1. INTRODUCTION

ISS payload racks include an Avionics Air Assembly (AAA) fan to provide forced-air cooling. This assembly is shared by all payloads within a specific rack volume to cool and circulate air within the rack. This use of cabin-air cooling is restricted for EXpedite the PRocessing of Experiments to the Space Station (EXPRESS) Rack (ER) payloads due to fire detection and suppression concerns and restricted heat dissipation allocation for racks.

2. QUALIFY

Figure 2 on page 3 is a color spectrogram computed from Space Acceleration Measurement System (SAMS) sensor 121f02 measurements. This sensor was mounted on the seat track of ER3 at rack location COL1A1, in the Columbus Module (COL). This first figure shows a daily overview (roadmap) analysis plot span of 8 hours. Such a wide time span here makes it difficult to see the temporal-frequency dynamics happening as related to this ER3 AAA fan, yet we show a magenta arrow pointing to the right at the left margin and a green arrow pointing down at the top margin of the plot to indicate the AAA vibratory signature transition area. The inclusion of this first figure was merely to demonstrate that routine, daily roadmap spectrogram plots can "hide" some significant vibratory dynamics. Figure 3 on page 4 is a **time zoom** to more clearly show the distinctive transition for the AAA fan signature. The magenta arrow on this figure points out the strongest vibratory spectral peak captured by the SAMS near a baseline of about 185 Hz. This frequency ramps down then back up between GMT 12:26 and 12:28. Finally, to more fully qualify this activity, Figure 4 on page 5 is a **frequency zoom** to narrow our focus and here the 2 rightward arrows along the left margin show what we will later assert are 2 harmonics of the AAA fan fundamental frequency.

Time Correlation with Independent Fan Speed Measurements

In reference to the discussion of SAMS measurements above, those data line up temporally with a report that "During the [ER3 recovery commanding] the AAA fan drops RPM from about 43,000 to about 25,000 before picking back up to about 43,000 when the rack configuration is loaded." Figure 5 on page 6 is a plot of directly-measured fan speed in RPM versus time that correlates with the temporal-frequency dynamics seen in the SAMS vibratory measurements. This shows that SAMS measurements can serve as a proxy for direct measurement as attested by the very close match-up in time when comparing these 2 independent measurement systems.

3. QUANTIFY

Figure 6 on page 7 shows an interval root-mean-square (RMS) acceleration versus time plot of computations from the SAMS 121f02 sensor data. This is the same time span as that shown in Figure 3, Figure 4, and Figure 5. The RMS acceleration levels in this plot come from applying Parseval's Theorem to the SAMS data in a narrow (3 Hz) band centered on 185.5 Hz. The distinctive features here are: (1) the steady-state value at about 2.29 mg before the transition between GMT 12:26 and 12:28, (2) the out-of-band RMS drop between GMT 12:26 and 12:28, and (3) the slightly lower, 2.27 mg steady-state RMS value after spin-up from 25,000 RPM to resume nominal operations at 43,000 RPM.

AAA Fan Disturbance Per-Axis Alignment

Figure 7 on page 8 shows a per-axis version of the total RMS plot shown in Figure 6. This rendering clearly shows that the AAA fan vibrations align with the nadir/zenith, Z-axis of the ISS with over 90% of the total RMS level contribution aligning with the Z-axis. See Figure 1 below along with Figure 6 and Figure 7.

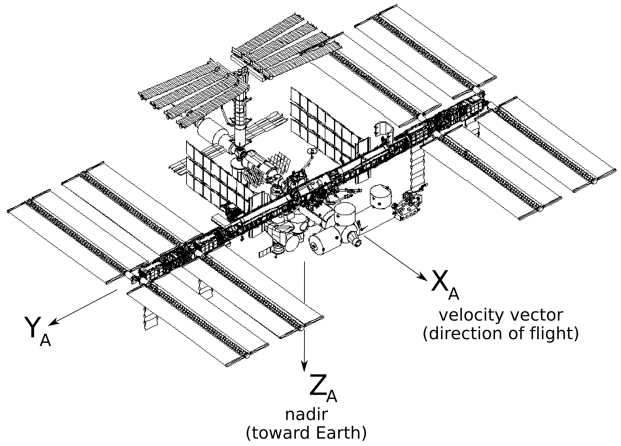

Fig. 1: Space Station Analysis (SSA) Coordinate System.

