

1. INTRODUCTION

At GMT 2025-09-03, 246/18:15, the International Space Station (ISS) was to begin about a 5-minute reboost using the Dragon SpX-33 thrusters via the so-called trunk kit. Figure 1 shows the visiting vehicles' layout updated as of 2025-08-25 with the Dragon vehicle as it was docked with its thrusters pointed in the "+XVV direction", which was needed for thrust in the "-XVV direction". This arrangement brings the necessary orbital mechanics into play so as to speed up the ISS in its direction of "flight", along its velocity vector. The thrusters' directional acceleration (increase in velocity), resulted in the altitude elevation of about 0.86 km for the space station during this dynamic event. An intended ΔV metric of 0.50 m/s for the gigantic space station was predicted.

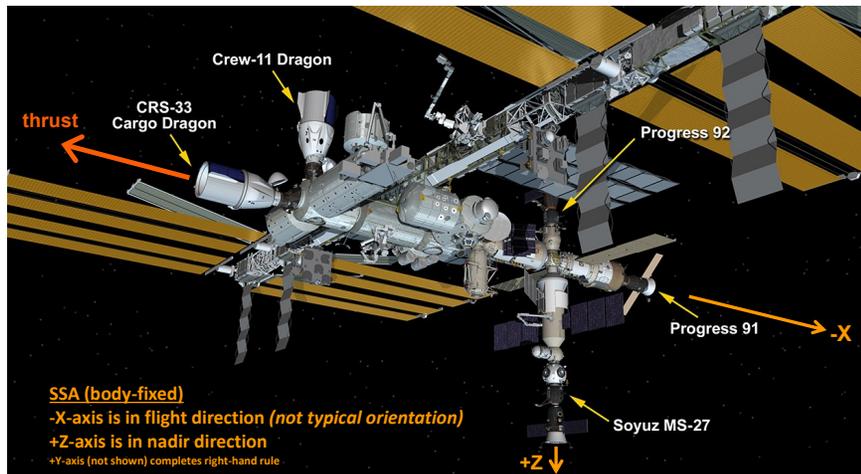


Fig. 1: Dragon SpX-33's Location and Alignment during Reboost.

2. QUALIFY

The information shown in Figure 2 on page 3 was calculated from the Space Acceleration Measurement System (SAMS) sensor 121f02 measurements made in the Columbus module from a sensor mounted on at the starboard endcone location of that module. This color spectrogram plot shows increased structural vibration

excitation contained mostly below 2 Hz or so, and a ~5.02-minute reboost (thruster firing) event was observed as annotated in black. We attribute much of the structural vibration increase to Russian Segment (RS) attitude control from about GMT 17:50 to about 18:47 as marked with white annotations. The RS thrusters are usually 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. More of a stark contrast against the baseline acceleration spectra due to this being during crew sleep period. 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 at their natural frequencies in reaction to sporadic, impulsive attitude control thruster forces. The actual reboost activity itself lasted ~5.02 minutes as evidenced by slightly more pronounced, vertical and horizontal orange-red streaks in Figure 2 starting about GMT 18:15:18.

Comparing the same reboost event across all 3 laboratories of the ISS, we expect the most energetic vibratory response from the SAMS sensors in the European laboratory (the Columbus module), and by sensors in the Japanese laboratory (JEM), and to a lesser extent by SAMS sensors in the US lab. This stems from the location of these sensors with respect to the structural dynamics of the space station. The analysis here focused on the acceleration power spectral density of vibratory accelerations below 6 Hz, which provides a measure of the intensity of vibratory motion at the natural frequencies of the larger space station structures (e.g. solar array panels, the main truss, waste heat radiators, etc.). At higher frequencies (up to 200 Hz), the SAMS sensors usually diverge greatly in terms of acceleration magnitude and frequency components as higher frequency vibrations tend to be more localized, i.e. "mostly" in/around the rack where the sensor is mounted, and mostly due to equipment operations or crew activity in that local vicinity.

For science operations and general situational awareness, it is wise to be aware that the transient and vibratory environment (primarily below about 10 Hz or so) is impacted not only during the relatively brief reboost event itself, but also during the relatively longer span of Russian Segment (RS) attitude control too. The difference being that during the shorter span of the reboost itself, the dominant factor might be considered to be the highly-directional step in the X-axis acceleration, while in the longer-time-span case of RS attitude control, the dominant impact was the excitation of lower-frequency vibrational modes of large space station structures.

