1. INTRODUCTION

Between GMT 2026-01-11/10:00 and 14:00, there were two crew exercise sessions on the International Space Station (ISS) each lasting a little over a half hour. This document seeks to both qualify and quantify the microgravity vibratory impact measured by SAMS below 5-10 Hz.

The data from all active SAMS sensors distributed throughout all 3 main labs (US LAB, COL, and JEM) were analyzed to provide context and the far reach of exercise on the low-frequency, structural vibratory regime.

2. QUALIFY

The spectrogram shown in Figure 1 (p. 3) was generated from Space Acceleration Measurement System (SAMS) sensor 121f08, mounted in the Columbus module at the COL1A3 (EPM) rack. This 10 Hz color spectrogram *focuses on the frequency regime associated with crew activity and structural modes (below 5 Hz)*. Examining the timeline below, you can see it clearly reveals both the exercise-induced vibration stimulus and the corresponding structural response of the ISS — predominantly concentrated below approximately 5 Hz.

Timeline of the Two Exercise Sessions

GMT 11:19–11:57	First exercise session	38 minutes
GMT 12:03–12:36	Second exercise session	33 minutes

White ellipses in the figure mark two prominent, periodic "blips" near 5 Hz originating from Ku-band antenna motion. These signatures serve as a clear reminder to avoid this frequency when attempting to isolate and quantify crew-exercise vibration contributions (to prevent confounding).

The other six spectrograms (Figures 2–7, pp. 4–9) provide supporting context and demonstrate that exercise-related disturbances are readily observable throughout the entire ISS complex.

3. QUANTIFY

While the spectrograms in the preceding "Qualify" section offer a useful picture of vibration levels (showing power spectral density magnitude via color intensity), the goal in this section is to quantify the microgravity impact of the two exercise sessions more intuitively using acceleration root-mean-square (RMS) values as the metric..."the effective, average shakiness".

Acceleration Interval Root-Mean-Square (RMS) from 0.5 to 5 Hz

To provide a more intuitive and quantitative measure of the microgravity disturbances caused by the crew exercise sessions, we compute the root-mean-square (RMS) acceleration restricted to the 0.5–5 Hz frequency range of interest. This band captures the dominant structural response and exercise-related vibrations while excluding confounds outside this band.

Using Parseval's theorem (which equates the mean-square value of a signal in the time domain to the integrated power spectral density in the frequency domain), the band-limited RMS acceleration for each SAMS sensor head is obtained by integrating the one-sided power spectral density (PSD) over the 0.5–5 Hz interval and taking the square root like so:

$$a_{\text{RMS}} = \sqrt{\int_{0.5}^{5} \text{PSD}(f)\, df}$$

where we display in units of mg albeit most of the non-exercise portions of the time span would better be rendered in units of μg not mg.

This approach is applied over the 4-hour observation window encompassing both exercise sessions, yielding an RMS value every 16-seconds (using 32-second stepping windows) – physically meaningful values per sensor head location that captures the crux of the vibration severity in the 7 figures starting with Figure 8 on page 10.

Strongest RMS Elevation at MSG: RMS–Spectrogram Overlay Alignment

To examine the temporal correspondence between spectral content and vibration amplitude via RMS, refer to Figure 15 (p. 17), which overlays the 0.5–5 Hz band-limited RMS acceleration trace directly onto the 4-hour, 10 Hz spectrogram for SAMS sensor es20 (Microgravity Science Glovebox, MSG rack at LAB1S2).

The black RMS trace, reproduced from the bottom subplot of Figure 9 (p. 11) and aligned to the spectrogram time axis, clearly shows both exercise sessions elevating the RMS level from quiescent background values in the μg range into the mg range. For reasons currently unknown, these elevated RMS levels during the crew exercise periods (GMT 11:19–11:57 and 12:03–12:36) were most pronounced at the LAB1S2 (MSG) location.

4. Conclusion

Two crew exercise sessions on GMT 2026-01-11 produced clear, low-frequency vibratory disturbances across the International Space Station, as registered by all seven analyzed SAMS sensor heads spanning the US Lab, and the Columbus and JEM modules.

Qualitative examination of 10 Hz spectrograms (Figures 1–7) expectedly reveals prominent exercise-induced excitation below 5 Hz, with structural responses dominating primarily below 3 Hz. Low-frequency disturbances such as these tend to be global in nature, detectable throughout the space station's pressurized volume.

Quantitative assessment using 0.5–5 Hz band-limited RMS acceleration (Figures 8–14), computed via Parseval's theorem over 32-second sliding windows, provides a direct measure of vibration severity. Peak RMS values during the exercise periods reach levels significantly above quiescent background and up into the low mg range during exercise activity versus μg baseline otherwise. For unknown reasons, the strongest and most sustained response occurs at sensor es20 (MSG rack, LAB1S2), where we saw RMS levels were notably higher than other sensor head locations.

The overlay of interval RMS on the spectrogram at es20 (Figure 15) visually confirms excellent temporal correspondence between elevated PSD and computed RMS peaks, reinforcing confidence in the band-limited RMS metric as a physically meaningful indicator of exercise-induced microgravity disturbances we observe qualitatively via spectrograms.

As expected, these results demonstrate that crew exercise on the ISS exercise devices impart non-negligible low-frequency structural excitation across the ISS. The methodology presented — combining qualitative spectrogram inspection with targeted band-limited RMS quantification — offers a robust, repeatable framework for evaluating such crew-system interactions and their implications for microgravity science.

