

## 1. INTRODUCTION

The Analyzing Interferometer for Ambient Air (ANITA) is a sophisticated trace gas monitoring system designed for the International Space Station (ISS). Ensuring high air quality is crucial for providing adequate life support to the crew aboard the ISS. Developed under a contract with the European Space Agency (ESA), ANITA utilizes Fourier-Transform-Infrared-Spectroscopy (FTIR) to measure gas concentrations by analyzing the spectral lines that correspond to specific gas absorptions of light.

The first iteration, ANITA-1, operated from September 2007 until August 2008, weighing over 55 kg and distributed across two Middeck Locker Inserts along with a laptop. It consumed approximately 150 W of power and was capable of measuring more than 32 trace gases on the ISS. ANITA-1's deployment led to the detection of Freon 218, likely leaking from a Russian cooling loop, demonstrating its critical role in maintaining the safety and health of the ISS crew.

ANITA-2, which launched aboard SpaceX CRS-24 in December 2021, has seen significant advancements. Its size has been reduced to fit into one Middeck Locker Insert, its mass decreased to less than 38 kg (down from 55 kg), and its power consumption lowered to approximately 80 W (down from 150 W). The system now features a WiFi connection and a touchscreen interface, enhancing its usability. With an increased signal-to-noise ratio by a factor of four compared to ANITA-1, ANITA-2 can detect 37 gases, most with detection limits well below 1 ppm. Installed initially in an EXPRESS Rack inside the LAB on January 5, 2022, ANITA-2 has been operating almost continuously since March 2022, effectively monitoring the gas environment on the ISS. ANITA-2, as of June 2024, resides in the Columbus module in the COL1A3 rack. Nearby, mounted on the same rack, is the Space Acceleration Measurement System (SAMS) sensor head S/N 121f08. See Figure 1 on page 2.

## 2. QUALIFY

Figure 2 on page 3 is a color spectrogram computed from SAMS sensor 121f08 measurements. This sensor was mounted on the front panel of the EPM rack location COL1A3, in the Columbus Module (COL). This first figure shows a daily overview (roadmap) analysis plot spanning 8 hours and up to 200 Hz. Such a wide time span here makes it difficult to see the temporal-frequency dynamics happening as related to the ANITA-2 pump, so we zoomed in on this figure to produce Figure 3 on page 4 to show what one might expect of this disturbance using typical, daily roadmap

spectrograms available on the web. To get a detailed look at the ANITA-2 pump, we zoomed in further on the 28 minutes you see in Figure 4 on page 5. The inclusion of this figure shows the temporal-spectral behavior of the ANITA-2 pump and its duty cycle: 2 minutes ON, 8 minutes OFF. This series of zoomed-in spectrogram figures demonstrates that routine, daily roadmap spectrogram plots can somewhat “hide” significant vibratory dynamics, not intentionally, just a fundamental trade-off. We do see from the last spectrogram (the most zoomed-in one) that the ANITA-2 pump has a strong fundamental around 18 Hz and a 2nd harmonic close to 36 Hz. Finally, to more fully qualify this activity, albeit not shown here, this disturbance is primarily aligned with YZ-plane, yet still an obvious and measurable component on the X-axis.

## 3. QUANTIFY

Figure 5 on page 6 shows an interval root-mean-square (RMS) acceleration versus time plot of computations from the SAMS 121f08 sensor data that corresponds to the last (most zoomed-in) spectrogram we looked at. The RMS acceleration levels in this plot come from applying Parseval's Theorem to the SAMS data in a narrow (2 Hz wide) band centered on 18 Hz. The distinctive features here are: (1) the plateau (step-up) value of about 280 micro-g, and (2) the baseline RMS value somewhere around 20 micro-g in this limited 28-minute span.

