RF Leakage Investigations & Atomic Clock Signal Phase Drift Analysis

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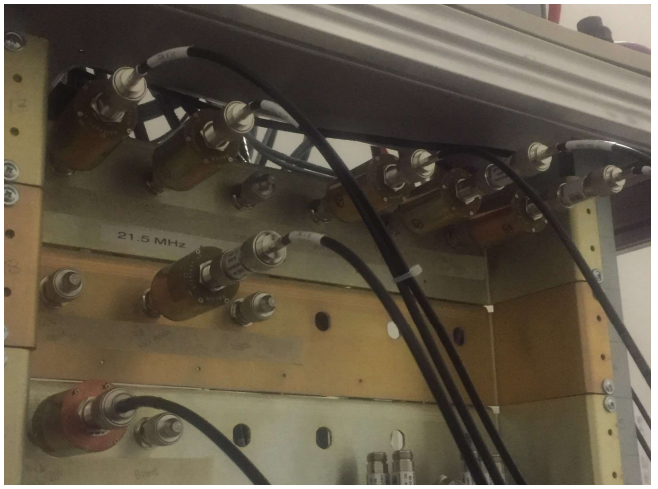
RF Signals and the IFO

- LIGO Radio Frequency (RF) roughly ranges from 100 kHz to 150 MHz
- RF signals used to derive control signals for achieving resonance in our optical cavities
  - Tells cavities whether they’re too short or too long and steers changes in cavity length accordingly
- RF leakages can contaminate signals in other electronics
- Suspected to be a reason behind some losses of lock and source of noise

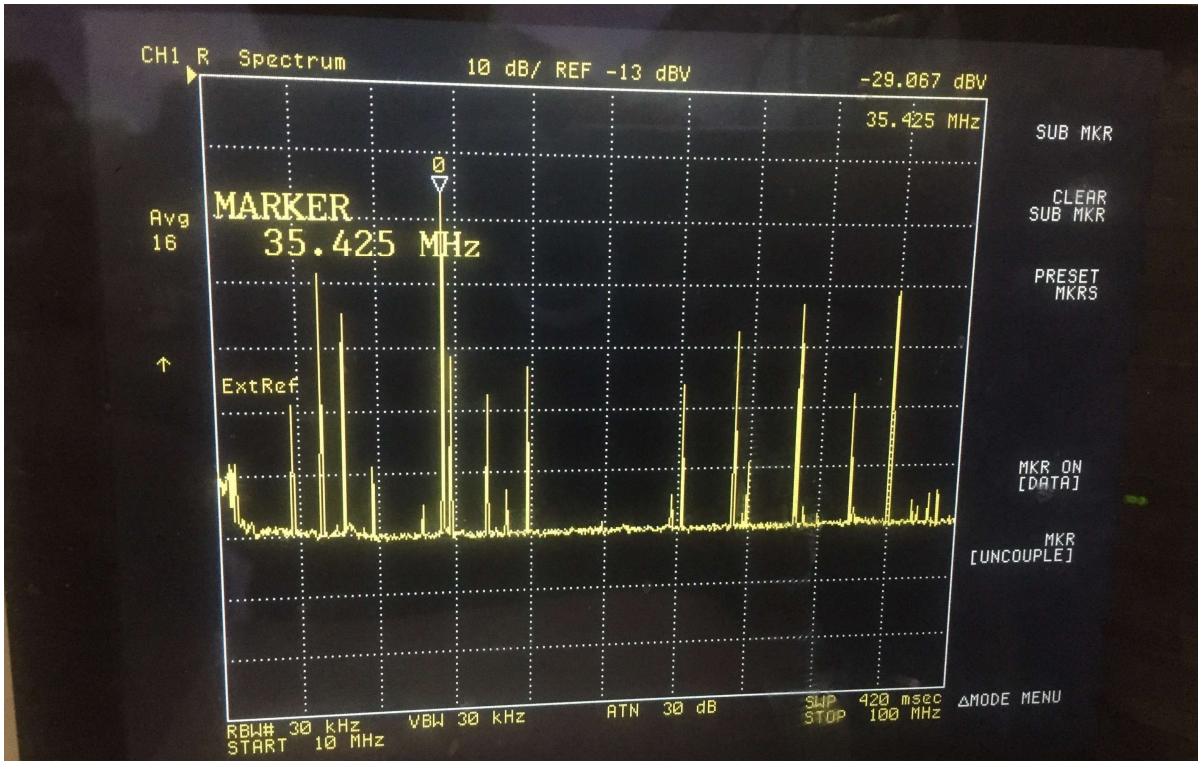
DC Ground Isolation Units (“Baluns”)

