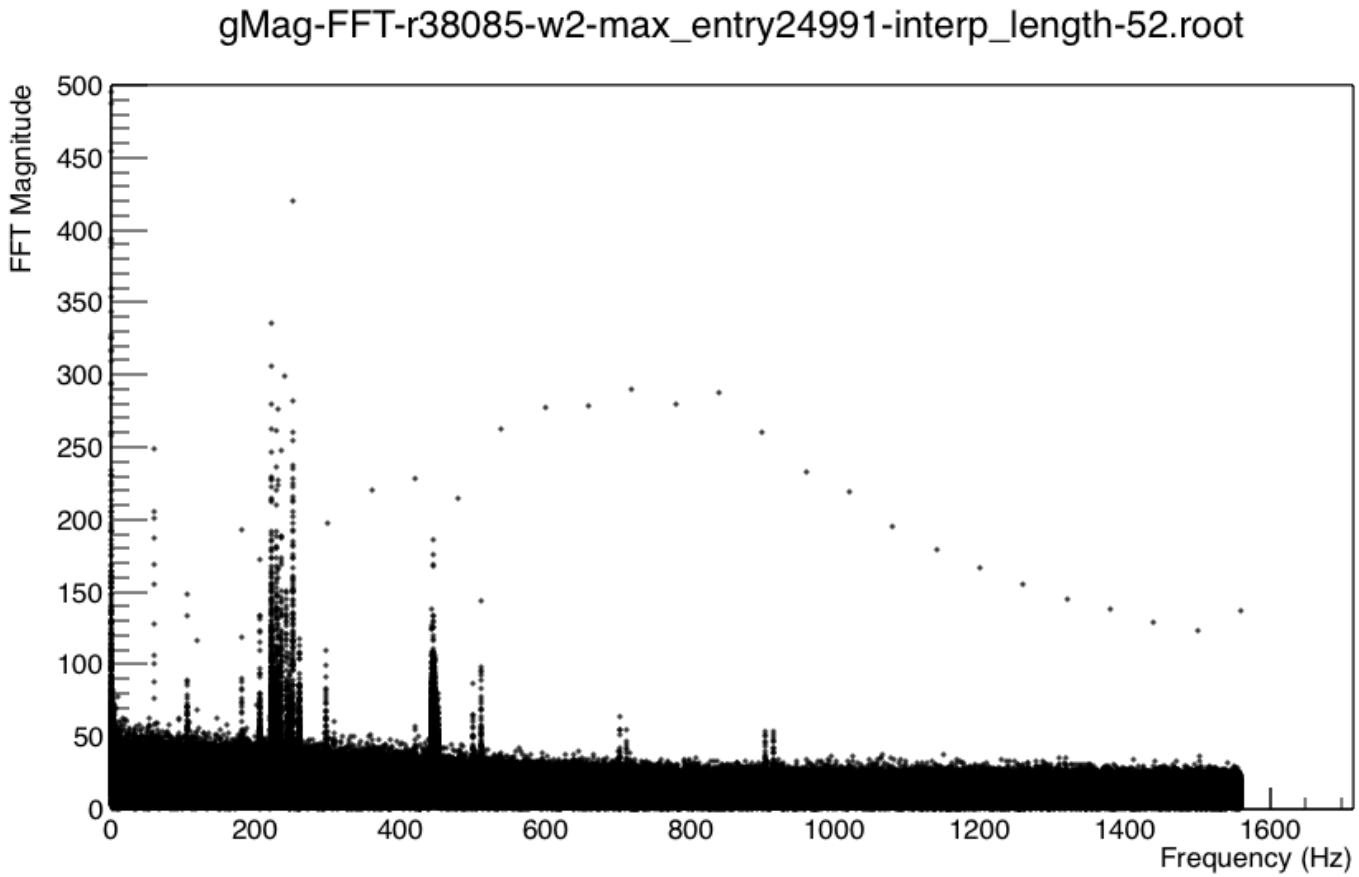

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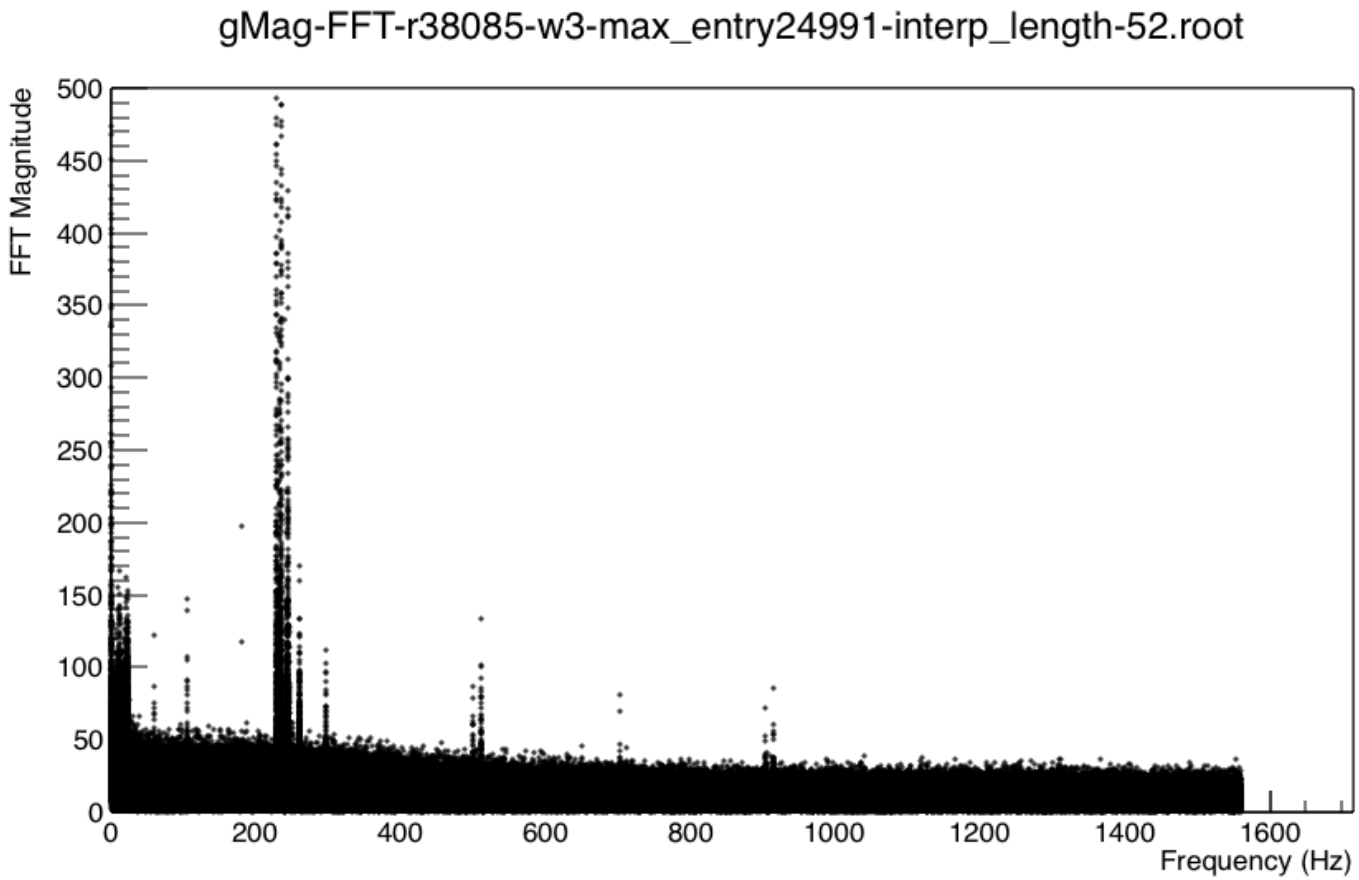