When we zoom-out in time to get the interval RMS versus time plot of Figure 6 on page 7 for that entire day, we see 3 distinct RMS levels at various times throughout the day (shown via median value calculations for each):

- Level 1 = 18.9 micro-g (baseline, ANITA-2 pump OFF)
- Level 2 = 282.7 micro-g (ANITA-2 pump ON)
- Level 3 = 471.3 micro-g (ANITA-2 pump ON)

## 4. CONCLUSION

We have shown some analysis of SAMS vibratory sensor measurements in the Columbus module on the EPM rack near the ANITA-2 equipment (particularly, its pump). These measurements showed at various times, 3 distinct acceleration RMS levels in a narrow band around its fundamental frequency near 18 Hz, from a low of just under 20 micro-g when the pump was off to over 470 micro-g when the ANITA-2 pump was on.

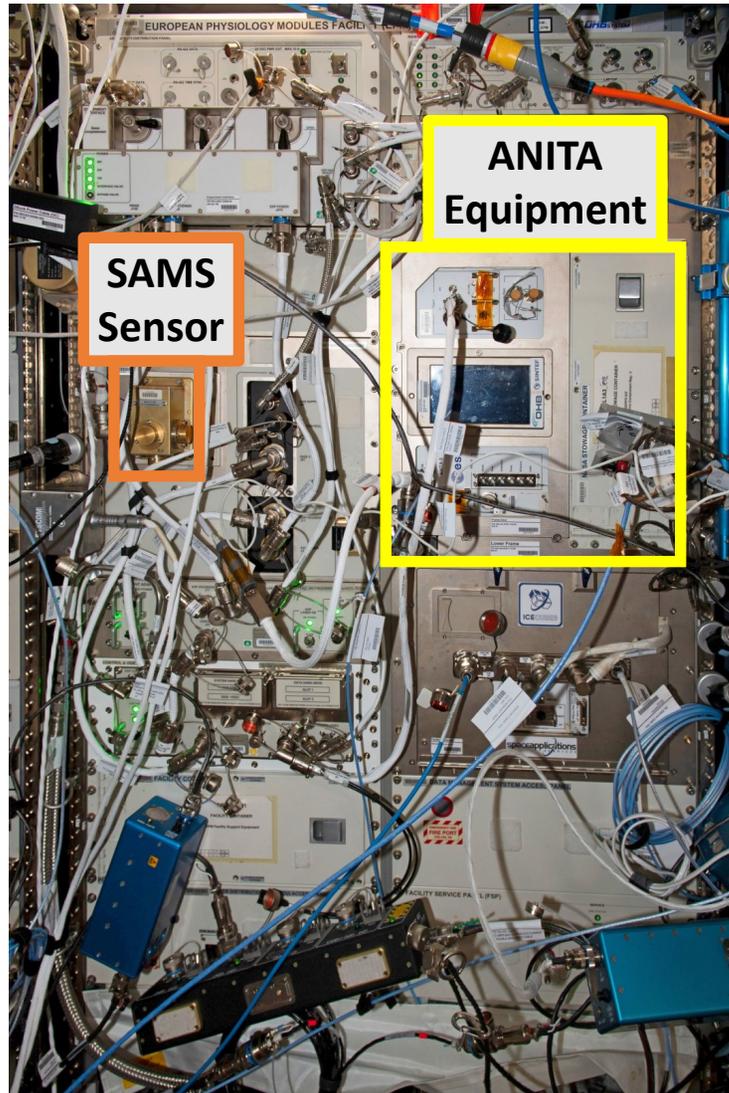


Fig. 1: COL1A3 Rack with SAMS Sensor and ANITA-2 Locations Outlined.