- Decouples DC grounds using a transformer and shields leakage with enclosure
- RF leakages observed when measuring ground to ground across the balun
- Largest leakage seen on balun mounted on PSL electronics rack with -22 dBV (~79 mV_{rms}) at 80 MHz



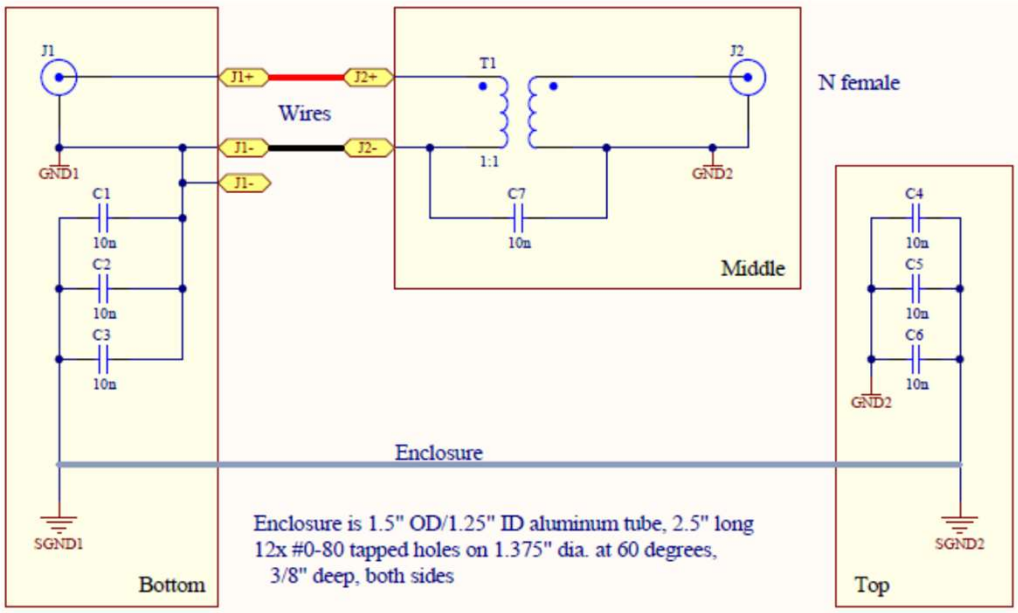
Typical Spectrum Analysis using RF Analyser

- Measured from cabling ground to cabling ground across balun
- This balun transmits a 35.5 MHz current
- -29 dBV is about 35 mV_{rms}
- Other peaks are suspected to be due to leakages from neighboring baluns



Circuit Diagram & Solutions

- Solution: Increase capacitance!
- Recall that $Z = \frac{1}{i\omega C}$
- Modifications:
  - Replace cap with conductor (copper)
  - Add more capacitors in parallel on the other cap
- Results: Peak goes from -22 dBV (~79 mV_{rms}) to -50 dBV (~3.2 mV_{rms}) at 80 MHz