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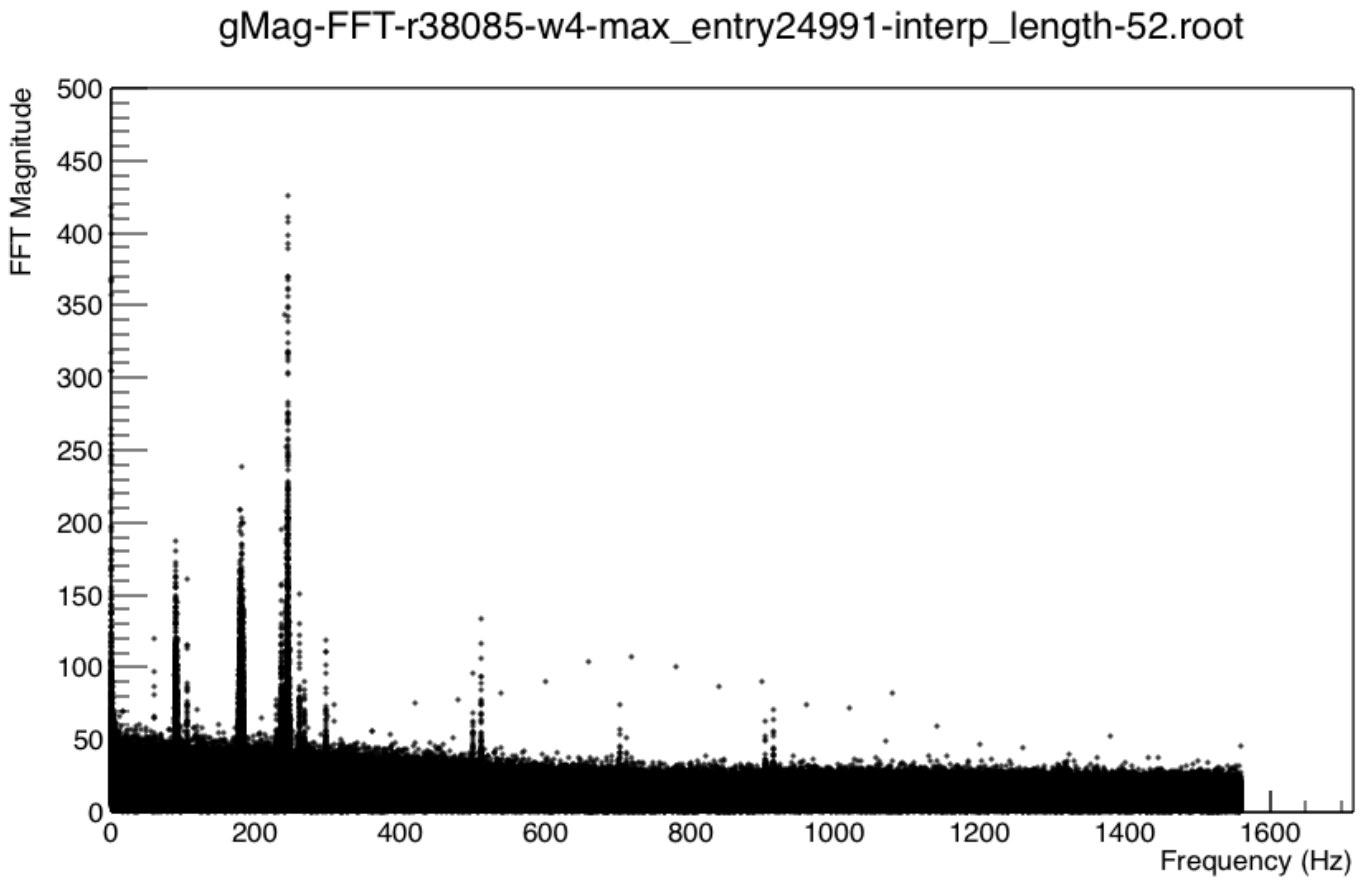
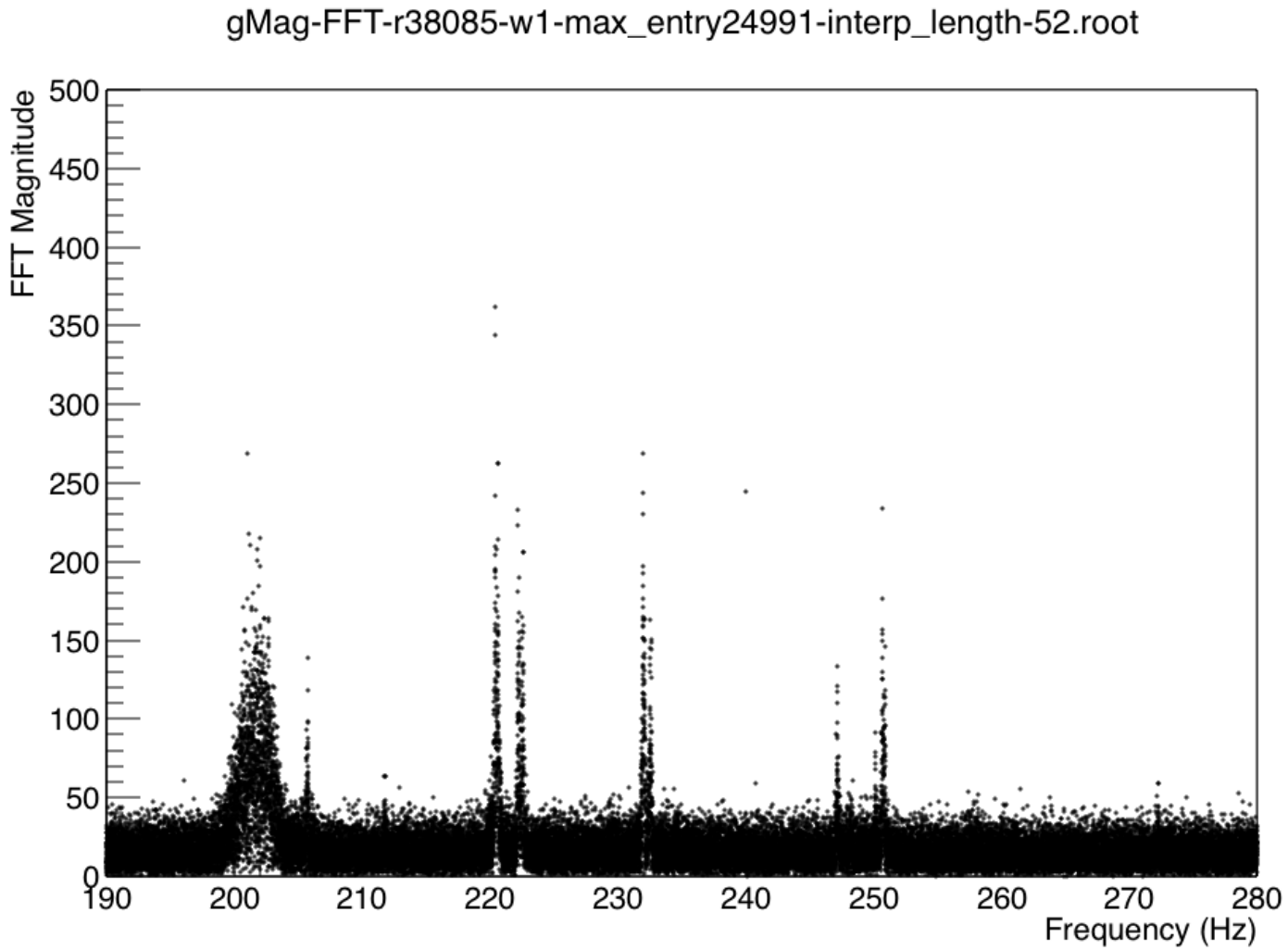


Used Linear Interpolation for Re-sampling.