4. CONCLUSION

We have shown that SAMS vibratory sensor measurements in the Columbus module correlated closely in time with direct AAA fan speed (RPM) measurements on GMT 2021-09-10. The fan's operation resulted in a strong, narrowband disturbance near 185 Hz that produced RMS levels on the order of about 2 mg concentrated in a 3 Hz band around 185 Hz. Finally, we showed that the majority of the vibratory impact came from this disturbance on the Z-axis.

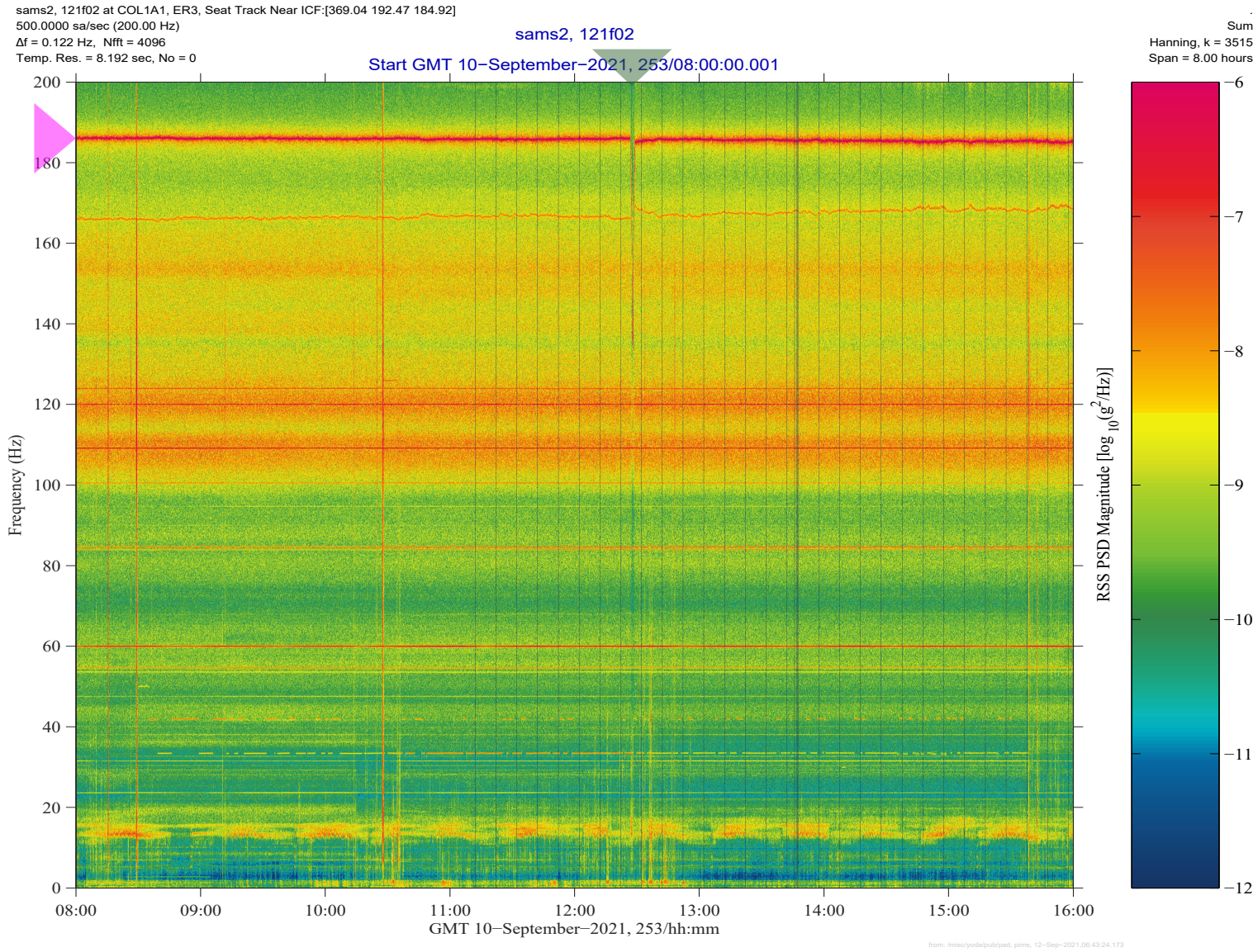

Fig. 2: Spectrogram showing AAA fan signature on GMT 2021-09-10.

