1. INTRODUCTION

At GMT 2022-11-30, 334/12:25, the International Space Station (ISS) began about a reboost that was to last 11 minutes and 52 seconds using the Progress 81P thrusters. Figure 1 shows that the Progress vehicle was docked with its thrusters facing aftwards, which put thrust and the necessary orbital mechanics into play so as to speed up the ISS in its direction of flight. This tangential acceleration, with its increase in velocity, resulted in an altitude reboost of the space station during this dynamic event.

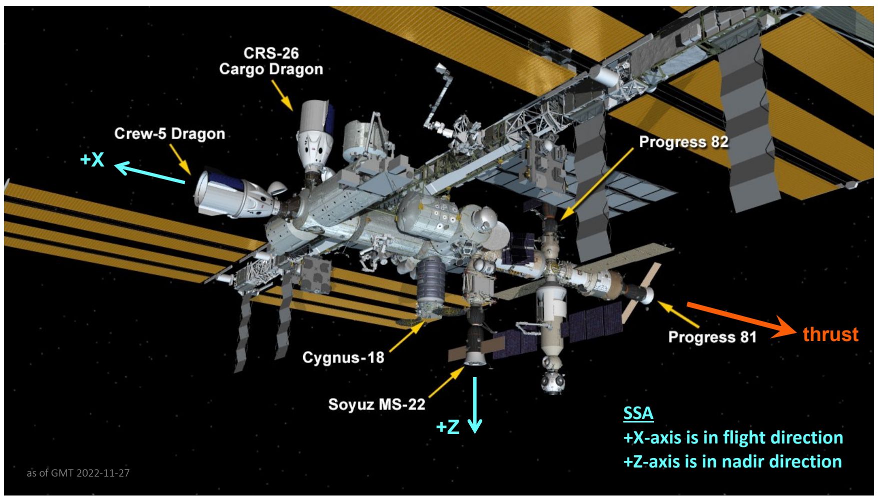

Fig. 1: Progress 81P's location and alignment during reboost.

2. QUALIFY

The information shown in Figure 2 was calculated from the Space Acceleration Measurement System (SAMS) sensor 121f04 measurements made in the US LAB from a triaxial sensor head mounted on the Cold Atom Lab facility in the LAB1P2 rack. This color spectrogram plot shows increased structural vibration excitation contained mostly below 1 Hz or so, and the approximately 12-minute reboost (thruster firing) event itself is annotated in black starting at GMT 12:25. We attribute much of the structural vibration increase to Russian Segment (RS) attitude control since the as-flown timeline shows RS control from about GMT 11:20 to about 13:03 (as shown with white annotations). The RS thrusters were used for station attitude control during the time around the reboost activity. This is expected, and typical behavior. The increased structural vibrations are evident as more noticeable horizontal streaks (structural/spectral peaks) that change from quieter (green/yellow) to more energetic (orange/red) sporadically during this period of RS control spanning about 130 minutes and clearly discernible below about 0.5 Hz in Figure 2. The flare up of these nebulous horizontal (spectral peak) streaks are the tell-tale signatures of large space station appendages as they flex, twist, or bend in reaction to impulsive attitude control thruster forces. The actual reboost activity itself lasted just a bit over 12 minutes as evidenced by slightly more pronounced, vertical orange-red streaks in Figure 2 starting around GMT 12:25. For science operations and general situational awareness, it is prudent to be aware that the transient and vibratory environment (primarily below about 10 Hz or so) on the space station is impacted not only during the reboost event itself, but also during the much longer span of Russian Segment (RS) attitude control too. The difference being that during the reboost itself, the dominant factor might be considered to be a highly-directional step in the X-axis acceleration, while in the much longer case of RS attitude control, the dominant impact was the excitation of lower-frequency vibrational modes of large space station structures.

3. QUANTIFY

The as-flown timeline for this event indicated the reboost would start at GMT 12:25 and have a duration of 11 minutes and 52 seconds. Analysis of Space Acceleration Measurement System (SAMS) data recordings in the US LAB – see Figure 3 on page 4 – shows the tell-tale X-axis acceleration step that started at GMT 12:25:17 and had a duration of 12 minutes and 5 seconds.