Note: Some peaks have points off the Y-axis range in about 1/3 of plots.

Showing multiple wires in run 38085 wire zoomed in on frequency range 190-280 Hz.

FFT Magnitude - r38085 - All 24991 Pulses



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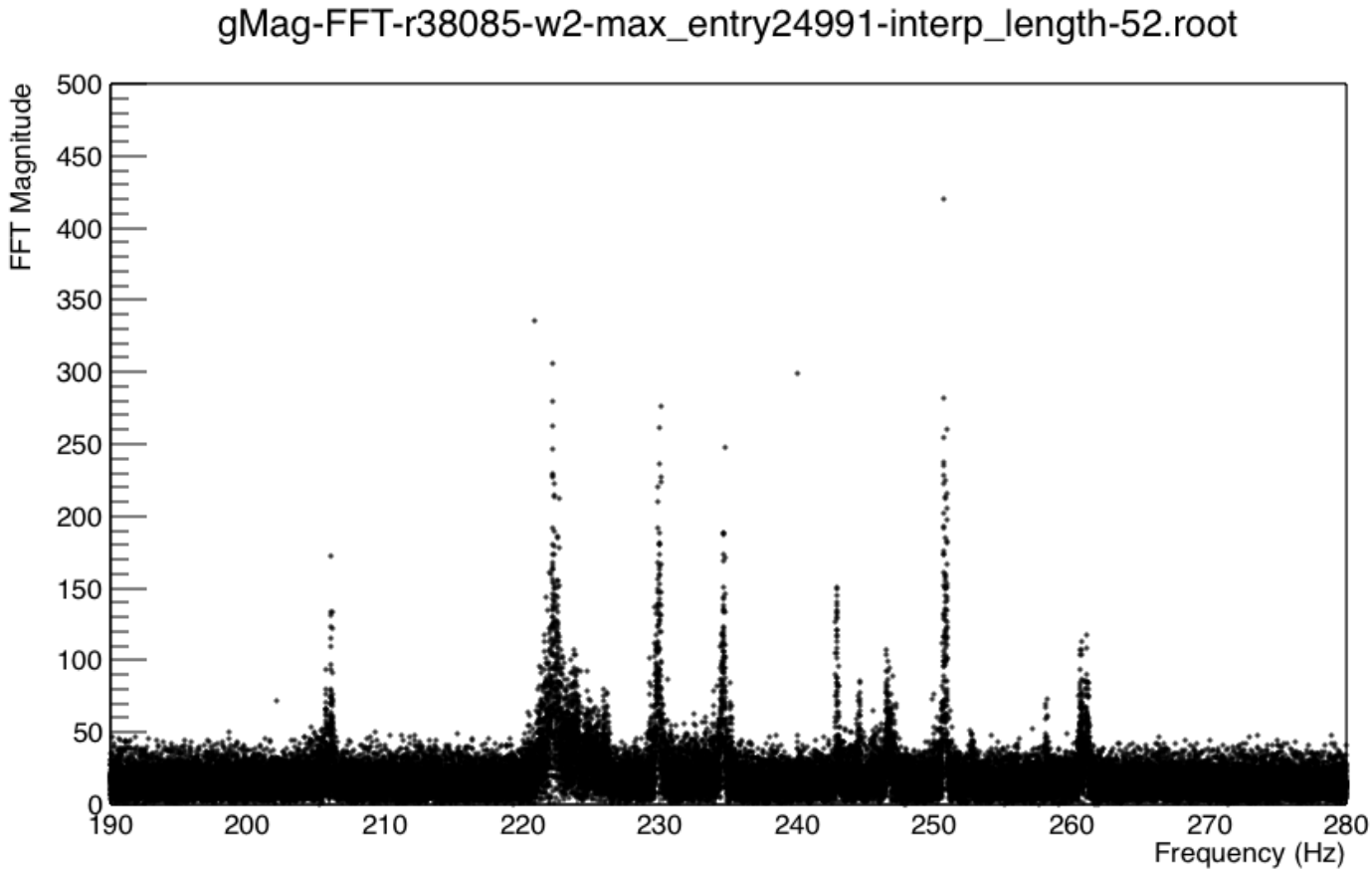

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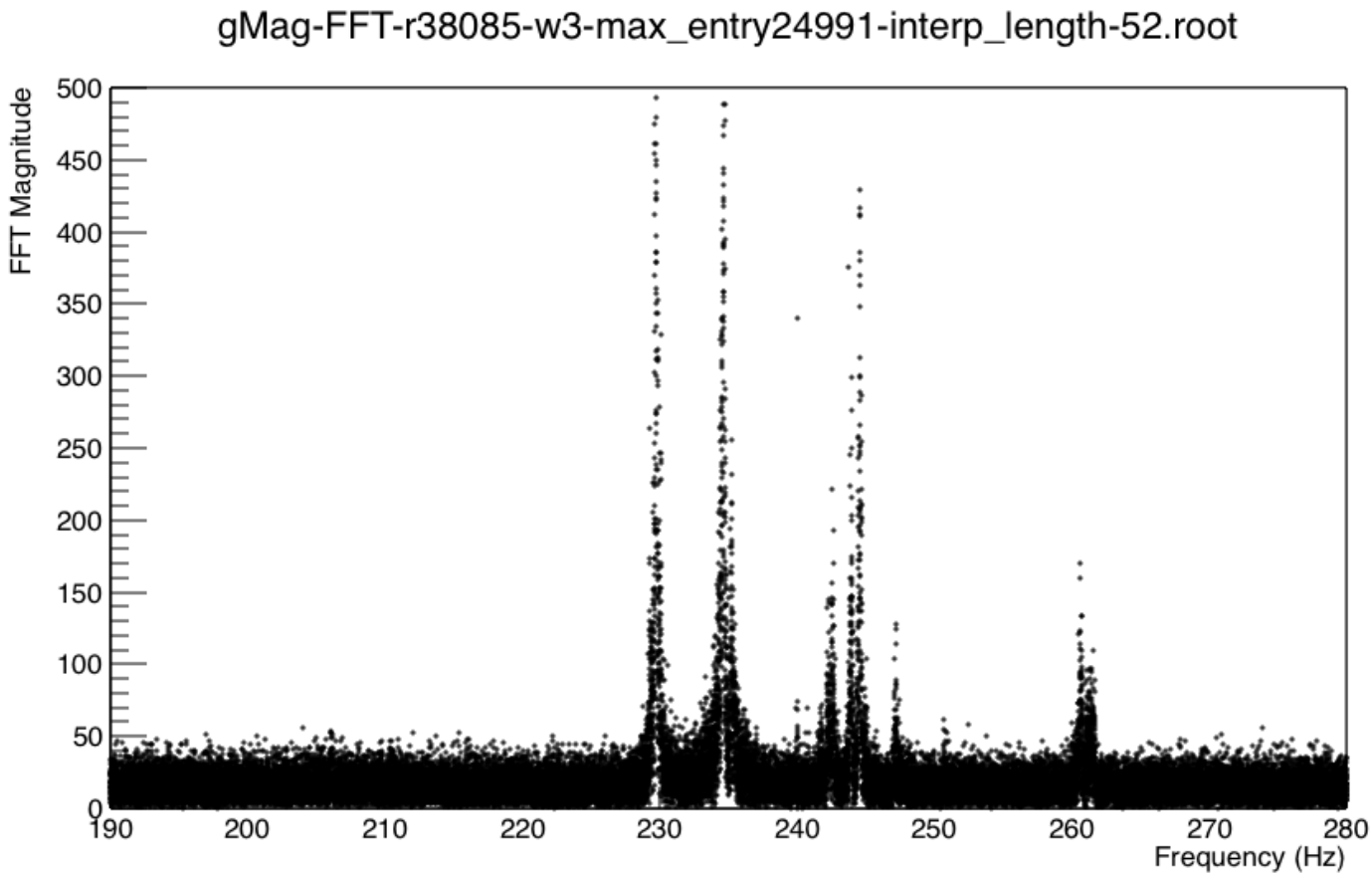

