1. Introduction

The European Space Agency (ESA) leverages its **Columbus Ka-Band (ColKa)** unit to facilitate unique communication capabilities with the Columbus module on the International Space Station (ISS).

Motivation for Columbus Ka-Band Unit Prime Sessions

The primary motivation for utilizing **Columbus Ka-Band Unit Prime Sessions** is to significantly enhance the communication bandwidth between ESA's Columbus laboratory module on the ISS and ground stations in Europe. These sessions offer several critical advantages:

- **Faster Data Delivery:** ColKa enables substantially higher communication rates for transmission of scientific data from Columbus module experiments to researchers on Earth. This significantly accelerates the pace at which European scientists can analyze their ISS experiment results.
- **High-Definition Video:** The increased bandwidth supports independent transmission of high-definition video feeds.
- **Independent Connection:** ColKa provides ESA with a dedicated, independent connection to ground, thereby reducing reliance on NASA's communication infrastructure for European-led experiments.
- **Real-Time Access:** Researchers on Earth gain near real-time access to their experiments, which facilitates more dynamic and responsive scientific investigations.

Understanding "Prime Sessions"

A "prime session" refers to a scheduled, primary communication link using the Ka-band system. These sessions involve high-priority, high-data-rate exchanges, predominantly for transferring science data, video, or experiment outcomes from Columbus to Earth, and subsequently uploading new instructions or payloads to ESA facilities.

The Ka-band offers significantly faster transmission rates—up to tens or hundreds of Mbps—compared to traditional S-band links. During a prime session, the ColKa terminal functions as the primary link for Columbus segment communications, ensuring sustained, direct, and robust connectivity with European ground networks.

ColKa System Overview and Data Collection

For the characterization of Columbus Ka-Band Unit Prime Sessions, Space Acceleration Measurement System (SAMS) data from July 22 and 23, 2025 (GMT) were analyzed. The ColKa antenna, mounted on the Columbus module, links the ISS to the European Data Relay System (EDRS) satellites. This linkage is what fully facilitates high-speed, high-bandwidth data transmission directly between Columbus and the following European ground stations:

- Harwell, Oxfordshire, United Kingdom
- Redu, Belgium
- Weilheim, Germany
- Matera, Italy

2. Qualify

In this document, we will briefly characterize vibratory signal features associated with ColKa Prime Sessions in July of 2025. We note that the SAMS sensor head of interest was mounted on the Columbus Starboard Endcone during these sessions. This sensor head has a passband up to 200 Hz for its triaxial (XYZ) acceleration measurement transmission and recordings.

Spectrogram Showing ColKa Prime Sessions

Figure 1 on page 3 presents a 200 Hz, 8-hour color spectrogram computed from the SAMS sensor head (S/N 121f02) data recorded on the Columbus Starboard Endcone. This spectrogram is intended to show frequency domain features of ColKa Prime Sessions - these being on GMT 2025-07-22 - between about 60 Hz and 160 Hz.

More Spectrograms Showing ColKa Prime Sessions

For more of a comprehensive look at ColKa prime sessions over a 2-day span, Figure 2 through Figure 7 starting on page 4 presents a sequence of 8-hour, 200 Hz color spectrogram using the same sensor as cited above. These spectrograms exhibit the same frequency domain feature associated with ColKa operations.

Per-Axis Acceleration Power Spectral Density During ColKa Ops

Figure 8 on page 10 illustrates more clearly a series of evenly-spaced peaks in the acceleration spectrum between about 60 Hz and 160 Hz, somewhat resembling a comb. This pattern is a key feature of the acceleration measurements during ColKa operations. The vibration signal is complex and contains many harmonic frequencies, primarily aligned with the XZ-plane.

3. QUANTIFY

In this section, we aim to quantify the impact of ColKa operations by focusing on just a portion of the acceleration spectrum. We employ Parseval's theorem to quantify in terms of root-mean-square (RMS) levels of acceleration. Before we show those results, we point out from Figure 8 on page 10 that even though ColKa presents a train of spectral peaks between about 60 Hz and 160 Hz, there are other, non-ColKa disturbances/contributors in that range. We will confine our quantification analysis here to the frequency range between 62.5 Hz and 83.5 Hz. As a result, we will see the majority of ColKa impact in terms of RMS acceleration levels, but not all of its impact. In effect, the RMS levels would be slightly higher if we notched out other, non-ColKa spectral contributors before invoking Parseval's theorem.

RMS Acceleration Levels During ColKa Sessions

For a one-to-one correspondence with the 2-days of spectrograms (every 8 hours) shown in the section above titled "*More Spectrograms Showing ColKa Prime Sessions*", we present in this section, the corresponding 8-hour interval RMS plots for the same 2-day span. Figure 9 through Figure 14 starting on page 11 presents our quantification results having applied Parseval's theorem to the SAMS measurements.

If you compare the 8-hour spectrogram in Figure 6 on page 8 with the RMS plot of Figure 13 on page 15, you will see 3 distinct ColKa sessions in each case. The latter figure showing baseline total RMS levels of less than 0.05 mg, which step up to between 0.1 mg and 0.2 mg during ColKa operations. The other, perhaps less attractive feature of ColKa operations is the large impulse associated with start-up of a session. Those can spike up over 0.5 mg in terms of RMS.

4. CONCLUSION

This document presents an analysis of Space Acceleration Measurement System (SAMS) data collected during several Columbus Ka-Band Unit Prime Sessions on the International Space Station across July 22 and 23, 2025.

Qualitative assessment through spectrograms and power spectral density plots revealed characteristic vibratory signatures. A prominent feature observed during ColKa operations is a "comb-like" pattern of regularly-spaced spectral peaks between approximately 60 Hz and 160 Hz, indicating a complex vibration signal rich in harmonics, primarily affecting the XZ-plane.

Quantitative analysis employed Parseval's theorem within a confined frequency range of 62.5 Hz to 83.5 Hz to avoid non-ColKa contributions. This demonstrated much (not all) of the vibrational impact of ColKa sessions. Baseline total RMS acceleration levels, typically below 0.05 mg, consistently increased to between 0.1 mg and 0.2 mg during active ColKa operations. Furthermore, the initiation of each ColKa session was marked by significant transient impulses, with RMS acceleration levels spiking over 0.5 mg. These findings provide some insights into the microgravity environment perturbations induced by the ColKa prime sessions. For further details or clarifications, please contact the SAMS team at *pimsops@lists.nasa.gov*.