Information from flight controllers indicated that this reboost event provided a space station rigid body ΔV of about 1.19 meters/second and the SAMS analysis indicated with red annotations in Figure 3 match the expected value. The SAMS does not directly measure altitude, but flight controllers indicated that the ISS gained 2.1 km in altitude above the Earth as a result of the increased tangential velocity imparted by the Progress vehicle thruster firing.

Six more plots of 5-second interval average acceleration versus time for SAMS sensors distributed throughout the ISS are shown at the end of this document starting with Figure 6 on page 5. The interval average processing effectively low-pass filtered the data so as to help emphasize the acceleration step that occurs on the X-axis during the reboost event. It should also be noted that we flipped the polarity of each acceleration data axis (inverted each) in the SAMS plots owing to a polarity inversion issue inherent in SAMS transducers. A somewhat crude quantification of the reboost as measured by the 7 distributed SAMS sensors is also given in Table 1 – expectedly consistent impact results measured by multiple SAMS sensor heads widely-distributed throughout the enormous space station.

Table 1. **X-axis** steps (mg) during reboost event for 7 SAMS sensors.

Sensor	**X-Axis**	**Location**
121f02	0.168	COL1A1 (ER3)
121f03	0.168	LAB1O1 (ER2)
121f04	0.168	LAB1P2 (ER7)
121f05	0.168	JPM1F1 (ER5)
121f08	0.168	COL1A3 (EPM)
es18	0.169	MSRR (ER6)
es20	0.169	LAB1P4 (4BCO2)

4. CONCLUSION

The SAMS measurements for 7 sensor heads distributed across all 3 main labs of the ISS was analyzed and showed an **X-axis step during the Progress 81P reboost of just under 0.17 mg**. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 (LAB1O1) in the US LAB indicate a ΔV metric of about 1.19 meters/second was achieved, and this result matched flight controllers' desired value.