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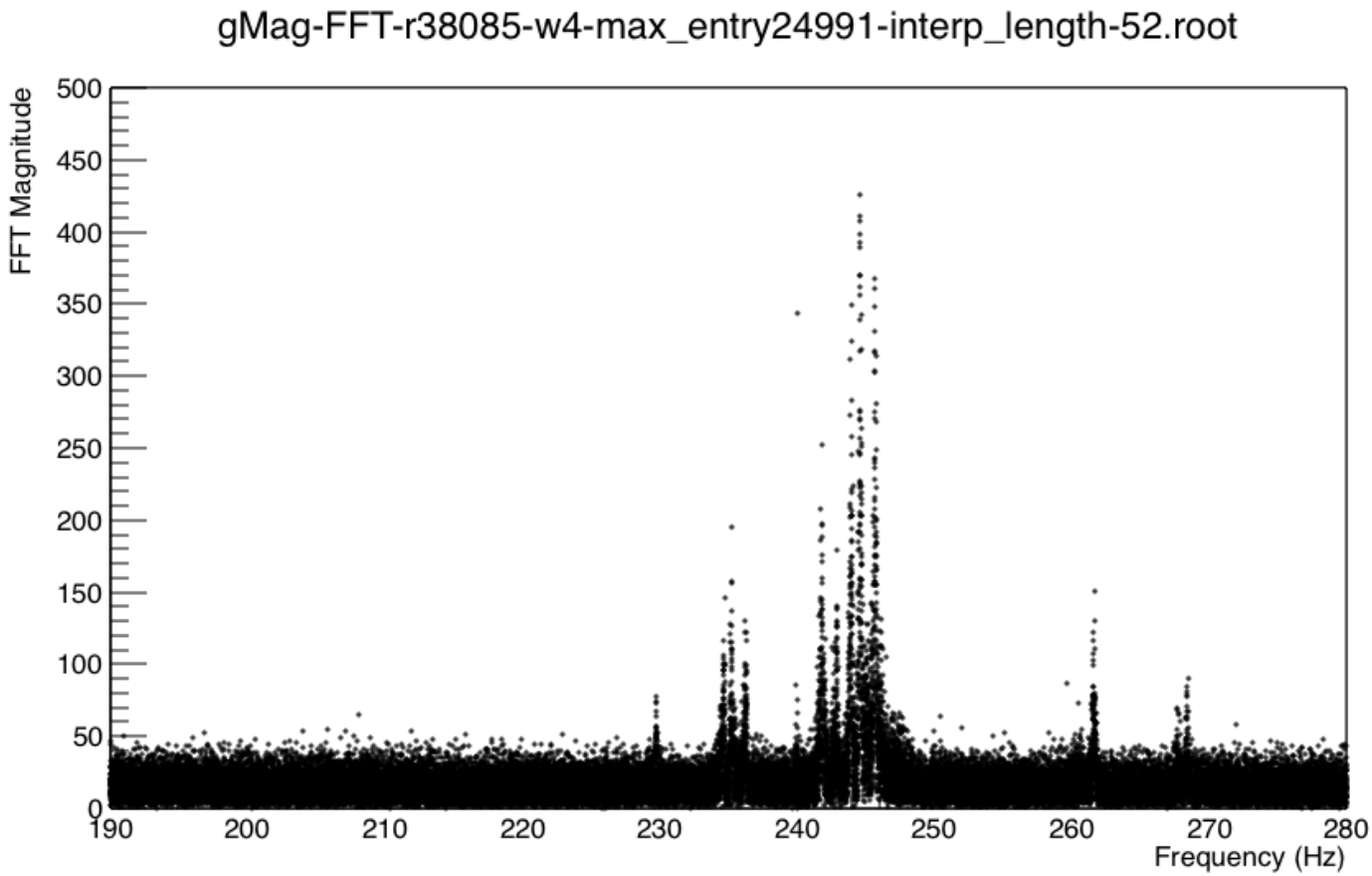

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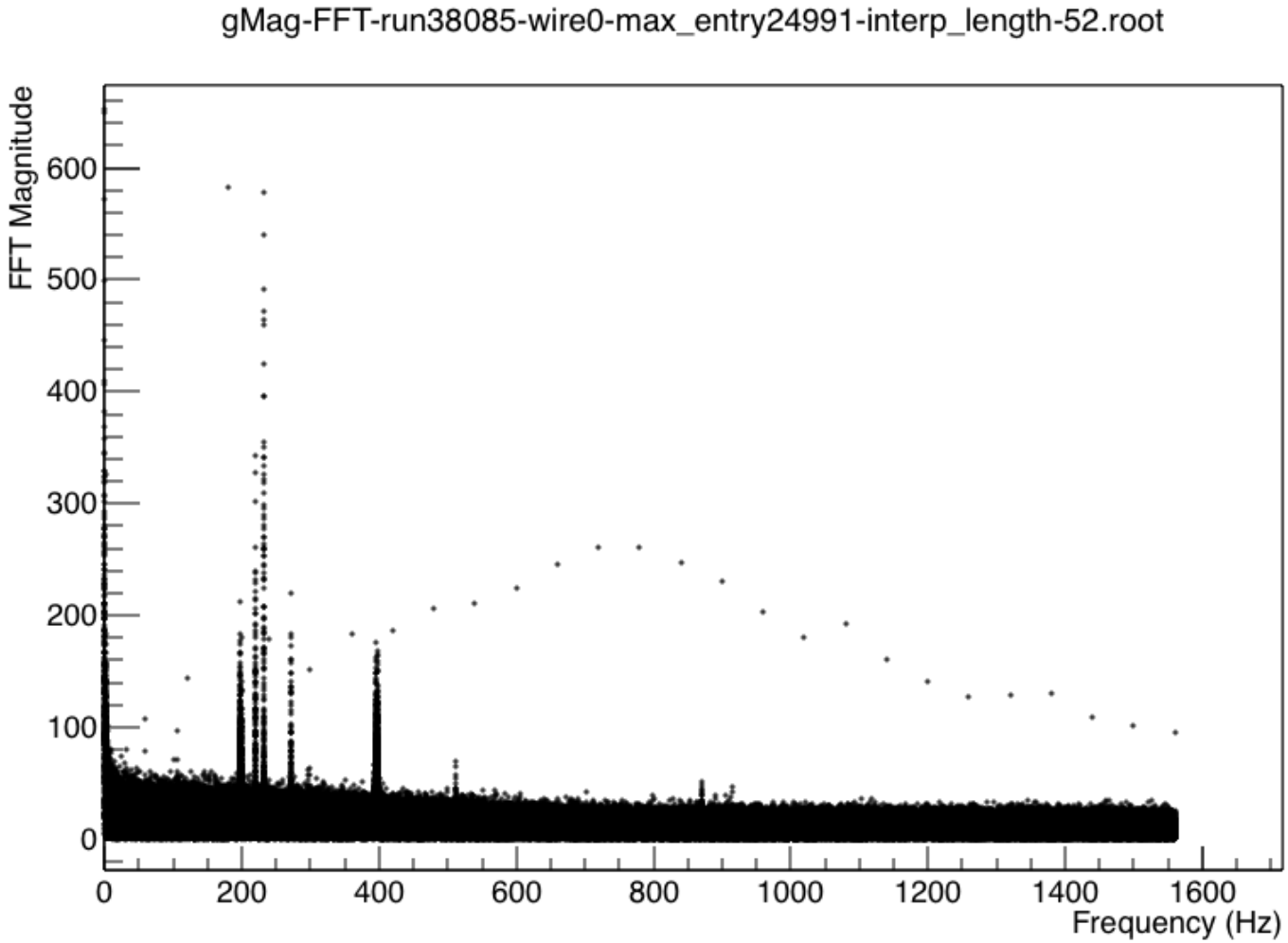
Showing the effect of changing run number on wire 0