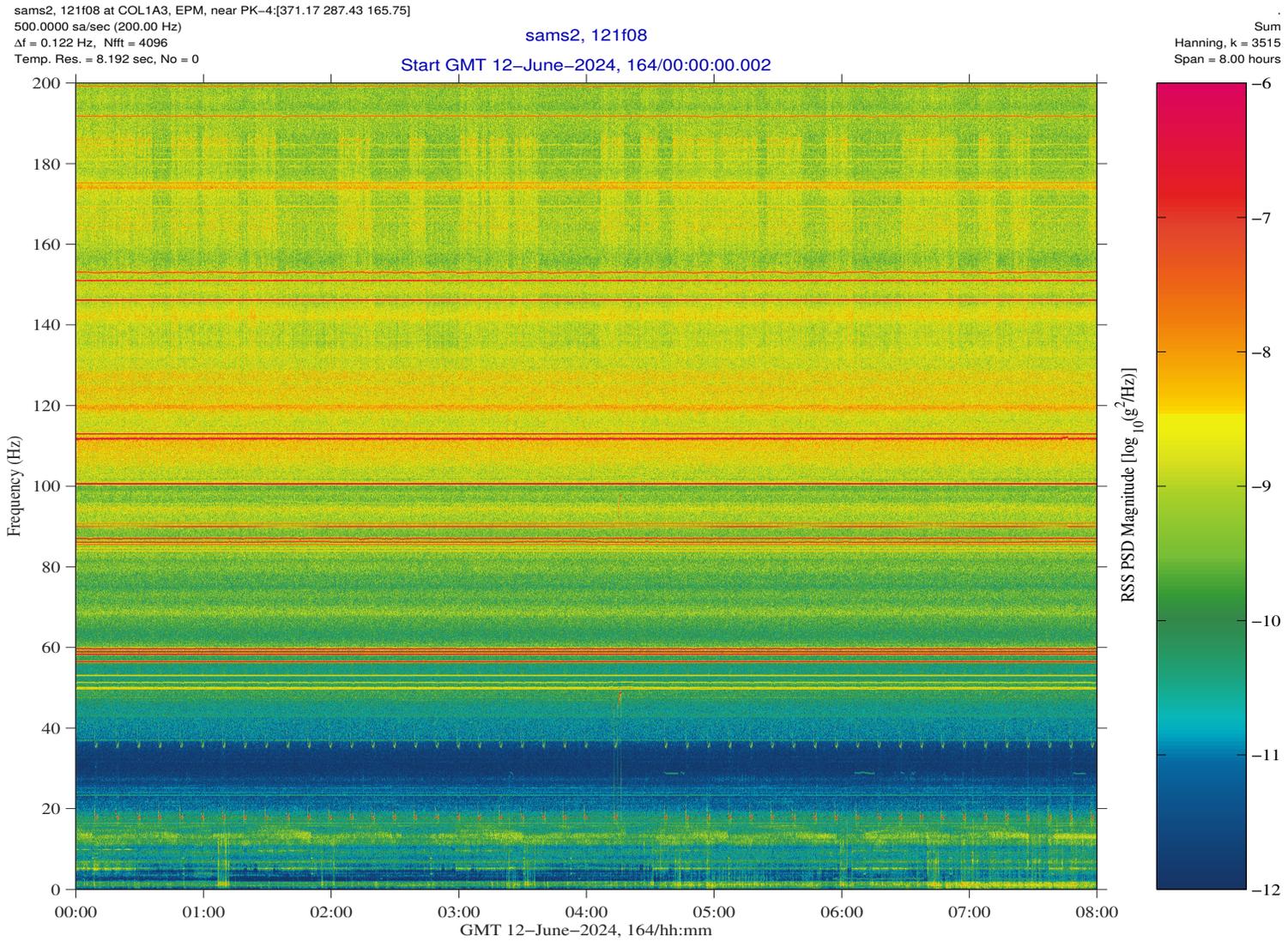


Fig. 2: Roadmap Spectrogram Showing ANITA-2 Pump Signature on GMT 2024-06-12 via SAMS Sensor on COL1A3 Rack.