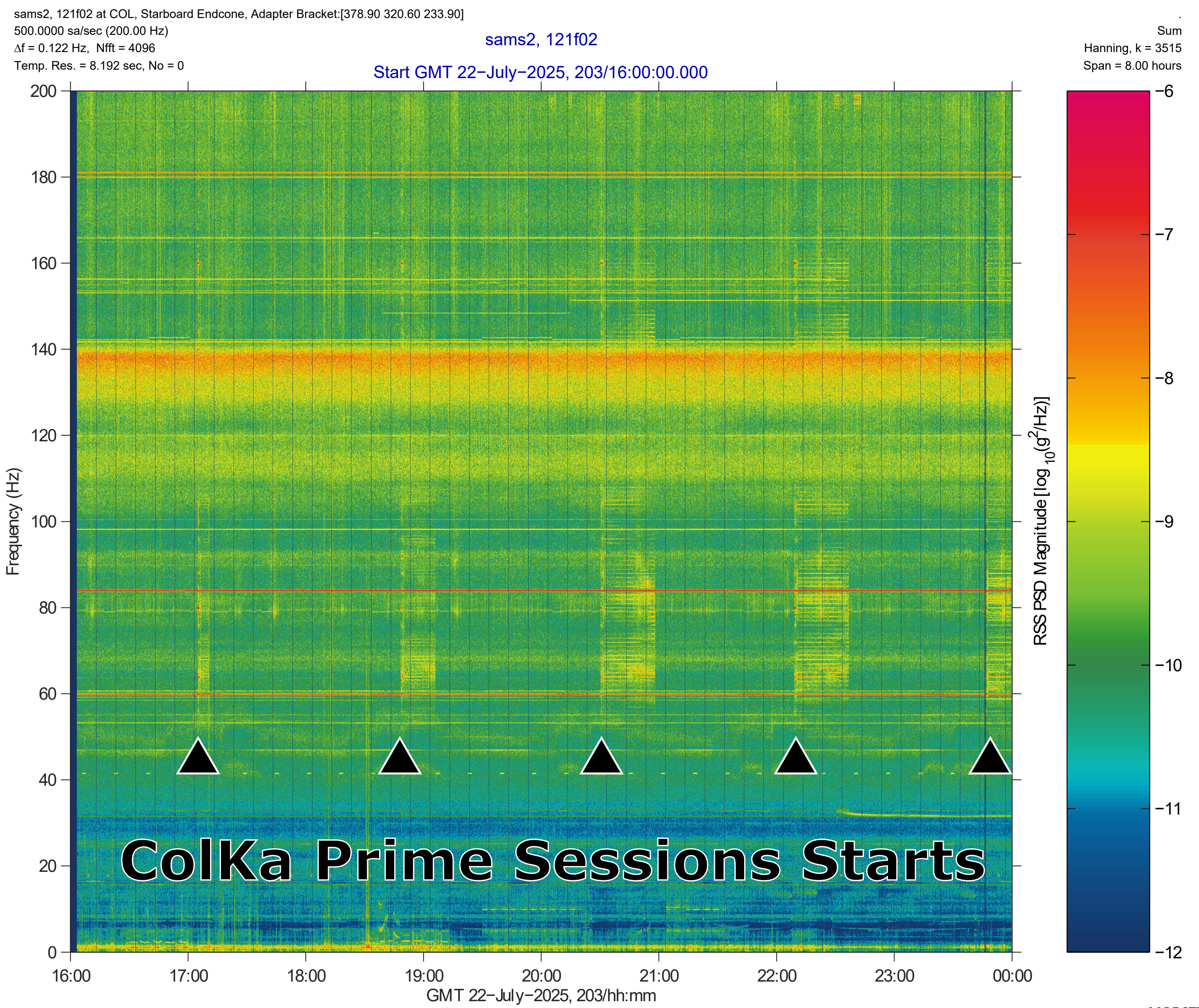

Fig. 1: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Session Starts on GMT 2025-07-22 from Measurements by SAMS Sensor on Columbus Endcone.

