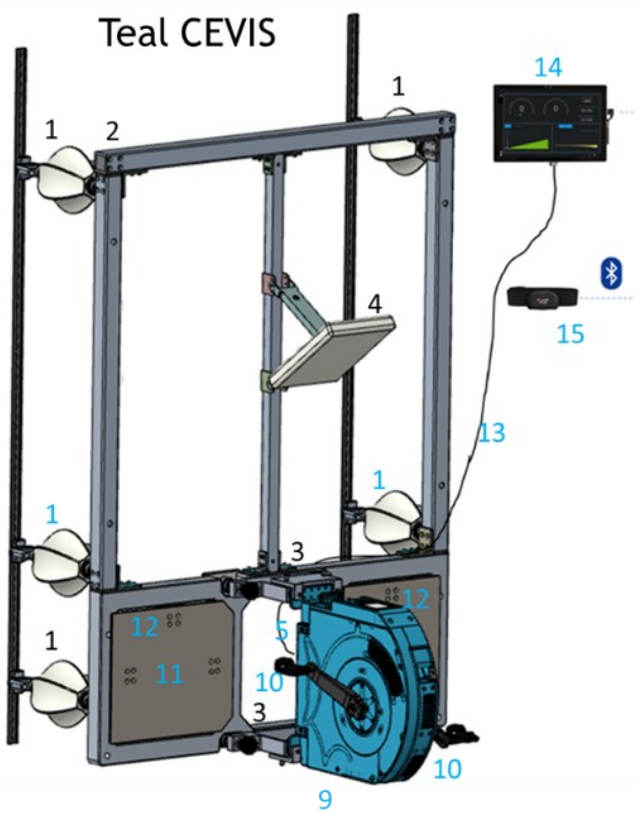
Space Acceleration Measurement System (**SAMS**) Analysis and Characterization of Teal Cycle Ergometer with Vibration Isolation System (**CEVIS**) Exercise Sessions, Oct-Nov. 2023

Introduction

1. Analysis of SAMS measurements during 43 Teal CEVIS exercise sessions.
2. Includes data from five SAMS sensor heads distributed throughout all 3 main laboratories of the ISS: 2 in LAB, 2 in COL, and 1 in JEM.
3. Primary focus put on a bellwether SAMS sensor head mounted on COL1A3, S/N 121f08.
4. Results ultimately yield a qualitative assessment of CEVIS exercise's impact on the vibratory regime of the ISS below 6 Hz.



Outline

- Data Analysis Overview
- Compare Teal CEVIS Exercise RMS Values (Below 6 Hz) to a Large Volume of SAMS Measurements.
- Two Significant CEVIS Exercise Sessions
- Table of CEVIS Sessions Summary
- Conclusion

