1. INTRODUCTION

Starting at about GMT 2023-06-14, 165/15:35, one of the International Space Station (ISS) crew began about a 45-minute exercise period using the BD-2 treadmill equipment located in Zvezda Service Module. This exercise period was relatively rare in that it was the only exercise happening during that period of time aboard the space station. A unique opportunity to isolate the impact of this device with the major disclaimer that crew vigor/input plays as a key factor for exercise vibrations.

For more details on BD-2 exercise, you can have a look at the following links:

(1) **BD-2 on GMT 2021-06-10**
(2) **Velo and BD-2 on GMT 2021-06-22**
(3) **BD-2 on GMT 2022-11-01**

2. QUALIFY

The treadmill is depicted in the historic photograph of Figure 1. Note the shoulder harness that anchors the crew to the treadmill, providing at least partial "down" force that otherwise comes from gravity in a 1g field. The spectrogram of Figure 2 on page 2 was calculated from SAMS sensor 121f02 acceleration measurements made in the Columbus module. This plot focuses on a lower-frequency portion of the acceleration spectrum usually dominated by vehicle structural modes and crew activity such as exercise. It shows increased structural vibration excitation for the BD-2 exercise period from GMT 15:35 to 16:20, whereas the original, planned period for this exercise is shown along the time axis. BD-2 treadmill exercise seen here gives rise to heightened vibrations (red, horizontal streaks) during the exercise period, primarily below about 2 Hz.

3. QUANTIFY

In order to quantify the impact of this BD-2 exercise, we again focus our attention below 5 Hz and show 16-second interval root-mean-square (RMS) values for five SAMS sensor heads distributed throughout the ISS. For example, Figure **??** shows RMS values computed before (GMT 14:30-14:50) and during (GMT 15:40-16:00) the exercise period and we contrast the median RMS values in those 2 spans with the green and magenta annotations. Results for this sensor along with 4 more SAMS sensor heads distributed throughout the ISS are shown in Table 1 on page 4.

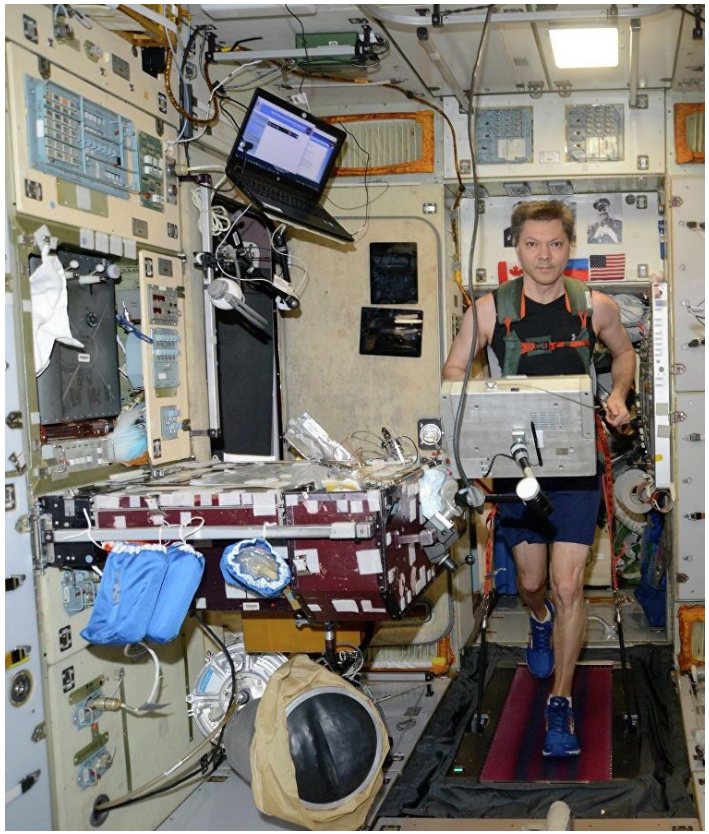

Fig. 1: Historic Photo of ISS Crew BD-2 Exercise.

4. CONCLUSION

The RMS values for SAMS sensors show notable impacts due to BD-2 exercise primarily below 5 Hz as this activity tends to excite vehicle structural modes. This is reinforced by the median values tabulated in Table 1 on page 4. Note that during this exercise period the SAMS sensor on the Cold Atom Lab (121f04) showed a bit more of an increase when looking at the RMS ratio during:before below 5 Hz.