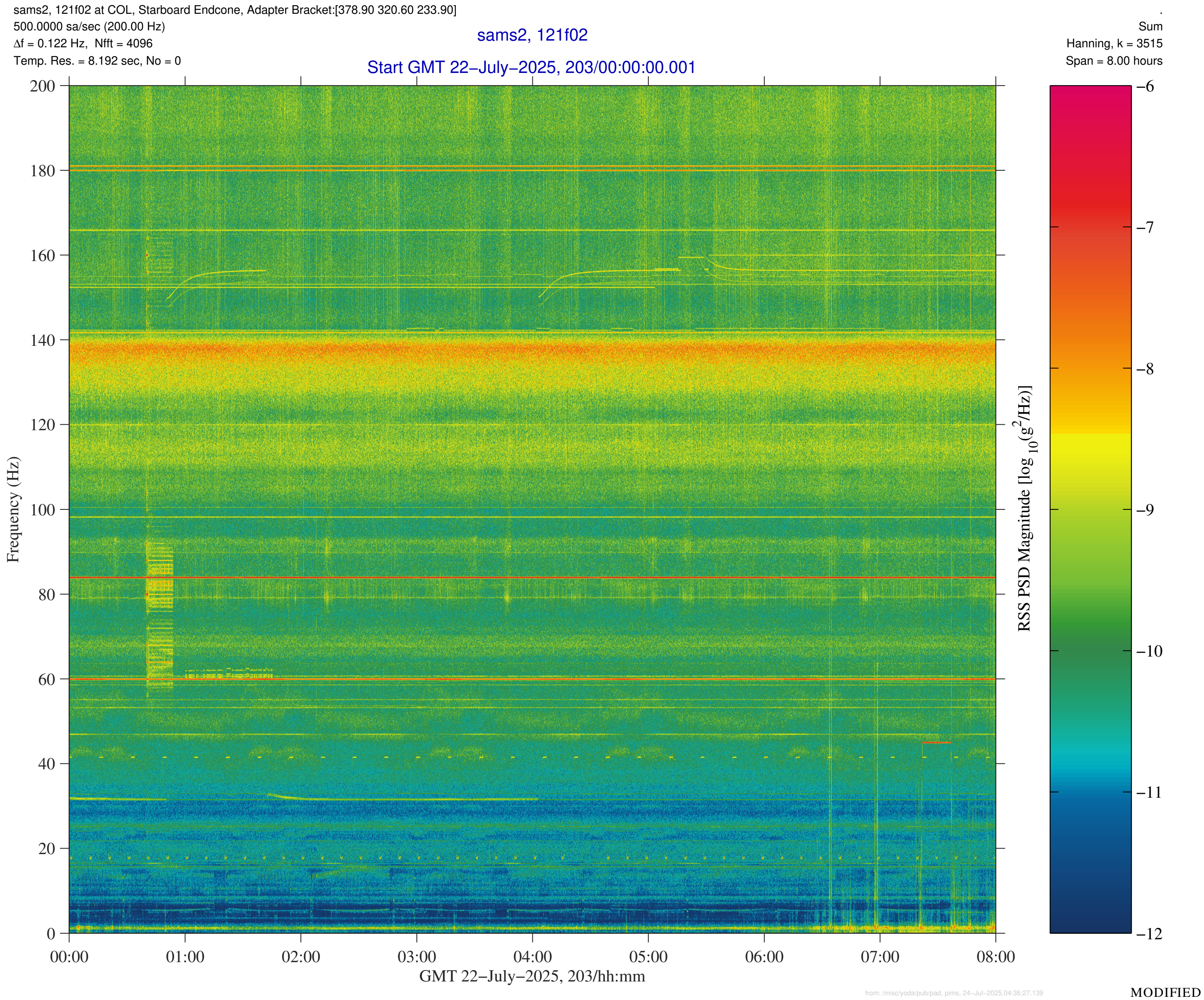

Fig. 2: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

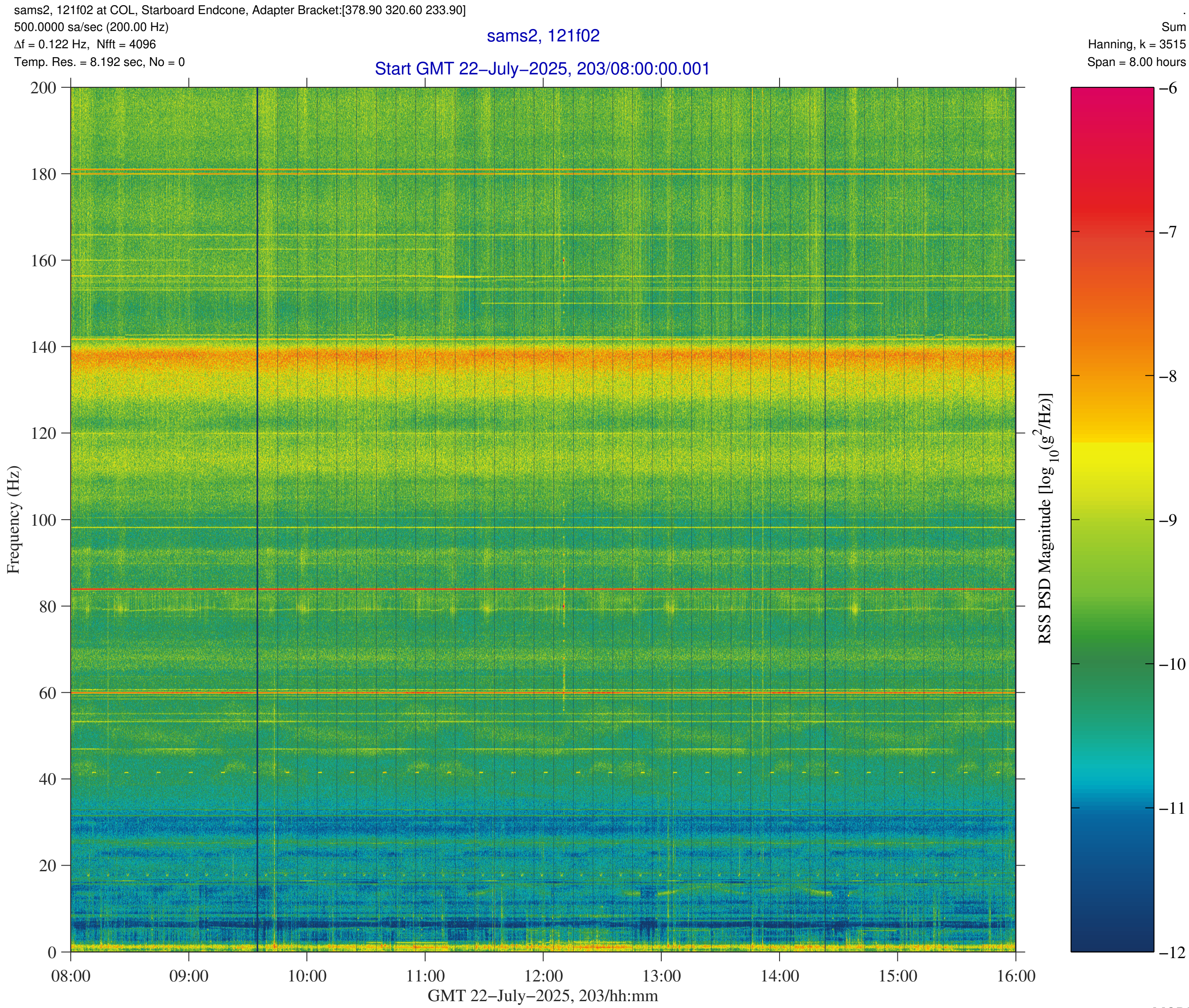

Fig. 3: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

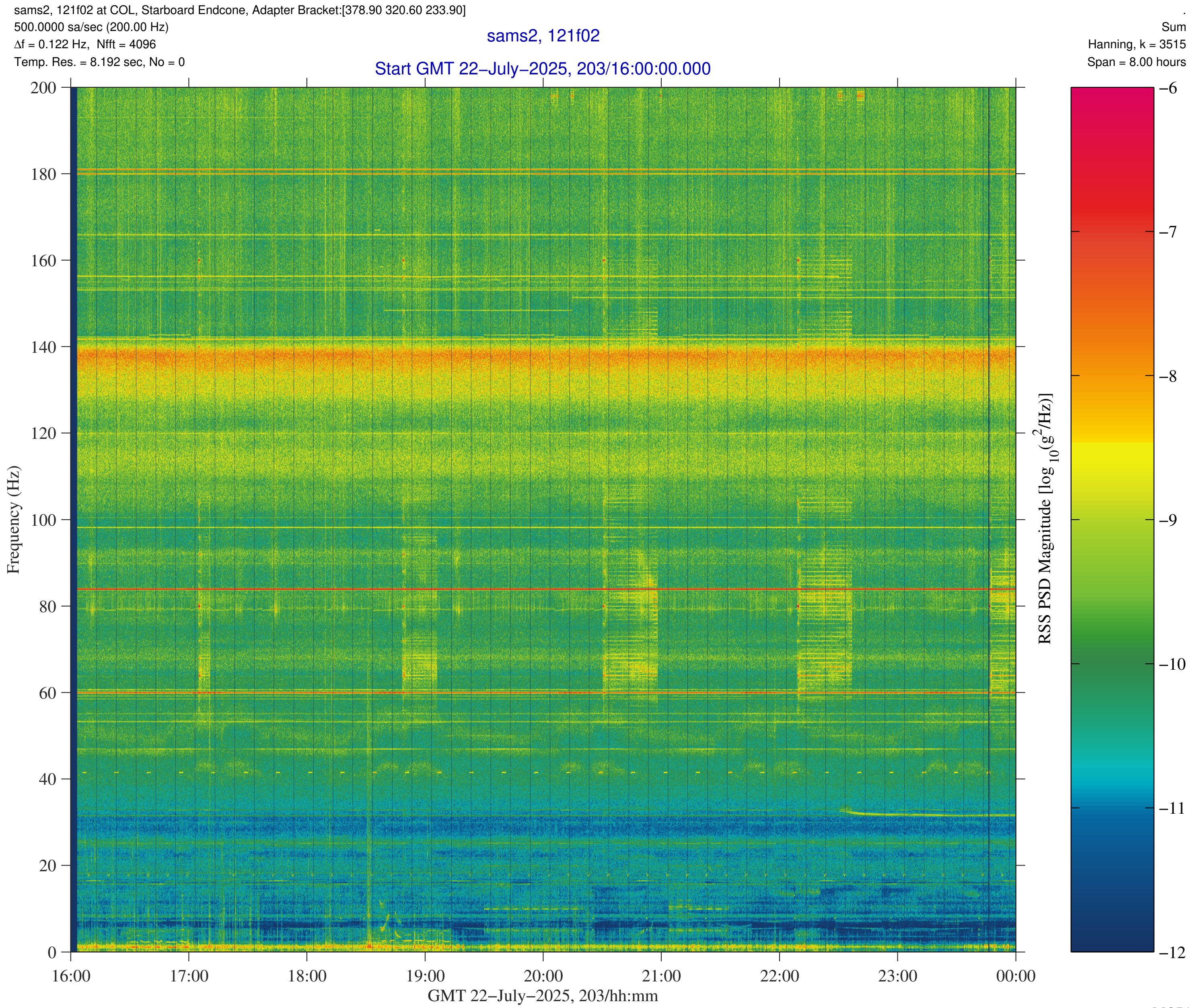

