1. INTRODUCTION

At GMT 2021-03-19, 078/16:38, the Soyuz 63S vehicle undocked from the International Space Station (ISS) in order to relocate from the MRM1 docking port to the MRM2 docking port. The visiting vehicles graphic of Figure 1 shows the location and alignment of the Soyuz vehicle before the relocation and Figure 2 shows it after successful relocation with a docking time of GMT 17:07. It took about a half hour to complete.

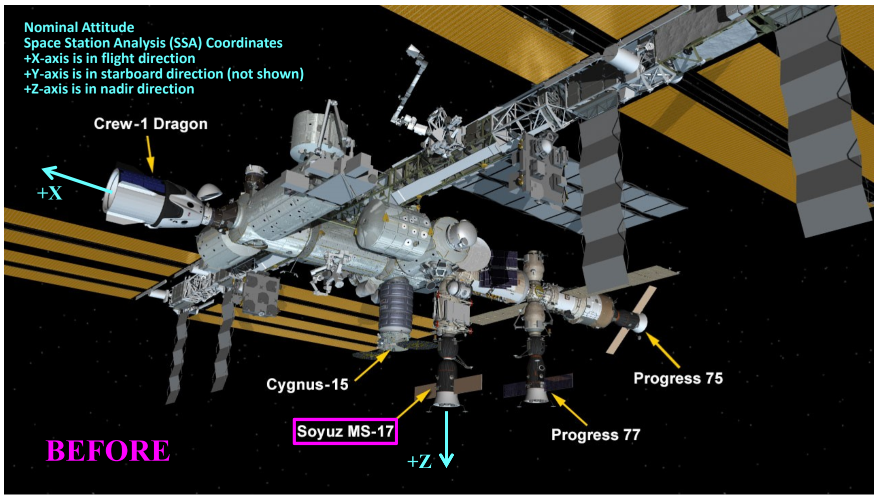

Fig. 1: Soyuz MS-17's location and alignment BEFORE relocation.

2. QUALIFY

Earlier in the day, well before the port relocation maneuvers, the ISS performed an Optimal Propellant Maneuver (OPM) to a -XVV attitude. Handover from the US to the Russian Segment (RS) started at about GMT 02:52. This maneuver was performed and control of attitude was handed back over from the RS to the US at GMT 05:28. The information shown in Figure 3 was calculated from SAMS sensor 121f02 measurements made in the Columbus module. This plot shows increased structural vibration excitation between about 02:52 and 05:28 (during crew sleep) and fairly-well confined below about 2 Hz or so. We can attribute this increase to the Russian Segment (RS) attitude control during the maneuver.

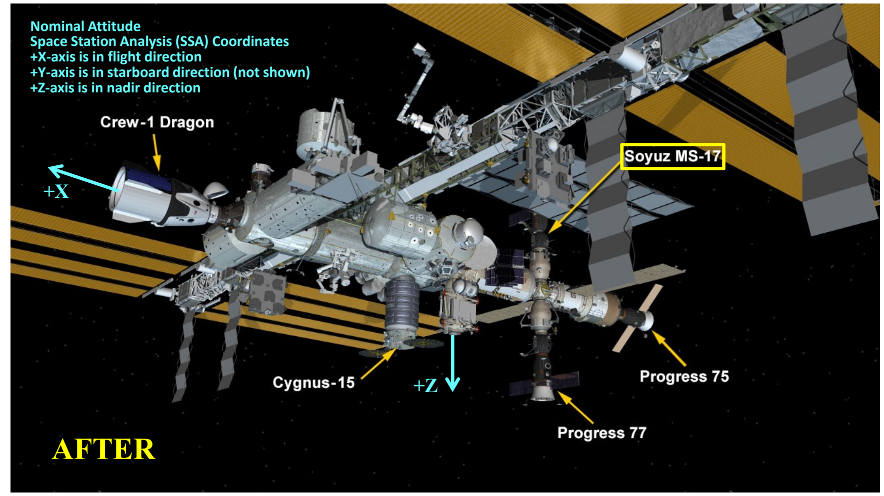

Fig. 2: Soyuz MS-17's location and alignment AFTER relocation.