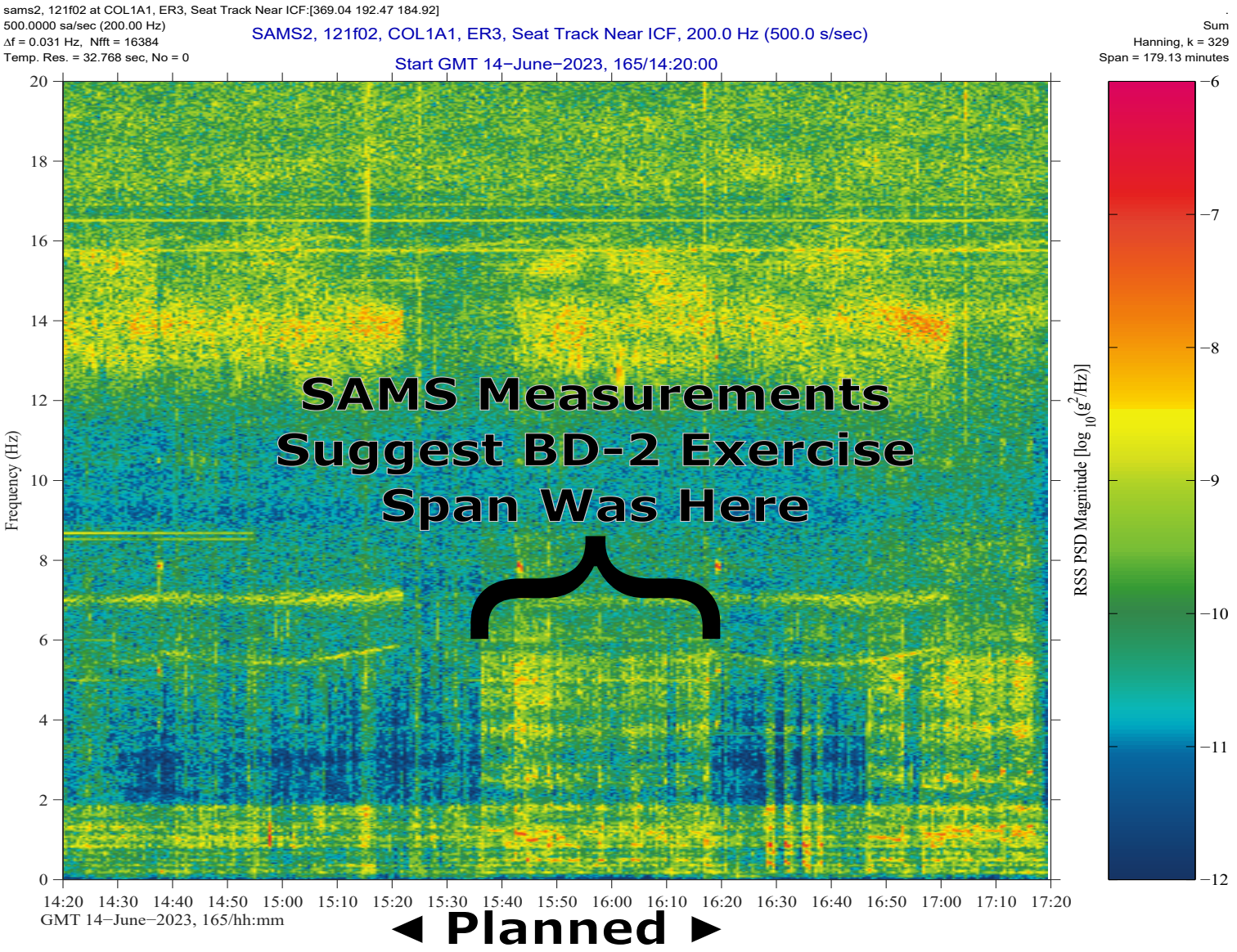

Fig. 2: 3-Hour **RSS Spectrogram**, SAMS Sensor 121f02 (COL1A1), Shows BD-2 Exercise on GMT 2023-06-14.