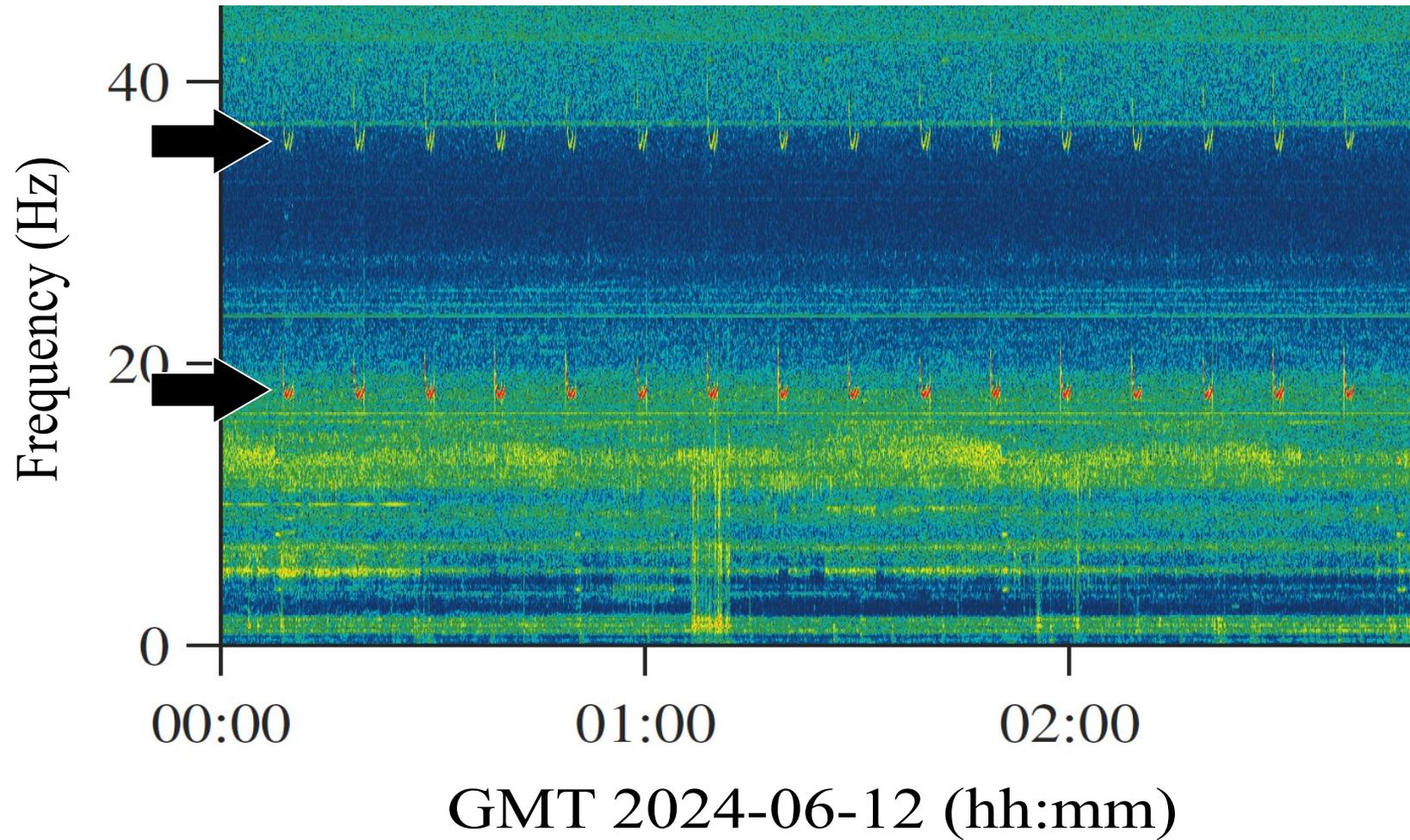


Fig. 3: Zoom-In Roadmap Spectrogram Showing ANITA-2 Pump Signature on GMT 2024-06-12 via SAMS Sensor on COL1A3 Rack.

