1. INTRODUCTION

We have two previous analyses of the vibratory environment via Space Acceleration Measurement System (SAMS) sensor head measurements from 2022 and again in 2023. Summaries for each are shown as introductory background information here.

Summary of SAMS Analysis for 4BCO2 in 2022

Our objective was to apply one-third octave band analysis to vibratory (0.01 to 200 Hz) measurements made by the SAMS sensor near the 4BCO2 equipment located within LAB1P4 rack on the ISS to compare two conditions: (1) 4BCO2 OFF (baseline), and (2) 4BCO2 ON to the ISS Microgravity Control Plan's stairstep curve.

The analysis results revealed one OTO band from 56.230 to 71.838 Hz, where ostensibly that vibrations from the blower and intermittent pump give rise to median RMS acceleration levels of about 1.2 milli-gRMS, which is just over the ISS Microgravity Control Plan level of 1.152 milli-gRMS for that band, and roughly an order of magnitude higher than the 4BCO2 OFF condition.

For full details, see this link from 2022.

Summary of SAMS Analysis for 4BCO2 in 2023

The analysis results from 4 SAMS sensor heads distributed across all 3 main labs of the ISS on GMT 2023-01-06 between about 13:15 and 15:30 during 4BCO2 operations, most notably the Blower and Air Save Pump, showed localized vibrations from both of those equipment sources:

- for tell-tale spectrograms computed from the SAMS sensor nearest 4BCO2, we had to rescale the color/magnitude in order to "pull the signal features out of saturation", i.e. compensate for "very loud narrowband vibrations
- the Air Save Pump signature had a fundamental frequency near 66.7 Hz and a 2nd harmonic near 133 Hz – we saw that pump turn on/off twice, each time for a duration just a bit over 10 minutes within about a 2-hour span of time
- direct identification of the Blower signature was confounded by its higher-than-SAMS-passband operating frequency, but we clearly saw what we attribute as alias signals from its fundamental or upper harmonics – these Blower signatures drop into the frequency band measured by SAMS from about 100 to about 200 Hz
- comparing 4 SAMS sensor head locations distributed throughout the ISS showed only one indication of propagation of 4BCO2 vibrations – that was between 180 and 200 Hz (i.e. the Blower) and that was limited to propagation to "two racks over on the port side in the US LAB"

For full details, see this link from 2023.

4BCO2 Channel 2 Unbalance Warning on GMT 2024-01-13

On Saturday, January 13th, there was a 4BCO2 Channel 2 Unbalance Warning. Ground teams began working 4CO2 Channel 1-5 Unbalance Warning actions, which had been pre-coordinated and included taking 4BCO2 to Standby. These actions were taken in order to gather data for an anomalous signature, which can lead to a 4BCO2 Blower Fault with Y1 Synchronous Vibration, first seen on GMT 2023-10-19. 4BCO2 is in Standby until a power cycle can be completed Tuesday morning, January 16th. Thermal Amine Scrubber (TAS) and Lab Carbon Dioxide Removal Assembly (CDRA) [were used instead for] providing CO2 scrubbing.

2. QUALIFY

The information shown in the entire-day, 200 Hz spectrogram of Figure 1 was calculated from SAMS sensor es20 measurements made in the US Laboratory, nearby the 4BCO2 equipment on GMT 2024-01-13 – the day or reported 4BCO2 unbalance warning. This plot demonstrates on that day, the narrowband spectral signatures of the 4BCO2 pump/blower are seen as narrow, horizontal red streaks at 64.7 Hz and 66.2 Hz. These are seen to turn OFF/ON/OFF, and the 66.2 Hz spectral peak also shows its [nominal?] duty cycle as well. The blue "OFF" annotations on Figure 1 show [likely] first the standby, then a "stand down" control by engineers troubleshooting the reported unbalance. Without detailed knowledge of the nature or symptoms of the unbalance, we see no obvious change in the spectral appearance via the SAMS spectrogram for these 2 narrowband signatures other than having been turned OFF/ON. Further analyis of these SAMS measurements in the Quantify section below focuses on a one-third octave (OTO) band that encompasses these narrowband frequencies is shown in the Quantify section below. This OTO band was chosen for direct comparison to the 2 other SAMS analyses mentioned in the Introduction section.

3. QUANTIFY

In order to quantify the vibratory impact associated with the OTO frequency band that encompasses the 4BCO2 pump and blower equipment, we turn to insights gained by employing Parseval's theorem. That is, we compute Power Spectral Densities (PSDs) from the SAMS measurements, then integrate and square root those PSDs to yield per-axis RMS values for the OTO band of interest. In effect, we can *mostly/somewhat* isolate the 4BCO2 pump/blower impact in this way.