Data Analysis Overview

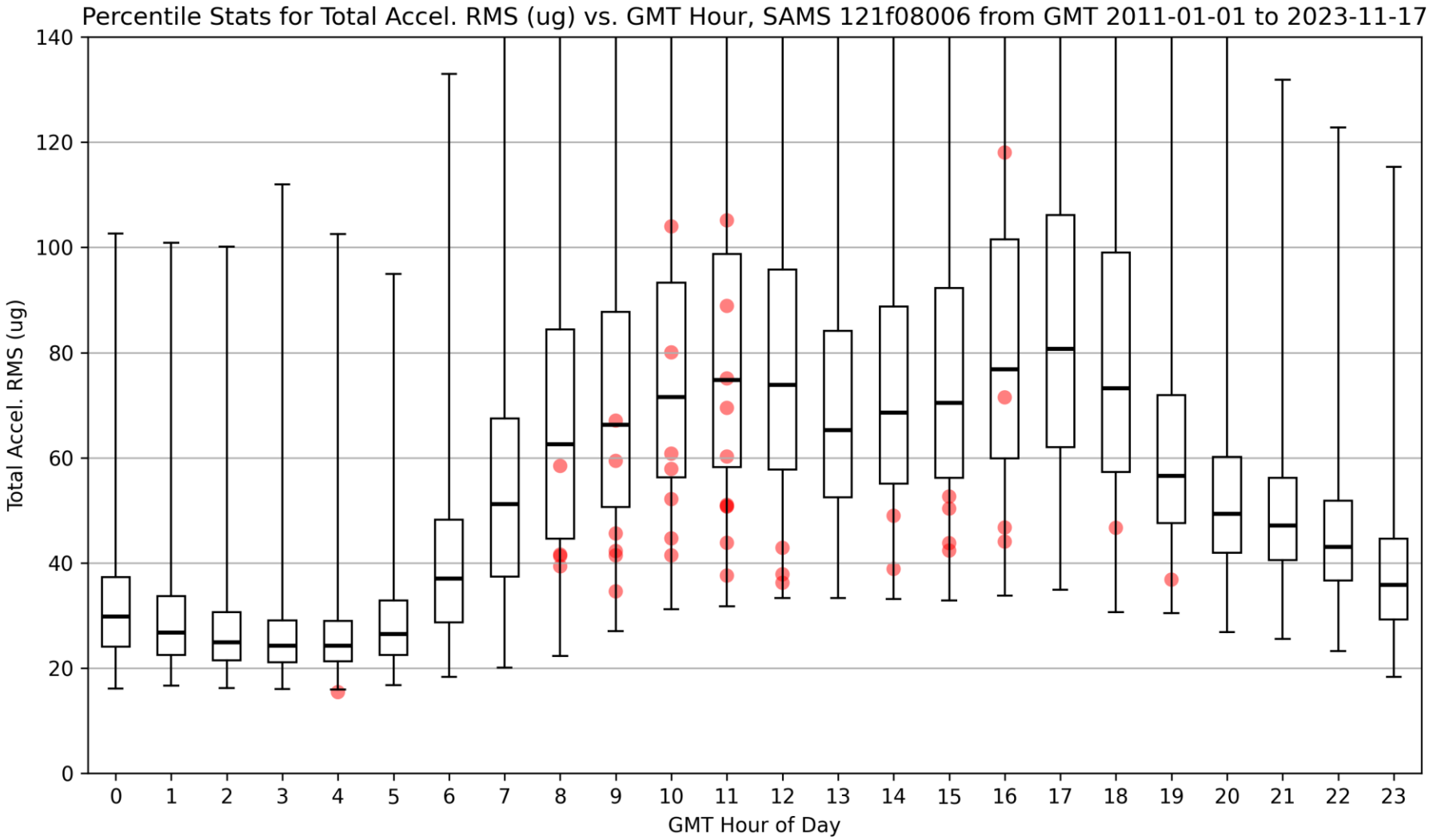
- Generally, concern arises when **exercise (stimulus)** results in **structural excitation (response)** resulting in sustained, resonant vibrations. A bellwether for monitoring exercise in this regard is the SAMS sensor head, S/N 121f08, in the Columbus module to gauge structural response regardless of where the stimulus/source is located.
- Two views of SAMS measurements were used for each time frame around the Teal CEVIS exercise sessions:
  1. **Qualitative**: roadmap/spectrogram plots below 10 Hz
  2. **Quantitative**: root-mean-square (RMS) acceleration plots below 6 Hz
- To be comprehensive, we overlaid all recent Teal CEVIS exercise sessions' RMS values (below 6 Hz) on top of a voluminous statistical summary of SAMS measurements.

NOTE:

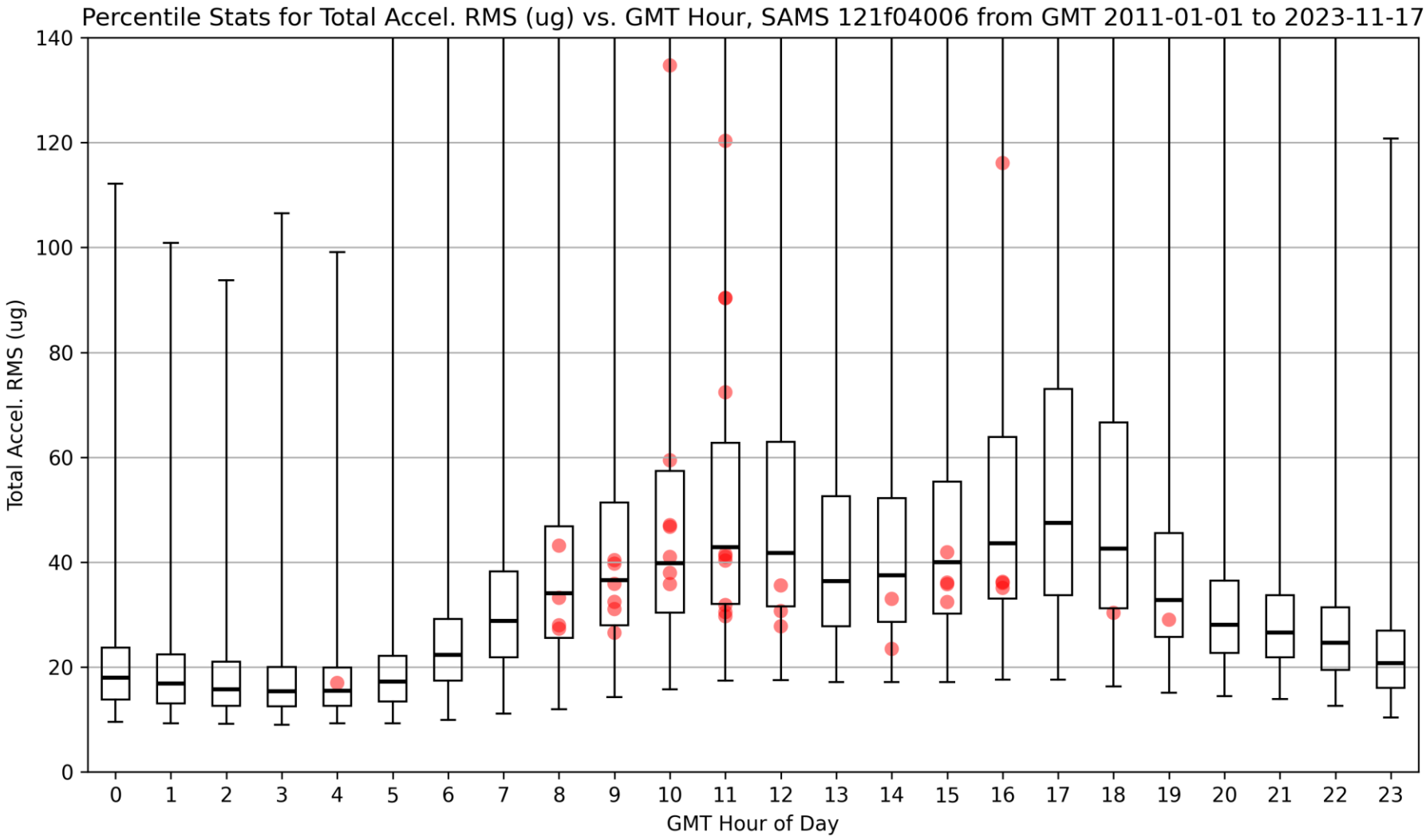
If a set of well-correlated sessions indicating CEVIS exercise ➔ elevated RMS acceleration levels had been established, then the interval RMS plots would have resulted in our means for **quantitave** assessment and for comparisons, i.e. "*how much of a vibratory impact & where*"…

…however, no definitive temporal correlations were observed that would attribute CEVIS exercise as source resulting in elevated RMS levels as measured by SAMS; instead, a preponderance of the observations show that we can only assert a **qualitative** assessment: *"no discernible impact of CEVIS exercise on the vibratory regime of 3 main labs of the ISS below 6 Hz as measured by multiple, distributed SAMS heads*".

