n3He Frequency Analysis - FFT Results Summary

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February 23, 2018

Chamber Layout

DAQ Setup

Run Selections

FFT Method

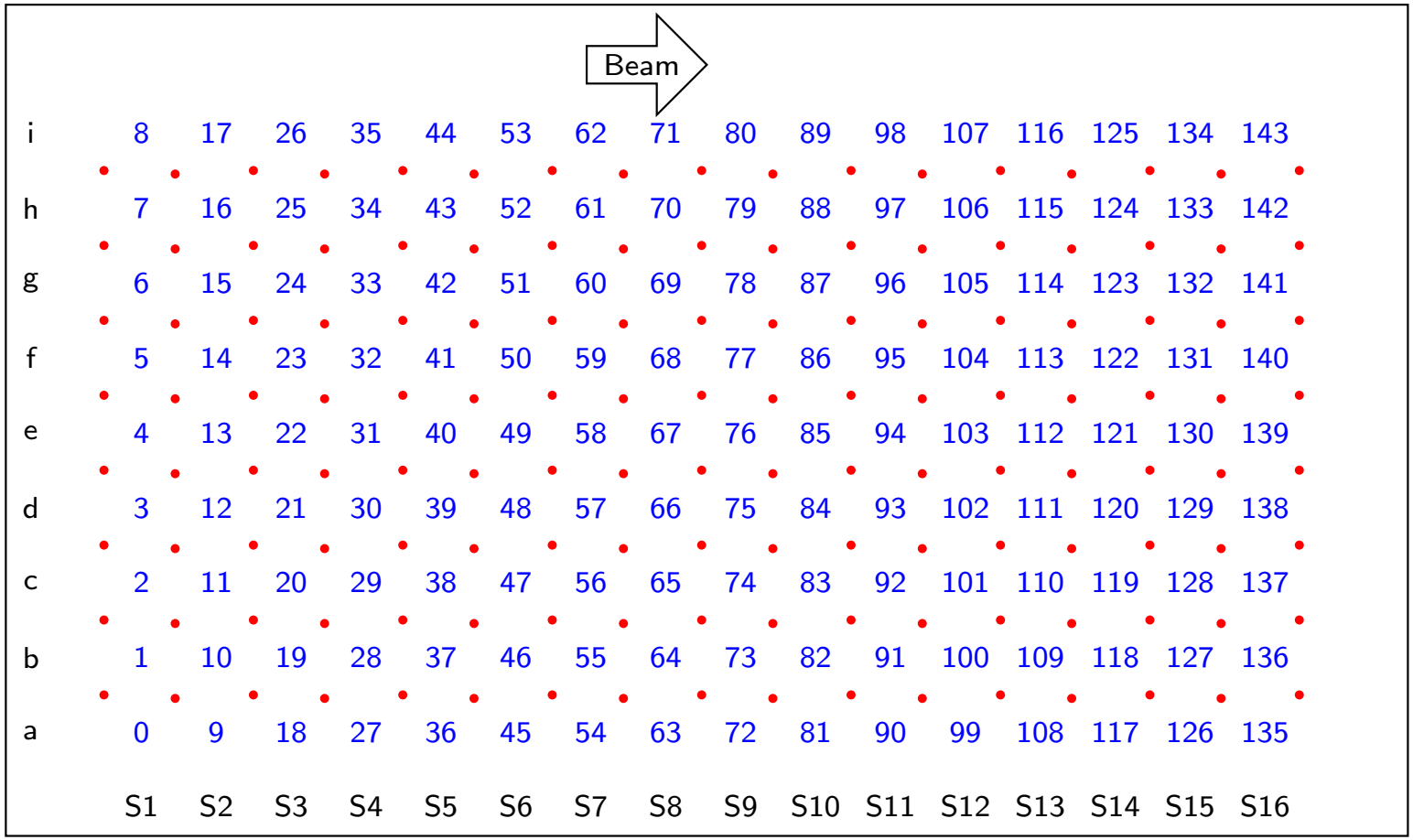
Tuesday Run

Low Asymmetry Summer Run

High Asymetry Summer Run

Additional Plots of FFTs

Signal Wire Numbering



17 HV Frames with 8 wires each

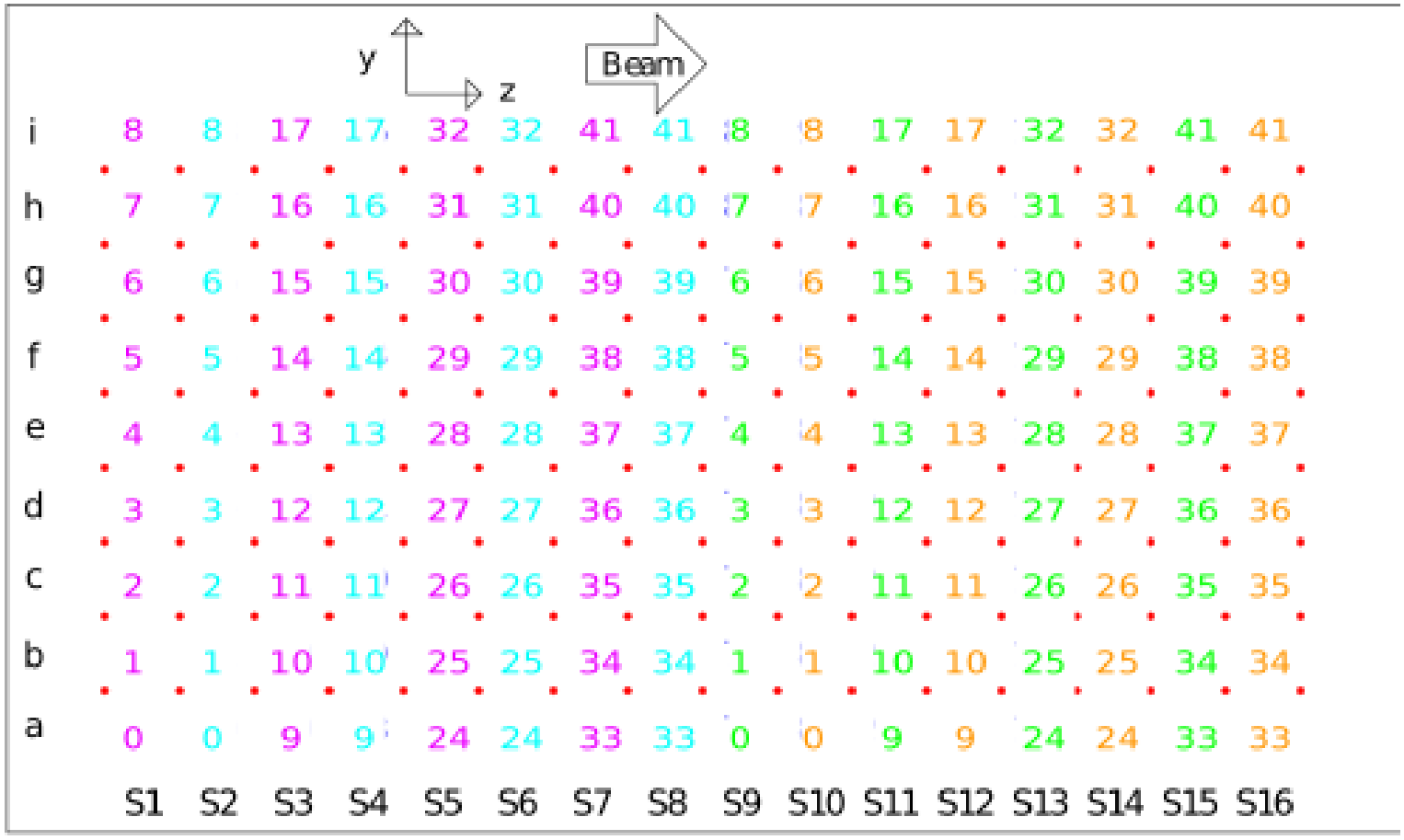
16 signal Frames with 9 wires each

- Signal

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



Tuesday Run List

Tuesday Run List

	Initial Run	Final Run		Initial Run	Final Run
T1	17784	17834	ST1	38386	38416
T2	19114	19158	ST2	38566	38588
T3	20444	20493	T10	45032	45054
T4	21869	21919	T11	46416	46466
T5	24011	24061	T12	49663	49697
T6	26461	26503	T13	51076	51127
T7	27729	27755	T14	52467	52517
T8	30058	30074	T15	56073	56076
T9	32503	32535			

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.

ST# runs are Tuesdays from the Summer that Kabir used in his beam off Tuesday asymmetry calculations.