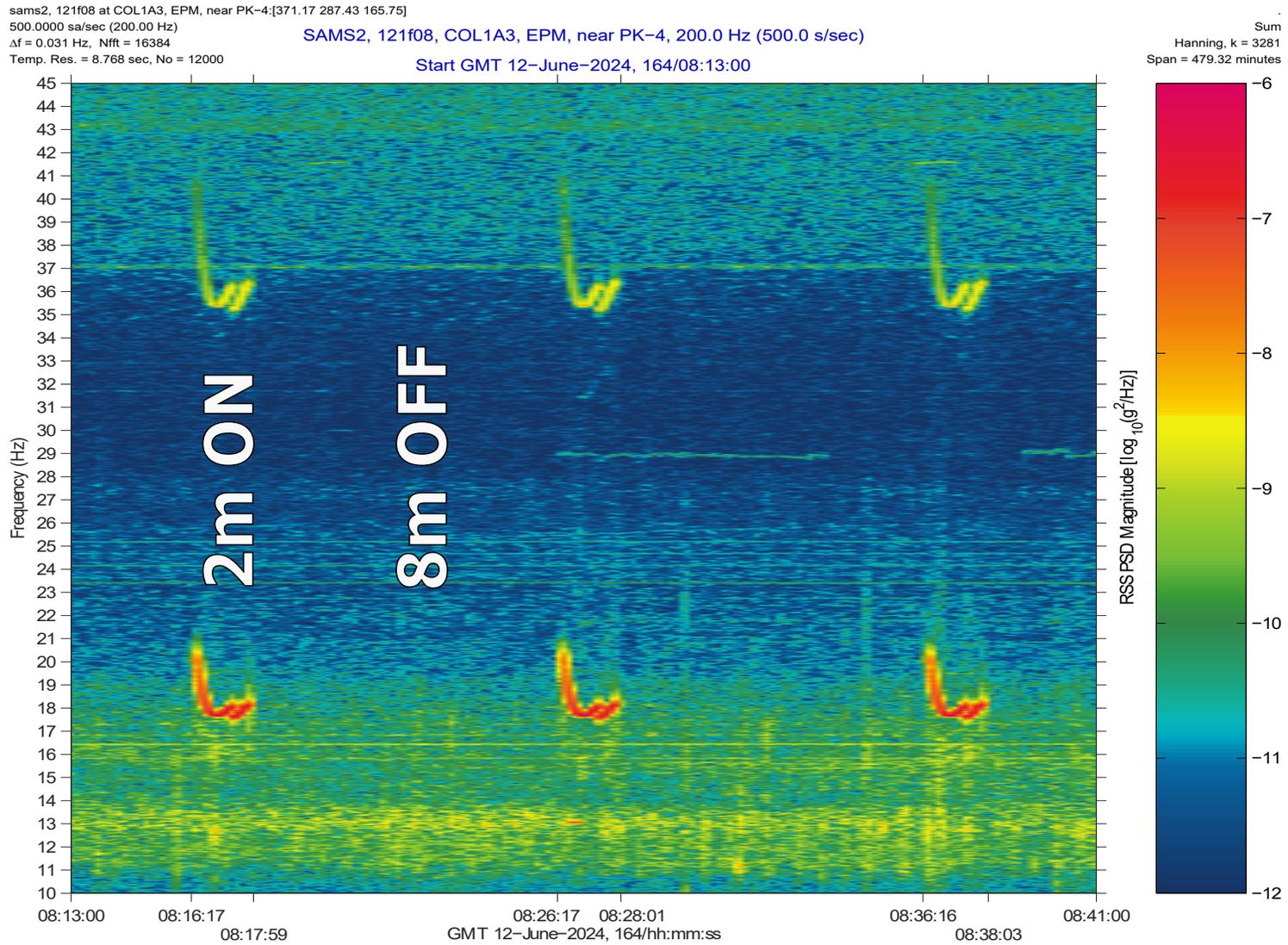


Fig. 4: Spectrogram **frequency zoom** to Better Show ANITA-2 Pump Signature on GMT 2024-06-12.