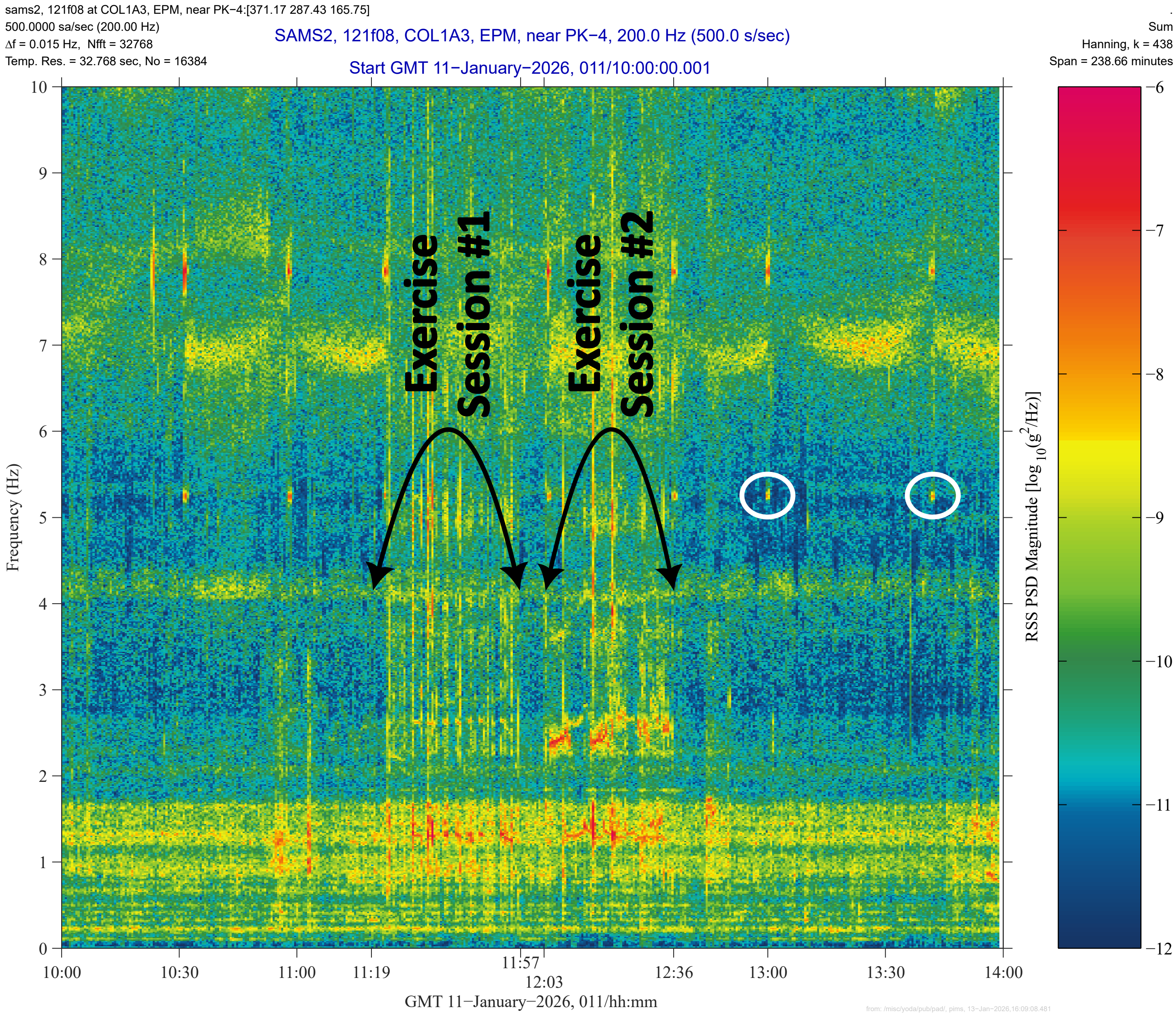

Fig. 1: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f08 at COL1A3 (EPM).**

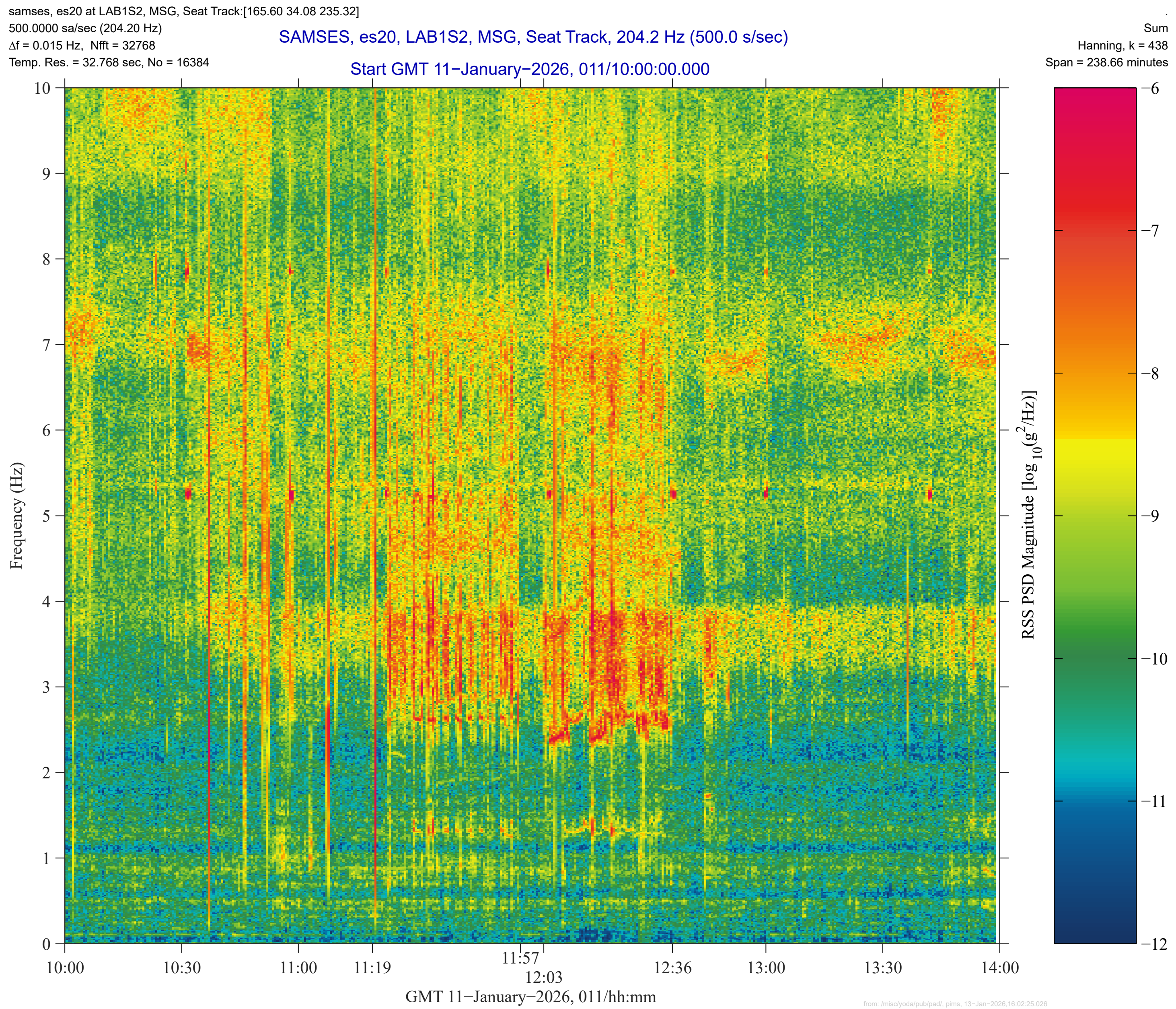

Fig. 2: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es20 at LAB1S2 (MSG).**

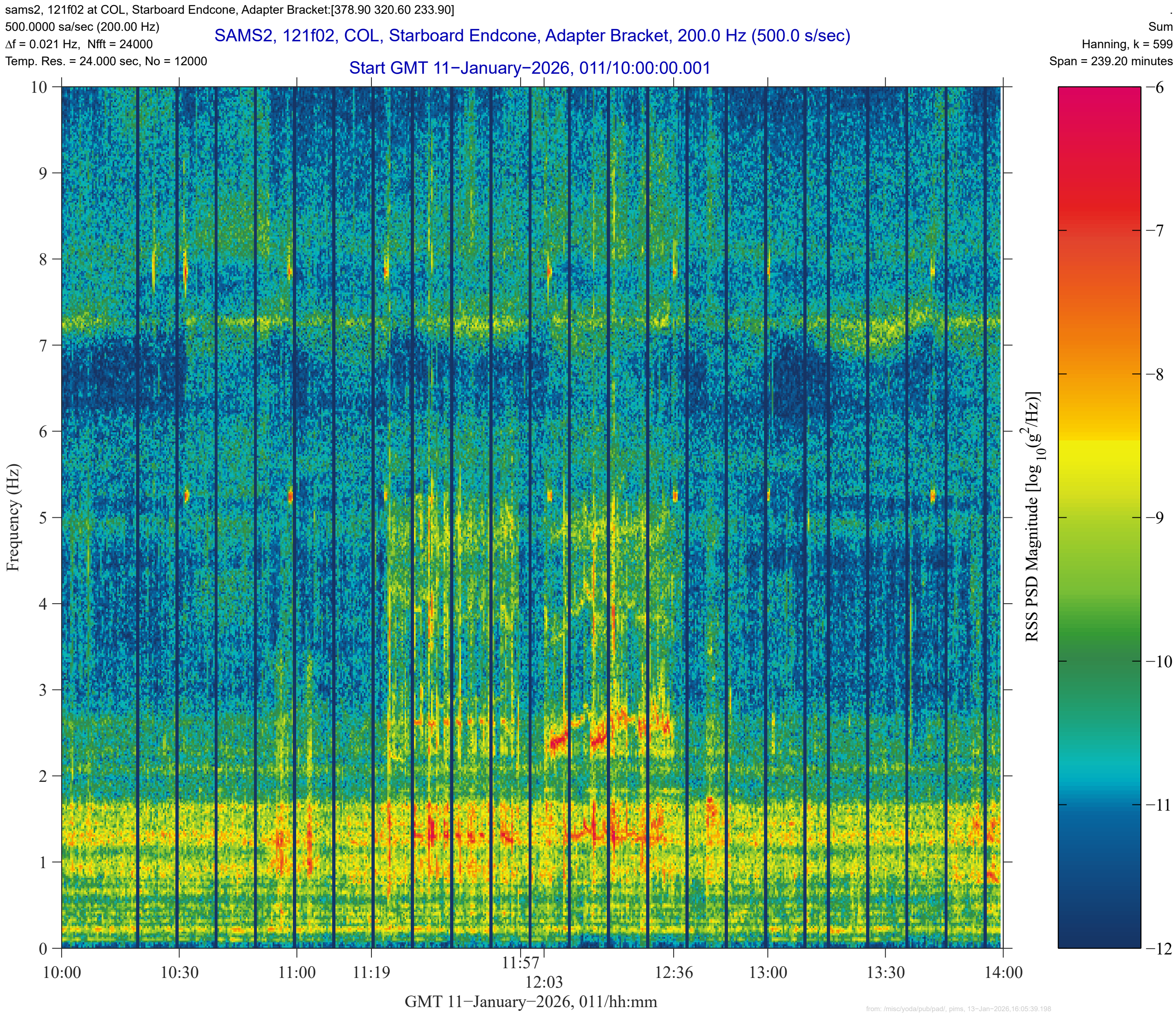

Fig. 3: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f02 at Columbus Endcone.**