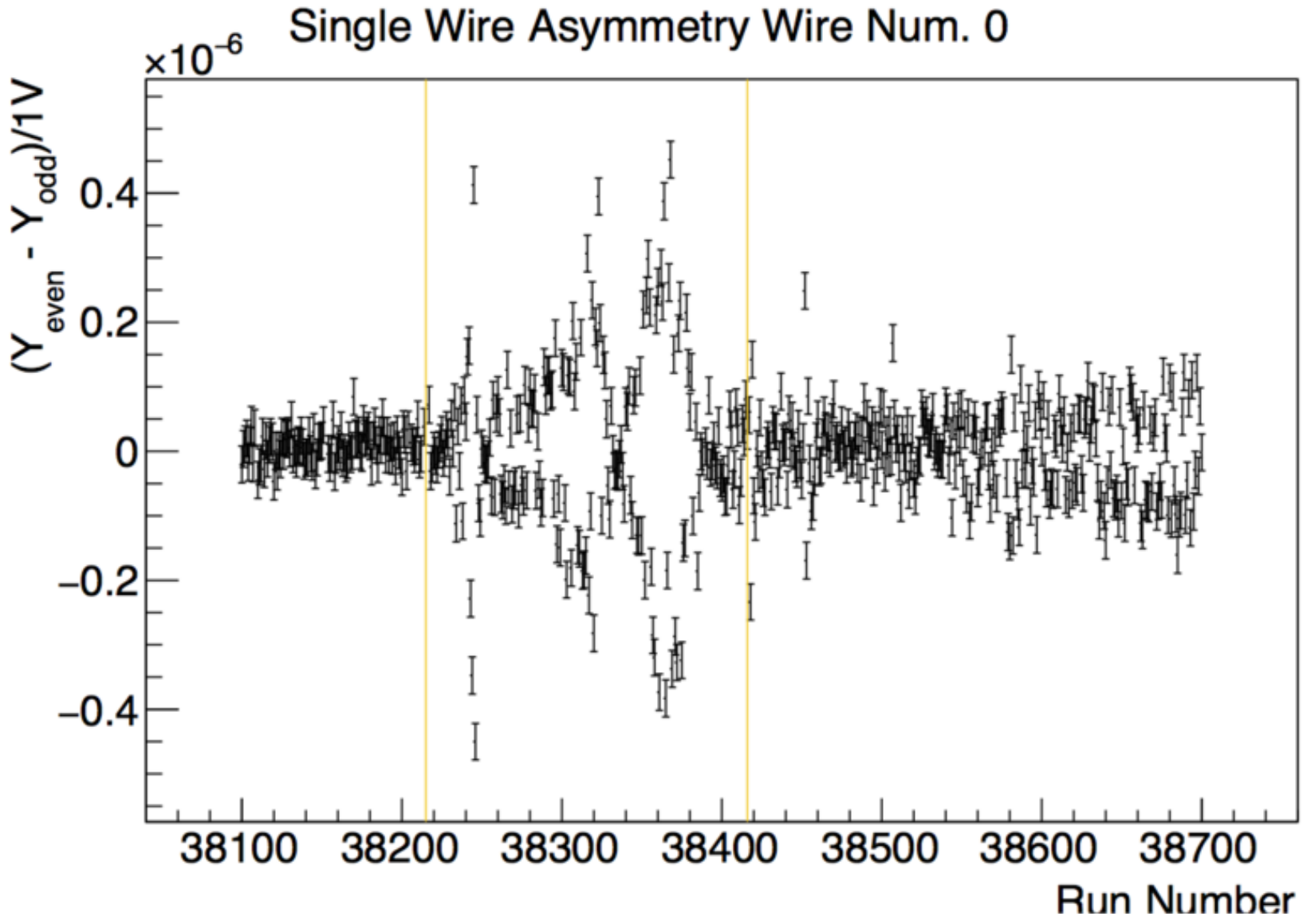
Summer Run List

A list of good beam off runs has been provided by Kabir, and are now on the n3He wiki Instrumental Asym. webpage for reference by the group.

Summer Run List

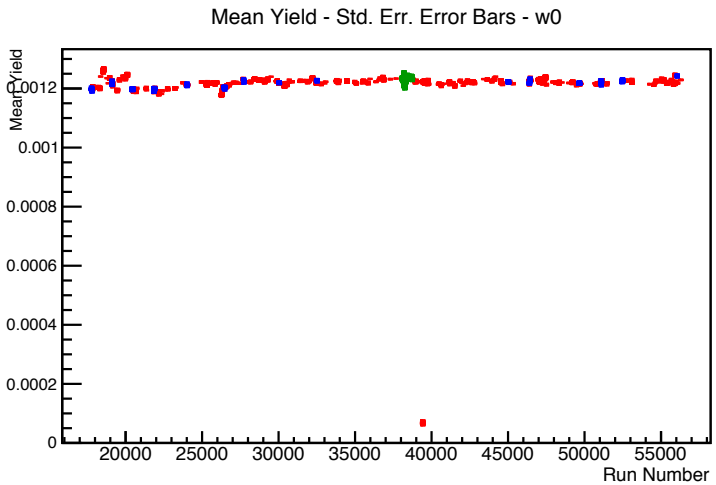
Date Range	Initial Run	Final Run
2015-06-25	38081	38124
2015-06-26	38125	38215
2015-08-03	38216	38301
2015-08-04	38302	38416
2015-08-10	38417	38493
2015-08-11	38494	38657
2015-08-12	38658	38769

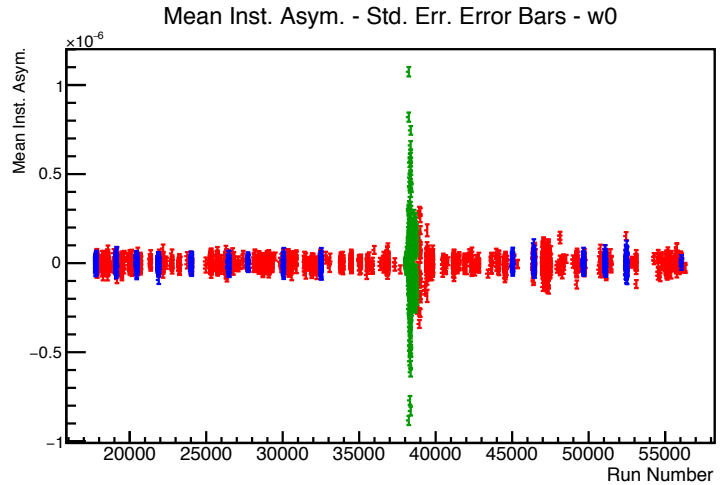
Unscaled Summer Running Asymmetry - w0

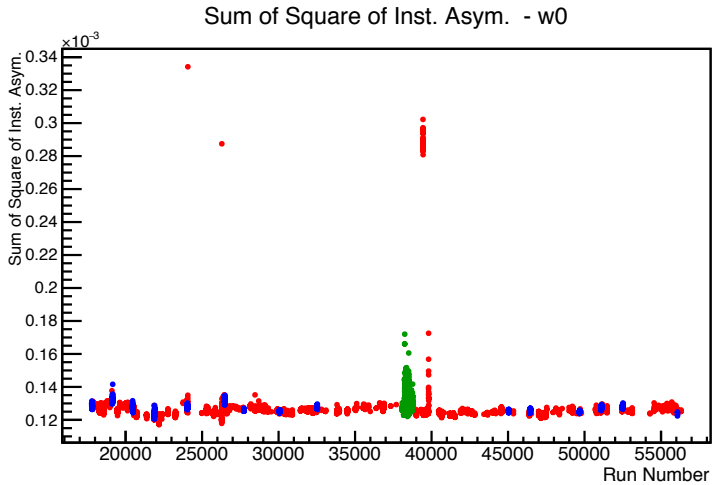


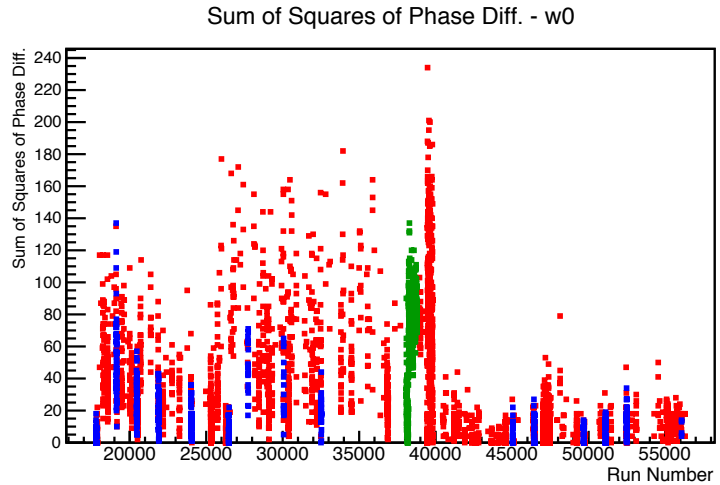
Blue is Tuesdays, Green is summer, Red is all other beam off runs.

All Beam Off Runs - Wire 0 Select Plots









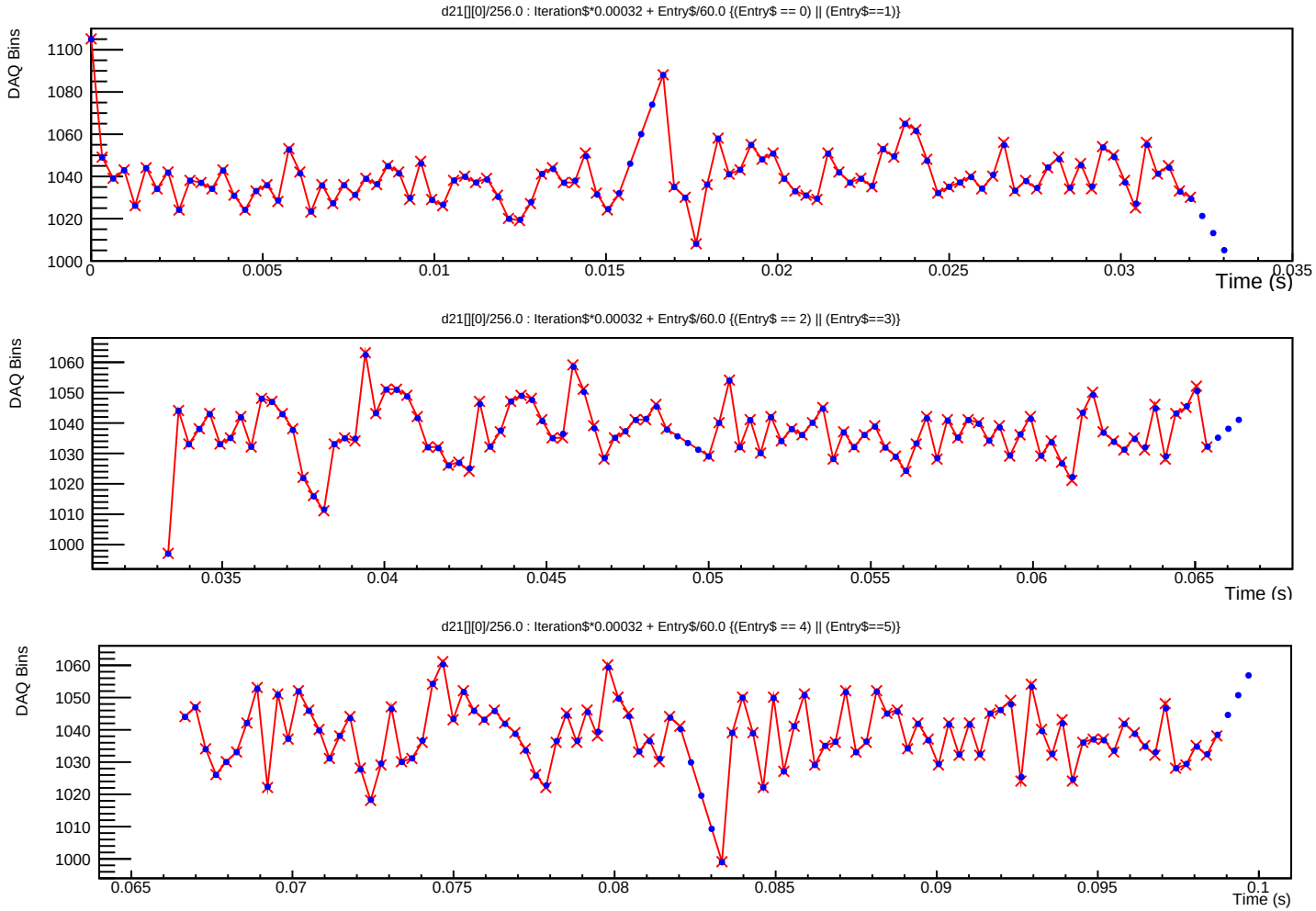
Blue is Tuesdays, Green is summer, Red is all other beam off runs.

