

1. INTRODUCTION

A Dedicated Thruster Firing (DTF) test was run from the ground and performed on the International Space Station (ISS) to gather data for characterizing vehicle structural modes and to verify ISS Roll-Out Solar Array (iROSA) modes. Three DTF Tests 1, 2, and 3 were performed on GMT 2025-01-28 to excite the -Y, +Z, and +Y/-Y modes, respectively. Post-DTF review of the data determined that no firings occurred during Test 2 for the +Z mode (pitch). As a result, Test 2 may need to be re-scheduled. In total, the tests lasted less than 12 minutes starting at about GMT 2025-01-28, 028/20:08. During the DTF test, several Space Acceleration Measurement System (SAMS) sensor heads were active, including at least one in each of the 3 main laboratories of the ISS. The technical narrative and plots in this document seek to show a high-level characterization of the SAMS measurement data collected by 3 sensor heads during the DTF tests.

2. QUALIFY

The entries in Table 1 show a timeline of events surrounding the SAMS-gleaned times of the 2 thruster firings that took place at GMT 20:08:20 for Test 1, and 20:14:20 for Test 3, respectively. Test 1 had a reported firing duration of 1 second, and Test 3’s firing duration was reported to be 1.6 seconds.

XYZ, Per-Axis SAMS Spectrograms

The information shown in Figure 1 on page 3 and Figure 2 on page 4 are color spectrograms computed from Space Acceleration Measurement System (SAMS) data from three sensor heads:

- (1) **121f08**: at the **COL1A3** rack position in the Columbus module.
- (2) **121f05**: at the **JPM1F1** rack position in the Japanese Experiment Module.
- (3) **121f03**: at the **LAB1O1** rack position in the U.S. Laboratory.

The SAMS sensor installed in the Columbus module detects vibrations more strongly during thruster firing events compared to say the sensor located in the U.S. Laboratory. This difference becomes clear when examining the spectrogram plots, where colors toward the orange/red end of the color/magnitude scale, indicate higher vibration levels. These thruster firings cause the large structures of the space station to vibrate at their natural frequencies — similar to how a bell rings at a distinct pitch when struck — revealing how the station responds to impulsive forces.

Dedicated Thruster Firing Test (M25_028_A_03.UAF)										01/28/2025
19	028/20:05:00	—	Y	-38	+XVV +ZLV TEA	LVLH	356 352.8 0.9	MMT FDO	Free Drift for Dedicated Thruster Firing (DTF) Test	
20	028/20:08:00 028/20:08:01	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Thruster Firing Test 1		
21	028/20:08:01 028/20:11:00	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Free Drift for DTF Test		
22	028/20:11:00 028/20:11:02	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Thruster Firing Test 2		
23	028/20:11:02 028/20:14:00	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Free Drift for DTF Test		
24	028/20:14:00 028/20:14:02	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Thruster Firing Test 3		
25	028/20:14:02 028/20:18:20	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO FDO	Free Drift for DTF Test		
26	028/20:18:20	—	Y	-38	+XVV +ZLV	LVLH	356 352.8 0.9	FDO THR	RS Snap and Hold	RS Recovery from Free Drift
27	028/20:18:21 028/20:23:21	N	-38	+XVV +ZLV TEA	LVLH	356 352.8 0.9	THR THR	Mnvr to LVLH TEA		
28	028/20:50:00	—	Y	-38	+XVV +ZLV TEA	LVLH	356 352.8 0.9	THR MMT	Handover RS to US Momentum Management	TEA for VV#1z_N1nCN2nezDfe, PSARJ Auto, SSARJ Auto

Table 1. Timeline Around Dedicated Thruster Firing on GMT 2025-01-28.

SAMS Time Correlation with DTF Timeline

All 3 SAMS sensors examined for this analysis lag by about 20 seconds from the timeline in Table 1. It is unclear if the table/published times fully account for the seconds place or e.g. round to nearest minute.

3. QUANTIFY

The color spectrograms above serve to qualify in time, frequency, and roughly for order of magnitude, the various responses seen at 3 SAMS sensor head locations in the 3 main laboratories. However, those plots do not serve well to quantify those responses. For that information, we turn to as-measured, per-axis acceleration versus time plots.

