EQUIPMENT OVERVIEW

The General Laboratory Active Cryogenic International Space Station (ISS) Experiment Refrigerator (GLACIER) is a rear-breathing or water-cooled cryogenic freezer that provides cryogenic transportation and preservation of samples requiring temperatures between +4 °C (39 °F) and −160 °C (−301 °F). The cold volume of the unit has a generic design that allows for multiple types of science samples requiring cryogenic thermal storage. The GLACIER has a cold volume sample storage area of 23.1 cm (10.75 in.) x 27.94 cm (11.00 in.) x 41.91 cm (16.5 in.) and is capable of supporting 10 kg (22 lb) of experiment samples with an internal cold volume of 20 L. The GLACIER can maintain a temperature of −160 °C (−256 °F) for 6 to 8 hours without power if it had been operating at −160 °C (−301 °F) prior to the power outage.

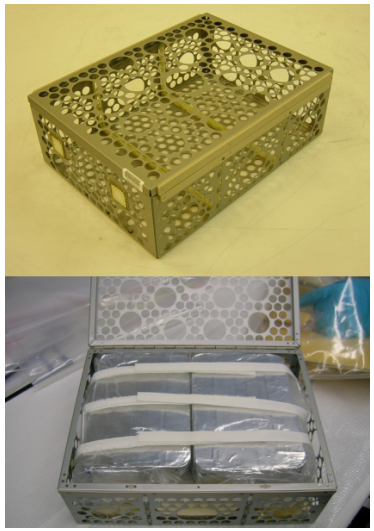