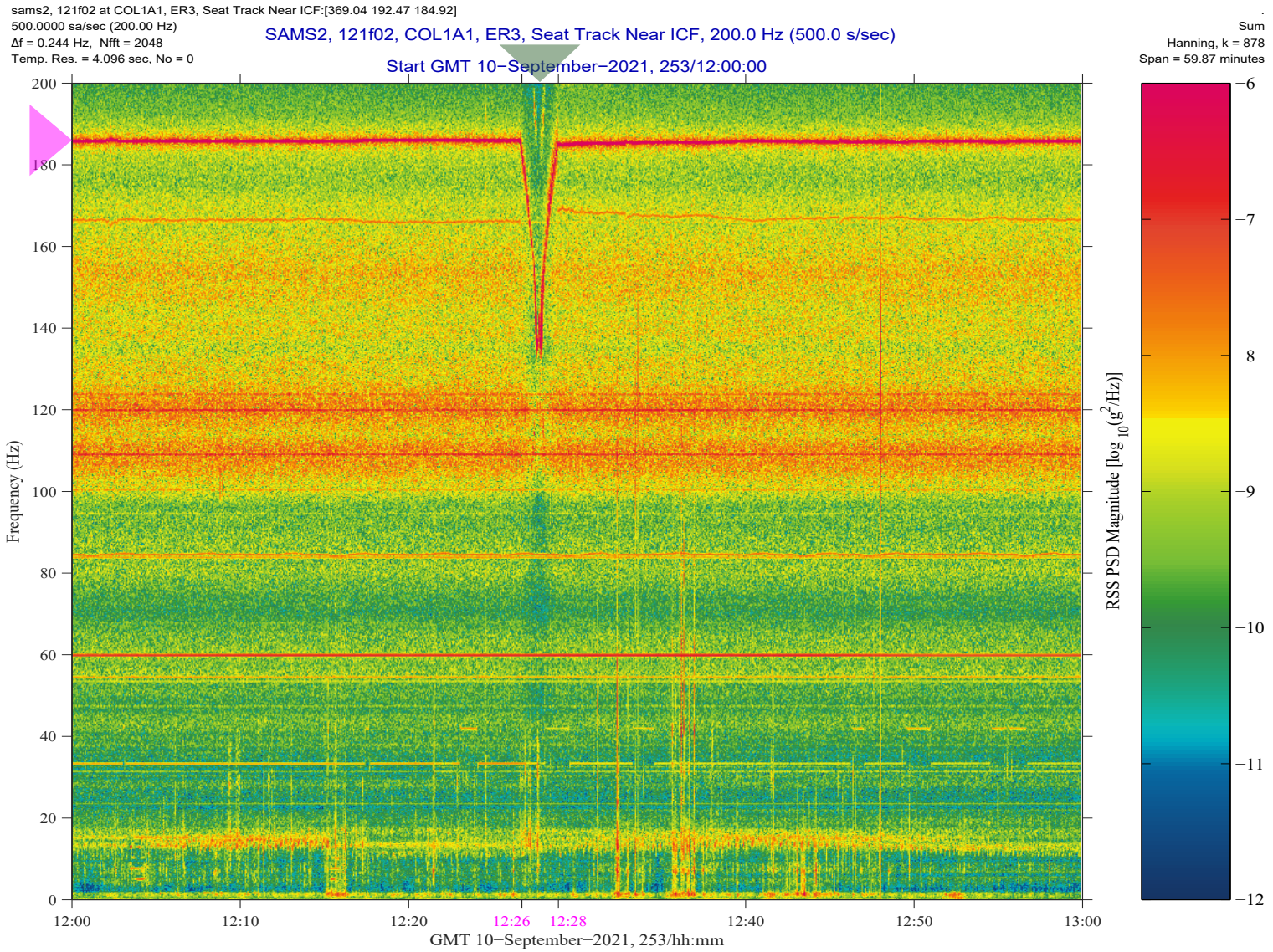

Fig. 3: Spectrogram **time zoom** to better show AAA fan signature on GMT 2021-09-10.