Around the time of the Soyuz undock, rendezvous and re-dock, a sequence of maneuvers was employed to facilitate the relocation. At GMT 16:03, attitude control was once again transferred from the US to the RS. A maneuver was performed to get to a good undock attitude for the Soyuz. Then, station in free drift was allowed for physical separation that took place at GMT 16:38:30. Following the undocking, the ISS was maneuvered to the docking attitude around GMT 16:40. Once this was complete, a snap-and-hold was held for docking of the Soyuz, which took place at GMT 17:07. After the vehicle was secured to the ISS, a maneuver took place to get to a -XVV attitude. From this attitude, the space station attitude control was handed back to the US. The spectrogram of Figure 4 shows elevated structural excitation mainly below 2 Hz again as we see more orange/red color in the spectrogram for the higher vibration levels as larger structures of the space station flex, twist or bend to dissipate the energy imparted from thruster reaction forces. Those vibrations dampen out and return to baseline as seen in the spectrogram after about GMT 19:00.

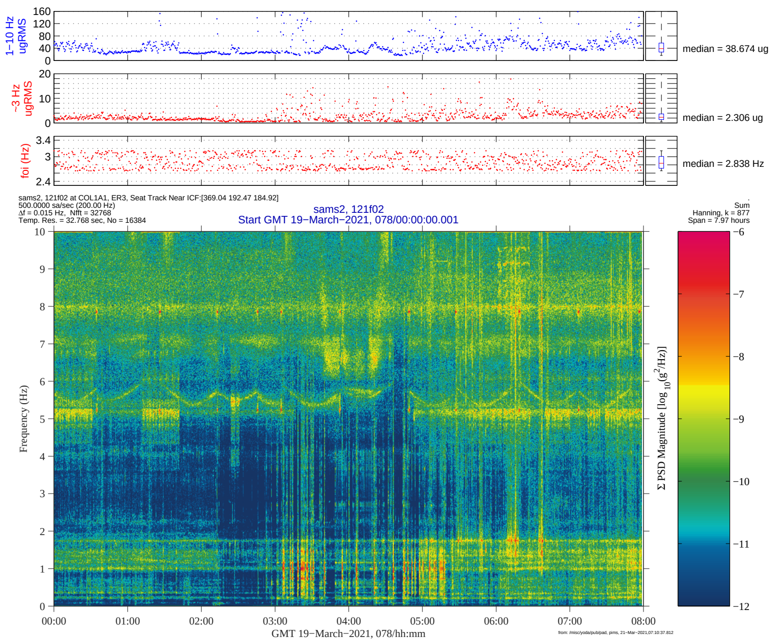

Fig. 3: Spectrogram of SAMS 121f02 data: maneuvers before Soyuz relocate.

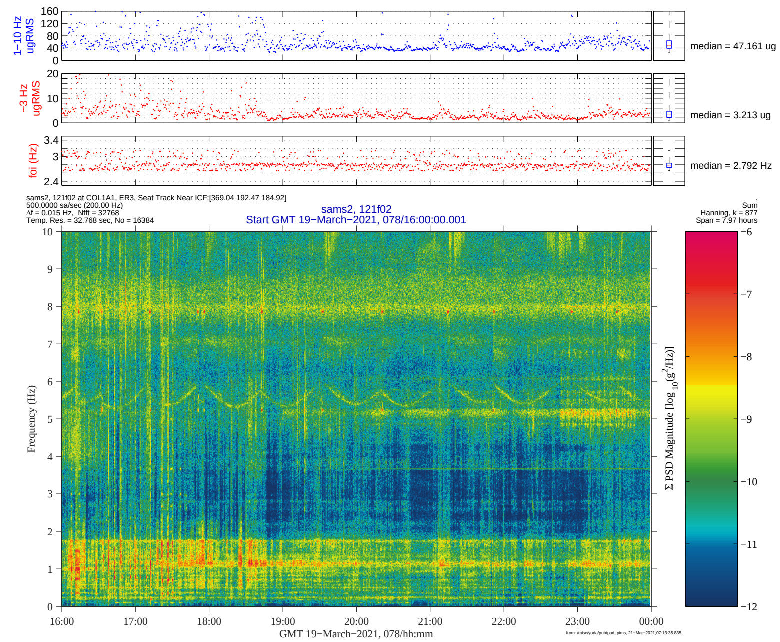

Fig. 4: Spectrogram of SAMS 121f02 data: maneuvers around Soyuz relocate.

