1. INTRODUCTION

The US LAB pump package assembly (PPA) is utilized in the Internal Thermal Control System (ITCS) of the International Space Station (ISS). The PPA circulates coolant throughout the ITCS system, and it provides for coolant expansion and contraction. The PPA is designed to circulate coolant for electronics and avionics cooling, experimental rack heat loads, and critical life support equipment.

In June of 2019, there was a series of PPA speed and flow tests. The main purpose of the tests was to establish a maximum value of payload flow availability based on ITCS mode and Three Way Mix Valve (TWMV) setpoint which is important for accommodating an increase in payload utilization. The ops team was to be assessing the flow rate correlations from the tests. The PPAs being tested were located in LAB1P6 (LT PPA) and LAB1S6 (MT PPA).

One such test on **GMT 2019/177 (2019-06-26)** was timelined as follows:

- **Lab transitioned to Dual at GMT 11:20**.
- LT PPA remained at 14,667 RPM (244.5 Hz) throughout test.
- **GMT 15:15-17:15: Speed incrementally increased from 17,200 RPM to 20,000 RPM, that is, from 286.7 Hz to 333.3 Hz**.

Another test on **GMT 2019/179 (2019-06-28)** was timelined as follows:

- Dual on LT PPA @ LTL TWMV = 9.4C.
- MT PPA remained at 17,200 RPM throughout test.
- **GMT 14:30-17:40: Speed incrementally increased from 14,667 RPM to 20,000 RPM, that is, from 244.5 Hz to 333.3 Hz**.
- GMT 19:20: Speed reduced to 17,020 RPM.
- GMT 20:20: Speed increased to 18,431 RPM.
- GMT 21:21: Speed returned to 14,667 RPM.

The Space Acceleration Measurement System (SAMS) has remote sensor heads distributed throughout all 3 of the main laboratories on the space station. This included a sensor on the Cold Atom Lab (LAB1P2) near the PPA units being tested. However, the nominal cut-off frequency of 200 Hz was not high enough to potentially capture any PPA vibrations above that cut-off frequency, so the SAMS ground team increased the sample rate and cut-off frequency of this sensor to monitor up to 400 Hz (and the sample rate to 1,000 samples/second) during testing.

2. QUALIFY

A routine daily "roadmap" spectrogram of SAMS data from sensor on Cold Atom Lab (with 400 Hz cut-off) around the time of the testing on GMT 2019-06-26 can be seen in Figure 1.

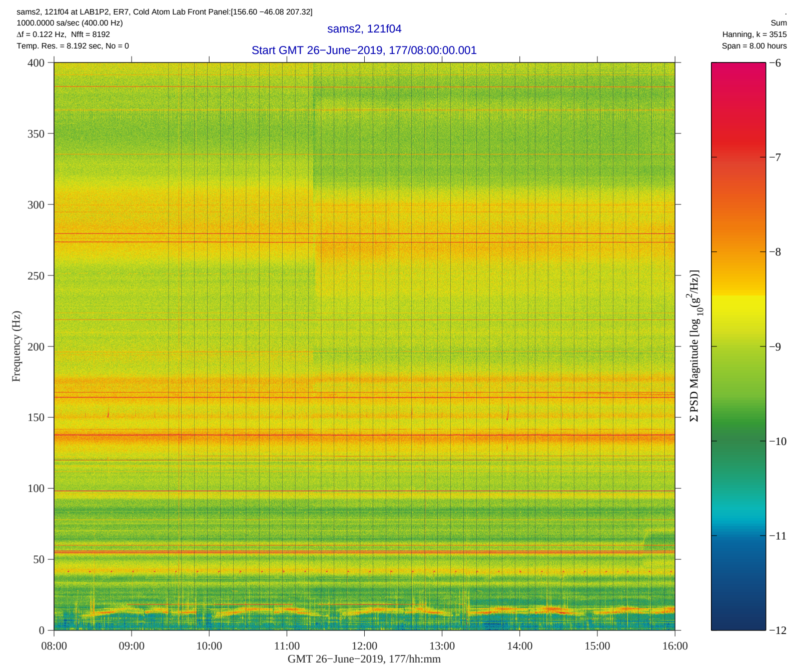

Fig. 1: Spectrogram around PPA testing on GMT 2019-06-26.

A zoom-in of time axis around the times given for the test on GMT 2019-06-26 is shown in Figure 2 on page 2.