DCC: LIGO-D1101077-v1

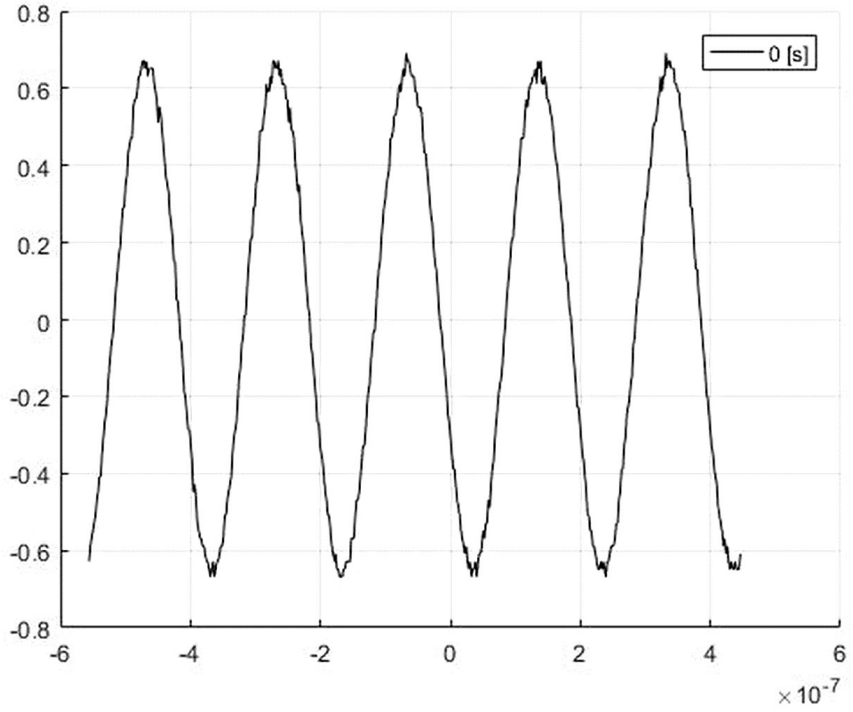
Future Plans

- Improve and test further modifications to the baluns (i.e. add more capacitors?)
- Identify other baluns that are candidates for replacement
- Investigate “big picture” impact on IFO