3. Quantify

A somewhat crude quantification of the day's events as measured by 5 distributed SAMS sensors is given in Table 1. Most notably, and expectedly, we see higher vibration levels for SAMS sensors in the Columbus and Japanese modules. The expectation there is that these modules are somewhat cantilevered out from the center-of-mass of the overall space station and thereby tend to flap more during global dynamic events such as thruster firings to maneuver the massive vehicle.

Five plots of interval root-mean-square (RMS) versus time for SAMS sensors distributed throughout the ISS are shown at the end of this document, starting with Figure 9 on page 6. The RMS values shown are computed below 5 Hz and shown for the entire day.

Finally, a per-axis breakout with 5 more RMS plots start with Figure 14 on page 9. These last 5 plots have a one-to-one correspondence with those starting on page 6. These suggest highest vibration levels on the X-axis in the Columbus module, and all sensors show somewhat heightened vibrations as we would expect for these dynamic events.

4. Conclusion

The SAMS sensor data when filtered below about 5 Hz tend to highlight the structural vibrations associated with dynamic events like those associated with maneuvers and docking activities. The primary impact of a Soyuz relocation comes with the maneuvers needed to align the massive space station for particular aspects of the docking, rendezvous and re-docking activities.

Table 1. **Approx.** RMS acceleration levels (μg) on the day for 5 SAMS sensors.

Sensor	RMS < 5 Hz	Location
121f02	600	COL1A1 (ER3)
121f03	400	LAB1O1 (ER2)
121f04	400	LAB1P2 (ER7)
121f05	500	JPM1F1 (ER5)
121f08	800	COL1A3 (EPM)

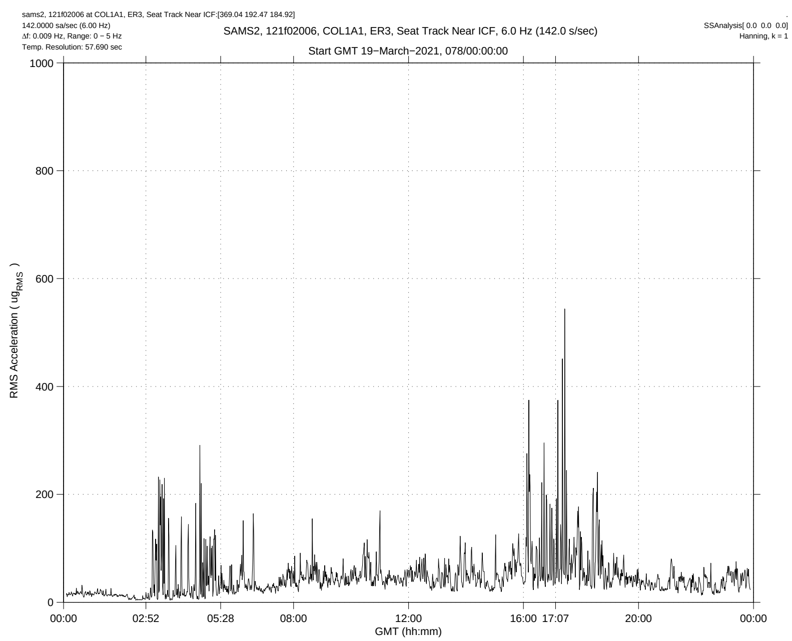

Fig. 5: Interval RMS below 5 Hz for SAMS 121f02 sensor in COL.