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.
- Calculate the spectral density

$$SD = fft_re^2 + fft_im^2 \tag{1}$$

Linear Interpolation Results - First 6 pulses



Red is original data points, blue interpolated data points.

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
  - This has a maximum of 52.083 samples per frame
  - 3125 Hz sample rate for the recorded data
  - 2940 samples recorded per second
  - 15.68 ms of data taking per neutron pulse
  - 0.98 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.

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

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

- Thus, with a constant sampling rate the longer data is taken the better the frequency resolution.

Frequency Range and Resolution Limits of Data

- For the target chamber:

$$N/2 = 49 \times 24991/2 = 612279.5 \tag{3}$$

$$f_{sample} = \frac{1}{0.00032\ \mathrm{s}} = 3125\ \mathrm{Hz} \tag{4}$$

$$f_{max} = \frac{1}{2} f_{sample} = \frac{1}{2} 3125\ \mathrm{Hz} = 1562.5\ \mathrm{Hz} \tag{5}$$

$$\Delta f = \frac{1562.5\ \mathrm{Hz}}{24991 * 49} = \frac{1562.5\ \mathrm{Hz}}{1224559} = 0.00128\ \mathrm{Hz} \tag{6}$$

- For the interpolated data:

$$N/2 = 52 \times 24991/2 = 649766 \tag{7}$$

$$f_{sample} = \frac{1}{0.00032051\ \mathrm{s}} = 3120.03\ \mathrm{Hz} \tag{8}$$

$$f_{max} = \frac{1}{2} \frac{1}{0.00032051} = \frac{1}{2} 3120.03\ \mathrm{Hz} = 1560.01\ \mathrm{Hz} \tag{9}$$

$$\Delta f = \frac{1560.01\ \mathrm{Hz}}{24991 * 52} = 0.00120\ \mathrm{Hz} \tag{10}$$

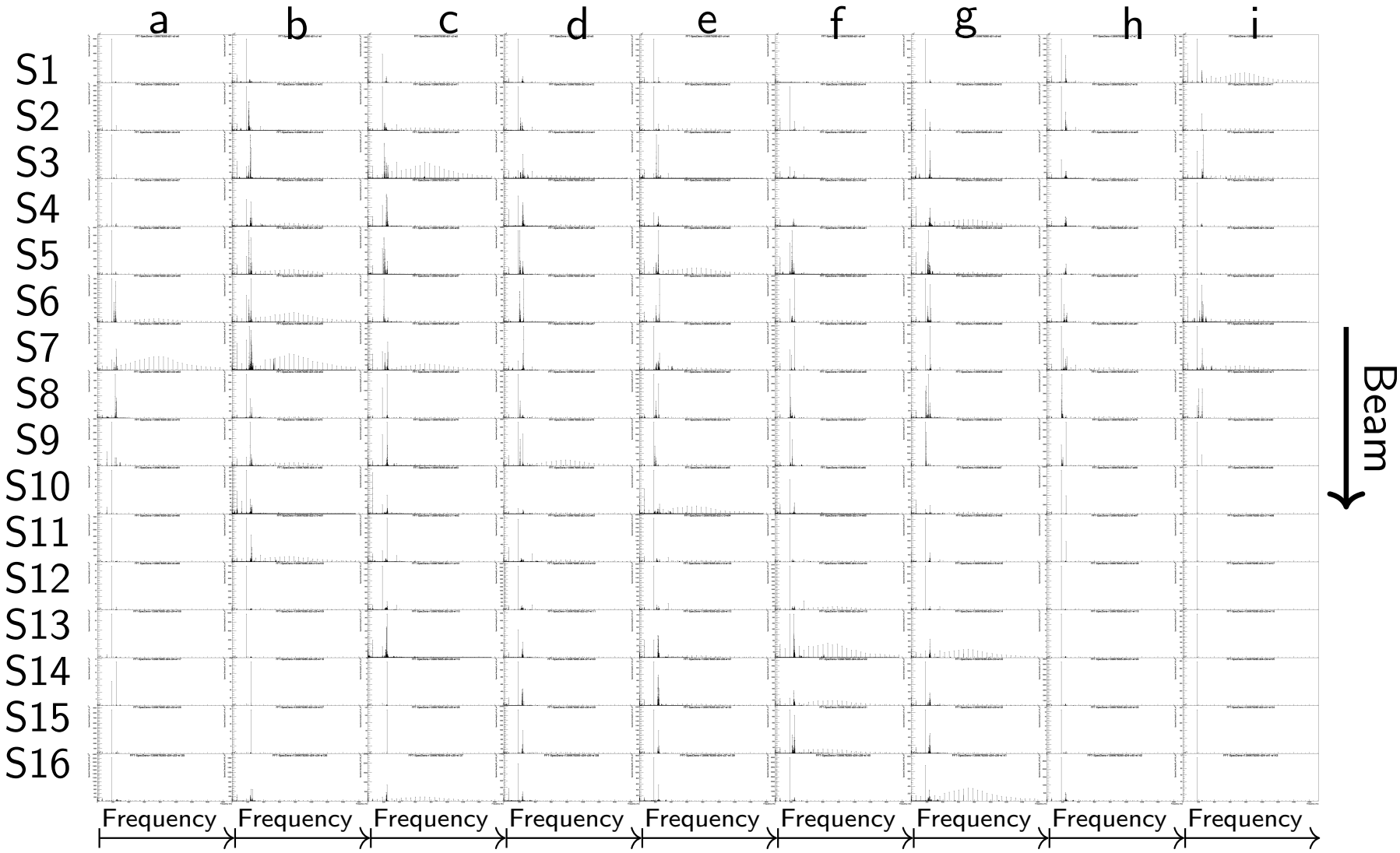
Spectral Density Calculation

$$SD(f) = FFT_{re}(f)^2 + FFT_{im}(f)^2 \tag{11}$$

where

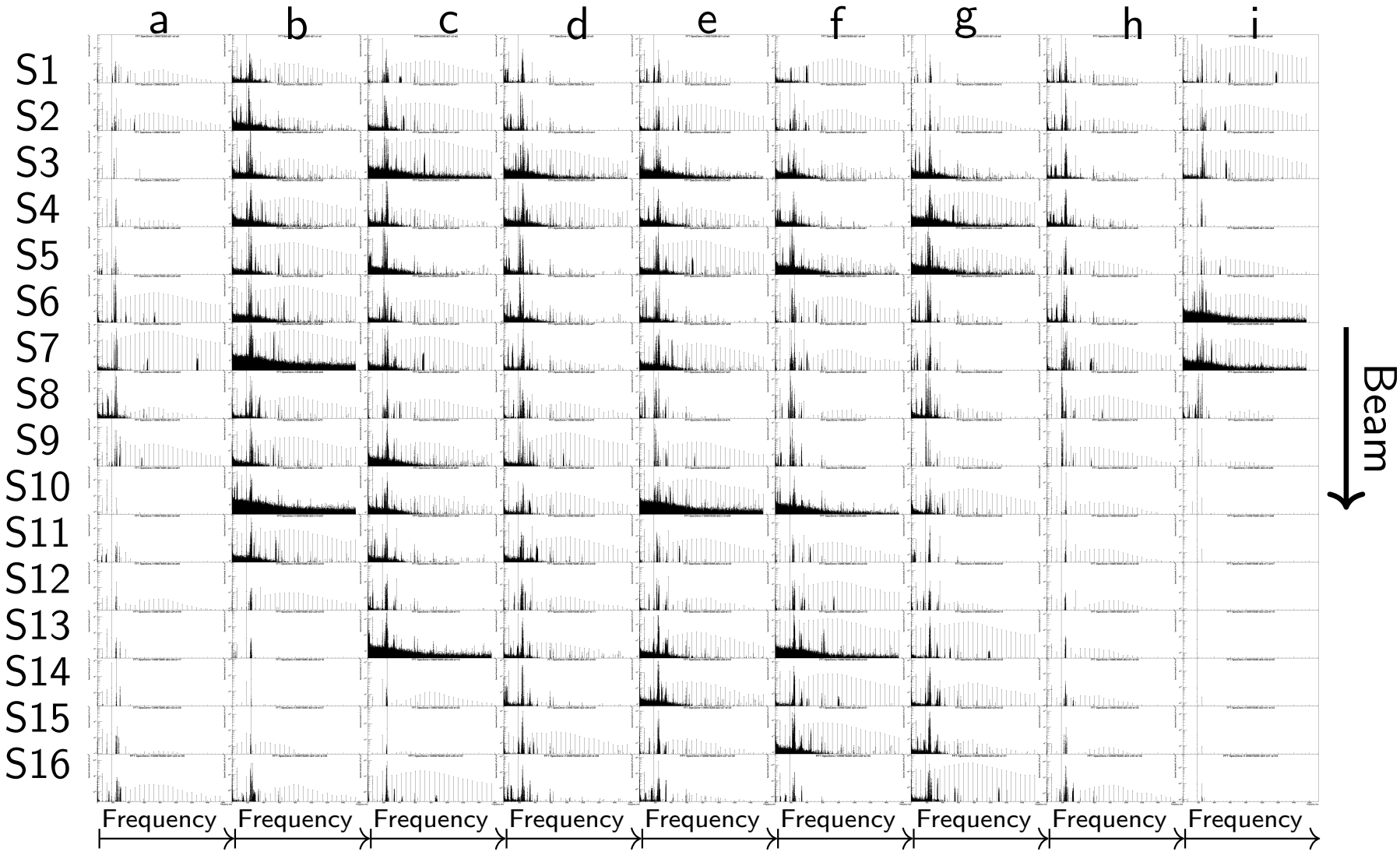
- f is the frequency
- $FFT_{re}(f)$ is the real part of the FFT for the bin containing the frequency f
- $FFT_{im}(f)$ is the real part of the FFT for the bin containing the frequency f
- $SD(f)$ is the spectral density