This zoomed-in spectrogram shows a somewhat subtle shift in broadband vibrations at about GMT 11:20:20 – this is the time when the PPA transitioned to dual mode, and is marked by a vertical, downward-pointing arrow at that time. The speed changes indicated by the test steps would be manifest between the 2 horizontal, rightward-pointing arrows on this plot, bounding the 17,200 RPM (286.7

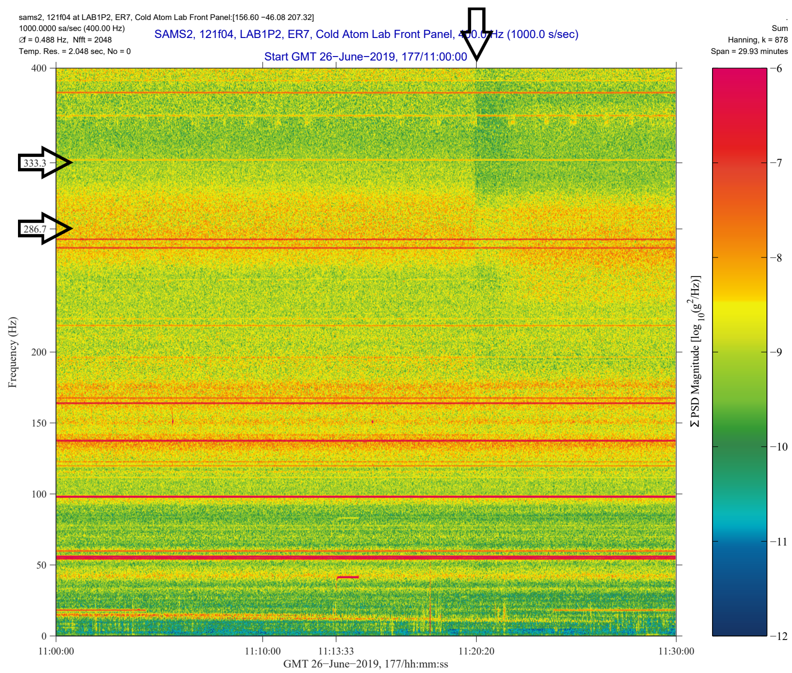

Fig. 2: Spectrogram (time-zoomed) around PPA testing on GMT 2019-06-26.

Hz) to 20,000 RPM (333.3 Hz) range. However, we do not see a tell-tale pump signature, which should show up as a ramp or series of steps/plateaus within that range as the speed was incremented up. It is important to note, however, that this SAMS sensor was mounted on Cold Atom Lab (LAB1P2), while the PPA being tested was in LAB1P6. Generally speaking, the higher the frequency of vibration, the more localized those vibrations tend to be, so no big surprises here.

The 3-panel (XYZ) acceleration plot of power spectral density in Figure 3 gives a bit more context to the shift in broadband vibrations with the transition to Dual mode at about 11:20 on GMT 2019/177 (2019-06-26). Note that the red traces were computed from "before Dual mode" (GMT 11:00-11:20), while the black traces were computed "during Dual mode" (GMT 11:30-11:50).