Two Thruster Firing Events, Per-Axis Acceleration vs. Time (30 Minutes)

The 3 per-axis plot figures starting with Figure 3 on page 5 show about 30 minutes of SAMS measurements after low-pass filtering below 6 Hz and including both thruster firing events and their structural ringout aftermath. A primary impact of thruster firings is the structural excitation that occurs at these lower frequencies. These plots will serve to quantify the impact in the form of a comparison between 3 SAMS sensors, one in each of the 3 main laboratories. The peak-to-peak values observed for the three SAMS sensor heads were:

- (1) **121f03**: below 1 mg at the **LAB1O1** rack position — see left side of Figure 3.
- (2) **121f05**: about 1 mg at the **JPM1F1** rack position — see right side of Figure 3.
- (3) **121f08**: about 3 mg at the **COL1A3** rack position — see left side of Figure 4.

3-Second Zoom-In of Last Thruster Firing, Per-Axis Acceleration vs. Time

The per-axis plot on the right side of Figure 4 on page 6 shows a zoom-in of about 3 seconds of SAMS measurements after low-pass filtering below 6 Hz and including just the last thruster firing event, emphasizing structural ringout.

4. CONCLUSION

The analysis of SAMS data collected during two Dedicated Thruster Firing (DTF) tests highlights significant insights into the structural dynamics of the International Space Station (ISS):

- **Structural Modal Responses:** Thruster firings effectively excited station-wide structural modes, with the Columbus module displaying the highest vibratory response due to its location and mode coupling.
- **Missed Opportunity:** The absence of firing(s) in Test 2 prevented achieving all objectives, i.e. characterization of the +Z (pitch) mode response, indicating perhaps the need for a retest.
- **Timing Discrepancy:** A consistent 20-second lag between expected and SAMS-recorded events suggests a potential data synchronization or lack of precision in reporting times to the seconds place.
- **Quantitative Performance:** Measured peak-to-peak accelerations confirmed variations across modules, with the Columbus module showing the highest magnitude (~3 mg) compared to JEM (~1 mg) and the US Lab (<1 mg).

sams2, 121f08 at COL1A3, EPM, near PK-4[371.17 287.43 165.75]
 500.0000 sa/sec (200.00 Hz)
 Δf = 0.025 Hz, Nfft = 20000
 Temp. Res. = 5.000 sec, No = 17500

SAMS2, 121f08, COL1A3, EPM, near PK-4, 200.0 Hz (500.0 s/sec)

SSAnalysis[0.0 0.0 0.0]
 Hanning, k = 353
 Span = 29.33 minutes

sams2, 121f05 at JPM1F1, ER5, Inside RTS/D2[466.80 -124.06 214.58]
 500.0000 sa/sec (200.00 Hz)
 Δf = 0.025 Hz, Nfft = 20000
 Temp. Res. = 5.000 sec, No = 17500

SAMS2, 121f05, JPM1F1, ER5, Inside RTS/D2, 200.0 Hz (500.0 s/sec)