Compare Teal CEVIS Exercise RMS Values to Stat Summary of 12+ Years of SAMS COL Measurements



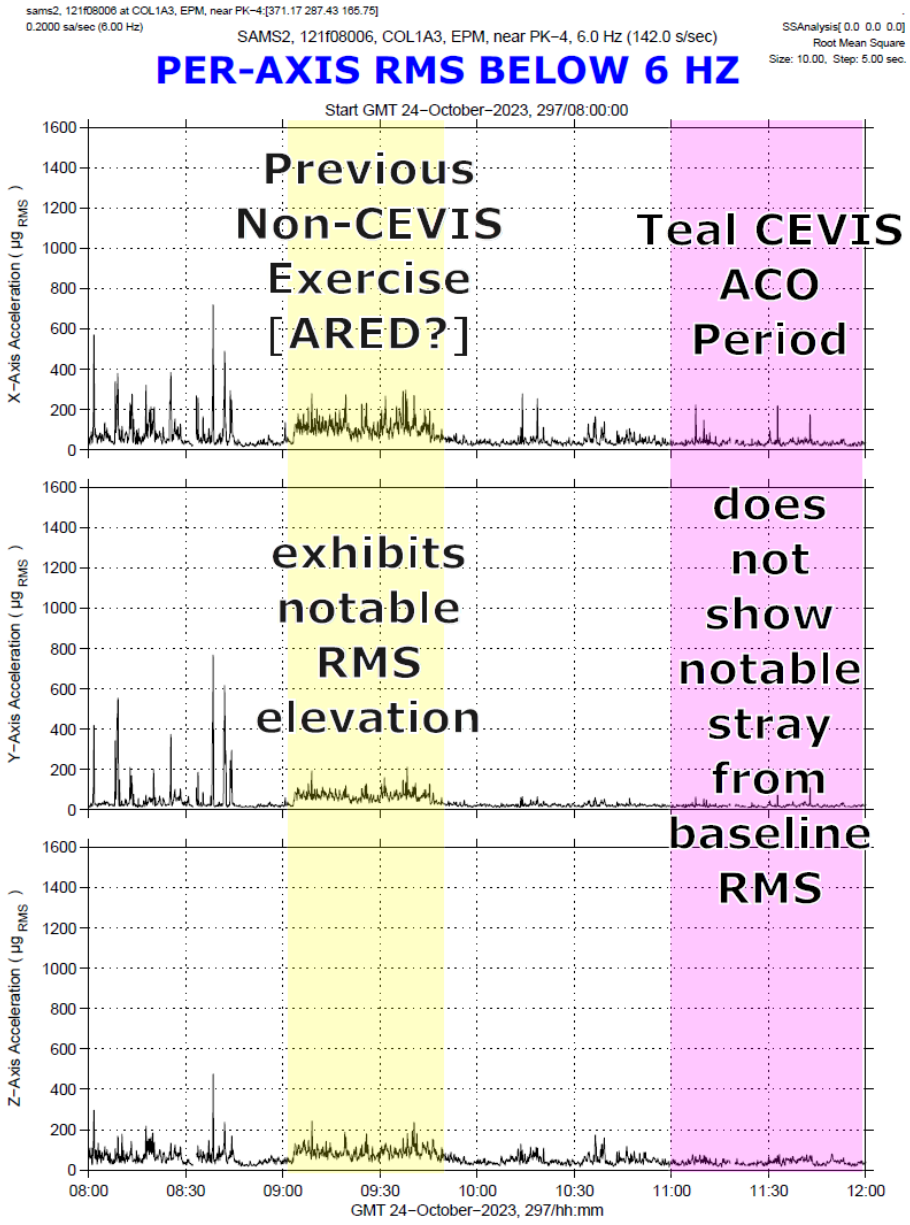
Compare Teal CEVIS Exercise RMS Values to Stat Summary of 12+ Years of SAMS **LAB** Measurements



Two Significant CEVIS Exercise Sessions

1. **GMT 2023-10-24**: Teal CEVIS Activation and Check Out (**ACO**). No confound, that is, no other exercise allowed during Teal CEVIS ACO. See pink region in figure on the left of next slide.