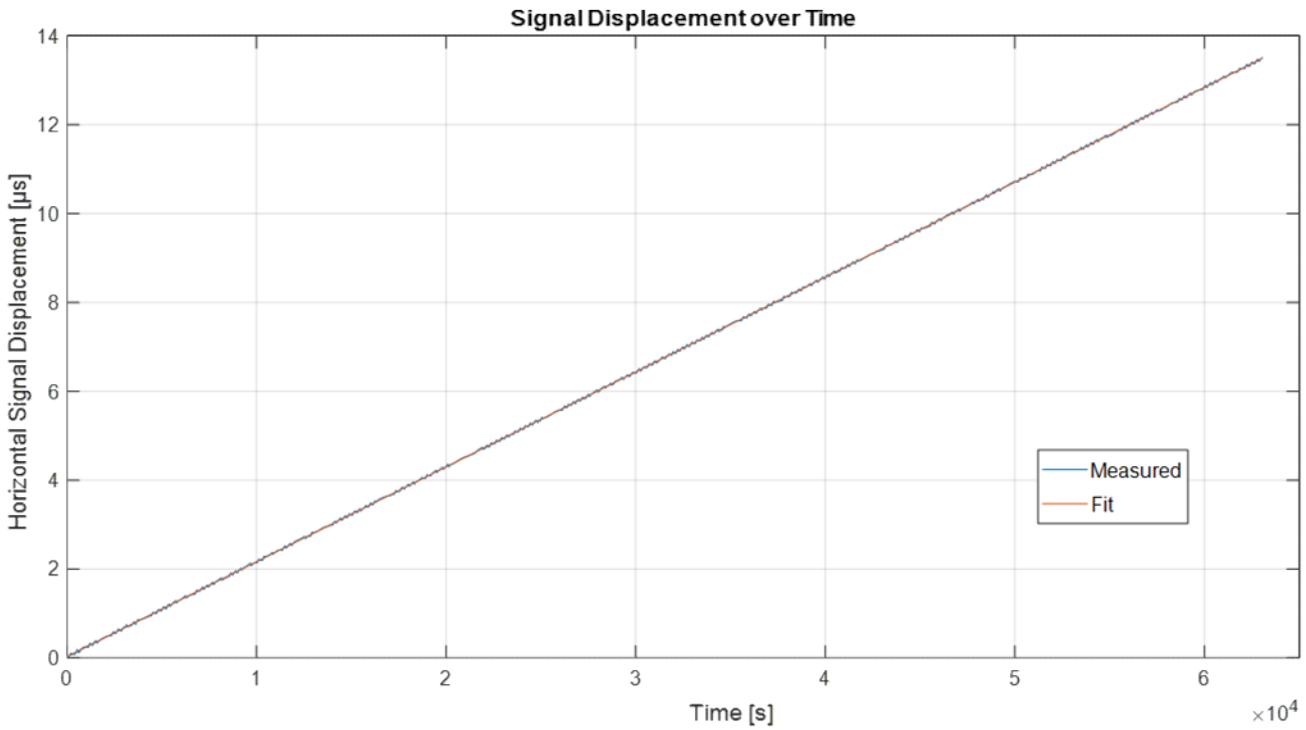
Atomic Clock Phase Drift

- We use an atomic clock as well as GPS for timing on the IFO
- When triggering a signal from a rubidium clock on a 1 PPS GPS signal, the signal seems to wander in phase
- Small phase shifts may not matter in small timescale measurements, but algorithms that use long integration times would see the effect
  - i.e. Algorithms that perform continuous wave searches