SSAnalysis[0.0 0.0 0.0]
 Hanning, k = 353
 Span = 29.33 minutes

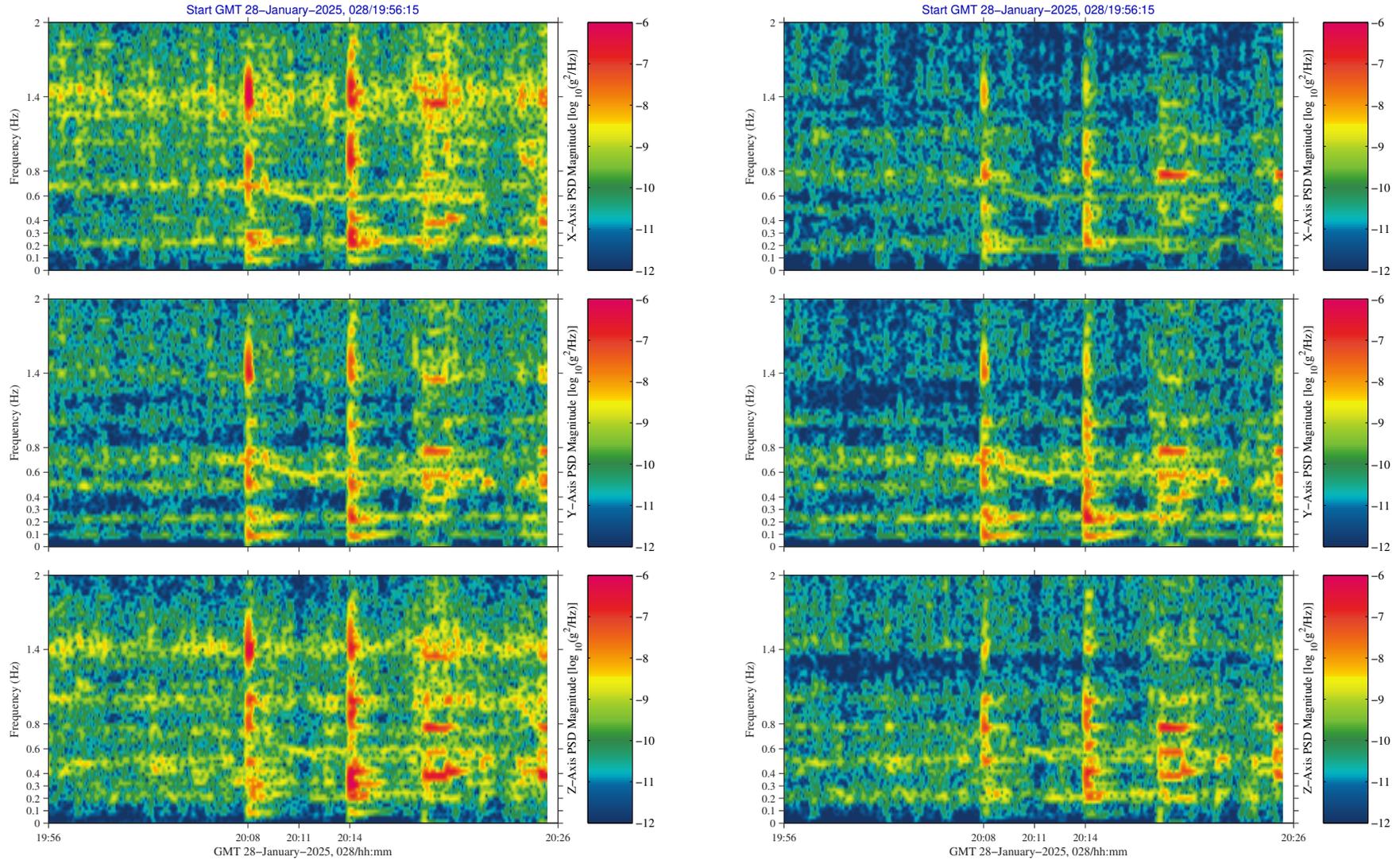


Fig. 1: SAMS Per-Axis Spectrograms Showing 30-Minute Span on GMT 2025-01-28: (Left) SAMS Sensor 121f08 in COL, (Right) SAMS Sensor 121f05 in JEM.

sams2, 121f03 at LAB101, ER2, Lower Z Panel[191.54 -40.54 135.25]
 500.0000 sa/sec (200.00 Hz)
 $\Delta f = 0.025$ Hz, Nfft = 20000 SAMS2, 121f03, LAB101, ER2, Lower Z Panel, 200.0 Hz (500.0 s/sec)
 Temp. Res. = 5.000 sec, No = 17500