Fig. 4: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

Columbus Ka-Band Unit Prime Sessions in July 2025

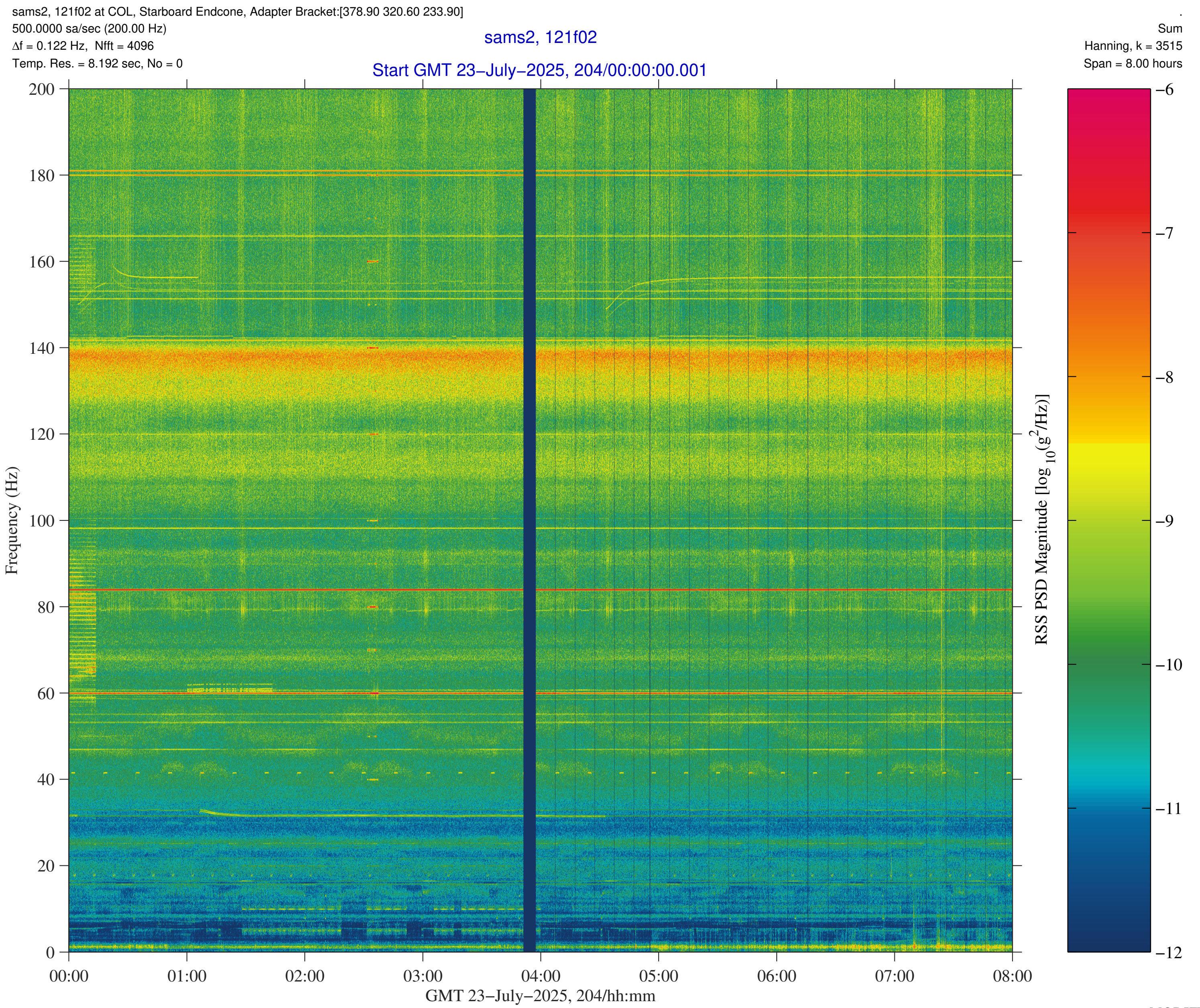

Fig. 5: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

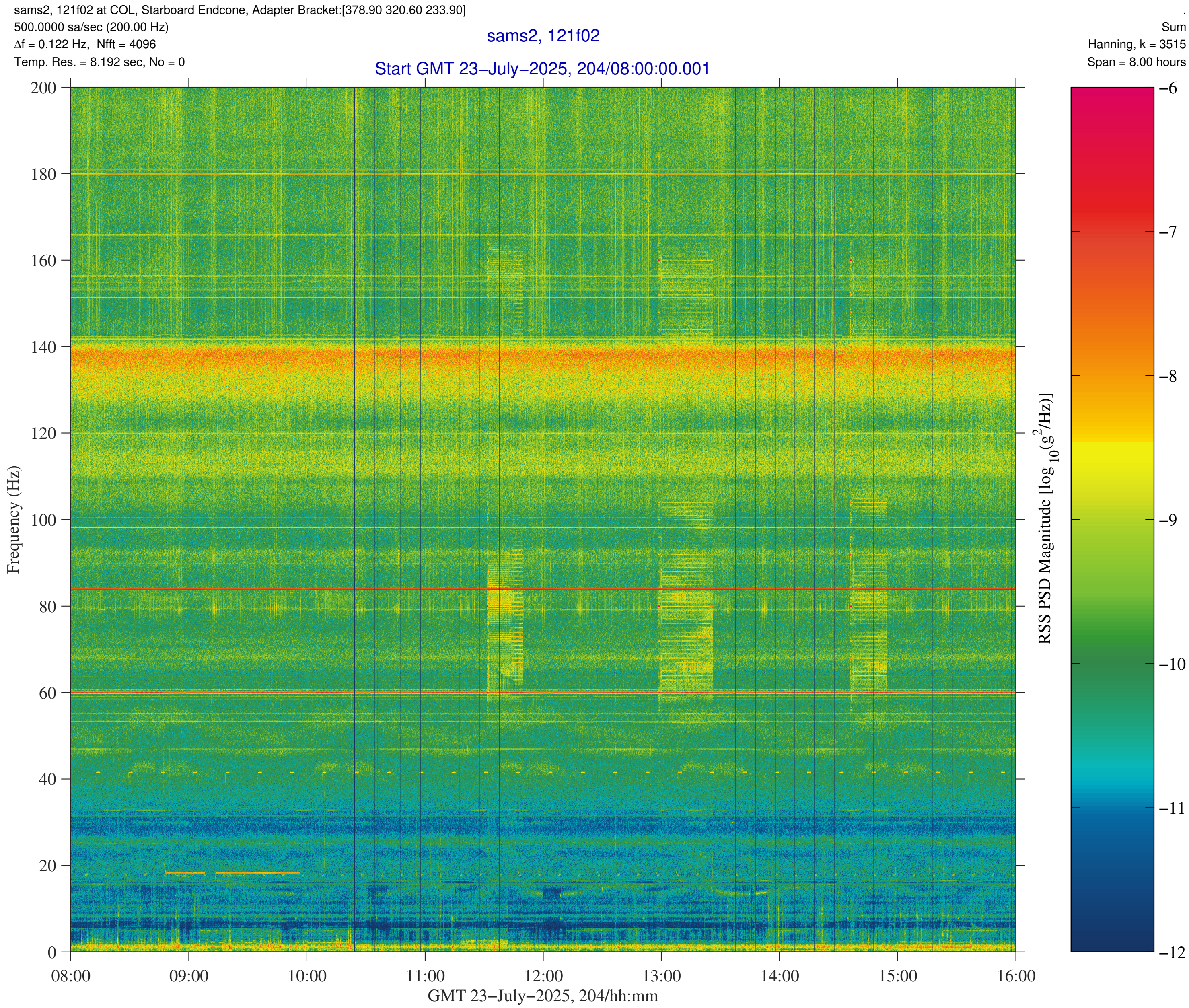