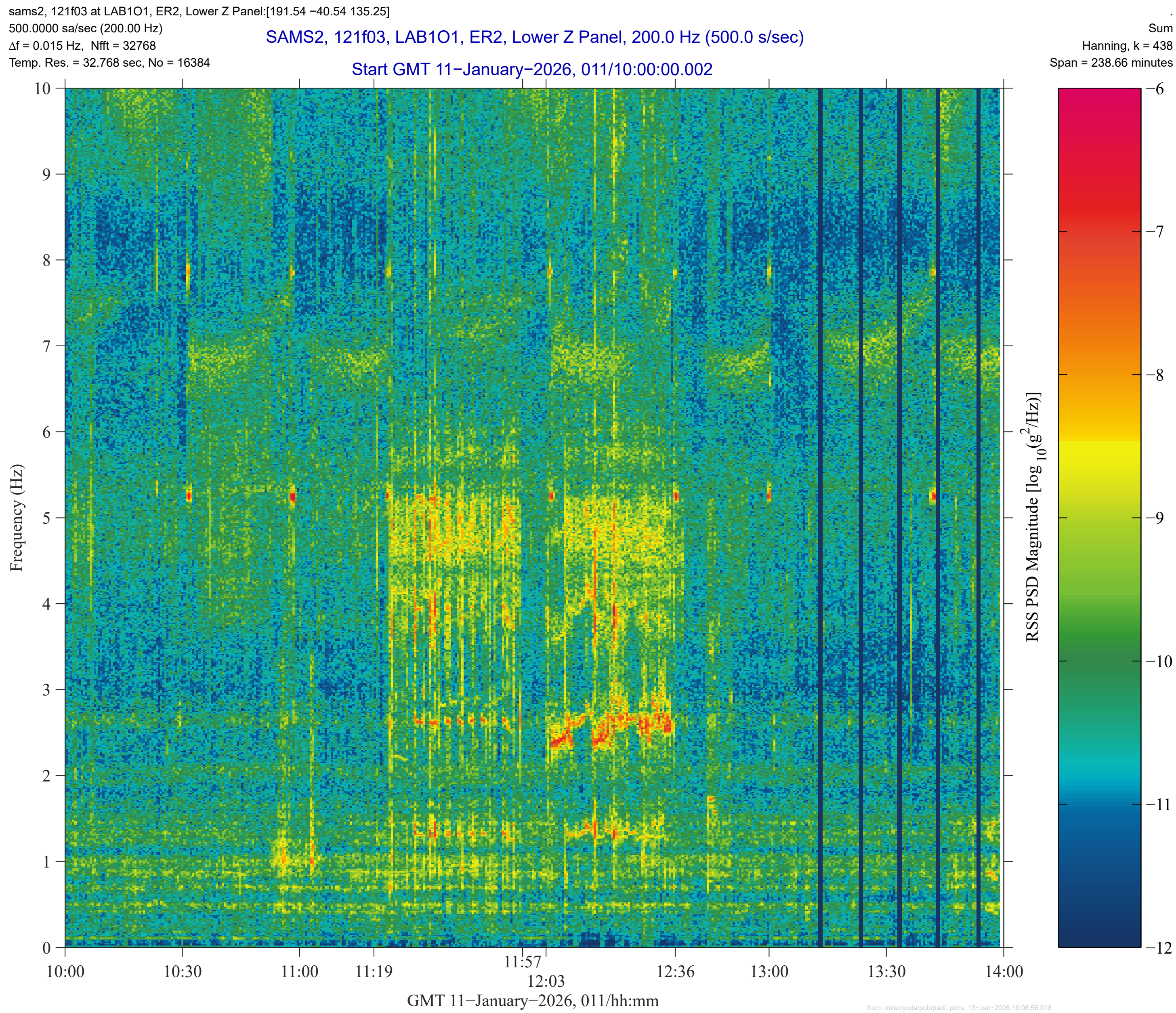

Fig. 4: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f03 at LAB1O1 (ER-2).**

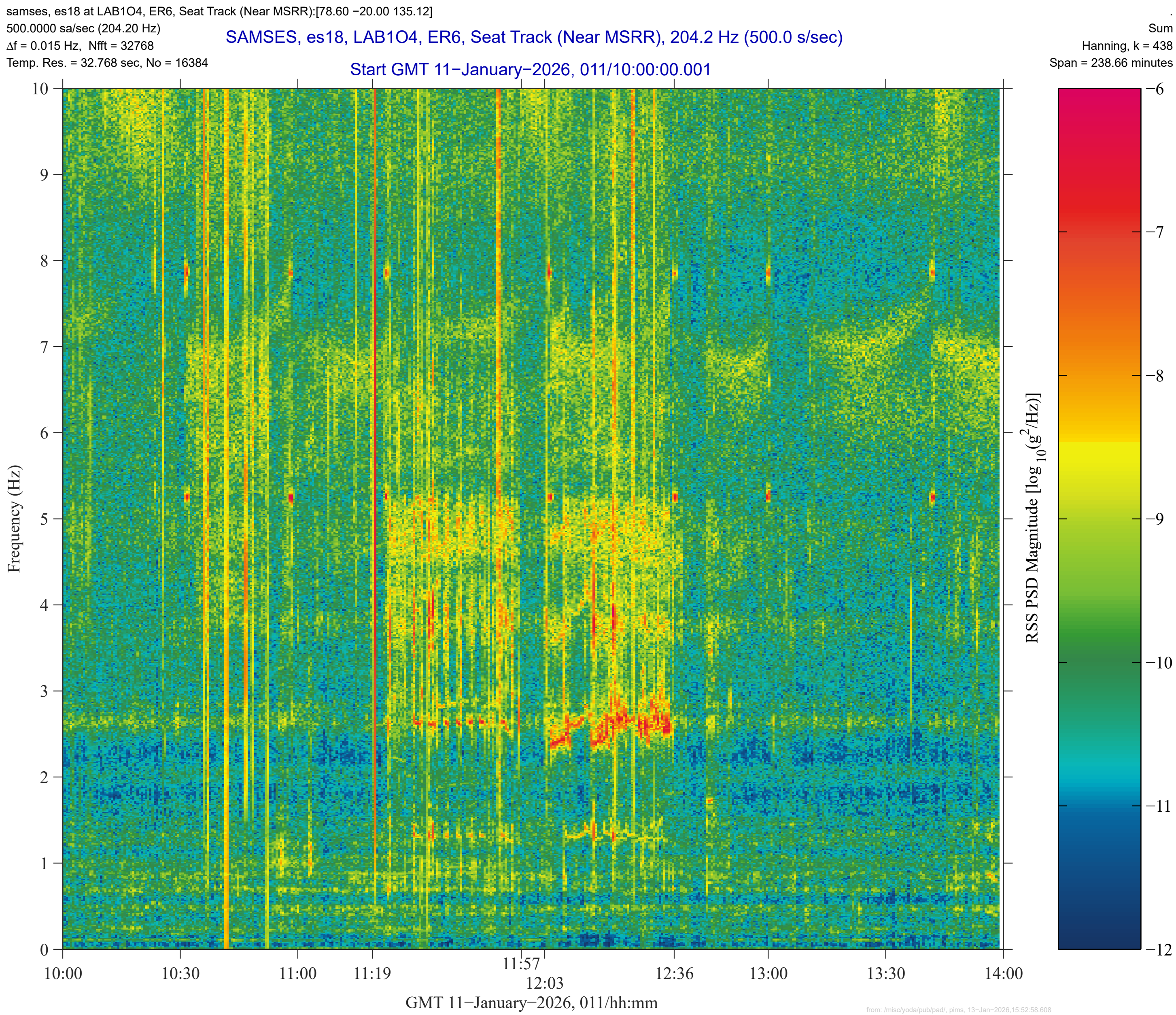

Fig. 5: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es18 at LAB1O4 (ER-6).**