SSAnalysis[0.0 0.0 0.0]
 Hanning, k = 353
 Span = 29.33 minutes

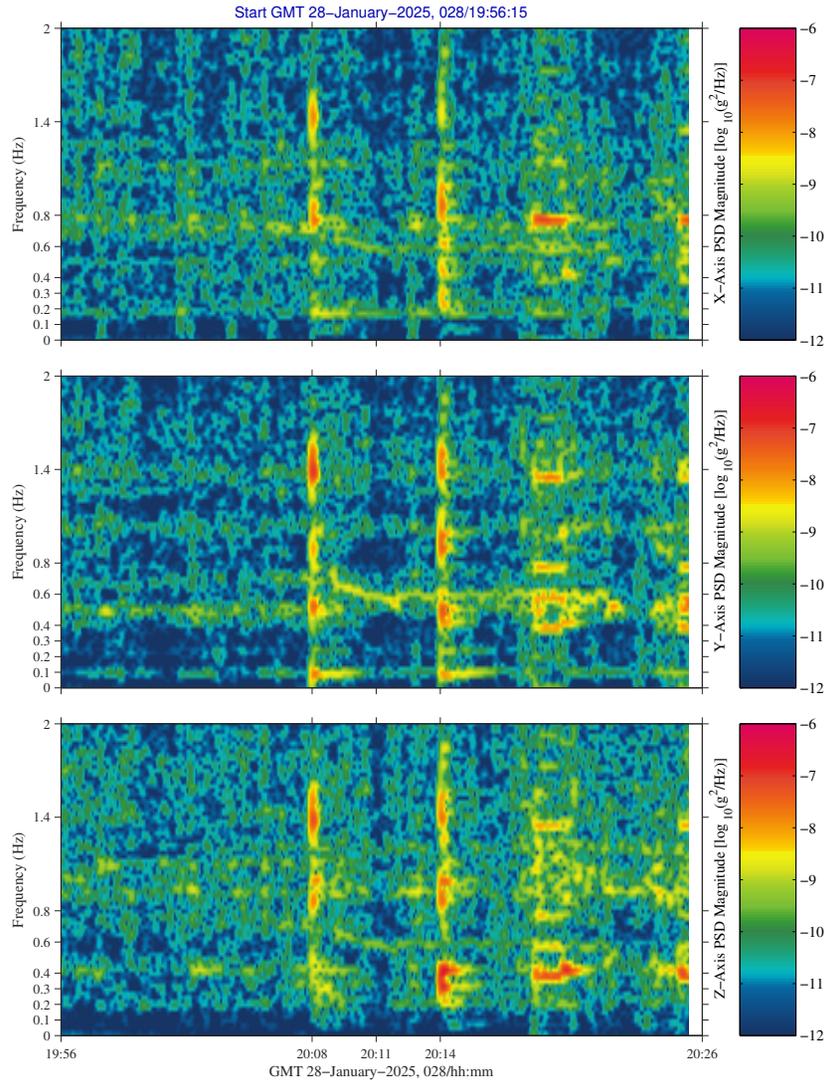


Fig. 2: SAMS Per-Axis Spectrograms Showing 30-Minute Span on GMT 2025-01-28, SAMS Sensor 121f03 in LAB.

inverted-sams2, 121f03006 at LAB1O1, ER2, Lower Z Panel[191.54 -40.54 135.25]
142.0000 sa/sec (6.00 Hz)

SAMS2, 121f03006, LAB1O1, ER2, Lower Z Panel, 6.0 Hz (142.0 s/sec)

SSAnalysis[0.0 0.0 0.0]

inverted-sams2, 121f05006 at JPM1F1, ER5, Inside RTS/D2[466.80 -124.06 214.58]
142.0000 sa/sec (6.00 Hz)

SAMS2, 121f05006, JPM1F1, ER5, Inside RTS/D2, 6.0 Hz (142.0 s/sec)

SSAnalysis[0.0 0.0 0.0]