Figures 2 through 4 on pages 4 and 5 show our focused per-axis RMS versus time plots for: (1) the day of the unbalance, (2) the day before, and (2) the day after, respectively. Figure 2 shows troubleshooting results/impact of going to standby, then "stand down" on GMT 2024-01-13. The other 2 figures on 5 show i.e. an ON/OFF comparison within this OTO band, albeit, it seems there was a brief ON period around GMT 2024-01-14/04:00 in Figure 4.

4. CONCLUSION

The analysis shown here, particularly for days 12-14 of January 2024, do not reveal the in-depth nature of the 4BCO2 unbalance, speculatively related to the blower. However, we do see an RMS attenuation of roughly a third for the OTO band that encompasses the 4BCO2 pump/blower equipment when comparing ON versus OFF times.

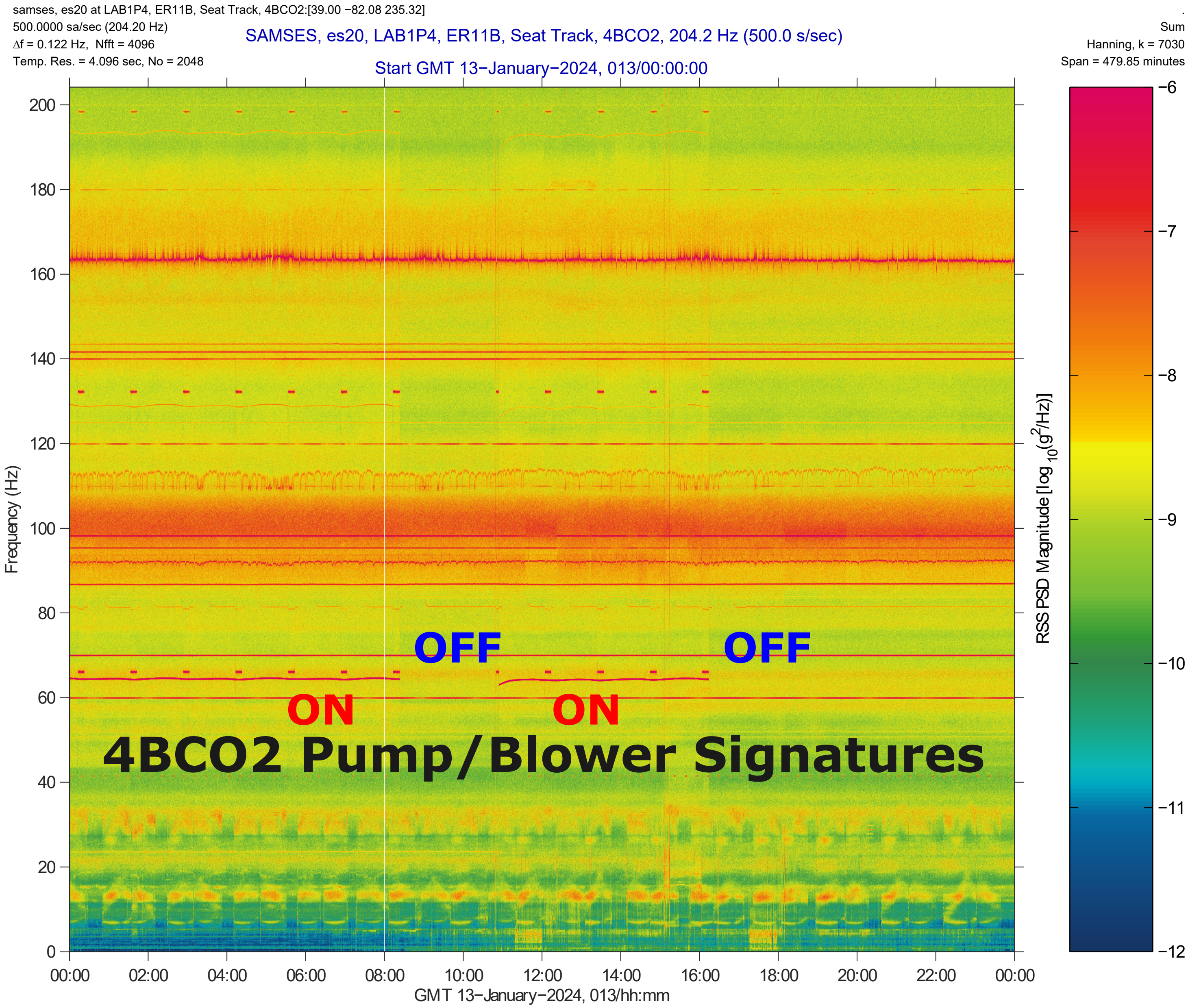

Fig. 1: 200 Hz, Entire Day (GMT 2024-01-13) Spectrogram showing 4BCO2 Pump/Blower Narrowband Signatures ON/OFF.

