35 ton noise

M. Johnson
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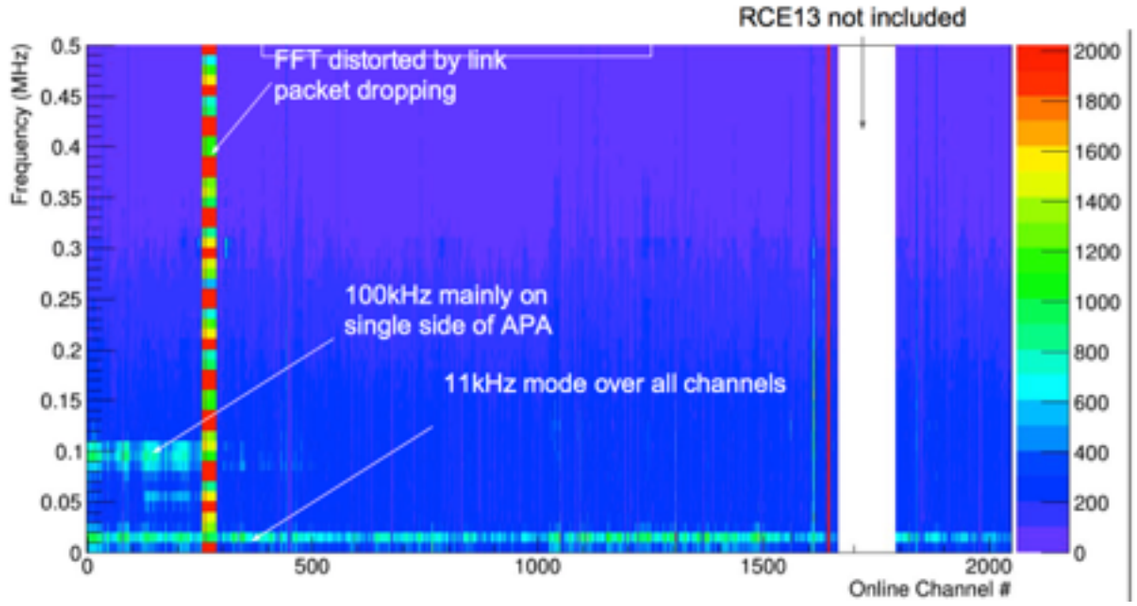
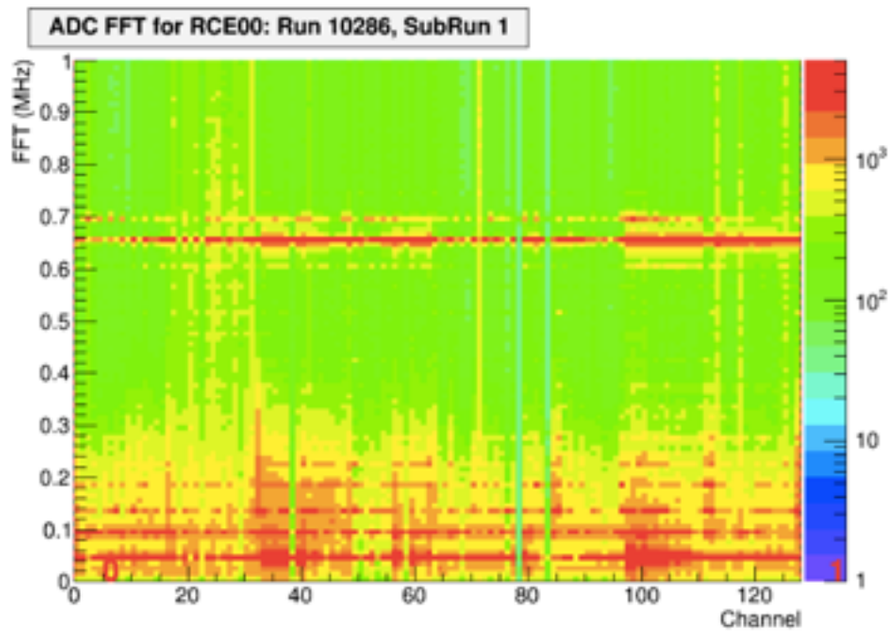
Two Noise States