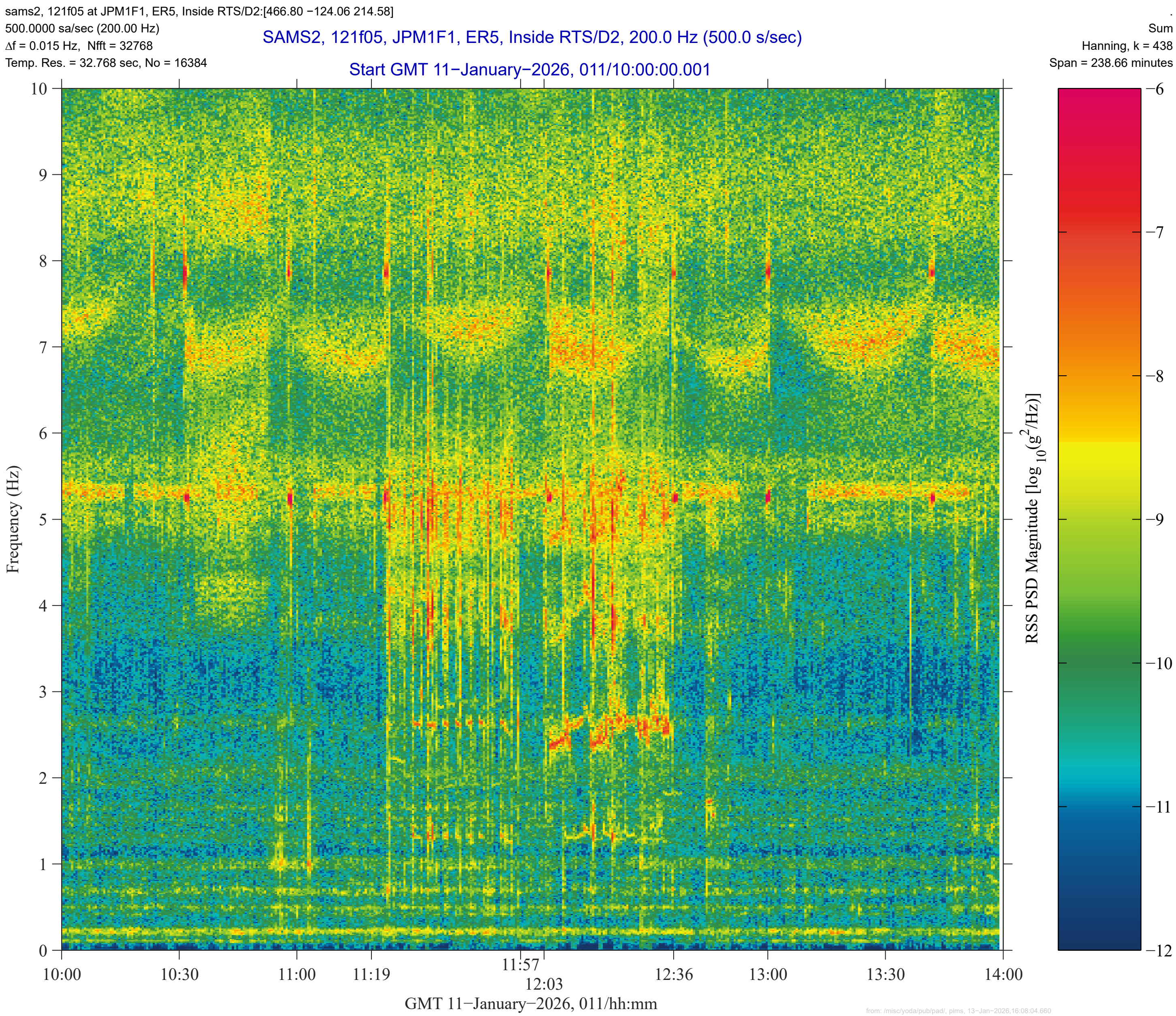

Fig. 6: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f05 at JPM1F1 (ER-5).**

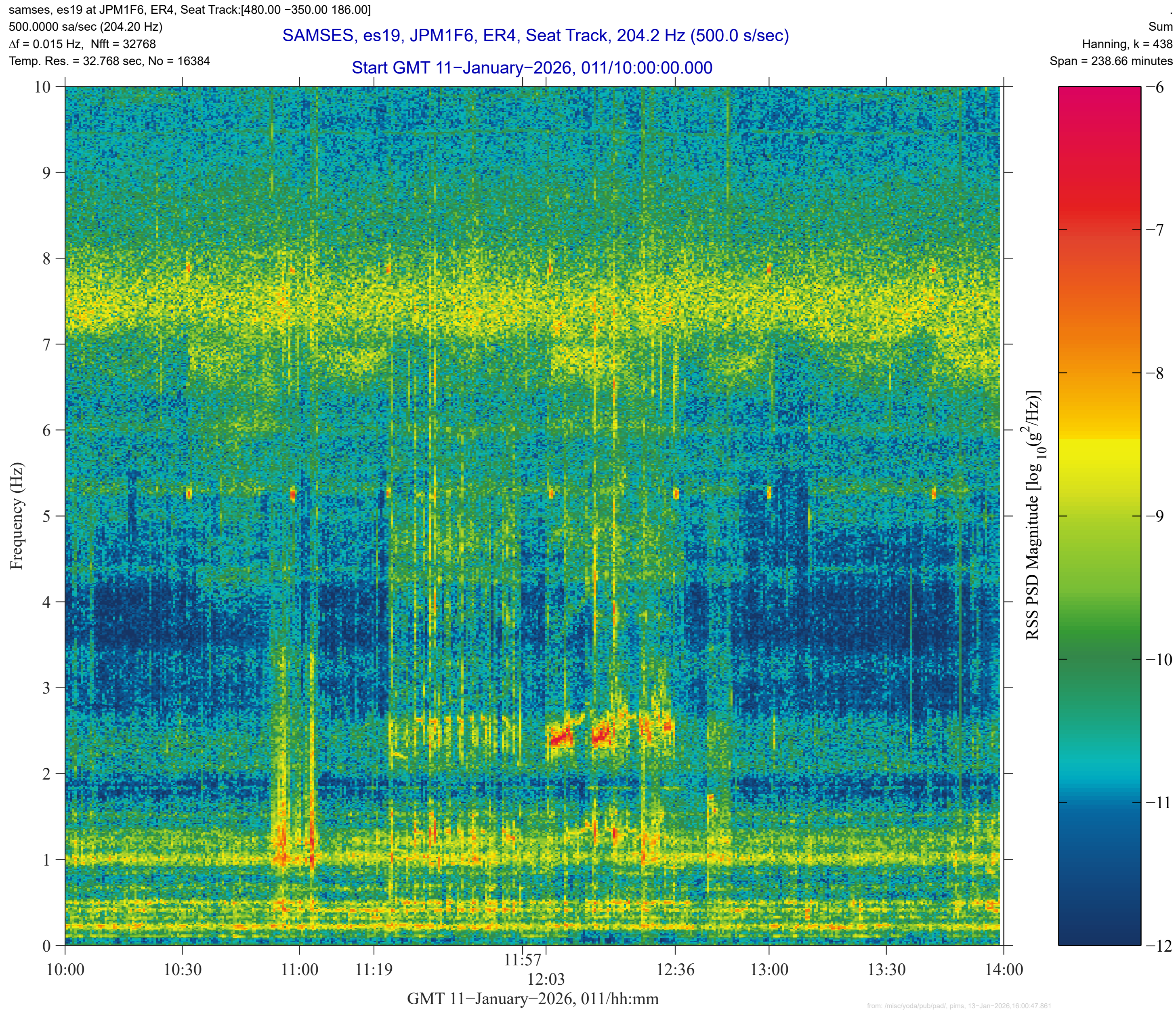

Fig. 7: 4-hour, 10 Hz spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es19 at JPM1F6 (ER-4).**