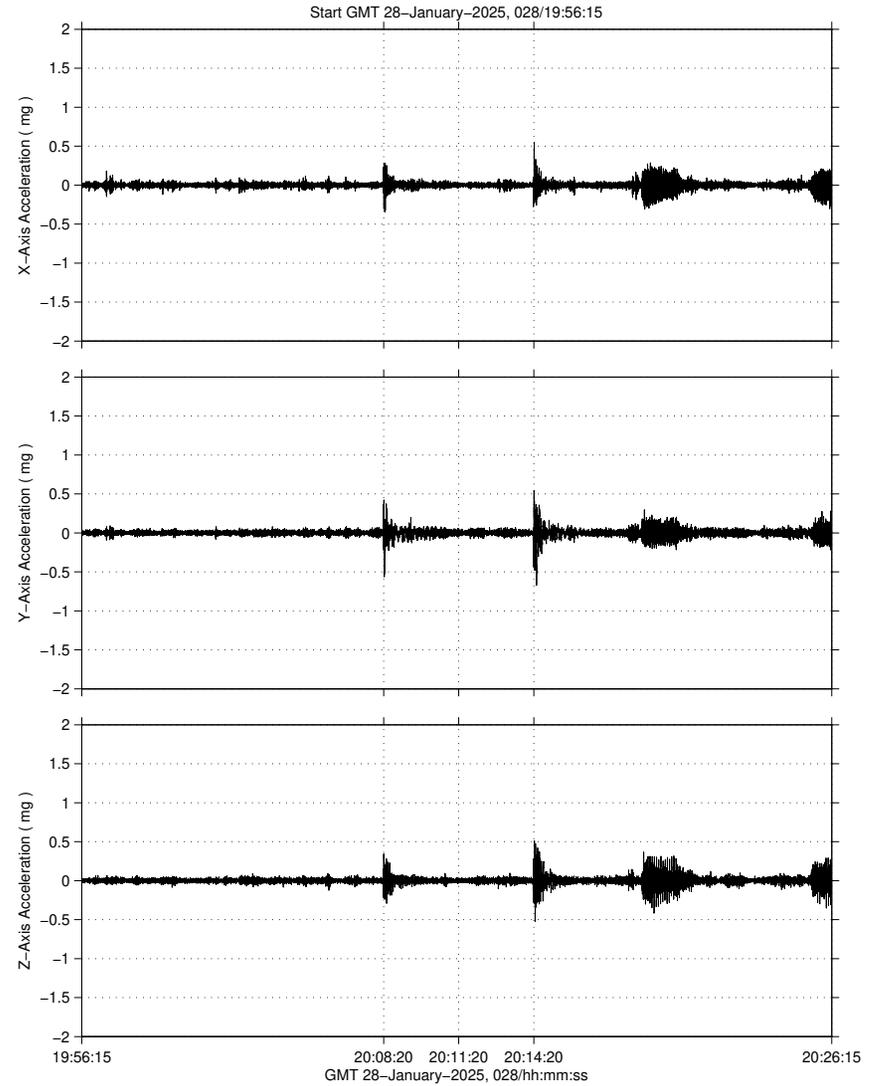
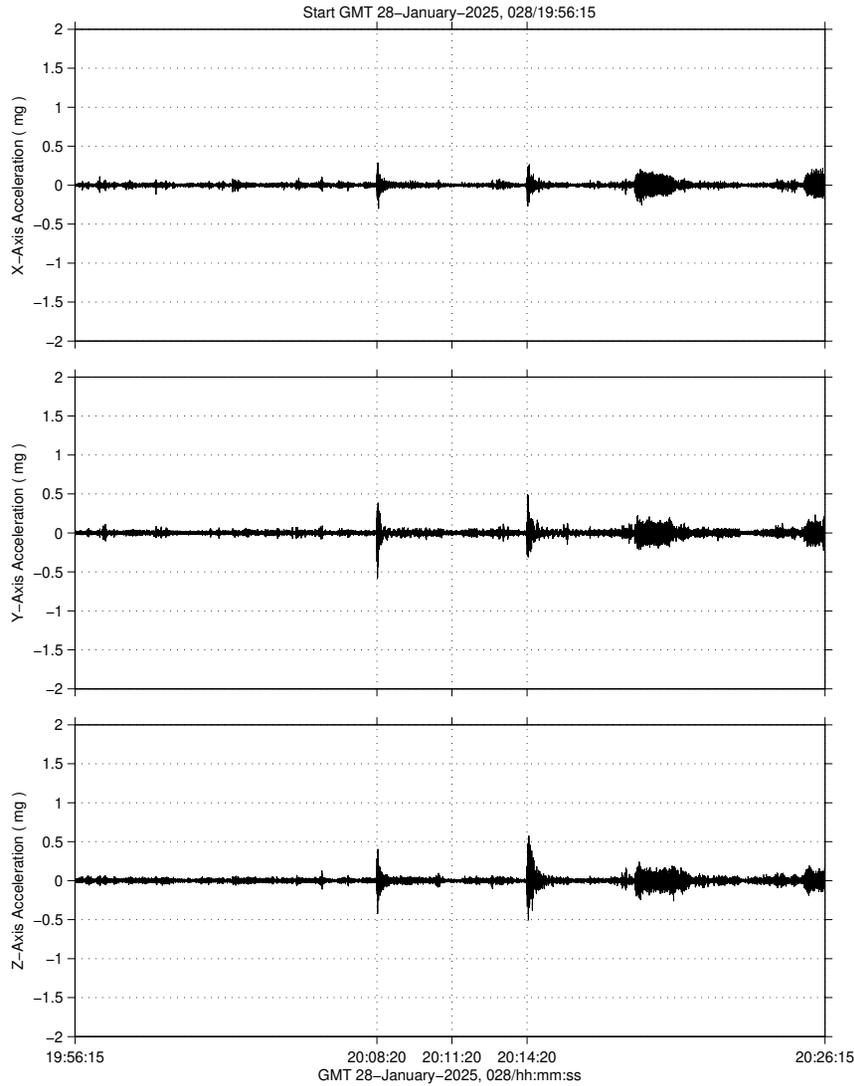


