> *The vibratory acceleration limits apply at the structural mounting interfaces to the internal user payload locations. In the case of the ISPR, this points to the structural interfaces between the rack and the payload, on the payload side of the interfaces. If an intermediate structure were incorporated into the design between the user payload and the ISPR, e.g. an active rack isolation system, the specification shall apply at the user payload side of its interface with such a system.*

… but that notwithstanding, measurements collected by SAMS 121f06 and MAMS HiRAP were processed for comparison to the ISS system combined vibratory acceleration limits and the results are shown in Figures 9.3.4-1 to 9.3.4-3. These three figures show crew impact below 10 Hz, ADVASC and EXPPCS impacts (discussed in next section) on HiRAP location. EXPPCS impact on HiRAP is shown at about 12 Hz (fundamental frequency of sample mix motor) along with 2^{nd} through 16^{th} harmonics. Whereas SAMS 121f06 shows that EXPPCS impacts the entire measured spectrum. It must be pointed out that the ISS requirement curve is only valid for assembly complete, ISS microgravity mode operations, on an ARIS rack, and with the ARIS Rack control system functioning. The data that are being compared here with the ISS requirement were not collected under the conditions mentioned above and are shown here only to illustrate how close the ISS microgravity environment is to the assembly complete requirement. The reader should be careful in drawing any final conclusion when looking at these curves (Increment-2 vs. ISS assembly complete requirement).

9.3.5 Experiment Operations

Microgravity experiment procedures typically employ mechanical equipment to prepare, conduct, analyze, diagnose, or preserve some aspect of the investigation. The forces produced by the moving parts of such equipment are transmitted in varying degrees to the spacecraft structure depending on the operating characteristics and on any mechanisms for vibration isolation.

9.3.5.1 EXPPCS Sample Mix

The EXPPCS was located in EXPRESS Rack (ER) 2. It has a number of moving parts, but the sample mixer is of particular interest from an acceleration environment perspective. In order to eliminate sedimentation and to produce uniform distribution, the initial EXPPCS procedures call for mixing each colloidal sample for a period of approximately one hour. The color spectrogram shown in Figure 9.3.5.1-1 shows an example of the sample mixer in operation starting at about GMT 04-June-2001, 22:20:40 and lasting for over an hour with a 50% duty cycle.

This spectrogram was computed from SAMS 121f06 measurements and shows the acceleration spectrum as a function of time. The sensor head was located about $1^{1}/_{2}$ feet from the mixer on the front-panel of the EXPPCS test section. As expected, extreme acceleration levels were registered. The period shown starts at GMT 04-June-2001,

22:10:00 and covers an 80-minute span. The red vertical streaks mark portions of the duty cycle when the mixer was active.

For improved temporal resolution and a more precise accounting of the measured accelerations, the interval minimum/maximum time history of Figure 9.3.5.1-2 was examined. That figure clearly shows the large accelerations that occur while the mixer is preparing a sample cell for an operational run. The acceleration vector magnitudes detected by this sensor were nominally about 150 mg with peak values routinely in excess of 200 mg. As indicated by the time axis tick marks, this mixer has a 50% duty cycle with each half-cycle being 30-seconds in duration.

For improved frequency resolution and a more precise accounting of the spectral content during sample mix operations, the PSDs of Figure 9.3.5.1-3 were computed. From close inspection of this figure, we conjecture that the fundamental frequency of this disturbance was 12 Hz and with significant 2^{nd} through 16^{th} harmonics within the passband of this sensor. The 9^{th} harmonic at 108 Hz was the most pronounced component and was aligned primarily with the sensor's YZ-plane. In strong contrast to this, the acceleration spectra during a 25-second span when the sample mix operation was off are seen in the PSDs of Figure 9.3.5.1-4.

Closer examination by means of the cumulative RMS acceleration versus frequency plot of Figure 9.3.5.1-5, serves to quantify this disturbance as a function of frequency.

During this 25-second period while the mixer was on, the overall RMS acceleration was slightly more than 80 mg_{RMS} for the frequency range from 0.06 to 200 Hz. For this same range, but during a 25-second span while the mixer was off, the cumulative RMS acceleration versus frequency plot of Figure 9.3.5.1-6 yields an overall RMS acceleration value more than an order of magnitude smaller at about 1.7 mg_{RMS}.

Further analysis of the sample mix operation was performed using other SAMS SEs. The color spectrograms of Figure 9.3.5.1-7 and Figure 9.3.5.1-8 show 5 cycles of a mix operation starting at about GMT 05-July-2001 23:45:20 for SAMS SE 121f03 and 121f04, respectively. The impact of these were examined at 2 SAMS sensor locations: (1) 121f03 on the Z-panel of ER2, and (2) 121f04 on the Z-panel of ER1. The 5 cycles are quite clear in the interval min/max plot of Figure 9.3.5.1-9 for 121f03. This sensor was nearer to the mix equipment than 121f04 as seen in Figure 9.3.5.1-10. Peak acceleration during the 5 mix cycles was about 10 mg for 121f04, and over 22 mg for 121f03. These accelerations, however, are about an order of magnitude less than those shown for the sample mix operations highlighted in Figure 9.3.5.1-2. Note that Figure 9.3.5.1-9 and Figure 9.3.5.1-10 were plotted in SSA coordinates and that the primary difference was registered on the X_A-axis.

9.3.5.2 EXPPCS Rheology

Rheology is performed at several different frequencies for each cell. The frequency range of operation is between 0 to 20 Hz. The same motor used to perform the Mix/Melt is used

for rheology. Rheology is performed on each sample when the sample has reached its final state.

According to the EXPPCS operations timeline shown in Table 9.3.5.2-1, a rheology was performed starting at GMT 25-June-2001 10:58:40. The color spectrogram shown in Figure 9.3.5.2-1 shows the end of an extended sample mix operation (not the usual 30-second duty cycle), which lasted from about GMT 25-June-2001 10:48:24 to 10:58:30 (temporal resolution of 16.384 seconds). The spectrogram below 20 Hz by itself does not yield conclusive indication of the exact impact of the rheology. It was noticed that occasional, brief spectral peaks do appear at about 7.8 Hz. For example, one of these peaks started at about GMT 25-June-2001 11:23:50 and lasted a little longer than 50 seconds. These must not be attributable solely to rheology operations because they appear before the aforementioned extended sample mix even begins.