Fig. 6: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

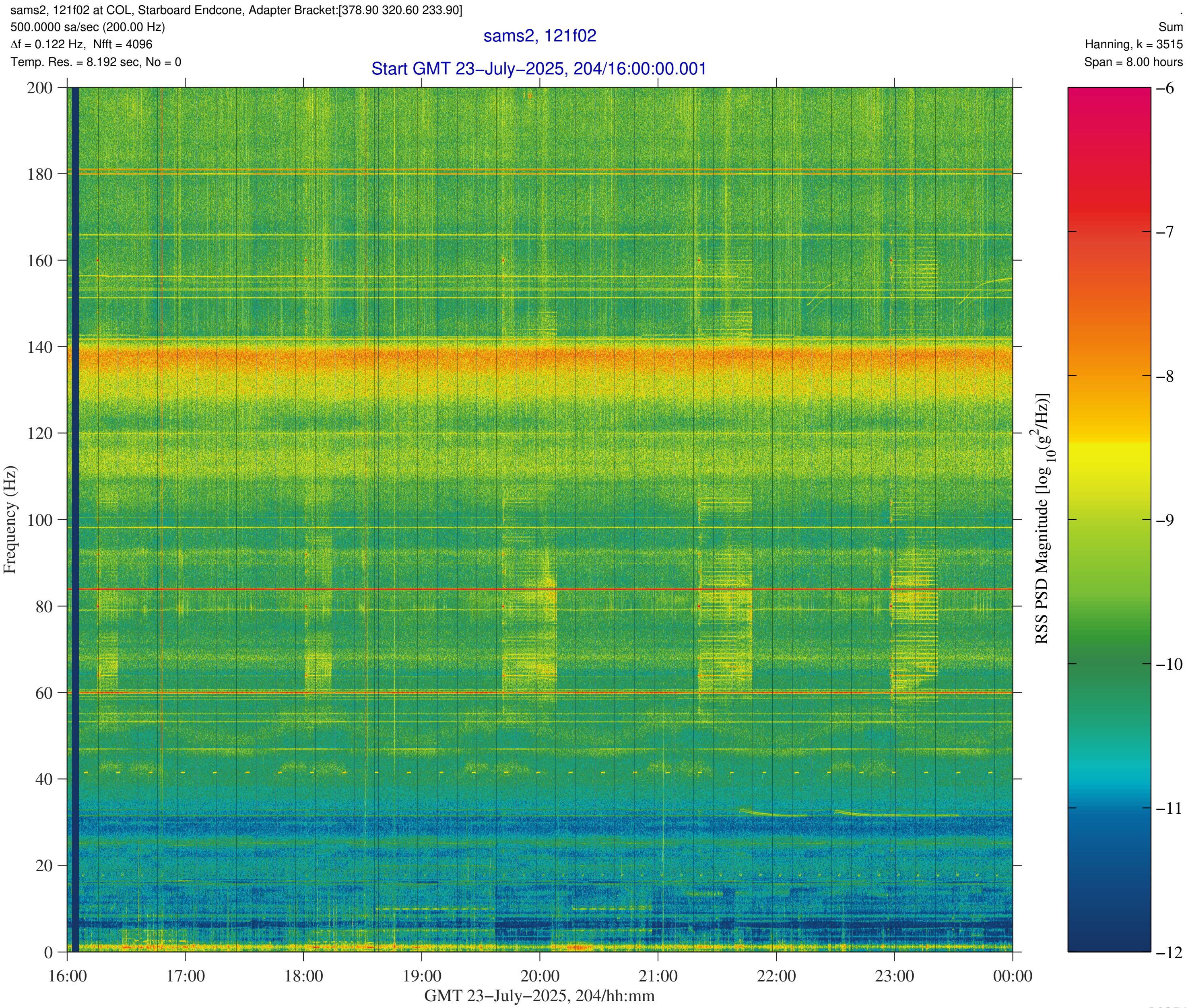

Fig. 7: 200 Hz, 8-Hour Spectrogram showing ColKa Prime Sessions.

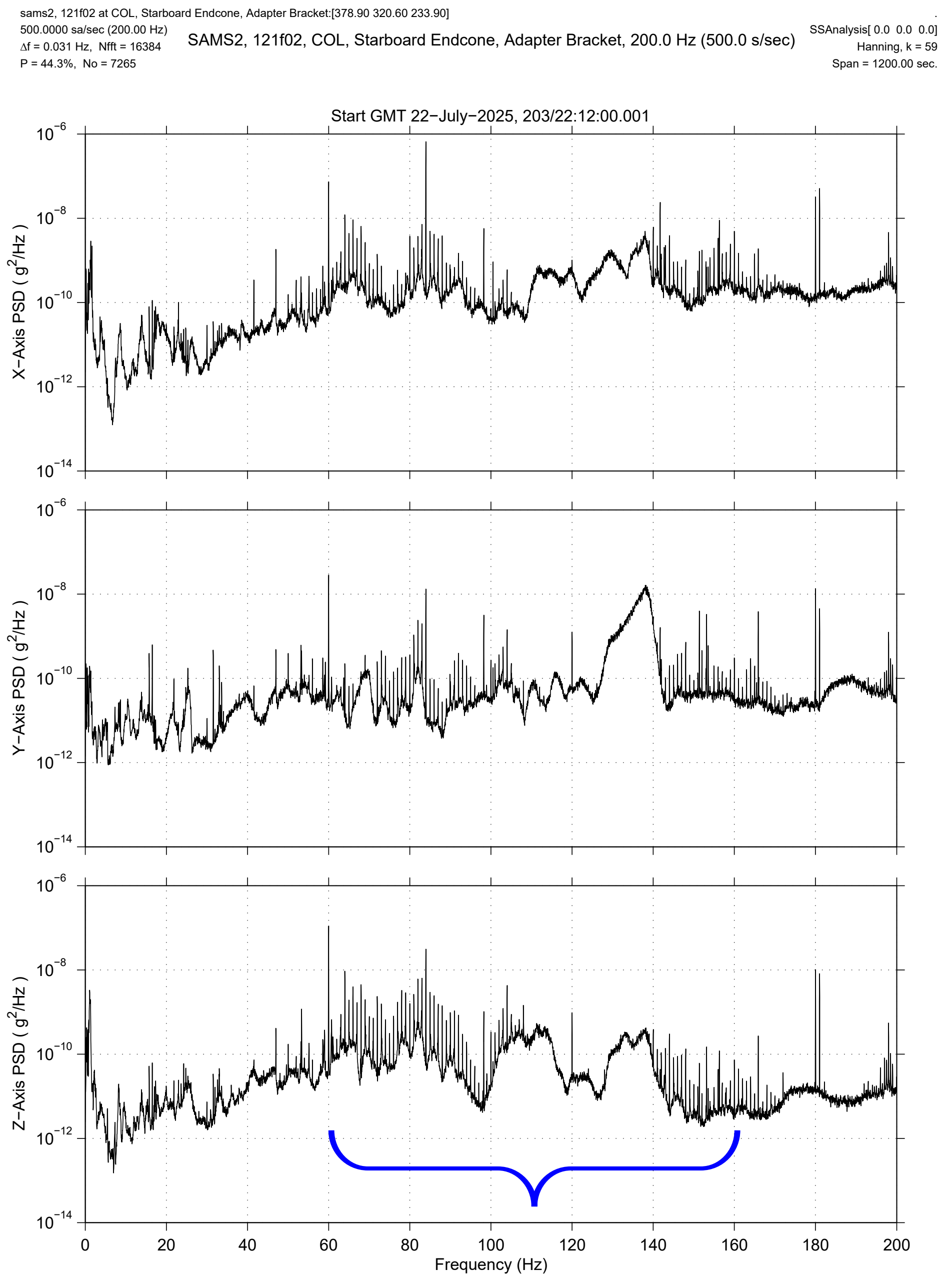

Fig. 8: Per-Axis Power Spectral Density Shows A ColKa Session on GMT 2025-07-22.