The cold volume is configured such that sample access and volume configuration may be varied for each sample type and the cold volume is separated from the external environment by two doors. The outer door provides insulation and strength to withstand crew-applied loads, while the inner door is divided into four insulated aperture doors.

See following pages and plots for correlation between GLACIER equipment ops and distinct acceleration (vibratory) signatures.

ACCELERATION ANALYSIS OVERVIEW

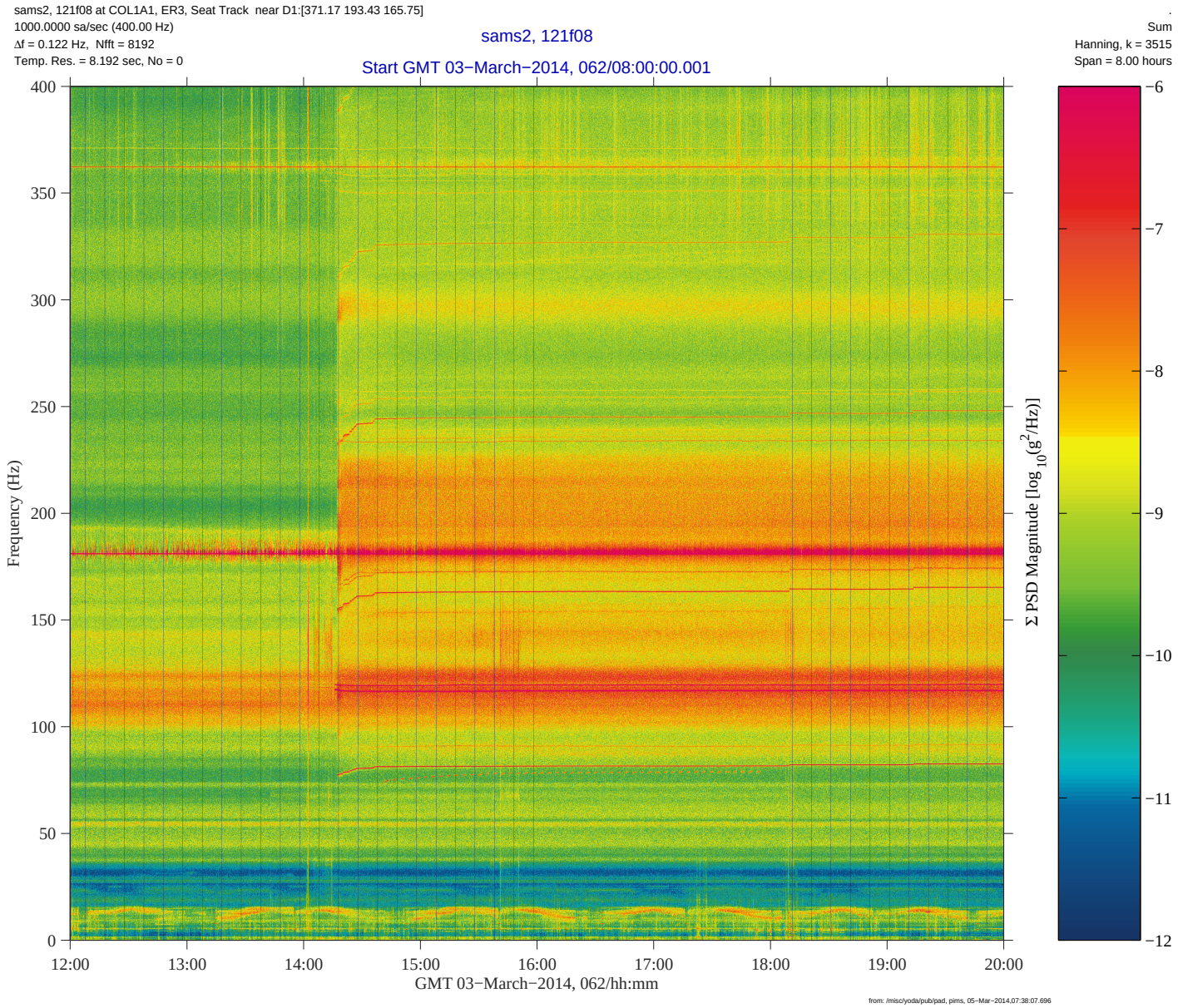
During ISS Increment 39, one such GLACIER, specifically GLACIER-3, was operating in the Columbus module in EXPRESS Rack 3 (COL1A1). The vibratory acceleration measurement data collected by the nearby SAMS sensor (121f08) showed distinctive start-up signatures that suggested a possible association with GLACIER-3 operations as itemized below and reinforced with plots and descriptions on subsequent pages:

- at about GMT 03-Mar-2014 14:15:46, we see the start-up of twin spectral peaks near 116.8 Hz and 119.4 Hz, and this time is within 14 seconds of GLACIER-3 activation*
- at about GMT 03-Mar-2014 14:17:06, we see the start of spectral peaks near 80 Hz (~4800 RPM, steady state) along with its 2nd through 5th harmonics, and this time is within 2 seconds of the GLACIER payload team receiving health and status data*
- a spectrogram zoom-in shows steady state for humidity cycle is just under 80 Hz, starts with first cycle on at about GMT 03-Mar-2014 14:41:51
- a plot seen later will show a humidity cycle every 4 minutes; that is, 10 cycles between GMT tick marks spaced every ~40 minutes



*Thanks to Chris Wakefield (PRO) for providing this information.

Columbus GLACIER-3 Qualify



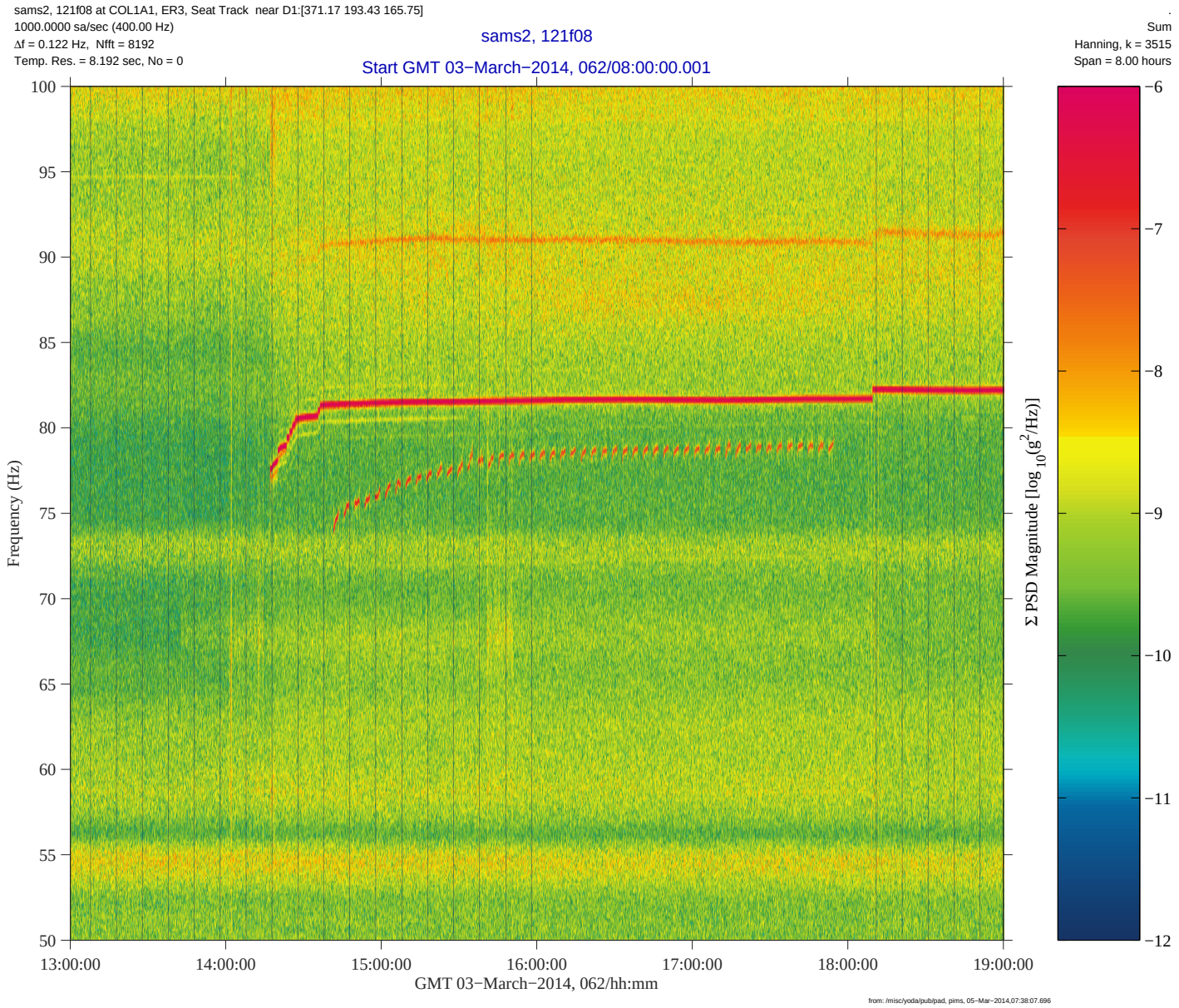
Description	
Sensor	SAMS 121f08 1000.0 sa/sec, 400.0 Hz
Location	COL1A1, ER3, Seat Track near D1
Plot Type	Color Spectrogram

Notes:

- This is a color spectrogram computed from SAMS sensor measurements made in the Columbus module near GLACIER-3.
- At about GMT 03-Mar-2014 14:15:46, we see the start-up of twin spectral peaks near 116.8 Hz and 119.4 Hz, and this time is within 14 seconds of reported GLACIER-3 activation.
- At about GMT 03-Mar-2014 14:17:06, we see the start of spectral peaks near 80 Hz (~4800 RPM, steady state) along with its 2nd through 5th harmonics, and this time is within 2 seconds of report that GLACIER payload team received health & status data.
- Subsequent plots will qualify and quantify an interesting cyclic signature associated with this equipment.