TABLE 9.3.5.2-1 EXPPCS OPERATIONS TIMELINE

Operation	GMT	
	Start	End
mix/melt	02-June-2001 22:23:56	02-June-2001 22:53:56
mix/melt	02-June-2001 23:26:55	02-June-2001 23:56:55
mix/melt	03-June-2001 00:29:54	03-June-2001 00:59:54
mix/melt	03-June-2001 19:00:53	03-June-2001 19:30:53
mix/melt	03-June-2001 20:03:52	03-June-2001 20:33:52
mix/melt	04-June-2001 22:50:40	04-June-2001 23:20:40
mix/melt	09-June-2001 01:03:46	09-June-2001 01:33:46
mix/melt	09-June-2001 04:53:11	09-June-2001 05:23:11
mix/melt	09-June-2001 23:42:22	10-June-2001 00:12:22
mix/melt	10-June-2001 05:32:51	10-June-2001 06:02:51
mix/melt	11-June-2001 21:09:54	11-June-2001 21:39:54
mix/melt	14-June-2001 08:38:16	14-June-2001 09:08:16
mix/melt	14-June-2001 12:30:14	14-June-2001 13:00:14
mix/melt	14-June-2001 14:41:49	14-June-2001 15:11:49
mix/melt	23-June-2001 04:15:00	23-June-2001 04:45:00
mix/melt	23-June-2001 04:18:34	23-June-2001 04:48:34
mix/melt	24-June-2001 18:27:56	24-June-2001 18:57:56
mix/melt	24-June-2001 21:37:40	24-June-2001 22:07:40
mix/melt	25-June-2001 10:28:40	25-June-2001 10:58:40
rheology	25-June-2001 10:58:40	25-June-2001 11:28:40
mix/melt	29-June-2001 11:05:12	29-June-2001 11:35:12
mix/melt	05-July-2001 22:00:21	05-July-2001 22:30:21
mix/melt	05-July-2001 23:20:22	05-July-2001 23:50:22
mix/melt	06-July-2001 00:47:06	06-July-2001 01:17:06
mix/melt	17-July-2001 13:53:13	17-July-2001 14:23:13
mix/melt	23-July-2001 06:54:54	23-July-2001 07:24:54
mix/melt	26-July-2001 23:32:31	27-July-2001 00:02:31
mix/melt	27-July-2001 00:30:40	27-July-2001 01:00:40
mix/melt	27-July-2001 04:25:14	27-July-2001 04:55:14
mix/melt	05-Sept-2001 01:54:12	05-Sept-2001 02:24:12
mix/melt	06-Sept-2001 15:53:43	06-Sept-2001 16:23:43
mix/melt	06-Sept-2001 16:14:46	06-Sept-2001 16:44:46
mix/melt	20-Sept-2001 03:20:39	20-Sept-2001 03:50:39
mix/melt	20-Sept-2001 04:12:34	20-Sept-2001 04:42:34

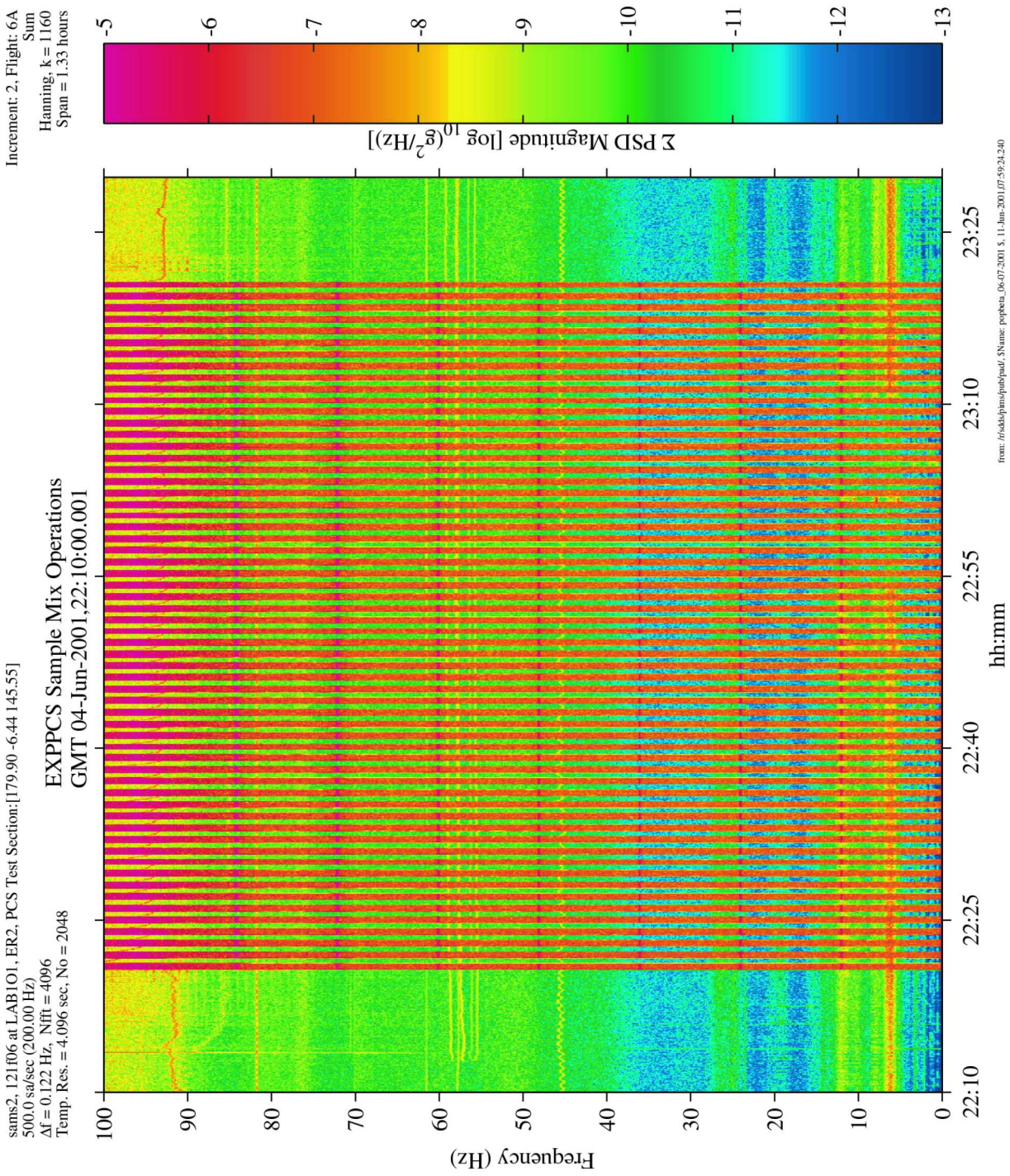

Figure 9.3.5.1-1 Spectrogram of EXPPCS Sample Mix Operation (121f06)