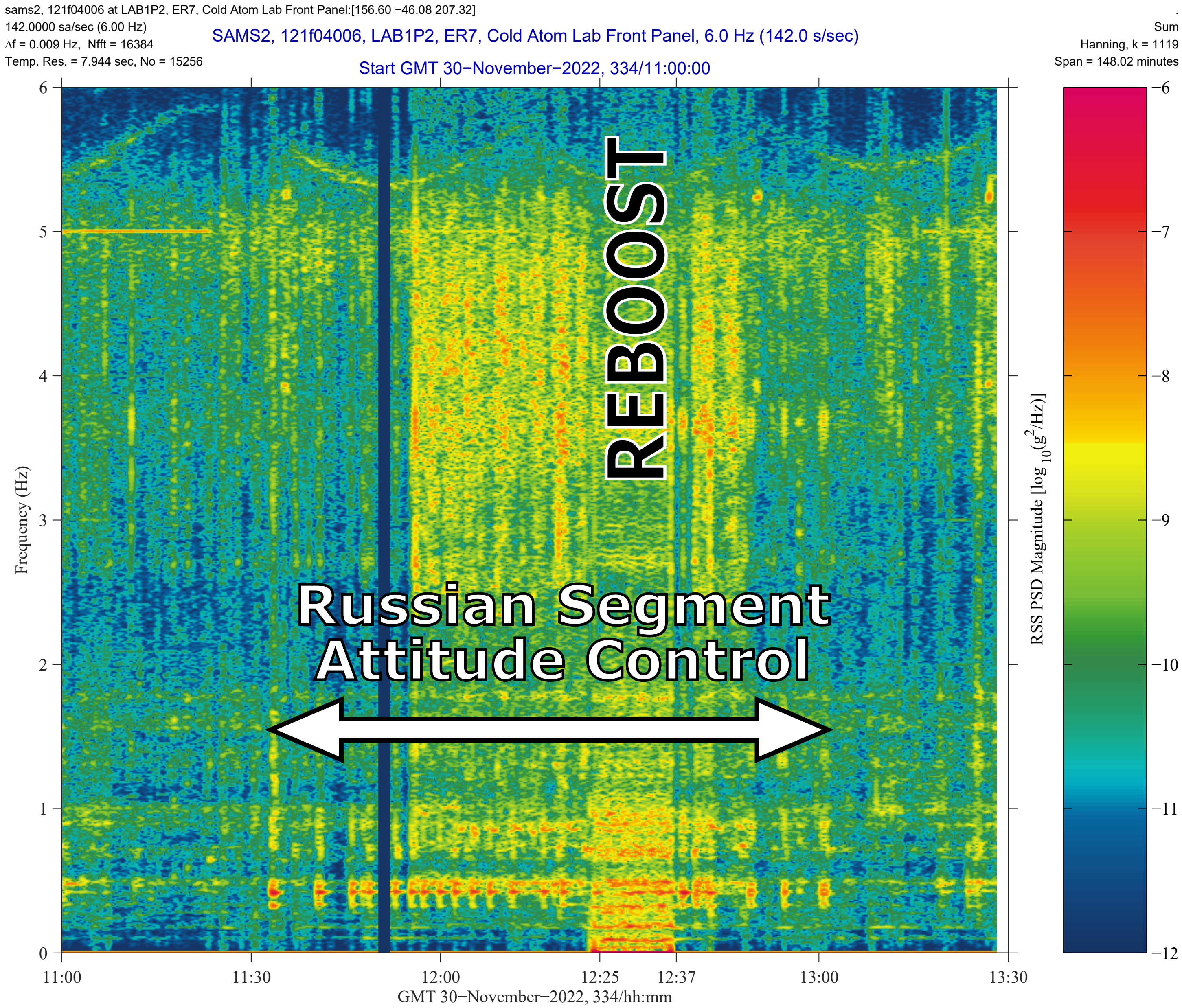

Fig. 2: Spectrogram showing Progress 81P Reboost on GMT 2022-11-30.

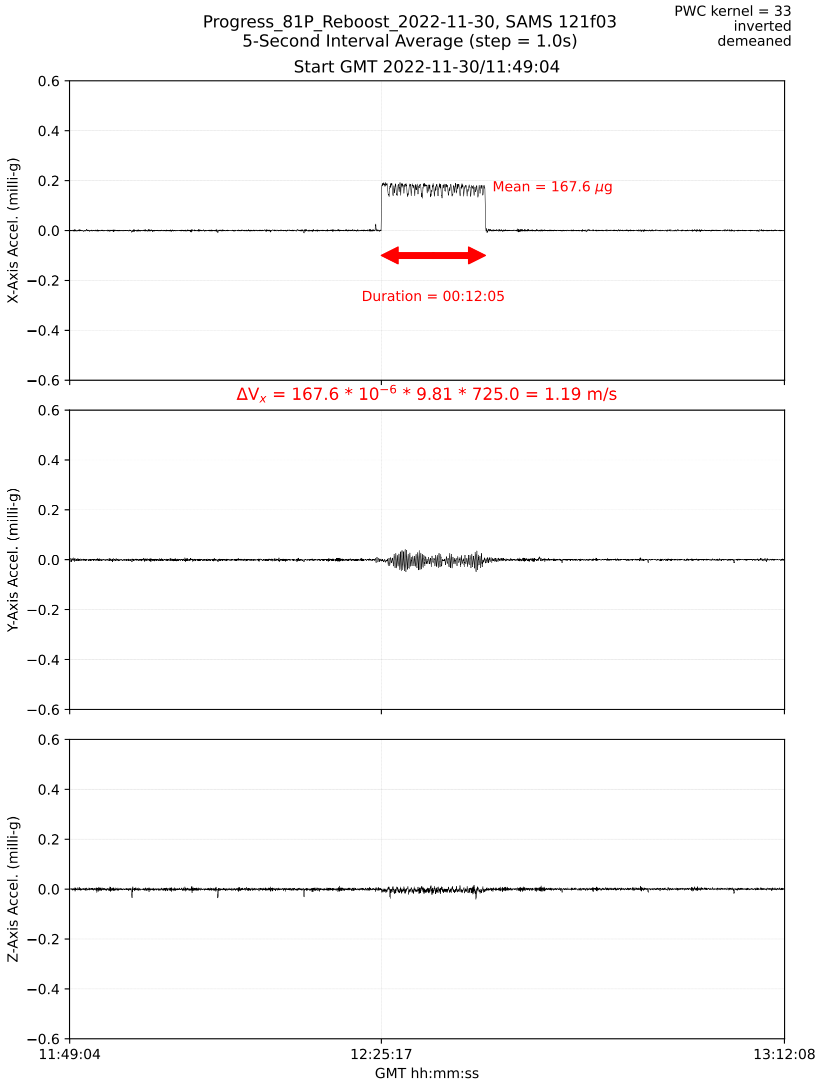

Fig. 3: 5-sec interval average for SAMS 121f03 sensor in the LAB.