3. QUANTIFY

While the spectrogram in the previous “Qualify” section crudely shows acceleration magnitude on a color scale – actually, acceleration “power” spectral density magnitude – we now seek to better quantify the microgravity environment impact of the reboost event across multiple SAMS sensor heads distributed across all 3 main laboratories of the ISS with more intuitive metrics. Figure 3 on page 4 through Figure 10 on page 7 show interval average acceleration results computed from SAMS measurements. Note that across all 8 of the SAMS sensor heads, the tell-tale X-axis step started at GMT 18:15:18 (within the time resolution of the plot type used) and had algorithmically-detected durations between 4.95 and 5.03 minutes. The slight time discrepancy across the SAMS sensor heads falls within the 5-second averaging window used to glean timing information, independently for each sensor head. Information from flight controllers indicated that this reboost event would provide a space station rigid body ΔV of 0.50 meters/second and the SAMS analysis indicated with red annotations in these interval average plots match the predicted value. SAMS does not directly measure altitude, but flight controllers indicated that the ISS would gain ~0.86 km in altitude above the Earth as a result of this reboost activity.

The interval-averaging process acted as a low-pass filter, attenuating higher-frequency vibrations and making the X-axis acceleration step during the reboost more evident. For this Dragon reboost, the vehicle’s docking position required the ISS to be in a “-XVV attitude” (flying backwards relative to its normal orientation). This orientation aligned Dragon’s thrusters opposite to the station’s velocity vector, in accordance with Newton’s Third Law, since the goal was to accelerate in the direction of orbital motion and thereby speeding up along the path (the velocity vector) that the station was falling at the time of reboost. It should also be noted that we flipped the polarity of each 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 these distributed SAMS sensors is also given in Table 1 – expectedly consistent impact results measured by SAMS throughout the space station structure.

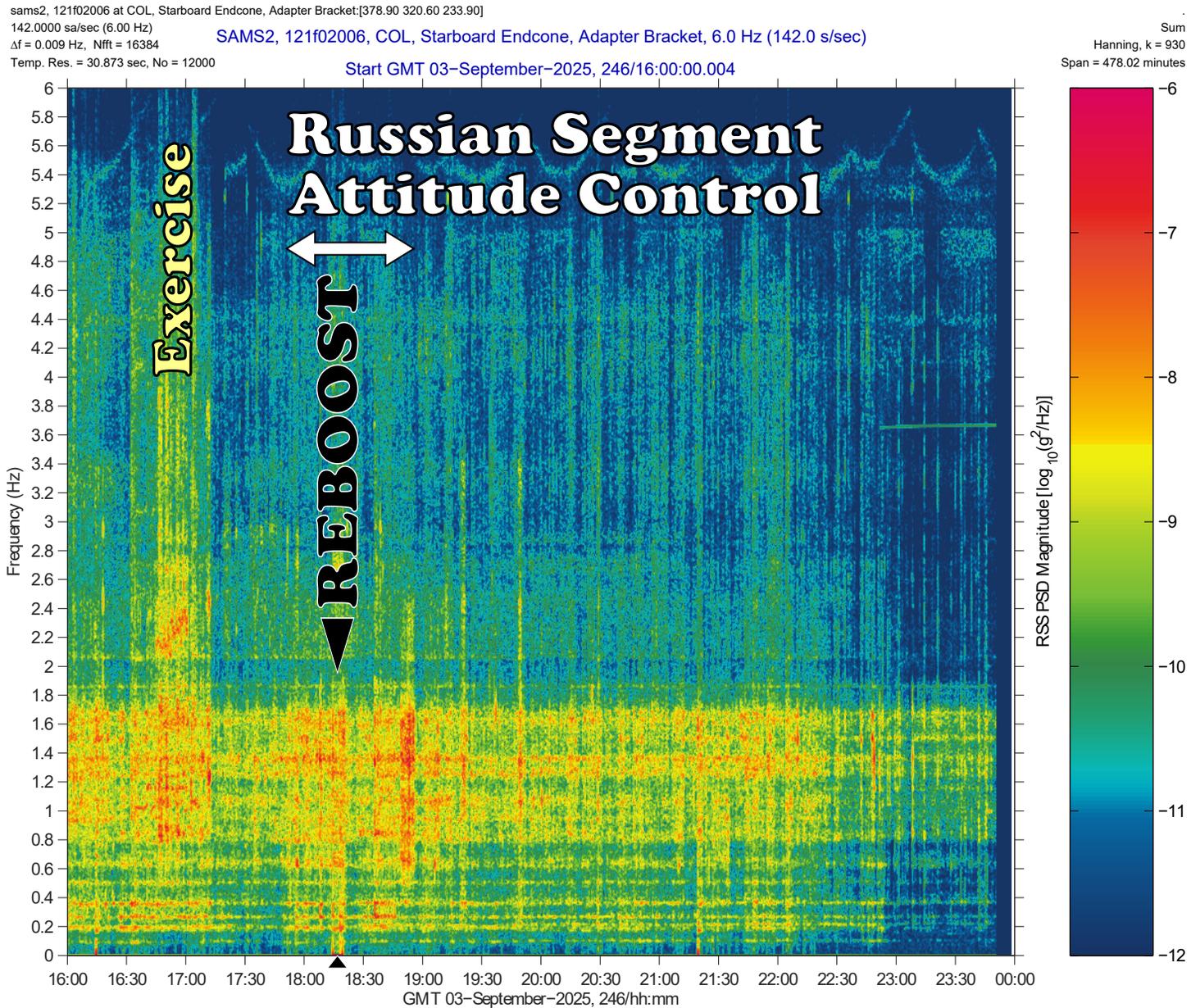
Table 1. **-X-axis** steps (mg) during reboost event for multiple SAMS sensors.