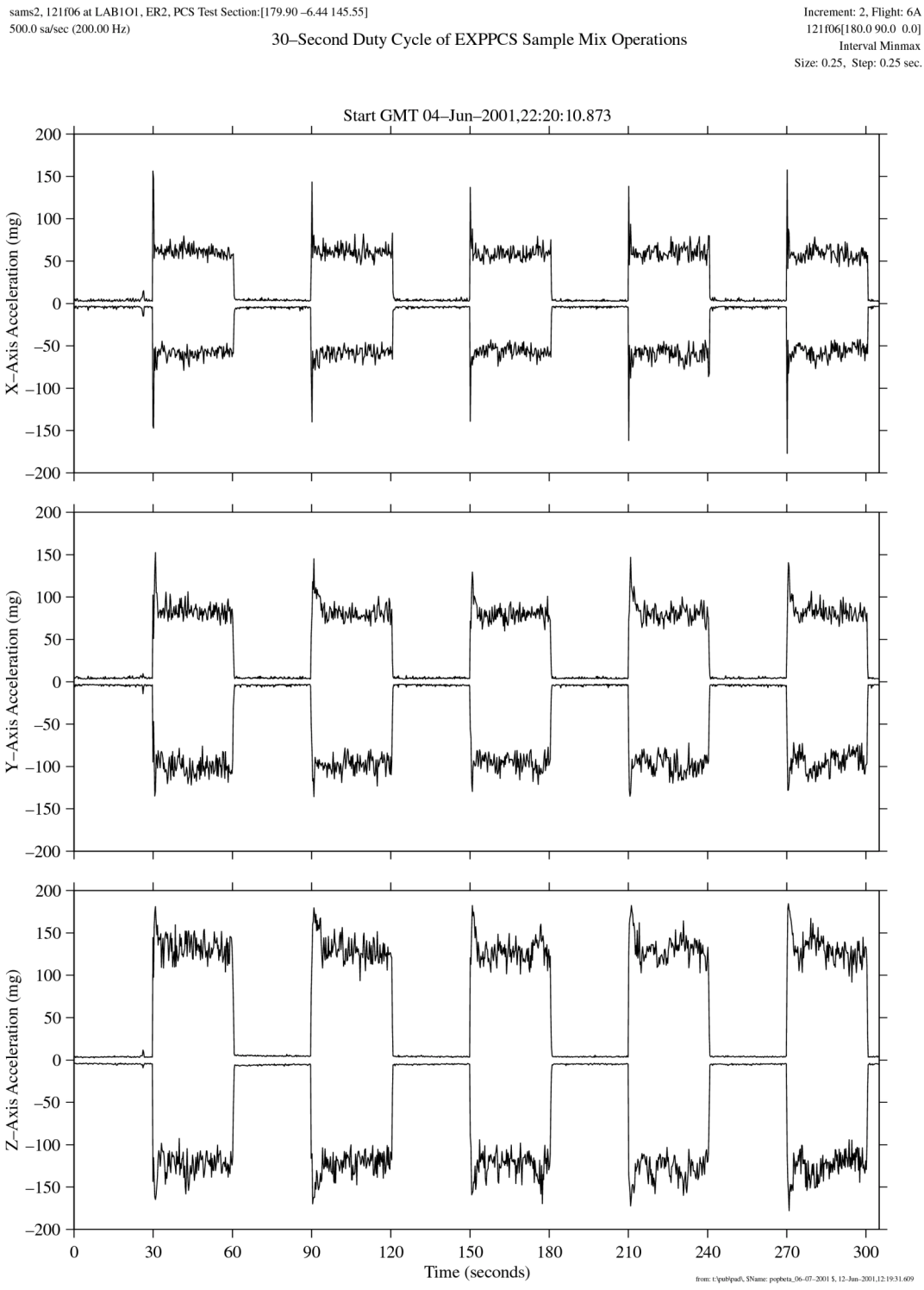

Figure 9.3.5.1-2 Interval Min/Max of EXPPCS Sample Mix Operation On (121f06)