Tuesday Run - 17785



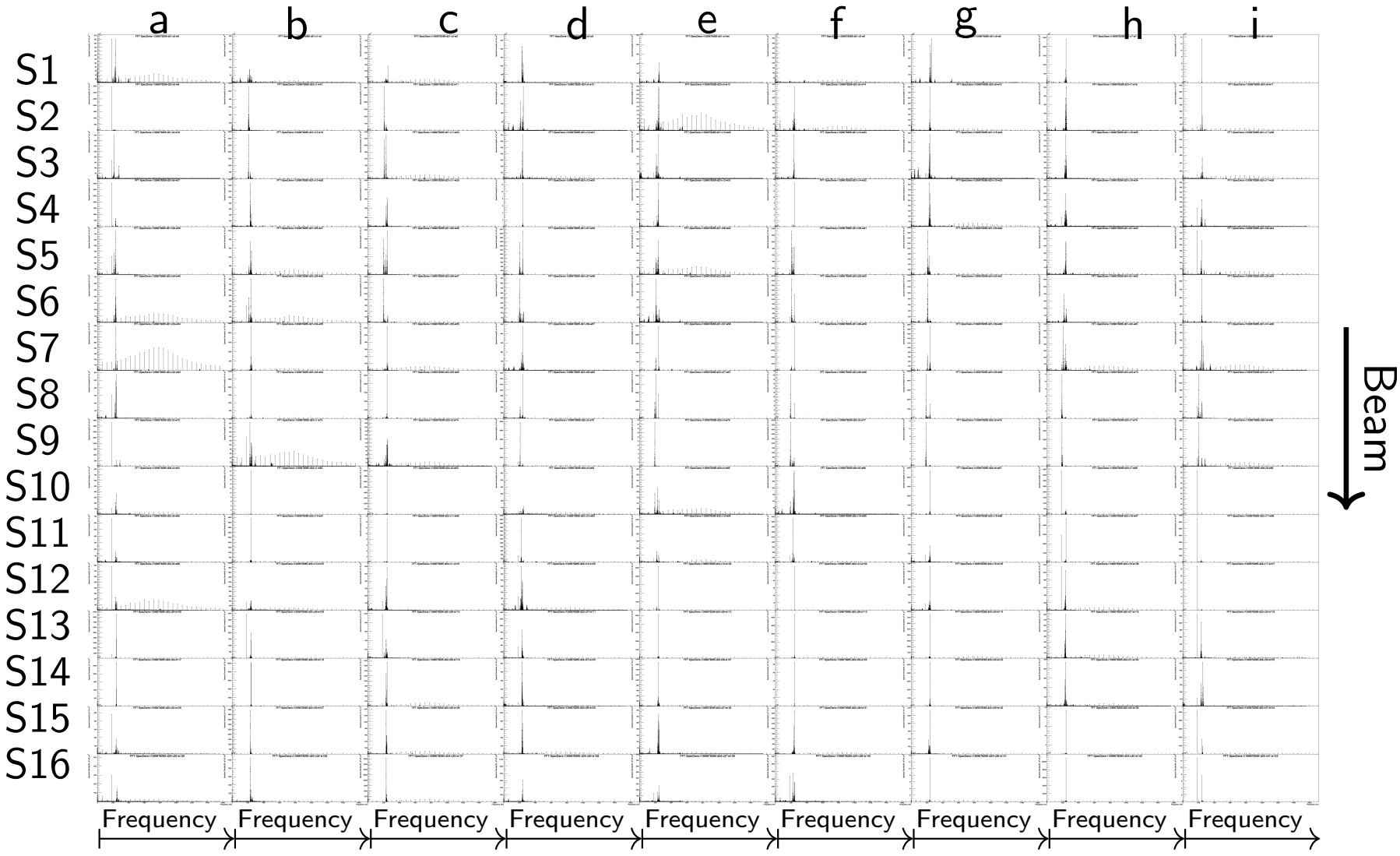
X-axis all all the same. Y-axis are all DIFFERENT.

Tuesday Run - 17785 - Log Scale Y-axis



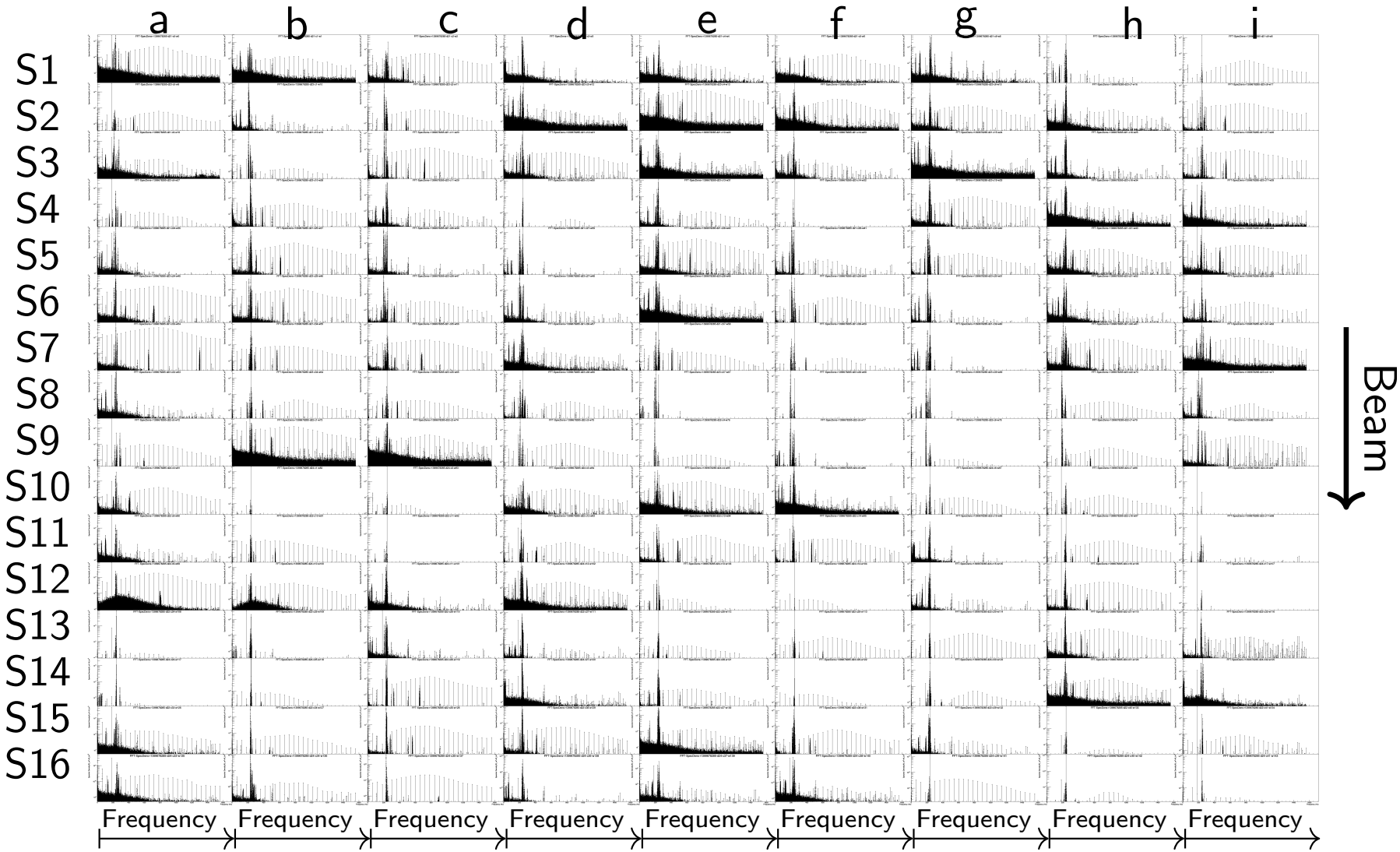
X-axis all all the same. Y-axis are all DIFFERENT.