2. **GMT 2023-11-09**: The most telling of all CEVIS exercise periods analyzed in this analysis campaign was the one that surprisingly took place during what is typically a crew sleep period, particularly as evidenced by SAMS sensor head, S/N 121f08, in the Columbus module. If that session was considered "typical vigor" [or otherwise representative] for Teal CEVIS, then SAMS analysis of that session yields key insight: **"Teal CEVIS leaves no obvious vibratory impact in SAMS measurements" and here we can add "…EVEN when the background ambient environment is about as vibrationally quiet as it gets [during crew sleep] AND from perspective of the SAMS bellwether sensor head"**. See green region in figure on the right of next slide.


sams2, 121f08006 at COL1A3, EPM, near PK-4:[371.17 287.43 165.75]
0.2000 sa/sec (6.00 Hz)
SAMS2, 121f08006, COL1A3, EPM, near PK-4, 6.0 Hz (142.0 s/sec)
SSAnalysis[0.0 0.0 0.0]
Root Mean Square
Size: 10.00, Step: 5.00 sec.
PER-AXIS RMS BELOW 6 HZ
Start GMT 24-October-2023, 297/08:00:00
Previous Non-CEVIS Exercise [ARED?]
Teal CEVIS ACO Period
exhibits notable RMS elevation
does not show notable stray from baseline RMS
X-Axis Acceleration (µg RMS)
Y-Axis Acceleration (µg RMS)
Z-Axis Acceleration (µg RMS)
0
200
400
600
800
1000
1200
1400
1600
08:00
08:30
09:00
09:30
10:00
10:30
11:00
11:30
12:00
GMT 24-October-2023, 297/hh:mm