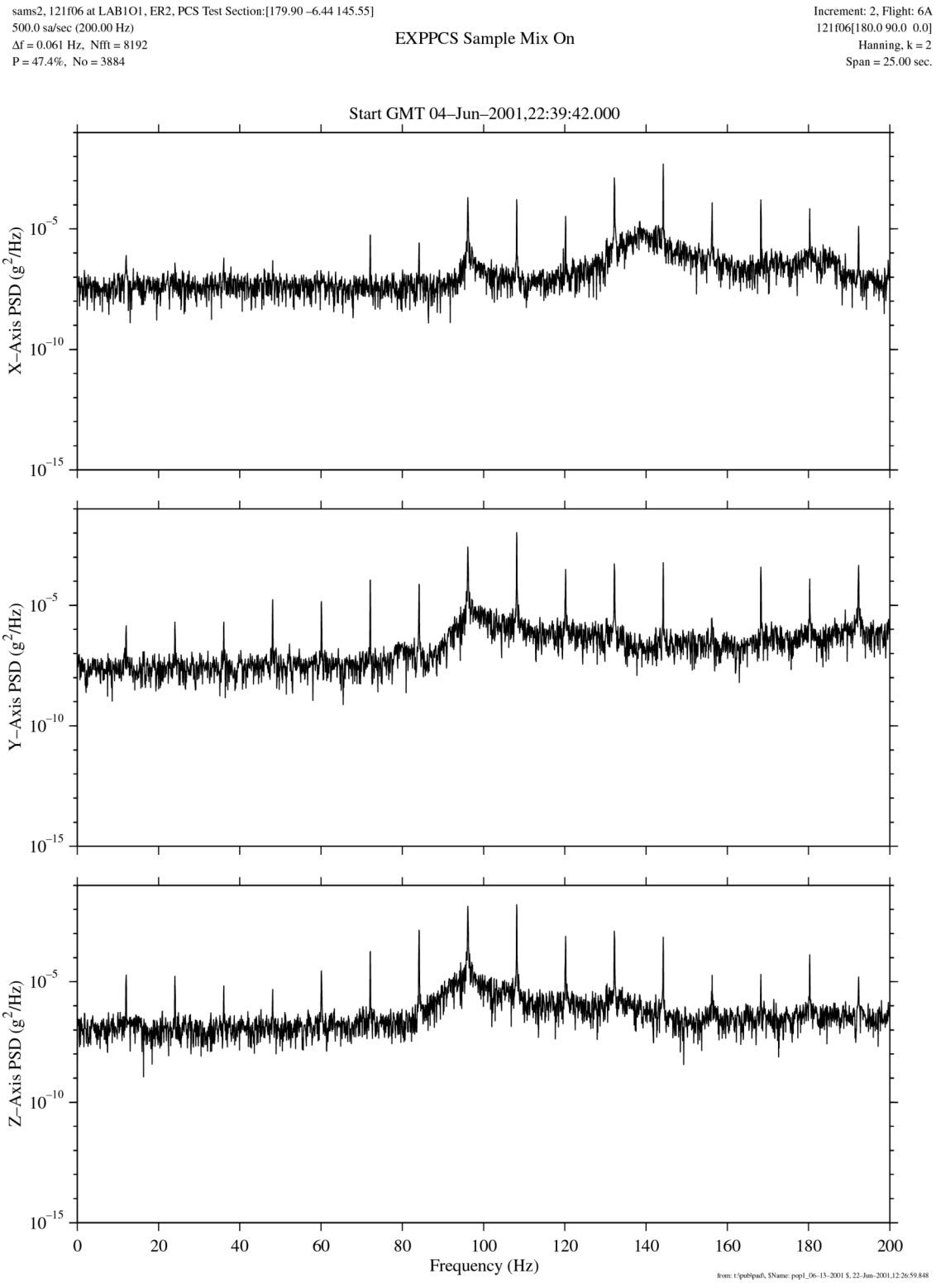

Figure 9.3.5.1-3 PSD of EXPPCS Sample Mix Operation On (121f06)

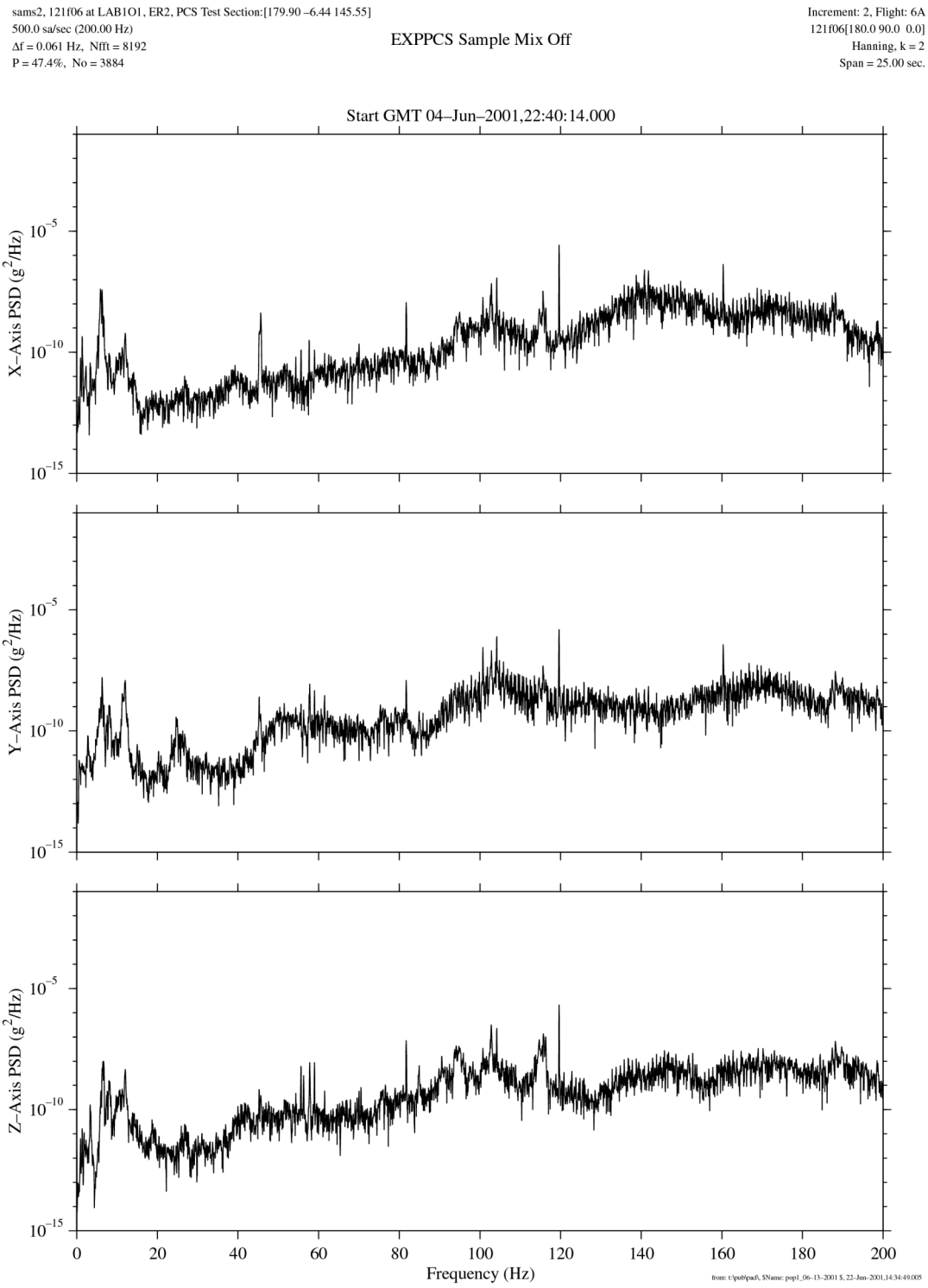

Figure 9.3.5.1-4 PSD of EXPPCS Sample Mix Operation Off (121f06)