FFT Magnitude - r38085 - All 24991 Pulses



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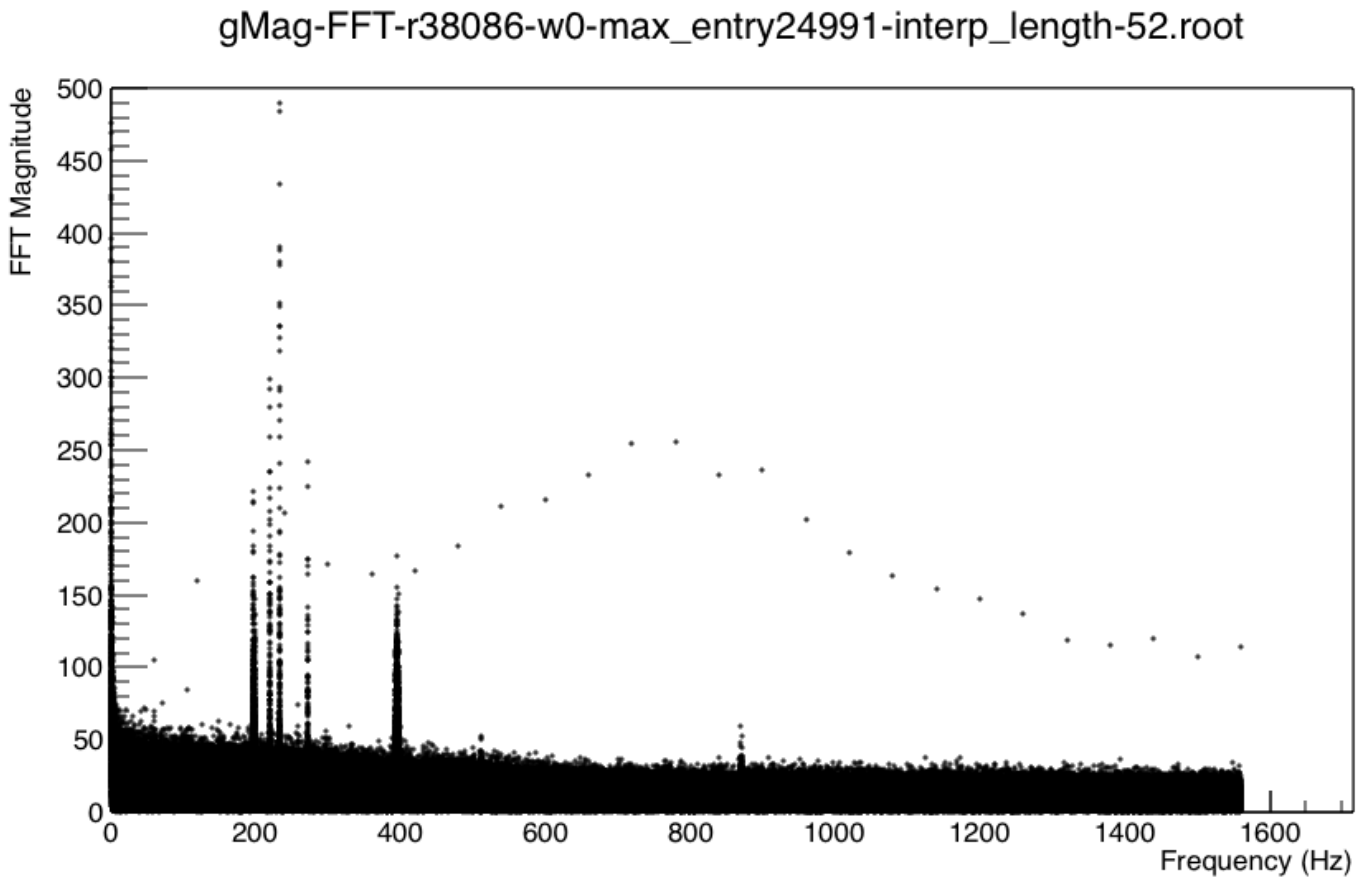
FFT Magnitude - r38086 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