- Low noise state (top plot) shows 11 KHz from regulator and 100 KHz on first FEMB

- High noise state has large number of frequencies with most of them below 300 KHz

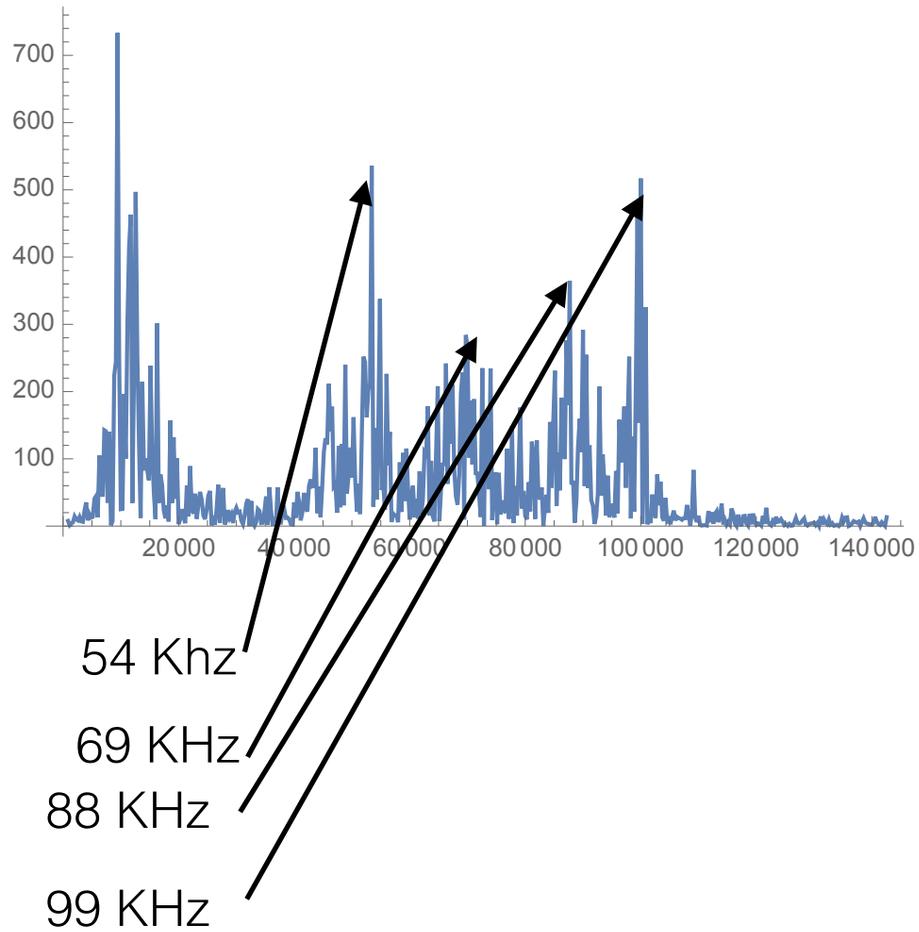




FFT of ADC values in RCE00

100 Khz Noise

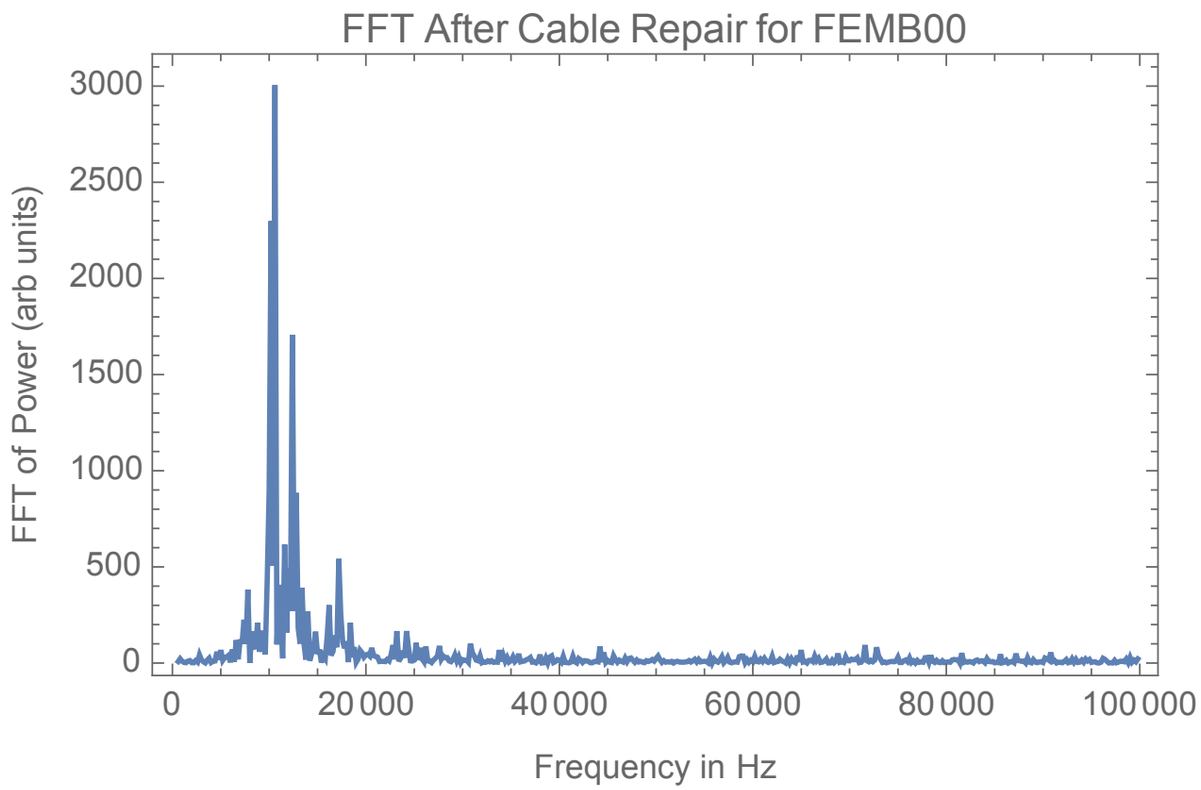
- Caused by short between analog power return and Weiner crate ground for FEMB 00 and 01
- This coupled Weiner crate switching noise to the front end analog ground
- Switching frequencies for the Weiner supplies are available from their monitoring software
  - 5 voltages; a:87, b:98, c:88, d:69,e: 118 Khz
- 54 KHz is from fluorescent lights
  - Observe this with scope outside of cryostat



Data for FEMB01 (mean of all channels)

After Repair

- 100 KHz signal is gone
- Lights are off
- Note that these plots are raw data with no correction for stuck ADC bits which affect detailed comparison of FFTs between runs