One last piece of background information, it has been reported that the crew can

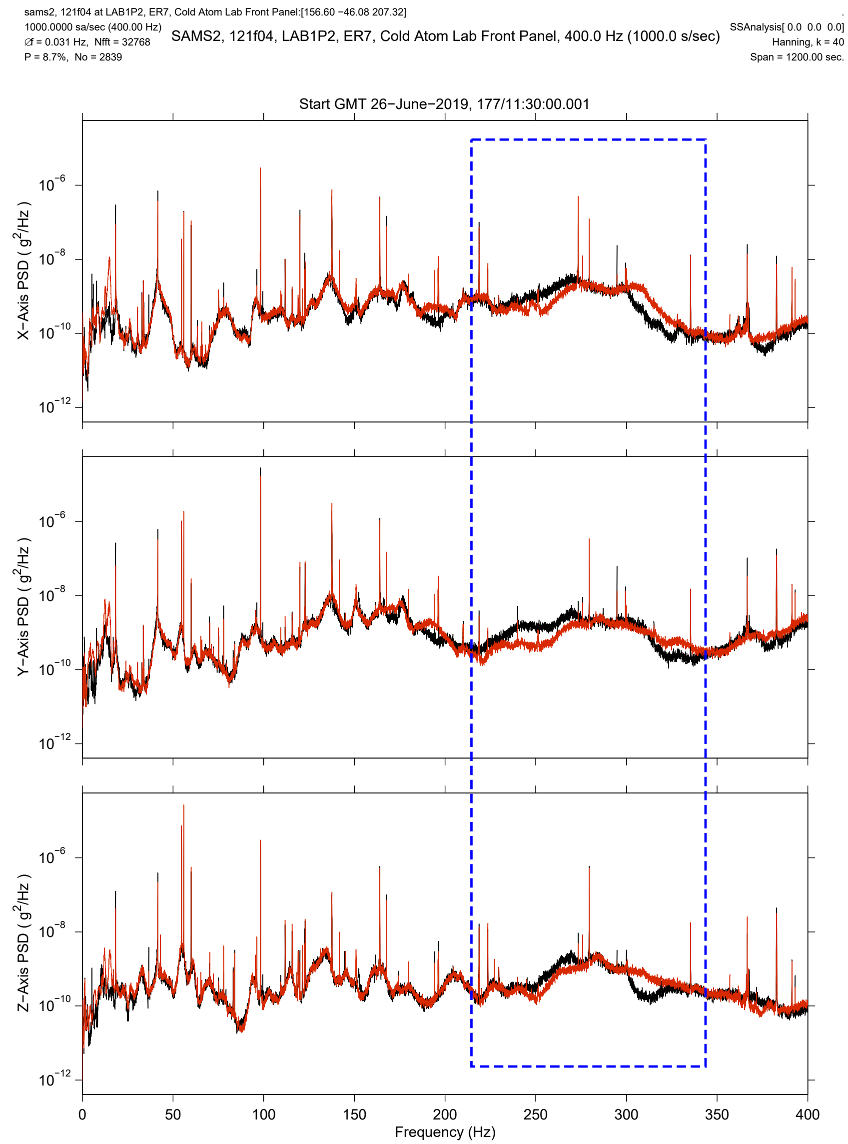

Fig. 3: XYZ power spectral density plots for PPA testing on GMT 2019-06-26.

sometimes hear the change in PPA speed. Most of the vibrational frequency range that SAMS measures is toward the bottom (or below) the lower end of typical human hearing.

The spectrogram in Figure 4 shows a typical "roadmap" plot for broad overview for subsequent testing, however, again we were not able to use SAMS measurements from a sensor head mounted on the Cold Atom Lab (LAB1P2) to discern the PPA speed changes.

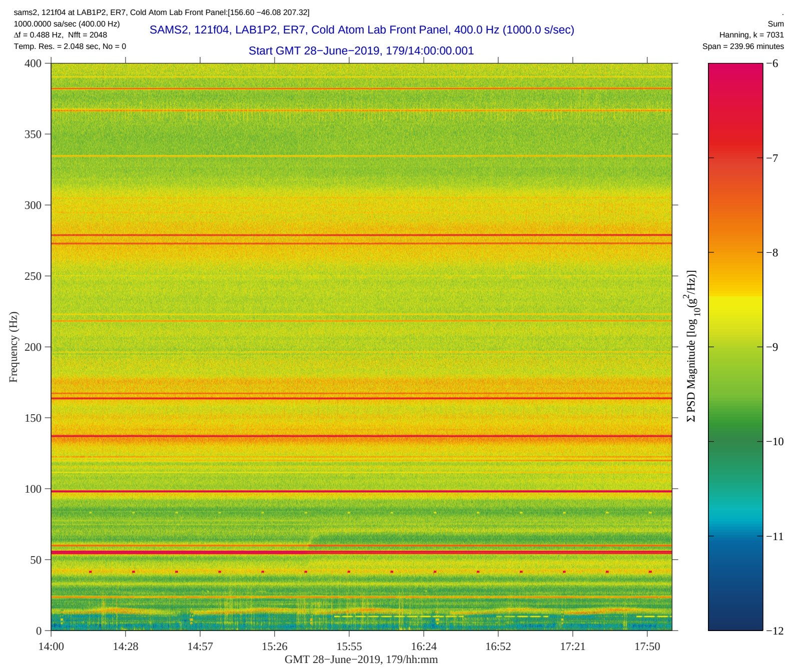

Fig. 4: Spectrogram around PPA testing on GMT 2019-06-28.

A zoom-in of the time, frequency and magnitude (color scale) axis around the times given for the test on GMT 2019-06-28 is shown in Figure 5 on page 4. While this zoom-in plot shows when the speed-change should have taken place as bounded by the magenta tick marks on each axis (time/frequency) and therefore, the magenta rectangle. Inside this rectangle, we would otherwise presume to see a ramp or series of steps up in frequency of the narrowband (relatively high frequency) vibrations induced by the pump. It seems that no such vibrations propagated to the SAMS sensor location from the PPA.