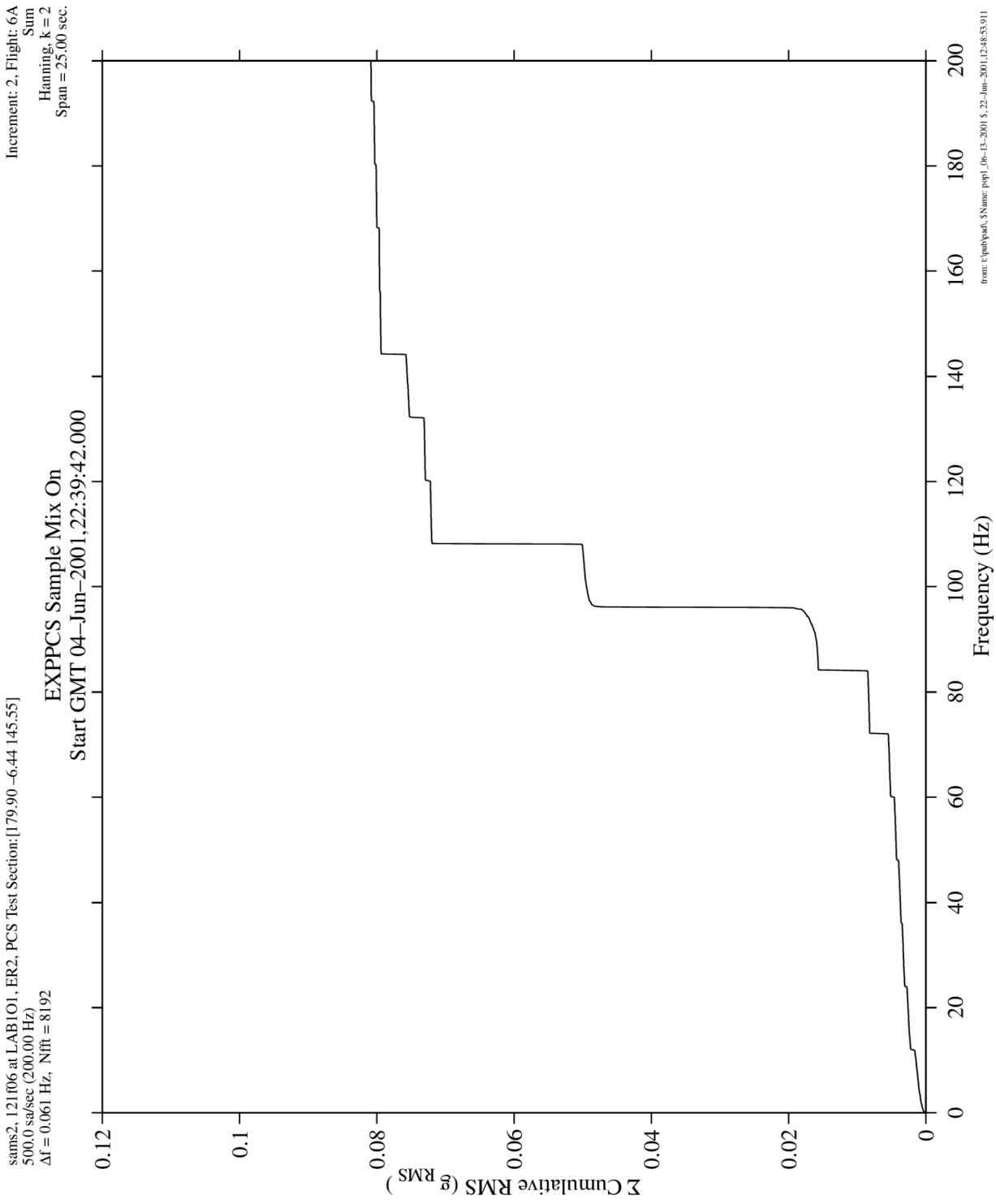

Figure 9.3.5.1-5 Cumulative RMS of EXPPCS Sample Mix Operation On (121f06)

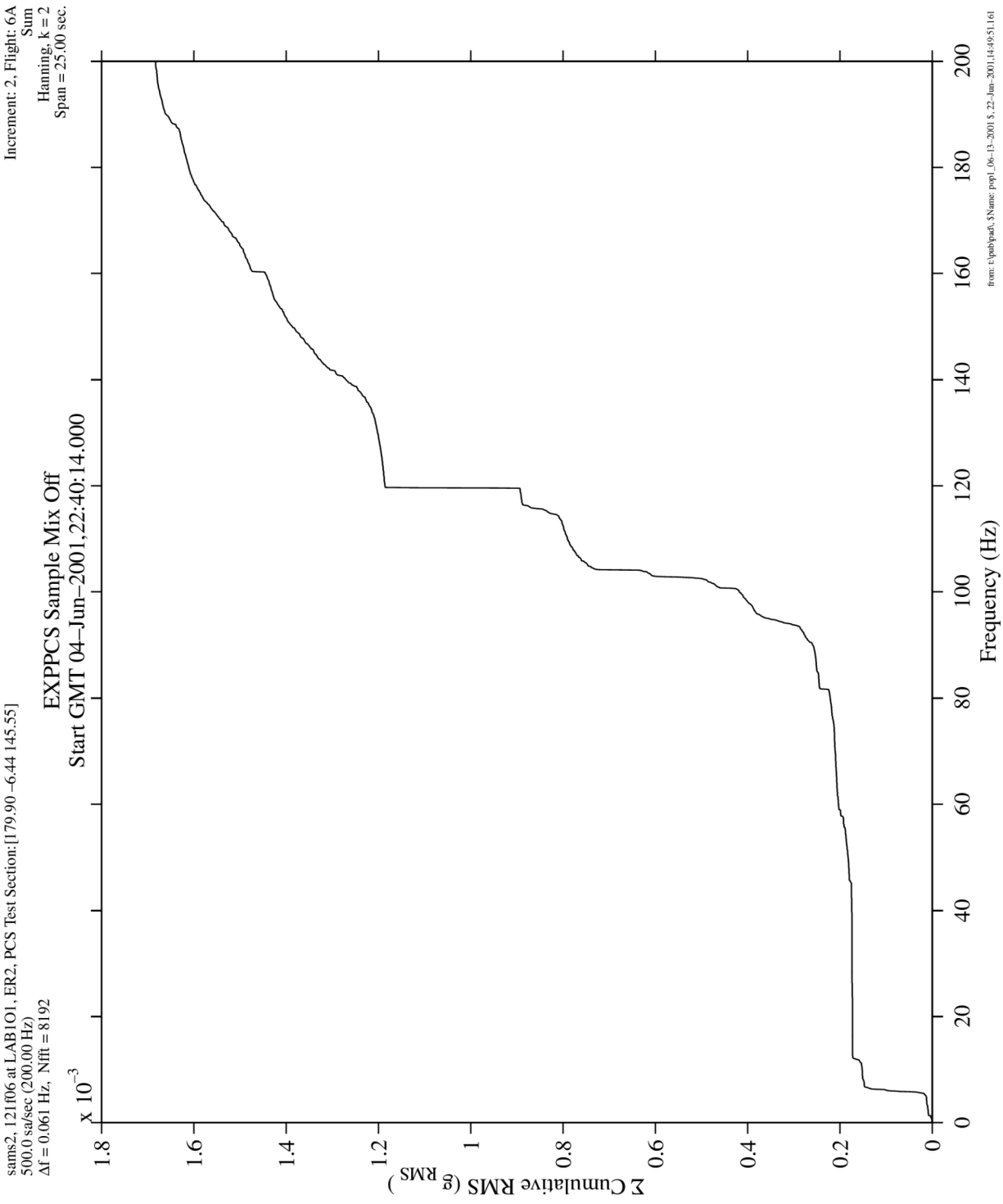

Figure 9.3.5.1-6 Cumulative RMS of EXPPCS Sample Mix Operation Off (121f06)