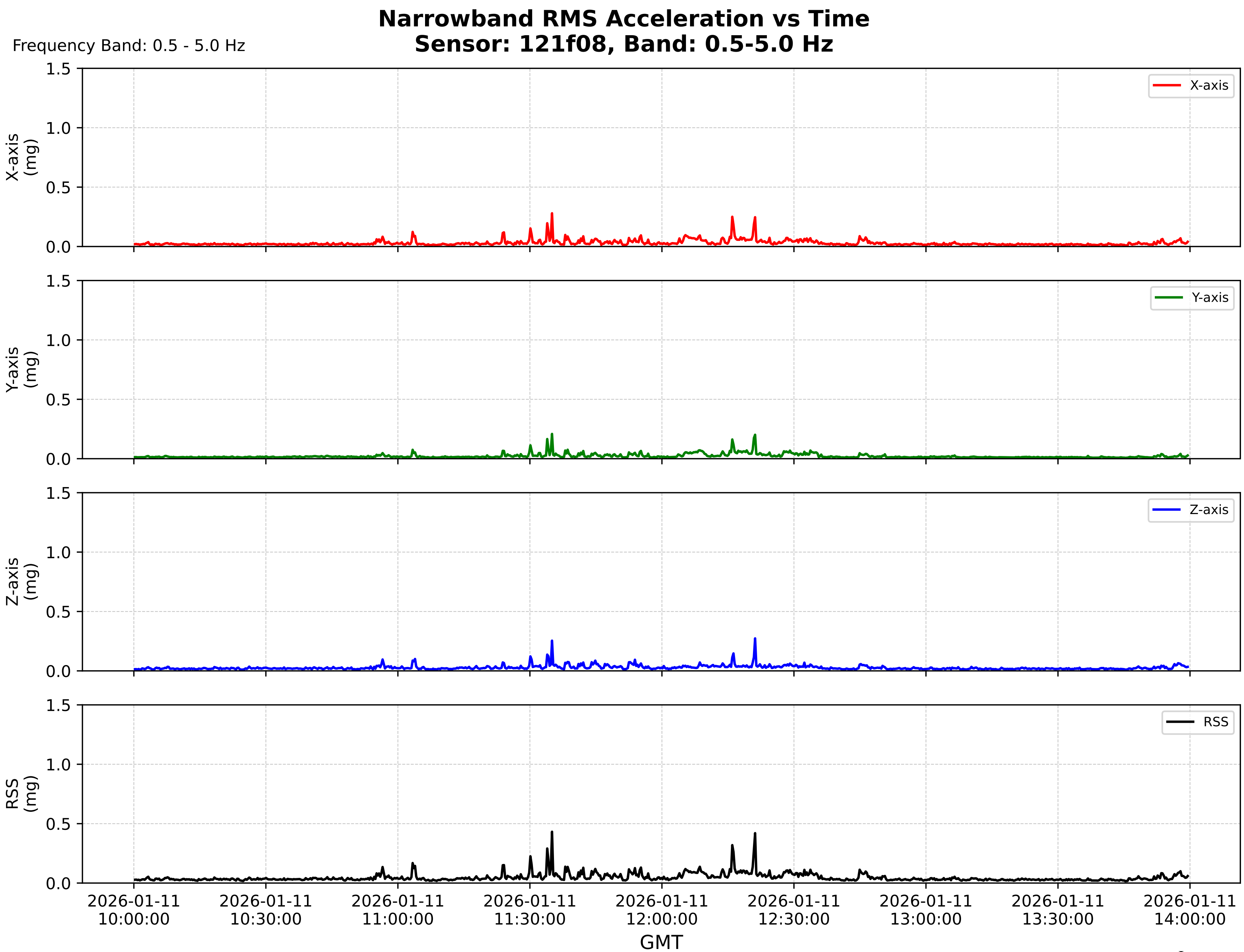

Fig. 8: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f08 at COL1A3 (EPM).**

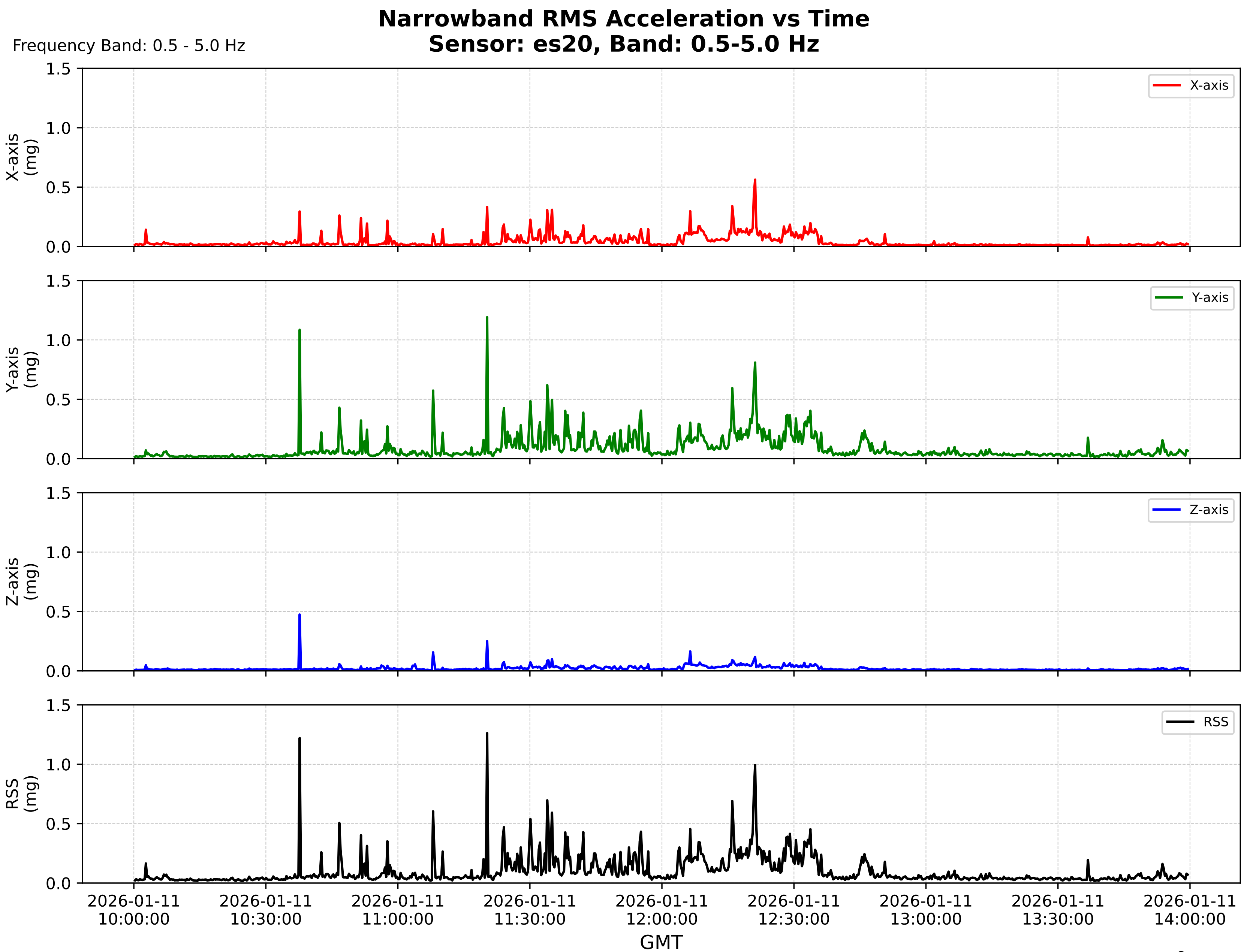

Fig. 9: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es20 at LAB1S2 (MSG).**