Noise from MPODS

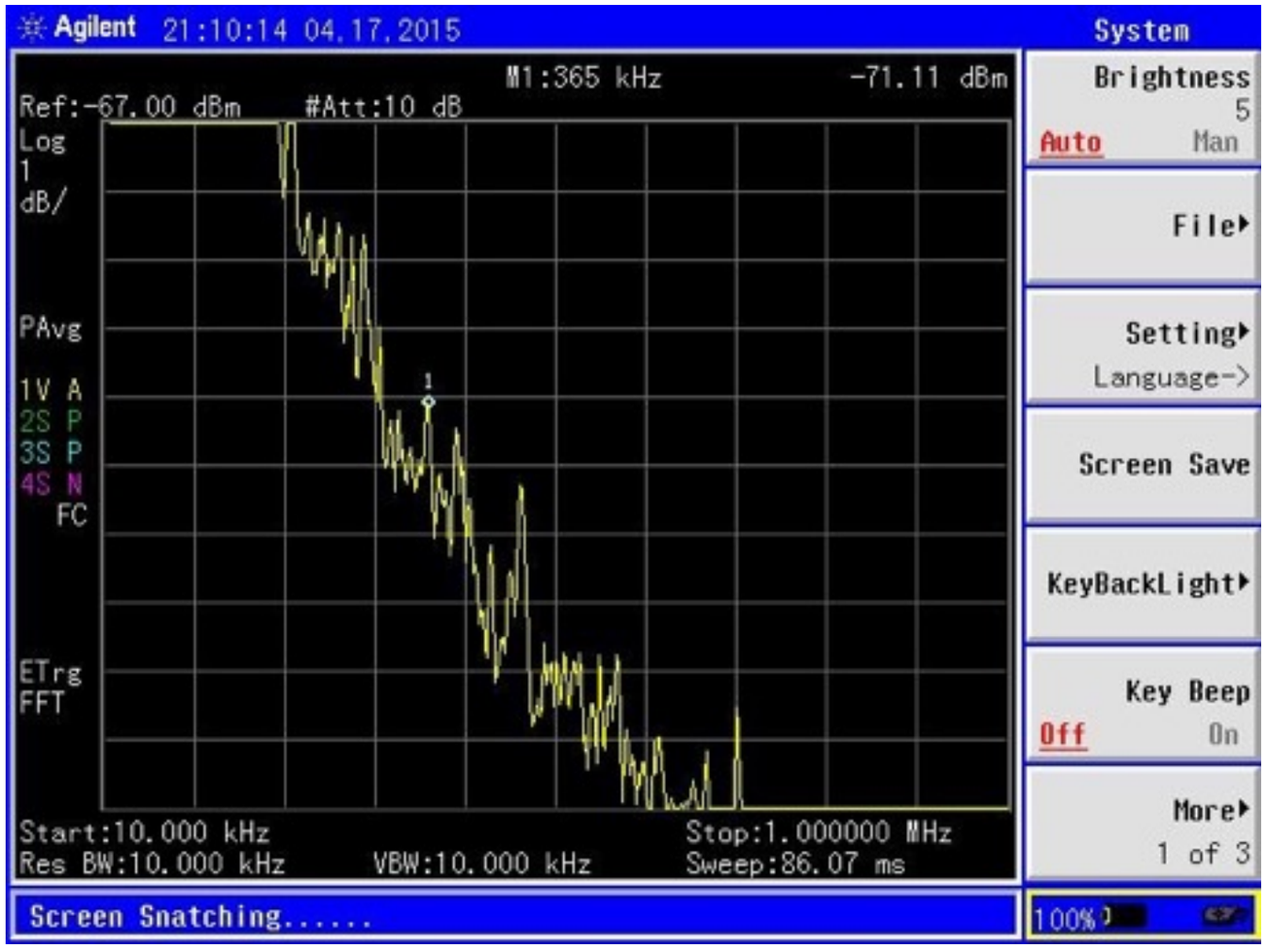
- Noise signal on ADC's in high noise state is large (~25000 electrons) but far from saturation so not likely local feed back through FE ASICs
- Each APA has a grid plane in front of the induction planes which is connected to a bias power supply
  - I used it as an antenna into the cryostat and connected it to a spectrum analyzer (not 50 ohm!)
  - Grid signal on top of cryostat is after a large RC filter so there must be a lot of power driving the grids