Low Asymmetry Summer Run - 38085



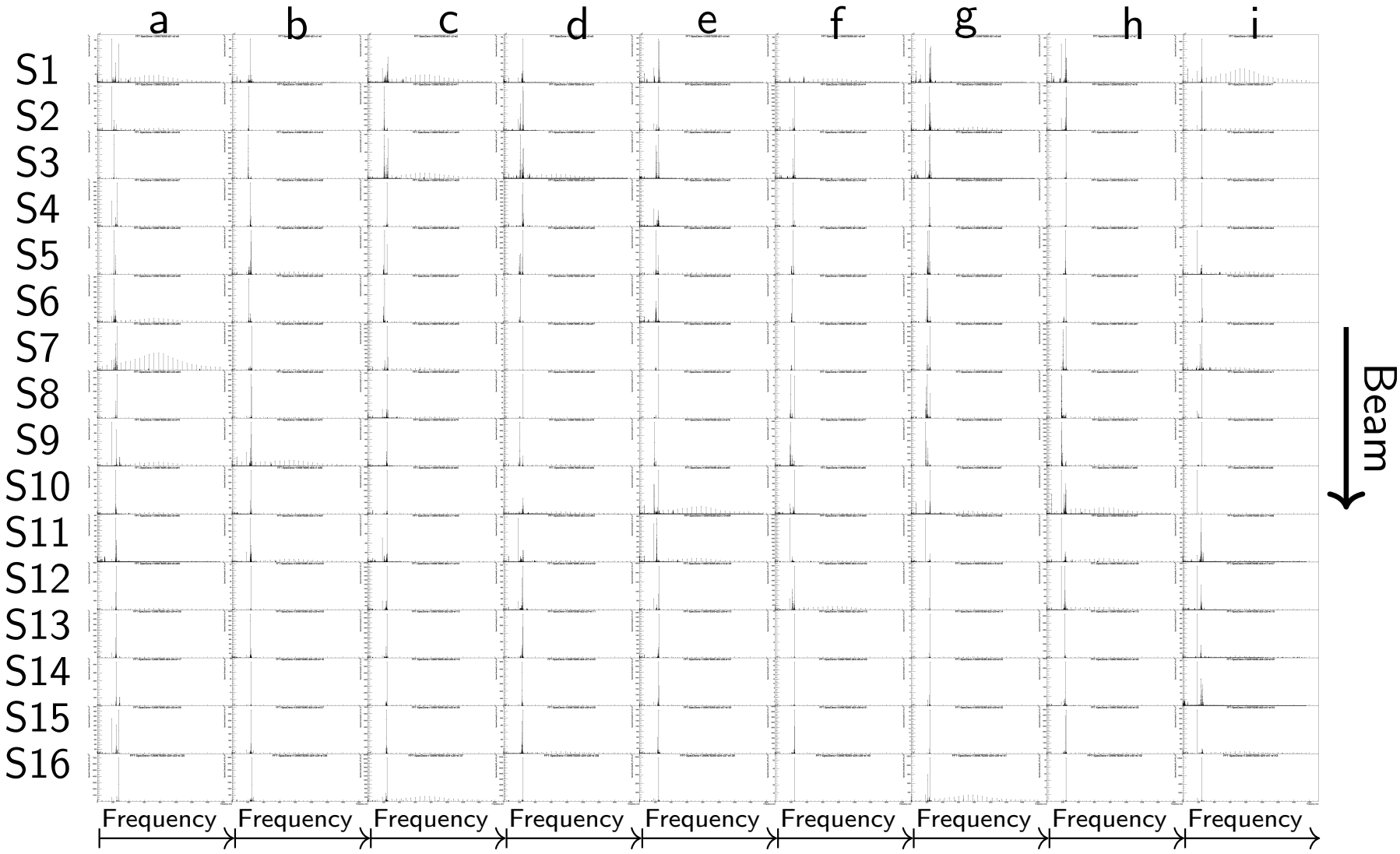
X-axis all all the same. Y-axis are all DIFFERENT.

Low Asymmetry Summer Run - 38085 - Log Scale Y-axis



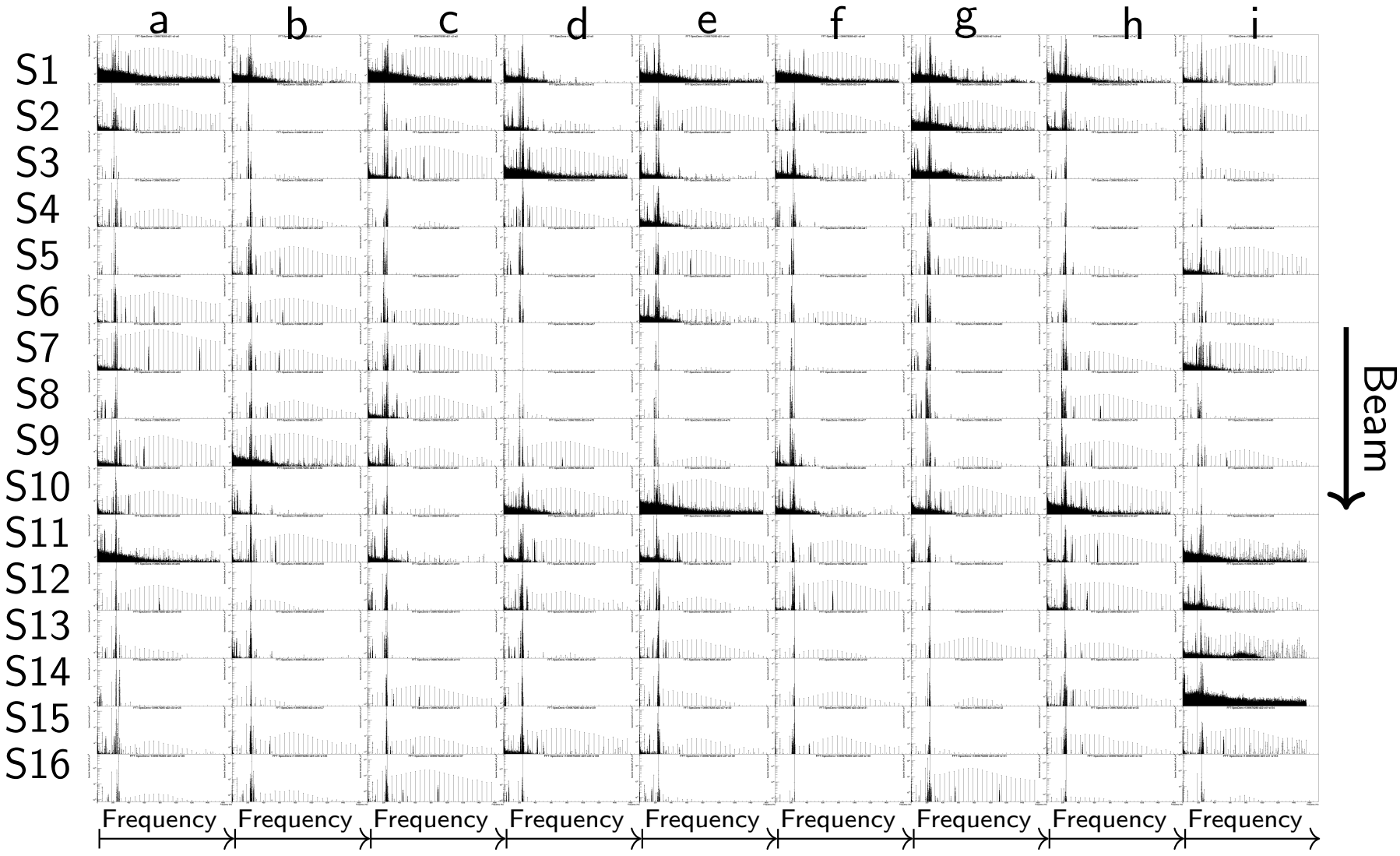
X-axis all all the same. Y-axis are all DIFFERENT.

High Asymmetry Summer Run - 38444



X-axis all all the same. Y-axis are all DIFFERENT.

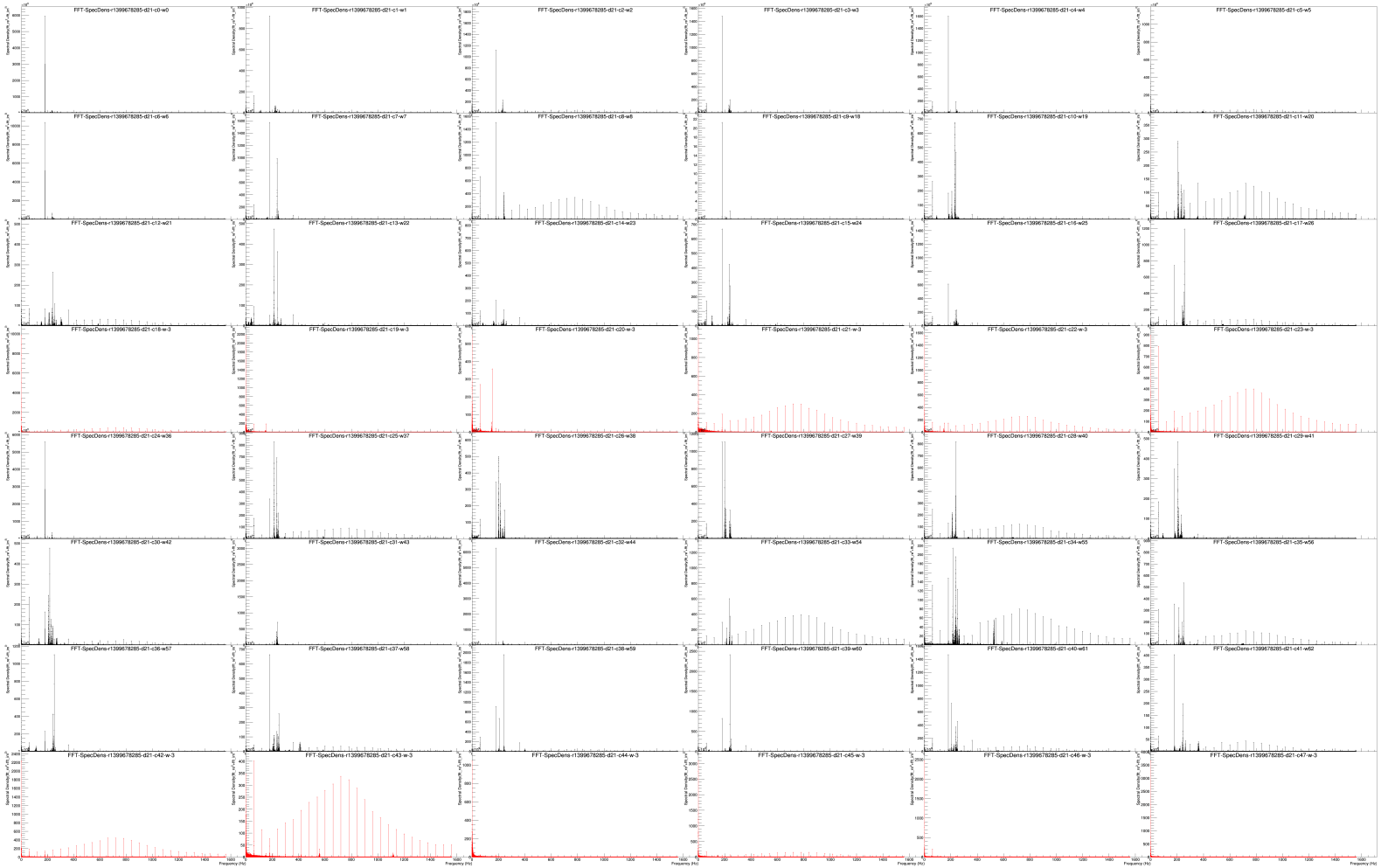
High Asymmetry Summer Run - 38444 - Log Scale Y-axis