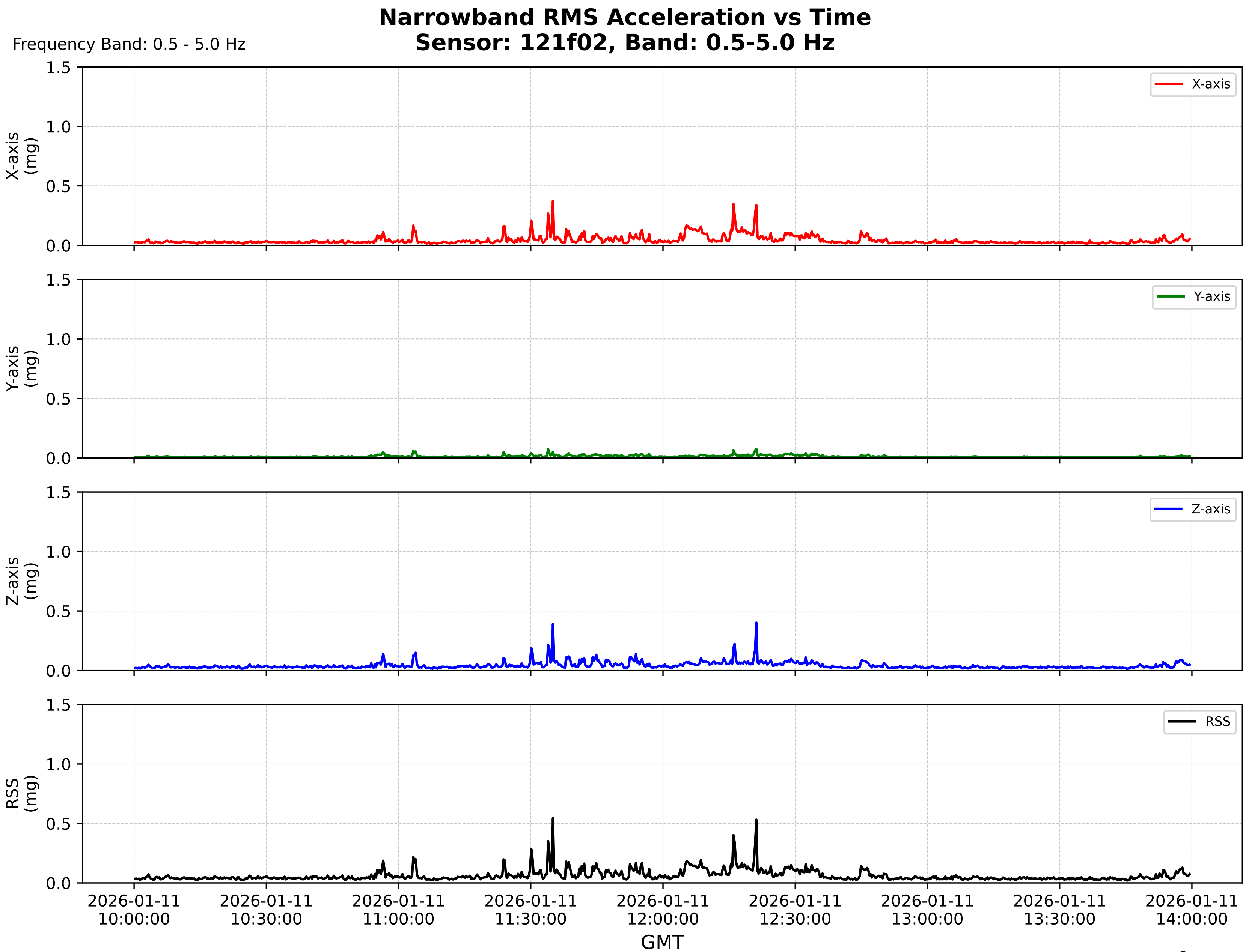

Fig. 10: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f02 at Columbus Endcone.**

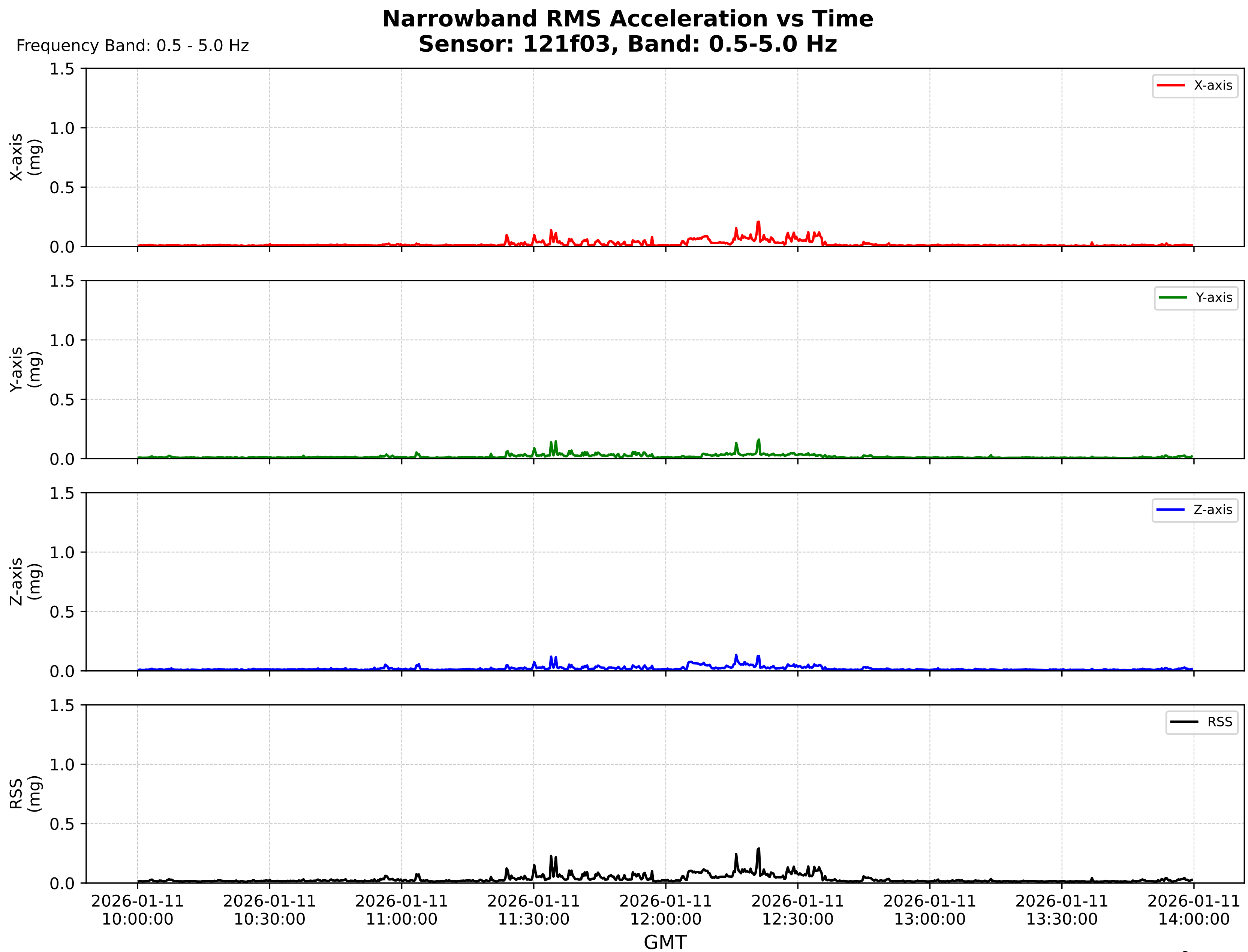

Fig. 11: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f03 at LAB1O1 (ER-2).**