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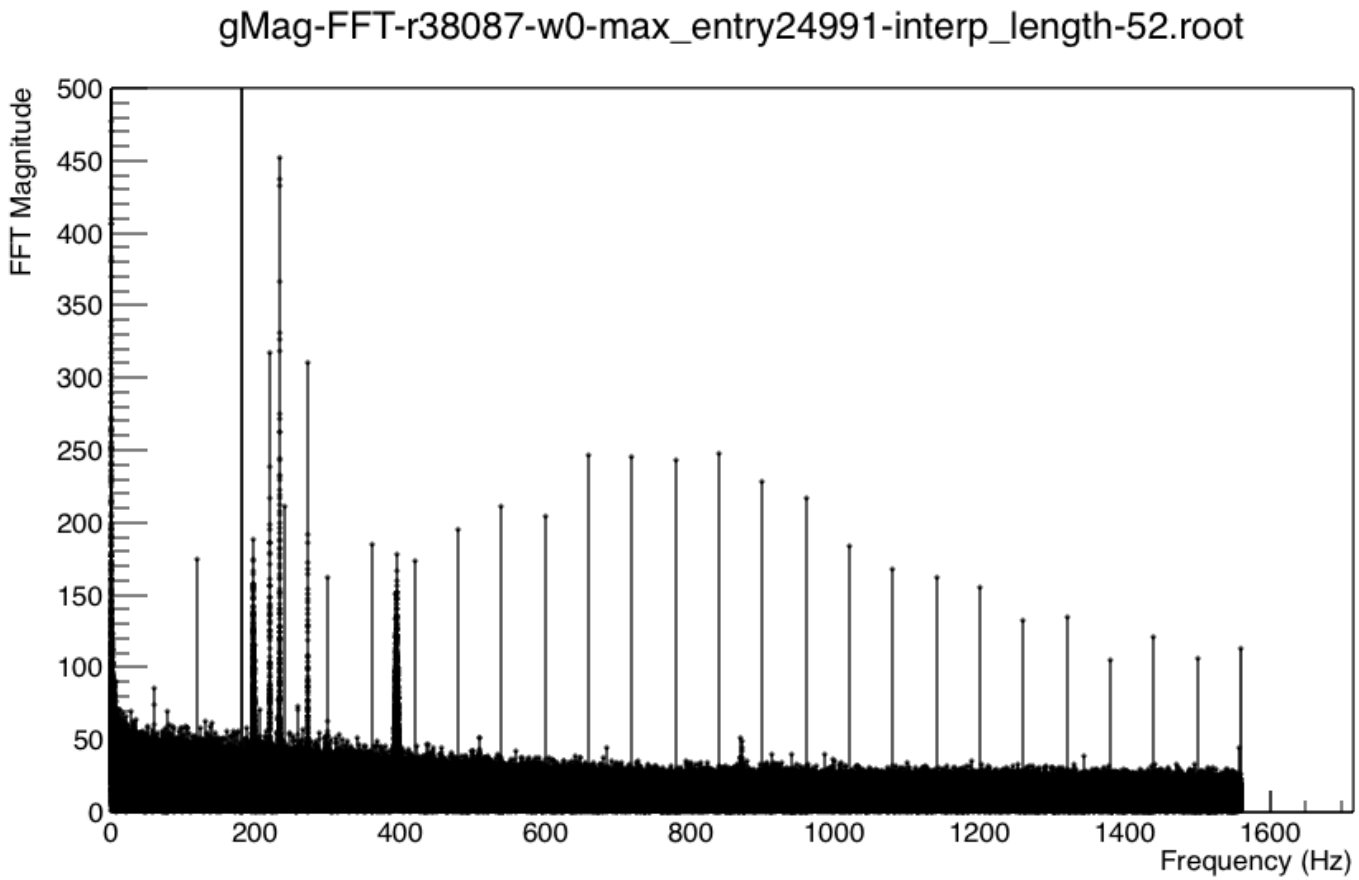
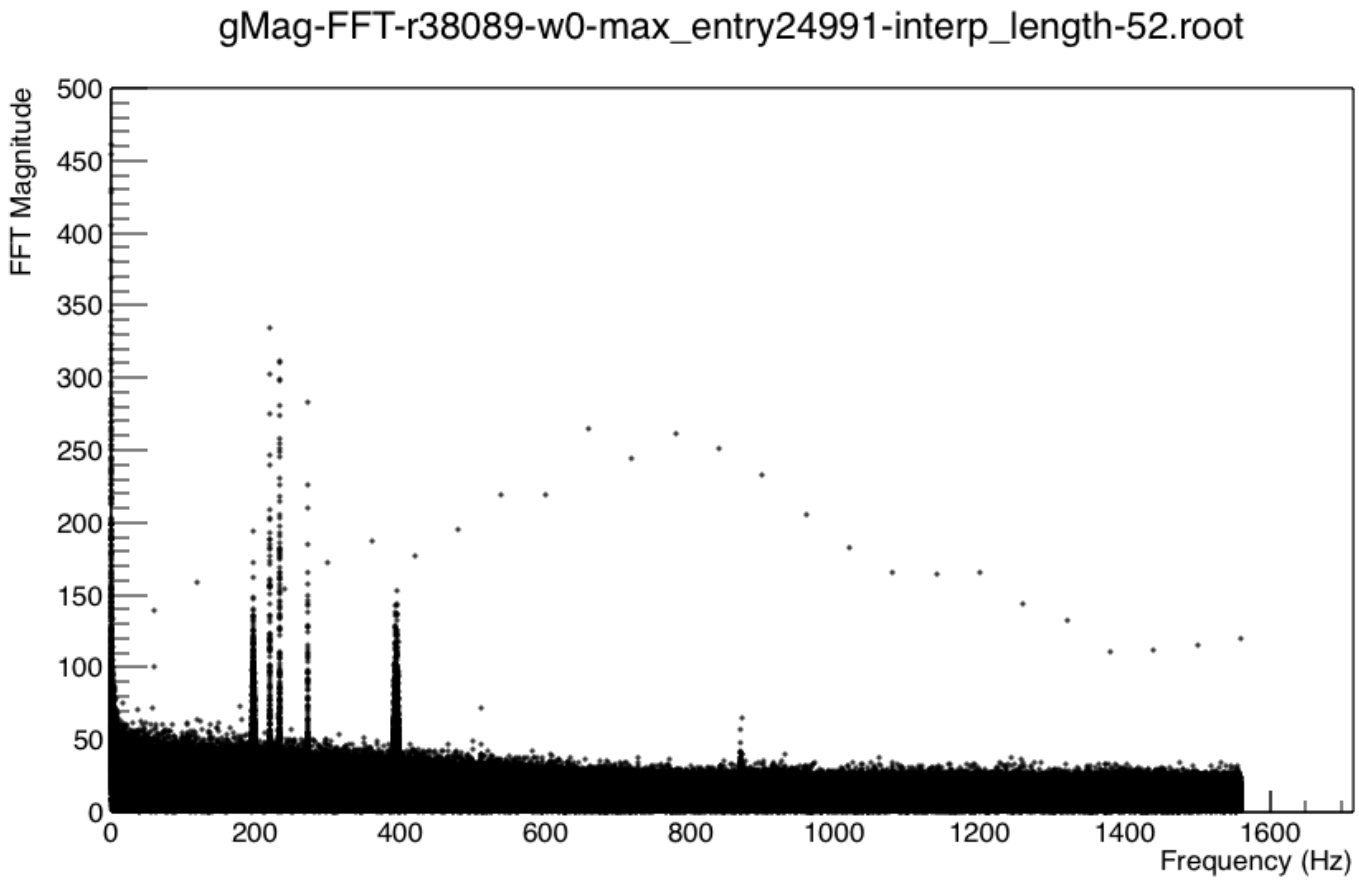
FFT Magnitude - r38087 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

Note: Some peaks have points off the Y-axis range in about 1/3 of plots.

FFT Magnitude - r38089 - All 24991 Pulses



Used Linear Interpolation for Re-sampling.