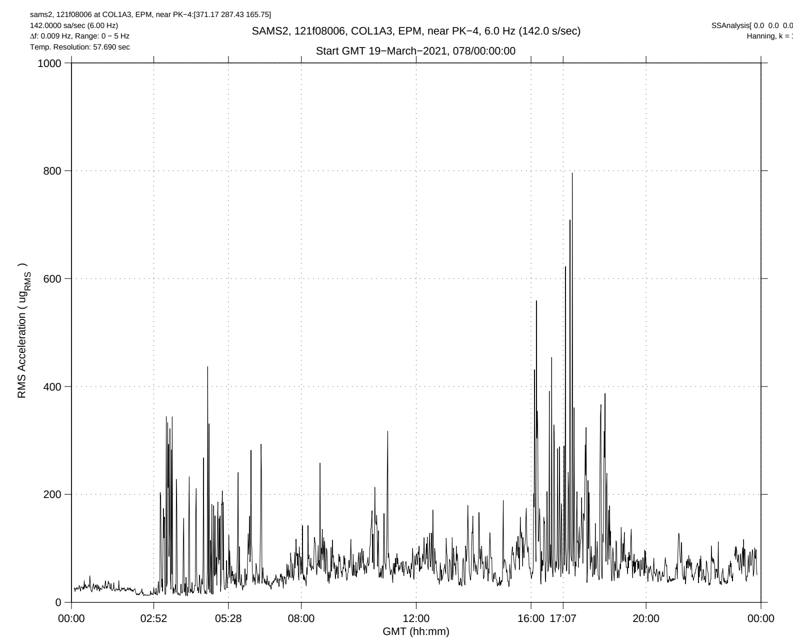

Fig. 6: Interval RMS below 5 Hz for SAMS 121f08 sensor in COL.

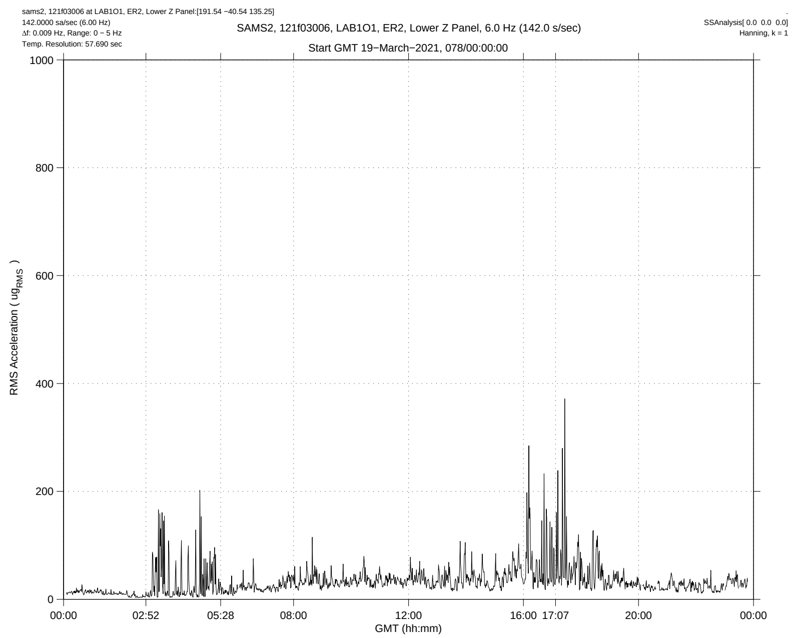

Fig. 7: Interval RMS below 5 Hz for SAMS 121f03 sensor in LAB.

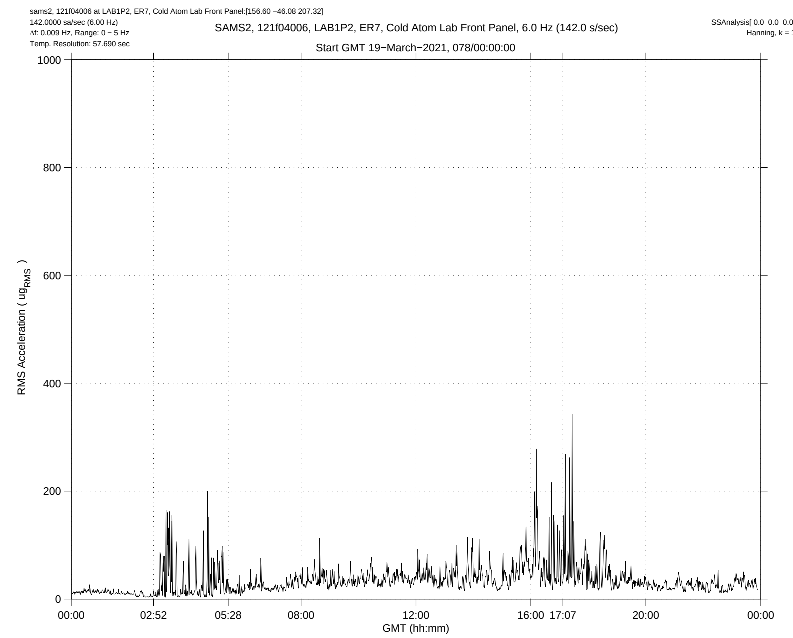

Fig. 8: Interval RMS below 5 Hz for SAMS 121f04 sensor in LAB.