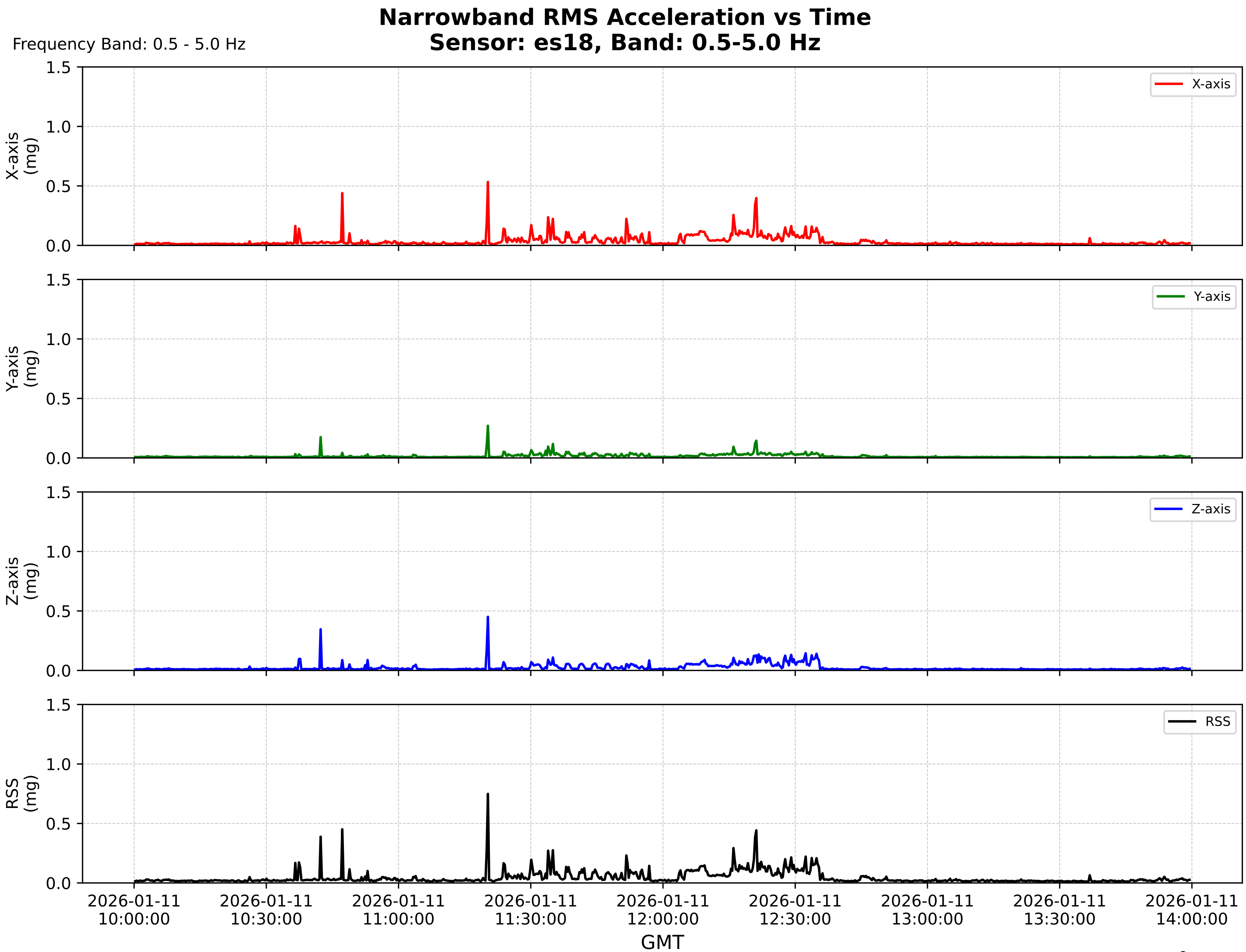

Fig. 12: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es18 at LAB1O4 (ER-6).**

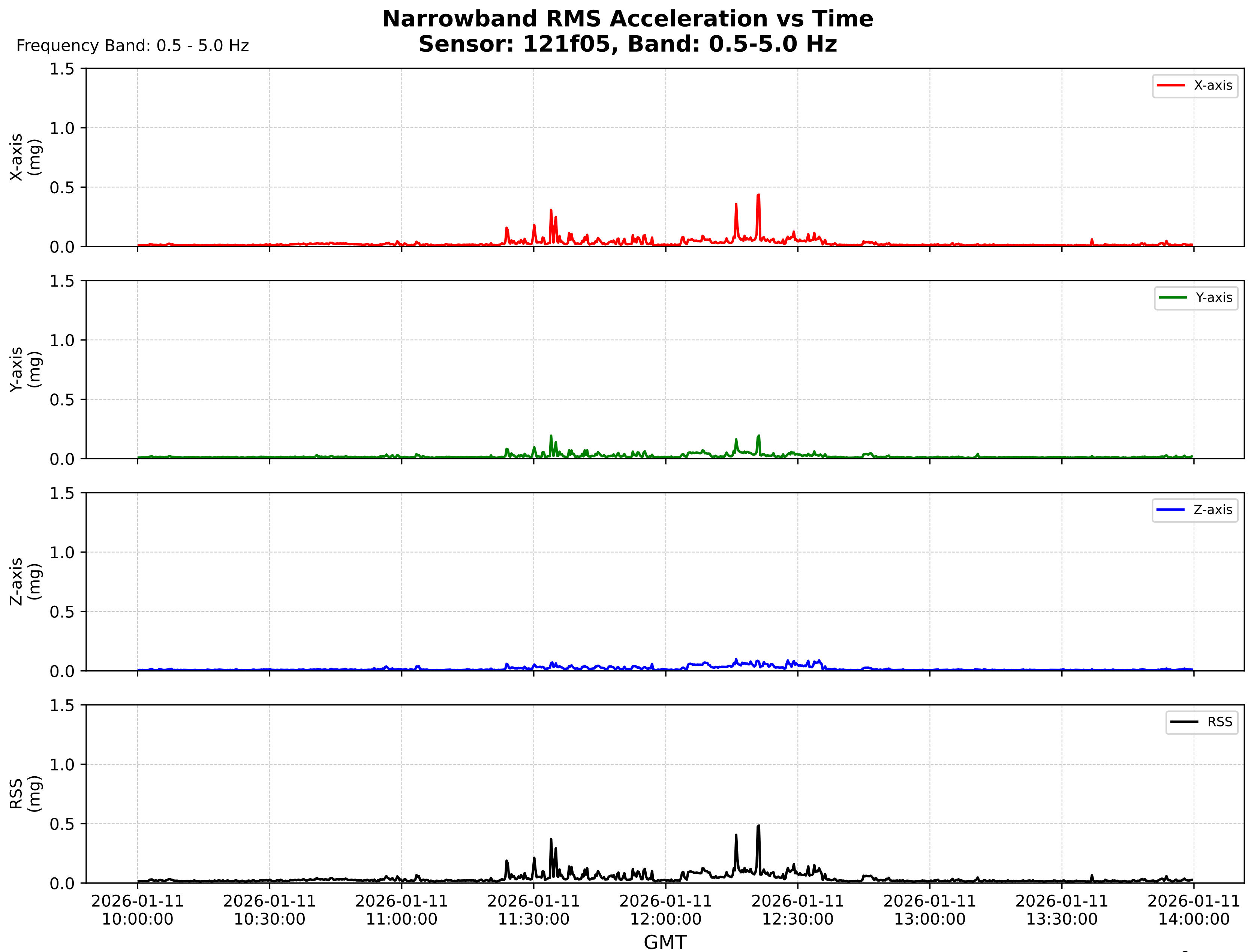

Fig. 13: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor 121f05 at JPM1F1 (ER-5).**