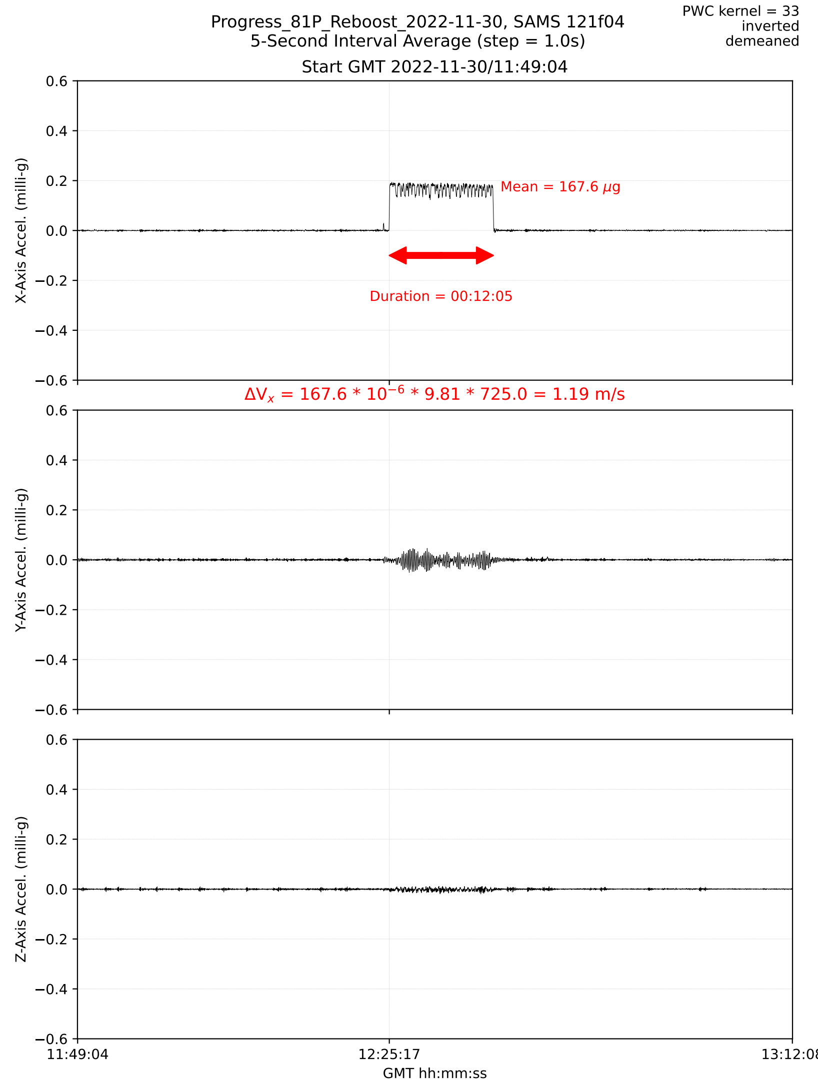

Fig. 4: 5-sec interval average for SAMS 121f04 sensor in the LAB.