X-axis all all the same. Y-axis are all DIFFERENT.

Additional DAQ grouped plot on following slides

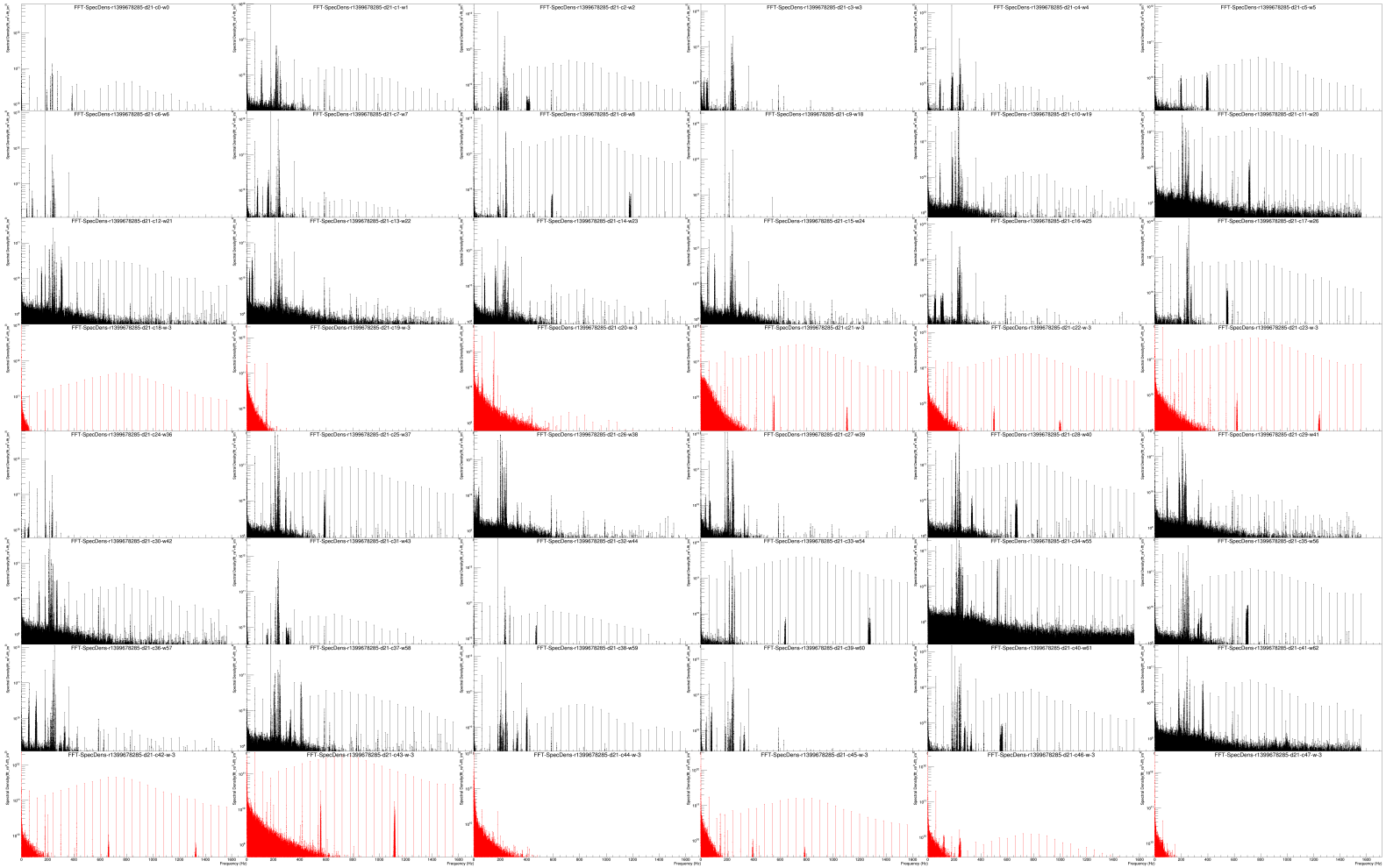
Tuesday Run - 17785 - DAQ21



X-axis all all the same. Y-axis are all DIFFERENT.

Red plots are from uninstrumented channels.

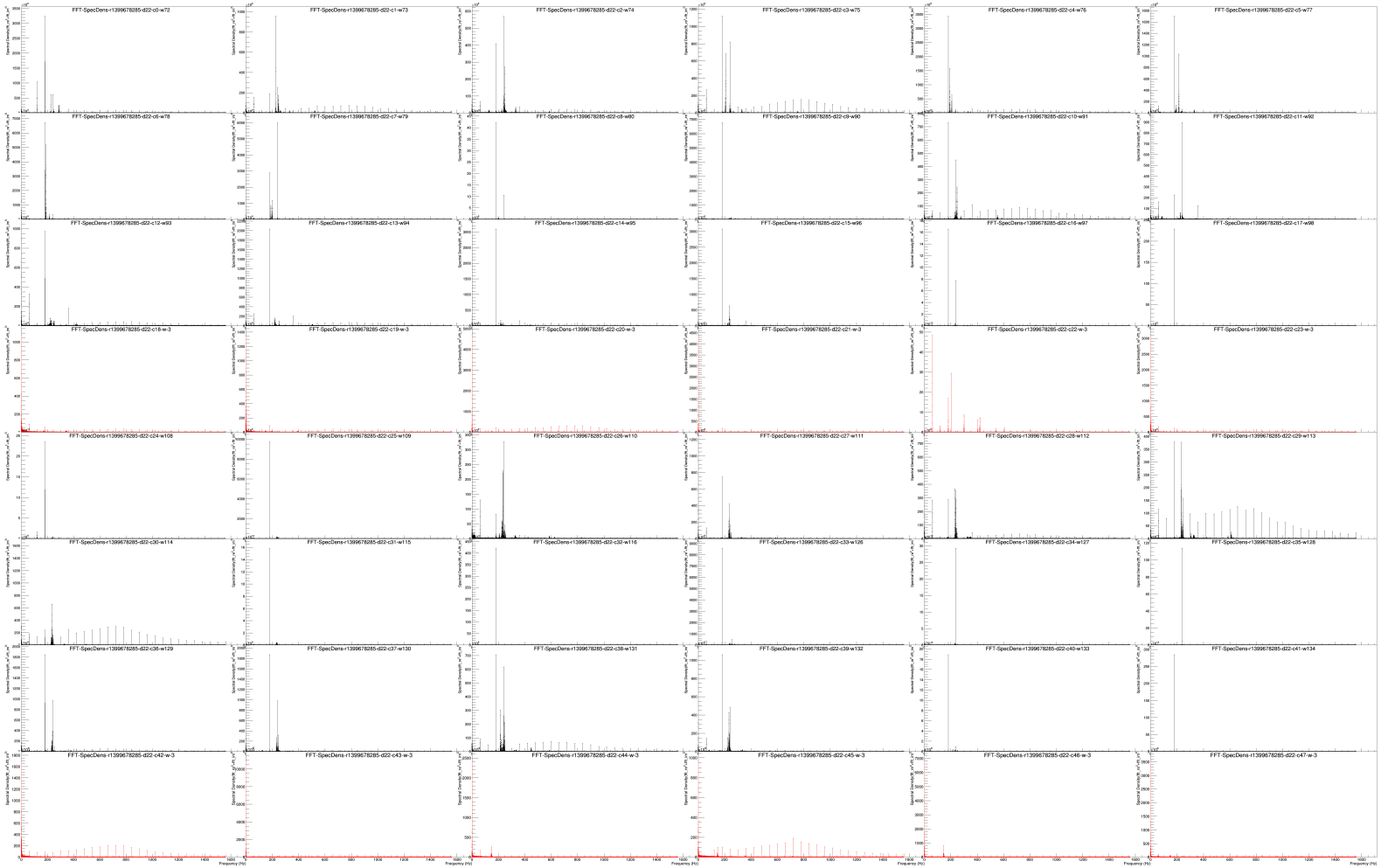
Tuesday Run - 17785 - DAQ21 - Log Scale Y-axis



X-axis all all the same. Y-axis are all DIFFERENT.

Red plots are from uninstrumented channels.