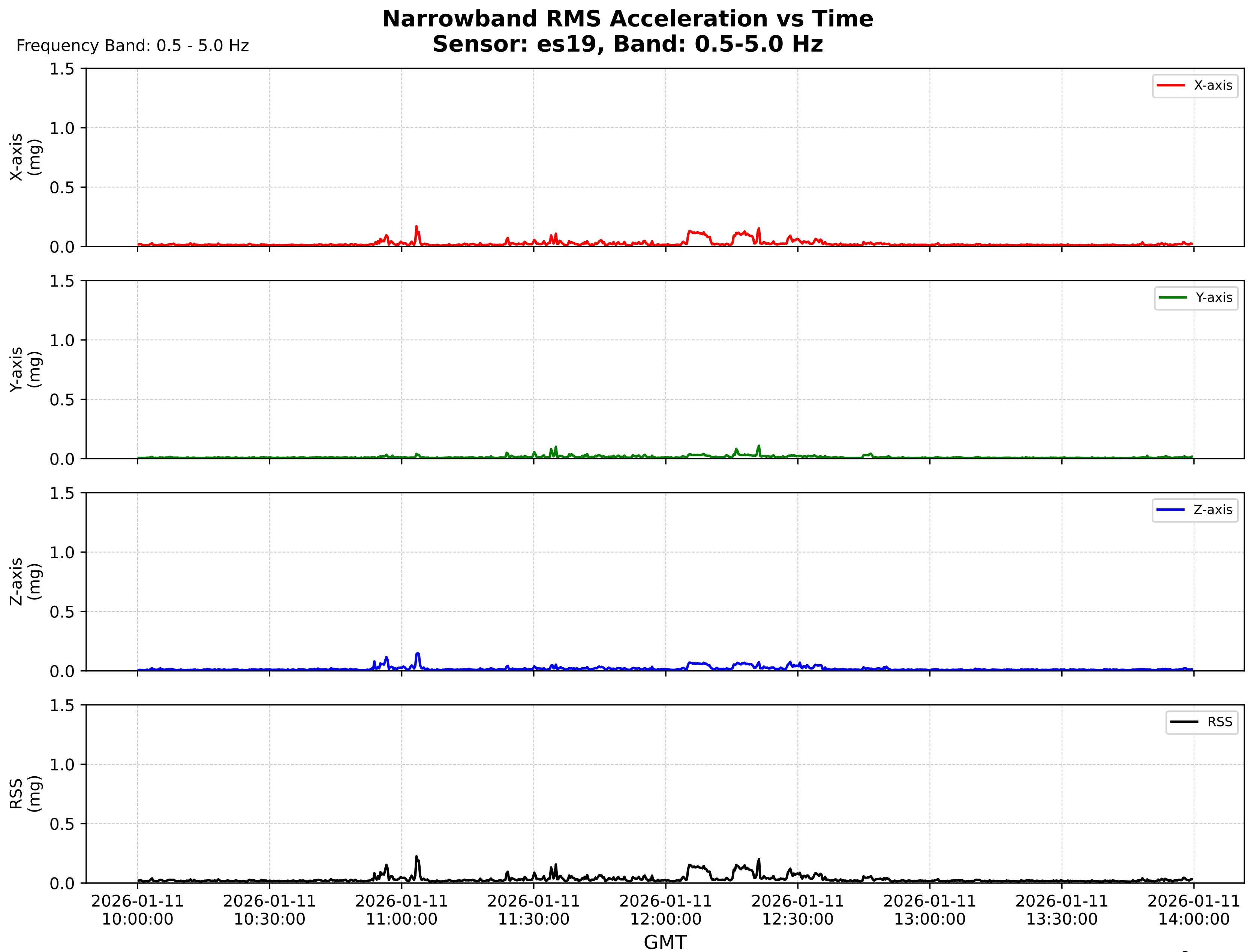

Fig. 14: 4-Hour, 32-sec Interval RMS vs. time showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es19 at JPM1F6 (ER-4).**

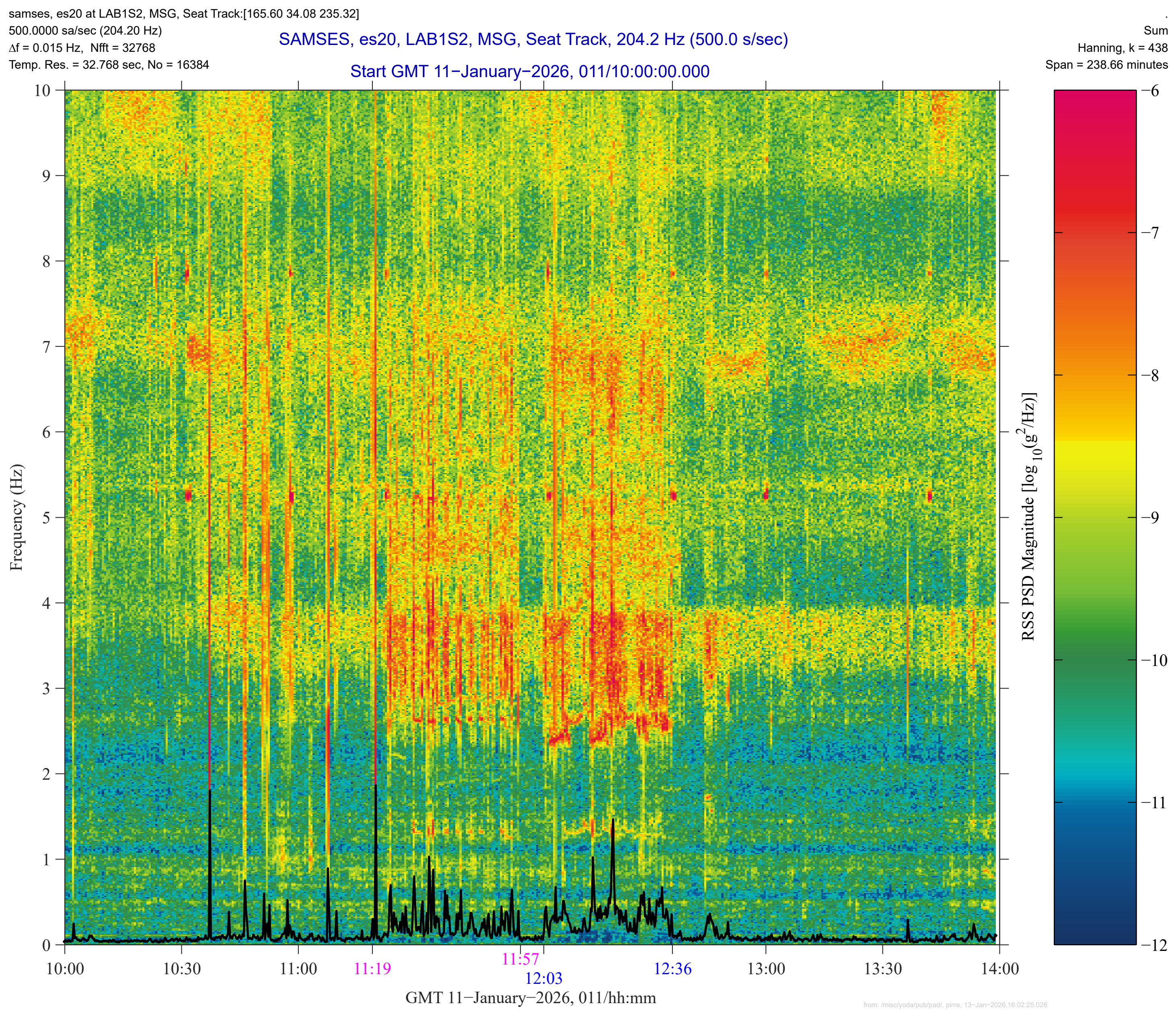

Fig. 15: 4-Hour, overlay interval RMS on spectrogram showing two crew exercise sessions on GMT 2026-01-11. **SAMS sensor es20 at LAB1S2 (MSG).**