Sensor	X-Axis (mg)	Location
121f02	0.171	COL1A1 (ER3)
121f03	0.170	LAB1O1 (ER2)
121f04	0.171	LAB1P2 (ER7)
121f05	0.170	JPM1F1 (ER5)
121f08	0.172	COL1A3 (EPM)
es18	0.172	LAB1O3 (MSRR)
es19	0.172	JPM1F6 (ER-4)
es20	0.172	LAB1S2 (MSG)

4. CONCLUSION

Analysis of SAMS measurements from multiple sensor heads across all three ISS laboratories revealed a distinct **-X-axis step during the Dragon SpX-33 reboost**. The step magnitude was consistently at 0.17 mg and persisted for slightly more than 5 minutes. These distributed measurements indicate a station rigid-body ΔV of approximately 0.50 m/s, in agreement with flight controller predictions and consistent with the observed altitude gain of ~0.86 km.

The results also show the effectiveness of interval-averaging in suppressing high-frequency vibrations, thereby highlighting the reboost-induced acceleration step. Note too that the polarity inversion inherent in SAMS transducers was corrected in processing to ensure consistency. Overall, the measurements validate both the planned reboost performance and the capability of SAMS to characterize structural dynamics of the ISS during such dynamic events.



VIBRATORY

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Fig. 2: 6 Hz Spectrogram showing Dragon SpX-33 Reboost on GMT 2025-09-03 from SAMS Sensor in the Columbus module on Endcone.