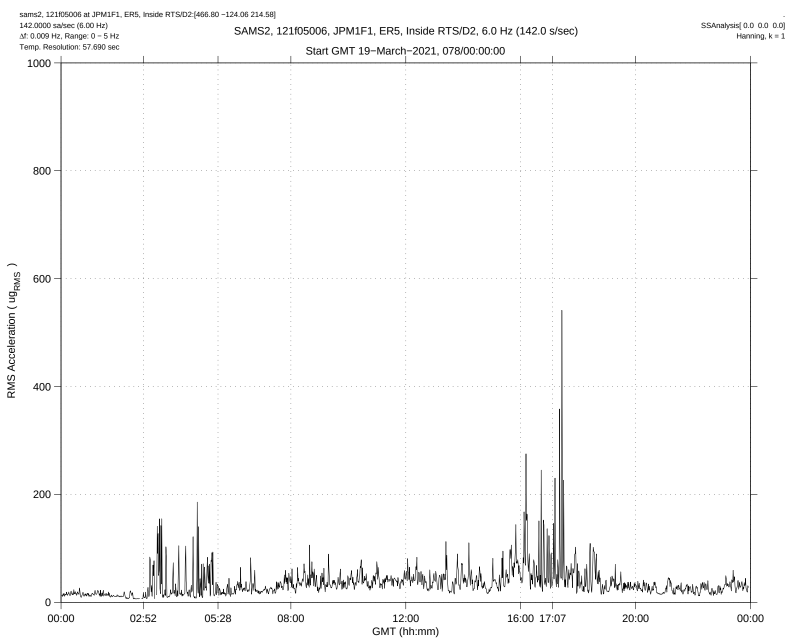

Fig. 9: Interval RMS below 5 Hz for SAMS 121f05 sensor in JEM.