Regime:	Vibratory
Category:	Equipment
Source:	Columbus GLACIER-3

Columbus GLACIER-3
Qualify



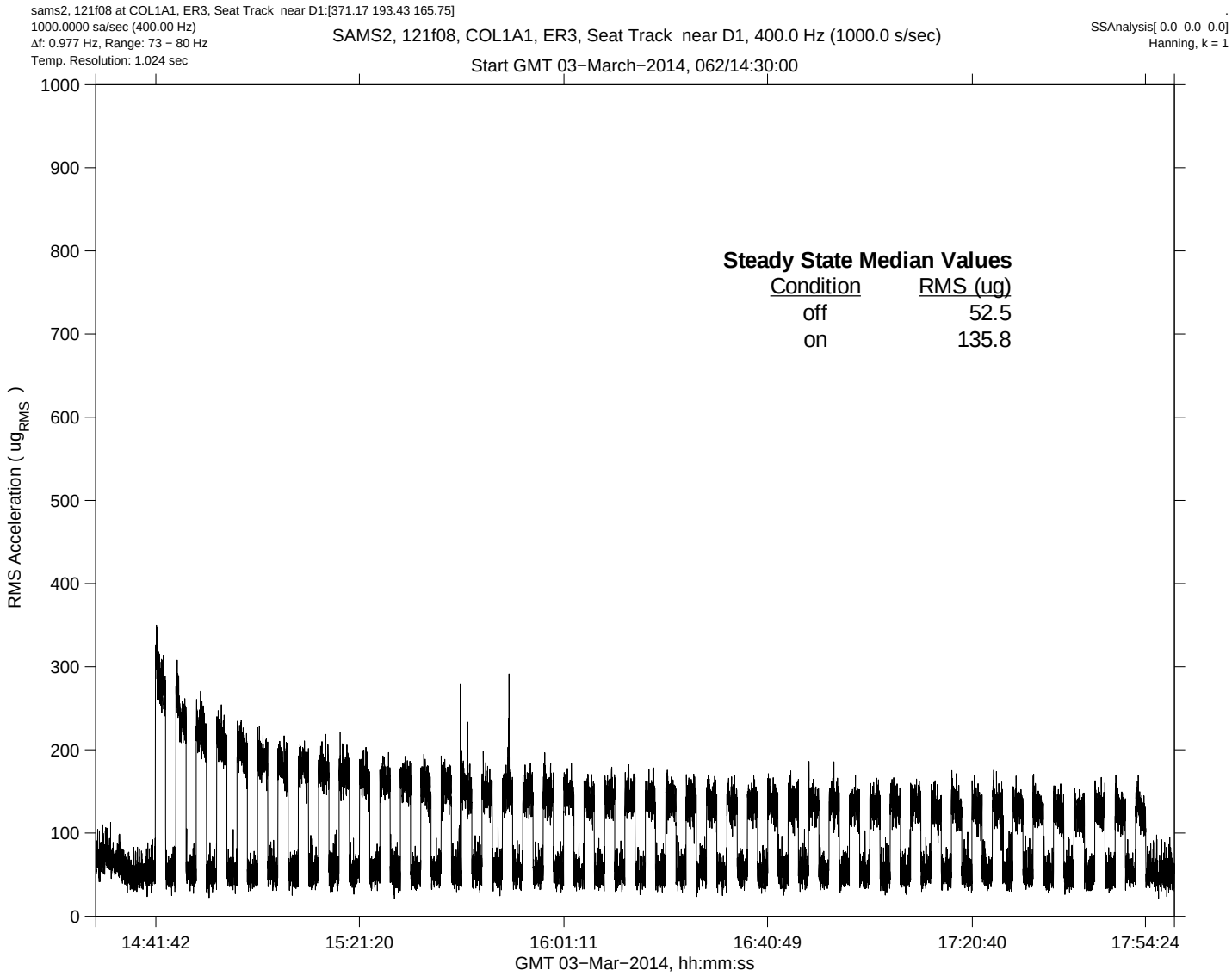
Description	
Sensor	SAMS 121f08 1000.0 sa/sec, 400.0 Hz
Location	COL1A1, ER3, Seat Track near D1
Plot Type	Color Spectrogram

Notes:

- This spectrogram is a zoom-in around the span of the humidity duty cycle starting between GMT 03-Mar-2014,14:00 and 15:00.
- What appears to be like red stitching on this spectrogram between 75 and 80 Hz corresponds to the duty cycle of this equipment. This duty cycle is seen clearer on next plot of RMS versus time.
- Note here that at start-up, this equipment operates at a lower frequency (below 75 Hz), but ends with steady state of just about 80 Hz.

Regime:	Vibratory
Category:	Equipment
Source:	Columbus GLACIER-3

Columbus GLACIER-3
Quantify and Qualify



Description	
Sensor	SAMS 121f08 1000.0 sa/sec, 400.0 Hz
Location	COL1A1, ER3, Seat Track near D1
Plot Type	RMS vs. Time (**73 < f < 80 Hz**)

Notes:

- This plot of RMS acceleration versus time shows a temporal zoom-in tight around the span of the humidity duty cycle starting at about GMT 03-Mar-2014,14:41:42, along with a spectral zoom-in between 73 and 80 Hz.
- The on/off signature seen here corresponds to what looks like red stitching on the previous spectrogram zoom-in plot between 75 and 80 Hz on spectrogram.
- We see from the square wave nature of this RMS plot the regulation that this equipment provides, presumably preparing for some specific sample storage.
- There are time-axis shows ticks at every tenth cycle, starting at 14:41:42 and like clockwork, ten cycles last 40 minutes between successive ticks, so there was a cycle every 4 minutes.
- At steady state, there is a difference of about 83 ugRMS for this frequency band.

Regime:	Vibratory
Category:	Equipment
Source:	Columbus GLACIER-3