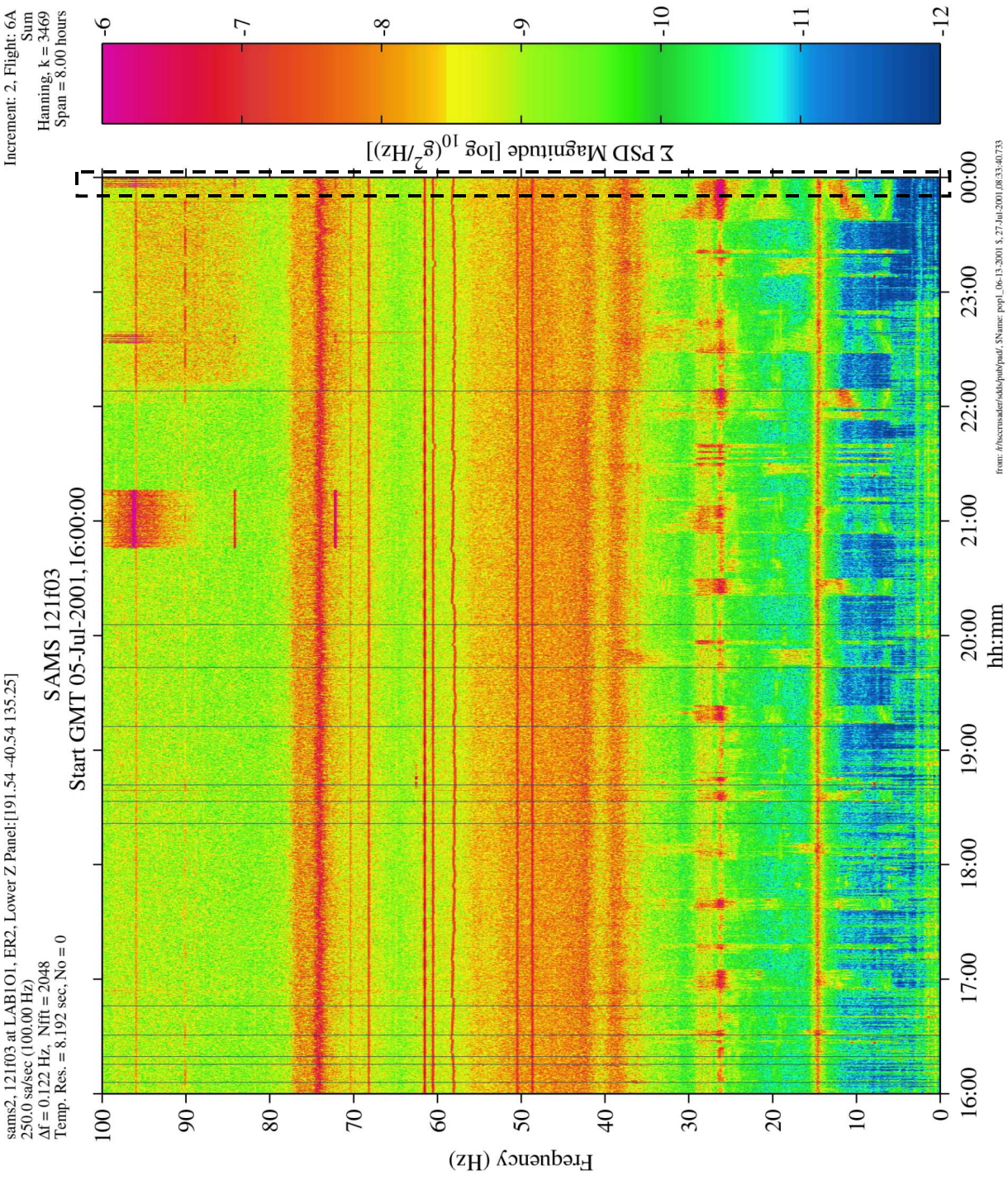

Figure 9.3.5.1-7 Spectrogram of EXPPCS Sample Mix Operation On (121f03)