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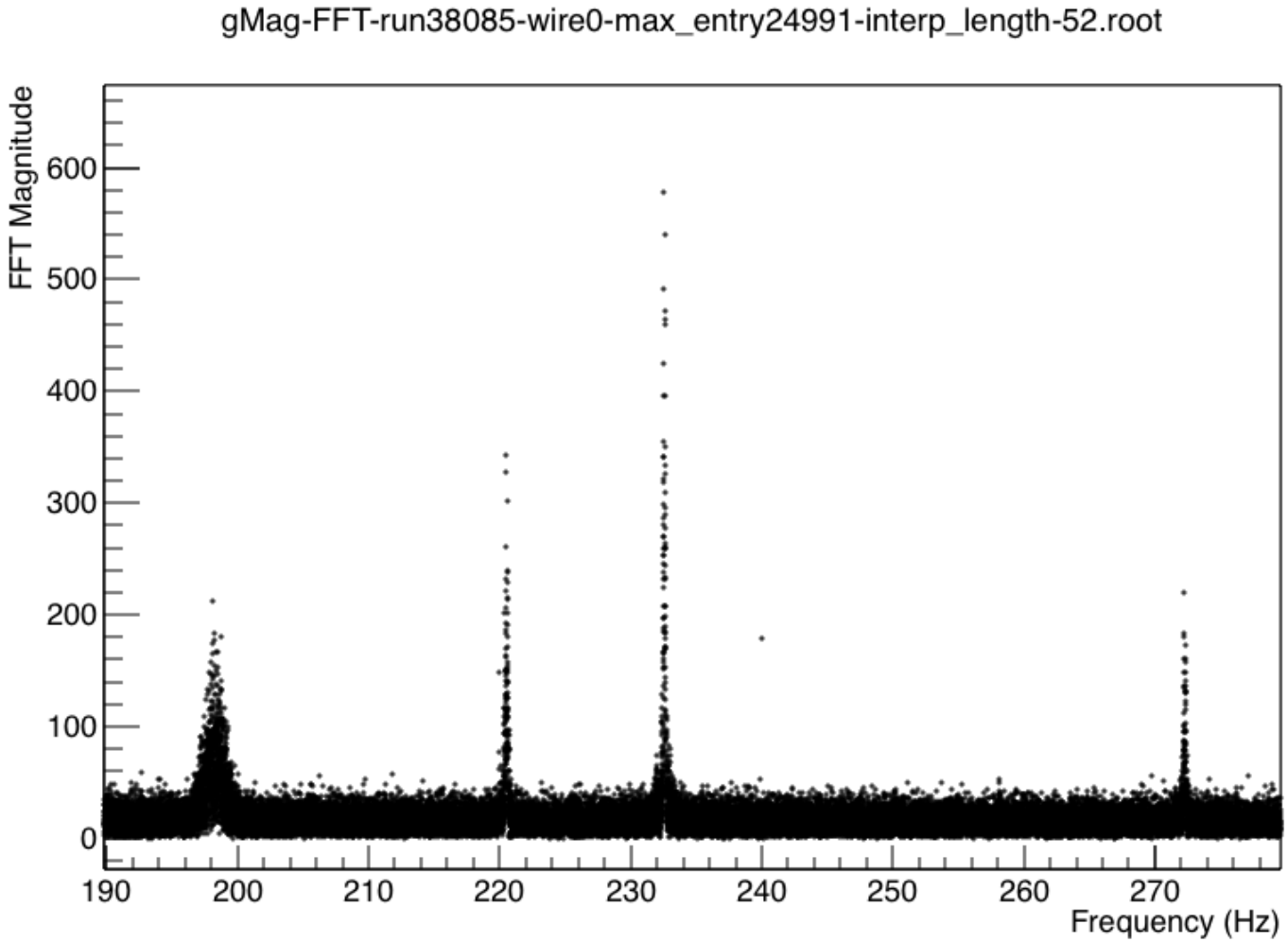
Showing the effect of changing run number on wire 0 zoomed in on frequency range 190-280 Hz.

FFT Magnitude - r38085 - All 24991 Pulses



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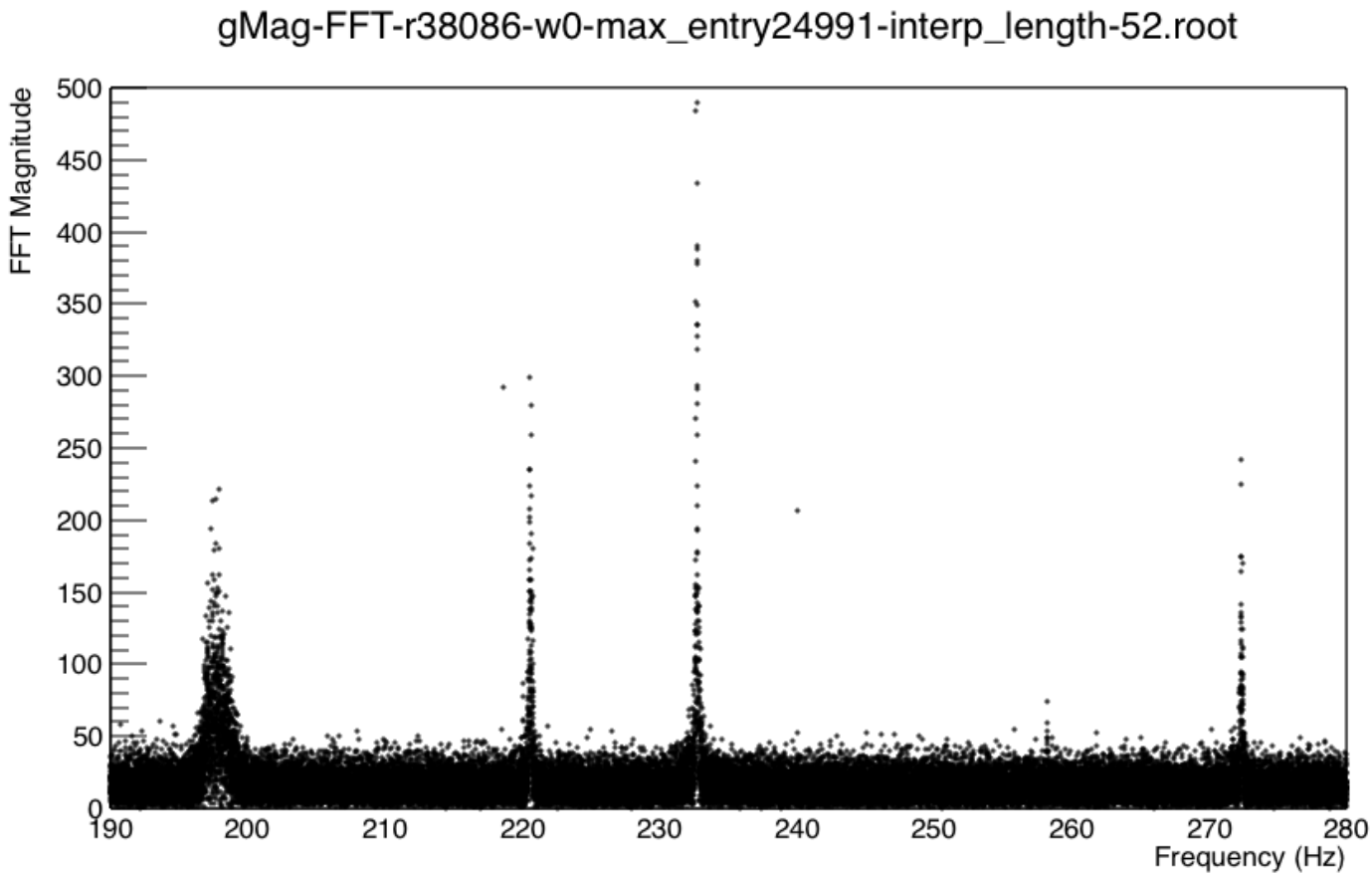
FFT Magnitude - r38086 - All 24991 Pulses