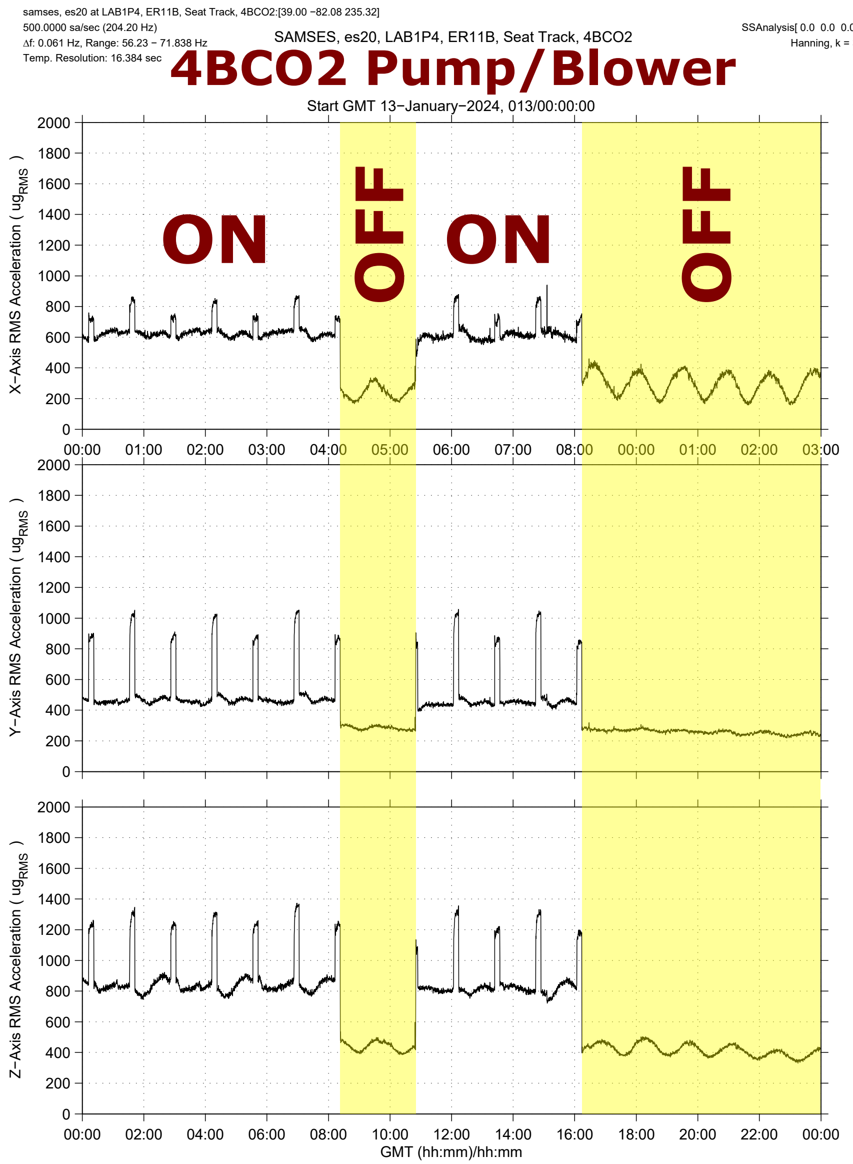

Fig. 2: Per-Axis RMS Accel. (56.2 < f < 71.8 Hz) for SAMS es20 Sensor Near 4BCO2 (LAB1P4).