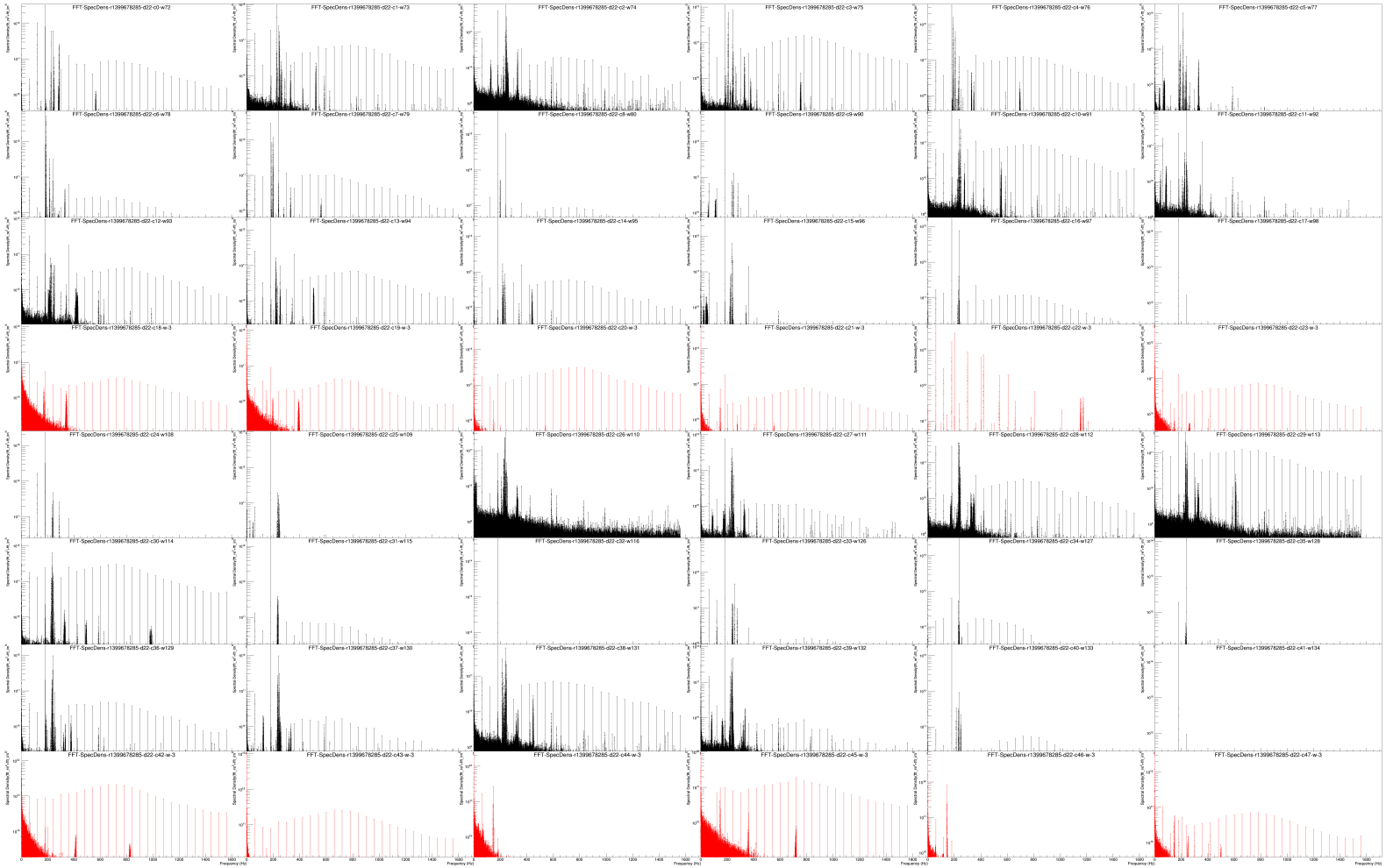
Tuesday Run - 17785 - DAQ22



X-axis all all the same. Y-axis are all DIFFERENT.

Red plots are from uninstrumented channels.

Tuesday Run - 17785 - DAQ22 - Log Scale Y-axis



X-axis all all the same. Y-axis are all DIFFERENT.

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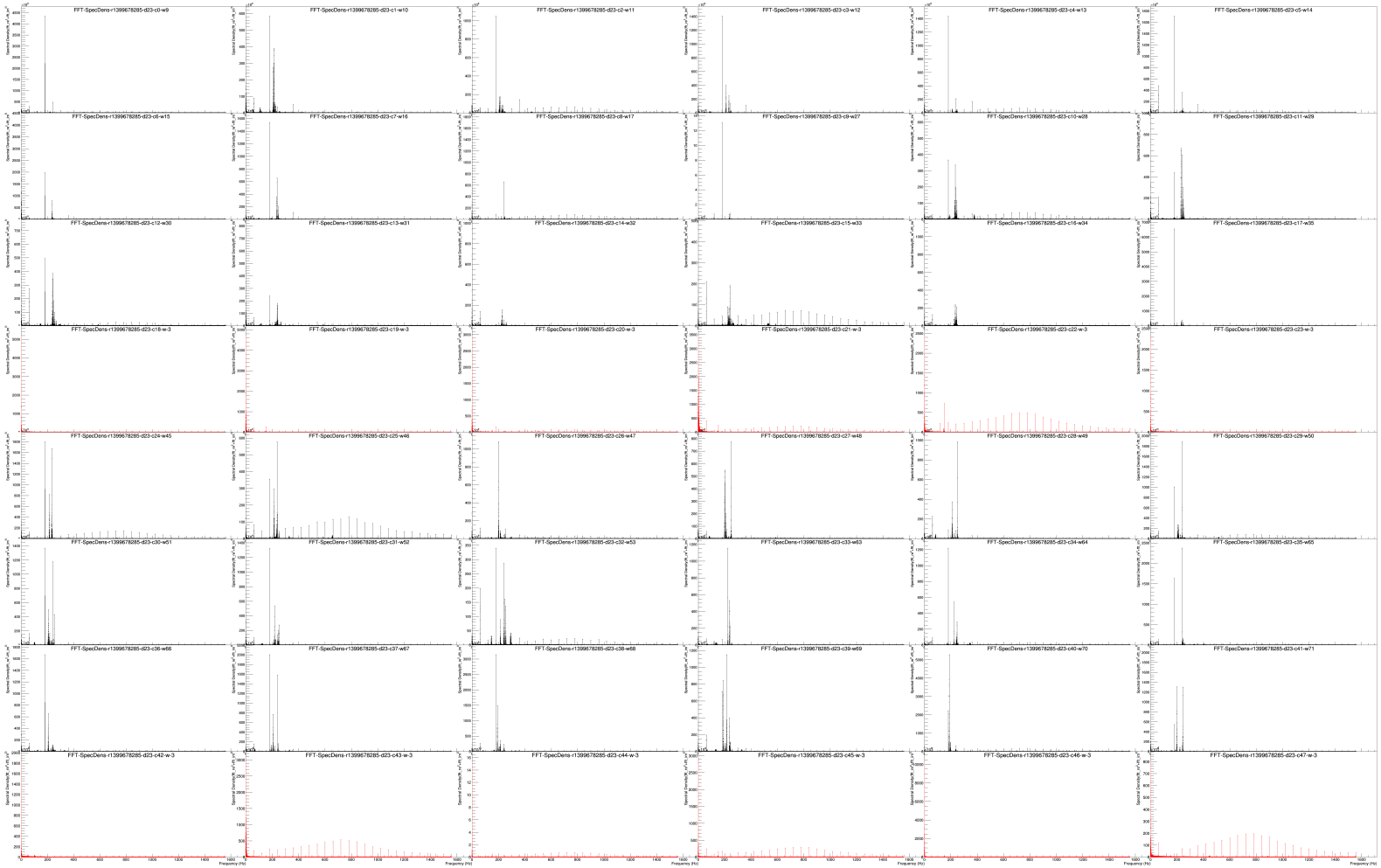
Tuesday Run - 17785 - DAQ23



X-axis all all the same. Y-axis are all DIFFERENT.