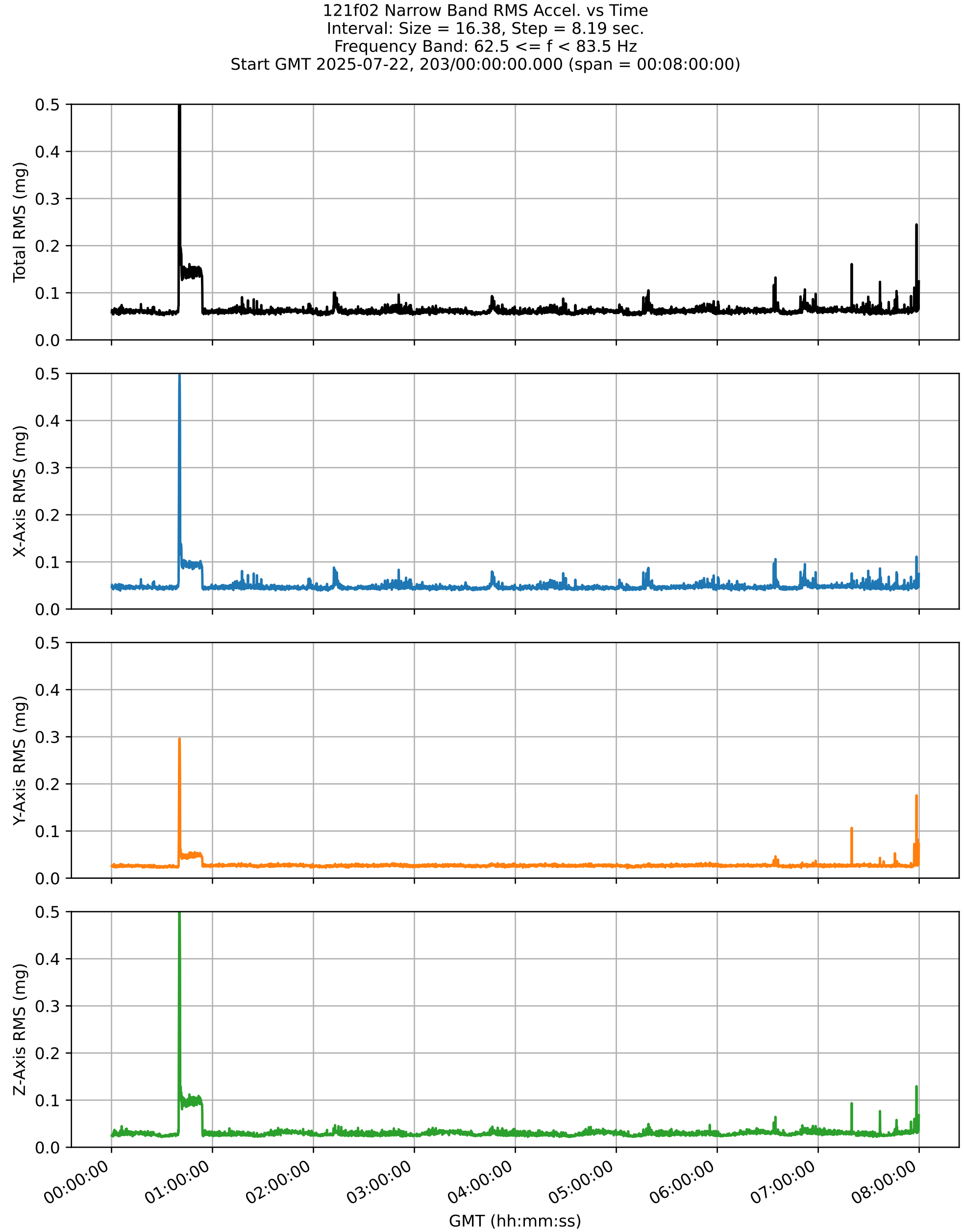

Fig. 9: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.

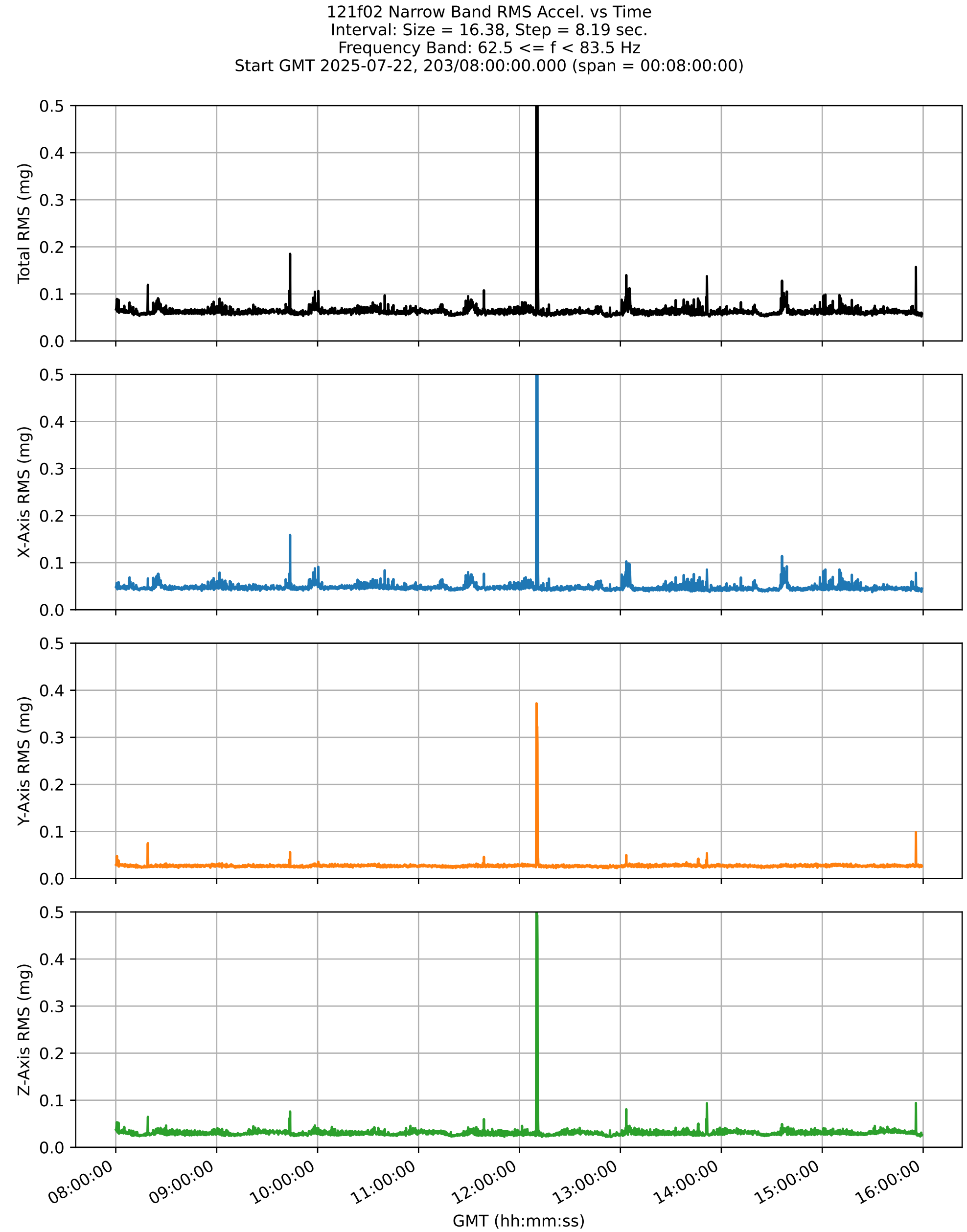

Fig. 10: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.