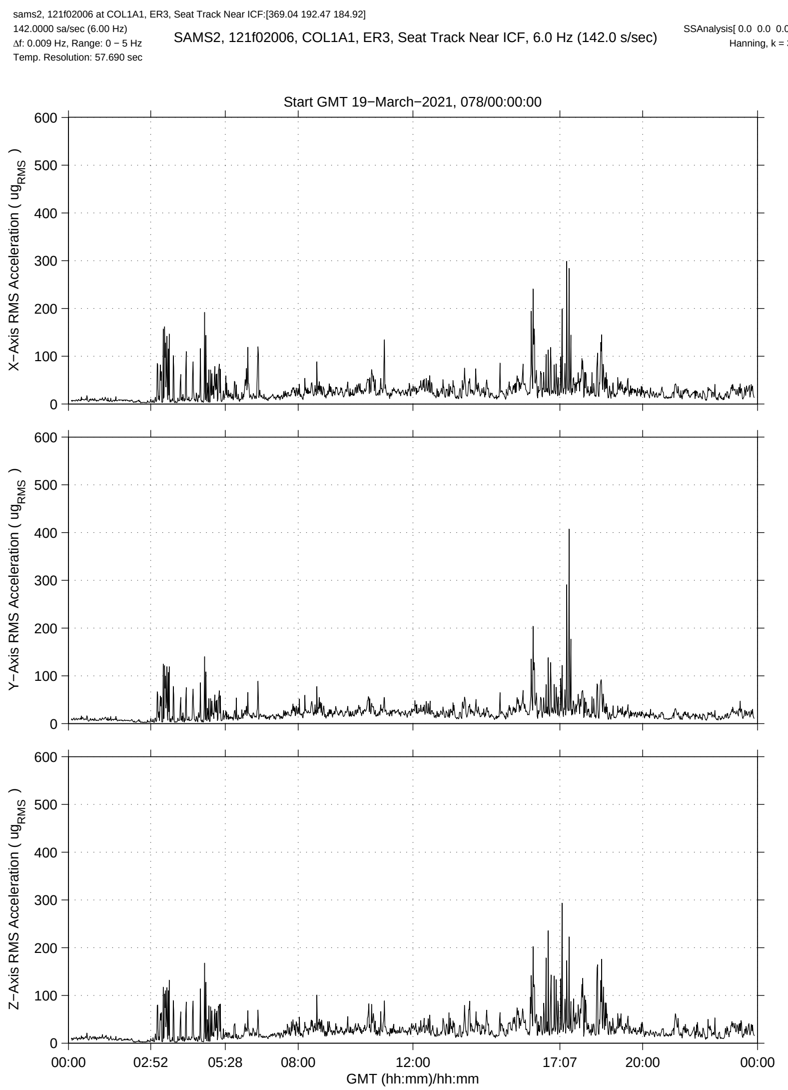

Fig. 10: Interval RMS below 5 Hz for SAMS 121f02 sensor in COL.

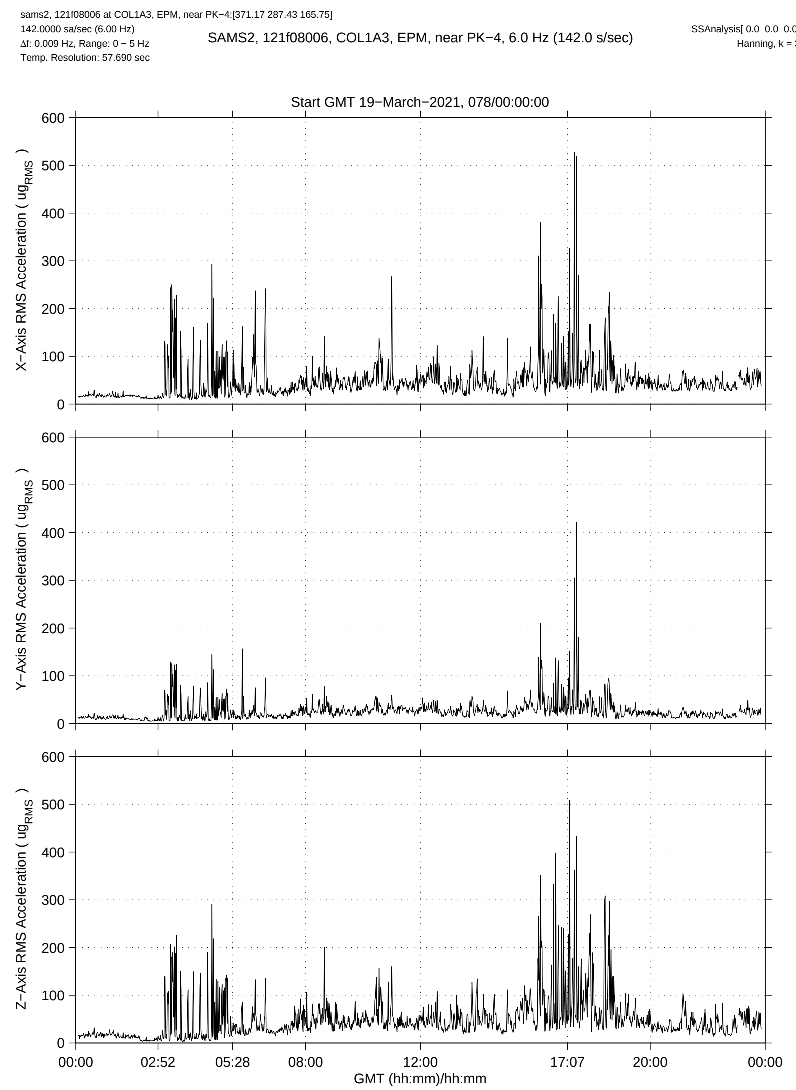

Fig. 11: Interval RMS below 5 Hz for SAMS 121f08 sensor in COL.