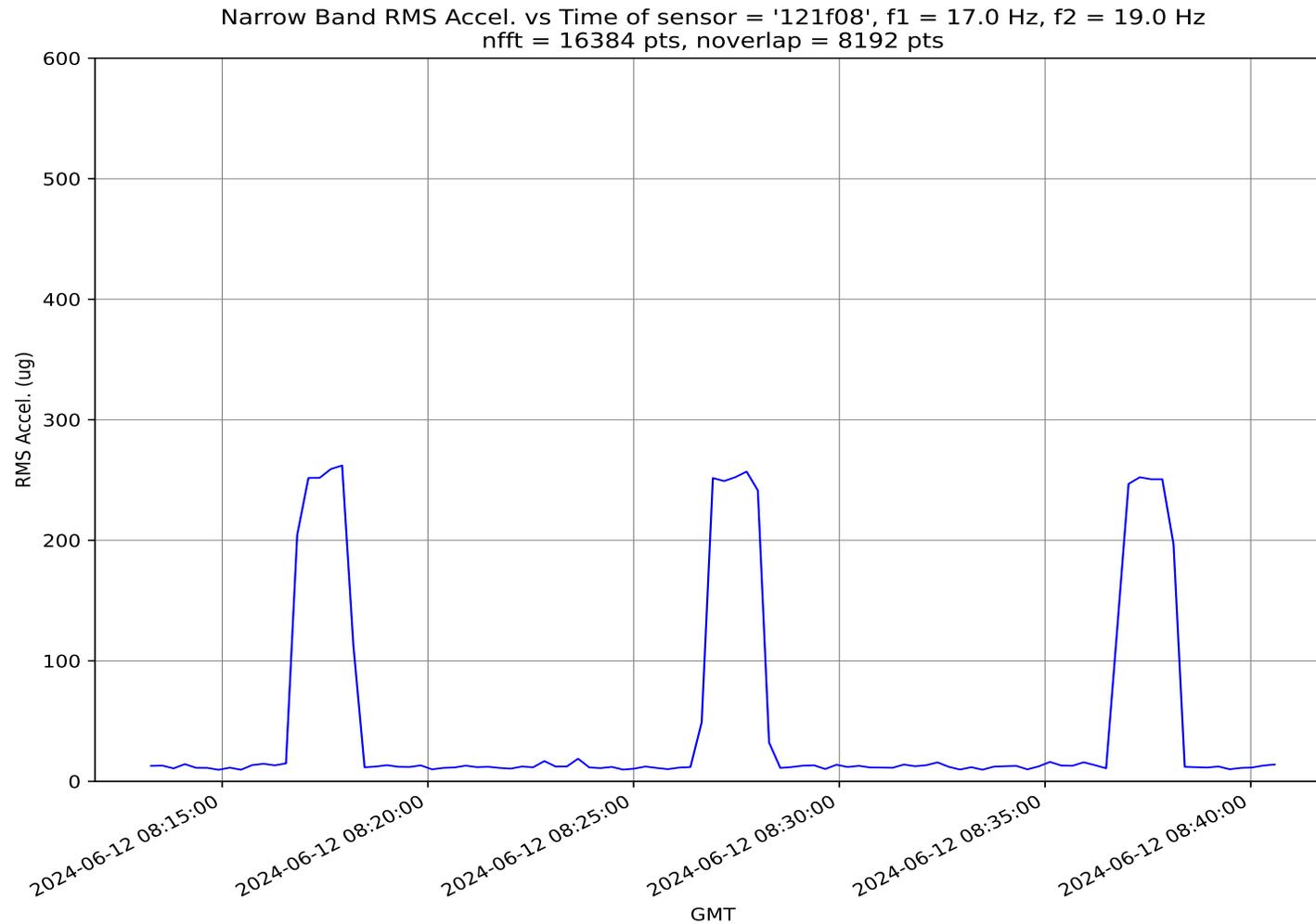


Fig. 5: Interval RMS for Narrow Band Around 18 Hz, ANITA-2 Pump Fundamental, on GMT 2024-06-12.