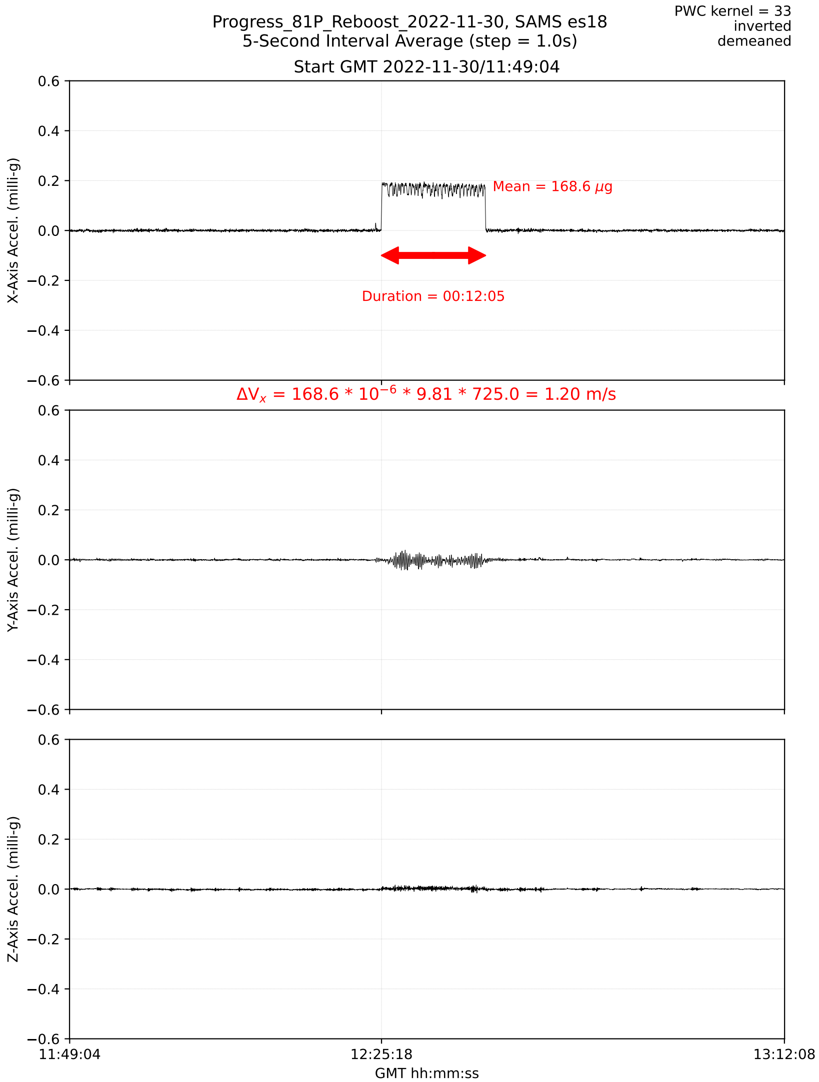

Fig. 5: 5-sec interval average for SAMS es18 sensor in the LAB.