3. Quantify

Since we were unable to extract features associated with the PPA speed tests in June 2019, we could not attempt to quantify their impact on the microgravity environment.

4. Conclusion

The SAMS sensor mounted on the Cold Atom Lab (LAB1P2) was not able to detect the expected narrowband signature of a pump. We were able to detect a subtle shift in broadband energy when switched to dual mode on GMT 2019-06-26.

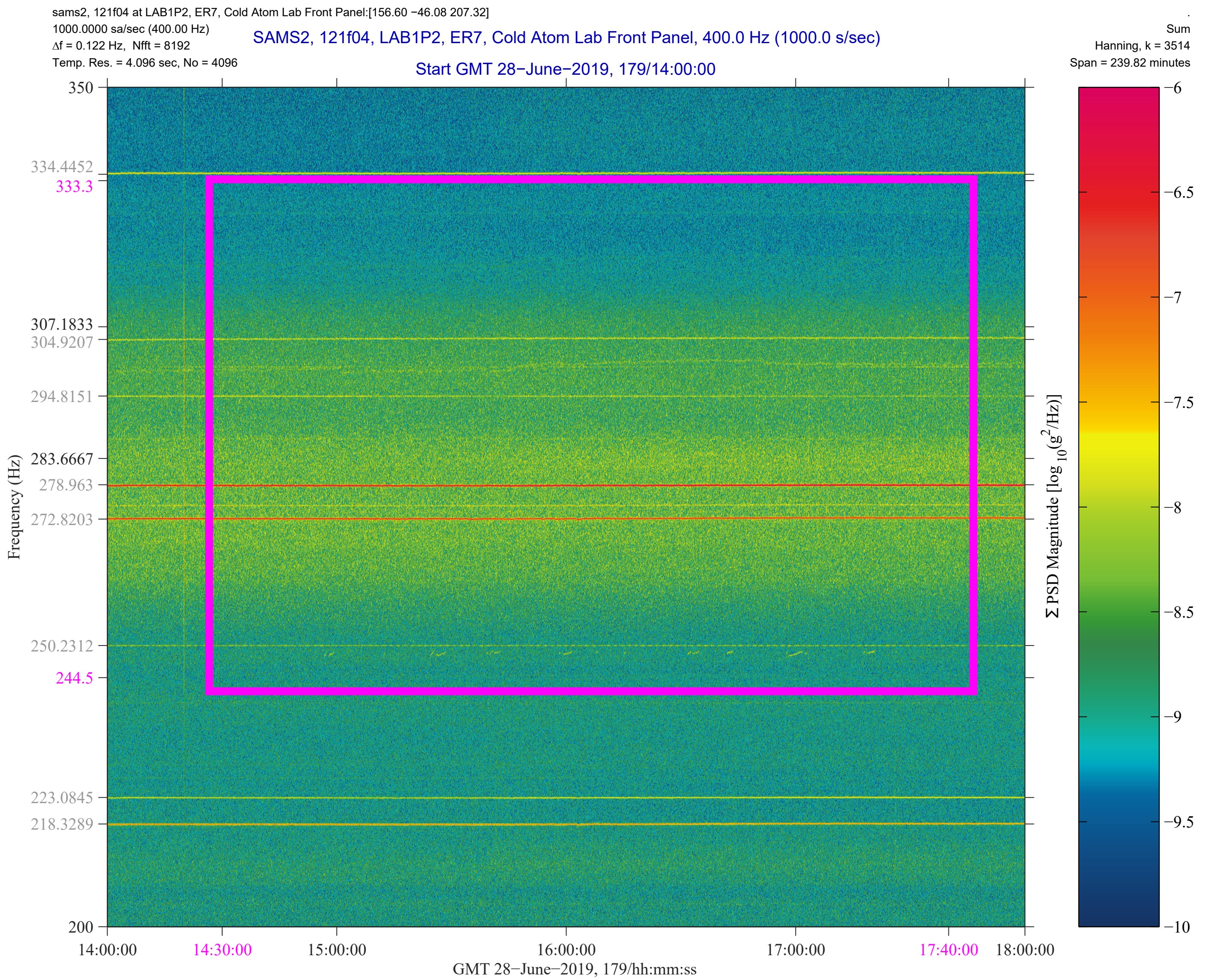

Fig. 5: Spectrogram (time, frequency & magnitude zoomed) around PPA testing on GMT 2019-06-28.