Grid on Spectrum Analyzer

- 2 GHz band width so values below 1 MHz were measured on the turn on slope

- Peaks were still obvious and exactly matched the ones found in the FFT

- Frequencies change every time the high noise state is entered



Grid signal on APA3
High noise state

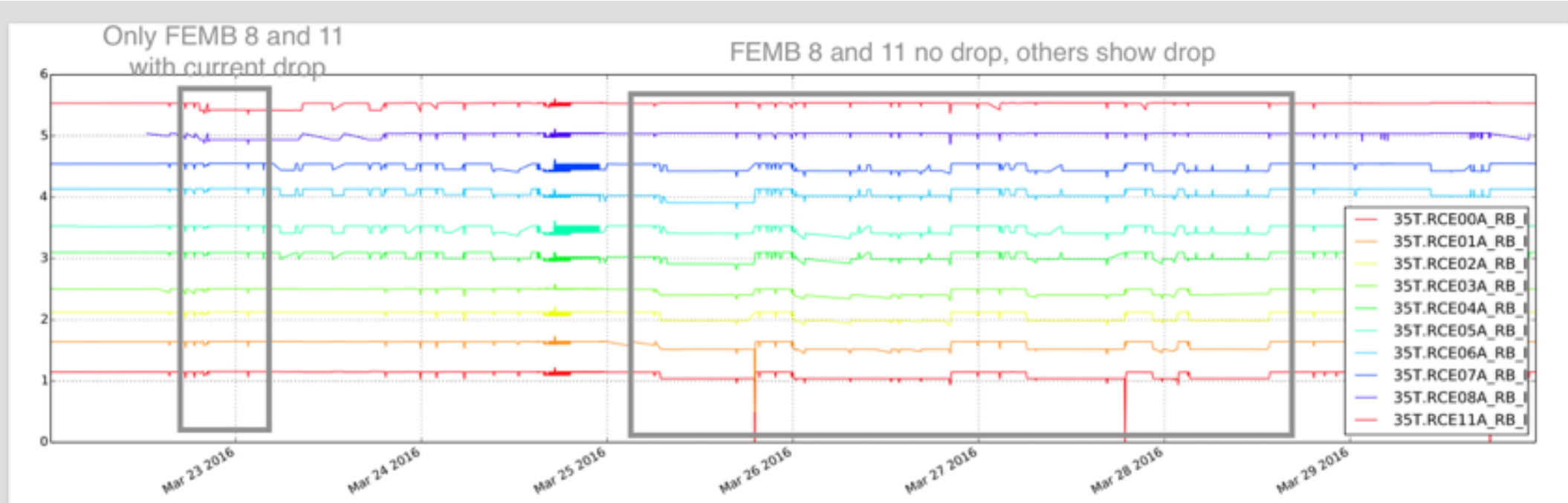
Cable Lengths

- 35 ton power cable is 21.5 meters long
- Sense point is at the supply back plane
  - μboone is about 2 meters after the sense point (sense at service board)
- 35 ton cable is too long for the bandwidth of the Weiner sense circuit

Noise continued

- MPODS use a variable frequency modulator depending on the current demand
    - Max frequency is ~300 KHz
- We observe many different frequencies in the 35 ton high noise state and these change every time we enter a high noise state
- Only the MPODS have the ability of generating the many different frequencies that we observe
- The MPOD current drops ~10% when entering the high noise state
    - FE ASIC is analog so power is constant or increasing with large input signals
- Most likely cause is that a large pulse of current from a spark or turning on a power supply causes the MPOD remote sense to oscillate.
    - All digital control simply makes a mistake and the operating frequencies jump to a somewhat random set