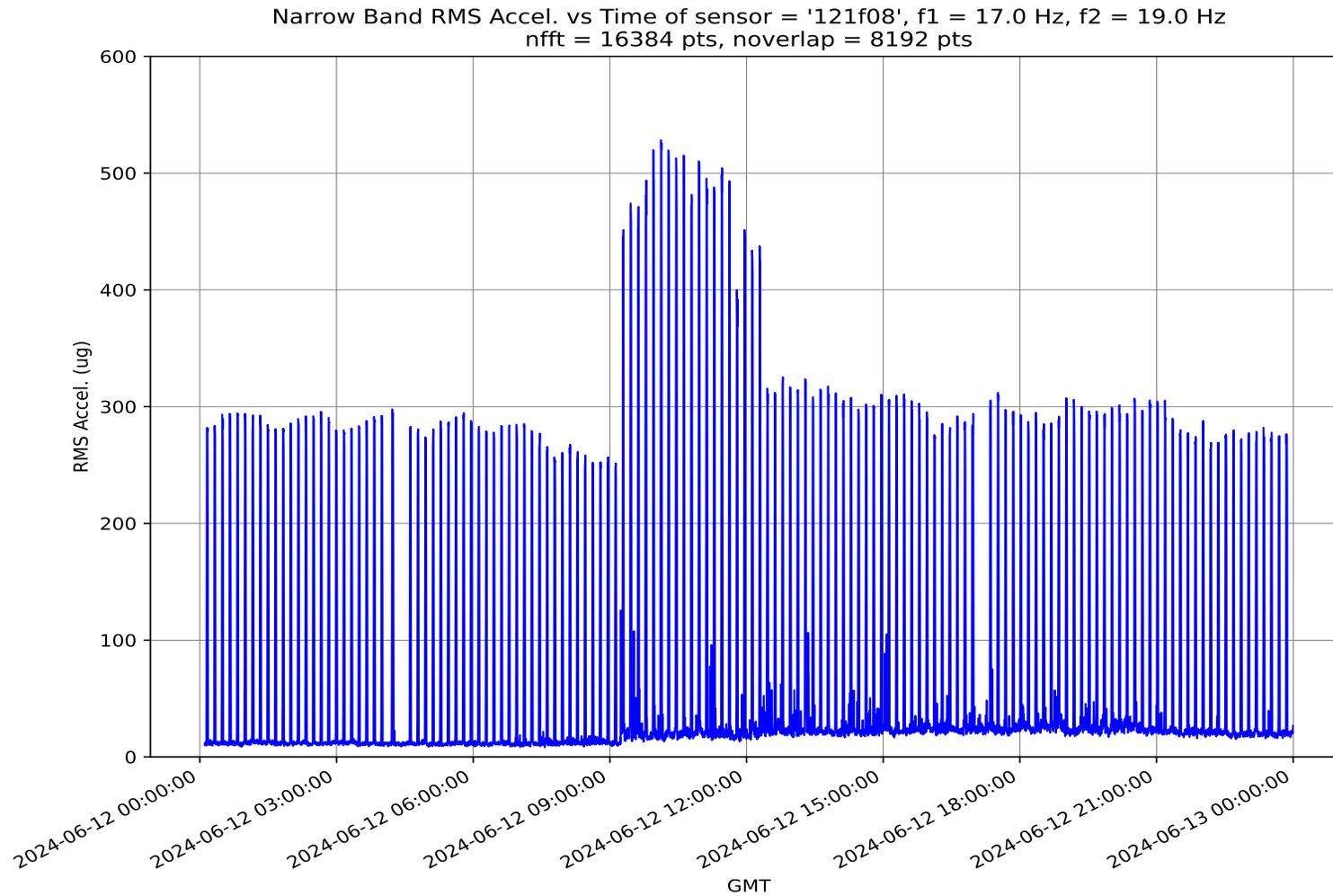


Fig. 6: Interval RMS for Narrow Band Around 18 Hz, ANITA-2 Pump Fundamental, for Entire Day of GMT 2024-06-12.