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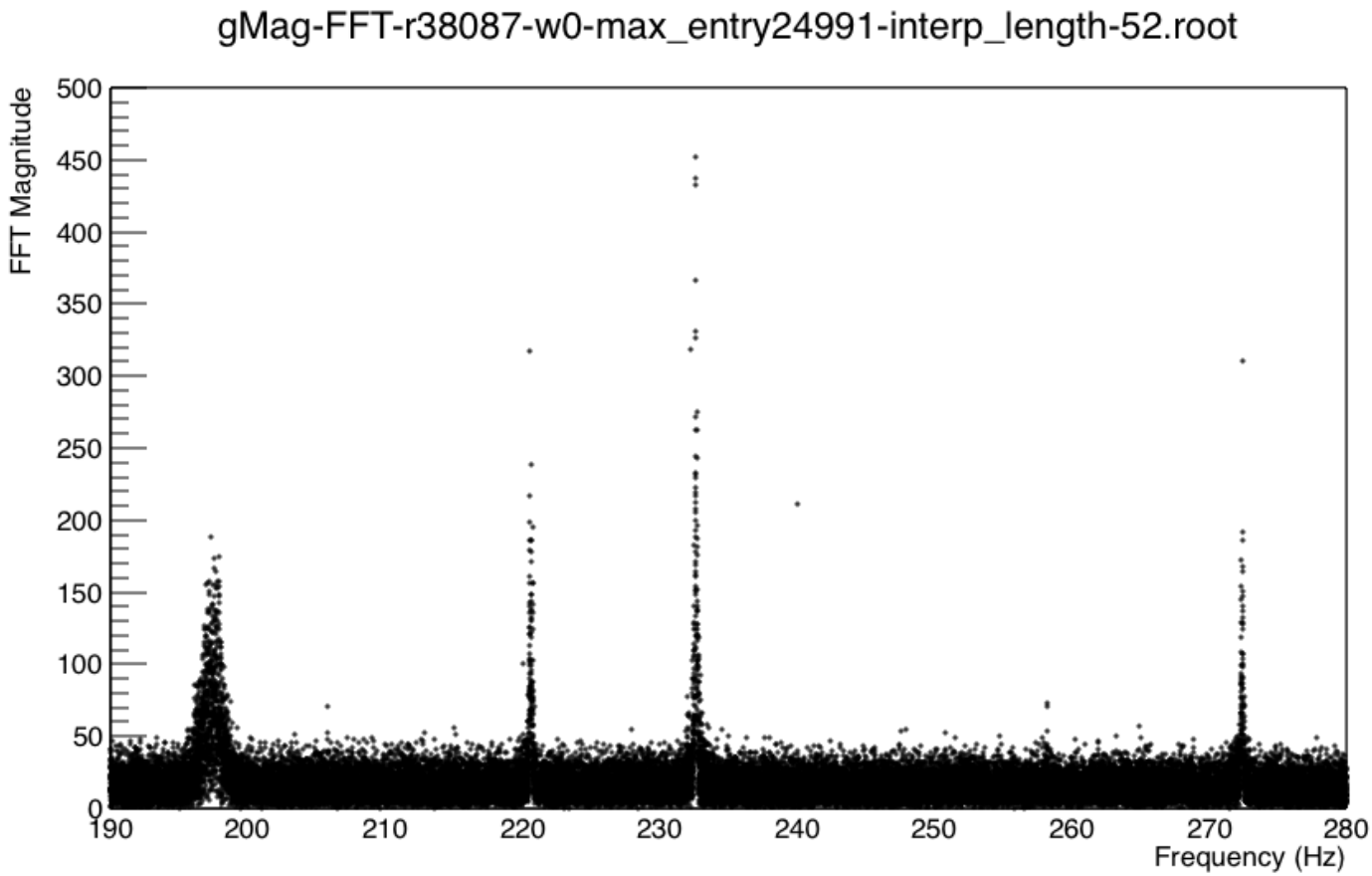
FFT Magnitude - r38087 - All 24991 Pulses



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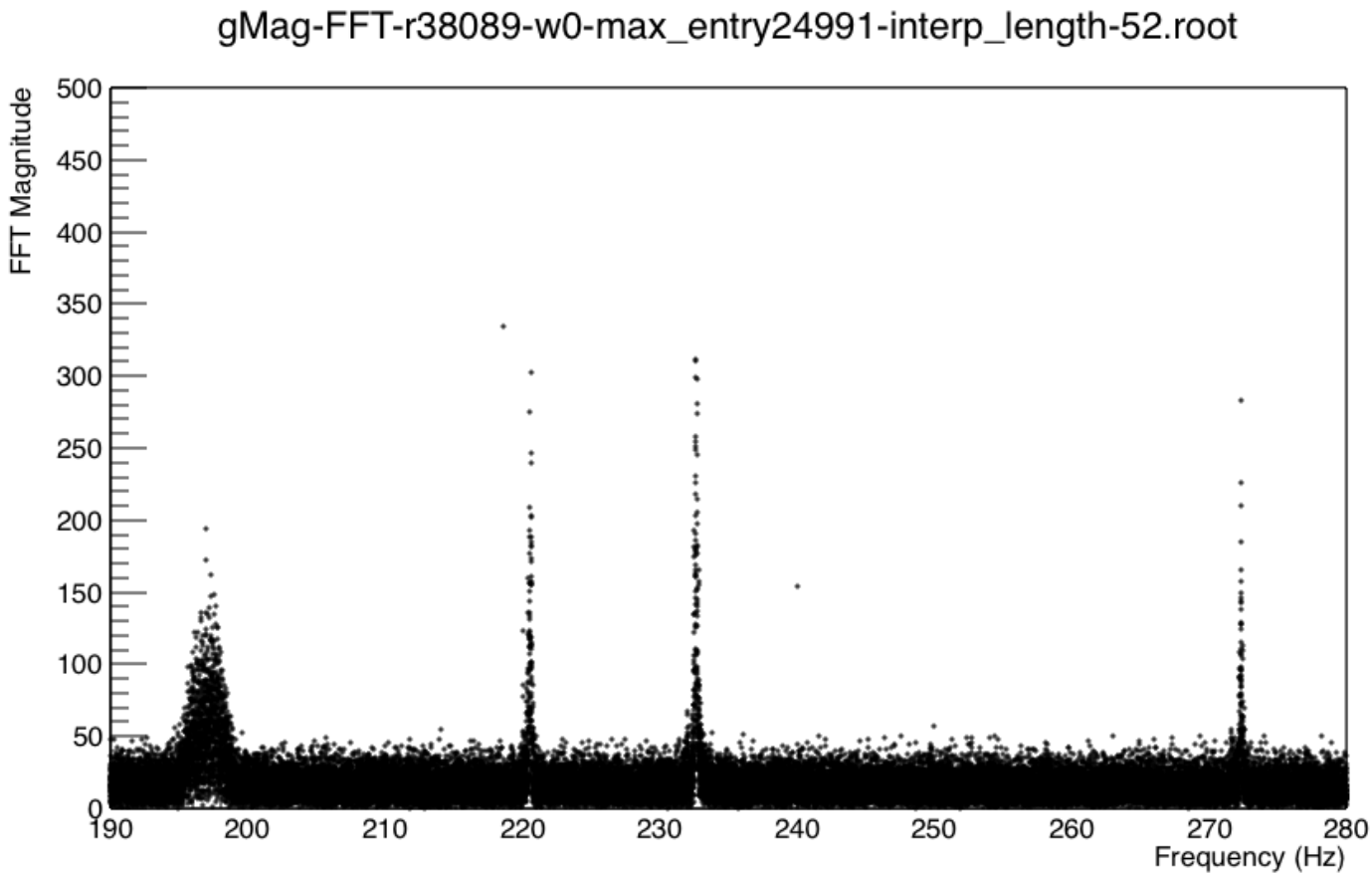
FFT Magnitude - r38089 - All 24991 Pulses



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