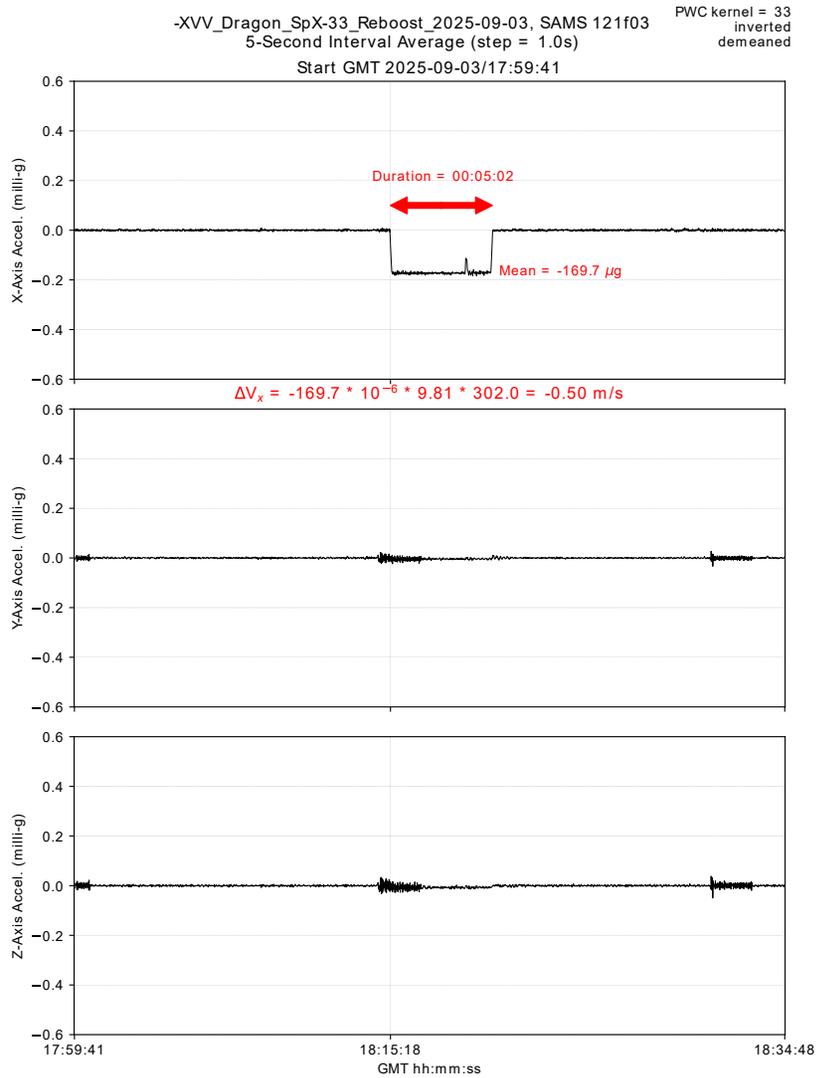


Fig. 3: 5-sec interval average for SAMS 121f03 sensor in the LAB.