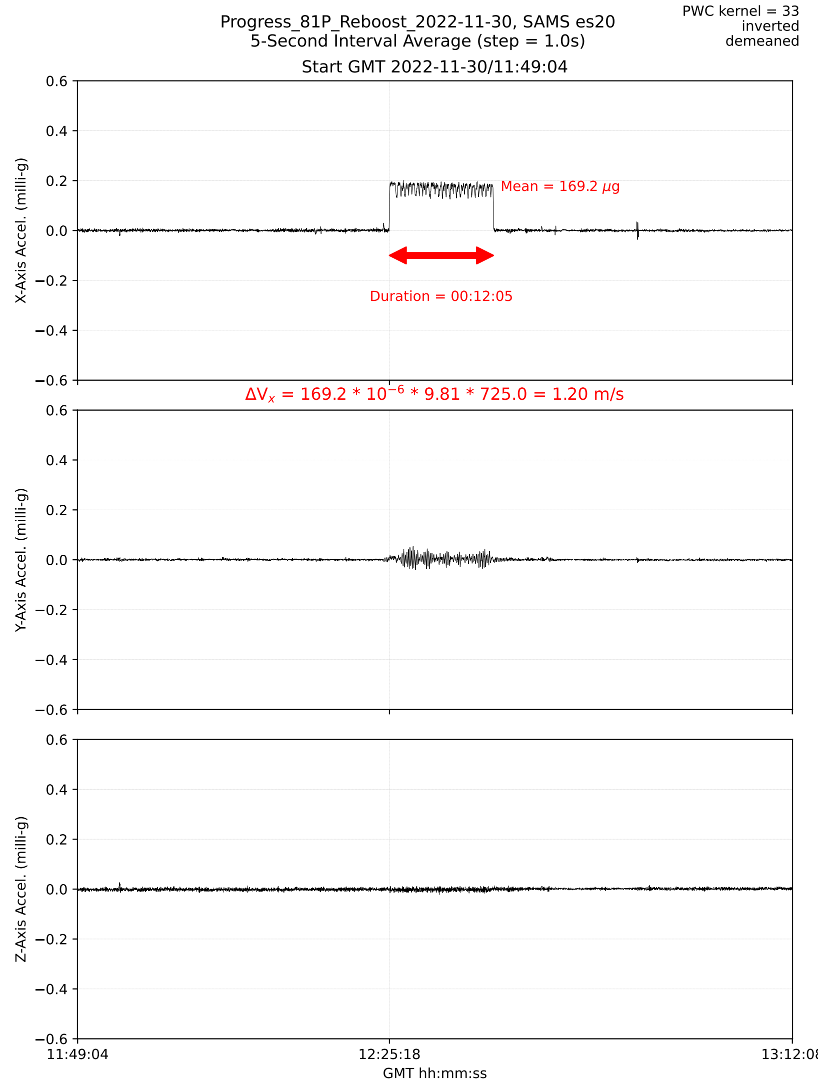

Fig. 6: 5-sec interval average for SAMS es20 sensor in the LAB.

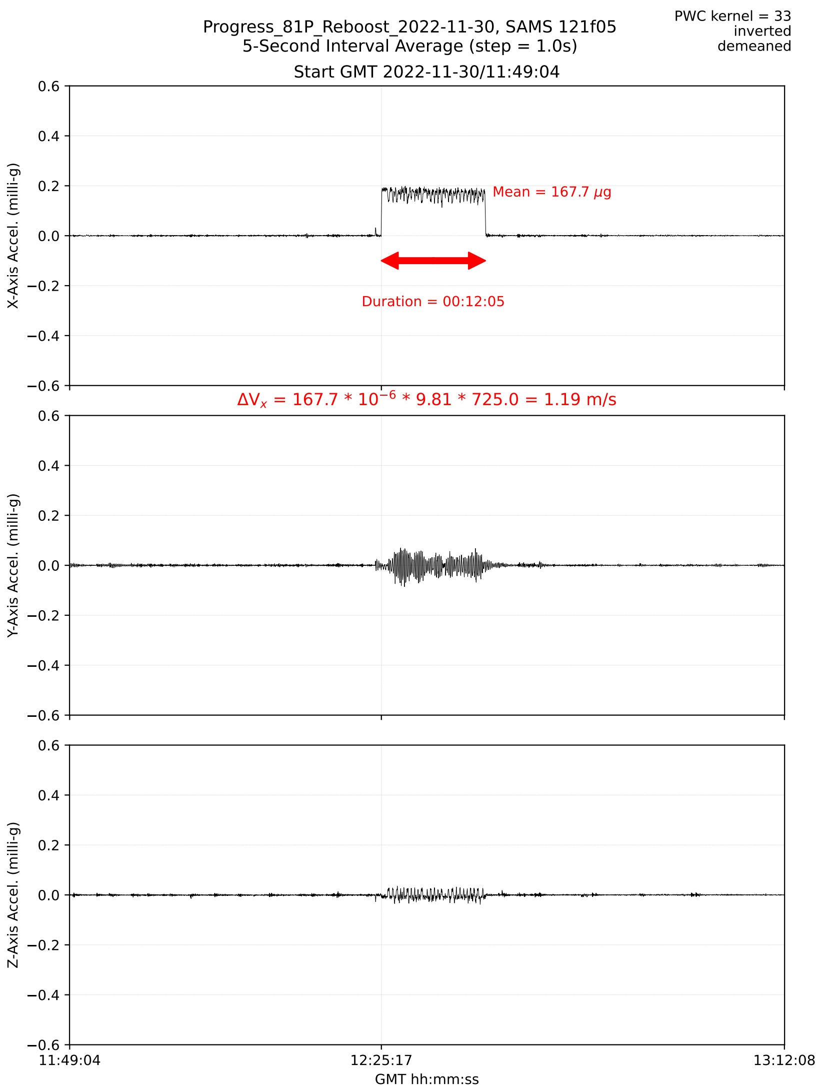

Fig. 7: 5-sec interval average for SAMS 121f05 sensor in the JEM.