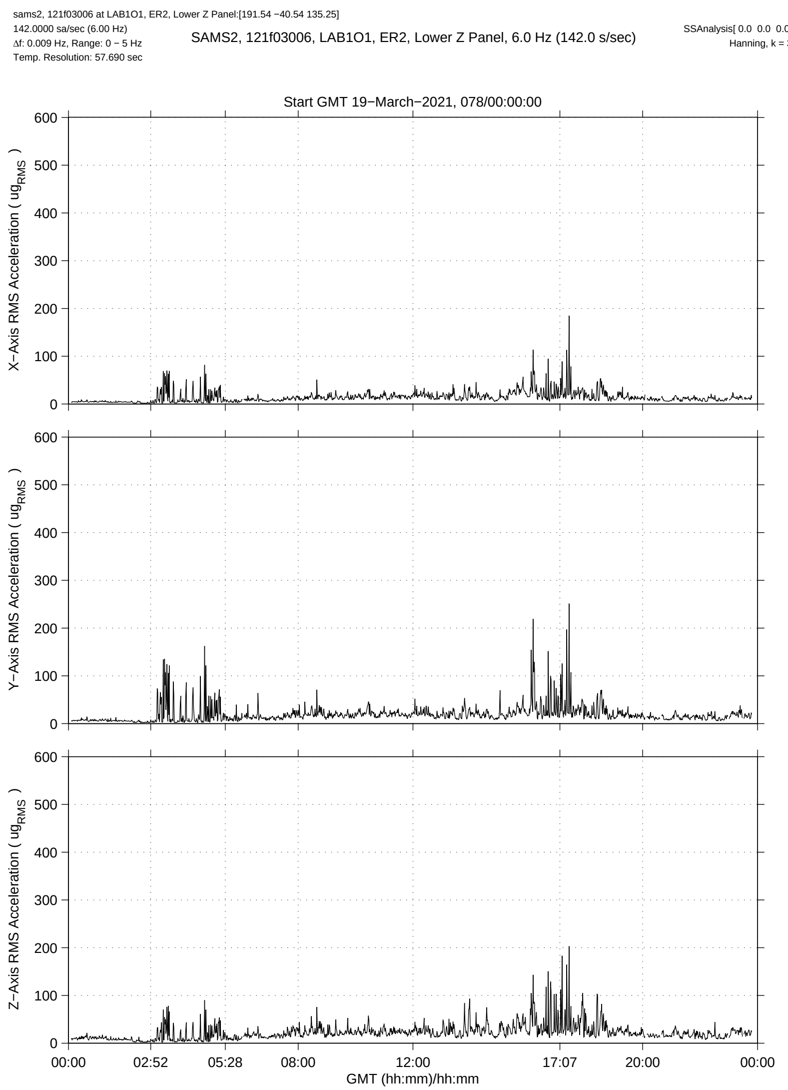

Fig. 12: Interval RMS below 5 Hz for SAMS 121f03 sensor in LAB.