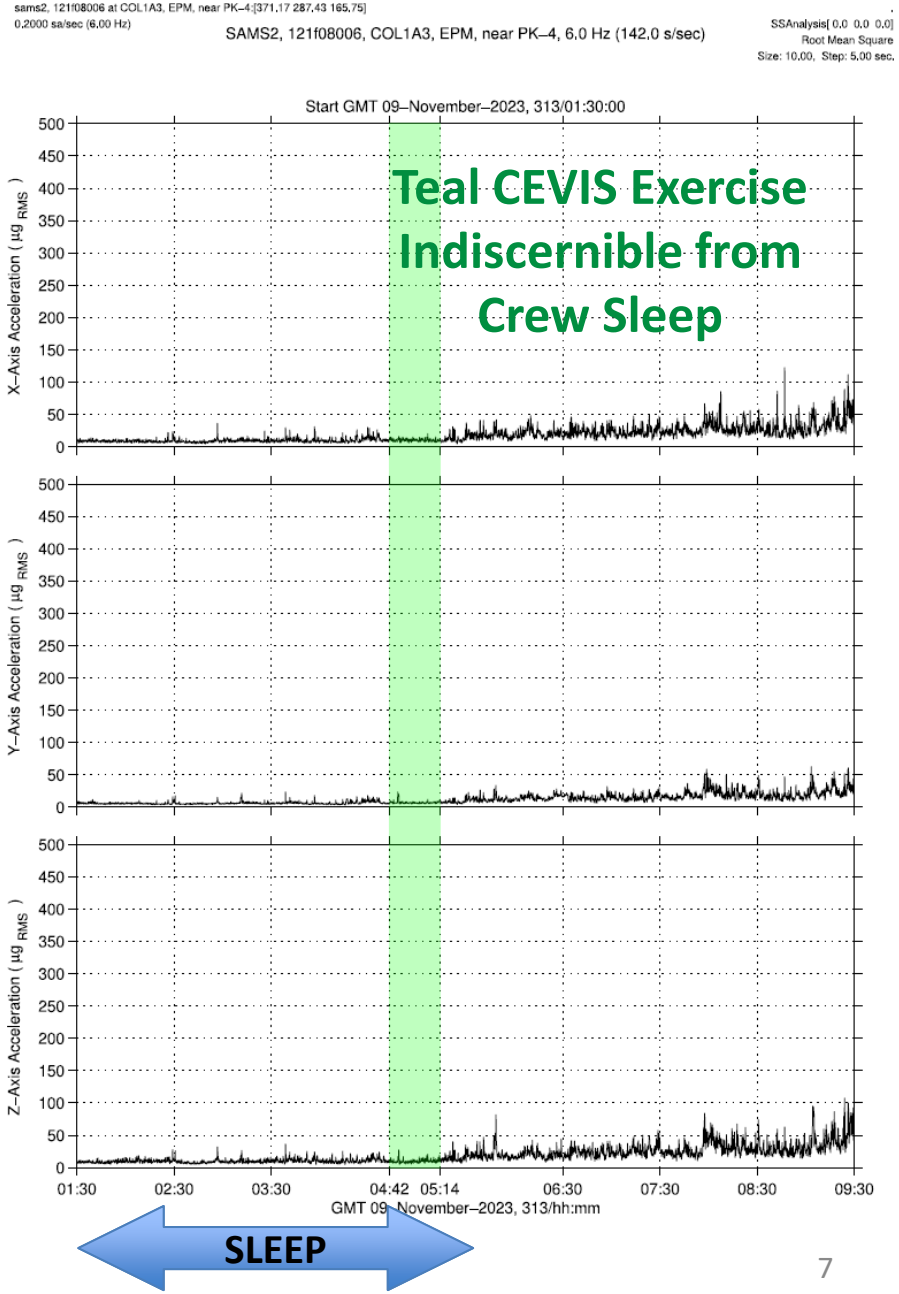

sams2, 121f08006 at COL1A3, EPM, near PK-4:[371.17 287.43 165.75]
0.2000 sa/sec (6.00 Hz)
SAMS2, 121f08006, COL1A3, EPM, near PK-4, 6.0 Hz (142.0 s/sec)
SSAnalysis[0.0 0.0 0.0]
Root Mean Square
Size: 10.00, Step: 5.00 sec.
Start GMT 09-November-2023, 313/01:30:00
Teal CEVIS Exercise Indiscernible from Crew Sleep
X-Axis Acceleration (µg RMS)
Y-Axis Acceleration (µg RMS)
Z-Axis Acceleration (µg RMS)
0
50
100
150
200
250
300
350
400
450
500
01:30
02:30
03:30
04:42
05:14
06:30
07:30
08:30
09:30
GMT 09-November-2023, 313/hh:mm
SLEEP

Table / Summary 1 of 2

					Total RMS < 6 Hz (micro-g)	
Session Date	**Session Start (GMT)**	**Session Stop (GMT)**	**HH**	**Comments**	**LAB 121f04**	**COL 121f08**
10-24-23	11:19:48	11:57:38	11	ACO - SAMS Data Reviewed	30.47	50.80
10-25-23	08:56:39	09:25:27	09	SAMS Data Reviewed	32.42	42.26
10-25-23	09:37:18	10:06:07	09	SAMS Data Reviewed	26.53	41.44
10-25-23	10:55:50	11:13:49	11	SAMS Data Reviewed	31.82	51.04
10-26-23	15:49:05	16:49:42	16	SAMS data shows confound/inconclusive	35.08	71.47
10-27-23	10:45:06	11:20:56	11	SAMS data shows no obvious CEVIS impact	40.28	69.47
10-27-23	15:46:19	16:14:35	16	SAMS data shows no obvious CEVIS impact	36.24	44.05
10-28-23	14:15:15	14:33:14	14	SAMS data shows 1st several minutes as no obvious impact BUT last few minutes as either CEVIS suddenly/notably impactful OR confounded	32.99	48.96
10-28-23	18:29:13	19:01:52	18	SAMS data shows no obvious CEVIS impact for 4 of 5 sensor heads AND the one exception in COL appeared to be confined to that one sensor head	30.33	46.67
10-29-23	08:15:15	08:48:13	08	SAMS data shows no obvious CEVIS impact	27.30	41.31
10-29-23	08:58:04	09:34:28	09	SAMS data shows no obvious CEVIS impact	31.04	34.59
10-30-23	09:11:47	09:43:00	09	SAMS data shows confound/inconclusive	40.38	67.05
10-31-23	09:54:58	10:12:56	10		40.99	52.13
11-3-23	08:51:16	09:22:29	09		39.71	59.40
11-3-23	12:05:39	12:23:38	12		27.76	36.22
11-3-23	15:19:22	15:49:34	15		32.39	42.34
11-4-23	11:01:25	11:30:13	11		90.36	75.07
11-4-23	15:36:48	16:12:29	15		41.88	52.62
11-5-23	09:45:10	10:20:17	10		35.80	41.44
11-5-23	11:35:10	12:10:59	11		72.38	60.22
11-5-23	13:54:02	14:12:58	14		23.45	38.86
11-6-23	10:39:12	10:46:15	10		59.42	80.02
11-6-23	11:09:35	11:19:38	11		120.31	105.13
11-6-23	12:14:32	12:50:31	12		30.67	37.84