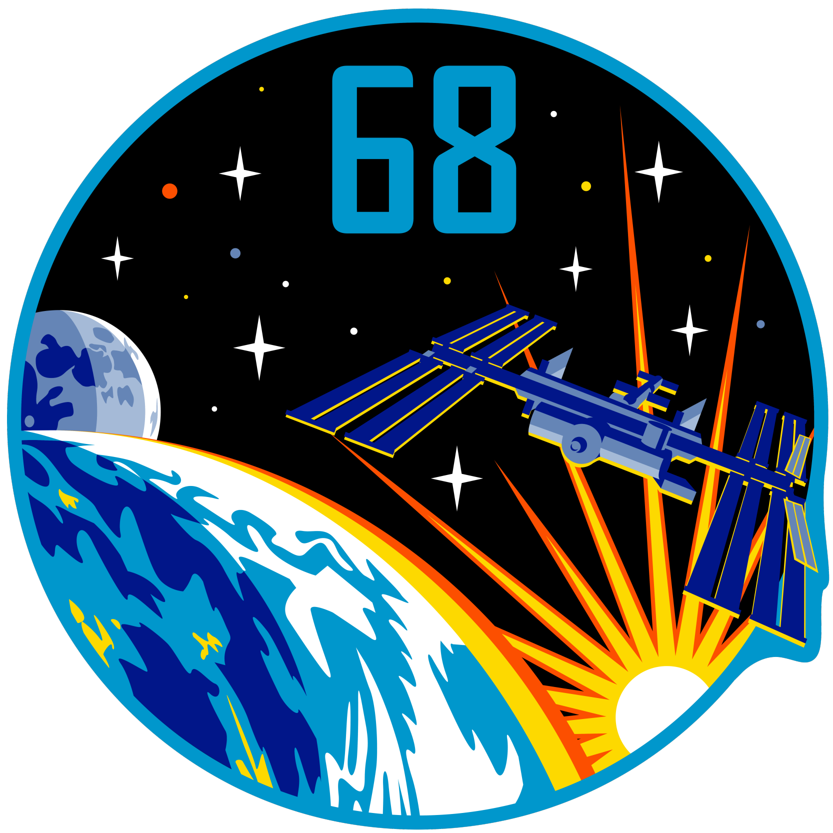

Fig. 8: ISS Expedition 68 Patch

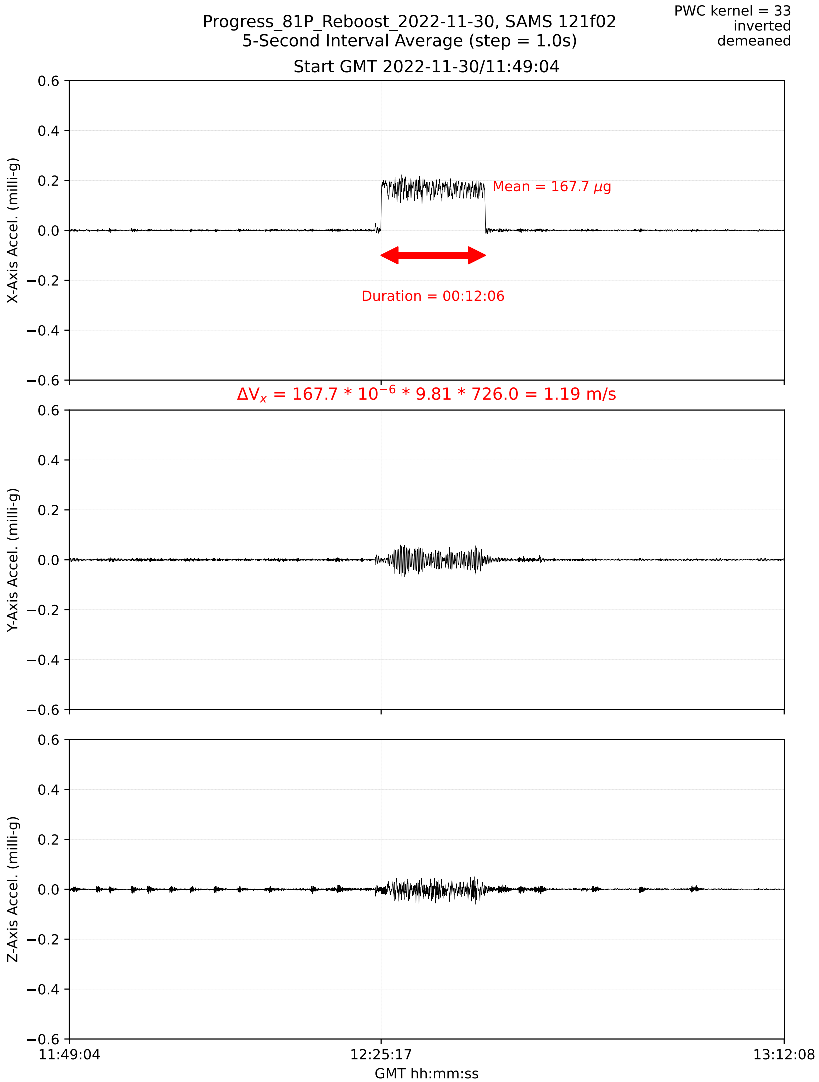

Fig. 9: 5-sec interval average