Phase Drift Sped Up

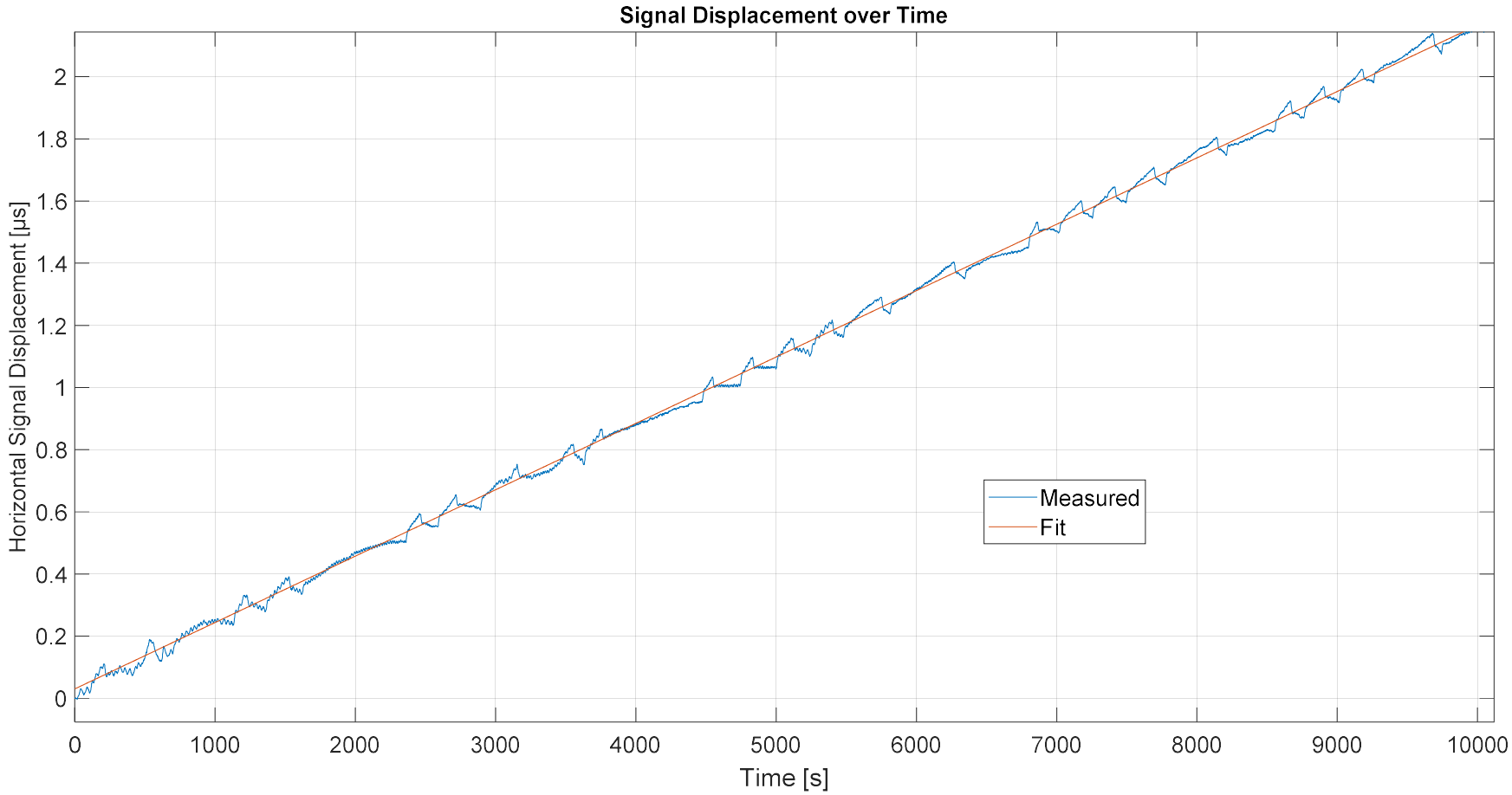


Long Term Measurement of Horizontal Shift

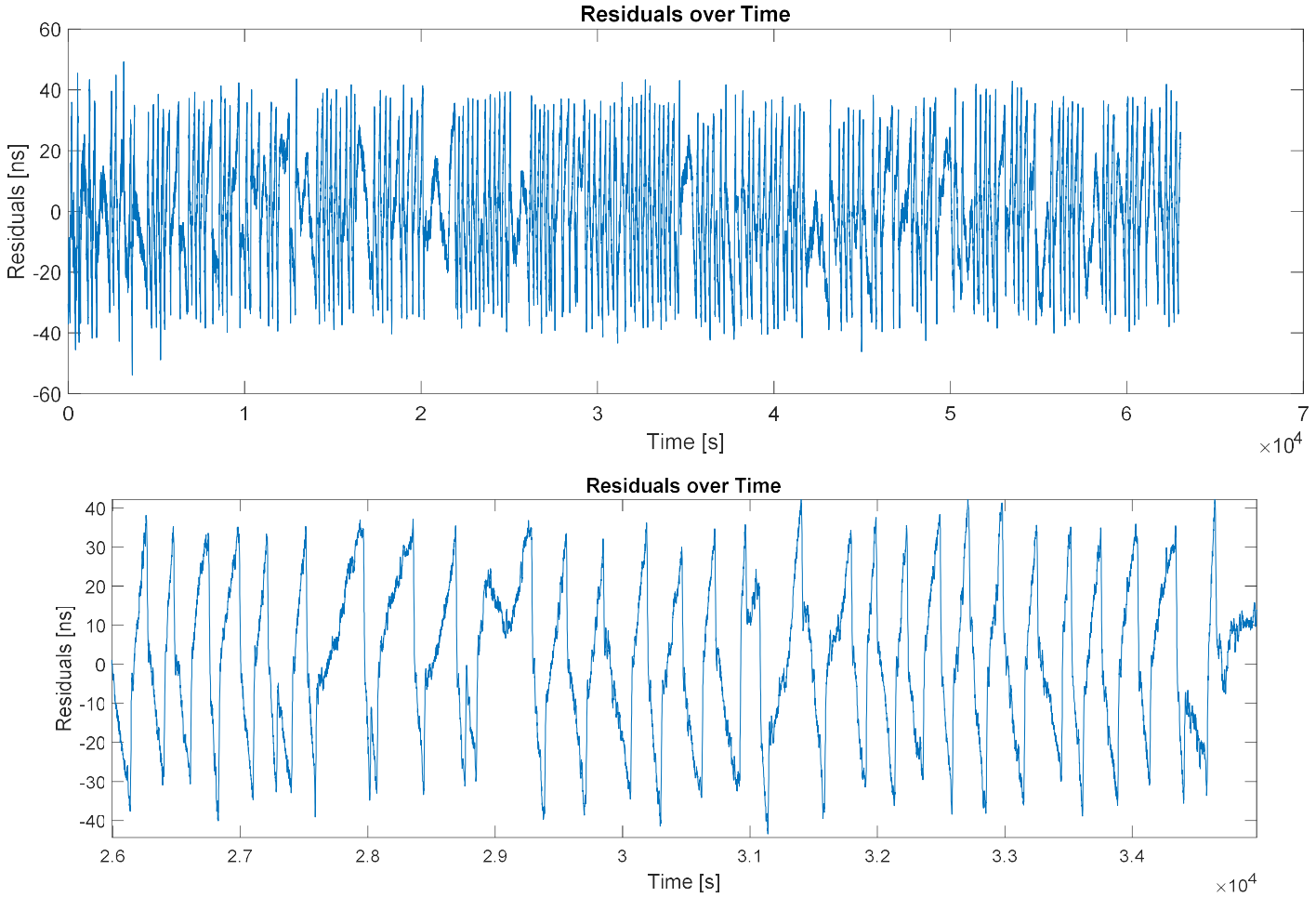


- Mean drift of 213.55 ps per second
- We can likely tune the clock to get rid of linear drift

But Not Perfectly Linear…

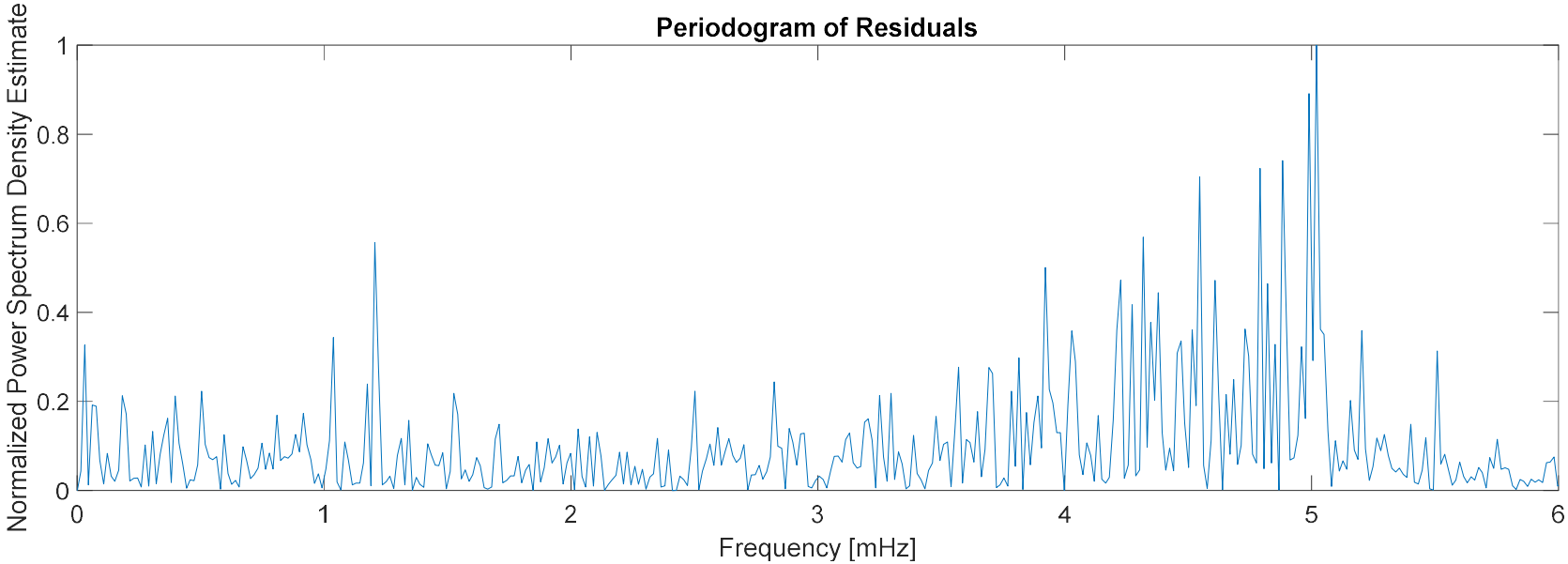


Observed Periodicity in Residuals



Test for Periodicity

- Creating periodogram we find the two most interesting peaks are
  - 5.02 mHz (~200 s period)
  - 1.205 mHz (~14 min period)



Future Plans

- Tune atomic clock to get rid of linear phase drift
- Investigate the sources of these periodicities
- Perform same analysis on an atomic clock more identical to the one use on H1
- Take two identical RF Oscillator Sources and have one disciplined by GPS and the other by an atomic clock and analyze the difference

Questions?