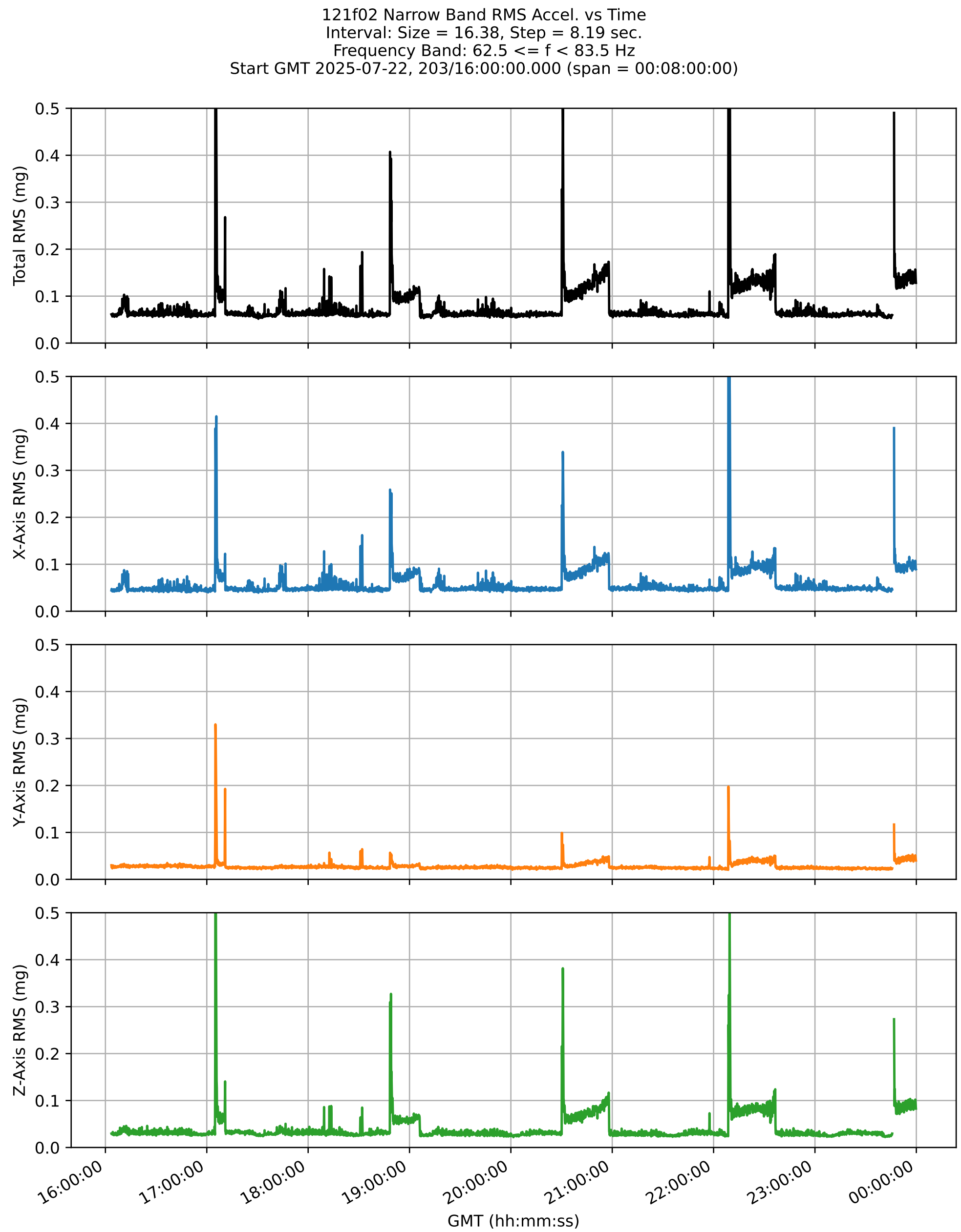

Fig. 11: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.

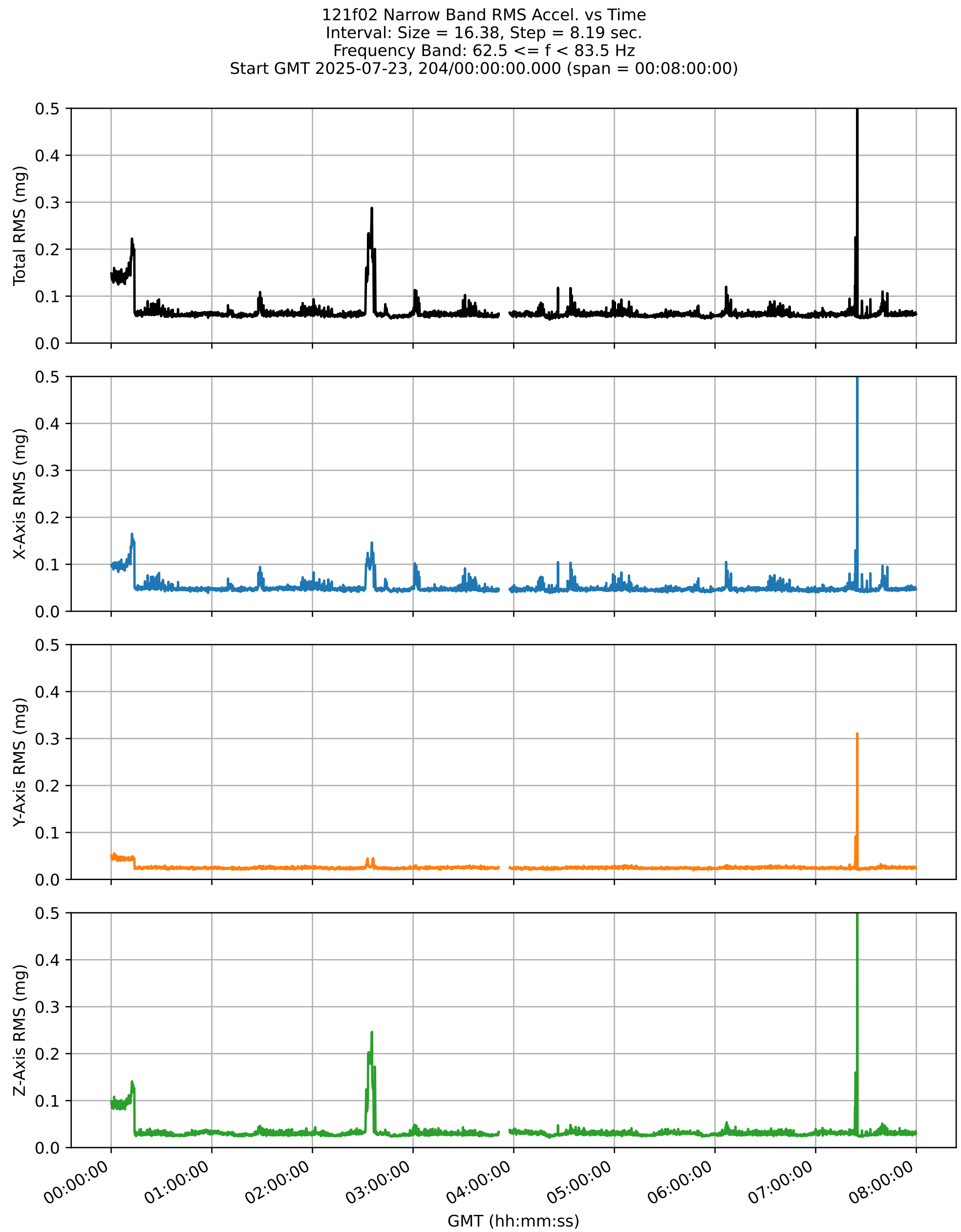

Fig. 12: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.