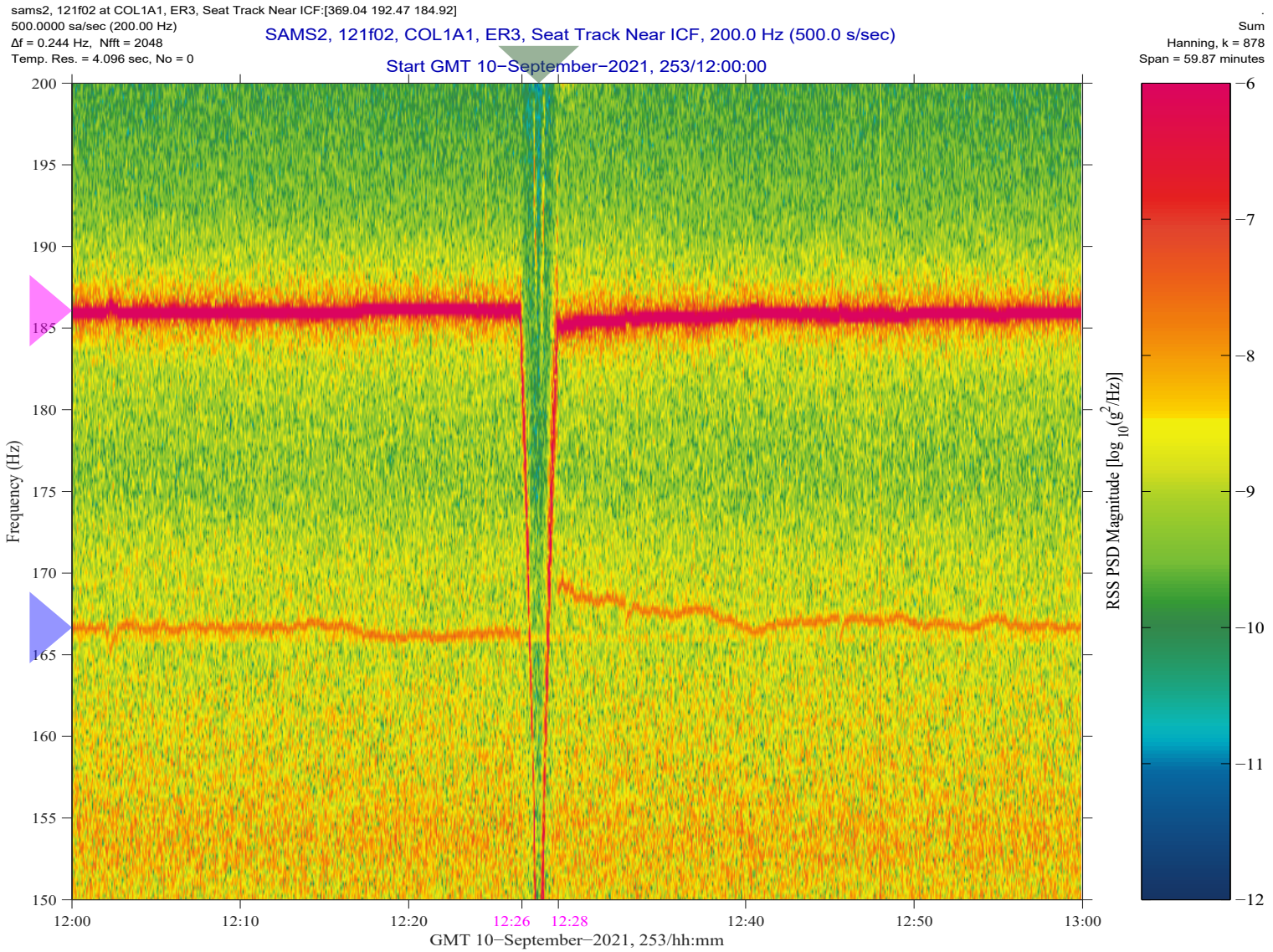

Fig. 4: Spectrogram **frequency zoom** to better show AAA fan signature on GMT 2021-09-10.