Table / Summary 2 of 2

					Total RMS < 6 Hz (micro-g)	
Session Date	**Session Start (GMT)**	**Session Stop (GMT)**	**HH**	**Comments**	**LAB 121f04**	**COL 121f08**
11-7-23	09:56:53	10:12:51	10	Max CEVIS - New Handrail Installed SAMS data shows no obvious CEVIS impact.	46.73	60.77
11-7-23	11:32:15	11:48:38	11	Max CEVIS - New Handrail Installed SAMS data shows no obvious CEVIS impact. A confound is easily explained via 121f04 data.	90.32	88.86
11-7-23	16:25:51	16:55:50	16	SAMS data shows no obvious CEVIS impact.	36.03	46.73
11-8-23	08:21:21	08:50:09	08	SAMS data shows no obvious CEVIS impact.	33.19	41.58
11-8-23	09:10:22	09:28:21	09	SAMS data shows no obvious CEVIS impact.	35.85	45.60
11-8-23	10:16:27	10:20:40	10	Skipped as **likely** partially or mostly confounded.	134.70	103.97
11-8-23	10:28:30	11:03:39	10	SAMS data shows no obvious CEVIS impact.	37.95	44.66
11-9-23	04:42:53	05:14:06	04	**RMS levels resemble crew sleep during what is typically crew sleep time frame -- includes all 5 SAMS sensor heads and most notably 121f08 in Columbus module.**	16.96	15.44
11-9-23	08:39:09	08:57:24	08	SAMS data shows no obvious CEVIS impact.	27.96	39.35
11-9-23	10:32:00	10:47:29	10	All 5 SAMS sensor heads show elevated RMS levels during CEVIS session time frame.	47.05	57.87
11-9-23	11:10:09	11:38:58	11	SAMS data shows no obvious CEVIS impact.	41.50	43.82
11-9-23	15:06:42	15:24:41	15	SAMS data shows no obvious CEVIS impact.	35.79	50.33
11-10-23	10:53:21	11:34:40	11	SAMS data shows no obvious CEVIS impact.	29.69	37.58
11-10-23	12:00:12	12:29:00	12	SAMS data shows no obvious CEVIS impact.	35.55	42.86
11-11-23	10:54:25	12:22:17	11	SAMS data shows no obvious CEVIS impact.	41.02	50.70
11-11-23	14:51:28	15:33:41	15	SAMS data shows no obvious CEVIS impact.	36.10	43.76
11-12-23	16:20:32	17:15:53	16	SAMS data shows strong temporal correlation with time frame of this CEVIS exercise session. Kristin asserts Russian BD-2 treadmill exercise session was happening for that same of nearly same time frame.	116.08	118.02
11-12-23	18:56:54	19:14:53	19	SAMS data shows no obvious CEVIS impact.	29.02	36.82

Conclusions

- Analysis of SAMS measurements in all 3 main labs during Teal CEVIS exercise indicate no discernible impact on the vibratory regime below 6 Hz.
- A fortunate coincidence of Teal CEVIS exercise [while the rest of the crew were sleeping?] gives keen insight based on bellwether SAMS S/N 121f08 sensor head in the Columbus module, that is, we were not able to detect any Teal CEVIS impact despite a “very accommodating” (vibrationally quiet) background, ambient environment at the time.