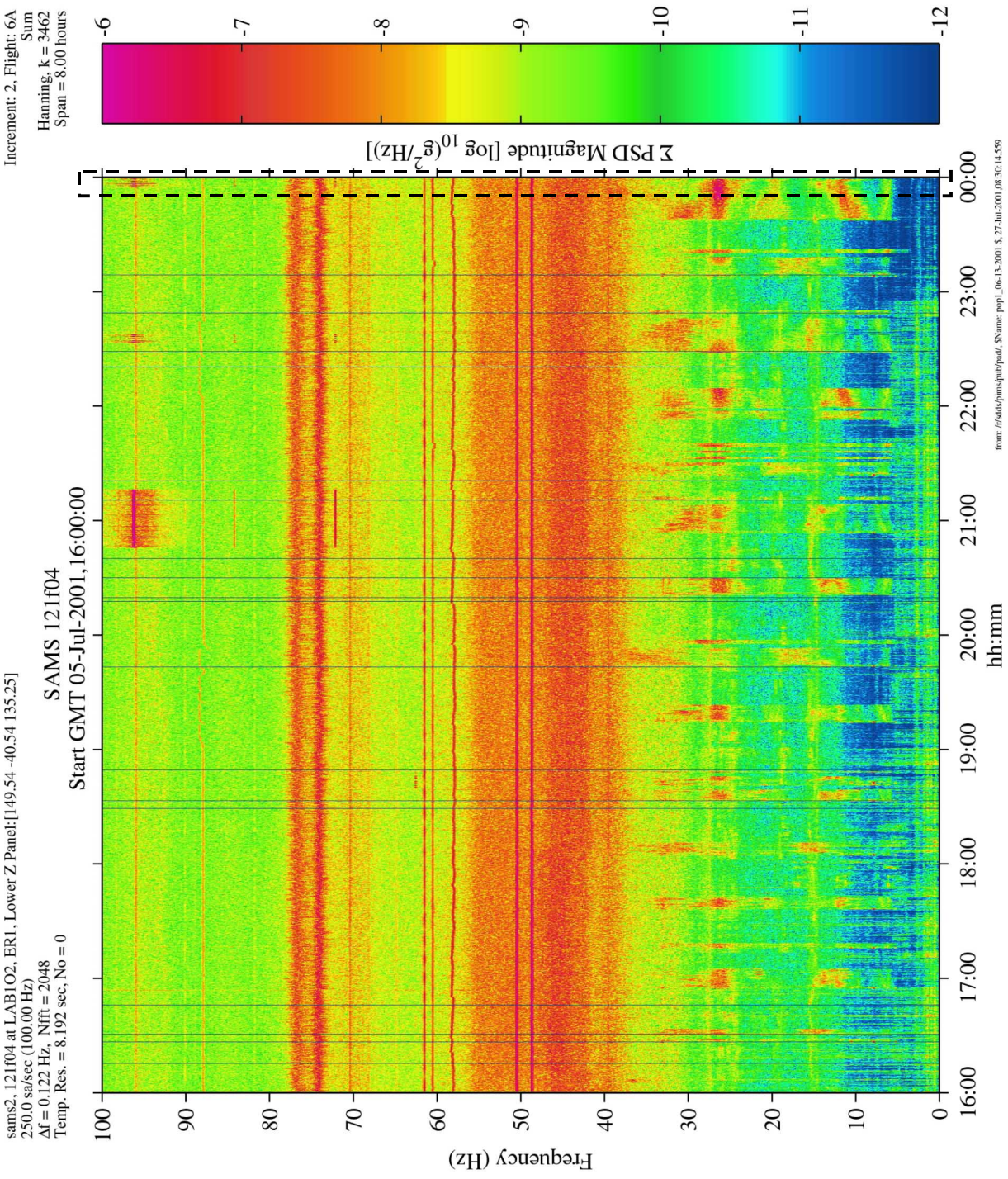

Figure 9.3.5.1-8 Spectrogram of EXPPCS Sample Mix Operation On (121f04)

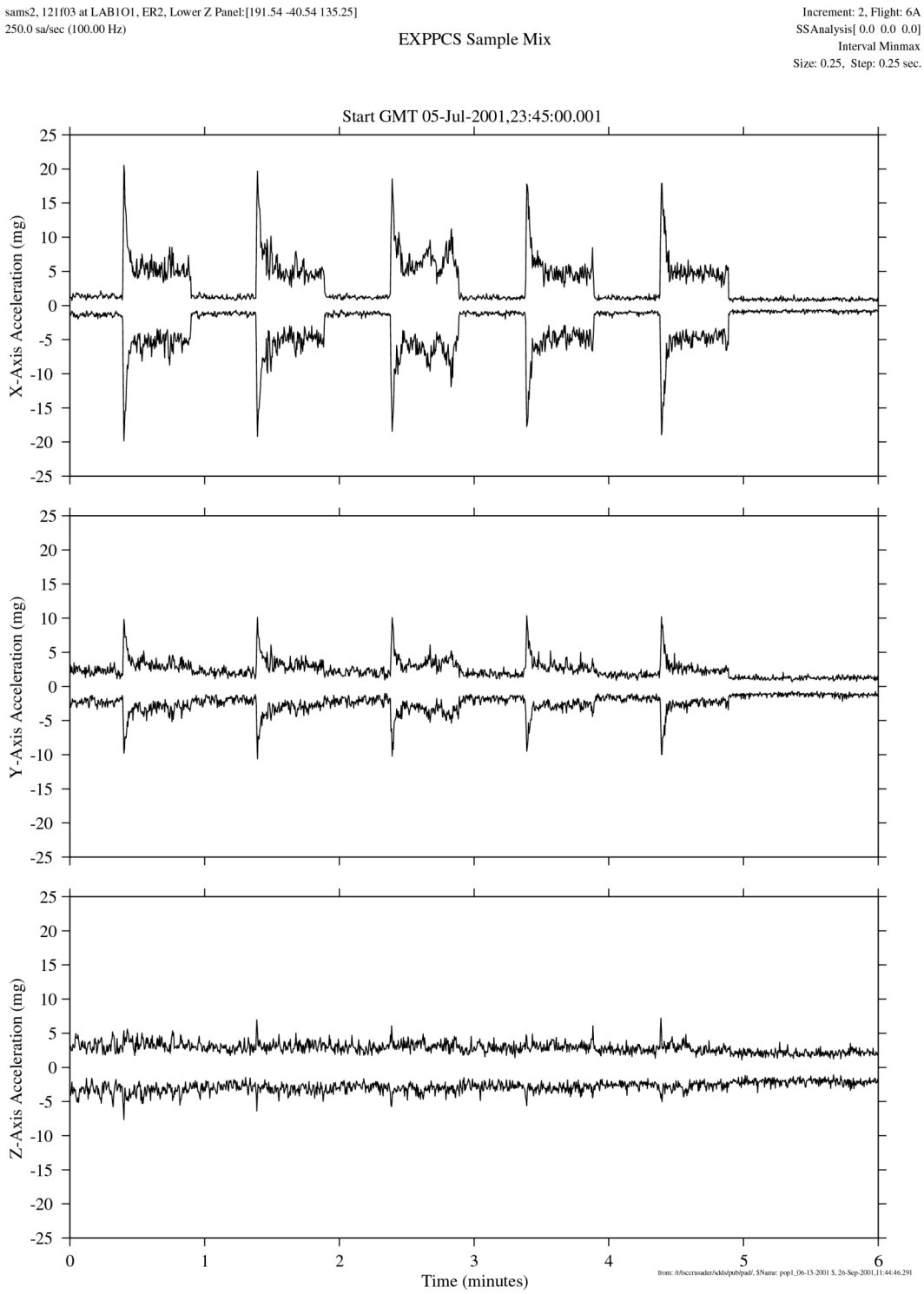

Figure 9.3.5.1-9 Interval Min/Max of EXPPCS Sample Mix Operation On (121f03)