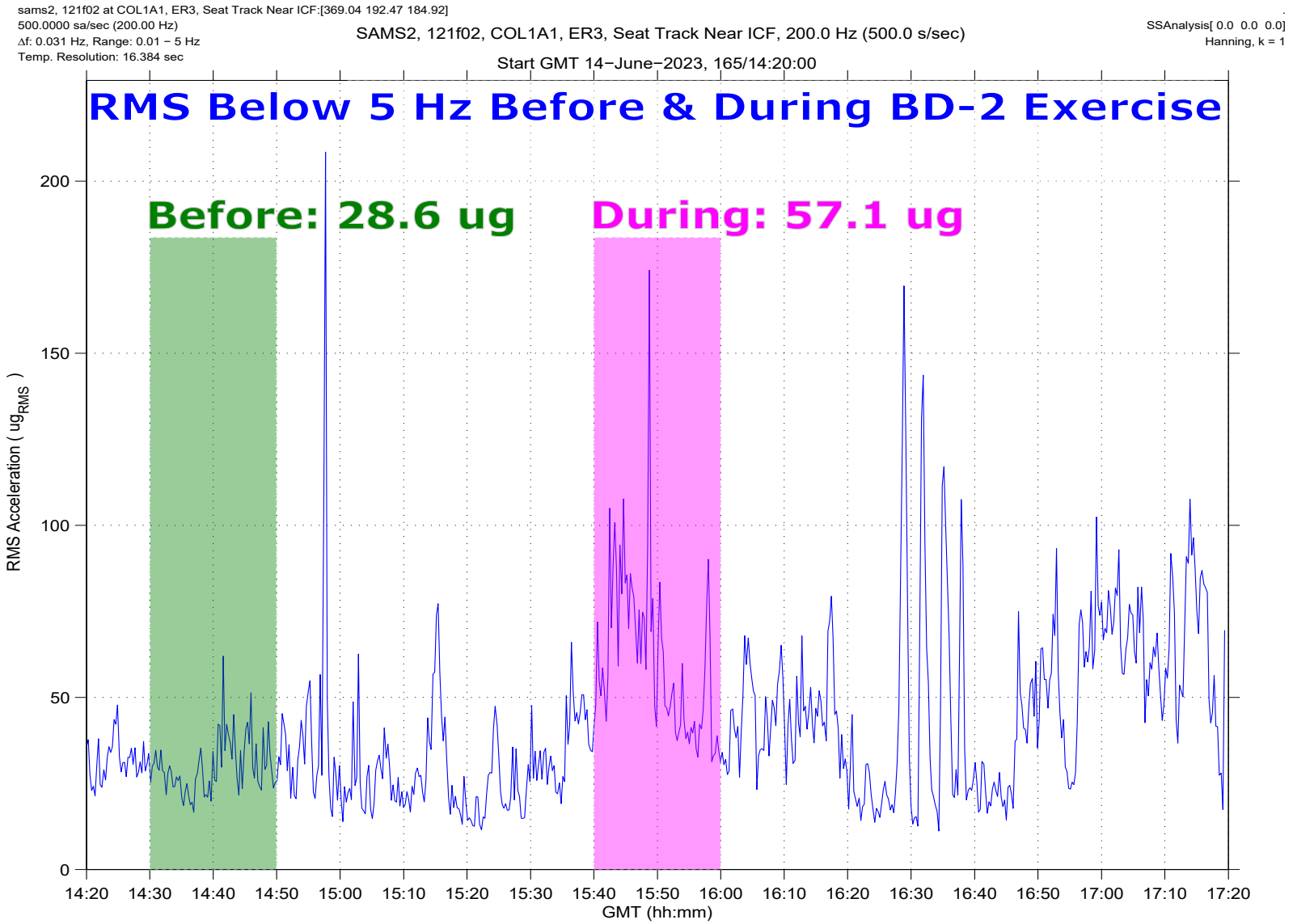

Fig. 3: **16-Second Interval RMS**, SAMS Sensor 121f02 (COL1A1), Shows BD-2 Exercise on GMT 2023-06-14.

			RMS Below 5 Hz (micro-g)	
Sensor	**Module**	**Rack**	**BEFORE BD-2**	**DURING BD-2**
121f02	COL	COL1A1 (ER3)	28.6	57.1
121f08	COL	COL1A3 (EPM)	44.7	84.7
121f05	JEM	JPM1F1 (ER5)	24.7	67.8
121f04	**LAB**	**LAB1P2 (ER7)**	**25.4**	**70.9**
121f03	LAB	LAB1O1 (ER2)	22.9	51.8

Table 1. **RMS Below 5 Hz**, SAMS Sensors, Compare Before/During BD-2 Exercise on GMT 2023-06-14.