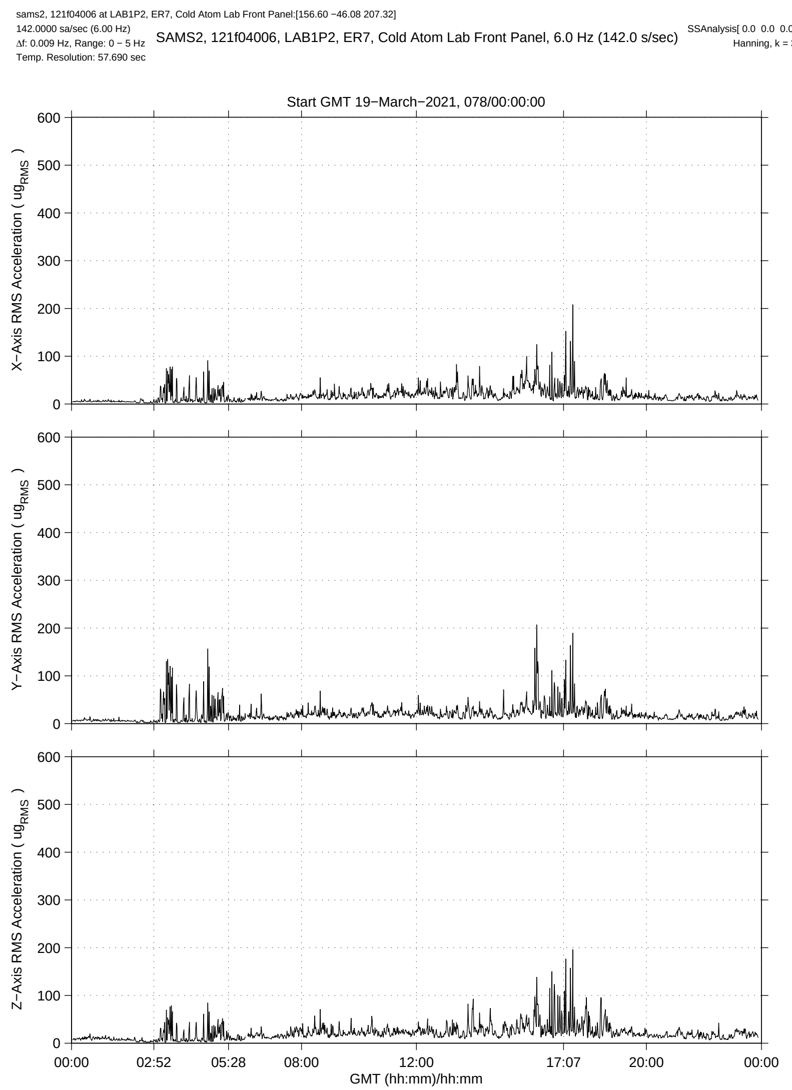

Fig. 13: Interval RMS below 5 Hz for SAMS 121f04 sensor in LAB.

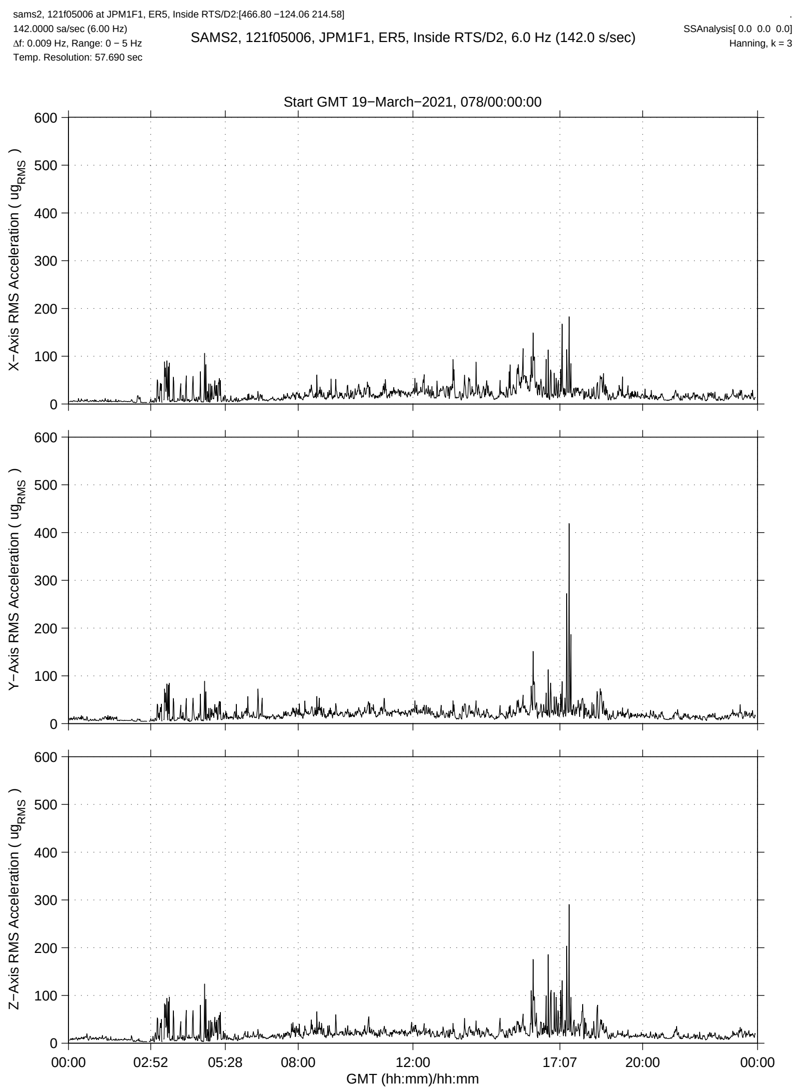

Fig. 14: Interval RMS below 5 Hz for SAMS 121f05 sensor in JEM.