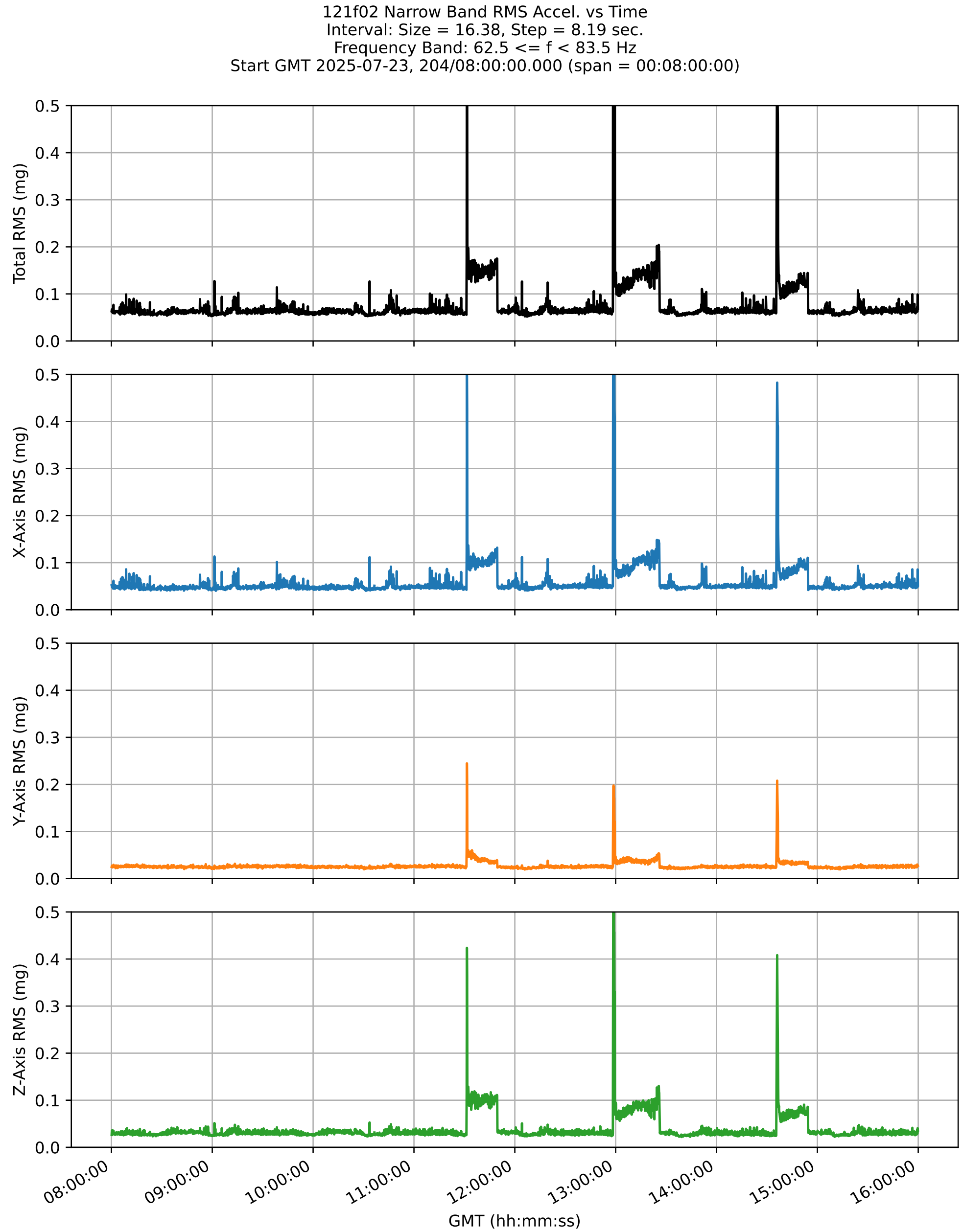

Fig. 13: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.

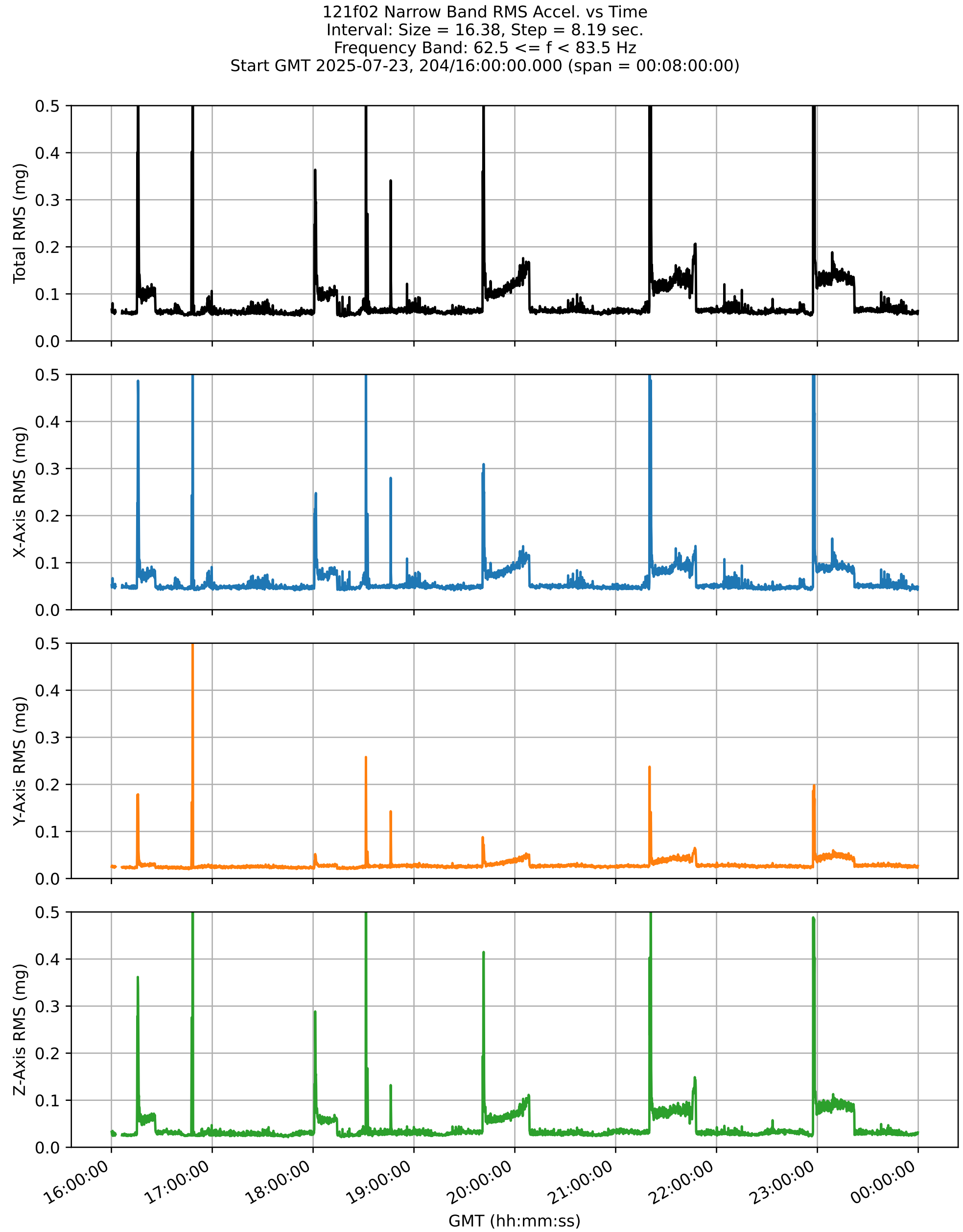

Fig. 14: Per-Axis and Total RMS Acceleration to Quantify ColKa Sessions.