Fig. 3: SAMS Showing Deactivation of MAMS in JEM on GMT 2025-01-27: (Left) Narrowband Interval RMS Acceleration, (Right) Acceleration vs. Time.

inverted-sams2, 121f08006 at COL1A3, EPM, near PK-4[371.17 287.43 165.75]
142.0000 sa/sec (6.00 Hz)

SAMS2, 121f08006, COL1A3, EPM, near PK-4, 6.0 Hz (142.0 s/sec)

SSAnalysis[0.0 0.0 0.0]

inverted-sams2, 121f08006 at COL1A3, EPM, near PK-4[371.17 287.43 165.75]
142.0000 sa/sec (6.00 Hz)

SAMS2, 121f08006, COL1A3, EPM, near PK-4, 6.0 Hz (142.0 s/sec)

SSAnalysis[0.0 0.0 0.0]

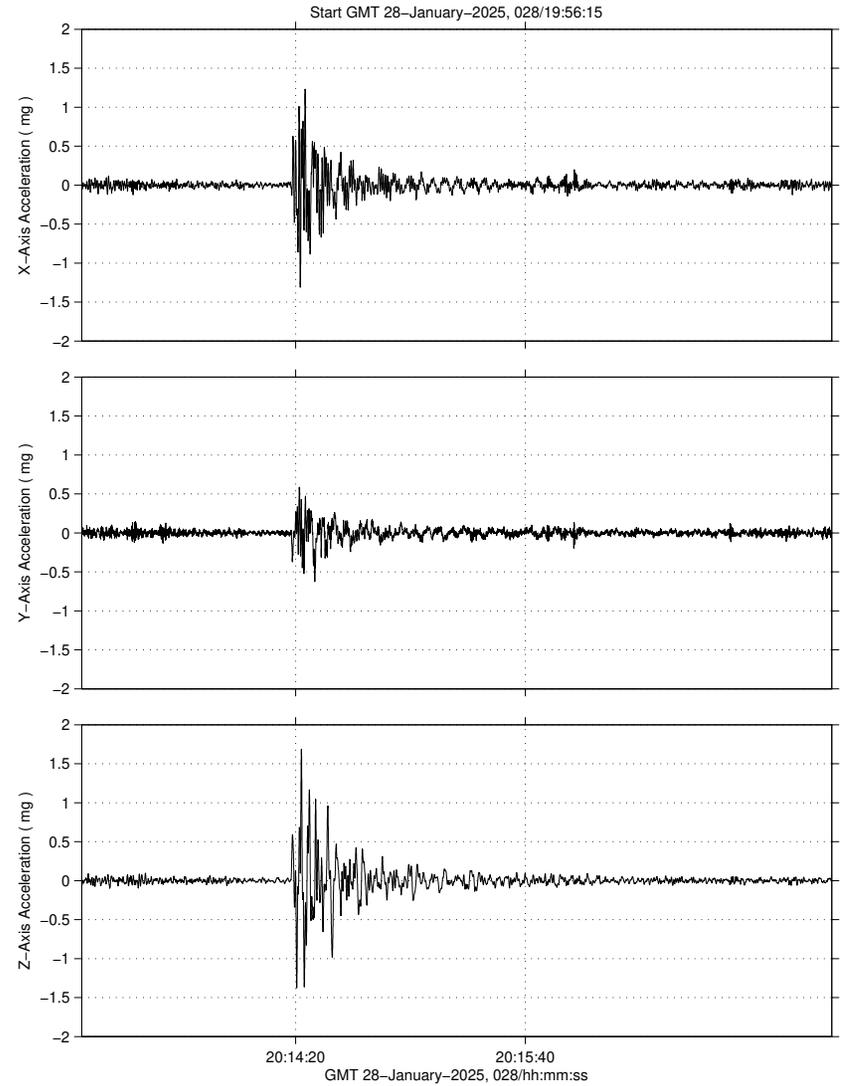
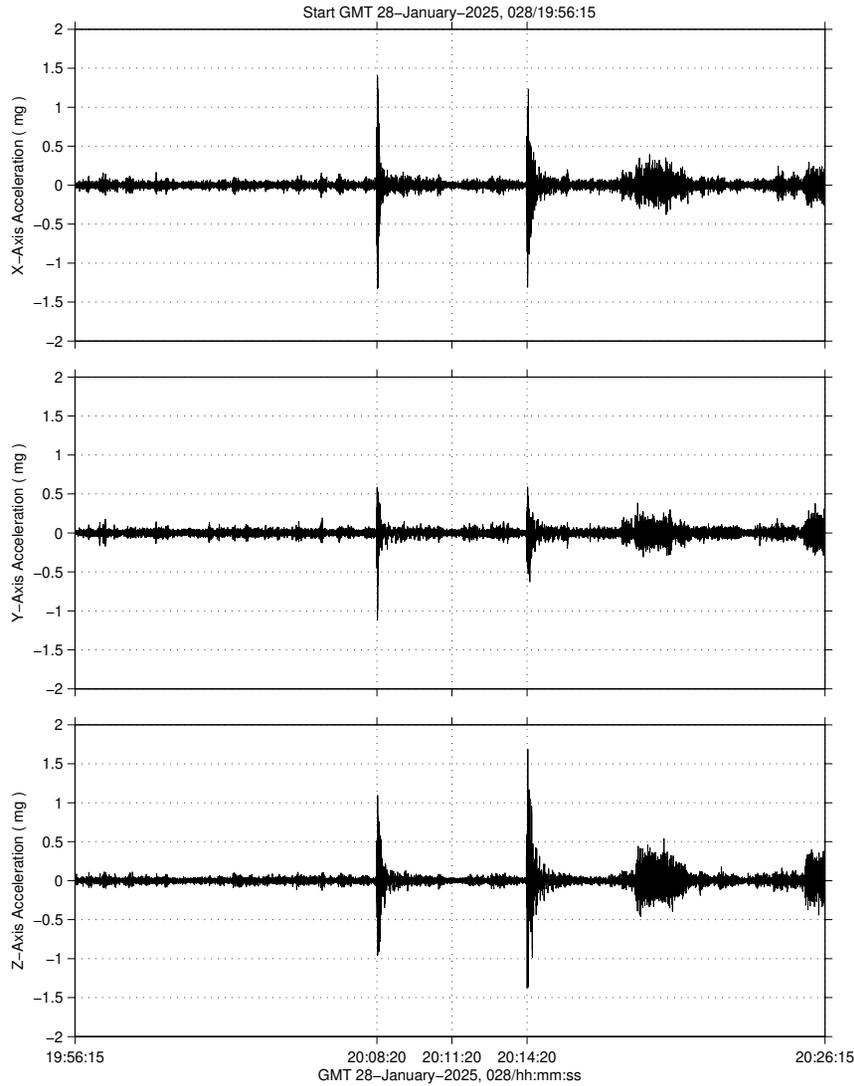


Fig. 4: SAMS Showing Deactivation of MAMS in JEM on GMT 2025-01-27: (Left) Narrowband Interval RMS Acceleration, (Right) Acceleration vs. Time.