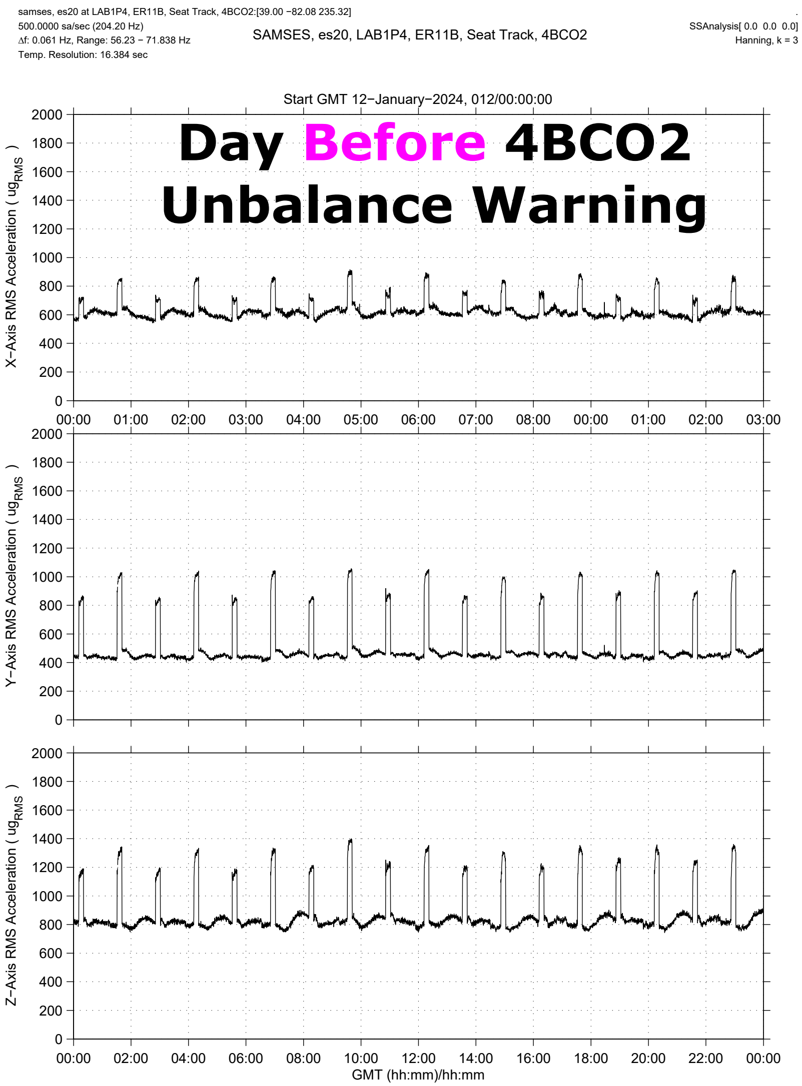

Fig. 3: "Day **Before** Unbalance" Per-Axis RMS Accel. (56.2 < f < 71.8 Hz) for SAMS es20 Sensor Near 4BCO2 (LAB1P4).

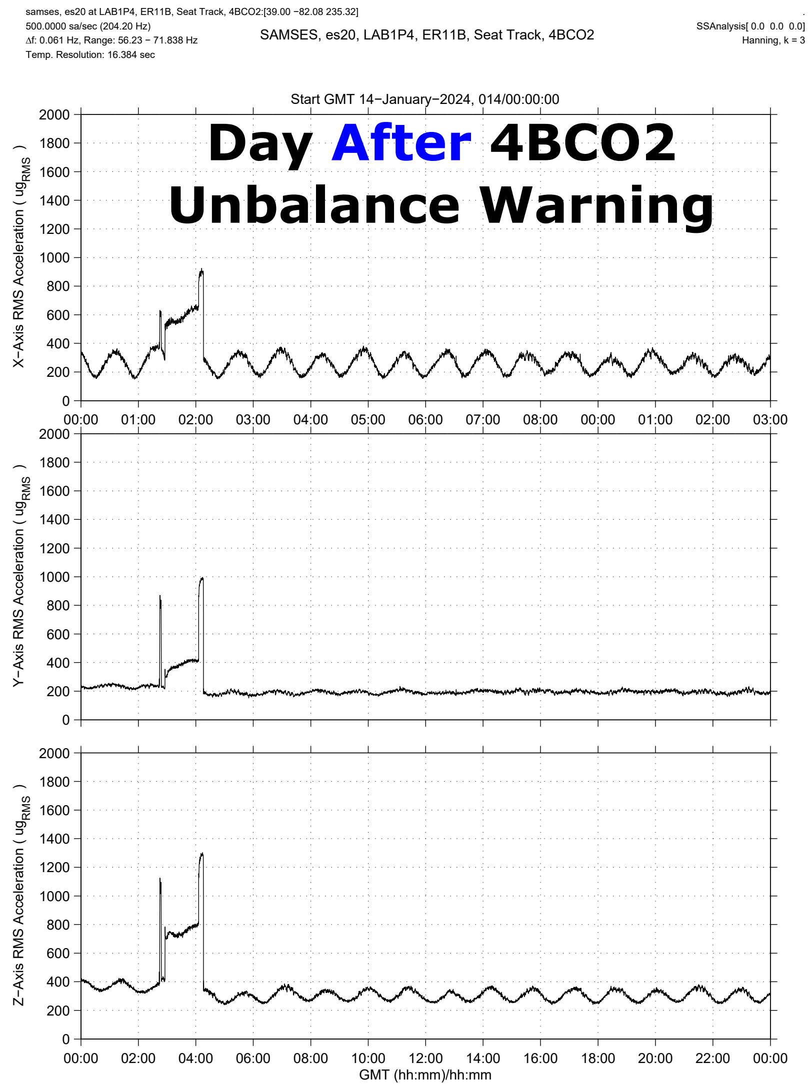

Fig. 4: "Day **After** Unbalance" Per-Axis RMS Accel. (56.2 < f < 71.8 Hz) for SAMS es20 Sensor Near 4BCO2 (LAB1P4).