Front End Current Draw



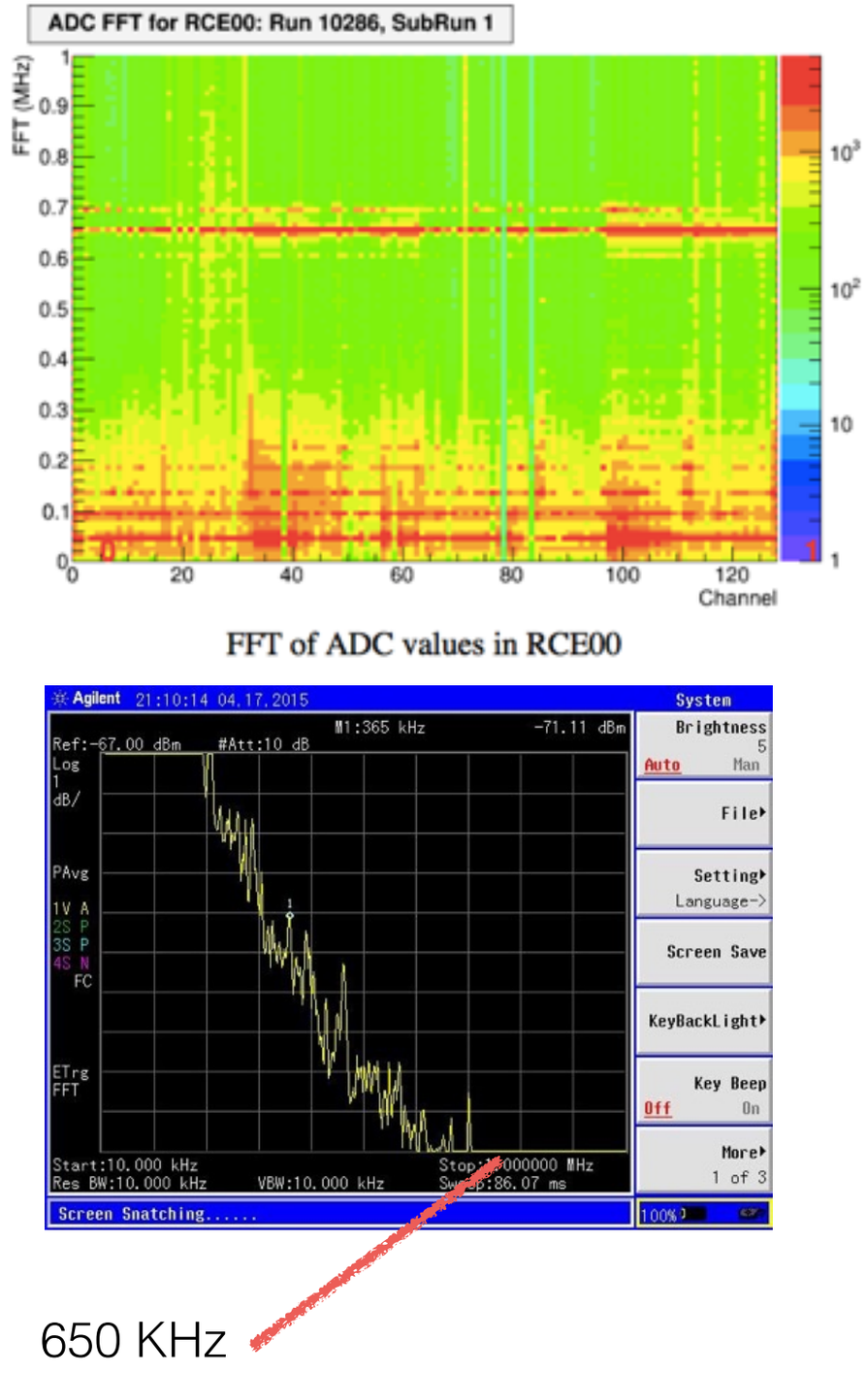
- Current to the front end ASICs shows a drop in value (about 10% or 100 mA) when entering the high noise state
- 100% correlation between current drop and high noise state
- Likely due Weiner measurement error

No High Noise When Warm

- The reason that there is no high noise state in air is due to the change in dielectric constant
  - power cables are unshielded twisted pair
  - In LAr (dielectric constant of 1.5) the local capacitance is larger and the propagation is slower
  - This is just enough of a change to cause the feed back to fail in LAr but not in air

650 KHz Noise

- Present in nearly all data and it is too high for the MPODs
- Likely a cable resonator
- Power cable is unterminated and driven by a wide range of frequencies from the MPODS so it is a good candidate for a cable resonator
- Resonator length is 2 times physical length times 4 for quarter wavelength
  - Gives 1.75 MHz frequency
  - Divide by 2 for aliasing giving 872 KHz. Note that no 650 KHz is observed on grid (and no 1.3 MHz because of stop frequency)
  - Ratio of 650 KHz to 872 KHz gives a cable propagation velocity of .74 which is very reasonable



Summary

- Comparison of signal with fluorescent light signal indicates that signal is in cryostat
- No high noise at room temperature also eliminates pick up
- Grid signal indicates significant power in the noise signal
- Power supply current drop indicates supply is making an error
- MPODS is the only source of variable frequencies observed in the data and on the grid
- The issue is a poor choice of the sense point location and not the Weiner supplies which work very well in μboone
    - Sensing at the flange board would likely have eliminated the problem (14.2 meter cold length)