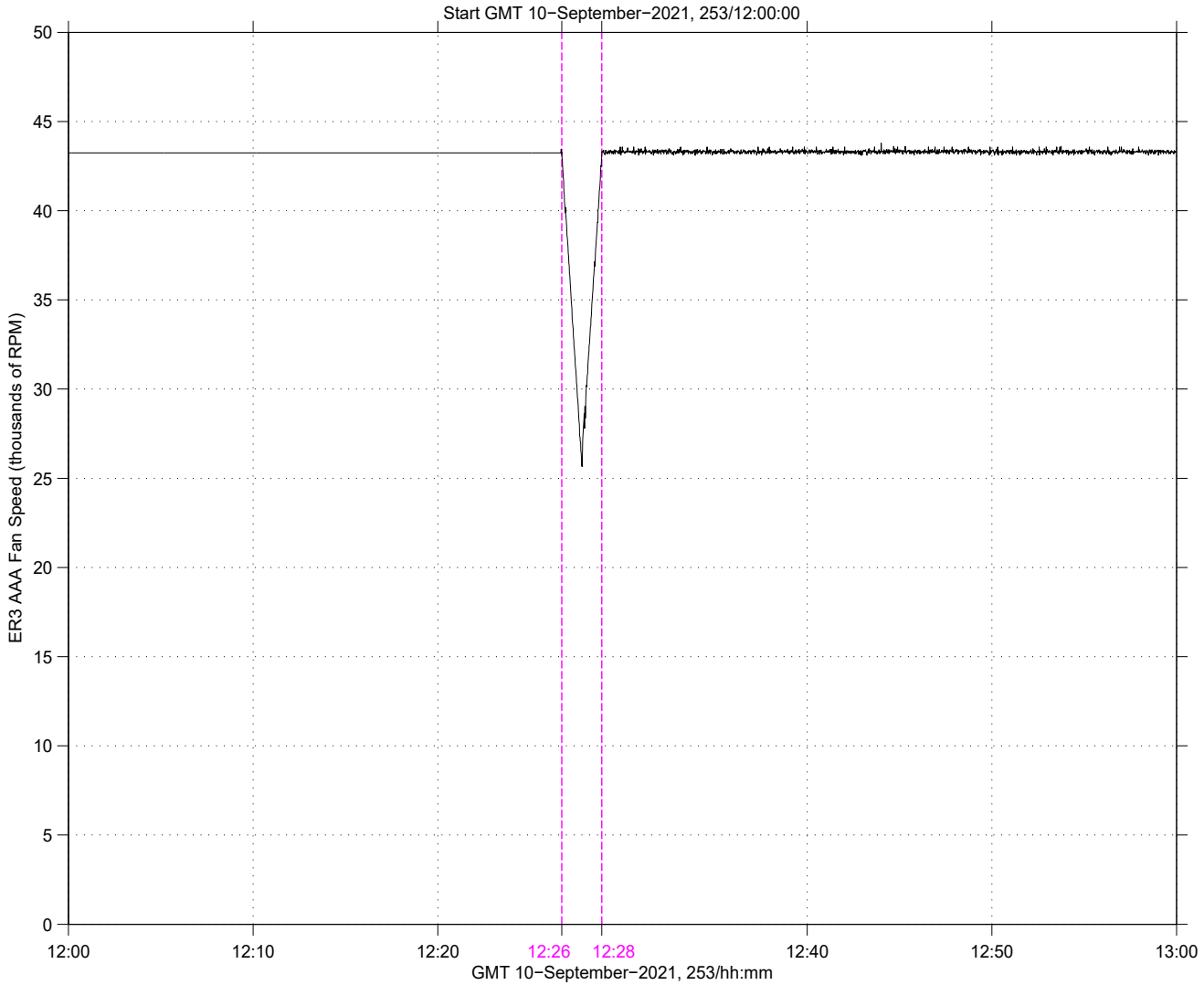

Fig. 5: Direct RPM measurements show AAA fan speed versus time on GMT 2021-09-10.