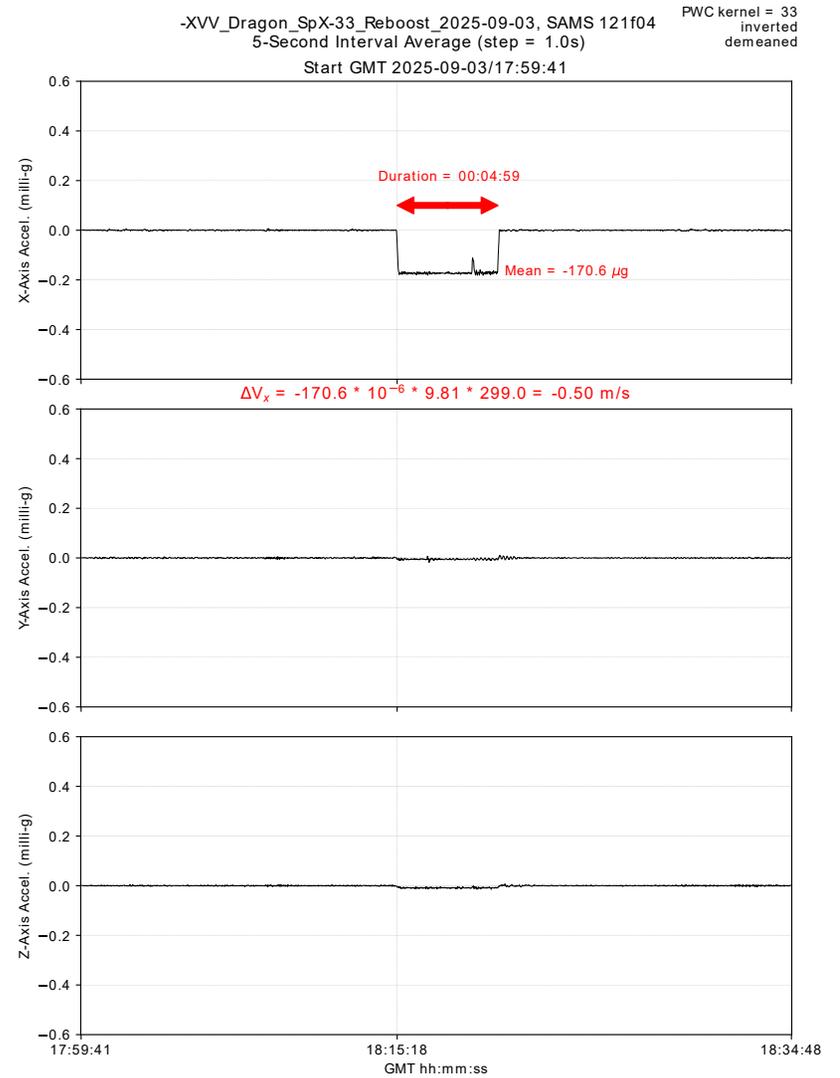


Fig. 4: 5-sec interval average for SAMS 121f04 sensor in the LAB.

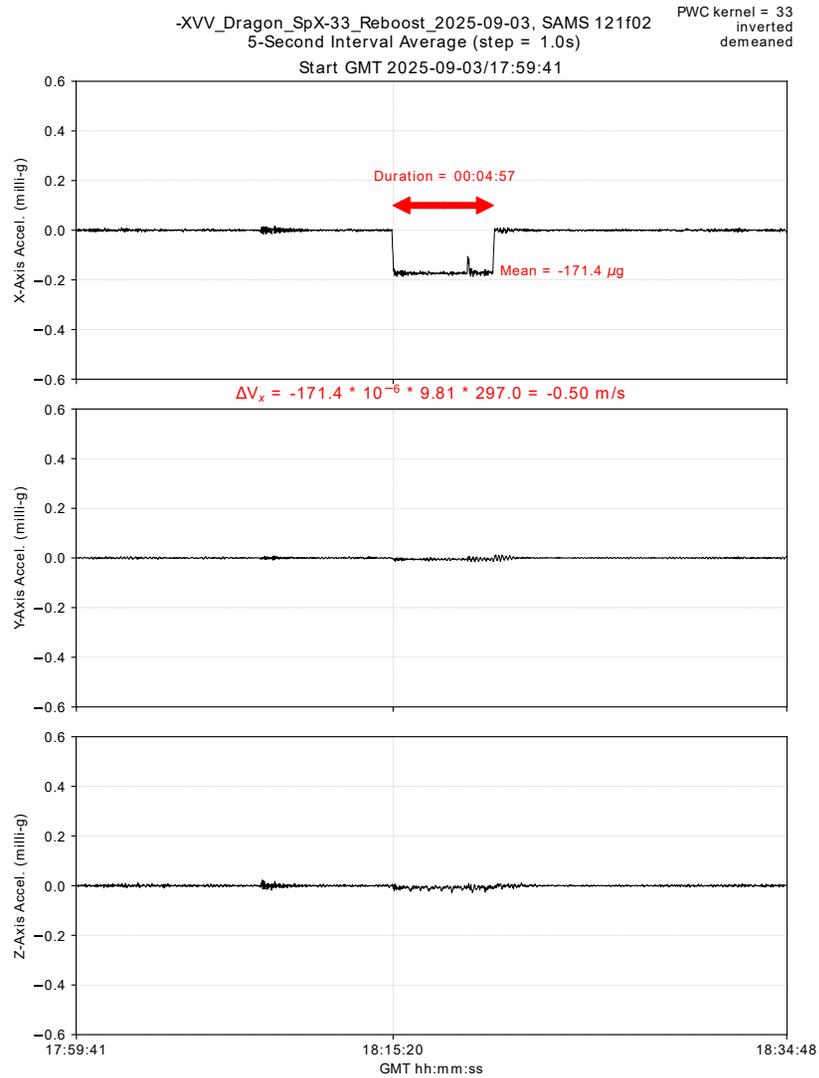


Fig. 7: 5-sec interval average for SAMS 121f02 sensor in the COL on Endcone.