for SAMS 121f02 sensor in the COL.

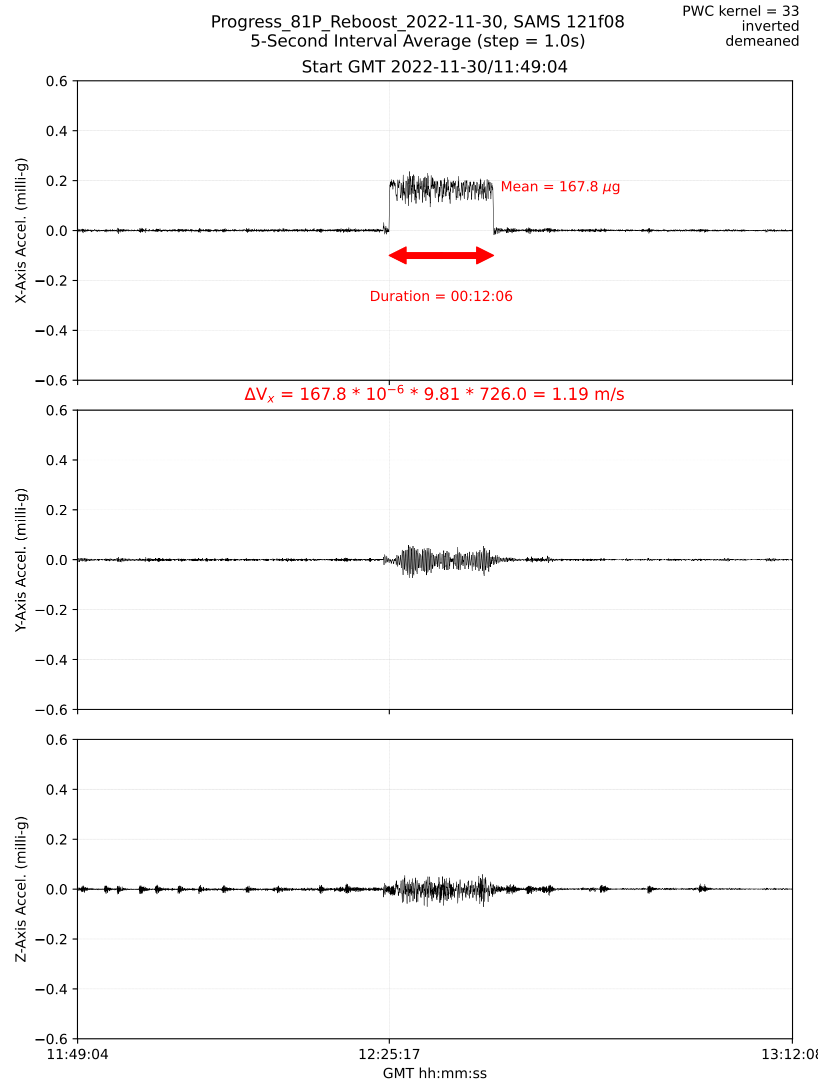

Fig. 10: 5-sec interval average for SAMS 121f08 sensor in the COL.