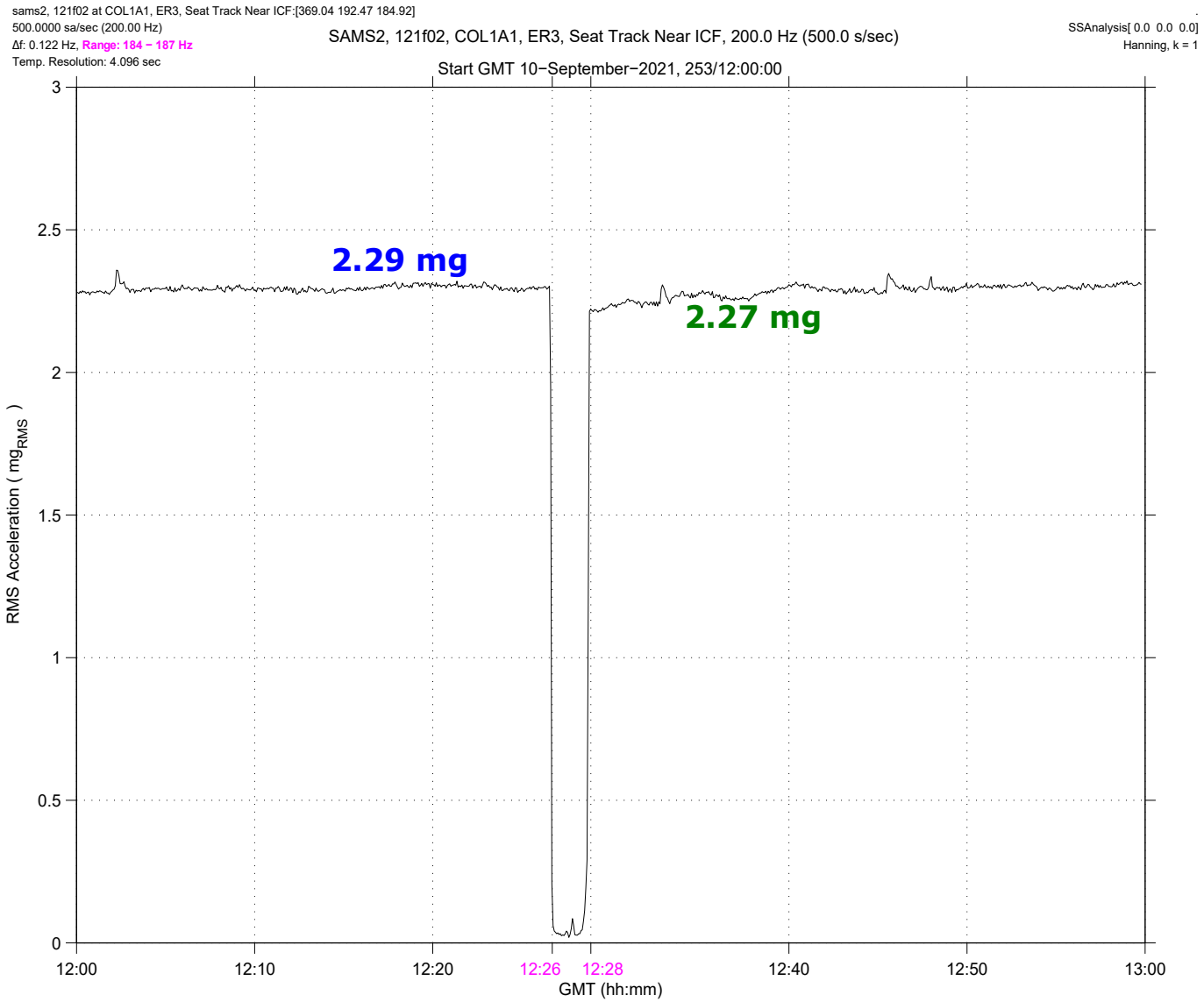

Fig. 6: Narrowband Interval RMS Accel. shows AAA fan vibratory impact on GMT 2021-09-10.