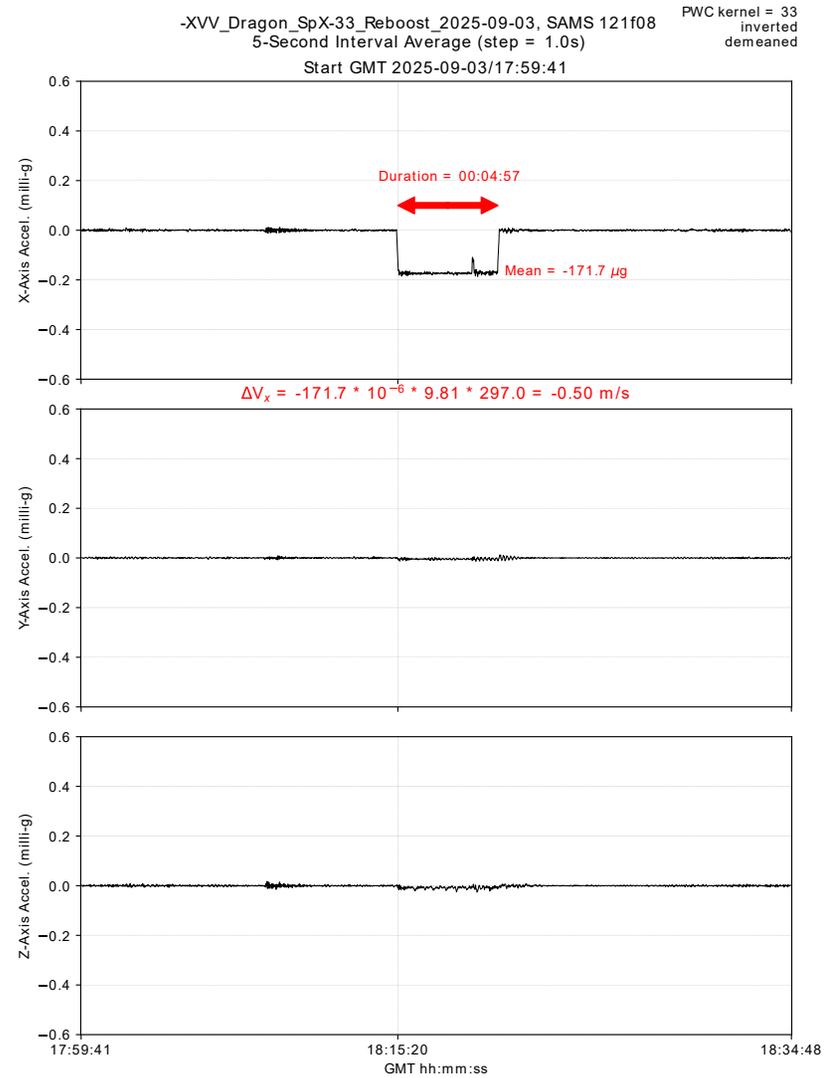


Fig. 8: 5-sec interval average for SAMS 121f08 sensor in the COL.