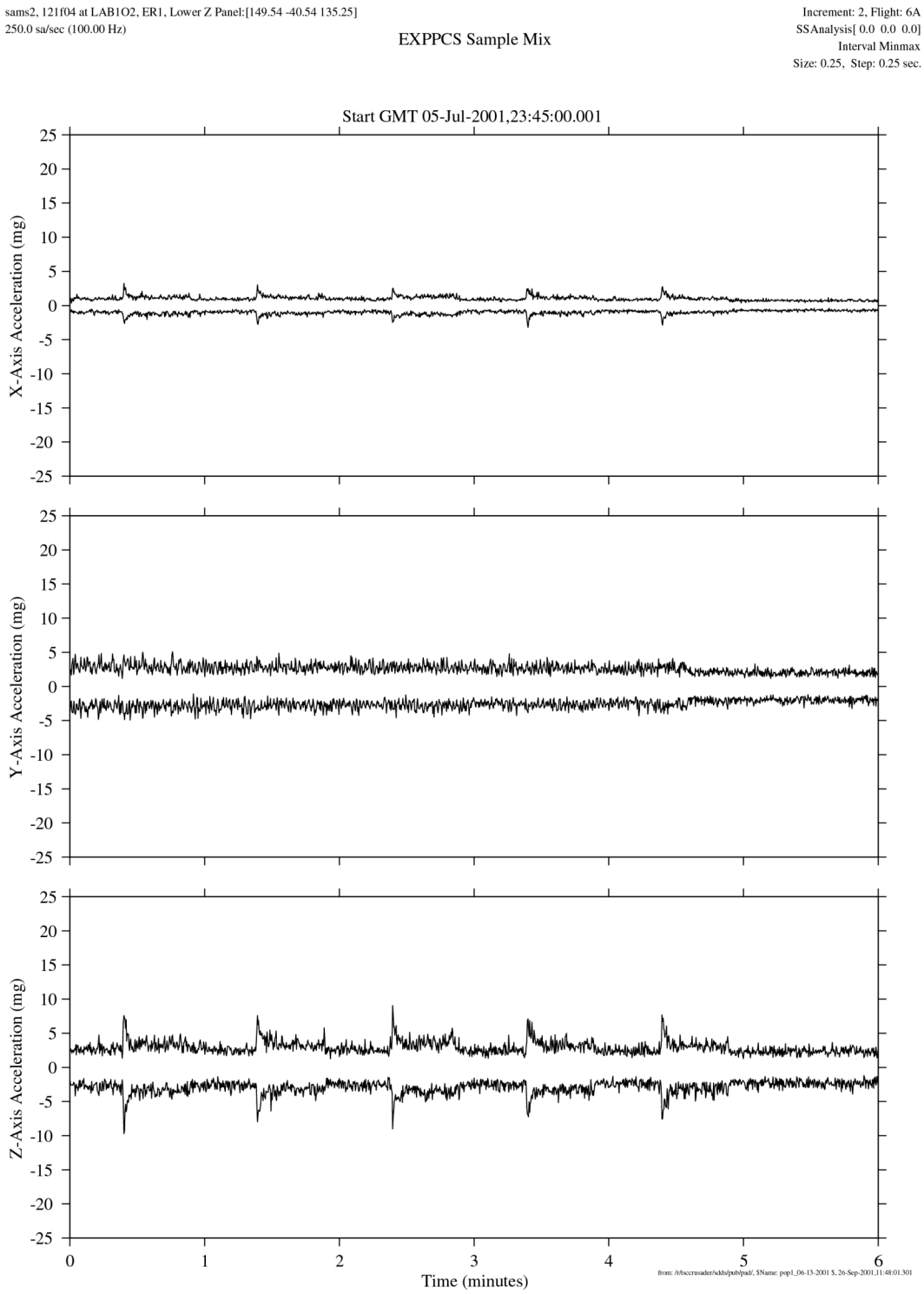

Figure 9.3.5.1-10 Interval Min/Max of EXPPCS Sample Mix Operation On (121f04)

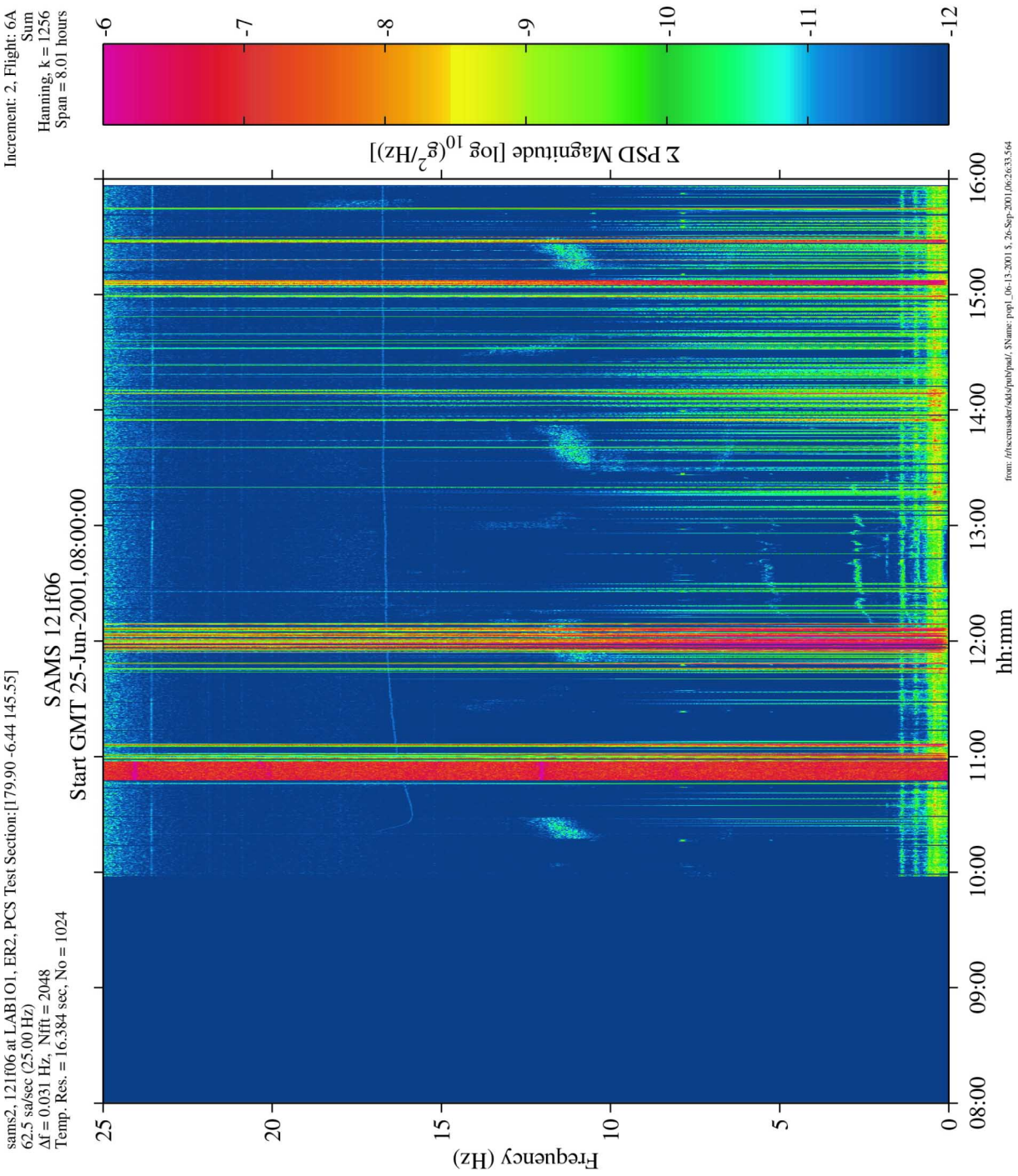

Figure 9.3.5.2-1 Spectrogram of EXPPCS Rheology On (121f06)