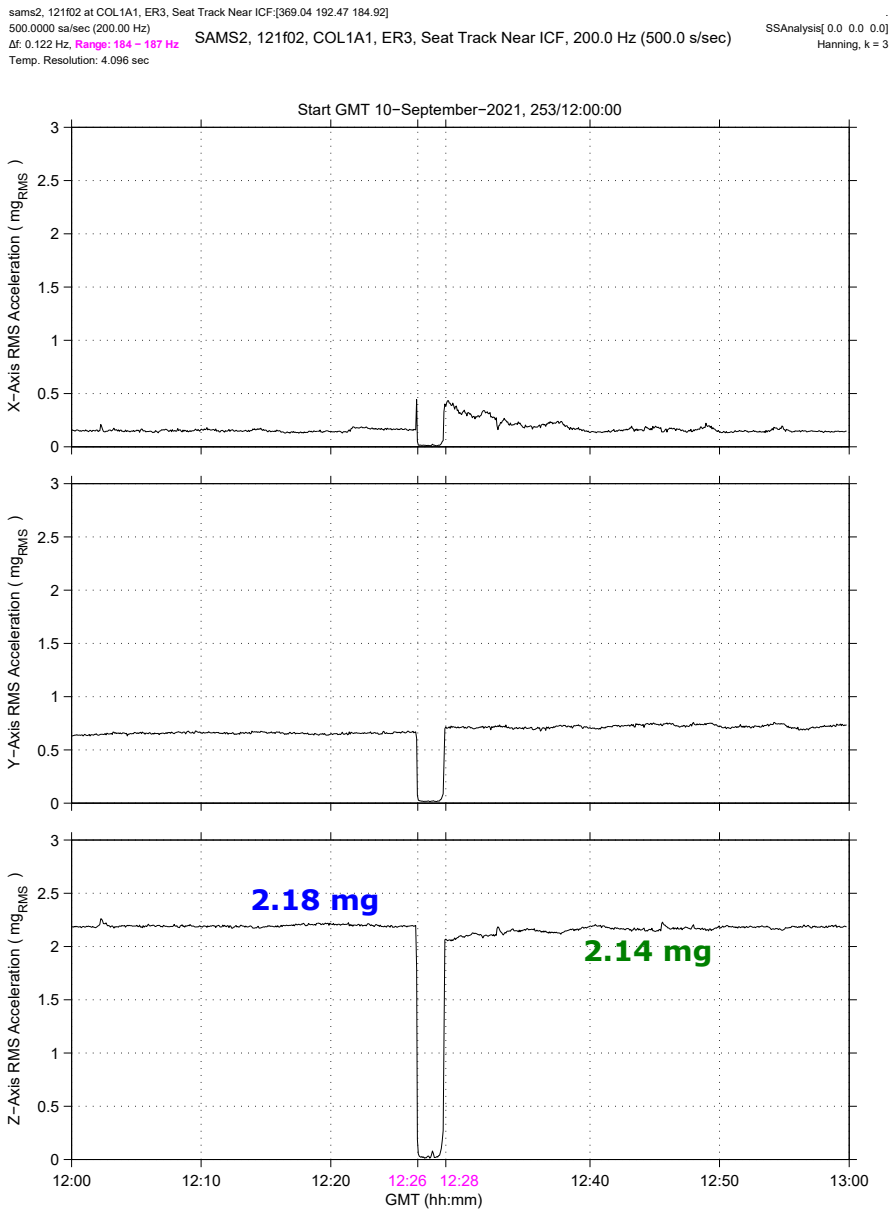

Fig. 7: Per-Axis Narrowband Interval RMS Accel. shows AAA fan vibratory impact on GMT 2021-09-10.