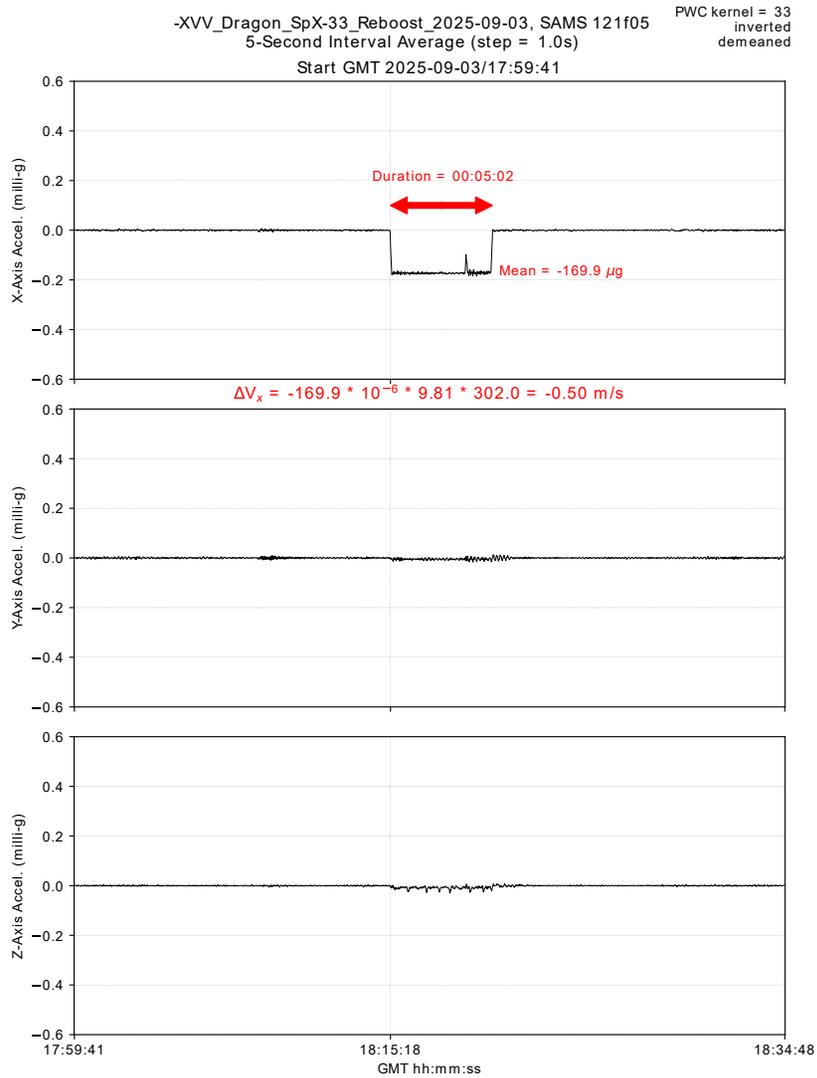


Fig. 9: 5-sec interval average for SAMS 121f05 sensor in the JEM.

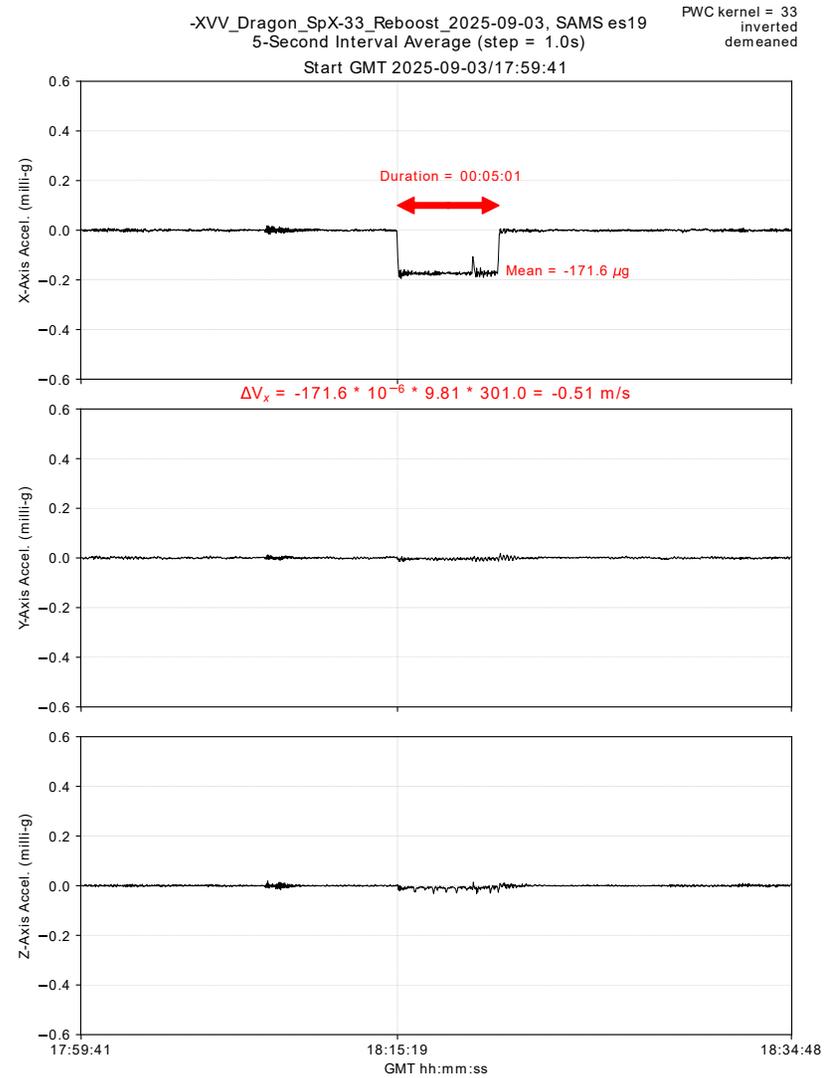


Fig. 10: 5-sec interval average for SAMS es19 sensor in the JEM.