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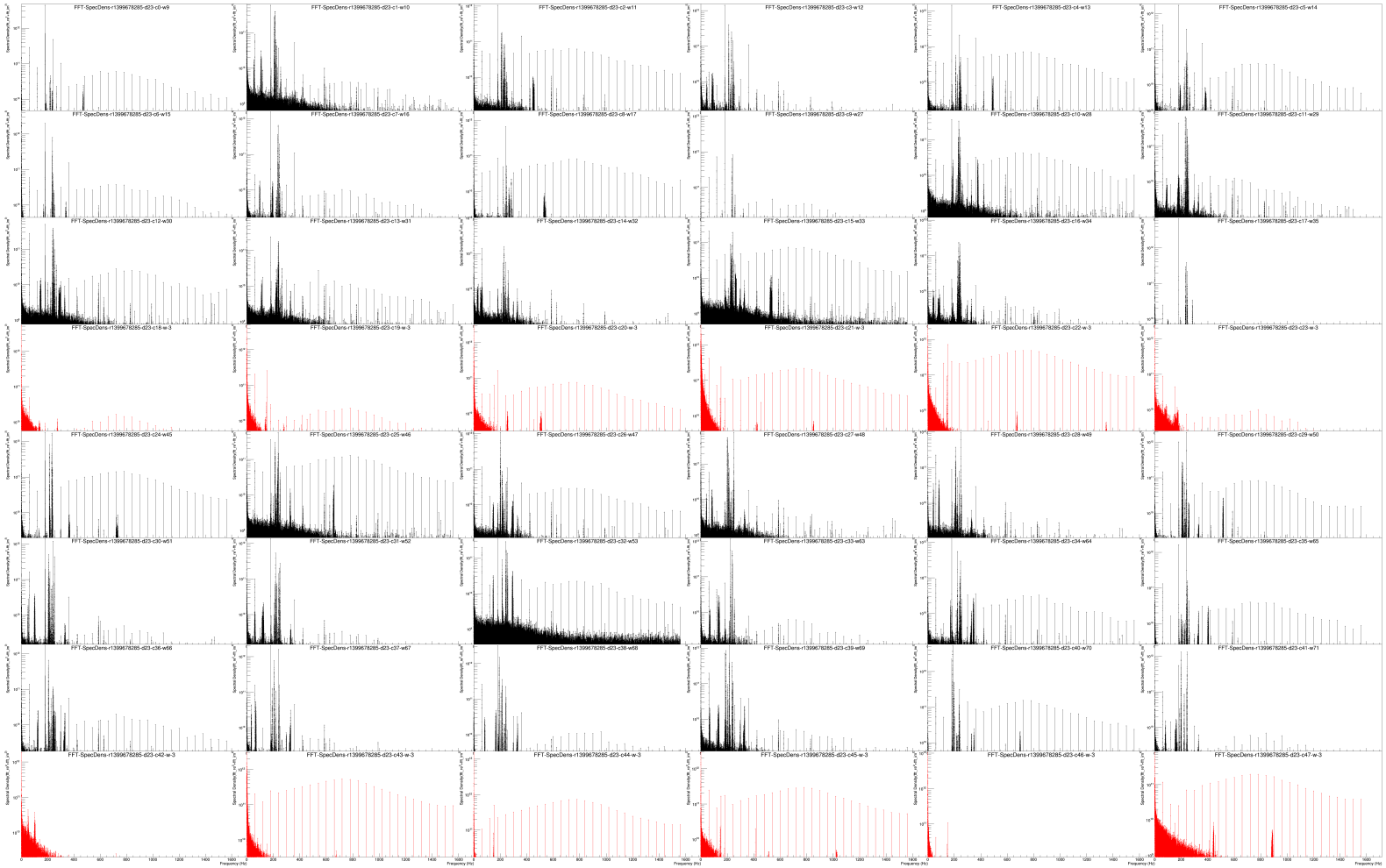
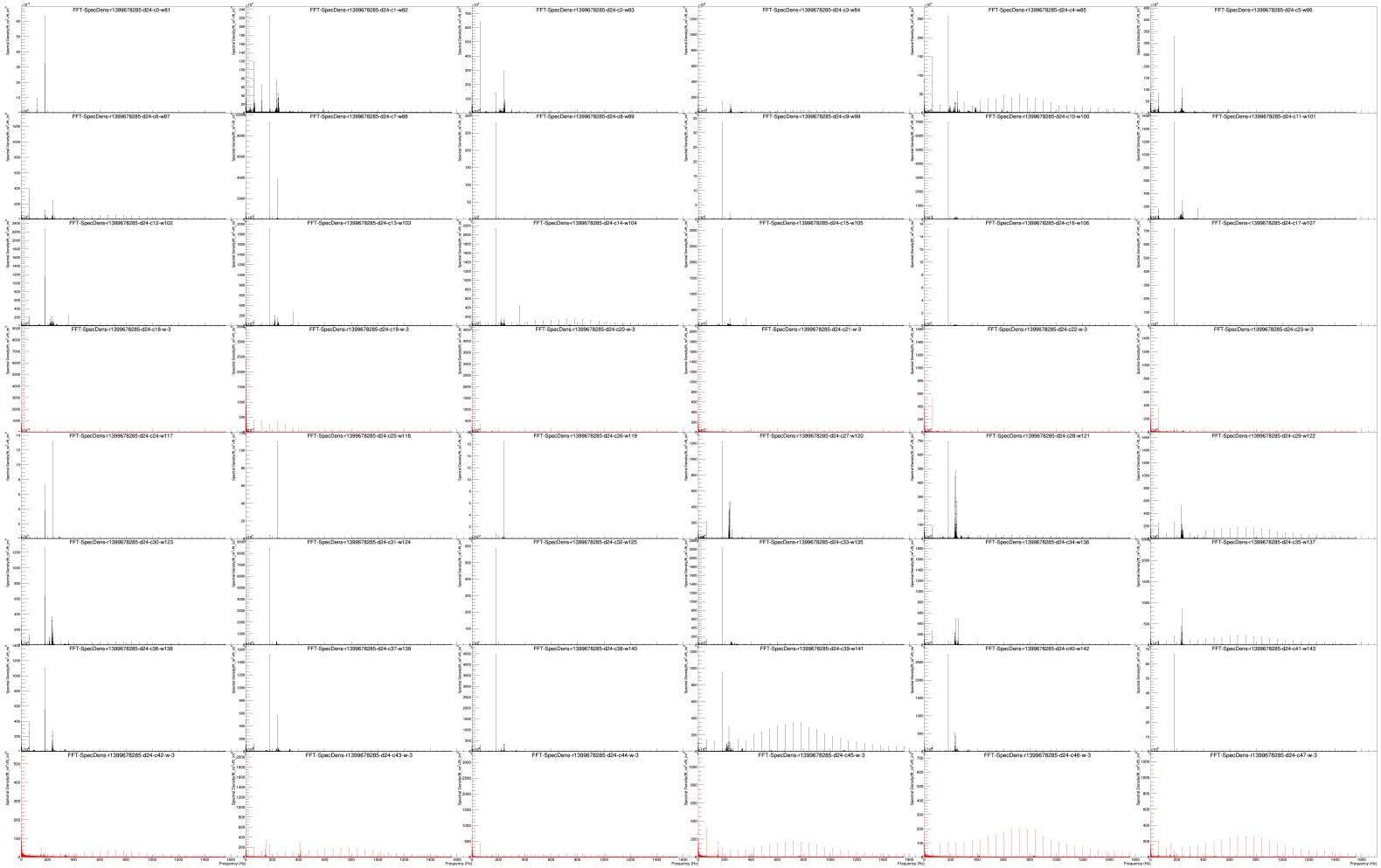
Tuesday Run - 17785 - DAQ23 - Log Scale Y-axis



X-axis all all the same. Y-axis are all DIFFERENT.

Red plots are from uninstrumented channels.

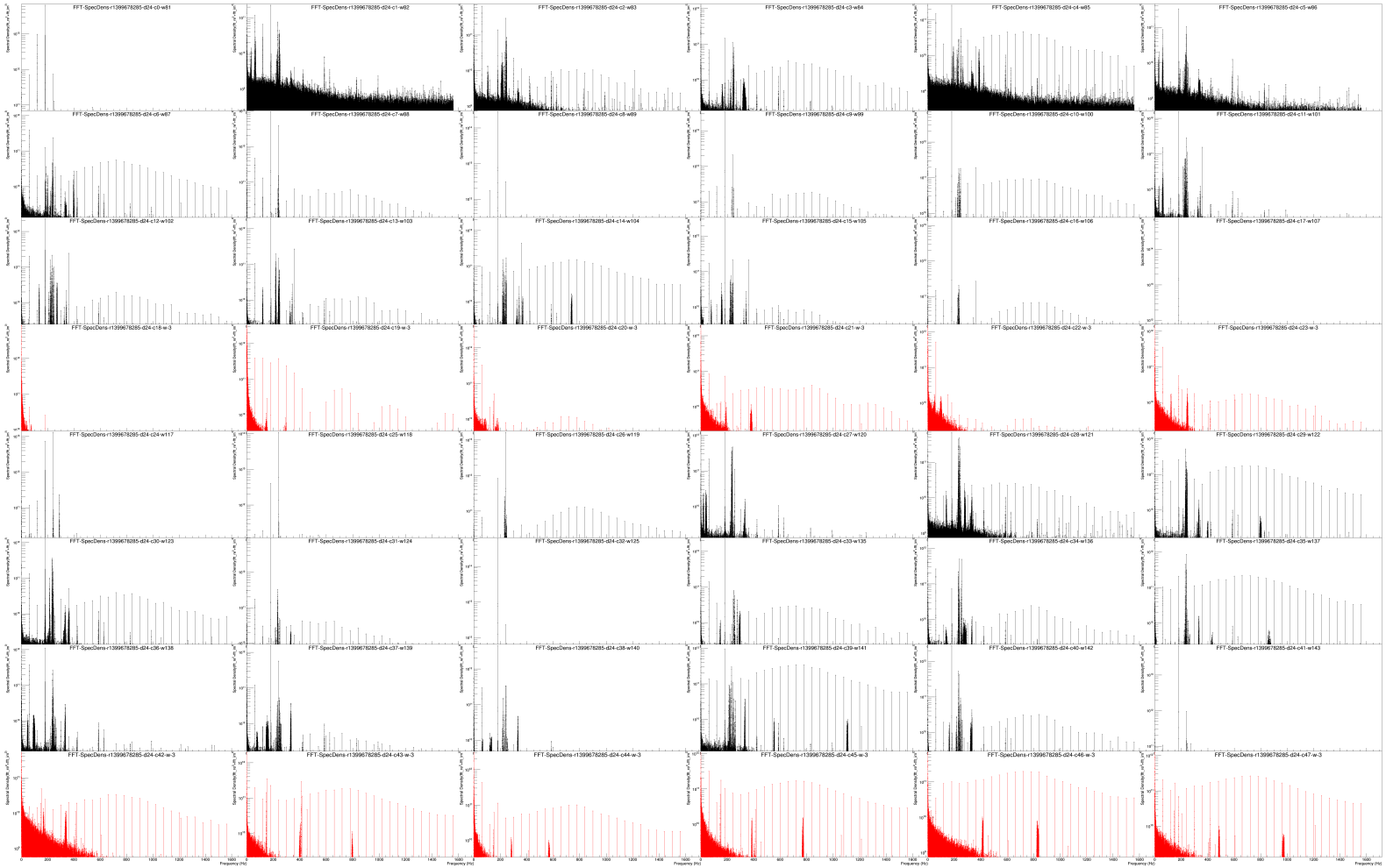
Tuesday Run - 17785 - DAQ24



X-axis all all the same. Y-axis are all DIFFERENT.

Red plots are from uninstrumented channels.

Tuesday Run - 17785 - DAQ24 - Log Scale Y-axis



X-axis all all the same. Y-axis are all DIFFERENT.

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